DID YOU **KNOW?**

DR. GEORGE GOBLE PIONEERED DYNAMIC TESTING 40 YEARS AGO AT CASE WESTERN RESERVE UNIVERSITY.

Pile Dynamics, Inc.

GRL engineers, inc. Dynamic Measurements and Analyses

PENETRATION TESTING TODAY

Jay Berger, GRL Colorado

The Standard Penetration Test (SPT) is the most common subsurface investigation method for deep foundation projects. It requires driving a sampler connected to a steel rod 18 inches (460 mm) deep into a soil strata with a 140 lb (64 kg) ram dropping 30 inches (760 mm). A soil sample is retrieved for classification and laboratory testing, while the number of hammer blows required to penetrate the rod the final 12 inches (300 mm) is referred to as the "N-value" and is a gauge of soil strength and liquefaction potential during an earthquake.

The N-value is not very accurate, in large part because of an uncertain energy transfer caused by the variety of hammer models and operator techniques. Energy measured in the SPT rod has been shown to vary between 25 and 95% of the theoretical potential energy. Such a broad range in energy transfer can have a profound influence on the measured N-value, with the potential for overly conservative or dangerously un-conservative foundation design and liquefaction analysis.

Recognizing the potential for erroneous foundation designs, many State Departments of Transportation are having their own SPT rigs, or those of their consultants, calibrated through dynamic energy measurements. The resulting calibration factor converts the N-value to a standardized N60, which corresponds to a nominal 60% energy transfer.

Additional information on soil strength can be obtained by attaching a torque wrench and transducer to the top of the SPT rod after the sampler has been driven and the N-value determined, but before the soil sample is retrieved. GRL Engineers, Inc. has performed such torque tests quickly and efficiently. The resulting torque versus rotation curve indicates a peak and a residual shear strength value that correlates well with the set-up soil strength and pile shaft resistance during driving. For some soils it may be necessary to perform the torque measurements some time after SPT driving to be able to determine the full soil setup strength.

There is evidence that gravelly soils can liquefy during earthquakes. Reliable methods for determining the liquefaction potential in gravelly deposits are therefore needed. SPT and Cone Penetration Tests (CPT) are not adequate for this purpose, since they may provide inaccurate or no results in coarse to very coarse grained soils. The Becker Penetration Test (BPT) has been designed to yield a blow count that can be correlated with the SPT N-values for liquefaction potential analysis in such materials

The Becker Drill Rig is a truck mounted double-acting diesel hammer that drives a double-walled 6.6 inch (168 mm) diameter pipe. The Becker pipe can be driven either open-ended, with disturbed samples collected via an airlift in the annulus between the two walls, or closed-ended, when the Becker test is simply a penetration test. As in the SPT test, the blow count required to advance the Becker pipe is recorded over one foot (300 mm) increments. As with all diesel hammers, however, the Becker hammer transferred energy varies depending on temperature, soil resistance, pipe length, hammer conditions and other

PDA monitoring of the Becker test improves its accuracy.

factors. For this reason it is critical to measure the Becker hammer energy transfer efficiency to "correct" the blow count. The accepted practice normalizes the blow count to a transfer efficiency of 30% and refers to the corrected Becker blow count as a BPT N30. The Becker energy measurements are made with a short instrumented section of a Becker drill rod that is placed at the top of the Becker pipe string. A Pile Driving Analyzer® (PDA) then collects strain and acceleration records, calculates transferred energy and records the measurements.

In addition to the correction of energy, the BPT N30 value needs correction for the effects of shaft resistance on the Becker pipe. CAPWAP® analysis of the PDA records yields the soil resistance distribution, and the BPT N30 values can then be adjusted for the effect of skin friction determined by CAPWAP analysis. GRL has also assessed the skin friction acting along the pipe shaft by means of a quick static uplift test, by measuring the load with standard PDI strain transducers and measuring the displacement with extensometers. The Becker hammer pipe extraction system provides the uplift load.

GRL has proposed an innovative use for the Becker system: The very mobile Becker hammer is deployed to a potential deep foundation location before completion of design. The Becker pipe is driven to a penetration of interest while instrumented with either a local or a remote PDA (PAL-R). After completion of short and/or long term instrumented restrikes, CAPWAP analysis is performed on data from end of installation and from restriking. The Becker pipe is then withdrawn and utilized at another site. The Becker test with the PDA and CAPWAP results provides information on both short and long term in-situ soil strength and pile driveability and therefore results in a more economical foundation design and installation.

PDA monitoring of SPT and Becker tests significantly improve the accuracy of geotechnical investigations and resulting interpretations. Considering the grave consequences of misinterpretations of soil strength and liquefaction potential, more and more geotechnical engineers throughout the world specify PDA penetration and energy measurements for improved reliability.

Calendar of **Events**

July 14-16, 2004, Logan, Utah: 9th Annual Pile Foundation Design Short Course. Organized by the Utah State University Department of Civil and Environmental Engineering. Visit www.engineering.usu.edu/cee/faculty/civil/caliendo/pile04.htm or email Joe Caliendo at joe@cc.usu.edu.

July 27-31, 2004, Los Angeles, CA: Geo-Trans 2004. ASCE presents the "The Geo-Institute Conference on Geotechnical Engineering for Transportation Projects". Visit www.asce.org/conferences/geotrans04/. **Visit our booth at this event.**

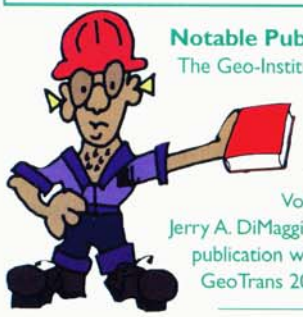
August 9-11, 2004, Petaling Jaya, Malaysia: The Seventh International Conference on The Application of Stresswave Theory to Piles, Stresswave 2004, the Millennium Challenge. Visit www.iem.org/my/external/stressway2004/ or email sec@iem.po.my. **Visit our booth at this event.**

August 12-14, 2004, Petaling Jaya, Malaysia: Pile Dynamics will hold PDA, CAPWAP, GRLWEAP and Integrity Workshops. The Foundation QA exam for certification of PDA testers will be offered in conjunction with this event. Visit www.pile.com/events/otherevents.

August 13, 2004, Cincinnati, OH: the Drilled Shaft and Testing and Evaluation Committees of DFI and the University of Cincinnati present Specialty Seminar: Non-Destructive Testing of Drilled Shafts. Visit www.dfi.org.

September 16-17, 2004, Los Angeles, CA: PDCA Design & Installation of Cost Efficient Driven Piles Symposium. Visit http://www.piledrivers.org or email info@piledrivers.org. **Visit our booth at this event.**

September 29-October 1, 2004, Vancouver, BC, Canada: DFI's 29th Annual Conference on Deep Foundations. Visit www.dfi.org or email staff@dfi.org. **Visit our booth at this event.**



Notable Publictions

The Geo-Institute of the American Society of Civil Engineers has published the Geotechnical Special Publication "Current Practices and Future Trends in Deep Foundations - A Volume Honoring George G. Goble" Jerry A. DiMaggio and Mohamad H. Hussein, eds. The publication will be released on July 27, during GeoTrans 2004 (see calendar of events above).

GRL Engineers is pleased to welcome the following engineers to its professional staff:

Ken Boie, M.S., GRL PA
Changsoo Hwang, Ph.D., GRL FL
Karen Webster, P.E., GRL NC
Nagaraj Eshwar, M.S., GRL II
Paul Bullock, Ph.D., P.E., GRL FL and Central

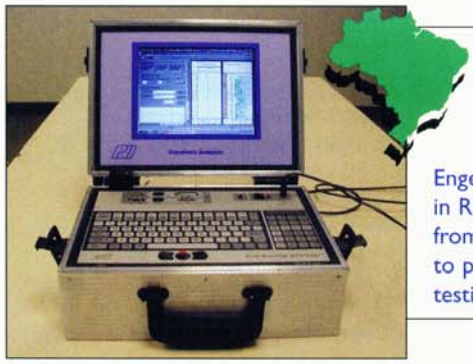
NEWS

GRLWEAP news

An updated GRLWEAP hammer data file and a complete maintenance upgrade for users of GRLWEAP 2003 are now available online at http://web.pile.com/pdi/products/grlweap.

Report on the Pile Drivers Contractors Association Winter Roundtable

The PDCA winter roundtable was held in Orlando, FL this past February. Mohamad Hussein (GRL Florida) and Dr. George Goble (George G. Goble Consulting Engineer, LLC) presented pre-conference workshops respectively on pile testing and pile design. The roundtable presentations included case studies of two projects in Florida where dynamic testing with the Pile Driving Analyzer resulted in savings of $1 million and $28 million. Other notable presentations were: Craig Christenbury, from Chris-Hill Construction Company in Memphis, TN, presented a case study on remote Pile Driving Analyzer (PAL-R) monitoring and its benefits. Chris Dumas from the Federal Highway Administration advocated the use of new technologies, among them the PAL-R and the E-Saximeter. The PDCA project of the year award (for the Minneapolis Waste Water Treatment Plant) was given to Bill Cody of American Engineering Testing Inc. for his innovative use of dynamic testing which resulted in savings of $1 million and a reduction of 2 months of construction time.



First Cross Hole Analyzer in South America

Pile Dynamics delivered the first CHA to Brazil in early May. PDI Engenharia (Pile Dynamics' representative in Rio de Janeiro) and InSitu Geotecnica from Curitiba jointly acquired the device to pioneer the offering of cross hole sonic testing services in Brazil.

30 Road Underpass Project in Mesa County, Co

by L Dorlac

In order to improve roadway safety, an underpass solution was selected to replace the 30 Road "at grade" crossing of the Union Pacific Railroad tracks in Mesa County, Colorado. Perhaps the most unique feature of the project was the retaining wall system. Three of the 4 properties abutting the underpass are commercial and therefore constrained the project limits to the existing Right of Way. For this reason conventional tie-back or spread footer designs for the retaining walls could not be considered. The design team eventually settled upon a ledger beam and soldier pile foundation system for the retaining walls, with vertical piles in tension at the back of the walls, and battered piles (1 in 3 batters) in compression at the toe of the ledger beam. Wall height varied from 12 to 23 feet (3.7 to 7 m). An extensive under drain system was installed to reduce hydraulic pressures on the walls as a result of the high water table at the project location. The bridge structure is comprised of three independent superstructures constructed on common abutments cast on footers supported by deep foundation piling. GRL Engineers provided a Pile Driving Analyzer® and CAPWAP® services to develop pile driving criteria and reduce excessive pile installation on the project. 526 steel H-beam piles (5.91 miles or 9.5 km) were driven. The project was completed in 20.5 months, 2-1/2 months ahead of schedule.

Louie Dorlac, Project Manager with the Mesa County (CO) Public Works, wrote to Jay Berger (GRL Colorado): "First I would like to say thanks for the great work you did for us on the 30 Road Underpass Project here in Mesa County. The project turned out great, and the confidence we gained regarding the deep foundation piles through the testing that GRL provided was very reassuring."

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