SECTION 451
PRESTRESSED SOIL ANCHORS

451-1 Description.

Construct prestressed soil anchors consisting of a high strength steel tendon anchored to the retaining wall on one end and to the soil on the other end through a bulb of pressure injected portland cement concrete grout. Test each anchor by prestressing to the load indicated in the Contract Documents before locking off to the retaining wall.

Select the prestressed soil anchor type and the installation method, and determine the bond length and anchor diameter. Assume responsibility for installing prestressed soil anchors that develop the load-carrying capacity indicated in the Plans in accordance with 451-7.

Provide corrosion protection for permanent prestressed soil anchors. The Engineer will not require corrosion protection for temporary prestressed soil anchors. Protect anchor tendons from corrosion as shown in the Plans in accordance with 451-8.

451-2 Definitions.

1. Anchorage Devices: The anchor head wedges or nuts which grip the prestressing steel.
2. Bearing Plate: The steel plate which distributes the prestressed soil anchor force to the structure.
3. Bond Length: The length of the prestressed soil anchor which is bonded to the ground and transmits the tensile force to the soil or rock. For a compression prestressed soil anchor, the bond length will be different from the tendon bond length.
4. Factored Design Load: The maximum anticipated load that will be applied to the prestressed soil anchor during its service life after completing stressing and testing. The factored design load includes appropriate load factors to ensure that the overall structure has adequate strength for its intended use.
5. Fine-grained Soils: Soils with at least 50% of the material smaller than the No. 200 sieve size.
6. Tendon: The complete anchor assembly, excluding grout, consisting of anchorage and prestressing steel with sheathing and coating when required.
7. Coupling: The means by which the prestressing force may be transmitted from one partial-length of prestressing tendon to another.
8. Sheathing: Enclosure around the prestressing steel to avoid temporary or permanent bond between the prestressing steel and the surrounding grout or to provide corrosion protection.
9. Coating: Material used to protect against corrosion or lubricate the prestressing steel.
10. Anchor Grout: Portland cement grout that is injected into the anchor hole to provide anchorage at the bond length of the tendon.
11. Proof Load: Temporary loading of an anchor to its factored design load for testing purposes.
12. Transfer (Lock-Off) Load: Prestressing force in an anchor after proof loading immediately after the force has been transferred from the jack to the stressing anchorage.
13. Stressing Anchorage: That portion of assembly not within the earth fill.
14. Alignment Load: A small load maintained on an anchor during testing sufficient to keep the testing equipment positioned.

15. Performance Test: Incremental test loading and unloading of a prestressed anchor recording the movement of the tendon at each increment.

16. Proof Test: Incremental loading of a prestressed anchor recording the movement of the tendon at each increment.

17. Creep Test: A test to determine the movement of the tendon at constant load during a certain period of time.

18. Lift-Off Reading: A check made to determine that the actual transfer load is within 10% of the desired transfer load. This check is made immediately after transferring the load to the stressing anchorage.

19. Residual Movement: The non-elastic (non-recoverable) movement of an anchor measured during soil anchor testing.

20. Elastic Movement: The recoverable movement of an anchor measured during soil anchor testing.

21. Prestressed Soil Anchor: A system, referred to as a tieback or a ground anchor, used to transfer tensile loads to soil or rock. A prestressed soil anchor includes all prestressing steel, anchorage devices, bearing plates, grout, coatings, corrosion protection, sheathings and couplers if used.

22. Minimum Specified Ultimate Tensile Strength: The minimum breaking strength of the prestressing steel as defined by the specified standard.

23. Tendon Bond Length: The length of the tendon which is bonded to the anchor grout.

24. Total Anchor Length: The unbonded length plus the tendon bond length.

25. Unbonded Length: The length of the tendon which is not bonded to the grout. The grout surrounding the unbonded length is a void filler and provides corrosion protection.

26. Service Load: The load anticipated to be applied to the prestressed soil anchor during its service life after completing stressing and testing in order to limit deflection. The service load does not include load factors.

27. Test Stressing Length: The unbonded length plus the length extending through the jack up to the anchorage devices during any anchor acceptance test (i.e. Performance Test, Proof Test or Creep Test).

451-3 Qualifications.

The Contractor or subcontractor performing the work described in this Section shall have installed prestressed soil anchors for a minimum of five years. At the preconstruction conference, the Contractor shall submit a list containing at least five projects, completed within the last five years, where the Contractor has installed prestressed soil anchors. Include a brief description of each project and a reference for each project listed. As a minimum, include with the reference an individual's name and current phone number.

Prior to the start of work, the Contractor shall submit a list identifying his engineer, drill operators, and on-site supervisors who will be assigned to the project. Include in the list a summary of each individual’s experience.

Assign a Specialty Engineer to supervise the work with at least five years of experience in the design and construction of permanently-anchored structures. Do not use manufacturers' representatives in order to meet the requirements of this Section. Provide drill operators and on-site supervisors that have a minimum of one year experience installing permanent prestressed soil anchors with the Contractor’s organization.

The Engineer will approve or reject the Contractor's qualifications and staff within 15 working days after receipt of the submission. Do not start work on any prestressed soil anchor wall system or order materials until receiving approval of the qualifications. The Engineer may suspend the prestressed soil anchor work if the Contractor or subcontractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the Contractor is fully liable for additional costs resulting from the suspension of work and the Department will not allow any adjustment in Contract Time resulting from the suspension of work.

451-4 Materials.

451-4.1 General: Meet the following requirements:

Concrete .....Section 346
Prestressed Construction.....Section 450
Structural Steel and Miscellaneous Metals.....Section 460

451-4.2 Prestressing Steel: Use prestressed soil anchor tendons fabricated from single or multiple elements of one of the following prestressing steels, unless otherwise shown in the Plans:

1. Steel bars meeting the requirements of AASHTO M275.
2. 7-wire, low-relaxation strands meeting the requirements of AASHTO M203.
3. "Compact" 7-wire, low-relaxation strands meeting the requirements of ASTM A779.

451-4.3 Anchorage Covers (include for temporary anchors only when shown in the Plans): Use exposed anchorage covers fabricated from steel or ductile cast iron with a minimum thickness of 0.10 inches. Ensure that the cover is securely attached to the anchorage device or bearing plate. If the cover is to be grease filled, ensure the cover forms a permanent watertight enclosure for the anchorage device.

451-4.4 Anchorage Devices: Use anchorage devices capable of developing 95% of the minimum specified ultimate tensile strength of the prestressing steel tendon. Use anchorage devices that meet the static strength requirements of Section 3.1.6(1) and Section 3.1.8(1) of the Post Tensioning Institute "Guide Specification for Post-tensioning Materials". Use couplers for tendon sections capable of developing 95% of the minimum specified ultimate tensile strength.

451-4.5 Cement Grout: Use grout for anchorage consisting of a pumpable mixture of Type I, II, or III portland cement meeting the requirements of AASHTO M85, sand, water, and admixtures. The Contractor may use admixtures which control bleed, improve flowability, reduce water content, and retard set in the grout subject to the approval of the Engineer. The Contractor may only add expansive admixtures to the grout used for filling sealed encapsulations, trumpets, and anchorage covers. Do not use accelerators. Use admixtures compatible with the prestressing steels and mixed in accordance with the manufacturer's recommendations.

Do not perform strength testing as system performance will be measured by proof-testing each anchor. The Department may require grout cube testing if the Contractor uses admixtures or irregularities occur in anchor testing. Use grout that attains a minimum cube strength of 3,400 psi within seven days.

451-4.6 Bearing Plate: Use bearing plates fabricated from steel meeting the requirements of AASHTO M270 or ASTM A709.

451-4.7 Bondbreaker: Use bondbreaker fabricated from a smooth plastic tube or pipe having the following properties:

1. Resistant to chemical attack from aggressive environments, grout, or grease
2. Resistant to aging by ultra-violet light
3. Fabricated from material non-detrimental to the tendon
4. Capable of withstanding abrasion, impact, and bending during handling and installation
5. Enable the tendon to elongate during testing and stressing
6. Allow the tendon to remain unbonded after lock-off.

451-4.8 Centralizers: Use centralizers fabricated from plastic, steel, or material that is nondetrimental to the prestressing steel. Do not use wood. Ensure that the centralizer is able to support the tendon in the drill hole, and position the tendon so a minimum of 0.5 inches of grout cover is provided over the tendon bond length. In addition, locate the upper centralizer a maximum of 5 feet from the top of the tendon bond length, and locate the lower centralizer a maximum of 12 inches from the bottom of the tendon bond length. The Engineer will not require centralizers on pressure injected tendons if the Contractor installs the anchor in coarse grained soils using grouting pressures greater than 150 psi. The Engineer will not require centralizers if the Contractor installs the anchors and grouts them through a hollow stem auger and maintains the hole full of stiff grout (slump less than 9 inches) during extraction of the auger.

451-4.9 Corrosion Inhibiting Grease (include for temporary anchors only when shown in the Plans): For corrosion inhibiting grease, meet the requirements of Section 3.2.5 of the Post Tensioning Institute Specification for Unbonded Single Strand Tendons.

451-4.10 Heat Shrinkable Tubes: Use heat shrinkable tubes fabricated from a radiation cross-linked polyolefin tube internally coated with an adhesive sealant. Prior to shrinking, ensure that the tube has a nominal wall thickness of 24 mils. Ensure that the adhesive sealant inside the tube has a nominal thickness of 20 mils.

451-4.11 Sheath (include for temporary anchors only when shown in the Plans): Use a sheath as part of the corrosion protection system for the unbonded length portion of the tendon fabricated from one of the following:

1. A polyethylene tube pulled or pushed over the prestressing steel. Use polyethylene Type II, III, or IV as defined by ASTM D1248 or approved equal, with a minimum wall thickness of 60 mils, plus or minus 10 mils.
2. A hot-melt extruded polypropylene tube. Use polypropylene cell classification PP 210 B5554211 as defined by ASTM D4101 or approved equal, with a minimum wall thickness of 60 mils, plus or minus 10 mils.
3. A hot-melt extruded polyethylene tube. Use polyethylene high density Type III as defined by ASTM D3350 and ASTM D1248 (or approved equal), with a minimum wall thickness of 60 mils, plus or minus 10 mils.
4. Steel tubing meeting the requirements of ASTM A500, with a minimum wall thickness of 0.20 inches.
5. Steel pipe meeting the requirements of ASTM A53, Schedule 40 minimum.
6. Plastic pipe meeting the requirements of ASTM D1785, Schedule 40 minimum.
7. A corrugated tube meeting the requirement of the tendon bond length encapsulation.

451-4.12 Spacers: Use spacers to separate elements of a multi-element tendon and which permit grout to flow freely up the drill hole. Use spacers fabricated from plastic, steel, or material which is nondetrimental to the prestressing steel. Do not use wood. The Contractor may use a combination centralizer-spacer.

451-4.13 Tendon Bond Length Encapsulations (include for temporary anchors only when shown in the Plans): When the Contract drawings require the tendon bond length to be encapsulated to provide additional corrosion protection, use encapsulation fabricated from one of the following:

1. High density corrugated polyethylene tubing meeting the requirements of AASHTO M252, with a minimum wall thickness of 30 mils
2. Deformed steel tubing or pipes with a minimum wall thickness of 25 mils
3. Corrugated, PVC tubes manufactured from rigid PVC compounds meeting the requirements of ASTM D1784, Class 13464-B.

451-4.14 Trumpet (include for temporary anchors only when shown in the Plans): Use a trumpet to provide a transition from the anchorage to the unbonded length corrosion protection fabricated from a steel pipe or tube meeting the requirements of ASTM A53 for pipe or ASTM A500 for tubing. Use a trumpet that has a minimum wall thickness of 0.125 inches for diameters up to 4 inches and 0.20 inches for larger diameters.

451-4.15 Water: Use potable water for mixing grout.

451-4.16 Grout Tube: Use a grout tube fabricated from a high density polyethylene tube, or a PVC pipe, or a steel pipe with a 0.5 inches minimum inside diameter.

451-5 Tendon Fabrication.

Provide tendons that are either shop or field fabricated. Fabricate the tendon as shown on the approved shop drawings.

Ensure that tendons are free of dirt, rust, or any other deleterious substance. Degrease the bond length.

Handle and protect tendons, prior to installation, in a manner to avoid corrosion and physical damage. The Engineer will consider damage such as abrasion kinks, welds and weld splatters, cuts, and nicks which impair the proper performance of the tendon cause for rejection.

Sheath tendons in the stressing length to prevent contact of the anchor tendon with the drill hole wall. The Contractor may use sheathing that consists of tubes surrounding individual tendon elements or a single tube surrounding the elements altogether.

The Contractor may use sheathing material of either steel, plastic, or any other material nondetrimental to the high strength prestressing steel. The Contractor may use tape to prevent grout from entering under the sheath on individually sheathed elements.

Select the type of tendon to be used. Unless otherwise shown in the Plans, size the tendon so the factored design load does not exceed 80% of the minimum specified ultimate tensile strength of the tendon. Increase the tendon size by the sacrificial steel thickness shown in the Plans. In addition, size the tendon so the maximum test load does not exceed 90% of the minimum yield strength of the tendon.

Assume responsibility for determining the bond length necessary to develop the design load indicated in the Plans or the shop drawings. Use a minimum bond length of 10 feet in rock and 15 feet in soil. Ensure that the minimum tendon bond length is 10 feet.

451-6 Installation.

451-6.1 General:

451-6.1.1 Drilling: Core drilling, rotary drilling, percussion drilling, auger drilling, or driven casing may be used. At the ground surface, locate the drill hole within 12 inches of the location shown in the Plans or the approved shop drawings. Locate the drill hole so that the longitudinal axis of the drill hole and the longitudinal axis of the tendon are parallel. In particular, do not drill the prestressed soil anchor hole in a location that requires the tendon to be bent in order to connect the bearing plate to the supported structure. At the point of entry, install the prestressed soil anchor within plus or minus 3 degrees of the inclination from horizontal shown in the Plans or the approved shop drawings. At the point of entry, make the horizontal angle formed by the prestressed soil anchor and the structure to within plus or minus 3 degrees of a line drawn perpendicular to the plane of the structure unless otherwise shown in the Plans or approved shop drawings. Do not allow the prestressed soil anchors to extend beyond the right-of-way or easement limits shown in the Plans.

451-6.1.2 Tendon Insertion: Insert the tendon into the drill hole to the desired depth. When the tendon cannot be completely inserted, remove the tendon from the drill hole, and then clean or redrill the hole to permit insertion. Do not drive or force partially inserted tendons into the hole.

451-6.1.3 Installation of Trumpet and Anchorage: When corrosion protection is required, extend that portion of the corrosion protection surrounding the unbonded length of the tendon, up beyond the bottom seal of the trumpet or 12 inches into the trumpet if no trumpet seal is provided. If the protection does not extend beyond the seal or sufficiently far enough into the trumpet, extend the corrosion protection, or lengthen the trumpet.

When required, ensure that the corrosion protection surrounding the unbonded length of the tendon does not contact the bearing plate or the anchor head during testing and stressing. If the protection is too long, trim the corrosion protection to prevent contact.

Place the bearing plate and anchor head so the axis of the tendon is perpendicular to the bearing plate within plus or minus 3 degrees and the axis of the tendon passes through the center of the bearing plate.

If using grout protected tendons, electrically isolate the bearing plate, anchor head, and trumpet from the surrounding concrete, soldier pile, or any metallic element embedded in the structure.

Completely fill the trumpet with corrosion inhibiting grease or grout. Trumpet grease may be placed any time during construction. Place trumpet grout after the prestressed soil anchor has been tested and stressed. Demonstrate to the Engineer that the procedures selected for placement of either grease or grout will produce a completely filled trumpet.

For permanent soil anchors, cover all anchorages permanently exposed to the atmosphere with a corrosion inhibiting grease-filled or grout-filled cover. Demonstrate to the Engineer that the procedures selected for placement of either grease or grout will produce a completely filled cover. If the Plans require restressable anchorages, use corrosion inhibiting grease to fill the anchorage cover.

451-6.2 Anchor Grouting: Provide grouting equipment that produces a grout free of lumps and undispersed cement. Use a positive displacement grout pump equipped with a

pressure gauge to monitor grout pressures. Ensure that the pressure gauge is capable of measuring pressures of at least 150 psi or twice the actual grout pressures used, whichever is greater. Size the grouting equipment to enable the grout to be pumped in one continuous operation. Ensure that the mixer is capable of continuously agitating the grout.

Inject the grout from the lowest point of the drill hole. Grout may be pumped through grout tubes, casing, hollow-stem-augers, or drill rods. The grout may be placed before or after insertion of the tendon. Record the quantity of the grout and the grout pressures. Control the grout pressures and grout takes to prevent excessive heave or fracturing.

Except where indicated below, the grout may be placed above the top of the bond length at the same time as the bond length grout but may not be placed under pressure. Ensure that the grout at the top of the drill hole does not contact the back of the structure or the bottom of the trumpet.

If the prestressed soil anchor is installed in a fine-grained soil using drill holes larger than 6 inches in diameter, place the grout above the top of the bond length after testing and stressing the prestressed soil anchor. The Engineer will allow the entire drill hole to be grouted at the same time if it can be demonstrated that the particular prestressed soil anchor system does not derive a significant portion of its load-carrying capacity from the soil above the bond length portion of the prestressed soil anchor.

If using grout protected tendons for prestressed soil anchors anchored in rock, use pressure grouting techniques. For pressure grouting, seal the drill hole, and inject grout until a 50 psi grout pressure (measured at the top of the drill hole) can be maintained on the grout for five minutes.

Upon completion of grouting, the grout tube may remain in the hole, but it must be filled with grout.

After grouting, do not load the tendon for at least three days.

Record the following data concerning the grouting operation:

1. Type of mixer
2. Water/cement ratio
3. Types of additives (if any)
4. Grout pressure
5. Type of cement
6. Strength test samples (if any)
7. Volume of first and second stage grout

451-7 Prestressed Soil Anchor Testing and Stressing.

451-7.1 General: Test each prestressed soil anchor. ~~Perform performance tests as follows:~~The Engineer will select the prestressed soil anchors to be performance tested and those to be creep tested, and~~,~~ at his discretion, may increase or decrease the number of tests.

~~1. on the first two soil anchors installed on the project prior to the grouting of any additional soil anchors. The purpose of these initial tests is to verify the Contractor's installation procedures and the performance of the bond length~~. Perform creep testing and performance testing at the beginning of the anchor installation, prior to installation of the remaining soil anchors, unless directed otherwise by the Engineer. In projects with multiple anchor row levels, the Engineer may request performance and creep testing at the beginning of the installation of soil anchors for subsequent levels. The purpose of these initial tests is to verify the Contractor's

installation procedures, the performance of the bond length, and~~,~~ the calibration of testing equipment.

Perform creep testing as follows:

1. as shown in the Plans

2. on 5% of the prestressed soil anchors.

Perform performance testing as follows:

~~2~~1. as shown ~~o~~in the Plans

~~3~~2. on 10% of the prestressed soil anchors or a minimum of three, whichever is greater.

~~Perform creep testing as follows:~~

~~1. as shown in the Plans~~

~~2. on 5% of the prestressed soil anchors~~

~~The Engineer will select the prestressed soil anchors to be performance tested and those to be creep tested and, at his discretion, may increase or decrease the number of tests.~~

Perform proof tests on all prestressed soil anchors, not subjected to a performance test or a creep test. Record the results of each test on forms approved by the Engineer, such as the testing forms provided in the appendix of the AASHTO/AGC/ARTBA Joint Committee Task Force 27 Report. Submit a separate form for each test. Submit the test results to the Engineer on a weekly basis within one week of testing. Do not apply a load greater than 10% of the factored design load to the prestressed soil anchor prior to testing. For the maximum test load, do not exceed 90% of the minimum yield strength of the tendon. Simultaneously apply the test load to the entire tendon. Do not perform stressing of single elements of multi-element tendons.

Provide testing equipment that consists of:

1. a dial gauge or vernier scale capable of measuring to 0.001 inch to measure the ground anchor movement. Use a movement-measuring device that has a minimum travel equal to the theoretical elastic elongation of the total anchor length at the maximum test load and that has adequate travel so the prestressed soil anchor movement can be measured without resetting the device.

2. a hydraulic jack and pump to apply the test load. Use the jack, with a minimum ram travel of not less than the theoretical elastic elongation of the total anchor length at the maximum test load, and a calibrated pressure gauge, graduated in 100 psi increments or less, or calibrated load cell with readout box, to measure the applied load. Ensure that the jack and pressure gauge are calibrated by an independent firm as a unit, and that the calibration is performed within ~~45~~60 ~~working~~calendar days of the date submitted.

3. ~~When~~Provide an electrical resistance load cell~~s~~ ~~will~~and readout to be used ~~for~~when performing a creep test. Load cell may also be used in performance and proof tests, at the Contractor's discretion. ~~e~~Ensure that the load cell is calibrated by an independent firm and that the calibration is performed within ~~45~~60 ~~working~~calendar days of the date submitted. Obtain the Engineer's approval of the calibration before testing commences. In case of disagreement between the load cell and pressure gage, use the load cell measurement.

~~3~~4. Keep a calibrated reference pressure gauge at the site in possession of the Engineer. Ensure that the reference gauge is calibrated with the test jack and pressure gauge.

~~4~~5. ~~Provide an electrical resistance load cell and readout to be used when performing a creep test. Ensure that the load cell is calibrated by an independent firm and that the~~

~~calibration is performed within 45 working days of the date submitted~~Place the reference pressure gauge in series with the pressure gauge during each performance test.

~~5~~6. Place the stressing equipment over the prestressed soil anchor tendon in such a manner that the jack, bearing plates, load cells and stressing anchorage are axially aligned with the tendon and the tendon is centered within the equipment.

If, during the performance of any load test (proof, performance, or creep), the load determined by the load cell or the load determined by the reference gauge differs by more than 10% from the load determined by the pressure gauge when the pressure gauge measures 80% of the Factored Design Load (0.80 DL), suspend the test, unload the anchor being tested, recalibrate the load cell, jack, pressure gauge, and reference pressure gauge, and repeat the test at no expense to the Department. Obtain the Engineer's approval of the recalibration data prior to resuming testing.

If, at any time, a pressure gauge, reference pressure gauge, or load cell is repaired or replaced, obtain the Engineer's written approval of calibration data of the repaired or the new measuring device (load cell or pressure gauge, or reference gauge) prior to resuming testing. Perform additional performance tests, at no expense to the Department, on the first two soil anchors using a new measuring device to verify the calibration of the equipment.

451-7.2 Criteria for Performing a Performance Test and a Proof Test: Raise the load from one increment to another immediately after recording the prestressed soil anchor movement. Measure and record the prestressed soil anchor movement to the nearest 0.001 inch with respect to an independent fixed reference point at the alignment load and at each increment of load. Monitor the load with a pressure gauge or load cell. At load increments other than the maximum test load, hold the load just long enough to obtain the movement reading.

Hold the maximum test load in a proof test for at least 10 minutes. Pump the jack as necessary in order to maintain a constant load. Start the load-hold period as soon as the maximum test load is applied, and measure and record the prestressed soil anchor movement, with respect to an independent fixed reference, at 1, 2, 3, 4, 5, 6, and 10 minutes. If the prestressed soil anchor movement between 1 minute and 10 minutes exceeds 0.04 inches, hold the maximum test load for an additional 50 minutes. If extending the load-hold, record the prestressed soil anchor movements at 15 minutes, 20, 25, 30, 40, 50 and 60 minutes.

451-7.2.1 Performance Test: ~~Place the reference pressure gauge in series with the pressure gauge during each performance test. If the load determined by the reference pressure gauge and the load determined by the pressure gauge differ by more than 10%, recalibrate the jack, pressure gauge, and reference pressure gauge at no expense to the Department.~~

Perform the performance test by incrementally loading and unloading the prestressed soil anchor in accordance with the following schedule:

Performance Test Schedule	
Load	Load
AL	AL
0.20 DL*	0.20 DL
AL	0.40 DL
0.20 DL	0.60 DL
0.40 DL*	0.80 DL
AL	0.90 DL*

Performance Test Schedule	
Load	Load
0.20 DL	AL
0.40 DL	0.20 DL
0.60 DL*	0.40 DL
AL	0.60 DL
0.20 DL	0.80 DL
0.40 DL	0.90 DL
0.60 DL	1.00 DL*
0.80 DL*	Reduce to lock-off load
AL - is the alignment load. DL - is the prestressed soil anchor factored design load.	

Plot the prestressed soil anchor movement versus load for each load increment marked with an asterisk (*) in the performance test schedule, and plot the residual movement of the tendon at each alignment load versus the highest previously applied load.

451-7.2.2 Proof Test: Perform the proof test by incrementally loading the prestressed soil anchor in accordance with the following schedule:

Proof Test Schedule	
Load	Load
AL	0.80 DL
0.20 DL	0.90 DL
0.40 DL	1.00 DL
0.60 DL	Reduce to lock-off load

Compare the proof test results to the performance test results. If there is any significant variation from the performance test results, perform a performance test on the next anchor.

Plot the prestressed soil anchor movement versus load for each load increment in the proof test.

451-7.3 Criteria for Performing a Creep Test: Perform the creep test by incrementally loading and unloading the prestressed soil anchor in accordance with the performance test schedule given above. At the end of each loading cycle, hold the load constant for the observation period indicated in the creep test schedule below. Use the following times for reading and recording the prestressed soil anchor movement during each observation period: 1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30, 40, 50, 60, 75, 90, 100, 120, 150, 180, 210, 240, 270, and 300 minutes as appropriate. Start each load-hold period as soon as applying the test load. ~~In a creep test, use the pressure gauge and reference pressure gauge or load cell to measure the applied load, and use the load cell to monitor small changes in load during a constant load-hold period.~~ Pump the jack as necessary in order to maintain a constant load.

Plot the prestressed soil anchor movement and the residual movement measured in a creep test as described for the performance test above, and plot the creep movement for each load-hold as a function of the logarithm of time.

Creep Test Schedule	
Load	Observation Period (minutes.)
AL	
0.20 DL	10
0.40 DL	30
0.60 DL	30
0.80 DL	40
0.90 DL	60
1.00 DL	300

451-7.4 Lock-Off: Upon satisfactory completion of all testing, reduce the load to the lock-off load, and transfer the load to the anchorage device. Use a lock-off load that is 80% of the prestressed soil anchor service load. The Contractor may completely unload the prestressed soil anchor prior to lock-off. After transferring the load and prior to removing the jack, take a lift-off reading. Use a lift-off reading that is within 10% of the specified lock-off load. If the load is not within 10% of the specified lock-off load, reset the anchorage, and take another lift-off reading. Repeat this process until obtaining the desired lock-off load.

451-7.5 Cutting of Tendon Protrusions: After an anchor has been accepted by the Engineer, saw cut the portion of the anchor tendon extending beyond the anchorage. Take care not to damage the tendon or the tendon anchorage.

451-7.6 Prestressed Soil Anchor Load Test Acceptance Criteria: The Engineer will accept a performance or proof-tested prestressed soil anchor with a 10 minute load hold if the:

1. Prestressed soil anchor carries the maximum test load with less than 0.04 inches of movement between 1 minute and 10 minutes; and

2. For performance tests, net movement at the maximum test load cycle (movement between alignment load after 0.90 DL and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length. For proof tests, net movement at the maximum test load (movement between alignment load and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length.

The Engineer will accept a performance or proof-tested prestressed soil anchor with a 60 minute load hold if the:

1. Prestressed soil anchor carries the maximum test load with a deformation rate that does not exceed 0.08 inches in the last log cycle of time; and

2. For performance tests, net movement at the maximum test load cycle (movement between alignment load after 0.90 DL and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length. For proof tests, net movement at the maximum test load (movement between alignment load and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length.

The Engineer will accept a creep tested prestressed soil anchor if the:

1. Prestressed soil anchor carries the maximum test load with a creep rate that does not exceed 0.08 inches/log cycle of time; and

2. Net movement at the maximum test load cycle (movement between alignment load after 0.90 DL and the final movement reading at 1.00 DL) exceeds 80% of the theoretical elastic elongation of the test stressing length.

If the total movement of the prestressed soil anchors at the maximum test load does not exceed 80% of the theoretical elastic elongation of the test stressing length, replace the prestressed soil anchor at no cost to the Department.

Stop the creep test as soon as the creep rate exceeds 0.08 inches/log cycle of time. Incorporate prestressed soil anchors which have a creep rate greater than 0.08 inches/log cycle of time in the finished work at a load equal to one-half its failure load. The failure load is the load carried by the prestressed soil anchor after the load has been allowed to stabilize for 10 minutes without exceeding 0.04 inches of movement between 1 and 10 minutes.

When a prestressed soil anchor does not satisfy the load test acceptance criteria, the Contractor may modify the design and/or the construction procedures. These modifications may include, but are not limited to, installing replacement prestressed soil anchors, reducing the factored design load by increasing the number of prestressed soil anchors, modifying the installation methods, increasing the bond length or changing the prestressed soil anchor type. Obtain the Engineer's approval prior to making any modification which requires changes to the structure. Perform any modifications at no additional cost to the Department. The Department will not allow additional Contract Time for modifications. The Engineer will not allow retesting of the failed prestressed soil anchor.

451-8 Corrosion Protection (include for temporary anchors only when shown in the Plans).

451-8.1 General: Protect prestressed soil anchors against corrosion using materials and procedures described herein. The following materials may be used independently or in various combinations:

1. Portland cement grout
2. Plastic pipe or tubing
3. Steel pipe or tubing
4. Greases specially compounded for post-tensioning
5. Bitumens
6. Heat shrinkable polyethylene tubing

Use corrosion protection materials with properties that are not detrimental to the prestressing steel and that prevent the intrusion of corrosive environments. Use coating materials that also have the following properties:

1. Free from cracks and not brittle or fluid over the entire anticipated range of temperature
2. Chemically stable for the life of the tendon
3. Nonreactive with the surrounding materials such as concrete, tendons, or sheathing
4. Corrosion-inhibiting
5. Impervious to moisture

When acidic water can enter the bore hole during the period subsequent to the drilling and flushing operation and prior to tendon insertion and grouting, introduce chemical additives for neutralizing purposes. Maintain a minimum pH of 9.0 when the prestressing steel is in contact with this water. During prolonged periods, monitor the pH at regular intervals, and add additional neutralization as required. Concentrated sodium hydroxide and calcium hydroxide have proven effective for this purpose.

451-8.2 Protection Systems:

451-8.2.1 Bond Length:

1. When the Plans require grout protected prestressed soil anchor tendons, meet the following requirements:

a. Provide corrosion protection of the tendon bond length by the cement grout cover.

b. Use spacers along the tendon bond length of multi-element tendons to separate each of the individual elements of the tendon so the prestressing steel will bond to the grout. Position spacers so their center to center spacing does not exceed 10 feet. In addition, locate the upper spacer a maximum of 5 feet from the top of the tendon bond length, and locate the lower spacer a maximum of 5 feet from the bottom of the tendon bond length.

c. Use centralizers to ensure a minimum of 0.5 inches of grout cover over the tendon bond length. Position centralizers so their center to center spacing does not exceed 10 feet. In addition, locate the upper centralizer a maximum of 5 feet from the top of the tendon bond length, and locate the lower centralizer a maximum of 12 inches from the bottom of the tendon bond length.

d. The Engineer will not require centralizers on pressure-injected prestressed soil anchor tendons if the prestressed soil anchor is installed in coarse-grained soils using grouting pressures greater than 150 psi.

e. The Engineer will not require centralizers on hollow-stem-augured prestressed soil anchor tendons if the prestressed soil anchor is grouted through the auger and the hole is maintained full of a stiff grout, (9 inches slump or less) during extraction of the auger.

2. When the Plans require the tendon bond length to be encapsulated:

a. Protect the tendon bond length portion of the tendon against corrosion by encapsulating the tendon in a grout-filled corrugated plastic or deformed steel tube. Grout the tendon inside the encapsulation prior to inserting the tendon in the drill hole or after the tendon has been placed in the drill hole. Mix expansive admixtures with the encapsulation grout if the tendon is grouted inside the encapsulation prior to inserting it in the drill hole. Centralize the tendon within the tendon bond length encapsulation with a minimum of 0.10 inches of grout cover. Use spacers along the tendon bond length of multi-element tendons to separate the elements of the tendon so the prestressing steel will bond to the encapsulation grout.

b. Use centralizers to provide a minimum of 0.5 inches of grout cover over the tendon bond length encapsulation. Position centralizers so their center to center spacing does not exceed 10 feet. In addition, locate the upper centralizer a maximum of 5 feet from the top of the tendon bond length, and locate the lower centralizer a maximum of 12 inches from the bottom of the tendon bond length.

c. The Engineer will not require centralizers on encapsulated, pressure-injected prestressed soil anchor tendons if the prestressed soil anchor is installed in coarse-grained soils using grouting pressures greater than 150 psi.

d. The Engineer will not require centralizers on encapsulated, hollow-stem-augured prestressed soil anchor tendons if the prestressed soil anchor is grouted through the auger and the hole is maintained full of a stiff grout (9 inches slump or less) during extraction of the auger.

451-8.2.2 Unbonded Length: For the minimum unbonded length of the tendon, use 15 feet or as indicated in the Plans or the approved shop drawings, whichever is greater.

If grouting the entire drill hole (tendon bond length and unbonded length) in one operation, provide the corrosion protection of the unbonded length by a sheath completely filled with corrosion inhibiting grease or grout, or a heat shrinkable tube internally coated with an elastic adhesive. If using grease under the sheath, make provisions to prevent the grease from escaping at the ends of the sheath. With grease, completely coat the tendon, fill the void between the tendon and the sheath, and fill the interstices between the wires of the 7-wire strands. Ensure that the shop drawings show how to provide a transition between the bond length and the unbonded length corrosion protection. If the sheath is grout filled, provide a separate bondbreaker that prevents the tendon from bonding to the grout surrounding the unbonded length.

If providing grease-filled sheath corrosion protection and the drill hole above the bond length is grouted after locking off the prestressed soil anchor, grout the tendon inside a second sheath.

451-8.2.3 Anchorage and Trumpet: Use non-restressable anchorage devices except where indicated in the Plans. Provide restressable anchorages on those prestressed soil anchors designated as restressable in the Plans. Ensure that the post-tensioning supplier provides a restressable anchorage compatible with the post-tensioning system provided along with written recommendations concerning the restressing of the tendons.

If using strand tendons, submit written recommendations from the post-tensioning supplier for seating the wedges. Include with the recommendations the minimum load required to properly seat the wedges in the anchor head.

Size the bearing plates so that:

1. the bending stresses in the plate do not exceed the yield strength of the steel when applying a load equal to 95% of the minimum specified ultimate tensile strength of the tendon; and

2. the average bearing stress on the concrete does not exceed that recommended in Section 3.1.7 of the Post Tensioning Institute Guide Specification for Post-Tensioning Materials.

Weld the trumpet to the bearing plate. Provide a trumpet that has an inside diameter equal to or larger than the hole in the bearing plate. Ensure that the trumpet is long enough to accommodate movements of the structure during testing and stressing. For strand tendons with encapsulation over the unbonded length, provide a trumpet that is long enough to enable the tendon to make a transition from the diameter of the tendon in the unbonded length to the diameter of the tendon at the anchor head without damaging the encapsulation. Ensure that trumpets filled with corrosion-inhibiting grease have a permanent Buna-N synthetic rubber or approved equal seal provided between the trumpet and the unbonded length corrosion protection. Ensure that trumpets filled with grout have a temporary seal provided between the trumpet and the unbonded length corrosion protection or that the trumpet overlaps the unbonded length corrosion protection by a minimum of 12 inches and fits tightly over the unbonded length corrosion protection.

451-9 Submittals.

Prepare and submit Shop drawings and a design submission describing the prestressed soil anchor system or systems intended for use to the Engineer for review and approval

30 working days prior to the commencement of the prestressed soil anchor work. Include the following in the shop drawings and design submission:

1. A prestressed soil anchor schedule providing the following:
    a. Prestressed soil anchor number
    b. Prestressed soil anchor factored design load
    c. Type and size of tendon
    d. Minimum total anchor length
    e. Minimum bond length
    f. Minimum tendon bond length
    g. Minimum unbonded length
2. A drawing of the prestressed soil anchor tendon and the corrosion protection system. Include details for the following:
    a. Spacers and their location
    b. Centralizers and their location
    c. Unbonded length corrosion protection system
    d. Bond length corrosion protection system
    e. Anchorage and trumpet
    f. Anchorage corrosion protection system
3. Certificates of Compliance for the following materials, if used, stating that the material or assemblies to be provided will fully comply with the requirements of the Contract.
    a. Prestressing steel, strand or bar
    b. Portland cement
    c. Prestressing hardware
    d. Bearing plates
    e. Corrosion protection system

The Engineer will approve or reject the shop drawings and design submission within 30 working days after receipt of the submission.

Submit to the Engineer for review and approval or rejection mill test reports for the prestressing steel and the bearing plate steel. The Engineer may require the Contractor to provide samples of any prestressed soil anchor material intended for use on the project. The Engineer will approve or reject the prestressing steel and bearing plate steel within five working days after receipt of the test reports. Do not incorporate the prestressing steel and bearing plates in the work without the Engineer’s approval.

Submit to the Engineer for review and approval or rejection calibration data for each test jack, pressure gauge, and reference pressure gauge to be used. The Engineer will approve or reject the calibration data within five working days after receipt of the data. Do not commence testing until the Engineer has approved the jack, pressure gauge, and reference pressure gauge calibrations.

Submit to the Engineer within 20 calendar days after completion of the prestressed soil anchor work a report containing:

1. prestressing steel manufacturer’s mill test reports for the tendons incorporated in the installation
2. grouting records indicating the cement type, quantity injected, and the grout pressures
3. prestressed soil anchors test results and graphs.

451-10 Tendon Storage and Handling.

Handle and store tendons in a manner to avoid damage or corrosion. The Engineer will consider damage to the prestressing steel as a result of abrasions, cuts, nicks, welds and weld splatter cause for rejection. Protect the prestressing steel if performing welding in the vicinity. Do not ground welding leads to the prestressing steel. Protect prestressing steel from dirt, rust, or deleterious substances.

The Engineer will allow a light coating of rust on the steel. If heavy corrosion or pitting is noted, the Engineer will reject the affected tendons.

Use care in handling and storing the tendons at the site. Prior to inserting a tendon in the drill hole, examine the tendon for damage to the encapsulation and the sheathing. If, in the opinion of the Engineer, the encapsulation is damaged, repair the encapsulation in accordance with the tendon supplier's recommendations. If, in the opinion of the Engineer, the smooth sheathing has been damaged, repair it with ultra high molecular weight polyethylene tape. Spiral wind the tape around the tendon to completely seal the damaged area at a pitch that ensures a double thickness at all points.

451-11 Method of Measurement.

Unless otherwise shown in the Plans, the quantity to be paid for will be the number of prestressed soil anchors, based on the maximum anchor spacing shown in the Plans, installed and accepted. For prestressed soil anchors that do not meet the acceptance criteria, the original prestressed soil anchor and any required additional work or prestressed soil anchors will be, in sum, considered to be one prestressed soil anchor for payment purposes.

451-12 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including furnishing the materials necessary to complete the anchors in place and accepted. The quantity of performance and creep tests to be paid for will be the number of tests performed on accepted anchors.

The cost of proof testing will be included in Item No. 451-70.

No payment will be made for tests performed on unaccepted anchors.

Payment will be made under:

Item No. 451- 70-	Prestressed Soil Anchors - each.
Item No. 451- 70-1	Prestressed Soil Anchor (Performance Tests) - each.
Item No. 451- 70-2	Prestressed Soil Anchors (Creep Tests) - each.