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UNDERWATER DYNAMIC PILE TESTING

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Offshore oil and gas projects all over the world require extremely large, sometimes called “mega-large”, jackets and monopiles to be installed offshore in deep water. In many instances, the most economical installation consists of driving the foundation piles underwater.

High strain dynamic pile testing during offshore pile installation has been common for several decades (readers unfamiliar with this test are referred to pile.com/reference), however in the past driving hammers were generally above water, and so were the accelerometers and strain transducers used to collect test data. Underwater driving requires that high strain dynamic testing be performed with underwater sensors. Underwater measurements are quite challenging due to the need for waterproof transducers, cables and connectors, due to the difficulties of handling the heavy cables and due to their physical interference with other equipment, such as Remotely Operated Vehicles (ROV).

GRL Engineers, Inc. recently performed underwater high strain dynamic testing on the Liwan 3-1 Gas Field located in the eastern South China Sea using equipment from Pile Dynamics, Inc. The Central Processing Platform (CEP) of the Gas Field is supported by an 8-leg steel jacket. Figure 1 shows the 31,375-tonnes (69,025 kips) jacket, which was floated to location, ready to be launched. The derrick barge Lanjing, owned by COOEC (China Offshore Oil Engineering Co. Ltd.) with a lifting capacity of 7,500 tonnes (16,500 kips), was used to install the CEP jacket in 190 m (623 ft) of water. Each corner leg was secured to the seafloor with 4 vertical, 158 m (518 ft) long skirt piles consisting of 2,743 mm (108 in) O.D. steel pipes with variable wall thickness ranging from 50 mm to 100 mm (approximately 2 to 4 in) for a total pile weight of 754 tonnes (1,660 kips). The piles were driven full length to the design penetration of 135 m (443 ft) for a required bearing capacity of approximately 130 MN (29,200 kips) each.

Soil borings indicated predominantly soft to very stiff clay layers, underlain by medium dense to dense sand and sandy silt grading to dense to very dense sand.



Figure 1: 8-leg jacket ready to be launched

Two piles were successfully tested underwater with a Pile Driving Analyzer® system (PDA). Underwater cable and sensors are shown in Fig. 2. Both test piles were driven with a Menck MHU 1200S (ram weight 66 tonnes or 145 kips, rated energy 1200 kJ – 885 kip-ft). Initially the pile settled under its own weight to about 12m (39 ft) below mud line; after several low energy blows the pile “ran away” from the hammer, stopping at 72 m (236 ft) penetration. After setting the hammer back onto the pile top, the piles were driven without incident to the final penetration of 135 m (443 ft) at blow counts of 120 to 140 blows per half meter (6 to 7 blows per inch).

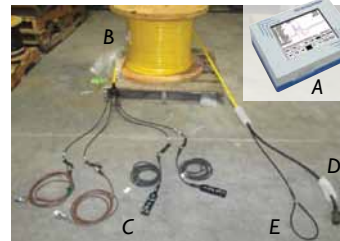


Figure 2: High Strain Dynamic Testing field equipment

- A) PDA
- B) Underwater cable;
- C) Underwater strain transducers and accelerometers;
- D) Connector to PDA;
- E) Steel wire for pulling cable

Data acquired by the PDA was of good quality and was immediately analyzed by the CAPWAP® software. Results, shown in Figure 3, indicated a mobilized capacity of 49 MN (11,000 kips) at the end of initial installation. The PDA testing had been requested out of a concern for potential pile refusal around at 110 m (360 ft) penetration, where the layer of dense sands begins. Based on the results, the designer felt confident that after the expected pile set-up the long term soil resistance of the piles would meet the required 130 MN (29,200 kips), provided a pile tip penetration reached the design 135 m (443 ft). Therefore, a restrike test was not requested.

The underwater sensors, cables and connectors performed reliably and yielded high quality data. GRL is confident this technology can routinely be applied to installations in even greater water depths.

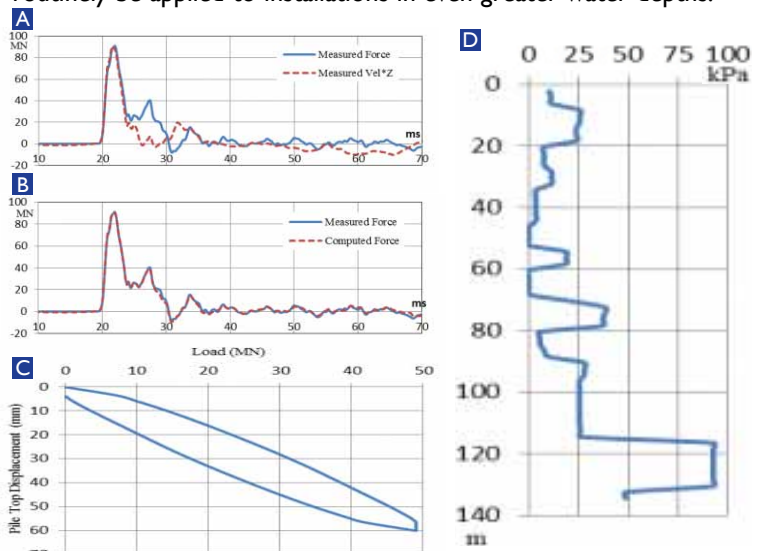


Figure 3: CAPWAP result: A) Measured force and velocity at pile top; B) Measured force and computed force based on the match at pile top; C) Simulated static load-set curve; D) Unit skin friction vs. depth based on CAPWAP analysis

Highlights of the 2013 Calendar of Events (May-Oct) for a complete list and details, visit www.pile.com/events

PDI Workshops, Seminars and Proficiency Tests:

July 17 San Francisco, CA: PDCA and Pile Dynamics **Seminar** on Deep Foundation Testing and Wave Equation Analysis, followed by

July 18-19 San Francisco, CA: Dynamic Foundation Testing **Workshop and Proficiency Test**. Info: www.piledrivers.com or Carolyn Wasdin at Carolyn@piledrivers.org

October 9, Cleveland, OH: PDCA and Pile Dynamics **Seminar** on Deep Foundation Testing and Wave Equation Analysis, followed by

October 10-11 Cleveland, Ohio: Dynamic Foundation Testing **Workshop and Proficiency Test**. Info: www.piledrivers.com or Carolyn Wasdin at Carolyn@piledrivers.org

PDI Webinars - Learn without leaving your desk:

Sessions last 1.5 - 2 hours and start at 9 am EST. Register at www.pile.com/events

May 21-22: Ensayos de Integridad/ Ensayos no Destructivos en pilotes (en Español) con **Jorge Beim**

July 30: SPT Hammer Energy Measurements with **Brent Robinson**

September 17: Introduction to High Strain Dynamic Foundation Testing with **Brent Robinson**

September 24-October 2: Advanced applications of CAPWAP® software with **Brent Robinson**

October 16: Thermal Integrity Profiling of Concrete Foundations with **Garland Likins**

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

May 15-16, Minneapolis, MN: **PDI** will exhibit at SuperPile 2012. www.dfi.org

May 16, Göteborg, Sweden: **Pile Dynamics Europe** will exhibit at Pålåg (Piling Day, in Swedish). www.palag.se

September 25-28, Phoenix, AZ: **PDI** will exhibit at the DFI 38th Annual Conference on Deep Foundations. www.dfi.org

September 29-October 3, Montreal, Canada: **PDI** will exhibit at GeoMontreal 2013. www.geomontreal2013.ca

September 30-October 2, Williamsburg, VA: **PDI** will exhibit at the ASCE G-GeoVirginia Conference. www.virginiageoinstitute.org

Other Learning Opportunities:

June 2-5, Pittsburgh, PA: **George Piscalko** will present at the 30th Annual International Bridge Conference. www.eswp.com/bridge

June 13, Vancouver, Canada: **Pat Hannigan** will co-present the PDCA Pile Driving Inspectors Course. www.piledrivers.org

July 10: **Garland Likins** will present the ASCE webinar Integrity Assessment of Deep Foundations: Principles and Limitations. <http://mylearning.asce.org/diweb/catalog/item/id/92696>

July 18, Columbus, OH: Pile Dynamics will present at the DFI Drilled Shaft Seminar www.dfi.org/conferences.asp

July 31-August 4, Coeur d'Alene, ID: Listen to a short Thermal Integrity Profiling presentation at the ADSC Summer Meeting. www.adsc-iafd.com

August 21: **Garland Likins** will present the ASCE webinar Installation, Verification and Application of Driven Piles. <http://mylearning.asce.org/diweb/catalog/item/id/92782>



First Thermal Integrity Profiling test in Asia

Geotech Engineering – PDI Representative for Indonesia – successfully conducted Thermal Integrity Profiling on a bored cast-in-place pile 48m long and one meter in diameter. The test, in Jakarta, was performed with Thermal Wire® cables, and was the first of its kind in Asia. Aksan Kawanda from Geotech Engineering reported that cable installation took no more than a half an hour and was quite easy. He added that results were available after only 24 hours, making it possible for Geotech to assess the shaft profile and report on its integrity. The quality of the results and the fact that the test caused no construction delay pleased the owner, the consultant and the contractor, said Aksan, adding that “TIP is the technology of the future”. (More information on TIP at www.pile.com/tip)

GRL expands Louisiana Office

GRL has expanded the operations of its Louisiana office to better serve the growing needs of the region. Brian Mondello, PE., who has been with the Florida office of GRL since 2001, took on the additional role of manager of the LA office on March 1. Jon Honeycutt, who holds a MS in Civil Engineering from Auburn University, has relocated to the area from the Central office of GRL. Jon was one of the instructors at the Dynamic Testing and Analysis workshop held in New Orleans earlier this year, and has worked on numerous job sites throughout the Midwest, East Coast and South. Mohamad Hussein will continue his involvement in Louisiana and other Southeastern States, and commented that “together, the three of us bring almost 50 years of foundation testing experience to the GRL Louisiana office.”

GRL welcomes new engineer

Bryan Shive has joined the team of the Pennsylvania office of GRL Engineers. Bryan has a BSCE from Morgan State University and has several years of foundation design experience, during which he became quite familiar with dynamic foundation testing. He joins Michael Morgano, who heads the PA office, Mario Saavedra and Alex Ryberg in serving Eastern Pennsylvania, Eastern New York, New Jersey, Delaware, Maryland, Maine, Massachusetts, Rhode Island, Connecticut, District of Columbia, and Northern Virginia. Welcome Bryan!

Frank Rausche earns DGE

Frank Rausche, PhD, PE, has been conferred the title of Diplomate, Geotechnical Engineering, by the Academy of Geo-Professionals. The Academy of Geo-Professionals was founded in October 2008 by the members of American Society of Civil Engineer's Geo-Institute, with the goal of providing advanced certification to geotechnical engineers. An engineer becomes a Diplomate through achieving advanced experience, licensure and education. Frank's certification was presented at a ceremony during Geo-Congress 2013 in San Diego, California on March 4, 2013. Congratulations Frank.

Continuing Education News

In addition to certifications in Louisiana and New York previously announced, Pile Dynamics, Inc. is now an Approved Sponsor of Continuing Professional Competency activities for Professional Engineers licensed by the State of North Carolina. Educational seminars, workshops and webinars offered by PDI qualify as such activities.

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

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