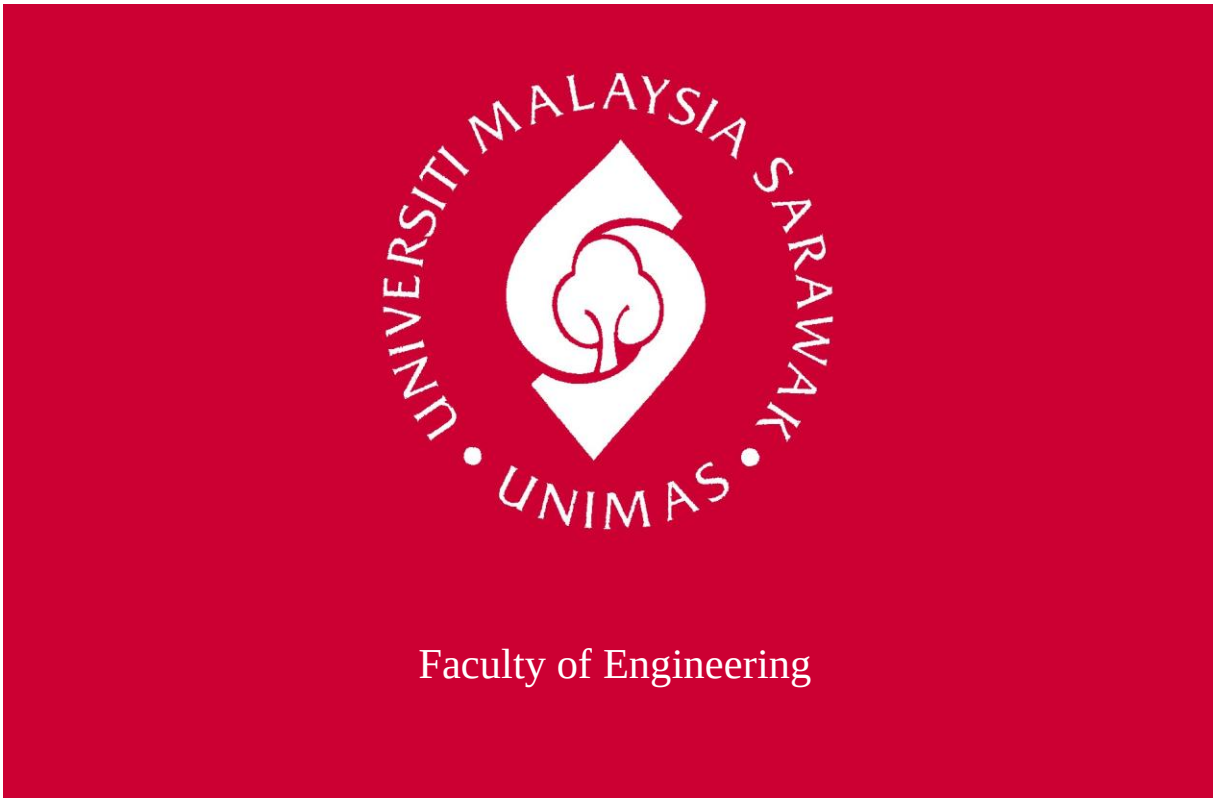

ONE – DIMENSIONAL CONSOLIDATION OF MODIFIED PEAT SOIL

Arasavindiran $^{A}/_{L}$ Mariappan

Bachelor of Engineering with Honours
(Civil Engineering)
2004

Universiti Malaysia Sarawak
Kota Samarahan

fk

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ONE – DIMENSIONAL CONSOLIDATION OF MODIFIED PEAT SOIL

ARASAVINDIRAN A/L MARIAPPAN

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ABSTRACT

Peat soil has been known to be the major group of problem soil in Malaysia. In Sarawak alone, peat covers 13% of the total land area. The main problem in peat is the excessive and differential settlement which results difficult design and construction condition. Furthermore, peat is difficult to sample and test using conventional method. One important characteristic that is important for analysis is the consolidation characteristic. This is because the consolidation behavior is related to the organic content of the soil. Therefore, the aim of this study is to investigate the consolidation behaviors of peat, in particular the consolidation parameters with respect to the organic content and relationships. The Oedometer consolidation test equipment will be used to obtain the results and effects of organic content on the coefficient of consolidation (C_v), coefficient of compression index (C_c) and coefficient of volume compressibility (m_v). From the experiments conducted, the value of C_v was found to be in the range of 0.094 to 0.848 cm^2/min. Where as the value of m_v was found to be decreasing as the organic content decreased. The value of C_c was also found to be decreasing as organic content decreased.

ABSTRAK

Tanah gambut telah dikenal pasti sebagai kumpulan tanah yang bermasalah di Malaysia. Di Sarawak sahaja, tanah gambut merangkumi 13% daripada jumlah tanah yang ada. Masalah bagi tanah gambut ialah pemendapan berlebihan dan berubah – ubah yang menyebabkan kesukaran kerja merekabentuk dan pembinaan. Tambahan pula, tanah gambut susah untuk disampel dan diuji menggunakan cara-cara konvensional. Salah satu ciri – ciri yang penting untuk dianalisa bagi tanah gambut ialah ciri – ciri pemendapannya. Ini adalah kerana sifat – sifat pemendapannya adalah bergantung kepada kandungan organiknya. Oleh itu, matlamat kajian ini ialah untuk menyiasat sifat – sifat tanah gambut, terutamanya parameter pemendapan dan hubungannya dengan kandungan organik. Ujian pengukuhan digunakan untuk memperolehi keputusan dan juga kesan kandungan organik terhadap parameter pemalar pemendapan (C_v), pemalar kebolehmampatan isipadu (m_v) dan pemalar index kebolehmampatan, (C_c). Daripada eksperimen yang dijalankan, didapati nilai C_v adalah dalam lingkungan 0.094 hingga 0848 cm^2/min. Manakala nilai m_v didapati semakin berkurangan selaras dengan pengurangan kandungan organik. Nilai C_c juga didapati berkurangan bila kandungan organik dikurangkan.

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1 INTRODUCTION AND SCOPE OF STUDY

1.1 Introduction

The aim of this study is to investigate the consolidation behavior of peat before and after being modified with an increasing percentage of sand. A series of tests are carried out to determine the properties of peat and its relationship with respect to the organic content after different percentage of sand increment. The following test are carried out in this study:

i) Moisture content

ii) Degree of humification

iii) Ignition loss

iv) Hydrometer analysis

v) Specific gravity

vi) Atterberg limits

vii) Compaction and

viii) Consolidation

1.2 Background

Organic soils especially peat or sometimes also known as peat swamps covers a total of 2.7 million hectares in Malaysia which is an overall 8% of the land. In Sarawak alone, peat covers 13% of the total state land area which is approximately 1.7 million hectares. Besides being part of the natural landscape of our country, peat has been identified as one of the major problem soils in Malaysia and other

countries. Peat is generally defined as soil having high organic content. The organic content are mainly decomposed plant remains whose accumulation rate is faster than the rate of decay*. These are then intermixed with sand, silt and clay. According to Coduto (1999), peat has dark brown to black color, a spongy consistency, and an organic odor. Soil scientist defines peat as soil with organic content higher than 35%.

In terms of geotechnical engineering, the Public Works Department, Malaysia defines soils with organic content more than 20% as organic soils where as peat is an organic soil with organic content more than 75%. Peat is sometimes classified as soft soils because of its instability and long term consolidation. The bulk density, porosity, wood content, degree of humification, hydrology and its water holding properties are mainly the factors that determine their physical properties (Sunday Tribune, 2003). Almost 90% of peat in Sarawak have depths more than 1.5m, i.e. which is classified as deep peat. Their depths increases from the coast towards the inlands.

Tropical peat in Sarawak are in general non-homogenous. The overall hydrological characteristic depends on the rainfall and the surface topography. Peatland is sometimes known as wetland because of the high depth of water table which is sometimes even higher than the peat surface. Peat has very high moisture content and capacity to hold water, making it very buoyant and high in pore volume. These characteristic are the main cause of peat to have low bearing capacity and bulk density. Due to this, peat is only capable of carrying little weight.

In order to develop peatlands for infrastructure or agriculture, the excess water has to be drained. But unfortunately drainage may cost bigger problems to

*Cited from Sunday Tribune, 2003, www

peatlands. According to the Sunday Tribune (2003), a study by Melling and HAtano has shown that draining out water may cause severe greenhouse effect. Other problems are oxidation, consolidation or subsidence of the land, flood occurrence, forest fire, pest infestation etc. Consolidation or subsidence also poses a great threat to peatland as it may cause flooding and damage of structures particularly roads. Years of study in the engineering field has come up with a few methods of improving peat. They are the excavation and replacement, vertical drains, piled supports, surface reinforcement (geotextile and geogrids) and the latest alternative which is the lightweight fill.

Even though faced with many problems, liming and fertilization of peat has been widely used in agriculture and has been successful especially for oil palm, sago and pineapple. Other application are such as fuel in many area of the world due high to organic content which makes peat a combustible material. Previous studies have also shown the suitability of peat as a filter medium in biofilters for wastewater treatment, (Shibchurn, 2001).

1.3 Scope of Present Study

The present study is mainly concerned on the settlement of peat. This is because the settlement of soil plays an important role in designing a civil engineering structures. When a structure is build, there is a compression of soil layers due to deformation of soil particles, relocation of soil particles and the expulsion of water or air from the void spaces (Das, 1998). The apparatus used in conducting the consolidation test is the Oedometer. From the test, 3 main phases that needs to be analyzed are;

Stage 1 : Initial Compression, mostly caused by preloading

Stage 2 : Primary Consolidation, during which excess pore water is gradually transferred into effective stress due to the expulsion of pore water.

Stage 3 : Secondary Consolidation, which occurs after dissipation of pore water pressure, when soil deforms due to plastic readjustment of soil fabric.

Since peat is considered as soft soils, it is important to analyze the consolidation properties before commencing on the actual work. The dependency of peat on its organic content makes it even harder to analyze and classify as results vary depending on the amount of organic content. Therefore, the aim of this is to analyze the consolidation of several modified peat soil samples. The reason is to compare the samples for future improvement of peat soils. The results of this modification will be used as guidelines in improving the peat soil condition is Sarawak.

The objectives of the project are as follows:

I. To determine the physical properties of modified peat soil and to compare with natural peat soil.
II. To find out the primary and secondary consolidation of the modified peat.
III. To compare the results and conclude the suitability of the modification.
IV. To study the consolidation parameters of the modified samples.

The outline of the project report are as follows:

Section 1 presents the introduction, background, scope and the objectives of the study.

Section 2 presents a review of the characteristic and properties of peat soil and its behavior with respect to different experiments.

Section 3 is concerned with the experimental investigation study of the soil used and the procedures of performing the test.

Section 4 presents the results and discussion of the experimental investigation outlined in Chapter 3. This chapter also presents the relationship and outcomes of the different range of modification.

Section 5 Contains an outline of the conclusions drawn in the project and the recommendations for further development of the present work for future research.

1.4 Limitations

Eventhough the Oedometer can be used to study the consolidation of peat soil to a certain extent. Still it does have certain limitations. Moreover, the number of equipment available was also insufficient. To perform the consolidation test on peat, ample time is needed and because of the time needed for each test, it was impossible to repeat the test to confirm results. More equipment should be made available so that test can be done simultaneously. Also to be taken note that the test is very sensitive to any movement and vibration. Therefore, the consolidation test should be performed in a separate room free from any disturbance. Finally, to make sure all test are done according to schedule, it is recommended that the test be

conducted as early as possible to make allowance for any long compression period or any repeating of test.

2 LITERATURE REVIEW

2.1 General

The main objective of this research is to study the effects on the consolidation parameters of peat soils which have been modified. To investigate this effect, all parameters related to this research are described below.

2.2 Basic Properties of Peat

In general, peat is classified in various different ways depending on the purpose for which they are being described. Different emphasis is given according to nature of study and research. The most relevant characteristic in research is the moisture relationship, acidity, bulk density, porosity, and the swelling and shrinking.

Information on the moisture relationship in peat is important especially when comes to the design of drainage. Various methods have been done to determine the water content of different organic soils. The results however vary from the other. The best method preferred by soil scientists is by using pressure plate and pressure membrane apparatus. The results (Table 2.1) shows great difference in water release characteristics between different organic materials (Andriesse,1988). Studies by Driessen and Rochimah (1977) : quoted from Andriesse (1988) on lowland Borneo peat has shown 79-91 percent by volume at suction of 0.01 bar, 75-89 percent by volume at 0.1 bar and 71-85 percent by volume at 0.33 bar (Andriesse,1998,). It is also shown that fibric peats lose their retained water at low suction.

Bulk density is the most characteristic as most properties are related to it. The value of bulk density is dependant on the amount of compaction, degree of decomposition, botanical composition, and the mineral and moisture content. Bulk density for organic soil is defined as the weight of a given volume of soil usually expressed on a dry weight basis in g/cm^3. Values range from 0.05 g/cm^3 in very fibric, undecomposed materials to 0.5 g/cm^3 in decomposed materials. According to Andriesse (1974), the mean bulk densities for Sarawak (Malaysia) peat is reported to be 0.12 and 0.09 g/cm^3. While Tie and Kueh (1979) reported that the bulk densities is 0.15 and 0.13 g/cm^3 in Sarawak. As for specific density (particle density), Driessen and Rochimah (1976) quoted that, for peats in general to be ranging from 1.26 g/cm^3 to 1.80 g/cm^3 (Andriesse,1988).

The porosity of peat is dependant on the bulk density. It also determines the water retention in soils. Table 2.2 shows the calculated total pore space for tropical lowland peats in Indonesia.

The texture and ignition loss of peat is important as the estimation of amount and distribution of mineral matter can predict the drainage behavior in the soil. Skaven-Haug (1972) stated that for tropical peat consisting of pure organic materials, a presumed ash percentage of one percent seems reasonable (Andriesse,1988).

Shrinkage is the percentage of the original volume. In general, organic soils shrinks when dried and swells when re-wetted. The shrinkage at range from 90 percent for aquatic peat to 40 percent for fibric peat. Similar to the Canadian peat, low land coastal peat usually show the greatest shrinkage (Andriesse,1988).

Although the chemical compound in peat is seldom taken into account in geotechnical engineering, it is still an important characteristic in the classification of

the soil. The degree of composition, parent vegetation and the original chemical environment is the main influence in the chemical composition of peat. The main organic constituents can be grouped into five fractions (Andriesse,1988,):

a) Water soluble compounds
b) Ether and alcohol soluble materials
c) Cellulose and hemicellulose
d) Lignin and lignin-derived substance
e) Nitrogeneous materials or crude proteins

The acidity or pH of organic soils depends on the organic content itself, iron sulphide and the exchangeable hydrogen and aluminium. For tropical peat of ombrogeneous and oligotrophic nature, the pH range in water is from 3 to 4.5. Furthermore, the thickest peat in lowland Borneo has an average of pH 3.3 whereas shallow peat with pH 4.3 (Andriesse,1988).

2.3 Moisture Content

In general, all soils contains water. For highly fibrous organic soils, such as peat, are generally characterized by relatively high moisture content, sometimes over 100 percent and an increase in organic content as little as 1 to 2 percent can result to a decrease of the maximum dry density and an increase in the optimum moisture content (Geotechnical News Quarterly, 2001). According to MARDI, field moisture content of peat ranges from about 100% to 1300%, on a dry weight basis. According to Vazirani and Chandola (1994), moisture content is the ratio of the weight of water present in the soil to the dry weight of soil which have been kept in the oven for 24 hours at a temperature of 105 to 110°C.

2.4 Particle Size Distribution

The particle distribution is an analysis which involves the determination of the percentage of weight within different ranges of size. According to Vazirani and Chandola (1994), in the field method of particle size distribution analysis, the rate of sedimentation is determined from the rate of decrease of density of the upper part of the liquid as larger particles settle out. The density is measured by hydrometer or sieve analysis. The actual dimensions are usually in terms of equivalent diameter and size fractions are specified as lying between certain limits of particle diameters. Vazirani and Chandola (1994) also stated the limits of equivalent diameter:

Gravel	60 - 2.0mm
Sand	2.0 – 0.06mm
Silt	0.06 – 0.002mm
Clay	Below 0.002mm

The results of particle size distribution are widely used in studies related with soil classifications. A soil is considered well-graded when it has good representation of particles of all sizes where as a soil is considered to be poorly graded if it has an excess of certain particles and deficiency of others.

2.5 Organic Content and Ignition Loss

Peat is a soil with high organic content (more than 75%) mainly consisting of decomposed or not fully decomposed plant remains. Geotechnical earthwork specifications generally require that selected fill be free of organic matter. According to Geotechnical News Quarterly (2001), fill materials containing more than 2.0 percent by weight of organic matter are generally not used in suitable for

engineering purposes. To assess fill materials, three randomly selected samples from each soil stratum or fill stockpile are tested. If any of these individual test results exceeds 3.0 percent, the stratum or stockpile is rejected.

According to Adel, Huat and Munzir (2003) , the American Society for Testing and Materials (ASTM) has classified peat and organic soil which are shown below:

I. OC 6 – 20% :Effects properties but behavior is still like mineral soils, organic silts and clays.

II. OC 21 – 74% :Organic matter govern properties ; traditional soil mechanics applicable.

III. OC>75% :Displays behavior distinct from traditional soil mechanics especially at low stresses i.e. peat.

BS 1377:Part 3 (1990) has stated the method of determining the organic content using the Walkley and Black method where as the mass loss on ignition is related to the organic content of the soil. Edil (2003) has stated the determination of organic content by ignition of the soil at high temperature of 440°C to 550°C to achieve destruction of organic matter. For Geotechnical purposes, the American Society for Testing and Materials (ASTM) has specified 440°C as percentage of oven dried mass at 105°C. According to Adel, et. al. (2003) and Skempton and Petley (1970) found the following relationship between ignition loss (N) and organic content (H)

$$H = 1 - 1.04\,(1 - N) \qquad (2.1)$$