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Instability Analysis in Three-Way and Four-Way Coal Mine Intersections

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ABSTRACT

It is well known that most roof falls in coal mines typically occur in and around intersections. Room-and-pillar and longwall coal mining systems typically develop 3-way and 4-way intersections. This research develops an improved scientific understanding of stress distribution and associated failure behavior around 4-way and 3-way coal mine intersections through 3-D numerical modeling for a mine in Illinois and limited field observations. The numerical analyses were performed to determine factors that influence intersection stability. The stability of immediate roof and rib at intersections were assessed for different orientations of intersections with respect to pre-mining stress orientation. Also, the effect of pre-mining horizontal stress and width of entry span was analyzed. Linear elastic and non-linear failure analyses using the Hoek-Brown failure criterion for rock mass were used. Failure criterion parameters were developed from rock mass classification data. Progressive failure zones around 3-way and 4-way intersections were developed

Intersection span and orientation of horizontal stress have a major influence on intersection stability. For a 4-way intersection, pillar corners across the intersection fail first and lead to progressive failure of immediate roof and floor layers. The mechanism of failure is similar for a 3-way intersection but the shape and extension of failed zones differ. Coal ribs mostly fail due to tensile stress, while roof and floor strata fail due to shear stresses. Rib corners fail due to a combination of shear and tensile stresses. In addition to stress distribution; safety factor contours analysis was performed to assess stability of intersections. For three way intersections, the effect of offset distance was also analyzed. It was concluded that minimum offset distance of about 10 m (center to center distance between two 3-way intersections) was required to minimize interaction between two intersections.

An instrumentation plan was developed to monitor ground movements around intersections. Field monitoring consisted of both manual monitoring and continuous monitoring systems for measuring of roof to floor convergence, differential horizontal displacement of pillars, rosettes mounted in the roof (roof bolts) and on the wooden cribs. This data was used to design the intersection geometry and validated using the numerical model.