Application of photogrammetry to estimates of mine pillar damage and strength

Ryan Preston

The room and pillar lead mines of The Doe Run Company's southeast Missouri operations span approximately 30 km at average depths ranging from 180-370 m. During secondary mining of pillars, there is a risk of domino type pillar failures, which pose a risk to mine infrastructure and workers. Displacement Discontinuity numerical models are used to forecast pillar conditions during extraction and are subject to constant refinement based on observations. Terrestrial photogrammetry is a rapidly developing field of remote sensing, which is highly applicable to rock mass characterization. In this study, repeated photogrammetric surveys were conducted on pillars in areas of secondary mining from May 2013 to January of 2014. 3D photomodels were used to characterize pillar damage resulting from increased loads during extraction by measuring failure depth and crack intensity as well as geological structures. Observations of damage vs. stress relationships and structure were used to calibrate numerical models for forecasting pillar condition.

Geological structures were characterized from 3D photomodels and used to generate stochastic Discrete Fracture Networks. The observed orientation, spacing and trace length of structures were found to agree well with published research. In addition, high resolution 3D photomodels allowed for preliminary work characterizing structural terminations and persistence. Observations of pillar damage progression suggest that it is largely controlled by splitting along sub-vertical joints.

Pillar conditions are currently assessed using the pillar damage rating system by Roberts et al. (2007) which rates pillars from 1 to 6, 1 being in perfect condition and 6 being failed and providing no support. Pillars observed in the study were rated using this system, which takes into account depth of spalling and presence of large cracks. Then, cracks were mapped and depth of failure was measured on 3D photomodels to produce areal crack intensity, D21, values and Depth of Failure, DOF, values. These measurements of damage displayed the expected trends when correlated to observed damage ratings with D21 values exhibiting greater scatter. Measured pillar damage was then correlated to pillar stresses predicted by Displacement Discontinuity numerical methods to derive stress vs. damage relationships. Shorter pillars were found to initiate damage at higher stresses and sustain less damage for an equal increase in stress when compared to taller pillars. This observation of shorter pillars being stronger than taller pillars agrees well with numerous previous studies.

Cross sectional profiles were developed from 3D photomodels and input into 2D elastic stress analysis software to estimate stresses at damage initiation and determine if numerically predicted stress concentrations agreed with observed damage locations. Stress magnitudes at locations of damage initiation were found to correlate well with published research as well as initiation values from the observed stress vs. damage relationships. Structural mapping results were used to generate fracture networks in Distinct Element numerical models, which were calibrated using previous empirical studies of pillar strengths at Doe Run as well as observations of pillar stress vs. damage from this study. Preliminary numerical results have successfully simulated pillar failure progression, but are subject to further refinement.