CHARACTERISTIC OF PEAT SOIL STABILIZED WITH NAOH AS CHEMICAL ADDITIVES UNDER COMPACTION CONDITIONS

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ABSTRACT

Peat in various phases of decomposition has a poor shear strength and a high compressive deformation, which causes problems when construction work is done on the deposit. The characteristic that has been noted before which is, high moisture content, poor shear strength, great compressibility and long-term settlement. Peat soil is a troublesome soil, and every engineer has sought to avoid working with it. When the major reason is peat soil, a variety of issues might arise, including slip failure, local sinking, and long-term settling as load increases. Normally, they will mix peat soils with some chemical substance or waste material like fly ash, shredded waste tire chips, Calcium Oxide (CaO), Sodium Hydroxide (NaOH) and many others. For this research study, it will focus on stabilizing peat soil using NaoH. There are tWO main testing that conducted in this research study, which are, Index Properties Testing and Compaction Test. For Index Properties testing, there were six (6) experiment conducted to study the index properties of disturbed peat soil which are, moisture content, fiber content, organic content, liquid limit, pH and specific gravity. Then, for the Compaction Test, a 4.5kg rammer have been used to determine the best mixture of stabilizer that blended with different volumes of 5%, 7%, and 9% stabilizer. The desired outcome of this study is to stimulate further research into the use of the chemical NaOH as a peat soil stabilizer for improved soil usage. The goal of this study is to fill in the gaps in the study of peat soil index properties with a specific concentration of stabilizers and to determine the stabilized peat soil. For 7% and 9% of NaOH only have a slight different and it can be concluded that was the optimum percentage of NaOH as a chemical stabilizer for peat soil. It can be seen clearly that 5% is the higher dry density with lesser moisture content of the peat. When the percentage of NaOH was increased, the graph pattern also changed.

ABSTRAK

CIRI-CIRI TANAH GAMBUT YANG DISTABIL DENGAN NAOH SEBAGAI TAMBAHAN KIMIA DI BAWAH KEADAAN PEMADATAN

Gambut dalam pelbagai fasa penguraian mempunyai kekuatan ricih yang lemah dan ubah bentuk mampatan yang tinggi, yang menyebabkan masalah apabila kerja pembinaan dilakukan pada deposit. Ciri-ciri yang telah dinyatakan sebelum ini ialah, kandungan lembapan yang tinggi, kekuatan ricih yang lemah, kebolehmampatan yang hebat dan penyelesaian jangka panjang. Tanah gambut adalah tanah yang menyusahkan, dan setiap jurutera telah berusaha untuk mengelak daripada bekerja dengannya. Apabila sebab utama adalah tanah gambut, pelbagai isu mungkin timbul, termasuk kegagalan gelinciran, penenggelaman setempat, dan pengendapan jangka panjang apabila beban meningkat. Biasanya, mereka akan mencampurkan tanah gambut dengan beberapa bahan kimia atau bahan buangan seperti abu terbang, serpihan tayar yang dicincang, Kalsium Oksida (CaO), Natrium Hidroksida (NaOH) dan lain-lain lagi. Untuk kajian penyelidikan ini, ia akan memberi tumpuan kepada penstabilan tanah gambut menggunakan NaoH. Terdapat dua ujian utama yang dijalankan dalam kajian penyelidikan ini iaitu, Pengujian Sifat Indeks dan Ujian Pemadatan. Bagi ujian Sifat Indeks, terdapat enam (6) eksperimen yang dijalankan untuk mengkaji sifat indeks tanah gambut yang terganggu iaitu, kandungan lembapan, kandungan serat, kandungan organik, had cecair, pH dan graviti tentu. Kemudian, untuk Ujian Pemadatan, rammer 4.5kg akan digunakan untuk menentukan campuran penstabil terbaik yang akan diadun dengan volum berbeza iaitu penstabil 5%, 7% dan 9%. Hasil daripada kajian ini adalah untuk merangsang penyelidikan lanjut mengenai penggunaan kimia NaOH sebagai penstabil tanah gambut untuk penggunaan tanah yang lebih baik. Matlamat kajian ini adalah untuk mengisi kekosongan dalam kajian sifat indeks tanah gambut dengan kepekatan tertentu penstabil dan untuk menentukan tanah gambut yang stabil. Bagi 7% dan 9% NaOH hanya mempunyai sedikit perbezaan dan dapat disimpulkan bahawa peratusan optimum NaOH sebagai penstabil kimia bagi tanah gambut. Ini kerana, bagi peratusan 5% NaOH, tidak terdapat perbezaan yang jelas antara sampel tanah gambut yang dirawat dan tidak dirawat. Apabila peratusan NaOH dinaikkan, corak graf juga berubah.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
B	-	Boron
BS	-	British Standard
C	-	Carbon
CaCo3	-	Calcium Carbonate
CaO	-	Calcium Oxide
CBR	-	California Bearing Ratio
cm	-	centi metre
CO2	-	Carbon Dioxide
CREAM	-	Construction Research Institute of Malaysia
CD	-	Consolidated Drained
Cu	-	Copper
Gs	-	Specific Gravity
Gt	-	Gigatonne
H	-	Height
Ha	-	Hectare
Kbpt	-	Klias- Beaufort Peat Soils
km	-	kilometre
kPa	-	kilo Pascal
LL	-	Liquid Limit
LOI	-	Loss on Ignition
m	-	metre
MATEC	-	Midwest AIDS Training Education Center
mm	-	mili metre
M	-	Mole
NaOH	-	Sodium Hydroxide
Na^{+}	-	Sodium ion
Nd	-	No date
OH^{+}	-	Hydroxide ion
OMC	-	Optimal Moisture Content
PL	-	Plastic Limit

POFA	-	Palm Oil Fuel Ash
Pto	-	Peat Organic
SPT	-	Standard Proctor Test
UCS	-	Uniaxial Compressive Strength
UCT	-	Unconfined Compression Test
UMS	-	Universiti Malaysia Sabah
USA	-	United State of America
USSR	-	United Socialist Soviet of Republic
W	-	Water Content

CHAPTER 1

INTRODUCTION

1.1 Background Study

From the literature, the organic surface layer of a soil is characterized as moderately degraded organic matter, mostly derived from plant material, that has developed under conditions of waterlogging, oxygen deprivation, high acidity, and nutrient depletion. As claimed by Adnan and Wijeyesekera (2007), individual peat particles are compressible, which allows it to defy another fundamental principle in soil mechanics. Pursuant to Khan (2018), peat soils are the most common type of organic soil, formed over generations by the accumulation of partially digested and undecomposed plant wastes under wetland conditions. The other type of organic soil is muck, which is formed by the accumulation of organic soil elements. However, the components in this type are pretty thoroughly decomposed, and the sources of the materials are unknown. Saturation or submergence of the substratum, along with the complete lack of free oxygen, results in very slow anaerobic breakdown of organic materials, allowing the evolution of deep organic soils called histosols. A peatland, on the other hand, is a large area of peat soil. Peatlands make up more than half of the world's wetlands, accounting for 3% of the planet's land and freshwater surface. Wetland types that produce peat soils include mires (bogs, fens), swamps, and marshes. Peat soils may be found in all climates, although they are more common in the Northern Hemisphere's temperate and cold zones. Individual peat particles are compressible, which allows it to defy another fundamental principle in soil mechanics. High water table, lack of oxygen, decreasing condition, poor bulk density and bearing capacity, soft spongy substratum, low fertility, and frequently high acidity define peat soils.

The 25 Mil. Ha of peatlands in Southeast Asia (equivalent to 56% of all tropical peatland were mostly underdeveloped until the 1980s due to challenging working conditions for heavy machinery, limited agricultural potential, and abundant supply of land on mineral soils. Peat swamp woods, in their natural condition, act as a carbon sink, resulting in a massive carbon deposit (69 Gt) in the region's peatlands. Peatlands also contain specific flora and fauna, some of which are native to the region, play an important role in hydrology by controlling water flow, and have major socioeconomic value for local residents. Forest cover in Peninsular Malaysia, Sumatra, and Borneo had declined to 42% while deforestation rates remained high. Over a quarter of peatlands had been converted to managed land cover types (11% small-holder areas and 18% industrial plantations), resulting in lower water table levels, and another 23% of peatland areas had been covered by highly fire-prone degraded fern, shrub, and secondary regrowth (Miettinen and Liew, 2010). Since 2007, deforestation and conversion to controlled land cover types has been predicted to continue, although the present land cover distribution in Southeast Asia's peatlands is uncertain. According to As’ari *et al.* (2016), peatland comprises roughly 2.76 million hectares in Malaysia, including 796,782 hectares in Peninsular Malaysia, 200,600 hectares in Sabah, and 1,765,547 hectares in Sarawak. Due to changes in climate and the plant species that breakdown to generate the peat layer, tropical peat differs from temperate peat.

Peat deposits are known to exist in Malaysia, as seen in Figure 1.1. Peat covers roughly 30,000 km^2 in Malaysia, accounting for around 8% of the country's total land area (Zainorabidin *et al.*, 2007). Sarawak has the greatest peat area, covering 16,500 km^2, with peat depths of more above 1 m in 89% of these places. Peat deposits in Malaysia ranged in depth from 1 to 20 meters. The image also demonstrates that, with the exception of Sri Aman, these deposits are mostly found towards the shore.

Figure 1.1: Location of Peat Swamps in Malaysia
(Modified from Mutalib *et al.*, 1991)

According to Teong *et al.* (2015), Malaysia has over 2.5 million hectares of peat soil, with Sabah accounting for roughly 4.76% of the country's peat soil area. Sarawak has the biggest peat soil in Malaysia, covering 1.66 million acres, or 13% of the state's total area. There are two surviving places in Sabah that support the biggest expanses of peat soil: The Klias Peninsula and the Kinabatangan-Segama Valleys. From an engineering standpoint, the Sabah peat soil data project was developed in 2016. Figure 1.2 below shows the distribution of peat soil in Sabah.

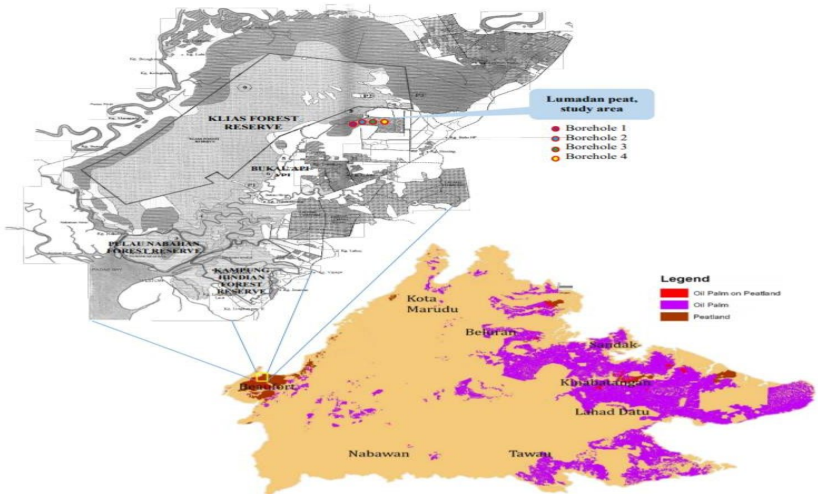

Figure 1.2: Distribution of Peatland in Sabah
Source from Robert *et al.* (1998), (Modified by Habib *et al.* (2016))

The carrying capacity of peat soil was shown to be relatively low in studies done by Islam *et al.* (2008) and Andriesse (1988), and was presumably impacted by the water table and the presence of underlying woody debris. Unexpectedly when treated to a low weight, peat creates major issues in the building sector because to its long-term consolidation settlements.

As a result, peat in its natural condition is regarded inappropriate for sustaining foundations. Wong *et al.* (2008) conducted a test on peatland in Peninsular Malaysia and discovered that the peat had a very high water holding capacity, was dark brown in colour, and was categorized H4 by the Von Post classification system.

Peat is a problematic or weak soil made up of decomposed organic matter. Low shear strength (3–16 kPa), high water holding capacity (up to 850%), high compressibility with an initial void ratio in the range of 5–15, and the possibility of degrading further over time make peat unsuitable for the foundation. As a result, stabilization is an unavoidable part of any infrastructure development in peat. (Khanday *et al.*, 2021). Soil stabilization is the mechanical or chemical modification of one or more soil qualities to produce a better soil material with the necessary engineering properties. In this further research, the chemical stabilizer is used is Sodium Hydroxide (NaOH). The goal of this study is to use NaOH as a stabilizing agent to chemically stabilize the soil. Sodium Hydroxide is a non-combustible, odorless, white flake solution that does not burn but is very reactive. NaOH decomposes into (Na+ and OH-) ions, which interact with soil minerals to modify their characteristics. For building and construction needs, soil from Ghana was stabilized by combining and curing it with various chemicals. These additives have the best failure resistance in the dry state, but NaOH has the best failure resistance in the wet condition. The decrease in liquid limit with increasing NaOH concentration was also discovered to be attributable to the major influence of increased electrolyte concentration. (Krishna *et al.*, 2018).

A laboratory compacting process for determining the optimal water content at which a soil can be compacted for maximum density (dry unit weight) according to Mindat.org (n.d). The approach is inserting a soil sample with a known water content in a mould with specific dimensions, subjecting it to a controlled compactive effort, and calculating the resulting unit weight (ASCE, 1958, term 74). The method is repeated for a variety of water contents until a relationship between water content and unit weight is established. The maximum dry density for a given compactive effort will usually result in a sample with near-maximal saturated strength. The type of compaction and the amount of energy provided for a given soil volume are both standard, thus the test focuses on changing the moisture level of a sample to determine the optimum water content. A 0.95-liter volume cylindrical mold is used in the typical test, in which the soil mass is put and compacted in three layers.

1.2 Problem Statement

Peat in various phases of decomposition has a poor shear strength and a high compressive deformation, which causes problems when construction work is done on the deposit (Hashim and Islam, 2008). Organic soil is defined as soil that contains more than 20% organic matter. Deep peat has problems because of its physical and chemical qualities. Peat absorbs an excessive amount of water in its natural condition due to its low physiography and water retention potential of 20 to 30 times its own weight. As a result, aeration is poor and bulk density is low at less than 0.1 g cm-3. When peat is drained, it will dry irreversibly and subside at a rate of 3.6 cm per year. Peat has traditionally been thought of as a material with a high compressibility and low bearing capacity, according to previous research. Prior to work of Habib *et al.* (2014), most engineers have been concerned about peat's reactions to roads and highways in Malaysia since peat soil is defined as "poorly, challenging, difficult accessibility, and problematic soil." Peat soil is a troublesome soil, and every engineer has sought to avoid working with it. When the major reason is peat soil, a variety of issues might arise, including slip failure, local sinking, and long-term settling as load increases. This problem appears to be best solved by stabilizing. To improve the shear strength of peat soil, using chemical stabilizer which is NaOH is the suitable way to increase the quality of peat soil and compaction test is the best method to improve soft soil shear strength, slope and embankment stability, and is especially useful for soils with low hydraulic conductivity.

1.3 Objective of Study

The goal of this research is to anticipate the ability of Sodium Hydroxide (NaOH) as a chemical addition in peat soil stabilization under compaction compression conditions, as well as the impacts of the approaches. However, the study's more precise objectives had to be achieved, which were as follows:

i. To study the index properties of peat soil.
ii. To study the behavior of NaOH with peat soil under compaction condition.
iii. To determine the dry density and moisture content of peat soil after stabilized.

1.4 Scope of Study

The scope of work covers all appropriate necessary work and important information to achieve the established goals of this research. The index properties of peat soil pH value, moisture content, liquid limit, density, specific gravity, organic content and fiber content are analyzed. Compaction have been used to compare the characteristics of peat soil before and after treatment. The peat soil sample came from Klias in Beaufort.

The soil samples were tested in the Geotechnical Engineering Laboratory of the University Malaysia Sabah (UMS). Explore undisturbed soil samples at a depth of 0.5 m from the surface. The undisturbed sample is cylindrical with an inner diameter of 50 mm and a height of 100 mm. A 0.95-liter volume cylindrical mold is used in the typical Proctor test, in which the soil mass is put and compacted in three layers. Each layer is compacted by dropping a 2.5 kg weight from a height of 30 centimeters 25 times.

1.5 Expected Result

The result of this research is to use compaction as a soil stabilizer method for peat soil to inspire and in-depth research on the combination of NaOH to better get rid of the problematic soil. This study also seeks to use a compaction test to determine NaOH as a suitable stabilizer for peat soil, in order to identify any problems that may arise during construction due to peat soil. This research attempts to learn more about peat soil index qualities including moisture content, pH value, liquid limit and others in order to compare the characteristics before and after treatment. This technology will help engineers understand the problems of peat for industrial purposes.

1.6 Significance of Study

The purpose of this study is to enlighten and dive deeper into the use of NaOH as a chemical stabilizer for peat soil stabilization using compaction testing in order to get the best out of the problematic soils. The goal of this study is to fill in the gaps in the understanding of peat soil behaviour with a specific stabilizer concentration and compaction test to improve shear strength. To date, no one has looked at the relationship between NaOH and the compaction test in order to develop the qualities of soft soils. This technology will aid engineers in understanding peat soil issues while also establishing a new strategy in the market.

1.7 Thesis Outline

This section provides an overview of each chapter discussed in this thesis. The first chapter is the introduction part, which consists of seven sub-units: background study, problem statement, objective of study, the scope of the study, expected results and the significance of the study.

The second chapter is mainly a literature review of peat soil. This chapter is a review of past peat soil research, covering the origin, formation, type, category, behavior and properties of peat soil. The source of the comments provided in this chapter comes from a large number of previous studies conducted by different researchers, and is evidenced by high index consistency and recognition as a sufficient reference.

The third chapter focuses on the methodology of this research. It includes applied strategies, sample preparation techniques, and mechanical testing procedures for each individual. This chapter also discusses the implementation, specifications and limitations of the instrument.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Peat soils are the maximum dominant sort of natural soils advanced through centuries below wetland situations with the aid of using the buildup of in part decomposed and undecomposed plant residues. The different sort of natural soil is muck which also develops with the aid of using the buildup of natural soil substances, however on this type, substances are quite properly decomposed, and the re-assets of substances aren't identifiable. Saturation or submergence of the sub-stratum and the entire absence of free oxygen purpose very gradual anaerobic decomposition of natural depend in order that deep natural soils or histosols can evolve. However, a big expanse of peat soil is called a peatland. More than 1/2 of the worldwide wetlands are composed of peatlands; they cowl three percentages of the land and freshwater floor of the earth. Peat soils broaden in numerous wetland types, along with mires (bogs, fens), swamps, marshes, and pocosins. Peat soils arise in all regions, however they may be greater good sized within side the temperate and bloodless zones of the Northern Hemisphere. There are 12.2 Mil. ha (million hectare) peatlands in Africa, 23.5 Mil. ha in Asia and the Far East, 7.4 Mil. ha in Latin America, 4.1 Mil. ha in Australia, 117.8 Mil. ha in North America and 75.0 Mil. ha in Europe. Peatland flowers consists of Sphagnum mosses, rushes and sedges, bathroom cotton, ling heather, bog rosemary, bog asphodel and sundew. There also are forested peatlands in Europe (Alder forests) and in lowland humid tropical regions of Southeast Asia (sparkling water swamp forests and mangroves). Peat soils are characterized with the aid of using excessive water table, absence of oxygen, decreasing condition, low bulk density and bearing capacity, tender spongy substratum, low fertility, and typically excessive acidity.

Soil stabilization is the mechanical or chemical modification of one or more soil qualities to produce a better soil material with the necessary engineering properties. Soil stabilization serves three goals. These include, among other things, enhancing the strength of an existing soil to improve its load-bearing capacity, improving permeability and improving soil resilience to weathering, and traffic utilization. A solution of sodium hydroxide is a non-volatile, colorless, odorless substance. It does not burn, but it is quite reactive. It interacts aggressively with water and a variety of other common compounds, producing enough heat to ignite flammable things nearby. Its main benefits are that it reacts quickly with water, resulting in a potent compaction aid that provides a greater density for the same compactive effort. Sodium hydroxide interacts particularly well with aluminium rich soil.

2.2 Peat Soil

Peat soil is described as an accumulation of waste and vegetation that has accumulated due to water logging. Environmental, meteorological, and vegetation kinds all have an impact on the organic matter of peat soil. The humification level of peat soil was traditionally used to classify it. Humification is the process of transforming a variety of substances (proteins, carbohydrates, lipids, and so on) and individual molecules found in living organic matter into a collection of substances having similar qualities (humic substances). Due to the breakdown of organic stuff such as plant residues, leaves, trunks, roots, and so on, peat or organic soil is very diverse. Peat may be found everywhere over the planet, with the exception of barren and arctic regions, which account for roughly 5%–8% of total land area. In Malaysia, Indonesia, Brazil, Uganda, Zambia, Zambia, Venezuela, and Zaire, tropical peats cover around 8–11% of the land. According to Sarawak's department of irrigation and drainage, Malaysia has roughly 2.7 million hectares of peat land (i.e., 8% of the total land area). Approximately 1.66 million hectares, or 63%, are found in Sarawak's deltas and coastal plains. This peatland region is flooded for the most of the year. High natural moisture content, high compressibility and water-holding capacity, low specific gravity, poor bearing capacity, and medium-to-low permeability are all features of peat. According to Osman KT (2018), peatlands or mires expand over a protracted length of time, for example >10,000 years, via way of means of the