RAIN INDUCED LANDSLIDES IN SRI LANKA

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ABSTRACT

Many of the rain-induced landslides are occurred in unsaturated colluvium soil. Stability of these slopes is high during dry periods due to the matric suction in the unsaturated region. Rainwater infiltration causes a loss of matric suction creating positive pore water pressures due to the perched water table. Variation of the shear strength parameters of the soil with the rainfall and the soaking effect are important considerations in this study. Due to the change of soil properties, the stability of slopes with unsaturated soil is declined. Therefore, it is important to study about the stability of the slope with the varying shear strength parameters. Cohesion is decreased by 85% and friction angle is decreased by 50% after 6 soaking days. Slope stability analysis using SLOPE/W software was done by incorporating the seepage analysis from SLOPE/W software. By slope stability analysis, the variation of shear strength parameters during the failure of Meeriyabedda landslide was determined.

1. INTRODUCTION

Rain-induced slope failures are very common natural hazards in tropical countries. During the last decade, landslide is one of the most catastrophic natural hazards in Sri Lanka (Disaster Management Center, 2009). The main cause for these failures is the loss of matric suction due to the development of perched water table and as a result of infiltration of rain water (Li et al., 2005).

The objectives of this research study is to study the variation of shear strength parameters with the moisture content and stability of slope due to development of perched water table affected by the rainfall taking Meeriyabedda landslide as a case study.

2. METHODOLOGY

Soil samples from the Meeriyabedda landslide area were collected and series of laboratory tests were conducted to determine the basic soil properties. The bulk density of the soil was 1600 kg/m³. The soil was with 8.97% field moisture, 2.7 specific gravity, 0.836 initial void ratio and 7.85×10⁻⁶ cm/s saturated permeability.

2.1 Determination of shear strength parameters

Variation of shear strength parameters with the moisture content and soaking effect was determined for the colluvium soil at Meeriyabedda. As the first approach series of direct shear tests were conducted by varying the moisture content of the soil maintaining the field density. Tests were conducted for 20, 40, 60 and 80 kPa normal stresses for particular moisture content with a 0.15 mm/s shearing speed and the shear strength parameters corresponding to that moisture content were determined. Cohesion and the friction angle for several moisture contents were determined using the direct shear test.

As the second approach, soaking effect on the shear strength parameters of the Meeriyabedda soil was determined. Soil samples of 89 mm diameter and 50 mm thickness were compacted to the field density in a sampling ring. They were soaked in a water bath for 1, 2, 3, 4, 5 and 6 days and direct shear tests were conducted for each soaking day following the same procedure as in the first case. The moisture content of the soil samples corresponding to the each soaking day was determined.

2.2 Slope stability analysis

The slope stability analysis was conducted using the SLOPE/W software incorporating the seepage analysis results of SEEP/W software. Three rain events of 100, 167 and 300 mm/day and initial water tables of 10, 30, 60 and 90 m below the ground surface were selected to study the development of the perched water table on the slope of Meeriyabedda under the different rainfalls per initial water tables. Figure 1 shows the slope geometry and the boundary conditions that were used in the analysis.

Using the parent analysis of SEEP/W, results were incorporated in SLOPE/W. Then the stability of the slope under these different conditions was checked and the variation of Factor of Safety was determined. The shear strength parameters during the failure were determined.
3. RESULTS AND DISCUSSION

3.1 Variation of shear strength parameters with moisture content
The variation of friction angle and cohesion with respect to moisture content are shown in Figure 2 and Figure 3 respectively. Further, effect of soaking on shear strength parameters is also presented. It can be noted that with the increase of degree of saturation due to soaking, shear strength parameters were decreased (Chen et al., 2013).

3.2 Variation of factor of safety with the soaking time and rainfall intensity
The variation of Factor of Safety (FOS) with the number of soaking days for different rainfall intensities is depicted in Figure 4. It is clear that initially the slope is stable under dry condition; however with the increase of the number of soaking days the slope becomes unstable (FOS has been dropped below 1.0). Effect of rainfall intensity on FOS is also presented in the figure, where higher rainfall intensity shows significant reduction in FOS with soaking time. This may due to the reduction of shear strength parameters under soaking condition as shown in Figure 2 and Figure 3.

4. CONCLUSIONS
Effect of moisture content and soaking time on shear strength parameters were studied in this research study. Based on the results, it can be concluded that the steep slopes made of unsaturated soil are stable during the dry season. The main reason behind the stability of steep slopes during the dry period is the matric suction or the negative pore water pressure. With the rainfall these steep slope become unstable due to the loss of matric suction and development of positive pore water pressure. From the seepage analysis it was very clear that the initial water table had risen up and a perched water table had developed.

Also it is obvious that the shear strength of unsaturated soil get depleted with the progression of the rainfall. When considering the effect of the variation of shear strength parameters on the stability of the slopes cohesion is much more important than that of friction angle.

It is very clear that the factor of safety of a particular slope is reduced due to the reduction of the shear strength of unsaturated soil. Further, it can be concluded that during the slope failures, 50-80 % reduction can be observed in the cohesion whereas 20-50 % reduction can be observed in friction angle.

REFERENCES
Chen, S., Chen, P.S., & Huang H.C., 2013, ‘Study on the influence of soaking effects to the shear strengths of the colluviums on Mt. Da-Lum’, Department of environmental and hazards resistant design, Huafan university, Taiwan.
