THE EFFECT OF SAWDUST ON COMPACTION PROPERTIES OF PEAT SOIL

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ABSTRACT

The improvement of soil is the one of the most importance criteria that should be considered for construction on soft soil. It is well known that improvement of the ground will affect the stability of the structure above it and there are many types of soil to deal with, depending on the area, its location, its surroundings and various other factors. This thesis is deals with the effect of sawdust on the compaction properties of peat soil. As we all known, in the civil engineering work, the construction of the roads , bridge, canals, dam and building is very important to make sure the base layer of these is strong enough to support the load from the superstructure. Thus, the proper soil analysis is very important so as to check the soil strength and the moisture content of soil and also to make sure the structure is stay safe and can endure from sinking. Compaction test is used on this research to determine the optimum moisture content of the peat soil and sawdust in various mixes, to determine the maximum dry density of peats soil and sawdust for various mixes and to define the optimum moisture mix for the peat soil sawdust which gives the maximum compaction properties performance. The acquired results indicates that when the amount of sawdust is increase, the maximum dry density is decrease and the optimum moisture content was increase. Therefore, the results concluded that the addition of sawdust has an influence in increasing physical strength of natural peat soil.

ABSTRAK

Penambahbaikan tanah adalah salah satu kriteria yang paling penting yang perlu dipertimbangkan bagi pembinaan di atas tanah lembut. Adalah diketahui umum bahawa kemajuan tanah akan menjejaskan kestabilan struktur di atas dan terdapat banyak jenis tanah untuk menangani, bergantung kepada kawasan, lokasi, persekitaran dan pelbagai faktor-faktor lain. Tesis ini memperkatakan kesan habuk papan atas sifat pemadatan tanah gambut. Seperti yang kita semua tahu, dalam kerja-kerja kejuruteraan awam, pembinaan jalan raya, jambatan, terusan, empangan dan bangunan adalah sangat penting untuk memastikan lapisan asas ini adalah cukup kuat untuk menyokong beban daripada struktur utama. Oleh itu, analisis tanah yang betul adalah sangat penting bagi memeriksa kekuatan tanah dan kandungan lembapan tanah dan juga untuk memastikan struktur adalah sentiasa selamat dan boleh bertahan dari tenggelam. Ujian pemadatan yang digunakan dalam penyelidikan ini untuk menentukan kandungan lembapan optimum tanah gambut dan habuk papan dalam pelbagai campuran, untuk menentukan ketumpatan kering maksimum tanah dan habuk papan gabus untuk pelbagai campuran dan untuk menentukan campuran kelembapan optimum bagi tanah gambut habuk papan yang memberikan pemadatan prestasi hartanah maksimum. Keputusan yang diperolehi menunjukkan bahawa apabila jumlah habuk kayu adalah peningkatan, ketumpatan kering maksimum adalah penurunan dan kandungan kelembapan optimum peningkatan. Oleh itu, keputusan membuat kesimpulan bahawa penambahan habuk kayu mempunyai pengaruh dalam meningkatkan kekuatan fizikal tanah gambut semulajadi.

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LIST OF SYMBOLS

µm	Micrometer
Gs	Specific Gravity
w	Moisture Content
wi	Initial Moisture Content
ɤd	Dry Unit Weight
ρd	Dry Density
Va	Void Air
ρw	Density of Water
kN/m^3	Kilo newton per meter cube

LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing Material
BIS	Bureau of Indian Society
BS	British Standard
EFNARC	European Federation for Specialist Construction Chemicals and Concrete Systems
LL	Liquid Limit
MS	Melamin Sulphonate
MDD	Maximum Dry Density
NS	Naphtalene Sulphonate
OMC	Optimum Moisture Content
OPC	Ordinary Portland Cement
PI	Plasticity Index
PL	Plastic Limit
SCC	Self- Compacting Concrete
SDA	Sawdust Ash

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The improvement of soil is the one of the most importance criteria that should be considered for construction on soft soil. It is well known that improvement of the ground will affect the stability of the structure above it and there are many types of soil to deal with, depending on the area, its location, its surroundings and various other factors. This research is about the effect of sawdust on the compaction properties of peat soil. As we all known, in the civil engineering work, the construction of the roads , bridge, canals, dam and building is very important to make sure the base layer of these is strong enough to support the load from the superstructure. Thus, the proper soil analysis is very important so as to check the soil strength and the moisture content of soil and also to make sure the structure is stay safe and can endure from sinking. Compaction test is used on this research to test the moisture content of peat soil with the mixing of sawdust.

1.1.1 Peat Soil

Peat soils are formed by disintegration of plant and organic matters and are characterized by terribly high void quantitave relation and water content (Kulathilaka, 1999). Peat soil is soft and simply compressed, under pressure and water within the peat is forced out. Upon drying, peat is used as fuel. It is an industrial importance as a fuel in some countries such as Finland and Ireland. However, these soils are also was founded in many countries throughout the world. In the US, peat is found in 42 states, with a total acreage of 30 million hectares. Canada and Russia are the two countries with the largest area of peat 170 and 150 million of peat respectively. According to Huat (2004), In Malaysia, the area covered by peat deposit is about 3 million hectares or 8% of the total area of Malaysia. While for this research, the peat soil was taken at Kampung Tanah Puteh, Pekan, Pahang.

Peat is an accumulation of partially decayed vegetation. Peat soil was formed in wetland conditions, where flooding obstructs in flows of oxygen from the atmosphere and reducing rates of decomposition. It is an organic matter and is characterized by having a very high void ration and water contents. Peat also has high water holding capacity, low specific gravity and medium to low permeability. Consequently, peats are widely considered as a problematic soil since it poses serious problems in construction due to its long-term consolidation settlements even when subjected to a moderate load.

There are close relationships between the decomposition of the degree and other properties of peat (see Table 1).

Table 1: Relationship between the degree of decomposition and other properties of peat (Ma Xuehui & Liuhuanguang, (1991)

Related correlation with the decomposition degree	**Correlation Coefficient**	
	Oligotrophic Peat	**Eutrophic Peat**
calorific value	0.83	< 0.50
water	-0.50	-0.65
carbon content	0.80	< 0.50
oxygen content	-0.80	< 0.50
asphalt content	0.80	< 0.50
content of water-soluble matter and easily hydrolyzed matter	-0.75	-0.53
reductive matter content	-0.62	-0 64
humus acid content	0.81	< 0.50
cellulose content	-0.62	< 0.50
particle size less than <250	0.79	0.61

Source I.I. Listhvan & N.T. Kololy (Dai Guoliang & Ma Xuehui translate into Chinese) (1989)

Moreover, construction over peat will be subjected to be massive primary and long-term secondary and even tertiary settlement. It is therefore understandable that constructions and buildings on this type of soil often avoided whenever possible. So, in practice, it was economical to stabilize the soil by mixing the peat soil with the sawdust.

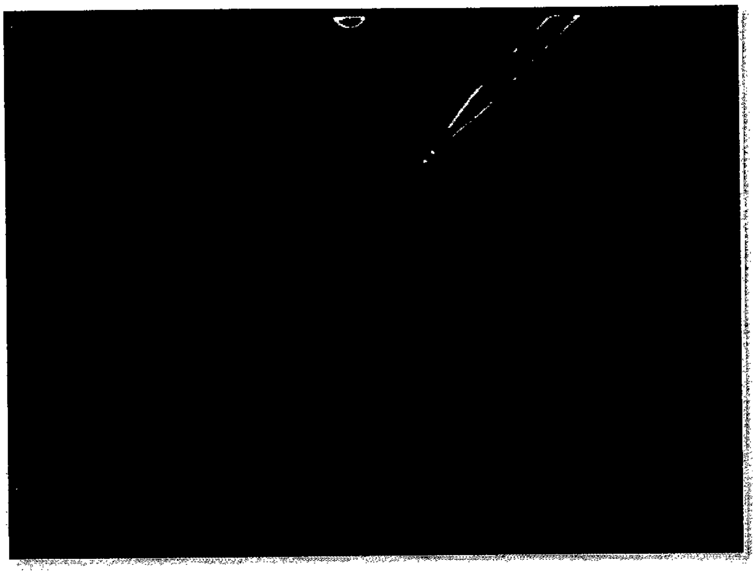

Figure 1.1: Peat soil

1.1.2 Sawdust

According to A.U. Elinwa and S.Abdulkadir ,(2011), sawdust is an industrial waste in the timber industry and posses a nuisance to both the health and environment when it is not in properly managed. Sawdust has pozzolanic properties and has been shown to react chemically with the calcium hydroxide released from the hydration of Portland cement, to form cement compounds by (Elinwa and Mahmood, 2002)

In addition, reusing organic wastes like sawdust is a good solution for saving the environment by preventing burning and preventing from air pollution of sawdust that may create an environmental hazard. In addition, a large volume of wood and large concentrations of these materials permeate into the runoff, and the toxicity cause is harmful to a broad range of organisms. Reuse to take the materials considered as waste and intended for production and consumption processes. However, Recovery, reuse and recycling can reduce environmental impacts, and increase the useful life of the raw materials employed and lower final production costs. Using of waste materials in infrastructure development is proven to be economically viable when environmental factors are considered. The use of sawdust and peat soil as for improvement of soil for construction would reduce sand mining and preserve the environment to achieve sustainable construction.

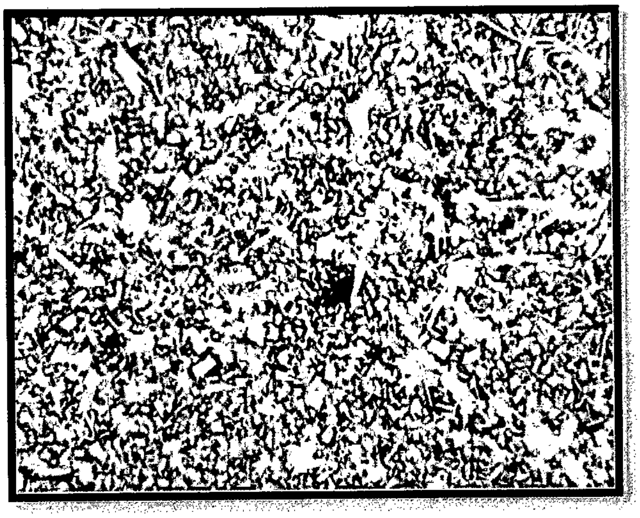

Figure 1 2 : Sawdust

1.1.3 Soil Improvement using Waste Material

Nowadays, there are many soil need to be improved because of the limited suitable soil for the construction work. The construction of structures on areas with soft and incapable soils necessitates the improvement of the soil condition. The choice of the appropriate technique has to be made depending on the type of soil, the load applied and the time available for the improvement process. So, one of the solution for this problem is by mixing the soil with the waste material. Mixing the waste material such as sawdust was used to stabilize soil in the field especially fined grained soil. The purpose of this soil stabilization is to;

1. Modify the soil.
2. Accelerate the construction.
3. Improved the strength and durability of the soil.

In this research, peat soil has been used and mixed with the sawdust as one of the technique to improve the peat soil.

1.2 Problem Statement

According to Said J.M and Taib S.NL, (2009) Peat is widely regarded as problematic soil. It poses serious problems in construction due to its long term settlements. Generally , peat is found in thick layers which is in limited areas, has low shear strength and high compressive deformation which is often results in difficulties when construction work is undertaken on the deposit. In settlement analysis, it is often that the long term compressibility parameters of peat are underestimating or neglected.

Figure 1.3 shows that the column supports a house which was built on peat soil. The figure was taken during the investigation in Parit Nipah, Johor on 2011. Most of the columns face the same problems. It is risky to the occupant. The figure also shows the distribution of load in a column due to the soil structure interaction. A gap can be clearly seen between column and footing. This is due to low bearing capacity and the settlement of peat soil to support the load from the superstructure (Siti Nooraiin Razali et.al, 2013) .

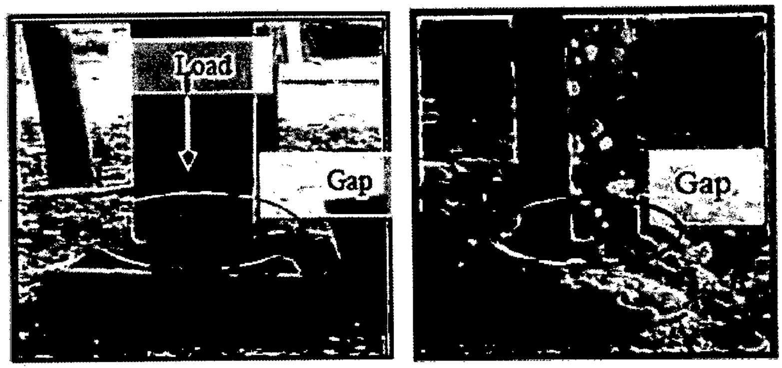

Figure 1.3: Settlement on Peat soil, Parit Nipah, Johor (Authors, 2011)

This situation could lead to the problem regarding on the structure stability in the future. So the knowledge on the shear strength and compression behavior is essential as it enables designers to understand the response of the soil to the load and to suggest the proper engineering solutions to overcome this problem. However, because of the demand of the soil increase, so the improvement of soil was needed.

1.3 Aim and Objectives

The main objective of this research is to find the compaction properties of peat soil with the mixing of sawdust. Apart from that the researcher is interested in the engineering properties of peat with response to their compressibility characteristics due to vibration of fiber content. Meanwhile the index properties such as liquid limit, plastic limit natural moisture content and specific gravity will be obtain in an establish in suitable correlation.

The specific objectives of this research are:

a) To determine the optimum water content of peat soil and sawdust for various mixes.
b) To determine the maximum dry density of peat soil and sawdust for various mixes.

c) To determine the optimum mix for the peat soil sawdust as this gives the maximum compaction performance.

1.4 Scope of Study

In this project, the peat soil has been used. This peat soil is taken at Kampung Tanah Puteh, Pekan, Pahang at latitude N 03'39'01.1'' E 103' 17'59.6''. During this experimental project, the investigation was carrying out by mixing the waste material with the peat soil through the compaction test. The compaction of the soil was investigated by carry out standard proctor test. While, the peat soil has been mixed with the sawdust in the various proportion. The sawdust was obtained from Terengganu at 'Kilang Papan Mohd Yusof dan Anak-anak' at Bukit Kubang Jambu, Kuala Terengganu.

Figure1 4: Kampung Tanah Puteh, Pekan (Google Earth)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This paper present the review on compaction behavior of peat soil mixed with the sawdust. For this project, sawdust was used as the waste material to improve the peat soil. The property of sawdust and peat soil has been introduced on chapter 1. So in this chapter, the reviews about these materials were discussed.

2.2 Assessing of the fresh concrete properties of self-compacting concrete containing sawdust ash

According to Augustine U. Elinwa et. al,(2008) evaluation of self-compactability of SCC mixes containing SDA as powder material and naphthalene sulphonate (NS) and melamine sulphonate (MS), respectively, shows that optimum workability range for the slump flow test lie between 665 mm and 680 mm, while theV-funnel test is 8.2 s and 8.4 s. These values show that adequate mix stability and self deaeration are achieved. Results of the self-compactability of the SCC mixes using the U and L-box are within the targets and tolerance values stipulated by EFNAC (2002). These are 28.5 mm/29 mm and 0.85/0.85, respectively, for mix containing NS and MS.

Self-compacting concrete (SCC) is a form of concrete that is able to flow under its own weight and completely fills the formwork even in the presence of dense reinforcement, without the need of any vibration, whilst maintaining homogeneity. It was originally developed in Japan10 years ago to off-set a growing shortage of skilled labour. At required levels, fresh self-compacting concrete must possess the following key properties:

(i) Filling ability: This is the ability of self-compacting concrete flowing into all spaces within the formwork under its own weight.

(ii) Passing ability: This is the ability of self-compacting concrete flowing under its own weight, through tight openings such as spaces between steel reinforcing bars.

(iii) Resistance to segregation: This is the ability of self-compacting concrete remaining homogenous in composition during transport and placing.

The steps usually employed in achieving self-compactability are;

(i) Limited coarse aggregate content.

(ii) Low water–binder ratio.

(iii) Use of super-plasticizer.

The development and use of SCC in many countries has shown that it can successfully be produced from a wide range of component materials, notably cement replacement materials (mineral admixtures) and super-plasticizers (high range water reducers). The present paper is an on-going research in the Civil Engineering Programme, Abubakar Tafawa Balewa University, Bauchi, Nigeria, on the use of sawdust ash (SDA) as powder material for the production of SCC. The work is in two phases: to determine self-compacting characteristics for concrete containing SDA and superplasticizers (MS and NS), and investigate the microstructural characteristics of Portland 'Ashaka' cement mortar containing SDA and naphthalene sulphonate. This is the fundamental research into the properties of the material.

The materials used in this study are Portland 'Ashaka'cement and SDA obtained from thermally activated timber wastes at temperatures of between 400 °C and 600 °C. SDA is a waste product with a highly beneficial effect. Its structure is so fine that it produces a very compact, tightly packed concrete texture. In addition, it is somewhat reactive, so it has certain binding properties. The chemical composition and average particle size (fineness) are given in Tables.2.1. The fine aggregate is river sand with a specific gravity of 2.57, moisture content of 14.4% and a bulk density of 1472 kg/m3 and falls in zone 2 in the classification table in accordance with BS 882 . The coarse aggregate has a maximum aggregate size of 20 mm and 0.35% was retained on sieve 20 mm. The specific gravity of the aggregate is 2.54, bulk density, 1351 kg/m3 and a crushing value of 10.96. The coarse aggregate falls in zone 2 in the classification chart in accordance with BS 882. Two types of super-plasticizers are used. They are (i) melamine sulphonate (MS) and (ii) naphthalene sulphonate (NS). The MS is produced by Burgoyne Burbidges and Co, India, and contains Assay (ex N)-97.5% and Sulphated ash-0.1%. The NS is produced by W. R. Grace and Co,USA with the commercial name of Daracem 19. It has a specific gravity of 1.18, pH of 9.5 and the dry extract by mass is 40%. The mortar or paste in self-compacting concrete requires high viscosity as well as high deformability. This can be achieved by the employment of a super-plasticizer, which results in a low water–powder ratio for high deformability The action of super-plasticizers is to equalize the surface charges (zeta potential) on all solid particles in the dispersion and in this way to disagglomerate the particles.

Table 2.1 Chemical analysis of raw materials (%) by weight (Augustine U. Elinwa et. al,2008)

Oxides	Ashka PC	Sawdust Ash
SiO_2	20.7	67.2
Al_2O_3	6.1	4.1
Fe_2O_3	2.3	2.3
CaO	62.1	10.0
Mg	1.2	5.8
Na_2O	0.9	0.1
K_2O	1.0	0.1
SO_2	1.6	0.5
P_2O_5	-	0.5
MnO	-	0.01

The results reported in this paper show that SDA can be used as powder material with cement and super-plasticizers to produce flowable concrete. It can be seen that the workability ranges fluctuate around the characteristic value for self-compaction of 665/680 mm and flow time of 8.2/8.4 s for NS and MS, respectively, as recommended by EFNARC The segregation resistance of the concrete and the placeability of the concrete as determined by the T5 minutes and the U- and L-box are within the limit recommended by EFNARC. The compressive strength development of SCC mortar shows a tremendous improvement over the control. At 90 days, the best strength was recorded at 10 wt% replacement and this is approximately 30% above the value of the control. SDA can defer the reaction of cement hydration and prolong the setting time of cement paste. It also reacts with Ca(OH)2 released during the cement hydration to produce secondary C–S–H gel inside the cement paste. The microstructure of cement paste matrix is improved by this gel and therefore imparts denseness on the structure.

2.3 Sawdust Ash (SDA) as Partial Replacement of Cement

Based on C. marthong stated that, the possibility of using Sawdust Ash (SDA) as a construction material was experimentally investigated. Saw dust was burnt and the ash sieved using a 90 micron sieve. Three grades of ordinary Portland cement (OPC) namely; 33, 43 and 53 as classified by Bureau of Indian Standard (BIS) are commonly used in construction industry. A comparative study on effects of concrete properties when OPC of varying grades was partially replaced by SDA is discussed in this paper. Percentage replacement of OPC with SDA was 0, 10, 20, 30 and 40% respectively. Experimental investigations are carried out on mortar cubes, concrete cubes and beams specimens. The mix was designed for target cube strength of 30 MPa at 28 days with water-cement ratio of 0.38. The compressive strength, water absorption, shrinkage and durability of concrete were mainly studied. Test results shows that, inclusion of SDA cause little expansion due to low calcium content. Early strength development was observed to be about 50-60% of their 28 days strength. The study suggests the use of SDA as partial replacement of cement up to a maximum of 10% by volume in all grades of cement.

According to American Society for Testing Materials (ASTM, C-618-1978), pozzolana is a siliceous or a siliceous aluminous material which contains little or no cementitious value, but in finely divided form and in the presence of moisture or water, chemically reacts with calcium of moisture at ordinary temperature to form compound possessing cementitious properties. Such material commonly includes fly ash, calcined diamotaceous earth, rice husk ash and pulverized burnt clay. Many researchers are being done on the possible use of locally available materials to partially replace cement in concrete as cement is widely noted to be most expensive constituents of concrete. Extensive research has shown the use of reaction (Meland, 1986). Cement according to (Shetty ,2005) is composed primarily of silica and lime, which form the essential cementing compounds tricalcium (C3S) and dicalcium silicate (C2S). Any alteration in silica content will invariably affect the strength characteristics of cement, which is expected when SDA is used to partially replace with any grades of cement for making concrete. The aimed of this