STUDY OF THE IMPACT OF BACKFILL MATERIALS BEHAVIOR ON THE ROCK MASSIFS STRESS-STRAIN STATE DURING STRATIFIED DEPOSITS CHAMBER MINING

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Significant increase of the percentage of the extracted reserves during the mining works is possible due to the creation of the artificial pillars made from the hardening backfill material based on sludge [1]. At the same time, there is a small amount of published results of the wide-scale researches of the stress-strain state (SSS) of the rock massifs [2], that allow to determine optimal physical and mechanical properties of the backfilling material, that ensure bearing capacity of the geomechanical system under consideration. Meanwhile, when stability of the geomechanical system depends on the bearing capacity of the artificial pillars, the type and the physical properties of the used backfilling material become extremely important, in order to provide relatively simple and cheap production, transportation and placement, high level of fill in chambers on the one hand, and required strength and stiffness after consolidation in a desired time interval on another hand.

The considered scheme of mining (figure 1) suggests the filling of the chambers of first stage (chambers 1-5) with the consolidating backfill and further extraction of pillars.

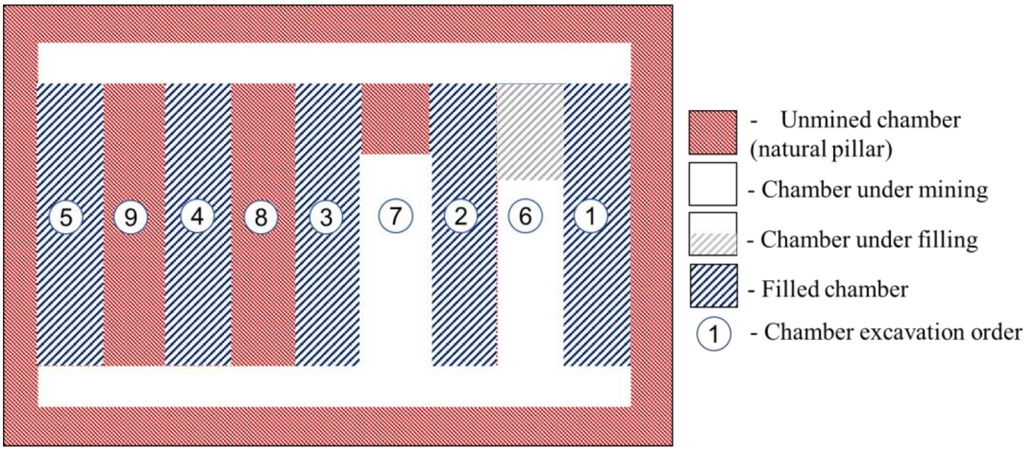


Figure 1. Technology of extraction with the technological scheme with consolidating backfill

During the mining of the one chamber the previous one is already filled. Between the chambers of first stage are located the natural pillars. After the last chamber of the first stage is filled, the natural pillars are also extracted and filled. The chambers are located close up to each other. This way, it is possible to extract the maximum amount of mineral resources. The extraction occurs in the time stages, determined in advance, which corresponds to the particular time from the beginning of the mining works.

The aim of the research is to determine the behavior of the backfill material (in particular, physical properties variation during the time and under the load) that ensure optimal geomechanical state of the massif for the particular technological mining scheme.

Geological layers are considered as homogeneous isotropic elastoplastic materials. For elastoplastic materials the Mohr-Coulomb model is used. The backfill material is considered as homogeneous isotropic elastic material. Mechanical properties of the backfill material are determined based on the result of the study [3].

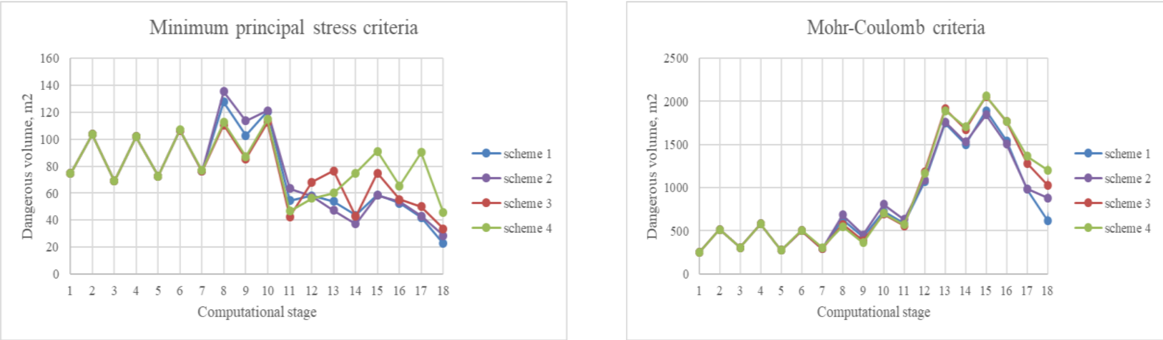
In order to study the impact of the different schemes of backfill behavior, the different models of backfill properties variation in time are under consideration (table 1).

Table 1. **Schemes of strength properties and deformation characteristics of the backfill material during the time**

<table>
<tr><td>Scheme №</td><td></td><td colspan="12">t, days</td></tr>
<tr><td></td><td></td><td colspan="4">0</td><td colspan="4">15</td><td colspan="4">30</td></tr>
<tr><td>1</td><td rowspan="6">$E(t)$, MPa</td><td colspan="4">$E_0=E=20$</td><td colspan="4">$E_1=50E=1*10^3$</td><td colspan="4">$E_2=100E = 2*10^3$</td></tr>
<tr><td>2</td><td colspan="4">$E_0= E=20$</td><td colspan="4">$E_1=100E=2*10^3$</td><td colspan="4">$E_2=100E = 2*10^3$</td></tr>
<tr><td>3</td><td colspan="4">$E_0= E=20$</td><td colspan="4">$E_1=10E=0,2*10^3$</td><td colspan="4">$E_2=100\mathrm{E} = 2*10^3$</td></tr>
<tr><td rowspan="3">4</td><td colspan="12">t, days</td></tr>
<tr><td colspan="3">0</td><td colspan="3">10</td><td colspan="3">20</td><td colspan="3">30</td></tr>
<tr><td colspan="3">$E_0=E=20$</td><td colspan="3">$E_1=4,6E=92,5$</td><td colspan="3">$E_2=21E=427$</td><td colspan="3">$E_3=100E=2*10^3$</td></tr>
</table>

For the estimation of the effectivity of particular backfill behavior scheme the concept of dangerous volume is used. Dangerous volume is a volume where massif turns into the limit state according to one of the criteria. The comparison is made by the value of dangerous volumes. On figure 2 the results of the modeling on all stages of excavation and filling are shown in the form of dangerous volumes plots.

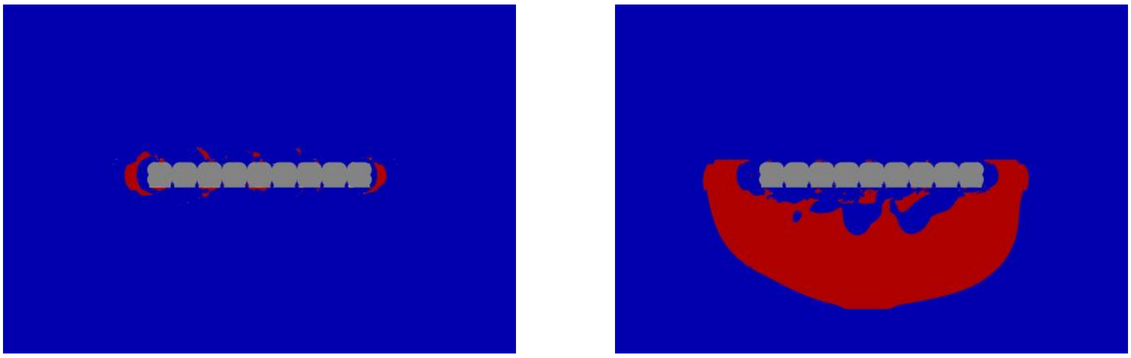
It will be noted, that maximum and minimum principal strain and maximum principal stress do not exceed the limit value or the value of dangerous volume is insignificant and do not affect the bearing capacity of the massif.



a) *b)*

Figure 2. Values of dangerous volumes of the limit state zones on the different computational steps by: a) minimum principal stress criteria; b) Coulomb-Mohr criteria

The common view of zones of the limit state that has formed after the filling of all chambers (on the last computational step) is shown on the figure 3 (considering scheme №4).



a) *b)*

Figure 3. Common view of the limit state zones (with red) on the last computational step (scheme no. 4) by: a) minimum principal stress criteria; b) Coulomb-Mohr criteria

Zones of possible crack growth mainly extend downwards from the worked-out space (Figure 3b). This fact is due to the peculiarities of the geological structure and strength properties of rocks.

In table 2, the numbers of schemes for possible mechanical state changes (consolidation) of the backfill material are marked in red, which show the most unfavorable state as a result of a comparative analysis of the geomechanical state in the vicinity of chambers.

Table 2. **Common view of the limit state zones (with red) on the last computational step (scheme no. 4) by: a) minimum principal stress criteria; b) Coulomb-Mohr criteria**

Stage № and description		Scheme №			
		1	2	3	4
1	Mining of chamber №1				
2	Mining of chamber №2				
3	Filling of chamber №1				
4	Mining of chamber №3				
5	Filling of chamber №2				
6	Mining of chamber №4				
7	Filling of chamber №3				
8	Mining of chamber №5	■	■		
9	Filling of chamber №4	■	■		
10	Mining of chamber №6		■		
11	Filling of chamber №5		■	■	■
12	Mining of chamber №7		■	■	
13	Mining of chamber №8			■	■
14	Filling of chamber №6			■	■
15	Mining of chamber №9			■	■
16	Filling of chamber №7			■	■
17	Filling of chamber №8			■	■
18	Filling of chamber №9			■	■

Conclusion. From the point of view of the influence of the backfill material consolidation regime on the geomechanical state of the enclosing array in the vicinity of the worked space the following facts are established:

• at the stages before the pillar excavation, the schemes with the backfill material with greater compliance are more preferable;

• at the stages after the pillar excavation, more effective schemes are schemes with the backfill material with greater stiffness, in particular, scheme №2.

So, it was found that the most effective scheme for a chamber mining of stratified mineral deposits with the backfilling of the undermined space is a two-stage increasing of the backfill material stiffness. Before the mining of the pillars the backfill material stiffness is slowly increasing, and after beginning of the pillars mining backfill material should be as compacted as possible.

It should be noted that the optimal behavior and consolidation of the backfill material should be established for a specific technological scheme of mining and filling of the massif.

References

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