Grant AFC719-67: Numerical Modeling of Overburden and Pillar Mechanics for Determination of Global Ground Stability in Underground Coal Mines

Organization and Principal Investigator: Colorado School of Mines (Gabriel Walton)

Focus Area: Health and Safety Interventions

Priority Area: Understanding the Role of Overburden Mechanics in Pillar Design and Global Ground Stability

Problem Statement and Research Approach: Pillars are critical support elements in underground mines. Accordingly, the strength of coal and rock pillars has been a subject of extensive study in the mining and rock mechanics literature over the past 60 years. This work has resulted in the development of largely empirical design approaches which have reduced the risk of pillar failure and mine collapse. Recent studies, however, have drawn attention to the fact that some of the assumptions used in the development of conventional pillar design methodologies, particularly that the overburden has no self-supporting capacity, are not generally valid. Accordingly, this means that our fundamental understanding of the mechanics which govern global mine stability is at best incomplete, and at worst, flawed. To overcome these limitations, further study of pillar strength and pillar loading conditions which consider various possible overburden influences must be performed.

Given the limitations of common empirical approaches and the inherent scaling issues associated with laboratory studies, we propose to study this topic using numerical models. In particular, we will use discrete-element-method models which allow for the explicit separation of horizontal bedding planes and vertical joints in overburden materials. Given that this line of research, which differs significantly from conventional approaches for thinking about ground stability, is still in its early stages, the project will begin with relatively simple studies focused on relatively well constrained problems that can be readily compared against in-situ observations documented in the literature (i.e. deformation characteristics of individual pillars/entries; immediate roof stability in individual entries; settlements associated with full panel extraction). Concurrently, simple larger-scale models based on the conceptual cases presented by Frith & Reed in the solicitation references will be tested to verify some of their "big picture" claims. Once confidence in the individual components of the proposed modeling approach has been developed through the preliminary investigations, and the broader mechanistic framework is understood based on the simple large-scale models, more complex models will be developed. These complex models, which will be the project focus for the latter half of the proposed project timeframe, will be used to test specific parametric influences to address the research questions identified in the Alpha Foundation project solicitation. Ultimately, the findings from these modeling activities will be synthesized to identify the key mechanisms and controlling design and geological parameters which must be considered in future studies and design activities. This outcome is expected to eventually lead to an improvement in pillar and roof support design approaches which will eliminate the potential for mine collapse and the associated risk to worker safety.

Specific Aims: Four specific aims are proposed to achieve the research objective:

- Establish an approach for numerical representation of pillar strength.
- Establish an approach for numerical representation of roof and overburden mechanics.
- Develop baseline numerical models to test illustrative conceptual model cases.
- Quantify parametric interactions and influences on overburden and pillar stability.