SECTION 03 38 00

POST-TENSIONED CONCRETE

PART 1 – GENERAL

1.1 PURPOSE

A. This guideline is intended to provide useful information to the Professional Service Provider (PSP) to establish a basis of design. PSP is to apply the principles of this section such that the University of Texas at Arlington (UTA) may achieve a level of quality and consistency in the design and construction of their facilities. Deviations from these guidelines must be approved by UTA and may require justification through Life Cycle Cost (LCC) analysis and submitted to UTA for approval.

1.2 LESSONS LEARNED AND DESIGN CONSIDERATIONS

A. Post-tensioned concrete shall wait a minimum of 2 days after the concrete has reached 75% its 28-day design strength. (Coordinate with Structural notes).

B. Maturity meter shall not be used to determine testing prior to the minimum 2 days.

C. Careful coordination required pre-construction.

1.3 REFERENCE DOCUMENTS

A. The Drawings and General Provisions of the Contract, including the General and Supplementary Conditions and Division 1 Specification Sections, apply to the work specified in this Section.

1.4 DESCRIPTION OF WORK

A. Work Included: Furnish all labor, materials, services, equipment, and appliances required in conjunction with the design, fabrication, and installation of post-tensioning reinforcing for cast- in-place concrete complete, including, but not limited to the following:
   1. Furnish all post-tensioning materials including tendons, anchorages, couplers, distribution plates, chairs, support bars, tendon enclosures, and bursting reinforcement.
   2. Place all post-tensioning tendons, anchorages, and bursting reinforcement.
   3. Perform all post-tensioning operations including jacking, anchoring, trimming, coating, and grouting.
   4. Record and provide detailed reports of tendon elongation and tension applied to each tendon including rechecking, as specified.
   5. Design all post-tensioning reinforcing.
   6. Design and furnish anchorage zone confinement reinforcing and auxiliary reinforcement around all pockets and blockouts required in conjunction with post-tensioning operations.

B. Extent of post-tensioned, cast-in-place concrete is indicated on Drawings.

C. Related Work Specified in Other Sections:
   1. Concrete reinforcement and embedded metal assemblies: Section 03 20 00.
   2. Rock anchors.
   3. Laboratory inspection: Division 01.

1.5 QUALITY ASSURANCE

A. Latest adopted edition of all standards referenced in this Section shall apply, unless noted otherwise. In case of conflict between Contract Documents and a referenced standard, Contract Documents shall govern. In case of conflict between Contract Documents and the Building Code, more stringent shall govern.

B. Testing Laboratory Services: Division 01.

C. Comply with Provisions of the Following Codes, Specifications and Standards:
   1. ACI 423.3, "Recommendations for Concrete Members Prestressed with Unbonded Tendons."
   2. PTI, Post-Tensioning Manual; current edition.
   3. PTI, "Specification for Unbonded Single Strand Tendons," current edition.
   4. PTI, "Guide Specification for Post-tensioning Materials."
   5. ACI 318, "Building Code Requirements for Reinforced Concrete."
   6. ACI 347, "Recommended Practice for Concrete Formwork."
   7. PTI, "Recommended Practice for Grouting of Post-Tensioned Prestressed Concrete."

D. Workmanship: Contractor is responsible for correction of concrete work which does not conform to specified

requirements including tendon placement, concrete strength, tolerances, and stressing operations. Correct deficient work as directed by Architect.

E. Qualifications: Post-tensioning supply and installation shall be executed by organizations that have successfully performed work of a nature similar to that involved in this project for a minimum of 5 years and have successfully completed a minimum of 5 similar projects, unless this requirement is waived by Architect prior to Contract award. Contractor shall submit supporting evidence acceptable to Architect that this qualification has been met.
   1. 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.

F. Source Quality Control: Certified mill reports indicating compliance with ASTM A416 and Low Relaxation Strand Supplement to ASTM A416, shall be submitted for all material delivered to project immediately upon shipment. Mill report shall be based upon a minimum of 2 tests for each reel, heat, or lot, and shall include breaking load as a minimum, modulus of elasticity, elongation at rupture, load at 1% extension, area of steel, stress-strain curve, yield point, coil and heat numbers, and drawing mill. One thousand hour relaxation test reports shall also be submitted if applicable.

G. Field Quality Control:
   1. Contractor shall maintain a consistent and good standard of workmanship. Check bulkheads, anchorage positioning, tendon chairing and tying, location, size and placement of reinforcement, and tendon quantity.
   2. Prior to pouring concrete, at frequency established for project, an inspection of tendons and mild reinforcing steel shall be made in accordance with Division 01.
   3. Inspection of stressing operations by testing agency will be performed as specified in Division 01.
   4. Contractor shall record all jacking forces, lift-off pressures, and elongations after seating for each tendon. Records shall be of a format acceptable to Architect and shall be kept with shop drawings. Copies of all records shall be submitted to laboratory within 48 hours after stressing and shall include:
      a) Calculated and actual measured elongation for each jacking point and totals for each tendon.
      b) Stressing ram and gauge number and date of last calibration.
      c) Jacking pressure or force for each tendon including restressing and lift-off readings where applicable.
      d) Floor, pour, and tendon identification numbers.
      e) Date of stressing operation and signature of Contractor's stressing personnel and laboratory inspector witnessing the operation.
   5. Before starting post-tensioning operations, Contractor shall have ram and gauge sets calibrated by an independent testing agency, cost of which shall be borne by Contractor. Once calibrated as a set, the ram and gauge shall be used as a unit. Rams and gauges shall not be used interchangeably. Submit to laboratory certificates of all ram calibrations used on project. Use of non-calibrated rams will not be allowed on this project.
   6. Ram and gauge sets used on project shall be recalibrated after each 100,000 square feet of floor area stressed, but not less than once per month. Recalibration shall be by an independent testing agency at no cost to Owner.

1.6 SUBMITTALS

A. Shop Drawings: Submit shop drawings for review and coordination. Drawings shall include, but not be limited to, the following:
   1. Tendon layout including dimensions which locate tendons in the horizontal plane and number of strands. Detail horizontal curvature of tendons at block-outs, openings and anchorages and show all openings in slabs and beams. Clearly designate each tendon.
   2. Tendon profiles showing chair heights and locations and any required support steel. Clearly show location of each tendon and method of support. Indicate bundling of strands where required to permit concrete flow.
   3. Details of reinforcement around stressing pockets, closures and openings including bursting reinforcement and interference with tendons. Coordinate with mild reinforcing steel drawings as required.
   4. Details of anchorages, pocket formers, couplers, and other related hardware, grout, and bonding agent. Details of conduits and grouting procedure for bonding tendons.
   5. Clearance requirements for hydraulic equipment and dimensions of any stressing pockets required.
   6. Sequence of construction including installation, pouring and stressing sequences. Show all construction joints and related tendon details.
   7. Samples of forms to be used for field record of stressing operations.
   8. Complete post-tensioning procedure including stressing system, methods of determining anchor force and

tendon slack and method of measuring and cutting off excess strand after anchorage.

B. Calculations:
   1. Submit 2 copies of design calculations, prepared and sealed by a Licensed Professional Engineer, licensed in the State of Texas, for all post-tensioning reinforcing. Calculations shall show how design forces will be attained, deducting for friction and short and long term losses. Minimum wobble (K) and curvature (V) coefficients shall be 0.001 and 0.070 respectively, unless proper test data is submitted substantiating lower values. Loss of stress in post-tensioning steel due to elastic shortening, creep and shrinkage of concrete, steel relaxation, friction, seating and sequence of stressing shall be calculated and clearly identified in submittal. Clearly show required tendon elongation for each tendon and method of measurement. Show method to verify wobble and curvature coefficients during tendon stressing operations.
   2. Shop drawings submitted without corresponding calculations will be returned as an incomplete submittal. Calculations are for Architect's record and will not be approved or returned.
   3. Once material has been purchased, adjust calculated elongations to reflect actual modulus of elasticity and cross-sectional area for each roll, as indicated by mill tests. Submit adjusted elongations for Architects file and for field use before stressing.

C. Submit Manufacturer's Data for Review and Coordination:
   1. Description of hardware including but not limited to: Anchorage system, coated strand, pocket formers, and other sub-assemblies required for complete installation.
   2. Manufacturer's mill test reports as described under "Source Quality Control."
   3. Certifications and other data as may be required to demonstrate compliance with other items in this Section.

D. Mill Certificates: Submit, for Architect's record mill test reports as described under "Source Quality Control."

E. LEED Documentation Submittals: These submittals are to be submitted one time with related submittals and/or if any changes exist during construction.
   1. Credit MR4.1 and 4.2: Provide a final summary at the end of construction documenting total recycled content in building materials.
      a) Product Data and certification letter indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating costs for each product having recycled content.
      b) Letter Template as appropriate to submittal content with actual values input.
   2. Credit MR5 and 5.2: Provide a final summary at the end of construction documenting total regional materials used:
      a) Product Data indicating location of material manufacturer for regionally manufactured materials.
         1) Include statement indicating cost, and distance from manufacturer to Project for each regionally manufactured material.
         2) Include statement indicating cost, and distance from point of extraction, harvest, or recovery to Project for each raw material used.
      b) Letter Template as appropriate to submittal content with actual values input.

F. Reports: Submit 2 copies of all post-tensioning and ram calibration reports, as described under "Field Quality Control" above, to testing laboratory for evaluation.

G. Design Responsibility:
   1. Details of post-tensioning system, including prestressing steel, anchorage and coupling systems, tendon supports, confinement reinforcing and tendon stressing and elongation schedules shall be responsibility of post-tensioning supplier.
   2. Post-tensioning supplier shall secure services of a Structural Engineer, licensed in the State of Texas, to select tendons and hardware necessary to produce the scheduled final post-tensioning forces and eccentricities. Shop drawings and calculations shall bear engineer's seal.
   3. Review of shop drawings and calculations will not alleviate post-tensioning supplier of responsibility for detailed design, as specified herein.
   4. By offering a proposal or entering into a contract for work of this Section, post-tensioning supplier accepts (at no additional cost to Owner) general design constraints shown on Drawings, even where he may feel that such constraints exceed specified performance requirements.
   5. Contractor shall provide Record Drawings to Owner, in care of Architect, of any approved changes from contract documents. Form of Record Drawings may be legible marked up prints of contract drawings, or separate drawings of same scale.
   6. Post-tensioning supplier shall be responsible for furnishing Contractor additional support and bursting steel and auxiliary reinforcement as may be required around pockets and block-outs for post-tensioning anchorages. Design bursting reinforcement to comply with ACI 318.

H. Review:
   1. After review, shop 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 operation will not relieve Contractor of his responsibility for completing work successfully in accordance with contract drawings and Specifications

PART 2 – PRODUCTS

2.1 POST-TENSIONING TENDONS

A. Strand:
   1. Post-tensioning tendons shall use strand conforming to "Specification for Uncoated Seven- Wire Low Relaxation Strand for Prestressed Concrete," ASTM A 416, and shall have a minimum guaranteed ultimate tensile strength of 270,000 psi based on nominal area of strand. Strand shall be free of dirt, corrosion or injurious marks, undue segregation, lamination, excessive die marks, scratches, seams, and sharp kinks. Oil-tempered strand is prohibited.
   2. Identification: Prestressing steel within every group, or in same member, shall be of the same heat where practical. Tendons shall be assigned a proper heat and coil number and so identified on fabrication lists which are to be sent to the field with each shipment. Identify tendons in accordance with placing Drawings.

B. Sheathing: All post-tensioning tendons shall be greased and sheathed with a high density polyethylene or polypropylene slippage sheathing designed to prevent intrusion of concrete, grout and water. Sheathing enclosing prestressing steel shall be of continuous plastic with a minimum thickness of 50 mils. Sheathing shall not rupture due to normal temperature changes, coiling and field handling. Grease shall lubricate the tendon and be specially compounded to permanently protect prestressing steel against corrosion. Grease shall be applied under pressure to ensure filling of interstices between individual wires of strand. There shall be no voids or pockets between plastic sheath and greased strand for water or air to collect.
   1. Grease shall be chemically stable and non-reactive with prestressing steel, sheathing material and concrete.

C. Tendon Encapsulation: Provide encapsulated tendon anchorage system employing a seal sleeve to lock the sheathing into each anchor (including intermediate anchors), and a grease cap over the wedge space, or equivalent system designed to positively seal out moisture and chemicals. Suncoast “Encapsulated”, VSL “CP+”, DSI “CPS”, or equal.

2.2 DISTRIBUTION PLATES AND ANCHORAGES

A. Anchor: Anchoring hardware shall be steel and shall meet minimum requirements set forth in ACI 318, except as modified herein. Anchorage shall be capable of developing at least 95% of minimum specified ultimate strength of prestressing steel without exceeding anticipated set, and shall be capable of passing static and dynamic tests as outlined in Chapter 3 of PTI Post- Tensioning Manual, 6th Edition. All anchorages, couplers, and miscellaneous hardware shall be standard products, manufactured by post-tensioning supplier, unless shown otherwise and shall be approved by ICC (International Code Council) or other agencies of equal stature and the Architect.

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 post-tensioning supplier consistent with anchorage to be provided.

C. Embedment: Anchorages at slab edges or beam ends shall be recessed a minimum 1½" at interior exposures and 2” at exterior exposures and at all locations in open parking garages. At construction joints, all anchorages or tendon force distribution plates (bearing plates) shall be embedded in the first of consecutive pours. Flat back castings, plates, etc., which are placed against previously cast concrete and then stressed will not be allowed. Washer type grommets shall be used at construction joints if grout exclusion is necessary for embedded item. If used, pocket formers at intermediate construction joints shall be as recommended by the post- tensioning supplier for that use and must be configured to insure that the resulting pocket will not allow the formation of air pockets or voids in the concrete. Standard end pull pocket formers shall not be used at intermediate construction joints.

D. Seating Loss: Maximum allowable anchor slip or seating loss shall be 1/4".

2.3 CONCRETE

A. Concrete shall have a minimum strength of 75% of required 28 day strength at transfer of prestress force, unless otherwise specified on contract drawings. Components or admixtures with chloride, fluoride, sulphite, or nitrate

ions or any other substance deleterious to prestressing steel shall not be used.

2.4 TENDON SUPPORT SYSTEM

A. Beam Tendons: Supports shall consist of reinforcing steel tied between stirrup legs as required to maintain tendons in their proper location during concrete placement.

2.5 TENDON FABRICATION

A. All tendons shall be fabricated in continuous lengths, without splices, except where splices are specifically detailed and shown on approved shop drawings.
B. All tendons shall be clearly marked and identified in accordance with approved shop drawings.
C. Tendons shall be manufactured and delivered in sequence and quantity so as to avoid lengthy jobsite storage.
D. All prestressing steel shall be satisfactorily protected from rust or other physical damage prior to placement and shall be kept free from detrimental substances such as chlorides, fluorides, sulphites, and nitrates. Provide protection for exposed prestressing steel beyond ends of members to prevent deterioration by rust or corrosion.

2.6 CORROSION-RESISTANT COATING

A. Corrosion-resistant coating shall be equal to ZRC cold galvanizing compound, by ZRC Chemical Products, Quincy, Mass.

2.7 POST-TENSIONING POCKET GROUT

A. Post-tensioning pocket grout shall be a low sag, chloride-free, premixed, polymer-modified microsilica enhanced cementitious repair mortar for vertical and overhead applications. The material shall be classified as low shrinkage (.025 to .05% or less) per ASTM C157. Acceptable products are Verticoat Supreme by Euclid Chemical Company, Cleveland, OH and Sonocrete Gel Patch by BASF Construction Chemicals, LLC., Shakopee, MN.

PART 3 – EXECUTION

3.1 POST-TENSIONING STEEL PLACEMENT

A. Profile: Post-tensioning tendons shall have a parabolic profile and conform to control points shown on contract drawings. Dimensions locating this profile apply to center of gravity of tendons measured from the slab or beam soffit, unless noted otherwise. Low points of tendons are at midspan, unless noted otherwise. Tendons shall be placed normal to anchorage plates. Curvature of tendons shall be smooth and uniform. Reverse drapes near bottom of a member shall not be permitted.
B. Interference: Slight deviation in spacing of slab tendons is permitted where required to avoid openings and inserts which are specifically located. Where interference occurs, contact the Architect before moving any tendons. Placement of mild steel reinforcement shall be coordinated with placement of post-tensioning tendons. Proper tendon location has priority.
C. Tolerances: Tendons and anchorages shall be firmly supported to prevent displacement during subsequent operations. They shall be placed with a tolerance of + 1/4" in concrete dimensions of 8" or less, + 3/8" in concrete dimensions over 8" but not over 2'-0", and + ½" in concrete dimensions over 2'-0". Tolerances apply separately in both vertical and horizontal dimensions and might be different for both directions. Horizontal sweeps to miss openings, inserts, etc., shall have minimum radius of 25'-0" and shall not exceed a maximum slope of 1:6. A minimum clearance of 6" shall be maintained at all openings.
D. Tendon Spacing: Maximum spacing of slab tendons shall be 6 times thickness of slab, but not greater than 3'-0", unless otherwise noted on contract drawings. Minimum clear spacing between tendons shall be 2".
E. Bundling Strands: Where required to reduce congestion and facilitate concrete placement and vibration, strands shall be bundled and wired together in groups not to exceed 6 strands per bundle. Maintain at least 2" clear spacing between and around each bundle to permit concrete flow and insertion of vibrators. Place strands parallel and do not allow them to twist. Separate (de-bundle) strands at horizontal curves which occur at high points or low points of the tendon profile.
F. Supports: Tendons shall be tied in such manner that both vertical and horizontal movement during concrete placing operation is held to a minimum. Tendons shall be securely supported at column lines, midspan, points of reverse curvature, and at a maximum of 4'-0" on center between control points. Support chairs or bolsters shall be stapled or otherwise secured to supporting form sufficiently to hold in position. Support bars in beams and girders shall be securely tied to stirrup legs. Where slab tendons pass over beams, do not rely on beam cage for

tendon support, but rather provide chairs on each side of beam for each such tendon.

G. Welding: Welding of cross bars or any welding in vicinity of tendons will not be allowed. Post- tensioning tendons shall not be used as an electrical ground for welding operations.

H. Sheathing: Should any tears or abrasions be detected during field installation, damaged area shall be repaired by wrapping spirally with 2 layers of plastic moisture-proof adhesive tape. Sheathing shall be continuous to back of stressing anchorages and to embedded dead ends. Where tendon sheathing does not extend to stressing anchorages or has been stripped to allow tensioning at intermediate anchorage, unsheathed region of tendon shall be recoated with grease and wrapped spirally with 2 layers of plastic moisture-proof adhesive tape.

I. Couplers: Tendon couplers shall not be used without prior approval of Architect and Structural Engineer.

J. Instructions: Post-tensioning supplier shall furnish initial instruction in placing operations at jobsite and periodically thereafter as required to ensure proper placing and securing of tendons by Contractor's personnel.

3.2 CONCRETE PLACEMENT

A. 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 inserts will not spall concrete and are located to avoid hitting tendons or anchorages. Contractor shall locate tendons on surface of slab if drilling or coring is to be done after concrete is placed.

B. Placement: Concrete shall be placed in conformance with requirements of Section 03 3000. No concrete shall be poured until placement of mild steel reinforcement and tendons have been inspected by the Architect, Structural Engineer, or independent testing agency at frequency established for project. Concrete shall be placed in such a manner as to ensure alignment of post-tensioning tendons remains unchanged. Special provisions shall be made to ensure proper vibration of concrete around anchorage plates. Tendon positioning shall be monitored during pour. All floors below the level that is to have concrete placement shall have been stressed before concrete is placed, unless shoring has been designed for the ensuing loads.

C. Openings: Shall not be cut into cast concrete without approval of Architect.

3.3 STRESSING

A. Methods: Post-tensioning shall be in conformance with generally accepted systems of prestressing. Variations of such generally accepted methods and equipment will be permitted with Architect approval, provided equal results can be obtained.

B. Concrete Strength: Post-tensioning operations shall not begin until tests of concrete cylinders indicate that concrete in members has attained a compressive strength of not less than 75% of 28 day strength or as otherwise specified on Drawings. See Section 03 3000, "Concrete Work" for testing and curing procedures.

C. Equipment: All tendons shall be stressed by means of hydraulic rams, equipped with accurate reading calibrated hydraulic pressure gauges to permit stress in prestressing steel to be computed at any time. A certified calibration curve shall accompany each ram. If inconsistencies between measured elongation and gauge reading occur, the ram and gauge set shall be immediately recalibrated.

D. Forces: Prestressing steel shall be anchored at an initial or anchor force that results in ultimate retention of the working or effective force shown on Structural Drawings. Jacking forces shall be those indicated on shop drawings. Stressing from each end of tendon shall be required when, in Architects opinion, there is excessive friction between prestressing steel and enclosures.

E. Elongations: Records shall be kept of all tendon elongations as previously described in this Section. Observed elongations, at required jacking pressure, will be considered satisfactory if within 7% of expected amount for unbonded tendons and 5% for bonded tendons. A force/elongation check may be ordered at any time by Architect or testing laboratory. Do not cut off tendon tails until elongation records have been reviewed and approved in writing by testing laboratory. Tendons which are out of tolerance shall not be cut. Restress, recheck or perform other remedial work as necessary to bring tendons into compliance with specified tolerances. Those remaining out of tolerance after attempting to bring them into compliance shall be reported to Architect.

F. Stressing Sequence: As shown on the shop drawings.

G. Safety: Precautions shall be taken to prevent workers from standing directly behind, above, or in front of stressing rams.

3.4 CUTTING TENDONS AND GROUTING ANCHORAGE RECESSES

A. After stressing records have been approved, cut off excess strand as required to provide a minimum of ¾” clear concrete cover over tendon end. Where a tendon encapsulation system is specified, cut off excess strand as required to provide a minimum of 1” clear concrete cover over the tendon cap. Cut tendons as recommended by

the system manufacturer to avoid damaging the anchorage. Remove any dirt, grit, oil, or P-T coating from pocket surfaces and P- T ends and anchorages. Stressing anchorages, including wedges, and tendon ends shall be coated with the specified corrosion-resistant coating. Do not allow corrosion-resistant coating on concrete surfaces of pocket. Anchorage recesses shall be filled with post-tensioning pocket grout, as specified. Care shall be taken to prevent contamination of the anchorage recess surface, which may reduce bonding capacity of post-tensioning pocket grout. Finished hardened surface of grout in anchorage recesses shall be coplanar with, and finished to match the texture of, adjacent concrete surfaces.

3.5 INSTALLATION SUPERVISION

A. Duties of 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.
   3. Measure and record tendon forces and elongations at stressing and submit copies of reports to testing laboratory.
   4. Require checking of tendon force and/or elongation if requested by Architect or testing laboratory.
   5. Do not allow cutting off of tendons without written approval of testing laboratory or Architect.

END OF SECTION