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Prediction of the initiation and orientation of the extension fractures ahead of and around faces and walls of mechanically driven excavations and their effect of stability

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ABSTRACT

Boring of shafts and tunnels in hard rock mines is more prevalent in recent years in South Africa. This normally takes place under substantial stress conditions, where fracturing of rock occurs around the boundaries and ahead of advancing faces of excavations. Fracturing can have a significant impact on boring activities, in some instances causing sidewall spalling which can be extensive, with machine grippers unable to reach the sidewalls. In brittle rock, these fractures are commonly extensional in nature.

This research has been undertaken to predict the initiation of extension fractures and their orientations ahead of machine driven tunnels. Furthermore, it will help to assess the stability of the excavations, by evaluating the potential for slab/plate failures. This was based on the typical in situ stress fields for underground deep level mines.

The numerical analyses involved the generation of different plots:

- Principal stress contour plots, depicting stress distributions around and ahead of tunnel excavation, using cutting planes;
- Isosurfaces, showing zones of extension or potential extents of fracturing, applying the extension strain criterion; and
- Trajectory ribbons, to demonstrate the orientations of fractures.

Based on the results of the stress analyses, potential slab or plate formation was determined. It was noted that the fracture zone is a function of a tunnel size. For instance, a four-metre diameter tunnel is

less likely to give boring problems than an eight-metre diameter tunnel.

The failure of the tunnels was predicted by employing slab analysis methods. An eight-metre diameter tunnel had slenderness ratio as low as 22.3 as compared with a four-metre diameter tunnel with a slenderness ratio of 27. Looking at buckling stress versus slenderness ratio, this translates to buckling stress values of above 100 MPa for an eight-metre tunnel and to values just below 50 MPa for a four-metre tunnel.

The outcome of the research gives a clear indication that boring activities could be undertaken under severe conditions. This could be detrimental to the cutter head, since large slabs and blocks could be encountered during boring. The results of this research can be beneficial in the evaluation of boring conditions prior to and during boring activities.