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SHORT NOTES

PERISI: A COMPUTER PROGRAM FOR PRELIMINARY EVALUATION OFRAINFALL-INDUCED SLOPE INSTABILITY

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Abstract: This paper introduces a computer program PERISI stands for Preliminary Evaluation of Rainfall-Induced Slope Instability. The program was developed by utilizing the concept of extreme rainfall and unique relationships between rainfall characteristics, hydraulic conductivity, suction, and water content of unsaturated soil to evaluate the minimum suction distribution in soil. The outcome of the program is the factor of safety of soil slope in the critical condition as compared to normal condition.

Keywords: *Hydraulic conductivity, Volumetric water content, Pore water pressure; Slope stability evaluation*

1.0 Introduction

The mass instability of soil slopes continue to affect large Malaysian populations each year. The occurrences of the slope failures can be attributed to two major factors: intense and frequent downpours, and natural characteristics of the soil mass. Slope stability analysis based on the assumption of saturated soil behaviour is commonly applied in current practice. The approach, however, is exposed to several weaknesses. For ~~an~~ example, the effect of rainfall infiltration on the soil water content, hence on the stability of slope could not be assessed since the soil is already in saturated condition.

The increasing acceptance of unsaturated soil mechanics has highlighted the need to correlate the slope failure with rainfall in order to understand the mechanisms of failure. The unsaturated soil mechanics could be used to explain the mechanisms of rainfall-induced slope failure (Li *et al*., 2005). The potential mechanisms of rainfall-induced slope failure include the development of perched water table, loss in soil suction, and rise of groundwater table. Previous

researches found that more than 80% of the rainfall-induced slope failures in tropical regions were due to the loss in soil suction (Au, 1998).

The application of unsaturated soil mechanics, however, is still not a common practice owing to a number of uncertainties associated with the stability analysis including the intensity and duration of rainfall, the minimum soil suction in the slope, and the depth of wetting front. The research gaps have initiated the need for development of simple model which is able to integrate the unsaturated soil mechanics to slope stability analysis (Gofar and Lee, 2008a).

This paper is aimed to introduce a computer program (*PERISI*) for preliminary evaluation of rainfall-induced slope instability. The program was developed based on the concept of extreme rainfall and unsaturated soil mechanics.

2.0 Development of *PERISI*

Gofar and Lee (2008a) have demonstrated a unique relationship between extreme rainfall condition and soil characteristics. The extreme rainfall, commonly referred as Intensity-Duration-Frequency (IDF) curve, indicates the highest possible rainfall intensity to occur at a location for a given duration and return period. Long duration (i.e. 30 days) IDF curve is required for slope stability evaluation to cater for the effect of antecedent rainfall (Lam and Leung, 1995; Rahardjo *et.al*., 2001). The unsaturated soil characteristics are presented by soil water characteristic curve (SWCC), and hydraulic conductivity function. Through such correlations, the minimum suction and water content in soil under extreme rainfall of any duration can be predicted. The minimum suction is an important input parameter in the computation of unsaturated soil shear strength, while the water content is essential for the estimation of wetting front depth based on the water balance theory. Besides, the slope geometry and shear strength properties of soil were also taken into account in the analysis since these parameters are the essential contributing factors in any slope stability analysis.

Figure 1 shows the IDF curve developed by Gofar and Lee (2008a) for slope stability analysis in Peninsular Malaysia, while Figures 2 and 3 represent the SWCC and hydraulic conductivity functions of typical soil. The unique relationship between extreme rainfall condition and soil characteristics as adopted by *PERISI* model is shown in Figure 4.

Figure 5 shows a view of the *PERISI* interface. Upon assigning the necessary input data, the program could be used to compute the suction envelope that represents the minimum suction distribution in the soil as the result of several extreme rainfall conditions. The extreme rainfall conditions include various durations of antecedent rainfall, combination of antecedent rainfall and major rainfall, as well as their suction

redistribution. Based on the suction envelope, the factor of safety of the slope is computed using the shear strength of unsaturated soil, as illustrated in Figure 6. The verification of the model were presented in Gofar and Lee (2008b), Gofar *et al*. (2009) and Lee *et al.* (2009)

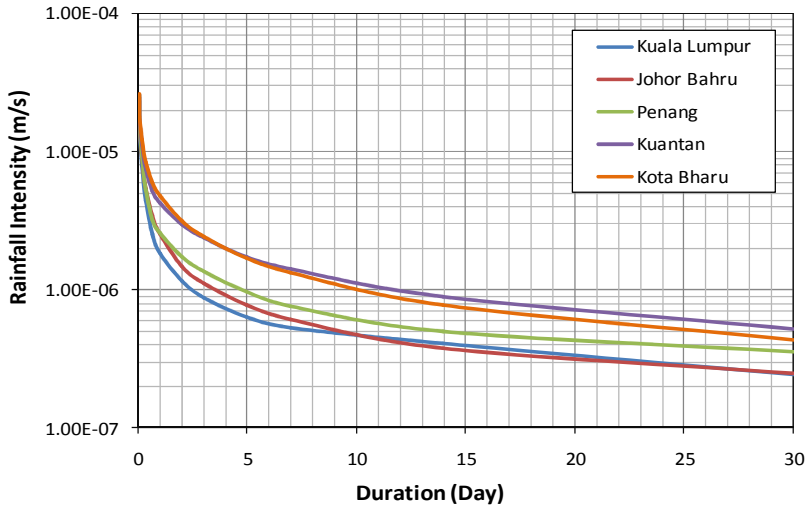

Figure 1: Ten year return period of extreme rainfall in Peninsular Malaysia

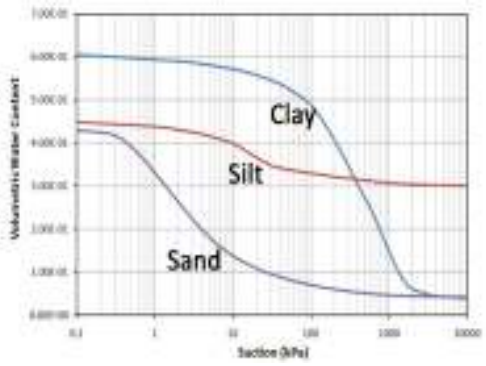

Figure 2:Typical SWCC curve for soil

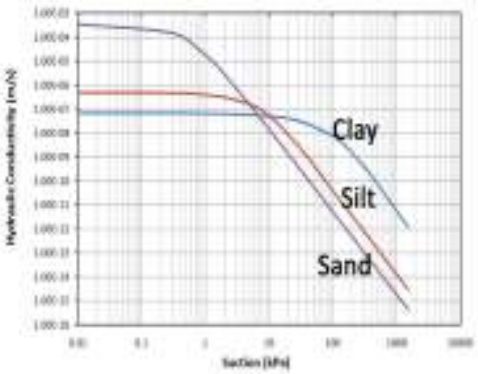

Figure 3:Typical hydraulic conductivity curve for soil

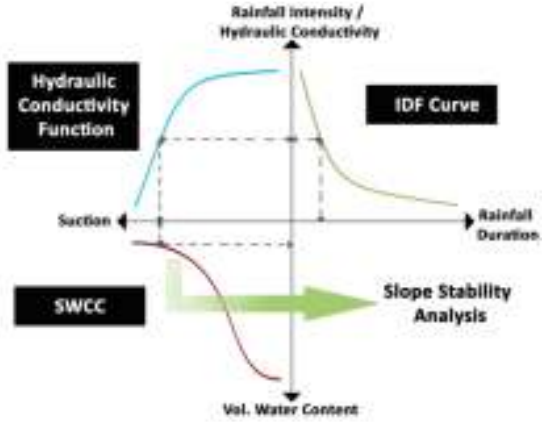

Figure 4: Unique relationships between IDF curve, hydraulic conductivity function, and SWCC adopted by *PERISI*

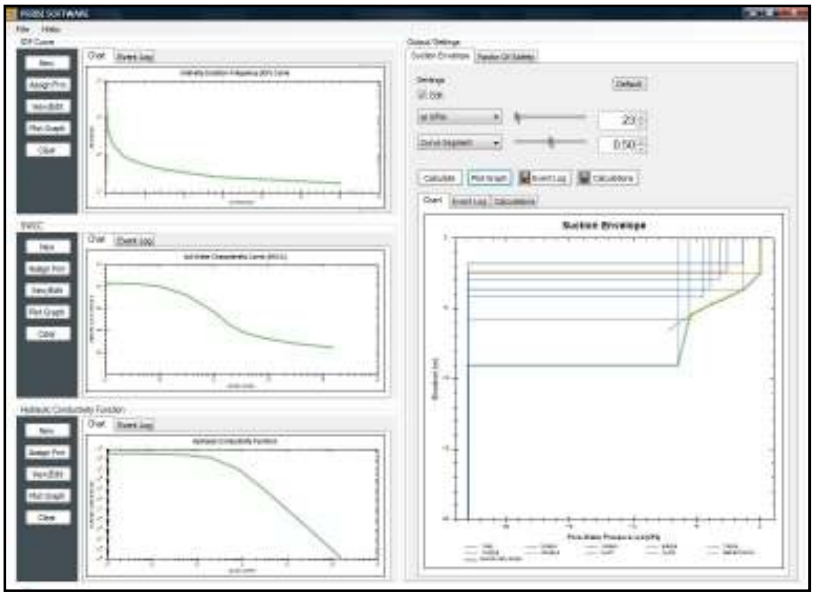

Figure 5: Interface of *PERISI*: Input and Output

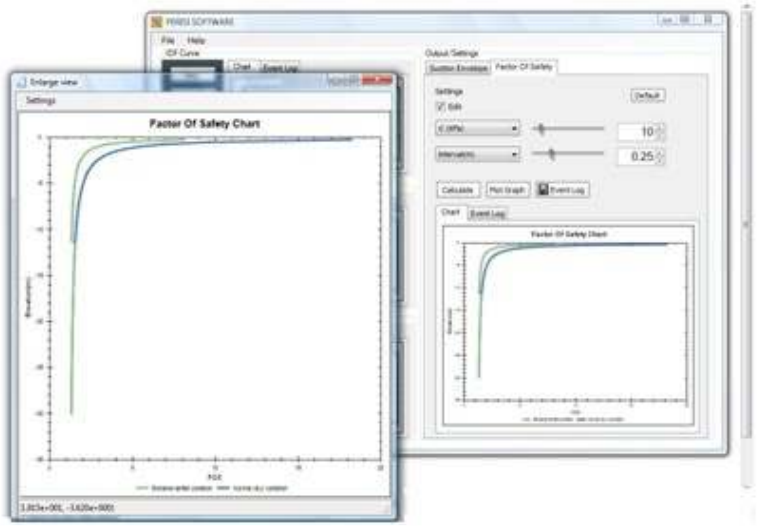

Figure 6: Relative Factor of Safety between extreme rainfall condition and normal condition as compueter by *PERISI*

3.0 Conclusions

A computer program (*PERISI*) has been developed based on a unique relationship between extreme rainfall condition and soil characteristics. The software was not designed to predict the ultimate factor of safety of the slope, but to compute the relative factor of safety between extreme rainfall and normal conditions. This feature is important to evaluate the stability of the slope in response to the rainfall infiltration. *PERISI* offers several advantages as follows:

i. The rainfall characteristics of specified location, and unsaturated soil properties are integrated into slope stability analysis, hence is capable to produce a more comprehensive analysis results.
ii. The suction envelope that represents the worst suction distribution in the soil slope for the extreme rainfall of specified return period can be predicted. This suction envelope is useful to promote the application of unsaturated soil mechanics in slope stability analysis.
iii. The effect of extreme rainfall infiltration on the slope stability can be assessed through the comparisons of factor of safety between normal and extreme rainfall conditions.
iv. The potential depth of failure plane can be predicted.
v. The analysis results have been verified through numerical simulations, laboratory tests, and field monitoring.

Acknowledgement:

PERISI- A Tool for Preliminary Evaluation of Rainfall Induced Instability is a Copyrighted Computer Program under Universiti Teknologi Malaysia in 2008.

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