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Original Article

Evaluation Of Swelling – Shrinkage Of Soil Stabilized With Cement and Matos Soil Stabilizer

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This study aims to investigate the effect of matos soil stabilizer on soil stabilized with cement. The study utilizes 5% Portland Composite Cement (PCC) ratio by weight of dry soil and matos soil stabilizer at 0%, 1%, 2%, 4%, and 8% by weight of Portland Composite Cement, with curing periods of 0 days, 7 days, and 14 days, focusing on the swelling and shrinkage characteristics. The best result showed in a mixture with a variation of 8% matos soil stabilizer under 14 days curing with a plasticity index 12,227% Swelling (CBR Soaked) 1,423, Swelling Pressure 1,469 kg/cm^2 and free swelling index 16,667%. The test results indicate that the mixtures with varying amounts of matos soil stabilizer in the cement-treated soil with different curing periods can reduce soil swelling, as observed from the values of plasticity index, Swelling (soaked CBR (California Bearing Ratio)), swelling pressure, and free swelling index, which decrease progressively. Therefore, it can be concluded that increasing the amount of matos soil stabilizer and prolonging the curing time can reduce the swelling and shrinkage characteristics of the soil.

Keywords: Cement; Matos Soil Stabilizer; Soil; Stabilization; Swelling.

1. Introduction

The construction of a structure may also be built on land with low bearing capacity. One type of soil with low bearing capacity is expansive soil. Expansive soil is a type of clay soil that exhibits significant swelling and shrinkage. The swelling and shrinkage properties of the soil itself are strongly influenced by the water content in the soil. If the water content in the soil increases, it will affect the bearing capacity of the soil. [1]

Soils with low bearing capacity can be improved through stabilization [2]. Soil stabilization is divided into four types: physical soil stabilization, chemical soil stabilization, hydraulic soil stabilization, and geosynthetic soil stabilization. The type of soil stabilization used in this study is chemical soil stabilization using chemicals in the form of cement and also matos soil stabilizer additives. Bentonite is used as an additive to increase soil swelling because it has the property of swelling when exposed to water.[3]

Matos soil stabilizer is a chemical substance used as a soil hardener. Matos soil stabilizer functions to physically and chemically compact (solidify) and stabilize the soil. Matos soil stabilizer is used with other binders such as cement [1]. Based on this, this study aims to investigate the effect of matos soil stabilizer as an additive in soil stabilization with cement. Therefore, the purpose of this study is to determine the effect of a mixture of matos soil stabilizer and the difference in curing time on soil stabilized with cement on the swelling and shrinkage characteristics of the soil.

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2. Materials and Methods

One of the efforts to decrease the swelling and shrinkage characteristics of the soil is soil stabilization. By using portland composite cement and Matos Soil Stabilizer as soil stabilization materials to study the heap swelling and shrinkage characteristics before and after stabilization.

The testing of soil swelling and shrinkage charateristics consists of Atterberg Limit[1] ,Swelling (California Bearing Ratio (CBR) Soaked) (SNI-1744-2012)[3],Free Swelling Index (IS: 2720-1977) [4] and Swelling Pressure (ASTM D4546-96) [5]. The results from swelling and shrinkage characteristics can be obtained after the experiment.

In this study, the testing conducted involves the examination of soil swelling characteristics using a mixture of cement and matos soil stabilizer. The mixture proportions vary with disturbed soil mixed with 5% cement and 0%, 1%, 2%, 4%, and 8%. The curing period for each mixture variation is 0 days, 7 days, and 14 days. After completing the aforementioned testing, the author will proceed with data analysis. Soil sampling in this research was conducted on capkala soil and bentonite. Capkala is located on Capkala Road, Bengkayang Regency, West Kalimantan [6, 9, 10].

This research conducts soil swelling and shrinkage characteristics testing with portland composite cement compound and matos soil stabilizer variations which consists of soil compound that is mixed with 5% portland composite cement combined with matos soil stabilizer variations of 1%, 2%, 4%, and 8% with curing time of 0, 7, and 14 days.

Table 1. Variations of soil mixture

Mix	Code
Disturbed Soil	S
Disturbed Soil + PCC 5%	SC
Disturbed Soil + Bentonite 40%	SB
Disturbed Soil + Bentonite 40% + PCC 5%	SBC
Disturbed Soil+ Bentonite 40%+ PCC 5% + Matos Soil Stabilizer 1%	SBCM-01
Disturbed Soil + Bentonite 40%+ PCC 5% + Matos Soil Stabilizer 2%	SBCM-02
Disturbed Soil + Bentonite 40%+ PCC 5% + Matos Soil Stabilizer 4%	SBCM-03
Disturbed Soil + Bentonite 40%+ PCC 5% + Matos Soil Stabilizer 8%	SBCM-04

Table 2. Result Of Plasticity Index and Classification

Code	Curing	IP	AASTHO	USCS
S	0	21,937	A-7-6	MH
S	7	21,710	A-7-6	MH
S	14	20,394	A-7-6	MH
SC	0	16,297	A-7-6	OL
SC	7	16,011	A-7-5	OL
SC	14	15,815	A-7-5	OL
SB	0	36,437	A-7-6	MH
SB	7	35,708	A-7-6	MH
SB	14	35,612	A-7-6	MH
SBC	0	24,131	A-7-5	MH
SBC	7	22,643	A-7-5	MH
SBC	14	21,718	A-7-5	MH
SBCM-01	0	23,600	A-7-5	MH
SBCM-01	7	21,228	A-7-5	MH
SBCM-01	14	19,469	A-7-5	MH
SBCM-02	0	19,205	A-7-5	OL

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Code	Curing	IP	AASTHO	USCS
SBCM-02	7	17,532	A-7-5	OL
SBCM-02	14	15,550	A-7-5	OL
SBCM-03	0	17,483	A-7-5	OL
SBCM-03	7	15,496	A-7-5	OL
SBCM-03	14	12,676	A-7-5	OL
SBCM-04	0	16,257	A-7-5	OL
SBCM-04	7	13,132	A-7-5	OL
SBCM-04	14	12,227	A-7-5	OL

After the necessary data is collected from test in laboratory, then there is a manual analysis of Atterberg Limit, Swelling (California Bearing Ratio Soaked), Swelling Pressure, and Free Swelling Index.

3. Results and Discussion

3.1. Compaction Test

Table 2. Compaction Test Result

Code	OMC (%)	MDD (gr/cm³)
S	21,500	1,391
SC	20,200	1,397
SB	24,500	1,313
SBC	23,600	1,336
SBCM-01	23,000	1,345
SBCM-02	22,800	1,364
SBCM-03	22,500	1,389
SBCM-04	22,300	1,412

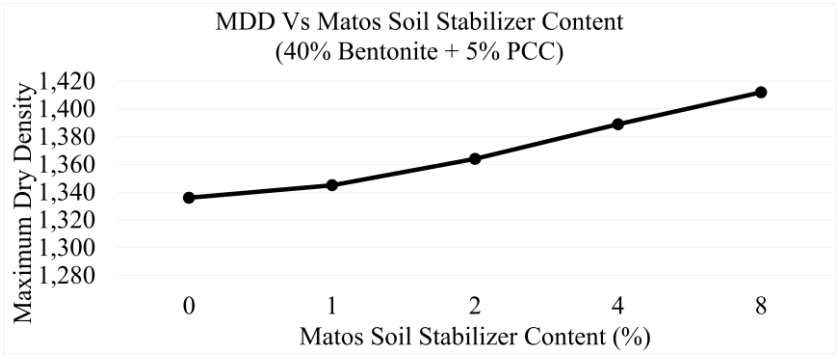

Figure 1. Graph of the Effect of Matos Soil Stabilizer on Maximum Dry Density

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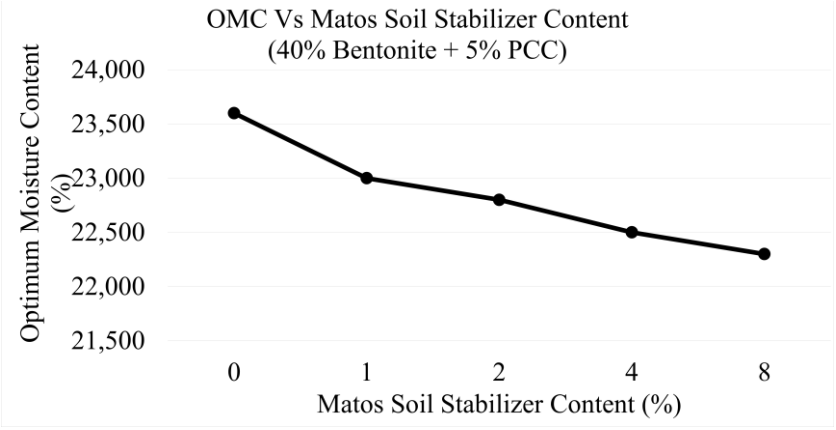

Figure 2. Graph of the Effect of Matos Soil Stabilizer on Optimum Moisture Content

Based on Table 2 and Figure 3 and Figure 6, it is evident that the soil density increases with the addition of bentonite in the mixture. Additionally, the optimum moisture content of the soil decreases as the content of matos soil stabilizer increases.

3.2. Specific Gravity

Table 3. Specific-Gravity-Test-Results

Code	Specific Gravity		
	0	7	14
S	2,569	2,573	2,576
SC	2,582	2,619	2,650
SB	2,325	2,327	2,334
SBC	2,359	2,493	2,531
SBCM-1	2,520	2,524	2,537
SBCM-2	2,526	2,538	2,546
SBCM-3	2,541	2,547	2,551
SBCM-4	2,552	2,552	2,572

Based on Table 7, the soil mixed with 40% bentonite has the lowest density, while the soil mixed with 40% bentonite, and 5% PCC, and 8% matos soil stabilizer under curing time of 14 days result the highest density. Therefore, it can be concluded that the density will increase with the addition of matos soil stabilizer in the mixture and with longer curing time.

3.3. Atterberg Limit Test

Table 3. Plasticity Index Test Results

Code	Plasticity Index (%)		
	0	7	14
S	21,937	21,710	20,394
SC	16,297	16,011	15,815
SB	36,437	35,708	35,612
SBC	24,131	22,643	21,718
SBCM-01	23,600	21,228	19,469
SBCM-02	19,205	17,532	15,550

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SBCM-03	17,483	15,496	12,676
SBCM-04	16,257	13,132	12,227

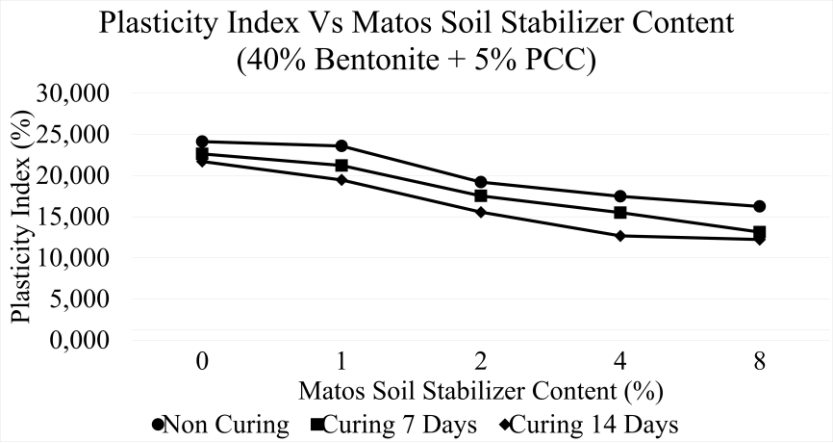

Figure 3. Graph of Analysis Results of Plasticity Index with Variations in Matos Content and Curing Time

Based on Table 8 and Figure 3, the soil mixed with 40% bentonite has the highest plasticity index, while the soil mixed with 40% bentonite, and 5% PCC, and 8% matos soil stabilizer under curing time of 14 days has the lowest plasticity index. Therefore, it can be concluded that the plasticity index decreases with the addition of matos soil stabilizer in the mixture and with longer curing time.

3.4. Soil Classification Test Results

Table 5. Classification Test Results According to USDA [7]

Code	Plasticity Index (%)		
	0	7	14
S	Lempung Berlanau	Lempung Berlanau	Lempung Berlanau
SC	Tanah Liat Berlanau	Tanah Liat Berlanau	Tanah Liat Berlanau
SB	Lempung Berlanau	Lempung Berlanau	Lempung Berlanau
SBC	Tanah Liat Berlanau	Tanah Liat Berlanau	Tanah Liat Berlanau
SBCM-01	Tanah Liat Berlanau	Tanah Liat Berlanau	Tanah Liat Berlanau
SBCM-02	Tanah Liat Berlanau	Tanah Liat Berlanau	Tanah Liat Berlanau
SBCM-03	Tanah Liat Berlanau	Tanah Liat Berlanau	Tanah Liat Berlanau
SBCM-04	Tanah Liat Berlanau	Tanah Liat Berlanau	Tanah Liat Berlanau

Table 6. Classification Test Results According to USCS [7]

Code	USCS		
	0	7	14
S	MH	MH	MH
SC	OL	OL	OL
SB	MH	MH	MH
SBC	MH	MH	MH
SBCM-01	MH	MH	MH
SBCM-02	OL	OL	OL
SBCM-03	OL	OL	OL
SBCM-04	OL	OL	OL

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Table 7. Classification Test Results According to AASTHO [7]

Code	AASTHO		
	0	7	14
S	A-7-6	A-7-6	A-7-6
SC	A-7-6	A-7-5	A-7-5
SB	A-7-6	A-7-6	A-7-7
SBC	A-7-5	A-7-5	A-7-5
SBCM-01	A-7-5	A-7-5	A-7-5
SBCM-02	A-7-5	A-7-5	A-7-5
SBCM-03	A-7-5	A-7-5	A-7-5
SBCM-04	A-7-5	A-7-5	A-7-5

3.5. Activity Results

Table 8. Activity Analysis Results

Code	Activity		
	0	7	14
S	0,225	0,223	0,210
SC	0,186	0,190	0,190
SB	0,369	0,363	0,362
SBC	0,290	0,273	0,264
SBCM-01	0,288	0,265	0,246
SBCM-02	0,236	0,223	0,199
SBCM-03	0,216	0,198	0,162
SBCM-04	0,206	0,171	0,159

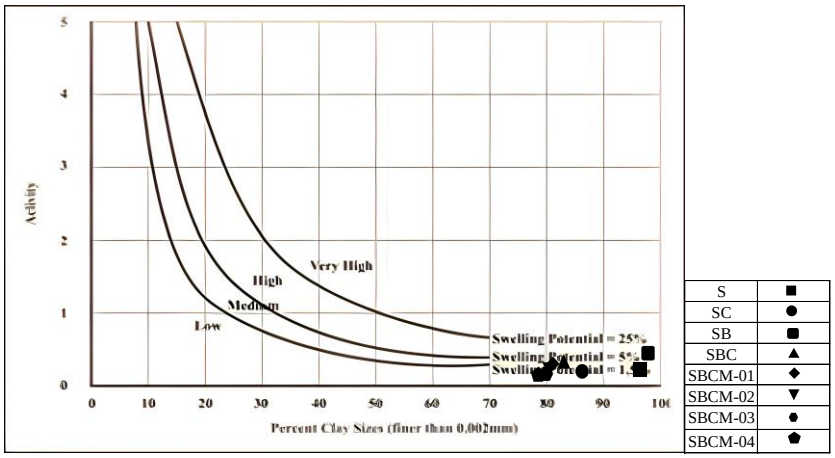

Figure 4. Graph of Activity Analysis Results with Variations in Matos Content and Non Curing [8]

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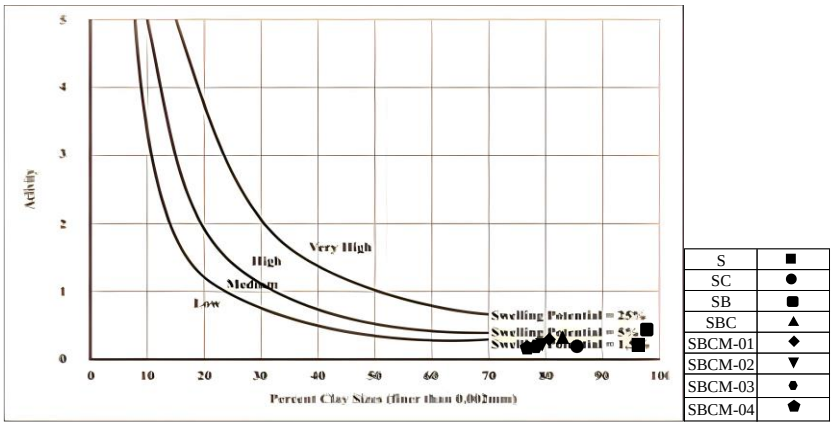

Figure 5. Graph of Activity Analysis Results with Variations in Matos Content and Curing 7 Days [8]

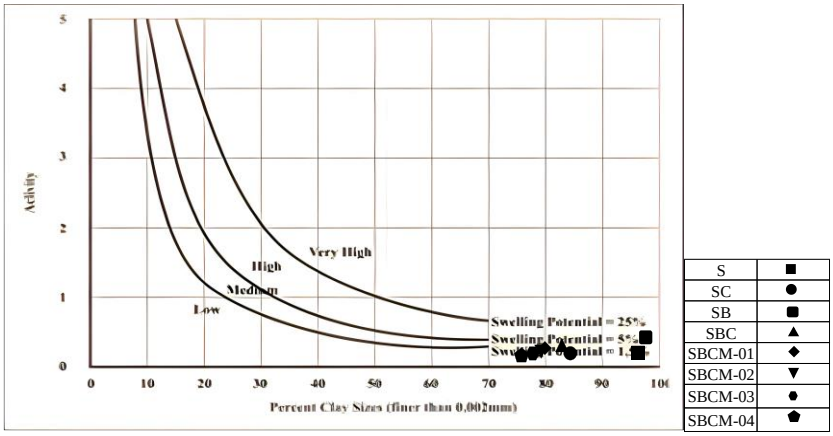

Figure 6. Graph of Activity Analysis Results with Variations in Matos Content and Curing 14 Days [8]

Based on Table 8, the soil mixed with 40% bentonite has the highest activity, while the soil mixed with 40% bentonite, 5% PCC, and 8% matos soil stabilizer with a curing time of 14 days has the lowest activity. Therefore, it can be concluded that the activity decreases with the addition of matos soil stabilizer in the mixture and with longer curing time, thereby reducing the soil's potential for swelling.

3.6. Swelling Test (CBR Soaked)

Tabel 9. Swelling Test Results

Code	Swelling (%)		
	0	7	14
S	2,653	2,574	2,606
SC	2,598	1,905	1,588
SB	5,533	5,452	5,363
SBC	4,590	3,247	3,197
SBCM-01	4,412	2,688	2,329
SBCM-02	4,273	2,341	2,021
SBCM-03	4,175	1,892	1,495
SBCM-04	4,127	1,496	1,423

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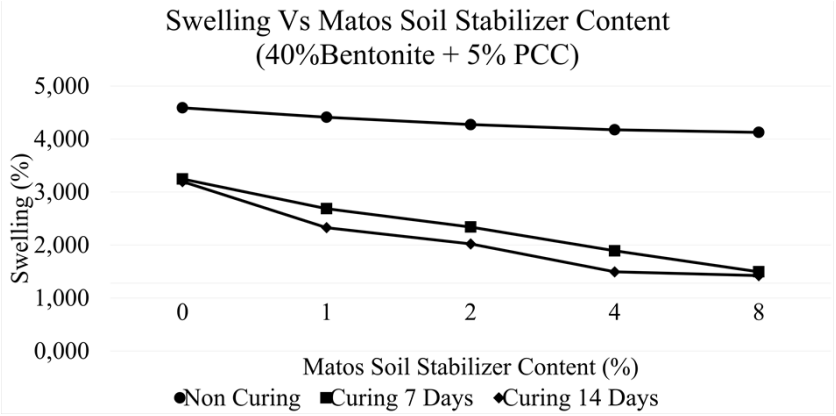

Figure 7. Graph of Swelling Results with Variations in Matos Content and Curing Time

Based on Table 9 and Figure 5, the soil mixed with 40% bentonite has the highest swelling, while the soil mixed with 40% bentonite, 5% PCC, and 8% matos soil stabilizer with a curing time of 14 days has the lowest swelling. Therefore, it can be concluded that the swelling decreases with the addition of matos soil stabilizer in the mixture and with longer curing time.

3.7. Swelling Pressure Test

Tabel 10. Swelling Pressure Test Results

Code	Swelling Pressure (Kg/Cm²)		
	0	7	14
S	2,427	2,335	2,257
SC	2,230	2,125	2,020
SB	4,133	4,054	4,028
SBC	3,674	3,411	2,952
SBCM-01	3,083	2,913	2,729
SBCM-02	2,781	2,650	2,440
SBCM-03	2,729	2,125	1,981
SBCM-04	2,427	1,601	1,469

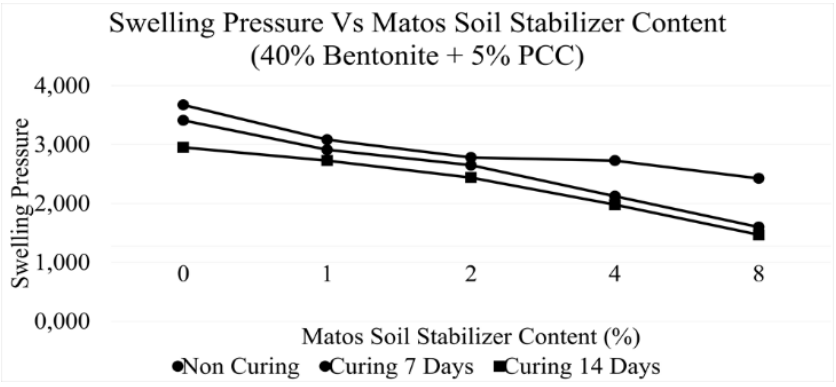

Figure 8. Graph of Swelling Pressure Results with Variations in Matos Content and Curing Time

Based on Table 10 and Figure 6 soil with 40% bentonite mixture has the highest swelling pressure and soil with 40% bentonite mixture, 5% PCC and 8% matos soil stabilizer with 14 days curing period has the lowest swelling pressure. So it can be known that the swellong will decrease by adding a mixture of matos soil stabilizer and the longer the curing time.

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3.8. Free Swelling Index

Tabel 11. Free Swelling Index Result

Code	Free Swelling Index (%)		
	0	7	14
S	26,667	26,667	25,000
SC	25,000	21,429	20,000
SB	45,455	45,455	41,667
SBC	33,333	30,769	28,571
SBCM-01	30,769	28,571	27,273
SBCM-02	28,571	25,000	23,077
SBCM-03	27,273	23,077	18,182
SBCM-04	21,429	18,182	16,667

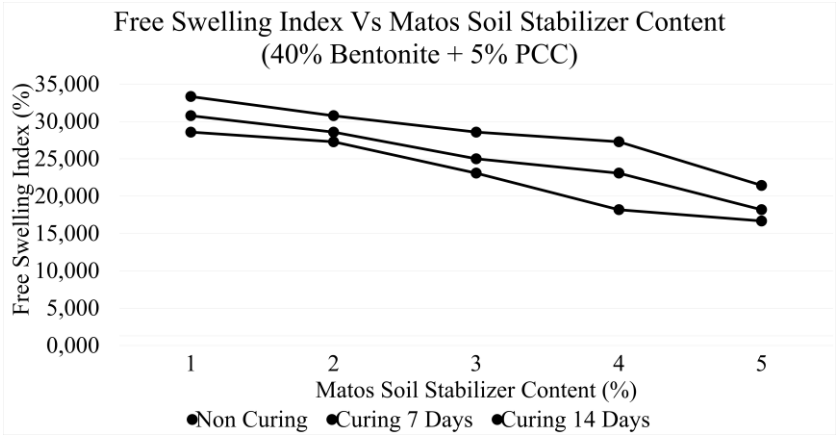

Figure 9. Graph of Free Swelling Index Results with Variations in Matos Content and Curing Time

Based on Table 11 and Figure 7, it can be observed that the soil mixed with 40% bentonite exhibits the highest free swelling index, while the soil mixed with 40% bentonite, 5% PCC, and 8% matos soil stabilizer with a curing time of 14 days demonstrates the lowest free swelling index. Therefore, it can be inferred that the addition of matos soil stabilizer and longer curing time contribute to a decrease in the free swelling index.

5. Conclusions

Based on the research conducted in the laboratory and the analysis and discussion of the soil samples mixed with cement and matos, along with different curing times for each sample, it can be concluded that these mixtures can affect the characteristics of soil swelling. The results of the testing revealed that the soil mixed with 40% bentonite exhibited a plasticity index of 36.437%, swelling of 5.553%, swelling pressure of 4.133 kg/cm2, and a free swelling index of 45.455%. On the other hand, the mixture with the smallest swelling characteristics was observed in the sample containing 8% matos soil stabilizer with a curing time of 14 days, which resulted in a plasticity index of 12.227%, swelling of 1.423%, swelling pressure of 1.469 kg/cm2, and a free swelling index of 16.667%.

No optimum content of matos soil stabilizer was identified in the testing since a higher content of matos soil stabilizer improved the characteristics of soil shrinkage and swelling. Therefore, it can be concluded that increasing the content of matos soil stabilizer and prolonging the curing time further decrease the characteristics of soil shrinkage and swelling. However, based on the obtained results, these mixtures still do not meet the requirements for road foundation layers.

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