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PERFORMANCE OF MODIFIED SAMPLING TECHNIQUE IN REDUCING DISTURBANCE ON PEAT SOIL

CECELIA ANAK LINGGANG

B. ENG (HONS) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

PERFORMANCE OF MODIFIED SAMPLING TECHNIQUE IN REDUCING DISTURBANCE ON PEAT SOIL SAMPLE

CECELIA ANAK LINGGANG

A report submitted in partial fulfilment of the
requirements for the award of
Bachelor's Degree of
Civil Engineering

Faculty of Civil Engineering & Earth Resources
Universiti Malaysia Pahang

JUNE 2016

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I declare that this thesis entitled “Performance of Modified Sampling Technique in Reducing Disturbance on Peat Soil Sample” is the result of my own research as cited in the references. The thesis has not been accepted for any degree and is not concurrently in candidature of any other degree.

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DEDICATION

To my beloved father (Linggang), my beautiful mother (Samai) and my amazing siblings. Your present in my life making it more wonderful.

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First of all, praise to the Lord God Almighty for giving me the blessing to be able to complete my final year project. I also would like to express my gratitude towards those who have contributed in completing this project.

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Last but not least, my heartfelt acknowledgement are expressed to my family especially my parents. They always believe in me and motivated me so that I always do the best I can in everything that I do. They are very supportive and help me a lot in terms of money. When I feel discouraged, their love gave me strength not to give up. I am very grateful having them in my life.

Thank you very much.

ABSTRACT

Peat soil was known as one of the most problematic soil in the construction industry. It has excessive moisture content, with high compressibility making it unsuitable for any type of foundation. In order to deal with the current urban land scarcity for development, geotechnical engineers have been challenged to design foundations in marginalized soil including peat. Hence a good sampling technique was necessary to accurately estimate soil properties and the strength to design suitable foundations on peat.

The main objective of this study is to measure the performance of modified peat sampler in reducing disturbances on peat soil during sampling work. There are two types of sampler used to obtain the undisturbed peat soil sample which was Tropiter and conventional tube sampler. Peat soil sample was obtained from Pekan, Pahang at the depth of 300 mm using conventional as well as the modified sampler for comparison. The degree of disturbance in Tropiter (23%) was less than the conventional tube sampler (37.33%).

Laboratory tests conducted on samples obtained from these samplers were compared with the existing field data from literature. Based on the result obtained, the sample was classified as H3 which is sapric peat with 33.24% organic content and 30.54% of fiber content. The moisture content is 362.12%. The specific gravity and unit weight is 1.91 and 12.82 kN/m^3 respectively. The liquid limit of the peat soil is quite high which was 166.7% with pH value of 4.4.

Besides that, the load settlement curve produced based on the one dimensional test shows that, Tropiter is able to produce a close result resembling in-situ condition. Thus, results show that Tropiter, the modified peat sampler was highly potential to reduce disturbance and able to produce samples which resembles the actual conditions of the soil.

ABSTRAK

Tanah gambut dikenali sebagai tanah yang paling bermasalah dalam industri pembinaan. Ia mempunyai kandungan kelembapan yang berlebihan, dengan kebolehmampatan yang tinggi menjadikannya tidak sesuai untuk mana-mana jenis pembinaan. Dalam usaha untuk menangani kekurangan tanah terutama di kawasan bandar untuk tujuan pembangunan, jurutera geoteknikal telah dicabar untuk merekabentuk asas di dalam tanah terpinggir termasuk tanah gambut. Oleh itu teknik persampelan yang baik sangat perlu untuk menganggarkan dengan tepat sifat-sifat tanah dan kekuatan untuk merekabentuk asas yang sesuai di tanah gambut.

Objektif utama kajian ini adalah untuk mengukur prestasi tabung sampel gambut yang diubahsuai dalam mengurangkan gangguan di atas tanah gambut semasa kerja persampelan. Terdapat dua jenis tabung yang digunakan untuk mendapatkan sampel tanah gambut yang tidak terganggu iaitu Tropiter dan tabung sampel konvensional. Sampel tanah gambut telah diperolehi dari Pekan, Pahang pada kedalaman 300 mm menggunakan konvensional serta tabung sampel yang diubah suai untuk perbandingan. Tahap gangguan dalam Tropiter (23%) adalah kurang daripada tabung sampel konvensional (37.33 %).

Ujian makmal yang dijalankan ke atas sampel yang diperolehi daripada kedua-dua tabung ini dibandingkan dengan data lapangan yang sedia ada dari sumber ilmiah. Berdasarkan keputusan yang diperolehi, jenis sampel diperolehi diklasifikasikan sebagai H3 iaitu gambut sapric dengan kandungan organik sebanyak 33.24 % dan 30.54 % kandungan serat. Kandungan lembapan adalah 362.12 %. Graviti tentu dan berat unit adalah 1.91 dan 12.82 (kN/m^3) masing-masing. Had cecair tanah gambut adalah agak tinggi iaitu 166.7 % dengan nilai pH 4.4 dicatatkan.

Selain itu , keluk penyelesaian beban dihasilkan berdasarkan ujian satu dimensi, dimana Tropiter dapat menghasilkan keputusan yang hampir menyerupai dengan keputusan ‘in-situ’. Oleh itu , keputusan menunjukkan bahawa Tropiter, adalah sangat berpotensi untuk mengurangkan gangguan dan dapat menghasilkan sampel yang menyerupai keadaan sebenar tanah.

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LIST OF SYMBOLS

A_r	-	Area ratio
c_v		Compression index
D_O	-	Outside diameter of the sampling tube
D_i	-	Inside diameter of the sampling tube
e_{min}	-	Minimum void ratio
e_{max}	-	Maximum void ratio
FC	-	Fiber Content
G_s	-	Specific Gravity
LL	-	Liquid Limit
m_v	-	Coefficient of Volume Compressibility
OC	-	Organic content
pH	-	Acidity
ɤ	-	Unit Weight
ω	-	Water content

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CHAPTER 1

INTRODUCTION

1.1 General

Even though Malaysia is just a small country but it has the 9th largest peatland in the world. Besides Sarawak, in Peninsular Malaysia there are also several other places with peat soil. One of it is Pekan districts located at Pahang Darul Makmur, the east coast of Malaysia.

Peat also can be defined as "generally unconsolidated organic material consisting largely of organic residues accumulated as a result of incomplete decomposition of dead plant constituents under conditions of excessive moisture" (Landva 2007). Peat soil contains highly organic content from plant materials. It has spongy consistency, brown to dark colour and organic odour. The presence of organic matter in peat leads to a high potential in agricultural industries.

Besides that, peat soil have different characteristics depends on the place where it is found. Moreover, among soil scientist and engineers, peat soil has no specific definition. Soil scientist defined peat soil as a soil with organic content greater than 35%, whereas geotechnical engineers defined peat soil with organic content greater than 20%.

Peaty soil is not suitable for any types of foundation because of high compressibility and known to be problematic for geotechnical purposes. Development of peat is important especially in Malaysia because peat has become increasingly necessary for economic purposes because the increase in growth population as well. Moreover, constructions on peaty soil make it tough for the engineers to deal with. Before any construction take place, it is important to have a site investigation which involves soil investigation before doing any improvement of the soil.

Soil sampling procedure can be divided into two parts which is the allocation of the samples over the region under survey and the sampling technique. However in this study it was focused more on the sampling technique which involving two different types of sampler; modified sampler and conventional sampler. Types and design of peat soil sampler is important in order to obtain a high quality of soil sample with fewer disturbances.

Besides that, the design of soil sampler also can give effect on the soil disturbance. They are many types of sampler produced to cope with the problem in obtaining undisturbed soil sample. Each has been designed to meet particular requirements of soil type and working conditions.

1.2 Statement of Problem

Peat soil is known as one of the problematic soil where its behavior and characteristics such as high moisture content, high compressibility and void ratio shows the unsuitability of this soil for any type of construction. However, in order to deal with the current urban land scarcity for development, geotechnical engineers have been challenged to design foundations in marginalized soil including peat.

Even though there are many kind of method have been made to improvise the soil, engineers need to identify the behavior, characteristics and strength in details in order to know what should be done next. Design of the sampler was also one of the factor that affect the quality of the peat soil sample.

Hence, to solve the problem of obtaining undisturbed soil sample is important because if the degree of the disturbance is high, then engineers might underestimate or overestimates the strength of the peat soil.

1.3 Aim

The main aim of this study was to identify the performance of modified sampling technique in reducing disturbance of peat soil samples.

1.4 Specific Objectives

In order to compare the load settlement curve of peat soil for both sampling technique, there were few objective need to be achieved. Followings were the objectives proposed in this study:

(1) To identify degree of disturbance of modified and conventional soil sampler

(2) To find the load settlement curve of peat soil sample obtained from conventional sampler using oedometer.

(3) To find the load settlement curve of peat soil sample obtained from modified sampler using oedometer.

(4) To compare the load settlement curve of peat soil sampler obtained from both type of sampler with the in-situ result.

1.5 Scope of Study

The study site is based on one location which was located at Indera Sempurna, Pekan, Pahang. Therefore, the interpretation of the results of the study was limited as indicated in the following

1. Peat soil was taken at Indera Sempurna, Pekan, Pahang.

2. Samples were obtained using modified sampler (Tropiter) and conventional tube sampler in undisturbed condition.

3. Peat soil sample was taken at the depth of 300mm.

4. Soil identification test included; water content, specific gravity, organic and fiber content, acidity, atterberg limit, and sieve analysis.

5. Initial stage of classification of peat was made based on Van Post Scale Method.

6. The undisturbed samples taken using modified and conventional sampler was then underwent Oedometer test.

7. Before undergoing Oedometer test, the soil sample inside the consolidation cell was cured for 24 hours to ensure the soil is fully saturated.

8. For control data, undisturbed sample was taken directly using the ring from consolidation cell and test for oedometer test as well.

9. A ring diameter with 50 mm and 20 mm in height were used for the consolidation test.

10. All the samples were subjected to specific loading stage which is 250g, 500g, 1kg and 2kg. For unloading stage, the load is 500g and 125g.

11. Load duration for each increment was the same and equal to 24 hours.

12. Finally, laboratory tests conducted on samples obtained from these samplers was compared with the control data for in-situ and existing field data from literature.

1.6 Significance of Study

Geotechnical engineers usually have difficulties on obtaining an undisturbed sample especially on peat soil ground. The accuracy in obtaining undisturbed peat soil sample is very important to avoid any problem that could be encountered in the future, geo-technically. Hence, the study to find the effectiveness of the two types of soil sampler which is the conventional sampler and modified sampler is very important. Comparison made to identify the performance between both the types of soil sampler can lead to successful sampling technique for peat soil in the future.

1.7 Thesis Structure

The thesis contain of six chapters. Chapter 1 was mainly an overview on the research study in general regarding background of study, statement of problem, aim and specific objectives, scope and significance of study, and thesis structure. For Chapter 2, it relates to the background of this research study based on previous researcher for the literature review. This chapter presents on the introduction, soil classification and characteristics, soil sampling, soil disturbance and laboratory test.

Next is Chapter 3 which is about the research methodology. This chapter is basically gave an overview on how the research studies was conducted based on the operational framework as the guidelines. Besides that, it gives important procedure in conducting the laboratory based on certain standard that have been identified.

In Chapter 4 it was the highlight chapter in this research study where all the results and discussion was presented. Finally, a conclusion with some recommendation was made in Chapter 5 for future research and reference.

CHAPTER 2

LITERATURE REVIEW

2.1 Distribution of Peat Soil in Peninsular Malaysia

According to Huat (2004), there were 3 million hectares or 8% area in Malaysia covered with peat. Peat soil occurs at both highland and lowlands. In Peninsular Malaysia, peat soil can be found in the areas of the east and west coasts, especially in the coastal areas of West Johor, Kuantan and Pekan districts, the Rompin-Endau area, northwest Selangor and the Trans-Perak areas in the Perak Tengah and Hilir Perak districts. Besides that, in Peninsular Malaysia, approximately 0.8 million are deep peat.

Table 2.1 Extent of peat swamp forest (PSF) by state in Peninsular Malaysia (Wetlands International, 2010)

State	Total Area of Peat (ha)
Johor	143,974
Pahang	164,113
Selangor	164,708
Perak	69,597
Terengganu	84,693
Kelantan	9,146
Negeri Sembilan	6,245
Federal Territory	381
Total	**642,867**

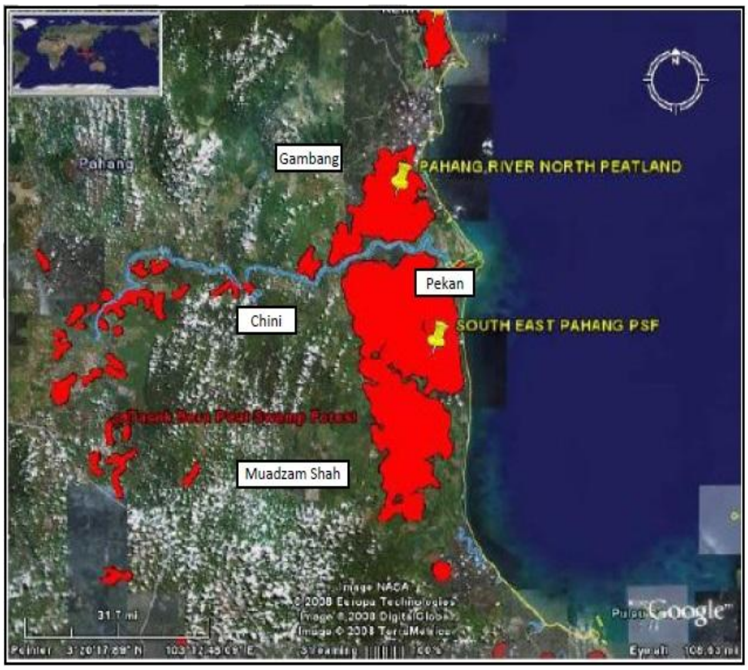


Figure 2.1 Pahang peatlands (Wetlands International, 2010)

Based on Table 2.1 and Figure 2.1, Pahang have the largest peat area in Peninsular Malaysia with an area of 59,097 ha. It has a total of 164,113 ha of peatlands which include Pahang River North Peatland, and the Pekan, Nenasi, Kedondong, and Resak Forest Reserves, including small peatland areas of Pahang.

2.2 Definition of Peat

According to Huat et. al (2014), peat is made up of plan remains produced by incomplete decomposition and disintegration. It is formed when organic from plants matter accumulates more quickly than it decays. The colour of peat soil usually was dark brown in colour with a strong odour (Figure 2.2). Peat soil is very spongy, highly compressible and combustible because of the main component is an organic matter. The peat deposit generally found in thick layers on limited areas and was found where the conditions are favourable for their formation.

Figure 2.2 Tropical peat soil

2.3 Index Properties of Peat

Peat soil is known as problematic soil because it is not only a soft soil, it is compressible too where this characteristics leads to excessive settlement which was a very serious problem. Basically, based on Farnham and Finney (1965) they are three main categories of peat soil; fibrous, hemic and amorphous peat (Table 2.2.1). American Society for Testing and Material annual book of standards (2000) stated that for fibric, it has more than 67% fiber content, hemic's fiber content between 33% to 67% and sapric having fiber content less than 33%.

However, the content in peat soil may differ from other location due to several factors such as temperature and degree of humidification (Huat, 2004). The definition of peat also different based on the purpose of application. The standard definitions was given in Table 2.3 .Hence, it is important to classify the type of peat soil in order to have an accurate analysis regarding the soil in terms of their characteristics and physical properties

Table 2.2 Physical and chemical properties of peat (Lin, 2011)

Soil type/ Characteristics		Moisture content	Von post class	Fibre content	Organic content	Linear shrinkage	Consistency limit		pH	Specific gravity
							LL	PL		
		%		%	%	%	%	%		
Peat soils	Matang , Sarawak (Kolay et al, 2011)	600	H4	79	91	5	200	-	3.8	1.2
	West Malaysia peat (Huat, 2002; Zainorabidin et al, 2003; Duraisamy et al, 2009; Kalantari et al, 2009)	200-700	H4-H8	31-77	65-92	-	190-360	100-200	-	1.2-1.7
	East Malaysia peat (Huat, 2002; Chan, 2009; Tang, 2009)	200-2207	-	-	76-98	-	210-550	125-297	3-7.2	1.1-1.6
	Klang, Selangor (Wong et al. 2008; Deboucha, 2009; Hashim et al, 2008)	414-850	H4	85- 90	89- 98	5.6	174	58	3.5-4.6	0.9- 1.4
Organic soils	West Malaysia coast clay	70-140	-	-	-	-	56-90	30-35	-	-
	East Malaysia coast clay (Huat, 2002)	36-73	-	-	-	-	-	-	-	-

Table 2.3 General definitions of peat (Zainorabidin, 2010)

Purpose of application	Definition	From Reference
Geotechnical Engineering	All soils with organic content greater than 75% are known as peat. Soils that have organic content below 75% are known as organic soils.	ASTM D4427 - 92
Agriculture	Peat is classified if the organic content is more than 20%.	USDA (Soil Taxonnomy)
Soil Science	All soils with organic content greater than 35% is categorized as peat.	USDA (Soil Taxonnomy)

2.3.1 Water Content

Peat soil contains high water content compared to other inorganic soil. Huat (2004) stated that the water content of peat soil was high in the ranges from 100 to 1300 percent based on the oven-dry weight at 105ºC. Usually fabric peat soil has higher water content than the other two types of peat soil which was hemic and amorphous.

2.3.2 Liquid Limit

Peat soil also have high liquid limit due to high water content. Generally, according to Hobbs, liquid limit are range from 200% to 700%. However, based on Duraisamy et. al (2007) previous research, liquid limit of the tropical soils was found to range from 150% to 400%. Besides that, the value of liquid limit also affected by the organic content where the liquid limit of peat increases with the increase in organic content (Figure 2.3).

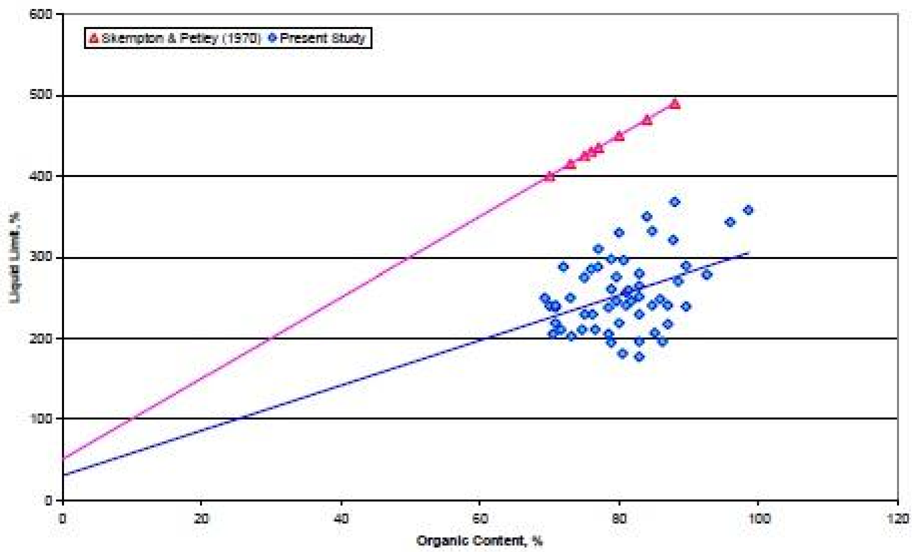


Figure 2.3 Liquid limits versus organic content (Duraisamy, 2007)

2.3.3 Chemical Properties of Peat Soil

Although the chemical properties in peat are seldom taken into account in geotechnical engineering, it was very important for the classification of soil to have better understanding on peat soil. The acidity or pH of peat soil was depending on the organic content itself. In terms of its chemical properties, peat soils were usually acidic with low pH values in the range of 3.2 to 4.9. However, the acidity of peat deposit decreases with depth.

2.3.4 Compressibility of Peat Soil

Peat soil is known by having high compressibility due to the void spaces that leads to high settlements. By having the void spaces, it affects the permeability and sub-sequent long-term settlement (Deghanbanaki 2015). Based on Leonard and Girault (1961), they proposed the range of 2-5 for the compression index (Cc) of peats, which indicates high in compressibility compared to inorganic soils. Even in Duraisamy et al (2009) previous research which also investigated the compressibility of peat soil in peninsular Malaysia was in the range of 1.453-3.211.

2.3.5 Density and Specific Gravity

Huat 2004 stated that the engineering property such as the bulk densities of peat was in the range of 0.8 – 1.2 Mg/m3 and in the range of 1.07 to 1.7 for specific gravity.

2.4 Classification of Peat Soil

The classification of soil was depending on the decomposition of fiber, vegetation forming of the organic content and the content of fiber. Besides that, the easiest and simplest way to distinguish a peat soil compared to other soil is through visual inspection by hand squeezing test was called Van Post Method. The test is conducted by taking a handful of peat and when it was pressed, the muddy water will squeezed out. The pressed residue was some-what thick and the material remaining in the hand has fibrous structure. The peat is classified on a scale of H1 to H10 (Table 2.2.3). For geotechnical engineer, Van Post Method usually the first test to conduct in identifying the peat soil.

According to Tang Bee Lin (2011), peat soil is generally brownish-black in color that composed of 90% water and 10% solid material with high organic matter and fiber content compared to other soil that was suitable for agriculture rather than for construction. Due to high in organic matter, the soil was very spongy and compressible. Moreover, Kazemian and Huat (2009) stated that the compression behavior of peat soil is relatively high where the characteristics is controlled by the fiber content, moisture content, void ratio, nature and arrangement of the soil particle.

Table 2.4 USDA classification of peat (Huat, 2004)

Type Of Peat	Fiber Content	Von Post Scale
Fibric Peat	Over 66%	H4 or less
Hemic Peat	33%-66%	H5 or H6
Sapric Peat	Less than 33%	H7 or more

Table 2.5 Determination of decomposition using Van Post Scale (van Post, 1922)

Condition of peat before squeezing				Condition of peat on sequeezing		
Degree of Humification	Soil color	Degree of decompo-sition	Plant structure	Squeezed solution	Material extruded (passing between fingers)	Nature of Residue
H_1	White or yellow	None	Easily identified	Clear, color-less water	Nothing	Not pasty
H_2	Very pale brown	Insignifi-cant	Easily identified	Yellowish water/pale brown-yellow	Nothing	Not pasty
H_3	Pale brown	Very slight	Still identified	Dark brown, muddy water not peat	Nothing	Not pasty
H_4	Pale brown	Slight	Not easily identified	Very dark brown muddy water	Some peat	Some what pasty
H_5	Brown	Moderate	Recognizable but vague	Very dark brown muddy water	Some peat	Strongly pasty
H_6	Brown	Moderately strong	Indistinct (more distinct after squeezing)	Very dark brown muddy water	About one-third of peat squeezed out	Very strongly pasty
H_7	Dark brown	Strong	Faintly recognizable	Very dark brown muddy water	About one-half of peat squeezed out	Very strongly pasty
H_8	Dark brown	Very strong	Very indistinct	Very dark brown pasty water	About two-third squeezed out	Very strongly pasty
H_9	Very dark brown	Nearly complete	Almost recognizable	Very dark brown muddy water	Nearly all the peat squeezed out as fairly uniform paste	Very strongly pasty
H_{10}	Black	Complete	Not discernible	Very dark brown muddy paste	All the peat passes between the fingers; no free water visible	N/A

2.5 Degree of Disturbance

The design of sampler was one of the important aspects that should be considered for quality sampling (Rahman and Siddique 2010). According to Gilbert (1992), the significance of peat soil sampling was to obtain the physical and characteristic of the soil and its behavior. In case of laboratory test, it was important to produce a result that was close enough with the in-situ result to guarantee the good quality of the peat soil sample. Usually, the source of disturbance in obtaining peat soil sample was relatively causes by the types of soil sampler used. The degree of disturbance was varies depending on the dimensions and design of the soil sampler. Due to the disturbance, the properties of the peat will change. According to Das (2012), to determine the degree of disturbance is based on the area ratio of the soil sampler.

The degree of disturbance for a soil sample is usually expressed as:

$$A_r(\%) = \frac{D_o^2 - D_i^2}{D_i^2}(100)$$

Where

A_R = Area ratio (ratio of disturbed area to total area of soil)
D_O = Outside diameter of the sampling tube
D_i = Inside diameter of the sampling tube

2.6 Soil Sampling

Soil samples can be obtained in two conditions either “disturbed” or “undisturbed”. A disturbed sample was when the natural condition or the in-situ properties of the soil were disturbed. In the other hand, undisturbed sample keeps the natural condition of the soil but close enough to the conditions of the soil in-situ. However, it is impossible to obtain a perfect undisturbed soil sample because no matter what type of sampler is used, each has their own degree of disturbance that need to be considered. Sampling of peat soil is difficult due to the texture (Kalantari et al. 2011).

According to M.M Rahman and A Siddique (2010), the design of a sampler was one of the most important criteria that should be considered for quality sampling. They were some level of disturbances in sampling that cannot be avoided which was the change in stress state of soil created by removal of overburden and from mechanical effects of sampling where the sample need to extruded. The less disturbed a sample is the more closely the lab results reflect its in-situ behavior. Hence, in order to preserve the moisture content and other characteristic of the sample, the sampler is then sealed using paraffin wax on both end of tube of the sampler.

Hence, the efficiency of obtaining undisturbed sample needs to be guaranteed in order to produce a reliable data for soil investigation. Undisturbed sample is in natural structure of the soil and material properties remains preserved. It retains as closely as practicable the true in-situ structure and water content of the soil. However, for undisturbed sample the stress changes cannot be avoided. They are various type of sampling technique use to obtain undisturbed sample such as standard split spoon, open drive and piston type sampler. Moreover, type of sampler need to be improved efficiently to obtain a good quality of peat soil sample.

2.6.1 Type of Samplers

They were variety of soil sampler that can be use according to the type of samples that need to be taken either in “disturbed” or “undisturbed” condition. Disturbed sample is defined as the natural structure of the soil is disturbed during the sampling operation. There are also called representative samples. On the other hand, undisturbed soil sample is the natural structure of the soil and material properties remain preserved. However, in this study, only undisturbed sample was used.

Obtaining undisturbed soil sample is not an easy job. According to Groenewoud (1960), many types of soil samplers have developed in attempts to solve the problem of obtaining undisturbed soil samples. Determination of suitable type of soil sampler is important and the degree of disturbance cannot be too large to produce a good quality of sample. Moreover, the design of soil sampler is one of the factors that contribute to the degree of disturbances of the peat soil sample.

Soil sampler is used to obtain soil sample for soil physical and characteristic determination. Hence, the laboratory result can be closely to in-situ result. Undisturbed samples generally taken by cutting the block, pushing or driving tubes into the ground.

(a) Thin-Walled Tube Sampler

Thin-walled tubes also known as Shelby Tubes were frequently used to obtain undisturbed soil samples. Thin-walled tubes usually have a diameter of 50.8mm and 76.2mm and the bottom tube is sharpened, helps to reduce the friction between the sampler and the soil taken. The tube is attached with drill rods and being pushed inside the soil. Then, the tube is pulled out and it is sealed at both ends.

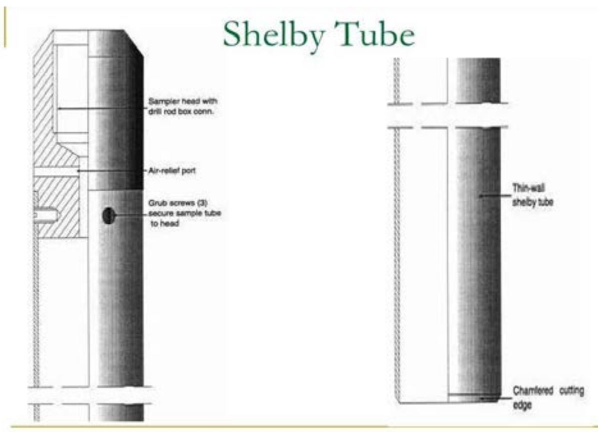


Figure 2.4 Shelby tube

(b) Thick-Walled Split Barrel Samplers

The device is an open-drive split barrel sampler is split longitudinally into two halves. The split barrel eased the extraction of the sample. The dimension of the sampler was defined in BS 1377:1975 and usually it was used during Standard Penetration Test (SPT). The inside diameter of the cutting shoe was 62,7mm and the outside diameter was in 82.6mm.

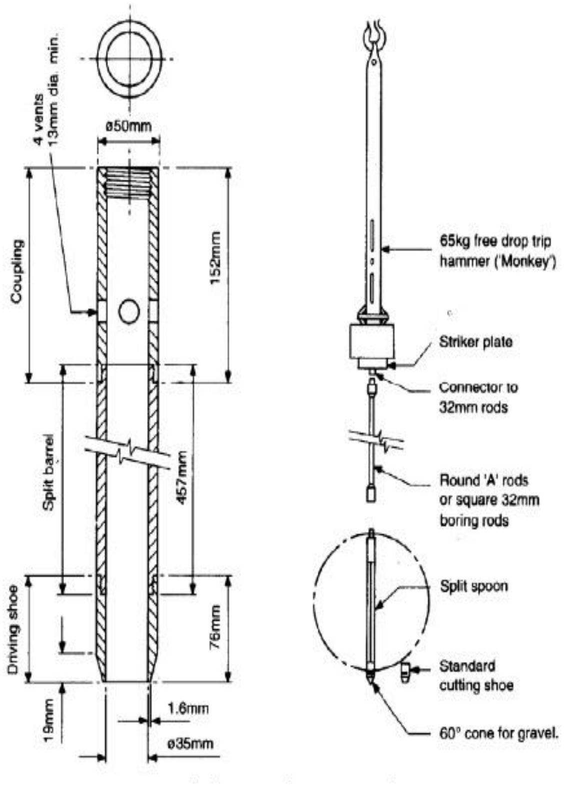


Figure 2.5 Thick-walled split barrel sampler

(c) Double-Walled Cylindrical Sampler

Double-Walled Cylindrical Sampler consists an outside cylinder protector, whereas inner cylindrical with lower cutting edge. This type of sampler is one of the effective samplers in obtaining undisturbed sample of peat soil. It was fully preserve the moisture content by sealing it using liquid air or dry ice. Two pipes are used where the outer diameter is 10cm with a beveled cutting edge. The frozen sample is then extruded by pouring hot water. The inner diameter of the outer pipe is 7.6cm and 7.4cm inner diameter for the inner pipe.

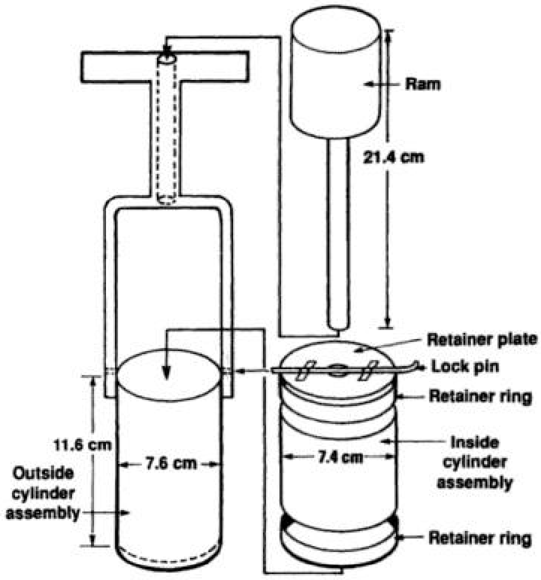


Figure 2.6 Double-walled cylindrical sampler

2.7 Previous Research

One Dimensional test was a process where they are reduction in the volume of water. It is a time-related process of increasing the density of a saturated soil by draining some of the water out of the voids. The direction flow of water was primarily vertical or one dimensional. Hence, the soil layer also underwent one-dimensional consolidation settlement in the vertical direction.

To have a better understanding on one dimensional test, it is often related to the spring analogy as shown in Figure 2.7. The description on the spring analogy was as below:

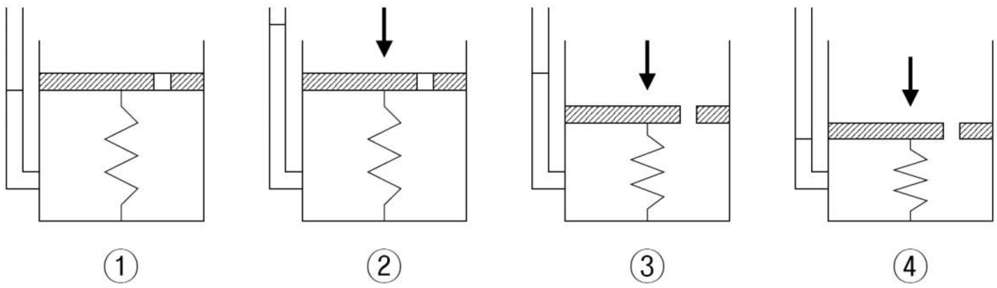


Figure 2.7 The spring analogy

1. At the initial condition, they are no loading on the piston with the hole closed. Nothing changed to the spring as well. The container is filled with water to represent the fully saturated soil.
2. When the load is applied on the piston, the water resists the applied load when hole is closed. Hence, the situation develops an excess of pore water pressure.
3. As soon as the hole is opened, with the same applied load, the water start to drain out through the hole and the spring shortens. At this moment, for a real situation, the drainage of excess pore water pressured was occurred.

4. After some time, there were no longer drainage of water and only the spring is left to resist the applied load. When this occurred, the consolidation process ended.

The compressibility characteristics of soil were usually determined from consolidation test that was commonly used which was One Dimensional Test. Usually, the test was conducted based on BS 1377: Part 5: 1990: Clause 3. The consolidation cell usually can fit 50mm in diameter and 20mm thick samples. The schematic diagram of consolidation test was shown in Figure 2.7.

Besides that, one consolidation test also suitable for testing the undisturbed soil sample. The soil sample in the consolidometer is subjected to a compressive strength because of the vertical load, which assumed to act uniformly over the area of the soil sample. The two-way drainage is permitted through porous disks at the top and bottom as shown in Figure 2.8.

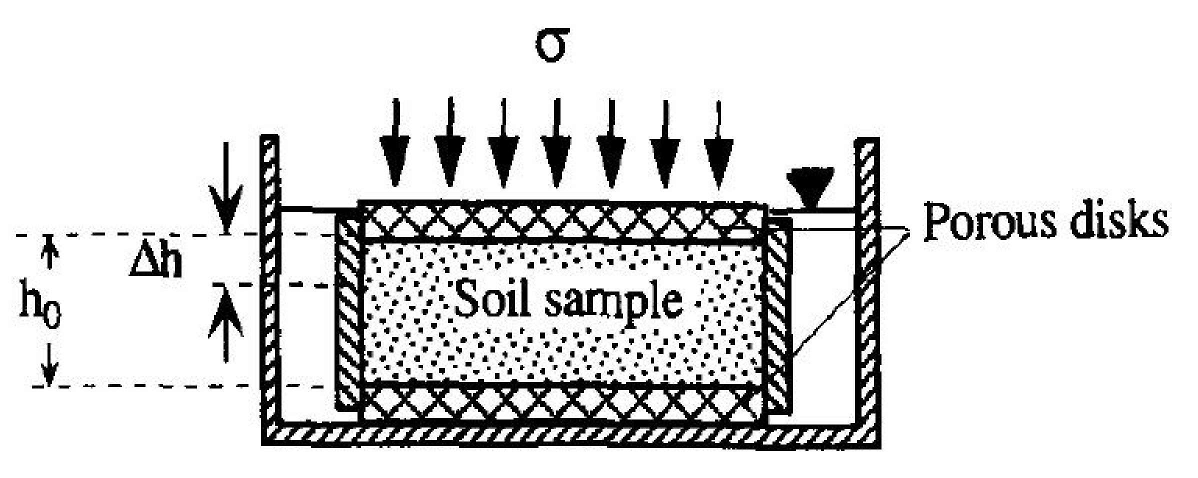


Figure 2.8 Schematic diagram of oedometer cell (Bardet, 1997)

From the test, we can determine the value such as the compression index, coefficient of volume compressibility and the coefficient of consolidation. In case of peat, the consolidation takes place faster than the other types of soil because of its high compressibility. Based on British Standard, the suggested initial pressures for the consolidation test on very soft soil is typically 6kPa or 12kPa. Besides that, we can gain the graph of void ratio at the end of each increment period against the corresponding load increment.

Based on the previous research, according to Duraisamy et. al (2007), the compression index (Cc) values from Oedometer test for fabric is 1.453 to 3.211, hemic was 1.29 to 2.78 and sapric was 1.15 to 2.44. Thus, it clearly shows that pear possess high compressibility when subjected to higher loading over the time period.

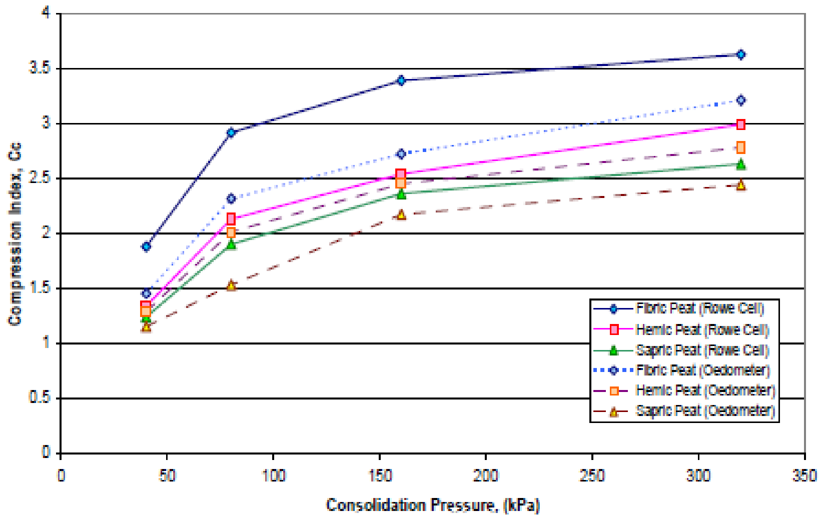


Figure 2.9 Compression index versus consolidation pressure (Duraisamy et. al, 2007)

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology for this research study. The types of soil used was peat soil. The soil sample was obtained using two different type of sampling technique which is modified; Tropiter and conventional; tube sampler sampling technique.

The focus for this research study was to identify the performance of modified sampling technique in reducing disturbance of peat soil sample. The main test which was used to conduct the research study was the one consolidation test. The sample was taken at Indera Sempurna located at Pekan, Pahang at the depth of 0.3m. The sample then underwent one consolidation test which also known as Oedometer test based on BS 1377: Part 5: 1990: Clause 3. The test was conducted to identify the performance of modified sampling technique in reducing disturbance of peat soil sample. The degree of disturbance of the sampler needs to be calculated first in order to get the accurate result. However, before conducting the one dimensional test, several test was conducted in order to identify the physical properties and characteristics of the soil. The physical properties test conducted was moisture content, organic and fiber content of the soil, and the particle size distribution. Only then, the result obtained from modified and conventional sampler was compared with the in-situ result and also previous research data.

3.2 Operational Framework

In order to ensure the smoothness of the research study, a specific methodology was designed as in flowchart as shown in Figure 3.1.

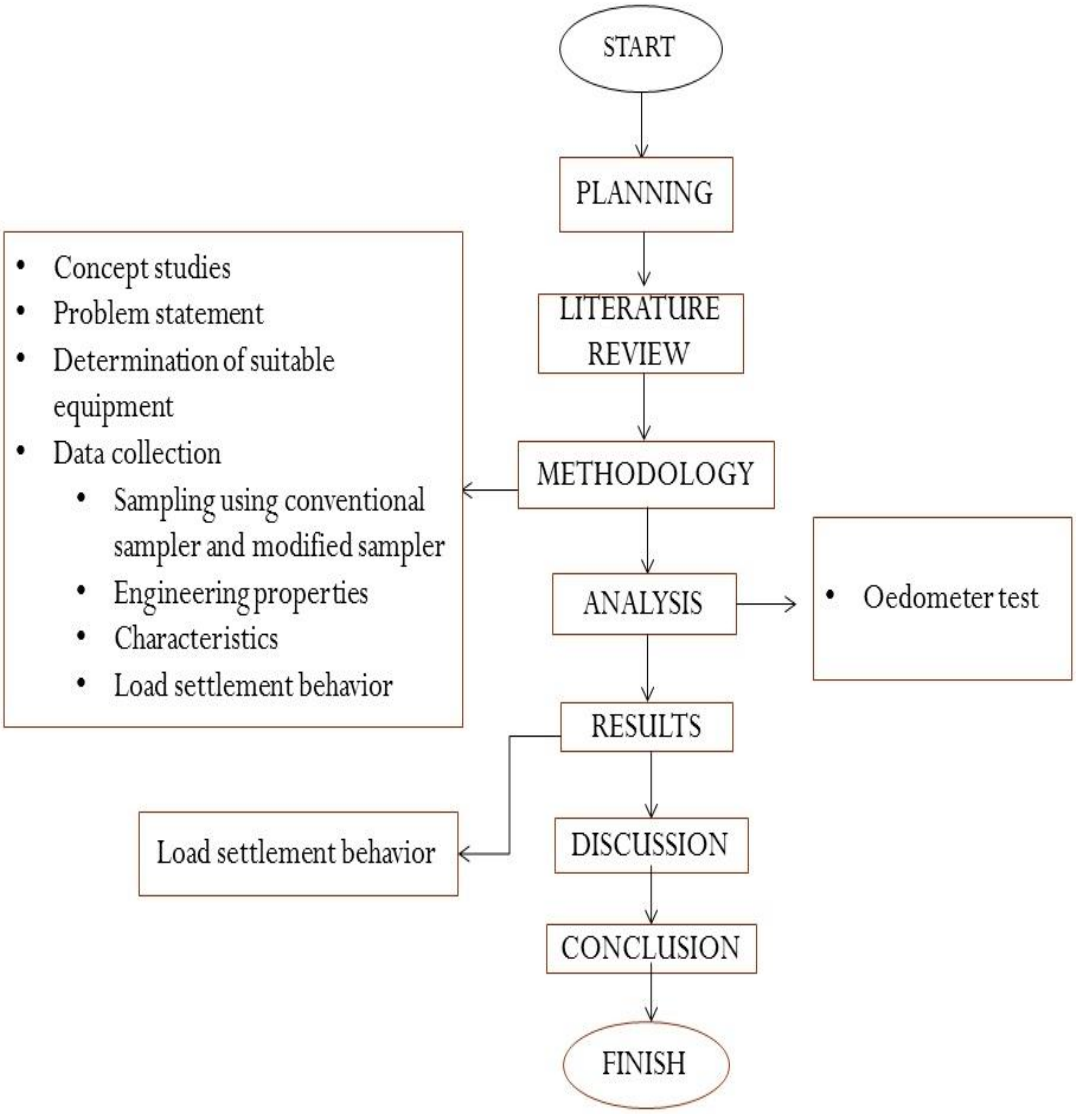


Figure 3.1 Framework for research methodology

3.3 Types of Sampler Used

In this research study, there were two main types of soil sampler used to obtain the undisturbed peat soil sample which was the modified sampler (Tropiter) and conventional tube sampler. For obtaining the controlled data, ring from the consolidation apparatus was used to obtain the sample and tested using oedometer as a representative for in-situ result (Figure 3.2).

Figure 3.2 Representative for in-situ

3.3.1 Tropiter

Tropiter (Figure 3.3) was the modified samplers invented in 2009 with patent number: MY-156990-A that was used to obtain the undisturbed peat soil sample. Before the research conducted, the Tropiter is predicted to have a good performance in obtaining undisturbed soil sample that are close to real situation. As the research completed, Tropiter showed a good performances in obtaining undisturbed peat soil sample with less disturbances. Below was the detail on the Tropiter:

Table 3.1 Details on Tropiter

Characteristic	**Measurement**
Area Ratio	23%
Taper Angle	7˚
Internal Diameter	54 mm
External Diameter	60 mm
Sampler Length	145 mm
Wall Thickness	3 mm

Figure 3.3 Tropiter

3.3.2 Conventional Tube Sampler

Tube sampler (Figure 3.4) was the conventional tube sampler used to obtain soil sample. For this research study the tube sampler was used to be compared with the Tropiter because tube sampler is what is commonly used in obtaining the soil sample and often to have several problems because the degree of disturbance is high. The tube sampler showed it has low performance than the Tropiter. Below was the detail on tube sampler:

Table 3.2 Details on Tube Sampler

Item	Measurement
Area Ratio	37%
Internal Diameter	64 mm
External Diameter	75 mm

Figure 3.4 Tube Sampler

3.4 Degree of Disturbance of Soil Sampler

One of the main contributions in this research study is to identify the degree of disturbance for both type of soil sampler. As mention earlier, types of soil sampler used in this study is Tropiter and conventional tube sampler. Design of soil sampler was important to obtain a good quality of undisturbed soil sample. Then, the classification of the soil sampler was based on Eurocode 7 Part 3: 2000 Clause 12.3.2.4 (5). Below was the formulae calculation on the degree of disturbance:

$$A_r(\%) = \frac{D_o^2 - D_i^2}{D_i^2}(100)$$

3.5 Method for Preparing Samples

Soil samples were taken from study site at Pekan, Pahang. The soil sample taken was peat soil and it was taken as undisturbed sample. The soil sample was collected by 2 different types of sampler which was modified soil sampler and conventional soil sampler. The significant of using 2 different type of sampler was to identify both of the soil sampler performances in obtaining undisturbed peat soil sample.

The undisturbed soil sample was taken at the depth of 0.3m using conventional tube sampler of 75 mm-diameter was pushed slowly into the peat soil (Figure 3.5) After several minutes, the conventional tube sampler was then taken out slowly and the sample inside was sealed using wax. Then, the Tropiter with 60mm external diameter was driven into the peat soil to obtain the sample and carefully driven out after obtaining the sample (Figure 3.6). The sample was then sealed using wax to preserve the moisture content of the peat soil sample.

Figure 3.5 Soil sample obtained using conventional tube sampler

Figure 3.6 Soil sample obtained using Tropiter

3.6 Preliminary Test

The purpose of preliminary test was to identify the physical and chemical properties of the soil and the soil classification. Firstly, before conduct any further research on the peat soil, their characteristic and properties was very important to understand the behavior so that the peat soil was not being underestimate or overestimate on its strength.

3.6.1 Physical and Chemical Properties

Several fundamental tests was conducted to obtain the physical and chemical properties of peat. The water content was measured in the laboratory by oven dry in an oven for 24 hours at 50 to 95 degree Celsius in case of peat accordance to BS1377: Part 2: 1990 clause 3.

For specific gravity of the soil, the test can be tested in accordance to BS1377: Part 2: 1990 clause 8.3 which tested using kerosene. The initial void ratio can be calculated based on the water content and the value of specific gravity. On the other hand, the test conducted for organic content was accordance to BS1377: Part 3: 1990 clause 3. The details of all tests are listed in Table 3.1.

Table 3.3 List of physical tests with different standard

Number	Test	Standard
1	Degree of humification	Van Post degree of humification
2	Moisture Content	BS1377: Part 2: 1990 clause 3
3	Specific Gravity	BS1377: Part 2: 1990 clause 8.3
4	Organic Content	BS1377 : Part 3: 1990 clause 3
5	Oedometer Test	BS1377: Part 5: 1990 clause 3

3.6.2 Classification

An early stage and easiest way to classify peat soil through visual inspection was based on Van Post degree of composition. The degree of decomposition was range in H1 to H10 in the Van Post System (Table 2.4 in Chapter 2). The peat soil is determined based on the appearance of soil water that was extruded after the soil is squeezed in hand. The sieve analysis was done to identify the fiber content in the soil that are retained in sieve no. 100 sieve (sieve opening more than 0.15 mm opening size) using the oven dried peat soil.

3.7 Laboratory Testing

3.7.1 One Dimensional Test

Purpose of this test was to determine the compression index, coefficient of consolidation, coefficient of volume compressibility and void ratio. From the measured data, the consolidation curve (pressure-void ratio relationship) can be plotted.

The one dimensional test also known as Oedometer test was conducted using the soil sample taken from the study site at Indera Sempurna, Pekan, Pahang. All together they were 3 soil sample taken at shallow depth of 0.3m. The undisturbed samples were taken for One Dimensional Test which was based on BS 1377: Part 5: 1990: clause 3. The consolidation apparatus can be referred in Figure 3.7. At first, the soil sample taken using the ring from consolidation cell was tested using One Consolidation test. The applied load during loading stage is 250g, 500g, 1kg and 2 kg. For unloading stage, the load is 500g and 125g. Load duration for each increment was the same and equal to 24 hours.

Figure 3.7 One dimensional test apparatus

The procedure for the consolidation test was listed as below:

1. Soil specimen was prepared for the test. The sample was prepared by trimming an undisturbed peat soil sample obtained from the sampler.
2. Collected excess soil that has been trimmed was put into the container for moisture content determination.
3. Weighed the consolidation ring (W1).
4. The soil specimen is placed into the consolidation ring. The trimmer is used to remove the excess sample and smoothen it so that the top and bottom is flattened according to the heights of the consolidation ring.
5. The weight of consolidation ring with the specimen inside was determined. It was recorded as W2.
6. The soil specimen was placed in the ring over the lower porous stone. Then the upper porous stone was placed on the specimen ring.
7. The consolidation ring with sample inside the consolidation cell was cured inside water bath for 24 hours.
8. After 24 hours, the consolidation cell was attached to the base of the consolidometer.
9. Water was added to the consolidometer to submerge the soil sample and to keep it saturated.
10. Make sure the indicator touch the top of the consolidation cell.
11. Next, make sure the lever arm is in straight horizontal position.
12. All the data recorded is keyed into the ELE International software.
13. At loading stage, place 250g, 500g, 1000g and 2000g. Then for unloading stage, place 500g and 125g with load duration for each increment is 24 hours.
14. At the end of the test, remove the soil specimen and determine its moisture content.

3.8 Assumptions and Limitations

They were several limitations when conducting the research study. The soil sample was taken at shallow depth of 0.3 m. This research study was limited to use only two types of sampler which was the modified and conventional sampler. The parameter used for this study was degree of disturbance of soil sampler, coefficient of volume compressibility, coefficient of consolidation and void ratio. Due to limitation of time and apparatus, the load duration for each loading and unloading was 24 hours only.

Besides that, due to difficulty in using the plate load test to obtain the in-situ settlement resulting from the consolidation cell was used to obtain the undisturbed sample and test using One Dimensional test to represent as the in-situ result and the control data for this research study.

3.9 Research Planning and Schedule (Gantt Chart)

Research planning in this study was divided into 3 phases, which is data collection phase, Analyzing the data phase, and finalizing.

3.9.1 Data Collection Phase

Table 3.4 Data collection phase

NO.	ACTIVITY	DURATION	START	FINISH
1.	Introduction to Final Year Project	1 week	Mon 7/9/15	Mon 14/9/15
2.	Brainstorming topic	2 week	Tue 15/9/15	Tue 29/9/15
3.	Prepare short proposal	1 week	Wed 30/9/15	Wed7/10/15
4.	Collect references and journal	2 week	Thu 8/10/15	Thu 22/10/15
5.	Prepare experimental framework	1 week	Fri 23/10/15	Fri 30/10/15
6.	Understand types of test on peat soil	2 weeks	Mon 2/11/15	Mon 16/11/15
7.	Literature Review	2 weeks	Tue 17/11/15	Tue 1/12/15
8.	Field test and taking soil sample	1 week	Wed 2/12/15	Wed 9/12/15
9.	Laboratory Test	7 weeks	Thu 10/12/15	Thu 25/2/16
10.	Preparation and Presentation	4 weeks	Mon 7/12/15	Mon 21/12/15

3.9.2 Analyzing Data Phase

Table 3.5 Analyzing data phase

NO.	ACTIVITY	DURATION	START	FINISH
1.	Analyzing the result	2 weeks	Mon 15/2/16	Mon 29/2/16
2.	Identifying the problem	1 week	Mon 22/2/16	Mon 29/2/16
3.	Evaluation	2 weeks	Tue 1/3/16	Tue 15/3/16

3.9.3 Finalizing Phase

Table 3.6 Finalizing phase

NO.	ACTIVITY	DURATION	START	FINISH
1.	Tabulation of result	1 week	Wed 16/3/16	Wed 23/3/16
2.	Discussion & conclusion	1 week	Thu 24/3/16	Thu 31/3/16
3.	Summary	2 weeks	Fri1/4/16	Fri 8/4/16
4.	Report completion	10 weeks	Wed 16/3/16	Wed 25/5/16

3.9.4 Summary Gantt Chart for Overall Phase

Table 3.7 Research planning and schedule (Gantt Chart)

No.	Activities	2015				2016						
		9	10	11	12	1	2	3	4	5	6	7
1	Preparation	■	■	■								
2	Literature Review		■	■	■	■	■	■	■			
3	Sample Preparation				■							
4	Laboratory Test				■	■	■	■	■	■		
5	Research proposal preparation presentation			■	■							
6	Analyzing the result				■	■	■	■	■			
7	Identifying the problem						■					
8	Evaluation							■	■	■		
9	Tabulation of Result							■	■	■		
10	Discussion and conclusion							■	■	■	■	
11	Project presentation									■		
12	Report Completion					■	■	■	■	■	■	■

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter it was about results and discussion which follow the objectives of the research study mentioned in Chapter 1. All the data and result conducted in laboratory was presented and discussed in this chapter, so that the objectives of the study can be achieved. The sample taken was undisturbed sample and the main laboratory test conducted for this research study was one dimensional test which also known as Oedometer test. Both of the samples taken from two types of sampler which underwent several laboratory tests.

However, before conducting the main test, the physical and engineering characteristics of the peat soil need to be known. Hence, in section 4.2, all presented data and result collected based on the laboratory test conducted for soil identification. The importance to study and identify the physical and characteristics of the peat soil was to have a better understanding about peat soil and the reason why it was known to be a problematic soil. The classification of the peat soil regarding the organic and fiber content was presented in section 4.3

In section 4.4 the degree of disturbance of the peat soil sampler was presented. Types of soil sampler used in obtaining the undisturbed peat soil sample was Tropiter and the conventional tube sampler. The degree of disturbance based on the area ratio was being compared for both types of soil sampler. Moreover, the design of soil sampler was very important in order to produce a good quality of peat sample. The design of soil sampler was one of the factors that will affect the quality of the soil sample.

In section 4.5, the main analysis of the research study was presented. The main focus of this study was to identify the performance of modified sampling technique in reducing disturbance on peat soil sample. Then, the results from both types of sampler was being compared to the in-situ result and also based on previous similar research study. In order to compare the performance, results from one consolidation test was used to produce the load settlement curve.

Besides that, from the consolidation test, the value of coefficient volume compressibility and coefficient of consolidation was also known. The graph voids ratio versus applied pressure was automatically generated from the test using BS 1377: Part 5: 1990: Clause 3.

4.2 Soil Identification

All the results on the fundamental of the peat soil were tabulated in Table 4.1 and also several comparisons from published data. They were many previous researches regarding the basic properties of the soil. However, peat soils are different according to its location and it may have similarity and differences as well. For this research study, peat soil sample was taken at Indera Sempurna, Pekan at the state of Pahang. For the particle size distribution, the soil sample underwent sieve analysis in dry state (Figure 4.1).

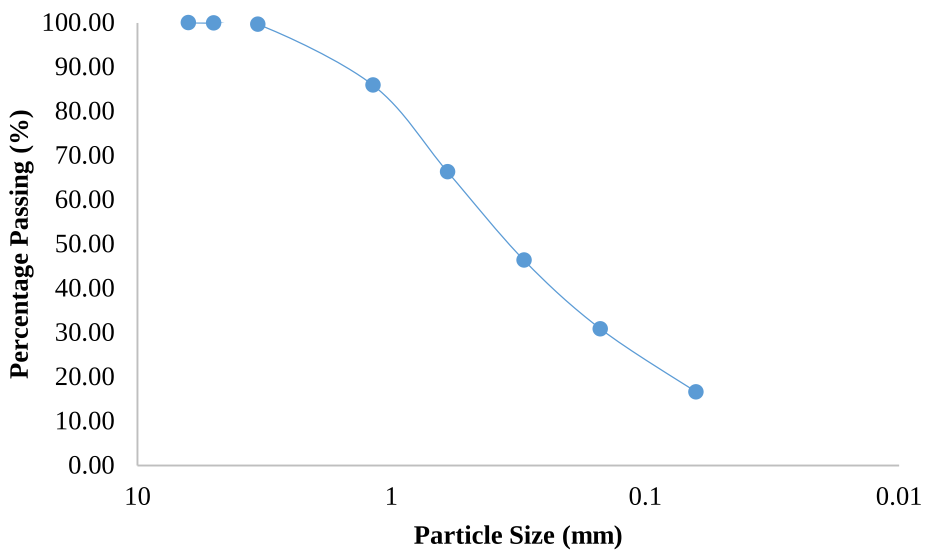


Figure 4.1 Particle size distribution curve of peat (dry state)

Table 4.1 Basic properties of peat soil

Properties	Results	Published Data
Moisture Content (%)	362.12	200-700 (Huat 2004)
pH Value	4.4	3.0-4.5 (Muttlib et al 1991)
Specific Gravity	1.91	1.3-1.9 (Huat 2004)
Unit Weight (kN/m^3)	12.82	8.3-11.5 (Huat 2004)
Liquid Limit (%)	166.7	150-400 (Duraisamy 2007)
Dry Unit Weight (kN/m^3)	166.7	
Optimum Water Content (%)	39.0	

The water content was 362.12% which was very high because peat soil has a high water-holding capacity making it watery and muddy. The specific gravity was obtained using kerosene on pycnometer test was 1.91 and it was within the range (Table 4.1). The pH value was 4.4 (Figure 4.2) and the liquid limit was 166.7%. For liquid limit it was calculated based on the organic content using the formula of LL = 0.5 + 5.0OC because in general the liquid limit of peat increases with increase in organic content. However, the unit weight was slightly higher than the previous research by Huat 2004 based on the Table 4.1. The dry unit weight was 17 kN/m^3 with 39.0 % optimum water content. Both of the properties were obtained from Standard Proctor Test.

Figure 4.2 Reading for pH value

4.3 Classification

At early stage, the peat soil in this research study was classified based on the degree of humidification which was also known as Van Post scale method. It was the easiest way to distinguish the peat soil using visual inspection. The peat soil was squeezed in the hand and the brown water came out from the soil and the fiber can be clearly seen, then the peat was classified with H3 according to Van Post scale (Figure 4.3)

Figure 4.3 Van post scale method

Based on the Table 4.2, we can conclude that the peat soil was slightly different from other peat soil in Peninsular Malaysia. The organic and fiber content was not very high which only 33.24% and 30.54% respectively. It was because the soil sample is taken at shallow depth of 0.3 m only. Hence, the decomposition of the peat soil was not fully completed as it was still new and fresh. However, if the sample taken much deeper, the characteristics especially on the organic and fiber content will be more high and significant.

Table 4.2 Summary on classification of peat soil

Parameters	Results	Published Data
Van Post Scale	H3	H1-H4 (Van Post 1992)
Moisture Content (%)	362.12	200-700 (Huat 2004)
Fiber Content (%)	33.24	more than 20 (Molenkamp 1994)

4.3 Degree of Disturbance of Soil Sampler

One of the important parts in this research study was to identify the degree of disturbance of the soil sampler. There were two types of soil sampler used in obtaining the undisturbed peat soil sample which was Tropiter and conventional tube sampler. Based on Eurocode 7 Part 3: 2000, Tropiter, the modified sampler was categorized in category A, B and C. It was used to obtain the soil sample at shallow depth. Based on the Table 4.3, shows that the Tropiter have fewer disturbances than the conventional tube sampler by having area ratio 23% which less than 30%.

Table 4.3 Degree of disturbance

Type of Sampler	Degree of Disturbance (%)
Tropiter	23<30
Tube Sampler	37.33

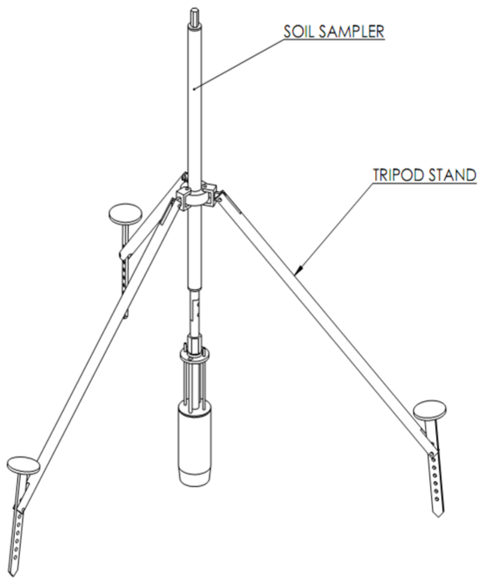


Figure 4.4 Tropiter

4.4 One Dimensional Test

Three samples were used for the One Dimensional test according to the standard procedure outlined in BS 1377 Part 5. The test was carried out to identify the consolidation of peat soil sample. Each sample has a thickness of 20 mm, a diameter of 50 mm, and was subjected to consolidation pressure. The pressure applied to the soil sample was 12.5 kPa, 25.0 kPa, 50 kPa and 100 kPa. For each incremental load duration is equal to 24 hours. From the consolidation test, the value of coefficient volume compressibility and coefficient of consolidation was also known.

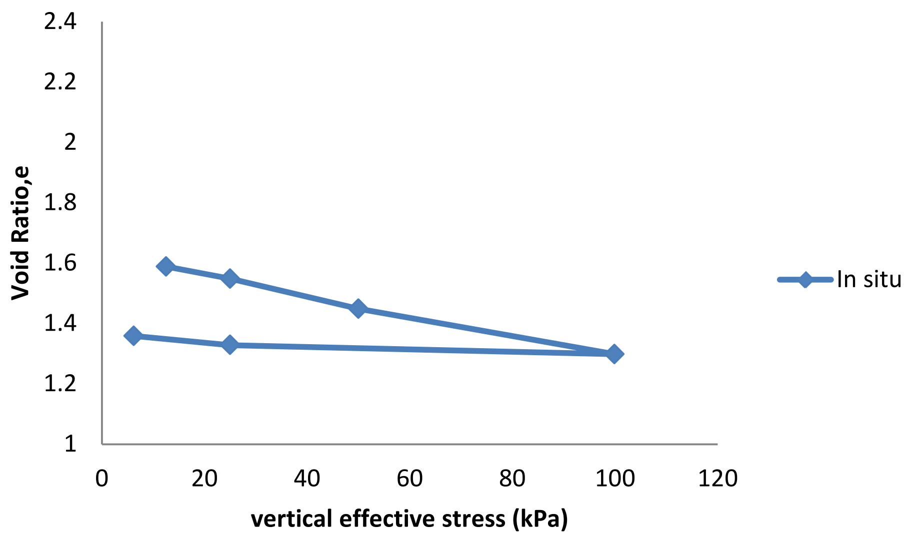
Based on Table 4.4, the consolidation of peat soil does not require a long time to consolidate. From the in-situ result, the coefficient of consolidation was higher because it resembles the actual result on field where the peat was still fresh and undisturbed. From there, it was very true that peat soil was indeed known to be a problematic soil because based on the consolidation rate, peat soil is not suitable for any type of construction for foundation.

Table 4.4 Result from consolidation test

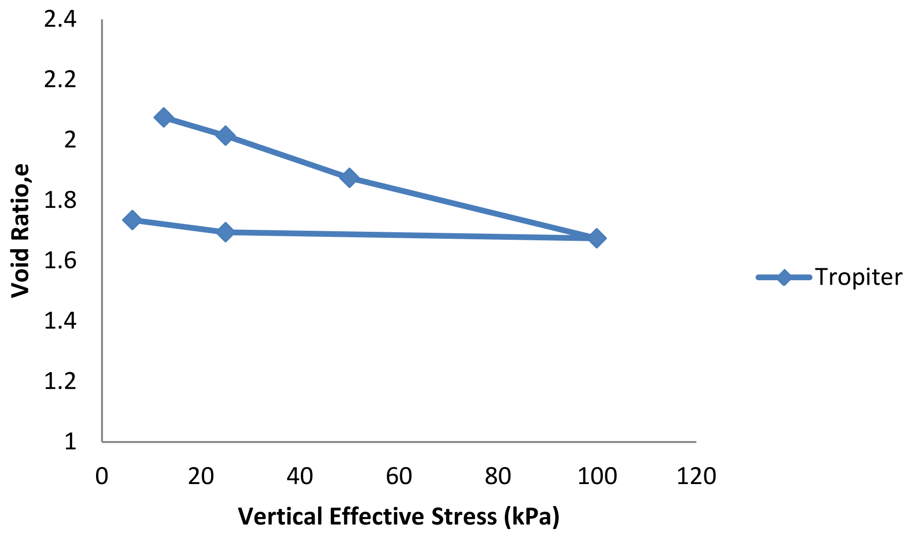
Pressure (Loading Stages) (kPa)	Type of Sampler					
	In-situ		Tropiter		Conventional Tube	
	m_v (m2/MN)	c_v (m2/yr)	m_v (m2/MN)	c_v (m2/yr)	m_v (m2/MN)	c_v (m2/yr)
12.5	1.07	10.67	3.24	5.03	2.08	2.78
25	1.41	13.55	1.86	6.33	1.71	3.84
50	1.54	8.76	1.82	4.33	2.1	3.59
99.9	1.23	8.16	1.38	4.95	1.37	3.48
25	0.13		0.16		0.16	
6.2	0.78		0.56		0.69	

4.4.1 Analysis of Voids Ratio versus Applied Pressure Graph

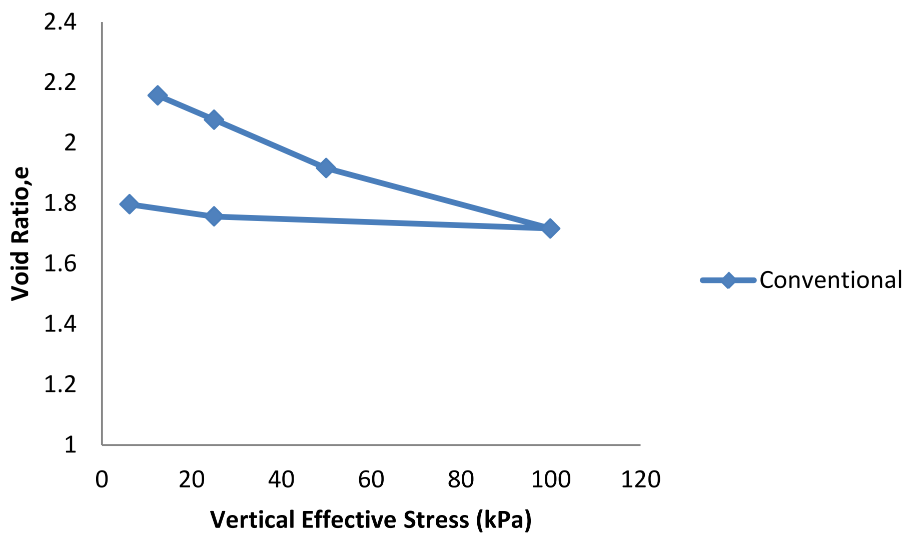
The voids ratio versus applied pressure was automatically obtained from the consolidation test. The comparison was made based on two types of sampler with the in-situ result. Based on Figure 4.5, results from in-situ shows lower void ratio than the soil sample taken using the Tropiter and conventional tube sampler. Besides that, both of the soil sampler graphs were quite far from the in-situ. However, comparing the tube sampler, the Tropiter produced closed results with the in-situ.



(a)



(b)



(c)

Figure 4.5 Voids Ratio Vs Applied Pressure Graph from (a) In-situ, (b) Tropiter, (c) Tube Sampler

4.4.2 Analysis of Load Settlement Curve

In this research study, the load settlement curve was obtained from the settlement formulae. The load settlement curve was used to estimate the strength of the soil which gives important information for the foundation engineer. Based on Table 4.5, it shows that peat soil was high in settlement. Thus, soil stabilization was needed for peat soil in order for it to be suitable for construction on foundation.

Besides that, based on the comparison made from Figure 4.6, it shows that Tropiter able to produce closed result with the in-situ. Thus, based on the objective, the performance of the modified soil sampler which was Tropiter, performed better than the conventional soil sampler.

Table 4.5 Settlement of peat soil

Load (kg)	**Settlement (mm)**		
	Tropiter	**Conventional Tube Sampler**	**In-situ**
0	0	0	0
0.375	0.39	0.507	0.309
0.75	0.929	1.04	0.785
1.5	1.392	1.372	1.392
1.25	-0.748	-0.295	-0.748
0.3125	-0.297	-0.29	-0.258

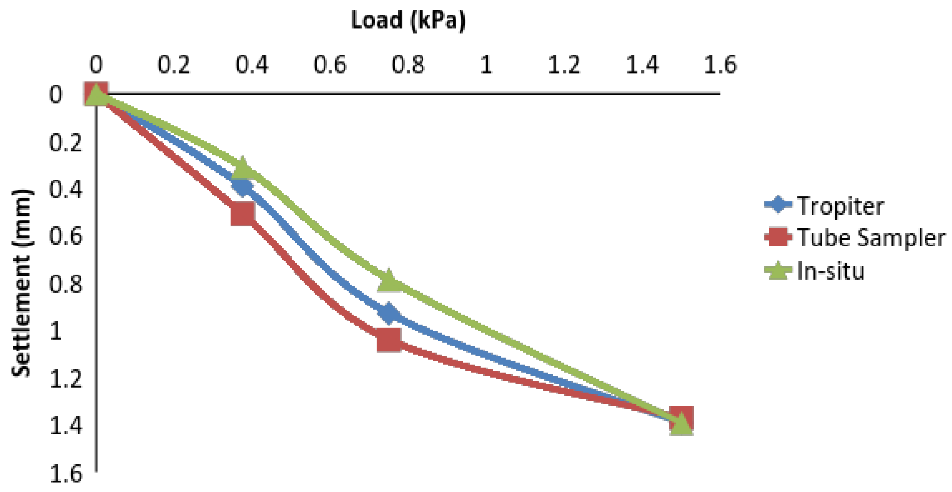


Figure 4.6 Load settlement curve

4.4.3 Summary

The summary from the degree of disturbance, the voids ratio vs applied pressure and the consolidation parameters obtained from three Oedometer test results including the coefficient of consolidation (c_v), coefficient of volume compressibility (m_v), and being compare to publish data was summarized in Table 4.6.

The coefficient of consolidation from in-situ, Tropiter and Tube sampler was 13.55 m2/yr, 6.33 m2/yr and 3.84 m2/yr respectively. Moreover, the coefficient of volume compressibility from in-situ, Tropiter and Tube sampler was 1.41 m2/MN, 1.86 m2/MN and 1.71 m2/MN respectively.

Based on the result, it shows peat soil have high rate of consolidation and settlement. Hence, peat soil is not suitable for any types of construction and it needs soil stabilization. Besides that, soil sample obtained from Tropiter have fewer disturbances because able to produce a closed result with the in-situ result.

Table 4.6 Summary result

Parameter	Type of Sampler			Published Data
	In-situ	Tropiter	Tube Sampler	
Coefficient of Consolidation (Cv)	13.55 m2/yr	6.33 m2/yr	3.84m2/yr	13.5 - 0.064 (Johari 2012)
Coefficient of Volume Compressibility (mv)	1.41 m2/MN	1.86m2/MN	1.71m2/MN	3.824 - 0.590 (Johari 2012)
Void Ratio (min)	1.298	1.674	1.716	
Void Ratio (max)	1.598	2.074	2.136	
Compression Index (Cc)	0.8	1.4	1.5	1-3 (Duraisamy 2009)
Degree of Disturbance	-	23%	37.33%	

CHAPTER 5

CONCLUSION AND RECOMMENDATION FOR FUTURE STUDY

5.1 Conclusions

For the conclusion the peat soil sample taken at Indera Sempurna, Pekan at the state of Pahang was a sapric peat based on its organic and fiber content. The peat soil indeed has high water content which was 362.12%. They are similarities and also differences on the physical and characteristics of the pet soil by comparing it from previous research study. However, the differences is caused by different location and also depends on the depth of the peat soil is taken.

The first specific objective of the study was to determine the degree of disturbance of the peat soil sampler. It is found that, Tropiter have less degree of disturbance compared to the conventional tube sampler. The degree of disturbance for Tropiter is 23% and 37.33% for tube sampler.

For the final objective was to find the load settlement curve of peat soil sample obtained from both modified and conventional types of sampler using one consolidation test. Based from the load settlement curve, once again it proves the Tropiter performed better than the conventional sampler because it able to produce results closer to in-situ.

5.2 Recommendation for Future Study

The aim for this research study was to identify the performance of the modified sampling technique in reducing disturbance on peat soil sample. Based on the result, it proves Tropiter shows good performances in obtaining undisturbed soil sample that was close to in-situ result.

Thus, as for the recommendation, the usage of Tropiter as a sampler to obtain undisturbed soil sampler should be encouraged so that the usage is more extensive in geotechnical area. Based on the research, the Tropiter is able to obtain a good quality of peat soil sample and the results are reliable for engineers to use for any soil stabilization. Usually they are many problems in obtaining undisturbed peat soil sample. Thus, engineers might face problem such as underestimating or overestimating the strength of peat soil. Hence, Tropiter was a recommended tool for sampling.

REFERENCES

Al-Ani, H., Oh, E. and Chai G. (2013). International Journal of Geomate. Characteristics of Embedded Peat in Coastal Environments, 610-619.

American. (1994). Annual Book of ASTM Standard. Vol. 04.08 and 04.09.

British Standards Instituion (1981). Methods of Test for Soil for Civil Engineering Purposes. London, BS 1377.

Boylan, N. and Long, M. (2012). Insitu Testing of Peat - A review and Update on Recent Development. Geotechnical Engineering Jurnal of SEAGS & AGSSEA, 43 (4), 41-55.

Bujang B.K Huat, A. P. (2014). Geotechnics of Organic Soils and Peat. New York: CRC Press.

Carter, M. R. (1993). Soil Sampling and Methods of Analysis. USA: Lewis Publishers.

CIDB Malaysia. (2015). Guidelines for Construction on Peat and Organic Soils in Malaysia. Contruction Research Institute of Malaysia (CREAM).

Das, B. M. (2016). Principles of Foundation Engineering (8 ed.). Boston: Cengage Learning.

Deghanbanadaki, A., Arefnia, A., Azrin, Ahmad K., Motamedi, S. and Hashim, R. A. (2015). Bull Engineering Geology Environment. Evaluating the compression index of fibrous peat treated with different binders. Springer Verlag Berlin Heidelbeg

Duraisamy, Y., Huat B. B. K. and Aziz A. A. (2007). Engineering Properties and Compressibility Behavior of Tropical Peat Soil. American Journal of Applied Sciences, 4 (10), 768-773.

Duraisamy Y, B. B. (2009). Geotechnical and Geological Engineering. Compressibility Behaviour of Fibrous Peat Reinforced with Cement Columns, 93-110.

Eurocode 7 (2000). Geotechnical Design Part 3: Design Assisted by Fieldtesting. Europe: CEN.

Gilbert, P. A. (1992). Effect of Sampling Disturbance on Laboratory - Measured Soil Properties. Washington: US Army Corps of Engineers.

Gofar, N. (2006). Determination of Coefficient of Rate of Horizontal Consolidation of Peat Soil. Faculty of Civil Engineering Universiti Teknology Malaysia.

Huang, P. T., Patel, M., Caterina, M. and Bobet, A. (2009). Classification of Organic Soils. School of Engineering Purdue University.

Huat, B. B. K. (2006). Pertanika Jornal Science & Technology. Deformation and Shear Strength Characteristics of Some Tropical Peat and Organic Soils, 14 (1 & 2), 61-74.

Jarrett, P. (1982). Testing of Peat & Organic Soils. Toronto, Canada: ASTM Special Technical Publication 820.

Kadir, M. I. (2009). Long Term Consolidation Study On the Tropical Peat at Pekan, Pahang, Malaysia. Faculty of Civil Engineering & Earth Resources Universiti Malaysia Pahang.

Kalantari, B. (2013). Global Journal of Researches in Engineering Civil and Structural Engineering. Civil Engineering Significant of Peat, 13(2), 1-5

Katapa, K. (2011). Undisturbed Sampling of Cohesionless Soil for Evaluation of Mechanical Properties and Micro-structure. Arizona State University.

Landva, A. L. (1983). Compressibility and Shear Characteristics of Radforth Peats. Testing of Peat and Organic Soils, 157-191.

Lin, T. B. (2011). Revitalisation of Organic and Peat Soils. Faculty of Civil & Environmental Engineering Universiti Tun Hussein Onn Malaysia.

Mariappan, A. (2004). One Dimensional Consolidation of Modified Peat Soil. Faculty of Engineering Universiti Malaysia Sarawak.

Mitsuru Osaki, N. T. (2016). Tropical Peatland Ecosystem. Sapporo, Japan: Springer.

Wong Leong Sing, R. H. (2008). Elecronic Journal of Geotechnical Engineering. Compression Rates of Untreated and Stabalized Peat Soils, 13, 1-13.

Wetlands International Malaysia. (2010). A Quick Scan of Peatlands in Malaysia. Project Funded by Kleine Natuur Initiatief Projecten.

Yulindasari. (2006). Compressibility Characteristics of Fibrous Peat Soil. Faculty of Civil Engineering Universiti Teknologi Malaysia.

APPENDIX A

INDEX TEST DATA

1. Particle Size Distribution

Table A1: Sieve Analysis Data

Sieve Size (mm)	Mass of Sieve (g)	Mass of soil retained +sieve (g)	Mass of Soil (g)	Cumulative Mass of Soil Retained (g)	Percentage Finer (%)	Percentage Retained (%)
6.3	515.75	515.78	0.03	0.03	99.99	0.01
5.0	524.93	525.32	0.39	0.42	99.92	0.08
3.35	542.36	543.69	1.33	1.75	99.65	0.35
1.18	427.62	496.94	69.32	71.07	85.90	14.10
600um	484.06	582.77	98.71	169.78	66.31	33.69
300um	448.32	548.87	100.55	270.33	46.35	53.65
150um	422.94	501.01	78.07	348.40	30.86	69.14
63um	258.00	329.80	71.80	420.20	16.61	83.39
pan	365.55	449.24	83.69	503.89	0.00	100.00

Table A2: Organic content for untreated peat soil

sample	mass of crucible (g)	mass of crucible + dried sample (g)	mass of crucible + ignition sample (g)	loss on ignition (%)
1	69.43	80.71	76.96	33.24
2	86.13	100.11	95.64	31.97
3	71.26	87.17	82.25	30.92
4	71.45	83.17	79.41	32.08

Table A3: Results for natural moisture content for untreated peat soil

container no	1	2	3	4	5	6	7	8
mass of container (g)	9.91	10.12	10.16	10.13	9.82	9.72	10.48	9.65
mass of wet soil + container (g)	49.74	50.32	48.41	45.45	41.31	35.83	51.15	32.68
mass of dry soil + container (g)	20.39	24.79	23.24	21.85	20.59	15.37	24.04	16.48
mass of wet soil (g)	39.83	40.2	38.25	35.32	31.49	26.11	40.67	23.03
mass of dry soil (g)	10.48	14.67	13.08	11.72	10.77	5.65	13.56	6.83
moisture content (%)	280.06	174.03	192.43	201.37	192.39	362.12	199.93	237.19

Table A4: Specific gravity

Test No.	Unit	Label	X			
			2/2/2016	3/2/2016	03-02-2016(b)	4/2/2016
Weight of Density Bottle	g		26.80	26.80	26.80	26.80
Weight of Bottle+Stopper	g	W1	31.92	31.92	31.92	31.92
Weight of Bottle+Stopper+Dry Soil	g	W2	38.00	38.00	38.00	38.00
Weight of Bottle+Stopper+Soil+Wate	g	W3	115.10	115.30	115.28	115.34
Weight of Bottle+Stopper+Water	g	W4	111.60	111.60	111.60	111.60
Weight of Dry Soil	g	W2-W1	6.08	6.08	6.08	6.08
Weight of Water	g	W4-W1	79.68	79.68	79.68	79.68
Weight of Water Used	g	W3-W2	77.10	77.30	77.28	77.34
Specific Gravity			2.36	2.55	2.53	2.60
Specific Gravity			1.91	2.07	2.05	2.10
Test No.	Unit	Label	Y			
			2/2/2016	3/2/2016	03-02-2016(b)	4/2/2016
Weight of Density Bottle	g		26.90	26.90	26.90	26.90
Weight of Bottle+Stopper	g	W1	32.17	32.17	32.17	32.17
Weight of Bottle+Stopper+Dry Soil	g	W2	38.23	38.23	38.23	38.23
Weight of Bottle+Stopper+Soil+Wate	g	W3	115.30	115.54	115.54	115.58
Weight of Bottle+Stopper+Water	g	W4	111.85	111.85	111.85	111.85
Weight of Dry Soil	g	W2-W1	6.06	6.06	6.06	6.06
Weight of Water	g	W4-W1	79.68	79.68	79.68	79.68
Weight of Water Used	g	W3-W2	77.07	77.31	77.31	77.35
Specific Gravity			2.32	2.56	2.56	2.60
Specific Gravity			1.88	2.07	2.07	2.11
Test No.	Unit	Label	Z			
			2/2/2016	3/2/2016	03-02-2016(b)	4/2/2016
Weight of Density Bottle	g		27.58	27.58	27.58	27.58
Weight of Bottle+Stopper	g	W1	32.66	32.66	32.66	32.66
Weight of Bottle+Stopper+Dry Soil	g	W2	38.74	38.74	38.74	38.74
Weight of Bottle+Stopper+Soil+Wate	g	W3	115.53	115.72	115.7	115.82
Weight of Bottle+Stopper+Water	g	W4	111.99	111.99	111.99	111.99
Weight of Dry Soil	g	W2-W1	6.08	6.08	6.08	6.08
Weight of Water	g	W4-W1	79.33	79.33	79.33	79.33
Weight of Water Used	g	W3-W2	76.79	76.98	76.96	77.08
Specific Gravity			2.39	2.59	2.57	2.70
Specific Gravity			1.94	2.10	2.08	2.19

Table A5: Standard proctor test result

water content	20%		25%		30%		35%		40%		50%	
mass of mould + base(m1)	4.073		4.073		4.073		4.073		4.073		4.073	
mass of mould + base + compacted specimen (m2)	5.192		5.308		5.425		5.53		5.55		5.506	
mass of compacted specimen (m2-m1)	1.119		1.235		1.352		1.457		1.477		1.433	
bulk density, p=(m2-m1)/V	1129.62		1246.72		1364.83		1470.83		1491.02		1446.60	
container no.	5C	82C	11C	25C	6C	35C	59C	108C	39C	68C	73D	99C
container weight	10	9.95	9.79	10.02	10.15	9.85	9.63	9.78	10.95	9.27	9.88	9.8
wet soil + container	22.86	29.8	28.25	31.53	36.38	35.67	36.92	46.26	52.32	51.07	72.35	67.6
wet soil (Ww)	12.86	19.85	18.46	21.51	26.23	25.82	27.29	36.48	41.37	41.8	62.47	57.8
Dry soil + container	20.61	26.38	24.48	27.15	30.13	29.56	29.66	36.6	37.9	38.98	50.97	47.95

Dry soil (Wd)	10.61	16.43	14.69	17.13	19.98	19.71	20.03	26.82	26.95	29.71	41.09	38.15
Moisture content	21.21	20.82	25.66	25.57	31.28	31.00	36.25	36.02	53.51	40.69	52.03	51.51
Average moisture content	21.01		25.62		31.14		36.13		47.10		51.77	
Dry density (pd)	933.48		992.48		1040.74		1080.44		1013.61		953.15	
Dry unit weight (Yd)	9.16		9.74		10.21		10.60		9.94		9.35	

APPENDIX B

Eurocode 7 Part 3: 2000 Clause 12

12 SOIL SAMPLING

12.1 General

(1)P The aim of soil sampling is to obtain samples for soil identification and for laboratory testing to determine geotechnical properties of the ground.

(2) Important soil properties needed in geotechnical design are strength and deformation properties. In the laboratory these properties can be obtained reliably only from high quality undisturbed samples, representative of each soil layer. From granular materials it is possible to obtain undisturbed samples only using special methods not covered in this section. Strength and deformation properties of these soils are usually supported by in-situ tests and confirmed by disturbed samples. Soil classification properties may be obtained also from disturbed samples.

(3) Commonly used laboratory tests for soil identification and determination of geotechnical properties of soils are covered in ENV 1997-2

12.2 Catagories and concepts

12.2.1 Categories of sampling methods

(1) There are three categories of sampling methods:

- category A sampling methods;
- category B sampling methods;
- category C sampling methods.

(2) By using category A sampling methods, the intention is to obtain samples in which no or only slight disturbance of the soil structure has occurred during the sampling procedure or in handling of the samples. The water content and the void ratio of the soil correspond to that in situ. No change in constituents or in chemical composition of the soil has occurred.

(3) By using category B sampling methods, samples contain all the constituents of the in situ soil in their original proportions and the soil has retained its natural water content. The general arrangement of the different soil layers or components can be identified. The structure of the soil has been disturbed.

(4) By using category C sampling methods, the soil's structure in the sample has been totally changed. The general arrangement of the different soil layers or components has been changed so that the in situ layers cannot be identified accurately. The water content of the sample may not represent the natural water content of the soil layer sampled.

12.2.2 Area ratio and inside clearance of the sample tube

(1)P The area ratio C_a (%) of the sample tube is defined by the following relation:

$$C_a = \frac{D_2^2 - D_1^2}{D_1^2} x100$$

where:

D_1 is the inside diameter of the cutting shoe;
D_2 is the greatest outside diameter of the cutting shoe.

12.3.2.6 Inside clearance

(1)P The inside of the sample tube or liner shall be clean and smooth without any protruding edges or irregularities which may disturb the soil.

(2)P The inside clearance shall be sufficient to allow some lateral expansion of the sample to take place, but it shall not be so much that it permits excessive deformations and causes unnecessary disturbance of the sample.The inside clearance shall not be so much that it completely eliminates the inside wall friction thereby causing loss of the sample during withdrawal or loss of lateral support thereafter.

(3) For catagory A sampling methods it is recommended to have an inside clearance ratio of 0,5 % to 1,0 % for sample tubes used in cohesive soils and up to 3,0 % in other types of soils.

12.3.2.7 Sample retainer

(1) A sample retainer between the cutting edge and the sample tube may be used in soils that are difficult to sample, but preferably not for cohesive soils. The use of a sample retainer causes disturbance of the sample.

12.4 Sampling procedure

12.4.1 Selection of sampling method

(1)P The sampling category and sampling method shall be selected in advance in accordance with the quality of the sample required for classification of soils and for the laboratory test to be performed.

(2) The sample diameter for soils containing large particles should be chosen by the size of the largest particles of the sampled material.

(3) Different disturbance of sample may be expected when using various sampling methods. The quality of a sample taken with the same sampler may vary depending on e.g. the soil type to be sampled, the presence of groundwater and the sampling operation.

APPENDIX C

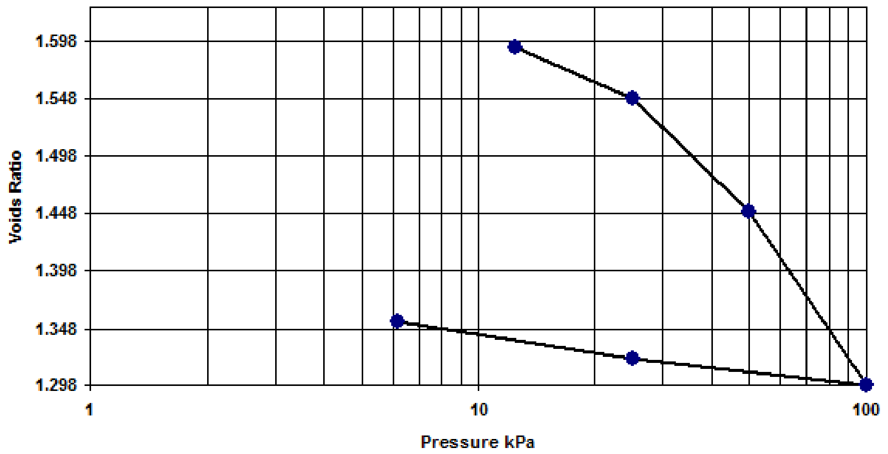
APPENDIX C1: Oedometer Test for soil sample taken in-situ

Test Details			
Standard	BS 1377: Part 5 : 1990 : Clause 3	Particle Density	1.91 Mg/m3
Sample Type	Core sample	Lab Temperature	0.0 deg C
Sample Depth	0.00 m		
Sample Description			
Variations from Procedure	None		

Specimen Details			
Specimen Reference	A	Description	
Depth within Sample	0.00mm	Orientation within Sample	
Specimen Mass	56.55 g	Condition	Natural Moisture
Specimen Height	20.00 mm	Preparation	
Comments			

Test Apparatus			
Ring Number	1	Ring Diameter	50.00 mm
Ring Height	20.00 mm	Ring Weight	68.34 g
Lever Ratio	10.00 : 1		

Voids Ratio Vs Applied Pressure



Height of Solid Particles	7.61 mm	Swelling Pressure	0.0 kPa

Initial Moisture Content*	98.1 %	**Final Moisture Content**	135.9 %
Initial Bulk Density	1.44 Mg/m3	**Final Bulk Density**	1.91 Mg/m3
Initial Dry Density	0.73 Mg/m3	**Final Dry Density**	0.81 Mg/m3
Initial Void Ratio	1.6281	**Final Void Ratio**	1.3548
Initial Degree of Saturation	115.14%	**Final Degree of Saturation**	191.57 %

- Calculated from initial and dry weights of whole specimen

Pressure (Loading Stages)	**Coefficient of Volume Compressibility (m_v)**	**Coefficient of Consolidation (c_v)**
0.00		
12.5 kPa	1.07 m2/MN	10.67 m2/yr
25.0 kPa	1.41 m2/MN	13.55 m2/yr
50.0 kPa	1.54 m2/MN	8.76 m2/yr
99.9 kPa	1.23 m2/MN	8.16 m2/yr
25.0 kPa	0.13 m2/MN	---------
6.2 kPa	0.78 m2/MN	---------

Method of Time Fitting Used	Square Root Time

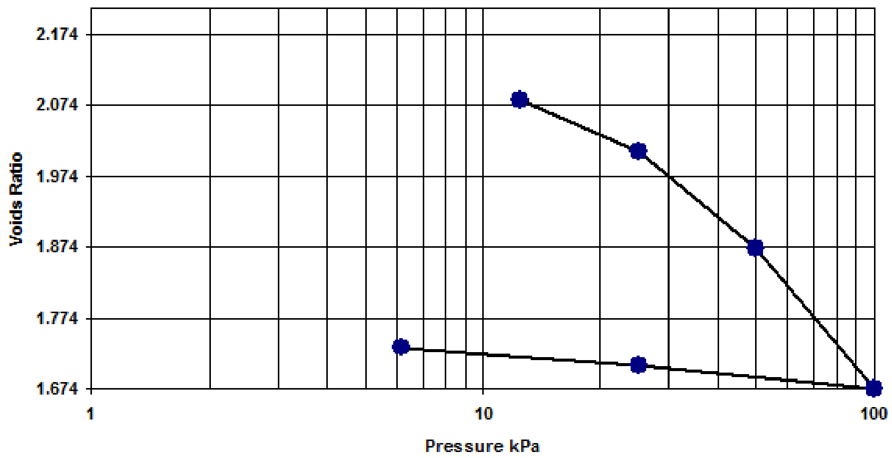
APPENDIX C2: Oedometer Test for soil sample taken using Tropiter (modified sampler)

Test Details			
Standard	BS 1377: Part 5 : 1990: Clause 3	**Particle Density**	1.91 Mg/m3
Sample Type	Core sample	**Lab Temperature**	0.0 deg.C
Sample Depth	0.00 m		
Sample Description			
Variations from Procedure	None		

Specimen Details			
Specimen Reference	B	**Description**	
Depth within Sample	0.00mm	**Orientation within Sample**	
Specimen Mass	48.87 g	**Condition**	Natural Moisture
Specimen Height	20.00 mm	**Preparation**	
Comments			

Test Apparatus			
Ring Number	2	**Ring Diameter**	50.00 mm
Ring Height	20.00 mm	**Ring Weight**	68.35 g
Lever Ratio	10.00 : 1		

Voids Ratio Vs Applied Pressure



Height of Solid Particles	6.23 mm	**Swelling Pressure**	0.0 kPa

Initial Moisture Content*	109.2 %	**Final Moisture Content**	149.1 %
Initial Bulk Density	1.24 Mg/m3	**Final Bulk Density**	1.74 Mg/m3
Initial Dry Density	0.59 Mg/m3	**Final Dry Density**	0.70 Mg/m3
Initial Void Ratio	2.2109	**Final Void Ratio**	1.7342
Initial Degree of Saturation	94.34%	**Final Degree of Saturation**	164.22 %

- Calculated from initial and dry weights of whole specimen

Pressure (Loading Stages)	**Coefficient of Volume Compressibility (m_v)**	**Coefficient of Consolidation (c_v)**
0.00		
12.5 kPa	3.24 m2/MN	5.03 m2/yr
25.0 kPa	1.86 m2/MN	6.33 m2/yr
50.0 kPa	1.82 m2/MN	4.33 m2/yr
99.9 kPa	1.38 m2/MN	4.95 m2/yr
25.0 kPa	0.16 m2/MN	---------
6.2 kPa	0.56 m2/MN	---------

Method of Time Fitting Used	Square Root Time

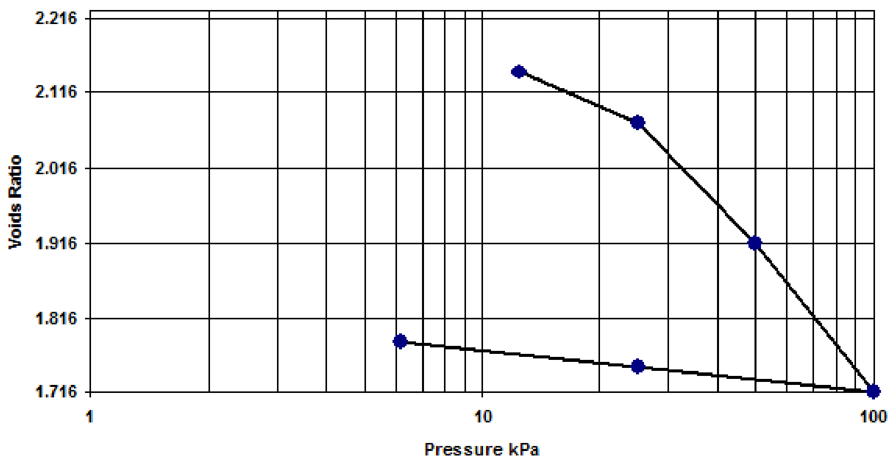
APPENDIX C3: Oedometer Test for soil sample taken using conventional tube sampler

Test Details			
Standard	BS 1377: Part 5 : 1990: Clause 3	**Particle Density**	1.91 Mg/m3
Sample Type	Core sample	**Lab Temperature**	0.0 deg.C
Sample Depth	0.00 m		
Sample Description			
Variations from Procedure	None		

Specimen Details			
Specimen Reference	C	**Description**	
Depth within Sample	0.00mm	**Orientation within Sample**	
Specimen Mass	49.06 g	**Condition**	Natural Moisture
Specimen Height	20.00 mm	**Preparation**	
Comments			

Test Apparatus			
Ring Number	3	**Ring Diameter**	50.00 mm
Ring Height	20.00 mm	**Ring Weight**	69.84 g
Lever Ratio	10.00 : 1		

Voids Ratio Vs Applied Pressure



Height of Solid Particles	6.20 mm	**Swelling Pressure**	0.0 kPa

Initial Moisture Content*	111.1 %	**Final Moisture Content**	148.5 %
Initial Bulk Density	1.25 Mg/m3	**Final Bulk Density**	1.70 Mg/m3
Initial Dry Density	0.59 Mg/m3	**Final Dry Density**	0.69 Mg/m3
Initial Void Ratio	2.2274	**Final Void Ratio**	1.7846
Initial Degree of Saturation	95.27%	**Final Degree of Saturation**	158.97 %

- Calculated from initial and dry weights of whole specimen

Pressure (Loading Stages)	**Coefficient of Volume Compressibility (m_v)**	**Coefficient of Consolidation (c_v)**
0.00		
12.5 kPa	2.08 m2/MN	2.78 m2/yr
25.0 kPa	1.71 m2/MN	3.84 m2/yr
50.0 kPa	2.10 m2/MN	3.59 m2/yr
99.9 kPa	1.37 m2/MN	3.48 m2/yr
25.0 kPa	0.16 m2/MN	---------
6.2 kPa	0.69 m2/MN	---------

Method of Time Fitting Used	Square Root Time