# TREE WATER UPTAKE ON SUCTION DISTRIBUTION IN UNSATURATED TROPICAL RESIDUAL SOIL SLOPE

MOHD FAKHRURRAZI BIN ISHAK

A thesis submitted in fulfilment of the
requirements for the award the degree of
Doctor of Philosophy (Civil Engineering)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

OCTOBER 2014

**In the name of ALLAH, the almighty and most merciful.**

To my beloved family

Nazirah Bte Brahim

Nurfarizah

Muhammad Afiq

Hj Brahim Bin Bujang

Hjh Ramlah Bte Hasan

In memory of Hj Ishak Bin Mohd Amin and Hjh Munah Bte Ahmad

## ACKNOWLEDGEMENT

I wish to gratitude my appreciation and indebtedness to my main supervisor, Associate Professor Dr. Nazri Bin Ali for the dedication, guidance, ideas, critics and passionate throughout to complete this research. Also, I would like to thanks for encouragements and kindness to Associate Professor Dr. Azman Bin Kassim and Associate Professor Dr. Tajul Anuar Bin Jamaluddin for assistance me especially at difficult moment. Their advice and guidance was always in my mind.

I would like to extend my appreciation to all Geotechnical Laboratory staff, especially to Mr Zulkifly and Mr Hidayat. I would like to express my gratefulness for their assistance in laboratory and field works. Lastly, I would like to thank all – the Ministry of Higher Education, University Malaysia Pahang (sponsorship) and University Teknologi Malaysia (research funds), fellow academicians and researchers, and friends for their involvements in any part of this research.

# ABSTRACT

This study provides an investigation of active root tree zone located at the toe of a slope. This section and its vicinity generated matric suction due to tree water uptake on tropical residual soil slope. The research employed several approaches i.e field monitoring, laboratory experimental and numerical modelling. A field monitoring was carried out to collect matric suction data at the slope with two conditions; in absence of a tree and with a tree located at the toe of a slope. The unsaturated shear strength behaviour of soil under different stress level is investigated, using uncomplicated testing procedure subject to actual matric suction encountered during field monitoring. The numerical simulation modelling was applied based on the laboratory results to obtain the most appropriate condition to replicate the tree water uptake within the soil slope. A decrease in matric suction occured after a long duration of intense rainfall. This condition was function as an initial condition before the water uptake driven by active root tree generated to the maximum matric suction (low moisture content). The pattern of matric suction profiles revealed that majority of matric suction changes was greater at the proximity of tree trunk below 4 m and at a shallow depth of 0.5 m. Transpiration on single mature tree has significantly altered the matric suction or moisture variation distribution on an unsaturated soil slope. This study also illustrated the nonlinear relationship between the apparent shear strength and suction influencing the stability of the slope. The assessment of slope stability due to the influence of a tree induced suction was provided in this research. The factor of safety against slope failure has improved up to 63 % on slope with tree at toe compared to a slope without tree. Lastly, the numerical simulation modelling of matric suction induced by a tree has been verified through comparison to actual field monitoring results recorded during the dry period. Generally, an acceptable aggrement between simulation and field monitoring results has been achieved. This research delivers a strong belief that a preserved mature tree can improve soil properties in slopes designs.

# ABSTRAK

Kajian ini merangkumi penyiasatan di zon aktif akar pokok yang terletak di kaki cerun. Di bahagian ini dan kawasan sekitarnya menjanakan sedutan matrik disebabkan pengambilan air daripada pokok di tanah tropika sisa pada sekitar cerun. Penyelidikan ini mengambil beberapa pendekatan iaitu pemantauan di lapangan, ujikaji-ujikaji makmal dan pemodelan berangka. Pemantauan di lapangan yang dijalankan bagi mengumpul data sedutan matrik di cerun dilakukan dalam dua keadaan; tanpa kewujudan pokok dan dengan kewujudan pokok yang terletak di kaki cerun. Sifat kekuatan ricih tanah tak tepu diuji dibawah tahap tekanan yang berbeza dengan menggunakan kaedah yang tidak rumit bergantung kepada nilai sebenar sedutan matrik yang direkodkan semasa pemantauan di lapangan. Simulasi berangka dijalankan berdasarkan keputusan makmal untuk mendapatkan nilai yang paling sesuai bagi menunjukkan pengambilan air daripada pokok di cerun tanah dengan corak sedutan matrik di lapangan. Penurunan sedutan matrik berlaku selepas hujan lebat yang panjang. Situasi ini berfungsi sebagai keadaan awalan sebelum pengambilan air didorong oleh akar pokok yang aktif menjana sedutan matrik kepada nilai yang paling tinggi (kandungan kelembapan yang rendah). Corak profil sedutan matrik mendedahkan bahawa kebanyakan perubahan sedutan matrik adalah lebih besar berdekatan batang pokok berdekatan (4 m) dan pada kedalaman yang cetek (0.5 m). Transpirasi hanya daripada sebatang pokok matang dapat memberikan sumbangan yang amat ketara dalam mengubah sedutan matrik atau kelembapan pada cerun tanah tak tepu. Terdapat hubungan tak linear di antara kekuatan ricih dan sedutan yang mempengaruhi kestabilan cerun. Penilaian kestabilan cerun disebabkan pengaruh sedutan oleh pokok juga terdapat dalam kajian ini. Faktor keselamatan terhadap kegagalan cerun telah bertambah sehingga 63 % pada cerun dengan pokok di kaki berbanding dengan cerun tanpa pokok. Terakhir sekali, simulasi pemodelan berangka sedutan matrik yang dijanakan oleh pokok dan disahkan secara langsung dengan keputusan pemantauan sebenar yang dicatatkan semasa tempoh keadaan kering. Secara amnya, keputusan simulasi dan pemantauan di lapangan menunjukkan hubungan yang munasabah. Kajian ini memberikan keyakinan yang kuat terhadap pemeliharaan pokok matang yang boleh memperbaiki sifat-sifat tanah dalam merekabentuk cerun..

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

## LIST OF SYMBOLS

| | | |
|---|---|---|
| $A_{ev}$ | - | Air entry value |
| $c'$ | - | Effective cohesion |
| $e$ | - | Void ratio |
| $g$ | - | Gravity = 9.81 m/s$^2$ |
| $G_s$ | - | Specific gravity |
| $I$ | - | Rainfall intensity |
| $k$ | - | Water coefficient of permeability |
| $k_{sat}$ | - | Saturated permeability |
| $K(\psi)$ | - | Hydraulic conductivity of wetted zone |
| $L_f$ | - | Wetting front depth |
| $L_r$ | - | Redistribution depth |
| $m_w$ | - | Slope of soil water characteristic curve (SWCC) |
| $n$ | - | Porosity |
| $q$ | - | Rainfall unit flux |
| $t$ | - | Time |
| $u_a$ | - | Pore-air pressure |
| $u_w$ | - | Pore-water pressure |
| $(u_a - u_w)$ | - | Matric suction |
| $W$ | - | Total weight of soil |
| $W_{ev}$ | - | Water entry value |

| | | |
|---|---|---|
| $\beta$ | - | Slope inclination angle |
| $\chi$ | - | Parameter related to the soil degree of saturation |
| $\phi'$ | - | Effective friction angle |
| $\phi^b$ | - | Angle indicating unsaturated |
| $\gamma_d$ | - | Unit weight of dry soil |
| $\gamma_w$ | - | Unit weight of water = 9.81 kN/m$^3$ |
| $\pi$ | - | Osmotic suction |
| $\theta$ | - | Volumetric water content |
| $\theta_i$ | - | Initial volumetric water content |
| $\theta_r$ | - | Residual volumetric water content |
| $\theta_s$ | - | Volumetric water content at saturation of absorption curve |
| $\rho_b$ | - | Bulk density |
| $\rho_d$ | - | Dry density |
| $\rho_w$ | - | Density of water |
| $\sigma$ | - | Total normal stress |
| $\sigma'$ | - | Effective normal stress |
| $\tau_f$ | - | Shear stress at failure |
| $\psi$ | - | Suction |
| $\psi_{min}$ | - | Minimum Suction value |
| $\psi_T$ | - | Total suction |
| $C(\psi)$ | - | Specific moisture capacity (cm$^{-1}$) |
| $r_r$ | - | Maximum rooting radial (cm) |
| $S_m$ | - | Shear force mobilized on the base of each slice (kN) |
| $S(\psi, z, r)$ | - | Sink term (cm$^3$/cm$^3$/s) |
| $T, T_j$ | - | Potential Transpiartion rate |

| | | |
|---|---|---|
| $z_r$ | - | Maximum rooting depth (m) |
| $\alpha(\psi)$ | - | Pressure head dependent reduction factor |
| $N$ | - | Total force on the base of the slice (kN) |
| $O$ | - | The centre of slip rotation |
| $\Theta$ | - | Normalized volumetric water content |
| $\chi$ | - | Parameter related to the soil degree of saturation |
| $C_{app}$ | - | Apparent shear strength |
| $q_u$ | - | Undrained compressive strength |
| $W_s$ | - | Weight of solid soils in the specimen |
| $W_T$ | - | Target weight of the specimen |
| $W_w$ | - | Weight of water in the specimen |
| $(\Delta\sigma_d)_f$ | - | Deviator stress at failure |
| $\varepsilon$ | - | Axial strain |
| $\omega$ | - | Moisture content |
| $\omega_0$ | - | Initial moisture content |
| $\omega_T$ | - | Target moisture content of the specimen |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Study

In recent years, rapid urbanisation, overdevelopment and deforestation have contributed further to the destabilising of soil and soil surrounding it, with a greater number of developments contributed to gradually weaken the earth structure. As a consequence, some of catastrophic slope failure events occurred in Malaysia due to the removal of mature trees at the toe of slopes. One of the events took place at Hidayah Madrasah Al-Taqwa orphanage at km 14 Jalan Hulu Langat, Selangor. This tragedy occurred during a long spell of daily torrential rainfall event which suddenly triggered the landslide, wrecked the houses and killing 16 orphans. Further investigation of the surrounding area revealed that cutting down trees at the toe of a slope lead to this disaster (Jamaluddin *et al.*, 2011).

Several case studies have shown that slope failures may have attributed to the clearing of trees that vanishes the reinforcement provided by roots to the soil (Wu, 1995; Hunt, 2007; Jamaluddin *et al*., 2011). Slope failures commonly occur when the shear strength of the soil is reduced through a decrease in effective stress due to pore water pressure increment (Glendinning *et al*., 2009). This may happen due to climate change and antecedent rainfall, which can be found mostly in Malaysia. In fact, sudden increase in porewater pressure can cause sudden weakening of the soil strength and lead to slope failure. Therefore, it is significantly important to find an economically and eco-friendly solution on how to minimise the risk and bring sustainability to the slopes. This study considers the vegetation approach in maintaining and enhancing soil strength through moisture content reduction in minimising the risk of slope failure.

Vegetation prevents collapse by reducing water pressure (increasing suction through water uptake) due to suction produced by vegetation and acts to stabilise the slopes by increasing effective stress, thus leading to an increase in soil shear strength. Simon and Collison (2002) claimed hydrological effect as an important key finding as mechanical effect, which it increases FOS up to 70%. It should also be noted that if trees are cut down it may result in failure when pore water pressures are recovered because strain softening has already occurred (due to previous seasonal cyclic loading effects). This is important in the management of vegetation and engineers must be wary of felling trees without first understanding the hydrology condition.

It is acknowledged that vegetation has various mechanical and hydrological effects on ground stability. Many researchers (Greenway, 1987; Greenwood, 2006; Genet et al., 2010; Schwarz et al., 2010; Ali, 2010) have attempted to quantify the focusing on the mechanical strengthening provided by the roots, while ignoring the implications of evapotranspiration on the soil pore water pressure. However, a model has been developed; an application of a numerical model of water uptake in the vicinity of established trees produced by Fatahi et al., (2010). They development of the mathematical model for the rate of root water uptake considers ground conditions which highlighted the inter-related parameter of contribution to the development of conceptual evapotranspiration and root moisture uptake equilibrium model.

The water-uptake numerical model was also provided by Ali and Rees (2008) which marked a new approach on hydrological effect for the stability of slope. They used a numerical model to develop a distribution soil moisture content profile to simulate the tree water-uptake. The sink term (extraction) was only applied within the pre-defined geometry of the root zone. However, moisture was still free to migrate towards this zone and simulated contours in terms of capillary potential after drying and heavy rainfall event.

The study conducted by Biddle (1998) on lime tree found that the active root zone has extended until 2 m depth with a radial of 5 m for both left and right direction. He also concluded that the pattern of soil moisture deficit contour has been affected by the soil moisture transfer from various species of trees. He discovered significant changes in soil moisture contour due to the different type of trees, regardless of the soil types. It was found that the pattern of soil moisture deficit has occurred and this may similar for different clay and the amount of clay shrinkage with the associated risk of structural damage depends on the clay characteristics. In tropical country such as Malaysia, the tropical monsoon rainfall and particularly dry period can reflect patterns of soil moisture. This result and analysis can revealed the effect of tree by correlation with meteorological data.

Tree root can help to prevent landslides in two ways, either hydrological effects; modifying the soil moisture regime via evapotranspiration and providing root reinforcement within the soils. The first factor can be very important to prevent landslides and debris flow form occurring during an extensive rainy season, especially in the tropics and sub-tropics country where evapotranspiration is high throughout the year. This condition can also lead to deeper-seated landslides, such as earthflows due to high moisture contents after vegetation is removed (Sidle and Ochiai, 2006). However, Greenway (1987) has suggested that it is possible to develop a model, which can indentify the relationship between transpiration to soil moisture content used in slope analysis. A model of this approach would be able to determine major influence of transpiration driven by tree integrated with slope stability.

This study explores the active root zone of a tree that lies at the toe of the slope and the matric suction generated within this section of the slope. The aim of the research was to investigate the pattern of matric suction distribution at slope in respond to tree water uptake. In relation to that, the significant matric suction changes can be relative to the behaviour of strength envelop in unsaturated tropical residual soil. The research was further extended by applying the changes of matric suction to the geotechnical slope stability problem as discussed below.

In this study, conditions such as the ground water table is deep enough and tree root activity is above ground water table that tree induced suction influence matric suction on soil. In this case, it is appropriate to perform slope stability analyses which include the shear strength contribution from the matric suction. A modified form of the Mohr-Coulomb equation can be used to link shear strength to soil matric suction. Theory of limit equilibrium of forces and moments used to compute the FOS (Factor of Safety) against failure. The limit equilibrium method of slices is widely used for its simplicity particularly when compared to the finite element method (Fredlund and Rahardjo, 1993, Renaud et al., 2003). The FOS is defined as that factor by which the shear strength of the soil must be reduced in order to bring the mass of soil into a state of limiting equilibrium along a selected critical slip surface.

## 1.2 Problem Statement

Many hill slope areas in Malaysia, both engineered slope and natural slope are particularly vulnerable to soil erosion, shallow landslides and the most catastrophic disaster are mass slope failures. Slope failures mostly occur during intense increase of soil moisture and porewater pressure due to antecedent and prolonged rainfall. The increasing soil moisture or pore water pressure can be seen as the main contributing factor for decreasing soil shear strength thus leading to the weakening of the slope stability, resulting in FOS reduction.

Many researchers (Thorne, 1990; Ali, 2010; Schmidt *et al.*, 2001; Normaniza *et al.*, 2007) have discovered the effect of mechanical on tree root that can benefit in preventing shallow slope failure but only a few studies to quantify the hydrological effect for the potential benefit stabilization of slope. Apart from providing natural mechanical soil reinforcement, tree roots dissipate excess pore water pressure and produce sufficient matric suction to increase the shear strength of the surrounding soil. The hydrological effect is related much closed to soil moisture variation and can be directed through transpiration. This effect is found to be important as mechanical effect provides significant increase in soil strength that will definitely improve slope stability in certain conditions. It must be considerate before cutting and felling down the trees without understanding the hydrological condition would have a great impact on the stabilization of slope and soil surrounding it.

## 1.3 Objectives Of Study

The aim of this study is to explore the soil matric suction distribution due to tree induced suctions generated within the toe of the slope. The changes of matric suction were analysed to reveal the soil moisture profiles in the vicinity of a tree. These soil matric suction changes affect the stability of unsaturated slopes in the study area. To achieve this aim, several objectives of the study are stated below;

I. To determine soil matric suction of a slope with mature tropical tree existing at the toe of the slope. This is accomplished through installations of equipments in the vicinity of tree with certain depths and distances to continuously measured matric suction for one and half year period.

II. To establish profiles that demonstrate influence of tree water-uptake with through condition from prolonged antecedent rainfall to dry period. The changes in matric suction data and suction profiles would be analyses to reveal the patterns in soil matric suction.

III. To develop a matric suction contour (soil moisture) distribution to reveal the moisture deficit at active root tree zone. The distributions of matric suction were used to represent the profile of matric suction influenced by single mature tree at toe of slope.

IV. To analyses the influence of tree induced suction on Factor of Safety (FOS) throughout this course of monitoring study.

V. To verify field monitoring and laboratory results through comparison with established numerical models. A detailed numerical modelling was carried out to simulate suction distributions and failure envelop of tropical residual soil in the study area.

## 1.4 Scope Of Study

This study presents patterns of soil moisture transfer and migration due to the influence of tree root water-uptake on the unsaturated soil condition. It focuses on the hydrological aspect on soil moisture pattern within the vicinity of the tree. The mechanical aspect of the tree roots such as tensile strength that bond between root and soils which can lead to increasing soil strength are not consider in this study.

The current work would consider the effect of single tropical mature tree such as *Acacia mangium* at the toe of the slope with the determination of root zone patterns limited to a depth less than 2 m and radius distance not more than 5 m. The root growth will be excluded in this work scope and only consider on transpiration by tree. The study also presented assessment the stability of typical geometry cut slope constructed 13 years ago at Faculty of Electrical Engineering, University Teknologi Malaysia. The approach to encounter soil matric suction profiles was based on field instrumentations monitoring and laboratory works.

Nevertheless, the focus on aspect of this study is limited to the influence of suction than changes on shear strength by using the extended Mohr-Coulumb equation (Fredlund *et al.*, 1978). The water-uptake consideration in this study only represents the soil near–saturated conditions until the drying period due to transpiration of tree by not considering the hyteresis effect. The calculations of FOS presented here only consider the magnitude of matric suction variation driven by transpiration only.

A series of condition during field monitoring works were analysed with the results in the laboratory. Apart from that, the field monitoring and laboratory result brought significant input parameters to apply in the numerical model and the stability analysis of slopes. To verify the numerical model, a parametric study has been conducted by considering conditions that could be incorporated in the field monitoring results. The comparison of these works revelled that tree moisture transfer or induce suction is beneficial in maintaining stability of unsaturated soil slopes.

## 1.5 Significance Of Study

The exploration of this research may be viewed as comprehensive or/and an alternative to the existing field monitoring and modification laboratory testing program for tropical residual soils. The benefits that would be gained from the study may include the followings:

I. Providing essential quantification information on the behaviour of matric suction (pore-water pressure) changes in relation to tree water up taken with measurable rainfall and soil parameters change with matric suction in assessing the stability of unsaturated residual soil slopes.

II. Representing hydrological condition in viewing the significant contribution of a single mature tree in altering the matric suction or moisture content variation distribution driven by transpiration on unsaturated soil slopes.

## 1.6 Thesis Organization

This thesis consists of eight (8) chapters; *Introduction* (Chapter 1), *Literature Review* (Chapter 2), *Research Methodology* (Chapter 3), *Preliminary Data* (Chapter 4), *Effect Of Tree Water Uptake On Suction Distribution Pattern* (Chapter 5), *Analysis Of Tree Induced Suction On Slope Stability* (Chapter 6), *Tree Induced Suction And Numerical Modelling* (Chapter 7) And *Conclusions And Recommendations* (Chapter 8). At the end of each chapter excluded Chapter 8, concluding remarks were provided to briefly summarize the content of the chapter.

As introduction to generally describe the background of problem related to slope failure associated with clearing of trees is the main discussion in Chapter 1. Apart from this problem statement, Chapter 1 also discusses the objectives, scopes and significance of the present study. The brief description on tree can improve slope stability from various effects of mechanical and hydrological are presented. Vegetation may prevent collapse by reducing water pressure as an economically and eco-friendly solution was also presented.

The related research work and review of literature is presented in Chapter 2. This chapter provides descriptions and concepts of appropriate theories published in literature pertaining on analysis of tree water uptake in unsaturated soil. In addition, Chapter 2 also outlines methodologies of the laboratory techniques, field monitoring work and numerical model that employed in the previous studies.

Research methodology particularly laboratory experiments and field monitoring are described detail in this study is explained in Chapter 3. One of the objectives is to collect basic data at study area. In Chapter 3 also describes the detail of the equipment and procedures to recorded and measured field and laboratory work.

The discussions on the following chapters in this thesis are related to the results and analyses, i.e. Chapter 4, Chapter 5 and Chapter 6. Chapter 4 presents and discusses the preliminary data obtained from two main components of experimental results and field monitoring data as described in Chapter 3. The results include the characterization of residual soil and the response of matric suction distribution particularly influence by tree water uptake through out field observation.

The discussion related to hydrological effect on unsaturated slope is presented in Chapter 5. The analyses are mainly focuses on the field monitoring results influence by tree water uptake. This revealed a contribution of single mature tree can be significant alter the suction or moisture variation distribution driven by transpiration on unsaturated soil slope.

Chapter 6 is considering on how matric suction generated by tree can be influence for an assessment of the stability on unsaturated soil slope. The typical of engineered slope geometry and behaviour of soil shear strength related to matric suction effects the Factor of Safety (FOS) against failure are examined. The FOS was presented with corresponding variation of actual matric suction of slope with tree at toe and slope without tree are consider.

Chapter 7 presents the exploration of the numerical model of moisture migration pattern in proximity of mature tree. The model is applied to simulated matric suction distribution and compared with field measurements that have been identified earlier in Chapter 4 and Chapter 5. The model serves to generate the matric suction by tree at toe of slope that influences the overall hydrological condition of the slope.

The final chapter of the thesis (Chapter 8) covers the overall conclusions of the thesis drawn from the present study and the recommendations for further researches.

## REFERENCES

Ahmad, K. (2004). *Improvement of a Tropical Residual Soil by Electrokinetic Process*. Doctor Philosophy, Universiti Teknologi Malaysia, Skudai.

Agus, S.S., Leong, E.C. and Rahardjo, H. (2001). Soil-Water Characteristic Curves of Singapore Residual Soils. *Journal of Geotechnical and Geological Engineering*. 19, 285-309.

Agus, S.S., Leong, E.C. and Rahardjo, H. (2005). Estimating Permeability Functions of Singapore Residual Soils. *Engineering Geology*. 78: 119-133.

Ali, F. (2010). Use Of Vegetation For Slope Protection: Root Mechanical Properties Of Some Tropical Plants. *International Journal of Physical Sciences*. Vol. 5(5), 496-506.

Ali, N. (2007). *The Influence Of Tree Induce Moisture Transfer On Unsaturated Soil*. Doctor Philosophy, University Of Cardiff, Cardiff.

Ali, N. and Mu'azu, M.A. (2010). Simulated Of Vegetation Induced Deformation In An Unsaturated Soil. *American Journal of Enviromental Sciences*, 6 (2): 130-136.

Ali, N. and Rees, S.W. (2008). Preliminary Analysis Of Tree-Induced Suctions On Slope Stability. *Proceedings Of The First European Conference On Unsaturated Soils, 2008*, Durham, United Kingdom. CRC Press, Taylor & Francis Group, London, Uk: 811 – 816.

Alva, A.K., Prakash, O., Fares, A. and Hornsby, A. G. (1999). Distribution Of Rainfall And Soil Moisture Content In The Soil Profile Under Citrus Tree Canopy And At The Dripline. *Irrig Sci,* Springer-Verlag 1999, 18: 109–115.

Alva, A.K. and Syvertsen, J.P. (1991). Irrigation Water Quality Affects Soil Nutrient Distribution Root Density, And Leaf Nutrient Levels Of Citrus

Under Drip Irrigation. *J. Plant Nutr.,* 14: 715–727.

Aitchison, G.D. (1961). Relationships Of Moisture Stress And Effective Stress Functions In Unsaturated Soils. *Pore Pressure and Suction in Soils Conference*. London, England: 47-52.

Anon, (1981). *Code of practice for site investigation (BS5930)*. London: British Standards Institute.

ASTM (2000). *Standard Test Method for Capillary-Moisture Relationships for Coarse- and Medium-Textured Soils by Porous-Plate Apparatus, Designation D2325-68*. West Conshohocken, Pennsylvania: American Society for Testing and Materials.

Babu, G.L.S. and Murthy, D.S.N. (2005). Reliability Analysis of Unsaturated Soil Slopes. *Journal of Geotechnical and Geoenvironmental Engineering, ASCE*. 131(11): 1423-1428.

Bacelar, E. A., Pereira, J. M., Goncalves, B. C., Ferreira, H. F. and. Correia, C. M. (2007). Changes In Growth, Gas Exchange, Xylem Hydraulic Properties And Water Use Efficiency Of Three Olive Cultivars Under Contrasting Water Availability Regimes. *Environmental and Experimental Botany*, 60, 183–192.

Bao, C.G., Gong, B. and Zhan, L. (1998). Properties of Unsaturated Soils and Slope Stability of Expansive Soil. Keynote Lecture, *2nd International Conference on Unsaturated Soils*. Beijing, China.

Bell, J. P. (1976*). Neutron Probe Practice*. Wallingford, Institute of Hydrology.

Berry, P.L. and Reid, D. (1987). *An Introduction to Soil Mechanics*. London: McGraw-Hill Book Company.

*Biddle, P. G. (1983).* Pattern Of Soil Drying And Moisture Deficit In The Vicinity Of Trees On Clay Soils. Ge´Otechnique, 33*, No. 2, 107 – 126.*

*Biddle, P.G. (1998).* Tree Root Damage To Buildings. *Wantage, Willowmead Publishing Ltd.*

Bishop, A.W. (1955). The use of the slip circle in the stability analysis of earth slopes. *Geotechnique*, 5 (1), 7 – 17.

Bishop, A.W. (1959). *The Principle of Effective Stress*. Oslo, Norway. Norwegian Geotechnical Institute.

Bishop, A. W., and Blight, G. E. (1963). Some Aspects of Effective Stress in Saturated and Unsaturated Soils. British*: Geotechnique.* 13(3), 177-197.

Bland, W. and Rolls, D (1998). *Weathering*. London: Arnold.

Blight, G.E. (1997). Origin and Formation of Residual Soils. *In: Mechanics of Residual Soil*. Rotterdam, Balkema: 1-15.

Blight, G.E. (2003). The Vadose Zone Soil Water Balance And Transpiration Rates Of Vegetation. Essex. *Geotechnique,* No.1, 55-64.

Blight, G.E. (2008a). The Repeatability Of Soil Water Balances At The Same Site From Year To Year. *Proceedings Of The First European Conference On Unsaturated Soils, 2008.* Durham, United Kingdom, Balkema. 889-894.

Blight, G.E. (2008b). Near-Surface Movement Of Water In Unsaturated Soil During Evaporation. *Proceedings Of The First European Conference On Unsaturated Soils, 2008.* Durham, United Kingdom, Balkema. 895-900.

Blight, G.E. (2012). *Origin And Formation Of Residual Soils. Mechanics Of Residual Soils.* London, UK, Taylor & Francis Group plc.

Boosinsuk, P. and Yung, R.N. (1992). Analysis of Hong Kong Residual Soil Slopes. *Engineering and Construction in Tropical Residual Soils; Proceedings of the 1981 Special Conference. ASCE*. Hawai: 463-482.

Bosch, J. M. and Hewlett, J. D. (1982). A Review Of Catchment Experiments To Determine The Effects Of Vegetation Changes On Water Yield And Evapotranspiration. *Journal of Hydrology*, 55.

Bouwer, H. (1966). Rapid Field Measurement of Air Entry Value and Hydraulic Conductivity of Soil as Significant Parameters in Flow System Analysis. *Water Resources Research*. 2(4): 729-738.

Brand, E.W. (1985). Predicting The Performance Of Residual Soil Slopes. *Proceedings of The Eleventh International Conference on Soil Mechanics and Foundation Engineering*, San Francisco. Volume 5, 2541-2578.

Brand, G.E. and Philipson, H.B. (1985). *Sampling and Testing of Residual Soils – A Review of International Practices*. Technical Committee on Sampling and Testing of Residual Soils, International Society for Soil mechanics and Foundation Engineering: 7–22.

Brisson, P., Garga, V.K. and Vanapalli, S.K. (2002). Determination of Unsaturated Flow Characteristics of Nickel Mine Tailings. *55th Canadian Geotechnical Conference*. October 2002, Niagara, Canada.

Braud, I., Varado, N. and Olioso, A., (2005). Comparison Of Root Water Uptake Modules Using Either The Surface Energy Balance Or Potential Transpiration. *Journal of Hydrology*, 301, 267 – 286.

BSI, (1999). *Code of Practice for Site Investigations, (BS 5930)*. London: British Standards Institution.

BS, (1990). *Methods of Test for Soils for Civil Engineering Purposes, (BS 1377: Part 1-9)*. London: British Standards Institution.

Buckingham, E. (1907). Studies On The Movement Of Soil Moisture. US Department Of Agriculture Bureau Soils, 38, Washington DC, 61.

Burton, C.K. (1973). *Geology and Mineral Resources Johore Bahru-Kulai Area South Johore*. Geological Survey of Malaysia, Ministry of Primary Industries Malaysia.

Cai, F. and Ugai, K. (2004). Numerical Analysis of Rainfall Effects on Slope Stability. *International Journal of Geomechanics*, *ASCE.* 4(2): 69-78.

Cameron, D. A. (2001). The Extant Of Soil Desiccation Near Trees In A Semi-Arid Environment. *Geotechnical and Geological Engineering, 19*, 357-370.

Carslaw, H. S. and Jaeger, J. C. (1959). Conduction of Heat in Solids. Oxford: Oxford University Press,

Cammeraat, L.H., van Beek, L.P.H. and Kooijman, A.M. (2005). Vegetation Succession And Its Consequences For Slope Stability In SE Spain. *Plant Soil 278*:135–147

Campbell, R.H. (1974). Debris Flows Originating From Soil Slips During Rainstorms In Southern California. *Q. J. Eng. Geol.,* 7(4), 339-349.

Chang, Y. Y. and Corapcioglu, M. Y. (1997). Effect of Roots on Water Flow in Unsaturated Soils. *Journal of Irrigation and Drainage Engineering*, 202 – 209.

Chaves, M. M. (1991). Effects Of Water Deficits On Carbon Assimilation. *J. Exp. Bot.* 42, 1–16.

Chin, F.K. (1988). Construction of Dams, Roads, Air Fields, Land Reclamation in and on Tropical Soils-General Report. *Proceedings of the 2nd International Conference on Geomechanics in Tropical Soils (Supplementary Documentations)*. 12-14 December: 92-102.

Chun-Ta, L. and Gabriel, K. (2000). The Dynamic Role Of Root-Water Uptake In Coupling Potential To Actual Transpiartion. Adv. In Water Res. 23, pp. 427-439.

Chowdhury, R., Flentje, P. and Bhattacharya, G. (2010). *Geotechnical Slope Analysis*. CRC Press, Taylor & Francis Group, London, Uk. 737.

Cienciala, E., Kucera, J. and Malmer A. (2000). Tree Sap Flow And Stand Transpiration Of Two Acacia Mangium Plantations In Sabah, Borneo. *Journal of hydrology,* 236, 109-120.

Collison, A.J.C., Anderson, M.G. and Lloyd, D.M. (1995). Impact Of Vegetation On Slope Stability In A Humid Tropical Environment: A Modelling Approach. *Proceeding Institute Civil Engineering Wat., Marit. & Energy*, 112, June, 168-175.

Collins, K., and McGown, A. (1974). The Form and Function of Microfabric Features in a Variety of Natural Soils. *Geotechnique*. 24(2): 223–254.

Cornic, G. and Massacci, A. (1996). *Leaf Photosynthesis Under Drought Stress*. Netherlands: Photosynthesis And The Environment, 347–366.

Corey, A. T. (1957). Measurement of Water and Air Permeability in Unsaturated Soils. *Proc. of the Soil Science Society of America*, 21(1), 7-10.

Craig, R.F. (2004). *Soil mechanics*. 5th Ed., London, Chapman & Hall.

Crow, P. (2004). Trees and Forestry on Archaeological sites in the UK: A review document. *Forest Research*.

Cutler, D. F. and Richardson, I. B. K. (1989). *Tree roots and buildings*. Singapore: Longman Scientific and Technical.

Dardanelli, J. L., Ritchie, J. T., Calmon, M., Andriani, J. M. and Collino, D. J. (2004). An Empirical Model For Root Water Uptake. *Field Crops Research,* 87, 59 – 71.

De Campos, T.M.P., Andrade, M.H.N. and Vargas Jr, E.A (1992). Unsaturated Colluvium Over Rock Slide In A Forested Site In Rio De Janeiro, Brazil. *In Landslides; Proceedings of the Sixth International Symposium, Christchurch, Volume 2,* Ed. D.H.Bell, pub Balkema, 1357-1364.

Dearman, W.R. (1976). Weathering Classification in the Characterisation of Rocks:

A Revision. *Prediction Soil Mechanics*. London: Thomas Telford.

Delage, P. (2002). Experimental Soil Mechanics. *Proceeding of 3rd International Conference on Unsaturated Soils, UNSAT 2002,* Brazil, (3), 973-996.

Delmhorst Instrument Co. (2000). Soil Moisture Tester Model KS-D1. Operating Instructions. Delmhorst Instrument Co., Towaco, New Jersey.

Dearman, W.R., Baynes, F.J. and Irfan, T.Y. (1978). Engineering Grading Of Weathered Granite. *Engineering Geology*, 345-374.

Dobson, M.C. and Moffat, A.J. (1993). The Potential For Woodland Establishment On Landfill Sites. London: Department of the Environment, HMSO.

Dombro, D.B. (2009). *Acacia Mangium*: *Amazonia Reforestation's Miracle Tree.* Planeta Verde Reforestación S.A. An e-book for tropical tree investor.

Escrio, V. and Juca, S. (1989). The Shear And Deformation Of Partly Saturated Soils. *Proceedings Of The 12th International Conference On Soil Mechanics And Foundation Engineering*, Rio De Janeiro: 3, 43-46.

Fatahi, B., Khabbaz, H. and Indraratna, B. (2010). Bioengineering Ground Improvement Considering Root Water Uptake Model. *Journal Ecological Engineering* 36, 222–229.

Fatahi, B., Khabbaz, H. and Indraratna, B. (2009). Parametric Studies On Bioengineering Effects Of Tree Root-Based Suction On Ground Behaviour. *Ecological Engineering,* 35, 1415-1426.

Fatahi, B., Indraratna, B. and Khabbaz, H. (2007). Analysing Soft Ground Improvement Caused By Tree Root Suction. *Advance In Measurement and Modeling of soil behaviour*. ASCE. 1-6.

Fan, C.H. and Su, C.F. (2008). Role Of Roots In The Shear Strength Of Root-Reinforced Soils With High Moisture Content. *Ecological Engineering* 33, 157-166.

Feddes, R. A., Kowalik, P. J., Malink, K. K., and Zaradny, H. (1976). Simulation Of Field Water Uptake By Plants Using A Soil Water Dependent Root Extraction Function. *J. Hydro*, 31, 13 – 26.

Feddes, R. A., Kowalik, P. J., and Zaradny, H., (1978). Simulation Of Field Water Use And Crop Yield. *Wageningen Center for Agriculture and Documentation, Wageningen*, 189.

Feddes, R. A., Hoff, H., Bruen, M., Dawson, T., Rosnay, P., Dirmeyer, P., Jackson, R. B., Kabat, P., Kleidon, A., Lilly, A. and Pitmank, A. J. (2001). Modeling Root Water Uptake in Hydrological and Climate Models. *American Meteorological Society*, 82(12), 2797 – 2809.

Fellenius, W. (1936). Calculation of the Stability of Earth Dams. Trans. 2nd Int. Cong. Large Dams, Washington, 445 – 459.

Fookes, P.G. (1997). Tropical Residual Soils. *Geological Society Engineering Group Working Party Revised Report*. The Geological Society, London.

Fourie, A.B. (1996). Predicting Rainfall-Induced Slope Instability. *Proceedings of the Institution of Civil Engineers, Geotechnical Engineering* 119, 211-218.

Fourie, A.B., Irfan T.Y., Queiroz de carvalho, J.B., Simmons J.V. and Wesley L.D. (2012). *Microstructure, Mineralogy And Classification Of Residual Soils*. Taylor & Francis Group plc, London, UK.

Fredlund, D. G., Morgenstern, N. R., and Widger, R. A. (1978). The Shear Strength of Unsaturated Soil. *Canadian Geotechical Journal*. 15: 313–321.

Fredlund, D.G. and Rahardjo, H. (1993). *Soil Mechanic for unsaturated Soils.* Canada: John Wiley & Sons, Inc, Printed Ltd.

Fredlund, D.G., Rahardjo, H. and Fredlund, M.D. (2012). *Unsaturated Soil Mechanics In Engineering Practice*. New Jersey: John Wiley &Sons, Inc, Printed Ltd.

Fredlund, D.G., Rahardjo, H. and Gan, J.K.-M. (1987). Non-Linearity Of Strength Envelope For Unsaturated Soils. *Proceeding, 6th International Conference On Expensive Soil*s, New Delhi, India, 49-54.

Fredlund, D. G., Ng, C. W. W., Rahardjo, H. and Leong, E. C. (2001). Unsaturated Soil Mechanics: Who Needs It? *Geotechnical News, December. GeoSpec*., Bi-Tech Publishing. Vancouver, B.C., Canada: 43–45.

Fredlund, D.G., Xing, A. and Huang, S. (1994). Predicting the Permeability Function for Unsaturated Soils Using the Soil-Water Character Curve. *Canadian Geotechnical Journal*. 31(3): 533-546.

Fredlund, D. G. and Xing, A. (1994). Equations for the Soil-Water Characteristic

Curve. *Canadian Geotechical Journal*. 31: 521–532.

Fredlund, D.G., Xing, A., Fredlund, M.D. and Barbour, S.L. (1996). The Relationship Of The unsaturated Shear Strength To The Soil-Water Characteristic Curve. *Canadian Geotechnical Journal*, 33(3): 440-448.

Futai, M.M., Almeida, M.S.S. and Lacerda, W.A. (2004). Yield Strength, and Critical State Behavior of a Tropical Saturated Soil. *Geotechnique.* 130(11):1169-1179.

Gardner, W., Israelsen, O.W., Edlefsen, N.E. and Clyde, D. (1922). The Capillary Potential Function And Its Relation To Irrigation Practice. Physics Review, 20, 196.

Gan, J.K.-M., Fredlund, D.G., and Rahardjo, H. (1988). Determination Of The Shear Strength Parameters Of An Unsaturated Soil Using The Direct Shear Test. Canadian Geotechnical Journal, 25(8): 500-510.

Gan, J.K.-M. and Fredlund, D.G. (1996). Shear Strength Characteristics Of Two Saprolitic Soils. Canadian Geotechnical Journal, 33: 595-609.

Gasmo. J., Hritzuk, K.J., Rahardjo, H., Leong E.C. (1999). Instrumentation Of An Unsaturated Residual Soil Slope. *Geotechnical Testing Journal*, 22(2),128-137.

GCO (1984). *Geotechnical Manual for Slopes.* 2nd Edition. Geotechnical Control Office, Hong Kong.

GEO—SLOPE ver 6.17 Software, (2004). GEO-SLOPE/W International Ltd, Calgary Alberta, Canada.

Gitirana, G.Jr. and Fredlund, D.G. (2004). Soil-Water Characteristic Curve Equation with Independent Properties. *Journal of Geotechnical and Geoenvironmental Engineering, ASCE*. 130(2): 209-212.

GiD ver 7.2, (2005). The Personal Pre And Post Processor, Barcelona, Spain.

*Glendinning, S., Loveridge, F., Starr-Keddle, R.E., Bransby, M.F. and Hughes, P.N. (2009). Role Of Vegetation In Sustainability Of Infrastructure Slopes.* Geotech. Eng., Proc. Inst. Civil Eng. *162, 101-110.*

Glass, R.J., Steenhuis, T.S., and Parlange, J.Y. (1989). Wetting Front Instability, Experimental Determination of Relationships between System Parameters and

Two Dimensional Unstable Flow Field Behavior in Initially Dry Porous Media. *Water Resources Research*. 25: 1195-1207.

Green, W.H. and Ampt, G.A. (1911). Studies on Soil Physics I. The Flow of Air and Water through Soils. *Journal of Agricultural Research*. 4: 1-24.

*Greenway D.R. (1987).* Vegetation and slope stability. *In: Anderson MG, Richards KS (eds) Slope stability. Chichester, Wiley, 187–230.*

Greenwood, J. R. BSc, Norris, J. E. and Wint, J. (2004). Assessing The Contribution Of Vegetation To Slope Stability. *Geotechnical Engineering*, 157, 199–207.

Greenwood, J.R. (2006). SLIP4EX—A Program For Routine Slope Stability Analysis To Include The Effects Of Vegetation, Reinforcement And Hydrological Changes. *Geotechnical and Geological Engineering*, 24: 449–465.

*Gribb, M.M., Kodesova, R. and Ordway, S.E. (2004). Comparison of Soil Hydraulic Property Measurement Methods.* Journal of Geotechnical and Geoenvironmental Engineering*, ASCE. 130(10): 1084-1095.*

Gan, J.K.-M, Fredlund, D.G. and Rahardjo, H. (1988). Determination Of The Shear Strength Parameters Of An Unsaturated Soil Using The Direct Shear Test. *Canadian Geotechnical Journal*, 25(8): 500-510.

Gan, J.K.-M and Fredlund, D.G. (1996). Shear Strength Characteristics Of Two Saprolitic Soils. *Canadian Geotechnical Journal*, 33: 595-609.

Gasmo, J. M., Rahardjo, H. and Leong, E. C. (1999). Infiltration Effects on Stability of a Residual Soil Slope. *Computer and Geotechnique.* 26: 145–165.

Genet, M., Stokes, A., Fourcaud, T. and Norris, J.E. (2009). The Influence Of Plant Diversity On Slope Stability In A Moist Evergreen Deciduous Forest. *Journal Ecological Engineering*, 36 (2010), 265-275.

Gofar, N., Lee, M.L. and Kassim, A. (2008). Response Of Suction Distribution To Rainfall Infiltration In Soil Slope. *Electronic Journal of Geotechnical Engineering, EJGE*. 13E.

Gofar, N. and Lee, M.L. (2008). Extreme Rainfall Characteristics for Surface Slope Stability in the Malaysian Peninsular. *Georisk.* 2(2): 65-78.

Gong, D., Kang, S., Zhang, L., Du, T. and Yao, L. (2006). A Two-Dimensional Model Of Root Water Uptake For Single Apple Trees And Its Verification With Sap Flow And Soil Water Content Measurements. *Agricultural Water Management*, 83, 119 – 129.

Han, K.K., Rahardjo, H. and Broms, B.B. (1995). Effect of Hysteresis on the Shear-Strength of a Residual Soil, Unsaturated Soils. *Proceedings 1st International Conference on Unsaturated Soils (UNSAT 95).* Paris, France: 499-504.

Hemmati S. and Gatmiri B. (2008). Numerical Modelling Of Tree Root-Water-Uptake In A Multiphase Medium. *Proceedings Of The First European Conference On Unsaturated Soils,* 2008, Durham, United Kingdom. CRC Press, Taylor & Francis Group, London, Uk. 785-790.

Houston, W.N. and Houston, S.L. (1995). Infiltration Studies For Unsaturated Soils. Proc. *1st Int. Conf. On Unsaturated Soils*, Paris, 869-875.

Huat, B.K., Ali F. and Abdullah, A. (2005). Shear Strength Parameters Of Unsaturated Tropical Residual Soils Of Various Weathering Grades. *Electronic Journal Geotechnical Engineering*. 0564: 1-13.

Huat, B.K., Gue, S. S. and Ali, F. (2004). Tropical Residual Soils Engineering. *Proceedings Of The Symposium On Tropical Residual Soils Engineering (Trse2004)*, University Putra Malaysia, Malaysia. London, UK, Taylor & Francis Group plc.

Hunt, R.E., (2007). *Geologic Hazards, A Field Guide For Geotecnical Engineering*. London: Taylor & Francis Group. 308.

IAEG (1981). Rock and Soil Description for Engineering Geological Mapping. *International Association of Engineering Geology Bulletin*. 24: 235-274.

Indraratna, B., Fatahi, B. and Khabbaz, H., (2006). Numerical Analysism of Matric Suction Effects of Tree Roots. *Geotech. Eng., Proc. Inst. Civil Eng*. 159, 77-90.

Irfan, T. Y. (1988). Fabric Variability and Index Testing of a Granitic Saprolite. *Proceeding of 2nd International Conference on Geomechanics in Tropical Soils*, Dec. 12-14, Singapore, 1, 25-35.

Irfan, T.Y. and Wood, N.W. (1988). The Influence of Relict Discontinuities on Slope Stability in Saprolitic Soils. *Proceedings 2nd International Conference on Geomechanics in Tropical Soils*. 1: 267-276.

Irfan, T.Y. (1998). Structurally Controlled Landslides in Saprolitic Soils in Hong

Kong. *Geotechnical and Geological Engineering*. 16: 215-238.

Irfan, T.Y. (1999). Characterization of Weathered Volcanic Rocks in Hong Kong. *Quarterly Journal Engineering Geology*. 32: 317-348.

ISRM (1981). Basic Geotechnical Description for Rock Masses. *International Journal of Rock Mechanics, Mining Science and Geomechanics*. 18: 85-110.

Jackson, R.B., Sperry, J.S. and Dawson, T.E. (2000). Root Water Uptake And Transport: Using Physiological Process In Global Predictions. *Trends Plant Sci*. 5, 482-488.

Jaksa, M.B., Kaggwa, W.S., Woodburn, J.A. and Sinclair, R. (2002). Influence Of Large Gums Trees On The Soil Suction Profile In Expensive Clays. Aust. *Geomechanics*, Vol. 71, no. 1, pp. 23-33.

Jamaluddin, T.A., Sian L. C. and Komoo I. (2011). *Laporan terbuka penyiasatan geobencana tanah runtuh madrasah al-taqwa, felcra sungai semungkis, batu 14, hulu langat, Selangor*. Institut Kajian Bencana Asia Tenggara (SEADPRI) Universiti Kebangsaan Malaysia. 31.

*Jamaluddin, T.A. and Komoo, I. (2007). Structurally-Controlled Landslide In Weathered Rock Masses – Typical Examples From Malaysia.* Proc. 2nd Malaysia-Japan Symposium On Geohazards & Geoenvironmental Engineering. *20-22 Nov. 2007. Langkawi. P.137-148.*

Janbu, N., Bjerrum, L. and Kjaernsli, B. (1956). Soil Mechanics Applied To Some Engineering Problems. Norwegian Geotechnical Institute Publication, 16.

Jennings, J.E. and Burland, J.B. (1962). Limitations to the Use of Effective Stresses in Partly Saturated Soils. *Géotechnique*. 12(2): 125-144.

Joel, A., Messing, I., Seguel, O. and Casanova, M. (2002). Measurement of Surface Water Runoff from Plots of Two Different Sizes. *Hydrological Processes*. 16(7): 1467-1478.

Jury, W.A., Wang, Z. and Tuli, A. (2003). A Conceptual Model of Unstable Flow in Unsaturated Soil during Redistribution. *Vadose Zone Journal*. 2: 61-67.

Kadir, W.R., and Kadir, A.A. (1998). Field Grown Acacia Mangium : How Intensive Is Root Growth? *Journal Of Tropical Forest Science*. 10(3): 283-291.

Kasim, F., Fredlund, D.G. and Gan, J.K.M. (1998). The Effect Of Steady State Rainfall On Long Term Matric Suction Conditions. *Slope engineering in Hong Kong*. Balkema, 75-85.

Kassim, K.A. and Kok, K.C. (1999). Mix Design for Lime Modification and Stabilisation. *Proceedings of the 5th Geotechnical Conference (GEOTROPIKA 99)*. 22-24 November 1999, Universiti Teknologi Malaysia: 235-244.

Kassim, A. (2011). *Modelling The Effect Of Heterogeneities On Suction Distribution Behaviour In Tropical Residual Soil*. Doctor Philosophy. Universiti Teknologi Malaysia, Skudai.

*Kassim, A, Gofar, N, Lee, M.L. and Rahardjo, H. (2012). Modelling Of Suction Distributions In An Unsaturated Heterogeneous Residual Soil Slope.* Engineering Geology. *131-132 (2012), 70-82.*

Kim, J., Park, S. and Jeong, S. (2006). Effect of Wetting Front Suction Loss on Stability of Unsaturated Soil Slopes. *Unsaturated Soils, Seepage, and Environmental Geotechnics, ASCE*. 148: 70-77.

Kleidon, A. and Heimann, M. (1998). Optimized Rooting Depth And Its Impacts On The Simulated Climate Of An Atmospheric General Circulation Model. *Geophysical Research Letters*, 25(3), 345 – 348, 1998.

Koumanov, K.S., Hopmans, J.W., Schwankl, L.J., Andreu, L. and Tuli, A. (1997). Application Efficiency Of Micro-Sprinkler Irrigation Of Almond Trees. *Agricultural Water Management* , 34 (1997) 247-263.

Kozlowski, T.T. (1971). *Growth And Development Of Trees.* vol. 2. New York: Academic Press, 520.

Krahn, J. (2004). *Stability model with SLOPE/W*. Canada: GEO-SLOPE/W International Ltd.

Kramer, P. J. (1969). *Plant and Soil Water Relationships: A Modern Synthesis*. New York: McGraw-Hill Book Company.

Krisdani, H., Rahardjo, H. and Leong, E.C. (2005). Behaviour Of Capillary Barrier System Constructed Using Residual Soil. *Waste containment and remediation*, ASCE, 142, 1-15.

Lai, C. T. and Katul, G. (2000). The Dynamic Role Of Root Water Uptake In Coupling Potential To Actual Transpiration. Advances in Water Resources, 23, 427 – 439.

Lubczynski, M. W. (2009). The Hydrological Role Of Trees In Water-Limited Environments. *Hydrogeology Journal,* 17: 247-259.

Lambe, T.W. and Whitman, R.V. (1969). *Soil Mechanic*. Wiley, New York, 363-365.

Lee, M. L. (2008). *Influence of Rainfall Pattern on Suction Distribution and Slope Stability*. Doctor Philosophy. Universiti Teknologi Malaysia, Skudai.

Lee, M. L., Gofar, N. and Rahardjo, H. (2009). A Simple Model For Preliminary Evalution Of Rainfall-Induce Slope Instability. *Engineering Geology*, 108, 272-285.

Lee, M.L., Kassim, A. and Gofar, N. (2010). Performance of Two Instrumented Laboratory Models for the Study of Rainfall Infiltration into Unsaturated Soils. *Engineering Geology*. 117: 78-89.

Lee, S.G. and de Freitas, M.H. (1989). A Revision of the Description and Classification of Weathered Granite and Its Application to Granite in Korea. *Quarterly Journal of Engineering Geology*. 22: 31-48.

Leong, E.C. and Rahardjo, H. (1995). Typical Soil-Water Characteristic Curve For Two Residual Soil From Granite And Sedimentary Formations. *Proc. Unsaturated 1995*:519-524.

Leong, E.C. and Rahardjo, H. (1997). Permeability Functions for Unsaturated Soils. *Journal of Geotechnical and Geoenvironmental Engineering, ASCE*. 123(12):1118-1126.

Little, A.L. (1969). The Engineering Classification of Residual Tropical Soils. *Proceedings of the 7th International Conference on Soil Mechanics and Foundation Engineering*. Mexico. 1: 1-10.

Lim, T.T., Rahardjo, H., Chang, M.F. and Fredlund, D.G. (1996). Effect of Rainfall on Matric Suctions in a Residual Soil Slope. *Canadian Geotechnical Journal*. 33(4): 618 – 628.

Lumb, P. B. (1962). The Properties of Decomposed Granite. *Geotechnique*. 12: 226-243.

McLean, A.C. and Gribble, C.D. (1979). *Geology for Civil Engineers*. London: E & FN Spon.

Malone, A.W. and Shelton, J.C. (1982). Landslides in Hong Kong 1978-1980. *Engineering and Construction in Tropical Residual Soils; Proceedings of the 1981*, Special Conference, Hawaii. American Society of Civil Engineers, 425-441.

Marto, A. and Novrial (1999). The Effect of Lime-Soil Cylinders on Laterite Slope Model. *Proceedings Of the 5th Geotechnical Conference (GEOTROPIKA 99)*. 22-24 November 1999, Universiti Teknologi Malaysia: 223-234.

Marto, A., Kasim, F. and Yusof, M.F. (2002). Engineering Characteristics of Residual Granite Soils of Southern Peninsular Malaysia. *Proceedings of the Research Seminar on Materials and Construction*. 29-30 October 2002, Universiti Teknologi Malaysia: 315-325.

McCulloch, J. S. G. and Robinson, M. (1993). History of forest hydrology. *Journal of Hydrology*, 150, 189–216, 1993.

Mitchell, J.K. (1993). *Fundamentals of Soil Behavior*. 2nd Edition. New York: John Wiley & Sons.

Megahan W.F. (1983). Hydrologic Effects Of Clearcutting And Wildlife On Steep Granitic Slopes In Idaho. *Water Resour Res, 19:811–819.*

Mein, R.G. and Larson, C.L. (1973). Modelling Infiltration During A Steady Rain. *Water Resources Research*, 9(2), 384-394.

Meteorology Department Malaysia (2012). Monsoon Report of Peninsular Malaysia. Kuala Lumpur, Meteorology Department Malaysia.

Mcinnes, D.B., (1986). Drying Effect Of Different Verge Planted Tree Species On Urban Roads. *In: 13 ARRB and 5th REAAA Conference*, 54-66.

Mu'azu, M. A., Ali, N. and Ahmed, K. (2010). Bioengineering Assessment On Sloppy Ground. *American Journal Of Environmental Sciences,* 6 (4): 357-364.

Mohamad, A. (2008). *Pokok-Pokok Untuk Tanaman Bandar*. Kuala Lumpur: Jabatan Landskap Negara.

Md. Noor M. J., Huat, B.K. and Ali, F. (2012). *Shear Strength Model For Tropical Residual Soil*. Handbook Of Tropical Residual Soils Engineering. Taylor & Francis Group, London, Uk, 186-212.

Md. Noor, M. J. (2012). *Understanding Rainfall-Induce Landslide*. Kuala Lumpur: Uitm Press. 198.

Morgenstern, N. R. and Price, V. E. (1965). The Analysis Of The Stability of General Slip Surfaces. *Geotechnique*, 15, 79 – 93.

Moye, O.G. (1955). Engineering Geology for Snowy Mountains Scheme. *Journal of Institution Engineers*. Australia. 27: 281-299.

Narasimhan, T.N. (1998). Hydraulic Characterization Of Aquifers, Reservoir Rocks, And Soils: A History Of Ideas. *Water Resources Research*, 34(1), 33-46.

Navarro, V., Candel, M., Yustres, A., Sanchez, J. and Alonso, J. (2009). Trees, Soil Movement And Foundation. *Computer and Geotechnics*, 36, 810-818.

Nisbet, T. (2005). Forestry:Water Use by Trees. *Conference of European Water Framework Directive 2000*. Planeta Verde Reforestacion S.A ,UK,USA. 1-3.

Ng, C.W.W. and Shi, Q. (1998). A Numerical Investigation Of The Stability Of Unsaturated Soil Slopes Subject To Transient Seepage. *Computers and Geotechnics,* Vol. 22, No.1, 1-28.

Normaniza O., Faisal, H.A. and Barakbah, S.S. (2007). Engineering properties of leucaena leucocephala for preventing of slope failure. *Journal Ecological Engineering*, 32 (2008): 215-221.

Ojha, C. S. P. and Rai, A. K. (1996). Nonlinear Root-Water Uptake Model. *Journal of Irrigation and Drainage Engineering*, 122(4), 198 – 202.

Philip, J. R. (1957). The Theory Of Infiltration: 1. The Infiltration Equation And Its Solution. *Soil Sci.*, 83, 345 – 357.

Poh, K.B., Chuah, H.L. and Tan, S.B. (1985). Residual Granite Soil Of Singapore. *Proc. 8th SEA geotechnical conference*, Kuala Lumpur,1-9.

Pollen-Bankhead, N., and Simon, A. (2010). Hydrologic And Hydraulic Effects Of Riparian Root Networks On Streambank Stability: Is Mechanical Root-Reinforcement The Whole Story? *Geomorpology*, 116(3-4), 353-362.

*Pollen-Bankhead N. and Simon, A. (2005). Estimating The Mechanical Effects Of Riparian Vegetation On Stream Bank Stability Using A Fiber Bundle Model.* Water Resources Research*, 41, No. 7, W07025.*

Prasad, R., (1988). A Linear Root Water Uptake Model. *J. Hydrology*, 99, 297 – 306.

Pradel, D. and Raad, G. (1993). Effect of Permeability on Surficial Stability of Homogeneous Slopes. *Journal of Geotechnical Engineering, ASCE*. 119(2): 315-332.

Protopapas, A.L. and Bras, R.L. (1992). Effects Of Weather Variability And Soil Parameter Uncertainty On The Soil-Crop-Climate System. *Am. Meteorol. Soc.*, 6, 645 – 656.

Public Works Institute Malaysia (1996). *Tropical Weathered In-Situ Materials*. Geoguides: 1-5.

Raats, P.A.C. (1974). Steady Flow Of Water And Salt In Uniform Soil Profiles With Plant Roots. *Soil Sci. Am. Proc*., 38, 717-722.

Rahardjo, H., Leong, E.C., Deutscher, M.S., Gasmo, J.M. and Tan, S.K. (2000). *Rainfall-Induced Slope Failures*. NTU-PWD Geotechnical Research Centre, Nanyang Technological University, Singapore.

Rahardjo, H., Lim, T.T., Chang, M.F. and Fredlund, D.G. (1995). Shear Strength Characteristics Of A Residual Soil. *Can. Geotech. J.*, 32,60-77.

*Rahardjo, H., Li X. W., Toll D. G. and Leong E. C. (2001). The Effect of Antecedent Rainfall on Slope Stability.* Journal of Geotechnical and Geological Engineering. *Netherlands: 19: 371-399.*

Rahardjo, H., Aung, K.K., Leong, E.C. and Rezaur, R.B. (2004). Characteristics of Residual Soils in Singapore as Formed by Weathering. *Engineering Geology*. 73: 157-169.

Rahman, S. (2011). *Development Plan Of Universiti Teknologi Malaysia*. Development Property Office.

Rasiah, V. and Kohl, R. A. (1989). Soybean Root Water Uptake in Two Soils. *Agricultural Water Management*, 15, 387-393.

Ravina, I. (1983). The Influence Of Vegetation On The Swelling And Shrinkage Of Clay. *Geotechnique*, 4th Symposium 33, 151 – 157.

Rees, S.W. and Ali, N. (2012). Tree Induced Soil Suction And Slope Stability. *Geomechanics and Geoengineering: An International Journal*. Taylor & Francis Group, London, Uk. Vol. 7, No. 2, 103-113.

Renaud, J. P., Anderson, M. G., Wilkinson, P. L., Lloyd, D. M. and Wood, D. M. (2003). The Importance Of Visualisation Of Results From Slope Stability. *Geotechnical Engineering*, 156 (1), 27–33.

Richards, L. A., (1931). Capillary Conduction Of Liquids In Porous Media. *Physics, 1*, 318 – 333.

Richard, B.G., Peter, P. and Emerson, W.W. (1983). The Effects Of Vegetation On The Swelling And Shinking Of Soils In Austarlia. *Geotechnique*, 33(2), 127-139.

Ridley, A., Ginnity, M. and Vaughan, P. (2004). Role Of Pore Water Pressures In Embankment Stability. *Geotechnical engineering*, 157, 193-198.

Roering, J.J., Schmidt, K.M., Stock, J.D., Dietrich, W.E. and Montgomery, D.R, (2003). Shallow Landsliding, Root Reinforcement, And The Spatial Distribution Of Trees In The Oregon Coast Range. *Can Geotech J* 40:237–253.

Russell, D., Ellis, E., O'Brien, A. S. and McGinnity, B. (2000). Role Of Vegetation On The Stability And Serviceability Of Railways Embankments. *1st Int. Conf. on Railway Engineering*, London, UK.

Ruxton, B.P. and Berry, L. (1957). Weathering of Granite and Associated Erosional Features in Hong Kong. *Bulletin of Geological Society American* ,68:1263-1292.

Sidle, R.C. and Ochiai, H. (2006). Landslides: processes, prediction, and land use. Am Geophysical Union, *Water Resour Monogr,* No. 18. AGU, Washington, DC, 312.

*Simon, A. and Collison, A.J. (2002). Quantifying The Mechanical And Hydrologic Effects Of Riparian Vegetation On Stream-Bank Stability. Earth* Surface Processes and Landforms*, 27: 527–546.*

Singh, M. (1992). Engineering Geological Assessment Stability Design and Treatment of Core Stones in Residual Cut Slopes in the North-South Expressway. *International Conference of Geotechnical Engineering*. Johor Bahru, Malaysia: 383-391.

Singh, H. and Huat, B.K. (2004). Origin, Formation and Occurrence of Tropical Residual Soils. *Tropical Residual Soils Engineering*: 1-19. London: Taylor and Francis Group.

Schmidt, K.M., Roering, J.J., Stock, J.D., Dietrich, W.E., Montgomery, D.R. and Schaub, T. (2001). Root Cohesion Variability And Shallow Landslide Susceptibility In The Oregon Coast. *Range Can Geotech J*, 38:995–1024.

Schmidhalter, U., Selim, H. M. and Oertli, J. J. (1994). Measuring And Modeling Root Water Uptake Based On Chloride Discrimination In A Silt Loam Soil Affected By Groundwater. *Soil Sci.*, 158, 97–105.

Schwarz, M., Preti, F., Giadrossich, F., Lehamann, P. and Or, D., (2010). Quantifying The Role Of Vegetation In Slope Stability: A Case Study In Tuscany (Italy). *Jounal Ecological Engineering*, 36, 285-291.

Sidle, R.C. and Ochiai, H., (2006). Landslides: Processes, Prediction And Land Use. *Am Geophysical Union, Water Resour. Monogr.* No. 18. AGU, Washington, DC, 312.

Sidle, R.C., Pearce, A.J. and O'Loughlin, C.L., (1985). Hillslope Stability And Land Use. Am *Geophysical Union, Water Resour. Monogr*., 11. Washington, DC, 140.

Simms, P.H. and Yanful, T.K. (2004). Estimation of Soil-Water Characteristic Curve of Clayey Till Using Measured Pore-Size Distributions. *Journal of Environmental Engineering*, ASCE. 130(8): 847-854.

Simon, A., Curini, A., Darby, S.E. and Langendoen, E.J. (2000). Bank And Near-Bank Processes In An Incised Channel. *Geomorphology*, 35: 193–217.

Soil Vision Systems Ltd. (2007). *SVFLUX 2D /3D Seepage Modelling Software Tutorial Manual*. Saskatoon, Saskatchewan, Canada.

Soilmoisture Equipment Corporation (2005a). *Jet-Fill Tensiometers Model 2725*. Operating Instructions. Soilmoisture Equipment Corporation, Santa Barbara, California.

Soilmoisture Equipment Corporation (2005b). *Soil Moisture Probe Model 2100F Operating Instructions*. Soilmoisture Equipment Corporation, Santa Barbara, California.

Sowers, G.F. (1985). *Residual Soils in the United States*. Technical Committee on Sampling and Testing of Residual Soils, International Society for Soil Mechanics and Foundation Engineering.

Spencer, E. (1967). A Method of Analysis of the Stability of Embankments Assuming Parallel Interslice Forces. *Geotechnique*, 17, 11 – 26.

Stokes, A., Atger, C., Bengough, A.G., Fourcaud, T. and Sidle R.C. (2009). *Desirable plant root traits for protecting natural and engineered slopes agaist* *landslides*. Plant Soil, in press.

Sun, H.L., Li, S.C., Xiong, W.L., Yang, Z.R., Cui, B.S. and Yange, T. (2008). Influence Of Slope On Root System Anchorage Of Pinus Yunnanesis. *Ecological Engineering*, 32, 60-67.

Tan, B.K. (2004). Country Case Study: Engineering Geology of Tropical Residual Soils in Malaysia. *Tropical Residual Soils Engineering:* 237-244. London: Taylor and Francis Group.

Toll, D.G., Ong, B.H. and Rahardjo, H. (2000). Triaxial Testing Of Unsaturated Samples Oof Undisturbed Residual Soil From Singapore. *Proceedings Of The Unsaturated Soils For Asia, Singapore:* 581-586.

Technical Committee of Investigation (1994). *The Collapse of Block 1 and the Stability of Blocks 2 and 3 Highland Towers Condominium.* Report of the Technical Committee, Hulu Klang, Malaysia.

Terzaghi, K. (1936). The Shear Resistance of Saturated Soils. *Proceedings 1st International Conference of Soil Mech. Found. Eng. Cambridge*. 1: 54-56.

Thomas, H. R. and Rees, S.W. (1991). A Comparison Of Field Monitored And Numerically Predicted Moisture Movement In Unsaturated Soil. *International Journal For Numerical And Analysis Meth. In Geomechanics,* 15, Issue 6, 417-431.

Thorne, C.R. (1990). *Effects of vegetation on riverbank erosion and stability. In Vegetation and Erosion: Processes and Environments*, John Wiley and Sons, 125–144.

Tsaparas, I., Rahardjo, H., Toll, D.G. and Leong, E.C. (2002). Controlling Parameters For Rainfall-Induced Landslides. *Computers and Geotechnics*, Vol. 29, 1-27.

Van Beek L.P.H., Wint J., Cammeraat L.H. and Edwards J.P. (2005). Observation And Simulation Of Root Reinforcement On Abandoned Mediterranean Slopes. *Plant Soil*, 278: 55–74.

Vanapalli, S.K., Fredlund, D.G., Pufahl, D.E. and Clifton, A.W. (1996). Model For The Prediction Of Shear Strength With Respect To Suction. *Canadian Geotechnical Journal*, 33(3): 379-392.

Vanapalli, S. K., and Fredlund, D. G. (1997). Interpretation of Unsaturated Shear strength of Unsaturated Soils in terms of Stress State Variables. *Proceedings of the 3rd Brazilian Symposium on Unsaturated Soils, Tacio de Campos,Vargas*, 35-45.

Vrugt, J. A., Hopman, J. W. and Simunek, J. (2001). One, Two And Three-Dimensional Root Water-Uptake Function For Transient Modelling. *Water Resources Res.* 37(10), 2467-2470.

Van Genuchten, M.T. (1980). A Closed-Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils. *Soil Science Society of America Journal.* 44: 892–898.

Wallach, R. (1990). Soil Water Distribution In A Nonuniformly Irrigated Field With Root Extraction. *J. Hydrol.,* 119, 137–150.

Wang, Z., Tuli, A. and Jury, W.A. (2003). Unstable Flow during Redistribution in Homogeneous Soil. *Vadose Zone Journal*. 2: 52-60.

Wu, T.H., (1995). *Slope stabilization. Slope Stabilization and Erosion Control: A Bioengineering Approach*. E & FN Spon, 2-6 Boundary Row, London. 221-264.

Wu, J., Zhang, R. and Gui, S. (1999). Modeling Soil Water Movement With Water Uptake By Roots. *Plant and Soil*, 215, 7–17.

Woon K.X., Leung A.K., Ng C.W.W., Chu L.M. and Hau B.C.H. (2011). An Experimental Investigation On Suction Influence Zone Induce By Plant Transpiration. *Unsaturated Soils: Theory and Practice. Proceeding of the 5 Asia-Pacific Conference on Unsaturated Soils, Dusit Thani Pattaya, Thailand*. Vol II, 861-866.

WUCOLS. (2000). *A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California*. Water Use Classifications of Landscape Species, University of California, 150.

Youngs, E.G. (1958). Redistribution of Moisture in Porous Materials after Infiltration. *Soil Science*. 86: 117-125.

Yang, H., Rahardjo, H. and Leong, E.C. (2006). Behaviour Of Unsaturated Layered Soil Columns During Infiltration. *Journal of Hidrologic Engineering*, 329-337.

Yong, R. N., and Warkentin, B. P. (1974). *Soil Properties And Behaviour*. Elsevier Publishing Company, Amsterdam.

Zeng, X., Dai, Y.J., Dickinson, R.E. and Shaikh, M. (1998). The Role Of Root Distribution For Climate Simulation Over Land. *Geophysical Research Letters*, 25(24), 4533 – 4536.

Zhan, T.L.T. and Ng, C.W.W. (2004). Analytical Analysis of Rainfall Infiltration

Mechanism in Unsaturated Soils. *International Journal of Geomechanics, ASCE.* 4(4): 273-284.

Zhang, Z., Tao, M. and Morvant, M. (2005). Cohesive Slope Surface Failure and Evaluation. *Journal of Geotechnical and Geoenvironmental Engineering,* ASCE. 131(7): 898-906.

Zhou. J. And Yu. J. (2005). Influences Affecting the Soil Water Characteristic Curve, *Journal of Zhejiang University Science*, 797-804.

*Zhuang, J., Nakayama, K., Yu, G. R. and Urushisaki, T. (2001). Estimation Of Root Water Uptake Of Maize An Ecophysiological Perspective.* Field Crops Research*, 69, 201 – 213.*

*Zienkiewicz, O. C., and Taylor, R. L. (1989). The Finite Element Method, London UK: McGraw-Hill Book Company.*