SP-159003a
(New)

SPECIAL PROVISIONS
FOR
CONCRETE DRILLED SHAFT

Allamakee County
STP-009-9(84)--2C-03

Effective Date
August 1, 2023

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE REPLACED BY THE FOLLOWING SPECIAL PROVISIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

159003a.01 DESCRIPTION.

A. A concrete drilled shaft foundation consists of reinforced concrete placed in a cylindrical hole. The cylindrical hole may or may not include temporary or permanent steel casing at the West Abutment at the discretion of the Contractor but shall include permanent steel casing at Piers 1, 2, and 3. The concrete drilled shafts also include uncased rock sockets. The dimensions of the concrete drilled shafts and rock sockets, along with the presence or lack of 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.

C. The Geotechnical Engineer shall be on-site to observe and in coordination with the Engineer accept the rock socket, base competency, and base cleanliness for every drilled shaft. The Contractor shall provide notice at least 3 days prior to rock socket excavation to allow the Geotechnical Engineer to arrive on-site. The Geotechnical Engineer is:

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159003a.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.
11. The Contractor shall provide the technical assistance of a representative of the slurry additive manufacturer at the site prior to introduction of slurry into the demonstration shaft. The representative shall be present during drilling and completion of the demonstration shaft to adjust the slurry mix to the specific site conditions. If two slurry types are used, one in the

soil overburden and the other in the rock socket, a representative must be present for both operations.

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 159003a.02-1 unless otherwise directed by the slurry representative and approved by the Engineer in writing:

Table 159003a.02-1: Polymer Slurry Requirements

Property	Test Method	Requirements
Density (lb/ft^3)	Slurry Density Materials I.M. 387	62 to 64
Viscosity (sec/quart)	Marsh Funnel and Cup Materials I.M. 387	55 to 135**
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 1.0%. **Viscosity may exceed 135 until immediately prior to placing concrete.		

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. A substantial amount of cleaning and associated polymer slurry volume exchange is anticipated. 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.
Comply with the following

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 8.5 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, except at Piers 1, 2 & 3 a maximum variation of ± 3.5% will be permitted up to an elevation of 611. Above elevation 611 at Piers 1, 2 & 3, the maximum variation in Article 2403.02, B, 3 of the Standard Specifications applies.

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. Limit total mineral admixture substitution rate to 40%. Between October 15 and March 15, do not substitute GGBFS for any portion of Type I, Type II, or Type IL cement; or fly ash for any portion of Type IP, IS, or IT cement.

9. The concrete mix shall be cohesive, stable, able to freely pass through the tremie pipe and the reinforcing cage, and remain sufficiently workable throughout the entire duration of the pour. The proposed concrete mix shall be demonstrated with a trial batch test that is tested, pumped, allowed to sit for the anticipated duration of the longest pour, and re-tested. The Contractor shall submit trial mix documentation that all concrete in the shaft will retain a minimum 4 inch slump for the longest anticipated placement period or 12 hours, whichever is greater. The concrete mix shall be sufficiently resistant to segregation, excessive bleed, and detrimental thixotropic behavior as determined by the Engineer.

10. The fine aggregate shall be natural sand that is not crushed aggregate.

11. The maximum particle size of the coarse aggregate shall not exceed 3/4 inch unless approved in writing by the Engineer.

C. Grout.

Grout mix shall consist of Type I, Type II, or ASTM C595 cement and adequate potable water to produce a neat, pumpable grout. Grout shall be preapproved with a 28-day compressive strength of 5000 psi per at least three tests in accordance with ASTM C39 as it relates to self-consolidating concrete.

D. Permanent Casing

1. Permanent casing shall meet or exceed requirements of ASTM A252 Grade 3. Supply casing of at least the minimum wall thickness shown on the plans. Permanent casing shall be rigid, smooth, clean, watertight, and free of hardened concrete. Casing shall be of ample strength and wall thickness to withstand handling and installation stresses and the pressures of drilling fluid, fluid concrete, and the surrounding earth materials.
2. Used material in like-new condition with no section loss may be used for permanent casing with approval of the Engineer.
3. For out-of-round tolerance of permanent casing before and after installation, the departure of any point on the periphery of the casing from a true circle shall not exceed 1 inch, measured radially.
4. Permanent casing shall be continuous wherever possible or practical. Permanent casing shall be extended to bedrock by twisting or other accepted method to stabilize the shaft excavation against collapse, or excessive deformation, while simultaneously preventing distress to the existing bridge structure. Casing meeting all specified requirements shall be installed to the elevations shown on the plans or as necessary to achieve a hydraulic seal and stable rock socket.

5. The casing may be fabricated with teeth or a cutting edge, and/or thickened sections to reinforce the casing at key locations to facilitate advancement into bedrock. If splices are required, the welding process shall be in accordance with the requirements specified herein. The Contractor shall be fully responsible for the adequacy of welds.

6. Shop welding of casing shall be performed by a fully automated welding process to develop the full capacity of the shell. Inspection of shop welds will be of a visual nature. If evidence indicating poor welding is found, the engineer may require radiographing. Field welded splices of sections of the steel casing shall be made by shielded metal-arc welding procedures performed by a field welder certified in the type of weld being performed. The welds shall be full penetration, watertight, and in accordance with Materials I.M. 558.

E. Temporary Casing

Temporary casing is not required but may be used at the West Abutment. Telescoping sections of successively smaller diameter temporary casing is not permitted. Temporary casing shall be steel; rigid, smooth, clean, watertight, and of ample strength to withstand handling and installation stresses and the stresses it will be subjected to during drilled shaft construction. Selection of length, wall thickness, and grade of temporary casing are at the discretion of the Contractor, as needed to provide a stable excavation. Temporary casing shall produce a shaft of the diameter shown on the plans or slightly larger, subject to acceptance by the Engineer.

F. Starter Casing

Non-permanent starter casing is not required but may be used to facilitate installation of permanent casing. Starter casing, while also temporary, differs from temporary casing in that it does not come into contact with fluid concrete during concrete placement. Starter casing shall be rigid, smooth, clean, watertight, and of ample strength to withstand handling and installation stresses and the stresses it will be subjected to during drilled shaft construction. Selection of length, wall thickness, and grade of starter casing are at the discretion of the Contractor, as needed to produce a stable excavation and a stable working template or platform.

G. Reinforcing Steel

Deformed reinforcing bars shall comply with the size, dimension, spacing, yield strength, and details shown on the plans. Deformed reinforcing shall conform to AASHTO M31, Grade 60 or Grade 80, and all the pertinent requirements of Section 4151 of the Standard Specifications.

H. Crosshole Sonic Logging (CSL) Tubes

Access tubes for CSL testing shall be 2 inches inside diameter (I.D.) schedule 40 steel pipe conforming to ASTM A53, Grade A or B, Type E, F, or S. Pipes shall have a round, regular I.D., free of defects or obstructions; including any defect at the pipe joints, to permit the free unobstructed passage of source and receiver probes. The joints shall be watertight. Each tube or steel pipe shall be fitted with a watertight shoe on the bottom and a removable cap at the top. Both shoe and cap shall be watertight and free from corrosion, and the internal and external faces of the tubes clean to ensure passage of the probes and good bond with the concrete. The watertight shoe at the bottom of the steel pipe shall, if necessary following drilled shaft construction and subsequent testing, be of a material that can be breached from the top of drilled shaft for subsequent repairs if warranted.

I. Thermal Integrity Profiler (TIP) Cables

TIP cables shall include temperature sensors (thermal nodes) on a 12 inch spacing. Thermal Wire® brand cables are an acceptable product. Follow the manufacture's installation recommendations. The cables shall be tied to the reinforcement with nylon zip-ties 1.5 to 2 inches from the top and bottom of each thermal node with two zip-ties securing the bottom node. The cables shall be aligned parallel with the longitudinal reinforcement of the shaft. Locate the cables on the sides of longitudinal bars (not on the inside or outside of the cage) to avoid damage during cage and concrete placement. If the cable is routed with a bend at any location, extra precautions on securing the cable with zip-ties on either side of each such bend must be taken.

Each cable shall be attached to a data logger capable of recording measurements every 15 minutes for at least 96 hours. The data logger should be suspended on a protruding rebar or otherwise suspended well above the top of the concrete.

159003a.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 feet at Piers 2 and 3 and 1/4 inch per 2 feet at the West Abutment and Pier 1. The verticality of the permanent steel casings at Piers 1, 2, and 3 shall be monitored during installation and their final alignment shall be measured and documented.

3. Set full depth reinforcing steel cages within 3 inches of the base of the excavated shaft prior to concrete placement. The CSL tubes shall extend to the bottom of the reinforcing cage.

4. Ensure that, after all the concrete is placed, the top of the reinforcing steel cage is no more than 2 inches above and no more than 2 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. Non-planar surfaces in competent bedrock may be acceptable based on the judgment of the Engineer.

B. Drilling and Excavation Equipment
Drilling equipment used to perform the drilled shaft work on this project must have the capability of providing sufficient torque and down-thrust for drilling and excavating shafts that are 20% greater in diameter than the largest shaft diameter and at least 25 feet deeper than the deepest shaft required for this project, for the geologic strata described in the project documents and project geotechnical information.

C. Pre-Construction Conference, Pre-qualifications, and Drilled Shaft Installation Plan

1. A pre-construction conference, in which the Contracting Authority, Engineer, Geotechnical Engineer, Contractor, and drilling staff discuss the anticipated drilled shaft construction process, will be required for this work prior to the start of demonstration shaft construction activities.

2. No later than 1 month prior to the pre-construction conference, 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 by the Contractor or Sub-Contractor responsible for the drilled shaft construction. 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 site, all the subsurface information made available in the contract documents and project geotechnical reports, the foundation drawings, and this Concrete Drilled Shaft special provision. The Contractor shall identify key personnel including: on-site supervisor, crew chiefs, and drill rig operators. The Contractor must submit the following key personnel experience records of the individuals assigned to the project. Do not use consultants or manufacturer's representatives to meet the requirements of this section.

- On-site supervisor - Assign an individual to supervise the work and serve as the Contractor's main contact on site who has at least 5 years of drilled shaft experience, at least 1 year of which is as an employee of the Contractor in good standing, and who has supervised at least three drilled shaft projects of similar scope and conditions.
- Crew chiefs and drill operators - Assign crew chiefs and drill operators who have at least 5 years of drilled shaft experience using equipment similar to the equipment proposed for this project, at least 1 year of which is as an employee of the Contractor in good standing. Include at least three projects completed using similar equipment.

Experience documentation for each project must include: a brief project description, dimensions of the shafts, construction methods used during installation, make and model of the drill rig used, methods used for hole stabilization, local subsurface conditions, and reference contacts consisting of an individual's name and current phone number. Contacts must be capable of verifying the individual's participation and performance.

3. No later than 1 month prior to the pre-construction conference, submit a drilled shaft installation plan for review and acceptance by the Engineer. For purposes of planning, the Contractor shall anticipate review comments by the Engineer and revision(s) to the installation plan. The expectation of installation plan revision(s) shall not relieve the Contractor from submission of a complete installation plan on their first attempt, in accordance with contract provisions, the installation plan shall provide the following information at a minimum:

a. Name and experience record of firms and associated personnel for the following:
  1) Confirmation boring.
  2) Crosshole sonic logging (CSL).
  3) Thermal Integrity Profiling (TIP).
  4) Name of load cell testing firm.
  5) Any other sub-contracted 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 drill rig, crane, reinforcing cage, and concrete access to each drilled shaft location. Specifically, whether by barge, temporary causeway, temporary work trestle, etc.

d. Details on how the temporary or starter casing, if used, or permanent casing will be supported and prevented from settling.

e. Details on a template or other means to adequately position and align the drilled shafts, and how the template will be supported.

f. Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.

g. Details of shaft excavation methods.

h. Details of casing and forms, including installation and removal.

i. 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.

j. 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.

k. Details of the slurry exchange process, if necessary.

l. Details of reinforcement picking and placement, including support and cage centering methods. The cage shall not rest on the bottom of the excavation. Note that a cage lift plan stamped by a licensed Professional Engineer registered in the State of Iowa must be submitted and accepted by the Engineer prior to lifting the cage. The cage lift plan may be submitted as part of or separately from the drilled shaft installation plan.

m. 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.

n. Details of concrete delivery and placement including procedures for tremie or pumping methods and methods to prevent slurry intrusion at the discharge end.

o. Concrete mix proposal.

p. Details of methods to control, handle and dispose of cuttings, water, slurry, and so forth.

q. Details of CSL testing, including location and attachment methods of the steel access pipes and bottom shoe material and installation.

r. Details of TIP testing, including location and attachment methods of the TIP cables and data loggers.

s. Include details of the test equipment used in the load cell test, and description of the load test procedures and program according to Article 159003a.03, N, 1, b.

t. Details of concrete finishing at the top of the shaft to remove contaminated concrete and verifying concrete uniformity for site specific conditions.

u. Include details on permanent, starter, and temporary casing to be used, including:

- Specific length/depth of all casing proposed, along with locations and details of stiffeners, if used, details of cutting teeth, if used, etc.
- Specific means and method to install the casing(s), 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.
- Specific means and methods on how temporary casings, if used, will be removed and when.

v. Include details on how the following will be addressed:

- River forecasting including maximum flow and flood stage limits necessitating stoppage of drilled shaft construction.
- Cold weather procedures including slurry and concrete handling.

w. Include detailed contingency plans for the following situations:

- Excavation instability,
- Movement of the existing bridge beyond the limits specified in the tilt and per Special Provision Vibration Monitoring to Protect Historic Structures,
- An interruption in concrete delivery, and
- A breach of the concrete discharge orifice from the fluid concrete.

4. The Engineer will evaluate the drilled shaft installation plan for conformance with the contract documents and intent of the design. 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. Acceptance of the Installation Plan does not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the contract documents and as demonstrated by the successful and acceptable completion of the demonstration shaft, as judged by the Engineer.

D. 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 159003a.03, D, 1, at no additional cost to the Contracting Authority.

E. Shaft Excavation.

1. General.

a. Construct drilled shafts at Piers 1, 2, and 3 by the wet and casing methods as necessary to produce sound, durable concrete foundation shafts free of defects. These methods are described below. Drilled shafts at the West Abutment may be constructed by the dry method if the rate of water infiltration is less than 1 ft per hour and there is less than 3 inches of water at the commencement of the concrete placement, otherwise, the wet and casing methods shall be used.

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, 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, include comprehensive information such as elevation, depth of penetration, tooling, drilling time in each of the strata, material description(s), and remarks. Furnish an electronic copy to the Engineer with the CSL and TIP results.

e. After the shaft excavation has been completed, immediately proceed with shaft clean-out, slurry cleaning, reinforcing cage placement, and concrete placement.

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.

2. Wet Method.

a. The wet method consists of:

- At all times, including during tool removal and over periods of no work such as overnight, weekends, holidays, etc., keeping the shaft filled with slurry a minimum of 4 feet above the highest water table encountered, including any artesian conditions encountered, throughout excavation, cleaning, slurry exchange, cage placement, and concrete placement,
- Desanding and cleaning of the slurry when required,
- Final cleaning of the excavation and slurry by means of an airlift or other similar device as approved by the Engineer, and
- Placing shaft concrete from the bottom up by tremie or pump.

b. The wet method utilizing starter casing and mineral, or polymer slurry may be used to install permanent casing.

c. The wet method using polymer slurry is required for rock socket excavation at Piers 1, 2, and 3 for this project.

d. Installation of driven piles at Pier 4 may not occur while slurry supported excavations are open at Pier 3.

3. Dry Method.

a. The dry method consists of:

- Drilling the shaft excavation,

- Removing accumulated water and loose material from the excavation,
- Visual inspection of base cleanliness,
- Placing the reinforcing cage, and
- Concreting the shaft in a dry excavation as defined below.

b. Use the dry method only at sites where:
- The ground water level and soil and rock conditions are suitable to permit construction of the shaft in a dry excavation, and
- The Engineer can visually inspect the sides and bottom of the shaft prior to placing the concrete.

c. The Engineer will approve the dry method only if the shaft excavation demonstrates:
- Less than 12 inches of water accumulates above the base over a 1 hour period when no pumping is permitted,
- The sides and bottom of the hole remain stable without detrimental caving, sloughing, or swelling between completion of excavation and concrete placement, and
- All loose material and water can be satisfactorily removed prior to inspection and concrete placement (less than 3 inches of water will be permitted in the bottom of the shaft excavation at the time of concrete placement).

d. Use the wet or casing method for shafts that do not meet the dry method requirements.

4. Casing Method.

a. The casing method is used to advance the hole through unstable soil material. Over-reaming to a diameter of up to 1 inch greater than outside diameter of permanent casing under slurry is allowed if necessary to advance the casing.

b. Permanent casing installed to bedrock is required at locations shown on the plans for structural purposes.

c. A single oversized starter casing may be used in combination with the wet method using slurry to install permanent casing. If used, the Contractor shall determine the appropriate depth to terminate the starter casing to ensure the stability of the shaft, template or work platform, existing bridge, and permanent casing. In addition to being relied upon in the structural design at Piers 1, 2, and 3, the purpose of the permanent casing is to stabilize the shaft walls during rock socket drilling and to prevent cave-ins as the result of potential vibrations.

d. At all times during excavation, cleaning, cage placement, and concrete placement, keep the shaft filled with drilling fluid a minimum of 4 feet above the highest water table encountered.

e. Maintain a minimum 10 foot soil plug within the casing or replace water with slurry in the excavation.

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. For drilled shafts constructed in the dry, the Engineer will visually verify the cleanliness of the base and suitability of the socket.

3. 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. Visual inspection is permitted in lieu of Mini-SID inspection for drilled shafts constructed in the dry.

H. Reinforcing Steel Cage Construction and Placement.

1. Assemble the reinforcing steel cage (consisting of longitudinal and transverse bars, ties, cage stiffener bars, spacers, cage centering devices, CSL tubes, TIP cables, and other necessary appurtenances). Place the steel cage immediately after the shaft excavation has been inspected and accepted, and prior to concrete placement. If the Engineer approves, the reinforcing steel cage may be placed as two approximately equal units joined together in the shaft excavation. Specific details of the cage construction, transportation, picking, placement, and splicing, if necessary, shall be provided in the Installation Plan. A cage lift plan must be stamped by a licensed Professional Engineer registered in the State of Iowa and accepted by the Engineer prior to lifting the cage. The Engineer will review the lift plan within 7 calendar days of receipt of the lift plan.

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. The reinforcing steel cage shall have sufficient rigidity to prevent racking or permanent deformations during delivery and placement. During picking, the reinforcing cage shall not be allowed to bend or rack. Temporary or permanent deformation of the reinforcing cage resulting from picking and standing the cage vertical will be grounds for rejection of the reinforcing cage at the sole discretion of the Engineer. 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, and to ensure the cage is in the center of the drilled shaft.
   - Of sufficient strength and stiffness to remain intact during reinforcing cage placement.

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 3 inches of the base. The CSL tubes and TIP cables 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. At Piers 1, 2, and 3, place concrete within 8 days of starting the rock socket excavation unless otherwise approved by the Engineer on a case-by-case basis. This 8 day duration shall be demonstrated during construction of the demonstration shaft and the ensuing load test, which may require the demonstration shaft to remain open longer than necessary. At the West Abutment, place concrete within 24 hours of starting the rock socket excavation unless otherwise approved by the Engineer.

b. Place shaft concrete prior to deterioration of shaft base or rock socket conditions, as soon as possible after placement of reinforcing steel, not to exceed 72 hours after satisfactory excavation inspection. The Contractor shall be responsible for maintaining acceptable shaft base and rock socket conditions through the time of concrete placement. This 72 hour duration shall be demonstrated during construction of the demonstration shaft and the ensuing load test, which may require the demonstration shaft to remain open longer than necessary.

c. 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.

d. Place concrete in a continuous manner.

e. Before continuing with column construction, remove a sufficient volume of concrete to ensure elimination of all contaminated concrete at the top of shaft in accordance with Article 159003a.03, I, 4. Also wait for shaft acceptance by the Engineer upon review of the drilled shaft construction log, CSL results, TIP results, and other pertinent information

f. For drilled shafts constructed in the wet, place concrete by either tremie or concrete pump.

g. For drilled shafts constructed in the dry, concrete may be placed by the free-fall method. Concrete shall be directed down the center of the shaft and shall not come into contact with the reinforcing cage.

h. Adjust admixtures, when approved for use, for the conditions encountered on the job so the concrete remains in a workable plastic state throughout the concrete placement.

i. Fluid concrete shall meet the workability and performance requirements of Article 159003a.02, B, 9.

j. For drilled shafts constructed in the wet, grout shall be used to initiate the concrete placement. The volume of grout placed shall be:

Table 159003a.03-1: Grout Volume Requirements

Shaft Diameter (feet)	Grout Volume (CY)
6.0	3
9.0	6
11.5	10

k. When used for drilled shafts constructed in the wet, the tremie or the pump discharge shall be positioned as close as practical to the shaft base at the commencement of the grout placement.

l. The top of the fluid concrete plus the slurry above the fluid concrete shall always exceed the level of the highest adjacent groundwater encountered during construction of the drilled shaft from the time concrete placement begins until the concrete has achieved a compressive strength of at least 2,000 psi.

m. The Contactor shall maintain records of the concrete placement including:
- Record truck arrival times.
- Record start and finish times for placement of each load/truck.
- Record start and end times for any pauses in placement.
- Record concrete quantity per load/truck
- Measure and record depth/elevation of top of concrete after each load/truck.
- Plot concrete volume curve during concrete.
- Verify placement is continuous.
- Monitor for breaching of tremie and record tremie embedment.
- Record any unusual events.
- Record ambient temperature during placement.

Furnish an electronic copy of the concrete placement records to the Engineer with the CSL results, TIP results, and other drilled shaft construction documentation.

2. Concrete Placement by Tremie:

a. For the tremie, comply with the following:
- Constructed so that it is watertight and will readily discharge concrete.
- At least 10 inches in diameter and no greater than 12 inches.
- No aluminum parts in contact with concrete.
- Use a plug or similar device to separate the concrete from the fluid in the hole until concrete placement 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.
- 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. Initiate concrete placement with the tremie positioned as close as practical to the shaft base. Maintain the tremie at the base of the shaft until a minimum 10 feet of fluid concrete has been placed, then maintain the discharge orifice between 10 feet and 25 feet below the surface of the fluid concrete. Breach of the tremie seal during the pour will be basis for rejection of the drilled shaft, and the Contractor shall develop a mitigation plan for review and approval by the Engineer.

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. Initiate concrete placement with the pump positioned as close as practical to the shaft base. Maintain the pump at the base of the shaft until a minimum 10 feet of fluid concrete has been placed, then maintain the discharge orifice between 10 feet and 25 feet below the surface of the fluid concrete. Breach of the pump seal during the pour will be basis for rejection of the drilled shaft, and the Contractor shall develop a mitigation plan for review and approval by the Engineer.

c. 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.

d. Maintain the discharge orifice between 10 feet and 25 feet below the surface of the fluid concrete. Breach of the discharge orifice seal during the pour will be basis for rejection of

the drilled shaft, and the Contractor shall develop a mitigation plan for review and approval by the Engineer.

e. Perform the pumping operation in a manner that prevents introduction of air pockets into the concrete.

4. Concrete Finishing.

a. The finished top of shaft shall be free of laitance, debris, and defective concrete.

b. The method for removing laitance, debris, and defective concrete at the top of the drilled shaft at the completion of the pour shall be specifically detailed in the installation plan subject to the Engineer's review and acceptance.

c. Maintain a positive fluid head relative to the highest ground water condition of at least 4 feet until concrete has achieved a compressive strength of at least 2,000 psi, unless otherwise approved by the Engineer in writing.

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 licensed Professional Engineer registered 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, with a maximum of eight tubes for shafts larger than 8 feet in diameter.

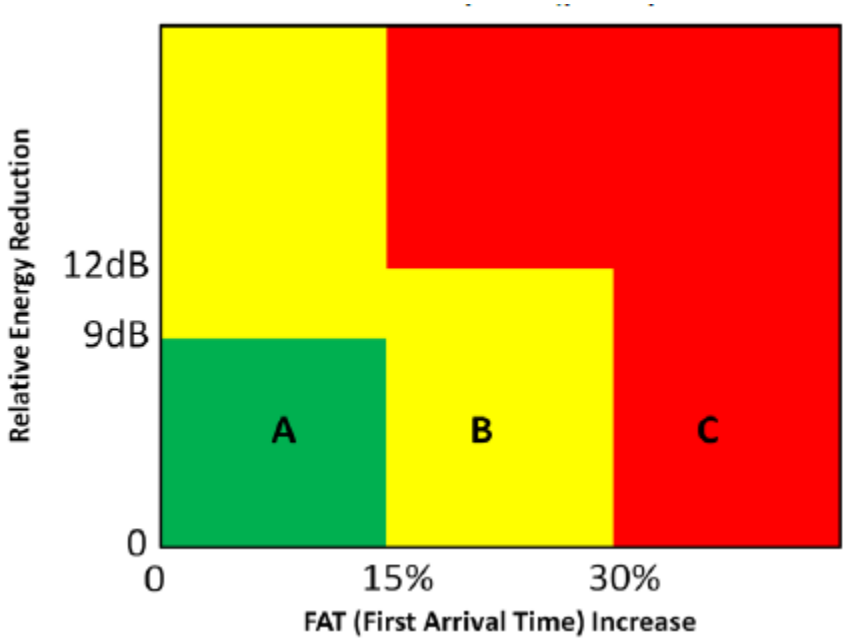
4. Securely attach the access pipes to the interior of the reinforcing cage such that each pipe is spaced as detailed on the plans within the reinforcing cage and extends to within 3 inches of the shaft base. If the rock socket is over excavated, the CSL pipes must be adjusted to extend to within 3 inches 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 159003a.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. Thermal Integrity Profiling (TIP) Testing.

1. Coordinate with an independent testing agency to perform TIP testing according to ASTM D 7949 Method B. Provide analysis and interpretation on each completed shaft. The agency performing the TIP testing shall have a licensed Professional Engineer registered in the State of Iowa supervising the testing and interpretation of results. All raw TIP data shall be made available to the Engineer upon request.

2. Furnish and install one TIP cable per 1 foot of shaft diameter, with a maximum of eight cables for shafts larger than 8 feet in diameter. The bottom most node shall be placed within 1 inch of the bottom of the reinforcing cage. After installation of the reinforcing cage, all TIP wires shall be verified to be functional and documented as such. Any TIP wires found to be non-functioning shall be replaced.

3. The data collection system shall be setup to automatically collect and record temperature along the length of the drilled shaft at 15 minute intervals. Collect temperature data for a duration of time sufficient to reach and record the peak heat of hydration temperature, but for a minimum of 24 hours or longer as recommended by the TIP testing agency.

4. Within 7 calendar days of completion of TIP testing, submit a TIP Testing Report for each drilled shaft tested to the Engineer. At a minimum the TIP testing reports must include:
   - Graphical displays of temperature measurements in each thermal wire versus depth at peak temperature.

- Graphical displays of temperature measurements in each thermal wire versus depth at approximately the median temperature between placement temperature and peak temperature.
- Indication of unusual temperatures, particularly significantly cooler local deviations of the average at any depth from the overall average.
- Graphical displays of temperature in each thermal wire versus elapsed time after completion of concrete placement for each depth with unusual temperatures and for the depth where the greatest average temperature was observed.
- The overall average temperature at peak temperature.
- A depiction of interpreted shaft radius vs. depth including the concrete cover at peak temperature.
- Variations in temperature between wires (at each depth) should be noted.
- The cage alignment or offset from center should be noted.
- Shaft specific construction information (e.g. elevations of the top of shaft, bottom of casing, bottom of shaft, etc.), should be noted on all pertinent graphical displays.
- Conclusions or recommendations concerning the acceptability of the drilled shaft based on the interpretation of the TIP testing results obtained.

5. All drilled shafts shall include TIP testing.

L. Shaft Integrity Acceptance.

1. The Engineer will:
- **a.** Determine final acceptance of each drilled shaft's integrity, based on the CSL test results, TIP 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, TIP, and construction records submittal.
- **c.** The CSL and TIP are complimentary test methods. The intent is for the Engineer to use one test method to demonstrate that anomalies from the other test are false positives, rather than treating all anomalies from both tests as assumed flaws.
- **d.** 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 and/or TIP 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 and/or TIP 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, TIP, 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 licensed Professional Engineer registered in the State of Iowa.

M. 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 near Pier 3 at a location the Engineer determines or accepts. Construction of the demonstration shaft rock socket shall approach the time duration limits specified in Article 159003a.03, I, 1, a, and Article 159003a.03, I, 1, b.

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 159003a.03, N, 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, TIP 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 and TIP 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.

N. 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 20 feet below the bottom elevation as shown in the contract documents.

2) Perform standard penetration tests according to ASTM D 1586 in the soil overlying bedrock. Perform the tests on 5 foot centers.

3) Determine moisture contents on the soil samples. Continue soil sampling and testing with split barrel (spoon) sampling, according to ASTM D 1586, until the top of bedrock is encountered.

4) 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.

5) 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.

6) 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.

7) Deliver soil samples to the Engineer.

8) 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.

9) 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 and TIP 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 or as required by the United States Coast Guard (USCG) 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.

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
Fax: (216) 831-0916

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
Fax: 352-378-3934

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
Fax: (216) 831-0916

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
Fax: 352-378-3934

159003a.04 METHOD OF MEASUREMENT.
Measurement will be as follows:

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

B. Permanent Casing.
Feet, to the nearest 6 inches, where required by the plans, as authorized and constructed. Where not required by the plans, permanent casing used at the Contractor's option, if used, will be considered incidental to the drilled shaft construction.

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

D. Load Test.
By count, constructed and accepted.

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

159003a.05 BASIS OF PAYMENT.
Payment will be the contract unit price as follows:

A. Concrete Drilled Shaft.

1. Per foot.

2. Payment is full compensation for all equipment, labor, and materials (except reinforcing steel and permanent casing) necessary to satisfactorily construct the shafts including:
- Drilling and excavation of shaft and rock socket,
- Slurry,
- Installation and removal of temporary or starter 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,
- All TIP cables and initial testing. Further investigation and remediation of shafts with proven 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.

If a suspected obstruction is encountered, the Contractor shall notify the Engineer immediately. Obstructions are defined as an impenetrable objects that a) cannot be removed or excavated with augers fitted with soil or rock teeth, drilling buckets and/or underreaming tools and b) cause a significant decrease in the rate of excavation advancement, relative to the rate of advancement for the rest of the shaft excavation with the particular strata that the obstruction is located in. The Engineer will be the sole judge of the significance of any reduced rate of shaft advancement and shall be present to evaluate the occurrence of the obstructions. Subsurface obstructions at drilled shaft locations shall be removed by the

Contractor. Such obstructions may include man-made materials such as old concrete foundations and natural materials such as boulders. The Contractor shall employ special procedures or tools which may include but are not limited to: chisels, boulder breakers, core barrels, air tools, hand excavation, temporary casings, and increasing the hole diameter. Blasting will not be permitted.

Tools and equipment lost in the excavation will not be considered obstructions and shall be promptly removed by the Contractor. All work required to remove lost tools or equipment, including but not limited to repair of hole degradation due to removal operations, will be noncompensable and any effect on time of performance nonexcusable.

B. Permanent Casing.

1. Per foot.

2. Payment is full compensation for all equipment, labor, and materials necessary to satisfactorily install permanent casing.

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

D. 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.

E. 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,
- Installation and removal of temporary or starter casing,
- Slurry,
- Sonar geometry and alignment testing,
- Furnishing and placing reinforcing bars,
- Furnishing and placing concrete,
- CSL pipe including furnishing, placing, and testing,
- TIP cables 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.