APPLICATION OF N... IMPROVEMENT

SITI AISYAH BINTI JAMIL

A thesis is submitted in fulfilment of the

requirements for the award of the degree of

Bachelor of Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2012

ABSTRACT

The ground improvement for enhancing earth structure and stability by natural material has acceptable demand due to reducing negative effect of cost and project. This thesis presented a new sand mixture design based on mineralogy and morphology. The sand-bentonite-oil palm fiber interaction has been studied for understanding design and analyzing unstable sandy subsoil. The ground improvement was simplified. The sand-bentonite-oil palm fiber was test for improving shear strength parameter. The bentonite thermally has been process under 100 °C, 300 °C, 500 °C and 700 °C for 1 hour. The percentage of bentonite and oil palm fiber were 1% and 2% by weight of the mixture. The result indicates that 2 % fiber and 2% modifies bentonite give the best result as 59 kPa by using 500°C of modifies bentonite.

ABSTRAK

Pembaikan tanah untuk meningkatkan struktur bumi dan kestabilan dengan bahan semulajadi mempunyai permintaan diterima kerana mengurangkan kesan negatif kos dan projek. Tesis ini membentangkan reka bentuk campuran pasir baru yang berdasarkan mineralogi dan morfologi. Interaksi antara pasir-bentonit -serat kelapa sawit telah dikaji untuk memahami reka bentuk dan menganalisis tanah berpasir yang tidak stabil. Pembaikan tanah telah dipermudahkan. pasir-bentonit -serat kelapa sawit telah diuji untuk memperbaiki parameter kekuatan ricih. Bentonit yang diubahsuai (pemanasan) telah menjadi proses di panaskan 100 ° C, 300 ° C, 500 ° C dan 700 ° C selama 1 jam. Peratusan bentonit dan serat kelapa sawit adalah 1% dan 2% berasakan berat campuran. Keputusan kajian menunjukkan bahawa 2% serat kelapa sawit dan 2% bentonit memberikan hasil yang terbaik iaitu 59 kPa dengan menggunakan bentonite ubahsuai 500 ° C .

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	TITLE PAGE	i
	SUPERVISOR'S DECLARATION	ii
	STUDENT'S DECLARATION	iii
	DEDICATION	iv
	ACKNOWLEDGEMENTS	v
	ABSTRACT	vi
	ABSTRAK	vii
	TABLE OF CONTENTS	viii
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF ABBREVIATIONS	xiv
	LIST OF SYMBOLS	xv

1 INTRODUCTION

1.1 Background of the study 1

1.2 Problem statement 2

1.3 Objectives 3

1.4 Scope of Study 3

LITERITURE REVIEW

2 2.1 Introduction 4

2.2 Bentonite 4

2.3 Fibers Used For Soil Improvement 6

2.3.1 Natural Fibers 6

2.3.2 Properties of Oil Palm Fiber 7

2.4 Mixed Soil Design 9

2.5 Material Modification 10

2.6 Liquefaction 11

2.7 Previous Research Investigation 11

2.7.1Soil – Oil Palm Fiber Mixture 12

2.7.1.1. Case Study 1 12

2.7.1.1. Case Study 2 14

2.7.1.1. Case Study 3 14

2.7.2.Soil - Bentonite Mixture 15

2.7.2.1. Case Study 1 15

3 METHODOLOGY

3.1 Introduction 16

3.2.Laboratory Testing 18

3.2.1.Particle size distributions 19

3.2.1.1.Sieve Analysis (Dry sieving method) 19

3.2.2.Compaction Test 20

3.2.3.Specific Gravity 20

3.3.Direct Shear Test 25

4 RESULT AND DISCUSSION

4.1.Soil Identification and Classification 23

4.2.Result of Direct Shear Test 25

5 CONCLUSION & RECOMMENDATIONS

5.1 Conclusion 30

5.2 Recommendation 31

REFERENCES 32

APPENDICES

Appendices A-B 35

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Properties of Bentonite	6
2.2	Physical and mechanical properties of oil palm empty fruit bunch fiber	8
4.1	Soil properties	25
4.2	Mean of the maximum cohesion and shear resistance	29

LIST OF FIGURES

FIGURE . NO.	TITLE	PAGE
2.1	Crushed unheated bentonite (room temperature)	5
2.2	Untreated OPEFB fiber	8
2.3	Typical Stress-strain curves obtained from triaxial CD test on soil reinforced with OPEFB fiber.	13
2.4	Volumetric curves obtained from triaxial CD test on soil reinforced with OPEFB fiber.	13
3.1	Flow chart of the experiment	17
3.2	Direct shear apparatus.	21
4.1	Gradation curve	24
4.2	Shear stress versus horizontal displacement	27
4.3	Maximum shear stress vs normal stress	27
4.4	Cohesion vs bentonite by percentage	28
4.5	Friction angle vs bentonite by percentage	28

LIST OF ABBREVIATIONS

OPEFB	=	Oil Palm Empty Fruit Bunches
WSI	=	Water Seismic Index
CU	=	Consolidated Undrained
CD	=	Consolidated-Drained
IPS	=	Interfacial Peak Strength
IRS	=	Interfacial Residual Strength

LIST OF SYMBOLS

φ	=	Angle Of Shear Strength
c	=	Cohesion
τ	=	Shear Stress

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Any soils have different characteristic, some very good in strength and some of them very poor in strength with highly compressibility characteristics. Without improvement of weak or soft soil it is unacceptable to construct any civil engineering structures. Various experimental investigations and theoretical studies have been done in order to improvement of soil mechanical properties like shear strength and permeability. There are varieties of ground improvement techniques such as soil stabilization or prefabricated vertical drain.

A wide range of reinforcements have been used for improving soil strength. Short fibers made of polymeric or natural material have been used to improve soil shear strength [1], [2] It has been suggested that natural resources may provide superior materials for improving soil structure, based on their cost-effectiveness and environment-friendly aspects [3] .

The efficacy of using fibers to reinforce soil for improved performance is well established [4]. Polymeric fiber in the form of woven and nonwoven geotextile or geogrid has been used for reinforcement. Recent studies examined the mechanical performance of reinforced soils using randomly distributed discrete fibers [5]. Due to their cost-effective and environment-friendly characteristics, natural fibers are desirable materials for improving soil structure [3].

Bentonite is composed essentially of montmorillonite clay, also known as hydrous silicate of alumina. The characteristic of bentonite itself where at high concentrations (~60 grams of bentonite per liter of suspension), bentonite suspensions begin to take on the characteristics of a gel. So, with the admixture of low amount of bentonite with sand with appeared to be very promising in greatly decreasing hydraulic conductivity [6].

1.2 Problem Statement

Before any construction take place it is importance to ensure that the soil condition is suitable. For sites that have unsuitable soil for construction like soft or loose soil, improving the quality have quite a few ways like using conventional method by either remove and replace the unsuitable soils or bypass them with the deep foundations. But these techniques need high cost and not environmental friendly.

Because of this matter it has been suggested to use natural sources in improving soil structure in order to overcome the problem of high cost and environment-friendly aspect. In Malaysia, Oil Palm Empty Fruit Bunches (OPEFB) fiber is an easy access as it comes in bulk and most important that its own strength. The fiber will be used to study the performance of the fiber in improvising the soil strength.

1.3 Objectives

The objectives this research work is as following:

a) Increasing shear strength parameter of sand.

b) Assessment of oil palm fiber-modifying bentonite interaction in improving loose sand mechanical characteristics.

1.4 Scope of Study

The study focuses on the shear strength characteristics of loose sand with the addition of OPEFB fiber and modified bentonite. The bentonite used are different in percentage which is from 1% to 2% and range from different degrees, from room temperature, 100 °C, 300 °C, 500 °C and 700 °C. The OPEFB used for this study are untreated OPEFB. The evaluation is limited to the results of direct shear test conducted in accordance to BS 1377 Methods of test for Soils for civil engineering purposes, Part 7: Shear strength tests (total stress) 1990 Clause 4..

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter presents background information about soil improvement using OPEFB fiber and modified bentonite. In the previous study there are several studies about the mixture of soil and fiber mixture in improving the soil condition and also only about the sand and bentonite mixture in improving the permeability and other sand characteristic. Now in this study it is about combination of both fibers and bentonite clay in improving the characteristics and the strength of the soil mixture.

2.2. Bentonite

Clay is a very fine grained, unconsolidated rock matter, which is plastic when wet, but becomes hard and stony when heated. Clay is composed of silica (SiO_2), Alumina (Al_2O_3) and water (H_2O) plus appreciable concentrations of oxides of iron, alkali and alkaline earth, and contains groups of crystalline substances known as clay minerals such as quartz, feldspar, and mica.

Bentonite is a clay mineral which is largely composed of Montmorillonite, which is mainly a hydrous aluminum silicate. Figure 2.1 show crushed unheated bentonite (room temperature). It is highly colloidal and plastic clay with the unique characteristic of swelling to several times its original volume when placed in water. There are different types of bentonite, each named after the respective dominant element, such as potassium (K), sodium (Na), calcium (Ca), and aluminum (Al). In the previous study, the properties of bentonite already had been summarized in the Table 2.1 below [6].

Figure 2.1 : Crushed unheated bentonite (room temperature)

Table 2.1 : Properties of Bentonite

Property	Value
Specific Gravity	2.24
Liquid Limit	250%
Plastic Limit	47%
Maximum Dry Density	1.17 g/cm^3
Optimum Moisture Content	46.70 %
Swelling Water Absorbed Per gm of Oven Dried Bentonite In Cc	7-8 times

2.3. Fibers Used For Soil Improvement

The increasing use of natural fibers as improvement of soft ground also increasing the attention of finding new accessible resource. Polymeric fibers and natural fibers are two main sources have been using in soil reinforcing. Natural resources are one of good materials due to cost effective and environment-friendly [3].

2.3.1.Natural Fibers

There are various natural fibers find applications as a resource for industrial materials. Properties of each natural fiber depend on the nature of the plant, locality of the plant, the age of the plant and also the extraction method use [7].

2.3.2.Properties of Oil Palm Fiber

Oil palm fiber is one of the most economical and very high potential natural fibers. It belongs to the *Elaeis guineensis* under the family of *Palmacea* and it was originally come from tropical forest in West Africa. In Southeast Asian countries such as Malaysia and Indonesia are the major of this industrial cultivation.

Oil palm fiber is extracted from oil palm's empty fruit bunch (OPEFB) and it is non-hazardous biodegradable materials. The fibers are clean, non-carcinogenic, and free from pesticides and soft parenchyma cells. In the process of producing oil there are two types of fibers left in the palm-oil mill, which are OPEFB fibers and oil palm mesocarp fibers.

The oil palm fiber is produced from empty fruit bunch that are considered as waste after the extraction oil palm fruits. Oil palm fibers are obtained after the subtraction of the oil seeds from fruit bunch for oil subtraction. Figure 2.2 show the untreated and extraction of OPEFB fiber.. Previous study shows the physical and chemical properties of OPEFB fibers. Table 1.2 show the summary of oil palm fiber properties [7] [8] [9]

Figure 2.2 : Untreated OPEFB fiber

Table 2.2: Physical and mechanical properties of oil palm empty fruit bunch fiber

Chemical constituents (%)	
Cellulose	65
Hemicellulose	–
Lignin	19
Ash content	2
Physical properties of oil palm fiber	
Diameter μm	150–500
Density g/cc	0.7–1.55
Tensile strength (MPa)	248
Young's modulus (MPa)	6700
Elongation at break%	14
Microfibrillar angle (°)	46

*1 denier = 1/9000 g/m

2.4. Mixed Soil Design

Soil mixing is used in several applications as a more economical or improved performance alternative to some traditional and other geo-system methods. These other systems include auger cast piles; stone columns; jet grouting; compaction grouting; wick drains/preloading; lightweight fills, and conventional retaining walls.

Understanding characteristics of soil mixtures lead to increasing the confidence level before applying such materials in the field. The outcomes of this study can provide insight into the swelling and the compressibility behavior of soil – bentonite mixtures, between non-swelling materials and swelling materials and also the mixture of soil- fiber mixture.

The swelling behavior of expansive soils often causes unfavorable problems, such as differential settlement and ground heaving. Recently, expansive soils are attracting greater attention. The soil is often designed as soil mixtures requiring among others low shrinkage and swelling properties, low hydraulic conductivity, and high strength.

Many attempts have been performed in the past to understand the properties, indices and geotechnical properties, of the soil mixtures. Previous researchers have concentrated on the swelling behavior of expansive clays but with little attention given to the compressibility characteristics. The soil mixtures are commonly a blend of swelling soils (montmorillonite) with non-swelling soils (kaolinite, and/or sand) [10]

Bentonite is contained within voids between sand particles and in presence of water, hydrates and swells. When the voids ratio of bentonite is less than its free-swell capacity bentonite completely fills the spaces and presses lightly against the sand particles, thereby acting as a minor part of the load-bearing structure of the mixture. [6]

The concept of fiber-reinforcement in geotechnical projects originally involved the use of plant roots as reinforcement. Most researchers reported that plant roots increase the shear strength of the soil and, consequently, the stability of natural slopes [11].

In the previous studies the behaviour of sand reinforced with discrete randomly oriented inclusions, among other factors, on particle shape and size of the sand. The effect of fiber-reinforcement was found to be more significant in fine sand with sub rounded particles than in medium grained sand with sub angular particles.

2.5. Material Modification

Clay refers to a naturally occurring materials composed primarily of fine-grained minerals, which is generally plastic at appropriate water contents and will harden when dried or fired [12].Clay have varying chemical composition depending on both the physical and chemical changes in the environment where clay deposits are found.

There is an investigation about thermal conductivity; one of them is bentonite thermal behavior in geotechnical engineering [13]. In this research the application of 500° C gives the best result in strength and weight. There is also a research about effect of additives on the thermal conductivity of clay [14]. It is also been reported that a research about effect of temperature on oscillatory shear behavior of cement paste incorporating chemical admixtures [15].

2.6. Liquefaction

The liquefaction has been reported in several past earthquakes especially during Alaskan Earthquake (1964) and Niigata Earthquake (1964) which is induced instability of subsoil and subsequently damage of several infrastructures [16].And the realistic modeling of saturated sandy subsoil affected by dynamic force was not easy task due to multiscale, multiphysics computational framework requirement [17]. And from the other hand the bearing capacity failure, permanent settlement with a slight residual tilt could be observed in layer which was under liquefaction [18],and sometimes the damage on structure were not sever but decreased structures factor of safety. It was unknown about subsoil liquefaction resistance, liquefaction time, depth of subsoil induced liquefaction and accurate effect of liquefied layer on other parts of subsoil. As it is well known that the underground water is one of main parameter in liquefaction phenomenon.

The water seismic index (WSI) is a method for identified of subsoil hydrological condition. The seismic refraction analysing was main tool for identification of compressional and shears wave velocity values for modelling subsoil water table [19]. The WSI recognized as a method for predicting converting unsaturated soil to the saturated soil for simulating earthquake caused dynamic liquefaction and changing soil layer characteristics.

2.7. Previous Research Investigation

Many researches had been carried out in order to study the performance of oil palm fiber and bentonite in the soil. Several case studies are discussed in the following segment.

2.7.1. Soil – Oil Palm Fiber Mixture

2.7.1.1.Case Study 1

A professor from School of Civil Engineering, University Sains Malaysia has conducted an experiment about Performance evaluation of silty sand reinforced with fibers [20]

A Series of triaxial compression tests were performed on fiber-reinforced silty sand samples to evaluate improvement of soil strength. Both consolidated undrained (CU) and consolidated-drained (CD) tests were carried out on fiber-reinforced silty sand soil.

Triaxial tests were conducted to determine the stress–strain and strength characteristics of reinforced soils with various fiber contents and fiber lengths. All specimens were fully saturated with a minimum measured B value of 0.97. Axial load applied under strain-controlled condition with a strain rate of 0.1 mm/min under the confining pressure of s3 equal to 50 kPa, 100 kPa and 250 kPa to define the shear strength parameters (effective angle of shear strength (φ) and cohesion (c) for both the unreinforced and reinforced silty sand..

The result shown from these study case shows that both length and percentage of the fiber content play the important role in the shear strength of the fiber-reinforced soil. In conclusion the addition of the OPEFB fiber can significantly increase the peak shear strength of the silty sand soil.

While coating the fibers, also give a different in the result. Coating fibers increased the shear strength of the soil. The layer of the coating increased the surface area and interface friction of the fiber and soil increase. Increasing the tensile strength and stiffness of fibers leads to an increase in shear strength of fiber-reinforced soil because of limiting affect the dilatancy of silty sand.

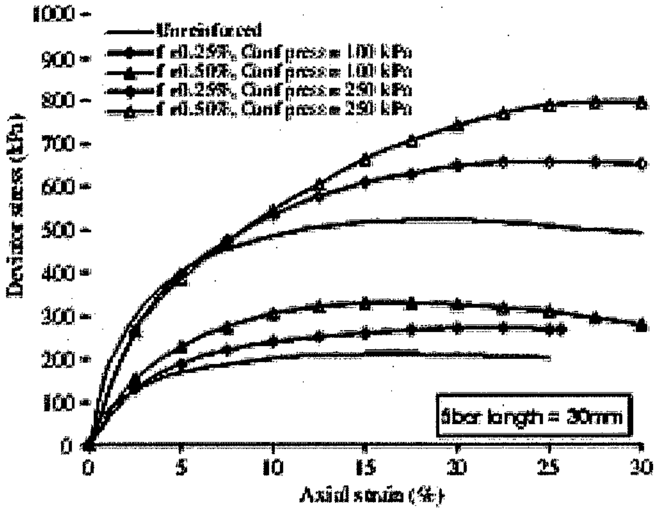

Figure 2.3: Typical Stress-strain curves obtained from triaxial CD test on soil reinforced with OPEFB fiber.

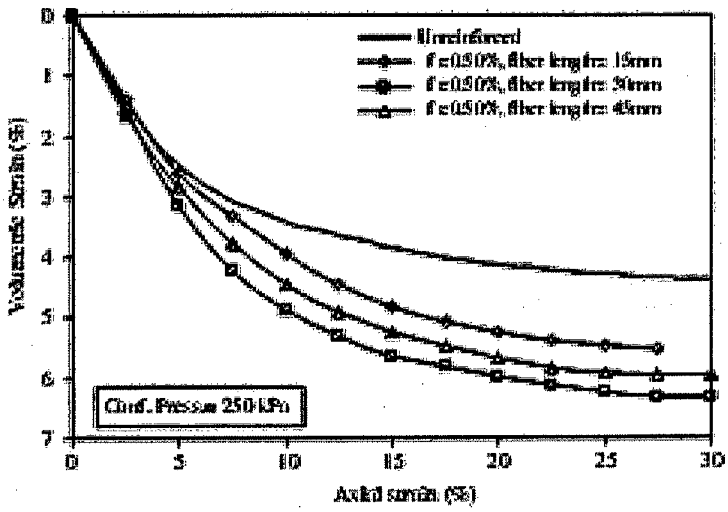

Figure 2.4 : Volumetric curves obtained from triaxial CD test on soil reinforced with OPEFB fiber.