GRL NEWSLETTER

No. 27

by the Deep Foundation Engineers and Piling Experts of Goble Rausche Likins and Associates, Inc.

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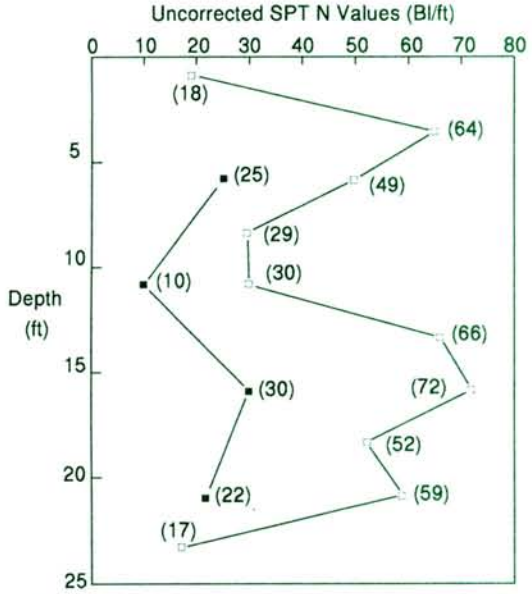
SPT IMPROVEMENTS

by George G. Goble

In much of the world, the Standard Penetration Test (SPT) remains the subsurface investigation technique of choice for geotechnical engineers. The test is well established in practice, provides a soil sample, and a vast amount of local experience and correlation data have been collected by practitioners. In cases where it has been used in competition with other methods such as the Cone Penetration Test (CPT) for pile capacity prediction, it has done about as well as the other methods. In many applications such as liquefaction evaluation or pile driveability prediction, the fact that the test is dynamic seems to be an advantage.

Two problems exist. First and most seriously, at least in North America, standardization lacks in the performance of the test. The graph below was published by Finno in 1989 to demonstrate this point. Secondly, although a soil sample and an N-value are obtained, electronic measurements might also be made during the test. Thus, after initial studies at the University of Colorado, GRL and PDI have responded to these shortcomings with an essentially self-funded research program. Funding and field support have also been received from the FHWA, the Colorado DOT, NIST and the Bureau of Reclamation.



SPT N-values for an automatic(■) and a safety(▫) hammer in the sand soil.

This research has addressed three areas of interest. First, force and acceleration measurements on steel-to-steel impacts, characteristic of SPT systems, were studied. In the past, SPT measurements frequently failed the quality checks that are usually applied to measurements on pile driving systems. Second, differences in SPT driving equipment have been evaluated by measuring the energy transferred to the rod. Finally, analytical methods were developed to extract wave equation dynamic soil parameters from SPT measurements.

Studies of the measurements have shown that the best quality force measurements are obtained from an instrumented section of the drill rod that is being used for the test. Foil strain gages are directly bonded to the rod and the rod is then calibrated. This approach avoids dynamic effects that can be present in some commercial load cells.

Velocity is almost always calculated from acceleration measurements. Previous accelerometers did not make these measurements reliably for the steel-to-steel impacts of most SPT driving systems. Recently developed state-of-the-art accelerometers have performed well on SPT tests and the problem now seems to be solved. In any event, the quality of force and velocity measurements can be checked by verifying that the two measurements are proportional at the time of impact. We believe that our success in routinely making these measurements over the past two years shows that we have completed our first research task.

With the availability of correct force and velocity measurements, it is possible to perform sort of a calibration test of a particular drill rig. The energy transferred to the drill rod can be correctly calculated from the measurements by integrating the product of force and velocity. This procedure has been used in the Pile Driving Analyzer® (PDA) for more than 25 years in measuring the performance of pile driving systems. With the driving energy measured for a particular drill rig, the N-value can be adjusted to some selected standard value of energy. Seed and others have suggested that the standard energy should be 60% of the theoretically available energy. The corrected N-value can then be calculated using the correction suggested by Schmertmann where N_{60} is the corrected N-value for the "standard" 60% SPT efficiency, E_m is the measured transfer efficiency (measured energy divided by the available energy) of the system in percent, and N_m is the observed N-value.

$$N_{60} = \frac{E_m}{60} N_m \qquad (1)$$

The value of the correction procedure can be illustrated using results from a test program that was organized by the Seattle Section of ASCE. At the test site, a loose sand was possibly liquefaction sensitive (GRL Newsletter No. 25). A number of different drill rigs were tested in close proximity to each other, and energy was measured on several of these rigs with wide variability in energy transfer and measured N-values.

AS THE YEAR ENDS

We thank you, our clients, colleagues and foundation professionals for the trust that you have placed in us and our work during the past year. We wish you and all our readers a peaceful, healthy and successful New Year and a continued mutually beneficial cooperation.

An example of the correction procedure is the N value of 22 recorded at 35 feet penetration under an automatic hammer with transfer efficiency of 91%. Substituting into Eq. (1) yields $N_{60} = 22(91)/60 = 33$. Obviously such a correction might seriously affect conclusions drawn from the data.

Over the past two years, GRL has performed about 40 energy calibration tests. A substantial amount of data has been generated and evaluated and will soon be available to the profession. It may allow for recommendations of typical efficiencies including mean values and coefficients of variation for various types of driving systems. For example, certain automatic hammers such as the system manufactured by the Central Mine Equipment Company will probably show values between 85 and 95%. The cathead-and-rope operated safety hammer may range between 65 and 80%; donut hammers will be still lower. Any cathead-and-rope operated systems are likely to have a high variability. Systems whose winch is spooled by the weight of the hammer will have efficiencies as low as 20%. Probably N-values from such inefficient systems cannot be reliably corrected with Eq. (1).

In the past, the PDA was used to perform these tests. Pile Dynamics, Inc. has now developed a simple, compact system (see enclosed flier) for measuring force and velocity on SPT systems, calculating the energy and recording the results. This equipment will reduce the cost and complexity of SPT rig evaluation. GRL has also done further research on analytical methods to evaluate the SPT data to increase its usefulness. The results of this work will be discussed in a future GRL Newsletter ■

GRL Begins Workshop Series

After extensively editing, updating, rewriting and converting to the SI unit system of the Federal Highway Administration's Manual on **Design and Installation of Impact Driven Piles**, *Pat Hannigan* (GRL Chicago) and *Dr. George Goble* (GRL Boulder-Research) have conducted pilot workshops in Portland, OR and Tallahassee, FL. Mr. C.T. Chang of the Office of Development and Messrs. Jerry DiMaggio and Dick Cheney (FHWA) have been coordinating, reviewing and technically guiding this effort. Prof. Joe Caliendo (Utah State Univ.), Dr. D. Michael Holloway (InSituTech), Bob Lukas (Ground Eng. Consultants, Inc.) and Prof. Frank Townsend (Univ. of Florida) participated in the updating effort. Both professors will also help to teach future workshops which deal with the complete design and construction process of driven pile foundations. Topics include soil exploration, economic pile selection, static design, dynamic testing and analysis, inspection, static testing, specifications and others.

Workshops have already been slated for the Indiana DOT in February and March 1996. Although future workshops will benefit primarily the interested DOT's, representatives of the private industry are also invited to participate on a space available basis. For general information, please contact Jerry DiMaggio (FHWA) at 202-366-1569, also contact GRL for scheduled workshops.

PDA Users Days, Seminars, Workshops

In September 1995, GRL engineers conducted seminars and workshops on wave equation and dynamic testing methods and four days of continued education for PDA Users. The events were held in Cleveland, OH and Heidelberg, Germany and attracted engineers from many countries.

In early 1996, Seminars and PDA Users Days will be conducted in Korea, Malaysia and China, among other Pacific Rim countries. After an introductory seminar on May 2, 1996, PDA Users Days will be conducted in Kuala Lumpur, Malaysia on May 3 and 4, 1996. Conveniently, the 5th SEAGC will follow on May 6-10, 1996 in the same city.

In September 1996, following the Fifth Int'l Stress Wave Conference, GRL will conduct a PDA Users Day for worldwide PDA Users attending the conference.

Plans are being formulated for a 3-day short course, "Design of Pile Foundations" at Utah State Univ., Logan, UT. Lecturers will be *Dr. George Goble* and Professors Joe Caliendo and Loren Anderson (Utah State Univ.). Seminar content will include static pile design based on geotechnical information, dynamic methods in capacity and integrity evaluation, and a workshop for hands-on wave equation analysis. To make hotel reservations, call the University Inn, 800-231-5634. For further information, please contact USU CE Dept., 801-797-2932 or GRL.

1996 Calendar of Events with GRL Participation

USA

Jan 7-11	Washington, D.C., TRB, 75th Annual Meeting, Sessions on LRFD and Quality Control of Deep Foundations, contact G.P. Jayaprakash, Ph: 202-334-2934.
Feb 12-15	Indianapolis, IN, FHWA Workshop on Design and Installation of Impact Driven Piles, contact GRL Chicago, Ph: 708-776-9890.
Mar 4-15	Indiana DOT, FHWA Workshop on Design and Installation of Impact Driven Piles, contact GRL Chicago, Ph: 708-776-9890.
Mar 18-22	Cocoa Beach, FL, Univ. of Florida, 20th Annual Short Course on Fundamentals of Deep Foundations, Ph: 904-392-1701 ext. 246.
July 15-17	Logan, UT, Short Course on Design of Pile Foundations, information from Utah Stat Univ., Civil Eng. Dept., Ph: 801-797-2932.
Sep 11-13	Orlando, FL, Stress-Wave '96, Fifth Int'l Conference on the Application of Stress-Wave Theory to Piles, contact Dr. F. Townsend, Ph: 904-392-0926.
Sep 14	Orlando, FL, PDA Users Day, for information contact GRL, Ph: 216-831-6131.

INTERNATIONAL

Jan 19-20	Seoul, Korea, Seminar by Korean Geotechnical Society, Dr. M.W. Lee (Piletech), Ph: 82-2-396-0617.
May 2	Kuala Lumpur, Malaysia, Seminar on Dynamic Testing Methods, contact Richard Yu, (Soil Dynamics Sdn. Bhd.), Ph: 60-3-7801915/6, Fax: 60-3-7801927.
May 3-4	Kuala Lumpur, Malaysia, PDA Users Days, contact Richard Yu.

Reader Response

Ms. DeAnna H. Fields, Southern Company Services, Inc., responded to GRL Newsletter 26:

"... Also I agree with the statements regarding the "professional service" you provide. I appreciate the fact that your PDA operators are very knowledgeable, qualified, and capable of providing fast-track results in the field. Scott Webster and Jay Berger have certainly made me look good in the field by providing test results in short order such that our recommendations could be integrated into the pile driving effort immediately. They were very willing to work as a team, and the client benefitted by the service we provided."

GRLWEAP News

GRL's *Brad Gipson* is currently preparing the 1996 update of GRLWEAP™ which will offer several simplifications in data input. The release is planned for the first quarter of 1996. We received a few inquiries which may be of general interest.

Is the slack dimension "inch" in the input help correct? No, it should read "feet" (this will be corrected in the next update); the SI input is correctly stated as "mm".

I have a fast computer and yet my speed of calculation and graphics display are very slow. Why? Be sure that the CONFIG.SYS file (accessible through DOS) contains the statement: HIMEM.SYS and EMM386.EXE.

Do I need the 2-pile option to analyze a follower (dolley) on a pile? The answer is "no", since follower and pile are in series. You just model a nonuniform pile with follower and, if present, cushion (between follower and pile; they must be separated by an unlimited tension slack) as a part of the pile. Pile top is then equated to follower top. A 2-pile analysis is only needed where two pile sections are in parallel such as in the case of a mandrel driving thin walled pipe through a plate or concrete plug at the bottom.

Why are results identical for different Gain/Loss factors when a pre-1994 data file is analyzed with 1.995-1? If the old data file includes zero sensitivity values then we recommend that you update the old data file using **Input Modification** of GRLWEAP 1.995-1.

News from Pile Dynamics, Inc.

Pile Dynamics (PDI) has released a new powerful software for the Pile Driving Analyzer® Model PAK. The PDAPC version of this program can "re-enact" the pile driving process on an office computer allowing the analyzing engineer to extract stress, hammer performance and estimated capacity values for all records stored during testing. Force-velocity records of up to 3440 blows can be saved and analyzed in one session. In early 1996, shipment of the above software will be sent to users with current support.

PDI, with the help of *Mark Johnson* (GRL Florida) has produced a video showing dynamic test equipment and explaining underlying methods. Copies of this video are available for the asking. Please specify NTSC (USA standard), PAL, or SECAM VHS format.

GRL Opens Office

A GRL Sr. Engineer, *Steve Abe, P.E.* who has been working for 7 years in many parts of the USA and in several Pacific Islands and countries, has opened a GRL branch office in northern California. This move hopefully will reduce travel time and expense associated with serving the West Coast deep foundations industry. You may contact *Steve Abe* at 510-685-8314.

GRL

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Oakland, CA	510-685-8314	510-685-8315
Orlando, FL	407-826-9539	407-826-4747
Philadelphia, PA	610-459-0278	610-459-0279
Seattle, WA	360-871-5480	360-871-5483