

SECTION 03 23 00
STRESSING TENDONS

SPEC WRITER NOTE: Delete between // // if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraphs.

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies furnishing, installing, grouting, and stressing tendons in post-tensioned building framing members as shown on the drawings and described herein.

1.2 RELATED WORK

- A. Section 01 45 29, TESTING LABORATORY SERVICES: Materials Testing and inspection during construction.
- B. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS
- C. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete.

1.3 QUALITY ASSURANCE

- A. Codes and Standards: Comply with requirements of Post-Tensioning Manual, except where more stringent requirements are specified or shown on the drawings. Maintain two copies at job site.
- B. Bearing Stresses: Comply with requirements of Post-Tensioning Manual, Chapter 3, Paragraph 3.1.7, and ACI 318, Chapter 18.
- C. Source Quality Control:
 - 1. Tests for Unbonded Single Strand Tendons or Bonded Tendons must comply with requirements of the Post-Tensioning Manual, Chapter 3, Paragraph 3.1.8.
 - 2. Certified data from prior tests may be submitted.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Shop Drawings:
 - 1. Submit fabrication and placement details to the Contracting Officer's Representative (COR) for review and approval. Show complete details of tendon layout, tendon sizes, type of post-tensioning enclosure, end anchorage and coupler details, and stressing equipment. Submit the type and chemical analysis of grease, and type, material and thickness of post-tensioning repair tape. Give details of jacking operation, including all calculations.

2. Locate and dimension penetrations in post-tensioned slabs.
 3. Detail horizontal and vertical curvature of tendons at blockouts and anchorage.
 4. Describe tensioning sequence, type of jack and pressure-monitoring devices, anchorage set, tendon elongation and tendon cutoff procedures, grouping, spacing, placing sequence, conduit size, supports and locations, and tendon supports.
- C. Calculations: Submit sealed detailed calculations prepared by a qualified professional structural engineer registered in the state where the project is located to substantiate stressing procedures. All losses shall be accounted for in the calculations. Submit the following:
1. Calculations shall be prepared under the supervision of a qualified registered professional structural engineer, of losses due to anchorage seating, elastic shortening, creep, shrinkage, relaxation, friction and wobble, used to determine tendon sizes and number.
 2. Calculations of test results of adequacy of anchorage.
 3. Statistical and field proof of stressing and fixed end seating losses.
 4. Calculations for final required jacking elongation corresponding to final jacking force of tendons.
- D. Mill Test Reports:
1. Furnish certified Mill Test Reports for each coil or pack of strand, containing as a minimum the following test information:
 - a. Heat number and identification.
 - b. Standard chemical analysis for heat of steel.
 - c. Ultimate tensile strength.
 - d. Yield strength at 1 percent extension under load.
 - e. Elongation at failure.
 - f. Modulus of elasticity.
 - g. Diameter and net area of strand.
 - h. Type of material (stress-relieved or low relaxation).
 2. Base relaxation losses for low relaxation type material on relaxation tests of representative samples for a period of 1000 hours, when tested at 21 degrees C (70 degrees F) and stressed initially to not less than 70 percent of minimum guaranteed breaking strength of strand.
 3. Tests in accordance with ASTM A416, and ASTM E328.

- E. Calibration Tests: Stressing rams and gauges shall individually be identified and calibrated against known standards at intervals not exceeding six months. Submit calibration certificates for each jack used to the COR for review and approval.
- F. Records: Keep post-tensioning records and submit to the COR. Record on each report items listed in PART 3-EXECUTION.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below form a part of this specification to extent referenced. Publications are referenced in text by basic designation only.
- B. American Concrete Institute (ACI):
318/318r-19.....Building code requirements for Structural Concrete and Commentary.
- C. ASTM International (ASTM):
A416/A416M-18.....Standard Specification for Low-relaxation, Seven-Wire Steel Strand for Prestressed Concrete
B117-19.....Standard Practice for Operating Salt Spray (fog) Apparatus
D92-18.....Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
D95-13 (2018).....Standard Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D512-12.....Standard Test Methods for Chloride Ion In Water
D566-20.....Standard Test Method for Dropping Point of Lubricating Grease
D2265-20.....Standard Test Method for Dropping Point of Lubricating Grease Over Wide Temperature Range
D3867-16.....Standard Test Methods for Nitrite-Nitrate In Water
E328-13.....Standard Test Methods for Stress-Relaxation Tests for Materials And Structures
- D. Post-Tensioning Institute, 1717 W. Northern Avenue, Suite 114, Phoenix, AZ 85021; 602/870-7540:
- E. Post-Tensioning Manual, Fifth Edition

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Post-Tensioning Steel:

1. Conform to ASTM A416, Grade (270K) Low Relaxation strand, with anchorages developing at least 95 percent of the minimum specified ultimate strength of the prestressing steel.
 2. Provide low relaxation strand with a mill applied continuous permanent physical marking to permit field identification.
 3. Package material at the source in a manner that prevents physical damage to strand during transportation and protects material from deleterious corrosion during transit and storage.
- B. Post-tensioning materials comply with Post-Tensioning Manual Guide Specifications.
- C. Anchorages and Couplings:
1. Design tendon anchorages and coupling to develop static and dynamic strength requirements of Section 3.1.6(a) and Section 3.1.8 (1) and (2) of Post-Tensioning Manual Guide Specifications for Post-Tensioning Materials. Castings shall be nonporous and free of sand, blowholes, voids, and other defects.
 2. Average compressive concrete bearing stress of anchorages shall not exceed limits set forth in Section 3.1.7 of Post-Tensioning Manual Guide Specifications for Post-Tensioning Materials.
 3. For wedge type anchorages, design wedge grippers to preclude premature failure of prestressing steel due to notch or pinching effects under static and/or dynamic test load conditions stipulated under Paragraph 1 for both stress relieved and low relaxation prestressing steel materials.
 4. Use couplings only at locations specifically indicated on contract documents or as approved.
 5. Coat couplings with the same corrosion preventive coating used on strand and enclose in sleeves.
 6. Anchorages shall include design features permitting a watertight connection of sheathing to anchorage, and watertight closing of wedge cavity, for stressing and nonstressing (fixed) anchorages. Design intermediate stressing anchorages to permit complete watertight encapsulation of prestressing tendons.
 7. Anchorages for unbonded slab tendons shall receive an epoxy corrosion protective coating. Correct field damage to coating by field touch-up of coating surface.
- D. Corrosion Preventive Coating of Unbonded Tendons:

1. Corrosion preventive coating material shall have following properties:
 - a. Provide corrosion protection to prestressing steel.
 - b. Provide lubrication between strand and sheathing.
 - c. Resist flow from sheathing within anticipated temperature range of exposure.
 - d. Provide a continuous nonbrittle film at lowest anticipated temperature of exposure.
 - e. Be chemically stable and nonreactive with the prestressing steel, sheathing material, and concrete.
2. Film shall be an organic coating with appropriate polar, moisture displacing, and corrosion preventive additives.
3. Minimum weight of coating material on prestressing strand shall be not less than 1.1 kg (2.5 pounds) of coating material per 30 m (100 feet) of 13 mm (0.5 inch) diameter strand, and 1.3 kg (3.0 pounds) of coating material per 30 m (100 feet) of 15 mm (0.6 inch) diameter strand. Amount of coating material used shall be sufficient to ensure essentially complete filling of annular space between strand and sheathing. Extend coating over entire tendon length.
4. Provide test results in accordance with Table I for corrosion preventative coating material.

TABLE I
PERFORMANCE SPECIFICATIONS FOR CORROSION
PREVENTATIVE COATING

Test	Test Method	Acceptance Criteria
Dropping Point, degrees F	ASTM D566 or ASTM D2265	Minimum 300
Oil separation at 160 degrees F; percent by weight	FIMS 791B Method 321.2	Maximum 0.5
Water, percent maximum	ASTM D95	0.1
Flash point, degrees F, (degrees Celsius) (Refers to oil component)	ASTM D92	Minimum 300
Corrosion test, 5 percent salt fog at 100 degrees F (37.8 degrees Celsius) 5 mils, minimum hours (Q Panel Type S)	ASTM B117	Rust Grade 7 or better after 1000 hours of exposure, test according to ASTM D610 (Note 1)
Water soluble ions (Note 2)	ASTM D512	10
Chlorides, ppm maximum	ASTM D3867	10
Nitrates, ppm maximum	APHA 4270	10
Sulfides, ppm maximum	(15th Edition)	
Soak Test 5 percent salt fog at 100 degrees F (38.8 degrees Celsius) 5 mils coating, Q panels, Type S. Immerse panes 50 percent in a 5 percent salt solution and expose to salt fog.	ASTM B117 (Modified)	No emulsification of the coating after 7200 hours of exposure

Notes To Table I:

Note 1: Extension of exposure time to 1000 hours for greases used in corrosive environments requires use of more or better corrosion inhibiting additives.

Note 2: Procedure: The inside (bottom and sides) of a 1l pyrex beaker (approximate outside diameter 105 mm, height 145 mm) is thoroughly coated with 100 + 10 grams of corrosion preventive coating material. The coated beaker is filled with approximately 900 cc of distilled water and heated in an oven at a controlled temperature of ± 38 degrees C (± 100 degrees F) for 4 hours. The water extraction is tested by the noted test procedures as ppm in the extract water.

E. Sheathing For Unbonded Single Strand Tendons:

1. Tendon sheathing for unbonded single strand tendons shall be made of material with following properties:

- a. Sufficient strength to withstand irreparable damage during fabrication, transport, installation, concrete placement and tensioning.
- b. Watertightness over entire sheathing length.
- c. Chemical stability, without embrittlement or softening over anticipated exposure temperature range and service life of structure.
- d. Nonreactive with concrete, steel and tendon corrosion preventive coating.

SPEC WRITER NOTE: Use 0.6 mm (0.025 inch)
for noncorrosive environments and 1 mm
(0.040 inch) for corrosive environments.

2. Minimum thickness of sheathing is // 0.6 mm (0.025 inch) // // 1 mm (0.040 inch) // for medium or high-density polyethylene or polypropylene.
3. Minimum inside diameter of sheathing at least 0.3 mm (0.010 inch) greater than maximum diameter of strand.
4. Connect sheathing to stressing end, intermediate and fixed end anchorages in a watertight fashion, thus providing a complete encapsulation of prestressing steel.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Accurately position, support, and secure bonded reinforcement and tendons against displacement by formwork, construction, or concrete placement operations. Locate and support bonded reinforcement and tendons by metal chairs, runners, bolsters, spacers and hangers, as required.
- B. Firmly support prestressing tendons at intervals not exceeding 1200 mm (4 feet) to prevent displacement during concrete placement. Placing tolerances shall be in accordance with the applicable Construction Specifications.
- C. Do not expose tendons to excessive temperatures, welding sparks or electric ground currents.
- D. Install stressing anchorages perpendicular to tendon axis. Curvature in tendon profile shall preferably not be closer than 900 mm (3 feet) from stressing anchorage.
- E. Attach stressing anchorage to bulkhead forms by either bolts, nails, or threaded pocket former fitting. Connections shall be sufficiently rigid

to avoid accidental loosening due to construction traffic or during concrete placement. Minimum concrete cover for anchorage shall not be less than minimum cover to reinforcement at other locations in structure.

- F. Pocket formers used to provide a void form at stressing and intermediate stressing anchorages shall positively preclude intrusion of concrete or cement paste into the wedge cavity during concrete placement. Depth of the pocket former from edge of concrete to face of anchorage shall not be less than 50 mm (2 inches).
- G. Intermediate Anchorages:
1. Intermediate anchorages may be installed either embedded in concrete or bearing against hardened concrete at construction joint. In the latter case, anchorage shall have a flat-bearing side and concrete bearing area shall be smooth and without ridges.
 2. When placing intermediate anchorages against already hardened concrete, special attention must be paid to the bulkhead form being perpendicular to the tendon during tendon placement.
 3. Minimum cover requirements of Section 3.1.E apply to intermediate anchorages.
- H. Fixed Anchorages:
1. Install fixed end anchorages on tendon at supplier's plant prior to shipment to job site.
 2. For wedge type anchorages, seat fixed end wedges, with a load of not more than 80 percent of minimum ultimate tensile strength of tendon. Seating load shall be sufficient to ensure adequate capacity of non-stressing anchorages.
 3. Place fixed end anchorages in the formwork at locations shown on placing drawings, and securely fastened to reinforcing steel. Minimum cover requirements of Section 3.1.E apply to fixed end anchorages.
 4. Fixed end anchorages shall be closed or capped at wedge cavity side with a watertight cover. Cover shall preferably be shop installed, after filling void around wedge grips with a corrosion preventive coating material, comparable to that used as a corrosion preventive coating over length of the tendon (See Table I).
- I. Sheathing Inspection:
1. After installing the tendons in forms and prior to concrete casting, inspect sheathing for possible damage.

2. Repair damaged areas by restoring corrosion preventative coating in damaged area and repairing sheathing. Repairs of sheathing shall be watertight and must be approved by the COR.
 3. To repair sheathing, use adhesive moisture proof tape, spirally wrapped around tendon to provide at least two layers of tape.
- J. Grouting of bonded tendons shall comply with the Post-Tensioning Manual Recommended Practice for Grouting of Post-Tensioned Prestressed Concrete.

3.2 STRESSING

- A. Unless otherwise indicated, do not start stressing until concrete has attained a compressive strength of no less than 75 percent of its 28-day strength as confirmed by field cured test cylinders.
- B. After tests indicate that concrete has reached sufficient strength, stress tendons by means of hydraulic jacks equipped with calibrated pressure gauges with an accuracy of 1 percent of scale range to permit the stress in tendons to be computed at any time. Equip hydraulic stressing rams used to stress unbonded single strand tendons with stressing grippers that will not notch strand more severely than normal anchoring wedges. Notify the COR 48 hours before any stressing operation that takes place.
 1. Conduct stressing operation as recommended by manufacturer of stressing tendons and in conformance with approved shop drawings.
 2. Keep records of elongation and of tension applied to each tendon and submit four copies to the COR promptly upon the completion of post-tensioning of each member. Make elongation measurements at each stressing location to verify that effective force has been properly achieved. Measured elongations shall agree with calculated elongations within ± 5 percent. Resolve discrepancies exceeding ± 5 percent with the COR. At time of stressing first member of each type, check stresses in individual tendons to establish a post-tensioning procedure producing uniform results.
 3. Complete stressing records during the tensioning operation, with following data recorded as a minimum:
 - a. Tendon mark or identification.
 - b. Required elongation.
 - c. Gauge pressure to achieve required elongation.
 - d. Actual elongation achieved.
 - e. Actual gauge pressure.

- f. Date of stressing operation.
 - g. Signature of stressing operator or inspector.
 - h. Serial or identification number of jacking equipment. Stressing records shall then be turned over to the Government and professional engineer of record for verification and approval.
4. Obtain written permission of the COR before cutting tendons or capping post-tensioned anchorages.
- C. Anchor prestressing tendons at an initial or "Transfer Stress" that will result in retention of working forces or stresses of not less than those shown on the drawings as the final prestress force after all losses. In no case shall tendons be anchored at stresses above 80 percent of specified tensile strength of tendon.
 - D. Do not do any welding around tendons.
 - E. Take reasonable care to prevent damage to tendons. In event that a single wire in multiple wire strands is broken, replacement will not be required providing total loss caused by broken strand is less than 2 percent of total prestress in the member. Contractor shall replace tendon at no additional cost to the Government in event prestress loss through breakage is greater than 2 percent.

3.3 FINISHING

- A. Trimming of excess tendon length: As soon as possible after tendon tensioning and satisfactory check of elongation by the COR, cut excess tendon length. Tendon length protruding beyond wedges after cutting shall be between 20 mm (0.75) and 30 mm (1.25 inches).
- B. Tendons may be cut by means of oxyacetylene cutting, abrasive wheel or hydraulic shears. In case of oxyacetylene cutting of tendons, take care to avoid directing flame toward wedges.
- C. Fill stressing pockets with non-shrink mortar as soon as practical after tendon stressing and cutting. Under no circumstances shall grout or mortar used for pocket filling contain chlorides or other chemicals known to be deleterious to prestressing steel.
- D. Coat exposed strand and wedge areas with tendon coating material comparable to that used over length of the tendon and a watertight cap shall be applied over the coated area. Prior to installing pocket mortar, coat or spray inside concrete surfaces of pocket with a resin bonding agent.

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