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DYNAMIC LOAD TESTING CONFORMS TO NEW ASTM D-7383 RAPID LOAD TESTING STANDARD

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Camilo Alvarez, GRL Engineers, Inc.

Stress waves in a pile or any other slender elastic element are a fascinating phenomenon. Mathematically described in the 19th century by Boussinesque, St. Venant and others, they can be studied graphically as shown by Fischer in the 1950's and 60's, or numerically as was most successfully done by Smith in his initial development of the "wave equation". Wave propagation theory helps us to interpret dynamic measurements on any type of slender pile. Such measurements record both an impact force that compresses the pile top and the echo that is generated by changes in soil resistance or changes in pile properties, most importantly the reflection at the pile toe.

In order to provide a visual representation of the stress wave propagation, Pile Dynamics prepared two computer programs which are freely accessible on www.pile.com and are easily used by anyone with an interest in mechanics. The first one, called PIT-S, shows the response of a pile to a very short and sharp impulse as typically generated by a pulse-echo or low strain integrity test (ASTM D5882). It also shows the stress wave paths generated by the light hammer pulse and allows for modeling soil and pile in a realistic manner.

The second program, called PDI-Wave, is based on Smith's wave equation concept and shows what happens when a heavy ram impacts a pile. The left part of Figure 1 shows by its size and blue color that the pile is in compression at some time during the impact event (PDI-Wave represents tension in red). To the right, pile top force, velocity and displacement show data that would be acquired in a high strain dynamic load test (ASTM D4945) or force-pulse (rapid) test (ASTM D7383) on a deep foundation element. Data acquisition and analysis are usually achieved with a Pile Driving Analyzer® (PDA) and CAPWAP®.

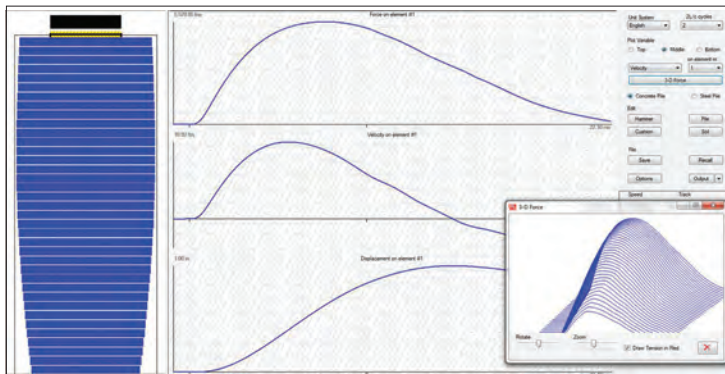


Figure 1: Simulation by PDI-Wave of a lightly cushioned, heavy ram impact

Interpretation of records by wave propagation theory is only successful if the applied pulse has a "wave front", in other words, if the force rises quickly. An over-cushioned impact causes a very slow increase of forces and the resulting reflections give no clear information as to their point of origin (depth along the pile). For this reason, over-cushioned impacts

do not lend themselves to the assessment of the soil resistance distribution and/or pile integrity solely from force and velocity measurements at the pile top. On the other hand, a relatively heavy ram has the advantage of making the impulse long enough to suppress tension stresses that may be detrimental to an under-reinforced shaft. According to Rausche et al. (2008) the suppression of tension stresses is primarily a function of the relative ratio of ram weight to pile weight ("alpha"), a conclusion that was already reached in closed form solutions by the 19th century mathematicians studying wave propagation. Figure 2 of Rausche et al. (2008) illustrates this concept.

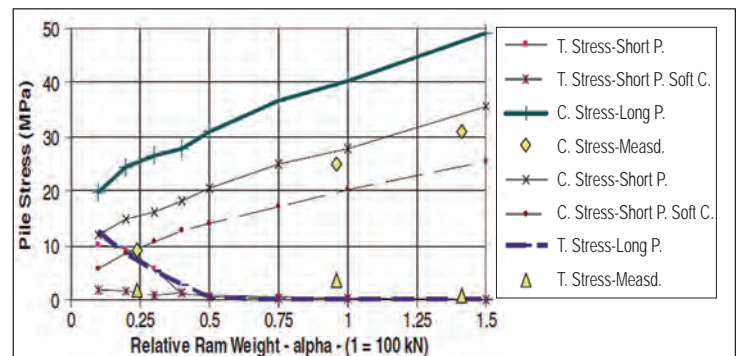


Figure 2: Relationship between ram-pile weight ratio and pile stresses for long and short piles.

GRL California recently tested several drilled shafts in Pico Rivera, CA, using the PDA and a weight of mass 15 ton for the impact. The shafts had a diameter of 900 mm and ranged in length between 9.7 and 10.4 m. The force records were measured by a load cell (unlike in a conventional PDA test which uses strain transducers for force measurements) when the weight was dropped from a height between 0.9 and 1.2 m onto a 0.6 m plywood cushion.

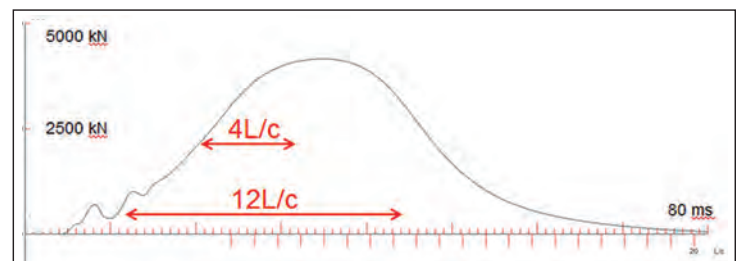


Figure 3: Force at shaft top from dynamic/rapid load test

CAPWAP-calculated static capacities were close to 5000 kN with about 50% end bearing for most test shafts. Tension stress levels were insignificant, which could be expected since the ram to pile weight ratio was 0.83.

Figure 3 shows a force record with a total duration well in excess of the ASTM D7383 requirements (12 times the wave travel time, L/c , overall and 4 times at half load). This shows that PDA tests (normally run according to ASTM D4945) can qualify as rapid load tests under D7383 when a ram of sufficient mass is used, with the considerable advantage that the data with a clear "wave front" can be analyzed by the rigorous CAPWAP analysis (Miyasaka et al, 2008).

References mentioned on this article may be downloaded from www.pile.com/references.

2012 Calendar of Events Highlights – for a complete list and event details, visit www.pile.com/events

MARCH

- 5** in Tampa, FL: Attend the PDCA and Pile Dynamics Seminar on Deep Foundations Testing and Wave Equation Analysis and learn from Dr. Frank Rausche and Garland Likins. Info: Lori@piledrivers.org.
- 6-7** in Tampa, FL: Attend a Dynamic Foundation Testing Workshop and take the PDCA/PDI Dynamic Measurement and Analysis Proficiency Test. Dr. Frank Rausche, Garland Likins and Mohamad Hussein will present. Info: Lori@piledrivers.org.
- 13, 14, 20, 21**, via Internet : Ensayos no Destructivos en Pilotes (en español). Jorge Beim suministrará 4 secciones de 1,5 a 2 horas de duración (9:00 Eastern Time). Info: registration@pile.com
- 14-17** Visit the PDI exhibit booth at the ADSC Equipment Expo and Technical Conference in San Antonio, TX. Info: www.adsc-iafd.com.
- 19, 12:00 PM - 1:30 PM Eastern Time:** Learn from Garland Likins by attending the ASCE webinar (Internet and Phone Connection) Integrity Assessment of Deep Foundations: Principles and Limitations. Register at www.asce.org/conted/seminars.
- 27-28 & April 3, 4**, Internet: Ensaios não Destrutivos em Estacas (em português). Jorge Beim apresentará 4 seções de 1,5 a 2 horas de duração (9:00 horário de Nova Iorque). Info: registration@pile.com
- 25-29** Visit the PDI - GRL joint exhibit booth at the ASCE Geo-Institute Geo-Congress 2012 in Oakland, California. Info: content.geoinstitute.org/GeoCongress2012.html.
- 30** in Carlsbad, CA: Learn about Analysis, Design and Testing of Pile Foundations from Prof. Bengt Fellenius. Seminar sponsored by EERI, ASCE Geotech (Geo-Institute San Diego), and DFI. Info: JMeneses@kleinfelder.com.

APRIL

25-27 in Albuquerque, NM: PDCA 16th Annual Conference. Info: www.piledrivers.org.

MAY

16-17 in Portland, OR: Visit the PDI booth at the Deep Foundations Institute's SuperPile 2012. Info: www.dfi.org/conferences.asp

15, 16, 22, 23, via Internet and Phone Connection: CAPWAP® for Users Webinar with Brent Robinson. Info: registration@pile.com

JUNE 17-20, 2012, São Paulo, SP, Brazil: Visit the booth of PDI representative Carmix do Brasil at the 7th Seminar on Special Foundations Engineering and Geotechnics and 1st Foundation and Geotechnics Industry Show (SEFE7). Sponsored by ABEF, ABMS and DFI. Info: www.sefe.com.br

September 18-20 in Kanazawa, Japan: The 9th International Conference on Testing and Design Methods for Deep Foundations. Sponsored by The Organizing Committee of IS-Kanazawa 2012. Info: <http://is-kanazawa2012.jp> or contact Prof. Tatsunori Matsumoto at matsumot@t.kanazawa-u.ac.jp. Successor to the International Conferences on the Application of Stresswave Theory to Piles.

October 17-19 in Cleveland, Ohio: Seminar on Deep Foundations Testing and Wave Equation Analysis, PDA and CAPWAP Workshop and Dynamic Measurement and Analysis Proficiency Test. Sponsored by PDCA and Pile Dynamics, Inc. Details forthcoming.

NEW YEAR, NEW FORMAT

The next few issues of our newsletter will be sent to you in both hard copy and as an email link. Many of you are already reading this newsletter on PDF format. If you are reading this in hard copy and would prefer to receive it sooner and in electronic format please sign up at www.pile.com/newsletter.

DYNAMIC FOUNDATION TESTING (PDA AND CAPWAP®) WORKSHOP AND REPRESENTATIVES DAY

PDCA and PDI held a successful PDA and CAPWAP Workshop at PDI's headquarters last October (photo below). Several of the participants took the PDCA/PDI Dynamic Measurement and Analysis Proficiency Test. The next opportunity to take this Proficiency Test is in March (see calendar of events). Following the workshop, PDI hosted a meeting for its world-wide Representatives. The event was designed to give representatives the tools to better serve PDI customers wherever in the world they may be interested in testing foundations. The words of those who attended say it all: "I really appreciate to your kindness during my stay in Cleveland." said Nobuhito Nagai, Geo5, representative in Japan; (it was a) "...great pleasure and wonderful experience during the Representatives day", added Aksan Kawanda, PDI representative in Indonesia; "I would like to take the opportunity to say "Thank you!" to all the PDI staff! (...) Not only did we learn something new and got up to date with new and improved products, but we also had a fun time together which is also very important" Mattias Grävare, Pile Dynamics Europe, PDI representative in Denmark, Estonia, Finland, Hungary, Ireland, Latvia, Lithuania, Norway, Poland, Sweden, Ukraine and United Kingdom.



PDI SALES DEPARTMENT NEWS

Nicole Angie, who has been Sales and Marketing Coordinator for Pile Dynamics, has moved to the role of Sales Manager. Nicole looks forward to helping PDI customers in her new capacity, along with Sales Team Members Bill Herman, Tony Barbieri and Dana Shea and PDI's 30 international representatives.

PDI CLIENTS WRITE

Mr. Parakrama Jayasinghe of Geotech Testing Services, Sri Lanka, sent the following note after attending a Pile Dynamics workshop: "Thank you very much for the opportunity given to us to gain a more intimate understanding of the PDA system and the CAPWAP. I am sure that both of us are feeling much more comfortable with the testing as well as the analysis."

"I want to thank you for all the help and information you supplied me/us (...). It has always been between zero and two days until I got a detailed answer from you (...). It's just so good to know, that someone is "out there" to support me..." Dipl.-Ing. Jan Fischer, Institut für Grundbau und Bodenmechanik, Technische Universität Braunschweig, Germany, in an email to Frank Rausche.

GRL ENGINEERS NEWS

Please join us in welcoming Jon Honeycutt, E.I., to the Central office of GRL Engineers in Cleveland, OH. Jon comes to GRL with experience in dynamic pile testing and expertise in SPT energy measurements, having published "Local and National Scale Energy Calibration of Standard Penetration Test Hammers." The GRL Central Office provides measurement and analysis services for Alaska, international locations and offshore sites, provides all GRL offices with assistance and expert advice in complex situations, and conducts research and educational activities.

Anna Klesney, from the Colorado Office of GRL Engineers, received letters of appreciation from C. L. "Butch" Otter, Governor of Idaho and from Brian Ness, Director of the Idaho Department of Transportation, for GRL's work on the Interstate 84 GARVEE reconstruction project.

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