VOL. 11, NO. 1, JANUARY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

CHARACTERISTICS OF LIME - STABILIZED DEPOK RESIDUAL SOIL

Damrizal Damoerin, Sigit P. Hadiwardoyo and Teodore I. Minaroy
Faculty of Engineering, University of Indonesia, Depok, Indonesia
E-Mail: damrizal@eng.ui.ac.id

ABSTRACT

Depok residual soil has generally been used as sub grade layer for road pavement. By applying lime stabilization, the California Bearing Ratio (CBR) of sub grade Depok residual soil is expected to improve. In the present work, the lime stabilization was applied by adding 10 percent of dry weight of soil and furthermore the soil lime samples were compacted by Modified Standard Proctor around the optimum water content of 31.10 %. The soil lime samples were prepared in two conditions. The first condition, the soil lime samples were cured for 0, 6, 24, 72 and 168 hours and then compacted, while in the second condition, the soil lime sample were compacted first and then cured for similar time. After this stage, the laboratory testing such as CBR and Unconfined Compression Test (UCT) were conducted on the samples. The result from this test indicated that the soil samples that were compacted first and then cured are better than the soil lime samples were cured first and then compacted. Using lime stabilization, the unsoaked CBR values increase from 50.72 % to 54.55 % and the soaked CBR values relatively did not change but decreased from 11.35 % to 10.57 %. Based on the results of laboratory tests carried out in this study, it was found that soil lime stabilization on Depok residual soil did not significantly alter both the soaked and unsoaked CBR values of the soil in the long term. However, it increases the strength of the soil provided it is not soaked.

Keywords: residual soil, lime, stabilization, soil strength, CBR, UCT.

1. INTRODUCTION

1.1 General Geology

Depok city is located in the south of Jakarta and is growing very fast in population and infrastructure development. Based on the geological map of Jakarta - Bogor area, the Depok soil area consists of residual soil as part of volcanic material weathering where it covers Bogor regency to the south of Jakarta area [1]. The Depok residual soil is well known as lateritic soil.

1.2 Soil lime

Soil stabilization is the improvement of native soils for the construction of shallow foundations, especially for highways, airfields, parking and similar facilities. Soil lime stabilization is one method of stabilization and it is especially effective in improving the engineering properties of heavy clayey soils or granular soils, but it has been found to be less effective for silt-loam soils [2].

Treatment with cement or lime has been mainly used in the field of highways, railroads and airport construction in order to improve the mechanical properties of bearing layer or sub grade [3].

In roads, lime stabilization is widely used for sub-base construction or sub grade improvement and lime requirement can be used in ratio of 3 - 8 per cent of heavy clay. The lime stabilization is more tolerant of construction delay than cement stabilization and more suitable for clay soils [4].

The effect of carbide lime on the engineering properties of a selected silty soil had been conducted. The results indicated that compressive strength increased significantly with the increase of lime content and curing period for particular amount of fly ash [5].

A investigate of lime stabilization on soil of a selected reclaimed site of Dhaka City, Bangladesh has also been carried out. The results showed that the unconfined compressive strength and soaked CBR values of treated samples increased. The unconfined compressive strength increased about five times from 380 kPa to 2173 kPa and soaked CBR increased from 13 % to 53 % [6].

Generally, the Depok residual soil in its natural has been used for sub grade layer of road pavement structure. On the other hand, due to much higher CBR values, the cement-stabilized Depok residual soil sometimes used for a sub-base layer to substitute the sand stone materials. The cement-stabilized soil has soaked CBR value of about 37.7 %, which is almost three times the original value of 13.23 % [7].

In this study, the 10 per cent lime stabilization of dry weight of soil is added and then the soil lime mixture sample is compacted by Modified Standard Proctor around the optimum water content of 31.10 %. Based on the Standard National Indonesia (SNI), the minimum standard of soaked CBR for sub grade layer is 3.6 % [8].

2. TEST PROCEDURE

The laboratory testing such as physical properties, California Bearing Ratio (CBR) and Unconfined Compression Test (UCT) were conducted on soil and soil lime samples [9]. The variation of lime

stabilization were used as 0, 5, 10, 15, 20 and 25 percent of dry weight of soil respectively and then the soil lime samples are conducted physical properties testing. Based on the physical properties, the optimal percentage of lime is 10 percent of dry weight of soil will be implied. This sample is then compacted by Modified Standard Proctor around an optimum water content of 31.10 %.

The soil samples were prepared in two conditions: (i), the soil samples A were cured first for 0, 6, 24, 72 and 168 hours and then compacted and (ii), the soil samples B were compacted and then cured for similar time. After this stage, the laboratory testing such as California Bearing Ratio and Unconfined Compression Test were conducted on the compacted soil lime samples.

3. TEST RESULT AND ANALYSIS

3.1 Physical properties

The test result of physical properties of natural soil is shown in Table-1, while those of natural soil and soil lime are presented in Table-2.

Table-1. Physical properties of natural soil.

No.	Physical parameters	Value
1	Color	red
2.	Specific gravity	2.69
3	Atterberg Limits: Liquid Limit, LL (%) Plastic Limit, PL (%) Plasticity Index, PI (%)	 82.00 49.40 32.60
4	Sieve Analysis: Sand (%) Silt (%) Clay (%)	 1 83 16

Table-2. Physical properties of natural soil and soil lime.

No.	Sample type and lime content	LL %	PL %	PI %
1	Natural soil	82	49.4	32.6
2	Soil lime (+ 5% lime)	72.1	44.86	27.24
3	Soil lime (+ 10% lime)	72.66	45.15	27.51
4	Soil lime (+ 15% lime)	73.01	48.12	24.89
5	Soil lime (+ 20% lime)	71.27	44.22	27.05
6	Soil lime (+ 25% lime)	64.28	46.02	18.26

The relation between Plasticity Index versus Lime Content can be seen in Figure-1.

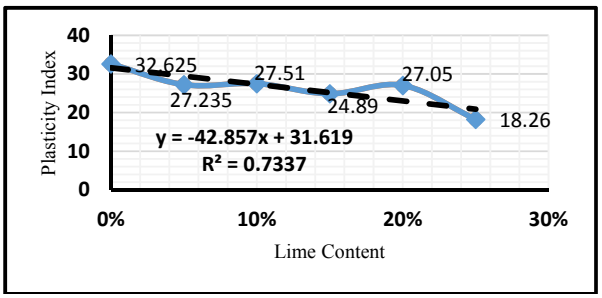

Figure-1. Relationship between plasticity index and lime content.

3.2 Soil lime

3.2.1 California bearing ratio test

The value of unsoaked and soaked CBR on natural soil is as 50.72 % and 11.35 % respectively. Using 10 percent lime stabilization by dry weight of soil, the soaked CBR value decreases slightly from 11.35 % to 10.80 % but the unsoaked CBR value still increases from 50.72 % to 54.55 %. After preparing the soil samples, the unsoaked and soaked CBR tests were conducted on the compacted soil lime samples. The relationship between the unsoaked and soaked CBR value of 10 percent lime content and Compaction Delay/Curing Time can be seen in Figures 2 and 3 respectively. The value of unsoaked and

soaked CBR and Compaction Delay/Curing Time can be seen in Table-3.

The results of the tests suggest that the unsoaked CBR values are higher for samples B which are compacted first and then cured later than those cured first and then compacted (samples A), for 1 and 3 days curing time. However, after 7 days, the unsoaked CBR values for both type of sample preparation are similar for practical purposes. The unsoaked CBR values are 53.27 % and 54.55 % respectively for samples A and B. It is expected that both samples will have similar properties in the long-term.

The soaked CBR test results in Figure-3 suggest similar trend that samples B have higher CBR values than samples A. However, for 7-day curing period, the CBR value for sample A is even lower than that for 3-day curing period. For practical purposes, the difference in the CBR values seems to be within the expected variation of the CBR values on site.

Based on the results of the limited tests in this study, lime soil stabilization on Depok clay soils does not seem to improve both the unsoaked and soaked CBR values for the long term condition. The results of the limited tests show that after 7 days the values of both soaked and un-soaked CBR are similar within the expected variation of the CBR values on site.

On the basis of the Standard National Indonesia (SNI), the minimum standard of soaked CBR for sub-grade layer is 3.6 %. The soaked C.B.R. value of the natural soil is 11.35 % and the 10 percent lime content in this study increased the unsoaked CBR values but did not significantly alter the soaked CBR values of the Depok soils. Both the natural and the lime-stabilized Depok soils satisfy the sub grade layer requirements.

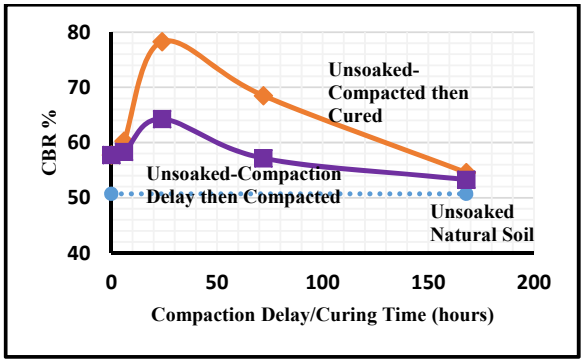

Figure-2. Relationship between unsoaked CBR and Compaction Delay/Curing Time for different samples.

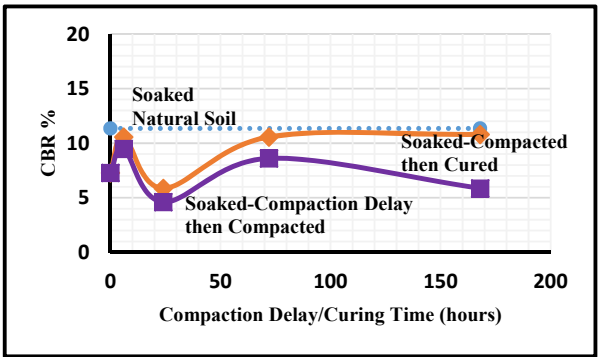

Figure-3. Relationship between soaked CBR and Compaction Delay/Curing Time for different samples.

Table-3. Compaction Delay/Curing Time, unsoaked and soaked CBR of natural soil and 10 percent lime.

No.	Sample type	Compaction delay /Curing time	Unsoaked CBR	Soaked CBR
		(days)	(%)	(%)
1	Compacted natural soil	0	50.72	11.35
2	Compacted	0	57.76	7.28
3	Compacted then cured (Samples B)	0.25	60.27	10.57
		1	78.27	5.87
		3	68.49	10.57
		7	54.55	10.80
4	Delayed in compaction then compacted (Samples A)	0.25	58.31	9.47
		1	64.26	4.62
		3	57.14	8.61
		7	53.27	5.87

3.2.2 Unconfined compression test

The soil samples were prepared in similar way as those used for the CBR testing described previously. After this stage, the Unconfined Compression Test (UCT) were carried out on the compacted soil lime samples with 10 percent lime content in unsoaked condition by applying a constant rate of 0.7 mm/minute until the samples reached the maximum compressive strength and the tests were stopped at axial strain of 9 %. The value of Unconfined Compressive Strength (UCS) on natural soils is 557 kPa.

The relation between the Unconfined Compressive Strength values of 10 percent lime content versus Compaction Delay/Curing Time can be seen in Figure-4. The Unconfined Compressive Strength value in unsoaked condition and Compaction Delay/Curing Time can be seen in Table-4.

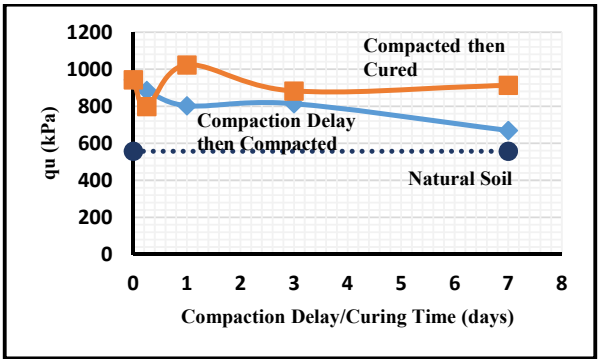

Figure-4. Relationship between unconfined compressive strength and compaction delay/curing time for different samples.

Table-4. Compaction delay/curing time, unconfined compressive strength on unsoaked condition of natural soil and 10 percent lime.

No.	Sample type	Compaction delay /Curing time	Unsoaked UCS
		(days)	(kPa)
1	compacted natural soil	0	557
2	compacted	0	943.16
3	compacted then cured (Samples B)	0.25	798.8
		1	1023.03
		3	881.99
		7	913.03
4	delayed in compaction then compacted (Samples A)	0.25	885.68
		1	802.78
		3	813.83
		7	669.37

The results of Unconfined Compressive Strength (UCS) shown in Figure 4 indicate that the addition of 10% lime to the natural Depok soils can improve the soil strength by at least 20%, i.e. from 557 kPa to 669 kPa. The increase of strength is perhaps related to the reduction of soil plasticity due to the lime addition, which is reduced from 32% in the natural soil to about 27% in the lime-stabilized samples. There seems to be some effect of sample preparation on the results of UCT, however the results of the tests are probably within the expected range of soil variation on site.

4. CONCLUSIONS

The addition of 10 percent lime by dry weight to the natural Depok residual soil practically did not alter both the soaked and unsoaked CBR values of soils. The soaked CBR values decrease from 11.35 % to 10.80 % and the unsoaked CBR values increase from 50.72 % to 54.55 %. The changes in the CBR values are considered within the range of expected variation on soil from the site.

The study also showed that, there were some effects of sample preparation for the unsoaked and soaked CBR values for 3 days curing period. The soil lime samples that were compacted and then cured are better than the soil lime sample that were cured first and then compacted. However, for 7 days curing period the

difference is less and is considered within the variation of CBR values from the site.

From strength point of view, the addition of 10% lime by dry weight could improve the natural strength of Depok soil by 20%, as long as the soils are not soaked.

ACKNOWLEDGMENT

The authors would like to express the gratitude to the Soil Mechanics Laboratory and Civil Engineering Department, Faculty of Engineering, University of Indonesia for supporting this study.

REFERENCES

[1] Department of Mining. 1980. Geological Map of Jakarta - Bogor, Geological Survey of Indonesia, Bandung, Indonesia.

[2] Winterkorn H.F. and Fang H.Y. 1975. Foundation Engineering Handbook, Van Nostrand Reinhold Ltd., Canada. p. 325.

[3] Bergado D.T., Anderson L.R., Miura N. and Balasubramanian A.S. 1996. Soft Ground Improvement, Published by ASCE PRESS, New York.

[4] Ingles O.G. and Metcalf J.B. 1972. Soil Stabilization Principles and Practice, Butterwoths, Sydney.

[5] Ahmed K.I., Hoque E. and Islam M.S. 2003. Use of Carbide Lime as a Potential Stabilizing Agent of a Selected Silty Soil. Proceedings of 12th Asian Regional Conf. on Soil Mechanics and Geotechnical Engineering. 1: 431-434, World Scientific Publishing Co. Pte. Ltd., Singapore.

[6] Ansary M.A., Siddique A. and Hasan K.A. 2003. A Study of Lime Stabilization on Soil of a Selected Reclaimed Site of Dhaka City. Proceedings of 12th Asian Regional Conf. on Soil Mechanics and Geotechnical Engineering. 1: 439-442, World Scientific Publishing Co. Pte. Ltd., Singapore

[7] Damoerin D., Hadiwardoyo S.P. and Yolanda. F. 2013. Increasing the Depok Residual Soil Strength for Sub-Base Layer by Using Soil Cement Stabilization, the 13th International Conference on Quality in Research [QIR], Faculty of Engineering, University of Indonesia, Yogyakarta, Indonesia.

[8] Department of Public Work. 2007. Design Manual of Soil Stabilization by Using Binder Powder Agent for Road Construction, Bandung, Indonesia.

[9] American Society of Testing and Material. 1989. Annual Book of ASTM Standards.