edition:30 September 2014

ACARP MATTERS

LONGWALL MONITORING TECHNOLOGY TAKES ANOTHER STEP FORWARD IN PREDICTING GROUND CONDITIONS

Measurement and analysis of shield convergence and canopy tilt is now possible and has demonstrated significant improvements over standard pressure monitoring in understanding and predicting longwall ground conditions.

Wireless tilt monitor deployed at Austar

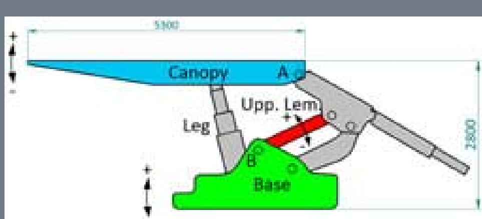


Diagram of support

All longwall mines in Australia now have shield leg pressure monitoring in real time to aid the identification, understanding and even in some cases prediction of roof control problems. Unfortunately when leg pressures reach yield (the most crucial time for assessing ground conditions), little information can be gained from monitoring leg pressures. This has become even more of an issue now that dedicated high set has become commonplace as shields spend very little time between set and yield and more time in yield. Convergence continues while the shields are in yield. The aim of this project was to obtain shield convergence and canopy tilt data from two sites in order to determine whether the addition of such data could significantly aid the understanding of how shields interact with the strata, assess stability and as a result, lead to improved strategies for predicting and preventing roof falls on longwall faces.

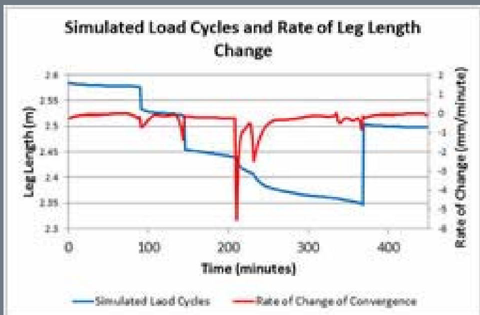
As part of this project, wireless, robust tilt sensors developed by CSIRO were installed at the Austar Mine on six shields to measure both convergence and canopy attitude. At the time of the project Narrabri mine had also installed commercial OEM tilt sensors (initially developed for the purpose of shearer/canopy collision avoidance and automation) on the full set of shields at Narrabri Mine, and three months of changes in shield height data were obtained from this site. Both of these systems have demonstrated that from tilt sensors located on the canopy, shield or lemniscate and base, shield convergence can be calculated.

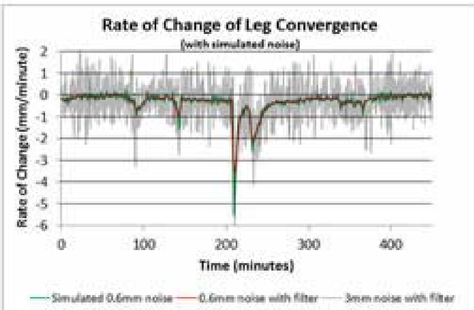
As part of the study the “resolution” of the data from the OEM and CSIRO sensors was determined. Resolution in this context is the minimum value that can be determined from “eyeballing” the signal and is defined as 4 times the root mean square (RMS) value, assuming normally distributed noise. An analysis of field data and the calculated convergence data from simulated load cycles for the CSIRO system concluded that the convergence resolution was 0.6 mm, indicating an inclinometer resolution of better than 0.02°. A similar analysis of the Narrabri system concluded a convergence resolution of 3.0-8.0 mm (depending on which pre-processed data set was used), which indicates a sensor resolution of about 0.1°.

For comparison, the resolution of the pressure sensors at Austar was determined. It was found that the pressure sensors had a resolution of about 2 Bar. For the Austar shields, a pressure change of 1 bar equates to a closure of 0.1mm in the pre-yield elastic range. This means that the pressure sensors have an equivalent closure resolution of about 0.2mm.

Preliminary evaluation of tilt data at Austar has indicated that a significantly greater understanding of how the shields are interacting with the strata can be obtained with a resolution of the tilt sensors that is equivalent or near equivalent to that of the pressure sensors. For example, it is not currently possible to determine measurements of pre-yield convergence, pre-yield convergence rate or the convergence and convergence rate of individual yield events from the collision avoidance sensors. This is in contrast to the pressure and pressure change rate equivalents from the leg pressure sensors due to their superior resolution.

The Longwall Visual Analysis (LVA) Program (currently in use by virtually all longwalls in Australia to display real time leg pressure monitoring) was extended to capture the shield height data from the Narrabri system. From this data the convergence was calculated for





individual load cycles and displayed in the trending along with leg pressures and shield height. The following load cycle maps were also produced for display:

- Shield height at the beginning of the cycle;
- Total convergence during the cycle;
- Average closure rate during the cycle;
- Cumulative convergence over 3 consecutive cycles.

Back-analysis was carried out for Narrabri and Austar using both the leg pressure, convergence and for Austar, canopy tilt data. These analyses demonstrated that a much greater understanding of support / strata interaction is possible through the combination of monitoring leg pressure and convergence, rather than monitoring leg pressure alone. As such, both the causes of roof control problems and their controls could be determined more accurately. The greater resolution of the CSIRO system enabled a significantly better understanding of load cycle behaviour, when compared to the Narrabri system. That is not to say that the current resolution of the Narrabri system results in no useful information, but that for ground control purposes an improved resolution appears much superior.

When supports reach the yield pressure (which they do routinely when high set pumps are enabled) it was demonstrated that the post-yield pressure signals give no indication of how the support is responding to the loading environment. This is in marked contrast to the post-yield convergence signals.

The main learning outcomes of this project are:

- Reliable convergence and tilt monitoring can be achieved and significantly increase our understanding of the causes of roof control problems on longwall faces;
- Canopy tilt can also be an important indicator of ground control problems;
- Resolution and accuracy of the sensors should be in line with the pressure sensors (better than 0.020 and 0.6mm equivalent convergence resolution) to maximise the ability to interpret and predict ground conditions;
- Sensors of this accuracy and resolution are available to OEMs off the shelf at prices insignificant to longwall costs;
- Collision avoidance sensors will determine convergence with a resolution estimated at 3-8mm which will measure large convergence incidents but will not be able to determine convergence rates during set to shield loading or allow determination of increasing trends in convergence rate development in the early stages of ground control problems.

ACARP Monitor Dan Payne, Manager of Geotechnical Services at BMA, said real time convergence monitoring on longwalls has been a vision of geotechnical engineers for 30 years and now with current technology has come to fruition. Convergence has been monitored in roadways for years. It is not just the logical next step for longwalls, but results in a massive improvement over leg pressure monitoring alone. This is due to its ability to continue to record critical data during yield, the ability to cross analyse with pressure data and the fact that the acquisition and display capabilities already exist across the industry for the pressure data anyway (Longwall Visual Analysis (LVA)). This project not only demonstrated the potential benefits but also went a long way toward understanding the optimum specifications. My belief is that this capability will become standard across all longwalls in Australia and each site will have convergence TARPs for their longwall. I also encourage industry to specify higher resolution tilt sensors from OEMs.

In an extension to the project, CSIRO sensors have been installed at Newlands North mine and will be re-installed at Austar. This extension intends on the development of the first ever near real time, longwall convergence TARPs.

ACARP
Australian Coal Industry's Research Program
PO Box 7148 Riverside Centre
Qld 4001 Australia

Phone 07 3229 7661
Email acarpmatters@acarp.com.au