SECTION 715

PRESTRESSED CONCRETE MEMBERS

715.1 DESCRIPTION

Manufacture, cure, handle and install prestressed concrete bridge beams and panels to the dimensions specified on the Contract Documents. Manufacture and cure concrete piling to the dimensions specified on the Contract Documents.

BID ITEMS	**UNITS**
Prestressed Concrete Beams (*)(**)	Linear Foot
Prestressed Concrete Panels	Square Foot
*Type	
**Size	

715.2 MATERIALS

Provide materials that comply with the applicable requirements.

Concrete and Admixtures	**DIVISION 400**
Reinforcing Steel	**DIVISION 1600**
Bearings and Pads For Structures	**DIVISION 1700**
Steel Strand	**DIVISION 1600**
Wire Mesh	**DIVISION 1600**
Water	**DIVISION 2400**

Provide a copy of mill certifications for reinforcing bar and wire mesh, as required in **DIVISION 1600**, to the Inspector prior to concrete placement.

Steel strand mill certifications and KDOT test reports are required prior to concrete placement. Due to variations in the modulus of elasticity, only one source of strand will be allowed in any unit. No more than 1 broken wire will be permitted in a bed.

Bearing plate mill certification is required. Coating for the plate will be tested for the requirements of ASTM A 153 or **SECTION 714** for painting.

Mill certifications and KDOT test reports are required for miscellaneous items, such as bolts, etc.

715.3 MANUFACTURE OF CONCRETE BRIDGE BEAMS, PILING AND PANELS

a. General. A minimum of 2 weeks before starting the production of prestressed concrete units, submit shop drawings according to **subsection 105.10**. With the exception of prestressed piles, which do not require drawings, do not perform any fabrication until the approved shop drawings are in the hands of the Inspector and fabricator, and the Engineer has authorized fabrication. Changes to approved shop drawings are subject to the approval of the Engineer. Do not revise the number or location of coil inserts or other connection devices shown on approved drawings without the approval of the Engineer. Submit revised sheets of the same size as the shop drawings originally approved. Include information covering the following items in the shop drawings.

- The method of forming, placing and securing the reinforcement.
- The plan for prestressing the units, including the type, number, size and location of the prestressing elements.
- The method of releasing units with draped strands.
- Descriptions and allowable loads for hardware items (e.g. hold down devices, threaded inserts, etc.).
- Identify the proposed concrete mix, including the slump desired at point of delivery.
- The casting length center to center of bearings and the calculated prestress shortening.

Manufacture units within the tolerances in **TABLE 715-1**, unless shown otherwise on the Contract Documents.

TABLE 715-1: DIMENSIONAL TOLERANCES	
DOUBLE TEE AND INVERTED BEAM	
Unit Feature	**Tolerance**
Length	± ½ in.
Width (overall)	± ¼ in.
Depth	± ¼ in.
Stem Thickness	± ⅛ in.
Flange Thickness	+ ¼ in., - ⅛ in.
Position of Block-out	± ½ in.
Horizontal Alignment (Deviation from straight line parallel to centerline of the member.)	¼ in. (up to 40 ft. lengths) ⅜ in. (40 ft. to 60 ft. lengths) ½ in. (greater than 60 ft. lengths)
Camber deviation from design camber	± ¼ in. per 10 ft, but not greater than ¾ in.
Differential camber between adjacent members of the same design	¼ in. per 10 ft, but not greater than ¾ in.
Tendon position	± ¼ in. in c.g. of strand group
Tolerance between tendons	± ⅛ in.
Position of handling devices	± 6 in.
Position of deflection points for deflected strands	± 6 in.
Stem to edge of top flange	± ⅛ in.
Distance between stems	± ⅛ in.
Position of weld plates	± 1 in.
Squareness of ends (vertical and horizontal alignment)	± ¼ in.
Stirrup bar spacing (individual or accumulative)	± 1 in.
Stirrup bar height	± ½ in.
SINGLE TEE BEAM	
Unit Feature	**Tolerance**
Length	± ¾ in.
Width (overall)	+ ⅜ in., - ¼ in
Depth	± ¼ in.
Width (stem)	+ ⅜ in., - ¼ in
Thickness (flanges and fillets)	+ ¼ in., - ⅛ in.
Position of block-outs	± ½ in.
Side inserts (center to center and center to end)	± ½ in.
Bearing area deviation from plane	± ⅛ in.
Bearing plate (center to end of beam)	± ¼ in.
Horizontal Alignment (Deviation from straight line parallel to centerline of the member.)	¼ in. (up to 40 ft. lengths) ⅜ in. (40 ft. to 60 ft. lengths) ½ in. (greater than 60 ft. lengths)
Camber deviation from design camber	± ¼ in. per 10 ft., but not greater than ±¾ in.
Differential camber between adjacent beams	¼ in. per 10 ft., but not greater than ¾ in.
Tendon position	± ¼ in. in c.g. of strand group
Tolerance between tendons	± ⅛ in.
Position of handling devices	± 6 in.
Position of deflection points for deflected strands	± 6 in.
Position of weld plates	± 1 in.
Squareness of ends (vertical and horizontal alignment)	± ½ in.
Stirrup bar spacing (individual or accumulative)	± 1 in.
Stirrup bar height	± ½ in.

TABLE 715-1 (continued)	
BRIDGE I-BEAM	
Unit Feature	**Tolerance**
Length	± ¾ in.
Width (flanges and fillets)	+ ⅜ in., - ¼ in.
Depth (overall)	+ ½ in., - ¼ in.
Width (web)	+ ⅜ in., - ¼ in.
Depth (flanges and fillets)	± ¼ in.
Bearing plates (center to center)	± ⅛ in. per 10 ft., but not greater than ± ¾ in.
Horizontal Alignment (Deviation from straight line parallel to centerline of the member.)	⅛ in. per 10 ft. of span, but not greater than 1 in.
Camber deviation from design camber	± ⅛ in. per 10 ft. of span, but not greater than ± ½ in.
Differential camber between adjacent members	1 in. maximum
Stirrup Bars (projection above top of beam)	± ¾ in.
Tendon position	± ¼ in. in c.g. of strand group
Tolerance between tendons	± ⅛ in.
Position of handling devices	± 6 in.
Position of deflection points for deflected strands	± 6 in.
Exposed beam ends (deviation from square or designated skew)	Horizontal: ± ¼ in. Vertical: ± ⅛ in. per 1 ft. of beam depth
Bearing plates (center to end of beam)	± ¼ in.
Side Inserts (center to center and center to end)	± ½ in.
Bearing area deviation from plane	± ⅛ in.
Stirrup bar spacing (individual or accumulative)	± 1 in.
Stirrup bar height	± ¾ in.
Position of post tensioning duct	± ¼ in.
Position of weld plates	± 1 in.

PRESTRESSED PILE	
Unit Feature	**Tolerance**
Length	± 1 in.
Width or diameter	± ⅜ in., - ¼ in.
Head out of square	⅛ in. per 1 ft. of width
Horizontal alignment (deviation from straight line parallel to centerline of pile)	⅛ in. per 10 ft. of pile
Position of void	± ¼ in.
Position of stirrup bars and spirals	± ¾ in.
Position of tendons	± ¼ in.
Position of handling devices	± 6 in.
Position of steel driving tips	½ in.

PRESTRESSED PANELS	
Unit Feature	**Tolerance**
Length	± ¼ in.
Width	± ¼ in.
Thickness	+ ¼ in., - ⅛ in.
Square ends (deviation from square)	± ¼ in.
Deviation from straightness of mating edge	+ ⅛ in.
Position of strands	± ⅛ in. vertical, ± ½ in. horizontal

Notify the Engineer a minimum of 2 business days for in-state production and 5 business days for out-of-state production, in advance of the date when casting is to begin to afford an opportunity for inspection of the casting beds and forms, the equipment for placement and tensioning of the strands, the equipment for proportioning, mixing, placing and consolidating the concrete, and the equipment for handling the units.

b. Equipment.

(1) Condition. Repair or replace unsafe or inadequately operating equipment.

(2) Concrete Mixers. Mix concrete in truck mixers or in a central mixing plant that comply with **SECTION 154**. When concrete is mixed in a central mixing plant and can not be adequately mixed according to **SECTION 401**, conduct tests, as required by the Engineer, to determine the minimum mixing time to achieve uniformity of the concrete mixture. For air-entrained concrete, the maximum mixing time may not exceed the mixing time established from uniformity tests by more than 60 seconds.

(3) Casting Beds. Portable casting beds are prohibited. The supporting foundations for casting beds must be such that no settlement will occur during the casting and curing of the units.

(4) Forms. Use forms that are true to line, mortar tight and provide access for placement of the reinforcement and concrete.

(5) Stressing Jacks. For stress application, use jacks equipped with hydraulic gauges or other approved stress measuring devices as a check against the applied load as measured by elongation. Recalibrate gauges when directed by the Engineer.

(6) Curing Enclosures. Use steam curing enclosures reasonably free from steam leakage and providing adequate circulation of steam. Arrange steam jets so that the steam shall not play directly on the forms or the concrete as it enters the enclosure. If non-waterproof tarpaulins are used for the enclosure, use a minimum of 2 layers. Use only waterproof tarpaulins or plastic sheeting for enclosures when prestressed concrete units are cured by radiant heat.

(7) Instruments. When accelerated curing is used, install instruments during the curing period for measuring and recording temperature and humidity inside curing enclosures and for measuring and recording temperature in the concrete for each 200 feet of casting bed. Provide a minimum of 2 instrument installations of each type for each enclosure. The location of each instrument must be approved by the Engineer. Humidity level indicators may be waived by the Engineer.

c. Manufacturing Requirements.

(1) General. Except as modified by the Contract Documents or approved by the Engineer, follow the latest edition of the Prestressed Concrete Institute's, "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products".

(2) Reinforcement. Place reinforcing bars as shown in the Contract Documents, and rigidly secure them to prevent movement during placement of the concrete. Welding of reinforcing steel cages is prohibited.

Accurately position steel strand within the tolerances specified in the Contract Documents. Rigidly secure the strand so it shall be retained in the specified locations. The minimum horizontal spacing, center to center of strands at the ends, is 2 inches. Install supports to prevent dead load sag. The roller size on the holddown device must match the strand size used. Provide strand supports as shown in the Contract Documents that consist of a device with freely turning rollers a minimum of ⅞ inch in diameter at each deflection point. A yoke type device may be used for top depressing of strands when approved by the Engineer. The prestress force and center of gravity must be as shown in the Contract Documents.

Perform tensioning and elongation according to the Contract Documents. No tensioning of strands or placement of concrete will be permitted when the ambient air temperature is below 20ºF. At the option of the Engineer, strand shall be brought to within 25°F of the concrete at placement in lieu of corrections in elongation due to temperature. The Engineer may use suitable equipment to determine if the strand tension is proper throughout the entire bed length. Make corrections as required.

Place welded wire fabric as shown in the Contract Documents.

(3) Concrete. Manufacture the units using concrete that consists of a mixture of 50% coarse aggregate and 50% fine aggregate by weight, portland cement, air entraining agent and water, as shown in **TABLE 715-2**. Do not use calcium chloride.

The Contractor is responsible for the design of the concrete mix including the proportions of water, cement and aggregates within the limits of this specification. Submit the design mix to the Engineer for approval before casting the units. If there is a change in design or material source, resubmit a concrete mix design for approval.

Unless shown otherwise in the Contract Documents, use Type I, Type IP, Type I(PM) or Type II portland cement to manufacture the units. Type III cement may be used for piling and beams, if they are to be covered by a reinforced concrete wearing surface. Only use cement from prequalified sources. The producer's certification must be available at the prestress plant for review by the Engineer.

For all aggregates being used, keep a copy of the KDOT Official Quality test report from the approved source on file at the prestress plant, and available for review by the Engineer.

For the approved source of water, keep a copy of the KDOT test report on file at the prestress plant and available for review by the Engineer.

The presence of any deleterious substance such a "bag paper" is cause for rejection.

No other additives may be used except with written approval from the Engineer. If approved, use admixtures that are prequalified. Maintain a copy of the Type C certification on file at the prestress plant and available for review by the Engineer.

TABLE 715-2: CONCRETE REQUIREMENTS

Concrete Type	Maximum Slump* (Inches)	Cement, lb. per cubic yard		Mixing Water: Maximum lb. per lb. cement	% Air Content
		Minimum	Maximum		
Air Entrained	4 ± ¾	602	752	0.44	6.5 ±1.5
Non-Air Entrained	4 ± ¾	602	752	0.49	

* Without mid-range or high-range water reducing admixtures. With water reducer, 7 inches ± 25%.
Non-air entrained concrete may be used in concrete piling not subject to freezing and thawing and wetting and drying.

At the option of the Contractor, fly ash from an approved source may be used as a partial replacement for portland cement.

Determine the consistency of the concrete by the standard slump test. The Contractor designates the slump desired at the point of delivery. A single re-dose of a water reducer is allowed at the bed site, when mixed in an approved manner. Flowing concrete shall be a cohesive mass with no evidence of separation or segregation regardless of the slump. The batch will be rejected if there is evidence of separation or segregation.

Unless shown otherwise in the Contract Documents, use concrete with the compressive strengths meeting **TABLE 715-3**. Cast all cylinders from the concrete used to manufacture the units. Determine the release and the shipping strength (required values shown in **TABLE 715-3**) by tests conducted on cylinders cured in the same manner as the units. Determine 28 day cylinder strengths by tests conducted on cylinders cured in the same manner as the units until the release strength is reached, after which they are removed from their molds and moist cured and tested in the standard manner.

TABLE 715-3: COMPRESSIVE STRENGTH OF CONCRETE

Type of Unit	For Stress Application (Release) and/or moving* (Minimum) (psi)	Age 28 Days (Minimum)** (psi)
Prestressed Bridge Beams	4000	5000
Prestressed Piles	3000	5000
Prestressed Panels	4000	5000

* From casting bed to producer's storage only. Not a shipping strength.
** Also required shipping strength.

Handle and place the concrete by methods that shall produce a dense, uniform product, free from sand streaks and honeycomb areas. Deliver concrete to the producer's site of the work and complete placement within the time limits specified in **SECTION 401**. Deliver and place successive batches at a constant rate and before the preceding batch has been perceptibly hardened or dried, or is no longer pliable, and in no case may the interval between successive batches in a unit exceed 20 minutes, or if the concrete mix or environmental conditions require otherwise, a period established by the Engineer. Do not add water to temper deposited concrete.

Place concrete during cold weather according to **SECTION 401**. In addition, the form temperature shall be a minimum of 40ºF before the concrete may be placed. When necessary, continue heating the forms during the placement and finishing of the concrete.

Provide concrete units meeting the tolerances specified in **TABLE 715-1**, unless shown otherwise in the Contract Documents.

(4) Surface Finish. Make all surfaces of the units reasonably straight and true to lines and grades, and free from fins or other projections. Form joint marks will be permitted. Give top surfaces of beams a wire brush or stiff broom finish applied transverse to the length of the beam. Rake the top surfaces of the panels, perpendicular to the prestressing strand, making depressions of approximately ¼ inch. Do not pull out the coarse aggregate when raking.

(5) Cracks. Produce concrete units free from cracks of sufficient width to impair the unit's strength and durability.

(6) Curing. Curing may be accomplished by either the moist curing method or accelerated curing with low pressure steam or radiant heat.

(a) Moist Curing Method (Normal Curing Temperatures). As soon as possible after the units have been cast, cover them with a minimum of 2 layers of burlap and keep wet until the side forms are removed. After the side forms are removed, protect the units with wet burlap or a vapor proof cover until they have attained the strength requirement for release shown in the Contract Documents.

If repairs to the concrete surface are required or to give the units a surface finish, remove the protective covering and complete the surface work, but keep the surfaces of the unit moist during the entire time that the protective covering is removed.

(b) Accelerated Curing with Low Pressure Steam or Radiant Heat. Perform low pressure steam curing or radiant heat curing under an enclosure to contain the live steam or the heat. Allow the initial set of the concrete to take place by delaying the initial application of steam or heat from 2 to 4 hours after the final placement of concrete. If retarders are used, increase the waiting period before application of the steam or radiant heat to 4 to 6 hours. If the time of initial set is determined by the standard method of test for "Time of Setting of Concrete Mixtures by Penetration Resistance", ASTM C 403, the time limits described above may be waived.

Do not apply live steam directly on the concrete forms causing localized high temperatures.

Radiant heat may be applied by means of pipes circulating steam, hot oil or hot water, or by electric heating elements. Perform radiant heat curing under a suitable waterproof enclosure to contain both heat and moisture. Minimize moisture loss by covering all exposed concrete surfaces with 2 layers of wet burlap.

While waiting for the initial set, the minimum temperature within the curing chamber shall be 50ºF. During this time, live steam or radiant heat may only be used to maintain the curing chamber at the minimum temperature.

During the initial application of live steam or radiant heat, increase the ambient air temperature within the curing enclosure at a maximum average rate of 40ºF per hour. The maximum curing temperature within the enclosure is 160ºF, while the maximum internal concrete temperature shall be limited to 180°F. Hold the maximum temperature until the concrete has reached the desired strength. Immediately after the steam or heat curing has been discontinued, accomplish release. Additional curing is not required after release.

Do not allow the temperature of the concrete to drop below 50ºF at any time.

Provide recording thermometers showing the time-temperature relationship throughout the curing period from placing concrete to transfer of prestress. All temperature records will be retained by the Engineer as part of the curing records. Missing or incomplete time-temperature records shall be cause for rejection of the corresponding prestressed units.

Temperature limits and use of recording thermometers are the same when curing with steam or radiant heat. Due to the slow rise of ambient temperatures with radiant heat, application of heat cycles may be accelerated to meet climatic conditions, however, do not increase the ambient air temperature within the curing enclosure by more than 40ºF per hour. In all cases, the curing procedure to be used must be well established and carefully controlled.

(7) Releasing Prestressed Units with Draped Strands. Units may be de-tensioned as soon as they have attained the strength requirements shown in Contract Documents. If the units have been cured by accelerated curing methods, transfer the stressing force to the concrete as soon as the release strength of the concrete has been reached, and while the concrete is still warm.

d. Inspection and Testing.

(1) General. Provide the Engineer free access to the manufacturing plant at all times for inspecting materials, plant facilities, manufacturing and curing procedures. Inform the Engineer of the planned concrete placement and curing schedule in advance of the start of any work. The Engineer will require time for testing of materials, inspection of equipment and reviewing of procedures that will be used in casting units, prior to beginning casting.

(2) Testing Equipment.

(a) Cylinder Molds. Provide an ample supply of cylinder molds for the casting of test cylinders. All molds are subject to approval of the Engineer. Use 6"∅ x 12" cylinders. The Engineer may approve the use of 4"∅ x 8" cylinders, provided reliable correction factors have been developed and submitted, along with supporting data, for review and acceptance.

(b) Compression Machine. Provide a machine capable of measuring the compressive strengths of concrete cylinders cast during the manufacturing of the units. All testing machines must be calibrated and approved by the Engineer.

(3) Test Cylinders.

(a) Casting and Curing. All test cylinders are the responsibility of the Contractor, and shall be cured under the same conditions as the concrete they represent except as specified above for 28 day cylinders. A group of cylinders is defined as a minimum of 3 sets of 3 cylinders. Make a minimum of 1 group of test cylinders for each 40 cubic yards of concrete or fraction thereof placed in each line, within each curing enclosure, during a continuous working period.

Make 1 set of 3 cylinders from the first third of the total concrete placement, a second set from the second third, and a third set from the last third. Note the location of the concrete represented by each of the sets of cylinders. Mark and identify all cylinders as set 1, 2 and 3 in the order of concrete placement. Mark cylinders within a group as 1A, 1B, 1C, 2A, 2B, 2C and 3A, 3B, 3C.

Follow the procedure of making sets of cylinders from early, middle and late production, during normal production operations. When operations are interrupted or changed (i.e. equipment break-down, very small placements, etc.), adjust the cylinder fabrication schedule to match the production, and provide adequate cylinders for later release and shipping strength testing. Coordinate this revised schedule with the Engineer on the production site.

(b) Testing. With the Engineer observing, test cylinders to measure the releasing and shipping strength at the producer's plant.

(i) Releasing Strength. Test 3 cylinders, 1 cylinder from each of the 3 sets of cylinders (i.e. 1A, 2A, 3A), prior to strand release to determine if the specified release strength shown in the Contract Documents has been reached. The average strength of the 3 tested cylinders must equal or exceed the design release strength. In addition, only 1 cylinder in the tested set may have a strength which is below the design release strength by a maximum of 100 psi. If the above conditions are not met, a minimum of 1 hour must pass before a second cylinder from each of the same 3 sets is tested (i.e. 1B, 2B, 3B).

(ii) Shipping Strength. Before reaching 28 days of age, at the Contractor's option, 1 cylinder from each of 3 sets of cylinders (i.e. 1B, 2B, 3B) may be tested to determine if the specified 28 day strength shown in the Contract Documents has been reached. Test all 3 cylinders at the same age. All cylinders must meet or exceed the specified minimum 28 day strength. If this requirement is met, the products represented by these cylinders are accepted for strength requirements and may be shipped 1 day (approximately 24 hours) after meeting the compressive strength requirement and 5 days (approximately 120 hours) after concrete placement, whichever is greater. If a cylinder from each of the 3 sets (i.e. 1B, 2B, 3B) is not available for testing, then early shipping will not be allowed.

(iii) 28 Day Strength. The remaining set of cylinders (i.e. 1C, 2C, 3C) shall be moist cured in the standard manner and tested when the concrete has reached an actual age of 28 days. Testing will take place at a location chosen by the Engineer. When the early shipping requirements described above have not been met, the average strength of these 3 cylinders must meet or exceed the specified minimum 28 day strength. In addition, only 1 of the cylinders in the tested set may be below the minimum strength by no more than 5%.

The average strength of 1 set of cylinders may be less than the specified minimum 28 day strength by no more than 5% or 300 psi, whichever is less, provided that the previous 9

consecutive sets of cylinders manufactured for the same KDOT project and using the same mix design complied with the 28 day strength criteria described above.

(iv) Coring. When either (but not both) of the following occur:

- the 28 day strength of an individual cylinder is less than the 5% criteria described above or
- a second of any 10 consecutively manufactured cylinder sets attains an average compressive strength below the specified minimum 28 day strength by no more than 5% or 300 psi, whichever is greater.

The Contractor may, with the approval of the Engineer, core the unit (or units) represented by such cylinder (or cylinders) and have them tested. The location of the cores must be approved by the Engineer. Follow AASHTO T 24 when obtaining, preparing, testing and calculating the strength of drilled cores.

If the adjusted compressive strengths of any of the cores are below the specified minimum 28 day compressive strength, the represented units will be rejected. Coring is not allowed on product represented by more than 1 out of any 10 consecutively manufactured cylinder sets, regardless of reason, and can only take place after the concrete has reached an age of 28 days.

e. Handling, Storage and Transportation.

(1) Handling. Do not lift or strain the units in any way before the stress application strength has developed. While lifting and handling, support the units only at points designated in the Contract Documents.

(2) Storage. When units are stacked for storage, support each unit at designated bearing points.

(3) Transportation. The units may be shipped 1 day (approximately 24 hours) after test cylinders have reached the specified 28 day compressive strength, and the units have attained a minimum age of 5 days (approximately 120 hours), whichever is greater. Support beams in an upright position. The required points of support and direction of reactions with respect to the beam are approximately the same during transportation as when the beam is in its final position in the structure. Transport piling and panels with the points of support approximately below the lifting points designated in the Contract Documents.

If during transportation, units are supported at points so that a portion of the unit is cantilevered past the points designated above, the unit must be adequately reinforced or the overhanging portion adequately supported to prevent damage.

(4) Damage. Units damaged in shipment or placement may be accepted provided the damage does not impair the structural qualities of the unit, and such damage can be repaired at the work site to the satisfaction of the Engineer.

f. Field Construction. Do not place concrete on prestressed bridge beam units until they have reached a minimum age of 28 days, or as noted in the Contract Documents. Install bridge beams as shown in the Contract Documents.

g. Piling. Do not place piling before the specified 28 day strength has been attained. See **SECTION 704** for placing piling.

715.4 MEASUREMENT AND PAYMENT

The Engineer will measure the length of prestressed concrete beams by the linear foot.

The Engineer will measure the area of prestressed concrete panels by the square foot.

Payment for "Prestressed Concrete Beams" and "Prestressed Concrete Panels" at the contract unit prices is full compensation for the specified work.