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## Supplemental Technical Specification for

# Bi-Directional Static Load Testing of Drilled Shafts

SCDOT Designation: SC-M-712 (01/18)

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### 1.0 GENERAL

This work shall consist of furnishing all materials, equipment, labor, and incidentals necessary for conducting bi-directional static load testing of 1 drilled shaft. In addition, the load-deflection and soil-load transfer relationships shall also be determined. Production drilled shaft lengths may be adjusted after results of the test drilled shaft have been analyzed. No materials shall be ordered until drilled shaft lengths are approved by the Department. The test shaft depth, diameter, and location shall be as specified in the plans. The testing specified in the project documents shall be conducted in general accordance with ASTM D1143 - *Standard Test Method for Piles Under Static Axial Load*. The Bi-Directional Static Load Test shall be performed as shown on the plans.

The Bi-Directional Static Load Test cell equipment shall have sufficient capacity to fully mobilize the test drilled shafts' nominal capacity. The applied load shall at least be equivalent to the test drilled shaft load specified in the plans.

The location of the test drilled shaft (non-production) shall be as indicated in the plans. The test drilled shaft shall maintain a minimum distance of 25 feet from any foundation element of any future bent. The Contractor shall submit the proposed location to the Department for approval.

Load testing of the test drilled shaft shall not begin until the concrete has attained a compressive strength ( $f'_c$ ) as indicated in the plans and had a curing time of no less than 7 days. High early strength concrete may be used to obtain the required strength at an earlier time to prevent testing delays, upon the approval of the Department.

The Bi-Directional Static Load Testing shall be performed using the number of load cells and at the locations indicated in the plans. The Contractor will be required to furnish and include all costs in the bid item for all materials, personnel, and equipment as described in the plans, this Supplemental Technical Specification, the Special Provisions and as required by the contract to adequately perform Bi-Directional Static Load Testing of Drilled Shafts. The Contractor shall engage the services of an approved Bi-Directional Static Load Test supplier for instrumenting, performing, and reporting of the Bi-Directional Static Load Test. The Contractor may contact the Engineer for names of Bi-Directional Static Load Test suppliers. The drilled shaft used for the load test program will be instrumented by the Bi-Directional Static Load Test device supplier. The Contractor shall subcontract with the Bi-Direction Static Load Test manufacturer to supply the load test cells and other necessary equipment and instrumentation, perform the test, and analyze the results of the Bi-Directional Static Load Test.

The Contractor shall submit to the Department for approval 3 sets of shop drawings, erection plans, test calculations and details associated with the axial bi-directional static load testing within 21 days following the Notice to Proceed. The submittal shall include details with respect to the reinforcement cage fabrication, instrumentation plans, reference beams and movement measuring systems. All details, drawings, calculations, and procedures shall be submitted to the Department for review a minimum of 21 days prior to beginning the axial Bi-Directional Static Load Test. Approval of this submittal by the Department shall not relieve the Contractor from making subsequent changes that may become necessary to carry out the test.

The Contractor, in cooperation with the selected Bi-Directional Static Load Test supplier, shall supply and supervise the mobilization, assembly, and operation of the Bi-Directional Static Load Test equipment. The of Bi-Directional Static Load Test supplier shall provide and install the required

instrumentation for the test drilled shaft, acquire the test data during testing, and reduce the data into a report. This report shall be presented to the Contractor and the Department for evaluation. Interpretation of the test data with regard to foundation recommendations will be performed by the Department.

## **2.0 MATERIALS & EQUIPMENT**

The Contractor shall supply all materials required to install the Bi-Directional Static Load Test device, conduct the load test, and remove the load test apparatus as required. The Contractor shall furnish the number of Bi-Directional Static Load Test assemblies as required in the plans for the test drilled shaft. The Bi-Directional Static Load Test assemblies to be provided shall have a capacity that fully mobilizes the test drilled shafts' nominal capacity and shall be equipped with all necessary hydraulic lines, fittings, pressure source, pressure gage and telltale devices.

Additional materials required include, but are not limited to, the following:

1. Fresh, clean, potable water from an approved source to be used as hydraulic fluid to pressurize the bi-directional static load test devices.
2. Materials sufficient to construct and shade a stable reference beam system for monitoring movements of the drilled shaft during testing. The system shall be supported at a minimum distance of 3 shaft diameters from the center of the test drilled shaft to minimize disturbance of the reference system. A tripod shall be provided to support an automated digital survey level used to monitor movement of the reference system during testing. Alternatively, 2 survey levels located in excess of 3 shaft diameters may be used to monitor the top of drilled shaft displacement in lieu of the beam. In this case, 2 tripods and weather protection (Quikshade or equivalent) shall be provided.
3. Materials sufficient to construct a protected work area (including provisions such as a tent or shed for protection from inclement weather for the load test equipment and personnel) of size and type required by the Engineer and the Bi-Directional Static Load Test supplier. In the case of cold weather, the protected work area shall be maintained at a temperature above 40° F in order to insure proper operation of the load testing equipment.
4. Stable electric power source, as required for lights, welding, instruments, etc.
5. Materials such as angle or channel iron, steel bearing plates and/or other devices needed to attach the bi-directional static load test assembly to rebar cage or carrying frame, as required.

Materials supplied which do not become a part of the finished structure become the property of the Contractor at the conclusion of the load test and shall be removed from the job site.

The Contractor shall supply equipment required to install the Bi-Directional Static Load Test devices, conduct the load tests, and remove the load test apparatus as required. Equipment required includes but is not limited to:

1. Welding equipment and certified welding personnel, as required, to assemble the test equipment under the supervision of the Bi-Directional Static Load Test supplier and to attach hydraulic fittings and telltales to the Bi-Directional Static Load Test devices, and prepare the work area.
2. Equipment and labor to construct the reinforcing steel cage and/or placement frame required for the test drilled shaft, including steel bearing plates as required.
3. Equipment and operators for handling the Bi-Directional Static Load Test device and instrumentation and placement frame or reinforcing steel cage during the installation of the Bi-Directional Static Load Test device and during the conduct of the test, including but not limited to a crane or other lifting device for Bi-Directional Static Load Test device and instrumentation,

manual labor, and hand tools as required by Bi-Directional Static Load Test supplier.

4. Equipment and labor sufficient to erect the protected work area and monitoring reference beam system, to be constructed to the requirements of the Engineer and Bi-Directional Static Load Test supplier.
5. Air compressor (minimum 150 cfm) for pump operation during load testing.
6. Strain Gauges – the Contractor shall supply the number of strain gauges as required at each level. The number of strain gauges will be determined as shown in the plans. All cost for supplying strain gauges will be included in the price bid for Bi-Directional Static Load Testing of Drilled Shafts, and no additional payment will be made for this equipment.

### **3.0 PREPARATION FOR TESTING**

The Contractor shall perform site and foundation preparation. Foundation preparation includes the cutting and cleaning of the surface of the test drilled shaft down to test elevation. The top of the test drilled shaft shall be smooth and level. The area around the test drilled shaft, on land, shall be leveled and compacted within a 15-foot radius. The top of the drilled shaft should be approximately 1-1/2 diameters above grade for axial testing. For over water or elevated work areas, the area provided shall be level and at the test elevation. The support falsework platform shall be assembled and installed by the Contractor at the test location.

Prior to performing the load test, the Testing Engineer shall be provided with soil boring logs, test shaft installation records, concrete properties (strength, etc.) and details regarding the anticipated dynamic loading equipment. If either the High Strain Dynamic or Rapid Load Tests become necessary after the construction letting, then the Contractor shall provide notice of this requirement to the Department at least 45 days in advance of the test. The Testing Engineer is required to perform wave equation analyses (using GRLWEAP or equivalent) to determine the suitability of the proposed dynamic load testing equipment and an acceptable range of drop weight heights so as not to cause damage in the test shaft during the test.

For the test drilled shaft, proposed instrumentation location shall be provided to the Department a minimum of 7 days prior to the fabrication of the drilled shaft reinforcement cage. The Department will provide comments for the final instrumentation locations within 3 days after receiving this information.

Strain and pressure gage instrumentation, displacement transducers, CSL access tubes, Bi-Directional Static Load Test devices and any other materials and equipment required by Bi-Directional Static Load Test supplier shall be installed on the reinforcing cage.

Immediately prior to placement of the reinforcement cage, the dimensions and verticality of the drilled shaft excavation shall be determined by Bi-Directional Static Load Test supplier using a method approved by the Engineer.

CSL testing will be performed by the Department personnel or a Department designated representative in accordance with Section 727 of the Standard Specifications.

The axial Bi-Directional Static Load Test shall not begin until at least 4 days after CSL testing and until the concrete has attained the compressive strength ( $f'_c$ ) as indicated in the plans.

The Contractor shall cooperate with the Department's personnel whom shall be granted access to all facilities necessary for observation of the test and the viewing of the test results.

The Contractor shall perform the test drilled shaft excavation in accordance with Section 712 of the Standard Specifications.

The Bi-Directional Static Load Test cells, hydraulic supply lines and other instruments will be

assembled and made ready for installation under the direction of Bi-Directional Static Load Test supplier and the Department, in a suitable area, adjacent to the test shaft, to be provided by the Contractor. The Bi-Directional Static Load Test assemblies shall be welded to the rebar cage or carrying frame. The plane of the bottom plate(s) of the Bi-Directional Static Load Test cell(s) shall be set at right angles to the long axis of the cage. The Contractor shall use the utmost care in handling the test assembly so as not to damage the instrumentation during installation. The Contractor shall limit the deflection of the cage to 2 feet between pick points while lifting the cage from the horizontal position to vertical. The maximum spacing between pick points shall be 25 feet. The Contractor shall provide support bracing, strong backs, etc. to maintain the deflection within the specified tolerance. The Bi-Directional Static Load Test assemblies must remain perpendicular to the long axis of the reinforcing cage throughout the lifting and installation process.

When the test drilled shaft excavation has been completed, inspected, callipered using the approved equipment and accepted by the Department, the Bi-Directional Static Load Test assembly and the reinforcing steel may be installed. A seating layer of concrete shall be placed in the base of the shaft to provide a level base and reaction for the lowest Bi-Directional Static Load Test assembly. The seating layer shall be placed using a pump line or tremie pipe extending through the Bi-Directional Static Load Test assemblies to the base of the shaft. After seating the bi-directional static load test device assembly, the remainder of the drilled shaft shall be concreted in a manner similar to that specified for production shafts. At least 4 concrete test cylinders, in addition to those specified elsewhere, shall be made from the concrete used in the test drilled shaft, to be tested at the direction of Bi-Directional Static Load Test test supplier. At least 1 of these test cylinders shall be tested prior to the load test and at least 2 cylinders shall be tested on the day of the load test.

#### **4.0 PROCEDURE FOR LOAD TESTING**

The load testing shall be performed by a qualified geotechnical engineer approved in advance by the Department. The geotechnical engineer must have a demonstrated knowledge of load testing procedures, and have performed at least 10 Bi-Directional Static Load Tests within the past 2 years. The load testing shall be performed in general compliance with ASTM D1143 using the Quick Load Test Method for Individual Piles. Initially the loads shall be applied in increments equaling 5 to 10% of the anticipated nominal capacity of the test shaft. The magnitude of the load increments may be increased or decreased depending on the project requirements but should not be changed during the test.

Loads shall be applied at the prescribed intervals until the ultimate capacity of the shaft is reached in either end bearing or side shear, until the maximum capacity or maximum stroke of an Bi-Directional Static Load Test device is reached, or unless otherwise directed by the Department. At each load increment, or decrement movement indicators shall be read at 1, 2, 4 and 8-minute intervals while the load is held constant. During unloading cycles the load decrement shall be such that at least 4 data points are acquired for the load versus movement curve. Additional cycles of loading and unloading using similar procedures may be required by the Department following the completion of the initial test cycle.

During the load test, no casings may be vibrated into place in the foundation area, within a 100 ft radius of the load test. Drilling may not continue within a 100-foot radius of the test drilled shaft. If test apparatus shows any interference due to construction activities outside of this perimeter, such activities shall cease immediately.

After the completion of the load test, and at the direction of the Department, the Contractor shall remove any equipment, material, waste, etc. which are not to be a part of the finished structure.

#### **5.0 INSTRUMENTATION**

Direct movement indicator measurements should be made of the following: Bi-Directional Static Load Test device expansion either directly or with telltales (minimum. of 3 indicators required), upward top-of-shaft displacement (minimum of 2 indicators required) and shaft compression above Bi-Directional Static Load Test device (minimum. of 2 indicators required). Displacement sensors used to measure

Bi-Directional Static Load Test device expansion and top-of-shaft displacement should have a minimum travel of 4 inches and be capable of being read to the nearest 0.001 inch division. When Bi-Directional Static Load Test device expansion is measured directly, Linear Vibrating Wire Displacement Transducers (LVWDTs) capable of measuring the full stroke of the bi-directional static load test device will be used (typically 6 inches). Displacement sensors used to measure shaft compression should have a minimum travel of 1 inch and be capable of being read to the nearest 0.001 inch division.

## **6.0 REPORTING OF RESULTS**

Unless otherwise specified by the Department, the Contractor will supply 4 paper copies of a report of each load test, as prepared by Bi-Directional Static Load Test device and a PDF electronic copy. An initial data report containing the load-movement curves and data tables will be provided to the Department within 3 working days of the completion of load testing, to allow evaluation of the test results. A final report on the load testing shall be submitted to the Department within 7 working days after completion of the load testing.

## **7.0 METHOD OF MEASUREMENT**

The Bi-Directional Static Load Tests of Drilled Shaft shall be considered to include any material, labor, equipment, load cells, etc. required above the requirements of production drilled shaft installation necessary to install, conduct, and remove the drilled shaft load test at the direction of the Department and Bi-Directional Static Load Test supplier representative. All costs of the axial load test including subcontracting to Bi-Directional Static Load Test supplier will also be included in the price bid for this work.

The quantity of the pay item "Bi-Directional Static Load Test of Drilled Shafts" is measured by each (EA) completed and accepted by the Department. A completed Bi-Directional Static Load Test shall be 1 test conducted on a test drilled shaft using Bi-Directional Static Load Testing System.

All costs associated with the normal production of the drilled shaft are measured and paid for elsewhere in the contract documents.

## **8.0 DISPOSITION OF TEST SHAFT**

After completion of all testing and the submittal of the required reports, the test drilled shaft shall be cut-off at a depth of 2 feet below the ground surface. The cut-off portion of the shaft shall be properly disposed of by the contractor and the resulting hole shall be backfilled with soil in accordance with Section 205 of the Standard Specifications. The test area shall be graded smooth. In addition, the location of this test drilled shaft shall be indicated on the As-Built plans for this project.

## **9.0 BASIS OF PAYMENT**

The complete and accepted "Bi-Directional Static Load Test" shall be paid for at the contract lump sum price for each. This shall constitute full compensation for all costs incurred during the procurement, installation, conducting of the test, subsequent removal of test apparatus and appurtenances and disposing of the test shaft as described in Section 8.0 above.

## **10.0 PAYMENT**

Payments shall be made under SCDOT Pay Item No. 7120700, "Bi-Directional Static Load Testing of Drilled Shafts".