Experience and Accuracy Key to Working Under Unstable Slopes

Tim Cartledge — August 24, 2020

Anyone with current or past experience in the coal mining industry knows that one of the major principal hazards is uncontrolled ground movement, particularly slope failures in open cut mines.

From a geotechnical engineering perspective, operating under unstable slopes can be done safely, as long as the risk profile of an unexpected collapse is clearly understood and controls are put in place to mitigate any unwanted consequences.

It is from this perspective that the problem of unstable slopes be addressed during extraction and safety planning for a site.

Thankfully, we have come a long way from the days when miners used very rudimentary methods such as visual observation or tell-tales, basically the measurement of the change-in-distance between two pegs hammered into the ground.

These days, slope stability monitoring using radar or LiDAR technology is common practise in open cut mines. This monitoring equipment provides pseudo-real time monitoring of slope deformation, allowing us to operate under unstable slopes by observing changes in the slope stability condition and response-behaviour to mining processes.

To operate under unstable slopes, you must first understand the mode of failure mechanisms controlling slope movement, which is usually controlled by geological structures. These geological structures can be interaction of faults, geological boundaries, poor rock mass conditions etc.

For mine sites to provide the minimal imposts to production, every site should have failure database with back-analyses of previous failures to allow the setting of optimal deformation alarm thresholds and expected deformation velocities prior to failure.

In accordance with each site's risk profile, this information can be used to estimate a nominal time prior to slope failure when production below the unstable zone must cease.

Additionally, methods exist to provide approximate forward predictions of slope failure times, such as the inverse velocity method, which calculates slope velocity and projects it forward using linear regression to predict a time range in which slope failure may occur.

The combination of historical data and predictive methods allows mines to operate under unstable slopes with a degree of confidence, to optimise reserve recovery and safe mining practices.

However, to reduce the impact on the mining schedule, a plan needs to be implemented to manage access to mining stock and reduce downtime.

By mining within the zone of influence of the slope failure (exclusion zone) first, and then retreating to mine areas outside that zone when evacuation alarms are triggered, mine operators can reduce the impact to their mining schedule and maximise tonnage in complex mining conditions.

The team at Cartledge Mining and Geotechnics is highly experienced with slope stability monitoring technologies currently available in the industry

Many of our clients have complex ground conditions and encounter unstable slopes in varying conditions, so accuracy is the key to productivity and safety.

A good example of this was when we recently monitored a slope at Millenium Mine, where a slope failure occurred within 30 minutes of our predicted time, allowing operations to recover the coal and safely exit the area prior to slope collapse.

This operation was so textbook that it was presented as a case study at an industry safety conference.

In my personal experiences working with both highwall and low wall instabilities, I have managed to predict slope failures with some considerable accuracy. In one particular case, such predictions allowed the mine to recover all the coal before the walls collapsed to within a 10 metre gap between the walls.

In subsequent strips, I developed an innovative mining plan that required non-sequential mining of the coal blocks to maintain stability of both the highwall and lowwall.

In an adjacent pit we encountered an intersection of two faults that we were unable to mitigate using conventional methods (e.g. softwall, strip re-alignment, slope flattening etc) so we had to manage the instability in successive strips.

We improved our plan each strip to reduce the impact the instability had on the mine schedule by developing a mining sequence that allowed mineable areas to be accessible as the slope was destabilising, reducing the impact to mine schedule.

We achieved this by mining under the unstable area first and maintaining mineable areas outside of the line-of-fire. This allowed mining to continue with monitoring and evacuated when deformation threshold alarms were triggered.

Open cut coal mining can be hazardous if hazards are not effectively mitigated, but due technical expertise and experience, we can now effectively mitigate those hazards and make the mining process safer.