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Evaluating The Disturbance Factor (D) On The Stability Of Rock Slopes In The Quasi-Static Analysis

Farzad Fehri[1], Vahid Hosseinitoudeshki[2*], Mohammad Hossein Noori Gheidari[3]

[1,2,3]Department of Civil Engineering, Zanjan Branch, Islamic Azad University, Zanjan, Iran

Corresponding e-mail address: toudeshki@gmail.com

***Abstract*— In this paper, the effect of disturbance factor on the stability of rock slopes in the quasi static analysis was investigated. For this purpose, four slopes with dips of 30, 45, 60 and 75 degrees were modeled by Phase2 software in the quasi static case and the effect of rock disturbance factor (D) was investigated on the slope stability. The stability of slopes with earthquake acceleration of 0.1g, 0.2g and 0.3g were determined using the critical strength reduction factor (SRF) of slopes. The results indicate that in the quasi static analysis, the excavation percentage has a higher effect than D parameter in reducing the SRF. Also, the SRF reduction rate shows disorganizations which is because the joints are located in the direction of the earthquake acceleration. Moreover, by increasing the D parameter, the earthquake acceleration effect on the SRF has decreased.**

Keywords— Rock slope; Quasi static analysis; Disturbance factor; Strength Reduction Factor (SRF)

1. INTRODUCTION

The stability of the slope is always of superior importance during the lifetime of the structures such as highways, railroads and power plants [1]. The slope stability analysis has many applications in the design of rock slopes, roads and open pits structures. 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.

A number of methods have been suggested by researchers [2, 3, 4, 5] to evaluate the stability issues of slopes. These methods consider a different set of geotechnical parameters such as weathering, discontinuity spacing and groundwater. A quasi-static load is time dependent but is slow enough such that the structure deforms very slow (very low strain rate) and inertial effects can be ignored. The load quasi-static for a given structure (made of some material) may not be quasi-static for another structure (made of a different material).

In this Research in order to study the effect of disturbance factor (D) on the stability of rock slopes, the slopes with different dips composed of dolomitic rocks were modeled.

2. GEOMECHANICAL PARAMETERS OF DOLOMITIC ROCKS

In this study, the geomechanical parameters of the dolomitic rocks were obtained using Roclab software [6]. These parameters are obtained based on The Hoek-Brown failure criterion and it is presented in Fig. 1.

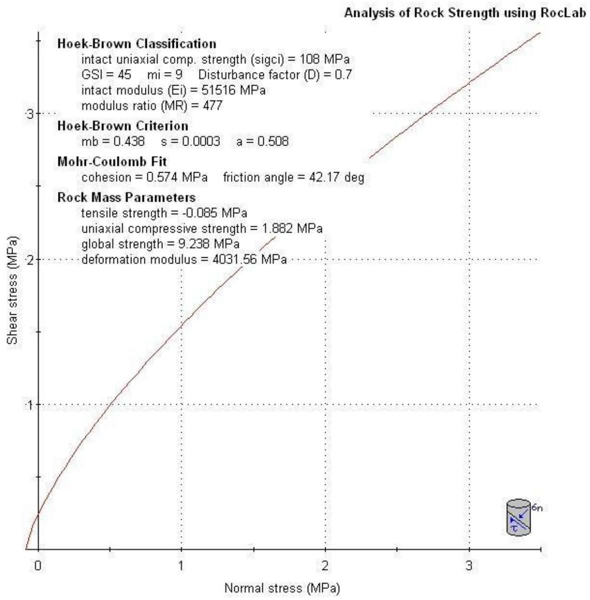

Fig.1. The geomechanical parameters of dolomitic rocks

3. MODELING OF ROCK SLOPES

To study the effect of disturbance factor on the stability of rock slopes, the slopes in different dips such as 30, 45, 60, and 75 are modeled by Phase2 software [7]. In the models, the pattern of Veneziano joints is used with direction and dip of 135 of 36 degree for joints, respectively (for example Fig. 2). Also, the joints all over the slopes have the same conditions in the spacing of joints, the roughness of joints' surface, and the resistance of joints' walls. Moreover, the disturbance factor for rocks is different in each slope including 0.7, 0.8, 0.9 and 1 which are defined for each excavation method.

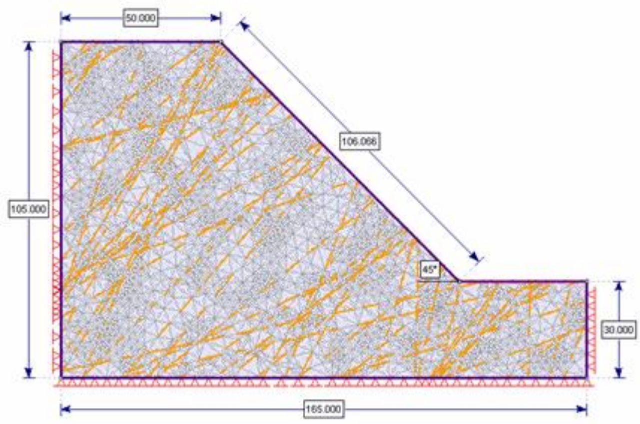

Fig.2. The modeled slope with dip of 45 degree

4. Analyzing slope stability in the quasi-static state

For analyzing the slope stability in the quasi static state, in the middle section of the slope, the excavations equal to 6, 13, 20, 26 and 33 percent were performed and in all cases, the four disturbance factors (0.7, 0.8, 0.9 and 1) were put into consideration. The analysis for three quasi static cases with earthquake accelerations of 0.1g, 0.2g and 0.3g was performed and in each case, the critical SRF was determined. In Figs. 3, 4, 5 and 6 the critical SRF for slope with dip of 45 degree and earthquake acceleration of 0.1g has been shown in the case of the slope surface excavated equal to 20 percent.

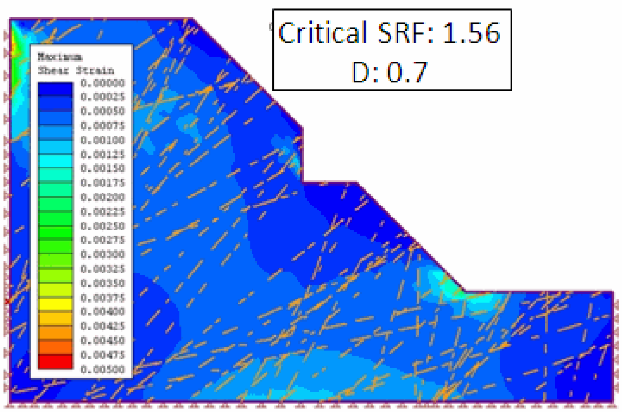

Fig. 3. The critical SRF for slope with dip of 45 degree and 20% excavation in the case of earthquake acceleration is 0.1g (D parameter is 0.7)

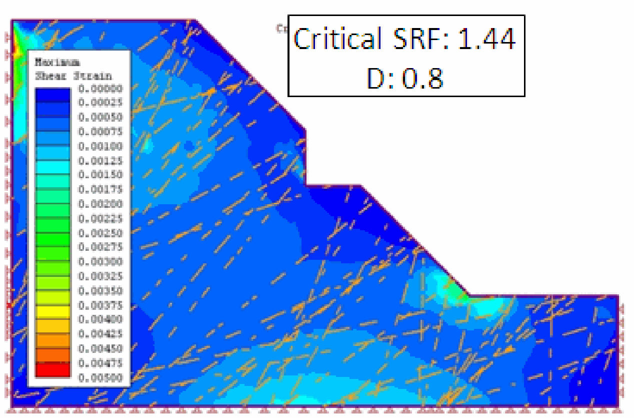

Fig. 4. The critical SRF for slope with dip of 45 degree and 20% excavation in the case of earthquake acceleration is 0.1g (D parameter is 0.8)

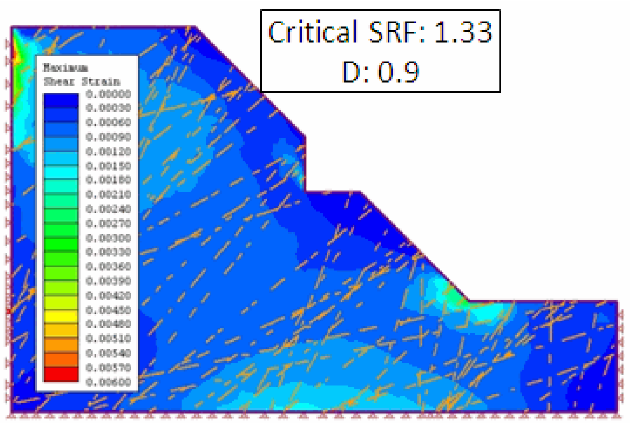

Fig. 5. The critical SRF for slope with dip of 45 degree and 20% excavation in the case of earthquake acceleration is 0.1g (D parameter is 0.9)

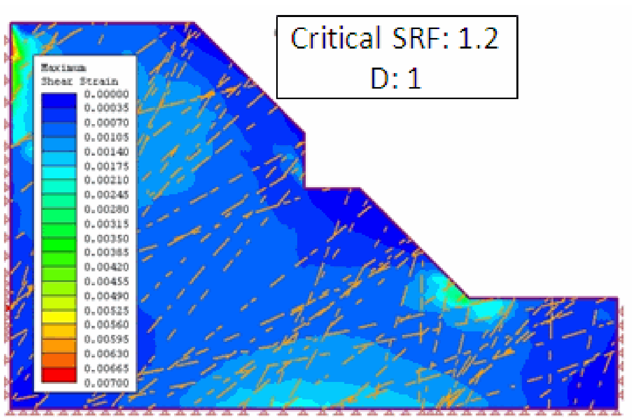

Fig. 6. The critical SRF for slope with dip of 45 degree and 20% excavation in the case of earthquake acceleration is 0.1g (D parameter is 1)

By run the all models, the critical strength reduction factor (SRF) of slopes was obtained and shown in Figs. 7 to 18.

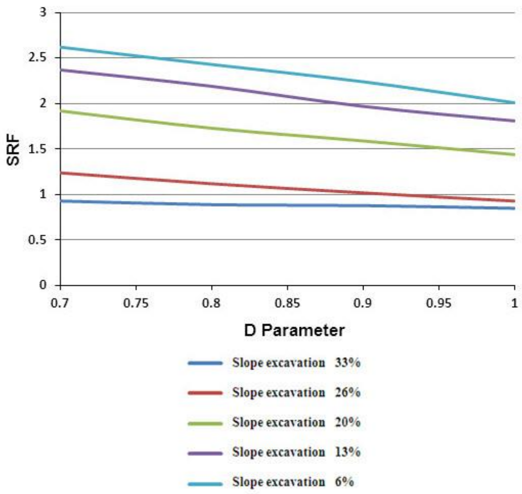

Fig.7. The SRF variations with different excavation percentages according to the D parameter in the slope of 30 degree for earthquake acceleration of 0.1g

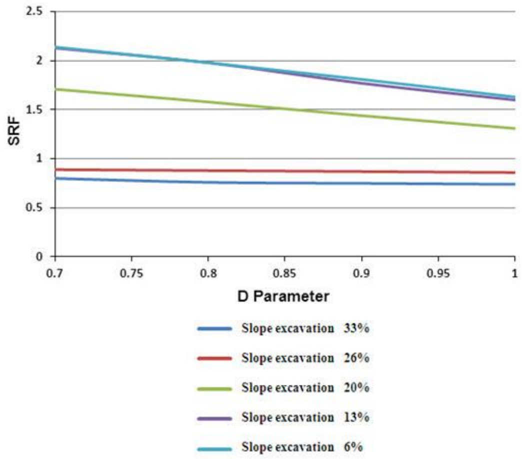

Fig.8. The SRF variations with different excavation percentages according to the D parameter in the slope of 30 degree for earthquake acceleration of 0.2g

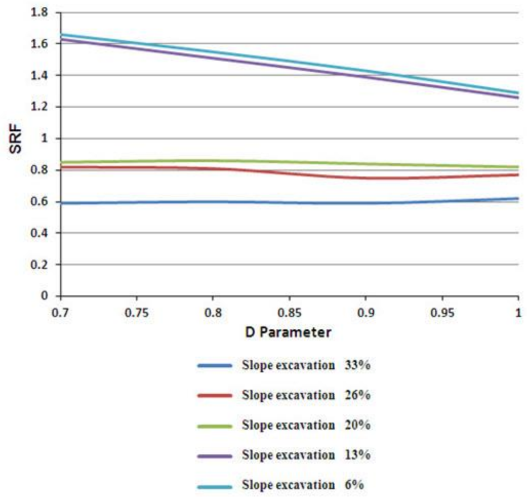

Fig.9. The SRF variations with different excavation percentages according to the D parameter in the slope of 30 degree for earthquake acceleration of 0.3g

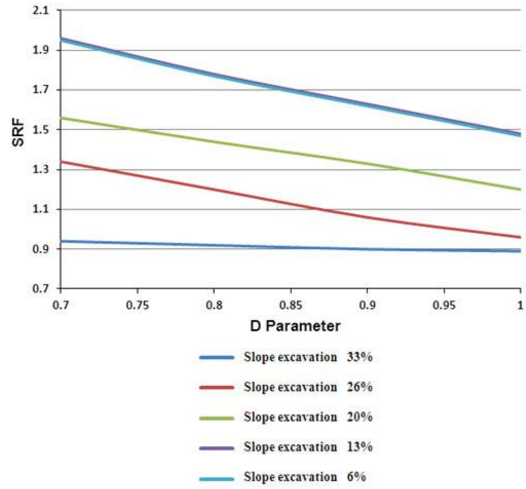

Fig.10. The SRF variations with different excavation percentages according to the D parameter in the slope of 45 degree for earthquake acceleration of 0.1g

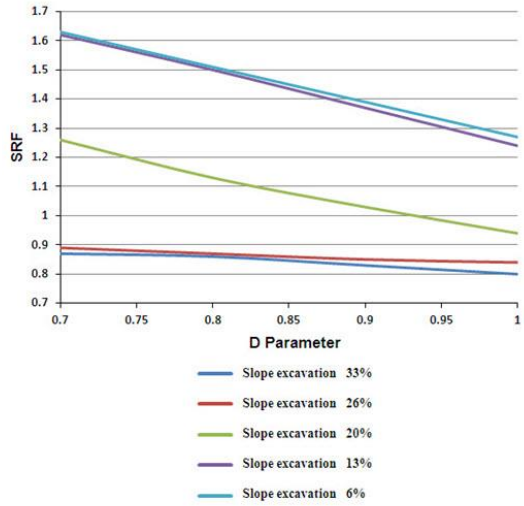

Fig.11. The SRF variations with different excavation percentages according to the D parameter in the slope of 45 degree for earthquake acceleration of 0.2g

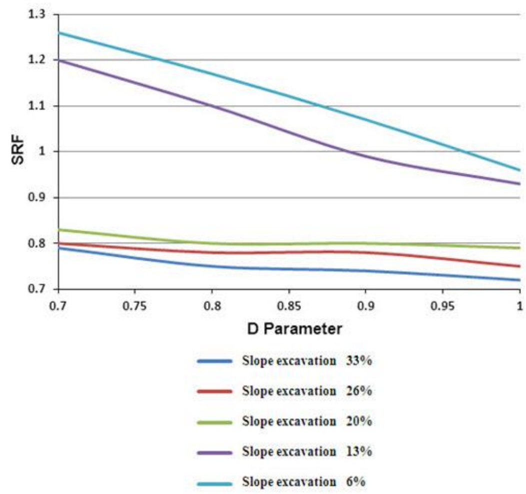

Fig.12. The SRF variations with different excavation percentages according to the D parameter in the slope of 45 degree for earthquake acceleration of 0.3g

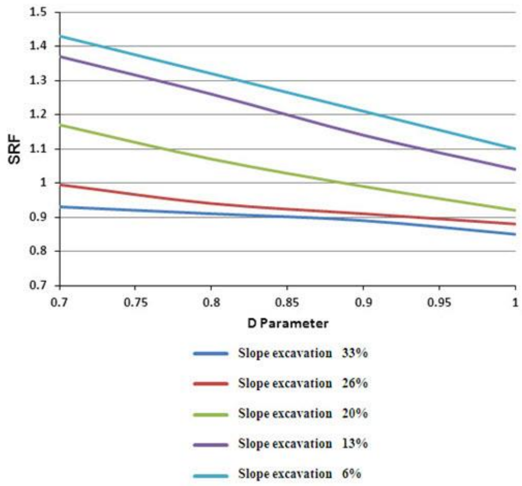

Fig.13. The SRF variations with different excavation percentages according to the D parameter in the slope of 60 degree for earthquake acceleration of 0.1g

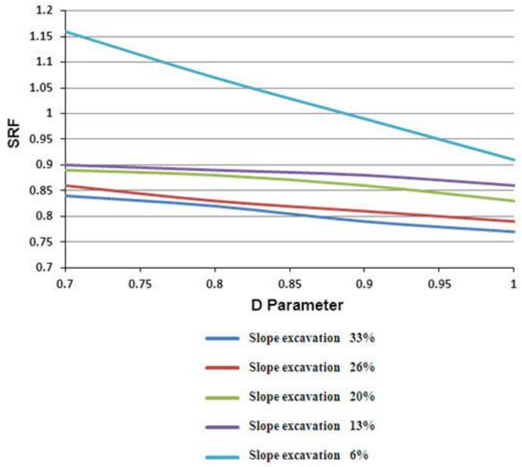

Fig.14. The SRF variations with different excavation percentages according to the D parameter in the slope of 60 degree for earthquake acceleration of 0.2g

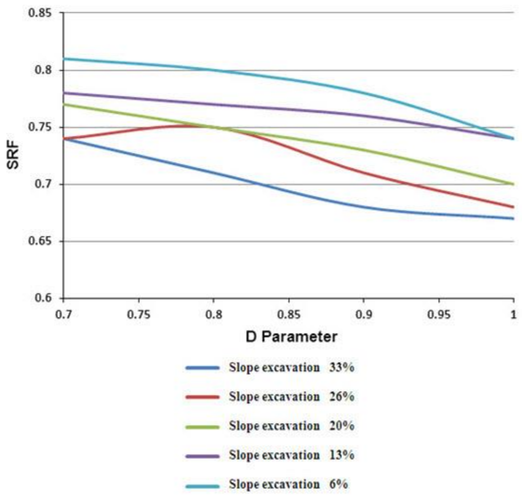

Fig.15. The SRF variations with different excavation percentages according to the D parameter in the slope of 60 degree for earthquake acceleration of 0.3g

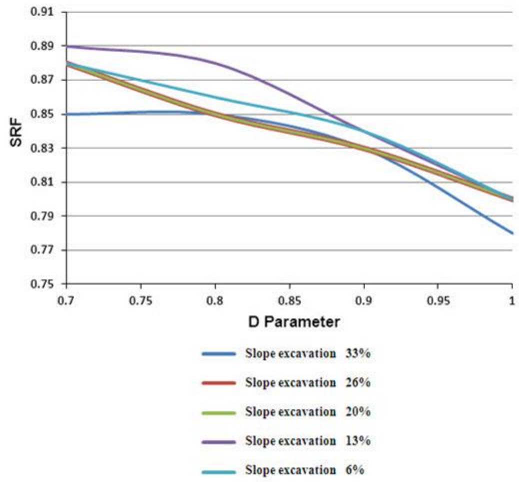

Fig.16. The SRF variations with different excavation percentages according to the D parameter in the slope of 75 degree for earthquake acceleration of 0.1g

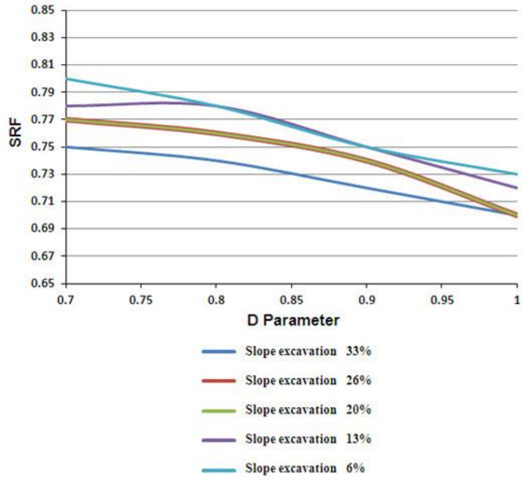

Fig.17. The SRF variations with different excavation percentages according to the D parameter in the slope of 75 degree for earthquake acceleration of 0.2g

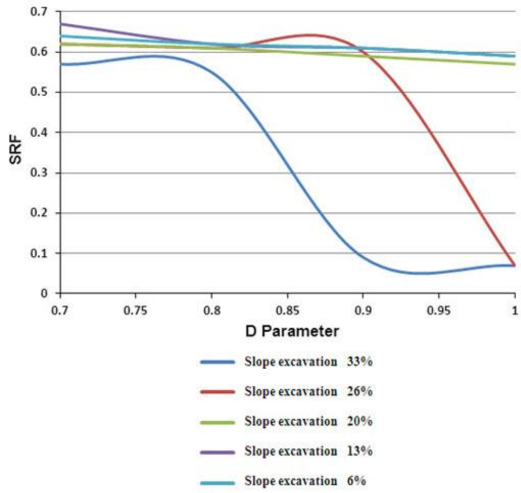

Fig.18. The SRF variations with different excavation percentages according to the D parameter in the slope of 75 degree for earthquake acceleration of 0.3g

The diagrams in Figs. 7 to 18 show a decrease in strength reduction factor (SRF) by increasing dip of slopes. The reason of decreasing in SRF by an increase in dip of slopes is that by enhancing the dip of slopes, the state of stresses in the slopes is changed and the minimum main stress (σ3) will reduces. This issue is resulted in a larger Mohr circle of stress so it will cause that the shear strength envelope Hoek-Brown to cut the Mohr circle and the decreasing of SRF will emerge. Moreover, in all slopes as the excavation percentage increases, the SRF decreases more quickly. This can be from the heterogeneous behavior of the joints against the earthquake acceleration.
Detailed evaluations on the diagrams show that by increasing dip of slope, excavation percentage and D parameter, the effect of D parameter decreases and the SRF reduces more slowly. But this effect is not seen in steep slopes. So it can be concluded that increasing the D parameter in the gentle slopes and lower earthquake accelerations have a higher effect in reducing the SRF. Furthermore, in steep slopes the increase of both earthquake acceleration and D parameter simultaneously has a lower effect on the SRF reduction.

5. CONCLUSION

In this research that with aim to analysis the effect of disturbance factor (D) on the stability of rock slopes is done the following results are obtained:

- In all slopes, by increasing dip of slopes, the strength reduction factor (SRF) has decreased.
- In the quasi static analysis, the excavation percentage has a higher effect than D parameter in reducing the SRF.
- In the quasi static analysis, the SRF reduction rate shows disorganizations which is because the joints are located in the direction of the earthquake acceleration.
- In the gentle slopes, the increase in the D parameter due to different excavation methods has a higher effect in reducing the SRF.
- In the steep slopes, the increase in both earthquake acceleration and D parameter has a much lower effect in decreasing the SRF.
- By increasing the D parameter, the earthquake acceleration effect on the SRF has decreased.

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