UNIVERSITI TEKNOLOGI MARA

EFFECTIVE STRESS-SHEAR STRENGTH INTERACTION ON THE COLLAPSE BEHAVIOUR OF UNSATURATED RESIDUAL SOIL GRADE V

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ABSTRACT

Granitic residual soils are generally suitable materials for filling embankments in Malaysia due to extensive occurrence in Malaysian land. Various types of these materials from grade IV to VI have been used in embankments successfully in the past. However, they can be problematic during continuous heavy rainfall. Infiltration of rainwater within the void spaces in unsaturated zone increases the pore water pressure and reduce the suction in the soil matrix. This can lead to a significant drop in soil shear strength especially the soil apparent cohesion as well as an increase in the bulk weight of soil mass which may cause massive settlement known as inundation settlement or wetting collapse. The same problem can occur in unsaturated granitic residual soil involves earth dams, shallow foundations, and roads. However, the conventional soils volume change models which are based on the effective stress concept for saturated soils dose not depict the volume change behaviour of unsaturated soil subjected to the wetting solely. The effect of shear strength in the interaction of effective stress is essential to be incorporated. The main aim of this study is to investigate the collapse behaviour of an unsaturated Malaysian granitic residual soil grade V subjected to loading and wetting by incorporating effective stress and shear strength. The soil was obtained from Kuala Klawang, Negeri Sembilan, Malaysia. The shear strength of the soil was characterized and the stress-strain curves were determined using consolidated drained triaxial tests conducted on both saturated and unsaturated compacted specimens. The experimental data of the saturated and unsaturated shear strength of the soil were fitted with a comprehensive constitutive shear strength model know as Curved Surface Envelope Soil Shear Strength Model that represents both linear and nonlinear shear strength behaviours with respect to suction and net stress/effective stress for unsaturated and saturated conditions. The study confirmed that the model provides the best fit for the experimental data and it is applicable for Kuala Klawang granitic residual soil grade V. A suction-controlled double wall triaxial test was carried out under certain applying stress and suction to obtain the axial strain of the compacted specimen subjected to the loading and wetting. The results showed that a massive settlement around 1.92% of the initial height occurred during wetting while the soil was nearly saturated. Besides, the unsaturated collapse behaviour of Kuala Klawang granitic residual soil was simulated using the Rotational Multiple Yield Surface Framework. The model is based on the unique relationship between minimum mobilized friction angle and axial strain which incorporates the effect of shear strength into the volume change of unsaturated soils. The stress-strain response of the soil in an unsaturated condition and the axial strain during loading and wetting were predicted applying the model. The predicted results were in good agreements with experimental tests results, proving the ability of the framework in simulating and predicting the settlement of Kuala Klawang granitic residual soil grade V during compression and wetting.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Residual soils are easily found in many parts of the planet Earth. They are products of their parent rocks which exposed to weathering and remaining in place. Tropical countries such as Malaysia are extensively covered with residual soil due to their climate and active in situ weathering forming process of rock and soil. More than 80% of the Malaysian land is covered with two types of residual soils which defined as granitic and sedimentary (Huat, Aziz, Ali, & Azmi, 2008). Like the more natural soils, they are used widely in construction, either to build upon, or as construction materials. Using a huge amount of these materials in engineering works can prove the significance of understanding the residual soil behaviour in Malaysia.

The characteristics of residual soils are dependent on many environmental factors including climate, parent material, topography and drainage, and age (Landon, 2014). Unlike the more familiar transported sediment soil, the engineering properties and behaviour of tropical residual soils may widely vary from place to place depending upon the rock of origin and the local climate during their formation; and hence are more difficult to predict their engineering behaviour mathematically (Blight & Leong, 2012). Groundwater table in residual soil usually is settled in a deep level. Therefore, in situ residual soils are often unsaturated. The pore water pressures are negative relative to atmospheric conditions. This negative pore water pressure is called matric suction when referenced to the pore air pressures and plays an important role to soil physical properties and stability (Rahardjo, Lim, Chang, & Fredlund, 1995). As a result, considering conventional soil mechanics which are based on saturated soil dose not depict the geotechnical behaviour of unsaturated soils and presenting an appropriate engineering concept related to unsaturated residual soil is essential.

Being mostly in unsaturated state, the surface soils are under the influence of evaporation and rainfall. Basically, the engineering properties of unsaturated soils vary from the saturated state (Ng & Menzies, 2007). In this aspect, various problems related to slope failure and inundation settlement (wetting collapse) can simply be solved using