DID YOU KNOW? *Newsletter No. 100 - December, 2021*

This is the 100th issue of the newsletter? The first issue came out in April 1986 and all 100 issues can be viewed on pile.com or grlengineers.com.

100th Issue

50 Years of Dynamic Pile Testing – A Success Story

By Frank Rausche, PhD, P.E., D.GE and Garland Likins, P.E.

Dynamic testing of piles meant only one thing 50 years ago: blow counting or observing how much or how little a pile penetrated under a "real good" hammer blow. Depending on how "acceptable" the hammer impact sounded, this crude dynamic test provided the observer with either a good feeling or an uneasy one.

Obviously, feelings don't establish a qualitative or reliable test. A qualitative pile test with only rated hammer energy and observed blow count requires high factors of safety and thus highly uneconomical foundations. The only alternative 50 years ago was expensive and time-consuming static load testing.

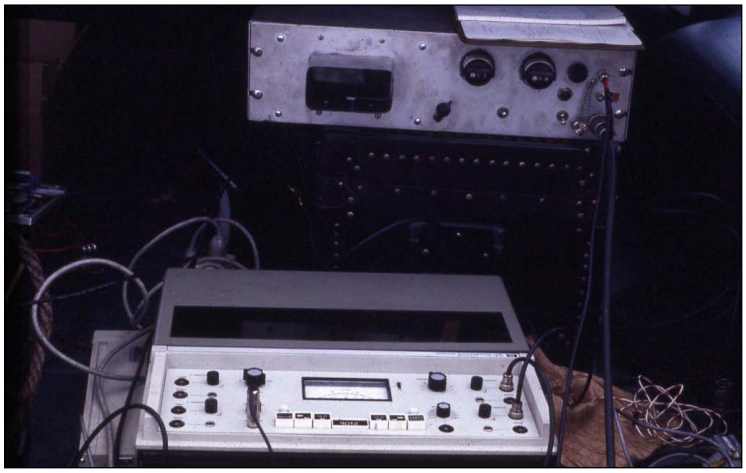

Image 1. PDA 1972 Prototype and Tape Recorder

Fifty years ago, a research team at Case Western Reserve University (CWRU) had completed their initial goal, producing a Pile Driving Analyzer® (PDA) prototype and provided evidence that real-time electronic measurements during a pile driving impact and data processing of these field measurements on piles was routinely possible. Significantly and maybe even more importantly, the basic stress wave based closed form analysis methods (Case Method) and CAPWAP® (signal matching by numerical analysis) had provided reliable results and good agreement with static load testing. The research system consisted of a multitude of wires, numerous components, and not so user-friendly software. Professor George Goble had the vision and, with the assistance of co-researchers Frank Rausche and Garland Likins, decided to make the system field worthy, demonstrate it, use it for consulting work and thus gain experience, and win over far-sighted individuals in the piling industry.

The task was formidable. Adapting radically different methods in an established industry always is challenging and takes considerable time and effort. While the available system was only a prototype which required intimate knowledge of its hardware and software components, greater obstacles were raised by many who were either bewildered by the new approach - "our piles are good, why complicate things" - or outright hostile because of misunderstanding of the test results - "it doesn't give the same result as the Engineering News Formula," even though the Engineering News Formula was known to be unreliable. The fact that pile capacity was not a clearly defined term (safe load, design load, ultimate resistance, end-of-driving capacity, restrike capacity etc.) did not help.

The team was helped by three major developments occurring during the following 50 years:

1. Significant advances in sensor technologies.
2. Continuous advances in digital computer systems.
3. The general recognition in the foundation industry that increased or improved testing leads to more economical foundations.

Taking advantage of the first and second developments, the newly formed company, Pile Dynamics, Inc. (PDI), was able to greatly simplify and improve the robustness of the hardware and user friendliness of the associated more powerful software.

PDI's newly founded sister company, now GRL Engineers, proved to foundation engineers, contractors and owners that the results of the dynamic tests were indeed reliable, allowing for reduced safety factors. LRFD codes and specifications, for example, now recognize that increased testing effort allows for reduced factors of safety. Today an overall factor of safety below 2 is permitted by performing a sufficient number of dynamic tests in conjunction with a static test. It also became apparent in the 1970's that the same measurements could assess the hammer transferred energy, pile integrity and driving stresses (particularly important for concrete piles) which the PDA now calculates in real time.

Image 2. 1971 PDA Testing

Image 3. 2021 PDA Testing

The CWRU research system required that data would be collected on site, recorded on magnetic tape, taken to the office, replayed and digitized, saved on punched paper tape, and signal matched by CAPWAP using an office computer and digital plotter. The initial field results by the then analog PDA and processed Case Method results were used for all blows not signal matched with CAPWAP.

Image 4. Field demonstration, Hamburg, Germany 1978

Major milestones to improve this process were (i) the leap from analog to digital field computation and digital data recording, (ii) placing the PDA in a PC platform eliminating the bulky tape recorder and oscilloscope making operation much simpler (iii) truly robust strain transducers and accelerometers for hammers with very hard or no cushions, (iv) the switch for signal matching from main frame to mini computers and finally microcomputers (v) the adoption of the Windows operating systems and (vi) wireless data collection for improved logistics and safety.

For the test providers the past 50 years have meant continued learning and adjusting. For example, while at first records were saved and reports prepared in the office, construction schedules soon required immediate, on-site result submission. In fact, certain owners or construction managers require continuous pile monitoring which accounts for each and every hammer blow. Thus reliability of sensors and recording equipment in any kind of weather and its immediate availability upon request is paramount. Moreover, the responsible test engineer must be able to not only vouch for good data quality of the measurements, but also for correct interpretation and adherence to specifications of bearing capacity, pile stresses and pile integrity. Thus in-person and virtual lectures and proper training is vital to ensuring the continued success of dynamic testing. To assure proper application of dynamic testing, PDI has promoted proficiency testing for the last 20 years, now in cooperation with the Pile Driving Contractors Association (PDCA). Today the test engineer may be remotely monitoring from the office via SiteLink® leaving the sensor installation to contractor personnel. Even the signal matching analysis, required by American Association of State Highway Transportation Officials (AASHTO) and other specifiers for optimal safety factors and economy, may be done automatically for every blow during testing of uniform profile piles with iCAP®.

Dynamic pile testing takes advantage of the impact induced stress wave propagation in the pile. It is not surprising then that this technology was also adapted to deep foundations other than driven piles. Indeed all over the world, testers have assembled dynamic loading equipment with ram weights reaching near 100 tons, allowing for activation of test loads in excess of at least 5000 tons. On the other end of the scale is the low strain test (PIT) which requires the impact of only a hand-held hammer to produce a stress wave in any type of concrete pile which, due to reflection at pile discontinuities, provides information about pile integrity. Even ultrasonic logging (CHA) relies on stress wave propagation to assess concrete quality.

Knowledge, capability, and hard work of truly dedicated PDI staff and GRL engineers were critical to the successful advances with hardware, software, and basic analysis methods. Without their hard work the current mature state of the art would not have been reached. It must be acknowledged, however, that equally important help came from “champions” in the foundation industry. Without the enthusiastic support from individuals in departments of transportation (originally Ohio DOT and Federal Highway Administration, but later also from many other states and even other countries), engineering firms and contractors we would not be where we are today. Significant contributions were also made by international clients and researchers who all saw the potential of the dynamic pile test and contributed with ideas and by sharing hands-on experience. A big Thank You to all is in order.

Together we accomplished that dynamic testing is now routine for driven piles, and at a significant reduction in cost compared to traditional static load testing.

Upcoming Events

Dec 15	**Webinar: Load Testing & Quality Control** *Register Today*
Dec 16-17	**Workshop: PDA Training and Proficiency Test; Boston, MA** *Register Today*
Jan 16-19	**Conference: ADSC Annual, Charleston, SC** *Visit Conference Website*
Jan 20-21	**Conference: FTBA Construction Conference, Orlando, FL** *Visit Conference Website*
Feb 9-12	**Conference: PDCA Annual, Phoenix, AZ** *Visit Conference Website*
Feb 17	**Webinar: The Incremental Rigidity Method** *Register Today*
Feb 22	**Seminar: State of Practice - QC of Deep Foundations, Calgary, Alberta, Canada** *Calgary Registration Form*
Feb 24	**Seminar: State of Practice - QC of Deep Foundations, Toronto, Ontario, Canada** *Toronto Registration Form*
Mar 1, 2, 8, 9	**Webinar: CAPWAP: Basic and Advanced CAPWAP Analysis Examples** *Register Today*
Mar 7	**Seminar: Deep Foundation Integrity Testing and Wave Equation Seminar, Orlando, FL** *Register Today*
Mar 8 & 9	**Workshop: High Strain Dynamic Foundation Testing, Orlando, FL** *Register Today*

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