

SECTION 5.14
PRESTRESSED CONCRETE MEMBERS

5.14.01--Description: Work under this item shall consist of furnishing, erecting, and joining prestressed members, such as beams and deck units of the type and size shown on the plans, including concrete, strands, reinforcing, pipe sleeves, threaded inserts, erection and tie plates, transverse tie strands, tie wires, lifting inserts or devices, mortar, void forms, grout, anchoring hardware, and all other necessary materials and equipment to complete the work.

5.14.02--Materials: The materials for prestressed beams and deck units shall conform to the requirements of Article M.14.01.

Prestressing and reinforcing steel shall be free of corrosion that imparts etching, pitting, or scaling of the surface. Light surface rusting shall be removed as ordered by the Engineer.

Prestressing and reinforcing steel shall be stored under shelter and kept free of deleterious material, such as grease, oil, wax, dirt, paint, loose rust, and other similar contaminants that reduce the bond between steel and concrete. It shall not be stored on surfaces which contribute to galvanic or battery action, nor shall it be used as a ground for electrical welding.

When called for on the plans, the deformed reinforcing steel bars shall be epoxy coated in conformance with the applicable sections of ASTM D3963M.

A representative 0.23 kg sample of the coating material shall be retained by the manufacturer from each batch. The sample shall be packaged in an airtight container and identified by batch number. When required, infrared spectroscopy, gas chromatography, or any other method which is deemed necessary shall be completed to ensure that the sample is of the same composition as the initial samples.

Epoxy material for touch up and repair work shall be subject to approval by the Engineer. It shall be furnished by the epoxy manufacturer, shall be compatible with the coating material, inert in concrete and shall be suitable for use by the fabricator installing the coated bars.

All wires, clips, chair and bar supports, and other metallic materials used for the installation of the epoxy coated reinforcing bars shall be coated with the powdered epoxy resin; or coated with an acceptable plastic material; or made of rustproof or coated material that has been approved in writing by the Engineer.

All systems for handling coated bars shall have padded contact areas for the bars wherever possible. All bundling bands shall be padded, and all bundles shall be lifted with a strong back, multiple supports, or a platform bridge so as to prevent bar-to-bar abrasion from sags in the bar bundle. Special attention shall be given to loading and unloading procedures and to equipment so that damage to the coating will not occur.

The epoxy coated steel bars shall be carefully unloaded and stored in such a manner as to avoid damage or contamination. The bars shall be installed in accordance with the plans, and care shall be taken to protect and preserve the epoxy coating.

During and after the installation of the bars, the fabricator shall repair all significant cuts, nicks, and abraded places in the coating on the bars with the epoxy repair material supplied by the manufacturer of the powdered epoxy resin. Any damaged metallic accessories shall also be repaired with a suitable material. All touchup material shall be fully cured prior to the pouring of concrete.

Damage caused during shipment of epoxy bars, or by installation, or by both, need not be repaired when the damaged area is 3 mm X 3 mm or smaller and the sum of all damaged areas in each 300 mm length of bar does not exceed two percent of the bar surface area. All damaged areas larger than 3 mm X 3 mm shall be repaired and all bars with total damage greater than two percent of bar surface shall be rejected and removed. The total bar surface area covered by patching material shall not exceed three percent.

The Fabricator shall exercise care to ensure that the coated bars incorporated into the work are reasonably free from dirt, paint, oil, grease, or other foreign substance; and when deemed necessary, the bars shall be cleaned to the satisfaction of the Engineer. The placing of the concrete shall be performed by using methods and equipment which will not damage the coated material.

Since the epoxy coating is flammable, the coated bars shall not be exposed to any fire or flame. Cutting coated bars by burning will not be permitted.

The coating applicator shall be responsible for performing quality control, tests and repairs of coated reinforcing steel bars in accordance with the requirements listed in ASTM D3963M.

The Department shall have free access to the plant of the epoxy coating applicator, and shall be permitted to have any or all the work specified performed in his presence. The inspector shall be furnished with check samples of the coated bars on a random basis for testing by the Department. If access to this facility is denied, the material shall be rejected.

Prior to fabrication of the prestressed item, the Contractor shall provide a Certified Test Report in accordance with Article 1.06.07 for epoxy coated bars to verify their conformance to specifications.

The Contractor shall also provide a Materials Certificate in accordance with Article 1.06.07 for the epoxy powder to verify its conformance with these specifications.

5.14.03--Construction Methods: The members shall be manufactured in a concrete products plant with approved facilities and equipment for pretensioning.

1--Shop Drawings: Before fabrication, the Contractor shall submit shop drawings to the Engineer for approval in accordance with Subarticle 1.05.02-3. These drawings shall include complete details of the methods, materials and equipment he proposes to use. Such details shall outline the method and sequence of stressing and give complete material designations and details of the prestressing steel and anchorage devices, and other data pertaining to the prestressing operations.

2--Prestressing: In all methods of tensioning, stress induced in the strands shall be determined by monitoring applied force and independently by measurement of elongation. Applied force may be monitored by direct measurement using a pressure gauge piped into the hydraulic pump and jack system, dynamometer or load cell. The two control measurements shall agree with their computed theoretical values, within a tolerance of ± 5 percent. If discrepancies are in excess of 5 percent between the two calculated forces, determined by elongation measurement and gauge reading, the tensioning operation shall be suspended and the source of error determined and evaluated by qualified personnel before proceeding. Additionally, the control measurements of force and elongation shall algebraically agree with each other within a 5 percent tolerance. If the measurements do not agree within 5 percent a load cell shall be added at the dead end and if force measurements agree within 5 percent between the gauge at a live end and the load cell at the dead end, the elongation agreement may be waived with permission from the Engineer.

After an initial force has been applied to the tendon, reference points for measuring elongation due to additional tensioning forces shall be established.

Calculations for elongation and gauge readings must include appropriate allowances for friction in the jacking system, strand seating, movement of abutments, bed shortening if under load, thermal corrections, and any other compensation for the setup. Copies of all calculations shall be made available to the Engineer.

Hydraulic gauges, load cells, or other devices for measuring the stressing load shall be graduated so they can be read within a tolerance of ± 2 percent. Gauges, jacks, and pumps shall be calibrated as a system in the same manner as they are used in tensioning operations. Calibrations shall be performed by an approved testing laboratory, calibration service, or under the supervision of a licensed professional engineer, and a certified calibration curve shall accompany each tensioning system. Pressure readings can be used directly if the calibration determines a reading is within a ± 2 percent tolerance of actual load. Calibrations shall be performed

at any time a tensioning system indicates erratic results and, in any case, at intervals not greater than six months.

Those producers using multiple strand tensioning systems may use a "Master Gauge" monitoring system for ongoing calibration of their systems after an initial calibration as a total system. The producer shall have a master gauge calibrated every six months by an approved testing laboratory, calibration service or under the supervision of a licensed professional engineer. Production gauges shall be checked by plumbing the master gauge adjacent to the production gauge and recording pressures shown on both gauges throughout the normal operating range. Should the difference in gauge pressures exceed 2 percent, the production gauge shall be taken out of service. This check shall be performed at any time a tensioning system indicates erratic results and, in any case, at intervals not greater than six months.

Pressure gauges or other measuring devices, such as digital readout, shall have a full range of measurement of 1 1/2 to 2 times their normal working pressure, whether for initial or final load.

Tensioning methods employing hydraulic gauges shall have appropriate bypass valve snubbers and fittings so that the gauge pointer will not fluctuate but will remain steady until the jacking load is released.

In all methods of pretensioning, the load shall be applied in two increments. An initial load is applied to the individual strands to straighten them, eliminate slack, and provide a starting or reference point for measuring elongation. The final load is then applied for which elongation of strands is computed and measured. This method of operation shall be mandatory except as noted below in multiple strand tensioning.

Initial tensioning shall not exceed fifteen percent of the specified tensioning force, or 13.3 kN, whichever is greater. In single-strand tensioning, the initial and final loads may be applied in immediate succession on each strand.

At the completion of initial tension, reference marks shall be established from which elongation by final tensioning forces can be measured. Elongations shall then be accurately measured from these reference points. Elongations shall be measured as outlined hereinafter.

Elongation measurement shall take into account all operational losses and compensations in the tensioning system.

Final Stressing of Straight Strands:

1--Single strand tensioning: After application of the initial load and establishment of reference marks for measuring elongation, the full strand load shall be applied. Loads indicated by gauging systems shall control the tensioning, with elongation checked on every strand. An exception is the case of a completely open bed with no headers or other possible sources of friction. In such instances, strand elongation shall be checked on only the first and last strands and ten percent of all others.

2--Multiple strand tensioning: Following application of initial stress and seating of each strand on the anchorage header, reference marks shall be established for measuring elongation and slippage.

Reference marks for slippage shall be made by marking a straight line across the strands in each row along the face of the anchorage. For uniform application of load to strands, the face of anchorage at final load must be in a plane parallel to its position under initial load. Parallel movement shall be verified by measurement of movement on opposite sides of the anchorage and a check of its plumb position before and after application of the final load.

Final Stressing of Draped Strands: Draped pretensioning strands may be finally stressed by one of the following methods:

1--Partial stressing and subsequent strains: In this method, the strands shall be tensioned in a straight position or one a partially draped trajectory to a predetermined, intermediate stress value between initial and

final stress. The final stress shall be induced by strains resulting from lifting or depressing strands at all other points of change in strand alignment. Final position and stress shall be offset symmetrically about the center of the setup to distribute friction evenly. Stress and elongation shall be measured as specified for the intermediate stress value. Suitable stress measurements at each anchorage at each end of the bed shall verify calculated strand stresses within five percent.

2--Final stressing in draped position: In this method the strands are stressed to final value in their draped position for the full length of the bed. The strands shall pass over devices which effectively minimize friction at all deflection points. Stress and elongation shall be measured as specified.

When final stressing is done by jacking strands from one end of the bed, even when that tensioning is within tolerance, the force shall be measured on at least two strands at the far end. This force shall not be below the theoretical values by more than five percent. If the theoretical elongation has not been attained at one end of the bed when the force, as indicated by pressure gauge or load cell, is exceeded by five percent, the strand shall be jacked from the other end of the bed to the theoretical elongation. If this requires an overstress as indicated by the gauge in excess of five percent overload, the number of deflection points on the bed shall be reduced until the elongation can be attained with not more than five percent overload or the hardware shall be improved to reduce friction. Remaining deflection points shall then be achieved as outlined.

If elongation is not obtained within five percent tolerance when theoretical force has been applied, the strand may be temporarily overstressed to overcome friction. Overstress shall not exceed eighty percent of the specified tensile strength of the strand. Strands shall not be seated in this overstress condition. Provision shall be made to reduce the force on the strand before anchorage. Anchorage by seating of strand into chucks shall be done within five percent tolerance of theoretical force.

Stress shall not be transferred to pretensioned members until concrete strength, as indicated by test cylinders or any other properly calibrated nondestructive test technique, is in accordance with specified transfer strength.

If concrete has been heat-cured, detensioning shall be performed immediately following the curing period while the concrete is still warm and moist.

In all detensioning operations, the prestressing forces shall be kept nearly symmetrical about the vertical axis of the member and shall be applied in a manner that will minimize sudden shock or loading. Maximum eccentricity about vertical axis of the member shall be limited to ten percent of the strand group. Limitation of vertical axis eccentricity shall be at the initial cutting of strands at the ends of the bed and as strands are cut between members in the setup. For unusual shapes and heavily stressed shapes, production drawings shall show detensioning procedures.

Forms, ties, inserts, or other devices that would restrict longitudinal movement of the members along the bed shall be removed or adequately loosened. Hold-downs shall be removed at the appropriate time for the product and setup. Alternately, detensioning shall be performed in such a manner sequence that longitudinal movement is precluded.

In a single strand detensioning, both ends of the bed shall be released simultaneously and symmetrically to minimize sliding of members.

The sequence used for detensioning strands shall be according to an approved pattern and schedule that keeps the stresses nearly symmetrical about the vertical axis of the members as specified above.

In multiple strand detensioning, strands shall be released simultaneously by hydraulic de-jacking. The total force shall be taken from the header by the jack, then released gradually.

The overstress required to loosen lock nuts or other anchoring devices at the header shall not exceed the force in the strand by five percent.

The maximum permissible time for holding tensioned strands in the bed before starting concrete placement is thirty-six hours.

Prestressing details that have been approved by the Engineer shall not be deviated from unless details of such deviations are approved in advance of use. The approval by the Engineer of any proposed method, materials, or equipment shall not relieve the Contractor of full responsibility for successfully completing the prestressing operations in accordance with the requirements of these specifications.

3--Forms: The forms for the beams and deck units shall be of substantial construction. A firm compressible material as indicated on the approved shop drawings, shall form the bottom of the casting bed near the ends of the beams in order that cracking and chipping of the beams will be minimized at the time of load transfer. A minimum concrete cover of 40 mm must be maintained for prestressing strands by the use of approved spreaders or by bundling in areas adjacent to openings, cavities, or inserts. Stirrups and ties shall have a minimum cover of 25 mm at these locations.

Side forms carrying no load may be removed after twenty-four hours with the permission of the Engineer or after the concrete has reached the strength required at time of transfer (f_{ci}).

4--Placing Concrete: Concrete shall not be deposited in the forms until the Engineer has inspected the placing of the prestressing elements and reinforcing steel, including all other cast-in-place components, and has given his approval thereof.

Concrete shall not be deposited into the forms when the ambient temperature is below 5° C or above 37° C, unless adequate heating or cooling procedures have been previously approved by the Engineer. The concrete temperature shall be 16° C to 32° C at the time of placement. At no time will truck-mixed or transit-mixed concrete be allowed.

Production during the winter season, from November 15 to March 15 inclusive, will be permitted only on beds located in a completely enclosed structure of suitable size and dimension that provides a controlled atmosphere for the protection of the casting operation and the product.

Outside concreting operations will not be permitted during rainfall unless the operation is completely under cover.

Void forms shall be held in place against uplift or lateral displacement during the pouring and vibrating of the concrete by substantial wire ties or other satisfactory means as approved by the Engineer.

The concrete shall be vibrated internally, or externally, or both, as ordered by the Engineer. The vibrating shall be done with care in such a manner as to avoid displacement of reinforcing steel, prestressing elements, voids, forms, or other components. There shall be no interruption in the pouring of any of the members. Concrete shall be carefully placed in the forms and vibrated sufficiently to produce a surface free from imperfections such as honeycombing, segregation, cracking, or checking. Any deficiencies noted in the members may be cause for rejection.

5--Finishing: Prestressing elements shall be recessed 3 mm to 6 mm into the member. The recess shall be patched with material approved by the Engineer. When the patch material has cured, it shall be coated with a waterproof material approved by the Engineer. Special care shall be given to the finishing of exposed surface areas. The surface area of all shear keys shall be blast cleaned. Additional finishing of members shall be as shown on the plans or as otherwise directed by the Engineer.

Formed surfaces shall not be finished in any manner unless permitted by the Engineer. Top surfaces shall be finished as follows:

Beams: The laitance shall be removed from the top of the beams. After the concrete has set sufficiently to prevent tearing loose of coarse aggregate, the top surface shall be transversely raked.

Deck Units: Deck units to be used in structures having a bituminous concrete wearing surface shall be given a float finish on the top surface as specified in Article 6.01.03-21. Where the deck units are used with a concrete deck, the top surface of the units shall be finished in accordance with the above requirements for beams.

6--Test Cylinders: During the casting of each prestressed member, the Contractor shall make test cylinders under the supervision of a representative of the Department. The dimensions, type of cylinder mold and number of cylinders shall be specified by the Engineer. At least four test cylinders shall be cured by the same methods employed for the curing of the member and shall be used to verify the (f'_{ci}) required for transfer of the prestressing load. The remaining test cylinders shall be used to determine when the required 28-day strength (f'_c) has been achieved.

Failure of any of the 28-day test cylinders to meet ninety percent of the minimum compressive strength or failure of the average to meet the full minimum compressive strength requirement may be cause for rejection.

7--Curing: Unless otherwise shown on the plans or indicated in the special provisions, prestressed concrete members shall be cured in accordance with the latest edition (including Interim Specifications) of "AASHTO Standard Specifications for Highway Bridges, Division II."

8--Patching: No patching of the complete members will be allowed unless permitted by the Engineer. The Contractor's proposal for methods and materials to be used in the patching operation shall be submitted to the Engineer for his approval. Failure to do so may be cause for rejection.

9--Joining Deck Units: The transverse tie strands shall be installed and tensioned to the total force shown on the plans. When the required length of the transverse tie strand is greater than 4 m, the strands shall be checked after a period of 36 hours and retensioned if necessary to the required force. After the check and required retensioning, the longitudinal shear keys between the adjacent deck units and the recesses at the ends of the transverse tie strands shall be filled with non-shrink grout conforming to the requirements of Subarticle M.03.01-12.

Before the non-shrink grout is placed, the key spaces and recesses shall be thoroughly cleaned. If portland cement non-shrink grout is used, the key areas shall be thoroughly wetted prior to placement of the grout. The portland cement grout shall be mixed and placed as directed by the Engineer. If premixed non-shrink grout is used, the key areas shall be prepared and the grout mixed and placed as recommended by the grout manufacturer's directions. Where the top surfaces of the adjacent deck units do not match, the grout shall be sloped to form a smooth transition.

No superimposed dead or live loads shall be applied to the adjacent deck units until the non-shrink grout in the longitudinal shear keys and recesses has cured.

The curing time for portland cement non-shrink grout shall be seven days. The curing time for premixed non-shrink grout shall be considered the time when the grout has attained a compressive strength of 31 MPa and as recommended by the grout manufacturer.

10--Quality Control: Quality control shall be the responsibility of the fabricator. Quality assurance shall be the prerogative of the State. At no expense to the State, there shall be provided a separate office building or room having an area of at least 7.5 m², with the least dimension to be 2 m. This office shall be equipped with a suitable heating system capable of maintaining a minimum temperature of 18° C. It shall be clean and free of extraneous material and equipment. Sufficient light and ventilation shall be provided. During the summer months, the office temperature shall not exceed the ambient temperature. A desk and chair shall be provided for the inspector, and a telephone shall be within audible range of the office.

The quality of fabrication and construction and the dimensional tolerance of the prestressed members shall conform to the limits specified in the "Manual for Quality Control for Plans and the Production of Precast Prestressed Concrete Products (MNL-116-Latest Edition)" published by PCI, unless otherwise specified herein, except that: 1. The tolerance for horizontal alignment shall be measured from a straight line intersecting the ends of beam at either or both faces of top and bottom flanges. 2. The tolerance for beam seat bearing area shall

apply to the entire width of the member. Deviations in excess of the permissible tolerances will be cause for rejection.

11--Marking: Beams and deck units shall be identified as to project, structure, casting date, and position in the structure by means of a non-corrosive metal tag embedded permanently in the bottom of the members at the mark end.

12--Inspection: The provisions of Article M.06.02-13 shall apply to the steel items, and the pertinent requirements contained herein shall apply equally to the work performed in the plant producing the precast concrete products.

13--Lifting Hooks: The number and location of lifting hooks shall be as shown on plans.

14--Special Considerations: Before erection, the Contractor shall recess, clean, patch and paint ends of strands in a neat and workmanlike manner. Projecting fins and surface imperfections shall be removed.

The bearing area at the bottom ends of the beams and deck units must lie in the same plane as the grade of the beam or deck units in their final erected position after application of full dead load. Prior to erection, any deviations of the bearing area from a true plane shall be remedied by grinding, by applying an approved epoxy mortar, or by a combination of both as approved by the Engineer.

15--Handling and Storage: Care shall be taken during storage, transporting, hoisting, and handling of all prestressed members to prevent cracking or damage. Members damaged by improper storing, transporting, or handling shall be replaced by the Contractor at his expense. All storage and handling operations shall be as directed by the Engineer.

After erection, any marking, chipping, or spalling sustained by the member shall be removed or repaired in a neat and workmanlike manner as directed by the Engineer.

16--Methods and Equipment: The Contractor shall be solely responsible for the adequacy of his erection scheme and for all details of plant, falsework, and other equipment and material necessary to carry it out. The Contractor's responsibility includes the investigation of erection stresses. The results of this investigation, including computations, shall be submitted to the Engineer upon request.

5.14.04--Method of Measurement: This work will be measured for payment by the actual number of meters of prestressed beams or deck units installed and accepted. Measurement will be made along the center line of each member.

5.14.05--Basis of Payment: Payment for this work will be made at the contract unit price per meter for Prestressed Beams --Pretensioned, Type () and Prestressed Deck Units, (size) as shown on the plans, completed and accepted, including all materials, equipment, tools, and labor incidental thereto, and without differentiation as to interior or exterior members.

| Pay Item | Pay Unit |
|--|----------|
| Prestressed Beams --Pretensioned, Type () | m |
| Prestressed Deck Units (size) | m |