Geotechnical
Instrumentation
NEWS

Geotechnical Instrumentation News

John Dunnicliff

Introduction

This is the sixtieth episode of GIN. Anyone want to send me a diamond? One article and a book review this time.

A Designer's Dilemma

When designers opt to monitor their projects by using instrumentation they are often required, by project owners, to include the field instrumentation tasks as part of the general construction contract documents. (For those of you who groan, on reading that, "Oh no, here he goes again, on his soap box!" please hang in there—this has more than before).

Assuming that designers have a valid reason for monitoring they have an obligation to ensure that it's done to a high enough standard so that data are reliable. In the full knowledge that construction contractors are typically not motivated to support monitoring efforts, designers therefore write 'tight' specifications for people and for means and methods. These specifications become lengthy, sometimes up to 50 pages long for large projects, and out of balance with the rest of the project specifications.

The following article by Emily Dail and Joel Volterra tells us about the consequences of this from the viewpoint of a specialist instrumentation subcontractor, and the negative consequences are pretty alarming. What's a possible solution to this "designer's dilemma"? Designers must campaign with decision-makers in their own companies, and with owners, to put forward reasons for avoiding the subcontracting procedure. Try the following:

- Read the article by Dail and Volterra, looking for relevant points
- Download their 2001 reference from www.bitech.ca/news.htm, and become familiar with alternative methods
- Meet with in-house decision-makers, and owners if necessary, to put forward the arguments for instrumentation field services to be performed directly for the owner. Three of these arguments are summarized below, but there are more in the above two articles. The quotations are from the article by Dail and Volterra.

1. "After the contract is awarded to a general contractor, potential instrumentation subcontractors are invited to re-bid, so that the general contractor can compare line item breakdowns. Instrumentation bidders revisit their costs and strip contingencies. The firm ultimately awarded the work has likely assumed that the more stringent specification requirements will not be enforced". In my experience this "stripping" can be up to 25%. For example, if the amount carried for instrumentation in the general contractor's bid is $2 million the owner pays that amount, but only receives work that costs $1.5 million.
2. "Use of this method (instrumentation services performed directly for the owner) … allows for the collection of adequate baseline data, for which there is generally insufficient time when the subcontractor procedure is used". I've worked on several projects where seasonal variations of deformation approached or even exceeded specified response values, so that it was essential to gather a full year of baseline data.
3. "The award of instrumentation work based on the 'bottom line' includes little consideration for quality, if any at all". Even though a very valid part of the argument, be aware that this is least likely to be received favorably, because it can be interpreted as self-serving to the geotechnical instrumentation community.

As a sideline to what I've written above, after lecturing on this subject during the last instrumentation course in Florida, an attendee commented, "You're preaching to the converted—you need to preach to owners, not us". He's right! But our access to owners is limited to our interactions when working on specific projects. So I plead with you—if you face this designer's dilemma, understand the solution, and go for it!

Risk Management

In the previous GIN I said that cost effective management of risk is one of the keys to success of our construction projects, and that a recent book provides us with a guide to formalize a step-by-step procedure for managing risk. A review of that book follows the article by Dail and Volterra.

Dam Safety Performance Monitoring and Data Analysis Management – Best Practices

The Dam Safety Interest Group (DSIG) of CEATI International (Centre for Energy Advancement through Technological Innovation) Inc. in Montreal is composed of 38 dam owners from the U.S., Canada, Europe, Australia, and New Zealand, represented by their civil engineering and/or dam safety program leaders.

A consortium established within the DSIG has recently awarded a contract to Paul C. Rizzo and Associates, Monroeville, Pennsylvania with the objective of documenting best practices for developing an instrumentation program for dam surveillance and inspection, including instrumentation needs and maintenance, data collection, data analysis, and data management.

In my view this is a much-needed effort—I'm often asked, "What are the best practices for monitoring the health of dams?", and I don't have good enough answers.

The assignment has three main tasks:

- A literature review.
- Development of model surveillance, monitoring, and analysis programs and plans for summarizing dam monitoring instruments and data.
- Preparation of guidelines for producing monitoring summaries, conclusions and recommendations.

It is expected that this project will be completed by fall 2010, and soon after that there will be a summary in GIN. Watch this space!

Closure

Please send contributions to this column, or an article for GIN, to me as an e-mail attachment in MSWord, to john@dunnicliff.eclipse.co.uk, or by mail: Little Leat, Whisselwell, Bovey Tracey, Devon TQ13 9LA, England. Tel. +44-1626-832919.

Uslast! (Croatia)

Instrumentation and Monitoring Trends in New York City and Beyond

Emily B. Dail
Joel L. Volterra

Introduction

Instrumentation and monitoring are driven by the type and complexity of each project. Concurrent with instrumentation demand on larger publicly funded infrastructure projects, we anticipate continued growth in instrumentation services on smaller private projects when the economy recovers. It is now commonplace to provide data in "real-time", with automatic notifications by email, text message or other alarms, thereby streamlining data distribution. As industry-wide improvements are incorporated in response to larger project demands, smaller projects benefit without sharing an unfair proportion of system improvement costs.

This article is based on a paper presented at FMGM (2007) and is published with permission from ASCE. The first part of that paper introduced and summarized some major projects in New York, including South Ferry, East Side Access, the Fulton Street Transit Center, the 7-Line Extension, Second Avenue Subway and the World Trade Center redevelopment.

Construction excavation for those projects was in geologic materials ranging from soft ground sands and clays to massive rock formations, using combinations of open cut, cut-and-cover, mined or jacked tunnels, drill and blast, road headers and tunnel boring machines. Complicated excavation support and underpinning of active rail, roadways and buildings was necessary and incorporated combinations of secant pile walls, steel sheeting, soldier pile and lagging, jet and chemical grouting, mini-caissons, micro-piles, slurry walls and ground freezing. Many roadways were decked over using top down construction to minimize impact to active urban streets. All of the projects are situated in highly urbanized locations, winding through or under adjacent high profile and sometimes historic, fragile or sensitive properties. Experiences on these projects led to the views presented in this article.

Instruments included automated total stations, in-place and horizontal inclinometers, borehole extensometers, liquid level gages, seismographs, tiltmeters and tilt beam sensors, open standpipe and vibrating wire piezometers, strain and crack gages, load cells, convergence systems and sound monitoring. All required centralized real-time web-based monitoring and notification systems for validation and reporting, with varying levels of interpretation required by the Engineer. Several had threshold criteria limiting deformations to as little as 1/10 of an inch immediately behind a 50-foot deep excavation.

Developing Subcontractor Bids for Instrumentation

Bids typically include material purchases, installation, maintenance, monitoring, data interpretation and removal. Material costs are often a very substantial part of the total bid, and considerations include the use of salvaged materials from previous projects, and the bidder's willingness to recover only the depreciation of large instrumentation purchases through established monthly rental rates on the assumption that the materials will be used on a later project. This plays better into the hands of larger companies who can absorb larger overhead and presumes that:

- Materials will not be obsolete when needed later
- Gross salvage labor cost for materials, and recalibrating and recertifying them for a later project, is a net cost benefit as opposed to purchasing the next generation of instruments
- Recalibrated or recertified instruments will qualify as "equal" to meet later project requirements that generally specify "all instruments shall be new and include the manufacturer's warranty."

To be competitive, some firms may staff projects with less experienced technicians

Providing quality instrumentation materials and service are vital program parts, and this requires adequate resources. Small (low bid) budgets do not have the flexibility to account for unanticipated issues associated with potential stray electrical interference, unanticipated deformations (thermally, tidally or otherwise induced), data exceeding threshold values, poor backsight layouts/configurations due to access restrictions, or network database or website accessibility issues. Should these occur, construction delays, meetings, action plan implementation or supplemental instrumentation costs may at least in part become the instrumentation subcontractor's fiscal responsibility.

Cost reduction during bidding may result in the implementation of underdesigned systems. A slower modem data transfer rate or lower power saves money over time, which may amount to the total difference in cost between several bidders on a small job. For automatically downloaded instruments, a slower lower power system may suffice. Alternatively, costs may run over budget estimates for manual queries using a slower connection or one that frequently disconnects due to a weak signal.

Separation of data interpretation and evaluation tasks from installation and data collection should be avoided

To be competitive, some firms may staff projects with less experienced technicians to collect, submit, interpret or summarize data. They may also automate systems completely such that they are free from even cursory sanity checks. Selecting an instrumentation bid based on lowest price affects the quality of service and may merely defer increased costs to third parties to evaluate the raw data, or bear increased risk that deformations signaling a potential problem pass unnoticed.

We believe that separating the data interpretation and evaluation from those who installed and collected the data is a long-term recipe for disaster and should be avoided.

Minority, Disadvantaged or Woman owned Business Enterprises (MBE, DBE, WBE)

As the demands for geotechnical instrumentation have expanded, so has the competition. General contactors often have trouble meeting a project's minimum requirements for minority participation. The instrumentation subcontract award is generally made on the basis of lowest cost and the highest MBE /DBE/WBE participation.

Specifications

Instrumentation and monitoring specifications are rarely governed by building codes. Technical specifications should employ a rational approach that ensures safety but that does not cause excess cost or delay. Instrumentation specifications should be unique and project specific. High demand for low-cost instrumentation program design drives a recycling of often inadequate technical specifications, often ignoring technological advances and twenty years or more of manufacturers' mergers and acquisitions. This often results in unnecessary monitoring resources, as specifications are typically developed for larger projects and recycled on smaller ones.

The Bidder's Risk

While recycling of specifications may result in superfluous spending and unwarranted services, over-specifying monitoring for bargaining purposes is just as common. Specifications are written anticipating that the owner will not obtain 100% of the specified scope. Excesses are specified to arrive at a middle ground. Though often specified, a geotechnical instrumentation engineer (GIE) with a professional license and ten years experience rarely has to be on-site full time when qualified field personnel working under their direct supervision perform the work. A responsible bidder decides either to:

- Increase the bid price to cover the unnecessary costs of overly stringent specifications, or
- Assume the requirements will not be enforced as is routinely the case and, as such, assume the associated risk.

The first approach prices you too high, while the GIE in the second approach assumes the risk of an insufficient budget where the specifications are enforced.

After the contract is awarded to a general contractor, potential instrumentation subcontractors are invited to re-bid, so that the general contractor can compare line item breakdowns. Instrumentation bidders revisit their costs and strip contingencies. The firm ultimately awarded the work has likely assumed that the more stringent specification requirements will not be enforced.

Increased remote monitoring without documentation of construction progress dangerously disconnects data from construction events

Remote Data Acquisition and Construction Progress Records

Improved data transmission and interpretation are typically the responsibility of the instrumentation subcontractor. This includes upgrading and improving the data collection methods by implementing remote data acquisition systems where appropriate. This requires a shift in the status quo for some public agencies accustomed to full time field technicians available for data request queries. The technician's mere presence on site does not provide continuous assurance or notification that alarm levels will not be exceeded, because generally data are manually collected only at shift change or after a specific vibration causing activity, e.g. a blast or a driven pile. Remote capabilities can relieve the full time on-site instrumentation technician and facilitate instant notification to any number of parties should a construction activity result in a recorded event above threshold values. Routinely scheduled and automated uploads to a website (hourly, daily, etc…) serve as verification that the system remains active.

Construction progress information is critical for data validation and evaluation. A regular but not full-time field presence by the GIE or a representative remains necessary unless detailed and timely site activity progress reports are received from others. With the increase in remote off-site receipt of monitoring data and a lack of documented construction progress comes the risk that the GIE disconnects with site activity, the recorded data and its effects on adjacent structures. Monitoring data are often collected, reported and posted to a website or filed independently of construction progress information, such that no correlation is ever made between the two.

Role of Technicians

When developing instrumentation bids for performing monitoring work, the role of technicians is a significant consideration. Their pay rate can be as little as one third that of entry level engineers. Some tasks are appropriate for technicians with minimal training, including tracking inventories, equipment maintenance, assistance with installations (especially as a second or third crew member), routine readings and database tasks and manual downloads or site visits to troubleshoot. We favor instrumentation engineers maintaining monitoring program control including daily, weekly or less frequent data evaluation, as applicable. The industry benefits from such a protocol. Removing the instrumentation engineer from even the installation procedures can result in a loss of the necessary detail to understand the causes of the recorded deformations. Knowing the power to an instrument is not from a grounded reliable power supply, for instance, can explain data spikes. Instrumentation is cross discipline, civil, mechanical, electrical and information technology, signal processing. Pairing knowledge of construction activities and anticipated movements with how and whether the internal sensor corrections, structural thermal or tidal corrections were made can vary conclusions. This is not to say that technicians cannot be properly trained to perform many instrumentation tasks, but in practice the training is generally lacking, and most technicians do not possess the engineering or construction knowledge to facilitate learning independently on the job or foreseeing problems before they grow.

Lessons Learned

The award of instrumentation work based on the "bottom line" includes little consideration for quality, if any at all. Monitoring services cannot be separated from associated risks. Bottom line bids are met by lowering the experience level of assigned personnel, and/or reducing or eliminating data interpretation. Weekly data review coupled with real-time alarm notifications cost significantly less, is "greener" and does not necessarily result in increased risk over daily hard copy reporting that is often specified, independent of the labor category utilized. These are issues that the professional engineering community must address in the design stage prior to finalizing specifications and contract documents.

At a minimum, specifications must be project-specific and include an appropriate data interpretation scheme. The instrumentation engineers who have installed the instruments are best suited for data interpretation and evaluation. Receiving a facsimile of daily tilt measurements in Hertz, or load measurements in volts should not be acceptable. Ideally, the person collecting data should be familiar with installation of the instruments and should also plot, validate and provide a trend line of a meaningful duration, with annotations of relative localized construction progress. This allows for a reader unfamiliar with the project to review the data and understand what construction is ongoing and what structural response has occurred. Incomplete specifications lead to data submitted without installation records and often without adequate baseline data.

Instrumentation and monitoring services should preferably be performed directly for the owner, as it is the owner who has the most at stake. This is not a new concept (Dunnicliff and Powderham, 2001). Use of this method overcomes many of the problems outlined in this article,

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and also allows for the collection of adequate baseline data, for which there is generally insufficient time when the subcontractor procedure is used. However this would require a major industry shift. This recommendation is in opposition to providing the instrumentation services as a subcontractor to the general contractor, who generally views monitoring as a cost with little potential benefit.

Construction may be slowed or stopped when threshold values are exceeded. As such, general contractors often do not consider monitoring to be in their best interest. Without the changes recommended in this article, much raw data will pile up and be posted to websites or be filed in drawers un-interpreted, with no benefit beyond meeting specification requirements. Such a disservice to the instrumentation and monitoring profession increases risk and undermines the intent of monitoring. This propagates a status quo attitude throughout the U.S. construction industry that monitoring is expensive or wasteful, or a necessary insurance program to reduce the frequency of false claims.

The U.S. construction market is generally viewed as lagging behind Europe and Asia. In those continents it appears that improved communication or collaboration occurs among owners, designers, and construction contractors, who work towards a common goal of efficient construction at reduced or shared risk.

There exists widespread resistance or denial (in the New York market at least) that the hurdles outlined in this article are impossible to overcome because of a lack of understanding or involvement of public agencies, their bureaucratic tendency, or their inability or resistance to change from yesteryear. This cannot be an indefinite pretext and must be addressed with properly allocated funding and resources mainly during the design stage, but also throughout construction, to educate and convince authorities that there is a better way. Fostering instrumentation and monitoring are tasks for the professional engineering community who possess excellent communication and interpretive skills.

It is the role of professional geotechnical engineers to educate our clients and the civil engineering community on the importance of monitoring. Improving communication from the start of design through the end of construction facilitates an increased understanding of the need and benefit of instrumentation and monitoring programs to aid in building safe, expedient and cost effective projects.

References

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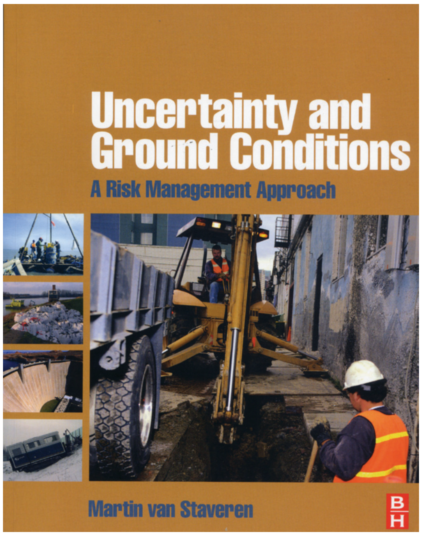
Review of Uncertainty and Ground Conditions - a Risk Management Approach

by Martin van Staveren



Reviewed by John Dunnicliff

We all know that ground-related uncertainty and risk often dominate in our construction projects. There is a growing acceptance among our geotechnical community that cost-effective management of risk is one of the keys to success. However, risk may often be assessed and managed in a haphazard way, but this book provides us with a guide to formalize a six-step procedure called "GeoQ" (the "Q" is for Quality) for gathering project iformation and for identifying, classifying, remediating and evaluating risk, and for mobilizing risk information.

Martin van Staveren is an engineering geologist, working for Deltares in The Netherlands. Deltares is a recent combination of three well-established Dutch companies: GeoDelft, Delft Hydraulics, TNO Soil and Groundwater, together with units of the Ministry of Public Works and Waste Management—all the stakeholders for flood management. About 50% of The Netherlands is below sea level, and protected by more than 10,000 miles of levees. Many areas, including major cities, are characterized by soft to very soft soil conditions with high groundwater tables, and there are abundant challenges for the geo-profession. The subject of risk is therefore predominant in the country, and had led to Deltares' leadership, from which we can all learn.

Martin's goal is clearly stated as:

I aim to create a much more positive image around the concepts of risk and risk management in general and ground-related risk management in particular. With this book I have tried to communicate the benefits of encountering risk and acting upon it in an effective way, rather than the conventional, very human impulse of risk aversion. My approach is to capture foreseeable risk within our zone of influence, or in the zones of influence of our project team, our client, our industry and our society. ... This book aims to give a contribution to this innovative approach and application of ground-related risk.

The book is divided into four Parts:

1. The context of ground risk and management in the construction industry
2. The people factor in ground risk management
3. The process factor in ground risk management
4. A look into the future

Parts 1 and 2, which occupy about half of the book, are identified as *conceptual thinking*, while Part 3 is identified as *practical application*. In Part 3 recommendations are given for application of the six GeoQ steps to each phase of a typical construction project, from the feasibility stage to the construction and maintenance phases. Each phase is discussed in its own chapter, so that there is a clear focus on the application of the GeoQ steps for each phase.

The book is written in the first person, and for me this gives it a liveliness that overcomes what could be a heavy subject. There are many boxed examples and anecdotes—again helping with readability.

If you're wondering how to approach the task of identifying risk, here's a quote from the book that should help you along the way. In the chapter on the application of GeoQ in the pre-design phase there's an introduction to the concept of the "Electronic Board Room (EBR)" for helping with risk identification and classification:

The Electronic Board Room (EBR) is an ICT-facilitated method for team-based risk brainstorming. It proves to be a fast and effective method for the identification and classification of project risks …

During an EBR session, 10 to 15 laptop computers are connected to a software package. Behind each computer one or two professionals identify risks, while they follow the results of the other EBR participants, real-time, on their screens. This may trigger them to identify other and new foreseeable risks, which is the brainstorming part of tile session …

Usually, the EBR system works anonymously, which means that the participants do not know who has identified which risk. This approach minimizes the unwanted group dynamics of conventional brainstorm sessions. You have probably also encountered those good-intended but rather loud and convincing voices who overrule the other participants and adversely dominate the brainstorm procedure.

You'll note the example of "liveliness" at the end of that quote. A later one is: *In construction, the proof of the pudding is in the eating*.

In summary, I'm delighted with the book as a source of well balanced practical information about risk management. It is published by Elsevier (www.books.elsevier.com), ISBN 0-7506-6958-6, and can be ordered on-line at http://www.elsevier.com/wps/find/bookdescription.cws_home/708477/description#description. The price is US$ 74.95. The author can be contacted at martin.vanstaveren@deltares.nl.