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Evaluation of Swelling-Shrinkage in Lime Stabilized Soil Due to the Addition of Matos Stabilizer

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Abstract: Bad soil properties such as high plasticity index values, high potential for swelling and shrinkage, and low shear strength are the problems encountered. To find out the swelling and shrinkage value of the soil, 2 stages of testing were carried out, namely testing the physical and mechanical properties of the soil and stabilizing it with additives in the form of 4% lime and 2%, 4% and 8% Matos soil stabilizer. The results of research on Capkala soil with a specific gravity value of 2.568, a liquid limit value of 51.444%, a plastic limit value of 29.507%, and an IP value of 21.937%. Then, based on sieving analysis, it shows that according to the AASHTO classification, Capkala soil is included in A-7-6, namely clay soil, while according to the USCS classification, it is included in the MH group, namely inorganic silt or fine sand, and according to the USDA classification, it includes silty clay. From the results of the disturbed soil swelling pressure test of 2.427 Kg/cm2 and included in the swelling potential low, while the 40% bentonite mixture obtained a swelling pressure result of 4.133 Kg/cm2 which was included in the swelling potential high. Meanwhile, the effect of adding Matos soil stabilizer to disturbed soil modified with 40% bentonite and Matos in the swelling pressure test resulted in the soil being included in the swelling potential medium. From the results of the disturbed soil FSI a value of 26.667% was obtained which has a moderate degree of development category. The effect of adding 40% bentonite to disturbed soil resulted in an increase of 45.455% in the category of high degree of development. Meanwhile, the effect of adding Matos soil stabilizer to disturbed soil modified with 40% bentonite in the free swelling index test included in the category of moderate degree of development.

Keywords: Clay, Lime, Matos, Stabilization, Swelling

1. Introduction

Soil is a place for various types of construction or structures, whether it is building structures, bends, or roads, which often becomes a problem if the soil itself has the bad properties of high plasticity, high shrinkage g, low shear strength. Land has a very large influence on all types of buildings that are on it, therefore land is a component that needs to be considered in construction planning.

Lime has been known as a good soil stabilizing agent, especially for stabilizing clay soils which have high swelling and shrinkage properties. The presence of Ca2 in lime can provide greater bonding between particles which counteracts theswelling properties of the soil (Mochtar 1994).

Matos is a fine powder of inorganic additive mineral composition which physically and chemically strengthens and stabilizes the soil. Matos helps supply more alternative ions and forms

aluminum siliceous acid compounds which then form a 3-dimensional honeycomb structure between soil particles and form micron cavities that can absorb water (porosity), so that the formation of sulfuric acid which causes cracks does not occur.

From the description above, this study aims to determine the effect of using lime and matos soil stabilizer additives. The use of these materials to increase the carrying capacity of the soil. In this study, the increase in soil carrying capacity was viewed from the swelling value of the soil.

2. Materials and Methods

Soil location and research materials to be carried out are as follows:

1. Soil Sample
   soil sampling from Capkala which is located in Bengkayang Regency, West Kalimantan.
2. Lime CaCO3
3. Matos Soil Stabilizer.
   The Matos Soil Stabilizer used came from PT. Joglo Matos Nusantara.
4. Water
   The water used for this research is fresh water, free from sediment and free from solution.

This study tested several soil samples taken from the location of the land to be studied. Additives used for chemical stabilization are lime and matos soil stabilization, with curing time of 0, 7 and 14 day. The tests carried out were testing the mechanical and physical properties of the soil with different mixture variations.

Table 1. Variety of soil, lime and matos mixtures

Kode	Tanah (%)	Bentonite (%)	Kapur (%)	Matos (%)
SBL	56	40	4	0
SBLM-01	55	40	4	1
SBLM-02	54	40	4	2
SBLM-03	52	40	4	4
SBLM-04	48	40	4	8

3. Results

3.1. The Results on the Index properties of Soil

Table 2. Results of testing disturbed soil physical properties

Properties	Value
Spesific Gravity Atterberg Limit,	2,568
LL, (%)	51,444
PL, (%)	29,507
IP, (%)	21,937
Soil Classification,	
AASHTO	A-7-6
USCS	MH
USDA	Silty Clay

Hydrometer Analysis,	
Sand, %	2
Silt, %	56
Clay, %	42
Swelling Test,	
Swelling Pressure, kg/cm^3	2,427
Free Swelling Index, %	26,667
CBR (soaked), %	2,653

3.2. Soil Density Test Results

Tabel 3. Soil density test results.

Sample Kode	OMC (%)	MDD (gr/cm^3)
SBL	23,20	1,368
SBLM-01	23,45	1,415
SBLM-02	23,50	1,400
SBLM-03	223,65	1,396
SBLM-04	23,90	1,391

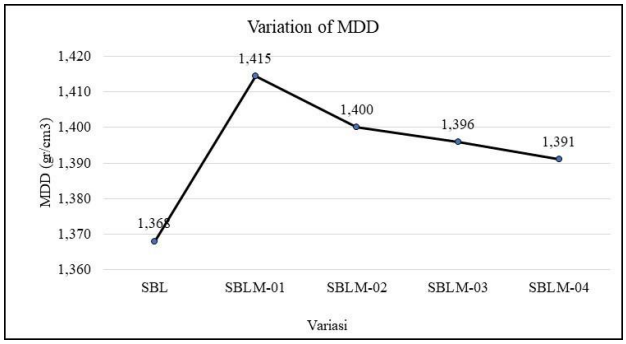

Figure 1. OMC values with 4% Lime and different percentages of Matos

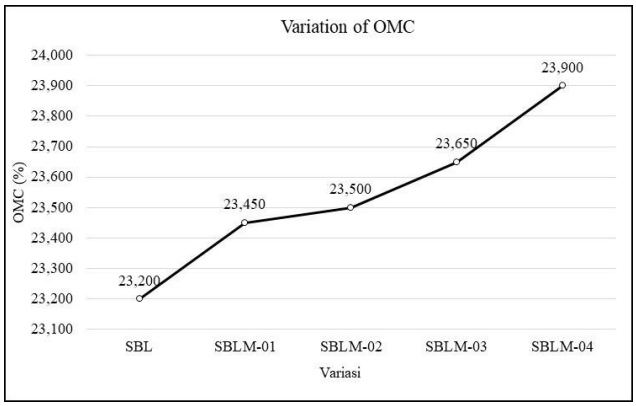

Figure 2. MDD values with 4% Lime and different percentages of Matos

It can be seen that the optimum moisture content (OMC) increased and the maximum dry unit weight (MDD) decreased when matos soil stabilizer was added with the lowest optimum moisture content and the highest maximum dry volume at SBLM-01 content.

3.3. Soil Density Test Results

Table 4. CBR test results

Sample Code	CBR (%)		
	0	7	14
SBL	2,821	2,467	2,257
SBLM-01	2.650	2,388	2,545
SBLM-02	3,031	2,663	2,742
SBLM-03	3,319	2,991	3,044
SBLM-04	3,529	3,228	3,267

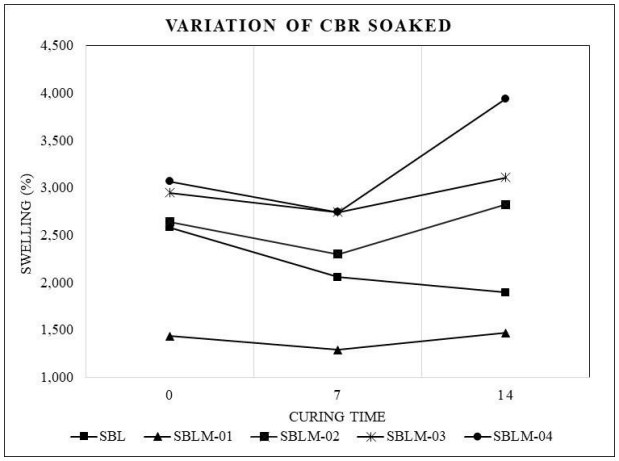

Figure 3 CBR values soaked with 4% Lime, different percentages of Matos, and different curing times

Based on the graph above, it was found that the lowest expansion value in the SBLM-01 mixture with a curing period of 7 days could reduce development to 1.292%, which based on the table includes a low degree of expansion.

Sample Code	IP (%)		
	0	7	14

SBL	26,932	25,944	21,276
SBLM-01	11,816	9,892	10,888
SBLM-02	15,332	15,159	16,536
SBLM-03	16,690	16,567	18,319
SBLM-04	18,992	18,197	19,198

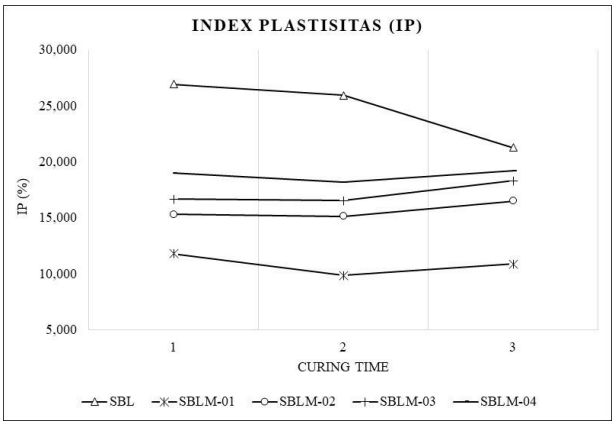

Figure 4. Plasticity Index Value with Lime 4%, different Matos percentages, and different curing times

Based on the graph, the lowest plasticity index value is obtained in a mixture of SBLM-01 with a curing period of 7 days can reduce the swelling pressure value.

Sample Code	Aktivitas		
	0	7	14
SBL	0,367	0,396	0,357
SBLM-01	0,166	0,147	0,152
SBLM-02	0,209	0,210	0,224
SBLM-03	0,226	0,228	0,248
SBLM-04	0,247	0,226	0,250

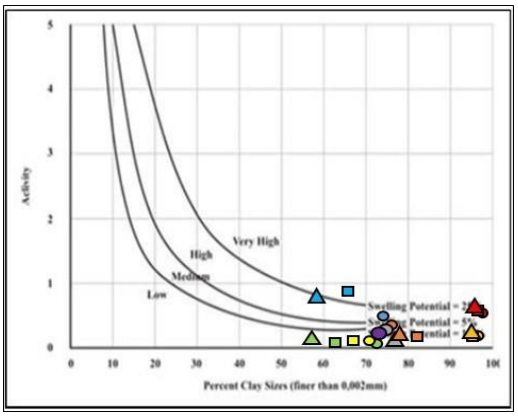

Figure 5. Effect of Lime and Matos Soil Stabilizer on Bentonite Soil on Soil Activity

It can also be concluded that the more the composition of matos soil stabilizer is used, the activity value of the soil will also increase. The more the activity value of a soil increases, the more the swelling potential of the soil increases.

3.5 USDA Method Soil Classification

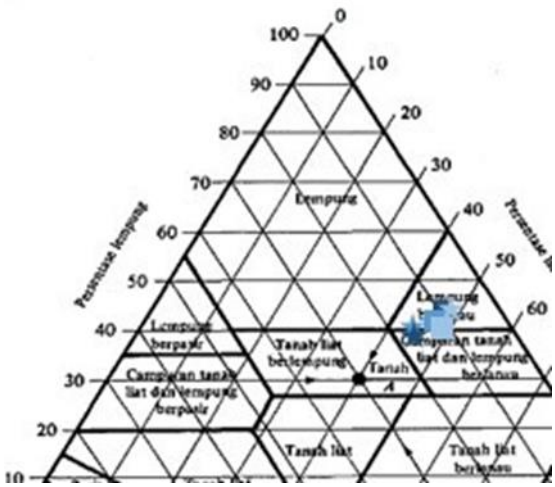

Figure 6. Triangular graph of the USDA soil classification method

The results of the USDA classification show that Capkala soil is classified as silty loam, whereas in lime stabilized soils, the soil is classified as sandy clay and silty clay. For soils with a mixture of matos it is classified as silty clay.

3.6. USCS Method Soil Classification

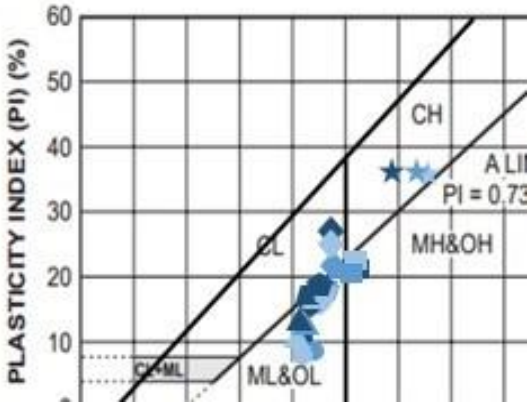

Figure 7. Graph of USCS soil classification method

Based on USCS, Capkala soil is classified as fine-grained soil because more than 50% of the soil passes the no.200 filter. The soil is classified as MH which is an inorganic loamy soil with a little loamy fine sand with little plasticity. While the soil that was given lime with a content of 4% changed the classification to OL, namely clay silt. And the matos variation also changes the MH classification to OL.

3.7 AAHSTO Method Soil Classification

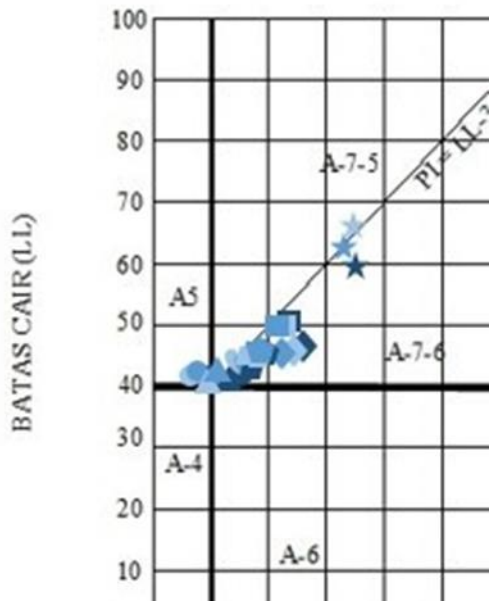

Figure 8. Graph of AAHSTO soil classification method

Based on the results of the AASHTO classification, the disturbed soil mixture and 40% bentonite are classified as classification A-7-6 which is clay soil. On disturbed soils which were given 4% lime and cured for 7 and 14 days the soil mixture only changed to A-7-5 because the lime changed the PL of the soil above 30%. Likewise, the Matos variation mix can only change to A-7-5.

3.8 Swelling Pressure Test Results

Table 7. Results of the swelling pressure test

Sample Code	Swelling Pressure (kg/cm²)		
	0	7	14
SBL	2,821	2,467	2,257
SBLM-01	2.650	2,388	2,545
SBLM-02	3,031	2,663	2,742
SBLM-03	3,319	2,991	3,044
SBLM-04	3,529	3,228	3,267

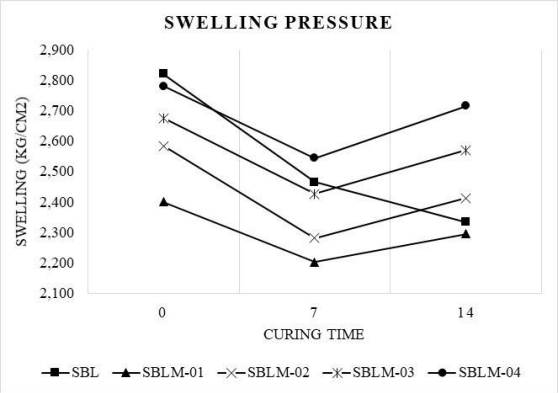

Figure 9. Graph of the Effect of Lime and Matos Soil Stabilizer Levels on Swelling Pressure

Based on the graph, the lowest swelling pressure value was obtained on the SBLM-01 mixture with a curing period of 7 days which can reduce the swelling pressure value which includes a low degree of expansiveness.

3.9 Free Swelling Index Test Results

Table 8. Free swelling index test results

Sample Code	FSI (%)		
	0	7	14
SBL	33,333	25,000	23,077
SBLM-01	18,182	16,667	25,000
SBLM-02	27,273	25,000	33,333
SBLM-03	30,769	28,571	35,714
SBLM-04	33,333	30,769	35,714

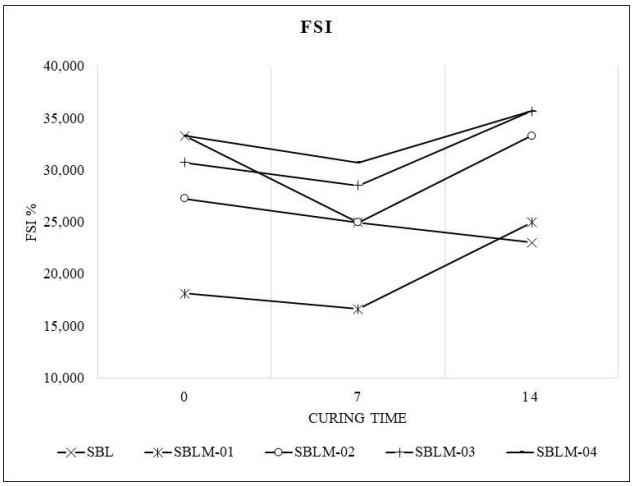

Figure 10. Graph of the Effect of Lime and Matos Soil Stabilizer Levels on the Free Swelling Index

Based on the lowest free swelling index value, the SBLM-01 mixture with a curing period of 7 days can reduce the free swelling index value which includes a low degree of expansiveness.

4. Conclusions

In the compaction test, the matos soil stabilizer has an effect, where the more levels of matos soil stabilizer used, the lower the density and thehigher the optimum soil water content. From the results of testing the plasticity index ofDisturbed soil of 21.937%, where with the plasticity index value of the Disturbed soil has moderate development potential. Testing the plasticity index with a soil mixture modified with 40% bentonite increased the value of the soil plasticity index to 36.437%. The plasticity index value is included in the medium development potential. The effect of adding matos soil stabilizer contentcan reduce the plasticity index of the soil mixture modified with 40% bentonite from high swelling potential down to low swelling potential with a plasticity index value of 9.892%. This value was obtained from a mixtureof 1% matos and ripening for 7 days. From the results of the disturbed soil California Bearing Ratio test, it was found that thedevelopment was 2.653%, which is included in the moderate degree of expansion category. The results of swelling with a modified soil mixture with 40% bentonite has a swelling value of 5.533%, which includes a high degree of expansiveness. From the results of the California Bearing Ratio test, the effect of adding matos soil stabilizer levels can reduce the swelling of the modified soil mixture with 40% bentonite from a highdegree of expansion to a low degree of expansion with a swelling value of 1.423%. This value was obtained in a modified soil mixture with 40% bentonite and 1% matos and a curing time of 7 days. From the results of the Disturbed Swelling Pressure test, a value of 2.034 kg/cm2 was obtained, which includes a low development potential. The results of swelling pressure increased when the soil mixture was modified with 40% bentonite with a value of 4.133 kg/cm2, which includes a high swellingpotential. The effect of adding matos soil stabilizer contentcan reduce the swelling pressure of the soil mixture modified with 40% bentonite from high swelling potential to low swelling potential with a swelling pressure value of 0.420 kg/cm2. This value was obtained in a modified soil mixture with 40% bentonite and 1% matos and a curing time of 7 days. From the results

of the Free Swelling Index of Disturbed soil, a value of 20% is obtained, with this value the Disturbed soil is classified as a low degree of expansiveness. The results of the free swelling index increase when the soil mixture modified with 40% bentonite has a value of 45.455%, which includes a high degree of expansiveness. The effect of adding matos soil stabilizer content can reduce the free swelling index of the soil mixture modified with 40% bentonite from ahigh degree of expansiveness to a low degree of expansiveness with a free swelling index valueof 16.667%. This value was obtained in a modified soil mixture with 40% bentonite and 1% matos and a curing time of 7 days.

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