International Journal of Rock Mechanics & Mining Sciences 80 (2015) 1–11

Contents lists available at ScienceDirect

International Journal of Rock Mechanics & Mining Sciences

journal homepage: www.elsevier.com/locate/ijrmms

An innovative approach for gob-side entry retaining in highly gassy fully-mechanized longwall top-coal caving

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ARTICLE INFO

Article history:
Received 1 June 2015
Received in revised form
3 August 2015
Accepted 2 September 2015
Available online 16 September 2015

Keywords:
Gateroad layout
Gob-side entry retaining
Longwall top coal caving
Roadside backfill body
Numerical modeling
Surrounding rock convergence

ABSTRACT

An innovative gateroad layout in highly gassy longwall top coal caving in a Chinese coal mine based on gob-side entry retaining (GER) was introduced. The numerical model was used to design the rational roadside backfill body (RBB) with high-water quick-setting materials. In order to improve the reliability of the numerical modeling, the double-yield model for gob modeling and the strain-softening model for RBB modeling are validated in detail. The results of the validated model indicate that when the RBB width is 1.5 m, the RBB peak vertical stress is minimal and surrounding rock convergence variation of GER becomes gentle. Consequently, the rational RBB width can be estimated as 1.5 m. Field test and field monitoring indicate that the GER in N2105 panel with a width of 1.5 m roadside backfill body and high-strength cable-rockbolt support could meet the requirement for gas drainage and ventilation during panel N2105 was retreating. It also proved that the new gateroad layout met the requirement for the highly gassy thick seam operation, and provided a new way to the coal mine safety production in similar conditions.

1. Introduction

In the past few decades, fully-mechanized longwall top-coal caving (FLTC) has been widely employed in Chinese coal mines.[1] With the increase of production per unit time, the relative abundance of methane increases and the required gateroad section was greater, especially in the coal mine with large gas content, which threatened gateroad layout and its ground control in FLTC. In order to solve these problems, multi-entry gateroad layout namely, *three-entry system*, *four-entry system* and *five-entry system* have been massively adopted in highly gassy FLTC.[2,3] For instance, four-entry gateroad layout system shaped with "double U" was employed in the FLTC of China (Fig. 1a). Both of the entry 6 and entry 7 were intake entries, and both of the entry 4 and entry 5 were air-return gateroads in panel #2. Intake entry (entry 7), gas-drainage entry (entry 4) and bleeder entry made up of the outer U ventilation system; headgate (entry 6) and air-return gateroad (entry 5), open-off cut, cross-cut and gas-drainage entry (entry 4) made up of another ventilation system. Meanwhile, in order to ensure a whole ventilation system air-return gateroad (entry 5) behind of the panel must be retained.

Wood cribs had been used for gob-side entry retaining (GER) inside the entry before (Fig. 1b). As a result, there were some disadvantages including small section of entry retaining, poor ventilation, inflammable, intensive labor, auxiliary transport and low construction speed. These disadvantages would have an influence upon gas drainage of the gob and upper corner. For the past few years, high-water quick-setting materials had been successfully employed for the roadside backfill body (RBB) of GER, which had the advantages including fast concretion, high intensity and rapid increase resistance.[4] Meanwhile, investigations on structure characteristics of GER surrounding rock, abutment pressure distribution of GER and control techniques of GER surrounding rock have been carried out in Chinese coal mines. Hence, the authors attempt to propose a new approach for GER in highly gassy FLTC (Fig. 1c) based on the field test and numerical modeling.

2. Mining and geological conditions

The present analysis was based on the mining conditions of the panel N2105 in Yuwu Colliery, Shanxi Province, China. The coal seam is 6.3 m thick. The average overburden depth is 575 m, and the average dip angle is 1.5°. Rock strata above the coal seam are composed of siltstone (5.2 m thick), fine sandstone (6.4 m thick), siltstone (3.1 m thick) in the ascending order. Meanwhile the floor

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http://dx.doi.org/10.1016/j.ijrmms.2015.09.001
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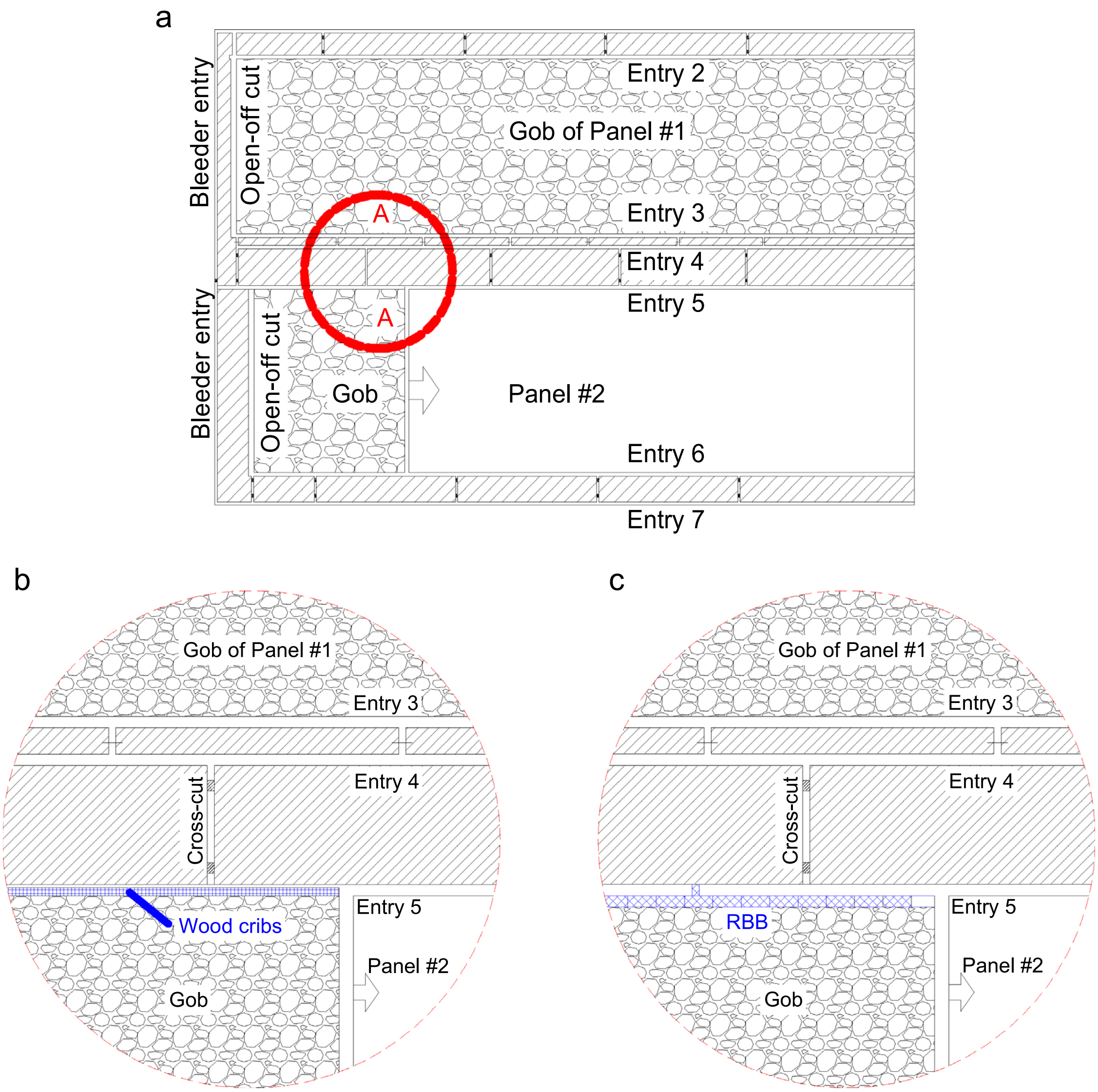

Fig. 1. Sketch of four-entry gateroad layout. (a) FLTC panel gateroad layout. (b) A-A magnification with wood cribs inside the entry. (c) A-A magnification with the roadside backfill body.

strata below the coal seam are composed of mudstone (1.5 m thick), fine sandstone (2.9 m thick), sandy mudstone (3.2 m thick) in the descending order. The generalized stratigraphy in the headgate zone of panel N2105 is shown in Fig. 2a. The panel N2105, a FLTC panel with mechanized mining height 3.6 m, is 285 m wide by 2,164 m long, extracts the No.3 coal seam, and develops by the four-entry system with all entries 3.6 m high by 4.8 m wide excavated along the seam floor (Fig. 2b). The panel N2105 cuts coal seam 6 slices with a single slice 0.8 m everyday. The panel N2105 is measured out that coal seam gas content was 8.51 m^3/t on average, and to the gassy face. The yield pillar width is 8 m, and the stiff pillar width is 35 m.

3. An innovative approach to GER in FLTC

3.1. The rational of gateroad layout in FLTC based on GER

3.1.1. Structure characteristics of GER surrounding rock with roadside backfill in FLTC

Roof strata movement of GER can be divided into three stages including early movement, transitional movement, and late movement (Fig. 3).[5,6] In the early movement stage, the top-coal caved, and the main roof will fracture for period weighting. The front abutment pressure has an effect on the gateroad before GER.

In the transitional movement stage, the main roof will fracture above the solid coal, and the roof above the GER will sink and rotate towards the gob, which makes the side abutment pressure transfer into the inner solid coal. Meanwhile, a fractured zone will form at the edge of solid coal and the de-stressed zone will be in the range of 0–7 m.

In the later movement stage, the main roof and the immediate roof will fracture beside the roadside backfill body (RBB) because of the RBB supporting and strata movement, which decreases the load-bearing of the RBB. The main roof will sink and rotate until the RBB resistance meets the requirements of cutting the main roof; after the main roof being cut, the main roof will form the stable masonry beam structure to provide a low stress environment for GER surrounding rock.

3.1.2. The abutment pressure distribution of GER with roadside backfill in FLTC

Four-entry gateroad layout system was employed in the USA to prevent coal bumps. Carr et al. published the measured vertical