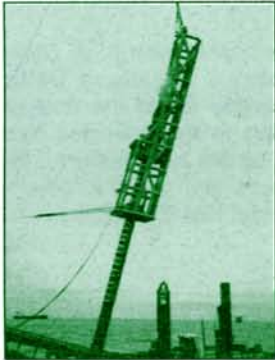




Just Run a Wave
By Frank Rausche



GRLWEAP™

Wave Equation Analysis: Engineers do it. Contractors do it. Hammer manufacturers do it. Most professionals involved in pile driving projects do it and specifications require it.

Why are they doing it? To be sure that a pile can be driven safely and efficiently.

What do they need to know as inputs? The pile properties, the hammer model and associated driving system, and soil information.

When do they run the wave equation analysis? Usually prior to the pile installation, during design, to check whether the selected pile can be driven to the desired depth or capacity, or if a change of pile size or wall thickness is indicated. The analysis also helps in cost estimating, by aiding in hammer selection and in the assessment of driving time.

Why not just use a formula? Doesn't a formula give you a required blow count for a hammer energy value and a required capacity? Sure, but most formulas give the same (inaccurate) result regardless of pile stiffness, hammer or soil type or other parameter variations. None of the formulas yields accurate capacity or stress prediction. Formulas have therefore fallen out of favor with most professionals, and have been generally replaced by user-friendly wave equation analysis.

A factor of safety must be applied to the calculated ultimate pile capacity. Some codes prescribe a factor of safety based on all sources of uncertainty, including project type, care used in pile installation, and accuracy of the method of capacity assessment. A good example is the design code of the Pile Driving Contractors Association (PDCA), which recommends a lower factor of safety for wave equation analysis than for formulas.

It is easy to run a basic wave equation analysis, particularly for anyone familiar with hammers, driving systems, piles and soils. Yes, you have to use the right input values for the various system components, but the GRLWEAP software contains

extensive recommendations. The "bearing graph" analysis makes it easy to compare two hammers by showing ultimate capacity and driving stresses versus blow count. You can also estimate how many minutes it should take to drive the pile to a certain depth. Such a "driveability" analysis requires an assessment of the ultimate pile capacity versus depth (here, assistance from a geotechnical engineer is helpful).

As a GRLWEAP example, consider a 300 mm diameter (12 inch) closed ended pipe pile driven into an increasingly dense sand (after driving it will be filled with concrete). The required working load of 50 tonnes with a required factor of safety of 2.5 leads to a minimum ultimate capacity of 125 tonnes. A static soil analysis indicates that the pile has to be driven to roughly 15 m depth to get the required capacity. You are to choose the wall thickness and hammer. An air hammer, acceptable according to the ENR formula, and a higher energy diesel are considered. The table below summarizes the results from GRLWEAP.

Obviously driving the thinner walled pipe with the small air hammer is uneconomical, requiring too many blows and a driving time of more than 1½ hours. Furthermore, damage might occur for mild steel piles because of the larger number of blows at high stresses. With the thicker wall, the pure driving time would be greatly reduced. The diesel hammer could drive either pile very quickly, however, high strength steel would be needed, at least for the 6 mm pile.

Stresses are normally predicted within 10% by GRLWEAP, and calculated blow counts and driving times also have a margin of error, primarily due to hammer performance variations. Thus, the wave equation results should be checked by field measurements during pile driving using a Pile Driving Analyzer®. The safety factor often used for wave equation analysis can be further lowered (by PDCA or AASHTO code) if the pile is either dynamically or statically tested.

PDI regularly offers workshops on wave equation analysis, and GRL Engineers provide individual training at a client's office or at its offices. GRL Engineers also perform the analysis on a consulting basis. The wave equation analysis is an invaluable tool for the selection of hammer and pile sizes, and reduces unnecessary costs due to high blow counts, or due to pile damage from excessive driving stresses.

Happy Holidays
The end of another successful year for GRL and PDI is a wonderful opportunity to thank you, our readers, and wish you the best for 2003.

GRLWEAP Calculated Results

Wall Thickness mm (inch)	Hammer	Ram Weight kN (kips)	Rated Energy kJ (kip-ft)	No. of blows (time in minutes)	Compressive Stress MPa (ksi)
6 (1/4)	air	22 (5.0)	20 (15)	5836 (106)	213 (31)
6 (1/4)	diesel	19 (4.3)	59 (43)	662 (16)	260 (38)
9 (3/8)	air	22 (5.0)	20 (15)	1640 (30)	140 (20)
9 (3/8)	diesel	19 (4.3)	59 (43)	635 (15)	220 (32)

CALENDAR OF EVENTS

2003

Feb. 13-15, Orlando, FL: GRLWEAP and PDA, CAPWAP, CHA and PIT Workshops. For information call 1-216-831-6131 or email info@pile.com. The "Foundation QA Dynamic Pile Testing Examination" will be offered in Florida. Interested engineers can refer to the website <http://www.foundationqa.com> for further information. Pile Dynamics endorses this examination for PDA testers.

Feb. 21-22, Atlanta, GA: Pile Driving Contractors Association (PDCA) Winter Roundtable. For information visit <http://www.piledrivers.org/pdca/events.cfm> or call the PDCA office at 1-888-440-7452.

March 6-8, St. Louis, MO: Geotechnical and Structural Design and Construction Monitoring of Deep Foundations. Presented by Foundation Courses, Inc. (Dr. George Goble and Jerry DiMaggio). For information call 1-303-494-0702 or email law@bridgetest.com

June 22-26, Cambridge, MA: 12th Panamerican Conference on Soil Mechanics and Geotechnical Engineering and the 39th US Rock Mechanics Symposium. For information visit www.soilrock.mit.edu

Sept. 18-19, Chicago, IL: PDCA Design & Installation of Cost Efficient Driven Piles Symposium. For information call 1-888-440-7452.

Oct. 23-25, Miami, FL: DFI 28th Annual Members Conference. For information call 1-201-567-4232 or email dfihq@dfi.org.

Workshops a Big Success, More Planned

PDA, CAPWAP, CHA, PIT and GRLWEAP Workshops held in Cleveland in November and in Germany in September once again attracted a large number of engineers and contractors. The new format of these educational sessions permits you to attend one or more workshops depending on your interests. IACET continuing education credits are awarded. The next workshops will be held in February in Orlando, FL. For those wishing to develop their expertise while enjoying balmy temperatures, this is a great opportunity!

Pile Driving Analyzer Makes History

As part of the celebration of 150 years of the American Society of Civil Engineers (ASCE), the October 2002 issue of Geo-Strata, the publication of the Geo Institute of ASCE, reviews 150 years of milestones in Geotechnical Design and Construction. The entry for 1968 reads "The first pile driving analyzer (PDA) is developed by the Case Project. Pile capacity predictions are made by 1970."

PDI Representation in France

Pile Dynamics is pleased to announce that G-Octopus SARL en Formation has been appointed as PDI's representative in France. Managing Director, [Martin Hammann](mailto:Martin.Hammann@g-octopus.com), can be contacted by email at info@g-octopus.com, phone (33-6-07-166415) or fax (33-6-87-85-0012). You can also visit their web site at <http://www.g-octopus.com>.

PDILOT Program

About a year ago PDI provided its users with a free trial license of the PDILOT program for reporting of Pile Driving Analyzer® results. Users should contact Pile Dynamics for a new version with an extended expiration date.

GRLWEAP Program

An update to the 2002 version will be available in the near future. This update contains an expanded and improved hammer data file and modifications to a few program details. PDI will contact users of the 2002 version with updating instructions.

New CHA Software Makes Cross Hole Sonic Logging Data Easier to Interpret

Pile Dynamics has released a new version of its Cross Hole Analyzer (CHA) software. Version 8 includes a Defect Analysis feature that represents a valuable aid to the analyst. Once thresholds and filters are applied to the collected data (suggested values for these are given by the Help feature), the program clearly identifies defect locations and prints a "defects report". Current CHA users should contact Pile Dynamics for the upgrade.

Readers Write

[Ravikiran Vaidya](#) from Geo Dynamics India emailed us saying: "I greatly appreciate you and your colleagues superb support that helps me in turn commit to my clients. It always feels nice and comfortable to know that help is always just around the corner when it is essential. This also saves lot of time for everybody including my clients."

[Juan Castellanos](#) from the State of Florida Department of Transportation writes: "I would like to express my appreciation to Mr. [Camilo Alvarez](#) (GRL Florida) for his performance (...) in the Districtwide projects we have with your firm. His assistance and the quality of his work have been excellent. I am very glad to have him in our projects. Please share this commendation with him and keep up the good work!!"

[Teh Kim Ong](#) thanked [Garland Likins](#) (PDI) for his "precious" and "enlightening" advice. Teh Kim Ong appreciates having learned about "many more capabilities of the 'magical' CAPWAP program".

Personnel News

We congratulate [Mohamad Hussein](#) (GRL Florida) for his appointment as the US representative on the Deep Foundations Committee of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE).

Since we last made personnel announcements, [Elliott Mecham](#) and [David Rancman](#) have joined GRL as staff engineers and [Steve Dewitt](#) has joined PDI as sales engineer. Elliott holds a BSCE degree from Utah State University and a MSCE degree from the University of Texas at Austin. David received a BSCE degree from Case Western Reserve University and Steve has a BSME degree from the University of Toledo.

After many years as office manager of GRL California, [Steve Abe](#) has decided to start an independent practice. We wish Steve success in his new venture. GRL will continue to serve its clients in the California region. Please call [Jay Berger](#) at 303-666-6127 for information.



GRL Engineers, Inc.

Main Office: Cleveland, Ohio
Branch Offices: Colorado • Florida • Illinois
North Carolina • Ohio • Pennsylvania



Pile Dynamics, Inc.

4535 Renaissance Parkway
Cleveland, OH 44128 USA

Phone: +1-216-831-6131

Fax: +1-216-831-0916

E-mail: info@pile.com

www.pile.com