Using plane models of optically active material ED6M, the authors have simulated the following: a) an active working in a seam with thickness 10 m and angle of dip 75°, driven through the whole height of the panel (80 m) and at different depths from the surface (Fig. 1a, b, c); b) two active workings in the same seam, driven in two different panels (Fig. 1d).

In contrast to [1-4], we simulated undeepened active workings of considerable extent to the dip (the ratio of the length of the working to the extractable thickness was 8 : 1), thus requiring allowance for the force due to the weight of the solid rock.

We studied the case of mining a seam with a pillar at the surface. The solid rock was assumed to be elastic, continuous, homogeneous and isotropic, and the active working free from caved rock, supports and stowage. The aim was to assess the elastic stress in the solid rock near active workings (including the abutment pressure zone) in relation to depth, and the effects of mining operations in the superincumbent panel and of different lateral thrusts.

To establish in the model stresses corresponding to those due to the weight of the solid rock, we used the "freezing" principle in a centrifuge with \( R = 1.25 \) m. The centrifuging coefficient \( K_c = 50-58 \), corresponding to a rate of rotation of the centrifuge arm \( n = 220 \) rpm, was calculated by a known method based on obtaining a band order sufficient for the measurements (Fig. 2a). Lateral-thrust stresses were established in the models by subjecting them to a "triangularly" distributed load in an oven (Fig. 2b).

In elastic models the relation between load and stress is linear, so if we determine the stresses in the model at any two values of \( \lambda \), the coefficient of lateral thrust, the stresses can be calculated for any value of \( \lambda \). We simulated three values:

\[ \lambda_0 = 0, \quad \lambda_1 = \frac{1}{3}, \quad \lambda_2 = 1 \]

For all other possible cases the following formula is proposed:

\[ \sigma_n = \frac{3}{2} \left[ (1 - \lambda_n) \tau_1 - \left( \frac{1}{3} - \lambda_n \right) \tau_2 \right] \]

where \( \sigma_1 \) is the stress in the model with \( \lambda_1 = 1/3 \); \( \sigma_2 \) is the stress in the model with \( \lambda_2 = 1 \); \( \sigma_n \) is the stress with \( \lambda = \lambda_n \).

Each of the four models was thus loaded and "frozen" in turn under the centrifugal force \( \lambda_n = 0 \) and two lateral thrusts \( \lambda_1 \) and \( \lambda_2 \). From the 12 band pictures thus obtained we calculated the stresses by graphical integration of the differential equations of equilibrium of the plane problem of elasticity theory. The overall stress distribution curves were obtained by the superposition principle.

Analysis of the total distribution curves of vertical normal stress \( \sigma_y \) and horizontal normal stress \( \sigma_x \) show that, in the solid rock around a single undeepened active working, the horizontal stresses are concentrated in regions lying near the upper and lower parts of the working at the side of the roof and floor. However, for a working at depth...
Fig. 1. Diagrams of plane models.

Fig. 2. Diagrams of loading of models: a) in centrifuge; b) in oven.

Fig. 3. Maximum abutment pressure $o_x$ versus depth of occurrence of working $H$ at $\lambda = 1$ at boundary with roof (a) and floor (b) of seam: 2) plotted versus distance $L$ to the dip from the face.

If an extraction working is situated in the residual abutment pressure zone from the same working of the superincumbent panel [6](see Fig. 1, model d), the stress distribution around it differs from the case of a single working. The regions of highest stress are the interpanel pillar (where $o_x$ reaches 4.2-4.8 $\gamma H$, while $o_y = 1.1-2.2 \gamma H$) and the solid rock of the floor and roof above and below the pillar, where $o_x$ reaches 1.3-2.2 $\gamma H$. In the abutment pressure zone of the lower extraction working the maximum of $o_x$ is 2.8 $\gamma H$ (as compared with 2.1-1.5 $\gamma H$ for a single working at the same depth). The presence of a second working has little effect on the distribution and values of $o_x$ and $o_y$ in the solid rock of the floor and roof.

The distribution near the working depends markedly on the lateral thrust $\lambda$. Thus, as $\lambda$ varies from 0 to 1, the absolute value of the horizontal stress $o_x$ near the upper and lower parts of the working, from the side of the roof and floor and in the abutment pressure zone, increases by a factor of 4-10; the deeper the working, the more rapid is the increase of $o_x$. On the other hand, as $\lambda$ varies from 0 to 1, the vertical compressive stress $o_y$ in the roof and floor near the working decreases, and even becomes tensile. At a distance of 40 m to the dip in the abutment pressure zone, however, the tensile stress $o_y$ decreases, becoming compressive, but remains less than $\gamma H$. Thus, for an extraction working of great extent to the dip in a steep seam, the high lateral thrust worsens the stresses in the surrounding rock, especially the roof rock over the middle of the working, in the sense that, when $\lambda = 1$, $o_x$ is near to zero while $o_y$ has a concentration of $-0.3 \gamma H$.

We can thus draw the following conclusions.

1) Ahead of the face in an undeepened active working in a steep seam, the abutment pressure is governed mainly by the horizontal stress $o_x$, rather than the vertical pressure $o_y$ as in the case of a horizontal working. In this zone the stress $o_x$ at depths of 90-230 m is 1.5-2.8 times greater than $\gamma H$. 

92