Geotechnical Instrumentation NEWS

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John Dunnicliff

Introduction

This is the thirty-second episode of GIN, with two articles and a longer-than-usual column with miscellaneous odds and ends.

BiTech on the Net

In case you missed it (page 2 in the June 2002 issue), BiTech now has a web site – *www.bitech.ca.*

More on Determining the Resistance Distribution in Piles

In the last episode of GIN, Bengt Fellenius told us about determining the resistance distribution in piles, and discussed the issue of what strain gage readings correspond to the 'no-load' condition in a pile loading test. He also demonstrated that if residual load is not accounted for in the analysis of data, the interpretation of the instrumentation risks being in error and the instrumentation has added very little to the value of the test. On the other hand, if residual load is accounted for, the analysis procedure not only provides a correct distribution of soil resistance, but also provides the spin-off benefit of increasing the understanding of pile-soil interaction.

In this episode of GIN, Bengt presents how to make the analysis, and includes examples. The method has the advantage of making the analysis independent of any zero shifts of strain gage readings due to strain transfer within the pile material, temperature change, or slippage at the wire clamping points. When discussing this I once said to Bengt, "that's impossible, unless it's some kind of magic". His reply, "no, just mathematics". So here it is.

A New Instrumentation Web Site

In the second article Elmo DiBiagio tells us about a new instrumentation web site. The basic idea is to have a neutral, non-commercial site not dominated by any one individual or organization, a site where anyone interested in field instrumentation can meet, exchange ideas, find useful information and communicate with others interested in instrumentation. Please read the article, look at the web site, and note in particular the last paragraph:

"If you have any comments or suggestions for improvement of the site please send them by email to me or use the "Feedback Page" provided in the site. If you would like to help in the development of the site, go to the "I Want to Help Page" and check the list of tasks to be worked on. Your help with any of these tasks, or any other contribution you feel appropriate to the goals of the site, would be greatly appreciated and acknowledged".

Instrumentation Course in Florida, March 2003

The next in the series of instrumentation courses in Florida will be on March 10-13, 2003. Preliminary information is on page 30. Note that Ralph Peck will be with us again for all four days, to give a lecture and to participate in discussions. We will have copies of *'Judgment in Geotechnical Engineering – The Professional Legacy of Ralph B. Peck'* available, so come and join us, and take home autographed copies for yourself and your colleagues. Visit *www.doce-conferences.ufl.edu/geotech/* for more details.

International Symposium on Field Measurements in Geomechanics (FMGM), Norway, September 2003

The 6th FMGM (Field Measurements in Geomechanics) Symposium, which is devoted specifically to instrumentation, will be held on September 15-18, 2003 in Olso, Norway. This event has become the once-every-four-years meeting place for members of the international 'geotechnical instrumentation club'.

Check the web site *www.fmgm.no* for details, and also look at page 46 in this issue of *Geotechnical News* for a summary, including the symposium themes. **Please note the early deadline for submission of abstracts: September 30, 2002.**

FMGM 2007 is planned for USA, so we hope to see as many as possible of our North American colleagues in Norway, so that they can experience an early flavor of the event.

International Symposium on Deformation Measurements, Greece, May 2003

A reminder about the 11th International Symposium on Deformation Measurements, which will be held on Santorini Island in Greece on 25-28 May 2003. A beautiful place for staying longer, to have a vacation in the sun! We're planning a full day for a seminar and discussion on geotechnical instrumentation. Visit www.heliotopos.net/conf/11fig/.

A Question

This from Dave Druss – "Why don't they do 3D excavation analyses in Barcelona?" Answer on page 29.

Conference on "The Response of Buildings to Excavation-induced Ground Movements", London, July 2001

In the September 2001 episode of GIN, pages 40 and 41, I reported on this conference, and conveyed how outstanding I thought it was. The conference focused on the monitoring data that were collected during the construction of a new subway line in London, the Jubilee Line Extension (JLE). The overall objective was to put the data in the form of coherent case studies so that the engineering of future soft ground tunneling projects (both bored tunnels and open cuts) could be undertaken with more confidence and at less cost. A condition of funding was that the research would be published. Both volumes of the research report are now available.

Volume 1, *Projects and Methods,* includes descriptions of the JLE, the methods of settlement prediction and building damage assessment used on the project, and the objectives of the research. There are chapters on the geology, the history of the project, the tunneling methods and protective measures, and details of design and construction of various sections of the project. The closing chapter, by John Burland, provides a summary of the results of the research.

Volume 2, *Case Studies,* presents twenty-seven case studies in their geographic sequence along the project alignment. Each case study includes descriptions of the buildings, the construction work that affected them, the protective measures, and the monitoring to record the response of the buildings to tunneling.

The two-volume set can be ordered via the CIRIA web site, *www.ciria.org.uk* for £135. The publisher's reference number is SP200. Click on 'bookshop', and search with 'tunnelling' – note the English spelling.

Measuring Techniques Used During Construction of Jubilee Line Extension (JLE)

Following on from the above topic, Chapter 18 of Volume 1, is titled "Measuring Techniques and their Accuracy". This chapter is 'must reading', for those of you involved with planning monitoring programs for underground construction alongside or under sensitive structures that may be affected by construction. Particularly impressive are the accuracies obtained with precise leveling (typically +/- 0.5 mm, sometimes +/- 0.2 mm), and details are given of the digital level, tripod, rod, benchmark, and measuring point. The last of these five items is the UK standard BRE (Building Research Establishment) 'socket and leveling plug', an arrangement better than any alternative that I've seen in use in North America. For those of you who want to know only about the precise leveling, you can buy a copy of *"Monitoring Building and Ground Movement by Precise Levelling", Building Research Establishment Digest 386, 1993,* from the BRE on-line bookshop, *www.brebookshop.com.* Code 862, price £10.50 – remember the English spelling of 'levelling 'if you use this to search. If you buy this, I recommend also buying *"Simple Measuring and Monitoring of Movement in Low-rise Buildings, Part 1: Cracks", Building Research Establishment Digest 343, 1989* – this describes measurements of crack width with a digital caliper. Code 814, price also £10.50.

Also impressive are the results of precise taping using the Ealey tape extensometer (*www.p-j-ealey.com*), giving accuracies as good as +/-0.2 mm with spans of 5 to 10 m. Chapter 18 gives details of the equipment, measuring procedures, factors affecting accuracy, and correcting and analysis of taping results. The chapter also includes details of horizontal strain measurements with a 'micrometer stick', essentially a 3 m long bar which rests on two posts, with a micrometer for measuring the changing distance between the posts. Also façade monitoring using total station procedures, and monitoring of crack width with a mechanical Demec strain gage.

Finally, the chapter discusses the use of electrolevels, and reports on major problems, such that data were of little value.

Chapter 19 in Volume 1 discussed data handling and storage. In Volume 2, *Case Studies*, numerous results of the monitoring are presented.

Rob Nyren, who worked on the JLE project and is now with Geocomp in Boxborough MA, will tell us about instrumentation of JLE during the March instrumentation course in Florida – see page 30.

Sealing Piezometers in Boreholes

This is an early warning notice about some topics that will be in GIN when we have something worth telling.

First, there is very little in the literature to help us select a grout mix for sealing piezometers in boreholes. Erik Mikkelsen, Allen Marr and myself have decided to plan and conduct a test program to mix various proportions of cement and bentonite, also fly ash and bentonite, and test for strength, permeability, compressibility and volume stability.

Second, Erik Mikkelsen is preparing an article for GIN to help the rest of us understand the why and how of using cement-bentonite grouts as backfill for borehole instruments.

Third, I'm working with RST Instruments Ltd. to plan a test program to evaluate the properties of commercially available bentonite chips and pellets, which will lead to recommendations with respect to their use for installation of piezometers.

Watch this space!

And Now for Something Completely Different

How many technical magazines do you read that allow non-technical content? Did you read Del Fredlund's article in the June issue of *Geotechnical News*, "Vietnam – the Beautiful"? Thank you Lynn (Managing Editor of GN, in case readers don't know) for accepting this kind of content – in my view it gives your magazine a welcome balance, and increases readability. After reading the article, I thought I'd stick my neck out (obviously Lynn has said 'okay' if you're reading this) and follow up on Del's tale of international friendship between a mature 'have' and a young 'have not'.

My wife Irene has discovered an organization called *Childreach*, which links 'haves' in developed countries with 'have nots' elsewhere. Any one of us has the opportunity to 'sponsor' a child (we can choose a country, whether a boy or girl, and we can even search the web site and learn about specific children), and this is followed by interchanges between sponsor and child. The sponsorship not only helps the child, but also the local community with needed developments such as creating clean sources of water, other health projects, and education. The organizers have committed to about 80% of contributions directly benefiting the child and community, and the long-term objective is to be able to leave the community when it is completely self-reliant and no longer needs outside help. Perhaps not as meaningful and close as the relationship between Del and Miss Thu, but pretty exciting nevertheless - Irene and Janice (The Philippines), John and Yanhong (China).
Visit *www.childreach.org.*

A Celebration of the Life of Walter Nold

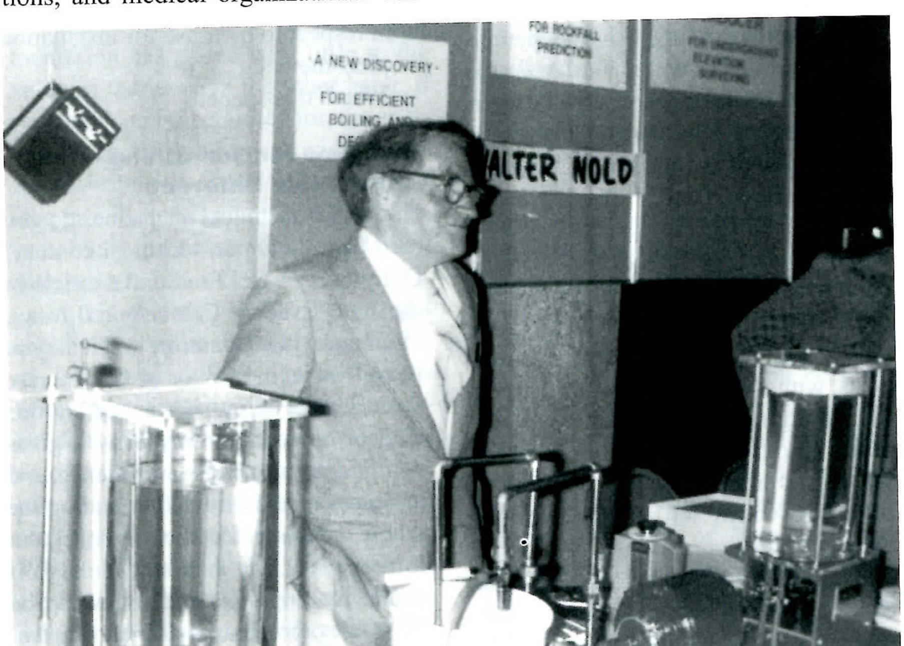
In the first episode of GIN, in September 1994, I told about Walter Nold's development of the DeAerator™ (red book pages 82 and 83), initially in response to the need for high quality de-aired water in twin-tube hydraulic piezometers and liquid level settlement gages. All methods existing in 1994 (spraying water through a vacuum, or boiling under a vacuum) were inadequate. Since that date Walter has made more than 800 DeAerators, as I said in GIN-1, "all with his own perfectionist hands". Users are geotechnical firms (for field instrumentation and for soil mechanics labs), university geotechnical departments, government agencies, the nuclear power industry and other industrial organizations, and medical organizations. The last have included non-surgical removal of tumors, prostate cancer treatment, cataract removal and examinations with ultrasound equipment. I ended my 1994 words with, "An exciting example of an engineer moving beyond the limited field of engineering to help society in a broader way".

Prior to developing the DeAerator Walter did pioneering work on development of the modern ballpoint pen, and developed the Seismitron™ for monitoring acoustic emissions and the Aquaducer™ for monitoring settlement.

Walter died on June 13, at the age of 88, after a brief illness. I had the privilege of participating in a truly memorable "Celebration of Life" on June 16, in Natick MA. John McRae (Geokon) had said to me, "Walt was a one-of-kind-guy. A great life", which I thought was perfect. I'd known Walt for 33 years, had worked on numerous instrumentation assignments with him, knew him to be a one-of-a-kind-guy, and so based my tribute on those words. I talked of his kindness, his integrity, his perfectionism, and his enthusiasm. He'd do anything he could to help anybody, never asking for anything in return. A word or a handshake was all that was needed for a business commitment. For all his creations, the goal was **quality**, even if this took enormous effort, as it often did. His enthusiasm, particularly for his favorite subject of de-aired water, was unbounded – all of you who met him will know this.

Geokon has now taken over manufacture of the DeAerator. As Barrie Sellers (President of Geokon) said at the celebration, "this will keep the legacy alive".

The immediate family - Marge, Gail, Leslie, Jayne, Elaine and Linda, and the large extended family will miss him deeply. Me too.



Walter Nold

Closure

Please send contributions to this column, or an article for GIN, to me as an e-mail attachment in MSWord, to *johndunnicliff@attglobal.net,* or by fax or mail: *Little Leat, Whisselwell, Bovey Tracey, Devon TQ13 9LA, England. Tel. and fax +44-1626-832919.*

Okole maluna! (Hawaii - OH CO LAY MA LUNA) – a version of "bottoms up". Thanks to Bobbi Daugherty for this.

Determining the Resistance Distribution in Piles

Part 2. Method for Determining the Residual Load

Bengt H. Fellenius

Introduction

The first part of this article stated, convincingly it is hoped, that unless residual load is accounted for in the analysis of data from a loading test, instrumentation adds very little of value to a pile test. On the other hand, when the residual load is accounted for, the procedure increases the understanding of the pile-soil interaction and adds significant value to the design of the specific project and — as a spin-off benefit — to the general understanding of pile behavior. The article left the reader with the cliffhanger of not indicating how residual load can be determined when all that is known is the increase of load in the pile due to the load applied to the pile head in the test. The second part of the article will present the "how to".

Case I. Analysis of static loading tests on an instrumented precast concrete pile

Altaee et al. (1992) present data and analysis of static loading tests on two instrumented 285 mm diameter square precast concrete piles driven to depths of 11.0 m and 15.0 m in a loose to compact sand. The instrumentation in the pile consisted of strain gages placed in the pile before casting. Fig. 4A presents the cone stress (q_c) of a cone penetration sounding and the SPT N-indices at the site. The CPT and SPT diagrams indicate that the soil is of uniform density. Fig. 4B shows the loads measured at the strain gage levels at plunging failure for the static loading tests. For both piles, the measured load distribution curves show a slight S-shape, that is, the slope of the curve goes from steep to less steep to steep again. Because the slope of the load-transfer curve is an indication of the unit shaft resistance in the soil, (the shaft resistance is equal to the reduction of load with depth) the S-shape suggests that the shaft resistance along the middle third of the pile is larger than along the lower third. However, the soil profile does not support that the unit shaft resistance would be smaller with depth. In fact, the S-shape is typical for results of a test on a pile affected by residual load and the measured distributions do not show the true distribution of resistance of the pile.

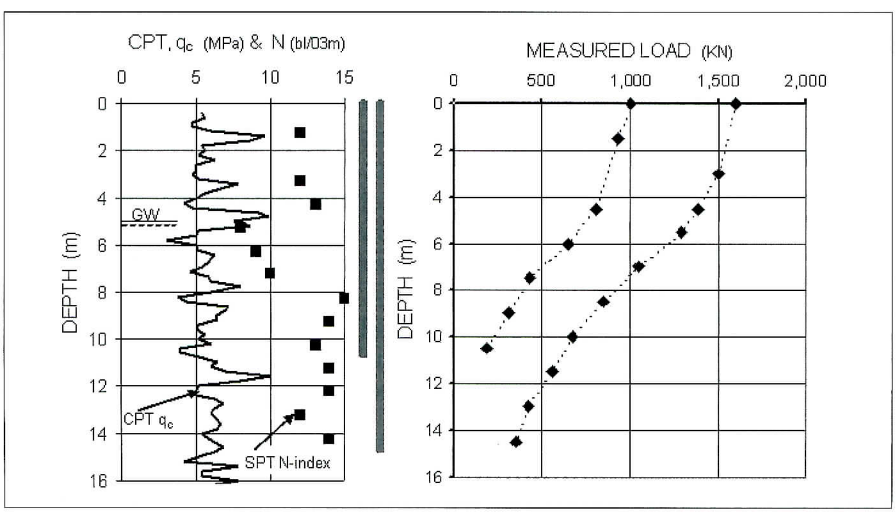


Fig. 4 Soil Test Results and Measured Load Distribution at Failure of Two Instrumented Precast Concrete Pile Driven 11 m and 15 m into a Uniform Loose to Compact Sand. (Data from Altaee et al. 1992)

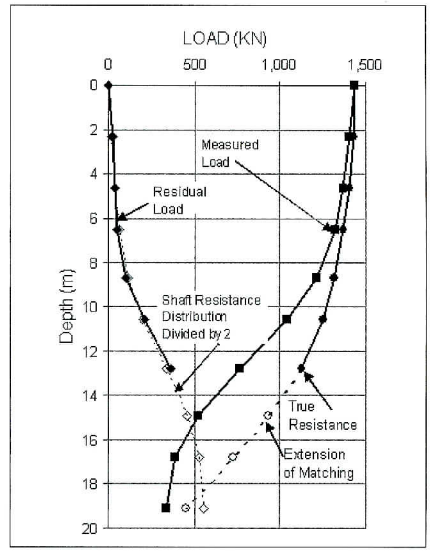


Fig. 5 Soil Test Results and Measured Load Distribution at Failure of a 15 m Long Instrumented Precast Concrete Pile Driven into a Uniform Loose to Compact Sand. (Data from Altaee et al. 1992)

Residual load develops from negative skin friction along the upper part of the pile. In the loading test, therefore, before the positive shaft resistance is mobilized, the residual load must first be unloaded. This means that the slope of the measured curve overestimates the mobilized shaft resistance by as much as a factor of two. (For all practical purposes, the shear resistance is independent of the direction of shear). Therefore, where the residual load is built up of fully mobilized negative skin friction, the reduction of load along the pile is twice the true shaft resistance. This fact can be used to determine the distribution of true shaft resistance. The method for the analysis is illustrated using the results of the test on the longer of the two piles.

The analysis begins by plotting half of the measured reduction of load, that is, the true shaft resistance, versus depth in a diagram, as shown by the solid diamond symbols in Fig. 5. (The solid square symbols indicate the measured loads in the pile). Thereafter, the so-determined "half curve" is matched to a theoretical distribution in an effective stress analysis. As indicated in the figure, a match is possible down to a depth of about 8.5 m. Below this depth, the rate of increase of the measured shaft curve (the "half curve") reduces, whereas the rate of the theoretical curve continues to increase. The depth where the two deviate from each other is where the transition from negative skin friction to positive shaft resistance begins, i.e., the transition from increasing to decreasing residual load. The true resistance distribution curve over the "matched length" is the difference between the load applied to the pile head and the calculated shaft resistance values.

Considering the soil profile, it is very likely that the soil response below depth 8.5 m is similar to that above this depth. This means that it is reasonable to assume that the soil parameters below 8.5 m are equal to those above. The dashed extension ("extrapolation") of the true resistance distribution is the result of an effective stress calculation applying the parameters that governed the fitting of the analysis to the data for the ground surface down to 8.5 m depth. The pile toe resistance indicated by the value at the depth of the pile toe is the load applied to the pile head minus the total shaft resistance (as calculated). Of course, had the soil profile indicated a different soil below 8.5 m, the extrapolation of the true resistance would have been less assured.

Finally, the distribution of residual load for the length below 8.5 m to the pile toe is now determined by subtracting the measured loads from the calculated true resistance distribution along the pile.

Two conditions serve as a check on the construction of the extension of the true distribution curve: (1) if the residual load in the lower portion of the pile (positive direction forces) is fully mobilized, the true distribution and the residual distribution are parallel, and, (2) if it is not fully mobilized, as in the example case, the slope of the true distribution can never be steeper than the slope of the distribution of residual load along this length of the pile. These conditions will assist in determining the length of the transition zone from negative skin friction to positive shaft resistance. For simple soil profiles, the conditions and the curve fitting can be handled by spread sheet calculations. Cases involving non-uniform soil profiles, non-hydrostatic distribution of pore water pressure, effect of adjacent piles and/or excavations require special software or the calculations will be very time-consuming. For example, the UniPile program (Fellenius and Goudreault, 1999).

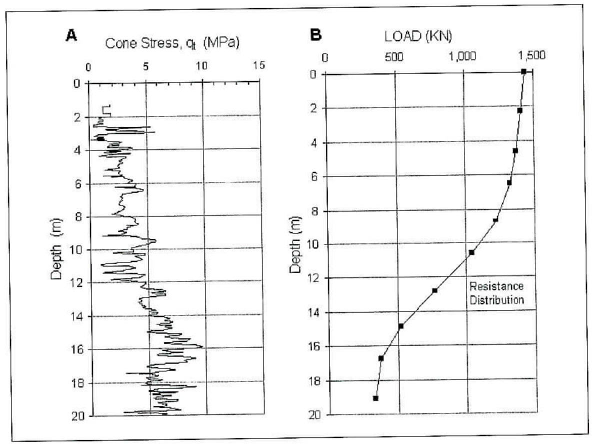


Fig. 6 Results of the Analysis of Both Piles (Data from Altaee et al. 1992)

The results of the testing of the 11.0 m long pile were also analyzed. The results of both analyses are presented in Fig. 6. Fig. 6A combines the distributions of measured load, true resistance, and residual load. Fig. 6B shows the distributions of measured shaft and corrected shaft resistance (for reference, the distribution of residual load is also shown). The calculations establish the parameters to use in the design at the site. Without the correction for residual load, the data could have been mistaken to show the presence of the so-called critical depth at about 25 and 30 pile diameters depths for the short and the long piles, respectively. Use of such mistaken interpretation for the design of piled foundations at the site involving piles of different length and/or diameters would then have been confusing, as calculations of a new pile based on the results from the 11-m pile would have been distinctly different from those based on the 15-m pile. A design based on the results corrected for residual load has no such difficulty.

Case II. Analysis of results from dynamic testing of a precast concrete pile

A residual load analysis on results from a static loading test requires that the pile is instrumented. Such tests are quite rare. However, regardless of type of test, any test that produces a load distribution as a change of load due to the applied load (initial values taken as "zero" at the start of the test) is suitable for analysis of residual load distribution. For example, a dynamic test using the Pile Driving Analyzer (PDA) with a CAPWAP[1] analysis, a test that is common for driven piles and occasionally also for bored piles. The CAPWAP analysis provides the distribution of static resistance along the pile in a manner similar to that of resistance distribution measured by strain gages in static loading test on an instrumented pile. Therefore, although this is not generally realized, CAPWAP results are similarly

[1] The CAPWAP analysis makes use of strain and acceleration measured for an impact with a pile driving hammer. The analysis delivers amongst other results the static resistance mobilized by the impact. In the calculation, the pile is simulated as a series of many short elements and the results are presented element per element, as if load measurements had been made at each element location along the pile. That is, each element can be considered having the role of a strain gage. Although the CAPWAP program allows an adjustment of the results for locked-in load due to the immediately preceding impact, the analysis cannot provide full recognition of the residual load in the pile.

influenced by residual load and may need similar adjustment before the true resistance distribution is found.

Where the strain-gage values obtained in a static loading test on an instrumented piles are independent of each other, the CAPWAP determined load values in the various elements simulating the pile in the analysis do exhibit a mutual dependence. It is not within the scope of this article to explain why and how, however. The fact is that a resistance indicated for a particular element should be considered as less definite than a value from a strain-gage reading in a static test and one should proceed with caution and carefully corroborate the results with static analysis based on good information on the soil profile. (This does not mean to say that pile capacity determined in a CAPWAP analysis is in any way less reliable that that determined in a static loading test).

Case History II is used to demonstrate the method of analysis for residual load on the results of a CAPWAP analysis on a pile subjected to residual load. The case is a test on a 250 mm diameter square precast concrete pile driven 19 m into a loose to compact sand deposit (the test data are from Axelsson, 1998). The soil profile at the test site is presented in Fig. 7A in the form of a CPT q_t-diagram from a sounding close to the test pile, showing a consistent cone resistance within the pile embedment depth. A dynamic test was carried out at restrike 143 days after the initial driving. The first blow of restrike was used in a CAPWAP analysis.

Fig. 7B shows the CAPWAP determined resistance distribution in a manner similar the strain-gage measured distribution obtained in a static loading test. The ultimate total resistance is 1,440 KN and the shaft and toe resistances are 1,110 KN and 330 KN, respectively. Again, the "measured" load distribution curve is "S"-shaped, which is typical for a "false distribution", i.e., a distribution influenced by residual load. That residual load exists in the pile is no surprise. Some load developed as a result of the driving of the pile and the rest developed during a series of earlier restrikes performed at different times after the end of the initial driving. Indeed, the question to resolve is not "if" but "how much" and "with what distribution".

The "measured" resistance distribution indicates that the unit shaft resistance increases to a depth of about 13 m. Progressively below this depth, it becomes smaller, and over the last 4 m length (below about 15 m), the unit shaft resistance is very small. This is inconsistent with evenness of the soil profile established by the CPT sounding.

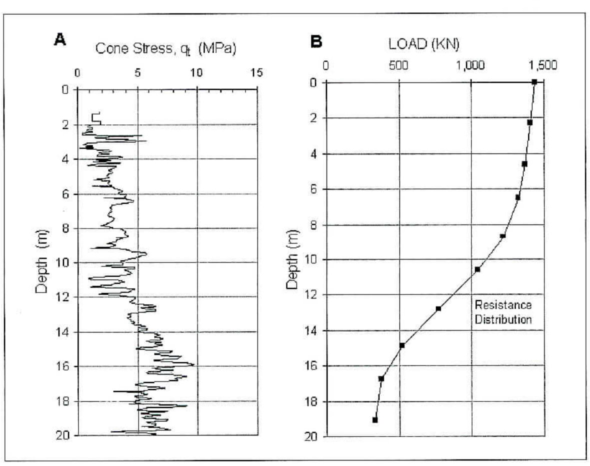


Fig. 7 Case 2 CAPWAP Analysis at Restrike of a 285 mm Diameter, 10 m Long Precast Concrete Pile Driven into Loose Sand
A. CPT Profile
B. CAPWAP Determined Resistance Distribution (Data from Axelsson 1998)

Fig. 8 demonstrates the results of the procedure for determining the true resistance distribution in the test. A calculated shaft resistance distribution was matched to the "half curve" and a good fit was obtained down to 13 m depth. Thereafter, the assumption was made that the effective stress parameter (beta-coefficient) found in calculations applied also to the soil below 13 m depth and the distribution of the true resistance was calculated. The CAPWAP determined loads (the "measured" loads) were then subtracted from the true resistance values to arrive at the distribution of the residual load. The full results are presented in Fig. 9.

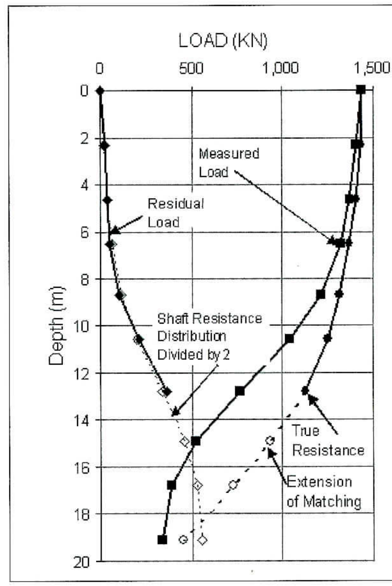


Fig. 8 Case II. Matching the Distributions of Measured and Calculated True Shaft Resistances

For the example case, the assumption that the same beta-coefficient applies above and below 13 m results in a distribution of residual load that indicates that the positive shaft resistance was not fully mobilized in the lower portion of the pile, but for the about 2 m length immediately above the pile toe.

The analysis could be polished by applying a slightly larger beta-coefficient near the pile toe. (Repeating the conditions, an upper boundary of the beta-coefficient is governed by that the resulting residual load distribution and the true resistance distribution can be parallel, but the slope of the true resistance distribution must not become steeper than the slope of the residual load distribution). However, the fact that the CAPWAP determined distribution (the "measured" resistance) is not quite vertical for the last element (below 17 m) does support that the positive shaft resistance immediately above the pile toe is not fully mobilized by residual load. At the same time, the CPT-profile supports the conclusion that the unit shaft resistance below 13 m depth is not smaller than above 13 m depth, that is, the choice of using the same value beta-coefficients above and below 13 m depth is supported. In other words, a good portion of engineering judgment and reasoning is necessary in the process and often the results of the analysis can only be obtained within upper and lower boundaries.

For the example case, the corrected shaft and toe resistances are 985 KN and 455 KN as opposed the uncorrected values of 1,110 KN and 330 KN. Hardly an insignificant correction. The objective of the analysis procedure is to obtain a true distribution of resistance for the test pile, and then to use this in analysis of the basic soil parameters, such as beta and toe bearing coefficients. False values will result in false conclusions and unreliable design recommendations.

Direct Measurement of Residual Load

In contrast to conventional "head-down" tests, tests using the Osterberg Cell (Osterberg 1998; Fellenius 2001) provide data that allow an analysis of the residual load in the pile. The O-Cell loading test consists of expanding a special hydraulic jack normally placed at the toe of a pile, pushing the shaft upward and the toe downward. The maximum test load is when either the ultimate shaft resistance is reached or a maximum toe movement is obtained. When the test starts, the load at the toe of the pile is the weight of the pile plus the residual load. This load is gradually transferred from a physical contact between the O-Cell top and bottom plates to being carried by the pressure in the cell. During this transfer, no or only insignificant separation movement occurs of the O-Cell plates. Once the load transfer is completed, continued increase of load in the O-Cell results in a much larger separation movement of the O-Cell plates, signifying increasing compression of the pile and corresponding increase of load in the pile. Thus, analysis of the early behavior of the O-Cell measurements load will establish the magnitude of the residual load in the pile at the location of the O-Cell. For other locations in the pile, the O-Cell test is routinely combined with strain gages placed at several levels in the pile. The analysis of the true distribution of resistance of these strain gages applies the same method as used for the conventional head-down test. Of course, the analysis must recognize that the O-Cell test engages the pile in negative skin friction for the entire length above the O-Cell. The advantage of the O-Cell test is that the analysis of the strain gage data is assisted by the actual knowledge of the residual load at the O-Cell.

Closing Words

The method has the advantage of making the analysis independent of strain-gage zero shift due to strain transfer within the pile material, temperature change, or slippage. This is because the method works only with the loads introduced (as measured at the gage levels) during the static loading test.

As mentioned in Part I, the mechanism behind the build-up of residual load is analogous to the build-up of dragload in a pile. Therefore, if a long-term test on an instrumented pile for the purpose of studying the development of negative skin friction and dragload is "finished" with a static loading test , the method can be applied to determine the dragload distribution and eliminate the potential influence of zero shifts (i.e., changes in the no-load reading) of the strain gages.

Before applying the analysis method, however, one must be certain that residual load indeed is present in the pile. It is easy to jump to conclusions, as the appearance of residual load can be deceiving and due to erroneous gage readings (e.g., gage damage and calibration changes due to mishaps during the construction of the pile). The procedure presented in this article applies to test data which can be accepted without reservations about accuracy and validity. Then, one must remember that the procedure is one of curve-fitting and shrewd curve-fitting will always produce good agreement between calculations and measurements. In other words, the accuracy of the final numbers is construed. Therefore, considerable judgment must be exercised in the analysis and use of the results and the results must be related to a static analysis of the soil response based on basic principles of soil mechanics. Don't attempt the analysis method without having the soil profile well established

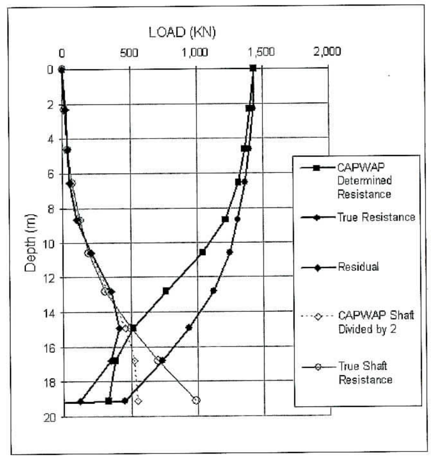


Fig. 9 Final Results: Measured Load, Residual Load, and True Resistance

from a CPTU sounding and independent soil sampling. A borehole log with SPT data and its intermittent soil information is rarely sufficient.

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Correction

In Part 1 of this article, *Geotechnical News, June 2002, page 27* ***References*** J-L Briaud's name was misspelled. The reference should be:

Baker, C.N., Park, G., Briaud, J-L., Drumright, E.E., and Mensah, F., 1993

A New Instrumentation Web Site: *http://www.fmgm.no*

Elmo DiBiagio

The idea of creating a web site for geotechnical instrumentation was proposed by Giorgio Pezzetti (Italy) at the last International Symposium on Field Measurements in GeoMechanics (FMGM 1999) in Singapore. Giorgio's suggestion was to create a site where all kinds of useful information relating to field instrumentation would be readily accessible to everyone, including a discussion forum for exchange of ideas and practical experience, or simply a place to raise questions. The symposium participants were very positive about the idea.

I was present at the symposium in Singapore and volunteered to set up a general FMGM instrumentation site and to serve as its first webmaster. The basic idea was to have a neutral, non-commercial site not dominated by any one individual or organization, a site where anyone interested in field instrumentation can meet, exchange ideas, find useful information and communicate with others interested in instrumentation.

In February 2001 a draft version of the site was put on the Internet for testing. At this time the site was not open to the public, thus, a User ID and Password were required to access it. An international review board was informed of the site and asked to review the contents and format, as were all major instrument manufacturers. Their comments were then integrated into the site development plans. The Norwegian Geotechnical Institute (NGI) purchased the domain name *fmgm.no* for the site and put it on NGI's server.

In June 2002 the site was opened to the public primarily to provide a channel for announcing the next FMGM symposium (FMGM 2003) and to provide a convenient and efficient means of distributing information about the symposium in the future.

The URL of the instrumentation site is: *http://www.fmgm.no*

The site, in its present form, is by no means complete or in its final form. However, the contents and structure indicate how this site will be according to current development plans. The present site consists of the following sections or *pages*:

- Home Page
- News and Events
- Theory and Practice
- Publications
- Discussions
- Links
- Glossary
- Feedback
- I Want to Help
- Credits

Some pages don't contain any information yet, except for a few comments to indicate what type of information will ultimately appear there.

Development of the site is based entirely on voluntary contributions, which have been limited to date, primarily because the site has been closed to the public. Now that the site is open to the public, it hopefully will grow and develop into a useful information site for both users and suppliers of instrumentation.

There is no professional society behind the FMGM web site or the FMGM symposia. There is no FMGM secretariat, there are no sponsors and there are no FMGM funds. The FMGM family, if you want to call it that, consists of individuals who are so interested in and dedicated to field instrumentation that they volunteer to do something just to keep the FMGM spirit alive. It is the hope that this web site will do just that - to help keep the FMGM movement alive and to promote worldwide interest in field instrumentation and monitoring the performance of civil engineering works and facilities.

Take a look at the FMGM website. If you have any comments or suggestions for improvement of the site please send them by email to me or use the "*Feedback Page*" provided in the site. If you would like to help in the development of the site, go to the "*I Want to Help Page*" and check the list of tasks to be worked on. Your help with any of these tasks, or any other contribution you feel appropriate to the goals of the site, would be greatly appreciated and acknowledged.

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Answer to the question on page 22. Because the strain in Spain stays mainly in one plane).

Continuing Education Course

Geotechnical Instrumentation for Field Measurements

March 10-13, 2003

The Comfort Inn Suites, Cocoa Beach, Florida

This continuing education course will includes presentations by users of instrumentation from USA, England, Canada, France and Switzerland. There will also be technical presentations and instrument displays by major manufacturers of geotechnical instrumentation from USA and Canada.

Ralph Peck will present a lecture "Observation, Instrumentation, Action – Chicago in the 30s to Today's Practices". He will also participate in all four days of the course, including a discussion on "People Issues with Observation and Instrumentation".

Instructors and Topics, March 10-12, 2003

John Dunnicliff, Course Director, Geotechnical Instrumentation Consultant, England.

- Systematic Approach to Planning Monitoring Programs. Lecture and Workshop.
- Overview of Hardware.
- Contractual Arrangements.
- Overview of Instrumentation of Slopes, Embankments on Soft Ground, Embankment Dams, Underground Excavations, Deep Foundations and Earth Retaining Structures.
- Discussion on People Issues with Observation and Instrumentation. Co-moderator with Ralph Peck.

Ralph B. Peck,
Civil Engineer: Geotechnics.

- Observation, Instrumentation, Action – Chicago in the 30s to Today's Practices.
- Discussion on People Issues with Observation and Instrumentation. Co-moderator with John Dunnicliff.

Pierre Choquet, Roctest Ltd.,

- Fiber Optic Sensors for Geotechnical Monitoring Applications

Gary R. Holzhausen, Applied Geomechanics Inc.

- Use of Tilt Measurements for Monitoring Structural and Ground Behavior.

Alan Jones, Slope Indicator Company

- The Development of In-place Inclinometers by Slope Indicator.

William F. "Bubba" Knight, Professional Service Industries, Chipley, FL.

- Case Histories: Instrumentation of Geogrid Reinforced Embankment over Soft Soils. Instrumentation of Deep Foundations for Static Load Testing.

Jean-Ghislain La Fonta, Sol Data, France.

- Case Histories: Amsterdam Metro, London's King's Cross Station Redevelopment, and Tunneling in Moscow.

P. Erik Mikkelsen, Consulting Engineer, Bellevue, WA.

- False Inclinometer Displacements and the Reasons Why They Occur.
- Simplify Piezometer Installations, Lower Costs and Get Better Results in Fully-grouted Boreholes.

Daniel Naterop, Solexperts AG, Switzerland.

- Recent Developments in Geotechnical Instrumentation – Fiber Optic Sensors, Time Domain Reflectometry, Global Positioning Systems, Motion-controlled Digital Levels and Total Stations, Extensometers with Logger and Radio Transmission.
- Deformation Measurements in Boreholes using Series Methods

Rob Nyren, Geocomp Corporation, Boxborough, MA.

- Monitoring of Buildings and Ground Response During Sub-surface Construction: The Jubilee Line Extension Project, London.

David Rutledge, Condor Earth Technologies, Inc., Sonora, CA.

- Deformation Monitoring using the Global Positioning System.

Tony Simmonds, Geokon, Inc.

- Vibrating Wire Instruments for Unique and Custom Applications.

Robert M. Taylor, RST Instruments.

- Automatic Data Acquisition Systems and Databases.

Optional Fourth Day, March 13, 2003

Discussion among Attendees and Instructors of Various Topics, to be selected by Attendees, moderated by John Dunnicliff and Erik Mikkelsen.

Attendees are encouraged to send requested discussion topics by e-mail to John Dunnicliff well before the course date.

Textbook Included:

Geotechnical Instrumentation for Monitoring Field Performance, by John Dunnicliff, published by Wiley in 1988 & 1993, will be part of the course materials. Copies of *Judgment in Geotechnical Engineering – The Professional Legacy of Ralph B. Peck* will be available for purchase and signing.

Web Site:

Visit *http://www.doce-conferences.ufl.edu/geotech/* for more detailed information, including registration, fees and accommodation.

For Additional Registration Information Contact:

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