Introduction by John Dunnicliff, Editor

This is the 83rd episode of GIN.
Just one article this time.

Decommissioning and removal of instrumentation

The article by David Cook and Thijs Claus describes decommissioning and removal of instrumentation after 13 years of monitoring at a large tunneling project in the center of Amsterdam. This is a subject that I'd rarely thought about, despite helping with many monitoring specifications, and the article woke me up to the importance of including this in the planning process and in specifications.

International Courses on Geotechnical and Structural Monitoring in Italy

This year's course attracted 84 registrants from 23 different countries, together with more than 20 exhibitors. The little town in Tuscany again closed off the main street for our street party on the first evening, and as you'll see in this photo, our wines (red, white and spumante) had labels with the name of our course. How about that?

Vino rosso, bianco, spumante.

Planning for the next course in June 2016 is well underway, and we're looking for improvements and innovation. Some new speakers will be invited. To increase the interaction among us all, we plan to invite selected exhibitors to make brief presentations about new trends in contact and remote monitoring, and about data acquisition and management. We also plan to invite selected registrants to make brief presentations about case histories and lessons learned. For updates, see www.geotechnicalmonitoring.com.

After the 2015 course we had an exciting field trip to the Poggio Baldi landslide (*www.landslidemonitoring.com*), where ten companies made demonstrations of their equipment. We're exploring the possibility of another field trip combined with the 2016 course.

Rugby, tradition and pomp

The rugby world cup will be played here in England during September and October (*www.rugbyworldcup.com*). Yes, USA will be competing, but not Canada. New Zealand are the cup-holders - how many of you have watched the fabulous haka, a traditional ancestral war cry of the Māori people of New Zealand, which the national rugby team performs before international matches? If not, watch the beginning of the 2011 final on youtube. Search for "best haka ever". What a great way to establish fear in the minds of opponents!

As I write this, the cup trophy is on a tour of UK. Last week it was in Dartmoor National Park, where I live. So, being a rabid fan, I went to see, and as it turned out, also to touch. It arrived on a display table in the back of a Landrover! I didn't know anything about the formalities of the event, and I learned that the location was selected for a formal handover from the jurisdiction of one mayor to another, hence the tradition and pomp. In the photo, from the right: Mayor of Plymouth; Mayor of Exeter (love the regalia!); flunky with mace (who is obligated to accompany the mayor of Exeter on formal occasions – love the mace, the hat and the sunglasses – no sun was visible!); Chairman of local district council; no idea (but someone said that he was a security guard, responsible for preventing me from stealing the trophy).

Tradition, pomp and the Webb-Ellis trophy.

As a very Americanized Englishman (having lived across the pond for 30 years), I found all this fascinating and amusing. How about having a ceremony like this, or a haka, at the beginning of the World Series?

Closure

Please send an abstract of an article for GIN to *john@dunnicliff.eclipse.co.uk* —see the guidelines on www.geotechnicalnews.com/instrumentation_news.php

Gan bei! (dry the cup). China.

Lessons learned during removal of instrumentation after 13 years of monitoring at a large urban tunnelling project

David K Cook and Thijs Claus

Background

In Amsterdam, one of Europe's biggest settlement monitoring contracts, the monitoring of the Noord/Zuidlijn (North/Southline) Metro line, has ended. Installation commenced in 2000 and removal completed in 2013. Following completion of 3.8 km of twin-bore metro tunnels, three large cut and cover stations and construction under the historic Amsterdam Central Station, project-related settlement and consequent risks had passed. After a period of close-out monitoring, the instrumentation was decommissioned and removed. Figure 1 shows a typical robotic total station for monitoring any deformation of buildings during tunnelling beneath the roadway.

Third parties

Although most third-party stakeholders understood that the ongoing risk of settlement was low and that the financial cost of keeping an automated network of robotic total stations (RTS) and associated prisms was large, there

Figure 1. Typical RTS installation – (Photograph courtesy of SolData; all rights reserved).

were objections to removal of the system. These generally came from occupants of buildings adjacent to the cut and cover stations. After 13 years of continuous monitoring they were accustomed to the security provided by the system. This was especially so for the inhabitants adjacent to one station where a number of construction incidents had occurred that resulted in very severe localised settlements. In the initial stages of close-out monitoring removal of the systems was discussed with these groups. By addressing their concerns the stakeholders were then convinced the monitoring system was no longer required.

General - removal of a monitoring system

Removal was the final element of the contract awarded to Soldata-Grontmij JV (SG) (by Dienst Metro (DM), who procured the Metro line for the Municipality of Amsterdam (MoA) who had installed, maintained and operated the monitoring system. The main components to be removed were:

- 74 RTS including computers, support brackets, wiring and power boxes.
- Over 6000 prisms.
- Communication infrastructure, including Wi-Fi, 3G modems, brackets, wiring and aerials.
- Combined in-place inclinometer/extensometers, piezometers and associated infrastructure, such as access chambers; ducts, cabling, data loggers & instruments.
- Power supplies.

A number of these elements were to be removed from the exterior of historic buildings such as Amsterdam Central Station, Beurs van Berlage (the old stock exchange) and De Munt Toren. To ensure that there were no building damage issues or planning problems, the removal had to be undertaken in an agreed fashion. Guidance in the contract was that after removal the contractor was responsible for making good the underlying materials.

Given this requirement DM and SG agreed on a removal strategy dictated by:

- Duration: A shorter time span for removal was more cost-effective for SG. This required DM to streamline permissions from various departments within MoA, building occupants and other stakeholders and communicate those plans in a timely fashion to occupants and building owners.
- Quality: Fast tracking was permitted providing only that quality was not compromised. SG trialled a number of removal/making good methods to various materials before work commenced. The successful methods were implemented and a rigorously documented system put in place. Each element to be removed was photographed both before and after removal.

Removal of monitoring equipment

Robotic total stations and monitoring prisms

The main component was the support bracket removal. During removal a number of issues were encountered.

Accessibility: Not all prisms and instruments were located on readily accessible places. This meant that sometimes the trade-off was made to not maintain or remove certain prisms.

Making good: After removal holes (diameter 8 mm) remained. The contractor was obliged to making this good. DM specified a number of requirements for this filling:-

- Aesthetically pleasing, e.g. flush with surface and matching colours of surrounding material.
- Ability to fix to a number of substrata.
- Not sensitive to differences in temperature (i.e. low alpha coefficient).
- Life expectancy similar to the surrounding materials.

Generally the material to which RTS brackets and prisms were attached consisted of brick, (from relatively new to very old), mortar joints and natural stone. Two main filler types were considered:

- 2-part epoxy based mortars
- Cement based mortars

After careful consideration and trials of both materials, epoxy mortar was the preferred option. Both could fulfil the requirements, but the ability to fix to all sub-strata and the consistent aesthetic quality of the epoxy mortar dictated.

Fixing to substrata was more difficult with cement based mortars because of the time lag between making the mortar and filling the small hole. This time could be large due to the scattered holes over the facades of the building and the busy streets of Amsterdam; that led to multiple position changes for cherry picker access.

Furthermore, the materials have different permeability. Dry stone drew moisture from a standard cement based filling, rendering it useless. It was necessary to either pre-wet the stone or treat with a hydrophobic agent.

Only in very specific instances, such as Amsterdam Central Station, was a mortar-based filler used. In these instances the authenticity of filler material prevailed above other requirements. At Central Station the costs for removing a single prism and making good tripled compared to elsewhere on the project. This increase in cost was mainly driven by hiring specialised personal and ensure all batches of mortar matched the respective facades.

Subsurface equipment

Subsurface monitoring installations consisted of boreholes used for:

- Deep datums.
- Combined in-place inclinometer/ extensometers.
- Piezometers.
- Cable ducts and manholes.

22 deep datums, located beyond the North/Southline zone of influence were installed to allow rigorous level control during the construction works. These were of ongoing value to the MoA and incorporated within their existing networks. No removal was therefore required of these items.

Other subsurface monitoring equipment consisted of a number of boreholes (up to 80 metres deep) adjacent to either the station boxes or tunnels. A number of issues arose whilst removing them:

- It was not practicable to remove the entire depth of a borehole, so with agreement from MoA boreholes were only removed over the top 1 metre. This depth included all chambers, ducts, cabling and extensometer heads.
- In-place inclinometers within the boreholes needed to be removed before removal of the other borehole elements. This proved difficult in a number of cases because friction had built up between the wheels of the inclinometers and the casings. This was caused by a number of reasons such as soil, corrosion and borehole deterioration. Special care was taken to try and remove the inclinometer assemblies completely but this was not achieved in all cases. Some chains broke after too much force was applied. It was found that the main reasons were the age and deterioration of the boreholes and the inclinometer chains. If friction builds up over the large lengths of the chain, there is little chance of removing the chain without complete excavation. In a small number of cases the inclinometer chain broke and a number of sensors could not be removed. An environmental impact assessment was undertaken determined that the instruments could be left (providing they were sealed) in the borehole. This environmental impact assessment was undertaken by SG after instruction by DM. It was determined that no hazardous chemicals of toxic heavy metals were present in the inclinometers that could pollute the soil or groundwater.
- A borehole spanning multiple soil layers can causes leaks between the impermeable layers. Later this may become an issue if boreholes deteriorate further. The consequence could be unwanted flow of water between soil layers, the inability to lower the hydraulic head when needed and possible damage to infrastructure. To avoid these potential problems the boreholes were filled with activated calcium bentonite. This was poured into the borehole and expanded when in contact with water. This expansion process took approximately 40 minutes. Using volume checks between boreholes and expanding clay it was confirmed that a seal had been achieved.

Disposal of monitoring equipment

The equipment to be disposed fell into two categories, that with monetary value and that with only scrap value. Each batch for sale required offers from a minimum of three independent parties – this was a Municipality requirement to avoid fraudulent practices.

Robotic total stations (RTS)

The modern RTS were popular saleable items. These were sold to third parties in a number of batches. Some of the older instruments, which were no longer supported by the manufacturer, had no commercial value and donating these instruments to non-profit organisations such as schools or charities was examined, but proved not to be a viable option.

All sales were carefully documented to verify the traceability of the instruments. This was performed with the manufacturer. One key component of the successful sale was that the instruments have been fully maintained, on a regular basis, during their use in the project and full service histories were available.

Other monitoring equipment

Equipment with no monetary value was sent to recycling plants. Considerable effort by both SG and DM was expended on documenting each element of the monitoring system, such as location, how removed and eventual disposal method.

Lessons learned - designing a monitoring system with removal in mind

A system is usually designed to monitor specific entities or parts of structures. During installation consideration of final removals is generally not given any priority. Location of monitoring equipment is as important for removal as for maintenance purposes.

- Consider maintenance options for equipment. Does it need maintenance, and if yes at what frequency?
- Consider product life span, will it need to be replaced during the project lifetime?
- Consider equipment fixing to the substrate, does it need to be permanent?

Over the duration of the contract changes occurred in the urban environment and also in applicable safety legislation. Certain elements could not be removed in a similar fashion to that used for installation and additional measures were required.

Some elements could not be removed. For example, at locations such as back facades of buildings, where access could only be achieved with the help of the residents, not all residents were willing to assist. Prisms were installed in difficult to reach locations within very narrow streets (no cherry picker/scissor lift access possible). These were installed up to 13 years before their removal under less rigorous health and safety requirements. If a prism could not be removed using normal methods a risk assessment was performed to determine whether or not leaving the prisms in place could lead to a future liability. In a number of cases these consisted of prisms located above pavements (sidewalks) where a falling prism could potentially hurt pedestrians below. A number of special measures were undertaken to remove these prisms. These included use of certified abseilers who accessed from the top of a building.

Projects with a lifespan such as North/Southline (13 years) should consider that circumstances change. This does not mean every possible option should be considered, but budgets may be stretched in ways which could not have been foreseen at the time of contract award. At the time of installation it was anticipated that the monitoring would be in place for a period of approximately 6 years. In practice it was in place for over double that time.

It is customary to produce as-built drawings and for large monitoring projects these are important for programmed removal. A complex monitoring system with a large number of parts (in total the GIS accounted for 21,998 individual measuring points and the monitoring database consisted of 208 million readings) cannot be fully removed without proper documentation and this needs to be produced over the monitoring period.

David K Cook

Mott MacDonald
8-10 Sydenham Road
Croydon
CR0 2EE, England
Tel: +44-20 -8774-2554
E-mail: david.cook@mottmac.com

Thijs Claus
Witteveen + Bos
Hoogoorddreef 15
1101 BA Amsterdam
The Netherlands
Tel: +31 570 69 79 11
E-mail:
thijs.claus@witteveenbos.com