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Evaluation of Coal Pillar Stability effect in geotechnical engineering

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Abstract
Geotechnical factors influencing pillar strength and overburden stability are analyzed in this paper. The work highlighted the importance of geological, mining and design factors The influence of design factors is quantified using FLAC as well as load transfer data from U.S. coal mines. Dynamic effects are analyzed using UDEC showing how marginally stable pillar designs could fail as dynamic stress is transferred over a 120 m wide barrier. Popular empirical methods are evaluated while proposing means for accounting for confinement. New data are included for weaker coal seams in soft tertiary strata of the study site at shallow cover.

Keywords: dynamic loading, pillar strength, load transfer, horizontal stress.

1. INTRODUCTION

This Prudent design of coal pillars in room-and-pillar panels or highwall miner panels requires an estimation of in-situ pillar strength, overburden lateral load transfer capability, and a failure criterion. Pillar strength is typically determined using one of empirical pillar strength formulae which are either based on laboratory testing (Bieniawski, 1968; Salamon and Munro, 1967; and van der Merwe, 2002) or theoretical considerations (Wilson, 1972; Baron, 1983). These empirical methods are useful for preliminary investigations but lack provisions for including site-specific conditions including layered coal, confinement stress and groundwater conditions, among other factors.

The determination of how much load a pillar is expected to take is partially dependent on the ability of overburden to transfer load laterally. The load transfer distance (LTD) is an important consideration for selection of panel widths and barrier pillar designs. It is the maximum distance over which the overburden can transfer loads. By limiting panel width below a distance equal to twice the LTD, the operator would prevent full tributary loading of pillars. To avoid any load transfer toward the next panel, the barrier pillar should be wider than the LTD. Because the LTD is depth dependent, wider panels can be protected by the pressure arch at greater depth but narrower panels are required at shallow cover near the outcrop. This is particularly important for highwall miner panels where panels are driven typically at low cover near the highwall face. Pillar stability near the free highwall face is further compromised by reduced confinement effects perpendicular to the highwall face.

In this paper, based on back analyses of stresses associated with local and regional failures over a large number of highwall mining panels, the authors identify geotechnical factors influencing pillar strength and overburden stability, emphasizing the role of horizontal stress, among other factors. The usefulness and limitations of popular empirical methods are discussed while proposing means for accounting for confinement for U.S. coal seams 4257 including a new lower bound for some weaker tertiary strata at the recent study site. At this site a series of overburden collapse events, some preceded by seismic events, resulted in a significant amount of subsidence, over a large central area encompassing 10 highwall miner panels under a variety of hydrogeologic, mining and stress conditions. In addition, gradual failure of the overburden over few panels in the northern highwall miner district provided additional insights. Figure 1 presents panel layouts and subsidence contours. Typical highwall mining layouts consist of 20-entry panels isolated by 10 m wide barrier pillars.