STATE OF OHIO
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
TESTING FOUNDATIONS WITH THE THERMAL INTEGRITY PROFILER (T.I.P.)

SUM-76/77/8-10.99/11.54/0.00 (PID 101402)
BRIDGE NO. SUM-76-1148Q – RAMP Q OVER IR-76 WB, LANE O, RAMP S, SR-8 NB/SB
BRIDGE NO. SUM-76-1152N – RAMP N OVER RAMP S, LANE O, IR-76 EB, SR-8 NB/SB, LANE M
BRIDGE NO. SUM-76-1180L – IR-76 WB OVER INMAN STREET
BRIDGE NO. SUM-77-1181 – RUBBER CITY HERITAGE TRAIL BRIDGE OVER RAMP N, LANE M, SR-8, LANE O

1. **Description.** This work consists of evaluating the structural integrity of drilled shafts using the Thermal Integrity Profiler (T.I.P.) method. The work also consists of furnishing and installing the thermal wire cables and equipment required to conduct the testing, employing the services of a testing consultant, and reporting of the results to the applicable parties.

   Nondestructive testing (NDT) shall be performed using the T.I.P. thermal wire cable methodology, or equal, to provide analytical data for the entire shaft (cage and cover) radius.

   The T.I.P. method uses the heat generated by curing cement (hydration energy) to assess the integrity and quality of cast-in-place concrete foundations such as drilled shafts, bored piles, micropiles, augered cast-in-place piles, continuous flight auger piles, and drilled displacement piles, herein referred to as "drilled shafts" or simply "shafts." The expected temperature at any location is dependent on the shaft diameter, mix design, time of measurement, and distance to the center of the shaft. T.I.P. measurements may be used to estimate the actual shape of the shaft. These estimates will be compared with concreting logs to assess the overall quality of the shaft. Because the method relies on the heat of hydration, T.I.P. testing shall begin immediately before casting and end 48 hours after placement. Good communication between Contractor and T.I.P. Consultant is therefore essential. Data is acquired via the thermal wire cables which are tied to the rebar cage or center reinforcing bars prior to the concreting process.

   T.I.P. measurements that are cooler than normal indicate inclusions, necks, or poor-quality concrete; while warmer than normal measurements are indicative of bulges. Variations in temperature between diagonally opposite pairs of thermal wire cables reveal cage eccentricities, such as cage misalignment.

   Testing procedures and equipment shall conform to: ASTM D7949 – "Standard Test Methods for Thermal Integrity Profiling of Concrete Deep Foundations", Method B.

2. **Materials**

   2.1 Thermal Integrity Profiler. Provide a Thermal Integrity Profiler and Thermal Access Ports (TAP) connected to thermal wire cables as follows:

A. The T.I.P. equipment shall have the following minimum requirements:

- A computer based T.I.P. data acquisition system to monitor and download temperature versus time after casting.
- Ability to automatically collect data at user defined time intervals (typically 15 minutes).

B. Furnish thermal wire cables with built-in sensors as recommended by the T.I.P. Consultant.

2.2. Grout. Furnish materials conforming to:

Portland cement 701.02
Chemical admixture.....705.12

Cement grout consists of a mixture of cement and water that provides a minimum 28-day compressive strength equal to, or greater than, the drilled shaft concrete. Determine the compressive strength of the cement grout according to ASTM C 39 or ASTM C 942. Admixtures which control bleed, improve flowability, reduce water content, and retard set may be used in the grout if approved by the Engineer. For grout, use water free from sewage, oil, acid, strong alkalis, vegetable matter, clay, and loam. Potable water is satisfactory for use in grout.

Submit the grout mix with the Drilled Shaft Installation Plan for the Engineer's acceptance.

3. Construction

3.1 Qualifications of T.I.P. Consultant. The T.I.P. Consultant shall be an independent testing agency with documented and approved experience in T.I.P. testing. The T.I.P. Consultant shall have an Ohio Registered Professional Engineer supervising the testing and interpretation of results. The qualifications of the T.I.P. Consultant, the specifications for the equipment, and the testing procedure and timing shall be submitted to the Department for approval prior to shaft installation.

3.2 Coordination Prior to and During T.I.P. testing. The Contractor shall provide cooperative assistance, suitable access to the site and drilled shafts to be tested, and labor as required to assist the T.I.P. Consultant in performing the required tests. Prior to T.I.P. testing, the Contractor shall document and provide the installed drilled shaft lengths, with elevations of the top and bottom; thermal wire cable serial numbers, lengths, and installed positions; construction date and time, construction inspection record, and concrete placement details including field volume logs, and the date and time of concrete placement for all drilled shafts to the Department and T.I.P. Consultant. The Contractor shall coordinate with the T.I.P. Consultant and install the necessary T.I.P. instrumentation prior to concreting the shaft. The Contractor shall obtain the necessary training from the manufacturer on proper installation practices prior to installation of the thermal wire cable assemblies.

3.3 Shaft preparation for thermal wire cables. Install evenly spaced thermal wire cables in each drilled shaft. Use Table 3.4-1 to determine the number of thermal wire cables and the wire spacing. If the drilled shaft diameter varies along the length of the shaft, use the largest diameter to determine the number of thermal wire cables.

Table 3.4-1		
Drilled Shaft Diameter (feet)	Number of Cables	Cable Spacing (degrees)
3.0 to 4.5	4	90
5.0 to 6.5	6	60
7.0 to 8.5	8	45
9.0 to 10.5	10	36
11.0 to 12.0	12	30

Every drilled shaft shall be equipped with thermal wire cables to permit possible integrity testing by T.I.P. The number of drilled shafts to be tested by T.I.P. is six for Bridge No. SUM-76-1148Q, six for Bridge No. SUM-76-1152N, two for Bridge No. SUM-76-1180L, and one for Bridge No. SUM-77-1181. All shafts supporting single-column piers shall be tested by T.I.P. At each multi-column pier, test one of the shafts by T.I.P. At the Forward Abutment of Bridge No. SUM-76-1152N, test two of the shafts by T.I.P. At each abutment of Bridge No. SUM-76-1180L, test one of the shafts by T.I.P. Shafts will be selected for testing as shown in the plans, or as directed by the Department based on construction records, either before casting concrete or immediately after casting concrete. If significant defects are detected, the number of drilled shafts tested may be increased by the Department.

Thermal wire cables shall be aligned with the longitudinal reinforcement of the shaft, and stretched to minimize the wire slack. Tie the thermal wire cables to the reinforcement at a maximum of 3-foot intervals, at locations on the reinforcement that are 90 degrees to the line connecting the reinforcement to the center of the shaft.

3.4 T.I.P. Procedure. Thermal wire cables shall be connected to a Thermal Access Port (TAP) prior to concrete placement. Care shall be taken to record the position of each thermal wire cable in the cage by serial number.

During T.I.P. testing, data shall be collected by the TAP at intervals of 15 minutes for a duration of 30 hours, or as recommended by the T.I.P. Consultant and approved by the Department. The timing interval and duration may be revised by the Department as the project conditions require. In the event peak temperature is not reached within the specified time period, the TAP units shall remain connected to the thermal wire cables for a longer duration as directed by the T.I.P. Consultant. After completion of the data collection period, the TAP shall be connected to the main T.I.P. data acquisition unit and the data files shall be downloaded for inspection of temperatures versus depth.

Potential local anomalies 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, shall be immediately reported to the Department.

3.5 T.I.P. testing results. Results of the T.I.P. tests shall be presented in a written report within 5 working days of completion of testing for each drilled shaft tested. The report shall present results

of T.I.P. tests by including:

1. The final analysis must include top of shaft and bottom of shaft adjustments per the manufacturer's recommendations, so that the temperature plots are adjusted for end effects.
2. Graphical displays of all temperature measurements versus depth.
3. Indication of unusual temperatures, particularly significantly cooler local deviations of the average at any depth from the overall average over the entire length.
4. 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.
5. Variations in temperature between thermal wire cables (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.
6. Shaft-specific construction information (e.g. elevations of the top of shaft, bottom of casing, bottom of shaft, etc.), shall be noted on all pertinent graphical displays.
7. Indicate all possible anomalies in graphical displays and include a summary of all possible anomalies. For each possible anomaly, the summary shall include:
   A. The shaft identification.
   B. Test date.
   C. Time between concrete placement and T.I.P. test.
   D. Thermal wire cable designations that were tested.
   E. Depth below the top of shaft.
   F. A characterization and evaluation of the anomaly.

3.6 Evaluation of Test Results. The T.I.P. Consultant and the Department will evaluate the T.I.P. test results and determine if the drilled shaft construction is acceptable. If the T.I.P. test results indicate possible defects in the drilled shaft, the Department may require coring of the drilled shaft to obtain samples in the area of the possible defect, or excavation of the drilled shaft to examine the condition of the concrete. The Department may require testing of the core samples. The Department will consider the T.I.P. test results, the condition of the concrete as shown by core samples, results of testing on the core samples, and other information when determining the acceptability of the drilled shaft. The Contractor shall not proceed with construction of substructures or structures above a drilled shaft until the Department has accepted the drilled shaft.

If examination of the drilled shaft concrete confirms the presence of a defect in the drilled shaft, then the Department will not pay for coring, testing on the core samples, or excavation costs, even if the drilled shaft is accepted by the Department. If a defect cannot be confirmed by coring, then the Department will pay for coring, testing on the core samples, and excavation costs as extra work according to C&MS 109.05.

If the Department determines a drilled shaft is not acceptable, the Contractor shall submit a plan for corrective work to the Department for acceptance in accordance with C&MS 501.05.D. Have an Ohio Registered Professional Engineer prepare, sign, seal, and date calculations and working drawings for all foundation elements affected by the corrective work plan. In addition to the requirements of C&MS 501.05.D, have a second Ohio Registered Professional Engineer check, sign, seal, and date the calculations and working drawings. The preparer and checker shall be two different engineers.

3.7 Coring of Drilled Shaft Concrete. If the T.I.P. test results indicate possible defects in the drilled shaft, the Department may require coring of the drilled shaft concrete to obtain samples in the area of the possible defect. If the Department requires coring, obtain core samples in accordance with ASTM D 2113 for the full length of the possible defect plus 3 feet above and below the possible defect, or as directed by the Department. Obtain core samples with a minimum diameter of 3.0 inches.

Use either a conventional double-tube, swivel-type core barrel with split liners or a wireline core barrel with split inner liners. Use a new diamond coring bit. Replace the coring bit and core barrel as necessary to achieve a high percentage of core recovery.

Record an accurate log of the coring. Place the core samples in a partitioned core box with a cover and fasteners to prevent accidental opening during handling. Identify the boxes of cores by Project Name, shaft number, depths sampled, box number, and total number of boxes per shaft. Clearly and permanently mark the top and bottom depths below the top of the drilled shaft of each core sample. Securely block the samples in a partially filled compartment to prevent shifting and dislocation. Protect the samples during transport and storage until testing can be accomplished. Submit the core samples and two copies of the coring logs to the Department for evaluation.

3.8 Grouting Holes. After T.I.P. testing and coring of the drilled shaft concrete is complete, remove all water from any cored holes. Fill core holes with grout.

4. **Method of Measurement.** The Department will measure T.I.P. testing by the number of shafts on which T.I.P. testing is performed per the plans (excluding extra testing or analysis required per section 3.3 or 3.7).

5. **Basis of Payment.** Payment shall constitute full compensation for all costs incurred to perform the T.I.P. testing including, but not limited to, procurement, preparation, and installation, conducting the tests, and subsequent reporting of results.

   The Department will pay for accepted quantities, after being provided the written test reports, at the contract price (each) for Item 524 - Drilled Shafts, Misc.: Thermal Integrity Profiler (T.I.P.) Wire Cable Testing of Drilled Shafts.