DID YOU KNOW? *Newsletter No. 99 - September, 2021*

Only 22 people throughout the world have achieved the highest ranking of Expert for the PDA Proficiency Test.

GRL Engineers, Inc. | Pile Dynamics, Inc.

SHAPE®ing the Future of Drilled Shaft Verticality and Geometry

By Ben White, P.E. and Patrick Hannigan, P.E.

The drilled shaft industry is incredibly innovative in methods to excavate a shaft, install a rebar cage, and place concrete. Ground conditions can pose numerous challenges. From equipment consisting of basic augers and barrels to reverse circulation drilling of large diameter shafts and bored piles in extremely hard rock formations, the industry's equipment, tooling, and methods have developed to overcome these challenges. In addition, advancements in quality control and quality assurance technology have resulted in highly reliable and improved foundation performance.

Drilled shaft verticality and geometry are often of particular interest and the focus of QA/QC requirements. Ensuring a shaft meets the verticality requirements reduces unexpected moments and stresses not accounted for in the design. Monitoring verticality also reduces the risk of openings in tangent shaft walls or at slurry wall panel interfaces. As shown below in **Table 1**, verticality requirements for drilled shafts and walls typically range from 1 to 2% based on governing specifications, bearing materials, and construction equipment.

Specification or Code	Verticality
US FHWA Guide Specification, Brown et. al., (2018)	• within 1.5% of plumb in soil (bored piles) • within 2.0% of plumb in rock (bored piles)
ICE Specification for Piling and Embedded Walls (2017)	• within 1.33% of vertical (bored piles) • within 1.0% of vertical (walls w/ cable grab) • within 0.7% of vertical (walls w/ hydraulic grab) • within 0.4% of vertical (walls w/ reverse circulation mill)
Eurocode EN 1536:2014 (2014)	• within 2% of vertical (bored piles)
Australian Standard AS-2159-2009 (2009)	• within 1% of vertical (bored piles)

Table1. Summary of Verticality Requirements for Bored Piles and Diaphragm Walls

Reliable verticality and profile information prior to concrete placement is important so that corrections, if necessary, can be made. Shaft or wall geometry measurements provide information on any unexpected construction occurrences such as bulges, cave-ins, and rock socket or panel misalignment. This geometry information can also be used to provide an estimate of the required concrete volume to fill the drilled shaft or wall excavation.

The Shaft Area Profile Evaluator (SHAPE®) is an effective tool for evaluating verticality and geometry. **Figure 1** displays the SHAPE devices in use. The 8-ultrasonic sensor SHAPE® (left) is applicable for wet and slurry filled excavations and the 8-LIDAR sensor SHAPE®-AIR (center) for dry excavations. The SHAPE devices store the data in on-board memory which can be downloaded and displayed on a tablet in the field for onsite assessment. If desired, a cable can be attached to the SHAPE device so that the data is displayed in real time. The 30 to 85 lb (14 to 39 kg) devices can be deployed using a drill rig's Kelly bar for easy set-up and quick testing or by utilizing an independent motorized winch system for construction equipment free operation and testing.

Figure 1. Kelly bar mounted SHAPE® (left) and SHAPE®-AIR (center) and winch-controlled SHAPE® with data transfer cable (right) testing drilled shaft excavations

The proprietary SHAPE software provides result profiles for drilled shafts or bored piles. For rectangular barrettes and walls, the data can be exported to Excel for evaluation. Profiles for a drilled shaft are presented in **Figure 2**. The drilled shaft is clearly drifting towards the northwest with depth. The calculated eccentricity in Profiles 5-1, 7-3, and 8-4 ranged from 0.18 to 0.27 m (0.59 to 0.88 ft). The maximum calculated base eccentricity in the x direction of -0.20 m and in the y direction of 0.18 m results in a verticality of 2.91%. This exceeds the magnitude allowed for drilled shaft or bored piles in any of the specifications listed in **Table 1**.

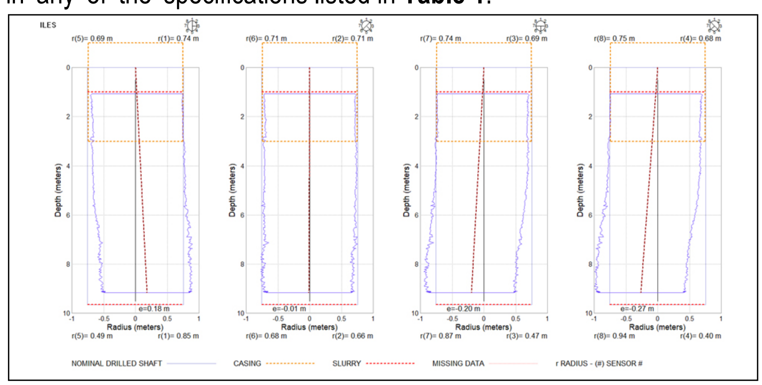


Figure 2. N-S, NE-SW, E-W, and SE-NW profiles of radius vs depth through drilled shaft

On a recent drilled shaft project, the drilling contractor was having difficulty keeping the base of the drilled shaft clean prior to concrete placement. The shaft was installed using a 50.5-inch (1283 mm) inside diameter casing that extended to approximately 2.4 ft (0.7 m) above the bedrock surface. The lower 8.8 ft (2.7 m) of the 84.5 ft (33.3 m) long shaft consisted of a 42-inch (1067 mm) diameter rock socket. A SHAPE profile from the project is presented in **Figure 3**. The orange rectangle depicts the casing which terminates at a depth of 73.3 ft (22.3 m) below grade. The red rectangle identifies the profiled shaft length starting at the water surface within the cased zone of the drilled shaft at 56 ft (17.1 m) and extending through the rock socket below the casing. The increased shaft radius or bulge immediately below the casing resulting from the cave-in below the casing and above the rock is apparent in the radius profile. With this information, the contractor was able to remedy the situation and successfully install the shaft.

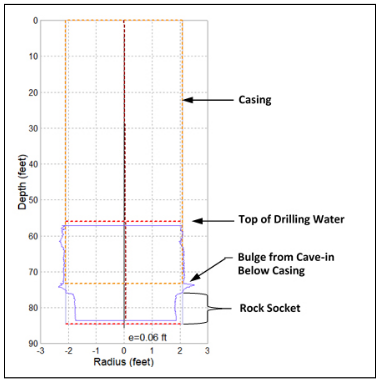


Figure 3. Annotated SHAPE Profile

For Additional information on SHAPE, visit pile.com/shape. To see SHAPE in action on a high-speed rail project in Fresno, CA, view Drill Tech Drilling & Shoring, Inc. video covering 150+ piles being installed across the state.

References:

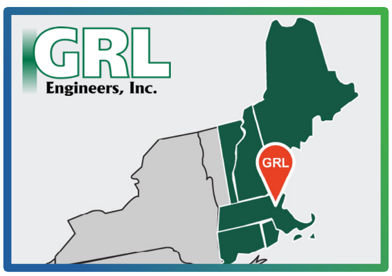
Australian Standard, AS 2159—2009, (2009). Piling—Design and installation, Standards Australia Committee CE-018, 90 p.

Brown, D.A., Turner, J.P., Castelli, R.J., and Loehr, E.L., (2018). Drilled Shafts: Construction Procedures and Design Methods, Geotechnical Engineering Circular No. 10, FHWA Report No. FHWA-NHI-18-024, National Highway Institute, U.S. Department of Transportation, Federal Highway Administration, Washington DC, 754 p.

Eurocode EN 1536:2014 (2014).

ICE Specification for Piling and Embedded Retaining Walls, Third Edition, (2017). ICE Publishing.

GRL Opens Massachusetts Office



GRL Engineers, Inc. opens its 13th office location in Massachusetts. The new office staff includes GRL Senior Engineer, Seth Robertson, Ph.D., P.E. Seth is a registered professional engineer in Massachusetts and holds an Advanced-Level rating on the PDCA/PDI Dynamic Measurement and Analysis Proficiency Test. The GRL-MA office will service deep foundation testing and analysis projects in Vermont, New Hampshire, Maine, Massachusetts, Rhode Island and Eastern Connecticut. Contact Seth at GRL-MA@ grlengineers.com for additional information.

Upcoming Events

Sep 26-29	**Conference: CGS GeoNiagara, Niagara Falls, Canada** *Visit Conference Website*
Oct 4, 5, or 7	**Webinar Series: QA/QC Remote Testing Continue Project Timelines** *October 4th at 11:00am EST Registration* *October 5th at 9:00pm EST Registration* *October 7th at 9:00am EST Registration*
Oct 13-15	**Conference: DFI Annual, Las Vegas, NV** *Visit PDI Booth #423*
Oct 22	**Webinar: PDA Practices Q&A** *Register Today*
Oct 28	**Webinar: Basics of High Strain Dynamic Testing** *Register Today*
Nov 3	**Seminar: Deep Foundation Integrity Testing and Wave Equation Analysis, Cleveland, OH** *Register Today*
Nov 4-5	**Workshop: High Strain Dynamic Foundation Testing, Cleveland, OH** *Register Today*
Nov 5	**Seminar: State of Practice - QC of Deep Foundations, Philadelphia, PA** *Philadelphia Registration Form*
Nov 9, 10, 16 & 17	**Webinar: Wave Equation Analysis of Piles using GRLWEAP14** *GRLWEAP Registration Form*
Nov 12	**Webinar: TIP Practices Q&A** *Register Today*
Nov 15, 16 or 18	**Webinar Series: QA/QC of Drilled/Bored Piles** *November 15th at 11:00am EST Registration* *November 16th at 9:00pm EST Registration* *November 18th at 9:00am EST Registration*
Nov 16	**Seminar: State of Practice - QC of Deep Foundations, Nashville, TN** *Nashville Registration Form*

Inaugural Recipient of the Goble Rausche Likins Scholarship Announced

Trevor Curran is the inaugural recipient of the Goble Rausche Likins Scholarship through the DFI Trust. The fund honors George G. Goble, Frank Rausche and Garland E. Likins who are the founders of GRL Engineers, Inc. (GRL) and Pile Dynamics, Inc. (PDI).

This scholarship not only seeks to honor the legacy of these pioneers' transformational work in the deep foundation sciences and industry over the past half century, but also to endow their vision to the next generation of engineers so that it remains ever dynamic and unceasing.

Mr. Curran is a Senior, studying Civil Engineering, at The University of South Carolina, as well as a Lab Assistant for USC's Geotechnical Department where he participates in research and lab preparation.

DFI Trust funds provide At-Large Scholarships to full-time undergraduate or graduate civil engineering, electrical engineering and computer science students attending any accredited college or university in the United States, and who demonstrate prior employment, co-op or intern experience with a civil engineering application. Donations to the Goble Rausche Likins Scholarship Fund can be made online at www.dfitrust.org.

PDI Welcomes Cassidy Pristov

Cassidy Pristov joins Pile Dynamics, Inc., sales team. Cassidy manages sales and customer support in PDI's international markets. She is a graduate of Cleveland State University and has strong customer service, organizational and leadership skills. Cassidy brings experience in client relationship management and is a valuable addition to the team. Cassidy can be reach at cpristov@pile.com

GRL Welcomes Gerado Sanchez

Gerado Sanchez recently joined the Texas office of GRL Engineers. He received his undergraduate degree from the University of Texas Rio Grande Valley in Civil Engineering and is fluent in Spanish and English. Gerry can be reached at gsanchez@grlengineers.com.

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