

Field monitoring challenges. Episode 1

Unforeseen piling details and damage to inclinometer casing

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Introduction

We have agreed with the editor of GIN to contribute a series of articles, titled *Field Monitoring Challenges*. In these articles we will describe situations where the recommended monitoring practices could not be performed, followed by the solutions to and consequences of these challenges. We present these from the perspective of a specialized monitoring contractor, believing that there is value in sharing our experiences and the lessons learned.

In an ideal world we all could execute perfect monitoring programs. We would be able to utilize a systematic approach to the planning and execution of each project. The process of systematically planning and executing a monitoring program is well understood and defined in texts such as *Geotechnical Instrumentation for Monitoring Field Performance* by John Dunnycliff.

However, real-world constraints force implementation of less than ideal monitoring programs. Practical constraints include short schedules, limited budgets, no easy access to areas, damage to equipment or instrumentation, lack of understanding of roles and responsibilities, unexpected changes, and conflicting priorities/goals/experience amongst project stakeholders.

In such cases we need to evaluate the situation and adapt the monitoring program in order to achieve its objective of providing vital information. We have to remember that the monitoring data is of importance for monitoring the performance of a design or structure, to verify assumptions and

mitigate risk, as well as the safety of all those involved in the construction.

Challenge 1 – Unforeseen piling details

At a high-rise condominium project in downtown Toronto, the monitoring plan included inclinometer casings attached to piles, and targets on the piles for monitoring movement of the shoring wall. These reflective targets are typically placed at the top of each pile for monitoring of horizontal and vertical movement of the shoring and are surveyed with an accuracy of ± 2 mm. A typical site can have 100 to 300 piles. While there is expected movement of the wall, neighbouring buildings and structures are not expected to experience movement. The plan also included precision targets using prisms or reflective targets that are placed on the structures, usually along the perimeter of the walls and in far fewer numbers than the targets on the piles, and are surveyed with an accuracy of ± 1 mm. In addition, five extensometers were installed in sensitive areas to measure horizontal wall movements and an array of electrolevels was placed along joints in the adjacent underground subway transit to monitor horizontal and vertical differential movements between tunnel segments.

Our typical installation detail for monitoring of shoring excavations involves attaching the inclinometer casings to the piles. The inclinometers were to be installed in eight locations and ranged from approximately 76 to 110 feet in length. However, due to their extreme depths, the piles for the shoring wall were not the typical wide flange I-beams used in local construction. Instead, two of the wide

flange beams were welded together along their length and a pipe pile was welded to the bottom to extend the overall lengths. Due to space, budget and schedule constraints switching to drilled inclinometers was not practicable, and we needed to work with the shoring contractor to achieve an atypical method of attaching the inclinometer casings.

An installation method was devised to run the casing along the outside of the double pile at the upper end. A long notch was cut out of the middle of the pile nearing the transition to the pipe pile at the bottom. The inclinometer would be slightly curved to run down into the notch and into the centre of the pipe pile below, shown in Figure 1.

To avoid excessive movement in the pipe pile section that would affect readings, centralizers were positioned along the length of the casing as seen



Figure 1. Lower section of pile with inclinometer casing transition to pipe pile.



Figure 2. Centralizers in pipe pile section.

in Figure 2. Figure 3 shows a custom-made base, consisting of a metal tube (which would contain the bottom of the inclinometer casing) welded to a flat plate, which was in turn welded to the edge of the bottom of the pipe pile to prevent any downward movement of the inclinometer casing.

With the successful installation of the inclinometer casing, readings proceeded as the shoring wall was installed and excavation progressed.

Challenge 2 – Damage to inclinometer casing

A problem arose when during the installation of a tieback, the drill rig hit an installed inclinometer casing. Fortunately, the site personnel contacted our staff to notify us of the situation. If the tieback installation

had continued, the inclinometer casing would have been filled with grout.

To salvage the inclinometer and the vital information it provided, staff developed a plan to thread a smaller diameter casing into the damaged casing. The annulus between the larger and smaller casing was grouted to prevent movement and anomalous readings. This remedy was successful and inclinometer readings were continued.

Lessons Learned

In this brief case history, the installation of the inclinometer casing was atypical and the execution was a challenge. There was also unforeseen damage to one of the inclinometer casings in the midst of construction and the monitoring program.

Lesson learned 1: Work with clients, owners and contractors that value the benefits obtained from the monitoring.

With respect to the unforeseen pile details, a good relationship with the shoring contractor (Anchor Shoring & Caissons Ltd) was vital in permitting a practicable solution to be achieved. Flexibility was essential to adapt to the challenge presented as we worked together with good communication towards a solution.

It is our experience that this type of challenge can be addressed when the

parties all understand the value of the monitoring. It is therefore important that those who do understand the value do all that they can to convince others.

Lesson learned 2: Have redundancy in the monitoring program.

When planning a monitoring program it is important to have back-up or build redundancy into the system. Inclinometers and targets on the piles utilize different methods to provide horizontal displacement data that can be correlated.

In this case, if the damaged inclinometer casing could not have been recovered, the targets on the piles were available as an alternative means of measuring movement of the shoring wall. In other instances, a string of targets on the piles have been added vertically to the face of the piles as a substitute for an inclinometer casing, although these alternatives would not provide data for sub- surface movements.

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Figure 3. Custom welded inclinometer base.