SECTION 03 23 00

STRESSING TENDONS

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes the requirements for providing stressing tendons at cast-in-place concrete Parking Structure.

B. Work included:
   1. Post-tensioning materials, including post-tensioning steel, anchorages, non-prestressed steel reinforcement, spacer bars and tendon enclosures.
   2. Placing and anchoring tendons and other devices.
   3. Placing anchor bolts, metal frames, and other embedded items.
   4. Performing post-tensioning operations including jacking and anchoring.
   5. Keeping and furnishing record of elongations, gage readings, deflections, and similar results of tensioning operations.

C. Related work:
   1. Concrete Reinforcing: Section 03 20 00
   2. Cast-In-Place Concrete: Section 03 30 00

1.2 QUALITY ASSURANCE

A. Testing: Refer to Division 01.

B. Standards: Maintain at least one copy of American Concrete Institute Publications (SP15) in project field office at all times. Comply with the applicable requirements.

C. Sequence of construction: Structural Engineer of Record shall provide for special sequence of construction requirements on drawings.

D. Code and standards: Comply with ACI-318, Building Code for Reinforced Concrete, as applicable.

E. Design, fabrication and erection of distribution plates and anchorages: Comply with AISC and AWS Standards, including qualification test of welders.

F. Prestress subcontractor qualifications:
   1. Prestress subcontractor shall have not less than 2 years experience in prestressed structural concrete work of the type and scope of this project.
   2. Work shall be performed under the direct supervision of an individual with experience in the type of construction required on the project. Exercise close checks and rigid control of all operations, as necessary, for full compliance with all Contract Documents.

G. Testing laboratory: Not less than 2 years experience in sampling and testing of prestressed assemblies of a similar type; testing shall be under the direct supervision of a California-registered structural engineer.

H. Inspection of stressing tendons:
   1. Prior to placing concrete in any portion of the structure, the stressing tendons will be checked and approved by the special inspector.
   2. Correct errors or discrepancies found before placing concrete.
   3. Such check and approval shall not relieve the Contractor from responsibility for compliance with Contract requirements.

I. Static and dynamic tests - the Contractor shall provide the following:
   1. A static test shall be performed on a representative specimen.
      a. The tendon assembly shall consist of standard production quality components; tendons shall be at least 10 feet long.
      b. Test the assembly in a manner to allow accurate determination of the yield strength, ultimate strength and percent elongation of the complete tendon to insure compliance with the Contract Documents.
   2. Submit certified mill test results and typical stress-strain curves for prestressing steel.
      a. Obtain the typical stress-strain curve using approved standard practices.
      b. For prestressing steels not covered by ASTM A416, submit the guaranteed tensile strength, yield strength, elongation, composition and other pertinent data to the Architect. Provide samples from each lot, properly marked, for verification of prestressing steel quality.
   3. Dynamic tests: Perform tests on a representative specimen(s); the tendon assembly shall withstand, without failure, 500,000 cycles from 60% to 66% of its minimum specified ultimate strength; and also 50 cycles from 40% to 80% its minimum specified ultimate strength.
      a. The period of each cycle involves the change from the lower stress level to the upper stress level and back to the lower.
      b. The specimen used for the second dynamic test need not be the same used for the first dynamic test.
   4. The static and dynamic test requirements may be waived if recent test data are available. Such previous tests shall have been performed on tendon assemblies of a similar type and quality as this project. Submit test report certified by a California-registered structural engineer.

J. Tolerances:
   1. Tendon location: Do not exceed the following:
      a. Deviation from straight line (sweep): 1/4" per 10 ft. x total length;
      b. Deviation in location from specified tendon center of gravity: plus or minus 1/8";
      c. Concrete cover to tendons: plus or minus 1/8".
   2. Prestress force: Do not exceed the following:
      a. Individual tendon force or elongation: plus or minus 5%.
      b. Total prestressing force or elongation: plus or minus 5%.

1.3 SUBMITTALS

A. Comply with requirements of Division 01.

B. Shop drawings: Submit drawings and calculations signed by a California-licensed structural engineer prior to fabrication of components. Include the following data:
   1. Show tendon layout and dimensions, locating tendons in horizontal plane at all points. Detail horizontal curvature of tendons at block-outs and anchorages. Show all slab openings.
   2. Indicate tendon profiles, give chair heights and locations, and all required placement steel. Show the location of each tendon, and the method of support.
   3. Show details of reinforcement around stressing pockets and closures and where interference with tendons may occur.
   4. Include calculations of all losses based on laboratory and field determined data to determine the effective post-tensioning cable forces. Furnish calculations or test results as to the adequacy of anchorages which may be required. See Structural drawings for minimum losses and other requirements.
   5. Show required elongation of each tendon at jacking point.
   6. Furnish complete prestressing procedure; include the following:
      a. Jacking force and jacking pressure.
      b. Maximum temporary jacking force and jacking pressure.
      c. Certified Jack calibrations and method of Jack identification. Non-calibrated Jack and pump combination will not be permitted.
      d. Method of determining slack, if any.
      e. Method of determining anchor force or force remaining in tendons after anchor.

C. Elongation and tensioning records: Maintain records of elongation and tension applied to each wire under the direct supervision of the special inspector. Submit records to the Architect immediately on completion of tensioning operations for each day.
   1. At the time of stressing the first member of each type, check the stresses in the individual tendons to establish a procedure for insuring uniform results.
   2. Be prepared to provide a re-check and redesign of cable spacing, as directed by the Architect, at any later time, should field records suggest design stresses are not being obtained

1.4 DELIVERY, STORAGE AND HANDLING

A. Comply with requirements of Division 01.

B. Delivery: Deliver reinforcement to the site bundled, tagged and marked; handle to prevent damage to material. Use metal tags indicating size, length and other markings shown on placement drawings. Maintain tags after bundles are broken.

PART 2 - PRODUCTS

2.1 DEFINITIONS

A. Tendon: The complete assembly consisting of anchorage and prestressing steel with sheathing. The tendon imparts post-tensioning forces to the concrete.

B. Unbonded tendons: Tendons in which the prestressing steel is permanently free to move relative to the concrete to which they are applying their post-tensioning forces.
   Note: All tendons are unbonded.

C. Anchorage: The means by which the post-tensioning force is permanently transmitted from the prestressing steel to the concrete.

D. Prestressing steel: That element of a post-tensioning tendon which is elongated and anchored to provide the necessary permanent prestressing force.

E. Coating: Material used to protect against corrosion and/or lubricate the prestressing steel.

F. Sheathing: Enclosure around the prestressing steel to avoid temporary or permanent bond between the prestressing steel and the surrounding concrete.

G. Coupling: The means by which the prestressing force may be transmitted from one partial-length prestressing tendon to another.

2.2 MATERIALS

A. Tendons:
   1. Prestressing steel strands in the post-tensioning tendons shall be ½" diameter 7 wire relaxation strands conforming to ASTM A-416 and E-318 270k grade.

B. Anchorages:
   1. Anchorages of unbonded tendons shall develop at least 100% of the minimum specified ultimate strength of the prestressing steel without exceeding anticipated set. The total elongation under ultimate load of the tendon shall not be less than 2% measured in a minimum gauge length of 10 ft. Average bearing stresses of the concrete created by anchorage plates, shall not exceed the allowable code values.
   2. Special reinforcement required for the required performance of the anchorage, shall be designed, supplied and installed by the prestress contractor. Reinforcement shall not be less than two No. 5 bars.

C. Coating:
   1. Coating for unbonded tendons shall permanently protect the prestressing steel against corrosion by a properly applied coating of nonvolatile low friction mineral base grease, or other approved material. The coating shall remain permanently ductile and free from cracks and shall not become fluid over the entire operating or anticipated temperature range.
   2. Coating shall be chemically stable, have a rust-inhibiting additive and be non-reactive to cement and the material used for sheathing.
   3. Coating material shall adhere to and be continuous over the entire tendon length to be unbonded and shall have a relatively uniform viscosity under temperature ranges of 20 deg. F. To 120 deg. F.

D. Sheathing:
   1. Sheathing for unbonded tendons shall have sufficient tensile strength, and waterproofing to resist irreparable damage and deterioration during transport, storage at job site and installation. Sheathing shall be continuous over the tendon length to be unbonded.
   2. Sheathing shall prevent the intrusion of cement paste and the escape of the coating material.
   3. Sheathing shall be a continuous plastic tube.
   4. All rips or tears shall be wrapped prior to concrete placement with a waterproof tape.

E. Couplings of unbonded tendons: Use only at locations specifically indicated.
   1. Do not use Couplings at points of sharp tendon curvature.
   2. Couplings shall develop at least 100% of the minimum specified ultimate strength of the prestressing steel without exceeding anticipated set. Coupling of tendons shall not reduce the elongation at rupture below the requirements of the tendon itself.
   3. Enclose couplings and coupling components in housings long enough to permit the necessary movements. Protect coupling components with coating material prior to final encasement in concrete.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive stressing tendons and associated work and conditions under which work will be installed. Do not proceed until satisfactory conditions have been corrected in a manner complying with the Contract Documents and acceptable to the Installer. Starting of the work within a particular area will be construed as installer's acceptance of surface conditions.

3.2 GENERAL

A. Prestressing steel within each group of the same type of members shall be of the same heat where practicable. Steel shall be assigned to a heat number, and tagged accordingly.

B. Protect prestressing steel from rust corrosion and bond reducing film. Provide sufficient protection for exposed prestressing steel at ends of members to prevent deterioration by rust or corrosion.

3.3 SPECIFIC REQUIREMENTS

A. Prestressing tendons:
   1. Straighten tendons to ensure proper positioning. Provide suitable horizontal and vertical spacers, chairs and profile bars as required to hold the tendons in true position and to obtain a smooth profile and prevent displacement of tendon during casting.
   2. Tendons showing severe fabrication defects shall be removed and replaced, and the member or slab may be rejected. Arrange concrete reinforcement as specified in Section 03200 to suit the method of prestressing.

B. Anchoring devices:
   1. Secure post tensioned prestressing steel at the ends with approved anchoring devices which prevent the wires to kink, neck down or otherwise be damaged.
   2. Anchorage devices shall hold the prestressing steel without slip of more than 1/8" at a load equal to the applied load on the wire at prestressing.

3. Distribution plates shall consist of welded steel or cast steel bearing assemblies that will support and distribute the load from the anchoring devices. Bending stresses in the plates induced by the pull of the prestressing steel shall not exceed 27,000 psi for structural steel and 15,000 psi for cast steel, except as test data may indicate that higher stresses are satisfactory. For higher strength steel, corresponding higher stresses may be permitted.
4. Materials shall meet requirements of ASTM A36 for structural shapes, ASTM A148 for cast steel, or higher quality materials as required to meet strain requirements.
5. Design, fabrication and erection shall comply with AISC Standards and AWS welding standards, including qualifications test of welders.

C. Tensioning strands:
1. Prestress in tendons at stressing points immediately after anchorage shall be 189 ksi (0.70 x 270) or 26.9 kips per strand. Verify prestress in strands by both Jack pressure gauge and elongation methods per ACI 318.18. Elongation requirements shall be taken from average load-elongation curves for the strands used.
2. Sequence of tensioning tendons shall be from the center of the building outward in both perpendicular directions in such manner as to gradually and uniformly develop the desired prestressing forces in the concrete, and as noted on structural drawings.

D. Prestressing: Do not start stressing of tendons until concrete cylinder tests show concrete has attained a strength of 3,500 psi and not until concrete has cured for a minimum of 3 days. Cure cylinders under field conditions. Perform prestressing as follows.
1. Stress prestressing steel using hydraulic jacks, equipped with accurate reading calibrated hydraulic pressure gauges, permitting the stress in prestressing steel to be computed at any time. Provide a certified calibration curve-with each Jack. When inconsistencies between the measured elongation and the Jack gauge reading occur, recalibrate Jack gauges immediately.
2. Perform from one or both ends of post-tensioned prestressing steel. Make proper allowances for friction losses; check one tendon for friction loss at the start of post tensioning.
3. Do not attempt tensioning until reasonable freedom from binding of the prestressing steel in the enclosure is demonstrated. Assume satisfactory evidence of unbound conditions, if inward movement of steel is observed at one end of member when normal pull is applied to the opposite end. Consider as satisfactory evidence, when an agreement not more than 5% between the observed and expected elongation after prestressing exists,
4. Anchor the prestressing steel at an initial stress that will result in the ultimate retention of working forces or stresses of not less than those shown on the drawings but at no time with tension of steel above 80% of the ultimate tensile strength of the wire. Do not permit initial stress remaining in steel, immediately after anchoring the prestressing steel to exceed 70% of the ultimate steel strength.
5. Remove and replace broken or bent strands, and strands showing severe fabrication or placement defects. Assume responsibility for damage and repair caused by strands or other stressing steel breakage during prestressing operations.
6. The prestressing steel subcontractor shall be responsible for maintaining the alignment of tendons, before, during and after placement of concrete.
7. Provide a line transfer method approved by structural engineer in the forms indicating location of tendons after deforming.
8. After stressing of the tendons has been completed, and elongation has been verified and approved, the stressing tendon shall be burned off 2" clear from the edge of slab. Fill void with non-shrink grout.

END OF SECTION