VOL. 11, NO. 11, JUNE 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

AN EXPERIMENTAL STUDY ON DUST SHELL AS AN ADMIXTURE IN SOFT SOIL STABILIZATION

Mardiha Mokhtar, Nor Baizura Hamid, Siti Aimi Nadia Mohd Yusoff and Salina Sani
Research Centre for Soft Soils (RECESS), University Tun Hussein Onn Malaysia, Johor, Malaysia
E-Mail: Mardiha@uthm.edu.my

ABSTRACT

Soil stabilization with cement has been extensively used for the improvement of soft clay soils, in enhancing the shear strength and limiting the deformation behaviours. The alternative cheaper admixture agents are essential since high costs are involved in the manufacture of cement production. The possibility of admixing cement with waste products such as dust shell (DS) as admixture for stabilizing soft soils will be presented in this paper. This study was aimed at assessing the usefulness of cement-dust shell (DS) as an effective soil admixture for improving some properties of clay soils. The stabilized specimens were prepared with the kaolin admixed with 5 % cement and various quantities of dust shell. Observation are made for the change in the properties of soil such as Atterberg Limits, Maximum dry density (MDD), Optimum moisture content (OMC) and Unconfined compressive strength (UCS). Result shows that the addition of dust shell slightly increases the maximum dry density and reducing optimum moisture content. In addition, the unconfined compressive strength of 5% cement-treated with dust shell samples increases with an increase of the amount of dust shell. This study indicates that cement-dust shell has a potential as an alternative soft soil stabilizer in soft soil stabilization with highlight the economical and environmental friendly material utilize.

Keywords: cement, dust shell, soft soil stabilization, maximum dry density (MDD), optimum moisture content (OMC), unconfined compressive strength (UCS).

1. INTRODUCTION

Clay soils are normally associated with volumetric changes when subjected to changes in water content due to seasonal water fluctuations. Kaolinite clays are among the soils that are affected by these problems. The minerals are formed under tropical weathering conditions in areas where precipitation is relatively high, and where drainage is good, which enables leaching of cations and iron from acidic granitic rocks [1,4]. Kaolin deposits are considered to have poor engineering characteristics, exhibiting expansive properties, high plasticity, poor workability, and low shear strength. This may cause severe damage to civil engineering structures and facilities. Hence, these soils must be treated prior to construction operations, so that desired properties can be achieved. In such problematic clays, chemical stabilization techniques have proven to be effective [2].The chemical stabilization of clays using cement is a common method that can be used to improve properties of soil to provide a workable platform for construction projects [3]. Cement is often used as an additive to improve the strength and stiffness of soft clayey soils, as stated by many authors [4]. They indicate that mixing cement into the soil leads to formation of a new structure within the soil grain accumulation. Traditionally, Portland cement and hydrated lime are commonly used for the soil stabilization. However, industrial by-products, construction and demolition waste and other waste materials ordinarily considered as environmental problems, are gradually finding applications in soil stabilization. Periwinkle and oyster shells have been used in concrete and other areas of civil engineering; but no technical information on the assessment of the utilization of crushed waste periwinkle shells for geotechnical engineering applications [5]. In this paper, further discusses the development of engineering behavior of cement-dust shell- treated kaolin clay and to identify its potential in geotechnical engineering applications. This paper therefore describes the initial laboratory tests of a planned extensive testing programmed to assess the effectiveness of the dust shells as an alternative stabilizer.

2. MATERIALS AND METHODOLOGY

In order to investigate the effect of dust shell on the physical and engineering properties, the treated and untreated kaolin were subjected to laboratory tests. These include Atterberg limits test, compaction test and unconfined compressive strength test (UCS).

The soil tested in this study is kaolin clay. It was mixed with 5 and 10% of cement, 3, 5 and 10% of dust shell and the combination of 5% cement with 3, 5 and 10% of dust shell. Table-1 summarizes basic properties of untreated kaolin.

There are two major chemical reactions which are induced by the addition of cement to clay and govern the soil cement stabilization process: the primary hydration reaction of the cement and water, and the secondary pozzolanic reactions between the limes released by the cement and the clay minerals [8]. The XRF analysis was conducted with the Bruker AXS machine running on the SPECTRA Plus analysis programme. The test was conducted to determine the chemical composition of the raw materials, i.e. cement and dust shell. Chemical compositions of the respective raw materials are given in Table 2. From the composition, it can be seen that Dust Shell contains high percentage of CaO (lime) up to 66.99, hence it shows that dust shell have a potential as an alternative to replace cement in pozzolanic reaction.

ARPN Journal of Engineering and Applied Sciences

Table-1. Basic properties of kaolin and dust shell.

Properties	Kaolin	Dust Shell
Specific gravity	2.47	3.00
Liquid Limit (%)	70	Non-plastic
Plastic Limit (%)	35.53	Non-Plastic
Plastic index (%)	33.47	-
Maximum dry density (Mg/m^3)	1.410	-
Optimum moisture content (%)	27	-
Unconfined Compressive strength, (kPa)	192.55	-
pH	5.54	-

Table-2. Chemical compositions of the respective raw materials.

Chemical composition		Concentration (%)	
		Cement	Dust Shell
SiO_2	Silica dioxide	21.0	-
Fe_2O_3	Ferric oxide	3.0	0.48
SO_3	Sulfite	1.9	-
CaO	Calcium oxide	62.0	66.9
MgO	Magnesium oxide	1.9	-
Al_2O_3	Alluminium oxide	5.5	-
C	Carbon	-	10.0
Na_2O	Sodium oxide	-	0.37

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. Atterberg limit

Table-3 shows Atterberg limit results for treated and untreated kaolin. It can be observed in Table 3, there is a reduction in the plasticity index and decreasing in both liquid and plastic limits. According to [6] the reduction in plasticity index shows that the additives make soils more friable and easily workable.

It was found that treated kaolin with dust shell show a huge reducing in liquid limit. Meanwhile in plastic limit results, all the treated soil shows almost same behavior where there are slightly changes among stabilized soil However, liquid limit change is less important, for geotechnical engineers comparing with plastic limit; this is because the maximum soil strength is attained when the soil is compacted at OMC that is close to the plastic limit [6].

Table-3. The effect of stabilized kaolin with cement and dust shell on Atterberg limits.

Samples	Liquid Limit (%)	Plastic Limit (%)	Plasticity index (%)
Kaolin (Control)	70	36.53	33.47
Kaolin + 5% Cement	60	31.71	28.29
Kaolin + 10% Cement	59	31.47	27.53
Kaolin + 3% Dust Shell	55.5	29.83	25.67
Kaolin + 5% Dust Shell	57	31.40	25.60
Kaolin + 10% Dust Shell	54	29.51	24.49
Kaolin + 5% Cement + 3% Dust Shell	59	30.60	28.40
Kaolin + 5% Cement + 5% Dust Shell	57	29.25	27.75
Kaolin + 5% Cement + 10% Dust Shell	55	31.04	23.96

3.2. Compaction test results

The compaction curve presented in Figure-1 was determined using the standard proctor method. The value of maximum dry densities (MDD) and optimum moisture contents (OMC) for treated and untreated kaolin has been summarized in Table-4.

Table-4. Summarize of standard proctor test result of treated and untreated kaolin.

Samples	Maximum Dry Density (Mg/m^3)	Optimum Moisture Content (%)
Kaolin (Control)	1.400	29
Kaolin + 5% Cement	1.425	22
Kaolin + 10% Cement	1.440	22
Kaolin + 3% Dust Shell	1.410	27
Kaolin + 5% Dust Shell	1.412	25
Kaolin + 10% Dust Shell	1.420	24
Kaolin + 5% Cement + 3% Dust Shell	1.430	23
Kaolin + 5% Cement + 5% Dust Shell	1.452	22
Kaolin + 5% Cement + 10% Dust Shell	1.460	21

VOL. 11, NO. 11, JUNE 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

Figure-1 shows an increase percentage of dust shell and cement content tends to result in a slight increase of the maximum dry density (MDD). It was also found that the OMC is not significantly influenced by cement. On the other hand, the maximum dry density (MDD) increases with an increase in cement content. The maximum dry density (MDD) obtained for 5% and 10% cement are range from 1.425 Mg/m³ to 1.440 Mg/m³ (Table 3). Meanwhile, the MDD is ranging from 1.410 Mg/m³ to 1.420 Mg/m³ for various dust shell content. It was found that, the highest value of MDD occur when the combination of 5% cements and 10% dust shell as shown in Figure-1. This result has been supported by the OMC results (Table-4) where the OMC reducing when the dust shells content is increased. This change is considered as an indication of the improvement of the compaction characteristics of the cement-dust shell stabilized kaolin. The increasing in the dry density occurs because the agglomerated and flocculated particles of soil occupy larger spaces and the reason for reducing OMC is that, the cement requires more water for the pozzolanic reactions [6].

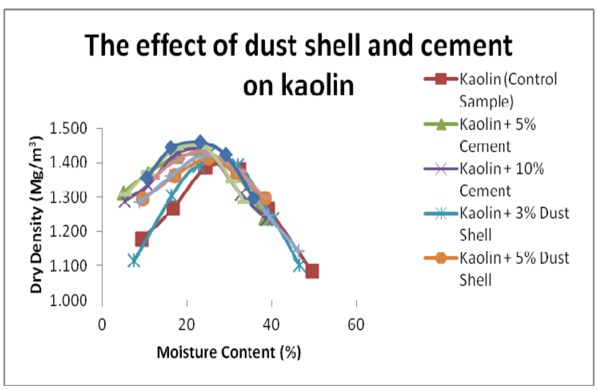

Figure-1. The variation of unconfined compressive strength and strain of treated and untreated kaolin.

3.3. Unconfined compressive strength test

Unconfined compressive strength (UCS) test were carried out on treated and untreated kaolin and the results are shown in Figure-2 and Table-5. From the results it shows that the UCS strength is increases with an increase of dust shell. For the cement + dust shell-treated kaolin is expected to increase, this is due to the cement hydration and the pozzolanic reaction. An increase in qu corresponded with increased cement and DS contents, compared to the unstabilized soil (Control). It is clear that the cement-DS specimens which are Kaolin +5%Cement +5%DS and Kaolin+ 5%Cement+ 10%DS show significantly higher qu than cement only mixes (Kaolin + 10% Cement). Note that 5C5DS achieved higher qu compared to 10C, proving the effectiveness of the addition of DS.

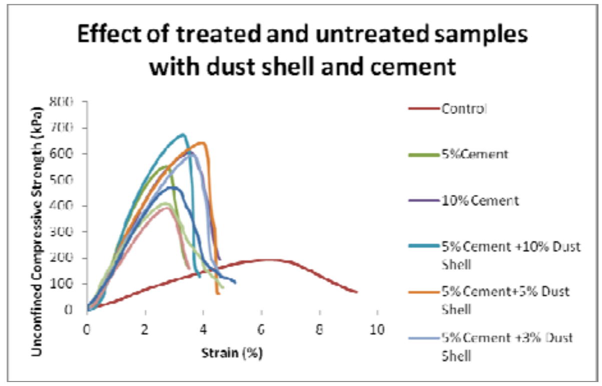

Figure-2. The variation of unconfined compressive strength and strain of treated and untreated kaolin.

Table-5.

Samples	Description	q_u (kPa)	C_u (kPa)
Control	Kaolin	192.55	96.28
5C	Kaolin + 5% Cement	549.79	274.89
10C	Kaolin + 10% Cement	605.43	302.71
3DS	Kaolin + 3% Dust Shell	391.97	195.98
5DS	Kaolin + 5% Dust Shell	407.38	203.69
10DS	Kaolin + 10% Dust Shell	471	235.5
5C3DS	Kaolin + 5% Cement + 3% Dust Shell	596.27	298.14
5C5DS	Kaolin + 5% Cement + 5% Dust Shell	639.86	319.93
5C10DS	Kaolin + 5% Cement + 10% Dust Shell	671.1	335.55

Figure-2 shows the stress-strain curves obtained from UCS test under various percentages of cement and dust shell. The strength of kaolin (control) shows a lower strength than other treated sample with 192.55kPa. Meanwhile for treated kaolin with cement, it was found that 10% of cement at the ultimate condition value is 605.43 kPa, meanwhile for treated kaolin with 5% cement shows 549.79 kPa. That shows that the cement-treated soil exhibited the trend of UCS increase with an increase in cement content for all percentages of cement. The cementations compounds of the treated clay increase with an increase in cement content. Then, the stabilized kaolin with dust shell also shows a strength gain behavior, it was found that with the increasing amount of dust shell, the strength was also increases [4]. In this research, the combination of dust shell and cement also has been investigates, in order to reducing the cost, 5% cement has been choose to mixed with other percentages of dust shell.

ARPN Journal of Engineering and Applied Sciences

This is also in agrrement with Uddin et al. [7] where they suggest that a minimum percentage of cement is also required to improve the strength of the untreated clay. As can be seen, the combination of 5%cement and 10% dust shell shows the highest strength improvement, and followed by the combination of 5%cement and 5% dust shell. Meanwhile the combination of 5% cement with 3% dust shell shows the same strength gain with the combination of kaolin with 10% of cement. This shows that with the combination of 5% cement and 5% of dust shell can save the use of 5% cement and in the other hand it can reducing costs.

4. CONCLUSIONS

Based on research conducted in this study, the following conclusions can be made:

- The addition of dust shell, cement and the combination of cement and dust shell to the tested soil is found to reducing the plastic and the liquid limits and decrease plasticity index. The reduction in the plasticity index values resulted from the decrease in liquid limit and plastic limit. With the decrease in the plasticity index and liquid limit, the engineering properties of soil are improved as the shear strength of the admixed soil improves and become more workable.
- The addition of dust shell slightly increases the maximum dry density and reducing optimum moisture content. The dry density rises at all of the treated soil.
- The compressive strength data presented in this study reveals that the unconfined compressive strength of 5% cement-treated with dust shell samples increases with an increase of the amount of dust shell.
- It is concluded that dust shell with the combination of cement has the potential to perform as a mechanical soil stabilizer or for the purpose of soil stabilization.

ACKNOWLEDGEMENT

This study was sponsored by 1341(STG), University Tun Hussein Onn Malaysia (UTHM). The authors are grateful to the technical staff of the Geotechnical Laboratory and RECESS of UTHM for their assistance during the experiments.

REFERENCES

[1] Mitchell, J. K., Soga, K.. 2005. "Fundamentals of Soil Behavior". (3rd edition). New York: John Wiley and Sons.

[2] Ingles, O.G., Metcalf, J.B. 1972. "Soil stabilization - principles and practice". Melbourne: Butterworth.

[3] Brandon, T., Brown, J., Daniels, W., DeFazio, T., Filz, G., Musselman, J., Forshaand, C., Mitchell, J. 2009. "Rapid Stabilisation/ Polymerization of Wet Clay soils, Literature Review," Air Force Research Laboratory, Blacksburg.

[4] Abdulhussein S, Khitam, K. A. Kassim, and Hadi N. 2014. "Physicochemical characterization of cement treated kaolin clay." Građevinar 66.06. (2014): 513-521.

[5] Otoko, G. R, and Cynthia E. I. 2014. "Mechanical Stabilization of Deltaic clayey soil using crushed waste periwinkle shells." International Journal of Engineering and Technology Research.

[6] Muhmed, A., & Wanatowski, D. 2013. Effect of Lime Stabilisation on the Strength and Microstructure of Clay. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 6, 87-94.

[7] Uddin, K., Balasubramaniam, A. S., Bergado, D.T. 1997. "Engineering behaviour of cement-treated Bangkok soft clay". Geotech. Eng., 2891, pp. 89–119.

[8] Bergado, D.T., Anderson, L.R., Miura, N. & Balasubramaniam, A.S. 1996. Soft Ground Improvement In Lowland And Other Environments. New York: ASCE Press.