

SIMULATION OF LINEAR AND NON-LINEAR SOIL WATER DEFICIT DUE
TO TREE WATER UPTAKE

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SIMULATION OF LINEAR AND NON-LINEAR SOIL WATER DEFICIT DUE
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To my beloved father and mother

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ABSTRACT

The simulation of water uptake model is extremely important to anticipate the moisture content changes in the soil. It is very helpful to the development of geotechnical foundation and geo-environmental problem. There are some water uptake models have been developed by other researchers. However it is lack of software programme to plot and analyse the model. Hence, this project focuses into the development of coding for linear and non-linear water uptake model. Prasad linear model and Li et al. exponential model was simulated by using Visual Basic 6.0. The result was verified and showed a good match with the model. The exponential model also compared with CERES model. The sensitivity of linear and exponential model was investigated and also the comparison between both simulated models. The results show that the total water extraction of linear model does not affected by rooting depth but very sensitive to potential transpiration. For exponential model, the increment of total water extraction is constant with the same increment of potential transpiration. Total water extraction of linear model is lower compare to exponential model. Besides, the extinction coefficient, b shows the least effect to the total water extraction. This value of 0.15/cm and higher shows that the rate of extraction is almost zero when deeper than or equal to 60% of rooting depth.

ABSTRAK

Simulasi pada model pengambilan air adalah sangat penting untuk menjangkakan perubahan kelembapan di dalam tanah. Ia sangat membantu kepada pembangunan masalah asas geoteknikal dan alam sekitar. Terdapat beberapa jenis model pengambilan air telah dibangunkan oleh penyelidik-penyelidik. Masalah pada masa ini adalah kekurangan program perisian untuk merancang dan menganalisis model tersebut. Oleh itu, projek ini memberikan tumpuan dalam membangunkan kod untuk model pengambilan air linear dan bukan linear. Model linear daripada Prasad dan model eksponen daripada Li et al. telah disimulasi dengan menggunakan kod program Visual Basic 6.0. Hasil ini telah disah dan menunjukkan satu persamaan yang baik dengan model. Model eksponen juga dibandingkan dengan model CERES. Kepekaan model linear dan eksponen telah dikaji dan perbandingan juga dibuat antara kedua-dua model tersebut. Keputusan menunjukkan bahawa jumlah pengambilan air daripada model linear tidak dipengaruhi oleh kedalaman akar tetapi sangat sensitif kepada potensi transpirasi. Untuk model eksponen pula, kenaikan jumlah pengambilan air adalah tetap dengan kenaikan potensi transpirasi yang sama. Jumlah pengambilan air model linear adalah lebih rendah berbanding dengan model eksponen. Selain itu, 'extinction coefficient', b menunjukkan kesan yang paling rendah kepada jumlah pengekstrakan air. Nilai ini pada 0.15/cm dan lebih tinggi menunjukkan bahawa kadar perahan adalah hampir sifar apabila kedalaman akar sama atau lebih daripada 60% kedalamannya.

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LIST OF SYMBOLS

$\alpha(h)$	-	Dimensionless function of pressure head
b	-	Extinction coefficient
j	-	j^{th} day
n	-	Number of layers
r	-	r^{th} day
S_{max}	-	Rate of extraction
z	-	Depth
z_r	-	Rooting depth
A	-	Area
D	-	Depletion
$K_{Z_1-Z_2}$	-	Fraction of total root length between depth $Z_1 - Z_2$
PT	-	Rate of potential transpiration
RD	-	Root length density

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays the development of construction is always improves and will stop down at every corner in the world. More and more high-rise buildings were built, mega projects were developed and housing areas were constructed. The geotechnical and foundation problems have become very critical and also the environmental sustainability as the pollution became a more serious problem where construction works in progress. Failure of geotechnical or foundation would affect the surrounding structure and create a lot of problems. The failure of geotechnical engineering that could happen at slope, embankment, dam and also foundation (Das, 2009). The lesson should be learned on the previous case of any failure by analyse the cause of the incident to improve the design and construction method or need some monitoring and maintenance

The soil nailed slope was failed and studied in Malaysia by Liew and Liong (2006). The results showed that the cause of the failure was due to inadequate factor of safety against overall failure. The nail tendons, nail pull-out, and facing failure were gave no sign to the failure. According to the failure case study in civil engineering (Bosela et al., 2013), the failure of Carsington embankment gave the attention to the role of construction equipment and procedures in the subsequent stability of a structure. In addition, the failure of Vajont Dam (1963) gave the lesson important of analysis and monitoring on slope movements. The difficulty of predicting when a slide mass will accelerate or fail became evident and the difficulty

of estimating changes in states of stress and strength during sliding was reinforced (Bosela et al., 2013).

Other than that, trees have the power that can damage the building services direct or indirectly. Direct damage from tree can be avoided by refer to the safe distances guidance given in BS5837: 2005. Indirectly, trees can cause the clay soils to shrink by drawing the water along their roots. Shrinkage will result in vertical and horizontal ground movements and the amount of shrinkage depends on the type of clay soil, size of tree and also climate. In a typical year expansive soils cause a greater financial loss to property owners than earthquakes, floods, hurricanes and tornadoes combined (Nelson and Miller, 1992).

According to Jones and Jefferson (2012), shrinkage and swelling of clay soil due to trees can cause the foundation movements that could damage the buildings. This is a serious problem that needs to be taken into consideration as a good civil engineer. The prediction of heave shrinkage should be made through the changes in soil moisture content. The soil suction is a limiting parameter for free water uptake and also nutrient uptake. The relationship of plant root system and soil water play an important role in agricultural science and geotechnical engineering. So, the variation in soil suction that occurs in presence or absence of plant is very important for an analysis. Therefore, a study on changes of moisture content in soil is required to analyse some geotechnical and geo-environmental problem.

1.2 Problem Statement

The relationship of plant root system and soil water could be obtained by modelling the water uptake of tree. The water uptake model and experimental work had been developed for a period of time with different approaches and factors by some researchers (Marto and Rao, 1999; Kumar et al., 2013; Dardanelli et al., 2004; Lv et al., 2013). The equation of the water uptake model had been established and validated with the site measurement by some specific plant and type of soil. From the

result, the water content was investigated and come out with the graph as water deficit curve to present the moisture condition at the site. However, there is lack of software programme to direct plot out and analyse the analytical or numerical model and non-linear problem. The estimated moisture content can be obtained easily and faster with the help of software. So, this is easier for any researcher to calculate the water deficit. In short, the development of the coding programme on the water deficit curve is very important to geo-environment development.

1.3 Objectives

The objectives of this study are as follows:

- a) To review the soil water deficit curve under 1-D tree water uptake.
- b) To develop the computer programming on soil water deficit estimation for linear and non-linear 1-D water uptake.
- c) To verify the simulation and analyse the water deficit curve.

1.4 Scope of Study

This study focused on the soil water relationship and the existing tree water uptake model. The parameters to be investigated are soil water deficit curve and method of coding the programme (visual basic 6.0). Due to the time constrain, the soil water relationship is fixed to two type of 1-D function (linear and exponential only). Besides, experimental work is not carry out in this study. Therefore, the developed coding programme is verified but not validated with site measurement.

1.5 Research Significant

The study analyse the soil water deficit curve under 1D-linear water uptake base on existing model and the developed coding programme was presented in this report. It is faster and easier to calculate the water deficit curve and the results of water deficit can be used for other analysis and as simulation of tree water uptake or suction in the soil.

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