LONG TERM CONSOLIDATION STUDY ON THE TROPICAL PEAT AT PEKAN, PAHANG, MALAYSIA

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ABSTRACT

Peats are formed by disintegration of plant and organic matters. In Malaysia, the area covered by peat deposit is about 3 million hectares or 8% of the total area of Malaysia. Peat has high compressive deformation, very high void ratio and water content and has low shear strength. It is widely regarded as a problematic soil since it poses serious problems in construction due to its long-term consolidation settlements even when subjected to a moderate load. Construction over peat will be subjected to massive primary and long term secondary and even tertiary settlement. This study will be conducted to gain a better understanding about the long term consolidation on tropical peat soil of East Coast of Peninsula Malaysia. The study will focused on the analysis of consolidation behavior of peat soil based on the time-deformation curve obtained from Oedometer Test. Based on this test, we can determine the consolidation time so that we can predict how long the time taken by the soil to settle. In the determination of consolidation time, the first thing we need to know is the consolidation coefficient value and this value may be obtained from Oedometer Test. It was expected that the value of settlement is high since peat is very soft and easily compressed. The study of the long term consolidation of peat soil is important to predict the amount of settlement that will occur to the peat soil in a long time period.

ABSTRAK

Tanah gambut terhasil daripada penguraian tumbuhan dan bahan-bahan organic. Di Malaysia, tanah gambut meliputi 3 juta hektar atau 8 % daripada jumlah keseluruhan keluasan tanah di Malaysia. Tanah gambut mempunyai daya mampat yang tinggi, liang udara yang banyak, tinggi kandugan air, dan mempunyai kekuatan ricih yang rendah. Ia dianggap sebagai tanah yang bermasalah kerana menyebabkan masalah serius dalam industri pembinaan disebabkan oleh ciri mendapan jangka panjang walaupun hanya dikenakan beban yang rendah. Kerja-kerja pembinaan di atas tanah gambut akan terdedah kepada mendapan primer dan mendapan sekunder dan mungkin juga mendapan tertier. Tujuan kajian ini dijalankan adalah untuk meningkatkan kefahaman dan pengetahuan tentang mendapan jangka panjang terhadap tanah gambut di semenanjung Malaysia. Kajian ini akan menumpukan kepada analisis ciri mampatan tanah gambut berdasarkan graf masa-mampatan yang diperoleh daripada eksperimen Oedometer. Berdasarkan kajian ini, masa mampatan dapat ditentukan dan boleh digunakan untuk membuat jangkaan masa tanah gambut untuk mendap. Dalam menentukan masa mendapan, perkara pertama yang perlu dikenalpasti adalah nilai pemboleh ubah mendapan dan nilai ini boleh didapati daripada eksperimen Oedometer. Menerusi kajian ini, dijangkakan nilai mendap tanah gambut adalah tinggi kerana ia adalah tanah yang lembut dan mudah mendap. Kajian ini adalah penting untuk menjangka jumlah mendapan tanah gambut yang berlaku dalam jangka masa yang panjang.

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LIST OF SYMBOLS

ASTM	=	American Standard Method
C_c	=	Compression Index
C_v	=	Coefficient of Consolidation
C_α	=	Secondary Compression
D	=	Diameter of Sample
D_0	=	Initial reading; Deformation
D_{100}	=	Deformation correspond to U = 100%
e	=	Void Ratio
e_0	=	Initial Void Ratio
G_s	=	Specific Gravity
Ha	=	Hectare
k	=	Coefficient of Permeability
m_v	=	Coefficient of Volume Compressibility
p’	=	Consolidation Pressure
S_c	=	Consolidation Settlement
S_s	=	Secondary Compression

T	=	Time
T_{50}, T_{90}	=	Theoretical Time Factors
T_v	=	Vertical Theoretical Time Factor
σ	=	Effective Stress

LIST OF FORMULA

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Peat is form by disintegration of plant and organic matters. It was identified as a one of a major group of soil found in Malaysia. According to Huat (2004), there are 3 million hectares or 8% area in Malaysia covered with peat.

In Peninsular Malaysia, they are found in the coastal areas of the east and west coast, especially in the coastal areas of west Johore, Kuantan and Pekan district, the Rompin-Endau area, northwest Selangor and the Trans-Perak areas in the Perak Tengah and Hilir Perak district. In Sarawak, peat occurs mainly between the lower stretches of the main river course (basin peat) and in poorly drained interior valleys (valley peats). They are found in the administrative division of Kuching, Samarahan, Sri Aman, Sibu, Sarikei, Bintulu, Miri, and Limbang. In Sabah, the organic soils are found on the coastal areas of the Klias peninsula, Krah swamps in Kota Belud, Sugut and Labuk estruaries and Kinabatangan floodplains.

Generally, peat is grouped into two categories; amorphous peat and fibrous peat. Amorphous peat is the peat with less than 20% of fiber content. It contain mostly particles of colloidal size (less than 2 microns), and the pore water is absorbed around the particle surface.

Fibrous peat is defined as a peat that contains more than 20% of fiber content. Both of amorphous and fibrous peat has own characteristics. However, in term of prediction of settlement and dissipation of pore pressure, they are show very close similarity.

In general, the process of consolidation can be divided into three stages. Each stage will display their respective characteristic. Those three stages are:

I. Immediate/initial deformation.
II. Primary Consolidation
III. Secondary Compression.

The primary consolidation of fibrous peat is much larger than that of other soils due to high initial water content, while the secondary compression occurs due to not only compression of solid particles, but also the plastic yielding (buckling, bending, and squeezing) of the particles (Samson and La Rochelle, 1972). Secondary compression is more significant part of compression of peat and plays important role in determining total settlement because it is occur during the design life of a structure after rapid primary consolidation. The consolidation process will take a long time because the composition of the soil is not homogenous and have high fibrous content.

Replacing the peat with good quality soil is still commonly practiced by the engineer when the construction has to take place on peat deposit. However, this method of solution leads to uneconomic design. Other alternative construction and stabilization methods such as surface reinforcement, preloading, chemical stabilization, sand or stone column, pre-fabricated vertical drains, and the use of piles also commonly used.

Construction over peat will subjected to massive primary and long term secondary settlement. Therefore, it is essential to understand the characteristics of peat and to interpret the compressibility parameters of peat deposit. Based on that parameter, the prediction of time period of settlement can be made.

1.2 Problem Statement

Peat is known as a one of the most problematic soil in the world. It can pose serious problem in the construction industry due to its consolidation settlement. It can be a nightmare for the engineer to design the structure over peat deposit. The characteristics of peat which is low in shear strength and easily compressed make it considered as unsuitable for the structure to be built on it. In settlement analysis, it is often that the long term compressibility parameters of peat is underestimated or neglected. This situation can lead to problem regarding on the structure stability in the future. The knowledge on the shear strength and compression behavior is essential as it enables designers to understand the response of the soil to load and to suggest proper engineering solutions to overcome the problem.

1.3 Objective of Study

Based on the importance of compressibility characteristics of peat in the evaluation of its response to loading, the following objectives were set for the study:

Main Objective:

1) To determine the long term consolidation parameters of tropical peat.

Specific Objective:

1) To determine engineering properties of Pekan peat.
2) To determine the consolidation parameters using fully automated consolidation test.

1.4 Scope and limitation of Study

The test was conducted using fully automated consolidation machine. The peat sample that used in this research study is tropical peat obtained from area of Pekan, Pahang. This experimental research limits its scope on the compressibility characteristics of peat based on time-compression curve obtained from consolidation test. The engineering properties of peat samples such as moisture content, liquid limit, organic content, fiber content, specific gravity, bulk density and dry density will be determined before conducting the consolidation test. The consolidation parameters like coefficient of consolidation (C_v), compression index (C_c), coefficient of volume compressibility (m_v), and secondary compression index (C_α) also was determined for settlement analysis.

1.5 Expected Result

Through this research, it was expected that the properties of peat at the study location can be identified. The engineering properties such as moisture content, liquid limit, organic content, fiber content, and specific gravity will be determined through the result of laboratory testing. The consolidation parameters which are important in predicting the settlement also expected to be determined through the consolidation test.

1.6 Thesis Organization / Framework

This thesis is consisted of five chapters. Chapter 1 presents general information regarding background, problem statement, objectives, scope of study, expected result, thesis organization/framework and gant chart/schedule of the project. Chapter 2 is literature review that provides the background of the study on different topics related to the research. This chapter outlines information on the general characteristics of peat, the definitions that relate to the research topic, the theory of consolidation, the compressibility of peat, the materials, and the methodology/experiments in general.

Chapter 3 described about the overall experimental program including laboratory tests in detail. The research methodology includes sampling of peat and laboratory soil tests performed to classify the soil and to determine the engineering properties of peat. This chapter also discusses the detail set up and procedures of consolidation test using fully automated consolidation machine.

Result and Analysis was discussed in chapter 4. Analysis of the test data for determining the compressibility parameters are presented and discussed in detail in this chapter. The applications of consolidation parameters from consolidation test for settlement analysis time-compression curve also discussed in this chapter.

Chapter 5 is Conclusion and Recommendation. It was presented the summary and conclusions of major findings of this research and recommendation for future work on the topic related to the present study.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction

Peat is known as a most problematic soil since it poses serious problem in construction industry due to its long term consolidation settlement. The major problem associated with such construction is the prediction of settlement because the conventional analysis usually under predicts the secondary compression or creep which continued for a long time. The behaviors of peat which is easily compressed make it unsuitable for the structure to be built on it. The low strength often causes stability problem and consequently the applied load is limited or the load has to be placed in stages. Large deformation may occur during and after construction period both vertically and horizontally, and the deformation may continue for a long time due to creep. Therefore, a good prediction of settlement is very important to get a good engineering design and solve this problem.

Recently, the utilization of peat-land in Malaysia is quite low although construction on marginal land such as peat has become increasingly necessary for economic reasons. Engineers are reluctant to construct on peat because of difficulty to

access the site and other problems related to unique characteristics of peat. Therefore, not much research has been focused on the behavior of peat and the development of soil improvement method for construction on peat soil area.

Replacing the peat with good quality soil is still a common practice when construction has to take place on peat deposit even though most probably this effort will lead to uneconomic design. Approaches have been developed to address the problems associated with construction over peat deposits (Lea and Brawer, 1963; Berry, 1983; Hansbo, 1991). Alternative construction and stabilization methods such as surface reinforcement, preloading, chemical stabilization, sand or stone column, pre-fabricated vertical drains, and the use of piles were discussed in literatures (Noto, 1991; Hartlen and Wolsky, 1996; Huat, 2004, and others). The selection of the most appropriate method should be based on the examination of the index and engineering characteristics of the soil. The knowledge on the shear strength and compression behavior is essential as it enables designers to understand the response of the soil to load and to suggest proper engineering solutions to overcome the problem.

The characterization of the peat soil has a significant effect for the consolidation behaviour as well as the strength of peat soil. Bearing Capacity of peat soil was very low and was apparently influenced by the water table and the present of subsurface woody debris (Islam et al., 2008 and Andriesse, 1988). Hence, in its natural state, peat is considered as unsuitable for supporting any structure.

2.2 Background

In Malaysia, the area covered by peat deposit is about 3 million hectares or 8% of the total area of Malaysia. On the west coast of Malaysian Peninsular, the deposits are formed in depressions consisting predominantly of marine clay deposits or a mixture of marine and river deposits especially in areas along river courses (R. Hashim *et al*., 2008).

Peat soils occur both in the highland and lowlands, however, the highland organic soils are not extensive. The lowlands peat occurs almost entirely in low-lying, poorly drained depressions or basins in the coastal areas.

In Peninsular Malaysia, they are found in the coastal areas of the east and west coast, especially in the coastal areas of west Johore, Kuantan and Pekan district, the Rompin-Endau area, northwest Selangor and the Trans-Perak areas in the Perak Tengah and Hilir Perak district. In Sarawak, peat occurs mainly between the lower stretches of the main river course (basin peat) and in poorly drained interior valleys (valley peats). They are found in the administrative division of Kuching, Samarahan, Sri Aman, Sibu, Sarikei, Bintulu, Miri, and Limbang. In Sabah, the organicsoils are found on the coastal areas of the Klias peninsula, Krah swamps in Kota Belud, Sugut and Labuk estruaries and Kinabatangan floodplains (www.mardi.my).

In tropical region such as Sarawak, Malaysian Peninsular and Sumatera, the peat form a doomed deposit consists of two layers: the top layer consist of fibrous peat containing long and slender roots and rootlets, while the bottom is a dense woody peat derived from the decomposition of the vegetation (Cameron, 1989).

Extent of Peat in Malaysia

Figure 2.1 and 2.2 shows the extent of peat in peninsular Malaysia and east Malaysia.

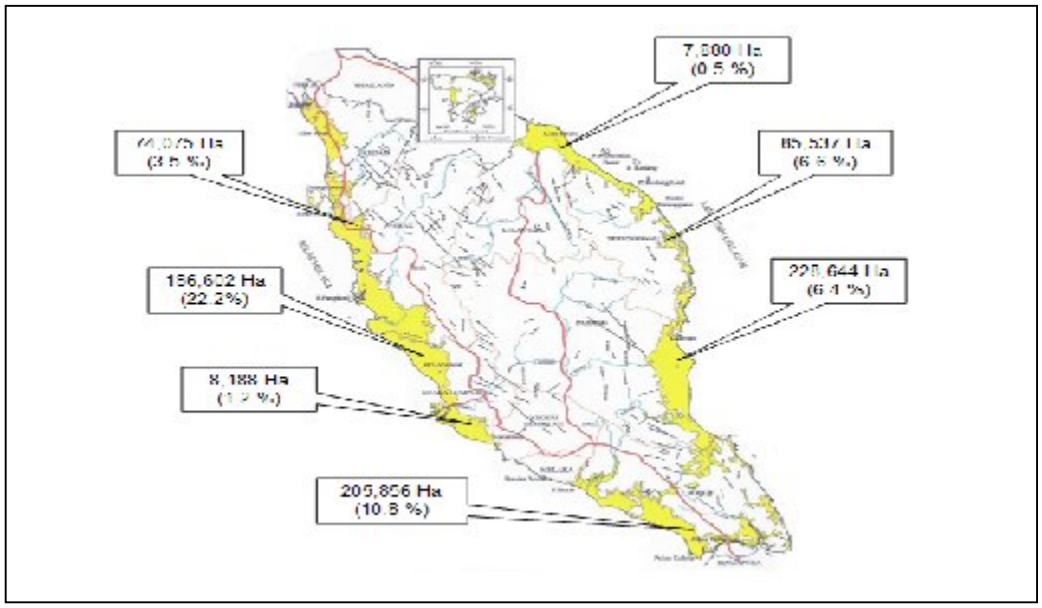

Figure 2.1: Extent of Peat in Peninsular Malaysia

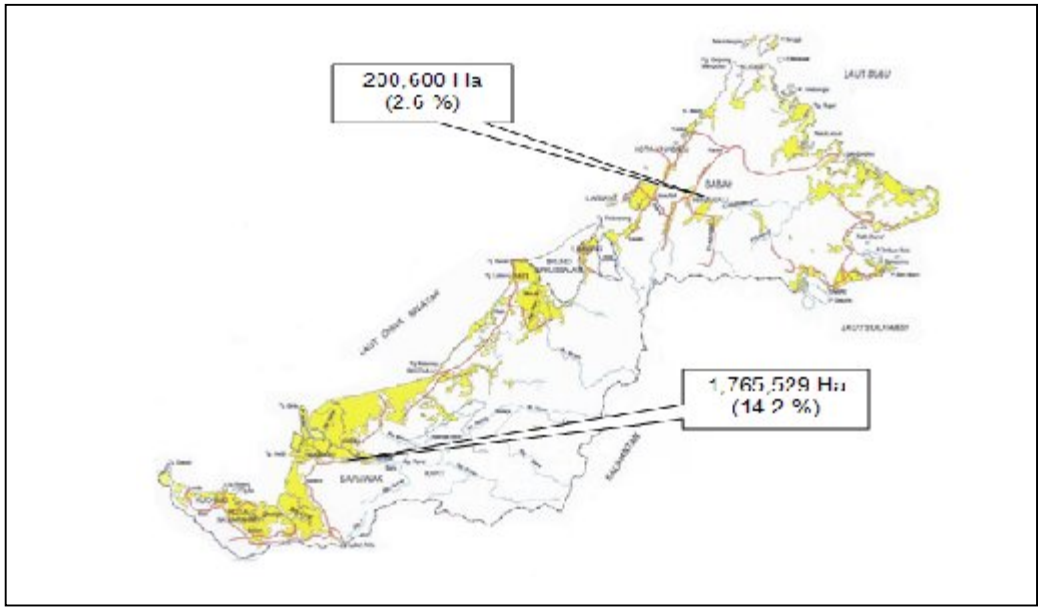

Figure 2.2: Extent of Peat in East Malaysia