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# RESEARCH OF POSSIBLE ZONES OF INELASTIC DEFORMATION OF ROCK MASS

**Abstract.** In the given work the sizes of conditional zones of inelastic deformations near mine excavations are determined at the combined development of the "Akzhal" deposit. Numerical analysis was carried out by the method of boundary integral equations with a stepwise loading of the rock mass. Modeling of geomechanical processes was carried out by an elastoplastic model of deformation. The refinement of physical and mechanical properties of rocks was carried out with the help of RocLab. In preparing the initial data for numerical analysis, the main strength index of rock mass was the geological index of strength GSI. When specifying the strength parameters, a transition is established from the strength of the sample to the strength of the rock mass. The research was carried out with the mine excavations at a depth of 100 to 500 m with a lateral pressure coefficient of 0.6 to 1. The dependence of the sizes and shapes of the possible zones of inelastic deformation around the mine excavations on the coefficient of lateral pressure and the depth of the excavations was established. Based on the results obtained, it is possible to assess the geomechanical state of the contour part of the rock mass, and also take into account the choice of types and parameters of fastening of mine excavations.

**Keywords:** zones of inelastic deformations, geological index of strength, strength criteria, numerical analysis, joint condition, coefficient of lateral pressure, mine excavations.

**Introduction.** The technogenic impact on the untouched rock mass leads to a change in the stress-strain state of rocks in the contour part of the mass. More preferable in justifying the stability parameters of mine excavations are numerical methods of investigation, which allow a lot of possible initial data to be taken into account.

Numerical simulation allows to quickly analyze the geomechanical state of the mass due to instantaneous interpretation of the change in the stress-strain state of the rock mass and the visualization. The advantageous aspect of numerical simulation is the creation of an identical geomechanical model of the investigated area with maximum allowance for the mining-geological and mining-technical conditions of the deposit.

The task of the research work is to determine the size of the given zones of inelastic deformations (fracture zones) near the mine excavations in the conditions of the "Akzhal" deposit.

**Materials and methods.** When assessing the stability of mine excavations, it is very important to choose the correct model for the behavior of the contour part of the rock mass. First of all, it must take into account the possibility of non-linear deformation of rocks near the mine excavations and the possibility of developing a zone of destruction in area [1].

To determine the possible zones of rock destruction (zones of inelastic deformations) around the mine excavations, a method of step-by-step loading by the method of boundary integral equations was adopted, which is implemented using the Hi-Fi application program developed at the Karaganda State Technical University.

Hi-Fi programs allow to take into account a wide variety of forms and sections of preparatory and cleaning excavations, the influence of a number of located excavations for the development of an effective

method of supporting workings and developments of steeply falling ore bodies, joint condition of rock mass, which is an important factor for the correct determination of the fracture zone. In addition, the calculation program is easily adapted to various mining and geological conditions [2].

The task of modeling is to determine the coordinates of the joint contour, based on information on the stress-strain state of the mass. In this case, the vertical section of the mass with a notch is considered, the geometry of which was determined by typical sections of the production. The contour is represented by a polygon. The geometry of this polygon is given by the coordinates of the nodes (vertices of the polygon). Since the entire region outside the output contour is an infinite number of points, and a numerical analysis of the stress state at all points is impossible, in our case we confine ourselves to considering a finite number of points (n) located in a strictly defined order. All the investigated points are located on the rays (m) emerging from the middle of the sections at a fixed distance from each other on the ray (figure 1).

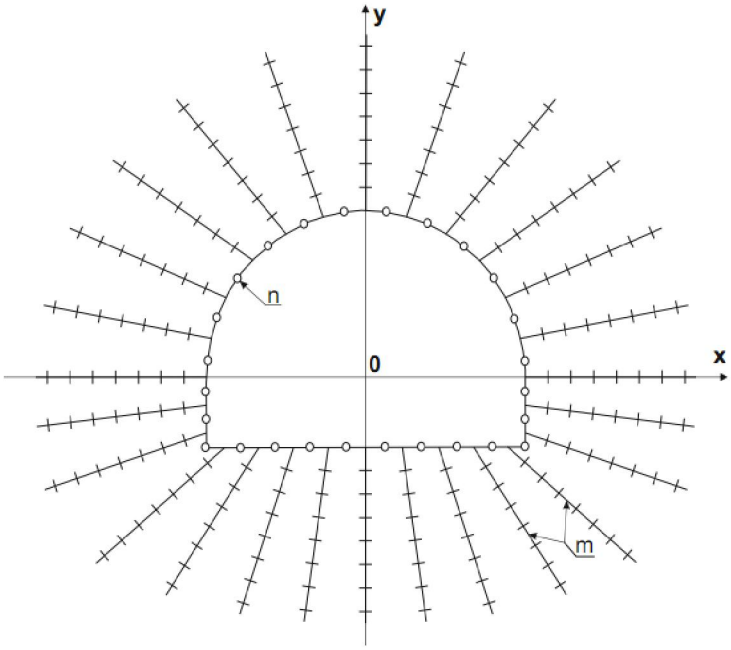


Figure 1 – Scheme of the location of the scanning beams

Carrying out the mine excavations violates the natural state of the rock mass, which leads to additional loading of the mass. This additional loading is divided into a number of stages. At each stage of loading, there is a stress-strain state of an elastic mass with a variable internal boundary (an elastoplastic problem is solved). At the first stage, this boundary is the output contour. At the second stage - the contour of the fracture zone that occurs during the first stage, etc. In this case, at each stage of loading on the internal circuit of the voltage the values are preserved, achieved at the previous stage of loading. It is assumed that the rock mass that fall into the fracture zone during further loading do not exert a resistance to deformation of the elastic part of the mass. Thus, at each loading stage, additional elastic displacements on the inner boundary of the elastic part of the mass take place without resistance, same as for a non-reinforced contour. At the same time, the deformations of this contour accumulated at previous stages remain unchanged [3].

Numerical analysis does not limit the number of destruction criteria, therefore, the shearing (Mohr-Coulomb) and discontinuous (the largest deformation stretching) criterion are used simultaneously.

The contours of the fracture zone are determined by the following equation [4]:

$$r_n = R_0\left(1+\frac{p-K}{nK}\right)^{\frac{n}{2}}, \qquad (1)$$

where $R_0$ – radius (width) of excavation; $p = \gamma H$ – voltage acting in an untouched mass; $K$ – maximum tangential stresses, $n$ – number of stages of loading.

One of the main difficulties in the numerical simulation of geomechanical problems is the absence of initial data - parameters of the mechanical behavior of the rock mass.

The use of certain patterns of behavior of the rock mass, available in modern numerical analysis programs, becomes difficult or practically impossible if there is no reliable initial data for the parameters of the adopted (chosen) model.

The initial data for the calculation includes the geometric characteristics and mining-geological conditions of the mine excavations, the strength properties of the rock mass, additional information on the presence in the rock layers of the planes of weakening of the ordered joint condition, weak interlayers, as well as geological disturbance and the wetting of a particular deposit.

The preparation of the initial data for numerical analysis was carried out with the help of the program RocLab, which allows to quickly determining the strength parameters of the rock mass on the basis of the criterion of destruction of Hoek-Brown and Mohr-Coulomb.

One of the important parameters of the initial data is the indicator of the Geological Strength Index (GSI), proposed by Evert Hoek in the 90s of the last century [5].

The GSI indicator is determined by the diagram shown in figure 2, based on the results of processing mine studies.

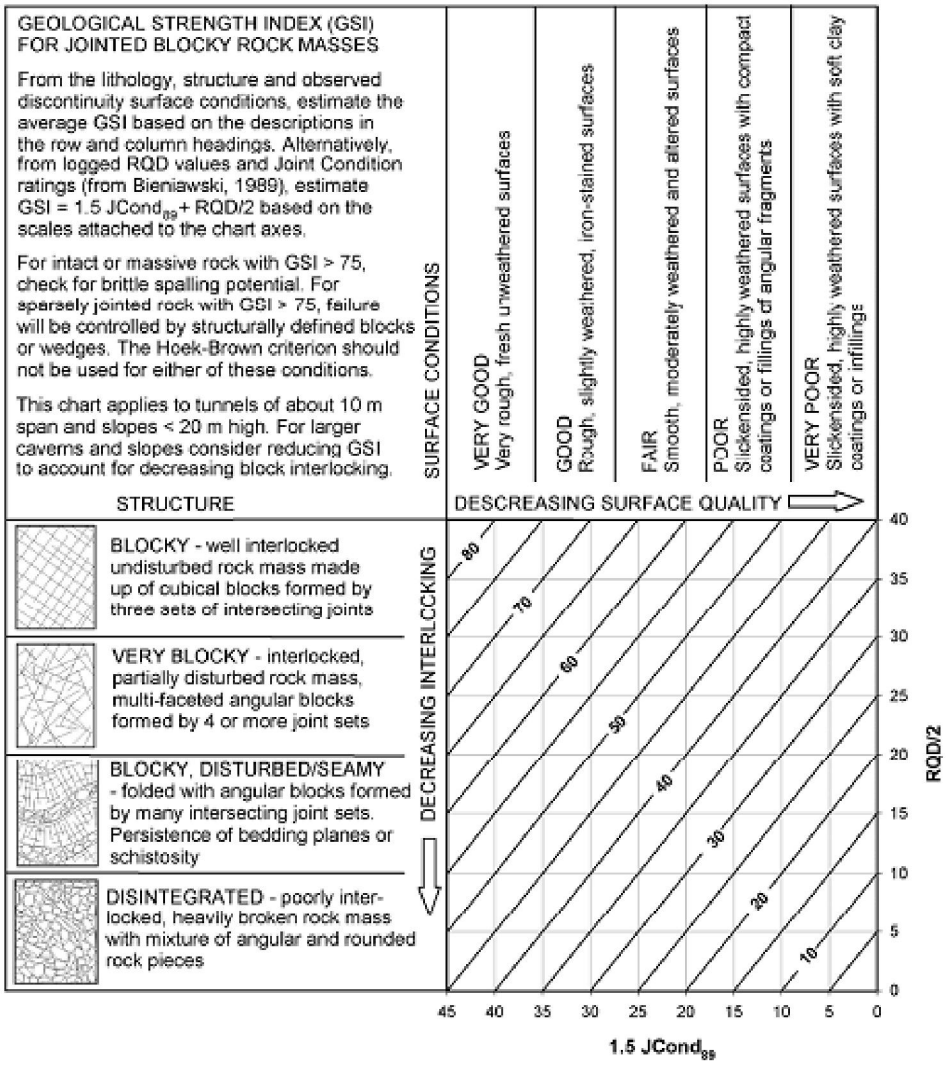


Figure 2 – GSI Indicator Definition Chart

The index is the initial data for refining the physical and mechanical properties of rocks using the RocLab program. The definition of GSI indicator is based on correlations [6]: