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APPENDIX D

Introduction

Generic specifications for production of precast and prestressed concrete products have not been published by the Precast/Prestressed Concrete Institute (PCI). Such specifications require extensive committee involvement and a lengthy concensus approval process within the PCI structure. As a temporary substitute for generic specifications, this Appendix lists, without technical alteration, the specifications used by the states of Nebraska and Washington. Nebraska represents Midwestern conditions, while Washington represents coastal conditions. These two sets of specifications are not claimed to be model specifications, nor are they representative of conditions throughout the country as diverse geographically and economically as the United States. For example, critical evaluation of the validity of weather-related provisions for applications in hot, humid locations in the Southeast or hot, dry locations in the Southwest need to be assessed. Also, the characteristics of aggregates and other local raw materials need to be taken into account in adapting sample specifications to a particular location.

Both sets of specifications have recently been updated, and are thus reflective of most recent thinking of professionals at the Nebraska Department of Roads and the Washington State Department of Transportation. Both states are known to have leadership in the area of precast/prestressed concrete and are known to have a strong partnership with PCI and its producer members.

Nebraska Department of Roads Specifications

705 PRECAST/ PRESTRESSED CONCRETE STRUCTURAL UNITS

705.01 Description

1. This work consists of all labor, materials and equipment required in the production of precast/prestressed structural units.

705.02 Material Requirements

1. The materials used shall meet the requirements prescribed in this specification.
2. Precast/prestressed concrete structural units whose compressive strength does not achieve design strength shall be rejected.
3. The concrete class used in the manufacture of precast/prestressed structural units shall be shown in the Plans.
4. The Contractor is responsible for the concrete mix design and may use other concrete mixes which are proportioned in accordance with ACI Standard 318 and the following additional requirements:
   a. The mix designs shall be submitted to the Engineer 30 working days before beginning any concrete work.
   b. Concrete shall consist of Type I, Type II or Type III Portland cement, aggregate, air-entraining admixture and water. Concrete may also contain Class C or Class F fly ash, and ASTM C494 approved Type A, Type B, Type D and Type F admixtures.
   c. The minimum cement content shall be 335 kg per cubic meter.
   d. Coarse aggregate shall have a minimum limestone content of 30 percent of the total aggregate by mass.
   e. Fly ash cannot exceed 15 percent of cement by mass.
   f. Data from at least 15 individual batches shall be collected and given to the Engineer. The data collected shall include the following:
      (1) The 28-day compressive and flexural strength test results.
      (2) The water cement ratio.
      (3) The air content between 2.0 percent and 6.0 percent inclusive.
      (4) The cement and fly ash content.
      (5) The amount of fine aggregate, coarse aggregate, and sand and gravel.
5. No change shall be made in the concrete mix design during the progress of the work without the prior written permission of the Engineer.
6. Welding reinforcing steel is prohibited unless specifically authorized by the Engineer.

7. Prestressed steel other than that specified in the Plans or Special Provisions may be furnished with the approval of the Engineer. The yield and ultimate strength and other pertinent characteristics of this steel shall be submitted to the Engineer.
8. The area of broken wires shall not exceed 2 percent of the cross-sectional area of the stressing strands when the number of strands is 14 or less.
9. The area of broken wire shall not exceed 1 percent of the cross-sectional area of the stressing strands when the number of strands exceeds 14.
10. No more than one broken wire will be allowed in a single strand.
11. Bars for post-tensioning shall be of high tensile strength steel. They shall be equipped with wedge-type end anchorages which will develop the minimum specified ultimate bar stress on the nominal bar area. The physical properties of the bar steel determined by static tensile tests shall conform to the following:

    High-Strength Steel Post-Tensioning Requirements

    Ultimate Stress . . . . . .1,000 MPa minimum

    Stress at 0.7% Elongation . . . . . .896 MPa minimum

    Stress at 0.3% Elongation . . . . . .517 MPa minimum

    Elongation in 20 Diameters . . . . . .4% minimum

    Modulus of Elasticity . . . . . .172 GPa minimum

    Diameter Tolerance . . . . . .Plus or Minus 2.54 mm
12. Materials specified for testing shall be furnished 30 days before anticipated time of use. All materials required for testing shall be furnished by the Contractor to the Engineer without additional costs to the Department. The Engineer shall select a representative sample length for the various prestressed steel as follows:
    a. Two meters for wires requiring heading.
    b. For wires not requiring heading, sufficient length to make up one parallel-lay cable two meters long consisting of the same number of wires as the cable to be furnished.
    c. Two meters between near ends of fittings for a strand furnished with fittings.
    d. Two meters between threads at the ends of bars furnished with threaded ends.
13. If the anchorage assemblies are not attached to prestressing steel samples, two anchorage assemblies shall be furnished for testing, complete with distribution plates of each size or type of prestressing steel to be used.
14. Any defective material shall be rejected.
15. Concrete quality control shall be the responsibility of the Contractor. Concrete shall be sampled and tested as shown in **Table 705.02**.
16. Plant Approval Requirements:
    a. (1) All precast/prestressed concrete structural units shall be produced in a Precast/Prestressed Concrete Institute (PCI) Certified Plant.
       (2) The method of manufacture and quality of concrete are also subject to Department approval/inspection.
    b. (1) A Contractor proposing to furnish precast/prestressed structural units shall submit the following additional details to the Department concerning the method of manufacture:

Table 705.02

Required Concrete Sampling and Testing		
Correlation Test	Contractor Test Samples*	Department Test Samples
Yield ASTM C138 Air meter measuring bowl.	One per day.	One per 10 Contractor tests.
Air content ASTM C231 (0.8% variation allowed)	One per load.	One every five production days.
Concrete temperature. ASTM C1064	One per load.	One every five production days.
Concrete Compressive Strength		
28-day strength ASTM C31 Section 9.3 cure.	Two cylinders - each from a different load; and one from the last load.	One set of two cylinders every five production days.
56-day strength (only if 28-day strength is less than specified.) ASTM C31 Section 9.7 cure.	Two cylinders - each from a different load and from same load as 28-day break.	NA

* At least 6 cylinders shall be made each production day and at least 2 cylinders are required from each load.

* Cylinders shall be 150 mm by 300 mm.

(i) Type, number, size and location of the prestressing elements, and the name of the manufacturer of the post-tensioning or pretensioning elements.

(ii) Complete information as to type, size and method of installation of devices for anchoring post-tensioning elements.

(iii) The proposed manufacturing methods, and the Plans and design details of proposed casting beds and forms.

c. The use of portable pretensioning beds for the manufacture of concrete structural units or piles will not be allowed.

705.03 Construction Methods

1. The Contractor shall construct precast structures and piles as shown in the Plans.
2. The Contractor shall erect precast concrete structures and drive precast concrete piles as prescribed in the Plans.
3. a. When the precast superstructure units have been erected, the Contractor shall pack the shear key openings with grout.

   b. A pneumatic tool shall be used.

   c. Grout to be used for constructing shear keys in the precast concrete superstructure shall be composed of either Type I or Type II Portland cement, aggregate and water.

(1) The aggregate shall be fine aggregate as specified for the class of concrete being furnished.

(2) The Portland cement and aggregate shall be proportioned on the basis of 350 kg of dry aggregate per 100 kg of cement.

(3) The water content of the grout shall be limited to that necessary for proper mixing and placement. In no case shall the total water content exceed 45 kg per 100 kg of cement.

4. a. No live load shall be allowed on the superstructure units until the shear keys and tie bolts have been placed and the shear key grout cured, unless cross planking or mats not less than 190 mm in thickness and 4.2 m long are placed on the structure to distribute the load.

b. In no case shall the live load vehicle mass exceed:

(1) 23 Mg.

(2) 9 Mg on any single axle.

(3) 18 Mg on any tandem axle.

5. Stressing Requirements:

a. (1) In all methods of tensioning, the stress induced in the prestressing elements shall be measured by the Contractor both with jacking gages and by elongation of the elements, and these results shall be the same within a five-percent tolerance.

(i) Means shall be provided for measuring the elongation of reinforcement to at least the nearest 3 mm.

(ii) All steel stressing devices, whether hydraulic jacks or screw jacks, shall be equipped with accurate reading calibrated pressure gages, rings or other devices as applicable to the jack being used.

(iii) All devices shall be calibrated and, if necessary, recalibrated so as to allow the stress in the prestressing steel to be computed at all times.

(iv) A certified calibration curve shall accompany each device.

(v) Safety measures must be taken by the Contractor to prevent accidents due to possible breaking of the prestressing steel or the slipping of the grips during the prestressing process.

(2) All calibrations and tests shall be performed at no additional cost to the Department.

(3) Pressure gages, load cells, dynamometers, and any other devices used in determination of loads and/or pressures shall be accurate in their effective range within a two-percent tolerance.

(i) Such equipment shall be calibrated by an approved testing laboratory.

(ii) The laboratory shall furnish calibration curves for each device and shall certify the curves as being accurate and verifiable.

(iii) The calibration of tensioning devices shall be accomplished in place.

(iv) The configuration of jacks, gages and other components during calibration shall be exactly the same as during the actual stressing operation.

(v) The method of calibration shall be as approved by the Engineer.

(vi) Tensioning devices shall be calibrated at least once a year and anytime a system appears to be operating in an erratic or inaccurate manner, or gage pressure and elongation measurements fail to correlate.

(4) If the strand tension indicated by the gage pressure and by elongation method fail to agree within five percent, the operation shall be carefully checked and the source of error determined before proceeding further.

b. (1) The Contractor's elongation and jacking pressure measurements shall make appropriate allowance for friction and all possible slippage or relaxation of the anchorage.

(2) For pretensioned members, independent references shall be established adjacent to each anchorage by the Contractor to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the cables.

(3) The Contractor may tension straight post-tensioned tendons from one end. The curved tendons shall generally be stressed by simultaneous jacking from both ends of the bar.

c. In all stressing operations, the Contractor shall keep stressing force symmetrical about the member's vertical axis.

6. Stressing Procedure:

a. Prestressing methods are shown in the Plans. When the Contractor elects to use a method other than that shown in the Plans, the Contractor shall submit complete shop Plans for the proposed method.

(1) Pretensioning method.

(2) Post-tensioning method.

(3) Combined method.

b. Pretensioning Method:

(1) The amount of stress to be given each strand by the Contractor shall be as shown in the Plans.

(2) All strands to be prestressed in a group shall be brought to a uniform initial tension before being given their full pretensioning. This uniform initial tension of approximately 4.5 to 9.0 kN shall be measured by a dynamometer or other approved means so that it can be used as a check against the computed and measured elongation.

(3) After initial tensioning, either single strand or multiple strand groups shall be stressed until the required elongation and jacking pressure are attained and reconciled within the five-percent tolerance.

(4) With the strand stressed in accordance with the Plan requirements and these Specifications, and with all other reinforcing in place, the Contractor shall cast the concrete to the lengths desired. Strand stress shall be maintained between anchorages until the concrete has reached the compressive strength specified in the Plans.

c. Post-tensioning Method: For all post-tensioned bars, the Contractor shall set the anchor plates exactly normal in all directions to the axis of the bar. Parallel wire anchorage cones shall be recessed within the beams. Tensioning shall not be done until the concrete has reached the compressive strength specified in the Plans.

d. Combined Method: In the event that the girders are manufactured with part of the reinforcement pretensioned and part post-tensioned, the applicable portions of the requirements listed above shall apply to each type.

7. Forms:

a. Forms for precast/prestressed concrete structural units shall conform to the requirements for concrete formwork as provided in Section 704.

b. Forms shall be accessible for the vibration and consolidation of concrete.

8. Placing Concrete:
   a. The Contractor shall provide the Department a 4-week production schedule that is updated as necessary. Unscheduled production changes may delay fabrication when the Department elects not to reschedule inspectors.
   b. The Engineer may observe any or all of the procedures and shall have access to all reported data anytime during fabrication. The Engineer shall report any inconsistencies to the job superintendent and note them in the plant diary.
   c. Concrete shall not be placed before completing the forming and placing of reinforcement.
   d. (1) Concrete shall be placed continuously in each unit, take care to avoid horizontal or diagonal planes of weakness.
      (2) However, if there is a delay in delivery of concrete, or for some other reason placement is interrupted for more than 30 minutes, then the concrete shall be rejected.
   e. (1) Special care shall be exercised to work and consolidate the concrete around the reinforcement and to avoid the formation of stone pockets, honeycombs and other defects.
      (2) The concrete shall be consolidated by vibrating, or other means approved by the Engineer.
   f. The forms shall be overfilled, the excess concrete screeded off, and the top surfaces finished to a uniform, even texture.
   g. Each precast/prestressed concrete structural unit shall be stamped or marked with an identification number and its manufacture date.
   h. (1) The optimum range of concrete temperatures from the time the concrete is completely mixed until the beginning of the presteam segment of the steam curing cycle shall be 10C to 35C. Failure to operate within the optimum range shall be cause for curtailment of operations to operate consistently within the range set forth. During the preset segment of the curing cycle, the temperature of the concrete shall not exceed 38C nor fall below 10C.
      (2) When placing concrete under cold weather conditions (ambient air temperature less than 2C), follow the cold weather Specifications in Section 1002.
      (3) Forms and reinforcing materials shall be preheated to a minimum temperature of 5C and a maximum temperature not to exceed that of the concrete at the time of placement.
      (4) The Contractor may preheat the drums of the mixer-trucks to the limits set for forms and reinforcing, but under no condition shall heat be applied to the drums while they contain any of the batch materials or concrete.
9. Curing:
   a. General:
      (1) The Contractor shall cure the concrete with wet burlap, waterproof covers, polyethylene sheets, or liquid membrane-forming compound. Liquid membrane-forming compound shall not be used on that portion of precast/prestressed concrete girders, twin tees, or bridge beams upon which concrete will be cast later.
      (2) Water spray curing, or other moist curing methods may be used, subject to the approval of the Engineer.

(3) The period of curing shall be determined by the results of the compressive strength test on cylinders made during the progress of the work and cured to closely approximate the concrete strength of the product it represents.

(4) Side forms may be removed 12 hours after placing the concrete, provided curing is continued with one of the approved NDOR curing procedures.

b. Steam or radiant heat will be allowed for accelerated curing provided the following procedure is adhered to:

(1) Curing chambers shall be reasonably free of leakage and shall have a minimum clearance of 75 mm between the enclosure and restricting portions of the forms in order to ensure adequate circulation of heat. The relative humidity within the curing enclosure shall be maintained between 70 and 100 percent.

(2) One approved continuous recording thermometer for each 35 meters of casting bed with a minimum of two continuous recording thermometers shall be located in each enclosure or curing chamber.

(i) Continuous temperature record charts for each casting shall be available to the Engineer for his examination and approval at anytime.

(ii) If the temperature records or other temperature readings taken by the Engineer indicate that hand control of heat is producing temperature changes in excess of those specified, the Engineer may direct that automatic controls which can be activated by the recording thermometers or by separate temperature switches be installed. These automatic controls are to control the rate of temperature change and maximum curing temperature according to a preset plan.

(3) Temperature of the curing concrete shall be 10C to 30C and shall be maintained near placement temperature until the concrete has reached initial set as determined by ASTM C403 "Time of Setting of Concrete Mixture by Penetration Resistance."

(i) The temperature rate of rise shall not exceed 30C per hour.

(ii) The concrete shall be completely covered with a waterproof curing chamber during accelerated curing periods.

(4) Steam jets shall not be directed at the concrete or the steel forms.

(5) When the heat has been applied for a minimum of 3 hours and the desired concrete temperature has been reached (not to exceed 80C), the heat source may be turned off. Should the temperature within the concrete rise above 80C, the concrete shall be rejected.

(6) The temperature in the concrete shall be maintained so that at any given time the difference between the highest and lowest temperature station readings will not be more than 15C. If the temperature varies more than 15C, the product shall be rejected.

(7) Eight hours after placing the concrete, individual sections may be uncovered to remove their forms. The curing may be discontinued during this operation. The section shall not be left uncovered longer than necessary and never longer than 30 minutes. Waterproofed covers shall be used to recover the product.

(8) After the heat source has been turned off, the curing cover shall be maintained in place during the soaking period until the release strength has been reached.

(9) Detensioning shall be accomplished before the temperatures of the units drop below 40C and while they are still moist.

(10) An automatic master slave heat curing system may be used for curing quality control cylinders.

10. Defects and Repair Procedures:

a. After the forms are removed, stone pockets, honeycombs, or other defects may be exposed. The Engineer shall determine if these defects affect the item's structural integrity and in which case the item will be rejected.

b. Precast/prestressed concrete structural units which have chips, spalls, honeycomb or otherwise defective areas which are not considered detrimental to structural integrity may be used after being repaired in the following manner:

(1) Remove all unsound concrete.

(2) Coat the affected area with epoxy resin binder. Care shall be taken to prevent getting epoxy on the exposed surface.

(3) Fill the prepared area with Class "47B-XX" concrete mix (Aggregate larger than 10 mm is not allowed) with the type of cement used in placing the unit. Where the unit is exposed to view, white cement shall be added to give a uniform appearance with the concrete surrounding the patch.

(4) Place and secure formwork to ensure all required configurations.

(5) Cure 24 hours with wet burlap. Steam curing at 25°C will be allowed.

(6) The patch shall be ground smooth to remove all joints.

11. Surface Finish:

a. The exterior face of all exterior girders or beams plus the bottoms and chamfers on all lower flanges shall be given the following finish:

(1) All uneven form joints in excess of 3 mm shall be ground smooth.

(2) The surface shall be steel brushed to remove scale and laitance, and to open partially obstructed holes.

(3) Dampen surface.

(4) The grout shall consist of 1.5 parts of fine sand, 1 part of Portland cement and sufficient water to produce a consistency of thick paint. The cement used in the grout shall be a blend of regular Type I and white Portland cement to duplicate the lighter appearance of the steam-cured units.

(5) If necessary, an admixture which will not discolor the concrete may be used in the grout to reduce shrinkage if approved by the Engineer. Admixtures containing iron particles shall not be used.

(6) Apply grout to the surface.

(7) The surface shall be float finished with a cork or other suitable float. This operation shall completely fill all holes and depressions on the surface.

(8) When the grout is of such plasticity that it will not be pulled from holes or depressions, sponge rubber or burlap shall be used to remove all excess grout.

(9) Surface finishing during cold weather shall not be performed unless the temperature is 50C and rising. The surface shall be protected against temperature drops below 5C for a period of 12 hours after finishing.

(10) A uniform appearance will be required. In the event the appearance produced by the above procedure is not uniform, both in texture and coloration, other methods approved by the Engineer shall be employed.

b. The interior face of an exterior girder or beam and all interior girders or beams shall be finished from the lower flange to the fillet of the web in accordance with subparagraphs (3), (4), (5) and (6) above.

12. Grouting for Post-Tensioned Units:

a. The Contractor shall install steel in flexible or other approved tubes which shall be cast in the concrete and shall be pressure-grouted after the prestressing process has been completed.

b. Bonding grout shall be made to the consistency of thick paint and shall be mixed in the proportions as follows: Portland cement (Type I), 45 kg; Fly ash (ASTM C618), 15 kg; Water, 20 to 27 kg (adjust at site); and admixture (Interplast B), 0.5 kg.

c. The final grouting pressure shall be at least 550 kPa.

d. The Contractor shall make provisions to demonstrate to the Engineer that grouting material has completely filled all areas within the conduit.

13. The Contractor shall paint all exposed metal, except weathering grade steel.

14. Handling, Transporting and Storing:

a. (1) After precast structural units have attained a compressive strength of 20 Mpa, the Engineer shall approve the method used to remove the units from the casting beds.

(2) Prestressed concrete structural units shall attain the "release" strength specified in the Plans before being delivered to the site. Prestressed concrete structural units will not be incorporated in the final product until the minimum age and strength specified in the Plans is attained.

(3) All precast/prestressed concrete structure units shall be supported at or within 150 mm of all lifting or bearing devices. When supported at the proper positions, no part of the units shall be allowed to rest on the ground. Prestressed concrete bridge girders shall be set on a level area to prevent field bowing, and adequate supports shall be placed under their lifting or bearing devices to prevent settlement into the ground.

(4) The girders shall be transported in an upright position and the points of support and direction of the reactions with respect to the girder shall be approximately the same during the transportation and storage, as when the girder is in its final position. If the Contractor finds it necessary to transport or store the precast girders in some other position, the Contractor should be prepared to prove no internal damage resulted.

(i) Adequate padding shall be provided between tile chains and cables to prevent chipping of the concrete.

(ii) Live loads shall not be allowed on the superstructure units until the floor slab is placed and has attained the design strength shown in the Plans.

15. Inspection Facilities:

a. The Contractor shall arrange with the producer of precast/prestressed concrete structural units to provide an office laboratory, and a bathroom for the Department's inspector. The areas shall meet the following requirements:

(1) Thermostatically controlled heating and air conditioning shall be provided so that temperature can be maintained between 20C and 25C.

(2) The floors shall be tile or a similar floor covering.

(3) Interior and exterior walls shall be well maintained and painted.

(4) All exterior doors shall have cylinder locks and all keys shall be turned over to the Engineer.

(5) Ceiling lighting shall provide a minimum of 5,000 lx of light on all working surfaces.

(6) Electrical outlets shall be spaced no more than 2 m apart with no less than one outlet on any wall of the office or lab.

(7) A single trunk telephone shall be installed in the office and the installation charges shall be paid by the Contractor. The monthly charges shall be paid by the State.

(8) A fire extinguisher and first aid kid shall be provided.

(9) A ventilated bathroom with a toilet and sink shall be provided in the structure. A fresh water supply and drain will be required in the lab area.

(10) The lab, office and bathroom shall be separate rooms with interconnecting doors.

(11) The minimum lab area is 21 m^2 .

(12) The minimum toilet area is 2 m^2 .

(13) The minimum office area is 15 m^2 .

(14) The Contractor shall clean and maintain the rooms and shall supply all heating fuel, electricity and water.

(15) The Contractor shall also supply for the sole use of the inspectors, all desks, work tables, chairs, files, lockers and sanitary supplies necessary and commensurate with the inspection of his/her plant. It is anticipated that the following minimum amount of office and lab equipment will be required: One desk with approximately 1 m x 2 m top; one upright locker or wardrobe, with shelves, approximately 1.5 m deep; two four-drawer file cabinets; one chair per inspector; one square meter of work surface per inspector in the office area; and a 1 m x 15 m lab counter with storage space beneath.

705.04 Method of Measurement and Basis of Payment

1. Precast/prestressed concrete superstructures will be measured for payment by the lump sum.
2. The cost of furnishing and maintaining the inspection facilities will not be paid for directly, but shall be considered subsidiary to the items for which the contract provides that direct payment will be made.
3. If a precast or prestressed structural item's 56-day compressive strength is less than the design strength, then the Engineer will determine if the item can be used. It the item is to be used, a payment deduction of 25 percent will be taken if the 56-day compressive strength is less than 95 percent of the design strength.
4. Payment is considered full compensation for all work prescribed in this Section including the cost of prestressing and precasting.

Washington Department Of Transportation Specifications

6-02.3(25) PRESTRESSED CONCRETE GIRDERS

The Contractor shall be required to 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 and shall be approved by WSDOT as a Certified Prestress Concrete Fabricator prior to the start of production. WSDOT certification will be granted at, and renewed during, the annual prestressed plant review and approval process.

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 rejected.

The Contracting Agency intends to perform Quality Assurance Inspection. By its inspection, the Contracting Agency 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 types of girders are:

- Prestressed Concrete Girder - Refers to prestressed concrete girders including Series W42G, W50G, W58G, and W74G girders, bulb-tee girders, and deck bulb-tee girders.
- Bulb-Tee Girder - Refers to a bulb-tee girder or a deck bulb-tee girder.
- Deck Bulb-Tee Girder - Refers to a bulb-tee girder with a top flange designed to support traffic loads (i.e., without a cast-in-place deck). This type of bulb-tee girder is mechanically connected to adjacent girders at the job site.

6-02.3(25)A Shop Plans

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

Shop plans shall allow 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 in accordance with Section 6-02.3(16). There shall be no field-drilled holes in prestressed girders.

The Contractor shall have the option to furnish Series W74G prestressed concrete girders with minor dimensional differences from those shown in the Plans. The 2-5/8-inch top flange taper may be reduced to 1-5/8 inches and the bottom flange may be increased to 2 feet 2 inches. Other dimensions of the girder shall be adjusted as necessary to accommodate the above mentioned changes. Reinforcing steel shall be adjusted as necessary. The overall height and top flange width shall remain unchanged.

If the Contractor elects to provide a Series W74G girder with an increased web thickness, shop plans along with supporting design calculations shall be submitted to the Engineer for approval prior to girder fabrication. The girder shall be designed for at least the same load carrying capacity as the girder shown in the Plans. The load carrying capacity of the mild steel reinforcement shall be the same as that shown in the Plans.

The Contractor may alter bulb-tee girder dimensions as specified from that shown in the Plans if:

1. The girder has the same or higher load carrying capacity (using current AASHTO Design Specification);
2. The Engineer approves, before the girder is made, complete design calculations for the girder;
3. The Contractor adjusts substructures to yield the same top of roadway elevation shown in the Plans;
4. The depth of the girder is not increased by more than 2 inches and is not decreased;
5. The web thickness is not increased by more than 1 inch and is not decreased;
6. The top flange minimum thickness of the girder is not increased by more than 2 inches, providing the top flange taper section is decreased a corresponding amount;
7. The top flange taper depth is not increased by more than 1 inch; and
8. The bottom flange width is not increased by more than 2 inches.

The Contractor shall provide four copies of the shop plans to the Engineer for approval. Only steel side forms will be approved, except plywood forms are acceptable on the end bulkheads. Approval of shop plans means only that the Engineer accepts the methods and materials. Approval does not imply correct dimensions.

6-02.3(25)B Casting

Before casting girders, the Contractor shall have possession of an approved set of shop drawings.

All concrete mixes to be used shall be pre-approved in the WSDOT plant certification process and must meet the requirements of Section 9-19.1. The temperature of the concrete when placed shall be between 50 F and 90 F. The temperature limits in Section 6-02.3(6)A do not apply to prestressed concrete girders.

Air entrainment is not required in the concrete placed into prestressed precast concrete girders unless otherwise noted. The Contractor shall use air-entrained concrete in the entire roadway deck flange of deck bulb-bee girders. Maximum and minimum air content shall be as specified in Section 6-02.3(3)A.

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, and W58G girders, and 6 inches or more for Series W74G girders, and
4. Be located within 1 foot 3 inches of the web centerline for bulb-tee girder.

The Contractor may form circular block-outs in the girder webs to support brackets for roadway slab 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 so as 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 one 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. Any time there are indications that the jack calibration is in error.

The Engineer may use pressure 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, all reinforcement used in girders shall be protected against dirt, oil, grease, damage, rust and all corrosives. If strands in the stressing bed are exposed before they are encased in concrete, the Contractor shall protect them from contamination or corrosion. The protection method requires the Engineer's approval. If steel has been damaged or if it shows rust or corrosion, it will be rejected.

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 pouring the concrete, and then increase no more than 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 once the concrete has reached a minimum compressive strength of 3,000 psi. All damage from stripping is the Contractor's responsibility.

6-02.3(25)E Contractor's 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 relationships for the cylinders for each girder to the Engineer. When two 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. The required design strength shall be increased 5 percent when using 4-inch by 8-inch cylinders. This 5 percent increase will not be applied for the determination of the release strength. If heat is used to shorten curing time, the Contractor shall let cylinders cool for at least 1/2 hour before testing.

Test cylinders may be cured in a moist room or water tank in accordance with 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 two 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 two cylinders do not pass the test, two 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 one girder, all girders in that line shall be cored. These cores shall measure 4 inches in diameter by web thickness high and shall be removed from just below the top flange, one approximately 3 feet to the left and the other approximately 3 feet to the right of the midpoints of the girder's length. The Engineer may accept the girder if these cores have the required 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 more than two holes or if they are not in a neutral location, they shall be patched prior to the release of prestress.

The Contractor shall coat cored holes with a Type II, Grade 2 epoxy 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 girder shall not be shipped until tests show the patches have reached the required design strength of the girder.

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 Plans.

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 Formula No. A-9-73. 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 dirt, oil and other foreign matter.

6-02.3(25)H Finishing

The Contractor shall apply a Class 2 finish, as defined in Section 6-02.3(14), to:

1. The vertical exterior surfaces of the outside girders;
2. The bottoms, sides, and tops of the lower flanges on all girders; and
3. The bottom of the outside roadway flange of each outside bulb-tee girder section.

All other girder surfaces shall receive a Class 3 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 1/2-inch to 1/4-inch wide, between 1/2-inch and 1/4-inch deep, and spaced 1/4-inch to 1/2-inch apart.

On the deck bulb-tee girder section, the Contractor shall test the roadway 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 1/4 inch within the straightedge length. This section of the roadway surface shall be finished to meet the requirements for finishing roadway slabs, as defined in Section 6-02.3(1).

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 Tolerances

The girders shall be fabricated as shown in the Plans and shall meet the dimensional tolerances listed below. 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. Length (overall): ±1/4 inch per 25 feet of beam length, up to a maximum of ±1 inch
2. Width (flanges): +3/8 inch, −1/4 inch
3. Width (narrow web section): +3/8 inch, −1/4 inch
4. Girder Depth (overall): ±1/4 inch
5. Flange Depth: +1/4 inch, −1/8 inch
6. Strand Position: ±1/4 inch from the center of gravity of a strand group and of an individual strand
7. Longitudinal Position of the Harping Point: ±18 inches
8. Bearing Recess (center recess to beam end): ±1/4 inch
9. Beam Ends (deviation from square or designated skew): Horizontal: ±1/2 inch from web centerline to flange edge; Vertical: ±1/8 inch per foot of beam depth
10. Bearing Area Deviation from Plane (in length or width of bearing): 1/16 inch
11. Stirrup Reinforcing Spacing: ±1 inch
12. Stirrup Projection from Top of Beam: ±3/4 inch
13. Mild Steel Concrete Cover: −1/8, +3/8 inch
14. Offset at Form Joints (deviation from a straight line extending 5 feet on each side of joint): ±1/4 inch
15. Differential Camber Between Girders in a Span (measured in place at the job site)

    For I-girders: 1/8 inch per 10 feet of beam length (Series W42G, W50G, W58G and W74G).

    For deck bulb-tee girders: Cambers shall be equalized by an approved method when the difference in cambers between adjacent girders or stages measured at mid-span exceeds 1/4 inch.
16. Position of Inserts for Structural Connections: ±1/2 inch
17. Position of Lifting Loops: ±3 inches longitudinal, ±1 inch transverse
18. Weld plates for bulb-tee girders shall be placed ±1/2 inch longitudinal, and ±1/8 inch vertical

6-02.3(25)J Horizontal Alignment

The Contractor shall check and record the horizontal alignment of both top and bottom flanges of each girder upon removal of the girder from the casting bed. The Contractor shall also check and record the horizontal alignment within a two-week period prior to shipment, but no less than three days prior to shipment. If the girder remains in storage for a period exceeding 120 days, the Contractor shall check and record the horizontal alignment at approximately 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 at a time 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 included in the Contractor's Prestressed Concrete Certificate of Compliance.

Immediately after the girder is removed from the casting bed, neither flange shall be offset more than 1/8 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 1/4 inch per 10 feet of girder length. Any girder within this tolerance may be shipped, but must be corrected at the job site to the 1/8 inch maximum offset per 10 feet of girder length before concrete is placed into the diaphragms.

The Engineer may permit the use of 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 roadway slab has been placed and cured ten days.

6-02.3(25)K Girder Deflection

The Contractor shall check and record the vertical deflection (camber) of each girder upon removal of the girder from the casting bed. The Contractor shall also check and record the vertical deflection (camber) within a two-week period prior to shipment, but no less than three days prior to shipment. If the girder remains in storage for a period exceeding 120 days, the Contractor shall check and record the vertical deflection (camber) at approximately 120 days. The Contractor shall perform and record each check at a time 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 included in the Contractor's Prestressed Concrete Certification of Compliance.

The "D" dimensions shown in the Plans are computed girder deflections at midspan based on a time elapse of 120 days after release of the prestressing strands. A positive (+) "D" dimension indicates upward deflection.

The Contractor shall control the deflection of prestressed concrete girders that are to receive a cast-in-place slab by scheduling fabrication or other means. The actual girder deflection at the midspan may vary from the "D" dimension at the time of slab forming by a maximum of plus 1/2 inch for girder lengths up to 80 feet and plus 1 inch for girder lengths over 80 feet. The method used by the Contractor to control the girder deflection shall not cause damage to the girders or any over stress when checked in accordance with the AASHTO Specifications.

All costs, including any additional Contracting Agency engineering expenses, in connection with controlling the girder deflection shall be borne by the Contractor.

6-02.3(25)L
Handling and Storage

During handling and storage, each girder shall always be kept plumb and upright. It shall be lifted only by the lifting strands at either end. Series W42G, W50G and W58G girders can be picked up at a maximum angle of 30 degrees to the vertical (measured in the longitudinal plane of the girder). All other prestressed girders shall be picked up vertical. Girders shall be braced laterally to prevent tipping or buckling as specified in the Plans.

Before moving a long girder, the Contractor shall check it for any tendency to buckling. Each girder that may buckle shall be braced on the sides to prevent buckling. This bracing shall be attached securely to the top flanges of the girder. The lateral bracing shall be in place during all lifting or handling necessary for transportation from the manufacturing plant to the job site and erection of the girder. The Contractor is cautioned that for some delivery routes more conservative guidelines for lateral bracing may be required. Before removing the bracing to cast diaphragms, the Contractor shall fasten all girders in place by other means.

If the Contractor wishes to deviate from these handling and bracing requirements, the vertical pickup, or the pickup location, the proposed method shall be analyzed by the Contractor's engineer and submitted with the supporting calculations to the Engineer for approval. The Contractor's analysis shall conform to Articles 5.2 and 5.3 of the PCI *Design Handbook, Precast and Prestressed Concrete,* Third 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.

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. For long-term storage of girders with initial horizontal curvature, the Contractor may wedge one 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-day design strength, and the fabricator believes it to comply with the specification, the girder and a completed Certification of Compliance (DOT 350-151), signed by a Precast/Prestressed Concrete Institute Certified Technician or a professional engineer, acceptable to the Contracting Agency, shall be presented 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 prestressed girders shall be shipped that are not stamped "Approved for Shipment."

No bulb-tee girder shall be shipped for at least seven days after concrete placement. No other girder shall be shipped for at least ten days after concrete placement.

Girder support during shipping shall meet these requirements unless otherwise shown in the Plans:

Type of Girder	Centerline Support Within This Distance From Either End
Series W42G and W50G and all bulb-tee girders	3 feet
Series W58G	4 feet
Series W74G	5 feet

If the Contractor wishes to use other support locations, they may be proposed to the Engineer for review and approval in accordance with Section 6-02.3(25)L. The Contractor's proposal shall include calculations showing that concrete stresses in the girders will not exceed those listed below:

Criteria for Checking Girder Stresses at the Time of Lifting or Transporting and Erecting

Stresses at both support and harping points shall be satisfied based on these criteria:

1. Allowable compression stress, $f'_c - 0.60\, f'_{cm}$
    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, f_t
    a. With no bonded reinforcement = $3\sqrt{f'_{cm}}$
    b. With bonded reinforcement to resist total tension force in the concrete computed on the basis of an uncracked section = $7.5\sqrt{f'_{cm}}$. The allowable tensile stress in reinforcement is 30 ksi (AASHTO M-31, Gr. 60)
3. Prestress losses
    a. 1 day to 1 month = 20,000 psi
    b. 1 month to 1 year = 35,000 psi
    c. 1 year or more = 45,000 psi (max.)
4. Impact on dead load
    a. Lifting from casting beds = 0 percent
    b. Transporting and erecting = 20 percent

6-02.3(25)N Prestress Concrete Girder Erection

Before beginning to erect 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 provide complete details of 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, and lifting devices, spreaders, angle of lifting strands in accordance with Section 6-02.3(25)L, etc.;
5. Crane(s) make and model, weight, 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 clearly 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, in accordance with Section 6-02.3(16).

The Contractor shall submit the erection plans, calculations and procedures directly to the Bridge and Structures Office, Construction Support Engineer, 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 Project Engineer will confirm that they are stamped "Approved for Shipment" 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 strands at the ends, always keeping the girders plumb and upright.

Instead of the oak block wedges shown in the Plans, the Contractor may use Douglas fir blocks if the grain is vertical.

Before the grout pads are placed, the concrete beneath them shall be thoroughly cleaned, roughened, and wetted with water to ensure proper bonding. Pads shall be kept wet continuously until they reach a compressive strength of at least 2,000 psi. Grout pads shall reach this strength before girders are set on them. Grout compressive strength will be determined by fabricating cubes in accordance with WSDOT Test Method 813 and testing in accordance with AASHTO T-106.

The Contractor shall check the horizontal alignment of both the top and bottom flanges of each girder 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.

6-02.3(25)O Deck Bulb-Tee Girder Flange Connection

The Contractor shall submit a method of equalizing deck bulb-tee girder deflections to the Engineer for approval. This submittal shall be prepared by, or under the direction of, a professional engineer licensed under Title 18 RCW, State of Washington, and shall carry the engineer's signature and seal. This submittal shall be made a min-

imum of 60 days prior to field erection of the deck bulb-tee girder. Deflection equalizing methods approved for previous Contracting Agency contracts will be acceptable providing the bridge configuration is similar and the previous method was satisfactory. A listing of the previous Contracting Agency contract numbers for which the method was used shall be included with the submittal.

On the 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 the nonshrink grout shall have a compressive strength of 4,000 psi before the equalizing equipment is removed. Compressive strength shall be determined by fabricating cubes in accordance with WSDOT Test Method 813 and testing in accordance with AASHTO T-106.

Welding grounds 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 4,000 psi.

6-02.3(26) Cast-In-Place Prestressed Concrete

Intentionally Omitted.

6-02.3(27) Concrete for Precast Units

Concrete for precast non-prestressed units shall meet all the requirements for a Contractor-provided mix design and the following acceptance limits:

Maximum Slump	4 inches
Minimum Entrained Air	4 1/2 percent
Compressive Strength	Specified Design Strength

If the design strength of the precast concrete is 4,000 psi or less, the Contractor may use Contracting Agency provided mix design Class 4000 with air.

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 C805.

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 WSDOT Test Method 809 Method 2 and compression tested in accordance with WSDOT Test Methods 801 and 811.

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 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 which 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.

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 units(s) will be rejected.

The Contracting Agency intends to perform Quality Assurance Inspection. By its inspection, the Contracting Agency 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.

If products are prestressed, all prestressing materials and methods shall be in accordance with Section 6-02.3(25).

6-02.3(28)A Shop Drawings

Before casting the structural elements, the Contractor shall submit:

1. Seven sets of shop drawings for approval by the Bridge and Structures Engineer, Department of Transportation, Transportation Building, Olympia, WA 98504; and,
2. Two sets of shop drawings to the Project Engineer.

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 shown the Plans unless the Engineer approves equally effective variations.

The shop drawings shall contain as a minimum:

1. Unit 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 6-01.9.

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.

All concrete mixes to be used shall be preapproved in the WSDOT plant certification process, and shall meet all the requirements for a Contractor provided mix design with the following acceptance limits:

Minimum Slump	4 inches
Maximum Slump	6 inches
Entrained Air	Per Section 6-02.3(3)A
Compressive Strength	Specified Design Strength

If the design strength of the precast concrete is 4,000 psi or less, the Contractor may use Contracting Agency-provided mix design Class 4000 with air.

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.

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 such time as 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 or convection or conducted stream of hot air. Heat the concrete to no more than 100°F during the first two 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 by means of 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 made available 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 Contractor's 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 that in the precast units. The cylinders shall be made, handled, and stored in accordance with WSDOT Test Method 809 Method 2 and compression tested in accordance with WSDOT test Methods 801 and 811.

For accelerated-cured units, concrete strength shall be measured on test cylinders cast from the same concrete as that in the unit. These cylinders shall be cured under time-temperature relationships and conditions that simulate those of the unit. 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 unit to the Engineer. When two or more units are cast in a continuous line and in a continuous pour, a single set of test cylinders may represent all units 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 required design strength shall be increased 5 percent when using 4-inch by 8-inch cylinders. This 5 percent increase will not be applied for the determination of the stripping strength. The Contractor shall let cylinders cool for at least one-half hour before testing for release strength.

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

To measure concrete strength in the precast unit, the Contractor shall randomly select two 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 two cylinders do not pass the test, two 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 Plans or Special Provisions require otherwise.

6-02.3(28)F Tolerances

The units shall be fabricated as shown in the Plans, and shall meet the dimensional tolerances listed in PCI MNL-116-85, unless otherwise required by the Plans or Special Provisions.

6-02.3(28)G Handling and Storage

The Contractor shall lift all units only by adequate devices at locations designated on the shop drawings. When these devices and locations are not shown in the Plans, Section 6-02.3(25)L shall apply.

Precast units shall be stored off the ground on foundations suitable to prevent differential settlement or twisting of the units. Stacked units shall be separated and supported by dunnage of uniform thickness capable of supporting the units. Dunnage shall be arranged in vertical planes. The upper units of a stacked tier shall not be used as storage areas for shorter units unless substantiated by engineering analysis and approved by the Engineer.

6-02.3(28)H Shipping

Precast units shall not be shipped until the concrete has reached the specified design strength. The units 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 units arrive on the project, the Project Engineer will confirm that they are stamped "Approved for Shipment." The Project engineer will evaluate the units for damage before accepting them.

The Contractor shall lift all units by suitable devices at locations designated on the shop drawings. Temporary shoring or bracing shall be provided, if necessary. Units shall be properly aligned and leveled as required by the Plans. Variations between adjacent units shall be leveled by a method approved by the Engineer.