Study of deformation manifestations in the excavation working floor when it is supported by roof bolting

VF Demin¹*, TK Isabek¹ and NA Nemova²**
¹Karaganda State Technical University, Karaganda, Republic of Kazakhstan
²Chinakal Institute of Mining, Siberian Branch, Russian Academy of Sciences, Novosibirsk, Russia

E-mail: *vladfdemin@mail.ru; **nemova-nataly@mail.ru

Abstract. The diagrams for supporting workings by floor and roof bolts are considered, which allow to reduce the swelling of floor rocks and manifestations of rock pressure. The degree of influence of mining and engineering factors on the bolting effectiveness of workings is established.

1. Introduction

Among major factors responsible for a decline in the underground excavation rates are: mining and geological conditions become more complicated, as the mining operations reach depths below 600 m; an increase by 35–40% in the cross-sectional area of the adjacent mine workings; a lack of knowledge of geomechanical processes in the rock mass around the workings (on lower horizons), and of the bolting efficiency under these conditions.

There are different methods to deal with rock swelling in mine workings known to the world that are capable to ensure their repair-free maintenance by means of artificial softening or strengthening of the marginal rock mass. The layers of marginal rock mass composing the floor rocks differ in physico-mechanical and geometrical parameters, strength characteristics and distance to the mine contours.

The floor rocks swelling decelerating strategy tested on coal seams in Karaganda coal basin was based on the simulation of the stress-strain state of the massif of mine workings with rectangular and arched sections using the floor and corner roof bolts of various lengths [1–3]. The maximal reinforcing effect was obtained by roof bolting in the case of workings of a rectangular section.

In this paper, we consider a scheme for installation of side bolts, which suggests placing the upper sidewall bolt (usually deep-seated) in the abutment pressure zone out by the working face for shifting the peak of rock pressure deeper into the rock massif beyond the deformation propagation zone, while the lower bolt serves as a shielding zone from the coal ribsides spalling and sloughing into the floor rocks.

2. Problem formulation and modeling results

The schematic diagram (Figure 1) shows the layers of different lithologies representing the roof and floor rocks favorable for gas drainage in the fringedrift of the Saranskaya mine, Karaganda coal basin.

It was established that the deformation processes were almost undetectable in the floor when roof and sidewall bolting was used in combination with the floor bolting, while manifestations of the rock pressure were equally negligible. The magnitude of the floor rocks heave equals the value of 0.02–0.04 m. The simulation of the stress-strain state of the workings in the coal seam with the use of different length floor bolts (from 5.0 to 2.4 m) revealed that the influence of the application of longer...
sidewall bolts 2.4-3.5 (floor bolts length : 5.0 m) on the deformation pattern associated with the swelling of floor rocks was insignificant (Figure 2). Shear stresses in the floor rocks vary from 20 to 25 MPa. The stress state of the floor rocks is not dependent on the floor bolts length. The deformations and stresses in both the sidewall and floor rocks are shown to be influenced by the sidewall bolts rather than by the floor bolts.

Figure 1. Geological conditions of the roof and floor rocks (Saranskaya mine).

Figure 2. Deformation characteristics of marginal rocks supported by the sidewall bolting (in the upper part) and by the floor bolting.

The disadvantage of the known floor rocks support systems stems from the fact that installation of the inclined bolts in the roof and sidewalls potentially leads to displacements of the ribside rocks [4–8]. Figure 3 shows a relationship between the time-dependent relative deformations in the floor rocks layers and the working face advancing deeper into rock mass.

Figure 3. Relative deformations of the floor rock horizons with time, m: 1—1; 2—1–2, 3—2–3; 4—3–4.5.
The method of roof bolting of the cross section of mine opening consists in blasthole drilling integrated into the roof bolt drilling task during setup entry development. In this case, the lower sectional bolts are installed in the sidewalls at an angle of 20–25° relative to the horizontal plane at the height of bolts placement on the sidewalls, which is equal to 1/3 of the headway. The bolting length is determined by the formula:

\[ L_{\text{bolt}} = \frac{\kappa_e B_w \Pi_{\text{swell}}}{P_n} \, \text{m}, \]

where \( \kappa_e = 6.75 \) is the coefficient for the conditions of the Karaganda coal basin; \( B_w \) is the rough width of the mined out section, m; \( \Pi_{\text{swell}} \) is the floor rocks swelling, m; \( P_n \) is the footwall compressive strength, MPa.

Figure 4 shows a technological scheme of reinforcing the floor rocks of mine workings with inclined blastholes. In the lower part, the sidewall rocks are reinforced with sectional bolts, causing thereby redistribution of the stresses in the rock mass and a shift in the peak stress zone relative to the initial stress.

The observed pattern of changes in the predicted degree of floor rocks swelling estimated from the relationship between the bolts length \( L_{\text{bolt}} \) and the mining width \( B_w \) is described by the equation

\[ \Pi_{\text{swell}} = 1.22 - 1.51 \frac{L_{\text{bolt}}}{B_w} \, \text{m} \]

3. Conclusions
The studies into deformations in the floor rocks reinforced with the bolting have shown that the best feasibility is achieved by combining the sidewalls reinforcing problem solution with measures preventing the floor rocks swelling. The deformations were not developing in the case of a rectangular configuration of the cross-section of mine workings, whereas the best effectiveness of the bolting was attained when installation of bolts in the roof and sidewalls was combined with the floor bolting.

References
[1] Demin VF, Demina TV, Steflyuk YY, Karataev AD and Grachev IA 2015 Evaluation of the stress-strain state of the rock mass surrounding the underground working with rock bolting support setting Reports of XXIII International Scientific Symposium: Miner’s Week-2015 Moscow pp 73–78 (in Russian)
[2] Demin VF, Yavorsky VV and Demina TV 2015 The study of the stress state of the marginal array around excavation workings, depending on the influence of mining and technological factors
International Journal of Applied and Basic Research No 7 Part 2 pp 196–200 (in Russian)

[3] Novikov AO, Sakhno IG, Gladky SYu and Shestopalov IN 2007 Mining studies of deformation features of bolted array School of Geomechanics-2007 Donetsk: DonNTU pp 53–58 (in Russian)

[4] Aleksandrov SN, Kasyan NN, Novikov AO and Shestopalov IN 2012 Deformation of the rock mass that accommodates the development workings with bolting Mining Informational and Analytical Bulletin pp125–134 (in Russian)

[5] Novikov AO and Sakhno IG 2007 Investigation of the features of deformation of the rock mass that accommodates production, bolted support Izv. DonNTU No 1 pp 82–88

[6] Novikov AO, Gladkiy SYu and Shestopalov IN 2008 On the peculiarities of deformation of the rock mass that accommodates preparatory workings with bolting Izv. DonNTU No 1 pp 120–129

[7] Novikov AO, Gladkiy SYu, Shestopalov IN and Navka EA 2012 On the deformation of the roof in the mounting bolting with bolting Prospects for the Development of Underground Space: Conference Proceedings pp46–50 (in Russian)

[8] Kovalevskaya IA, Malykhin AV, Gusev AS and Movchan VS 2015 Research and calculation of side bolts that are set at a height of roof brushing in excavation Sbornik nauchnykh trudov Vol 9 pp 313–317