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HYDRAULIC CONDUCTIVITY OF TROPICAL PEAT SOIL

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fk

BORANG PENYERAHAN TESIS

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HYDRAULIC CONDUCTIVITY OF TROPICAL PEAT SOIL

SHAHRUL BIN SHAFIEE

This project is submitted in partial fulfillment of
the requirements for the degree of Bachelor of Engineering with Honours
(Civil Engineering)

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APPROVAL SHEET

This project report attached here to, entitled "HYDRAULIC CONDUCTIVITY OF TROPICAL PEAT SOIL" prepared and submitted by Shahrul Bin Shafiee in partial fulfillment of the requirements for the degree of Bachelor of Engineering (Civil) is hereby accepted.

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Date

To;

My beloved Mom Siah Bt. Hj. Hasan, Dad Shafiee B. Hj. Mohd. Shariff and all my family members

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ABSTRACT

Malaysia is moving towards a developed country status by the year 2020. As the rapid structural and infrastructure developments, projects are located on almost everywhere including construction over peaty soil, which is known as a problematic soil, especially in engineering field for development sector. Therefore, it is important to understand the physical and geotechnical properties of peat soils. Sarawak has approximately 1.6 million ha (13%) peat land of the total land area of 2.7 million ha. The present study investigates the physical and geotechnical properties, mainly hydraulic conductivity of four (4) peat soil samples collected from different location of Sarawak (i.e., Matang and Asajaya). The results showed that the permeability or hydraulic conductivity values of peat soil is generally high as the organic content increases. The permeability values for Asajaya samples (i.e., A1 and A2) show higher as compared to the Matang (i.e., M1 and M2) samples, compacted at their maximum dry densities and optimum moisture content's. Samples from Asajaya recorded higher permeability value (i.e., 4.0167×10^{-6} cm/min and 1.3541×10^{-6} cm/min, with 98% and 93% organic content, for samples A1 and A2, respectively) compared to the permeability value for Matang sample (i.e., 2.5737×10^{-6} cm/min and 5.0247×10^{-8} cm/min, with 51% and 48% organic content, for samples M1 and M2, respectively).

ABSTRAK

Malaysia kini sedang menuju kearah mencapai status negara maju menjelang tahun 2020. Kerancakan pembangunan struktur dan infrastruktur menyebabkan banyak projek-projek pembangunan dijalankan hampir ke seluruh tempat termasuk pembangunan di kawasan tanah gambut yang merupakan tanah bermasalah dan sukar dibangunkan terutamanya dalam sektor kejuruteraan pembangunan. Oleh hal yang demikian, adalah penting untuk mengetahui ciri-ciri dan sifat-sifat fizikal dan geoteknik tanah gambut.

Sarawak mempunyai kira-kira 1.6 juta hektar atau 13% daripada tanah gambut keseluruhan negara iaitu 2.7 juta hektar.

Kajian yang dijalankan adalah untuk menyelidik dan mengenalpasti sifat-sifat fizikal dan geoteknik terutamanya kadar ketelapan air keempat-empat sampel tanah gambut yang diperolehi (diambil) dari kawasan Matang dan Asajaya dengan lokasi yang berbeza-beza kedudukan.

Keputusan yang diperolehi daripada kajian yang telah dijalankan menunjukkan kadar ketelapan air tanah gambut adalah tinggi dengan peningkatan kandungan organik.

Ini dibuktikan dengan kajian yang telah dijalankan ke atas kedua-dua sampel dengan ketumpatan tertinggi dan kandungan kelembapan yang optimum, dimana didapati sampel dari Asajaya mencatatkan kadar ketelapan air tertinggi (A1 dengan 4.0167×10^{-6} cm/min dan A2 sebanyak 1.3541×10^{-6} cm/min dengan kandungan organik masing-masing sebanyak 98% dan 93%) berbanding dengan kadar ketelapan air sampel dari

Matang (M1 dengan 2.5737 x 10^{-6} cm/min dan M2 sebanyak 5.0247 x 10^{-8} cm/min dengan kandungan organik masing-masing sebanyak 51% dan 48%).

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CHAPTER 1

INTRODUCTION

1.1 General

Malaysia is one of the countries possessing large land areas of peat. Peat soil in Malaysia is known as tropical peat soil which covers about 8.2 % of the total land area which equivalent about 2.7 million hectares of peat land (Mutalib et al., 1991). Andriesse (1988) refers peat is an accumulation of a purely 100 percent organic material. Sarawak has the largest extent of peat swamp at approximately 1.6 million ha or 13 percent of the state land and approximately 1.5 million ha or 89 percent of Sarawak’s peat soils are classified as ‘deep’ peat that is greater than 1.5 m ombrogeneous peat (Jabatan Pertanian Sarawak, 2001).

Most engineers use the Unified Soil Classification System (USCS) to classify soil. In the USCS peat are described as soils consisting 'predominantly' of plant remains, fiber, and woody remnants; dark-brown to black color and often with a distinctive smell. Most common definitions of peat are based on ash (or organic) content.

Peat is used in horticulture and agriculture including general soil improvement, potting soils, earthworm culture, nursery, business, golf course maintenance and construction. The vastness of the peat land coverage and its occurrence close to or within population centers and existing cultivated areas cause some difficulties in infrastructure development that has to be carried out in these areas. These would include road crossing and in some instances, housing development that encroached into the peat land areas as available land become more and more scarce.

Engineers recognize peat land or peat soil as a very problematic soil that would be avoided as far as possible. Peat soil having low bearing capacity and high compressibility and the extremely compressible nature of peat can lead to very large settlements under even moderate loads, it is considered to be among the worst foundation materials. Peat subjected to instability such as localized sinking and slip failure and massive primary and long term secondary and even tertiary settlements when subjected to even moderate load increases. In addition, there is discomfort and difficulty of access to the sites, a tremendous variability in material properties and difficulty in sampling.

Mutalib et al. (1991) reported that the tropical peat soil has chemically and structurally different from the fibrous peat soil of Europe and Canada. In their natural state, tropical peat soil have generally been recognized as a problematic soil with marginal agriculture capability unless with proper conditioning (Jamaluddin, 2002).

An important characteristic of peat is their chemical and biological changes with time. Further decomposition of the organic constituents would alter the mechanical properties such as hydraulic conductivity. Degree of decomposition, porosity and bulk density influences hydraulic conductivity and they provide a good basis for its assessment (Murtedza, 2002). Fibric materials in tropical peat commonly exhibit high hydraulic conductivity, which gradually diminishes as the peat decomposes. Decreasing pore space and higher water retention in developing sarpic materials affect the hydraulic conductivity considerably.

The permeability or better known as hydraulic conductivity is a soil property, which expresses or describes how water flows through soils. Water is very strongly affects the engineering behaviour of most soils and it is an important factor in most geotechnical engineering problems. Most geotechnical engineering problems somehow have water associated with them in various ways, either because of the water flowing through the voids and pores in the soil mass or because of the state of stress or pressure in the water in the pores. Problems of settlement of structures and the stability of foundations and slopes also involve water to some extent. As an indication of the practical importance of water in soils, it has been estimated that more people have lost their lives as a result of failures of dams and levees due to permeability then to all the other failures of civil engineering works combined. Therefore, knowledge of permeability is required for the design of engineering works (Holtz and Kovacs, 1981).

According to Leonards (1962), void ratio or porosity of a soil affects how water flows through it and thus the value of permeability of a particular soil. The effective grain size (effective pore size) has an important influence, much as it does on the height of capillary rise. The shapes of the voids and flow paths through the soil pores, called tortuosity also affects the k value. For saturated peat soils, the degree of saturation, S, must influence the actual permeability and lastly, the properties of the fluid have some effect; viscosity, which depends on, the temperature and the density immediately come to mind.

Although there were so many studies on the tropical peat soils, most of the information given are generally about the compressibility characteristics rather than study on the permeability itself (Pandian et al., 1995). Moreover, very few studies are available on the hydraulic conductivity of tropical peat soil in Malaysia, especially in Sarawak. Thus, more studies of hydraulic behaviour of organic or peat soils in Sarawak should be carried out.

1.2 Objectives of the present study

The main objective of this project is to study and determine the hydraulic conductivity of tropical peat soil by performing permeability tests. For conducting the studies, four different peat soil samples have been collected from two (2) different locations of Sarawak (e.g., Matang and Asajaya). Studies on hydraulic conductivity will be performed for each of the peat soil samples.

The objectives of this project are:

a) To characterize the peat soil samples collected from different locations in Sarawak.

b) To determine the hydraulic conductivity (k) values of peat soil samples by various methods (i.e., falling head method and constant head method).

c) To compare the hydraulic conductivity (k) values from two different sites and also for four different samples.

d) To establish a relationship between hydraulic conductivity with different peat soil physical properties.

1.3 Scope of work

The main scope of this project is to find the permeability or hydraulic conductivity (k) values of tropical peat soils from Sarawak, Malaysia. Properties that will be studied are as follows:

Moisture or water content; Degree of decomposition; Organic content, Loss on Ignition (LOI); Particle size distribution, Fiber content; Bulk density; Liquid Limit (LL); Compaction by standard Proctor apparatus and Permeability test.

1.4 Organization of the Thesis

Chapter 1: Introduction

Briefly explained some background of the project, about the peat soils and hydraulic conductivity, the importance of this study; objectives and scope of work.

Chapter 2: Literature Review

A review of existing literature on the hydraulic conductivities of peat soils.

Chapter 3: Methodology

Some guidelines and explanation about the methods, materials and procedures, which have been used in this study.

Chapter 4: Results and Discussion

Discussed and analyzed all results of the experimental investigation conducted at the lab.

Chapter 5: Conclusion and Recommendations

CHAPTER 2

LITERATURE REVIEW

2.1 General

A review of existing literature on the hydraulic conductivity values for different peat soil samples by different methods has been discussed in this chapter.

Baird (1997) studied the water and solute movement in unsaturated Fen peats. They used tension infiltrometer to measure the hydraulic conductivity (k) value and it was observed that macropores are important in water and solute movement in Fen peats. They also found that:

a) The k in this peat was less than reported for other peats and mineral soil and

b) The k data were better described by a log-normal distribution

Holden and Burt (2003) have studied the variability of hydraulic conductivity in upland blanket peat in wetland hydrological and landform development models. They have made some assumptions. The head recovery tests are not suitable for non-rigid soils such as peat to measure the k value because the tests are usually confined to rigid soil theory. The values of hydraulic conductivity using compressible techniques that have been presented for fenland peats never had been compared with other peat types. Thus, the test head recovery tests were performed on piezometers and comparison was made between these two techniques; rigid and compressible soil theories from the results obtained. It was observed that the compressible soil theory gives values five times higher than rigid soil calculations. On the other hand, hydraulic conductivity was found to vary significantly between sampling sites.

Beckwith et al., (2003) had investigated the effect of anisotropy and heterogeneity on groundwater flow in bog peat using a steady-state groundwater model. Three main conclusions were made from the results obtained:

a) Heterogeneity and not anisotropy has greater influence on producing complex patterns of groundwater flow.
b) Rates of groundwater flow are reduced when measured k values are aggregated to create a more uniform distribution of k.
c) Presence of a drainage ditch can increase seepage through a modeled cross section when measured k values are used.

Surridge et al., (2005) have studied the comparison between slug test data with laboratory determinations of vertical and horizontal k obtained using a new method. They stated that the results suggest from insertion tests gave similar results to those initiated by withdrawal. Values for k estimated using the slug tests were in the range 1×10^{-4} to 1.6×10^{-3} cms^{-1} (generally within range reported for peats). Laboratory tests yielded similar values of k as the slug tests. Thus, showing that the peat was anisotropic and hence the k value from slug tests proved good estimates of both vertical and horizontal k.

Kennedy et al. (2001) have studied the impact of density on the hydraulics of peat filters. They presents the results of a field study to evaluate the hydraulics of a peat filter used to treat the septic tank effluent from a public school west of Ottawa, Ontario, Canada. Samples of peat were collected and functions of dry density (including hydraulic conductivity) were determined in laboratory experiments. A 1D unsaturated flow model and 2D model scenarios were used to predict the pressure response and demonstrate the impact of density variations on model simulations, respectively. The final result showed that the model simulations accounted for dry density measured in field are more accurate than the pressure responses.

2.2 Degree of decomposition

Once deposited, the vegetative material in the peat swamp decomposes by microbial activity. This process of peat decomposition is termed humification. During humification process organic matter is lost either as gas or in solution; the peat structure breaks down and the chemistry of the deposit changes. The Von Post Degree of humification classification system has 10 categories describing the structure of pure peat. Well-know is the soil taxonomic scale employing the terms fibric, hemic and sapric as an indication of degree of humification. Magnan 1994, presents the French system of classification for organic soils. The Extended Malaysian Soil Classification System for engineering investigations also subdivides peat into three sub-groups e.g., fibric, humic & sapric and associates degree of humification with each category i.e. H1-H3, H4-H6 and H7-H10, respectively.

The ten (10) degrees of humification of Von Post are reduced to 3 classes for fibrous, semi-fibrous and amorphous peat, respectively. Apart from giving an impression of the probable state of the fibres in the peat, and thus of shear strength, the degree of humification is not an important quantity for establishing correlations with geotechnical parameters. It has been used to correlate quantities such as bulk density, liquid limit and natural water content. These correlations are all very approximate, showing only very generally that bulk density increases with Hn and that liquid limit and natural water content increase with decrease Hn and they are of little use when it comes selecting parameters for design.