CHAPTER

5

TREE-INDUCED SUCTION ON TWO-LAYERED SLOPE UNDER INFLUENCES OF DIFFERENT RAINFALL PATTERNS

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5.1 INTRODUCTION

The frequency of landslide and slope failures has become a popular public issue and concern. Rainfall is the most frequent triggering factor for the failures, especially in tropical regions such as Malaysia. The features of failures were usually shallow and parallel to the slope surface (Cho, 2009). The rainfall infiltration into the slope surface has led to a rise of pore-water pressure and effectively has decreased the shear strength of the soil slope which is susceptible to failure (Rahardjo et al., 2001). In the natural slope, the groundwater table was very much lower compared to the surface and negative pore-water pressure (i.e. matric suction) existed during the dry period. Negative pore-water pressures in the slope contributed to the increment of soil strength and helped to stabilise the slope. However, when rainfall occurred, the matric suctions had reduced which lead to a sudden decrease in strength and made the slope first move to failure (Toll et al., 2011). Hence, the effect of rainfall patterns on slope stability has remained a great uncertainty to be resolved in the research niche area.

The use of native vegetation has become popular for stabilising the slope. The tree roots not only help to reinforce the soil, but they also drain out the excess pore-water pressure and subsequently generate adequate matric suction to accelerate the capacity of soil shear strength (Indraratna et al., 2006). The pore-water pressure condition in the slope is non-constant during infiltration and its distribution become complex especially induced by tree suction. The pore-water pressure affects the apparent shear strength along the probable failure surface and the measurement of pore-water pressure gives a reliable forecast of failure of the slope. The factor of safety of the slope determined by estimating the soil shear strength induced by tree suction and destabilising force acting on the slope only indicates how stable the slope. It does not indicate under what climate condition; the slope is most likely to fail. Moreover, the accurate prediction of the pore-water changes induced by vegetation is still questionable.

Previous researchers such as Cai and Ugai (2004), Cho and Lee (2002), and Rahimi et al. (2010), are looking at the influence of infiltration on the stability of homogenous slopes. However, most of the natural slope in Malaysia was found not homogenous (Marto & Kassim, 2003). The slope consists of residual soil of a fine-grained layer (Grade VI) overlay coarse-grained layer (Grade V). The disparity in permeability of the two-layered soil prevents the water infiltrates through the bottom layer and creates a capillary barrier effect. This capillary barrier effect is effective in maintaining negative pore-water pressure within the soil and the effect can be employed as a slope stabilisation method. However, the high intensity and continuous rainfall might cause percolation to take place where the capillary barrier is no longer able to stop water from infiltrating deeper into the slope (Rahardjo et al., 2012). Therefore, the rainfall mechanism into the layered soil slope and the corresponding change in pore-water pressure distribution as well as its transient seepage analysis are important to assess the strength of the slope.

5.2 TREE-INDUCED SUCTION

This chapter presents the effect of tree-induced suction on two layered slopes under rainfall patterns. Nowadays, vegetation is the most common method used in slope stabilisation due to its economy and sustainability. When rainfall water penetrates a slope, part of the water is held by the vegetation and does not infiltrate into the soil. The loss of moisture from the soil is used for the metabolism of plant tissue and water has been transpired to the atmosphere. The water demand by vegetation depends on the climate. Water demand by the vegetation is the greatest during the dry period while the water demand is minimal during the wet period. This phenomenon shows that vegetation-induced suction can vary with the climate condition (Smethurst et al., 2012).

The increase of slope stability for a homogenous slope with tree-induced suction compared with the same slope without a tree is about 33.07% (Ishak et al., 2012). However, Greenwood et al. (2004) concluded that tree root reinforcement increases the stability of the slope by only about 10%. The tree-induced suction is obviously the main factor in stabilising the slope. But there are insufficient studies to relate the change of tree-induced suction to the rainfall patterns at a two-layered slope as well as its slope stability.

Significant infiltration into the residual soils leads to slope failure. Two important processes have to be determined to evaluate the stability of the slope, i.e. the change in pore-water pressure and the change in shear strength of soil due to the increase in pore-water pressure (Leong et al., 1999). Ng and Shi (1998) carried out the parametric analysis to investigate the influence of rainfall and transient seepage and hence slope stability in unsaturated soil. The findings show the position of the initial groundwater table and the intensity of rainfall significantly affects the factor of safety of a slope. The slope however can still remain stable during high intensity of rainfall if the initial groundwater table is low. The stability of the slope reduces as the rainfall duration increases until the critical duration is achieved.