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Numerical Modelling of Slope Stability and Transient Seepage Analysis: Jalan Puncak Borneo Road Case Study

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Abstract: A slope failure event in 2015 at KM 6+500 of Jalan Puncak Borneo in Padawan, Kuching was modelled using Seep/w and Slope/w software of commercial geotechnical programme GEOSTUDIO. The failure was occurred after a prolonged three days of heavy rain. The state road which connected the villagers from Puncak Borneo was cut off and caused traffic congestion. In this study, the slope stability was evaluated based on finite element and limit equilibrium method by considering the transient seepage analysis due to rainfall infiltration. The slope failure was modelled based on ground investigation report and published data to replicate the field condition. A hyetograph was plotted using daily rainfall data and cumulative rainfall depth was determined to obtain the total rainfall during the wet monsoon. As a result of numerical analyses, the factor of safety was observed to fluctuate with time of infiltration. Based on this case study, the factor of safety or FOS reduced with time and a perched water table also has been observed developed just below the pavement. However, the factor of safety calculated from Slope/w could not replicate the actual failure. Nevertheless, it can be observed that factor of safety had decreased with respect to infiltration in the analyses. The steady state condition provided FOS 1.38 and had reduced to 1.08 after 110 days of rainfall event. Thus, the analyses of this current study have illustrated that the transient analysis is essential to model the seepage behaviour and infiltration event that caused slope failure along Sarawak's roads.

Keywords: Numerical model, transient analysis, rainfall infiltration, factor of safety

1. Introduction

The slope failure regularly occurred during the raining monsoons in Malaysia which particularly appeared in residual soil slope. The hydrological factors, such as precipitation, infiltration, evaporation, and transpiration cycles, are greatly affect the stability of residual soil slopes [1]. Residual soil is the product of the decomposition of parent rock in-situ, and it is not transported over any significant distance. The properties of unsaturated soil are influenced by parent material and the degree of weathering [2]. The engineering behaviour of residual soils is different compared to other soil types due to the presence of negative pore water pressure. In dry seasons, unsaturated residual soils have great matric suction, but they can be lowered during the rainy seasons.

Most of the previous research work concluded that rainfall infiltration is the most significant triggering factor to unsaturated soil slope instability in either tropical or subtropical regions [3]- [13]. These research works were essentially considering how the distribution of suction and its redistribution affected slope stability. However, as stated by Wu et al. [14], it is a great challenge to accurately address the effect of rainfall to slope failure as the mechanisms of rainfall triggered slope failures are very complex due to several factors including erosion, soil softening, seepage, stress redistribution and other different failure modes. Lee et al. [15] studied slope in Hulu Kelang area also claimed that the

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