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(New)

Iowa Department of Transportation

SPECIAL PROVISIONS
FOR
TIE BACK ANCHORS
FOR
SOLDIER PILE AND LAGGING RETAINING WALL

Polk County
STP-S-C077(173)--5E-77

Effective Date
December 20, 2011

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS. THESE ARE SPECIAL PROVISIONS AND SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

1.0 GENERAL

1.1 Description

A. The work covered under this special provision includes all necessary design and construction requirements for providing Tie Back Anchors for the soldier pile and lagging retaining walls shown on the plans. The tie back anchors shall consist of permanent ground anchors. The Contractor shall design and construct the tie back anchors in accordance with these Special Provisions, the standard specifications, and the plan.

1.2 Qualifications

A. The performance of tie back walls is strongly influenced not only by the methods and materials used, but also the experience of the Contractor. Contractors specializing in the design and construction of tie back walls shall be responsible for the tie back anchor final design. The guidelines presented herein are intended for evaluating tieback anchor design, stability considerations, and corrosion protection requirements.

B. The subcontractor selected for the design and construction shall be pre-qualified as a specialty contractor for the design and construction of permanent tie back walls in order for the contract to be awarded. The Contractor shall submit proof of five permanent tie back walls successfully completed within the past 2 years. The Contractor's staff shall include an Engineer with at least 5 years experience in the design and construction of permanent tie back structures. The engineer shall be a professional engineer licensed in the State of Iowa. In addition, his staff shall include a supervisory engineer for the project, having at least three years of design and construction experience in tie back work, and a foreman and drill operator with a minimum of two years experience.

C. The Engineer will approve or reject the Contractor's qualifications and staff within 15 working days after receipt of the submission. Work shall not be started on any anchored wall system nor materials ordered until approval of the Contractor's qualifications are given. The Engineer may suspend the ground anchor work if the Contractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the Contractor shall be fully liable for additional costs resulting from the suspension of work and no adjustment in contract time resulting from the suspension of work will be allowed.

1.3 Design Criteria

A. The tie back anchor design shall be in accordance with the 17th edition of the "Standard Specifications for Highway Bridges", Series 2002, adopted by the American Association of State Highway and Transportation officials, and the "Recommendations for Prestressed Rock and Soil Anchors" from the Post-Tensioning Institute. The design shall consider the internal and global stability of the wall system. The Contractor's design of the tie back anchors shall be based on the following information.

1. Wall layout and location drawings and cross-sections as shown on the plans.

2. Service loads and unbonded lengths provided in the plans.

3. New and existing utility locations.

4. Location of Right-of-Way and easements.

5. The geotechnical investigation report(s), which can be provided upon request that has been completed for this project. Any additional soil investigation desired shall be at the cost of the Contractor.

6. Geochemistry of soil and ground water for corrosion potential.

B. The tie back anchors shall be designed to safely support the service loads provided in the plans and all construction loads, and all temporary and permanent loads without allowing undesirable deflections and settlement. Design drawings shall be prepared showing the proposed method for tie back retaining wall work, including plan, elevation and sections of the wall, and a sufficient number of details to clearly illustrate the work. The relationship of the tie backs to right-of-way and easement lines, existing buildings, other structures, utilities, streets and other construction shall be clearly indicated. Utility locations as shown on the plans and as provided to the Contractor by the Owner shall be shown. Also, the Contractor shall develop a procedure to monitor movements on the retaining wall system throughout the construction period as described in Section 1.4. These drawings, showing all of the above information, shall be prepared by a professional engineer licensed in the State of Iowa who meets the qualifications described in Section 1.2, and shall bear his seal and signature.

1.4 Submittals

A. The Contractor shall provide design calculations and drawings of the proposed tie back anchors. All final design calculations and final plans shall be stamped and signed by the professional engineer licensed in the state of Iowa, as described in Section 1.2 B. The wall(s) shall follow the lines, grades, and location as shown on the plans. The wall shall be designed to conform to the right-of-way and easement restrictions provided and shall protect existing and proposed utilities given on the plans or discovered during construction.

B. The drawings shall include all details, dimensions, and cross-sections necessary to construct the wall. The drawings and calculations shall include, but are not limited to, the following:

1. A description of the tie back installation including drilling procedures, grout mix design and placement method, and stressing information. The Contractor shall also submit the methods and materials used in filling the annulus over the unbonded length of the anchor.

2. A description of any temporary supports needed to support the soldier pile and lagging wall until the tie back anchors have been installed and loaded to the design load.

3. Anchor capacity, ground anchor design load, type of tendon/rod, anchorage hardware, minimum bonded length and unbonded lengths, minimum anchor lengths, angle of installation, spacers and centralizers, and tie back locations and spacings.

4. The Contractor shall submit detailed plans as specified in Section 3.13 for the method proposed to be followed for the permanent ground anchor testing to the Engineer for approval prior to the tests. This shall include all necessary drawings and details to clearly describe the method proposed.

5. The Contractor shall submit to the Engineer calibration data for each load cell, test jack, pressure gauge and master pressure gauge to be used. The calibration tests shall have been performed by an independent testing laboratory and shall have been performed within 60 calendar days of the

date submitted. The Engineer shall approve or reject the calibration data after receipt of the data. Testing shall not commence until the Engineer has approved the load cell, test jack, pressure gauge and master pressure gauge calibrations.

6. Corrosion protection details for anchorages and tendons/rods.

7. Details of the soldier piles and a description of their installation method, steel sheet pile lagging details and a description of their installation method and details of the connection of the tie back anchors to the soldier piles. The soldier piles and lagging have been sized and the information is provided in the plans.

8. Details of the pre-drilled holes for the installation of the soldier piles, including method of construction and any slurry or casing which may be needed.

9. An elevation view indicating the elevation at the top of the wall, the elevation at the bottom of the wall, all horizontal and vertical break points and showing tie back anchor identification number.

10. A plan view of the wall indicating the offset from the construction centerline to the face of the wall at all changes in horizontal alignment.

11. A plan to monitor alignment, tilt and elevation of the retaining wall system throughout the construction period. This plan shall include inclinometers or survey monitoring points on the wall spaced every 25 feet on every soldier pile and lagging retaining wall. The data shall be collected at least every 15 days, and at the completion of the project, and submitted to the Engineer for review. If alignment movements are detected, they shall be reported to the Engineer immediately.

12. All details for construction of drainage facilities associated with the soldier pile and lagging retaining walls shall be clearly indicated.

13. The relationship between the soldier pile and lagging retaining wall and tie back anchors to the existing and proposed utilities shall be clearly shown.

14. All plans shall be prepared on 11 inch by 17 inch sheets including borders. Each sheet shall have a title block in the lower right-hand corner. Design calculations shall be on 8 1/2 inch by 11 inch sheets.

C. Before construction begins, the Engineer shall be allowed 30 days to review the Contractor's design calculations and drawings. Included in this review is a check of global stability by the Geotechnical Engineer. The review and acceptance of the final plans and methods of construction by the Engineer shall not in any way relieve the Contractor of their responsibility for the successful completion of the work. Upon final acceptance of the project, the Contractor shall furnish the Engineer with a complete set of reproducible drawings.

1.5 Pre-construction Conference

A. A pre-construction conference shall be held at least five working days prior to the Contractor beginning any retaining wall work at the site to discuss construction procedures, personnel, and equipment to be used. Those attending shall include:

1. (Representing the Contractor) The superintendent, on site supervisors, and all foremen in charge of installing the tie back wall, permanent ground anchors and grout, and tensioning and testing the permanent ground anchors.

2. (Representing the Contracting Agency) The Project Engineer, the Geotechnical Engineer, key inspection personnel, and representatives from Polk County Public Works and the Iowa Department of Transportation.

If the Contractor's key personnel change, or if the Contractor proposes a significant revision of the approved retaining wall installation plan, an additional conference shall be held before any additional retaining wall work is performed.

2.0 MATERIALS

2.1 Structural and Reinforcing Steel

A. Structural steel shall be in accordance with AASHTO M 270 Grade 50W and ASTM A709 Grade 50W.

B. Steel sheet pile AASHTO M 270 Grade 50W and ASTM A709 Grade 50W.

C. Reinforcing steel shall be in accordance with ASTM A-615, Grade 60.

D. Welding shall be in accordance with ANSI/AASHTO/AWS D1.5 Bridge Welding Code.

2.2 Tie Back Anchors

A. All materials for tie back anchors shall comply with the current "Recommendations for Prestressed Rock and Soil Anchors" from the Post-Tensioning Institute.

B. Tie back tendons shall be fabricated from prestressing steel conforming to one of the following requirements:

1. Continuously threaded steel bars conforming to AASHTO A-722 "Uncoated High-strength Steel Bars for Prestressed Concrete"; or

2. Seven-wire strand conforming to the requirements of AASHTO M203 (ASTM A-416) "Uncoated Seven-wire Stress Relieved Strand for Prestressed Concrete."

C. Anchorages shall be capable of developing 95 percent of the guaranteed minimum ultimate tensile strength of the prestressing steel tendon.

D. Prestressing steel couplers shall be capable of developing 95 percent of the guaranteed minimum ultimate tensile strength of the prestressing steel.

E. Spacers shall be used to separate elements of a multi-element tendon in the bond length. They shall be fabricated from plastic, steel or other materials (except wood), which is non-detrimental to the prestressing steel. A combination centralizer-spacer may be used.

F. Centralizers shall be fabricated from plastic, steel or materials (except wood) that are non-detrimental to the tieback tendon. The centralizer shall be 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 and shall permit grout to freely flow up the drill hole.

G. Corrosion protection for the tieback tendons shall be in accordance with Section 3.8 and fabricated from the following:

    1. Corrosion-inhibiting grease shall conform to the requirements of Section 3.2.5 of the PTI "Specification for Unbonded Single Strand Tendons."

    2. The bondbreaker for strand tendon unbonded length shall be:

        a. A polyethylene tube pulled or pushed over a strand. The polyethylene shall be Type II, III or IV as defined by ASTM D-1248 (or approved equal). The tubing shall have a minimum wall thickness of 60 mils +/- 10 mils; or

        b. A hot-melt extruded polypropylene tube applied over a corrosion inhibiting grease coated strand. The polypropylene shall be cell classification PP 21 0 B5554211, as defined by ASTM D-4 101 (or approved equal). The tubing shall have a minimum wall thickness of 60 mils +/- 10 mils; or

        c. A hot-melt extruded polyethylene tube applied over a corrosion inhibiting grease coated strand. The polyethylene shall be high density Type III as defined by ASTM D-335 0 and ASTM D-1248 (or approved equal). The tubing shall have a minimum wall thickness of 60 mils +/- 10 mils.

H. The bondbreaker for bar tendon unbonded length shall be a low density polyethylene tubing, polypropylene tubing or polyvinyl chloride tubing with a minimum wall thickness of 40 mils +/- 10 mils.

I. Corrugated tubes shall be:

    1. High density corrugated polyethylene tubing conforming to the requirement of AASHTO M 252 with a minimum wall thickness of 30 mils; or

    2. Corrugated polyvinyl chloride tubes manufactured from rigid PVC compounds conforming to ASTM D-1784, Class 13464-8; or

    3. Deformed steel tubing or pipes with a minimum wall thickness of 25 mils.

J. Fusion bonded, epoxy coating shall be in accordance with AASHTO M284, except that it shall have a film thickness of 15 mils.

K. Heat-shrink tubing shall be an irradiated, heat shrinkable polyethylene tube internally coated with a thixotropic sealant. Prior to shrinking the tube shall have a nominal wall thickness of 24 mils. The adhesive sealant inside the tube shall have a nominal thickness of 20 mils.

L. A trumpet shall be used to provide a transition from the anchorage to the unbonded length corrosion protection and shall be fabricated from a steel pipe or tube conforming to the requirements of ASTM A-53 for pipe or ASTM A-500 for tubing. The trumpet shall have a minimum wall thickness of 0.125 inches for diameters up to 4 inches and 0.20 inches for larger diameters.

2.3 Concrete for Backfill of Soldier Beams

A. Concrete for the soldier beam drill hole shall be a minimum 1.5 sack cement lean mix backfill, with a minimum 28 day compressive strength of 2,500 psi and a w/c ratio less than 0.50.

2.4 Grout for Tie Back Anchors

A. Water for mixing grout shall be potable.

B. Admixtures that control bleed, improve flowability, reduce water content and retard set may be used in the grout. Expansive admixtures may only be added to the grout used for filling encapsulations, trumpets and anchorage covers. Expansive admixtures shall not be permitted in the bond length grout. Accelerators shall not be permitted. Admixtures, if used, shall be compatible with prestressing steels and mixed in quantities not to exceed the manufacturer's recommendations.

3.0 CONSTRUCTION

3.1 Soldier Pile Installation Plan

A. The soldier piles shall be placed in drilled holes (shafts), and backfilled with lean concrete. No pile driving will be allowed.

B. At least thirty days prior to the beginning of shaft construction, the Contractor shall submit an installation plan for approval by the Engineer. In preparing the submittal, the Contractor shall reference the available subsurface data provided in the geotechnical report(s) prepared for this project. This plan shall provide at least the following information:

1. An overall construction operation sequence and the sequence of shaft construction.

2. List, description, and capacities of proposed equipment including but not limited to cranes, drills, augers, bailing buckets, final cleaning equipment, and drilling units. The narrative shall describe why the equipment was selected, and describe equipment suitability to the anticipated site and subsurface conditions. The narrative shall include a project history of the drilling equipment demonstrating the successful use of the equipment on shafts of equal or greater size in similar soil/rock conditions.

3. Details of shaft excavation methods including proposed drilling methods, methods for cleanout of the shafts, disposal plan for excavated material and drilling slurry (if applicable), and a review of method suitability to the anticipated site and subsurface conditions.

4. Details of the method(s) to be used to ensure shaft stability (i.e., prevention of caving, bottom heave, etc. using temporary casing, slurry, or other means) during excavation and concrete placement. This shall include a review of method suitability to the anticipated site and subsurface conditions. If temporary casings are proposed, casing dimensions and detailed procedures for casing installation and removal shall be provided. If slurry is proposed, detailed procedures for mixing, using, maintaining, and disposing of the slurry shall be provided. A detailed mix design and a discussion of its suitability to the anticipated subsurface conditions shall also be provided for the proposed slurry.

5. Details of soldier pile placement including internal support bracing and centralization methods.

6. Details of concrete placement including proposed operational procedures for pumping and/or tremie methods.

7. Details of the device used to prevent unauthorized entry into a shaft excavation.

8. The method to be used to form the horizontal construction joint at the top elevation specified for the lean concrete in the shaft.

9. Work shall not begin until the installation plan has been approved in writing by the Engineer.

3.2 Shaft Excavation for Soldier Piles

A. Shafts shall be excavated to the required depth as shown in the plans. The minimum diameter of the shaft shall be as shown in the plans. The excavation shall be completed in a continuous operation using equipment capable of excavating through the type of material expected to be encountered.

B. The Contractor may use temporary telescoping casing to construct the shafts. The Contractor shall submit the request to use temporary telescoping casing to the Engineer for approval. The request shall specify the diameters of the temporary telescoping casing, and shall specify the shafts where use is requested. The Contractor shall not proceed with the use of temporary telescoping casing until receiving the Engineer's approval.

C. If the shaft excavation is stopped, the shaft shall be secured by installation of a safety cover. It shall be the Contractor's responsibility to ensure the safety of the shaft and surrounding soil and the stability of the side walls. A temporary casing, slurry, or other methods specified in the shaft installation plan as approved by the Engineer shall be used if necessary to ensure such safety and stability.

D. Where caving-in conditions are encountered, no further excavation will be allowed until the Contractor has implemented the method to prevent ground caving as submitted in accordance with subsection 3.1.B.4 of this Special Provision and approved by the Engineer.

E. The Contractor shall use appropriate means such as a cleanout bucket, or airlift to clean the bottom of the excavation of all shafts. No more than 1 inch of loose or disturbed material shall be present at the bottom of the shaft just prior to beginning concrete placement.

F. The excavated shaft shall be inspected and approved by the Engineer prior to proceeding with construction.

G. When obstructions are encountered, the Contractor shall notify the Engineer promptly. An obstruction is defined as a specific object (e.g., including but not limited to boulders, logs, existing foundations) which to advance past it to the design shaft tip elevation, the rate of advance of the shaft drilling equipment is significantly reduced relative to the rate of advance for the rest of the shaft excavation. The method of removal of such obstructions, and the continuation of excavation shall be as proposed by the Contractor and approved by the Engineer.

3.3 Soldier Pile Placement and Alignment

A. The prefabricated steel soldier piles shall be lowered into the drilled shafts and secured in position. Concrete cover over the soldier pile shall be 3 inches minimum.

B. The steel soldier piles and attachments shall be built with weathering steel. The steel shall be kept free of oil, grease, dirt, crayon or chalk marks, concrete splatter and any other foreign matter that may affect the natural oxidation of the steel. Any foreign matter remaining on the steel after completion of construction shall be removed by the Contractor as directed by the Engineer. The resultant surface shall be free of all visible residues.

C. Soldier piles shall be set in predrilled holes and encased with lean concrete. Methods and equipment used for soldier beam installation shall be determined by the Contractor. The lean concrete shall be placed from the top of the hole. Vibration of the lean concrete is required. The soldier piles may be set prior to, or after lean concrete placement at the option of the Contractor, and as approved by the Engineer.

D. The tolerance on soldier pile placement and alignment perpendicular to the wall shall be +/- 2 inches of designated location at the top. Along the wall, the soldier pile may be within three inches of location. A 10 degree twist is allowed in the front flange of the soldier pile. The top of the soldier piles shall be cut off within a tolerance of plus one inch to minus one inch of cutoff elevations specified.

E. Soldier pile may be furnished in full length sections or may be spliced according to the Contractor's working drawings.

F. Any structural welding on the steel soldier pile shall be made by personnel qualified to perform the type of welding involved, in accordance with the qualification procedure of ANSI/AASHTO/AWS D1.5 Bridge Welding Code, except as amended on the plans.

G. Any field welder performing structural welding will be required to present a certificate stating that he has been qualified in accordance with the requirements of these Specifications within the previous 24 month period. A welder having a certificate that expired within the last 12 months may be permitted to commence welding provided a retest specimen is submitted immediately. The Engineer may require a confirming qualification test during the progress of the work.

3.4 Backfilling Shaft

A. Placement of lean concrete after installation of the soldier pile shall be placed in one continuous operation to the elevation shown in the approved Plans. A vibrator will be required inside the shafts for placement of the lean concrete.

B. The lean concrete shall be deposited by a method to prevent segregation of aggregates. The Contractor's method for depositing lean concrete shall have approval of the Engineer prior to lean concrete placement.

C. If water is present in the shafts, it shall be removed before placing backfill, or a slurry method of construction may be used with approval of the Engineer.

3.5 Steel Sheet Pile Lagging Installation

A. The lagging shall be installed from the top of the soldier piles proceeding downward. The steel sheet pile lagging shall be embedded a minimum of one foot below the proposed ground in front of the retaining wall. The bottom of lagging elevation is the same elevation as the top of the concrete encasement. The top of the wall shall be level and uniform. Any adjustments required to achieve this shall be accomplished at the bottom of the lagging. There will be no payment for adjustments made to the lagging to achieve a level and uniform top of wall, these adjustments shall be considered incidental to the bid item “Piles, Steel, Sheet”.

B. Along the lagging line, the soil shall be removed as shown in the plan details. The bottom of the excavation shall be level on both sides of the wall. The Contractor shall direct the excavation work so the retention system can be safely constructed.

C. The Contractor shall provide temporary support to the soldier pile and lagging retaining wall (as required) until the tie back anchors have been installed, tested and loaded to the design load. All costs associated with the temporary support shall be considered incidental to the bid item “Structural Steel”.

3.6 Tieback Tendon Fabrication

A. The tendons can be either shop or field fabricated from prestressing steel and materials conforming to the requirements of the Materials subsection of this Specification. The tendon shall be fabricated as shown on the approved Working Drawings.

B. The Contractor shall select the type of tendon to be used. The tendon shall be sized so the design load does not exceed 60 percent of the minimum specified ultimate tensile strength of the tendon, and the maximum test load does not exceed 80 percent of the minimum specified ultimate tensile strength of the tendon.

3.7 Tieback Corrosion Protection

A. The Contractor shall provide "Class 1" corrosion protection (double corrosion protection) for all tiebacks in accordance with the "Recommendations for Prestressed Rock and Soil Anchors" from the Post-Tensioning Institute.

B. The corrosion protection of the tendon unbonded length shall be provided by a sheath completely filled with corrosion inhibiting grease or grout, or a heat shrinkable tube internally coated with an elastic adhesive. If grease is used under the sheath, provisions shall be made to prevent the grease from escaping at the ends of the sheath. The grease shall completely coat the tendon, fill the void between the tendon and the sheath and fill the interstices between the wires of the seven-wire strands. The Working Drawings shall show how the Contractor will provide a transition between the bond length and the unbonded length corrosion protection. If the sheath is grout filled, a separate bondbreaker must be provided. The bondbreaker shall prevent the tendon from bonding to the grout surrounding the unbonded length.

3.9 Tendon Bond Length

A. The Contractor shall be responsible for determining the bond length and tendon bond length necessary to develop the design load required, and in accordance with the Testing subsection of this Special Provision. The total anchor length shall not be less than that indicated in the approved shop plans. The minimum bond length shall be 10 feet in rock and 15 feet in soil.

B. The unbonded tendon length shall extend beyond the critical failure surface and be a minimum of the lengths shown in the plans. The critical failure surface starts at the bottom of the prebored hole or at the soil/rock interface whichever is lower. The wall anchor system shall be checked for adequate stability. The overall stability of the earth mass being retained shall be checked and shall have a minimum factor of safety of 1.3.

3.10 Storage and Handling of Tieback Tendons

A. Tendons shall be handled and stored in such a manner as to avoid damage or corrosion. Damage to the prestressing steel as a result of abrasions, cuts, nicks, welds and weld splatter will be cause for rejection. The prestressing steel shall be protected if welding is to be performed in the vicinity. Ground of welding leads to the prestressing steel is forbidden. Prestressing steel shall be protected from dirt, rust or deleterious substances. A light coating of rust on the steel is acceptable. If heavy corrosion or pitting is noted, the tendons shall be rejected.

B. The Contractor shall use care in handling and storing the tendons at the site. Prior to inserting a tendon in the drill hole, the Contractor and the Inspector shall examine the tendon for damage to the prestressing steel, the encapsulation and the bond breaker. If the encapsulation is damaged, it shall be repaired in accordance with the tendon supplier's recommendations. If the bond breaker has been damaged, it can be repaired with ultra high molecular weight polyethylene. The tape should be spirally wound around the tendon so as to completely seal the damaged area. The pitch of the spiral shall ensure a double thickness at all points.

3.11 Drilling and Grouting Tiebacks

A. The Contractor shall select the drilling method, the grouting procedure, and the grouting pressure used for the installation of the ground anchor.

B. Drill holes for the tiebacks at the locations indicated on the approved shop plans. Core drilling, rotary drilling, or auger drilling may be used. A tolerance of +/- 3 degrees in any direction will be permitted on the tieback angle, and +/- 12 inches on the location at the point of entry. Tieback angles shown in the Contractor's working drawings may be changed providing the design loads are changed accordingly.

C. When caving conditions are encountered, no further drilling will be allowed until the Contractor selects a method to prevent ground movement. The Contractor may use a temporary casing. The Contractor's method to prevent ground movement shall be approved by the Engineer. The casings for the anchor holes, if used, shall be removed. The drill hole shall be located so the longitudinal axis of the drill hole and the longitudinal axis of the tendon are parallel. The ground anchor shall not be drilled in a location that requires the tendon to be bent in order to enable the tendon to be connected to the soldier pile. The ground anchors shall not extend beyond the Tie Back Anchor Limits as shown in the Contractor’s working drawings.

D. The tendon shall be inserted into the drill hole to the desired depth without difficulty. When the tendon cannot be completely inserted, the Contractor shall remove the tendon from the drill hole and clean or re-drill the hole to permit insertion. Partially inserted tendons shall not be driven or forced into the hole.

E. The Contractor shall use a neat cement grout or a sand-cement grout as shown on the approved mix design. The cement shall not contain lumps or other indications of hydration. Admixtures, if used, shall be mixed in accordance with the manufacturer's recommendations. Design strength of the grout shall be a minimum of 4,000 psi. However, adequacy of grout strength shall be determined by testing each tieback.

F. The grouting equipment shall produce a grout free of lumps and undispersed cement. A positive displacement grout pump shall be used. The pump shall be equipped with a pressure gauge to monitor grout pressures. The pressure gauge shall be capable of measuring pressures of at least 150 psi or twice the actual grout pressures used by the Contractor, whichever is greater. The grouting equipment shall be sized to enable the grout to be pumped in one continuous operation. The mixer should be capable of continuously agitating the grout.

G. The grout shall be injected from the lowest point of the drill hole. The grout may be pumped through grout tubes, casing, hollow-stem augers or drill rods. The grout can be placed before or after insertion of the tendon. The quantity of the grout and the grout pressures shall be recorded. The grout pressures and grout takes shall be controlled to prevent excessive heave in soils or fracturing of rock formations.

H. Except where indicated below, the grout above the top of the bond length may be placed at the same time as the bond length grout, but it shall not be placed under pressure. The grout at the top of the drill hole shall not contact the back of the structure or the bottom of the trumpet before testing the tiebacks.

I. Upon completion of the grouting, the grout tube may remain in the hole, but it shall be filled with grout. After grouting, the tendon shall not be tested for a minimum of 3 days.

J. If the ground anchor is installed in fine-grained soils using drill holes larger than 6 inches in diameter, no grout shall be placed above the top of the bond length during the time the bond length grout is placed. The grout above the top of the bond length shall be placed after the ground anchor has been tested and stressed. The grout at the top of the drill hole shall not contact the back of the structure or the bottom of the trumpet. Except as otherwise noted, only nonstructural filler shall be placed above the bond length grout prior to testing and acceptance of the anchor. The Contractor may place structural grout above the bond length grout prior to testing and acceptance of the anchor subject to the following conditions:

    1. The anchor unbonded length shall be increased by 8.5 feet minimum.

    2. The grout in the unbonded zone shall not be placed by pressure grouting methods.

3.12 Installation and Corrosion Protection of the Trumpet and Anchorage

A. The corrosion protection surrounding the unbonded length of the tendon shall extend up beyond the bottom seal of the trumpet or 1 foot 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, the Contractor shall extend the corrosion protection or lengthen the trumpet.

B. The corrosion protection surrounding the unbonded length of the tendon shall not contact the bearing plate or the anchorhead during testing and stressing. If the protection is too long, the Contractor shall trim the corrosion protection to prevent contact.

C. The bearing plate and anchorhead shall be placed so the axis of the tendon is perpendicular to the bearing plate within +/- 3 degrees and the axis of the tendon shall pass through the center of the bearing plate.

D. If grout protected tendons or fusion-bonded epoxy encapsulations are used, the bearing plate, anchorhead and trumpet shall be electrically isolated from the surrounding concrete, soldier pile or any metallic element embedded in the structure.

E. The most critical area to protect from corrosion is in the vicinity of the trumpet and anchorage. Trumpets shall be completely filled with grout or corrosion inhibiting grease after the tieback has been tested and locked-off. Trumpet grease can be placed anytime during construction. Trumpet grout shall be placed after the ground anchor has been tested. The Contractor shall demonstrate to the Engineer that the procedures selected by the Contractor for placement of either grease or grout will produce a completely filled trumpet.

F. All anchorages permanently exposed to the atmosphere shall be covered with a corrosion inhibiting grease-filled or grout-filled cover. The Contractor shall demonstrate to the Engineer that the procedures selected by the Contractor for placement of either grease or grout will produce a completely filled cover. If the Plans require restressable anchorages, corrosion inhibiting grease must be used to fill the anchorage cover and trumpet.

G. Anchorage devices shall be capable of developing 95 percent of the minimum guaranteed ultimate tensile strength of the prestressing steel tendon. The anchorage devices shall conform to the static strength requirements of Section 3.1.1 and Section 3.1.8(1) of the Post Tensioning Institute "Guide Specification for Post Tensioning Materials".

H. The bearing plates shall be sized so the bending stresses in the plate do not exceed the yield strength of the steel when a load equal to 95 percent of the minimum guaranteed ultimate tensile strength of the tendon is applied; and 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."

I. The trumpet shall have an inside diameter equal to or larger than the hole in the bearing plate. The trumpet shall be long enough to accommodate movements of the structure during testing and stressing. For strand tendons with encapsulation over the unbonded length, the trumpet shall be 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 anchorhead without damaging the encapsulation. Trumpets filled with corrosion-inhibiting grease shall have a permanent Buna-N rubber or approved equal seal provided between the trumpet and the tendon unbonded length corrosion protection. Trumpets filled with grout shall have a temporary seal provided between the trumpet and the tendon unbonded length corrosion protection or the trumpet shall overlap the tendon unbonded length corrosion protection.

3.13 Tie Back Testing Procedure

A. Each tie back shall be tested in accordance with the "Recommendations for Prestressed Rock and Soil Anchors" from the Post-Tensioning Institute.

B. The Owner will engage a testing laboratory to verify all proof, performance and creep tests by the Contractor. The testing laboratory will also perform strength tests of the tie back anchor grout.

C. Each tie back anchor shall be tested. No load greater than 10 percent of the design load can be applied to the tie back anchor prior to testing. The maximum test load shall not exceed 80 percent of the minimum specified tensile strength of the tendon. The test load shall be simultaneously applied to the entire tendon. Stressing of single elements of multi-element tendons shall not be permitted.

D. Supplementary Extended Creep Testing will be required.

E. The loads on the tie backs during the testing shall be monitored with an electric load cell. The Contractor shall provide the electric load cell and a readout device.

F. The testing equipment shall consist of:

1. A dial gauge or vernier scale capable of measuring to 0.001 inches shall be used to measure the tie back anchor movement. The movement measuring device shall have a minimum travel equal to the theoretical elastic elongation of the total anchor length at the maximum test load and it shall have adequate travel so the tie back anchor movement can be measured without resetting the device.

2. A hydraulic jack and pump shall be used to apply the test load. The jack and a calibrated pressure gauge shall be used to measure the applied load. The jack and pressure gauge shall be calibrated by an independent firm as a unit. The calibration shall have been performed within 45 working days of the date submitted. Testing cannot commence until the Engineer has approved the calibration. The pressure gauge shall be graduated in 100 psi increments or less. The ram travel of the jack shall not be less than the theoretical elastic elongation of the total anchor length at the maximum test load.

3. A calibrated reference pressure gauge shall also be kept at the site. The reference gauge shall be calibrated with the test jack and pressure gauge.

4. The Contractor shall provide an electrical resistance load cell and readout to be used when performing a creep test.

5. The stressing equipment shall be placed over the tie back 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.

G. Performance Testing:

1. The Engineer shall select the tie back anchors to be performance tested. The first production tie back anchor shall be performance tested.

2. Five percent of the tie back anchors or a minimum of three tie back anchors per wall, whichever is greater, shall be performance tested in accordance with the following procedures. The remaining tie back anchors shall be tested in accordance with the proof test procedures.

   a. The performance test shall be made by incrementally loading and unloading the tie back anchor in accordance with the following schedule. The load shall be raised from one increment to another immediately after recording the tie back anchor movement. The tie back anchor movement shall be measured and recorded to the nearest 0.001 inches with respect to an independent fixed reference point at the alignment load and at each increment of load. The load shall be monitored with a pressure gauge. The reference pressure gauge shall be placed 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 percent, the jack, pressure gauge and reference pressure gauge shall be recalibrated at no expense to the Owner. At load increments other than the maximum test load, the load shall be held just long enough to obtain the movement reading.

PEFORMANCE TEST SCHEDULE			
INCREMENT	LOAD	INCREMENT	LOAD
1	AL	15	AL
2	0.25DL *	16	0.25DL
3	AL	17	0.50DL
4	0.25DL	18	0.75DL
5	0.50DL	19	1.00DL
6	AL	20	1.20DL *
7	0.25DL	21	AL
8	0.50DL	22	0.25DL
9	0.75DL *	23	0.50DL
10	AL	24	0.75DL
11	0.25DL	25	1.00DL
12	0.50DL	26	1.20DL
13	0.75 DL	27	1.33DL *
14	1.00DL *	28	REDUCE TO LOCK-OFF LOAD
Where: AL – is the alignment load DL – is the tie back anchor design load			

3. The maximum test load in a performance test shall be held for 10 minutes. The jack shall be re-pumped as necessary in order to maintain a constant load. The load hold period shall start as soon as the maximum test load is applied and the tie back anchor movement, with respect to a fixed reference, shall be measured and recorded at 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 minutes. If the tie back anchor movement between 1 minute and 10 minutes exceeds 0.04 inches, the maximum load test shall be held for an additional 50 minutes. If the load hold is extended, the tie back anchor movement shall be recorded at 15, 20, 25, 30, 45, and 60 minutes.

4. The Contractor shall plot the tie back 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.

E. Proof Testing:

1. The proof test shall be made by incrementally loading the tie back in accordance with the Proof Test Schedule.

2. The proof test shall be performed by incrementally loading the tie back anchors in accordance with the following schedule. The load shall be raised from one increment to another immediately after recording the tie back anchor movement. The tie back anchor movement shall be measured and recorded to the nearest 0.001 inches with respect to an independent fixed reference point at the alignment load and at each increment of load. The load shall be monitored with a pressure gauge. At load increments other than the maximum test load, the load shall be held just long enough to obtain the movement reading.

   a. The maximum test load in a proof test shall be held for 10 minutes. The jack shall be re-pumped as necessary in order to maintain a constant load. The load hold period shall start as soon as the maximum test load is applied and the tie back anchor movement with respect to a fixed reference shall be measured and recorded at 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 minutes. If the tie back anchor movement between 1 minute and 10 minutes exceeds 0.04 inches, the maximum test load shall be held for an additional 50 minutes. If the load hold is extended, the tie back anchor movements shall be recorded at 15, 20, 25, 30, 45 and 60 minutes.

PROOF TEST SCHEDULE	
INCREMENT	LOAD
1	AL
2	0.25DL
3	0.50DL
4	0.75DL
5	1.00DL
6	1.20DL
7	1.33DL
8	REDUCE TO LOCK-OFF LOAD
Where: AL – is the alignment load DL – is the tie back anchor design load	

3. The contractor shall plot the tie back anchor movement versus load for each load increment in the proof test.

F. Creep Testing:

1. The Engineer shall locate two tie back anchors to be creep tested for Soldier Pile and Lagging Retaining Walls No. 1 & No. 3. The Engineer shall locate one tie back anchor to be creep tested for Soldier Pile and Lagging Retaining Wall No. 2.

2. The creep test shall be made by incrementally loading and unloading the tie back anchor in accordance with the performance test schedule given above. At the end of each loading cycle, the load shall be held constant for the observation period indicated in the creep test schedule below. The times for reading and recording the tie back anchor movement during each observation period shall be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 45, 60, 75, 90, 100, 120, 150, 180, 210, 240, 270 and 300 minutes, as appropriate. Each load hold period shall start as soon as the test load is applied. In a creep test, the pressure gauge and reference pressure gauge will be used to measure the applied load and the load cell will be used to monitor small changes in load during a constant load hold period. The jack shall be re-pumped as necessary in order to maintain a constant load.

CREEP TEST SCHEDULE	
LOAD	OBSERVATION PERIOD (min.)
AL	-
0.25DL	10
0.50DL	20
0.75DL	30
1.00DL	45
1.20DL	60
1.33DL	300

3. The Contractor shall plot the tie back anchor movement and the residual movement measured in the creep test as described for the performance test above. The Contractor shall also plot the creep movement for each load hold as a function of the logarithm of time.

G. Tie Back Test Acceptance Criteria:

1. General:

   a. Acceptance criteria shall follow the "Recommendations for Prestressed Rock and Soil Anchors" from PTI, and the following sections.

   b. Retesting of the tie back shall not be allowed.

2. Performance and Proof Testing:

   a. A performance or proof tested tie back anchor with a 10 minute load hold is acceptable if the tie back anchor carries the maximum test load with less than 0.04 inches of movement between 1 minute and 10 minutes, and if the total movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length.

   b. A performance or proof tested tie back anchor with a 60 minute load hold is acceptable if the tie back anchor carries the maximum test load with a creep rate that does not exceed 0.08 inches per log cycle of time and if the total movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length.

3. Creep Testing:

   a. A creep tested tie back anchor is acceptable if the tie back anchor carries the maximum test load with a creep rate that does not exceed 0.08 inches per log cycle of time and if the total movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length.

4. If the total movement of a tie back anchor at the maximum test load does not exceed 80 percent of the theoretical elastic elongation of the unbonded length, the Contractor shall replace the tie back anchor at no additional cost to the Owner.

5. Tie back anchors which have a creep rate greater than 0.08 inches per log cycle of time can be incorporated in the finished wall at a load equal to one-half their failure load. To determine the failure load, allow the load to stabilize for 10 minutes after the tie back has failed.

6. When a tie back anchor fails, the Contractor may modify the design and/or construction procedures. These modifications may include, but are not limited to, installing replacement tie back anchors, reducing the design load by increasing the number of tie back anchors, modifying the installation methods, increasing the bond length or changing the tie back anchor type. Any modification which requires changes to the structure must have prior approval by the Engineer. Any modifications of design or construction procedures shall require a revised submittal as detailed in section 1.4 of this special provision. Any modifications of design or construction procedures shall be at no change in the contract price or contract time.

7. Retesting of the tie back anchor shall not be allowed.

H. Lock-off:

1. Upon completion of the test, the load shall be adjusted to the lock-off load indicated in the working drawings and transferred to the anchorage device. The tie back anchor may be completely unloaded prior to lock-off. After transferring the load and prior to removing the jack, a lift-off reading shall be made. The lift-off reading shall be within 10 percent of the specified lock-off load.

5. If the load is not within 10 percent of the specified lock-off load, the anchorage shall be reset and another lift-off reading shall be made. This process shall be repeated until the desired lock-off load is obtained.

4.0 METHOD OF MEASUREMENT

A. The quantity of tie back anchors to be paid will be the number of tie back anchors shown on the plans. For tie back anchors that do not meet the acceptable criteria, the original tie back anchor and any required additional work or tie back anchors shall be, in sum, considered to be one tie back anchor for payment purposes. The quantity of proof, performance and creep tests as specified shall be included as part of the contract sum.

5.0 BASIS OF PAYMENT

A. The number of tie back anchors shown on the plans will be paid at the contract unit price for “Tie Back Anchors (Each)”. This payment shall be full compensation for all work associated with the tie back anchors as shown on the plans, and as described in these special provisions and specifications. This includes all design work, submittals, materials, tie back installation and testing, monitoring of soils stability and movement, and all other incidental items.