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Utilization of Spent Bleaching Earth Waste in Soil-Lime Stabilization for Road Body Foundation Layers Based on Index Properties

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Abstract
Spent Bleaching Earth (SBE) is a mixed material between bleaching earth and organic compounds derived from bleached crude oil. In addition, spent bleaching earth still contains a component of phosphoric acid. This phosphoric acid comes from the degumming process which is brought to the bleaching process by oil. According to Government Regulation Number 22/21 concerning Implementation of Environmental Management and Protection, this spent bleaching earth is classified as non-B3 waste depth. Chemical stabilization is by mixing chemicals into the soil material which causes a chemical reaction to occur between the mixing material and the soil which will produce new materials that have better quality. From the results of the physical properties experiment, it was found that the mixture with the optimum value for soil-lime stabilization was 10% SBE.

Keywords: Soil Stabilization, Spent Bleaching Earth, Index Properties, Lime

1. Introduction

With the population that continues to increase, this requires rapid infrastructure development as well. Among them is the highway infrastructure. Planning of highway structures will be better if supported by a good soil carrying capacity situation as well. In highway pavement structures, soil with poor quality will cause the carrying capacity of the pavement layer to be reduced. This needs to be improved by stabilization.

Soil stabilization is a method to improve soil properties by adding or changing the structure of the soil layer in order to increase the carrying capacity of the soil. Soil stabilization methods include mechanical, chemical, hydrolycal, and geosynthetic. In this study, chemical stabilization was carried out by utilizing spentnbleaching earth (SBE) waste as a soil-lime stabilization material for the lower foundation layer of the road in terms of the physical properties of the soil. The lime used is lime ($CaCO3$). The soil used in this study is land originating from the area of Peniraman Village, Mempawah Regency.

2. Material and method

2.1 Research Location

CaCO3 lime is lime from the combustion of limestone at a temperature of ± 90 ° C, with a composition mostly in the form of calcium carbonate (CaCO3). It is a compound that is

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slightly soluble in water, so it dissolves into the natural water system which then hardens. Calcium carbonate is found in limestone and limestone. Spent Bleaching Earth is the waste left over from the manufacture of vegetable oil production taken at PT. Energi Unggul Persada – KPN Corp Sungai Kunyit, Mempawah Regency, West Kalimantan. The soil used for stabilization is land originating from Peniraman Village, Mempawah Regency.

2.2 Theoretic Structure

Soil stabilization is a method to improve soil properties by adding or changing the structure of the soil layer in order to increase the carrying capacity of the soil. Index properties tests carried out are water content (ASTM D2216-80), unit weight (ASTM D2973-83), specific gravity (ASTM D854-83), Atterberg limit (ASTM-4318), Hydrometer analysis (ASTM-7928), Sieve analysis (ASTM D422-72), Permeability. The test results are then modified in according to the General Specifications for 2018 road and bridge works (Revision 2).

2.3 Data

In this study, testing was carried out to test the physical properties of soil using variations of limestone and Spent Bleacing Earth. The mixture variations used are 5% lime and Spent Bleaching Earth mixture variations are 0%, 5%, 10%, 15%, and 20%. Each variation of the mixture is carried out curing for 0 days, 7 days, and 14 days.

Table 1 Mixed variations

No	Kode	Kapur (%)	SBE (%)	Keterangan	*Curing Time* (Hari)
1	S	0	0	Tanah *Undisturb*	0, 7, 14
2	SL	4	0	Tanah *Disturb* + 4% Kapur	
3	SLS 5	4	5	Tanah *Disturb* + 4% Kapur + 5% SBE	
4	SLS 10	4	10	Tanah *Disturb* + 4% Kapur + 10% SBE	
5	SLS 15	4	15	Tanah *Disturb* + 4% Kapur + 15% SBE	
6	SLS 20	4	20	Tanah *Disturb* + 4% Kapur + 20% SBE	

2.4 Analysis Method

The data obtained from the test, then analyzed and classified. Soil classifications are determined based on USDA, USCS, and AASHTO standards. The indeks properties data obtained are then adjusted to the general specifications for road and bridge construction work in 2018 (revision 2).

3. Results and Data Analysis

From the tests of physical properties carried out, results are obtained which are then carried out data analysis according to the sources of literature that have been collected.

3.1 Water Content

Table 2 Water Content Test Result

SAMPLE		CODE	WATER CONTENT (%)
0 DAY CURING	Undisturb Soil	S	24,090
	DS + 4% L	SL	22,222
	DS + 4% L + 5% SBE	SLS 5	21,556
	DS + 4% L + 10% SBE	SLS 10	21,909
	DS + 4% L + 15% SBE	SLS 15	22,292
	DS + 4% L + 20% SBE	SLS 20	23,278
7 DAY CURING	Undisturb Soil	S	24,088
	DS + 4% L	SL	21,622
	DS + 4% L + 5% SBE	SLS 5	20,947
	DS + 4% L + 10% SBE	SLS 10	21,723
	DS + 4% L + 15% SBE	SLS 15	21,752
	DS + 4% L + 20% SBE	SLS 20	22,588
14 DAY CURING	Undisturb Soil	S	24,087
	DS + 4% L	SL	20,821
	DS + 4% L + 5% SBE	SLS 5	20,123
	DS + 4% L + 10% SBE	SLS 10	20,950
	DS + 4% L + 15% SBE	SLS 15	21,300
	DS + 4% L + 20% SBE	SLS 20	22,320

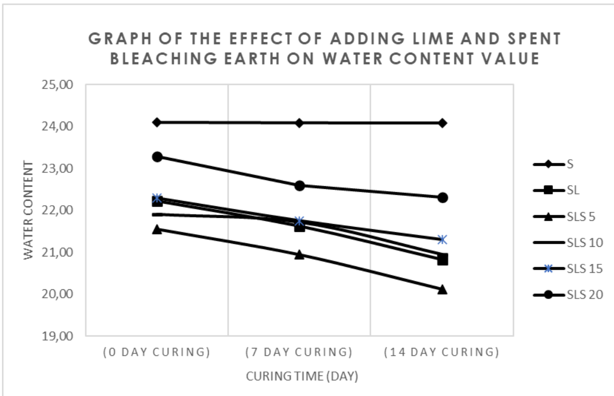

Figure 1 Graph of the Effect of Adding Lime and Spent Bleaching Earth on Water Content Value

Based on the results of the moisture content test, the moisture content value of the curing time decreased, while the moisture content value of the mixture variation decreased optimally in the TA + 4% Lime + 5% SBE variation of 20.123% at 14 days of planting.

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3.2 Volume Weight

Table 3 Volume Weight Test Result

SAMPLE		CODE	VOLUME WEIGHT (g/cm3)
0 DAY CURING	Undisturb Soil	S	1,811
	DS + 4% L	SL	1,792
	DS + 4% L + 5% SBE	SLS 5	1,801
	DS + 4% L + 10% SBE	SLS 10	1,820
	DS + 4% L + 15% SBE	SLS 15	1,811
	DS + 4% L + 20% SBE	SLS 20	1,792
7 DAY CURING	Undisturb Soil	S	1,811
	DS + 4% L	SL	1,783
	DS + 4% L + 5% SBE	SLS 5	1,792
	DS + 4% L + 10% SBE	SLS 10	1,811
	DS + 4% L + 15% SBE	SLS 15	1,801
	DS + 4% L + 20% SBE	SLS 20	1,783
14 DAY CURING	Undisturb Soil	S	1,811
	DS + 4% L	SL	1,773
	DS + 4% L + 5% SBE	SLS 5	1,783
	DS + 4% L + 10% SBE	SLS 10	1,801
	DS + 4% L + 15% SBE	SLS 15	1,792
	DS + 4% L + 20% SBE	SLS 20	1,773

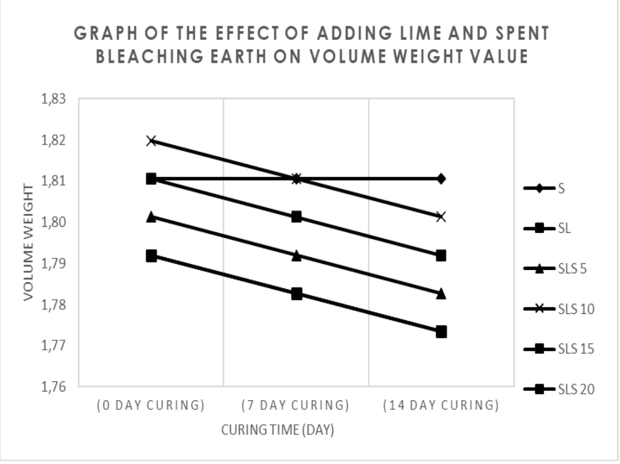

Figure 2 Graph of the Effect of Adding Lime and Spent Bleaching Earth on Volume Weight Value

Based on the results of volume weight testing, the volume weight value of wet soil base on curing time decreased, while the volume weight value of the mixture variation increased optimally in the variation of TA + 4% lime + 10% SBE by 1.820% during the 0-day curing time.

3.3 Specific Gravity

Table 4 Specific Gravity Test Result

SAMPLE		CODE	SPECIFIC GRAVITY
0 DAY CURING	Undisturb Soil	S	2,612
	DS + 4% L	SL	2,665
	DS + 4% L + 5% SBE	SLS 5	2,460
	DS + 4% L + 10% SBE	SLS 10	2,304
	DS + 4% L + 15% SBE	SLS 15	2,243
	DS + 4% L + 20% SBE	SLS 20	2,165
7 DAY CURING	Undisturb Soil	S	2,615
	DS + 4% L	SL	2,670
	DS + 4% L + 5% SBE	SLS 5	2,468
	DS + 4% L + 10% SBE	SLS 10	2,338
	DS + 4% L + 15% SBE	SLS 15	2,254
	DS + 4% L + 20% SBE	SLS 20	2,170
14 DAY CURING	Undisturb Soil	S	2,617
	DS + 4% L	SL	2,678
	DS + 4% L + 5% SBE	SLS 5	2,470
	DS + 4% L + 10% SBE	SLS 10	2,342
	DS + 4% L + 15% SBE	SLS 15	2,269
	DS + 4% L + 20% SBE	SLS 20	2,172

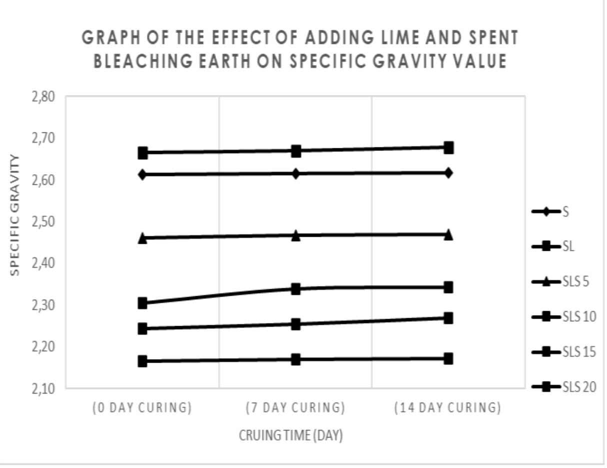

Figure 3 Graph of the Effect of Adding Lime and Spent Bleaching Earth on Spesific Gravity Value

Based on the results of specific gravity testing, the specific gravity value of mixed variations tends to decrease due to organic waste contained in spent bleaching earth waste, while the specific gravity value of curing increases. The highest specific gravity increases in the TA+4% variation of lime was 2.678 at the 14-day curing time.

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3.4 Atterberg Limits

Table 5 Atterberg Limits Test Result

SAMPLE		CODE	LL	PL	SL	IP
			(%)	(%)	(%)	(%)
0 DAY CURING	Undisturb Soil	S	43,290	29,105	34,423	14,252
	DS + 4% L	SL	40,508	29,860	33,120	10,647
	DS + 4% L + 5% SBE	SLS 5	40,118	30,007	32,342	10,111
	DS + 4% L + 10% SBE	SLS 10	39,951	30,122	31,214	9,828
	DS + 4% L + 15% SBE	SLS 15	40,223	29,403	31,432	10,821
	DS + 4% L + 20% SBE	SLS 20	40,632	29,302	33,784	11,330
7 DAY CURING	Undisturb Soil	S	43,288	29,107	34,421	14,250
	DS + 4% L	SL	39,725	30,304	32,866	9,421
	DS + 4% L + 5% SBE	SLS 5	39,355	30,539	31,865	8,816
	DS + 4% L + 10% SBE	SLS 10	39,035	30,804	30,865	8,232
	DS + 4% L + 15% SBE	SLS 15	39,539	29,847	31,146	9,692
	DS + 4% L + 20% SBE	SLS 20	39,969	29,663	33,341	10,306
14 DAY CURING	Undisturb Soil	S	43,285	29,108	34,419	14,249
	DS + 4% L	SL	39,289	30,743	32,475	8,546
	DS + 4% L + 5% SBE	SLS 5	38,824	30,925	31,456	7,899
	DS + 4% L + 10% SBE	SLS 10	38,679	31,244	30,349	7,434
	DS + 4% L + 15% SBE	SLS 15	39,035	30,266	30,786	8,769
	DS + 4% L + 20% SBE	SLS 20	39,510	30,162	32,974	9,348

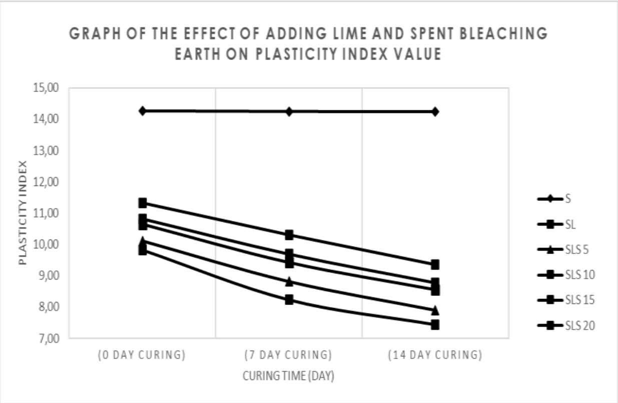

Figure 4 Graph of the Effect of Adding Lime and Spent Bleaching Earth on Plasticity Index Values

The result of the plasticity index value of curing time decreased, while the plasticity index value of the mixture variation decreased the highest in the variation of TA + 4% lime + 10% SBE by 7.434% during the 14-day curing time.

3.5 Permeability

Table 6 Permeability Test Result

SAMPLE		CODE	PERMEABILITY (cm/sec)
0 DAY CURING	Undisturb Soil	S	0,00000251
	DS + 4% L	SL	0,00000245
	DS + 4% L + 5% SBE	SLS 5	0,00000239
	DS + 4% L + 10% SBE	SLS 10	0,00000234
	DS + 4% L + 15% SBE	SLS 15	0,00000247
	DS + 4% L + 20% SBE	SLS 20	0,00000255
7 DAY CURING	Undisturb Soil	S	0,00000245
	DS + 4% L	SL	0,00000241
	DS + 4% L + 5% SBE	SLS 5	0,00000236
	DS + 4% L + 10% SBE	SLS 10	0,00000230
	DS + 4% L + 15% SBE	SLS 15	0,00000243
	DS + 4% L + 20% SBE	SLS 20	0,00000251
14 DAY CURING	Undisturb Soil	S	0,00000241
	DS + 4% L	SL	0,00000237
	DS + 4% L + 5% SBE	SLS 5	0,00000232
	DS + 4% L + 10% SBE	SLS 10	0,00000226
	DS + 4% L + 15% SBE	SLS 15	0,00000239
	DS + 4% L + 20% SBE	SLS 20	0,00000247

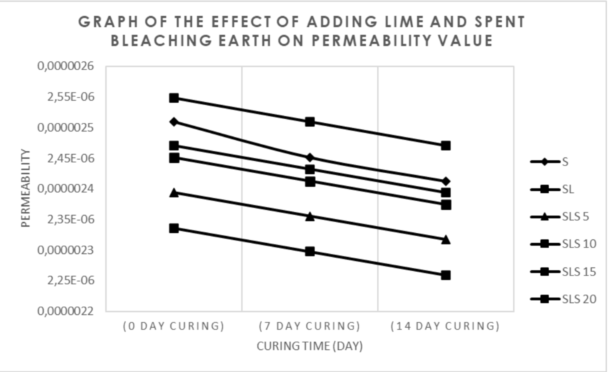

Figure 5 Graph of the Effect of Adding Lime and Spent Bleaching Earth on Permeability Values

Based on the graph above, it can be seen that the value of the permeability coefficient to the curing time in all mixed variances has decreased. The lowest decrease in the liquid limit value is in the variation of "SL" by 3,240 x 10-6 cm/second during the 14-day curing time.

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3.6 Clay Soil Activity

The value of soil activity (A) is used to determine how much the activeness value of a clay soil is tested to determine how much potential for the development of clay soil.

Table 7 Value of Clay Soil Activity

Curing Time	Code	Plasticity index (%)	Passed Filter Number 200 (%)	Activity
0 Day	S	14,252	83,280	0,171
	SL	10,647	43,136	0,247
	SLS 5	10,111	63,142	0,160
	SLS 10	9,828	58,202	0,169
	SLS 15	10,821	70,280	0,154
	SLS 20	11,330	61,728	0,184
7 Day	S	14,250	82,138	0,173
	SL	9,421	43,136	0,218
	SLS 5	8,816	54,020	0,163
	SLS 10	8,232	49,594	0,166
	SLS 15	9,692	62,040	0,156
	SLS 20	10,306	65,668	0,157
14 Day	S	14,249	80,514	0,177
	ST-02	8,546	35,082	0,244
	ST-03	7,899	48,584	0,163
	ST-04	7,434	42,084	0,177
	ST-05	8,769	54,180	0,162
	ST-06	9,348	61,728	0,151

3.7 Classification According to USDA

Table 8 USDA Method Soil Classification Results

Curing	Sample	Classification According to USDA
0 Day	Undisturb Soil	Silt Loam
	DS + 4% L	Sandy Loam
	DS + 4% L + 5% SBE	
	DS + 4% L + 10% SBE	
	DS + 4% L + 15% SBE	
	DS + 4% L + 20% SBE	Loam
7 Day	Undisturb Soil	Silt Loam
	DS + 4% L	Sandy Loam
	DS + 4% L + 5% SBE	
	DS + 4% L + 10% SBE	
	DS + 4% L + 15% SBE	
	DS + 4% L + 20% SBE	
14 Day	Undisturb Soil	Silt Loam
	DS + 4% L	Sandy Loam
	DS + 4% L + 5% SBE	
	DS + 4% L + 10% SBE	
	DS + 4% L + 15% SBE	
	DS + 4% L + 20% SBE	

From the results of classification using the USDA method, it can be concluded that the addition of lime and SBE in different curing periods experienced the highest increase in the type of sandy grain in the variation "SLS 10" and the increase in the type of silt grain highest in the variation "SLS 20".

3.8 Classification According to USCS

Table 9 USCS Method Soil Classification Results

Curing	Sample	Classification According to USCS	Soil Type
0 Day	Undisturb Soil	ML	Inorganic silt, very fine sand, rock powder, fine silted sand
	DS + 4% L		
	DS + 4% L + 5% SBE	OL	Organic silt and organic silt clay with low plasticity
	DS + 4% L + 10% SBE		
	DS + 4% L + 15% SBE		
	DS + 4% L + 20% SBE		
7 Day	Undisturb Soil	ML	Inorganic silt, very fine sand, rock powder, fine silted sand
	DS + 4% L		
	DS + 4% L + 5% SBE	OL	Organic silt and organic silt clay with low plasticity
	DS + 4% L + 10% SBE		
	DS + 4% L + 15% SBE		
	DS + 4% L + 20% SBE		
14 Day	Undisturb Soil	ML	Inorganic silt, very fine sand, rock powder, fine silted sand
	DS + 4% L		
	DS + 4% L + 5% SBE	OL	Organic silt and organic silt clay with low plasticity
	DS + 4% L + 10% SBE		
	DS + 4% L + 15% SBE		
	DS + 4% L + 20% SBE		

Based on the USCS chart, it can be seen that the original soil after mixing with lime and SBE soil classification undergoes changes resulting from a decrease in the liquid boundary and plasticity index. The decrease makes the soil classification point shift towards the lower left. For mixes, SBE variations are categorized OL.

3.9 Classification According to AASHTO

Table 10 AASHTO Method Soil Classification Results

Curing	Sample	Classification According to AASHTO	F	GI
0 Day	Tanah Undisturb	A-7-6	83,280	13,353
	DS + 4% L	A-7-5	43,136	1,830
	DS + 4% L + 5% SBE		63,142	5,699
	DS + 4% L + 10% SBE	A-4	58,202	4,561
	DS + 4% L + 15% SBE	A-7-6	70,280	7,549
	DS + 4% L + 20% SBE		61,728	6,052
7 Day	Tanah Undisturb	A-7-6	82,14	13,056
	DS + 4% L	A-4	43,136	1,453
	DS + 4% L + 5% SBE		54,020	3,281
	DS + 4% L + 10% SBE		49,594	2,237
	DS + 4% L + 15% SBE		62,040	5,201
	DS + 4% L + 20% SBE	A-6	65,668	6,284
14 Day	Tanah Undisturb	A-7-6	80,51	12,634
	DS + 4% L	A-4	35,082	-0,276
	DS + 4% L + 5% SBE		48,584	1,931
	DS + 4% L + 10% SBE		42,084	0,675
	DS + 4% L + 15% SBE		54,180	3,261
	DS + 4% L + 20% SBE		61,728	4,975

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Based on the AASHTO chart, it can be seen that the original soil after mixing with lime and SBE soil classification undergoes changes resulting from a decrease in the liquid boundary and plasticity index. The decrease makes the soil classification point shift towards the lower left.

4. Conclusion

From the results of tests that have been carried out in the laboratory, soil stabilization research with a mixture of lime and SBE with different curing periods can be drawn as follows Based on the results of specific gravity testing, the specific gravity value of mixed variations tends to decrease due to organic waste contained in spent bleaching earth waste, while the specific gravity value of curing increases. The highest specific gravity increases in the TA+4% variation of lime was 2.678 at the 14-day ripening period.

Based on the results of the water content test, the water content value of the curing time decreased, while the water content value of the mixture variation decreased optimally in the TA + 4% Lime + 5% SBE variation of 20.123% at 14 days of curing. Based on the results of volume weight testing, the volume weight value of wet soil against the planting time decreased, while the volume weight value of the mixture variation increased optimally in the variation of TA + 4% lime + 10% SBE by 1.820% during the 0-day curing period. Based on the results of Atterberg limit testing, the results of the plasticity index value on the age of curing and mixed variations have decreased, the lowest decrease in TA + 4% lime + 10% SBE variation during the 14-day curing period of 7.434%. Based on the General Specification of Highways, the lowest plasticity index value obtained can be used into the class B foundation layer.

Based on the results of permeability testing, the permeability value to the age of curing and mixed variation has decreased. The lowest decrease in variation TA + 4% lime + 10% SBE during the 14-day curing period was 2,259 x 10-6 cm/second.

As a result of soil classification according to USDA, soils mixed with lime and SBE with different curing periods have increased in sandy grain types and decreased clay levels. The highest increase in sand grains and decrease in clay content was found in the variation of TA + 4% lime + 10% SBE at the 14-day curing time.

As a result of soil classification according to USCS and AASHTO, soils mixed with lime and SBE with different curing periods change location as the planting period increases. The change in location tends to the lower left, this is due to a decrease in the liquid limit and an increase in the plastic limit. Changes in the liquid limit and plastic limit cause a decrease in the plasticity index as well. The lowest decrease in plasticity index was found in the variation of TA + 4% lime + 10% SBE during the 14-day curing period of 7.434%.

Based on all the physical properties tests carried out, it can be concluded that soil mixed with lime and spent bleaching earth can change the fraction of mixed grains to coarser. With a maximum increase in Spent Bleaching Earth of 10%.

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