NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

TEMPORARY EROSION AND SEDIMENT BEST MANAGEMENT PRACTICES

1. GENERAL

Install, maintain and remove appropriate Temporary Best Management Practices (BMPs).

Definitions:

A. Temporary Erosion and Sediment BMPs are to be installed and maintained before and during the term of the land disturbance activity. These items are removed when permanent erosion and sediment BMPs are installed.

B. Permanent Erosion and Sediment BMPs are to be installed and maintained once the project is completed so that the applicable permits can be terminated.

In some instances, individual temporary and permanent erosion and sediment BMPs for a site may consist of identical BMPs. In these cases, the temporary erosion and sediment BMPs may be used as the permanent erosion and sediment BMPs if they meet the following criteria:

1. The BMP was installed correctly,
2. Is in a functional condition,
3. Has had all accumulated sediment removed.

C. The Stormwater Pollution Prevention Plan (SWPPP) is the document that identifies potential sources of sediment or other pollution from construction activity and ensures practices are used to reduce the contribution of pollutants from construction site runoff.

D. Contractor Controlled Areas are areas not included in the contract, but are obtained and solely controlled by the Contractor (e.g., concrete or asphalt batch plants, concrete washout areas, equipment staging yards, material storage areas, excavated material disposal areas, Contractor furnished borrow areas, etc.).

E. Maintenance is any action taken to keep a BMP in working condition. These actions may consist of repairing failures of the BMP itself.

F. Noncompliance is any action or inaction that violates the regulations imposed by the applicable permits or the requirements of this special provision and other contract documents. Failure of a BMP does not necessarily constitute noncompliance as long as the BMP is repaired, replaced or supplemented within the timelines established in the applicable permits and no sediment is discharged from the site or into a water of the state.

2. CONSTRUCTION REQUIREMENTS

Develop a SWPPP specific to the project. The creation of the SWPPP is a cooperative effort between the NDDOT who creates the project plan sheets and the Contractor who creates a complete SWPPP which incorporates the plan sheets and the Contractor's means and methods. The project plan sheets by themselves do not meet the requirements of a complete SWPPP and should not be considered as such. The Contractor has the flexibility to modify the design and implementation of the temporary erosion and sediment controls to match the Contractor's means and methods and/or field conditions. These changes must be documented in the SWPPP and meet all regulatory requirements.

Obtain appropriate permit coverage for the activities conducted in Contractor Controlled Areas. A permit will be required for these areas regardless of their size. The NDDOT will have no responsibility for these areas.

Install perimeter erosion and sediment BMPs according to the plans/SWPPP prior to site disturbance.

Change the location of temporary erosion and sediment BMPs to fit the field conditions.

Update the SWPPP as work progresses, or as directed by the Engineer. Update the SWPPP to show changes due to revisions in work schedules or sequence of construction. Update the site map to reflect erosion and sediment BMPs that have been installed, changed, or removed.

Do not rely on perimeter BMPs as the sole method of controlling erosion. As the project progresses, install temporary erosion and sediment BMPs within the perimeter BMPs to control erosion resulting from the construction of the project.

Use temporary erosion and sediment BMPs to prevent contamination of adjacent streams or other watercourses, lakes, ponds or other areas of water impoundment.

Coordinate temporary erosion and sediment BMPs with the construction of permanent erosion and sediment BMPs to provide continuous erosion control. Do not install temporary erosion and sediment BMPs when permanent erosion and sediment BMPs are able to be installed. Once the permit is terminated or transferred to the Department, the maintenance of the permanent erosion and sediment BMPs becomes the responsibility of the NDDOT.

Install stabilization BMPs (mulch, seeding and mulch, etc.) in areas that have been disturbed where work has temporarily or permanently ceased following the timelines established in the applicable permits. If implementation of stabilization is precluded by snow cover, undertake such measures as soon as conditions allow.

Maintain the effectiveness of the temporary erosion and sediment BMPs as long as required to contain sediment runoff. Inspect the temporary erosion and sediment BMPs and complete the inspection and maintenance reports every 14 days and within 24 hours of a rainfall event of 0.25 inch or more. During prolonged rainfall (more than 1 day), conduct an inspection within 24 hours of the first day of the event and within 24 hours after the end of the event. Inspections are required only during normal business hours. Install a rain gauge to monitor rainfall amounts as required by the appropriate permit.

Correct any deficiencies in the BMPs within the timelines established in the applicable permits. If conditions do not permit access to the BMP, corrective actions can be taken by installing additional BMPs. Correct the original deficiencies as soon as conditions allow access to their location without causing additional damage to the slopes. In the inspection logs, document the conditions that prohibit access.

Provide copies of all inspections, documentation, record keeping, maintenance, remedial actions, and repairs required by the applicable permits to the Engineer. Provide inspection and maintenance reports within 3 working days after an inspection has been conducted.

Provide immediate written notification to the Engineer of proposed changes to the erosion control plan or SWPPP. The Engineer will review the proposed changes and determine if they are adequate. Documentation of maintenance and inspections that does not affect the erosion control plan or SWPPP does not require approval by the Engineer.

Remove the temporary devices when directed by the Engineer or when permanent erosion and sediment controls are installed.

3. Erosion and Sediment Control Supervisor.

A. General. Designate an erosion and sediment control supervisor. Provide the name and contact information for the supervisor at the preconstruction meeting. If this erosion and sediment control supervisor becomes unavailable on the project, designate a replacement supervisor. Notify the Engineer if this supervisor changes and provide the contact information for the new supervisor.

B. Qualifications. The supervisor shall be:

1. An employee of the Prime Contractor;

2. Familiar with installation, maintenance and removal of BMPs and the requirements of the erosion and sediment control plans, applicable permit requirements, specifications, plans and this provision; and

3. Competent to supervise personnel in erosion and sediment control operations.

C. Duties. The supervisor shall:

1. Provide erosion and sediment control as required by the SWPPP, Plans, and Specifications.

2. Be on the site to supervise the installation, operation, inspection, maintenance, and removal of the erosion and sediment BMPs.

3. Update the SWPPP as work progresses to show changes due to revisions in work schedules or sequence of construction, or as directed by the Engineer. Update the site map to reflect erosion and sediment BMPs that have been installed, changed, or removed.

4. Propose changes to improve erosion and sediment control.

5. Be accessible to the job site within 24-hours.

6. Provide the Engineer with documentation of all erosion and sediment control activities and inspections as required above.

3. PERFORMANCE

Correct all areas of noncompliance within 24 hours after notification of noncompliance. If corrective actions are not taken within 24 hours, the Engineer may:

1. Assess a liquidated damage of $500 per day per instance;

2. Have deficiencies corrected by another Contractor and deduct the cost of the work from the monies due or to become due to the Contractor;

3. Suspend all work; or

4. Withhold payment on other contract items/pay estimates.

These actions will be applied until deficiencies have been corrected.

4. BASIS OF PAYMENT

BMP installation will be paid for at the contract unit price for erosion and sediment control for the appropriate items and sections. The plans will detail the required BMPs for temporary and permanent installations. The same bid items may be used for temporary and permanent BMPs.

BMP items will be measured as specified in the “Method of Measurement” portion of the appropriate section of the specifications.

BMP item removal will be paid for at the contract unit price for “Remove _____”in the appropriate section of the specifications.

Include the costs for labor, materials, maintenance, equipment, disposal, adherence to the permit, and SWPPP modifications in the respective pay items.

When the Engineer directs the replacement of temporary erosion and sediment BMPs that are no longer functional because of deterioration or functional incapacity and those items were installed as specified in the Contract or as directed by the Engineer, the Department will pay for replacement BMPs

No payment will be made for replacing temporary erosion and sediment BMPs that the Engineer determines are ineffective because of improper installation, lack of maintenance, or the Contractor’s failure to pursue timely installation of permanent erosion and sediment BMPs as required in the Contract.

No payment will be made for replacing temporary erosion and sediment BMPs due to contractor operations. Include the cost to move Flotation Silt Curtain as work progresses in the price bid for “Flotation Silt Curtain”.

Erosion and sediment controls for Contractor Controlled Areas are the responsibility of the Contractor and will not be paid for by the Department.

Removal of sediment from silt fence and fiber rolls will be paid for at the price listed in the “Price Schedule PS-1.”

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

CROSSHOLE SONIC LOG TESTS

Project SER-5-094(107)030 – PCN 20549

1. DESCRIPTION

This work consists of furnishing adequate equipment, materials and experienced labor to complete crosshole sonic log (CSL) testing of completed drilled shafts. Repair drilled shafts defects reported by the CSL tests at no additional cost to the Department.

2. MATERIALS

A. CSL Access Tubes and Caps

Access tubes for CSL testing consist of non-galvanized, standard weight, schedule 40 steel tubes with an inside diameter of 1½ inches to 2 inches as appropriate for compatibility with the CSL probe sizes. The access tubes shall be round with a uniform regular inside diameter free of defects and obstructions, including all tube joints, in order to permit the free, unobstructed passage of source and receiver probes used for the crosshole sonic log tests. The access tubes shall be watertight and free from corrosion, with clean internal and external faces to ensure a good bond with the drilled shaft concrete and CSL grout. The access tubes shall be fitted with watertight, threaded caps on the bottom and removable watertight caps on the top.

B. Grout for CSL Access Tubes

Grout for filling the access tubes at the completion of the CSL tests shall be a homogeneous mixture of neat cement grout and potable water. The grout shall be produced using Portland cement Type I/II. The water to cementitious material ratio shall not exceed 0.45 and water-reducing admixtures may be used. The minimum compressive strength shall be 4,000 psi at 28 days when tested in conformance to ASTM C 1107.

This document was originally issued and sealed by Gregory Robert Fischer, Registration Number PE-4324, on 02/09/15 and the original document is stored at the North Dakota Department of Transportation

3. CONSTRUCTION REQUIREMENTS

A. CSL Testing Consultant

Submit a resume of the CSL Consultant retained by the Contractor, for approval by the Engineer. List a minimum of 5 projects over the past 3 years consisting of similar sized drilled shafts (diameter and length) constructed in similar conditions. Describe the overall results of the testing including problems discovered during testing and remediation. The CSL Consultant shall have a ND licensed Professional Engineer supervising the testing and interpretation of the results.

B. Access Tubes for CSL Testing

1. Drilled Shafts Requiring CSL Access Tubes

   Equip drilled shafts with CSL access tubes prior to CSL testing. If, in the opinion of the Engineer, the condition of the drilled shaft excavation permits drilled shaft construction in the dry, the Engineer may specify that the access tubes be omitted for that shaft and designate another drilled shaft for CSL testing.

2. Orientation and Assembly of the CSL Access Tubes

   Securely attach the access tubes to the interior of the reinforcement cage of the shaft. Furnish and install four access tubes in each drilled shaft per Section B.1. and as shown on the Plans. Place the access tubes equally spaced around the shaft, inside the spiral or hoop reinforcement and bundled with the vertical reinforcement as shown in the Plans. Where circumferential components of the rebar cage bracing system prevent bundling the access tubes directly to the vertical reinforcement, place the access tubes inside the circumferential components of the rebar cage bracing system as close as possible to the nearest vertical steel reinforcement bar.

   Install the access tubes in straight alignment and as near to parallel to the vertical axis of the reinforcement cage as possible. Extend the access tubes from 0.5 feet from the bottom of the drilled shaft to at least 2 feet above the top of the shaft. Splice watertight joints in the access tubes to achieve full length access tubes, as required. Clear the access tubes of all debris and extraneous materials before installing the access tubes. Debur the tops of access tubes. Prevent damage to access tubes by carefully installing and placing the reinforcement cage and concrete in the shaft excavation.

3. Care for CSL Access Tubes

   Fill the access tubes with potable water before concrete placement and securely install the top, watertight caps. Do not allow any other material to enter the access tubes during construction of the drilled shaft. Keep access tubes full of water through the completion of CSL testing of that

shaft. When temperatures below freezing are possible, protect the access tubes against freezing by wrapping the exposed tubes with insulating material, adding antifreeze to the water in the tubes, or other methods as approved by the Engineer.

C. CSL Testing of Drilled Shaft

1. Inspection of CSL Access Tubes

   Inspect the access tubes after placing the shaft concrete and before beginning the CSL testing to verify that the CSL test probes can travel easily to the bottom of the access tubes without encountering obstructions or snags. Each access tube that a test probe cannot pass through shall be replaced, at no additional cost to the Department, with a 2-inch diameter hole cored through the concrete for the entire length of the shaft in accordance with Section 3.H. *Coring Drilled Shafts and Remedial Action Plan* of the Drilled Shaft Special Provision. Unless directed otherwise by the Engineer, locate cored holes approximately 6 inches inside the reinforcement without damaging the drilled shaft reinforcement. Log descriptions of inclusions and voids encountered in the cored holes and submit a copy of the log to the Engineer. Preserve the core from the holes in wooden core boxes, identified as to location and depth, and make available for inspection by the Engineer.

2. Conduct CSL Testing

   Perform CSL testing and analysis, except as otherwise noted, on each of the first four drilled shafts completed. Perform additional CSL testing on any of the remaining drilled shafts as designated by the Engineer. Conduct CSL testing in accordance with ASTM D 6760. Notify the Engineer of the date and time of each CSL test at least 48 hours prior to the scheduled test. Perform CSL testing after the drilled shaft concrete has cured at least 72 hours and after the concrete compressive strength reaches or exceeds 2,500 psi.

   Pull the CSL probes simultaneously, starting from the bottoms of the access tubes, over an electronic depth measuring device. Perform the CSL tests with the source and received probes in the same horizontal plane. Continuously record CSL signals at depth intervals of 2.5 inches or less from the bottom of the tubes to the top of each shaft. Perform CSL testing on every possible tube combination (a total of six combinations). Submit a report stamped by a ND Professional Engineer to the Engineer for review and acceptance. The report shall contain at a minimum, a description of the testing equipment, date and location of test, the number of days between concrete placement and CSL testing, the results of concrete compressive strength tests and the date tested, the CSL ultrasonic profiles with analyses of first pulse arrival time (FAT) versus depth and relative pulse energy / amplitude versus depth for each tube pair tested with any defect zones identified on the profiles and discussed in the test report, a presentation of the nested signal peak (e.g. “waterfall”) diagram as a function of time plotted

versus depth, an assessment of the data quality, and integrity condition of the tested drilled shaft. (An ultrasonic profile or profile is the record of a complete investigation from bottom to top between two pairs of access tubes.)

Evaluate the concrete in the shaft using the following classification on each CSL profile:

Satisfactory	(G) Good	FAT increase 0 to 10% and Energy Reduction < 6 decibels
Anomaly	(Q) Questionable	FAT increase 11 to 20% and Energy Reduction < 9 decibels
Flaw	(P/F) Poor/Flaw	FAT increase 21 to 30% or Energy Reduction between 9 and 12 decibels
Defect	(P/D) Poor/Defect	FAT increase > 31% or Energy Reduction > 12 decibels

The rating of the drilled shaft concrete considers the increases in FAT and the energy reduction relative to the arrival time or energy in a nearby zone of good concrete.

Within the report, indicate the Flaw or Defect zones, if any, on the CSL profiles for each tube pair tested and list them in a table with their magnitude (horizontal and vertical extent) and location on the shaft. Flaws must be addressed if they occur in 3 or more profiles at the same elevation. Defects must be addressed if they occur in more than one profile at the same elevation. Flaws or Defects covering the entire cross section require repair.

"Addressing" a Flaw or Defect means providing an additional CSL test for all tube combinations after a longer waiting time to verify the CSL test results or in the case of localized (e.g. not a full cross section), completing an additional offset CSL test between all tube pair combinations and an 3-D tomographic evaluation of all CSL data. Depending on the results of the additional CSL tests and the depths of the Flaws or Defects, additional measures such as core drilling, repair or drilled shaft replacement may be required.

3. Engineer's Final Acceptance of CSL Tested Drilled Shafts

The Engineer will determine final acceptance of each drilled shaft tested, based on the CSL test report(s) received for the tested shafts, and will

provide a response to the Contractor within 5 working days after receiving the test report. Contractor's Investigation and Remedial Action Plan

For all drilled shafts determined to be unacceptable, submit a plan for further investigation or remedial action to the Engineer for approval in accordance with Section 3.H. *Coring Drilled Shafts and Remedial Action Plan* of the Drilled Shaft Special Provision. Submit supporting calculations and work drawings for all proposed modifications to the drilled shafts, required by the investigation and remedial action plan. Submit all investigation and remedial correction procedures and designs to the Engineer for approval. Do not begin repair operations until receiving the Engineer's approval of the investigation and remedial action plan. Include CSL testing in the remedial action plan to verify the effectiveness of the proposed remediation.

4. Requirements for CSL Access Tubes and Cored Holes after CSL Testing

Dewater and fill all CSL access tubes and cored holes with grout conforming to this Special Provision after CSL tests are completed and final acceptance of the drilled shaft is obtained. Fill the access tubes and cored holes using tremie tubes that extend to the bottom of the tube, cored hole or into the grout already placed.

4. METHOD OF MEASUREMENT

Drilled shafts will be measured in accordance with the Special Provision for Drilled Shafts.

CSL Testing will be measured by each drilled shaft tested and accepted by the Engineer (e.g. does not require further testing or remediation).

All CSL tests, including initial CSL tests and subsequent CSL tests conducted to verify Flaws and Defects found in the initial testing and conducted to verify the effectiveness of proposed remediation, as well as related 3-D tomographic evaluations will not be measured for payment and are provided at no additional cost to the Department.

5. BASIS OF PAYMENT

Drilled shafts will be paid for in accordance with the Special Provision for Drilled Shafts.

The unit price of CSL testing shall be full compensation for each drilled shaft tested including, but not limited to: furnishing the four steel access tubes, end caps and installing the access tubes to the steel reinforcement cage; filling tubes with water; providing experienced personnel to conduct the CSL testing; furnishing adequate equipment to complete the tests; preparation of the CSL report that includes presentation of the CSL data, interpretation of the CSL data and assessment of drilled shaft's integrity; submittal of report; removing the water and filling the access tubes with the specified grout; and for furnishing all tools, labor, equipment, materials and incidentals necessary to complete the CSL testing work.

The accepted quantities for CSL testing will be paid for at the Contract unit price per each tested drilled shaft tested and reported to be free of addressable flaws and defects.

Item No.	Pay Item	Pay Unit
930-4250	Crosshole sonic log test	Each

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

DRILLED SHAFT

Project SER-5-094(107)030 – PCN 20549

1. DESCRIPTION

This work consists of furnishing adequate equipment, materials and experienced labor to complete drilled excavations filled with steel reinforcement bars and concrete.

2. MATERIALS

A. Concrete for Drilled Shafts

Provide a mix design for AA-5 Portland Cement Concrete conforming to Section 802 of the Standard Specifications with the following revisions:

1. Attain a compressive strength of 4,000 psi at 28 days.

2. Maintain a concrete slump equal to or greater than 7 inches throughout placement of concrete for the entire drilled shaft.

3. Provide water reducing and/or retarding concrete admixtures Types A, B or D, as classified under ASTM C 494 that meet the requirements of AASHTO M 194 to achieve the required concrete workability and slump throughout concrete placement.

In addition to other standard concrete sampling and testing procedures conducted by the Department the following tests and frequencies will occur as follows:

Concrete Slump, AASHTO T 119, 1 test per truck at point of discharge

Concrete Compressive Strength, AASHTO T 23 & T 22, 1 set of cylinders per Drilled Shaft at point of discharge (cast at least four cylinders for 6x12 inch specimens or six cylinders if 4 x 8 inch and carefully transport the cylinders to the job site curing facility).

B. Reinforcing Steel

Provide steel reinforcement bars in conformance with Section 612 of the Standard Specifications.

C. Temporary Casing

Temporary casing consists of a clean, watertight, smooth wall, steel cylinder of ample strength to resist damage and deformation from transportation and handling, installation and extraction stresses, and all pressures and forces acting on the casing.

D. Mineral Slurry

A manufactured product consisting predominantly of clay minerals and water prepared and maintained in conformance with the manufacturer's recommendations, the following table and the quality control plan specified in the Shaft Installation Narrative Submittal.

Property	Test	Requirement
Density (pcf)	Mud Weight (Density) API 13B-1 Section 1	63 to 75
Viscosity (seconds/quart) Bentonite Attapulgite	Marsh Funnel and Cup API 13b-1, Section 2.2	28 to 50 28 to 40
pH	Glass Electrode, pH Meter, or pH Paper	8 to 11
Sand Content (percent) • Prior to final cleaning • Immediately prior to placing concrete	Sand Content API 13B-1, Section 5	4.0 max

Maintain slurry temperature at 40 degrees Fahrenheit or greater when tested.

E. Synthetic Slurry

Use synthetic slurries prepared and maintained in conformance with the manufacturer's recommendations, the following tables and the quality control plan specified in the Shaft Installation Narrative Submittal.

The synthetic slurry must be one of the materials shown in the following table:

Synthetic Slurry Product Name	Manufacturer
SlurryPro CDP	KB INTERNATIONAL LLC 735 BOARD ST STE 209 CHATTANOOGA TN 37402 (423) 266-6964
Super Mud	PDS CO INC 105 W SHARP ST EL DORADO AR 71731 (870) 863-5707
Shore Pac GCV	CETCO CONSTRUCTION DRILLING PRODUCTS 2870 FORBS AVE HOFFMAN ESTATES IL 60192 (800) 527-9948
Terragel or Novagel Polymer	GEO-TECH SERVICES LLC 220 N. ZAPATA HWY STE 11A-449A LAREDO TX 78043 (210) 259-6386

Use synthetic slurries in compliance with the manufacturer's instructions. Provide certification of compliance from slurry manufacturer in accordance with Section 106.01 C. that indicates their product meets the requirements of this Special Provision and is suitable to the known subsurface site conditions indicated in the plans.

SlurryPro CDP synthetic slurry must comply with the requirements shown in the following table:

SLURRYPRO CDP		
Property	**Test**	**Value**
Density During drilling Before final cleaning and immediately before placing concrete	Mud Weight (density), API 13B-1, section 1	≤ 67.0 pcf ≤ 64.0 pcf
Viscosity During drilling Before final cleaning and immediately before placing concrete	Marsh Funnel and Cup. API 13B-1, section 2.2	50–120 sec/qt ≤ 70 sec/qt
pH	Glass electrode pH meter or pH paper	6.0–11.5
Sand content, percent by volume Before final cleaning and immediately before placing concrete	Sand, API 13B-1, section 5	≤ 0.5 percent

Slurry temperature must be at least 40 degrees F when tested.

Super Mud synthetic slurry must comply with the requirements shown in the following table:

SUPER MUD		
Property	**Test**	**Value**
Density During drilling Before final cleaning and immediately before placing concrete	Mud Weight (Density), API 13B-1, section 1	≤ 64.0 pcf ≤ 64.0 pcf
Viscosity During drilling Before final cleaning and immediately before placing concrete	Marsh Funnel and Cup. API 13B-1, section 2.2	32–60 sec/qt ≤ 60 sec/qt
pH	Glass electrode pH meter or pH paper	8.0–10.0
Sand content, percent by volume Before final cleaning and immediately before placing concrete	Sand, API 13B-1, section 5	≤ 0.5 percent

Slurry temperature must be at least 40 degrees F when tested.

Shore Pac GCV synthetic slurry must comply with the requirements shown in the following table:

SHORE PAC GCV		
Property	**Test**	**Value**
Density During drilling Before final cleaning and immediately before placing concrete	Mud Weight (Density), API 13B-1, section 1	≤ 64.0 pcf ≤ 64.0 pcf
Viscosity During drilling Before final cleaning and immediately before placing concrete	Marsh Funnel and Cup. API 13B-1, section 2.2	33–74 sec/qt ≤ 57 sec/qt
pH	Glass electrode pH meter or pH paper	8.0–11.0
Sand content, percent by volume Before final cleaning and immediately before placing concrete	Sand, API 13B-1, section 5	≤ 0.5 percent

Slurry temperature must be at least 40 degrees F when tested.

Terragel or Novagel Polymer synthetic slurry must comply with the requirements shown in the following table:

TERRAGEL OR NOVAGEL POLYMER		
Property	**Test**	**Value**
Density During drilling Before final cleaning and immediately before placing concrete	Mud Weight (Density), API 13B-1, section 1	≤ 67.0 pcf ≤ 64.0 pcf
Viscosity During drilling Before final cleaning and immediately before placing concrete	Marsh Funnel and Cup. API 13B-1, section 2.2	45–104 sec/qt ≤ 104 sec/qt
pH	Glass electrode pH meter or pH paper	6.0–11.5
Sand content, percent by volume Before final cleaning and immediately before placing concrete	Sand, API 13B-1, section 5	≤ 0.5 percent

Slurry temperature must be at least 40 degrees F when tested.

F. Water Slurry

Water without site soils may be used as slurry when casing is used for the entire length of the drilled hole. Prepare and maintain water slurry in conformance to the following requirements:

Property	Test	Requirement
Density (pcf)	Mud Weight (Density) API 13B-1 Section 1	65 max.
Sand Content (percent)	Sand API 13B-1, Section 5	1.0 max

Maintain slurry temperature at 40 degrees Fahrenheit or greater when tested.

G. Steel Reinforcing Bar Cage Centralizers, Boots and Base Plates

Provide devices manufactured commercially for properly aligning, centering and supporting steel rebar cages in drilled shaft excavations that will maintain the concrete cover specified in the Plans.

3. CONSTRUCTION REQUIREMENTS

A. Quality Assurance

1. Shaft Construction Tolerances

   Excavate shafts within a 3 inch horizontal tolerance of plan location (center at the top of the shaft) and within 2 percent plumb.

   Frequently check the plumbness, alignment and dimensions of the shaft during drilling or excavation of the shaft. Correct any deviation exceeding the allowable tolerances with a procedure approved by the Engineer.

2. Shaft Preconstruction Conference

   At least 5 working days prior to beginning the drilled shaft construction work at the site, convene a shaft preconstruction conference to discuss construction procedures, personnel, and equipment to be used, and the other elements of the approved Shaft Construction Submittal. Those attending shall include the Engineer, the Contractor's Superintendent, on-site supervisors, and all foremen in charge of excavating the shaft, placing the casing and slurry as applicable, placing the steel reinforcing bars, and placing the concrete. If mineral or synthetic slurry will be used to construct the shafts, the slurry manufacturer's representative and approved Contractor's employees trained in the use of the mineral or synthetic slurry shall also attend.

   During drilled shaft construction operations, the Contractor shall promptly notify the conference attendees listed above of significant variations, changes, revisions and updates to the Shaft Construction Submittal, as they are approved by the Engineer.

B. Shaft Construction Submittal

Furnish a shaft construction submittal, for Engineer approval, comprised of the following three components: construction experience; shaft installation narrative; and shaft slurry technical assistance. Submit the document in a PDF format to the Engineer a minimum of 14 calendar days prior to the Shaft Preconstruction Conference. The Engineer will evaluate the shaft construction submittal for conformance to the project within 10 working days and approve or reject the submittal. If rejected, resubmit the submittal with adjustments, clarifications, and changes as requested by the Engineer. Once approved, the Engineer will suspend drilled shaft construction if personnel, equipment or methods, listed and described on the approved Shaft Construction Submittal are substituted or changed on the project without pre-approval by the Engineer. The Contractor shall be fully liable for the additional costs resulting from the suspension of work, and no adjustments in contract time resulting from the suspension of work will be allowed.

1. Construction Experience

   a. List of Qualifying Projects.

      Provide a list containing at least five successful projects on which the company has installed drilled shafts of similar size and depth using similar installation methods in similar ground conditions. Briefly describe each project and include a reference for each project listed. Include an individual's name and current phone number for the reference. Use no more than five total pages for the complete list.

b. On-Site Personnel Resumes

Provide one-page resumes for the supervisor(s) and drill rig operator(s) that will perform their duties on the project site.

(1) **Supervisor(s) Qualifications**

Provide on-site supervisors with at least 3 years of working experience in supervising construction of drilled shafts of similar size (diameter and depth) and scope to those shown in the Plans, and in similar geotechnical conditions to those described in the geotechnical data report. Show only work experience that consists of direct supervisory responsibility for the on-site drilled shaft construction operations including but not limited to: drilled shaft excavations; preparation and placement of steel reinforcement cages in the drilled shaft excavation; and placing concrete in the drilled shaft excavation within. Project management level positions indirectly supervising on-site shaft construction operations are not acceptable for this experience requirement.

(2) **Drill Rig Operator(s) Qualifications**

Provide drill rig operators that have a minimum of 1 year experience in construction of shaft foundations on the equipment proposed for this project using the methods proposed for this project (wet method drilled shaft construction, etc.).

2. Shaft Installation Narrative

Submit a Shaft Installation Narrative referencing the available subsurface data for the project. Account for potential ground movement due to the active landslide and drilling through the existing horizontal drains in the selection of drilling equipment, drill tooling, stabilization of the drilled shaft excavation and steel reinforcement cage placement and concrete placement operations. . At a minimum, include the following information in the Shaft Installation Narrative:

a. Proposed overall construction operation sequence.

b. Provide the description, size, and capacities of proposed drilling equipment, including but not limited to, cranes, drills, auger, bailing buckets, final cleaning equipment, and drilling unit. Describe why the equipment was selected and describe equipment suitability to the anticipated site conditions and work methods. Include a project history of the drilling equipment demonstrating the successful use of the equipment on drilled shafts of equal or greater hole size in similar soil/rock conditions. Include specific details of drilled shaft excavation and cleanout methods.

c. Provide a list of potential problems that could occur during construction of the drilled shafts and proposed solutions. Include equipment breakdowns and related contingency plans. Include potential problems related to the

subsurface conditions at the site, the rate of ground movement measured at the active landslide and conflicts with the existing horizontal drains.

d. Provide details of method(s) proposed to ensure drilled shaft stability (i.e., prevention of caving, bottom heave, using temporary casing, slurry, or other means) during excavation (including pauses and stoppages during excavation) and concrete placement.

e. Provide a slurry mix design (if slurry is proposed), listing and describing all additives and their specific purpose in the slurry mix, with a discussion of their suitability to the anticipated subsurface conditions along with the procedures for mixing, using, and maintaining the slurry.

f. Provide a detailed plan for quality control of the selected slurry (if slurry is proposed), listing the tests to be performed, test methods to be followed, testor's name and qualifications, and minimum and/or maximum slurry material property requirements to achieve that ensures the slurry functions as intended with consideration of the anticipated subsurface conditions and shaft construction methods, in accordance with the slurry manufacturer's recommendations and these Special Provisions. At a minimum, include the following tests in the slurry quality control plan:

Property	Test Method
Density	Mud Weight (Density), API 13B-1, Section 1
Viscosity	Marsh Funnel and Cup, API 13B-1, Section 2.2
pH	Glass Electrode, pH Meter, or pH Paper
Sand Content	Sand, API 13B-1, Section 5

g. Provide a complete copy of the test methods listed in the slurry quality control plan.

h. Provide a description and details of the storage and disposal plan for excavated material and drilling slurry (if applicable). Include permit applications and approved permits required for slurry storage and disposal.

i. Describe the details of concrete placement, including proposed operational procedures for pumping methods, and a sample uniform yield form for plotting the approximate volume of concrete placed versus the depth of shaft for all shaft concrete placement (except concrete placement in the dry).

j. Provide reinforcing steel work drawings with reinforcement placement details, bracing, centering and lifting methods, and the method to ensure the reinforcing cage position is maintained during construction, including use of bar boots and/or rebar cage base plates.

At a minimum include the following items on the reinforcing steel work drawings:

(1) Procedure and sequence of steel reinforcing bar cage assembly.
(2) The tie pattern, tie types, and tie wire gages for all ties on permanent reinforcing and temporary bracing.
(3) Number and location of primary handling steel reinforcing bars used during lifting operations.
(4) Type and location of all steel reinforcing bar splices.
(5) Details and orientation of all internal cross-bracing, including a description of connections to the steel reinforcing bar cage.
(6) Description of how temporary bracing is to be removed.
(7) Location of support points during transportation.
(8) Cage weight and location of the center of gravity.
(9) Number and location of pick points used for lifting for installation and for transport (if assembled off-site).
(10) Crane charts and a description and/or catalog cuts for all spreaders, blocks, sheaves, and chokers used to equalize or control lifting loads.
(11) The sequence and minimum inclination angle at which intermediate belly rigging lines (if used) are released.
(12) Pick point loads at 0, 45, 60, and 90 degrees and at all intermediate stages of inclination where rigging lines are engaged or slackened.
(13) Methods and temporary supports required for cage splicing.
(14) For picks involving multiple cranes, the relative locations of the boom tips at various stages of lifting, along with corresponding net horizontal forces imposed on each crane.

3. Shaft Slurry Technical Assistance

If slurry other than water slurry is used to construct the shafts, provide or arrange for technical assistance in the use of the slurry as specified in Section 3.D.3. *Slurry Sampling and Testing.* Submit the following to the Engineer:

a. The name and current phone number of the slurry manufacturer's technical representative assigned to the project, and the frequency of scheduled visits to the project site by the synthetic slurry manufacturer's representative.

b. The name(s) of the Contractor's personnel assigned to the project and trained by the slurry manufacturer in the proper use of the slurry. Include a copy of a signed training certification letter from the slurry manufacturer for each trained Contractor's employee listed, including the date of the training.

C. Shaft Excavation

Excavate the shafts to the required depth as shown in the Plans. Shaft excavation operations shall conform to this Section and the Shaft Installation Narrative as approved by the Engineer.

1. Conduct of Shaft Excavation Operations

   Conduct shaft excavation operations, including casing installation and removal, such that the soil adjacent to the shaft for the full height of the shaft is not disturbed. Disturbed soil is defined as soil whose geotechnical properties have been changed from those of the original in situ soil, and whose altered condition adversely affects the structural integrity of the drilled shaft or the interface between the drilled shaft and the soil.

   Conduct the excavation in a continuous operation until the excavation of the shaft is completed, except for pauses and stops as noted, using approved equipment capable of excavating through the types of material indicated on the boring logs. Pauses during this excavation operation, except for casing splicing, tooling changes, slurry maintenance, and removal of obstructions, are not allowed. Stops are shaft excavation operation interruptions not conforming to this definition. Stops for uncased excavations (including partially cased excavations) shall not exceed 16 hours duration. Stops for fully cased excavations, excavations in rock, and excavations with casing seated into rock, shall not exceed 65 hours duration. For stops exceeding the time durations specified above in excavations where mineral or synthetic slurry is not present, stabilize the excavation using one or both of the following methods:

   a. For an uncased excavation, before the end of the work day, install casing in the hole to the depth of the excavation. The outside diameter of the casing shall not be smaller than 6 inches less than either the plan diameter of the shaft or the actual excavated diameter of the hole, whichever is greater. Sound the annular space between the casing and the excavation prior to removing the casing and resuming shaft excavation. If the sounding operation indicates that caving has occurred, do not remove the casing nor resume shaft excavation until stabilizing the excavation in conformance with the approved Shaft Installation Narrative Submittal.

   b. For both a cased and uncased excavation, backfill the hole with granular material. Backfill the hole to the ground surface, if the excavation is not cased, or to a minimum of 5 feet above the bottom of temporary casing, if the excavation is cased.

   During stops, stabilize the shaft excavation to prevent bottom heave, caving, head loss, and loss of ground. The Contractor bears full responsibility for selection and execution of the method(s) of stabilizing and maintaining the

shaft excavation. Stabilize the shaft in conformance to the approved Shaft Installation Narrative Submittal.

If slurry is present in the shaft excavation, conform to the requirements of Section 3.D.2. *Minimum Level of Slurry in the Excavation* regarding the maintenance of the slurry. Maintain the minimum level of drilling slurry throughout the stoppage of the shaft excavation operation, and recondition the slurry to the required slurry properties prior to recommencing shaft excavation operations.

Collect and dispose of excavated soil and drilled shaft spoils without allowing erosion or runoff to disperse soil into the existing water collection basin near the outlet of the existing horizontal drains or onto the nearby National Park property. Follow all local, state and federal laws and regulations for handling, collecting, storage, transporting and disposing of the drilled shaft spoils. Completely remove the drilled shaft excavated soil from the landslide area before beginning the excavation for the next drilled shaft. Stockpile the excavated soil away from the landslide to the northwest of the stabilization work area, as designated by the Engineer.

Contain all water, including water slurry, for disposal away from the landslide area. Do not allow water from the excavation to enter the nearby National Park.

Clean excavation soil (no slurry contamination) may be used as borrow and placed along the cap beam using compaction control Type C in accordance with Section 203 after all permanent ground anchors have been locked-off

2. Temporary Drilled Shaft Casing

   If applicable, furnish temporary drilled shaft casing in conformance to Section 3.B.2. *Shaft Installation Narrative*, item c and in conformance with these Special Provisions.

   Temporary casing is installed to facilitate shaft construction only and is not designed as part of the drilled shaft structure. To maintain stable excavations and to facilitate construction, the Contractor may furnish and install temporary casing. If so, provide temporary casing at the site in sufficient quantities to meet the needs of the anticipated construction method. Provide a casing with an outside diameter that is equal to or greater than the specified diameter of the shaft. Completely remove temporary casing after shaft construction is complete without deforming and causing damage to the completed shaft and without disturbing the surrounding soil. As the temporary casing is withdrawn, maintain the concrete and slurry inside the casing at a level sufficient to balance the hydrostatic pressure outside the casing.

3. Bottom of Shaft Excavation

   Use appropriate means such as a cleanout bucket or air lift to clean the bottom of the excavation of all shafts. Ensure that no more than 2 inches of

loose or disturbed material is present at the bottom of the shaft just prior to placing concrete.

Sound the bottom of the excavated shaft with an airlift pipe, a steel tape with a heavy weight of at least 1 pound attached to the end of the tape, or other means acceptable to the Engineer to determine that the shaft bottom is at the depth shown in the plans.

After observing the Contractor inspecting each shaft for acceptable cleanliness and depth, the Engineer will approve each shaft prior to the Contractor proceeding with construction.

4. Required Use of Slurry in Shaft Excavation

Use slurry, in accordance with this Special Provision, to maintain a stable excavation during excavation and concrete placement operations once water begins to enter the shaft excavation at an infiltration rate of 12 inches of depth or more in 1 hour. If concrete is to be placed in the dry, pump all accumulated water in the shaft excavation down to a 3-inch maximum depth prior to beginning concrete placement operations.

D. Slurry Installation Requirements

1. Slurry Technical Assistance

If slurry other than water slurry is used, the manufacturer's representative, as identified to the Engineer in accordance with Section 3.B.3. *Shaft Slurry Technical Assistance* shall:

a. Provide technical assistance for the use of the slurry,

b. Be at the site prior to introduction of the slurry into the first drilled hole requiring slurry.

c. Remain at the site during the construction of at least the first shaft excavated to adjust the slurry mix to the specific site conditions.

After the manufacturer's representative is no longer present at the site, the Contractor's employee trained in the use of the slurry, as identified to the Engineer in accordance with Section 3.B.3. *Shaft Slurry Technical Assistance*, shall provide technical assistance for testing, mixing, maintaining and adjusting the slurry mix in accordance with the manufacturer's requirements and this Special Provision throughout the remainder of shaft slurry operations.

2. Minimum Level of Slurry in the Excavation

   Use of slurry in a shaft excavation requires the following:

   a. Sustain the height of the slurry as required to provide and maintain a stable hole to prevent bottom heave, caving, or sloughing of all unstable zones.

   b. Provide casing, or other means, as necessary to meet these requirements.

   c. Maintain a slurry level in the shaft above the groundwater level equal to or greater than the following:

      (1) 5 feet or more for mineral slurries.
      (2) 10 feet or more for water slurries.
      (3) 10 feet or more for synthetic slurries.

3. Slurry Sampling and Testing

   When synthetic slurry is used, keep a written record of all additives and concentrations of the additives in the synthetic slurry. Provide these records to the Engineer once the slurry system has been established in the first drilled shaft on the project. Provide revised data to the Engineer if changes are made to the type or concentration of additives during construction.

   Sample and test all slurry in the presence of the Engineer, unless otherwise directed. Record the date, time, names of the persons sampling and testing the slurry, and the results of the tests. Submit a copy of the recorded slurry test results to the Engineer at the completion of each shaft. Provide a copy of the recorded slurry test results during construction of each shaft when requested by the Engineer.

   To verify that the slurry conforms to the specified slurry material properties, collect and test slurry sample sets, at the beginning of drilling operations, every 4 hours during drilling shifts and prior to cleaning the bottom of the drilled shaft excavation. A slurry sample set is composed of slurry samples taken at the mid-height and within 2 feet of the bottom of the storage area; and, at mid-height and within 2 feet of the bottom of the drilled shaft excavation, for a total of 4 slurry samples. Collect and test slurry sample sets at least once every 2 hours if the previous slurry sample set was non-conforming with the specified slurry material properties. Recirculate or agitate all slurry within the drilled shaft excavation with the drilling equipment, when tests show that the slurry sample sets are non-conforming with the specified slurry material properties.

   Collect and test slurry sample sets, as specified, to verify control of the specified slurry material properties after final cleaning of the bottom of the

drilled shaft excavation just prior to placing concrete. Do not place concrete until the slurry samples taken at mid-height and within 2 feet of the bottom of the drilled shaft excavation conform to the specified slurry material properties.

The table below summarizes the slurry sampling and testing requirements at different stages of drilled shaft construction.

Shaft Construction Stage	Slurry Sample Locations	Results
Prior to placing slurry in excavation	At mid-height and within 2 feet of the bottom of the Slurry Storage Area	Test results within Specified Range for the Slurry Product
During Drilling: At beginning of drill shift and every 4 hours during drilling. Increase testing frequency to every 2 hours if test results are nonconforming.	At mid-height and within 2 feet of the bottom of the Slurry Storage Area and the Drilled Shaft	If test results are nonconforming with the Specified Range for the Slurry Product adjust slurry mix, agitate, re-circulate and clean; as required, to bring the slurry into conformance.
After cleaning the bottom of the hole and immediately prior to placing the rebar cage	At mid-height and within 2 feet of the bottom of Drilled Shaft.	Adjust slurry mix, agitate, circulate and clean as required to bring slurry into conformance prior to placing rebar cage in the excavation.
Immediately prior to placing concrete	At mid-height and within 2 feet of the bottom of Drilled Shaft	Adjust slurry mix, agitate, re-circulate and clean as required to bring slurry into conformance prior to placing concrete in the excavation.

4. Maintenance of Required Slurry Properties

   Clean, recirculate, de-sand, or replace the slurry to maintain the required slurry properties.

5. Maintenance of a Stable Drilled Shaft Excavation

   Demonstrate to the satisfaction of the Engineer that stable conditions are being maintained. If the Engineer determines that stable conditions are not being maintained, take immediate action to stabilize the shaft. Submit a revised Shaft Installation Narrative that addresses the problem and prevents future instability. Do not continue with shaft construction until the damage that has occurred is repaired in accordance with the specifications and until receiving the Engineer's approval of the revised Shaft Installation Narrative.

6. Disposal of Slurry and Slurry Contaminated Spoils

   Dispose of the slurry and slurry-contaminated spoils off-site as specified in the Shaft Installation Narrative Submittal, in accordance with Section 107.17 of the Standard Specifications, and in accordance with all applicable local, state and federal regulations. Provide copies of all permits, agreements and manifests to the Engineer documenting the transport and final disposal of the slurry and slurry-contaminated spoils.

   Water slurry must be disposed of off-site and shall not be allowed to enter the stabilization area.

E. Assembly and Placement of Reinforcing Steel

1. Steel Reinforcing Bar Cage Assembly

   Rigidly brace the reinforcing cage to retain its configuration during handling and construction. Individual or loose bars will not be permitted. Show bracing and any extra reinforcing steel required for fabrication of the cage on the work drawings. Support shaft reinforcing bar cages on a continuous surface to the extent possible. Locate all rigging connections at primary handling bars, as identified in the reinforcing steel assembly and installation plan as approved by the Engineer. Internal bracing is required at each support and lift point.

   Carefully position and securely fasten the reinforcement to provide the minimum clearances as shown on the Plans, and to ensure no displacement of the reinforcing steel bars occurs during placement of the concrete. Securely hold the steel reinforcing bars in position throughout the concrete placement operation.

2. Steel Reinforcing Bar Cage Centralizers

   Submit details of the proposed reinforcing cage centralizers with the work drawings. Provide products that are manufactured specifically for centralizing steel reinforcing cages in drilled shaft excavations. Place reinforcing steel centralizers at each longitudinal space plane at the quarter points around the circumference of the steel reinforcing bar cage, and at a maximum longitudinal spacing of either 2.5 times the shaft diameter or 20 feet, whichever is less. Carefully position and securely fasten the centralizers to

provide the minimum concrete cover as shown on the Plans, and to ensure proper positioning of the cage is maintained during placement of the concrete.

3. Steel Reinforcing Cage Bottom Supports

   Provide cylindrical concrete feet (bottom supports) approved by the Engineer, to ensure that the bottom of the cage is maintained the proper distance above the base of the shaft as shown on the Plans. Skids, or chairs constructed of steel or other electrical conductor material shall not be allowed.

F. Access Tubes for Crosshole Sonic Log Testing and Inclinometer Casing

Furnish and install access tubes for Crosshole Sonic Log (CSL) testing and provide CSL testing in accordance with the Special Provision for Crosshole Sonic Log Tests.

Furnish and install inclinometer casing in accordance with the Special Provision for Instrumentation.

G. Placing Concrete

1. Concrete Class for Shaft Concrete

   Provide AA-5 concrete for the drilled shaft in accordance with Section 802 of the Standard Specifications as revised in this Special Provision.

2. Concrete Placement Requirements

   Commence concrete placement immediately after inspection by the Engineer and placement of the reinforcing steel cage. Immediately prior to commencing concrete placement, the shaft excavation and the properties of the slurry (if used) shall conform to Section 3.C.3. *Bottom of Shaft Excavation* and Section 3.D *Slurry Installation Requirements*, respectively, of these Special Provisions. Place concrete in one continuous operation to the top of the shaft.

   During concrete placement, monitor and minimize the difference in the level of concrete inside and outside of the steel reinforcing bar cage. Conduct concrete placement operations to maintain the differential concrete head at a 1-foot maximum.

   If water is not present, deposit the concrete through the center of the reinforcement cage by a method that prevents segregation of aggregates and splashing of concrete on the reinforcement cage. Place the concrete such that the free-fall is vertical down the center of the shaft without hitting the sides of the excavation, the steel reinforcing bars, or the steel reinforcing bar cage bracing.

When placing concrete underwater, including when water in a shaft excavation exceeds 3 inches in depth, place the concrete at the bottom of the shaft by pressure feed using a concrete pump and a watertight tremie pipe having a minimum diameter of 4 inches. The discharge end of the tremie pipe must extend to the bottom of the shaft during placement of the concrete until the concrete level is at least 5 feet above the discharge end of the tremie pipe. Include a device to seal out water from the discharge end of the tube on the tremie pipe while it is first filled with concrete. Alternatively, use a plug or pig manufactured for use in concrete tremie pipes that is inserted at the top of the tremie pipe and travels through the tremie to keep the concrete separated from the water and slurry. Completely fill the tremie pipe and hopper with concrete prior to allowing the plug or pig to discharge from the end of the tremie pipe. Concrete placement by gravity feed without a tremie is not allowed.

Throughout the underwater concrete placement operation, the discharge end of the tube shall remain submerged in the concrete at least 5 feet and the tube shall always contain enough concrete to prevent water from entering. The concrete placement shall be continuous until the work is completed, resulting in a shaft composed of seamless, uniform concrete. Overpump the concrete in the shaft until uniform concrete visually free from slurry, soil and laitance reaches the top elevation of the shaft. Remove excess concrete and contaminated concrete above the top elevation of the shaft.

3. Concrete Vibration Requirements

When placing concrete in the dry, remove all contaminated concrete, laitance, loose gravel, and sediment on the upper surface of the drilled shaft concrete and vibrate the upper 5 feet of the drilled shaft concrete in accordance with Section 602.04 C.2. of the Standard Specifications. If a temporary casing is used, remove it before vibration. This requirement may be waived if a temporary casing is used and removed with a vibratory hammer during the concrete placement operation. Requirements for Placing Concrete Underwater

4. Testing and Repair of Shaft Concrete Placed Underwater

If the underwater concrete placement operation is interrupted, the Engineer may require the Contractor to prove by core drilling or other tests that the shaft contains no voids or horizontal joints. If testing reveals voids or joints, the Contractor shall repair them or replace the shaft at no expense to the Department. Responsibility for coring costs, and calculation of time extension, shall be in accordance with Section 109.03 of the Standard Specifications.

5. Cleaning and Removal of Placed Drilled Shaft Concrete

   Thoroughly clean the projecting reinforcing steel and other tubes attached to the reinforcing cage of all accumulations of splashed concrete, slurry and other debris immediately following concrete placement and removal of casing and slurry. Remove all accumulations of soil, loose aggregate, contaminated concrete or other debris on the surface of the drilled shaft concrete to expose fresh concrete and smooth any high spots on the upper surface of the exposed fresh concrete that would prevent the cap beam steel reinforcing bar cage from being placed in the position required by the Plans. Verify that the top of the drilled shaft is in conformance with the planned elevation.

6. Protection of Fresh and Curing Concrete From Vibration

   Do not subject freshly placed concrete to excessive vibration and shock waves during the curing period until it has reached at least 2,000 psi minimum compressive strength for structural concrete. Maintain all vibration producing operations a safe horizontal distance from the freshly placed concrete for the first 5 hours from the time the concrete has been placed.

7. Uniform Yield Form

   Except for shafts where the shaft concrete is placed in the dry, complete a uniform yield form, consistent with the sample form submitted to the Engineer as part of the shaft installation narrative as specified in Section 3.B.2, item i, for each shaft and submit the completed form to the Engineer within 24 hours of completing the concrete placement in the shaft.

8. Requirements for Placing Concrete Above the Top of Shaft

   Do not place concrete above the top of shaft (for cap beam splice zones) until Engineer acceptance of the CSL testing is received, if performed at that shaft, and Engineer acceptance of the shaft.

9. Rejection of Shafts and Revisions to Concrete Placement Operations

   If the Engineer determines that the concrete placed under slurry for a given shaft is structurally inadequate, that shaft will be rejected. Suspend subsequent placement of concrete under slurry until submitting written changes to the methods of shaft construction needed to prevent future structurally inadequate shafts to the Engineer, and receiving the Engineer's written approval of the submittal.

H. Coring Drilled Shafts and Remedial Action Plan

At the Engineer's request, drill a corehole in any questionable quality shaft, as determined from CSL testing and analysis or by observation of the Engineer, to explore the shaft condition. Coring is also required to replace an unusable CSL access tube per the Crosshole Sonic Log Test Special Provision.

Prior to beginning coring, submit the method and equipment used to drill and remove cores from the shaft concrete and provide to the Engineer and receive the Engineer's written approval. Use either a conventional double-tube, swivel-type core barrel with split liners or a wireline barrel with split inner liners. Use a new diamond coring bit. Replace the coring bit and core barrel as necessary to achieve a high percentage of core recovery. Obtain core samples in accordance with ASTM D 2113 to 5 feet below the bottom elevation of the possible defect or as directed by the Engineer. Obtain core samples with a minimum diameter of 3.0 inches except that coring to replace an unusable CSL access tube can be 2.0 inches in diameter. Preserve all core in wooden core boxes, identified as to location and depth and make available for inspection by the Engineer.

If a flaw or defect is confirmed, submit a proposed remedial action plan with supporting calculations and work drawings for correcting the shafts. Submit all remedial correction procedures and designs to the Engineer for approval. Do not begin repair operations until receiving the Engineer's approval of the remedial action plan. Include CSL testing in the remedial action plan to verify the effectiveness of the proposed remediation.

If no defect is encountered, the Department will pay for all coring and grouting costs.

Grout the core holes in accordance with the Crosshole Sonic Log Test Special Provision.

All materials and work necessary, including engineering analysis, testing, evaluations and redesign, to investigate and effect corrections for shaft flaws, defects or to replace the shaft shall be furnished to the Engineer's satisfaction at no additional cost to the Department.

4. METHOD OF MEASUREMENT

Drilled shafts will be measured by the linear foot from the top drilled shaft elevation shown on the Plans to the bottom depth of the drilled shaft excavation as indicated on the Plans. Access tubes for CSL testing and CSL testing will be measured in accordance with the Special Provision for Crosshole Sonic Log Tests. Inclinometer casing will be measured in accordance with the Special Provision for Instrumentation.

5. BASIS OF PAYMENT

The unit price of drilled shafts shall be full compensation for making all excavations; hauling, stockpiling and disposal of excavated material; performing all necessary pumping; furnishing and placing required concrete and reinforcement steel, including the reinforcement blocking, splices, chairs and the reinforcement projecting above the tops of the drilled shaft concrete necessary for splicing; all backfilling; placement and removal of temporary casings; permits, placement, maintenance, testing, storage, removal and disposal of slurry; and for furnishing all tools, labor, equipment, materials and incidentals necessary to complete the work.

CSL Testing will be paid for in accordance with the Special Provision for Crosshole Sonic Log Tests.

The accepted quantities for drilled shafts will be paid for at the contract bid price for:

Item No.	Pay Item	Pay Unit
930-3990	4.0 ft diameter drilled shaft	Linear Feet

This document was originally issued and sealed by Gregory Robert Fischer, Registration Number PE-4324, on 02/09/15 and the original document is stored at the North Dakota Department of Transportation

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

GROUND ANCHOR

Project SER-5-094(107)030 – PCN 20549

1. DESCRIPTION

This work consists of furnishing adequate equipment, materials, work drawings and experienced labor to install, test, stress and complete the permanent grouted ground anchors as specified. Grouted ground anchors, also referred to as ground anchors, consist of multi-strand wire tendons installed in grout-filled holes drilled in soil or rock. The tendons transfer tensile forces from an attached structure to the ground.

Select the drilling method, grout mix, drill hole diameter, post-grouting injection pressures, and number of post-grouting cycles to achieve the specified acceptance criteria for every permanent ground anchor.

2. DEFINITIONS

For this specification, these terms are defined as follows:

A. Alignment load: A nominal load applied to the ground anchor during testing to keep the testing equipment in the correct position.

B. Anchorage: The combined system of the anchor head, bearing plate, and trumpet that transfers the force in the tendon to the ground surface or supported structure.

C. Anchor grout: Grout that is injected into the drill hole just before or just after the Contractor installs the tendon. The anchor grout within the bond length transfers the applied tensile force from the tendon to the surrounding soil or rock.

D. Bearing Plate: A steel plate that evenly distributes the ground anchor force to the cap beam.

E. Bond length: The length of the tendon that is bonded to the grout and transfers the applied tensile force to the surrounding soil or rock.

F. Ground Anchor: A system, referred to as a tieback or as an anchor, used to transfer tensile loads to soil or rock. A ground anchor includes all prestressing steel, anchorage devices, grout, coatings, sheathings, and couplers if used.

G. Lock-off load: The tensile force or load in a ground anchor immediately after transferring the load from the jack to the anchorage after testing is complete.

H. Maintaining Consistency of Load: Maintaining the test load within 5 percent of the specified value.

I. Maximum test load: The maximum load applied to the ground anchor during testing. The maximum test load is equal to the factored design load (FDL) for load and resistance factor design (LRFD) and to 1.33 times the design load (DL) for allowable stress design (ASD).

J. Minimum Ultimate Tensile Strength (MUTS): The minimum specified breaking load of the prestressing steel as defined by the specified standard.

K. Post-grouting: The injection of grout along the anchor bond length after the primary grout has set. Post-grouting is performed to increase the pullout resistance of the anchor.

L. Tendon and Tendon Steel: The tendon includes the steel strands, the corrosion protection, the sheaths, centralizers, and spacers, but specifically excludes the grout and anchorage. The tendon steel consists of the high strength, steel strands.

M. Unbonded length: The length of the tendon that is not bonded to the grout and surrounding ground.

3. MATERIALS

A. General

Provide materials meeting the requirements in the following sections. Do not deliver the materials to the site until the Engineer has approved the contractor experience and ground anchor work drawing submittals. Protect the designated storage location or locations from theft, vandalism, passage of vehicles, and other sources of damage to materials delivered to the site. Store and handle ground anchors in accordance with the manufacturer's recommendation and in such a manner that no damage to the component parts occur. Store cement and additives for grout under cover and protect against moisture.

B. Tendons

Furnish multi-strand, high strength, steel wire tendons for ground anchor tendons conforming to the ASTM A416 including S1.

C. Centralizers and spacers

Furnish centralizers and spacers made from plastic or steel. Centralizers must support the tendon in the hole and position it to provide at least 0.5 inch of grout

cover over the encapsulation. Centralizers and spacers used inside the encapsulation must position the tendon steel to provide at least 0.2 inch of grout cover between the tendon steel and the inside surface of the encapsulation. Centralizers must permit grout to flow freely around the tendon and along the drill hole. Furnish spacers to separate multiple strands or bars within the bond length.

D. Sheath, bond breaker, and encapsulation

Furnish plastic tubing or pipe with the following properties:

1. Resistant to chemical attack from aggressive environments, grout, or corrosion inhibiting compounds.

2. Resistant to aging by ultraviolet light.

3. Fabricated from material that is not detrimental to the tendon.

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

5. Allow the tendon to elongate during testing and stressing.

For the sheath, furnish plastic tubing or pipe, corrugated or smooth. A smooth sheath may also function as a bond breaker. Furnish a separate bond breaker with a corrugated sheath.

For the bond breaker, furnish smooth plastic tubing or pipe that allows the tendon to elongate with minimal friction during testing and stressing.

Furnish high density polyethylene corrugated pipe and end caps conforming to AASHTO M 252, Type C, for tendon bond length encapsulation.

E. Corrosion inhibiting compound

Furnish either grease, wax, or gel with corrosion inhibiting additives that conform with Section 4.6 of Recommendations for Prestressed Rock and Soil Anchors by the Post-Tensioning Institute (2014).

F. Heat shrink sleeves and tape

Furnish heat shrink sleeves and tape fabricated from radiation cross-linked polyolefin coated with an adhesive sealant.

G. Wax tape

Furnish petrolatum (wax) tape consisting of synthetic fabric saturated with a stable composition of petrolatum compound (wax) with inert fillers.

H. Cement Grout

Furnish materials for grout conforming to the following:

Portland cement 804.01

Furnish water conforming to Subsection 812. If using fine aggregate in the grout mix, furnish natural sand with 100 percent passing the No. 16 sieve (1.18 mm) and no more than 5 percent passing the No. 200 sieve (75 µm).

Provide a pumpable, stable fluid, grout mix that exhibits less than 2 percent bleed in accordance with ASTM C 940. The compressive strength of two-inch cubes, molded, cured, and tested in accordance with ASTM C 942, to be a minimum of 3,000 psi at the time of stressing. Admixtures which control bleed, improve flowability, and reduce water content, conforming to ASTM C 494, Types A or F, may be used in the grout subject to the approval of the Engineer. Admixtures, if used, are to be compatible with prestressing steels and mixed in accordance with the manufacturer's recommendations. Expansive admixtures may only be used for filling sealed encapsulations, trumpet and anchorage covers. Do not use accelerating admixtures.

Provide compressive strength test results of two-inch cubes, molded, cured and tested in accordance with ASTM C 942 for each proposed grout mix design prior to installing the first ground anchor. Provide 3 additional compressive strength test results on samples randomly selected by the Engineer. Demonstrate that the grout achieves a 3,000 psi compressive strength at the time of stressing.

I. Anchorages

Furnish anchor heads conforming to either ASTM A36, ASTM A108 Grades 1040 or 1045, ASTM A536 Grade 80-55-06, or ASTM A576 Grade 1045.

For strand tendons, furnish three-part wedges conforming to ASTM A108 Grade 12L14, case hardened from 0.012 to 0.015 inches thick to Rockwell C 59 to 65. For strand tendons, furnish the anchor heads and wedges from the same supplier.

Furnish bearing plates conforming to ASTM A36, ASTM A529, ASTM A536, ASTM A572, or ASTM A588.

Furnish trumpets fabricated from steel pipe conforming to ASTM A53 or steel tubing conforming to ASTM A500. Furnish trumpets with a minimum wall thickness of 0.20 inch. Provide a watertight seal between the trumpet and bearing plate by welding the two together.

Furnish anchorage covers, also referred to as end caps, that completely cover the anchor head and provide a permanent watertight joint between the cover and the bearing plate. Furnish anchorage covers with a minimum thickness of 0.20

inch and fabricated from either steel pipe conforming to ASTM A53, steel tubing conforming to ASTM A500, or steel conforming to either ASTM A36, ASTM A529, ASTM A572, or ASTM A588.

Provide certificates of compliance for the anchorages, anchorage components and corrosion protection requirements described herein in accordance with Section 106.01 C. of the Standard Specification.

4. CONSTRUCTION REQUIREMENTS

Account for potential ground movement due to the active landslide and drilling through the existing horizontal drains in the selection of drilling equipment, drill tooling, stabilization of the ground anchor borehole and grout placement operations.

A. Ground Anchor Pre-Construction Conference

At least 5 working days prior to beginning ground anchor construction work at the site, convene a ground anchor preconstruction conference to discuss construction procedures, personnel, and equipment to be used, and the other elements work. Those attending shall include the Engineer, the Contractor's Superintendent, on-site supervisors, and all foremen in charge of ground anchor construction, constructing the sacrificial anchor reaction block and conducting the ground anchor testing.

B. Contractor Experience Requirements

Prior to the beginning of construction, submit proof that the Contractor performing the work described in this special provision has successfully installed similar sized and length ground anchors in comparable ground conditions using post-grouting pressure injection techniques. Provide a list describing at least 5 projects completed over the past 5 years. Include a brief description of each project, the project's location, project date, owner, and a reference for each project. At the minimum, include an individual's name, relationship to the project and current phone number for each reference.

The Contractor shall assign an engineer to supervise the Work with at least 3 years of experience in the design and construction of permanently anchored structures. The Contractor shall not use consultants or manufacturer's representatives in order to meet the requirements of this Section.

Submit a list of projects for each of the drill operators and on-site supervisors demonstrating at least 1 year of experience installing permanent, post-grouted, ground anchors.

Allow up to 10 calendar days for the Engineer's review of the qualifications and staff as noted above. Do not start on any anchored wall system or order materials until approval of the Contractor's qualifications and other submittals are given.

C. Ground Anchor Work Drawing

The pullout capacity of a ground anchor depends on many factors in addition to the soil or rock conditions at the site. Furnish the ground anchor tendon size, unbonded free stressing lengths and bond lengths as specified in the Plans. Select the drilling method, grout mix, post-grouting pressures and hole diameter appropriate for the soil and rock conditions at the site, so that every ground anchor meets the specified acceptance criteria.

Prepare the Ground Anchor Work Drawings, including the following listed items, under the supervision and direction of a North Dakota Registered Engineer and have the Registered Engineer sign and seal the work drawings. Submit the sealed Ground Anchor Work Drawings to the Engineer for acceptance prior to ordering the permanent ground anchors. Department acceptance of any submittal does not relieve the Contractor of the responsibility for obtaining the required results.

1. Permanent Ground Anchor Tendon. Furnish details of a 5-strand, high strength steel wire tendon as indicated in the Plans in accordance with these specifications. Show locations of centralizers and spacers. Show locations and type of grout tubes for initial grouting and pressurized post-grouting.

2. Instrumented Permanent Ground Anchor Tendon. Furnish separate details of the ground anchor tendon in item 1 above showing locations of strand anchor strain gauge and permanent load cell instruments. Show adjustments to corrosion protection of strand at gage locations and the signal cable wiring plan extending from gages through anchor heads and end caps with descriptions, locations and details of any and all weatherproof duct ports located in the end caps. Modify dimensions of end caps to accommodate load cells and platens. Show locations of extra centralizers and spacers to protect gages, as needed. Show locations and type of grout tubes for initial grouting and pressurized post-grouting.

3. Sacrificial Instrumented Ground Anchor Tendon. Furnish details of a 7-strand, high strength steel wire tendon in accordance with these specifications. Show locations of centralizers and spacers. Show locations and type of grout tubes for initial grouting and pressurized post-grouting. Show details of strand anchor strain gauges installed in the ground anchor bond zone as follows: one at 5 feet, one at 20 feet and one at 40 feet from the transition between the free stressing length and the bond length.

4. Bond length. Use the bond length that is equal to the bond length shown in the plans for all of the ground anchors.

5. Unbonded length. Use an unbonded length for each ground anchor that is equal to or greater than the unbonded length shown on the Plans. Do not extend the ground anchor beyond Right-of-Way or easement boundaries.

6. Tail length. Show lengths of tail extensions at front of ground anchor that is necessary to accommodate pre-stressing chairs, hydraulic jacks, stressing anchor heads and load cell instrumentation where appropriate.

7. Centralizers and Spacers. Place a centralizer within 1 foot of the bottom of the tendon. Place additional centralizers along the length of the tendon at a maximum spacing of 10 feet, measured center-to-center. Also place a centralizer within 5 feet of the top of the bond length. Place spacers for strand tendon no more than 10 feet apart within the bond length, with one each located within 5 feet of the top and bottom of the bond length.

8. Blockout Pipe. Show dimensions of blockout pipe located in cap beam at primary and secondary ground anchor locations. Size blockout pipe to allow easy passage of drill steel and drill tooling.

9. Bearing Plate and Trumpet. Show dimensions of a bearing plate and trumpet, sized for safely supporting minimum ultimate tensile strength of the permanent ground anchor tendons on the concrete cap beam around the blockout pipe and for a trumpeted bearing plate, sized for safely supporting the minimum ultimate tensile strength of the sacrificial ground anchor tendons on a reinforced concrete reaction block designed by the Contractor. Provide calculations in accordance with *AASHTO LRFD Bridge Design Specifications,* demonstrating sufficiency of the bearing plate dimensions. The trumpet provides a transition from the bearing plate to the anchor tendon corrosion protection. Provide a watertight seal between the trumpet and bearing plate by welding the two together. Provide a trumpet long enough to overlap the corrosion protection in the unbonded length of the tendon by at least 4 inches with a seal between the trumpet and the corrosion protection, or by at least 12 inches without a seal.

10. Ground Anchor Reaction Block. Design a Ground Anchor Reaction Block capable for safely supporting the minimum ultimate tensile strength of the sacrificial 7-strand ground anchors. Provide sufficient details, dimensions and calculations that demonstrate the reaction block shall exert a maximum ground pressure of 3500 psf or less when the sacrificial ground anchor is tested to 80 percent of the minimum ultimate tensile strength. Provide details of the anchor block's composition, size, fasteners , spacing and orientations. Provide details of the material strength and individual component dimensions. Show the size and location of the opening (blockout) on the ground anchor

reaction block and the position of the sacrificial ground anchor and bearing plate.

11. Anchorage Head and End Cap. Provide details and dimensions of anchorage head wedge plate and end cap. Show details of waterproof end cap seal at bearing plate.

12. Permanent Ground Anchor Corrosion Protection. Provide Class I corrosion protection for permanent, encapsulated strand, ground anchors as described in *Recommendations for Prestressed Rock and Soil Anchors by the Post-Tensioning Institute, 2014*.

13. Corrosion protection is not required for the sacrificial ground anchors.

14. Provide continuous corrosion protection at the transition from the bond length to the unbonded length of the anchor tendon.

15. Hot dip galvanize the bearing plates and anchorage end cap covers in accordance with ASTM A-153.

16. Electro zinc plate anchorage head wedge plates in accordance with ASTM B-633.

17. Sacrificial Ground Anchor Corrosion Protection. For use with the sacrificial ground anchors only. Corrosion protection is not required for the sacrificial ground anchors, bearing plates or the anchorage head wedge plates. Trumpets are required to protect the strain gage signal cables and anchor strands. End caps are not required for the sacrificial ground anchors.

18. Hole diameter. Size the hole diameter for the ground anchor to provide sufficient surface area along the grout-ground interface to hold the factored design load and at least 0.5 inch grout cover over the encapsulation. Ensure that the area of the steel strands does not exceed 15 percent of the total area of the hole. Provide separate calculations demonstrating sufficiency of drill hole diameter with bond length for the anticipated subsurface materials shown on the plans and the proposed post-grouting pressures.

19. Anchor inclination. Incline the ground anchor as shown on the plans. Do not modify the anchor inclination shown on the plans.

D. Anchor Installation Plan and Anchor Testing Plan

Submit the Anchor Installation and Testing Plans to the Engineer at least 14 Calendar days before the Ground Anchor Preconstruction Conference . Use the results of the Ground Anchor Testing program on the two sacrificial ground anchors to develop or verify the details of the Anchor Installation Plan and Anchor Testing Plan submitted at least 30 Calendar days prior to installing the permanent ground anchors. Use the same or similar drilling procedures and equipment from the sacrificial Ground Anchor Testing program. Obtain the Engineer's approval for each set of submittals before beginning ground anchor installation. The Anchor Installation and Testing Plans do not need to be signed and sealed by a Registered Engineer.

1. Anchor installation plan

    a. Drilling procedure and equipment
    b. Hole diameter
    c. Initial grout mix design
    d. Grouting methods and equipment
    e. Post-grouting procedure, including grout mix, post-grouting pressures and range of elapsed time between grouting stages.

2. Anchor testing plan

    a. Testing equipment, including hydraulic jack, pump, pressure gage, load cell and displacement gages
    b. Calibration certificates for jack, gages, and load cell
    c. Sample testing forms
    d. Test load Schedule (provide the factored design load at all test load increments in both force and pressure gage units)
    e. Lengths of tendon extensions, jack, load cell, and jacking chair

Follow the Sacrificial Ground Anchor Test Load Schedule in Table 1 for the sacrificial ground anchor testing and the Performance, Proof and Extended Creep Test Load Schedule in Tables 2-4 for the permanent ground anchors.

E. Investigative Ground Anchor Testing.

Perform investigative pullout tests on two, nonproduction (sacrificial) ground anchors to verify minimum factor of safety and creep characteristics of the production ground anchors design load. Install the investigative sacrificial ground anchors, perform the testing and submit the test results before beginning installation of the permanent ground anchors.

Select the site location of the investigative test anchors so that the ground conditions are similar to the production anchors. Obtain the Engineer's approval of the site location before installing and testing the investigative test anchors. Excavate and grade the approved site location for the test and construct or place

the ground anchor reaction block. Drill and install the investigative test anchors at the same length, inclination and orientation as the permanent ground anchors shown in the Plans. Do not apply a test load to the investigative test anchors that is greater than 80 percent of the ultimate tensile strength of the tendon steel.

If the Contractor makes any modifications to the work drawings, ground anchor schedule, design calculations, or anchor installation plan after the results of investigative pullout testing, submit the revisions and obtain the Engineer's approval before beginning or resuming ground anchor installation.

F. Ground Anchor Installation.

Select the drilling method, drill hole diameter and post grouting pressures so that every permanent ground anchor meets the specified acceptance criteria. Perform all work according to the work drawings and anchor installation plans approved by the Engineer.

1. Drilling for Permanent Ground Anchor. Drill the hole for the ground anchor through the blockout pipe in the cap beam at the location shown on the Plans for primary ground anchor location. Locate the top of the hole so that the anchor tendon fits within the cap beam as shown on the Plans. Ensure the inclination of the drill hole is within 3 degrees of the inclination shown on the Plans. Provide casing when required to maintain an open hole in unstable soil or rock formations.

2. Drilling for Sacrificial Ground Anchor. Drill the hole for the ground anchor at the approved site location and properly aligned with the ground anchor reaction block. Locate the top of the hole so that the anchor tendon fits within the ground anchor reaction block, but not more than 6 inches (150 mm) in any direction from the plan location. Ensure the inclination of the drill hole is within 3 degrees of the inclination shown on the work drawings. Provide casing when required to maintain an open hole in unstable soil or rock formations

3. Anchor Installation and Grouting. Inspect the permanent and sacrificial anchor tendon for signs of damage or corrosion before installation. Anchor tendons with a light coating of rust are acceptable, but do not use anchor tendons that show signs of heavy corrosion or pitting. Clean open holes, blockout pipe and cased holes before inserting the anchor tendon and grouting. Insert the anchor tendon in the drill hole without damaging the tendon, corrosion protection, grout tubes, strain gages or signal cables connected to strain gages. Begin grouting no more than 18 hours after completing the drilling for the bond length. Do not drive or force the tendon into the drill hole. If the tendon cannot easily reach to the design length, then remove the tendon and clean or redrill the hole to allow insertion. Insert the tendon after initial grouting. Inject grout at the lowest point of the drill hole by pumping through grout tubes, casing, hollow-stem augers, or drill rods. Either

leave the grout tube in place or withdraw the grout tube during grouting, but ensure that the discharge end of the tube remains below the top of the grout during grout placement. If leaving the grout tube in place, ensure that it is filled with grout at the completion of grouting.

4. Fill the hole with grout in one continuous operation. Do not pressure grout the unbonded length. Do not allow grout near the top of the hole to reach the portion of the hole to be occupied by the trumpet; otherwise remove grout in this area before it hardens.

5. Post-grouting. Install the ground anchor with a post-grouting system. Inject grout under pressure in the bond zone through the post-grouting tube after the initial grout has set in accordance with the appropriate Anchor Installation Plan. Repeat the post-grouting pressure injection procedure as needed to achieve the required bond capacity.

6. Anchorage Installation. Install the trumpeted anchor bearing plate and the anchor head wedge plate perpendicular to the anchor tendon with a tolerance of ±3 degrees. Do not bend or kink the anchor tendon or damage signal cables from the instrumentation. Ensure that the wedges and wedge holes are free of rust, grout, and dirt.

7. Ensure the trumpet overlaps the corrosion protection in the unbonded length of the permanent ground anchor tendon by at least 4 inches when a seal is provided between the trumpet and the corrosion protection. When a seal is not provided, ensure the trumpet overlaps the corrosion protection in the unbonded length by at least 12 inches. Also ensure the corrosion protection in the unbonded length does not contact the anchor bearing plate or anchor head wedge plate. If necessary, trim the corrosion protection to prevent contact.

G. Ground Anchor Testing.

Test each permanent ground anchor to demonstrate that it meets the specified acceptance criteria. Conduct a minimum of three performance tests and two extended creep tests on the permanent ground anchors as indicated in the plans. Conduct proof tests on all ground anchors that are not subject to performance testing or extended creep testing. Performance test the first production ground anchor and then evenly distribute the rest of the performance tests (and extended creep tests) among the remaining ground anchors, or as directed by the Engineer. During the hold periods for all types of tests, maintain a constant load by adjusting the jack pressure as necessary. Do not allow the jack pressure to drop more than 50 psi during a hold period. Measure and record anchor movement to the nearest 0.001 inch. Avoid regripping strands or creating wedge bite marks on the strand below the anchor head. Consider the effect of seating losses from the wedges when analyzing displacement measurements.

1. Testing Equipment. Provide testing equipment conforming to the following.

    a. Provide a hydraulic jack and pump with a rated capacity greater than the factored design test load. Provide a hydraulic jack with a stroke length at least 1 inch greater than the theoretical elastic elongation of the tendon steel at the factored design test load.
    b. Provide two pressure gages to measure the pressure in the hydraulic jack, a production gage and a reference gage. Provide pressure gages with graduations of 50 psi or smaller. Ensure the hydraulic jack and the pressure gages have been calibrated as a unit within 9 months of the beginning of anchor testing. Ensure the calibration is traceable to the National Institute of Standards and Technology (NIST). Use the reference gage to check the production gage at least once per day when testing.
    c. Provide a load cell and readout with a rated capacity greater than the factored design test load for extended creep tests. Ensure the load cell and readout have been calibrated as a unit within 9 months of the beginning of anchor testing. Ensure the calibration is traceable to NIST.
    d. Provide a displacement gage that can measure movement in increments of 0.001 inch or less. Provide a displacement gage with a 4.0 inch minimum range of travel. If the anticipated elongation of the tendon steel at the factored design test load will exceed 4.0 inches, provide displacement gages with a sufficient range of travel, or provide multiple displacement gages that can be arranged in series to allow the continuous measurement of the displacement of the anchor head.
    e. Provide a jack chair that can transfer 100 percent of the ultimate tensile strength of the tendon steel.
2. Testing Equipment Setup. Position the hydraulic jack, load cell (for extended creep tests), and other necessary items (such as bar extensions, stressing anchorages, and jack chair) over the anchor tendon and parallel to its axis. Apply the alignment load to hold the jack in place.

    Set the displacement gage after applying the alignment load. Support the displacement gage on a tripod or other support device that is independent of the ground anchor and the structure. Position the displacement gage so that its axis is parallel to the axis of the anchor tendon within 5 degrees. Check that the stem of the displacement gage is free to move over its entire measurement range.

3. Sacrificial Ground Anchor Test. Perform a sacrificial ground anchor load test by incrementally loading the sacrificial ground anchor according to the following schedule shown in Table 1. Use a load cell to monitor the load during hold periods.

TABLE 1 SACRIFICIAL GROUND ANCHOR LOAD TEST SCHEDULE

Load Increment	Load Increment for LRFD	Hold Period (minutes)	Time for Displacement and Strain Gauge Reading (minutes)
1	AL (0.05 MUTS)	---	Initial Reading
	0.10 MUTS	10	1, 2, 3, 4, 5, 6, 10
2	0.20 MUTS	60	*
3	0.30 MUTS	60	*
4	0.40 MUTS	60	*
5	0.50 MUTS	60	*
6	0.60 MUTS	60	*
7	0.70 MUTS	60	*
8	0.80 MUTS	60	*
9	AL (0.05 MUTS)	1	Final Reading

* - Record Displacement Readings and Strain Gauge Readings at 1,2,5,10,20,30 and 60 minutes.
AL = Alignment Load;
MUTS = Minimum Ultimate Tensile Strength

Conduct the sacrificial ground anchor load tests until completion or until reaching a pullout failure. Submit copies of all the test data to the Engineer.

After completing both tests on the sacrificial ground anchors and after receiving approval from the Engineer, remove and dispose of the reinforced concrete anchor block in accordance with the Project Specifications. Remove and dispose of the ground anchor end hardware, cut the ground anchors and restore the grading to the pre-testing condition to the satisfaction of the Engineer.

4. Proof Test. Complete a proof test by incrementally loading and unloading the ground anchor according to the following schedule shown in Table 2.

TABLE 2 PROOF TEST LOAD SCHEDULE

Load Increment for	Hold Period	Time for Displacement
AL (0.10 FDL)	---	Initial Reading
0.20 FDL	*	*
0.40 FDL	*	*
0.60 FDL	*	*
0.75 FDL	*	*
0.90 FDL	*	*
1.0 FDL	10	1, 2, 3, 4, 5, 6, 10
0.40*FDL	*	*
AL (0.10 FDL)	---	1

* Hold load just long enough to read displacement, but not longer than one minute

[1] If the amount of movement between the 1 minute and 10 minute displacement readings exceeds 0.04 inch, then hold the load for 60 minutes and take additional displacement readings at the times shown in parentheses.

AL = Alignment Load FDL = Factored Design Load

5. Performance Test. Complete a performance test by incrementally loading and unloading the ground anchor according to the following schedule shown in Table 3.

TABLE 3 PERFORMANCE LOAD TEST SCHEDULE

Load Cycle	Load Increment for LRFD	Hold Period (minutes)	Time for Displacement, Load Cell and Strain Gauge Readings (minutes)
	AL (0.10 FDL)	---	Initial Reading
1	0.20 FDL	*	*
	AL (0.10 FDL)	---	1
2	0.20 FDL	*	*
	0.40 FDL	*	*
	AL (0.10 FDL)	---	1
	0.20 FDL	*	*
3	0.40 FDL	*	*
	0.60 FDL	*	*
	AL (0.10 FDL)	---	1
	0.20 FDL	*	*
4	0.40 FDL	*	*
	0.60 FDL	*	*
	0.75 FDL	*	*
	AL (0.10 FDL)	---	1
	0.20 FDL	*	*
	0.40 FDL	*	*
5	0.60 FDL	*	*
	0.75 FDL	*	*
	0.90 FDL	*	*
	AL (0.10 FDL)	---	1
	0.20 FDL	*	*
	0.40 FDL	*	*
	0.60 FDL	*	*
6	0.75 FDL	*	*
	0.90 FDL	*	*
	1.0 FDL	10	1, 2, 3, 4, 5, 6, 10
		(60) [1]	(20, 30, 40, 50, 60) [1]
	AL (0.10 FDL)	---	1

* Hold load just long enough to read displacement, but not longer than one minute

[1] If the amount of movement between the 1 minute and 10 minute displacement readings exceeds 0.04 inch, then hold the load for 60 minutes and take additional displacement readings at the times shown in parentheses.

AL = Alignment Load FDL = Factored Design Load

6. Extended Creep Test. Perform an extended creep test on permanent ground anchors indicated in the Plans, by incrementally loading and unloading the ground anchor according to the following schedule shown in Table 4. Use a load cell to monitor the load during hold periods. Record displacement and

TABLE 4 EXTENDED CREEP LOAD TEST SCHEDULE

Load Cycle	Load Increment for LRFD	Hold Period (minute	Time for Displacement, Load Cell and Strain Gauge Readings (minutes)
	AL (0.10 FDL)	---	Initial Reading
1	0.20 FDL	10	1, 2, 3, 4, 5, 6, 10
	AL (0.10 FDL)	---	1
2	0.20 FDL	*	*
	0.40 FDL	30	1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30
	AL (0.10 FDL)	---	1
	0.20 FDL	*	*
3	0.40 FDL	*	*
	0.60 FDL	30	1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30
	AL (0.10 FDL)	---	1
	0.20 FDL	*	*
4	0.40 FDL	*	*
	0.60 FDL	*	*
	0.75 FDL	45	1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30, 45
	AL (0.10 FDL)	---	1
	0.20 FDL	*	*
	0.40 FDL	*	*
5	0.60 FDL	*	*
	0.75 FDL	*	*
	0.90 FDL	60	1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30, 45, 60
	AL (0.10 FDL)	---	1
	0.20 FDL	*	*
	0.40 FDL	*	*
	0.60 FDL	*	*
6	0.75 FDL	*	*
	0.90 FDL	*	*
	1.0 FDL	300	1, 2, 3, 4, 5, 6, 10, 15, 20, 25, 30, 45, 60, 75, 90, 100, 120, 150, 180, 210, 240, 270, 300
	AL (0.10 FDL)	---	1

* - Hold load just long enough to read displacement, but not longer than one minute AL = Alignment Load FDL = Factored Design Load

7. Acceptance Criteria for Permanent Ground Anchors. A ground anchor is acceptable when it holds the maximum test load and it meets the acceptance criteria for creep movement and apparent free length during testing.

   a. Creep movement. Creep movement of a ground anchor is the displacement of the anchor head under a relatively constant load during the hold period of the test due to relaxation of the bond in the bond zone. However, some time dependent movement or creep of wire strand tendons may complicate the creep measurements.

      The acceptance criteria for ground anchors subject to proof or performance testing is 0.04 inches of creep movement or less between the 1 and 10 minute displacement readings, or 0.08 inches of creep movement or less between the 6 and 60 minute displacement readings.

      The acceptance criteria for ground anchors subject to extended creep testing is 0.08 inches or less of creep movement in the last log cycle of time for each hold period. A log cycle of time is the time between 2 displacement readings where the second reading is at a time 10 times longer than the time of the first reading (for example, 1 minute to 10 minutes, 6 to 60 minutes, and 30 to 300 minutes are each one log cycle of time).

      Tendons which have not been proof stretched may require adjustments to the creep displacement readings to account for the creep of the wire strand tendons. Determine necessary adjustments from test results furnished by the tendon supplier.

   b. Apparent Free Length. The apparent free length of a ground anchor is the equivalent length of the tendon steel that has the same elongation as the measured elastic movement under the same net load (the test load minus the alignment load). Calculate the apparent free length at the maximum test load in a proof test and at the maximum test load in each load cycle in a performance test or extended creep test. Use the following equation to calculate the apparent free length.

$$\text{Apparent Free Length} = \frac{A \times E \times d}{TL - AL}$$

      Where:

      A = cross-section area of the tendon steel
      E = modulus of elasticity of the tendon steel
      d = elastic movement (displacement reading at the test load minus the subsequent displacement reading at the alignment load)
      TL = test load
      AL = alignment load

An acceptable apparent free length is equal to or greater than the theoretical elastic elongation of 80 percent of the unbonded free stressing length of the ground anchor plus the jack length. If movement measured during a ground anchor test does not meet this acceptance criterion, but can hold the factored design test load and it meets the acceptance criteria for creep movement, then repeat the test load cycle by reducing the test load to the alignment load and then incrementally increasing the test load to the factored design test load according to the proof test schedule. If the ground anchor fails to meet the apparent free length acceptance criteria on the second attempt, repeat the test load cycle a third time. If after three attempts the ground anchor still fails to meet the apparent free length acceptance criteria, replace the ground anchor.

8. Permanent Ground Anchors Not Meeting Acceptance Criteria. When a ground anchor does not meet the acceptance criteria, correct the problem at no additional expense to the Department. The corrections may include, but are not limited to, completing additional post-grouting cycles on the ground anchor, replacing the unacceptable ground anchor, reducing the ground anchor design load and installing additional ground anchors in an adjacent secondary ground anchor location, changing installation methods, or increasing anchor total length or anchor bond length.

   Ground anchors that do not meet one of the acceptance criteria may still be incorporated into the Work under the following conditions.

   a. If the ground anchor cannot hold the factored design test load and the post-grouting system is still intact, then conduct additional post-grouting cycle(s) on the ground anchor and repeat the testing using the original acceptance criteria.
   b. If the ground anchor holds the factored design test load but does not meet the acceptance criteria for creep movement at the factored design test load and the post-grouting system is still intact, then conduct additional post-grouting cycle(s) on the ground anchor and repeat the testing using an enhanced acceptance criterion for creep movement. The enhanced acceptance criterion consists of no more than 0.04 inches of creep movement between the 1 and 60 minute displacement readings at the factored design load.
   c. If the ground anchor does not meet the acceptance criteria for creep movement or if it cannot hold the factored design load, the ground anchor may be incorporated into the Work at a reduced load. Lock off the ground anchor at no more than 50 percent of the stabilization load (the load that the anchor holds without detectable movement at the end of testing). To determine the stabilization load, stop adjusting the jack pressure, wait until the displacement reading has not changed for 10 minutes, and then measure the load in the anchor. When incorporating a ground anchor into the Work in this manner, install additional ground anchors or use some other corrective procedure to compensate for the reduced anchor load.

Except for items a and b above (post-grouting), submit the proposed corrective work to the Engineer in writing before beginning corrective work.

9. Permanent Ground Anchor Lock-off. After successful testing of a ground anchor is complete, adjust the load on the ground anchor to the specified lock- off load shown in the plans, but not less than the minimum seating load which is 50 percent of the minimum ultimate tensile strength of the strand tendons. Increase the load as necessary to compensate for seating losses. Transfer the load from the jack to the anchorage device. Before removing the jack, perform a lift-off test to confirm the load in the anchor tendon. Perform the lift-off test by re-applying load to the anchor tendon until the wedge plate lifts off the bearing plate or the wedges lift. The lift-off reading must be within 5 percent of the specified lock-off load. If the lift-off reading is more than 5 percent below the specified lock-off load, increase the lock-off load by lifting the anchor head and placing shims under the anchor head. If the lift-off reading is more than 5 percent above the specified lock-off load, notify the Engineer and adjust the procedures to ensure this does not occur on subsequent ground anchors.

   Cut off excess tendon steel leaving at least 0.5 inch extending above the wedges or anchor nut and completely fill the trumpet with grout. Take adequate precautions to prevent grout from freezing. For permanent anchors that require an anchorage cover, ensure the cover fits over the anchor head and seals against the bearing plate. Completely fill the cover with grout.

5. METHOD OF MEASUREMENT.

Permanent ground anchors that are installed, tested and accepted will be measured from the base of the bearing plate (in contact with the cap beam) to the end of the installed anchor as shown in the Plans. Additional permanent ground anchors installed by the contractor in secondary ground anchor locations to achieve the acceptance criteria are considered corrective measures and will not be measured for payment.

Sacrificial ground anchor testing will be measured by each test completed and submitted to the Engineer.

6. BASIS OF PAYMENT.

The unit price of a permanent ground anchor is for full compensation of the work including but not limited to completing the drill hole for the permanent ground anchor; hauling and disposal of drill cuttings; furnishing the multi-strand ground anchor tendon with Class I corrosion protection; furnishing end hardware including the bearing plate with trumpet, anchorage heads with wedge grips and end caps; furnishing and placing initial grout through grout tubes; completing pressurized post-grouting cycles through grout tubes; placement and removal of temporary drill casing; all costs associated with performance, proof and extended creep testing;

costs of submittals and test reports; and for furnishing all tools, labor, equipment, materials and incidentals necessary to complete the work. Costs associated with instrumenting the permanent ground anchors will be measured and paid for under the Instrumentation Pay Items in accordance with the Special Provision for Instrumentation.

The unit price of sacrificial ground anchor testing is for full compensation of the work including but not limited to design, construction and disposal of the ground anchor reaction block, furnishing the 7-strand sacrificial ground anchors, completing the drill hole for the sacrificial anchors, hauling and disposal of drill cuttings; furnishing end hardware including the bearing plate with trumpet, anchorage heads with wedge grips and end caps; furnishing and placing initial grout through grout tubes; completing pressurized post-grouting cycles through grout tubes; placement and removal of temporary drill casing; all costs associated with sacrificial ground anchor load testing; costs for instrumenting the sacrificial ground anchors; costs of submittals and test reports; and for furnishing all tools, labor, equipment, materials and incidentals necessary to complete the work.

The Department will pay for accepted quantities at the contract price as follows:

Item No.	Pay Item	Pay Unit
930-4150	Ground Anchor	Linear Feet
930-4155	Sacrificial Ground Anchor Testing	Each

This document was originally issued and sealed by Gregory Robert Fischer, Registration Number PE-4324, on 02/09/15 and the original document is stored at the North Dakota Department of Transportation

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

HORIZONTAL DRAINS

Project SER-5-094(107)030 – PCN 20549

1. DESCRIPTION

This work consists of furnishing and installing horizontal drains and associated outlet pipes, casings, pipe fittings, grout plugs and riprap. Maintain and restore existing grading, riprap fills and other improvements including access roads, if utilized, during construction. Condition of existing grading and riprap fills to be returned to pre-construction condition or as approved by Engineer.

2. MATERIALS

A. Slotted Horizontal Drain Assembly.

A slotted horizontal drain assembly consisting of nominal 1½ -inch I.D., Schedule 80 poly-vinyl chloride (PVC) pipe conforming to ASTM designation D1785 with the type, grade, and design stress designation of the pipe either 1120, 1220, 2110, 2112, 2116, or 2120.

The perforated portion of the horizontal drain pipe shall have two rows of slots. The rows shall be in the longitudinal direction of the pipe and the slots shall be cut in the circumferential direction of the pipe. Orient the rows 120 degrees apart from the center of the pipe. Each row of slots shall have 22 slots per linear foot, each with a 0.020-inch opening providing a minimum opening per linear foot of 0.46 square inches. Slots shall be spaced uniformly along the pipe. The minimum opening will be measured on the inner surface of the pipe.

Fittings for the horizontal drain pipe shall be Schedule 80 Type II PVC solvent weld type fittings. Machined male and female ends may be used in lieu of couplings. Fittings shall be flush, providing a smooth exterior pipe surface.

B. Outlet Sleeve

Provide an outlet sleeve consisting of a 5-inch diameter unslotted, steel drill casing.

C. Grout Seal

Prove a grout seal consisting of a Portland Type II cement grout, with 5% by volume bentonite powder mixed with clean water, free of turbidity, strong acids, alkalis, oils and organic material. Mix the grout to a uniform, fluid consistency, without segregation of the constituent parts. Portion the grout mixture (by volume) of 1 part Portland cement and 1 part water, or as approved by the Engineer. Mix the bentonite with the water prior to adding cement.

D. Air relief pipe and grout pipe

Provide an air relief pipe and the grout pipe consisting of a maximum ½ -inch I.D. polyethylene pipe conforming to ASTM D1785.

E. Centralizer/grout Plug

Provide a water well type packer to center the horizontal drain pipe in the bore-hole and provide a barrier for water and grout.

3. CONSTRUCTION REQUIREMENTS

A. Work Force Experience

The work shall be performed by a qualified Contractor with at least five years of experience in drilled horizontal drain installation of similar drains of more than 300 feet in length in similar soils and site access conditions.

Provide a full-time superintendent or foreman who is experienced in the use of the materials and equipment being used at this site for installations similar to those proposed. Do not perform horizontal drain drilling and installation unless the supervisor or foremen meeting the above experience requirements is onsite and in actual supervision of this portion of the work.

B. Submittals

Submit the following at least 45 days before the planned early start of horizontal drilling. Do not begin horizontal drain installation until written approval of the submittals is provided by the Engineer.

1. Contractor Experience

   Provide resumes of the Contractor and any subcontractors, as well as the supervisors and foremen assigned to construct the horizontal drains. At a minimum, provide the names, address, and telephone numbers of three references for the Contractor, and any subcontractors, as well as the supervisors and foremen assigned to the project.

2. Horizontal Drain Construction Plan

   Provide a horizontal drain construction plan consisting of the proposed method for horizontal drain drilling. Include a description of the drill rigs and equipment including type, size, weight and proposed drill rig operators to be used. Include descriptions of the proposed drill tooling including borehole diameter, types and sizes of drill bits and drill rods, water or drilling mud requirements, and space required for drill rig and drilling operations, including methods and means of access and moves between holes.

3. Material Descriptions

   Provide a description of the horizontal drain materials, including manufacturer, method of joining segments, method of creating slots and slot dimensions, and the open area per linear foot.

4. Drill Heading Methods

   Provide a description of the equipment and proposed methods for establishing the required inclination and azimuth for the drilled horizontal drains.

5. Grout Seal Design

   Provide the bore hole grout seal mix design and descriptions of equipment used for proportioning, mixing, pumping and placing the grout seal. Describe the procedures for installing centralizer/grout plug packer and seal around the outlet sleeve.

C. Horizontal Drain Construction

Drill each hole at the azimuth and inclination as shown on the Plans, or as approved by the Engineer. The exact location and sequence of placing horizontal drains shall be approved by the Engineer.

Provide a reference point and establish the horizontal drain outlet position for each drain. In addition, two reference points per horizontal drain will be set at the required azimuth for Contractor use in establishing each drains alignment. No more than two site visits by the surveyor will be provided. Collar location and slope stakes forward and back of the drill rig will be established for each drain for alignment purposes.

Do not begin horizontal drain construction until the temporary surface water collection system and erosion control measures are installed and approved by the Engineer. Additional horizontal drains beyond those shown on the Drawings may be directed by the Engineer during construction.

Drill the horizontal drains with rotary equipment capable of drilling 3-inch minimum diameter holes up to 300 feet in length through the anticipated subsurface formations and at the inclinations and azimuths shown on the Plans.

Install the horizontal drain pipe by inserting the pipe inside the drill rod or casing and then retracting the drill rod or casing so that the drilled hole is protected from collapse for the full depth during drain installation. Tightly plug the inner tip of the perforated horizontal drain pipe with a rounded or pointed extension that extends less than 0.5-foot beyond the end of the pipe. The nonperforated portion of the horizontal drain pipe shall extend a minimum of 18-inches from the exposed cutface or ground surface, and 20 feet into the borehole as shown on the Plans.

Install an outlet sleeve in each drilled hole to protect the outlet of the horizontal drains. The outlet sleeve is grouted in the borehole as shown on the Plans. Ex-

tend the outlet sleeve a distance of 1 foot beyond the existing ground surface adjacent to the bore hole.

Equip the outlet ends of all horizontal drains with an outlet assembly consisting of a tee, threaded plug, and a length of flexible HDPE pipe. Extend the flexible HDPE pipe into a riprap fill that matches the nearby riprap.

D. Grout Seal Construction

A detail of the borehole containing the outlet sleeve, the horizontal drain pipe, the grout pipe, the air relief pipe, and the grout seal is shown on the Plans. Grout the annular space between the bore hole, the outlet sleeve, and the horizontal drain pipe to form a grout seal as shown. Place two centralizers/grout plugs of contractor design to centralize the drain pipe and to confine the grout seal. Place the grout placement pipe and an air relief pipe in the annular space inside the outlet sleeve between the grout plugs. Locate the grout pipe at the bottom of the bore, below the unslotted drain pipe, and extend into the bore hole beyond the soil face to within 1 foot of the upslope centralizer/grout plug. Locate the air relief pipe at the top of the bore and extend into the bore hole to the highest elevation point beyond the inner edge of the grout plug. The grout seal direct all water into the drain pipe. Check the air relief pipe prior to grouting to determine that it is not blocked.

Inject grout into the annular space in a single uninterrupted placement with grout pressures limited to a maximum 30 psi. Continue grout placement until a steady flow of undiluted grout is observed coming out of the air relief pipe. Seal the air relief pipe after 30 seconds of continuous grout flow while grouting continues. Continue grouting for another 30 seconds then seal the grout pipe. Upon initial set of the grout, the air relief and grout lines will be observed to disclose any water leakage. If leakage through these lines is observed, additional grout will be injected through the leaking lines to complete the permanent grout seal. Following completion of grouting, approval of the Engineer, and setting of the grout, all grout and air relief pipes will be cut flush with the finished grade at the ground surface. Dispose of any grout not used within 30 minutes after mixing water has been introduced.

Wash out the horizontal drain pipe after completing the grout seal by inserting a hose a minimum of 30 feet into the drain and flushing the drain until the drain flow consists of clear water.

The grout may be placed in the horizontal drain outlet assembly as soon as it is installed to design depth. Do not leave more than five drains ungrouted at any time. If drilling operations at a drilling pad cease for more than five days, grout the completed drains at that drilling pad and connect the drains to the surface collector system. Repair surface erosion from the drain outflow that occurs prior to the drain being grouted and connected with the surface collector system, at no expense to the Department.

Replace horizontal drains which cannot be successfully grouted due to mechanical failure of the equipment, inadequacy of the grout supply, or improper injection procedures at no expense to the Department. As an alternative, the Contractor may redrill the drain, remove the inadequate grout plug, replace the drain pipe, and regrout the drain.

E. Inclination Measurements

Measure the inclination of the drain bore by determining the elevation difference of the bore tip elevation versus the bore collar elevation at a minimum of 3 depth increments during the drilling process. Submit the details of the proposed inclination measurement equipment and measurement procedures to the Engineer for review and approval prior to use. The Engineer may want to be onsite during collection of the measurements to confirm results**.**

F. Site Restoration

After completing the horizontal drains, restore the grading at the drill rig access site to pre-construction conditions and place riprap matching the nearby riprap to cover the flexible pipe to the satisfaction of the Engineer.

4. METHOD OF MEASUREMENT

Horizontal drains will be measured by the linear foot from the outlet end of the non-perforated Schedule 80 pipe to the tip end of the perforated Schedule 80 pipe.

5. BASIS OF PAYMENT

The unit price of horizontal drains shall be full compensation for preparing the drill rig access, drilling the length of the drain; furnishing and installing the outlet sleeve and grout seal; hauling and disposal of excavated material; furnishing, preparing and pumping the grout mix, determining the inclination and azimuth of the horizontal drain, restoring the access site to pre-construction conditions, providing riprap cover over the flexible drain pipe; and for furnishing all tools, labor, equipment, materials and incidentals necessary to complete the work.

The accepted quantities for Horizontal Drains will be paid for at the contract bid price for:

Item No.	Pay Item	Pay Unit
714-7005	Pipe PVC 1.5 in Slotted Drains	Linear Feet

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NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

INSTRUMENTATION

Project SER-5-094(107)030 – PCN 20549

1. DESCRIPTION

This work consists of procuring, installing, and measuring geotechnical instrumentation pertaining to loads and deformations of selected structural components within the project in accordance with these specifications.

2. DEFINITIONS

A. Instrumentation. Inclinometers, load cells and anchor strand gages.

B. Inclinometers. Vertical casings installed in drilled shafts to measure horizontal displacements.

C. Load cells. Instruments installed at cap beam to measure applied load at head of ground anchors.

D. Anchor strain gages. Instruments installed on ground anchor strands within the bonded and unbonded zone to measure distribution of load along anchor.

3. MATERIALS

A. Drilled Shaft Inclinometer Casing

Furnish inclinometer casings as supplied by Slope Indicator Company (SINCO), Geokon, or approved equal.

Provide casing with:

1. A minimum 1.9-inch outside diameter, ABS plastic pipe with internal longitudinal grooves (SINCO model 51150210, Geokon Model 6400).

2. Self-aligning couplings, caps, and fittings compatible with casing.

3. All necessary installation tools and accessories.

   Provide lockable metal protective cover for installing above the top of the inclinometer. Install the cover flush with the concrete at the top of the cap beam. Select the cover from the inclinometer manufacturer's list of standard commercial products produced for this application. Furnish a lockable cover with at least 8 inches of internal diameter, and coated or otherwise protected from corrosion.

B. Ground Anchor Load Cells

Furnish hollow center vibrating wire load cells, such as Geokon Model 4900, RST Model VWA-600-3.0, or approved equal.

Measurement requirements:

1. Resolution: 0.025 percent of Full Scale

2. Accuracy: $\pm$0.5 percent of Full Scale

3. Range: 500 kips (500,000 pounds)

   Provide ancillary equipment including bearing plates, angle washers, spherical seats, and other equipment in accordance with the manufacturer's recommendations as required for a complete and functional, weatherproof monitoring system.

   Provide portable readout capable of reading the vibrating wire load cell instruments, such as Geokon GK-404, RST VW 2106, or approved equal.

Ensure that readout is compatible with new load cells and existing vibrating wire piezometers.

Provide a stand-alone datalogger capable of monitoring the 4 load cells, such as Geokon Model 8002-4, RST DT 2055B, or approved equal.

Provide a lockable metal protective box to house and protect the datalogger from the same manufacturer as the datalogger. Install the protective box on the cap beam at a location near the four load cells.

Provide signal cable from the same source as the load cell and integrally connected into the instrument. Provide cables of sufficient length to reach stand-alone datalogger locations from each load cell (approximately 320 total feet).

4. Ensure datalogger is battery powered with a D-cell or similar.

5. Ensure datalogger is compatible with load cells.

C. Ground Anchor Strain Gages.

Furnish elasto-magnetic anchor strand gages for measuring loads, such as DYNA Force Sensors, from Dywidag-Systems International, EM Sensor from Intelligent Instrument Systems Inc., or approved equal.

Install gages in conjunction with fabrication of ground anchors at manufacturer's plant, prior to corrosion protection installation. Complete corrosion protection after strand gage is attached to strand without damage to gage, gage cable, strand anchor or compromising corrosion protection of strand anchor.

Size gages appropriately for the anticipated range of load in the strand anchors.

Provide sufficient length of signal cable from each gage to extend from gage, out through head, and to portable readout unit.

Provide portable readout unit, compatible with anchor strand gages and from the same manufacturer as the elasto-magnetic anchor strand gages.

4. CONSTRUCTION REQUIREMENTS

Provide and install all new instruments indicated on the Plans and as described herein.

Perform readings and data collection, for all new instruments as described herein, during the term of the Contract. Perform readings as frequently as necessary in accordance with this Special Provision.

Collect data from the ground anchor load cells and anchor strand gages during stressing and lock-off.

All instruments, reading devices, fixtures, cables, recorded data, data transfer and reduction software, and data templates become the property of the Department upon completion of the Contract. Transfer all hardware, recorded data, instrumentation warranties, calibration certificates and software in good working condition and within calibration to the Department upon completion of the Contract.

A. Quality Assurance

Install the instrumentation systems in strict conformance to the manufacturer's requirements and these specifications.

Instrument calibration:

1. The instrumentation systems shall, at all times during the duration of the Contract, meet the manufacturer's minimum calibration requirements.

2. In the cases of instrument failure or other reasons of nonperformance during the term of the Contract, replace those instruments with acceptable instruments at no additional cost to the Department.

B. Submittals

1. Instrumentation Specialist Qualifications:

   Submit resume listing experience and qualifications of the instrumentation specialist. At a minimum, submit at least 4 projects that demonstrate the individual performing this work has procured, installed and monitored similar geotechnical instruments on similar projects over the last 3 years. Include a brief description of each project, instruments used, the project's location, date of project, owner, and a reference for each project listed. At the minimum, include an individual's name and current phone number for each reference.

2. Instrumentation Plan.

   Submit an instrumentation plan and detailed drawings containing the following:

   a. Schedule and outline of procedures for instrument installation.

   b. Comprehensive list and description of each type of instrument, readout device, length of cabling and software. Include name of manufacturer and model number, as appropriate. Include operating manuals, specifications and installation procedures for each type of instrument.

c. Detailed plan of instrumentation locations and proposed readout stations.

d. Details including casing, covers, protection of signal cables and backfill.

e. Documentation of calibration on instruments and readout devices.

C. Existing Instrumentation

Existing on-site instrumentation include several inclinometer casings. Protect these casings and provide access for the Department to perform periodic monitoring. Repair or replace damaged inclinometers within 2 weeks of occurrence, at no additional cost to the Department.

Vibrating wire piezometers (Geokon Model 4500) are installed with existing inclinometer casings at several locations at the site. The piezometers are monitored with stand-alone dataloggers. Repair or replace any component damaged by the Contractor within 2 weeks of occurrence at no additional cost to the Department.

D. Instrumentation Locations

1. Install the instrumentation as close as practicable to the locations indicated on the Plans. Adjust for actual conditions in the field.

2. Install instruments in accordance with manufacturer's recommendations and as described herein.

E. Installing Instrumentation

1. Inclinometer casing:

   (1) Assemble the inclinometer casing in accordance with the manufacturer's recommendations. Seal all joints with duct tape and cap the bottom of the casing. Attach casing to the drilled shaft rebar cage at the locations and to the depths shown on the Plans. .

   (2) Extend the top of inclinometer casing to 4-inches below the design elevation of the cap beam top.

   (3) Prior to placement of concrete for cap beam, construct blockouts for flush-mount protective cover to be installed at top of inclinometer casing.

   (4) Prevent concrete inflow into top of inclinometer casing.

(5) After placement of concrete for cap beam, remove blockout and install flush-mount protective cover. Center over inclinometer casing and secure to cap beam with concrete.

2. Strand anchor gage installations:

(1) Install strand anchor gages and signal cables at the strand anchor manufacturer's shop location per gage manufacturer's recommendations.

(2) Ensure strand anchor corrosion protection is intact after gage and signal cables are attached.

(3) Protect instrument signal cables and gages during transportation and installation of instrumented anchor.

(4) Provide access to signal cables at least six feet beyond the head of the strand anchor by threading the cables through sealed duct ports on the strand anchor end caps and openings on the strand anchor wedge plate without compromising the strand anchor's corrosion protection.

3. Load cell installation:

(1) Install load cells during construction of the instrumented ground anchor at locations indicated on the Plans.

(2) Install load cells with machined platens (bearing plates) on either side of load cell using hardware as recommended by the load cell manufacturer, to ensure that load is transmitted evenly and concentrically through the cell, and that bending or eccentric loading is minimized.

(3) Do not weld load cells to bearing plates or structural members.

(4) Extend load cell signal cables beyond the head of the strand anchor to the datalogger by threading the cables through sealed duct port(s) on the strand anchor end caps and openings on the strand anchor wedge plate without compromising the strand anchors corrosion protection

F. Maintenance

During the Contract term, protect and maintain all instruments in accordance with manufacturer's recommended procedures, or as directed by the Engineer.

Report all damaged or non-functional instrumentation to the Engineer immediately. Repair or replace damaged instrumentation, as a result of construction activities, at no additional cost to Department.

G. Instrument Monitoring

The Engineer will monitor existing and newly installed instrumentation during the Contract term. Provide access and necessary assistance to enable the Engineer to perform these periodic measurements. This may include, but not limited to, removing obstacles, equipment or obstructions.

The Engineer will perform initial measurements of the inclinometer casings in the drilled shafts, and periodic measurements of ground anchor instruments after they are loaded.

Record measurements of load cells and strand anchor strain gages during each hold point of the ground anchor performance tests and ground anchor extended creep tests schedule in accordance with the Ground Anchor Special Provision unless otherwise directed by the Engineer. Record ground anchor gage measurements at lock-off, 24 hours after lock off, and 7 days after lock-off for each instrumented ground anchor. Provide the data to the Engineer with the performance test and extended creep test data in accordance with the Ground Anchor Special Provision.

5. METHOD OF MEASUREMENT

Furnishing and installing instruments will be measured as follows:

1. Inclinometer casing, by linear foot, from tip of casing to top of cap beam.
2. Load cell, by each.
3. Strand anchor strain gages, by each.

6. BASIS OF PAYMENT

The unit price of the installed instruments is for full compensation of the work including but not limited to inclinometer casing tied to the drilled shaft reinforcement cage; costs associated with the inclinometer protective cover; costs associated with the instrumentation specialist's labor, per diem and travel costs; costs associated with installing gages onto ground anchor including travel expenses to the manufacturer's plant for strand anchor gage attachment; costs associated with manufacturer's preparation of strand for gage installation and restoration of Class 1 corrosion protection onto strand anchor; costs of submittals, instrumentation monitoring; maintenance of instruments and data reports; acquisition of instrumentation; calibration of instrumentation; costs for data collection, readout devices, data cables and for furnishing all tools, labor, equipment, materials and incidentals necessary to complete the work.

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Costs associated with the datalogger and protective box to house the datalogger will be included in the Load Cell cost.

The Department will pay for accepted quantities at the contract price as follows:

Item No.	Pay Item	Pay Unit
930-4200	Instrumentation – Inclinometer	Linear Feet
930-4205	Instrumentation – Load Cell	Each
930-4210	Instrumentation – Strain Gage	Each

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

SEDIMENT COLLECTION BAG

Project SER-5-094(107)030 – PCN 20549

1. DESCRIPTION

This work will consist of filtering water coming out of the existing and new horizontal drains. The water from the horizontal drains will be discharged with a sediment collection bag as a control measure at the discharge point.

2. MATERIALS

The materials will conform to the following requirements:

A. The sediment collection bag fabric will be a non-woven geotextile conforming to the following properties:

Property Method	Minimum Value	Test
Weight	8 oz/sy	ASTM D 3776
Tensile strength (minimum average of 5 specimens)	200 lb	ASTM D 4632
Puncture Resistance	120 lb	ASTM D 4833
Initial Flowrate	75 gal/min-sf	ASTM D 4491
Bursting Strength	350 psi	ASTM D 3786
Permittivity	1.00 sec-1	ASTM D 4991
UV Stability, % of Initial Tensile Strength after 500 hrs	70%	ASTM D 4355
Apparent Opening Size	100 Sieve =0.15 mm	ASTM D 4751

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B. The Geotextile sediment collection bag will be sewn with a high strength thread; the seams will have a minimum average wide-width strength of 100 lb/in when tested according to ASTM D 4884.

C. Bags will be a minimum size of 10 feet by 15 feet and will have:

1. Sewn in spout.
2. Strapping for holding hose in place.
3. Hose opening to accommodate up to a 6 inch hose.

3. CONSTRUCTION REQUIREMENTS

Sediment collection bags will be installed in accordance with the manufacturer's instructions and the contract documents.

Sediment collection bags will be removed and replaced under any of the follow conditions:

1. When sediment collection bags are full.
2. When sediment collection bags have been in place for more than 30 days.
3. When sediment collection bags are damaged.

Sediment collection bags will be disposed of as specified in Section 107.17. Care will be taken to minimize loss of entrapped sediment during removal and disposal.

4. METHOD OF MEASUREMENT

The quantity will be the number of sediment bags installed and used.

5. BASIS OF PAYMENT

The unit price bid for this work will include the cost of furnishing all labor, equipment, and materials necessary to complete the work, including earthwork for placement of bag, installation, maintenance, removal and disposal of each sediment collection bag.

Item No.	Pay Item	Pay Unit
920-0900	Sediment Collection Bag	Each

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