STRENGTH CHARACTERISTIC OF SOFT SOIL REINFORCED WITH COIR FIBRES

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ABSTRACT

Use of natural fibres in civil engineering construction practice is often advantageous as they are cheap, locally available, biodegradable, and friendly. Among the available natural fibres, coir fibre especially coconut coir fibre is produced in large quantities in Malaysia and others country such as India, Philippines, Indonesia and so on. The coir fibres also have better mechanical properties in tensile strength. For this research the soil samples are taken about 4 m depth from ground surface at Kampung Beruas, Pekan. The tests were conducted to determine engineering properties of soil samples such as classification, Standard Proctor Compaction Test, Unconsolidated Undrained Test (UUT) and Oedomoter Consolidation Test. The soil was classified as clay with high plasticity, having liquid limit, plastic limit, plastic index and shrinkage limit of 72.0%, 31.36%, 40.64%, and 7.86% respectively and specific gravity was 2.51. Maximum dry density (MDD) and optimum moisture content (OMC) from compaction test were used as the basis in preparing sample for Undrained Unconsolidated Test (UUT). The soil samples reinforced with coir fibres of different sizes and content were test to determine the compaction, strength and the consolidation of soil response due to fibre inclusion and the results were compared with that of unreinforced soils. The results show that addition of coir fibre with different content (0.25%, 0.50%, 0.75%, 1.0%) and length (15 mm, 25 mm, 35 mm, 45 mm) as random reinforcing material increase the compaction and strength of soft soil. The effectiveness of coir fibre in shear strength is 105.68 kPa for 35 mm in fibre length and 0.50% in fibre content. Besides, the MDD and OMC is 16.10 kPa and with 13% which is from 45 mm at 0.50% of fibre length and content. For consolidation the soil after treated produced the less consolidation and decreases the void ratio of the soil samples in stabilized soft soil.

ABSTRAK

Penggunaan serat semulajadi dalam amalan pembinaan kejuruteraan awam sering menguntungkan kerana murah, mudah di dapati, boleh terurai dan mesra alam. Di antara serat semulajadi yang ada, serat sabut terutamanya sabut kelapa dihasilkan dalam jumlah yang besar di Malaysia dan negara-negara lain seperti India, Filipina, Indonesia dan sebagainya. Sabut kelapa juga memiliki sifat mekanik yang lebih baik dalam kekuatan tarikan. Untuk kajian ini sampel tanah yang diambil adalah dalam kedalaman 4 m dari permukaan tanah di Kampung Beruas, Pekan. Ujian yang telah dijalankan untuk menentukan sifat-sifat kejuruteraan sampel tanah adalah seperti klasifikasi, ujian pemadatan Proctor Piawai, ujian tak terkukuh tak tersalir (UUT) dan Ujian pengukuhan Oedometer. Tanah diklasifikasikan sebagai tanah liat dengan keplastikan yang tinggi, mempunyai had cecair, had plastik, indek keplastikan dan had susut masing-masing adalah 72.0%, 31.36%, 40.64%, dan 7.86% dan nilai graviti tentu adalah 2.51. Nilai ketumpatan kering maksimum (MDD) dan kandungan lembapan optimum (OMC) daripada ujian pemadatan digunakan sebagai asas untuk menyediakan sampel bagi UUT. Untuk penyediaan tanah yang telah dirawat, sampel tanah akan dicampurkan dengan sabut kelapa dengan saiz dan kandungan yang berbeza akan diuji untuk mendapatkan pemadatan, kekuatan dan pengukuhan bagi mendapatkan tindak balas tanah setelah dimasukkan dengan serat dan hasilnya akan dibandingkan dengan tanah tanpa sabut kelapa. Keputusan kajian menunjukkan bahawa penambahan sabut kelapa dengan perbezaan kandungan (0.25%, 0.50%, 0.75%, 1.0%) dan panjang (15 mm, 25 mm, 35 mm, 45 mm) secara rawak untuk memperkuatkan tanah meningkatkan pemadatan dan kekuatan tanah lembut. Keberkesanan serat sabut dalam kekuatan ricih ialah 105.68 kPa untuk 35 mm panjang serat dan 0.50% pada kandungan serat. Selain itu, nilai MDD dan OMC adalah 16.10 kPa dan 13% dari 45 mm pada 0.50% dari panjang serat dan kandungan. Untuk ujian pengukuhan, tanah setelah dirawat mengurangkan pengukuhan dan nisbah lompang sampel tanah dalam penstabilan tanah.

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LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
SL	Shrinkage Limit
LI	Liquidity Index
w	Moisture Content or
γ_d	Unit weight of dry soil
γ_w	Unit weight of water
MDD	Maximum Dry Density
OMC	Optimum Moisture Content
UUT	Unconsolidated Undrained test
S	Shear strength
c'	Effective stress cohesion intercept
∂'	Effective stress angle in friction
θ'	Effective stress
e	Void Ratio
C_v	Coefficient of consolidation
H_{dr}	Average longest drainage path during consolidation
t_{50}	The formation at 50% primary consolidation
t_{90}	Square root of time 90% consolidation
m_v	Volume of compressibility
SG	Specific Gravity
W_1	Weight of density bottle and the cover
W_2	Weight density bottle with soil

W_3	Weight density bottle with soil after putting into constant temperature water bath
W_4	weight of the bottle with distilled water
$\sigma_1 - \sigma_3$	Stress of failure
ε_f	Strain at failure
C_u	Shear strength of Soil
C	Cohesion of Soil
kPa	Kilo Pascal
μm	Micro meter
in.	inch
B.C	Before Century
BS	British Standard

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CHAPTER 1

INTRODUCTION

1.1 Background of Research

There are many different types of soils, and each one has unique characteristics like colour, texture, structure, and mineral content. The depth of the soil also varies. Soil is formed slowly as rock (the parent material) erodes into tiny pieces near the Earth's surface. Organic matter decays and mixes with inorganic material such as rock particles, minerals and water to form soil. There are three basic types of soil which is sand, loam or peat soil and also clay or silt particle. Sand is very workable but won't hold water or nutrients well while loam is poor in nutrients, reasonably workable, but hold water well. Clay is difficult to work, compact easily, but holds water and nutrients well, but is reluctant to release these to plants.

In engineering construction, the problems with soil always occur even during construction or after construction. This happen as the soil cannot reach the required specification such as the bearing capacity of soil is too weak to support superstructure above it. The existing soil at a construction site are not always be totally suitable for supporting structures such as buildings, bridges, highways, and dams. Hence, if the building is constructed on the poor soil, many problems will occur after the construction finish. The building will be crack because of the settlement of the soil.

The building settlement usually occur by the movement of the soil which caused by the surcharge or change of ground water table. If the settlement doesn't stop moving, the wall cracks will come bigger and the building will suddenly begins to exhibit movement without any reason. Preventing settlement problems begins with the recognition of the soil of a foundation rest, recognize the differences among soil types, determine the solution for the soils that respond to building loads and identify potential problems.

The Pisa's Tower is one of the examples of building which encountered with settlement problem. During the third floor construction, the Pisa Tower starts sinking. This building can be considered as a real masterpiece of architecture because this building is famous for its strong inclination. Regarding this inclination, it can be safely stated that it is still undoubtedly safe building although the ground sinking right of the time of its construction. Until now The Pisa's tower still sinking about 1 mm every year and not collapse because of the strong foundation.

Special soil-improvement techniques are required to overcome such soil problem. There are many types of soil improvement such as consolidation of soil, stabilization soil and soil densification. The consolidation of soil is a process the removal of water from soil. In other words, it is the squeezing out of water from the soil to make it denser.

The purpose of soil densification technique is to increase the unit weight and thus the shear strength. The granular soil deposits the in situ soil usually very loose, and could present a large elastic settlement for site construction and to prevent this, the soil densification should apply for this problem to decrease the void ratio between the particles.

Therefore, the stabilization of soil is important to be applied in the construction. The main purposes of soil stabilization are to modify the soil, expedite construction and improve the strength and durability of the soil. Beside that, soil stabilization also can be defined as the modification of the characteristics of soil in order to enhance the engineering performance of the soil, for example improve the density of soil, mixing the soil with additives to change the chemical and physical properties such as stiffness, compressibility, permeability, workability, lower the ground water level and eliminate weak soil.

1.2 Problem Statement

Soft soil present several challenges for the geotechnical engineer as they pose problems related to stability and settlements. Soft soil covers the majority of west coast and east coast of Peninsular Malaysia. This deposit generally consists of thick layer of unconsolidated soil strata predominantly soft marine clays and silts. As major economic activities and social developments are concentrating along the coastal area, the construction industry is constantly facing with challenges dealing with soft soil construction.

The characteristics of soft soil are high compressibility, low shear strength and low permeability. Compare to other type of soils, the strength development of soft soil is time dependent. General construction problems in this deposit are insufficient bearing capacity, excessive post construction settlement and instability on excavation and embankment forming. The engineering characteristics of soft soil are well documented through researches and field trials. Experiences gained from full scale trial embankments in this region on soft soils.

With the rapidly development of highway and building construction, the settlement of soft soil foundation has become one of the key problems for foundation design. In general, the settlement is not strength enough for the foundation that controls the design. For the building construction on the soft ground, the shallow foundation cannot be applied because of the condition of soil. For this situation, the other method should be applied such as piling method. This method more costly compares the shallow foundation. So, to prevent this from occur, the soft soil stabilization should be consider to reduce the cost of the project.

Otherwise, when a road embankment is constructed over soft ground, there is a surcharges or an increase of stress in the soft ground including the strain or settlement. If the surcharge load due to filling and constructions traffic load is high near the ultimate bearing capacity of the supporting soft ground, excessive yielding or plastic deformation in vertical and lateral direction of the soft ground will occur and followed by tension crack, deep seated rotational or translational slip when the deformation is large and extensive.

The failure of road embankment on soft ground also is commonly preceded by the gradual lateral displacement of the soft soil beneath the embankment toes and by the gradual ground heave. The rate of displacement also will increase as failure is approached. Such failure generally occurs during or immediately after construction, this occurred because of the shear strength of the soft ground gradually increase on account of consolidation provided there is dissipation of pore water pressure and the deformation or filling is slow and gradual (not abrupt).

Excessive and uneven settlement is very often to be characterizing by pavement rutting, distortion, undulation or lateral tilt, change of chamber or super elevation on road surfacing. Pavement distortion or localizes depression may result in pavement surface rutting and ponding. These problems can end up in damage in drains, culverts, buried utilities and traffic hazard to road user.

1.3 Objective

The aim of this study is to investigate the strength characteristic of soft soil reinforced with coir fibre. By carry out this study, the following objectives will be achieved:

1. To determine the properties of soft soil
2. To compare the effectiveness strength between treated and untreated soft soil.
3. To find the effectiveness of coir fibre in soft soil

1.4 Scope of study

For this study, the material that has been prepared is the sample of soft soil and coir fiber. The sample of soil is taken as an undisturbed and disturbed sample. The soil is considered as near-normally consolidated clays and clayey silts.

The term of soil that has been used in this study purposely to describe that the clays consist a high moisture content, approaching that of the liquid limit and have a high sensitivity. Soil samples is taken from Kampung Beruas which located nearby Universiti Malaysia Pahang at Pekan campus.

The coir fibre that has been used is a coconut coir fibre. The coir fibre is measured based on four different length which is 15 mm, 25 mm, 35 mm and 45 mm and the fibre content is 0.25%, 0.50%, 0.75% and 1.0% by raw of sample. .

The soil sample has been taken in range 4 to10 m below ground surface and it is considered as a soft soil or soft clay. One bore hole sample is obtained and the sample is brought to the geotechnical laboratory to be examined and tested. The engineering properties of soil samples such as classification of soil, the compaction strength, shear strength and consolidation of soil samples between treated and untreated is determined. To determine the properties of soft soil, grain size analysis has been conducted like sieve analysis test and laser particle size analyzer. The value of the specific gravity soil is obtained from the density bottle test. It is important and related to the next testing which is UUT and consolidation. The Atterberg Limit test is implemented to determine the soil characteristics such as Plasticity Index, Plastic Limit, Liquid Limit and Shrinkage Limit.

In order to determine the compaction and shear strength of soil, the three testing has been conducted. The standard proctor test has been done to get the optimum moisture content (OMC) and maximum dry density (MDD) of the soil. 17 samples is prepared which is the five different ratio of coir fibre is mixed randomly with soft soil which are 0%, 2.5%, 0.50%, 0.75% and 1.0% by the raw sample of soil. The different length of coir fibre measured from 15 mm, 25 mm, 35 mm and 45 mm. This test is using an improved Harvard compaction hammer to compact the specimens layer by layer.

By determined the OMC and MDD from the compaction test, cylindrical soil specimens of 38 mm in diameter by 76 mm height is prepared for Unconsolidated Undrained Test (UUT) or Triaxial test. For this testing, the 17 samples have been prepared same like the previous testing. For this testing, the undisturbed and disturbed soil has been taken, the undisturbed sample has been tested for 0% content fibre while the disturbed after mixed with coir fibre. This method has been used to determine the shear strength of soil without measurement of pore pressure while the specimen is sheared at constant rate of confining pressure until failure occurs. The confining pressure is used about 200 kPa. This test also is to investigate the complete stress, strain and strength behavior of soil.

The Oedometer test or One-Dimensional consolidation test is to determine the consolidation characteristics of soil for low permeability. The compressibility of soil which is measure of the amount by which the soil will compress when loaded and allowed consolidating. The loading that has been used is 1 kg, 2 kg, 4 kg, 8 kg, 16 kg and for unloading is 4 kg and 1kg.

1.5 Significant of Study

In engineering construction, many methods are applied to increase the strength of soft soil. One of the methods is soil stabilization with additive such as cement, lime, asphalt emulsion and natural product. The applications of this method have recently been further expanded. The more common uses today are for stream bank protection, grade control (drop) structures, and pond liners.

In Malaysia, most of the soft ground such as coastal alluvial soil is extremely soft, and easy to find at coastal area. Soft soil faced many problems in construction area even at road construction and building construction. Settlement will be occurring at the soft ground if not treated properly. The ground improvement is a very important and as a key basic in the engineering construction.

Treatment of soft soils with natural product offers economical, ecological and environmental benefits. For the advantages, coir fibre is a versatile product, available abundantly throughout the country, produced at cheaper costs, it is, as such a sure and economical answer. The coir fibre also is easy to find at Malaysia and the other countries such as India, Philippines, Thailand and Indonesia.

The coir fibre also has strong characteristic and durable, making it suitable for use in the cementitious matrix for high performances structural element. Flexural properties are very important for construction materials, especially when their intended applications are in area such as country road or pavement. The advantages of using natural fiber as reinforcements to improved bending strength, post crack load bearing capacity and much higher energy absorption.

The coir fibre as a reinforced to stabilize the soft soil is a relevant because of the strength characteristic and also these materials are biodegradable organic fibre and hardest among other natural fibres. The coir fibre also is sufficiently eco-friendly product and so its application will never sustain any damages to environment and so is far free from resentments. This method will prevent the failure of road embankment, settlement prevention, stream bank protection and pond liners. Besides, indirectly this method will increase the shear strength of soft soil.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Soil is made up of many things like weathered rock particles and decayed plant and animal matter. It takes a long time for soil formation and more than thousand years for the formation of a thin layer of soil. Since soil is made up of such diverse materials like broken down rock particles and organic material, it can be classified into various types, though based on the size of the particles it contains. Soils are generally called gravel, silt or clay.

Soft soil also called as soft clay. Clays are mostly flake shaped microscopic and submicroscopic particle of mica, clay minerals, and other minerals. Particles are classified as clay on the basis of their size. Clays are defined as those particles which develop plasticity when mixed the limited amount of water (Grim, 1953).

Soft soil will give many problems at site constructions even in design, construction and maintenances. From Figure 2.1, the soft soil will be finding at area