DIVISION 6 STRUCTURES

SECTION 6-01 GENERAL REQUIREMENTS - STRUCTURES

6-01.1 DESCRIPTION

This section relates to structural and incidental items used in any or all types of existing or proposed Structures. These provisions supplement the detailed Specifications supplied for any Structure. These provisions apply only when relevant and when they do not conflict with the Contract.

6-01.2 FOUNDATION DATA

If obtained, foundation data in the Contract (from test borings, test pits, or other sources) are only to guide the Owner in planning and designing the project. These data reasonably represent the information at the test sites when the investigations were made. See Section 1-02.4(2).

6-01.3 CLEARING THE SITE

The Contractor shall clear the entire site of the proposed Structure to the limits shown in the Drawings or determined by the Engineer.

6-01.4 APPEARANCE OF STRUCTURES

To achieve a more pleasing appearance, the Engineer may require the Contractor to adjust the height and alignment of bridge railings, traffic barrier, and structural curbs.

6-01.5 RESERVED

6-01.6 LOAD RESTRICTIONS ON BRIDGES UNDER CONSTRUCTION

Bridges under construction shall remain closed to all traffic, including construction equipment, until the Substructure and the Superstructure, through the bridge deck, are complete for the entire Structure, except as provided herein. Completion includes release of all falsework, removal of all forms, and attainment of the minimum design concrete strength and specified age of the concrete under these Specifications. Once the Structure is complete, Section 1-07.7 shall govern all traffic loading, including construction traffic (equipment).

If necessary and safe to do so, and if the Contractor requests it in writing, the Engineer may approve traffic on a bridge prior to completion. The maximum distributed load at each construction equipment support shall not exceed the design load by more than 33-percent. The written request shall:

1. Describe the extent of the Structure completion at time of the proposed equipment loading;
2. Describe the loading magnitude, arrangement, movement, and position of traffic (equipment) on the bridge, including but not limited to :
    a. Location of construction equipment, including outriggers, spreader beams and supports for each, relative to the bridge framing plan (bridge girder layout);
    b. Mechanism of all load transfer (load path) to the bridge;
3. Provide stress calculations under the design criteria specified in the AASHTO LRFD Bridge Design Specifications, current edition, prepared by (or under the direction of) a professional engineer, licensed under Title 18 RCW state of Washington, and carrying the professional engineer's signature and seal, including but not limited to the following:
    a. Supporting calculations showing the flexural and shear stresses in the main load carrying members due to the construction load are within the allowable stresses;
    b. Supporting calculations showing the flexural and shear stresses in the bridge deck due to the construction load are within the allowable stresses;
4. Provide supporting material properties, catalogue cuts, and other information describing the construction equipment and all associated outriggers, spreader beams, and supports; and,
5. State that the Contractor assumes all risk for damage.

6-01.7 NAVIGABLE STREAMS

The Contractor shall keep navigable streams clear so water traffic may pass safely, providing and maintaining all lights and signals required by the U.S. Coast Guard. The Contractor shall also comply with all channel depth and clearance line requirements of the U.S. Corps of Engineers. This may require removing material deposited in the channel during construction.

6-01.8 APPROACHES TO MOVABLE SPANS

No bridge deck or sidewalk slab on the approach span at either end of a movable span may be placed until after the movable span has been completed, adjusted and closed.

6-01.9 WORKING DRAWINGS

The Contractor shall submit supplemental working Drawings with calculations as required for the performance of the Work. The Drawings shall be on sheets measuring 22 by 34 inches, 11 by 17 inches, or on sheets with dimensions in multiples of 8 1/2 by 11 inches. All drawings shall be to scale in keeping with standard drafting procedures. The design calculations shall be on sheets measuring 8 1/2 by 11 inches. They shall be legible, with all terms identified, and may include computer printouts. The drawings and calculations shall be provided far enough in advance of actual need to allow for the review process by the Owner which may involve rejection, revision, or resubmittal. Unless otherwise stated in the Contract, the Engineer will require up to 30 calendar days from the date the submittals are received until they are sent to the Contractor. This time will increase if the drawings submitted do not meet the Contract requirements or contain insufficient details.

Unless designated otherwise by the Contractor, submittals of working Drawings will be reviewed in the order they are received by the Engineer. In the event that several working Drawing are submitted simultaneously, the Contractor shall specify the sequence in which these plans are to be reviewed. The Engineer's review time shall be as specified above for the first plan in the specified sequence and up to an additional 2 weeks for each plan lower in the specified sequence. A plan is identified as one or more working Drawings that pertain to a unit of Superstructure or a complete pier. If the Contractor does not submit a working Drawing review sequence for simultaneous plan submittals, the review sequence shall be at the Engineer's discretion

Working drawings and calculations shall be prepared by (or under the direction of) a Professional Engineer, licensed under Title 18 RCW, State of Washington, and shall carry the Professional Engineer's signature and seal.

If more than the specified numbers of days are required for the Engineer's review of any individual submittal or resubmittal, an extension of time will be considered in accordance with Section 1-08.8.

6-01.10 RESERVED

6-01.11 NAME PLATES

The Contractor shall install no permanent plates or markers on a Structure unless the Drawings show it.

6-01.12 FINAL CLEANUP - STRUCTURE

When the Structure is completed, the Contractor shall leave it and the entire site in a clean and orderly condition. Structure decks shall be swept and washed. Temporary buildings, falsework, piling, lumber, equipment, and debris shall be removed. The Contractor shall level and fine grade all excavated material not used for backfill, and shall fine grade all slopes and around all piers, bents, and abutments. This clean-up is inclusive to the requirements of Section 1-04.11, Project Cleanliness and final cleanup.

6-01.13 ARCHITECTURAL FEATURES

To ensure uniform texture and color, the Contractor shall obtain all cement for the Structure from the same manufacturing plant unless the Engineer waives this requirement in writing.

6-01.14 PREMOLDED JOINT FILLER

When the Drawings call for premolded joint filler, the Contractor shall fasten it with galvanized wire nails to one side of the joint. The nails shall be no more than 6-inches apart and shall be 1½-inches from the edges over the entire joint area. The nails shall be at least 1½-inches longer than the thickness of the filler.

The Contractor may substitute for the nails any adhesive approved by the Engineer. This adhesive, however, shall be compatible with the Material specified in Section 9-04.1(2) and capable of bonding the filler to Portland cement concrete.

6-01.15 NORMAL TEMPERATURE

Bridge Drawings state dimensions at a normal temperature of 64ºF. Unless otherwise noted, these dimensions are horizontal or vertical.

6-01.16 MAINTENANCE OF BRIDGE DRAINS

Unless measures are necessary to prevent construction stormwater discharge, the Contractor shall keep existing and new bridge drains open and functioning during construction. Before bridge drain work begins, the Contractor shall verify existing drains are clear and free flowing, and if not, the Contractor shall immediately notify the Engineer. Maintenance includes keeping drains clean, free of debris, and free flowing. During the construction, drainage shall be addressed under the applicable Construction Stormwater Pollution Prevention Plans (Section 8-01). Before acceptance of the bridge drains, the existing and new bridge drains shall be tested for drainage, and clogged or non-flowing drains shall be cleaned and cleared to a free flowing state acceptable to the Engineer.

SECTION 6-02 CEMENT CONCRETE STRUCTURES AND CEMENT CONCRETE FOR MISCELLANEOUS WORK

6-02.1 DESCRIPTION

This Work comprises the construction of all Structures (and their parts) made of cement concrete with or without reinforcement, including bridge approach slabs. Any part of a Structure to be made of other materials shall be built as these Specifications require elsewhere. This Section also provides cement concrete requirements for miscellaneous Work by reference.

6-02.2 MATERIALS

Materials shall meet the requirements of the following sections:

Portland and Hydraulic Cement	9-01
Aggregates for Portland Cement Concrete	9-03.1
Gravel Backfill	9-03.12
Joint and Crack Sealing Materials	9-04
Reinforcing Steel	9-07
Epoxy-Coated Reinforcing Steel	9-07
Pigmented Sealer Materials for Coating of Concrete Surface	9-8.2(1)
Prestressed Concrete Girders	9-19
Grout	9-20.3
Mortar	9-20.4
Curing Materials, Pozzolans and Admixtures	9-23
Fly Ash	9-23.9
Ground Granulated Blast Furnace Slag (GGBFS)	9-23.10
Microsilica Fume	9-23.11
Metakaolin	9-23.12
Plastic Waterstop	9-24
Water	9-25
Elastomeric Bearing Pads	9-35

6-02.3 CONSTRUCTION REQUIREMENTS

6-02.3(1) CLASSIFICATION OF STRUCTURAL CONCRETE

The class of concrete to be used shall be as noted in the Drawings and these Specifications. The class includes the specified minimum compressive strength in psi at 28 days (numerical class) and may include a letter suffix to denote structural concrete for a specific use. Letter suffixes include A for bridge approach slabs, D for bridge decks, P for piling and shafts, and W for underwater. The numerical class without a letter suffix denotes structural concrete for general purposes.

Concrete of a numerical class greater than 4000 shall conform to the requirements specified for either Class 4000 (if general-purpose) or for the appropriate Class 4000 with a letter suffix, as follows:

1. Mix ingredients and proportioning specified in Sections 6-02.3(2) and 6-02.3(2)A.
2. Consistency requirements specified in Section 6-02.3(4)C.
3. Curing requirements specified in Section 6-02.3(11).

The Contractor may request, in writing, permission to use a different class of concrete with either the same or a higher compressive strength than specified. The substitute concrete shall be evaluated for acceptance based on the specified class of concrete. The Engineer will respond in writing. The Contractor shall bear any added costs that result from the change.

The phrase **"w/ ___% minimum pozzolans"** following the class of concrete and any designation identifies a minimum use of Pozzolans (fly ash and/or ground granulated blast furnace slag) not exceeding 40 percent is required. Ground granulated blast furnace slag and fly ash maximums shall not be exceeded individually. See table on Cementitious Requirement for Concrete.

6-02.3(2) PROPORTIONING MATERIALS

The soluble chloride ion content shall be determined by the concrete supplier and included with the mix design. The soluble chloride ion content shall be determined by (1) testing mixed concrete cured at least 28-Days or (2) totaled from tests of individual concrete ingredients (cement, aggregate, admixtures, water, fly ash, ground granulated blast furnace slag, and other supplementary cementing materials). Chloride ion limits for admixtures and water are in Sections 9-23 and 9-25. Soluble chloride ion limits for mixed concrete shall not exceed the following percent by mass of cement when tested under AASHTO T260:

Category	Acid-Soluble	Water-Soluble
Prestressed concrete	0.08	0.06
Reinforced concrete	0.10	0.08

Unless otherwise specified, the Contractor shall use Type I or II Portland cement in all concrete as defined in Section 9-01.2(1).

Using fly ash is required for Class 4000D and 4000P concrete; except that ground granulated blast furnace slag may be substituted for fly ash at a 1:1 ratio. The use of fly ash and ground granulated blast furnace slag is optional for all other classes of concrete and may be substituted for Portland cement at a 1:1 ratio as noted in the table below.

Cementitious Requirement for Concrete

Class of Concrete	Minimum Pounds of Cementitious Material per Cubic Yard	Minimum Percent Replacement of Pozzolans for Portland Cement	Maximum Percent Replacement of Fly Ash for Portland Cement	Maximum Percent Replacement of Ground Granulated Blast Furnace Slag for Portland Cement
6000	658	0[1]	35	40
5000	611	0[1]	35	40
4000	564	0[1]	35	50
4000A	564	0[1]	20	30
4000D	660	10[1]	20	30
4000P	600	15[1]	35	50
4000W	564	0[1]	35	50
3000	564	0[1]	35	50
Commercial Concrete	N/A	0	35	50

[1] – Unless otherwise specified in Bid item

When both ground granulated blast furnace slag and fly ash are in the concrete mix, the total weight of both these materials is limited to 40-percent by weight of the total cementitious material.

The water/cement ratio shall be calculated on the total weight of cementitious material. The following are considered cementitious materials: Portland cement, fly ash, ground granulated blast furnace slag, microsilica flume and metakaolin. With the Engineer's written approval, microsilica fume and metakaolin can be used in all classifications of Class 4000, Class 3000, and commercial concrete and is limited to a maximum of 10 percent of the cementitious material.

As an alternative to fly ash, ground granulated blast furnace slag and cement as separate components, a blended hydraulic cement that meets the requirements of Section 9-01.2(4) Blended Hydraulic Cement may be used.

6-02.3(2)A CONTRACTOR MIX DESIGN

The Contractor shall provide a mix design in writing to the Engineer for all classes of concrete specified in the Drawings except for those accepted based on a Certificate of Compliance. No concrete shall be placed until the Engineer has reviewed the mix design. The required average 28-Day compressive strength shall be selected per ACI 318, Chapter 5, Section 5.3.2. ACI 211.1 and ACI 318 shall be used to determine proportions. All proposed concrete mix shall meet the cementitious material requirements listed in the table on Cementitious Requirement for Concrete in Section 6-02.3(2).

The Contractor's submittal of a mix design shall be per Section 1-05.3 and shall provide a unique identification for each mix design, and shall include the mix proportions per cubic yard, the proposed sources, the average 28-Day compressive strength for which the mix is designed, the fineness modulus, and the water cement ratio. Concrete placeability, workability,

and strength shall be the responsibility of the Contractor. The Contractor shall notify the Engineer in writing of any mix design modifications.

Fine aggregate shall conform to Section 9-03.1(2) Class 1 or Class 2.

Coarse aggregate shall conform to Section 9-03.1(3). An alternate combined aggregate gradation conforming to Section 9-03.1(4) may also be used. The nominal maximum size aggregate for Class 4000P shall be 3/8-inch. The nominal maximum size aggregate for Class 4000D shall be 1-inch. The nominal maximum size aggregate for Class 4000A shall be 1-inch.

Nominal maximum size for concrete aggregate is defined as the smallest standard sieve opening through which the entire amount of the aggregate is permitted to pass.

Class 4000D and 4000P concrete shall include a water reducing admixture in the amount recommended by the manufacturer. A retarding admixture is required in concrete Class 4000P. Water reducing and retarding admixtures are optional for all other concrete classes.

A high-range water reducer (superplasticizer) may be used in all mix designs. Microsilica fume may be used in all mix designs. Using a high-range water reducer or microsilica fume shall be submitted as a part of the Contractor's concrete mix design.

Air content shall be a minimum of 4.5-percent and a maximum of 7.5-percent for all concrete placed above the finished ground line.

6-02.3(2)B COMMERCIAL CONCRETE

Commercial concrete shall have a minimum compressive strength at 28-Days of 3000-psi under AASHTO T 22. Commercial concrete placed above the finished ground line shall be air entrained and have an air content from 4.5-percent to 7.5-percent per AASHTO T 152. Commercial concrete does not require plant approval, mix design, or source approvals for cement, aggregate, and other admixtures.

Where concrete Class 3000 is specified for items such as culvert headwalls, plugging culverts, concrete pipe collars, pipe anchors, thrust blocks, monument cases, light standard foundations, pedestals, cabinet bases, guardrail anchors, signpost foundations, fence post footings, sidewalks, curbs, and gutters, the Contractor may use commercial concrete. If commercial concrete is used for sidewalks, curbs, and gutters, it shall have a minimum cementitious material content of 564 pounds per cubic yard of concrete, shall be air-entrained, and the tolerances of Section 6-02.3(5)C shall apply. Commercial concrete shall not be used for items such as bridges, retaining walls, box culverts, curb walls, stairs, or foundations for high mast luminaires, mast arm traffic signals, cantilever signs, and sign bridges. The Engineer may approve using commercial concrete for other applications not listed above.

6-02.3(2)C RESERVED

6-02.3(2)D LEAN CONCRETE

Lean concrete shall contain between 145 and 200-pounds of cement per cubic yard and have a maximum water/cement ratio of 2.

6-02.3(3) ADMIXTURES

Concrete admixtures shall be added to the concrete mix at the time of batching the concrete or under the manufacturer's written procedure and as approved by the Engineer. A copy of the manufacturer's written procedure shall be furnished to the Engineer prior to use of any admixture. Any deviations from the manufacturer's written procedures shall be submitted to the Engineer for acceptance under Section 1-05.3. Admixtures shall not be added to the concrete with the modified procedures until the Engineer has approved them in writing.

When the Contractor is proposing to use admixtures from different admixture manufacturers they shall provide evidence to the Engineer that the admixture will be compatible and not adversely effect the air void system of the hardened concrete. Test results complying with ASTM C 457 shall be provided as the evidence to satisfy this requirement. Proposed combinations shall meet this requirement.

Accelerators shall not be used.

Air entrained cement shall not be used to air entrain concrete.

6-02.3(4) READY-MIX CONCRETE

All concrete, except commercial concrete and lean concrete shall be batched in a prequalified manual, semi-automatic, or automatic plant as described in Section 6-02.3(4)A. The Engineer is not responsible for any delays to the Contractor due to problems in getting the plant certified.

6-02.3(4)A QUALIFICATION OF CONCRETE SUPPLIERS

Batch Plant Prequalification may be obtained through methods:

1. Certification by the National Ready Mix Concrete Association (NRMCA). Information concerning NRMCA certification may be obtained from the NRMCA at 900 Spring Street, Silver Springs, MD 20910 or online at

www.nrmca.org. The NRMCA certification shall be good for a 2-year period. When this method of certification is used the following documentation shall be submitted to the Engineer.

a. A copy of the current NRMCA Certificate of Conformance, the concrete mix design(s), along with copies of the truck list, batch plant scale certification, admixture dispensing certification, and volumetric water batching devices (including water meters) verification.

2. Independent evaluation certified by a Professional Engineer using NRMCA checklist. The Professional Engineer shall be licensed under title 18 RCW, state of Washington, qualified in civil engineering. The independent certification using the NRMCA checklist shall be good for a 2-year period. When this method of certification is used the following documentation shall be submitted to the Engineer.

a. A copy of the Professional Engineer's stamped and sealed NRMCA Verification of Inspection and Application for Certificate page from the NRMCA checklist, the concrete mix design(s), along with copies of the truck list, batch plant scale certification, admixture dispensing certification, and volumetric water batching devices (including water meters) verification.

3. Inspection conducted by the Plant Manager, defined as the person directly responsible for the daily plant operation, using the NRMCA Plant Certification checklist. The Plant Manager certification shall be done prior to the start of a project, and every 6-months throughout the life of the project, and meet the following requirements:

a. The Agreement to Regularly Check Scales and Volumetric Batching Dispensers page in the NRMCA Plant Certification checklist shall be signed by the Plant Manager and notarized.

b. The signed and notarized Agreement to Regularly Check Scales and Volumetric Batching Dispensers page and a copy of the NRMCA Plant Certification checklist cover page showing the plant designation, address and Company operating plant shall all be submitted to the Engineer with the concrete mix design, along with copies of the truck list, batch plant scale certification, admixture dispensing certification, and volumetric water batching devices (including water meters) verification.

c. The NRMCA Plant Certification checklists shall be maintained by the Plant Manager and are subject to review at any time by the Owner.

d. Volumetric water batching devices (including water meters) shall be verified every 90-Days.

For central-mixed concrete, the mixer shall be equipped with a timer that prevents the batch from discharging until the batch has been mixed for the prescribed mixing time. A mixing time of 1 minute will be required after all materials and water have been introduced into the drum. Shorter mixing time may be allowed if the mixer performance is tested under (AASHTO M 157 Annex A1 Concrete Uniformity Requirements). Tests shall be conducted by an independent testing lab or by a commercial concrete producer's lab. If the tests are performed by a producer's lab, the Engineer or a representative will witness all testing.

For shrink-mixed concrete, the mixing time in the stationary mixer shall not be less than 30-seconds or until the ingredients have been thoroughly blended.

For transit-mixed or shrink-mixed concrete, the mixing time in the transit mixer shall be a minimum of 70-revolutions at the mixing speed designated by the manufacturer of the mixer. Following mixing, the concrete in the transit mixer may be agitated at the manufacturer's designated agitation speed. A maximum of 320-revolutions (total of mixing and agitation) will be permitted prior to discharge.

All transit-mixers shall be equipped with an operational revolution counter and a functional device for measurement of water added. All mixing drums shall be free of concrete buildup and the mixing blades shall meet the minimum Specifications of the drum manufacturer. A copy of the manufacturer's blade dimensions and configuration shall be on file at the concrete producer's office. A clearly visible metal data plate (or plates) attached to each mixer and agitator shall display: (1) the maximum concrete capacity of the drum or container for mixing and agitating, and (2) the rotation speed of the drum or blades for both the agitation and mixing speeds. Mixers and agitators shall always operate within the capacity and speed-of-rotation limits set by the manufacturer. Any mixer, when fully loaded, shall keep the concrete uniformly mixed. All mixers and agitators shall be capable of discharging the concrete at a steady rate. Only those transit-mixers which meet the above requirements will be allowed to deliver concrete to any Owner project covered by these Specifications.

In transit-mixing, mixing shall begin within 30-seconds after the cement is added to the aggregates.

Central-mixed concrete, transported by truck mixer/agitator, shall not undergo more than 250-revolutions of the drum or blades before discharging. To remain below this limit, the suppler may agitate the concrete intermittently within the prescribed time limit. When water or admixtures are added after the load is initially mixed, an additional 30-revolutions will be required at the recommended mixing speed.

For each project, at least biannually, or as required, the Plant Manager will examine mixers and agitators to check for any buildup of hardened concrete or worn blades. If this examination reveals a problem, or if the Engineer wishes to test the quality of the concrete, slump tests may be performed with samples taken at approximately the ¼ and ¾ points as the batch is discharged. The maximum allowable slump difference shall be as follows:

If the average of the 2 slump tests is < 4-inches, the difference shall be < 1-inch or if the average of the 2 slump tests is >4-inches, the difference shall be < 1½-inches.

If the slump difference exceeds these limits, the equipment shall not be used until the faulty condition is corrected. However, the equipment may continue in use if longer mixing times or smaller loads produce batches that pass the slump uniformity tests.

All concrete production facilities will be subject to verification inspections at the discretion of the Engineer. Verification inspections are a check for: current scale certifications; accuracy of water metering devices; accuracy of the batching process; and verification of coarse aggregate quality.

If the concrete producer fails to pass the verification inspection, the following actions will be taken:

1. For the first violation, a written warning will be provided.
2. For the second violation, the Engineer will give written notification and the Owner will assess a price reduction equal to 15-percent of the invoice cost of the concrete supplied from the time of the infraction until the deficient condition is corrected.
3. For the third violation, the concrete supplier is suspended from providing concrete until all such deficiencies causing the violation have been permanently corrected and the plant and equipment have been reinspected and meets all the prequalification requirements.
4. For the fourth violation, the concrete supplier shall be disqualified from supplying concrete for 1-year from the date of disqualification. At the end of the suspension period the concrete supplier may request the facilities be inspected for prequalification.

6-02.3(4)B JOBSITE MIXING

For small quantities of concrete, the Contractor may mix concrete on the job site provided the Contractor has requested in writing and received written permission from the Engineer. The Contractor's written request shall include a mix design, batching and mixing procedures, and a list of the equipment performing the job-site mixing. All job site mixed concrete shall be mixed in a mechanical mixer.

If the Engineer permits, hand mixing of concrete will be permitted for pipe collars, pipe plugs, fence posts, or other items approved by the Engineer, provided the hand mixing is done on a watertight platform to distribute materials evenly throughout the mass. Mixing shall continue long enough to produce a uniform mixture. No hand mixed batch shall exceed ½-cubic yard.

Concrete mixed at the jobsite is never permitted for placement in water.

6-02.3(4)C CONSISTENCY

The maximum slump for concrete shall be:

1. 3.5-inches for vibrated concrete placed in all bridge decks, bridge approach slabs, and flat slab bridge Superstructures.
2. 4.5-inches for all other vibrated concrete.
3. 7-inches for non-vibrated concrete. (Includes Class 4000P)
4. 9-inches for shafts when using Class 4000P, provided the water cement ratio does not exceed 0.44 and a water reducer is used meeting the requirements of 9-23.6.
5. 5.5-inches for all concrete placed in curbs, gutters, and sidewalks.

When a high range water reducer is used, the maximum slump listed in 1, 2, 3, and 5 above, may be increased an additional 2-inches.

6-02.3(4)D TEMPERATURE AND TIME FOR PLACEMENT

Concrete temperatures shall remain between 55°F and 90°F while it is being placed. Precast concrete that is heat cured per Section 6-02.3(25)D shall remain between 50°F and 90°F while being placed. The batch of concrete shall be discharged at the Project Site no more than 1½-hours after the cement is added to the concrete mixture. The time to discharge may be extended to 1¾-hours if the temperature of the concrete being placed is less than 75°F. With the approval of the Engineer and as long as the temperature of the concrete being placed is below 75°F, the maximum time to discharge may be extended to two-hours. When conditions are such that the concrete may experience an accelerated initial set, the Engineer may require a shorter time to discharge. The time to discharge may be extended upon written request from the Contractor. This discharge time extension will be considered case by case and requires using specific retardation admixtures and the approval of the Engineer.

6-02.3(5) ACCEPTANCE OF CONCRETE

6-02.3(5)A GENERAL

Lean concrete and commercial concrete will be accepted based on a Certificate of Compliance to be provided by the supplier as described in Section 6-02.3(5)B.

All other concrete will be accepted based on conformance to the requirement for temperature, slump, air content for concrete placed above finished ground line, and the specified compressive strength at 28-Days for sublots as tested and determined by the Owner.

A sublot is defined as the material represented by an individual strength test. An individual strength test is the average compressive strength of cylinders from the same sample of material.

Each sublot will be deemed to have met the specified compressive strength requirement when both of the following conditions are met:

1. Individual strength tests do not fall below the specified strength by more than 12.5-percent or 500-psi, whichever is least.
2. An individual strength test averaged with the 2 preceding individual strength tests meets or exceeds specified strength (for the same class and exact mix I.D. of concrete on the same Contract).

When compressive strengths but the Individual strength tests do not fall below the specified strength, the Engineer may core at locations determined by the Engineer.

When compressive strengths fail to satisfy one or both of the above requirements, the Contractor may:

1. Request acceptance based on the Contractor/Suppliers strength test data for cylinders made from the same truckload of concrete as the Owner cylinders; provided:
   a. The Contractor's test results are obtained from testing cylinders fabricated, handled, and stored for 28-Days under AASHTO T 23 and tested under AASHTO T 22. The test cylinders shall be the same size cylinders as those cast by the Owner.
   b. The technician fabricating the cylinders is qualified by either ACI, Grade 1 or WAQTC to perform this Work.
   c. The Laboratory performing the tests per AASHTO T 22 has an equipment calibration/certification system, and a technician training and evaluation process per AASHTO R-18.
   d. Both the Contractor and Owner have at least 15 test results from the same mix to compare. The Contractor's results could be used if the Contractor's computed average of all their test results is within 1 standard deviation of the Owner's average test result. The computed standard deviation of the Contractor's results shall also be within plus or minus 200-psi of the Owner's standard deviation.
2. Request acceptance of in-place concrete strength based on core results. This method will not be used if the Engineer determines coring would be harmful to the integrity of the Structure. Cores, if allowed, will be obtained by the Contractor under AASHTO T 24 and delivered to the Owner for testing under AASHTO T 22. If the concrete in the Structure will be dry under service conditions, the core will be air dried at a temperature of between 60°F and 80°F and at a relative humidity of less than 60-percent for 7-Days before testing, and will be tested air dry.

Acceptance for each sublot by the core method requires that the average compressive strength of 3 cores be at least 85-percent of the specified strength with no 1 core less than 75-percent of the specified strength. When the Contractor requests strength analysis by coring, the results obtained will be accepted by both parties as conclusive and supersede all other strength data for the concrete sublot.

If the Contractor elects to core, cores shall be obtained no later than 50-Days after initial concrete placement. The Engineer will concur in the locations to be cored. Repair of cored areas shall be the responsibility of the Contractor. The cost incurred in coring and testing these cores, including repair of core locations, shall be borne by the Contractor.

6-02.3(5)B CERTIFICATION OF COMPLIANCE

The concrete producer shall provide a Certificate of Compliance for each truckload of concrete. The Certificate of Compliance shall verify that the delivered concrete complies with the mix design and shall include:

1. Manufacturer plant (batching facility)
2. Owner Contract number.
3. Date
4. Time batched
5. Truck No.
6. Initial revolution counter reading
7. Quantity (quantity batched this load)
8. Type of concrete by class and producer design mix number
9. Cement producer, type, and Mill Certification No. (The mill test number as required by Section 9-01.3 is the basis for acceptance of cement.)
10. Fly ash (if used) brand and Type
11. Approved aggregate gradation designation

Mix design weight per cubic yard and actual batched weights for:

1. Cement
2. Fly ash (if used)
3. Coarse concrete aggregate and moisture content (each size)
4. Fine concrete aggregate and moisture content
5. Water (including free moisture in aggregates)
6. Admixtures brand and total quantity batched
   a. Air-entraining admixture
   b. Water reducing admixture
   c. Other admixture

For concretes that use combined aggregate gradation, the Certificate of Compliance shall include the aggregate components and moisture contents for each size in lieu of the aggregate information described above.

The Certificate of Compliance shall be signed by a responsible representative of the concrete producer, affirming the accuracy of the information provided. In lieu of providing a machine produced record containing all of the above information, the concrete producer may use the Owner-provided printed forms, which shall be completed for each load of concrete delivered to the project.

For commercial concrete, the Certificate of Compliance shall include, as a minimum, the batching facility, date, and quantity batched per load.

6-02.3(5)C CONFORMANCE TO MIX DESIGN

Cement, coarse and fine aggregate weights shall be within the following tolerances of the mix design:

Batch Volumes less than or equal to 4-cubic yards		
Cement	+5%	-1%
Aggregate	+10%	-2%
Batch Volumes more than 4-cubic yards		
Cement	+5%	-1%
Aggregate	+2%	-2%

If the total cementitious material weight includes different components, these component weights shall be within the following tolerances:

1. Portland cement weight plus 5-percent or minus 1-percent of that specified in the mix design.
2. Fly ash and ground granulated blast furnace slag weight plus or minus 5-percent of that specified in the mix design.
3. Microsilica weight plus or minus 10-percent of that specified in the mix design.

Water shall not exceed the maximum water specified in the mix design.

6-02.3(5)D TEST METHODS

Acceptance testing will be performed by the Owner. The test methods to be used with this Specification are:

AASHTO T 22	Compressive Strength of Cylindrical Concrete Specimens
AASHTO T 23	Making and Curing Concrete Test Specimens in the Field
AASHTO T 119	Slump of Hydraulic Cement Concrete
WAQTC TM 2	Sampling Freshly Mixed Concrete
AASHTO T 152	Air Content of Freshly Mixed Concrete by the Pressure Method
AASHTO T 231	Capping Cylindrical Concrete Specimens
AASHTO T 309	Temperature of Freshly Mixed Portland Cement Concrete

6-02.3(5)E POINT OF ACCEPTANCE

Determination of concrete properties for acceptance will be made based on samples taken as follows:

Bridge decks, overlays, and barriers at the discharge of the placement system. All other placements at the truck discharge.

It shall be the Contractor's responsibility to provide adequate and representative samples of the fresh concrete to a location designated by the Engineer for testing concrete properties and making of cylinder specimens. Samples shall be provided as directed in Sections 1-06.1 and 1-06.2. Once the Contractor has turned over the concrete for acceptance testing, no more mix adjustment will be allowed. The concrete will either be accepted or rejected.

6-02.3(5)F WATER/CEMENT RATIO CONFORMANCE

The actual water cement ratio shall be determined from the certified proportions of the mix, adjusting for on the job additions. No water may be added after acceptance testing or after placement has begun, except for concrete used in slip forming. For slip-formed concrete, water may be added during placement but shall not exceed the maximum water cement ratio in the mix design, and shall meet the requirements for consistency as described in Section 6-02.3(4)C. If water is added, an air and temperature test shall be taken prior to resuming placement to ensure that Specification conformance has been maintained.

6-02.3(5)G SAMPLING AND TESTING FREQUENCY FOR TEMPERATURE, CONSISTENCY, AND AIR CONTENT

Concrete properties shall be determined from concrete as delivered to the project and as accepted by the Contractor for placement. The Owner will test for acceptance of concrete for slump, temperature, and air content, if applicable, as follows:

Sampling and testing will be performed before concrete placement from the first truck load. Concrete shall not be placed until tests for slump, temperature, and entrained air (if applicable) have been completed by the Engineer, and the results indicate that the concrete is within acceptable limits. Except for the first load of concrete, up to ½-cubic yard may be placed prior to testing for acceptance. Sampling and testing will continue for each load until 2 successive loads meet all applicable acceptance test requirements. After 2 successive tests indicate that the concrete is within specified limits, the sampling and testing frequency may decrease to 1 for every 5 truck loads. Loads to be sampled will be selected under the random selection process as outlined in WAQTC FOP for TM 2.

When the results for any subsequent acceptance test indicates that the concrete as delivered and approved by the Contractor for placement does not conform to the specified limits, the sampling and testing frequency will be resumed for each truck load. Whenever 2 successive subsequent tests indicate that the concrete is within the specified limits, the random sampling and testing frequency of 1 for every 5 truck loads may resume.

Sampling and testing for placing one class of concrete comprising 50-cubic yards or less will be as listed above, except:

Sampling and testing will continue until 1 load meets all of the acceptance requirements, and

After 1 set of tests indicate that the concrete is within specified limits, the remaining concrete to be placed may be accepted by visual inspection.

6-02.3(5)H SAMPLING AND TESTING FOR COMPRESSIVE STRENGTH AND INITIAL CURING

Acceptance testing for compressive strength shall be conducted at the same frequency as the acceptance tests for temperature, consistency, and air content.

The Contractor shall provide, and maintain cure boxes for curing concrete cylinders. The Contractor shall also provide, maintain and operate all necessary power sources and connections needed to operate the curing box. Concrete cylinders shall be cured in a cure box under AASHTO T 23. The cure boxes shall maintain a temperature between 60°F and 80°F for concrete with specified strengths less than 6000-psi and between 68°F and 78°F for concrete with specified strengths of 6000-psi and higher. A minimum/maximum thermometer shall be installed to measure the internal temperature of the cure box. The thermometer shall be readable from outside of the box and be capable of recording the high and low temperatures in a 24-hour period. The cure boxes shall create an environment that prevents moisture loss from the concrete specimens. The top shall have a working lock and the interior shall be rustproof. A moisture-proof seal shall be provided between the lid and the box. The cure box shall be the appropriate size to accommodate the number of concrete acceptance cylinders necessary or the Contractor shall provide additional cure boxes. Once concrete cylinders are placed in the cure box, the cure box shall not be moved until the cylinders have been cured under these Specifications. When concrete is placed at over 1 location simultaneously, multiple cure boxes shall be provided.

The Contractor shall protect concrete cylinders in cure boxes from excessive vibration and shock waves during the curing period under Section 6-02.3(6)D.

6-02.3(5)I VACANT

6-02.3(5)J VACANT

6-02.3(5)K REJECTING CONCRETE

Rejection Without Testing — The Engineer, prior to sampling, may reject any batch or load of concrete that appears defective in composition; such as cement content or aggregate proportions. Rejected material shall not be incorporated in the Structure.

6-02.3(5)L CONCRETE WITH NON-CONFORMING STRENGTH

Concrete with cylinder compressive strengths (fc) that fail to meet acceptance level requirements shall be evaluated for structural adequacy. If the material is found to be adequate, payment shall be adjusted under the following formula:

$$\textbf{Pay adjustment} = \frac{2(f'c-fc)(UP)(Q)}{f'c}$$

where f′c = Specified minimum compressive strength at 28-Days.

fc = Compressive strength at 28-Days as determined by AASHTO Test Methods.

UP = Unit Contract price per cubic yard for the class of concrete involved.

Q = Quantity of concrete represented by an acceptance test based on the required frequency of testing.

Concrete that fails to meet minimum acceptance levels using the coring method will be evaluated for structural adequacy. If the material is found to be adequate, payment shall be adjusted under the following formula:

$$\textbf{Pay adjustment} = \frac{3.56(.85f'c-f\ cores)(UP)(Q)}{f'c}$$

where f'c = Specified minimum compressive strength at 28-Days.

f cores = Compressive strength of the cores as determined by AASHTO T-22.

UP = Unit Contract price per cubic yard for the class of concrete involved.

Q = Quantity of concrete represented by an acceptance test based on the required frequency of testing.

Where these Specifications designate payment for the concrete on other than a per cubic yard basis, the unit Contract price of concrete shall be taken as $300 per cubic yard for concrete Class 4000, 5000, and 6000. For concrete Class 3000, the unit contract price for Concrete shall be $160 per cubic yard.

6-02.3(6) PLACING CONCRETE

The Contractor shall not place concrete:

1. On frozen or ice-coated ground or Subgrade;
2. Against or on ice-coated forms, reinforcing steel, structural steel, conduits, precast members, or construction joints;
3. Under rainy conditions; placing of concrete shall be stopped before the quantity of surface water affects or damage surface mortar quality or cause a flow or wash the concrete surface;
4. In any foundation until the Engineer has approved its depth and character;
5. In any form until the Engineer has approved it and placing any reinforcing in it; or
6. In any Work area when vibrations from nearby Work may harm the concrete's initial set or strength.

When a foundation excavation contains water, the Contractor shall pump it dry before placing concrete. If this is impossible, an underwater concrete seal shall be placed that complies with Section 6-02.3(6)B. This seal shall be thick enough to resist any uplift.

All foundations, forms, and contacting concrete surfaces shall be moistened with water just before the concrete is placed. Any standing water on the foundation, on the concrete surface, or in the form shall be removed.

The Contractor shall place concrete in the forms as soon as possible after mixing. The concrete shall always be plastic and workable. For this reason, the Engineer may reduce the time to discharge even further. Concrete placement shall be continuous, with no interruption longer than 30-minutes between adjoining layers unless the Engineer approves a longer time. Each layer shall be placed and consolidated before the preceding layer takes initial set. After initial set, the forms shall not be jarred, and projecting ends of reinforcing bars shall not be disturbed. The submittal to the Engineer shall include justification that the concrete mix design will remain fluid for interruptions longer than 30-minutes between placements.

In girders or walls, concrete shall be placed in continuous, horizontal layers 1.5 to 2.5-feet deep. Compaction shall leave no line of separation between layers. In each part of a form, the concrete shall be deposited as near its final position as possible.

Any method for placing and consolidating shall not segregate aggregates or displace reinforcing steel. Any method shall leave a compact, dense, and impervious concrete with smooth faces on exposed surfaces. Plastering is not permitted. Any section of defective concrete shall be removed at the Contractor's expense.

To prevent aggregates from separating, the length of any conveyor belt used to transport concrete shall not exceed 300-feet. If the mix needs protection from sun or rain, the Contractor shall cover the belt. When concrete pumps are used for

placement, a Contractor's representative shall, prior to use on the first placement of each day, visually inspect the pumps water chamber for water leakage. No pump shall be used that allows free water to flow past the piston.

If a concrete pump is used as the placing system, the pump priming slurry shall be discarded before placement. Initial acceptance testing may be delayed until the pump priming slurry has been eliminated from the concrete being pumped. Eliminating the priming slurry from the concrete may require that several cubic yards of concrete are discharged through the pumping system and discarded. Use of a concrete pump requires a reserve pump (or other backup equipment) at the site.

If the concrete will drop more than 5-feet, it shall be deposited through a sheet metal (or other approved) conduit. If the form slopes, the concrete shall be lowered through approved conduit to keep it from sliding down 1 side of the form. No aluminum conduits or tremies shall pump or place concrete.

Before placing concrete for bridge decks on steel spans, the Contractor shall release the falsework under the bridge and let the span swing free on its supports. Concrete in flat slab bridges shall be placed in 1 continuous operation for each span or series of continuous spans.

Concrete for bridge decks and the stems of T-beams or box-girders shall be placed in separate operations if the stem of the beam or girder is more than 3-feet deep. First the beam or girder stem shall be filled to the bottom of the slab fillets. Bridge deck concrete shall not be placed until enough time has passed to permit the earlier concrete to shrink (at least 12-hours). If stem depth is 3-feet or less, the Contractor may place concrete in 1 continuous operation if the Engineer approves.

Between expansion or construction joints, concrete in beams, girders, bridge decks, piers, columns, walls, and traffic and pedestrian barriers, etc., shall be placed in a continuous operation.

No traffic or pedestrian barrier shall be placed until after the bridge decks are complete for the entire Structure. No concrete barriers shall be placed until the falsework has been released and the span supports itself. The Contractor may choose not to release the deck overhang falsework prior to the barrier placement. The Contractor shall submit calculations to the Engineer indicating the loads induced into the girder webs due to the barrier weight and any live load placed on the Structure do not exceed the design capacity of the girder component. This analysis is not required for bridges with concrete Superstructures. No barrier, curb, or sidewalk shall be placed on steel or prestressed concrete girder bridges until the bridge deck reaches a compressive strength of at least 3,000-psi.

The Contractor may construct traffic and pedestrian barriers by the slipform method. However, the barrier may not deviate more than ¼-inch when measured by a 10-foot straightedge held longitudinally on the front face, back face, and top surface. Electrical conduit within the barrier shall be constructed under the requirements of Section 8-30.

When placing concrete in arch rings, the Contractor shall ensure that the load on the falsework remains symmetrical and uniform.

Unless the Engineer approves otherwise, arch ribs in open spandrel arches shall be placed in sections. Small key sections between large sections shall be filled after the large sections have shrunk.

6-02.3(6)A WEATHER AND TEMPERATURE LIMITS TO PROTECT CONCRETE

6-02.3(6)A1 HOT WEATHER PROTECTION

The Contractor shall provide concrete within the specified temperature limits by:

1. Shading or cooling aggregate piles (sprinkling of fine aggregate piles with water is not allowed). If sprinkling of the coarse aggregates is used, the piles moisture content shall be monitored and the mixing water adjusted for the free water in the aggregate. When removing the coarse aggregate, it shall be removed from at least 1-foot above the bottom of the pile.
2. Refrigerating mixing water; or replacing all or part of the mixing water with crushed ice, provided the ice is completely melted by placing time.

If the concrete would probably exceed 90°F using normal methods, the Engineer may require approved temperature-reduction measures be taken before the placement begins.

If air temperature exceeds 90°F, the Contractor shall use water spray or other approved methods to cool all concrete-contact surfaces to less than 90°F. These surfaces include forms, reinforcing steel, steel beam flanges, and any others that touch the mix. The Contractor shall reduce the time between mixing and placing to a minimum and shall not permit mixer trucks to remain in the sun while waiting to discharge concrete. Chutes, conveyors, and pump lines shall be shaded.

If bridge decks are placed while air temperature exceeds 90°F, the Contractor shall:

1. Cover the top layer of reinforcing steel with clean, wet burlap immediately before concrete placement;
2. Sprinkle cool water on the forms and reinforcing steel just before the placement if the Engineer requires it;
3. Finish the concrete slab without delay; and
4. Provide at the site water-fogging equipment to be used if needed after finishing to prevent plastic cracks.

If the evaporation rate at the concreting site is 0.10-pounds per square foot of surface per hour or more (determined from Table 6-02.3(6)), the Contractor shall surround the fresh concrete with an enclosure. This enclosure will protect the concrete from wind blowing across its surface until the curing compound is applied. If casting deck concrete that is 80°F or hotter, the Contractor shall install approved equipment at the site to show relative humidity and wind velocity.

6-02.3(6)A2 COLD WEATHER PROTECTION

This Specification applies when the weather forecast predicts air temperatures below 35°F at any time during the 7-Days following concrete placement. The weather forecast is based on predictions from the Western Region Headquarters of the National Weather Service. This forecast can be found at http://www.wrh.noaa.gov/.

To achieve adequate curing, the temperature of the concrete shall be maintained above 50°F during the entire curing period or 7-Days, whichever is greater. The concrete temperature shall not be allowed to fall below 35°F during this time. Prior to placing concrete in cold weather, the Contractor shall provide a written procedure for cold weather concreting to the Engineer. The procedure shall detail how the Contractor will adequately cure the concrete and prevent the concrete

temperature from falling below 35°F. Extra protection shall be provided for areas especially vulnerable to freezing (such as exposed top surfaces, corners and edges, thin sections, and concrete placed into steel forms). Concrete placement will only be allowed if the Contractor's cold weather protection plan has been approved by the Engineer.

The Contractor shall not mix nor place concrete while the air temperature is below 35°F, unless the water or aggregates (or both) are heated to at least 70°F. The aggregate shall not exceed 150°F. If the water is heated to more than 150150 °F, it shall be mixed with the aggregates before the cement is added. Any equipment and methods shall heat the materials evenly. Concrete placed in shafts and piles is exempt from such preheating requirements.

The Contractor may warm stockpiled aggregates with dry heat or steam, but not by applying flame directly or under sheet metal. If the aggregates are in bins, steam or water coils or other heating methods may be used if aggregate quality is not affected. Live steam heating is not permitted on or through aggregates in bins. If using dry heat, the Contractor shall increase mixing time enough to permit the super-dry aggregates to absorb moisture.

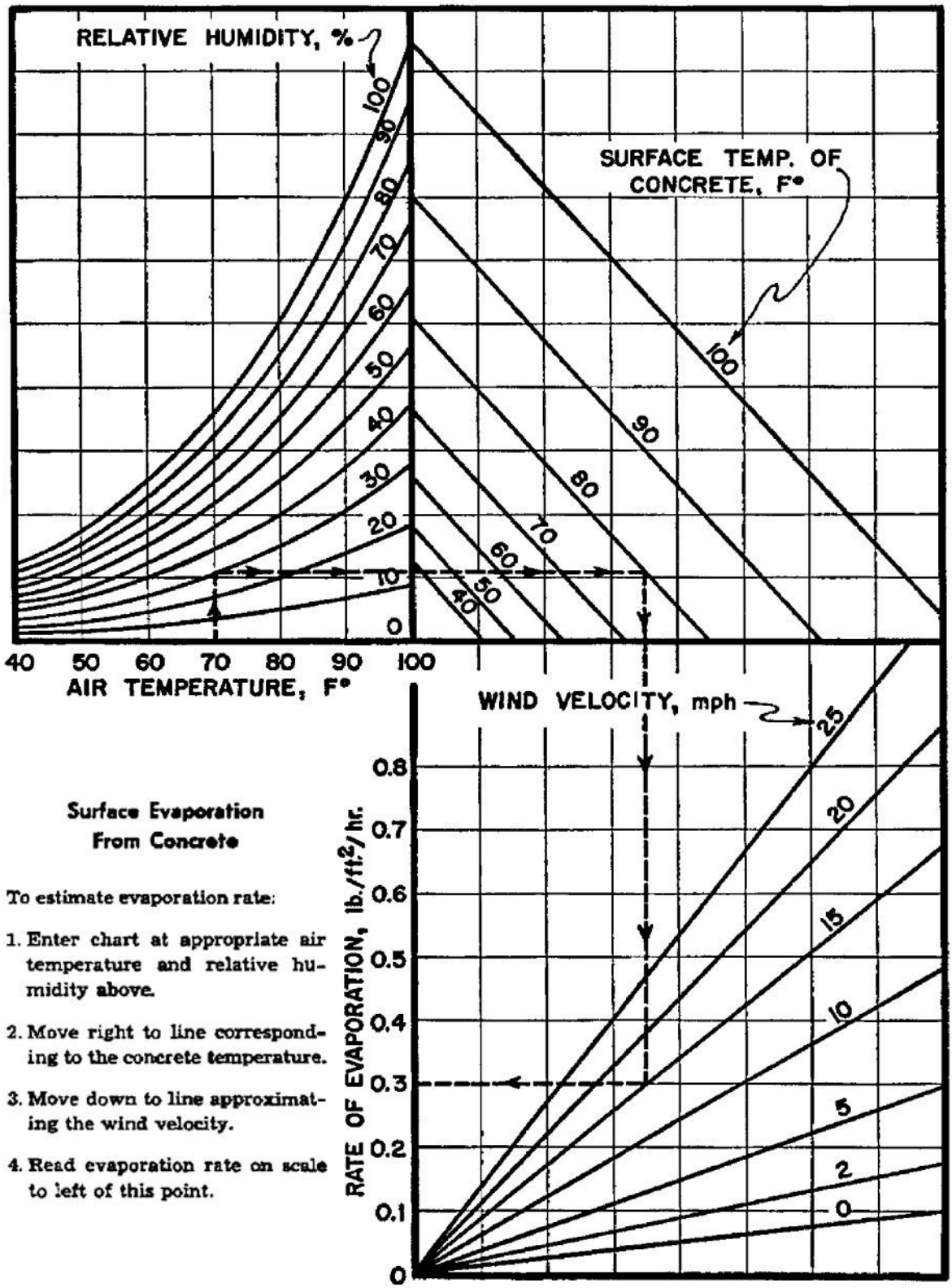
The Contractor shall provide and maintain a maturity meter sensor, continuously recording time and temperature during the curing period, in the concrete at a location specified by the Engineer for each concrete placement. The Contractor shall also provide recording thermometers or other approved devices to monitor the surface temperature of the concrete. During curing, data from the maturity meter and recording thermometer shall be readily available to the Engineer. The Contractor shall record time and temperature data on hourly intervals. Data shall be provided to the Engineer upon request.

Starting immediately after placement, the concrete temperatures measured by the maturity meter and recording thermometer shall be maintained at or above 50°F and the relative humidity shall be maintained above 80-percent. These conditions shall be maintained for a minimum of 7-Days or for the cure period required by Section 6-02.3(11), whichever is longer. During this time, if the temperature falls below 50°F on the maturity meter or recording thermometer, no curing time is awarded for that day. Should the Contractor fail to adequately protect the concrete and the temperature of the concrete falls below 35°F during curing, the Engineer may reject it.

The Contractor is solely responsible for protecting concrete from inclement weather during the entire curing period. Permission given by the Engineer to place concrete during cold weather will in no way ensure acceptance of the Work by the Owner. Should the concrete placed under such conditions prove unsatisfactory, the Engineer shall still have the right to reject the Work although the plan and the Work were carried out with the Engineer's permission.

Surface Evaporation from Concrete

Table 6-02.3(6)



Surface Evaporation From Concrete

To estimate evaporation rate:

1. Enter chart at appropriate air temperature and relative humidity above.
2. Move right to line corresponding to the concrete temperature.
3. Move down to line approximating the wind velocity.
4. Read evaporation rate on scale to left of this point.

6-02.3(6)B PLACING CONCRETE IN FOUNDATION SEALS

If the Drawings require a concrete seal, the Contractor shall place the concrete underwater inside a watertight cofferdam, tube, or caisson. Seal concrete shall be placed in a compact mass in still water. It shall remain undisturbed and in still water until fully set. While seal concrete is being deposited, the water elevation inside and outside the cofferdam shall remain equal to prevent any flow through the seal in either direction. The cofferdam shall be vented at the vent elevation in the Drawings. The thickness of the seal is based upon this vent elevation.

The seal shall be at least 18-inches thick unless the Drawings show otherwise. The Engineer may change the seal thickness during construction which may require redesign of the footing and the pier shaft or column. Although seal thickness changes may cause the use of more or less concrete, reinforcing steel, and excavation, payment will remain as originally defined in unit Contract prices.

To place seal concrete underwater, the Contractor shall use a concrete pump or tremie. The tremie shall have a hopper at the top that empties into a watertight tube at least 10-inches in diameter. The discharge end of the tube on the tremie or concrete pump shall include a device to seal out water while the tube is first filled with concrete. Tube supports shall permit the discharge end to move freely across the entire Work area and to drop rapidly to slow or stop the flow. One tremie may concrete an area up to 18-feet per side. Each additional area of this size requires 1 additional tremie.

Throughout the underwater concrete placement operation, the discharge end of the tube shall remain submerged in the concrete and the tube shall always contain enough concrete to prevent water from entering. The concrete placement shall be continuous until the Work is completed, resulting in a seamless, uniform seal. If the concreting operation is interrupted, the Engineer may require the Contractor to prove by core drilling or other tests that the seal contains no voids or horizontal joints. If testing reveals voids or joints, the Contractor shall repair them or replace the seal at no expense to the Owner.

Concrete Class 4000W shall be used for seals, and it shall meet the consistency requirements of Section 6-02.3(4)C.

6-02.3(6)C DEWATERING CONCRETE SEALS AND FOUNDATIONS

After a concrete seal is constructed, the Contractor shall pump the water out of the cofferdam and place the rest of the concrete in the dry. This pumping shall not begin until the seal has set enough to withstand the hydrostatic pressure (3-Days for gravity seals and 10-Days for seals containing piling or shafts). The Engineer may extend these waiting periods to ensure structural safety or to meet a condition of the operating permit.

If weighted cribs are used to resist hydrostatic pressure at the bottom of the seal, the Contractor shall anchor them to the foundation seal. Any method used (such as dowels or keys) shall transfer the entire weight of the crib to the seal.

No pumping shall be done during or for 24-hours after concrete placement unless done from a suitable sump separated from the concrete Work by a watertight wall. Pumping shall be done to rule out any chance of concrete being carried away.

6-02.3(6)D PROTECTION AGAINST VIBRATION

Freshly placed concrete shall not be subjected to excessive vibration and shock waves during the curing period until it has reached a 2000-psi minimum compressive strength for structural concrete and lower-strength classes of concrete. After the first 5-hours from the time the concrete has been placed and consolidated, the Contractor shall keep all vibration producing operations at a safe horizontal distance from the freshly placed concrete by following either the prescriptive safe distance method or the monitoring safe distance method. These requirements to protect freshly placed concrete against vibration shall not apply for plant cast concrete, nor shall they apply to the vibrations caused by the traveling public.

6-02.3(6)D1 PRESCRIPTIVE SAFE DISTANCE METHOD

After the concrete has been placed and consolidated, the Contractor shall keep all vibration producing operations at a safe horizontal distance from the freshly placed concrete as follows:

MINIMUM COMPRESSIVE STRENGTH, f ’c	SAFE HORIZONTAL DISTANCE (1)	
	EQUIPMENT CLASS L (2)	EQUIPMENT CLASS H (3)
< 1000-psi	75-feet	125-feet
1000-psi to < 1400-psi	30-feet	50-feet
1400-psi to 2000-psi	15-feet	25-feet

(1) The safe horizontal distance shall be reduced to 10-feet for small rubber tire construction equipment like backhoes under 50,000-pounds, concrete placing equipment, and legal Highway vehicles if such equipment travels at speeds of:

- ≤ 5-mph on relatively smooth Roadway surfaces or
- ≤ 3-mph on rough Roadway surfaces (i.e. with potholes)

(2) Equipment Class L (Low Vibration) shall include tracked dozers under 85,000-pounds, track vehicles, trucks (unless excluded above), hand-operated jack hammers, cranes, auger drill rig, caisson drilling, vibratory roller compactors under 30,000-pounds, and grab-hammers.

(3) Equipment Class H (High Vibration) shall include pile drivers, vibratory hammers, machine-operated impact tools, pavement breakers, and other large pieces of equipment.

After the concrete has reached a minimum compressive strength specified above, the safe horizontal distance restrictions would no longer apply.

6-02.3(6)D2 MONITORING SAFE DISTANCE METHOD

The Contractor may monitor the vibration producing operations to decrease the safe horizontal distance requirements of the prescriptive safe distance method. If this method is chosen, all construction operations that produce vibration or shock waves in the vicinity of freshly placed concrete shall be monitored by the Contractor with monitoring equipment sensitive enough to detect a minimum peak particle velocity (PPV) of 0.10-inches per second. Monitoring devices shall be placed on or adjacent to the freshly placed concrete when the measurements are taken. During the time subsequent to the concrete placement, the Contractor shall cease all vibration or shock producing operations in the vicinity of the newly placed concrete when the monitoring equipment detects excessive vibration and shock waves defined as exceeding the following PPV's:

MINIMUM COMPRESSIVE STRENGTH, f 'c	MAXIMUM PPV
< 1000-psi	0.10-in/sec
1000-psi to < 1400-psi	1.0-in/sec
1400-psi to 2000-psi	2.0-in/sec

After the concrete has reached a minimum compressive strength specified above, the safe horizontal distance restrictions would no longer apply.

6-02.3(7) CONCRETE EXPOSED TO SEA WATER

If sea water will contact a completed concrete Structure, the Contractor shall:

1. Mix the concrete for at least 2-minutes.
2. Control water content to produce concrete as impermeable as possible.
3. Consolidate the concrete as the Engineer may require, avoiding the formation of any stone pockets.
4. Place only clean, rust-free reinforcement bars in the concrete.
5. Coat form surfaces heavily with shellac and any approved form release agent.
6. Leave forms intact for at least 30-Days after concrete placement (longer if the Engineer requires) to prevent sea water from contacting the concrete.
7. Leave the surface of concrete just as it comes from the forms.
8. Provide special handling for any concrete piles used in sea water to avoid even slight deformation cracks.

The Engineer shall decide the range of disintegration possible by exposure to sea water. This range shall extend from a point below the level of extreme low tide up to a point above the level of extreme high tide. Wave action and other conditions will also affect the Engineer's decision on this range. Unless the Engineer approves otherwise, the Contractor shall not locate construction joints within this range. All concrete within this range shall be poured in the dry.

6-02.3(8) CONCRETE EXPOSED TO ALKALINE SOILS OR WATER

The requirements for concrete in seawater shall also apply to concrete in alkaline soils or water. The Contractor shall:

1. Let the concrete set at least 30-Days (longer if possible) before allowing soil or water to contact it directly;
2. Vibrate each batch of concrete immediately after it has been placed into the forms, using enough vibrating tampers to do this effectively; and
3. Hand tamp, if necessary, to produce smooth, dense outside surfaces.

6-02.3(9) VIBRATION OF CONCRETE

The Contractor shall supply enough vibrators to consolidate the concrete (except that placed underwater) according to the requirements of this section. Each vibrator shall:

1. Be designed to operate while submerged in the concrete,

2. Vibrate at a rate of at least 7,000-pulses per minute, and
3. Receive the Engineer's approval on its type and method of use.

Immediately after concrete is placed, vibration shall be applied in the fresh batch at the point of deposit. In doing so, the Contractor shall:

1. Space the vibrators evenly, no farther apart than twice the radius of the visible effects of the vibration;
2. Ensure vibration intensity is great enough to visibly affect a weight of 1-inch slump concrete across a radius of at least 18-inches;
3. Insert the vibrators slowly to a depth that will effectively vibrate the full depth of each layer, penetrating into the previous layer on multilayer pours;
4. Protect partially hardened concrete (i.e., nonplastic, which prevents vibrator penetration when only its own weight is applied) by preventing the vibrator from penetrating it or making direct contact with steel that extends into it;
5. Not allow vibration to continue in one place long enough to form pools of grout;
6. Continue vibration long enough to consolidate the concrete thoroughly, but not so long as to segregate it;
7. Withdraw the vibrators slowly when the process is complete; and
8. Not use vibrators to move concrete from one point to another in the forms.

When vibrating and finishing top surfaces that will be exposed to weather or wear, the Contractor shall not draw water or laitance to the surface. In high lifts, the top layer shall be shallow and made up of a concrete mix as stiff as can be effectively vibrated and finished.

To produce a smooth, dense finish on outside surfaces, the Contractor shall hand tamp the concrete.

6-02.3(10) BRIDGE DECKS AND BRIDGE APPROACH SLABS

6-02.3(10)A PREOPERATIONAL MEETING

A pre-operational meeting shall be held 5 to 10-Working Days before placing concrete to discuss construction procedures, personnel, and equipment to be used. Those attending shall include:

1. (Representing the Contractor) The superintendent and all foremen in charge of placing the concrete, finishing it; and
2. (Representing the Owner) The Engineer, key inspections, and a design representative.

If the project includes over one deck or slab, and if the Contractor's key personnel change between concreting operations, or at request of the Engineer, an additional conference shall be held just before each deck or slab is placed.

The Contractor shall not place bridge decks until the Engineer agrees that:

1. Concrete producing and placement rates will be high enough to meet placing and finishing deadlines;
2. Finishers with enough experience have been employed;
3. Adequate finishing tools and equipment are at the site, and
4. Curing procedures consistent with the Specification requirements are employed.

6-02.3(10)B SCREED RAIL SUPPORTS

The Contractor shall place screed rails outside the finishing area. When screed rails cannot be placed outside the finishing area as determined by the Engineer, they shall rest on adjustable supports that can be removed with the least possible disturbance to the screeded concrete. The supports shall rest on structural members or on forms rigid enough to resist deflection. Supports shall be removable to at least 2-inches below the finished surface. For staged constructed bridge decks, the finishing machine screed rails shall not be supported on the completed portion of deck and shall deflect with the portion of structure under construction.

Screed rails (with their supports) shall be strong enough and stiff enough to permit the finishing machine to operate effectively on them. All screed rails shall be placed and secured for the full length of the deck/slab before the concreting begins. If the Engineer approves in advance, the Contractor may move rails ahead onto previously set supports while concreting progresses. However, such movable rails and their supports shall not change the set elevation of the screed.

On steel truss and girder spans, screed rails and bulkheads may be placed directly on transverse steel floorbeams, with the strike-board moving at right angles to the centerline of the Roadway.

6-02.3(10)C FINISHING EQUIPMENT

The finishing machine shall be self-propelled and be capable of forward and reverse movement under positive control. The finishing machine shall be equipped with a rotating cylindrical single or double drum screed not exceeding 60-inches in length. The finishing machine shall have the adjustments to produce the required cross section, line, and grade. Provisions shall be made for the raising and lowering of all screeds under positive control. The upper vertical limit of screed travel shall permit the screed to clear the finished concrete surface.

For bridge deck widening of 20-feet or less, and for bridge approach slabs, or where jobsite conditions do not allow using the conventional configuration finishing machines described above, the Contractor may propose using a hand-operated motorized power screed such as a "Texas" or "Bunyan" screed. This screed shall be capable of finishing the bridge deck and bridge approach slab to the same standards as the finishing machine. The Contractor shall not place bridge deck or bridge approach slab concrete until receiving the Engineer's approval of this screed and the placing procedures.

On bridge decks, the Contractor may use hand-operated strike-boards only when the Engineer approves for special conditions where self-propelled or motorized hand-operated screeds cannot be employed. These boards shall be sturdy and able to strike off the full placement width without intermediate supports. Strike-boards, screed rails, and any specially made

auxiliary equipment shall receive the Engineer's approval before use. All finishing requirements in these Specifications apply to hand-operated finishing equipment.

6-02.3(10)D CONCRETE PLACEMENT, FINISHING, AND TEXTURING

Before placing bridge approach slab concrete, the subgrade shall be constructed under Sections 2-09 and 5-05.3(6).

Before any concrete is placed, the finishing machine shall be operated over the entire length of the deck/slab to check screed deflection. Concrete placement may begin only if the Engineer approves after this test.

Immediately before placing concrete, the Contractor shall check (and adjust if necessary) all falsework and wedges to minimize settlement and deflection from the added mass of the concrete deck/slab. The Contractor shall also install devices, such as telltales, by which the Engineer can readily measure settlement and deflection.

The Contractor shall schedule the concrete placement so it can be completely finished during daylight. After dark, finishing is permitted if the Engineer approves and if the Contractor provides adequate lighting.

The placement operation shall cover the full width of the Roadway or the full width between construction joints. The Contractor shall locate any construction joint over a beam or web that can support the deck/slab on either side of the joint. The joint shall not occur over a pier unless the Drawings permit. Each joint shall be formed vertically and in true alignment. The Contractor shall not release falsework or wedges supporting pours on either side of a joint until each side has aged as these Specifications require.

Placement of concrete for bridge decks and bridge approach slabs shall comply with Section 6-02.3(6).The Engineer shall approve the placement method. In placing the concrete, the Contractor shall:

1. Place it (without segregation) against concrete placed earlier, as near as possible to its final position, approximately to grade, and in shallow, closely spaced piles;
2. Consolidate it around reinforcing steel by using vibrators before strike-off by the finishing machine;
3. Not use vibrators to move concrete;
4. Not revibrate any concrete surface areas where workers have stopped prior to screeding;
5. Remove any concrete splashed onto reinforcing steel in adjacent segments before concreting them;
6. Tamp and strike off the concrete with a template or strike-board moving slowly forward at an even speed;
7. Maintain a slight excess of concrete in front of the cutting edge across the entire width of the placement operation;
8. Make enough passes with the strike-board (without overfinishing and bringing excessive amounts of mortar to the surface) to create a surface true and ready for final finish; and
9. Leave a thin, even film of mortar on the concrete surface after the last pass of the strike-board.

Workers shall complete all postscreeding operations without walking on the concrete. This may require work bridges spanning the full width of the slab.

After removing the screed supports, the Contractor shall fill the voids with concrete (not mortar).

If necessary, as determined by the Engineer, the Contractor shall float the surface left by the finishing machine to remove roughness, minor irregularities, and seal the surface of the concrete. Floating shall leave a smooth and even surface. Float finishing shall be kept to a minimum number of passes so air bubbles in the concrete are not released. The floats shall be at least 4-feet long. Each transverse pass of the float shall overlap the previous pass by at least half the length of the float. The first floating shall be at right angles to the strike-off. The second floating shall be at right angles to the centerline of the span. A smooth riding surface shall be maintained across construction joints.

Expansion joints shall be finished with a 1/2-inch-radius edger.

After floating, but while the concrete remains plastic, the Contractor shall test the entire deck/slab for flatness (allowing for crown, camber, and vertical curvature). The testing shall be done with a 10-foot straightedge held on the surface. The straightedge shall be advanced in successive positions parallel to the centerline, moving not more than 1/2 the length of the straightedge each time it advances. This procedure shall be repeated with the straightedge held perpendicular to the centerline. An acceptable surface shall be one free from deviations of more than 1/8-inch under the 10-foot straightedge.

If the test reveals depressions, the Contractor shall fill them with freshly mixed concrete, strike off, consolidate, and refinish them. High areas shall be cut down and refinished. Retesting and refinishing shall continue until an acceptable, deviation-free surface is produced. The hardened concrete shall meet all smoothness requirements of these Specifications even though the tests require corrective Work.

The Contractor shall texture the bridge deck and bridge approach slab by combing the final surface perpendicular to the centerline. Made of a single row of metal tines, the comb shall leave striations in the fresh concrete approximately 3/16-inch deep by 1/8-inch wide and spaced approximately 1/2-inch apart. The Engineer will decide actual depths at the site. (If the comb has not been approved, the Contractor shall obtain the Engineer's approval by demonstrating it on a test section.)

The Contractor may operate the combs manually or mechanically, either singly or with several placed end to end. The timing and method used shall produce the required texture without displacing larger particles of aggregate. Texturing shall end 2-feet from curb lines. This 2-foot untextured strip shall be hand-finished with a steel trowel.

If the Drawings call for an overlay (to be constructed under the same Contract), such as hot mix asphalt, latex modified concrete, epoxy concrete, or similar, the Contractor shall produce the final finish by dragging a strip of damp,

seamless burlap lengthwise over the full width of the deck/slab or by brooming it lightly. A burlap drag shall equal the deck/slab in width. Approximately 3-feet of the drag shall contact the surface, with the least possible bow in its leading edge. It shall be kept wet and free of hardened lumps of concrete. When it fails to produce the required finish, the Contractor shall replace it. When not in use, it shall be lifted clear of the slab.

After the deck/slab has cured, the surface shall not vary more than 1/8-inch under a 10-foot straightedge placed parallel and perpendicular to the centerline.

The Contractor shall cut high spots down with a diamond-faced, saw-type cutting machine. This machine shall cut through mortar and aggregate without breaking or dislodging the aggregate or causing spalls.

Low spots shall be built up utilizing a grout or concrete with a strength equal to or greater than the required 28-Day strength of the deck/slab. The method of build-up shall be submitted to the Engineer for acceptance in accordance with Section 1-05.3.

The surface texture on any area cut down or built up shall match closely that of the surrounding bridge deck or bridge approach slab area. The entire bridge deck and bridge approach slab shall provide a smooth riding surface.

6-02.3(10)E SIDEWALK ON STRUCTURES

Concrete for sidewalk shall be well compacted, struck off with a strike-board, and floated with a wooden float to achieve a surface that does not vary more than 1/8-inch under a 10-foot straightedge. An edging tool shall finish all sidewalk edges and expansion joints. The final surface shall have a granular texture that will not turn slick when wet.

6-02.3(10)F BRIDGE APPROACH SLAB ORIENTATION AND ANCHORS

Bridge approach slabs shall be constructed full bridge deck width from outside usable Shoulder to outside usable Shoulder at an elevation to match the Structure. The bridge approach slabs shall be modified as shown in the Drawings to accommodate the grate inlets at the bridge ends if the grate inlets are required.

Bridge approach slab anchors shall be installed as detailed in the Drawings, and the anchor rods, couplers, and nuts shall conform to Section 9-06.5(1). The steel plates shall conform to ASTM A 36. All metal parts shall receive one coat of paint conforming to Section 9-08.2 Item 18-B, (1) Primer or be galvanized in accordance with AASHTO M232. The pipe shall be any nonperforated PE or PVC pipe of the diameter specified in the Drawings. Polystyrene shall conform to Section 9-04.6. The anchors shall be installed parallel both to profile grade and centerline of Roadway. The Contractor shall secure the anchors to ensure they will not be misaligned during concrete placement. For Method B anchor installations, the epoxy bonding agent used to install the anchors shall be Type IV conforming to Section 9-26.1. The compression seal shall be as noted in the Contract documents. Dowel bars shall be installed in the bridge approach slabs in accordance with the requirements of the Standard Plans, Drawings and Section 5-05.3(10).

After curing bridge approach slabs under Section 6-02.3(11), the bridge approach slabs may be opened to traffic when a minimum compressive strength of 3,000-psi is achieved.

6-02.3(11) CURING CONCRETE

After placement, concrete surfaces shall be cured as follows:

1. Bridge decks (except those made of concrete Class 4000D), flat slab bridge Superstructures, bridge sidewalks, roofs of cut and cover tunnels — curing compound covered by white, reflective type sheeting or continuous wet curing. Curing by either method shall be for at least 10-Days.
2. Class 4000D concrete (regardless of Structure type) — 2 coats of curing compound and continuous wet cure using heavy quilted blankets or burlap for 14-Days.
3. Bridge approach slabs (Class 4000A concrete) – 2 coats of curing compound and continuous wet cure using heavy quilted blankets or burlap for 10-Days.
4. All other concrete surfaces (except traffic barriers and rail bases) — continuous moisture for at least 3-Days. When continuous moisture or wet curing is required, the Contractor shall keep the concrete surfaces wet with water during curing.

The Contractor may provide continuous moisture by watering a covering of heavy quilted blankets, by keeping concrete surfaces wet with water continuously and covering with a white reflective type sheeting, or by wetting the outside surfaces of wood forms. Runoff water shall be collected and disposed of in accordance with all applicable regulations. In no case shall runoff water be allowed to enter any lakes, streams, or other surface waters.

When curing Class 4000D and 4000A, 2 coats of curing compound that complies with Section 9-23.2 shall be applied immediately (not to exceed 15 min.) after tining any portion of the bridge deck or bridge approach slab. The surface shall be covered with presoaked heavy quilted blankets or burlap when the concrete has set enough to allow covering without damaging the finish. Soaker hoses are required and shall be placed on top of burlap or blankets and shall be charged with water frequently to keep the entire deck covering wet during curing.

For all other concrete requiring curing compound, the Contractor shall apply 2 coats (that complies with Section 9-23.2 and manufactured specifically for colored concrete when applicable) to the fresh concrete. The compound shall be applied immediately after finishing. Application of the second coat shall run at right angles to that of the first. The 2 coats shall

total at least 1-gallon per 150-square feet and shall obscure the original color of the concrete. If any curing compound spills on construction joints or reinforcing steel, the Contractor shall clean it off before the next concrete placement.

If the Drawings call for an asphalt overlay, the Contractor shall use the clear curing compound (Type 1D, Class B), applying at least 1-gallon per 150-square feet to the concrete surface. Otherwise, the Contractor shall use white pigmented curing compound (Type 2), agitating it thoroughly just before and during application. If other materials are to be bonded to the surface, the Contractor shall remove the curing compound by sandblasting or acceptable high pressure water washing.

The Contractor shall have on the site, back-up spray equipment, enough workers, and a bridge from which they will apply the curing compound. The Engineer may require the Contractor to demonstrate (at least 1-Day before the scheduled concrete placement) that the crew and equipment can apply the compound acceptably.

The Contractor shall cover the top surfaces with white, reflective sheeting, leaving it in place for at least 10-Days. Throughout this period, the sheeting shall be kept in place by taping or weighting the edges where they overlap.

The unit Contract prices shall include all concrete curing costs.

6-02.3(11)A CURING AND FINISHING CONCRETE TRAFFIC AND PEDESTRIAN BARRIER

The Contractor shall supply enough water and workers to cure and finish concrete barrier as required in this section.

6-02.3(11)A1 FIXED-FORM BARRIER

The edge chamfers shall be formed by attaching chamfer strips to the barrier forms.

After troweling and edging a barrier (while the forms remain in place), the Contractor shall:

1. Brush the top surface with a fine bristle brush;
2. Cover the top surface with heavy, quilted blankets; and
3. Spray water on the blankets and forms at intervals short enough to keep them thoroughly wet for 3-Days.

After removing the forms, the Contractor shall:

1. Remove all lips and edgings with sharp tools or chisels;
2. Fill all holes with mortar conforming to Section 9-20.4(2);
3. True up corners of openings;
4. Remove concrete projecting beyond the true surface by stoning or grinding;
5. Cover the barrier with heavy, quilted blankets (not burlap);
6. Keep the blankets continuously wet for at least 7-Days.

The Contractor may do the finishing Work described in steps 1 through 4 above during the second (the 7-day) curing period if the entire barrier is kept covered except the immediate Work area. Otherwise, no finishing Work may be done until at least 10-Days after pouring.

After the 10-Day curing period, the Contractor shall remove from the barrier all form-release agent, mud, dust, and other foreign substances in either of 2 ways: (1) by light sandblasting and washing with water, or (2) by spraying with a high-pressure water jet. The water jet equipment shall use clean fresh water and shall produce (at the nozzle) at least 1,500-psi with a discharge of at least 3-gpm. The water jet nozzle shall have a 25-degree tip and shall be held no more than 9-inches from the surface being washed.

After cleaning, the Contractor shall use brushes to rub mortar conforming to Section 9-20.4(2) at a ratio of 1:1 cement/aggregate ratio into air holes and small crevices on all surfaces except the brushed top. As soon as the mortar takes its initial set, the Contractor shall rub it off with a piece of sacking or carpet. The barrier shall then be covered with wet blankets for at least 48-hours.

No curing compound shall be used on fixed-form concrete barrier. The completed surface of the concrete shall be even in color and texture.

6-02.3(11)A2 SLIP-FORM BARRIER

The edge radius shall be formed by attaching radius strips to the barrier slip form.

The Contractor shall finish slip-form barrier by: (1) steel troweling to close all surface pockmarks and holes; and (2) for plain surface barrier, lightly brushing the front and back face with vertical strokes and the top surface with transverse strokes.

After finishing, the Contractor shall cure the slip-form barrier by using either method A (curing compound) or B (wet blankets) described below.

Method A. Under the curing compound method, the Contractor shall:

1. Spray 2 coats of clear curing compound (Type 1D) on the concrete surface after the free water has disappeared. (Coverage of combined coats shall equal at least 1-gallon per 150-square feet.)

2. No later than the morning after applying the curing compound, cover the barrier with white, reflective sheeting for at least ten-Days.

3. After the 10-Day curing period, remove the curing compound as necessary by light sandblasting or by spraying with a high-pressure water jet to produce an even surface appearance. The water jet equipment shall use clean fresh water and shall produce (at the nozzle) at least 2,500-psi with a discharge of at least 4

gpm. The water jet nozzle shall have a 25-degree tip and shall be held no more than 9-inches from the surface being cleaned. The Contractor may propose to use a curing compound/concrete sealer. The Engineer will evaluate the proposal and if found acceptable, shall approve the proposal in writing. As a minimum, the Contractor's proposal shall include:

a) Product identity

b) Manufacturer's recommended application rate

c) Method of application and necessary equipment

d) Material Safety Data Sheet (MSDS)

e) Sample of the material for testing

Allow 14-Working Days for the Engineer to evaluate the proposal and to test the material.

Method B. Under the wet cure method, the Contractor shall:

1. Provide an initial cure period by continuous fogging or mist spraying for at least the first 24-hours.

2. After the initial cure period, cover the barrier with a heavy quilted blanket.

3. Keep the blankets continuously wet for at least 10-Days. (No additional finishing is required at the end of the curing period.)

6-02.3(12) CONSTRUCTION JOINTS

6-02.3(12)A CONSTRUCTION JOINTS IN NEW CONSTRUCTION

If the Engineer approves, the Contractor may add, delete, or relocate construction joints shown in the Drawings. Any request for such changes shall be in writing, accompanied by a drawing that depicts them. The Contractor will bear any added costs that result from such changes.

All construction joints shall be formed neatly with grade strips or other approved methods. The Owner will not accept irregular or wavy pour lines. All joints shall be horizontal, vertical, or perpendicular to the main reinforcement. The Contractor shall not use an edger on any construction joint, and shall remove any lip or edging before making the adjacent pour.

If the Drawings require a roughened surface on the joint, the Contractor shall strike it off to leave grooves at right angles to the length of the member. The grooves shall be ½-inch to 1-inch wide, ¼-inch to ½-inch deep, and spaced equally at twice the width of the groove. If the first strike-off does not produce the required roughness, the Contractor shall repeat the process before the concrete reaches initial set. The final surface shall be clean and without laitance or loose material.

If the Drawings do not require a roughened surface, the Contractor shall include shear keys at all construction joints. These keys shall provide a positive, mechanical bond. Shear keys shall be formed depressions and the forms shall not be removed until the concrete has been in place at least 12-hours. Forms shall be slightly beveled to ensure ready removal. Raised shear keys are not allowed.

Shear keys for the tops of beams, at tops and bottoms of boxed girder webs, in diaphragms, and in crossbeams shall:

1. Be formed with 2 by 8-inch wood blocks;

2. Measure 8-inches lengthwise along the beam or girder stem;

3. Measure 4-inches less than the width of the stem, beam, crossbeam, etc. (measured transverse of the stem); and

4. Be spaced at 16-inches center to center.

Unless the Drawings show otherwise, in other locations (not named above), shear keys shall equal approximately ⅓ of the joint area and shall be approximately 1½-inches deep.

Before placing fresh concrete against cured concrete, the Contractor shall thoroughly clean and saturate the cured surface. All loose particles, dust, dirt, laitance, oil, or film of any sort shall be removed by method(s) as approved by the Engineer. The cleaned surface shall be saturated with water for a minimum of four hours before the fresh concrete is placed.

Before placing the reinforcing mat for footings on seals, the Contractor shall: (1) remove all scum, laitance, and loose gravel and sediment; (2) clean the construction joint at the top of the seals; and (3) chip off any high spots on the seals that would prevent the footing steel from being placed in the position required by the Drawings.

6-02.3(12)B CONSTRUCTION JOINTS BETWEEN EXISTING AND NEW CONSTRUCTION

If the Contract require a roughened surface on the joint, the Contractor shall thoroughly roughen the existing surface to a uniformly distributed 1/4-inch minimum amplitude surface profile, with peaks spaced at a maximum of 1-inch, by method(s) as approved by the Engineer.

If the Contract does not require a roughened surface on the joint, the Contractor shall remove all loose particles, dust, dirt, laitance, oil, or film of any sort by method(s) as approved by the Engineer.

Before placing fresh concrete against existing concrete, the Contractor shall thoroughly clean and saturate the existing surface. All loose particles, dust, dirt, laitance, oil, or film of any sort shall be removed by method(s) as approved by the Engineer. The cleaned surface shall be saturated with water for a minimum of four hours before the fresh concrete is placed.

6-02.3(13) EXPANSION JOINTS

This section outlines the requirements of specific expansion joints shown in the Drawings. The Drawings may require other types of joints, seals, or materials than those described here.

Joints made of a vulcanized, elastomeric compound (with neoprene as the only polymer) shall be installed with an approved lubricant adhesive as recommended by the manufacturer. The length of a seal shall match that required in the Drawings without splicing or stretching.

Open joints shall be formed with a template made of wood, metal, or other suitable material. Insertion and removal of the template shall be done without chipping or breaking the edges or otherwise injuring the concrete.

Any part of an expansion joint running parallel to the direction of expansion shall provide a clearance of at least ½ inch (produced by inserting and removing a spacer strip) between the two surfaces. The Contractor shall ensure that the surfaces are precisely parallel to prevent any wedging from expansion and contraction.

All poured rubber joint sealer (and any required primer) shall conform with Section 9-04.2(2).

6-02.3(14) FINISHING CONCRETE SURFACES

All concrete shall show a smooth, dense, uniform surface after the forms are removed. If it is porous, the Contractor shall pay for repairing it. The Contractor shall clean and refinish any stained or discolored surfaces that may have resulted from their Work or from construction delays.

Subsections A and B (below) describe 2 classes of surface finishing.

6-02.3(14)A CLASS 1 SURFACE FINISH

The Contractor shall apply a Class 1 finish to all surfaces of concrete members to the limits designated in the Drawings.

The Contractor shall follow steps 1 through 8 below. When steel forms have been used and when the surface of filled holes matches the texture and color of the area around them, the Contractor may omit steps 3 through 8. To create a Class 1 surface, the Contractor shall:

1. Remove all bolts and all lips and edgings where form members have met;
2. Fill all holes greater than ¼-inch and float to an even, uniform finish with mortar conforming to Section 9-20.4(2) at a 1:2 cement/aggregate ratio;
3. Thoroughly wash the surface of the concrete with water;
4. Brush on a mortar conforming to Section 9-20.4(2) at a 1:1 cement/aggregate ratio, working it well into the small air holes and other crevices in the face of the concrete;
5. Brush on no more mortar than can be finished in 1-day;
6. Rub the mortar off with burlap or a piece of carpet as soon as it takes initial set (before it reaches final set);
7. Fog-spray water over the finish as soon as the mortar paint has reached final set; and
8. Keep the surface damp for at least 2-Days.

If the mortar becomes too hard to rub off as described in step 6, the Contractor shall remove it with a Carborundum stone and water. Random grinding is not permitted.

6-02.3(14)B CLASS 2 SURFACE FINISH

The Contractor shall apply a Class 2 finish to all above-ground surfaces not receiving a Class 1 finish as specified above unless otherwise in the Contract. Surfaces covered with fill do not require a surface finish.

To produce a Class 2 finish, the Contractor shall remove all bolts and all lips and edgings where form members have met and fill all form tie holes.

6-02.3(14)C PIGMENTED SEALER FOR CONCRETE SURFACES

All surfaces specified in the Drawings to receive pigmented sealer shall receive a Class 2 surface finish, (except that concrete barrier surfaces shall be finished under Section 6-02.3(11)A) and shall receive a light brush sandblasting in order that complete neutralization of the surface and subsequent penetration of the pigmented sealer is achieved. All curing agents and form release agents shall be removed. The surface shall be dry, clean and prepared under the manufacturer's written instructions. The Contractor shall submit four copies of the manufacturer's written instructions.

The Contractor shall not apply pigmented sealer from a batch greater than twelve months past the initial date of color sample approval of that batch by the Engineer.

The pigmented sealer color or colors for specific concrete surfaces shall be as specified in the Contract.

The pigmented sealer shall be spray applied under the manufacturer's written instructions for application, air temperature required for sealer application and curing, qualification of applicator, rate of application, and number of coats to apply. Pigmented sealer shall not be applied until the concrete has cured for at least 28-Days. Pigmented sealer shall not be applied upon damp surfaces, nor shall it be applied when the air is misty, or otherwise unsatisfactory for the work, in the opinion of the manufacturer or the Engineer. The final appearance shall have an even and uniform color acceptable to the Engineer.

For concrete surfaces such as columns, retaining walls, pier walls, abutments, concrete fascia panels, and noise barrier wall panels, the pigmented sealer shall extend to one foot below the finish ground line, unless otherwise shown in the Drawings

6-02.3(15) DATE NUMERALS

Standard date numerals shall be placed where shown in the Drawings. The date shall be for the year in which the Structure is completed. When traffic barrier is placed on an existing Structure, the date shall be for the year in which the original Structure was completed. Unit Contract prices shall cover all costs relating to these numerals.

6-02.3(16) PLANS FOR FALSEWORK AND FORMWORK

The Contractor shall submit all plans for falsework and formwork for acceptance under Section 1-05.3, as described in Section 6-02.3(16)A. The Contractor shall also submit 2 sets of the falsework and formwork plans to the Engineer. Approval will not reduce the Contractor's responsibility for ensuring the adequacy of the formwork and falsework. All falsework and formwork shall be constructed under approved falsework and formwork plans.

Except to place falsework foundation pads and piles, constructing any unit of falsework shall not start until the Engineer has reviewed and approved the falsework plans for that unit. Falsework driven piling, temporary concrete footings, or timber mudsills may be placed as described in Section 6-02.3(17)D prior to approval at the Contractor's own risk, except for the following conditions:

1. The falsework is over or adjacent to Roadways or railroads as described in Section 6-02.3(17)C, or
2. The falsework requires prior placement of shoring or cofferdams as described in Sections 2-07 and 2-08.

Costs associated with modifying falsework to bring it into compliance with the approved falsework plans shall be at the Contractor's expense.

The Engineer will review the falsework and formwork plans and calculations, and if they are acceptable, and unless otherwise specified in the Contract, will obtain the required approvals as applicable.

Plan approval is not required for footing or retaining walls unless they are more than 4-feet high (excluding pedestal height).

The design of falsework and formwork shall be based on:

1. Applied loads and conditions no less severe than those described in Section 6-02.3(17)A, "Design Loads;"
2. Allowable stresses and deflections no greater than those described in Section 6-02.3(17)B, "Allowable Stresses and Deflections;"
3. Special loads and requirements no less severe than those described in Section 6-02.3(17)C, "Falsework and Formwork at Special Locations;" and
4. Conditions required by other Sections of 6-02.3(17), Falsework and Formwork." Plan approval can be done by the Engineer for footings and walls 4-feet to 8-feet high (excluding pedestal height) provided:
5. Concrete placement rate is 4-feet per hour or less.
6. Facing is ¾-inch plywood with grade as specified per Section 6-02.3(17)J.
7. Studs, with plywood face grain perpendicular, are 2x4's spaced at 12-inches.
8. Walers with 3,000-pound safe working load ties spaced at 24-inches are 2-2x4's spaced at 24-inches.

Plan approval can be done by the Engineer for manufactured certified steel round column forming for column heights up to 20-feet. Concrete placement rate shall not exceed 10-feet per hour. Bracing requirements shall be per manufacturer's recommendations or submitted according to this Section 6-02.3(16).

The falsework and formwork plans shall be scale drawings showing the details of proposed construction, including: sizes and properties of all members and components; spacing of bents, posts, studs, wales, stringers, wedges and bracing; rates of concrete placement, placement sequence, direction of placement, and location of construction joints; identify falsework devices and safe working load and identifying any bolts or threaded rods used with the devices including their diameter, length, type, grade, and required torque. Show in the falsework plans the proximity of falsework to utilities or any

nearby Structures including underground Structures. Formwork accessories shall be identified according to Section 6-02.3(17)H, "Formwork Accessories." All assumptions, dimensions, material properties, and other data used in making the structural analysis shall be noted on the drawing.

The Contractor shall furnish the associated design calculations to the Engineer for examination as a condition for approval. The design calculations shall show the stresses and deflections in load supporting members. Construction details which may be in the form of sketches on the calculation sheets shall be in the falsework or formwork drawings as well. Falsework or formwork plans will not be approved where it is necessary to refer to the calculation sheets for information needed for complete understanding of the falsework and formwork plans or how to construct the falsework and formwork.

All falsework and formwork plans and design calculations submitted to Engineer shall be prepared by (or under the direct supervision of) a Professional Engineer, licensed under Title 18 RCW, State of Washington, in the branch of Civil or Structural Engineering.

Each sheet of falsework and formwork plans shall meet the Shop Drawing and Professional Engineer submittal requirements of section 1-05.3.

Design calculations shall meet the Shop Drawing and Professional Engineer submittal requirements of section 1-05.3.

6-02.3(16)A NONPREAPPROVED FALSEWORK AND FORMWORK PLANS

The Contractor shall submit in accordance with section 1-05.3, all non-preapproved falsework and formwork plans, and design calculations, for review and acceptance.

Reviewed falsework and formwork plans will be returned to the Contractor within the time allowed according to Section 1-05.3. The time allowed begins when the Contractor's transmittal and submittal including all required copies of the falsework and/or formwork plans and calculations, catalog data, and other technical information are received

Drawings returned to the Contractor for correction shall be corrected and clean (with no previous Engineer stamps and comments) revised falsework and formwork plans resubmitted to the Engineer for review and acceptance.

The Contractor may revise approved falsework and formwork plans, provided sufficient time is allowed for the Engineer's review and approval before construction is started on the revised portions. Such additional time will not be more than that which was originally allowed per Section 1-05.3. After a plan or drawing is approved and returned to the Contractor, all changes that the Contractor proposed shall be submitted to the Engineer for review and approval.

6-02.3(16)B RESERVED

6-02.3(17) FALSEWORK AND FORMWORK

Formwork and falsework are both structural systems. Formwork contains the lateral pressure exerted by concrete placed in the forms. Falsework supports the vertical and/or the horizontal loads of the formwork, reinforcing steel, concrete, and live loads during construction.

The Contractor shall set falsework, to produce in the finished Structure, the lines and grades in the Drawings. Setting falsework shall allow for shrinkage, settlement, falsework girder camber, and any structural camber the Drawings or the Engineer require.

Concrete forms shall be mortar tight, true to the dimensions, lines, and grades of the Structure. Curved surfaces shown in the Drawings shall be constructed as curved surfaces and not chorded, except as allowed in Section 6-02.3(17)J. Concrete formwork shall be of sufficient strength and stiffness to prevent overstress and excess deflection as defined in Section 6-02.3(17)B. The rate of depositing concrete in the forms shall not exceed the placement rate in the approved formwork plan. The interior form shape and dimensions shall also ensure that the finished concrete will conform with the Drawings.

If the new Structure is near or part of an existing one, the Contractor shall not use the existing Structure to suspend or support falsework unless the Contract state otherwise. For prestressed girder and T-beam bridge widenings or stage construction, the bridge deck and the diaphragm forms may be supported from the existing Structure or previous stage, if approved by the Engineer. For steel plate girder bridge widenings or stage construction, only the bridge deck forms may be supported from the existing Structure or previous stage, if approved by the Engineer. See Section 6-02.3(17)E for additional conditions.

On bridge decks, forms designed to stay in place made of steel or precast concrete panels shall not be used.

For post-tensioned Structures, both falsework and forms shall be designed to carry the additional loads caused by the post-tensioning operations. The Contractor shall construct supporting falsework to leave the Superstructure free to contract and lift off the falsework during post-tensioning. Forms that will remain inside box girders to support placing the bridge deck concrete shall, by design, resist girder contraction as little as possible. See Section 6-02.3(26) for additional conditions.

6-02.3(17)A DESIGN LOADS

The design load for falsework comprise the sum of dead and live vertical loads, and a design horizontal load. The minimum total design load for any falsework shall not be less than 100-lbs./sf. for combined live and dead load regardless of Structure thickness.

The entire Superstructure cross-section, except traffic barrier, shall be considered to be placed at one time for purposes of determining support requirements and designing falsework girders for their stresses and deflections, except as follows:

For concrete box girder bridges, the girder stems, diaphragms, crossbeams, and connected bottom slabs, if the stem wall is placed more than 5-Days prior to the top slab, may be considered to be self supporting between falsework bents at the time the top slab is placed, provided that the distance between falsework bents does not exceed 4 times the depth of the portion of the girder placed in the preceding concrete placements.

Falsework bents shall be designed for the entire live load and dead load, including all load transfer that takes place during post-tensioning, and braced for the design horizontal load.

Dead loads shall include the weight of all successive placements of concrete, reinforcing steel, forms and falsework, and all load transfer that takes place during post-tensioning. The weight of concrete with reinforcing steel shall be assumed to be not less than 160-pounds per cubic foot.

Live loads shall consist of the actual mass of any equipment to be supported by falsework applied as concentrated loads at the points of contact, and a minimum uniform load of not less than 25-lbs./sf. applied over the entire falsework plan area supported, plus a minimum load of not less than 75-pounds per linear foot applied at the outside edge of deck overhangs.

The design horizontal load to be resisted by the falsework bracing system in any direction shall be:

The sum of all identifiable horizontal loads due to equipment, construction sequence, side-sway caused by geometry or eccentric loading conditions, or other causes, and an allowance for wind plus an additional allowance of 1-percent of the total dead load to provide for unexpected forces. In no case shall the design horizontal load be less than three-percent of the total dead load.

The minimum horizontal load to be allowed for wind on each heavy-duty steel shoring tower having a vertical load carrying capacity exceeding 30-kips per leg shall be the sum of the products of the wind impact area, shape factor, and the applicable wind pressure value for each height zone. The wind impact area is the total projected area of all the elements in the tower face normal to the applied wind. The shape factor for heavy-duty steel shoring towers shall be taken as 2.2. Wind pressure values shall be determined from the following table:

Wind Pressure on Heavy-Duty Steel Shoring Towers		
	Wind Pressure Value	
Height Zone (Feet Above Ground)	**Adjacent to Traffic**	**At Other Locations**
0 to 30	20-psf	15-psf
30 to 50	25-psf	20-psf
50 to 100	30-psf	25-psf
Over 100	35-psf	30-psf

The minimum horizontal load to be allowed for wind on all other types of falsework, including falsework girders and forms supported on heavy-duty steel shoring towers, shall be the sum of the products of the wind impact area and the applicable wind pressure value for each height zone. The wind impact area is the gross projected area of the falsework support system, falsework girders, forms and any unrestrained portion of the permanent Structure, excluding the areas between falsework posts or towers where diagonal bracing is not used. Wind pressure values shall be determined from the following table:

Wind Pressure on All Other Types of Falsework		
	Wind Pressure Value	
Height Zone (Feet Above Ground)	**For Members Over and Bents Adjacent to Traffic**	**At Other Locations**

	Openings	
0 to 30	2.0 Q psf	1.5 Q psf
30 to 50	2.5 Q psf	2.0 Q psf
50 to 100	3.0 Q psf	2.5 Q psf
Over 100	3.5 Q psf	3.0 Q psf

The value of Q in the above tabulation shall be determined as follows:

Q = 1 + 0.2W; but Q shall not be over 10.

Where: W is the width of the falsework system, in feet, measured normal to the direction of the wind force being considered.

The falsework system shall also be designed so it will be sufficiently stable to resist overturning prior to placing the concrete. The minimum factor of safety against falsework overturning in all directions from the assumed horizontal load for all stages of construction shall be 1.25. If the required resisting moment is less than 1.25 times the overturning moment, the difference shall be resisted by bracing, cable guys, or other means of external support.

Design of falsework shall include the vertical component (whether positive or negative) of bracing loads imposed by the design horizontal load. Design of falsework shall investigate the effects of any horizontal displacement due to stretch of the bracing. This is important when using cable or rod bracing systems.

If the concrete is to be post-tensioned, the falsework shall be designed to support any increased or redistributed loads caused by the prestressing forces.

6-02.3(17)B ALLOWABLE DESIGN STRESSES AND DEFLECTIONS

The maximum allowable stresses listed in this Section are based on the use of identifiable, undamaged, high-quality materials. Stresses shall be appropriately reduced if lesser quality materials are to be used.

These maximum allowable stresses include all adjustment factors, such as the short term load duration factor. The maximum allowable stresses and deflections used in the design of the falsework and formwork shall be as follows:

6-02.3(17)B1 DEFLECTION

Deflection resulting from dead load and concrete pressure for exposed visible surfaces, $^{1}/_{360}$ of the span.

Deflection resulting from dead load and concrete pressure for unexposed non-visible surfaces, including the bottom of the deck slab between girders, $^{1}/_{270}$ of the span.

In the foregoing, the span length shall be the center line to center line distance between supports for simple and continuous spans, and from the center line of support to the end of the member for cantilever spans. For plywood supported on members wider than 1½-inches, the span length shall be taken as the clear span plus 1½-inches. Also, dead load shall include the weight of all successive placements of concrete, reinforcing steel, forms and falsework self weight. Only the self weight of falsework girders may be excluded from the calculation of the above deflections provided that the falsework girder deflection is compensated for by the installation of camber strips.

Where successive placements of concrete act compositely in the completed Structure, deflection control becomes extremely critical. Maximum deflection of supporting members — $^{1}/_{500}$ of the span for members constructed in several successive placements (such as concrete box girder and concrete T-beam girder Structures) falsework components shall be sized, positioned, and/or supported to minimize progressive increases in deflection of the Structure which would preload the concrete or reinforcing steel before it becomes fully composite.

6-02.3(17)B2 TIMBER

Each species and grade of timber/lumber used in constructing falsework and formwork shall be identified in the drawings. The allowable stresses and loads shall not exceed the lesser of stresses and loads given in the table below or factored stresses for designated species and grade in Table 7.3 of the *Timber Construction Manual, latest edition,* by the American Institute of Timber Construction.

Compression perpendicular to the grain reduced to 300-psi for use when moisture content is 19 percent or more (areas exposed to rain, concrete curing water, green lumber).	450-psi
Compression parallel to the grain but not to exceed 1,500-psi.	480,000-psi

	$(L/d)^2$
Flexural stress for members with a nominal depth greater than 8-inches.	1,800-psi
Flexural stress psi for members with a nominal depth of 8-inches or less.	1,500-psi
The maximum horizontal shear.	140-psi
AXIAL tension.	1,200-psi
The maximum modulus of elasticity (E) for timber.	1,600,000-psi

Where:

L is the unsupported length; and

d is the least dimension of a square or rectangular column, or the width of a square of equivalent cross-sectional area for round columns.

The allowable stress for compression perpendicular to the grain, and for horizontal shear shall not be increased by any factors such as short duration loading. Additional requirements are found in other parts of Section 6-02.3(17). Criteria for the design of lumber and timber connections are found in Section 6-02.3(17)I.

Plywood for formwork shall be designed under the methods and stresses allowed in the *APA Design/Construction Guide for Concrete Forming* as published by the American Plywood Association, Tacoma, Washington. As concrete forming is a special application for plywood, wet stresses shall be used and then adjusted for forming conditions such as duration of load, and experience factors. Concrete pour pressures shall be per Section 6-02.3(17)J.

6-02.3(17)B3 STEEL

For identified grades of steel, design stresses shall not exceed those specified in the *Steel Construction Manual, latest edition,* by the American Institute of Steel Construction, except as follows:

Compression, flexural but not to exceed $0.6F_y$	12,000,000-psi
	Ld/bt
The modulus of elasticity (E) shall be	29,000,000-psi

When the grade of steel cannot be positively identified as with salvaged steel and if rivets are present, design stresses shall not exceed the following:

Yield point f_y	30,000-psi
Tension, axial, and flexural	16,000-psi
Compression, axial except L/r shall not exceed 120	$14,150 - 0.37(KL/r)^2$ psi

Shear on gross section of the web of rolled shapes	9,500-psi
Web crippling for rolled shapes	22,500-psi
Compression, flexural but not to exceed 16,000-psi and L/b not greater than 39	16,000 - 5.2$(L/b)^2$ psi
The modulus of elasticity (E) shall be	29,000,000-psi

Where:

L is the unsupported length;

d is the least dimension of rectangular columns, or the width of a square of equivalent cross-sectional area for round columns, or the depth of beams;

b is the flange width;

t is the thickness of the compression flange;

r is the radius of gyration of the compression flange about the weak axis of the member; and

F_y is the specified minimum yield stress, psi, for the grade of steel used.

All dimensions are expressed in inches.

6-02.3(17)C FALSEWORK AND FORMWORK AT SPECIAL LOCATIONS

In addition to the minimum requirements specified in Sections 6-02.3(17)A and 6-02.3(17)B, falsework towers or posts supporting beams directly over Roadways or railroads which are open to traffic or the public shall be designed and constructed so the falsework will be stable if subjected to impact by vehicles. Using damaged materials, unidentifiable material, salvaged steel or steel with burned holes or questionable weldments shall not be used for falsework described in this section. For this Specification the following public or private facilities shall also be considered as “Roadways”: pedestrian pathways and other Structures such as bridges, walls, and buildings.

The dimensions of the clear openings to be provided through the falsework for Roadways, railroads, or pedestrian pathways shall be as specified in the Contract.

Falsework posts or shoring tower systems which support members that cross over a Roadway or railroad shall be considered as adjacent to Roadways or railroads. Other falsework posts or shoring towers shall be considered as adjacent to Roadways or railroads only if the following conditions apply:

1. Located in the row of falsework posts or shoring towers nearest to the Roadway or railroad; and
2. Horizontal distance from the traffic side of the falsework to the edge of pavement is less than the total height of the falsework and forms; or
3. The total height of the falsework and forms is greater than the horizontal clear distance between the base of the falsework and a point 10-feet from the centerline of track.

The Contractor shall provide any additional features for the Work needed to ensure that the falsework will be stable for impact by vehicles; providing adequate safeguards, safety devices, protective equipment, and any other needed actions to protect property and the life, health, and safety of the public; and shall comply with the provisions in Section 1-07.23 and Section 6-02.3(17)M. The falsework design at special locations, shall incorporate the minimum requirements detailed in this Section, even if protected by concrete median barrier.

The vertical load used for the design of falsework posts and towers which support the portion of the falsework over openings, shall be the greater of the following:

1. 150-percent of the design load calculated under Section 6-02.3(17)B, but not including any increased or redistributed loads caused by the post-tensioning forces; or
2. 100-percent of the design load plus the increased or redistributed loads caused by the post-tensioning forces.

Each falsework post or each shoring tower leg adjacent to Roadways or railroads comprise either steel with a minimum section modulus about each axis of 9.5-inches cubed or sound timbers with a minimum section modulus about each axis of 250-inches cubed.

Each falsework post or shoring tower leg adjacent to Roadways or railroads shall be mechanically connected to its supporting footing at its base, or otherwise laterally restrained, to withstand a force of not less than 2,000-pounds applied at the base of the post or tower leg in any direction except toward the Roadway or railroad track. Posts or tower legs shall be connected to the falsework cap and stringer by mechanical connections capable of resisting a load in any horizontal direction of not less than 1,000-pounds.

For falsework spans over Roadways and railroads, all falsework stringers shall be mechanically connected to the falsework cap or framing. The mechanical connections shall be capable of resisting a load in any direction, including uplift on the stringer, of not less than 500-pounds. All associated connections shall be installed before traffic is allowed to pass beneath the span.

When timber members are used to brace falsework bents located adjacent to Roadways or railroads, all connections shall be bolted through the members using ⅝-inch diameter or larger bolts.

Concrete traffic barrier shall protect all falsework adjacent to traveled Roadways. The falsework shall be located so falsework footings, mudsills, or piles are at least 2-feet clear of the traffic barrier and all other falsework members shall also be at least 2-feet clear of the traffic barrier. Traffic barrier used to protect falsework shall not be fastened, guyed, or blocked to any falsework but shall be fastened to the pavement according to details in the Drawings. The installation of concrete traffic barrier shall be completed before falsework erection is begun. The traffic barrier at the falsework shall not be removed until approved by the Engineer. Falsework openings provided for the Contractor's own use (not for public use) shall also use concrete traffic barrier to protect the falsework, except the minimum clear distance between the barrier and falsework footings, mudsills, piles, or other falsework members shall be at least 3-inches.

Falsework bents within 20-feet of the center line of a railroad track shall be braced to resist the required horizontal load or 2,000-pounds whichever is greater.

Pedestrian openings through falsework shall be paved or surfaced with full width continuous wood walks which shall be wheel chair accessible and shall be kept clear. Pedestrians shall be protected from falling objects and water falling from construction above. Overhead protection for pedestrians shall extend at least 4-feet beyond the edge of the bridge deck. Drawings and details of the overhead protection and pathway shall be submitted with the falsework plans for review and approval. Pedestrian openings through falsework shall be illuminated by temporary lighting, constructed and maintained by the Contractor. The temporary lighting shall be constructed under local electrical code requirements. The temporary lighting shall be steady burning 60-watt, 120-volt lamps with molded waterproof lamp holders spaced at 25-foot centers maximum. All costs relating to pedestrian pathway paving, wood walks, overhead protection, maintenance, operating costs, and temporary pedestrian lighting shall be incidental to applicable adjacent items of Work.

6-02.3(17)D FALSEWORK SUPPORT SYSTEMS: PILING, TEMPORARY CONCRETE FOOTINGS, TIMBER MUDSILLS, MANUFACTURED SHORING TOWERS, CAPS, AND POSTS

The Contractor shall support all falsework on either driven piling, temporary concrete footings, or timber mudsills. Temporary concrete footings shall be designed as reinforced concrete which may be cast in place or precast. All components for a falsework support system shall be sized for the maximum design loads and allowable stresses described in the preceding sections.

The falsework drawings shall include a Superstructure placing diagram showing the concrete placing sequence, direction of placements, and construction joint locations. When a sequence for placing concrete is in the Drawings or Specifications, no deviation will be permitted.

If the Drawings call for piling or foundation shafts to support permanent Structures, the Contractor may not use mudsills or temporary concrete footings for falsework support unless the underlying soil passes the settlement test described in this section.

6-02.3(17)D1 PILING

When using piling to support the falsework, the Contractor's falsework plans shall specify the minimum required bearing and depth of penetration for the piling. Also, the falsework drawings shall show the maximum horizontal distance that the top of a falsework pile may be pulled to position it under its cap. The falsework plans shall show the maximum allowable deviation of the top of the pile, in its final position, from a vertical line through the point of fixity of the pile. The calculations shall account for pile stresses due to combined axial and flexural stress and secondary stresses.

Timber piling (untreated) shall be banded before driving. The following shall be identified in the falsework plans: lengths, minimum tip diameter, and expected diameter at ground line. The Contractor shall comply with the requirements of Sections 9-10.1. The maximum allowable load for timber piles shall be 45-tons. Steel piling shall be identified in the falsework plans. If steel pipe piling is used, the pipe diameter and wall thickness shall be identified in the falsework plans. Steel piling shall meet the requirements of Section 9-10.5. The formulas in Section 6-05.3(12) shall determine the bearing capacity of the falsework piling. If the Engineer approves, the pile bearing capacity may instead be determined by test loading the piling to twice the falsework design load. The Contractor shall provide the Engineer an opportunity to witness these tests and provide a plan of the test and cross-sections showing the locations and elevations of the proposed tests to the Engineer for approval.

6-02.3(17)D2 TEMPORARY CONCRETE FOOTINGS AND TIMBER MUDSILLS

Timber mudsills or temporary concrete footings may be used in place of driven piling, provided tests show that the soil can support twice the falsework design load and that the mudsill or temporary concrete footing will not settle more than ¼-

inch when loaded with the design load. The tests shall be done at the falsework site, at the same elevation of the mudsill, and conducted under conditions representative of the actual site conditions. The acceptable tests for various soil types are:

1. Granular Soil. The Contractor shall conduct on-site tests according to AASHTO T 235. The Contractor shall provide the Engineer an opportunity to witness these tests and provide a plan of the test and cross-sections showing the locations and elevations of the proposed tests to the Engineer for approval.

2. Fine Grained or Organic Soil. The Contractor shall employ a Geotechnical Engineer to investigate the foundation soils and certify in writing each mudsill or temporary footing will meet the load-settlement requirements described above. The allowable bearing capacities, elevations and locations of specific falsework mudsills shall be in the certification. Soils information used to determine the soil bearing capacity and settlement shall be submitted with the written certification to the Engineer for review and approval.

Timber mudsills or temporary concrete footings for falsework shall be designed to carry the loads imposed upon them without exceeding the estimated soil bearing capacity and specified maximum settlement. Where mudsills or temporary footings are used in the vicinity of permanent spread footings, the allowable mudsill bearing pressure shall be less than that of the permanent footings. This is because elevation difference, smaller bearing area, and the lack of surrounding overburden provides a lower bearing capacity than the permanent spread footings. The mudsills shall be designed for bearing capacities at the location they are to be used. Timber mudsills or temporary concrete footings shall be designed as unyielding foundations under full design loads. The soil pressure bearing values assumed in the design of the falsework (normally not over 3,000-pounds per sq. ft.) shall be in the falsework drawings. The minimum edge distances from the edge of the post or shoring tower leg to the edge or end of the mudsill member shall be in the falsework drawings. Timber mudsills and temporary concrete footings shall be designed such that member deflections do not exceed ¼-inch and that member allowable stresses are not exceeded.

Full cross-sectional views of all falsework on timber mudsills or temporary concrete footings to be placed in side slopes or above excavations shall be in the falsework drawings. Footings or mudsills stepped or placed above an excavation shall have all related geometry and slope stability items identified in the falsework plan. Details and calculations for any shoring system to support the embankment or excavation shall be included.

Mudsills or temporary concrete footings placed in benches in slopes shall be set back from the face of the slope ½ the mudsill or temporary concrete footing width, but not less than 1-foot 0-inches. The bench including the setback shall be level in its narrow dimension. Slopes between benches measured from the top of slope at one bench to the toe of slope at the next bench below shall be no steeper than 1½ horizontal to 1 vertical.

Falsework shall be founded on a solid footing, safe against undermining, protected from softening, and capable of supporting the loads imposed. Preparing the soil to receive the temporary footing is important to ensure that the falsework does not experience localized settlement that could cause falsework failure. In preparing the soil for a timber mudsill or temporary concrete footing, the Contractor shall:

1. Place it on dry soil either undisturbed or compacted to 95-percent of maximum density, as determined by the compaction control tests in Section 2-11 performed by the Contractor and submitted to the Engineer for review;

2. Place mudsills or footings level with full contact bearing on the soil with no voids. Place each distribution plate or corbel member between the post or tower leg and the mudsill members such that there is full contact bearing;

3. Place a compacted layer of fine material under the mudsill if it is supported by rock or coarse sand and gravel;

4. Provide the Engineer with a sample of any off-site material to be used under the mudsill;

5. Allow up to 5-Working Days for the Engineer's approval before using the off-site material; and

6. Provide erosion control measures to protect the soil of the mudsill or footing from undermining and softening.

Anticipated total settlements and incremental settlements of falsework and forms due to successive concrete placements shall be in the falsework plans. These shall include falsework footing settlement and joint take-up. Total anticipated settlements shall not exceed 1-inch including joint take-up. When using mudsills, the Contractor shall prepare for the possibility of reshoring with such devices as screw jacks or hydraulic jacks and adjustment of wedge packs. The placing of concrete shall be discontinued if unanticipated settlement occurs, including settlements that deviate more than plus or minus ⅜-inch from those indicated on the approved falsework drawing. Concrete placement shall not resume until corrective measures satisfactory to the Engineer are provided. If satisfactory corrective measures are not provided prior to initial set of the concrete in the affected area, placing of concrete shall be discontinued at a location determined by the Engineer. All unacceptable concrete shall be removed as determined by the Engineer.

Where the maximum leg load exceeds 30-kips, foundations for individual steel towers shall be designed and constructed to provide uniform settlement at each tower leg for all loading conditions.

6-02.3(17)D3 BENTS, SHORING TOWERS, PILING, POSTS, AND CAPS

Drawings for falsework bents or shoring tower systems, including manufactured tower systems shall have plan, cross-section, and elevation view scale drawings showing all geometry. Show in the falsework plans the proximity of falsework to utilities or any nearby Structures including underground Structures. The ground elevation, cross-slopes, relation of stringers to one another, and dimensions to posts or piling shall be in the falsework plans. Column, pile, or tower heights shall be indicated. Member sizes, wall thickness and diameter of steel pipe columns or piles shall be in the falsework plans. Location of wedges, minimum bearing area and type of wedge material shall be identified in the falsework plans. Bracing size, location, material and all connections shall be described in the falsework plans.

The relationship of the falsework bents or shoring tower systems to the permanent Structure's pier and footing shall be shown. Load paths shall be as direct as possible. Loads shall be applied through the shear centers of all members to avoid torsion and buckling conditions. Where loads cause twisting, biaxial bending, or axial loading with bending, the affected members shall be designed for combined stresses and stability.

Posts or columns shall be constructed plumb with tops and bottoms carefully cut to provide full end bearing. Caps shall be installed at all bents supported by posts or piling unless approved falsework plans specifically permit otherwise. Caps shall be fastened to the piling or posts. The falsework shall be capable of supporting non uniform or localized loading without adverse effect. For example, the loading of cantilevered ends of stringers or caps shall not cause a condition of instability in the adjacent unloaded members.

Timber posts and piling shall be fastened to the caps and mudsills by through-bolted connections, drift pins, or other approved connections. The minimum diameter of round timber posts shall be in the falsework plans. Timber caps and timber mudsills shall be checked for crushing from columns or piling under maximum load.

Steel posts and piling shall be welded or bolted to the caps, and shall be bolted or welded to the foundation. Steel members shall be checked for buckling, web yielding, and web crippling.

Wedges shall be used to permit formwork to be taken up and released uniformly. Wedges shall be oak or close-grained Douglas fir. Cedar wedges or shims shall not be used anywhere in a falsework or forming system. Wedges shall be used at the top or bottom of shores, but not at both top and bottom. After the final adjustment of the shore elevation is complete, the wedges shall be fastened securely to the sill or cap beam. Only 1 set of wedges (with 1 optional block) shall be used at 1 location. Screw jacks (or other approved devices) shall be used under arches to allow incremental release of the falsework.

Sand jacks may be used to support falsework and are used for falsework lowering only. Sand jacks shall be constructed of steel with snug fitting steel or concrete pistons. Sand jacks shall be filled with dry sand and the jack protected from moisture throughout its use. They shall be designed and installed in such a way to prevent the unintentional migration or loss of sand. All sand jacks shall be tested per Section 6-02.3(17)G.

When falsework is over or adjacent to Roadways or railroads, all details of the falsework system which contribute to the horizontal stability and resistance to impact shall be installed when each element of the falsework is erected and shall remain in place until the falsework is removed. For other requirements see Section 6-02.3(17)C.

Transverse construction joints in the Superstructure shall be supported by falsework at the joint location. The falsework shall be constructed in such a manner that subsequent pours will not produce additional stresses in the concrete already in place.

6-02.3(17)D4 MANUFACTURED SHORING TOWER SYSTEMS AND DEVICES

Manufactured proprietary shoring tower systems shall be identified in the falsework plans by make and model and safe working load capacity per leg. The safe working load for shoring tower systems shall be based upon a minimum 2½ to 1 factor of safety.

The safe working load capacity, anticipated deflection (or settlement), make and model shall be identified in the falsework plans for manufactured devices such as: single shores, overhang brackets, support bracket and jack assemblies, friction collars and clamps, hangers, saddles, and sand jacks. The safe working load for shop manufactured devices shall be based on a minimum ultimate strength safety factor of 2 to 1. The safe working load for field fabricated devices and all single shores shall be based on a minimum ultimate strength safety factor of 3 to 1.

The safe working load of all devices shall not be exceeded. The design loads shall be as defined by Section 6-02.3(17)A. The maximum allowable free end deflection of deck overhang brackets under working loads applied shall not exceed $^{3}/_{16}$-inch measured at the edge of the concrete slab regardless of the fact that the deflection may be compensated for by pre-cambering or of setting the elevations high. The Contractor shall comply with all manufacturer's Specifications; including those relating to bolt torque, placing washers under nuts and bolt heads, cleaning and oiling of parts, and the reuse of material. Devices which are deteriorated, bent, warped, or have poorly fitted connections or welds, shall not be installed.

Shoring tower or device capacity as shown in catalogs or brochures published by the manufacturer shall be considered as the maximum load which the shoring can safely support under ideal conditions. These maximum values shall be reduced for adverse loading conditions; such as horizontal loads, eccentricity due to unbalanced spans or placing sequence, and uneven foundation settlement.

Depending on load-carrying capacity, steel shoring systems are classified as pipe-frame systems, intermediate strength systems, and heavy-duty systems. The 2 types of pipe-frame shoring base frames in general use are the ladder type

and the cross-braced type. In the ladder type, frame rigidity is provided by horizontal struts between the vertical legs, whereas in the cross-braced type rigidity is provided by diagonal cross-bracing between the legs.

Copies of catalog data and/or other technical data shall be furnished with the falsework plans to verify the load-carrying capacity, deflection, and manufacturers installation requirements of any manufactured product or device proposed for use. Upon request by the Engineer, the Contractor shall furnish manufacturer certified test reports and results showing load capacity, deflection, test installation conditions, and identify associated components and hardware for shoring tower systems or other devices. In addition to manufacturer's requirements, the criteria shown in the following sections for manufactured proprietary shoring tower systems and devices shall be complied with when preparing falsework plans, calculations, and installing these shoring tower systems and devices as falsework.

Alternative criteria and/or systems may be approved if a written statement on the manufacturer's letter head, signed by the shoring or device manufacturer (not signed by a material supplier or the Contractor) is submitted to the Engineer for approval and addresses the following:

1. Identity of the specific Contract on which the alternative criteria and/or system will apply;
2. Description of the alternative criteria and/or system;
3. Technical data and test reports;
4. The conditions under which the alternative criteria may be followed;
5. That a design based on the alternative criteria will not overstress or over deflect any shoring component or device nor reduce the required safety factor.

Where the falsework drawings detail a manufactured product and the manufacturer's safe working load, load versus deflection curves, factor of safety, and installation requirements cannot be found in any catalog, the Engineer may require load testing per Section 6-02.3(17)G to verify the safe working load and deflection characteristics.

Tower leg loads shall not exceed the limiting values under any loading condition or sequence. Frame extensions and any reduced capacity shall be in the falsework plans. Screw jacks shall fit tight in the leg assemblies without wobble. Screw jacks shall be plumb and straight. Shoring towers shall be installed plumb, and load distribution beams shall be arranged such that vertical loads are distributed to all legs for all successive concrete placements. There shall be no eccentric loads on shoring tower heads unless the heads have been designed for such loading. Shoring towers shall remain square or rectangular in plan view and shall not be skewed. There shall be no interchanging of parts from one manufactured shoring system to another. Bent or faulty components shall not be used.

For manufactured shoring towers that allow ganging of frames, the number of ganged frames shall be limited to 1 frame per opposing side of a tower, and the total number of legs per ganged tower shall not exceed 8 legs. Ganged frames shall be installed per the manufacturer's published standards using the manufacturer's components. Other gang arrangements shall not be used.

For manufactured steel shoring tower systems, the Contractor shall have bracing designed and installed for horizontal loads and falsework overturning per Section 6-02.3(17)A. Minimum bracing criteria and allowable leg loads are described in the following paragraphs.

All shoring tower systems and bracing shall be thoroughly inspected by the Contractor for plumb vertical support members, secure connections, and straight bracing members immediately prior to, at intervals during, and immediately after every concrete placement. For manufactured shoring tower systems, the maximum allowable deviation from the vertical is ⅛-inch in 3-feet. If this tolerance is exceeded, concrete shall not be placed until adjustments have brought the shoring towers within the acceptable tolerance.

6-02.3(17)D5 CROSS-BRACED TYPE BASE FRAMES

The maximum allowable load per leg for cross-braced type base frame shoring is limited by the height of the extension frame and the type of screw jack (swivel or fixed head) used at the top of the frame. The maximum load on 1 leg of a frame shall not exceed 4 times the load on the other leg under any loading condition or sequence. The maximum load on 1 of the 2 frames making up a tower shall not exceed 4 times the load on the opposite frame under any loading condition or sequence. If swivel-head screw jacks are used, the allowable leg loads shall not exceed that shown in the following table:

Maximum Allowable Leg Load in Pounds				
Extension Frame Height	2′-0"	3′-0"	4′-0"	5′-0"
Screw height 12" or less	11,000	11,000	10,000	9,400
Screw height exceeds 12"	8,200	8,200	8,000	7,800

If fixed-head screw jacks are used at the top of the extension frame, the maximum allowable load per leg shall be 11,000-pounds for all extension frame heights up to 5-feet with screw jack height extensions of 12-inches or less. Fixed-head

screw jacks exceeding 12-inches shall use the values in the table above. Screw jack extensions shall not exceed the manufacturer's published recommendations. Extension frames shall be braced. Side cross-braces are required for extension heights up to 2-feet 0-inches. Both side and end cross-braces are required from over 2-feet 0-inches to 5-feet 0-inches extension heights.

Supplemental bracing shall be installed on shoring towers 20-feet or more in height and shall connect rows of towers to each other so rows of frames are continuously cross-braced in 1 plane. Supplemental bracing shall be installed as follows:

1. In the transverse direction (the direction parallel to the frame) 1 horizontal brace and 1 diagonal brace shall be attached to each tower face, for every 3 frames of shoring height, including an extension frame if used. The lowest horizontal brace shall be located near the top of the third tower frame, and any additional horizontal braces spaced no farther than 3 frames apart. The diagonal braces shall be on opposite tower faces, and shall run in opposite directions across the plane of the tower row.
2. In the longitudinal direction (the direction perpendicular to the frames), when shoring height is 4 frames or more, a horizontal brace shall be installed on 1 face of each tower, with the lowest brace located no higher than the top of the fourth frame and any additional horizontal braces spaced no farther than 4 frames apart. When shoring height is 6 frames or more, diagonal cross-bracing shall be installed in the longitudinal direction similar to the transverse direction.
3. When Roadway grade, soffit profile, or superelevation exceeds 4-percent slope for any height of shoring tower, a continuous brace parallel to the slope shall be attached to each frame extension or screw jack of the tower within 6-inches of the top. These braces shall be in addition to bracing previously described.

The bracing shall be fastened securely to each frame leg and shall be located within 6-inches of the frame member intersections. The ends of diagonal braces shall not be attached to shoring frames at locations where towers have little or no load. Diagonal brace ends shall be attached to tower frames near the top and bottom at locations where significant gravity load is maintained throughout all construction sequences, such as directly below box girder outside websprecluding lift-off due to the vertical component of the brace reaction. Supplemental bracing shall be in the falsework drawings. The connection details, including the method of connection and exact location of the connecting devices, shall be under the manufacturer's recommendations and shall be in the falsework drawings.

6-02.3(17)D6 LADDER TYPE BASE FRAMES

Ladder type base frame shoring shall be limited to the following maximum loads and conditions, regardless of any conflicting information which may be found in manufacturer's catalogs or brochures:

1. If the shoring system comprises a single tier of braced base frames, leg loads shall not exceed 10,000-pounds.
2. If the shoring system comprises 2 or 3 tiers of base frames, leg loads shall not exceed 7,500-pounds.
3. If an extension staff is used, the maximum allowable leg load shall be reduced to 6,000-pounds.
4. The maximum load on 1 leg of a frame shall not exceed 4 times the load on the other leg under any loading condition or sequence. The maximum load on 1 of the 2 frames making up a tower shall not exceed 4 times the load on the opposite frame under any loading condition or sequence.

Maximum allowable leg loads as shown above shall apply when fixed-head screw jacks are used, or when swivel-head jacks are used at either the top or bottom of the tower. A screw jack extension shall not exceed 12-inches. Swivel-head screw jacks shall not be used at both the top and bottom of ladder-type frames. For any combination of ladder-type base frames or base frames with staff extensions, the total height of the shoring shall not exceed 20-feet, including screw jack extensions.

When Roadway grade, soffit profile, or superelevation exceeds 4-percent slope for heights of shoring towers 20-feet or less, a continuous brace parallel to the slope shall be attached to each staff extension or screw jack of the tower within 6-inches of the top. These braces shall be attached per conditions described previously for cross-braced frames.

6-02.3(17)D7 INTERMEDIATE STRENGTH SHORING

Steel shoring, comprising cross-braced tubular members capable of carrying up to 25-kips per tower leg, is considered intermediate strength shoring. The use of a 25-kip type falsework shoring system shall meet the following conditions and limitations:

1. If swivel-head screw jacks are used at either the top or bottom of the tower, the maximum allowable load shall be reduced to 20-kips per tower leg.
2. The screw-jack extensions shall not exceed 14-inches.
3. Extension frames shall be braced. Side cross-braces are required for all extension-frame heights. End cross-braces (braces across the face of the extension frame) shall be provided for extension frame heights of 3-feet or more.
4. The maximum load on 1 leg of a frame, or on 1 frame of a tower, shall not exceed 4 times the load on the opposite leg or frame under any loading condition or sequence.

5. Shoring towers 20-feet or more in height shall have supplemental bracing installed under the criteria for bracing "Cross-braced Type Base Frames," except that no supplemental bracing will be required in the longitudinal direction (the direction perpendicular to the frame).

6. When Roadway grade, soffit profile, or superelevation exceeds 4-percent slope for any height of shoring tower, a continuous brace parallel to the slope shall be attached to each frame extension or screw jack of the tower within 6-inches of the top. These braces shall be in addition to bracing required in item 5.

The use of 25-kip shoring, when designed and erected in conformance with the above criteria, is acceptable for tower heights up to 5 frames plus a fully-extended extension frame plus the maximum allowable screw-jack adjustment. For any proposed use exceeding this limiting height, the Contractor shall furnish a statement signed by the shoring manufacturer covering the specific installation. The statement shall provide assurance that the shoring will carry the loads to be imposed overstressing no shoring component or reducing the required safety factor.

6-02.3(17)D8 HEAVY-DUTY SHORING SYSTEMS

Shoring capable of carrying up to 100-kips per tower leg is considered heavy duty shoring. The following criteria applies to these systems.

If tower legs, including any extension unit, are utilized as single-post shores braced in 1 direction only, the shores shall be analyzed as individual steel columns.

If the total height of the shoring does not exceed the height of a single tower unit, including any extension unit, and if both the base and extension units are fully braced in both directions under the manufacturer's recommendations, individual tower legs may be considered as capable of carrying the safe working load recommended by the manufacturer without regard to the load on adjacent legs.

If the shoring comprises 2 or more units stacked 1 above the other, either with or without an extension unit, the differential leg loading within a tower unit shall not exceed the following limitations:

Differential Leg Loading	
Maximum load on any leg in the tower unit	Maximum to Minimum load ratio
10-kips or less	10 to 1
10-kips to 50-kips	6 to 1
50-kips to 75-kips	5 to 1
75-kips or more	4 to 1

A complete stress analysis of steel beams used as continuous caps over 2 or more tower units shall be performed to determine the effect of continuity on tower leg loads. Resulting moment shear shall be added to or subtracted from the simple beam reaction to obtain the actual leg load and may produce a significant load differential.

Heavy-duty shoring shall be diagonally braced or otherwise externally supported at the top unless the towers are stable against overturning as defined in Section 6-02.3(17)A. When designing external bracing, including cable bracing, attention shall be given to the bracing connection to the falsework. Connections shall be designed to transfer horizontal and vertical forces from the falsework to the bracing system overstressing no tower component. All external bracing, attachment locations, and connection details shall be in the falsework plans.

6-02.3(17)E STRINGERS, BEAMS, JOISTS, BRIDGE DECK SUPPORT, AND DECK OVERHANGS

All stringers, beams, joists, and bridge deck support shall be designed for the design loads, deflections, and allowable stresses described in the preceding Sections 6-02.3(17)A, B, and C and for the following conditions.

At points of support, stringers, beams, joists, and trusses shall be restrained against rotation about their longitudinal axis. The effect of biaxial bending shall be investigated where falsework beams are not set plumb and the Structure cross-slope exceeds 3-percent.

For box girder and T-beam bridges, the centerline of falsework beams or stringers shall be located within 2-feet of the bridge girder stems and preferably directly under the stems or webs. Stringers supporting formwork for concrete box girder and T-beam slab overhangs shall be stiff enough so the differential deflection due to the bridge deck pour is no more than $^{3}/_{16}$-inch between the outside edge of the bridge deck and the exterior web even if camber strips can compensate for the deflection.

Friction shall not be relied upon for lateral stability of beams or stringers. If the compression flange of a beam is not laterally restrained, the allowable bending stress shall be reduced to prevent flange buckling. If flange restraint is provided and since it is impossible to predict the direction in which a compression flange will buckle, positive restraint shall be in both directions. Flange restraint shall be designed for a minimum load of 2-percent of the calculated compression force in the beam flange at the point under consideration.

Camber strips shall compensate for falsework take-up and deflection, vertical alignment, and the anticipated Structure dead load deflection in the camber diagram in the Drawings. Camber is the adjustment to the profile of a load-supporting beam or stringer so the completed Structure will have the lines and grades shown in the Drawings. The dead load camber diagram in the Drawings is the predicted Structure dead load deflection due to self mass. This dead load camber shall be increased by:

1. Amount of anticipated falsework take up;
2. Anticipated deflection of the falsework beam or stringer under the actual load imposed; and
3. Any vertical curve compensation.

Camber strips shall be fastened by nailing to the top of wood members, or by clamping or banding in steel members. Camber strips shall have sufficient contact bearing area to prevent crushing under total load. As a general rule, camber strips are not required unless the total camber adjustment exceeds ¼-inch for exterior falsework stringers and ½-inch for interior stringers.

On concrete box girder Structures, the forms supporting the bridge deck shall rest on ledgers or similar supports and shall not be supported from the bottom slab except as provided below. The form supports shall be fastened within 18-inches of the top of the web walls, producing a clear span between web walls. The bridge deck forms may be supported or posted from the bottom slab if the following conditions are met:

1. Permanent access, shown in the Drawings, is provided to the cells, and the centerline to centerline distance between web walls is greater than 10-feet;
2. Falsework stringers designed for total load, stresses and deflections per Section 6-02.3(17)A and B are located directly below each row of posts;
3. Posts have adequate lateral restraint; and
4. All forms (including the bridge deck forms), posts, and bracing are completely removed.

The falsework and forms on concrete box girder Structures supporting a sloping web and deck overhang shall consist of a lateral support system designed to resist all rotational forces acting on the stem, including those caused by placing deck slab concrete, bridge deck formwork mass, finishing machine, and other live loads. Stem reinforcing steel shall not be stressed by constructing the bridge deck slab placement. Overhang brackets shall not be used for the support of bridge deck forms from sloping web concrete box girder bridges.

Deck slab forms between girders or webs shall be constructed such that there is no differential settlement relative to the girders. The support systems for form panels supporting concrete deck slabs and overhangs on girder bridges (such as steel plate girders and prestressed girders) shall be designed as falsework. Falsework supporting deck slabs and overhangs on girder bridges shall be supported directly by the girders so there will be no differential settlement between the girders and the deck forms during placement of deck concrete.

6-02.3(17)F BRACING

All falsework bracing systems shall be designed to resist the horizontal design load in all directions with the falsework in either the loaded or unloaded condition. All bracing, connection details, specific locations of connections, and hardware used shall be in the falsework plans. Falsework diagonal bracing shall be thoroughly analyzed with particular attention given to the connections. The allowable stresses in the diagonal braces may be controlled by the joint strength or the compression stability of the diagonal. Timber bracing for timber falsework bents shall have connections designed per Section 6-02.3(17)I. Any damaged cross-bracing, such as split timber members shall be replaced. Steel strapping shall avoid making sharp angles or right-angle bends. A means of preventing accidental loss of tension shall be provided for steel strapping. See Sections 6-02.3(17)A, B, and C for design loads and allowable stresses.

Bracing shall not be attached to concrete traffic barrier, guardrail posts, or guardrail.

To prevent falsework beam or stringer compression flange buckling, cross-bracing members and connections shall be designed to carry tension and compression. All components, connection details and specific locations shall be in the falsework plans. Bracing, blocking, struts, and ties required for positive lateral restraint of beam flanges shall be installed at right angles to the beam in plan view. If possible, bracing in adjacent bays shall be set in the same transverse plane. However, if because of skew or other considerations, it is necessary to offset the bracing in adjacent bays, the offset distance shall not exceed twice the depth of the beam.

All falsework and bracing shall be inspected by the Contractor for plumbness of vertical support members, secure connections, tight cables, and straight bracing members immediately prior to, during, and immediately after every concrete placement.

Bracing shall be provided to withstand all imposed loads during erection of the falsework and all phases of construction for falsework adjacent to any Roadway, sidewalk, or railroad track open to the public. All details of the falsework system which contribute to horizontal stability and resistance to impact, including the bolts in bracing, shall be installed at the time each element of the falsework is erected and shall remain in place until the falsework is removed. The falsework plans shall show provisions for any supplemental bracing or methods to be used to conform to this requirement during each phase of erection and removal. Wind loads shall be included in the design of such bracing or methods. Loads, connections, and materials for falsework adjacent to Roadways, shall also be under Section 6-02.3(17)C.

6-02.3(17)F1 CABLE OR TENSION BRACING SYSTEMS

When cables, wire rope, steel rod, or other types of tension bracing members are used as external bracing to resist horizontal forces, or as temporary bracing to support bents while falsework is being erected or removed adjacent to traffic, all elements of the bracing system shall be in the falsework plans. Bracing shall not be attached to concrete traffic barrier, guardrail posts, or guardrail. Any damaged bracing, such as frayed and kinked guying systems shall be replaced. Wire rope shall avoid making sharp angles or right-angle bends and a means of preventing accidental loss of tension shall be provided. The following information shall be submitted to the Engineer for approval:

1. Cable diameter, rod, or tension member size, and allowable working load.
2. Location and method of attaching the cable, rod, or tension member to the falsework. The connecting device shall be designed to transfer both horizontal and vertical forces to the cable overstressing no falsework component.
3. The type of cable connectors or fastening devices (such as U-bolt clips, plate clamps, etc.) to be used and the efficiency factor for each type. If cables are to be spliced, the splicing method shall be shown.
4. Method of tightening cables, rods, or tension members after installation if tightening is necessary to ensure their effectiveness. Method of preventing accidental loosening.
5. Anchorage details, including the size and mass of concrete anchor blocks, the assumed coefficient of friction for surface anchorages, and the assumed lateral soil bearing capacity for buried anchorages.
6. Method of pre-stretching or preloading cable or tension members.
7. Determination of the potential stretch or elongation of the tension member under the design load and if the resulting lateral deflection will cause excessive secondary stresses in the falsework.

Copies of manufacturer's catalog or brochure showing technical data pertaining to the type of cable to be used shall be furnished with the falsework plans. Technical data shall include the cable diameter, the number of strands and the number of wires per strand, ultimate breaking strength or recommended safe working strength, and any other information to identify the cable.

Absent sufficient technical data to identify the cable, or if it is old and worn, the Contractor shall perform cable breaking tests to establish the safe working load for each reel of cable furnished. For static guy cable the minimum factor of safety shall be 3 to 1. The Contractor shall provide the Engineer an opportunity to witness these tests.

When cable bracing is used to prevent the overturning of heavy-duty shoring, attention shall be given to the connections by which forces are transferred from the shoring to the cables. Cable restraint shall be designed to act through the cap system to prevent the inadvertent application of forces which the shoring is not designed to withstand. Cables shall not be attached to any tower component.

Cable splices made by lapping and clipping with "Crosby" type clamps shall not be used. Other splicing methods may be used; however, at each location where the cable is spliced, cable strength shall be verified by a load test.

When cables are used as external bracing to resist overturning of a falsework system, the horizontal load to be carried by the cables shall be calculated as follows:

1. When used with heavy-duty shoring systems, cables shall be designed to resist the difference between 1.25 times the total overturning moment and the resistance to overturning provided by the individual falsework towers.
2. When used with pipe-frame shoring systems where supplemental bracing is required, cables shall be designed to resist the difference between 1.25 times the total overturning moment and the resistance to overturning provided by the shoring system as a whole.
3. When used as external bracing to prevent overturning of all other types of falsework, including temporary support during erection and removal of falsework at traffic openings, cables shall be designed to resist 1.25 times the total overturning moment.

The maximum allowable cable design load shall be determined using the following criteria:

1. If the cable is new, or is in uniformly good condition, and if it can be identified by reference to a manufacturer's catalog or other technical publication, the allowable load shall be the ultimate strength of the cable as specified by the manufacturer, multiplied by the efficiency of the cable connector, and divided by a safety factor of 3 (i.e., safe working load = breaking strength x connector efficiency/safety factor).

2. If the cable is used but still in serviceable condition, or is new or nearly new but cannot be found in a manufacturer's catalog, the Contractor shall perform load breaking tests. , the cable design load shall not exceed the breaking strength, as determined by the load test, multiplied by the connector efficiency factor, and divided by a safety factor of 3.

3. If the cable is used and still in serviceable condition, or is a new or nearly new cable which cannot be identified, and if load breaking tests are not performed, the cable design load shall not exceed the safe working load in the wire rope capacities table multiplied by the cable connector efficiency.

Cable connectors shall be designed under criteria shown in the following tables "Efficiency of Wire Rope Connections" and "Applying Wire Rope Clips." Cable safe working loads are provided in table "Wire Rope Capacities."

Efficiency of Wire Rope Connections (As compared to Safe Loads on Wire Rope)	
Type of Connection	Connector Efficiency
Wire Rope	100%
Sockets — Zink Type	100%
Wedge Sockets	70%
Clips — Crosby Type With Thimble	80%
Knot and Clip (Contractors Knot)	50%
Plate Clamp — 3 Bolt Type With Thimble	80%
Spliced Eye and Thimble:	
¼" and smaller	100%
⅜" to ¾"	95%
⅞" to 1"	88%
1⅛" to 1½"	82%
1⅝" to 2"	75%
2⅛" and larger	70%

Wire Rope Capacities Safe Load in Pounds for New Plow Steel Hoisting Rope 6-Strands of 19-Wires, Hemp Center (Safety Factor of 6)		
Diameter Inches	Weight Lbs./Ft.	Safe Load Lbs.
¼	0.10	1,050
5/16	0.16	1,500
⅜	0.23	2,250
7/16	0.31	3,070
½	0.40	4,030

9/16	0.51	4,840
⅝	0.63	6,330
¾	0.95	7,930
7/8	1.29	10,730
1	1.60	15,000
1⅛	2.03	18,600
1¼	2.50	23,000
1⅜	3.03	25,900
1½	3.60	30,700
1⅝	4.23	35,700
1¾	4.90	41,300

6-02.3(17)F2 APPLYING WIRE ROPE CLIPS

The only correct method of attaching U-bolt wire rope clips to rope ends places the base (saddle) of the clip against the live end of the rope, while the “U” of the bolt presses against the dead end.

The clips are usually spaced about 6 rope diameters apart to give adequate holding power. A wire-rope thimble shall be used in the loop eye to prevent kinking when wire rope clips are used. The correct number of clips for safe application, and spacing distances, are shown below:

Number of Clips and Spacing for Safe Application			
	Number of Clips		Minimum
Improved Plow Steel Rope Diameter Inches	Drop Forged	Other Material	Spacing (Inches)
⅜	2	3	3
½	3	4	3½
⅝	3	4	4
¾	4	5	4½
⅞	4	5	5¼
1	5	6	6
1⅛	6	6	6¾
1¼	6	7	7½
1⅜	7	7	8¼
1½	7	8	9

6-02.3(17)F3 ANCHOR BLOCKS

Concrete anchor blocks and connections used to resist forces from external bracing shall be in the falsework plans. Concrete anchor blocks shall be proportioned to resist both sliding and overturning. When designing anchor block stability, the mass of the anchor block shall be reduced by the vertical component of the cable or brace tension to obtain the net or effective mass to be used in the anchorage computations. The coefficient of friction assumed in the design shall not exceed the following:

	Friction Coefficient
Anchor block set on sand	0.40
Anchor block set on clay	0.50
Anchor block set on gravel	0.60
Anchor block set on pavement	0.60

Note: Multiply the friction coefficient by 0.67 if it is likely the supporting material is wet or will become wet during the construction period.

The method of connecting the cable or brace to the anchor block is part of the anchor block design. The connection shall be designed to resist both horizontal and vertical forces.

6-02.3(17)F4 TEMPORARY BRACING FOR BRIDGE GIRDERS

Bridge girders (such as steel plate girders and prestressed girders) shall be braced and tied to resist forces that would cause rotation or torsion in the girders caused by the placing of concrete for diaphragms or the deck. These conditions also apply to bridge widenings and stage constructed bridges where construction sequences can cause rotation or torsion in the girders. Falsework support brackets or braces shall not be welded to structural steel members or reinforcing steel.

On prestressed girder spans, the Contractor shall install cross-bracing between girders at each end and midspan to prevent lateral movement or rotation. This bracing shall be placed prior to the release of the girders from the erection equipment. The bracing shall not be removed until the diaphragms or the deck have been placed and cured for a minimum of 24-hours.

When deck overhang or the distance from the centerline of the exterior girder (or outside girder of a staged construction) to the near edge of the bridge deck on a prestressed girder span exceeds the distances listed in the table below, the Contractor shall provide extra bracing for the exterior girder at the midpoint between diaphragms (or at more frequent intervals). This bracing shall include: (1) a cross-tie connecting the top flange of each exterior girder with its counterpart on the other side, and (2) braces between the bottom flanges and top flanges of all girders.

Girder Series	**Distance in Inches**
W42G	30
W50G	42
W58G	63
W74G	66
Prestressed concrete tub girders with webs with flanges	30
WF36G, WF42G, WF50G, WF58G, WF66G, WF74G, WF83G, WF95G, and WF100G	70
W32BTG, W38BTG, and W62BTG	70

WF74PTG, WF83PTG, WF95PTG, and WF100PTG	70

If a concrete finishing machine is supported at the outside edge of the slab, the Contractor shall account for its added mass in the design of bracing.

Bridge deck forming systems may require bracing or ties between girders for the girder to adequately support the form loading. When braces, struts, or ties are required, they shall be designed and detailed by the Contractor and shall be in the falsework/formwork plans submitted to the Engineer for approval. These braces, struts, and ties shall be furnished and installed by the Contractor at no additional cost to the Owner.

6-02.3(17)G TESTING FALSEWORK DEVICES

The Contractor shall establish the load capacity and deflection (or settlement) of all friction collars and clamps, brackets, hangers, saddles, sand jacks, and similar devices utilizing a recognized independent testing Laboratory approved by the Engineer. Laboratory tests shall use the same materials and design that will be used on the project. Test loads shall be applied to the device in the same manner that the device will experience loading on the project. Any bolts or threaded rods used with the device shall be identified as to diameter, length, type, grade, and torque. Any wedges, blocks, or shims used with the device on the project shall also be tested with the device. Any adjustable jack system used as a part of a device shall be tested with the device and shall have its maximum safe working extended height identified. Devices shall not be tested in contact with the permanent Structure. Independent members with the same properties as the permanent Structure shall test device connections.

At least 14-Days prior to the test, the Contractor shall submit a test procedure and scale drawing for the Engineer's approval showing how the device will be tested and how data will be collected. The Contractor shall provide the Engineer an opportunity to witness these tests.

The approved independent testing Laboratory shall provide a certified test report which shall be signed and dated. The test report shall identify the device tested including trademarks and model numbers; identify all parts and materials used, including grade of steel, or lumber, member section dimensions; location, size, and the maximum tested extended height of any adjustable jacks; indicate condition of materials used in the device; indicate the size, length and location of all welds; indicate how much torque was used with all bolts and threaded rods. The report shall describe how the device was tested, report the results of the test, provide a scale drawing of the device showing the location(s) of where deflections or settlements were measured, and show where load was applied. Deflections or settlements shall be measured at load increments and the results shall be graphed and labeled. Prior to installation of falsework devices named in this section, the Contractor shall submit the certified test reports to the Engineer for review and approval.

The safe working load for shop manufactured devices named in this section shall be derived by dividing the ultimate strength by a safety factor of 2.0. The safe working load for field fabricated or field modified devices (including using timber blocks or wedges with the device) shall be determined by dividing the ultimate strength by a safety factor of 3.0. Working load shall include masses of all successive concrete placements, falsework, forms, all load transfer that takes place during post-tensioning, and any live loads; such as workers, Roadway finishing machines, and concrete delivery systems. The maximum allowable free end deflection of deck overhang brackets with combined dead and live working loads applied shall be $^{3}/_{16}$-inch even though deflection may be compensated for by pre-cambering or setting the elevations high. The Contractor shall comply with all manufacturer's Specifications; including those relating to bolt torque, cleaning and oiling of parts, and the reuse of material. Devices which are deteriorated, bent, warped or have poorly fitted connections or welds, shall not be installed.

6-02.3(17)H FORMWORK ACCESSORIES

Formwork accessories such as form ties, form anchors, form hangers, anchoring inserts, and similar hardware shall be identified in the formwork plans including the name and size of the hardware, manufacturer, safe working load, and factor of safety. The grade of steel shall also be indicated for threaded rods, coil rods, and similar hardware. Wire form ties and taper ties shall not be used. Welding or clamping formwork accessories to Contract Plan reinforcing steel will not be allowed. Driven types of anchorages for fastening forms or form supports to concrete, and Contractor fabricated "J" hooks shall not be used. Field drilling of holes in prestressed girders is not allowed.

The following table from ACI 347R-88 provides minimum safety factors for formwork accessories. The hardware proposed shall meet these minimum ultimate strength requirements or the manufacturer's minimum requirements, whichever provides the greater factor of safety. The Contractor shall attach copies of the manufacturer's catalog cuts and/or test data of hardware proposed, to the formwork plans and submit the falsework and formwork plans and calculations for review and approval per Section 6-02.3(16). Where catalog cuts and/or test data are not available, testing shall be performed under Section 6-02.3(17)G.

Minimum Safety Factors of Formwork Accessories*		
Accessory	**Safety Factor**	**Type of Construction**

Form Tie	2.0	All applications.
Form Anchor	2.0	Formwork supporting form mass and concrete pressures only.
Form Anchor	3.0	Formwork supporting masses of forms, concrete, construction live loads, and impact.
Form Hangers	2.0	All applications.
Anchoring Inserts	2.0	Placed in previous opposing concrete placement to act as an anchor for form tie.

*Safety factors are based on ultimate strength of the formwork accessory.

The bearing area of external holding devices shall be adequate to prevent excessive bearing stress on form lumber. Form ties and form hangers shall be arranged symmetrically on the supporting members to minimize twisting or rotation of the members. Form tie elongation shall not exceed the allowable deflection of the wale or member it supports. Inserts, bolts, coil rods, and other fasteners shall be analyzed and designed for appropriately combined bending, shear, torsion, and tension stresses. The formwork shall not be attached to Contract Plan rebar or rebar cages. However, the Contractor may install additional reinforcing steel for formwork anchorage.

Frictional resistance shall not be considered as contributing to the stability of any connection or connecting device, except those designed as friction connectors such as U-bolt friction-type connectors.

Form anchors and anchoring inserts shall be designed considering concrete strength at time of loading, available embedment, location in the member, and any other factors affecting their working strength, and shall be installed in concrete per the manufacturer's published requirements. Form anchors and anchoring inserts embedded in previous concrete placements shall not be loaded until the concrete has reached the required design strength. The required design strength of concrete for loading of an anchor shall be in the formwork drawing if it is assumed that the anchor will be loaded before the concrete has reached its 28-Daystrength.

Installation of permanent concrete inserts, such as form ties hangers, or embedded anchor assemblies, shall permit removal of all metal to at least ½-inch below the concrete surface. Holes shall be patched under Section 6-02.3(14). During removal of the outer unit, the bond between the concrete and the inner unit or rod shall not be broken.

6-02.3(17)I TIMBER CONNECTIONS

Timber connections shall be designed in accordance with the methods, stresses, and loads allowed in the Timber Construction Manual, Current Edition by the American Institute of Timber Construction (AITC). Timber falsework and formwork connections shall be designed using wet condition stresses for all installations West of the Cascade Range crest line and by criteria provided in the following sections. Frictional resistance shall not be considered as contributing to the stability of any timber connection.

6-02.3(17)I1 BOLTED CONNECTIONS

Tabulated values in the AITC Timber Construction Manual, Current Edition are based on square posts. For a round post or pile, the main member thickness shall be the side of a square post having the same cross-sectional area as the round post used.

The AITC Table 6.20 for Douglas Fir-Larch bolt Group 3 and for Hem-Fir bolt Group 8 show design values for bolts to be used when the load is applied either parallel or perpendicular to the direction of the wood grain. When the load is applied at an angle to the grain, as is the case with falsework bracing, the design value for the main member shall be obtained from the Hankinson formula in the AITC manual.

Design values in the AITC Table 6.20 apply only to 3-member joints (bolt in double-shear) in which the side members are each ½ the thickness of the main member. This joint configuration is not typical of bridge falsework where side members are usually much smaller than main members. For 2 member joints (single shear bolt condition), the AITC Table 6.20 values shall be adjusted by a single shear load factor as follows:

1. 0.75 for installations East of the Cascade Range crest line, except as shown in item 3 below;
2. 0.50 for installations West of the Cascade Range crest line; and
3. 0.50 for load acting at an angle to the bolt axis, as is the case with longitudinal bracing when falsework bents are skewed.

Except for connections in falsework adjacent to or over railroads or Roadways, threaded rods and coil rods may be used in place of bolts of the same diameter with no reduction in the tabulated values. At openings for Roadways and railroads, all connections shall be bolted using ⅝-inch diameter or larger through bolts.

Bolt holes shall be a minimum $^{1}/_{32}$-inch to a maximum ⅛-inch larger than the bolt diameter. A washer not less than a standard cut washer shall be installed between the wood and the bolt head and between the wood and the nut to distribute the bearing stress under the bolt head and nut and to avoid crushing the fibers. In lieu of standard cut washers, metal plates or straps with dimensions at least equal to that of a standard cut washer may be substituted.

When steel bars or shapes are diagonal bracing, the tabulated design values in AITC Table 6.20 for the main members loaded parallel to grain (P value) are increased 75-percent for joints made with bolts ½-inch or less in diameter, 25-percent for joints made with bolts 1½-inch in diameter, and proportionally for intermediate diameters. No increase in the tabulated values is allowed for perpendicular-to-grain loading (Q value).

Clearance requirements for end, edge, and bolt spacing distance shall be as shown below. All distances are measured from the end or side of the wood member to the center of the bolt hole. For members subject to load reversals the larger controlling distances shall be used for design. For parallel-to-grain loading, the minimum distances for full design load:

1. In tension, minimum end distance shall be 7 times the bolt diameter;
2. In compression, minimum end distance shall be 4 times the bolt diameter; and
3. In tension or compression, the minimum edge distance shall be 1.5 times the bolt diameter.

For perpendicular-to-grain loading, the minimum distance for full design load:

1. Minimum end distance shall be 4 times the bolt diameter;
2. Edge distance toward which the load is acting shall be at least 4 times the bolt diameter; and
3. Distance on the opposite edge shall be at least 1.5 bolt diameters.

Minimum clearance (spacing) between adjacent bolts in a row shall be 4 times the bolt diameter, measured center-to-center of the bolt holes.

When over 2 bolts are used in a line parallel to the axis of the side member, additional requirements shall be followed as shown in the AITC manual.

6-02.3(17)I2 LAG SCREW CONNECTIONS

Design values for lag screws subject to withdrawal loading are found in AITC Table 6.27. Values for wood having a specific gravity of 0.51 for Douglas Fir-Larch or 0.42 for Hem-Fir shall be assumed when using the table. The withdrawal values are in pounds per inch of penetration of the threaded part of the lag screw into the side grain of the member holding the point, with the axis of the screw perpendicular to that member. The maximum load on a screw shall not exceed the allowable tensile strength of the screw at the root section.

AITC recommends against subjecting lag screws to end-grain withdrawal loading. However, if this condition cannot be avoided, the design value shall be 75-percent of the corresponding value for withdrawal from the side grain.

Values in the Group II wood species column shall be used for Douglas Fir-Larch and the Group III wood species column shall be used for Hem-Fir. When the load is applied at an angle to the grain, as is the case with falsework bracing, the design value shall be obtained from the Hankinson formula in the AITC manual.

When lag screws are subjected to a combined lateral and withdrawal loading, as would be the case with longitudinal bracing when the falsework bents are skewed, the effect of the lateral and withdrawal forces shall be determined separately. The withdrawal component of the applied load shall not exceed the allowable value in withdrawal. The lateral component of the applied load shall not exceed the allowable lateral load value.

Lag screws shall be inserted in lead holes as follows:

1. The clearance hole for the shank shall have the same diameter as the shank, and the same depth of penetration as the length of unthreaded shank;
2. The lead hole for the threaded portion shall have a diameter equal to 60 to 75-percent of the shank diameter and a length equal to at least the length of the threaded portion. The larger percentile figure in each range shall apply to screws of the greater diameters used in Group II wood species;
3. The threaded portion of the screw shall be inserted in its lead hole by turning with a wrench, not by driving with a hammer; and
4. To facilitate insertion, soap or other lubricant shall be used on the screws or in the lead hole.

6-02.3(17)I3 DRIFT PIN AND DRIFT BOLT CONNECTIONS

When drift pins or drift bolts are used, the required length and penetration shall be determined using the following criteria. The lateral load-carrying capacity of drift pins and drift bolts driven into the side grain of a wood member shall be limited to 75-percent of the design values for a common bolt of the same diameter and length in the main member. For drift pin

connections, the pin penetration into the connected members shall be increased to compensate for the absence of a bolt head and nut. For drift bolts or pins driven into the end grain of a member, the lateral load-carrying capacity shall be limited to 60-percent of the allowable side grain load (perpendicular to grain value) for an equal diameter bolt with nut. To develop this allowable load the drift bolt or pin shall penetrate at least 12-diameters into the end grain. To fully develop the allowable load of the drift bolts or pins, they shall be driven into predrilled holes, $^{1}/_{16}$-inch less in diameter than the drift pin or bolt diameter.

The criteria shown in the AITC Timber Construction Manual, Current Edition shall apply to drift bolt or pin connection allowable loads for the following conditions:

1. Withdrawal resistance; and
2. When there are over 2 drift bolts or pins in a joint, allowable loads shall be further reduced by applying modification factors shown in the AITC Table 6.3.

6-02.3(17)I4 NAILED AND SPIKED JOINTS

Joints using nails or spikes shall conform to AITC. For side grain withdrawal, the values in AITC Table 6.35 for wood having a specific gravity of 0.51 for Douglas Fir-Larch and a specific gravity of 0.42 for Hem-Fir shall be used. End grain withdrawal shall not be used. For lateral loading, the values in AITC Table 6.36 for wood species Group II for Douglas Fir-Larch and wood species Group III for Hem-Fir shall be used. Diameters listed in the tables apply to fasteners before application of any protective coating.

When over 1 nail or spike is used in a joint, the total design value for the joint in withdrawal or lateral resistance shall be the sum of the design values for the individual nails or spikes.

The tabulated design values for lateral loads are valid only when the nail penetrates into the main member at least 11-diameters for Douglas Fir-Larch and 13-diameters for Hem-Fir. Note the values are maximum values for the type and size of fastener shown. The tabulated values shall not be increased even if the actual penetration is exceeded.

When main member penetration is less than 11-diameters for Douglas Fir-Larch and 13-diameters for Hem-Fir, the design value shall be determined by straight-line interpolation between zero and the tabulated load, except that penetration shall not be less than ⅓ of that specified.

Double-headed or duplex nails used in falsework and formwork construction are shorter than common wire nails or box nails of the same size designation. They have less penetration into the main member and therefore their load-carrying capacity shall be adjusted accordingly.

Nail and spike minimum spacing in timber connections shall be as follows:

1. The average center-to-center distance between adjacent nails, measured in any direction, shall not be less than the required penetration into the main member for the size of nail being used; and
2. The minimum end distance in the side member, and the minimum edge distance in both the side member and the main member, shall not be less than ½ of the required penetration.

Allowable values for withdrawal and lateral load resistance are reduced when toe nails are used in accordance with the following:

1. For withdrawal loading, the design load shall not exceed ⅔ of the value in the applicable design table; and
2. For lateral loading, the design load shall not exceed $^{5}/_{6}$ of the value in the applicable design table.

Toe nails are recommended to be driven at an approximate angle of 30-degrees with the piece and started approximately ⅓ of the length of the nail from the end or side of the piece.

6-02.3(17)I5 TIMBER CONNECTION ADJUSTMENT FOR DURATION OF LOAD

Tabulated values for timber fasteners are for normal duration of load and may be increased for short duration loading, except for connections used in falsework and formwork for post tensioned Structures and staged construction sequences. Duration of load adjustment for timber connections shall not be allowed for all post tensioned Structures and for staged construction sequences where delayed and/or staged loading occurs for any type of concrete Structure. The adjustment for duration of load as described in this section applies only to design values for timber connectors, such as nails, bolts, and lag screws. Allowable stresses for timber and structural steel components used in the connection, as described in Section 6-02.3(17)B, are maximums and shall not be increased.

Tabulated values for nails, bolts, and lag screws may be adjusted by the following duration-of-load factors:

1. 1.25 for falsework design governed by the minimum design horizontal load or greater (3-percent or greater of the dead load);
2. 1.33 for falsework design governed by wind load; and
3. 2.00 for falsework design governed by impact loading.

6-02.3(17)J FACE LUMBER, STUDS, WALES, AND METAL FORMS

Elements of this section shall be designed for the loads, allowable stresses, deflections, and conditions which pertain from other subsections of Section 6-02.3(17).

Forms battered or inclined above the concrete will tend to lift up as concrete is placed and shall have positive anchorage or counterweights designed to resist uplift and shall be in the formwork plans. Where the concrete pouring sequence causes fresh concrete to be significantly higher along one side of tied forms than the opposite side, a positive form anchorage system shall be designed capable of resisting the imbalance of horizontal thrust, and prevent the dislocation and sliding of the entire form unit.

Wooden forms shall be faced with smooth sanded, exterior plywood. This plywood shall meet the requirements of the National Bureau of Standards, U.S. Product Standard PS 1, and the Design Specification of the American Plywood Association (APA). Each full sheet shall bear the APA stamp. The Contractor shall list in the form plans the grade and class of plywood. If the Engineer approves the manufacturer's certification of structural properties, the Contractor may use plywood that does not carry the APA stamp. Plywood panels stamped "shop" or "shop cutting," shall not be used.

Plyform is an APA plywood specifically designed and manufactured for concrete forming. Plyform differs from conventional exterior plywood grades in strength and the exterior face panels are sanded smooth and factory oiled. Likewise, there is a significant difference between grades designated Class 1, Class 2, and Structural I Plyform.

The grades of plywood for various form applications shall be as follows:

1. **Traffic and Pedestrian Barriers** (except those that will receive an architectural surface treatment) — Plywood used for these surfaces shall be APA grade High Density Overlaid (HDO) Plyform Class I. But if the Contractor coats the form to prevent it from leaving joint and grain marks on the surface, plywood that meets or exceeds APA grades B-B Plyform Class I or B-C (Group I species) may be used. Under this option, the Contractor shall provide for the Engineer's approval a 4-foot square, test panel of concrete formed with the same plywood and coating as proposed in the form plans. This panel shall include 1 form joint along its centerline. The Contractor shall apply coating material, according to the manufacturer's instructions, before applying chemical release agents.
2. **Other Exposed Surfaces** (all but those on traffic and pedestrian barriers) — Plywood used to form these surfaces shall meet or exceed the requirements of APA grades B-B Plyform Class I or B-C (Group I series). If 1 face is less than B quality, the B (or better) face shall contact the concrete.
3. **Unexposed Surfaces** (such as the undersides of bridge decks between girders, the interiors of box girders, etc., and traffic and pedestrian barriers where surfaces will receive an architectural treatment) — Plywood used to form these surfaces may be APA grade CDX, provided the Contractor complies with stress and deflection requirements stated elsewhere in these Specifications.

Form joints on an exposed surface shall be in a horizontal or vertical plane. But in wingwalls and box girders, side form joints shall be placed at right angles and parallel to the Roadway grade. Joints parallel to studs or joists shall be backed by a stud or joist. Joints at right angles to studs and joists shall be backed by a stud or other backing the Engineer approves. Perpendicular backing is not required if studs or joists are spaced:

1. Nine-inches or less on center and covered with ½-inch plywood, or
2. Twelve-inches or less on center and covered with ¾-inch plywood.

The face grain of plywood shall run perpendicular to studs or joists unless shown otherwise on the Contractor's formwork plans and approved by the Engineer. Proposals to deviate from the perpendicular orientation shall be accompanied by supporting calculations of the stresses and deflections.

Forming for all exposed curved surfaces shall follow the shape of the curve in the Drawings and shall not be chorded except as follows. On any retaining wall that follows a horizontal circular curve, the wall stems may be a series of short chords if:

1. The chords within the panel are the same length, unless otherwise approved by the Engineer;
2. The chords do not vary from a true curve by more than ½-inch at any point; and
3. All panel points are on the true curve.

Where architectural treatment is required, the angle point for chords in wall stems shall fall at vertical rustication joints.

For exposed surfaces of abutments, wingwalls, piers, retaining walls, and columns, the Contractor shall build forms of plywood at least ¾-inch thick with studs no more than 12-inches on center. The Engineer may approve exceptions, but deflection of the plywood, studs, or wales shall never exceed $^{1}/_{360}$ of the span (or $^{1}/_{270}$ of the span for unexposed surfaces, including the bottom of the deck slab between girders).

All form plywood shall be at least ½-inch thick except on sharply curved surfaces. There, the Contractor may use ¼-inch plywood if it is backed firmly with heavier material.

Round columns or rounded pier shafts shall be formed with a self-supporting metal shell form or form tube that leaves a smooth, nonspiralling surface. Wood forms are not permitted.

Metal forms shall not be used elsewhere unless the Engineer is satisfied with the surface and approves in writing. The Engineer may withdraw approval for metal forms at any time. If permitted to use a combination of wood and metal in forms, the Contractor shall coat the forms so the texture produced by the wood matches that of the metal. Aluminum shall not be used for metal forms.

For design, the Contractor shall assume that on vertical surfaces concrete exerts 150-pounds per sq. ft. per foot of depth. However, when the depth is reached where the rate of placement controls the pressure, the following table applies:

Rate of Placing Feet per Hour	**Pressure, Pounds per Square Foot for Temperature of Concrete as Shown**	
	60°F	**70°F and above**
2	470	375
3	640	565
4	725	625
5	815	690
6	900	750
7	990	815
8	1,075	875
9	1,165	935
10	1,250	1,000
15	1,670	1,300

The pressures in the above table have been increased to provide an allowance for the vibration and impact.

All corners shall be beveled ¾-inch. However, footings, footing pedestals, and seals need not be beveled unless required in the Drawings.

All forms shall be as mortar-tight as possible with no water standing in them as the concrete is placed.

The Contractor shall apply a parting compound on forms for exposed concrete surfaces. This compound shall be a chemical release agent that permits the forms to separate cleanly from the concrete. The compound shall not penetrate or stain the surface and shall not attract dirt or other foreign matter. After the forms are removed, the concrete surface shall be dust-free and have a uniform appearance. The Contractor shall apply the compound at the manufacturer's recommended rate to produce a surface free of dusting action and yet provide easy removal of the forms.

If an exposed concrete surface will be sealed, the release agent shall not contain silicone resin. Before applying the agent, the Contractor shall provide the Engineer a written statement from the manufacturer stating whether the resin in the base material is silicone or nonsilicone.

The Contractor shall select a parting compound from the current Qualified Products List, or submit to the Engineer a sample of the parting compound at least 10-Working Days before its use. Approval or disapproval shall be based on Laboratory test results.

The Engineer may reject any forms that will not produce a satisfactory surface.

6-02.3(17)K CONCRETE FORMS ON STEEL SPANS

Concrete forms on all steel Structures shall be removable and shall not remain in place. Where needed, the forms shall have openings for truss or girder members. Each opening shall be large enough to leave at least 1½-inches between the concrete and steel on all sides of the steel member after the forms have been removed. Unit Contract prices cover all costs related to these openings.

The Contractor shall weld no part of the form to any steel member.

The compression member or bottom connection of cantilever formwork support brackets shall bear either within 6-inches maximum vertically of the bottom flange or within 6-inches maximum horizontally of a vertical web stiffener. The Contractor's bridge deck form system shall be designed to prevent rotation of the steel girder. This can be achieved by temporary struts and ties or other methods the Contractor shows to be effective. Partial depth cantilever formwork support brackets that do not conform to the above requirements shall not be used, unless the Contractor submits details showing the additional formwork struts and ties used to brace the steel girder against web distortion caused by the partial depth bracket, and receives the Engineer's approval of the submittal.

If the Engineer permits bolt holes in the web to support form brackets, the holes shall be shop drilled unless otherwise approved by the Engineer. The Contractor shall fill the holes with fully torqued AASHTO M 164 bolts per Section 6-03.3(33). Each bolt head shall be placed on the exterior side of the web. There shall be no holes made in the flanges.

6-02.3(17)L FINISHING MACHINE SUPPORT SYSTEM

Before using any finishing machine, the Contractor shall obtain the Engineer's approval of detailed drawings that show the system proposed to support it. The Contractor shall not attach this (or any other) equipment support system to the sides or suspend it from any girder unless the Engineer permits. The Engineer will not permit such a method if it will unduly alter stress patterns or create too much stress in the girder.

6-02.3(17)M RESTRICTED OVERHEAD CLEARANCE SIGN

The Contractor shall notify the Engineer not less than 15-Working Days before the anticipated start of each falsework and girder erection operation whenever such falsework or girders will reduce clearances available to the public traffic. Falsework openings shall not be more restrictive to traffic than shown in the Drawings.

Where the height of vehicular openings through falsework is less than 15-feet, a W 12-2 "Low Clearance Symbol Sign" shall be erected on the Shoulder in advance of the falsework and 2 or more W 12-301 and/or W 12-302 signs shall be attached to the falsework to provide accurate usable clearance information over the entire falsework opening. The posted low clearance shall include an allowance for anticipated falsework girder deflection (rounded-up to the next whole inch) due to design dead load, including all successive concrete pours. W 12-302 signs shall designate prominent clearance restrictions and limits of usable clearance. Where the clearance is less than the legal height limit (14-feet 0-inches), a W 12-2 sign shall be erected in advance of the nearest intersecting road or wide point in the road at which a vehicle can detour or turn around. A W 13-501 sign indicating the distance to the low clearance shall be installed below the advance sign. The Engineer will furnish the above noted signs and the Contractor shall erect and maintain them, all under Section 1-10.3(3).

When erecting falsework that restricts overhead clearance above a railroad track, the Contractor shall immediately (when the restriction occurs) place restricted overhead clearance signs. Sign details are in the Standard Drawings. Unit Contract prices cover all costs relating to these signs.

6-02.3(17)N REMOVAL OF FALSEWORK AND FORMS

If the Engineer does not specify otherwise, the Contractor may remove forms based on an applicable row of criteria in the table below. Both compressive strength and minimum time criteria shall be met if both are listed in the applicable row. The minimum time shall be from the time of the last concrete placement in the forms. In no case shall the Contractor remove forms or falsework without the Engineer's approval.

Concrete Placed In	Percent of Specified Minimum Compressive Strength1	Minimum Compressive Strength1	Minimum Time
Side forms not supporting the concrete weight, including columns, walls, crossbeams, nonsloping box girder webs, abutments, and traffic and pedestrian barriers.			3-days
	or		
		1,400 psi	18 hours
Side forms of footings, pile caps, and shaft caps.[2]	—	—	18 hours
Crossbeams, sloping box girder webs, struts, inclined columns, inclined walls and other forms that support the concrete weight.	80	—	5 days
Bridge decks supported on wood or steel stringers or on steel or prestressed concrete girders.[3]	80	—	10 days
Box girders, T-beam girders, and flat-slab Superstructure.[3]	80	—	14 days
Arches.[3]	80	—	21 days

1 Strength shall be proved by test cylinders made from the last concrete placed into the form. The cylinders shall be cured according to AASHTO T 23.

2 Curing compound shall be immediately applied to the sides when forms are removed.

3 Where continuous spans are involved, the time for all spans will be determined by the last concrete placed affecting any span.

Before releasing supports from beneath beams and girders, the Contractor shall remove forms from columns to enable the Engineer to inspect the column concrete.

Curing shall comply with Section 6-02.3(11). The concrete surface shall not become dry during form removal if removed during the cure period.

Before placing forms for traffic and pedestrian barriers, the Contractor shall completely release all falsework under spans.

Before releasing forms under concrete subjected to temperatures colder than 50°F, the Contractor shall first prove that the concrete meets desired strength — regardless of the time that has elapsed.

The Engineer may approve leaving in place forms for footings in cofferdams or cribs. This decision will be based on whether removing them would harm the cofferdam or crib and whether the forms will show in the finished Structure.

All cells of a box girder Structure which have permanent access shall have all forms completely removed, including the bridge deck forms. All debris and all projections into the cells shall be removed. Unless otherwise shown in the Drawings, the bridge deck interior forms in all other cells where no permanent access is available, may be left in place.

Falsework and forms supporting sloping exterior webs shall not be released until the bridge deck and deck overhang concrete has obtained its removal strength and number of Days criteria in the table above. Stem reshoring shall not be used.

Open joints shown in the Drawings shall have all forms completely removed, including Styrofoam products and form anchors, allowing the completed Structure to move freely.

If the Contractor intends to support or suspend falsework and formwork from the bridge Structure while the falsework and formwork is being removed, the Contractor shall submit a falsework and formwork removal plan and calculations for review and approval. The falsework and formwork removal plan shall include the following:

1. The location and size of any cast-in-place falsework lowering holes and how the holes are to be be filled;
2. The location, capacity, and size of any attachments, beams, cables, and other hardware used to attach to the Structure or support the falsework and formwork;
3. The type, capacity and factor of safety, weight, and spacing of points of reaction of lowering equipment; and
4. The weight at each support point of the falsework and formwork being lowered.

All other forms shall be removed whether above or below the level of the ground or water. Sections 6-02.3(7) and 6-02.3(8) govern form removal for concrete exposed to sea water or to alkaline water or soil. The forms inside of hollow piers, girders, abutments, etc. shall be removed through openings shown in the Drawings or approved by the Engineer.

6-02.3(17)O EARLY CONCRETE TEST CYLINDER BREAKS

The fabrication, curing, and testing of the early cylinders shall be the responsibility of the Contractor. Early cylinders are defined as all cylinders tested in advance of the design age of 28-Days whose purpose determines the in-place strength of concrete in a Structure prior to applying loads or stresses. The Contractor shall retain a testing Laboratory to perform this Work. Testing Laboratories' equipment shall be calibrated within 1-year prior to testing and testers shall be ACI certified or qualified under AASHTO R 18.

The concrete cylinders shall be molded under AASHTO T 23 from concrete last placed in the forms and representative of the quality of concrete placed in that pour.

The cylinders shall be cured under AASHTO T 23.

The concrete cylinders shall be tested for compressive strength under AASHTO T 22. The number of early cylinder breaks shall be in accordance with the Contractor's need and as approved by the Engineer.

The Contractor shall furnish the Engineer with all test results, proof of equipment calibration, and tester's certification. The test results will be reviewed and approved before any forms are removed. The Contractor shall not remove forms without the approval of the Engineer.

All costs with furnishing cylinder molds, fabrication, curing, and testing of early cylinders shall be in the unit Contract prices for the Bid items of Work involved.

6-02.3(18) PLACING ANCHOR BOLTS

The Contractor shall comply with the following requirements in setting anchor bolts in piers, abutments, or pedestals:

1. If set in the wet concrete, the bolts shall be accurately placed before the concrete is placed.
2. If the bolts are set in drilled holes, hole diameter shall exceed bolt diameter by at least 1-inch. Grouting shall comply with Section 6-02.3(20).
3. If the bolts are set in pipe, grouting shall comply with Section 6-02.3(20).
4. If freezing weather occurs before bolts can be grouted into sleeves or holes, they shall be filled with an approved antifreeze solution (non-evaporating).

6-02.3(19) BRIDGE BEARINGS

6-02.3(19)A RESERVED

6-02.3(19)B BRIDGE BEARING ASSEMBLIES

For all fixed, sliding, or rolling bearings, the Contractor shall:

1. Machine all sliding and rolling surfaces true, smooth, and parallel to the movement of the bearing;
2. Polish all sliding surfaces;
3. Anchor expansion bearings securely, setting them true to line and grade;
4. Avoid placing concrete in such a way that it might interfere with the free action of any sliding or rolling surface.

Grout placement under steel bearings shall comply with Section 6-02.3(20).

6-02.3(20) GROUT FOR ANCHOR BOLTS AND BRIDGE BEARINGS

Grout shall conform to Section 9-20.3(2)

Grout shall be a workable mix with viscosity suitable for the intended application.

If the Contractor elects to use a prepackaged grout, it shall conform to Section 9-20.3(2) for bearing assemblies with bearing plates, and shall conform to Section 9-20.3(3) for elastomeric bearing pads and fabric pad bearings without bearing plates, and a material sample and Laboratory test data from an independent testing Laboratory shall be submitted to the Engineer for approval with the request for approval of material sources.

If the Contractor elects to use a neat cement grout it shall conform to Section 9-20.(3)4, and the mix proportions and Laboratory test data from an independent test Laboratory shall be submitted to the Engineer for approval with the request for approval of material sources.

The Contractor shall receive approval from the Engineer before using the grout.

Field grout cubes shall be made under WSDOT Test Method 813 for either prepackaged grout or a Contractor provided mix when requested by the Engineer, but not less than 1 per bridge pier or 1 per day.

Before placing grout, the concrete on which it is placed shall be thoroughly cleaned, roughened, and wetted with water to ensure proper bonding. The grout pad shall be cured as recommended by the manufacturer or kept continuously wet with water for 3-Days. The grout pad may be loaded when a minimum of 4000-psi compressive strength is attained.

Before placing grout into anchor bolt sleeves or holes, the cavity shall be thoroughly cleaned and wetted to ensure proper bonding.

To grout bridge bearing masonry plates, the Contractor shall:

1. Build a form approximately 4-inches high with sides 4-inches outside the base of each masonry plate;
2. Fill each form to the top with grout;
3. Work grout under all parts of each masonry plate;
4. Remove each form after the grout has hardened;
5. Remove the grout outside each masonry plate to the base of the masonry plate;
6. Bevel off the grout neatly to the top of the masonry; and
7. Place no additional load on the masonry plate until the grout has set at least 72-hours.

After all grout under the masonry plate and in the anchor bolt cavities has attained a minimum strength of 4,000-psi, the anchor bolt nuts shall be tightened to snug-tight. “Snug-tight” means either the tightness reached by (1) a few blows from an impact wrench, or (2) the full effort of a person using a spud wrench. Once the nut is snug-tight, the anchor bolt threads shall be burred just enough to prevent loosening of the nut.

6-02.3(21) DRAINAGE OF BOX GIRDER CELLS

To drain box girder cells, the Contractor shall provide and install, according to details in the Drawings, short lengths of nonmetallic pipe in the bottom slab at the low point of each cell. The pipe shall have a minimum inside diameter of 4-inches. If the difference in Plan elevation is 2-inches or less, the Contractor shall install pipe in each end of the box girder cell. All drainage holes shall be screened in accordance with the Drawings.

6-02.3(22) DRAINAGE OF SUBSTRUCTURE

The Contractor shall use weep holes and gravel backfill that complies with Section 9-03.12(2) to drain fill material behind retaining walls, abutments, tunnels, and wingwalls. To maintain thorough drainage, weep holes shall be placed as low as possible. Weep holes shall be covered with geotextile meeting the requirements of Section 9-37.2, Table 2 Class C before backfilling. Geotextile screening shall be bonded to the concrete with an approved adhesive. Gravel backfill shall be placed and compacted as required in Section 2-10. If the Drawings require tiling; French or rock drains, or other drainage devices shall be installed.

If underdrains are not installed behind the wall or abutment, all backfill within 18-inches of weep holes shall comply with Section 9-03.12(4). Unless the Drawings require otherwise, all other backfill behind the wall or abutment shall be gravel backfill for walls.

6-02.3(23) OPENING TO TRAFFIC

Bridges with a bridge deck made of Portland cement concrete shall remain closed to all traffic, including construction equipment, until the concrete has reached the 28-Day specified compressive strength. This strength shall be determined by testing cylinders made of the same concrete as the deck slab and cured under the same conditions. A concrete deck bridge shall never be opened to traffic earlier than 10-Days after the deck concrete was placed and never without the written approval of the Engineer.

For load restrictions on bridges under construction, refer to Section 6-01.6.

6-02.3(24) REINFORCEMENT

Although the Drawings may include a bar list and bending diagram, these shall be used at the Contractor’s risk. Reinforcement fabrication details shall be determined from the information provided in the Drawings.Before delivery of the reinforcing bars, the Contractor shall submit to the Engineer two informational copies of the supplemental bending diagrams.

6-02.3(24)A FIELD BENDING

If the Drawings call for field bending of steel reinforcing bars, the Contractor shall bend them in keeping with the Structure configuration and the Drawings and Specifications.

Bending steel reinforcing bars partly embedded in concrete shall be in accordance with the following requirements:

Field bending shall **not** be done:

1. On bars size No. 14 or No. 18,
2. When air temperature is lower than 45°F,
3. With hammer blows or pipe sleeves, or
4. While bar temperature is 400° to 700°F.

In field-bending steel reinforcing bars, the Contractor shall:

1. Make the bend gradually;
2. Apply heat as described in Tables 2 and 3 for bending bar sizes No. 6 thru No. 11 and for bending bar sizes No. 5 and smaller when the bars have been previously bent. Previously unbent bars of sizes No. 5 and smaller may be bent without heating;
3. Use a bending tool equipped with a bending diameter as listed in Table 1;
4. Limit any bend to these maximums — 135-degrees for bars smaller than size No. 9, and 90-degrees for bars size No. 9 and No. 11;
5. Straighten by moving a hickey bar (if used) progressively around the bend.

In applying heat for field-bending steel reinforcing bars, the Contractor shall:

1. Use a method that will avoid damages to the concrete;
2. Insulate any concrete within 6-inches of the heated bar area;
3. Ensure, by using temperature-indicating crayons or other suitable means, that steel temperature never exceeds the maximum temperatures in Table 2 below;
4. Maintain the steel temperature within the required range in Table 2 below during the entire bending process;
5. Apply 2 heat tips simultaneously at opposite sides of bars larger than size No. 6 to assure a uniform temperature throughout the thickness of the bar. For size No. 6 and smaller bars, apply 2 heat tips, if necessary;
6. Apply the heat for a long enough time that within the bend area the entire thickness of the bar — including its center — reaches the required temperature;
7. Bend immediately after the required temperature has been reached;
8. Heat at least as much of the bar as Table 3 below requires;
9. Locate the heated section of the bar to include the entire bending length; and
10. Never cool bars artificially with water, forced air, or other means.

Table 1
Bending Diameters for Field-Bending Reinforcing Bars

	Bend Diameter/Bar Diameter Ratio	
Bar Size	**Heat Not Applied**	**Heat Applied**
No. 4, No. 5	8	8
No. 6 through No. 9	Not Permitted	8
No. 10, No. 11	Not Permitted	10

The minimum bending diameters for stirrups and ties for No. 4 and No. 5 bars when heat is not applied shall be specified in Section 9-07.

Table 2
Preheating Temperatures for Field-Bending Reinforcing Bars

	Temperature (F)	
Bar Size	**Minimum**	**Maximum**
No. 4	1,200	1,250
No. 5, No. 6	1,350	1,400
No. 7 through No. 9	1,400	1,450

No. 10, No. 11	1,450	1,500

Table 3
Minimum Bar Length to be Heated (d = nominal diameter of bar)

	Bend Angle		
Bar Size	**45°**	**90°**	**135°**
No. 4 through No. 8	8d	12d	15d
No. 9	8d	12d	Not Permitted
No. 10, No. 11	9d	14d	Not Permitted

6-02.3(24)B PROTECTION OF MATERIALS

The Contractor shall protect reinforcing steel from all damage. When placed into the Structure, the steel shall be free from dirt, loose rust or mill scale, paint, oil, and other foreign matter.

When transporting, storing, or constructing in close proximity to bodies of salt water, plain and epoxy-coated steel reinforcing bar shall be kept in enclosures that provide protection from the elements.

If plain or epoxy-coated steel reinforcing bar is exposed to mist, spray, or fog that may contain salt, it shall be flushed with fresh water prior to concrete placement.

When the Engineer requires protection for reinforcing steel that will remain exposed for a length of time, the Contractor shall protect the reinforcing steel:

1. By cleaning and applying a coat of paint conforming to Section 9-08.2 Item 3, Formula A-9-73 over all exposed surfaces of steel, or
2. By cleaning and painting paint conforming to Section 9-08.2 Item 3, Formula A-9-73 on the first 6-inches of the steel bars protruding from the concrete and covering the bars with polyethylene sleeves.

The paint shall have a minimum dry film thickness of 1-mil.

6-02.3(24)C PLACING AND FASTENING

The Contractor shall position reinforcing steel as the Drawings require and shall ensure that the steel does not move as the concrete is placed.

When spacing between bars is 1-foot or more, they shall be tied at all intersections. When spacing is less than 1-foot, every other intersection shall be tied. If the Drawings require bundled bars, they shall be tied together with wires at least every 6-feet. All epoxy-coated bars in the top mat of the bridge deck shall be tied at all intersections. Other epoxy-coated bars shall also be tied at all intersections, but shall be tied at alternate intersections when spacing is less than 1-foot in each direction. Wire used for tying epoxy-coated reinforcing steel shall be plastic coated. **Tack welding is not permitted on reinforcing steel**.

Abrupt bends in the steel are permitted only when one steel member bends around another. Vertical stirrups shall pass around main reinforcement or be firmly attached to it.

For slip-formed concrete, the reinforcing steel bars shall be tied at all intersections and cross braced to keep the cage from moving during concrete placement. Cross bracing shall be with additional reinforcing steel. Cross bracing shall be placed both longitudinally and transversely.

After reinforcing steel bars are placed in a traffic or pedestrian barrier and prior to slip-form concrete placement, the Contractor shall check clearances and reinforcing steel bar placement. This check shall be accomplished by using a template or by operating the slip-form machine over the entire length of the traffic or pedestrian barrier. All clearance and reinforcing steel bar placement deficiencies shall be corrected by the Contractor before slip-form concrete placement.

Mortar blocks (or other approved devices) shall maintain the concrete coverage required by the Drawings. The Mortar blocks shall:

1. Have a bearing surface measuring not greater than 2-inches in either dimension, and
2. Have a compressive strength equal to that of the concrete in which they are embedded.

In slabs, each mortar cube shall have either: (1) a grooved top that will hold the reinforcing bar in place, or (2) an embedded wire that protrudes and is tied to the reinforcing steel. If this wire is used around epoxy-coated bars, it shall be coated with plastic.

Mortar blocks may be accepted based on a Manufacturer's Certificate of Compliance.

In lieu of mortar blocks, the Contractor may use metal or plastic chair supports to hold uncoated bars. Any surface of a metal chair support not covered by at least ½-inch of concrete shall be 1 of the following:

1. Hot-dip galvanized after fabrication in keeping with AASHTO M 232 Class D,
2. Coated with plastic firmly bonded to the metal. This plastic shall be at least 3⁄32-inch thick where it touches the form and shall not react chemically with the concrete when tested in the SPU's Materials Laboratory. The plastic shall not shatter or crack at or above -5°F and shall not deform enough to expose the metal at or below 200°F, or
3. Stainless steel that meet the requirements of ASTM A 493, Type 302. Stainless steel chair supports are not required to be galvanized or plastic coated.

In lieu of mortar blocks, epoxy-coated reinforcing bars may be supported by 1 of the following:

1. Metal chair supports coated entirely with a dielectric material such as epoxy or plastic,
2. Other epoxy-coated reinforcing bars, or
3. Plastic chair supports.

Plastic chair supports shall be lightweight, non-porous, and chemically inert in concrete. Plastic chair supports shall have rounded seatings, shall not deform under load during normal temperatures, and shall not shatter or crack under impact loading in cold weather. Plastic chair supports shall be placed at spacings greater than 1-foot along the bar and shall have at least 25-percent of their gross place area perforated to compensate for the difference in the coefficient of thermal expansion between plastic and concrete. The shape and configuration of plastic supports shall permit complete concrete consolidation in and around the support.

In bridge decks, roadway and sidewalk slabs, the Contractor shall place reinforcing steel mats carefully to provide the required concrete cover. A "mat" is 2 layers of steel. Top and bottom mats shall be supported enough to hold both in their proper positions. If No. 4 bars make up the lower layer of steel in a mat, it shall be blocked at not more than 3-foot intervals (or 4-foot intervals for bars No. 5 and larger). Wire ties to girder stirrups shall not be considered as blocking. To provide a rigid mat, the Contractor shall add other supports and tie wires to the top mat as needed.

If a bar will interfere with a bridge drain, it shall be bent in the field to bypass the drain.

Clearances shall be at least:

4-inches between:	Bars and the surface of any concrete masonry exposed to the action of salt or alkaline water.
3-inches between:	Bars and the surface of any concrete deposited against earth without intervening forms.
2-½-inches between:	Adjacent bars in a layer. Bridge deck bars and the top of the bridge deck.
2-inches between:	Adjacent layers. Bars and the surface of concrete exposed to earth. Reinforcing bars and the faces of forms for exposed aggregate finish.
1-½-inches between:	Bars and the surface of concrete when not specified otherwise in this Section or in the Plans. Barrier and curb bars and the surface of concrete.
1-inch between:	Bridge deck bars and the bottom of the bridge deck. Slab bars and the top surface of the bottom slab of a cast-in-place concrete box girder.

Cover to ties and stirrups may be ½-inch less than the values specified for main bars but shall not be less than 1-inch.

Reinforcing steel bars shall not vary more than the following tolerances from their position in the Drawings:

Members 10-inches or less in thickness	±¼-in.
Members more than 10-inches in thickness	±⅜-in.
Drilled Shafts top of rebar cage elevation	+6-in./-3-in.

Except:	
The distance between the nearest reinforcing steel bar surface and the top surface of the bridge deck slab	+¼-in.
Longitudinal spacing of bends and ends of bars	±1-in.
Length of bar laps	-1½-in.
Embedded length	
No. 3 through No. 11	-1-in.
No. 14 through No. 18	-2-in.
When reinforcing steel bars are to be placed at equal spacing within a plane:	
Stirrups and ties	±1-in.
All other reinforcement	±1 bar dia.

Before placing any concrete, the Contractor shall:

1. Clean all mortar from reinforcement, and
2. Obtain the Engineer's permission to place concrete after the Engineer has inspected the placement of the reinforcing steel. (Any concrete placed without the Engineer's permission shall be rejected and removed.)

6-02.3(24)D SPLICING

The Contractor shall supply steel reinforcing bars in the full lengths the Drawings require. Unless the Engineer approves in writing, the Contractor shall not change the number, type, or location of splices.

The Engineer may permit the Contractor to use thermal or mechanical splices in place of the method in the Drawings if they are of an approved design. Use of a new design may be granted if:

1. The Contractor provides technical data and proof from the manufacturer that the design will perform satisfactorily, and
2. Sample splices and materials from the manufacturer pass the Engineer's tests.

After a design has been approved, any changes in detail or material shall require new approval.

The Contractor shall:

1. Not lap-splice reinforcing bars Nos. 14 or 18.
2. Not permit any welded or mechanical splice to deviate in alignment more than ¼-inch per 3½-feet of bar.
3. Distribute splices evenly, grouping them together only at points of low tensile stress.
4. Ensure at least 2-inches clearance between any splice and the nearest bar or the surface of the concrete (or 1½-inch for the length of the sleeve on mechanical splices).
5. Rigidly clamp or wire all splices in a way the Engineer approves.
6. Place lap-spliced bars in contact for the length of the splice and tie them together near each end.
7. Securely fasten the ends and edges of welded-wire-fabric reinforcement, overlapping them enough to maintain even strength.

6-02.3(24)E WELDING REINFORCING STEEL

Welding of steel reinforcing bars shall conform to the requirements of ANSI/AWS D1.4 Structural Welding Code - Reinforcing Steel, latest edition, except where superseded by the Contract, Drawings, and these Specifications.

Before any welding begins, the Contractor shall obtain the Engineer's approval of a written welding procedure for each type of welded splice to be used, including the weld procedure Specifications and joint details. The weld procedure Specifications shall be written on a form taken from AWS D1.4 Annex A, or equivalent. Test results of tensile strength, macroetch, and visual examination shall be included. The form shall be signed and dated.

Welders shall be qualified under AWS D1.4. The Contractor shall be responsible for the testing and qualification of welders, and shall submit welder qualification and retention records to the Engineer for approval. The weld joint and welding position a welder is qualified in shall be under AWS D1.4. The welder qualifications shall remain in effect indefinitely unless, (1) the welder is not engaged in a process of welding for which the welder is qualified for a period exceeding 6-months, or (2) there is some specific reason to question a welder's ability.

Filler metals used for welding reinforcing bars shall be under AWS D1.4 Table 5.1. All filler metals shall be low-hydrogen and handled in compliance with low-hydrogen practices specified in the AWS code.

All welding shall be protected from air currents, drafts, and precipitation to prevent loss of heat or loss of arc shielding. Short circuiting transfer with gas metal arc welding will not be allowed. Slugging of welds will not be allowed.

The minimum preheat and interpass temperature for welding shall be under AWS D1.4 Table 5.2 and mill certification of carbon equivalence, per lot of reinforcing. Preheating shall be applied to the reinforcing bars and other splice members within 6-inches of the weld, unless limited by the available lengths of the bars or splice member.

Generally, post heating of welded splices is only required for direct butt welded splices of AASHTO M 31 Grade 60 bars size No. 9 or larger and shall be done immediately after welding before the splice has cooled to 700°F. Post heating shall not be less than 800°F nor over 1,000°F and held at this temperature for not less than 10-minutes before allowing the splice to cool naturally to ambient temperature.

For compatibility with AWS D1.4, welded lap splices for spiral or hoop reinforcing shall be considered Flare-V groove welds, indirect butt joints.

The Contractor is responsible for using a welding sequence that will limit the alignment distortion of the bars due to the effects of welding. The maximum out-of-line permitted will be ¼-inch from a 3.5-foot straight-edge centered on the weld and in line with the bar.

The following procedure for welding steel reinforcing bars is recommended:

Sheared bar ends shall be burned or sawed off a minimum of ½-inch to completely remove the ruptured portion of the steel shear area prior to welding butt splices. Surfaces to be welded shall be smooth, uniform, and free from fins, tears, cracks, and other defects. Surfaces to be welded and surfaces adjacent to a weld shall also be free from loose or thick scale, slag, rust, moisture, grease, paint, epoxy covering, or other foreign materials. All tack welds shall be within the area of the final weld. No other tack weld will be permitted. Double bevel groove welds require chipping, grinding, or gouging to sound metal at the root of the weld before welding the other side. Progression of vertical welding shall be upward. The ground wire from the welding machine shall be clamped to the bar being welded.

Should the Contractor elect to use a procedure which differs from the procedure recommended, the Contractor shall submit the changes, in writing, to the Engineer for approval. Approved weld procedures shall be strictly followed.

6-02.3(24)F MECHANICAL SPLICES

The Contractor shall form mechanical splices with an Engineer-approved system using sleeve filler metal, threaded coupling, or another method that complies with this section.

If necessary to maintain required clearances after the splices are in place, the Contractor shall adjust, relocate, or add stirrups, ties, and bars.

Before splicing, the Contractor shall provide the Engineer with the following information for each shipment of splice material:

1. The type or series identification (and heat treatment lot number for threaded-sleeve splices),
2. The grade and size of bars to be spliced,
3. A manufacturer's catalog with complete data on material and procedures,
4. A written statement from the manufacturer that the material is identical to that used earlier by the Engineer in testing and approving the system design, and
5. A written statement from the Contractor that the system and materials will be used according to the manufacturer's instructions and all requirements of this section.

All splices shall meet these criteria:

1. Mechanical splices shall develop at least 125 percent of the specified yield strength of the unspliced bar. The ultimate tensile strength of the mechanical splice shall exceed that of the unspliced bar.
2. The total slip of the bar within the spliced sleeve of the connector after loading in tension to 30.0 ksi and relaxing to 3.0 ksi shall not exceed the following measured displacements between gage points clear of the splice sleeve:
    a. 0.01 inches for bar sizes up to No. 14.
    b. 0.03 inches for No. 18 bars.

3. The maximum allowable bar size for mechanical laps splices shall be No. 6.

The Engineer will visually inspect the splices and accept all that appear to conform with the test samples. For sleeve-filler splices, the Engineer will allow voids within the limits on file in the design approval. If the Engineer considers any splice defective, it shall be removed and replaced at the Contractor's expense.

In preparing sleeve-filler metal splices, the Contractor shall:

1. Clean the bar surfaces by: (a) oxyacetylene torch followed by power wire brushing, or (b) abrasive blasting;
2. Remove all slag, mill scale, rust, and other foreign matter from all surfaces within and 2-inches beyond the sleeve;
3. Grind down any projection on the bar that would prevent placing the sleeve;
4. Prepare the ends of the bars as the splice manufacturer recommends and as the approved procedure requires; and
5. Preheat, just before adding the filler, the entire sleeve and bar ends to 300°F, plus or minus 50°F. (If a gas torch is used, the flame shall not be directed into the sleeve.)

When a metallic, sleeve-filler splice is used (or any other system requiring special equipment), both the system and the operator shall qualify in the following way under the supervision of the Owner's Materials and Fabrication Inspector. The operator shall prepare 6 test splices (3 vertical, 3 horizontal) using bars having the same AASHTO Designation and size (maximum) as those to be used in the Work. Each test sample shall be 42-inches long, made up of two 21-inch bars joined end-to-end by the splice. The bar alignment shall not deviate more than ⅛-inch from a straight line over the whole length of the sample. All 6 samples shall meet the tensile strength and slip criteria specified in this section.

The Contractor shall provide labor, materials, and equipment for making these test samples at no expense to the Owner. The Owner will test the samples at no cost to the Contractor.

6-02.3(24)G JOB CONTROL TESTS

As the Work progresses, the Engineer may require the Contractor to provide a sample splice (thermal or mechanical) to be used in a job control test. The operator shall create this sample on the job site with the Engineer present using bars of the same size as those being spliced in the Work. The sample shall comply with all requirements of these Specifications, and is in addition to all other sample splices required for qualification. The Engineer will require no more than 2 samples on any project with fewer than 200-splices and no more than 1 sample per 100-splices on any project with more than 200-splices.

6-02.3(24)H EPOXY-COATED STEEL REINFORCING BAR

This Work is furnishing, fabricating, coating, and placing epoxy-coated steel reinforcing bars as the Drawings, these Specifications, and the Contract require. Coating material shall be applied electrostatically, by spraying, or by the fluidized-bed method.

All epoxy-coated bars shall comply with the requirements of Section 9-07. Fabrication may occur before or after coating.

The Contractor shall protect epoxy-coated bars from damage using padded or nonmetallic slings and straps free from dirt or grit. To prevent abrasion from bending or sagging, the Contractor shall lift bundled bars with a strong-back, multiple supports, or a platform bridge. Bundled bars shall not be dropped or dragged. During shop or field storage, bars shall rest on wooden or padded cribbing. The Contractor may substitute other methods for protecting the bars if the Engineer approves. If the Engineer believes the coated bars have been badly damaged, they will be rejected.

Metal chairs and supports shall be coated with epoxy (or another inert coating if the Engineer approves). The Contractor may use other support devices with the Engineer's approval. Plastic coated tie wires (approved by the Engineer) shall protect the coated bars from being damaged during placement.

The bars shall be placed as the Drawings require and held firmly in place during placing and setting of the concrete. All bars shall be placed and fastened as specified in Section 6-02.3(24)C.

In the interval between installing coated bars and concreting the deck, the Contractor shall protect the coating from damage that might result from other construction Work.

The Engineer will inspect the coated bars after they are placed and before the deck concrete is placed. The Contractor shall patch any areas that show significant damage (as defined below).

Significant damage means any opening in the coating that exposes the steel in an area that exceeds:

1. 0.05-square inch (approximately ¼-inch square or ¼ -inch in diameter or the equivalent).
2. 0.012-square inches (approximately ⅛-inch square or ⅛-inch in diameter) when the opening is within ¼-inch of another opening of equal or larger size.
3. 6-inches long, any width.
4. 0.50-square inch aggregate area in any 1-foot length of bar.

The Contractor shall patch significantly damaged areas with Engineer-approved patching material obtained from the epoxy resin manufacturer. This material shall be compatible with the coating and inert in concrete. Areas to be patched shall be clean and free of surface contaminants. Patching shall be done before oxidation occurs and according to the resin manufacturer's instructions.

6-02.3(25) PRESTRESSED CONCRETE GIRDERS

The Contractor shall perform quality control inspection. The manufacturing plant of prestressed concrete girders shall be certified by the Precast/Prestressed Concrete Institute's Plant Certification Program for the type of prestressed member to be produced.

Prior to the start of production of girders, the Contractor shall advise the Engineer of the production schedule. The Contractor shall give the Inspector safe and free access to the Work. If the Inspector observes any nonspecification Work or unacceptable quality control practices, the Inspector will advise the plant manager. If the corrective action is not acceptable to the Engineer, the girder(s) will be subject to rejection by the Engineer.

The Owner intends to perform Quality Assurance Inspection. By its inspection, the Owner intends only to facilitate the Work and verify the quality of that Work. This inspection shall not relieve the Contractor of any responsibility for identifying and replacing defective material and workmanship.

The various girders are:

Prestressed Concrete Girder – Refers to prestressed concrete girders of all types, including prestressed concrete I girders, prestressed concrete wide flange I girders, bulb tee girders, deck bulb tee girders, thin flange deck bulb tee girders, precast prestressed members, spliced prestressed concrete girders, and prestressed concrete tub girders.

Prestressed Concrete I Girder – Refers to a prestressed concrete girder with a flanged I shaped cross section, requiring a cast-in-place concrete deck to support traffic loads. Standard girders in this category include Series W42G, W50G, W58G, and W74G.

Prestressed Concrete Wide Flange I Girder – Refers to a prestressed concrete girder with an I shaped cross section with wide top and bottom flanges, requiring a cast-in-place concrete deck to support traffic loads. Standard girders in this category include Series WF36G, WF42G, WF50G, WF58G, WF66G, WF74G, WF83G, WF95G and WF100G.

Bulb Tee Girder – Refers to a prestressed concrete girder, with a wide top flange requiring a cast-in-place concrete deck to support traffic loads. Standard girders in this category include Series W32BTG, W38BTG, and W62BTG.

Deck Bulb Tee Girder – Refers to a bulb tee girder with a top flange designed to support traffic loads, and designed to be mechanically connected at the flange edges to adjacent girders at the job site. Except where specific requirements are otherwise specified for these girders, deck bulb tee girders shall conform to all requirements specified for bulb tee girders. Standard girders in this category include Series W35DG, W41DG, W53DG, and W65DG.

Thin Flange Deck Bulb Tee Girder – Refers to a bulb tee girder with a top flange width equal to the girder spacing and requiring a cast-in-place concrete deck to support traffic loads. Except where specific requirements are otherwise specified for these girders, thin flange deck bulb tee girders shall conform to all requirements specified for bulb tee girders. Standard girders in this category include Series W32TFG, W38TFG, W50TFG, and W62TFG.

Precast Prestressed Member (PCPS Member) – Refers to a precast prestressed slab, precast prestressed ribbed section, or a deck double tee girder. PCPS members are designed to be mechanically connected at the flange or member edges to adjacent PCPS members at the job site. Except where specific requirements are otherwise specified for these girders, PCPS members shall conform to all requirements specified for deck bulb tee girders.

Spliced Prestressed Concrete Girder – Refers to prestressed concrete girders initially fabricated in segments to be longitudinally spliced together with cast-in-place concrete closures at the job site. Except where specific requirements are otherwise specified for these girders, spliced prestressed concrete girders shall conform to all requirements specified for prestressed concrete girders. Anchorages shall conform to Sections 6-02.3(26)B, 6-02.3(26)C, and 6-02.3(26)D. Ducts shall conform to the Section 6-02.3(26)E requirements for internal embedded installation, except that ducts for I girders may be 24-gage, semi-rigid, galvanized, corrugated, ferrous metal. Ducts shall be round, unless the Engineer approves use of elliptical shaped ducts. Duct-wedge plate transitions shall conform to Section 6-02.3(26)E. Prestressing reinforcement shall conform to Section 6-02.3(26)F. Standard girders in this category include Series WF74PTG, WF83PTG, WF95PTG and WF100PTG.

Prestressed Concrete Tub Girder – Refers to prestressed concrete trapezoidal box or bathtub girders including those fabricated in segments to be spliced together with cast-in-place concrete closures at the job site. Except where specific requirements are otherwise specified for these girders, prestressed concrete tub girders shall conform to all requirements specified for prestressed concrete girders and spliced prestressed concrete girders. Standard girders in this category include Series U**G* or Series UF**G*, where U specifies webs without flanges, UF specifies webs with flanges, ** specifies the girder height in inches, and * specifies the bottom flange width in feet.

6-02.3(25)A SHOP DRAWINGS

The Drawings show design conditions and details for prestressed girders. Deviations will not be permitted, except as allowed by these Specifications, the Shop Drawings as approved by the Engineer, and by manufacturing processes approved by the annual plant approval process.

Shop drawings shall show the size and location of all cast-in holes for installation of deck formwork hangers and/or temporary bracing. Holes for formwork hangers shall match approved deck formwork plans designed under Section 6-02.3(16). There shall be no field-drilled holes in prestressed concrete girders. Post-tensioning ducts in spliced prestressed concrete girders shall be located so their center of gravity is under the Drawings.

The Contractor may alter prestressed concrete girder dimensions from that shown in the Drawings provided:

1. The girder has the same or higher load carrying capacity (using the current AASHTO LRFD Design Specifications and WSDOT Bridge Design Manual LRFD) as demonstrated by design calculations submitted to the Engineer for approval under Section 1-05.3, and accompanying the Shop Drawing submittal;
2. The Contractor receives the Engineer's approval of the Shop Drawing and design calculation submittal for the modified girder section prior to beginning fabrication of the girder;
3. The Contractor adjusts Substructures to yield the same top of Roadway elevation shown in the Drawings; and
4. The depth of the girder is not increased by more than 2-inches and is not decreased, except that in no case shall an increase in the girder depth reduce the minimum vertical clearance of the bridge and girder over a Traveled Way to less than 16-feet 6-inches, or to less than the minimum vertical clearance specified in the Drawings if the Drawings already specify a minimum vertical clearance of less than 16-feet 6-inches.

The Contractor shall provide Shop Drawings to the Engineer for approval under Section 1-05.3. Shop drawings for spliced prestressed concrete girders shall conform to Section 6-02.3(26)A. The Shop Drawings for spliced prestressed concrete girders shall include all details related to the post-tensioning operations in the field, including details of hardware required, tendon geometry, blockout details, and details of additional or modified steel reinforcing bars required in cast-in-place closures.

6-02.3(25)B CASTING

Before casting girders, the Contractor shall have possession of an approved set of Shop Drawings. Side forms shall be steel except that cast-in-place concrete closure forms for spliced prestressed concrete girders, interior forms of prestressed concrete tub girders, and end bulkhead forms of prestressed concrete girders may be wood. Interior voids for precast prestressed slabs with voids shall be formed by either wax soaked cardboard or expanded polystyrene forms. The interior void forms shall be secured in the position as shown in the Shop Drawings as approved by the Engineer, and shall remain in place.

All concrete mixes to be used shall meet the requirements of Section 9-19.1. The temperature of the concrete when placed shall be between 50°F and 90°F.

Slump shall not exceed 4-inches for normal concrete nor 7-inches with a high range water reducing admixture, nor 9-inches when both a high range water reducing admixture is used and the water/cement ratio is less than or equal to 0.35. The high range water reducer shall meet the requirements of Sections 9-23.6.

Air-entrainment is not required in the concrete placed into prestressed precast concrete girders, including cast-in-place concrete closures for spliced prestressed concrete girders.

No welds will be permitted on steel within prestressed girders. Once the prestressing steel has been installed, no welds or grounds for welders shall be made on the forms or the steel in the girder, except as specified.

The Contractor may form circular block-outs in the girder top flanges to receive falsework hanger rods. These block-outs shall:

1. Not exceed 1-inch in diameter;
2. Be spaced no more than 72-inches apart longitudinally on the girder;
3. Be located 3-inches or more from the outside edge of the top flange on Series W42G, W50G, W58G, girders, and all prestressed concrete tub girders with webs with flanges, and 6-inches or more for all other prestressed concrete girders with flanges.

The Contractor may form circular block-outs in the girder webs to support brackets for bridge deck falsework. These block-outs shall:

1. Not exceed 1-inch in diameter,
2. Be spaced no more than 72-inches apart longitudinally on the girder, and
3. Be positioned to clear the girder reinforcing and prestressing steel.

6-02.3(25)C PRESTRESSING

Each stressing system shall have a pressure gauge or load cell that will measure jacking force. Any gauge shall display pressure accurately and readably with a dial at least 6-inches in diameter or with a digital display. Each jack and its gauge shall be calibrated as a unit and shall be accompanied by a certified calibration chart. The Contractor shall provide 1 copy of this chart to the Engineer. The cylinder extension during calibration shall be in approximately the position it will occupy at final jacking force.

Jacks and gauges shall be recalibrated and recertified:

1. Annually,
2. After any repair or adjustment, and
3. Anytime there are indications that the jack calibration is in error.

The Engineer may use load cells to check jacks, gauges, and calibration charts before and during tensioning.

All load cells shall be calibrated and shall have an indicator that shows prestressing force in the strand. The range of this cell shall be broad enough that the lowest 10-percent of the manufacturer's rated capacity will not be used to measure jacking force.

From manufacture to encasement in concrete, prestressing strand shall be protected against dirt, oil, grease, damage, and all corrosives. Strand shall be stored in a dry, covered area and shall be kept in the manufacturer's original packaging until placement in the forms. If prestressing strand has been damaged or pitted, it will be rejected. Prestressing strand with rust shall be spot-cleaned with a nonmetallic pad to inspect for any sign of pitting or section loss.

Post-tensioning of spliced prestressed concrete girders shall conform to Section 6-02.3(26)G, and the following requirements:

1. Before tensioning, the Contractor shall remove all side forms from the cast-in-place concrete closures. From this point until 48-hours after grouting the tendons, the Contractor shall keep all construction and other live loads off the Superstructure and shall keep the falsework supporting the superstructure in place.
2. No welds or welding grounds shall be attached to metal forms, structural steel, or steel reinforcing bars of the structural member.
3. The Contractor shall not tension the post-tensioning reinforcement until the concrete in the cast-in-place closures reaches the minimum compressive strength specified in the Drawings (or 5,000-psi if the concrete strength is not specified in the Drawings). This strength shall be measured with concrete cylinders made of the same concrete and cured under the same conditions as the cast-in-place closures.
4. All post-tensioning shall be completed before placing the sidewalks and barriers on the Superstructure.

6-02.3(25)D CURING

During curing, the Contractor shall keep the girder in a saturated curing atmosphere until the girder concrete has reached the required release strength. If the Engineer approves, the Contractor may shorten curing time by heating the outside of impervious forms. Heat may be radiant, convection, conducted steam, or hot air. With steam, the arrangement shall envelop the entire surface with saturated steam. The Engineer will not permit hot air curing until after approving the Contractor's proposed method to envelop and maintain the girder in a saturated atmosphere. Saturated atmosphere means a relative humidity of at least 90-percent. The Contractor shall never allow dry heat to touch the girder surface at any point.

Under heat curing methods, the Contractor shall:

1. Keep all unformed girder surfaces in a saturated atmosphere throughout the curing time;
2. Embed a thermocouple (linked with a thermometer accurate to plus or minus 5°F) 6 to 8-inches from the top or bottom of the girder on its centerline and near its midpoint;
3. Monitor with a recording sensor (accurate to plus or minus 5°F) arranged and calibrated to continuously record, date, and identify concrete temperature throughout the heating cycle;
4. Make this temperature record available for the Engineer to inspect;
5. Heat concrete to no more than 100°F during the first two-hours after placing the concrete, and then increase 25°F per hour to a maximum of 175°F;
6. Cool concrete, after curing is complete, no more than 25°F per hour, to 100°F; and
7. Keep the temperature of the concrete above 60°F until the girder reaches release strength.

The Contractor may strip side forms from prestressed concrete girders once the concrete has reached a minimum compressive strength of 3,000-psi. All damage from stripping is the Contractor's responsibility.

Curing of cast-in-place concrete closures for spliced prestressed concrete girders shall conform to Section 6-02.3(11).

6-02.3(25)E CONTRACTORS CONTROL STRENGTH

Concrete strength shall be measured on test cylinders cast from the same concrete as that in the girder. These cylinders shall be cured under time-temperature relationships and conditions that simulate those of the girder. If the forms are heated by steam or hot air, test cylinders will remain in the coolest zone throughout curing. If forms are heated another way, the Contractor shall provide a record of the curing time-temperature relationship for the cylinders for each girder to the Engineer. When 2 or more girders are cast in a continuous line and in a continuous pour, a single set of test cylinders may represent all girders provided the Contractor demonstrates uniformity of casting and curing to the satisfaction of the Engineer.

The Contractor shall mold, cure, and test enough of these cylinders to satisfy Specification requirements for measuring concrete strength. The Contractor may use 4-inch by 8-inch or 6-inch by 12-inch cylinders. If heat is used to shorten curing time, the Contractor shall let cylinders cool for at least ½-hour before testing.

Test cylinders may be cured in a moist room or water tank under AASHTO T-23 after the girder concrete has obtained the required release strength. If, however, the Contractor intends to ship the girder prior to the standard 28-Day strength test, the design strength for shipping shall be determined from cylinders placed with the girder and cured under the same conditions as the girder. These cylinders may be placed in a noninsulated, moisture-proof envelope.

To measure concrete strength in the girder, the Contractor shall randomly select 2 test cylinders and average their compressive strengths. The compressive strength in either cylinder shall not fall more than 5-percent below the specified strength. If these 2 cylinders do not pass the test, 2 other cylinders shall be selected and tested.

If too few cylinders were molded to carry out all required tests on the girder, the Contractor shall remove and test cores from the girder under the surveillance of the Engineer. If the Contractor casts cylinders to represent more than 1 girder, all girders in that line shall be cored and tested.

For precast prestressed members, a test shall consist of 4 cores measuring 3-inches in diameter by 6-inches in height (for slabs) and by the thickness of the web (for ribbed sections). Two cores shall be taken from each side of the member and on each side of the member's span midpoint, at locations approved by the Engineer. The core locations for precast prestressed slabs shall be near mid-depth of the slab, within the middle third of the span length, and shall avoid all prestressing strands and steel reinforcing bars. The core locations for precast prestressed ribbed sections shall be immediately beneath the top flange, within the middle third of the span length, and shall avoid all prestressing strands and steel reinforcing bars.

For prestressed concrete tub girders, a test shall consist of 4 cores measuring 3-inches in diameter by the thickness of the web, taken from each web approximately 3-feet to the left and to the right of the center of the girder span. The cores shall avoid all prestressing strands and steel reinforcing bars.

For all other prestressed concrete girders, a test shall consist of 3 cores measuring 3-inches in diameter by the thickness of the web and shall be removed from just below the top flange; 1 at the midpoint of the girder's length and the other 2 approximately 3-feet to the left and approximately 3-feet to the right.

The cores shall be taken under AASHTO T 24 and shall be tested under AASHTO T 22. The Engineer may accept the girder if the average compressive strength of the 4 cores from the precast prestressed member, or prestressed concrete tub girder, or of the 3 cores from any other prestressed concrete girder, is at least 85-percent of the specified compressive strength with no 1 core less than 75-percent of specified compressive strength.

If the girder is cored to determine the release strength, the required patching and curing of the patch shall be done prior to shipment. If there are over 3 holes or if they are not in a neutral location, the prestress steel shall not be released until the holes are patched and the patch material has attained a minimum compressive strength equal to the required release compressive strength or 4,000-psi, whichever is larger.

The Contractor shall coat cored holes with an epoxy bonding agent and patch the holes using the same type concrete as that in the girder, or a mix approved during the annual plant review and approval. The epoxy bonding agent shall meet the requirements of Section 9-26.1 for Type II, Grade 2 epoxy. The girder shall not be shipped until tests show the patch material has attained a minimum compressive strength of 4,000-psi

6-02.3(25)F PRESTRESS RELEASE

Side and flange forms that restrain deflection shall be removed before release of the prestressing reinforcement.

All harped and straight strands shall be released in a way that will produce the least possible tension in the concrete. This release shall not occur until tests show each girder has reached the minimum compressive strength required by the Drawings.

The Contractor may request permission to release the prestressing reinforcement at a minimum concrete compressive strength less than specified in the Drawings. This request shall be submitted to the Engineer for approval under Section 1-05.3 and shall be accompanied with calculations showing the adequacy of the proposed release concrete compressive strength. The release strength shall not be less than 3,500-psi, except that the release strength for spliced prestressed concrete girders shall not be less than 4,000-psi. The calculated release strength shall meet the requirements outlined in the Washington State Department of Transportation (WSDOT) Bridge Design Manual for tension and compression at release. The proposed minimum concrete compressive strength at release will be evaluated by the Owner. Fabrication of girders using the revised release strength shall not begin until the Owner has provided written approval of the revised release compressive strength. If a reduction of the minimum concrete compressive strength at release is allowed, the Contractor shall bear any added cost that results from the change.

6-02.3(25)G PROTECTION OF EXPOSED REINFORCEMENT

When a girder is removed from its casting bed, all bars and strands projecting from the girder shall be cleaned and painted with a minimum dry film thickness of 1-mil of paint conforming to Section 9-08.2 Item 3, Formula A-9-73. All steel reinforcing bars, including welded wire fabric, projecting from the girder shall be protected in accordance with Section 6-02.3(24)B. During handling and shipping, projecting reinforcement shall be protected from bending or breaking. Just before

placing concrete around the painted projecting bars or strands, the Contractor shall remove from them all spattered concrete remaining from girder casting, dirt, oil, and other foreign matter.

Grouting of post-tensioning ducts for spliced prestressed concrete girders shall conform to Section 6-02.3(26)H.

6-02.3(25)H FINISHING

The Contractor shall apply a Class 1 finish, as defined in Section 6-02.3(14), to:

1. The exterior surfaces of the outside girders; and
2. The bottoms, sides, and tops of the lower flanges on all girders.

All other girder surfaces shall receive a Class 2 finish.

The interface on I-girders and other girders that contact the cast-in-place deck shall have a finish of dense, screeded concrete without a smooth sheen or laitance on the surface. After vibrating and screeding, and just before the concrete reaches initial set, the Contractor shall texture the interface. This texture shall be applied with a steel brooming tool that etches the surface transversely leaving grooves ⅛-inch to ¼-inch wide, between ⅛-inch and ¼-inch deep, and spaced ¼-inch to ½-inch apart.

On the deck bulb tee girder section and all precast prestressed members, the Contractor shall test the bridge deck surface portion for flatness. This test shall occur after floating but while the concrete remains plastic. Testing shall be done with a 10-foot straightedge parallel to the girder centerline and with a flange width straightedge at right angles to the girder centerline. The Contractor shall fill depressions, cut down high spots, and refinish to correct any deviation of more than ¼-inch within the straightedge length. This section of the bridge deck surface shall be finished to meet the requirements for finishing bridge decks, as defined in Section 6-02.3(10) except that, if approved by the Engineer, a coarse stiff broom may be used to provide the finish in lieu of a metal tined comb.

The Contractor may repair rock pockets and other defects in the girder provided the repair is covered in the annual plant approval package. All other repairs and repair procedures shall be documented and approved by the Engineer prior to acceptance of the girder.

6-02.3(25)I FABRICATION TOLERANCES

The girders shall be fabricated as shown in the Shop Drawings as approved by the Engineer, and shall meet the dimensional tolerances listed below. Construction tolerances of cast-in-place closures for spliced prestressed concrete girders shall conform to the tolerances specified for spliced prestressed concrete girders. Actual acceptance or rejection will depend on how the Engineer believes a defect outside these tolerances will affect the Structure's strength or appearance:

1.	Prestressed Concrete Girder Length (overall):	± ¼-inch per 25-feet of beam length, up to a maximum of ± 1½-inch.
2.	Precast Prestressed Member Length (overall):	± 1-inch.
3.	Width (flanges):	+ ⅜-inch, - ¼-inch.
4.	Width (narrow web section):	+ ⅜-inch, - ¼-inch.
5.	Width (Precast Prestressed Member):	± ¼-inch.
6.	Girder Depth (overall):	± ¼-inch.
7.	Flange Depth:	
	For I and Wide Flange I girders:	± ¼-inch
	For bulb tee and deck bulb tee girders:	+ ¼-inch, - ⅛-inch
	For PCPS members:	+ ¼-inch, - ⅛-inch
8.	Strand Position in Prestressed Concrete Girder:	± ¼-inch from the center of gravity of an individual strand; ± ½-inch from the center of gravity of a bundled strand group; ± 1-inch from the center of gravity of the harped strands at the girder ends.
9.	Strand Position in Precast Prestressed Member:	± ¼-inch from the center of gravity of a bundled strand group and of an individual strand.
10.	Longitudinal Position of the Harping Point:	
	Single harping point	± 18-inches
	Multiple bundled strand groups	
	First bundled strand group	± 6-inches
	Second bundled strand group	± 18-inches

Third bundled strand group ± 30-inches

11. Position of an interior void, vertically and horizontally (Precast Prestressed Slab with voids):

± ½-inch.

12. Bearing Recess (center recess to beam end): ± ¼-inch.

13. Beam Ends (deviation from square or designated skew):

Horizontal: ± ½-inch from web centerline to girder flange

Vertical: ± ⅛-inch per foot of beam depth

14. Precast Prestressed Member Ends (deviation from square or designated skew):

± ½-inch.

15. Bearing Area Deviation from Plane (in length or width of bearing):

$^{1}/_{16}$-inch.

16. Stirrup Reinforcing Spacing: ± 1-inch.

17. Stirrup Projection from Top of Beam: ± ¾-inch.

18. Mild Steel Concrete Cover: - ⅛-inch, + ⅜-inch.

19. Offset at Form Joints (deviation from a straight line extending 5-feet on each side of joint):

± ¼-inch.

20. Deviation from Design Camber (Precast Prestressed Member):

± ¼-inch per 10-feet of member length measured at midspan, but not greater than
± ¾-inch total.

21. Differential Camber Between Girders in a Span (measured in place at the job site):

For I, Wide Flange I, bulb tee, and spliced prestressed concrete girders:	⅛-inch per 10-feet of beam length.
For deck bulb tee girders:	Cambers shall be equalized by an approved method when the differences in cambers between adjacent girders or stages measured at mid-span exceeds ¼-inch.
For PCPS members:	± ¼-inch per 10-feet of member length measured at midspan, but not greater than ± ½-inch total.
For prestressed concrete tub girders:	± ¼-inch per 10-feet of member length measured at midspan, but not greater than ± ½-inch total.

22. Position of Inserts for Structural Connections: ± 1-inch.

23. Position of Lifting Loops: ± 3-inches longitudinal, ± ¼-inch transverse.

24. Weld plates for bulb tee girders shall be placed: ± ½-inch longitudinal and
± ⅛-inch vertical.

25. Position of post-tensioning ducts at girder and CIP closure ends:

± ¼-inch.

26. Position of post tensioning ducts along segments of segmental prestressed concrete girders:

± ¼-inch.

27. Deviation from a smooth curve for post-tensioning ducts at closures based on the sum total of duct placement and alignment tolerances:

± ⅜-inch.

6-02.3(25)J HORIZONTAL ALIGNMENT

The Contractor shall check and record the horizontal alignment of the top and bottom flanges of each girder at the following times:

1. Initial – Upon removal of the girder from the casting bed;
2. Final – Within 2-weeks, but not less than 3-Days prior to shipment; and
3. Storage – Between 115 to 125-Days after casting, if the girder remains in storage for a period exceeding 120-Days.

Each check shall be made by measuring the distance between each flange and a chord that extends the full length of the girder. The Contractor shall perform and record each check when the alignment of the girder is not influenced by temporary differences in surface temperature. Records for the initial check shall be in the Contractor's prestressed concrete certificate of compliance. Records for the final and storage checks shall be provided to the Engineer for approval.

Immediately after the girder is removed from the casting bed, neither flange shall be offset more than ⅛-inch for each 10-feet of girder length. During storage and prior to shipping, the offset (with girder ends plumb and upright and with no external force) shall not exceed ¼-inch per 10-feet of girder length. Any girder within this tolerance may be shipped, but shall be corrected at the job site to the ⅛-inch maximum offset per 10-feet of girder length before concrete is placed into the diaphragms.

The Engineer may permit using external force to correct girder alignment at the plant or job site if the Contractor provides stress calculations and a proposed procedure. If external force is permitted, it shall not be released until after the bridge deck has been placed and cured 10-Days.

The maximum deviation of the side of the precast prestressed slab, or the edge of the bridge deck slab of the deck double tee girder or the precast prestressed ribbed section, measured from a chord that extends end to end of the member, shall be ± ⅛-inch per 10-feet of member length, but not greater than ½-inch total.

All precast prestressed members which exceed the specified horizontal alignment tolerance may be subject to rejection.

6-02.3(25)K GIRDER DEFLECTION

The Contractor shall check and record the vertical deflection (camber) of each girder at the following times:

1. Initial – Upon removal of the girder from the casting bed; and
2. Storage – Within 2-weeks, but not less than 3-Days prior to shipment, if the girder remains in storage for a period exceeding 120-Days.

The Contractor shall perform and record each check when the alignment of the girder is not influenced by temporary differences in surface temperature. These records shall be available for the Engineer's inspection, and in girders older than 120-Days, shall be transmitted to the Engineer when feasible for evaluation of the effect of long-term storage on the "D" dimension. Records for the Initial check shall be in the Contractor's Prestressed Concrete Certificate of Compliance. Records for the Storage check shall be provided to the Engineer for approval.

The "D" dimensions shown in the Drawings are computed girder deflections at midspan based on a time lapse of 40 and 120-Days after release of the prestressing strands, and should advise the Contractor as to the expected range of girder deflection at the time of deck forming. A positive (+) "D" dimension indicates upward deflection.

The Contractor shall control the deflection of prestressed concrete girders to receive a cast-in-place slab by scheduling fabrication between 40 and 120-Days of slab placement on the erected girders.

If it is anticipated that the girders will be older than 120-Days at the time of erection, the Contractor shall submit calculations to the Engineer showing the estimated girder deflection at midspan at the age anticipated for erection. This submittal shall also include the Contractor's proposal for accommodating any excess camber in the construction. The Contractor shall not proceed with girder fabrication until this submittal is approved by the Engineer. The actual girder deflection at the midspan may vary from the maximum estimated "D" dimension at the time of slab forming by a maximum of plus ½-inch for girder lengths up to 80-feet, and plus 1-inch for girder lengths over 80-feet, but less than or equal to 140-feet, and plus 1½-inches for girder lengths over 140-feet.

All costs, including bridge deck form adjustments required to maintain specified steel reinforcing bar clearances and deck profiles, and any additional Owner engineering expenses, for accommodating excess girder deflection shall be at the Contractor's expense.

6-02.3(25)L HANDLING AND STORAGE

During handling and storage, each girder shall always be kept plumb and upright, and each precast prestressed member and prestressed concrete tub girder shall always be kept in the horizontal orientation as shown in the Drawings.

It shall be lifted only by the lifting embedments (strand lift loops or high-strength threaded steel bars) at either end. For strand lift loops, only ½-inch diameter or 0.6-inch diameter strand conforming to Section 9-07.10 shall be used, and a minimum 2-inch diameter straight pin of a shackle shall be used through the loops. Multiple loops shall be held level in the girder during casting to allow each loop to carry its share of the load during lifting. The minimum distance from the end of the girder to the strand lift loops shall be 3-foot 0-inches. The loops shall project a minimum of 1-foot 6-inches from the top of the girder, and shall extend to within 3-inches clear of the bottom of the girder, terminating with a 9-inch long 90-degree hook. Loads on individual loops shall be limited to 12-kips, and all girders shall be picked up at a minimum angle of 60-degrees from the top of the girder. For high-strength threaded steel bars, a minimum of two 1⅓-inch diameter bars conforming to Section 9-07.11 shall be used at each end of the girder. The lifting hardware that connects to the bars shall be designed, detailed, and furnished by the Contractor. The minimum distance from the end of the girder to the centroid of the lifting bars shall be 3-feet 0-inches. Lifting bars shall extend to within 3-inches clear of the bottom of the girder and shall be anchored in the bottom flange with steel plates and nuts. The minimum size of embedded plates for lifting bars shall be ½-inch thick by 3-inches square. Lifting forces on the lifting bars shall not exceed 58-kips on an individual bar, and shall be within 10-degrees of perpendicular to the top of the girder.

For some girders, straight temporary top flange strands may be specified in the Drawings. The lifting locations and concrete release strengths in the girder schedule in the Drawings assume that these temporary strands are pretensioned. Alternatively, these temporary strands may be post-tensioned, provided the same lifting locations indicated in the girder schedule are used and the strands are tensioned prior to lifting the girder from the form. These temporary strands shall be of the same diameter, and shall be tensioned to the same force, as the permanent strands. The inside diameter of the debonding sleeves shall be large enough such that the temporary strands fully retract upon cutting. When temporary top strands are specified for spliced prestressed concrete girders, the temporary top strands shall be post-tensioned prior to lifting the assembled girder. When the post-tensioned alternative is used, the Contractor shall be responsible for properly sizing the anchorage plates, and the reinforcement adjacent to the anchorage plates, to prevent bursting or splitting of the concrete in the top flange. Temporary strands shall be cut or released under Section 6-02.3(25)N.

The Contractor may request permission to use lifting embedments, lifting embedment locations, lifting angles, concrete release strengths, or temporary top strand configurations other than specified in the Drawings. The number of temporary top strands may be increased from the number shown in the Drawings but shall not be decreased. When temporary top strands are not needed for lifting but are required for shipping, they shall be post-tensioned on the same day that the permanent prestress is released into the girder. The request, including calculations showing the adequacy of the proposed lifting method, shall be submitted to the Engineer for approval in accordance with Section 1-05.3 and 6-01.9. The Contractor's analysis shall conform to Article 5.4.1 of the *PCI Design Handbook*, *Precast and Prestressed Concrete*, Sixth Edition, or other approved methods. The Contractor's calculations shall verify that the concrete stresses in the prestressed girder do not exceed those listed in Section 6-02.3(25)M. The Contractor shall not begin girder lifting operations under the lifting method submittal until receiving the Engineer's written approval of the submittal, and shall perform the girder lifting operations at no additional expense to the Owner.

If girders are to be stored, the Contractor shall place them on a stable foundation that will keep them in a vertical position. Stored girders shall be supported at the bearing recesses or, if there are no recesses, approximately 18-inches from the girder ends. Precast prestressed members shall be supported at points between 1-foot 0-inches and 2-feet 0-inches from the member ends. After post-tensioning, segmental prestressed concrete girders shall be supported at points between 2-feet 0-inches and 5-feet 0-inches from the girder ends, unless otherwise shown in the Drawings. For long-term storage of girders with initial horizontal curvature, the Contractor may wedge 1 side of the bottom flange, tilting the girders to control curvature. If the Contractor elects to set girders out of plumb during storage, the Contractor shall have the proposed method analyzed by the Contractor's engineer to ensure against damaging the girder.

6-02.3(25)M SHIPPING

After the girder has reached its 28-Daydesign strength, and the fabricator believes it to comply with the Specification, the girder and a completed Certification of Compliance, signed by a Precast/Prestressed Concrete Institute Certified Technician or a Professional Engineer, acceptable to the Owner, shall be submitted to the Engineer for inspection. If the Engineer finds the certification and the girder to be acceptable, the Engineer will stamp the girder "Approved for Shipment."

No double tee girder, deck double tee girder, precast prestressed slab or precast prestressed ribbed section shall be shipped for at least 3-Days after concrete placement. No deck bulb tee girder or prestressed concrete tub girder shall be shipped for at least 7-Days after concrete placement, except that deck bulb tee girders or prestressed concrete tub girders may be shipped 3-Days after concrete placement when L/(bd) is less than or equal to 5.0, where L equals the shipping length of the girder, b equals the girder top flange width (for deck bulb tee girders) or the bottom flange width (for prestressed concrete tub girders), and d equals the girder depth, all in feet. No other girder shall be shipped for at least 10-Days after concrete placement.

Girder support during shipping shall be located as shown in the Drawings and shall be no closer than the girder depth to the ends of the girder at the girder center line. Support locations have been determined in accordance with the criteria specified in the WSDOT Bridge Design Manual LRFD Section 5.6.3.D. The Contractor shall verify the applicability of these criteria to the trucking configuration intended for transport of the girders. If the trucking configuration differs from these criteria,

the Contractor shall submit a girder shipping plan, with supporting calculations, to the Engineer for approval in accordance with Section 1-05.3 and 6-01.9.

The Contractor may request permission to use support locations other than those specified. The Contractor shall submit the support location modification proposal, with supporting calculations, to the Engineer for approval in accordance with Section 1-05.3 and 6-01.9. If the support locations are moved closer to the longitudinal ends of the girders, the calculations shall demonstrate adequate control of bending during shipping. The calculations shall also show that concrete stresses in the girders will not exceed those listed below.

If the Contractor elects to assemble spliced prestressed concrete girders into components of 2 or more segments prior to shipment, the Contractor shall submit shipment support location Working Drawings with supporting calculations to the Engineer in accordance with Section 1-05.3 and 6-01.9. The calculations shall show that concrete stresses in the assembled girders will not exceed those listed below.

Lateral bracing for shipping is not required for prestressed concrete tub girders and precast prestressed members as defined in Section 6-02.3(25).

For all prestressed concrete girders, except prestressed concrete tub girders and precast prestressed members, the Contractor shall provide bracing to control lateral bending during shipping, unless the Contractor furnishes calculations under Section 1-05.3 demonstrating that bracing is unnecessary. External bracing shall be attached securely to the top flange of the girder. The Contractor is cautioned that more conservation guidelines for lateral bracing may be required for some delivery routes. The Contractor shall submit a bracing plan, with supporting calculations, to the Engineer for approval under Section 1-05.3. The Contractor shall not begin shipping the girders until receiving the Engineer's approval of the bracing plan, and shall perform all bracing operations at no additional cost to the Owner.

Criteria for Checking Girder Stresses at the Time of Lifting or Transporting and Erecting.

Stresses at both the support and harping points shall be satisfied based on these criteria:

1. Allowable compression stress, fc = 0.60f'cm
   a. f'cm = compressive strength at time of lifting or transporting verified by test but shall not exceed design compressive strength (f'c) at 28-Days in psi + 1,000-psi
2. Allowable tension stress, ksi
   a. With no bonded reinforcement = 3 times square root (f'cm) ≤ 0.20 ksi
   b. With bonded reinforcement to resist total tension force in the concrete computed on the basis of an uncracked section = 6.0 times square root (f'cm). The allowable tensile stress in the reinforcement is 30 ksi
3. Prestress losses
   a. for lifting from casting beds = computed losses at 1-day
   b. for transportation = computed losses at 10-Days
4. Impact on dead load
   a. Lifting from casting beds = 0-percent
   b. Transporting and erecting = 20-percent

6-02.3(25)N PRESTRESSED CONCRETE GIRDER ERECTION

Before erecting any prestressed concrete girders, the Contractor shall submit to the Engineer for review and shall have received approval for the erection plan and procedure describing the methods the Contractor intends to use. The erection plan and procedure shall explain the erection process including but not limited to:

1. Temporary falsework support, bracing, guys, deadmen, and attachments to other Structure components or objects;
2. Procedure and sequence of operation;
3. Girder stresses during progressive stages of erection;
4. Girder weights, lift points, lifting embedments and devices, spreaders, and angle of lifting cables under Section 6-02.3(25)L, etc.;
5. Crane(s) make and model, mass, geometry, lift capacity, outrigger size and reactions;
6. Girder launcher or trolley details and capacity (if intended for use); and
7. Locations of cranes, barges, trucks delivering girders, and the location of cranes and outriggers relative to other Structures, including retaining walls and wing walls.

The erection plan shall include drawings, notes, catalog cuts, and calculations showing the above listed details, assumptions, and dimensions. Material properties and Specifications, structural analysis, and any other data used shall also be included. The plan shall be prepared by (or under the direct supervision of) a Professional Engineer, licensed under Title 18 RCW, State of Washington, in the branch of Civil or Structural, and shall carry the engineer's seal and signature, under Section 6-02.3(16).

The Contractor shall submit the erection plans, calculations, and procedure to the Engineer in accordance with Section 1-05.3, and in accordance with Section 6-02.3(16). After the plan is approved and returned to the Contractor, all changes that the Contractor proposes shall be submitted to the Engineer for review and approval.

When prestressed girders arrive on the project, the Engineer will confirm they are stamped "Approved for Shipment," that the final horizontal alignment and deflection (camber) check records have been approved, and that they have not been damaged in shipment before accepting them.

The concrete in piers and crossbeams shall reach at least 80-percent of design strength before girders are placed on them. The Contractor shall hoist girders only by the lifting embedments at the ends, always keeping the girders plumb and upright. Once erected, the girders shall be braced to prevent tipping until the intermediate diaphragms are cast and cured. **When temporary strands in the top flange are used, they shall be cut after the girders are braced and before the intermediate diaphragms are cast**. The Contractor shall place the cast-in-place deck on the girders within 30-calendar Days of cutting the temporary strands, except as otherwise approved by the Engineer.

For situations where the Contractor proposes to delay placing the cast-in-place deck on the girders beyond 30-calendar Days after cutting the temporary strands, the Contractor shall submit supporting girder camber calculations to the Engineer for approval under Section 1-05.3. The Contractor shall not cut the temporary strands until receiving the Engineer's approval of the girder camber calculations.

Instead of the oak block wedges shown in the Drawings, the Contractor may use Douglas fir blocks if the grain is vertical. The aspect ratio (height/width) of oak block wedges at the girder centerline shall not exceed 1.0.

The Contractor shall check the horizontal alignment of both the top and bottom flanges of each girder after girder erection but before placing concrete in the bridge diaphragms as described in Section 6-02.3(25)J.

The Contractor shall fill all block-out holes and patch any damaged area caused by the Contractor's operation, with an approved mix, to the satisfaction of the Engineer.

For precast prestressed concrete slabs, the Contractor shall place the 1¼-inch diameter vertical dowel bars at the top of the pier walls as shown in the Drawings. The Contractor shall either form the hole or core drill the hole following the alternatives in the Drawings. The portion of the dowel bar in the top of the pier walls shall be set with either grout that complies with Section 9-26.3 or type II epoxy bonding agent conforming to Section 9-26.1 following placement of each precast prestressed slab.

6-02.3(25)O DECK BULB TEE GIRDER FLANGE CONNECTION

The Contractor shall submit a method of equalizing deck bulb tee girder (and precast prestressed member) deflections to the Engineer for approval under Section 1-05.3, except that the submittal shall be included with the deck bulb tee girder fabrication Shop Drawing submittal specified in Section 6-02.3(25)A. Deflection equalizing methods approved for previous Owner Contracts will be acceptable providing the bridge configuration is similar and the previous method was satisfactory. Listing the previous Owner Contract numbers for which the method was used shall be included with the submittal. The weld-ties may be a component of the equalizing system provided the Contractor's procedure outlines how the weld-ties be used, and that the Contractor's submittal includes a list and description of previous bridge projects where the Contractor has successfully used weld-ties as a component of the equalizing system.

The concrete diaphragms for deck bulb tee girders shall attain a minimum compressive strength of 2,500-psi before any camber equalizing equipment is removed.

On deck bulb tee girders, girder deflection shall be equalized utilizing the approved method before girders are weld-tied and before keyways are filled. Keyways between tee girders shall be filled flush with the surrounding surfaces with nonshrink grout conforming to Section 9-20.3(2), except that keyways for deck bulb tee girders receiving a cast-in-place concrete deck slab need not be filled with grout. This nonshrink grout shall have a compressive strength of 5,000-psi before the equalizing equipment is removed. Compressive strength shall be determined by fabricating and testing cubes under WSDOT Test Method 813 and testing under AASHTO T-106.

Welding ground shall be attached directly to the steel plates being welded when welding the weld-ties on bulb tee girders.

No construction equipment shall be placed on the Structure, other than equalizing equipment, until the girders have been weld-tied and the keyway grout has attained a compressive strength of 5,000-psi.

6-02.3(26) CAST-IN-PLACE PRESTRESSED CONCRETE

Unless otherwise shown in the Drawings, concrete for cast-in-place prestressed bridge members shall be Class 4000D in the bridge deck, and Class 4000 at all other locations. Air entrainment shall conform to Sections 6-02.3(2)A and 6-02.3(3).

The Contractor shall construct supporting falsework to leave the Superstructure free to contract and lift off the falsework during post-tensioning. Forms that will remain inside box girders to support the bridge deck shall, by design, resist girder contraction as little as possible.

Before tensioning, the Contractor shall remove all side forms from girders. From this point until 48-hours after grouting the tendons, the Contractor shall keep all construction and other live loads off the Superstructure and shall keep the falsework supporting the Superstructure in place.

Once the prestressing steel is installed, no welds or welding grounds shall be attached to metal forms, structural steel, or reinforcing bars of the structural member.

The Contractor shall not stress the strands until all concrete has reached a compressive strength of at least 4,000-psi (or the strength in the Drawings). This strength shall be measured on concrete test cylinders made of the same concrete cured under the same conditions as the cast-in-place unit.

All post-tensioning shall be completed before sidewalks and barriers are placed.

6-02.3(26)A SHOP DRAWINGS

Before casting the structural elements, the Contractor shall submit Shop Drawings under section 1-05.3.

These Shop Drawings shall show complete details of the methods, materials, and equipment the Contractor proposes to use in prestressing Work. The Shop Drawings shall follow the design conditions in the Drawings unless the Engineer permits equally effective variations.

The Shop Drawings shall show:

1. The method and sequence of stressing.
2. Technical data on tendons and steel reinforcement, anchorage devices, anchorage device efficiency and acceptance test results and records, anchoring stresses, types of tendon conduit, and all other data on prestressing operations.
3. Stress and elongation calculations. Separate stress and elongation calculations shall be submitted for each tendon if the difference in tendon elongations exceeds 2-percent.
4. That tendons in the bridge will be arranged to locate their center of gravity as the Drawings require.
5. Details of additional or modified reinforcing steel required by the stressing system.
6. Procedures and lift-off forces at both ends of the tendon for performing a force verification lift-off if discrepancies occurs between measured and calculated elongations.

Couplings or splices will not be permitted in prestressing strands. Couplings or splices in bar tendons are subject to the Engineer's approval.

Friction losses used to calculate forces of the post-tensioning steel shall be based on the assumed values used for the design. The assumed anchor set, friction coefficient "μ", and friction wobble coefficient "k" values for design are shown in the Drawings. The post-tensioning supplier may revise the assumed anchor set value provided all the stress and force limits listed in Section 6-02.3(26)G are met.

The Contractor shall determine all points of interference between the mild steel reinforcement and the paths of the post-tensioning tendons. Details to resolve interferences shall be submitted with the Shop Drawings for approval. Where reinforcing bar placement conflicts with post-tensioning tendon placement, the tendon profile in the Drawings shall be maintained. Mild steel reinforcement for post-tensioning anchorage zones shall not be fabricated until after the post-tensioning Shop Drawings have been approved by the Engineer.

Approval of these Shop Drawings will mean only that the Engineer considers them to show a reasonable approach in enough detail. Approval will not indicate a check on dimensions.

The Contractor may deviate from the approved Shop Drawings only after obtaining the Engineer's approval of a written request that describes the proposed changes. Approval of a change in method, material, or equipment shall not relieve the Contractor of any responsibility for completing the Work successfully.

Before physical completion of the project, the Contractor shall provide the Engineer with reproducible originals of the Shop Drawings (and any approved changes). These shall be clear, suitable for microfilming, and on permanent sheets that measure no smaller than 11 by 17-inches. Alternatively, the Shop Drawings may be in an electronic format with approving the Bridge and Structures Engineer.

6-02.3(26)B GENERAL REQUIREMENTS FOR ANCHORAGES

Post-tensioning reinforcement shall be secured at each end with an approved anchorage device, which shall not kink, neck down, or otherwise damage the post-tensioning reinforcement. The anchorage assembly shall be grouted to the Engineer's satisfaction.

The Structure shall be reinforced with steel reinforcing bars in the anchorage zone in the vicinity of the anchorage device. This reinforcement shall be categorized into two zones. The first or local zone shall be the concrete surrounding and

immediately ahead of the anchorage device. The second or general zone shall be the overall anchorage zone, including the local zone.

The steel reinforcing bars required l for concrete confinement in the local zone shall be determined by the post-tensioning system Supplier and shall be shown in the Shop Drawings. The calculations shall be submitted with the Shop Drawings. The local zone steel reinforcing bars shall be furnished and installed by the Contractor, at no additional cost to the Owner, in addition to the structural reinforcement required by the Drawings. The steel reinforcing bars required in the general zone shall be as shown in the Drawings and are included in the appropriate Bid items.

The Contractor shall submit details, certified test reports, and/or supporting calculations, as specified below, which verify the structural adequacy of the anchorage devices for approval by the Engineer. This requirement does not apply where the anchorage devices have been previously approved by the Owner for the same Structure configuration. The Contractor shall also submit any necessary changes to the Drawings. The test report shall specify all test data.

Dead ended anchorages will not be permitted. Dead ended anchorages are defined as anchorages that cannot be accessed during the stressing operations.

Materials and workmanship shall conform to the requirements of Sections 6-03 and 9-06.

Before installing the anchorage device, the Contractor shall submit to the Engineer a Manufacturer's Certificate of Compliance under Section 1-06.3.

Anchorage devices shall meet the requirements listed in either Sections 6-02.3(26)C or 6-02.3(26)D.

All anchorages shall develop at least 96% of the actual ultimate strength of the prestressing steel, when tested in an unbounded state, without exceeding anticipated set. This anchor efficiency test shall be performed, or inspected and certified, by an independent testing agency approved by the Engineer.

6-02.3(26)C NORMAL ANCHORAGE DEVICES

Normal anchorage devices, defined as post-tensioning anchorage assemblies conforming to the factored bearing resistance requirements specified in this Section, shall provide a factored bearing resistance greater than or equal to 1.2 times the maximum jacking force. The Contractor shall submit calculations showing that the factored bearing resistances of the anchorage devices are not exceeded.

The factored bearing resistance of the anchorages shall be taken as:

$$Pr = \varphi f_n A_b$$

For which f_n is the lesser of:

$$f_n = 0.7 f'_{ci} (A/A_g)^{1/2}$$

$$f_n = 2.25 f'_{ci}$$

where:

φ = Resistance factor of 0.70

A = Maximum area of the portion of the supporting surface that is similar to the load area and concentric with it and does not overlap similar areas for adjacent anchorage devices (square inches)

A_b = Effective net area of the bearing plate calculated as the area A_g, minus the area of openings in the bearing plate (square inches)

A_g = Gross bearing area of the bearing plate calculated in accordance with the requirements specified below (square inches)

f'_{ci} = Nominal compressive strength of concrete at the time of application of the tendon force (ksi)

The full bearing plate area may be used for A_g and the calculation of A_b if the plate material does not yield at the factored tendon force and the slenderness of the bearing plate, n/t, conforms to:

$$(n/t) \leq 0.08(E_b/f_b)^{0.33}$$

where:

E_b = Modulus of elasticity of the bearing plate material (ksi)

f_b = Stress in the anchor plate at a section taken at the edge of the wedge hole or holes (ksi)

n = Projection of the base plate beyond the wedge hole or wedge plate, as appropriate (inches)

t = average thickness of the bearing plate (inches)

For anchorages with separate wedge plates,n may be taken as the largest distance from the outer edge of the bearing plate. For rectangular bearing plates, this distance shall be measured parallel to the edge of the bearing plate. If the anchorage has no separate wedge plate, n may be taken as the projection beyond the outer perimeter of the group of holes in the direction under consideration.

For bearing plates that do not meet the slenderness requirement specified above, the effective gross bearing area, A_g, shall be taken as:

1. For anchorages with separate wedge plates, the area geometrically similar to the wedge plate, with dimensions increased by twice the bearing plate thickness.
2. For anchorages without separate wedge plates, the area geometrically similar to the outer perimeter of the wedge holes, with dimensions increased by twice the bearing plate thickness.

6-02.3(26)D SPECIAL ANCHORAGE DEVICES

Special anchorage devices, defined as post-tensioning anchorage assemblies that do not conform to the factored bearing pressure requirements specified in Section 6-02.3(26)C, shall conform to the acceptance test requirements below. Acceptance testing shall be performed, or inspected and certified, by an independent testing agency approved by the Engineer. Results of the special anchorage device acceptance testing shall be recorded and submitted to the Engineer for approval in accordance with section 1-05.3 and 6-01.9..

6-02.3(26)D1 TEST BLOCK REQUIREMENTS

The test block shall be a rectangular prism of sufficient size to contain all the special anchorage components that will also be embedded in the concrete of the Structure being post-tensioned. The arrangement of the special anchorage device components shall conform to practical application to the project and the special anchorage device manufacturer's recommendations. The test block shall contain an empty duct of the size appropriate for the maximum tendon size that can be accommodated by the special anchorage device.

6-02.3(26)D2 TEST BLOCK DIMENSIONS

The dimensions of the test block perpendicular to the tendon in each direction shall be the smaller of the minimum edge distance or the minimum spacing specified by the special anchorage device manufacturer, with the stipulation that the concrete cover over any confining reinforcing steel or supplementary skin reinforcement shall be appropriate for the project-specific application and circumstances. The length of the block along the axis of the tendon shall be at least two times the larger of the cross-section dimensions.

6-02.3(26)D3 LOCAL ZONE REINFORCEMENT FOR CONFINEMENT

The confining reinforcement steel in the local zone of the test block shall be the same as that recommended by the special anchorage device manufacturer.

6-02.3(26)D4 SUPPLEMENTARY SKIN REINFORCEMENT

In addition to the special anchorage device and the associated zone reinforcement for confinement, supplementary skin reinforcement may be provided throughout the test block. Such supplementary skin reinforcement shall be as specified by the special anchorage device manufacturer, but shall not exceed a volumetric ratio of 0.01.

The Contractor shall furnish and install supplementary skin reinforcement in the anchorage zone of the Structure similar in configuration and equivalent in volumetric ratio to the supplementary skin reinforcement used in the test block at no additional cost to the Owner. The steel reinforcing bars in the Drawings in corresponding portions of the general zone may be counted toward this reinforcement requirement.

6-02.3(26)D5 TEST BLOCK CONCRETE STRENGTH

The compressive strength of the test block at the time of acceptance testing shall not exceed the compressive strength of Structure being post-tensioned at the time of post-tensioning.

6-02.3(26)D6 SPECIAL ANCHORAGE DEVICE ACCEPTANCE TESTING

Special anchorage device acceptance testing shall be conducted under one of the following test methods:

1. Cyclic load test.
2. Sustained load test.
3. Monotonic load test.

The loads specified for the tests are specified in fractions of the ultimate load F_{pu} of the largest tendon that the special anchorage device is designed to accommodate. The specimen shall be loaded under conventional usage of the device in post-tensioning applications, except that the load may be applied directly to the wedge plate or equivalent area.

6-02.3(26)D7 CYCLIC LOADING

A load of $.8F_{pu}$ shall be applied. The load shall be cycled between $0.1F_{pu}$and $0.8F_{pu}$ until crack widths stabilize, but for no less than ten cycles. Crack widths are stabilized if they do not change more than 0.001 inches over the last three readings. Upon completion of the cyclic loading portion of the test, the specimen shall be loaded to failure, or, if limited by the capacity of the loading equipment, to at least $1.1F_{pu.}$

Crack widths and patterns shall be recorded at the initial load of $0.8F_{pu}$, at least at the last three consecutive peak loadings before termination of the cyclic loading portion of the test, and at $0.9F_{pu}$. The maximum load shall also be reported.

6-02.3(26)D8 SUSTAINED LOADING TEST

A load of $0.8F_{pu}$ shall be applied and held constant until crack widths stabilize, but not less than 48-hours. Crack widths are stabilized if they do not change by more than 0.001 inches over the last three readings. Upon completion of the sustained loading portion of the test, the specimen shall be loaded to failure, or, if limited by the capacity of the loading equipment, to at least $1.1F_{pu}$. Crack widths and crack patterns shall be recorded at the initial load of $0.8F_{pu}$, at least three times at intervals of no less than 4 hours during the last 12 hours of the sustained loading time period, and at $0.9F_{pu}$. The maximum load shall also be reported.

6-02.3(26)D9 MONOTONIC LOADING TEST

A load of $0.9F_{pu}$ shall be applied and held constant for 1-hour. Upon completion of the 1-hour load hold period, the specimen shall be loaded to failure, or, if limited by the capacity of the loading equipment, to at least $1.2F_{pu}$.

Crack width and crack patterns shall be recorded at $0.9F_{pu}$, at the conclusion of the 1-hour load hold period, and at $1.0F_{pu}$. The maximum load shall be reported.

6-02.3(26)D10 SPECIAL ANCHORAGE DEVICE TEST PERFORMANCE REQUIREMENTS

The test block shall conform to the following load requirements under test load:

1. The maximum test load for cyclic loading and sustained loading tests shall be $1.1F_{pu}$ minimum.
2. The maximum test load for monotonic load testing shall be $1.2F_{pu}$ minimum.

The test block shall conform to the following crack width requirements under test load:

1. Cracks shall not exceed 0.010 inches in width at $0.8F_{pu}$ at completion of the cyclic loading test or sustained loading test, or at $0.9F_{pu}$after the 1-hour load hold period of the monotonic loading test.
2. Cracks shall not exceed 0.016 inches at $0.9F_{pu}$ for the cyclic loading test or the sustained loading test, or at $1.0F_{pu}$ for the monotonic loading test.

6-02.3(26)D11 TEST SERIES REQUIREMENTS

A test series shall consist of three test specimens. Each one of the test specimens shall conform to the acceptance criteria specified above. If one of the three specimens fails to pass the test, a supplementary test series of three additional specimens shall be conducted. The three additional test specimens shall conform to the specified acceptance criteria.

6-02.3(26)D12 SPECIAL ANCHORAGE DEVICE ACCEPTANCE TESTING RESULTS REPORT

The special anchorage device acceptance testing results report comprise the following:

1. Dimensions of the test specimen.
2. Working drawings with details and dimensions of the special anchorage device, including all confining reinforcing steel.
3. Amount and arrangement of supplementary skin reinforcement.
4. Type and yield strength of the reinforcing steel.
5. Type and compressive strength of the concrete at the time of testing.
6. Type of testing procedure and all measurements specified for each specimen under the test.

The special anchorage device manufacturer shall specify auxiliary and confining reinforcement, minimum edge distance, minimum anchor spacing, and minimum concrete strength at the time of stressing required for proper performance of the local zone

6-02.3(26)E DUCTS

Ducts shall be round, except that ducts for transverse post-tensioning of bridge deck slabs may be rectangular. Ducts shall conform to the following requirements for internal embedded installation and external exposed installation. Elliptical shaped duct may be used if approved by the Engineer.

6-02.3(26)E1 DUCTS FOR INTERNAL EMBEDDED INSTALLATION

Ducts, including their splices, shall be semi-rigid, air and mortar tight, corrugated plastic ducts of virgin polyethylene or polypropylene materials, free of water-soluble chlorides or other chemicals reactive with concrete or post-tensioning reinforcement. Ducts, including their splices, shall either have a white coating on the outside or shall be of a white material with ultraviolet stabilizers added. Ducts, including their splices, shall be capable of withstanding concrete pressures without deforming or permitting the intrusion of cement paste during placement of concrete. All fasteners shall be appropriate for use with plastic ducts, and all clamps shall be of an approved plastic material.

Polyethylene ducts shall conform to ASTM D 3350 with a cell classification of 345464A. Polypropylene ducts shall conform to ASTM D 4101 with a cell classification range of PP0340B14541 to PP0340B67884. Resins used for duct fabrication shall have a minimum oxidation induction time of 20-minutes, under ASTM D 3895, based on tests performed by the duct fabricator on samples taken from the lot of finished product. The duct thickness shall be as specified in Section 10.8.3 of the AASHTO LRFD Bridge Construction Specifications, latest edition and current interims.

All duct splices, joints, couplings, and connections to anchorages shall be made with devices or methods (mechanical couplers, plastic sleeves, shrink sleeves) that are approved by the duct manufacturer and produce a smooth interior alignment with no lips or kinks. All connections and fittings shall be air and mortar tight. Taping is not acceptable for connections and fittings.

Each duct shall maintain the required profile within a placement tolerance of plus or minus 1/4-inch for longitudinal tendons and plus or minus $^{1}/_{8}$-inch for transverse slab tendons during all phases of the work. The minimum acceptable radius of curvature shall be as recommended by the duct manufacturer and as supported by documented industry standard testing. The ducts shall be completely sealed to keep out all mortar.

Each duct shall be located to place the tendon at the center of gravity alignment in the Drawings. To keep friction losses to a minimum, the Contractor shall install ducts to the exact lines and grades shown in the Drawings. Once in place, the ducts shall be tied firmly in position before they are covered with concrete. During concrete placement, the Contractor shall not displace or damage the ducts.

The ends of the ducts shall:

1. Permit free movement of anchorage devices, and
2. Remain covered after installation in the forms to keep out all water or debris.

Immediately after any concrete placement, the Contractor shall force blasts of oil-free, compressed air through the ducts to break up and remove any mortar inside before it hardens. Before deck concrete is placed, the Contractor shall satisfy the Engineer ducts are unobstructed and contain nothing that could interfere with tendon installation, tensioning, or grouting. If the tendons are in place, the Contractor shall show they are free in the duct.

Ducts shall be capped and sealed until completing grouting to prevent the intrusion of water.

Strand tendon duct shall have an inside cross-sectional area large enough to accomplish strand installation and grouting. The area of the duct shall be at least 2.5 times the net area of prestressing steel in the duct. The maximum duct diameter shall be 4½-inches.

The inside diameter of bar tendon duct shall at least be ¼-inch larger than the bar diameter. At coupler locations the duct diameter shall at least be ¼-inch larger than the coupler diameter.

Ducts installed and cast into concrete prior to prestressing steel installation, shall be capable of withstanding at least 10-feet of concrete fluid pressure.

Ducts shall have adequate longitudinal bending stiffness for smooth, wobble free placement. A minimum of 3 successful duct qualification tests are required for each diameter and type of duct as follows:

1. Ducts with diameters 2-inches and smaller shall not deflect more than 3-inches under its own weight, when a 10-foot. duct segment is supported at its ends.
2. Ducts larger than 2-inches in diameter shall not deflect more than 3-inches under its own weight, when a 20-foot duct segment is supported at its ends.
3. Duct shall not dent more than ⅛-inch under a concentrated load of 100-pounds applied between corrugations by a #4 steel reinforcing bar.

When the duct must be curved in a tight radius, more flexible duct may be used, subject to the Engineer's approval.

6-02.3(26)E2 DUCTS FOR EXTERNAL EXPOSED INSTALLATION

Duct shall be high-density polyethylene (HDPE) conforming to ASTM D 3350. The cell classification for each property listed in the table below:

Property	Cell Classification
1	3 or 4
2	2, 3, or 4
3	4 or 5
4	4 or 5
5	2 or 3
6	2, 3, or 4

The color code shall be C.

Duct for external tendons, including their splices, shall be water tight, seamless or welded, and be capable of resisting at least 150-psi grout pressure.

Transition couplers between ducts shall conform to either the standard pressure ratings of ASTM D 3505 or the hydrostatic design stresses of ASTM F 714 at 73°F. The inside diameter through the coupled length shall not be less than that produced by the dimensional tolerances specified in ASTM D 3505.

Workers performing HDPE pipe welding shall have satisfactorily completed a certified HDPE pipe welding course and shall have a minimum of 5-years experience in welding HDPE pipe.

The Contractor shall submit the name and HDPE pipe welding work experience of each HDPE pipe welder proposed to perform this Work in the project. The experience submittal for each HDPE pipe welder shall include:

The Engineer may require the HDPE pipe welder to demonstrate test HDPE pipe welding before receiving final approval.

1. The name of the pipe welder.
2. The name, date, and location of the certified HDPE pipe welding course, with the course completion certificate.
3. A list of at least 3 projects in the last 5-years where the pipe welder performed HDPE pipe welding, including:
   a. The project name and location, and date of construction.
   b. The Governmental Agency/Owner.
   c. The name, address, and phone number of the Governmental Agency/Owner's representative.

The Contractor shall not begin HDPE pipe welding operations until receiving the Engineer's approval of the work experience submittal for each HDPE pipe welder performing HDPE pipe welding in the project. The Engineer may require the HDPE pipe welder to demonstrate test HDPE pipe welding before receiving final approval.

6-02.3(26)E3 TRANSITIONS

Transitions between ducts and wedge plates shall have adequate length to reduce the angle change effect on the performance of strand-wedge connection, friction loss at the anchorage, and fatigue strength of the post-tensioning reinforcement.

6-02.3(26)E4 VENTS, GROUT INJECTION PORTS, DRAINS, AND CAPS

The Contractor shall install vents at high points and drains at low points of the tendon profile (and at other places if the Drawings require). Vents at high points comprise a set of three vents: one to be installed at the high point of the duct, and flanking vents to be installed on either side of the high-point vent at locations where the duct profile is 8 to 12-inches below the elevation of the high-point vent. Vents shall include grout injection ports.

Vents and drains shall have a minimum inside diameter of 3/4-inches, and shall be of either stainless steel, nylon, or polyolefin materials, free of water-soluble chlorides or other chemicals reactive with concrete or post-tensioning reinforcement. Stainless steel vents and drains shall conform to ASTM A 240 Type 316. Nylon vents and drains shall conform to cell classification S-PA0141 (weather-resistant). Polyolefin vents and drains shall contain an antioxidant with a minimum oxidation induction time of 20-minutes under ASTM D 3895. Polyolefin vents and drains shall also have a stress crack resistance of 3-hours minimum when tested at an applied stress of 350-psi under ASTM F 2136.

All fasteners shall be appropriate for use with plastic ducts, and all clamps shall be of an approved plastic material. Taping of connections is not allowed. Valves shall be positive mechanical shut-off valves. Valves, and associated caps, shall have a minimum pressure rating of 100-psi.

Vents shall point upward and remain closed until grouting begins. Drains shall point downward and remain open until grouting begins. Ends of stainless steel vents and drains shall be removed 1-inch inside the concrete surface after grouting has been completed. Ends of nylon or polyolefin vents and drains may be left flush to the surface unless otherwise specified by the Engineer. Vents, except for grout injection, are not required for transverse post-tensioning ducts in the bridge deck unless specified in the Drawings.

Caps shall be made of either stainless steel or fiber reinforced polymer (FRP). Stainless steel caps shall conform to ASTM A 240 Type 316L. The resin for FRP caps shall be nylon, polyester, or acrylonitrite butadiene styrene (ABS). Nylon shall conform to cell classification S-PA0141 (weather-resistant). Caps shall be sealed with "O" ring seals or precision-fitted flat gaskets placed against the bearing plate. Caps shall be fastened to the anchorage with stainless steel bolts conforming to ASTM A 240 Type 316L.

6-02.3(26)E5 LEAK TIGHTNESS TESTING

The Contractor shall test each completed duct assembly for leak tightness prior to casting concrete and placing post-tensioning reinforcement. The Contractor shall submit the equipment used to conduct the leak tightness testing and to monitor and record the pressure maintained in and lost from the closed assembly, and the process to be followed in conducting the leak-tightness testing, to the Engineer for approval with the post-tensioning system Shop Drawings under Section 6-02.3(26)A.

Prior to testing, all vents, grout injection ports, and drains shall either be capped or have their shut-off valves closed. The Contractor shall pressurize the completed duct assembly to an initial air pressure of 50-psi. This pressure shall be held for five minutes to allow for internal adjustments within the assembly. After five minutes, the air supply valve shall be closed. The Contractor shall monitor and measure the pressure within the closed assembly, and any subsequent loss of pressure, over a period of 1-minute following the closure of the air supply valve. Locations of leakage shall be identified, repaired, or reconstructed, and the repaired reassembled duct system retested. The cycle of testing, repair, and retesting of each completed duct assembly shall continue until the completed duct assembly completes a test with pressure loss within the specified amount. The maximum pressure loss for duct assemblies equal to or less than 150-feet in length shall be 25-psig. The maximum pressure loss for duct assemblies greater than 150-feet in length shall be 15-psig.

All duct splices, joints, couplings and connections to anchorages shall be made with devices or methods (mechanical couplers, plastic sleeves, shrink sleeve) approved by the duct manufacturer and produce a smooth interior alignment with no lips or kinks. All connections and fittings shall be air and mortar tight. Taping is not acceptable for connections and fittings

6-02.3(26)F PRESTRESSING REINFORCEMENT

All prestressing reinforcement strand shall comply with Section 9-07.10. They shall not be coupled or spliced. Tendon locations in the Drawings indicate final positions after stressing (unless the Drawings say otherwise). No tendon made of 7-wire strands shall contain over 37 strands of ½-inch diameter, or over 27 strands of 0.6-inch diameter.

All prestressing reinforcement bar shall conform to Section 9-07.11. They shall not be coupled or spliced except as otherwise specified in the Drawings or Contract.

Prestressing reinforcement not conforming to either Section 9-07.10 or 9-07.11 will not be allowed except as otherwise noted. Such reinforcement may be used provided it is specifically allowed by the Drawings or Contract, it satisfies all material and performance criteria specified in the Drawings or Contract, and receives the Engineer's approval.

From manufacture to encasement in concrete or grout, prestressing strand shall be protected against dirt, oil, grease, damage, and all corrosives. Strand shall be stored in a dry, covered area and shall be kept in the manufacturer's original packaging. If prestressing strand has been damaged or pitted, it will be rejected. Prestressing strand with rust shall be spot-cleaned with a nonmetallic pad to inspect for any sign of pitting or section loss. If the prestressing reinforcement will not be stressed and grouted for more that 7-calendar Days after it is placed in the ducts, the Contractor shall place an approved corrosion inhibitor conforming to Federal Specification MIL-P-3420F-87 in the ducts.

The feeding ends of the strand tendons shall be equipped with a bullet nosing or similar apparatus to facilitate strand tendon installation.

Strand tendons may be installed by pulling or pushing. Any equipment capable to performing the task may be used, provided it does not damage the strands and conforms to the following:

1. Pulling lines shall have a capacity of at least 2.5 times the dead weight of the tendons when used for horizontal tendon installation.
2. Metal pushing wheels shall not be used.
3. Bullets for checking duct clearance prior to concreting shall be rigid and be ⅛-inch smaller than the inside diameter of the duct. Bullets for checking duct after concreting shall be less than ¼-inch smaller than the inside diameter of the duct.

6-02.3(26)G TENSIONING

Equipment for tensioning post-tensioning reinforcement shall meet the following requirements:

1. Stressing equipment shall be capable to produce a jacking force of at least 81-percent of the specified tensile strength of the post-tensioning reinforcement.
2. Jacking force test capacity shall be at least 95-percent of the specified tensile strength of the post-tensioning reinforcement.
3. Wedge seating methods shall assure uniform seating of wedge segments and uniform wedge seating losses on all strand tendons.
4. Accumulation of differential seating losses during tensioning cycling shall be prevented by proper devices.
5. Jacks used for stressing tendons less than 20-feet long shall have wedge power seating capability.

The Contractor shall not begin to tension the tendons until:

1. All concrete has reached a compressive strength of at least 4,000-psi or the strength specified in the Drawings (demonstrated on test cylinders made of the same concrete cured under the same conditions as that in the bridge), and
2. The Engineer is satisfied that all strands are free in the ducts.

Tendons shall be tensioned to the values in the Drawings (or approved Shop Drawings) with hydraulic jacks. When stressing from both ends of a tendon is specified, it need not be simultaneous unless otherwise specified in the Drawings. The jacking sequence shall follow the approved Shop Drawings.

Each jack shall have a pressure gauge that will determine the load applied to the tendon. The gauge shall display pressure accurately and readably with a dial at least 6-inches in diameter or with a digital display. Each jack and its gauge shall be calibrated as a unit and shall be accompanied by a certified calibration chart. The Contractor shall provide 1 copy of this chart to the Engineer for monitoring. The cylinder extension during calibration shall be in approximately the position it will occupy at final jacking force.

All jacks and gauges shall be recalibrated and recertified: (1) at least every 180-Days, and (2) after any repair or adjustment. The Engineer may use pressure cells to check jacks, gauges, and calibration charts before and during tensioning.

These stress limits apply to all tendons (unless the Drawings set other limits):

1. During jacking prior to seating: 90 percent of the yield strength of the steel.
2. At anchorages after seating: 70 percent of the specified tensile strength of the steel.

3. At service limit state after losses: 80 percent of the yield strength of the steel.

Tendons shall be anchored at initial stresses that will ultimately maintain service loads at least as great as the Drawings require.

As stated in Section 6-02.3(26)A, the assumed design friction coefficient “μ” and wobble coefficient “k” shown in the Drawings shall be used to calculate the stressing elongation. These coefficients may be revised by the post-tensioning supplier by the following method provided it is approved by the Engineer:

Early in the project, the post-tensioning supplier shall test, in place, 2 representative tendons of each size and type shown in the Drawings, for accurately determining the friction loss in a strand and/or bar tendon.

The test procedure comprise stressing the tendon at an anchor assembly with load cells at the dead end and jacking end. The test specimen shall be tensioned to 80-percent of the specified tensile strength in 10 increments. For each increment, the gauge pressure, elongation, and load cell force shall be recorded and the data furnished to the Engineer. The theoretical elongations and post-tensioning forces shown on the post-tensioning Shop Drawings shall be re-evaluated by the post-tensioning supplier using the results of the tests and corrected as necessary. Revisions to the theoretical elongations shall be submitted to the Engineer for evaluation and approval. The apparatus and methods used to perform the tests shall be proposed by the post-tensioning supplier and be subject to the approval of the Engineer.

All costs associated with testing and evaluating test data shall be in the unit Contract prices for the items of Work involved.

As tensioning proceeds, the Engineer will be recording the applied load, tendon elongation, and anchorage seating values.

Elongation measurements shall be made at each stressing location to verify that the tendon force has been properly achieved. If proper anchor set has been achieved and the measured elongation of each strand tendon is within plus or minus 7-percent of the approved calculated elongation, the stressed tendon represented by the elongation measurements is acceptable to the Owner.

If discrepancies greater than 7-percent exist between the measured and calculated elongations, the jack calibration shall be checked and stressing records reviewed for any evidence of wire or strand breakage. If the jack if properly calibrated and there is no evidence of wire or strand breakage, a force verification lift off shall be performed to verify the force in the tendon. The post-tensioning supplier force verification lift off procedure shall provide access for visual verification of anchor plate lift off. The jacking equipment shall be capable of bridging and lifting off the anchor plate. The tendon is acceptable if the verification lift off force is not less than 99-percent of the approved calculated force nor more than 70-percent of the specified tensile strength of the prestressing steel or as approved by the Engineer.

Elongation measurements shall be recorded for bar tendons to verify proper tensioning only. Acceptance will be by force verification lift off. The bar tendon is acceptable if the verification lift off force is not less than 95-percent nor more than 105-percent of the approved calculated force or as approved by the Engineer.

When removing the jacks, the Contractor shall relieve stresses gradually before cutting the prestressing reinforcement. The prestressing strands shall be cut a minimum of 1-inch from the face of the anchorage device.

6-02.3(26)H GROUTING

Grout for post-tensioning reinforcement shall conform to Section 9-20.3(1). Prepackaged components of the grout mix shall be used within 6-months or less from date of manufacture to date of usage. Grout for post-tensioning reinforcement will be accepted based on manufacturer's certificate of compliance under Section 1-06.3, except that the water-cementitious material ratio of 0.45 maximum shall be field verified.

All grout produced for any single structure shall be furnished by one supplier.

All grouting operations shall be conducted by ASBI-certified grout technicians.

The Contractor shall submit a Grouting Operation Plan to the Engineer for approval under Section 1-05.3. The grouting operation Plan shall include, but not be limited to;

1. Names of the grout technicians, accompanied by documentation of their ASBI certification.
2. Type, quantity, and brand of materials used in the grouting operations, including all manufacturer's certificates of compliance.
3. Type of equipment to be used, including meters and measuring devices used to positively measure the quantity of materials used to mix the post-tensioning grout, the equipment capacity in relation to demand and working conditions, and all back-up equipment and spare parts.
4. General grouting procedure.
5. Duct leak tightness testing and repair procedures as specified in Section 6-02.3(26)E.
6. Methods used to control the rate of grout flow within the ducts.

7. Theoretical grout volume calculations, and target flow rates recommended by the grout manufacturer as a function of the mixer equipment and the expected range of ambient temperatures.

8. Grout mixing and pumping procedures.

9. Direction of grouting.

10. Sequence of use of the grout injection ports, vents, and drains.

11. Procedures for handling blockages.

12. Procedures for post grouting repairs.

The Contractor shall not grout operations until receiving the Engineer's approval of the grouting operation Plan.

Post-tensioning grout shall be mixed under the prepackaged grout manufacturer's recommendations using high-shear colloidal mixers. Mechanical paddle mixers will not be allowed. The grout produced for filling post-tensioning ducts shall be free of lumps and undispersed cement. All equipment used to mix each batch of post-tensioning grout shall be equipped with appropriate meters and measuring devices to positively measure all quantities of all materials used to produce the mixed grout. The field test for water-cementitious materials ratio shall be performed prior to beginning the grout injection process. Grouting shall not begin until the material properties of each batch of grout have been confirmed as acceptable.

After tensioning the tendons, the Contractor shall again blow oil-free, compressed air through each duct. All drains shall then be closed and the vents opened. Grout caps shall be installed at tendon ends prior to grouting. After completely filling the duct with grout, the Contractor shall pump the grout from the low end at a pressure of not more than 250-psig, except for transverse tendons in deck slabs the grout pressure shall not exceed 100-psig. Grout shall be continuously wasted through each vent until no more air or water pockets show. At this point, all vents shall be closed and grouting pressure at the injector held between 100 and 200-psig for at least 10-seconds, except for transverse tendons in deck slabs the grouting pressure shall be held between 50 and 75-psig for at least 10-seconds. The Contractor shall leave all plugs, caps, and valves in place and closed for at least 24-hours after grouting.

Grouting equipment shall:

1. Include a pressure gauge with an upper end readout of between 275 and 325-psig;

2. Screen the grout before it enters the pump with an easily reached screen that has clear openings of no more than 0.125-inches;

3. Be gravity fed from an attached, overhead hopper kept partly full during pumping; and

4. Be able to complete the largest tendon on the project in no more than 20-minutes of continuous grouting.

The Contractor shall have standby equipment (with a separate power source) available for flushing the grout when the regular equipment cannot maintain a 1-way flow of grout. This standby equipment shall be able to pump at 250-psig.

The grout ejected from the end vent shall have a minimum flow of 11-seconds.

The grout mix shall be injected within 30-minutes after the water is added to the cement. Temperature of the surrounding concrete shall be at least 35°F from the time the grout injecting begins until 2-inch cubes of the grout have a compressive strength of 800-psi. Cubes shall be made under WSDOT Test Method T 813 and stored under AASHTO T 23. If ambient conditions are such that the surrounding concrete temperature may fall below 35°F, the Contractor shall provide a heat source and protective covering for the Structure to keep the temperature of the surrounding concrete above 35°F. Grout temperature shall not exceed 90°F during mixing and pumping. If conditions are such that the temperature of the grout mix may exceed 90°F, the Contractor will make necessary provisions, such as cooling the mix water and/or dry ingredients, to ensure that the temperature of the grout mix does not exceed 90°F.

6-02.3(27) CONCRETE FOR PRECAST UNITS

Precast units shall not be removed from forms until the concrete has attained a minimum compressive strength of 70-percent of the specified design strength as verified by rebound number determined in accordance with ASTM C 805. Type III portland cement is permitted to be used in precast concrete units.

Precast units shall not be shipped until the concrete has reached the specified design strength as determined by testing cylinders made from the same concrete as the precast units. The cylinders shall be made, handled, and stored in accordance with AASHTO T 23 and compression tested in accordance with AASHTO Test Method T 22 and AASHTO Test Method T 231.

6-02.3(27)A USE OF SELF-CONSOLIDATING CONCRETE FOR PRECAST UNITS

Self-Consolidating Concrete (SCC) is concrete that is able to flow under its own weight and completely fill the formwork without the need for any vibration while maintaining homogeneity, even in the presence of dense reinforcement. SCC shall be capable of flowing through the steel reinforcing bar cage without segregation or buildup of differential head inside or outside of the steel reinforcing bar cage.

SCC may be used for the following precast concrete structure elements:

1. Precast roof, wall, and floor panels and retaining wall panels in accordance with Section 6-02.3(28).
2. Precast reinforced concrete three-sided structures in accordance with Section 6-02.3(28) as supplemented in the Special Provisions.
3. Precast concrete barrier in accordance with Section 6-10.3(1).
4. Precast concrete wall stem panels in accordance with Section 6-11.3(3).
5. Precast concrete noise barrier wall panels in accordance with Section 6-12.3(6).
6. Structural earth wall precast concrete facing panels in accordance with Section 6-13.3(4).
7. Precast drainage structure elements in accordance with Section 9-05.50.
8. Precast junction boxes, cable vaults, and pull boxes in accordance with Section 9-29.2.

6-02.3(27)B SUBMITTALS FOR SELF-CONSOLIDATING CONCRETE FOR PRECAST UNITS

With the exception of items 3, 7, and 8 in Section 6-02.3(27)A, the Contractor shall submit the mix design for SCC to the Engineer for annual approval in accordance with Section 6-02.3(28)B. The mix design submittal shall include items specified in Section 6-02.3(2)A, and results of the following tests conducted on concrete that has slump flow within the slump flow range defined below:

1. Slump Flow.
   a. The mix design shall specify the target slump flow in inches, in accordance with WSDOT FOP for ASTM C 1611. The slump flow range is defined as the target slump flow plus or minus 2 inches.
   b. The visual stability index (VSI) shall be less than or equal to one in accordance with ASTM C 1611, Appendix X1, using Filling Procedure B.
   c. The T_{50} flow rate results shall be less than 6 seconds in accordance with ASTM C 1611, Appendix X1, using Filling Procedure B.
2. Column Segregation.
   a. The maximum static segregation shall be 10 percent in accordance with ASTM C 1610.
   b. The Maximum Hardened Visual Stability Index (HVSI) shall be one in accordance with AASHTO PP 58.
3. J ring test results for passing ability shall be less than or equal to 1½ inches in accordance with the WSDOT FOP for ASTM C 1621.
4. Air content shall be tested in accordance with WSDOT Test Method T 818 and shall conform to Section 6-02.3(2)A.
5. Concrete unit weight results in pounds per cubic foot shall be recorded in accordance with AASHTO T 121, except that the concrete shall not be consolidated in the test mold.
6. The temperature of all concrete laboratory test samples shall be tested in accordance with AASHTO T 309 and shall conform to the placement limits specified in Section 6-02.3(4)D.
7. The modulus of elasticity in pounds per square inch at 28 days shall be recorded in accordance with ASTM C 469.

Use of Type III cement is permitted.

Placement for construction may include consolidation using light vibration, but the requirements of Section 6-02.3(4)C for consistency will not apply.

Items 3, 7, and 8 in Section 6-02.3(27)A require the precast plant to cast one representative structure acceptable to the Engineer and have the structure sawn in half for examination by the Owner to determine that segregation has not occurred. The Owner's approval of the sawn structure will constitute approval of the precast plant to use SCC, and a concrete mix design submittal is not required.

6-02.3(27)C ACCEPTANCE TESTING OF SELF-CONSOLIDATING CONCRETE FOR PRECAST UNITS

Acceptance testing shall be performed by the Contractor and test results shall be submitted to the Engineer. Placement of SCC for concrete testing such as cylinder preparation shall be in accordance with WSDOT Test Method T 819.

SCC for items 1, 2, 4, 5, and 6 in Section 6-02.3(27)A will be accepted in accordance with Section 6-02.3(5) procedures and based on conformance to the requirements specified above and in Section 6-02.3(2)A for the following:

1. Temperature.
2. Air content.
3. Compressive strength at 28 days.
4. Slump flow within the target slump flow range.
5. J ring passing ability less than or equal to 1½ inches.
6. VSI less than or equal to 1.

SCC for concrete barrier will be accepted in accordance with temperature, air, and compressive strength testing listed above.

SCC for precast junction boxes, cable vaults, and pull boxes will be accepted in accordance with the temperature and compressive strength testing listed above.

SCC for precast drainage structure elements will be accepted in accordance with the requirements of AASHTO M 199.

6-02.3(28) PRECAST CONCRETE PANELS

The Contractor shall perform quality control inspection. The manufacturing plant for precast concrete units shall be certified by the Precast/Prestressed Concrete Institute's Plant Certification Program for the type of precast member to be produced, or the National Precast Concrete Association's Plant Certification Program or be an International Congress Building Officials or International Code Council Evaluation Services recognized fabricator of structural precast concrete products, and shall be approved by WSDOT as a Certified Precast Concrete Fabricator prior to the start of production. WSDOT Certification will be granted at, and renewed during, the annual precast plant review and approval process. Products that shall conform to this requirement include noise barrier panels, wall panels, floor and roof panels, marine pier deck panels, retaining walls, pier caps, and bridge deck panels. Precast concrete panels that are prestressed shall meet all the requirements of Section 6-02.3(25).

Prior to the start of production of the precast concrete units, the Contractor shall advise the Engineer of the production schedule. The Contractor shall give the Inspector safe and free access to the Work. If the Inspector observes any nonspecification Work or unacceptable quality control practices, the Inspector will advise the plant manager. If the corrective action is not acceptable to the Engineer, the panel(s) will be rejected.

6-02.3(28)A SHOP DRAWINGS

Before casting the structural elements, the Contractor shall submit Shop Drawings under section 1-05.3.

These Shop Drawings shall show complete details of the methods, materials, and equipment the Contractor proposes to use in prestressing/precasting Work. The Shop Drawings shall follow the design conditions in the Drawings unless the Engineer approves equally effective variations.

The Shop Drawings shall contain as a minimum:

1. Panel shapes (elevations and sections) and dimensions.
2. Finishes and method of constructing the finish (i.e., forming, rolling, etc.).
3. Reinforcing, joint, and connection details.
4. Lifting, bracing, and erection inserts.
5. Locations and details of hardware attached to the Structure.
6. Relationship to adjacent material.

Approval of these Shop Drawings shall not relieve the Contractor of responsibility for accuracy of the drawings or conformity with the Contract. Approval will not indicate a check on dimensions.

The Contractor may deviate from the approved Shop Drawings only after obtaining the Engineer's approval of a written request that describes the proposed changes. Approval of a change in method, material, or equipment shall not relieve the Contractor of any responsibility for completing the Work successfully.

Before completion of the Contract, the Contractor shall provide the Engineer with reproducible originals of the Shop Drawings (and any approved changes). These shall be clear, suitable for microfilming, and on permanent sheets that conform with the size requirements of Section 1-05.3.

6-02.3(28)B CASTING

Before casting precast concrete units, the Contractor and Fabrication Inspector shall have possession of an approved set of Shop Drawings.

Concrete shall meet requirements of Section 6-02.3(25)B for annual pre-approval of the concrete mix design, and slump. If SCC is used, the concrete shall conform to Sections 6-02.3(27)B and 6-02.3(27)C.

Precast units shall not be removed from forms until the concrete has attained a minimum compressive strength of 70-percent of the specified design strength. A minimum compressive strength at other than 70-percent may be used for specific precast units if the fabricator requests and receives approval as part of the WSDOT plant certification process.

Forms may be steel or plywood faced, providing they impart the required finish to the concrete.

6-02.3(28)C CURING

Concrete in the precast units shall be cured by either moist or accelerated curing methods. The methods to be used shall be preapproved in the WSDOT plant certification process.

1. For moist curing, the surface of the concrete shall be kept covered or moist until the compressive strength of the concrete reaches the strength specified for stripping. Exposed surfaces shall be kept continually moist by fogging, spraying, or covering with moist burlap or cotton mats. Moist curing shall commence as soon as possible following completion of surface finishing.
2. For accelerated curing, heat shall be applied at a controlled rate following the initial set of concrete in combination with an effective method of supplying or retaining moisture. Moisture may be applied by a cover

of moist burlap, cotton matting, or other effective means. Moisture may be retained by covering the unit with an impermeable sheet.

Heat may be radiant, convection, conducted steam or hot air. Heat the concrete to no more than 100°F during the first 2-hours after pouring the concrete, and then increase no more than 25°F per hour to a maximum of 175°F. After curing is complete, cool the concrete no more than 25°F per hour to 100°F. Maintain the concrete temperature above 60°F until the unit reaches stripping strength.

Concrete temperature shall be monitored with a thermocouple embedded in the concrete (linked with a thermometer accurate to plus or minus 5°F). The recording sensor (accurate to plus or minus 5°F) shall be arranged and calibrated to continuously record, date, and identify concrete temperature throughout the heating cycle. This temperature record shall be provided to the Engineer for inspection and become a part of the documentation required.

The Contractor shall never allow dry heat to directly touch exposed unit surfaces at any point.

6-02.3(28)D CONTRACTORS CONTROL STRENGTH

The concrete strength at stripping and the verification of design strength shall be determined by testing cylinders made from the same concrete as the precast panels. The cylinders shall be made, handled, and stored under AASHTO T 23 and compression tested under AASHTO Test Method T 22 and AASHTO Test Method T 231.

For accelerated cured units, concrete strength shall be measured on test cylinders cast from the same concrete as that in the panel. These cylinders shall be cured under time-temperature relationships and conditions that simulate those of the panelt. If the forms are heated by steam or hot air, test cylinders will remain in the coolest zone throughout curing. If forms are heated another way, the Contractor shall provide a record of the curing time-temperature relationship for the cylinders for each panel to the Engineer. When 2 or more panels are cast in a continuous line and in a continuous pour, a single set of test cylinders may represent all panels provided the Contractor demonstrates uniformity of casting and curing to the satisfaction of the Engineer.

The Contractor shall mold, cure, and test enough of these cylinders to satisfy Specification requirements for measuring concrete strength. The Contractor may use 4-inch by 8-inch or 6-inch by 12-inch cylinders. The Contractor shall let cylinders cool for at least ½-hour before testing for release strength.

Test cylinders may be cured in a moist room or water tank under AASHTO T-23 after the unit concrete has obtained the required release strength. If, however, the Contractor intends to ship the panel prior to standard 28-Day strength test, the design strength for shipping shall be determined from cylinders placed with the panel and cured under the same conditions as the panel. These cylinders may be placed in a noninsulated, moisture-proof envelope.

To measure concrete strength in the precast panel, the Contractor shall randomly select 2 test cylinders and average their compressive strengths. The compressive strength in either cylinder shall not fall more than 5-percent below the specified strength. If these 2 cylinders do not pass the test, 2 other cylinders shall be selected and tested.

6-02.3(28)E FINISHING

The Contractor shall provide a finish on all relevant concrete surfaces as defined in Section 6-02.3(14), unless the Contract requires otherwise.

6-02.3(28)F TOLERANCES

The panels shall be fabricated as shown in the Drawings, and shall meet the dimensional tolerances listed in the latest edition of PCI-MNL-116, unless otherwise required by the Contract.

6-02.3(28)G HANDLING AND STORAGE

The Contractor shall lift all panels only by adequate devices at locations designated on the Shop Drawings. When these devices and locations are not shown in the Drawings, Section 6-02.3(25)L shall apply.

Precast panels shall be stored off the ground on foundations suitable to prevent differential settlement or twisting of the panels. Stacked panels shall be separated and supported by dunnage of uniform thickness capable of supporting the panels. Dunnage shall be arranged in vertical planes. The upper units of a stacked tier shall not be used as storage areas for shorter panels unless substantiated by engineering analysis and approved by the Engineer.

6-02.3(28)H SHIPPING

Precast panels shall not be shipped until the concrete has reached the specified design strength, and the Engineer has reviewed the fabrication documentation for Contract compliance and stamped the precast concrete panels “Approved for Shipment”. The panels shall be supported in such a manner that they will not be damaged by anticipated impact on their dead load. Sufficient padding material shall be provided between tie chains and cables to prevent chipping or spalling of the concrete.

6-02.3(28)I ERECTION

When the precast panels arrive on the project, the Engineer will confirm that they are stamped “Approved for Shipment.” The Engineer will evaluate the present panels for damage before accepting them.

The Contractor shall lift all panels by suitable devices at locations designated on the Shop Drawings. Temporary shoring or bracing shall be provided, if necessary. Panels shall be properly aligned and leveled as required by the Drawings. Variations between adjacent panels shall be leveled out by a method approved by the Engineer.

6-02.3(29) PATTERNED, COLORED, AND EXPOSED AGGREGATE TREATMENTS

The following three treatments may be used with cement concrete referencing section 6-02. Patterned and Colored or Exposed Aggregate and Colored may be combined for architectural landscaping or artistic surfaces. Payment for the extra effort required to create these three treatments will be per Section 6-02.5**Patterned Cement Concrete Surface Treatment:**

Patterned cement concrete is defined as additional work necessary to imprint cement concrete with a pattern, and is referenced by "Patterned" and “Running Bond Used Brick” or (other pattern) in the Bid item description and call-outs for locations on the Drawings. Other patterns may be shown in on the Drawings or on Drawing Details in the Appendix of the Contract. This extra work is described in Sections 5-05.3(29).

Colored Cement Concrete Treatment:

Colored cement concrete is defined as additional work necessary to color cement concrete with a color, and is referenced by "Colored" and a Federal Standard 595B "F (color code)" in the Bid item description and call-outs for locations on the Drawings. This extra work is described in Sections 5-05.3(29).

Exposed Aggregate Cement Concrete Surface Treatment:

Exposed aggregate cement concrete is defined as additional work necessary to expose aggregate on the surface of cement concrete. This extra work is described in Sections 5-05.3(30).

6-02.4 MEASUREMENT

Except as noted below, all classes of concrete will be measured in place by the cubic yard to the neat lines of the Structure as shown in the Drawings.

Exception: concrete in cofferdam seals. Payment for Class 4000W concrete used in these seals will be based on the volume calculated using the neatline dimensions for the seal as shown in the Drawings. For calculated purposes, the horizontal dimension will be increased by 1-foot outside the seal neatline perimeter. The vertical dimension is the distance between the top and bottom neatline elevations. No payment will be made for any concrete that lies outside of these limits to accommodate the Contractor’s cofferdam configuration. If the Engineer eliminates the seal in its entirety a Contract change order will be issued.

Exception: concrete in a separate lump-sum, Superstructure Bid item. Any concrete quantities noted under this item in the Contract will not be measured. Although the Contract lists approximate quantities for the Contractor’s convenience, the Owner does not guarantee the accuracy of these estimates. Before submitting a Bid, the Contractor shall have verified the quantities. Even though actual quantities used may vary from those listed in the Contract, the Owner will not adjust the lump sum Contract price for Superstructure (except for approved changes).

The Owner will not pay for concrete placed below the established elevation of the bottom of any footing or seal.

Lean concrete will be measured by the cubic yard for the quantity of material placed per the producer’s invoice, except that lean concrete included in other Contract items will not be measured.

No deduction will be made for pile heads, reinforcing steel, structural steel, bolts, weep holes, rustications, chamfers, edgers, joint filler, junction boxes, miscellaneous hardware, ducts or less than 6-inch diameter drain pipes when computing concrete quantities for payment.

All reinforcing steel will be measured by the computed weight of all metal, including mechanical splices, actually in place and required by the Drawings or the Engineer. Epoxy-coated bars will be measured before coating. The Contractor shall furnish (without extra allowance):

1. Spreaders, form blocks, wire clips, and other fasteners.
2. Extra steel in splices not shown in the Drawings or specified in the Drawings as optional.
3. Extra shear steel at construction joints not shown in the Drawings when the Engineer permits such joints for the Contractor’s convenience.

The weight of mechanical splices will be based on the weight specified in the manufacturer’s catalog cut for the specific item.

The following table shall be used to compute weight of reinforcing steel:

Steel Reinforcing Bar

Deformed Bar Designation Number	Nominal Diameter Inches	Unit Weight Pounds per Foot
3	0.375	0.376
4	0.500	0.668
5	0.625	1.043
6	0.750	1.502
7	0.875	2.044
8	1.000	2.670
9	1.128	3.400
10	1.270	4.303
11	1.410	5.313
14	1.690	7.650
18	2.260	13.600

Gravel backfill will be measured as specified in Section 2-10.

Bridge approach slab will be measured by the square yard.

Measurement for "Patterned Cement Concrete, (pattern)" will be by the square yard of area where imprinting tools is applied.

Measurement for "Colored Cement Concrete, (color), F(color code)", will be by the square yard of area of color cement concrete.

Measurement for "Exposed Aggregate Cement Concrete", will be by the square yard of area of exposed aggregate cement concrete.

6-02.5 PAYMENT

Payment shall be made under Section 1-04.1, for each of the following Bid items:

1. "**Conc. Class** ____", per cubic yard.

2. "**Conc. Class ____ w/ ___% minimum pozzolans**", per cubic yard.

3. "**Commercial Concrete**", per cubic yard.

All concrete, except in Superstructure when this is covered by a separate Bid item, shall be paid for at the unit Contract price per cubic yard in place for the various classes of concrete. All costs with furnishing and applying pigmented sealer to concrete surfaces as specified shall be in the unit contract price per cubic yard for "Conc. Class ____..." If the concrete is paid for other than by class of concrete, then the costs shall be in the applicable adjacent item of work

4. "**Superstructure (name bridge)**", lump sum.

5. "**Superstructure (name bridge) w/ ___% minimum pozzolans**", lump sum.

All costs in connection with providing holes for vents, for furnishing and installing cell drainage pipes for box girder Structures, and furnishing and placing grout and shims under steel shoes shall be in the unit Contract prices for the Bid items involved.

All costs with the construction of weep holes, including the gravel backfill for drains surrounding the weep holes except as provided in Section 2-10 shall be included by the Contractor in the unit Contract price per cubic yard for "Conc. Class ____...".

6. "**Lean Concrete**", per cubic yard.

Lean concrete, except when included in another Bid item, shall be paid for at the unit Contract price per cubic yard.

7. "**Steel Reinforcing Bar**", per pound.

8. "**Epoxy-Coated Steel Reinforcing Bar**", per pound.

Payment for reinforcing steel shall include the cost of furnishing, fabricating, placing, and splicing the reinforcement. In Structures of reinforced concrete where there are no structural steel Bid items, such minor metal parts as expansion joints, bearing assemblies, and bolts will be paid for at the unit Contract price for "Reinforcing Bar" unless otherwise specified.

9. "**Gravel Backfill for Foundation Class A**", per cubic yard.

10. "**Gravel Backfill for Foundation Class B**", per cubic yard.

11. "**Gravel Backfill for Wall**", per cubic yard.

12. "**Deficient Strength Conc. Price Adjustment**", by calculation.

"Deficient Strength Conc. Price Adjustment" shall be calculated and paid for as described in Section 6-02.3(5)L. To provide a common Proposal for all Bidders, the Owner has entered zero as an amount for the item "Deficient Strength Conc. Price Adjustment" in the Bid Proposal to become a part of the total Bid by the Contractor. The item "Deficient Strength Conc. Price Adjustment" covers all applicable classes of concrete.

All costs for providing, operating, maintaining, moving and removing the cure boxes and providing, maintaining and operating all necessary power sources and connections needed to operate the curing boxes shall be in the applicable concrete Bid items..

13. "**Bridge Approach Slab**", per square yard.

14. "**Bridge Approach Slab w/ ___% minimum pozzolans**", per square yard.

The unit Contract price per square yard for "Bridge Approach Slab…" shall be full pay for providing, placing, and compacting the crushed surfacing base course, furnishing and placing Class 4000A concrete, and furnishing and installing compression seal, anchors, and reinforcing steel.

15. "**Patterned Cement Concrete Treatment, (pattern)**", per square yard.

The Bid item price for "Patterned Cement Concrete Treatment" shall include all costs for additional work as described in Section 5-05.3(29) and necessary to imprint cement concrete with a pattern referenced in the Bid item description.

16. "**Colored Cement Concrete Treatment, (color), F(color code)**", per cubic yard.

The Bid item price for "Colored Cement Concrete Treatment" shall include all costs for additional work as described in Section 5-05.3(29) and necessary to color cement concrete with a color referenced in the Bid item description.

17. "**Exposed Aggregate Cement Concrete Treatment** ", per square yard.

The Bid item price for "Exposed Aggregate Cement Concrete Treatment" shall include all costs for additional work as described in Section 5-05.3(30) and necessary to expose aggregate of cement concrete per the Contract.

SECTION 6-03 STEEL STRUCTURES

6-03.1 DESCRIPTION

Section 6-03 addresses the work of furnishing, fabricating, erecting, cleaning, and painting steel structures and the structural steel parts of nonsteel Structures.

Any part of a steel Structure made of nonsteel Materials shall comply with the Sections of the Standard Specifications governing those Materials.

6-03.2 MATERIALS

Materials shall meet the requirements of the following Sections:

Structural Steel and Related Materials	9-06
Paints	9-08

Structural steel shall be classified as:

1. Structural carbon steel (to be used whenever the Contract does not specify another classification);
2. Structural low alloy steel; and
3. Structural high strength steel.

Unless the Contract states otherwise, the following shall be classified as structural carbon steel: shims; ladders; stairways; anchor bolts and sleeves; pipe, fittings and fastenings used in handrails; and other metal parts, even if made of other materials, for which payment is not specified.

All AASHTO M 270 material used in what the Drawings show as main load-carrying tension members or as tension components of flexural members shall meet the Charpy V-notch requirements of AASHTO M 270, temperature zone 2. All AASHTO M 270 material used in what the Drawings show as fracture critical members shall meet the Charpy V-notch requirements of AASHTO M 270, Fracture Critical Impact Test requirements, temperature zone 2. Charpy V-notch requirements for other steel materials shall be as specified in the Contract. Filler metals for welding shall meet the toughness requirements of the welding code specified in Section 6-03.3(25).

The Contractor shall submit for the Engineer's approval a written plan for visibly marking the material so it can be traced. These marks shall remain visible at least through the fit-up of the main load-carrying tension members. The marking method shall include the following information:

(1) material specification designation,

(2) heat number, and

(3) material test reports to meet any special requirements.

As-built drawings: for steel in main load-carrying tension members and in tension components of flexural members, the Contractor shall include the heat numbers on the reproducible copies of the as-built Shop Drawings (see Section 1-05.3(11)).

6-03.3 CONSTRUCTION REQUIREMENTS

Structural steel fabricators of girders, floorbeams, truss members, and stringers, for permanent steel bridges, shall be certified under the AISC Quality Certification Program, Category III, Major Steel Bridges. When fracture critical members are specified in the Contract, structural steel fabricators shall also have an endorsement F, Fracture Critical, under the AISC Quality Certification Program.

6-03.3(1) NOTICE OF ROLLING

Before rolling work begins, the Contractor shall provide enough advance notice that the Engineer may observe it. The Contractor shall inform the Engineer of who is to do the work and where it is to be done. No material shall be rolled until the Engineer gives written notice to Proceed.

6-03.3(2) FACILITIES FOR INSPECTION

See Sections 1-05.6 and 1-06 for the Engineer's right to inspect Material and workmanship.

6-03.3(3) INSPECTOR'S AUTHORITY

See Section 1-05.

6-03.3(4) REJECTIONS

See Sections 1-05 and 1-06.

6-03.3(5) MILL ORDERS AND SHIPPING STATEMENTS

The Contractor shall furnish as many copies of mill orders and shipping statements as the Engineer requires.

6-03.3(6) WEIGHING

Structural steel need not be weighed unless specified otherwise in the Contract. When weight is specified, it may either be calculated or obtained by scales. The Contractor shall furnish 4 copies of the calculations or weight slips unless the Contract specifies another quantity. If scale weights are used, the Contractor shall record separately the weights of all tools, erection material, and dunnage.

6-03.3(7) SUBMITTALS

6-03.3(7)A SHOP DRAWINGS AND AS-BUILT RECORDS

The Contractor shall submit to the Engineer for review all Shop Drawings, and certified mill test reports, for fabricating the steel. Prints of the Shop Drawings shall be supplied in these quantities:

Ten sets to the Engineer (four more sets are required for each affected railroad company on any grade separation structure that carries a railroad over a highway).

The Engineer will return the Shop Drawings to the Contractor. When Shop Drawing sheets returned by the Engineer require correction, the Contractor shall correct and resubmit them in the quantities required above. No material shall be fabricated until:

(1) the Engineer has reviewed all Shop Drawings; and

(2) the SPU Materials Laboratory has approved the Material source(s) and the fabricator(s).

See Section 1-05.3 regarding Shop Drawings.

As-built records: Before the Physical Completion Date can be established, the Contractor shall furnish the Engineer one set of reproducible copies of the as-built Shop Drawings (see Sections 1-05.3(13) and 1-05.3(14)). An additional set of as-built Shop Drawings is required for each affected railroad company on any grade separation Structure that carries a railroad over a transportation Right of Way. The reproducible as-built Shop Drawings shall be 22 inches by 34 inches and shall meet the requirements of Section 1-05.3(11).

6-03.3(7)B ERECTION METHODS

The Contractor shall submit a steel erection plan and procedure describing the methods the Contractor intends to use to the Engineer for review. The Contractor shall have received the Engineer's returned submittal for the erection plan and procedure before doing this work. The Contractor's erection plan and procedure shall first be reviewed by the steel fabricator prior to being submitted to the Engineer. The Contractor's submittal shall include evidence that the fabricator has reviewed the erection Shop Drawings and procedures; and shall submit the fabricator's review comments with the erection plan submittal.

The erection plan and procedure shall explain the erection process including but not limited to:

1. Temporary falsework support, bracing, guys, deadmen, and attachments to other structure components or objects;
2. Procedure and sequence of operation;
3. Girder stresses during progressive stages of erection;
4. Girder masses, lift points, and lifting devices, spreaders, glommers, etc.;
5. Crane(s) make and model, masses, geometry, lift capacity, outrigger size and reactions;
6. Girder launcher or trolley details and capacity (if intended for use); and
7. Locations of cranes, barges, trucks delivering girders, and the location of cranes and outriggers relative to other structures, including retaining walls and wing walls.

The erection plan shall include Shop Drawings, notes, catalog cuts, calculations showing the above listed details, assumptions, and dimensions, material properties, specifications, structural analysis, and any other necessary data. The erection plan shall be prepared by a professional engineer under Section 1-05.3(12).

The Contractor shall submit the erection Shop Drawings, calculations, procedure, and fabricator's comments directly to the Engineer, under Section 6-02.3(16). After the plan is reviewed and returned to the Contractor, any change that the Contractor proposes to the reviewed submittal shall be under Section 1-05.3(6).

6-03.3(8) SUBSTITUTIONS

The Contractor shall not substitute sections that differ from Drawings or Engineer reviewed Shop Drawings dimensions unless the Contractor has submitted the substitution for review by the Engineer. If the Contractor's submittal requests substitution of heavier members which exceed Contract requirements, such substitution shall be at no additional cost to the Owner. Also see the requirements of Sections 1-05.3(6).

6-03.3(9) HANDLING, STORING, AND SHIPPING OF MATERIALS

Markings applied at the mill shall distinguish structural low alloy steel from structural carbon steel. The fabricator shall keep the two classes of steel carefully separated.

Before fabrication, all material stored at the fabricating plant shall be protected from rust, dirt, oil, and other foreign matter. The Owner will not accept rust-pitted material.

After fabrication, all material awaiting shipment shall be subject to the same storage requirements as unfabricated material.

All structural steel shall arrive at the Project Site in a condition meeting or exceeding the specified requirements. Steel damaged by salt water shipment shall be thoroughly cleaned by high pressure water flushing, chemical cleaning, or sandblasting, and repainted with the specified shop coat in compliance with specified requirements.

All material shall be stored to prevent rust and loss of small parts. Piled material shall rest on skids or platforms, and shall not make contact with the ground or with water.

The loading, transporting, unloading, and stockpiling of the structural steel material shall be so conducted that the metal is kept clean and free from injury from rough handling.

In field assembly of structural parts, the Contractor shall use methods and equipment that shall not twist, bend, deform, or otherwise injure the metal. Any bent or twisted member shall be corrected before it is placed. The Owner will accept no member with damage.

Girder sections shall be handled to prevent damage to the girders. The Contractor shall provide temporary stiffeners to prevent buckling during erection as necessary.

6-03.3(10) CORRECTING BENT MATERIAL

Plates, angles, other shapes, and built-up members may be straightened if authorized in writing by the Engineer. Straightening methods shall not fracture or injure the metal. Distorted members shall be straightened mechanically. A limited amount of localized heat may be applied only if carefully planned and supervised, and only if the Engineer has approved a heat-straightening procedure in writing.

Parts to be heat-straightened shall be free from all stress and external forces except those that result from the mechanical pressure used with the heat.

After straightening, the Contractor shall inspect the member for fractures using a method specified in the Contract.

The Engineer will reject metal showing sharp kinks and bends.

The procedure for heat straightening of universal mill (UM) plates by the mill or the fabricator shall be submitted to the Engineer for review prior to doing this work.

6-03.3(11) WORKMANSHIP AND FINISH

Workmanship and finish shall be first-class, equaling the best practice in modern bridge fabrication shops. Welding, shearing, burning, chipping, and grinding shall be done neatly and accurately. All parts of the work exposed to view shall be neatly finished.

Wherever the Drawings show a surface finish symbol, the surface shall be machined.

6-03.3(12) FALSEWORK

All falsework shall conform to the requirements specified in Section 6-02.

6-03.3(13) FABRICATING TENSION MEMBERS

Plates for main load-carrying tension members or tension components of flexural members shall be:

1. Blast cleaned entirely or blast cleaned on all areas within 2 inches of welds to SSPC-SP6, Commercial Blast Cleaning; and
2. Fabricated from plate stock with the primary rolling direction of the stock parallel to the length of the member.

6-03.3(14) EDGE FINISHING

All rolled, sheared, and flame-cut edges shall be true to line and free of rough corners and projections. Corners along exposed edges shall be rounded to a minimum radius of 1/16-inch.

Sheared edges on plates more than 5/8 inch thick shall be planed, milled, ground, or flame-cut to a depth of at least 1/8 inch.

Re-entrant corners or cuts shall be filleted to a minimum radius of 3/4 inch.

Exposed edges of main load-carrying tension members or tension components of flexural members shall have a surface roughness no greater than 250 micro-inches as defined by the American National Standards Institute, ANSI B46.1, Surface Texture. Exposed edges of other members shall have surface roughness no greater than 1,000 micro-inches.

The hardness of flame-cut edges of structural low alloy plates, as specified in Section 9-06.2, for main load-carrying tension members or tension components of flexural members shall meet the requirements outlined in Appendix A, “Testing Rockwell Hardness of Flame-cut Edges” to be found in the appendix of the Project Manual. The Contractor shall prevent excessive hardening of plate edges through preheating, postheating, or control of the burning process as recommended by the steel manufacturer and approved by the Engineer.

6-03.3(15) PLANING OF BEARING SURFACES

Ends of columns that bear on base and cap plates shall be milled to true surfaces and accurate bevels.

When assembled, caps and base plates of columns and the sole plates of girders and trusses shall have full contact. If warped or deformed, the plates shall be heat straightened, planed, or corrected in some other way to produce accurate, even contact. If necessary for proper contact, bearing surfaces that are in contact with other metal surfaces shall be planed or milled. Surfaces of warped or deformed base and sole plates that are to in contact with masonry shall be rough finished.

On the surface of expansion bearings, the cut of the planer shall be in the direction of expansion.

6-03.3(16) ABUTTING JOINTS

Abutting ends of compression members shall be faced accurately so they bear evenly when in the Structure. On built-up members, the ends shall be faced or milled after fabrication.

Ends of tension members at splices shall be rough finished to produce neat, close joints. A contact fit is not required.

6-03.3(17) END CONNECTION ANGLES

On floorbeams and stringers, end connection angles shall be flush with each other and set accurately in relationship to the position and length of the member. End connection angles shall not be finished unless specified otherwise in the Contract. If, however, faulty assembly requires them to be milled, milling shall not reduce thickness by more than 1/16 inch.

6-03.3(18) BUILT-UP MEMBERS

The various pieces forming one built-up member shall be straight and close-fitting, true to detailed dimensions, and free from twists, bends, open joints, or other defects.

When fabricating curved girders, localized heat or using mechanical force shall not be used to bend the girder flanges about an axis parallel to the girder webs.

6-03.3(19) HAND HOLES

Hand holes, whether punched or cut with burning torches, shall be true to sizes and shapes shown on the Drawings. Edges shall be true to line and ground smooth.

6-03.3(20) LACING BARS

Unless the Contract states otherwise, ends of lacing bars shall be neatly rounded.

6-03.3(21) PLATE GIRDERS

6-03.3(21)A WEB PLATES

If web plates are spliced, clearance between plate ends shall not exceed 3/8 inch.

6-03.3(21)B RESERVED

6-03.3(21)C WEB SPLICES AND FILLERS

Web splice plates and fillers under stiffeners shall fit within 1/8 inch at each end. In lieu of the steel material specified in the Drawings or Special Provisions, the Contractor may substitute ASTM A 1008 or ASTM A 1011 steel for all filler plates less than ¼ inch thickness, provided that the grade of filler plate steel meets or exceeds that of the splice plates.

6-03.3(22) EYEBARS

Eyebars shall be straight, true to size, and free from twists or folds in the neck or head and from any other defect that would reduce their strength. Heads shall be formed by upsetting, rolling, or forging. Dies in use by the manufacturer may determine the shape of bar heads if approved in writing by the Engineer. Head and neck thickness shall not overrun by more than 1/16 inch. Welds shall not be made in the body or head of any bar.

Each eyebar shall be properly annealed and carefully straightened before it is bored. Pinholes shall be on the centerline of each bar and in the center of its head. Holes in bar ends shall be so precisely located that in a pile of bars for the same truss panel, the pins may be inserted completely without driving. All eyebars made for the same locations in trusses shall be interchangeable.

6-03.3(23) ANNEALING

All eyebars shall be annealed by being heated uniformly to the proper temperature, then cooled slowly and evenly in the furnace. At all stages, the temperature of the bars shall be under full control.

Slight bends on secondary steel members may be made without heat. Crimped web stiffeners need no annealing.

6-03.3(24) PINS AND ROLLERS

6-03.3(24)A GENERAL

Pins and rollers shall be made of the class of forged steel as specified on the Drawings. They shall be turned accurately to detailed dimensions, smooth, straight, and flawless. The final surface shall be produced by a finishing cut.

Pins and rollers 9 inches or less in diameter may either be forged and annealed, or made of cold-finished carbon steel shafting.

Pins over 9 inches in diameter shall have holes at least 2 inches in diameter bored longitudinally through their centers. Pins with inner defects will be rejected.

The Contractor shall provide pilot and driving nuts for each size of pin unless the Contract specifies otherwise.

6-03.3(24)B BORING PIN HOLES

Pin holes shall be bored true to detailed dimensions, smooth and straight, and at right angles to the axis of the member. Holes shall be parallel with each other unless the Contract specifies otherwise. A finishing cut shall always be made.

The distance between holes shall not vary from detailed dimensions by more than 1/32 inch. In tension members, this distance shall be measured from outside to outside of holes. In compression members, this distance shall be measured from inside to inside of holes.

6-03.3(24)C PIN CLEARANCES

Each pin shall be 1/50-inch smaller in diameter than its hole. All pins shall be numbered after being fitted into their holes in the assembled member.

6-03.3(25) WELDING AND REPAIR WELDING

6-03.3(25)A GENERAL

Welding and repair welding of all steel bridges shall comply with the AASHTO / AWS D1.5M/D1.5:2010, Bridge Welding Code. Welding and repair welding for all other steel fabrication shall comply with AWS D1.1/D1.1M, latest edition, Structural Welding Code. The requirements described in the remainder of this Section shall prevail whenever they differ from either of the above welding codes.

Welding of structural steel will be permitted only to the extent shown on the Drawings. No welding, including tack and temporary welds, shall be done in the shop or field unless the location of the welds is shown on the submitted Shop Drawings reviewed by the Engineer.

Welding procedures shall be submitted with the Shop Drawings. The procedures shall specify the type of equipment to be used, electrode selection, preheat requirements, base materials, and joint details. When the procedures are not prequalified by AWS or AASHTO, evidence of qualification tests indicating the approval of a recognized agency shall be in the submittal.

Welding shall not begin until after the Contractor has received the Engineer's review of Shop Drawings as required in Section 6-03.3(7). These Shop Drawings shall include procedures for welding, assembly, and any heat-straightening or heat-curving.

Any welded shear connector longer than 8 inches may be made of two shorter shear connectors joined with full-penetration welds.

In shielded metal-arc welding, the Contractor shall use low-hydrogen electrodes.

In submerged-arc welding, flux shall be oven-dried at 550°F for at least 2 hours, then stored in ovens held at 250°F or more. If not used within 4 hours after removal from a drying or storage oven, flux shall be redried before use.

Preheat and interpass temperatures shall conform to the welding code as specified in this Section. When welding main members of steel bridges, the minimum preheat shall not be less than 100°F.

If groove welds (web-to-web or flange-to-flange) have been rejected, they may be repaired no more than twice. If a third failure occurs, the Contractor shall at the Engineer's discretion:

1. Trim the members, if the Engineer approves, at least 1/2 inch on each side of the weld; or
2. Replace the members at no additional cost to the Owner.

By using extension bars and runoff plates, the Contractor shall terminate groove welds to ensure the soundness of each weld to its ends. The bars and plates shall be removed after the weld is finished and cooled. The weld ends shall then be ground smooth and flush with the edges of abutting parts.

The Contractor shall not:

a. Weld with electrogas or electroslag methods;
b. Weld nor flame cut when ambient temperature is below 20°F; or
c. Use coped holes in the web for welding butt splices in the flanges unless the Drawings show them.

6-03.3(25)B WELDING INSPECTION

The Contractor's inspection procedures, techniques, methods, acceptance criteria and inspector qualifications for welding of steel bridges shall be in accordance with the AASHTO / AWS D1.5M/D1.5: 2010, Bridge Welding Code. The Contractor's inspection procedures, techniques, methods, acceptance criteria and inspector qualifications for welding of steel Structures other than steel bridges shall be in accordance with AWS D1.1/D1.1M, latest edition, Structural Welding Code. The requirements described in the remainder of this section shall prevail whenever they differ from either of the above welding codes.

Nondestructive testing, in addition to visual inspection, shall be performed by the Contractor. Unless otherwise specified in the Contract, the extent of inspection shall be as specified in this Section. Testing and inspection shall apply to welding performed in the shop and in the field.

After the Contractor's welding inspection is complete, the Contractor shall allow the Engineer sufficient time to perform quality assurance ultrasonic welding inspection.

Visual Inspection

All welds shall be 100 percent visually inspected. Visual inspection shall be performed before, during, and after completing welding.

Radiographic Inspection

Complete penetration tension groove welds in highway bridges shall be 100 percent radiographically inspected. These welds include those in the tension area of webs where inspection shall cover the greater of these two distances:

a. 15 inches from the tension flange or
b. one third of the web depth. In addition, edge blocks conforming to the requirements of AASHTO/AWS D1.5M/D1.5: 2010 Bridge Welding Code Section 6.10.14 shall be used for radiographic inspection.

The Contractor shall maintain the radiographs and the radiographic inspection report in the shop until the last joint to be radiographed in that member is accepted by the radiographer representing the Contractor. Within 2 Working Days following this acceptance, the Contractor shall submit the film and two copies of the radiographic inspection report to the Engineer.

Ultrasonic Inspection

Complete penetration groove welds on plates thicker than 5/16 inch in the following welded assemblies or structures shall be 100 percent ultrasonically inspected:

a. Welded connections and splices in highway bridges and earth retaining Structures, excluding longitudinal butt welds in beam or girder webs;
b. Bridge bearings and modular expansion joints;
c. Sign bridges, cantilever sign Structures, and bridge mounted sign brackets excluding longitudinal butt joint welds in beams;
d. Light, signal, and strain pole standards; and Steel Casing for concrete columns. Steel Casing for concrete columns.

The testing procedure and acceptance criteria for tubular members shall conform with Section 10 of the latest edition of the AWS Structural Welding Code D1.1/D1.1M.

Magnetic Particle Inspection

a. Fillet and partial penetration groove welds: At least 30 percent of each size and type of fillet welds (excluding intermittent fillet welds) and partial penetration groove welds in the following welded assemblies or Structures shall be tested by the magnetic particle method:
   (1) Flange-to-web connections in highway bridges;
   (2) End and intermediate pier diaphragms in highway bridges;
   (3) Stiffeners and connection plates in highway bridges;
   (4) Welded connections and splices in earth retaining Structures;
   (5) Boxed members of trusses;
   (6) Bridge bearings and modular expansion joints;
   (7) Sign bridges, cantilever sign Structures, and bridge mounted sign brackets; and
   (8) Light, signal, and strain pole standards.
b. Longitudinal butt welds in beam and girder webs: At least 30 percent of each longitudinal butt weld in the beam and girder webs shall be tested by the magnetic particle method.
c. Complete penetration groove welds on plates 5/16 inch or thinner shall be 100 percent tested by the magnetic particle method. Testing shall apply to both sides of the weld, if backing plate is not used.
d. The ends of each complete penetration groove weld at plate edges shall be tested by the magnetic particle method.

The Contractor shall have all welds of structural members inspected by 100% radiographic or ultrasonic inspection, or by a combination of both, under the specification in 2. and 3. above and in compliance with the last paragraph of this section.

Where 100 percent testing is not required, the Engineer reserves the right to select the location(s) for testing.

If rejectable flaws are found in any test length of weld in item 4. Magnetic Particle Inspection, subitems (a) or (b) in this Section, the full length of the weld or 5 feet on each side of the test length, whichever is less, shall be tested.

After repairs of defects have been made, additional nondestructive testing shall be performed to ensure that the repairs are acceptable. This testing shall include the repaired area plus at least 2 inches on each side of the repaired area.

After the Contractor has completed his welding inspection, the Contractor shall allow the Engineer sufficient time to perform quality assurance ultrasonic welding inspection.

The Contractor shall maintain the video records of ultrasonic inspections and the ultrasonic inspection reports in the shop until the last joint to be tested by ultrasonic means has been accepted by the inspector conducting these inspections for the Contractor. Within 2 Working Days following this acceptance, the Contractor shall mail the film and video record with 2 copies each of the radiographic and ultrasonic inspection reports to the Engineer.

6-03.3(26) SCREW THREADS

Screw threads shall be U.S. Standard and shall fit closely in the nuts.

6-03.3(27) HIGH STRENGTH BOLT HOLES

At the Contractor's option under the conditions described in this Section, holes may be punched or subpunched and reamed, drilled or subdrilled and reamed, or formed by numerically controlled drilling operations.

The hole for each high strength bolt shall be 1/16-inch larger than the nominal diameter of the bolt.

In fabricating any connection, the Contractor may subdrill or subpunch the holes and then ream full size after assembly or drill holes full size from the solid with all thicknesses of material shop assembled in the proper position. If the Contractor chooses not to use either of these methods, the following shall apply:

1. Drill bolt holes in steel splice plates full size using steel templates;
2. Drill bolt holes in the main members of trusses, arches, continuous beam spans, bents, towers, plate girders, box girders, and rigid frames at all connections as follows:
   a. A minimum of 30 percent of the holes in one side of the connection shall be made full size using steel templates;
   b. A minimum of 30 percent of the holes in the second side shall be made full size assembled in the shop; and
   c. All remaining holes may be made full size in unassembled members using steel templates; and
3. Drill bolt holes in crossframes, gussets, lateral braces, and other secondary members full size using steel templates.

The Contractor shall submit for the Engineer's review, a detailed outline of the procedures proposed to accomplish the work from initial drilling through shop assembly.

6-03.3(27)A PUNCHED HOLES

For punched holes, die diameter shall not exceed punch diameter by more than 1/16 inch. Any hole requiring enlargement to admit the bolt shall be reamed. All holes shall be cut clean with no torn or ragged edges. The Owner will reject components having poorly matched holes.

6-03.3(27)B REAMED AND DRILLED HOLES

Reaming and drilling shall be done with twist drills, or with short taper reamers, producing cylindrical holes perpendicular to the member. Reamers and drills shall be directed mechanically, not hand-held. Connecting parts that require reamed or drilled holes shall be assembled and held securely as the holes are formed, then match-marked before disassembly. The Contractor shall provide the Engineer with a diagram showing these match-marks. The Owner will reject components having poorly matched holes.

Burrs on outside surfaces shall be removed. The Contractor shall disassemble parts to remove burrs as applicable.

If templates are used to ream or drill full-size connection holes, the templates shall be positioned and angled with accuracy and bolted securely in place. Templates for reaming or drilling matching members, or the opposite face of one member, shall be duplicates. All splice components shall be match-marked.

6-03.3(27)C NUMERICALLY CONTROLLED (N/C) DRILLED CONNECTIONS

In forming any hole described in Section 6-03.3(27), the fabricator may use numerically controlled (N/C) drilling or punching equipment if it meets the requirements in this Section.

The Contractor shall submit for review, a detailed outline of proposed N/C procedures. This outline shall:

1. Cover all steps from initial drilling or punching through check assembly; and
2. Include the specific members of the Structure to be drilled or punched, hole sizes, locations of the common index and other reference points, makeup of check assemblies, and all other information needed to describe the process fully.

N/C holes may be drilled or punched to size through individual pieces, or may be drilled through any combination of pieces restrained from moving while being drilled.

At the Engineer's request, the Contractor shall demonstrate that the N/C procedures consistently produces holes and connections meeting the requirements of these Specifications.

6-03.3(27)D ACCURACY OF PUNCHED, SUBPUNCHED AND SUBDRILLED HOLES

After shop assembly and before reaming, all punched, subpunched, and subdrilled holes shall meet the following standard of accuracy. At least 75 percent of the holes in each connection shall permit passing a cylindrical pin 1/8-inch smaller in diameter than nominal hole size. This pin shall pass through at right angles to the face of the member without drifting. All holes shall permit passage of a pin 3/16-inch smaller in diameter than nominal hole size. The Owner will reject any pieces that fail to meet these standards.

6-03.3(27)E ACCURACY OF REAMED AND DRILLED HOLES

At least 85 percent of all holes in a connection of reamed or drilled holes shall show no offset greater than 1/32-inch between adjacent thicknesses of metal. No hole shall have an offset greater than 1/16-inch.

Centerlines from the connection shall be inscribed on the template, and holes shall be located from these centerlines. Centerlines shall also be used for accurately locating the template relative to the milled or scribed ends of the members.

Templates shall have a hardened steel bushing inserted into each hole. These bushings may be omitted, however, if the fabricator can acceptably demonstrate this to the Engineer:

(1) that the template is used only 5 times, and

(2) that use produces no template wear.

Each template shall be at least 1/2-inch thick. Thicker templates shall prevent buckling and misalignment as the holes are formed.

6-03.3(27)F FITTING FOR BOLTING

Before drilling, reaming, and bolting begins, all parts of a member shall be assembled, well pinned, and drawn firmly together. If necessary, assembled pieces shall be taken apart to permit removal of any burrs or shavings produced as the holes are formed. The member shall be free from twists, bends, and other deformation.

In shop-bolted connections, contacting metal surfaces shall be sandblasted clean before assembly. Sandblasting shall meet the SSPC Specifications for Commercial Blast Cleaning (SSPC-SP 6).

Any drifting done during assembly shall be only enough to bring the parts into place. Drifting shall not enlarge the holes or distort the metal.

6-03.3(28) SHOP ASSEMBLY

6-03.3(28)A METHOD OF SHOP ASSEMBLY

Unless the Contract specifies otherwise, the Contractor shall choose from the following 5 described shop assembly methods, the method that best fits the proposed erection method. The Contractor shall submit and obtain review from the Engineer, both the shop assembly and the erection methods before this work begins.

1. **Full Truss or Girder Assembly**: Each truss or girder is completely assembled over the full length of the superstructure.
2. **Progressive Truss or Girder Assembly**: Each truss or girder is assembled in stages longitudinally over the full length of the superstructure.
   a. **For trusses**: The first stage shall include at least three adjacent truss panels. Each truss panel shall include all of the truss members in the space bounded by the top and bottom chords and the horizontal distance between adjacent bottom chord joints.
   b. **For girders**: The first stage shall include at least three adjacent girder shop sections. Shop sections are measured from the end of the girder to the first field splice or from field splice to field splice.
   c. **For trusses and girders**: After the first stage has been completed, each subsequent stage shall be assembled to include: two truss panels or girder shop sections of the previous stage and one or more truss panels or girder shop sections added at the advancing end. The previous stages shall be repositioned if necessary, and pinned to ensure accurate alignment.

      For girders on tangents without skews or tapers, the Contractor may assemble subsequent stages which include one girder shop section of the previous stage and two or more girder shop sections at the advancing end.

      If the bridge is longer than 150 feet, each longitudinal stage shall be at least 150 feet long, regardless of the length of individual continuous truss panels or girder shop sections.

      The Contractor may begin the assembly sequence at any point on the bridge and proceed in either or both directions from that point.

      No assembly shall have less than three truss panels or girder shop sections.
3. **Full Chord Assembly**: The full length of each chord for each truss is assembled with geometric angles at the joints. Chord connection bolt holes are drilled/reamed while members are assembled. The truss web member connections are drilled/reamed to steel templates set by relating geometric angles to the chord lines.

   At least one end of each web member shall be milled or scribed at right angles to its long axis. The templates at both ends of the member shall be positioned accurately from the milled end or scribed line.

4. **Progressive Chord Assembly**: Adjacent chord sections are assembled in the same way as specified for Full Chord Assembly, using the procedure specified for Progressive Truss or Girder Assembly.
5. **Special Complete Structure Assembly**: All structural steel members (superstructure and substructure, including all secondary members) are assembled at one time.

6-03.3(28)B CHECK OF SHOP ASSEMBLY

The Contractor shall check each assembly for alignment, accuracy of holes, fit of milled joints, and other assembly techniques. Drilling or reaming shall not begin until the Engineer has given written approval. If the Contractor uses N/C drilling, this written approval from the Engineer shall be obtained before the assembly or stage is dismantled.

6-03.3(29) WELDED SHEAR CONNECTORS

All welded shear connectors on steel girder top flanges shall be installed in the field after the forms for the concrete bridge deck are in place. The steel surface to be welded shall be prepared to SSPC-SP 11, power tool cleaning, just prior to welding. Installation, production control, and inspection of welded shear connectors shall conform to Chapter 7 of the AASHTO/AWS D1.5M/D1.5: 2010 Bridge Welding Code. After the welded shear connectors are installed, the weld and the disturbed steel surface shall be cleaned and painted in accordance with Section 6-07.3(9)I.

6-03.3(30) PAINTING

All painting shall be in accordance with Section 6-07.

6-03.3(30)A RESERVED

6-03.3(30)B RESERVED

6-03.3(30)C ERECTION MARKS

Erection marks to permit identification of members in the field shall be painted on previously painted surfaces.

6-03.3(30)D MACHINE-FINISHED SURFACES

As soon as possible and before they leave the shop, machine-finished surfaces on abutting chord splices, column splices, and column bases shall be covered with grease. After erection, the steel shall be cleaned and painted as specified.

All surfaces of iron and steel castings milled to smooth the surface shall be painted with the primer called for in the specified paint system.

While still in the shop, machine-finished surfaces and inaccessible surfaces of rocker or pin-type bearings shall receive the full paint system. Surfaces of pins and holes machine-finished to specific tolerances shall not be painted. However, as soon as possible and before they leave the shop, they shall be coated with grease.

6-03.3(31) ALIGNMENT AND CAMBER

6-03.3(31)A GENERAL

Before beginning field bolting, the Contractor shall:

1. Adjust the structure to correct grade and alignment;
2. Regulate elevations of panel points (ends of floorbeams); and
3. Delay bolting at compression joints until adjusting the blocking to provide full and even bearing over the whole joint.

On truss spans, a slight excess camber will be permitted as the bottom chords are bolted. But camber and relative elevations of panel points shall be correct before the top chord joints, top lateral system, and sway braces are bolted.

6-03.3(31)B MEASURING CAMBER

The Contractor shall provide the Engineer with a diagram for each truss that shows camber at each panel point. This diagram shall display actual measurements taken as the truss is being assembled.

6-03.3(32) ASSEMBLING AND BOLTING

To bolt any field connection or splice, the Contractor shall install and tighten to snug-tight enough bolts to bring all parts into full contact with each other prior to tightening the bolts to the specified minimum tension.

"Snug-tight" means either the tightness reached by:

(1) a few blows from an impact wrench, or

(2) the full effort of a person using a spud wrench.

As erection proceeds, all field connections and splices for each member shall be securely drift-pinned and bolted as described below, before the weight of the member can be released or the next member is added. Field erection Shop Drawings shall specify pinning and bolting requirements that meet or exceed the following minimums:

1. **Joints in Normal Structures**: Fifty percent of the holes in a single field connection and 50 percent of the holes on each side of a single joint in a splice plate shall be filled with drift pins and bolts. 30 percent of the filled holes shall be pinned. 70 percent of the filled holes shall be bolted and tightened to snug-tight. Once all these bolts are snug-tight, each bolt shall be systematically tightened to the specified minimum tension. "Systematically tightened" means beginning with bolts in the most rigid part, which is usually the center of the joint, and working out to its free edges. The fully tensioned bolts shall be located near the middle of a single field connection or a single splice plate.

2. **Joints in Cantilevered Structures**: 75 percent of the holes in a single field connection and 75 percent of the holes on each side of a single joint in a splice plate shall be filled with drift pins and bolts. 50 percent of the filled holes shall be pinned. 50 percent of the filled holes shall be bolted and tightened to snug-tight. Once all these bolts are snug-tight, each bolt shall be systematically tightened to the specified minimum tension. The fully tensioned bolts shall be located near the middle of a single field connection or a single splice plate.

Cylindrical erection pins (drift pins) shall be placed throughout each field connection and each field joint with the greatest concentration in the outer edges of a splice plate or member being bolted. Drift pins shall be double-tapered barrel pins of hardened steel. The diameter of the drift pins shall be at least 1/32 inch larger than the diameter of the bolts in the connection or the full hole diameter.

To complete a joint following the method listed above, the Contractor shall fill all remaining holes of the field connection or splice plate with bolts and tighten to snug-tight. Once all of these bolts are snug-tight, each bolt shall be systematically tightened to the specified minimum tension. After these bolts are tightened to the specified minimum tension, the Contractor shall replace the drift pins with bolts tightened to the specified minimum tension.

The Contractor may complete a field bolted connection or splice in a continuous operation before releasing the mass of the member or adding the next member. The Contractor shall utilize drift pins to align the connection. The alignment drift pins shall fill between 15 and 30 percent of the holes in a single field connection and between 15 and 30 percent of the holes on each side of a single joint in a splice plate. Once the alignment drift pins are in place, all remaining holes shall be filled with bolts and tightened to snug-tight starting from near the middle and proceeding toward the outer gage lines. Once all of these bolts are snug-tight, the Contractor shall systematically tighten all these bolts to the specified minimum tension. The Contractor shall then replace the drift pints with bolts. Each of these bolts shall be tightened to the specified minimum tension.

All bolts shall be placed with heads toward the outside and underside of the bridge. All high-strength bolts shall be installed and tightened before the falsework is removed.

The Contractor may erect metal railings as erection proceeds. But railings shall not be bolted or adjusted permanently until the falsework is released and the deck placed.

The Contractor shall not begin painting until the Engineer has inspected and accepted field bolting.

6-03.3(33) BOLTED CONNECTIONS

Fastener components shall consist of bolts, nuts, washers, tension control bolt assemblies, and direct tension indicators. Fastener components shall meet the requirements of Section 9-06.5(3).

The Contractor shall submit documentation of the bolt tension calibrator for approval by the Engineer and shall include brand, capacity, model, date of last calibration, and manufacturer's instructions for use. The Contractor shall supply the approved bolt tension calibrator and all accompanying hardware and calibrated torque wrenches to conduct all testing and inspections described herein. Use of the bolt tension calibrator shall comply with manufacturer's recommendations.

Fastener components shall be protected from dirt and moisture in closed containers at the site of installation. Only as many fastener components as are anticipated to be installed during the Work shift shall be taken from protected storage. Fastener components that are not incorporated into the Work shall be returned to protected storage at the end of the Work shift. Fastener components shall not be cleaned or modified from the as-delivered condition. Fastener components that accumulate rust or dirt shall not be incorporated into the Work. Tension control bolt assemblies shall not be relubricated, except by the manufacturer.

All bolted connections are slip critical. Painted structures require either Type 1 or Type 3 bolts. Unpainted structures require Type 3 bolts. AASHTO M 253 bolts shall not be galvanized or be used in contact with galvanized metal.

Washers are required under turned elements for bolted connections and as required in the following:

1. Washers shall be used under both the head and the nut when AASHTO M 253 bolts are to be installed in structural carbon steel, as specified in Section 9-06.1.
2. Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, a beveled washer shall be used.
3. Washers shall not be stacked unless otherwise approved by the Engineer.
4. It is acceptable to place a washer under the unturned element.

All galvanized nuts shall be lubricated by the manufacturer with a lubricant containing a visible dye so a visual check for the lubricant can be made at the time of field installation. Black bolts shall be lubricated by the manufacturer and shall be "oily" to the touch when installed.

After assembly, bolted parts shall fit solidly together. Bolted parts shall not be separated by washers, gaskets, or any other material. Assembled joint surfaces, including those next to bolt heads, nuts, and washers, shall be free of loose mill scale, burrs, dirt, and other foreign material that would prevent solid seating.

When all bolts in a joint are tight, each bolt shall carry at least the proof load shown in the following Table 1:

Table 1		
Minimum Bolt Tension		
Bolt Size (Inches)	**AASHTO M 164 ASTM F 1852**(Pounds)	**AASHTO M 253** (Pounds)
½	12,050	14,900
5/8	19,200	23,700
¾	28,400	35,100
7/8	39,250	48,500
1	51,500	63,600
1-1/8	56,450	80,100
1-1/4	71,700	101,800
1-3/8	85,450	121,300
1-1/2	104,000	147,500

Prior to final tightening of any bolts in a bolted connection, the connection shall be compacted to a snug tight condition. Snug tight shall include bringing all plies of the connection into firm contact and snug tightening all bolts in accordance with Section 6-03.3(32).

Final tightening may be done by the Turn-of-Nut Method, the direct-tension indicator method, or the twist off-type tension control structural bolt/nut/washer assembly method. Preferably, the nut shall be turned tight while the bolt is prevented from rotating. However, if required by either turn-of-nut or direct-tension-indicator methods because of bolt entering and/or wrench operational clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

1. Turn-of-Nut Method – After all specified bolting conditions are satisfied, and before final tightening, the Contractor shall match-mark with crayon or paint the outer face of each nut and the protruding part of the bolt. Each bolt shall be final tightened to the specified minimum tension by rotating the amount specified in Table 2. To ensure this tightening method is followed, the Engineer will (1) observe as the Contractor installs, snug tightens, and final tightens all bolts and (2) inspect each match-mark.

Table 2			
Turn-of-Nut Tightening Method Nut Rotational from Snug-Tight Condition			
Bolt Length	**Disposition of Outer Faces of Bolted Parts**		
	Condition 1	Condition 2	Condition 3
$L \leq 4D$	1/3 turn	½ turn	2/3 turn
$4D < L \leq 8D$	1/2 turn	2/3 turn	5/6 turn
$8D < L \leq 12D$	2/3 turn	5/6 turn	1 turn

Bolt length measured from underside of head to extreme end of point.

Condition 1: both faces at right angles to bolt axis.

Condition 2: one face at right angle to bolt axis, one face sloped no more than 1:20, without bevel washer.

Condition 3: both faces sloped no more than 1:20 from right angle to bolt axis, without bevel washer.

Nut rotation is relative to the bolt regardless of which element (nut or bolt) is being turned.

Tolerances permitted:

± 30 degrees (1/12 turn) for final turns of 1/2 turn or less; ± 45 degrees (1/8 turn) for final turns of 2/3 turn or more.

D = nominal bolt diameter of bolt being tightened.

When bolt length exceeds 12D, the rotation shall be determined by actual tests in which a suitable tension device simulates actual conditions.

2. **Direct-Tension-Indicator Method**:

Direct Tension Indicators (DTIs) shall not be used under the turned element. DTIs shall be placed under the bolt head with the protrusions facing the bolt head when the nut is turned. DTIs shall be placed under the nut with the protrusions facing the nut when the bolt is turned.

Gap refusal shall be measured with a 0.005 inch tapered feeler gage. After all specified bolting conditions are satisfied, the snug tightened gaps shall meet Table 3 snug tight limits.

Each bolt shall be final-tightened to meet Table 3 final-tighten limits. If the bolt is tensioned so that no visible gap in any space remains, the bolt and DTI shall be removed and replaced by a new properly tensioned bolt and DTI.

The Contractor shall tension all bolts, inspecting all DTIs with a feeler gage, in the presence of the Engineer. DTIs shall be installed by two-person (or more) crews, with one individual (1) preventing the element at the DTI from turning and (2) measuring the gap of the DTI to determine the proper tension of the bolt.

If a bolt, that has had its DTI brought to full load, loosens during the course of bolting the connection, it shall be rejected. Reuse of the bolt and nut are subject to the provisions of this Section. The used DTI shall not be reinstalled.

Table 3
Direct Tension Indicator Requirements

Bolt Size (inches)	DTI Spaces		Maximum Snug Tight Refusals		Minimum Final Tighten Refusals	
	M 164	M 253	M 164	M 253	M 164	M 253
½	4	5	1	2	2	3
⅝	4	5	1	2	2	3
¾	5	6	2	2	3	3
⅞	5	6	2	2	3	3
1	6	7	2	3	3	4
1⅛	6	7	2	3	3	4
1¼	7	8	3	3	4	4
1⅜	7	8	3	3	4	4
1½	8	9	3	4	4	5

3. **Twist Off-Type Tension Control Structural Bolt/Nut/Washer Assembly Method (Tension Control Bolt Assembly)**

Tension control bolt assemblies shall include the bolt, nut, and washer(s) packaged and shipped as a single assembly. Tension control bolt assembly components shall not be interchanged for testing or installation and shall comply with all provisions of ASTM F 1852.

The tension control bolts shall incorporate a design feature intended to either indirectly indicate, or to automatically provide, the minimum tension specified in Table 1.

The Contractor shall submit the tension control bolt assembly to the Engineer for approval with: bolt capacities; type of bolt, nut, and washer lubricant; method of packaging and protection of the lubricated bolt; installation equipment; calibration equipment; and installation procedures.

The tension control bolt manufacturer's installation procedure shall be followed for installation of bolts in the verification testing device, in all calibration devices, and in all structure connections.

In some cases, proper tensioning of the bolts may require more than one cycle of systematic partial tightening prior to final yield or fracture of the tension control element of each bolt. If yield or fracture of the tension control element of a bolt occurs prior to the final tightening cycle, that bolt shall be replaced with a new one.

Additional field verification testing shall be performed as requested by the Engineer.

All bolts and connecting hardware shall be stored and handled in a manner to prevent corrosion and loss of lubricant. Bolts that are installed without the same lubricant coating as tested under the verification test will be rejected, and they shall be removed from the joint and be replaced with new lubricated bolts at no additional cost to the Owner.

AASHTO M 253 bolts, galvanized AASHTO M 164 bolts, and ASTM F 1852 tension control bolt assemblies shall not be reused. Black AASHTO M 164 bolts may be reused once if approved by the Engineer. All bolts to be reused shall have their threads inspected for distortion by reinstalling the used nut on the bolt and turning the nut for the full length of the bolt threads by hand. Bolts to be reused shall be relubricated in accordance with the manufacturer's recommendation and as approved by the Engineer. Used bolts shall be subject to a rotational capacity test as specified in Section 6-03.3(33)A Pre-Erection Testing. Touching up or retightening bolts previously tightened by the Turn-of-Nut Method, which may have been loosened by the tightening of adjacent bolts shall not be considered as reuse, provided the snugging up continues from the initial position and does not require greater rotation, including the tolerance, than that required by Table 2.

6-03.3(33)A PRE-ERECTION TESTING

High-strength bolt assemblies (bolt, nut, direct tension indicator, and washer), both black and galvanized, shall be subjected to a field rotational capacity test, as outlined below, prior to any permanent fastener installation. For field installations, the rotational capacity test shall be conducted at the jobsite. Each combination of bolt production lot, nut production lot, washer production lot, and direct tension indicator production lot shall be tested as an assembly, except tension

control bolt assemblies, which shall be tested as supplied by the manufacturer. Each rotational capacity test shall include three assemblies. Once an assembly passes the rotational capacity test, it is approved for use for the remainder of the project unless the Engineer deems further testing is necessary. All tests shall be performed in a bolt tension calibrator by the Contractor in the presence of the Engineer. High-strength bolt assemblies used in this test shall not be reused. The bolt assemblies shall meet the following requirements after being pretensioned to 15 percent of the minimum bolt tension in Table 1. The assembly shall be considered as nonconforming if the assembly fails to pass any one of the following specified requirements:

1. The measured torque to produce the minimum bolt tension shall not exceed the maximum allowed torque value obtained by the following equation:

Torque = 0.25 PD

Where: Torque = Calculated Torque (foot-pounds)

P = Measured Bolt Tension (pounds)

D = Normal Bolt Diameter (feet)

2. After placing the assembly through two cycles of the required number of turns, where turns are measured from the 15 percent pretension condition, as indicated in Table 2,

a.The maximum recorded tension after the two turns shall be equal to or greater than 1.15 times the minimum bolt tension listed in Table 1.

b.Each assembly shall be successfully installed to the specified number of turns.

c.The fastener components in the assembly shall not exhibit shear failure or stripping of the threads as determined by visual examination of bolt and nut threads following removal.

d.The bolts in the assembly shall not exhibit torsional or torsional/tension failure.

3. If any specimen fails, the assembly will be rejected. Elongation of the bolt between the bolt head and the nut is not considered to be a failure.

Bolts that are too short to test in the bolt tension calibrator shall be tested in a steel joint. The Contractor shall (1) install the high-strength bolt assemblies (bolt, nut, direct tension indicator, and washer) in a steel joint of the proper thickness; (2) tighten to the snug tight condition; (3) match-mark the outer face of each nut and the protruding part of the bolt with crayon or paint; (4) rotate to the requirements of Table 2; and (5) record the torque that is required to achieve the required amount of rotation. The assembly shall be considered as nonconforming if the assembly fails to pass any one of the following specified requirements:

1. The recorded torque to produce the minimum rotation shall not exceed the maximum allowed torque value obtained by the following equation:

Torque = 0.25 PD

Where: Torque = Calculated Maximum Allowed Torque (foot-pounds)

P = Specified Bolt Tension per Table 1, multiplied by a factor of 1.15 (pounds)

D = Normal Bolt Diameter (feet)

2. After placing the assembly through two cycles of the required number of turns, where turns are measured from the snug tight condition specified in Section 6-03.3(32):

a.Each assembly shall be successfully installed to the specified number of turns.

b.The fastener components in the assembly shall not exhibit shear failure or stripping of the threads as determined by visual examination of bolt and nut threads following removal.

c.The bolts in the assembly shall not exhibit torsional or torsional/tension failure.

3. If any specimen fails, the assembly will be rejected. Elongation of the bolt between the bolt head and the nut is not considered to be a failure.

The Contractor shall submit the manufacturer's detailed procedure for pre-erection (rotational capacity) testing of tension control bolt assemblies to the Engineer for approval and shall have an approved procedure prior to testing.

Three DTIs, per lot, shall be tested in a bolt tension calibrator. The bolts shall be tensioned to 105 percent of the tension shown in Table 1. If all of the DTI protrusions are completely crushed (all five openings with zero gap), this lot of DTIs is rejected.

6-03.3(33)B BOLTING INSPECTION

The Contractor, in the presence of the Engineer, shall inspect the tightened bolt using a calibrated inspection torque wrench, regardless of bolting method. The Contractor shall supply the inspection torque wrench. If the bolts to be installed are not long enough to fit in the Owner furnished tension calibrator, five bolts of the same grade, size and condition as those under inspection shall be selected by the Contractor in the presence of the Engineer and shall be tested using Direct-Tension-Indicators (DTI) to measure bolt tension. This tension measurement test shall be done at least once each inspection day. The Contractor shall supply the DTIs. The DTI shall be placed under the bolt head. A washer shall be placed under the nut, which shall be the element turned during performing this tension measurement test. Each bolt shall be tightened by any convenient means to the specified minimum tension as indicated by the DTI. The inspecting wrench shall then be applied to the tightened bolt to determine the torque required to turn the nut 5 degrees (approximately 1 inch at a 12-inch radius) in the tightening direction. The job inspection torque shall be taken as the average of three values thus determined after rejecting the high and low values. Five representative bolts/nuts/washers and DTIs if used (provided by the Contractor) of the same grade, size, and condition as those under inspection shall be placed individually in a bolt tension calibrator to measure bolt tension. This calibration operation shall be done at least each inspection day. There shall be a

washer under the part turned in tightening each boltif washers are used on the Structure. In the bolt tension calibrator, each bolt shall be tightened by any convenient means to the specified tension. Inspection torque wrench shall then be applied to the tightened bolt to determine the torque required to turn the nut or head 5 degrees (approximately 1 inch at a 12-inch radius) in the tightening direction. The job-inspection torque shall be taken as the average of three values thus determined after rejecting the high and low values.

Ten percent (at least two), or as specified by the Engineer, of the tightened bolts on the Structure represented by the test bolts shall be selected at random in each connection. The job-inspection torque shall then be applied to each with the inspection wrench turned in the tightening direction, with no restraint applied in the opposite end of the bolt. If this torque turns no bolt head or nut, the Owner will accept the connection as being properly tightened. If the torque turns one or more bolt heads or nuts, the job-inspection torque shall be applied to all bolts in the connection. Except for tension control bolt assemblies and DTIs with zero gap at all protrusion spaces, any bolt whose head or nut turns at this stage shall be tightened and reinspected. Any tension control bolt assemblies or DTIs that have zero gap at all protrusion spaces shall be replaced if the head or nut turns at this stage.

The Contractor shall submit the manufacturer's detailed procedure for routine observation to ensure proper use of the tension control bolt assemblies to the engineer for approval and shall have an approved procedure prior to any assembling of bolted connections.

6-03.3(34) ADJUSTING PIN NUTS

All pin nuts shall be tightened thoroughly. The pins shall be placed so members bear fully and evenly on the nuts. The pins shall have enough thread to allow burring after the nuts are tightened.

6-03.3(35) SETTING ANCHOR BOLTS

Anchor bolts shall be set in masonry as required in Section 6-02.3(18). Anchor bolts shall be grouted in after the shoes, masonry plates, and keeper plates have been set and the span or series of continuous spans are completely erected and adjusted to line and camber.

6-03.3(36) SETTING AND GROUTING BEARING PLATES

The following procedure applies to masonry plates for all steel spans, including shoes, keeper plates and turning racks on movable bridges.

To set masonry plates, the Contractor shall:

1. Set masonry plates on the anchor bolts;
2. Place steel shims under the masonry plates to position pin centers to line and grade and in relationship to each other. Steel shims shall be no more than 2-1/2 inches square and placed under plate webs;
3. Level the bases of all masonry plates;
4. Draw anchor bolt nuts down tight;
5. Recheck pin centers or bearings for alignment; and
6. Leave at least 3/4 inch of space under each masonry plate for grout.

After the masonry plates have been set and the span or series of continuous spans are completely erected and swung free, the space between the top of the masonry plate and the top of the concrete bearing seat shall be filled with grout. Main masonry plates for cantilever spans shall be set and grouted in before any steel work is erected.

Grout mixture and placement shall be as required in Section 6-02.3(20).

6-03.3(37) SETTING STEEL BRIDGE BEARINGS

Masonry plates, shoes, and keeper plates of expansion bearings shall be set and adjusted to center the expansion shoe at a normal temperature of 64°F. Adjustment for any inaccuracy in fabricated length shall be made after dead-load camber is out.

6-03.3(38) PLACING SUPERSTRUCTURE

The concrete in piers and crossbeams shall reach at least 80 percent of design strength before girders are placed on them.

6-03.3(39) SWINGING THE SPAN

Forms weighing less than 5 pounds per square foot of bridge deck area and uniformly distributed along the steel spans may be placed before the spans swing free on their supports. Steel reinforcing bars or concrete bridge deck shall not be placed on steel spans until the spans swing free on their supports and elevations are recorded. No simple span or any series of continuous spans will be considered as swinging free until all temporary supports have been released. Reinforcing steel or concrete bridge decks shall not be placed on any simple or continuous span steel girder bridge until all its spans are adjusted and its masonry plates, shoes, and keeper plates grouted. For this specification, the structure shall be considered as continuous across hinged joints.

After the falsework is released (spans swung free), the masonry plates, shoes, and keeper plates are grouted, and before any load is applied, the Engineer will (Or, if the Contractor is specified as responsible for surveying, the Contractor shall) measure elevations at the tenth points along the tops of girders and floorbeams.

The Engineer will compare steel mass camber elevations with the elevations measured above, and will furnish the Contractor with new dead-load camber dimensions.

6-03.3(40) DRAINING POCKETS

The Contractor shall provide enough holes to drain all water from pockets in trusses, girders, and other members. Unless shown on submitted and reviewed by Engineer Shop Drawings, drain holes shall not be drilled without the written review of the Engineer.

6-03.3(41) FLOORBEAM PROTECTION

Each floorbeam that supports a concrete slab joint shall be coated on its top and flange edges with a heavy mop of roofing grade asphalt applied hot. This asphalt shall conform to ASTM D 312 (not mineral stabilized). A protective covering of asphalt coated glass fiber sheet (ASTM D 4601, Type 1, non-perforated) shall be placed over the hot coat of asphalt. This combination coating shall be applied over the shop paint. It shall take the place of the two field coats of paint specified for other parts of the structural steel. The second and third coats are acceptable exceptions and shall comply with Section 6-07.3(1)B.

6-03.3(42) SURFACE CONDITION

As the Structure is erected, the Contractor shall keep all steel surfaces clean and free from dirt, concrete, mortar, oil, paint, grease, and other stain-producing foreign matter. Any surfaces that become stained shall be cleaned as follows:

1. Painted steel surfaces shall be cleaned by methods required for the type of staining. The method shall be submitted to the Engineer for approval; and
2. Unpainted steel surfaces shall be cleaned by sandblasting. Sandblasting to remove stains on publicly visible surfaces shall be done if, in the Engineer's opinion, the uniform weathering characteristics of the Structure are preserved.

6-03.3(43) CASTINGS, STEEL FORGINGS, AND MISCELLANEOUS METALS

6-03.3(43)A GENERAL

Castings, steel forgings, and miscellaneous metals shall be built to comply with Section 9-06.

6-03.3(43)B SHOP CONSTRUCTION, CASTINGS, STEEL FORGINGS, AND MISCELLANEOUS METALS

This Section's requirements for structural steel (including painting requirements) shall also apply to castings, steel forgings, and miscellaneous metals.

Castings shall be:

1. True to pattern in form and dimensions;
2. Free from pouring faults, sponginess, cracks, blow holes, and other defects in places that would affect strength, appearance, or value;
3. Clean and uniform in appearance;
4. Filleted boldly at angles; and
5. Formed with sharp and perfect arises.

Iron and steel castings and forgings shall be annealed before any machining, unless indicated otherwise in the Contract.

6-03.4 MEASUREMENT

Bid items of work completed under the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs in this Section.

Cast or forged metal (kind) or copper seals shown on the Drawings will be measured by the pound or will be paid for on a lump sum basis as shown on the Bid Form.

In computing pay weight on the basis of scale weights, the pay quantity of structural steel will be the shop scale weight of the fabricated members weighed on scales meeting the requirements of Section 1-09.2 in the presence of the Engineer. If the shop paint has been applied to the completed member when weighed, 0.4 of 1 percent of the weight of the member shall be deducted from the scale weights to compensate for weight of shop paint.

6-03.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-03 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. **"Structural Carbon Steel",** per pound.
2. **"Structural Low Alloy Steel",** per pound.
3. **"Structural High Strength Steel",** per pound.

The Bid item prices Bid for the Bid items "Structural Carbon Steel", "Structural Low Alloy Steel", and "Structural High Strength Steel" shall include all costs for the work required for manufacture, fabrication, transportation, erection, welding inspection, and painting of all structural steel used in the completed structure, including protective coating or treatment as called for in the Contract.

For payment, such minor items as bearing plates, pedestals, forged steel pins, anchor bolts, field bolts, shear connectors, etc., shall not be considered as structural carbon steel even though it is made of other materials.

All costs related to inspection of structural welds shall be in the Bid item price Bid for structural steel and shall, in each case, refer to the appropriate inspection method for obtaining optimum quality assurance and shall be at no additional cost to the Owner.

4. **"(Cast or Forged) Steel",** lump sum or per pound.
5. **"(Cast, Malleable, or Ductile) Iron",** lump sum or per pound.
6. **"Cast Bronze",** lump sum or per pound.

The Bid item prices for "(Cast or Forged) Steel", for "(Cast, Malleable or Ductile) Iron", and for "Cast Bronze" shall include all costs for the work required to furnish and install the Material as specified.

7. **Other payment information.**

When no Bid item is in the Bid Form and payment is not otherwise provided, the castings, forgings, and miscellaneous metal shall be considered as incidental to the construction, and all costs therefore shall be in the Bid item prices for the Bid items involved and shall be at no additional or separate expense to the Owner.

Prospective Bidders shall verify the estimated weight of structural steel before submitting the Bid.

All costs related to filling pockets shall be in the Bid item prices for structural or cast steel and shall be at no additional or separate expense to the Owner.

The weight of field bolts shall be based on the Engineer reviewed shipping list. No payment will be made for any weight over 1-1/2 percent above the computed net weight of the whole item.

Reinforcing bars threaded will be paid as "Steel Reinforcing Bar, (Grade)" or "Steel Reinforcing Bar, (Grade), Epoxy Coated" under Section 6-02.5.

All costs related to providing drain holes shall be in the Bid item prices for structural or cast steel and shall be at no additional or separate expense to the Owner.

All costs related to providing drain holes per Section 6-03.3(40) shall be included in the Bid item prices for structural or cast steel and shall be at no additional or separate expense to the Owner.

SECTION 6-04 TIMBER STRUCTURES

6-04.1 DESCRIPTION

Section 6-04 addresses the work of building of any Structure or parts of Structures (except piles) made of treated timber, untreated timber, or both. The Contractor shall erect timber structures on prepared foundations. The Structures shall conform to the dimensions, lines, and grades required by the Drawings, the Engineer, and these Standard Specifications.

Any part of a timber structure made of nontimber Materials shall comply with the sections of the Standard Specifications that govern those Materials.

6-04.2 MATERIALS

Materials shall meet the requirements of the following Sections:

Structural Steel and Related Material	9-06
Paints	9-08
Timber and Lumber	9-09

6-04.3 CONSTRUCTION REQUIREMENTS

6-04.3(1) STORING AND HANDLING MATERIAL

At the Project Site, the Contractor shall store all timber and lumber in stacked piles. Weeds and rubbish under and around these piles shall be removed before the lumber is stacked.

Untreated lumber shall be open stacked at least 12 inches above the ground and shall be piled to shed water and prevent warping.

Treated timber shall be:

1. Cut, framed, and bored (whenever possible) before treatment;
2. Close stacked and piled to prevent warping;
3. Covered against the weather to prevent warping or deterioration;
4. Handled carefully to avoid sudden drops, broken outer fibers, and surface penetration or bruising with tools; and
5. Lifted and moved with rope and chain slings (without using cant dogs, peaveys, hooks, or pike poles).

6-04.3(2) WORKMANSHIP

See Section 1-05.13. Poor workmanship includes deep hammer marks in wood surfaces. Workmanship on metal parts shall comply with requirements of Section 6-03.

6-04.3(3) SHOP DRAWINGS

The Contractor shall provide the Engineer with six sets of Shop Drawings for all Structures built with treated timber. These Shop Drawings shall show dimensions for all cut, framed, or bored timbers.

The Engineer will return to the Contractor one set of reviewed Shop Drawings. No material shall be framed or bored until the Engineer has completed review of the Shop Drawings. Shop Drawings shall be drawn on sheets that conform to the sizes required in Section 1-05.3(11).

6-04.3(4) FIELD TREATMENT OF CUT SURFACES, BOLT HOLES, AND CONTACT SURFACES

All cut surfaces, bolt holes, and contact surfaces shall be treated under Section 9-09.3 for all timber and lumber requiring preservative treatment.

All cuts and abrasions in treated timber piles or treated timbers shall be trimmed carefully and treated again at the cut or abrasion under Section 9-09.3.

6-04.3(5) HOLES FOR BOLTS, DOWELS, RODS, AND LAG SCREWS

Holes shall be bored:

1. For drift pins and dowels: with a bit 1/16 inch smaller in diameter than the pins and dowels.
2. For truss rods or bolts: with a bit the same diameter as the rods or bolts.
3. For lag screws in two parts:
   (a) with the shank lead hole the same diameter as the shank and as deep as the unthreaded shank is long; and
   (b) with the lead hole for the threaded part approximately two thirds of the shank diameter.

6-04.3(6) BOLTS, WASHERS, AND OTHER HARDWARE

Bolts, flat-head bolts, dowels, washers, and other hardware, including nails, shall be black or galvanized as specified on the Drawings. Hardware not otherwise specified shall be galvanized when used in treated timber Structures. Flat-head bolts are detailed in the Standard Plans.

Washers of the size and type specified shall be used under all bolt heads and nuts that contact wood. Flat-head bolts require washers under the nuts only.

All bolts shall be checked by burring the threads after the nuts have been finally tightened. Vertical bolts shall have nuts on the lower ends.

Wherever bolts fasten timber to timber, timber to concrete, or timber to steel, the members shall be bolted tightly together at installation and retightened just before the Owner accepts the Work. These bolts shall have surplus threading of at least 3/8 inch per foot of timber thickness to permit future tightening.

6-04.3(7) COUNTERSINKING

Countersinking shall be done wherever smooth faces are in the Contract. Each recess shall be treated under Section 9-09.3.

6-04.3(8) FRAMING

The Contractor shall cut and frame lumber and timber to produce close-fitting, full-contact joints. Each mortise shall be true to size for its full depth, and its tenon shall fit it snugly. Neither shimmed nor open joints are permitted.

6-04.3(9) FRAMED BENTS

Mudsills shall be of pressure-treated timber, firmly and evenly bedded to solid bearing, and tamped in place.

Concrete pedestals that support framed bents shall be finished so sills bear evenly on them. To anchor the sills, the Contractor shall set dowels in the pedestals when cast. The dowels shall be at least 3/4 inch in diameter and protrude at least 6 inches above the pedestal tops. Pedestal concrete shall comply with Section 6-02.

Each sill shall rest squarely on mudsills, piles, or pedestals. It shall be drift-bolted to mudsills or piles with 3/4 inch diameter or larger bolts that extend at least 6 inches into the mudsill or pile. The Contractor shall ensure no earth touches the sills and that free air circulation surrounds them.

Each post shall be fastened to sills with 3/4 inch diameter or larger dowels that extend at least 6 inches into the post.

6-04.3(10) CAPS

Timber caps shall rest uniformly across the tops of posts or piles and cap ends shall be aligned evenly. Each cap shall be fastened with a drift bolt 3/4 inch in diameter or larger that penetrates the post or pile at least 9 inches. The bolt shall be approximately in the center of the pile or post.

If the roadway grade exceeds 2 percent, each cap shall be beveled to match the grade.

6-04.3(11) BRACING

When pile bents are taller than 10 feet, each bent shall be braced transversely. Every other pair of bents shall be braced longitudinally. No single cross-bracing shall brace over 20 feet of vertical distance on the piles. More than one cross-bracing shall be used if the vertical distance exceeds 20 feet. Each brace end shall be bolted through the pile, post, or cap with a bolt at least 3/4 inch in diameter. Other brace/pile intersections shall be bolted or boat-spiked as indicated on the Drawings. Cross-bracing shall lap both upper or lower caps and shall be bolted to the caps or sills at each end.

6-04.3(12) STRINGERS

All stringers that carry laminated decking or vary more than 1/8 inch in depth shall be sized to an even depth at bearing points. Outside stringers shall be butt jointed and spliced.

Interior stringers shall be lapped so that each rests over the full width of the cap or floorbeam at each end. Stringers may cover two spans except on sharp horizontal and vertical curves. In this case, joints shall be staggered and the stringers either toenailed or drift bolted as indicated in the Contract. To permit air circulation on untreated timber structures, the ends of

lapped stringers shall be separated. This separation shall be done by fastening across the lapping face a 1-inch by 3-inch wood strip cut 2 inches shorter than the depth of the stringer.

Any cross-bridging or solid bridging shall be neatly and accurately framed, then securely toenailed at each end (with two nails for cross-bridging and four nails for solid bridging). The Drawings show bridging size and spacing.

6-04.3(13) TIMBER WHEEL GUARDS AND TIMBER RAILINGS

Timber wheel guards and timber railings shall follow the construction requirements of Section 6-06.3(1). Construction methods not addressed in Section 6-06.3(1) shall follow the construction requirements of Section 6-04.

6-04.3(14) SINGLE-PLANK FLOORS

Single-plank floors shall be made of a single thickness of plank on stringers or joists.

The planks shall be:

1. Laid heart side down with tight joints;
2. Spiked to each joist or nailing strip with at least two spikes that are at least 4 inches longer than the plank thickness;
3. Spiked at least 2 1/2 inches from the edges;
4. Cut off on a straight line parallel to the centerline of the roadway;
5. Arranged so that no adjacent planks vary in thickness by no more than 1/16 inch; and
6. Surfaced on one side and one edge (S1S1E) unless otherwise specified in the Contract.

6-04.3(15) LAMINATED FLOORS

The strips shall be placed on edge and shall be drawn down tightly against the stringer or nailing strip and the adjacent strip and, while held in place, shall be spiked. Each strip shall extend the full width of the deck, unless otherwise in the Contract.

Each strip shall be spiked to the adjacent strip at intervals of not over 2 feet, the spikes being staggered 8 inches in adjacent strips. The spikes shall be of sufficient length to pass through two strips and at least halfway through the third. Unless bolting is specified in the Contract, each strip shall be toenailed to alternate stringers with 40d common nails and adjacent strips shall be nailed to every alternate stringer. The ends of all pieces shall be toenailed to the outside stringer. The ends of the strips shall be cut off on a true line parallel to the centerline of the roadway. When bolts are used to fasten laminated floors to stringers, the bolts shall be placed at the spacing shown in the Contract, and the pieces shall be drawn down tightly to the bolting strips. The bolt heads shall be driven flush with the surface of the deck. Double nuts or single nuts and lock nuts shall be used on all bolts. The strips shall be spiked together as specified above.

6-04.3(16) PLANK SUBFLOORS FOR CONCRETE DECKS

Any plank subfloor shall be laid surfaced side down with close joints at right angles to the centerline of the roadway. Planks shall be spiked in place as required in Section 6-04.3(14).

Floor planks shall be treated as Section 9-09.3 requires.

6-04.3(17) TRUSSES

Completed trusses shall show no irregularities of line. From end to end, chords shall be straight and true in horizontal projection. In vertical projection they shall show a smooth curve through panel points that conforms to the correct camber. The Engineer will reject any pieces cut unevenly or roughly at bearing points. Before the Contractor places the hand railing, the Contractor shall complete all trusses, swing them free of their falsework, and adjust them for line and camber.

6-04.3(18) PAINTING

See Section 6-07.3(3) for painting of timber Structures.

6-04.4 MEASUREMENT

Bid items of work completed under the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs in this Section.

The criteria in Section 6-03.4 will determine the weight of structural metal other than hardware.

Timber and lumber (treated or untreated) will be measured by the 1,000 board feet (MBM), using nominal thicknesses and widths. Lengths will be actual lengths of individual pieces in the finished structure with no deduction for daps, cuts, or splices. To measure laminated timber decking, the Engineer will use the number and after-dressing sizes of pieces required on the Drawings. The length of each lamination shall be the length remaining in the finished Structure.

No specific unit of measurement will apply to the lump sum item of “Structural Metal”.

6-04.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-04 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. “**Timber and Lumber (untreated or name treatment)**”, per MBM.
2. “**Structural Metal**”, lump sum.

Where no Bid item for structural metal is in the Bid Form, full pay for furnishing and placing metal parts shall be in the Bid item price per MBM for Timber and Lumber (untreated or name treatment).

SECTION 6-05 PILES

6-05.1 DESCRIPTION

Section 6-05 describes work comprising furnishing and driving piles (timber, precast concrete, cast-in-place concrete, and steel) of the sizes and types in the Contract require. This work also includes cutting off or building up piles when required.

6-05.2 MATERIALS

Materials shall meet the requirements of the following sections:

Reinforcing Steel	9-07
Prestressing Steel	9-07.10
Timber Piling	9-10.1
Concrete Piling	9-10.2
Cast-In-Place Piling	9-10.3
Steel Pile Tips and Shoes	9-10.4
Steel Piling	9-10.5
Mortar	9-20.4

6-05.3 CONSTRUCTION REQUIREMENTS

6-05.3(1) PILE TERMS

Allowable Bearing Capacity — Allowable bearing capacity is the ultimate bearing capacity divided by a factor of safety. The Contract may state the factor of safety to be used in calculating the allowable bearing capacity from the ultimate bearing capacity. Absent a specified factor of safety, a value of three (3) shall be used.

Auger Cast-In-Place Piles – Auger cast-in-place piles are auger drilled soil penetrations to the limits called for in the Contract and then filled with concrete as the auger is removed. A steel cage is typically inserted in the concrete after the concrete is placed.

Concrete Piles — Concrete piles may be precast or precast-prestressed concrete,or steel casings driven to the ultimate bearing capacity called for in the Contract which are filled with concrete (cast-in-place) after driving.

Developed Hammer Energy — The developed hammer energy is the actual gross energy produced by the hammer for a blow. This value shall never exceed the rated hammer energy. The developed energy may be calculated as the ram weight times the drop (or stroke) for drop, single acting hydraulic, single acting air/steam, and open-ended diesel hammers. For double acting hydraulic and air/steam hammers, the developed hammer energy shall be calculated from ram impact velocity measurements or other means approved by the Engineer. For closed-ended diesel hammers, the developed energy shall be calculated from the measured bounce chamber pressure for a blow. Hammer manufacturer calibration data may correlate bounce chamber pressure to developed hammer energy. For a single acting diesel hammer the developed energy is determined using the blows per minute.

Follower — A follower is a structural member placed between the hammer assembly, which includes the helmet, and the pile top when the pile top is below the reach of the hammer.

Hammer cushion — The hammer cushion is a disk of material placed on top of the helmet but below the anvil or striker plate to relieve impact shockprotecting the hammer and the pile.

Helmet — The helmet, also termed the cap, drive cap, or driving head, is used to transmit impact forces from the hammer ram to the pile top uniformly across the pile top such that the impact force of the ram is transmitted axially to the pile. The term helmet can apply to the complete impact force transfer system, which includes the anvil or striker plate, hammer cushion and cushion block, and a pile cushion if used, or just the single piece unit into which these other components (anvil, hammer cushion, etc.) fit. The helmet does not include the follower, if one is used. For hydraulic hammers, the helmet is sometimes referred to as the anvil.

Maximum Driving Resistance — The maximum driving resistance is the pile ultimate bearing capacity, or ultimate bearing capacity plus overdriving to reach minimum tip elevation is specified in the Contract, whichever is greater.

Minimum Tip Elevation — The minimum tip elevation is the elevation to which the pile tip shall be driven. Driving deeper to obtain the required bearing capacity may be required.

Overdriving — Over-driving of piles occurs when the ultimate bearing capacity calculated from the equation in Section 6-05.3(12), or the wave equation if applicable, exceeds the ultimate bearing capacity required in the Contract to reach the minimum tip elevation specified in the Contract, or as required by the Engineer.

Pile Cushion — The pile cushion is a disk of material placed between the helmet and the pile top to relieve impact shock, primarily to protect the pile.

Pile Driving Analyzer — A pile driving analyzer (PDA) is a device which can measure the transferred energy of a pile driving system, the compressive and tensile stresses induced in the pile due to driving, the bending stresses induced by hammer misalignment with the pile, and estimate the ultimate capacity of a pile at a blow.

Pile Driving Refusal — Pile driving refusal is defined as 15 blows per inch for the last 4 inches of driving. This is the maximum blow count allowed during overdriving.

Pile Driving System — The pile driving system includes, but is not limited to, the hammer, leads, helmet or cap, cushion and pile.

Pile Head – The end of the pile struck by the hammer for driving. Also known as head, head end, butt, butt end, and pile top.

Pile Shoe - A hard metal tip secured to the driving end of a pile for protecting the pile tip during penetration into the soil.

Pile Tip – The penetrating end of the pile opposite the pile head where end bearing may occur. Also known as tip.

Rated Hammer Energy — The rated energy represents the theoretical maximum amount of gross energy that a pile driving hammer can generate. The rated energy of a pile driving hammer shall be stated in the hammer manufacturer's catalog or specifications for that pile drive hammer.

Steel Piles — Open-ended or closed-ended pipe piles, or H-piles.

Transferred Hammer Energy — The transferred hammer energy is the energy transferred to the pile for a blow. This value shall never exceed the developed hammer energy. Factors that cause transferred hammer energy to be lower than the developed hammer energy include friction during the ram downstroke, energy retained in the ram and helmet during rebound, and other impact losses. The transferred energy can only be measured directly by sensors attached to the pile. A pile driving analyzer (PDA) may measure transferred energy.

Ultimate Bearing Capacity — Ultimate bearing capacity refers to the vertical load carrying capacity (in units of force) of a pile as determined by the equation in Section 6-05.3(12), the wave equation analysis, pile driving analyzer and CAPWAP, static load test, or any other means as required by the Contract.

Wave Equation Analysis — Wave equation analysis is an analysis performed using the wave equation analysis program (WEAP) with a version dated 1987 or later. The wave equation may be specified to verify the Contractor's proposed pile driving system. The pile driving system includes, but is not limited to, the pile, the hammer, the helmet, and any cushion. The wave equation may also be used by the Engineer to determine pile driving criteria as required in the Contract.

6-05.3(2) ORDERING PILES

The length of piles given in the Bid Form is for estimating purposes only and is not to be used as an order list.

No order list for piles will be furnished by the Engineer.

All piles shall be ordered by the Contractor. The Contractor shall determine the length required from the results obtained by the driving of the test piles called for in the Contract and from subsurface exploration data. The Contractor shall increase the lengths, at no additional cost to the Owner, the amount to provide for fresh heading and to reach from the cutoff elevation up to the position of the driving equipment.

See Section 6-05.3(10) regarding test piles.

6-05.3(3) MANUFACTURE OF PRECAST CONCRETE PILES

Precast concrete piles comprise concrete sections reinforced to withstand handling and driving stresses. These may be reinforced with deformed steel bars or prestressed with steel strands. The Drawings show dimensions and details. If the Drawings require piles with square cross-sections, the corners shall be chamfered 1 inch.

13-inch diameter precast or prestressed piles shall meet the requirements of WSDOT Standard Plan no. E-4.

16-inch and 18-inch diameter precast-prestressed piles shall meet the requirements of WSDOT Standard Plan no. E-4a.

Temporary stress in the prestressing reinforcement of prestressed piles (before loss from creep and shrinkage) shall be 75 percent of the minimum ultimate tensile strength. (For short periods during manufacture, the reinforcement may be overstressed to 80 percent of ultimate tensile strength if stress after transfer to concrete does not exceed 75 percent of that strength.)

Prestressed concrete piles shall have a final (effective) prestress of at least 1,000 psi.

Unless the Engineer approves splices, all piles shall be full length.

The Engineer intends to perform inspection under Section 1-06.1.

6-05.3(3)A CASTING AND STRESSING

Reinforcing bars, hoops, shoes, etc. shall be placed as shown in the Contract. All parts shall be securely tied together and placed to the specified spacings. No concrete shall be placed until all reinforcement is in place and the forms are secured.

The Contractor shall perform quality control inspection. The manufacturing plant for precast concrete piles shall be certified by the Precast/Prestressed Concrete Institute's Plan Certification Program for the type of precast piles to be produced and shall be approved by WSDOT as a Certified Precast Concrete Fabricator prior to start of production.

Prior to the start of production of the piles, the Contractor shall provide the Engineer advance notification of the production schedule. The Engineer may inspect the fabrication of concrete piles under Sections 1-05 and 1-06.

In casting concrete piles, the Contractor shall:

1. Cast them either vertically or horizontally;
2. Use metal forms with smooth joints and inside surfaces that can be thoroughly cleaned after each use;
3. Brace and stiffen the forms to prevent distortion;

4. Place concrete continuously in each pile, guarding against horizontal or diagonal cleavage planes;
5. Ensure the reinforcement is properly embedded;
6. Use internal vibration around the reinforcement during concrete placement to prevent rock pockets from forming; and
7. Cast test cylinders with each set of piles as concrete is placed.

Forms shall be metal and shall be braced and stiffened to retain their shape under pressure of wet concrete. Forms shall have smooth joints and inside surfaces easy to reach and clean after each use. That part of a form which shapes the end surface of the pile shall be a true plane at right angles to the pile axis.

Each pile shall contain a cage of nonprestressed reinforcing steel sized and located as indicated on the Drawings. Spiral steel reinforcing shall be secured in position and shall have a minimum 1-1/2 inch concrete cover from the outside pile surface.

Prestressing steel shall be tensioned as required in Section 6-02.3(25)C.

The Drawings specify tensioning stress for strands or wires. Tension shall be measured by jack pressure as described in Section 6-02.3(25)C. Mechanical locks or anchors shall temporarily maintain cable tension. All jacks shall have hydraulic pressure gauges (accurately calibrated and accompanied by a certified calibration curve no more than 180 days old) that permit stress calculations at all times.

All tensioned piles shall be pretensioned. Post-tensioning is not allowed.

The Contractor shall stress no pile until test cylinders made with it reach a compressive strength of at least 3,300 psi.

6-05.3(3)B FINISHING

As soon as the forms for each precast concrete pile are removed, the Contractor shall fill all holes and irregularities in the pile with 1:2 mortar. That part of any trestle pile to be underground or below the low-water line and all parts of any pile to be used in salt water or alkaline soil shall receive only this mortar treatment. That part of any trestle pile that shows above the ground or water line shall be given a Class 2 finish as described in Section 6-02.3(14)B.

6-05.3(3)C CURING

Precast Concrete Piles. The Contractor:

1. Shall keep the concrete continuously wet with water after placement for at least ten days with Type I or II Portland cement or at least three days with Type III;
2. Shall remove side forms no sooner than 24 hours after concrete placement, and then only if the surrounding air remains at no less 50°F for five days with Type I or II Portland cement or three days with Type III; and
3. May cure precast piles with saturated steam or hot air, as described in Section 6-02.3(25)D, provided the piles are kept continuously wet until the concrete has reached a compressive strength of 3,300 psi.

Precast-Prestressed Concrete Piles. These piles shall be cured as required in Section 6-02.3(25)D.

6-05.3(4) MANUFACTURE OF STEEL CASINGS FOR CAST-IN-PLACE CONCRETE PILES

The diameter of steel casings shall be as specified in the Contract. Spiral welded steel pile casings are not allowed for steel pile casings greater that 24 inches in diameter. A full penetration groove weld with a maximum 1/16 inch offset between welded edges is required.

6-05.3(5) MANUFACTURE OF STEEL PILES

Steel piles shall be made of rolled steel H-pile sections, steel pipe piles, or of other structural steel sections described in the Contract. Spiral welded steel pile casings are not allowed for steel pipe piles greater than 24 inches in diameter. A full penetration groove weld with a maximum 1/16 inch offset between welded edges is required.

6-05.3(6) SPLICING STEEL CASINGS AND STEEL PILES

The Engineer will normally permit steel piles and steel casings for cast-in-place concrete piles to be spliced. However, the Contractor shall obtain the Engineer's advance approval on the need and the method for splicing. Welded splices shall be spaced at a minimum distance of *10 feet*. Only welded splices will be permitted.

Splice welds shall comply with Section 6-03.3(25) and AWS D1.1 Structural Welding Code. Splicing of steel piles shall be performed under an approved weld procedure. The Contractor shall submit a weld procedure to the Engineer for approval prior to welding. For ASTM A 252 Material, mill certification for each lot of pipe to be welded shall accompany the submittal.

Weld splicing of steel casings for cast-in-place concrete piles shall be the Contractor's responsibility. Casings that collapse or are not watertight, shall be replaced at no additional cost to the Owner.

Steel casing joints shall not be offset more than 1/16 inch.

6-05.3(7) STORAGE AND HANDLING

The Contractor shall store and handle piles in ways that protect them from damage.

6-05.3(7)A TIMBER PILES

Timber piles shall be stacked closely and in a manner to prevent warping. The ground beneath and around stored piles shall be cleared of weeds, brush, and rubbish. Piles shall be covered against the weather if the Engineer requires it.

The Contractor shall take special care to avoid breaking the surface of treated piles. They shall be lifted and moved with equipment, tools, and lifting devices which do not penetrate or damage the piles. If timber piles are rafted, any

attachments shall be within 3 feet of the butts or tips. Any surface cut or break shall be repaired as per Section 9-09.3. The Engineer may reject any pile because of a cut or break.

6-05.3(7)B PRECAST CONCRETE PILES

The Contractor shall handle no pile until test cylinders made with the same batch of concrete as the pile reach a compressive strength of at least 3,300 psi.

Storing and handling methods shall protect piles from fractures by impact and undue bending stresses. Handling methods shall never stress the reinforcement over 12,000 psi. An allowance of twice the calculated load shall be made for impact and shock effects. The method of lifting the piles shall be submitted to the Engineer for approval. The Contractor shall take extra care to *not* damage the surface of any pile to be used in sea water or alkaline soil.

6-05.3(7)C STEEL CASINGS AND STEEL PILES

The Engineer will reject bent, deformed, or kinked piles.

6-05.3(8) PILE TIPS AND SHOES

Timber piles shall be driven with squared ends unless subsurface conditions require attaching metal shoes. Pile tips and shoes shall be securely attached to the piles under the manufacturer's recommendations.

When required in the Contract, conical steel pile tips shall be used when driving steel casings. The tips shall be inside fit, flush-mounted such that neither the tip nor weld bead protrudes more than 1/16 inch beyond the nominal outside diameter of the steel casing.

If conical tips are not required in the Contract, the lower end of each casing shall have a steel driving plate thick enough to keep the casing watertight and free from distortion as it is driven. The diameter of the steel driving plate shall not be greater than the outside diameter of the steel casing.

Where called for in the Contract, inside-fit cutting shoes shall be used when driving open-ended steel piles. The cutting shoes shall be flush-mounted such that neither the shoe nor the weld bead protrudes more than 1/16 inch beyond the nominal outside diameter of the steel pile. The cutting shoe shall be of an inside diameter at least 0.75 inch less than the nominal inside diameter of the steel pile.

The Contractor shall submit to the Engineer for approval, Shop Drawings of the proposed pile tip or shoe with design calculations, specifications, material chemistry and installation requirements, and shall also be prepared to provide a pile driving test demonstrating suitability of the proposed pile tip. The test shall be performed in the presence of the Engineer or an acceptable to the Engineer independent AASHTO certified testing agency, and comprise driving a pile fitted with the proposed tip. The pile shall be located outside the proposed foundation limits if the pile cannot be visually inspected (see Section 6-05.3(11)F). The pile shall be driven to a depth sufficient to develop the required bearing capacity specified in the Contract and in ground conditions determined by the Engineer to be equivalent to the ground conditions at the Project Site. For closed-ended casings or piles, the pile need not be removed if, in the opinion of the Engineer, the pile can be evaluated for evidence of damage to the pile or the tip. For open-ended steel casings or piles, timber piles or H-piles, the pile shall be removed for evaluation.

6-05.3(9) PILE DRIVING EQUIPMENT

6-05.3(9)A GENERAL

Prior to driving any piles, the Contractor shall submit to the Engineer for approval, the details of each proposed pile driving system. The pile driving system shall meet the minimum requirements for the combinations of hammer type and pile type specified in this Section. These requirements are minimums and may need to be increased to ensure that the required bearing capacity can be achieved, that minimum tip elevations can be reached, and to prevent pile damage.

The Contractor shall submit a wave equation analysis for pile driving systems required by Contract or for all pile driving systems used to drive piles with required ultimate bearing capacities of 300 tons or greater. The wave equation analysis shall be performed by, and bear the stamp of, a civil engineer licensed under Title 18 RCW in the State of Washington (see Section 1-05.3(12)). The wave equation analysis shall be performed under the requirements of this Specification Section and the user's manual for the program. The wave equation analysis shall verify that the proposed pile driving system does not produce stresses greater than 90 percent of the yield stress for steel piles, or steel casings for cast-in-place concrete piles. For prestressed concrete piles, the allowable driving stress shall be 3 times the square root of f'_{cm}, plus prestress in tension, and $0.85f'_c$ minus prestress in compression. For precast concrete piles that are not prestressed, the allowable driving stress shall be 70 percent of the yield stress of the steel reinforcement in tension, and 0.85f'c in compression. The wave equation shall also verify that the pile driving system does not exceed the refusal criteria at the depth of penetration anticipated for achieving the required ultimate bearing capacity and minimum tip elevation. The wave equation analysis shall verify that at bearing, the maximum driving resistance is 100 blows per foot or less. Unless otherwise specified in the Contract, the following default values shall be input to the wave equation analysis program:

Output option (IOUT)	0
Factor of safety applied to (R_{ult})	1.0
Type of damping	Smith
Residual stress option	No
(R_{ult}) is equal to the maximum driving resistance for the pile	

HAMMER EFFICIENCIES		
Hammer	For Analysis of Driving Resistance	For Analysis of Driving Stresses
Single acting diesel hammers	0.72	0.84
Closed-ended diesel hammers	0.72	0.84
Single acting air/steam hammers	0.60	0.70
Double acting air/steam hammers	0.45	0.53
Hydraulic hammers or other external combustion hammers having ram velocity monitors that may be used to assign an equivalent stroke.	0.85	1.00

Within 15 Working Days after the Engineer receipt of the submittal, the Contractor will be notified of the Engineer's review. If the Contractor wishes to change the pile driving system after the Contractor's proposed system has been approved, the Contractor shall comply with the requirements of Section 1-05.3(5).

6-05.3(9)B PILE DRIVING EQUIPMENT MINIMUM REQUIREMENTS

For each drop hammer used, the Contractor shall weigh it in the Engineer's presence or provide the Engineer with a certificate of its weight. The exact weight shall be stamped on the hammer. Drop hammers shall have a weight of not less than:

1. 3,000 pounds for piles under 50 feet long that have an ultimate bearing capacity of not over 60 tons; and
2. 4,000 pounds for piles 50 feet and longer or that have an ultimate bearing capacity of 60 to 90 tons.

If a drop hammer is used for timber piles, it is preferable to use a heavy hammer and operate with a short drop.

For each diesel, hydraulic, steam, or air-driven hammer used, the Contractor shall provide the Engineer with the manufacturer's specifications and catalog. These shall show all data needed to calculate the developed energy of the hammer used.

Underwater hammers may be used only with approval of the Engineer.

Drop hammers on timber piles shall have a maximum drop of 10 feet. Drop hammers shall not be used to drive timber piles that have ultimate bearing capacities of over 60 tons.

When used on timber piles, diesel, hydraulic, steam, or air-driven hammers shall provide at least 13,000 foot-pounds of developed energy per blow. The ram of any diesel hammer shall have a weight of at least 2,700 pounds.

Precast concrete, and precast-prestressed concrete piles shall be driven with a single-acting steam, air, hydraulic, or diesel hammer with a ram weight of at least half as much as the weight of the pile, but never less than the minimums stated in the tables following. The ratio of developed hammer energy to ram weight shall not exceed six. Steel casings for cast-in-place concrete, steel pipe, and steel H-piles shall also be driven with diesel, hydraulic, steam, or air hammers.

These hammers shall provide at least the following developed energy per blow:

Minimum Developed Energy per Blow (ft-lbs)				
Maximum Driving Resistance (tons)	Air or Steam Hammers	Open Ended Diesel Hammers	Closed Ended Diesel Hammers	Hydraulic Hammers
Up to 165	21,500	23,000	30,000	18,500
166 to 210	27,500	29,500	38,000	23,500
211 to 300	39,000	41,500	54,000	33,500
301 to 450	59,000	63,000	81,000	50,500

The ram of any diesel or hydraulic hammer shall have the following minimum weights:

Maximum Driving Resistance (tons)	Minimum Ram Weight (lbs)
Up to 165	2,700
166 to 210	4,000
211 to 300	5,000
301 to 450	6,500

The minimum hammer size requirement may be waived by the Engineer if a wave equation analysis demonstrates the ability of the hammer to obtain the required bearing capacity and minimum tip elevation without damage to the pile.

Vibratory hammers may drive piles provided the location and plumbness requirements of this Section are met. The required bearing capacity for all piles driven with vibratory hammers will be determined according to Section 6-05.3(12) by driving the pile at least an additional 2 feet using an impact hammer. This method of determining bearing capacity will be accepted provided the blows per inch are constant or increasing. If the pile cannot be driven 2 feet, the pile will be acceptable for bearing if the pile is driven to refusal.

If water jets are used, the number of jets and water volume and pressure shall be enough to erode the material next to the pile at the tip. The equipment shall include a minimum of two water jet pipes and two 3/4 -inch jet nozzles. The pump shall produce a constant pressure of at least 100 psi at each nozzle.

6-05.3(9)C PILE DRIVING LEADS

All piles shall be driven with fixed-lead drivers. The leads shall be fixed on the top and bottom during the pile driving operation. Leads shall be long enough to eliminate the need for any follower (except for timber piles as specified in Section 6-05.3(11)E). To avoid bruising or breaking the surface of treated timber piles, the Contractor shall use spuds and chocks as little as possible. In building a trestle or foundation with inclined piles, leads shall be adapted for driving batter piles.

A helmet of the right size for the hammer shall distribute the blow and protect the top of steel pile or steel casing from driving damage. The driving head shall be positioned symmetrically below the hammer's striking parts, so the impact forces are applied concentric to the pile top.

For piles with specified ultimate bearing capacities of 300 tons or greater, pile driving leads other than those fixed at the top and bottom may complete driving when all of the following criteria are met:

1. Each plumb and battered pile is located and initially driven at least 20 feet in true alignment using fixed leads or other approved means; and
2. The pile driving system (hammer, cushion and pile) shall be analyzed by Pile Driving Analyzer (PDA) to verify that driving stresses in the pile are not increased due to eccentric loading during driving, and transferred hammer energy is not reduced due to eccentric loading during driving, for all test piles and at least one production pile per pier.

The Contractor shall submit the revised fixing of leads set-up and PDA analysis to the Engineer prior to pile driving.

6-05.3(10) TEST PILES

If specified in the Contract, the Contractor shall drive test piles to determine pile lengths satisfying the specified load-carrying capacity, penetration, or both. Test piles shall:

1. Be made of the same material and have the same tip diameter as the permanent piles (although test piles for treated timber piles may be treated or untreated);
2. Be driven with pile tips if the permanent piles have tips;
3. Be prebored when preboring is specified for the permanent piles;
4. Have the same cross-section and other characteristics of the permanent piles for steel casings for cast-in-place concrete, precast concrete, precast-prestressed concrete, or steel pipe or H piles;
5. Long enough to accommodate Project Site soil conditions and Contract requirements;
6. Driven with the same equipment and methods to be used for the permanent piles;
7. Located where the Engineer directs; and
8. Driven before the permanent piles in a pier.

Test piles may also be driven by the Contractor, at no additional cost to the Owner, as evidence that the pile driving system selected does not damage the pile or result in refusal prior to reaching any specified minimum tip elevation.

Timber test piles shall be driven outside the footing and cut off 1 foot below the finished ground line. Timber test piles shall not be used in place of permanent piles.

Steel test piles and all types of concrete test piles shall become permanent piles. The Engineer has reduced the number of these permanent piles by the number of test piles.

The Contractor shall base test pile length on test-hole data provided in the Contract. Any test pile not long enough to meet Contract requirements shall be replaced (or spliced if the Contract allows splicing) at no additional cost to the Owner.

In foundations and trestles, test piles shall be driven to at least 15 percent more than the bearing capacity required for the permanent piles, except where pile driving criteria is determined by the wave equation. When pile driving criteria is specified to be determined by the wave equation, the test piles shall be driven to the same ultimate bearing capacity as the production piles. Test piles shall penetrate to at least the minimum tip elevation(s) specified in the Contract. If no minimum tip elevation is specified, test piles shall extend at least 10 feet below the bottom of the concrete footing or groundline, and 15 feet below the bottom of the concrete seal.

When any test pile to be left as a permanent pile has been damaged by handling or driving, the Contractor shall remove and replace the pile at no additional cost to the Owner. The Engineer may direct the Contractor to overdrive the test pile to over 15 percent above the minimum bearing capacity for permanent piles or above ultimate bearing capacity if the wave equation is used to determine driving criteria. In this case, the overdriving shall be at no additional cost to the Owner. But if pile damage results from this overdriving, any removal and replacement will be at the Owner's expense.

6-05.3(11) DRIVING PILES

6-05.3(11)A TOLERANCES

For elevated pier caps, the tops of piles at cut-off elevation shall be within 2 inches of the locations in the Contract. For piles capped below final grade, the tops of piles at cut-off elevation shall be within 6 inches of the horizontal locations in the Contract. No pile edge shall be nearer than 4 inches from the edge of any footing or cap. Piles shall be installed such that the axial alignment of the top 10 feet of the pile is within 4 percent of the specified alignment. No misaligned steel or concrete piles shall be pulled laterally. A properly aligned section shall not be spliced onto a misaligned section for any type of pile. All piles shall be driven vertically unless indicated otherwise on the Drawings.

6-05.3(11)B FOUNDATION PIT PREPARATION

The Contractor shall replace any damaged pile whether before or during driving at no additional cost to the Owner.

The Contractor shall complete all foundation pits (and build any required cofferdams or cribs) before driving foundation piles. The Contractor shall adjust pit depths to allow for upheaval caused by pile-driving. Before constructing the footing or pile cap, the Contractor shall restore the pit bottom to the specified elevation by removing heaved material or by backfilling with granular material specified in the Contract.

6-05.3(11)C PREPARATION FOR DRIVING

Treated and untreated timber piles shall be cut square on the butt ends on-site just before driving. If piles aredriven into or through hard soils, then caps, collars, or bands shall be placed on the butt ends to prevent crushing or brooming. If the head area of the pile is larger than that of the hammer face, the head shall be snipped or chamfered to fit the hammer. On treated piles, the heads shall be snipped or chamfered to at least the depth of the sapwood to avoid splitting the sapwood from the pile body.

The Contractor shall match timber pile sizes in any single bent to prevent sway braces from undue bending or distorting.

When driven, pile faces shall be turned as shown on the Drawings.

No precast-prestressed pile shall be driven until sample concrete test cylinders taken of the pile concrete pour reach the minimum compressive strength specified in the Contract. On all other precast piles, the concrete test cylinders shall reach a compressive strength of at least 4,000 psi before the piles are driven.

Helmets of approved design shall protect the heads of all precast concrete piles as they are driven. Each helmet shall have fitted into it a cushion next to the pile head. The bottom side of the helmet shall be recessed sufficiently to accommodate the required pile cushion and hold the pile in place during positioning and driving. The inside helmet diameter shall be determined before casting the pile, and the pile head shall be formed to fit loosely inside the helmet.

Steel Casing, steel pipe, or H-piles shall have square-cut ends. During driving, each pile head shall be protected by a fitted metal pile helmet.

6-05.3(11)D ACHIEVING MINIMUM TIP ELEVATION AND BEARING

Once pile driving has started, each pile shall be driven continuously until the required load bearing capacity shown in the Contract has been achieved. Pauses during pile driving, except for splicing, mechanical breakdown, or other unforeseen events, shall not be allowed.

If the Contract specifies a minimum tip elevation, the pile shall be driven to at least the minimum tip elevation, even if the load bearing capacity has been achieved. If a pile does not develop the required load-bearing capacity at the minimum tip elevation, the Contractor shall continue driving the pile until the required bearing capacity is achieved. If no minimum tip elevation is specified, then the piles shall be driven to the load bearing capacity shown in the Contract and the following minimum penetrations:

Pile Application	Pile Tip Minimum Penetration
Pile supporting cross-beams bents	10 feet below final top of ground elevated pile caps elevation
Piles supporting foundations	10 feet below bottom of foundation
Piles with a concrete seal	15 feet below bottom of seal

If overdriving is required to reach a specified minimum tip elevation, the Contractor shall provide a pile driving system that does not result in damage to the pile, or produces refusal before the minimum tip elevation is reached.

So long as the pile is not damaged and the embankment or foundation material being driven through is not permanently damaged, the Contractor shall use "normal means" necessary to:

1. Secure the minimum depth specified;
2. Penetrate hard material that lies under a soft upper layer;
3. Penetrate through hard material to obtain the specified minimum tip elevation; or
4. Penetrate through a previously placed embankment.

"Normal means" refer to methods such as preboring, spudding, or jetting. Blasting or drilling through obstructions are not considered "normal means" and shall not be used.

Prebored holes and pile spuds shall have a diameter no larger than the least outside dimension of the pile. After the pile is driven, the Contractor shall fill all open spaces between the pile and the soil caused by the preboring or spudding with dry sand, or pea gravel, or controlled density fill as approved by the Engineer.

If water jets are used, the jets shall be withdrawn before the pile reaches its final penetration, and the pile shall then be driven to its final penetration and bearing capacity. The pile shall be driven a minimum of 2 feet to obtain bearing after the jets are withdrawn, or to refusal, whichever occurs first. If the water jets loosen a pile previously driven, it shall be redriven in place or pulled and replaced by a new pile. To check on pile loosening, the Contractor shall attempt to redrive at least one in every five piles as selected by the Engineer.

If the Engineer requires, the Contractor shall overdrive the pile beyond the minimum load-bearing capacity and minimum tip elevation shown in the Contract. In this case, the Contractor will not be required to:

1) Use other than "normal means" to achieve the additional penetration;
2) Bear the expense of removing or replacing any pile damaged by overdriving; or
3) Bear the expense of overdriving the pile over 3 feet as specified in Section 6-05.5.

In driving piles for footings with seals, the Contractor shall use no method (such as jetting or preboring) that might reduce friction capacity.

6-05.3(11)E USE OF FOLLOWERS FOR DRIVING

Followers shall not be used to drive concrete or steel piles. On timber piles, the Contractor may use steel followers if the driving head and cap fit snugly over the pile head. Wood followers will not be allowed. The Engineer prefers, however, that the hammer strike the pile head directly with no cushion, block, or follower. If a follower is used, the Contractor shall, in every group of 10 piles, drive one long pile without a follower to the required bearing capacity and minimum tip elevation. This long pile shall be used to test the bearing capacity of the piles driven with a follower in the group. The tip elevation of the long pile shall be similar to the tip elevations of the piles driven with the follower. If the tip elevations vary considerably, the Contractor shall redrive the remaining piles in the group to the tip elevation of the longer pile.

6-05.3(11)F PILE DAMAGE

The Contractor shall remove and replace any pile which is damaged at no additional cost to the Owner.

After driving a steel casing for a cast-in-place concrete pile, the Contractor shall leave it empty until the Engineer has inspected and accepted it. The Contractor shall provide to the Engineer a light suitable for inspecting the entire length of its interior. The Engineer will reject any casing improperly driven, that shows partial collapse that would reduce its bearing capacity, that has been reduced in diameter, or that does not keep out water. The Contractor shall remove and replace any rejected casing at no additional cost to the Owner.

Pile heads which have been broomed, rolled, or otherwise damaged shall be cut back to undamaged material before proceeding with driving or acceptance of the pile.

6-05.3(11)G PILE CUTOFF

The Contractor shall trim the tops of all piles to the true plane and to the elevation in the Contract. If a pile is driven below cutoff elevation without the Engineer's approval, the Contractor shall remove and replace the pile at no additional cost to the Owner even if this requires a longer pile. Any pile that rises as nearby piles are driven shall be driven down again.

Any piles under timber caps or grillages shall be sawed to the exact plane of the structure above them and fit it exactly. No shimming on top of timber piles to adjust for inaccurate pile top elevations will be permitted. If a timber pile is driven out of line, it shall be straightened without damage before it is cut off or braced.

Steel casings shall be cut off at least 6 inches below the finished ground line or at the low water line if a casing may be visible.

6-05.3(11)H PILE DRIVING FROM OR NEAR ADJACENT STRUCTURES

The Contractor shall not drive piles from an existing structure unless all of the following conditions are met:

1. The existing structure is demolished within the Contract;
2. The existing structure is permanently closed to traffic; and
3. Working Shop Drawings are submitted in accordance with Section 6-01.9 and 6-02.3(16), showing the structural adequacy of the existing structure to safely support all of the construction loads.

To minimize the detrimental effects of pile driving vibrations on new concrete less than 28 days old, piles shall not be driven closer to the new concrete than the distance determined by the following formula:

D = C times the square root of E

Where: D = distance in feet

E = rated hammer energy in foot-pounds

C = coefficient in the following table based on the number of days of curing time

Curing Time (days)	Coefficient (C)	Curing Time (days)	Coefficient (C)
1	0.34	6	0.12
2	0.23	7-9	0.11
3	0.18	10-13	0.10
4	0.15	14-20	0.09
5	0.13	21-28	0.08

This distance may be reduced if approved in writing by the Engineer.

6-05.3(12) DETERMINATION OF BEARING VALUES

The following formula shall determine ultimate bearing capacities:

$P = F \times E \times L_n(10N)$

Where:

P = ultimate bearing capacity, in tons

F = 1.65 for air/steam hammers

= 1.55 for open ended diesel hammers

= 1.2 for close ended diesel hammers

= 1.9 for hydraulic hammers

= 0.6 for drop hammers

E = developed energy, equal to W times H[1], in ft-kips

W = weight of ram, in kips

H = vertical drop of hammer or stroke of ram, in feet

N = average penetration resistance in blows per inch for the last 4 inches of driving

L_n = the natural logarithm, in base "e"

[1]For closed-end diesel hammers (double-acting), the developed hammer energy (E) is determined from the bounce chamber reading. Hammer manufacturer calibration data may correlate bounce chamber pressure to developed hammer energy. For double acting hammer hydraulic and air/steam hammers, the developed hammer energy shall be calculated from ram impact velocity measurements or other means approved by the Engineer. For open ended diesel hammers (single-acting), use the blows per minute to determine the developed energy (E).

The above formula applies only when:

1. The hammer is in good working condition and operating in a manner within the manufacturer's recommendations;
2. A follower is not used;
3. The pile top is not damaged;
4. The pile top is free from broomed or crushed wood fiber;
5. The penetration occurs at a reasonably quick, uniform rate; and the pile has been driven at least 2 feet after any interruption in driving greater than 1 hour in length;
6. There is no perceptible bounce after the blow. If a significant bounce cannot be avoided, twice the height of the bounce shall be deducted from “H” to determine its true value in the formula;
7. For timber piles, bearing capacities calculated by the formula above shall be effective only when it is less than the crushing strength of the piles; and
8. If "N" is greater than or equal to 1.0 blow/inch.

If "N" required to achieve the required ultimate bearing capacity using the above formula is less than 1.0 blow/inch, the pile shall be driven until the penetration resistance is a minimum of 1.0 blow/inch for the last 2 feet of driving.

The Engineer may require the Contractor to install a pressure gauge on the inboard end of the hose to monitor pressure at the hammer.

If water jets are used in driving, bearing capacities shall be determined either: (1) by calculating it with the driving data and the formula in this Section after the jets have been withdrawn and the pile is driven at least 2 feet, or (2) by applying a test load.

6-05.3(13) TREATMENT OF TIMBER PILE HEADS

After cutting timber piles to correct elevation, the Contractor shall thoroughly coat the heads of all untreated piles with two coats of an approved preservative that meets the requirements of Section 9-09 (except concrete-encased piles).

After cutting treated timber piles to correct elevation, the Contractor shall brush three coats of an approved preservative that meets the requirements of Section 9-09 on all pile heads (except those to be covered with concrete footings or concrete caps). The pile heads shall then be capped with alternate layers of an approved roofing asphalt and a waterproofing fabric that conforms to Section 9-11.2. The cap shall be made of four layers of an approved roofing asphalt and three layers of fabric. The fabric shall be a single piece cut large enough to cover the pile top and fold down at least 6 inches along all sides of the pile. After the fabric cover is bent down over the pile, its edges shall be fastened with large-head galvanized nails or with three turns of galvanized wire. The edges of the cover shall be neatly trimmed.

On any treated timber pile encased in concrete, the cut end shall receive two coats of an approved preservative that meets the requirements of Section 9-09 and then a heavy coat of an approved roofing asphalt.

6-05.3(14) EXTENSIONS AND BUILD-UPS OF PRECAST CONCRETE PILES

The Contractor shall add extensions, or build-ups (if necessary) on precast concrete piles after they are driven to the required bearing capacity and minimum tip elevation.

Before adding extensions or build-ups to precast-prestressed piles, the Contractor shall remove any spalled concrete, leaving the pile fresh-headed and with a top surface perpendicular to the axis of the pile. The concrete in the build-up shall reach a minimum compressive strength of 5,000 psi at 28 days.

Before adding to a non-prestressed precast concrete pile, the Contractor shall cut the pile head to a depth 40 times the diameter of the vertical reinforcing bar. The final cut shall be perpendicular to the axis of the pile. Reinforcement of the same density and configuration as used in the pile shall be used in the build-up and shall be fastened firmly to the projecting steel. Forms shall be placed to prevent concrete from leaking along the pile. The concrete in the build-up shall reach a minimum compressive strength of 4,000 psi at 28 days.

Just before placing the concrete for extensions or build-ups to precast or precast-prestressed concrete piles, the Contractor shall thoroughly wet the top of the pile. Forms shall remain in place at least three days.

6-05.3(15) COMPLETION OF CAST-IN-PLACE CONCRETE PILES

After acceptance of the casing by the Engineer (see Section 6-05.3(11)F), the driven casing shall be cut off horizontally at the required elevation. They shall be clean and free of water when concrete and reinforcing steel are placed.

These piles comprise steel casings driven into the ground, reinforced as specified, and filled with designation P concrete.

6-05.3(15)A REINFORCEMENT

All reinforcing bars shall be fastened rigidly into a single unit, then lowered into the casing before the concrete is placed. Loose bars shall not be used.

Spiral hooping reinforcement shall be deformed steel bar, plain steel bar, cold-drawn wire, or deformed wire.

6-05.3(15)B PLACING CONCRETE

The Contractor shall remove all debris and water from the casing before placing concrete. If the casing cannot be dewatered, the casing shall be removed (or cut off 2 feet below the ground surface and filled with sand) and a new casing shall be driven at a location determined by the Engineer.

The Contractor shall place concrete continuously through a rigid conduit at least 5 feet long. The concrete shall be directed down the center of the pile casing completely filling the casing including around the reinforcement. The top 5 feet of concrete shall be placed with the tip of the conduit below the top of fresh concrete. The Contractor shall vibrate, as a minimum, the top 10 feet of concrete. In all cases, the concrete shall be vibrated to a point at least 5 feet below the original ground line.

6-05.4 MEASUREMENT

Bid items of work completed under the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs in this Section.

Measurement for driving (type) pile will be the number of piles driven in place.

In these categories, measurement will be the number of linear feet driven below pile cutoff:

1. Furnishing timber piles (untreated or name of treatment).
2. Precast concrete and precast-prestressed concrete piles.
3. Cast-in-place concrete piles.
4. Furnishing steel piles.

Measurement for furnishing and driving test piles will be the number furnished and driven as the Contract requires.

Measurement for steel pile tips or shoes will be by the number of tips or shoes actually installed and driven in place on steel casings or steel piles.

No specific unit of measurement will apply to the item “Precast Concrete Pile Buildup”.

6-05.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-05 will be made at the Bid item prices Bid for Bid items listed or referenced as follows:

1. “**Furnishing and Driving (Type) Test Pile**”, per each.

The Bid item price for “Furnishing and Driving (Type) Test Pile” shall include all costs for the work required for furnishing and driving test piles to the bearing capacity or penetration required by the Engineer, furnishing and installing a pile tip when pile tips are specified for the permanent piles, preboring when preboring is specified for the permanent piles, for pulling the piles or cutting them off as required, and for removing them from the site or for delivery to the Owner for salvage when ordered by the Engineer. For cast-in-place concrete test piles, this price shall include furnishing, fabricating, and installing the steel reinforcing bar cage and furnishing, casting, and curing the concrete. This Bid item price shall also include all costs with moving all pile driving equipment or other necessary equipment to the Project Site and for removing all such equipment from the Project Site after the piles have been driven. If, after the test piles have been driven, it is found necessary to eliminate the pile from all or any part of the Structure, moving the pile driving equipment to and from the site of this work shall be at no additional cost to the Owner.

2. “**Driving Timber Pile (untreated or name treatment)**”, per each.

The Bid item price for “Driving Timber Pile (untreated or name treatment)” shall include all costs for the work required to drive the specified timber pile including any metal shoes which the Contractor has determined to be beneficial to the pile driving.

3. “**Driving Concrete Pile (Size)**”, per each.
4. “**Driving Steel Pile**”, per each.

The Bid item prices for “Driving Concrete Pile (Size)” and for “Driving Steel Pile” shall include all costs for the work required to drive the pile to the bearing and/or penetration specified.

5. “**Furnishing Timber Piles, (Untreated or Name Treatment)**”, per linear foot.
6. “**Furnishing Concrete Piles, (Size)**”, per linear foot.
7. “**Furnishing Steel Piles**”, per linear foot.

The unit Contract price per linear foot for “Furnishing (type) Piling (____)” shall be full pay for furnishing the piling specified, including furnishing, fabricating, and installing the steel reinforcing bar cage, and furnishing casting, and curing the concrete, as required for concrete piling. Such price shall also be full pay, for furnishing timber, precast concrete, or precast-prestressed concrete piling length ordered from an Engineer’s order sheet but not driven.

8. “**Precast Concrete Pile Buildup**”, per each.

Payment for build-ups of precast or precast-prestressed concrete piles will be made under Section 1-09.4. No payment will be made for build-ups or additional lengths of build-up made necessary because of damage to the pile during driving. The length of splice for precast concrete piles includes the length cut off to expose reinforcing steel for the splice. The length of splice for precast-prestressed piles includes the length in which holes are drilled and reinforcing bars are grouted.

9. "**Furnishing Steel Pile Tip or Shoe (Size)**", per each.

The Bid item price for "Furnishing Steel Pile Tip or Shoe (Size)" shall include all costs for the work required to furnish and install the pile tip or shoe. Payment for pile tip or shoe for test piles or test piles incorporated as permanent piles shall be in the Bid item "Furnishing and Driving (Type) Test Pile" and no separate or additional payment will be made.

10. **Other payment information.**

Payment for build-ups of precast or precast-prestressed concrete piles will be made under Section 1-09.4. No payment will be made for build-ups or additional lengths of build-up made necessary because of damage to the pile during driving. The length of splice for precast concrete piles includes the length cut off to expose reinforcing steel for the splice. The length of splice for precast-prestressed piles includes the length in which holes are drilled and reinforcing bars are grouted.

Any pile damaged or destroyed before or at the time it is being driven shall be replaced by the Contractor at no additional cost to the Owner.

The Bid item prices for driving piles shall cover all costs related to water jets, preboring, or spudding. All costs the Contractor incurs in redriving piles loosened because of water jets, preboring, or spudding shall be at no additional cost to the Owner.

The Bid item price for furnishing concrete pile (size specified) shall cover all costs related to the pile build-up above the steel casing.

All costs to remove and replace test piles intended to remain as permanent piles but which were damaged in handling or driving shall be at no additional cost to the Owner.

All costs to remove and replace any pile damaged in driving or straightening or driven below grade shall be at no additional cost to the Owner.

Should it be determined by survey that the elevations of the pile tops have heaved after installation, the Contractor shall redrive the heaved piles to a pile tip penetration equal to or greater than that achieved during initial driving of the heaved pile at no additional cost to the Owner.

All pile cutoffs and damaged pile shall become the property of the Contractor and shall be disposed of by the Contractor.

The Engineer will inspect all piles prior to driving and reserves the right to have any pile damaged or destroyed before or when it is being driven replaced by the Contractor at no additional cost to the Owner.

The Contractor shall furnish the lengths of pile to reach from cutoff elevation up to the position of the driving equipment at no additional cost to the Owner.

All cost and expense to perform the work of removing the heaved soil within the limits of the footing excavation and filling the voids remaining from extracted piles with sand and pea gravel shall be incidental to the construction and shall be in the Bid item prices for the Bid items of Work involved in the project at no additional cost to the Owner.

All cost and expense for design of pile including uplift and pile build-ups, and pile markings for blow count shall be incidental to the pile Bid items and shall be at no additional cost to the Owner.

All cost for submittals shall be as specified in Section 1-05.3.

Payment for "Steel Reinforcing Bar" shall be under Section 6-02.5.

All cost and expense for jetting, sand and pea gravel, and vibration monitoring shall be incidental to the Bid item price for the pile Bid item and shall be at no additional cost to the Owner.

Unless otherwise specified in the Contract, the cost of PDA testing per Section 6-05.3(9)C shall be in the various Bid item prices for driving piles and shall be at no additional cost to the Owner.

The cost of overdriving per Section 6-05.3(11)D shall be incidental to the Bid item prices for furnishing and driving piles and shall be at no additional cost to the Owner.

SECTION 6-06 BRIDGE AND PEDESTRIAN RAILINGS

6-06.1 DESCRIPTION

Section 6-06 addresses the work of providing and building bridge railings and pedestrian railings that meet the requirements of the Contract.

6-06.2 MATERIALS

Material shall meet the requirements of the following Sections:

Timber Railing	9-09
Metal Railing	9-06.18

6-06.3 CONSTRUCTION REQUIREMENTS

6-06.3(1) TIMBER WHEEL GUARDS AND RAILINGS

Timber wheel guards and timber railings shall be true to line and grade and framed accurately. Construction methods not specified in this Specification Section shall follow the construction requirements of Section 6-04.

Unless the Contract indicates otherwise, wheel guards shall be:

1. Beveled and surfaced on the roadway side and surfaced on the top edge. They may be surfaced on four sides (S4S);
2. Laid in sections at least 12 feet long; and
3. Bolted through the floor plank and outside stringer (or nailing piece) with 3/4 inch diameter bolts spaced no more than 4 feet apart.

All rails and rail post material shall be S4S and painted as required in Sections 6-04 and 6-07. Railing members shall be fastened securely together, with the bolts tightened once at installation, and again just before the Physical Completion Date. The Contractor shall provide the Engineer at least 3 Working Days advance notice of the last tightening.

6-06.3(2) METAL RAILINGS

Metal railing includes posts, web members, and horizontal members of the sidewalk and roadway railing. Unless the Contract indicates otherwise, railings shall be made of aluminum alloy or steel.

Before fabricating the railing, the Contractor shall submit Shop Drawings for the Engineer's review as specified in Section 1-05.3. The Contractor may substitute other rail connection details for those shown on the Drawings if details of these changes are shown and noted in the Shop Drawings and if the Engineer approves (Section 1-05.3(6)). Anchor bolts or wedge anchors shall be positioned with a template to ensure that bolts match the hole spacings of the bottom channels or anchorage plates.

Where specified, cover plates shall fit the bottom channel tightly after being snapped into position.

Metal railings shall be installed true to line and grade (or camber). After first setting the railing, the Contractor shall readjust all or part , if necessary, to create an overall line and grade as indicated on the Drawings.

6-06.4 MEASUREMENT

Bid items of work completed under the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs in this Section.

Timber railing will be measured by the linear foot along the line and slope at the base of the completed railing.
Metal railing will be measured by the linear foot along the line and slope at the base of the completed railing.

6-06.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-06 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. "**Bridge Railing, (Type)**", per linear foot.
2. "**Metal Railing, (Type)**", per linear foot.

The Bid item prices for "Bridge Railing, (Type)" and for "Metal Railing, (Type)" shall include all costs for the work required to construct the railings as shown on the Drawings and as specified in this Section, including longitudinal, vertical and inclined structural members, plates, fastenings, anchor bolts, galvanizing, grouting, and painting as specified. In case no Bid item is in the Bid Form for "Bridge Railing, (Type)" and "Metal Railing, (Type)" and payment is not otherwise provided, all metal railings shall be included in the Bid item price for the Bid item "Structural Carbon Steel" as specified in Section 6-03.

3. "**Timber Railing, (Type)**", per linear foot.

The Bid item price for "Timber Railing, (Type)" shall include all costs for the work required to construct, provide hardware, and paint the complete railings and posts as shown on the Drawings.

SECTION 6-07 PAINTING

6-07.1 DESCRIPTION

This work consists of containment, surface preparation, shielding adjacent areas from unwanted surface preparation, testing and disposing of surface preparation debris, furnishing and applying paint, shielding adjacent areas from unwanted paint, and cleaning up after painting is completed. The work shall comply with all requirements of the Drawings, these specifications, and the engineer. Terminology used herein is in accordance with the definitions used in volume 2, systems and specifications, of the SSPC steel structures painting manual.

6-07.2 MATERIALS

Materials shall meet the requirements of the following sections:

Paint	9-08.1
Powder Coating Materials for Coating Galvanized Surfaces	9-08.2
Abrasive Blast Media	9-08.4(1)
Lead Abatement Additive	9-08.4(2)
Bird Guano Treatment	9-08.5(1)
Fungicide Treatment	9-08.5(2)

Water	9-08.5(3)
Filter Fabric	9-08.6
Single Component Urethane Sealant	9-08.7
Foam Backer Rod	9-08.8

6-07.3 CONSTRUCTION REQUIREMENTS

6-07.3(1) WORK FORCE QUALIFICATIONS

6-07.3(1)A WORK FORCE QUALIFICATIONS FOR SHOP APPLICATION OF PAINT

Facilities for shop application of paint shall be approved through the Owner's Request for Approval of Material process.

6-07.3(1)B WORK FORCE QUALIFICATIONS FOR FIELD APPLICATION OF PAINT

The Contractor preparing the surface and applying the paint shall be certified under SSPC-QP 1.

The Contractor removing and otherwise disturbing existing paint containing lead and other hazardous materials shall be certified under SSPC-QP 2, Category A.

In lieu of the above SSPC certifications, the Contractor performing the specified work may complete one of the following actions:

1. The Contractor may substitute documentation of successful completion of two bridge painting projects in the past ten years involving complete paint removal, including paint containing lead and other hazardous materials, with reapplication of a three-component moisture-cured polyurethane paint system. The documentation shall include the name and size of the project, the dates of the work, the owner's name, and name and contact information for an owner's contact person.
2. The Contractor's quality control inspector(s) for the project shall be NACE-certified CIP Level 3.

6-07.3(2) SUBMITTALS

The Contractor shall submit a painting plan to the Engineer for approval in accordance with Section 1-05.3.

For shop application of paint, the painting plan shall include the documents listed in Sections 6-07.3(2)B and 6-07.3(2)E, item 2, the product data sheet for the primer coat with coefficient of friction certification, and paint samples in accordance with Section 6-07.3(7).

For field application of paint, the painting plan shall include the documents listed in Section 6-07.3(2)A through 6-07.3(2)F.

6-07.3(2)A WORK FORCE QUALIFICATIONS SUBMITTAL COMPONENT

The work force qualifications submittal component of the painting plan shall include the following:

1. Documentation of the Contractor's workforce qualifications as specified in Section 6-07.3(1).
2. Resumé of qualifications and contact information for the Contractor's on-site supervisors. An on-site supervisor shall be present for each work shift at the bridge site, and each on-site supervisor shall have 3 years' minimum of industrial painting field experience with 1 year minimum of field supervisory or management experience in paint removal projects.

6-07.3(2)B CONTRACTOR'S QUALITY CONTROL PROGRAM SUBMITTAL COMPONENT

The Contractor's quality control program submittal component of the painting plan shall include the following:

1. Description of the inspection procedures and techniques and the acceptance criteria for all phases of work.
2. Procedure for implementation of corrective action.
3. The paint system manufacturer's recommended methods of preventing defects.
4. The Contractor's frequency of quality control inspection.
5. Description of the equipment used for inspection of prepared surfaces and inspection of paint.
6. Example completed form(s) of the daily quality control report used to document the inspection work and tests performed by the Contractor's quality control personnel.

6-07.3(2)C PAINT SYSTEM MANUFACTURER AND PAINT SYSTEM INFORMATION SUBMITTAL COMPONENT

The paint system manufacturer and paint system information submittal component of the painting plan shall include the following:

1. Product data sheets and information on the paint materials, paint preparation, and paint application, as specified by the paint manufacturer, including:
   a. Samples and documents specified in Section 6-07.3(7) for each paint and thinner.
   b. All application instructions, including the mixing and thinning directions.
   c. Recommended spray nozzles and pressures.
   d. Minimum and maximum drying time between coats.
   e. Restrictions on temperature and humidity.

f. Repair procedures as specified in Section 6-07.3(10)P.

g. Maximum dry film thickness for each coat.

h. Minimum wet film thickness for each coat to achieve the specified minimum dry film thickness.

2. Identification of, and contact information for, the paint system manufacturer's technical representative.

3. For painting of new steel, the friction coefficient of the faying surface, including test results and the paint manufacturer's Certificate of Compliance in support of the friction coefficient.

6-07.3(2)D HAZARDOUS WASTE CONTAINMENT, COLLECTION, TESTING, AND DISPOSAL SUBMITTAL COMPONENT

The hazardous waste containment, collection, testing, and disposal submittal component of the painting plan shall include the following:

1. Filter fabric attachment and support in accordance with Section 6-07.3(10)A.

2. Abrasive blasting containment system attachment and support in accordance with Section 6-07.3(10)A.

3. Details of jobsite material storage facilities and containment waste storage facilities, including location, security, and environmental control.

4. Methods and materials used to contain, collect, and dispose of all containment waste and all construction-related waste, including transportation of waste.

5. Details of the containment waste sampling plan conforming to WAC 173-303 for waste designated as dangerous waste or extremely hazardous waste.

6. The name of, and contact information for, the accredited analytical laboratory performing the testing of the containment waste samples in accordance with Section 6-07.3(10)F.

7. Process for tracking the disposal of hazardous waste, including a sample form of the tracking documentation.

6-07.3(2)E CLEANING AND SURFACE PREPARATION EQUIPMENT SUBMITTAL COMPONENT

The cleaning and surface preparation equipment submittal component of the painting plan shall include the following:

1. Details of the water jetting operation, including:

   a. Water source.

   b. A list and description of the water jetting equipment, including maximum water discharge rates and pressure.

   c. Methods and materials used to protect vehicular and pedestrian traffic from wash water when conducting overhead water jetting operations.

2. Details of the abrasive blast cleaning operation, including:

   a. Description of the abrasive blast cleaning procedure.

   b. Type, manufacturer, and brand of abrasive blast material and all associated additives, including Materials Safety Data Sheets (MSDS).

   c. Description of the abrasive blast cleaning equipment to be used.

6-07.3(2)F PAINT APPLICATION EQUIPMENT AND OPERATIONS SUBMITTAL COMPONENT

The paint application equipment and operations submittal component of the painting plan shall include the following:

1. Description of the equipment used for paint application operations.

2. Details of jobsite material storage facilities, including location, security, and environmental control.

3. Description of the supports and platforms used to support equipment, materials, and workers, including scaffolds, platforms, accordion lifts, and barges, and the methods used to attach, moor, and anchor these supports and platforms.

4. Drip tarps in accordance with Section 6-07.3(10)O.

5. Methods and materials used to protect surrounding structures, equipment, and property from exposure to, and damage from, painting operations.

6. Details of paint application operations for areas of limited and restricted access.

7. Description of the method for the removal of any accidental spills or drips on traffic that occur during the normal painting operations, and provisions for providing a vehicle-cleaning station.

6-07.3(2)G PAINTING PLAN MEETING

At the option of the Owner, a painting plan meeting may be scheduled following review of the Contractor's initial submittal of the plan. The Contractor shall be represented by the superintendent, on-site supervisors, and quality control inspectors.

6-07.3(3) QUALITY CONTROL AND QUALITY ASSURANCE

6-07.3(3)A QUALITY CONTROL AND QUALITY ASSURANCE FOR SHOP APPLICATION OF PAINT

For shop application of paint, quality control procedures shall be as approved by the Engineer.

6-07.3(3)B QUALITY CONTROL AND QUALITY ASSURANCE FOR FIELD APPLICATION OF PAINT

For field application of paint, the Contractor shall conduct quality control inspections as required by SSPC-PA 1, using the personnel and the processes outlined in the painting plan as approved by the Engineer. The Contractor shall maintain current copies of the SSPC *Painting Manual*, Volumes 1 and 2, at the project site at all times. The Contractor's quality control operations shall include monitoring and documenting the following:

1. Equipment, personnel, and materials used.
2. Environmental conditions (ambient air temperature and humidity, steel surface temperature, dew point, wind direction, and velocity).
3. Steel surface condition, profile, and preparation.
4. Paint application and film thickness.

A copy of the Contractor's daily quality control report, signed and dated by the Contractor's quality control inspector, accompanied by copies of the test results of quality control tests performed on the work covered by the daily quality control report, shall be submitted to the Engineer before the end of the next day's work shift.

The Contractor shall provide the Engineer time and access to perform quality assurance testing. Each painting operation phase shall be considered a hold point, from which the Contractor shall not proceed with continuing work until receiving the Engineer's approval.

The Engineer may perform quality assurance testing at each of the following phases of painting operations:

1. After SSPC-SP 1 cleaning.
2. After water jetting.
3. After abrasive blast cleaning, hand and power tool surface cleaning, and compressed air surface cleaning.
4. After applying each coat when dry.
5. During final inspection of all work at the end of the project.

Quality assurance testing may include the following tests:

1. Environmental conditions for painting in accordance with ASTM D 337.
2. Cleanness of abrasive blasting media and ionic contamination of abrasive blasting media in accordance with ASTM D 4940.
3. Cleanness of compressed air in accordance with ASTM D 4285.
4. Pictorial of surface preparation standards in accordance with SSPC-VIS 1, 3, 4, and 5.
5. Surface profile by Keanne-Tator comparator in accordance with ASTM D 4417.
6. Surface profile by replica tape in accordance with ASTM D 4417.
7. Wet film thickness in accordance with ASTM D 4414.
8. Dry film thickness by magnetic gage in accordance with SSPC-PA 2 modified.
9. Dry film thickness by Tooke gage in accordance with ASTM D 4138.

The Contractor shall repair all damage to paint resulting from Owner's quality assurance inspections at no additional cost or time to the Owner

6-07.3(4) PAINT SYSTEM MANUFACTURER'S TECHNICAL REPRESENTATIVE

The paint system manufacturer's technical representative shall be present at the jobsite for the pre-painting conference and for the first day of paint application, and shall be available for consultation for the full project duration.

6-07.3(5) PRE-PAINTING CONFERENCE

A pre-painting conference shall be held 5 to 10 Working Days before beginning painting operations to discuss the painting plan, construction operations, personnel, and equipment to be used. Those attending shall include:

1. (Representing the Contractor) The superintendent, on-site supervisors, and all crew members in charge of cleaning and preparing the surfaces, containing, collecting and disposing of all removed materials, applying the paint, and performing all quality control inspections, measurements and tests; and the paint system manufacturer's technical representative; and
2. The Engineer

If the Contractor's key personnel change between any work operations, an additional conference may be held.

For projects that include painting of multiple structures, a separate conference may be held for each structure, at the discretion of the Engineer.

6-07.3(6) PAINT CONTAINERS, STORAGE, AND HANDLING

6-07.3(6)A PAINT CONTAINERS

Paint container labels shall include the following information:

1. Manufacturer's name and product name, with batch number and date of manufacture.
2. Color name and Federal Standard 595 color number, where applicable.
3. Shelf life of the product, from date of batch manufacture.
4. Storage requirements and temperature limits.

Paint containers shall conform to U.S. DOT hazardous material shipping regulations. Paint shall be delivered to the jobsite in the manufacturer's original unopened containers with the original manufacturer's label legible and intact. Paint will be rejected if the container has a puncture or if the lid shows signs of paint leakage. Each container shall be filled with paint and sealed airtight. Each container shall be filled with the amount of paint required to yield the specified quantity when measured at 70°F. All paint shall be shipped in new suitable containers having a capacity not greater than 5 gallons.

6-07.3(6)B PAINT STORAGE

Paint materials shall not be used or stored on-site after the shelf life expiration date.

Paint material shipping, handling, and storage shall conform to Sections 1-06.4 and 9-08.1(4) and the following requirements:

1. Paint materials shall be stored in the manufacturer's original containers in a weather-tight space where the temperature is maintained within the storage temperature range recommended by the paint manufacturer, but in no case where the temperature is lower than 40°F or greater than 100°F.
2. The Contractor shall monitor the paint material storage facility with a high-low recording thermometer device.
3. The paint material storage facility shall be separate from the storage facilities used for storing painting equipment and used for storing containment waste and construction-generated waste.

6-07.3(7) PAINT SAMPLING AND TESTING

The Contractor shall provide the Engineer 1 quart of each paint and each thinner representing each lot. Samples shall be accompanied with a Material Safety Data Sheet and a paint drawdown sample.

If the quantity of paint required for each component of the paint system for the entire project is 20 gallons or less, then the paint system components will be accepted as specified in Section 9-08.1(7) with a paint drawdown sample.

Sampling and testing performed by the Owner shall not be construed as determining or predicting the performance or compatibility of the individual paint or the completed paint system.

6-07.3(8) EQUIPMENT

6-07.3(8)A PAINT FILM THICKNESS MEASUREMENT GAGES

Paint dry film thickness measurements shall be performed with either a Type 1 pull-off gage or a Type 2 electronic gage as specified in SSPC Paint Application Specification No. 2, *Measurement of Dry Paint Thickness with Magnetic Gages*.

Paint wet film thickness measurement gages shall be stainless steel with notches graduated in 1-mil increments.

6-07.3(9) PAINTING NEW STEEL STRUCTURES

All materials classified as nongalvanized structural steel shall be painted with a four-coat paint system as specified in Section 6-07.3(9)A. The primer coat shall be shop-applied. The intermediate, intermediate stripe, and top coats shall be field-applied after erection and following any primer coating repair operations.

Steel surfaces embedded in concrete, and faying (contact) surfaces of bolted connections (including all surfaces internal to the connection and all filler plates) shall receive the primer coat only. Stainless steel surfaces are not required to be painted. Welded shear connectors are not required to be painted except for the weld area.

Temporary attachments or supports for scaffolding or forms shall not damage the paint system.

6-07.3(9)A PAINT SYSTEM

The paint system applied to new steel surfaces shall consist of the following:

Primer Coat	9-08.1(2)C
Intermediate Coat	9-08.1(2)G
Intermediate Stripe Coat	9-08.1(2)G
Top Coat	9-08.1(2)H

All paint coating components of the selected paint system shall be produced by the same manufacturer. The paint system selected shall be used throughout the entire structure.

Paint formulations to be used on faying surfaces shall be Class B coatings with a mean slip coefficient not less than 0.50. The slip coefficient shall be determined by testing in accordance with "Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints" as adopted by the Research Council on Structural Connections.

6-07.3(9)B PAINT COLOR

Each successive coat shall be a contrasting color to the previously applied coat. The color of the top coat shall be as specified in the Drawings or Special Provisions and shall conform to Section 9-08.1(8).

6-07.3(9)C MIXING PAINT

Paint shall be mixed in accordance with the manufacturer's written recommendations to a smooth, lump-free consistency. Mixing shall be done, to the extent possible, in the original containers and shall be continued until all of the metallic powder or pigment is in suspension. The mixed paint shall be kept under continuous agitation up to and during the time of application.

6-07.3(9)D COATING THICKNESS

Dry film thickness shall be measured in accordance with SSPC Paint Application Specification No. 2. Measurement of Dry Paint Thickness with Magnetic Gages.

The minimum dry film thickness of the primer coat shall not be less than 2.5 mils.

The minimum dry film thickness of the intermediate stripe and top coats shall be not less than 3.0 mils.

The dry film thickness of each coat shall not be thicker than the paint manufacturer's recommended maximum thickness.

If the specified number of coats does not produce a combined dry film thickness of at least the sum of the thicknesses required per coat, the Contractor shall apply another full coat of the top coat of paint. The dry film thickness shall not be thicker than the paint manufacturer's recommended maximum thickness.

6-07.3(9)E SURFACE TEMPERATURE REQUIREMENTS PRIOR TO APPLICATION OF PAINT

For application of the paint system, the temperature of the steel surface shall be greater than 40°F and less than 115°F.

6-07.3(9)F SHOP SURFACE CLEANING AND PREPARATION

A roughened surface profile shall be provided by an abrasive blasting procedure as approved by the Engineer. The profile shall be in accordance with the paint manufacturer's recommendations, whichever is greater. The entire steel surface to be painted, including surfaces specified in Section 6-07.3(9)G to receive a mist coat of primer, shall be cleaned to a near white condition in accordance with SSPC-SP 10 and shall be in this condition immediately prior to paint application.

6-07.3(9)G APPLICATION OF SHOP PRIMER COAT

After receiving the Engineer's approval of the prepared surface, the primer shall be applied so as to produce a uniform, even coating that has fully bonded with the metal. Primer shall be applied with the spray nozzles and pressures recommended by the manufacturer of the paint system, so as to attain the film thicknesses specified.

Steel girder top flanges and soldier pile flanges to be embedded in concrete shall be prepared in accordance with Section 6-07.3(9)F and shall then receive a mist coat of the specified primer with a dry film thickness of 0.5 to 1.0 mils.

The Contractor shall provide access to the steel to permit inspection as approved by the Engineer. The access shall not mar or damage any freshly painted surfaces.

High-strength field bolts shall not be painted before erection.

6-07.3(9)H CONTAINMENT FOR FIELD COATING

The Contractor shall use a containment system in accordance with Section 6-07.3(10)A.

6-07.3(9)I APPLICATION OF FIELD COATINGS

Prior to applying field coatings, the Contractor shall field install welded shear connectors on the steel girder top flanges in accordance with Section 6-03.3(29) and as shown in the Drawings.

Upon completion of erection Work, all uncoated areas remaining, including bolts, nuts, washers, and splice plates, shall be prepared in accordance with Section 6-07.3(9)F, followed by a field primer coat of an organic zinc paint selected from the same approved paint system and paint manufacturer as the other paint for the Structure. The intermediate and top coats shall be applied in accordance with the manufacturer's written recommendations.

The minimum drying time between coats shall be as shown in the approved product data sheets, but not less than 12 hours. The Contractor shall determine whether the paint has cured sufficiently for proper application of succeeding coats.

The maximum time between intermediate and top coats shall be in accordance with the manufacturer's written recommendations. If the maximum time between coats is exceeded, all newly coated surfaces shall be prepared to SSPC-SP 7, brush-off blast cleaning, and shall be repainted with the same paint that was cleaned, at no additional cost to the Owner.

Dry film thickness measurements will be made in accordance with Section 6-07.3(9)D.

All paint damage that occurs shall be repaired in accordance with the manufacturer's written recommendations and as approved by the Engineer. On bare areas or areas of insufficient primer thickness, the repair shall include the application of the field-applied organic zinc primer system, and the final two coats of the paint system. On areas where the primer is at least equal to the minimum required dry film thickness, the repair shall include the application of the final two coats of the paint system. All paint repair operations shall be performed by the Contractor at no additional cost or time to the Owner

6-07.3(10) PAINTING EXISTING STEEL STRUCTURES

Painting existing steel structures includes providing containment, cleaning, preparing the surface, painting metal surfaces, and disposal of generated waste. Painting of existing steel structures shall be done in the following sequence:

1. Containment.
2. Bird guano, fungus, and vegetation removal.
3. Dry cleaning.
4. Surface preparation.
5. Treatment of pack rust and gaps.
6. Paint system application.

6-07.3(10)A CONTAINMENT

The containment system shall be in accordance with SSPC Technology Guide No. 6, *Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations* Class 2. The Contractor shall protect the surrounding environment from all debris or damage resulting from the Contractor's operations.

The containment length shall not exceed the length of a span (defined as pier to pier). The containment system shall not cause any damage to the existing structure. All clamps and other attachment devices shall be padded or designed such that they shall not mark or otherwise damage the steel member to which they are attached. All clamps and other attachment devices shall be fully described in the Contractor's painting plan submittal as approved by the Engineer. Field-welding of attachments to the existing structure will not be allowed. The Contractor shall not drill holes into the existing structure or through existing structural members except as shown in the Contractor's painting plan submittal as approved by the Engineer. All provisions for dust collection, ventilation, and auxiliary lighting within the containment system shall be fully described in the Contractor's painting plan submittal as approved by the Engineer.

The containment system shall be capable of being removed rapidly in case of high winds. The Engineer will make the final determination on whether operations shall cease.

Emissions shall be limited to the Level 2 Emissions standard in SSPC Technology Guide No. 6, Section 5.5, and assessed by Method A, Visible Emissions. If failure to the containment system occurs or if signs of failure to the containment system are present, the Contractor shall stop work immediately. Work shall not resume until the failure has been corrected to the satisfaction of the Engineer.

The containment system shall not be removed until all cleaned and painted surfaces have been inspected and approved by the Engineer.

Prior to beginning work each day, all containment systems shall be inspected by the Contractor to verify they are in place and functioning properly. Any necessary maintenance to restore full function shall be completed prior to beginning work.

6-07.3(10)B BIRD GUANO, FUNGUS, AND VEGETATION REMOVAL

Bird guano and bird nesting materials shall be removed in the dry. Following dry removal, the Contractor shall apply a treatment solution in accordance with Section 9-08.5(1), followed by hand-scrubbing and rinsing with water in accordance with Section 9-08.5(3). The bird guano, bird nesting materials, and treatment solution shall be contained and collected.

The Contractor shall treat all areas of fungus growth and vegetative growth. The Contractor shall apply a treatment solution in accordance with Section 9-08.5(2) to the fungus areas for a period recommended by the solution manufacturer or as specified by the Engineer, but in no case less than 5 minutes. The fungus, vegetative growth, and treatment solution shall be contained and collected.

Bird guano, bird nesting materials, fungus, and vegetative growth shall be disposed of at a land disposal site approved by the Engineer. The Contractor shall provide the Engineer with one copy of the disposal receipt, which shall include a description of the disposed material.

6-07.3(10)C DRY CLEANING

Dry cleaning shall include removal of accumulated dirt and debris on the surfaces to be painted. Collected dirt and debris shall be disposed of at a land disposal site approved by the Engineer. The Contractor shall provide the Engineer with one copy of the disposal receipt, which shall include a description of the disposed material

6-07.3(10)D SURFACE PREPARATION PRIOR TO OVERCOAT PAINTING

The Contractor shall remove any visible oil, grease, and road tar in accordance with SSPC-SP 1.

Following any preparation by SSPC-SP1, all steel surfaces to be painted shall be prepared in accordance with either SSPC-SP 12 WJ-4/LP WC water jetting surface cleaning or SSPC-SP 7, brush-off blast cleaning. Surfaces inaccessible to water jetting or brush-off blast shall be prepared in accordance with SSPC-SP 15, commercial grade power tool cleaning, as allowed by the Engineer.

Following water jetting or brush-off blast cleaning, the Contractor shall perform spot abrasive blast cleaning in accordance with SSPC-SP 6, commercial blast cleaning. Spot abrasive blast cleaning shall be performed in such a manner that the adjacent areas of work are protected from damage. Areas exhibiting coating failure down to the steel substrate, and those exhibiting visible corrosion, shall be prepared down to clean bare steel in accordance with SSPC-SP 6. Exposed steel areas that have an average exposed diameter of less than 1½ inches and no other similar area closer than 4 inches do not require spot abrasive blast cleaning or edge feathering unless required by the Engineer. The Contractor shall provide a sharp angular surface profile by an abrasive blasting procedure as approved by the Engineer. The profile shall be 1 mil minimum or

in accordance with the paint manufacturer's recommendations, whichever is greater. For small areas, as allowed by the Engineer, the Contractor may substitute cleaning in accordance with SSPC-SP 11, power tool cleaning. The prepared area shall extend at least 2 inches into adjacent tightly adhering, intact coating.

Following spot abrasive blast cleaning of exposed steel surfaces, edges of tightly adherent coating remaining shall be feathered so that the recoated surface has a smooth appearance. Water jetting shall be performed with water conforming to Section 9-08.5(3). Immediately prior to painting, the Contractor shall clean all steel surfaces and staging areas with dry, oil-free compressed air conforming to ASTM D 4285.

6-07.3(10)E SURFACE PREPARATION – FULL PAINT REMOVAL

For structures where full removal of existing paint is specified, all steel surfaces to be painted shall be prepared in accordance with SSPC-SP 10, near-white metal blast cleaning. Surfaces inaccessible to near-white metal blast cleaning shall be prepared in accordance with SSPC-SP 11, power tool cleaning to bare metal, as allowed by the Engineer.

6-07.3(10)F COLLECTING, TESTING, AND DISPOSAL OF CONTAINMENT WASTE

The sealed waste containers shall be labeled as required by State and Federal laws. All confined materials shall be collected and secured in sealed containers at the end of each shift or daily at a minimum to prevent the weight of the confined materials from causing failure to the containment system. The sealed waste containers shall be stored in accordance with Section 1-06.4, the painting plan as approved by the Engineer, and the following requirements:

1. The containers shall be stored on an impermeable surface that accommodates sweeping or vacuuming.
2. Landside storage of the containers shall be at an elevation above the ordinary high water level (OHWL) elevation. The container storage area shall not be in a stormwater runoff course and shall not be in an area of standing water.
3. The container storage area shall be a fenced, secured site, separate from the storage facilities for paint materials and paint equipment.
4. The containers shall not be stored at the on-site landside storage site for longer than 90 calendar days.

All material collected by and removed from the containment system shall be taken to a landside staging area, provided by the Contractor and approved by the Engineer, for further processing and storage prior to transporting for disposal. Handling and storage of material collected by and removed from the containment system shall conform to Section 1-06.4. Storage of containment waste materials shall be in a facility separate from the storage facilities used for paint materials and paint equipment.

Containment waste is defined as all paint chips and debris removed from the steel surface and all abrasive blast media, as contained by the containment system. After all waste from the containment system has been collected, the Contractor shall have a minimum of three samples of the wastes tested by an accredited analytical laboratory. Each sample shall be taken from a different storage container unless directed otherwise by the Engineer.

The debris shall be tested for metals using the Toxicity Characteristics Leaching Procedure (TCLP) and EPA Methods 1311 and 6010. At a minimum, the materials to be analyzed shall include Arsenic, Barium, Cadmium, Chromium Coppers, Lead, Mercury, Selenium, and Silver.

If the average of the tested samples is at or above all threshold limits as stated in the Dangerous Waste Regulation, WAC 173-303, the containment waste will be designated as "Dangerous Waste" and shall be disposed of at a permitted hazardous waste repository. If the average of the tested samples is below the threshold limits, the containment waste will be designated as "Solid Waste" and shall be disposed of at a permitted sanitary landfill that will accept the waste. Disposal shall be in accordance with WAC 173-303 for waste designated "Dangerous Waste" or "Extremely Hazardous Waste" and in accordance with WAC 173-304 for waste designated as "Solid Waste".

The Contractor shall supply two copies of the transmittal documents or bill of lading listing the waste material shipped from the construction site to the waste disposal site. One copy of the shipment list shall show the signature of the Engineer and shall have the waste site operator's confirmation for receipt of the waste.

In the event that the containment wastes are designated as "Dangerous Wastes" or "Extremely Hazardous Waste" under WAC 173-303, Owner will provide to the Contractor the appropriate EPA identification number.

Unless noted otherwise, a waste site will not be provided by the Owner for the disposal of excess materials and debris.

The Contractor shall submit one copy of all TCLP results to the Engineer.

The Contractor shall submit waste disposal documentation to the Engineer within 15 Working Days of each disposal. This documentation shall include the quantity and type of waste disposed of with each disposal shipment.

6-07.3(10)G TREATMENT OF PACK RUST AND GAPS

Pack rust is defined as the condition where two or more pieces of steel fastened together by rivets or bolts have been pressed apart by crevice corrosion caused by the buildup of corrosion products at the interface of the steel pieces.

Pack rust forming a gap between steel surfaces of 1/16 inch or greater shall be cleaned to a depth of one half of the gap width, up to a maximum of ¼ inch. The cleaned gap shall be treated with rust penetrating sealer and caulked to form a watertight seal along the top edge and the two sides of the steel pieces involved, using the rust penetrating sealer and caulk as approved by the Engineer. The bottom edge or lowest edge of the steel pieces involved shall not be caulked.

The type of rust penetrating sealer and caulk used shall be compatible with the paint system used and shall be applied in accordance with the rust penetrating sealer and caulk manufacturer's instructions.

When caulking joints where only one steel piece edge is exposed, a fillet of caulk shall be formed that is not less than ⅛ inch or the width of the pack rust gap. The fillet is not required where there is no separation of the steel pieces due to pack rust.

At locations where gaps between steel surfaces exceed ¼ inch, the Contractor shall fill the gap with foam backer rod material and sealant as approved by the Engineer. The foam backer rod material shall be of sufficient diameter to fill the crevice or gap. The Contractor shall apply sealant over the foam backer rod material to form a watertight seal.

6-07.3(10)H PAINT SYSTEM

The paint system applied to existing steel surfaces shall consist of the following five-coat system:

Primer Coat	9-08.1(2)F
Primer Stripe Coat	9-08.1(2)F
Intermediate Coat	9-08.1(2)G
Intermediate Stripe Coat	9-08.1(2)G
Top Coat	9-08.1(2)H

All paint coating components of the selected paint system shall be produced by the same manufacturer. Only one paint system from a singular manufacturer shall be used throughout the project unless otherwise approved in writing by the Engineer. The Contractor shall not change to a different paint system once the initial paint system has been applied to any portion of the bridge unless otherwise approved in writing by the Engineer.

6-07.3(10)I PAINT COLOR

Each of the five coats shall be a contrasting color to the previously applied full coat. The color of the top coat shall be as specified in the Drawings or Special Provisions and shall conform to Section 9-08.1(8). Tinting shall occur at the factory at the time of manufacture and placement in containers, prior to initial shipment. Application site tinting will not be allowed except as otherwise approved by the Engineer.

6-07.3(10)J MIXING AND THINNING PAINT

The Contractor shall thoroughly mix paint by mechanical means to ensure a uniform composition. Paint shall not be mixed by means of air stream bubbling or boxing. Paint shall be mixed in the original containers and mixing shall continue until all pigment or metallic powder is in suspension. Care shall be taken to ensure that the solid material that has settled to the bottom of the container is thoroughly dispersed. After mixing, the Contractor shall inspect the paint for uniformity and to ensure that no unmixed pigment or lumps are present.

Catalysts, curing agents, hardeners, initiators, or dry metallic powders that are packaged separately may be added to the base paint in accordance with the paint manufacturer's written recommendations and only after the paint is thoroughly mixed to achieve a uniform mixture with all particles wetted. The Contractor shall then add the proper volume of curing agent to the correct volume of base and mix thoroughly. The mixture shall be used within the pot life specified by the manufacturer. Unused portions shall be discarded at the end of each work day.

The Contractor shall not add additional thinner at the application site except as approved by the Engineer. The amount and type of thinner, if allowed, shall conform to the manufacturer's specifications.

When recommended by the manufacturer, the Contractor shall constantly agitate paint during application by use of paint pots equipped with mechanical agitators.

The Contractor shall strain all paint after mixing to remove undesirable matter, but without removing the pigment or metallic powder.

Paint shall be stored and mixed in a secure, contained location to eliminate the potential for spills into State waters and onto the ground and highway surfaces.

6-07.3(10)K COATING THICKNESS

The minimum dry film thickness of each coat (primer, intermediate, top, and all stripe coats) shall not be less than 3.0 mils. The dry film thickness shall not be thicker than the paint manufacturer's recommended maximum thickness.

The minimum wet film thickness of each coat shall be specified by the paint manufacturer to achieve the minimum dry film thickness.

Film thickness, wet and dry, will be measured by gages conforming to Section 6-07.3(8)A.
Wet measurements will be taken immediately after the paint is applied in accordance with ASTM D 4414. Dry measurements will be taken after the coating is dry and hard in accordance with SSPC Paint Application Specification Section No. 2.

Each painter shall be equipped with wet film thickness gages and shall be responsible for performing frequent checks of the paint film thickness throughout application.

Coating thickness measurements may be made by the Engineer after the application of each coat and before the application of the succeeding coat. In addition, the Engineer may inspect for uniform and complete coverage and appearance. One hundred percent of all thickness measurements shall meet or exceed the minimum wet film thickness. In areas where wet film thickness measurements are impractical, dry film thickness measurements may be made. If a question arises about an individual coat's thickness or coverage, it may be verified by the use of a Tooke gage in accordance with ASTM D 4138.

If the specified number of coats does not produce a combined dry film thickness of at least the sum of the thicknesses required per coat, if an individual coat does not meet the minimum thickness, or if visual inspection shows

incomplete coverage, the coating system will be rejected and the Contractor shall discontinue painting and surface preparation operations and shall submit a proposal for repair to the Engineer. The repair proposal shall include documentation demonstrating the cause of the less-than-minimum thickness, along with physical test results, as necessary, and modifications to Work methods to prevent similar results. The Contractor shall not resume painting or surface preparation operations until receiving the Engineer's approval of the completed repair.

6-07.3(10)L ENVIRONMENTAL CONDITION REQUIREMENTS PRIOR TO APPLICATION OF PAINT

Paint shall be applied only during periods when:

1. Air temperature and paint temperature are between 35°F and 115°F.
2. Steel surface temperature is between 35°F and 115°F.
3. Steel surface does not show wet drops and is not wet.
4. Relative humidity is within the manufacturer's recommended range.
5. The anticipated ambient temperature will remain above 35°F during the paint drying period.

Application will not be allowed if conditions are not favorable for proper application and performance of the paint.

Paint shall not be applied when weather conditions are unfavorable to proper curing. If a paint system manufacturer's recommendations allow for application of a paint under environmental conditions other than those specified, the Contractor shall submit a letter from the paint manufacturer specifying the environmental conditions under which the paint can be applied. Application of paint under environmental conditions other than those specified in this Section will not be allowed without the Engineer's approval.

6-07.3(10)M STEEL SURFACE CONDITION REQUIREMENTS PRIOR TO APPLICATION OF PAINT

The steel surface to be painted shall be free of moisture, dirt, dust, grease, oil, loose, peeling or, chalky paint, abrupt paint edges, salts, rust, mill scale, and other foreign matter and substances that would prevent the bond of the succeeding application. The Contractor shall protect freshly painted surfaces from contamination by abrasives, dust, or foreign materials from any other source. The Contractor shall prepare contaminated surfaces to the satisfaction of the Engineer before applying additional paint.

Prepared surfaces shall be kept clean at all times, before painting and between coats.

Edges of existing paint shall be feathered in accordance with SSPC-PA 1, Note 16.9.

6-07.3(10)N FIELD COATING APPLICATION METHODS

The Contractor shall apply paint materials by air or airless spray, brush, roller, any combination of these methods, or as recommended by the paint manufacturer, unless otherwise specified. Spray application of the paint shall be accomplished with spray nozzles and at pressures as recommended by the paint manufacturer to ensure application of paint at the specified film thickness. Regardless of the primary paint application method, the Contractor shall use brushes to apply the stripe coat, to ensure complete coverage around structural geometric irregularities and to push the paint into gaps between existing steel surfaces and around rivets and bolts. All application techniques shall conform to Section 7, SSPC-PA 1. Painters using brushes shall work from pails containing a maximum of 2 gallons of paint. This is intended to minimize the impact of any spill.

6-07.3(10)O APPLYING FIELD COATINGS

The first coat shall be a primer coat applied to steel surfaces cleaned to bare metal. The second coat shall be a primer stripe coat applied to all steel surfaces cleaned to bare metal and defined to receive a stripe coat. The third coat shall be an intermediate coat. The fourth coat shall be an intermediate stripe coat applied to steel surfaces defined to receive a stripe coat. The fifth coat shall be the top coat. The intermediate (third) and top (fifth) coats shall encapsulate the entire surface area of the structure members specified to be painted.

Prior to the application of paint, the Contractor shall clean the bridge deck surface for the purpose of dust control.

During painting operations the Contractor shall furnish, install, and maintain drip tarps below the areas to be painted to contain all spilled paint, buckets, brushes, and other deleterious material, and prevent such materials from reaching the environment below or adjacent to the structure being painted. Drip tarps shall be absorbent material and hung to minimize puddling.

In addition to the requirements of the Specifications, paint application shall conform to:

1. The best practices of the trade.
2. The written recommendations of the paint manufacturer.
3. All applicable portions of the SSPC-PA 1.

No primer paint shall be applied to any surface until the surface has been inspected and approved by the Engineer. Any area to which primer paint has been applied without the Engineer's inspection and approval will be considered improperly cleaned. The unauthorized application shall be completely removed and the entire area recleaned to the satisfaction of the Engineer. After the area has been recleaned, inspected, and approved, the Contractor may again initiate the painting sequence. No additional compensation or extension of time in accordance with Section 1-08.8 will be allowed for the removal of any unauthorized paint application and recleaning of the underlying surface.

All steel surfaces cleaned to bare metal by abrasive blast cleaning shall receive the primer coat within the same working day as the completion of the abrasive blast cleaning and before any rust begins to form. Each successive coat shall be applied as soon as possible over the previous coat, accounting for drying time of the preceding coat, weather, atmospheric temperature and other environmental conditions, and the paint manufacturer's recommendations. Each coat shall be dry

before recoating and shall be sufficiently cured so that succeeding or additional coats may be applied without causing damage to the previous coat. Recoat times shall be as shown in the paint manufacturer's recommendations, but not less than 12 hours. Revision of recoat times to other than recommended by the paint manufacturer requires the approval of the Engineer. If the maximum time between coats is exceeded, all affected areas shall be prepared to SSPC-SP 7, brush-off blast cleaning, and recoated with the Contract-specified system at no additional expense or time to the Owner.

Each coat shall be applied in a uniform layer, completely covering the preceding coat. The Contractor shall correct runs, sags, skips, or other deficiencies before application of succeeding coats. Such corrective work may require recleaning, application of additional paint, or other means as determined by the Engineer, at no additional cost to the Owner.

If fresh paint is damaged by the elements, the Contractor shall replace or repair the paint to the satisfaction of the Engineer at no additional cost to the Owner.

After applying the primer or intermediate coats, the Contractor shall apply a primer or intermediate stripe coat, respectively, on all edges, corners, seams, crevices, interior angles, junction of joint members, rivet or bolt heads, nuts and threads, weld lines, and any similar surface irregularities. The coverage of each stripe coat shall extend at least 1 inch beyond the irregular surface. The stripe coat shall be of sufficient thickness to completely hide the surface being covered and shall be followed as soon as feasible by the application of the subsequent coat to its specified thickness.

If the primer coat leaves unsealed cracks or crevices, these shall be sealed with single-component urethane sealant conforming to Section 9-08.7 (applied in accordance with the manufacturer's recommendations) before the intermediate coats are applied.

The Contractor shall correct paint deficiencies before application of succeeding coats. Such corrective work may require recleaning, application of additional paint, or other corrective measures in accordance with the paint manufacturer's recommendations and as specified by the Engineer. Such corrective work shall be completed at no additional expense or time to the Owner.

Each application of primer, primer stripe, intermediate, intermediate stripe, and top coat shall be considered as separately applied coats, including for the purposes of film thickness and coverage requirements. The Contractor shall not use a preceding or subsequent coat to remedy a deficiency in another coat. The Contractor shall apply the top coat to at least the minimum specified top coat thickness, to provide a uniform appearance and consistent finish coverage, even if the total thickness of the prime and intermediate coats is found to exceed the specified total thickness for the primer and intermediate coats.

If roadway or sidewalk planks lie so close to the metal that they prevent proper cleaning and painting, the Contractor shall remove or cut the planks to provide at least a 1-inch clearance. Any plank removal or cutting shall be done as approved by the Engineer. The Contractor shall replace all planks after painting. If removal breaks or damages the planks and makes them unfit for reuse, the Contractor shall replace them at no expense to the Owner

6-07.3(10)P FIELD COATING REPAIR

Paint repair shall conform to SSPC-PA 1. Repair areas shall be cleaned of all damaged paint and the system reapplied using all coats typical to the paint system. Each coat shall be thoroughly dry before applying subsequent coats. Paint repair shall be in accordance with the paint manufacturer's recommendations and as approved by the Engineer. All paint repair operations shall be performed by the Contractor at no additional cost or time to the Owner.

6-07.3(10)Q CLEANUP

Cleaning of equipment shall not pollute the environment per section 1-07.5. Solvents, paints, paint sludge, cans, buckets, rags, brushes, and other waste associated with this project shall be collected and disposed of off-site.

Cleanup of the project site shall conform to Sections 1-04.11 and 6-01.12

6-07.3(11) PAINTING OR POWDER COATING OF GALVANIZED SURFACES

Galvanized surfaces specified to be coated after galvanizing shall receive either paint in accordance with Section 6-07.3(11)A or powder coating in accordance with Section 6-07.3(11)B. The color of the finish coat shall be as specified in the Special Provisions.

6-07.3(11)A PAINTING OF GALVANIZED SURFACES

All galvanized surfaces receiving paint shall be prepared for painting in accordance with the ASTM D 6386. The method of preparation shall be as agreed upon by the paint manufacturer and the galvanizer. The Contractor shall not begin painting until receiving the Engineer's approval of the prepared galvanized surface.

6-07.3(11)A1 ENVIRONMENTAL CONDITIONS

Steel surfaces shall be:

- Greater than 35ºF, and
- Less than 115ºF.

or in accordance with the manufacturer's recommendations, whichever is more stringent.

6-07.3(11)A2 PAINT COAT MATERIALS

The Contractor shall paint the dry surface as follows:

	Paint Type	Name
First Coat	Section 9-08.1(2)E	Epoxy polyamide
Second Coat	Section 9-08.1(2)H	Moisture-cured aliphatic polyurethane

The Contractor shall select all coats from the approved products listed in the current Qualified Products List. The coating material for the first and second coats shall be from the same manufacturer.

Each coat shall be dry before the next coat is applied. All coats applied in the shop shall be dried hard before shipment.

6-07.3(11)B POWDER COATING OF GALVANIZED SURFACES

Powder coating of galvanized surfaces shall consist of the following coats:

	Paint Type	Name
First Coat	Section 9-08.2	Epoxy powder primer coat
Second Coat	Section 9-08.2	Polyester finish coat

6-07.3(11)B1 SUBMITTALS

The Contractor shall submit the following information to the Engineer for approval:

1. The name, location, and contact information (mail address, phone, and email) for the firm performing the powder coating operation.
2. Quality control (QC) programs established and followed by the firm performing the powder coating operation. Forms to document inspection and testing of coatings as part of the QC program shall be included in the submittal.
3. Project-specific powder coating plan, including identification of the powder coating materials used (and manufacturer), and specific cleaning, surface preparation, preheating, powder coating application, curing, shop and field coating repair, handling, and storage processes to be taken for the assemblies being coated for this project.
4. Product data and MSDS sheets for all powder coating and coating repair materials.

6-07.3(11)B2 GALVANIZING

Prior to the galvanizing operation, the Contractor shall identify to the galvanizer the specific assemblies and surfaces receiving the powder coating after galvanizing, to ensure that the galvanizing method used on these assemblies is compatible with subsequent application of a powder coating system. Specifically, such assemblies shall neither be water-quenched nor receive a chromate conversion coating as part of the galvanizing operation.

6-07.3(11)B3 GALVANIZED SURFACE CLEANING AND PREPARATION

Galvanized surfaces receiving the powder coating shall be cleaned and prepared for coating in accordance with ASTM D 6386, and the project-specific powder coating plan as approved by the Engineer.

Assemblies conforming to the ASTM D 6386 definition for newly galvanized steel shall receive surface smoothing and surface cleaning in accordance with ASTM D 6386, Section 5, and surface preparation in accordance with ASTM D 6386, Section 5.4.1.

Assemblies conforming to the ASTM D 6386 definition for partially weathered galvanized steel shall be checked and prepared in accordance with ASTM D 6386, Section 6, before then receiving surface smoothing and surface cleaning in accordance with ASTM D 6386, Section 5, and surface preparation in accordance with ASTM D 6386, Section 5.4.1.

Assemblies conforming to the ASTM D 6386 definition for weathered galvanized steel shall be prepared in accordance with ASTM D 6386, Section 7 before then receiving surface smoothing and surface cleaning in accordance with ASTM D 6386, Section 5, and surface preparation in accordance with ASTM D 6386, Section 5.4.1 except as follows:

1. Ferrous metal abrasives are prohibited as a blast media for surface preparation.
2. Surface preparation shall be accomplished using dry abrasive blasting through a blast nozzle with compressed air. Abrasive blasting with a centrifugal wheel is prohibited.

The Contractor shall notify the Engineer of all surface cleaning and preparation activities and shall provide the Engineer opportunity to perform quality assurance inspection, in accordance with Section 1-05.6, at the completion of surface cleaning and preparation activities prior to beginning powder coating application.

6-07.3(11)B4 POWDER COATING APPLICATION AND CURING

After surface preparation, the two-component powder coating shall be applied in accordance with the powder coating manufacturer's recommendations, the project-specific powder coating plan as approved by the Engineer, and as follows:

1. Preheat. The preheat shall be sufficient to prevent pinholes from forming in the finished coating system.
2. Apply the epoxy primer coat, followed by a partial cure.
3. Apply the polyester finish coat, followed by the finish cure.

6-07.3(11)B5 TESTING

The firm performing the powder coating operation shall conduct, or make arrangements for, QC testing on all assemblies receiving powder coating for this project, in accordance with the powder coating firm's QC program as documented in item 2 of the Submittal Subsection above. Testing may be performed on coated surfaces of production fabricated items, or on a representative test panel coated alongside the production fabricated items being coated. There shall be a minimum of one set of tests representing each cycle of production fabricated items coated and cured. Additional tests shall be performed at the request of the Engineer. Repair of damaged coatings on production fabricated items shall be the responsibility of the firm applying the powder coating, and shall be in accordance with the project-specific powder coating plan as approved by the Engineer. At a minimum, the QC testing shall test for the following requirements:

1. Visual inspection for the presence of coating holidays and other unacceptable surface imperfections.
2. Coating thickness measurement in accordance with Section 6-07.3(5). The minimum thickness of the epoxy primer coating and polyester finish coating shall be 3 mils each.
3. Hardness testing in accordance with ASTM D 3363, with the finish coat providing a minimum hardness value of H.
4. Adhesion testing in accordance with ASTM D 4541 for 400 psi minimum adhesion for the complete two-component coating system.
5. Powder Coating Institute (PCI) #8 recommended procedure for solvent cure test.

The results of the QC testing shall be documented in a QC report and submitted to the Engineer for approval.

The Engineer shall be provided notice and access to all assemblies at the powder coating facility for the purposes of Owner's acceptance inspection, including notice and access to witness all hardness and adhesion testing performed by the firm conducting the QC testing, in accordance with Section 1-05.6.

Assemblies not meeting the above requirements will be subject to rejection by the Engineer. Rejected assemblies shall be repaired or recoated by the Contractor, at no additional expense to the Owner in accordance with the project-specific powder coating plan as approved by the Engineer, until the assemblies satisfy the acceptance testing requirements.

Assemblies shall not be shipped from the powder coating firm's facility to the project site until the Contractor receives the Engineer's approval of the QC Report and assembly inspection performed by the Engineer.

6-07.3(11)B6 COATING PROTECTION FOR SHIPPING, STORAGE, AND FIELD ERECTION

After curing and acceptance, the Contractor shall protect the coated assemblies with multiple layers of bubble wrap or other protective wrapping materials specified in the project-specific powder coating plan as approved by the Engineer.

During storage and shipping, each assembly shall be separated from other assemblies by expanded polystyrene spacers and other spacing materials specified in the project-specific powder coating plan as approved by the Engineer.

After erection, all coating damage due to the Contractor's shipping, storage, handling, and erection operations shall be repaired by the Contractor, at no additional expense to the Owner, in accordance with the project-specific powder coating plan as approved by the Engineer. The Contractor shall provide the Engineer access to all locations of all powder-coated members for verification of coating conditions prior to and following all coating repairs.

6-07.3(12) RESERVED

6-07.3(13) PAINTING TIMBER STRUCTURES

6-07.3(13)A NUMBER OF COATS AND COLOR

Unless the Contract specifies otherwise:

1. Rails and rail posts on timber bridges shall receive 2 coats (with the wheel guard painted only on its top edge and roadway side).
2. Other timber work shall receive 3 coats if the Contract requires other timber work to be painted.

Paint color shall be as indicated in the Contract.

6-07.3(13)B APPLICATION

All wood surfaces which are to be painted shall be prepared in accordance with the paint manufacturer's recommendations and be thoroughly dry and free from oil and dirt. Paint shall be applied by brush, spread evenly, and worked thoroughly into all seasoning cracks, corners, and recesses. No later coat shall be applied until the full thickness of the previous coat has dried.

Final brush strokes with aluminum paint shall be made in the same direction to ensure that powder particles "leaf" evenly.

If a painted surface has been stained by creosote, it shall be given one or more coats of an approved shellac before repainting.

6-07.3(13)C PAINTING TREATED TIMBER

Timber treated with creosote or oil-borne pentachlorophenol preservatives shall not be painted unless otherwise specified.

Timber treated with water-borne preservatives shall be clean and be reduced to no more than 18 percent moisture content before it is painted. Any visible salt crystals on the wood surface shall be washed and brushed away with the moisture content reduced again to the specified level before painting. Stored timber awaiting painting shall be covered and stacked with spreaders to ensure air circulation.

6-07.4 MEASUREMENT

Bid items of work completed pursuant to the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs herein this Section.

Spot abrasive blast cleaning of steel surfaces in accordance with Section 6-07.3(10)D will be measured by the square foot of surface area to be cleaned to bare metal as specified by the Engineer.

No specific unit of measurement will apply to the lump sum items of "Cleaning and Painting – _____" and "Containment of Abrasives".

6-07.5 PAYMENT

Payment will be made in accordance with Section 1-04.1 for each of the following Bid items that are included in the Bid Forml:

"Cleaning and Painting - _____", lump sum.

The lump sum Contract price for "Cleaning and Painting – _____" shall be full pay for performing the work as specified, including developing all submittals; arranging for and accommodating contact and on-site attendance by the paint manufacturer's technical representative; furnishing and placing all necessary staging and rigging; furnishing, operating, and mooring barges; furnishing and operating fixed and movable work platforms; accommodating Owner inspection access; conducting the Contractor's quality control inspection program; providing material, labor, tools, and equipment; collecting and storing containment waste; collecting, storing, testing, and disposing of all containment waste not conforming to the definition in Section 6-07.3(10)F; performing all cleaning and preparation of surfaces to be painted including Cleaning, Sealing and Caulking pack Rust and Spot Abrasive Blast Cleaning; applying all coats of paint and sealant; correcting coating deficiencies; completing coating repairs; and completing project site cleanup.

Progress payments for "Cleaning and Painting – _____" will be made on a monthly basis and will be based on the percentage of the total estimated area satisfactorily cleaned and coated as determined by the Engineer. Payment will not be made for areas that are otherwise complete but have repairs outstanding.

"Spot Abrasive Blast Cleaning", per square foot.

The unit contract price per square foot for "Spot Abrasive Blast Cleaning" shall be full pay for performing the spot abrasive blast cleaning work in accordance with Section 6-07.3(10)D.

"Containment of Abrasives", lump sum.

The lump sum contract price for "Containment of Abrasives" shall be full payment for all costs incurred by the Contractor in complying with the requirements as specified in Section 6-07.3(10)A to design, construct, maintain, and remove containment systems for abrasive blasting operations.

All costs in connection with testing containment waste, transporting containment waste for disposal, and disposing of containment waste in accordance with Section 6-07.3(10)F will be per the Special Provisions.

No separate payment for painting new steel or timber structures will be made. All costs related to painting new steel structures and painting or powder coating of galvanized surfaces shall be included in payment items in Section 6-03.5. Payment for painting of timber structures will be in accordance with Section 6-04.5.

SECTION 6-08 WATERPROOFING

6-08.1 DESCRIPTION

Section 6-08 addresses the work of applying waterproofing materials to Portland cement concrete surfaces as required by the Contract.

6-08.2 MATERIALS

Materials shall meet the requirements of the following sections:

Asphalt for Waterproofing	9-11.1
Waterproofing Fabric	9-11.2
Portland Cement Mortar	9-11.3
Mortar	9-20.4
Waterproofing Admixture	9-23.8

6-08.3 CONSTRUCTION REQUIREMENTS

6-08.3(1) STORAGE OF FABRIC

The fabric shall be stored in a dry, protected place. Rolls shall not be stored standing on end.

6-08.3(2) PREPARATION OF SURFACE

Preparation of surfaces shall be under the manufacturer's recommendations. Concrete surfaces shall be reasonably smooth and without projections or holes that might puncture the waterproofing membrane. The surfaces shall be dry, with all dust and loose material removed. The Contractor shall not apply waterproofing in wet weather or when the air temperature is below 35°F unless the Engineer approves in writing.

6-08.3(3) APPLICATION OF WATERPROOFING

Unless the manufacturer's instructions state otherwise, waterproofing asphalt shall be stirred frequently as it is heated to between 300°F and 350°F. Each heating kettle shall have a thermometer.

Each coat of primer or asphalt shall begin at the low point of the surface so water runs over (not against or along) the laps.

In applying the waterproofing, the Contractor shall:

1. Apply a coat of primer and let it dry before applying the first asphalt coat;
2. Mop hot asphalt on a band about 20 inches wide across the full length of the surface;
3. Immediately roll a starter strip of half-width fabric into the asphalt, pressing it into place to rid it of all air bubbles and to conform it closely to the surface;
4. Mop hot asphalt over the starter strip and an adjacent section of surface so the fresh asphalt forms a band slightly wider than the full width of the fabric;
5. Immediately roll a full-width strip of fabric into the fresh asphalt, pressing it into place as before;
6. Mop hot asphalt on the latest strip and on an adjacent band of the surface slightly wider that the full width of the fabric;
7. Immediately roll another strip of fabric into the asphalt, lapping the earlier strip by at least 2 inches and pressing it into place as before;
8. Repeat steps 6 and 7 until the entire surface is covered; and
9. Mop the entire surface with a final coating of hot asphalt.

The three complete moppings of asphalt shall ensure that no fabric layer ever touches another fabric layer or the concrete surface. The Contractor shall examine all laps and ensure they are thoroughly sealed down.

Each mopping shall cover completely, with a coat heavy enough to hide the fabric weave and all gray spots from the concrete. On horizontal surfaces, at least 12 gallons of asphalt shall be used for every 100 square feet of finished work. On vertical surfaces, at least 15 gallons per 100 square feet shall be used.

At the end of each day's work, all fabric laid shall have received its final mopping of asphalt.

Wherever the membrane ends or is punctured by drains, pipes, etc., the Contractor shall seal the area to prevent water from entering between the waterproofing and the concrete surface.

All flashing (at curbs, against girders, spandrel walls, etc.) shall be made of separate sheets that lap the main membrane by at least 12 inches. Flashing shall be sealed closely:

(1) with full metal flashing; or

(2) by imbedding its upper edges in a groove poured full of an acceptable joint cement.

At each expansion joint, the membrane shall not be broken but shall be folded to permit movement. At either end of the bridge, the membrane shall run well down abutments and shall allow for expansion and contraction.

6-08.3(4) PROTECTION COURSE

If the Drawings require, the Contractor shall place a layer of mortar at least 1 1/2 inches thick over the whole surface of the membrane just after it has cooled to air temperature. This layer shall be a mix of one part Portland cement to two parts sand. It shall be distributed evenly over the membrane, tamped gently into place, finished by hand to a smooth, hard surface, then covered and kept moist for one week.

6-08.4 MEASUREMENT

Bid items of work completed under the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs this Section.

Measurement for "Waterproofing" will be the number of square yards of the actual surface of the waterproofed area and will not include required overlap.

6-08.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-08 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows:

1. "**Waterproofing**", per square yard.

The Bid item price for "Waterproofing" shall include all costs for the work required to furnish and construct the waterproofing.

2. Other payment information.

Waterproofing of construction joints not shown on the Drawings shall be included in the Bid item price for "Waterproofing".

6-09 MODIFIED CONCRETE OVERLAYS

6-09.1 DESCRIPTION

This Work consists of scarifying concrete bridge decks, preparing and repairing bridge deck surfaces designated and marked for further deck preparation, and placing, finishing, and curing modified concrete overlays.

6-09.2 MATERIALS

Materials shall meet the requirements of the following Sections:

Portland Cement	9-01.2(1)
Fine Aggregate	9-03.1(2)B
Coarse Aggregate	9-03.1(4)C
Mortar	9-20.4
Burlap Cloth	9-23.5
Admixtures	9-23.6
Fly Ash	9-23.9
Microsilica Fume	9-23.11
Water	9-25.1

Portland cement shall be either Type I or Type II. Type III portland cement will not be allowed.

Fine aggregate shall be Class 1. Coarse aggregate shall be AASHTO grading No. 7 or No. 8.

Fly ash shall be Class F only.

Microsilica admixture shall be either a dry powder or a slurry admixture. Microsilica will be accepted based on submittal to the Engineer of a Manufacturer's Certificate of Compliance conforming to Section 1-06.3. If the microsilica is a slurry admixture, the microsilica content of the slurry shall be certified as a percent by mass.

Latex admixture shall be a non-toxic, film-forming, polymeric emulsion in water to which all stabilizers have been added at the point of manufacture. The latex admixture shall be homogeneous and uniform in composition, and shall conform to the following:

Polymer Type Styrene Butadiene

Stabilizers:

Latex	Non-ionic surfactants
Portland Cement	Polydimethyl siloxane
Percent Solids	46.0 to 49.0
Weight per Gallon	8.4 pounds at 77ºF
Color	White
PH (as shipped)	9 minimum
Freeze/Thaw Stability	5 cycles (5ºF to 77ºF)
Shelf Life	2 years minimum

Latex admixture will be accepted based on submittal to the Engineer of a Manufacturer's Certificate of Compliance conforming to Section 1-06.3.

High Molecular Weight Methacrylate (HMWM) resin for crack and joint sealing shall conform to the following:

Viscosity	<25 cps (Brookfield RVT with UL adaptor, 50 rpm at 77°F) … California Test 434
Density	8.5 to 8.8 pounds per gallon at 77°F… ASTM D 2849
Flash Point	>200°F, PMCC (Pinsky-Martens CC)
Vapor Pressure	<0.04 inches Hg at 77°F, ASTM D 323
Tg (DSC)	>136°F, ASTM D 3418
Gel Time	60 minutes minimum

The promoter/initiator system for the methacrylate resin shall consist of a metal drier and peroxide.

Sand for abrasive finish shall be crushed sand, oven dried, and stored in moisture proof bags. The sand shall conform to the following gradation:

Sieve Size	Percent Passing	
	Minimum	Maximum
No. 10	98	100
No. 16	55	75
No. 20	30	50

No. 30	8	25
No. 50	0	5
No. 100	0	3

All percentages are by weight.

6-09.3 CONSTRUCTION REQUIREMENTS

6-09.3(1) EQUIPMENT

6-09.3(1)A POWER DRIVEN HAND TOOLS

Power driven hand tools may be used for concrete scarification in areas not accessible to scarification machines, and for further deck preparation Work, except for the following:

1. Jack hammers more forceful than the nominal 30-pound class.
2. Chipping hammers more forceful than the nominal 15-pound class.

The power driven hand tools shall be operated at angles less than 45 degrees as measured from the surface of the deck to the tool.

6-09.3(1)B ROTARY MILLING MACHINES

Rotary milling machines shall have a maximum operating weight of 50,000 pounds and conform to the requirements in Section 1-07.7.

6-09.3(1)C HYDRO-DEMOLITION MACHINES

Hydro-demolition machines shall consist of filtering and pumping units operating in conjunction with a remote-controlled robotic device, using high-velocity water jets to remove ½ inch of sound concrete with the simultaneous removal of all deteriorated concrete. Hydro-demolition machines shall also clean any exposed reinforcing steel of all rust and corrosion products.

6-09.3(1)D SHOT BLASTING MACHINES

Shot blasting machines shall consist of a self-contained mobile unit, using steel abrasive to remove ½ inch of sound concrete. The shot blasting machine shall vacuum and store all material removed from the scarified concrete surface into a self-contained unit.

6-09.3(1)E AIR COMPRESSOR

Air compressors shall be equipped with oil traps to eliminate oil from being blown onto the bridge deck during sandblasting and air cleaning.

6-09.3(1)F VACUUM MACHINE

Vacuum machines shall be capable of collecting all dust, concrete chips, freestanding water and other debris encountered while cleaning during deck preparation. The machines shall be equipped with collection systems that allow the machines to be operated in air pollution sensitive areas and shall be equipped to not contaminate the deck during final preparation for concrete placement.

6-09.3(1)G WATER SPRAYING SYSTEM

The water spraying system shall include a portable high-pressure sprayer with a separate water supply of potable water. The sprayer shall be readily available to all parts of the deck being overlaid and shall be able to discharge water in a fine mist to prevent accumulation of free water on the deck. Sufficient water shall be available to thoroughly soak the deck being overlaid and to keep the deck wet prior to concrete placement.

The Contractor shall certify that the water spraying system meets the following requirements:

Pressure	2,200 psi minimum
Flow Rate	4.5 gpm minimum
Fan Tip	15° to 25° Range

6-09.3(1)H MOBILE MIXER FOR LATEX MODIFIED CONCRETE

Proportioning and mixing shall be accomplished in self-contained, self-propelled, continuous-mixing units conforming to the following requirements:

1. The mixer shall be equipped so that it can be grounded.
2. The mixer shall be equipped to provide positive measurement of the portland cement being introduced into the mix. An approved recording meter, visible at all times and equipped with a ticket printout, shall be used.

3. The mixer shall be equipped to provide positive control of the flow of water and latex admixture into the mixing chamber. Water flow shall be indicated by an approved flow meter with a minimum readability of ½ gallon per minute, accurate to ± 1 percent. The water system shall have a bypass valve capable of completely diverting the flow of water. Latex flow shall also be indicated by an approved flow meter with a minimum readability of 2 gallons per minute, accurate to ± 1 percent. The latex system shall be equipped with a bypass valve suitable for obtaining a calibrated sample of admixture.
4. The mixer shall be equipped to be calibrated to automatically proportion and blend all components of the specified mix on a continuous or intermittent basis as required by the finishing operation, and shall discharge mixed material through a conventional chute directly in front of the finishing machine.

Inspection of each mobile mixer shall be done by the Contractor in the presence of the Engineer and in accordance with the following requirements:

1. Check the manufacturer's inspection plate or mix setting chart for the serial number, the proper operating revolutions per minute (rpm), and the approximate number of counts on the cement meter to deliver 94 pounds of cement.
2. Make a general inspection of the mobile mixer to ensure cleanliness and good maintenance practices.
3. Check to see that the aggregate bins are empty and clean and that the bin vibrators work.
4. Verify that the cement aeration system operates, that the vent is open, and that the mixer is equipped with a grounding strap. Check the cement meter feeder to ensure that all fins and pockets are clean and free from accumulated cement. If the operator cannot demonstrate, through visual inspection, that the cement meter feeder is clean, all cement shall be removed from the bin and the cement meter feeder inspected. The aeration system shall be equipped with a gauge or indicator to verify that the system is operating.
5. Verify that the main belt is clean and free of any accumulated material.
6. Check the latex strainer to ensure cleanliness.

The initial calibration shall consist of the following items:

1. **Cement Meter**
   a. Refer to the truck manufacturer's mix setting chart to determine the specified operating rpm and the approximate number of counts required on the cement meter to deliver 94 pounds of cement.
   b. Place at least 40 bags (about 4,000 pounds) of cement in the cement bin.
   c. Ensure the mixer is resting on a level surface.
   d. Ensure the mixer is grounded.
   e. Adjust the engine throttle to obtain the specified rpm. Operate the unit, discharging cement until the belt has made one complete revolution. Stop the belt. Reset the cement meter to zero. Position a suitable container to catch the cement and discharge approximately one bag of cement. With a stopwatch, measure the time required to discharge the cement. Record the number of counts on the cement meter and determine the weight of the cement in the container. Repeat the process of discharging approximately one bag of cement until six runs have been made. Reset the cement meter to zero for each run.

      Example:

Run No.	Cement Counts	Weight of Cement	Time In Seconds
1	66	95	31
2	68	96	31.2
3	67	95.5	31.0
4	66	95	29.8
5	67	95.25	30.5
6	66	95	30.8
TOTAL	400	571.75	184.3

Pounds of cement per count on cement meter:

$$\frac{\text{Weight of Cement}}{\text{No. of Counts}} = \frac{571.75}{400} = 1.43 \text{ LB./Count}$$

Counts per bag (94 pounds):

94 1.43	=	65.7 Counts Bag

Pounds of cement discharged per second:

Weight of Cement Time in Seconds	=	571.7 5 184.3	=	3.10 LB./SEC.

Required time to discharge one bag:

Time =	94 3.10	=	30.32 SEC./Bag

2. **Latex Throttling Valve**
   a. Check to be sure that the latex strainer is unobstructed.
   b. The latex throttling valve shall be adjusted to deliver 3.5 gallons of latex (29.4 pounds) for each bag of cement. From the above calculation 30.32 seconds are required to deliver one bag of cement.
   c. With the unit operating at the specified rpm, discharge latex into a container for 30.3 seconds and determine the weight of latex. Continue adjusting the valve until 29.4 to 29.5 pounds of latex is discharged in 30.3 seconds. Verify the accuracy of this valve setting three times.
3. **Water Flow Meter**
   a. Set the water flow meter by adjusting it to flow at ½ gallon per minute.
   b. Collect and weigh the water discharged during a 1-minute interval with the equipment operating at the specified rpm. Divide the weight of water by 8.34 to determine the number of gallons.
   c. Repeat items a. and b., above, with the flow meter adjusted to 1½ gallons per minute.
4. **Aggregate Bin Gates**
   a. Set the gate openings to provide the amount of aggregate required to produce concrete having the specified proportions.
   b. Discharge a representative sample of the aggregates through the gates and separate on the No. 4 sieve. Aggregates shall meet the requirements for proportions in accordance with Section 6-09.3(3)E.
   c. Adjust the gate openings if necessary to provide the proper ratio of fine aggregate to total aggregate.
5. **Production of Trial Mix** – Each mobile mixer shall be operated to produce at least ½ cubic yard of concrete, which shall be in compliance with these Specifications, prior to acceptance of the mobile mixer for job use. The Engineer will perform yield, slump, and air tests on the concrete produced by each mixer. Calibration of each mobile mixer shall be done by the Contractor in the presence of the Engineer. A complete calibration is required on each mixer on each concrete placement unless, after the initial calibration, the personnel having the responsibility of mixer calibration on subsequent concrete placement were present during the initial calibration of the mixer and during the concrete placement operations and are able to verify the dial settings of the initial calibration and concrete placement.

If these criteria are met, a complete calibration need not be repeated provided that a single trial run verifies the previous settings of the cement meter, latex throttling valve, water flow meter, and aggregate gradations, and that the mixer has not left the project and the Engineer is satisfied that a complete calibration is not needed.

6-09.3(1)I READY-MIX TRUCKS FOR FLY ASH MODIFIED AND MICROSILICA MODIFIED CONCRETE

Ready-mix trucks shall conform to Section 6-02.3(4)A.

6-09.3(1)J FINISHING MACHINE

The finishing machine shall meet the requirements of Section 6-02.3(10) and the following requirements:

The finishing machine shall be equipped with a rotating cylindrical double drum screed not exceeding 60 inches in length preceded by a vibrating pan. The vibrating pan shall be constructed of metal and be of sufficient length and width to properly consolidate the mixture. The vibrating frequency of the vibrating pan shall be variable with positive control between 3,000 and 6,000 rpm. A machine with a vibrating pan as an integral part may be proposed and will be considered for approval by the Engineer. Other finishing machines will be allowed subject to approval of the Engineer.

6-09.3(2) SUBMITTALS

The Contractor shall submit the following items to the Engineer for approval in accordance with Section 6-01.9:

1. The type of machine (rotary milling, hydro-demolition, or shot blasting) selected by the Contractor for use in this project to scarify concrete surfaces.
2. The axle loads and axle spacing of the rotary milling machine (if used).

3. The Runoff Water Disposal Plan (if a hydro-demolition machine is used). The Runoff Water Disposal Plan shall describe all provisions for the containment, collection, filtering, and disposal of all runoff water and associated contaminants and debris generated by the hydro-demolition process, including containment, collection and disposal of runoff water and debris escaping through breaks in the bridge deck.
4. The method and materials used to contain, collect, and dispose of all concrete debris generated by the scarifying process, including provisions for protecting adjacent traffic from flying debris.
5. The mix design for concrete Class M, and either fly ash modified concrete, microsilica modified concrete, or latex modified concrete, as selected by the Contractor for use in this project in accordance with Section 6-09.3(3).
6. Samples of the latex admixture and the portland cement for testing and compatibility (if latex modified concrete is used).
7. Paving equipment Specifications and details of the screed rail support system, including details of anchoring the rails and providing rail continuity.

The Contractor shall not begin scarifying operations until receiving the Engineer's approval of items 1 through 4 as applicable for the Contractor's scarifying method. The Contractor shall not begin placing modified concrete overlay until receiving the Engineer's approval of items 5 through 7 as applicable for the Contractor's selected type of modified concrete.

6-09.3(3) CONCRETE OVERLAY MIXES

6-09.3(3)A GENERAL

For fly ash, microsilica, and latex modified concrete, the Contractor shall adjust the slump to accommodate the gradient of the bridge deck, subject to the maximum slump specified.

For fly ash and microsilica modified concrete, the maximum water/cement ratio shall be calculated using all of the available mix water, including the free water in both the coarse and fine aggregate, and in the microsilica slurry if a slurry is used.

For fly ash and microsilica modified concrete, all water-reducing and air entraining admixtures, and superplasticizers, shall be used in accordance with the admixture manufacturer's recommendations, and as approved by the Engineer.

6-09.3(3)B CONCRETE CLASS M

Concrete Class M for further deck preparation patching concrete shall be proportioned in accordance with the following mix design:

Portland Cement	705 pounds
Fine Aggregate	1,280 pounds
Coarse Aggregate	1,650 pounds
Water/Cement Ratio	0.37 maximum
Air (± 1½ percent)	6 percent
Slump (± 1 inch)	5 inches

The use of a water-reducing admixture conforming to AASHTO M 194 Type A will be required to produce patching concrete with the desired slump, and shall be used in accordance with the admixture manufacturer's recommendations. Air entraining admixtures shall conform to AASHTO M 154 and shall be used in accordance with the admixture manufacturer's recommendations. The use of accelerating admixtures or other types of admixtures is not allowed.

6-09.3(3)C FLY ASH MODIFIED CONCRETE

Fly ash modified concrete shall be a workable mix, uniform in composition and consistency. Mix proportions per cubic yard shall be as follows:

Portland Cement	611 pounds
Fly Ash	275 pounds
Fine Aggregate	38 percent of total aggregate
Coarse Aggregate	62 percent of total aggregate
Water/Cement Ratio	0.30 maximum
Air (± 1½ percent)	6 percent
Slump	7 inches maximum

6-09.3(3)D MICROSILICA MODIFIED CONCRETE

Microsilica modified concrete shall be a workable mix, uniform in composition and consistency. Mix proportions per cubic yard shall be as follows:

Portland Cement	658 pounds
Microsilica Fume	52 pounds
Fine Aggregate	1,515 pounds
Coarse Aggregate	1,515 pounds
Water/Cement Ratio	0.33 maximum
Air (± 1½ percent)	6 percent
Slump	7 inches maximum

6-09.3(3)E LATEX MODIFIED CONCRETE

Latex modified concrete shall be a workable mix, uniform in composition and consistency. Mix proportions per cubic yard shall be as follows:

Portland Cement	1.00 parts by weight
Fine Aggregate	2.40 to 2.75 parts by weight
Coarse Aggregate	1.75 to 2.00 parts by weight
Latex Admixture	3.50-gallons per bag of cement
Water/Cement Ratio	0.33 maximum
Air Content of Plastic Mix	6 percent maximum
Slump	7 inches maximum

The aggregates shall be proportioned such that the amount of aggregate passing the No. 4 sieve is 65 ± 5 percent of the total aggregate (fine plus coarse). All calculations shall be based on dry weights.

The moisture content of the fine aggregate and coarse aggregate shall be no more than 3.0 and 1.0 percent, respectively, above the saturated surface dry condition.

The water limit for calculating the water/cement ratio shall include the added water, the free water in the aggregates, and 52 percent of the latex admixture.

6-09.3(4) STORING AND HANDLING

6-09.3(4)A AGGREGATE

Aggregates shall be stored and handled in a manner to prevent variations of more than 1.0 percent in moisture content of the stockpile.

For latex modified concrete, the moisture content of the aggregate at the time of proportioning shall be as specified in Section 6-09.3(3)E.

6-09.3(4)B LATEX ADMIXTURE

The admixture shall be kept in suitable containers that will protect it from freezing and from exposure to temperatures in excess of 85ºF. Containers of the admixture shall not be stored in direct sunlight for periods in excess of 10 days. When stored in direct sunlight the top and sides of the containers shall be covered with insulating blanket material.

Storage of the admixture may extend over a period greater than 10 days as long as the conditions specified above are maintained and the latex admixture is agitated or stirred once every 10 days. Stirring or agitation of the admixture shall be done mechanically in accordance with the manufacturer's recommendation and as approved by the Engineer. If the ambient temperature is higher than 85ºF at any time during the storage period, the admixture shall be covered by insulated blankets or other means that will maintain the admixture temperature below 85ºF.

The admixture shall be strained through a Number 10 strainer at the time it is introduced into the mixing tank from the storage containers.

6-09.3(4)C HIGH MOLECULAR WEIGHT METHACRYLATE RESIN (HMWM)

The HMWM resin shall be stored in a cool dry place and protected from freezing and exposure to temperature in excess of 100ºF. The promoter and initiator, if supplied separate from the resin, shall not contact each other directly. Containers of promoters and initiators shall not be stored together in a manner that will allow leakage or spillage from one to contact the containers or material of the other.

6-09.3(5) SCARIFYING CONCRETE SURFACE

6-09.3(5)A GENERAL

The Contractor shall not begin scarifying a concrete bridge deck surface unless completion of the scarification and concrete overlay can be accomplished within the current construction season.

The Contractor shall not begin scarifying a concrete bridge deck surface until receiving the Engineer's written approval of the machine to be used for scarifying

The Contractor shall protect adjacent traffic from flying debris generated by the scarification process in accordance with item 4 of Section 6-09.3(2) and as approved by the Engineer.

The Contractor shall collect, contain, and dispose of all concrete debris generated by the scarification process in accordance with item 4 of Section 6-09.3(2) and as approved by the Engineer.

All areas of the deck that are inaccessible to the selected scarifying machine shall be scarified to remove the concrete surface matrix to a maximum depth of ½ inch by a method approved by the Engineer. If these areas are hand-chipped then the equipment shall meet the requirements as specified in Section 6-09.3(1)A.

Dense, sound areas of existing bridge deck repair material shall be sufficiently scarified to provide 1-inch minimum clearance to the top of the fresh modified concrete overlay.

6-09.3(5)B TESTING OF HYDRO-DEMOLITION AND SHOT BLASTING MACHINES

A trial area shall be designated by the Engineer to demonstrate that the equipment and methods of operation are capable of producing results satisfactory to the Engineer. The trial area shall consist of two patches each of approximately 30 square feet, one area in sound concrete and one area of deteriorated concrete as determined by the Engineer.

In the "sound" area of concrete, the equipment shall be programmed to remove ½ inch of concrete.

Following the test over sound concrete, the equipment shall be located over the deteriorated concrete and using the same parameters for the sound concrete removal, remove all deteriorated concrete. The Engineer will grant approval of the equipment based on successful results from the trial area test.

6-09.3(5)C HYDRO-DEMOLISHING

Once the operating parameters of the Hydro-Demolition machine are defined by programming and calibration as specified in Section 6-09.3(5)B, they shall not be changed as the machine progresses across the bridge deck, in order to prevent the unnecessary removal of sound concrete below the required minimum removal depth. The Contractor shall maintain a minimum production rate of 250-square feet per hour during the deck scarifying process.

All water used in the Hydro-Demolition process shall be potable. Stream or lake water will not be permitted.

All bridge drains and other outlets within 100 feet of the Hydro-Demolition machine shall be temporarily plugged during the Hydro-Demolition operation. When scarifying a bridge deck passing over traffic lanes, the Contractor shall protect the traffic below by restricting and containing scarifying operations, and implementing traffic control measures, as approved by the Engineer.

The Contractor shall provide for the collection, filtering and disposal of all runoff water generated by the Hydro-Demolition process, in accordance with the Runoff Water Disposal Plan as approved by the Engineer in accordance with item 3 of Section 6-09.3(2). The Contractor shall comply with applicable regulations concerning such water disposal.

6-09.3(5)D SHOT BLASTING

Once the operating parameters of the Shot Blasting machine are defined by programming and calibration, as specified in Section; 6-09.3(5)B, they shall not be changed as the machine progresses across the bridge deck, in order to prevent the unnecessary removal of sound concrete below the required minimum removal depth. The Contractor shall maintain a minimum production rate of 250 square feet per hour during the deck scarifying process.

6-09.3(5)E ROTOMILLING

The entire concrete surface of the bridge deck shall be scarified to remove the surface matrix to a maximum ½ inch depth of the concrete. The operating parameters of the rotary milling machine shall be monitored in order to prevent the unnecessary removal of concrete below the ½-inch maximum removal depth.

6-09.3(5)F REPAIR OF STEEL REINFORCING BARS DAMAGED BY SCARIFYING OPERATIONS

All reinforcing steel damaged due to the Contractor's operations shall be repaired by the Contractor. For bridge decks not constructed under the same Contract as the concrete overlay, damage to existing reinforcing steel shall be repaired and paid for in accordance with Section 1-09.6 if the existing concrete cover is ½ inch or less. All other reinforcing steel damaged due to the Contractor's operations shall be repaired by the Contractor at no additional expense to the Contracting Agency.

The repair shall be as follows or as directed by the Engineer:

1. Damage to epoxy coating, when present on existing steel reinforcing bars, shall be repaired in accordance with Section 6-02.3(24)H.
2. Damage to bars resulting in a section loss of 20 percent or more of the bar area shall be repaired by chipping out the adjacent concrete and splicing a new bar of the same size. Concrete shall be removed to provide a ¾-inch minimum clearance around the bars. The splice bars shall extend a minimum of 40 bar diameters beyond each end of the damage.
3. Any bars partially or completely removed from the deck shall have the damaged portions removed and spliced with new bars as outlined in item 2 above.

6-09.3(5)G CLEANUP FOLLOWING SCARIFICATION

After scarifying is completed, the lane or strip being overlaid shall be thoroughly cleaned of all dust, freestanding water and loose particles. Cleaning may be accomplished by using compressed air, water blasting, with a minimum pressure of 5,000 psi, or vacuum machines. Vacuum cleaning shall be used when required by applicable air pollution ordinances.

6-09.3(6) FURTHER DECK PREPARATION

Once the lane or strip being overlaid has been cleaned of debris from scarifying, the Contractor, with the Engineer, shall perform an inspection of the completed work in accordance with ASTM D 4580, Method B, except as otherwise noted for concrete surfaces scarified by hydro-demolition. The Contractor shall mark those areas of the existing bridge deck that are authorized by the Engineer for further deck preparation by the Contractor. When hydro-demolition is used as the method of scarification, the inspection for further deck preparation shall be a visual inspection and shall take place after one pass of the hydro-demolition machine.

Further deck preparation will be required when any one of the following conditions is present:

1. Unsound concrete.
2. Lack of bond between existing concrete and reinforcing steel.
3. Existing nonconcrete patches as authorized by the Engineer.
4. Additionally, for concrete surfaces scarified by rotomilling only, exposure of reinforcing steel to a depth of one-half of the periphery of a bar for a distance of 12 inches or more along the bar.

Further deck preparation performed beyond the areas authorized by the Engineer will be at the Contractor's expense in accordance with Section 1-05.7. If the concrete overlay is placed on a bridge deck as part of the same Contract as the bridge deck construction, then all Work associated with the further deck preparation shall be performed at no additional expense to the Contracting Agency.

6-09.3(6)A EQUIPMENT FOR FURTHER DECK PREPARATION

Further deck preparation shall be performed using either hand operated tools conforming to Section 6-09.3(1)A, or hydro-demolishing machines conforming to Section 6-09.3(1)C.

6-09.3(6)B DECK REPAIR PREPARATION

All concrete in the repair area shall be removed by chipping, hydro demolishing, or other approved mechanical means to a depth necessary to remove all loose and unsound concrete.

For concrete surfaces scarified by rotomilling, concrete shall be removed to provide a ¾-inch minimum clearance around the top mat of steel reinforcing bars only where unsound concrete exists around the top mat of steel reinforcing bars, or if the bond between concrete and top mat of steel is broken.

Care shall be taken in removing the deteriorated concrete to not damage any of the existing deck or steel reinforcing bars that are to remain in place. All removal shall be accomplished by making neat vertical cuts and maintaining square edges at the boundaries of the repair area. Cuts made by using sawing or hydro demolishing machines shall be made after sufficient concrete removal has been accomplished to establish the limits of the removal area. In no case shall the depth of the vertical cut exceed ¾ inch or to the top of the top steel reinforcing bars, whichever is less.

The exposed steel reinforcing bars and concrete in the repair area shall be sandblasted or hydro-blasted and blown clean just prior to placing concrete. Bridge deck areas outside the repair area or steel reinforcing bar inside or outside the repair area damaged by the Contractor's operations, shall be repaired by the Contractor at no additional expense to the Contracting Agency, and to the satisfaction of the Engineer.

All steel reinforcing bars damaged due to the Contractor's operations shall be repaired in accordance with Section 6-09.3(5)F.

6-09.3(6)C PLACING DECK REPAIR CONCRETE

Deck repair concrete for modified concrete overlays shall be either modified concrete or concrete Class M as specified below.

Before placing any deck repair concrete, the Contractor shall flush the existing concrete in the repair area with water and make sure that the existing concrete is well saturated. The Contractor shall remove any freestanding water prior to placing the deck repair concrete. The Contractor shall place the deck repair concrete onto the existing concrete while it is wet.

Type 1 deck repairs, defined as deck repair areas with a maximum depth of one-half the periphery of the bottom bar of the top layer of steel reinforcement and not to exceed 12-continuous inches along the length of the bar, may be filled during the placement of the concrete overlay.

Type 2 deck repairs, defined as deck repair areas not conforming to the definition of Type 1 deck repairs, shall be repaired with concrete Class M and wet cured for 42 hours in accordance with Section 6-09.3(13), prior to placing the concrete overlay. During the curing period, all vehicular and foot traffic shall be prohibited on the repair area.

6-09.3(7) SURFACE PREPARATION FOR CONCRETE OVERLAY

Following the completion of any required further deck preparation the entire lane or strip being overlaid shall be cleaned.

If either a rotary milling machine or a shot blasting machine is used for concrete scarification, then the concrete deck shall be sandblasted or shot blasted, using equipment approved by the Engineer, until sound concrete is exposed. Care shall be taken to ensure that all exposed reinforcing steel and the surrounding concrete is completely blasted. Bridge grate inlets, expansion dams and barriers above the surface to be blasted shall be protected from the blasting.

If a hydro-demolition machine is used for concrete scarification, then the concrete deck shall be cleaned by an approved method of water blasting with 7,000 psi minimum pressure, until sound concrete is exposed.

The final surface of the deck shall be free from oil and grease, rust and other foreign material that may reduce the bond of the new concrete to the old. These materials shall be removed by detergent-cleaning or other method as approved by the Engineer followed by sandblasting.

After all scarifying, chipping, sandblasting and cleaning is completed, the entire lane or strip being overlaid shall be cleaned in final preparation for placing concrete using either compressed air or vacuum machines. Vacuum machines shall be used when warranted by applicable air pollution ordinances.

Scarifying with either rotary milling machines or shot blasting machines, hand tool chipping, sandblasting and cleaning in areas adjacent to a lane or strip being cleaned in final preparation for placing concrete shall be discontinued when final preparation is begun. Scarifying and hand tool chipping shall remain suspended until the concrete has been placed and the requirement for curing time has been satisfied. Sandblasting and cleaning shall remain suspended for the first 24 hours of curing time after the completion of concrete placing.

If the hydro demolishing scarification process is used, scarification may proceed during the final cleaning and overlay placement phases of the Work on adjacent portions of the Structure so long as the hydro demolisher operations are confined to areas which are a minimum of 100 feet away from the defined limits of the final cleaning or overlay placement in progress. If the hydro demolisher impedes or interferes in any way with the final cleaning or overlay placement as determined by the Engineer, the hydro demolishing Work shall be terminated immediately and the hydro demolishing equipment removed sufficiently away from the area being prepared or overlaid to eliminate the conflict. If the grade is such that water and contaminates from the hydro demolishing operation will flow into the area being prepared or overlaid, the hydro demolishing operation shall be terminated and shall remain suspended for the first 24 hours of curing time after the completion of concrete placement.

If, after final cleaning, the lane or strip being overlaid becomes wet, the Contractor shall flush the surface with high-pressure water, prior to placement of the overlay. All freestanding water shall be removed prior to concrete placement. Concrete

placement shall begin within 24 hours of the completion of deck preparation for the portion of the deck to be overlaid. If concrete placement has not begun within 24 hours, the lane or strip being overlaid shall be cleaned by a light sand blasting followed by washing with the high-pressure water spray or by cleaning with the high-pressure spray as approved by the Engineer.

Traffic other than required construction equipment will not be permitted on any portion of the lane or strip being overlaid that has undergone final preparation for placing concrete unless approved by the Engineer. To prevent contamination, all equipment allowed on the deck after final cleaning shall be equipped with drip guards.

6-09.3(8) QUALITY ASSURANCE

6-09.3(8)A QUALITY ASSURANCE FOR MICROSILICA MODIFIED AND FLY ASH MODIFIED CONCRETE OVERLAYS

The Engineer will perform slump, temperature, and entrained air tests for acceptance in accordance with Section 6-02.3(5)D and as specified in this Section after the Contractor indicates that the concrete is ready for placement. Concrete from the first truckload shall not be placed until tests for acceptance have been completed by the Engineer and the results indicate that the concrete is within acceptable limits. Sampling and testing will continue for each load until two successive loads meet all applicable acceptance test requirements. Except for the first load of concrete, up to ½ cubic yard may be placed prior to testing for acceptance. After two successive tests indicate that the concrete is within specified limits, the sampling and testing frequency may decrease to one for every three truckloads. Loads to be sampled will be selected in accordance with the random selection process outlined in FOP for WAQTC TM2.

When the results of any subsequent acceptance test indicates that the concrete does not conform to the specified limits, the sampling and testing frequency will be resumed for each truckload. Whenever two successive subsequent tests indicate that the concrete is within the specified limits, the random sampling and testing frequency of one for every three truck loads may resume.

The Engineer will test for slump and/or air any load of concrete the Engineer deems necessary.

6-09.3(8)B QUALITY ASSURANCE FOR LATEX MODIFIED CONCRETE OVERLAYS

The Engineer will perform operational control testing as the concrete is being placed. The Contractor shall provide the Engineer with a ¼ cubic yard container and assistance in obtaining and handling samples. The ¼ cubic yard container shall have a 9 inch minimum depth and shall be placed on a level surface. A minimum of one test per mobile mixer per shift will be conducted. The test will be conducted after 8 minutes of mixer operation.

The Engineer will perform slump, temperature, and entrained air tests for acceptance in accordance with Section 6-02.3(5)D and as specified in this Section. The Engineer will perform slump and air tests as the concrete is being placed. The minimum number of tests will be one slump test and one air test per mobile mixer, beginning with the first charge and every other charge thereafter. The sample will be taken after the first 2 minutes of continuous mixer operation. The concrete will be sampled as follows:

1. While concrete is being deposited onto the bridge deck, the stream will be diverted into a wheelbarrow or other suitable container. Approximately 1 cubic foot of concrete will be sufficient to conduct one slump test and one air test.
2. Take the sample to the test site. The test site should be located away from the mobile mixer and off the end of the bridge if practical.
3. Allow the sample to stand undisturbed. The fresh concrete sample shall be protected from sunlight and wind until the conclusion of the testing. Total time from discharge to time of start of slump testing will not exceed 6½ minutes.

During the initial proportioning, mixing, placing, and finishing operations, the Engineer may require the presence of a technical representative from the latex admixture manufacturer. The technical representative shall be capable of performing, demonstrating, inspecting, and testing all of the functions required for placement of the latex modified concrete as specified in Section 6-09.3(11) and as approved by the Engineer. This technical representative shall aid in the proper installation of the latex modified concrete. Recommendations made by the technical representative on or off the jobsite, and approved by the Engineer, shall be adhered to by the Contractor at no additional expense to the Contracting Agency. The Engineer will advise the Contractor in writing a minimum of 5 Working Days before such services are required.

6-09.3(9) MIXING CONCRETE FOR CONCRETE OVERLAY

6-09.3(9)A MIXING MICROSILICA MODIFIED OR FLY ASH MODIFIED CONCRETE

Mixing of concrete shall be in accordance with Section 6-02, with the following exceptions:

1. The mixing shall be done at a batch plant.
2. The volume of concrete transported by truck shall not exceed 6-cubic yards per truck.

6-09.3(9)B MIXING LATEX MODIFIED CONCRETE

The equipment used for mixing the concrete shall be operated with strict adherence to the procedures set forth by its manufacturer.

A minimum of two mixers will be required at the overlay site for each concrete placement when the total volume of concrete to be placed during the concrete placement exceeds the material storage capacity of a single mixer. Additional mixers may be required if conditions require that material be stockpiled away from the jobsite. The Contractor shall have sufficient mixers on hand to ensure a consistent and continuous delivery and placement of concrete throughout the concrete placement.

Charging the mobile mixer shall be done in the presence of the Engineer. Mixing capabilities shall be such that the finishing operation can proceed at a steady pace.

6-09.3(10) OVERLAY PROFILE AND SCREED RAILS

6-09.3(10)A SURVEY OF EXISTING BRIDGE DECK PRIOR TO SCARIFICATION

Prior to beginning the scarifying concrete surface finish work specified under Section 6-09.3(5), the Contractor shall complete a survey of the existing bridge deck(s) specified to receive modified concrete overlay for use in establishing the existing cross section and grade profile elevations.

The Contracting Agency will provide the Contractor with primary survey control information consisting of descriptions of two primary control points used for the horizontal and vertical control. Primary control points will be described by reference to the bridge or project-specific stationing and elevation datum. The Contracting Agency will also provide horizontal coordinates for the beginning and ending points and for each Point of Intersection (PI) on each centerline alignment included in the project. The Contractor shall provide the Engineer 21 Calendar Days notice in advance of scheduled concrete surface scarification work to allow the Contracting Agency time to provide the primary survey control information.

The Contractor shall verify the primary survey control information furnished by the Contracting Agency and shall expand the survey control information to include secondary horizontal and vertical control points as needed for the project. The Contractor's survey records shall include descriptions of all survey control points, including coordinates and elevations of all secondary control points.

The Contractor shall maintain detailed survey records, including a description of the work performed on each shift, the methods utilized to conduct the survey, and the control points used. The record shall be of sufficient detail to allow the survey to be reproduced. A copy of each day's survey record shall be provided to the Engineer within 3 (three) Working Days after the end of the shift. The Contractor shall compile the survey information in an electronic file format acceptable to the Contracting Agency (Excel spreadsheet format is preferred).

Survey information collected shall include station, offset, and elevation for each lane line and curb line. Survey information shall be collected at even 20-foot station intervals and also at the centerline of each bridge expansion joint. The Contractor shall ensure a surveying accuracy to within ± 0.01 feet for vertical control and ± 0.2 feet for horizontal control. The survey shall extend 100 feet beyond the bridge back of pavement seat.

Except for the primary survey control information furnished by the Contracting Agency, the Contractor shall be responsible for all calculations, surveying, and measuring required for setting, maintaining, and resetting equipment and materials necessary for the construction of the overlay to the final grade profile. The Contracting Agency may post-check the Contractor's surveying, but these post-checks shall not relieve the Contractor of responsibility for internal survey quality control.

The Contracting Agency will establish the final grade profile based on the Contractor's survey, and will provide the final grade profile to the Contractor within 3 (three) Working Days after receiving the Contractor's survey information.

The Contractor shall not begin scarifying concrete surface work specified under Section 6-09.3(5) until receiving the final grade profile from the Engineer.

6-09.3(10)B ESTABLISHING FINISH OVERLAY PROFILE

The finish grade profile shall be + ¼ inch/- ⅛ inch from the Engineer's final grade profile. The final grade profile shall be verified prior to the placement of modified concrete overlay with the screed rails in place. The finishing machine shall be passed over the entire surface to be overlaid and the final screed rail adjustments shall be made. If the resultant overlay thickness is not compatible with the finish grade profile generated by the Contractor's screed rail setup, the Contractor shall make profile adjustments as approved by the Engineer. After the finish overlay profile has been verified, changes in the finishing machine elevation controls will not be allowed. The Contractor shall be responsible for setting screed control to obtain the specified finish grade overlay profile as well as the finished surface smoothness requirements specified in Section 6-02.3(10).

Screed rails upon which the finishing machine travels shall be placed outside the area to be overlaid, in accordance with item 7 of Section 6-09.3(2), and as approved by the Engineer. Interlocking rail sections or other approved methods of providing rail continuity are required.

Hold-down devices shot into the concrete are not permitted unless the concrete is to be subsequently overlaid. Hold-down devices of other types leaving holes in the exposed area will be allowed provided the holes are subsequently filled with mortar conforming to Section 9-20.4(2) mixed at a 1:2 cement/aggregate ratio. Hold-down devices shall not penetrate the existing deck by more than ¾ inch.

Screed rails may be removed at any time after the concrete has taken an initial set. Adequate precautions shall be taken during the removal of the finishing machine and rails to protect the edges of the new surfaces.

6-09.3(11) PLACING CONCRETE OVERLAY

Five to ten Working Days prior to modified concrete overlay placement, a preoverlay conference shall be held to discuss equipment, construction procedures, personnel, and previous results. Inspection procedures shall also be reviewed to ensure coordination. Those attending shall include:

1. (Representing the Contractor) The superintendent and all foremen in charge of placing and finishing the modified concrete overlay, and
2. (Representing the Contracting Agency) The Project Engineer and key inspection assistants.

If the project includes more than one bridge deck, an additional conference shall be held just before placing modified concrete overlay for each subsequent bridge deck.

The Contractor shall not place modified concrete overlay until the Engineer agrees that:

1. Modified concrete overlay producing and placement rates will be high enough to meet placing and finishing deadlines,

2. Finishers with enough experience have been employed, and
3. Adequate finishing tools and equipment are at the site.

Concrete placement shall be made in accordance with Section 6-02 and the following requirements:

1. After the lane or strip to be overlaid has been prepared and immediately before placing the concrete, it shall be thoroughly soaked and kept continuously wet with water for a minimum period of 6 hours prior to placement of the concrete. All freestanding water shall be removed prior to concrete placement. During concrete placement, the lane or strip shall be kept moist.

   The concrete shall then be promptly and continuously delivered and deposited on the placement side of the finishing machine.

   If latex modified concrete is used, the concrete shall be thoroughly brushed into the surface and then brought up to final grade. If either microsilica modified concrete or fly ash modified concrete are used, a slurry of the concrete, excluding aggregate, shall be thoroughly brushed into the surface prior to the overlay placement.

   Care shall be exercised to ensure that the surface receives a thorough, even coating and that the rate of progress is limited so that the brushed concrete does not become dry before it is covered with additional concrete as required for the final grade. All aggregate which is segregated from the mix during the brushing operation shall be removed from the deck and disposed of by the Contractor.

   If either microsilica modified concrete or fly ash modified concrete are used, the Contractor shall ensure that a sufficient number of trucks are used for concrete delivery to obtain a consistent and continuous delivery and placement of concrete throughout the concrete placement operation.

   When concrete is to be placed against the concrete in a previously placed transverse joint, lane, or strip, the previously placed concrete shall be sawed back 6 inches to straight and vertical edges and shall be sandblasted or water blasted before new concrete is placed. The Engineer may decrease the 6 inch saw back requirement to 2 inches minimum, if a bulkhead was used during previous concrete placement and the concrete was hand vibrated along the bulkhead.
2. Concrete placement shall not begin if rain is expected. Adequate precautions shall be taken to protect freshly placed concrete in the event that rain begins during placement. Concrete that is damaged by rain shall be removed and replaced by the Contractor at no additional expense to the Contracting Agency, and to the satisfaction of the Engineer.
3. Concrete shall not be placed when the temperature of the concrete surface is less than 45ºF or greater than 75ºF, when the combination of air temperature, relative humidity, fresh concrete temperature, and wind velocity at the construction site produces an evaporation rate of 0.15 pound per square foot of surface per hour as determined from Table 6-02.3(6), or when winds are in excess of 10 mph. If the Contractor elects to Work at night to meet these criteria, adequate lighting shall be provided at no additional expense to the Contracting Agency, and as approved by the Engineer.
4. If concrete placement is stopped for a period of ½ hour or more, the Contractor shall install a bulkhead transverse to the direction of placement at a position where the overlay can be finished full width up to the bulkhead. The bulkhead shall be full depth of the overlay and shall be installed to grade. The concrete shall be finished and cured in accordance with these Specifications.

   Further placement is permitted only after a period of 12 hours unless a gap is left in the lane or strip. The gap shall be of sufficient width for the finishing machine to clear the transverse bulkhead installed where concrete placement was stopped. The previously placed concrete shall be sawed back from the bulkhead, to a point designated by the Engineer, to straight and vertical edges and shall be sandblasted or water blasted before new concrete is placed.
5. Concrete shall not be placed against the edge of an adjacent lane or strip that is less than 36 hours old.

6-09.3(12) FINISHING CONCRETE OVERLAY

Finishing shall be accomplished in accordance with the applicable portions of Section 6-02.3(10) and as follows. Concrete shall be placed and struck-off approximately ½ inch above final grade and then consolidated and finished to final grade with a single pass (the Engineer may require additional passes) of the finishing machine. Hand finishing may be necessary to close up or seal off the surface. The final product shall be a dense uniform surface.

Latex shall not be sprayed on a freshly placed latex modified concrete surface; however, a light fog spray of water is permitted if required for finishing, as determined by the Engineer.

As the finishing machine progresses along the placed concrete, the surface shall be given a final finish by texturing with a comb perpendicular to the centerline of the bridge. The texture shall be applied immediately behind the finishing machine. The comb shall consist of a single row of metal tines capable of producing ⅛-inch wide striations approximately 0.015 foot in depth at approximately ½-inch spacing. The combs may be operated manually or mechanically, either singly or in gangs (several combs placed end to end). This operation shall be done in a manner that will minimize the displacement of the aggregate particles. The texture shall not extend into areas within 2 feet of the curb line. The non-textured concrete within 2 feet of the curb line shall be hand finished with a steel or magnesium trowel.

Construction dams shall be separated from the newly placed concrete by passing a pointing trowel along the inside surfaces of the dams. Care shall be exercised to ensure that this trowel cut is made for the entire depth and length of the dams after the concrete has stiffened sufficiently that it does not flow back.

After the burlap cover has been removed and the concrete surface has dried, but before opening to traffic, all joints and visible cracks shall be filled and sealed with a high molecular weight methacrylate resin (HMWM). Cracks 1⁄16 inch and greater in width shall receive two applications of HMWM. Immediately following the application of HMWM, the wetted surface shall be coated with sand for abrasive finish.

6-09.3(13) CURING CONCRETE OVERLAY

As the texturing portion of the finishing operation progresses, the concrete shall be immediately covered with a single layer of clean, new or used, wet burlap. The burlap shall have a maximum width of 6 feet. The Engineer will determine the suitability of the burlap for reuse, based on the cleanliness and absorption ability of the burlap. Care shall be exercised to ensure that the burlap is well drained and laid flat with no wrinkles on the deck surface. Adjacent strips of burlap shall have a minimum overlap of 6 inches.

Once in place the burlap shall be lightly fog sprayed with water. A separate layer of white, reflective type polyethylene sheeting shall immediately be placed over the wet burlap. The concrete shall then be wet cured by keeping the burlap wet for a minimum of 42 hours after which the polyethylene sheeting and burlap may be removed.

Traffic shall not be permitted on the finished concrete until the specified curing time is satisfied and until the concrete has reached a minimum compressive strength of 3,000 psi as verified by rebound number determined in accordance with ASTM C 805.

6-09.3(14) CHECKING FOR BOND

After the requirements for curing have been met, the entire overlaid surface shall be sounded by the Contractor, in a manner approved by and in the presence of the Engineer, to ensure total bond of the concrete to the bridge deck. Concrete in unbonded areas shall be removed and replaced by the Contractor with the same modified concrete as used in the overlay. Removal and replacement of the overlay in unbonded areas shall be performed at the expense of the Contracting Agency, except as specified in Section 6-09.3(6) when the overlay is placed on a bridge deck as part of the same Contract as the bridge deck construction. All cracks, except those that are significant enough to require removal, shall be thoroughly filled and sealed as specified in Section 6-09.3(12).

After the curing requirements have been met, the Contractor may use compressed air to accelerate drying of the deck surface for crack identification and sealing.

6-09.4 MEASUREMENT

Bid items of work completed under the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs in this Section.

Scarifying concrete surface will be measured by the square yard of surface actually scarified.

Modified concrete overlay will be measured by the cubic foot of material placed. For latex modified concrete overlay, the volume will be determined by the theoretical yield of the design mix and documented by the counts of the cement meter less waste. For both microsilica modified concrete overlay and fly ash modified concrete overlay, the volume will be determined from the concrete supplier's Certificate of Compliance for each batch delivered less waste. Waste is defined as the following:

1. Material not placed.
2. Material placed in excess of 6 inches outside a longitudinal joint or transverse joint.

Finishing and curing modified concrete overlay will be measured by the square yard of overlay surface actually finished and cured.

When further deck preparation is measured by volume, it will be measured by the cubic foot of material removed from the deck repair locations. The depth measurement at each deck repair location will be the average depth beneath a straightedge placed at the level of the existing deck surface. The area measurement at each deck repair location will be the surface area of the removed concrete.

6-09.5 PAYMENT

Payment will be made in accordance with Section 1-04.1, for each of the following Bid items that are included in the Bid Form:

1. "**Scarifying Conc. Surface**", per square yard.

The unit Contract price per square yard for "Scarifying Conc. Surface" shall be full pay for performing the Work as specified, including testing and calibration of the machines and tools used, containment, collection, and disposal of all water and abrasives used and debris created by the scarifying operation, measures taken to protect adjacent traffic from flying debris, and final cleanup following the scarifying operation.

2. "**Modified Conc. Overlay**", per cubic foot.

The unit contract price per cubic foot for "Modified Conc. Overlay" shall be full pay for furnishing the modified concrete overlay, including the overlay material placed into Type 1 deck repairs in accordance with Section 6-09.3(6)C.

3. "**Finishing and Curing Modified Conc. Overlay**", per square yard.

The unit Contract price per square yard for "Finishing and Curing Modified Conc. Overlay" shall be full pay for performing the Work as specified, including placing, finishing, and curing the modified concrete overlay, checking for bond, and sealing all cracks.

4. "**Further Deck Preparation**", per cubic foot.

When "Further Deck Preparation" is measured by volume, the unit Contract price per cubic foot for "Further Deck Preparation" shall be full pay for performing the Work as specified, including removing and disposing of the concrete within the repair area, and furnishing, placing, finishing, and curing the repair concrete.

5. "**Further Deck Preparation**", force account.

When "Further Deck Preparation" is not measured by volume, payment for the Work required will be by force account in accordance with Section 1-09.6.

6. "**Structure Surveying**", lump sum.

The lump sum contract price for "Structure Surveying" shall be full pay to perform the work as specified, including establishing secondary survey control points, performing survey quality control, and recording, compiling, and submitting the survey records to the Engineer.

SECTION 6-10 CONCRETE BARRIER

6-10.1 DESCRIPTION

Section 6-10 addresses the work of building precast or cast-in-place cement concrete barriers as required by the Contract.

6-10.2 MATERIALS

Materials shall meet the requirements of the following sections:

Portland Cement	9-01
Aggregates	9-03
Premolded Joint Fillers	9-04.1
Reinforcing Steel	9-07
Grout	9-20.3

Wire rope shall be Class 6 x 19, made of improved plow steel galvanized and preformed. Galvanizing shall meet ASTM A 603. The wire rope shall have right regular lay and a fiber core. It shall be 5/8 inch in diameter and have a minimum breaking strength of 15 tons.

All hardware (connecting pins, drift pins, nuts, washers, etc.) shall be galvanized in keeping with AASHTO M 232.

Connecting pins, drift pins and steel pins for Type 3 anchors shall conform to Section 9-06.5(4) and be galvanized in accordance AASHTO M232. All other hardware shall conform to Section 9-06.5(1) and be galvanized in accordance with ASHTOM232.

Grout for permanent installations of precast single slope barrier shall conform to section 9-20.3(3) and shall be placed in accordance with Section 6-02.3(20).

6-10.3 CONSTRUCTION REQUIREMENTS

Single slope barrier shall be cast-in-place or slipformed, except when precast single slope barrier is specified in the Plans or approved by the Engineer. Concrete barrier installed in conjunction with light standard foundations and sign bridge foundations, regardless of the barrier shape, shall be cast-in-place using stationary forms.

Concrete barrier transition Type 2 to bridge f-shape shall be precast.

Steel welded wire reinforcement deformed, conforming to Section 9-07.7, may be substituted in concrete barrier in place of deformed steel bars conforming to Section 9-07.2, subject to the following conditions:

1. Steel welded wire reinforcement spacing shall be the same as the deformed steel bar spacing shown in the Standard Plans.
2. The minimum cross sectional area for steel welded wire reinforcement shall be no less than 86 percent of the cross sectional area for the deformed steel bars being substituted.
3. Development lengths and splice lengths shall conform to requirements specified in the AASHTO LRFD Bridge Design Specifications, current edition.

6-10.3(1) PRECAST CONCRETE BARRIER

The concrete in precast barrier shall reach a compressive strength of at least 4,000 psi at 28 days. No concrete barrier shall be shipped until test cylinders made of the same concrete and cured under the same conditions show the concrete has reached this strength. Class 4000 concrete that complies with Section 6-02 will meet this strength requirement. The Contractor may, however, alter the mix and aggregate grading if:

1. The Contractor indicates the substitution under Section 1-05.3(5);
2. The altered mix meets the requirement of a Contractor-provided mix design; and
3. No aggregate is used that is larger than the maximum for Class 4000 concrete.

The Contractor may use Type III Portland cement at no additional cost to the Owner.

Precast barrier shall be cast in steel forms. After release, the barrier shall be finished to an even, smooth, dense surface, free from any rock pockets or holes larger than 1/4 inch across. Toweling shall remove all projecting concrete from the bearing surface.

Precast concrete barrier shall be cured under Section 6-02.3(25)D except that the barrier shall be cured in the forms until a rebound number test, or test cylinders cured under the same conditions as the barrier, indicate that the concrete has reached a compressive strength of at least 2,500 psi. No additional curing is required once the barrier is removed from the forms.

All barrier shall be the same length, except end sections and variable length units needed for closure. All barrier shall be new and unused. The manufacturer shall be responsible for any damage or distortion that results from manufacturing.

Only one section less than 10 feet long may be used in any single run of precast barrier, and it shall be at least 8 feet long. It may be precast or cast-in-place. Hardware identical to that used with other sections shall interlock such a section with adjacent precast sections.

When the barrier is being built next to roadway lanes open to traffic, a terminal section shall be connected temporarily to the end of the barrier built each day.

6-10.3(2) CAST-IN-PLACE CONCRETE BARRIER

Forms for cast-in-place barrier shall be made of steel or of exterior plywood coated with plastic. At the Contractor's option, the barrier may be constructed by the slip-form method.

The barrier shall be made of Class 4000 concrete that meets the requirements of Section 6-02. The Contractor may use Portland cement Type III and shall be at no additional cost to the Owner.

Immediately after removing the forms, the Contractor shall complete any finishing work needed to produce a uniformly smooth, dense surface. The surface shall have no rock pockets and no holes larger than 1/4 inch across. The barrier shall be cured under the requirements described in Section 6-02.3(11)A.

The maximum allowable deviation from a 10-foot straightedge held longitudinally on all surfaces shall be 1/4 inch.

The Contractor may build cast-in-place concrete barrier by the slip-form method. Concrete for slip-form barrier shall meet the requirements for concrete Class 4000 as outlined in Section 6-02, except that the fine aggregate gradation may be Class 1 or Class 2. Slip-form barrier shall be finished and cured as specified in Section 6-02.3(11)A.

At least 3 Working Days in advance of delivery to the Project Site, the Contractor shall request the Engineer to verify the concrete barrier to be free from stains, smears, and any discoloration.

6-10.3(3) RESETTING CONCRETE BARRIER

The Contractor shall reset concrete barrier as in the Contract. If resetting is impossible immediately after removal, the Contractor shall store the barrier at locations approved by the Engineer.

6-10.3(4) JOINING PRECAST CONCRETE BARRIER TO CAST-IN-PLACE BARRIER

The Contractor may join segments of cast-in-place barrier to precast barrier where transitions, split barriers, or gaps shorter than 10 feet require it. At each joint of this type, the cast-in-place segment shall include hardware that ties both its ends to abutting precast sections.

6-10.3(5) TEMPORARY CONCRETE BARRIER

For temporary concrete barrier, the Contractor may use new or used precast barrier that complies with WSDOT Standard Plan requirements and cross-sectional dimensions, except that:

(1) it may be made in other lengths than those shown in the WSDOT Standard Plan; and
(2) it may have permanent lifting holes no larger than 4 inches in diameter or lifting loops.

The word "temporary" shall be visibly stamped or stencil painted on each barrier segment.

All barrier shall be in good condition, without cracks, chips, spalls, dirt, or traffic marks. If any barrier segment is damaged during or after placement, the Contractor, at no additional cost to the Owner, shall immediately repair the damage to a condition acceptable to the Engineer, or replace it with an undamaged section.

Temporary barrier no longer needed shall be removed from the Project. Site.

6-10.3(6) PLACING CONCRETE BARRIER

Precast concrete barrier shall rest on a paved foundation shaped to a uniform grade and section. The foundation surface shall meet this test for uniformity:

When a 10-foot straightedge is placed on the surface parallel to the centerline for the barrier, the surface shall not vary more than 1/4 inch from the lower edge of the straightedge. If deviations exceed 1/4 inch, the Contractor shall correct them as required in Section 5-04.3(12).

The Contractor shall align the joints of all precast segments so that they offset no more than 1/4 inch transversely and no more than 3/4 inch vertically. Grouting is not permitted. If foundation grade and section are acceptable, the Engineer may permit the Contractor to obtain vertical alignment of the barrier by shimming. Shimming shall be done with a polystyrene, foam pad (12 by 24 inches) under the end 12 inches of bearing surface.

Precast barrier shall be handled and placed with equipment that does not damage or disfigure it.

6-10.4 MEASUREMENT

Bid items of work completed under the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs in this Section.

Precast concrete barrier will be measured by the linear foot along its completed line and slope.

Temporary concrete barrier will be measured by the linear foot along the completed line and slope of the barrier, one time only for each setup of barrier protected area. Any intermediate moving or resetting will not be measured.

Cast-in-place concrete barrier will be measured by the linear foot along its completed line unless the Contract specifies measurement per cubic yard for concrete Class 4000 and per pound for steel reinforcing bar per Section 6-02.4.

Cast-in-place concrete barrier light standard section will be by the unit for each light standard section installed.

Removing and resetting existing permanent barrier will be measured by the lineal foot and will be measured one time only for removing, storage, and resetting. No measurement will be made for barrier that has been removed and reset for the convenience of the Contractor.

Concrete Barrier transition Type 2 to bridge F-shape will be measured by the linear foot installed.

Single slope concrete barrier light standard foundation will be measured by the unit for each light standard foundation installed.

Traffic barrier, traffic pedestrian barrier, and pedestrian barrier will be measured as specified for cast-in-place concrete barrier.

6-10.5 PAYMENT

Compensation for the cost necessary to complete the work described in Section 6-10 will be made at the Bid item prices Bid only for the Bid items listed or referenced as follows;

1. "**Precast Concrete Barrier Type** ____", per linear foot.
2. "**Cast-In-Place Concrete Barrier**", per linear foot.
3. "**Concrete Class (Strength)---------**", per cubic yard.
4. "**St. Reinf. Bar--------**", per pound.
5. "Removing and Resetting Existing Permanent Barrier", per linear foot.

The Bid item prices for "Precast Concrete Barrier Type ____" and for "Cast-In-Place Concrete Barrier" shall include all costs for the work required for excavation, forms, placement, special construction features, and all other materials, tools, equipment, and labor necessary to complete the work as specified; except that when the Contract specifies, the Bid item price per cubic yard for "Concrete Class (Strength)" and the per pound Bid item price for "Steel Reinforcing Bar" shall be full pay for excavation, forms, placement, special construction features, and all other materials, tools, equipment, and labor necessary to complete the work as specified.

6. "**Cast-In-Place Concrete Barrier Light Standard Section**", per each.
7. "**Temporary Concrete Barrier**", per linear foot.

The Bid item prices for "Cast-In-Place Concrete Barrier Light Standard Section" and for "Temporary Concrete Barrier" shall include all costs for the work required to furnish, install, connect, anchor, maintain, temporary storage, and final removal of the temporary barrier. Contractor furnished barrier shall remain the property of the Contractor.

Payment for transition sections between different types of barrier shall be made at the Bid item price for the type of barrier indicated on the Drawings for each transition section.

6-11 REINFORCED CONCRETE WALLS

6-11.1 DESCRIPTION

This Work consists of constructing reinforced concrete retaining walls, including those shown in the WSDOT Standard Plans, L walls, and counterfort walls.

6-11.2 MATERIALS

Materials shall meet the requirements of the following sections:

Cement	9-01
Aggregates for Portland Cement Concrete	9-03.1
Gravel Backfill	9-03.12
Premolded Joint Filler	9-04.1(2)
Steel Reinforcing Bar	9-07.2
Epoxy-Coated Steel Reinforcing Bar	9-07.3
Concrete Curing Materials and Admixtures	9-23
Fly Ash	9-23.9
Water	9-25

Other materials required shall be as specified.

6-11.3 CONSTRUCTION REQUIREMENTS

6-11.3(1) SUBMITTALS

The Contractor shall submit all excavation shoring plans to the Engineer for approval in accordance with Section 2-09.3(3)D.

The Contractor shall submit all falsework and formwork plans to the Engineer for approval in accordance with Sections 6-02.3(16) and 6-02.3(17).

If the Contractor elects to fabricate and erect precast concrete wall stem panels, the following information shall be submitted to the Engineer for approval in accordance with Sections 6-01.9 and 6-02.3(28)A:

1. Working drawings for fabrication of the wall stem panels, showing dimensions, steel reinforcing bars, joint and joint filler details, surface finish details, lifting devices with the manufacturer's recommended safe working capacity, and material Specifications.
2. Working drawings and design calculations for the erection of the wall stem panels showing dimensions, support points, support footing sizes, erection blockouts, member sizes, connections, and material Specifications.

3. Design calculations for the precast wall stem panels, the connection between the precast panels and the cast-in-place footing, and all modifications to the cast-in-place footing details as shown in the Drawings or Standard Plans.

The Contractor shall not begin excavation and construction operations for the retaining walls until receiving the Engineer's approval of the above submittals.

6-11.3(2) EXCAVATION AND FOUNDATION PREPARATION

Excavation shall conform to Section 2-09.3(3), and to the limits and construction stages shown in the Drawings. Foundation soils found to be unsuitable shall be removed and replaced in accordance with Section 2-09.3(1)C.

6-11.3(3) PRECAST CONCRETE WALL STEM PANELS

The Contractor may fabricate precast concrete wall stem panels for construction of Standard Plan Retaining Walls. Precast concrete wall stem panels may be used for construction of non-Standard Plan retaining walls if allowed by the Drawings or Special Provisions. Precast concrete wall stem panels shall conform to Section 6-02.3(28), and shall be cast with Class 4000 concrete. If Self-Consolidating Concrete is used, the concrete shall conform to Sections 6-02.3(27)B and 6-02.3(27)C.

The precast concrete wall stem panels shall be designed in accordance with the following codes:

1. For all loads except as otherwise noted – AASHTO LRFD Bridge Design Specifications, latest edition and current interims. The seismic design shall use the acceleration coefficient and soil profile type as specified in the Drawings.
2. For all wind loads – AASHTO Guide Specifications for Structural Design of Sound Barriers, latest edition and current interims.

The precast concrete wall stem panels shall be fabricated in accordance with the dimensions and details shown in the Drawings, except as modified in the Shop Drawings as approved by the Engineer.

The precast concrete wall stem panels shall be fabricated full height, and shall be fabricated in widths of 8, 16, and 24 feet.

The construction tolerances for the precast concrete wall stem panels shall be as follows:

Height	±¼ inch
Width	±¼ inch
Thickness	+¼ inch -⅛ inch
Concrete cover for steel reinforcing bar	+⅜ inch -⅛ inch
Width of precast concrete wall stem panel joints	±¼ inch
Offset of precast concrete wall stem panels (Deviation from a straight line extending 5 feet on each side of the panel joint)	±¼ inch

The precast concrete wall stem panels shall be constructed with a mating shear key between adjacent panels. The shear key shall have beveled corners and shall be 1½ inches in thickness. The width of the shear key shall be 3½ inches minimum and 5½ inches maximum. The shear key shall be continuous and shall be of uniform width over the entire height of the wall stem.

The Contractor shall provide the specified surface finish as noted, and to the limits shown, in the Drawings to the exterior concrete surfaces. Special surface finishes achieved with form liners shall conform to Sections 6-02.2 and 6-02.3(14) as supplemented in the Special Provisions. Rolled on textured finished shall not be used. Precast concrete wall stem panels shall be cast in a vertical position if the Drawings call for a form liner texture on both sides of the wall stem panel.

The precast concrete wall stem panel shall be rigidly held in place during placement and curing of the footing concrete.

The precast concrete wall stem panels shall be placed a minimum of 1 inch into the footing to provide a shear key. The base of the precast concrete wall stem panel shall be sloped ½ inch per foot to facilitate proper concrete placement.

To ensure an even flow of concrete under and against the base of the wall panel, a form shall be placed parallel to the precast concrete wall stem panel, above the footing, to allow a minimum 1-foot head to develop in the concrete during concrete placement.

The steel reinforcing bars shall be shifted to clear the erection blockouts in the precast concrete wall stem panel by 1½ inches minimum.

All precast concrete wall stem panel joints shall be constructed with joint filler installed on the rear (backfill) side of the wall. The joint filler material shall extend from 2 feet below the final ground level in front of the wall to the top of the wall. The joint filler shall be a nonorganic flexible material and shall be installed to create a waterproof seal at panel joints.

The soil bearing pressure beneath the falsework supports for the precast concrete wall stem panels shall not exceed the maximum design soil pressure shown in the Drawings for the retaining wall.

6-11.3(4) CAST-IN-PLACE CONCRETE CONSTRUCTION

Cast-in-place concrete for concrete retaining walls shall be formed, reinforced, cast, cured, and finished in accordance with Section 6-02, and the details shown in the Drawings. All cast-in-place concrete shall be Class 4000.

The Contractor shall provide the specified surface finish as noted, and to the limits shown, in the Drawings to the exterior concrete surfaces. Special surface finishes achieved with formliners shall conform to Sections 6-02.2 and 6-02.3(14) as supplemented in the Special Provisions.

Cast-in-place concrete for adjacent wall stem sections (between vertical expansion joints) shall be formed and placed separately, with a minimum 12-hour time period between concrete placement operations.

Premolded joint filler, ½ inch thick, shall be placed full height of all vertical wall stem expansion joints in accordance with Section 6-01.14.

6-11.3(5) BACKFILL, WEEPHOLES, AND GUTTERS

Unless the Drawings specify otherwise, backfill and weepholes shall be placed in accordance with the Standard Plans and Section 6-02.3(22). Gravel backfill for drain shall be compacted in accordance with Section 2-09.3(1)E. Backfill for Bridge Approach Embankment in shall be compacted in accordance with Method C of Section 2-03.3(14)C. All other backfill shall be compacted in accordance with Method B of Section 2-03.3(14)C, unless otherwise specified.

Cement concrete gutter shall be constructed as shown in the Standard Plans.

6-11.3(6) TRAFFIC BARRIER AND PEDESTRIAN BARRIER

When shown in the Drawings, traffic barrier and pedestrian barrier shall be constructed in accordance with Sections 6-02.3(11)A and 6-10.3(2), and the details shown in the Drawings and Standard Plans.

6-11.4 MEASUREMENT

Bid items of work completed under the Contract will be measured as provided in Section 1-09.1, Measurement of Quantities, unless otherwise provided for by individual measurement paragraphs in this Section.

Concrete Class 4000 for retaining wall will be measured as specified in Section 6-02.4.

Steel reinforcing bar for retaining wall and epoxy-coated steel reinforcing bar for retaining wall will be measured as specified in Section 6-02.4.

Traffic barrier and pedestrian barrier will be measured as specified in Section 6-10.4 for cast-in-place concrete barrier.

6-11.5 PAYMENT

Payment will be made in accordance with Section 1-04.1 for each of the following Bid items when they are included in the Bid Form:

1. "**Conc. Class 4000 For Retaining Wall**", per cubic yard.

All costs in connection with furnishing and installing weep holes and premolded joint filler shall be included in the unit Contract price per cubic yard for "Conc. Class 4000 for Retaining Wall".

2. "**St. Reinf. Bar For Retaining Wall**", per pound.
3. "**Epoxy-Coated St. Reinf. Bar For Retaining Wall**", per pound.
4. "**Traffic Barrier**", per linear foot.
5. "**Pedestrian Barrier**", per linear foot.

The unit Contract price per linear foot for "___ Barrier" shall be full pay for constructing the barrier on top of the retaining wall, except that when these Bid items are not included in the Proposal, all costs in connection with performing the Work as specified shall be included in the unit Contract price per cubic yard for "Conc. Class 4000 For Retaining Wall", and the unit Contract price per pound for "___ Bar For Retaining Wall".