DID YOU KNOW?

If approved, the Texas High-Speed Train will be the United State's first of its kind, with trains running smoothly at 186 mph.

Newsletter No. 96 - December, 2020

Innovations in Wave Equation Analysis with GRLWEAP14

By Brent Robinson, PhD, P.E.

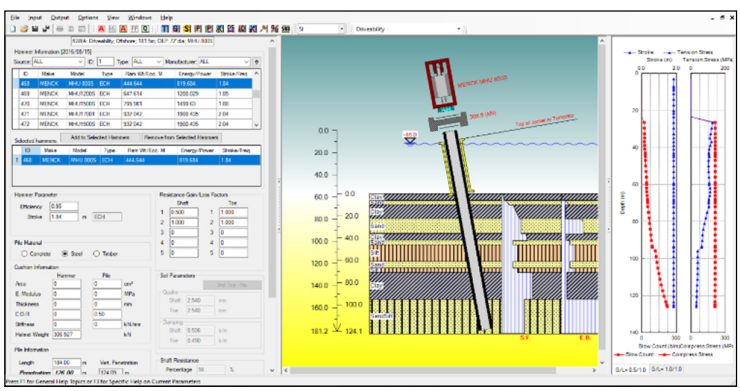
On April 15, 1986, PDI/GRL's first newsletter announced the anticipated release of the second version of WEAP, wave equation analysis of pile driving, WEAP86. Here in our 96th newsletter, we proudly announce the next major release of the program, GRLWEAP14, available in February 2021.

GRLWEAP is a one-dimensional Wave Equation Analysis Software Program that simulates a pile's response to pile driving equipment. It is the industry's standard program for pile simulation and analysis. The program enables users to determine the most sufficient and economical hammer to drive a job specific pile per estimated soil conditions prior to hammer mobilization.

For each analyzed geotechnical resistance at the time of driving, the program calculates hammer energy, driving resistance (blow count), as well as maximum compressive and tension stresses. As in earlier versions, GRLWEAP14's installation package includes help data files and background reports. The program is available in two versions: professional and offshore. GRLWEAP Offshore Wave Version includes exclusive features designed for challenging situations (free riding hammers and battered piles) and special analysis options such as fatigue output tables.

GRLWEAP14 allows the user to apply multiple hammers and driving systems to the same pile and soil model in a bearing graph analysis, while reducing the number of required input files. Also, the process of evaluating multiple hammers is streamlined. For driveability analyses, the program supports hammer changes at different pile penetrations. For example, users can start with a smaller hammer and change to a larger hammer as the driving resistance increases with further penetration.

After modeling the driving scenarios, GRLWEAP14 allows users to review the graphical output in a quick results tab adjacent to the "Input Screen." Alternatively, users can review the results on separate output screens for a more traditional graphical and tabular preview. Then, with a single click, users can export the results to a summary report to present the findings of multiple hammers. From other output views, users can review additional variables versus time or extrema tables for fatigue analyses.



GRLWEAP14 "Input Screen" and "Quick Results" Graphical Summary

GRLWEAP14 added more static analysis options. These newly incorporated options include the FHWA/driven method, as adapted from the Federal Highway Administration's (FHWA) driven program, the CPT based Alm & Hamre (A&H) Friction Fatigue (FF) Method, and the API2 Method, which consists of a soil-type based method and four CPT Analysis Methods. These static analysis methods help to prepare static resistance inputs.

Analysis options from earlier versions were carried over from GRLWEAP 2010. For example, users that cannot use A&H because of a lack of CPT data, the GRLWEAP 2010 FF algorithm remains available. Additionally, the different calculated resistance distributions for all analyzed pile tip penetrations are directly displayed to help novice users better understand the FF approach.

For new GRLWEAP users, or for those who need a refresher on key concepts, PDI currently offers real-time webinar courses and hopes to resume in-person courses in the near future. Visit PDI's On Demand recorded webinars library located at www.pile.com. Additionally, GRL Engineers can provide wave equation analyses services for those with minimal program experience or for those that need a quick turnaround on analyses for complex situations.

Whatever your needs may be, we look forward to serving them with continual innovations in GRLWEAP. For additional information, please visit pile.com/products/grlweap.

A New Code for SPT Energy Evaluation Emerges in Brazil

In October 2020, the Brazilian Association of Technical Codes (ABNT) published code NBR 16796:2020, whose title translates to "Soil – Standard method for energy evaluation in SPT". Because of this new code, interest in the SPT Analyzer has increased in Brazil and other neighboring countries.

SPT Energy Evaluation with the SPT Analyzer

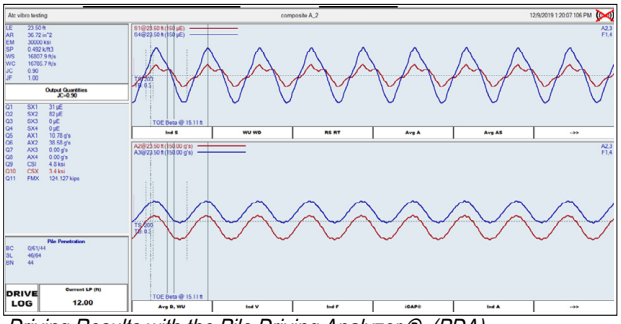
Case Study: Dynamic Measurements of Vibratory Driven Composite Steel Piles Subjected to Axial and Bending Forces

By Alex Ryberg, P.E.

During a vibratory driving project, a challenging test program involved taking dynamic measurements on non-uniform piles during vibratory driving. This measurement and interpretation project was performed to aid in the investigation of weld fractures occurring during pile installation.

The composite piles were built-up steel members with an overall open cross-section. The hammer was a Movax Sonic Grip model with 50 Hz maximum driving frequency with a maximum centrifugal force of 200 kips (900 kN). Initially, the vibratory hammer was clamped to brackets welded to the pile's sides approximately one third of the length below the pile's top. This was done to set and correctly align the pile. Then, the pile was vibratory driven as far as possible with a side-mounted hammer before it was top driven with the vibratory hammer clamped to brackets welded to a heavy steel plate that was welded to the pile's top.

One level of instrumentation was located a short distance below the top pile plate and a second one near the lower attachment brackets. The sensors on the lower level of instrumentation were removed when the hammer clamping was switched from side to top brackets. During the side mounted driving, 8 PDA data channels were used for analysis. During top driving to design depth, 4 PDA data channels were used. Dynamic testing was conducted at a site with easy pile driving conditions, and at a second site where refusal driving occurred. At both sites, the driving progress was monitored with a video camera in addition to recording the PDA data.



Driving Results with the Pile Driving Analyzer® (PDA)

After field testing, the PDA strain and acceleration measurements were analyzed using a post processing program, which balanced the signals, integrated the acceleration to velocity under consideration of the pile penetration speed, and integrated velocity to displacement. Next, the video recordings were analyzed for pile penetration speed vs. depth. The strain measurements were converted to force after adding a static component which represented the hammer weight.

Given the corrected force records, the post processing program calculated the peak values of stress, force, soil resistance (at the time of driving) and power transfer. It also generated summary plots and time histories of measured and derived quantities.

The soil resistance proved less important than stresses, acceleration and forces. For that reason, averaged strains, stresses, forces, as well as the individual signals were evaluated. The bending stresses were estimated at the bracket attachment points with the offset of the strain sensors from the neutral axis. The bending stresses were highest when the soil resistance was minimal, or when the pile was practically only supported by the vibrating hammer. All processed records were searched for maxima and minima of stresses and accelerations.

The test program results determined that the axial stresses were typically less than 5 ksi (35 MPa) during hard driving. During easy driving, the stresses could almost reach 6 ksi (42 MPa) because of bending. Generally, the maximum acceleration levels were less than 10 g's. Depending on the soil resistance, hammer frequencies varied between 15 and 50 Hz.

For additional information, visit www.grlengineers.com.

Pile Driving with a Vibratory Hammer

Upcoming Events

January 2021

11,12, or 14:	**Webinar Series:** Benefits of PDA-DLT Software (Register)

February 2021

05:	PDI Office Hours: PDA Webinar (Register)
12:	PDI Office Hours: TIP Webinar (Register)
17-18:	Basics of CAPWAP® Webinar (Register)
24-25:	Advanced CAPWAP® Webinar (Register)

March 2021

8, 9, & 10:	**DFDTA Workshop:** Orlando, FL, *PDA Proficiency Test Administered* (Register)
15,16, or 18:	**Webinar Series:** IGRLWEAP14-Exploring the User Interface (Register)

Due to COVID-19, any of the above events may be canceled or postponed as restrictions unfold. Please visit our websites for updates.

GRL/PDI extends gratitude to our readers and wish all a safe and prosperous 2021! Happy Holidays!

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