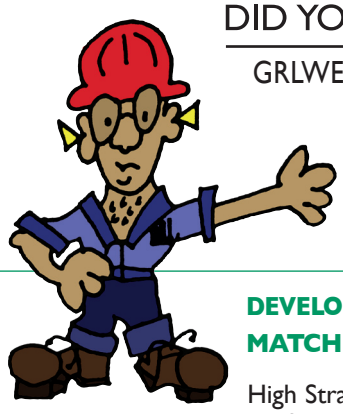


DID YOU **KNOW?**

GRLWEAP contains geotechnical static analyses using SPT or CPT data.

Pile Dynamics, Inc.

GRL engineers, inc.

DEVELOPMENT OF AUTOMATIC SIGNAL MATCHING PROCEDURE - ICAP®

High Strain Dynamic Foundation Testing with the Pile Driving Analyzer® (PDA) is the standard of practice for evaluation of driven pile foundations. Required by various specifications and codes, it is also routinely applied to drilled and augered cast-in-place piles.

When High Strain Dynamic Testing is performed on a typical driven pile with a uniform cross section along the pile length, the process consists of:

1. Acquisition of axial force and velocity data, either during pile installation or after a wait period during restrike.
2. Using stress wave propagation theory and Case Method closed form solutions, calculation of stresses along the pile, assessment of shaft integrity, evaluation of hammer performance, and an ultimate capacity estimate from an assumed damping constant.
3. Analysis by the signal matching software CAPWAP® to more accurately assess the total capacity and its resistance distribution along the shaft and at the pile toe. Compression and tension stresses at all points along the shaft are better determined by this extensive numerical analysis ("signal matching" takes the field measured velocity record, assumes a static and dynamic soil model, calculates the force which holds the system in dynamic equilibrium, compares the calculated record with the measured one, refines the soil model, and repeats the process until the measured and calculated curves "match").

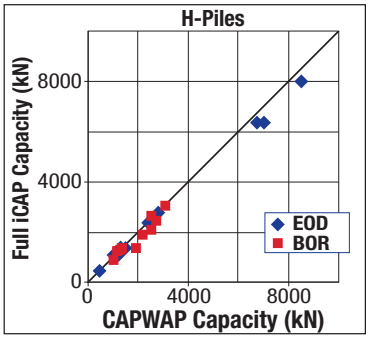
Until recently, the Pile Driving Analyzer® displayed only Case Method quantities in step 2. The Case Method capacity depends on the assumed soil damping constant. Since soil properties vary across the project site and along the various soil layers that the pile penetrates, this assumption leads to some uncertainty unless a static load test or a confirming CAPWAP analysis is performed. The number of static load tests per site is usually limited, and it is generally impractical to statically test multiple piles penetrating to various depths. Step 3 - signal matching - is therefore performed after the conclusion of the dynamic pile testing.

Load Resistance Factored Design codes now require high quality signal matching. Also, increased time pressures call for a faster dynamic pile testing procedure, with more accurate pile capacity information often desired immediately. Despite advances in computational power, a full CAPWAP analysis still takes considerable time. However, faster signal matching analysis is fortunately possible. The iCAP program, derived from CAPWAP, performs completely automatic signal matching in the field, in real-time, during pile testing, and giving a more reliable capacity result than the Case Method with some assumed damping factor.

When the testing engineer sets the PDA to run iCAP, the iCAP program uses the measured force and velocity data and generates a continuous pile model and an initial soil model. It then determines the resistance distribution along the shaft and at the toe. A fully automatic search process then finds the optimum set of damping factors and quakes and adjusts the total capacity to improve the match. When the solution converges the PDA displays the results: total capacity, shaft resistance distribution and end bearing, the maximum compression and tension forces at any location in the pile, and the toe compression stress.

CAPWAP and iCAP results for 68 uniform driven piles - including H, steel pipe, and concrete - were compared. For each, both a Quick iCAP (fewer searches; best suited when time is limited, such as during pile driving) and a Full iCAP (more searches; suitable when analysis time is not as critical, as in restrike tests or for reviewing results after driving) were performed.

The figure on the right plots the total resistances calculated with Full iCAP versus the CAPWAP solutions for H piles at end of drive (EOD) or beginning of restrike (BOR). Results for other pile types are found in Likins Liang and Hyatt (2012).



A reasonable overall agreement between total capacities estimated by iCAP and CAPWAP was observed in all situations studied, with iCAP results slightly more conservative than CAPWAP:

	MEAN	STANDARD DEVIATION	within 10%
Quick iCAP/CAPWAP	98.3%	8.8%	80%
Full iCAP/CAPWAP	96.8%	8.0%	85%

Although iCAP was developed based on CAPWAP models, may be quickly performed on each blow during driving or restrike, gives a more reliable capacity result than the traditional Case Method and correlates well with CAPWAP, it currently has limitations. It is applicable only to uniform driven piles. Joints, slacks, mechanical splices with "gaps", or cracks cannot currently be modeled. Radiation damping or residual stress analyses are not considered. On the plus side, since a large database of comparisons of CAPWAP with static load tests exhibits good correlations, it is reasonable to assume that iCAP results also correlate well with static load test results.

In conclusion, iCAP presents many important benefits to the time-pressed, cost-conscious engineer. However, it does not excuse the engineer from performing a CAPWAP analysis as soon as practical, and comparing it with the iCAP result.

Condensed by G. Beim from a similarly titled paper by G. Likins, L. Liang, and T. Hyatt, 9th Int'l Conf. on Testing and Design Methods of Deep Foundations, Kanazawa Japan, Sept 2012.

2012 Calendar of Events Highlights – for a complete list and event details, visit www.pile.com/events

Workshops and Seminars throughout the world:

October 16, Mannheim, Germany: GSP presents a Low Strain Integrity Testing (Impact Echo) Workshop (in German). Info: ok@gsp-mannheim.de.

October 17, Mannheim, Germany: GSP presents a High Strain Dynamic Testing (PDA and CAPWAP) Workshop (in German). Info: ok@gsp-mannheim.de.

October 18, São Paulo, Brazil: PDCA, PDI and CARMIX do Brazil present a PDA and CAPWAP Workshop (in Portuguese). **The PDI/PDCA Dynamic Measurement & Analysis Proficiency Test will be offered.** Registration flyer at www.pile.com/events/pdievents

October 24, Cleveland, Ohio: PDCA and PDI present a Seminar on Deep Foundation Testing and Wave Equation Analysis. Registration flyer at www.pile.com/events/pdievents

October 25-26, Cleveland, Ohio: PDCA and PDI present a PDA and CAPWAP Workshop. The PDI/PDCA Dynamic Measurement & Analysis Proficiency Test will be offered. Registration flyer at www.pile.com/events/pdievents

November 9, New Orleans, LA: PDCA Gulf Coast Chapter presents a GRLWEAP seminar and workshop

PDI Webinars: Learn without leaving your desk

All webinars are presented live via web and phone connection and start at 9:00 am Eastern Time (New York time). While the number of sessions vary, each session is typically 2 hours long. Registration flyers with more details are on www.pile.com/events/pdievents. Watch for our monthly email announcing scheduled webinars.

October 10: Thermal Integrity Profiling (with Garland Likins)
October 30 & 31 and November 6 & 7: CAPWAP (with Brent Robinson)
November 27: Pile Driving Hammer Performance (with Frank Rausche)
December 4: Load Testing & Quality of Pile Foundations (with Michael Morgano)

PDI and/or its Representatives will exhibit at the following events:

October 3-6, Piacenza, Italy: Visit Italian representative DRC at Geofluid - Drilling and Foundations. www.geofluid.it

October 16-19, Houston, TX: DFI 37th Annual Conference on Deep Foundations. www.dfi.org

October 22-25, Richmond, VA: 43rd Annual Southeastern Transportation Geotechnical Engineering Conference. http://www.stgec.org/exhibitors

October 24-26, Hershey, PA: 26th Central Pennsylvania Geotechnical Conference. www.central-pa-asce-geotech.org

Other Learning Opportunities

October 16, Houston, TX: George Piscsalko will present at the DFI Augured Cast-in-Place Pile Short Course & Specialty Seminar and at the Annual conference that follows.

October 30-31, Columbus, OH: Ben White and Brandon Phetteplace will present at the Ohio Transportation Engineering Conference.

November 16, Garland Likins will present the ASCE Webinar: Installation, Verification and Application of Driven Piles. https://secure.asce.org/ASCEWebsite/Webinar/ListWebinar.aspx.

ASTM STANDARD GETS MINOR REVISION

ASTM D4945, Standard Test Method for High-Strain Dynamic Testing of Deep Foundations, has been revised and is now designated D4945-12. The changes from the previous D4945-08 are minor, and pertain solely to the number of significant digits required in the reporting of density, wave speed and dynamic modulus of elasticity. Three significant digits are now required, but not to exceed precision of the measurement.

PDI WELCOMES NEW CIVIL ENGINEER

Pile Dynamics is pleased to welcome Anna Sellountou, PhD, to its staff. Anna has a doctorate from the University of Houston under the supervision of the late professor Dr. Michael O'Neill, one of the worlds' leading experts on Deep Foundations, and for a few years was with the Deep Foundation Division of Fugro Onshore Geotechnical. Anna will use her experience on deep foundations design, construction and testing to further support PDI clients.

THERMAL INTEGRITY PROFILER (TIP) NEWS

Readers of our May 2011 newsletter may recall that Pile Dynamics and Foundation & Geotechnical Engineering, LLC (FGE) developed an instrument that uses the heat during curing of concrete to assess concrete integrity of drilled shafts both inside and outside the reinforcing cage – the Thermal Integrity Profiler, or TIP. TIP makes use of the fact that low quality concrete or local defects result in relatively low measured temperatures. TIP results are processed with the TIP Reporter Software. The latest version of the software has powerful visual resources, as seen in Figure 1 below.

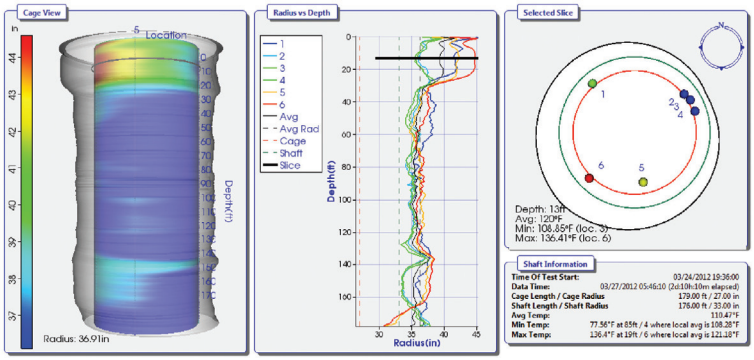


Figure 1: TIP Reporter screen shot. On the left is a 3D image of the effective shape of the shaft that can be rotated to any orientation. The center image plots effective radius versus depth. On the right, a "horizontal slice" shows the inner cage radius (inner circle), the nominal shaft diameter (middle circle), and outer shaft profile (outer circle). The slice is from the upper, temporary cased portion of the shaft; its location is indicated in the center image by a horizontal line.

Notice on the right of Figure 1 that measurements show that the axis of the shaft does not coincide with the axis of the temporary case. The upper portion of the shaft was indeed built this way. In the uncased portion of the shaft, however, the cage is centered on the axis, as seen on the center image of Figure 1.

PDI SUPPORT IS ACKNOWLEDGED:

David W. Kozera, P.E, with D.W. Kozera, Inc. in Baltimore, recently wrote: "My life with you folks started several decades ago when I was tasked with evaluating a dynamic pile testing system (…) We correctly chose the [PDI] system. Ever since that time I have had the pleasure of working with your people. On the equipment side, whenever we have had a problem either with your equipment (…) you had someone at the end of the phone to talk us down from the ledge. But even better than that, whenever there was a technical issue that we needed help in understanding Garland and company found time to explain and teach us. Many Thanks and Continued Success."

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