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RESEARCH OF GEOMECHANICAL AND GEOPHYSICAL PARAMETERS FOR ASSESSING OF ROCK MASS STABILITY

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Preliminary Note – Prethodno priopćenje

The paper presents the results of laboratory such as in situ geomechanical and geophysical measurements. The results were the basis for mathematical modeling of slope stability in the design of foundations for new technological line for crushing stones. In situ research aimed to verify the strength of dolomite on Schmidt Hammer tests. Geophysical measurements were determined the speed of propagation of seismic waves and the degree of fracturing of the rock massif. Slope stability assessment of new technological line was made planar and spatial mathematical model and have been proposed rock slope stabilization.

Key words: geomechanical and geophysical measurements, rock, laboratory test, seismic measurements, mathematical model

INTRODUCTION

Geotechnical engineering is a discipline that seeks an optimal technical solution for construction and mining-related problems, for example, to the establishment, protection of buildings and their environment from the negative effects of different mining processes. Among the major causes of wasteful but also risky solutions it includes insufficient knowledge of the parameters characterizing the properties of the natural environment and construction works. Comprehensive and optimal solution of geotechnical problems requires necessary knowledge of engineering geology, hydrogeology, soil and rock mechanics, foundation engineering and the like. Measurements were designed to determine the density (ρ_o) with paraffin method, index of rock strength at point load - PLT test, strength of irregular bodies (σ_N).

BRIEF DESCRIPTION OF THE GEOLOGICAL OBJECT

The studied area is part of the Mesozoic strip constituting the packaging crystalline mountains of Čierna Hora, in the east Slovakia. It built fine-grained dolomite Triassic. Compact Dolomites irregularly crossing into positions dolomitic breccia that appear near the major dislocation.

In terms of geological, exposed wall (also located in front of it it is paid) is formed Ramsau dolomite strata that are largely banked layering (with a thickness of 5 to 50 cm). Lithological is mostly a substitution thinner and more powerful positions gray to dark gray, often heavily fractured dolomite originally of solid or dolomite strata.

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Next fracturing within individual layers of dolomite is caused by the development of fissures, which extend almost always a layer (with a density of fracturing from a few mm to a few cm to dm). The fissures are mainly oriented perpendicularly to the individual layers, and in the cross and longitudinal. Were originally open, they are now healed quartz (SiO_2 thickness of the veins from 0,5 to 2 cm).

Transverse cracks have direction of inclination from 0 ° to 40 °, and the size of the inclination is 75 ° to 85 °. Longitudinal cracks have direction of inclination of 310 ° up to 280 °, but the inclination is moderate, about 50 ° to 60 °. Moreover, some are represented here diagonally cracks [1, 2]. On the one hand this is a positive factor in the process of production of crushed stone, but at the same time adversely affecting the stabilization of the fracture walls or walls that are to fulfill the role of a stable slope as in our case [3-5].

LABORATORY TESTS

Within the engineering geological survey was conducted three core drilling. Given the nature of the massif is unable to obtain intact cores of which could be to prepare test specimens of regular shape for fixing basic physical - mechanical properties of dolomites (Table 1). Therefore, studies are conducted on samples of irregular shape.

Determined to Barton [6]:

- density / ρ_o, paraffin method,
- index of rock strength at point load - PLT test,
- strength of irregular bodies / σ_N.

The strength σ_N irregular specimens/MPa was determined by dividing force in breach area. The results of the strength of random ensembles can be roughly correlated with the strength inpure compression σ_{tl} [6].

Table 1 **Mechanical properties of rock material**

Place of sampling	ρ_o / kg·m^{-3}	$I_{s(50)}$ / MPa	σ_N / MPa
lower level	2 774	0,8	5,6
upper level	2 971	0,9	6,2

TESTS IN SITU

In situ research aimed to verify the strength of dolomite on Schmidt Hammer tests. Geophysical measurements were determined the speed of propagation of seismic waves and the scale of ruptured massif. Measurement method include Schmidt Hammer between the so-called by hardness (scleroscopic's) method when the desired value ascertained indirectly by measuring the size of the flexible response drawn in the strike. The observed reflectance Q is converted to the compressive strength of the impact hammer observed diagrammatically, part of the standard PCSN 45-79 "Determination of compressive strength used hardness methods". For testing was used N-type hammer with impact energy of 2,25 J. Summary results of measurements are shown in the table below (Table 2) [6]. Based on the results of laboratory and field measurements we were categorized according to slope Rock Mass Rating (RMR) classification. RMR index value, the figure ranges from 16 to 32, corresponding to poor to very poor quality rock mass [7, 8].

Table 2 **Results of Schmidt Hammer Tests**

Place of measurement No.	Mean value Q /-	Compressive strength / MPa
1	33,5	7,5
2	36,0	9
3	35,0	8,5
4	26,0	5
5	32,0	7
6	31,5	6,8
7	29,5	6

Experimental measurement the speed of propagation of seismic waves was carried out on the quarry wall. Using seismic instruments ABEM Terraloc Mk8 we measured the speed of propagation of seismic waves directly at the fracture wall. The source of seismic waves was a hammer blow to the quarry wall. Twelve geophones was placed on a parallel profile at a distance of 1 m. Profile had a length of 13 m. The average value of the velocities in the study of the quarry wall was 2 000 ms^{-1}. By using the refractive and reflective seismic methods we have found that the surface portion to a depth of about 0,5 m is the propagation rate of 900 ms^{-1} with a frequency of 69 Hz. Towards a depth of 4 to 6 m the rate of increase up to 2 400 ms^{-1} with a frequency of 193 Hz. These speeds correspond to the disrupted rock massif [9].

COMPUTATIONAL MODEL

The mathematical model is constructed such that the most plausible captured by the model (Figure 1). The

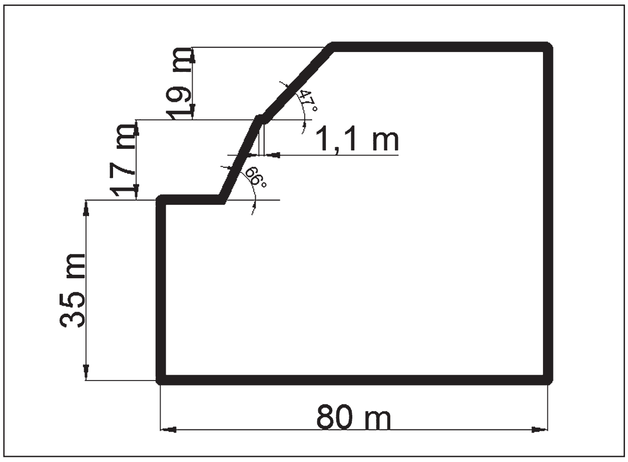

Figure 1 The geometric dimensions of the model

calculation is performed both for unsecured slope, simulating the construction phase immediately after towing the excavation, both for the construction phase locked slope expanded mesh, shotcrete and Store-Norfors-Anchors. Geotechnical parameters used stability calculations are summarized in Table 3.

According to measurements carried out by the average speed of propagation of longitudinal waves approx v_p = 900 ms^{-1} for violation of the environment and the less disturbed environment is v_p = 2 000 ms^{-1}. For the velocity 900 ms^{-1} is E = 1 564 MPa, for v_p = 2 000 ms^{-1} is 10 066 MPa.

Modulus of elasticity (ie. deformation modulus E_m) of rocks was determined in two ways. The first method is based on the relationship by Seraphim and Pereira [9]:

$$E_m = 10\ (RMR - 10)/40\ /Pa \qquad (1)$$

According to this relationship E_m = 1 400 MPa and the value for RMR = 16 and for RMR = 32, is E_m = 3 550 MPa.

The second method of calculation modulus is evaluated from the measured velocities of longitudinal waves v_p respectively P - waves by a simple classic formula:

$$E_{seiz} = v_p{}^*\rho_o{}^*g^{-1}{}^*(1+\mu)^*(1-2\mu)^*(1-\mu)^{-1} \qquad (2)$$

The practical experience it is known that the E_{seiz} and E there is a ratio between the module according to the state of the environment. E_{seiz}/E = 2 is for solid rock, E_{seiz} / E = 6 for fractured rock [10] .

As already indicated, we chose ratio for ratios considered slope [11]:

$$E_{seiz}/E = 4\ /- \qquad (3)$$

For the calculation of E were used average values derived from seismic measurements and based on the classification RMR (relationship by Seraphim and Pereira) [12].

The results of seismic vibration measurements shall be taken into account in the calculation model factor in the horizontal k_h and vertical acceleration k_v. For illustration, it presents the following picture output from a plane model (Figure 2), which was implemented GEO5. In this case, the slope unsecured assessed taking into account the seismic effects [13, 14].

Table 3 **Geotechnical parameters of the ground**

Rock material	ρ_o / kg · m^{-3}	φ / °	c / kPa	E / MPa	μ / -
rupture dolomite	2 600	22	90	371	0,3
benched dolomite	2 873	30	400	1 702	0,22

In Table 3 is: ρ_o - density, φ - angle of internal friction, c- cohesion, μ- Poisson's ratio (determined by estimation), E - modulus of elasticity.

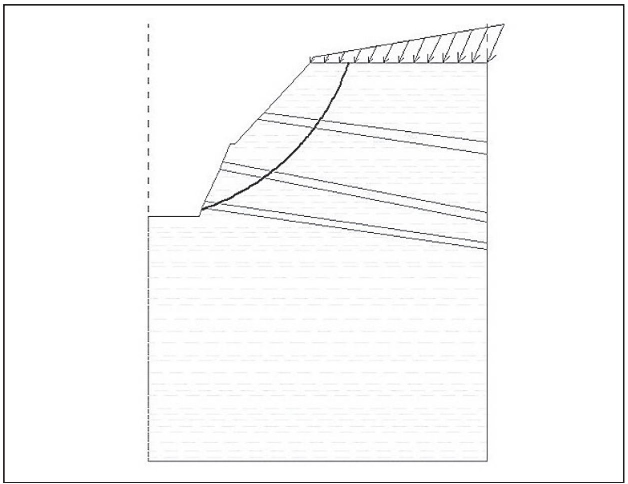

Figure 2 Determination of the degree of safety limit equilibrium method - GEO 5

Figure 2 shows the interface of different strength materials, the overload from the higher overburden and the position of the critical failure surface. Safety factor calculated using the equilibrium limit is within the range˝F_s = 1,26 to 1,30 of the Bishop, Fellenius/Petterson and Spencer, the result is comparable to the space solution [15, 16].

CONCLUSION

Laboratory and field tests have been carried out to investigate the rock slope stabilization in highly weathered dolomite rock. Schmidt Hammer, PLT and rock strength of irregular bodies tests results ranked the dolomitic massif to low and very low strength of the material under test. Stability analyses of an rock slope by new technological line for crushing stones represents the critically failure mechanism of slopes in limit equilibrium (GEO 5) and finite difference method (FDM - Flac3D). FDM provide a lot of benefits over limit equilibrium because these techniques are suitable for indication of the stress and strain distribution within critically instable failure zones, element displacement vectors and the plastic state of slopes.

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