ITEM 525 DEMONSTRATION SHAFT AND BI-DIRECTIONAL STATIC LOAD TESTING OF DEMONSTRATION SHAFT, Bridge No. CUY-90-16.96

May 22, 2024

525.1 Description.

This work consists of furnishing and installing the Demonstration Shaft with load cell assembly (Bi-Directional Jack Assembly) and instrumentation, and completing the Bi-Directional Static Load Test near Bridge No. CUY-90-16.96 (i.e., Bridge 14) as indicated herein and on the Contract Plans.

Complete the bi-directional axial compression static load test according to ASTM D8169/D8169M Procedure A: Quick Test, except as modified below. Use the test results to produce a top-load curve for the Demonstration Shaft. The target design nominal compression resistance is 500 tons for the portion of the Demonstration Shaft that exists below the Bi-Directional Jack Assembly. The Specified Maximum Test Load is 1,000 tons and the required minimum capacity of the Bi-Directional Jack Assembly is 550 tons (e.g., shared equally between 3 hydraulic jacks) according to ASTM D8169/D8169M paragraph 7.2.1.

Complete the integrity testing of the concrete that is placed in the Demonstration Shaft according to ASTM D6760, Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Crosshole Testing (CSL Testing).

After successful completion of the Demonstration Shaft and Bi-Directional Load Test, demolish the Demonstration Shaft to a depth of at least 1 foot below the existing ground surface, abandon the remainder of the Demonstration Shaft in place, and restore the ground surface equal to or better than the condition that was present before intrusive activity at the Demonstration Shaft Test area.

525.2 General.

The purpose of the load test is to ascertain that the as-designed drilled shaft foundations (i.e., production shafts) for Bridge 14 have sufficient verifiable factored axial resistance below the Design Dredge Line (i.e., elevation 629). If the load test suggests that the available factored axial resistance is equal to or greater than the as-designed production shafts, the production shaft tip(s) will remain at elevation 560. Otherwise, the load test results must provide sufficient information for the Engineer to determine the additional drilled shaft length that is required to provide the required factored axial resistance (e.g., deeper production shaft tip elevation).

The primary scope of services is summarized below:

- Furnish and install a 48-inch diameter Demonstration (test) Shaft with a Bi-Directional Jack Assembly and instrumentation as indicated on the Plans.
- Perform and document caliper log profiling on the drilled shaft excavation to measure and document the as-built diameter versus depth profile for the Demonstration Shaft.
- Perform Crosshole Sonic Logging (CSL) to document the concrete tremie placement for the Demonstration Shaft.
- Set up, perform, monitor, analyze, and report test results for the bi-directional static load test.

525.3 Contractor's Installation Plan.

Submit, for the Engineer's acceptance, a written installation plan of procedures to follow when excavating the drilled shaft hole, placing the concrete, monitoring the concrete placement, conducting the CSL test, fabricating and installing the Bi-Directional Jack Assembly and instrumentation, performing the load test, analyzing the test data, and reporting the results. Submit the installation plan at least 14 Calendar Days before constructing the Demonstration Shaft. Include the following information:

A. Details of the sequence proposed for the overall drilled shaft construction operation.
B. Procedures for maintaining correct horizontal and vertical alignment of the excavation.

C. If using a casing, method to advance the casing.
D. If using a temporary casing, details of the methods to extract the temporary casing and to maintain the concrete slump to keep concrete workable by adding admixtures such as retarders or superplasticizers.
E. If using slurry, details of the methods to mix, circulate, and de-sand the slurry. Submit the manufacturer's recommendations for the use of the polymer slurry.
F. Details of methods to clean the shaft excavation.
G. Details of reinforcement placement including support and centralization methods.
H. Details of concrete placement including proposed operational procedures for free fall, tremie, or pumping methods.
I. A list of proposed equipment to be used such as cranes, drills, augers, bailing buckets, final cleaning equipment, de-sanding equipment, slurry pumps, tremies, concrete pumps, casings, etc. Acceptance of the installation plan will not relieve the Contractor of the responsibility for obtaining the required results.
J. Details to secure the Bi-Directional Jack Assembly and instrumentation in a stable position, including the use of strong backs and multi-pick points to raise the reinforcement cage and Bi-Directional Jack Assembly from a horizontal to a vertical position.
K. Procedures used, when the rebar cage is raised into the vertical position, to verify the location of the instrumentation and Bi-Directional Jack Assembly, accurate to the nearest inch and referenced to the top of the steel reinforcement cage.
L. Procedural Details including, but limited to, the approach to the performance and monitoring of the CSL and Bi-Directional Static Load Tests. As a minimum, the procedural details must include:
    1. Statement of qualifications including the names and experience of testing personnel, for the specialty firm(s) that will be engaged to complete the CSL, caliper log profiling, and bi-directional static load test (minimum of 3 years of relevant experience performing bi-directional load tests required).
    2. Caliper log profiling details.
    3. Measures to protect the instrumentation, especially when the reinforcement cage is raised from the horizontal to the vertical position, when the reinforcement cage is lowered into the excavated hole, and when concrete is placed. This item must include operational checks for all of the instrumentation that is made before the completed reinforcement cage is raised, after the reinforcement cage is raised into the vertical position and set in the excavated hole, and again after the fresh concrete is placed but before the initial set.
    4. Details about the Bi-Directional Jack Assembly and hydraulic pump system. As a minimum, provide details to demonstrate what measures have been taken to load the Demonstration Shaft uniformly and symmetrically about the pile axis, typically using jacks of the same make, model, and capacity with each jack having separate hydraulic pressure supply hoses originating from a pressure manifold, and vent pipe(s).
    5. Calibration details for the Bi-Directional Jack Cell(s), Pressure Gauge(s), manifold, and hydraulic pump that are used to complete the load test.
    6. Details about the instrumentation including, but not limited to, manufacturer brochures, manufacturer recommended installation instructions, and instrument calibration data.
    7. Instrument operational checks that are completed within 14 calendar days after receipt from the instrument manufacturer.
    8. Load test procedures and schematics.
    9. Analysis methodology and sample calculations.
    10. Sample forms and report.
    11. Miscellaneous relevant information, such as groundwater dewatering planned to be employed before and/or during construction of the Demonstration Shaft and completion of the load test.

525.4 Shop Drawings.

Submit, to the Engineer before incorporation, two copies of the shop drawings and catalog cuts which identify and describe each manufactured item that is being incorporated into the construction. Certify in writing that each manufactured item is in conformance with all contract requirements for that item. Ensure that the documents describing each item indicate the project number (including the construction year) and the bid reference number under which the item is being installed and that the documentation contains all of

the information needed to allow the Engineer to determine that the item to be supplied meets all applicable requirements. When multiple items are to be incorporated under a single bid reference number, submit the documentation for all such items together.

525.5 Materials.

Furnish material conforming to:

Concrete, Class QC 5	Item 499, 511
Epoxy-coated reinforcing steel	Item 509
Bi-Directional Jack Assembly* and Instrumentation	In accordance with the approved shop drawings

Materials supplied, that do not become a part of the finished structure, become the responsibility of the Contractor after the load test and shall be removed from the job site.

525.6 Incidentals.

Furnish and install all incidentals necessary to provide a complete and practical working unit or system., Furnish a separate and complete documentation package for each bid item referenced.

525.7 Equipment.

Supply all installation and testing equipment necessary to install the Demonstration Shaft and perform the required testing according to ASTM D8169/D8169M and ASTM D6760.

Furnish and use a Bi-Directional Jack Assembly with a minimum rated nominal capacity of 550 tons and a minimum operational stroke of 6 inches. Refer to the Plans for a schematic and details for the Demonstration Shaft. Final detailing for the Bi-Directional Jack Assembly and instrumentation shall be according to the approved Procedural Details and Shop Drawings (i.e., subsections 525.3 and 525.4).

Furnish and use two (2) automatic self-leveling digital survey levels with an accuracy of 0.01 inch at 100 feet or better, according to ASTM D8169/D8169M paragraphs 8.1.8 and 8.2.2. Use each survey level to monitor a separate survey grade invar-rod that is rigidly mounted to the top of the shaft from a minimum distance of at least five shaft diameters from the center of the test shaft. Provide a survey-level / invar-rod reference system with a precision of 0.001 inch. Use the digital survey levels to automatically record and display readings at a maximum frequency of 1 complete set of readings per minute over the entire duration of the load test.

Top of shaft displacement monitored in this method is not expected to require a reference beam system and therefore no correction for reference system movement is expected to be required.

Provide a piano wire that is affixed to an independent reference (outside the zone of test influence) with mirror and machinist scale (attached to the top of concrete shaft) according to ASTM D8169/D8169M paragraph 8.2.5 to provide a secondary redundant measurement of the top of shaft movement.

Furnish, install, and use three (3) pairs of equally spaced unstrained steel telltale rods with a diameter of 0.25 inches to measure the displacement between the top of the Demonstration Shaft and the top of the telltale rod during the load test. Anchor one-half of the telltale rod tips within 6 inches of the bottom of the Demonstration Shaft; anchor the second half of the telltale rod tips at the top of the Bi-Directional Jack Assembly. Install each telltale rod within a tube with an inside diameter of one-half inch over the full length of the telltale rod.

Furnish and install linear vibrating wire displacement transducers (LVWDT) to measure the expansion of the Bi-Directional Jack Assembly and to measure telltale movement. Provide LVWDTs with an operating range of 9 inches and 3 inches to measure the displacement of the Bi-Directional Jack Assembly and telltales, respectively. Provide LVWDTs with lightning protection and, 0.25 percent of the full range or better resolution, +/- 0.1 percent of the full operating range accuracy, less than 0.5 percent over the full operating range non-linearity, and compatible readout unit. Provide LVWDTs with a 4-conductor signal cable, 22 AWG, twisted pair, foil shield, PVC jacket, and no splices over the full length of the signal cable.

Furnish and install vibrating wire (VW) strain gages with thermistors, lightning protection, #4 deformed steel sister bars, and a compatible readout unit. Install the VW strain gages in pairs that are orthogonally opposite each other, equidistant from and parallel to the shaft axis. Provide strain gages with a minimum range of 3,000 microstrains, 0.5 microstrains or better resolution, +/- 0.25 percent of the full operating range accuracy, and less than 0.5 percent over the full operating range non-linearity. Provide strain gages with 4-conductor signal cable, 22 AWG, twisted pair, foil shield, PVC jacket, and no splices over the full length of the signal cable.

525.8 Demonstration Shaft Installation.

A. Construction Tolerances and Inspection Records. Stake out and inspect the Demonstration Shaft at the location shown on the Plans according to subsections 524.14 and 524.15. Stake out the location of the Demonstration Shaft by instrument survey, and re-survey (e.g., x/y/z State Plane survey coordinates) the as-drilled Demonstration Shaft location within 48 hours after the initial set of the subject shaft concrete.

B. Tolerance for Placement of Bi-Directional Jack Assembly and Instrumentation. Document the location of the actual installed instrumentation and Bi-Directional Jack Assembly to the nearest inch or less, referenced to the top of the steel reinforcement cage.

C. Demonstration Shaft Excavation. Excavate the hole for the Demonstration Shaft according to subsection 524.04 through 524.08, except drilling slurry if used must be a polymer type (mineral type is not acceptable due to risk of formation of a mud cake on the sidewall of the drilled shaft). Document and report what if any effect that the construction procedures may have on the Bi-Directional Load Test.

D. Caliper Logging of Shaft Excavation. Complete caliper logging to determine the actual shaft diameter versus depth for the excavated length of the Demonstration Shaft with a four-arm mechanical caliper. Measure the diameter by soft contact of the caliper arms with the sidewall of the excavated hole and record the diameter at a maximum two (2) foot vertical spacing over the entire depth of the excavated hole. Complete a minimum of two (2) passes with the caliper. Present the caliper results in real-time in the field. Process the caliper data and present the results as a summary profile log; report the raw data, field sketch to reference the data to the top of Demonstration Shaft longitudinal reinforcement, calculations performed to reduce the raw data, and written summary report.

E. Reinforcement Steel, Bi-Directional Jack Assembly, and Instrumentation. Assemble and place the steel reinforcement cage immediately after the inspection of the shaft excavation and before concrete placement according to subsection 524.09. Comply with the approved Procedural Details and shop drawings (i.e., subsections 525.3 and 525.4). Provide temporary steel reinforcement to stiffen the reinforcement cage to maintain the cage geometry and integrity when the cage is lifted from a horizontal to a vertical position. Provide re-bar spacers according to subsection 524.09. Complete operational checks for all of the instrumentation before the completed reinforcement cage is raised, and again after the reinforcement cage is raised into the vertical position and set in the excavated hole; raise the reinforcement cage, if necessary, to replace any non-functioning strain gages that are damaged during cage handling. Pick and install the reinforcement cage in a single section. No more than two feet of deflection per 25 feet of cage length is permitted, to mitigate against instrumentation damage. Bundle the hydraulic hoses for the Bi-Directional Jack Assembly and instrumentation signal cables at the top of the Demonstration Shaft. Obtain strain readings before and after the pile installation to provide a complete strain history and provide the data needed to assess residual stress behavior. Document and report what if any effect that the construction procedures may have on the Bi-Directional Load Test.

F. Concrete for Demonstration Shaft. Use Class QC 5 concrete according to Item 511, except as modified and supplemented in subsections 524.10, 524.12, and 524.13. The required tremie-placed concrete slump is 8 +/- 1 inch. Achieve the additional slump over 4 inches by using chemical admixtures conforming to Item 705.12, Type F or G. Use a maximum water-cement ratio of 0.44. If placing concrete under water, add 10 percent more cement to the concrete mix. As a minimum, document the actual pile size, shape, material

composition, and properties at the time of concrete placement including, but not limited to physical measurements, slump tests, concrete unit weight, yield, and air content according to ASTM C138/C138M, batch tickets for concrete placed, a quality control comparison plot of theoretical concrete volume and actual concrete volume placed versus depth plot, and concrete compressive strength test results. Document and report what if any effect that the construction procedures may have on the Bi-Directional Load Test.

G. Crosshole Sonic Logging (CSL) Test. Furnish and install 4 access tubes that permit entry of the CSL test probes; install the access tubes equidistant from each other in a straight alignment with a watertight cap; securely attach the access tubes to the interior of the spiral or hoop reinforcement and a minimum of 3-inch clear of the longitudinal reinforcement; if there is not sufficient space to prove 3-inch clear cover, then bundle the CSL tube(s) with the longitudinal reinforcement; extend the access tubes from the bottom of the reinforcement cage to 2 feet above the top of the reinforcement cage; fill the access tubes with water before concrete placement. Before performing CSL tests, remove the laitance to expose sound concrete at the top of the drilled shaft. Provide at least 48 hours notice to the Engineer before performing the CSL tests. The CSL tests shall be performed after the shaft concrete has cured at least 72 hours; additional curing time may be required if the concrete was placed with admixtures, such as a set retarding admixture or water-reducing admixture; CSL tests shall be completed within 30 calendar days of concrete placement; no subsequent operations at the Demonstration Shaft shall be completed until the CSL test results have been accepted by the Engineer in writing. The Engineer shall determine final acceptance of the CSL test results; if the Engineer determines that the concrete placed under slurry is structurally inadequate, the Demonstration Shaft will be rejected; the placement of concrete under slurry shall be suspended until the Contractor submits to the Engineer written changes to the means and methods of shaft construction to prevent future structurally inadequate shafts and receives the Engineer's written approval of the submittal; if the Contractor requests, the Engineer may direct additional testing (e.g., concrete core sampling) be performed on the Demonstration Shaft at no additional cost to the Department.

525.9 Bi-Directional Load Test Procedure.

Complete the Bi-Directional Static Load Test according to ASTM D8169/D8169M Procedure A, Quick Test, except as modified herein. Refer to ASTM D8169/D8169M paragraph 7.1.1 for jack calibration requirements. Weld or lock the jack assembly so that it remains closed during handling and installation in the Demonstration Shaft; The welds or locks shall be designed so that they may be disengaged completely (no resistance to expansion) before testing or to provide no resistance after 0.04 inch or less of assembly expansion. Design the jack assembly and its connection to the steel reinforcement to safely withstand handling and placement stresses. Apply the test load in 25-ton increments according to ASTM D8169/D8169M paragraphs 9.2.1 and 9.2.1.1. Apply a maximum jack assembly load of 500 tons, which is 50 percent of the Maximum Specified Test load of 1,000 tons (see paragraph 525.1). Add load increments until reaching half of the maximum specified test load; continue adding more load increments until reaching the maximum expansion or load capacity of the jack assembly, or until observing continuing, progressive expansion of the jack assembly with no appreciable increase in jack pressure, according to ASTM D8169/D8169M paragraph 9.2.1. Remove the load in 50-ton increments according to ASTM D8169/D8169M paragraph 9.2.1.1. Record the test readings according to ASTM D8169/D8169M paragraphs 9.3.1 and 9.3.2. Record and report benchmark readings for each survey level according to ASTM D8169/D8169M paragraph 9.3.1.3. Use a data logger system to condition and store the test data in digital form according to ASTM D8169/D8169M paragraph 9.3.1.2 at a maximum reading frequency of 1 complete set of (strain, LVWDT, pressure gauge) readings per minute over the entire duration of the load test. Obtain quick test readings according to ASTM D8169/D8169M paragraph 9.3.2.

525.10 Demonstration Shaft Installation and Testing Report.

Submit to the Engineer six copies of a Preliminary Load Test Report within 48 hours after completion of the Bi-Directional Static Load Test, which includes the following at a minimum:

A. Load-movement curves and test data for nominal side shear and end bearing with extrapolated results if failure is not reached.

B. Nominal or extrapolated end bearing resistance (TSF) for the Demonstration Shaft.

C. Nominal or extrapolated side shear resistance (TSF) of the Demonstration Shaft.

Submit to the Engineer six copies of a Final Demonstration Shaft Report within 14 calendar days of the completion of the Bi-Directional Static Load Test. The final report shall include the following information at a minimum:

A. As installed location of Demonstration Shaft.

B. Schematic indicating the location of all the instrumentation.

C. Summary of load test procedures and data collected during testing.

D. Summary of all applicable shaft dimensions, areas, elevations, and properties used for analysis purposes.

E. Plots of load-movement curves, nominal end bearing resistance, and side shear resistance.

525.11 Basis of Payment.

Payment for the Demonstration Shaft and Bi-Directional Static Load Testing of the Demonstration Shaft, Bridge No. CUY-90-16.96 includes all labor, equipment, material, instrumentation, reporting, and specialty engineering that is required to complete the Bi-Directional Static Load Test including any demolition and site restoration that is required, all to the satisfaction of the Engineer.

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

Item	Unit	Description
525	Lump Sum	Demonstration Shaft and Bi-Directional Static Load Testing of Demonstration Shaft, Bridge No. CUY-90-16.96