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Mitigation of floor heave in West Kentucky Coal Mine

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ABSTRACT

A West Kentucky mine operation in No. 11 seam encountered floor heave, due to the localized increase in the thickness of the fireclay mine floor. Floor heave has overridden seals installed in two mined out panels. The third seal's location was planned for isolating that area from the Mains. A plan of support has been developed to prevent repetition of the floor heave and related problems outby the seals. The applied ground control measures were successful. An attempt of a 3D numerical modeling was made; thus, it would match the observed behavior of the mine floor and could be used as a design tool in similar conditions. The paper describes sequence of events, an applied mitigation ground control system, and the first stage of numerical modeling.

1. Introduction

West Kentucky Coal Mine operation in the No. 11 seam has approached an area where the fireclay floor thickness increases to about 1.5 m. Delayed floor heave has been observed. In the first sealed area (Panel KK), floor heave has overridden the seals and has begun to progress outby. This could not be allowed at the new seal location PP described in this paper because such override would affect the Mains. Previously numbers of standing support systems were used, but their effectiveness was not satisfactory as is illustrated in Figs. 1–3. Therefore, with sealing of the next area approaching, a better solution that would eliminate the problem was looked forward. In that stage, our team studied carefully the geology and strength of roof and floor, as well as the characteristics of ground failure around the seal at the first site. The technical literature has been searched as well by Haramy et al., Hsiung and Peng, Peng, Santos and Bieniawski, leading to factors caused ground failure can be identified [1–4]. It has been determined that increased fireclay thickness from typically less than 0.6 to about 1.5 m, when compared to the previously mined parts of reserve, and the strong limestone strata just above the immediate roof composed of 0.6 m of black shale, created conditions for failure. It appeared that, when pillars were punching into the mine floor, the strong roof did not break but bended and exerted high pressure on outby pillars, causing rib failures and closure. This is a similar mechanism to a strong roof affecting longwall shields. The remedial action planned was additional support.

As noted in Fig. 1, an arrow shows the change of strata, and fireclay (FC) thickness around 1.5 m out of it a top of 10.16 cm is soft and rooted, below that FC is still weak but less rooted, and its strength increases with depth as it becomes more limey and sandy.

Numerical modeling has been used to assess the contributions of the particular type of ground control used at the site. The applied system has been successful, but it is not certain whether it was conservative, though certainly it was expensive. The first stage presented in this paper deals with floor heave calibration of the model. Future efforts will focus on examining the contribution of other means of support and the presplit.

2. Description of the site

Fig. 4 shows the site map. Mining height was 2 m. Pillar centers in the panel were 18.3 m × 21.3 m and in the Mains 21.3 m × 24.4 m.

Seals KK were overridden from severe heaving, pillar/rib failures, and damage to standing support; blue dots are convergence stations; and orange presplit line created in strong roof strata (Fig. 4).

3. Geology

Geologic sequence at the site was determined based on the closest core hole (Fig. 5), floor composition exposed at the undercast

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Fig. 1. View of floor composition at undercast.

Fig. 2. Floor heave in the area without support.

Fig. 3. Rib failure and spalling.

and bore scoping observations in the drill holes for pre-splitting, as shown in Fig. 6. The strata composition at the site was similar to that in the core hole, as observed through bore scoping.

No. 11 coal seam (arrow) is from 225.16 to 227.02 m, and it was determined that 3.66 m would be an appropriate depth of a pres-plit to break the strong roof (Fig. 5).

4. Secondary support implementation

The additional supports at seal location PP are as follows:

(1) Introduction of additional support near the seal area before ground deformation started.
(2) Presplitting of the strong roof strata by blasting along the second inby break parallel to the new seals (PP).
(3) Confinement provided for the weak floor strata by wall-to-wall screen mats, on which there are 90.72 tonne cribs and steel channels with Heintzman posts standing on them.
(4) Two sag stations set in the entries of the Mains (in front of the seals and in the entry next to the barrier pillar separating the sealed panel).

The ground control system has been succeed to this point (March 2015) since closing seal set PP (in late September 2014), and both sag stations did not show closure (0 and 12.7 mm, respectively). Previous floor heaving and other stability problems occurred within six weeks.

Fig. 7 is a hand sketch of the secondary supports installed near sealing location PP. The presplitting blasting pattern has been tested for its effectiveness at the site. The blast holes drilled vertically to the roof were 35 mm diameter and approximately 3.66 m deep, every 0.46 m along the presplit line. In the first test, every second hole was loaded and blasted, but a continuous crack was not achieved. In the second test, every hole was loaded and shot, which gave a continuous presplit crack as planned. The details of the standing supports and blasting arrangements are shown in Figs. 8 and 9, respectively. Fig. 10 is a photograph of the presplit line produced by blasting.

As noted in Fig. 8, there is an another view of the inby, near seal support consisting of 7.62 cm crib on 18 m centers, Heintzman leg 90.72 tonne in the crib, steel channel 15 22.32 kg/m, over 0.66 cm welded mesh.

As is evident in Fig. 10, a close-up of the effect of roof shot-a continuous crack in the limestone (blue arrows) between the neighboring holes has been created as planned.

5. Numerical model

The plan for full analysis of this case study can be seen in items 1–4, although only item 1 is included in this paper:

(1) No additional support other than mine development (presented in this paper).
(2) Presplitting of roof only (future efforts).
(3) Floor control with screen and cribs (future efforts).
(4) Combined presplitting and support as in item 3 (future efforts).

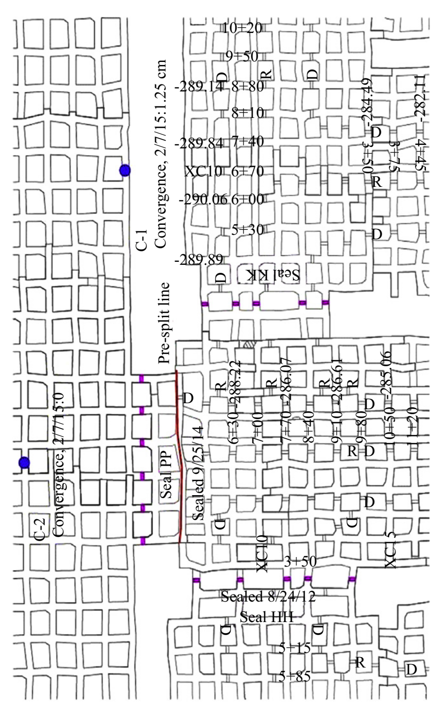

Fig. 4. Map of the area to be sealed (PP).