



## DID YOU KNOW?

The Incas built suspension bridges made of grass to cross Andean gorges.



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### THE $\beta$ -METHOD, RELIABLE AND PROVEN FOR PILE QA/QC

Frank Rausche and Garland Likins

In the late-1970s GRL Engineers (then called Goble and Associates, Inc.) was called to a construction site in upper New York State where a large number of mechanically spliced, pre-stressed concrete piles were installed. The piles were long (up to 73 m - 240 ft.) and their driving behavior suggested that some suffered damage during installation. What to do?

An instrument that performed dynamic testing by the Case Method could already be routinely used at that time. Frank Rausche and Garland Likins packed up their somewhat bulky predecessor of the Pile Driving Analyzer<sup>®</sup> (PDA) system of today, and measured a large number of piles during restrrike. The collected records, they quickly found out, showed a clear relationship between the set per blow and the magnitude of a reflection from the damage location. They then calculated an integrity factor  $\beta = (1 - \alpha)/(1 + \alpha)$ . This  $\beta$  value represented the ratio of the cross section at the suspected damage location to that at the pile top. A  $\beta = 100\%$  therefore represented an intact pile with zero loss of cross section. Thus was born the " $\beta$ -Method" for pile integrity evaluation.<sup>1</sup> The published  $\beta$  equation considered the effects of soil resistance above the damage location.

From the time delay after impact it was apparent the damage was always mid-length near the splice locations. Quantifying the damage was extremely important to the project management. Clearly, rejecting all piles with some damage reflection, including those apparently suffering only minor distress, would have been unreasonable. Thus GRL recommended that if the  $\beta$ -Method suggested a loss of cross section greater than 20% but less than 40% ( $80\% > \beta > 60\%$ ) then all information available to the project management would be reviewed before rejecting the pile. A pile with a theoretical cross section loss greater than 40% ( $\beta < 60\%$ ) was rejected while a pile with a loss of 20% or less ( $\beta > 80\%$ ) was considered acceptable. All parties involved in the project accepted this approach allowing them

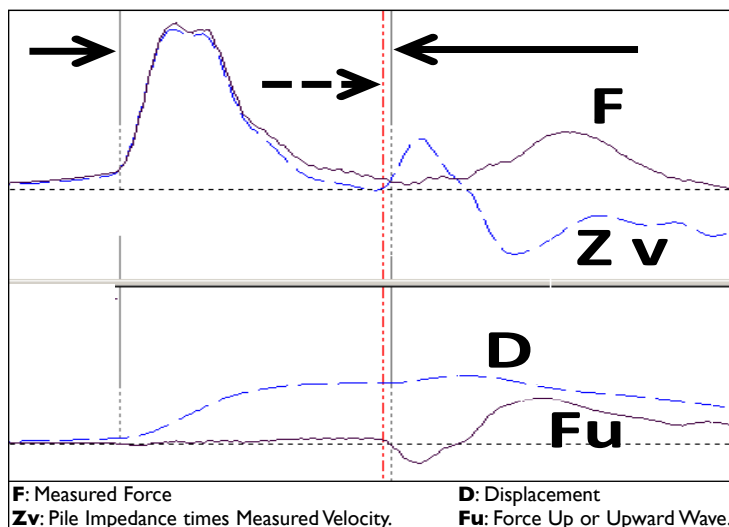


Figure A. PDA displays near-toe damage (dashed arrow) just prior to  $2L/c$  time



Figure B. Extracted concrete pile showing the pile damage.

to complete the foundation successfully. Since then, damage in test piles has been detected on countless construction sites in many countries by the  $\beta$ -method and verified by extraction, substantiating the original recommendations.

The  $\beta$ -Method only requires instrumentation near the pile head to detect potential damage at any location below this point of measurement. This single point of measurement makes instrumentation reusable and therefore economical since it can be employed either during pile installation (preferred) or after-the-fact when the installation records suggest problems, and only on piles that are questioned. The  $\beta$ -Method is applicable to any uniform cross section pile, including steel and concrete piles, covering the vast majority of all driven piles. For non-uniform piles, unless continuous monitoring is performed, which would show relative changes due to developing damage from blow to blow, a more rigorous signal matching analysis such as CAPWAP<sup>®</sup> is needed to evaluate pile integrity.

Where near-toe pile damage is indicated, the  $\beta$ -Method cannot evaluate the extent of the damage due to superposition of the closely following reflection from the pile toe. However, damage near the pile toe can be detected automatically by the PDA by looking for a reflection occurring prior to the expected reflection from the pile toe (Figure A; damage confirmed by extraction in Figure B). However, near-toe pile damage should always be evaluated along with an assessment of pile bearing and its stiffness using CAPWAP analysis. The results of these analyses are invaluable when deciding on the acceptance of a pile with near-toe damage. A recent publication<sup>1</sup>, which interested readers are encouraged to obtain from [www.pile.com/Reference](http://www.pile.com/Reference), gives a more thorough treatment of this subject.

<sup>1</sup> Rausche, F., and Goble, G., 1979. *Determination of Pile Damage by Pile Top Measurements, Behavior of Deep Foundations*, ASTM STP 670, pp 500-506.

<sup>11</sup> Likins, G. E., Rausche, F., 2014. *Pile Damage Prevention and Assessment Using Dynamic Monitoring and the Beta Method*. ASCE Geotechnical Special Publication No. 233: Reston, VA; pp 428-442.

## Highlights of the 2014 Calendar of events (May-September)

More events and information at [www.pile.com/events](http://www.pile.com/events)

### PDI Workshops, Seminars and Proficiency Tests:

May 12-14 in Dubai, United Arab Emirates: **Seminar on Deep Foundation Testing and Wave Equation Analysis**, followed by **Dynamic Foundation Testing Workshop and Proficiency Test**. **Jorge Beim** will be the lecturer. Info: [rose@albatech.ae](mailto:rose@albatech.ae).

May 20 in Stockholm, Sweden: **Seminar on Dynamic Testing - Pile Capacity and Pile Integrity**. **George Pisciaklo, Anna Sellountou, Oswald Klingmuller** and **Mattias Gravare** will be speaking. Info: [mattias@palanalis.se](mailto:mattias@palanalis.se)

September 17-19 in Cleveland, OH: **Seminar on Deep Foundation Testing and Wave Equation Analysis**, followed by **Dynamic Foundation Testing Workshop and Proficiency Test**. Info: [jessica@piledrivers.org](mailto:jessica@piledrivers.org).

### PDI and GRL Webinars: Learn without leaving your desk:

All sessions are presented via Internet and phone connection, last 1.5 - 2 hours and start at 9:00 am EST (New York Time). Info: [registration@pile.com](mailto:registration@pile.com)

June 10, 11, 17 and 18 (four 1.5 hours long sessions): **Advanced applications of CAPWAP® software** with **Brent Robinson**.

### GRL, PDI and/or PDI representatives will exhibit at the following events (a good chance to learn about new developments!)

May 19-22 in Albuquerque, NM: Visit the **PDI** exhibit booth at the FHWA - NMDOT 39th SW Geotechnical Engineering Conference.

May 21-23 in Stockholm, Sweden: Visit the booth of **PDI** Representatives **PDI Europe, GSP, SLP** and **DRC**, and watch an educational video on TIP, at the DFI and EFFC International Conference on Piling and Deep Foundations. [www.dfi-efcc2014.org](http://www.dfi-efcc2014.org)

May 26-28 in Shanghai, China: Visit the booth of **PDI** Representative **Earth Products China** at the GeoShanghai International Conference. [www.geoshanghai2014.org](http://www.geoshanghai2014.org)

June 19-20, 2014, Cambridge, MA: Visit the **PDI** booth at SUPERPILE 2014, and listen to presentations by Anna Sellountou and Mohamad Hussein. [www.dfi.org](http://www.dfi.org).

July 29-August 2 in Nashville, TN: Visit the **GRL** exhibit booth and listen to a GRL presentation at the ADSC 2014 Summer Meeting. [www.adsc-iafd.com](http://www.adsc-iafd.com)

### Other Learning Opportunities

May 20 in Fort Lauderdale FL: **Mohamad Hussein** speaks at the PDCA FL Meeting. Info and register: [van@piledrivers.org](mailto:van@piledrivers.org)

May 30 from 11:30 to 1:00 New York (Eastern) Time: **Garland Likins** will teach the ASCE webinar *Installation, Verification, and Application of Driven Piles*. Info and register: [www.asce.org/Continuing-Education/Webinars/Live-Webinars/](http://www.asce.org/Continuing-Education/Webinars/Live-Webinars/)

July 23-24 in Johannesburg, South Africa: **Frank Rausche** will teach a 2 day workshop organized by Amahubesi. Info: [trisha@amahubesi.co.za](mailto:trisha@amahubesi.co.za)

September 25-26 in Orlando, FL: **Mohamad Hussein** will be speaking at the ASCE seminar *Deep Foundations: Design, Construction, and Quality Control*. Info and register: [www.asce.org/Continuing-Education/Seminars/Face-to-Face-Seminars/](http://www.asce.org/Continuing-Education/Seminars/Face-to-Face-Seminars/)

### New books of interest to foundation engineers

*Recommendations on Piling* is the English translation of EA-Pfähle, edited by the German Geotechnical Society and published by Wiley/Ernst & Sohn. Widely respected in the German speaking world, the book has several chapters dedicated to load and integrity tests.

*From Soil Behavior Fundamentals to Innovations in Geotechnical Engineering*, GSP 233, compiles papers honoring Roy E. Olson. Edited by Maged Iskander, Ph.D., P.E., John E. Garlanger, Ph.D., P.E. and Mohamad H. Hussein, P.E., it is published by the ASCE Geo-Institute.

### ADSC Announces Mike O'Neill Lecture Award

The International Association of Foundation Drilling, ADSC, has announced the creation of the "ADSC's Michael W. O'Neill Lecture Award". The award will be presented "for outstanding contributions to the advancement of the state-of-the-practice in the design and construction of deep foundations through practical, applied research and/or through recommended improvements to design and/or construction methodologies." Dr. O'Neill, a professor at the University of Houston, passed away in 2003, leaving a legacy of exceptional contributions to the deep foundation industry both in academia and in practice. The Lecture Award is the brainchild of Pile Dynamics' Dr. Anna Sellountou and is fully underwritten by ADSC. The inaugural lecture will be delivered by Jerry A. DiMaggio, P.E..

### Pile Dynamics revamps

#### Pile Integrity Tester models V and FV

The traditional Pile Integrity Tester (wired model) got an updated look, along with larger color screen, a lighter enclosure and a standard USB port for more convenient data transfer. Its functionality remains unchanged, and it is still available with one or two channels of data acquisition. The 2 channel model, known in the industry as PIT-FV, is most often supplied with one accelerometer and one instrumented hammer, but may also be used with 2 accelerometers, technically making it a "PIT-VV". The smaller PIT-X and PIT-X2, which are supplied with or without wireless transmission capabilities, continue to be offered.



### GRL Engineers opens 9th office, in Seattle, WA

The Washington Office will serve the states of WA, OR, ID, and Western Canada, enabling GRL to provide a quick response to its Northwestern clients. Marty Bixler, P.E., who has been with GRL Florida for almost 20 years, will lead the office starting May 21. Marty can be reached at 425-381-9690 or [mbixler@GRLengineers.com](mailto:mbixler@GRLengineers.com).

### Florida office of GRL Welcomes New Engineers

Sean Killingsworth, E.I. and William Soehaili have joined the Florida office of GRL Engineers. William comes to GRL with a BS in Civil and Environmental Engineering from the University of Wisconsin, Madison, and with international experience. Sean has a BS in Civil Engineering from the University of Central Florida. Please join us in welcoming William and Sean and wishing them successful careers as foundation engineers.

### Recent notes from clients and customers:

"This is simply a thanks letter to you for your continuous support to us (...) Your support is also appreciated by our client." Mohammad Alam, Arab Center for Engineering Studies.

Hossein Rashidi, Ph.D., P.E., Principal of EarthSpectives, CA, thanked Frank Rausche for doing an excellent job (on a GRLVEAP Webinar), noting "I enjoyed listening to him even though I had to be at the office (...) for a 6 am presentation". He later added "recently (my staff and I) attended another webinar on PIT/CSL with Ryan Allin and we enjoyed that too."

To Jon Honeycutt and Brian Mondello: "Our Operations Manager, David Williams, was on site (Rosedale, Mississippi) last week for the Dynamic Testing on the Auger Piles for this project (...) LGB was very impressed with your field crew, their ability to lead others who were not very familiar with your testing and their willingness to work in far from ideal conditions." Todd B. Kalwei, Vice President, L. G. Barcus and Sons, Inc.

To Garland Likins: "Thank you very much for joining us in the recent user's day in Malaysia; it felt so great to be able to meet you again after these long years. For years, many people like us worldwide have been working under the success of and support from PDI. Your presence has certainly inspired us in many ways to move forward more confidently and, happily". Teh Kim Ong, Malaysia

**www.pile.com:** the portal for deep foundation testing services, instruments and software

### GRL Engineers, Inc.

216-831-6131

[info@GRLengineers.com](mailto:info@GRLengineers.com)

[www.GRLengineers.com](http://www.GRLengineers.com)

California • Colorado • Florida • Illinois • Louisiana  
North Carolina • Ohio • Pennsylvania • Washington

### Pile Dynamics, Inc.

30725 Aurora Road

Cleveland, Ohio 44139 USA

+1-216-831-6131

[info@pile.com](mailto:info@pile.com)

[www.pile.com/pdi](http://www.pile.com/pdi)

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