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Study of Single Weak Soil Layer Effect in Slope Stability Analysis

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Abstract

One of the most important problems in civil engineering, especially in urban areas, is slope stability analysis. The type of soil material is very important in slope stability analysis. If slopes are made from soils with desirable resistance properties, then the stability increases. In this article, the aim is to study the effect of single weak layer on safety factor of a slope stability in static and quasi-static situations also unreinforced slopes and reinforced slopes using nails. Also, the effects of the depth and thickness of the weak layer are considered. Results are obtained from GEOSLOPE software, which shows reduction in safety factor and also when single weak layer and the depth and thickness increases, safety factor decreases.

Keywords: Slopes, static and quasi-static, nailing, GEOSLOPE software.

Introduction

The word slope denotes to any natural or artificial inclined surface that might be made of soil, rock, or both materials. Instability and landslide of natural and artificial slopes occur in Iran and everywhere else. Movement and landslide of slopes, including soils and rocks, has significant adverse effects on communication linkages, tunnels, water and sewage lines, buildings, etc. As a commonsense, damage caused by failure of slopes are estimated less than the actual one. Therefore, U.S. Geological Organization has reported that slope landslides and failures in urban and inter-urban regions result in an estimated 50 deaths and damage exceeding $1 billion annually. For countries other than United States this estimate is thousands deaths and damage exceeding $100 billion per year(Spiker & Gori, 2003).

Naturally, slope failures can be due to weight of the unstable mass, earthquakes, long heavy rains, and floodwater. Although in natural failures, other factors like water and wind erosion,gradual rise of groundwater level, and even human activities including loading and unloading of slopes can intensify instability (Chen & Zhuang, 2001). Small or big displacements can occur in slope and backfill failures, which can cause damage to structures (U.A ,1999). Soil nailing is one of the ways to stabilize slopes and has broad usage in Iran. In fact, this method is a passive maintenance system while methods like Anchoring and Rock Bolt are active ones. In other words, forces are mobilized in nails as a tensile force and allow maintenance system to operate if displacement and deformation happen in soil. Therefore, the interaction between soil and nails prevents extra displacement in instable slopes. Also, nails would be able to resist against bending moments, tensile, and shear stresses (Zhou & Cheuk & Tham 2009).

For the significance of the issue, we study the effect of single weak layer on the stability of a static and quasi-static slope.

Materials and method

In this paper, a slope is modeled with GEOSLOPE software in dry mode meaning that groundwater level is assumed lower than the base of excavation. Slope geometry condition is considered to be a single layer of weak soil. In order to study the effect of mentioned layer in a better fashion, thickness is assumed to be 0.5, 1.0, and 1.5 with each layer moving downwards through height of the slope. Safety factor is calculated for both static and quasi-static slopes.

Since in Morgenstern – Price method forces and moments equilibrium are considered, we use this method for our analysis. Also, we analyzed these slopes with Bishop and Janbu methods. Results obtained for safety factor from these methods are not mentioned since they are very similar to Morgenstern – Price's. In quasi-static analysis, earthquake coefficient is 0.2 horizontally and 0.075 vertically. Effects of various quasi-static coefficients are negligible since it is clear that as quasi-static coefficient increases , safety factors decrease.

The modeled slopes are 10m height with sufficient width. Specifications of nails and slope soil, weak soil layer are presented in tables 1 and 2.

Results and Discussion

After modeling and analyzing the slope with software, results are shown in Tables 3, 4 and 5.