GRL NEWSLETTER

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GOBLE RAUSCHE LIKINS AND ASSOCIATES, INC.

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TESTING EXISTING PILE FOUNDATIONS

by Robert F. Miner, GRL Washington

When old foundations are incorporated into new construction, a reanalysis of their strength is usually undertaken. Such analyses of existing structures may be for expansion, rehabilitation, seismic retrofit, or simply reuse of an existing foundation. Also, when bridges are to be recertified, foundations often have to be investigated for their ability to withstand the effects of scour.

In many cases, available as-built information is incomplete, unreliable, or unsatisfactory for reanalysis of new design requirements. In particular, details about pile lengths and pile installation may be unavailable. In other cases, the original structure or foundation may be damaged from impact, storm loading, decay or scour, and the integrity of the piles must be investigated. Dynamic testing and analyses with wave propagation methods may provide the information needed for the reexamination of pile foundations. Two dynamic methods, *high strain* and *low strain* tests, are available.

High Strain Testing

This approach requires restriking the pile with a pile driving hammer and measuring the response of the piles using a **Pile Driving Analyzer® (PDA)**. The method is particularly effective when it is possible to isolate the test pile(s) such that a ram impact induced pile set will not cause damage to the structure. The advantage of the *high strain* test over the low strain method is that it will not only provide answers as to pile length and pile integrity, but also pile bearing capacity. Furthermore, this method is usually not limited by pile length or high soil resistance as long as sufficient ram energy is provided. It is, however, less likely than the low strain method to find small cracks in the piles.

Low Strain Testing

Also called Sonic Pulse-Echo Test, this method is more common than high strain testing for existing foundations. The method is made very simple by the **Pile Integrity Tester™ (PIT)**, yet it provides information on length and integrity of timber, concrete piles, concrete shafts and concrete-filled pipe piles. In PIT, a hand held hammer generates an axial strain wave in the pile, and reflected waves are measured providing information about pile integrity and pile length.

PIT Test on an existing bridge foundation; photograph by Mohamad Hussein, GRL Florida

The simplest configuration for a PIT test involves both hammer impact and accelerometer measurement on the pile top surface. For existing structures it is often impossible or impractical to test on the pile top. Then, accelerometers may be attached to the side of the pile while the PIT hammer impacts the pile cap or other structural element, above the piles.

For an accurate calculation of pile length from PIT data, one must know or estimate the sonic wave speed in the pile. The wave speed may be estimated from experience with similar materials. For more accuracy, it is often possible to obtain site specific wave speed data and thus increase confidence in PIT results. For example, when piles extend significantly above the ground or water, then analysis of data from two measurement points separated by an axial distance of 5 to 10 ft will yield wave speed data. Also, known lengths of a few PIT test piles will allow for an accurate back-calculation of the wave speed.

It's the 10th ANNIVERSARY of the
GRL Newsletter
Thanks for your continued interest

BEST WISHES
*for the holiday season and thanks to our clients, friends and readers for your continued interest in our work. As we in Cleveland prepare for another brutal Ohio winter, **you** will hopefully enjoy peace, warmth, shelter, food, drink and merriment in good company during this time and in the year to come.*

Several factors influence the effectiveness of a PIT length and integrity evaluation. Good access to the pile, sound concrete or timber near the measurement location(s), and good transmission of energy from the impact surface to the pile are desirable. Multiple or complex interfaces or structural elements below the impact or measurement are undesirable. Energy losses due to high shaft friction reduce the strength of reflections and make analyses more difficult. Thus, in many cases, the length that can be effectively tested is limited to about 40 times the pile diameter. While length determination is simple in many instances, for complex cases (long piles, variable cross section), PIT data should be complimented by other supporting data and should not be the sole basis for pile evaluation.

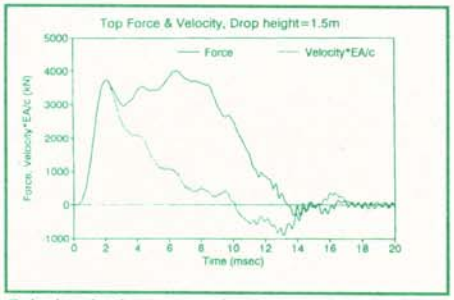
The constraints and details of individual cases often require adaptation of the PIT method to make optimum use of the available information and measurement opportunities. For example, during pouring rains causing a flood which inundated a bridge in the State of Washington, successful PIT tests of bridge piles were made using impact and acceleration measurements on the concrete road deck because it was feared that scour would wash out the pile foundation. Both pile length and approximate embedment depth were assessed. After the water receded, the piles were accessed from a small boat, and measurements were made with accelerometers on the pile and hammer impact on the road surface. This second test series provided wave speed data to refine the initial PIT pile length estimates.

As engineers seek to extend the life and performance of existing bridges and other structures, both PIT and PDA tests will provide valuable data at a modest cost. PIT, though limited in scope, has the advantage of quick and low-cost execution and can be applied to any installed pile with only minimal preparation.

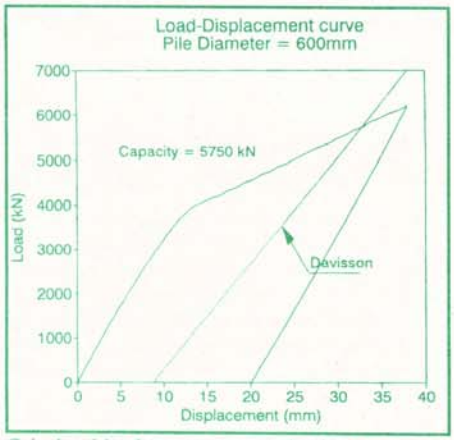
TIPWHIP
Static and Dynamic Analysis of Piles and Shafts

GRL's *Dr. Hasan Aboumatar* has developed a finite element program which can be used either in a pure analysis mode like GRLWEAP™ or based on measurements like CAPWAP®. The name of the program is actually **T**ransients **I**n **P**iles-**W**ave, **H**alfspace and **I**nterface **P**rogram (TIPWHIP). The program models the soil as a halfspace and uses a soil-pile interface for the modeling of large strains.

This program is particularly useful for large diameter piles or shafts and for pipe piles that may plug statically but not dynamically. An example in the figures below demonstrates the calculated pile top force and velocity (under these dynamic loads the 600 mm dia. open-end pipe did not plug) and the calculated static load-set curve (plugging occurred under the simulated static loads).



Calculated pile top records; dynamic load did not cause plugging



Calculated load-set curve; static loading caused plugging

For Users of WINDOWS NT

If you are considering upgrading to NT 4.0 and are running a Key version of GRL Software, please take a minute to contact either *Beth Richardson* or *Brad Gipson* at GRL in Cleveland (phone and fax, please see below).

California Office Relocation

Steven K. Abe, GRL's engineer in California, has relocated. The new office address is: 2230 Lariat Lane, Walnut Creek, CA 94596; Ph: 510-944-6363; Fax: 510-944-6570.

Calendar of Events

INTERNATIONAL

1996
Dec 2-6 China, PDA Lectures; contact Frank Ko, Earth Products China, Ph: 852-2392-8698, Fax: 852-2395-5655.

1997
Apr 24-26 China, PDA Users Days; contact Earth Products China (see above).

May 1, 2 Hong Kong, PDA Users Days; contact Earth Products China (see above).

May 6, 7 Korea, PDA Users Days; contact J. S. Cha, Young Shin Trading, Ph: 822-529-8803, Fax: 822-3461-3021.

USA

1996
Dec 3-5 Atlanta, GA, FHWA Conference on the Design of Bridges for Extreme Events, Ph: 801-797-2663, Fax: 801-797-0036.

1997
Feb 14-15 New Orleans, LA, First Annual Winter Round Table; Pile Driving Contractors Association.

July 16-19 Logan, UT, GeoLogan Piling Seminar; contact Prof. Joseph Caliendo, University of Utah, Ph: 801-797-2896, Fax: 801-797-1185.

National Highway Institute Workshops

For information please contact Jerry DiMaggio at Ph: 202-366-1569, Fax: 202-366-3378.

Jan 27-31	Lansing, MI	Feb 3-4	Ames, IA	Feb 18-21	Schaumburg, IL
Mar 4-5	Schaumburg, IL	Mar 10-14	Frankfort, KY	Mar 18-19	Topeka, KS
Apr 1-4	Houston, TX	May 12-16	Houston, TX		

News from PDI

Pile Dynamics, Inc. and Geokon India have completed a representation agreement. Mr. A.K. Rai, Director, came to Cleveland, OH to view the PDI facilities and receive information necessary to conduct educational programs in the Indian subcontinent. Mr. Rai can be reached in Lucknow at Tel: 091 522 388405 and Fax: 091 522 388573. Indian geotechnical engineers and contractors are encouraged to contact Geokon for information on GRL methods and PDI products.

GRLWEAP News

GRL is currently preparing the 1997.1 update. The new release will include an updated driving system (helmet weights, cushion materials) data bank which we are currently sending to manufacturers or their representatives for approval. The program will also simplify the retrieval of driving system data.

For those using the driveability option: please be aware that pre-1994 program versions would produce no changes in capacity for different gain/loss factors if all soil sensitivities were left zero. The current program produces a capacity change according to non-unity gain/loss factors when all setup factors are left at zero. Thus, reanalysis of pre-1994 data files with the new program would produce different results.

GRL Personnel News

GRL welcomes *Marty Bixler* to its full-time testing staff at the Florida office. While finishing work on his Masters of Science in Engineering degree at Case Western Reserve University in 1995, *Marty* also worked for GRL in the Cleveland office on some GRL research projects.

The International Stress Wave Conference

(a) Past: (Sept. 11-13, 1996) It was a record breaking event as far as number of attendants and quality of papers were concerned according to *Dr. G. G. Goble* who gave an introduction to the conference and a summary of accomplishments. Prof. B. Fellenius was the keynote lecturer. He reported on dynamic pile measurements taken by his father starting in 1948.

Conf. Chairman Prof. F. Townsend and Secretary *M. Hussein* obviously breathed a sigh of relief when the event had been brought to a successful conclusion. They report that there are still a few copies of the Proceedings for sale; please contact Prof. Townsend for information at Ph: 352-392-0926 or Fax: 352-392-3394.

(b) Future: The 6th SWC in 2000 Dr. Sussumu Niyama of IPT, at the end of the Fifth Int. Stress Conference, presented an invitation from the people and government officials of the State and City of Sao Paolo. Brazilian geotechnical engineers have for years been very active in the dynamic measurement area. The invitation for the 6th Stress Wave Conference in Sao Paolo in the year 2000 was accepted by the conference delegates.

GRL
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