



DID YOU KNOW?

With SiteLink® Technology an engineer performs real-time field-to-office Pile Driving Monitoring or Dynamic Load Testing data transmission via the internet- saving time and money.



Newsletter No. 87 - March 2018

Pile Diameter Modeled Using Thermal Integrity Profiling Verified with Extracted Pile Measurements

By Daniel Belardo and Camilo Alvarez, P.E.

By definition, any type of drilled deep foundation is buried in the ground, hiding its constructed shape from visual inspection. This complicates the quality assurance process, leaving reasonable potential foundation performance questions. Fortunately, a very quick, reliable, and convenient means of indirect cast-in-situ pile visualization is available: The Thermal Integrity Profiler or TIP.

Thermal Integrity Profiling is a non-destructive integrity test method used for evaluating the post-construction quality of cast-in-place foundations. This method uses the temperature measurements, or hydration energy, from the curing cement to assess integrity. These measurements are obtained using embedded Thermal Wire® cables attached to the reinforcing cage for drilled shafts or to a center bar for smaller diameter auger cast-in-place (ACIP) piles. In general, reductions in temperature correlate to reductions in the effective radius or the presence of lower quality concrete/grout. Increases in temperature correlate to increases in cover or areas of increased cross-section. TAP boxes automatically record the temperature every 15 minutes at each thermal sensor location (one foot or 300 mm depth increments). This process is typically complete within 10 to 48 hours after initial concrete/grout placement.

On a project in Los Angeles, California, GRL Engineers, Inc., contracted by [Shoring Engineers](#), was given a rare opportunity to observe the entire ACIP pile after construction. Project specifications required both a static load test to determine the bearing capacity and shaft resistance distribution (using embedded strain gages), and TIP for pile integrity evaluation. After completion of the tests, the contractor extracted the pile for inspection (**Figure 1**) and comparison with the TIP predicted pile shape, as shown in **Figure 2**.

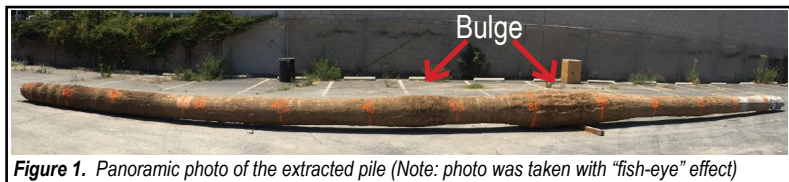


Figure 1. Panoramic photo of the extracted pile (Note: photo was taken with "fish-eye" effect)

The installed pile had a planned pile diameter of 18 inches (450 mm) and a length of 65 feet (19.8 m). The reported soil profile consisted of lean clay (CL) from 0 to 23 feet (7.0 m), underlain by silty sand (SM) from 23 to 40 feet (7.0 m to 12.2 m), and then again lean clay (CL) to the pile base. The center bar was instrumented from 0 to 62 feet (18.9 m) with a single Thermal Wire® cable. The installed grout volume was reported to be 5.4 cubic yards (4.1 cubic meters) or approximately 127 percent of the theoretical volume.

The as-constructed pile diameter was calculated using circumference measurements at one foot intervals from 5 to 62 feet (1.5 m to 18.9 m) below pile top. These visual inspections and field measurements indicated a relatively uniform pile from 5 to 21 feet (6.4 m) and from 40 feet (12.2 m) to the pile base. A sizable increase in the pile cross section was observed from 25 to 30 feet (7.6 m to 9.1 m). A second, smaller bulge in the pile was observed near 37 feet (11.3 m).

The "T-Soil" analysis method was utilized to calculate the effective pile diameter (**Figure 2**) which is correlated from the measured temperature

and total grout volume. This T-Soil method is recommended for single-wire (i.e. center bar) applications on piles up to 24 inches (610 mm) in diameter. It differs from the analysis technique used for drilled shafts where temperatures are typically monitored on a reinforcing cage rather than a central location. A plot of the Effective Diameter vs. Depth based on both TIP and circumference measurements is presented in **Figure 2**. Overall, the effective diameter based on the TIP results deviated by approximately 2% from the actual measurements over the instrumented length of the center bar.

Where shaft resistance has to be calculated from strain values measured during a static load test, a reasonably accurate pile cross sectional area is important. The accuracy of the TIP calculated effective diameter surpasses that of simply assuming a uniform pile, which often times becomes conventional practice without any additional information available.

Naturally, TIP is an indirect evaluation method and there are potential error sources such as an inaccurate reported total grout or concrete volume, or a center bar which is not placed near the center of the pile (thus yielding a non-centralized Thermal Wire cable). However, with proper care, these error sources can be easily minimized with reliable results obtained within a very short time of concrete/grout placement. The experienced test engineer can also detect whether or not the center bar was properly installed from the temperature vs. depth profile. If within a few hours after concrete/grout placement TIP suggests a pile bulge, then appropriate remedial actions can be promptly implemented (e.g. another static test pile can be selected) avoiding costly test duplications or construction delays.

It is hoped that more opportunities for pile extraction and shape comparisons will occur in the future. In this way the profession will gain confidence in the various testing methods which may benefit owners, engineers and contractors with a higher level of confidence in the foundation and, therefore, better economy.

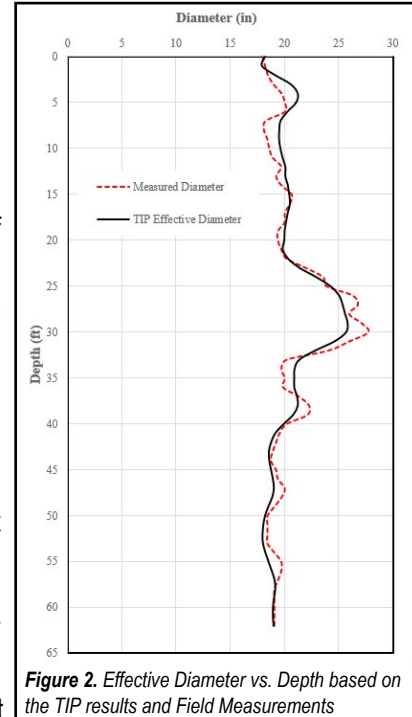
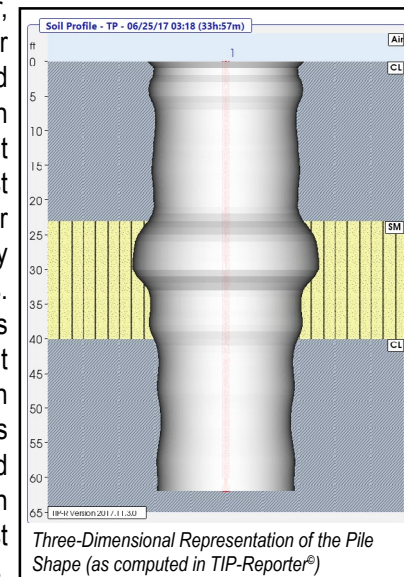


Figure 2. Effective Diameter vs. Depth based on the TIP results and Field Measurements



Three-Dimensional Representation of the Pile Shape (as computed in TIP-Reporter®)

State of Practice: Quality Control of Deep Foundations Workshop Tour

PDI is hosting One Day Workshops throughout the US and Canada to review the importance and benefits of Deep Foundation testing from pre-installation to post-installation, the economics and codes involved. The workshops offer 6.5 PDHs and the ability to take the PDA Proficiency Test in most cities. However, space is limited to the first 30 registrants.

- Assess capacity of drilled shafts by various field testing applications including Dynamic Load Testing, Static Load Tests and Bi-Directional Load Tests
- Assess integrity of drilled shafts by various NDT methods including Crosshole Sonic Logging, Low Strain Integrity Testing, Thermal Integrity Profiling and other inspection methods
- Learn the advantages and limitations of various integrity and capacity methods in drilled shafts, while choosing the appropriate methods for each analysis
- Understand basic concepts of PDA testing and advancements in Dynamic Load Testing
- Learn the appropriate interpretation of integrity testing results and the integrated method of data collection, processing, management and presentation of results

PDI's industry pioneers and experts will be instructing the workshops and discussions. Choose the location that's right for you. Register today!

[BOSTON](#) – 3/20/18

[MEMPHIS](#) – 9/11/18

[HARTFORD](#) – 3/21/18

[KANSAS CITY](#) – 9/13/18

[NEW YORK CITY](#) – 3/23/18

[CHICAGO](#) – 9/14/18

[TORONTO](#) – 4/24/18

[RALEIGH, NC](#) – 11/13/18

[OTTAWA](#) – 4/26/18

[COLUMBIA, SC](#) – 11/14/18

[MONTREAL](#) – 4/27/18

[ATLANTA](#) – 11/15/18

"...This workshop was excellent. George, Garland and Ryan were great. Their respective presentations were very informative as was their response to the many questions. Their answers... were sprinkled with related incidents and anecdotal references... They were at ease with the topics and attendees, which to me, indicated they are truly experts in their field...This workshop had a great value and was very professionally presented! Thank you!"

- David W. Patterson, PE, PLS, Sec., Susquehanna Supply Co., Inc.



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Upcoming Events

Complete list of 2018 events available at www.pile.com/events

MARCH

5-9: IFCEE (Booth #136 & 138)

13-14: **Webinar: Dynamic Pile Testing for Non-PDA Users** ([Register Today!](#))

20-23: **Workshops: QC of Deep Foundations: Boston, Hartford and Manhattan** ([Register Today!](#))

21-23: Design Build in Transportation (Booth # 707)

26-28: The Big5 Heavy, Dubai

27: **Webinar: Accelerated QC of Drilled Shafts Prior to Casting** ([Register Today!](#))

APRIL

3-6: International Offshore Wind Partnering Forum

11: **Seminar: Deep Foundation Integrity Testing & Wave Equation Analysis in Orlando, Florida** ([Register Today!](#))

12-13: **Workshop: High Strain Dynamic Foundation Testing and Proficiency Test in Orlando, Florida** ([Register Today!](#))

17-18: **Webinar: Wave Equation Analysis / GRLWEAP part 1** ([Register Today!](#))

19-20: Construction Congress (Vienna, Austria)

24-25: **Webinar: Wave Equation Analysis / GRLWEAP part 2** ([Register Today!](#))

24-27: **Workshops: QC of Deep Foundations: Toronto, Ottawa, and Montreal** ([Register Today!](#))

MAY

2: **Webinar: QC of ACIP and CFA Piles** ([Register Today!](#))

8: **Seminar: Deep Foundation Integrity Testing & Wave Equation Analysis in Calgary, Alberta** ([Register Today!](#))

9-10: **Workshop: High Strain Dynamic Foundation Testing and Proficiency Test in Calgary, Alberta** ([Register Today!](#))

17: **Webinar: All Driven Piles- ASCE**

22-24: **Workshop: QA/QC of Deep Foundations; PDA Training and Proficiency Test in Paris** ([Register Today!](#))

GRL at IFCEE: Deep Foundation Testing Sessions

GRL Engineers, Inc. will be sharing their experiences in Deep Foundation analyses via short courses, papers and panel participation at the upcoming International Foundations Congress and Equipment Expo, March 5-10 in Orlando, Florida. To learn more on each topic, or to continue the conversation please visit us at **Booth 136**.

Thursday, March 8, 2018 – PAPERS/PANEL

TECHNICAL SESSION 7 – 8:30am – 10:30 am – Sabal Ballroom

- *Savings from Testing the Driven Pile Foundation for a High-Rise Building*, Van Komurka, P.E., D.GE.
- *Bonner Bridge Replacement Project – Pile Driving Experience*, Scott Webster, P.E.

TECHNICAL SESSION 9 – 8:30am – 10:30 am – Sabal Ballroom

- *50 Years of FHWA Geotechnical Panel*, Garland Likins, P.E.

TECHNICAL SESSION 17 – 10:30am – 12:00 pm – Sabal Ballroom & Citron East

- *State of Practice and Advances in Quality Control Methods from Drilled Shafts*, George Pisciacko, P.E and Pat Hannigan, P.E.
- *Recommendations of Two Acceleration Measurements with Low Strain Dynamic Test*, Marty Bixler, P.E.
- *Quantitative Assessment of Drilled Shafts Base Cleanliness Using the Shaft Quantitative Inspection Device (SQUID)*, Rozbeh Moghaddam, PhD, P.E. and Pat Hannigan, P.E.

Friday, March 9, 2018 – 8:00am – 9:30am

TECHNICAL SESSION 36 - Sabal Ballroom & Citron East

- *Driven Piles: A Solution for Difficult Soil and Site Conditions*, Mohamad Hussein, P.E.

In addition to the above, GRL **Booth 136** will feature Bi-Directional Load Test with the GRL Cell, along with a vast array of Deep Foundation solutions.

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