

The Effect of Adding Spent Bleaching Earth on Clay Stabilization to CBR Value

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SUBMITTED 8 May 2024 REVISED 2 January 2025 ACCEPTED 25 April 2025

ABSTRACT SBE (Spent Bleaching Earth) from the process of refining palm oil is recently categorized as non-B3 (hazardous and toxic materials) material by the new Government Regulation of the Republic of Indonesia Number 22 Year 2021 (PP 22/2021). Not only SBE is abundant, it also has waterproof properties and good cohesion, potentially applicable as subgrade for road when mixed with clay. This paper look into the utilization of SBE to stabilize clay, which usually has a Californian Bearing Ratio (CBR) of 2%, improving its CBR to the minimum required value for subgrade of 6%. The clay specimen used has a fine content of 93.05%, with liquid limit of 45.51% and plasticity index of 17.56%. Based on the AASHTO classification, the clay is categorized as clayey soil (A-7-6). The maximum dry density (MDD) obtained for the clay specimen (100% clay) from the standard proctor test is 1.424 gr/cm³ at an optimum moisture content (OMC) of 18.77%. For a 75% to 25% mixture of clay specimen and SBE, the MDD reduces to 1.318 gr/cm³ and OMC increases to 21.19%. At 50% to 50% mixture of clay specimen and SBE, the MDD further drops to 1.278 gr/cm³ and OMC also further increases to 24.35%. The obtained Laboratory CBR value for 100% clay, 75%-25% clay-SBE mixture and 50%-50% clay-SBE mixture are 4.81%, 3.45% and 2.70%, respectively. From the test results, it can be concluded that addition of SBE does not improve the CBR value.

KEYWORDS Spent Bleaching Earth; Clay Soil; Stabilization; Soil Compaction; CBR Laboratory

1 INTRODUCTION

High subgrade quality often leads to good road quality. This is because the traffic load on the road surface is transferred to the subgrade layer, hence a stronger subgrade can resist cyclic traffic load better. Apart from material strength, another requirement to maintain the quality of road is to limit water infiltration to the subgrade. This requires materials that have water-resistant properties. In this research, SBE (Spent Bleaching Earth) material, which is a water-resistant material, is mixed with clay with the aim to improve its strength. The strength of the clay-SBE mixture when compacted under optimum moisture content is evaluated using Californian Bearing Ratio (CBR) value. The target is to improve the clay's CBR to the minimum CBR value required for subgrade of 6% (Road Pavement Manual, 2017).

SBE usually comes from waste obtained from refinement of palm oil. SBE used to be categorized as hazardous and toxic materials (B3 in Indonesian term), but since 2021, based on Government Regulation of the Republic of Indonesia (Peraturan Pemerintah Republik Indonesia) No. 22/2021, SBE is no longer categorized as hazardous and toxic materials. Therefore, mixing SBE in soil is considered safe. SBE can come in the form of pozzolan material, making it possible to be used as a soil stabilization material (Sumarno, 2021). Earlier research by Sumarno shows that increasing the percentage of SBE reduces the overall density of the clay soil, the lower the density, the lower its self-weight will be, lowering magnitude of settlement when used as fill.

2 METHODOLOGY

In this study, the clay specimen was sourced from Sungai Alam Village, Bengkalis Regency, Riau Province, Indonesia. Disturbed sample was taken from ground surface to ± 50 cm depth. Most of the soil sample was then dried under the sun for 5 days. Soil clumps are pulverized using a rubber mallet (Figure 1, third picture from the left). A small portion of the sample was dried in the oven (Figure 1, second picture from the left) with temperature $105 \pm 5^\circ\text{C}$ for 24 hours, to enable the sample to reach water content as close to zero as possible. As for the SBE, it was sourced from various palm oil mills around Dumai City, Riau Province, Indonesia. Before sieving The SBE sample was first dried in an oven for 24 hours, only those that passed sieve no. 40 (0.425 mm) was used. This was done to remove lumps of residual palm oil deposits. Since there is no standard for SBE testing procedures, the testing of SBE physical properties was based on standards for clay, considering the characteristics of SBE are similar to clay (fine-grained and cohesive). Atterberg limit tests were conducted on both the clay specimen and SBE specimen.



Figure 1. Preparation of clay samples

For the compaction tests, two combinations of clay and SBE were used, i.e., 75% clay-25% SBE and 50% clay-50% SBE. The control test was given test ID of SO, while the 75%-25% was called SS-1 and 50%-50% was called SS-2. For SS-1 and SS-2, the clay and SBE were mixed based on dry weight, before water was added, the mixture is stirred evenly in a small container. The moisture content used for the standard proctor test for the three sets of tests are listed in table 1. The ASTM standards and Indonesian National Standards used for the testings are tabulated in table 2.

Table 1. Composition of the number of soil samples and the effect of soil with SBE

Sample Code	Composition (%)		Number Samples and Water content		
	Clay	SBE	N Proctor	Moisture Content (%)	N CBR Lab
SO = Soil Original (Control)	100	0	6	10, 15, 17, 20, 23, 25	2
SS (Soil + SBE) - 1	75	25	5	17, 20, 25, 27, 30	2
SS (Soil + SBE) - 2	50	50	5	17, 20, 26, 30, 32	2

Note: N refers to the number of test

Table 2. List of standards used for testing

No	Test Type	Testing Method
1	Sieve analysis test	ASTM D 1140-00
2	Atterberg limit test	ASTM D-4318-00
3	Standard Proctor Test	ASTM D-698-00A – Method B
4	CBR Laboratory Testing	ASTM D 1183-16/ SNI 03-1744-2012

3 RESULT AND DISCUSSION

3.1 Atterberg limits and soil classification

The grain size distribution of clay specimen is shown in Figure 2. The fine content of clay specimen, and Atterberg limits obtained for the clay and SBE specimens are shown in table 3. Based on the results, the clay specimen falls under the AASHTO category of A-7-6.

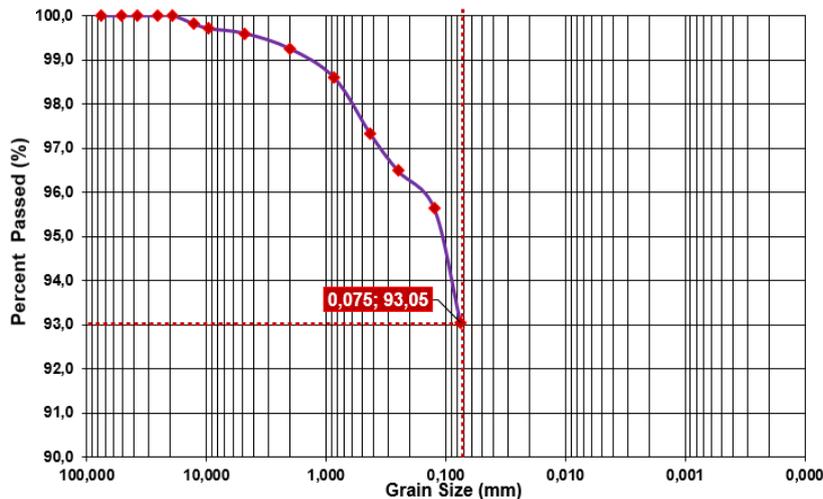


Figure 2. Grain size distribution of clay specimen

Table 3. Test results of sieve analysis and Atterberg limits of clay and SBE specimens

No	Test Type	Test result	AASHTO Terms	Soil Type
1	Sieve analysis test (clay)	93.05% fines	> 35% pass #200	A-7-6
2	Atterberg limit test (clay)	LL = 45.51%, PI = 17.56%	LL = > 40%, PI = > 10%	
3	Atterberg limit test (SBE)	LL = 62.08%, PI = 8.44%	-	-

The plastic limit for SBE was 53.64%, meaning a lot of water was required to make SBE become plastic. At low water content, there was not enough water to bind the SBE grains together. At low water content, only lumps (pozzolan) that were slightly wet but not sticky were formed.

3.2 Standard Proctor test results

The proctor test results for clay specimen, as well as two combination of clay-SBE specimens are tabulated in Table 4, 5 and 6. The results are also plotted in three separate graphs, Figure 3, 4 and 5. From the results, the optimum water content of 100% clay, 75% clay-25% SBE and 50% clay-50% SBE are 18.77%, 21.19% and 24.35% respectively. As for the maximum dry density, they are 1.424, 1.318 and 1.278 gr/cm^3 for 100% clay, 75% clay-25% SBE and 50% clay-50% SBE, respectively. From the results, it can be seen that addition of SBE to the clay increases the water required to obtain the maximum dry density. On the other hand, addition of SBE reduces the clay's maximum dry density. The results agree with Sumarno's (2021) earlier research.

The summary of the optimum water content and maximum dry density ($\gamma_{d \max}$) for all three test ID are tabulated in table 7, while the combined compaction curves from the three set of tests are presented in Figure 6. The trend of optimum water content and maximum dry density with addition of SBE is also plotted in the figure.

Table 4. Proctor test results for pure clay specimen (SO)

γ_b (g/cm ³)	w (%)	γ_d (g/cm ³)
1.334	12.98	1.181
1.424	16.15	1.226
1.691	18.77	1.424
1.641	22.34	1.341
1.621	24.94	1.297
1.616	29.08	1.252

Table 5. Proctor test results of 75% clay-25% SBE specimen (SS-1)

γ_b (gr/cm ³)	w (%)	γ_d (gr/cm ³)
1.515	16.64	1.299
1.597	21.19	1.318
1.601	25.49	1.276
1.570	29.38	1.214
1.538	32.83	1.158

Table 6. Proctor test results of 50% clay-50% SBE specimen (SS-2)

γ_b (gr/cm ³)	w (%)	γ_d (gr/cm ³)
1.453	17.78	1.234
1.492	20.28	1.241
1.590	24.35	1.278
1.557	27.22	1.224
1.572	31.79	1.193

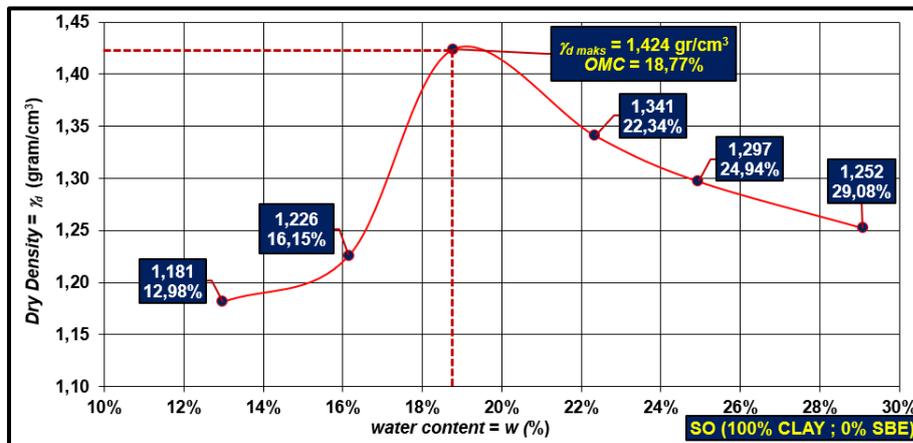


Figure 3. Compaction curve of clay specimen (SO)

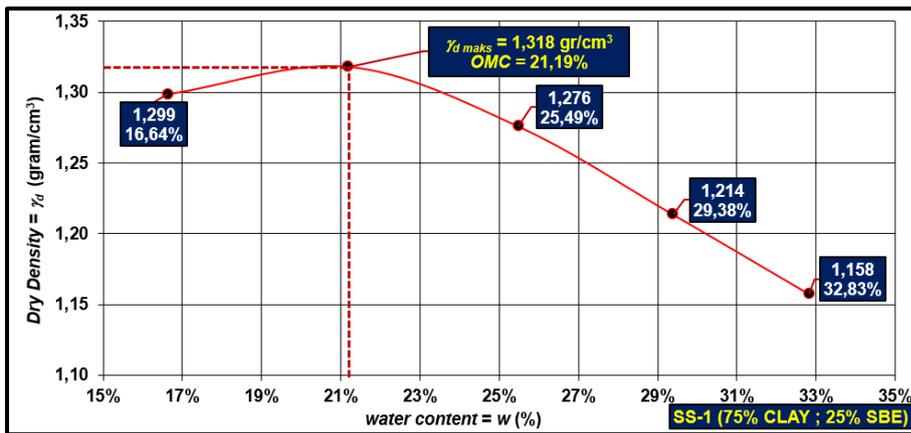


Figure 4. Compaction curve of 75% clay-25% SBE specimen (SS-1)

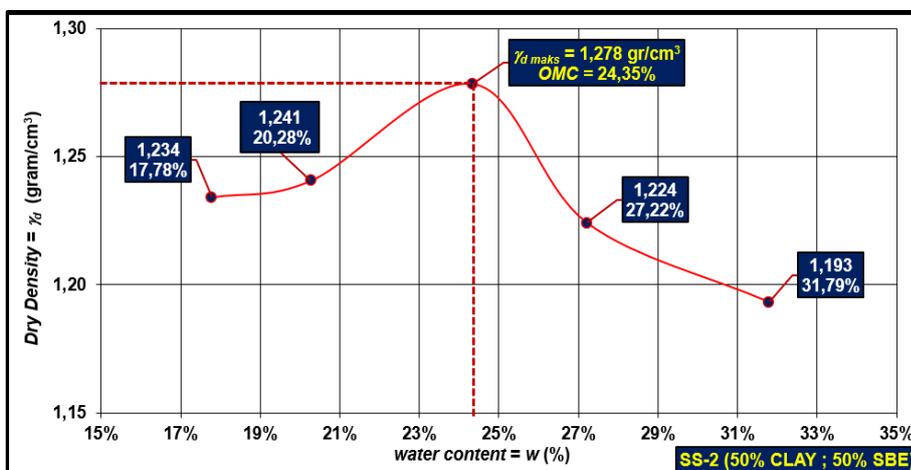


Figure 5. Compaction curve of 50% clay-50% SBE specimen (SS-2)

Table 7. Proctor test results for SO, SS-1 and SS-2

Test ID	γ _b (gr/cm ³)	OMC (%)	γ _{d maks} (gr/cm ³)
SO	1.691	18.77	1.424
SS-1	1.597	21.19	1.318
SS-2	1.590	24.35	1.278

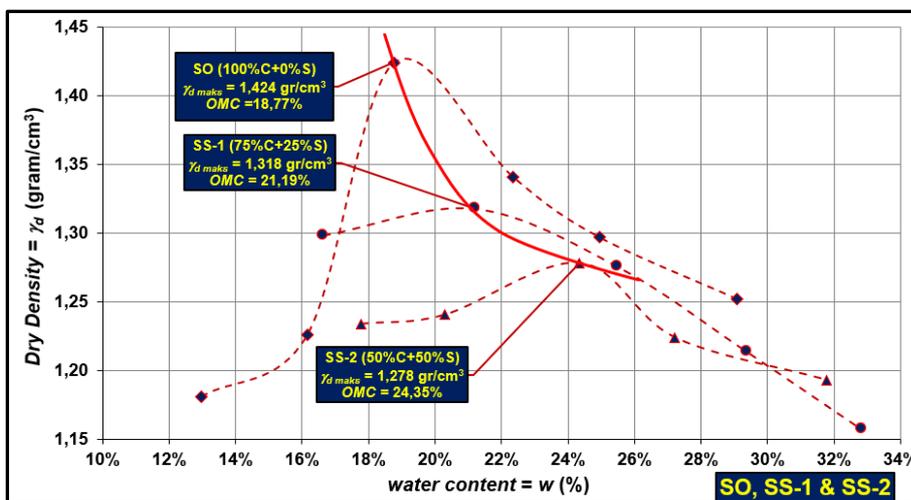


Figure 6. Compaction curves for SO, SS-1 and SS-2

3.3 Determination of CBR Laboratory Value Results

For each combination (SO, SS-1 and SS-2), two samples at optimum water content compacted to their respective maximum dry density are prepared for the CBR tests. Table 8 shows the standards load for CBR (Soedarmo and Purnomo, 1997). The penetration load at 2.54 mm and 5.08 mm obtained from the samples are expressed in terms of percentage with regards to the standard load. Based on the provisions of ASTM D-1883-73 if the CBR Laboratory value with penetration of 5.08 mm is greater than the penetration of 2.54 mm, then the penetration of 5.08 mm is taken as the design CBR value.

Table 8. Standard load values used in CBR test (Soedarmo and Purnomo, 1997)

Penetration (mm)	Total standard load (kg)
2.54	1370
5.08	2055
7.50	2630
10.00	3180
12.50	3600

Figure 7, 8 and 9 show the penetration results (average of two samples) for 100% clay (SO), 75% clay-25% SBE (SS-1) and 50% clay-50% SBE (SS-2), respectively. The penetration load for SO, SS-1 and SS-2 at 2.54 mm are 0.62 kN, 0.42 kN and 0.30 kN, respectively. As for penetration load at 5.08 mm, the obtained loads are 0.96 kN, 0.69 kN and 0.54 kN, respectively. These give CBR values of 4.81%, 3.45% and 2.70% for SO, SS-1 and SS-2, respectively. The results are summarized in Table 9 and Figure 10. It can be seen that addition of SBE not only reduces the maximum dry density, but also reduces the penetration load, i.e., the mixture of clay-SBE gets softer as more SBE is added. Unfortunately this results mean that addition of SBE cannot stabilize the clay to obtain CBR of 6% as required by the Road Pavement Manual (2017) for subgrade.

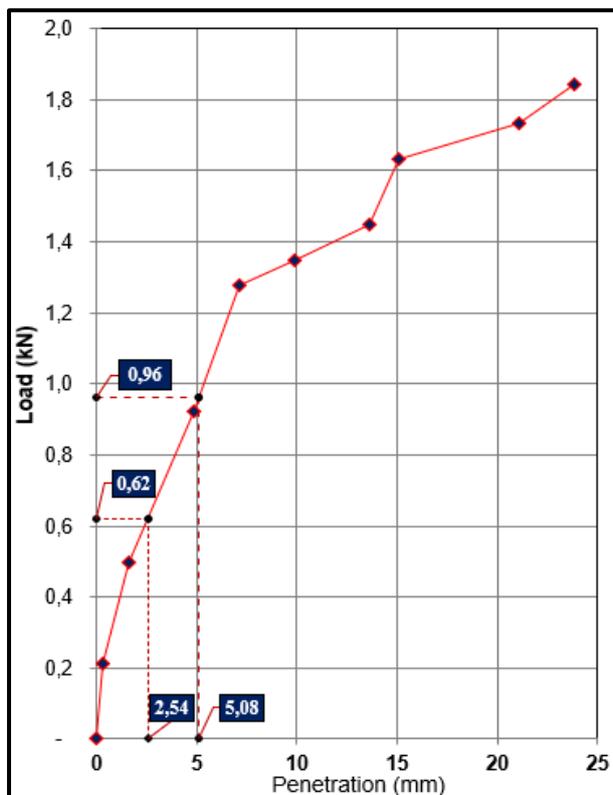


Figure 7. Penetration test (P_i) value of CBR Laboratory compression test on SO samples.

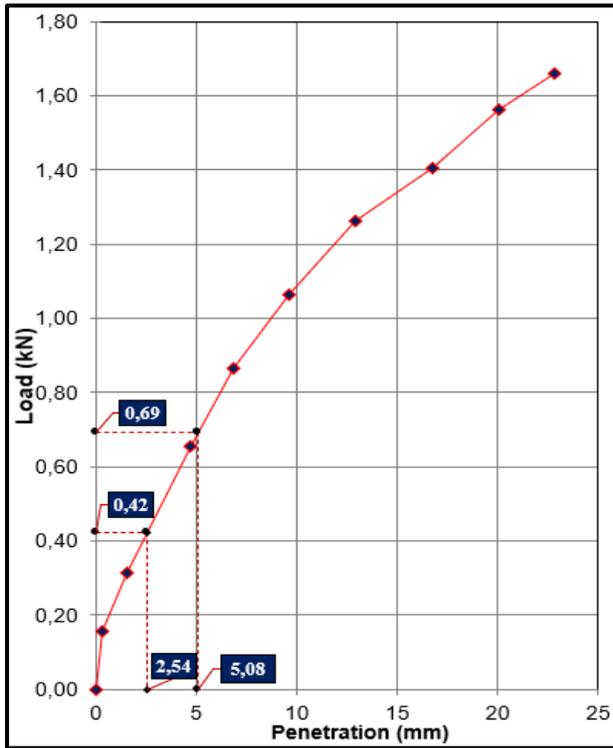


Figure 8. Penetration test (P_1) value of CBR Laboratory compression test on SS-1 samples.

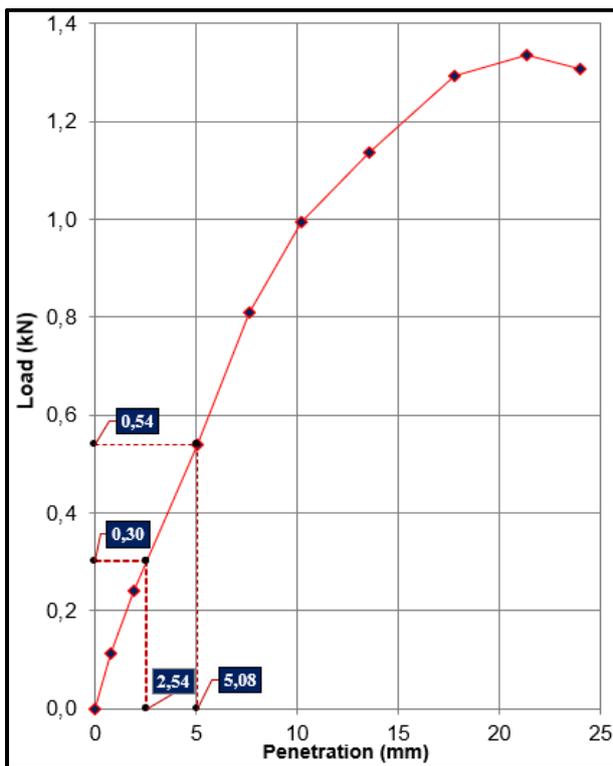


Figure 9. Penetration test (P_1) value of CBR Laboratory compression test on SS-2 samples.

Table 9. Penetration load at 2.54 mm and 5.08 mm for all test samples

Test ID	Penetration load at 2.54 mm (kN)	CBR	Penetration load at 5.08 mm (kN)	CBR	CBR used
SO	0.62	4.58%	0.96	4.81%	4.81%
SS-1	0.42	3.12%	0.69	3.45%	3.45%
SS-2	0.30	2.23%	0.54	2.70%	2.70%

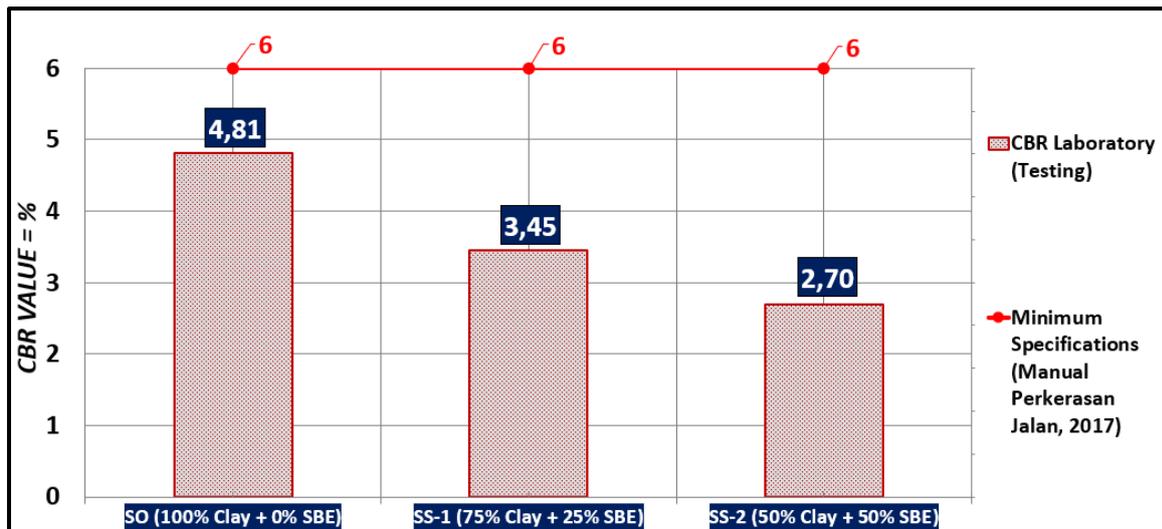


Figure 10. CBR Laboratory values for SO, SS-1 and SS-2 samples.

4. CONCLUSIONS

From the test results involving the effects of adding Spent Bleaching Earth (SBE) on clay, the following conclusions are reached:

1. The greater the percentage of SBE added, the higher the water absorption capacity. This is shown by the higher plastic limit of SBE than clay.
2. The higher water absorption capacity causes a decrease in the maximum dry density achieved by the clay-SBE mixture in comparison with pure clay
3. The decrease in maximum dry density of clay-SBE mixture in turn resulted in lower CBR values obtained as more SBE was added
4. The test results show that SBE cannot be used to stabilize clay as addition of SBE fails to improve the CBR of clay to above 6% as required by the Road Pavement Manual (2017).

Suggestions for further research:

1. To enable usage of SBE in stabilization of clay, other materials, such as cement, lime ash, fly ash and bottom ash, etc., can also be added in attempt to improve the CBE value.
2. Tests to be repeated in full-scale experiment to ensure the results obtained are also applicable in field conditions.
3. Soaked CBR to be carried out as CBR value of soil changes depending on weather conditions for fine-grained soil, such as silt and clay. By doing immersion CBR test, the minimum CBR value will be obtained corresponding to the worst conditions.

ACKNOWLEDGEMENTS

The highest appreciation is given to PT. Dumai Jaya Beton as the supplier of Spent Bleaching Earth (SBE) materials from Palm Oil Mills in Dumai City area and its surroundings.

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