

Thermal Integrity Profiler – Innovation Description

Thermal Integrity Profiling is a technology that utilizes the heat generated by curing cement (hydration energy) to evaluate the integrity of cast in place concrete foundations such as drilled shafts, bored piles, augered cast-in-place, continuous flight auger piles and drilled displacement piles. The technology may also be used to evaluate the shape of jet grouting columns and diaphragm or slurry walls, or other concrete structures. The expected concrete temperature at any point within the foundation is dependent on the shaft diameter, concrete mix design, time of measurement and distance to the center of the shaft. Regions that are colder than expected are indicative of necks or inclusions - a cross-sectional area smaller than intended for the shaft. Regions that are warmer than usual indicate bulges - an excess of concrete in a particular location. Temperature measurements may therefore be used, along with concreting logs, to estimate the actual shape of the shaft. It is also possible to identify misalignments of the shaft reinforcing cage and estimate the concrete cover along the entire length of the shaft.

The innovation - Thermal Integrity Profiler (TIP) - consists of a system (instrument and accessories) that makes it practical to employ the technology for foundation testing in construction sites. The TIP allows temperature measurements to be taken by two alternative methods. The first method uses a probe fitted with four orthogonal infrared temperature sensors. The probe is inserted in standard plastic or steel access tubes commonly built in drilled shafts to permit testing by cross hole sonic logging, the most prevalent integrity testing method currently used. Tests conducted by this method typically take place at the expected time of peak heat generation - within 12 to 48 hours of shaft installation. The second method includes cables fitted with evenly spaced digital thermal sensors that are attached to the reinforcing cage prior to concreting. Temperature data sampling and storage happens automatically once concrete is poured and the system is initialized; data is downloaded from the system at any convenient time after peak heat generation. Data collected by either system is then analyzed by a proprietary software that displays measured temperatures versus depth, temperatures mapped on cross sections of the shaft, and a three dimensional representation of the foundation.

The Thermal Integrity Profiler is unlike any other system of assessing quality and integrity of cast in place concrete foundations in which it uses a phenomenon - heat generation by curing concrete - not previously used to assess the quality and integrity of cast in place concrete foundations. The Probe Method of the Thermal Integrity Profiler is patented in Mullins, A. G. and Kranc, S. C., (2004), "Method for Testing the Integrity of Concrete Shafts," US Patent 6,783,273. The THERMAL WIRE cable method is patented in: Colton, D., Ference, M., Pisciacko, G., and Rausche, F., (2010) "Pile Sensing Device and Method of Making and Using the Same" US Patent 8,382,369.

TIP has the potential to challenge or replace the prevailing methods of assessing quality of cast in place concrete foundations such as drilled shafts because TIP evaluates the entire foundation element and provides earlier results. Other current methods of integrity testing have limitations. Cross Hole Sonic Logging (CSL) can only evaluate the concrete inside the cage, leaving the concrete cover unexplored. Gamma-Gamma testing assesses only a limited zone near the access tubes. Pulse Echo testing has restriction on length and cannot evaluate the shaft below the first major cross section change. TIP scans the entire shaft for concrete anomalies, both length-wise without maximum length limitations and through the entire cross-section including the concrete cover outside the reinforcing cage. It also shows if the foundation reinforcement is properly aligned, something other test methods cannot do. Lastly, current test methods can only be performed after the concrete of the foundation has cured, a process that takes several days. This sometimes results in construction delays since construction cannot proceed until foundations are approved. TIP, on the other hand, can yield results as early as 12 to 24 hours (depending on shaft diameter).

The thermal integrity profiling technology was developed initially at the University of South Florida (USF). A 2005 USF report to the Florida Department of Transportation described a "preliminary system for recording continuous thermal traces on the interior walls of access tubes." By 2007, researchers at USF issued a final report on that system. A joint effort undertaken by Foundation & Geotechnical Engineering, LLC (FGE) and Pile Dynamics, Inc. (PDI) starting in 2009 incorporated the thermal integrity profiling technology into the instrument Thermal Integrity Profiler (TIP). The instrument was taken to market in 2011.

Naturally, projects that were early adopters of the thermal integrity profiling technology were concentrated in Florida (Marion County Courthouse in Ocala; I-4 SR 42 in Deland; Florida Turnpike in Lake Worth, Tampa Port Authority REK Docks; Jolley Bridge to Marco Island in Naples to name a few). More than 100 shafts were tested by this method in the high profile Crosstown Connector project, a \$613 million dollar mile long elevated section of highway in Tampa. The technology has now been employed in other projects throughout the USA (Governor Williams Highway over Black Creek, Darlington, SC; Nalley Valley SR-16, Tacoma WA; I-465 Ramp "PNP" over Big Eagle Creek, Pier 2 North Bound, Indianapolis, IN; Milwaukee Zoo Interchange, Milwaukee, WI ; I-269 Over Relocated SR 178, Marshall County, MS; Innerbelt Bridge replacement, Cleveland OH, among others). More recently, TIP was used in the Canary Wharf in London, UK, and, in a jet grouting application, in Austria.

Thermal Integrity Profiler – Innovation Illustration



Thermal Integrity Profiler



Thermal probe



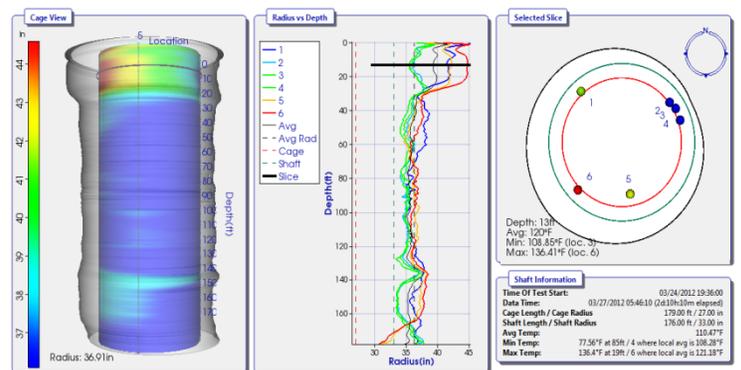
Testing by probe method



Digital thermal sensor on cable



Shaft fitted with THERMAL WIRE cables and data acquisition ports (one per cable)



TIP Reporting software