ENGINEERING CHARACTERISTICS OF SOME UNSATURATED RESIDUAL SOILS OF SRI LANKA

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Bentara Galhenage Nadeeka Tharanganie

Department of Civil Engineering
University of Moratuwa
Sri Lanka

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DECLARATION

The work included in this thesis in part or whole has not been submitted for any other academic qualification at any institute.

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ABSTRACT

Theories and formulations developed for the behaviour of unsaturated soils incorporate the behaviour of saturated soils as a special case, leading to a generalization of the theory on mechanics for soils. The net normal stress (σ-u_a) and the matric suction (u_a-u_w) are the two stress state variables that are required to describe the state of an unsaturated soil. The soil-water characteristic curve has been shown to be a key soil property function which can be used to approximately simulate the behaviour of unsaturated soils. As the soil moves from a saturated state to a dry state, the distribution of soil, water and air phases change, giving rise to changes in the stress state. The influence of these phases on the soil-water characteristic curve and hence on the engineering behaviour of unsaturated soils, is of importance in the prediction of unsaturated soil properties.

Unsaturated shear strength functions and soil-water characteristic curves of soils obtained from Pussellawa and Kahagalla landslide sites, Sri Lanka, are developed over a matric suction value range of 0 – 800 kPa, based on the results obtained from a series of laboratory tri-axial tests on saturated and unsaturated samples. During tri-axial tests on unsaturated samples, pore-air pressure and pore-water pressure are controlled to maintain suction at a constant value in the soil specimen throughout any stage of the test. Saturated high air entry disks are installed at the bottom of the soil specimen to prevent the entry of pressurized air into the water supply system maintained at a lower pressure. The soil-water characteristic curves developed are compared with such typical curves reported in the literature.

The shear strength function of the soil at Pussellawa landslide site for the matric suction range of 50 kPa – 575 kPa can be expressed as:

$$t = 20 + (s_n - u_a) \tan 33+ ^\circ (u_a\text{-}u_w) \tan 11.77^\circ$$

The shear strength function of the soil at Kahagalla landslide site for the matric suction range of 100 kPa - 500 kPa can be expressed as:

$$t = 22.3 + (s_n - u_a) \tan 25.2+ ^\circ (u_a\text{-}u_w) \tan 18.99^\circ$$

In a parallel study, a 5 bar pressure plate apparatus is used to develop soil-water characteristic curves of Pussellawa and Kahagalla landslide sites for a limited range of matric suction values. In the laboratory, a matric suction is applied to the soil specimen by maintaining a zero excess pore-water pressure (i.e., atmospheric pressure) and applying a positive pore-air pressure. In this case also, a saturated ceramic plate is used to prevent the entry of high pressure air into the compartment below the disk.

The soil-water characteristic curves of soil at Pussellawa and Kahagalla landslide sites were developed by using Modified tri-axial tests and Pressure plate tests.

Slope stability of Pussellawa and Kahagalla landslides are investigated to demonstrate the effect of partial saturation on the factor of safety against failure. Stability of each slope is analysed by developing a computer spread-sheet programme to consider saturated and unsaturated cases. The Modified Janbu's simplified method is used to analyze two slopes to obtain factor of safety values. For the analysis, location of the water table is changed in such a way that full saturation and partial saturation of slopes are achieved.

The slope stability analysis of Pussellawa and Kahagalla landslides show that slopes are currently stable with the parameters obtained from laboratory tests. The slope stability analysis shows that lowering the water table increases the factor of safety against failure of a soil slope, due to the influence of matric suction (partial saturation).

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