SECTION 503
PRESTRESSED CONCRETE BRIDGE MEMBERS

503.01. DESCRIPTION.

This work consists of furnishing and placing in the bridge structure, precast prestressed beams and other precast concrete bridge components in accordance with these Specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the contract drawings, approved shop drawings, or established by the Engineer.

Prestressing shall be by the pretensioning method in which the reinforcing tendons are tensioned, concrete is placed and cured, and, after the development of specified concrete strength, the tendons are released from anchorages, stressing the concrete. Refer to Section 517 for post-tensioning requirements.

503.02. MATERIALS.

(a) **General.** Use materials conforming to this section and the following sections and subsections:

Structural Concrete	509
Joint Fillers and Sealers	701.08
Reinforcing Steel for Structures	511
Bearing Pads	733.06
Strands for Prestressing	723.04

(b) **Concrete.** Unless otherwise specified, use Class P concrete satisfying strength requirements specified in the contract documents. Design concrete to have a minimum strength, at transfer of prestress (detensioning), of 75% of the 28-day specified strength, unless otherwise specified. Cast all members of the same specified strength from the same mix design.

(c) **Strand and Structural Steel.** For a structure, use the same type, grade, and manufacturer of strand. For a member, limit the variation in modulus of elasticity to ±1%.

Tension stress-relieved strand to 70% of its ultimate strength and low-relaxation strand to 75% of its ultimate strength. If low-relaxation strand is substituted for stress-relieved strand, tension to 70% of its ultimate strength and substitute strand for strand. Do not substitute stress-relieved strand for low-relaxation strand.

Use strand that is free of corrosion, rust, scale, pitting, flaking, dirt, grease, wax, oil, or other foreign material that may reduce bond between the strand and the concrete. Within members, do not use broken strand, strand that has been steamed, or strand that has been fully stressed and relaxed more than two times. Do not weld to, or near, strand.

Comply with Section 506 for structural steel items. Use weathering steel for anchor bolts and bearing assemblies. Unless otherwise specified in the contract documents, galvanize anchor bolt assemblies and paint bearing assemblies and embedded plates with the IZ-E-U paint system.

503.03. EQUIPMENT.

(a) **Prestressing Equipment.** Perform prestressing with approved jacking equipment. Use hydraulic jacks capable of providing and sustaining the necessary forces and equipped with either a pressure gauge or a load cell for determining the jacking stress. Provide appropriate plumbing and gauges to prevent fluctuation in the gauge readings until the jacking load is released.

For measuring initial stress, use dynamometers or other devices graduated to be read within a tolerance of ±100 lb (500N). For measuring final stress, use pressure gauges, load cells, or other devices graduated to be read within a tolerance of ±2% of the stress. Do not use load cells to measure stress less than 10% of the load cell capacity. Indicate the allowable operating range on or near the measuring device dial or display. Measure tendon elongation within a tolerance of ±0.1 inch (2mm).

Use jacks and stress measuring gauges calibrated by approved testing laboratory. Calibrate each jack and gauge as a unit with the jack cylinder extended to the position approximately corresponding to final jacking force. Supply a certified calibration chart or curve for each jack/gauge combination. Repeat the calibration process annually and whenever stresses and elongations differ more than specified limits.

(b) **Forms and Beds.** Comply with Section 502, "Temporary Structures," unless otherwise specified.

Use forms made of steel, except bulkheads may be made of either steel or wood. Use wooden bulkheads only once. Do not use forms or finishing tools made of aluminum. Make forms smooth, mortar-tight, and free of dings, dimples, or other surface irregularities. Provide a $^{3}/_{4}$ inch (19 mm) bevel on all exposed edges of prestressed concrete members.

Support forms on unyielding casting beds. Use abutments, beds, and forms designed by a registered professional engineer. Design beds to minimize differential settlement and movement.

The Engineer may reject the use of forms that do not produce satisfactory results.

(c) **Calibration Records.** Keep calibration records for plant equipment such as prestressing equipment, batch plant scales, compression testing machine, and other necessary equipment available for use and inspection. Utilize calibrat**ion records for tensioning.**

503.04. CONSTRUCTION METHODS.

(a) **Shop Drawings.** Submit shop drawings for all prestressed concrete bridge members. Refer to Subsection 105.02 for general shop drawing requirements.

Include in all sets of shop drawings, a title sheet, erection sheets, and detail sheets of each fabricated member and component. On the title sheet, provide an index of shop drawing sheets and general notes. On the erection sheets, show the locations of all members, anchor bolts, and diaphragms. Include beam lengths and spacings, centerlines of bearings, span numbers, and construction phases.

On the detail sheets for fabricated members, show all member dimensions, pretensioned and mild reinforcement, plates, chair and tie requirements, inserts, diaphragm holes, dunnage and handling locations, piece mark locations, bills of materials, and design information. Design information includes casting length adjustment due to elastic shortening, strand specification, member weight, stressing data, detensioning procedure reference, mix design identification, and all compressive strength requirements. Include, as needed, detail sheets for fabricated components, such as bent rebar, embedded plates, anchor plates, and bearing pads. Show items, such as reinforcing steel, strand, anchors, inserts, and diaphragm holes, with sufficient detail so that conflicts in the placement of these items are avoided. Show, by way of sketch or note, lap lengths of reinforcing steel including steel mesh, maximum strand support (chair) spacings, and reinforcing added for support of other reinforcing.

(b) **Contractor's Quality Control.** Provide quality control (QC) personnel, a production and QC manual, inspection, and testing to ensure that all prestressed concrete bridge members meet specifications.

Before fabricating, submit and obtain approval for a manual of production and quality control (QC) procedures detailing step-by-step the methods for fabricating each type of member and controlling quality. Resubmit after two years or whenever procedures change.

In the manual, describe stressing procedures, concrete mix design, batching and mixing, placement and finishing, curing, materials requirements, and other production practices. In the stressing procedure, describe initial strand tensioning for equalizing stresses and eliminating slack in the strands, uplift and holddown devices, methods for pretensioning and detensioning, and measurement of elongation and stress, and anchorage details. Describe QC procedures including all materials sampling and testing procedures, bed and product inspection methods, member identification, record keeping for bed and product inspection, stressing records, materials testing, and calibration records, and any other QC functions. Describe implementation of standard testing methods, such as those from ASTM or AASHTO. Make all QC records available to the Engineer.

(c) **Preparation of Beds and Forms.** Thoroughly clean beds and forms before each use. Use commercial quality form oil or other approved form release agent that permits the ready release of the forms and does not discolor the concrete. Do not allow coatings of release agents to build up. Prevent contamination of any bonded reinforcement, prestressed or nonprestressed, by the form release agent. Replace contaminated reinforcement.

Make form joints smooth and tight enough to prevent significant leakage of paste. Inspect forms for dimensional conformance and maintain as needed. Check form alignment and grade before each casting according to the approved production/QC manual. Maintain form alignment during the casting operation.

(d) **Tensioning Requirements.**

1. *General.* Notify the Engineer sufficiently in advance of tensioning to allow inspection by the Engineer.

Tension tendons, straight or draped, using either the single or multiple-strand stressing method. Design the stressing method to assure uniform stress both among the strands and along the length of the strands. Leave sufficient space between members to permit access for cutting the strands during release. Record all stressing measurements, and include the date, time, and ambient temperature during stressing.

Inspect the strands after the tensioning. Clean or replace any strand contaminated with form release agent. If more than 72 hours has elapsed since stressing, restress the strands before placing the concrete.

2. *Initial Tensioning.* Equally tension each tendon to eliminate slack before elongation readings are started. Use a tension intensity between 5% and 25% of the final jacking force. After initial tensioning, mark each strand before and after final tensioning to measure elongation and to monitor each anchor wedges for slippage.
3. *Target Stressing Values.* Compute the target force and elongation. The target force is the total jacking force needed for tensioning. The target elongation corresponds with the target force. Compute target values making appropriate allowances for all losses, such as, friction, slippage, and relaxation of anchors and splices. Adjust target values when the difference in temperature between the tendons and the concrete at the time of placement is more than 30°F (15°C). Limit overstressing of strand to 80% of its ultimate strength.
4. *Stress Measurement.* Measure tension in tendons using a pressure gauge or load cell. Mark tendons to measure elongations. Do not damage tendons when marking. For single and multiple-strand stressing, record force and elongation measurements for each tendon and tendon group, respectively. Monitor slippage of individual strands for multiple-strand stressing and restress individual strands as needed to meet specifications. Record heat numbers for all strand.

   Tension until both force and elongation targets are reached. Stop tensioning before the targets are reached if either force or elongation exceeds the target value by more than 5%, or 7% for tendons less than 50 feet (15 m) long. If such a discrepancy occurs, check the entire stressing operation carefully, determine the source of error, and correct before proceeding. Use a third method of stress measurement if the problem cannot be determined.
5. *Draped Tendons.* Tension draped tendons by either partially jacking the tendons in a straight position from one end of the bed and finishing by vertically displacing the tendons into their draped positions, or jacking from both ends of the bed with the tendons held in the draped position by rollers, pins, or other approved low-friction devices.
6. *Strand Splicing.* Use no more than one splice per strand. Splice strands of similar physical properties, having the same source and "twist" or "lay." When multiple-strand stressing is used, splice either less than 10% of the strands or all of the strands. Locate all splices outside of the prestressed members.

(e) **Concrete.**

1. *General.* Comply with the requirements of Section 509, except as modified in this Section. Vibrate the concrete internally, externally, or both. Avoid damaging or displacing reinforcement during vibrating. Replace honeycombed members.

Unless otherwise specified, finish the top surface of members with a rough float, followed by transverse finishing with a stiff broom.

2. *Curing.* Unless otherwise permitted, cure precast members by either the water method or the steam or radiant heat method as specified in Section 509. If needed, fog exposed concrete surfaces until regular curing starts.

   During curing, if differential movement between forms and beds causes damage to members, either anchor the forms to prevent differential movement, or loosened the side forms so that movements do not cause damage. If side forms are to be loosened, wait until loosening does not cause damage to the members.

   During curing, record the temperature surrounding the member using a minimum of three continuous temperature recorders per line.

3. *Testing.* Notify the Engineer in advance of casting so that the Engineer may be present for inspection. Conduct sampling and testing by the methods required in Section 509, except as modified in this Section.

   For girders and piles, sample concrete for acceptance at the minimum rate of once per member. For PS stay-in-place form deck panels, sample concrete for acceptance at the minimum rate of once for each 10 cubic yards ($10m^3$) or less of concrete placed in deck panels. Randomly select batches to be sampled, in advance. Vary sampling patterns for each casting operation. From each acceptance sample, determine slump, air content, temperature, yield, and compressive strength. Do additional sampling and testing for quality control purposes, as needed. Use the results of slump, air content, and yield tests to adjust the mix, as needed, within the limits established for the mix design.

   Before detensioning, cure all cylinders in the same manner as the members they represent, as described by Subsection 9.4 of AASHTO T23. After detensioning, cure remaining cylinders by Subsection 9.3 of AASHTO T23. Make at least four cylinders from each sample, one for detensioning and three for 28-day testing. Make additional cylinders for detensioning and for early testing of 28 day requirements, as needed. Test the 28-day cylinders at 28 days, regardless of the results of any previous testing.

   For detensioning, determine sample strength using the last cylinder tested from each concrete sample. Detension when all sample strengths in the line satisfy detensioning strength requirements.

   For 28-day strength, determine sample strength using the average of three cylinders from the same concrete sample. The compressive strength of a member will be acceptable if all strength tests satisfy strength requirements.

(f) **Detensioning.** Detensioning is the transfer of stress from the tendons into the concrete. Design detensioning procedures to:

- minimize shock to the members, and
- minimize movement against restrained items such as forms, inserts, and holddowns, and
- prevent overstressing or damaging members.

Determine the appropriate detensioning procedure for each member. List or reference on

the shop drawings the detensioning procedure for each member. List referenced procedures in full in the production and quality control manual.

Detension after the concrete has attained the required strength as specified in the previous subsection. If using steam or radiant heat curing, detension immediately after curing while the concrete is still warm and moist. Do not allow the temperature surrounding the members to drop below 45°F (7°C) before detensioning.

If jacking, limit tension force to 5% over the target stressing force or 80% of the ultimate strength of the strand, whichever is least. Cut or release strands in an order that minimizes lateral eccentricity of prestress. When cutting strand with an acetylene torch, minimize shock loading by first heating the strand to induce slow yielding and then cutting after the stress has been relieved through yielding. Correct the strand cutting procedure if indications of shock loading, such as brooming of strand, are evident.

Unless otherwise specified, cut all strands flush with the end of the member. Clean and paint flush-cut strand ends and adjoining concrete within 1 inch (25mm) of the strand. Use wire brushing or abrasive blast cleaning to remove all dirt and residue not firmly bonded to the metal or concrete surfaces. Coat with a minimum of 5 mils (150mm) zinc-rich paint conforming to the requirements of Federal Specification TT-P-641. Thoroughly mix the paint at the time of application and work the paint into voids.

(g) **Storage, Inspection, and Transportation.** Maintain members in an upright position. Handle members using the lifting eyes. Support beams in storage and transit within 2 feet (0.5m) of the designed bearing locations. Support stay-in-place panels and piles as shown on the approved shop drawings. Note that improper handling or support of a member could result in collapse of the member.

Use care during storage, handling, and transportation to prevent cracking, excessive camber and sweep, overstressing, or other damage. Replace damaged members at no additional cost to the Department. Repair minor chipping, spalling, and scars as directed.

Mark each member with a clearly legible piece mark as shown on the shop drawings. Include the member mark number, piece number, job identification, and date cast.

At least two days before shipping a member to the project, provide sufficient access for the Engineer to inspect, approve, and stamp the member. Do not ship members that are not approved and stamped. Approval of the member before shipment will not relieve the Contractor of responsibility for defects found after shipment.

Allow members to age at least 7 days before shipment provided the specified 28-day compressive strength has been attained.

(h) **Bearings and Anchor Bolts.** Provide bearing surfaces on both members and bridge seats with a true surface giving full and uniform bearing over the entire bearing area. Comply with the requirements of Section 509.04(k)1 for cast-in-place bearing surfaces. Except as modified in Subsection 503.02(c), comply with the requirements of Subsection 509.04(k)2 and 3 for anchor bolts and bearing assemblies. Bearing assemblies include anchor plates and elastomeric bearing pads. Apply inorganic zinc primer to all surfaces of sole plates before embedding in concrete.

Block and brace prestressed girders when set in place to assure lateral stability.

Construct anchors as specified. Position slotted anchor plates for expansion as specified for the temperature of the members at the time of erection. Field weld anchor plates to embedded sole plates of the members making, as needed, minor horizontal adjustments to the locations of elastomeric bearing pads and anchor plates. Weld according to Subsection 724.03. Do not weld until the bearings have been inspected. Repair the primer in welded areas and paint completed bearing assemblies with intermediate and top coats of the IZ-E-U paint system.

(i) **Concrete Floors and Diaphragms.** Construct concrete floors and diaphragms by Section 504.

Add, in the haunch, stirrups matching the size and spacing of the member stirrups if the stirrups in the member do not extend at least 2 inches (50mm) above the haunch height into the bridge floor.

Do not drill or core members for diaphragm hole installation, compressive strength determination, or any other purpose.

(j) **Tolerances.** Produce members that are well within the specified acceptable range. Correct the production process when members approach or equal a specified limit. Immediately notify the Engineer of any out-of-tolerance members. Check applicable dimensional tolerances before casting and after removal from the forms. Recheck time-dependent tolerances, such as, length, camber, and sweep, within 3 days before shipment. Check camber and sweep at a time when thermal effects of sunlight are negligible such as on a cloudy day or early morning. Sweep is defined as the horizontal deviation from a straight line parallel to the centerline of the member. Camber is defined as upward deflection of the member caused by prestress. Check local smoothness with a 5-foot (1.5m) straightedge.

Comply with the maximum dimensional tolerances in Table 503-1 for AASHTO girders and bulb-tees, Table 503-2 for double-tees, Table 503-3 for prestressed piling, and Table 503-4 for prestressed deck panels:

Table 503-1
Maximum Dimensional Tolerances for AASHTO Girders and Bulb-tees

Length	±1/4 inch / 25 ft, ±1 inch max.	(±0.8mm/m, ±25mmmax.)
Width (overall)	+3/8 inch, -1/4 inch	(+10mm, -6mm)
Width (web)	+3/8 inch, -1/4 inch	(+10mm, -6mm)
Depth (overall)	+1/2 inch, -1/4 inch	(+13mm, -6mm)
Depth (flanges)	±1/4 inch	(±6mm)
Sweep	1/8 inch / 10 ft	(1mm/m)
Variation from end squareness or skew	±3/16 inch / ft, ±1 inch max.	(±16mm/m, ±25mm max.)
Camber variation from design camber[1]	±1/8 inch / 10 ft	(±1mm/m)
For spans of 80 ft or less	±1/2 inch max.	(±13mm max.)
For spans more than 80 ft	±1 inch max.	(±25mm max.)
Differential camber between adjacent members	1/8 inch / 10 ft	(1mm/m)
Position of Strands:		
Individual	±1/4 inch	(±6mm)
Bundled	±1/2 inch	(±13mm)
Draped strand holddown point	±20 inches	(±0.5m)
Position of plates:		
Bearing plates	±5/8 inch	(±16mm)
Other plates	±1 inch	(±25mm)
Tipping and flushness of plates:		
Bearing plates	±0.5%, ±1/8 inch max.	(±0.5%, ±3mm max.)
Other plates	±1/4 inch	(±6mm)
Position of inserts including diaphragm holes	±1/2 inch	(±13mm)
Position of handling devices:		
Parallel to length	±6 inches	(±150mm)
Transverse to length	±1 inch	(±25mm)
Position of stirrups:		
Longitudinal spacing	±2 inches	(±50mm)
Projection above top	±3/4 inch	(±19mm)
Local smoothness of any formed surface	±1/4 inch / 10 ft	(±3mm/1500mm)

[1]Use this camber tolerance when a design camber is specified.

Table 503-2
Maximum Dimensional Tolerances for Double-tees

Length	±1/4 inch / 25 ft, ±1 inch max.	(±0.8mm/m, ±25mm max.)
Width (overall)	±1/4 inch	(±6mm)
Width (webs)	±1/8 inch	(±3mm)
Depth (overall)	±1/4 inch	(±6mm)
Thickness (flanges)	+1/4 inch, -1/8 inch	(±6mm, -3mm)
Flange Overhang (flange edge to web edge)	±1/4 inch	(±6mm)
Distance between Webs	±1/4 inch	(±6mm)
Sweep	1/8 inch / 10 ft	(1mm/m)
Variation from end squareness or skew	±3/16 inch / ft, ±1 inch max.	(±10mm/m, ±25mm max.)
Camber variation from design camber[1]	±1/8 inch / 10 ft, ±3/4 inch max.	(±1mm/m, ±19mm max.)
Differential camber between adjacent members	1/8 inch / 10 ft, 3/4 inch max.	(1mm/m, 19mm max.)
Position of Strands:		
Individual	±1/4 inch	(±6mm)
Bundled	±1/2 inch	(±13mm)
Draped strand holddown point	±12 inches	(±300mm)
Position of plates:		
Bearing plates	±1/2 inch	(±13mm)
Other plates	±1 inch	(±25mm)
Tipping and flushness of plates:		
Bearing plates	±0.5%, ±1/8 inch max.	(±0.5%, ±3mm max.)
Other plates	±1/4 inch	(±6mm)
Position of inserts including diaphragm holes	±1/2 inch	(±13mm)
Position of handling devices:		
Parallel to length	±6 inches	(±150mm)
Transverse to length	±1 inch	(±25mm)
Position of stirrups:		
Longitudinal spacing	±2 inches	(±50mm)
Projection above top	±3/4 inch	(±19mm)
Local smoothness of any formed surface	±1/4 inch / 10 ft	(±3mm/1500mm)

[1]Use this camber tolerance when a design camber is specified.

Table 503-3
Maximum Dimensional Tolerances for Prestressed Concrete Piling

Length	±1 inch (±25mm)
Width or Diameter	±3/8 inch (±10mm)
Variation from longitudinal axis (bow)	±1/8 inch / 10 ft (1mm/m)
Variation from end squareness or skew	±1/4 inch / 1 foot, ±1/2 inch max. (±6mm/300mm,±13mm max.)
Position of Individual Strands:	±1/4 inch (±6mm)
Position of handling devices:	±6 inches (±150mm)
Longitudinal spacing of spiral reinforcement:	±3/4 inch (±19mm)
Local smoothness of any formed surface	±1/4 inch / 10 ft (±3mm/1500mm)

Table 503-4
Maximum Dimensional Tolerances for Prestressed Concrete Stay-in-Place Forms

Length (in direction of panel strands)	+3/4 inch, -1/4 inch (+18mm, -6mm)
Width	+1/4 inch, -1/2 inch (+6mm, -12mm)
Thickness	+1/4 inch, - 1/8 inch (+6mm, -3mm)
Variation from end squareness or skew	±1/4 inch (±6mm)
Camber, sweep, and warping[1]	±1/4 inch / 10 ft (±2mm per meter of length)
Position of individual strands:	
Vertically	+0, -1/4 inch (+0mm, -6mm)
Horizontally	±1/2 inch (±12mm)
Position of handling devices:	
Parallel to length	±3 inches (±75mm)
Transverse to length	±2 inches (±50mm)
Local smoothness of any formed surface	±1/4 inch / 10 ft (±3mm/1500mm)

[1]When measuring panel camber, account for dead load deflection of the panel. SIP form deck panels are designed to have no camber, only dead load deflection.

Remedy out-of-tolerance members in one of the following ways:

- Replace the member at no additional cost to the Department.
- Correct the member tolerance problem, if possible, using an approved correction procedure at no additional cost to the Department.
- If correction is not possible but the member is considered usable, submit the member for review and acceptance at a reduced price under Subsection 105.03. Include a description of the problem and any proposed corrective action. Provide structural and physical evaluation by a qualified professional engineer registered in Oklahoma, as required. Replace the member at no additional cost to the Department if the submittal is rejected.

503.05. METHOD OF MEASUREMENT.

Prestressed concrete beams and double tees will be measured by the linear foot (meter), complete in place, as shown on the plans. Concrete and reinforcing steel placed in haunches in excess of the plan quantity will not be measured for payment.

Prestressed concrete piling will be measured as specified in Section 514. Prestressed concrete stay-in-place forms will not be measured for payment; Refer to Section 502.

Anchor plates, anchor bolt assemblies, and diaphragm bolt assemblies for prestressed concrete members will be measured as structural steel under Section 506. Embedded plates will not be measured for payment.

503.06. BASIS OF PAYMENT.

The accepted quantities, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section.

(A) PRESTRESSED CONCRETE BEAMS. .....LINEAR FOOT (METER)
(B) PRESTRESSED CONCRETE DOUBLE TEES .....LINEAR FOOT (METER)

SECTION 504

BRIDGE DECKS, APPROACHES, RAILS AND PARAPETS

504.01. DESCRIPTION.

This work consists of constructing concrete bridge decks and approach slabs according to these Specifications and in reasonably close conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

This work also consists of the construction of railings and parapets for bridges, roadways, wing walls, retaining walls, and other structures, in accordance with these Specifications and in reasonably close conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

Comply with the requirements of Section 414 for approach slabs, except as modified in this Section.

504.02. MATERIALS.

Use materials conforming to following Sections and Subsections.

Structural Concrete (*Class AA*)	509
Joint Fillers and Sealers	701.08
Reinforcing Steel for Structures	511
Curing Materials	701.07
Metal Beam Railing	732.01
Aluminum Alloy Tubes for Railings	732.03
Cast Aluminum Alloy Bridge Railing Posts	732.03
Pipe Railing	732.04