STRATA CONTROL CONSIDERATIONS FOR IMPROVED MINE ROADWAY AND PANEL DRIVEAGE RATES

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ABSTRACT

The major strata control considerations which affect the optimisation of roadway driveage in highly stressed strata in the performance of reinforcement placed and the extent of stress induced rock deformation.

High development rates and opening stability requires efficient rock reinforcement and stress relief strategies which maximise the integrity of the rock about roadways created.

Current studies demonstrate the capability to reduce lateral stress distributions across panels and research is aimed toward a higher capacity bolting system.

It is the intention to provide industry with more efficient reinforcement and stress control alternatives which will allow high production development equipment to operate without the restriction of delays caused by poor ground conditions.

INTRODUCTION

Underground coal mining is to be undertaken at increasing depth and within highly stressed rock masses. Mining excavations are subject to the effects of virgin stressfields and stress redistributions occurring about excavation panels.

Coal measure rocks are relatively weak engineering materials which require support or reinforcement to maintain effective opening utilisation. Rock failure commonly occurs about roadways created in siltstone, laminite and shale roof under highly stressed conditions.

High production mining operations require rapid roadway development techniques and unobstructive means of stabilisation during extraction operations.

To achieve these objectives, mining operations within weak coal measure strata require mine layout and excavation design to be based on efficient rock reinforcement and stress control strategies which optimise the integrity of strata about roadways created.

The work conducted to date indicates that roadway stability is maintained by the capability to:-
1) enhance the structural integrity of the failed rock about the roadway by reinforcement, and
2) control the stresses under which roadways are subjected and thereby minimise the extent of rock failure.

This paper presents a brief discussion of current state of some rock reinforcement and stress control methods together with the direction for future optimisation of driveage in high lateral stressfields.

1. ROCK REINFORCEMENT

The aim of rock reinforcement using rock bolts, cable bolts and rib bolts is to strengthen the rock mass about an excavation to sustain greater stresses and increase the structural strength of failed/partially failed rock.

Design techniques for roof reinforcement have been developed using in-situ monitoring of axial forces and bending strains developed in roof bolts and rib bolts. These
techniques have been developed over the past 4 years, and have been presented elsewhere (Gale, 1986, Gale and Fabjanczyk, 1986). These design techniques have been used to define the anchor and performance of bolts (roof, rib, cable) in providing reinforcement to the deforming (or failing) rock about the excavation.

Details of the:
1) Modes of rock deformation and failure,
2) Axial forces developed along the bolts,
3) Bending strain and moments along the bolt,
4) Bolt-grout-rock 'bonding' or load transfer capability,
5) Resin encapsulation length,
6) Bolt length requirement,
7) Performance and capability of reinforcement placed to maintain the structural integrity of the rock; has been obtained from a wide variety of mining and geological environments.
8) Bolt patterns appropriate to the rock deformation mode.

The performance of individual bolts and the interaction of a strap of bolts acting as a system has been monitored. Examples of single bolt and bolt system performance are represented in Figure 1 and Figure 2, respectively.

![Diagram](attachment:image.png)

**Figure 1.** Forces generated along a fully encapsulated roof bolt at various excavation stages

**Figure 2.** Plots of the axial forces (kN) developed by a set of bolts contoured above a seam to delineate the geometry of loading (rock failure) and the system response during various excavation sequences.

The principal modes of reinforcement developed by a set of bolts is to provide restraint against axial and shear displacement in the rock mass. This is designed to enhance the structural strength of the failed rock and to restrict the height of failure above the roof. The general modes of reinforcement provided is presented in Figure 3. The interaction of bolts with the rock mass in this manner is presented in Figure 4 which shows the bolt axial reinforcement developed, the roof displacement and the height of rock failure for various excavation stages. This data shows that after the yield capacity of the bolts is reached
thin a deforming roof, reduced resistance to further deformation and in many cases to propagation in height failure occurs. Field monitoring has shown that a current limitation to reinforcement capacity in maintaining Mining stability is the yield strength of the bolts placed.

This is particularly evident in areas of weak roof subject to high stresses. In these circumstances high bolt densities are required to provide sufficient reinforcement and as such driveage rates are adversely affected.

In order to increase the capacity of reinforcement systems and the efficiency of their use, current research is directed toward increasing the yield strength and ultimate capacity of bolts available. This is aimed to:

1) Provide greater capacity to roof bolt reinforcement systems to enhance roadway stability in difficult conditions.
2) Allow a potential reduction in bolt density where stability can be maintained by the use of a higher strength reinforcement system. It is the intention to increase or maintain stability whilst optimising the density of reinforcement placed to maximise driveage rates achievable under the conditions experienced.

This work is being pursued under AMIRA project funding.

Significant increase in driveage rates can be achieved by modest reduction in bolt density. The bolt density required will be related to the severity of conditions experienced, the capacity of reinforcement placed and its interaction with the roof strata.

2. STRESSFIELD CONSIDERATIONS

Rock reinforcement techniques are designed to restrain rock failure and enhance the structural strength of failed rock, they do not necessarily stop rock failure occurring about the face.

Rock failure about excavations is commonly induced by high virgin stresses redistributed during mining operations.

The effect of in-situ stresses upon roadway conditions has been discussed elsewhere (Gale, 1986a; Gale 1986b; Gale and Blackwood 1987). These studies have demonstrated that key factors which affect the result of stress redistributions are:

1) the direction of driveage
2) the magnitude of in-situ stresses
3) excavation geometry and layout.

The effect upon roof behaviour of roadway orientation relative to the stressfield is presented in Figure 5 as an example.
Although optimisation of roadway layout can be accomplished on a mine wide scale, panel driveage is still required in directions or locations for which roadways are subject to major stress related rock deformation. Recent research has been directed toward minimising the magnitude of stressfield into which key roadways are driven. The aim is to minimise the horizontal stresses about excavations and thereby:
1) reduce the extent of rock failure, and
2) reduce the required reinforcement density.

Current studies have centred on utilisation of softened (failed but not fallen) roadways to provide stress relief to roadways driven in close proximity.

The general concept has been discussed elsewhere (Gale et al., 1987). In brief, lateral stress can be redistributed about softened roadways to provide stress relief up to 30 - 40 m adjacent. The extent and magnitude of this stress relief is dependent upon the stress relief properties and the magnitude of in-situ stresses.

An example of theoretical analysis is given in Figure 8 which shows a roadway softened 8 m into the roof and floor. The results indicate significant stress relief close to the roadway increasing to the virgin value progressively further from the initial roadway.

Field studies have been conducted which confirm this phenomenon and show significant optimisation in roadway stability and reinforcement requirements. An example of driveage under high stress conditions is presented in Table 1.

The table shows that rock displacement, reinforcement behaviour and requirements together with the height of rock softening is dramatically affected by the location of roadways within the stress relieved zone. The magnitude of stress relief is affected by proximity to a softened roadway and the excavation sequence. A roadway driven between two softened roadways (Table 1) showed maximum effect.

The current work indicates the practical application of stress control methods. At present these techniques have been adopted for longwall face installation roadways and also to optimise panel driveage stability of key roadways.

It is the intention to extend this work to provide an integrated stress control design capability by which in-situ stresses can be modified to minimise the rock failure and maximise development rates by reducing the reinforcement density required. This may be achieved by purposeful roadway sequencing, sacrificial cave headings and, potentially, pre-blasting techniques where appropriate.

CONCLUSIONS

The discussion above demonstrates a two-fold approach toward optimising driveage rates and opening stability. Research is aimed toward:
1) increasing the efficiency of rock reinforcement systems to maximise the strength of failed (softened) rock, and
2) reducing the lateral stressfield across areas of ground to reduce the occurrence and extent of failure about
openings driven. This approach is necessary under high stress moderate/weak rock conditions. It is the intention to provide the industry with more efficient reinforcement systems and stress control alternatives which will allow high production development equipment to work at their rated capacity and not be restricted by poor ground conditions.

REFERENCES


