Grant: AFC820-52

Title: Large Scale Testing and Modeling of Supported and Unsupported Pillar Analogs

Organization: Colorado School of Mines

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Topic: Health and Safety Interventions

Priority Area: Ground Control

SYNOPSIS

Problem Statement: Pillars are perhaps the most fundamental structures in all sectors of underground mining. Despite decades of research on pillar behavior, pillar-related ground failures such as pillar bursts, rib collapses, and complete mine failures/collapses continue to injure and kill miners in the United States. Accordingly, a need remains to re-evaluate existing understanding of pillar strength and to advance knowledge related to pillar post-yield behavior and ground-support interaction.

Research Approach: Prior studies on pillar behavior have focused largely on in-situ observation, where it is often difficult to conduct truly controlled experiments, and small scale laboratory testing, where uncertain scale effects limit our ability to extrapolate findings to actual mining conditions. In addition, previous studies have focused primarily on pillar strength, with limited emphasis on post-yield behavior and ground-support interaction.

We propose to conduct a series of large-scale laboratory tests on coal and limestone blocks; unlike prior research, such an approach allows for controlled study of rock behavior at sizes that are more directly comparable to in-situ pillars than conventional laboratory testing. The large-scale specimens used will serve as pillar analogs, and accordingly will be tested using different geometric configurations (width-to- height ratio) and different types of ground support. In addition to consideration of the stress-strain curves associated with the tests, we will collect photogrammetric data for the purposes of digital image correlation analysis as well as high-resolution strain-data from fiber optic extensometers installed within the specimens. These data will allow for detailed interpretations of damage localization, fracture generation, and ground-support interaction to made.

Because of the high cost of conducting large-scale testing, we additionally propose to advance and validate a numerical modeling approach for the study of pillar mechanical behavior. In particular, we will develop bonded-block models and calibrate micro-properties for the modeling of coal and limestone damage and deformation processes. The reliability of the models will then be tested by confirming that they can replicate both unsupported and supported large-scale specimen behaviors observed in the laboratory without further calibration. Finally, these models will be used to test a variety of conditions that would be impractical to test in reality due to logistical and financial limitations.

Impact of the Research: Although the proposed research is fundamental in nature, it will clearly lead to future practical research outcomes in the short term, which will in turn lead to reductions in the number of worker injuries and fatalities in underground mines. In particular, the proposed fundamental research will naturally advance the potential for applied research to be completed in areas related to ground control, such as the following:

- Development of updated pillar design guidelines including consideration of post-yield behavior and support effects
- Development of rib support guidelines
- Development of pillar recovery guidelines for retreat mining