



Load Confusions

by George Goble

Picture this: It is 7 am, the GRL Engineer arrives at a job site for some pile testing and asks his client:

GRL: "What capacity are you looking for?"

Client: "100 tons."

GRL: "Is that design load or ultimate?"

Client: "That's what the specs say we have to get; we want no more and no less."

The question is perhaps repeated, but the GRL Engineer soon realizes that the client does not know the answer, and considerable embarrassment results. Probably this confusion originated in the use of the dynamic formula in which the factor of safety is embedded. With the rise of Wave Equation analysis, PDA testing and more frequent static load tests, the pile capacity determined by these methods is always the ultimate value.

DEAR READER

For years the GRL Newsletter has brought you just that: GRL News. Starting with this issue we want to add more of an educational content in a dedicated column. Our first article has been written by our Senior Principal, Dr. G. Goble, who is very much concerned about educational matters, having been a university professor for many years. Maybe the "load" subject is interesting to you or you may want another issue discussed. In any event, please contact us with any concerns or suggestions.

Let us briefly review the fundamental concepts behind working stress design. The goal of working stress design is to find a system such that the Design Load for a particular element (say a pile) is less than the Allowable Load or more formally

Design Load \leq Allowable Load

The Design load is that load that can be expected to occur during the life of the structure. It may consist of dead, live, wind, soil pressure, earthquake, or other load types. The Allowable Load can be defined as that load that can be safely applied to the structure. It is obtained by dividing the Ultimate Capacity by a **factor of safety**. In the limiting condition, the Design Load and the Allowable Load are equal, and sometimes the term Allowable Load is used in place of Design Load. Thus we can also write

$$\text{Design Load} \times \text{Factor of Safety} \leq \text{Ultimate Capacity}$$

The foundation engineer is usually expected to specify the factor of safety and very frequently a value of 2.0 is used. The factor of safety should be defined with input from the structural engineer since the variability of loads is an important consideration. Also, the choice of safety factor should consider the methods of capacity determination and quality control. All pile capacity determination methods such as Wave Equation, PDA testing and static load testing determine **Ultimate Capacity**, and therefore must be used with a factor of safety. A discussion of factor of safety will be a topic of some later issue of this column.

Let's now review the above by going through the determination of the loads for a typical design project. The structural engineer will assemble the critical load combination from the various Design Loads for the structure. This may include dead loads from the structure's dimensions and materials, live loads probably from a design code, soil pressure loads supplied by the geotechnical engineer, etc. Lately, combinations of loads are specified by design codes.

The forces acting on the foundations (pile caps) are found using a linear elastic structural analysis. For foundation elements, the loads applied by the structure often include both bending and axial forces. Therefore, within the same cap the axial pile load may vary considerably from pile to pile. Usually those piles on the edge of the pile cap will carry larger loads than those in the center. This can be an important consideration if the pile capacities are found to be marginal when pile driving begins. The structural engineer will transmit these Design Loads to the foundation engineer and a factor of safety must be chosen by the structural engineer and foundation designer to obtain the minimum required ultimate pile capacity. The foundation designer will select a pile type and length that has an Ultimate Capacity sufficient to carry the Design Load multiplied by a factor of safety.

SEASON'S GREETING'S

We know it is early, but in recent years we were always late in wishing you most peaceful and enjoyable holidays. We hope that you can look back on 1994 with satisfaction and that the new year will bring you health, happiness and prosperity.

The reason for this early holiday mailing is the upcoming International Conference on The Design and Construction of Deep Foundations (see enclosure), to be held December 6, 7 and 8 in Orlando, Florida. We hope that we will see you there, and that you may also consider participating in our workshops or seminar (see box on page 2 and enclosure).



It is important that, in preparing the construction specifications, the loads are clearly defined. Again, if a "100 ton" pile is specified with reference to Design Load, the contractor may not know that a factor of safety must be applied to this specified load. Claims may result. ■

GRLWEAP NEWS

As this newsletter is being written, GRL engineers are preparing the 1994 GRLWEAP version for release. Our users should get the new version in December. The program will contain a vibratory hammer analysis (see GRL Newsletter No. 23 of June 1994), a driveability analysis which can handle piles with variable outside dimensions and those that are driven with add-on lengths (by splicing). These features require that unit shaft resistance in ksf or kPa and pile circumference vs pile length are required input quantities rather than friction force per unit length for driveability studies. One new feature for multi-material piles is the selection of a critical tension and compression stress rather than a maximum stress. The selection of the critical stress is based on the input of a pile material strength value. The program update also features optional research oriented soil model enhancements. If you are interested in your current GRLWEAP support status, please contact GRL software manager *Barbara Strader*.

GRLWEAP WORKSHOP

At the end of September, GRL conducted a workshop and seminar on dynamic pile testing and analysis held at the Philadelphia airport. Unfortunately, several interested persons could not attend because of a busy schedule. However, there is no need to despair. New opportunities for learning are being organized. For example, on Dec. 9, 1994, following the International Conference on the Design and Construction of Deep Foundations, GRL's engineering staff will be available for a GRLWEAP, hands-on-workshop. Also, for persons experienced with dynamic testing practices and/or implementation of dynamic pile testing results, a round table seminar will be conducted. Lecturers include *Dr. G. Goble, M. Hussein* and *G. Likins* (see enclosure).

Furthermore, as in past years, on March 2 and 3, 1995, a seminar and workshop will be held in Boulder, Colorado. These seminars have been very successful in the past and we hope that our readers will mark their calendar accordingly.

EUROPEAN PDA USERS DAYS IN THE RIGHT PLACE

A huge historic brewery in Göteborg, Sweden, converted to a hotel, was the site of the 1994 PDA Users gathering on Sept. 28 and 29. Among the 11 countries represented were delegates from Indonesia. *Dr. Z. Indrawan*, PT Multi Ageotescon, helped lecturers from Pile Dynamics Europe, Ltd. and Pile Dynamics, Inc. by presenting case studies about the use of P.I.T. and GRL's vibration monitoring program RSVP.

GRL CHARLOTTE NC OFFICE OPENS

In August *Scott Webster*, formerly GRL Chicago has become manager of GRL's newest office. Please note phone and fax numbers shown below. We hope that this office helps to better serve North Carolina and neighboring states with even quicker response and lower travel related cost. Please note phone and fax numbers shown below.

GUAM

Steve Abe, GRL Cleveland, has returned from a 6 week assignment, testing piles of an extensive indicator program for the U.S. Navy and contracted through *Mr. Abe De Guzman*, Black Construction Corporation.

CALENDAR OF EVENTS WITH GRL PARTICIPATION 1994 AND 1995

U.S.A.

- Dec 6-8 Orlando, FL, **FHWA International Conference on Design and Construction of Deep Foundations**, All American Soils, Inc. (Ph: 714-549-7688, Fax: 714-549-4668).
- Dec 9 Orlando, FL, **GRLWEAP Workshop, PDA Users Discussion Group and Round Table Discussion on Dynamic Testing Methods**, organized by GRL Cleveland (Ph: 216-831-6131, Fax: 216-831-0916).

1995

- Mar 2-3 Boulder, CO, **GRLWEAP Seminar**, organized by GRL Colorado (Ph: 216-831-6131, Fax: 216-831-0916).

INTERNATIONAL

1995

- May 4 Bangkok, Thailand, **GRLWEAP Seminar**, organized by Pyramid Development Int'l Corp. Ltd. and ABV Singapore (Ph: 662-235-8976-7, Fax: 662-236-9958).
- May 5-6 Bangkok, Thailand, **PDA Users Days**, organized by Pyramid Development Int'l Corp. Ltd. and ABV Singapore (Ph: 662-235-8976-7, Fax: 662-236-9958).

PERSONNEL NEWS

GRL is happy to welcome *Neil Harnar* to its engineering staff. Neil graduated last May from Case Western Reserve University, birthplace of **Case Method** and **CAPWAP®**, with a Bachelor of Science degree. His current activities include updating the FHWA Manual on the Design and Installation of Driven Piles together with *Pat Hannigan*, GRL Chicago. Of course, PDA field testing is Neil's first and foremost priority.

NEWS FROM UNISOFT

Bengt Fellenius announces the release of UNIPILE Version 2 for Windows. Users of GRLWEAP will appreciate that UNIPILE now can produce a soil profile in GRLWEAP format; it also can simultaneously compute the pile capacity and resistance distribution at initial driving and at restriking. Many other new program features include one that plots all results automatically and residual loads analysis. For information, contact UNISOFT at 735 Ludgate Court, Ottawa, Ontario, K1J 8K8, Fax: 613-741-5594.

THAILAND

Cob Krai Tungsanga of Pyramid Development International Corp. Ltd. participated in "EnTech '94", the 17th International Exhibition & Conference on Engineering and Technology on Oct. 5-8, 1994 and "Inter-Construction Thailand '94" on Oct. 13-15, 1994 at Queen Sirikit National Conventional Center in Bangkok, Thailand.

In both the exhibitions and conventions, Pyramid Development International Corp. Ltd. displayed a PDA model PAK and P.I.T. system. Many engineers expressed their interest and requested technical information.

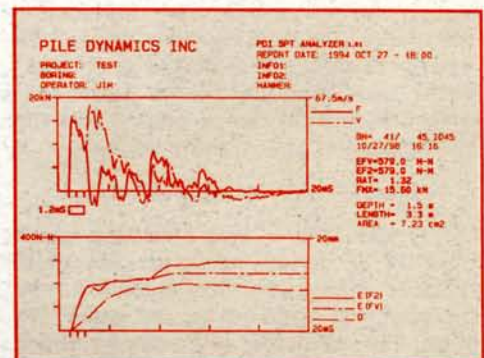
HIROSHIMA, JAPAN

In September, our new North Carolina manager *Scott Webster* and *Charles R. Heidengren* participated in a training program and demonstration project for Yorigami Maritime Construction Co. Ltd., Hyogo, Japan. Battered steel pipe piles 800 mm dia. with lengths 38 to 43 m for an LNG facility of Hiroshima Gas Co. were tested dynamically with PDA model PAK.

During the hands-on training program and demonstration project, visitors included prime contractors: Kauma Corp., Penta Ocean Construction Co. and Mitsui Fudo Construction Co., and pipe pile supplier Nippon Steel Corp.

NEWS FROM PILE DYNAMICS

PDI has successfully developed and tested the SPT Analyzer; a small, convenient to operate, hand-held device that calculates energy transferred to an SPT drive rod from measurements at the rod top. The device responds to or fills the need for a calibrating device such as specified by ASTM D 4633. The PDI SPT Analyzer is capable of calculating the ENTHRU value either based on force, F, alone, E(F2) or on both velocity, V, and force, E(FV).



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