Characteristics of Spent Bleaching Earth Substitution in Limestone as Landfill Material

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Abstract- The subsitution SBE in limestone can significantly improve the characteristics of limestone as a landfill material, especially in increasing the CBR hardness value without changing the limestone grain size distribution. This is because SBE acts as a filler in the SBE-limestone mixture. The existence of SBE in the mixture does not change the value of the mixture plasticity index, because SBE and limestone are both not plastic. SBE material can be used as substitution material (matrix material) up to 30% by weight in the SBE-limestone mixture. The role of SBE as a filler becomes very important in mixed materials for non-limestone structural material requirements, especially for matrix material sizes from 0.4 to 10 mm or sand to gravel. Of course, more research is needed on the physical and mechanical characteristics of mixed materials due to the use of SBE as a filler in matrix multi grand size (sand to gravel).

Keywords: *SBE, Limestone, Substitution, Filler, Landfill.*

I. INTRODUCTION

Spent bleaching earth is a waste from the production process of the palm oil processing industry so that it is included in the category of waste resulting from processing animal/ vegetable fats and their derivatives. The waste based on Indonesian Government Regulation No. 85 Year 1999 includes B3 waste (Hazardous and Toxic Materials) from specific sources. According to PP 74/2001, hazardous and toxic materials (B3) are materials whose properties, concentration, and / or quantity, either directly or indirectly, can pollute and or damage the environment, and or can endanger the environment, health, survival humans and other living things (Damanhuri, 2009).

SBE contains a high residual or organic compounds within in range of 20-40% from Palm Oil Refinery. The main chemical composition SBE is SiO_2 (>50%) but has lower CaO (10%) compare to limestone (Yunus et al., 2019). The physical properties of SBE according to (Farahiyah et al., 2020) claim that mean particle size SBE was 29,3μm, the particle size of SBE was 80,42μm and the specific gravity of SBE was 1,93.

However, SBE can be recycled or processed into materials that are used as landfill material, as what written at Minister of Environment and Forestry Regulation Number 10 of 2020. SBE can be recycled and used as material for building such as brick, concrete, cement replacement, and so on. On the previous research, showed that the compressive strength of concrete blocks made from SBE which was extracted without using aggregates, both domato soil, river sand, and split gravel, did not fulfill the SNI and PUBI requirements. However, the composition of the SBE 25% is better than the SBE composition of 50% and 75% (Pojoh, 2016). On the other research has been mentioned that the composition used of SBE waste which results in compliance with the required compressive strength standard is SBE with a composition of 15% and 25%, and the composition of more than 25% SBE can't be used as a brick (Abrar,2019). Based on (Sharom, 2016) determine that SBE can becomes potential innovation product for construction materials. This study is to investigate the optimum SBE as replacement through a some several mixtures of foamed concrete. The best performance properties for replace cement is 30% compared to control foamed concrete. The main aim of this research is to determine the percentage of SBE substitution in limestone used as a landfill material. Therefore, in this study 30, 40, 50% of SBE were used to partially replace/substitution limestone.

II. METHODS

The material that used in this study is limestone and SBE. The variations of the mixture are made based on the ratio of % by weight (Table I).

TABLE I
LIMESTONE AND SBE MIXTURE

No	SBE (%)	Limestone (%)
1	0	100
2	30	70
3	40	60
4	50	50
5	100	0

The SBE in this study has been through an extraction process, so that the value of the oil content is below than 3%. The testing methods used are as follows:

1. Analysis of Sieves

Sieves testing is a method for calculating grain size distribution based on soil sedimentation in water. Dry the material in the sun until it is completely dry then sift until the fraction filter is held and pass filter No. 200.

2. Atterberg Limits Testing (Liquid Limit and Plastic Limit)

The condition of the material that has the lowest water content where the soil behaves from plastic to liquid conditions or the state of the material that has a water content between plastic and liquid. The liquid limit is the water level when the nature of the soil at the limit from the liquid state becomes plastic (SNI 1966: 2008). Methodology: soil samples that have been inserted into the cassagrande tool, made a gap in the middle with a standard grooving tool then the cassagrande tool is rotated at a speed of 2 beats per second and the height of the fall is 10 mm, so that on the 25th tap of the soil sample that is scratched with the grooving tool close as far 0.5 inch.

Plastic limit is the lowest limit of water content conditions when the soil is still in plastic conditions (SNI 1966: 2008). Methodology: sift the soil sample with sieve No. 40 and then take a soil sample of about the size of the thumb and then roll it on a glass plate until it reaches a diameter of 3 mm until it cracks or break. Put the test object into a container then the weigh it. The last is to determine the water content of the test specimen.

3. Proctor Testing

Proctor testing is intended to determine the maximum soil through collision, which is to find out the relationship between water content and soil density. Take a soil sample of 2.5 kg and add water little by little until evenly mixed. When the stirred soil is evenly clenched by hand. When the hand is opened, the ground is not crushed and sticky in the hands. By using Proctor Standard, the land is divided into 3 parts. The first part put into the mold crushed 25 times until evenly distributed. The same way is done for the second and third parts.

4. CBR (California Bearing Ratio) Laboratory Testing

CBR (California Bearing Ratio) is a method for assessing soil strength. The CBR value is the ratio number (in percent) between the pressure needed to penetrate the ground with a round piston that is 3 inci2 wide and the penetration speed of 0.05 inches/ minute to the pressure needed to penetrate a certain standard material.

III. RESULT AND DISCUSSION

The test method of substitution SBE in limestone have been carried for several variation in the composition of SBE - limestone mixture. The test methods are intended to obtain physical and mechanical characteristics of the material based on 4 test methods that is, the sieve test, Atterberg test, Proctor test, and CBR test.

The result of the sieve test shown that the distribution of SBE grain sizes (more than 90%) pass from sieve number 200. This indicate that the grain size of the SBE material is smaller than 0.075 mm. The grain size of limestone varies from larger than 1 mm (65% in distribution) to less than 0.075 mm (35% in distribution). Based on Table II indicated that the substitution SBE in limestone composition does not change the grain size distribution of the limestone. Because of SBE act as a filler in the mixture so the substitution in limestone does not affect the gradation of limestone. Even the substitution of SBE up to 50% in the mixed composition does not change the size distribution of limestone grain size. In its application for landfills, in terms of grain size distribution, SBE substitution in limestone can be used up to 50% of its weigh but the best gradation is shown in the 30% SBE substitution.

The Atterberg test is used to determine the characteristics of plasticity material. The result of

Atterberg test is indicated that both of the initial material is non-plastic (PI = 0%) (Fig.1). Therefore, the two initial materials are non-plastic, so the mixture will automatically be non-plastic. Index Plasticity (PI) can indicate the plasticity condition of a material or the ability of grains to deformation without change in shape or volume. According to SNI-03-6797-2002 (AASHTO M145) that the maximum PI value for landfill is 6%, so the initial material and the mixture material can be used as a landfill material. The Soil Activity (A) is used as an index to identify the ability of soil to swelling. Soil activity (A) is a comparison between the Plasticity Index (PI) with a percentage of grains smaller than 0.002 mm (Fig.2). Based on SNI that the maximum Soil Activity (A) for landfill is 1,25%, so the result of Soil Activity (A = 0%) test from all materials indicate that the materials can be used for landfill (Fig.2).

TABLE II
SIEVE TEST RESULT OF SBE SUBSTITUTION IN LIMESTONE

Grand Size	Unit	Initial material		Mixture		
		SBE	LM	LM 50% vs SBE 50%	LM 60% vs SBE 40%	LM 70% vs SBE 30%
Gravel (2-64 mm)	%	0	15,6	18,88	17,01	16,96
Sand (1-0.125 mm)	%	4,28	49,3	46,71	32,05	34,14
Clay and Silt (0.04-<1/256 mm)	%	95,7	35,1	34,41	50,94	48,9
AASHTO		A-4	A-4	A-2-4	A-4	A-4

TABLE III
PROCTOR TEST RESULT OF SBE SUBSTITUTION IN LIMESTONE

	Unit	SBE 100%	LM 100%	LM 50% vs SBE 50%	LM 60% vs SBE 40%	LM 70% vs SBE 30%
Specific Gravity		2,62	2,62	2,63	2,62	2,62
OMC	%	33	14,7	16,2	16,9	15,9
γd max	gr/cc	1,04	1,77	1,45	1,42	1,53

Proctor testing aims to obtain the maximum dry weight and optimum water required to compact a material. The compaction is intended to improve the quality of the soil by increasing the shear strength of the soil, minimizing settlement, reducing permeability, and controlling changes in relative volume due to the shrinkage-swelling of soil. Based on the general guidelines for the selection of landfill materials suggested by Gregg (1960), it is stated that limestone is included in the moderate to very good material category while SBE is included in the not satisfactory material category. Based on the test results (Table 3), the substitution of SBE in limestone shows a value that tends to decrease compared to the initial material value (LM 100%), but the quality of the material is still in the good category for landfills. This case is indicated from dry density value, SBE dry density is 40% lower than limestone but the substitution SBE in limestone until 50% only reduce the value of dry density limestone by 16%, not a significant change in use. The best compaction value is obtained from SBE 30% - limestone 70% by weight material with a maximum dry weight value of 1,53 gr/cc and an optimum moisture content of 15,9%, so it is categorized as a poor to good performance.

CBR testing is used to evaluate the potential strength of the landfill material. The test was conducted using SNI standard 03-1744-2012 referring to AASHTO T193-99 (2007). The greater of CBR value indicates the better carrying capacity of the land. But this can be influenced by several factors. The factor which greatly influences the CBR value is material compaction. The greater of maximum dry weight and optimum moisture content in the compaction process (see Table 3), then the CBR value will also be greater. SNI Standard CBR value for selected fill material is at least 10%, for ordinary fill material a minimum value at least 6%. The CBR value of the SBE substitution of the limestone obtained is greater than the CBR value of the initial limestone, however this condition is inversely proportional to the maximum dry weight value and the optimum water content is much lower than the initial limestone (Fig.3). Based on Fig. 3, the best CBR value is obtained at SBE substitution of 30% in limestone resulting in a CBR value of 43.20. This value is greater than the initial material CBR value (LM 100%). This is indicated by the presence of SBE filling the pore in the limestone causing the soil to be more compact, but the compaction value is smaller due to the nature of SBE which cannot absorb water well. The nature of SBE is due to the gradation of this material which is homogeneous and fine.

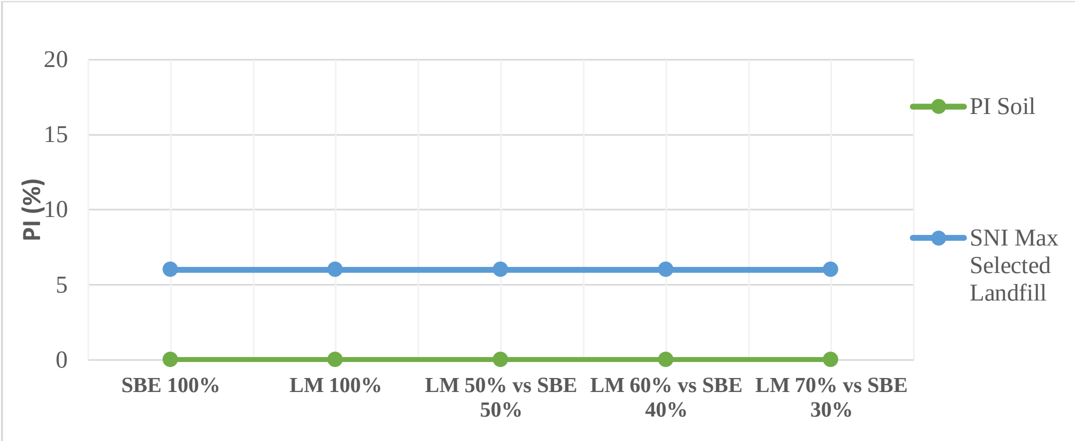

Fig. 1. Index plasticity (PI) test result

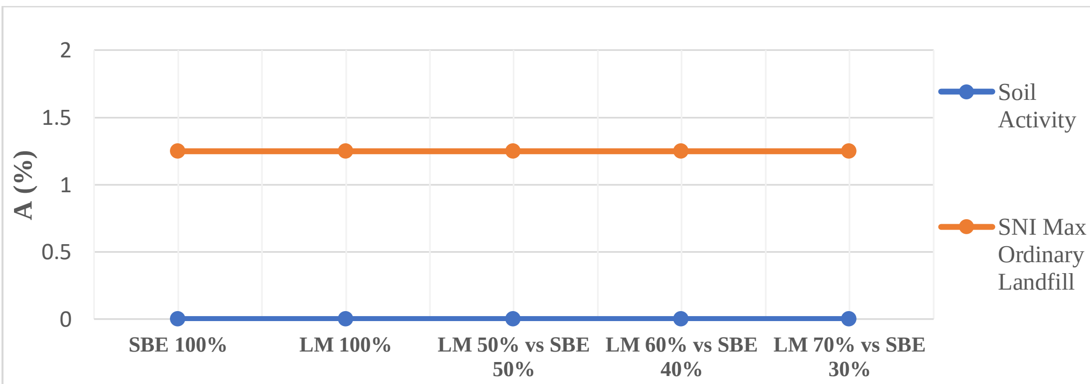

Fig. 2. Soil activity (A) test result

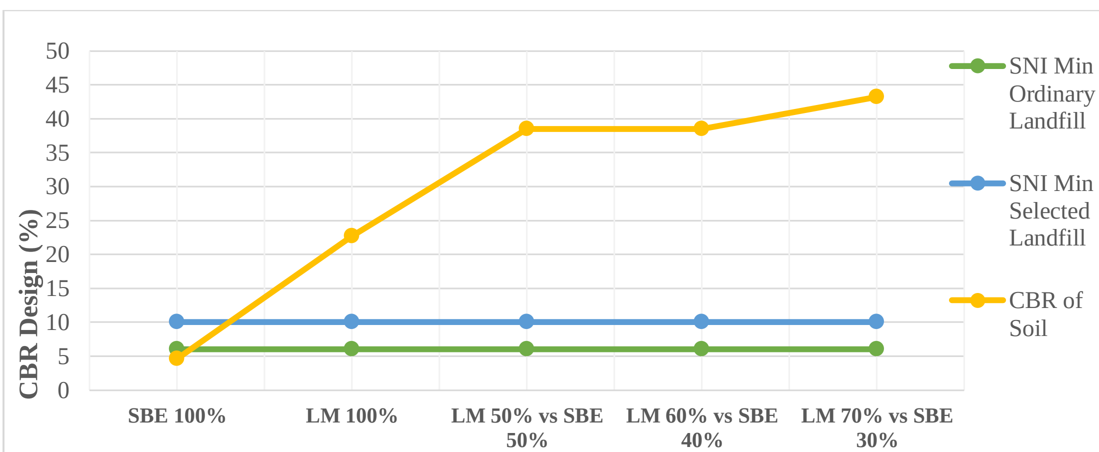

Fig. 3. California Bearing Ratio (CBR) test result

IV. CONCLUSION

SBE substitution in limestone as a landfill material can be used up to 30% by weight based of the test result. The substitution SBE in limestone does not change the grain size composite material even up to 50% by weight substitution. SBE and limestone are non-plastic material, so both of them do not have a swelling or shrinking characteristic due the changes in water saturation value in the material and according to SNI-03-6797-2002 (AASHTO M145) SBE substitution in limestone can be used as a landfill material. The Proctor test shows that the SBE dry density level is 40% lower than limestone.

However, SBE substitution of up to 50% by weight in limestone only reduce the value of limestone dry density by 16%, not a significant change in use. So, the substitution SBE in limestone up to 50% does not significantly change the characteristics of the limestone-based landfill material with moderate performance. The best performance is obtained at 30% SBE substitution. SBE substitution can increase the CBR value of the mixture up to 200% or 2 times the original CBR limestone value. So as a fine material (90% distribution in clay and silt grand size), SBE acts as a filler in the SBE-limestone mixture for landfill material.

V. REFERENCES

Abrar, Aidil and Nuryasin Abdillah. *Studi Eksperimen Pemnafaatan Limbah Spent Bleaching Earth (SBE) sebagai Bahan Pembuat Bata*. Siklus: Jurnal Teknik Sipil 5 (2): 70-78. https://doi.org.10.31849/siklus.v5i2.3223.

Ajemba, R.O., dan Onukwuli, O.D., 2013, *Nitric Acid*-Activated *Nteje Clay: Structural and Bleaching Properties, International Journal of Engineering*, 26 (5): 495-500.

Damanhuri, E. 2010. *Diktat Kuliah: Pengelolaan Bahan Berbahaya Dan Beracun (B3)*. Teknik Lingkungan ITB.

Damayanti, Cendy, 2019, *Pengaruh Jenis dan Konsentrasi Asam Terhadap Proses Reaktiviasi Spent Bleaching Earth (SBE) Hasil Samping Produksi Biosola*r, Skripsi Universitas Lampung, Bandar Lampung.

East Java Provincial Government, General Specifications of the Public Works Department of Highways in East Java Province, 2018.

Farahiyah, R., Rahman, A., Asrah, H., Rizalman, A. N., Abdul, K., & Rajak, M. A. A. (2020). *Study of Eco-Processed Pozzolan Characterization as Partial Replacement of Cement*. *8*(3), 967–970.

Farihahusnah, H., Mohamed, K. A., dan Wan, M. A. W. D., 2011, Textural Characteristics, Surface Chemistry and Activation of Bleaching Earth, Indonesian Journal Chemical Science, 5 (3): 202-205.

Helbianurramdan, Noor Hindryawati, R.R Dirgarini Julia N.S, 2017, *Aktivasi Deoiled Spent Bleaching Earth (DSBE) dengan Menggunakan Metode Ultrasonik untuk Mengadsorpsi Ion Logam Pb2+*, Jurnal Atomik: 02, Hal. 241-247.

National Standardization Agency, Test Method for *Determination* of Plastic Limits and Soil Plasticity Index, SNI 1966-2008.

National *Standardization* Agency, Light Density Test Method for Land, SNI 1742-2008.

National Standardization Agency, Laboratory CBR Test Method, SNI 03-1744-2012.

National Standardization Agency, Test Method for Analysis of Soil Grain Size, SNI 3423-2008.

Pojoh, Broerie and A. Luther Ola. 2016. *Handling of Spent Bleaching Earth Waste Pile of Coconut Oil Factory Through "Batako" Making*. *Jurnal Penelitian Teknologi Industri* 8 (1): 1-10.Farahiyah, R., Rahman, A., Asrah, H., Rizalman, A. N., Abdul, K., & Rajak, M. A. A. (2020). *Study of Eco-Processed Pozzolan Characterization as Partial Replacement of Cement*. *8*(3), 967–970.

Sharom, N. B. I. N. (2016). *Iii Performance of Eco Process Pozzolan Foamed Concrete As Cement Replacement*. *January*.

Utama, Widya, 2019, *Karakterisasi Subsitusi EPP pada Campuran Limestone dan Mud untuk Tanah Urugan*. ITS, Surabaya.

Wahyudi, MY. 2000. Studi Penggunaan kembali Bleaching Earth Bekas sebagai Adsorben dalam Proses Refining CPO. Tesis Magister. Program Studi Teknik Lingkungan. Institut Teknologi Bandung, Bandung.

Yunus, E., Asrah, H., & Rizalman, A. N. (2019). *Compressive Strength of Eco-Processed Pozzolan Concrete under Chloride and Sulphate Exposure*. *1*(1), 1–9.