SECTION 440 — PRESTRESSED CONCRETE BEAMS AND SLAB PANELS

440.01 DESCRIPTION. This work shall consist of furnishing and placing all prestressed concrete beams and slab panels, elastomeric bearing pads, bearing plates and embedded items, all steel strands, jacks, and other devices required to provide in place the finished member in conformance with the Contract Documents.

440.02 MATERIALS.

Fine Aggregate	901.01
Coarse Aggregate	901.01
Cement	902.03
Admixtures:	
Air Entraining	902.06.01
Retarding	902.06.02
Water Reducing	902.06.02, 902.06.03
Pozzolans	902.06.04, 902.06.05
Mixing Water	921.01
Shear Key Grout	902.11
Reinforcement Steel	908.01
Welded Steel Wire Fabric	908.05
Prestressing Strand	908.11
Elastomeric Bearing Pads	910.02
Closed Cell Neoprene Sponge Elastomer	911.10
Fusion Bonded Epoxy Powder Coating for Steel	917.02
Epoxy Adhesive	921.04
Anchor Rod Dowel Bars	A 242
Threaded Tie Rods	A 663, Grades 300 thru 410
Concrete Protective Coatings	Contract Documents

440.02.01 Portland Cement Concrete. The composition, proportioning, and mixing of concrete shall produce a homogeneous concrete mixture of a quality that will conform to the materials and design requirements specified in the Contract Documents.

The required cylinder strength of the concrete at transfer of the tensioning load and the minimum required cylinder strength of the concrete at 28 days will be specified in the Contract Documents. The concrete mix shall contain an air entraining admixture and a Type D or G admixture.

Type G high range water reducing admixtures may only be used if the Engineer determines that the producer can design and show by trial mix that the concrete conforms to the strength requirements specified in the Contract Documents and the following:

(a) Maximum slump of 6 in.

(b) Air content of 5-1/2 ± 1-1/2 percent.

(c) Minimum cement factor of 700 lb/yd^3.

(d) Maximum WCM ratio of 0.45.

The Engineer shall be allowed to take six test cylinders from each member or members cast and cured as a unit for the purpose of checking the quality of the concrete being produced, for determining the time when forms may be removed, and for determining the time when prestressing forces may be applied to a member. These cylinders shall be made in metal or plastic molds and cured with the beams. At least three test cylinders shall be made and cured under laboratory conditions as specified in T 126. Test cylinders shall be made and tested at the manufacturing site, by the manufacturer's quality control technician, in conformance with T 22 and shall be witnessed by the Engineer.

440.02.02 Reinforcement Steel and Tie Rod Tubes. All reinforcement steel to extend into the roadway slab shall be epoxy coated.

Tie rod tubes shall consist of corrugated, rigid or semi-rigid type, galvanized steel sheathing or rigid plastic sheathing.

440.02.03 Debonding Material. Material used for debonding of pretensioning steel strands shall be solid or split plastic sheathing having a minimum thickness of 0.025 in.

440.02.04 Joint Sealers. Joint sealers shall conform to the manufacturer's specifications.

440.03 CONSTRUCTION.

440.03.01 Working Drawings. When the Contractor elects to use methods other than specified in the Contract Documents, the Contractor shall provide working drawings to the Engineer for approval. The drawings shall include reinforcement, anchorages, steel strand profiles, lifting inserts, and all other pertinent information required. Whether the Engineer accepts or rejects any of the Contractor's proposed changes, the members shall be constructed at no additional cost to the Administration.

440.03.02 Prestressed Concrete Plants. The prestressed concrete manufacturing plant shall be registered and certified under the Precast/Prestressed Concrete Institute Program and a valid certificate shall be submitted to the Engineer prior to the start of production.

440.03.03 Beds and Forms. Casting beds shall be supported on unyielding foundations. The beds and forms shall be cleaned after each use. Accumulation of coatings used for bond breakers shall be prevented.

Prior to stringing steel strands, the bottom of forms shall be inspected for cleanliness and accuracy of alignment. The contact surfaces of forms shall be coated with bond breaker that dries to a surface hardness. The coating shall be dry before the steel strand comes in contact with it to prevent contamination of the steel strand.

440.03.04 Meetings. A pre-pour meeting, which shall include a representative of the prestress concrete plant, shall be held prior to commencement of any prestress concrete work.

440.03.05 Protection of Prestressing Steel Strand. Prestressing steel strand shall be stored under shelter and kept free of deleterious material such as grease, oil, wax, dirt, paint, loose rust, or other similar contaminants. Steel showing corrosion, etching, pitting, or scaling of the surfaces shall not be used. A light coating of surface rust is acceptable if it can be removed completely from the steel by wiping with a cloth.

Prestressing steel strand shall not be stored on a surface that contributes to galvanic or battery action. Steel strand shall not be used as a ground for electric welding and shall be protected from electric welding sparks.

440.03.06 Reinforcement Steel, Inserts, and Chairs. Reinforcement steel shall be placed within the specified tolerances, and shall be secured to beds and forms using chairs, blocking, or ties. Cages of bars shall be fabricated by tying only. Cages shall not be supported by tensioned strands. Tie wire ends shall be bent into the slab panel. The type and placement of inserts shall be shown on the working drawings.

Form ties, chairs, and inserts shall be recessed in the concrete by at least 1 in. or stainless steel accessories shall be used.

440.03.07 Methods of Force Measurement. Forces shall be measured using one of the following methods as the primary measuring system and checked by using one of the other methods as the secondary measuring system. Methods of force measurement are:

(a) Curves. Current stress-strain or elongation curves furnished by the strand manufacturer may be used. An average modulus may be used if acceptable to the Engineer. Means shall be provided for measuring the elongations of the strands to at least 1/8 in.

(b) Pressure Gauges. Gauges shall be used to measure force by the pressure applied to hydraulic jacks. These gauges shall be furnished with dials calibrated with the jacking system.

(c) Dynamometers. Dynamometers connected in tension to the stressing system for the initial force may be used.

Gauging System. Tensioning systems shall be equipped with accurately calibrated hydraulic gauges, dynamometers, load cells, or other devices for measuring the stressing load to an accuracy of reading within two percent. A qualified testing laboratory shall calibrate and issue a certified calibration curve with each gauge. A gauging system shall be recalibrated whenever it shows erratic results, when directed by the Engineer, and at intervals not greater than six months. Gauges for single strand jacks may be calibrated by an acceptable and calibrated load cell. Calibrate gauges for large multiple strand jacks, acting singly or in parallel, by proving rings or by load cells placed on either side of the movable end carriage. All jacks and gauges shall be calibrated by an independent laboratory at no additional cost to the Administration and documentation forwarded to the Engineer.

Pressure gauges and dynamometers shall be provided preferably with full pressure and load capacities of approximately twice their normal working range. Loads shall be limited to a minimum of 25 percent and a maximum of 75 percent of the total graduated capacity, unless calibration data establishes consistent accuracy over a wider range.

Each gauge shall indicate loads directly in pounds or shall be accompanied by a chart with which the dial reading can be converted into pounds.

Tensioning systems employing hydraulic gauges shall be equipped with appropriate bypass pipes, valves, and fittings so the gauge reading remains steady until the jacking load is released.

Gauge readings, elongation measurements, and calculations for elongation shall include appropriate allowances for operational losses in the tensioning system due to strand slippage, movement of anchorages and abutments, elongation of abutment anchorage rods, strand rotation, temperature variation, friction, bed shorting, and other forces and influences acting on the strand.

Friction in Jacking System. In multiple strand tensioning systems, the sliding surfaces shall be cleaned and lubricated to minimize friction. A force override (compensatory operational loss correction) shall be established for standard strand pattern series.

Thermal Effects. The design prestress force shall be increased by 0.5 percent for each 5 F ambient temperature below 80 F. No adjustment is required when the ambient temperature is above 80 F. Steel strands shall not be stressed when the ambient temperature is below 40 F. After the steel strands are tensioned, the temperature of the air surrounding the steel strands shall be maintained at 40 F or more until the prestress force is transferred to the concrete.

Control of Jacking Force. Either manual or automatic pressure cutoff valves may be used for stopping the jacks at the required load. Automatic cutoffs capable of adjustment shall be used to ensure that the jacking load corresponds to the required load. The setting accuracy for the automatic cutoff valves shall be verified whenever there is reason to suspect improper results and at the beginning of each days operation.

440.03.08 Stringing Steel Strands. Steel strands containing former vise grip points shall not be reused unless the points are outside the new steel strand vise locations. Steel strands that have been draped shall not be reused.

All steel strands shall have the same lay or direction of twist. The ends shall be cut using shears or abrasive cutting wheels. Steel strands shall be positioned over chairs to eliminate sagging of steel strands in the bottom rows.

440.03.09 Steel Strand Splices. There shall only be one splice per steel strand. For single steel strand tensioning, the number of steel strands that may be spliced in each bed is not restricted. For multiple steel strand tensioning, either all strands shall be spliced and the elongation shall be adjusted for average slippage, or no splices are permitted.

440.03.10 Steel Strand Vises. Steel strand vises shall be capable of anchoring stressing loads positively with a minimum of slippage and shall be cleaned, lubricated, and inspected between each use. Grips that become visibly worn or distorted, or that allow slippage in excess of 1/4 in. shall not be used. A full set of steel strand vises shall be cleaned and inspected before starting each prestressing operation.

The maximum permissible time for holding tensioned steel strands in the bed before placing concrete shall be 72 hours.

440.03.11 Wire Failure in Steel Strands. Seven wire steel strand with any broken wire shall be removed and replaced. All steel strands shall be checked for wire breaks before placement of concrete.

440.03.12 Pretensioning. The total load to be applied to each strand shall be as specified in the Contract Documents. The load shall be applied as a total of two loading stages. The initial load shall straighten the steel strand, eliminate slack, and provide a starting or reference point for measuring elongation.

The initial load shall not exceed 10 percent of the specified tensioning force. Any initial loading exceeding 10 percent shall be approved by the Engineer (i.e. multiple bed casting). The initial load shall be measured within a tolerance of ± 100 lb. The initial elongation measurement shall not be used to determine the initial force.

In all stressing operations, the stressing force shall be kept symmetrical about the vertical axis; however, in tensioning single steel strands, the initial and final loads may be applied in immediate succession to each steel strand.

Jack mounted pressure gauges shall be the primary system of force measurement for the final tensioning of straight single steel strands. Elongation shall be checked against pressure gauge readings on all steel strands. Slippage shall be checked at steel strand vises. The computed elongation, including operational losses and equivalent elongation for the initial tensioning force, shall agree with the pressure gauge reading within three percent.

Jack mounted pressure gauges shall be the primary system of force measurement for the final tensioning of multiple steel strands. For uniform application of load to the steel strands, the position of the face of the anchorage at final load shall be parallel to its position under initial load. Parallel movement shall be verified by measurement of equal movement on opposite anchorage sides and by checking the plumb position of the anchorage before and after final load application. Slippage shall be checked at steel strand vises.

After the steel strands are stressed as specified and with all other reinforcement in place, the concrete member shall be cast to the specified lengths. Strand stress shall be maintained between anchorages until the concrete has reached the compressive strength specified in the Contract Documents.

440.03.13 Steel Strand Tensioning. In all methods of tensioning, the stress induced in the steel strands shall be measured both by jacking gauges and by elongation of the steel strands. If any jack or gauge

appears to be giving erratic results or gauge pressures and elongations indicate materially different stresses during manufacturing, recalibration will be required. Means shall be provided for measuring the elongation of the steel strands to at least the nearest 1/8 in.

A difference in indicated stress between jack pressure and elongation of up to five percent may occur. In this event, the difference shall be placed so that the discrepancy will be on the side of a slight overstress rather than understress. In an apparent discrepancy between gauge pressure and elongation in excess of five percent, the entire operation shall be carefully checked and the source of the discrepancy determined before proceeding further.

Split plastic sheathing for debonded steel strands shall be thoroughly sealed with tape prior to placing concrete.

All pretensioned steel strands shall be cut flush with the end of the member. Where the end of the member will not be covered by concrete, the exposed ends of the steel strands and the concrete face at the end of the member shall be cleaned and coated with a protective coating as specified in the Contract Documents. Cleaning shall be by wire brushing or abrasive blast cleaning to remove all dirt and residue that is not firmly bonded to the metal or concrete surfaces. Care shall be taken to work the protective coating into all voids in the prestressing steel strands.

440.03.14 Curing. Initial curing of all members shall be accomplished by fogging, wet burlap, or other approved methods and shall begin as soon as the concrete is hardened sufficiently to withstand surface damage. The initial curing shall continue until the concrete has attained its initial set; however, the minimum initial curing period shall be three hours. When a retarding agent is used, the minimum period shall be five hours. Following the initial curing, curing shall be resumed using an accelerated curing method.

Accelerated Curing. Accelerated curing of the concrete shall be done by one of the following methods:

(a) Low Pressure Steam Curing. Low pressure steam curing shall be done under a suitable enclosure to contain the live steam and minimize moisture and heat loss. The concrete shall be allowed to attain its initial set before application of the live steam.

Application of the live steam shall not be directed on the concrete or the forms so as to cause localized high temperatures. The temperature of the interior of the enclosure shall be 80 to 160 F. During initial application of the steam, the ambient air temperature within the enclosure shall increase at a rate not to

exceed 40 F per hour. The maximum temperature shall be held until the concrete has reached the required release strength. The steam temperature and the curing temperature shall be maintained uniformly throughout the extremities of the prestressed member. At the end of curing, the concrete temperature shall be reduced at an average of 40 F per hour.

The producer shall furnish at least one recording thermometer for each enclosure. If the enclosure is longer than 300 ft, an additional recording thermometer shall be furnished for each additional 300 ft of length or fraction thereof. The temperature at any point within the enclosure shall not vary more than 10 F from that of the recording thermometer or the average of the recording thermometers if more than one is used.

(b) Radiant Heat Curing. Radiant heat may be applied by means of pipes circulating steam, hot oil, or hot water, or by electric heating elements. Radiant heat curing shall be done under a suitable enclosure to contain the heat, and moisture loss shall be minimized by covering all exposed concrete surfaces with a plastic sheeting or applying an approved liquid membrane curing compound to all exposed surfaces. The heat application shall be maintained uniformly throughout the extremities of the member. All temperature constraints shall be the same as outlined for low pressure steam curing.

440.03.15 Detensioning.

(a) Slab Panels. The tension force shall not be transferred to the prestress slab panel until the concrete strength, as indicated by cylinder strengths, conforms to the specified transfer strength. In control of the prestress concrete, the compressive strength cylinders shall be used to satisfy two essential control requirements:

(1) Concrete in the precast slab panel shall attain the specified strength before the stress in the strands may be transferred.

(2) The design strength shall be met before the slab panel may be handled, except to move to storage, or released for shipment.

Forms, ties, inserts, hold downs, or other devices that restrict the slab panel's longitudinal movement along the bed shall be removed or loosened prior to detensioning or a method and sequence to minimize longitudinal movement shall be used.

Prestressing forces shall be released using a method to minimize sudden or shock loading.

Single steel strand detensioning may be accomplished by heat cutting the steel strands. The single steel strand detensioning sequence shall maintain prestressing forces nearly symmetrical around the slab panel's vertical axis. Eccentricity around the vertical axis shall be limited to one steel strand. The steel strand cutting pattern shall be approved by the Engineer prior to its use.

Multiple steel strand detensioning may be accomplished by gradually reducing the force applied to each strand equally and simultaneously.

(b) Beams. The schedule for detensioning of beams having deflected steel strands shall incorporate the following:

(1) The manufacturer's sequence of releasing deflected steel strands and uplift points shall be approved by the Engineer.

(2) All hold down devices for deflected steel strands shall be disengaged and all hold down bolts removed from the beams.

(3) The manufacturer's sequence of releasing the remaining straight steel strands shall be approved by the Engineer.

All hold down devices may be released prior to release of tension in deflected steel strands if:

(1) The weight of the prestressed beam is more than twice the total of the forces required to hold the steel strands in the low position.

(2) The weight or other approved vertical restraints are applied directly over the hold down points to counteract the uplifting forces, at least until the release of deflected steel strands has proceeded to a point that the residual uplifting forces are less than half the weight of the beam.

All procedures for releasing prestressing forces of deflected steel strands shall be followed carefully. Failure to follow these procedures may result in the rejection of the beams.

All beams shall be adequately separated in storage immediately following removal from the bed to facilitate the repair of surface blemishes and to allow inspection of the finished surfaces.

440.03.16 Camber. During the beam fabrication period, the Contractor shall select a representative number of beams to be known as "Camber Control Beams", subject to the Engineer's approval. They shall be clearly and permanently identified so that the camber readings taken as indicated below can be associated with the proper beam.

Camber readings shall be taken as follows:

(a) Just prior to prestressing.

(b) Immediately after prestressing.

(c) At weekly intervals thereafter within the three months after casting.

(d) At biweekly intervals, after the three month period expires.

(e) Just prior to shipment from the casting yard to the job site.

(f) Camber determinations shall be continued at these intervals if the beams are stored or stockpiled at the job site.

Two copies of the camber reports shall be furnished to the Engineer prior to the erection of the beam.

440.03.17 Tolerances. The tolerances for each beam or slab panel shall be as shown in Tables 440.03.17 A or B, respectively unless otherwise specified in the Contract Documents:

TABLE 440.03.17 A

PRESTRESSED CONCRETE BEAM	TOLERANCE
Depth (overall)	± 1/4 in.
Width (flanges & fillets)	± 1/4 in.
Width (web)	± 1/4 in.
Length of Beam	± 1/8 in. per 10 ft or 1/2 in. whichever is greater
Exposed Beam Ends (deviation from square or designated skew)	Horizontal ± 1/4 in. Vertical ± 1/8 in. per ft of beam height
Side Inserts (spacing between center of inserts and from the centers of inserts to the ends of the beams)	± 1/2 in.
Bearing Plate (spacing from the centers of bearing plates to the ends of the beams)	± 1/2 in.
Stirrup Bars: Average of all bars Individual bar longitudinal spacing	 ± 1/2 in. ± 1 in.
Horizontal Alignment (deviation from a straight line parallel to the center line of beam)	1/8 in. per 10 ft, max
Camber Differential between adjacent beams of same type and steel strand pattern	1/8 in. per 10 ft at time of erection or 1/2 in. max
Center of Gravity of steel strand group	± 1/4 in.
Center of Gravity of depressed group steel strand at end of beam	± 1/2 in.
Position of hold down points for depressed strand	± 6 in.

TABLE 440.03.17 B

PRESTRESSED CONCRETE SLAB PANEL	TOLERANCE
Depth (overall)	+1/2 in., –1/4 in.
Width (overall)	± 1/4 in.
Slab Panel Length @ center line (based on design length specified)	± 1/2 in.
Horizontal Alignment (deviation from a straight line parallel to the slab panel center line)	1/4 in. max
Horizontal Misalignment of adjacent form sections	1/2 in. max
Camber Deviation from specified camber, as measured at prestress transfer or at the beginning of slab panel storage at the fabrication plant	± 1/2 in.
Location of each strand	± 1/8 in.
Center of Gravity of strand group	± 1/4 in.
Stirrup Bars (longitudinal spacing)	± 1 in.
Longitudinal Position of handling devices	± 3 in.
Concrete Bearing Area (variation from plane surface when tested with a straightedge through middle half of slab panel	± 1/8 in.
Tie Rod Tubes (spacing between the tube centers and from tube centers to slab panel ends)	± 1/2 in.
Tie Rod Tubes (spacing from tube center to slab panel bottom)	± 3/8 in.
Threaded Inserts (spacing between the center of inserts and from center of inserts to ends of slab panels)	± 1/2 in.
Skew Ends (deviation from designated skew)	± 1/2 in.
Vertical Ends (deviation from specified dimension)	± 3/8 in.

440.03.18 Marking, Handling, Shipping, and Storage. Each member shall be marked with an erection mark for identification, weight marks for beams 6000 lb or more, and inspection stamps. The erection marks on beams shall be painted on the top surface of the top flange. Markings of any kind are prohibited on any surface of a beam that will be visible in the completed structure.

Slab panels shall be marked with an individual, consecutive identification mark at a permanently exposed location. The identification mark shall match that shown on the approved working drawings to allow erection as specified in the Contract Documents.

The Contractor shall furnish the Engineer with an erection diagram clearly indicating erection marks that show the position of the member in the structure.

The cast-in-place lifting devices, and a sufficient number of cranes and spreader beams shall be utilized whenever the prestress concrete members are lifted during loading, unloading, storage, erection, etc.

The Contractor shall furnish the Engineer copies of material orders and shipping statements. The weight of each individual prestress concrete member shall be shown on the statements.

When shipping prestress concrete members, blocking shall be placed at intervals that will prevent sag and distortion. All members shall be shipped in their upright position and be adequately supported and braced to dampen vibrations during transport as shown on the working drawings. Any member too long to fit inside of a truck or trailer shall not cantilever beyond the bed more than one quarter of its length. Members too long to comply with this requirement shall be supported on dollies, additional vehicles, or other vehicles that shall support the long pieces as approved by the Engineer.

Load restrictions shall be as specified in GP-5.10. Prestress members shall not be shipped until approved in writing by the Engineer, a minimum of five days have elapsed since the prestress transfer, and they have attained the minimum 28 day compressive strength.

Beams shall be stored off the ground in an upright position, shall be protected as far as practical from surface deterioration, and be kept free of accumulations of dirt, oil, or other deleterious material.

440.03.19 Erection. Erection shall conform to 430.03.27, .28, .29, .31, .32, and .33.

Slab Panels. Immediately prior to erection of slab panels, the abrasive blasted shear key surfaces shall be cleaned with compressed air, stiff bristle fiber brushes, or vacuumed. Slab panels shall be pulled together and field tightened in the transverse direction by tie rods. Field tightening shall be performed with approved impact wrenches. After tightening, all tie rod holes shall be grouted.

After field tightening all slab panels, the joint below the shear keys shall be sealed using a method approved by the Engineer. Shear keys shall then be grouted by overfilling the joints. Grout shall be driven or tamped compactly in to the keyways and not vibrated. After a half hour the excess grout shall be struck off flush with the top of the slab panels. The manufacturer's recommendations shall be followed for grouting in cold or hot weather.

440.03.20 Bearing Pads. Bearing pads delivered to the bridge site shall be stored under cover on a platform above the ground surface. Pads shall be protected from damage at all times and shall be kept dry, clean, and free of dirt, oil, grease, and foreign substances.

The surfaces of the concrete bearing areas that will be in contact with the bearing pads and the full contact area of the bearing pads shall be coated with epoxy adhesive. The Contractor shall strictly adhere to the manufacturer's recommendations for mixing and applying the epoxy adhesive material. The surface temperatures when applying epoxy adhesive shall be a minimum of 50 F with a predicted ambient temperature for the next four hours of 50 F or above. The surfaces to be coated shall be clean, dry, and sound. The Contractor shall be prepared to use water jets, abrasive blasting, air blasting, etc. for cleaning the surfaces to the satisfaction of the Engineer.

The bearing pads shall be accurately set in the epoxy adhesive and secured in place by blocking or other mechanical means until the adhesive sets.

440.04 MEASUREMENT AND PAYMENT. Prestressed concrete members will not be measured but will be paid for at the Contract lump sum price for the pertinent Prestress Concrete Beams or Prestress Concrete Slab Panels item. The payment will be full compensation for all concrete, forms, reinforcement, bearing pads, steel strands, sheathing, steel components, steel rods, inserts, grout, bearing pads, epoxy adhesive, testing, furnishing and applying concrete protective coatings when specified, transporting, storage, erection, and for all material, labor, equipment, tools and incidentals necessary to complete the work.

SECTION 441 THRU 449 — RESERVED