The Integrity Testing Tool Box

A BRIEF SUMMARY OF THE MOST COMMONLY EMPLOYED TESTS AND INSTRUMENTS

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Owners and design or construction engineers often require that foundation piles or shafts be tested for structural integrity. They are seeking straightforward "yes" or "no" answers from the integrity tests - Is the foundation intact? Is it built to the design specifications? etc...

The problem is, however, that it is not possible to see or touch this important part of a structure and, therefore, the answer is not at all straightforward. Inside the integrity tester's tool box lays a variety of hardware and software. All of them present their own strengths and challenges. Furthermore, many of the tests require considerable experience in data interpretation. Complicating the decision – to the relief or the chagrin of the responsible engineers –are the new technologies entering the playing field. What is the engineer to specify?

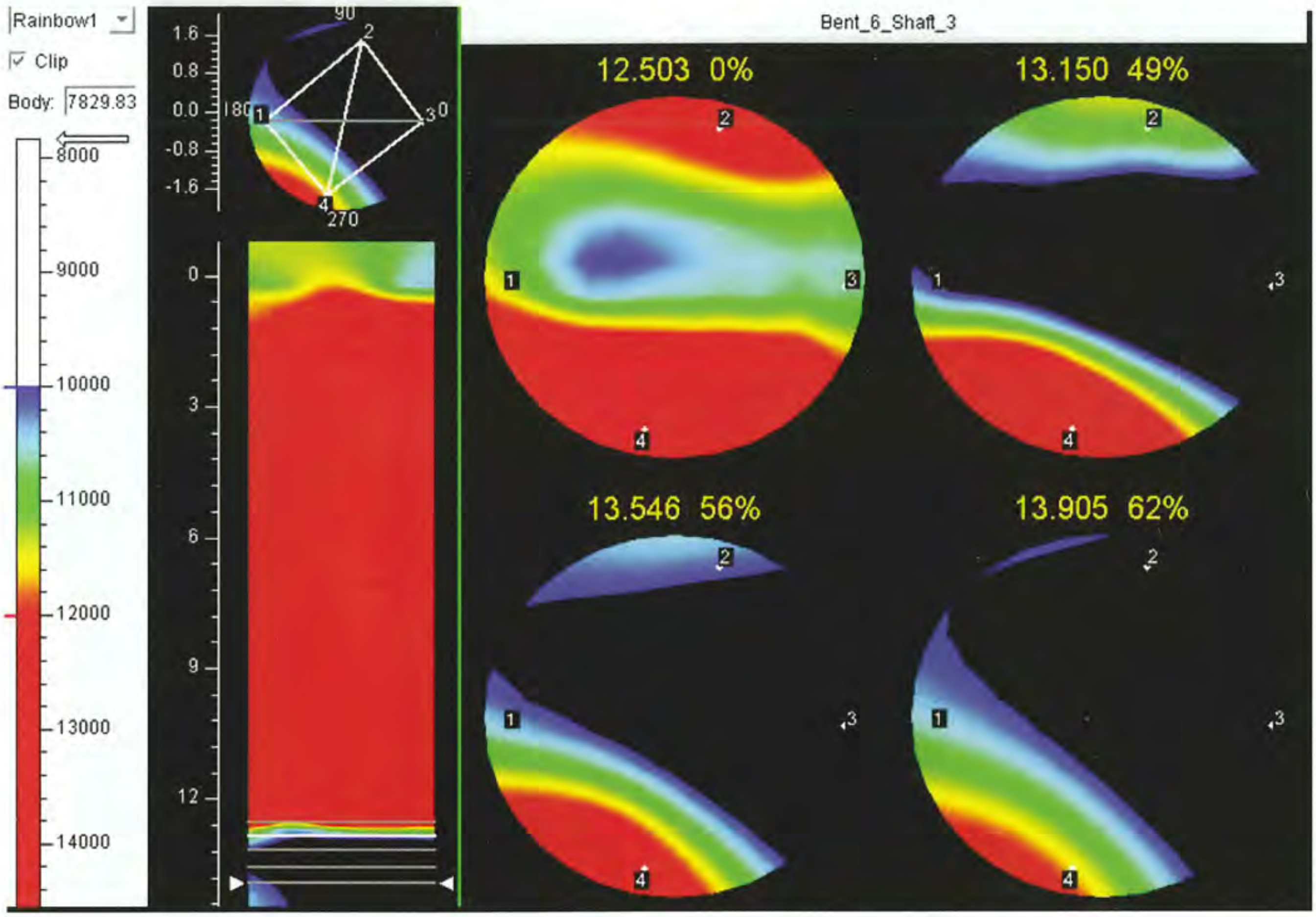
The following is a brief summary of the most commonly employed tests and instruments. Obviously, the array of available tools is ever expanding and all parties involved should have a fairly good understanding of their benefits and limitations.

The Pulse Echo Method – standardized by ASTM 5882 as Low Strain Impact Integrity Testing Method and frequently simply called Pile Integrity Testing, or PIT, can be quickly applied to test most drilled shafts, precast concrete or auger cast-in-place piles. In many countries, construction specifications require a large percentage or all cast-in-situ shafts or piles to be pulse-echo tested, and if doubts about the quality of the foundation arise, the first response is to perform this test. The necessary equipment – see Figure 1 – consists of a small accelerometer, a hand held hammer and a data acquisition unit. The instrument the engineer on Figure 1 is using- PIT-X - transmits data from the accelerometer to the main unit via radio, dispensing with cables or wires.

In a PIT test, a light hammer tap generates a stress wave that can travel 50 metres or more down the foundation, reflect at its bottom, travel back to the top and there, upon arrival, generate a slight but measurable movement from which integrity information can be gathered. Even though the test does not involve much advance planning, it does require proper pile top preparation and use of sensitive equipment with high digital resolution. The Pulse Echo Method can generally provide information about only the first (from pile top) major variation in shaft size or concrete quality. However, particularly where the important upper pile portion is concerned, these limited results can be of great value to the engineer.

In some parts of the world a variation of the Low Strain method in which the hammer is also instrumented with an accelerometer is preferred. This more complex Transient Response Method does not introduce any additional test preparation requirements other than the availability of the instrumented hammer plus two channel data acquisition hardware and software.

Cross Hole Sonic Logging (CSL) does perform better for long and complex concrete shafts, but at a higher cost than PIT requiring access holes inside the deep foundation. CSL testing of cast in place piles, shafts or slurry wall panels, built with access tubes, requires lowering a transmitter into one access tube while simultaneously lowering a receiver into a neighboring tube. The transmitter generates ultrasonic pulses that travel through the concrete to the receiver, the travel time and intensity of the received signal being a func-



tion of concrete quality. Received signals are processed and displayed by CSL equipment such as the Cross-Hole Analyzer by Pile Dynamics and evaluated by a test engineer. Cross Hole Sonic Logging is standardized by ASTM D6760. CSL is more applicable to shaft diameters greater than 600 millimetres, but should also be considered when the pile length to diameter ratio exceeds 30, where PIT records may become complex depending on construction methods and soil properties.

Lacking access tubes, foundation elements that could have been tested by CSL had they been prepared for it, instead end up being tested with the more limited pulse echo method. CSL results, particularly when combined with Tomography, yield a graphical representation of the foundation shape and/or quality. Unfortunately, the CSL method cannot check the concrete quality outside of the reinforcement cage.

A variation of the CSL test is sometimes specified for smaller shafts or augered cast-in-place piles; only one access tube is installed and the method is aptly called Single Hole Sonic Logging.

Gamma-Gamma Logging (GGL) of drilled shafts requires pre-built access tubes, much like CSL does. A probe with a radioactive emitter and detector measures the gamma count rate. Higher gamma count rates indicate lower density - weaker - concrete. GGL results are not limited by the depth of the foundation, and do shed some light on the quality of concrete outside of the reinforcement cage, but only within a 75 millimetre radius of each access tube. Further, because data interpretation is based on statistical variance of the results within a shaft, a shaft with uniformly poor concrete quality may be mistaken for a sound structure.

The latest addition to the Integrity Testing Tool Box is the Thermal Integrity Profiler, which gathers information on concrete quality based on temperature measurements during concrete curing. The sensors that gather data may either be inside probes that are inserted into the shafts through access tubes, or in Thermal WiresTM attached to the reinforcement cage. Thermal Wires measure temperature at discreet locations, typically at one foot intervals. Unlike PIT, but just like CSL and GGL, TIP requires planning, as tubes or Thermal Wires have to be attached to the reinforcement cage prior to concreting. The advantages of this method are twofold. First, it is the testing method that can be performed the earliest among the other ones in the testing tool box. In fact, it must be performed while the concrete is curing and generating heat, shortly after pouring. Second, it is the only available method that covers the entire cross sectional area, both within and outside the reinforcement cage.

So there you have it – tools for integrity testing. Then come test interpretation, often accompanied by the need for hard decisions regarding acceptance, repair or rejection. And then the ultimate – no pun intended – question. How about foundation bearing capacity? A whole other tool box is needed to address that question, indeed. ■