Technology News

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LAYOUT: A Bump Hazard Assessment Model

Objective

To provide coal operators with an easy-to-use stress control design procedure to minimize coal mine bumps during room-and-pillar retreat mining conducted with available continuous mining machine technology.

Approach

The goal of this U.S. Bureau of Mines (USBM) research was to facilitate safe and efficient room-and-pillar retreat mining of bump-prone coalbeds by limiting coalbed stress adjacent to expanding gob areas through variation of section layouts. The first step was design of total-extraction pillars and their associated pillar-extraction plans. The second step was development of a coalbed strength model. The third step was development of stress limit design criteria. The fourth and final step was development of a methodology to estimate the magnitude and distribution of development and abutment loads applied to the pillar line.

The linear geometry of unlimited-width sections allowed for the accomplishment of step four with the tributary-area and linear shear-angle concepts. Increasing overburden depths required limited-width sections separated by barrier pillars to control stress within total-extraction panels. The accomplishment of step four with limited-width section designs required prediction of abutment load distributions for rectangular gobs and apportionment of these loads over mixed pillar sizes. A parametric study of the complicated interaction of various combinations of overburden depths, total-extraction panel widths, and abutment pillar widths was conducted with the USBM-developed boundary-element program MULSIM/NL.

Total-Extraction Pillar Design

This method does not require multiple working places within pillars; thus, roof support and ventilation personnel are not subjected to the extreme bump hazard of working within a pillar while it is being mined. As pillar width and length increase, the ability of the pillar to support the combination of development and abutment loading increases. Therefore, as overburden depth increases, so must pillar size, while allowing for efficient and bump-free extraction. However, even nominal pillar size increases can dramatically complicate pillar extraction. Pillar-extraction plans using extended-cut mining could allow for the efficient extraction of relatively large pillars. A "Christmas tree" extended-cut pillar-extraction plan approved by the Mine Safety and Health Administration (MSHA) that employs four mobile roof supports to extract 18.3- by 24.4-m (60- by 80-ft) pillars is suggested (figure 1).

Pseudoductile Coal Pillar Strength Model

To facilitate consistent coal strength input for the design methodologies for both the analytical unlimited-width section width and the numerical (MULSIM/NL) limited-width section, the USBM developed a pseudoductile coal pillar strength model. Confined pillar core, yielded perimeter strength, and depth of the yielded perimeter were based on in-mine geotechnical evaluations.

Stress Limit Design Criteria

The criteria for selecting the appropriate section design for a given overburden thickness are twofold: (1) total-extraction pillars at maximum strength must be confined to the first pillar row outby the active gob and (2) the

barrier pillar separating the previous gob and the active gob must not yield until the total-extraction panels on both sides of the abutment pillar have been mined. The first row of total-extraction pillars is designed not to yield under the combination of development and abutment loads. The abutment pillar criteria ensure that the abutment pillar does not yield until it is encompassed by gob on both sides.

Unlimited-Width Section Design

The unlimited-width section consists of uniformly sized pillars extracted against an infinitely wide gob. The model compares the pillar strength assumptions to approximations of development and gob-side abutment loading. Development loads are the result of the weight of the overburden directly over the coal pillar and are predicted by tributary-area theory. A linear shear angle concept is used to predict gob-side abutment loads. Distribution of the abutment load on pillars adjacent to the gob edge has been approximated by an inverse square stress decay function. Given the total-extraction pillar dimensions, overburden thickness, and coalbed thickness, a stability factor can be calculated for the unlimited-width section. The stability factor is the coal pillar strength as predicted by the simplified pseudoductile model divided by the sum of the development and the gob-side abutment pillar load. The stability factor is inversely proportional to both coalbed thickness and overburden thickness.

Limited-Width Section Design

With increasing overburden thickness and coalbed thickness, the unlimited-width section stability factor eventually falls to less than 1.0 for a given total-extraction pillar size. Such a stability factor indicates that with the unlimited-width design procedure, the strength of the gob-side pillar row is insufficient to carry the combined development and abutment loads. The simple linear geometry of unlimited-width sections requires approximation of in situ tributary load, infinitely wide gob edge behavior, and uniformly sized total-extraction pillar strength. The limited-width design criteria require prediction of abutment load distributions for rectangular gobs and apportionment of these loads over mixed pillar sizes. A parametric study of the complicated interaction of various combinations of overburden depths, total-extraction panel widths, and abutment pillar widths was conducted with the boundary-element program MULSIM/NL.

The MULSIM/NL output, when subjected to the previously described stress limit criteria, resulted in section designs appropriate for overburden depths up to 671 m (2,200 ft) in a 1.8-m (6-ft) thick coalbed.

LAYOUT: A Bump Hazard Assessment Model

The USBM developed a bump hazard assessment model, LAYOUT, as a spreadsheet template to use with LOTUS 1-2-3 in which unlimited-width and limited-width section design criteria are employed. The model assists a mining engineer in the design of room-and-pillar retreat sections for continuous miner extraction of bump-prone coalbeds. The model LAYOUT provides an essential first step in the mine design process. LAYOUT assumes that the mined coalbed is contained within bump-prone strata.

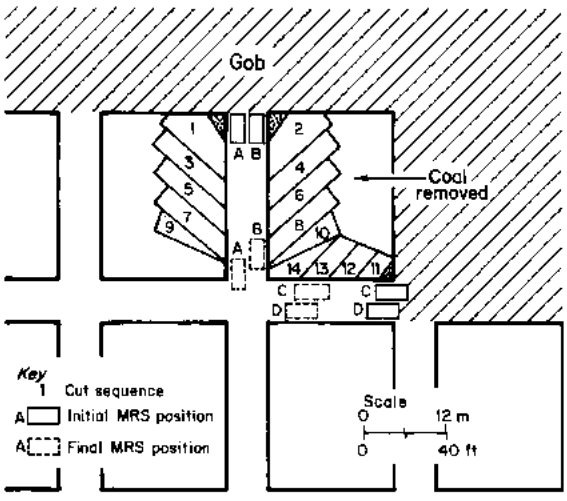
The user is requested to specify overburden depth, coalbed thickness, and total-extraction pillar dimensions. Based on this input, LAYOUT calculates (1) the stability factor for the first two pillar rows in an unlimited-width section, (2) a suggested barrier pillar width to separate adjoining sections, and (3) a suggested limited-width section design. The LAYOUT model was verified against coal mine bump case studies.

For More Information

Single copies of the LAYOUT program may be obtained by sending a blank, formatted diskette to Alan A. Campoli, U.S. Bureau of Mines, Pittsburgh Research Center, Cochrans Mill Rd., P.O. Box 18070, Pittsburgh, PA 15236-0070.

Additional information on this USBM research is contained in the report "Bump Control Design Protocol for Room-and-Pillar Coal Mining" by Alan A. Campoli, Thomas P. Mucho, and R. Karl Zipf, Jr. This paper appears in USBM Special Publication (SP) 01-95, "Proceedings: Mechanics and Mitigation of Violent Failure in Coal and Hard-Rock Mines," pp. 181-199 (1995). This 355-page proceedings volume may be ordered from NTIS, Springfield, VA 22161. NTIS stock number: PB95-211967. Phone: (703) 487-4650; fax: (703) 321-8547.

Figure 1



MSHA-approved "Christmas tree" pillar-extraction plan.