Geomechanical evaluation of a coal mine arched entry

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Summary

In an effort to minimize cutter roof failures in longwall development entries of a West Virginia coal mine, a three-entry system was developed with the center entry arched into the strata above the coal seam. The purpose of the arched entry was to modify the horizontal stress envelope associated with the three-entry system and improve roof conditions in the adjacent outside entries.

Contrary to the predictions of elastic analyses, the presence of the arched entry improved roof conditions by eliminating cutter roof failures in the outside entries. In situ stress determinations and numerical modeling techniques were employed to quantify the impact of the arch and investigate the mechanism of stress relief associated with the arched entry. Stress determinations and underground observations indicated that the roofs of the outside entries were within the zone of stress relief generated by the arch, and that failure or movement along bedding plane discontinuities played a major role in the formation of the stress relieved zone. The numerical model incorporated horizontal joints to simulate bedding plane discontinuities. The properties of the joints were adjusted until roof stresses predicted by the model were in agreement with measured stress profiles. This process resulted in a calibrated analytical tool that could be used to evaluate alternate mining geometries.

Keywords: Longwall mining; stress measurement; roof failure discontinuities; entry stability

Introduction

Cutter roof failures are caused by vertical or near-vertical roof fractures that initiate near the rib of coal mine entries. Such failures can generate roof falls that may run hundreds of feet along an entry. Conventional roof support practices do little to prevent cutters and once the roof rock is fractured, secondary supports (trusses or cribs), installed to prevent roof collapse, have limited effect or nullify the usefulness of the entry. Investigators that have evaluated cutter roof failures are in general agreement that the initial failure is caused by an
adverse combination of vertical and horizontal stresses near the corner formed by the roof and rib. In order to modify roof stresses and prevent cutter failures in longwall development entries of a West Virginia coal mine, a three-entry system was developed with the center entry arched into the strata above the coal seam. The arched entry effectively eliminated cutter failures in the outside entries.

This paper describes an investigation that was initiated to quantify the impact of the arched entry on the roof stress distribution and to gain an improved understanding of the mechanics of stress relief in bedded strata. *In situ* stress determinations and numerical modeling techniques were employed.

**Background**

Cutter roof problems occur in numerous mines, but are especially prevalent in the coal mines of South-western Pennsylvania and West Virginia. In these areas, cutter roof failures frequently develop in the mains and longwall development entries. The cutter failure initiates in the roof near the rib, with the fracture propagating vertically into the roof strata. If these vertical fractures intersect a weak bedding plane or propagate above the roof bolt anchorage horizon, a massive roof fall can occur. Such failures can propagate long distances (hundreds of feet) along an entry and often result in the abandonment of entries or section (Su and Peng, 1985).

Cutter roof failures have been evaluated by numerous investigators, including: Aggson (1978), Nichols (1978), Peng (1978), Aggson (1979), Kripakov (1982), Su and Peng (1984), and Su and Peng (1985). From these investigations, it is concluded that a number of complex, interrelated factors are responsible for the formation of cutter roof failures. However, these investigators generally agree that the cutter failure is a shear failure caused by stress concentration at the intersection of the roof and rib.

Aggson (1978) and Su and Peng (1985) have proposed changes in mining geometries to avoid roof cutters. These geometry changes, which induce changes in the vertical and horizontal stresses, include modification of pillar sizes, entry widths and entry orientations. However, in some cases, such geometry changes may not be either effective or practical. An alternate approach is to directly modify the stresses at the potential failure location. One method of vertical stress modification, known as pillar softening, has been proposed by Wang *et al.* (1974). This method would generate stress changes by drilling horizontal holes which soften the pillar rib and transfer vertical stress away from the entry and into the pillar core. While this method may offer a potential solution to the cutter roof problem, it has not been successfully demonstrated to date. Another method of directly altering the roof stress and reducing the potential for cutter failures is to relieve or reduce the horizontal stress in one entry by generating a controlled cave in an adjacent entry. This controlled cave or arched entry concept has been successfully demonstrated in a West Virginia coal mine. The remainder of this paper describes:

1. the rationale behind the arched entry concept,
2. the stress determinations that were conducted to verify the horizontal stress relief generated by the arch, and
3. numerical analyses that were conducted to enhance the understanding of the arched entry stress relief concept.