Computer modelling of a floor heave in coal mines

A A Ilinets, A A Sidorenko, Y G Sirenko

Saint-Petersburg mining university, 2, 21 linia, Vasilievski ostrov, Saint-Petersburg, 199106, Russia

E-mail: andrey4729@hotmail.com

Abstract. The paper presents results of numerical modeling of the longwall gateroad floor heave in the Taldinskaya-Zapadnaya-2 mine. The research is conducted using the finite element method. The research has shown that the floor heave can be reduced when using the relieve slots which are cut in two areas. The reasons and the mechanism of a floor heave of entries are considered. Influence of the major geological and mining factors is revealed. Recommendations about decrease in heave in entries of coal mines are made.

1. Introduction

The main method of underground coal mining is longwall mining [1-2]. One of the basic reasons for a decline in longwall output while seams mining at depths of 400 m and deeper is stability violation of entries as a result of a floor heave [3-7]. The floor heave of entries is a result of swellings of rocks formation during increase in their humidity, or extrusion and crushing of floor rocks in folds from under the regional parts or pillars which are stress concentrators.

In the conditions of the Taldinskaya-Zapadnaya-2 mine, when mining thick flat seam 70 on longwall panel 7009, the increased swelling of rocks of the floor of the ventilating entry protected by a coal pillar 40 m wide (figure 1) was observed. The heaving intensity of rocks of the floor increased in a bearing pressure zone of longwall 7009. On the roadway of a longwall to a ventilating entry, the floor heave in some cases reached 3.0-3.5 m. As a result of a floor heave on the considerable part of a longwall panel and roof rock collapse, work of a longwall 70-09 was characterized by low outputs, which were 5-10 times lower than planned that led to an increase the duration of longwall panel mining of more than twice and has caused a considerable economic disbenefit.

Considerable experience of floor heave control is accumulated in deep mines of the Donetsk and Pechora coal-mining field [8]. There are two groups of floor heave control methods [9, 10]. The first group contains methods of unloading of the array surrounding entry:

- using of protective effect of seam mining (overmining or undermining);
- application of camouflage detonation of the floor;
- application of the coupled narrow rubble strips directly on each side of the extraction entries;
- a method of unloading of the floor of bedded entries by the boreholes in entry ribs;
- drilling of a relieve slot in the floor of entry.

The second method is an active unloading and the subsequent hardening of rocks of the floor:

- bolting of rocks of the floor;
- use of flexible and rigid circular supports or roof supports with the outbye arch;

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• application in a bearing pressure zone ahead and behind a longwall face of the preliminary strengthening supports from a special profile with compound sole pieces.

The technological schemes of carrying out and maintenance of extraction entries applied now using the roof bolting, including support setting of strengthening in a zone of influence of a clearing face or in increased rock pressure zones, in some cases do not provide maintenance of free roadway that leads to additional costs and losses from equipment downtimes of longwall faces.

The method of protection of development openings by compensation of the roadway offered in the paper of Kuzmin S.V. [11] is interesting for the mining thick coal seams. The idea of work consists in providing an inconsequential loss of cross-sectional area with the development opening protected by means of compensation openings. Recommendations about the sizes and location of compensation openings of rather mined-out space are made. However application of this method in real mining-and-geological conditions demands considerable economic and temporary resources. Besides, at the solution of a task the author leaned on researches on flat models which do not consider influence of bearing pressure of the operating longwall.

According to the conclusion on the Taldinskaya-Zapadnaya-2 mine carried out by the Kemerovo Representative office "VNIMI" [12] the preventive method of fight against floor heave consequences in working space of entry by means of compensation of loss of design height by a method of increase in height in a driving on 1.0-1.8 m is offered. Such approach to a solution does not influence process of a floor heave, and only allows to carry out works without critical loss of height of entry.

Proceeding from international experience and the analysis of experience of coal mines of Vorkuta and Donbass [13-17], it is offered to consider option of application of slot-hole unloading in entry sides for reduction of size of a floor heave.

When forming a relieve slot the shift of a maximum of tension from an entry contour deep into of an array (pillar) is provided; therefore the zone of possible crushing of rocks is also displaced deep into an array (pillar). The efficiency of such method of fight against swelling is defined by variables of the cut slot. As the machine, use of serially released Urals 50 machine having the following characteristics is possible: technical production rates at the resilience of rocks to cutting $A = 450$ N/mm – not less than 1.5 m/min; slot depth – not less than 1.2 m; width of the cut slot – up to 0.14 m.

2. Methods

The numerical analysis was carried out for Taldinskaya-Zapadnaya mine conditions with use of a finite element method. For research the 2D model of the rock massif has been created. The model consisted of: the containing rocks, coal seam, a goaf and a coal pillar (figure 1). We modelled deformed states of the intense rock massif in the conditions of plain strain.
At the first stage research modeling of heave in the conditions of the 70 seam of the Taldinskaya-Zapadnaya-2 mine was carried out. Prior to numerical modeling mine observations of a floor heave have been executed that has allowed to specify data on strength properties of rocks. Results of mine observations were used at numerical modeling. At the second stage the floor heave decrease method with using an unloading slot was modelled. Two options of carrying out the unloading slot were considered: on the one hand entries and from two areas.

3. Results and Discussion
Figure 3 shows results of numerical modeling and mine observations in the conditions of seam 70 of the mine Taldinskaya-Zapadnaya-2. The floor heave leads to reduction of height of entry by 1-1.5 m out of a zone of influence of bearing pressure of a longwall. the 2D model does not allow to model influence of a longwall; therefore heave is a result of elevated pressure in a coal pillar and low strength of rocks of the floor which are prone to a soil soaking.

Figure 1. 2D rock massif model.

Figure 2. Floor heave: a) result of modeling; b) mine observations.
Figure 3 shows results of modeling of methods of unloading an array in the neighborhood of entry with use of one compensation slot cut towards a mezhlavny pillar, and two compensation slots cut in both parties from a ventilating entry 70-09. It is possible to observe significant reduction of a floor heave in case of carrying out relieve slots in both parties from a longwall gateroad.

![Figure 3](image)

**Figure 3.** Floor heave: a) a relieve slot in a pillar; b) a relieve slot from two areas.

4. Conclusion
The executed mine observations and numerical modeling have allowed to draw the following conclusions:

- The operating longwall has a decisive influence on a floor heave in the entry protected, not desintegrated coal entirely, therefore holding research with the use of 3D models of the rock massif is necessary.
- The greatest floor heave is observed on the site of entry, small in extent (10-15 m) in a longwall that is caused by influence of bearing pressure.
- Significant decrease in a floor heave in a longwall gateroad is provided with carrying out relieve slots in two areas on depth of not less than 1.2 m. Application of the relieve slots cut only in the direction of an interpillar pillar does not provide significant decrease in a floor heave in entry.
- Application of the relieve slots changes a stress-strain state of rock massif vorokrug entries, therefore strengthening of a roof support of entry is necessary for ensuring stability of ribs and entry roof.
- Cutting of relieve slots in both parties of a ventilating entry 70-09 demands additional costs, however provides significant decrease in a floor heave of entries and allows to provide their maintenance.

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