DESCRIPTION

A. Summary

This work shall consist of the Contractor securing and providing the services of an independent Thermal Integrity Profiling (TIP) firm to furnish and operate all equipment necessary to perform TIP testing at drilled shafts and prepare the test reports. The TIP testing firm shall have a minimum of two years experience in the use of the test equipment and interpretation of the test data.

The Thermal Integrity Profiler uses the heat generated by curing cement (hydration energy) to assess the quality of cast in place concrete foundations, herein referred to as “drilled shafts” or simply “shafts”. The temperature at any location is dependent on the shaft diameter, mix design, time of measurement and distance to the center of the shaft. TIP measurements may be used to estimate the actual shape of the shaft. These estimates may be compared with concreting logs to assess the overall quality of the shaft.

Because the method relies on the heat of hydration, TIP testing is generally done between 12 and 48 hours of casting the concrete. Smaller diameter shafts are tested earlier. Good communication between Contractor and TIP Consultant is therefore essential. Data can be acquired either with thermal probes in access tubes cast into the shaft or using Thermal Wires® (hereby referred to also as wires) tied to the rebar cage, installed prior to concreting. The Contractor shall provide cooperative assistance, suitable access to the site and drilled shafts to be tested, and labor as required to assist the TIP Consultant in performing the required tests. Prior to testing, provide the drilled shaft lengths and top and bottom elevations, tube lengths and top and bottom elevations, tube positions (probe method only), and dates of construction of drilled shaft to the TIP Consultant and coordinate with TIP Consultant to install the necessary TIP instrumentation (wire method only) prior to concreting the shaft.

B. Submittals

Prior Experience

The TIP consultant shall have a professional engineer, licensed and registered in the State of New York, supervising the testing and interpretation of results. The TIP Consultant shall be an independent testing agency with documented and approved experience in TIP testing. The Consultant qualifications and the specifications for the equipment used shall be submitted to the Engineer for approval prior to beginning drilled shaft installation.

MATERIALS

A. Required Equipment

Provide Thermal Integrity Profiler (TIP) equipment with the following minimum requirements:

1. (Probe or wire option) A computer based TIP data acquisition system for (a) display of signals during data acquisition (probe option only), or (b) to monitor temperature versus time after casting (wire option only).
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2. (Probe option only) Thermal probe with four infrared sensors equally spaced at 90 degrees around the perimeter that read temperatures of the tube wall to within 1°F accuracy (0.56°C). The probes shall be less than 3.18 cm (1.25 inches) in diameter and shall freely descend through the full depth of properly installed access tubes in the drilled shafts.

3. (Probe option only) One depth encoder sensor to determine probe depths.
4. (Probe option only) Ability to collect data at user specified depth increment.
5. (Wire option only) Ability to collect data at user defined time intervals (typically 15 to 60 minutes).

B. Grout. Provide cement or sand-cement grout for filling access pipes. The Contractor's proposed grouting methods and grout mixes are subject to the approval of the Engineer. All grout constituents must meet the material requirements of §700 Materials and Manufacturing

PROCEDURE

A. TIP access tube preparation (Probe option only)

1. Install one access tube for each foot of drilled shaft diameter, but not less than a minimum of four access tubes.

2. Every drilled shaft shall be equipped with access tubes to permit possible inspection by TIP. The number of tests shall be as shown on the contract plans or as directed by the Engineer. Based on the test results, if, significant defects are detected, the number of drilled shafts tested may be increased by the Engineer.

3. Access tubes shall be 1.5-inch or 2.0-inch nominal inside diameter standard weight Schedule 40 steel tubes. Round tubes with a regular internal diameter free of defects and obstructions, including any tube joints, shall be used to permit the free, unobstructed passage of the probes. Tubes shall be watertight and free from corrosion with clean external faces to ensure a good bond between the concrete and the tubes. Tubes may be extended with mechanical couplings. Tubes shall be installed by the Contractor in a manner such that the TIP probes pass through the entire length of the tube without binding. Ensure that the access tubes are plumb and verify that unobstructed passage of the probes is achievable before the TIP Consultant arrives.

4. The tubes shall be fit with a watertight shoe on the bottom and a removable threaded cap on the top. Tubes shall be secured to the interior of the reinforcement cage at regular intervals not to exceed 3 ft. Tubes shall be installed uniformly and equidistantly around the circumference such that each tube is spaced parallel for the full length and at the maximum distance possible from each adjacent tube. Tubes shall be spaced as far as possible from the main axial reinforcing steel. Tubes shall be extended to within 4 inches of the bottom of the drilled reinforcing shaft, to at least 3 feet above the top of the concrete, and to at least 2 feet, but not more than 5 feet above the ground surface. Tubes shall not be damaged during installation of the reinforcement cage.

5. TIP testing with probes must occur in tubes that are not filled with water. If CSL testing is also required on the same shaft, the access tubes shall be filled with clean fresh water.
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prior to concrete placement. Prior to TIP testing, the water must be removed from the tubes.

6. Tube tops shall be threaded and capped to prevent debris from entering the access tubes. Do not apply excessive torque, hammering or other stresses which could break the bond between the tube and concrete when removing caps from the tubes. This is not of particular importance for TIP testing, however, it can degrade the signal of CSL systems when both tests are to be used.

7. After all required TIP and CSL testing is complete, and after acceptance of the drilled shaft by the Engineer, the Contractor shall remove the water in the tubes, if any, and place grout tubes extending to the bottom of the access tube, and fill all access tubes in the drilled shafts with cement grout. Use a neat cement grout (cement and water) with a water to cement ratio of 0.45 or less (4 to 5 gallons per 94-pound bag of cement) for filling the access tubes, as recommended by TIP Consultant, and approved by the Engineer. The grout should be placed using tremie method. The Contractor's proposed grouting methods and grout mixes are subject to the approval of the Engineer. All grout constituents must meet the material requirements of §700 Materials and Manufacturing.

B. Shaft preparation for thermal wires (wire option only)
   1. Install one thermal wire in each foot of drilled shaft diameter. The thermal wire shall be installed uniformly and equidistantly around the circumference such that each wire is spaced parallel for the full length and at the maximum distance possible from each adjacent wire.
   2. Drilled Shafts to be tested shall be equipped with thermal wires to permit inspection by TIP. If significant defects are detected, the number of drilled shafts tested may be increased by the Engineer.
   3. Thermal wires shall be aligned with the longitudinal reinforcement of the shaft, and stretched to minimize the wire slack. The wires shall be tied at a maximum of every 3 ft to the reinforcement. Wires shall extend from the top of the drilled shaft to within 4 inches of the bottom of the drilled shaft, and provided with additional wire length to reach the thermal access port for monitoring and recording.

C. Timing of the TIP test (probe method only)
   1. The optimal time is when the core temperature is at its peak, and this depends on the shaft diameter and concrete mix. The drilled shaft shall be tested no sooner than 12 hours after placement of all concrete in any drilled shaft, and typically within one day of concrete placement, but within three days after concrete placement. If concrete retarders are used, the time before the test should be extended. The Contractor shall obtain the time of testing from the TIP Consultant’s recommendation based on shaft diameter and concrete mix, and coordinate with the TIP Consultant to be on site at the appropriate time.
D. TIP procedure (probe method only)

1. Prior to TIP testing, the Contractor shall provide the Engineer and TIP Consultant with a record of all drilled shaft lengths, elevations of the top and bottom of shafts, elevations of the top and bottom of access tubes or thermal wires, and installation date and times for all drilled shafts. The access tubes shall be clearly labeled for identification by the TIP Consultant. If the access tubes are filled with water, the water shall be removed. The Contractor shall supply a sufficient sized AC generator to power a compressor of sufficient pressure rating to air lift the water from the tubes. Water shall be stored in a container and shall be reinstalled in the tubes after test completion to maintain tube viability for other subsequently performed test methods. The stored water shall be kept as warm as practical during the extraction period.

2. The TIP probe shall be acclimated to the ambient temperature of the shaft for a minimum 15 minutes prior to the first test either by immersing in the removed water, or installed into either filled or unfilled access tubes to a depth of at least 10 feet below the top of concrete.

3. The TIP testing shall be performed with the probe inserted in and at the top of the dewatered access tube. The cable for the probe shall be positioned over the encoder wheel positioned at the top of the access tube being tested. Both thermal probe and encoder shall be attached to the TIP data acquisition system and monitored during the entire tube length.

4. The TIP probe shall be slowly lowered from the top at a rate not to exceed 0.5 feet per second with TIP measurements taken at 2 to 6 inch intervals. The test shall be repeated until two sets of data from the same access tube give similar results. The probe and encoder shall then be moved to the next dewatered tube and the process repeated until all tubes have been successfully tested.

5. Potential local defects indicated by locally low temperatures relative to the average temperature at that depth, or average temperatures significantly lower than the average temperatures at other depths, or large temperature variations around the shaft, shall be immediately reported to the Engineer.

E. TIP Procedure (thermal wire method only)

1. Thermal wires shall be connected to a Thermal Access Port (TAP) preferably prior to casting concrete, or immediately following casting. Data shall be collected by the TAP at 60-minute intervals for a duration of 24 hours or as recommended by the TIP Consultant. After completion of the data collection period, the TAP shall be connected to the main TIP data acquisition unit and the data files shall be downloaded for inspection of temperatures versus depth.

2. Potential local defects indicated by locally low temperatures relative to the average temperature at that depth, or average temperatures significantly lower than the average temperatures at other depths, or large temperature variations around the shaft, shall be immediately reported to the Engineer.
F. TIP Report

1. Results of the TIP shall be presented in a written report. The report shall present results of TIP tests by including:
   a. Graphical displays of all temperature measurements (probes or wires) versus depth for each reading time shall be included.
   b. Indication of unusual temperatures, particularly significantly cooler local deviations of the average at any depth from the overall average over the entire length, in either probe or thermal wire measurements.
   c. The overall average temperature. This temperature is proportional to the average radius computed from the actual total concrete volume installed (assuming a consistent concrete mix throughout). Radius at any point shall then be determined from the temperature at that point compared to the overall average temperature.
   d. Variations in temperature between tubes (at each depth) which in turn correspond to variations in cage alignment. Where concrete volume is known, the cage alignment or offset from center shall be noted.
   e. The shaft specific construction information, including elevations of the top of shaft, bottom of casing and bottom of shaft, and top and bottom of each access tube or thermal wire shall be noted on all pertinent graphical displays.

2. Final reports shall be signed and sealed by a professional engineer, licensed and registered in the State of New York, and submitted to the Engineer within five working days of completion of TIP testing at each drilled shaft

METHOD OF MEASUREMENT
This work will be measured as the number of drilled shafts on which TIP testing is acceptably performed as determined by the Engineer in accordance with the specification.

BASIS OF PAYMENT
The unit price bid shall include the cost of furnishing all labor, materials and equipment necessary to perform TIP testing and report the results. The cost of repairing possible defects in the shaft concrete, and coring or CSL testing to verify the effectiveness of the repairs, are at the Contractor’s expense.