# Review of Working Drawings – Prestressed Concrete

## A. Procedure

The instructions in this memo apply to working drawings for both cast-in-place prestressed bridges and precast prestressed girders. Working drawings for prestressed piling and precast concrete deck panels are for use by field personnel only and are not routinely reviewed by the designers. A copy of this memo is included in Memo 160-6.0 of the *Structures Construction Records and Procedure Manual*. See Article 8 below for review of projects designed by local agencies and consultants.

To provide uniform treatment in checking prestressed concrete working drawings other than piling and precast concrete deck panels, the following procedure shall be followed:

1. The responsibility for checking working drawings is shared by the designer (checker) and the Structure Representative. Working drawings shall not be returned to the contractor until the designer has discussed and resolved the details with the Structure Representative. The comments returned to the contractor must be acceptable to both the designer and the Structure Representative.

   A brief file memo shall be written by the designer to document controversial decisions or to keep other involved parties informed. For example, a memo is required for *any* change or clarification of details in the contract plans. A copy of the memo is to be sent to the Structure Representative (routed thru Construction) and two copies are to be sent to the Division of New Technology, Materials and Research.

   The time allowed for review of working drawings is covered by Section 50-1.02 of the Standard Specifications.

2. When the initial three sets of drawings are received, one set with correspondence will go to the Design Section involved, one set will be sent through the Prestress Committee and one unchecked set with correspondence will be forwarded to the Structure Representative. The Documents Unit will make these distributions.

3. It is the designers responsibility to insure that the shop plans comply with the contract plans and specifications. The set of drawings sent to the Design Section will be the work and file set, that is, it will be marked as necessary by the Design Section in yellow crayon to indicate the checking performed, and in red to indicate any changes required.

*Supersedes Memo to Designers 11-1 dated April 1990*

The set sent thru the Prestress Committee will be checked to insure that the proposed stressing and anchorage system has been approved by the Division of New Technology, Materials and Research and returned to the Design Section and will ultimately be returned to the Contractor. This set should not be marked and stamped until all details are resolved between the Structure Representative, the Designer, and Structures Local Assistance Section if a local agency structure is involved.

4. Subsequent submittals of working drawings for final review, which shall include six sets of drawings, etc., will not be routed to the Structure Representative or Prestress Committee. If there are any significant changes the Structure Representative will be advised by the designer.

5. In general, questions concerning prestressed concrete working drawings should be directed to the Prestressed Concrete Committee. Standard details of prestressing systems are available in the Prestressed Concrete Committee files.

6. The Documents Unit will keep the latest set of drawings on file and make them available to the designer as necessary. When corrected or revised drawings are received, the initial prints will be marked X with a blue crayon and returned to the Design Section. These superseded sheets should be retained temporarily when the Design Engineer anticipates the need to reconstruct the history of the project, such as when a change order is pending.

## 7. *Special Procedure for Structures Carrying Railroads*

a. Specifications require an initial submittal of five sets of drawings. If less than five are received, the Documents Unit should immediately request the missing sets.

b. Two sets are sent to the Railroads for their review, with a request that they expedite.

c. One set is sent to the Structure Representative, one to the Design Section and one to the Prestress Committee. (See also paragraph 8).

d. The Design Section shall not return an "approved" or "disapproved" set until comments are received from the Railroad and the Structure Representative.

e. When the Railroad comments are received, the Design Section will mark the plans accordingly, or resolve differences as necessary.

f. The set returned to the Contractor will incorporate both State and Railroad comments.

## 8. *Review of Projects Designed by Local Agencies and Consultants*

a. Review and oversight of project involving structures designed by local agencies or private consultants is the responsibility of the Local Assistance Branch, the Externally Financed Projects Branch, or the Consultant Contract Management Branch.

b. Structures Local Assistance Branch will coordinate the review of the working drawings and handle all plan distribution activities.

c. For projects with oversight by the Externally Financed Projects Branch or the Consultant Contract Management Branch, the procedures for distributing and reviewing working drawings are outlined in Section 4-4 of the *EFPB Information and Procedures Guide.*

## 9. Stamping of Working Drawings

a. Initial Review

(1) If they are correct on initial review, the checker shall stamp and date:

**APPROVED**
**PURSUANT TO SECTION 5—1.02**
**OF THE STANDARD SPECIFICATIONS**

AUG 1 1989

**STATE OF CALIFORNIA**
**DEPARTMENT OF TRANSPORTATION**
**DIVISION OF STRUCTURES**

Checker shall initial one set of prints only (yellow crayoned set). This will be retained in the job file by the Documents Unit. The Documents Unit will then order the remaining sets for final distribution and will stamp them accordingly.

(2) If any corrections *whatsoever* are noted, the sheets in error shall be returned for correction. The sheets with corrections shall be stamped and dated:

Prints Reviewed by State Office of Structure and
RETURNED

JUL 1 1989

FOR
CORRECTION

Checker shall initial one set of prints only (yellow crayoned set). This set will be retained in the job file by Documents Unit.

(3) Calculation sheets may be stamped on the reverse side if there is not enough space on the front.

b. Second or Subsequent Review

If stamped "Returned for Correction" on subsequent review, prints will be handled in the same manner as prints for initial review.

If only a few minor corrections are made, all sheets needed for distribution and file must be marked with the same corrections and all stamped:

**APPROVED**
**PURSUANT TO SECTION 5—1.02**
**OF THE STANDARD SPECIFICATIONS**

AUG 1 1989

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**DIVISION OF STRUCTURES**

**MINOR CORRECTIONS SHOWN**
**IN RED**

Checker shall initial one set of prints only (yellow crayoned set). This set will be retained in the job file by the Documents Unit.

Note: The checker is responsible for stamping *all* drawings unless otherwise noted above.

## *10. Return to Contractor*

After checking and the discussion with the Structure Representative is completed, all copies of the working drawings shall be returned to the Documents Unit. (Return through Structure's Local Assistance Section if a local agency project is being reviewed.)

### 11. Final Approval

Shop plans may be approved on a sheet by sheet basis. Frequently the first sheet of a submittal covering the anchorage hardware is approved at initial submittal, while the details sheet(s) is returned for correction.

### 12. Distribution of Final Approved Drawings

a. Working Drawing File – 1 print

b. Contractor – 1 print

c. Structure Representative – 2 prints (one for State staff and one for Contractor's Field Representative).

d. Division of New Technology, Materials and Research – 2 prints (Additional prints will be furnished where out-of-state fabricators are involved.)

e. Railroads – 2 prints for each Railroad Company involved.

f. Local agency – 1 print (thru Local Assistance Section).

### 13. Final Disposition of Working Drawings

After completion of a project, the fabricator will furnish 11 × 17 bond prints of working drawings to the Office of Structure Design as required by the specifications. These prints are checked and verified by the Documents Unit prior to filing in the unit files.

After these prints are received the file copies of working drawings and *calculations* will be sent to the Design Section (or to Local Assistance Section if a local project is involved). The drawings can then be discarded at the option of the Design Engineer. However, since copies of the *calculations* are not usually obtained, the Contractor's calculations should be retained by the designer and filed with other calculations.

## B. Guide for Checking Working Drawings

As a means of establishing uniform practice and avoiding omissions, but not as a substitute for common sense, the following outline is submitted as a general guide for the checking of prestressed concrete working drawings. Some items are included which should fall within the duties of the Structure Representative. An overlap may avoid an oversight. These items will be reviewed in the discussion between the designer and the Structure Representative. General responsibility for the individual items on shop plans are as follows:

Design Engineer:

Tendon profile and layout
Prestressing calculations including elongations
Stressing Sequence
Girder Flares
General conformance to contract plans

Structure Representative:

Blockout dimensions
Abutment and hinge diaphragm thickness
Bearing plate slope

Prestressed Concrete Committee:

Stressing and anchorage system hardware

If the individual Design Engineer feels that certain factors need not be considered, or that others should be added, it is his prerogative to do so, providing the Structure Representative is agreeable.

1. Read the Standard Specifications and the Special Provisions for the particular job. The Special Provisions may modify the usual procedure. Read the correspondence file; there may have been changes approved by the Construction Department since the contract was let. Call the Structure Representative to establish a working relationship and to become familiar with any pending changes or special problems.

2. Changes from the contract plans or specifications, regardless of magnitude, should not be allowed unless they have been discussed and approved by the Structure Representative. Revisions may be satisfactory structurally but create administrative problems. Changes requiring Contract Change Orders as determined by the Structure Representative need special attention. These change orders could be grouped into two categories.

   a. Those involving changes requested by the State and minor changes requested by the fabricator where there is no question on approval of the change order by both parties. The working drawings can be approved but the note "Contract Change Order to be processed" added to each detail sheet involved.

   b. Those involving controversial changes requested by the fabricator. These should be returned to the fabricator with the note "Request must be made by the Contractor to the Resident Engineer for Contract Change Order." The fabricator may ask that the working drawings be held by Design pending such negotiation. Design should not hold any plans without such a request.

   See Section 4.b, "Working Drawings", for changes to be made to bar reinforcement to accommodate the contractor's proposed prestress method.

## 3. Contractor's Stressing Calculations to be Checked

a. Prestressing force, as per contract plans or Special Provisions. (Require that the Contractor round-up when determining the number of strands.)

b. Modulus of elasticity and ultimate strength of samples of steel.

This information is furnished for the field personnel. The office staff will have to obtain it from the correspondence file (under "Material") or from the Laboratory. However, results of Laboratory tests usually are not available at the time of working drawings review; therefore, a stamp should be placed on the appropriate sheet as follows:

PLANS REVIEWED ON THE BASIS OF ULTIMATE STRENGTH AND MODULUS OF ELASTICITY OF STEEL SHOWN ON THESE SHOP PLANS AND CALCULATIONS. VALUES TO BE VERIFIED BY "TRANSPORTATION LABORATORY"

The following are average values for $E_S$:

Wire = 28,000,000 psi to 29,500,000 psi
Bars = 28,000,000 psi to 34,000,000 psi
Strand = 27,500,000 psi

c. Elongation of prestressing steel.

(1) Refer to the Prestress Manual for equations.

(2) Calculate elongation, making note of $E_S$ used.

(3) To compensate for slack, tendons are usually stressed to 20% of the required load before it is marked for elongation measurements. The Contractor may submit calculations showing 80% of the total elongation. This is generally referred to as measurable elongation.

d. Variation of force between cast-in-place girders.

(1) Variation of final force between girders.

- Unless otherwise specified on the contract plans or in the special provision the allowable variation of force between girders, except for railroad bridges, shall be in the ratio of 3 to 2.

- The maximum force variation between girders shall not exceed 725 kips. The force shall be computed assuming the stress in the strand is (0.7 $f'_s$ – Losses). Tendons shall be arranged symmetrically in the structure.

- For bridges that carry railroad traffic the following guide shall be used when checking shop plans. The allowable variation of force between girders, for bridges with 3 or more girders, shall not be greater than the ratio of 6 to 5 and the interior girders shall not have less force than the exterior girders. The distribution of total force shall be symmetrical.

(2) Temporary variation of force during stressing.

- No more than ½ of the prestressing force in any girder may be applied before an equal force is applied in all of the girders (this assures a reasonable force distribution between the girders.)
- At no time during the stressing operations will more than ⅙ of the total prestressing force be applied eccentrically about the centerline of the structure.
- The maximum force variation between giders shall not exceed 1054 kips. The force shall be computed assuming the stress in the strand is (.75f's).

(3) A single duct layout scheme may be used for all girders in a span even though the contractor varies the number of ducts/force between girders. Check to be certain that the overall c.g. of strand provided will meet the c.g. path shown on the Contract Plans.

e. One end stressing.

(1) Simple spans are designed to be stressed entirely from one end.

(2) When one end stressing is allowed in multiple span structures it will be shown on the plans.

f. Two end stressing is allowed to be done non-simultaneously. Check Contractor's proposed stressing sequence at second end as well as initial end.

## 4. *Working Drawings*

a. Placement of prestressing units, i.e., size, number, type, location and clearance.

b. Section 50-1.02, "Drawings," of the Standard Specifications require complete details to be shown on the working drawings of the prestress system to be used. Any additions or rearrangement of reinforcing steel from that shown on the Contract Plans to accommodate the prestress system used must be included. This insures that significant changes can be approved, before installation, by both Design and Construction. Areas of specific concern are around anchorages, and where ducts may displace cap reinforcement in continuous structures, or where caps are prestressed. Significant changes in reinforcing steel placement are also shown on bond prints submitted after completion of the project. This does not preclude minor placement variations to be made and approved in the field, or later significant changes which were overlooked on the original submittal to be detailed and submitted for approval. No contract change order is involved since additional reinforcement, if needed, is included in the price paid for prestressing cast-in-place concrete.

Significant rebar displacements and additions should be reviewed for compliance with allowable stresses.

The Structure Representative checks the rebar placement for clearances and rearrangement.

c. Provisions for forming camber, if required. *Camber calculations for precast-prestressed I-girders and trapezoidal girders* are to be furnished by the Contractor and shown in the shop plan submittal.

(1) Check the camber calculations for completeness and that the calculations include, (a) immediate and time dependent deflections due to prestressing force and girder self weight up until the date of placement of deck concrete, and (b), camber if shown on the contract plans.

(2) *Do not approve or disapprove* the Contractor's submitted calculations of camber since responsibility for the accuracy of the calculations rests with the Contractor.

d. Details of Anchorages

(1) The Structural Materials Branch of the Division of New Technology, Materials and Research witnesses physical testing of prestress systems and approves either on a job-by-job basis or general use basis. In either case, approval may be rescinded by reason of unsatisfactory results. Consult with the Prestress Committee for current status and/or details.

(2) Block-out requirements are to be shown and dimensioned. Bearing plates should be normal (± 2°) to ducts. Factors that enter into the calculation of duct alignment include; bridge profile slope, prestress path, duct splay, and bridge camber. Rough check the Contractor's anchor plate alignment and remind the Structure Representative to verify satisfactory alignment in the field.

(3) Multi-plane anchorage systems generally require spiral reinforcing in the area immediately ahead of the anchors. Check to see that room is being provided for the spiral reinforcing. Diaphragm width may need to be adjusted from that shown on the Contract Plans.

e. Details may be omitted on working drawings that are adequately shown on the contract plans.

f. Prestressing systems, which have been previously tested and approved for use, need not be furnished as complete tendon assemblies for testing, provided there is no change whatsoever in the materials, design or details previously approved.

g. New Systems.

(1) Any new or modified system must have Division of New Technology, Materials and Research approval before approval of the working drawings.

(2) The Contractor shall be notified that he must submit complete details and test data together with test tendons to the Laboratory on any new system before working drawings can be processed.

## 5. *Segmental Construction Working Drawings*

### a. Precast Segmental Construction.

(1) We currently allow precast girders to be cast in segments. They can then be assembled and post-tensioned on the job site, either on falsework or on the ground. For the present, we are making no restrictions on the location of splices. The purpose of doing this is both to promote competition and to allow more flexibility in design.

(2) The Contractor is required to submit working drawings showing the details for doing the segmental work. When checking working drawings, read the Special Provisions and see that the required details are supplied.

(3) The following points are offered for guidance and uniformity:

- Match cast segments are allowed. As the segments are match cast they must be precisely aligned to achieve the final structure geometry. At this time corrections for deflections and camber must be compensated for in the form.
- Keyways between segments should be used for shear transfer and alignment.
- Match cast segments shall be joined with epoxied joints and care shall be exercised to maintain compression over the entire joint area until the permanent post-tensioning tendons are stressed.
- All prestressing tendons shall be properly aligned and a suitable means of maintaining alignment at the joint during manufacture must be provided.
- Couplers for rods can be located in a closing pour or "windows" in the web, and should be staggered about 6 feet.
- Additional mild steel shall be provided to lap when a closing pour is used.
- Concrete strength for a closing pour should be the same as the entire precast girder.
- Epoxy bonding of closing pours is not necessary.
- The surface to receive a closing pour should be "abrasive" cleaned as required for horizontal construction joints.
- The working drawings should indicate what the Contractor intends to do to obtain matching concrete color and texture in closing pours. This is important for exterior girders, but additional refinements should not be required for interior girders.
- Any additional reinforcement necessary to handle the segments is the responsibility of the contractor.

b. Cast-in-Place Segmental Construction.

(1) This method of construction has been used on the Pine Valley, Eel River and Napa River Bridges.

(2) To achieve full flexibility, design will assume a construction sequence and note it on the plan. The normal sequence will be either free cantilever or fully continuous. The Contractor generally will have his own method of construction somewhere between these two and will be given the option of submitting working drawings and calculations. Additional materials such as concrete, prestressing and reinforcing required for the construction method used shall be for the Contractor's convenience and no additional payment is required.

(3) These working drawings can be very complex and require considerable checking effort. Design calculations may be extensive and a structural check is required for each step of the construction sequence. This will call for close cooperation between all parties involved.

(4) The following points are offered for guidance and uniformity:

- Organize your calculations in such a way that they can easily be updated, revised and understood by others. It may be necessary to quickly check the structure for changed circumstances.
- Review prestressing duct, anchorage, coupler and reinforcing steel placement carefully. Precise placement is generally required to insure that concrete can be properly placed and vibrated.
- The construction sequence shall be checked with the following things in mind:

  (a) Camber will be influenced by each step. The Contractor will be required to check camber at intermediate erection steps and provide camber adjustments as necessary including supporting calculations.

  (b) Fiber stresses must be checked for each step. Locked in stresses due to the Contractor's operation must be accounted for.

  (c) Unbalanced pier moments shall not exceed that shown on the plans.

  (d) Formwork at closing pours and hinges shall be supported such that applied loads yield equal deflections to both sides.

  (e) Falsework loads will depend on the construction sequence.
- Prestress losses have a significant effect on construction deflections. The losses shown on the plans are for the final structure after 40 years. The Contractor may submit revised loss values, based on tests of material used and substantiating calculations for the Engineer's approval. These values will influence the total prestress requirements, deflections, etc., so they should be set as soon as possible.

- The Contractor will submit the construction camber based on segment lengths, concrete properties, creep and shrinkage of concrete, prestressing, prestress losses and other characteristics unique to the method of construction. Variables such as temperature, relative humidity, and daily length of exposure to sun can affect camber significantly. The Contractor shall account for assumed variables in his camber calculations for construction during all seasons of the year.

- One of the important requirements of segmental construction is early removal of supporting forms. Things that can adversely effect timing are grouting and concrete cure. Both are covered in the specifications.

c. General to both Precast and Cast-In-Place Segmental.

(1) Blind or fixed anchorages should not be used for longitudinal strand tendons.

(2) Localized tension zones at tendon anchorages should be avoided if possible. Provide mild reinforcing for transition purposes.

(3) Vertical or diagonal shear tendons present inherent problems:

- They generally cannot be fully stressed initially because dead loads are being added in stages as the work progresses.

- Their anchorages must be located within the slabs so that interaction with slab reinforcement may occur.

(4) Careful arrangement of mild reinforcing is required when anchoring tendons in thin sections.

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