JIT Journal of Innovation and Technology
e-ISSN: 2721-8562; p-ISSN: 2721-8570
Vol. 5, No. 2, October 2024. Page: 34 – 39

The Effect of Matos Soil Stabilizer on Mechanical Properties of Soil Stabilzed with Cement

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Article history
Received: 07.06.2024
Revised: 01.07.2024
Accepted: 13.07.2024

DOI:10.31629/jit.v5i2.7240

Abstract
Soil stabilization with cement is commonly used for sub base course. This research aims to determine the effect of Matos Soil Stabilizer on the cement-stabilized soil used for the sub base course. The variables considered in terms of soil mechanical properties are using Matos at 0%, 1%, 2%, 4%, and 8% in addition to cement as a binder at 5%, as well as different curing periods of 0, 7, 14 days on the soil's mechanical properties. The results show that increasing the use of Matos can enhance the dry density (ɣd) of the soil, soaked and unsoaked CBR (California Bearing Ratio), unconfined compressive strength (qu), soil shear angle (ϕ), soil cohesion (c), and soil consolidation coefficient (Cv). The use of Matos can also reduce the optimum water content of the soil and the soil's compression index (Cc).

Keywords: Soil Stabilization, Matos, *Soil Stabilizer*, Mechanical Properties.

1. Introduction

The highway is one of the essential facilities for the community. Highways serve the purpose of enabling users to reach their desired destinations, which is why people require safe and comfortable roads to travel on. In highway planning, pavement design plays a crucial role in accommodating traffic loads. The pavement layers bear the traffic loads, starting from the surface course, which distributes the load to the underlying layers, including the base course, subbase course, and subgrade.

The road foundation layer is situated between the subgrade and the road pavement. This layer requires high-quality materials capable of withstanding the transportation loads passing through the road. In the construction of the road foundation layer, soil stabilization using cement is a common practice. Stabilization is a method employed to improve the properties and parameters of the soil to meet the required criteria for its designated purpose.

Chemical soil stabilization involves enhancing the soil by adding additive substances to it [13]. In this study, Matos soil stabilizer was utilized as the additive substance. Matos soil stabilizer functions as a compaction agent and soil stabilizer. In its application, soil stabilizer requires other binding materials to mix with the soil. Cement is one of the binding materials that facilitate the homogenization of the soil and soil stabilizer. This research aims to investigate the effects of adding Matos soil stabilizer and cement on the mechanical properties of the soil through testing.

2. Materials and Method

The test of mechanical properties including compaction test (SNI-1743-2008) [2], California Bearing Ratio (SNI-1744-2012) [4], Unconfined Compressive Strength (SNI-6887-2012) [5], Direct Shear (SNI-3420-2016) [7], and Consolidation (SNI-2812-2011) [3]. The test results obtained are then adjusted based on the General Specifications for 2018 road and bridge works (revision 2) specifically for Unconfined Compressive Strength and California Bearing Ratio Test [10]. In this study, testing is conducted to evaluate the mechanical properties of soil with a mixture of cement and Matos soil stabilizer. The mixture variations include natural soil mixed with 5% cement, and different percentages of Matos soil stabilizer, namely 0%, 1%, 2%, 4%, and 8%. The curing periods for each mixture variation are 0 days, 7 days, and 14 days. After completing these tests, data analysis will be performed.

Table 1 Soil Mixture Variations

Number	Soil Mixture	Curing Period (day)	Mixture Code
1	Disturbed Soil	0	S
2	Soil + 5% Cement	0,7,14	SC
3	Soil + 5% Cement +1% Matos *Soil Stabilizer*	0.7,14	SCM-01
4	Soil + 5% Cement +2% Matos Soil Stabilizer	0,7,14	SCM-02
5	Soil + 5% Cement +4% Matos Soil Stabilizer	0,7,14	SCM-03
6	Soil + 5% Cement +8% Matos Soil Stabilizer	0,7,14	SCM-04

2.1 Testing of Soil Mechanical Properties without Mixture

Table 2 Analysis Results of Existing Soil Conditions

Number	Test Type	Test Results
1	Compaction	
	> Optimum Water Content (Wopt = %)	24,09
	> Maximum Dry Density (γdry = gr/cm3)	1,463
2	California Bearing Ratio	
	>CBR Soaked (%)	5,421
	>CBR Unsoaked (%)	24,680
3	Unconfined Compressive Strength (qu = Kg/cm2)	4,470
4	Direct Shear	
	>Cohesion (c = Kg/cm2)	0,130
	>Shear Angle (ϕ= °)	37,603
5	Consolidation	
	>Cc	0,02990
	>Cv	0,01570

2.2 Effects of Matos Soil Stabilizer and Cement Addition on Mechanical Properties Results

Table 3 Compaction Test Results

Number	Variety Code	MDD (gr/cm^3)	OMC (%)
1	S	1,463	24,090
2	SC	1,470	23,900
3	SCM-01	1,477	23,600
4	SCM-02	1,488	23,400
5	SCM-03	1,518	22,800
6	SCM-04	1,535	21,500

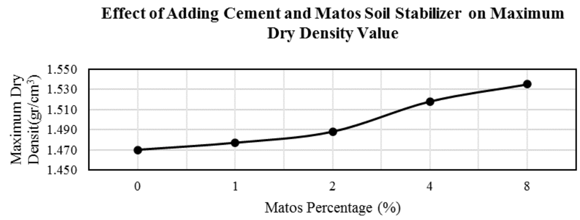

Figure 1 Effect of Adding Cement and Matos Soil Stabilizer on Maximum Dry Density Value

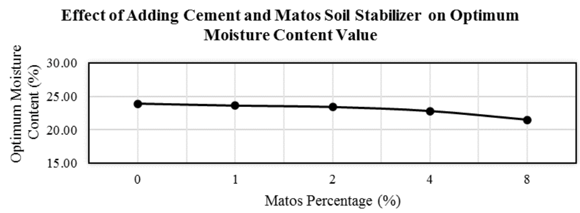

Figure 2 Effect of Adding Cement and Matos Soil Stabilizer on Optimum Moisture Content Value

Based on Table 3, along with Figures 1 and 2, it can be observed that the addition of cement and Matos Soil Stabilizer can increase the maximum dry density value and decrease the optimum water content.

Table 4 CBR Test Results

Number	Variety Code	CBR Value (%)			
		unsoaked			*soaked*
		0	7	14	
1	S	24,680	25,797	26,171	5,421
2	SC	28,227	41,126	59,819	30,844
3	SCM-01	29,349	51,719	68,917	50,286
4	SCM-02	32,153	59,632	74,961	58,698
5	SCM-03	37,387	64,493	81,005	61,689
6	SCM-04	42,621	73,092	103,001	67,484

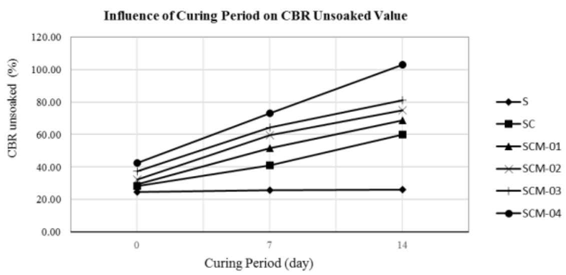

Figure 3 Influence of Curing Period on CBR Unsoaked Value of Soil Stabilized with Cement and Matos Soil Stabilizer

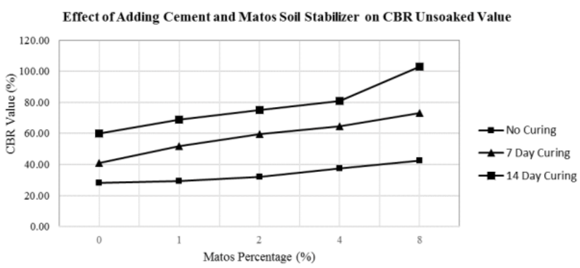

Figure 4 Effect of Adding Cement and Matos Soil Stabilizer on CBR Unsoaked Value

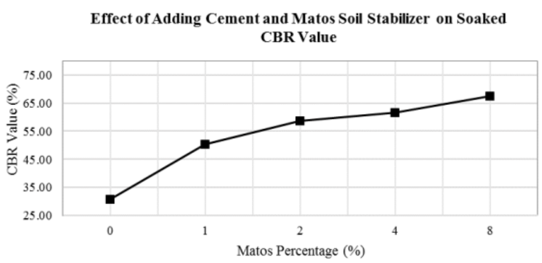

Figure 5 Effect of Adding Cement and Various Matos Soil Stabilizer Variations on Soaked CBR Value

Based on Table 4, along with Figures 3, 4, and 5, it can be observed that the addition of cement and Matos Soil Stabilizer can increase the soaked and unsoaked CBR values. The curing period also has an effect on the unsoaked CBR value, with longer curing periods resulting in higher CBR values.

Table 5 UCS Test Results

Number	Variety Code	Unconfined Compressive Strength (q_u) (kg/cm^2)		
		0	7	14
1	S	4,470	4,888	4,971
2	SC	8,268	14,380	15,213
3	SCM-01	9,308	14,665	15,967
4	SCM-02	10,088	15,211	16,250
5	SCM-03	10,990	16,239	17,092
6	SCM-04	11,677	17,634	20,170

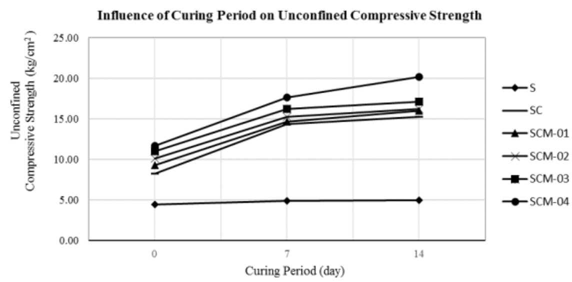

Figure 6 Influence of Curing Period on Unconfined Compressive Strength of Soil Stabilized with Cement and Matos Soil Stabilizer

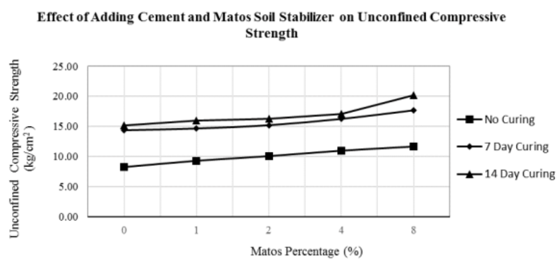

Figure 7 Effect of Adding Cement and Matos Soil Stabilizer on Unconfined Compressive Strength

Based on Table 5, along with Figures 6 and 7, it can be observed that the addition of cement and Matos Soil Stabilizer can increase the unconfined compressive strength of the soil. The curing period also has an effect on the unconfined compressive strength.

Table 6 Direct Shear Test Results

Number	Variety Code	Cohesion (c) Kg/cm²			Shear Angle (ϕ) °		
		0	7	14	0	7	14
1	S	0,130	0,148	0,157	37,603	38,291	38,883
2	SC	0,251	0,278	0,281	39,132	40,198	40,758
3	SCM-01	0,272	0,281	0,290	40,837	41,387	41,621
4	SCM-02	0,296	0,299	0,314	42,233	42,459	42,834
5	SCM-03	0,320	0,332	0,341	43,128	43,423	43,786
6	SCM-04	0,347	0,350	0,362	45,738	45,938	46,730

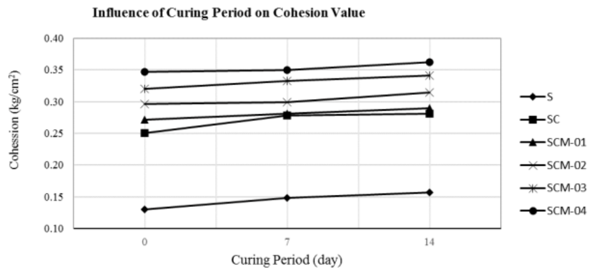

Figure 8 Influence of Curing Period on Cohesion Value of Soil Stabilized with Cement and Matos Soil Stabilizer

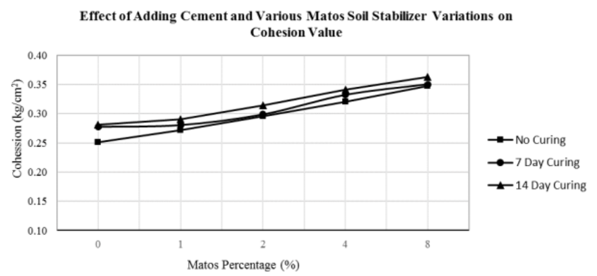

Figure 9 Effect of Adding Cement and Various Matos Soil Stabilizer Variations on Cohesion Value

Based on Table 6, along with Figures 8 and 9, it can be observed that the addition of cement and Matos Soil Stabilizer can increase the cohesion value of the soil. The curing period also has an effect on the cohesion value of the soil.

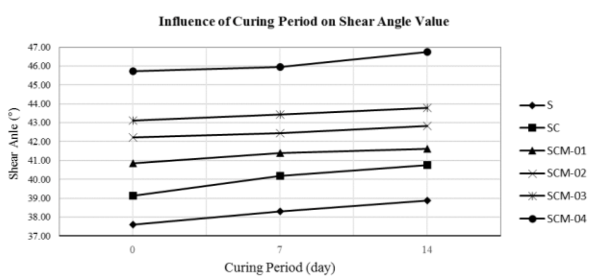

Figure 10 Influence of Curing Period on Shear Angle Value of Soil Stabilized with Cement and Matos Soil Stabilizer

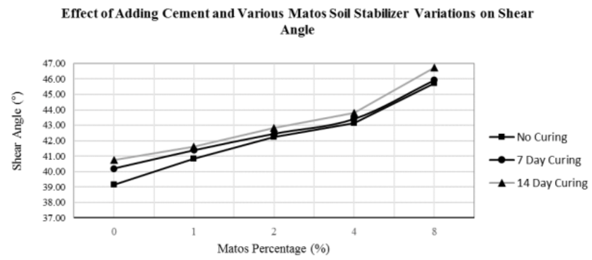

Figure 11 Effect of Adding Cement and Various Matos Soil Stabilizer Variations on Shear Angle Value

Based on Table 6, along with Figures 10 and 11, it can be observed that the addition of cement and Matos Soil Stabilizer can increase the shear angle value of the soil. The curing period also affects the shear angle value of the soil.

Table 7 Consolidation Test Results

Number	Variety Code	C_c	C_v
1	S	0,02990	0,0157
2	SC	0,01100	0,0219
3	SCM-01	0,00650	0,0378
4	SCM-02	0,00600	0,0525
5	SCM-03	0,00115	0,0635
6	SCM-04	0,00110	0,1550

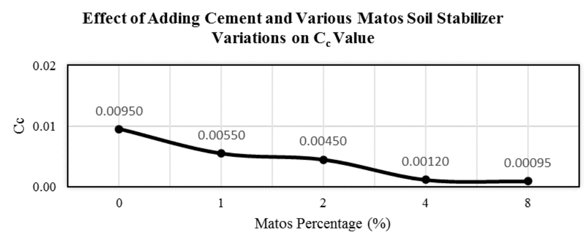

Figure 12 Effect of Adding Cement and Various Matos Soil Stabilizer Variations on C_c Value

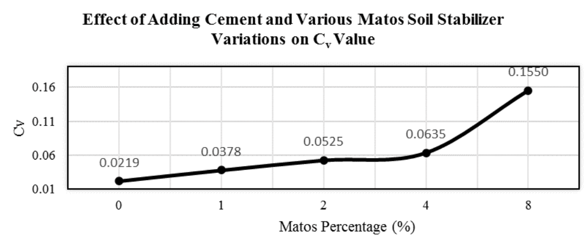

Figure 13 Effect of Adding Cement and Various

Matos Soil Stabilizer Variations on C_v Value

Based on Table 7 along with Figures 12 and 13, it can be observed that the addition of cement and Matos Soil Stabilizer can decrease the value of C_c and increase the value of C_v.

3. Conclusion

Based on the research conducted in the laboratory and data analysis, the following conclusions can be drawn:

The addition of Matos Soil Stabilizer to the soil, whether in its pure form or stabilized with PCC, results in a decrease in the optimum moisture content and an increase in the dry density of the soil. This indicates that the addition of Matos Soil Stabilizer can enhance the soil's density.

The CBR test results for the soil without any additives, both in soaked and unsoaked conditions, yielded values of 5.421% and 24.68% respectively. The highest CBR value in the soaked condition was obtained with the SCM-8 mixture at 67.48%, while the highest CBR value in the unsoaked condition was obtained with the SCM-04 mixture at 103.001% after 14 days of curing.

The unconfined compressive strength (UCS) test conducted on the soil without any additives yielded a value of 4.536 kg/cm2. The highest UCS value was obtained with the SCM-04 mixture after 14 days of curing, reaching 20.17 kg/cm2.

The direct shear strength test conducted on the natural soil revealed a cohesion value of 0.130 kg/cm2 and an angle of internal friction of 37.603°. The highest cohesion and angle of internal friction were obtained with the SCM-04 mixture, with cohesion reaching 0.362 kg/cm2 and angle of internal friction reaching 46.730° after 14 days of curing.

The consolidation test conducted on the soil without any additives resulted in a C_c value of 0.0299 and a C_v value of 0.0157. The smallest C_c value was obtained with the SCM-04 mixture at 0.0011, while the highest C_v value was 0.155.

According to the General Specifications of Bina Marga (2018), the highest UCS value was obtained with the SCM-04 mixture, which consists of 5% PCC and 8% Matos Soil Stabilizer. However, it did not meet the property limits for the soil foundation layer of cemented roads after 7 days of curing. But after po minimum property limits for the soil foundation layer.

Based on the planned variations, the design for the roadbed foundation layer is carried out based on the CBR value in the soaked condition, as the target specified in the General Specifications of Bina Marga (2018) of a minimum CBR value of 60% has been achieved with the SCM-03 mixture. It is observed that the addition of Matos Soil Stabilizer in percentages of 1%, 2%, 4%, and 8% to the cemented soil stabilization resulted in an improvement in the mechanical properties compared to the natural soil and the soil stabilized with cement alone. This suggests that the addition of Matos Soil Stabilizer as a mixture material in cemented soil stabilization can shorten the curing period.

In conclusion, the use of Matos Soil Stabilizer as a mixture material in cemented soil stabilization can enhance the load-bearing capacity of the embankment soil from Desa Peniraman based on the mechanical properties obtained from the testing.

Acknowledgement

I want to thanks to my family because of their prayer and support ia can finish this research. I also want to thank to Mr. Ir. Aprianto, M.sc. and thank Mrs. Vivi Bachtiar S.T., M.T., that have given me the instructions and suggestions and all the knowledge that were bestowed to me during my mentorship progress.

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