STRENGTH OF SOFT CLAY REINFORCED WITH 13MM DIAMETER OF SINGLE CRUSHED COCONUT SHELL COLUMN

NURRUL NISYA BINTI ANUAR

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

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

Signature :

Name of Supervisor : ASSOC. PROF. DR. MUZAMIR BIN HASAN

Position : ASSOCIATE PROFESSOR

Date : JUNE 2018

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :

Name : NURRUL NISYA BINTI ANUAR

ID Number : AA14243

Date : JUNE 2018

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NURRUL NISYA BINTI ANUAR

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Dedicated to my parents and my siblings.

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ABSTRAK

Lajur batu boleh digunakan sebagai teknik pembaikan tanah di mana sebahagian tanah lembut diganti dengan bahan berbutir seperti batu atau pasir. Manfaat menggunakan batu di tanah berkurang rendah telah dibuktikan sebagai kaedah yang cekap untuk meningkatkan kapasiti galas dan mengurangkan penyelesaian tanah lembut. Kajian ini bertujuan untuk mengkaji peningkatan kekuatan ricih tanah liat dengan menguatkan tempurung kelapa 13mm yang dihancurkan. Kajian ini dilakukan dengan menentukan kesan nisbah penggantian kawasan dan nisbah penembusan ketinggian satu lajur kelapa tunggal pada ciri kekuatan ricih. Ujian Triaxial Mampatan yang Tidak Ditentukan (UCT) telah dijalankan untuk 12 sampel kaolin termasuk sampel kawalan untuk menentukan kekuatan ricih. Pembolehubah penyelidikan adalah diameter dan ketinggian tempurung kelapa yang dihancurkan di bawah konsep panjang kritikal. Peningkatan kekuatan ricih dengan tertanam dengan lubang kelapa dihancurkan adalah 17.28%, 20.50% dan 18.25% dengan nisbah penggantian 6.76% pada nisbah penembusan lajur sebanyak 0.60, 0.80 dan 1.0 masing-masing. Dari hasil yang diperoleh, hubungan kenaikan kekuatan ricih dengan penembusan pelbagai ruangan menunjukkan corak yang berbeza.

ABSTRACT

Stone column could be used as a ground improvement technique where a portion of soft soil is replaced with granular material such as stone or sand. The benefit of using stone columns in low strength soil has been proved as an efficient method to improve bearing capacity and reduce settlement of soft soils. This study was aimed to investigate the improvement in shear strength of soft clay by reinforce the 13mm crushed coconut shell column. This research was done by determine the effect of area replacement ratio and height penetration ratio of a single coconut shell column on shear strength characteristics. Unconfined Compression Triaxial Test (UCT) was conducted for 12 batch kaolin samples including control sample in order to determine the shear strength. The research variable are diameter and height of crushed coconut shell column which under a concept of critical length of column. The increment of shear strength by embedded with crushed coconut shell column are 17.28%, 20.50% and 18.25% with 6.76% area replacement ratio at column penetration ratio of 0.60, 0.80 and 1.0 respectively. From the result obtained, the relationship of the increment of shear strength with the various column penetration show different pattern.

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LIST OF SYMBOLS

A	Area
A_s	Area of kaolin clay sample
c	Cohesion
c’	Apparent cohesion
D	Diameter
D_r	Relative density
G_s	Specific gravity
H	Height
v	Specific volume
V_s	Volume of kaolin clay sample
kN	Kilo Newton
kPa	Kilo Pascal
M_g	Mega Gram
MN	Mega Newton
m/s	Metre per second
mm	Millimetre
µm	Micrometre

e	Void ratio
W_L	Liquid limit
W_P	Plastic limit
I_p	Plastic index
w_{opt}	Optimum moisture content
γ	Unit weight
γ_{max}	Maximum unit weight
q_u	Deviator stress
s_u	Undrained shear strength
Δs_u	Improvement undrained shear strength
ρ_d	Dry density
R^2	Correlation cohesion
%	Percent
°	Degree
H_c	Height of column
D_c	Diameter of column
ρ_d	Dry density
$\rho_{d(max)}$	Maximum dry density

$\rho_{d(min)}$	Minimum dry density
H_s	Height of sample

LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
BS	British Standard
BSCS	British Soil Classification System
CSP	Coconut Shell Powder
C	Controlled Sample
CU	Consolidated Undrained
CSA	Crushed stone aggregate
LL	Liquid Limit
ONP	Old-Newspaper
PP	Polypropylene
PL	Plastic Limit
S	Single Column
SEM	Scanning Electron Microscope
PHP	Parts per hundreds of total polymer
UCT	Unconfined Compression Test

US	United StateType equation here.
USCS	Unified Soil Classification System

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Malaysia in 2020 target to become the fully develop country with green technologies applied in construction. In order to achieve the vision, researcher today need to come out more with the sophisticated technologies and brilliant idea. For this upcoming era, Prime Minister Datuk Seri Mohd Najib Bin Tun Haji Abdul Razak, have implement The National Green Technology Policy which are headed by himself. This policy is aiming to become the largest green construction sector in the South-east Asian region.

There are so many waste materials are produce in Malaysia. Waste materials can be formed in many sector such as from construction site, food manufacturing, and agriculture. In the agriculture sector, there will be waste materials such as coconut shell. Nowadays coconut shell can be reused or recycle in many ways. In industry, the mechanical potential of coconut shell has been recognized in the context of structural composites, particularly for application of its fibers as a cheap, environmentally friendly matrix reinforcement for polymers (Harish et al., 2009, Smith et al. 2008, Monteiro et al. 2008), and even concrete (Ali et al., 2012, Gunasekaran et al., 2011, Ramli et al., 2013). Lightweight concrete has been implement often in construction works due to cost, energy and time management. Coconut shell concrete can be classified under structural lightweight concrete. Coconut is grown in more than 86 countries. India occupies the premier position in the world with an annual production of 13 billion nuts. The coconut industry in Malaysia is one of the higher country that using coconut in industrial foods. Waste of coconut shell is set to grow further with the global increase in demand. However the using of coconut shell in Malaysia is very minimize.

Table 1.1 showed that selected production statistics. Figure 1.1 showed that graph of coconut producers.

Table 1.1: Selected coconut production statistics (Gunasekaran, 2005)

Country	Production		Area	
	Coconut Production (kilotonnes)	Percent (%)	Hectare (ha)	Percent (%)
Indonesia	16300 kt	30.1	267	25.0
Philipines	14797 kt	27.3	3242	30`4
India	9500 kt	17.5	1860	17.4
Brazil	3034 kt	5.6	281	2.6
Thailand	1500 kt	2.8	343	3.2
Vietnam	972 kt	1.8	110	1.0
Maxico	950 kt	1.8	150	1.4
Sri Lanka	890 kt	1.6	395	3.7
Papua New Guinea	650 kt	1.2	180	1.7
Malaysia	642 kt	1.2	179	1.7

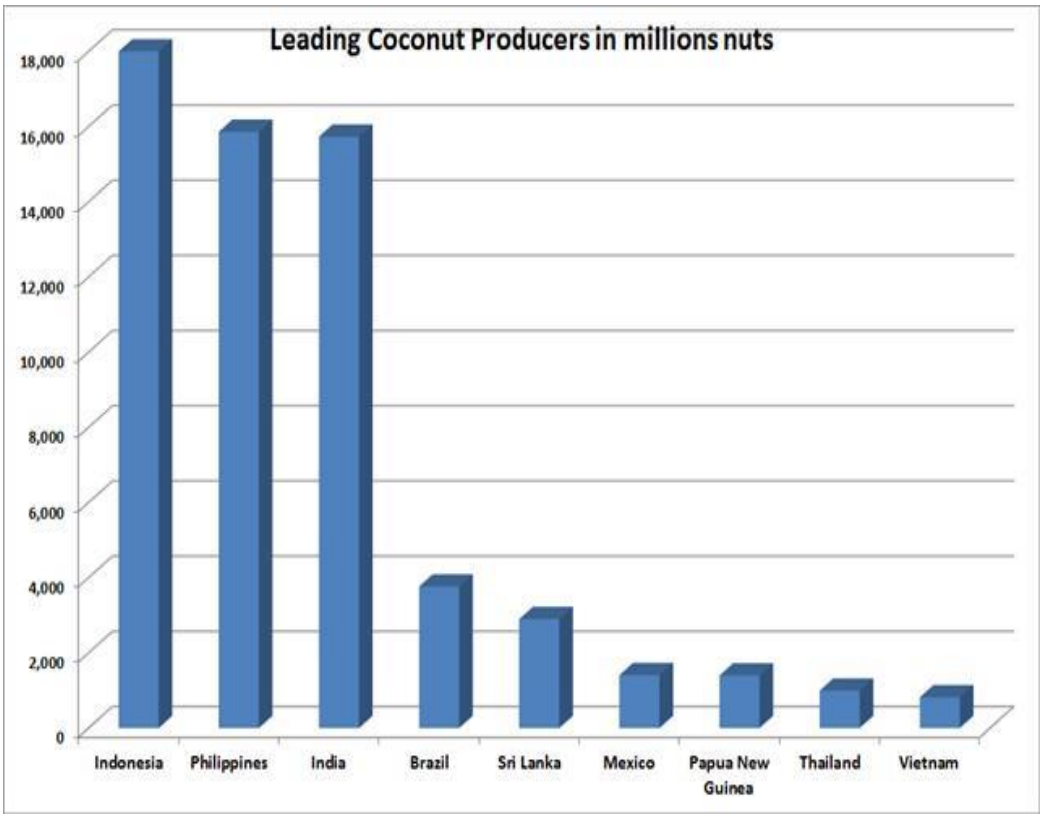

Figure 1.1 : Graph of coconut producers (Gunasekaran, 2005)

Peninsular Malaysia has so many potential area that have industrial mineral such as soft kaolin clay. According to Huat (1969), soft 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. 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. Kaolin is a claystone comprised mostly of kaolin minerals that is white or nearly white, or can be beneficiated or fired to become white or nearly white (Pruett, 2012). Figure 1.2 showed that the potential areas of industrial mineral in Malaysia.

REFERENCES

AASHTO. (1987). Soil Mechanics Level 1.

Ali, I., Bahaitham, H., & Naibulharam, R. (2017). A comprehensive kinetics study of coconut shell waste pyrolysis. *Bioresource Technology*, *235*, 1–11. https://doi.org/10.1016/j.biortech.2017.03.089

Ahmad N.S., Karunaratne G.P., Chew S.H., Lee S.L. (2000). *Bentonite-Kaolinite Mix for Barrier Systems.* Environmental Geotechnics. American Society of Civil Engineers: 93-104.

Alonso A.J., Jimenez R. (2011). *Reliability Analysis of Stone Columns for Ground Improvement.* Geo-Risk 2011: 493-500.

Amin J.M. (1997). *Prediction and Determination of Undrained Shear Strength of Soft Clay at Bukut Raja.* Science & Technol. : 114.

Asaoka A. (1997). *Deformation and Progressive Failure in Geomechanics*, Elsevier Science.

Black J., Sivakumar V., McKinley J.D. (2007). *Performance Of Clay Samples Reinforced With Vertical Granular Columns*. Canadian Geotechnical Journal 44(1): 89-95.

BS 1377-9:1990. (1990). Soils for civil engineering purposes. *British Standards*, *3*(1).

BS 5930:1999. (1999). Code of practice for site investigations. *British Standard*, *3*(March), 192. https://doi.org/10.1016/0148-9062(81)90248-5

Bouassida M., Hadhri T. (1995). *Extreme Load Of Soils Reinforced By Columns: The Case Of An Isolated Column.* (Soils Found): 35.

Bergado, D. T., & Rajagopal, K. (2015). Soft ground improvement with geosynthetics. *Geotextiles and Geomembranes*, *43*(6), 472. https://doi.org/10.1016/j.geotexmem.2015.07.011

Chan, Y. (2010). *An Experimental Investigation Of The Behaviour Of Compacted Clay/Sand Mixtures.*

Che Mamat, R. B. (2013). Engineering properties of Batu Pahat soft clay stabilized with lime, cement and bentonite for subgrade in road construction, 105. https://doi.org/10.1007/s13398-014-0173-7.2

Choo, L. (2016). Partial Replacement Of Cement With Incinerated Sewage Sludge Ash (ISSA) In Mortar Brick With Natural Calcium Carbonate As Additive, 1–105.

Costa, J., Karstunen, M., & Sivasithamparam, N. (2014). Influence of stone column installation on settlement reduction. *Computers and Geotechnics, 59,* 87–97. https://doi.org/10.1016/j.compgeo.2014.03.003

Das B. M. (2014). *Principle of Geotechnical Engineering.*

Damrizal Damoerin, Widjojo A. Prakoso, Y.U., (2015). Improving Shear Strength Of Clay By Using Cement Column. , pp.709–717.

El-Maaty M.I., Bassett D.C., Olley R.H., Hine P.J. and Ward I.M. (1996). *The Hot Compaction Of Polypropylene Fibres*. Material Science 31: 1158.

Equistar (2000). *Introduction to Polypropylene.* Texas, Lyondell Chemical Company.

Frikha W., Bouassida M. and Canou J. (2013). *Observed Behaviour Of Laterally Expanded Stone Column In Soft Soil.* Geotechnical and Geological Engineering 31(2): 739-752.

Frikha W., Bouassida M. and Canou J. (2015). *Parametric Study Of A Clayey Specimen Reinforced By A Granular Column.* International Journal of Geomechanics 15(5): 04014078.

Gludovatz, B., Walsh, F., Zimmermann, E. A., Naleway, S. E., Ritchie, R. O., & Kruzic, J. J. (2017). Multiscale structure and damage tolerance of coconut shells. *Journal of the Mechanical Behavior of Biomedical Materials, 76*(May), 76–84. https://doi.org/10.1016/j.jmbbm.2017.05.024

Gunasekaran, K., Annadurai, R., & Kumar, P. S. (2013). Plastic shrinkage and deflection characteristics of coconut shell concrete slab. *Construction and Building Materials*, *43*, 203–207. https://doi.org/10.1016/j.conbuildmat.2013.02.019

Harish A.J., Smith R., Monteiro J. (2011). *Reliability Analysis of Stone Columns for Ground Improvement.* Geo-Risk 2011: 493-500.

Hasan M. (2013). *Strength and Compressibility of Soft Soil Reinforced with Bottom Ash Columns.*

Huat B.K. (1994). *Behaviour Of Soft Clay Foundation Beneath An Embankment.* Science & Technol. : 1.

Head K.H, (1992). *Manual of Soil Laboratory Testing.* 2nd Edition.

Holtx R.D., William D.K. and Thomas C.S. (1981). *An Introduction to Geotechnical Engineering*, Prentice Hall.

Kanojia, A., & Jain, S. K. (2017). Performance of coconut shell as coarse aggregate in concrete. *Construction and Building Materials*, *140*, 150–156. https://doi.org/10.1016/j.conbuildmat.2017.02.066

Khalid, N. et al., The Properties of Nano-kaolin Mixed with Kaolin. , 5(Ipsc 2005), pp.4247–4255.

Keerthika, B., Umayavalli, M., Jeyalalitha, T., & Krishnaveni, N. (2016). Coconut shell powder as cost effective filler in copolymer of acrylonitrile and butadiene rubber. *Ecotoxicology and Environmental Safety*, *130*, 1–3. https://doi.org/10.1016/j.ecoenv.2016.03.022

Mokhtar, M. B. (2011). Mechanical Properties of Soft Clay Stabilized With Cement-Rice Husks (Rh), (September).

Maakaroun T., Najjar S. and Sadek S. (2010). *Effect of Sand Columns on the Undrained Load Response of Soft Clays.* Journal of Geotechnical and Geoenvironmental Engineering 136(9): 1263-1277.

Murad, N., Aisha, S. R., & Ishak Muhammad, M. (2017). Effects of Cooling Rates on Microstructure, Wettability and Strength of Sn3.8Ag0.7Cu Solder Alloy. *Procedia Engineering*, *184*, 266–273. https://doi.org/10.1016/j.proeng.2017.04.094

Muhmed, A. A. B., & Musa, A. (n.d.). Unconfined Compressive Strength Characteristics of Lime Treated Clay Unconfined Compressive Strength Characteri, 1–11.

Murray A., Gandhi S. (2007). *Behavior of Stone Columns Based on Experimental and FEM Analysis.* Journal of Geotechnical and Geoenvironmental Engineering 133(4): 405-415.

McKelvey, S. & Wong, L.S., 2004. Behavior of Critical Column Depth Effect *Geothechnical Journal of Civil Engineering*, 9(4), pp.477–486.

Pruett, R. J. (2016). Kaolin deposits and their uses: Northern Brazil and Georgia, USA. *Applied Clay Science*, *131*, 3–13. https://doi.org/10.1016/j.clay.2016.01.048

Rahman, A., Viiri, H., Pelkonen, P., & Khanam, T. (2015). Have stump piles any effect on the pine weevil (Hylobius abietis L.) incidence and seedling damage? *Global Ecology and Conservation*, *3*, 424–432. https://doi.org/10.1016/j.gecco.2015.01.012

Rediker J. (2012). *Soil Compaction & Nutrient Decline.* from http://www.oakwilt.com/soil/soilcompaction.html.

Sree, D., Ajitha, A.R. & Evangeline, Y.S., 2011. Study On The Shrinkage , Swelling And Strength Characteristics Of Clay Soils Under Different Environmental Conditions. , (L), pp.2–5.

Serrano A., Espinach F.X., Julian F., Rey R., Mendez J.A. and Mutje P. (2013). *Estimation Of The Interfacial Shears Strength, Orientation Factor And Mean Equivalent Intrinsic Tensile Strength In Old Newspaper Fiber/Polypropylene Composites*. Composites Part B: Engineering 50: 232-238.

Wu C.S., Hong Y.-S. and Lin H.-C. (2009). *Axial Stress–Strain Relation Of Encapsulated Granular Column.* Computers and Geotechnics 36(1–2): 226-240.

Yaya, A., Tiburu, E. K., Vickers, M. E., Efavi, J. K., Onwona-Agyeman, B., & Knowles, K. M. (2017). Characterisation and identification of local kaolin clay from Ghana: A potential material for electroporcelain insulator fabrication. *Applied Clay Science*, *150*(September), 125–130. https://doi.org/10.1016/j.clay.2017.09.015

Yu, T. Y., Ing, D. S., Choo, C. S., & Thong, Y. H. (2016). The Potential Use of SSA and ISSA in Construction Field . A Review, *3*(4), 171–179.

Zhao, Q., & Wang, J. H. (2010). One-dimensional compressibility of soft clay related to clay minerals, (January).