SPECIAL SPECIFICATION

4684

Thermal Integrity Profiler (TIP) Testing of Drilled Shaft

1. Description. Perform the nondestructive testing (NDT) method termed Thermal Integrity Profiler (TIP) testing by obtaining records of the heat generated by curing cement (hydration energy) to assess the quality of drilled shafts. TIP measurements that are colder than normal indicate necks, inclusions, or poor quality concrete, while warmer than normal measurements are indicative of bulges. Variations of temperatures between tubes reveal cage eccentricity. Furnish all materials, equipment, and labor necessary to conduct TIP testing on production drilled shafts. The TIP testing will meet the requirements of ASTM D 7949, except as noted below.

2. Equipment. Supply all materials and equipment required to perform TIP tests. Equipment to perform the test shall have the following minimum requirements:

- **A.** (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).
- **B.** (Probe option only) Thermal probe with four infrared sensors equally spaced at 90^{o} around the perimeter that read temperatures of the tube wall to within 1^{o} F accuracy. The probes shall be less than 1.25 inches in diameter and shall freely descend through the full depth of properly installed access tubes in the drilled shafts; One depth encoder sensor to determine probe depths; Ability to collect data at user specified depth increment.
- **C.** (Wire option only) Ability to collect data at user defined time intervals (typically 15 to 60 minutes).

3. Testing Procedure. Conform to testing procedures in ASTM D 7949 specification.

4. Result Reporting.

Submit a written report within (5) working days of completion of testing. The report shall present results of TIP tests by including:

- **A.** Graphical displays of all temperature measurements (probes or wires) versus depth
- 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 can 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 should be noted.
E. Where shaft specific construction information is available (e.g. elevations of the top of shaft, bottom of casing, bottom of shaft, etc.), these values should be noted on all pertinent graphical displays.

5. Measurement.

TIP testing will be measured by each successful test that is approved by the Engineer. Quantities of TIP testing will be shown on the plans.

6. Payment.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for each "Thermal Integrity Profiler (TIP) Testing of Drilled Shaft" of size and type specified. This price is full compensation for material, equipment, labor, work, tools, and incidentals.

SPECIAL SPECIFICATION

4618

High Strain Dynamic Testing of Drilled Shaft

1. Description. Perform high-strain dynamic testing by obtaining records of drilled shaft force and velocity under drop weight impacts for evaluations of drilled shaft load carrying capacity, structural integrity, load-movement, and soil load transfer relationships. Furnish all materials, equipment, and labor necessary to conduct high-strain dynamic tests on test shafts. High-strain dynamic tests (herein also called dynamic tests) are non-destructive, quick tests and it is intended that the test shaft be left in a condition suitable for use in production. The test shafts will meet the requirements of ASTM D 4945, except as noted below.

2. Equipment. Supply all materials and equipment required to prepare the top surface of the test shaft, dynamically test it, and return the test shaft to a condition suitable for use in the finished structure. Equipment and procedures required to perform the test include but are not limited to:

- **A.** A drop weight in the range of one to two percent (1 - 2%) of the anticipated test shaft capacity, or as determined by the Engineer. Size the impacting surface of the drop weight to have an area between 70 and 130% of the test shaft top area.
- **B.** A guide allowing variable drop heights typically between 3 and 7 feet, or as determined by the Engineer.
- **C.** A top cushion consisting of new sheets of plywood with total thickness between 2 to 6 inches, or as determined by the Engineer.
- **D.** Surveyors' transit, laser light, or equivalent for measurements (precise to nearest one-tenth inch) of shaft set under each impact.

Perform dynamic testing using an independent specialist with a minimum of five (5) years experience in dynamic testing. Perform dynamic testing in the presence of the Engineer, under the direct supervision of an individual with at least two (2) years of dynamic testing experience or who has achieved Basic Level or better on the Foundation QC High Strain Dynamic Pile Testing Examination. Perform CAPWAP data reduction by an individual that has achieved Master Level or better on the Foundation QC High Strain Dynamic Pile Testing Examination. Provide the following testing instrumentation in addition to that outlined in ASTM D 4945 Section 5:

- Pile Driving Analyzer (PDA).
- Four calibrated strain transducers.
- Four calibrated accelerometers.

3. Testing Procedure. Conform to testing procedures in ASTM D 4945 specification unless as otherwise noted below.

A. Prior to performing the dynamic test, obtain available soil borings, shaft installation records, concrete properties (strength, etc.) and details regarding the anticipated dynamic loading equipment. Determine the suitability of the proposed dynamic load testing equipment and an acceptable range of ram drop heights so as not to cause damage in the test shaft during the test.

B. Construct the test shaft using the approved drilled shaft installation plan. Include method of building up or excavating below existing grade to expose sufficient amount of shaft for testing in the Drilled Shaft Installation plan.

C. If a permanent casing is not used to construct the test shaft, then use a shaft top extension, consisting of a thin walled casing or equivalent, to extend the test shaft by length equal to two diameters. Insure this top length, defined as the "test area", is exposed and readily accessible at the time of the test. Have equipment available to remove surrounding soil (creating a safe working environment) so as to completely expose a test area as described above, if the top of the test shaft is below grade. There should not be soil contamination or non-uniformities in the concrete located within the test area, the shaft should be smooth.

D. Insure the top surface of the test area is flat, solid, and level, (axial to test shaft). Provide a concrete surface level with, or above any casing.

D. Coordinate with the Engineer so that the Engineer is present at the testing.

E. Prior to the test, locate and remove four "windows" (approximate size of 6 by 6 inches) diametrically opposite of each other from the casing, if appropriate, or remove an entire band of the casing to expose a smooth concrete surface for attachment of the sensors. Sensors are typically attached at least one and a half diameters below the shaft top. Use sensors comprised of either: 1) load cell and accelerometers or 2) strain gauges and accelerometers.

F. In cases where casing is not present, smooth (by grinding) areas around the shaft circumference such that proper sensor attachment can be accomplished. For high mast illumination pole foundations, smooth form the upper 5' or one shaft diameter below the top of shaft.

G. Attach sensors to the exposed concrete or steel casing in a secure manner as to prevent slippage under impact.

H. Examine shaft top to insure concrete is flush with or above the casing when casing is used.

I. Apply plywood cushion and then striker plate to the shaft top. If protruding reinforcing bars are present, either incorporate the reinforcing steel in the test area by casting concrete, or provide a steel beam or pipe as described below. Upon completion of the dynamic test, remove the surrounding concrete in accordance with Item 429, "Concrete Structure Repair" to make the foundation suitable for use in the structure. If the Contractor selects not to incorporate the steel in such a manner as described above, then supply a steel beam or pipe (cross sectional area approximately 20% of the shaft cross sectional area) with sufficient length such that the ram impact will not interfere with the reinforcing bars. Steel striker plates and plywood cushion must also be sized so that they cover as much of the impact area as possible.

K. Return the shaft to acceptable production condition upon completion of the test.

4. Result Reporting.

Submit the raw test data and reduced test data for each shaft tested within one (1) day of testing. Reduce the data using the Case Pile Wave Analysis Program (CAPWAP) or approved equal and provide to the Engineer for analysis. If requested, submit revisions to the reduced data within five (5) calendar days after comment.

Include the following in the data submission for each impact:

A.
- maximum measured force,
- maximum calculated tension force,
- transferred energy to the sensor location,
- corresponding stresses,
- the Case Method bearing capacity.

B. The test results with respect to drilled shaft capacity.

5. Measurement.

Dynamic testing will be measured by each successful dynamic test that is approved by the Engineer. Quantities of dynamic testing will be shown on the plans.

6. Payment.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for each "High Strain Dynamic Testing of Drilled Shaft" of size and type specified. This price is full compensation for material, equipment, labor, work, tools, and incidentals.

Test shafts that are part of the permanent structure will be paid for under "High Strain Dynamic Testing of Drilled Shaft" of size and type specified.