UNDRAINED SHEAR STRENGTH OF SOFT CLAY REINFORCE WITH SINGLE 16MM DIAMETER ENCAPSULATED BOTTOM ASH COLUMN

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A thesis submitted in fulfillment of the requirement for award of the degree of

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LIST OF SYMBOLS

A_c	Area of a column
A_s	Area of a sample
H_c	Height of a column
H_s	Height of a sample
V_c	Volumes of a column
V_s	Volumes of a sample
D_c	Diameter of a column
Si	Immediate settlement
Sc	Primary consolidation
τ	Shear strength of the soil
σ	Effective normal stress
ϕ	Cohesion
W_L	Liquid limit
W_p	Plastic limit
I_p	Plastic Index
w_{opt}	Optimum water content
q_u	Deviator stress
s_u	Undrained shear stress
Δs_u	Improvement undrained shear strength
ρ_d	Dry density
R^2	Correlation cohesion

LIST OF ABBREVIATION

ACAA	American Coal Ash Association
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society of Testing Material
BS	British Standard
BSCS	British Soil Classification System
EDS	Energy Dispersive Spectrometry
EPF	Employee Provided Fund
FHWA	Federal Highway Administration
MIT	Massachusetts Institute of Technology
ML	Low Plasticity Silt
USCS	Unified Soil Classification System
USDA	US Department of Agriculture
WV	West Virginia
XRF	X-Ray Fluorescence

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ABSTRACT

Soft clay soil can be categorized as problematic soil. It consists of low shear strength, low permeability and high compressibility characteristics affect the stability and settlement of the structures constructed on this type of soil. A careful design analysis could be taken for any structure built on it. However, those characteristics could be improved through many methods and the easiest method that is being used in the construction field was stone column. On the other hand, coal is one of the world's most important sources of energy. Disposal of bottom ash become environmental issues if it is not effectively reused or recycled for other application. This study is to present suitability in term of shear strength by using bottom ash to replace sand or granular material in column for ground improvement technique using laboratory scale model. Since sand is one of non-renewable material so by using by-product or waste material such bottom ash we can reduce the cost of construction as well as keep the non-renewable natural material in balance. Several experimental procedures are carried out to know the physical and mechanical properties of bottom ash and kaolin clay sample. Kaolin is being used as soil sample and bottom ash as the reinforced columns. The shear strength of the encapsulated bottom ash column measured by Unconfined Compression Test. A total 4 batches of kaolin sample had been tested and each batch consist of 5 specimens represent sample without bottom ash, partially penetration and fully penetration for singular bottom ash column. The specimen used were 50mm in diameter and 100mm in height. The diameter of bottom ash is 16mm and the height of the column are 60mm, 80mm and 100mm. The encapsulated bottom ash was installed at the centre of the specimen. The encapsulated bottom ash column with 10.24% area replacement ratio are 58.21%, 58.66% and 42.58% at sample penetration ratio, H_c/H_s of 0.6, 0.8 and 1.0 respectively. It can be concluded that the shear strength of soft clay could be improved by installation of encapsulated bottom ash column. However the value of shear strength of soft clay inserted with partially penetration column increased more significant compared to the fully penetration column.

ABSTRAK

Tanah lembut adalah tanah yang dikategorikan sebagai tanah yang bermasalah. Ia terdiri daripada kekuatan ricih yang rendah, keupayaan kebolehtelapan yang rendah dan ciri kebolehmampatan yang tinggi. Analisis reka bentuk yang teliti mesti diambil kira untuk setiap struktur yang di bina di atas tanah tersebut. Walau bagaimanapun, ciri- ciri tersebut boleh diperbaiki melalui banyak kaedah dan kaedah yang paling mudah digunakan dalam bidang pembinaan adalah tiang batu. Sebaliknya, arang batu adalah salah satu sumber yang paling penting bagi sumber tenaga. Pelupusan abu bawah menjadi isu alam sekitar jika ia tidak digunakan semula atau dikitar semula untuk aplikasi lain dengan berkesan. Kajian ini adalah untuk membentangkan kesesuaian dari segi kekuatan ricih dengan mengunakan abu bawah untuk mengantikan pasir atau batu dalam ruangan teknik pembaikan tanah mengunakan model skala makmal. Oleh kerana pasir merupakan salah satu bahan yang tidak boleh diperbaharui maka pengunaan produk sampingan atau bahan sisa sepertu abu bawah dapat mengurangkan kos pembinaan serta dapat menyimpan bahan semulajadi dengan seimbang. Beberapa prosedur eksperimen dijalankan untuk mengetahui sifat-sifat fizikal dan mekanikal abu bawah dan sampel tanah liat kaolin. Kaolin digunakan sebagai sampel tanah dan abu bawah seperti lajur bertetulang. Kekuatan ricih tiang abu bawah yang terkandung diukur oleh ujian mampatan tak terkurung. Sebanyak 4 kumpulan sampel kaolin telah diuji dan setiap kelompok terdiri daripada 5 spesimen mewakili sampel tanpa abu bawah, sebahagiannya penembusan dan penembusan sepenuhnya untuk lajur abu bawah singular. Spesimen yang digunakan ialah 50mm diameter dan 100mm tinggi. Diameter abu bawah adalah 16mm dan ketinggian tiang adalah 60mm, 80mm dan 100mm. Abu bawah diletakkan ditengah-tengah specimen. Tiang abu bawah dengan nisbah luas 10.24% adalah 58.21%, 58.66% dan 42.58% dengan nisbah penembusan H_c/H_s 0.6, 0.8 dan 1.0. Dapat disimpulkan bahawa kekuatan ricih tanah liat lembut boleh diperbaiki dengan pemasangan tiang abu bawah terkandung. Bagaimanapun, nilai kekuatan ricih tanah liat lembut dimasukkan dengan sebahagiannya ruangan penembusan meningkat lebih ketara berbanding dengan ruang penembusan sepenuhnya.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia is a developing nation that aiming to be a fully developed country by the year 2020. In order to achieve the vision , engineer of today need to come up with more and more sophisticated technologies and brilliant idea to create products that will save people time, money as well as sustaining the environment. As a developing country, Malaysia desire to implement National Green Technology Policy which headed by the Prime Minister Najib Tun Abdul Razak himself. Malaysia is set to become the largest green construction sector in the South-east Asian region.

The mentioned initiative are as a result of the rising demand for energy. Gas is remain the main fuel source for generation industry however coal is getting favors in the electricity industry. According to Huang (1990), basically there is about 10% of total weight of coal burned produces ash annually in Malaysia. Therefore, every year the value of coal by-product will be increased. Recently, there are four coal fired power plant in Peninsular Malaysia which are located in Port Dickson, Kapar, Manjung, and Pontian while the other three is in Sarawak and Sabah which located at Sejingkat, Mukah and Lahad Datu. Since human understood that burning coal generate electricity ,coal combustion such fly ash and

bottom ash can be consider as waste material have been around and disposed coal ash become an environmental issues and need to be reused effectively.

The coal combustion produce large volume of fly ash and bottom ash. According to Huang (1990), basically 10% of the total weight of coal burner produce coal combustion by-product. Bottom Ash in the other hand has angular in shape and had rough, gritty surface texture with size ranges from gravel to fine sand based on Kim et al. (2005). Since bottom ash is a raw material and had similarity with sand and aggregate, it suitable to be use in the construction to replace that non-renewable materials. An effective utilizing of bottom ash in construction material will decrease the accumulation of by-product in landfills as well as reduce environmental pollution.

Soft clay, in particular soft soil, are found in many areas around the world as well as in Malaysia. This unstable ground according to Brand et al. (1981) is geologically young and under stable condition due to its own weight has not yet undergone significant secondary consolidation by its formation. Generally, soft soil has low shear strength and cannot bear a high imposed load by itself. Mostly the problem of soft soil is related to the stability and settlement. Thus, there are some method to improve its properties and modify the technique such as sand drill, stone column and pilling. Although, there are many methods, but it is costly and uneconomical for large project. Since all method is using non-renewable material, bottom ash which has same characteristic as granular materials can be use and offer an alternative to reduce the disposal cost and conservation of natural soils and land.

As Malaysian, we need to take up the challenge for the use of green and recycle by-product in order to decrease the usage of non-renewable material as well as method for transform the status of ‘by-product’ to more recently ‘product’ that are sought for construction and other material.

1.2 Problem Statement

Soft clay, in particular soft soil, are found in many areas around the world as well as in Malaysia. Soft clay is a soil which has a low shear strength and generally cannot bear a high imposed load by itself. According to Huat (1969), he reported that clay deposits in coastal area of Peninsular Malaysia is between 5 to 30m. Therefore, structure such as bridge, building, dams and highway may not suitable to be construct in this area due to lack of bearing capacity of existing soil. The construction on soft soil is increasing due to lack of suitable land for infrastructures and other developments. Imported soils from cutting of hills and highlands are used for various construction purposes. Thus, soil improvement need to be done on soft soil area.

Soil improvement is a method to increase the bearing capacity and properties of the soil. There are so many method to improve its properties and modify the technique such as sand drill, stone column and pilling. Challenges are faced by geotechnical engineers if the site has soft soil and the problem may occur related to the settlement and stability. However, the usage of non-renewable materials is slightly high in cost. In order to demonstrate effort in protecting the environment against negative impact derive from human activities, we need to emphasis on sustainability.

Bottom ash is a waste material from coal fired power plant. When coal is burned, about 80-90% of unburned material is entrained in flue gas and is captured and recovered as fly ash, remaining 10-20% of the ash is dry bottom ash. The resulting coal ash generated is deposited either in landfill over a vast area of land which is not possible in urban areas or deposited in an ash pond which also has its shortcomings. Tanjung Bin power station produce 180 tonnes per day of bottom ash and 1,620 tonnes per day of fly ash from 18,000 tonnes per day of coal burning alone based on Muhardi et al. (2010).