SECTION 00596E – GROUND ANCHORS

(Follow all instructions and make all edits with "Track Changes" turned on. This Section is not published in the Oregon Standard. If there are no instructions [orange text] above a subsection, paragraph, sentence, or bullet, then include it in the project, unless the item(s) that are included in the subsection, paragraph, sentence, or bullet are not required on the Project and then they should be deleted. In general do not re-number or re-letter subsections when item(s) are deleted. Delete all orange text before preparing the final document. All other modifications to this Section will require ODOT Technical Resource and State Specifications Engineer approval.)

(Notes for use: Provide LRFD factored design loads, locations, minimum unbonded length, minimum bond lengths, soil or rock-grout bond strength, Class I corrosion protection requirement, and any limitations on anchor inclination in the plans or special provisions. The Contractor is then responsible for selecting the type of anchor and designing the anchor system to satisfy the design criteria provided. Sufficient foundation information must be given to permit the Contractor to perform the design and installation. This special provision is written for common downward inclined ground anchors like those used as tie-backs for top-down construction retaining walls. Special uses such as vertical seismic tie-down anchors will need additional project specific revision.)

Section 00596E, which is not a Standard Specification, is included in this Project by Special Provision.

Description

00596E.00 Scope - This Work consists of designing, furnishing, installing, testing, stressing and locking-off prestress load in permanent Ground Anchors at locations shown and as specified. The Work also includes installation and testing of sacrificial Ground Anchors for design verification, and furnishing, installing and removing assemblies necessary to perform the Work.

Select the Ground Anchor type, drill hole diameter, Bond Length, drilling method, installation method and grouting method to provide the specified load-carrying capacity and satisfy the acceptance criteria.

00596E.01 Definitions:

Alignment Load (AL) - A nominal load applied to each anchor to maintain correct position of testing equipment.

Anchor Head - The Anchor Head includes wedges and a wedge plate for strand tendons or an anchor nut for bar tendons. The Anchor Head transfers the prestressing force from the prestressing steel to the Bearing Plate.

Anchorage - The combined system of Anchor Head, Bearing Plate, Trumpet, and corrosion protection that transfers prestressing force from the prestressing steel to the surrounding ground or the supported structure.

Bearing Plate - A steel plate under the Anchor Head that distributes the prestressing force to the anchored structure.

Bond Length - The grouted length of the Ground Anchor that is bonded to surrounding Soil or Rock and transfers applied tensile load to the surrounding Soil or Rock.

Class I Corrosion Protection System - A Class I Corrosion Protection System encases the prestressing reinforcement inside a plastic sheath filled with either grout or corrosion-inhibiting compound. A Class I protected tendon is also referred to as an encapsulated tendon or a double-corrosion-protected tendon.

Creep Test - A test to determine the movement of the Ground Anchor at a constant load. Ground Anchor movement is recorded at specified intervals in the Creep Test.

Factored Design Load (FDL) - The value shown or specified for the Ground Anchor design controlling limit state combination of factored loads determined by AASHTO LRFD methodology. Test schedules presented herein present incremental load and the maximum test load in terms of Factored Design Load (FDL).

Free Stressing Length - The designed length of the tendon that is not bonded to the surrounding ground or grout during stressing. Free Stressing Length is also referred to as unbonded length.

Ground Anchor - A structural system consisting of a tendon installed in a drilled and grouted hole in the ground (Soil or Rock) that is stressed after installation and used to transmit the applied tensile load to the ground. Anchorage, Free Stressing Length, and Bond Length are the basic components of a Ground Anchor.

Lock-Off Load - The load transferred to the Anchorage after the load testing is complete and the anchor has been accepted.

Performance Test - Cyclic incremental test loading and unloading of a production anchor and recording the total movement of the Anchor Head at each increment. A Creep Test is performed at the maximum test load in a cycle as indicated in the Performance Test schedule.

Preproduction Verification Test - Cyclic incremental test loading and unloading of a sacrificial anchor and recording the total movement of the Anchor Head at each increment. A Creep Test is performed at the maximum test load in a cycle as indicated in the Preproduction Verification Test schedule. Preproduction Verification Test is used to verify Contractor's Ground Anchor design and installation procedure.

Proof Test - Incremental loading and unloading of a production anchor and recording the total movement of the Anchor Head at each increment. A Creep Test is performed at the maximum test load as indicated in the Proof Test schedule. Proof Test is used to verify grout/ground bond strength.

Tendon Bond Length - The length of tendon bonded to the anchor grout.

Transition Tube - A common sheath that is inserted into the top of the fluid grout and extended into the Trumpet.

Trumpet - Device to provide corrosion protection in the transition length from the Bearing Plate to the Free Stressing Length.

00596E.04 Preconstruction Working Drawings, Design Calculations, and Submittals - Submit preconstruction Working Drawings, design calculations and submittals according to 00150.35 except as modified by this Subsection.

(a) Ground Anchor Design - Design Ground Anchors with Class 1 corrosion protection using LRFD design method according to the current edition of the following:

- *AASHTO LRFD Bridge Design Specifications,*
- *Geotechnical Engineering Circular No. 4 Ground Anchors and Anchor Systems (FHWA-IF-99-015),*
- *Post Tensioning Institute Recommendations for Prestressed Rock and Soil Anchors.*

Select the type of tendon and size the tendon to ensure the Factored Design Load and maximum test load do not exceed 80 percent of the minimum ultimate tensile strength of the prestressing steel.

(The minimum bond lengths in the following paragraph may be reduced/revised if recommended by the geotechnical report.)

Determine the Bond Length necessary to develop the given Factored Design Load. The minimum Bond Length for strand is 15 feet. The minimum Bond Length is 10 feet for bars 1.75 inch diameter and smaller, and 15 feet for bars larger than 1.75 inch diameter.

The minimum Free Stressing Length (unbonded length) is 15 feet for strand and 10 feet for bar, unless a greater minimum length is shown or specified.

(b) Stamped Working Drawings - Before beginning construction of permanent Ground Anchors, submit the following stamped Working Drawings and calculations according to 00150.35. Include all stamped design calculations, details, dimensions, quantities, ground profiles, and cross-sections necessary to construct Ground Anchor tiebacks, and for members and connections for any portion of the anchor not shown. Include the following:

(1) Ground Anchor schedule including:

- Ground Anchor number,
- Type, size and specification of Ground Anchor tendon,
- LRFD Factored Design Load and maximum test load,
- Lock-off Load,
- Minimum Tendon Bond Length,
- Minimum Bond Length,

- Minimum unbonded length,
- Minimum total anchor length.

(2) Shop drawings of the Ground Anchor and the corrosion protection system including the following details:

- The relationship of the Ground Anchors to Right-of-Way and easement lines, utilities, structures and other construction,
- Tendon bar size or number of strands,
- Spacers and their location,
- Centralizers and their location, including the permanent rubber seal between the Trumpet and the tendon unbonded length corrosion protection and the transition between the Tendon Bond Length and the unbonded tendon length,
- Bar tendon coupler locations, if used,
- Unbonded length corrosion protection system,
- Bond breaker in the unbonded length,
- Bond Length corrosion protection system,
- Anchorage and Trumpet,
- Anchorage corrosion protection system,
- Grout tubes,
- Drilling methods including drill hole diameter, Equipment, and access space requirements,
- Grout mix design, test procedure, placement Equipment and procedure, minimum cure time,
- Jacking frame and bracing assembly, method and Equipment for testing and measuring movement during testing.

(3) Design calculations including:

- The Ground Anchor system and Bond Length,
- Testing and stressing frame assembly,
- Verification test reaction pad.

(4) Construction procedure, installation plan, and testing procedure

(c) Unstamped Submittals - Submit the following before beginning construction of permanent Ground Anchors:

- Materials certificates of compliance and quality compliance documents for:

  - Prestressing reinforcement,
  - Portland cement,
  - Prestressing hardware,
  - Bearing Plates,

- Corrosion protection system.
- Personnel qualifications according to 00596E.30.
- Equipment list according to 00596E.20.
- Calibration data for each test jack, load cell, primary pressure gauge and reference pressure gauge to be used.

00596E.05 Ground Anchor Construction and Test Data Report Submittals - Submit a summary report to the Engineer before the end of the ~~W~~work ~~D~~day that each anchor is installed and tested unless otherwise noted. Include the following information:

- Project and date,
- Names of personnel responsible for design, fabrication, installation and testing of the anchor and Agency's Inspector,
- List of testing Equipment used,
- Drawing showing the Ground Anchor's location, orientation, anchor type, anchor capacity, tendon type, total anchor length, Bond Length, unbonded length, and Tendon Bond Length,
- Drill hole diameter, drilling method, elevation groundwater encountered, subsurface conditions encountered,
- Grouting pressure and quantity,
- Results of the load test, including completed testing field data records for load increments and time periods in 00596E.42(b), 00596E.42(d), and 00596E.42(e) and appropriate presentation figures, charts and graphs,
- Summary statement of test results, including whether the load test met or failed to meet the criteria.

Submit test data reports as Stamped Working Drawings according to 00150.35.

Materials

00596E.10 General - Provide Materials meeting the requirements of this Section. Do not deliver Materials to the site until the Engineer has approved the Materials submittals outlined in 00596E.04. Store and handle prestressing steel strands and bars according to the manufacturer's recommendations and in such a manner that no damage to the component parts occurs. Protect all steel components from the elements at all times. Store cement and additives for grout under cover and protect against moisture.

00596E.11 Materials - Furnish Materials meeting the following requirements:

(a) Ground Anchor - Furnish the complete anchor system according to the *Post Tensioning Institute (PTI) Recommendations for Prestressed Rock and Soil Anchors*, including prestressing reinforcement, Anchorage, Class I corrosion protection, sheathings, spacers, centralizers and grout. Corrosion protection is not required for sacrificial verification test anchors.

(In the bullet list, delete the types of prestress reinforcement that will not be considered for use on the project, if any. Check with the designer.)

(b) Prestressing Reinforcement - Fabricate tieback tendons from single or multiple elements of the following:

- Seven-wire low-relaxation strand according to 02515.10,
- Continuously Threaded High Strength Steel Bars according to 02515.30,
- “Compact” seven-wire, low-relaxation strands according to ASTM A779,
- Epoxy coated steel bars according to ASTM A775.

Hollow-core, self-drilling bar tendons are not acceptable.

Use prestressing steel bar couplers capable of developing 100 percent of the minimum ultimate tensile strength of the prestressing steel bar.

Use continuous prestressing strand reinforcement without splices or couplers.

(c) Tendon Bond Length Encapsulations - Fabricate the Tendon Bond Length encapsulation from one of the following:

- High density corrugated polyethylene tubing conforming to the requirements of AASHTO M 252 and having a minimum wall thickness of 0.16 inch except pregrouted tendons which may have a minimum wall thickness of 0.04 inch.
- Deformed steel tubing or pipes conforming to ASTM A53 Grade B or ASTM A500 Grade B (Fy = 46 ksi for square sections, and Fy = 42 ksi for round sections) with a minimum wall thickness of 0.04 inch.
- Corrugated, polyvinyl chloride tubes manufactured from rigid PVC compounds conforming to ASTM D1784, Class 13464-B.
- Fusion-bonded epoxy conforming to the requirements of AASHTO M 284.

Furnish end caps from the same material as the encapsulation tubing.

Provide Tendon Bond Length encapsulation that meets all of the following performance requirements:

- Capable of transferring stresses from the grout surrounding the tendon to the Bond Length grout,
- Able to accommodate movements during testing and after lock-off,
- Resistant to chemical attack from aggressive environments, grout or grease,
- Resistant to aging by ultra-violet light,
- Fabricated from materials nondetrimental to the tendon,
- Capable of withstanding abrasion, impact and bending during handling and installation,
- Capable of resisting internal grouting pressures developed during grouting.

(d) Anchorage Devices - Provide a combination of either a steel Bearing Plate with wedge plate and wedges, or a steel Bearing Plate with a threaded anchor nut. The steel bearing and wedge plate may also be combined into a single element. Ensure Anchorage devices are capable of developing 95 percent of the minimum ultimate tensile strength of

the prestressing steel tendon. Ensure Anchorage devices conform to the static strength requirements of Section 3.1.6(1) and 3.1.8(1) and (2) of the *PTI Post-Tensioning Manual*.

(1) Bearing Plate - Fabricate the Bearing Plate from steel conforming to AASHTO M 270, Grade 36, or a ductile iron casting conforming to ASTM A536.

(2) Wedges and Wedge Plates - Use wedges designed to preclude premature failure of the prestressing steel due to notch or pinching effects under static and dynamic strength requirements of Section 3.1.6(1) and Sections 3.1.8(1) and (2) of the *PTI Post-Tensioning Manual*. Do not reuse wedges.

(3) Anchor Nuts - Size anchor nuts and other threaded hardware for epoxy coated bars to thread over the epoxy-coated bar and still comply with the requirements for carrying capacity.

(4) Trumpet - Furnish Trumpets fabricated from steel pipe or tube conforming to ASTM A53 for pipe or ASTM A500 for tubing. Furnish steel Trumpets having a minimum wall thickness of 1/8 inch for diameters up to 4 inches and 3/16 inch for larger diameters.

(5) Anchorage Cover - Furnish Anchorage covers fabricated from steel or plastic with a minimum thickness of 1/8 inch. Ensure the joint between the cover and the Bearing Plate is watertight.

(e) Bondbreaker - Fabricate the bondbreaker sleeve for the anchor Free Stressing Length from a smooth plastic tube or pipe having the following properties:

- Resistant to chemical attack from aggressive environments, grout, or corrosion inhibiting compound,
- Resistant to aging by ultraviolet light,
- Fabricated from material non-detrimental to the tendon,
- Capable of withstanding abrasion, impact, and bending during handling and installation,
- Enables the tendon to elongate during testing and stressing,
- Allows the tendon to remain unbonded after lock-off.

(f) Corrosion Inhibiting Compound - Furnish corrosion inhibiting compound for placement in the Free Stressing Length or the Trumpet area. Furnish grease, gel or wax corrosion inhibiting compound meeting the requirements of Section 4.6 of *PTI Recommendations for Prestressed Rock and Soil Anchors*.

(g) Sheathings - Use a sheath as part of the corrosion protection system for the unbonded length portion of the tendon.

Furnish sheathing fabricated from one of the following:

- A polyethylene tube pulled or pushed over the prestressing steel. Use Type II, III, or IV polyethylene as defined by ASTM D1248 (or approved equal). Use tubing with a minimum wall thickness of 0.06 inch.

- A hot-melt extruded polypropylene tube. Use polypropylene of cell classification B55542-11 as defined by ASTM D4101 (or approved equal). Use tubing with a minimum wall thickness of 0.06 inch.
- A hot-melt extruded polyethylene tube. Use high density Type III polyethylene as defined by ASTM D1248 (or approved equal). Use tubing with a minimum wall thickness of 0.06 inch.
- Steel tubing conforming to ASTM A500, Grade B (Fy = 46 ksi for square sections, and Fy = 42 ksi for round sections). Use tubing with a minimum wall thickness of 0.25 inch.
- Steel pipe conforming to ASTM A53, Grade B. Use pipe with a minimum wall thickness of 0.25 inch.
- Plastic pipe or tube of PVC conforming to ASTM D1784 Class 13464-B. Use Schedule 40 pipe or tube at a minimum.
- Heat shrink sleeves according to 00596E.11(h) with a minimum wall thickness of 0.04 inch

Provide sheathing that meets all of the following performance requirements:

- Resistant to chemical attack from aggressive environments, grout or corrosion inhibiting compound,
- Resistant to aging by ultraviolet light,
- Fabricated from material nondetrimental to the tendon,
- Capable of withstanding abrasion, impact and bending during handling and installation,
- Enables the tendon to elongate during testing and stressing,
- Allows the tendon to remain unbonded after lock off.

(h) Bar Tendon Coupler Protection - On encapsulated bar tendons, cover the coupler and any adjacent exposed bar section with a corrosion-proof compound or wax-impregnated cloth tape. Cover the coupler area with a smooth plastic tube complying with 00596E.11(g), overlapping the adjacent sheathed tendon by at least 1 inch. Seal the two joints with a coated heat-shrink sleeve of at least 6 inches in length, or approved equal. Completely fill the space inside the cover tube with the corrosion-proof compound.

Provide heat shrinkable sleeves fabricated from a radiation cross-linked polyolefin tube with a nominal thickness of 0.24 inches and internally coated with an adhesive sealant with a nominal thickness of 0.2 inches.

(i) Spacers and Centralizers:

(1) Spacers - Use spacers to separate the elements of a multi element tendon and permit grout to freely flow around the tendon and up the drill hole. Fabricate spacers from plastic, steel, or material which is non-detrimental to the prestressing steel. Do not use wood. A combination centralizer-spacer may be used. Use spacers to separate individual steel strands at intervals of no more than 10 feet.

(2) Centralizers - Fabricate centralizers from plastic, steel or material which is non-detrimental to the prestressing steel. Do not use wood. Use centralizers capable of

supporting the tendon in the drill hole and position the tendon so a minimum of 1/2 inch of grout cover is provided and permits grout to freely flow around the tendon and up the drill hole.

Provide centralizers at intervals of no more than 10 feet with the deepest centralizer located 1 foot from the end of the anchor and the upper centralizer for the bond zone located no more than 5 feet from the top of the Tendon Bond Length.

(j) Grout and Grout Tubes - Use Type I, II, or III Portland cement according to AASHTO M 85 (ASTM C150) for grout. Use grout that is a pumpable neat mixture of cement and water that is stable (bleed less than 2 percent), fluid, and provides a compressive strength of at least 3,000 psi at time of stressing. Provide water for mixing grout according to Section 02020.

Admixtures which control bleed, improve flowability, reduce water content and retard set may be used in the grout subject to the approval of the Engineer. Admixtures, if used, shall be compatible with prestressing reinforcement and mixed according to the manufacturer's recommendations. Expansive admixtures may only be used for filling sealed encapsulations, Trumpet, and Anchorage covers. Do not use accelerators.

Submit a detailed written mix design of the exact brand and batch quantities of pre-packaged grout and water including dosages proposed. Prior to installing the first Ground Anchor, mix a trial batch of grout using the Equipment, Materials, proportions, and grouting crew proposed for use on the Project. Perform the following tests:

- **Bleeding** - Determine bleed resistance according to ASTM C940. The maximum allowable bleeding is 2 percent.
- **Compressive Strength** - Determine compressive strengths according to ASTM C109. Sample 2 sets of 3 cubes at least once for each trial batch. Demonstrate the grout achieves at least 3,000 psi compressive strength at the end of the wait time before stressing.

If the proposed grout mix design does not produce acceptable trial batch results, revise the mix design and perform another trial batch. Results from previous projects will not be considered acceptable documentation. Grouting may proceed after approval of the trial batch.

Provide grout tubes with an adequate inside diameter to enable the grout to be pumped to the bottom of the drill hole and capable of withstanding a minimum grouting pressure of 150 psi or the Contractor's maximum anticipated grout pressure.

Equipment

00596E.20 General - Provide an Equipment list and a review of all Equipment suitability based on the Contractor's understanding of the site subsurface conditions, the associated installation plan, and Ground Anchor testing procedures. Before drilling, obtain approval in writing of drilling, grouting, stressing and testing Equipment.

00596E.21 Drilling Equipment - Furnish drilling Equipment appropriate for the subsurface conditions shown. Drilling Equipment includes all Equipment necessary to make holes of the diameter and depth required, maintain an open hole, and place anchors.

00596E.22 Mixing and Grouting Equipment - Furnish mixers, storage tanks, pumps, and necessary Equipment that satisfy the following:

- Mixer that produces a neat cement grout that is free of lumps and undispersed cement and continuously agitated during grouting operations,
- Pump and pressure gauge capable to monitor grout pressures at least 150 psi or twice the actual grout pressures used, whichever is greater,
- Grouting Equipment sized to enable the grout to be pumped in one continuous operation.

00596E.23 Anchor Stressing and Testing Equipment - Furnish Equipment to demonstrate the anchor acceptance criteria through testing and to stress and lock off the tendon at the load specified. Furnish Equipment with rated capacity adequate for stressing the tendon to the maximum specified test load.

(a) Hydraulic Jack and Pump – Furnish the following:

- Stressing Equipment capable of stressing the whole tendon in one stroke to the specified test load within 75 percent of the rated capacity. Provide a pump capable of applying each load increment in less than 60 seconds.
- Stressing Equipment capable of stressing the anchor in increments so that the anchor load can be raised or lowered according to the test specifications and allow the anchor to be lift-off tested to confirm the Lock-off Load and properly selected for the type and number of stressing elements.

(b) Stressing Anchorage - Furnish stressing Anchorage according to 00596E.11(d) to grip the prestressing reinforcement during loading.

(c) Pressure Gauges and Load Cells – Furnish the following:

- A primary pressure gauge consisting of 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 plus two inches and adequate travel so the Ground Anchor movement can be measured without resetting the device at an interim point.
- A reference calibrated pressure gauge for checking the primary pressure gauge.
- An electrical resistance load cell and readout for use in combination with a pressure gauge for extended Creep Test.

Adjustment or repair of jacks, gauges, or load cell after certification requires recalibration at no additional cost to the Agency.

Furnish stressing Equipment calibrated by an independent firm traceable to the National Institute of Standards and Technology (NIST). Perform certified calibration of stressing

system within 55 Calendar Days of the date of calibration submittal to the Engineer. Provide calibration accuracy of plus or minus 2 percent prior to use. Keep the calibration certificate and graph available on site during testing and stressing.

Labor

00596E.30 Personnel Qualifications - Perform the Work using personnel with the required minimum experience in Ground Anchor installation, stressing, and testing. Submit for review a list identifying the Subcontractor (if not performed by the Contractor), Project Site supervisors and drill rig operators assigned and the experience relevant to the Project. Submit the following:

- Project reference list of at least three Ground Anchor projects successfully completed in the last 5 years. Include a brief description of each project and the owner's contact person's name and current phone number for each project listed.
- Experience documentation of the supervising engineer for the On-Site Work with at least 3 years' experience in Ground Anchor design and construction. Provide experience information including the direct supervisory responsibility for the installation, stressing and testing operations.
- Provide experience information for drill operators with at least 1 year experience in the construction of permanent Ground Anchors.

Construction

00596E.40 Ground Anchor Storage and Handling - Store and handle anchors so as to avoid mechanical damage, corrosion and contamination with dirt or deleterious substances. Use padding under banding for prefabricated anchors to avoid damage to the anchor corrosion protection. Store Materials delivered prior to time required in a dry, clean ventilated place, heated, if necessary, to prevent accumulation of moisture on the Materials or in the wrapping. Do not store on the ground or expose to weather. Rusting sufficient to cause excessive surface roughness, pitting visible to the naked eye, or unevenness, will be cause for rejection. Bent anchors that have surface damage or have been subject to excessive rusting will be rejected.

The storage method is subject to review and approval prior to delivery of Materials to the Project Site. Do not weld anchor components. Protect anchors from any nearby welding operations to avoid touching the anchor with the electrode and to avoid electrical circuits that may cause resistance heating from passing through the anchors. Lift pre-grouted anchors so as to avoid excessive bending, which can debond the prestressing steel from the surrounding grout. Do not expose prestressing steel to excessive heat.

00596E.41 Ground Anchor Installation:

(a) Drilling Anchor Holes - Drill anchor holes to the length and diameter shown on the approved shop drawings and within 1 degree of the inclination shown. Utilize a drilling method to establish a stable hole of adequate dimensions within the tolerances specified. Drilling methods may involve, amongst others, rotary, percussion, rotary/percussive or auger drilling; or percussive- or vibratory-driven casing. Jetting is not allowed. Case the drilled anchor holes as necessary to prevent sloughing or caving of material into the hole.

Thoroughly clean the holes of loose debris and re-drill any anchor hole that caves, sloughs, or otherwise does not provide suitable Anchorage as required.

(b) Anchor Insertion - Place anchors according to the Plans, details and recommendations of the anchor manufacturer. Insert the anchor into the drill hole to the desired depth without damaging the sheathing, coating, and grout tubes. Align the center of the anchor with the center of the drill hole. If the anchor cannot be completely inserted, remove the anchor from the drill hole and clean or re-drill the hole to permit insertion. Do not drive or force partially inserted anchors into the hole.

Prior to inserting an anchor in the drilled hole, allow the Engineer to examine the entire anchor for damage. Repair damaged anchors according to the manufacturer's recommendations, as approved by the Engineer, and replace anchors as required, at no additional cost to the Agency.

(c) Anchor Grouting - After the anchor is inserted, grout the drill hole in one continuous grouting operation. Inject grout from the lowest point of the drill hole.

Record the quantity of the grout and grout pressures.

Provide separation between grout and the back of the Structure or the bottom of the Trumpet at the top of the drill hole. The grout tube may remain in the hole on completion of grouting if the tube is filled with grout.

After grouting, do not load the anchor for a minimum of 3 Calendar Days and the time demonstrated in the trial batch testing.

(d) Anchorage Installation - Install the anchor Bearing Plate and the Anchor Head or nut perpendicular to the anchor, within ± 3 degrees and centered on the Bearing Plate, without bending or kinking of the prestressing elements. Ensure that wedge holes and wedges are free of rust, grout, and dirt. Clean and protect the stressing tail and protect from damage until final testing and lock-off. After the anchor has been accepted, cut the stress tail to its final length according to the anchor manufacturer's recommendations.

Extend the corrosion protection surrounding the unbonded length up beyond the bottom seal of the Trumpet or 4 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.

Do not contact the corrosion protection surrounding the unbonded length with the Bearing Plate or the Anchor Head during testing and stressing. If the protection is too long, trim the corrosion protection to prevent contact.

00596E.42 Ground Anchor Testing - Test Ground Anchors according to the following:

(a) General - Test each Ground Anchor. Apply the Alignment Load and set dial gauges. Do not stress anchors beyond the Alignment Load prior to testing. Do not exceed 80 percent of the anchor's minimum ultimate tensile strength during testing.

Measure and record anchor movement to the nearest 0.001 inch with respect to an independent fixed reference point. Monitor load with the primary pressure gauge. Place reference pressure gauge in series with the primary pressure gauge during each test.

For Performance and Proof Tests, at loads other than the maximum test load, hold load just long enough to obtain the movement reading. Hold the maximum test load for a minimum of 10 minutes. Continually adjust jack pressure to maintain a constant load. Start load-hold period as soon as the maximum test load is applied. Record anchor movement at 1 minute, 2, 3, 4, 5, 6 and 10 minutes. If anchor movement between 1 minute and 10 minutes exceeds 0.04 inches, hold the maximum test load for an additional 50 minutes, and record anchor movement at 15 minutes, 20, 30, 40, 50 and 60 minutes.

For all verification, Performance, and Proof tests, submit an anchor test data report, according to 00596E.05. The Engineer will respond within 5 Calendar Days after receipt of the report with either acceptance or rejection of the tested anchor.

(b) Preproduction Verification Tests - Prior to installation of permanent Ground Anchors, construct two sacrificial verification test anchors and verification test reaction pads according to the approved Working Drawings and in the locations shown.

Perform verification tests to verify that the Contractor installed anchors meet the anchor acceptance criteria, verify that the length of the anchor bond zone is adequate, and verify the Contractor's design and installation methods. For each verification test, provide the anchor Test Data Report to the Engineer within 5 Calendar Days of completing the testing. Do not begin installation of permanent ground anchors until verification test reports have been reviewed and accepted by the Engineer.

Verification test anchor locations may be adjusted by the Engineer depending on actual site conditions and other factors. If additional verification test anchors are needed, the location will be determined by the Engineer.

For verification test anchors, use the drilling and grouting methods, casing and reinforcement details, depth of embedment (bond zone), and all other installation Materials and methods specified for the production anchors, unless otherwise approved by the Engineer. At the completion of verification testing, remove test anchors down to 2 feet below Roadway Subgrade or as directed.

Conduct verification tests according to the Performance Test schedule in 00596E.42(c).

Do not proceed with further Ground Anchor testing or construction without verification test approval.

(1) Verification Test Anchor Acceptance Criteria - The acceptance criteria for anchor verification load tests are:

- Total elastic movement at the maximum test load exceeds 90 percent of the theoretical elastic elongation of the unbonded length.
- At the end of the 1.0 FDL Creep Test load increment, test pile creep rate does not exceed 0.04 inch/log cycle time (1 to 10 minutes) or 0.08 inch/log cycle time

(6 to 60 minutes or the last log cycle if held longer) and the creep rate is linear or decreasing throughout the creep load hold period.

- Failure does not occur at the 1.0 FDL maximum test load. Failure is defined as the load where the slope of the load versus head deflection curve (at the end of increment) first exceeds 0.025 inch/kip.

(2) Verification Test Anchor Rejection - If a verification-tested Ground Anchor fails to meet the acceptance criteria, modify the design, the construction procedure, or both. These modifications may include modifying the installation methods, increasing the Bond Length, or changing the Ground Anchor type. Submit to the Engineer any modifications that necessitate changes to the Structure.

(c) Performance Test - Performance Test the first production anchors installed for each row and as directed by the Engineer. If changes are made to the Equipment, means, or methods, conduct an additional Performance Test at no additional cost to the Agency. Conduct Performance Test according to the following schedule:

Performance Test Schedule		
Step	Loading	Applied Load
1		AL
2	Cycle 1	0.20FDL*
		AL
3	Cycle 2	0.20FDL
		0.40FDL*
		AL
4	Cycle 3	0.20FDL
		0.40FDL
		0.60FDL*
		AL
5	Cycle 4	0.20FDL
		0.40FDL
		0.60FDL
		0.80FDL*
		AL
6	Cycle 5	0.20FDL
		0.40FDL
		0.60FDL
		0.80FDL
		0.90FDL*
		AL
7	Cycle 6	0.20FDL
		0.40FDL
		0.60FDL
		0.80FDL

		0.90FDL
		1.00FDL*
8	Maximum load 1.00FDL hold period per 00596E.42(e)	
9	Cycle 6 continued	Reduce to Lock-off Load
10	Lift off test	
11	Adjust Lock-off Load	

AL=Alignment Load
FDL=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.

(d) Proof Test - Proof Test each production anchor not performance tested. Perform Proof Test by incrementally loading the Ground Anchor according to the following schedule:

Proof Test Schedule	
Applied Load (LRFD Design)	
AL	
0.20FDL	
0.40FDL	
0.60FDL	
0.80FDL	
1.00FDL	Hold test load 10 minutes minimum.[1]
Reduce to Lock-off Load	
Lift-off test	

AL = Alignment Load
FDL = Factored Design Load

[1]Perform Creep Test measurements on the maximum load in the test. Start the load-hold period as soon as the maximum test load is applied. Measure and record the Ground Anchor movement at 1 minute, 2, 3, 4, 5, 6, and 10 minutes. If the Ground Anchor movement between 1 minute and 10 minutes exceeds 0.04 in., hold the maximum test load for an additional 50 minutes. If the load hold is extended, record the Ground Anchor movement at 15 minutes, 20, 30, 40, 50, and 60 minutes. If the Creep Test is extended, the creep movement between the 6 and 60 minute readings is required to be less than 0.08 inches for acceptance. Construct a graph

showing a plot of Ground Anchor movement versus load for each load increment in the Proof Test. Obtain Engineer's approval of graph format prior to use.

(e) Ground Anchor Acceptance Criteria - The Engineer will analyze the permanent Ground Anchor test results. Ground Anchor acceptance is based on satisfying each of the following criteria: creep, movement, and Lock-off Load:

- A performance or proof tested anchor with a 10 minute load hold is acceptable if the anchor resists the maximum test load with less than 0.04 inches of movement between 1 minute and 10 minutes and the total elastic movement at the maximum test load exceeds 90 percent of the theoretical elastic elongation of the unbonded length.
- A performance or proof tested anchor with a 60 minute load hold is acceptable if the anchor resists the maximum test load with a creep rate that does not exceed 0.08 inches in the last log cycle of time and the total elastic movement at the maximum test load exceeds 90 percent of the theoretical elastic elongation of the unbonded length.
- A verification, performance, or proof tested anchor subjected to extended Creep Testing is acceptable if the anchor resists the maximum test load with a creep rate that does not exceed 0.08 inches in the last log cycle of time and the total elastic movement at the maximum test load exceeds 90 percent of the theoretical elastic elongation of the unbonded length.
- Initial lift-off reading is within ±5 percent of the designed Lock-off Load. Perform liftoff test according to 00596E.42(h).

(f) Procedures for Anchors Failing Acceptance Criteria - Anchors that fail the acceptance criteria will be handled as follows:

- Anchors that do not satisfy the minimum apparent free length criteria will be rejected and replaced at no additional cost to the Agency.
- Re-groutable anchors satisfying the minimum apparent free-length criteria but failing to satisfy creep criteria may be post-grouted and retested. Anchors which cannot be post-grouted or re-grouted anchors that do not pass the acceptance criterion will be rejected.

In the event that an anchor fails, modify the design or construction procedures. These modifications may include installing additional anchors, modifying the installation methods, increasing the Bond Length, reducing the anchor design load by increasing the number of anchors, increasing the total anchor length, or changing the anchor type. Complete design or construction modification at no additional cost to the Agency. Submit a description of any proposed modifications to the Engineer in writing. Do not implement proposed modifications until receiving written approval from the Engineer.

(g) Anchor Lock-Off - Apply Lock-off Loads to permanent Ground Anchors as follows:

- After testing has been completed and anchors have been accepted by the Engineer, set the Anchorage to achieve the design Lock-off Load considering seating losses.
- Limit the Lock-off Load to a maximum 70 percent of the anchor minimum ultimate tensile strength.

- Seat the wedges at a minimum load of 50 percent of the anchor minimum ultimate tensile strength. If the Lock-off Load is less than 50 percent of the anchor minimum ultimate tensile strength, use shims under the wedge plate and seat the wedges at 50 percent of the anchor minimum ultimate tensile strength Remove shims after seating to reduce the load in the anchor to the design Lock-off Load.
- Adjust Lock-off Load using shims. Do not regrip strand anchors where regripping would result in overlapping wedge bites below the Anchorage wedge plate.

(h) Anchor Liftoff Test - After transferring the Lock-off Load to the Anchorage, and prior to removing the jack, conduct a liftoff test to confirm the magnitude of the load in the anchor. This load is determined by reapplying load to the anchor to lift off the wedge plate (or anchor nut) without unseating the wedges (or turning the anchor nut). This moment represents zero time for any long term monitoring. In the event that the load is removed from the anchor for any reason, repeat the anchor liftoff test procedure.

If the initial liftoff reading for any anchor is not within 5 percent of the designated Lock-off Load, adjust the anchor load accordingly and repeat the liftoff test. Repeat the liftoff until the liftoff reading is within 5 percent of the designated Lock-off Load.

Measurement

00596E.80 Measurement - The quantities of Work performed under this Section will be measured on the unit basis.

Payment

00596E.90 Payment - The accepted quantities of Work performed under this Section will be paid for at the Contract unit price, per unit of measurement, for the following items:

Pay Item	Unit of Measurement
(a) Permanent Ground Anchor	Each
(b) Performance Test	Each
(c) Verification Test	Each

Item (a) includes Contractor design of bonded length and for designing, furnishing, placing, and proof testing permanent Ground Anchors.

Item (c) includes design and construction of verification test reactions pads, and for designing, furnishing, placing, and testing of sacrificial anchors.

Payment will be payment in full for furnishing and placing all Materials, and for furnishing all Equipment, labor, and Incidentals necessary to complete the Work as specified.