

SECTION 03 38 00 – POST-TENSIONED CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this section.
- B. Related work in other Sections related to Post-tensioned Concrete include:
 - 1. Section 01 45 29 Structural Testing Laboratory Services.
 - 2. Section 03 10 00 Concrete Forming and Accessories.
 - 3. Section 03 20 00 Concrete Reinforcing.
 - 4. Section 03 30 00 Cast-In-Place Concrete.

1.2 SCOPE OF WORK

- A. The post-tensioning supplier and installer shall furnish all labor, materials, services and equipment required to produce a complete post-tensioned structural system. The work shall include the following items:
 - 1. Furnishing all post-tensioning materials including prestressing steel, anchorages, wedges, pocket formers, couplers, plates, support bars, chairs, tendon enclosures, and bursting reinforcement.
 - 2. Placing of all items listed above.
 - 3. Performing all post-tensioning operations including stressing, anchoring, trimming, encapsulating tendon anchors, and grouting pockets.
 - 4. Cooperating with the Owner's Testing Laboratory in their function of recording and reporting tendon elongation and tension applied to the prestressing steel.
 - 5. Performing all engineering required to fully design a post-tensioning system that complies with the final force and tendon profiles as shown on the structural drawings and to prepare complete shop drawings and field placing drawings.
- B. Tendons shall be unbonded as shown on the drawings.

1.3 ENVIRONMENTAL OBJECTIVES

- A. The Owner has established environmental goals and strategies for achieving them for this project based upon the LEED[®] Green Building Rating System for New Construction & Major Renovations Version 2009, as developed by the U.S. Green Building Council. Refer to Division 01 Section "Sustainable Design Requirements."
- B. Manufacturer to supply documentation of level of compliance or non-compliance with the following requirements before consideration as an "acceptable manufacturer:"

1. The following are mandatory requirements for the overall project:
 - a. The material(s) in the product(s) supplied shall have a recycled content such that the sum of the post-consumer recycled content plus one-half of the pre-consumer content constitutes at least [Percentage of required recycled materials]% of the total value of the material in the project.
 - b. [Percentage of close proximity material]% of the product(s) supplied is extracted, processed, and manufactured regionally within a radius of 500 miles of this project.

1.4 REFERENCE STANDARDS AND CODES

- A. American Concrete Institute (ACI):
 1. ACI 117 Specifications for Tolerances for Concrete Construction and Materials
 2. ACI 301. – Specification for Structural Concrete
 3. ACI 308.1 – Standard Specification for Curing Concrete
 4. ACI 318. – Building Code Requirements for Structural Concrete and Commentary
- B. Concrete Reinforcing Steel Institute (CRSI): “Manual of Standard Practice”, CRSI MSP-2.
- C. Post-Tensioning Institute (PTI):
 1. “Specification for Unbonded Single Strand Tendons”.
 2. “Field Procedure Manual for Unbonded Single Strand Tendons”.
 3. “Post-Tensioning Manual”.
- D. Local Building Code.

1.5 SYSTEM DESCRIPTION

- A. Unbonded post-tensioning system described herein is intended to perform without long-term corrosion or other distress in an aggressive environment as defined in the Specification for Unbonded Single-Strand Tendons. Post-tensioning strand, couplers, intermediate, and end anchorages shall be completely protected with a watertight, encapsulated system. Tendon sheathing and grease shall be as specified herein.

1.6 SUBMITTALS

- A. Due to the interdependent nature of Sections “03 10 00 – Concrete Forming and Accessories”, “03 20 00 – Concrete Reinforcing”, “03 30 00 - Cast-In-Place Concrete” and “03 38 00 - Post-Tensioned Concrete,” the Contractor shall review all supplier’s shop drawings/field-placing drawings against each other and inform Architect/Engineer of any potential interferences or conflicts.
- B. Drawings, Reports, Procedures : Submittals shall be submitted for review and approval and shall include but not be limited to the following:

1. Tendon layout, including dimensions, which locates the tendons in the horizontal plane. Detail horizontal curvature of tendons at block-outs, openings and anchorages, and show all openings in slabs and beams. Clearly designate each tendon.
 2. Size and grade of tendon profiles showing support heights and locations, and any required reinforcing support steel. Show clearly the location of each tendon and the method of support. Coordinate the location of post-tension anchorages to eliminate conflicts with other embedded items such as curtain wall anchorages, or other similar type anchorages.
 3. Value of the wobble and curvature coefficients and anchorage set used in the design to calculate the tendon elongation.
 4. Details of reinforcement around stressing pockets, closures and openings, including bursting reinforcement, and any interference with tendons. Coordinate with mild reinforcing steel drawings as required.
 5. Details of anchorages, the positive connection between the anchorage and sheathing, pocket formers, couplers, and other related hardware.
 6. Details of the method for sealing the anchorage recesses after the tendon stressing tails have been removed.
 7. Clearance requirements for the hydraulic equipment and the dimensions of any stressing pockets required.
 8. Sequence of construction, including installation, pouring, jacking procedure, and stressing sequences. Show all construction joints and related tendon details.
 9. Samples of forms to be used for field record of stressing operations.
 10. Type and thickness of post-tensioning sheathing.
 11. Type and chemical analysis of P-T coating showing compliance with Table 1 of the "Specification for Unbonded Single Strand Tendons".
 12. Shop drawings shall be signed and sealed by a qualified professional engineer, licensed in the state of Texas who was in responsible charge of the drawing preparation.
- C. Manufacturer's Data: Submit for review and approval.
1. Sample hardware, including but not limited to: Anchorage system, coated strand, wedges, pocket formers, and other sub-assemblies required for complete installation including all accessories required to complete the system. Submit valid Evaluation Service Report (ESR) from ICC Evaluation Service, Inc for each product.
 2. Post-tensioning system brochures.
 3. Complete post-tensioning procedure, including but not limited to: Stressing system, method of determining anchor force, method of determining tendon slack, and method of cutting off excess strand after anchorage.

4. Mill Certificates: Submit certified mill reports of post-tensioning steel immediately upon shipment indicating compliance with specified requirements for all material that is to be delivered to the project.
5. Equipment Calibration: Submit certification of the calibration of all ram and gauge sets to the Architect/Engineer as specified herein.
6. Certifications and other data as may be further required to demonstrate compliance with other items in this section.

D. Calculations:

1. Submit calculations showing all engineering required to fully design the post-tensioning system, including friction loss calculations, bursting reinforcement calculations, number of prestressing tendons, anchorage and coupling systems, tendon supports, and tendon stressing procedures, as required to fully comply with the final force and tendon profiles as shown on the structural drawings. The design shall be in accordance with the requirements of ACI 318. Submit tendon manufacturer's data that documents the wobble and curvature friction coefficients used in the friction loss calculations. Clearly show on the shop drawings the values of wobble and curvature coefficients used in the design.
2. Post-Tensioning Supplier shall secure the services of a qualified professional engineer, licensed in the state of Texas, to provide the design as specified above. Calculations shall be signed and sealed by the professional engineer and shall be submitted to Architect/Engineer for Owner's record only.
3. Review of shop drawings and calculations by the Architect/Engineer will not relieve the Post-Tensioning Supplier of responsibility for final design as specified herein.
4. By offering a proposal or entering into a contract for work of this Section, Post-Tensioning Supplier accepts the general design shown on the drawings as adequate for compliance with performance requirements at no additional cost to the Owner.

E. Stressing Records: The contractor shall provide the appropriate cooperation and access to the Owner's Testing Laboratory to allow them to measure, record, and clearly report the following information. In the absence of a Testing Laboratory representative, the post-tensioning installer shall measure, record, report and submit the information described below. Submit records to the Architect/Engineer for approval within 24 hours after stressing.

1. Floor, pour and tendon identification numbers. For walls, indicate wall location. Calculated elongation and actual measured elongation for each jacking point, and totals for each tendon.
2. Stressing ram number, initial and final gauge load reading during stressing for each tendon.
3. Date of stressing operation and signature of the Contractor's stressing personnel and inspector witnessing the operation.
4. Range of allowable elongations for jacking force or a measure of the deviation of the measured elongations from the calculated elongations. Deviations that do

not comply with the specified tolerances shall be noted for the Architect/Engineer to review.

5. Obvious irregularities or stress loss during anchoring procedures.
 6. Required and actual concrete strength at time of jacking.
- F. Record Drawings: The Contractor shall provide record drawings to the Owner, in care of the Architect/Engineer, of any approved changes from the contract documents. Form of record drawings may be legible marked-up prints of contract drawings, or separate drawings of same scale.
- G. Review:
1. After review, shop drawings/field-placing drawings and data shall not be changed nor shall construction operations be deviated from, unless resubmitted under a cover letter delineating such change and reapproved.
 2. Review of details and construction operations will not relieve the Contractor of his responsibility for completing the work successfully in accordance with the contract drawings and specifications.
- H. LEED Submittals (Projects authorized for LEED certification only)
1. Recycled Content- Credit MR4.1/MR 4.2: Provide documentation indicating percentages of post-consumer and pre-consumer recycled content by weight per unit of product or assembly containing the product. Indicate the percentage of the dollar value of the recycled content compared to the total dollar value of the product or assembly containing the product.
 2. Material Proximity- Credit MR 5.1/MR 5.2: Where the distance to the project site is 500 miles or less, indicate location and distance to project site of extraction, harvesting, recovery and manufacturing of all materials. Indicate the dollar value of the material cost of the product containing local/regional materials. Where product components are sourced or manufactured in separate locations, provide location and percentage by weight of each component per unit of product.

1.7 QUALITY ASSURANCE

- A. Qualifications: The supply and installation of post-tensioning shall be executed by organizations that have successfully performed major work of a nature similar to that involved in this project for a minimum of five (5) years and have successfully completed a minimum of five (5) similar projects in own name, unless this requirement is waived by the Architect/Engineer prior to Contract award. The Contractor shall submit supporting evidence acceptable to the Architect/Engineer that this qualification has been met. Post-tensioning shall be performed using methods and related equipment that are in conformance with generally accepted systems of post-tensioning. Experienced individuals shall control and supervise all operations.
- B. Fabrication Quality Assurance: The post-tensioning material shall be fabricated by a plant that is fully PTI-certified at the time of bidding, and that shall maintain this certification throughout the duration of this project as described in the Post-Tensioning Institute's "Manual for Certification of Plants Producing Unbonded Single Strand Tendons." Installer Quality Assurance: All installers of unbonded post-tensioned tendons

shall be certified under the Post-Tensioning Institute's "Post-tensioning Certification Program of Field Personnel for Unbonded Post-tensioning Installers".

- C. Inspection and Testing: Inspection and testing shall be provided in accordance with the Structural Testing Laboratory Services Specification.
- D. Source Quality Control:
 - 1. If requested by the Architect/Engineer, take two (2) strand samples from one end of each coil at the fabrication plant prior to greasing and sheathing. The Post-Tensioning Supplier shall notify the Architect/Engineer when the coils are ready to be sampled.
 - 2. Submit certified mill reports indicating compliance with ASTM A416, and if requested, the test data showing evidence of compliance with the Low Relaxation Strand requirement of ASTM A416, to the Architect/Engineer immediately upon shipment for all material delivered to the project. The mill report shall be based upon a minimum of two (2) tests for each reel, heat or lot, and shall include as a minimum the breaking load, modulus of elasticity, elongation at rupture, load at 1% extension, diameter and area of strand, standard chemical analysis and drawing mill.
 - 3. Furnish all materials and handling which testing agency requires. Submit certification by the Post-Tensioning Supplier that any submitted samples are representative of the material to be furnished.
 - 4. Package the post-tensioning strands at the supplier's fabrication facility in a manner that prevents damage to strand and protects strand from moisture during transportation and storage.
- E. Field Quality Control:
 - 1. The Contractor shall maintain a consistent and good standard of workmanship. Check bulkheads, position of anchorages, tendon chairing and tying, location, size and placement of reinforcement, and tendon quantity.
 - 2. Identify wedges and anchorages by individual concrete placement areas, floor sequence or both. Use materials only in their identified concrete placement areas. In the event materials intended for one concrete placement area are exchanged into another concrete placement area, notify architect/engineer and testing agency for tracking purposes.
 - 3. Prior to pouring concrete, at a frequency as established for the project, an inspection of the tendons and mild reinforcing steel shall be made by the Architect/Engineer, or Independent Testing Agency. Placement of concrete shall not begin until acceptance of conditions is documented by the Architect/Engineer, or Independent Testing Agency.
 - 4. Inspection of stressing operations shall also be performed as directed by the Architect/Structural Engineer.
 - 5. The Contractor shall cooperate with the Owner's Testing Laboratory in their efforts to record tendon elongations. The Contractor shall keep a copy of the stressing records with the shop drawings.

6. Submit certificates of all ram and gauge calibrations used on the project to the Architect/Engineer. Use of non-calibrated ram and gauge sets are not allowed on this project. If requested by the Architect/Engineer, Owner, or Field Inspector, the Contractor shall have the ram and gauge sets calibrated by an Independent Testing Agency, the cost of which shall be borne by the Contractor.
7. Manufacture and deliver tendons in sequence and quantity so as to avoid lengthy job site storage. Deliver tendons as close as practicable to the designated storage area to avoid excessive handling. Do not use chains or hooks to handle tendons.
8. Satisfactorily protect all prestressing steel from all moisture and rust or other physical damage prior to placement and keep steel free from deleterious substances, such as chlorides, fluorides, sulfites and nitrates. Provide protection for exposed prestressing steel beyond ends of members to prevent deterioration by rust or corrosion.
9. Do not store post-tensioning strand in such a manner that it is in direct contact with soil or fresh concrete or exposed to rain, snow, de-icing salts or other corrosive elements. Protect plastic materials planned to be stored for more than one month from exposure to sunlight.
10. Damage to tendon sheathing in excess of 2% of its length shall be grounds for rejection of sheathing.
11. Contractor shall inspect tendon sheathing for damage and to verify watertight seal between sheathing and anchor. Repair all damaged sheathing to the satisfaction of the Architect/Engineer.

PART 2 - PRODUCTS

2.1 POST-TENSIONING STEEL

- A. Strand: Prestressing steel shall use strand conforming to ASTM A416, Low-Relaxation Type, and shall have a minimum guaranteed ultimate tensile strength of 270,000 psi based on the nominal area of the strand. The strand shall additionally conform to the "Specification for Unbonded Single Strand Tendons". The strand shall be free of dirt, corrosion or injurious marks, scratches, seams, and sharp kinks. Surface rust shall be removed with a fine steel wool pad or by vigorous rubbing with a cloth. Pits on steel surface shall not exceed .002 in. in diameter or length. Oil-tempered strand is prohibited. Certified mill reports giving name of drawing mill shall be submitted.
- B. Bar: Prestressing bars shall conform to ASTM A722, Type II-Deformed, and shall have a minimum ultimate tensile strength of 150 ksi.
- C. Identification: All prestressing steel within every group or in the same member shall be of the same heat where practical. All tendons shall be assigned a proper heat and coil number and so identified on fabrication lists that are to be sent to the field with each shipment. Identify tendons in accordance with placing drawings. Unidentified steel shall not be allowed unless approved by the Architect/Engineer and tested.
- D. Sheathing: All post-tensioning tendons shall be coated and sheathed with an approved slippage sheathing designed to prevent the intrusion of cement paste and the loss of the P-T coating material and be watertight and impermeable to water vapor over the entire

length. Such sheathing shall enclose the prestressing steel that shall then be placed in the forms prior to placement of concrete. The sheathing shall be continuously extruded polyethylene or polypropylene with a minimum density of 0.034 lb./in., a minimum thickness of 50 mils, and an inside diameter at least .03 inches greater than the maximum diameter of the strand. The sheathing shall not rupture due to normal temperature changes, coiling and field handling. The sheathing material shall be chemically stable, without embrittlement or softening over the anticipated exposure temperature range and service life of the structure. It shall be non-reactive with concrete, prestressing steel, reinforcing steel, and corrosion preventive P-T coating. Heat-sealed or plastic-wrapped sheathing is not acceptable.

- E. P-T Coating: The corrosion preventive coating shall lubricate the tendon and permanently protect the prestressing steel against corrosion. It shall resist flow caused by gravity within the anticipated temperature range of exposure and provide non-brittle coating at the lowest anticipated temperature of exposure. It shall be chemically stable and non-reactive with prestressing steel, reinforcing steel, sheathing material, and concrete. The coating shall be applied under pressure to ensure the filling of the interstices between the individual wires of the strand. There shall be no voids or pockets between the sheathing and the coated strand for water or air to collect. The minimum amount of coating on the prestressing strand shall be 2.5 pounds of material per 100 feet of strand for a 0.5 inch diameter strand and 3.0 pounds per 100 feet for a 0.6 inch diameter strand. The P-T coating shall satisfy the requirements of table 1 of the "Specification for Unbonded Single-Strand Tendons and Commentary".
- F. Repair tape: The tape used to repair damaged sections of sheathing or to wrap exposed strand shall be a minimum of 2 inches wide and shall be of a color that contrasts with the sheathing. The tape shall be self-adhesive and moisture-proof and shall be non-reactive with the sheathing, P-T coating, prestressing steel, or concrete.

2.2 MILD REINFORCEMENT

- A. Refer to Specification Section 03 32 00 for requirements for mild reinforcement used as bursting reinforcement and tendon support.

2.3 ANCHORAGES AND COUPLERS

- A. Performance and Specification:
 - 1. Anchoring hardware shall be steel and shall meet the minimum requirements set forth in ACI 318, except as modified herein. The anchorage shall be capable of developing at least 95% of the minimum specified ultimate strength of the prestressing steel without exceeding anticipated set, and shall be capable of passing the static and dynamic tests as outlined in the PTI Post-Tensioning Manual. All anchorages, couplers, and miscellaneous hardware shall be the standard products as manufactured by the Post-Tensioning Supplier, unless shown otherwise, and shall be evaluated by the ICC Evaluation Service and be listed in a current Evaluation Service Report (ESR).
 - 2. Anchors and couplers used shall include design features permitting a positive mechanical and watertight connection of the sheathing to the anchorage, and watertight closing of the wedge cavity, for stressing and non-stressing (fixed) anchorages. Friction connections between the anchor and the sheathing shall not be allowed. Intermediate stressing anchorages shall be designed to permit complete watertight encapsulation of the prestressing steel.

3. All anchorages shall have the demonstrated ability to remain watertight when subjected to a hydrostatic pressure of 1.25 psi over a period of 24 hours.
 4. Sleeves used to connect the sheathing to the anchorages shall meet the same requirements as the sheathing for durability during fabrication, transportation, handling, storage and installation and have a minimum thickness of 50 mils. The overlap between the end of the extruded sheathing and the end of the sleeve and seal shall be a minimum of 4 inches. The sleeve shall be translucent or have another method to verify both that the P-T coating material is free of voids and the proper overlap with the sheathing.
- B. Size: Anchorages and distribution (bearing) plates shall be sized according to ACI 318 unless certified test reports are submitted proving acceptable deviation. Bursting steel shall be designed by the Post-Tensioning Supplier consistent with the anchorage to be provided.
- C. Anchorages at Construction Joints: At construction joints, all anchorages or tendon force distribution plates (bearing plates) shall be embedded in the first of the consecutive pours. Flat back castings, plates, etc. which are placed against previously cast concrete and then stressed shall not be allowed. Washer type grommets shall be used at construction joints if grout exclusion is necessary for the embedded item. Normal depth pockets at intermediate construction joints shall not be used unless adequate measures are taken to ensure that the pocket is completely filled with concrete during subsequent pours.
- D. Seating loss: Maximum allowable anchor slip or seating loss shall be 1/4 inch.

2.4 CONCRETE

- A. The concrete shall have a minimum 28-day strength as specified on the drawings. Components or admixtures with chloride, fluoride, sulphite or nitrate ions or any other substance deleterious to prestressing steel shall not be used.
- B. The chloride ion content of the concrete used in post-tensioned concrete contributed from the water, aggregate, cementitious materials and admixtures used in the mix shall not be greater than 0.06 percent by weight of cement.
- C. See Section 03 30 00 Cast-In-Place Concrete for additional requirements for concrete.

2.5 TENDON SUPPORT SYSTEM

- A. Slab Tendons: Support points shall consist of a bar support and continuous orthogonal steel as shown on the Contract Drawings. Bar supports shall be plastic, plastic tipped, epoxy coated or stainless steel.
- B. Beam Tendons: Supports shall consist of reinforcing steel tied between stirrup legs as shown on the Contract Drawings.
- C. For exterior exposure conditions, any supports that come in contact with the forming surface shall be plastic tipped stainless steel or high density plastic (grey in color).

2.6 PRE-CONSTRUCTION CONFERENCE

- A. At least 30 days prior to post-tensioned concrete construction, the Contractor shall hold a meeting to review the detailed requirements for preparing the concrete design mixes and

to determine the procedures for producing proper post-tensioned concrete construction. Also review requirements for submittals, status of coordinating work and availability of materials. Establish work progress schedule and procedures for materials inspection, testing and certifications.

- B. The Contractor shall require responsible representatives of every party who is concerned with the post-tensioned concrete work to attend the conference, including but not limited to the following:

Contractor's Superintendent
Laboratory responsible for the concrete design mix
Laboratory responsible for field quality control
Concrete Subcontractor
Post-Tensioning Supplier
Post-Tensioning and Mild-Reinforcement Installer
Ready-Mix Concrete Producer
Admixture Manufacturer(s)
Concrete Pumping Equipment Manufacturer
MEP Subcontractor
Owner's and Architect's/Engineer's Representative
Engineer-of-Record

- C. Minutes of the meeting shall be recorded, typed and printed by the Contractor and distributed to all parties concerned within 5 days of the meeting. One copy of the minutes shall be transmitted to the following for information purposes:

Owner's Representative
Architect
Engineer-of-Record

- D. The Contractor shall coordinate the scheduled date of the conference with the Architect/Engineer.

PART 3 - EXECUTION

3.1 POST-TENSIONING STEEL PLACEMENT

- A. Profile: Post-tensioning tendons shall conform to the control points shown on the Contract Drawings and approved shop drawings and shall have a parabolic drape between supports unless noted otherwise. Harped tendons shall be straight between control points as shown on the drawings. Dimensions locating this profile apply to the center of gravity of the tendons. Low points of the tendons are at mid-span unless noted otherwise. Place the tendons normal to and concentric with anchorage plates. The transition curvature in tendon profile shall not start closer than 1 foot from end anchorages.
- B. Interference: Slight deviation in spacing of the slab tendons is permitted where required to avoid openings and inserts that are specifically located. Horizontal sweeps to miss openings, inserts, etc. shall have minimum radius of 480 strand diameters. Where radius of curvature less than 480 diameters is necessary, contact the Architect/Engineer before moving those tendons. Coordinate the placement of mild steel reinforcement with placement of post-tensioning tendons. Proper tendon location has priority. Maintain sufficient concrete cover around tendons. Coordinate bursting steel requirements with details and post-tensioning subcontractor.

- C. Tolerances: Firmly support tendons and anchorages to prevent displacement during subsequent operations. Place them with a vertical tolerance of plus or minus 1/4 inch in concrete members with depths of 8 inches or less, plus or minus 3/8 inch in concrete depths over 8 inches but less than 24 inches, and plus or minus 1/2 inch in concrete depths over 24 inches. In no case shall tendons violate the absolute minimum cover stated in ACI 117. Maintain a minimum clearance of 6 inches at all openings. Twisting or entwining of individual tendons within a bundle is not permitted.
- D. Tendon Spacing: Maximum spacing of slab tendons shall be eight (8) times the thickness of the slab, but not greater than 54 inches, unless otherwise noted on the Contract Drawings. Bundle tendons in such a manner to allow proper concreting and the maintenance of the center of gravity of steel.
- E. Supports: Provide a sufficient number of horizontal and vertical positioning supports to firmly support tendons to prevent displacement due to construction operations. Spacing of supports shall not exceed 4'-0" on center. Show all support devices on the shop drawings.
- F. Welding: Welding of cross bars or any welding in the vicinity of the tendons is not allowed. Do not use post-tensioning tendons as an electrical ground for welding operations.
- G. Sheathing
 - 1. The sheathing shall be continuous from end to end of all stressing anchorages and all embedded dead ends including intermediate anchorages, unless shown otherwise on the Contract Drawings, or otherwise approved by the Architect/Engineer.
 - 2. After installing the tendons and prior to concrete placement, inspect the sheathing on each tendon for its entire length to detect possible damage. Repair any detected tears or abrasions by procedures conforming to the "Field Procedures Manual for Unbonded Single Strand Tendons" by PTI. The repair of sheathing shall prevent intrusion of cement paste or loss of coating. The repair of sheathing shall also be watertight and approved by the Architect/Engineer.
- H. Encapsulation: Complete the encapsulation of the post-tensioning system the same day as the tendons are installed.
- I. Couplers: Do not use tendon couplers without prior approval of the Architect and Structural Engineer.

3.2 ANCHORAGES AND BLOCK-OUTS

- A. Attachment
 - 1. Attach anchorages securely to bulkhead forms using fasteners that will not corrode or are protected from corroding such that the anchor is perpendicular to the tendon axis.
 - 2. Cover: Top, bottom, and edge concrete cover for anchorages shall be not less than the specified cover for reinforcement. Minimum concrete cover from the exterior edge of the concrete to wedge cavity area of anchor shall be 2 inches, unless otherwise noted on the drawings.

B. Bursting Reinforcement:

1. Provide and install bursting reinforcement behind anchorages as required by calculations subject to the following minimums:
 - a. Slab: Provide 2-#4 bars, one above and one below the tendon, continuous along concrete edges behind slab anchorages. Provide a #3 hairpin with 9" long legs around continuous #4's between each anchorage. Provide 2-#4 corner bars with 3'-6" legs, one each above and below the tendon center of gravity.
 - b. Beam: Provide 2-#4 bars, horizontal or vertical, with appropriate development length, behind all beam anchorages.

C. Block-outs and Pockets:

1. Adequately reinforce all block-outs or pockets required for anchorages so as to not decrease the strength of the structure.
2. Pocket formers used to provide a void form at anchorages shall be designed to prevent intrusion of concrete or cement slurry into the wedge cavity.
3. Do not coat block-out forms or pocket formers with grease, form oil, or any other substance that will decrease the bonding capacity of the patching grout to the surrounding concrete.
4. Install sleeves and seals connecting sheathing to anchorage to completely seal tendon against moisture infiltration.

3.3 CONCRETE PLACEMENT

- A. Formwork: Design of the formwork shall take into account the possibility of the slab or girder lifting off the formwork during tensioning, thereby transferring the entire load to the support areas. Construct the formwork to permit movement of the member without damage during application of the post-tensioning force. Supporting forms in post-tensioned areas are not to be removed until concrete is fully stressed or as required by Section 03 10 00 whichever is later. The Contractor shall submit his proposed shoring and reshoring schemes prior to commencement of forming work.
- B. Construction Joints: Locate construction joints at or near where the center-of-gravity of the strands coincides with the center-of-gravity of the concrete section unless otherwise approved by the Architect/Engineer. The contractor shall submit construction joint locations in post-tensioned members to the Architect/Engineer for approval.
- C. Inserts, Anchors, and Coring: All inserts and anchors for suspended mechanical and architectural work shall be cast-in-place wherever feasible. Additional fasteners will be permitted only when it can be shown that the inserts will not spall concrete and are located so as to avoid hitting tendons or anchorages. The Contractor shall identify tendon locations on the surface of the slab if drilling or coring is to be done after concrete is placed.
- D. Placement: Place the concrete in conformance with the requirements of the Specifications. Do not place the concrete until the Architect/Engineer, or Independent Testing Laboratory has inspected the placement of the mild steel reinforcement and tendons at the frequency established for the project. Place the concrete in such a manner as to ensure that alignment of post-tensioning tendons remains unchanged.

Make special provisions to ensure proper vibration of the concrete around the anchorage plates. When concrete is distributed across an area being poured by way of horizontally supported slick-tube and/or rubber pump hose, the slick-tube and/or rubber hose shall be supported in such a way that does not contact the reinforcing steel or post-tensioning tendons. The slick-tube and/or rubber hose shall be braced to prevent surging of the lines that could dislodge the reinforcing and/or tendon locations. Monitor the tendon positioning during the concrete placement. All floors below the level that is to have concrete placement shall have been stressed before this concrete is placed, unless the shoring has been designed for the ensuing loads.

- E. Openings: Openings shall not be cut into cast concrete without the approval of the Architect/Engineer.

3.4 STRESSING

- A. Methods: Perform post-tensioning by methods and related equipment that are in conformance with generally accepted systems of post-tensioning. Variations of such generally accepted methods and equipment will be permitted with Architect/Engineer approval, provided equal results can be obtained.
- B. Concrete Strength: Do not begin the post-tensioning operations until tests or readings have indicated that the concrete in the members has attained a compressive strength that is adequate for the requirements of the anchorages but not less than 3000 psi unless otherwise specified on the Contract Drawings. See Concrete Formwork section 03 10 00 for acceptable methods for determining *in situ* concrete strengths.
- C. Equipment: Stress all tendons by means of hydraulic rams, equipped with accurate reading hydraulic pressure gauges that have been individually calibrated with a particular ram to permit the stress in the prestressing steel to be computed at any time. A certified calibration curve shall accompany each ram and gauge set. Immediately recalibrate the ram and gauge set if inconsistencies between the measured elongation and the gauge reading occur.
- D. Forces: Anchor the prestressing steel at an initial or anchor force that will result in the ultimate retention of the working or effective force shown on the plans. Jacking forces shall be those indicated on the shop drawings. The length of a tendon pull more than that shown by the required friction calculations or more than 125 feet for a one-way pull or 250 feet for a two-way pull is not permitted unless it is justified by calculations and specifically approved by the Architect/Engineer. The Field Inspector shall verify the wobble and curvature friction coefficients during the stressing operation and shall report to the Post-Tensioning Engineer deviations greater than 10% from the values assumed in the design. Required adjustments to the stressing operation shall be recommended by the Post-Tensioning Engineer and approved by the Architect/Engineer.
- E. Elongations: Keep records of all tendon elongations as previously described in this Section. Agreement within 7% between the gauge reading and the measured elongation and between the measured and the calculated elongation after stressing will be considered satisfactory. Deviations greater than 7% will be reported to the Architect/Engineer prior to completing stressing operation. No tensioning will be permitted until it is demonstrated that the prestressing steel is reasonably free and unbonded in the enclosure. Evidence that the steel is unbonded will be considered satisfactory if inward movement of steel is observed at one end of the tendon when a nominal pull is applied to the steel at the other end. The Architect/Engineer may order a force/elongation check at any time. Do not cut off tendons until elongation records have been reviewed and approved in writing by the Architect/Engineer.

- F. Stressing Sequence: The stressing sequence shall be as shown on the approved shop drawings. Use the following general stressing sequence except as otherwise noted or approved by the Architect/Engineer.
1. Beam and Slab:
 - Step #1. Stress temperature tendons, if applicable.
 - Step #2. Stress continuous uniform slab tendons.
 - Step #3. Stress added uniform slab tendons.
 - Step #4. Stress continuous beam tendons.
 - Step #5. Stress added beam tendons.
 - Step #6. Stress girder tendons, if applicable.
- G. Safety: Precautions shall be taken to prevent workers from standing directly behind, above or in front of the stressing rams.
- H. Broken Tendons: The total loss of prestressing force in any post-tensioned concrete member due to unreplaced broken tendons shall not exceed 2% of the total prestressing force, unless otherwise accepted by the Architect/Engineer.

3.5 GROUTING ANCHORAGE RECESSES

- A. Cut the tendon tails within 24 hours after the stressing records have been approved. Cut off the excess strand at least 1/2 inch inside the face of the finished concrete surface, and not more than 3/4 inch from the face of the anchorage. Cutting may be done by means of abrasive wheel, hydraulic shears, or, to prevent heating of the wedges, oxy-gasoline cutting flame is permitted. Do not allow the wedges to become heated.
- B. Cover the end of tendon with approved coating-filled encapsulation cap, or other approved method no more than 24 hours after the tendon tails have been cut to ensure encapsulation of the exposed tendon.
- C. Coat the anchorage recesses with an approved bonding agent and fill flush with a non-shrink, non-stain, chloride free grout compatible for use with prestressing steel or approved equal in accordance with manufacturer's recommendations. Do not allow contamination of the anchorage recess surface that reduces the bonding capacity of the non-shrink grout.

3.6 INSTALLATION SUPERVISION

- A. The duties of the post-tensioning installer's supervisor shall include:
1. Check tendon placement before and during pouring of concrete. Be present during pours and check for tendons being moved out of position.
 2. Mark tendons prior to stressing and verify with the Owner's Testing Laboratory that all initial marks are accurate.
 3. Observe that tendon elongation measurements are made and recorded by Testing Laboratory or, in the absence of a Testing Laboratory representative, measure, record and report tendon elongations after stressing and submit copy of original to Architect/Engineer.
 4. Compare results of actual tendon elongations with hydraulic ram gage reading and with calculated elongation.

5. Require checking of tendon force and/or elongation if requested by the Architect/Engineer.
6. Do not allow cutting off of tendons without the Architect/Engineer's written approval.

3.7 QUALITY ASSURANCE TESTING AND INSPECTION DURING CONSTRUCTION

- A. See Testing Laboratory Services section of these Specifications for post-tensioning inspection and test requirements.

END OF SECTION 03 38 00