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The effect of excavation in rock slopes on their stability

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ABSTRACT: Stability of rock slopes is one of the most important subjects of the geotechnics and excavation play an important role in the stability of slopes. Since excavation can be done in different parts of slopes, the parametric analysis of their effects on the stability of slopes seems very important. This study aims to analysis of the effect of excavation on different parts of slopes. For this purpose the slopes with different dips namely 30, 45, 60, and 75 degrees using the Phase2 software were modeled and their stability using the critical strength reduction factor (SRF) of slopes were determined. In the next step, the excavation with different sizes, in three different parts of up, middle and down of slopes were done and in each case the stability of rock slopes using SRF were determined. The obtained results show that excavation in different parts of slopes has different effects on instability of slopes. The greater effect of excavation on instability of slopes is relevant to down parts of slopes so that as dip of slopes increases, this effect is more significant.

***Keywords*:** Rock slopes, Strength Reduction Factor (SRF), Phase 2, Excavation.

INTRODUCTION

The stability of the slope is always of superior importance during the lifetime of the structures such as highways, railroads and power plants (Aydan, 1989).A great variety of numerical analyses such as finite element and distinct element methods are performed with development of many kinds of numerical programs on the geotechnical problems. A number of methods are being used for the assessment of slope stability (Crosta, 2003; Bhasin and Kaynia, 2004; Eberhardt, 2004).

Stability by strength reduction is a manner that the factor of safety is determined by weakening the soil or rock in stages in an elastic-plastic finite element analysis until the slope fails. The factor of safety is considered to be the factor by which the soil or rock strength needs to be reduced to reach failure (Dawson, 1999; Griffiths and Lane, 1999).

In the Strength Reduction approach, the soil or rock strength is dummy reduced, and so there is a need to redistribute the stresses. This can be done by the stress redistribution algorithm, and so this option can be indirectly used to do a strength reduction stability analysis.
The strength reduction factor (SRF) is defined as:

$$SRF = \left[\tan\varphi / \tan\varphi f \right] = \left[c / cf \right]$$

where φf and cf are the effective stress strength parameters at failure, or the reduced strength. The strength reduction method usually uses the same SRF for all material and for all strength parameters, so that the stability factor reduces to one number in the end.

In this Research in order to study the parametric effect of excavation on stability of rock slopes, slopes with different dips composed of dolomite rocks were modeled. Then, excavations were carried out in three sections of up, middle and down of slopes.

Geomechanical parameters of dolomitic rocks

In this study, the geomechanical parameters of the jointed dolomitic rock masses in Taham-Chavarzagh road, located in the Zanjan province, were obtained by using Roclab software (Hoek et al. 2002). These parameters are obtained based on The Hoek-Brown failure criterion and it is presented in Table 1.

Table 1. Geomechanical parameters of dolomitic rock mass obtained by using Roclab software

Input and output of Roclab software						
Hoek-Brown classification				Hoek-Brown criterion		
Hoek Brown Classification				Hoek Brown Criterion		
σ_{ci}(Mpa)	GSI	m_i	D	mb	s	a
Intact Uniaxial compressive strength	Geological strength index	Constant Hoek-Brown criterion for intact rock	Disturbance Factor	Hoek-Brown criterion		
108	45	9	0.7	0.438	0.0003	0.508
Parameters of the Mohr - Coulomb equivalent		Rock Mass Parameters				
Mohr-Coulomb Fit		Rock Mass Parameters				
C (Mpa)	φ (degree)	σ_t (Mpa)	σ_c(Mpa)	σ_{cm}(Mpa)	E_{rm}(Mpa)	
Cohesion	Friction angle	Tensile strength	Uniaxial compressive strength	Golobal strength	Deformation modulus	
0.574	42.17	-0.085	1.882	9.238	4031.56	

Modeling of rock slopes

To study the effects of excavation on the stability of rock slopes, slopes with dips of 30, 45, 60, and 75 degrees in the jointed dolomitic rock masses were modeled. (Fig.1)

The Veneziano joint network model is used for numerical analysis (Fig. 1) and this model is based on a Poisson line process. It adapts the Poisson process to generate joints of finite length (Dershowitz, 1985).

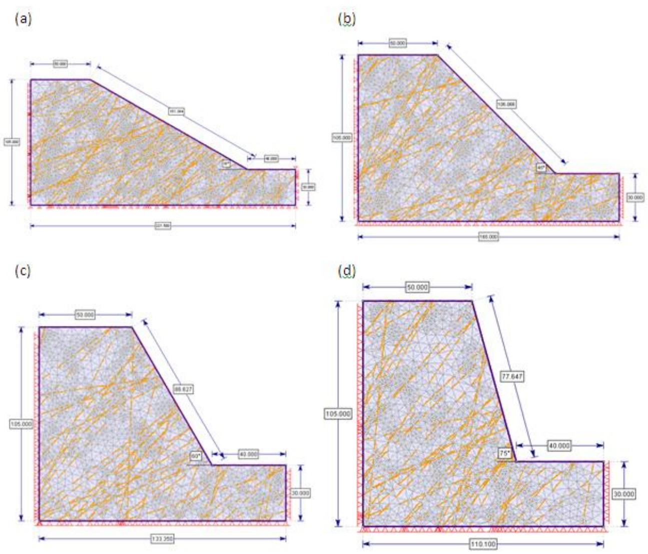

Figure 1. The models of slopes with dips of 30 degree (a), 45 degree (b), 60 degree (c) and75 degree (d), the Veneziano joint network is also shown

By run the made models, the critical strength reduction factor (SRF) of slopes was obtained. This amount is 4.23 for 30degree slope, 2.8 for 45degree slope, 2.08 for 60degree slope, and 1.55 for 75degree slope.

Excavation on the slopes

At this stage in three sections of up, middle, and down of slopes, excavations are carried out with different values and in each case the critical strength reduction factor (SRF) of slopes are achieved. These excavations related to 45degree slopes are shown in Figs. 2, 3 and 4.

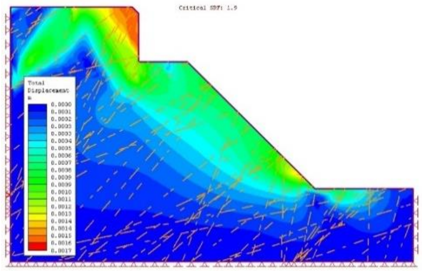

Figure 2. The excavation on the up of 45 degree slope (the critical SRF is equal to 1.9)

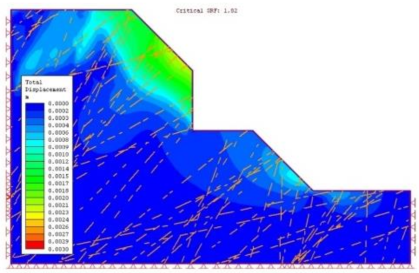

Figure 3. The excavation on the middle of 45 degree slope (the critical SRF is equal to 1.82)

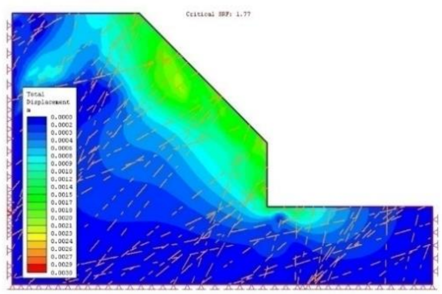

Figure 4. The excavation on the down of 45 degree slope (the critical SRF is equal to 1.77)

The values of SRF obtained for all of the excavated slopes are presented to diagrams shown in Figs. 5 to 8.

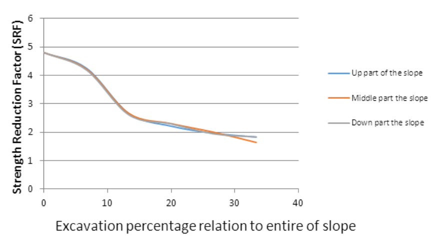

Figure 5. The diagram shows the amounts of SRF versus the excavation percentage on the slope with dip of 30 degree

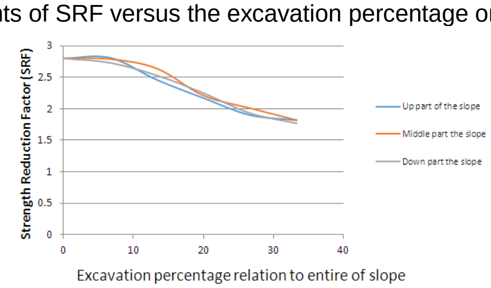

Figure 6. The diagram shows the amounts of SRF versus the excavation percentage on the slope with dip of 45 degree

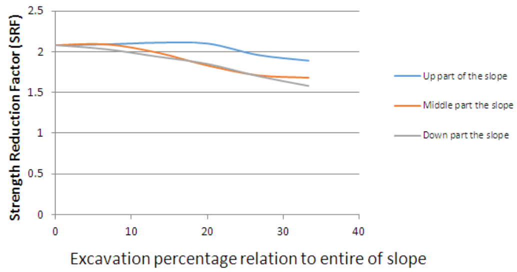

Figure 7. The diagram shows the amounts of SRF versus the excavation percentage on the slope with dip of 60 degree

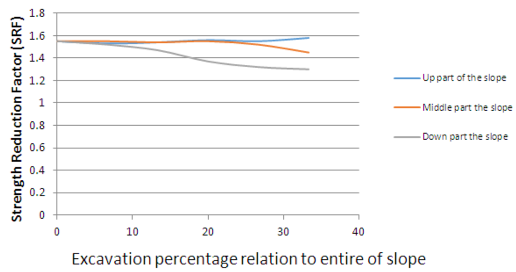

Figure 8. The diagram shows the amounts of SRF versus the excavation percentage on the slope with dip of 75 degree

As the above diagrams show, in all of the slopes by excavation, the amount of critical strength reduction factor (SRF) has decreased that this matter suggests they become unstable due to excavation. However the difference is that as the dip of slopes increases, the reduction rate of SRF has greatly declined. This matter indicates that as dip of slopes increase, the effect of excavation on instability decreases. Also, the above diagrams show that by increasing dip of slopes, excavation location has a greater importance relating to instability of slope, so that in 30degree slope the diagrams of sections of up, middle, and down of slopes are almost overlapped. However, in 60 degree and 70 degree slopes, excavation in down part of slope has greater effect on the instability of slopes. The sudden fall of SRF in 30 degree slope is in 5 to 10 percent of excavation and in 45 degree slope it is in 15 percent of excavation. As dip of slopes increases, the amount of sudden fall in SRF diagrams declines so that in high dips this sudden fall completely disappears.

CONCLUSION

In this research that with aim to analysis of the effect of excavation on different parts of slopes is done the following results are obtained:

-By excavation on slopes the strength reduction factor (SRF) of slopes decreases and as the amount of excavation gets larger, slope instability has increased.

-Excavation in different parts of slopes has different effects on instability of slopes.

-The greater effect of excavation on instability of slopes is relevant to down parts of slopes, so that as dip of slopes increases, this effect is more significant.

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