THE SHEAR STRENGTH OF SOFT CLAY REINFORCED WITH GROUP CRUSHED BRICK COLUMNS

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I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Civil Engineering.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Industri pembinaan di Malaysia telah menjana banyak sisa pembinaan yang akan dibuang ke tapak pelupusan sampah. Sisa di tapak pembinaan dihasilkan oleh bahan rosak, pembaziran dan sisa selepas kerja. Sumber-sumber pembentukan sisa dalam aktiviti pembinaan jarang ditangani oleh kontraktor di Malaysia. Sisa pembinaan yang tidak dapat dielakkan harus ditukar kepada produk yang dapat memanfaatkan ekonomi, membantu menghasilkan pendapatan baru untuk sebuah projek, dan juga mengurangkan kesan kepada alam sekitar. Untuk menstabilkan tanah liat yang bermasalah dengan sisa bata yang dihasilkan dalam aktiviti pembinaan, kaedah tiang batu boleh dapat mengurangkan sisa binaan dan juga memperbaiki kondisi tanah. Batu bata yang dihancurkan yang membentuk tiang direka untuk meningkatkan kekuatan tanah liat yang lembut, dan dapat membantu mempercepatkan proses penyatuan dan mengurangkan kekuatan tanah. Ini juga dijangka meningkatkan tanah, supaaya menjadikannya lebih sesuai untuk aktiviti pembinaan. Terdapat kelompok dengan 21 sampel telah menjalani Ujikaji Mampatan Tak Terkurung. Setiap kelompok termasuk sampel tanah liat yang diperkuat dengan tiang bata dengan nisbah penembusan sebanyak 0.6, 0.8, 1.0, bagi lajur 10mm dan 16mm, dan sampel tanpa sebarang tetulang. Sampel tanpa sebarang tetulang digunakan sebagai sampel terkawal untuk menentukan kekuatan sampel yang tidak diperkuat untuk digunakan sebagai perbandingan. Sampel kaolin dimasukkan ke dalam acuan dan dibor untuk memasang lajur. Lubang untuk lajur digerudi dengan bit gerudi 10mm dan diameter 16mm untuk kedalaman masing-masing. Bata yang dihancurkan dituangkan ke lubang pra-digerudi dari 10mm di atas permukaan spesimen tanah liat untuk tiga lapisan. Hasil kajian menunjukkan bahawa peningkatan kekuatan untuk nisbah penembusan ketinggian 1.0 adalah 13.33% iaitu yang tertinggi, manakala untuk nisbah 0.6 dan 0.8 mencapai peningkatan 12.31% dan 9.79% masing-masing untuk tiang bata kelompok dihancurkan dengan diameter 10mm. Peningkatan kekuatan tertinggi untuk nisbah penembusan ketinggian 1.0 dengan peningkatan 16.10% , lebih tinggi daripada nisbah 0.6 dan 0.8 dengan 13.49% dan 11.35% dalam sampel yang diperkuat dengan lajur berkumpulan dengan diameter 16mm.

ABSTRACT

The construction industry in Malaysia has been generating tons of construction waste which will then be thrown into the landfills. Waste in construction sites are generated due to defective materials, wastage and leftover after works. The sources of waste generation in construction activities are rarely taken seriously by the contractors in Malaysia. The unavoidable generated waste should be turned to an economical effective product, which can help in generating new income for a project, at the same time reduce its destructive impact to the environment. To stabilize the problematic soft clay with the brick waste generated in construction activities by using stone column soil improvement method can be a method to reduce the construction waste at the same time improve the soil condition. Crushed brick particles forming columns are designed to increase the permeability of soft clay, which can help in accelerating the consolidation process and decrease the compressibility of soil. This is also expected to increase the shear strength and bearing capacity of soil, making it more suitable for construction activities. There are tree batches with 21 samples undergo Unconfined Compression Test. Each batch includes sample of clay reinforced with brick columns with penetration ratio of 0.6, 0.8, 1.0, for both 10mm and 16mm columns, and a sample without any reinforcement. The sample without any reinforcement is used as the controlled sample to determine the shear strength of unreinforced sample for comparison use. The kaolin specimens are inserted into the mould and being drilled for columns installation. The holes for the columns are drilled with drill bits of 10mm and 16mm diameter for the respective depths. The crushed brick poured into the pre-drilled hole from 10mm above the surface of clay specimen for three layers. The result shows that the improvement shear strength for height penetration ratio of 1.0 is 13.33% which was the highest, while 0.6 and 0.8 are 12.31% and 9.79% respectively for group crushed brick columns with diameter 10mm. The improvement of shear strength is highest for height penetration ratio of 1.0 with 16.10% improvement which was slightly higher than 0.6 and 0.8 which are 13.49% and 11.35% respectively in sample reinforced with grouped columns with diameter 16mm.

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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
Sc	Primary consolidation
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 ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society of Testing Material
BS	British Standard
ML	Low Plasticity Silt
USCS	Unified Soil Classification System

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Soft clay is commonly known as problematic soil due to its behaviors when contacting with water and it is low in shear strength. Many places in Malaysia are widely distributed with soft clay, which always create problems when developments are to be held on these areas. Soft clay always creates problem such as excessive settlement, landslide and causing slope failure during excavation. This has made the development of residential area, commercial area as well as road networks which are going to be built on those area more challenging, and even causes failure on built-up structures. In order to solve this problem, the mechanical properties of soft soil has to be engineered so that proper treatment can be done accordingly base on this problem. Figure 1.1 shows the settlement pattern of buildings on soft clay.

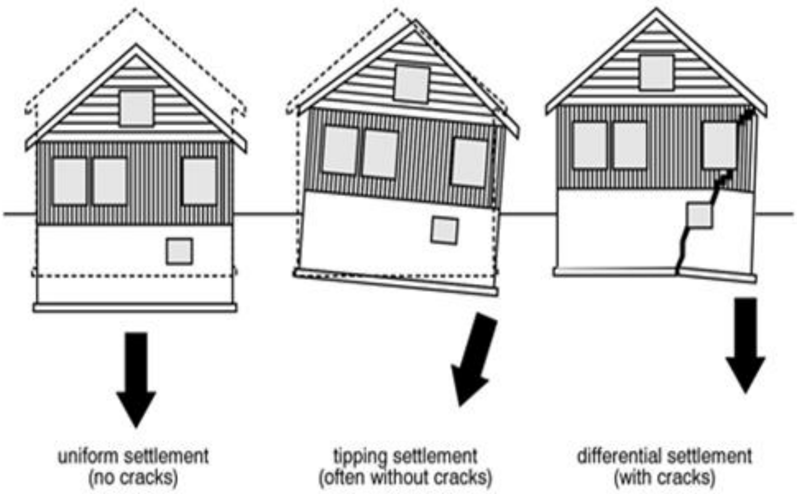

Figure 1.1 Settlement pattern of buildings on soft clay

Source: American Society of Home Inspectors (2003)

The construction industry in Malaysia has been generating tons of construction waste which will then be thrown into landfills. Waste in construction sites are generated due to defective materials, wastage and leftover after works. The sources of waste generation in construction activities are rarely taken seriously by the contractors in Malaysia. Malaysian contractors do not have proper way to address the waste generated in the first place, which is due to the improper designs and the method of works during the planning stage (Hassan *et al.*, 2015). These wastes has been causing environmental problems such as land settlement as well as ground water pollution, and it will be incurring high extra construction cost due to its managing fee (Nagapan *et al*, 2012). Figure 1.2 shows the construction waste illegally dumped in mangrove swamp in Melaka, Malaysia.

Figure 1.2 Construction waste illegally dumped in mangrove swamp

Source: The Star Newspaper (2011)

Brick work has been a wide practice in construction industry and it is classified as one of the highest rate waste generating activity in construction sites (Hassan *et al.*, 2015). When the brick works are started after the completion of structural works, the generation of brick waste starts as well. When workers are distributing brick to the area needed to be worked in a construction site, some bricks will be damaged due to improper handling of the material. Other than that, when the workers are working in cutting the bricks to a desired shape matching the requirement of design, many leftover bricks will be produced and it will be thrown together with other waste, increasing the amount of the overall construction waste.

1.2 Problem Statement

Construction projects in Malaysia has been encountering soil with not enough shear strength and bearing capacity to withstand the load of the structures above. These properties often cause extra settlement and incur damages to the built- up structures above the soil. Problematic soft clay also causes landslide which will lead to severe damage to existing structures and even depletion of life (Hussein, 2004). This is due to problematic properties of soft clay which has very high compressibility and low permeability. Therefore, the properties has to be improved to allow the construction process to be carried out above of it, without causing any damage to the structures due to the failure of soil. The rapid development of Malaysia has brought up the blooming of construction sector. Building infrastructures, as well as new housing estate will increase the demand of construction materials to another new high. With more and more development projects being started in Malaysia, the construction waste produced will be increased tremendously, and thus creating impacts to the environment. Brick as one of the most common construction materials will also be contributing to the rising amount of waste. Therefore, the unavoidable generated waste should be turned to an economical effective product, which can help in generating new income for a project, at the same time reduce its destructive impact to the environment. Figure 1.3 shows the brick waste generated at construction sites.

Figure 1.3 Brick waste generated at construction sites

Source: Hassan *et al.* (2015)

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