SECTION 716

POST-TENSIONING
(Haunched Slab Bridges)

716.1 DESCRIPTION

Provide and install all post-tensioning system components as shown in the Contract Documents to construct a post-tensioned haunched slab bridge.

BID ITEM	UNITS
Post-Tensioning for Slab Bridge	Pound

716.2 MATERIALS

Comply with all material requirements in the Contract Documents in addition to **subsection 716.2**.

a. Prestressing Steel. Provide uncoated, 7 wire, Grade 270 (1860), low-relaxation strands for prestressed concrete complying with AASHTO M 203 (ASTM A 416). Provide strands with a minimum ultimate strength of 270 ksi. Fabricate the tendons with sufficient length beyond the anchor bearing plates to allow for stressing and anchorage device installation.

The Engineer will accept the strands based on **subsection 716.2h**. Protect all strands against physical damage and rust or other results of corrosion at all times, from manufacture to grouting or encasing in concrete. Reject strands that have sustained physical damage at any time. Use wire that is bright and uniformly colored, having no foreign matter or surface pitting.

Package the strands in containers or forms to protect against damage and corrosion during shipping and storage. Provide an inhibitor carrier type packaging material complying with the provisions of Federal Specifications MIL-P-3420F-87. Place a rust preventative corrosion inhibitor or other corrosion inhibiting material in the package, incorporate a corrosion inhibitor carrier type packaging material or apply directly to the steel when approved by the Engineer. Use a corrosion inhibitor that has no deleterious effect on the strands or grout or bond strength of strands to grout.

Clearly mark the shipping package or forms with a statement that the package contains high-strength prestressing steel strands, the care to be used in handling, the type, kind and amount of corrosion inhibitor used, including the date when placed, safety orders and instructions for use.

b. Post-Tensioning System. Use an approved post-tensioning system of proper size and type to construct tendons as shown on the Contract Documents. Do not substitute components of the approved post-tensioning system. Do not use tendon couplers. Use only post-tensioning systems that utilize tendons fully encapsulated in anchorages, ducts and fully filled with approved grout.

Systems which transfer prestress force by bonding the prestress steel strand directly to concrete are prohibited.

c. Post-Tensioning Anchorage. Provide anchorages meeting or exceeding:

- Article 5.10.9 of the AASHTO LRFD Bridge Design Specifications, latest edition and interims; and
- Article 10.3.2 of the AASHTO LRFD Bridge Construction Specifications, latest edition and interims.

The Post-Tension Manufacturer shall supply the special reinforcement, such as spirals or grids, for the longitudinal and transverse tendons. Such reinforcement is required in the concrete end-zones of anchors. All anchorage devices shall develop 96% of the actual ultimate strength of the prestressing steel, when tested in an unbonded state, without exceeding anticipated set. The design of the end anchorages and end-zone reinforcing is the sole responsibility of the Post-Tension Manufacturer.

Galvanize the body of the anchorages according to ASTM 123. Other components of the anchorage including wedges, wedge plate and local zone reinforcement are not required to be galvanized. Construct the bearing surface and wedge plate from ferrous metal. Equip all anchorages with a permanent fiber reinforced plastic grout cap that encloses the whole wedge plate. Vent grout caps and bolt to the anchorage.

d. Post-Tensioning Ducts. Provide semi-rigid, mortar-tight plastic ducts, including connection joints, capable of withstanding concrete pressures without deforming or permitting the intrusion of cement paste during the placement of concrete. Use all duct material complying with AASHTO and the Post Tensioning Institute (PTI) for bonded tendons. Do not use ducts manufactured from recycled materials. Provide ducts for multi-strand tendons with an inside area a minimum of 2 ½ times the net area of the tendons. Provide ducts that do not cause electrolytic action or deterioration of the concrete or the duct. Provide ducts that will bend without crimping or flattening, and with sufficient strength to maintain their correct alignment during the placement of the concrete.

Provide corrugated plastic ducts for both the longitudinal and transverse ducts. Provide the proper fasteners for the ducts. Use an approved plastic on all parts of the clamps. Construct the ducts from either polyethylene or polypropylene. The minimum acceptable radius of curvature shall be established by the duct supplier according to standard testing methods. The material thickness of ducts is 0.08 inches ± 0.01 inch. Fabricate polyethylene ducts from resins complying with ASTM D 3350 with a cell classification of 345464A. Fabricate polypropylene ducts from resins complying with ASTM D 4101 with a cell classification of PP0340B44544 or PP0340B65884.

e. Inlets and Outlets. Use inlets for injecting grout into the duct. Use outlets to allow the escape of air, water, bleed water and grout. Provide inlets and outlets at locations shown in the Contract Documents. Provide ¾ inches minimum internal diameter plastic pipe for inlets and outlets made of ASTM A 240 Type 316 stainless steel, nylon or polyolefin materials. If nylon inlets/outlets are used, a cell class of S-PA0141 (weather resistant) is required. Only use polyolefin products which contain antioxidant(s) with a minimum Oxidation Induction Time (OIT) according to ASTM D 3895 a minimum of 20 minutes. Test the remolded finished polyolefin material for stress crack resistance using ASTM F 2136 at an applied stress of 350 psi, resulting in a minimum failure time of 3 hours. Provide pipes that are mortar-tight. Provide plastic components that do not react with concrete or enhance corrosion of the strands, and are free of water soluble chlorides.

Provide the proper plastic connectors and fasteners to attach the pipes to the ducts. Provide positive mechanical shut-off valves for all inlets for a minimum pressure rating of 100 psi. Provide cap, valves or other devices capable of withstanding the pumping pressures for all outlets. No tape is allowed at any connection.

f. End Anchorages Permanent Grout Cap. Use permanent grout caps made from fiber reinforced polymer or ASTM A 240 Type 316L stainless steel. Use nylon, Acrylonitrite Butadiene Styrene (ABS) or polyester resins in the fiber reinforced polymer. For products made from nylon, a cell class of S-PA0141 (weather resistance) is required. Seal the cap with "O" ring seals or precision fitted flat gaskets placed against the bearing plate. Equip the grout cap with a top grout vent. Use grout caps rated for a minimum pressure of 100 psi. Use ASTM A 240 type 316L stainless steel bolts to secure the cap to the anchorage. When stainless steel grout caps are supplied, provide certified test reports documenting the chemical analysis of the steel.

g. Grout. Provide grout of a brand listed in **TABLE 716-1** or approved by the Bureau Chief of Materials and Research, unless otherwise shown in the Contract Documents. Use only one supplier for any single structure.

TABLE 716-1: GROUT USED IN POST TENSIONING

Supplier	Product
Sika Corporation	Sika Grout 300PT
Master Builder	Masterflow 1205
Euclid Chemical Company	Euco Cable Grout PTX

h. Testing Requirements. Provide all materials for testing. Conduct all tests according to the applicable AASHTO and ASTM specifications.

(1) Testing by the Engineer. Provide 3 samples of prestressing strand of sufficient length to provide 5 feet measured between fittings for each size strand from each heat, reel or coil.

Provide the Engineer with a certification stating the manufacturer's minimum guaranteed ultimate strength of the strand for each size supplied from each lot.

(2) Testing by the Contractor. Provide the Engineer with a certificate of test performance from the manufacturer of the strand for each size from each heat, reel or coil to determine the modulus of elasticity prior to stressing the initial tendon in the bridge. Re-evaluate the theoretical elongations shown on the post-tensioning

working drawings using the results of the tests and correct as required. Submit revisions of the theoretical elongations to the Engineer for approval.

716.3 CONSTRUCTION REQUIREMENTS

a. Alternate Post-Tensioning Designs. Use 0.6 inch diameter strands longitudinal and transverse post-tensioning systems as shown in the Contract Documents.

The Contractor may propose an alternate to the transverse post-tensioning system shown in the Contract Documents. Before materials are provided and any post-tensioning operations begin, submit the proposed alternate to the Bureau of Design, State Bridge Office (SBO). The SBO will consider an alternate transverse post-tensioning system, provided:

- The tendon spacing and profile are the same as shown in the Contract Documents;
- The jacking force per tendon is the same as shown in the Contract Documents; and
- The end anchorage assembly dimensions and duct size do not exceed the maximum dimensions shown in the Contract Documents.

The SBO will approve (or disapprove) the Contractor's proposed alternate transverse post-tensioning system within 5 working days of receiving the required information.

b. Qualification of the Post-Tensioning System Manufacturer (System Manufacturer). Select a system manufacturer with experience (in the United States) in post-tensioning concrete haunched slab or concrete box girder bridges that were designed and constructed according to AASHTO LRFD Construction specifications.

Before materials are provided and any post-tensioning operations begin, the system manufacturer must be approved by the SBO. If the system manufacturer has not been previously approved, provide the SBO with the necessary information to consider their qualifications. Provide the SBO with:

- Certificate of compliance with OSHA and other applicable industry standards for safety;
- In-house capability to design end anchorage assemblies, local zone and general zone design according to AASHTO specifications, sealed by a Professional Engineer licensed in the state of Kansas;
- Certificate of compliance with AASHTO LRFD Construction specifications for testing of the end anchorage assemblies, performed by an independent testing laboratory, and sealed by a Professional Engineer licensed in the state of Kansas;
- In-house QC/QA implementation for manufacturing, assembling, storage, delivery, installation, stressing and grouting supervision;
- Names, qualification and experience of the field personnel to be assigned to assist the Contractor to supervise installation, stressing and grouting;
- The technician that supervises all grouting operations must be a valid American Segmental Bridge Institute (ASBI) Certified Grouting Technician. Provide the SBO with verification of the technician's ASBI Certification;
- Proof of continuous post-tensioning operations. Firms with less than 10 years of experience may be approved if sufficient related project experience is demonstrated, but in any event a minimum of 7 years of experience is required;
- List of post-tensioned haunched slab bridges completed within the past 5 years including owner and identifying bridge information; and
- List any unfavorable claims within the last 10 years.

The SBO will approve (or disapprove) the system manufacturer within 5 working days of receiving the required information.

A system manufacturer may submit the necessary information to be considered for qualification at any time. The SBO will maintain a list of approved system manufacturers. Any change in a system manufacturer's system or evidence of poor performance will require re-approval.

c. Shop Drawings. Provide the SBO with 9 sets of shop drawings from the system manufacturer for all work related to post-tensioning (see **subsection 105.10)**. The shop drawings must be sealed by a Professional Engineer licensed in the state of Kansas. The shop drawings must be approved by the SBO before beginning fabrication.

As a minimum, include in the shop drawings:

- A Post-Tensioning System that meets the requirements in the Contract Documents;
- Tendon geometry and layouts;
- Distance from the bottom of slab to bottom of duct;
- Duct support detail and spacing according to the Contract Documents;
- The locations of grout ports and grout vents;
- Connection details such as duct coupler, anchorage to duct and grout ports/ vents to duct;
- Anchorage local-zone reinforcement;
- Permanent grout cap details, concrete recess, pour backs and temporary protection;
- Jacking forces and initial forces;
- Anchor set;
- Stressing operation and equipment data;
- All material specifications (e.g. strands, ducts and grout);
- Grouting operation and equipment data;
- Safety procedures;
- Elongation calculations and tolerances;
- All required computations;
- If duct sizes different from the sizes shown in the Contract Documents are approved, modify the spacer frame details shown in the Contract Documents; and
- Computations and a typical tendon force diagram (for all types of tendons), after friction and anchor set losses, based on an expected actual friction coefficient for the system to be used.

d. Installation. Install the hardware including ducts, tendons, end anchorage assemblies and special reinforcing according to the Contract Documents and the instructions of the system manufacturer.

Provide a qualified on-site representative of the system manufacturer, who is skilled and thoroughly experienced in the use of the system to supervise or provide appropriate guidance of the work. The system manufacturer's representative will provide the Engineer pertinent information as required. The system manufacturer's representative must be available full-time during post-tensioning hardware installation for inspecting and approving all installation prior to concrete placement, stressing, anchoring all tendons and grouting operations.

As a minimum, the following items require inspection and approval by the system manufacturer's representative:

- Installation of all hardware;
- Instructions to the Contractor regarding concrete placement around the ducts, end-anchorage assemblies and other appurtenances; and
- Supervision of stressing procedures, record keeping, certification of stressing results and grouting operations

The representative of the system manufacturer that supervises all grouting operations must be a valid American Segmental Bridge Institute (ASBI) Certified Grouting Technician.

Do not place any concrete in the bridge abutments and superstructure until the hardware installation is approved by the Engineer and the system manufacturer's representative.

Reject all unidentified strands or anchorage assemblies.

Provide all ducts or anchorage assemblies with inlet/outlet pipes.

Provide concrete test cylinders at both abutments. Do not begin stressing until testing of concrete cylinders verifies minimum bridge concrete strength for jacking has been obtained.

Do not begin the stressing before the concrete strength has reached the f'_{ci} shown in the Contract Documents and a minimum of 72 hours after completing the slab pour. Complete the stressing within 7 days after completing the slab pour.

Vibrate the concrete slab, as required, to obtain proper consolidation and compaction of the concrete specified in the Contract Documents.

Proper vibration at the abutments and around the end anchorage assemblies is especially critical and should be considered a "confined" area. Exercise care to obtain concrete consolidation around the end anchorages without disturbing the reinforcing or post-tensioning assemblies.

e. Stressing Tendons.

(1) Stresses. Tension all strands using hydraulic jacks. The minimum force of the strands is the value shown on the approved shop drawings. Do not allow the maximum temporary tensile stress (jacking stress) in the strands to exceed 80% of the specified minimum ultimate tensile strength. Anchor the strands at stresses (initial stresses) that shall result in the ultimate retention of permanent forces of not less than those shown in the Contract Documents. After seating, do not exceed 70% of the specified minimum ultimate tensile strength at the anchorages locations and 74% of the specified minimum ultimate tensile strength in the span.

Consider permanent force and permanent stress as the force and stress remaining in the strands after all losses, including creep, shrinkage, elastic shortening of concrete, relaxation of steel, post-tensioning losses due to the sequence of stressing, friction, take-up of anchorages and any other losses due to the method or system of post-tensioning. Complete stressing of the strands to within -0 to +5% of the forces shown in the Contract Documents.

(2) Stressing Jacks. Apply post-tensioning forces only after the concrete has attained the specified compressive strength as determined by the cylinder tests and within the time requirements in **subsection 716.3d**. Equip each jack used to stress tendons with a pressure gauge (a minimum of 6 inches in diameter) for determining the jacking pressure. Calibrate each jack and its pressure gauge as a unit with the cylinder extension in the approximate position that it will be at final jacking force. As a minimum, provide 2 jacks at each site to guard against breakdowns. Provide certified calibration charts (by an independent laboratory) with each jack, hydraulic system and pressure gauge used on the project. Perform the calibration while the jack is in the identical configuration as will be used on the site (e.g., the same length hydraulic lines).

Provide a calibrated master gauge at each job site. Supply the master gauge in a protective waterproof container capable of protecting the calibration of the master gauge during shipment to a laboratory. Provide a quick-attach coupler on the calibrated master gauge to verify the permanent gauge readings. Calibrate and provide the Engineer with the master gauge for the duration of the project. Any repair of the jacks, such as replacing the seals or changing the length of the hydraulic lines, will be cause for re-calibration of the jack with a load cell. Conduct hydraulic jack calibration a minimum of every 6 months.

(3) Elongations. Conduct the tensioning process so that the tension being applied and the resulting elongation of the strands may be measured at all times. Keep a permanent record of gauge pressures and elongations, and submit it to the Engineer. Using only a rigid metal ruler, measure elongations to the nearest ⅛ inch.

Preload tendons to 20% of their total jacking force. Inspect dead end anchors for adequacy before completing the post-tensioning of the tendon.

If a tendon's measurable elongation is greater by more than 7% of the calculated measurable elongation, the tendon will be evaluated by the Engineer in conjunction with the SBO and subject to rejection.

If a tendon's measurable elongation is less than the calculated measurable elongation by more than 7%, overstress the tendon to 80% of its ultimate strength from either end. If this yields an elongation within 7% of the calculated measurable elongation, the tendon will be accepted; otherwise it will be evaluated and subject to rejection.

Evaluation of out of tolerance elongations procedure:

It is of primary importance that the evaluation be performed as soon as the potential failure happens, since completion of the entire process is time critical.

In the event of a failure to meet the 7% requirements above, a tendon evaluation is required, and will consist of one or all of the following procedures as determined by the Engineer in conjunction with the SBO:

- Modification of the friction and wobble coefficient: Perform in-place friction tests or modify the K-factor by using the data from the tendon in question.
- Verification of the tendon modulus of elasticity: Perform additional bench tests.
- Re-calibration of the stressing jack: Verify elongation through jack or extension if used.
- Perform lift-off at dead end.

Submit to the Engineer and SBO for approval, a proposal of a tendon evaluation sealed by a Professional Engineer licensed in the State of Kansas, representing the system manufacturer.

Submit to the Engineer and SBO the results of the tendon evaluation.

Should the evaluation fail to justify the discrepancy between the actual and calculated measurable elongation, the tendons will be rejected.

(4) Record of the Post-Tensioning Operation. Keep a record of the following post-tensioning operations for each tendon installed:

- Date strands installed;

- Date strands stressed;
- Date grouted;
- Supervisor's and Inspector's names;
- Coil number for strands installed or heat number for bars installed;
- Jacking ends;
- The theoretical and actual elongation;
- The theoretical and actual anchor set;
- Actual tendon lengths;
- Gauge pressure and forces (initial, intermediate intervals, and before anchor set);
- Accepted or number of items rejected; and
- Comments as to problems.

Upon completion of the post-tensioning, submit to the Engineer for approval a record of gauge pressures and tendon elongations. The records submitted must be sealed by a Professional Engineer (licensed in the state of Kansas) representing the system manufacturer.

Do not cut off stressing tails of tendons until the stressing records have been approved by the Engineer. Do not torch cut strands or bars at any time.

f. Grout. Provide the Engineer with a minimum of 3 days advance notice of the beginning of the grouting operations to allow adequate time for ASBI-certified KDOT inspection staff to get to the job site.

Grout the annular space between the duct and the tendons after the tensioning of all tendons has been completed and the strands have been anchored.

Weather permitting, begin grouting immediately or within 24 hours after stressing all tendons within an independent unit.

(1) Equipment. Provide a grouting mixer capable of continuous mechanical mixing which shall produce grout free of lumps and undispersed cement. Batch all materials using batching equipment which provides accurate solid and liquid measures. Provide grout equipment capable of continuously grouting the longest tendon on the project within a maximum of 20 minutes.

Use grouting equipment utilizing gravity feed to the pump inlet from a hopper attached to and directly over it. Keep the grout hopper at least partially full of grout at all times during the pumping operation to prevent air from being drawn into the post-tensioning duct.

Use positive displacement type pumps, capable of producing the outlet pressure required by the grout manufacturer. Use a pump with seals, adequate to prevent introduction of oil, air or other foreign substance into the grout, and to prevent loss of grout or water. Place a pressure gauge at some point in the grouting line between the pumping outlet and the duct inlet, and having a full scale reading of a maximum of 300 psi. Use grouting equipment containing a screen having clear openings of ⅛ inch maximum size to screen the grout prior to its introduction into the grout pump.

(2) Mixing. Mix the grout according to the manufacturer's directions. The pumpability of the grout may be determined by the Engineer according to ASTM C 939. When this method is used, do not exceed 11 seconds for the efflux time of the grout sample immediately after mixing. Do not use the flow cone to test grout which incorporates a thixotropic additive.

(3) Grout Operations. Keep all grout inlets and high point outlets open when the grouting operation begins. Allow grout to flow from the first outlet past the inlet until any residual flushing water or entrapped air has been removed, at which time close the outlet. Close remaining outlets in the same manner and in the order shown on the plans.

Perform normal grout pumping operations at 75 psi. Do not exceed 250 psi for pumping pressure at the inlet. Pump the grout through the duct and continuously waste at the outlets until there is no evidence of water or air being ejected.

If the actual grouting pressure exceeds the maximum recommended pumping pressure, inject grout at any outlet that has been, or is ready to be closed as long as a one-way flow of grout is maintained. If this procedure is used, fit the outlet that is to be used for injection with a positive shutoff. When one-way flow of grout can not be maintained as outlined above, flush the grout immediately out of the duct with water.

To keep the tendon filled with grout under pressure, close the outlets and inlets in the order shown on the plans, when the tendon duct section at the outlet and inlet is completely filled with grout. Do not remove or open positive shutoffs required at the inlets and outlets until the grout has set.

In temperatures below 32°F, keep ducts free of water to avoid damage due to freezing. Maintain the temperature of the concrete slab between 35 and 85°F from the time grouting begins until jobsite cured 4 inch diameter cylinders of grout reach a minimum compressive strength of 800 psi, when tested according to AASHTO T22. The maximum grout temperature is 90°F, during mixing or pumping. When required, cool the mixing water.

Remove ends of inlets and outlets a minimum of 1 ½ inches below the concrete surface after the grout has set and fill the recess in the concrete with an approved epoxy grout.

Grout all anchorages, before the winter shut down.

g. Protection of End Anchorages. Clean exposed end anchorages, strands and other metal accessories of rust, misplaced mortar, grout and other such materials as soon as possible after tensioning and grouting is completed. Immediately following the cleaning operation, apply a coat of zinc-rich epoxy paint, minimum thickness of 4 mils.

h. Recess Pocket Filling. Fill all longitudinal and transverse end anchorage recess pockets as shown in the Contract Documents. Apply an approved epoxy resin bonding agent according to the manufacturer' prior to placing an approved non-shrink, non-metallic grout. Apply grout according to the grout manufacturer's instructions. Finish the outside exposed surfaces of the recess pockets smooth and flush with the surrounding concrete surface. Select grout to match the color of the surrounding concrete slab.

716.4 MEASUREMENT AND PAYMENT

The Engineer will compute the weight of the post-tensioning tendons in pounds by measuring the theoretical plan length, end to end of wearing surface, and using a unit weight of 0.6 inch strand of 0.74 pounds per foot.

Payment for "Post-Tensioning for Slab Bridge" at the contract unit price is full compensation for the specified work.