DID YOU KNOW?

On average, the foundation of a structure forms 15% of its total weight.

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New Drilled Shaft Testing Methods Help Expedite Bridge Construction in West Virginia

by Seth Robertson, PhD, P.E. and Michael Sharp, P.E.

Commonly, drilled excavations are used to support large axial and lateral loads. The constructed drilled shaft's quality is critical because of the heavy foundation loads and limited foundation redundancy. It is important to evaluate that the shaft's shape, vertical alignment, base cleanliness, cage alignment, concrete cover, and concrete integrity are within the design requirements and intent via available quality assurance methods.

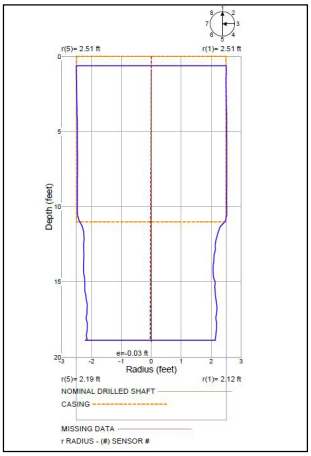
Pile Dynamics, Inc. (PDI) has developed several quality control methods which offer owners, engineers, and contractors innovative and powerful tools for testing drilled shafts. Quality assurance of the shaft prior to concrete placement can be evaluated with the Shaft Area Profile Evaluator (SHAPE), which assesses vertical alignment and excavation geometry, and utilizing the Shaft Quantitative Inspection Device (SQUID) to measure the debris thickness at the shaft bottom. The Thermal Integrity Profiler (TIP) assesses shaft integrity, concrete cover and cage alignment.

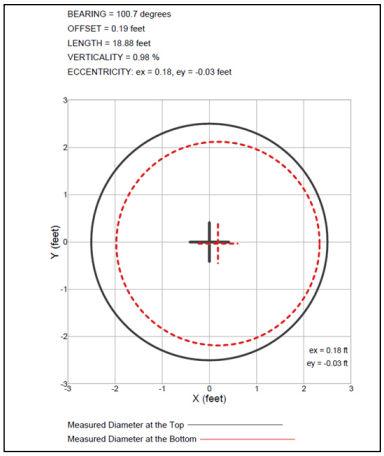
Currently, GRL Engineers, Inc. (GRL) is utilizing SHAPE, SQUID and TIP on several bridge projects for the West Virginia Division of Highways (WVDOH). One project is the replacement of the *Dingess Street Bridge* in Logan, WV. Foundations for this structure consist of 60-inch diameter drilled caissons with 48-inch diameter rock sockets. Permanent steel casing was used above the rock socket.

Drilled Shaft Profile and Verticality Evaluation (SHAPE Testing)

Because the drilled shaft excavations for this project were completed using drilling slurry, it was not possible to visually inspect the hole prior to concreting. In this type of installation, the rock socket sidewalls are frequently profiled to determine the shaft shape. Most traditional sidewall profiling devices are time consuming and lack sufficient resolution. The SHAPE quickly and effectively profiles the sidewalls in a wet-cast drilled shaft excavation using high frequency ultrasonic pulses. It also provides an evaluation of the overall verticality.

On this project, the SHAPE was quickly connected to the drill rig's Kelly bar and then lowered into the excavated shaft while transmitting and receiving signals, which measured the distance to the side wall. Simultaneously, data was collected from all ultrasonic sensors every second while the SHAPE was lowered and raised through the excavation. After data collection, the SHAPE generated plots depicting the geometry and verticality of the excavation, as shown. Typically, a SHAPE test takes less than 15 minutes. Testing indicated deviations from vertical ranging from 0.58 to 1.47%, which were less than the maximum 1.50% deviation allowed.

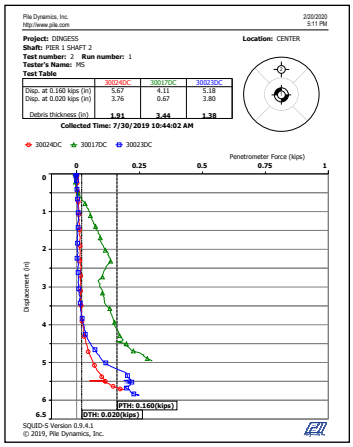


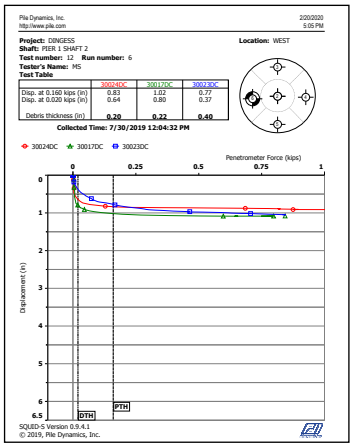


Data output from SHAPE tests

Drilled Shaft Base Cleanliness Evaluation (SQUID Testing)

The base cleanliness of drilled shaft excavations is typically evaluated prior to concrete placement to determine if it meets design specifications. Shaft excavation base cleanliness requirements vary depending on the design and expected load transfer mechanism, the bearing materials, and excavation construction methods (e.g. wet versus dry excavation). The *Dingess Street Bridge* project required that a minimum of 70% of the base have less than 0.5 inch (1.27 cm) of sediment at concrete placement and that the sediment depth did not exceed 1.5 inches (3.81 cm) at any location.





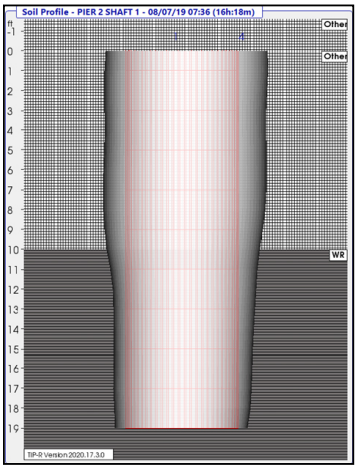
To evaluate the debris thickness layer, the SQUID measures the force of three penetrometers as a function of the movement of displacement sensing plates. Like the SHAPE, the SQUID was quickly deployed by attaching it to the drill stem or Kelly bar of the drill rig following excavation bottom clean-out activities. The device was then lowered to the excavation's bottom, and measurements were taken at the center, as well as in the North, South, East, and West quadrants of each excavation. Each test is typically completed within 15 minutes. The testing engineer remained at a safe distance from the shaft excavation, while the hand-held SQUID tablet revealed real-time output results. The SQUID's quick deployment and ability to produce immediate display results allowed for test completion with minimal interruption to construction.

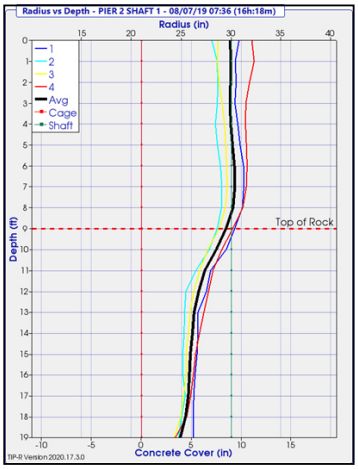
For one shaft, the debris thickness initially exceeded the project specifications; as shown above in the sample results. As a result, additional clean-out measures were required. The results, displayed as the individual penetrometer force versus vertical penetration displacement, indicated significantly different force-displacement behavior before (above left image - 5 inches - 125mm) and after (above right image - less than 0.5 inches - 12.5mm) shaft base cleaning.

Thermal Integrity Profiling (TIP Testing)

Thermal Integrity Profiling is a non-destructive testing technology that utilizes the temperature generated by curing cement (hydration energy) to assess the quality of cast-in-place concrete foundations. Thermal integrity results are best analyzed from a few hours after concrete placement to the time of the peak temperature. Depending on the shaft size, peak temperature generally occurs 18 to 24 hours after placement. During curing, a shortage of competent concrete (necks,

inclusions, or low cement content) is often indicated by relatively cool regions. Conversely, the presence of extra concrete (e.g. bulge) is indicated by relatively warm regions. Compared to conventional integrity test methods, TIP greatly shortens the time from shaft construction to shaft acceptance. It allows for an evaluation of the concrete outside the reinforcing cage and at the shaft base within a few hours of concrete casting.





For the *Dingess Street Bridge* project, four Thermal Wire® cables, with thermal sensors located one foot apart, were attached around the reinforcing cage at approximately equidistant locations. After cage placement, TAP-Edge data loggers were attached to the Thermal Wire cables and automatically collected temperature data from each wire every 15 minutes from the time casting began until the shaft peak temperature was reached. Automatically, the data from each TAP-Edge was sent to the cloud where a GRL engineer remotely assessed the data for analysis. Results of the analyses included graphical displays of measured temperatures versus depth, as well as shaft shape or integrity and the relative location of the reinforcing cage. Thermal Integrity Profiling on these shafts did not indicate any integrity issues, and all shafts for this project were categorized as Satisfactory.

In summary, GRL implemented SHAPE, SQUID, and TIP testing methods on rock-socketed drilled caissons on the *Dingess Street Bridge* replacement project in Logan, WV under the WVDOH. The testing program accommodated the required construction timelines with quick turnaround of testing results. These methods proved to be highly effective tools for quality assurance of rock-socketed drilled caissons.

PDI/GRL Team Up for 2020 Seminar Tour

Over the past few years, Pile Dynamics, Inc. has conducted State of Practice One-Day Seminars throughout the United States. In 2020, PDI and GRL have joined forces to expand the Seminar focus. The ***State of Practice: Benefits, Methods, Risks and Implementation of Deep Foundation QC Practices*** Seminar's main sessions include:

Session 1: Benefits, Methods and Implementation of Testing

Session 2: Test Methods and their Interpretations

Session 3: Illustrative Examples and Cost Benefits

Session 4: Testing Qualifications & Specifications

The State of Practice Seminars offer 6.5 professional development hours (PDHs) for designers, specifiers, owners, structural engineers, geotechnical engineers, risk managers, or anyone involved in a deep foundations project looking to optimize construction time and money. A combination of lecturers will include George Piscsalko, P.E., Patrick Hannigan, P.E. and/or Ryan Allin, P.E. as well as various GRL Engineers presenting case studies specific to each geographic area.

The 2020 Seminar Tour will visit Houston, TX and Dallas, TX in March; Nashville, TN in September; New York City; Boston, MA, and Philadelphia, PA in October; and Toronto and Calgary, Canada in November. These Seminars demonstrate how testing of Deep Foundations improves the safety for site personnel while assessing the reliability of the foundation, and thus lowering the inherent risks.

Upcoming Events

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

March

11: **State of Practice Seminar**: Orlando, FL (Register)

12-13: **Workshop**: High Strain Dynamic Foundation Testing and Proficiency Test- Orlando, FL (Register)

24: **Webinar**: Basic Principles of High Strain Testing and Understanding Results with Ryan Allin (Register)

24: **State of Practice Seminar**: Houston, TX (Register)

26: **State of Practice Seminar**: Dallas, TX (Register)

26-28: **Workshop**: Quality Control/Quality Assurance of Deep Foundations- Guwahati, Assam, India (Register)

April

5-8: **SEI Structures**: St. Louis, MO, Booth #248

20-23: **IPF Wind**, Providence RI. Booth #213

22-24: **Design Build 2020:** Dallas, TX, Booth #905

May

7-9: **PDCA Annual,** Phoenix, AZ, Booth #23

20-23: **SW Geotech,** Austin, TX, Booth # 10

25-27: **Baltic Sea Geotech Conference,** Helsinki, Finland

June

3-5: **SuperPile**: St. Louis, MO

GRL Welcomes Two New Engineers

Jourdan Labonte, E.I.

GRL Engineers, Inc. proudly announces the addition of two engineers to its team.

Jourdan Labonte, E.I. joined the GRL-Texas office in early January. Previously, he worked for Thurber Engineering in Calgary, Canada, where he provided geotechnical engineering analyses on energy and infrastructure projects. Jourdan received his BSCE from the University of Alberta, and his Masters of Engineering from the University of British Columbia. Welcome Jourdan!

Christopher McCann, E.I.

Christopher McCann, E.I. joined the GRL-Central staff, but will be in the Texas office. His experience includes 9 years of heavy civil construction with PCL Civil Constructors in Tampa, FL. Recently, he performed contract inspection work for FEMA, inspecting roads and bridges damaged by Hurricane Harvey. Welcome Christopher!

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