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Thermal Integrity Profiling for Augered Cast-In-Place Piles – Implementation Plan

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Current Situation

Auger-cast-in-place (ACIP) piles are created when an auger the diameter and length of the desired pile is drilled into the ground. Concrete is pumped through the central axis of the auger as it is withdrawn, pulling up excavated soil as concrete fills the shaft. Steel reinforcement is placed in the still-fluid concrete. The entire process is conducted blind and instrumentation is rarely added to the reinforcing steel giving no way to verify the two key quality control elements that help assure the expected load-bearing performance of the pile: the consistency of the pile's diameter along its length and the positioning of the reinforcement. Because of this, the Florida Department of Transportation (FDOT) restricts the projects in which ACIP piles can be used, despite the advantages of this construction method.

Steel reinforcing cage wired with temperature sensors before placement in concrete pile.

Research Objectives

University of South Florida researchers conducted two projects aimed at developing thermal integrity profiling (TIP) as a quality control method for ACIP piles.

Project Activities

Use of TIP data to derive pile diameter and reinforcement position was developed in a previous project (FDOT Project: BDV25-977-09). In the current project, the researchers explored implementation by testing all aspects of the TIP method, from instrumentation to data analysis and interpretation, on seven full-scale piles, 40 or 60 feet long and 18 or 24 inches in diameter. The piles were reinforced with a full-length, central reinforcement bar and/or a partial-length, reinforcement cage. The TIP instrumentation, including the number and length of thermal wires or access tubes (steel or PVC) for the TIP probe, was dictated by the reinforcement type.

Temperature profiles along the pile length were measured with a thermal probe lowered into an access tube and/or with a series of sensors connected by thermal wires attached to the reinforcement cage. These profiles were measured at various times after casting to show the time evolution of temperature in the concrete. Probe testing would normally be conducted once and, if not out of limits, not repeated; but in these experiments, probe testing was conducted every six hours to compare against the thermal wire measurements, which were monitored continuously. For example, pile temperatures at 5 ft below the ground surface were generally above 90°F at 6 hr and around 130°F at 24 hr. Peak temperatures occurred between 12 to 18 hr for these piles.

Various methods of deriving the pile diameter and reinforcement position from the temperature profile were investigated. The size and shape of one pile, extracted for direct measurement of its diameter for comparison with calculated results, was well predicted by the TIP method. However, the results were very sensitive to the eccentricity of the central reinforcement bar and the accurate determination of grout volumes from construction field logs. For piles larger than 2 ft, use of central bar measurements was not recommended; for these piles, reinforcement cage measurements for thermal analyses were preferred. If central bar measurements are used, the thermal profiling indicated that single bar reinforcement is often eccentric, and tighter controls are needed to maintain its position in the center of the pile (using stiffer, more closely spaced centralizers).

Project Benefits

Good quality control techniques can make ACIP piles usable in a wider range of projects, thus taking advantage of the cost efficiency and high production rates of the technique. Thermal integrity profiling showed promising capabilities to assess the quality and integrity of the as-built piles.

For more information, please see www.fdot.gov/research/.