Instrumentation of a Graphite Zone in the #3 Shaft at Brunswick Mine

A. Turichshev, P. P. Andrieux & R. K. Brummer
Itasca Consulting Canada Inc, Sudbury, Ontario, Canada

P. Mercier & R. Harrisson
Xstrata Zinc – Brunswick Mine, Bathurst, New Brunswick, Canada

ABSTRACT: The #3 Shaft at Brunswick Mine, Bathurst, New Brunswick, Canada, intersects a soft graphite zone just below the 3400 Level. Ground movement within this zone causes the concrete liner of the shaft to be deflected towards the shaft's interior, affecting the steel framework of the conveyance. In some areas, the clearance between the cage and the liner has been reduced to less than 2 cm, which is a concern. An innovative surface-mounted extensometer was designed in 2008 to monitor potential movements of the shaft's liner. Four such novel extensometers were installed in the shaft for the surveillance of a particularly critical 3.0m by 5.5m area. This article describes the approach taken to instrument the shaft, the principle of the new extensometer, as well as the performance of the instrumentation following its installation.

1 INTRODUCTION

Xstrata Zinc's Brunswick Mine is an underground zinc mine situated near Bathurst, New Brunswick, in Atlantic Canada. The ore body was discovered in 1953, and the mine began production in 1964. It currently produces over 9,000 tonnes of ore per day.

The main shaft used for mine access is the #3 Shaft. It is a circular concrete-lined shaft with the inner diameter of 7.9m. It is 1,337m deep and is used for hoisting ore, personnel and equipment. The #3 Shaft is critical to the life of the mining operation.

The shaft intersects a soft graphite zone at a depth of approximately 1,050m below surface, just below the 3400 Level. Ground movements around the graphite zone cause the shaft's concrete liner to be displaced towards the shaft's interior. This, in turn, affects the steel framework inside the shaft, causing interference with the movement of the cage.

A particularly critical 3.0m by 5.5m area has been identified in the south wall of the shaft. This area encompasses a concrete wedge that is being pushed into the shaft by the material behind. The area had been rehabilitated in 2007, whereby the displaced concrete had to be chipped in places to ensure unobstructed movement of the cage. Additional support in the form of steel straps and Rockweb™ liner had also been installed (see Figure 1).

Following the rehabilitation work, the mine's Ground Control Department started looking into instrumenting the area. Itasca Consulting Canada, Inc. (Itasca Canada) was approached to assist with the task.

Figure 1. Steel straps and Rockweb spray-on liner installed to support the concrete wedge in the south wall of #3 Shaft.

2 APPROACH

2.1 *Challenges*

Several challenges were identified early in the project. As the shaft contains a number of moving conveyances, such as the cage and skips, instrumentation components in the shaft must not interfere with any of them. Any instrument installed in the shaft cannot cross the shaft's interior. Therefore, locations where a displacement instrument can be anchored in "stable" ground are somewhat limited. This, of course, depends on the type of instrument utilised.

It was also desired for the system to avoid the use of point-measurement-type devices, which are only capable of detecting movement at a single point. The instrumentation called for the use of a transducer capable of providing area coverage.

Finally, the installation of an instrument had to be fairly simple. The installation was to proceed from the top of the cage where space is limited. It was also undesirable to have the shaft tied by the installation process for prolonged periods of time.

2.2 *Surface-Mounted Extensometer*

Taking into account the restrictions posed by the situation, Itasca Canada developed a unique surface-mounted extensometer. This instrument consists of an aluminium enclosure housing a transducer and a cable that is designed to detect displacements. The transducer itself is a rotary linear potentiometer – it is connected to a movement-detecting cable that can be virtually of any length. Each transducer is individually calibrated. An assembled transducer is shown in Figure 2.

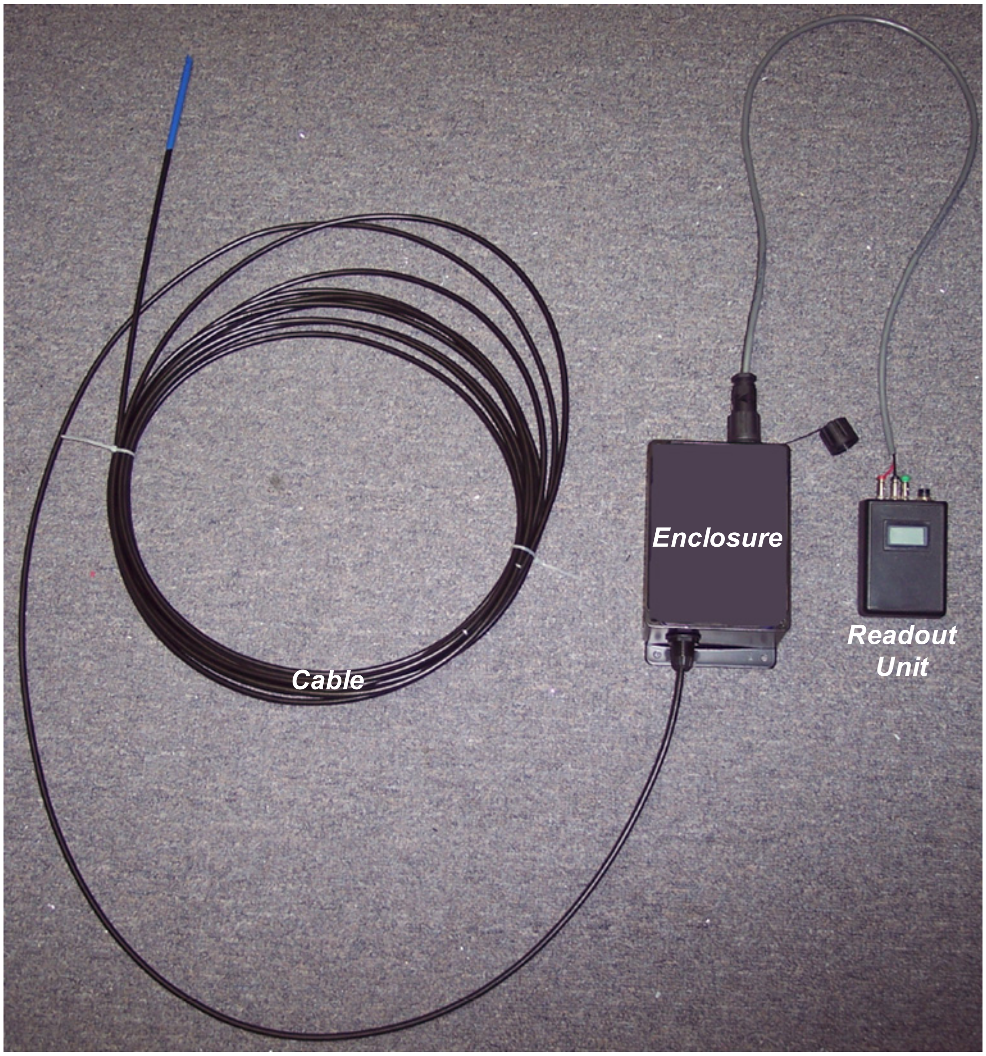

Figure 2. Photograph of an assembled transducer with a 12m-long cable and a readout unit.

The extensometer is designed to be attached to rock surface using concrete fasteners. The principle of operation is illustrated in Figure 3. The enclosure and the free end of the detection cable are attached outside the zone of potential movement. As movement occurs, the cable transmits movement to the transducer, which is used to quantify the amount of displacement. Note that the detection cable can be shotcreted over.

One of the advantages of this extensometer is in the fact that it can be simply attached to surfaces, with no borehole being required. Detection cables can potentially be hundreds of metres long, allowing to monitor significant areas. The instrument's main drawback is that it does not allow one to tell where the detected movement has occurred along the cable; only the magnitude of the total displacement can be obtained.

3 INSTRUMENTATION SYSTEM FOR BRUNSWICK MINE

The conceptual design of the instrumentation system for the monitoring of the #3 Shaft at Brunswick Mine is shown in Figure 4. The system was designed to have four surface-mounted extensometers, each fitted with a 12m-long detection cable. The four instruments were to be installed inside two 0.55m long by 0.35m wide by 0.10m deep trenches cut in the shaft's liner. The trenches allowed the transducer enclosures to be recessed in the liner, giving the necessary clearance for the cage's movement.

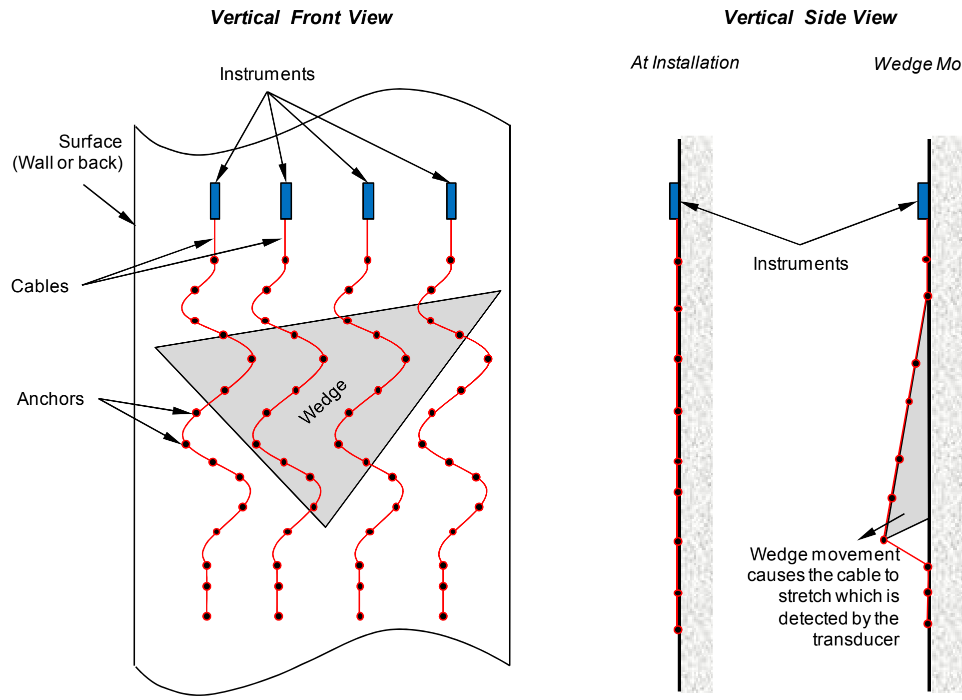

Figure 3. Sketch showing the principle of operation of the surface-mounted extensometer.

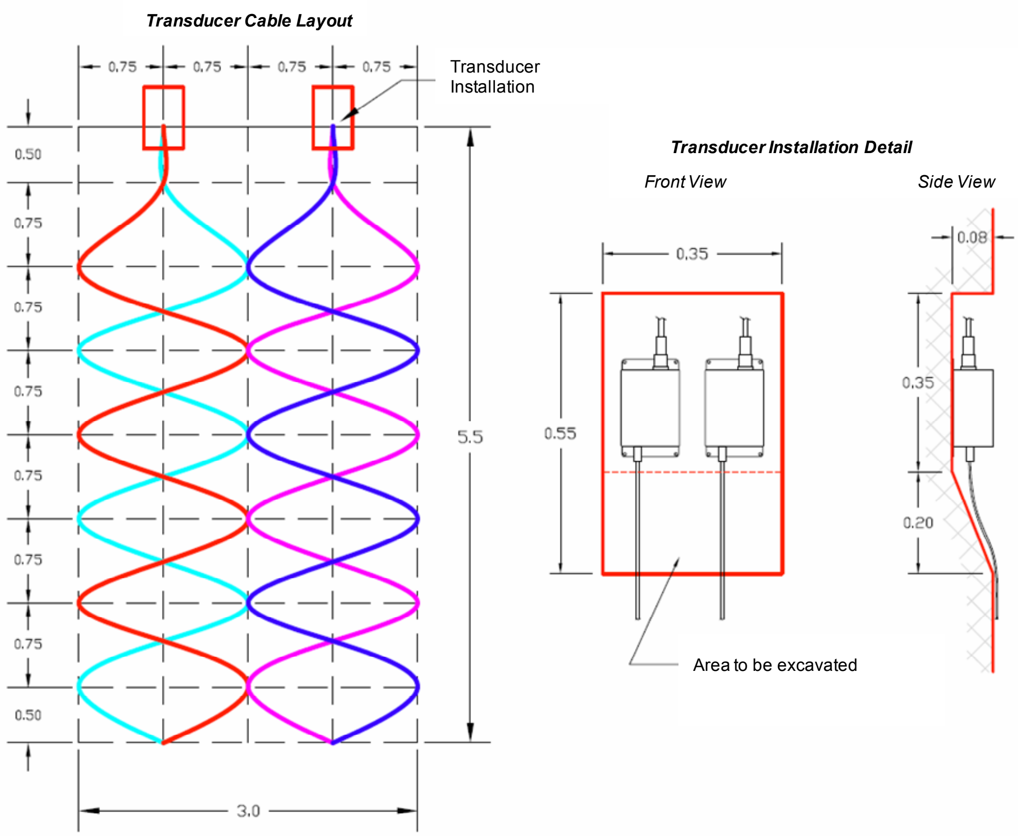

Figure 4. Schematics showing the details of the transducer installation on the wall of the #3 Shaft at Brunswick Mine.

The shaft instrumentation system was designed to be connected to the mine-wide PI instrumentation monitoring system. This system already provides real-time monitoring capabilities for various processes, and is set up such that mine personnel can access it at any time from any computer station at the mine. Incorporation of the shaft monitoring system into the PI system was, therefore, logical.

4 INSTALLATION

Four instruments were installed in the shaft in July 2008. As mentioned, two trenches had been cut in the concrete liner of the shaft prior to installation. The grid, identical to the one shown in Figure 4, was painted on the wall of the shaft. The installation of the four instruments took approximately 8 hours to complete by a team of two people. The galvanised anchors used to attach the detection cables to the liner of the shaft were spaced approximately 0.3m apart. These anchors were bolted to the liner using 5cm-long concrete fasteners. Figure 5 and Figure 6 show details of the instruments' installation.

Figure 5. Photograph showing the four surface-mounted extensometers installed in the #3 Shaft. Extensometer enclosures are recessed inside the shaft wall to allow for unobstructed movement of the cage.

5 PERFORMANCE

The instruments were connected to the mine-wide PI system shortly after their installation. The performance of the extensometers has since been closely monitored by the Ground Control Department. Figure 7 shows plots of the displacements recorded by the instruments during a period of 46 days following installation. The instruments are automatically read once per minute, which generates large amounts of data. The data are quite noisy and require some post-processing. To produce the plots shown in Figure 7, the data were first reduced to three readings per hour, by averaging the values read over 20 minute intervals. Then, the nine-reading moving averages (three hour window) of the reduced data set were plotted.

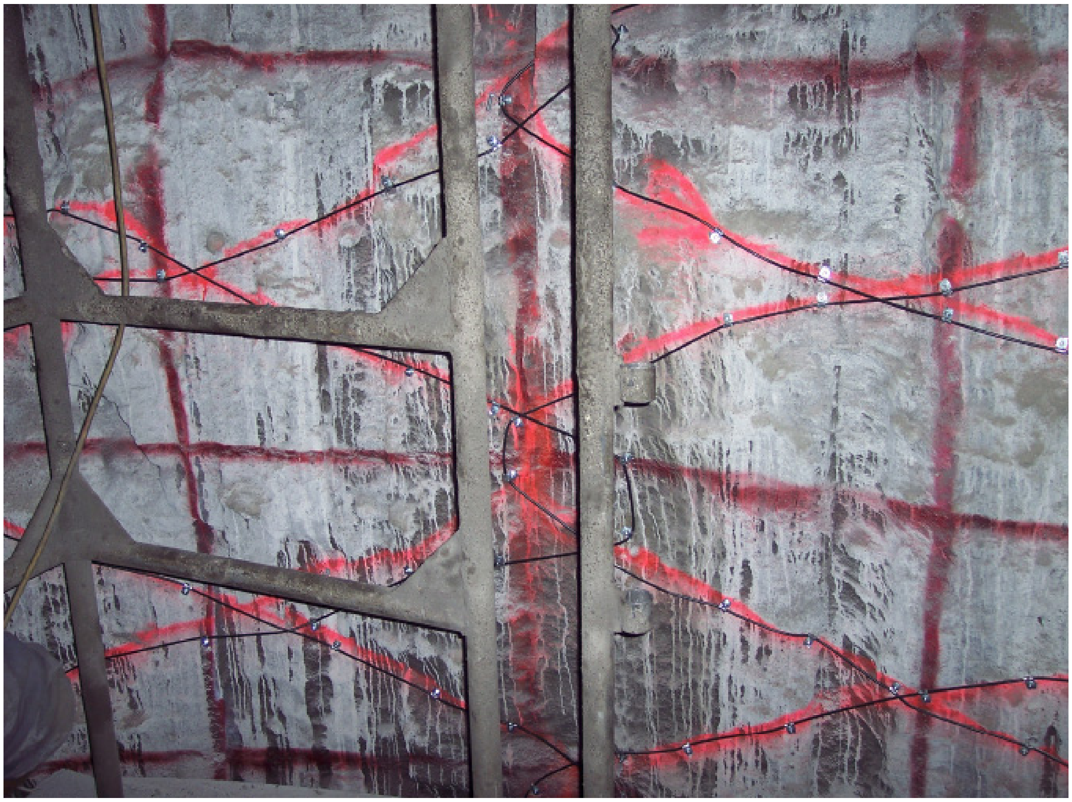

Figure 6. Photograph of the instrumented section of the shaft, showing the anchored detection cables.

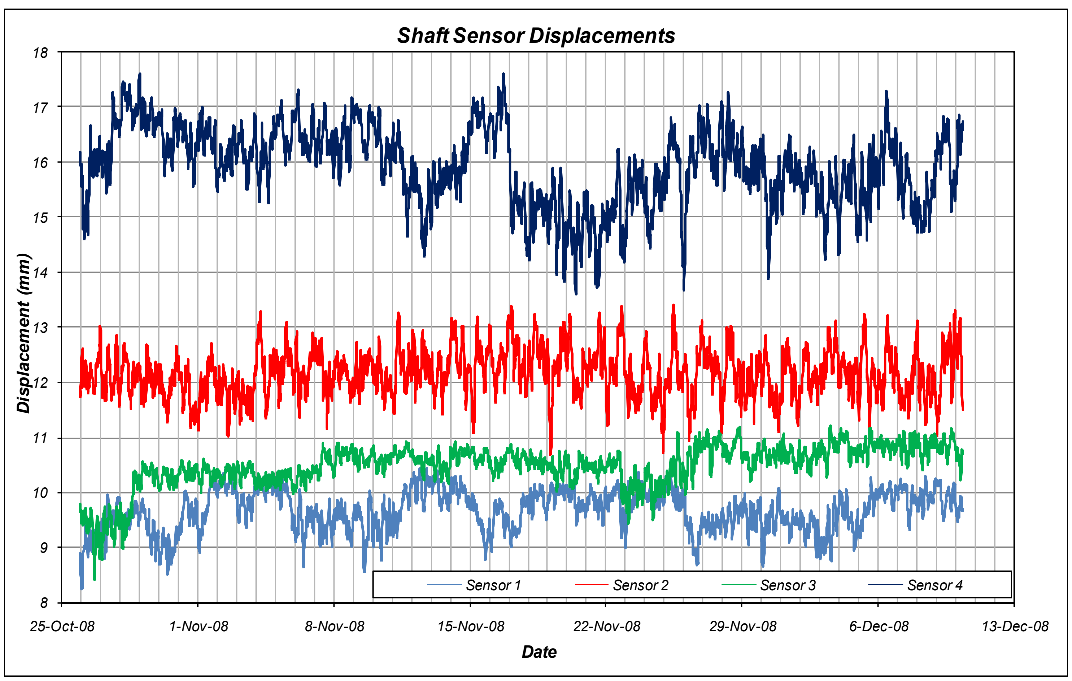

Figure 7. Displacement plots over a 46 day period.

The plots seem to indicate that the new instruments are performing well. From Figure 7, one can see that variations in the readings are in the order of 1-3 mm, which is approximately 0.5% to 1.0% of the instruments' movement range.

Variations in the readings can be attributed to several factors. The instability of the extensometer excitation voltage may be one of the reasons (changes in this voltage will directly cause changes in the readings). Another reason for the variation may be the movement of the conveyances inside the shaft. For example, as the cage travels up and down the shaft it causes air in the shaft to move as well. Air moving along the shaft wall where the instruments are installed is capable of exerting pressure onto the extensometer cables and deflecting them, thus causing slight variations in the readings.

6 CONCLUSIONS

Measuring displacement in shaft walls is not a trivial exercise. The usage of conventional transducers may be limited by conveyance movements inside the shaft and by the space and time required to carry-out the preparation and/or the installation of the transducers.

A novel surface-mounted extensometer has been developed for installation in the #3 Shaft at Brunswick Mine. The instrument is rugged and therefore well-suited for long-term mining applications. The detection cables can be made of any reasonable length. The installation of four such extensometers at Brunswick Mine has shown that they require minimal preparation prior to installation and are easy to install. All four instruments have so far been performing well.

At present, the authors see the primary use for this extensometer in monitoring displacements on surfaces, such as in underground openings (backs and walls), pillars, and shotcrete posts.

Note: Rockweb is a registered trademark of Spray-On Plastics, Ltd., Rockwood, Ontario, Canada.