MICHIGAN

DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

FOR

**GROUND ANCHORS**

BRG:AJM 1 of 22 APPR:MJF:RWS:06-21-21

**a. Description.** This work consists of furnishing, installing, testing, and stressing cement-grouted ground anchors that will develop the load-carrying capacity specified on the plans. This work also consists of designing the grout mix and designing, furnishing, installing, and removing the load testing apparatuses. Complete all work in accordance with the standard specifications, except as modified herein.

Examine the plans and visit the site prior to bidding the work to assess the site geometry, equipment access conditions, subsurface conditions, location of existing structures, overhead restrictions, and any other factors that may influence the bid.

1. Ground Anchor Contractor Qualifications. The Ground Anchor Contractor is the contractor performing the work described in this special provision. The Ground Anchor Contractor must submit their qualifications to the Engineer for review and approval no more than 14 calendar days after the preconstruction meeting. Submit qualifications that meet all of the requirements indicated below. The Engineer will determine if the Ground Anchor Contractor meets the requirements indicated below. The Engineer will approve or reject the Ground Anchor Contractor’s qualifications within 7 calendar days after receiving the submission. One resubmittal of the qualifications will be allowed. The requirements indicated below must be met as of the letting date of the contract. Projects completed or personnel hired after the letting date of the contract will not be considered. No additional time or costs will be allowed if a Ground Anchor Contractor is rejected.

A. Provide a list containing at least 5 projects completed in the last 5 years on which the Ground Anchor Contractor installed ground anchors. Projects listed must have been performed by the Ground Anchor Contractor. Projects performed by personnel at other companies will not be considered. Provide a short narrative for each project. Provide the names and contact information of owner’s representatives who can verify the Ground Anchor Contractor’s participation on the listed projects. Each project listed must show experience with ground anchors with the following requirements:

(1) Free stressing lengths of the same length or larger than what is required for this project;

(2) The cross-sectional area (Aps) of the anchor was the same or larger than what is required for this project;

(3) The design loads (DL) was the same or larger than what is required for this project;

B. Provide a list containing at least 2 projects completed in the last 5 years on which the Ground Anchor Contractor installed ground anchors from an elevated work platform at least 10 feet above the ground. Provide a short narrative for each project. Provide the names and contact information of owner’s representatives who can verify the Ground Anchor Contractor’s participation on the listed projects. Projects listed must have been performed by the Ground Anchor Contractor. Projects performed by personnel at other companies will not be considered.

C. Provide the names and experience records of the Ground Anchor Contractor’s personnel assigned to the project indicating a minimum of 3 years of experience installing ground anchors. Experience at other contractors installing ground anchors will be allowed. The personnel listed must include the onsite superintendent and the drill rig operator.

Do not substitute any of the proposed personnel without the written approval of the Engineer. Do not start work or order materials until the Engineer approves the qualifications submittal. The Engineer may suspend the work if the Ground Anchor Contractor substitutes unqualified personnel for the approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, no additional costs or time will be allowed resulting from the suspension of work.

2. Definitions. The definitions given in section 2.0 of the *Recommendations for Prestressed Rock and Soil Anchors*, published by the *Post-Tensioning Institute (PTI)* apply throughout this special provision. In addition, the following definition(s) apply throughout this special provision:

**Alignment Load (AL)**. A small load applied to an anchor during testing to keep the testing equipment correctly positioned.

**Anchor**. Any prestressed ground anchor that is intended to remain and function as part of a structure. An anchor has to fulfill its function for an extended period of time and thus requires special design, corrosion protection, and supervision during installation. An anchor is used to transfer tensile load to the ground (soil or rock), which includes the prestressing steel, anchorage, corrosion protection, sheathings, spacers, centralizers, and grout.

**Anchor Head**. The means by which the prestressing force is permanently transmitted from the prestressing steel to the bearing plate. The anchor head includes an anchor nut for bar tendons.

**Anchor Nut**. The threaded device that transfers the prestressing force in a bar to a bearing plate.

**Anchorage**. The combined system of anchor head, bearing plate, trumpet, and corrosion protection that is capable of transmitting the prestressing force from the prestressing steel to the surface of the ground or the supported structure.

**Anchorage Cover**. A cover to protect the anchorage from corrosion and physical damage.

**Apparent Free Tendon Length**. The length of the anchor that is not bonded to the surrounding ground, as calculated from the elastic load extension data during testing.

**Bearing Plate**. A steel plate under the anchor head that distributes the prestressing force to the anchored structure.

**Bond Breaker**. A sleeve or coating placed around the anchor prestressing steel to prevent load transfer.

**Bond Length**. The length of the anchor that is bonded to the surrounding ground and which is used to transfer the applied axial loads to the surrounding ground.

**Centralizer**. A device to support and position the prestressing steel in the drill hole so that a minimum grout cover is provided.

**Consolidation Grout**. Portland cement grout that is injected into the hole prior to inserting the prestressing steel to either reduce the permeability of the rock surrounding the hole or improve the ground conditions.

**Corrosion Inhibiting Compound**. Material used to protect against corrosion and/or lubricate the prestressing steel inside a bond breaker.

**Coupler**. The means by which the load can be transmitted from one partial length prestressing steel to another.

**Creep Movement**. The movement that occurs during a creep test of an anchor under a constant load.

**Design Load (DL)**. The anticipated final maximum load in the anchor after allowance for time dependent losses or gains. The design load is based on loads in accordance with the *AREMA Specifications.*

**Elastic Movement**. The recoverable movement measured during an anchor test.

**Encapsulation**. A corrugated tube protecting the prestressing steel against corrosion.

**Free Stressing (Unbonded) Length**. The designed length of the anchor that is not bonded to the surrounding ground or grout during testing.

**Lift-Off**. The load (lift-off load) in the tendon which can be checked at any specified time with the use of a hydraulic jack, by lifting the anchor head off the bearing plate.

**Lock-Off Load**. The prestressing force in an anchor immediately after transferring the load from the jack to the stressing anchorage.

**Performance Test**. An anchor load test performed to verify the ground anchor design based on the construction methods proposed. This includes incremental cyclic test loading of a prestressed anchor in which the total movement of the anchor is recorded at each load increment. Performance tests are performed on non-production anchors, prior to installation of production anchors, unless otherwise directed by the Engineer.

**Primary Grout**. Portland cement based grout that is injected into the anchor hole prior to or after the installation of the prestressing steel to provide the load transfer to the surrounding ground along the anchor and affords a degree of corrosion protection in compression.

**Proof Test**. Incremental loading of a production anchor, recording the total movement at each load increment.

**Pulling Head**. Temporary anchoring device behind the hydraulic jack during stressing.

**Relaxation**. The decrease of stress or load with time while the tendon is held under constant strain.

**Residual Movement**. The non-elastic (non-recoverable) movement of an anchor measurement during load testing.

**Restressable Anchor Head**. An anchor head that permits the anchor load, throughout the life of the structure, to be measured by lift-off checking and adjusted by shimming/unshimming or thread turning.

**Safety Factor**. The ratio of the ultimate capacity to the working load used for the design of any component or interface.

**Sheath**. A smooth or corrugated pipe or tube protecting the prestressing steel in the free stressing length against corrosion.

**Spacer**. A device to separate elements of multiple element reinforcement.

**Tendon**. The complete anchor assembly (excluding grout) consisting of prestressing steel, corrosion protection, sheathings, and coating when required, as well as spacers and centralizers.

**Trumpet**. Device to provide corrosion protection in the transition length from the anchorage to the free stressing length.

**Waler**. A structural steel member spanning between the vertical soldier piles which transfers the load from the wall to the anchor.

**b. Materials.** Furnish materials in accordance with *AREMA* requirements and the standard specifications.

1. Structural Steel. Use structural steel in accordance with section 906 of the Standard Specifications for Construction. Provide structural steel of the minimum grade specified on the plans or as specified in this special provision.

2. Anchorage Devices.

A. Stressing Anchorages. Furnish a steel bearing plate with a threaded anchor nut. Ensure anchorage devices are capable of developing at least 95 percent of the specified minimum ultimate tensile strength (SMTS) of the prestressing steel tendon. Ensure anchorage devices meet the static strength requirements of section 3.1.6(1), 3.1.8(1), and 3.1.8(2) of the *PTI Post-Tensioning Manual*.

B. Bearing Plate. Furnish bearing plates fabricated from Grade 50 structural steel.

C. Trumpet. Furnish trumpets fabricated either from a steel pipe in accordance with *ASTM A53/A53M* or steel tube in accordance with *ASTM A500/A500M*. Furnish trumpets with a minimum wall thickness of 1/4 inches.

D. Anchorage Covers. Furnish anchorage covers fabricated from Grade 36 structural steel with a minimum thickness of 1/8 inches. Ensure the joint between the cover and the bearing plate is watertight.

3. Bond breaker. Furnish bond breaker fabricated from a smooth plastic tube or pipe having the following properties:

A. Resistant to chemical attack from aggressive environments, grout, or corrosion inhibiting compound;

B. Resistant to aging by UV light;

C. Fabricated from material that is not detrimental to the tendon;

D. Capable of withstanding abrasion, impact, and bending during handling and installation;

E. Enables the tendon to elongate during testing and stressing; and

F. Allows the tendon to remain unbonded after lock-off.

4. Anchor Grout.

A. Water. Use water in accordance with section 911 of the Standard Specifications for Construction.

B. Cement. Use Type I, Type II, Type III, or Type V Portland cement in accordance with *AASHTO M85* from one manufacturer. Furnish a grout with a minimum 28 day compressive strength of at least 5000 psi.

C. Fine Aggregate. If proposed, use natural sand in accordance with *ASTM C144*.

D. Admixtures. Use admixtures in accordance with *ASTM C494/C494M*. Use admixtures from one manufacturer.

E. Grout Tubes. Use grout tubes with an adequate inside diameter to enable the grout to be pumped to the bottom of the drill hole. Ensure grout tubes are strong enough to withstand a minimum grouting pressure of 150 psi.

5. Centralizers. Use schedule 40 PVC pipe or tube, or epoxy-coated steel in accordance with subsection 905.03.C of the Standard Specifications for Construction, or other materials that are not detrimental to the prestressing steel. Do not use wood. Ensure centralizers and spacers are securely attached to the prestressing steel and are sized to position the prestressing steel so that a minimum of 1/2 inch of grout cover is provided. Ensure that the centralizers will allow grout to flow freely around the prestressing steel and up the drill hole.

6. Corrosion Inhibiting Compound. For placement in the free stressing length and the trumpet area, provide an organic compound (i.e., grease or wax) with appropriate polar moisture displacing, corrosion inhibiting additives and self-healing properties. Ensure that the compound remains viscous and is chemically stable and nonreactive with the prestressing steel, the sheathing material, and the anchor grout. Use corrosion inhibiting compounds meeting section 3.2.5 of the *PTI Specification for Unbonded Single Strand Tendons*.

7. Heat Shrinkable Sleeves. Fabricate heat shrinkable sleeves from a radiation crosslinked polyolefin tube, with a minimum nominal wall thickness of 0.024 inch, internally coated with an adhesive sealant, having a minimum nominal thickness of 0.02 inch.

8. Prestressing Steel.

A. Tendons. Provide ground anchor tendons fabricated from a single element of one of the following prestressing steels as shown on the plans:

(1) Steel bars meeting *AASHTO M275M/M275*.

(2) Epoxy coated reinforcing steel bars meeting *ASTM A775/A775M*.

B. Centralizers. Furnish centralizers at maximum intervals of 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.

C. Prestressing Steel Couplers. Furnish prestressing steel bar couplers that are capable of developing 100 percent of the minimum specified ultimate tensile strength of the prestressing steel bar.

9. Sheath. Use a sheath as part of the corrosion protection system for the unbonded length portion of the tendon. Fabricate the sheath from one of the materials specified in Table 1.

**Table 1: Sheath Materials**

|  |  |  |
| --- | --- | --- |
| Material | Reference | Minimum Wall  Thickness |
| Polyethylene Tube | *ASTM D1248, Type II, III or IV* | 0.0625 inch |
| Hot-Melt Extruded Polypropylene Tube | *ASTM D4101, cell classification B55542-11* | 0.0625 inch |
| Hot-Melt Extruded Polyethylene Tube | *ASTM D1248, Type III* | 0.0625 inch |
| Steel Tubing | *ASTM A500/A500M* | 0.1875 inch |
| Steel Pipe | *ASTM A53/A53M* | 0.1875 inch |
| PVC Pipe or Tube | *ASTM D1784, Class 13464-B* | Schedule 40 |

10. Tendon Bond Length Encapsulations. If the plans require the tendon bond length to be encapsulated to provide additional corrosion protection, fabricate the encapsulation from one of the materials specified in Table 2.

11. Steel Reinforcement. Use Grade 60 epoxy coated steel reinforcement in accordance with section 905 of the Standard Specifications for Construction for local reinforcement at ground anchor anchorages bearing on concrete.

**Table 2:** **Encapsulation for Tendons**

|  |  |  |
| --- | --- | --- |
| Material | Reference | Minimum Wall Thickness |
| High Density Corrugated Polyethylene Tubing | *AASHTO M252* | 0.0625 inches, except for pregrouted tendons, which may have a minimum wall thickness of 0.04 inches. |
| Deformed Steel Tubing or Pipes | *ASTM A500/A500M* | 0.1875 inch |
| Corrugated, Polyvinyl Chloride Tubes | *ASTM D1784, Class 13464-B* | 0.0625 inch |
| Fusion-Bonded Epoxy | *ASTM A775/A775M* | 0.015 inch film thickness |

**c. Construction.**

1. Submittals. Ensure all submittals are electronically transferred as a PDF file. Submit items from subsections c.1.A through c.1.E to the Engineer not less than 21 calendar days prior to anchor construction. Submit items from subsections c.1.F through c.1.J to the Engineer not less than 21 calendar days prior to load testing or incorporation of the respective materials into the work. The Department requires 14 calendar days to review a submittal after it has been received. For ground anchors supporting Steel Sheet Piling, Special within the influence of railroad live load, submit items from subsections c.1.A through c1.J and relevant items from the Conrail Sheeting and Shoring Checklist to Conrail a minimum of 30 calendar days prior to anchor construction. Additional review time necessary due to incomplete or unacceptable submittals is not cause for a claim for additional time or compensation. All costs and delays associated with incomplete or unacceptable submittals will be borne by the Contractor.

A. A working drawing of the ground anchor tendon and the corrosion protection system including details for the following:

(1) Spacers and their location;

(2) Centralizers and their location;

(3) Unbonded length corrosion protection system;

(4) Bond length corrosion protection system;

(5) Anchorage and trumpet;

(6) Anchorage corrosion protection system;

(7) Drilled or formed hole size;

(8) Level of each stage of grouting; and

(9) Any revision to structure details necessary to accommodate the ground anchor system intended for use.

B. Installation plan that includes a step-by-step description of the proposed anchor construction procedure (including access methods), including drilling equipment, drilling methods, casings, flushing medium, grouting methods, flush control and disposal, personnel, testing, and testing equipment to ensure quality control. In addition, if the anchors are an integral part of a retaining wall, the construction procedure must incorporate the steps in conjunction with the related foundation and wall construction step-by-step process. Include the step-by-step procedure on the working drawings in sufficient detail to allow the Engineer to monitor and validate the construction and quality of the anchors.

Existing facilities including active railroad tracks, utilities and other structures that are located at or in close proximity to the site. Prior to start of any ground anchor installation activity, the Contractor and Engineer will jointly inspect the site to observe and document the preconstruction condition of the site, existing facilities, structures, and grounds.

Install tiebacks using means and methods that prevent ground loss or densification that could result in settlement or vibration induced damage to existing facilities at the site. Locate equipment and material stockpiles for installing ground anchors at a safe distance and outside the influence zone of existing structure footings or other below grade facilities to avoid loading those facilities. The Contractor is responsible for any or all damages to any adjacent structures or services resulting from ground anchor construction. Damage to existing facilities as a result of the Contractor’s work will be repaired by the Contractor at no additional cost and no extension of time to the contract.

C. Proposed start date and anchor installation schedule.

D. Information on headroom and space requirements for installation equipment to verify that the proposed equipment can perform at the site. Where the anchors are installed adjacent to an existing structure, inspect the condition and site of the existing structure in the presence of the Engineer. Provide a copy of photographic documentation of the preconstruction conditions to the Engineer.

E. Mill Test Reports. Submit mill test reports for the prestressing steel and the bearing plate steel to the Engineer for review and approval. The Engineer may require samples of any ground anchor material intended for use on the project. The Engineer will approve or reject the prestressing steel and bearing plate steel within 5 working days after receipt of the test reports. Do not incorporate the prestressing steel and bearing plates in the work without the Engineer’s approval.

F. Detailed description of proposed management procedures for the control and disposal of excess surface water, drill flush, grout, and any resultant product of the anchor installation. Do not excavate flush pits at or below the floodplain elevation in accordance with subsection 205.03.P of the Standard Specifications for Construction.

G. Grouting Plan. Provide complete descriptions, details and supporting calculations for:

(1) Grout mix design and type of materials to be used, including certified test data and trial batch reports.

(2) Specific gravity of the grout mix.

(3) Methods and equipment for accurately monitoring and recording the grout depth, grout volume, and grout pressure as the grout is being placed.

(4) Grouting rate calculations, if requested by the Engineer. Base the calculations on the initial pump pressures or static head on the grout and losses throughout the placing system, including anticipated head of drilling fluid (if applicable) to be displaced.

(5) Estimated curing time for grout to achieve the required strength. Submit previous test results for the proposed grout mix. The test results must have been completed within 1 year of the start of grouting for initial verification load test. Test grout during production as specified herein.

(6) Procedure and equipment proposed for monitoring grout quality and consistency.

H. Detailed working drawings for the proposed anchor load testing. Include all drawings and details necessary to clearly describe the proposed test methods, reaction frame, reaction anchors, system test load capacity, equipment setup, types and accuracy of apparatus to be used for applying and measuring the test loads, and anchor top movements in accordance with the load test requirements specified herein. Submit structural design calculations for all structural components of the test apparatus.

I. Calibration reports and data prepared by an independent testing laboratory within 90 calendar days of the date submitted for each test jack, pressure gauge, master pressure gauge, and electronic load cell to be used. Do not perform load testing until the Engineer has reviewed and accepted the calibration reports and data.

J. General Certification in accordance with the *Materials Source Guide* for the following materials, if used, stating that the material or assemblies provided will comply fully with the requirements of the contract.

(1) Prestressing steel bar;

(2) Portland cement;

(3) Prestressing hardware;

(4) Bearing plates;

(5) Corrosion protection system; and

(6) Steel Reinforcement.

K. Reports and As-Built Drawings. Within 14 calendar days after completing the ground anchor work, submit a report to the Engineer containing the following information:

(1) Grouting records indicating the cement type, quantity injected, and the grout pressures;

(2) As-built drawings showing the location and orientation of each ground anchor, anchor capacity, tendon type, total anchor length, bond length, unbonded length, and tendon bond length as installed.

The costs for providing the information in subsection c.1.K is included in the pay item Ground Anchor, Equipment, Furn.

2. Existing Conditions.

A. Utilities. Field-verify the location of all utilities shown on the plans. Notify the Engineer of any utility locations different than what is shown on the plans that may require anchor relocations or structure design modifications. Additional costs due to anchor relocation and/or structure design modifications resulting from utility locations different than what is shown on the plans will be paid for extra work.

B. Visually survey the condition of adjoining properties and record and photograph evidence of settlement or cracking of adjacent structures. Submit a visual survey report to the Engineer before beginning work.

3. Construction Quality Assurance. Assist the Department as necessary during inspection and any material testing. Account for inspection, testing and monitoring activities by the Department in the construction schedule. Correct deficiencies and nonconformities identified by the Engineer at no cost to the contract.

4. Corrosion Protection. Construct corrosion protection systems as shown on the plans to meet these requirements.

A. Anchorage Protection.

(1) Provide stressing anchorages that will be exposed to the atmosphere with a grout-filled cover, except, for restressable anchorages, use a corrosion inhibiting compound. Stressing anchorages encased in concrete at least 2 inches thick do not require a cover.

(2) Seal the trumpet to the bearing plate. Ensure the trumpet overlaps the unbonded length corrosion protection by at least 6 inches. Provide a trumpet of adequate length to accommodate movements of the structure and the tendon during testing and stressing.

(3) Completely fill the trumpet with grout, except use corrosion inhibiting compounds for restressable anchorages. Compounds may be placed at any time during construction. Provide a seal between compound-filled trumpets and the unbonded length corrosion protection. Place grout after the ground anchor has been tested and stressed to the lock-off load. For trumpets filled with grout, a temporary seal may be provided between the trumpet and the unbonded length corrosion protection. Alternatively, the trumpet may be tightly fit over the unbonded length corrosion protection for a minimum of 4 inches.

B. Unbonded Length Protection.

(1) Provide corrosion protection of the unbonded length using a combination of sheaths, sheath filled with a corrosion inhibiting compound or grout, or a heat shrinkable tube internally coated with a mastic compound, depending on the tendon class. Ensure the corrosion inhibiting compound completely coats the tendon elements and fills the void between them and the sheath. Ensure the compound remains within the sheath.

(2) Surround the unbonded length of the tendon with a corrosion protective sheath that is long enough to extend into the trumpet, but that does not come into contact with the stressing anchorage during testing. Trim off excessive protection length.

(3) For pregrouted encapsulations and all Class I tendons, provide a separate bondbreaker or common sheath for supplemental corrosion protection or to prevent the tendon from bonding to the grout surrounding the unbonded length.

C. Unbonded Length/Bond Length Transition. Fabricate a transition between the corrosion protection for the bonded and unbonded lengths to ensure continuous protection from corrosive attack.

D. Tendon Bond Length Protection for Encapsulated Tendons (Class I):

(1) Use a grout-filled, corrugated plastic encapsulation or a grout-filled, deformed steel tube. Grout the prestressing steel inside the encapsulation prior to inserting the tendon into the drill hole or after the tendon has been placed.

(2) Use centralizers or grouting techniques that ensure a minimum of 1/2 inches of grout cover over the encapsulation.

E. Epoxy (Class I). Fusion-bonded epoxy may be used to provide a layer of protection for the steel tendon in addition to the cement grout.

F. Coupler Protection. For encapsulated bar tendons (Class I), cover the coupler and any adjacent exposed bar sections with a corrosion-proof compound or wax-impregnated cloth tape. Cover the coupler area with a smooth plastic tube, meeting the requirements for sheaths specified herein, and overlap 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 an approved equal. Ensure the corrosion-proof compound completely fills the space inside the cover tube.

5. Storing and Handling Tendons.

A. Handle and store tendons in a manner that will prevent damage or corrosion. The Engineer will reject tendons with damage to the prestressing steel, corrosion protection, and/or the epoxy coating as a result of abrasions, cuts, nicks, welds and weld splatter. Protect the prestressing steel if welding is to be performed in the vicinity. Do not ground welding leads to the prestressing steel. Protect prestressing steel from dirt, rust, and other deleterious substances. The Engineer will consider a light coating of rust on the steel as being acceptable; however, if heavy corrosion or pitting is noted, the Engineer will reject the affected tendons.

B. Prior to inserting a tendon in the drill hole, examine, along with the Engineer, the tendon for damage to the encapsulation and the sheathing. If, in the opinion of the Engineer, the encapsulation is damaged, repair the encapsulation in accordance with the tendon supplier’s recommendations. If, in the opinion of the Engineer, the smooth sheathing has been damaged, repair the sheathing with ultrahigh molecular weight polyethylene tape. Wind the tape in a spiral around the tendon to completely seal the damaged area. Ensure the pitch of the spiral provides a double thickness at all points.

C. Pad banding for fabricated tendons to avoid damage to the tendon corrosion protection. Upon delivery to the site, store and handle fabricated anchors, or the prestressing steel for fabrication of the tendons on site, and all hardware in a manner that avoids mechanical damage, corrosion, and contamination with dirt or deleterious substances.

D. Lift pre-grouted tendons in a manner that does not cause excessive bending, which can debond the prestressing steel from the surrounding grout.

E. Do not expose prestressing steel to temperatures exceeding 450 ºF.

6. Fabricating Anchors.

A. Fabricate anchors either in the shop or in the field using materials that comply with this special provision and the approved working drawings and schedules.

B. Cut the prestressing steel with an abrasive saw.

C. Ensure that the entire tendon bond length is free of dirt, manufacturer’s lubricants, corrosion-inhibitive coatings, or other deleterious substances that may significantly affect the grout-to-tendon bond or the service life of the tendon.

D. Pregrout encapsulated tendons on an inclined, rigid frame or bed by injecting the grout from the low end of the tendon.

E. Weld trumpet to the bearing plate. Ensure the inside diameter of the trumpet is at least 1/4 inches greater than the diameter of the tendon at the anchorage. Ensure the trumpet is long enough to accommodate movements of the structure during testing and stressing.

7. Drilling.

A. Drilling Method. Use a drilling method that will establish a stable hole of adequate dimensions, within the tolerances specified. Drilling methods may involve rotary, percussion, rotary/percussive or auger drilling, or percussive or vibratory driven casing. Select a drilling method that does not damage and/or settle existing structures, pavement, or utilities. Coordinate the work and excavations so that the ground anchors are safely constructed.

B. Holes for Anchors. Drill holes for anchors at the locations and to the length, inclination, and minimum diameter shown on the plans or the approved working drawings. Depending on hole location at the structure, provide equipment to drill holes for either top-down construction or bottom-up construction. This may require equipment to access elevated hole locations.

Use a drill bit or casing crown that is not more than 0.125 inches smaller than the hole diameter specified in the approved working drawings. Locate the drill hole at the ground surface within 6 inches of the location shown on the plans or the approved working drawings. Locate the drill hole so the longitudinal axis of the drill hole and the longitudinal axis of the tendon are parallel. Do not drill ground anchor holes in a location that would require the tendon to be bent in order to connect the bearing plate to the supported structure. At the back side of the waler or pile, install the ground anchor within ±3 degrees of the inclination from horizontal shown on the plans or the approved working drawings. At the back side of the waler or pile, ensure that the horizontal angle made by the ground anchor and the structure is within ±3 degrees of a line drawn perpendicular to the plane of the structure unless otherwise shown on the plans or approved working drawings. Ensure that the ground anchors do not extend beyond the right-of-way or easement limits shown on the plans.

Drilling tools that are lost in excavation will be promptly removed by the Contractor without compensation and/or extension of time. All costs due to lost tool removal will be borne by the Contractor including but not limited to, costs associated with hole degradation due to removal operations or the time the hole remains open.

The minimum distance between drilling and grouting of anchors will not be less than 10 foot center to center unless a completed anchor is between the two anchors to be drilled and grouted. Drilling and grouting of ground anchors closer than 10 foot center to center is acceptable if the time between the end of drilling and beginning of drilling is at least 24 hours. If drilling operations affect an already completed anchor, then the affected anchor may be rejected by the Engineer. If a ground anchor is rejected due to Contractor’s drilling operations, then additional anchor(s) may be required at no additional cost to the contract.

C. Site Drainage Control. Control and properly dispose of excavated soil, drill flush, excess grout and any other construction related waste in accordance with the 1994 PA 451, Part 115 – Solid Waste Management and Part 31 – Water Resources Protection and all other applicable regulations. Repair damage caused by construction activity and waste at no additional cost to the contract. Immediately notify the Engineer if unanticipated existing subsurface drainage structures are discovered during excavation or drilling. Suspend work in these areas until remedial measures, meeting the approval of the Engineer, are implemented. The remedial measures or repair work resulting from encountering unanticipated subsurface drainage structures will be paid for as extra work.

8. Inserting Tendons.

A. Place tendons in accordance with the plans and the recommendations of the tendon manufacturer or specialist anchor contractor. Insert the tendon into the drill hole to the desired depth without difficulty. If the tendon cannot be completely inserted, remove the tendon from the drill hole and clean or redrill the hole to allow insertion. Do not drive or force partially inserted tendons into the hole.

B. Inspect each anchor tendon during installation into the drill hole or casing. Repair damage to the corrosion protection system or replace the tendon if not repairable. Reconnect loose spacers or centralizers to prevent shifting during insertion. Repair damaged fusion-bonded epoxy coatings in accordance with the manufacturer’s recommendations. If the patch is not allowed to cure prior to inserting the tendon in the drill hole, protect the patched area using tape or other suitable means.

C. Control the rate of placement of the tendon into the hole to ensure that no damage occurs to the sheathing, coating, and grout tubes during installation of the tendon. Ensure anchor tendons are not subjected to sharp bends. A cap or bullnose may be fit to the bottom end of the tendon to aid its insertion into the hole, casing, or sheathing.

9. Grouting.

A. Place grout the same day the bonded length is drilled. Use a neat cement grout or a sand-cement grout. Ensure grout contains no lumps or other indications of hydration. Mix admixtures, if used, in accordance with the manufacturer’s recommendations.

B. Use grouting equipment that produces a grout free of lumps and undispersed cement. Use a positive displacement grout pump equipped with a pressure gauge to monitor grout pressures. Ensure the pressure gauge is capable of measuring pressures of at least 150 psi or twice the actual grout pressures to be used, whichever is greater. Size the grouting equipment so that the grout may be pumped in one continuous operation. Use a mixer capable of continuously agitating the grout.

C. Based on the subsurface conditions, select a grouting procedure that meets the project requirements. Inject the grout under pressure of at least 50 psi from the lowest point of the drill hole. Grout may be pumped through grout tubes, casings, hollow-stem augers, or drill rods. Place the grout either before or after inserting the tendon. The tremie pipe or casing must always be immersed at least 10 feet in grout after beginning of grouting. Record the quantity of grout placed and the grout pressures. Control the grout pressures and grout takes to prevent excessive heave or fracturing.

D. After installing the tendon, the drill hole may be filled in one continuous grouting operation, except do not use pressure grouting in the free length zone. Ensure that the grout at the top of the drill hole does not contact the back of the structure or the bottom of the trumpet.

E. If the ground anchor is installed in a fine-grained soil using drill holes larger than 6 inches in diameter, place the grout above the top of the bond length after testing and stressing the ground anchor. Grouting the entire drill hole at the same time will be allowed if the Contractor can demonstrate that the particular ground anchor system does not derive a significant portion of its load carrying capacity from the soil above the bond length portion of the ground anchor.

F. If grout protected tendons are used for ground anchors anchored in rock, use pressure grouting techniques. Pressure grouting requires that the drill hole be sealed and that the grout be injected until a minimum 50 psi grout pressure (measured at the top of the drill hole) can be maintained on the grout for at least 5 minutes.

G. Do not load the tendon for a minimum of 3 calendar days after grouting and has attained the minimum compressive strength required for design.

During installation of anchors, make six 2 inch grout cubes from each plant each day of operation or per every 10 anchors, whichever occurs more frequently. Test three of the grout cubes in accordance with *AASHTO T106M/T106* by an independent testing laboratory. The compressive strength will be determined from the average of the compressive strengths of the three grout cubes.

Immediately prior to pile grouting, measure grouting density in accordance with *AASHTO T133* or *API RP-13B-1*. Conduct at least one grout density test per anchor.

Submit compressive strength and density test results to the Engineer within 24 hours of testing.

10. Installing Anchors.

A. Install the anchor bearing plate and the anchor head or nut perpendicular to the tendon, within ±3 degrees and centered on the bearing plate, without bending or kinking of the prestressing steel elements. Ensure the wedge holes and wedges are free of rust, grout, and dirt.

B. Clean and protect the stressing tail from damage until final testing and lock-off. After the anchor has been accepted by the Engineer, cut the stress tail to its final length in accordance with the tendon manufacturer’s recommendations. Flame cutting is prohibited.

C. Extend the corrosion protection surrounding the unbonded length of the tendon beyond the bottom seal of the trumpet or 6 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.

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

11. Stressing, Load Testing, and Acceptance. Submit a load testing program for review by the Department and Conrail with the Contractor’s submittal. The Contractor’s load testing designer must reference FHWA Publication No. FHWA-IF-99-015 (Geotechnical Engineering Circular No. 4, Ground Anchors and Anchored System) in the design and load testing program. Test each ground anchor under the direction of a Professional Engineer licensed in the State of Michigan. Summarize the report to the Engineer within 24 hours of each load test. Notify the Engineer in writing 3 working days prior to any load test. Do not perform load tests without a representative from the Department’s Geotechnical Services Section being on site to witness the load test.

Do not apply loads greater than 10 percent of the design load to the ground anchor prior to testing. Ensure that the maximum test load is at least 1.33 times the design load, but does not exceed 80 percent of the specified minimum ultimate tensile strength (SMTS) of the prestressing steel of the tendon. Apply the test load simultaneously to the entire tendon.

A. Testing Equipment. Provide testing equipment consisting of the following:

(1) Use a dial gauge or vernier scale capable of measuring to the nearest 0.001 inches to measure the ground anchor movement. Provide a movement-measuring device having a minimum travel equal to the theoretical elastic elongation of the total anchor length at the maximum test load. Ensure that the device has adequate travel so the ground anchor movement can be measured without resetting the device at an interim point.

(2) Use an appropriately sized hydraulic jack and pump to apply the test load. Measure the applied load using a jack and a calibrated primary pressure gauge. Engage an independent firm to calibrate the jack and primary pressure gauge as a unit. Ensure that the calibration was performed no longer than 90 calendar days prior to date on which the calibration submittals are provided to the Engineer. Do not begin testing until the Engineer has approved the calibration. Use a primary pressure gauge that is graduated in increments of 50 psi or less. Ensure that the ram travel is at least 6 inches and not less than the theoretical elongation of the tendon at the maximum test load.

(3) Keep a calibrated reference pressure gauge at the site to periodically check the production (i.e., primary pressure) gauge. Calibrate the reference gauge with the test jack and primary pressure gauge. Store the reference pressure gauge indoors and do not subject to rough treatment.

(4) Provide an electrical resistance load cell and readout to be used when performing an extended creep test.

(5) Place the stressing equipment over the ground anchor tendon in a manner that will ensure that the jack, bearing plates, load cells, and stressing anchorage are axially aligned with the tendon and that the tendon is centered within the equipment.

B. General Stressing Procedures.

(1) Determine the stressing equipment, the sequence of stressing and the procedure to be used for each stressing operation during the planning stage of the project. Operate equipment in accordance with the manufacturer’s instructions.

(2) Use stressing equipment capable of stressing the whole tendon in one stroke to the specified test load and of stressing the tendon to the maximum specified test load within 75 percent of the rated capacity. Use a pump capable of applying each load increment in less than 30 seconds.

(3) Ensure equipment allows stressing of the tendon in increments so that the load in the tendon can be raised or lowered in accordance with the test specifications, and allows the anchor to be lift-off tested to confirm the lock-off load.

(4) Ensure stressing equipment has been calibrated within an accuracy of ±2 percent prior to use. Have the calibration certificate and graph available on site at all times. Ensure that the calibration is traceable to the *NIST*.

C. Load Testing Setup.

(1) Place a dial gauge to bear on the pulling head of the jack, with their stems coaxial with the tendon direction. Support the gauge on an independent, fixed frame, such as a tripod, that will not move as a result of stressing or other construction activities during the operation.

(2) Prior to setting the dial gauge, place the Alignment Load (AL) accurately on the tendon. The magnitude of AL depends on the type and length of the tendon.

(3) Do not stress and test multiple element tendons with single element jacks.

(4) Do not begin stressing until the grout has reached adequate strength.

D. Performance Tests. Unless otherwise specified on the plans, perform a performance test on 10 percent of the ground anchors or a minimum of 3 ground anchors, whichever is greater. The performance tests are to verify the anchor design and the construction procedures used to install the ground anchor. Performance tests are to be performed on test anchors specified on the plans or as directed by the Engineer.

(1) Conduct the performance test by incrementally loading and unloading the ground anchor in accordance with the schedule provided in Table 3. Raise the load from one increment to another immediately after recording the ground anchor movement. Measure and record the ground anchor movement to the nearest 0.001 inches with respect to an independent fixed reference point at the alignment load and at each increment of load. Monitor the load with the primary pressure gauge. Place the reference pressure gauge in series with the primary pressure gauge during each performance test. If the load determined by the reference pressure gauge and the load determined by the primary pressure gauge differ by more than 10 percent, recalibrate the jack, primary pressure gauge, and reference pressure gauge at no cost to the contract. At load increments other than the maximum test load, hold the load just long enough to obtain the movement reading.

(2) Hold the maximum test load in a performance test for 10 minutes. Use a load cell to monitor small changes in load during constant load-hold periods.

(3) Adjust the jack as necessary to maintain a constant load. Start the load-hold period as soon as the maximum test load is applied. Measure and record the ground anchor movement, with respect to a fixed reference, at 1, 2, 3, 4, 5, 6, and 10 minutes. If the ground anchor movement between 1 minute and 10 minutes exceeds 0.04 inches, hold the maximum test load for an additional 50 minutes. If the load-hold is extended, record the ground anchor movement at 15, 20, 30, 40, 50, and 60 minutes.

**Table 3: Steps for the Performance Test**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Step | Loading | Applied Load | Record and Plot Total Movement (δti) | | | Record and Plot Residual Movement (δri) | | | Calculate Elastic Movement (δei) |
| 1 | Apply AL | AL |  | | |  | | |  |
| 2 | Cycle 1 | 0.25DL | δt1 | | |  | | |  |
| AL |  | | | δr1 | | | δt1 – δr1 = δe1 |
| 3 | Cycle 2 | 0.25DL | δ2 | | |  | | |  |
| 0.50DL | δt2 | | |  | | |  |
| AL |  | | | δr2 | | | δt2 – δr2 = δe2 |
| 4 | Cycle 3 | 0.25DL | δ3 | | |  | | |  |
| 0.50DL | δ3 | | |  | | |  |
| 0.75DL | δt3 | | |  | | |  |
| AL |  | | | δr3 | | | δt3 – δr3 = δe3 |
| 5 | Cycle 4 | 0.25DL | δ4 | | |  | | |  |
| 0.50DL | δ4 | | |  | | |  |
| 0.75DL | δ4 | | |  | | |  |
| 1.00DL | δt4 | | |  | | |  |
| AL |  | | | δr4 | | | δt4 – δr4 = δe4 |
| 6 | Cycle 5 | 0.25DL | | δ5 | | |  | |  |
| 0.50DL | | δ5 | | |  | |  |
| 0.75DL | | δ5 | | |  | |  |
| 1.00DL | | δ5 | | |  | |  |
| 1.20DL | | δt5 | | |  | |  |
| AL | |  | | | δr5 | | δt5 – δr5 = δe5 |
| 7 | Cycle 6 | 0.25DL | | δ6 | |  | | |  |
| 0.50DL | | δ6 | |  | | |  |
| 0.75DL | | δ6 | |  | | |  |
| 1.00DL | | δ6 | |  | | |  |
| 1.20DL | | δ6 | |  | | |  |
| 1.33DL | | δt6, Zero reading for creep test | |  | | |  |
| 8 | Hold load for 10 minutes while recording movement at specified times. If the total movement measured during the load hold exceeds the specified maximum value, then extend the load hold to a total of 60 minutes. | | | | | | | | |
| 9 | Cycle 6 (continued) | AL |  | | δr6 | | | δt4 – δr6 = δe6 | |
| 10 | Adjust to lock-off load if test results satisfy acceptance criteria | | | | | | | | |
| Notes  1. AL = Alignment Load  2. DL = Design Load  3. δi = total movement at a load other than maximum for cycle  4. i = number identifying a specific load cycle. | | | | | | | | | |

Performance anchors constructed using methods different from the methods submitted for production anchors will be rejected and additional performance anchor(s) will be required at no additional cost to the contract.

Do not install production anchors for a section of wall until the performance test results for the same section of wall have been reviewed and accepted by the Engineer.

E. Proof Tests. Perform a proof load test on all ground anchors. Once the loading sequence is complete at 1.00 DL, either reduce load to the designated lock-off load (top down construction sequence) or unload completely (bottom up construction sequence). Jacking against the soldier pile members in areas of bottom up construction will not be allowed during the proof load tests. For bottom up construction methods, reload the anchor to the lock-off load denoted on the plans at a later time in the construction sequence or as approved on the shop drawings by the Engineer.

(1) Perform the proof test by incrementally loading the ground anchor in accordance with the schedule provided in Table 4. Raise the load from one increment to another immediately after recording the ground anchor movement. Measure and record the ground anchor movement to the nearest 0.001 inches with respect to an independent fixed reference point at the alignment load and at each increment of load. Monitor the load with the primary pressure gauge. At load increments other than the maximum test load, hold the load just long enough to obtain the movement reading.

**Table 4: Proof Test Schedule**

|  |  |
| --- | --- |
| Step | 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 (top down construction) |
| 8A | AL (bottom up construction) |
| 9 | Adjust to lock-off load (at later point in bottom up construction sequence) |
| Notes  1. DL = Design Load  2. AL = Alignment Load | |

(2) Hold the maximum test load in a proof test for 10 minutes. Adjust the jack as necessary to maintain a constant load. Start the load-hold period as soon as the maximum test load is applied. Measure and record the ground anchor movement with respect to a fixed reference at 1, 2, 3, 4, 5, 6, and 10 minutes. If the ground anchor movement between 1 minute and 10 minutes exceeds 0.04 inches, hold the maximum test load for an additional 50 minutes. If the load-hold is extended, record the ground anchor movements at 15, 20, 30, 40, 50, and 60 minutes.

F. Extended Creep Test.

(1) Perform extended creep tests on anchors specified on the plans. If anchors are not specified, then the Engineer will select the ground anchors to be extended creep tested. Use stressing equipment capable of measuring and maintaining the hydraulic pressure within 50 psi.

(2) Conduct the extended creep test by incrementally loading and unloading the ground anchor in accordance with the performance test schedule provided herein. At the end of each loading cycle, maintain a constant load for the observation period indicated in the creep test schedule in Table 5. Read and record the ground anchor movement during each observation period at 1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30, 45, 60, 75, 90, 100, 120, 150, 180, 210, 240, 270, and 300 minutes, as appropriate for the load increment. Start each load-hold period as soon as the test load is applied. In a creep test, use the primary pressure gauge and reference pressure gauge to measure the applied load, and use the load cell to monitor small changes in load during constant load-hold periods. Adjust the jack as necessary to maintain a constant load.

(3) Plot the ground anchor movement and the residual movement measured in an extended creep test. In addition, plot the creep movement for each load-hold as a function of the logarithm of time.

**Table 5: Extended Creep Test Schedule**

|  |  |
| --- | --- |
| Load | Observation Period, minutes |
| AL | 1 |
| 0.25DL | 10 |
| 0.50DL | 30 |
| 0.75DL | 30 |
| 1.00DL | 45 |
| 1.20DL | 60 |
| 1.33DL | 300 |
| Notes  1. DL = Design Load | |

G. Ground Anchor Test Acceptance Criteria.

(1) A performance-tested or proof-tested ground anchor with a 10 minute load-hold is acceptable if:

(a) ground anchor resists the maximum test load with less than 0.04 inches of movement between 1 minute and 10 minutes; and

(b) total elastic movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length (apparent free length criteria).

(2) A performance-tested or proof-tested ground anchor with a 60 minute load-hold is acceptable if:

(a) ground 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

(b) total elastic movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length (apparent free length criteria).

(3) A ground anchor subjected to extended creep testing is acceptable if:

(a) ground 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

(b) total elastic movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length (apparent free length criteria).

(4) Ensure the initial lift-off reading is within ±5 percent of the designed lock-off load. If this criterion is not met, adjust the tendon load accordingly and repeat the initial lift-off reading.

H. Procedures for Anchors Failing Acceptance Criteria.

(1) Reject and replace anchors that do not satisfy the acceptance criteria at no additional cost to the contract. Submit a replacement plan to the Engineer for approval. Rejected anchors may be locked off at not more than 50 percent of the maximum acceptable load attained.

(2) Regroutable anchors that satisfy the minimum apparent free length criteria but fail the extended creep test at the test load may be postgrouted and subjected to an enhanced creep criterion. This enhanced criterion requires a creep movement of not more than 0.04 inches between 1 and 60 minutes at the maximum test load. Lock off anchors that satisfy the enhanced creep criterion at the design lock-off load.

I. Anchor Lock-Off.

(1) After completing testing, load the tendon so that after seating losses (i.e., wedge seating), the lock-off load will have been applied to the anchor tendon.

(2) Ensure the lock-off load does not exceed 70 percent Fpu, the minimum tensile strength of the tendon.

(3) Seat the wedges at a minimum load of 50 percent Fpu. If the lock-off load is less than 50 percent Fpu, use shims under the wedge plate and the wedges seated at 50 percent Fpu. Then remove the shims to reduce the load in the tendon to the desired lock-off load. Bar tendons may be locked off at any load less than 70 percent Fpu.

J. Anchor Lift-Off Test. After transferring the load to the anchorage, and prior to removing the jack, conduct a lift-off test to confirm the magnitude of the load in the anchor tendon. If the lift-off test is not within 10 percent of the specified lock-off load, reset the anchorage and perform another lift-off test. Repeat this process until the desired lock-off load is obtained. Determine this load by reapplying load to the tendon to lift off the wedge plate (or anchor nut) without unseating the wedges (or turning the anchor nut).

K. Cutting Stressing Tails. Cut tendons using an abrasive disk. Leave not less than 1/2 inch and not more than 2 inches of tendon remaining beyond the wedges. Do not cut tendons until after testing, stressing and lift-off readings are complete. Do not cut tendons until the anchor is accepted by the Engineer.

**d. Measurement and Payment.** The completed work, as described, will be measured and paid for at the contract unit price using the following pay items:

**Pay Item Pay Unit**

Ground Anchor Equipment, Furn (Structure Identification) Lump Sum

Ground Anchor Each

Ground Anchor Test, Performance Each

Ground Anchor Test, Proof Each

Ground Anchor Test, Extended Creep Each

1. **Ground Anchor Equipment, Furn (Structure Identification)** will be measured as a unit for each structure. **Ground Anchor Equipment, Furn (Structure Identification)** includes furnishing and removing equipment for installing ground anchors, making submittals, obtaining approval or acceptance from the Engineer for submittals, and maintaining installation records.

2. **Ground Anchor** will be measured per each anchor installed and accepted by the Engineer. **Ground Anchor** includes furnishing all materials, equipment, casing, labor, incidentals, and disposing of excess materials and spoils for the work as specified herein. No additional compensation will be given for grout overruns.

3. **Ground Anchor Test, Performance** includes furnishing all materials, submittals, data collection and reports, equipment, labor, and incidentals for the work as specified herein which meets the acceptance criteria.

4. **Ground Anchor Test, Proof** includes furnishing all materials, data collection and reports, equipment, labor, and incidentals for the work as specified herein which meets the acceptance criteria. This includes loading the anchor to the design load specified, unloading, and then reloading to the specified lock-off load at a later time in the construction process. A lift off test for each anchor is also included with this pay item.

5. **Ground Anchor Test, Extended Creep** includes furnishing all materials, equipment, labor, and incidentals for the work as specified herein which meets the acceptance criteria.

Steel reinforcement for local anchorage zone reinforcement for ground anchors bearing on concrete will not be paid for separately but included in the pay item **Ground Anchor**.