

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

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## **SUPERVISOR'S DECLARATION**

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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## **STUDENT'S DECLARATION**

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, supaya 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 three 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.

## TABLE OF CONTENT

<b>DECLARATION</b>	
<b>TITLE PAGE</b>	
<b>ACKNOWLEDGEMENTS</b>	<b>ii</b>
<b>ABSTRAK</b>	<b>iii</b>
<b>ABSTRACT</b>	<b>iv</b>
<b>TABLE OF CONTENT</b>	<b>v</b>
<b>LIST OF TABLES</b>	<b>ix</b>
<b>LIST OF FIGURES</b>	<b>x</b>
<b>LIST OF SYMBOLS</b>	<b>xii</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xiii</b>
<b>CHAPTER 1 INTRODUCTION</b>	<b>14</b>
1.1 Background of Study	14
1.2 Problem Statement	16
1.3 Objectives	17
1.4 Scope of Study	17
1.5 Significance of Study	18
<b>CHAPTER 2 LITERATURE REVIEW</b>	<b>19</b>
2.1 Introduction	19
2.2 Clay	19
2.2.1 Engineering Behaviour of Clay	22
2.3 Kaolin	24



2.3.1	Physical Properties of Kaolin	24
2.3.2	Engineering Properties of Kaolin	25
2.4	Clay Brick	29
2.4.1	Physical Properties of Brick	29
2.4.2	Compressive Strength of Brick	32
2.4.3	Flexure Strength and Breaking Load	34
2.4.4	Durability	36
2.5	Small Scale Modelling On Granular Column	37
2.5.1	General Modelling Work	37
2.5.2	Undrained Shear Strength of Granular Columns	42
2.5.3	Critical Column Length	45
2.6	Sustainable Construction	47
<b>CHAPTER 3 METHODOLOGY</b>		<b>49</b>
3.1	Introduction	49
3.2	Selection of Ground Improvement Technique	51
3.3	Selection of Materials	51
3.4	Laboratory Tests	51
3.4.1	Specific Gravity Test (BS 1377: Part 2: 1990: 8.3)	52
3.4.2	Mechanical Sieve Analysis (BS 1377-Part 2: 1990: 9.6)	53
3.4.3	Hydrometer Test (BS 1377: Part 2 1990: 9.6)	53
3.4.4	Atterberg limits Tests (BS 1377: Part 2: 1990: 4.3& 5.3)	54
3.4.5	Standard Compaction Test (BS 1377-Part 4:1990)	56
3.4.6	Falling Head Permeability Test	57
3.4.7	Constant Head Permeability Test (ASTM D 2434)	57
3.4.8	Unconfined Compression Test (ASTM D 2166)	58

3.5	Soft clay reinforced with group crushed brick columns	59
3.5.1	Kaolin Clay Samples	60
3.5.2	Brick Columns	60
<b>CHAPTER 4 RESULTS AND DISCUSSION</b>		<b>62</b>
4.1	Introduction	62
4.2	Summary of Properties	62
4.3	Physical Properties	63
4.3.1	Specific Gravity	63
4.3.2	Particle Size Distribution	65
4.3.3	Atterberg Limit Test	66
4.3.4	Standard Proctor Compaction Test	67
4.3.5	Permeability	69
4.4	Reinforcing Soft Clay with Group Crushed Brick Columns	70
4.4.1	Stress – Strain Behaviour under Axial Load	70
4.4.2	Effect of Group Crushed brick Columns on Shear Strength	72
4.4.3	Effect of Column Penetration Ratio	75
4.4.4	Effect of Height over Diameter of Column Ratio	78
4.4.5	Effect of Volume Replacement Ratio	81
<b>CHAPTER 5 CONCLUSION</b>		<b>86</b>
5.1	Introduction	86
5.2	Conclusion	86
5.3	Recommendation	88
<b>REFERENCES</b>		<b>89</b>
<b>APPENDIX A SPECIFIC GRAVITY TEST RESULT</b>		<b>92</b>

<b>APPENDIX B PARTICLE SIZE DISTRIBUTION OF KAOLIN</b>	<b>93</b>
<b>APPENDIX C PARTICLE SIZE DISTRIBUTION OF CRUSHED BRICK</b>	<b>94</b>
<b>APPENDIX D ATTERBERG LIMITS TEST</b>	<b>96</b>
<b>APPENDIX E COMPACTION TEST</b>	<b>97</b>
<b>APPENDIX F CONSTANT HEAD TEST FOR CRUSHED BRICK</b>	<b>99</b>
<b>APPENDIX G FALLING HEAD TEST FOR KAOLIN</b>	<b>100</b>

## LIST OF TABLES

Table 2.1 USCS Soil Classification	20
Table 2.2 Results of Atterberg limit and specific gravity of kaolin from previous works	25
Table 2.3 The physical properties of kaolin clay	25
Table 2.4 Results of standard compaction and falling head permeability of kaolin	26
Table 2.5 Dry density of control and biosolid bricks at different heating rates	30
Table 2.6 Geotechnical properties of brick soil and biosolids	30
Table 2.7 Summary results of undrained shear strength of granular columns from previous works	44
Table 3.1 Test and standards of laboratory testing for materials	52
Table 3.2 Classification of strength of clay	59
Table 3.3 Density of various dimensions of crushed brick columns installed in kaolin specimens	61
Table 4.1 Summary of kaolin clay properties	63
Table 4.2 Summary of crushed brick properties	63
Table 4.3 The specific gravity of kaolin from previous and current research works	64
Table 4.4 Specific gravity of kaolin and crushed brick	64
Table 4.5 Comparison on the maximum dry density and optimum moisture content of kaolin S300 from previous research works	68
Table 4.6 Permeability of kaolin from previous researches	70
Table 4.7 Maximum deviator stress and axial strain values at different area replacement ratio and different height penetration ratio	71
Table 4.8 Result of unconfined compression test	73
Table 4.9 Improvement of shear strength	74
Table 4.10 The summary of the equation of correlation of shear strength and improvement shear strength	85

## LIST OF FIGURES

Figure 1.1 Settlement pattern of buildings on soft clay	14
Figure 1.2 Construction waste illegally dumped in mangrove swamp	15
Figure 1.3 Brick waste generated at construction sites	16
Figure 2.1 Malaysian soft clay distribution map	21
Figure 2.2 Typical Malaysian soil clay profile	21
Figure 2.3 Primary and secondary consolidation	23
Figure 2.4 The compaction result of kaolin sample and addition 3% of Nano Kaolin	27
Figure 2.5 The hydraulic conductivity result of kaolin samples	27
Figure 2.6 The effect of kaolin on dry density and moisture content of clay	27
Figure 2.7 The graph for various types of mix and pure kaolinite	28
Figure 2.8 The graph for pure kaolinite and various type of mix	28
Figure 2.9 Brick after burning in kiln	29
Figure 2.10 Particle size distribution of fly ash and bottom ash	30
Figure 2.11 Relationship between bulk density and heating temperature	31
Figure 2.12 Compressive strength of fired clay brick	32
Figure 2.13 Effect of fly ash dosage on compressive strength	33
Figure 2.14 Compressive strength of brick samples with different heating rate	33
Figure 2.15 Effect of fly ash dosage on flexure strength	34
Figure 2.16 Brick specimen under breaking load test setup	35
Figure 2.17 Effect of fly ash dosage on breaking load	35
Figure 2.18 Cold water absorption of brick sample at different heating rates	36
Figure 2.19 Effect of fly ash dosage on water absorption	36
Figure 2.20 Loading pattern and column arrangement	37
Figure 2.21 Load Tests on a group of stone columns	38
Figure 2.22 Sample configuration: (a) soil sample; (b) sample with cement column	39
Figure 2.23 Details of model test studies for single and group column pattern	40
Figure 2.24 Uniformity of sample and the quality of column formation: (b) preformed cavity for replacement method	41
Figure 2.25 Detail column arrangement for single and group bottom ash columns installed in clay specimens	42
Figure 2.26 Deviator stress at failure for single column under uniform undrained loading. $H_c/H_s$ , ratio of column length to sample height	43
Figure 2.27 Schematic diagrams of soft kaolin clay reinforced with penetrating granular columns	45

Figure 2.28 Effect of height to diameter ratio on undrained shear strength	46
Figure 2.29 Effect of height penetrating ratio to the improvement of shear strength.	47
Figure 2.30 Level of implementation of sustainability practices	48
Figure 3.1 Flow chart of methodology process in the research	50
Figure 3.2 Container with sample for liquid limit tests	55
Figure 3.3 Plasticity chart of soil	55
Figure 3.4 shows the process of compaction of sample in mould.	56
Figure 3.5 British Standard one-liter compaction mould	57
Figure 3.6 Details of falling head permeameter cell	58
Figure 3.7 Sample undergoing UCT	58
Figure 3.8 Sample of the model of reinforced soft clay	60
Figure 3.9 Detailed columns arrangement for group crushed brick columns installed in clay specimens	61
Figure 4.1 Particle size of distribution of kaolin S300	65
Figure 4.2 Particle size of distribution of crushed brick	66
Figure 4.3 USCS plasticity chart for kaolin plasticity classification	67
Figure 4.4 Compaction curve of standard proctor test of kaolin S300	68
Figure 4.5 Compaction curve of standard proctor test of crushed brick	69
Figure 4.6 Deviator stress versus axial strain for different reinforced samples	71
Figure 4.7 Shear strength versus height penetration ratio	75
Figure 4.8 Improvement shear strength with height penetration ratio for group crushed brick columns with diameter 10mm and 16mm	76
Figure 4.9 Correlation of shear strength versus height penetration ratio	77
Figure 4.10 Correlation of shear strength improvement versus height penetration ratio	78
Figure 4.11 The graph of shear strength versus ratio of column height over diameter	79
Figure 4.12 The shear strength improvement versus ratio of column height over diameter	79
Figure 4.13 Correlation of shear strength versus column height over diameter	80
Figure 4.14 Correlation of shear strength improvement versus column height over diameter	81
Figure 4.15 Shear strength versus column volume replacement ratio	82
Figure 4.16 Shear strength improvement versus column volume penetration ratio	82
Figure 4.17 Correlation of shear strength versus column volume penetration ratio	83
Figure 4.18 Correlation of shear strength improvement versus column volume penetration ratio	84

## 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
$\Delta S_u$	Improvement undrained shear strength
$\rho_d$	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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