SP- 230204
(New)

SPECIAL PROVISIONS
FOR
CONCRETE DRILLED SHAFT

Polk County
IM-NHS-080-4(82)139--03-77

Effective Date
August 20, 2024

THE STANDARD SPECIFICATIONS, SERIES 2023, ARE AMMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

230204.01 DESCRIPTION.

A. A concrete drilled shaft foundation consists of reinforced concrete placed in a cylindrical hole. The cylindrical hole shall include permanent steel casing at Piers 1 and 2. The concrete drilled shafts also include uncased rock sockets. The dimensions of the concrete drilled shafts and rock sockets, along with the presence required permanent casing, are shown in the contract documents.

B. Ensure elevations, dimensions, and depth of the drilled shafts and rock sockets are as specified in the contract documents. If bearing strata are encountered at elevations different from the plans or are judged to be of a different quality, as determined by the Engineer, the Engineer may adjust the socket elevation and/or length.

230204.02 MATERIALS.

A. Slurry.

1. Mineral or polymer slurries shall be used when excavating soil within or below the bottom 10 feet of casing unless the Engineer, in writing, approves other drilling fluids.

2. Polymer slurry shall be used during rock socket drilling unless the Engineer, in writing, approves other drilling fluids.

3. Ensure the percentage and specific gravity of the material used to make the suspension is sufficient to maintain the stability of the excavation and to allow proper concrete placement. In the event of a sudden, significant loss of slurry to the excavation, stop foundation construction until the Engineer has accepted either: 1) methods to stop slurry loss; or 2) an alternate construction procedure as proposed by the Contractor.

4. Perform all tests at a slurry temperature of 40°F or higher.

5. Thoroughly premix mineral slurry or polymer slurry with clean, fresh water. Mix for the adequate time (as prescribed by the manufacturer) allotted for hydration in slurry tanks. Adequate capacity slurry tanks are required for slurry circulation, storage, treatment, and disposal. Excavated slurry pits are not allowed.

6. Prior to introduction of polymer slurry into the shaft excavation, draw sample sets from the slurry tanks and test the samples for conformance with the specified material properties. A sample set consists of samples taken at mid-height and within 2 feet of the bottom of the slurry tanks.

7. During rock socket excavation, take and test sample sets of polymer slurry, composed of samples taken at mid-height and within 2 feet of the bottom of the shaft, as necessary to verify the control of the slurry properties. As a minimum, take and test sample sets at least once every 2 hours after beginning rock socket excavation. When consecutive test results show the slurry is within specified properties, the Engineer may relax testing frequency to a minimum of once every 4 hours during excavation and cleaning. When tests show that the sample sets do not meet the specified properties, the Contractor shall take corrective actions.

8. Record the date, time, persons' names sampling and testing the slurry, and the test results. Submit a copy of the recorded slurry test results to the Engineer at the completion of each shaft, and during construction of each shaft when the Engineer requests.

9. When samples are found to be unacceptable, either clean, recirculate, desand, or replace the slurry to maintain the required slurry properties. Do not begin cleaning the bottom of the excavation and placing concrete until after tests show that the sample sets have consistent specified properties.

10. Demonstrate to the Engineer's satisfaction that stable conditions are being maintained. If the Engineer determines that stable conditions are not being maintained, immediately take action to stabilize the shaft. Submit a revised installation plan which corrects the problem and prevents future instability. Do not continue with shaft construction until the Engineer has accepted the revised installation plan.
    a. **Mineral Slurry.**
    If used in the soil overburden, mineral slurry shall have properties necessary to: 1) maintain stability of the excavation; 2) allow installation and seating of the permanent casing; 3) be entirely exchanged with polymer slurry to the satisfaction of the Engineer. The mineral slurry shall be replaced by polymer slurry prior to beginning rock socket excavation by removing mineral slurry from the bottom of the excavation and replacing with polymer slurry at the top of the excavation.
    b. **Polymer Slurry.**
        1) For polymer slurry use, comply with the manufacturer's recommendations and this specification. Submit to the Engineer the name and telephone number of the manufacturer's representative. The manufacturer's representative is to provide technical assistance in the use of the polymer slurry as needed.
        2) Ensure polymer slurry complies with Table SP-230204.02-1 unless otherwise directed by the slurry representative and approved by the Engineer in writing:

Table 230204.02-1: Polymer Slurry Requirements

Property	Test Method	Requirements
Density (lb/ft^3)	Slurry Density Materials I.M. 387	62 to 63
Viscosity (sec/quart)	Marsh Funnel and Cup Materials I.M. 387	136 to 227 231 to 252 (dry sand/gravel)
pH	pH Paper	8 to 11

Sand Content (%)	Sand Content Test Materials I.M. 387	*
*The sand content of polymer slurry prior to placing the reinforcing steel cage and immediately prior to placing concrete less than 2.0%.		

3) The base of the drilled shafts shall be thoroughly cleaned with an airlift or other method approved by the Engineer. To the satisfaction of the Engineer, the polymer slurry shall be thoroughly clean and free of particles, including clay- and silt-sized particles that may settle out of suspension with time and accumulate at the base after cleaning. Slurry sampling and associated testing shall be conducted upon acceptance of the shaft cleanliness by the Engineer. After the reinforcing steel cage is placed in the excavation, take and test a sample set of slurry immediately prior to concrete placement.

B. Concrete.

1. All materials, proportioning, air entraining, mixing, slump, and transporting of PCC shall be according to Section 2403 of the Standard Specifications, except as modified herein.

2. Water/cement ratio: not to exceed 0.45.

3. Drilled shaft construction: use Class D PCC mixture with a slump of 8 inches ±1.5 inches.

4. Portland cement: meet the requirements Section 4101 of the Standard Specifications.

5. Air entrainment: apply Section 2403 of the Standard Specifications.

6. Mid-range or high-range water reducer is required according to Materials I.M. 403.

7. Retarder is required according to Materials I.M. 403 to maintain workable concrete.

8. Refer to Table SP-230204.02-2 for the maximum allowable substitution rates:

Table 230204.02-2: Maximum Allowable Substitution Rates.

Cement Type	Maximum Allowable Substitution[(a)]	Time Period
Type I, II, IL	35% GGBFS 20% Fly Ash	March 16 through October 15
Type IS, IP, IT	0% GGBFS 20% Fly Ash	March 16 through October 15
All	0% GGBFS 0% Fly Ash	October 16 through March 15
[(a)] Maximum total mineral admixture substitution is 50%.		

C. Grout.
Apply Materials I.M. 388.

230204.03 CONSTRUCTION.

A. Construction Tolerances.
Drilled shaft excavations and completed shafts not constructed within the required tolerances will be subject to rejection. Correct all unacceptable shaft excavations and completed shafts to the

Engineer's satisfaction. Furnish materials and work necessary, including engineering analysis and redesign, to complete corrections for out of tolerance drilled shaft excavations (without either cost to the Contracting Authority or an extension of the completion dates of the project).

1. Ensure the drilled shaft is within 3 inches of plan position at the top of shaft.

2. Ensure the vertical alignment of shaft excavation does not vary from the plan alignment by more than 1/4 inch per 4 foot.

3. Set full depth reinforcing steel cages at no less than 6 inches above the bottom of the excavated shaft prior to concrete placement.

4. Ensure that, after all the concrete is placed, the top of the reinforcing steel cage is no more than 6 inches above and no more than 2.75 inches below plan position.
5. Casing dimensions are subject to American Pipe Institute tolerances applicable to regular steel pipe.

6. The top elevation of the shaft may have a tolerance of +1 inch or -3 inches from the plan top of shaft elevation. Ensure sufficient reinforcement bar splice length for splices above the shaft.
7. Use excavation equipment and methods that produce a completed shaft excavation having a planar bottom. Ensure the excavation equipment cutting edges are normal to the equipment's vertical axis within a tolerance of 3/8 inch per foot of diameter.

B. Drilled Shaft Installation Plan

1. No later than 30 days prior to the start of drilled shaft construction, submit a list containing at least three drilled shaft projects, of similar diameter and length to those shown on the plans, completed in the last 3 years. In the list of projects include names and phone numbers of owner's representatives who can verify the Contractor's participation and performance on those projects. In addition, submit a signed statement that the Contractor has inspected the project.

2. No later than 45 days prior to the start of drilled shaft construction, submit a drilled shaft installation plan for the Engineer to review. In this plan provide the following information:
   - **a.** Name and experience record of firms and associated personnel for the following:
     - **1)** Driller.
     - **2)** Drilled shaft superintendent.
     - **3)** Site exploration.
     - **4)** Confirmation boring.
     - **5)** Crosshole sonic logging (CSL).
     - **6)** Name of load cell testing firm.
   - **b.** List of all proposed equipment to be used, including cranes, drills, augers, bailing buckets, drilling buckets, core barrels, clean-out buckets, final cleaning equipment, tremies, concrete pumps, water pumps, slurry pumps, slurry tanks, temporary casing, starter casing, associated slurry equipment, and so forth. If multiple diameters for any tool are used, they must all be listed individually.
   - **c.** Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
   - **d.** Details of shaft excavation methods.
   - **e.** Details of casing and forms, including installation and removal.
   - **f.** Details of the type and methods to mix, circulate, desand, test, and dispose of all proposed slurry types. Submit data on manufacturer's requirements for slurry control.
   - **g.** Details of methods to clean the shaft excavation, including airlift or other approved methods to clean the base beyond just using a clean-out bucket.
   - **h.** Details of the slurry exchange process, if necessary.

i. Details of reinforcement placement, including support and cage centering methods.
j. Reinforcing steel cage splicing method, if proposed, including details of dimensions, installation, splice location, support and cage centering methods, and estimated time required for splicing.
k. Details of concrete delivery and placement including procedures for tremie or pumping methods and methods to prevent slurry intrusion at the discharge end.
l. Concrete mix proposal.
m. Details of methods to control, handle and dispose of cuttings, water, slurry, and so forth with adjacent traffic conditions.
n. Details of CSL testing, including location and attachment methods of the steel access pipes.
o. Include details of the test equipment used in the load cell test, and description of the load test procedures and program according to Article SP-230204.03, M, 1, b.
p. Details of final discharge of concrete at the top of the shaft to remove contaminated concrete and verifying concrete uniformity for site specific conditions.
q. Include details on casing including:
- Specific length/depth of all casing proposed, and
- Specific evaluation and determination of casing (size, depth, etc.) required to prevent all shaft installation procedures from having an effect or impact on adjacent structures.

3. The Engineer will evaluate the drilled shaft installation plan for conformance with the contract documents. Within 14 calendar days after receipt of the plan, the Engineer will notify the Contractor of additional information required or changes necessary to meet the contract requirements, or both, as needed. Field test the Engineer's procedural approvals. These approvals do not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the contract documents.

C. Control and Disposal of Materials.

1. Dispose of excavated material, as well as slurry and/or water removed from the shaft excavation. Collect and properly dispose off-site all slurry and untreated water displaced during final cleaning and concrete placement. Open pits for collection of materials are not allowed. Control all excavated material, slurry, water, and other matter so that at no time it enters or encroaches upon the adjacent travel lanes, railroads, waterways, and so forth.

2. Water properly treated to remove sediment may be disposed on site. Take measures to prevent scour erosion at discharge point. Ensure turbidity of treated water does exceed 25 Nephelometric Turbidity Units (NTUs) greater than receiving water at the point of discharge; pH shall not be less than 6.5 nor greater than 9.0 at point of discharge; ensure pH is within 0.5 of receiving water; and discharge does not create objectionable color in receiving water. Contractor is responsible for testing prior to discharge and while discharging. If water is not able to be properly treated, dispose of off-site per Article SP-230204.03, D, 1, at no additional cost to the Contracting Authority.

D. Shaft Excavation.

1. General.
a. Construct drilled shafts by the wet method as necessary to produce sound, durable concrete foundation shafts free of defects. This method is described below.
b. Remove surface and subsurface obstructions. Special tools and/or procedures may be required.
c. If the Engineer determines that the material encountered during excavation and/or present at tip elevation is unsuitable and/or differs from that anticipated in the design, extend the drilled shaft tip elevations including the permanently cased portion and/or the rock socket, as directed by the Engineer.

d. Maintain a detailed drilling log during shaft and socket excavation. In the log, place information such as elevation, depth of penetration, drilling time in each of the strata, material description and remarks. Furnish two copies of the log (signed by the contractor) to the Engineer within 1 week after completion of the excavation.
e. After the shaft excavation has been completed, immediately proceed with shaft construction.
f. Do not excavate a shaft within a distance of three shaft diameters of a previously constructed shaft within 36 hours of completing concrete placement, unless approved by the Engineer.
g. The dry method of construction will not be allowed.

2. Wet Method.
The wet method consists of:
a. Keeping the shaft filled with slurry a minimum of 4 feet above the highest water table encountered during drilling and excavation,
b. Desanding and cleaning of the slurry when required,
c. Installation of permanent casing to bedrock,
d. Final cleaning of the excavation and slurry by means of an airlift or other similar device as approved by the Engineer, and
e. Placing shaft concrete which displaces the slurry.

E. Brushing Sidewalls.
Perform brushing prior to final cleaning of the base of shaft

F. Final Cleaning.

1. For drilled shafts constructed in the wet, use a cleanout airlift, dredge pump, or other similar device, subject to the Engineer's acceptance, to clean the base of the shaft and exchange the entire slurry column. A bailing or cleanout bucket alone is not sufficient for final cleaning, and, at a minimum, a full exchange of the slurry column is required. To the satisfaction of the Engineer, the polymer slurry shall be thoroughly clean and free of particles, including clay- and silt-sized particles that may settle out of suspension with time and accumulate at the base after cleaning and inspection. Inspection with the Mini-Shaft Inspection Device (Mini-SID) shall be performed after final cleaning in combination with weighted tape inspection as specified below. If shaft cleanliness cannot be verified, additional cleaning is required followed by re-testing with the Mini-SID.

2. Clean the base of each shaft so that a minimum of 50% of the base will have less than 1/2 inch of sediment at the time of concrete placement. Ensure the maximum sediment or debris depth at the base of the shaft does not exceed 1.5 inches.

G. Excavation Inspection.

1. Provide equipment for checking the dimensions and alignment of each shaft excavation. Under the direction of the Engineer, verify the dimensions and alignment of the shaft under construction. After final cleaning, use a suitable weighted tape or other approved methods to measure final shaft depths.

2. The primary means of base cleanliness inspection of drilled shafts shall be by Mini-SID along with weighted tape soundings. The Mini-SID shall be used following final cleaning of the shaft and a weighted tape inspection shall be conducted directly after the passing Mini-SID. Immediately prior to and following cage installation and again immediately prior to concrete placement, weighted tape inspection shall be re-performed to ensure the quality and cleanliness of the base has not deteriorated compared to the sounding conducted immediately following the passing Mini-SID.

H. Reinforcing Steel Cage Construction and Placement.

1. Assemble the reinforcing steel cage (consisting of longitudinal and transverse bars, ties, spacers, CSL tubes, and other necessary appurtenances). Place the steel cage immediately after the shaft excavation has been inspected and accepted, and prior to concrete placement.

2. Ensure the reinforcing steel in the shaft is tied at intersections and supported in such a way that the reinforcing steel will remain within allowable tolerances given in this specification. Use concrete spacers or other approved non-corrosive spacing devices at sufficient intervals near the top and bottom, and at intervals not exceeding 10 feet along the shaft, to ensure concentric spacing for the entire cage length. Ensure spacers are:

- Constructed of approved material equal in quality and durability to the concrete specified for the shaft.
- Of adequate dimension to ensure a minimum distance of 3 inches between the cage and the excavated hole.

3. Design and furnish a system to support the reinforcing cage within construction tolerances until the concrete has sufficiently set to support the cage. Details of the support system shall be provided in the drilled shaft installation plan. The reinforcing cage shall not bear on the base of the excavated shaft but shall be within 6 inches of the base. The CSL tubes shall extend to the base of the reinforcing cage.

4. Check the elevation of the top of the steel cage before and after the concrete is placed. If the reinforcing cage is not maintained within the specified tolerances, make necessary corrections to the satisfaction of the Engineer. Do not construct additional shafts until after modifying the reinforcing cage support in a manner satisfactory to the Engineer.

I. Concrete Placement.

1. General.

a. Place shaft concrete within 24 hours of the start of excavation of the rock socket. Place concrete as soon as possible after placing reinforcing steel.

b. Coordinate concrete batching and delivery with the batch plant such that time limits, as stated in the contract documents, between batching and delivery are not exceeded.

c. Place concrete in a continuous manner. Continue concrete placement after the shaft excavation is full until good quality concrete is evident at the top of shaft.

d. Before continuing with column construction, remove a sufficient volume of concrete to ensure elimination of all contaminated concrete at the top of shaft.

e. Place concrete through either a tremie or a concrete pump.

f. Complete placement of the concrete in the shaft within 3 hours. Adjust admixtures, when approved for use, for the conditions encountered on the job so the concrete remains in a workable plastic state throughout the 3 hour placement limit.

2. Concrete Placement by Tremie:

a. For the tremie, comply with the following:

- Constructed so that it is watertight and will readily discharge concrete.
- No more than 12 inches in diameter.
- No aluminum parts in contact with concrete.
- Discharge end of the tremie constructed to prevent water or slurry intrusion and permit the free flow of concrete during placement operations.
- Sufficient mass so that it will rest on the shaft bottom before start of concrete placement.
- Sufficient length to extend to the bottom of the shaft.

b. Maintain the discharge orifice between 5 feet and 10 feet below the surface of the fluid concrete.

c. Support the tremie so that it can be raised to increase the discharge of concrete and lowered to reduce the discharge of concrete.
d. Maintain a continuous flow of concrete. Ensure the concrete in the tremie maintains a positive pressure differential at all times to prevent introduction of air pockets or contaminants into the concrete.

3. Concrete Placement by Pump.
a. Concrete pumps and lines may be used for concrete placement. Use minimum 4 inch diameter pump lines constructed with watertight joints. Do not begin concrete placement until the pump line discharge orifice is at the shaft base elevation.
b. Use a plug or similar device to separate the concrete from the fluid in the hole until pumping begins. Either remove the plug from the excavation or use a plug of a material approved by the Engineer which will not be a detriment to the shaft if not removed.
c. Maintain the discharge orifice between 5 feet and 10 feet below the surface of the fluid concrete. When lifting the pump line during concreting, temporarily reduce the line pressure until the orifice has been repositioned at a higher level in the excavation.
d. Perform the pumping operation in a manner that prevents introduction of air pockets into the concrete. If breaking the pump line is required, temporarily position the discharge orifice 3 feet to 5 feet below the surface of the fluid concrete in the hole. The Contractor may propose additional methods to eliminate introduction of air into the concrete.

J. Crosshole Sonic Logging (CSL) Testing.

1. Coordinate with an independent testing agency to perform CSL testing according to ASTM D 6760. Provide analysis and interpretation on each completed shaft. The agency performing the CSL testing shall have a Professional Engineer licensed in the State of Iowa supervising the testing and interpretation of results. All raw CSL data shall be made available to the Engineer upon request.

2. The procedure in ASTM D 6760 will be followed with the exceptions listed below:
a. Plastic access ducts and drilled boreholes are not allowed.
b. Perform CSL testing after the shaft concrete has cured at least 4 calendar days but no later than 14 calendar days.
c. Grout the access ducts after the Engineer's acceptance of the testing results. Place grout with a pump, starting at the bottom of each access duct.
d. Include the waterfall diagram (which is a nesting of ultrasonic pulses in an ultrasonic profile) in the report.
e. Include the relative energy and FAT data in tabular format for all zones of Class B or C concrete as described below.

3. Furnish and install one access pipe per 1 foot of shaft diameter.

4. Securely attach the access pipes to the interior of the reinforcing cage such that each pipe is spaced as detailed on the plans within the reinforcing cage and extends to within 3 inches of the shaft base. If the rock socket is over excavated, the CSL pipes must be adjusted to extend to within 3 inches of the shaft base.

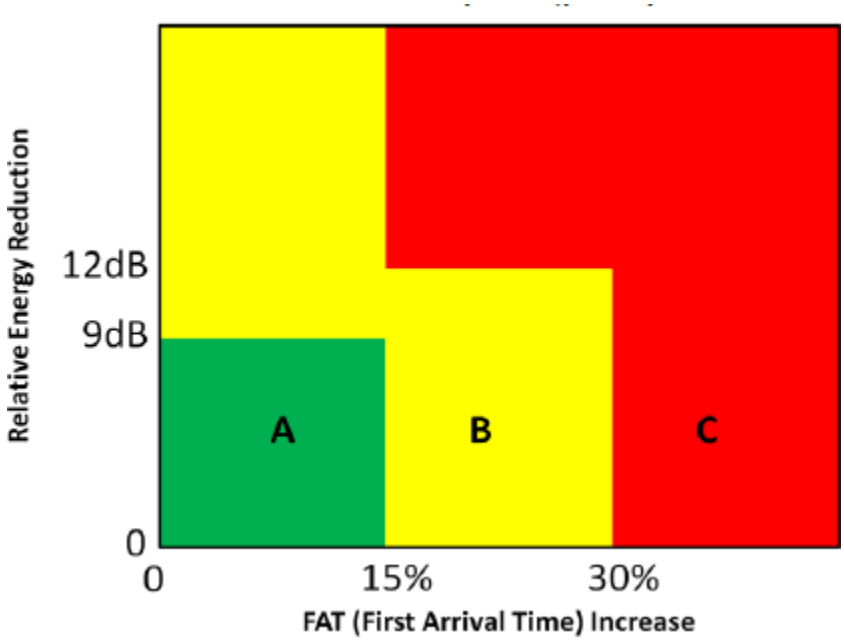
5. Install the access pipes in straight alignment and parallel to the vertical axis of the reinforcing cage. Access pipes shall terminate at the bottom of the reinforcing cage or, for the demonstration shaft, extend to the top plate of the hydraulic jack assembly. Extend the access pipe at least 2 feet above either the top of the continuous concrete placement operation or the top of the shaft. Do not damage the access pipes during the reinforcing steel cage installation.

6. Fill the access pipes with clean water prior to concrete placement. To prevent debris from entering the pipe, reseal each access pipe immediately after water placement. Immediately

prior to CSL testing, the CSL tester shall note and record the level of water in each CSL tube. If water needs to be added to any tube, the volume of water added shall be documented by the CSL tester. Dewater all access tubes and fill with grout after the tests are completed, and the shaft has been accepted by the Engineer. Place grout with a pump, starting at the bottom of each access tube. Use grout meeting the requirements of Article SP-230204.02, C.

7. CSL rating criteria shall be as follows:
- Class A: Acceptable CSL test results.
- Class B: Conditionally acceptable CSL test results.
- Class C: Highly abnormal CSL test results.

Where, the classes are defined in the figure below.



8. Submit the test results, analysis, and interpretation for the shafts to the Engineer within 7 calendar days of testing.

9. All drilled shafts shall include CSL testing.

K. Shaft Integrity Acceptance.

1. The Engineer will:
- **a.** Determine final acceptance of each drilled shaft's integrity, based on the CSL test results and construction records including the shaft drilling log and concrete placement records for the tested shaft, and
- **b.** Provide a response within 7 calendar days after receiving the CSL and construction records submittal.
- **c.** Although not all-inclusive, possible occurrences that may require drilled shaft remediation based on the Engineer's review of all available information include:
  - **1)** CSL anomalies subsequently confirmed to be a defect at the base of the drilled shafts due to possible loss or reduction of available base resistance, which is being relied upon in the design. Likely mitigation may include hydro-demolition or removal of poorly cemented materials, pressure grouting through CSL tubes and core holes with the aid of packers and valves, etc.
  - **2)** CSL anomalies that compromise the available geotechnical side resistance in the

rock sockets, which is being relied upon in the design. Likely mitigation may include hydro-demolition or removal of poorly cemented materials, downhole video camera assessment(s), pressure grouting through core holes with the aid of packers, etc. Other mitigation measures may also be warranted depending on the nature, extent, and location of the anomalous zone.

3) CSL anomalies in zones of high flexural demand. Likely mitigation may include hydro-demolition or removal of poorly cemented materials, downhole video camera assessment(s), pressure grouting through core holes with the aid of packers, etc. Other mitigation measures may also be warranted depending on the nature, extent, and location of the anomalous zone.

4) CSL anomalies subsequently confirmed to be a defect in all other zones of the drilled shafts compromising its structural ability to transfer the necessary load demands. Likely mitigation may include hydro-demolition or removal of poorly cemented materials, pressure grouting through core holes with the aid of packers and valves, etc. Other mitigation measures may also be warranted depending on the nature, extent, and location of the anomalous zone.

2. Further investigation or data analysis may be required of shafts with potential defects or poor-quality concrete.

a. If observations during construction or subsequent testing or analysis (CSL, tomography, coring, etc.) at a drilled shaft indicates the presence of a defect in the drilled shaft, testing costs and delay costs resulting from each of the additional testing methods and required remediation shall be borne by Contractor.

b. If core investigation is required, the location(s) will be specified by the Engineer. To determine if defects are present, coring the concrete using double barrel diamond coring methods producing a minimum 1.75 inch core according to ASTM D 2113, or other approved sampling method may be used. At the sole discretion of the Engineer, if the location of a potential defect exists in a location of high stress in the drilled shaft, cores according to ASTM C 42 shall be performed along with subsequent compressive strength testing on recovered core samples as directed by the Engineer. Keep records, including Percent Core Recovery and Rock Quality Designation, according to ASTM D 2113 and D 6032. Perform unconfined compression tests on samples selected by the Engineer. A formal core log, including photographs, shall be developed and submitted for each core hole drilled. The recovered cores shall be appropriately placed and protected in core boxes. Detailed notes of the coring operation shall be documented, including drilling behavior, water return, rod drops, rate of penetration, etc.

c. If this additional testing indicates the drilled shaft has no defect, testing costs and delay costs resulting from the test which provided acceptable results will be paid by Contracting Authority.

3. Do not proceed with subsequent substructure construction operations until the integrity of all drilled shafts for each individual substructure have been accepted.

4. For all shafts determined to be unacceptable, submit a plan for remedial action, including correction procedures and designs, to the Engineer for approval. Do not begin repair operations until receiving the Engineer's acceptance of the remedial action plan. Corrective action plans must be signed and sealed by a Professional Engineer licensed in the State of Iowa.

L. Demonstration Shaft.

1. Demonstrate equipment and methods, prior to construction of the first production drilled shaft, by installing a non-production drilled shaft. The demonstration shaft shall be installed at the location shown in the plans.

2. The demonstration shaft will be load tested and must meet the requirements of the contract

documents for a load test.

3. Construct the demonstration shaft as shown in the plans. The final selected depth of the demonstration shaft will be based on the Engineer's review of the confirmation boring (Article SP-230204.03, M, 1, a to evaluate the geometry and alignment of the demonstration shaft after final cleanout and prior to reinforcement cage placement. Radial measurements shall be collected on minimum intervals of 2 feet below the permanent casing and 10 feet within the permanent casing.

4. If the demonstration shaft installation demonstrates the equipment and methods used to construct drilled shafts to the requirements of the contract documents are inadequate, the Engineer will require appropriate alterations in equipment or methods, or both, to eliminate the unsatisfactory results. If the Engineer determines the demonstration shaft to be unacceptable, submit a plan for remedial action to the Engineer for approval. The Engineer may require another demonstration shaft with a load test, at no additional expense to the Contracting Authority.

5. Do not begin constructing production drilled shafts until the Engineer approves the methodology, reviews the CSL report, the load test report, and makes any necessary changes to the required rock socket lengths following the test results. The Engineer will complete the methodology and CSL review process within 5 working days of receipt of the complete construction submittal. The Engineer will complete the load test results review process, including changes to the required rock socket lengths, if necessary, within 21 calendar days of the load test report submittal.

M. Load Test.

1. Perform a load cell test (bi-directional load test) on the demonstration shaft. The final selected depth of the demonstration shaft will be based on the Engineer's review of the confirmation boring, and observations made by the Engineer during construction of the demonstration shaft.

a. Confirmation Boring and Sampling.

1) Prior to installation of the demonstration shaft, complete a confirmation boring at the demonstration shaft location (within the footprint of the shaft) to a depth at least 15 feet below the bottom elevation as shown in the contract documents.

2) Core the rock using double barrel diamond coring methods producing a minimum 1.75 inch core according to ASTM D 2113, or other approved sampling method. Keep records, including Percent Core Recovery and Rock Quality Designation, according to ASTM D 2113 and D 6032. Preserve rock samples at their natural moisture content and condition. Transport them to the laboratory for classification by a Professional Engineer licensed in the State of Iowa.

3) Test representative samples of intact rock for unconfined compressive strength according to ASTM D 2938, except record stress and strain according to ASTM D 2166, up to 20% strain or failure, whichever occurs first. Prepare a stress-strain plot. In addition, list the unconfined compressive strength.

4) Perform one unconfined compression test for every 3 feet of rock core, where recovered samples are sufficient for unconfined compression testing. The Engineer will select test samples.

5) Deliver soil samples to the Engineer.

6) Do not install the demonstration shaft until the results of the confirmation boring, in the form of a formal boring log including photographs of the recovered rock core, have been submitted and reviewed and incorporated in the proposed load test program by the Engineer.

7) The Engineer will complete the review of the confirmation boring report within 7 calendar days after submittal of the final load test boring log including all laboratory testing results.

b. Hydraulic Jack Assembly Test (Bi-Directional Load Test).

1) Furnish all materials and labor necessary to conduct a bi-directional load test on the demonstration shaft.

2) The testing specified in the project documents shall be conducted in accordance with ASTM D 1143 – Procedure A, Quick test. The Bi-Directional Static Load Test shall be performed as shown on the plans.

3) Install telltale casings on the reinforcing cage to allow measurement of shaft movement during load cell test.

4) Use the utmost care in handling the rebar cage/test equipment assembly so as not to damage the hydraulic jack assembly and instrumentation during installation.

5) After the CSL tests have been approved and the concrete has reached a minimum required strength of 3500 psi, internally pressurize the hydraulic jack assembly creating an upward force on the shaft and an equal, but downward force. The total load for a given internal pressure shall be calibrated to the hydraulic jack assembly being used. Ensure this is performed prior to shipment of the hydraulic jack assembly to the site. During the period required to perform the bi-directional load test, no casings may be vibrated into place or piles installed within 200 feet of the load test. Concrete strength and elastic modulus will be determined per ASTM C 39 and C 469 on the day of the load cell test.

6) Continue the test until a geotechnical strength limit state as determined by the Engineer is reached or until the appropriately sized hydraulic jack assembly has reached a limit condition.

7) Within 14 calendar days of test completion, submit an electronic copy of the formal report for each test. Provide preliminary field results within 3 days after completion of the test. In the formal report include, at a minimum, the following:

a) Load distributions, side resistance, and base resistance for the various strata instrumented by the strain gages.

b) Summary of drilled shaft's dimensions, elevations, areas, and masses.

c) Boring logs, test data, and other relevant information from the confirmation boring.

d) Log of the Contractor's installation along with actual mapping of the shaft profile.

e) Load movement for base resistance and upward shear.

f) Equivalent top load movement curve.

g) Side resistance creep limit curve.

h) Base resistance creep limit curve.

i) Side resistance load transfer for each shaft segment between strain gages or hydraulic jack assembly.

j) Plots of mobilized side resistance load transfer versus vertical displacement for each shaft segment between strain gages or hydraulic jack assembly.

k) Tables of all test data, including all recorded measurements.

2. Do not begin construction of production shafts until the Engineer reviews and accepts the load test results.

3. The Engineer will complete the load test results review process within 21 calendar days of the load test report submittal.

4. The load test results will be used to evaluate the shaft capacities within the bedrock and to define the final bottom elevation of the production shafts. The final bottom elevation of the production shafts may vary from what is shown on the plans on the basis of the load test results.

5. Once the load test has been completed and the Engineer has accepted it, clean up the demonstration shaft site. Remove the top of the shaft to 3 feet below final ground level and clean the area according to Article 1104.08 of the Standard Specifications.

6. Load Test Firm's Responsibility.

- Prepare shop drawing for the hydraulic jack assembly and all other test apparatus.
- Supply all materials and equipment necessary to perform a load test in accordance with the contract documents.
- Provide on-site engineering/technical staff during demonstration shaft construction to supervise installation of testing equipment, including hydraulic jack assembly and instrumentation.
- Conduct the load test.
- Record and analyze data.
- Prepare load test reports.

7. Only load test firms that are approved prior to letting to furnish bi-directional load testing services shall be allowed.

a. Approved Firms.

- Applied Foundation Testing, Inc.
  2345 Success Drive
  Odessa, FL 33556
  Phone: (727) 376-5040
- GRL Engineers, Inc.
  30725 Aurora Rd.
  Solon, OH 44139
  Phone: (216) 831-6131
- Load Test Consulting, Ltd.
  4203 NW 15th Place
  Gainesville, FL 32605
  Phone: (678) 262-6932
- LoadTest, Inc.
  2631 Northwest 41st Street, Suite D
  Gainesville, Florida 32606
  Phone: (352) 378-3717 or (800) 368-1138

b. Approved Bidirectional Devices.

- AFT-Cell
  2345 Success Drive
  Odessa, FL 33556
  Phone: (727) 376-5040
- GRL-Cell
  30725 Aurora Rd.
  Solon, OH 44139
  Phone: (216) 831-6131
- LTC Jack
  4203 NW 15th Place
  Gainesville, FL 32605
  Phone: (216) 831-6131
- Osterberg Load Cell
  2631 Northwest 41st Street, Suite D
  Gainesville, Florida 32606
  Phone: (352) 378-3717 or (800) 368-1138

230204.04 METHOD OF MEASUREMENT.

A. Concrete Drilled Shaft.
Feet, to the nearest 6 inches, as authorized and constructed. Rock socket length is measured from tip of casing.

B. Reinforcing Steel.
Section 2404 of the Standard Specifications applies.

C. Load Cell Test.
By count, constructed and accepted.

D. Demonstration Shaft
Feet, to the nearest 6 inches, constructed and accepted.

230204.05 BASIS OF PAYMENT.

A. Concrete Drilled Shaft.

1. Per foot.

2. Payment is full compensation for all equipment, labor, and materials (except reinforcing steel) necessary to satisfactorily construct the shafts including:
- Drilling and excavation of shaft and rock socket,
- Slurry,
- Furnishing and installation of permanent casing,
- Shaft inspection,
- Furnishing and placing concrete,
- All CSL pipe and initial testing. Further investigation and remediation of shafts with confirmed defects or poor-quality concrete is also included, and
- Disposal of excavated materials and water, and all other materials.

3. Removal of obstructions during excavation is considered as extra work and payment will be as provided in Article 1109.03, B, of the Standard Specifications.

B. Reinforcing Steel.
Section 2404 of the Standard Specifications applies.

C. Load Test.

1. Each.

2. Payment is full compensation for:
- Installation,
- hydraulic jack assembly,
- Instrumentation with strain gages, telltales, and all other necessary instrumentation,
- Conducting of the test,
- Subsequent removal of test apparatus, appurtenances, grouting cell tubes, and
- Reporting.

D. Demonstration Shaft.

1. Per foot.

2. Payment is full compensation for all equipment, labor, and materials necessary to satisfactorily construct the approved shaft including:
- Confirmation boring,
- Drilling and excavation of drilled shaft and rock socket,
- Furnishing and installation of permanent casing,
- Slurry,
- Furnishing and placing reinforcing bars,
- Furnishing and placing concrete,
- CSL pipe including furnishing, placing, and testing,
- Shaft inspection, and

- Disposal of excavated materials, slurry, water, and all other materials.
- Remove the top of the shaft to 3 feet below final ground level or as required by the USCG and clean the area according to Article 1104.08 of the Standard Specifications.