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Investigation of vertical distance effect in steps on the stability of slopes

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ABSTRACT: This article studies the vertical distance effect in the steps on the factor of safety and stability of slopes. For slope modeling the plaxis software has been used and models with supposition of even state and with two dimensions has been established. Furthermore, in two dimensions analytic, two bottom of slope has been relinquished. The obtained results show increasing in height leading to a deepening in sliding surface. But, changes in sliding surface depend on locating of steps. When step is toward above the slope, sliding surface is less clear than it is in the middle slope. Furthermore establishing step in slope lead to increase factor of safety and deepening of the failure mechanism.

Keywords: Slope stability, Vertical distance steps, Sliding surface, factor of safety.

INTRODUCTION

General and scientific study on slide earth phenomenon for various reasons is one of the most important subjects in the world. It could be said that one of the most important and sensitive subjects on main developmental projects, for example, selecting the site of building large constructions, dam construction, selecting the path of highways construction, traffic tunnels, and any mineral developmental relates to natural slopes of area.

Various factors such as geology conditions, hydrology, hydrogeology, morphology, topography condition, climate and weathering can effect on slopes and lead to landslide. A number of methods are being used for the assessment of slope stability (Crosta et al., 2003; Bhasin and Kaynia, 2004; Eberhardt et al., 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 et al., 1999; Griffiths and Lane, 1999).

This paper proposes a simple and practical numerical procedure to evaluate the stability of slopes with vertical distance in steps. The proposed model is regulated in a united manner to accommodate the Mohr–Coulomb criterion. In this model, all the strength parameters are assumed to be a function of deviatoric plastic strain and to decrease linearly to the residual values.

Studied models

Selected slope is located in the rock and has 10, 15 and 20 meters height and 70 degree dip. It is considered that mentioned slope in source state has no steps. For modeling slopes, used from software of Plaxis V8.2 and in made analysis, margins of two directions has been located about in 60 meters distance from each other (Fig. 1). Furthermore, beneath margin of model, has been selected in 15 meters height from the earth. In order to determine margins distance we use formed wedge failure. If wedge failure does not spread till margins, margins distance will be suitable.in each model. General view of made model in software presented as Fig. 1.

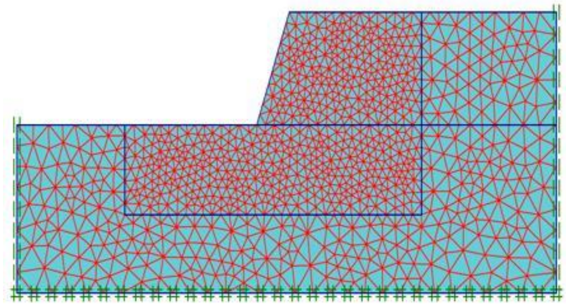

Figure 1. Numerical modeling of slope

Vertical distance effect in steps

One of the ways to increase factor of safety in natural and artificial slopes is by making some steps. Two factors can be effective in the steps functions. The first one is vertical distance steps and the second one is scale of the steps.in this section. We will study about the vertical distance effect in made steps in slope. For each slope, we consider three vertical distance step in sequence 0, 5, 8 meters. The zero distance is the construction which has no step. Horizontal length for each step has been selected in 3 meters.

Figures 2 and 3 presents formed profile in 10 meters slope with 5 and 8 meters distances. With noticing to made models in this section, it is clear the effect of presence, number and steps locations in resistance of each slope.

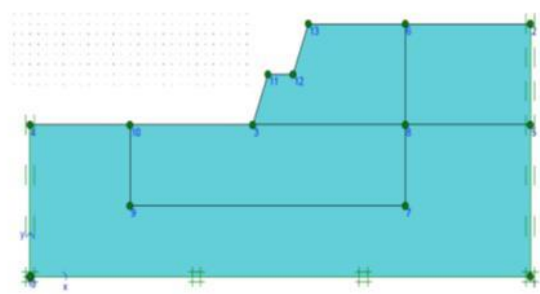

Figure 2. The model in 10 meters slope with 5 meters distances

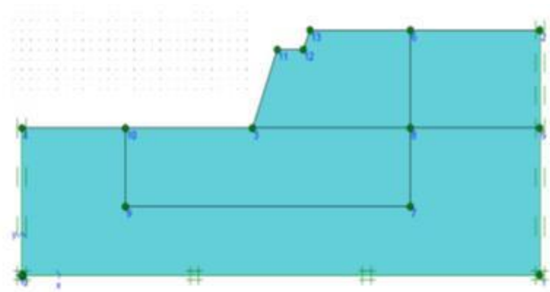

Figure 3. The model in 10 meters slope with 8 meters distances

For 10 meters slope, in two states of distance 5 and 8 meters, one step locate in slope height. When steps locate in the middles of the steep, have more effects than when locate in the above it.

The sliding surface of two other states has presented in figures 4 and 5. It is clear that step in the slope leading to a deepening of the sliding surface. But, changes in sliding surface depend on locating of step. When step is toward above the slope, sliding surface is less clear than it is in the middle slope. Therefore, it could be declared that making rupture in 5 meters step is more difficult than other cases and in 8 meters step also is more difficult than the case of no step. Also, for making rupture in 5 meters step, it needs less transformation for rupturing and transformation in 8 meters step is less than the case of no step. We can conclude that rupture in steps which is located in the center of slope will form more difficult.

The curve in figure 6 presented changes factor of safety against steps distance. It is clear that steps in each state leading to increase factor of safety in slope.

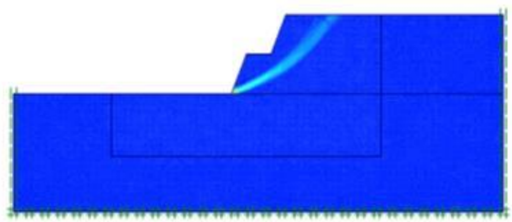

Figure 4. The rupture surface in 10 meters slope with 5 meters vertical distance in steps

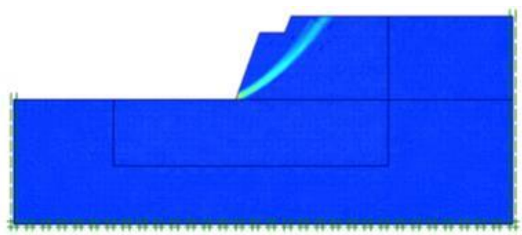

Figure 5. The rupture surface in 10 meters slope with 8 meters vertical distance in steps

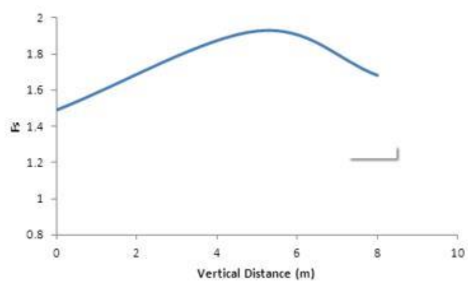

Figure 6. The changes of factor of safety against vertical distance of steps in 10 meters slope

For 15 meters slope, in the case of 5 meters distance, 2 steps is located and in the case of 8 meters distance, 1 step is located in the slope surface (Figs. 7 and 8). The curve in figure 9 presented changes factor of safety against steps distance.

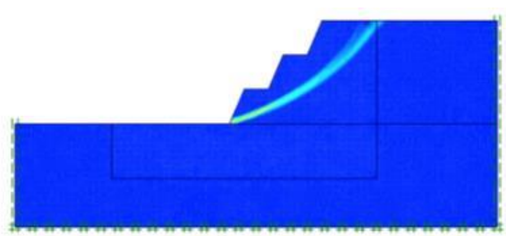

Figure 7. The rupture surface in 15 meters slope with 5 meters vertical distance in steps

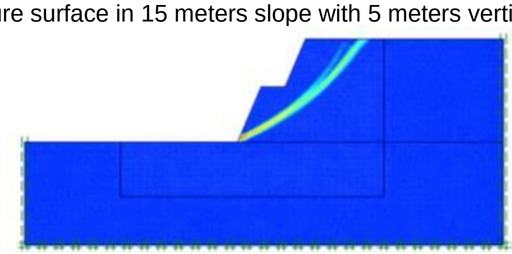

Figure 8. The rupture surface in 15 meters slope with 8 meters vertical distance in steps

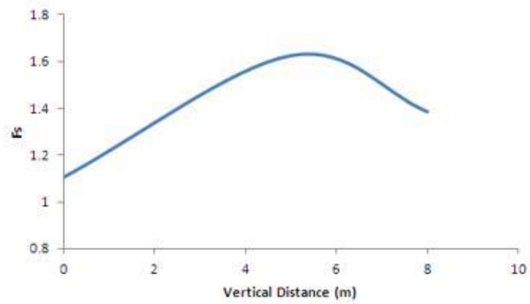

Figure 9. The changes of factor of safety against vertical distance of steps in 15 meters slope

For 20 meters slope, in the case of 5 meters distance, 3 steps is located in 0.25 ,0.5 and 0.75 of height and in the case of 8 meters distance, 2 steps is located in 0.4 and 0.8 of height (Figs. 10 and 11). The curve in figure 12 presented changes factor of safety against steps distance for 20 meters slope.

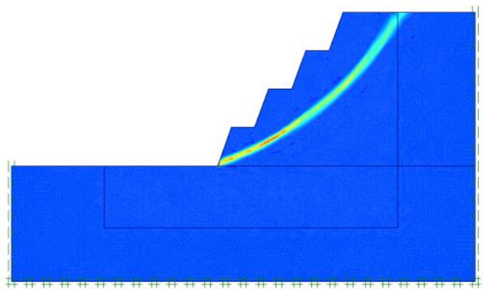

Figure 10. The rupture surface in 20 meters slope with 5 meters vertical distance in steps

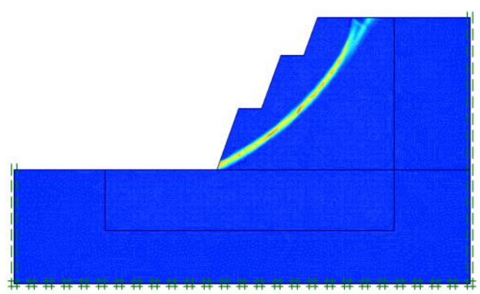

Figure 11. The rupture surface in 20 meters slope with 8 meters vertical distance in steps

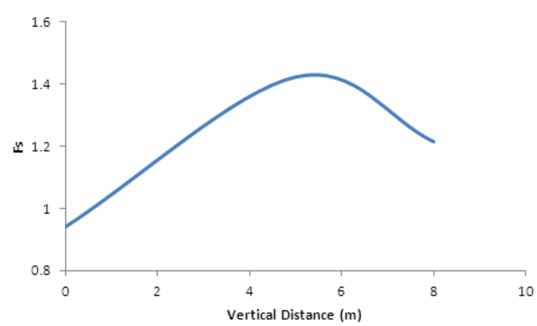

Figure 12. The changes of factor of safety against vertical distance of steps in 20 meters slope

In all case, when the number of step is much, the factor of safety is increased. In slopes with more height, it is better to spread steps in sections between 0.25 and 0.75 of height.

CONCLUSION

In three mentioned slopes, we can declare that increasing in height of slopes leading to a deepening in sliding surface but it makes no effect on general figure and the wedge failure passes from slope but does not enter to base. Also, in three cases, wedge failure is similar to circular slide. Furthermore establishing step in slope lead to increase factor of safety and deepening of the failure mechanism. If we are supposed to locate a step, the middle section of slope is the best ones. If we want to put more step, it suggests that put them between 0.75 and 0.25 section of slope.

REFERENCES

Bhasin R and Kaynia AM. 2004. Static and dynamic simulation of a 700-m high rock slope in western Norway, Engineering Geology, 71: 213-226 .

Crosta GB, Imposimato S and Roddeman DG. 2003. Numerical modelling of large landslides stability and run out, Natural Hazards and Earth System Sciences, 3: 523- 528.

Dawson EM, Roth WH and Drescher A. 1999. Slope Stability Analysis by Strength Reduction, Geotechnique, 49(6): 835-840.

Eberhardt E, Stead D and Coggan JS. 2004. Numerical analysis of initiation and progressive failure in natural rock slopes—the1991 Randa rockslides, Rock Mechanics and Mining Sciences, 41: 69-87.

Griffiths DV and Lane PA. 1999. Slope Stability Analysis by Finite Elements, Geotechnique, 49(3): 387-403.