Reconstruct rock mass stress state of the Upper Kama potassium salts deposit by solving inverse problems using full-scale experimental data

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In the course of prospecting and operating a mineral deposit, a huge bulk of direct and indirect real data on stress state of rocks is accumulated but remains scarcely utilized in theoretical modeling. This paper proposes an approach to taking into account such data in geomechanical modeling through solving inverse problems. To that end, a theoretical geomechanical model of stress state will be refined using data of field testing.

A test object is selected to be the Upper Kama Potassium Salt Deposit. The source information for the verification on of the geomechanical model of the object are the data of hydro fracturing stress measurement implemented in mines SKRU-1,2,3 of "Uralkali" Company.

The experimental assessment of stress state in mines of the Potassium Salt Deposit was carried out at the depth of 350 m below daylight surface. The real data were obtained during hydro fracturing stress measurement. According to the experiment data, the rock mass stress state is non-equicomponent: the vertical stresses are nearly equal to the lithostatic pressure, and the while horizontal stresses exceed by 2–3 times.

Using the finite element method, the 2D geomechanical model of horizontal cross-section (depth 350 m) of stoping zone has been developed. The computational domain *G* is a rectangle with the dimensions *Lx*=100 km and *Ly*=88 km. In the field generated mesh of quadrangle elements comprising 400×352 units and was formulated boundary conditions. The calculations were performed using the original code, implementing the 2D finite-element method for the structurally inhomogeneous media with discontinuities.

The inverse boundary-value problem is formulated as finding the external stresses and their orientation by the data of stress measurement in the discrete set of points. Using the method of hydraulic fracturing stress measurement, the maximal *S*1 and the minimal *S*2 stresses are determined at *N*=10 points [1]. We introduce an objective function:

$$\Psi(\sigma_1,\sigma_2,\alpha)=\frac{\sqrt{N\sum_{n=1}^{N}[(s_1^{*}(x_n,y_n,\sigma_1,\sigma_2,\alpha)-S_1(x_n,y_n))^2+(s_2^{*}(x_n,y_n,\sigma_1,\sigma_2,\alpha)-S_2(x_n,y_n))^2]}}{\sum_{n=1}^{N}[S_1(x_n,y_n)+S_2(x_n,y_n)]}$$

The minimum of this function provides the solution of the formulated inverse problem. The latter is a boundary inverse problem, which allows using the original rapid algorithm [2] based on separation of the direct and inverse ways of solving a set of linear equations relative to nodal displacements (global stiffness matrix).

References

[1] Skulkin, A.A.. *Experimental determination of stress field parameters in Solikamsk salt mine*. Proceedings of IX International Conference of Young Scientists and Students, Novosibirsk,168–174.

[2] Panov, A.V., Nazarov, L.A. *Method of determining horizontal stresses and properties of rock mass by solving inverse problems*. Mining Informational and Analytical Bulletin, Special Issue: Far East, OV4: 61–72.