



Thank you for your support  
in 2012; may 2013 bring  
you health, happiness  
and prosperity.



### JET GROUTING: AN APPLICATION OF THERMAL INTEGRITY PROFILING

George Piscalko, Pile Dynamics, Inc. and  
Dr. Klaus Meinhard, Porr Bau GmbH

Jet grouting is a ground improvement technique used to increase the bearing capacity of most types of weak, unstable, or liquefiable soils. It is performed by first drilling to the design depth using small diameter rods and then injecting grout or lime-ash slurry into the subsoil, under pressure and with high speed jets. The high speed fluid injection causes the soil structure to break down and mix with the grout. As the drill rod is slowly rotated and raised, grouted soil/cement columns are formed. The grout columns expand and solidify, consolidating and stabilizing the subsoil.

Jet grouting is performed without the possibility of any visual inspection throughout the entire installation process. This makes quality control quite challenging: it is difficult to know with certainty the final diameter along the length of the jet grouted column.

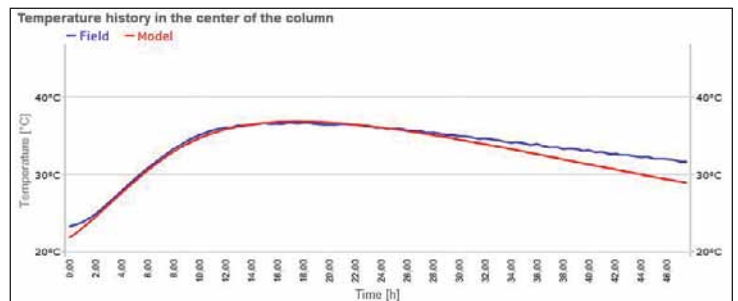


THERMAL WIRE cable installed in completed jet grouted column

Porr Bau GmbH, a contractor from Vienna that is part of one of Austria's largest construction companies, the PORR Group, has developed a system for using temperature measurements in jet grouted columns to determine their diameter: TEMPJET ([www.tempjet.com/about\\_en.ft](http://www.tempjet.com/about_en.ft)). Pile Dynamics, Inc. has partnered with Porr Bau GmbH to use its Thermal Integrity Profiler (TIP) system with Thermal Wire® brand cables to measure the temperature at the center of jet grouted columns. THERMAL WIRE cables feature a digital temperature sensor at every 305 mm (12 inches), and are now routinely used for quality control of drilled shafts, augered cast-in-place (ACIP) and continuous flight augered (CFA) piles. THERMAL WIRE cables are ruggedly constructed to withstand embedment in a concrete structure, and can be installed either prior (typically done for drilled shafts) or after casting (technique used for ACIP/CFA piles and jet grouted columns).

In the jet grouting application, THERMAL WIRE cables are installed through the drill rod immediately upon completion of the jet grouted column (Figure 1). A Thermal Acquisition Port (part of the TIP system) is connected to the THERMAL WIRE cables shortly after their installation, and temperature measurements from all sensors are collected and stored every 10 minutes throughout the grout curing process. The measured temperatures are transferred to a computer for further analysis by the TEMPJET software.

The TEMPJET software compares the measured temperature history with results from a numerical simulation of the thermo-chemical phenomenon of grout curing. Temperature history is a function of jet grout column diameter, grout mix cement content, and thermo-chemical properties of the grout and surrounding soil. Given known soil and grout properties, TEMPJET simulates a temperature profile as a function of an assumed jet column shape and cement content. Column diameter (shape) and cement content have distinctly different effects on the shape of the measured temperature history: the cement content affects the heating period at the beginning of the curing process, while the jet grout column diameter mainly influences the decrease of the temperature during cooling. For each combination of shape and cement content, TEMPJET simulates a unique temperature history and compares it with the one measured in the field. The software then refines its cement content and column shape assumptions until differences in the measured and simulated temperature histories are sufficiently small, at which point the program outputs the predicted diameter and cement content as a function of depth.



Measured (BLUE) and simulated (RED) temperatures versus time at one given depth of a jet grouted column.

The TEMPJET method of identifying the diameter and cement content has been applied to more than 300 jet grouted columns at various construction sites throughout Europe. The diameters for many of these tests were verified by excavation or other methods, with all diameter predictions correlating very nicely with the actual field-measured diameters.

A more thorough discussion of the software is found in Meinhard, K., Lackner, R. and Adam, D. *Temperature measurements to determine the diameter of jet grouted columns*. Proceedings, 11th International Conference on Geotechnical Challenges in Urban Regeneration, May 26-28, 2010, London, UK. Note that at the time of publication of that paper the application described in this article was still in development, and field temperature measurements were obtained by a different process.

## Highlights of the 2013 Calendar of Events (Jan-June) for a complete list and details, visit [www.pile.com/events](http://www.pile.com/events)

### PDI Workshops, Seminars and Proficiency Tests:

Some organizations require that persons performing high strain dynamic foundation testing have obtained a certain rank on the PDI-PDCA Dynamic Testing and Analysis Proficiency Test. These workshops offer a review prior to the test.

February 25, New Orleans, LA: PDCA and Pile Dynamics **Seminar** on Deep Foundation Dynamic Testing and Wave Equation Analysis, followed by...

February 26-27 New Orleans, LA: PDCA and Pile Dynamics Dynamic Foundation Testing **Workshop and Proficiency Test**, Frank Rausche and Brian Mondello will present at both events. For information and registration for both Seminar and Workshop visit [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents)

May 15-17, West Coast, PDCA and Pile Dynamics Dynamic Foundation Testing **Seminar, Workshop and Proficiency Test**. Details forthcoming.

### PDI Webinars: Learn without leaving your desk.

Each session lasts 2 hours and starts at 9 am Eastern Standard Time. Registration forms at [www.pile.com/events/pdievents](http://www.pile.com/events/pdievents).

February 26 – Quality Control of Augered Cast-in-Place / Continuous Flight Auger Piles with **George Piscsalko**

March 12, 13, 19 and 20 – Wave Equation Analysis of Piles using GRLWEAP with **Frank Rausche**

April 16 and 17 – Integrity Testing by Low Strain and Crosshole Sonic Logging Methods with **Ryan Allin**

May 7 and 8 – Dynamic Testing of Specialty Piles (Helical Piles & Augered Cast-in-Place) with **Brent Robinson**

21 y 22 de Mayo – Ensayos de Integridad/ Ensayos no Destructivos en pilotes (**en Español**) con **Jorge Beim**

### PDI and/or its Representatives will exhibit at the following events (a good chance to see new developments!):

February 6-9, Bonita Springs, FL: **PDI** will exhibit at the ADSC Annual Meeting. [www.adsc-iafd.com](http://www.adsc-iafd.com)

February 21-22, Brunswick, Germany: PDI Representative **GSP** will exhibit at Pfahlsymposium (in German). [www.pfahlsymposium.de](http://www.pfahlsymposium.de)

March 3-6, San Diego, CA: **PDI** will exhibit at the ASCE Geo-Institute Geo Congress. <http://content.asce.org/conferences/geo-congress2013/index.html>

**Other Learning Opportunities:** February 18-20, Baton Rouge, LA: **Frank Rausche** will present at the Louisiana Transportation Conference. Also visit the **GRL** exhibit booth.

June 2-5, Pittsburgh, PA: **George Piscsalko** will present “Non Destructive Testing of Drilled Shafts – Current Practice and New Method” at the 30th Annual International Bridge Conference.

**Continuing Education News:** Pile Dynamics, Inc. has been approved by the **Louisiana Professional Engineering and Surveying Board** to be a *Continuing Professional Development Provider* and by the **New York State Engineering Board** to be a *Continuing Education Sponsor for Engineering*.

**Pile Dynamics releases video:** Pile Dynamics has released a video showcasing all its products in both English and Spanish. Contact PDI [info@pile.com](mailto:info@pile.com) to request a copy!

## GRL has new Office Manager for Illinois office and welcomes new engineer.

Travis Coleman, P.E., an engineer with the Illinois office since 2005, is now GRL Illinois office manager. The Illinois office serves the states of Illinois, Indiana, Wisconsin, Iowa, Minnesota, South Dakota, North Dakota, Montana and Missouri (including Kansas City Metro area). John Holman, after completing a Masters of Science in Civil Engineering at Case Western Reserve University, has joined the Central office of GRL Engineers. The Central Office serves international locations, offshore sites and the State of Alaska, provides other offices with back up and expert advice and conducts research and educational activities. Please join us in congratulating Travis on his promotion and on welcoming John.

## Wireless hammer for the Pile Integrity Tester

PDI is now offering a wireless instrumented hammer to be used with the Pile Integrity Tester model PIT-X2. This addition increases the options for users of this low strain testing device. While the traditional single channel PIT-V and two-channel PIT-FV continue to be available, customers may also purchase the smaller PIT-X with a wireless accelerometer, as well as the PIT-X2 with 2 channels of data acquisition (Force and Velocity or 2 velocities).



## PDI and GRL engineers participate in the 9<sup>th</sup> International Conference on Testing and Design Methods on Deep Foundations in Japan

The September 2012 conference attracted more than 230 participants from 35 countries. **Garland Likins** presented the keynote lecture “A Brief Overview of Testing of Deep Foundations”, covering both traditional foundation testing methods and state of the art ones such as thermal integrity profiling (TIP) of drilled shafts. **Frank Rausche** and **Jorge Beim** addressed the challenges of calculating foundation capacity from dynamic measurements obtained during pile installations with vibratory hammers in “Analyzing and Interpreting Dynamic Measurements Taken During Vibratory Pile Driving”. **Garland Likins, Liqun Liang** and **Tom Hyatt** presented “Development of Automatic Signal Matching Procedure - iCAP<sup>®</sup>”, summarized in the previous edition of this newsletter. These papers are available at [www.pile.com/Reference](http://www.pile.com/Reference).

## PDI Representatives Write:

Aksan Kawanda (**Geotech Engineering**, PDI Representative in Indonesia): PDI gives me their best response for after-sales service. Fast response, very helpful staff and of course makes me feel like parts of your team. Makes me proud to be a PDI family member. Thank you everyone.

Gorazd Strnisa (**SLP**, PDI Representative in Slovenia): I don't know how you always find time to answer me so quickly on any of my questions. Thank you so much.

Sidney So (**Earth Products China**, PDI Representative in China): We much appreciate all the kind support of your professional team!

**PDI answers:** Excellent service is what differentiates us, and we could not do it without representatives like you!

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