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TUNNEL ANALYSIS IN FAULT ZONES AND THE EFFECTS OF STRESS DISTRIBUTION ON THE SUPPORT

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Abstract

Tunnel or any other underground room construction in general is a complex problem. The complexity of the problem is reflected in the spatial position of underground room, which may be close to the surface terrain and environment in which the object is located. In many cases environment is heterogeneous, and special attention in this work is given to the fault zone impact on distribution of the stress and deformation states around the room.

The calculations is performed in steps of load increasing, and in this work are given the views of vertical shifts allocation, the appearance of plasticity in the massif and the position of occurrence of cracks in the tunnel screening. It also presents a distribution of vertical and tangential stress of the massif.

Analysis of stress – deformation state was made with the finite element method. Rock material was modeled as elasticity-plastic material with Mohr-Coulomb fracture condition and the support material is concrete MB 300 and it was modeled as concrete material.

Key words: *rock massif, fault zone, stress - deformation state, finite element method.*

1. Introduction

Design and built tunnels assumed isotropic environment and tunnel routes are simplified with this assumption. However, rock massif is expressed with greater or less anisotropy. The calculations are taken with less value of geomechanical parameters, which with high values of safety factors eliminate the consequences of these approximations. Today we meet with the situation that the tunnels that are built under one conditions found in the other conditions. These changes are mainly related to the change of the vertical component of the load (the construction of embankment above the tunnel). Load changes above underground

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facility will cause a stress – deformation change in the status of massif, which may be reflected on the tunnel or its parts. As the first exposed are areas that are in the engineering geological terms classified in the zone of risk. Checking the impact changes of the vertical components values must be made, and in this paper is given an example of assessment of increasing the amount of deferred mass on the tunnel construction.

2. Describe of the problem

Necessity of increasing capacity of flotation tailing dump, and also increasing overtop of the dams 1A, 2A and 3A to the level of K+385 m has brought along evacuation of Krivelj´s river by two tunnels: the one that already exists, and the other one who will be located on the right bank of the flotation tailing dump.

For delay of flotation tailing, open pit mine "Veliki Krivelj" uses an area, got by partitioning of the Krivelj's river valley.

In the beginning of the mine work, the area near flotation objects was taken (field 1) for tailing dump. Flotation tailing dump expanded in 1990 by taking extra space of the Krivelj's river valley, downstream from field 1.

Flotation tailing dump is bordered with dams 1A and 2A, which were projected to the level of K+375 m, and with total capacity of $94{,}3 \cdot 10^6$ [m^3].

New flotation tailing dump (field 2) is bordered with dams 2A and 3A, which were projected to the level of K+350 m, and with total capacity of $89{,}4 \cdot 10^6$ [m^3].

Considering that the dams were projected to the level of K+350 m, including fact that it is possible to store flotation tailing dump only till the middle of this year (2008), it is necessary to ensure increasing level of the dams up to the K+385 m.

Therefore, Krivelj's river (figure 1) has to be evacuating by:
- existing tunnel (zone of the field 1); D = 3,0 [m] and L = 1.414 [m],
- new built tunnel; D = 3,0 [m] and L = 2.400 [m], along the right bank of the flotation tailing dump.

Construction of new tunnel on the right bank of the flotation tailing dump makes possible increasing level in the field 2, which significantly increase capacity of storage space (approximately $83{,}3 \cdot 10^6$ [m^3]) [6].

Geomechanic characteristics of the massif, in which is considered a problem and characteristics of the support material are given in table 1.

Table 1. Geomechanical parameters

Parameters	sandstone	marl	concrete
Young's Modulus E (MPa)	213	173	24800
Poisson's ratio ν	0.4	0.34	0.15
Cohesion c (MPa)	4.5	3.5	-
Tensile strength σ_z (MPa)	0.18	0.11	4.1
Friction angle φ (^{0})	38	26	-
Density ρ (kg/m^3)	2457	2000	2500

3. Calculation of stress-deformation state

Analysis of stress – deformation state was made with the finite element method. Rock material was modeled as elasticity-plastic material with Mohr-Coulomb fracture condition and the support material is concrete MB 300 and it was modeled as concrete material. Load modeling of the dumped mass was carried as balanced load with the intensity $g_{dyke} * H_{dyke}$. Performed calculating model is shown in Figure 3, as well as the position of the fault zone, based on engineering-geological description of the location in which the elements of fault position in space are given.

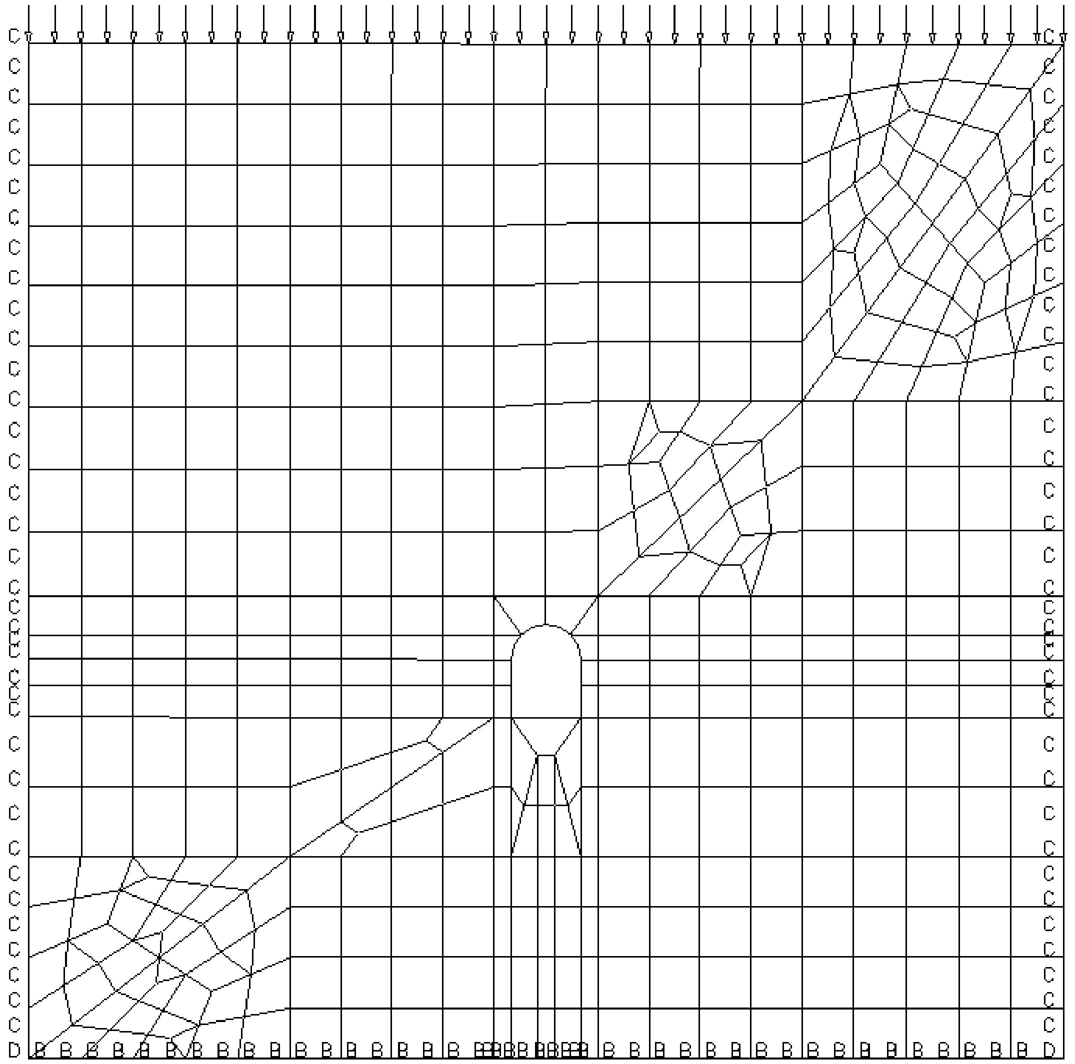


Figure 1. Model for finite element method analysis

Embankment load activity is simulated with increasing of intensity of the continuous load, where the value 1 shows the current state of dumped mass (TIME 3) and values over 1 represent increase of stockpiling height of the masses. The calculation is done with two variations of the position of layers:

- Variant 1 with sandstone above and
- Variant 2 Marlon above (in the ceiling of the room).

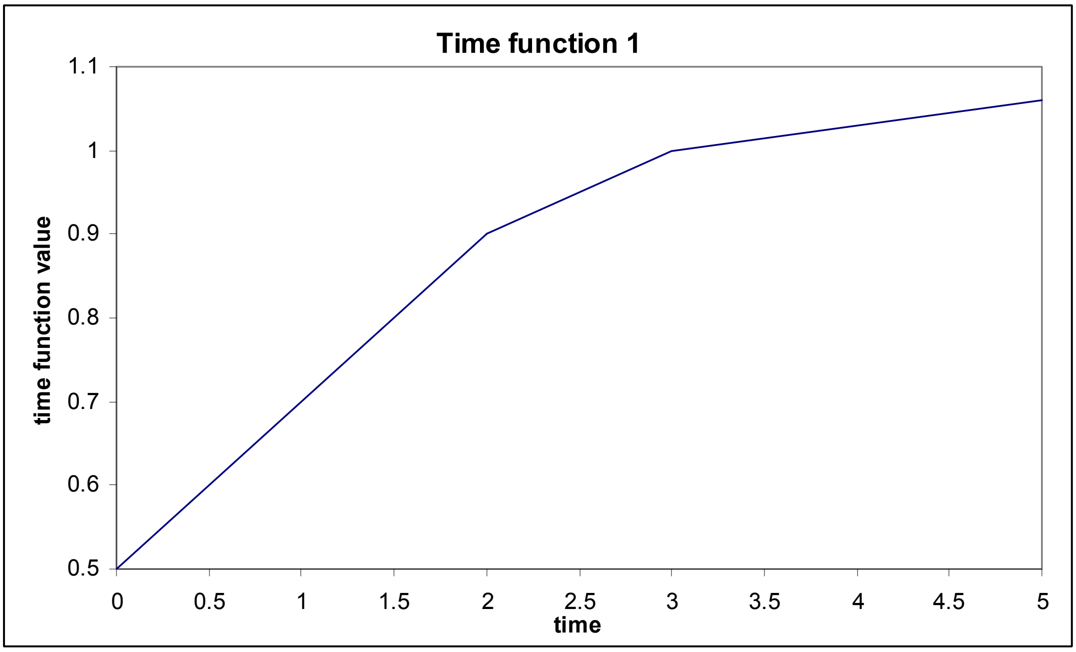
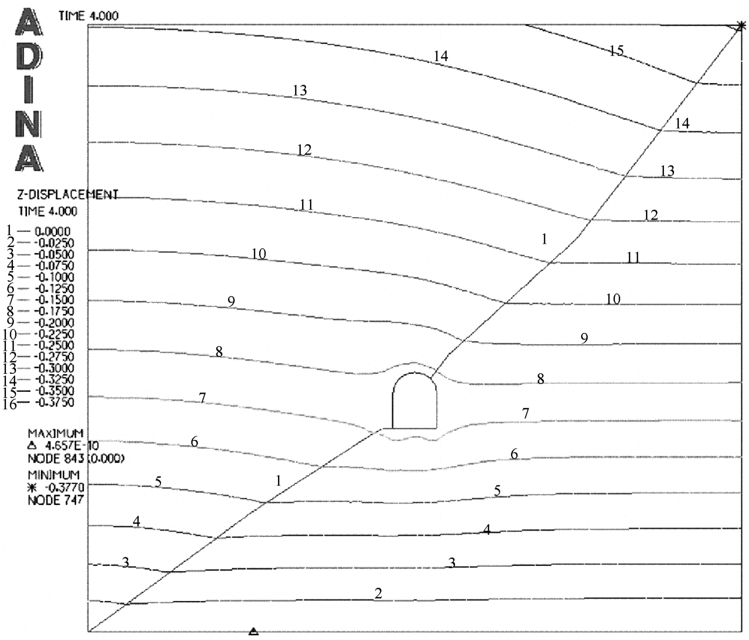


Figure 2. Increase load function

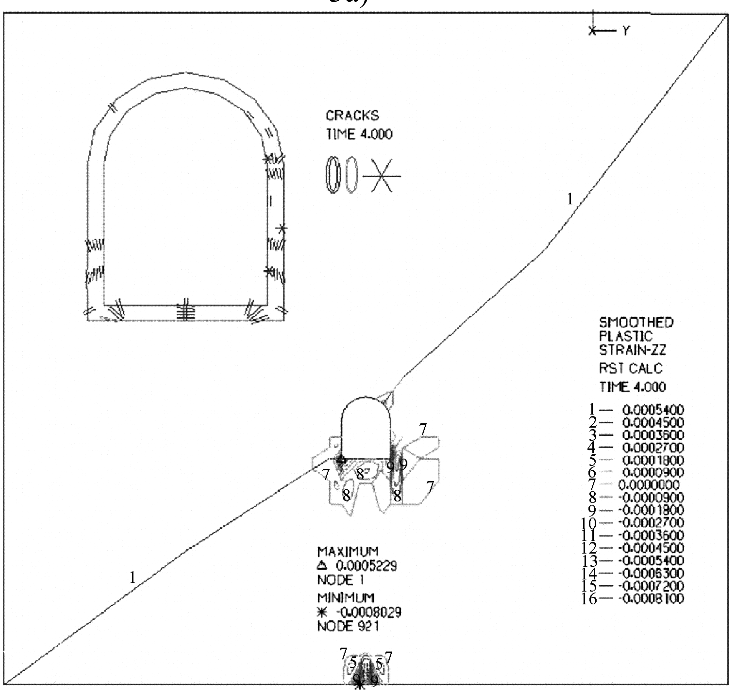
4. Analysis of calculation results

The calculations is performed in steps of load increasing, and in this work are given the views of vertical shifts allocation, the appearance of plasticity in the massif and the position of occurrence of cracks in the tunnel screening (Figures 3a and 3b for the first variant, and Figures 5a and 5b for the second variant). It also presents a distribution of vertical and tangential stress of the massif (Figures 4a and 4b and Figures 6a and 6b).

The end of solution convergence was after 4th steps, i.e. after increasing the amount of 10% compared to the previous level of dumping. The first version of the position of the layers observed a large number of cracks in support elements, while in the second variant the number and position are quite different. Also, in the second variant we have significantly different timing and intensity of plastic deformation. However, common to both variants is that increasing of the level over 10% presents great risk, compared to the previous height.

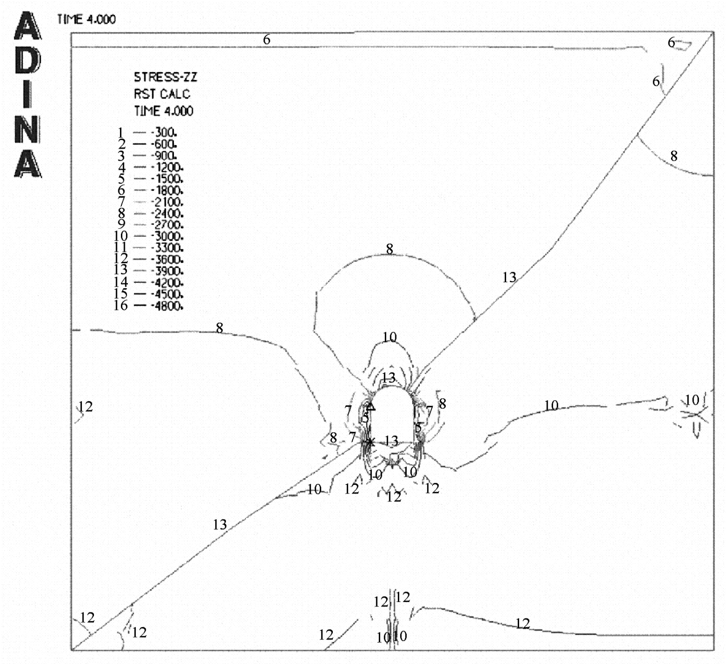


3a)

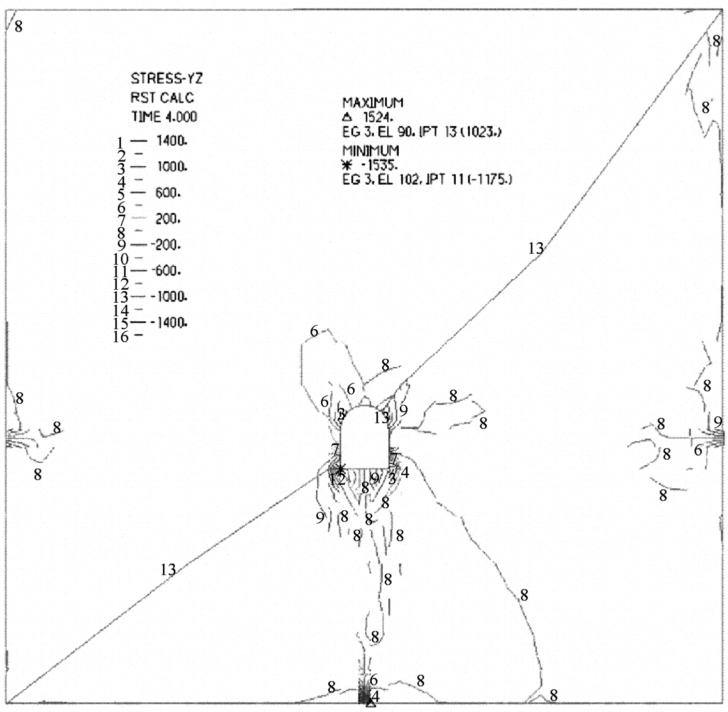


3b)

Figures 3a and 3b. Vertical displacement, plastic deformations and cracking for 1st variation of the layers position

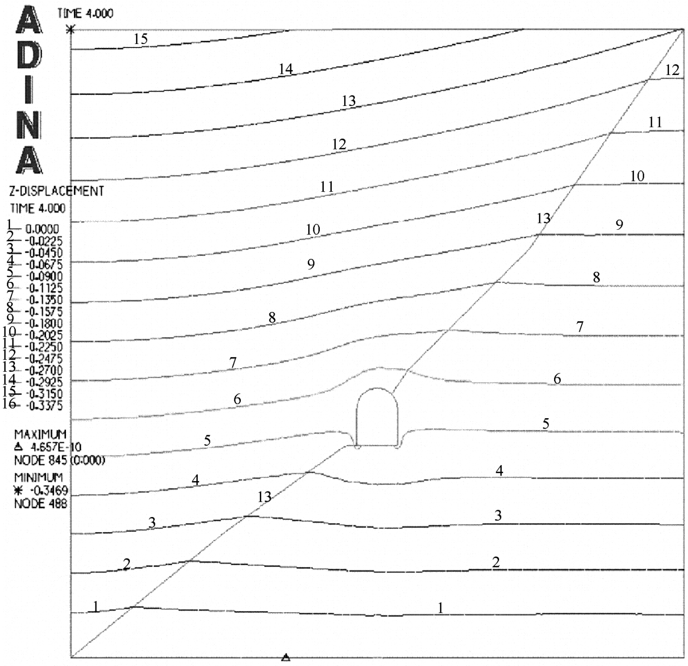


4a)

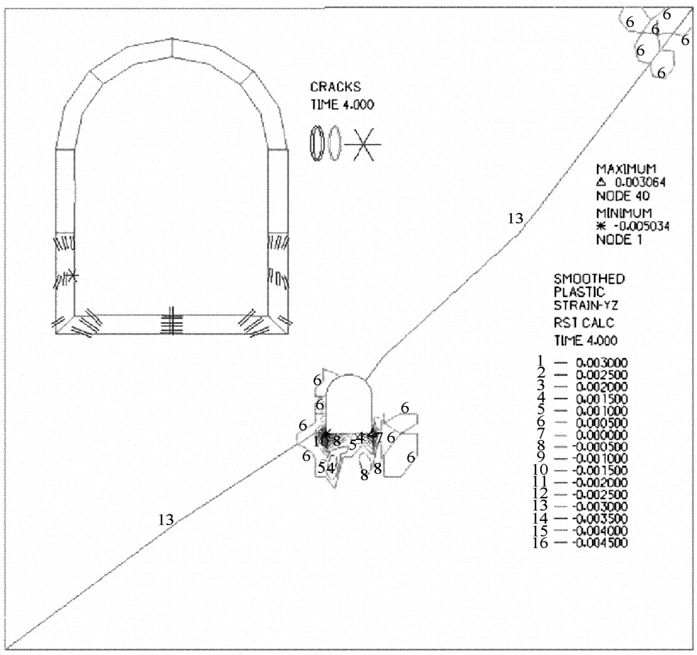


4b)

Figures 4a and 4b. Distribution of the vertical and shearing stress in massif for 1st variation of the layers position

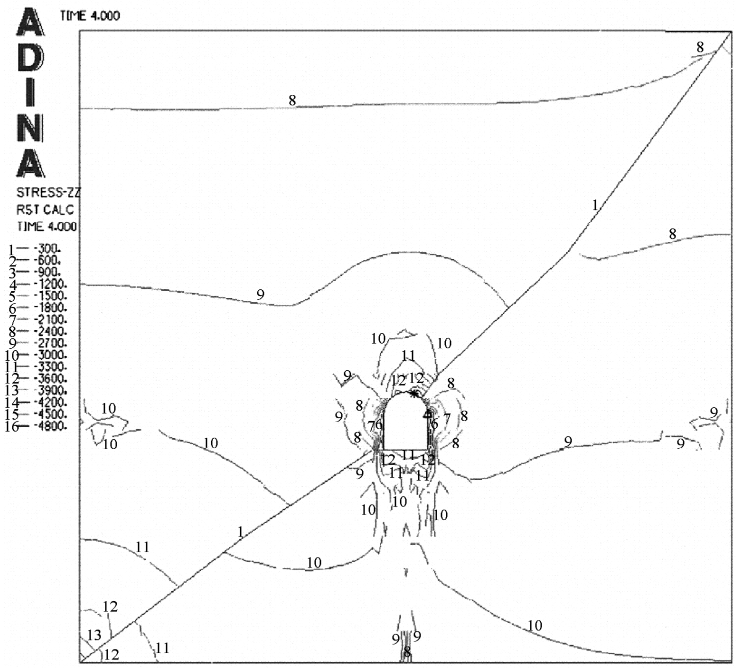


5a)

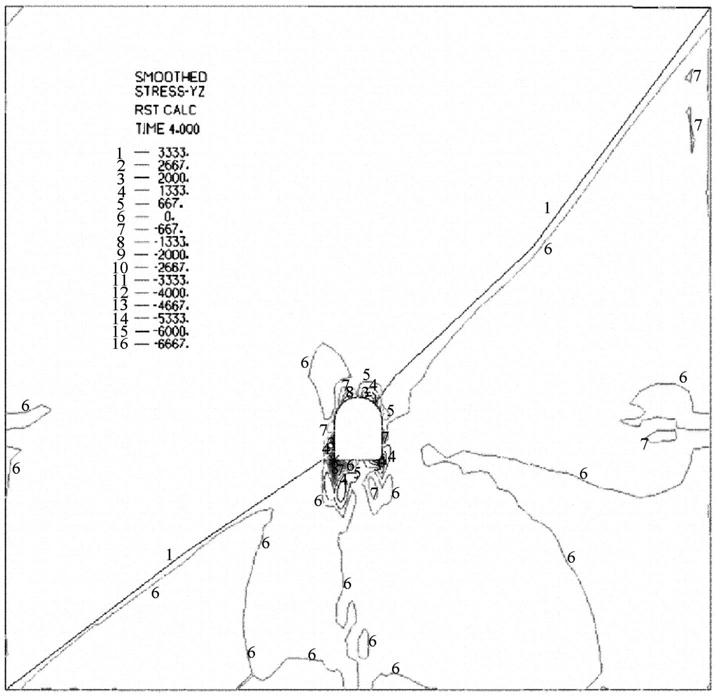


5b)

Figures 5a and 5b. Vertical displacement, plastic deformations and cracking for 2nd variation of the layers position



6a)



6b)

Figures 6a and 6b. Distribution of the vertical and shearing stress in massif for 2nd variation of the layers position

5. Conclusion

The work indicates the possibility of applying numerical analysis to assess the conditions of exploitation of underground facilities. The paper gives an example of applying FEM, and elasticity-plastic analysis of the problem of increasing the embankment above the tunnel. The validity of the resulting data would be complete if the analysis took into account the time factor. Influence of time factor is very important, since dumping material has to consolidate and hardening, which is a positive feature, but on the other side, under the influence of load screening changes its properties. To obtain better data it is necessary to check the characteristics of the tunnel screening and the parameters of previously dumped mass. If there are observation dates of landmark's points in the tunnel, calculation could be making with elasticity – viscous - plastic analysis.

6. References

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