Pile profiling

Dean Cotton, senior electrical engineer at Pile Dynamics, presents a technique for assessing the integrity and quality of drilled shafts and CFA piles

Thermal Integrity Profiling (TIP), developed by Professor Gray Mullins at the University of South Florida, is a method of testing 100% of the cross-section of drilled shafts and continuous flight auger (CFA) piles. The technique measures heat generated during the hydration process and uses it to determine pile integrity.

Foundation-testing equipment manufacturer Pile Dynamics has been demonstrating this technology for two years. Now, with the adoption of American Society for Testing and Materials (ASTM) Standard D7949, it is gaining interest worldwide.

Previous testing methods could not evaluate the entire cross-sectional area of a pile. Crosshole sonic logging (CSL), for example, could only test between tubes installed on the rebar cage. With TIP, the sensor wire is mounted to the cage in the area where a tube normally would be installed. The wire then sends temperature measurements to a data-collection device. Analysis of the data can determine the amount of concrete cover on the outside of the cage.

MEASUREMENT METHODS

Ohio-based Pile Dynamics has developed two measurement methods for TIP: one uses a thermal probe passed through dewatered access tubes, and the other has Thermal Wire brand cables attached to the reinforcing cage. The thermal probe is lowered down the access tube as temperature is recorded as a function of depth. This measurement is made near the expected peak in hydration temperature (typically 12 to 48 hours after pouring, estimated by pile diameter and concrete mix.

The wired method uses Thermal Wires that are attached to the reinforcing cage before installation in the shaft. The wires are placed equally spaced around the reinforcing cage with one wire for every 300mm (1ft) of pile diameter, attached to the cage with plastic wire ties. A data logger is attached to the top of the wire after pouring is complete. It stores the temperature reported from every sensor along the wire, with readings taken every 15 minutes.

After the peak temperature has occurred, the data can be downloaded for processing and analysis. If it is found that the shaft has not yet reached its peak temperature, the logger can be returned to the wire for further collection.

The basic data output in both probe and wire methods shows temperature versus depth for each of the wires or access tubes. Areas of lower than average temperature indicate a lack of concrete or poor concrete quality. Conversely, higher temperatures indicate a bulge. The TIP can also give information about the alignment of the reinforcing cage. If the cage is not placed concentric in the shaft, the side of the cage closer to the shaft core will have a higher temperature while the opposing side, which is closer to the soil interface, will have a lower temperature.

Further analysis in the TIP Reporter software can be made from the concrete-volume field log. The program can estimate shaft diameter at all locations, as well as the amount of concrete covering the reinforcing cage.

DRILLED SHAFT

The example shown in Figure 1 is the data from a 50m (165ft) shaft, 1.7m (66in) in diameter, with the top 8.5m (28ft) oversized with a 2.1m (84in)-diameter temporary casing. The elevated average temperature on the upper 8.5m clearly shows the increase in cross-sectional area from the oversized casing. The data also shows that in the upper 21m the cage is slightly offset from the centre of the shaft.

Figure 2 shows the three-dimensional drawing of the shaft created by the program with the bulge extending out on one side of the shaft. The shaft was later excavated, and as seen in Figure 3, the thermal results reflect its actual shape. In addition, the radius of the bulge was measured, and it matched the TIP predicted radius.

Many days after pouring, a CSL test was performed on this shaft, indicating no anomalies. The test could not evaluate concrete cover or cage alignment, but did verify that the integrity of the shaft's central section was good.

CFA PILE

The TIP test can also be applied to CFA piles by installing a single Thermal Wire on the centre reinforcing bar. After the concreting of the pile is completed, the instrumented centre bar is placed in the pile and the data logger is connected.

In Figure 4, the data from a 22m (73ft)-long, 45cm (18in)-diameter CFA pile is shown. The data suggests a bulge around 12m (40ft) down, but with the pile returning to its nominal diameter below that. Figure 5 is a graphical representation of the pile.

A low-strain integrity test was done on this pile, and the results did not indicate the bulge and could not see the bottom of it, as no clear toe reflection was present. The TIP result can test the entire pile and indicate changes in the cross-sectional area throughout the length of the pile. ▼

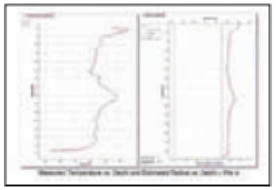

Figure 1: Data from a 50m drilled shaft (1.7m in diameter, with the top 8.5m oversized and bearing a 2.1m-diameter temporary casing)

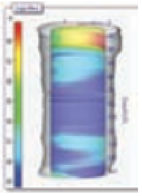

Figure 2: 3-D drawing of the shaft

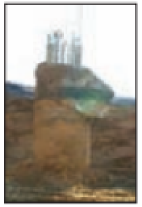

Figure 3: Excavated shaft

Figure 4 (above): Data from a 22m-long, 45cm-diameter CFA pile

Figure 5 (left): Graphical representation of the CFA pile