Geotechnical Aspects Of Longwall Mining At Dartbrook

Rod Doyle
Geotechnical Engineer
Dartbrook Coal
PO Box 517
Muswellbrook NSW 2333

Abstract

The most significant geotechnical aspect of the operations at Dartbrook Mine is its thick seam mining environment. The thick seam has created some unique geotechnical issues that are currently being addressed including, rib instability, face slabbng and high chock leg pressures. The mining section ranges from 4.0 to 4.5m and averages 11% ash in-situ. This section is enveloped by coal above and below combining to give a 24m thick "megaseam". Dartbrook Mine produced 2.3Mt of thermal coal in its first year of longwall production.

Key Words: Thick seam mining, stress, pillars, extensometers.

Introduction

Dartbrook Mine is located in the Upper Hunter Valley some 140kms by rail from the port of Newcastle, New South Wales. It is a Joint Venture operation managed by Shell Coal Pty Ltd. Figure 1 shows the location of Dartbrook Mine, which operates in the Muswellbrook and Scone Shires in the Upper Hunter Region of New South Wales. Geologically, it is on the northern margin of the Sydney Basin.

In the longwall area three seams coalesce to form the “mega-seam”, stratigraphically they are the Broonie, Bayswater and the Upper Wynn seam. All seams average about 8m in thickness, the top half of the Wynn seam is the working section. The mining seam section, the Upper Wynn A seam, is contained within the Wittingham Coal Measures and is Permian in age. Figure 3 shows the “mega-seam” and the coal thickness together with the mining section.

The major geotechnical issues associated with Dartbrook’s longwall include, face slabbng, rib instability and pillar behaviour. Slabbing associated with strong jointing and high longwall face loading is experienced, while in contrast roof conditions are experienced to date have been superb. Rib conditions are generally superb on development and deteriorate with exposure to the abutments from the goaf.
Mine Layout - Longwall 1.

Dartbrook Mine has a north-south longwall layout, with development mains in an easterly direction. Two main entries also act as intakes to provide the mine with the high degree of ventilation required to ventilate the mine, some 350 m³/sec. A ventilation shaft with three fans removes all the return air from the mine. Figure 2 shows the mine layout.

Figure 2. Mine Plan – Longwall Layout.

Longwall 1 was 1924 m in length in the maingate with a lead of some 8 m from the tailgate. A monocline on the installation face reached grades of 1 in 5 over 100 m. This was due in part to faulting and igneous intrusions immediately to the east of the longwall area. The gradient required some special requirements including cementing the floor in this area to ensure that machinery would be placed without incident. In general the mine operates with 1 in 10 grades, with some areas being steeper locally.
With the thick seam mining section, pillar design has also been challenging. Pillar design incorporates 30 and 35m chain pillars (centres), some monitoring has been undertaken in conjunction with extensometry.

Secondary support is used extensively throughout the extraction process. Fibrecrete blocks were originally used to create masonry chocks, designed specifically to ensure seal security. These were later replaced by timber chocks and subsequently “The Can”, a cementitious filled steel pipe.

Other issues of interest include computer modelling which has been utilised throughout mine planning and operations. Extensive underground mapping has been undertaken together with definition of the stress field. Gate road behaviour during development and extraction, highlights the level and orientation of the predominant vertical stress.
Geotechnical Work Undertaken

Because of the size of the longwall equipment and the seam section to be mined the longwall face also needed to be wide. The face was driven in two passes and was an average of 8.5m in width and 9.5m where the shearer was to be installed.

Computer modelling of the seam conditions was undertaken prior to drivage and predicted levels of sag up to 60mm. A conservative approach was recommended that the chocks should be installed during the widening out sequence of the face line.

A strata management team discussed the recommendations and took into account behaviour of the seam in all parts of the mine. Despite the known geological difficulties and some poor rib conditions in places alternate arrangements were made.

Support used included, W-straps at 1m centres with six 2.4m fully grouted AX bolts installed on the first pass and on the second pass the same level of support with an overlap in the central section of the double pass. A 2m square pattern for 6m long flexibolts was utilised in the main and tailgate intersections.

Monitoring of the roadway required the placement of 11, 7.2m sonic extensometers spaced at 20m along the centre of the face heading. These extensometers were installed during the first pass of the face, from the continuous miner, prior to the widening out by the second pass to maximise the data capture. The extensometers were monitored on a regular basis and a representative result is shown in Figure 4.

The significant feature about this result was that the roof initially showed downward movement and then an accelerated sag, during the widening out sequence and with time was followed by a distinct upward rebound. This upward movement although minor is consistent with the roof actually expanding as a response to the reduced in-situ stress, due to the reduction of both gas and water pressure by the intensive gas drainage programme. (Pers. comm. Winton Gale).

Figure 3. Stratigraphy highlighting the Mega-seam.
With the effect of gas and water considered the original computer modelling was re-run with these features taken into consideration and the resultant sag was significantly reduced. This complimented the actual observations and measurements made. Figure 5 demonstrates this phenomenon.

![Extensometer Output Diagram](Image)

**Figure 4.** Extensometer data from Longwall 2 Station at 60m
Longwall 2 installation face was essentially a repeat of longwall 1 face line, except that it was slightly wider at the shearer bay and the face area did not suffer from any geological structures. The face was once again monitored with 11 extensometers spaced out at 20m along the installation face. Similar upward rebound trends were also measured on longwall two.

![Diagram showing stress conditions](image)

**Figure 5. Demonstrates the Upward Rebound Effect.**

Underground mapping of all geological features is undertaken and recorded on a mine plan. Some minor faulting (<1m) and minor igneous and sedimentary intrusions (<2.0m) were located with the aid of aero and surface magnetics together with in-seam drilling. However, the major structural feature affecting the longwall panels is jointing. This is so ubiquitous that it is frequently misconstrued as the cleat. The cleat in the coal is relatively minor and is generally restricted to the bright coal within the mining section.

The jointing is orientated at between 100 and 110° and is infilled with various forms of carbonate. The latter aspect was detailed by unpublished company reports by Hutton (1994). The important aspect from a geotechnical perspective is that although these weaknesses exist, their significance is slightly diminished due to the carbonate cement. This feature is in part why rib conditions around the mine are generally very good (with the exception of gate roads adjacent to a goaf).

The effect of slabbing on the longwall face has been investigated and the impact has been measured by its association with delays, both along the face and in particular at the stage loader. In practice the shearer tends to push slabs ahead of itself and can literally force these slabs up over the AFC and brethy, blocks of up to 2m³ have found themselves on the wrong side of the AFC. Clearly, this is a safety issue of some magnitude and the
initial solutions were twofold. Firstly, the workforce had to remain behind the chock legs where the main access walkway is. Secondly, a pre-cutter was installed on the tailgate drum to break up the slabs so that they would be smaller in size.

Anecdotal evidence as reported by the workforce suggests that the pre-cutter was a success and that slabbing was significantly reduced. However, observations could not detect in the face any bench/trench cut by the pre-cutter on any visits. The front abutment was affecting the longwall face/rib to such an extent that it caused it to bullnose and the path of the pre-cutter could not be seen. This stress impacts on the face/rib but does not impact on the face/roof. Throughout the life of longwall 1 the only time the face/roof experienced poor conditions was in association with geological structures. In general the roof remained immaculate.

Evever and Doyle (1996) report stress conditions in the strata at Dartbrook. In general the stress conditions within the megaseam are protected by the sponge like behaviour of the coal. Here the predominant stress is vertical and the horizontal stress takes a lesser role. Outside the “protection” of the megaseam the magnitude of stress generally increases in the horizontal direction.

Early work conducted on determining the height of the immediate roof in the goaf and establishing bulking factors suggested that the likely height of goaf formation would be at the upper part of the Broomie seam, some 14m above the roof of the working section. Using this information the loading characteristics were derived for the chocks by Ward, and Doyle (Unpublished Company Reports, 1994). Estimates of chock capacity ranged from 600 to 1200 tonnes. Eventually, two legged Westfalia (later MTA) 914 tonne chocks were selected. The longwall equipment consists of MTA 914 tonne shields and matching AFC. Hayward 1998, details the equipment in use.

Shell geotechnical engineers initially investigated the design of chain pillars and MINCAD Systems Pty. Ltd., were contracted to also conduct a design. MINCAD made recommendations based on empirical and numerical modelling which had been undertaken. The Department of Mineral Resources reviewed the work of MINCAD and considered the coal strength used to be too high. They requested a second opinion and the University of New South Wales Pillar Design method was used to present this. This method utilises two relatively simple calculations both use a constant density of 2.5 tonnes per cubic metre. After some review of overburden density by investigating geophysical logs the density was revised from the average 2.50 to 2.20 tonnes per cubic metre. The revised overburden figure is a resultant of the numerous overlying coal seams, amounting to 30% coal in some locations.

In strong contrast to the University of NSW model the ALPS strategy of Mark (1990), bases pillar design on serviceability of the roadway rather than the stability of the pillar, per se. (ALPS is currently under Australian review by Colwell with the support of ACARP funding.) The experience of the first longwall extracted and to a limited extent the second longwall, only just underway at the time of writing, highlights that roadway
conditions are significantly impacted by the extraction of the adjacent longwall. With severe rib spall occurring due to the increase in the vertical stress, affecting the upper roof level on the up dip side of the seam and the floor section on the down dip side of the seam.

Rib conditions benefited from increased levels of secondary support. Two rows of 2.1m AX bolts were installed in the chain pillar side while the plastic HOPE bolt (2.1m) was installed in the solids of longwall two. The extra support was soon put to the test and proved its worth, when the longwall extracted coal past the areas that had this extra support installed. This extra secondary support has been installed on the chain pillar side on longwall two minimising rib deformation.

Pillar monitoring was undertaken with mixed results, the main conclusion that can be drawn from the work, indicates the depth of deformation suffered by the pillar edges, with significant rib deterioration up to 1.5m in depth with minor movement beyond. This deformation was largely controlled by vertical stress which impacted on the roadway during development and was exacerbated during longwall extraction.

Support levels have changed with depth and experience within the seam being mined. With this experience the level of roof support has been modified slightly, from 4*2.1m AX bolts fully grouted as the norm, up to 6 bolts per metre in intersections. Originally only minor rib support was installed and with increasing depth this has increased from 1 rib bolt per metre up 3 bolts per metre advance, with mesh where required.

The behaviour of gates rods has been varied and although the presence and orientation of horizontal stress would suggest that the main gate should suffer an increased loading this has not resulted in significant deformation. The main gate does not suffer any significant deterioration or loading apart from the ribs. The tailgate in longwall one would appear to be slightly worse, than the main gate area. Again in longwall two the main gate appears to be enjoying excellent conditions, whereas the tailgate is suffering a significant increase in pillar loading being between two goafs. This tailgate effect is predominantly exhibiting itself as severe rib spall.

Microseismic activity although not measured is rampant, noise of the face can clearly be identified to occur ahead of and above the longwall face which impacts on the ribs in the gates rods and along the faceline. Anecdotal evidence suggests that adjacent longwall development units have heard the ground shearing as a result of longwall mining.

The takeoff procedure for longwall 1 was designed to minimise time lost to bolt up the faceline. A geogrid mesh was used and whilst it slowed production it afforded secure protection to the face area. On the final shear the AFC was pulled back one metre and the shearer was removed making access for an Eimco with a platform to enter the face area and under cover of the shearer flippers commence bolting and meshing of the roof and face rib. The process worked very efficiently. When chocks were removed, cans and timber chocks were placed to insure that a return airway remained open for ventilation.
Difficulties were experienced with the take off chute which the longwall face cut into some 1.2m below the floor leaving a uneven roof which needed extra support. Deteriorating conditions in the chute meant that it was not used to remove chocks and the goaf advanced prematurey in this area, busting the geogrid and flushing the face with coal from the overlying seams. Slow and steady, the chocks were removed until the chute had been passed and the conditions had returned to normal.

Conclusions

The geotechnical features of interest at Dartbrook Mine include rib deformation, pillar sizes and slabbing on the longwall face, the impact of which relate to the 4.0m mining height on development. The mine has only one longwall extracted and has relatively little experience with the Wynn seam which has never been mined anywhere else. Nevertheless the advances that have been made to tackle these problems have resulted in a better definition of strata management with secondary support being installed to minimise rib deformation. A Strata Management Plan has now been put in place and is being utilised to guard against accidents and to ensure safe and productive mining. A constant monitoring and mapping of geological features such as joints and the implementation of the pre-cutter has improved the behaviour of face conditions and has reduced delays associated with this deformation. A goal for us this year will be to undertake studies on the leg pressures of the chocks to establish their behaviour patterns and determine optimum setting points that may improve face slabbing. Pillar sizes are continuing to undergo a constant review and we will enlarge longwall 5 pillar width from 35 to 40m.

Acknowledgment

Shell Coal Pty Ltd is thanked for their permission to publish this information. The invaluable assistance of Winton Gale and fellow SCT colleagues is gratefully acknowledged.

References

