Abstract

Stability analysis of Pillars in Deep Underground Metal Mines using Finite Element Method

Hemant Kumar

Increase in mineral resource consumption and drying up of resource in shallow ground has necessitated deep exploitation of minerals in the world. A serious problem must be settled when deep underground mines are exploited in terms of variation of mechanical response of rock masses under high stress condition and its influence on pillar design. The major causes of sill and crown pillar failure in hard rock mines identified so far are the lack of understanding of Indian geo-mining conditions in terms of rock mass properties, insitu stress conditions and inadequate of pillar dimensions. The dimension of crown and sill pillars are needed to be judiciously designed such that they stand until the entire stoping operation is over having optimum conservation of minerals. This problem has become a hotspot to the academician, researchers and field mining engineers. Thus, in this research, the focus of the study is to identify and understand the behavior of crown and sill pillars in terms of varying stress and geo-mining conditions with/without reinforcement using finite element method (FEM). The study has also extended to develop a statistical relationship between safety factor and various input parameters.

In this thesis, a steeply dipping ore body having decreasing width with depth (most common type of orebody in India) has been modeled considering horizontal cut and fill method of stoping at four depth levels. Analysis of stresses, displacements and extent of yield zones around the excavation are carried out by varying rock mass conditions such as geological strength index (*GSI*), uniaxial compressive strength (*UCS or* σ_{ci}), modulus of elasticity (*E*), and thickness of crown and sill pillars (*T*). These analyses have been conducted based on 135 non-linear numerical models considering Drucker-Prager material model in plane strain condition. Results of the study provide valuable insight into the safety factors of the pillars highlighting stress distributions, yield zones and support requirements. This thesis develops a generalized statistical relationship (multivariate regression model) between the safety factors of sill and crown pillars with above mentioned input parameters for further utilization in generating design/ stability charts of pillars for different geo-mining conditions. Performance of rock bolts and their impact on safety factors and confining stresses near excavation boundary are also evaluated for proper design of reinforcement.

Key Words: Stability of deep underground working, Crown and sill pillar, Druker-Prager material model, FEM, Regression model, Design/ stability chart