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New Method to Assess the Quality of Cast-in-Place Concrete Foundations

Gray Mullins, FGE, Garland Likins, PDI and George Piscsalko, PDI

The Thermal Integrity Profiler uses the heat generated by the curing cement to assess the quality of cast-in-place concrete foundations such as drilled shafts, augered cast-in-place (ACIP) or continuous flight auger (CFA) piles. Thermal Integrity Profiling is a method developed in response to the limits that other integrity assessment methods present - each have their unique advantages but may be imperfect in comprehensively evaluating the quality of the foundation.

The integrity of drilled shafts (bored piles) is of vital importance. Low strain integrity testing (also called PIT and Pulse Echo), Cross Hole Sonic Logging (CSL) and Gamma-Gamma logging (GGL) are known integrity assessment methods, and each has its unique advantages. Each of these methods also has limits in evaluating the quality of the foundation: CSL assessments are restricted to the area inside the reinforcing cage, GGL assesses only the area within a few inches of access tube, and PIT results may be limited by shaft length and difficult data interpretation below major non-uniformities. The Thermal Integrity Profiler has been developed in response to these challenges. It uses the heat generated by the curing cement to assess the quality of cast-in-place concrete foundations such as drilled shafts, augered cast-in-place (ACIP) or continuous flight auger (CFA) piles. The Thermal Integrity Profiler (TIP) evaluates concrete quality over the entire cross-section and shaft length. TIP measures temperature either by an Infrared Probe[i] containing 4 orthogonal sensors and inserted into access tubes, or by Thermal Wires™[ii] that have uniformly spaced sensors and are tied to the rebar cage. The recommended number of tubes or thermal wires is the same as for CSL or GGL applications. A single thermal wire is attached to a center rebar to test smaller diameter ACIP or CFA piles. With the Probe Method, temperature data are collected typically 24 to 48 hours after concrete casting. With the Thermal Wire Method data are automatically (and, if possible, remotely) sampled at user defined intervals (e.g. 15 minutes), thereby continuously monitoring the concrete curing process. TIP by either method provides concrete quality data at a very early time, allowing construction to progress more quickly, because engineers no longer need to wait for the concrete to fully cure to assess shaft integrity.

In general, a shortage of competent concrete is registered by relatively cool regions (necks, inclusions or poor concrete); extra concrete (over-pour bulging into soft soil strata) is registered by relatively warm regions. The average temperature at any depth is proportional to the shaft diameter. Temperature measurements at the cage, obtained by either the Probe or Thermal Wire method, may also be used to evaluate concrete cover and cage alignment. The measured temperatures have an almost linear relationship to the concrete cover: if the cage is closer to one side of the excavation (less cover) its temperature is lower than average while sections closer to the shaft center will exhibit higher than average temperatures.

Field measurements alone already highlight significant foundation problems, since a plot of the average temperature versus depth is an approximate image of the shaft geometry. This level of review may reveal cage alignment irregularities, casing or rock socket location, and locations of over-pour bulges or necking. Further refinement of concrete cover location is possible by measuring the gradient between 2 thermal sensors offset over a known, radial distance. Thermal Modeling is the highest level of analysis, estimating temperatures of the entire shaft based on the surrounding soil type, climatic history and specific heat generation for a particular concrete mix. Simulated temperatures are matched to field measurements, generating a probable concrete shape, a 3-D rendering of the as-built shaft, 2-D slices of the shaft cross section at any depths of interest and vertical slices through any radial orientation.

The method of testing employed by Thermal Integrity Profiler was developed at the **University of South Florida** under the direction of the first author, who also directed its practical implementation by **Foundation & Geotechnical Engineering (FGE)** of Plant City, FL. Further research and development is a joint effort of FGE and **Pile Dynamics, Inc.** ■

Thermal testing by probe method

i Mullins, A. G. and Kranc, S. C., (2004), "Method for Testing the Integrity of Concrete Shafts," US Patent 6,783,273
ii Cotton, D., Ference, M., Piscsalko, G., and Rausche, F., (2010) "Pile Sensing Device and Method of Making and Using the Same" Patent Pending

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قامت جامعة جنوب فلوريدا بتطوير طريقة الاختبار التي تستعملها الجانبية الكلية الحرارية . وهذه الأخيرة تستخدم الحرارة التي يبعثها الاسمنت المعالج لتقييم نوعية الأساسات الخرسانية المصبوبة على سبيل المثال حفر الآبار أو الأكوام المصبوبة المثقوبة (ACIP) أو الأكوام المثقوبة السريعة المستمرة (CFA). لقد تمّ تطوير هذه الطريقة من أجل إكمال عمل طرق تقدير الكليّة غير الكافية لتقييم نوعية الأساسات. وتجدر الإشارة إلى أن هذه الطرق تتمتّع بإيجابيات كثيرة ومزايا فريدة.