Instrumentation

John Dunnicliff

Introduction

This is the tenth episode of GIN. Did anybody notice that there was no GIN in the December 1996 issue of Geotechnical News? Both my fault and yours. Mine because I didn't manage to find the time, and yours because you haven't sent me sagacious [this is a John Gadsby – Publisher of Geotechnical News – word. I delved into my schoolboy memories of Latin, to question whether this related to wisdom or to arrows] articles.

Contract Practices IV

More on one of my soapbox topics. The September 1994 issue of Geotechnical News included a series of articles discussing contract practices for geotechnical instrumentation. Projects and authors were:

- Central Artery/Third Harbor Tunnel, Boston. *David L. Druss, Siamac Vaghar*
- Mn/ROAD, MN. *Christopher Groves*
- Superconducting Supercollider, TX. *Hanson Bratton, Roy F. Cook, Eric Eisold, Robert A. Robinson.*
- Megabuck Tunnel. *Charles W. Daugherty*
- Mount Baker Ridge Tunnel, Seattle, WA. *Gordon E. Green*
- Rapid Transit Expansion Program, Toronto. *J. Nick Shirlaw*

My goal in assembling those articles was to look at what the North American geotechnical community has experienced in recent years, both those who have written specifications and those who have had to live with specifications written by others. I hoped that by doing that I could point towards some better directions for the future.

At the conclusion of the articles I wrote "Pointing Directions for the Future":

I remain convinced that geotechnical instrumentation work should be considered as a professional service, rather than as a low-bid construction item. I once heard Wally Baker say "The person with the greatest vested interest in the quality of the data should be given direct line responsibility for producing the data accurately", and to me this "says it all."

In my view, the following are some key points:

- *Use professional service specifications whenever you can. They are the best way to ensure good motivation and quality.*
- *Be very careful with specification wording relating to the responsibilities of the prime contractors [some suggestions were included in the articles].*
- *Avoid the use of lump sum payment methods, both for procurement of instrumentation materials and for field instrumentation services.*
- *If you are forced to use a low-bid method, write a clear, consistent, complete, correct and equitable specification. Specify stringent personnel experience criteria and submittal requirements, and other tasks listed in the articles (Table 6 on page 41). If this results in a large number of specification pages, out of balance with the remainder of the specifications, so be it.*
- *Enforce the specifications fully.*
- *Give serious thought to the use of the assigned supplier and assigned subcontractor methods. In my experience they work well. They are not used enough.*

I closed by pleading for ongoing contributions on this subject.

The following article by Fritz Klingler is noteworthy because it documents a case history of "the right way", with a public agency owner. I've been promised another article, for the next issue of GIN, with a similar message about poor quality work when the bid method is used. These contributions should be useful as precedents when we try to convince other public agencies to accept the professional service method. Again, I'd welcome comments, discussions, and other contributions on this subject.

Continuing Education Courses

Two continuing education courses on geotechnical instrumentation are now scheduled.

The first will be at Columbia University, New York, on Sunday, June 29, 1997, immediately preceding the International Society of Rock Mechanics international Symposium and 36th U.S. Rock Mechanics Symposium. The focus will be on rock mechanics instrumentation, with the following topics:

- Overview of hardware
- Systematic approach to planning monitoring programs, illustrated with a rock tunnel case history
- Instrumentation of underground excavations
- Instrumentation of rock slopes

For more information contact me, or *Professor Kunsoo Kim, Columbia University, 811 Seeley W. Mudd Building, New York, NY 10027, Tel: (212) 854-8337, fax (212) 854-8362, or E-mail kk21@columbia.edu.*

The second will be at Coca Beach, Florida (the hotel is **on the beach**: this emphasis is addressed to those of you who want to flee from November cold), on November 11-13, 1997. The format will be the established one for three-day courses, and will include presentations by Dick Davidson on automatic data acquisition systems, by Tom Porter and Bubba Knight on case histories, and presentations by several manufacturers of instrumentation. An optional fourth day is scheduled for November 13, with topics selected by attendees or from the following list:

- Tricks of the trade (nuts and bolts details)
- Installation of piezometers in boreholes

- Installation of inclinometer casings
- Workshop on evaluation of data
- Real time dial-up of automatic data acquisition system
- Lessons learned from our mistakes
- Questions and discussion

More details of this course are given on page 39 of this issue of Geotechnical News.

For more information or to register, contact: *Ole Nelson, Associate Director, DOCE/Conferences, Tel. (352) 392-1701, ext. 244, fax (352) 392-6950, E-mail ole@nervm,nerdc.ufl.edu.*

As an indication of "where the action is", a mid-September 1996 three-day course in Hong Kong had an attendance of about 60, whereas a late-September 1996 two-day course in St. John's, Newfoundland attracted only three registrants, hence was cancelled.

Strain Gage Workshops

Measurements Group, Inc. have a comprehensive schedule of workshops on resistance strain gage technology, most in Raleigh, NC, but also some at other locations. They also have VHS videotape cassettes for purchase, covering a variety of strain gage installation techniques. Contact: Training Program Coordinator, Measurements Group, Inc., P.O. Box 27777, Raleigh, NC 27611, Tel. (919) 365-3800, fax (919) 365-3945.

ASCE Geo-Institute

Most readers of Geotechnical News will know that the former ASCE Geotechnical Division is now ASCE Geo-Institute. The goals of the Geo-Institute are to:

- Advance the state-of-the-art and state-of-the-practice of the world-wide geo-industry,
- Provide effective and timely technology transfer, and
- Integrate the technology activities of individuals engaged in all aspects of the geo-industry including research, education, design, testing, manufacturing, construction, operations, and maintenance.

What advantages does that provide for those of us who work with instrumentation? I've often contended, both in this column and elsewhere, that we should do all we can to tear down any barriers that exist between manufacturers and users. As indicated above, this is one of the goals of the Geo-Institute. The institute's first major activity will be conducting a National Conference July 16-19, 1997, known as "Geo-Logan 97", at Utah State University in Logan, Utah.

At most conferences, exhibitors do not attend technical sessions (sometimes exhibitors are even barred from attending the sessions, so that users are free to say things that they wouldn't say "in public": a very undesirable practice in my view.) When there is an instrumentation session, the instrumentation exhibitors are rarely there, hence manufacturers don't benefit from listening to and discussing the users' experiences and users don't benefit by hearing manufacturers' views. Why not? Because the expense of exhibiting must be offset by maximum effort to sell products — of course. There seem to be two possible approaches to encouraging exhibitors to attend technical sessions. First, close the exhibits during the sessions. Not a popular idea, because it limits exhibitor exposure and limits time during which attendees can visit exhibits. Second, allow one representative from each exhibitor to attend technical sessions without charging a registration fee, hence encouraging two to attend: one to participate in sessions and one to exhibit.

This second approach is being taken at Geo-Logan, in the hope of "tearing down barriers". Recognizing this, and recognizing that the thrust of Geo-Logan is to integrate the activities of all participants, come and join us.

The conference program includes:

- The H.B. Seed Memorial Lecture, presented by John Burland, Imperial College, London. (I asked John what his topic would be: *"My present intention is to develop the concept of pile group design when piles are being used purely for settlement reduction. Vast sums of money are being spent because of an inappropriate approach to this problem.")*
- A special lecture by Ralph Peck, dealing with our expanding geo-industry
- A "field day" of field trips, demonstrations of lab and field instrumentation, demonstrations of the installation and testing of deep foundations, computer software demonstrations, training on utilizing the World Wide Web, and other hands-on activities. A demonstration of axial and lateral load testing of driven pipe piles is planned, with both vibrating wire and fiber optic strain gage instrumentation.
- Plenary and technical sessions
- Pre-conference short courses

For more information, contact: *Dr. Loren R. Anderson, Department of Civil and Environmental Engineering, Utah State University, Logan UT 84322-4110, Tel. (801) 797-2938, fax (801) 797-1185, E-mail: loren@lab.cee.usu.edu.*

For exhibit information, contact: *Scot Litke, Exhibit Chair, ADSC, P.O. Box 280379, Dallas, TX 75228, Tel. (214) 343-2091.*

Boart Longyear and Interfels

The following "press release" has been set to me by Helmut Bock, formerly President of Interfels GmbH in Germany.

> Boart Longyear has acquired Interfels GmbH, a leading company in the provision of geotechnical instrumentation and in situ testing of rock, soil and concrete. Interfels was established in 1961 by Professor Leopold Müller, the "father" of rock mechanics, and also the founder of the International Society for Rock Mechanics (ISRM).
>
> The acquisition is regarded by Boart Longyear as a necessary step in guaranteeing its customers technical and scientific competence at the very highest level. This combination has been identified by Boart Longyear as "key to dealing with the complexities of the geotechnical measurement business." In order to ensure these standards, the company will continue to be managed by Professor Helmut Bock.
>
> Traditionally, Interfels has among its many proven techniques —

performance monitoring equipment for NATM tunnels and large scale in situ testing, particularly of dam abutments, underground caverns and foundations. Among its innovative products are 3D deformation measurements in boreholes by either stationary or mobile probes, multiple rod extensometers with packer anchors and borehole slotting equipment for in situ stress measurements in rock and ageing structures.

Regional Director Fred Flemming sees Interfels as "contributing significant synergistic effects to the Boart Longyear Exploration and Geotechnical Division. Building on the successes of Boart Longyear UK and Slope Indicator Company, the group's existing supplier of installation, monitoring and data processing equipment, we will be in a position to offer this specialist market a full range of products as well as providing application know-how and complete systems. We have identified the geotechnical area as critical for our future growth and are committed to investing in competitive, total package solutions for all our customers."

Boart Longyear is a leading supplier of tools, equipment and services to the international mining, quarrying, construction, industrial, geotechnical and environmental markets. Comprising over 60 companies, the group employs some 9,000 people based in 30 countries on five continents.

As indicated in the press release, Slope Indicator Company, Bothell, WA, is a Boart Longyear Group company. Hence Interfels GmbH and Slope Indicator Company are now "sister companies." Slope Indicator Company is now responsible for marketing and sales of Interfels geotechnical products in the Americas and Southeast Asia.

For more information, contact:

Dympna Hughes, Marketing Services Manager, Boart Longyear Europe, 18—24 Städeweg, D—36151 Burghaun, Germany, Tel. +49 6652 82135, fax +49 6652 82190.

or

Helmut Bock, Interfels GmbH, P.O. Box 1265, D—48443 Bad Bentheim, Germany, Tel. +49 5922 98980, fax +49 5922 989898.

or

Slope Indicator Company, P.O. Box 3015, 3450 Monte Villa Parkway, Bothell, WA 98041-3015, USA, Tel. (206) 806-2200, fax (206) 806-2250.

Closure

Please send contributions to this column, or a separate article for GIN, to me: 16 Whitridge Road, South Natick, MA 01760. Tel. (508) 655-1775, fax (508) 655-1840.

Kull sinneh wo entehsãlem! (Syria)

Geotechnical Instrumentation Funded as a Professional Service on a Public Agency Contract

Fritz J. Klingler

Introduction

Geotechnical instrumentation programs are often considered essential by the designers of large underground construction projects, in order to protect existing facilities and provide documentation when ground movements occur. Although the instrumentation plan for public projects is typically prepared by the project design team, and proper execution of the plan is vital to the construction manager during construction, the actual installation, monitoring, and reporting are many times included as a contract bid item, and performed by the contractor (or contractor's subcontractor) during construction. This appears to be the result of a desire by many public agency owners to fund the instrumentation program through the construction budget. As a result, a potentially powerful tool for the construction manager to control the construction operation, is often weakened. This author is happy to report on one ongoing public works project where the instrumentation plan was developed by the geotechnical engineering consultant during design, and is being installed, monitored and reported on by the same consultant as part of the design team's construction administration responsibilities (construction management).

The Downriver Regional Storage and Transport System is an approximately $100 million combined sewage overflow remediation project, designed under a team led by Wade-Trim/ Associates, Inc. of Taylor, Michigan, and owned by a group of communities represented by Wayne County, Michigan. NTH Consultants, Ltd. of Detroit, Michigan, provided geotechnical consulting and design services, including the instrumentation program design.

Description of Project

The project consists of approximately 72,000 lineal feet of sewer, which along with appurtenant structures, is divided into seven construction contracts. Three of the contracts have recently been bid, and four are expected to be bid in 1997 and 1998. The internal diameter of the sewer ranges from 48 inches to 84 inches with almost all of the sewer to be constructed in-tunnel. Initial ground support will be steel ribs and wood lagging. Approximately 30 mining shafts and 15 connection/diversion structure shafts are expected to be constructed, with shaft diameters ranging from 15 to 50 feet, and depths ranging from 30 to 65 feet. Ground conditions along the project alignment are typically medium consistency silty clay, although granular

soils under approximately 40 feet of artesian head are also expected to be encountered occasionally. Typical shear strengths of the clay at the tunnel face are in the range of 500 to 1000 psf, corresponding to soil overload factors in the range of 8 to 20.

The project alignment extends along and across several major roadways, railways and utility corridors, all of which are susceptible to damage from potential ground movements. Almost all above-ground structures are outside the expected settlement trough for the tunnel mining, but not necessarily outside the potential settlement zone adjacent to shafts. Major existing underground structures which must be protected during mining include sewers up to 12 feet in diameter, several high pressure gas mains, and several large diameter water mains.

Instrumentation Plan Development

During the design process, it was recognized that an important element in reducing costs during this project will include minimizing ground movements and associated damage to roadways and utilities. Tunnel Contract Nos. 1 through 3 were set up so that repair of all damage to existing structures and facilities resulting from the construction is incidental to the bid. Under this arrangement, the contractor was advised within the bid documents that ground movements, settlement, and some damage to existing structures should be expected, and should be considered when preparing the bid (i.e. no separate bid items are provided for such repair). The arrangement is intended to encourage the contractor to use equipment and methods which will minimize ground movements, and to include funds within the bid for repair of damage to existing structures and facilities.

Tunnel Contract Nos. 4 through 6 were set up with a specific limit for surface settlement, and require repair of damage where settlement exceeds that limit. These contracts also include an allowance for repair of areas where surface settlement is less than the limit, but where the owner determines that unacceptable damage has occurred. This arrangement is also intended to encourage the contractor to use equipment and methods which will minimize ground movements, and to include funds within the bid for repair of damage to existing structures and facilities. By specifying an allowable limit for settlement, it is expected that the bid will not include costs for unnecessary repairs (due to minor damage resulting from settlement less than the allowable limit).

Both of the contractual methods for addressing construction-related damage to existing facilities require an efficient and accurate means for measuring and documenting ground movements. As such, detailed instrumentation plans were developed during the design process for each of the separate tunnel contracts. The planned instrumentation consists primarily of surface monitoring points, inclinometers, vibration monitoring, and telltales for measurement of vertical deformation of underground structures. The instrumentation monitoring and reporting frequencies were developed with the objective that the data could be used to evaluate movements during construction, and if necessary, construction methods could be adjusted to reduce movements and associated repair costs. In addition, the data will serve as a useful base of information for evaluating possible property damage claims which could develop as a result of construction activities.

Contractual Method for Instrumentation

Several methods were considered for funding the geotechnical instrumentation installation, monitoring and reporting. These included:

- Making the instrumentation part of the construction bid as a bid item.
- Including the instrumentation as an allowance within the construction contract.
- Including the instrumentation within the construction management contract (in this case, the work would be performed under the direction of the construction manager and funded as a professional service with a not-to-exceed budget).

The advantages and disadvantages of each of the funding options were discussed with the lead designer of the project, Wade-Trim/ Associates, Inc., and with Mr. Roger VanOmen, Chief Engineer for the owner, Wayne County Department of Public Services.

It was recognized that funding the instrumentation program as part of the contractor's bid would probably result in a competitive price for the work, but could also result in a reduced level of control by the construction manager and owner. Specifically, a high level of vigilance would be required by the construction manager and owner to ensure that the instrumentation program is carried out properly, and reports are submitted in a timely manner. Our experience with this arrangement on similar projects is that regardless of the contract requirements, the quality and performance of the instrumentation program is often low on the list of contractor concerns. The natural result is that:

- The quality of instrument installation suffers.
- Readings are often missed.
- Reports are incomplete and/or late.

As a result, the original objective of the instrumentation program (that a means be available for measuring ground movements so that construction methods can be modified to minimize construction damage) often cannot be realized. While the contractor may be contractually responsible for damage due to ground movements, the magnitude of ground movements may not be clear, and the owner can often end up paying in the form of dispute resolution costs.

Including the instrumentation as an allowance within the construction contract was examined, however this method of funding was not considered desirable for several reasons, including that the owner and construction manager would have limited control (as discussed above for the bid option), while the owner would not benefit from a competitive bid.

Funding the geotechnical instrumentation program as a professional service under the construction management contract would provide the construction manager and owner with maximum control over the instrumentation installation, monitoring, and reporting. As

ground movements occur, the contractor would be advised, and would be responsible for limiting movements and related damage. In addition, instrumentation data can be efficiently transmitted to separate contractors on adjacent contracts so that construction conflicts are minimized. Instrumentation data and reports would be in a consistent format throughout the seven contracts, which would allow the construction manager to more easily compare ground movement measurements resulting from different methods of construction.

The project owner agreed that the instrumentation installation, monitoring and reporting for this project should be performed as a professional service under the construction management contract. The construction management and construction engineering services are being performed under the direction of the design team leader, Wade-Trim/ Associates, Inc., with instrumentation installation, monitoring and reporting being performed under the direction of NTH Consultants, Ltd. As a result of the efficiency gained from the design/construction engineering team installing and monitoring the instrumentation, we expect that the overall cost of the project will be reduced.

Fritz J. Klingler, P.E. is a Project Manager and Associate in the Detroit office of NTH Consultants, Ltd., 277 Gratiot, Suite 600, Detroit, Michigan 48226. Tel:(313)965-0036 Fax:(313)965-0683.

Geotechnical Instrumentation for Field Measurements
November 10-13, 1997
Howard Johnson Plaza Hotel *on the beach*, Cocoa Beach, Florida

Course Emphasis:

This is a course for practitioners, taught by practitioners. The emphasis is on why and how. The topic is instrumentation for monitoring performance during construction and operation rather than instrumentation to determine in situ parameters.

This is unique: a continuing education course that includes technical presentations by major manufacturers of geotechnical instrumentaiton in the USA and Canada, in addition to presentations by users. Other courses emphasize the users' views: this course is a cooperative effort between manufacturers and users.

Who Should Attend:

- Engineers, geologists, or technicians who are involved with performance monitoring of geotechnical features during construction and operating phases
- Project managers and other decision-makers who are concerned with safety or performance of geotechnical construction and consequential behavior

Why You Should Attend:

- To learn the who, why and how of successful geotechnical monitoring
- To meet with leading manufacturers of geotechnical instrumentation
- To ensure that your monitoring programs are tailored to match your specific geotechnical questions
- To avoid the common problem of poor quality data
- To learn up-to-date methods for automatic acquisition of data

Topics Presented by John Dunnicliff

- Benefits of using geotechnical instrumentation
- Overview of hardware for measuring groundwater pressure, deformation, load and strain in structural members, and total stress in soil
- Instrumentation for various types of projects, selected by attendees from the following list:
  - ❑ Braced excavations
  - ❑ Embankment dams
  - ❑ Excavated and natural slopes
  - ❑ Underground excavations
  - ❑ Driven piles
  - ❑ Drilled shafts
- Systematic approach to planing monitoring programs
- Workshop on planning a monitoring program:embankment on soft ground
- Contractual arrangements for instrumentation
- General guidelines on calibration, maintenance, installation and data handling

Topics to be Presented by Others

- Presentation by manufacturers of geotechnical instrumentation
- Automatic data acquisition systems (Richard Davidson)
- An observational approach to design and construction in soft clays (Thomas Porter)
- Case histories:deep foundation, and embankment on soft ground (Bubba Knight)

Optional Fourth Day, November 13, 1997
Topics to be Selected by Attendees

- Topics requested by attendees
- Tricks of the trade (nuts and bolts details)
- Installation of piezometers in boreholes
- Installation of inclinometer casings
- Workshop on evaluation of data
- Real time dial-up of automatic data acquisition system
- Lessons learned from our mistakes
- Questions and discussion

Textbook Included:

Geotechnical Instrumentation for Monitoring Field Performance, by John Dunnicliff, published by Wiley in 1988 & 1993, will be part of the course materials.

Accommodations

The course will be held at the Howard Johnson Plaza Hotel, Cocoa Beach, FL. Rates are $69 + tax Single/Double in Towers; $59 Single/Double in Courtyard. To make reservations, call (800) 55 BEACH. To ensure a room at these rates make reservations by October 20, 1997 and mention the Geotechnical Instrumentation for Field Measurements short course

Registration Fee

The three day registration fee (course Nov. 10-12, received by October 6) is $950. Late registration (after October 6) is $1025. Including the optional fourth day, the fees are: by Oct.6, $1,100; after Oct. 6, $1,175. All the above fees include the textbook and break refreshments. If you have, and bring, the text, each fee is reduced $50.

For Registration Information Contact:

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