THE EFFECTS OF RICE HUSK ON THE COMPACTION PROPERTIES OF PEAT SOIL

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ABSTRACT

Soil stabilization has been extensively used for the improvement of peat soils, in enhancing the shear strength and limiting the deformation behaviour. Cement is widely used as a stabilizing materials for soils, but the increasing price is causing economic concerns among practitioners and clients alike. The quest for alternative cheaper stabilizing agents is therefore more urgent than before. Rice husk is a major agricultural waste in Malaysia and the common disposal method of open burning has notoriously contributed to environmental pollution. The possibility of admixing rice husks with cement for stabilizing soft soils could be a solution to both problems. This study was aimed to investigate the effect of rice husk on the compaction properties of peat soil. Laboratory experiment were carried out on a stabilized peat soil to determine the optimum water content, maximum dry density of the soil and waste for various mixes of rice husk. Peat soil samples were collected from Kampung Tanah Putih, Pekan, Pahang. The stabilized specimens were prepared with the peat soil admixed with various quantities of rice husk and water content, then compacted using Standard Proctor Test. The specimens were observed to undergo reduction in compressibility and increase in strength highlighting the great potential of rice husk as an alternative soil stabilizer.

ABSTRAK

Penstabilan tanah telah digunakan secara meluas untuk memperbaiki tanah gambut, meningkatkan kekuatan ricih dan menghadkan tingkah laku ubah bentuk. Simen digunakan secara meluas sebagai bahan penstabilan untuk tanah, tetapi dengan kenaikan harga simen yang semakin meningkat menyebabkan kebimbangan ekonomi dalam kalangan pelanggan. Usaha untuk menstabilkan ejen penstabil yang lebih murah, satu alternatif telah dilakukan untuk menghasilkan ejen yang lebih efektif. Sekam padi adalah sisa pertanian utama di Malaysia dan kaedah pelupusan pembakaran terbuka telah meluas dan menyumbang kepada pencemaran alam sekitar. Kemungkinan campuran sekam padi dengan simen untuk menstabilkan tanah lembut boleh menjadi penyelesaian kepada kedua-dua masalah. Kajian ini bertujuan untuk mengkaji kesan sekam padi terhadap sifat pemadatan tanah gambut. Eksperimen makmal telah dijalankan ke atas tanah gambut untuk menentukan kandungan air optimum, ketumpatan kering maksimum tanah dan sisa untuk pelbagai campuran sekam padi. Sampel tanah gambut telah diambil dari Kampung Tanah Putih, Pekan, Pahang. Spesimen tanah gambut yang telah dikeringkan dicampur dengan pelbagai kuantiti sekam padi dan kandungan air, kemudian dipadatkan menggunakan Ujian Proctor Standard. Melalui pemerhatian, specimen menjalani pengurangan kebolehmampatan dan peningkatan kekuatan yang menonjolkan potensi besar sekam padi sebagai penstabil tanah alternatif.

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W_w = mass of wet soil (in gram)

W_d = mass of dry soil (in gram)

ω = moisture content (in %)

ρ_w = dry density of water (kg/m^3)

ρ_d = dry density (kg/m^3)

γ_d = dry unit weight (kN/m^3)

v_a = air voids

Gs = specific gravity

LIST OF ABBREVIATION

RH = rice husk

RHA = rice husk ash

OMC = optimum moisture content

MDD = maximum dry density

STP = standard proctor test

ZAV = zero air voids

CHAPTER 1

INTRODUCTION

1.1 Background of study

Soil is known as the basic construction material. It is an important medium that can be used as a base for roads and buildings. However, there is soil that may not suitable for the construction due to its poor bearing capacity and higher compressibility or has an excessive swelling in case of expansive soils. The topic of will discuss about improving a soil by mixing it with a stabilizing agent using certain test. For example, peat soil is not suitable for the construction purposes because the characteristics of peat which is low in shear strength and easily compressed make it considered as unsuitable for the structure to be built on it. Therefore, an innovation has to be made in order to improve the strength of the peat soil. The soil can be improved by mixing it with a binding agent such as cement, rice husk, and lime. The incorporating of this binder into the soil with the addition of water, additional mixture or less, generally in situ, will obtain a material which is homogenous enough to possess new properties. Compaction is one of technique used to test the chemical similarities of the soil and the mixture, as opposed to a mechanical treatment only. In this topic, rice husk is used as a stabilizing agent. Rice husk is obtained from the rice which is extremely prevalent in East and South-East Asia because of the rice production in this area.

1.1.1 Peat Soil

Peat is a natural soil which consists of high organic material because it is formed from the accumulation of soil residues from some rot plants and disintegration of plant and organic matters. Peat soil can be found in various places. In Malaysia, the area covered by peat deposit was about 3 million hectares or 8% of the total area of Malaysia. The peat soil samples for these studies were collected at Kampung Tanah Putih, Pekan, Pahang.

Peat has high compressive deformation, high void ratio and water content. Peat can be categorized in problematic soil because it has low shear strength and high compressibility and not suitable for the construction purposes. Besides that, peat soil is an extremely soft soil and often referred to as problematic soil by engineers. It's soft texture and compressibility lead to excessive settlement which is a very serious problem. Since land are very expensive and very limited nowadays, therefore it is essential to find an alternative to improve the strength of the soil.

The physical properties of peat soil can be seen through its color and texture. A series of test is conducted in order to determine the physical properties of the natural peat soil. The physical properties of peat include water content, specific density, bulk density, fiber content, and decomposition degree. The water content of peat can be measures. The humidity and the saturated soil water content in *Sphagnum* peat are the highest, and they are least in herbaceous-woody peat (Hu Jinming & Ma Xuehui, 2003). When the water contents were expressed on either an oven-dry or wet weight basis, all the organic materials appeared to contain much more water than the mineral soil as shown in table 1.

Table 1: Water Contents of Peat Materials Expressed as Per cent of Oven-Dry Weight, Per Cent of Wet Weight, and Per Cent of Volume

Material	Bulk density (g/cc)	Water content as per cent of		
		Oven-dry weight	Wet weight	Volume
Peat				
Sphagnum moss	0.02	2000	95	40
Herbaceous	0.16	250	71	40
Well decomposed	0.24	167	62	40
Mineral soil				
Barnes loam	1.29	31	24	40

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Den Haan (29) stated that the specific gravity of organic peat is affected by the organic constituents. For example, cellulose and lignin are having lower specific gravity which is 1.58 and 1.40 respectively. This causes the reduction in specific gravity of peat. Consequently, the specific gravity of the peat depends on the organic and fiber constituents. For fibre content, the increasing decomposition decreases the content of the particles or fibres larger than a designated size. Farnham and Finney (1965) have arbitrarily selected fibre greater than 0.1 mm as a criterion for classification of peats. Their designations are as shown in Table 2.

Table 2: Peat Classification by Proportion of Fibre Size Larger Than 0.1 mm

Portion of the total mass consisting of fibres larger than 0.1mm	Designation of material
Less than one third	Sapric (the most decomposed peat)
One-third to two-third	Hemic (intermediate stage of decomposition)
More than two-thirds	Fibric (the least decomposed peat)

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The decomposition degree of peat is the proportion of the matter which has lost its cellular structure due to the decomposition of plant residues. Decomposition degree is usually expressed as a percentage. Table 3 shows the three level of the decomposition degree of peat soil.

Table 3: Decomposition Degree's Level, (Hu Jinming & Ma Xuehui, 2003).

Lowly decomposed peat	Less than 20%
Moderately decomposed peat	20% - 40%
Highly decomposed peat	Higher than 40%

1.1.2 Rice Husk

Rice husk is the shell produced during dehusking of paddy. Rice is a heavy staple in the world market since it is the primary source of food for billions of people around the world. It has become the second largest amount of any grain produced in the world. Rice can easily grow in tropical regions on any type of terrain. It is well-suited to countries and regions with low labor cost and high rainfall, as it is very labor-intensive to cultivate and requires plenty of water for cultivation (Wikipedia, Rice). The table shown in Table 4 is the significant the amount of rice cultivated and the amount of rice husk accumulated across the world.

Figure 1.1: Rice Husk

Table 4: World Production Rate for Rice Paddy and Risk Husk (Million Metric Tons), courtesy of Hwang & Chandra

Country	Rice Paddy	Rice Husk
Bangladesh	27	5.4
Brazil	9	1.8
Burma	13	2.6
China	180	36.0
India	110	22.0
Indonesia	45	9.0
Japan	13	2.6
Korea	9	1.8
Philippines	9	1.8
Taiwan	14	2.8
Thailand	20	4.0
US	7	1.4
Vietnam	18	3.6
Others	26	5.2
Total	500	100

From the table, we can see that the production of rice paddy is around 500 million tons and 100 million tons of rice husks are produced, Hwang (185). Furthermore, rice husk took a very long period to decompose and not appropriate for composting or manure due to its low nutritional value. Therefore, the disposal of rise husk has become important issue in those countries which cultivate large quantities of rice. There were 100 million tons produced globally and this situation will begin to impact the environment if it not disposed properly. Rice husk can be useful for many things. One of the effective methods that can be used to rid planet from rice husk is by using it as a binder or a stabilizing agent or use it to fuel kilns.

1.1.3 Soil Improvement

In order to propose a construction on any land-based structure, the foundation has to be strong to support the entire structure. The soil around the foundation plays an important role to make sure that the foundation is strong enough for that purpose. Therefore, we need to study and gain knowledge about the properties of the soil and investigate the factors which affect their behavior. A soil improvement process must be done in order to achieve the required properties of soil that needed for the construction work. In this research, the soil improvement has been investigated by mixing the peat soil with rice husk under compaction test. The improvement in the compressibility parameter and comparative study have been carried out using different percentage and proportion of moisture content and rice husk. The addition of rice husk to the soil will enhance the workability and strength of the soil. Keeping in view of environmental consideration, energy conservation, and economy, the using of rice husk will help the disposal of rice husk properly.

1.2 Problem Statement

Nowadays, there is a high demand in construction purposes and the building construction grows rapidly. Construction work requires soil as a base and important foundation to enable the construction to construct. However, not all soil suitable for the purposes because there is a soil that has been classified as weak soil such as peat soil. Peat is known as one of the most problematic soil in the world. It can pose serious problem in the construction industry due to its consolidation settlement. In future, the soil will be limited and the construction work cannot be done. Therefore, we have to treat and find an alternatives way to replaced the soil by improving the soil properties.

1.3 Aim and Objectives

The main objective of this research is to investigate the effect of rice husk in the compaction of peat soil. Apart from that, the index properties such as natural water content, fiber content, liquid limit, atterberg limit, specific gravity and density of peat soil were obtained to establish suitable correlation.

The specific objectives of this research are:

1) To determine the optimum water content of the peat soil and waste for various mixes of rice husk.
2) To determine the maximum dry density of the peat soil and waste for various mixes of rice husk.
3) To determine the optimum peat soil and waste mix of rice husk which gives the maximum compaction performance.

1.4 Scope of Study

In this research, peat soil will be used. The peat sample was tropical peat which obtained from area of Kampung Tanah Putih Pekan, Pahang. There are two tests that will be conducted in this research, which is minor test and major test. The minor test includes the basic engineering properties of peat samples such as moisture content, liquid limit, fiber content, specific gravity, and dry density. The major test in this research will be compaction test by using standard proctor test equipment. Here, the soil will be mixed with rice husk at various proportions varying from 0%, 2%, 4%, 6% and 8%. The rice husk was obtained from Bernas Factory at Bagan Serai, Perak.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The main topic of literature review is the review of compaction behavior of peat soil mix with waste material such as rice husk. The properties of rice husk was stated in the previous chapter. In this chapter, some review of the current work of the experiment will be discussed. Soil stabilization using rice husk ash and lime has been more attractive recently due to its promising results compared to other siliceous sources. Overview about the methods and the basis of the rice husk ash utilization in this application will be presented in this section. The common criteria and methods to evaluate the activity of the rice husk ash will also be introduced and these will be the basis for the evaluation of the rice husk ash in the next section.

2.2 Available Reagents for Soil Stabilization

Soil stabilization mentioned in the overview is the alteration of the current properties of the soil to meet the specified engineering requirements, and using chemical reagents is one of the main techniques. The mechanism which helps to stabilize the soil is that the reagents create matrix within the soil mass, hence particles are bonded together and the overall strength is increased while water absorption is reduced.

The matrix can be created by physical or chemical reactions. The most common method of physical reaction for soil stabilization is bitumen in road construction. The bitumen is made to be more fluid before operation, and it will come back to the viscous semi-solid state inside the soil mass by temperature reduction and evaporation. By this way, the soil particles are fixed in the bitumen matrix, nevertheless the bonding is relatively weak.

Chemical reactions for soil stabilization can be either the reaction between different reagents so that the matrix will cover the soil particles or the reactions between the reagents with soil. The precipitation of calcium silicate from sodium silicate and calcium chloride is an example for the case which the soil does not join into the reaction but sinks into the product of the reaction.

When the soil joins into the reaction, hydrated lime is the typical reagent for this case because of its intermediate affect in drying the soil and the pozzolanic reaction with some clay minerals for long-term shear strength development of the soil mass.

Available reagents for soil stabilization are categorized into two groups. The primary stabilizing reagents are the ones which they themselves can stabilize the soil. So the reagents mentioned above, which are bitumen and lime are in this group. The secondary stabilizing reagents need the lime or cement to be activated, and these are the blast furnace slag or the pozzolanas such as fly ash or rice husk ash.

2.2.1. Cement and Lime To Be The Primary Reagent

The primary stabilizing reagent which are cement and lime are very well known because they can work with wide range types of soil in various foundation conditions. The main effect of the additives is modifying both the physical and chemical properties of the soil in such a way that the strength, volume stability, durability and permeability are improved.

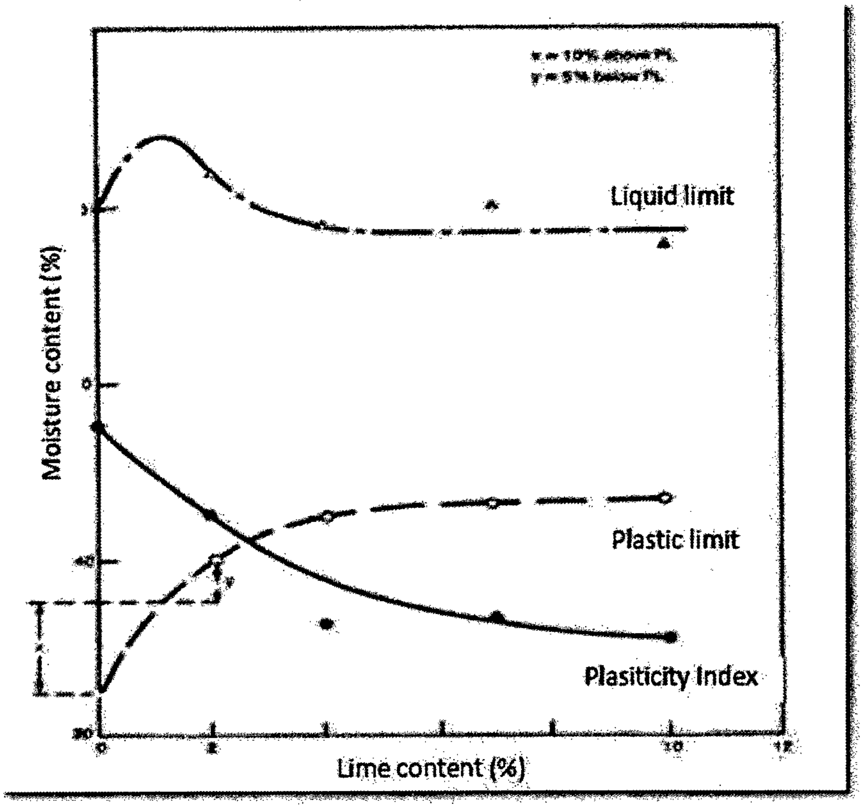

Figure 2.1: Effect of the addition of lime on the plasticity properties of London Clay, (Sherwood 1993)

When lime is added into the soil, the improvement mechanism can be separated into two phases. With the present of clay minerals, the clay anion is immediately isolated by the calcium cation Ca^{2+} in the lime from other weaker cations existing in the soil, hence the soil texture is the changed. This ion exchange leads to flocculation in the first phase and it dramatically reduces the plasticity of the soil as seen in Figure 2.1 (Sherwood 1993). For the clay whose water content is 35% and plastic limit is 25%, it is plasticity and not preferred for construction. But by adding 2% of lime, the plastic limit is upgraded to be 40%, consequently makes the soil be dry and possibly ready for construction purposes.

The appearance of hydroxyl anion from lime increases the pH to about 12.4 and helps to dissolve the silica existing in soil, hence the pozzolanic reaction happens. Depends on the mineral components of the soil that this stabilized matrix is strong or