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The effect of water level on the stability of slopes

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ABSTRACT: In this paper, we investigate the effect of water on the stability of slopes. For this purpose, reference geometry of slopes has been defined in the application. For slope modeling, the finite element software of Plaxis is used. Models have been created in dimensional forms supposing plain strain. The obtained results show that water does not affect the safety factor of slopes unless water level rises and it enters into the rupture surfaces in the slopes. By penetrating of water into the slopes, a sharp decline in strength and safety factor of slopes will occur. So, stability of slopes can be increased by preventing of the water penetration into the slopes. Furthermore, the water level has no effect on the depth and shape of sliding surface in the slopes.

Keywords: Slope stability, Water level, Sliding surface, Safety factor

INTRODUCTION

The rock slope stability is one of the most important problems in large construction projects and factors that cause instability of slopes lead to rock fall, soil and debris and finally destroying the balance of mass in slope. Generally to prevent slope instability or designing a stable one, we can decrease the water level (decrease sliding forces). Addition of water from rainfall or snow melt adds weight to the slope. Water can seep into the soil or rock and replace the air in the pore space or fractures. Since water is heavier than air, this increases the weight of the soils so, the stress increases and this can lead to slope instability.

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 et al., 2003; Bhasin and Kaynia, 2004; Eberhardt et al., 2004).
In this paper we survey on the effect of water level progression. Recognition the areas with weak drainage or active points in displacements and slump like previous sliding areas are the main actions to prevent vibration risk at studying level and identifying the plan. This will help to decide where place or displace the plan. If the reliability against vibration is more than one, slight reduction on resistant forces like progression on water level can cause instability.

STUDIED MODELS

Selected slope is located in the rock and has 10 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 V.8.2 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.

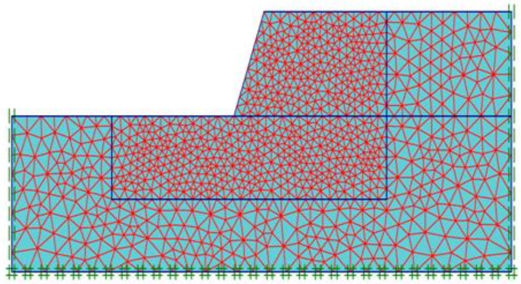

Figure 1. Numerical modeling of slope

EFFECT OF WATER LEVEL ON THE SLOPE STABILITY

To evaluate the effect of water level on the behavior and the safety factor of slopes, a slope with 10 meters height was chosen and was investigated in three cases. First state, the slope was considered dry. In the latter case, the water is assumed on the surface of slopes, and in the third case, the water level has risen and it has penetrated into center of slopes.

The sliding surface in three modes is shown in Figs. 2 to 4. Comparison of sliding surfaces in three modes shows that the changing of water level does not affect the depth and shape of the sliding surface. Furthermore, comparison of the plastic parts in three modes show that in the first and second modes, plastic parts are similar but in the third case, the plastic parts are somewhat more limited than the other two modes, which indicates the easier and faster formation of a wedge in this mode. In other words, the rising the groundwater level will lead to decrease confidence slopes and failure rate of slopes increases.

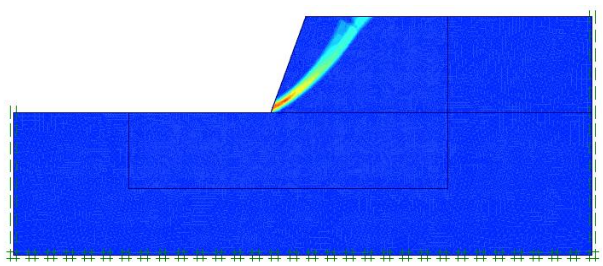

Figure 2. The rupture surface in 10 meters slope in the dry condition

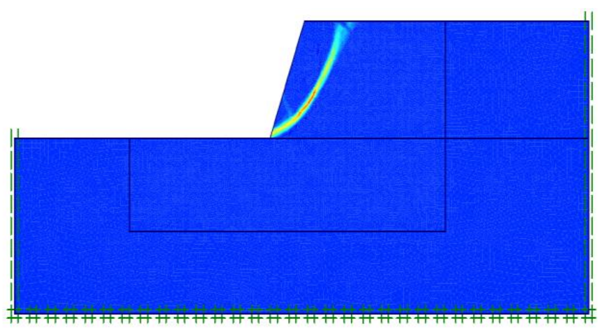

Figure 3. The rupture surface in 10 meters slope in condition of water on the surface of slopes

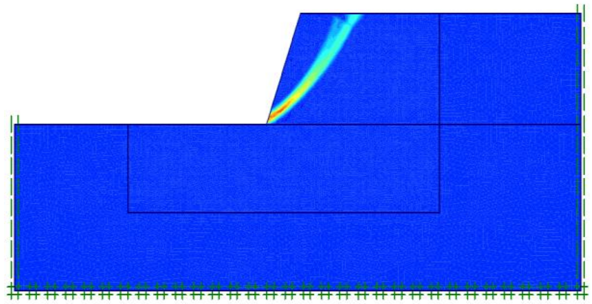

Figure 4. The rupture surface in 10 meters slope in condition of water level has penetrated into center of slope

In Fig. 5 the variation of safety factor is plotted in all three modes. As can be seen by increasing of water level, the safety factor of slope decreases. The reason of this subject can be attributed to increase in weight due to rising of water level. Whatever, the water level rises to up, the saturation density of the mass increases and therefore, the safety factor of slope decreases. As the graph show the safety factor in the second case does not change. In the third case that the water level is at the center of slope, the safety factor of slope greatly decreases. In this case, the bulk of the sliding wedge is below the water level and water has a significant impact on the safety factor.

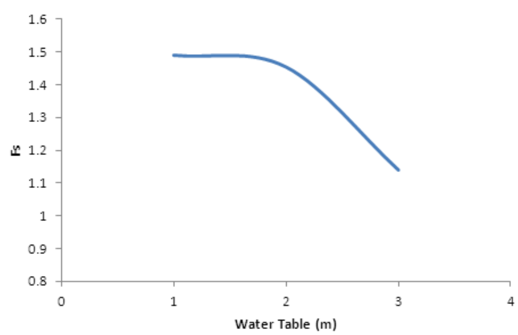

Figure 5. This graph shows variations of safety factor with water level in the slopes

In general, about the impact of water level, we can say that by increasing the water level, if the water does not penetrate into the slope, the safety factor of slopes will not change but by entering the water into slope, a sharp decrease in strength and safety factor of slopes will take place. So, we can increase stability of slopes by preventing of water penetrate into the slopes via drainage techniques.

CONCLUSION

This study aimed to investigate the effect of water on the stability of slopes, the numerical models in three modes (dry, no penetration of water into the slopes, with penetration of water into the slopes) was made. The obtained results show that water does not affect the safety factor of slopes unless water level rises and it enters into the rupture surfaces in the slopes. Therefore, stability of slopes will decrease as the water level increase and the water penetrates into slopes but, the water level has no effect on the depth and shape of sliding surface in the slopes.

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