

# Special Specification 4149

## Prestressed Ground Anchors



### 1. DESCRIPTION

Install post-tensioned permanent ground anchors in place, with grouting in accordance with these specifications. Ensure the ground anchors provide the load carrying capacities that will develop the load as required in the plans and the approved working drawings and in accordance with the testing requirements of this specification.

The Contractor is responsible for the design of the soil anchor system in accordance with the general design criteria provided in the plans. The Contractor has the option of furnishing any type of post-tensioning system and chooses the anchor diameter to develop the required load and meet the requirements of these specifications. If approved by the Engineer, the Contractor may also propose to use proprietary systems, which do not conform to the provisions of this specification. Assure that the system selected provides the magnitude and distribution of design prestressing force and minimum ultimate strength required by the plans without exceeding allowable temporary stresses. Install additional anchors if the Contractor cannot provide the load carrying capacities in accordance with the plans. The Contractor has the option to change the anchoring procedure with the approval of the Engineer, as long as the required load carrying capacity is achieved. Ensure design procedures, coefficients, and allowable stresses are in accordance with the latest Standard AASHTO Specifications for Highway Bridges.

The Contractor is responsible for the design of the anchor and bearing plate, determining drilling methods, and determining hole diameter and bond length. Submit design computations and data for the soil anchors, bearing plates, and bond zones. Include in the computations drawings, design assumptions, calculations, and other information in sufficient detail to verify the proposed design. Sign and seal the design by a licensed professional engineer with proven experience in design of soil anchor components. Include calculations for the stressing frames.

The Engineer's review and approval of the design calculations does not relieve the Contractor of responsibility for unsatisfactory performance of the installed soil anchors. Describe the sequence for installation and other restrictions as outlined on the plans or as specified herein. Determine the anchor and casing installation procedures as part of the anchor design.

### 2. MATERIALS

Provide materials required for use under this Item conforming to Table 1:

Table 1  
Materials

Material	Conform to Item
Structural Steel	Item 441, "Steel Structures" and Item 442, "Metal for Structures"
Grout, Prestressing Steel	Item 426, "Post-Tensioning"
Galvanizing	Item 445, "Galvanizing"

Provide prestressing steel conforming to one of the following types:

- Seven wire strand conforming to ASTM Designation A416 or,
- High-tensile strength alloy bars conforming to the requirements of ASTM designation A722.

Bars with greater minimum ultimate strength, but otherwise produced and tested in accordance with ASTM Designation A722, may be used provided they have no properties which make them less satisfactory than the specified material.

Wire or strand with greater ultimate strength but otherwise produced and tested in accordance with ASTM designation A416 and A421, and the requirements of this specification, are permitted provided the physical properties as outlined in the applicable specification are shown on the shop drawings and provided they have no properties which make them less satisfactory than the specified material.

Each ground anchor tendon is either a single bar or group of strands having a common end anchorage used to apply a stressing force to the structural member. Provide coated (unbonded) tendons except the portion which is established as the anchorage length. Coat the tendons a minimum of the unbonded length shown in the plans. Ensure the anchorage length is bare and completely free of grease or other contaminants. Provide the minimum acceptable anchorage lengths shown in the plans.

Provide end anchorages and tendon couplers that develop at least 100% of the required ultimate strength of the tendon with a minimum elongation of 2%.

Use material for coating unbonded tendons that is non-volatile, low friction mineral oil base grease, with a rust preventing additive having a relatively uniform viscosity in a temperature range of 20 F to 120 F. Provide a protective sheathing around the tendon throughout the coated length consisting of 0.04 in. minimum thickness polyethylene or polyvinyl chloride tubing capable of maintaining the tendon tightly bundled and containing the lubricant.

Provide grout for ground anchors that is a neat cement or sand cement mixture, with a 7-day compressive strength of 3500 psi. Determine grout strengths by testing 2-in. cubes in accordance with Test Method TEX-442-A or 3 in. diameter by 6 in. high cylinders in accordance with Test Method TEX-418-A. Determine the grout strength by testing the initial grout batch. Additional testing is necessary if the grout mixture is modified or if required by the Engineer. If allowed by the Engineer, test results from previous projects using an identical grout mix may be accepted.

Identify the tendons by heat number, or reel number in the case of seven-wire strand, and tag them for identification. Identify anchorage assemblies in a like manner. At the request of the Engineer, furnish specimens for test purposes in accordance with Test Method TEX-710-I. Provide mill test reports for tendons used in permanent anchors.

Test complete tendons for compliance with the requirements of this specification at no expense to the Department and certify the results in writing. In addition, furnish for testing, one specimen of each size of prestressing tendon with end fittings attached at each end for ultimate strength tests only.

Provide a specimen 5 ft. in clear length measured between the ends of the fittings. If the results of the test indicate the necessity of check tests, furnish additional specimens at no cost to the Department. For prestressing systems previously tested and approved on Department projects, complete tendon samples need not be furnished provided there is no change in the material, design, or details previously approved. For the shop drawings or prestressing details, identify the project on which approval was obtained, otherwise sampling will be necessary. For prefabricated ground anchor assemblies, notify the Engineer at least 10 days before installing the end fittings or heading the wires so that sampling and testing may be arranged.

Hot dip galvanize bearing anchor plates and components of the anchor assembly in accordance with Item 445, "Galvanizing."

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### 3. PACKAGING, STORING, AND HANDLING

Protect the prestressing steel against physical damage and corrosion from the time of manufacture to grouting or encasing in concrete.

Rust on prestressing steel, which can be removed by light rubbing, is acceptable. Streaks or spots, which may remain after rust removal, are acceptable if no pitting is present. Tight mill scale is acceptable but remove loose mill scale.

Protect prefabricated ground anchor assemblies from moisture by taping, wrapping, or by other acceptable means.

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#### 4. EQUIPMENT

Furnish suitable equipment to drill the holes to the diameter, depth, and line as specified in this specification or on the approved working drawings.

Furnish suitable hydraulic jacks for stressing the tendons. Equip jacks with gauges graduated to read directly to one percent of the total load applied, and calibrated to measure accurately the stress induced in the steel.

Provide jacks with a stroke of adequate length so that the stressing, including temporary overstress, can be done in one movement. Equip them with proper ports or windows for adequate visual examination and measurement of tendon movement. Ensure they are also capable of slow release of stress to allow relaxation from overstress to the proper seating force.

Furnish a grout mixer and pump of sufficient capacity to properly place grout in the quantities required.

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#### 5. WORKING DRAWINGS

Submit references from 3 constructed projects over the last 5 years substantiating experience in the design of prestressed grouted anchors by the Contractor's licensed professional engineer. Submit design and working drawings (i.e. shop drawings) for the ground anchors a minimum of one month before the installation of the ground anchors. Provide the details containing the necessary information for construction including:

- 5.1. **Prestressing Details.** On the drawings show details of type, size, number of units per ground anchor, ground anchor diameter, inclination, forces applied per anchor, end anchorage systems, grouting and venting ports, grouting procedure, acceptable elongation, temporary overstress, and other information necessary to properly complete the work.

On these details, show the method of support for the ground anchors to ensure that the proper location in the center of the hole can be maintained.

- 5.2. **Anchor Layout.** Provide drawings showing the layout of the anchors and required load.

Electronically submit working drawings formatted to fit standard 11 in. x17 in. sheets in accordance with the Department's "Guide to Electronic Shop Drawing Submittals."

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#### 6. CONSTRUCTION

- 6.1. **General.** Before stressing the anchors, furnish certified copies of load calibration curves on the jacks and gauge systems to be used in the work. Recalibrate the stressing systems when required by the Engineer.

- 6.2. **Drilling.** Drill the hole within +/- 3 degrees from the line specified on the approved working drawings to the depth and diameters determined by the Contractor to provide the design bond length and capacity.

- 6.3. **Grouting.** Clear the hole of debris before placing the tendon. Insert the tendon in the hole and use supports to ensure that the tendon is centered in the hole with a maximum 1 in. of sag between the supports. Provide a grouting pipe that allows placing the grout from the bottom of the hole. Before beginning to pump the grout, check the grout tubes to ensure they are clear. When the tendon is grouted through the center of a hollow auger, no grout tube or centralizers are required as long as grout pressure is maintained while withdrawing the auger.

Grout the anchors immediately after placing them in the hole. Pump the grout from the bottom of the hole toward the top, continuously under pressure, until the grout is within approximately one foot of the top of the hole. Grout the hole full length in one stage with clearance provided between the grout and the tendon anchorage.

If the grout level in the hole cannot be maintained, withdraw the tendon and redrill the hole after at least 24 hrs. have passed.

Record the data shown in Table 2 concerning the grouting:

**Table 1**  
**Grouting Data to Record**

Water-cement ratio  
Types of additives  
Types of cement  
Volume of grout  
Type of Mixer

- 6.4. **Corrosion Protection.** Provide "Double Corrosion Protection" in which the post-tensioned strand or bar is encapsulated in a corrugated plastic sheath (>40 mil) and cement grout annulus. Submit this detail to the Engineer for review and approval.
- 6.5. **Post-Tensioning.** Do not begin post-tensioning until the concrete in the associated structural members has reached the sufficient design strength in accordance with the Contractor's design.

Provide suitable means for measuring the movement of the anchor head to the nearest 0.001 in.

Indicate on the prestressing details, a sequence of post-tensioning that prevents overstressing the structural member.

Ensure the prestressing details submitted reflect the following general tensioning procedure modified as required for each particular installation, unless otherwise required by the plans.

- Show tendons in the sequence designated in the Prestressing Details.
- Perform initial tensioning to take the slack out of the tendons at 10% of the maximum tensioning load unless otherwise shown on the approved Prestressing Details.
- After the initial tensioning, set up an independent reference to measure the anchor movement.

Ensure the movement measured between the maximum proof load and the lock-off load is within the following limits:

- Determine the minimum movement limit based on the elastic elongation calculated using 80% of the unbonded length.
- Determine the maximum movement limit based on the elastic elongation calculated using the entire unbonded length plus 50% of the bonded length.

If the movement measured is not within the above specified limits, the anchor will be rejected. In that case, install a replacement anchor at no cost to the Department.

- Proof load every anchor to not less than 133 percent of its design loading. During the proof loading operation, the prestressing force is not allowed to be more than 80 percent of the guaranteed ultimate strength of the prestressing steel. Perform the proof loading for 2 minutes. Successively apply and record total movements for the following load increments to the test load: 0.25DL, 0.50DL, 0.75DL, 1.00DL, 1.20DL, 1.33DL (i.e., the test load). Hold the test load for 2 min. and record the movement. If the anchor movement exceeds 0.02 in. during the 2 min. hold, proceed as described in the performance

test section with the test load held for a total of 60 min. Assure that the prestressing force is transferred (locked-off) at a level of between 10 and 70 percent of its guaranteed ultimate tensile strength as required to provide the design loads shown on the plans.

- Conduct performance testing of 5 percent or a minimum of 3 anchors, whichever is greater, in accordance with the following procedures. Designate the first 3 anchors at any section of the bulkhead as demonstration test anchors used to verify soil quality and the adequacy of the Contractor's anchor design and installation procedures. Ensure demonstration test anchors pass the performance test before placing other anchors within that section.

For the performance test, incrementally load and unload the anchor in accordance with the following schedule. All loads except the maximum test load need only be held long enough to obtain the movement reading.

**Performance Test Schedule**

AL	AL
0.25 DL	0.25 DL
AL	0.50 DL
0.25 DL	0.75 DL
0.50 DL	1.00 DL
AL	1.20 DL
0.25 DL	AL
0.50 DL	0.25 DL
0.75 DL	0.50 DL
AL	0.75 DL
0.25 DL	1.00 DL
0.50 DL	1.20 DL
0.75 DL	1.33 DL Maximum Test Load
1.00 DL	AL

AL - Alignment Load; DL - Design Load

Hold the maximum test load for 10 min. Record the anchor movement with respect to a fixed reference at 1, 2, 3, 4, 5, and 10 min. If the movement between 1 min. and 10 min. exceeds 0.04 in., continue the test for an additional 50 min. If the test is extended, record the movement at 15, 20, 30, and 60 min. Measure time after reaching the 1.33 DL increment. If the movement exceeds 0.08 in. during the 50 min. hold (i.e. from 10 min. to 60 min.) the anchor will be rejected and considered a failure.

- If anchor fails at a certain pre-assigned location, the Contractor has the option to offset the anchor location at a distance of 3 times the sleeve diameter. The Contractor will submit shop drawings for additional locations for the approval by the Engineer.
- Before final grouting, perform lift off tests 48 hr. after the initial tensioning on the first permanent ground anchor and on the same anchors for which performance testing was carried out on. Ensure the lift off load is within 10% of the lock off load.
- Perform final grouting of the anchor plate area as indicated on the plans within 3 days after tensioning and lift off tests for an anchor have been completed.

Ground anchors will be considered acceptable if the anchor movement in any testing does not exceed the 0.08 in. per log cycle of time. Assure that the anchor movements fall within the limits stated in Article 6.

Anchors which fail to attain the maximum test load required as stated above may be incorporated into the anchorage system at a load capacity equal to one half their failure loads. The failure load is the load indicated by the pressure gauge 10 min. after failure occurs. Install additional anchors to replace or supplement the failed anchor. The Contractor is responsible for the entire cost of installing any required additional anchors, or changes in the original anchor design.

Size the holes drilled in existing sheet piling for prestressed ground anchor assemblies as small as practicable to allow for installation of the assembly.

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**7. MEASUREMENT**

This Item will be measured by foot of fully acceptable anchors complete in place.

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**8. PAYMENT**

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Prestressed Ground Anchors." This price is full compensation for design, work performed, materials furnished, bearing anchor plates, ground anchor tests, labor, tools, equipment, and incidentals.