

Anchoring of development workings in a zone of influence of mining in case of the level anchoring system

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Abstract. Regularities of the change of the stress-strain state of coal containing rock masses, depending on mining-geological factors, were revealed. These factors allow establishing rational parameters of anchoring of wall rocks to enhance the stability of development workings. Specific conditions of the deflected mode, displays of rock pressure, terms of maintenance depending on technological parameters are investigated. Researches allowed determining the degree of their development influence on the efficiency of application of the anchoring of the hollow making and will allow a reasonable application of anchoring certificates, provide stability of the rocks mining and reduce expenses on its realization and maintenance.

1. Introduction

The increase of the underground coal mining is possible only with high-performance technology and maintenance development workings, providing an increase of the volume of mining and preparatory works. An important task is the determination of the deflected mode of the massif taking into account the factors influencing the stability of the borders of the mine workings. Setting of parameters of rock massif deformation around development workings with the anchorage is an important task of the mining industry [1-7].

2. The influence of controllability of the roof rocks (with the increase of the layer of free caving mudstone) with a trapezoidal shape of a roadway cross-section

The parameters of the design diagram are: the stratum dip angle is 15° , the stratum depth is 3.8 m; the mining depth is 400 m; the mine working cross section is 1.5 m^2 ; the anchor length is 3 m with the anchor diameter of 0.022 m.

Figure 1 presents the distribution of the longitudinal stresses in the 7.5 m layer of claystone along the border of the mine working. Analysis of stress distribution shows that the areas of unstable rocks appear around the mine working. To a greater extent, it concerns the roof and the soil of the mine working, as well as its sides in the area of the lower part of lateral faces of the mine working boundaries. The maximal value of normal stresses occurs in the anchor located on the roof of the mine working in the rightmost anchor in the place of its attachment. The maximal value of the longitudinal



stress arises in the anchor located on the right lateral surface of the mine working (the first one from the bottom).

In order to reduce costs while maintaining the mine workings in the mines of Karaganda basin, the anchor support is used, which quickly takes the load and prevents the stratification of the surrounding massif and the increase of the sizes of the areas of inelastic deformations, which results in the reduction of the support load. The rock, 'stitched' by anchors, acts as a support and helps to reduce rocks displacement along the border of the mine workings cross section.

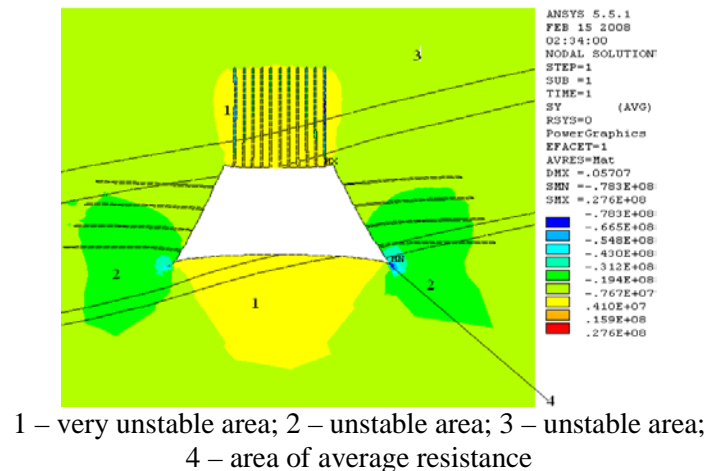


Figure 1. Distribution of areas of equal longitudinal stresses in the massif.

Rock pressure manifestations with the determination of the degree of technological factors influence are detected by the finite element method with program-methodical complex ANSYS. This method is used for the conditions of the manufacturing scheme of treatment works with reciprocal-flow airing on the K_7 stratum of the mine named after Kostenko (MD JSC 'ArcelorMittal Temirtau') with the lava 200 m long using the anchor support of mine workings. The change in stresses of the rocks massif is determined depending on the inclination angle of the anchors in the roof with the anchor length and the anchor diameter equal to 2.4 m and 0.022 m, respectively, in the mine working having a 17.5 m² section at a 650 m depth.

By changing the inclination angle of the anchors in the roof of the mine working, the normal (along axis Y) and shear stresses are changed as well. Let us present the stress distributions by the example of shear stresses τ_{xy} in the rock massif corresponding to the inclination angles of the anchors in both directions from the axis of the mine working relative to horizontal plane $\alpha = \beta = 45^\circ$ (figure 2, a), $\alpha = \beta = 75^\circ$ (figure 2, b), $\alpha = \beta = 90^\circ$ (figure 2, c). Table 1 presents the values of maximal normal and shearing stresses using the model of maximal displacement.

Table 1. Values of maximal normal and shearing stresses

α, β (degree)	σ_x (MPa)	σ_y (MPa)	τ_{xy} (MPa)	u_x (m)	u_y (m)
30	93.6	19.7	54.1	0.0028	0.1382
45	93.4	28.2	46.5	0.0028	0.1382
60	93.4	26.1	30.6	0.0028	0.1382
75	93.4	9.05	29.1	0.0028	0.1382
90	93.4	5.73	29.1	0.0028	0.1382

It has become clear from the undertaken study that the optimal minimal angle of anchors location in the roof are the angles of their installation relative to the horizontal plane equal to $\alpha = \beta = 75^\circ$. At

that, minimal normal stresses are provided from the direction of the roof rocks (2 - 3 times), and lengthy anchors (cable ones) do not fall into the failure zone of the rocks belonging to the immediate and main roof. The dependences of maximal normal stresses along axis Y are determined depending on the inclination angle of the anchor relative to the horizontal plane:

$$\sigma_{\max}^y(\alpha) = 2.7 \cdot 10^{-5} \cdot \alpha^4 - 5.9 \cdot 10^{-3} \cdot \alpha^3 + 0.4 \cdot \alpha^2 - 13.1 \cdot \alpha + 153.5$$

In accordance with the undertaken studies, the certificates of anchors, intended for development workings in the area of influence of mine workings in case of a three-level anchoring system, were designed: cable anchors – 5 m long, steel-polymeric anchors – 2.4 m long, and lateral plastic anchors – 1.8 m long. Such kind of system allowed stabilizing vertical and lateral deformations of lateral rocks. These certificates are realized when mining lava of stratum K_{12} under conditions of the mine ‘Saranskaya’ in Karaganda coal basin (figure 3).

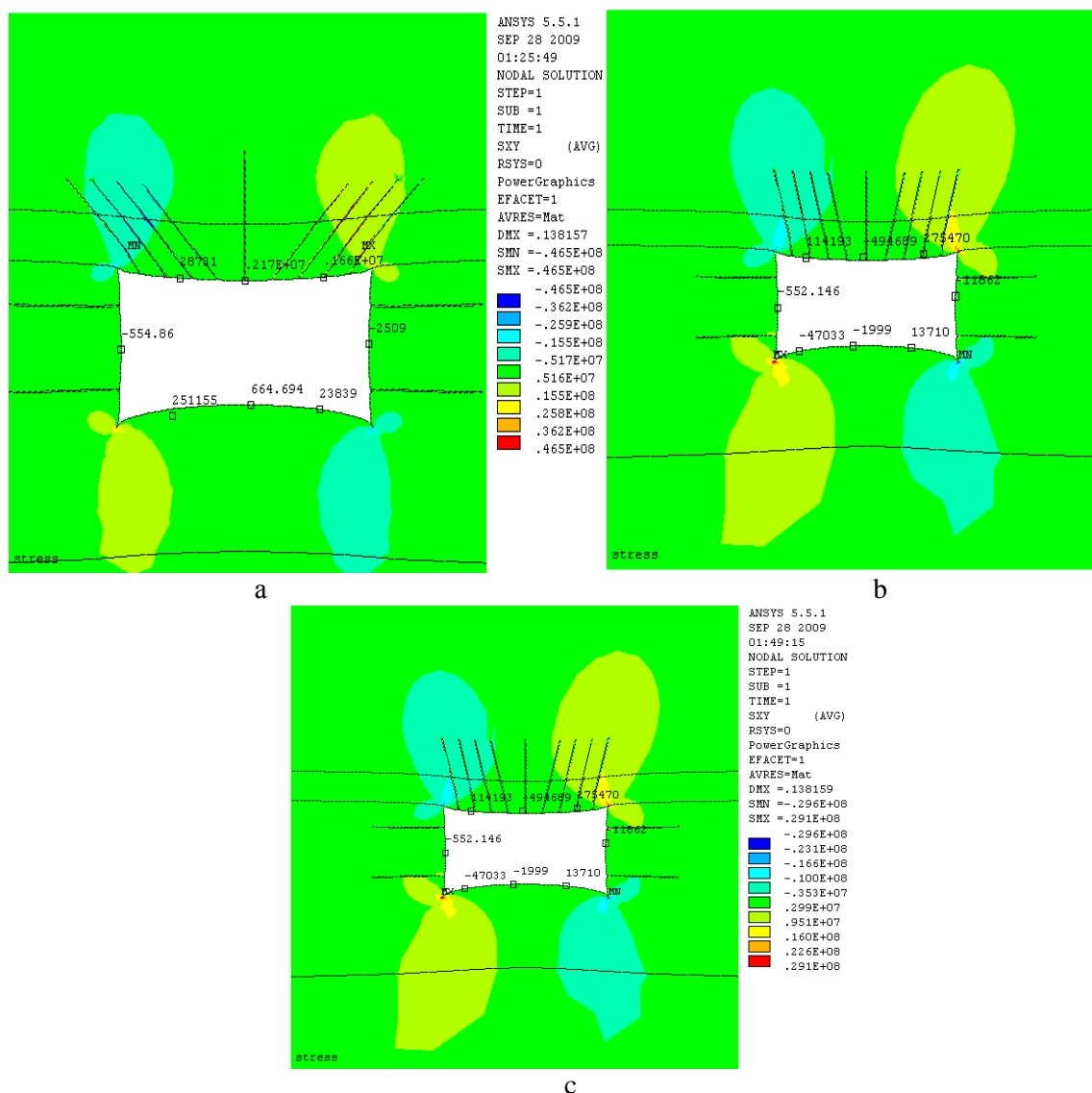


Figure 2. The distribution of shearing stresses τ_{xy} .

3. Anchoring of development workings

In connection with the identification of fractures in the upper and lower layers of the roof rocks and their subsidence over the area of linking of lava to the belt roadway of stratum K_{12} , rope anchors 5 m

long were installed at a distance of 1.5 m between them and a number of anchors. In total, at the mine working site, 100 rope anchors were installed from PC 119 to PC 112. Further observations of the state of the roof rocks with the cable anchors have established that grabs deflection in these zones is much smaller (0.3-0.4 m delamination) and allows reducing repair costs and maintenance of workings.

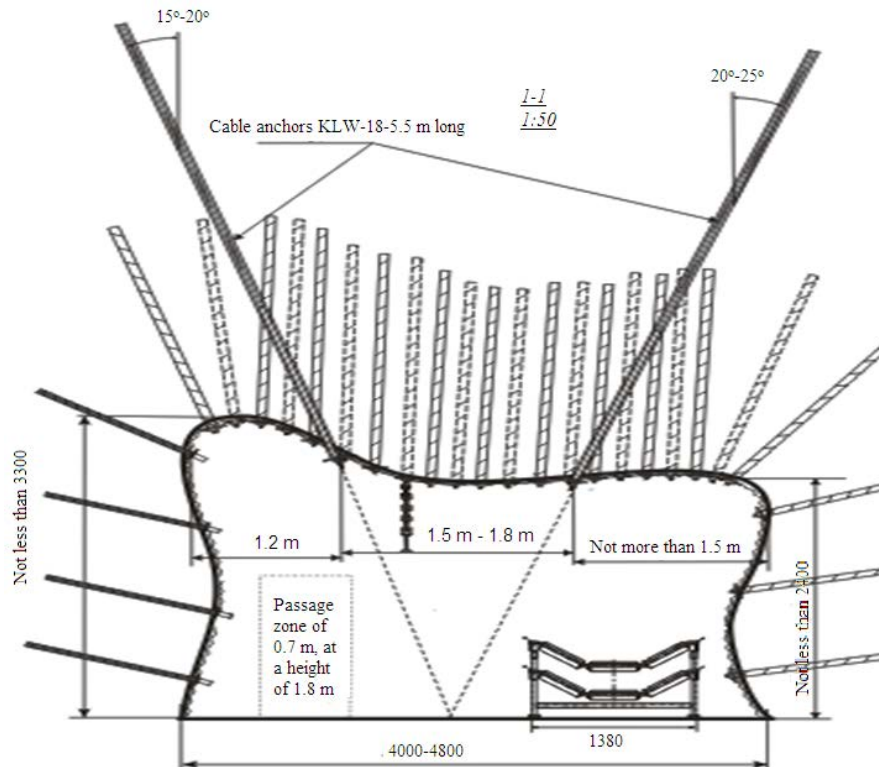


Figure 3. Development workings anchoring in the zone of influence of mining in case of a three-level anchoring system.

In future, when mining an extraction pillar in stratum K_7 , a progressive certificate of linking of the lava to the belt entry has been introduced. Anchoring of the fractured zone between the linear sections of the powered roof support and the road support with the help of steel-polymeric and rope anchors will allow consolidation of the rock in this region, which in its turn will provide the stability of rocks in the roof and reduce the labor expenditures required for retimbering of the fractured zone (figure 4). At a distance of 10-15 m ahead of the lava, 1-2 'threads' of the summer made of special section SVP-22(27), each 2.0-2.5 m long, will be hung up simultaneously with installation of hydraulic props GVKU under these threads with one meter spacing [8-10].

The discovered regularities of the change of the stress-strain state of coal containing rock massifs depending on mining and geological factors allow establishing rational parameters of adjoining rocks anchoring in specific external environment to enhance the stability of development workings and their linking to lavas.

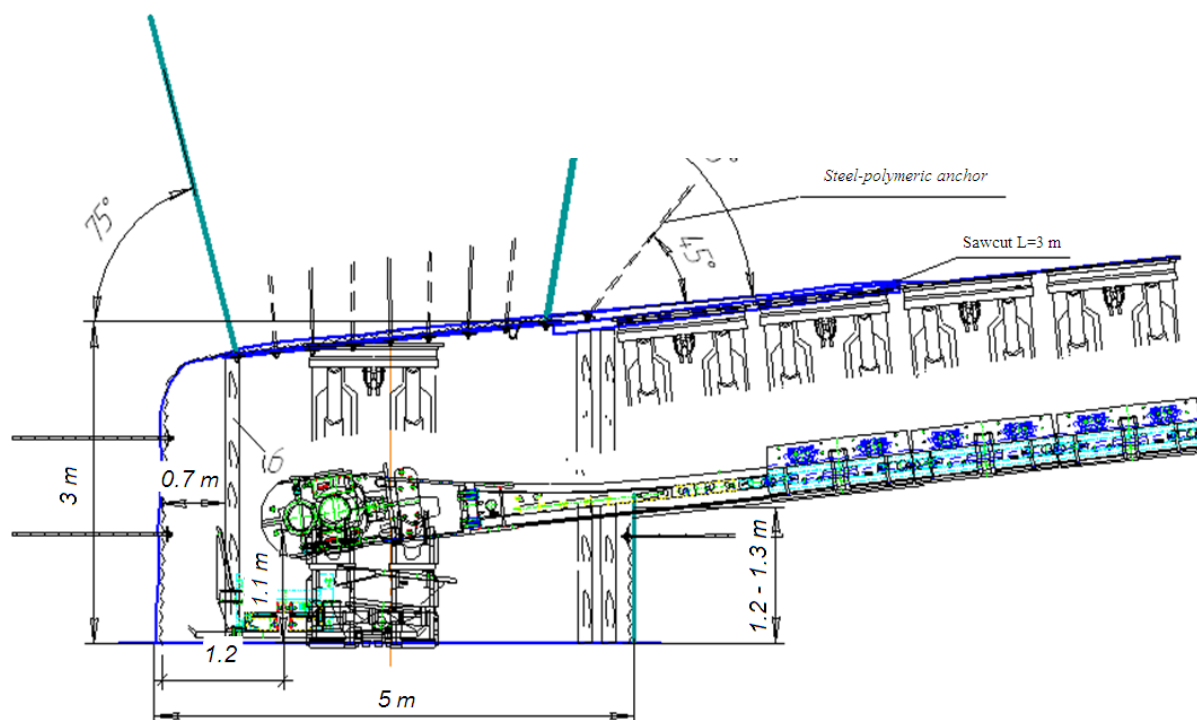


Figure 4. Anchoring of the fractured zone between the linear sections of the powered roof support and the road support.

4. Conclusion

Application of the anchoring support allows us to considerably increase labor productivity and its rate (by 30-40 %), to reduce expenses on mine workings (by 50-60 %), to lower expenditure and to reduce the cost of dunnage, repair costs and mine workings maintenance, to improve the condition of the mine workings, to approximate the cross-sectional area of the mine working in clear to the area of advance and to tighten the safety measures of mine workings.

The empirical dependences of changing of maximal normal stresses, depending on the change in the anchor length as well as on the anchor inclination angle for generation of the rectangular cross section, are obtained.

A comparative evaluation of the conducted researches and testings in the plant conditions has been made. It has shown a satisfactory convergence of the considered parameters of the deflected mode of rocks massifs.

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