



May 2006 bring peace to the world and happiness, health and prosperity to all our readers. Thank you PDI and GRL clients for your continuing business.



## Dynamic APPLE Load Testing Over Water

by Michael Morgano, GRL Engineers (Ohio)

Approximately 6 years ago, GRL began to design and build a series of dynamic loading systems – called APPLES – for testing the capacity of drilled shafts. Since then APPLE systems have mobilized ultimate test loads of up to 22 MN (2500 tons), utilizing drop heights of up to approximately 2.7 meters (9 ft).

APPLE systems are modular and use ram weights ranging from 7 to 20 tons. The rams are guided by a square lead with a 2.3 m footprint and a height of 6 meters. A hydraulic mechanism allows the ram load to be transferred from the crane to the leads prior to free-releasing the ram, effectively eliminating crane whip.

The APPLE was recently used over water for the first time, in cooperation with Mr. John Bennett of Toledo Caisson. GRL used an APPLE system with a 180 kN (20 ton) ram to test two drilled shafts for a bridge expansion of State Route 2 over the Sandusky Bay in Ohio. The loading system was transported on a barge and

assembled on location. The test shafts were caissons with 2 m (78 in) outside diameter, a 1.8 m (72 inch) diameter rock socket and included a permanent steel casing seated into the top of bedrock. The two caissons tested had lengths of 15.5 and 19.5 m (51 and 64 ft), including socket lengths of 1.8 and 4.9 m (6 and 16 ft), respectively. The required ultimate capacity of the caissons was almost 9 MN (1000 tons). The soil consisted of medium stiff to very stiff silty clay overlying dense gravel and sand. The underlying bedrock formation was hard dolomite.

Dynamic testing normally requires mounting strain and acceleration sensors to the side of the shafts approximately one diameter below their top. In the present case this location was below water level. A 3.2 m (126 inch) diameter steel pipe was installed around the test shafts with a vibratory hammer to provide working space. The water in the space between shaft and pipe was then pumped out to expose the test shaft perimeter. The loading system was supported by H-beams welded to the side of the shaft at the 90 degree points (see Figure 1). For safety, the legs of the APPLE lead were welded to the H support beams.

GRL applied drop heights ranging from 0.3 to 1.2 m (1 to 4 ft) for the load testing. Results from CAPWAP<sup>®</sup> analyses performed on data from the 1.2 m drop tests indicated, respectively for the shorter and longer shafts, mobilized capacities of 18 and 20 MN (2250 tons) with zero permanent set. This exceeded the required ultimate capacity by more than a factor of two. Throughout the testing, impact induced compressive and tension stresses and pile integrity were monitored, to assure a successful test.



Figure 1 (left):  
APPLE on  
Sandusky shaft  
(photo by Anna Klesney)



Figure 2 (right):  
APPLE IV ram assembly

The Sandusky test is one of the latest of many APPLE testing projects GRL has performed throughout the United States. GRL currently stations one APPLE system in California and the others in Ohio, trucking them to job sites as needed; plans are to base multiple APPLE systems throughout the US to reduce mobilization costs.

The newest addition to the APPLE family of load testing systems is a 360 kN (40 ton) modular system, the APPLE IV, shown in Figure 2. The APPLE IV tests loads up to 36 MN (4000 tons) capacity thanks to the available energy of 900 kJ (640 kip-ft) with its maximum drop height of 2.5 m (8 ft). (The capacity actually mobilized depends primarily on the soil type. Wave equation analyses prior to testing provide for a check on the adequacy of the system.) APPLE loading systems are an economical solution to test the larger drilled shafts now in use by the deep foundation industry to very high loads.



## January to June 2006 Events

**February 2-5**, Scottsdale, AZ: The International Association of Foundation Drilling (ADSC) presents ADSC Annual Meeting. [www.adsc-iafd.com](http://www.adsc-iafd.com)

**February 26-March 1**, Atlanta, GA: The Geo-Institute of the ASCE presents Geo-Congress '06. Geotechnical Engineering in the Information Technology Age. [www.asce.org/conferences/geocongress06/](http://www.asce.org/conferences/geocongress06/)

**March 2-4**, San Antonio, TX: The Pile Driving Contractors Association presents 10th Anniversary PDCA Annual Meeting. [www.piledrivers.org/events.php](http://www.piledrivers.org/events.php)

**March 7-8**, Orlando, FL: Pile Dynamics, Inc. presents a PDA and CAPWAP Workshop. [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents)

**March 9**, Orlando, FL: Pile Dynamics, Inc. presents a Wave Equation Workshop. [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents)

**March 10**, Orlando, FL: Pile Dynamics, Inc. presents A Seminar on Foundation Testing and Analysis. [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents)

**March 23-24**, Portland, OR: American Society of Civil Engineers (ASCE) presents Deep Foundations: Design, Construction & Quality Control. [www.asce.org](http://www.asce.org)

**May 24**: Ljubljana, Slovenia: Pile Dynamics, Inc. presents a Seminar on Foundation Testing and Analysis. [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents)

**May 25**: Ljubljana, Slovenia: Pile Dynamics, Inc. presents a PDA and CAPWAP Workshop. [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents)

**May 26**: Ljubljana, Slovenia: Pile Dynamics, Inc. presents a Wave Equation Workshop. [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents)

**May 31-June 2**, Amsterdam, The Netherlands: Deep Foundations Institute and the European Federation of Foundation Contractors present The 10th International Conference on Piling and Deep Foundations. [www.pilinganddeepfoundations.com/](http://www.pilinganddeepfoundations.com/)

### SEE OUR NEW WEBSITE

Both GRL Engineers and Pile Dynamics have fresh new internet looks at [www.pile.com](http://www.pile.com). We encourage our readers to visit and enjoy the new features and enhanced usability. The Technical Library area contains the popular downloads of sample specifications, reference papers, newsletters and brochures, now with expanded search functions. Each



GRL office now has its own page complete with staff and job site pictures.

### ASTM REINSTATES SPT ENERGY MEASUREMENT STANDARDS

ASTM D4633-05 - Standard Test Method for Energy Measurement of Dynamic Penetrometers has been approved by ASTM committee D 18, The Committee on Soil and Rock, for reinstatement into the Annual Book of Standards. The new standard is already available at [www.astm.org](http://www.astm.org)

The PDI line of products offers two options for performing Energy Measurements on SPT rigs. Both the Pile Driving Analyzer® and the SPT Analyzer comply with the reinstated standard by measuring force and acceleration at the top of the drill rod and calculating the energy transmitted to the drill rod.

A related ASTM standard, D6066-96, Standard Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential, describes how the energy transmitted to the rod serves to adjust the measured penetration resistance (N-value) to a normalized one,  $N_{60}$ .  $N_{60}$  is a widely used indicator of soil density, strength and stiffness.

The  $N_{60}$  will be smaller than the measured N if transferred energy is low.

GRL Engineers has provided SPT calibration services for many years. This service is particularly important in dam and levee projects, and in earthquake prone zones.



### PILE DYNAMICS RELEASES SMALLER CROSS-HOLE ANALYZER, CHAMP

The CHAMP retains all testing functionality of the original CHA model at one third of its size and half its weight, and fits, with all its probes and cables, in one single transporting case. It incorporates the touch-screen technology that is so popular with users of Pile

Dynamics' other foundation testing instruments and its battery may last through an entire day of testing. PDI will not only continue to offer the traditional CHA but has enhanced it to run on Windows XP. That original model is now known as CHA-QX. Testing accessories for both the CHAMP and CHA-QX were also enhanced and now include shorter probes in brass housing, cables that are stronger and detachable, and an optional depth encoder wheel arrangement with a tripod. Visit Pile Dynamics website for technical details.

### SEMINAR AND WORKSHOPS IN FLORIDA

Pile Dynamics, Inc. will hold its always well attended foundation testing and analysis educational events at the Renaissance Hotel in Orlando, Florida in March of 2006:

**March 7-8: Pile Driving Analyzer® and CAPWAP® Workshop.** Geared towards Pile Driving Analyzer and CAPWAP users interested in sharpening their skills; engineers, foundation testing professionals, students and professors already familiar with the basic concepts of deep foundation dynamic testing and analysis. Taught by Dr. Julian Seidel. The Foundation QA certification exam will be offered during this event.

**March 9: Wave Equation Workshop (GRLWEAP).** Geared to all engineers interested in an introduction or a refresher to the GRLWEAP software for pile driving simulation and analysis. A portion of the workshop is devoted to the theory of wave equation.

**March 10: Seminar on Foundation Testing and Analysis.** Geared towards geotechnical, structural engineers and construction engineers, as well as to contractors and other professionals involved in the design, construction and specification of deep foundations. Suitable for those new to this field.

Register for one or more of the events at [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents). IACET Continuing Education Units will be awarded. Early registration is encouraged.

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

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