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INTEGRITY IS JUST THE BEGINNING

Frank Rausche, PhD and Gina Beim

Deep foundation professionals frequently agonize about the structural integrity of their product. After all, a very expensive project may be rendered unserviceable, and the safety of people compromised, if the building or superstructure is supported by an inadequate pile, shaft or barrette. Case in point, the Ocean Tower on South Padre Island in Texas, which started out as an ambitious luxury condominium and after sinking almost 40 cm ended up as the largest building ever imploded.

Major voids or honeycombs, concrete contaminated by water or slurry, insufficient concrete strength due to inappropriate mix design or admixtures are just a few reasons why, according to some reviews, 20% of cast-in-situ foundations have anomalies, flaws or defects. It is therefore not surprising that codes in various countries such as the UK, Australia, United Arab Emirates and China require integrity testing, while many others (various US States, Argentina and others) recommend it.

When QA/QC project plans require foundation integrity testing, the most appropriate method has to be specified. Most frequently, the choice is made between either the Pulse Echo Method (PEM) or the Cross Hole Sonic Logging Method (CSL). They are incorporated in Pile Dynamics' instruments PIT and CHAMP, respectively. As a rule of thumb, CHAMP testing is more applicable to pile diameters greater than 600 mm (24"), but should also be considered when the pile length to diameter ratio exceeds 30 (where PEM records may become complex depending on construction methods and soil properties). Since CSL testing requires installation of access tubes, foundation elements that could have been tested by CSL, had they been prepared for it, end up instead being tested with the more limited PEM (pulse echo method limitations are discussed in Rausche et al, 2004 and other references, consult www.pile.com/ reference).

CHAMP results, particularly when combined with tomography, yield an impressive view of the pile integrity in terms of concrete wave speed (a measure of concrete quality). The method is versatile enough to provide clear results in slurry wall panels. For example, the late PDPSA engineer Antonio Mendez tested curved panels in Mexico City, lining sewer access shafts of up to 20 m diameter and 45 m depth. They required concrete evaluation between access tubes of more than 4 m distance. Very clear and easily interpreted results were obtained. On the other hand, the CSL method cannot check the concrete quality outside of the reinforcement cage.

PIT records generally can only provide information about one and only one major variation in shaft size or concrete quality. However, particularly where the important upper pile portion is concerned, these limited results can be of great value to the foundation professional.

The actual field testing is only the beginning. A sometimes simple, sometimes very demanding data interpretation follows which should classify the test records (Likins et al, 2007). Typical categories are "acceptable" or indicative of an "anomaly", "flaw" or "defect". Record interpretation should always be made within the context



PDI's Dr. Liqun Liang tests an ACIP Pile with PIT-X2 (2 velocity test) in Cleveland, OH

of the specific job site - taking into account soil borings and, in the case of augered cast in place (ACIP) or continuous flight auger (CFA) piles, also the installation records from automated monitoring equipment such as PDI's Pile Installation Recorder (PIR).

A record indicative of a defect requires the decision to accept, reject or repair the foundation, enlist a peer reviewer or call for additional testing. GRL Engineers has been involved in situations where, after CSL of large diameter shafts pointed to defects, access holes were drilled into the foundation, the foundation was cleaned out and high pressure grouting was then performed, followed by additional CSL testing to attest to the effectiveness of the repair. In another case, after a PEM indicated a defect, a high strain dynamic load test was performed, which not only provided information about the structural integrity, but also the geotechnical performance of the shaft.

There is absolutely no point in calling for integrity testing in the project specification, if the specification does not also establish a clear procedure for correcting perceived defects. If all parties involved agree on such a specification before the job is executed, then there will be no painful, construction delays, and at bid time the contractor will be able to provide a better estimate of potential cost.

Integrity testing is just the beginning of delivering a project with, well, integrity. And integrity methods as they exist today are, in the view of Pile Dynamics, in just the beginning stages of progress. PDI is currently developing new methods that hold the promise to overcome some of the limitations of current ones, to provide more information and to speed up both testing and the decision making. Stay tuned.

Rausche, F., et al, January, 2004. *Economy, Benefits and Limitations of NDT for Augered-Cast-in-Place-Piles*. Proceedings from the Michael Wayne O'Neill Auger Cast-in-Place Pile Sessions: Recent Experiences & Advancements in the U.S. and Abroad on the Use of Auger Cast-in-Places Piles, 83rd Annual Transportation Research Board Meeting: Washington. (CD-ROM)

Likins, G. E., et al, February, 2007. *Defect Analysis for CSL Testing*. Geotechnical Special Publication No. 158 Contemporary Issues in Deep Foundations; Proceedings from Geo-Denver 2007 New Peaks in Geotechnics: Denver, CO. (CD-ROM)

Winter – Spring 2011 Calendar of Events – See more at www.pile.com/events

- **January 24, Noon to 1:00 pm Eastern Time: ASCE Webinar on NDT Methods for the Integrity Assessment of Deep Foundation: Principles, Capabilities, and Limitations. Garland Likins will present.** <https://secure.asce.org/ASCEWebsite/WEBINAR/LISTWEBINAR.aspx>
- January 31-February 2, Madison, Wisconsin: University of Wisconsin's 36th National Course of Foundation Engineering and Design. **Pat Hannigan will present.** <http://epd.engr.wisc.edu/webL700>
- February 1-5, New Orleans, LA: ADSC 2011 Annual Meeting. www.adsc-iafd.com. **Visit the PDI/GRL table and watch PDI's product presentation on Friday the 4th.**
- February 1, Mannheim, Germany: Low Strain Integrity Testing (Impact Echo) Workshop (in German). **Presented by PDI's representative GSP.** For more information contact Dr.-Ing. Oswald Klingmüller at ok@gsp-mannheim.de
- February 2, Mannheim, Germany: Dynamic Load Testing Workshop (in German). **Presented by PDI's representative GSP.** For more information contact Dr.-Ing. Oswald Klingmüller at ok@gsp-mannheim.de
- **February 1, 2, 8 and 9, 9:00 am Eastern Time: PDI offers a GRLWEAP Webinar presented by Frank Rausche. Four, 1.5 to 2 hour long sessions. For more information contact Bill Herman at askpdi@pile.com**
- **February 16-17, New Orleans, LA: PDI and PDCA offer a PDA and CAPWAP Workshop. Garland Likins and Brent Robinson will present. For more information contact Gina Beim at gina@pile.com. Dynamic Measurement and Analysis Proficiency Test will be offered.**
- **February 17, New Orleans, LA: PDI and PDCA offer a half day GRLWEAP Workshop. Brent Robinson will present. For more information contact Gina Beim at gina@pile.com**
- **February 18, New Orleans, LA: PDI and PDCA offer a Workshop on Integrity Testing and QA/QC of Cast in Place Piles. Garland Likins and Brent Robinson will present. For more information contact Gina Beim at gina@pile.com**
- February 17-18, Braunschweig, Germany: Pfahlsymposium 2011 (in German). Presented by Institut für Grundbau und Bodenmechanik der TU Braunschweig. **Frank Rausche will present.** www.igb-tubs.de/
- March 13-16, Dallas, TX: Geo-Frontiers 2011 Sponsored by the Geo-Institute of ASCE and others. **Visit the PDI/GRL exhibit booth.** www.geofrontiers11.com
- March 17, Dallas, TX: DFI Seminar "Helical Foundations & Tiebacks". **Jorge Beim will present.** www.dfi.org
- March 17-18, Boston, MA: ASCE Seminar "Deep Foundations: Design, Construction and Quality Control". **Mohamad Hussein will present.** <https://secure.asce.org/ASCEWebsite/Webinar/ListSeminar.aspx?CatCode=CED-GEOT&catName=Geotechnical#5>
- March 30-April 1, Hershey, PA: ASCE Central PA 25th Annual Geotechnical Conference. **Visit the PDI exhibit booth.** www.central-pa-asce-geotech.org

GRLWEAP 2010 AND GRLWEAP OFFSHORE WAVE

Our last newsletter whetted everyone's appetite for GRLWEAP 2010, which was then in final beta testing phase. The wait is now over; the software has been officially released. Current users of the Wave Equation Analysis of Pile Driving who upgrade to the 2010 version will enjoy its friendlier interface with Office programs, simplified input for driveability and battered pile analyses, and the increased number of geotechnical analysis options.

GRLWEAP now has an option designed specifically for the Offshore industry – GRLWEAP Offshore Wave. GRLWEAP Offshore Wave makes it possible to model complex pipe pile sections and hammer locations at any point along the pile, performs static bending analysis for inclined pile driving, and outputs fatigue analysis tables.



PIT-X2: INTEGRITY TESTING WITH TWO ACCELERATION CHANNELS

The smaller and wireless Pile Integrity Tester, PIT-X, was an instant success when it was released about a year ago. However, those that wanted to perform the low strain test using two accelerometers (to test piles under existing structures, to determine wave speed and evaluate unknown foundation length or to better analyze the records of relatively large piles), had to use the larger PIT-FV. That is no longer the case! The PIT-X2 looks exactly like the PIT-X, and acquires data from two accelerometers coupled to a wireless transmitter. A model that will work with an instrumented hammer is in the works.



DYNAMIC MEASUREMENT AND ANALYSIS PROFICIENCY TEST

PDI, in cooperation with the Pile Driving Contractors Association, has developed a Dynamic Measurement and Analysis Proficiency Test. This proficiency test will be offered for the first time in the USA in New Orleans this coming February (it was offered in Spain, Indonesia and Korea this past Fall). The test, which covers the theory of high strain dynamic testing, PDA data interpretation, application and quality, and CAPWAP analysis, is designed to be completed in 90 minutes or less, with minimal calculations required. PDI and PDCA plan to offer workshops to prepare for the test on a regular basis. The Foundation QA High Strain Dynamic Testing Examination is still available and may be taken at any Regis location. The workshops offered by PDI and PDCA will provide adequate preparation for either the FQA exam or the PDI/PDCA test. Pile Dynamics' main interest is to encourage PDA testers to become experts in their field, something that can be demonstrated by passing with a high ranking either the FQA exam or the new PDI/PDCA test.

PDI WELCOMES NEW INTERNATIONAL REPRESENTATIVE

PDI has added a new representative in the past few months: Nasiruddin Ahmed with Shamsun International represents PDI in Bangladesh.

Visit us at WWW.PILE.COM



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