INVESTIGATION ON THE COMPACTION CHARACTERISTIC OF SABAH PEAT SOIL STABILISED WITH ECO-PROCESSED POZZOLAN (EPP)

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FACULTY OF ENGINEERING
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ABSTRACT

Peat soil was defined as the highly organic surface layer derived primarily from plant remains. Peat, on the other hand, was the subsurface of wetland systems, consisting of unconsolidated superficial layers with high non-crystalline colloid (humus) content. It has a dark brown to black colour, an organic odour, and a spongy consistency in general. Peat soil was mainly found in swamp areas. It was a partly decomposed organic layer of soil generated primarily from plant matter that has collected under waterlogging, high acidity, oxygen scarcity, and nutritional insufficiency. Peat soils have a low shear strength of 5 to 20 kPa, high compressibility of 0.9 to 1.5, and a high moisture content of >100%. Peat also has a lot of deformation, a lot of magnitudes, and many screens, and it contains a lot of organic stuff (>75%). The purpose of the study was to prognosticate the potential of Eco-Processed Pozzolan (EPP) as peat soil stabilisation material with improved technique and its consequence of the methods, which was the peat soils index properties and analyse thecharacteristics of the peat soil stabilisation before and after treatment using Eco-Processed Pozzolan (EPP). The undistributed soil sample was taken 0.5m underground from the surface in cylindrical shape 150 mm high and 90mm inner diameter. The soil was mixed with 10%, 20%, and 30% Eco-Processed Pozzolan (EPP) then compacted (compaction test) in a metal mould of internal diameter 105 mm using a 2.5 kg rammer, of 50 mm diameter, free-falling from 300 mm above the top of the soil Three layers compaction of approximately equal depth and 27 blows spread evenly over the soil surface for each layer. The expected result to accomplish the main purpose was to prognosticate the potential Eco-Processed Pozzolan (EPP) as peat soil stabilization material with improvement technique and its consequence of the methods. According to the findings, peat soil treated with EPP will transform its qualities from peat to usable soil. However, the presence of moisture will reduce the mixture's ability. According to the findings of this study, the optimum EPP for stabilising peat soils was 30-40%.

ABSTRAK

SIASATAN TERHADAP CIRI-CIRI KEKUATAN RICIH TAK TARIK TANAH GAMBUT SABAH YANG DISTABIL DENGAN POZZOLAN ECO-PROCESSED (EPP)

Tanah gambut ditakrifkan sebagai lapisan permukaan yang sangat organik yang diperoleh terutamanya daripada sisa tumbuhan. Gambut pula ialah subpermukaan sistem tanah lembap, yang terdiri daripada lapisan cetek yang tidak disatukan dengan kandungan koloid (humus) bukan kristal yang tinggi. Ia mempunyai warna coklat gelap hingga hitam, bau organik dan konsistensi span secara umum. Tanah gambut kebanyakannya ditemui di kawasan paya. Ia adalah lapisan tanah organik yang terurai sebahagiannya yang dijana terutamanya daripada bahan tumbuhan yang terkumpul di bawah genangan air, keasidan yang tinggi, kekurangan oksigen dan kekurangan nutrisi. Tanah gambut mempunyai kekuatan ricih yang rendah iaitu 5 hingga 20 kPa, kebolehmampatan tinggi 0.9 hingga 1.5, dan kandungan lembapan tinggi >100%. Gambut juga mempunyai banyak ubah bentuk, banyak magnitud, dan banyak skrin, dan ia mengandungi banyak bahan organik (>75%). Tujuan kajian adalah untuk meramalkan potensi Pozzolan Eko-Proses (EPP) sebagai bahan penstabilan tanah gambut dengan teknik yang lebih baik dan akibat daripada kaedah, iaitu sifat indeks tanah gambut dan menganalisis ciri kekuatan ricih tidak berdrainas gambut. penstabilan tanah sebelum dan selepas rawatan menggunakan Eco-Processed Pozzolan (EPP). Sampel tanah yang tidak teragih akan diambil 0.5m di bawah tanah dari permukaan dalam bentuk silinder setinggi 150 mm dan diameter dalam 90mm. Tanah dicampur dengan 10%, 20%, dan 30% Eco-Processed Pozzolan (EPP) kemudian dipadatkan (compaction test) dalam acuan logam diameter dalam 105 mm menggunakan rammer 2.5 kg, diameter 50 mm, jatuh bebas. dari 300 mm di atas bahagian atas tanah Pemadatan tiga lapisan dengan kedalaman yang lebih kurang sama dan 27 tiupan tersebar secara merata ke atas permukaan tanah untuk setiap lapisan. Mengikut penemuan, tanah gambut yang dirawat dengan EPP akan mengubah kualitinya daripada tanah gambut kepada tanah yang boleh digunakan. Namun, kehadiran lembapan akan mengurangkan keupayaan campuran. hasil dapatan kajian ini, EPP optimum untuk menstabilkan tanah gambut ialah 30-40%.

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ASTM	**American Society for Testing and Materials**
BS	British Standard
Cu	Shear Strength
D	Diameter
EPP	Eco Processed Pozzolan
Gs	Specific Gravity
GHG	Greenhouse gases
H	Height
Ha	Hectare
Kpa	Kilo pascal
KPSFC	Klias Peat Swamp Field Center
LL	Liquid limit
M	Million
MDD	Maximum Dry Density
m	Meter
mm	Millimetre
OPC	Ordinary Portland Cement
OMC	Optimum Moisture Content
PL	Plastic limit
PVC	Polyvinyl chloride
UMS	University Malaysia Sabah
SBE	Spent Bleaching Earth
Wn	Natural moisture content

LIST OF EQUATION

CHAPTER 1

INTRODUCTION

1.1 Background Study

In the previous study, the terms peat soil was defined as the highly organic surface layer which was derived primarily plant remains. In other hands, peat was unconsolidated superficial deposits with high non-crystalline colloid (humus) content, constituting the subsurface of wetland systems. Generally, it has a dark brown to black colour, an organic odour, and mostly has a spongy consistency. There was a time when the plant fibres were visible and sometimes, they may not in the advanced stages due to decomposition of the peat soil as claimed by Huat et-al., (2014). Botanical composition and degree of coalification were the main things that need to be considered before categorizing the types of peat soils, the coalification process was only beginning, and lignin, cellulose, and even microorganism proteins can be seen in its structure. Pyrolysis of peat generates compound typical for its component that allows identification of information on the peat component, classification the peat by its origin, and allow the evaluation of the degree coalification according to Serban C. Moldoveanu (2021) (Moldoveanu, 1998). According to the statement by Dennis et-al., (2017), in terms of chemical properties peat soils contain a high-water content around (88%-92%), (50%-60%) of carbon, typically consisting of hydrogen (5%-7%), with nitrogen (2%-3%), phosphorus (<0.2%) and mineral nutritional element and oxygen which does not have more than 35% of dry ingredient weight mass. Peat soils were characterized by high water table, absence of oxygen, reducing condition, low bulk density and bearing capacity, soft spongy substratum, low fertility, and usually high acidity. Peatland vegetation includes Sphagnum mosses, rushes and sedges, bog cotton, ling heather, bog rosemary, bog asphodel and sundew. There were also forested peatlands in Europe (Alder forests) and

in lowland humid tropical areas of Southeast Asia (freshwater swamp forests and mangroves). Peat soils were characterized by high water table, absence of oxygen, reducing condition, low bulk density and bearing capacity, soft spongy substratum, low fertility, and usually high acidity (Osman, 2018).s

Peat soils occur in all regions, they were more common in the Northern Hemisphere's temperate and frigid zones. The table 1.0 shows the region covered by peatlands.

Table 1.1: Region covered by Peatlands

Regions	Area (ha)
Africa	12.2 M
Latin America	7.4 M
Asia and the Far east	23.5 M
Australia	4.1 M
North America	117.8 M
Europe	75.0 M
Total	**240 M**

Source: Osman, K. T. (2018)

North America has covered 117.8 M ha (million hectare) peat soils which was the largest among the other region and followed by Europe which was 75.0 M ha while 23.5 M ha in Asia and the Far East, 12.2 M ha peatlands in Africa, 7.4 M ha in Latin America, 4.1 M ha in Australia. Latest research by Gumbricht et al. (2017), found that 1,689,171 km^2 was in the tropical peatland zones. The findings from Miettinen et al., (2011) found a 1.0 percent annual reduction in forest cover throughout insular Southeast Asia (including the Indonesian half of New Guinea), peat swamp forests clearly experienced the highest deforestation rates at an average annual rate of 2.2% with main change trajectories to secondary vegetation and plantations. Total land in Malaysia was covered by peat soil about 2.5 million ha (7.74%). The figure 1.1 shows the distribution peat soil in Malaysia.

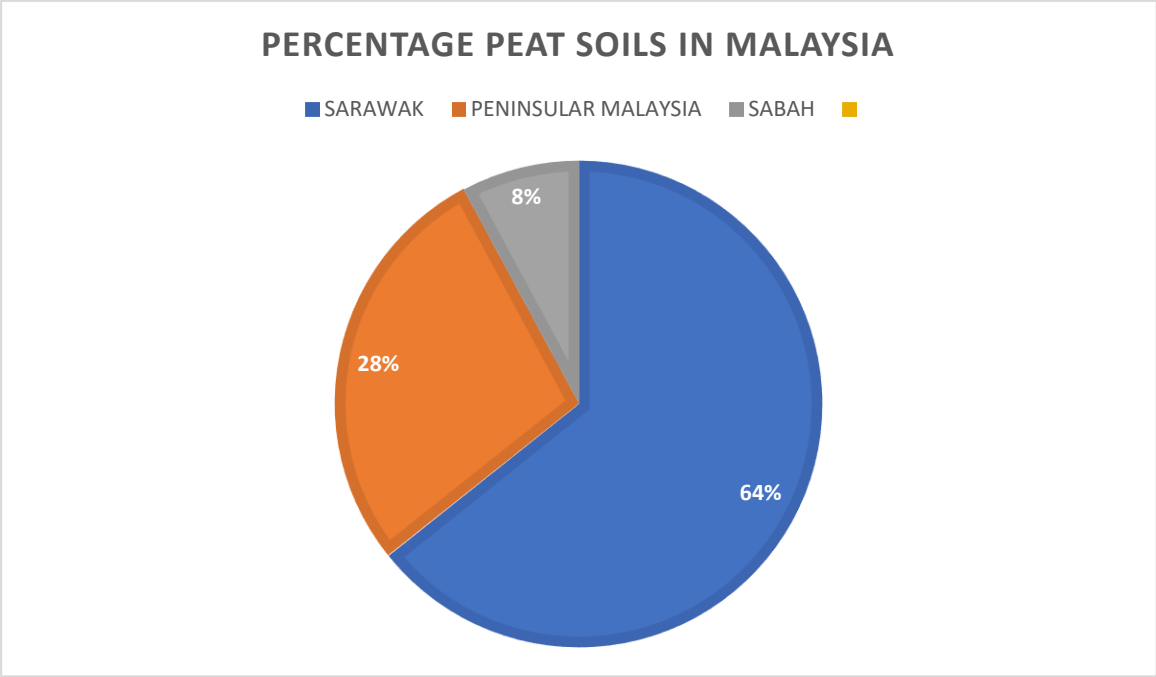

Figure 1.1 : Distribution Peat Soil in Malaysia

Source : International Journal of Advanced Research in Engineering and Technology-IJARET (2021)

According to Sapar et al., (2020), Sarawak state has 1,645,585 ha (64.27 %) of Malaysia's peat soils, Peninsular Malaysia has 714,156 ha or 27.89%, and Sabah state has the smallest covered area with 200,600 ha or 7.83% of Malaysia's peat soils where these peat deposits were observed mainly along the coastal area. There were two main area in Sabah was covered by peat soils which was in Klias peninsula and in the kinabatangan-segama Valley. The Sabah peat soil information from engineering perspective project was established in 2016, According Adnan Zainorabidin & Habib (2016). Figure 1.2 shows the distribution of peat soil in sabah.

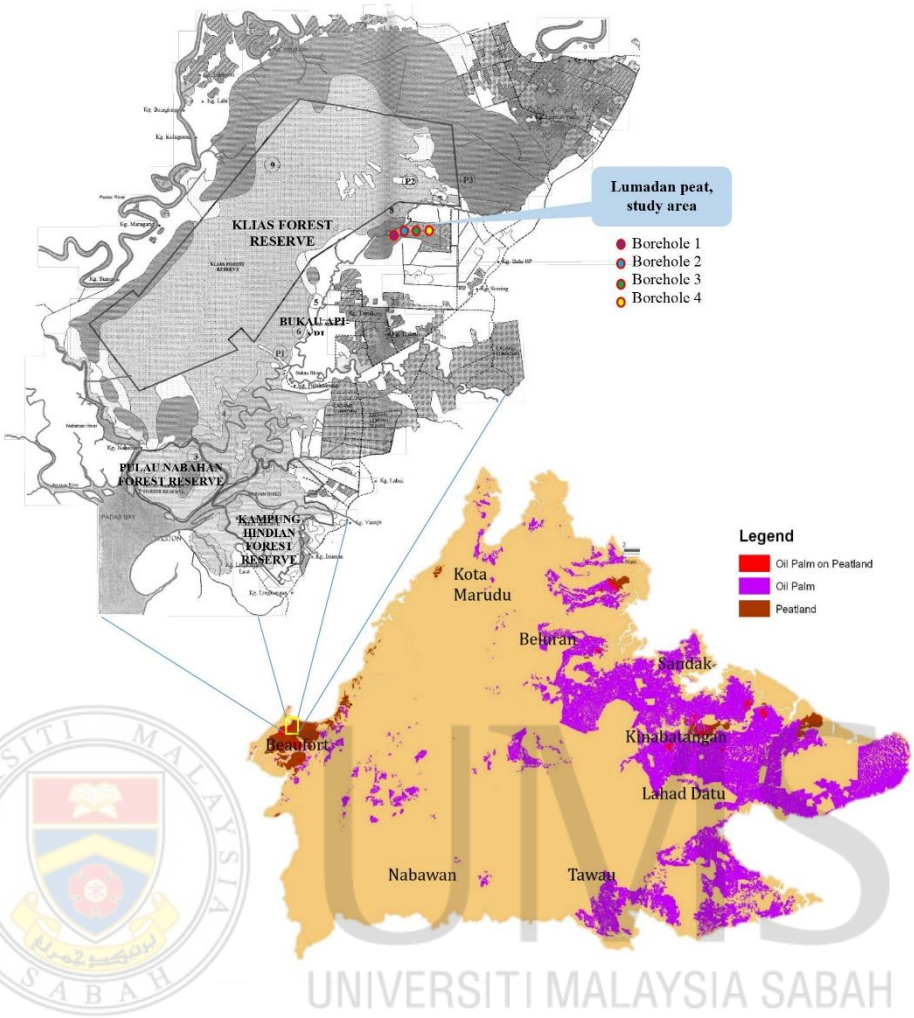

Figure 1.2 : Distribution of Peatland in Sabah

Source : Robert et. al., (1998), Hamzah and Rashid, (2015)

Peat soil was regarded as one of the most problematic soils to work with. Peat has a high compressibility, low shear strength, high moisture content and low bearing capacity (Bujang, 2004, Adnan et al., 2007). According to Siti Nooraiin Mohd Razal et al., (2013) stated that peat was considered as an undesirable soil for supporting foundations in its natural state due to the high high compressibility (0.9 - 1.5), moisture content (>100%) and low shear strength (5-20 kPa) values. Peat also contains high organic matter (>75%), large deformation, high compressibility and high magnitude and rates of creep. These characteristics lead to the problems and challenges in the construction process in a various aspects such as pre-construction difficulty, post construction failures, cost of construction, maintenance issues, as well as short and long term impacts. Sustainable design, select suitable materials, reduce the cost of construction, prolong the service duration, and minimize the necessity of maintenance

impact was the challenges to be considered and adopt before constructing infrastructures on peatland (Hua et al., 2016).

Every problem has a solution to overcome same as the peat soil condition, there were several techniques and method to overcome the problematic on the compaction characteristic of peat soil by stabilised with Eco-Processed Pozzolan (EPP). Eco-processed pozzolan (EPP) was a sustainable product recycled from spent bleaching earth (SBE). It was recently used as a blended cement. The pretreatment method of palm oil generates SBE as waste material in the refinery plant. Despite sending the SBE to the landfill, which can lead to environmental pollution, it was extracted to produce sustainable products. The physical, chemical, mineralogical, and microstructural characteristics of EPP were analysed (Farahiyah et al., 2020). The physical properties of EPP. The particle size, d90 of EPP 94.36 μm. The mean particle size, d50 of EPP was 29.3 μm. Based on the results, the specific gravity of EPP 1.93. The XRF result reveals that the EPP composed of SiO2 at 47.6% and the combination value of SiO2, aluminium oxide (Al2O3), and iron oxide (Fe2O3) was 68.98%. The value was less than 70% as according to the c However, it was more than 50% which the EPP can be classified in the Class C pozzolan. The EPP contains high percentage of SiO2. The loss on ignition of EPP was 3.3% which was less than 6% as specified in the ASTM C618 standard. From the chemical compositions, according to the ASTM C168 standard, the EPP can be classified as a Class C pozzolan. In this research, Compaction test was used for determining maximum unit weight and optimum moisture content principal factors influencing maximum dry unit weight and optimum moisture content (W & R, 2021). Terzaghi's principle of experimental examination and its effective stress were discussed (W & Bjerrum, 2021). An amount of EPP were added to the peat to stabilise the soil and tested again for the results

1.2 Problem Statement

Peat soil can be found in swamp area which was the surface area was organic layer of a soil that consist partially of decomposed organic matter that derived mostly from plant matter which has accumulated under conditions of waterlogging, high acidity, oxygen deficiency, and nutrient insufficiency. Prior to the work of Razal et al., (2013), Peat soils have a low shear strength around 5kpa-20kpa, high compressibility (0.9-1.5), and high moisture content (>100%). Peat also has a large deformation, high magnitude, and rates of screen, with contain organic matter (>75%). Therefore, the peat soil was not suitable for placement any foundation or road and any construction in peatland.

According to Duraisamy et al., (2007), Peat commonly occurs as extremely soft, wet, unconsolidated superficial deposits normally as an integral of wetland systems. They may also occur as stratum underneath layers of superficial deposits. The term peat was described as a highly organic chemical formed mostly from plant components which occurs naturally. It was formed when organic matter accumulates more quickly than it decays. This was usually occurring when organic matter was preserved below high-water table like in swamps or wetland. Peat soils need to be stabilised so that can be used as the construction area and any used in the future. Therefore, this research will focus on stabilize the peat soils on the compaction characteristic by using method of compaction test of the peat soils at Klias Peat Swamp Forest, Sabah. Result of the test was taken before and after mixed the sample with Eco-Processed Pozzolan (EPP). Expecting result was the soil stabilised that will give a high shear strength, low compressibility, and normal moisture content.

1.3 Objective of Study

The purpose of the study was to prognosticate the potential of Eco-Processed Pozzolan (EPP) as peat soil stabilization material with improvement technique and its consequence of the methods. Therefore, specific objectives of the study that needed to be accomplished as below:

1. To determine the peat soil index properties.
2. To determine the optimal mixture of Eco-Processed Pozzolan (EPP) for peat soils stabilisation
3. To analyse the behaviour of dry density for the peat soil before and after treatment using Eco-Processed Pozzolan (EPP).

1.4 Scope of Study

Scope of work covered all applicable necessary work and important data to accomplish the stated objectives of this research. Organic content, pH, moisture content, fibre content, and other index properties of peat soil was identified. The compaction characteristic was investigated by adding Eco-Processed Pozzolan (EPP) to the peat soils. Sample of peat soil was obtained from Klias, Beaufort.

The sample was undergoing compaction test at Geotechnical Laboratory Faculty of Engineering, University Malaysia Sabah. The undistributed soil sample was taken 0.5m underground from the surface in cylindrical shape 150 mm high and 90mm inner diameter. The soil was mixed with 10%, 20%, 30%, and 40% Eco-Processed Pozzolan (EPP) then compacted in a metal mould of internal diameter 105 mm using a 2.5 kg rammer, of 50 mm diameter, free falling from 300 mm above the top of the soil. Three layers compaction of approximately equal depth. 27 blows which were spread evenly over the surface of the soil for each layer.

1.5 Expected Result

The expected result to accomplish the main purpose was to prognosticate the potential Eco-Processed Pozzolan (EPP) as peat soil stabilization material with improvement technique and its consequence of the methods. Simultaneously, this research purpose to determine the peat soil index properties, evaluate the strengthening and stiffening effects of behaviour with optimal mixture Eco-Processed Pozzolan (EPP), analyse the

compaction characteristic of peat soil behaviour on the load-carrying capacity and its compressibility, and analyse the dry density against moisture content characteristics peat soil stabilisation with Eco-Processed Pozzolan (EPP) before and after the treatment. This investigation was to find the suitable method to improve peat soil behaviour and characteristics, for peat to enhance the application of peat soil in industries and to be used in construction. Besides that, produce optimal Eco-Processed Pozzolan (EPP) as a new product that can be traded in upcoming future to stabilize peat soil for other used.

1.6 Significance of Study

The findings of this research were to appraise and look at the use of EPP material in more depth by it as soil stabilisation for peat soil to get the better out of the problematic soils. Besides that, this study enlarges from the previous research on peat soil and at the same time provides suitable behaviour of peat soil with EPP to improve soil properties. This research was done to fill the gap on the compaction characteristic that focuses on peat soil. Up to date, no researchers have found out on the mixture of Eco-Processed Pozzolan (EPP) as a stabilizer with peat soil to improve their soils properties. This will give advantages to an engineers for better understanding with the peat soil issues using this method, within the same time it will establish a new method in the industry that can be traded as a new product for peat soil stabilisation.

1.7 Thesis Outline

An overview for every chapter discussed in this thesis was in this segment. Chapter 1 was for the introduction part, be made up of seven sub-unit, which were background study, problem statement, objectives of study, the scope of the study, expected result and the significance of the study.

Besides that, Chapter 2 primarily the literature review for peat soil. This chapter was a review of past research regarding to the peat soil, covering from its origin, formation, types, classes, behaviour and properties. The review sources provided in this chapter were drawn from numerous previous studies performed by different researchers and demonstrated by high indexed consistency and acknowledgement as adequate references.

Furthermore, Chapter 3 focuses on the methodology of this research. It includes the tactic applied, sample preparation techniques and everyone the mechanical testing procedures. This chapter also discussed the implementation of apparatus, specification and its limitations.

Moreover, Chapter 4 was providing and present the information of compressibility index of peat soil which was included also its index properties.

Lastly, Chapter 5 framed to line the conclusion of this research and summarized the key results and findings that were analysed from this research. An extra recommendation for future research works has been made during this chapte