SUCCESSFUL USE OF A STRESS RELIEF ROADWAY AT APPIN COLLIERY

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ABSTRACT: High horizontal stress levels can lead to extensive roadway deformation requiring expensive secondary support to ensure stability; this is particularly the case with longwall installation faces. Longwall installation roadways are a critical construction within coal mines. The use of a purpose built 'Stress Relief Roadway' to minimise roof deformation in the nearby longwall installation roadway, by reducing stress impacts has been undertaken at Appin Colliery – BHP Billiton Illawarra Coal. Its use led to significant cost and operational benefits. This paper outlines the process used; from identifying horizontal stress as an issue, as well as generating computer models through the various options and culminating in ground monitoring of the constructed roadways to the successful start of the longwall panel.

INTRODUCTION

Appin Colliery is located in the Southern Coalfield of New South Wales some 30km from the city of Wollongong and around 40kms from the port of Port Kembla. The Bulli seam is coking coal and is utilised in the local and international steel making industries. Appin Colliery has been operating for some 40 years and during that time has produced in excess of 40 Million tonnes of coal. The mine has been the backbone of coal production for the BHPBilliton Illawarra Coal Group of collieries.

Overburden at the mine consists of sedimentary rocks with a depth of cover at about 500m and as a result the vertical loading is of the order of 12-14MPa. Horizontal stress is of greater significance and measurements have been taken from near the area of interest. Stress levels range in the order of 20-30MPa and are significant enough to cause serious roof deformation. The previous two longwall panels had stress effects that caused operational issues with both longwall installation faces. This was the primary cause to seek a viable alternative – the stress relief roadway.

PURPOSE

The purpose of a stress relief roadway is essentially to improve roadway conditions in the nearby wider longwall installation roadway at the expense of the pre-driven stress relief roadway. The logic behind such a development is that the initial drivage suffers deformation as a result of the high horizontal stress. The stress causes significant roof guttering and or slabbing. This process in turn forces the stress field to readjust itself and the later formed longwall installation roadway is driven in an environment protected from the higher stress.

HISTORY

Stress Relief Roadways have a long and successful history of operation at Appin Colliery. Figure 1 shows the mine layouts and identifies mining areas and the region of the stress relief roadway discussed in this paper. Figure 2 highlights the area this paper deals with. In some instances lifting off of the relief roadway was undertaken to ensure that significant deformation took place, thereby ensuring stress relief for the wider installation face.

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For some time the mine stopped providing stress relief roadways as it was considered that they interfered with the critical path development rates. But in practise experience has shown that a smoother longwall installation process offsets the economics of slower development rates.

GEOLOGICAL MAPPING

Geological mapping of all roadways in the underground environment is undertaken to monitor geological structures as well as stress deformation. Hazard plans for the mine are prepared and indicate the nature of hazards, such as faults, dykes, stress and gas as well as cross-sections indicating the proximity of adjacent coal seams.

While the immediate roof strata varies it is predominantly a sequence of interbedded fine-grained sediments typically consisting of massive siltstones or fine-grained sandstones ranging in strength from 30-80MPa (UCS). Estimates of Coal Mine Roof Rating (CMRR) would be in the vicinity of 40 to 50 (weak to moderate).

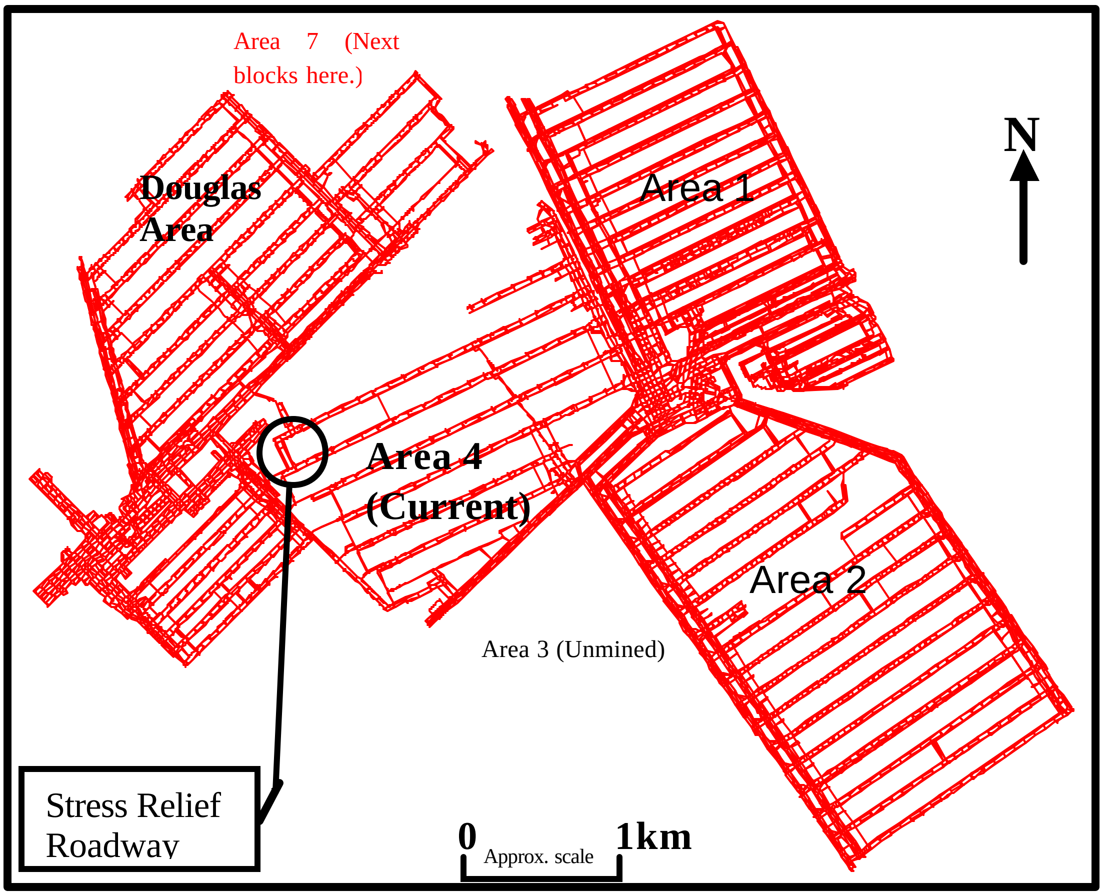

Fig 1 - Appin Mine layout – goafs not blacked out.

STRATA CHARACTERISATION & COMPUTER MODELLING

To ensure the correct geometry for the stress relief roadway and longwall installation face separation it was considered advantageous to conduct computer modelling. Strata Control Technology Operations (SCT) undertook extensive computer modelling to simulate the behaviour of the roof around the roadways in the area of the longwall 406 installation face.

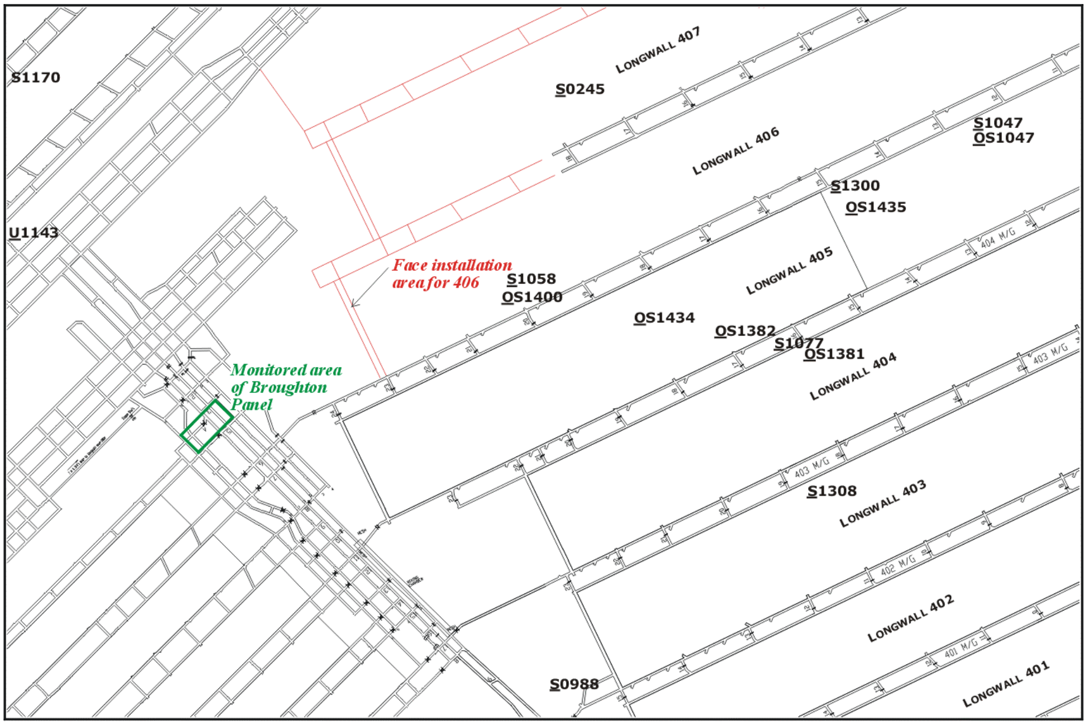

Fig 2 – Mine layout and borehole location

Previous studies undertaken by SCT focussed on the nearby Broughton Panel of the previous Tower Mine – now incorporated as part of Appin Colliery (See Figure 2.). Information available to develop a model of the strata included bore logs and core photographs, geophysical logs and underground monitoring together with extensometer data. Some UCS data was available and estimates were also made from geophysical logs, the latter combined with core assisted in developing bedding plane cohesion charts.

In the roof fine-grained sediments make way for sandstones and generally range from 40-90MPa. The magnitude of the horizontal stress is estimated in the range of 25-28MPa. The Bulli seam is some 3.30m in thickness and has an estimated in-situ strength of 6MPa and the floor is typically shale about 1.5m thick before grading into sandstone. This sandstone overlies the Balgownie Seam which is the latter being about 1.0m in thickness and about 8m below the Bulli Seam.

It should be recognised that computer models are based on the characterisation of the strata and in this instance have been used to simulate the likely strata behaviour during drivage. Underground mapping and observations were also conducted prior to running the model to improve confidence in the outcome. The model utilised the FLAC Version 3.4 with rock failure and stress input routines that have been developed by SCT Operations.

The model has the capacity to review the drivage of individual roadways or a sequence of drivages to determine their impact upon one another. Thereby assessing the impact of stress relief on the installation road. Figures 3, 4 and 5 highlights various aspects of the modelling. Figure 3 highlights the construction of the model and the breakdown of the strata horizons that have been characterised – note their UCS strengths. Figure 3 shows the final layout of the stress relief roadway (Right Hand Side) and the longwall installation roadway (LHS).

Figure 4 examines the case of the single roadway. For a single roadway the model indicates that the height of fracturing will extend to 5m above the roof of the opening when the stability level of stress is exceeded. The stability limit is estimated at about 17MPa for the existing ground conditions. The nature of the fracturing is clearly evident in the model.

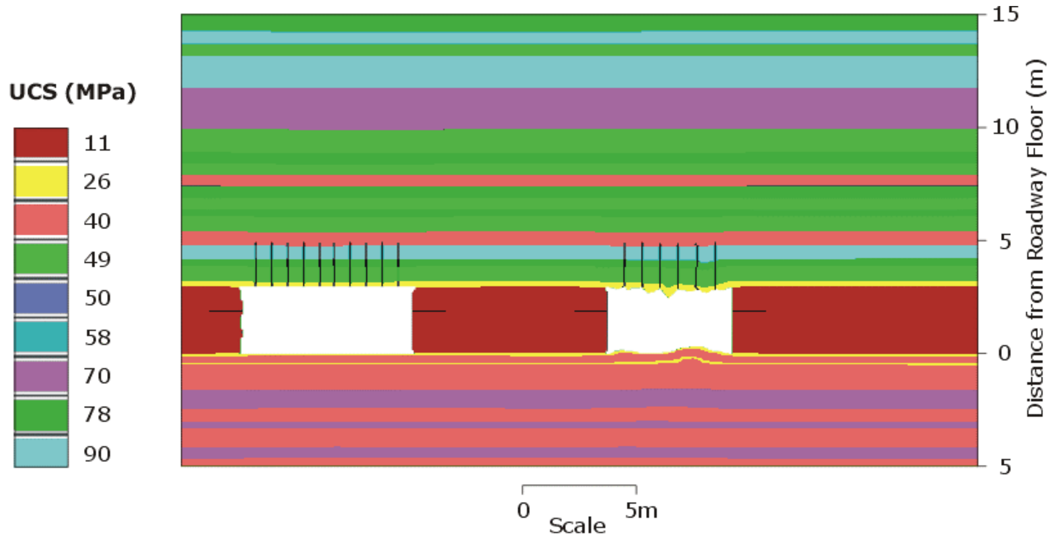

Fig 3 – UCS model of roadway and face heading

The benefit of a stress relief roadway is that it deforms significantly enough that it causes the stress field to readjusts so that it doesn't act to the same extent upon a nearby roadway i.e. the longwall installation roadway. The critical factor is to ensure that there has been sufficient stress relief to achieve the desired benefit. In some older examples of stress relief roadways lifting off coal (fendering) ensured that the benefits of the extra wide stress relief roadways was achieved and that the stress field was actively interfered with. However in this instance fendering was postponed to observe the nature of the monitoring and when results were satisfactory fendering was not considered essential. While SCT Operations made a recommendation that fendering of the stress relief roadway be undertaken – in this instance this was not undertaken. The purpose of this was to induce more failure at a greater height into the roof. Thereby ensuring that the stress was driven well above the influence levels likely to impact upon the installation roadway.

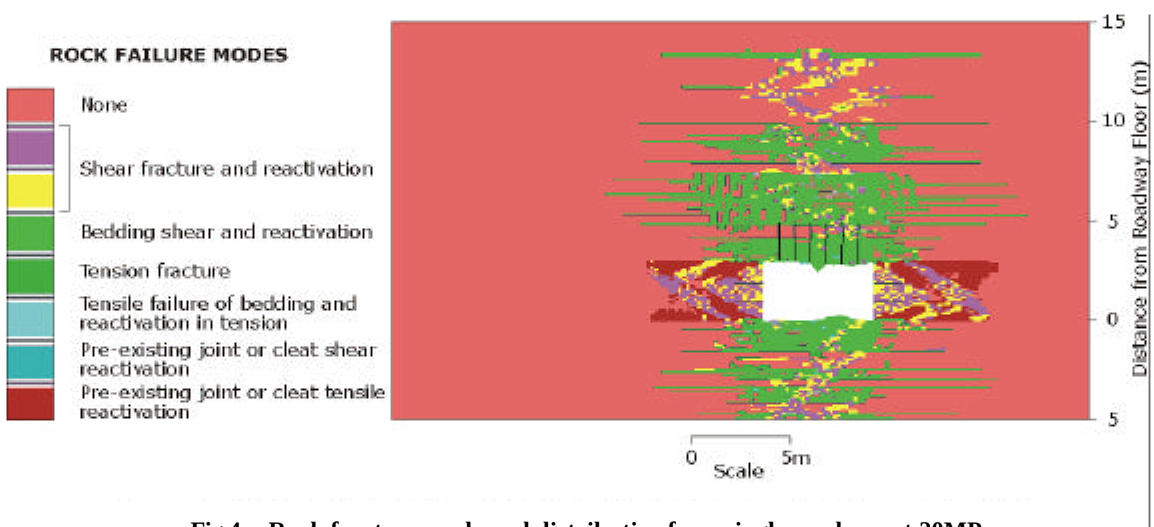

Fig 4 – Rock fracture mode and distribution for a single roadway at 20MPa

Running the various models (Figure 5) allowed a recommendation of a distance between 8 to 15 metres of solid coal between the stress relief roadway and the face installation roadway. It was considered that this would allow the stress field to be sufficiently modified to allow a successful longwall installation roadway to be opened up (first pass) and then widened out. Figure 5 shows the level of deformation around the roadways. The roof displacement anticipated in the face installation roadway was less than 10mm.

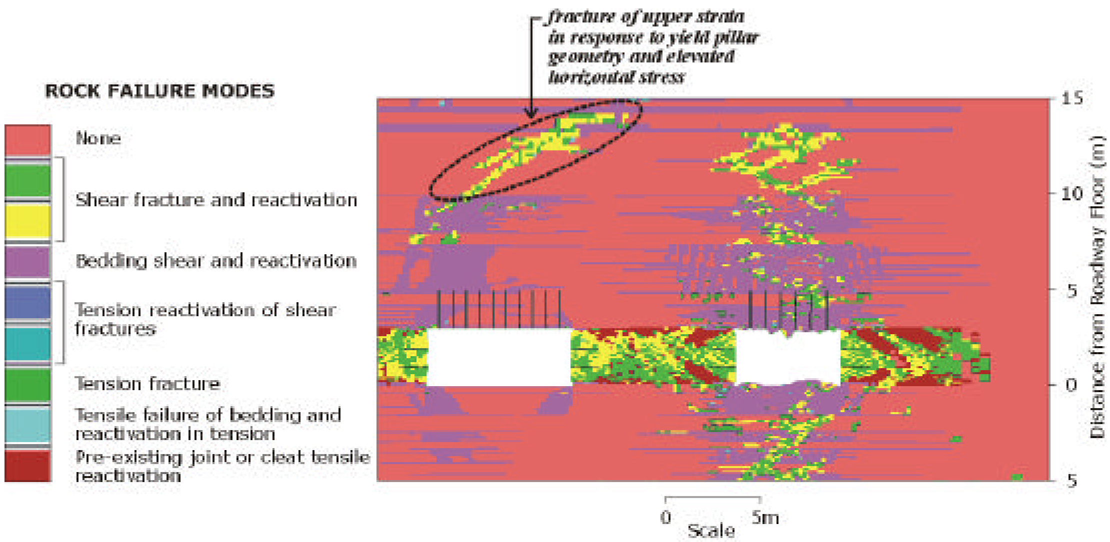

Fig 5 – Rock fracture distribution for stress relief installation roadway – 8m pillar

COST BENEFITS

In the past stress relief roadways were utilised quite successfully at this mine. However with the drive to ensure longwall continuity and reduce costs the stress relief roadway process was abandoned. However on longwall 405 the face installation roadway suffered considerably due to the impact of high horizontal stress to such extents that it resulted in several episodes of PUR injection and considerable installation of megabolts to lock the roof up. These secondary support measures were successful and were a credit to their use. Nevertheless the cost of secondary support for this installation heading was excessive. Alternative measures were sought for longwall 406 panel.

The additional cost of drivage – in this instance some 255m of drivage at a nominal cost of $1500 p.m. ($380K) was offset by the revenue of the coal mined (5m*3.2m*SG1.4*$A67 = $1500 – Example Only). This essentially makes the cost of the heading cost neutral in term s of economics. However the real cost is therefore in the use of the mining equipment and human resources to cut the stress relief roadway when it could be producing additional development metres in a different area in other words - opportunity. Which can be an important factor in its own right. However, when considering the potential for difficulty in a face installation roadway and the additional cost of secondary support together against the cost of driving the stress relief roadway it is considered to be a minor investment which pays huge dividends in terms of having a face installation roadway of excellent attributes. This presents a greater opportunity to increase and improve longwall productivity, which is where the real benefits of a smooth transition flow.

OBSERVATIONS & MONITORING

As part of the ventilation requirements a guaranteed back heading was required to remain standing during longwall retreat and as such a twin heading panel was driven to create the 'bleeder' (ventilation roadway) and the stress relief roadway. The drivage experience of these roadways was as expected with both roadways suffering from some significant stress deformation. Tell tales were installed in the bleeder roadway at 50m spacings and ranged from 80 to 100m of total convergence. Six bolt patterns spaced at one-metre intervals controlled the roof and full mesh was utilised. Full mesh modules were used to minimise any slabbing of the roof and thereby ensure the safety of mining personnel during drivage.

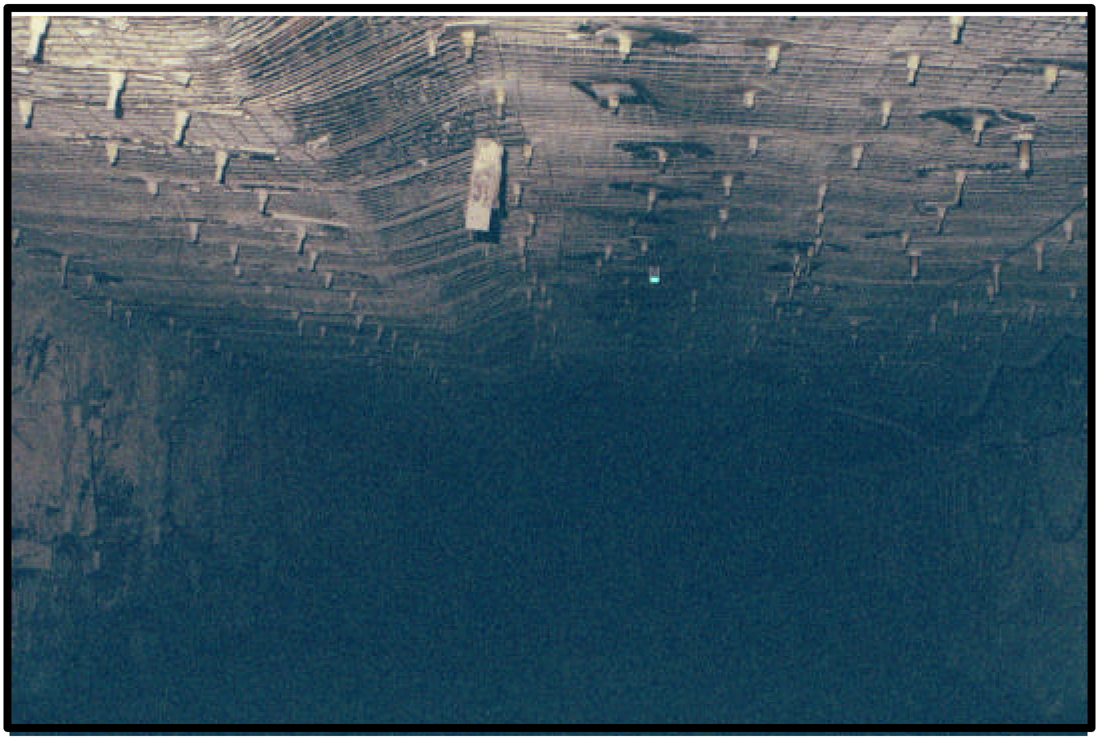

Fig 6 - Photograph of the LW406 Installation Roadway after widening. First Pass on RHS

In the installation face as the first pass progressed tell tales were installed offset from the centre of the roadway to be in the centre of the heading when widened out. These tell-tales were placed at 25m spacings. In 3 locations sonic extensometers were used to replace tell-tales with the aim of providing additional information of roof deformation. In all cases the total level of movement was less than 10 mm up to the time of longwall support placement i.e. when the tell-tales could no longer be measured. In general the roof was visually in a very good condition as Figure 6 shows. The placement of some megabolts was used around the intersections and around the tailgate intersection in particular, which did showed signs of deterioration.

CONCLUSIONS

Appin Colliery has a mixed history of using stress relief roadways. This recent method utilised a scientific approach with geological mapping, stress mapping and measurements together with monitoring of strata as well as computer modelling to assist in the development of the installation face and to ensure its success. The process worked well and is believed to be of both economic and operational benefits.

The success of this work has given the confidence to go ahead with stress relief roadways to assist in the protection of the remaining two longwall panels in this current mining area.

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