

## SECTION 490 PRESTRESSED CONCRETE BEAMS

### 490.1 DESCRIPTION

This work consists of furnishing and installing prestressed concrete beams.

### 490.2 MATERIALS

**A. General:** Materials shall conform to the requirements of Division III except as specified in this section.

**B. Concrete:**

1. Fine aggregate shall conform to Section 800.
2. Coarse aggregate shall be the product of crushing limestone or quartzite ledge rock or other ledge rock and shall conform to Section 820. Coarse aggregate shall meet the gradation requirements of Size No. 1 or Size No. 1A. The aggregate size shall be consistent throughout the entire structure. One source shall be used to produce each aggregate size.
3. The Contractor shall submit a concrete job mix design for approval ten working days prior to fabrication. The mix design shall include all admixtures proposed for use and shall contain a minimum of 58 percent coarse aggregate by weight. When a plant has been in operation and satisfactorily producing beams, the Contractor will not be required to submit a concrete mix design, unless changes have been made to the preapproved mix design or the material used in the mix design.

The concrete shall attain a 28 day compressive strength equal to or greater than the minimum compressive strength specified.

The concrete **without HRWRA** shall have a maximum slump of five inches (125 mm) and shall contain 6 percent entrained air plus or minus 1.5 percent.

**When high range water reducing admixtures (HRWRA) are used the maximum slump prior to the addition of HRWRA shall be three inches (75 mm), and maximum slump at the time of placement shall be seven inches (175 mm).**

**Measurement of slump prior to the addition of HRWRA is required to determine proper dosage of HRWRA and is the responsibility of the Contractor. The preliminary slump measurement may be accomplished by visual inspection or by the use of concrete plant watt or amp meters specifically designed to indicate the slump of the mix.**

**The HRWRA shall be compatible with the concrete mix. The HRWRA shall not be used in amounts that cause segregation or rapid slump loss that would hinder concrete placement.**

## PRESTRESSED CONCRETE BEAMS

C. **Pretensioning Reinforcement:** The prestressing steel shall be high tensile strength seven wire strand of the nominal diameter specified and shall conform to ASTM A 416.

D. **Sampling and Testing:**

1. **Concrete:** The test cylinders shall be cured with the beams, or in a similar manner (similar curing method and concrete curing temperature) as the beams, until minimum compressive strength has been obtained.

A minimum of one group of test cylinders shall be made for each line of concrete beams for each pour for each curing chamber. One group of cylinders will represent a specific number of beams not to exceed 160 foot (50 meters) of casting bed length.

A group of test cylinders shall consist of the following:

- a. A minimum of two cylinders for determining the strength of concrete for prestress transfer.
- b. Two additional cylinders to determine design strength when the Contractor desires to make delivery and obtain acceptance by the Department before the 28 day test.
- c. And two test cylinders are required for the 28 day compressive test, with the results averaged.

The beams will be accepted when the minimum concrete compressive design strength has been met. Accepted beams, tested under paragraph b. above, may be delivered to the project and will not require the 28 day cylinder test.

2. **Reinforcement:** All wire, strand, bars, and anchor bar assemblies shall be assigned a lot number and tagged for identification.

Each lot of wire or bars and each reel of strand reinforcement shall be accompanied by a certificate of compliance, a mill certificate, and a test report from the manufacturer. The mill certificate and test report shall include the chemical composition (not required for strand), cross sectional area, yield and ultimate strengths, elongation at rupture, modulus of elasticity, and the stress strain curve for the specific prestressing steel intended for use. All values certified shall be based on test values and nominal sectional areas of the material certified.

The Contractor shall furnish the samples described in the Materials Manual to the Engineer, for each lot, for verification testing. When ordered by the Engineer, the selection of samples shall be made at the manufacturing plant by the inspector.

All samples submitted shall be representative of the lot to be furnished and, in the case of wire or strand, shall be taken from the same master roll.

## PRESTRESSED CONCRETE BEAMS

The actual strength of the prestressing steel shall not be less than specified by the applicable ASTM Standard, and shall be determined by tests of representative samples of the tendon material in conformance with ASTM Standards.

All of the materials specified for testing shall be furnished at no cost to the Department and shall be delivered at least 14 days prior to anticipated use.

### 490.3 CONSTRUCTION REQUIREMENTS

- A. General:** The Contractor shall furnish the Engineer with the shop drawings 30 days prior to fabrication.

The shop drawings shall consist of fabrication details and all information necessary for the fabrication and erection of the precast, prestressed concrete beams, including the method and sequence of stressing.

The Contractor shall notify the Engineer at least seven days prior to fabrication to permit inspection of the forms and reinforcement by Department personnel.

The Contractor shall have a technician, skilled in the prestressing method used, available to provide assistance and instruction in the use of the prestressing equipment and installation of materials.

Safety measures shall be taken by the Contractor to prevent accidents due to potential breaking of the prestressing steel strands or the slipping of the wedges during prestressing operations.

Prestressing shall be by the pretensioning method. All common or similar elements shall be prestressed using the same method.

The Contractor shall prevent damage to prestressing steel that weakens the prestressing steel or may cause failure under stress. Nicking, kinking, or twisting of the prestressing steel will not be permitted. Sparks or pieces of molten metal from welding or burning equipment shall not contact any prestressing steel. The use of prestressing steel as a ground for welding equipment will not be permitted. The cutting of surplus tendons by burning will be permitted providing the burning is done rapidly and neatly. The term "prestressing steel" shall be that portion of the prestressing tendons which will be incorporated in the work.

Equipment and methods used for batching, mixing, and transporting of concrete shall be approved by the Engineer.

- B. Forms:** The forms shall be designed to withstand the fluid pressure of the concrete and the added forces due to vibration and impact without distortion. The forms shall be mortar tight and free from warp.

Joints in sectional forms shall have a tight fit without excessive offset.

## PRESTRESSED CONCRETE BEAMS

Forms shall be set on a rigid foundation and the soffit form shall be a plane surface at right angles to the vertical axis of the beam.

The beams shall be accurately cast to the dimensions shown in the plans or in the shop drawings. Requests for minor shape changes to accommodate the available forms shall be accompanied by design calculations.

The form area in contact with the concrete shall be treated with an approved form oil or wax before the form is set in position. The forms shall be thoroughly cleaned of all other substances.

When beam end blocks are required, the length of the end block shown in the plans is a minimum dimension and may be increased up to 12 inches (300 mm) to accommodate sectional forms. The length of the end blocks for beams of the same length in the same span shall be equal.

- C. Steel Units:** Reinforcement and tendons shall be placed in the position specified and securely held during the placing and setting of the concrete. The distances between the forms and steel shall be maintained by metal bar chairs, spacers, hangers, and precast mortar or concrete blocks of approved shape and dimensions. Metal devices in contact with the forms shall be galvanized. Distances between layers of units shall be maintained by metal spacers, precast mortar, or concrete blocks. Welding of reinforcement or tendons will not be allowed.

Loose rust, dirt, oil, or other foreign substances shall be removed from the prestressing tendons before the side forms are erected.

The hold down devices for deflected strands shall provide for the removal of the device for a distance of one inch (25 mm) or more from the exposed face of the concrete and the resulting hole patched with mortar. As an alternative, the device shall rest on the bottom form and remain in place after concrete placement. When the hold down devices are to remain in place, the portion of the devices in contact with the forms shall be galvanized for a minimum distance of one inch (25 mm).

**D. Tensioning:**

- 1. Equipment:** Equipment, tools, and machinery used in the work shall be adequate for the purpose for which they are to be used and shall be appropriately maintained.

In all methods of tensioning, the stress induced in the prestressing elements shall be measured both by jacking gages and by elongation of the elements. The results shall check as specified in paragraph two below. Means shall be provided for measuring the elongation of reinforcement to the nearest 1/16 inch (whole millimeter). Stressing devices, whether hydraulic jacks or screw jacks, shall be equipped with accurate calibrated pressure gages, rings, or other devices applicable to the type of jack being used. Jacks, gages, and pumps shall be calibrated as a unit by a competent laboratory under conditions similar to operating conditions. A dated,

## PRESTRESSED CONCRETE BEAMS

certified calibration curve shall be furnished for each combination used. Calibration of jacks shall be repeated at intervals of three years or after an overhaul. Gages and load cells shall be calibrated annually. Recalibration will be required for all equipment that produces erratic results during tensioning operations.

The sensitivity and accuracy of the gages shall be such that at final elongation the total load on the jack(s) can be accurately determined within a tolerance of three percent of the total indicated stress at that time.

2. **General Procedures:** The tensioning procedure shall be conducted so the indicated stress on the tendons based on gage pressures and the indicated stress based on the corresponding elongation of the tendons may be measured and compared at any time. When the two indicated stresses, corrected for friction loss, differ by five percent or less, the tendons shall be stressed so the lower of the two indicated stresses is equal to the required tension in the tendon. If the difference exceeds five percent, tensioning operations shall cease until the source of the discrepancy has been determined and corrected.

Tendons shall be tensioned to produce the forces shown in the plans, or on the approved working drawings with appropriate allowances for all losses. Losses to be provided for shall be as specified in Section 9.16 of Division I, Design, of the AASHTO Standard Specifications for Highway Bridges. The maximum temporary stress (jacking stress) and the stress in the steel before loss due to creep and shrinkage shall not exceed the values allowed in Section 9.15 of Division I, Design, of the AASHTO Specifications.

- a. **Pretensioned Beams:** Each strand shall be given an initial tension of such magnitude and shall be supported at such intervals that the strand is straightened and the slack removed before jacking is started. Strands tensioned as a group shall have the same initial tension and all strands in the group shall be from the same manufacturer.

The tensioning of deflected strands shall be done so that the final tension in all parts of the strand is uniform and means shall be provided to reduce frictional forces at the bend points to a minimum.

Tension elongation measurements shall be corrected for losses as determined in the field due to slippage of wedges or anchorages, and friction, to obtain the required prestress force in the strands after anchorages are set.

Appreciable changes in elongation of the strands due to a temperature differential in the strands between the tensioning and time of concrete placement shall be considered in the final elongation measurements to obtain the required prestress force at the time of casting. The change in elongation due to temperature shall be based on **C** inch per 100 feet (1.17 mm per 100 meters) of strand length for each 15EF (1.0EC) variation in temperature.

## PRESTRESSED CONCRETE BEAMS

- E. Placement of Concrete:** The surface temperature of the forms and reinforcing steel, which come into contact with the concrete being placed shall be raised to a temperature above freezing prior to concrete placement. All deleterious material shall be removed from the forms prior to concrete placement.

Beams shall be cast in an upright position and the concrete shall be placed in continuous lifts not exceeding one half the depth of the beam. Cold joints or initial set between lifts will not be allowed.

The rate of placement shall be maintained at a minimum rate of 60 lineal feet per hour (18 meters per hour).

The concrete in each beam shall be vibrated internally, externally, or both to produce uniformly dense concrete and to avoid displacement of enclosures or steel units.

The top surface of the beam shall be float finished to seal the surface and depress the coarse aggregate. After finishing and prior to initial set, the top surface shall be given a transverse grooving. The grooves shall be approximately  $\frac{1}{4}$  inch (6 mm) deep by  $\frac{1}{4}$  inch (6 mm) wide at one inch (25 mm) spaces. A smooth spot shall be left at the span tenth points.

- F. Concrete Cure:** The beams may be cured by low pressure steam, radiant heat, or as specified in Section 460.3 N. When curing in accordance with Section 460.3 N., the concrete temperature requirements of Section 460.3 J. shall apply. Curing shall be maintained until the concrete has gained sufficient strength for prestress transfer.

The Contractor shall provide all approved continuous recording thermometers located in each enclosure and curing chamber. Two recording thermometers shall be provided for each casting chamber having a casting bed length of 100 feet (30 meters) or less. For each additional 100 feet (30 meters) or less in the length of the casting bed, within each chamber, an additional thermometer shall be provided. The thermometers shall record temperatures at intervals not to exceed 15 minutes and have an accuracy of plus or minus 5EF (3EC).

Complete temperature recording charts for all cures shall be submitted to the Engineer prior to acceptance of the beams.

If the records indicate that the specified temperature and time element pertaining to the curing are not being complied with, the affected beams will be subject to rejection.

Low pressure steam or radiant heat curing shall be done under an enclosure to contain the live steam or the heat and prevent heat loss. The concrete shall be allowed to attain initial set before application of the steam or heat. The initial application of the steam or heat shall be three hours after the final placement of concrete to allow the initial set to occur. When retarders are used, the waiting period before application of the steam or radiant heat shall be five hours. When the time of initial is determined by ASTM C 403, the time limits

## PRESTRESSED CONCRETE BEAMS

described above may be waived.

During the waiting period, the minimum temperature within the curing chamber shall not be less than 50EF (10EC) and live steam or radiant heat may be used to maintain the curing chamber at the proper minimum temperature. During the waiting period the concrete shall be kept wet.

Application of live steam shall not be directed on the concrete forms causing localized high temperatures. Radiant heat may be applied by pipes circulating steam, hot oil, hot water, or by electric heating elements. Moisture loss shall be minimized by covering exposed concrete surfaces with a plastic sheeting or by applying an approved liquid membrane curing compound to exposed concrete surfaces. The top surface of concrete members for use in composite construction shall be free of membrane curing compound residue unless suitable mechanical means for full bond development are provided.

During the initial application of live steam or radiant heat, the concrete temperature shall increase at an average rate not exceeding 40EF (22EC) per hour until the curing temperature is reached. The maximum concrete temperature shall not exceed 160EF (71EC). The maximum temperature shall be held until the concrete has reached the desired strength. Detensioning shall be accomplished after the steam or radiant heat curing has been discontinued and before the concrete temperature drops below 65EF (18EC). After discontinuing the steam or radiant heat application, the temperature of the concrete shall decrease at a rate not to exceed 40EF (22EC) per hour until the concrete temperature is within 20EF (11EC) of the ambient air temperature.

- G. Form Removal:** When side forms are removed from the curing chamber before the curing cycle (including temperature cooling process) is complete, only the minimum area of the curing chamber enclosure shall be removed and remain uncovered at any one time. The open area in the enclosure shall be immediately closed as each form section is removed. The enclosure shall not remain open for more than 15 minutes.

When the Contractor elects to remove the beams from the casting bed during the cooling process, appropriate measures shall be taken to keep the beams warm during moving operations, and shall immediately resume the cooling process at the storage area.

- H. Prestress Transfer:** For pretensioned beams, the prestress transfer shall not be made until the control cylinders, cured with the beams, indicate that the concrete has reached the compressive strength specified in the plans or at least 4000 psi (27.5 MPa).

The prestress transfer sequence shall keep the lateral eccentricity of the prestress to a minimum and shall prevent cracking in the top flange of the beams.

In addition, the prestress transfer shall be made in accordance with the following:

When steam or other added heat is used for cure, the prestress transfer shall be made while the concrete in the beams is still warm and moist.

## PRESTRESSED CONCRETE BEAMS

The prestress transfer may be made by the gradual release of hydraulic jacks, or by heating exposed portions of individual strands to failure.

When heating of individual strands is employed, it shall be subject to the following:

Heating of each individual strand shall be done simultaneously on the strand at a minimum of two locations along the casting bed. The sequence of heating each strand along the bed, the sequence of prestress transfer between individual strands, and the sequence of release of the hold downs for deflected strands for the prestress transfer shall be such that no deleterious effect will result. A schedule of the proposed prestress transfer operations shall be submitted with the shop drawings.

Heating shall be done with a large, low oxygen flame along the strand for a minimum distance of 5 inches (125 mm). The application of heat shall be controlled so that failure of the first wire in the strand does not occur for at least five seconds after heat is applied, followed by gradual elongation and failure of the remaining wires. If the release is not gradual and damages the beam, this method of release shall be discontinued.

- I. Surface Finish and Patching:** If a beam shows excessive stone pockets, honeycomb, or other defects which are detrimental to the structural capacity of the beam, it will be rejected. Minor surface irregularities or cavities which do not impair the service of the beam and which are satisfactorily repaired will not constitute cause for rejection. Repairs shall not be made until the Engineer has inspected the extent of the irregularities and has determined whether the beam will be rejected.

Depressions resulting from the removal of metal ties or other causes shall be carefully pointed with a mortar of sand and cement in the proportions which are similar to the specific class of concrete in the beams. When numerous voids are present, the Engineer may require a sack rub finish.

- J. Tolerances:** Dimensional tolerances of the completed beams shall not exceed the dimensional tolerances specified in the current edition of Prestressed Concrete Institute Manual for Quality Control for Plants and Production of Precast Prestressed Concrete Products.
- K. Handling, Storage, Transportation, and Installation:** Pretensioned beams may be moved from the casting bed to the storage yard after the prestress transfer strength has been reached but shall not be removed from the casting yard or installed until they have reached the specified minimum design compressive strength, as indicated by the test cylinders cured with the beams.

Prestressed beams shall remain in an upright position at all times. The beams shall be supported during storage, lifting, and transportation at only two points. Each point shall be within the limit of the beam end blocks or, if the design does not require end blocks, each point shall be not farther from the end of the beam than the depth of the beam. During storage, the points shall not be farther from the end of the beam than one third the

## **PRESTRESSED CONCRETE BEAMS**

depth of the beam.

The prestressed concrete beams shall be installed and fastened in accordance with the details shown in the plans.

### **490.4 METHOD OF MEASUREMENT**

Prestressed beams will be measured by the each, furnished and accepted.

The concrete in end caps and diaphragms required to be cast in place after the beams are placed will be measured as provided in Section 460.

### **490.5 BASIS OF PAYMENT**

Prestressed beams will be paid for at the contract unit price per each. Payment will be full compensation for furnishing the beams complete in place including reinforcing bars, prestressing steel, and all other accessories embedded in the beam.

The concrete in end caps and diaphragms will be paid for as provided in Section 460.