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Paul Buddery
Anglo American

Clare Morton
Anglo American

Duncan Scott
Anglo American

Nathan Owen
NOME Services

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A CONTINUOUS ROOF AND FLOOR MONITORING SYSTEM FOR TAILGATE ROADWAYS

Paul Buddery [1], Claire Morton[2], Duncan Scott [3], Nathan Owen[4]

ABSTRACT: Moranbah North Mine has employed the use of Remote Reading Tell Tale Systems (RRTT Systems) since 2012 for the purposes of ensuring accurate, continuous and real time roof movement monitoring for critical infrastructure roadways.

Recently an integrated monitoring system was installed in the tailgate roadway of LW112 to monitor and record the continuous ground movement outbye of the retreating longwall face to better understand both the roof and floor movement. Vertical convergence of the tailgate roadway during longwall retreat is typically managed by installing both active support elements and standing support at Moranbah North Mine. The data has provided significant insights into the magnitude of both roof and floor movement outbye of the longwall which has enhanced the understanding of the required densities of standing support at various locations throughout the tailgate. The system has also demonstrated its potential to be used as a management tool, e.g. during extended face stoppages. Once installed, the monitoring system is entirely automated and the data is automatically collected and transferred to the surface via an optical fibre cable. The system and real-time communication are flexible and can be tailored to meet site specific monitoring needs.

The system includes: an RRTT System, real time convergence monitoring probes and a real time data acquisition, communication and reporting system.

The system enables Moranbah North to be able to measure total vertical roadway convergence and roof displacement continuously without having to access the tailgate at regular intervals. The combined data can be used to investigate: required standing support capacity and density; tailgate roadways ‘zones’ of increased vertical loading associated with intersections; the influence of strata and structural variation; and the optimum support strategy for ensuring roadway stability outbye of the longwall face. The analysis and results produced indicate that standing support densities appear to exceed the required support loads and with continued monitoring providing more data, it may prove possible to optimise support spacings.

INTRODUCTION

The Remote Reading Tell Tales (RRTT) System was initially introduced to Moranbah North Mine following a significant roof failure in the mines entry drift and has since been applied throughout the mine in outbye critical excavations and active production areas. Once installed, the monitoring system is entirely automated and the data is automatically collected and transferred to the surface via an optical fibre cable. Alarms are pre-set to defined triggers and alerts are sent out automatically if triggers are reached. The real time data can be accessed anywhere with available internet connections and log on details.

While historically data collection relied upon personnel conducting physical inspections of conditions or mechanical monitoring devices, the real time communication systems are designed to detect changes and provide notification of abnormal or unexpected roadway behaviour. Confirming alerts in real time can ensure action can be taken immediately and the TARP system can eventually be evolved and redesigned to move from a reactive approach to

1 Principal Geotechnical Engineer, Anglo American. Email: paul.buddery@angloamerican.com
2Geotechnical Engineer, Anglo American. Email: claire.morton@angloamerican.com
3 Geotechnical Engineer, Anglo American. Email: duncan.scott@angloamerican.com
4 Director, NOME Services, Email: nathan@nomeservices.com.au

a proactive management strategy. The system and real time communication systems are flexible and can be tailored to meet site specific monitoring needs.

Use of the RRTT System in Moranbah North's tailgate roadways has been introduced to provide benefits of reduced personnel exposure to tailgate roadway conditions, to verify support adequacy and provide potential opportunity for optimisation of support densities.

Tailgate roadway stability outbye and alongside the production face is critical to the safe, continued operation of longwall mining. Typically tailgate roadways present limited access to personnel due to respirable dust exposure, elevated gas during cutting and poor roof and rib conditions. The Remote Reading Tell Tales RRTT system are routinely installed in Moranbah North Mine tailgates in order to reduce the exposure time of personnel to carry out district inspections and read mechanical tell tales by providing continuous real time roof movement data which gives an insight into tailgate conditions outbye of the face.

In areas where the tailgate experiences elevated horizontal stress generated during retreat, this has the potential to adversely affect the behaviour of both the roof and floor. While roof movement is captured constantly, to determine the presence and magnitude of floor heave; requires physical observation. Recently an integrated monitoring system was installed in the tailgate roadway of LW112 to monitor and record the continuous ground movement outbye of the retreating longwall face to better understand both the roof and floor movement. With the introduction of real time convergence monitoring, Moranbah North is able to measure total vertical roadway convergence continuously without requiring personnel to access the tailgate at regular intervals.

REAL TIME MONITORING INSTRUMENTATION

The integrated roadway movement monitoring system consists of:

1) 2 - anchor Remote Reading Tell Tales,
2) Real Time Convergence Monitoring Probes (measuring total vertical roadway convergence)
3) Real time data acquisition, communication reporting and recording system

Remote reading Tell Tales (RRTT)

The RRTT system (Figure 1) is an approved Intrinsically Safe (IS) electronic Telltale system which allows real time measurement of roof displacement to a surface computer/anywhere in the world. Each anchor has a coil and ferrite core. Roof displacement causes the coil to move over the ferrite resulting in a change in the inductance which is converted to a displacement. The accuracy is ± 0.1mm. Although 2-anchor RRTTs are currently used, 4 anchor versions are available.

Real Time Convergence Monitoring Probes (RTCMP)

The RTCMP system (Figures 2 and 3) is an approved IS electronic convergence measuring system which, as with the RRTTs, allows real time measurement of vertical roadway convergence to a surface computer/anywhere in the world. They function in the same way as the RRTTs.

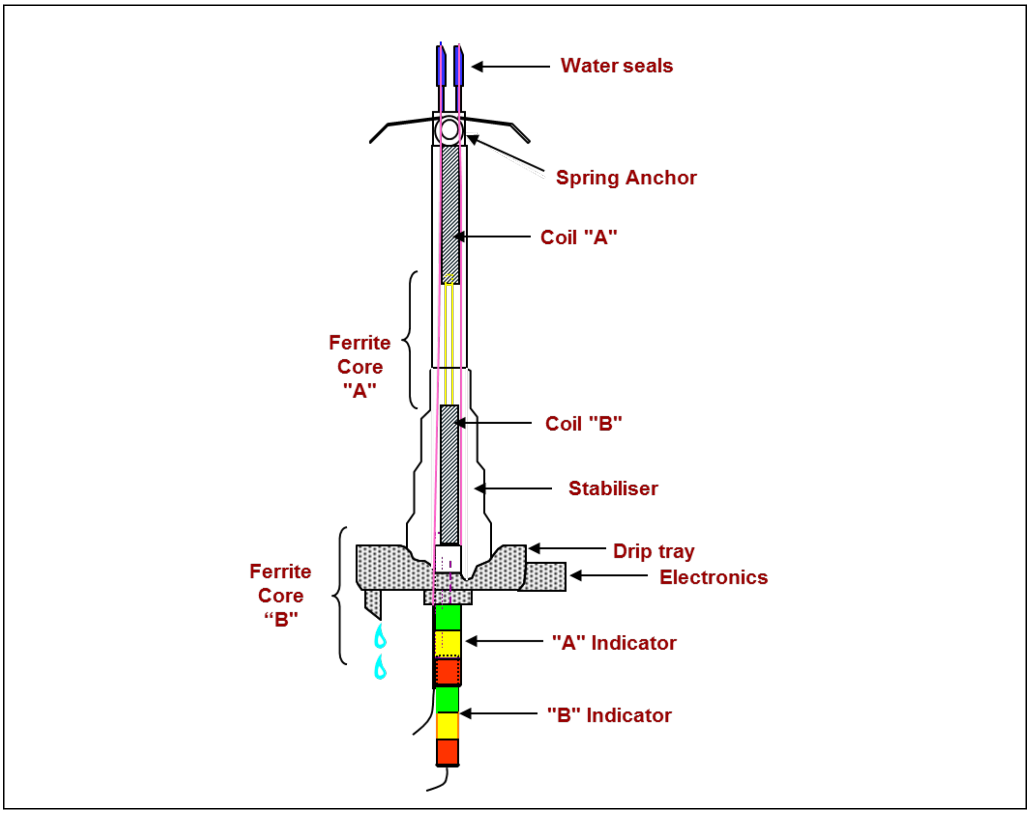


Figure 1: RRTT two-anchor schematic

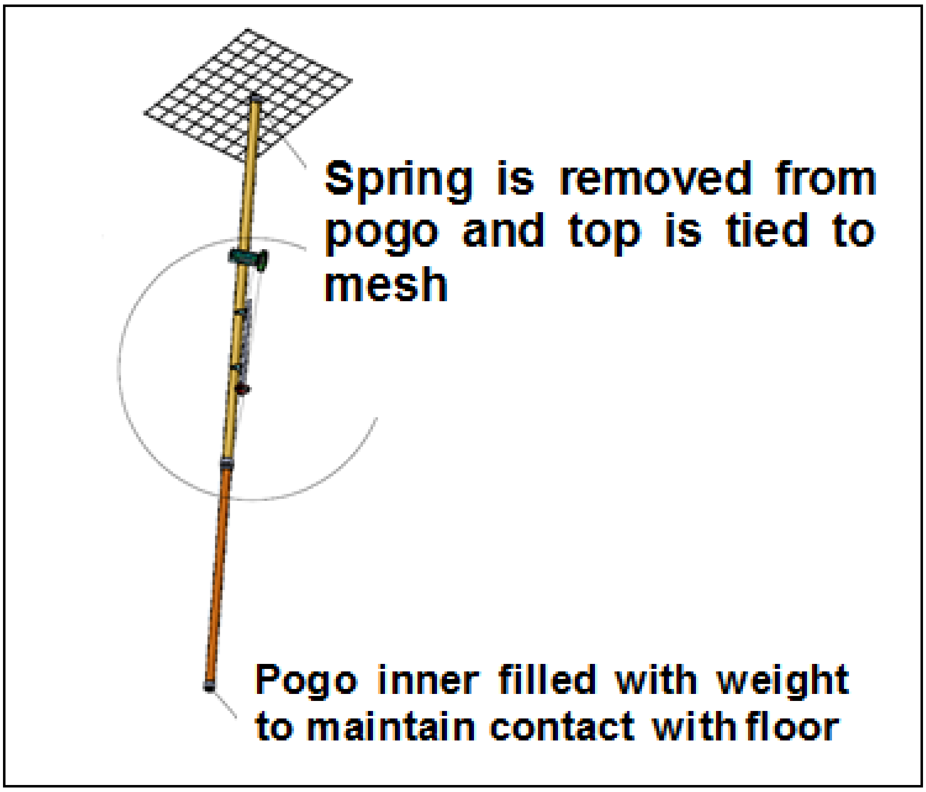


Figure 2: Real time convergence monitoring pogo schematic

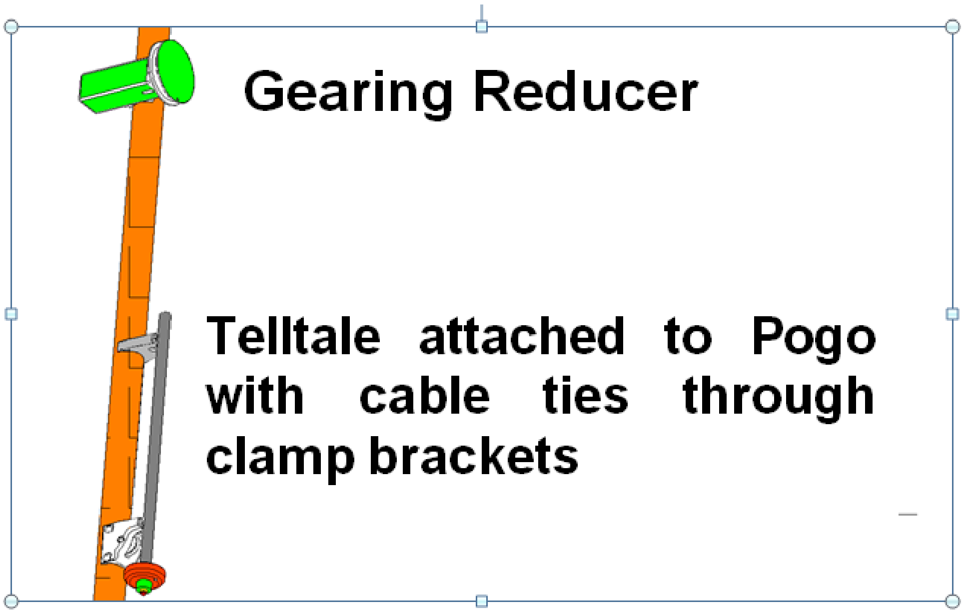


Figure 6: Zoom in on section B of Figure 2.

COMMUNICATION and INTEGRATION OF THE SYSTEM

The components of the monitoring system are integrated and communicate via the connections shown in Figure 4. The RRTT and RTCMP are installed in the gateroad and connected to an underground data logger which scans connected instruments continuously, recording data at 30 minute intervals and transferring these updates to the mine Ethernet via a Surface to Underground modem.

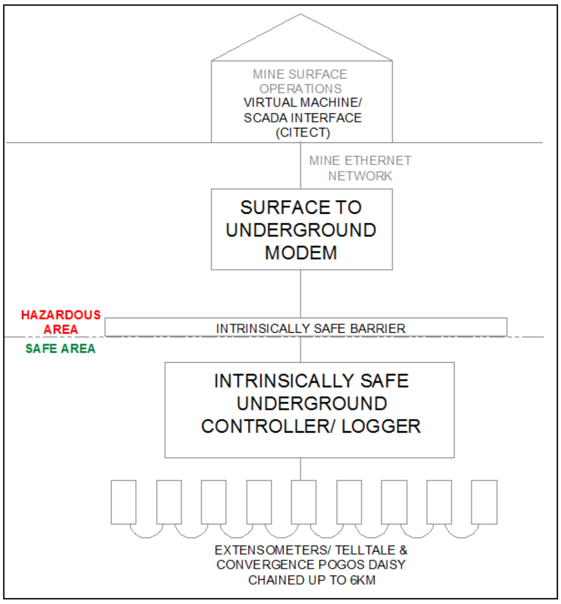


Figure 4: Integrated monitoring system schematic

HISTORY OF MONITORING TAILGATE ROADWAYS AT MORANBAH NORTH MINE

Moranbah North Mine has undertaken several significant monitoring campaigns in the tailgate roadways since 2012, in efforts to better understand the tailgate roof, floor and support behaviour in order to:

- Ensure support adequacy

- Consider potential support optimisation strategies
- Investigate roadway convergence events

Monitoring campaigns outside standard mechanical telltale and visual inspections were originally started in 2012 in TG109 and involved simple convergence monitoring of Link'n'Lock compression requiring regular physical inspections. Tape measures were secured to installed Link'n'Locks and one end fixed with a record marker nail installed at the other end (Figure 5). As the roadway experiences convergence, the free end of the tape measure would move past the record marker nail and the magnitude of this movement would be recorded by the observer during regular inspections. This movement value recorded in millimetres and then converted to a strain value which, based on laboratory data, could be used to give an estimate of the load on the Link'n'Lock.

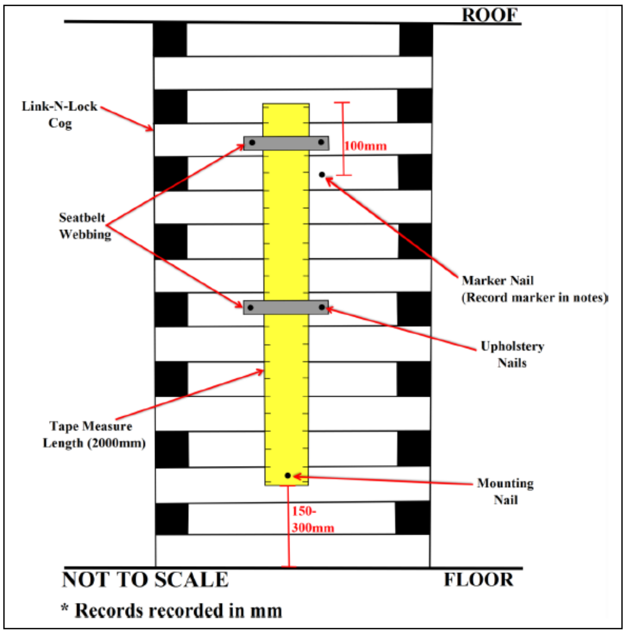


Figure 5: Arrangement for Link'n'Lock strain measurements in TG109

The original spacing of the Link'n'Locks was 3 m centre to centre in headings and 2 m centre to centre across intersections. This was opened up first in headings to 4.5 m centre to centre and subsequently across all intersections. An increase in strain at the face of the order of 0.005 was recorded as a result of increasing the spacing, i.e. headings from about 0.014 to 0.019 and intersections from about 0.019 to 0.024. The maximum recorded strain value (0.024) suggesting a total load at the face of no more than about 150 tonne and the difference of 0.005 represented an increase in load of no more than 30 tonne. The study provided sufficient information to carry out a section of retreat successfully, without the use of routine standing support installed. On the basis of this initial monitoring trial, further work was done on alternative secondary support designs LW601 and LW204 without the routine use of standing support, but with increased tendon support. As part of the ongoing monitoring strategy, simple convergence pogos were used to measure roadway convergence where standing support was not installed and therefore unable to be measured. Figure 6 shows strain data from the Link'n'Locks in LW109 and convergence pogos in LW601 and LW204. It can be seen that there was significantly less convergence in the latter two LWs although it should be noted that they were shallower than LW109, about 60 m in the case of LW601 relative to LW109. This strategy was employed for mining of the subsequent longwalls 110, 602, 111 and the current longwall block, 112 (Figure 7).

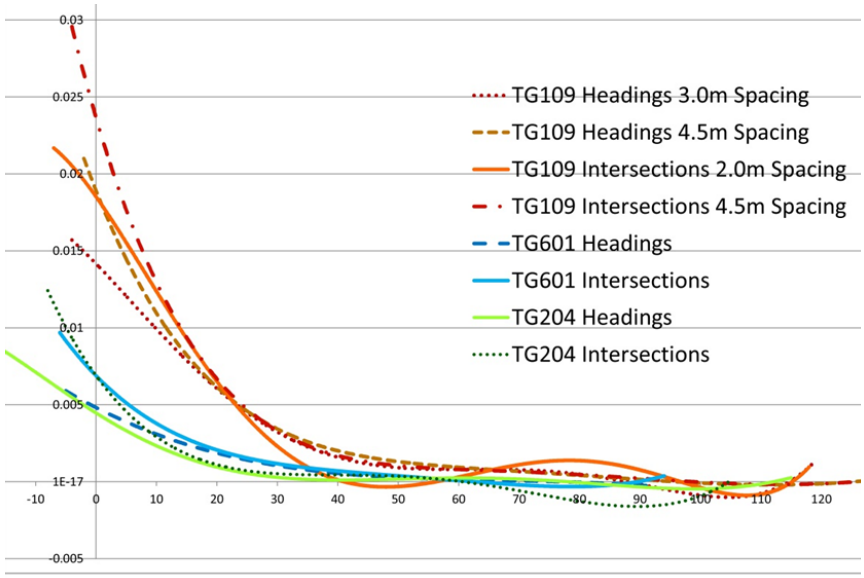


Figure 6: Comparison of Link'n'Lock compression in headings at 3.0m and 4.5m spacing

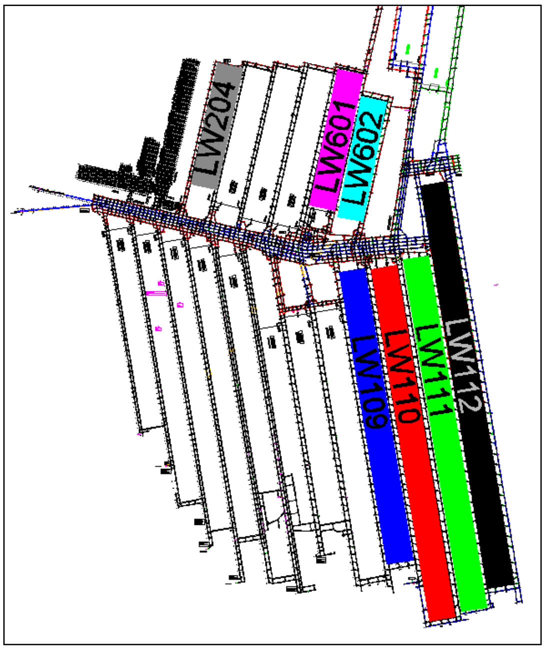


Figure 7: Moranbah North mine longwall block locations

THE USE OF REAL TIME MONITORING FOR TAILGATES AT MORANBAH NORTH MINE

Initially, the geotechnical information collected for the tailgate standings support study came from mechanical Tell Tales and roadway inspections and observation. However, the significant investment of personnel resources and the requirement for regular access to the tailgate to gather data such as this prompted the extensive use of a continuous and remotely accessible monitoring system. The introduction of the RRTT System in tailgate roadways commenced as a restricted trial in the tailgate roadway of LW601, which was mined directly following LW109. The trial had several objectives including: proving the viability of the RRTT system; reducing the requirement for personnel to access the tailgate roadway, thus reducing the amount of exposure to adverse environmental conditions; facilitating continued production due to reduced downtime to allow tailgate access for personnel and providing the real time data to help to make decisions on production activites that could potentially impact tailgate serviceability, e.g. the viability of planned stoppages.

LW601 proved to be a successful trial of the viability of the RRTT with the expected benefits listed above being realised. The monitoring information can be observed at the MG Drive by longwall personnel as well as on the surface in real time, providing for transparency for decision making.

The installation of RRTT has become an integral part of tailgate monitoring at Moranbah North Mine. An example of the data which is gathered and made available is presented in Figure 8.

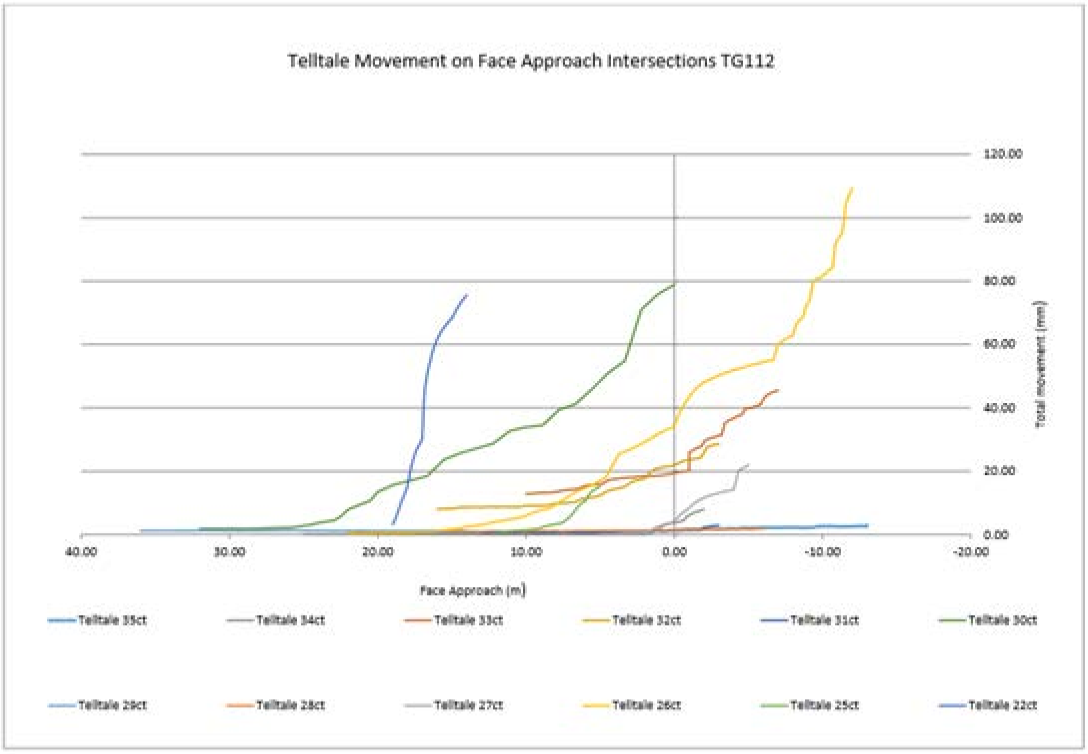


Figure 8: Comparison of Telltale movement for intersections of TG112

OPERATIONAL USE OF MONITORING RESULTS

The details below provide an example of how the real time data can be used to assist operational decisions:

- 13th of October, a 2 anchor RRTT at 22ct (Figures 9 and 10) alerted of significant roof movement in the intersection. Triggering a rate of movement Trigger Action Response Plan (TARP) on the 8 m roof anchor.
- From the continuous monitoring at Moranbah North mine it was possible to track the rate of movement and complete a comparison against recent movement in inbye cut throughs. Movement rates indicated anomalous and early roof movement in relation to the longwall face position.
- The movement curve was similar only to increased roadway spans such as 4-way intersections, e.g. 25ct monitoring data which recorded early and higher rates of movement due to being a 4-way intersection.
- This early indication which was triggered at only 2.4 mm of movement, gave an opportunity for remote monitoring of the movement rates in real time so that decisions could be made over access to the tailgate by personnel and continuing operations to mitigate the impact of increased rates of roof movement.
- Rates of movement resulted in a goaf overrun for 9 m which was able to be predicted prior to occurring and the impact mitigated.

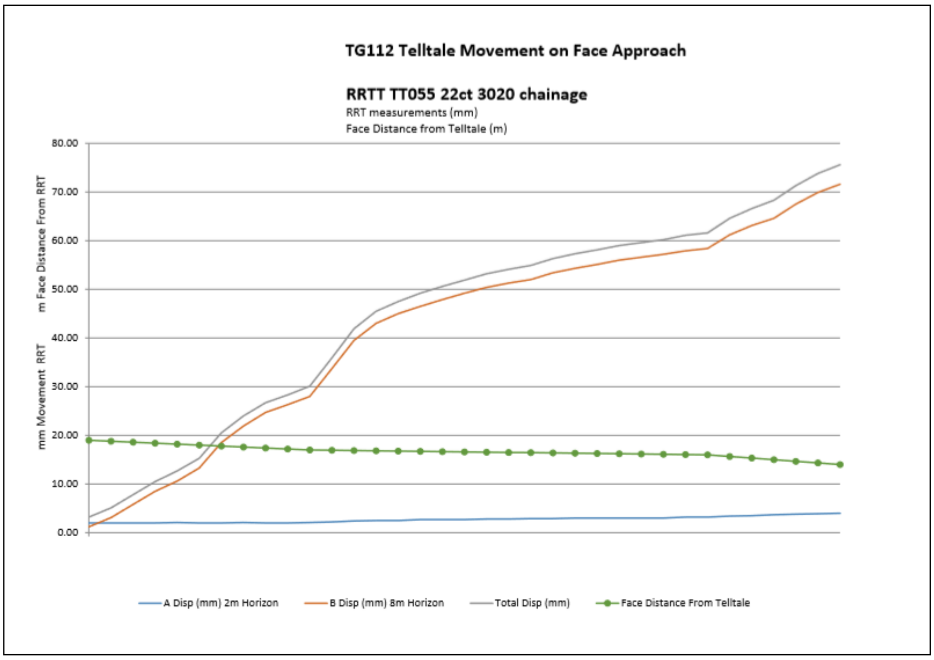


Figure 9: RRTT Movement on Face Approaching 22 ct

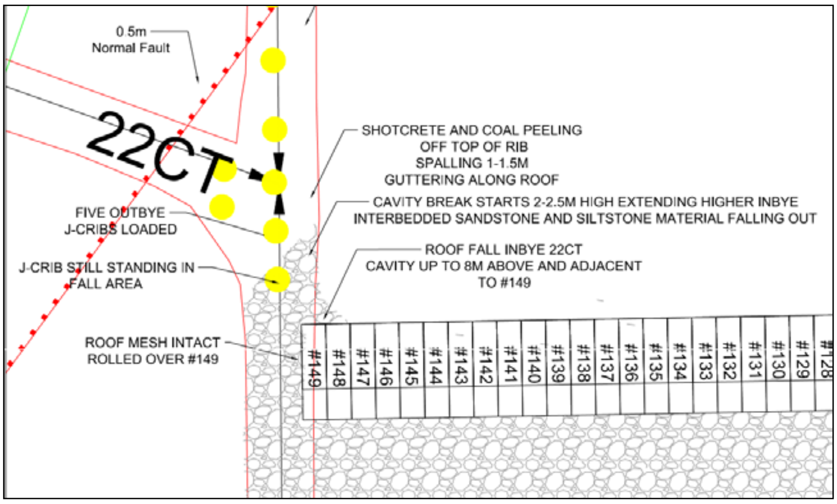


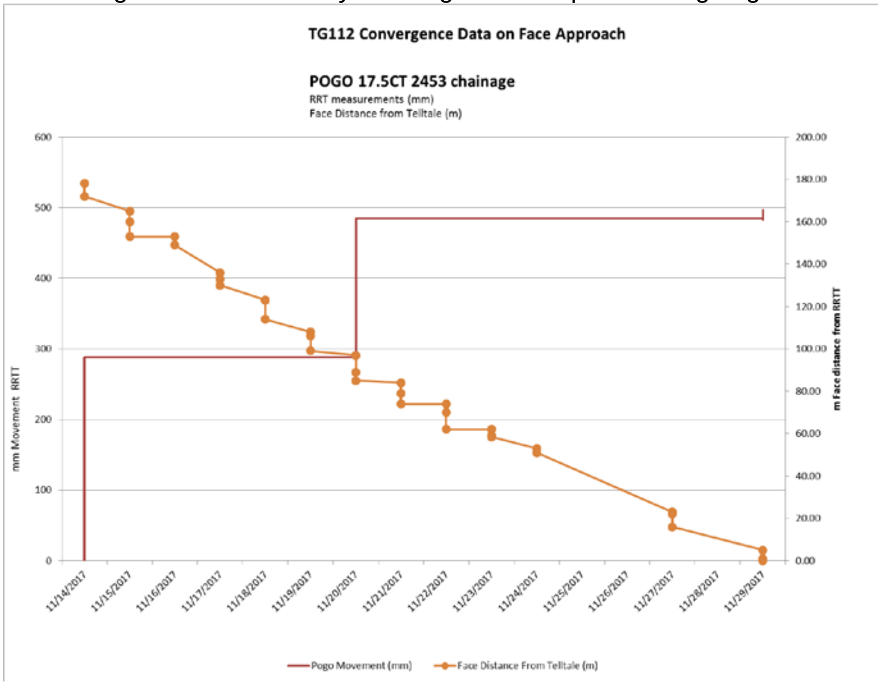
Figure 10: Drawn representation of 22ct goaf overrun which occurred following 8m anchor exceeding 75 mm movement

INTEGRATED MONITORING DATA

During retreat of the later 100 series panels, significant levels of floor heave accompanied by loss of rib-side stability have been experienced, on some occasions resulting in roof fall. As a result, RTCMP were installed concurrent with RRTT in order to determine the magnitude of floor heave resulting in roadway instability. Data from RTCMP installed at 17.5ct and 17.25ct (Figure 11) correlate to earlier convergence data that indicates that the highest levels of roadway convergence occur approaching intersections where higher stress loading is present. Floor movement is occurring further outbye of the face than roof movement alone when comparing RRTT and RTCMP data.

FUTURE PLANS FOR CONTINUED MONITORING

While in its infancy, the integrated monitoring system engaged in TG112 has provided beneficial, useable and relevant data in a short period of time. Due to the nature of the system – delivering data in real time and continuously, it has also offered the opportunity to observe the absolute magnitudes of roadway convergence and provide ongoing movement



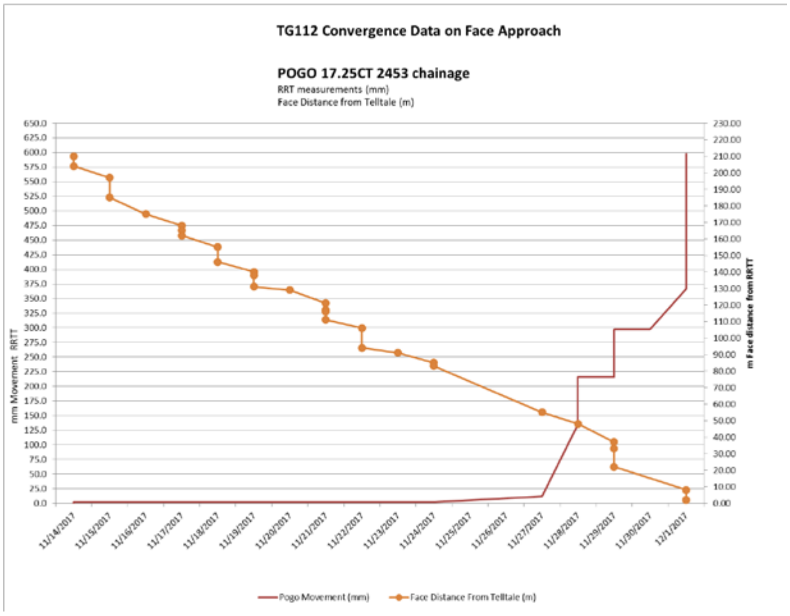


Figure 11: RTCMP data from TG112

feedback so that time critical decisions can be made around personnel access to the tailgate, planning of maintenance or retreat strategies. The system has the potential to increase understanding of the critical geological and geotechnical conditions that impact on tailgate roadway serviceability and provide alerts in real time for proactive strata control management. Some critical parameters that are yet to be quantified to continue to improve control of tailgate roadways to ensure continued serviceability and minimal production impact are:

- Understanding the magnitude of floor heave occurring due to the presence of weak floor strata associated with lower seams coming in closer proximity to the Goonyella Middle Seam.

- Further understanding of the high strain zones identified above the working seam or near to the face. Information such as this could assist in better developing hazard zoning for the purposes of support design and refining scheduling for longwall retreat.
- Early and rapid warning of deteriorating conditions – particularly around tailgate intersections or when an excessive roof span develops between the tailgate chain pillar rib and the last longwall powered support.

SUMMARY and CONCLUSIONS

The evolution of roadway monitoring at Moranbah North Mine has provided many interesting results. The development of reliable real time monitoring systems has successfully monitored roadway stability and provides valuable data for ongoing support design while keeping people out of harm's way.

ACKNOWLEDGMENTS

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