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The Behaviour of the Unconfined Compressive Strength of the SiCC Mortar Improved Clays at Optimum-Wet Moisture Content

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Abstract

Soil stabilization using chemical additives might be influenced strongly by the moulding moisture content for the compaction. In this paper, the result of a laboratory investigation on the application of the pozzolanic mortar column. The mortar was made of the sand and the binder microsilica and microcalcium mixtures from fine rice husk ash and carbide waste. The water to binder ratio was The primary objective of this paper is to study the effect of moisture content on the behaviour of the unconfined compressive strength of the clay-improved with SiCC mortar. The specimens were prepared in optimum – wet moisture content regime that range from 30% to 55%. The specimen size was 100 mm in diameter and 120 mm in height. The diameter of the SiCC column was 25.4 mm (1 in). The unconfined compression test was performed for each mixture after 1, 3, 7, 14 and 28 days of curing. In general, it can be concluded that the unconfined compressive strength decreased with increasing of soil moisture content for both specimen group. The specimen with SiCC column at soil moisture near OMC have the highest unconfined compressive strength. However, at a high soil moisture content, the strength development of the SiCC column supported soil was higher than the specimen at near OMC state. The unconfined compressive strength increased corresponding curing time for all soil moisture states. The results confirmed that the strength development of SiCC column supported soil depends on the soil moisture content surrounding column and curing time.

Keywords: clay, compressive strength, SiCC column, water content

1 Introduction

Soil stabilization refers to the process of changing soil properties, improve strength and durability. A cementing material or another chemical material was added to problematic soil to improve one or more of its properties. Nowadays, there are many techniques for soil stabilization, including compaction, dewatering and by adding material to the soil. One may achieve stabilization by mechanically mixing the natural soil and stabilising material together. So as to achieve a homogeneous mixture or by adding stabilizing material to an undisturbed soil deposit and obtaining interaction by letting it permeate through soil voids. Many research have been done on the subject of soil stabilization using various additives, the most common methods of soil stabilisation of clay soils in geotechnical and highway works are cement and lime stabilisation.

Chemical stabilization used cementitious or pozzolanic materials to improve the soil properties by mixing the materials with soil. The quality of the stabilization was affected by some factor including the water content and the mixing process [1]. The other method that can be applied to soil stabilization was a lime column or cement column technique [2,3,4,5,6,7]. Utilization of pozzolanic materials from rice husk ash and carbide were a superior cementing material for Portland cement replacement [8,9]. However, the use of the cementing materials from rice husk ash and carbide waste for soil improvement need to be further investigated. In this study, the rice husk ash and carbide waste was mixed with sand and water to produce a mortar, known as SiCC mortar. The SiCC mortar was formed as a column to strengthen the soil. The main objective of this research is to investigate the effect of the soil moisture on the unconfined compressive strength of the clay soil supported by the SiCC mortar column.

2 Experimental Method

2.1 Materials Used

Soils

The soil used in this study was obtained from Kasihan districts in Yogyakarta province. The physical properties of the soil are presented in Table 1. The soil predominantly comprised of silt/clay particles as shown in the grain size distribution in Figure 1. The soil was classified as high plasticity clay (CH) according to the USCS method.

Table 1 The physical properties of the soil used

Parameter	Values
Natural water content, w_N (%)	14- 14.5
Specific gravity, Gs	2.48 – 2.80
Consistency limits:	
Liquid limits, LL (%)	68 – 72.5
Plastics limits, PL (%)	25,8 – 28.6
Plasticity index, PI (%)	39.8 – 46.7
Compaction characteristics:	
Maximum dry density, γ_{dmax} (kN/m^3)	12.3 – 13.4
Optimum moisture content, OMC (%)	29.7 - 31

Sand

The sand was collected from Progo river where is located in Kulonprogo district, Yogyakarta province. The specific gravity of the sand was about 2.2 – 2.3. The grain size distribution of the sand is illustrated in Figure 1. The sand consisted of 97% of sand fraction and 3% fines fraction. The coefficient of uniformity (Cu) and coefficient of curvature (Cc) of the grain size distribution was 5 and 1.45 respectively, which was classified into poorly graded sand (SP).

Fines Rice Husk Ash and Carbide Waste

The rice husk ashes were collected from the open field burning in the brick industry at Godean, in Sleman district, Yogyakarta province. The fine rice husk ash was obtained by mean grinding the rice husk ash in a special grinding machine for two hours. This method produced fineness and proper surface area of RHA respectively 12.4% and 25 mm^2/g. The chemical composition of the fine RHA is presented in Table 2.

The lime was obtained from oven-dried carbide waste. The carbide was collected from electroplating industry in Sedayu, Bantul district, Yogyakarta province. The oven-dried carbide waste was pulverized and ground in special grinding machine for 3 hours to obtain a fine particle. The chemical composition of the carbide waster is presented in Table 2.

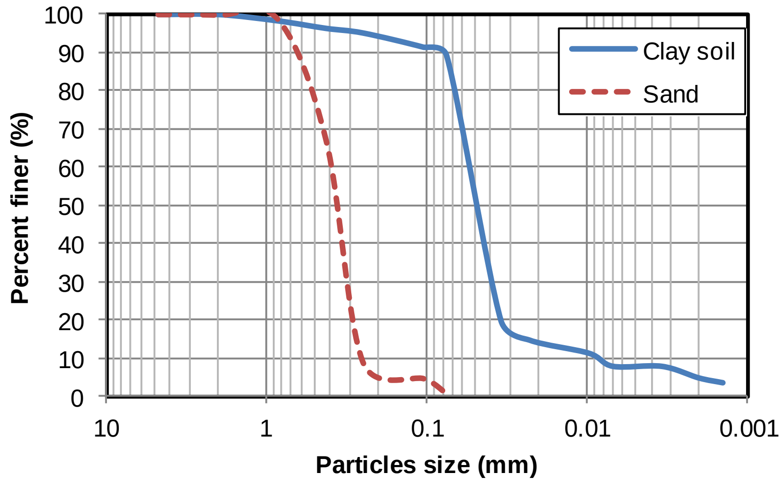

Figure 1 The grain size distribution of the soil and sand used in this study

Table 2 The physical properties of the soil used

Material	Al_2O_3	CaO	Fe_2O_3	MgO	Na_2O	K_2O	SiO_2	SO_3	LOI
RHA	1.17	0.48	0.98	0.13	0.22	1.54	87.68	0.39	7.78
Carbide waste	8.95	58.00	0.11	0.10	0.01	0.03	2.31	0.21	31.02

2.2 *Specimens Preparation*

Two groups specimens were prepared i.e. specimen without columns as controlled, and specimen with columns. The soil was dried in the oven for 24 hours. An amount of 2 kg dried soil was weighted and mixed thoroughly with water. The amount of the added water was varied as 400 ml, 600 ml, 800 ml, and 1000 ml. The mixture will result in the slurry that have moisture content near OMC and optimum wet side. The slurry was kept in a plastic bag for about 6 hours to have a constant soil humidity. Then, the slurry was compacted in cylindrical compaction mold of 100 mm diameter and 120 mm height. The soil was compacted in three layers by standard proctor's hammer. The compaction effort was performed as many as 25 blows for each layer. A hole of 25.4 mm (1 inch) was made in the compacted soil by using hand auger machine. The SiCC mortar was poured into the hole. The SiCC mortar was made from the mixture of the fine rice husk ash, carbide waste, sand, and water. The total weight of the mortar to form a column was 200 g that comprised of 50 g rice husk ash, 50 g carbide waste, and 100 g sand. The binder water ratio (b/w) was 0.6, which the binder was the combination of rice husk ash and carbide waste. The completed specimen with SiCC mortar was then kept in a plastic bag for 24 hours to allow hardening of mortar. Then, the specimen was dismantled from the mould. The diameter and height of the specimens were measured, and the mass was weighted. Finally, the specimens were cured in the plastic bag and stored at 27±2^{o}C room temperature for 1, 3, 7, 14 and 28 days. For each curing days and water content, two specimens were prepared for the test.

2.3 Unconfined Compressive Strength Testing Procedure

Before the test, the dimension of specimens was measured, and the mass was recorded. The specimen was then placed on the base plate of the compressive testing machine. The position of the specimen was adjusted, so that centred to the upper platen. The loading device was adjusted carefully so that the upper platen just made contact with the specimen. The deformation indicator was set to be zero for initial reading. Then, the load was applied gradually with the axial strain at a rate of 1 % per minute. The load, deformation, and time values were recorded at sufficient intervals to define the shape of the stress-strain curve. Loading was continued until the load values decrease with increasing strain. After completing the loading, the water content of the test specimen was determined using the entire specimen. Figure 2 shows the condition of the specimen after the test.

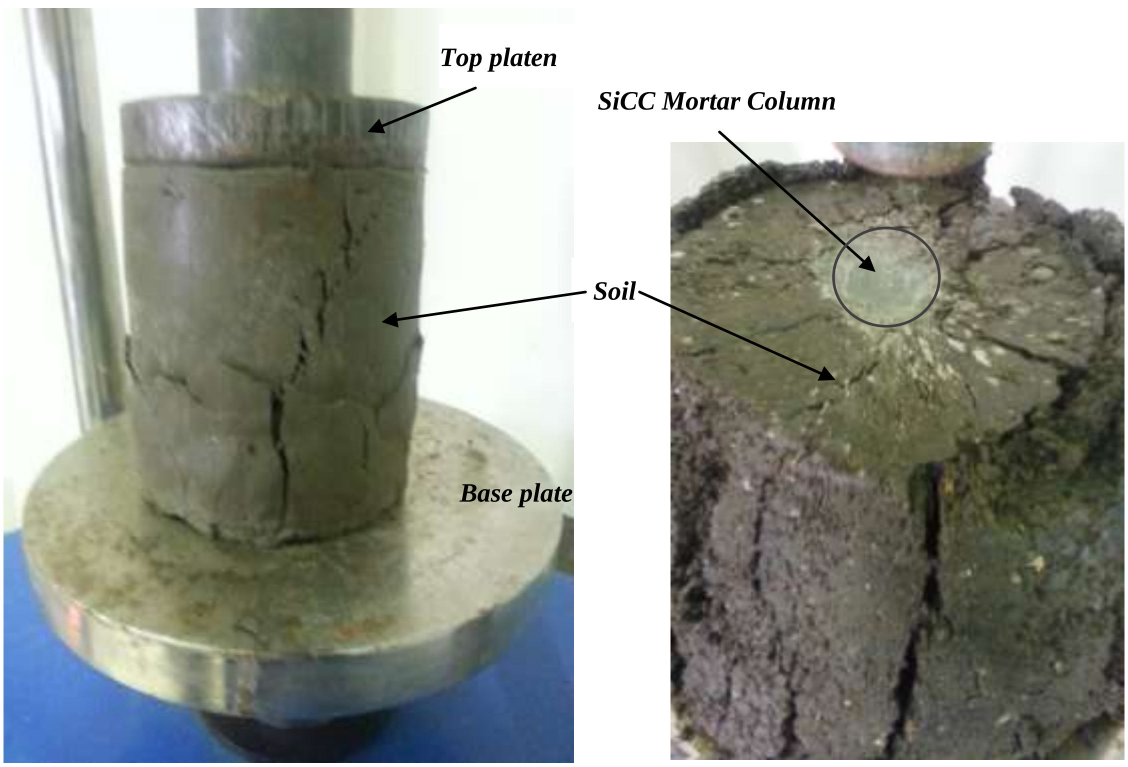

Figure 2 The failure specimen after compression test

The unconfined compressive strength (q_u) is defined as the maximum load (P_{max}) per unit area at which the cylindrical specimen falls in compression (A_f). The unconfined compressive strength was calculated using equation 1 as follow:

$$q_u = \frac{P_{\max}}{A_f} \quad (1)$$

which is,

$$A_f = \frac{A_o}{1-\varepsilon_f} \tag{2}$$

where,
P_{max} = maximum compression load,
A_f = cross section area of specimen at failure,
A_o = initial cross section area of specimen,
ε_f = axial strain at failure.

3 Results and discussion

Figure 3a shows the relationship between the variation of soil moisture content and unconfined compressive strength with various curing time. The figure illustrates that the unconfined compressive strength of the SiCC column supported soil was higher than the soil without soil. In general, the unconfined compressive strength decreased with the increases in soil moisture content. The decreasing unconfined compressive strength was caused by decreasing the density of soil due to compaction. The results seem to conclude that a higher soil moisture surrounding SiCC column did not contribute any significant improvement in unconfined compressive strength. But, if the specimen with column compared to the specimen without column, it is shown that strength development of the SiCC column was affected by the soil moisture as illustrated in Figure 3b. Figure 3b indicated that the strength development increased with increase in soil moisture. Hence, it can be concluded that installation of SiCC column contributed significant strength development in a high soil moisture content.

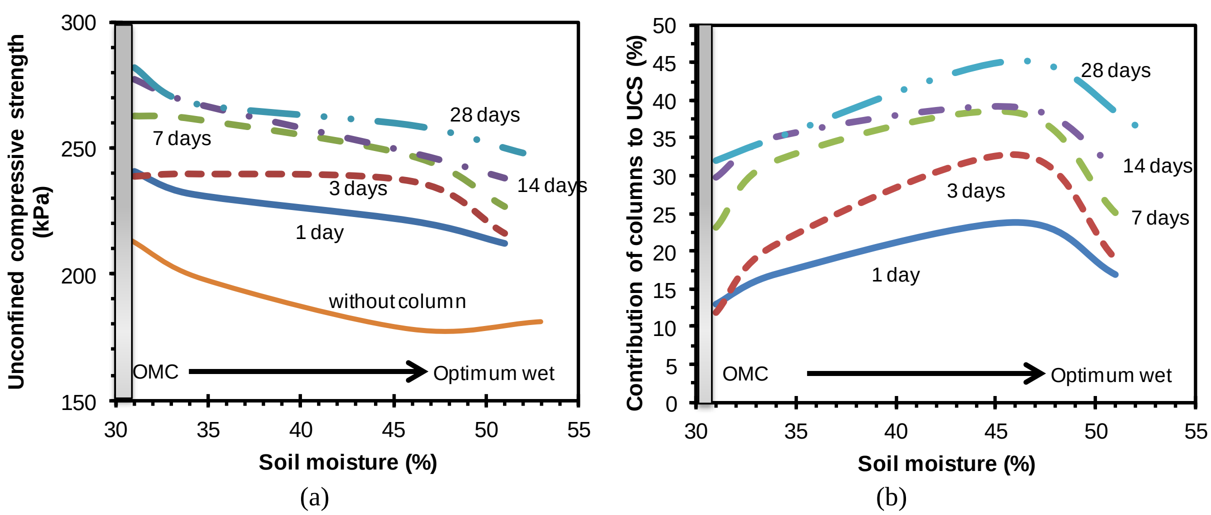

Figure 3 (a) The relationships between unconfined compressive strength and water content, (b) Contribution of SiCC column to the unconfined compressive strength

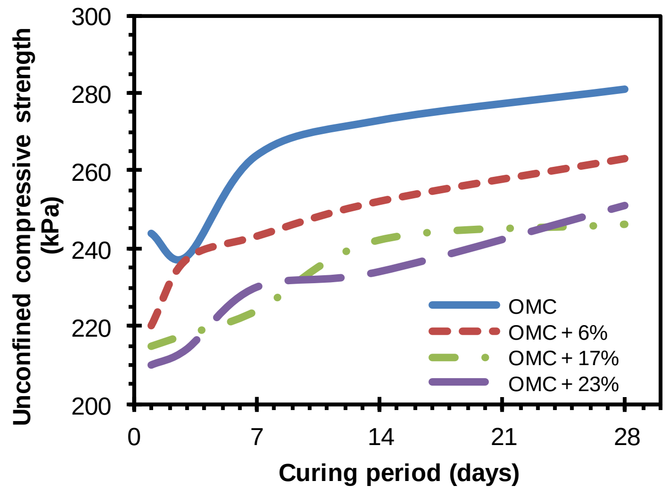

Figure 4 The relationships between curing days and unconfined compressive strength of the SiCC columns supported soil

The effect of curing time is shown in Figure 4. It is clearly shown that the unconfined compressive strength increased corresponding curing time for all soil moisture states. The SiCC column at soil moisture near OMC has the highest unconfined compressive strength. However, based on the Figure 3b, the strength development at soil moisture near OMC was lower than the specimen compacted at higher soil moisture. The results from figure 3b and 4 were alluding to conclude that the strength development of SiCC column supported soil depends on the soil moisture content surrounding column and curing time. In this case, the soil moisture content surrounding column was needed to maintain the pozzolanic reaction in the SiCC mortar. Hence, the strength development at soil moisture content is greater than at soil moisture near OMC.

4 Conclusions

The research has been successfully conducted to evaluate the unconfined compressive strength of the clay soil supported by SiCC column. The test was performed in the optimum wet moisture content from 31% to 52%. In general, it can be concluded that the unconfined compressive strength decreased with increasing of soil moisture content for both specimen group. The specimen with SiCC column at soil moisture near OMC have the highest unconfined compressive strength. However, at a high soil moisture content, the strength development of the SiCC column supported soil was higher than the specimen at near OMC state. The unconfined compressive strength increased corresponding curing time for all soil moisture states. The results confirmed that the strength development of SiCC column supported soil depends on the soil moisture content surrounding column and curing time.

Acknowledgement

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5 References

[1] Sholeh, M., “Pengaruh Proses Pembasahan Dan Pengeringan Pada Tanah Ekspansif Yang Distabilisasi Dengan Kapur Dan Eco Cure21 (Studi Kasus : Jalan Bojonegoro - Padangan Km 133 + 550)”, Master Thesis, Department of Civil Engineering, Institut Teknologi Sepuluh November, Surabaya, 2010.

[2] Budi, G.S., “Penyebaran kekuatan dari kolom yang terbuat dari limbah karbit dan kapur”. Jurnal Dimensi Teknik Sipil, Vol. 5 No.2, 2003, pp. 99-102

[3] Tonoz, M.C., Gokceoglu, C., and Ulusau, R., “A laboratory-scale experimental investigation on the performance of lime in expansive Ankara (Turkey) clay”, Bulletin Engineering Geology & environmental, Vol. 62, 2003, pp. 91-106.

[4] Muntohar, A.S., 2003, “Lime-column in expansive soil: A study on the compressive strength”, Proceeding the 1st International Conference on Civil Engineering, 1-3 October 2003, Malang, East Java.

[5] Muntohar, A.S., “A laboratory test on the strength and load-settlement characteristic of improved soft soil using lime-column”, Dinamika TEKNIK SIPIL, Vol. 10 (3), 2010, pp. 202-207

[6] Apriyono, A., dan Sumiyanto, “Pengaruh Variasi Jarak Kolom Kapur Dalam Stabilisasi Lempung Lunak Pada Tinjauan Nilai Indek Pemampatan (Cc) Tanah”, Dinamika TEKNIK SIPIL, Vol. 11 No. 1, 2011, pp. 61 – 65

[7] Malekpoor, M.R, and Toufigh, M.M., “Laboratory Study of Soft Soil Improvement using Lime Mortar-(Well Graded) Soil Columns”, Geotechnical Testing Journal, Vol. 33 No. 3, 2010, pp. 1-11

[8] Romano, J.S., Rodrigues, F.A., Bernardi, L.T., Rodrigues, J.A., and Segre, N., ”Calcium silicate cements obtained from rice hull ash: A comparative study”, Journal of Material Sciences, Vol. 41, 2006, pp. 1775–1779

[9] Jaturapitakkul, C., and Roongreung, B., “Cementing Material from Calcium Carbide Residue-Rice Husk Ash”, Journal of Materials in Civil Engineering, Vol. 15, No. 5, 2003, pp. 470–475