Geomechanical substantiation of parameters of workings intersection taking into account the influence of dynamic bearing pressure

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Abstract. The technique of initial data preparation for geomechanical substantiation of parameters of mine workings interfaces is offered. The results of the mine experiment on a stressed-deformed state of a rock massif in the intersection of a belt road with a diagonal connection are presented taking into account the spatio-temporal location of the mining face. A comparative evaluation of the results of instrumental measurements and calculated displacements of the roof rocks in the intersection of mine workings was carried out.

1. Introduction

The relevance of studies of geomechanical processes in the vicinity of the interfaces of mine workings is confirmed by the difficulty of maintaining them near the faces. This is due to the dynamic change in the parameters of the bearing rock pressure, which depend on the distance between the workings intersection and the face, as well as the the rock overhang length of active roof over the gob. Therefore, studies that take into account the spatio-temporal position of the workings intersection, the face and the state of the underworked roof rocks are relevant.

Objective of the study. To carry out a mine experiment and determine the parameters of the strained-deformed state (SDS) of the rock massif in the vicinity of the intersection of the faces and development workings taking into account the effect of the dynamic bearing pressure.

Tasks of the study:

1) to develop a program and methodology for the mine experiment.
2) to make visual observations of the change in the shape, deformation and destruction of the roof and wall rocks in the intersection of the mine workings when the face advances to the site under consideration.
3) to carry out instrumental measurements of coal convergence and sloughing from the walls of the workings in the junction zone with a different spatial location of the face.
4) to conduct an assessment of the geomechanical parameters of the rock massif in the vicinity of the intersections of the mining faces and developing workings taking into account the effect of the dynamic bearing pressure.
5) to compare the results of instrumental measurements and calculated displacements of the roof rocks in the intersection of the workings.
2. Research methodology

The mine studies were conducted in accordance with the developed methodology, which included:

- V – visual observations of the rock massif condition in the vicinity of the workings intersections;
- inspection of the state of the support in the intersection of mine workings;
- monitoring of mixing depth benchmark stations (DBS) in the investigated area;
- measurement of height and width of the workings in the intersection with the help of a range finder;
- sketching;
- taking photographs.

A mine experiment was carried out at one of the mines of the Kuznetsk coal basin at the time of mining working area 1-1 (stage I), 1-2 (stage II). The mining works on the development of a flat coal seam 1 with a thickness of 3.6 m was made at a depth of 385 m in difficult mining and geological conditions.

The investigated site was located at the intersection of the best road 1-2 with a connection 1-5 and a diagonal connection 1-2-2 (then, the drift, connection, diagonal connection) prepared for the next working area 1-2 (figure 1).

![Figure 1. Fragment from the mining plan.](image)

The length of the face 1-1 was 200 m. The length of the face 1-2 to the diagonal connection 1-2-1 was 200 m, after 120 m and in the area of the diagonal connection 1-2-2 70 m. The drift, connection and diagonal connection were driven with a width of 4.9 m, 4.6 m, 4.6 m, respectively, in the coal seam with an anchorage (figure 2).
The instrumental measurements of the rock deformation in the intersection of mine workings were carried out using a mine range finder according to the proposed scheme (figure 3).

Monitoring of rock displacements in the dome of natural equilibrium of the investigated area of intersections was carried with the help of depth benchmark stations. The scheme of the stations includes the mine working, the vertical borehole, the benchmarks fixed in the borehole, the system of change in the displacement of the benchmarks (figure 3, c). For the upper benchmarks $R_{II0}$, the displacements were assumed to be zero. The displacements of the lower benchmarks $R_{II1}$, $R_{II2}$ were determined with respect to the upper benchmark $R_{II0}$.

At the first stage, when mining the working area 1-1, a visual observation of the rock massif condition in the vicinity of the investigated area and the examination of the state of the roof support and the walls of the workings intersections were carried out.

It was established that at a distance of 100-150 m behind the mining face, deformation of the bearing elements of the support was observed at 40 m from the investigated area in the direction of the gob of face 1-1. On the section of the junction of the drift with the connection the following was noted: intensive development of cracks in the roof at the intersection, delamination of the roof rocks, coal sloughing with the subsequent breach of the latticed set lagging from the side of the gob of working area 1-1 (figure 4, a).
As a result, in order to bring drift 1-2 into operational condition, the muck draw was performed with the subsequent cleaning, installation of the metal support of KMPT-27 type with a step of 1 m and baking the voids with timber (figure 4, b). Connection 1-5 and the diagonal connection were strengthened with wooden pit-prop in two rows along the walls of the working.

Figure 4. Conveyor drift 1-2 in the intersection between the connections: a – after deformation of the working; b – after strengthening with a metal support of KMPT-27 type.

At the second stage of the mine experiment, the visual observations and instrumental measurements of rock convergence at the intersection of the drift with a diagonal connection were performed while mining the working area 1-2.

3. Results and discussion
Based on the results of processing the mine convergence measurements in the investigated area and analyzing the data of roof rock displacements according to the DBS, a dependency graph of the vertical displacements distribution on the distance to the face 1-2 was plotted (figure 5).

Figure 5. The dependence of the of vertical displacements distribution on the distance to the face 1-2.

According to the results of the survey of the support on the mating of the excavations, a repeated deformation of the anchorage in the form of extrusion of the supporting elements of the anchors on the
sides was recorded at a distance of 300 m from the face of the lava (Fig. 5, section 1). At the junction with the drift, coal was extruded and subsequently exposed.

With the approach of the stoping at a distance of 100 m from the face in the roof of the drift at the intersection and for 20 m, the SVP deflection was observed in the locking part of KMPT-27 support (figure 5, section 2).

At a distance of 70 m from the face, a re-convergence of the working roof at the intersection is fixed (figure 5, section 3).

At a distance of 50-30 m from the face in the zone of influence of the bearing pressure of face 1-2, the props breach of the metal supports were observed in the places at the welding seams in 5 m from the intersection of the draft with a diagonal connection. As a result, at the walls of the drift the ejection of the coal pillar started from the finished extraction pillar 1-1 (figure 5, section 4).

In 10 m from the studied area, the intensive lowering of the drift roof was recorded during the face advancement (figure 5, section 5).

At the time of the intersection location in the alignment with the face, a critical condition of the drift support was noted (figure 6). The rock taking-down was performed at the intersection of the workings. Polymer resins were used to fill the voids of the domes in the roof.

Figure 6. Intersection of the belt road and a diagonal connection in-line with the face.

In accordance with the objectives of the study, the displacement of the roof rocks at the intersection of the mine workings was calculated on the basis of normative documents [1, 2] and instructions [3, 4] for the following options of mining engineering and geological conditions:

1) favorable geological conditions;
2) near a discontinuous geological disturbance;
3) in the zone of increased rock pressure, near the breaking disruption and water cut of rocks;
4) in the zone of increased rock pressure, near the faulting and water content of the rocks after additional exploration.

The core was taken at the site of influence of the face bearing pressure 1-2 to carry out supplementary exploration. According to the results of these studies, it was revealed that at a distance of 50 m from the face in the roof of the workings intersection, an increased fracturing of rocks was registered, which is the reason for the redistribution of stresses and as a consequence the decrease in the physical and mechanical parameters of the roof rocks, which were taken into account during obtaining calculated displacements.

Figure 7 shows the results of calculated rock displacements in the intersection roof of the drift and a diagonal connection for 3 stages of coal-face work (spatial and temporal location of the face):

1) in the zone of the bearing rock pressure (70 m);
2) for the section of workings intersection 10 m ahead of the face;
3) for the section of workings intersection in a line with a cleaning face.
Figure 7. Graphs of vertical displacements distribution in the intersection of mine workings: 1-4 according to the instruction, 5 – instrumental measurements.

The analysis of the mine measurements makes it possible to state that the calculated displacements in the investigated area in the bearing pressure zone of 10 m and in in a line with the face have a discrepancy of about 20%.

Graph 3 of displacements with calculated values according to the instruction has a similar character with the actual data up to the zone of influence of the face; however, it does not fully ensure the correctness of the forecast of the SDS geomechanical parameters of the rock massif in the zone of influence of the bearing pressure. This is the cause for unreasonable selection of the support parameters at the intersection of mining and development workings, since in most cases the calculated values are either too high or less than the actual ones.

4. Conclusions
The obtained results of the calculated displacements of the roof rocks do not fully ensure the correctness of the choice of the support parameters at the workings intersection under the influence of the dynamic bearing pressure. To obtain a more complete volume of information on rock displacements, it is proposed to perform numerical simulation of geomechanical processes and determine the parameters of the SDS rock massif in the vicinity of the intersections of faxes and development workings taking into account the influence of dynamic bearing pressure with subsequent mathematical model calibration based on the results of mine measurements.

References
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[4] Method of calculation and selection of support parameters at the intersections of workings for single and paired preparation of extraction pillars 2004 (St. Petersburg: Department of Coal Industry of the Ministry of Energy of Russia) p 84