



DID YOU KNOW:

THERE ARE PILE DRIVING ANALYZERS IN CURRENT USE IN MORE THAN 40 COUNTRIES THROUGHOUT THE WORLD?



## Testing Self-Consolidating Concrete

E. Attigbe<sup>1</sup> and F. Rausche<sup>2</sup>

Drilled shafts are massive concrete structures often designed with reinforcement cages consisting of densely spaced steel bars. Commonly performed integrity tests of drilled shafts have shown that the high concentration of reinforcement bars may hamper concrete flow, which can be detrimental to drilled shaft quality. Self-Consolidating Concrete (SCC) has superior flow properties that reduce the possibility of voids, incomplete concrete cover around the reinforcing bars and other potential drilled shaft defects.

Two extensive tests series were jointly conducted by Degussa Admixtures (formerly Master Builders), Inc. and GRL Engineers, Inc. The experiments aimed to demonstrate the attractive flow properties of SCC and how the resulting concrete quality can be verified with the commonly employed Cross-hole Sonic Logging (CSL) and Low Strain integrity testing methods for drilled shafts. The experiments further intended to verify if integrity testing could take place sooner on SCC shafts than when conventional concrete is used. The integrity tests were performed with the Cross Hole Analyzer (CHA) and Pile Integrity Tester (PIT), both manufactured by Pile Dynamics, Inc.

Twenty-four concrete specimens composed of twelve concrete mixtures were prepared. The specimens were large enough to simulate drilled shafts under field conditions. In preparation for Cross Hole Sonic Logging, two tubes, 940 mm long with 50 mm outer diameter and 5 mm wall thickness, were placed in each specimen form at approximately 70 mm from the edges of the form prior to casting. The concrete mixtures included conventional concrete, SCC with a polycarboxylate-based high-range water-reducing (HRWR) admixture to achieve high slump flows of up to 700 mm, and a mix with a viscosity-modifying admixture to stabilize the high slump flow. A hydration control admixture was added to two of the mixtures to purposefully retard setting for approximately two hours. To further evaluate the effectiveness of using standard integrity testing methods on shafts where SCC is used, two of the mixtures were purposely segregated by using a dosage level of HRWR admixture higher than the manufacturer's maximum recommended dosage. Low slump concrete specimens were also included in the study for comparison with the SCC specimens.

The concrete strength, static elastic modulus and wave speed of each mixture were measured, the latter with the CHA and/or PIT, at various times during hydration, starting after a few hours. This yielded correlations between strength, static and dynamic elastic moduli and sonic wave speed, all as a function of time.

The study showed that conventional concrete would not flow satisfactorily through the gap between the inspection tubes and the form (see photo) whereas high-slump flow SCC flowed well and



Eric Mack (left), Cleveland State University and Brent Robinson, formerly a GRL engineer who is currently at North Carolina State University, conducting CHA testing on a specimen of conventional concrete.

produced specimens with very good surface finish. This is an indication that similar flow behavior would occur in the field around the reinforcement cage, and could therefore contribute to the quality of drilled shafts. In addition, it was found that commonly used integrity tests such as the ones performed with the CHA and the PIT are as suitable for SCC testing as they are for more conventional mixtures. In fact, the experiment indicated that it should be possible to perform meaningful quality assurance tests on SCC shafts as early as 24 hours after concrete placement.

The next step in the implementation of SCC to drilled shafts would be to perform actual field comparisons between conventional and SCC mixtures placed in shafts with demanding properties (e.g., high degree of reinforcement) and partially excavating the shafts to demonstrate the difference in quality. Continued use of Cross-hole Sonic Logging and Low Strain integrity testing would ensure that severe integrity problems are avoided in the application of the different types of concrete mixtures.

The researchers will present their findings this year at various conferences. Please contact either of the two authors for further information.

<sup>1</sup> Director, Technical Services, Degussa Admixtures, Inc., 23700 Chagrin Blvd., Cleveland, OH 44122, USA

<sup>2</sup> President, GRL Engineers, Inc., 4535 Renaissance Parkway, Cleveland, OH 44128, USA

## 2005 Calendar of Events

**June 17**, Baltimore MD: "Driven Pile Specialty Seminar" by the Deep Foundations Institute (DFI). Information at: [www.dfi.org](http://www.dfi.org)

**June 19 - 24** Logan, UT: "Professor's Institute" by the Pile Driving Contractors Association (PDCA). Information at: [www.piledrivers.org](http://www.piledrivers.org)

**July 21**, New York: Nondestructive Testers of Deep Foundations by DFI. Information at: [www.dfi.org](http://www.dfi.org).

**July 28 - 30**, Acme, MI: ADSC, the International Association of Foundation Drilling, holds their Summer Meeting. Information at: [www.adsc-iafd.com](http://www.adsc-iafd.com)

**August 25 - 27, Cleveland, OH: Pile Dynamics Workshop on Deep Foundation Dynamic Testing and Analysis. Topics include PDA, CAPWAP, Integrity Testing and one full day on GRLWEAP. The DFI / Foundation QA Examination will be offered. Information and registration form at: [www.pile.com/events/pdievents/default.asp](http://www.pile.com/events/pdievents/default.asp)**

**September 12 - 16**, Osaka, Japan: 16th International Conference on Soil Mechanics and Geotechnical Engineering by ISSMGE. Information at: [www.icsmge2005.org](http://www.icsmge2005.org)

**September 15 - 16**, Boston, MA: "Design & Installation of Cost Efficient Driven Piles" by PDCA. Information at: [www.piledrivers.org](http://www.piledrivers.org)

**September 22 - 24**, Chicago, IL: DFI's 30th Annual Conference on Deep Foundations. Information at: <http://www.dfi.org>

**October 12 - 14**, Riga, Latvia: The Geotechnical Societies of Latvia, Estonia and Lithuania present The X Baltic Conference on problems for harbors, onshore and near shore structures. Information at: [www.balticgeotechnics.lv](http://www.balticgeotechnics.lv)

**November 6 - 9**, Dallas, TX: GEO<sup>3</sup>, Quality Assurance/Quality Control Technical Conference and Interactive Field Day, by ADSC. Information at: [www.adsc-iafd.com](http://www.adsc-iafd.com)

## Education in Foundation Testing and Analysis is hot.

Pile Dynamics has observed strong interest in educational initiatives related to Foundation Testing and Analysis. Due to high demand, we had to turn several interested people away from our recent two-day workshop on PDA, CAPWAP and GRLWEAP held in Orlando Florida in early March. We are pleased to announce that our next workshop will take place August 25 to 27 in Cleveland, Ohio; Early registration is encouraged. **Workshop information, program and registration form are available at: [www.pile.com/events/pdievents/default.asp](http://www.pile.com/events/pdievents/default.asp).**

Mohamad Hussein from GRL Florida and Dr. Frank Townsend from the University of Florida presented a one-day course in Port of Spain, Trinidad on April 6. Geotech Associates, Ltd. organized the event in association with the Engineering Institute of the University of the West Indies. The 160 attendees represent most of the civil engineering community of Port of Spain, and constitute 0.11% of the total population of the Island!

### Our Clients' Voice:

#### On training:

Nadia Halawi, Assistant Branch Manager for ACES in Abu Dhabi: "I would like to express the deep appreciation of ACES Management to PDI and personally to Mr. (Michael) Morgano (GRL Ohio) for the outstanding training session (...). We have experienced the pleasure of interacting with your representative, who has demonstrated high professional knowledge and skills as well as excellent personal attitude."

In reference to PDA training held in Cleveland during the first week of April, Kirk McGeachy, of Jacques Whitford Limited thanks "Garland, Frank and the other staff for the excellent seminar/training course. Chris (Carr) commented that the training was the best course that he could ever recall attending."

#### On the reference papers available on our website:

Prof Dan Brown of Auburn University found the paper from Stresswave 2004 he was looking for in the Reference Papers section of [www.pile.com](http://www.pile.com), and wrote: "Thanks (...) that is a great resource." (The Reference Papers section of our website has been recently made even easier to use by the addition of "sort by subject" and "sort by author" features.)

#### On monitoring augercast (CFA) piles:

Philip Erbland, of Ardaman Construction told PDI's John Wargelin about his experience with the Pile Installation Recorder for Augercast piles, PIR-A: "The first time we used it, we identified a soft area at the toe that we had missed during our regular inspection. Since then, we specify the PIR-A on all of our augercast pile projects." Ardaman was responsible for inspection of the construction of a new building at the existing Tampa Bay Ship Building and Repair Facility.

## GRL Colorado's Jay Berger Begins a New Career

After working 18 years for GRL, most of the time as the Branch Manager of GRL Colorado, Jay Berger has assumed the position of Experimental Site Operations Manager with NEESinc. NEESinc manages the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES), which is comprised of fifteen universities. Jay, a very talented engineer with a thorough understanding of the dynamics of pile driving, never neglected the human side of civil engineering and therefore will be missed by all of us at GRL and PDI. Jay and Maureen will move to Davis, CA. We wish them the best of success and satisfaction in this new venture.



GRL will maintain a presence in Colorado, with Frank Rausche dividing his time between Cleveland and the new Denver office. Phone and fax numbers will remain unchanged. Please check GRL Colorado's webpage for updates.

## Notable Project

For a major bridge project in Tampa, Florida, GRL performed high-strain dynamic testing on several drilled shaft supported piers using the APE 750 hydraulic hammer which has a ram weight of 120 kips (534 kN) and drop height of up to 6.5 feet (2 meters). The scale of the job made the front page of the local newspaper. Two Pile Driving Analyzers were simultaneously utilized to monitor strain and acceleration records on the pier and shaft. A total of eight strain transducers and eight accelerometers were used, four each on the pier and shaft.



## New Release of GRLWEAP

GRLWEAP version 2005 has been released, featuring major enhancements and updates, most notably a static analysis method based on simple soil descriptions. This version contains a substantially enlarged hammer database, which is now continuously being updated and is available to current users of

GRLWEAP on our web page, [www.pile.com/pdi/products/grlweap/hammer.asp](http://www.pile.com/pdi/products/grlweap/hammer.asp). Users can also add their own hammer entries, generating a personal portion of the database that will remain unchanged as updates are made. The new program version also has enhanced help functions and updated graphics.

Visit us at [WWW.PILE.COM](http://WWW.PILE.COM)

**GRL** Dynamic Measurements and Analyses  
engineers, inc.

**GRL Engineers, Inc.**  
Main Office: 4535 Renaissance Parkway  
Cleveland, Ohio 44128 USA  
E-mail: [info@pile.com](mailto:info@pile.com)

Phone: +1-216-831-6131  
Fax: +1-216-831-0916

**PDI**  
Pile Dynamics, Inc.

**Pile Dynamics, Inc.**  
4535 Renaissance Parkway  
Cleveland, Ohio 44128 USA  
E-mail: [info@pile.com](mailto:info@pile.com)  
Phone: +1-216-831-6131  
Fax: +1-216-831-0916