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Numerical approach for estimation of stress strain state of deep tunnels

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Abstract. Numerical approach and results of theoretical calculation of deep tunnels are described in this issue. Here described surrounding continuum is fractured rocks. Calculation provided in static case. Results of this investigation aimed for estimation of stress state and development of strengthening measures of deep excavations.

1. Introduction

The problem of ensuring the strength of tunnel workings in mining of mineral deposits is characterized by stable relevance and becomes more important with the deepening of mining. In this regard, there is a need for continuous improvement of technologies and means of fixing special workings, and of the ways to maintain them in difficult mining and geological conditions.

However, the development of such measures cannot continue without the accumulation of a knowledge base on the complex mechanism of inelastic strain of fractured rocks around the workings.

At present, In Uzbekistan provided wide spectra investigations of soils response at dynamic loading and for water saturated soils also [1, 2]. Behavior of fractured rocks around the workings in elastic case has been studied in sufficient detail too. The stages of beyond-limit strain have been studied not wide.

2. Main part

The analysis carried out in the paper shows that if the elastic stage of strain is studied in sufficient detail in mathematical models, taking into account the nature of the stress and strain redistribution around the mine, then the beyond-limit stages of strain of enclosing rocks have been studied mainly by laboratory experimental methods based on physical modeling and instrumental observations in the mines.

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At the same time, elastic processes generate the displacements on the excavation contour comparable with minor displacements, whereas displacements, measured in greater quantities, are due exclusively to irreversible processes: plastic strains, destruction, beyond-limit strain and irreversible displacement of blocks and pieces of fractured rocks. Recent studies have shown that such displacements occur alternately around the excavation, which is a consequence of the self-locking effect of previously broken rock. On the base of fracture mechanics approaches and using boundary element techniques metal behaviors well studied [3-6], however in rock continua we have not so analysis yet.

Below, we consider and estimate the stress-strain state of a rectangular entry (of the excavation) of mineral deposits in a fractured rock continua.

When calculating the soil base of fractured rocks, we proceed from the assumptions that local destructions can occur on the contact surface of the cracks and it is believed that there are partially filled cracks in the rock.

The rock strength model, based on the Coulomb-More theory, makes it possible to simulate the process of nonlinear strain of the enclosing rock, including the section of beyond-limit strain. Figure 1, shows the design 2D scheme of the problem (finite element approaches was used). Mechanical characteristics of undisturbed blocks of limestone, and the crack filler are given in Table 1.

Table 1. Mechanical characteristics of limestone

Undisturbed limestone blocks			**Crack filler**		
E, MPa	φ, degree	C, MPa	E, MPa	φ, degree	C, MPa
10000	41	1,2	20 MPa	26	0,033

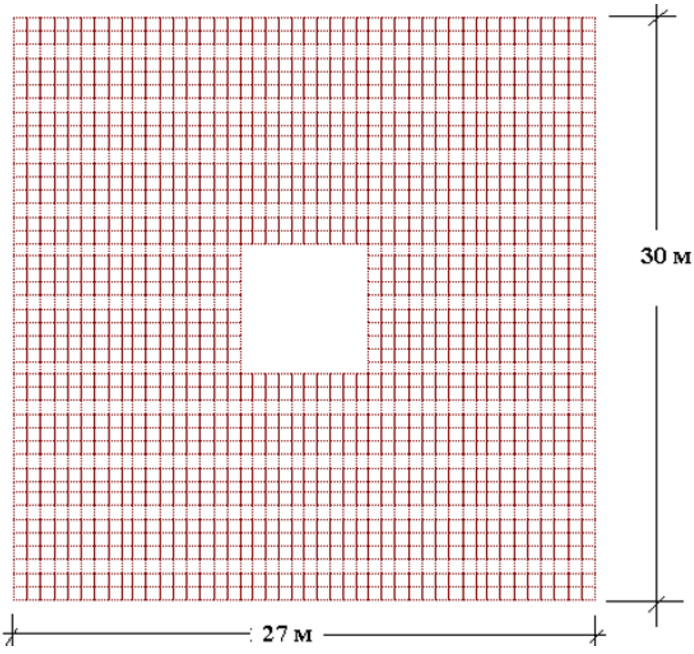

Fig. 1. Design scheme of the problem for excavation in fractured rock

Considered excavation is located at a depth of 12 meters, it has a rectangular cross section. The boundaries of the calculated area down under the soil, up from the upper boundary and away from the side walls of the excavation are located at distances of 30 and

27 meters, respectively. The simulated rock mass is divided into horizontal layers, within which the properties of fractured rocks have been set. At the vertical boundaries perpendicular to the X and Y axes, the displacements along these axes have been limited, and at the lower boundary of the calculated area, vertical displacements have been limited; the displacements with a predetermined value in the form of uniformly distributed loads have been applied to the upper boundary.

Analysis of the calculation results has shown that rock displacements are displayed in vertical deep excavations; displacements of rocks on the excavation contour increase with the transfer of the angular elements to inelastic state. Since the problem is solved by the step method, it is possible to trace changes in the stress-strain state around the mine. Figure 5 show the nature of destruction of enclosing rocks and their displacements on the contour of the excavation. The most intense inelastic strains occur in the upper boundary above the walls and on the side walls of the excavation, in the central part of soil (chute) and in the upper boundary. Analysis of the simulation results shows that in the process of development of the zone of destroyed rocks around the mine, the stresses decrease, and their maximum moves deep into the rock mass

From figures 2, 3 and 4 one can see how much the fracturing of rocks affects the distribution of principal stresses and on the possible zones of beyond-limit states through the Mohr-Coulomb flow functions. The figures show how the formation of local stress concentrations occurs and the mechanism of irreversible displacement of blocks of rock mass. Such structures are called the clusters. When exceeding the permissible level of the limit stresses, the cluster is destroyed. In this case, the cluster disintegration occurs along the previously destroyed boundaries, that is, along the cracks or a section of an undisturbed massif, that is, a block of previously destroyed rock is destroyed and divided into smaller fragments. An account of these features allows the engineer-designer to rationally select the passive and active measures to improve the strength of excavation.

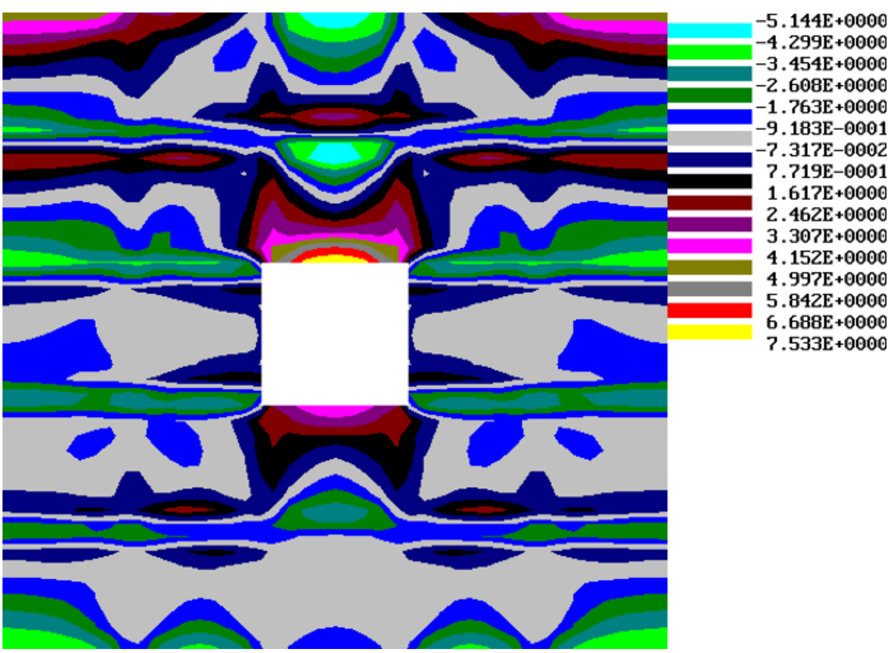

Fig. 2. Isochromes of the principal stresses σ_1

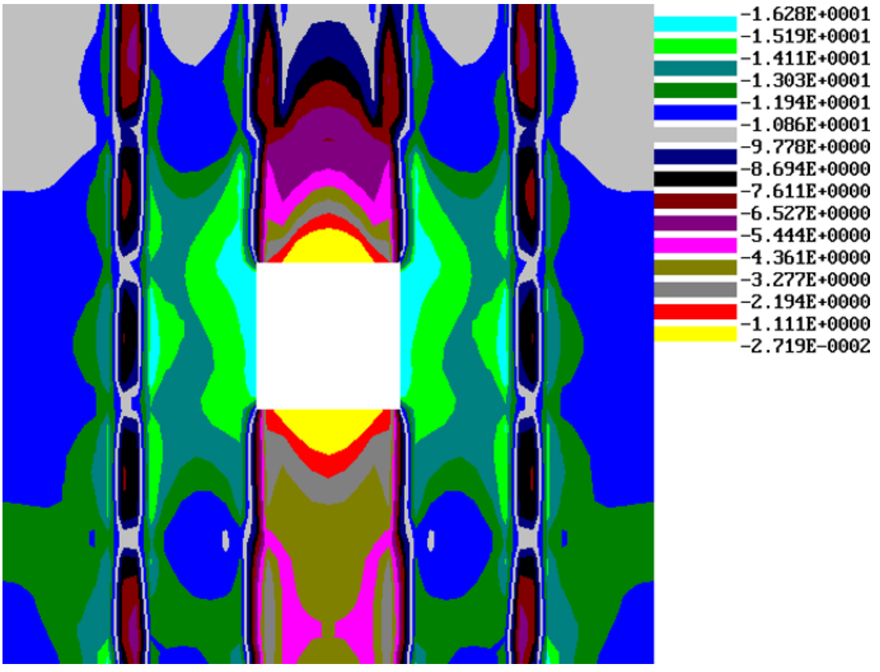

Fig. 3. Isochromes of the principal stresses σ_2

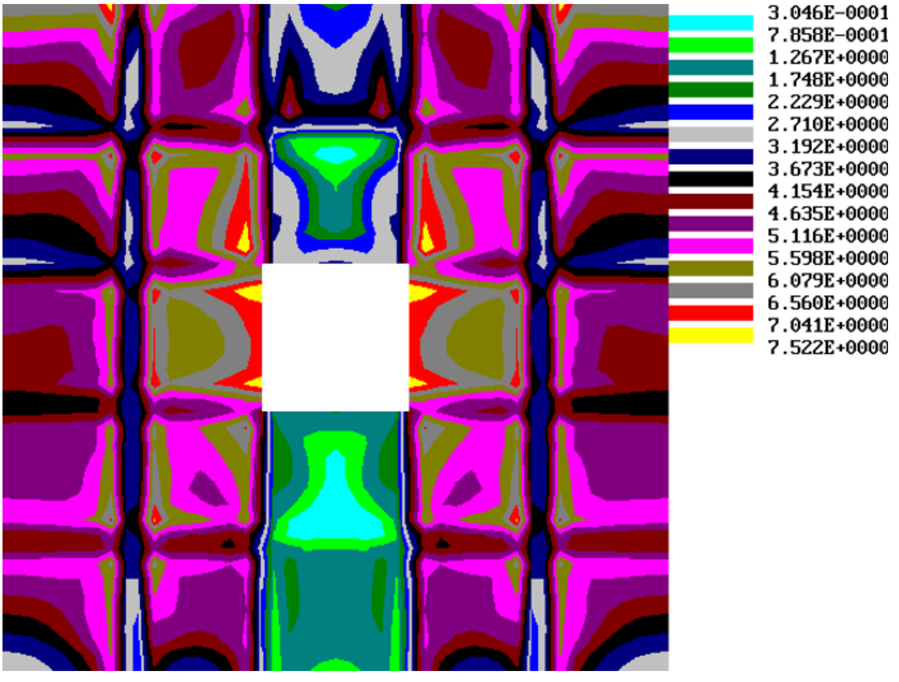

Fig. 4. Isochromes of the Coulomb-More plasticity function

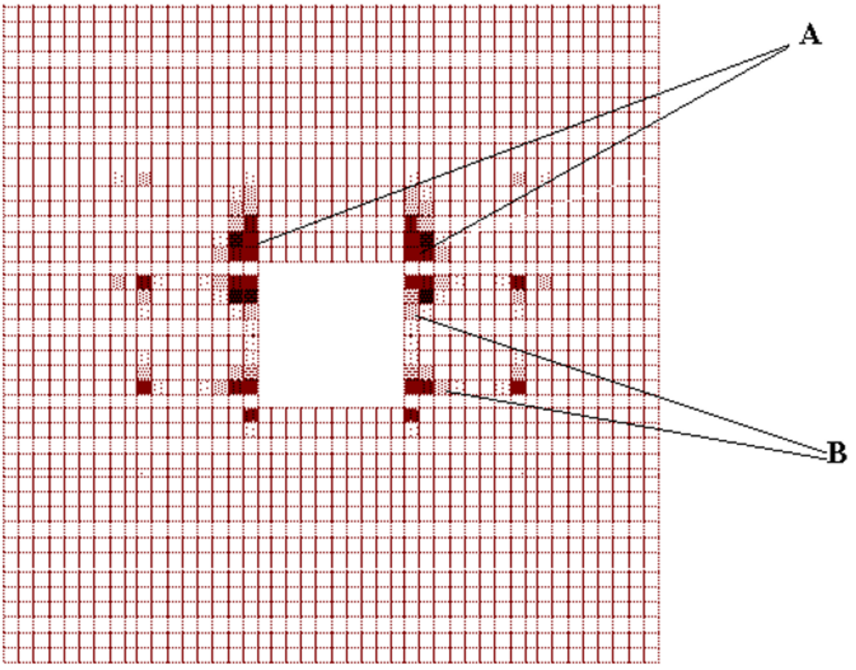

Fig. 5. Beyond-limit zones and the nature of rock destruction around the mine in its vicinity (A - elements that can transfer to plastic state, B - elements that can transfer to beyond-limit state at load increase)

Here we consider and analyze the mechanism of destruction of fractured rocks. It is lead us for development of measures for mitigation of risk for urban areas [7] and landslides hazards [8] for civilian structures even under seismic impact too.

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