SOIL SUCTION PROFILE DUE TO TREE INDUCED SUCTION

FARAH FARHANA BINTI SULAIMAN

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Special dedicated with love and affection

To my beloved family members,

Especially to my father and my mother,

SULIMAN ABDULLAH & NORAINI CHATIB,

& my entire friends.

Who inspired me to do the best I can do and to share what we have learned together.

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ABSTRACT

Suction exerted by the roots water uptake of vegetation can have substantial effects on soil moisture, where it will influence the strength of the soil. However, rainfall pattern is one of the major factors that influence the changes of suction and lead to instability in unsaturated soils. This study discuss an exploration of soil suction is affected by water uptake by tree root at various condition from wet season (high rainfall) to dry season (prolonged no rainfall). The suction at study area are measured using Jet-fill tensiometers and Gypsum moisture block that placed at various depths and distances near vicinity of tree. A total of 18 Jet-fill tensiometers and Gypsum moisture blocks were installed in 6 stations, 3 stations at sloping ground and 3 stations at flat area. Each station consists of 3 Jet-fill tensiometers which at top, middle and bottom of the root zone to monitor the matric suction changes. The results of the soil suction obtained were used as an input data to develop soil suction contour using GID 7.2 software. From analysis of the pattern soil suction profile shown the suction rate is higher at near vicinity of tree and significant increase during dry period. However, a reduction in suction during high rainfall.The effect of tree induces suction will generate high suction in soil and can created dry condition to increase shear strength.

ABSTRAK

Sedutan yang digunakan oleh penyerapan air akar tumbuh-tumbuhan boleh mempunyai kesan yang besar kepada kelembapan tanah, di mana ia akan mempengaruhi kekuatan tanah. Walau bagaimanapun, corak hujan adalah salah satu faktor utama yang mempengaruhi perubahan sedutan dan membawa kepada ketidakstabilan dalam tanah tak tepu. Kajian ini membincangkan eksplorasi sedutan tanah yang dipengaruhi oleh penyerapan air oleh akar pokok pada pelbagai keadaan dari musim basah (hujan yang tinggi) hingga ke musim kering (berpanjangan tiada air hujan). Sedutan di kawasan kajian diukur menggunakan Jet-fill tensiometer dan Gypsum moisture block yang diletakkan pada pelbagai kedalaman dan jarak berhampiran kawasan sekitar pokok. Sebanyak 18 Jet-fill tensiometer dan Gypsum moisture block telah dipasang di 6 stesen, 3 stesen di kawasan cerun dan 3 stesen di kawasan yang rata. Setiap stesen terdiri daripada 3 tensiometer iaitu di tengah-tengah atas, dan bawah zon akar untuk memantau perubahan sedutan matrik. Keputusan sedutan tanah yang diperolehi telah digunakan sebagai data input untuk membangunkan kontur sedutan tanah dengan menggunakan perisian GID 7.2. Daripada analisis profil corak sedutan tanah yang ditunjukkan kadar sedutan adalah lebih tinggi di kawasan sekitar berhampiran pokok dan peningkatan yang ketara semasa tempoh kering. Walau bagaimanapun, berlaku pengurangan dalam sedutan sewaktu hujan yang tinggi. Kesan sedutan pokok akan mendorong menjana sedutan yang tinggi dalam tanah dan akan mewujudkan keadaan kering untuk meningkatkan kekuatan ricih.

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m	-	Meter
ua	-	Pore-air pressure
uw	-	Pore-water pressure
θ	-	Water content
θ_r	-	Residual water content
θ_s	-	Saturated water content
ψ	-	Soil water potential
w	-	Water content
S	-	Degree of saturation
cR	-	Root cohesion
hR	-	Root zone
τ	-	Shear strength
ϕ_b	-	Angle indicating the rate of increase in shear strength relative to matric suction
c’	-	Effective cohesion
ϕ	-	Angle of friction
$u_a - u_w$	-	Matric suction
$\sigma_n - u_a$	-	Net normal stress

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CHAPTER 1

1.0 INTRODUCTION

1.1 Overview

Rainfall has been considered as the cause of the majority of slope failures and landslides that occurred in areas that have high seasonal rainfall which is tropical region. For example, in Malaysia, the annual year rainfall is quite high and it increases the risk of soil become unstable and collapse. Heavy and prolonged rainfall in certain months of the year will weaken the shear strength of soils as well as changes in ground water table. Increased of water level at slope is resulting in increased pore-water pressure. This has lead to increase the stresses in the slope of the land which contributes to slope failure. Failure mechanism is due to the loss of soil matric suction which is increase of pore-water pressure by the rain.

Unsaturated soils or soils with negative pore-water pressures can occur in essentially any geological deposit. An unsaturated soil can be a residual soil or any other soil or rock type. Fredlund et. al. (2012) has stated that the region has a hot, humid summer and a mild, dry winter climate with an annual rainfall of less than 1500 mm, the structure of residual soil is very porous and in some cases may not be stable, resulting in collapse when saturated. The soil deposits are often unsaturated and the in-situ pore water pressure is negative.

Suction plays an important role in the stability of unsaturated soil slopes in a tropical region, the size of suction in the soil is important for the assessment of slope stability. While, the suction pores are an important element in stability of geotechnical structures, at least temporarily, and this suction is highly dependent on soil type and infiltration conditions (Krahn. J. et al., 1989 and Griffiths DV and N. Lu, 2005).

At present, soil bioengineering or plants become popular in civil engineering structures and is considered a practical alternative to more traditional methods such as soil stabilization or soil nail reinforcement geosynthetics where they had roots as reinforcement to the soil (Norris. J.dan Greenwood. JR, 2006 and Mafian. S. et al., 2009). Soil-bioengineering has been mostly used in controlling erosion, but it has also been shown to be successful in stabilization of slopes against shallow failures. In slope stabilization, vegetation provides increased shear strength immediately and modifies the saturated soil water regime. The lateral resistance of the poles has contributed to the shearing resistance along the slip surface because the root systems can contribute an additional component to the shearing resistance (Mafian. S. et al., 2009).

Huat and Kazemian (2010) was study on root reinforcement theories for utilizing bio-engineering on the slope stability, with an emphasis on effects of roots on strength and suction of soil. The continued growth of live pole species provide a form of vegetated soil nailing or dowelling would be beneficial for the slope as its stability would be subsequently increased over time through the development of a root system, increase in soil suction and a reduction in the soil moisture.

Generally, roots have two main functions. First, roots anchorage the plant to the soil. Second, roots absorption of water and inorganic nutrients (mineral salts) from the soil. However, Indraratna. B. et al. (2006) and Fatahi et. al. (2007) had stated that the tree roots provide three stabilizing functions, where they reinforce the soil, dissipate excess pore pressures and provide sufficient matric suction to increase the shear strength.

1.2 Problem Statement

Most soils in Malaysia are unsaturated residual soils. Slope failures in residual soils and weathered rock are common in tropical climates and often occur during periods of intense rainfall. Rainfall infiltration into the soils and reduce soil matric suction and shear strength of soils.

Soil suction has a significant effect on water penetration, structural stability, strength, and shear strength and volume changes. Lim. et. al. (1996) and Hossain (2010) investigated the variation in matric suction due to changes in climatic condition and its effect on slope stability. The results showed matric suction in the soil increased during dry periods and decreased during wet periods. From the suction profile observations, the maximum change in matric suction occurred near the ground surface and the magnitude of matric suction change decreased with depth.

However, vegetation is currently being evolved to improve soil stiffness, slope stabilization, and erosion control. Suction exerted by the roots water uptake of vegetation can have substantial effects on soil moisture, where it will influence the strength of the soil. The roots of water uptake increases the strength of the soil by increasing soil matric suction due to dissipation of pore pressure in the soil mass, inducing an increasing number of stress or water intake.

In this regard, soil suction as a possible major contributor to shallow slope stability is noticeable. Therefore, efforts to improve the quantification of the effect and mechanism of roots as soil stabilizer are required and should fully integrate the contribution of the whole root array, and include more of the possible effect of soil suction (Mafian. S. et al., 2009). Until now, very limited amounts of information about the effect of tree induce suction in the soil suction influenced by climatic condition changes.

1.3 Objectives of the Study

i. To analyze the soil suction profile with related to develop soil suction contour with effect of tree at toe of the slope.
ii. To analyze the effect of the tree induce suction at various condition from wet period (high rainfall) to dry period (prolonged no rainfall).

1.4 Scope of the Study

This study is focused on the pattern of soil suction at near vicinity of tree influenced by rainfall intensity. The suctions will generated within near vicinity of a single representative mature tropical tree *acacia mangium* which is near the toe of the slope by using Jet-fill tensiometer. The Jet-fill tensiometer will be placed at various depths and distances from tree trunk that were conducted. The changes of soil suction will be analyzed and developed the soil suction contour using the GID 7.2 software.

1.5 Significant of the Study

The aim of this study is to analyze the pattern of the soil suction due to tree induce suction at various condition from wet period (high rainfall) to dry period (prolonged no rain). The significant show when the soil suction at near vicinity of tree is increase due to the tree induces suction especially during dry season. The higher soil suction is related to the decrease of the moisture content of the soil. Therefore, the soil shear strength will increase. This study is to give better understanding of effect of tree induce suction on the soil suction.

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