INFLUENCE OF DEFORMATION AT THE CONTACT BETWEEN TWO ROCK UNITS
ON THE STRESS DISTRIBUTION DURING CUTTING OF A MINE WORKING

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Occurrences of dynamic rock pressure in ore mines show that it is very often observed when a mine working is cut through a contact between two rock units, i.e., when the advancing working emerges from one rock into another, or intersects a seam of another rock or a dike. In developing safety measures for cutting mine workings, it is therefore important to elucidate the causes of rock bursts and shock bumps at the contact between two rock units.

Let us assume that one of the rock units has a modulus of elasticity $E_1$ and a Poisson's ratio $\mu_1$, and that the corresponding quantities for the other are $E_2$ and $\mu_2$. The stresses in the bulk are the same in both rock units.

If we consider the rock units separately, then after the working has been cut, the stresses near it will also be the same at similar points in the two units. However, after cutting of the working the deformations of elementary volumes of rock at similar points will be different, and will be given by the following equations:

\[
\varepsilon'_{\rho_1} = \frac{1 - \mu_2}{E_1} \left( \sigma_{\rho_1} - \frac{\mu_1}{1 - \mu_1} \sigma_\theta' \right),
\]

\[
\varepsilon'_{\rho_2} = \frac{1 - \mu_1}{E_2} \left( \sigma_{\rho_2} - \frac{\mu_2}{1 - \mu_2} \sigma_\theta' \right),
\]

\[
\varepsilon'_{\theta_1} = \frac{1 - \mu_1}{E_1} \left( \sigma_{\theta_1} - \frac{\mu_1}{1 - \mu_1} \sigma_\rho' \right),
\]

\[
\varepsilon'_{\theta_2} = \frac{1 - \mu_2}{E_2} \left( \sigma_{\theta_2} - \frac{\mu_2}{1 - \mu_2} \sigma_\rho' \right).\]

where $\varepsilon'_{\rho_1}$, $\varepsilon'_{\rho_2}$, $\varepsilon'_{\theta_1}$, $\varepsilon'_{\theta_2}$ are the relative radial and tangential deformations in the first and second rocks, respectively, due to the cutting of the working, $\sigma_\rho = \sigma_\rho - \sigma_\rho^b$ is the change in the radial stresses at the point in question after the working has been cut, $\sigma_\theta = \sigma_\theta - \sigma_\theta^b$ is the same for the tangential stresses, $\sigma_\rho$ and $\sigma_\theta$ are the stresses near the contour of the workings, and $\sigma_\rho^b$ and $\sigma_\theta^b$ are the stresses in the rock mass existing at the point before the working has been cut.

If there is cohesion at the contact, the different deformations of elementary volumes in the first and second rock units will have the result that one unit will try to stretch or compress the other to some particular level. After equal amounts of energy have been expended, their deformation will stop in some intermediate position. Then the forces exerted by one unit on the other must be equal in modulus.

The action of one rock unit on the other leads to disturbance to the stresses near the periphery of the working, and this will be propagated from the contact to a distance equal to the diameter of the working [1]. The disturbance leads to nonuniform deformation of the periphery (Fig. 1). In mining practice we may encounter two modes of passage of a working through a contact between two rocks. The first is when the rock units are thick (Fig. 1a); the second is when one unit is thin (being a seam or dike) (Fig. 1b). In the second mode,
Fig. 1. Scheme of deformation near the periphery of working at contact between two rocks. a) Contact of thick seams of rock; b) working intersecting dike or thin seam.

in the seam or dike the disturbed stresses due to the two contacts are superimposed, and therefore the deformation of the rock unit will be in inverse proportion to the thickness. If the thickness of the seam is greater than or equal to 2d, the zones of disturbance of the stresses due to the contacts will not influence one another, and each contact can be considered separately, as in the first mode, i.e., this is a particular case of the second mode. Let us therefore consider the second mode of interaction.

The nominal periphery of the working in undisturbed rock is along line A'A. After cutting of the working in rock unit No. 1 in the absence of cohesion at the contact, its periphery will take up position C'C', and in rock No. 2, B'B'. If there is cohesion at the contact, the periphery of the working will take up position CDDC. Curve CDDC may be convex or concave, according to the ratio of stresses in the bulk of the rocks, the particular section along the working, and the values of E₁, E₂, μ₁, and μ₂.

The functions describing the variation of the stress in each rock unit with distance from the periphery will be the same. Therefore, remembering that the forces exerted by either rock unit on the other are equal, and that the volume in which the disturbed stresses act in rock unit No. 2 is m/2d times less than that in rock unit No. 1, we can assume that the ratio of the disturbed stresses in these rocks is in inverse proportion, and is given by

\[
\sigma_{\theta_1}^0 = -\rho_{\theta_2}^0 \frac{m}{2d},
\]

where \(\sigma_{\theta_1}^0\) and \(\sigma_{\theta_2}^0\) are the radial and tangential disturbed stresses in rock No. 1, \(\sigma_{\theta_1}^0\) and \(\sigma_{\theta_2}^0\) are those in rock unit No. 2, m is the thickness of the seam, and d is the diameter of the working.

The quantities \(\sigma_{\rho_1}^0\) and \(\rho_{\rho_2}, \sigma_{\theta_1}^0, \rho_{\theta_1}, \sigma_{\theta_2}^0\), and \(\sigma_{\theta_2}^0\) have different signs, because compression of one rock unit corresponds to tension of the other, and vice versa.

The disturbed stresses cause additional deformations in the rock units, given by Eqs. (1) and (2) where we use the actual stresses \(\sigma_{\rho_1}^0, \sigma_{\theta_1}^0, \sigma_{\rho_2}^0, \) and \(\sigma_{\theta_2}^0\):

\[
\begin{align*}
\varepsilon_{\rho_1}^0 &= -\frac{1 - \mu_1^2}{E_1} \frac{m}{2d} \left( \sigma_{\rho_2}^0 - \frac{\mu_1}{1 - \mu_1} \sigma_{\theta_2}^0 \right), \\
\varepsilon_{\rho_2}^0 &= -\frac{1 - \mu_2^2}{E_2} \left( \sigma_{\rho_2}^0 - \frac{\mu_2}{1 - \mu_2} \sigma_{\rho_2}^0 \right), \\
\varepsilon_{\theta_1}^0 &= -\frac{1 - \mu_1^2}{E_1} \frac{m}{2d} \left( \sigma_{\theta_2}^0 - \frac{\mu_1}{1 - \mu_1} \sigma_{\theta_2}^0 \right), \\
\varepsilon_{\theta_2}^0 &= -\frac{1 - \mu_2^2}{E_2} \left( \sigma_{\theta_2}^0 - \frac{\mu_2}{1 - \mu_2} \sigma_{\theta_2}^0 \right).
\end{align*}
\]

If we consider the deformation of the working at the contact between the rock units,

\[
AB = U'_{\rho_2} = \sum_{\rho = d/2}^{\infty} \varepsilon_{\rho_2}^0 \Delta \rho, \quad AC' = U'_{\rho_1} = \sum_{\rho = d/2}^{\infty} \varepsilon_{\rho_1}^0 \Delta \rho,
\]