ULTIMATE BEARING CAPACITY OF CEMENT COLUMNS TREATED PEAT SOIL USING PHYSICAL MODEL

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LOI SHI JUN

Thesis submitted in fulfilment of the requirements for the award of the degree of
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering and Earth Resources
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June 2016

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LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
BS	British Standard
CDM	Cement Deep Mixing
G_s	Specific gravity of soil solids
LL	Liquid Limit
M	Initial total mass of specimen
m_a	Mass of required replacement sand to fill the hole in gram
M_{DS}	Mass of dry soil
M_f	Dry mass of soil after washing
M_{OC}	Mass of organic content
M_s	Initial dry mass of specimen
m_w	Mass of soil excavated from the hole in gram
OPC	Ordinary Portland cement
PI	Plasticity Index
PL	Plastic Limit
POFA	Palm Oil Fuel Ash
UBC	Ultimate Bearing Capacity
UCS	Unconfined Compressive Strength
V	Volume of the hole in m^3
α	Area Improvement ratio
ϕ	Internal friction angle
γ	Unit weight of soil
γ_{dry}	Dry unit weight of soil
ρ_o	Density of the replacement sand in Mg/m^3
w	Moisture content of soil
ρ	Bulk density of soil

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ABSTRACT

Peat soil is classified as soft soil and problematic soil due to its natural properties of high compressibility, low shear strength and high initial water content. Cement column method is commonly used to stabilise the soil by changing the properties of soil. This research aimed to study the unconfined compressive shear strength and ultimate vertical bearing capacity of stabilized tropical peat of East Coast of Penisular Malaysia by a group of deep mixed cement column using a series of physical model test. To study the strength behaviour of peat soil with or without the cement stabilization, a series of physical laboratory models were conducted with different factor of variables, the number of cement column, proportion of binders (Ordinary Portland Cement) and pozzolanic materials (Palm Oil Fuel Ash). In this research, a total of 9 physical models of peat soil including one without the stabilized cement column as the control sample were conducted. A group of 4 and 6 cement columns with 25 mm diameter and 200 mm in length was considered. All the sample was cured for 28 days after the mixing of cement column. After the curing process, a series of axial loads were applied uniformly on the pre-fabricated steel plate footing from the top of the cement column in order study the ultimate bearing capacity of the stabilised soil. The change in strength of the samples was evaluated using Unconfined Compressive Strength (UCS) test. Based on the results from the tests, the highest recorded ultimate bearing capacity is in Model 6 with 6 cement columns with the area improvement ratios of 18.83 %. This research found that the sample with 300kg/m^3 OPC has the highest UCS value of 106.88 kPa. However, the cement columns mixed with OPC and POFA aided in improving the strength and the ultimate bearing capacity of the peat soil.

ABSTRAK

Tanah gambut dikategorikan sebagai tanah lembut dan tanah bermasalah disebabkan ciri-ciri tanah seperti kebolehmampatan yang tinggi, kekuatan mampatan yang rendah dan kandungan air yang tinggi. Tiang simen merupakan salah satu kaedah yang biasa digunakan untuk mengukuhkan tanah lembut. Tesis ini bertujuan untuk menyelidik kesan penggunaan tiang simen terhadap keupayaan galas muktamad dan kekuatan mampatan tak terkurung tanah gambut tropika dari Pantai Timur Semenanjung Malaysia dengan menggunakan ujikaji model fizikal. Sebanyak 9 model yang terdiri daripada factor pembolehubah yang berbeza seperti bilangan tiang simen, dos bahan tambah (simen) dan bahan pozzolanik (abu kelapa sawit) telah disediakan untuk mengkaji kekuatan tanah gambut sebelum dan selepas penstabilan oleh simen tiang. Dalam kajian ini, hanya kumpulan yang terdiri daripada 4 dan 6 tiang simen yang berdimensi 25 mm diameter dan 200 mm ketinggian telah dikaji. Semua sampel telah dirawat selama 28 hari dalam model selepas pemasangan tiang simen. Selepas proses pengawetan, tekanan yang berbeza telah dikenakan pada tapak besi dari bahagian atas tiang simen untuk pengajian keupayaan galas muktamad tanah gambut selepas penstabilan. Perubahan kekuatan tanah telah dikajikan dengan menggunakan kajian kekuatan mampatan tak terkurung. Berdasarkan keputusan yang diperolehi daripada kajian, Model 6 yang mempunyai 6 tiang simen dan nisbah peningkatan kawasan sebanyak 18.83 % mempunyai keupayaan galas muktamad yang tertinggi. Selain itu, kajian ini juga mendapati sampel tanah yang mengandungi 300 kg/m^3 simen portland biasa menunjukkan nilai kekuatan mampatan yang paling tinggi berbanding dengan sampel yang lain. Nilai yang diperolehi oleh sampel tersebut ialah sebanyak 106.88 kPa. Walaubagaimanapun, tiang simen yang mengandungi simen portland biasa dan abu kelapa sawit juga meningkatkan kekuatan dan keupayaan galas muktamad tanah gambut.

CHAPTER 1

INTRODUCTION

1.1 Introduction and Background

In Malaysia, there is around 3 million hectares or approximately 8 % of the land is covered with peats. In state of Sarawak, 1.66 million of the land is covered with peat soil (Huat, Prasad, Asadi, & Kazemian, 2014). Peat is an organic soil where the organic content is higher than 75%. The formation of peat soil layer is due the rate of accumulation of plant's remaining is higher and faster the rate of decomposition. Peat represents an accumulation of disintegrated plant remains which have been preserved under conditions of incomplete aeration and high water content. The formation of peats is more favourable when the area is waterlogged, with excess rainfall and low permeability ground, irrespective of latitude or altitude (Huat et al., 2014). The peat soil is classified as problematic soil due to its natural properties of high compressibility, low shear strength, high initial water content. The high compressibility of peat soil will poses problem of secondary settlement and even tertiary settlement in long term due to the further decomposition of peats. It is found that peat has the potential to be decomposed further and its decomposition rate could be accelerated by controlling the influencing factors like oxygen supply, C:N ratio, pH value and temperature for optimum condition (Pichan & O'Kelly, 2012). The high water content rendering the soil unsuitable for construction. The water content of peat normally varies from 500 % to 2000 % while for those peat where the water content of less than 500 % are usually indicates that there are high mineral fractions within the peat sample (Huat et al., 2014). According to Hwang, Humphrey, Bobet, & Santagata (2005),when dealing with organic and peat soil, few options are available to improve or strengthen the soil, the engineer or owner can choose to strengthen the foundation, eliminate the problem soil (cut & replace), soil treatment or relocate the project. The second and last option are always selected by owner or engineer.

This is because the peat soil is hard to deal with and further consolidation and stability problem may occur in future due to high compressibility and further decomposition of peat. Problem arise when the country facing limitation or shortage of land for development. Hence, solution in strengthening or improving the peat soil plays an important in future development of the country like Malaysia. Several methods such as surface reinforcement, preloading, vertical drain, deep stabilization, piling and chemical stabilization had been introduced by previous researcher in order to improve organic soil and peat soil. Dry Deep Soil Mixing (DSM) also referred to Cement Column is a common method for soft soil stabilization. This in-situ stabilization method involves the mechanical mixing of cementitious compound such as Ordinary Portland cement (OPC) and lime with weak/soft soil.

1.2 Problem Statement

Peat soil is considered as problematic soil due to its natural properties of low shear strength, high compressibility and high initial water content. It is suitable for plantation and agricultural purpose but when comes to construction field, it becomes unsuitable and unfavourable for the engineer to construct the structure like road, building and foundation on it. This is because construction problems like secondary settlement and stability problem may occur when the structure is built on the peat soil. Construction on peat soil is always the last option for engineer and developer as it is very costly and the effectiveness of existing treatment is questionable. However, due to the rapid development in country, lack of land for construction becomes another issue. Thus, solution for the strengthening and improving the peat soil is essential and important in future country development. It is important to understand the properties of peat soil in order to overcome and improve the properties of peat.

Many methods and approaches have been introduced in order to improve the peat soil. However, some of them require huge amount of budget and yet the effectiveness of the ground improvement method is questionable. Hence, elements like environment friendliness, cost, effectiveness, reliability and durability should be considered in selecting the best method of ground improvement.

Cement column stabilization is a common method for soft soil stabilization. In construction industry, OPC is always the first choice cementitious materials for the cement column stabilization because it economically-friendly and high accessibility. However, OPC is highly not environmental friendly and it will contributes to climate changes and global warming. The huge amount of carbon dioxide due to the production of Cement contributes to global warming.

1.3 Research Objectives

The main purpose of this research is to study the effectiveness of cement column in increasing the shear strength and ultimate vertical bearing capacity of homogenous stabilized tropical peat of East Coast of Penisular Malaysia (Pekan Peat). Three specific objectives have been listed below in order to achieve the aim of this research.

Objective 1: To determine the properties of Tropical Peat.
Objective 2: To measure the shear strength of soil cement column after the stabilization.
Objective 3: To measure the ultimate vertical bearing capacity of footing on stabilized tropical peat.

1.4 Research Questions

This study aimed to address the following research questions

1 What is the effect of cement column which consisting of different proportion of OPC and Fly Ash towards the shear strength of peat soil?
2 What is the effect of cement column which consisting of different proportion of OPC and Fly Ash towards the shear strength of peat soil?