Severin Pabst

Graduate Candidate	Severin Pabst
Examiner	Reto Schnellmann
Co-Examiner	David Wagner, Schläpfer & Partner, Ingenieurbüro AG, Zürich
Subject Area	Geotechnik
Project Partner	Prof. Dr. Harianto Rahardjo, NTU Nanyang Technological University, Singapore

Effect of Vegetation on Stability of Unsaturated Soil Slopes

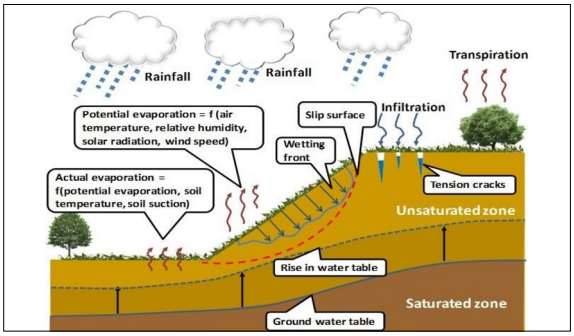

Figure 1: Mechanism of rainfall-induced slope failure

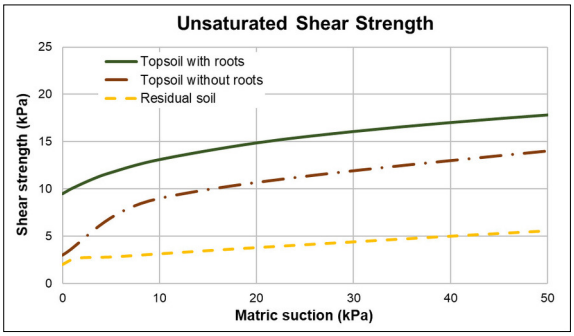

Figure 2: Unsaturated shear strength

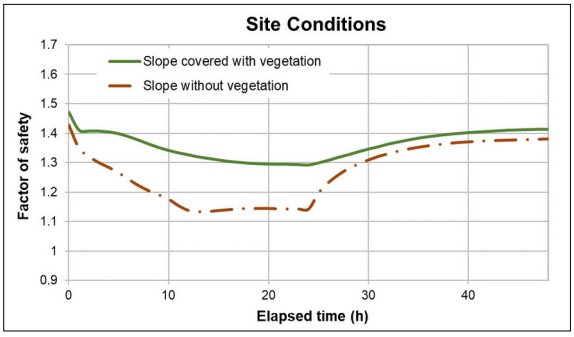

Figure 3: Factor of safety - Elapsed time, rainfall 22 mm/h for 24 h

Introduction: Climatic changes have caused more extreme weather conditions such as intense rainfalls and droughts, especially in tropical countries like Singapore. Soil slopes in Singapore are generally in an unsaturated state, having negative pore-water pressures which contribute to their stability. These negative pore-water pressures are greatly influenced by climatic conditions such as rainfall, evaporation and transpiration.
Water infiltration into an unsaturated soil slope due to rainfall causes an increase of the negative pore-water pressures (i.e., decrease in matric suction). As a result, the contribution of shear strength due to matric suction decreases which might trigger a slope failure (Figure 1). It is therefore important to prevent water infiltration into unsaturated soil slopes to avoid possible rainfall-induced slope failures. Studies have further shown that vegetation reduces the risk of rainfall-induced slope failures. Vegetation on soil slopes increases the matric suction, reinforces the soil and reduces the erosion and thus, increases the overall stability.

Objective: The objective of this project was to investigate the mechanical behaviour of unsaturated soil slopes with vegetation under varying climatic conditions. Laboratory tests were carried out to determine the relevant soil characteristics such as the Soil-Water Characteristic Curve, the permeability and the shear strength of soil specimens with and without roots. Seepage and stability analyses for varying slope geometries and climatic conditions were carried out to assess the seepage behaviour and stability of unsaturated soil slopes with and without vegetation.

Result: The performed laboratory tests indicate that root systems may change the structure of the soil significantly. More fine particles were found in soil specimens with roots, as compared to soil specimens without roots. The increased content of fine particles in the soil specimens with roots reduces the permeability, whereas the shear strength increases (Figure 2).
Stability analyses show that soil slopes with vegetation provide a higher factor of safety during and after heavy rainfalls as compared to soil slopes without vegetation (Figure 3). This is mainly caused by the lower permeability and the higher shear strength of soils with roots. In addition, analyses of soil slopes with vegetation result, for some geometries, in higher initial factors of safety during dry periods. Furthermore, a change in slope angle influences the factor of safety more significantly than a change in slope height.
In conclusion, vegetation has a significant effect on the stability of unsaturated soil slopes by reducing the amount of water infiltration into the slope and therefore increasing the shear strength. Hence, vegetation is an economical option to reduce the risk of a rainfall-induced slope failure.