GRL NEWSLETTER

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GOBLE RAUSCHE LIKINS AND ASSOCIATES, INC.

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Hydraulic Hammers and GRLWEAP™

by Garland Likins

Times are changing and so are pile driving hammers. Engineers performing wave equation analyses should understand the operation of these new hammers and inspect them properly during pile driving. Contractors must learn how to utilize the new technology for maximum productivity and minimum danger of pile damage.

New hydraulically powered hammers are available from several manufacturers. Most models allow for a **continuously variable energy or stroke** between some small minimum and the maximum rated energy to improve control of driving stresses and optimize productivity. For most single-acting hydraulic hammers, the ram is raised by hydraulics and then, either by mechanical or hydraulic design, the drop often is more or less a free fall; guides cause some friction losses which are higher for inclined piles. Double-acting hammers use either hydraulic or nitrogen assistance in addition to gravity (g) to speed the fall.

Many hydraulic hammers have **built-in sensors** to measure the ram impact velocity and hence the "kinetic impact energy" or "equivalent stroke" (kinetic energy divided by ram weight). Usually this measurement occurs when the ram is about 30 to 100 mm above impact; thus, the velocity may change between the time of measurement and impact.

When running a wave equation analysis the user inputs an **equivalent stroke**, h, and a hammer **efficiency** value, e. This input is converted to a velocity of the ram immediately prior to impact from square root of 2g(h)(e). When the efficiency is unity, all potential energy is converted to kinetic energy. A lesser efficiency would result in a reduced ram impact velocity to account for various loss factors (friction, poor alignment induced lateral motions, *etc.*; losses in cushions are accounted for separately).

Often wave equation users ask GRL how to perform a wave equation analysis for hydraulic hammers. First, the equivalent stroke must be input. This might be the maximum stroke, or a reduced value from either visual inspection or the built-in sensor results. We strongly recommend that the field inspector should continuously observe the monitor for kinetic energy or equivalent stroke, and record the result in the driving log.

Next, a hammer efficiency must be given. GRL assigned efficiency values in the GRLWEAP hammer data file from hammer specifications or experience. For hammer models which are **always** fitted with built-in sensors and a kinetic energy readout, the hammer file efficiency is 0.95. Efficiency reductions for inclined pile driving are not required.

For hydraulic hammers without a built-in monitor as standard equipment, the efficiency may be listed as only 0.67 unless there is a positive indication that the ram falls freely (and not pushing against the hydraulics). For inclined pile driving a smaller value should be used.

Before pile driving starts, the GRLWEAP analyst may run the wave equation with several strokes and capacities to obtain stroke versus blow count that yields tolerable driving stresses. The field inspector and hammer operator are given a graph of maximum allowable stroke versus observed blow count. A "**drivability analysis**" with user inputs of unit friction and end bearing as a function of depth is another possibility. An assumed stroke (and even different cushion stiffness and hammer efficiency) can be specified for each analyzed depth of penetration; output includes capacity, stresses, stroke and blow count as a function of pile penetration.

When analyzing an already installed pile with energy reading, we recommend that the wave equation analysis be performed with this readout energy converted to equivalent stroke (by dividing observed energy by the ram weight) and a hammer efficiency of .95, thus allowing for some losses during impact.

Any wave equation analysis contains assumptions regarding dynamic soil properties and hammer performance. **To assess soil and cushion behavior and investigate actual driving stresses and actual hammer energy transferred to the pile, we always recommend dynamic testing with a PDA (Pile Driving Analyzer®).** We have occasionally observed the built-in hammer monitor to give incorrect readings ■

STRESS WAVE '96

THE FIFTH INTERNATIONAL CONFERENCE ON THE APPLICATION OF STRESS-WAVE THEORY TO PILES

This very important conference is held every four years and will be held for the first time in 1996 in the USA (see Calendar of Events on reverse). It covers all aspects of dynamic pile testing and we hope that you will be able to attend. Please mark your calendar.

CALL FOR PAPERS

Conference Secretary, *Mohamad Hussein* reminds all stress wave engineers that abstracts of papers to be submitted for the September 1996 Orlando Conference are due on May 15, 1995. Please send abstracts to the Conference Chairman:

Professor Frank C. Townsend
Department of Civil Engineering
Box 116580, University of Florida
Gainesville, FL 32611-6580
Ph: 904-392-0926 Fax: 904-392-3394
Accepted Papers due: November 1, 1995

A poster announcing the conference has been commissioned by Pile Dynamics, Inc. and is now available for display. Please contact GRL if you can display one or more of these collectors' items.