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DESK STUDY INTO STRESS CONDITION OF BOTTOM LAYER OF THICK COAL BED

Prospective of underground coal mining in Russia significantly depends on mining efficiency of flat coal seams with the thickness of 7–10 m. Economic resource base of high rank coals deposited in such seams are concentrated in the Kuznetsk Basin and amount up to 12.6 bln. tons. The most common technique currently used in thick coal mining is the long-pillar method with separation of thick seam into two inclined layers. Among critical practicalities arising in thick seam slicing are the issues of securing efficient and safe mining of bottom layers, namely stability enhancement of slice sections. As a rule in present conditions the cost-performance ratio is significantly decreasing in transition of mining operations from the top to the bottom layer: roadway construction costs are increasing by 1.5–2 times, expenses on maintenance of operating conditions in workings are rising multifold, while loss of prepared reserves step up by 10–15% [2].

The goal of this desk study was to assess impact from primary mining of sections in the 1st (top) and 2nd (bottom) layers and to determine the most rational location of the layer gateways in the 2nd layer, which would secure good operating conditions throughout their performance life combined with low costs of their construction and maintenance.

The finite element method was chosen to solve the tasks of assessing the stress and strain state at the edge of the rock massive (and pillars), which applicability and efficiency are confirmed by their wide application to solve various tasks in mining geomechanics by a large number of researchers.

Design diagrams corresponding to real mine engineering situations in thick coal seam mining prone to self-ignition at the Kuznetsk Basin (Russia) were used to assess impact of various factors on the gateway condition.

Design diagram No 1 (fig. 1a) helps to assess the impact from primary mining of the 1st layer on the condition of the 2nd layer in various mine engineering situations. In this regard, impact of the 1st layer is assessed both in areas of support pressure from the sections previously

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mined to the full depth and in intact areas bordering on the coal massif. The main parameters of this design diagram are: depth of the mining operation *H*, m; pillar width between the longwall faces *b*, m; length of the longwall face *l*, m; stress-strain properties of the layer.

Design diagram No 2 (fig. 1b) helps to assess the impact from mining of the 1st layer on the condition of the section workings of the bottom layer in various mine engineering situations. The main parameters of this design diagram are all the abovementioned as well as the location of workings in the bottom layer in relation to stoping contours in the top layer: z_1, *m* — at the edge of the massif; z_2 — at the pillars between the longwall faces.

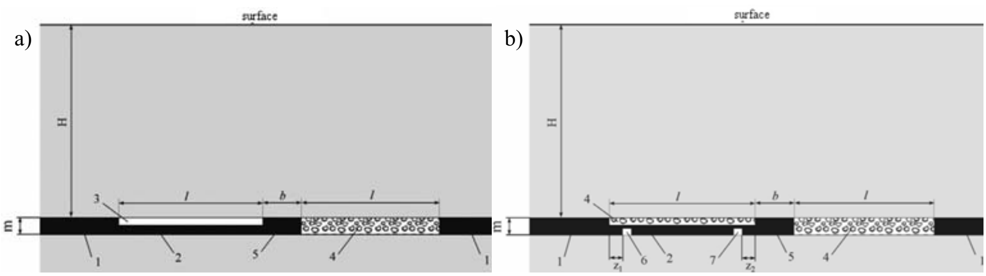

Fig. 1. Design diagrams: a — to assess impact from 1st layer mining,
b — to assess condition of workings in the bottom layer.
1 — edge of massif in 1st layer, 2 — bottom layer, 3 — mined-out space (not filled with rock),
4 — mined-out space of 1st layer, 5 — pillar between longwall faces,
6 — section workings of the bottom layer at the edge of the massif,
7 — section workings of bottom layer at pillars between longwall faces.

As the result of performed desk studies stress distribution diagrams (fig. 2) were built which show regularities of stress condition of the bottom layer at the edge of the massif and pillars between the longwall faces. The horizontal (Y) axis shows the distance from the edge parts which were taken as the reference point both towards the massif and towards the mined-out space. As it is shown, the stress concentration factor in support pressure zones was equal 2.2 at the massif edge in the 1st layer and 3 in the pillar. The zone of increased horizontal stresses continues 3 m below the mined-out space of the 1st layer at the edge of the massif (Line 2) and 5 m at the 40-m wide pillar between the longwall faces (Line 2′). Horizontal stresses in this zone exceed 5 MPa, which corresponds to the value of ultimate unixial compression stresses that lead to coal collapsing.

Thus, in this case we can draw a conclusion that at the given depth (*H* = 600 m) workings should be located outside of the increased rock pressure zones, i.e. workings bordering on the massif within the 1st layer should be located with at least a 7 m shift towards the mined-out space and workings bordering on the pillar between the longwall faces with a shift of at least 10 m.

During the survey it was determined that neighboring abandoned workings offer a significant impact on the condition of workings in the bottom layer. Presence of such workings leads to an essential increase in strains along the cross section of the working.

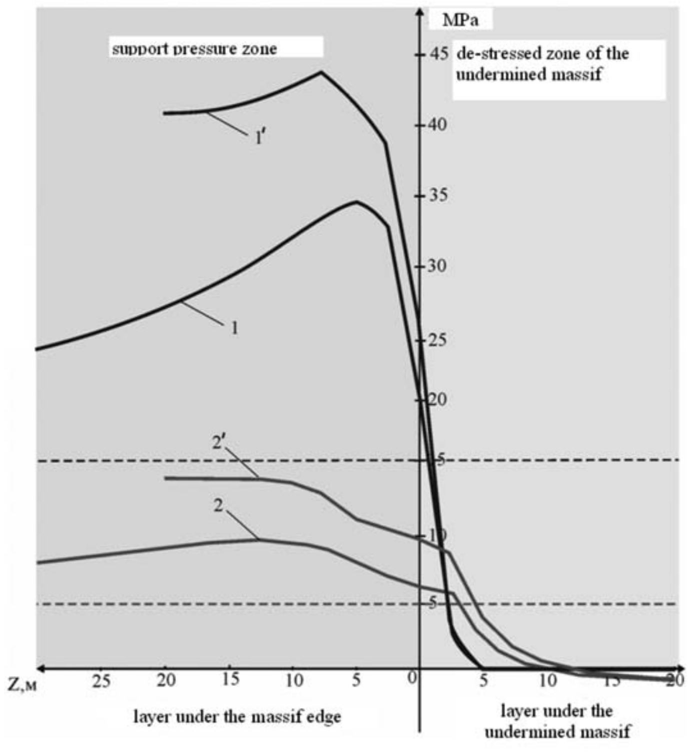

Fig. 2. Stress distribution in the bottom layer at the edges of the coal massif and at the pillar: 1 — vertical stresses, 2 — horizontal stresses

All other conditions being equal, the strain level of workings driven and maintained near the pillars between the longwall faces under workings in the 1st layer (fig. 3b and 3d) significantly (two and tree-fold, and even more) exceeds the corresponding strain level of workings driven at the massif edge in the 1st layer (fig. 3a and 3c). Meanwhile shifting of workings in the bottom layer below under the mined-out space results in considerable decrease of the strain level at their cross-section (fig. 3) and at a certain distance from the working to the edges of the bottom layer varying from 5 to 15 m no critical impact of the top layer is observed [1].

The following conclusions were made as the result of the performed desk study:

1) One of the main mining and geological factors determining the condition of sectional gateways in the bottom layers is the stress-strain properties of the coal seam. Other conditions equal, the strain level at the cross-section of the working is increasing by 2–5 times with the coal strength degreasing from $f = 1$ down to $f = 0.5$.
2) The main mine engineering factors determining the strain level in workings within the bottom layer are: location of the bottom layer workings in relation to the edge elements in the upper layer; the depth of mining operations; impact from previously mined neighboring sections.

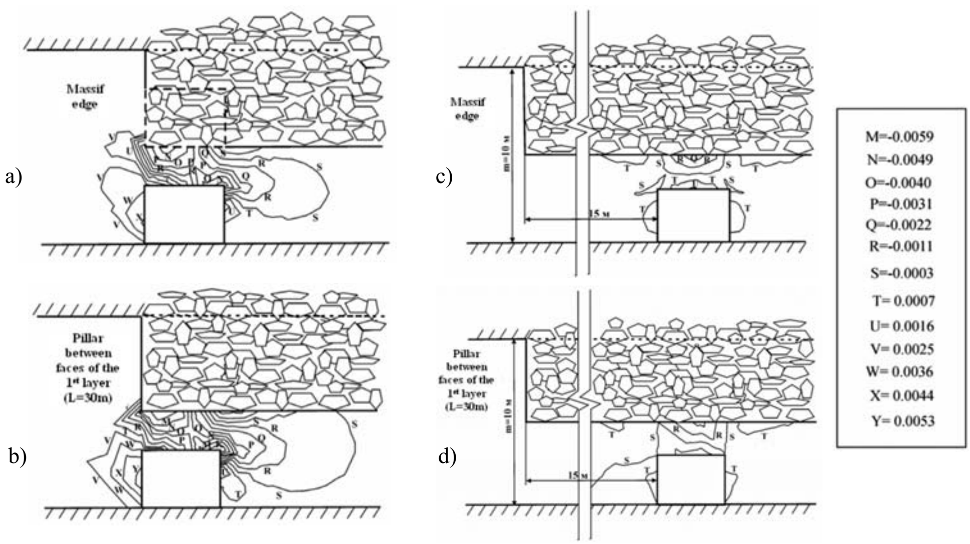

Fig. 3. Counter lines of total strain ε_x in vicinities of working of the 2nd layer

3) Minimization of costs on construction and maintenance of sectional gateways in bottom layers is achieved through their rational positioning with reference to edge elements (pillars) in the top layer. At the same time the impact of the workings location on the abovementioned costs increases with the increase in the mining depth. Thus, at the depth of 100–150 m the workings location, as a rule, demonstrates no significant impact on the expenditure level and their location below the workings of the top layer can be recommended as rational. With increasing depth of mining operations the main option is location of workings with shifting down under the mined-out space. In this case the main parameter is the degree of workings displacement in the bottom layer against the edge elements of the massif (pillars) in the top layer.
4) Location of the bottom layer workings should be determined with account for the stress level at the edge elements of the massif (pillars) in the top layer. When the bottom layer workings are located with a shift down under the mined-out space, the workings should be located outside of the zone with increased horizontal stresses, which is formed in the bottom layer at the edge elements (pillars) and is connected with the support pressure zone at the border with the mined-out space.

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