"Geotechnical Risk Assessment of Mine Developments in Deep Metal Mines".

Wael Rashad Elrawy Abdellah

Abstract:

Mine developments such as haulage drifts and cross-cuts are the primary access to the mining blocks of an orebody in multilevel mining systems for tabular ore deposits. Thus, their stability is of utmost importance during the planned period of production or the life of a mine plan. Many Canadian underground mines use longitudinal and transverse stoping with delayed backfill to extract tabular ore deposits. These methods require access to the orebody through a number of sill drives or cross-cuts which link the orezone to the haulage drift hence creating intersections on multiple levels. Mine development instability could lead to serious consequences such as injuries, production delays and higher operational cost. The objective of this research is to develop a hybrid approach in which deterministic numerical modelling is integrated with probabilistic methods to evaluate the stability of mine developments due to nearby mining activity. A case study comprising four consecutive mine levels in a deep underground metal mine in Sudbury, Ontario has been adopted for this study. The stability performance of the haulage drift is assessed using two separate evaluation criteria, namely Mohr-Coulomb yield function and Brittle Shear Failure. Random Monte-Carlo (RMC) technique is then employed in conjunction with Finite difference modelling software FLAC to determine the probability of instability or unsatisfactory performance of the haulage drift with respect to nearby mining sequence. In this study, the haulage drift performance is considered unsatisfactory when the yield zones or brittle shear failure around the haulage drift extend beyond the anchorage limit of the rock support. A comparison of the results from Mohr-Coulomb and Brittle Shear conditions has revealed that Mohr-Coulomb is more conservative from a design point of view. A three-dimensional, elastoplastic, finite difference model (FLAC 3D) is then constructed to simulate the case study mining orezone. The unsatisfactory performance of the intersection is evaluated with respect to mining sequence in terms of the strength-to-stress ratio computed by FLAC3D. Unsatisfactory stability performance is defined by a strength-to-stress ratio that is less than 1.4 and its corresponding extent into the rockmass around the intersection. Due to the large size of the FLAC3D model, the probabilistic simulations are conducted with the Point-Estimate Method (PEM), which requires significantly lesser number of simulations than Random Monte-Carlo (RMC). The results are presented and categorized with respect to probability, instability, and mining stage. In order to validate the numerical model, Multi-point borehole extensometers (MPBX) are installed at selected intersections to monitor the rock deformations as mining activities progress. The monitoring results revealed a lateral shift of the drift walls toward the orebody and much less deformations in the drift back. Finally, a methodology is developed to estimate the geotechnical risk of drift instability by considering the probability of failure and cost of consequence of such failure at an intersection. A 5-level risk index is derived which ranges from low to extreme. The methodology is demonstrated through an intersection from the case study mine, and the risk index is shown to vary with mining sequence. It is shown that the risk-index methodology can be used to confirm the need for enhanced supports, but it can also be used as basis for the comparison alternative mine designs.

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