

UTILIZATION SPENT BLEACHING EARTH AS A FILLER OF MATERIAL CONSTRUCTION

Yusnimar, J. N. Rahman and P. Ningendah

Departmen of Chemical Engineering, Universitas Riau, Pekanbaru 28293, Indonesia.

Email : yusnimarsahan@gmail.com; yusnisahan@lecturer.unri.ac.id

ABSTRACT

Spent bleaching earth (SBE) is a waste from cooking oil industry. It is categorized as one of the hazardous and toxic materials, because oil residues in it. Generally, SBE is overcome by landfill and it's sometimes become problems. Basically SBE contains SiO_2 and the size of the grain is very fine, almost the same as the fine aggregate of sand used for making brick. In this study, the making of brick used SBE with several variations (2.75% - 27.52%) of the total raw materials used. Brick making methods are based on SNI 03-0348-1989 for raw material ratio, SNI 03-0348-1989 for molding and pressing, SNI 03-6825-2002 for drying and curing. The brick quality was determined based on fineness modulus parameters, dry weight, brick absorption to water and compressive strength. Brick contain SBE 2.75% was produced with molding size of 15cm x 30cm x 9cm, it has an average dry weight of 7.80 kg, compressive strength of 8.95 MPa and absorbing power of 1.26%.

Key words: Absorbing power, compressive strength, dry weight.

1. INTRODUCTION

In the palm oil refinery industry, crude palm oil (CPO) is processed in several stages into cooking oil, namely degumming for removing gum in CPO, neutralization process for removing free fatty acids from CPO, bleaching for change the color of oil from brown to clear yellow, and deodorizing oil in deodorization process. Generally, bleaching earth (BE) is used in the bleaching process and spent bleaching earth (SBE) as a waste. It is the largest waste in industry. Based on Indonesian Government Regulation No. 18 of 1999 [1], SBE is one of the B3 hazardous material with the second hazard category, because it's oil content. In the summer SBE will be very flammable [2]. Tackling of SBE is carried out in landfills method. This method always requires extensive space, actually it does not cause a very detrimental effect if there is a

small quantity. But, in large quantities it can cause fires and sources of pollution caused by oil residues in it.

The amount of earth bleaching (BE) used in the industry is about 0.5%-2.0% of the total mass of CPO processed [3, 4]. If the bleaching process is used \pm 5 million tons of CPO per year, it will require 100,000 tons of BE per year. Jumlah konsumsi bleaching earth untuk pemucatan CPO di Indonesia dari tahun ke tahun semakin meningkat seiring dengan pengembangan industri minyak goreng di Indonesia. Jika jumlah CPO sebanyak 26 juta ton yang akan diolah dalam proses pemucatan CPO, maka diperlukan jumlah BE sebanyak 6-12 kg/ton minyak sawit mentah atau sekitar 0,6-1,2%. Maka dalam proses pemurnian CPO diperlukan bleaching earth sebesar 312.000 ton per tahun. In 2014 there were 94 refineries of CPO refineries in Indonesia, most of which were located on the island of Sumatra, and in Riau there were the most compared to other provinces [5]. The total capacity of processed CPO in the industry is 15,430,000 tons [5]. This informs the number of SBE is increasing, along with the development of the cooking oil industry at this time.

Basically, SBE is a bentonite or a clay type and its main composition consisting of SiO_2 , Al_2O_3 , Fe_2O_3 , CaO , and MgO [3, 4, 6, 7]. Bentonite has a chemical composition of \pm 80% monmorillonite (Na,Ca) minerals $0.33 (\text{Al,Mg})_{12}\text{Si}_4\text{O}_{10} (\text{OH})_2 \cdot n\text{H}_2\text{O}$ and the rest attapugite, soft and heavy metal oxide compounds [3, 4, 6, 7, 8, 9]. SBE has SiO_2 or a silica dust around 83.5% [3, 6]. In industry, SBE is overcome by landfill, so amount of SBE is abundant and its utilization not many, it is sometimes become problems. Therefore SBE can be used as a raw material for the manufacture of concrete brick [7, 8, 9], and the addition of silica dust can increase the value of concrete compressive strength [10, 11, 12, 13].

In this study, SBE was used as a filler for partial substitute of sand filler in the brick making. Management of solid waste with solidification techniques has been carried out by some researchers [14, 15, 16, 17], and can be decreasing the concentration of heavy metal elements in a hazardous material. Solidification aims to non-mobilize harmful contaminants which contained in the waste, the contaminants are in a stable state not easily penetrated into the environment. Other research reported that the solidification of spent catalyst from the petroleum industry into light bricks [14]. Another research conducted a study on the use of fly ash solid waste as an aggregate substitute for paving

block compressive strength [15]. One research has conducted research on the manufacture of wall-pair material made from a mixture of sand, cement, fly ash and Lapindo mud at a certain ratio [16]. One study mentioned that concretes with SBE substitution which achieve the planned compressive strength high [17], and other study showed that SBE is a dangerous material but can be recycled or processed into a material that can be used as raw material from red-bricks[18].

2. EXPERIMENTAL SECTION

2.1 Materials

Materials used in this research are Portland cement produced by PT. Semen Padang-Indonesia, fine sand for making brick, SBE from refinery crude palm oil in Dumai-Indonesia and water.

2.2 Mass Determination of Raw Material

The volume of the brick making is based on SNI 03-0348-1989 with molding size 15cm x 30cm x 9 cm. The procedure for calculating raw materials used according to SNI 03-4810-1998 and ASTM Standard, Vol.04.02.1995 [19, 20]. the density of Portland cement of 3100 kg /m³ and sand of 2600 kg /m³, the ratio of cement: sand is 1: 4. The mixture for making a brick are cement 2,511 kg and sand 8.424 kg. A constant of the cement water factor (FAS) in this study was 0.5. This method is taken from technical guidelines issued by the Public Works Department [19]. Water with density is 1 gr/cm³, so needed water mass = FAS × cement mass = 0.5 × 2500 gr = 1250 gr = 1.25 kg.

Table 1. Raw Material Composition for Making Brick

Brick Code	Raw material (kg)			
	cement	Sand	SBE	Water
A	2.5	8.40	0	1.25
B	2.5	8.10	0.30	1.25
C	2.5	7.80	0.60	1.25
D	2.5	7.50	0.90	1.25
E	2.5	7.20	1.20	1.25
F	2.5	6.90	1.50	1.25
G	2.5	5.40	3.00	1.25

In principle, making bricks is done using several raw materials (Table 1). By adding SBE, the amount of sand is reduced by 0.3 kg for each of the bricks variations A to F. While for bricks G and H which have SBE variations of 3 kg and 4.5 kg which aims to find out the addition of excess SBE to the quality of the resulting block. The first step taken in making bricks is to weigh cement, sand and SBE in accordance with the variations specified in Table 1. Then the SBE in the form of powder is mixed with cement and sand, to the mixture of cement, sand and SBE water is added slowly to as much as 1.25 kg, then the mixture is stirred in a container manually using a sand shovel until evenly distributed for approximately 15 minutes. After being mixed evenly, the material mixture is put into the mould and it is press using press machine ± 7.7 hp in accordance with SNI 03-0348-1989. Then, brick is drying and curing for 28 days refers to SNI 03-6825-2002.

2.3 Drying and Curing

The process of drying and maintenance on brick or curing refers to SNI 03-4810-1998 [19]. Curing is needed to maintain the desired humidity and temperature conditions for the brick, because the temperature and humidity in the brick directly affect the properties of the brick. Curing also prevents water from disappearing and makes more hydration of cement. To maximize the quality of the brick, it is necessary to apply curing because curing is critical for making the brick surface resistant.

Cement requires water to start the hydration process and to maintain the internal temperature produced by this process to optimize the freezing and strength of the cement [21]. The length of curing of the brick is carried out for 28 days based on SNI 03-2492-2002 [24], this is because the perfect maturity level for brick making is 28 days. Then after the age of the 28 day brick, a heavy examination was carried out, testing of water absorption and compressive strength on product [21, 22, 23].

2.4 Water Absorption Test

Water absorption test of the brick was carried out according to SNI 03-0349-1989 [24, 25]. The specimens were completely soaked in clean water that had room temperature for 24 hours. Then, the specimen is removed from the soaking, and the remaining water is allowed to slice for approximately 1 minute, then the surface of the specimen field is wiped with a damp cloth, so that the excess water is still adjacent to the surface of the specimens absorbed by the damp cloth. Next, object was weighed

(M_j), after that the test specimens are dried in the dryer at $105 \pm 5^\circ\text{C}$ until it's weigh no more than 0.2% of the known scales (M_k). The weighing difference in wet condition (M_j) and in dry condition (M_k) is the amount of water absorption, and should be calculated based on weight percent weight of dry specimens. The water absorption of brick is calculated by equation (1)

$$W_a = \frac{M_j - M_k}{M_k} \times 100\% \quad (1)$$

Where w_a is water absorption (%), and M_j is specimen mass in dried condition (g) and M_k is specimen mass in wet condition (g).

2.5 Compressive Strength Test

The compressive strength of a material is a comparison of the amount of maximum load that can be held by the load with the cross-sectional area of the material that experiences this force. The concrete brick compressive strength test is carried out by using the Ultimate Testing Machine, then the brick also has a concrete compressive strength requirement that refers to SNI 03-1974- [26, 27]. Compressive strength test was carried out by providing a compressive force of 7.7 h.p. extensive unity of brick, so the brick is destroyed. ThFor the measurement of compressive strength on brick is refers to the standard SNI 03-2492-2002 [28] and calculated by Equation 2.

$$F_{maks} = \frac{P}{A} \quad (2)$$

2.6 Examination of physical appearance

The procedure for calculating the weight of the concrete brick is done as follows, the concrete brick is dried in the open area exposed to the direct sun, then it is weighed. Results of the weight of the concrete brick obtained was compared with the weight of the concrete brick in different composition. The size of the concrete brick was tested through the visual appearance of the brickwork visually, and measurements of the concrete brick dimensions were measured in length, width and thickness.

3. RESULTS AND DISCUSSION

3.1 Drying Test Results

The brick has been dried for 28 days was determined by its quality based on brick dry weight. Data for the dry weight of brick is presented in Table 2. The brick which does not contain SBE or normal brick has a dry weight greater than SBE. The dry weight of the SBE-brick produced decreases, along with the increasing number of SBE used and the amount of fine sand used decreases. This is due to the specific gravity (SG) of SBE 1,249 kg /cm³ lower than SG sand ranging from 2.35 - 2.55 kg / cm³ [8].

Table 2. Dry Weight of Brick

Brick Code	Raw material composition (kg)				SBE (%)	Dry Weight Of Brick (Kg)
	Cement	Sand	SBE	Water		
A	2.5	8.40	0	1.25	0.00	8.28
B	2.5	8.10	0.30	1.25	2.75	7.80
C	2.5	7.80	0.60	1.25	5.51	7.68
D	2.5	7.50	0.90	1.25	8.26	7.43
E	2.5	7.20	1.20	1.25	11.01	7.33
F	2.5	6.90	1.50	1.25	13.76	7.23
G	2.5	5.40	3.00	1.25	27.52	5.76

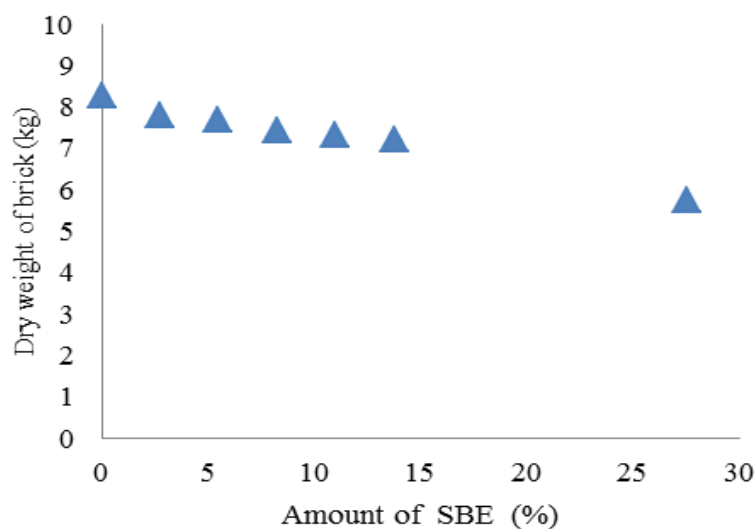


Fig. 1 Correlation between amount of SBE used and dry weight of brick.

Replacement of part of fine sand aggregate with SBE from 2.75% to 27.52% of the volume of raw material produces a relatively dry brick of about 7.80 - 5.76 kg which is lighter than the dry weight of brick without SBE (8.28 kg). The lighter the building materials used, the lower the load received by the building structure so that it can be more economical, the mass of the building will also be smaller so that this concrete brick is suitable for use in earthquake areas [29].

3.2 Brick Absorption to Water Result

In Table 4 all bricks containing SBE are quality I according to SNI-03-0349-1989 [29]. According to SNI 15-2094-2000 [26] the absorption of the brick to water is 20% maximum and this brick has a value of quality I. Increasing the number of SBE in the brick, the absorption brick to water is increasing too. The value of the absorption of water by brick is strongly influenced by the pores or cavities contained in it [8, 9]. The more pores contained in the brick, the greater the absorption of water so that the resistance will decrease. Water absorption that is too high on the brick can cause a decrease in the compressive strength of the brick, because the porosity level in the brick structure is also increasing so that the brick becomes easily cracked and broken [29, 30].

Table 3. Brick Absorption to Water

Brick Code	SBE (%)	Brick absorption to water (%)	Brick quality SNI 03-0349-1989 (%)
A	0.00	1.19	I
B	2.75	1.26	I
C	5.51	1.93	I
D	8.26	2.02	I
E	11.01	2.75	I
F	13.76	4.16	I
G	27.52	4.42	I

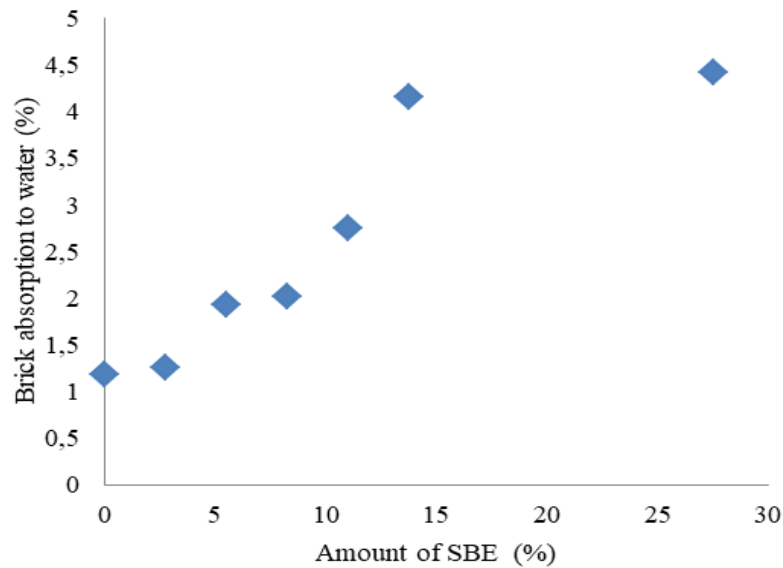


Fig. 2 Correlation between amount of SBE used and brick absorption to water

In general, SBE is calcium-bentonite which most of its composition consists of montmorillonite minerals which has an easy to absorb water. Calcium-bentonite has the property of being able to adsorb, because the size of colloidal particles is very small and has a high surface capacity. Bentonite is easy to expand in water, because of the replacement of its isomer in the octohedral layer (Mg ion by Al ion) in compensating for the excess load at the end of the lattice. There is an electrolysis force that binds the crystal at a distance of 4.5 Å from the surface of its units, and will keep the unit from sticking together [3, 4, 6]. In mixing bentonite with water, the development process makes the distance between each unit widens and the layer becomes a splinter shape, and has a wide surface if in the suspending agent. Because of its nature, bentonite can be used as a bleaching agent or adsorbent.

3.3 Compressive Strength Result

The definition of concrete compressive strength refers to the SK SNI M-14-1989-F about testing the compressive strength of concrete, which means the compressive strength of concrete is the magnitude of the broad unity load that causes concrete specimens to break when burdened with certain compressive forces produced by the press machine. In SNI 03-0691-1996, it is explained about the quality of paving blocks which are classified into four types based on strength and water absorption. The compressive strength of a paving block is influenced by several factors, including: 1)

the type and quality of cement, sand and other ingredients, 2) the ratio of the amount of cement to sand, 3) the ratio of the weight of water to cement and 4) how to make it based on how large compacting paving block. Measurement of compressive strength of paving blocks is carried out on several paving block ages, namely 7 days, 14 days, 21 days and 28 days.

The value of compressive strength in brick is decreases with increasing number of SBE in brick making (Figure 3). Factors that affect the compressive strength of bricks are the type and quality of raw materials, brick making methods, comparison of the amount of raw materials used and brick building treatment [31]. The maximum compressive strength value of the brick is obtained from a certain composition. The addition of SBE material which more affects the adhesion between cement and SBE thereby reducing the strength of the product [8, 9, 30]. The compressive strength of bricks is presented in Figure 3 and Table 4.

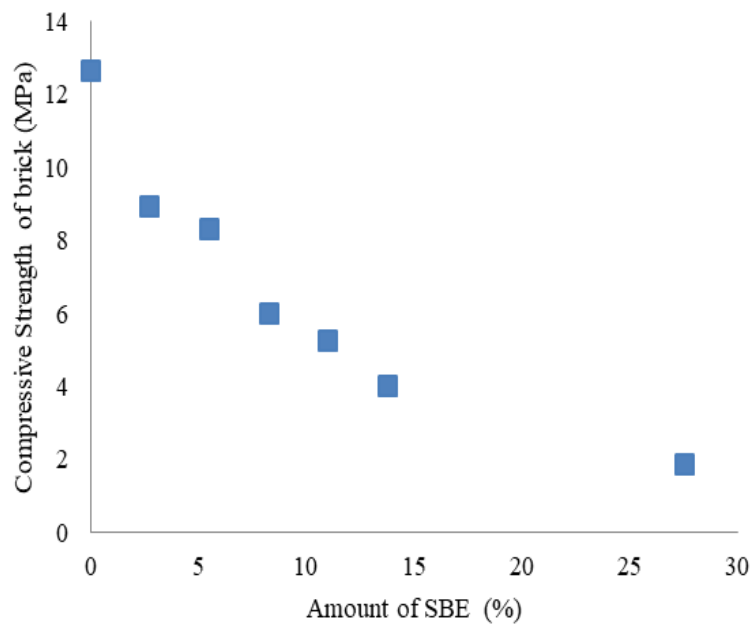


Fig 3. Correlation between amount of SBE used and compressive strength of brick

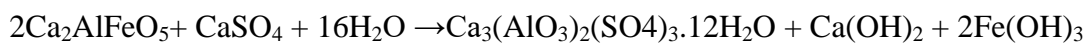
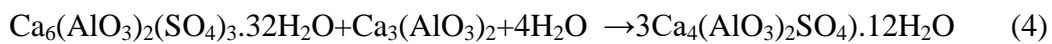
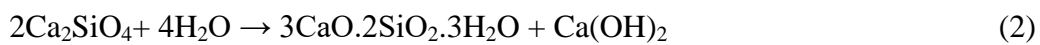
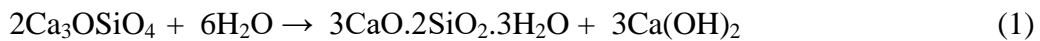
Table 4. Compressive Strength of Brick

Brick Code	SBE (%)	Compressive strength of brick (MPa)	Brick quality SNI 03-0349- 1989 (%)
A	0.00	12.65	I
B	2.75	8.95	I
C	5.51	8.33	II
D	8.26	5.98	III
E	11.01	5.24	III
F	13.76	4.01	III
G	27.52	1.85	IV

Based on the results of the analysis note that the treatment of variations in raw materials namely the number of SBE factors and the factor of the amount of sand aggregate has a significant effect on the compressive strength. The results of the analysis of the treatment of variations in the number of SBE and sand on compressive strength showed that the formulations in the code bricks A and B were the best formulations with the highest average compressive strength values. However, the compressive strength test value will decrease with increasing number of SBE used. The formulation of raw materials that meet the standard I required by SNI is a brick with code A and B. The addition of spent bleaching earth material in the making of an increasingly brick building will greatly affect the attachment between cement and spent bleaching earth, thereby reducing the compressive strength of the brick.

Additionally, SBE still contains 10-20% oil and when it is exposed to water can expand [31], this causes the hydration reaction that occurs in the brick being interrupted. The bonding between the material, especially the bond between the cement and SBE decreases. This is due to the fact that SBE properties can absorb water causing hydration reactions between cement and water are not perfect, since some of the water trapped in SBE pores does not react with cement [30]. The reduction in the good absorption between SBE and cement paste will result in a decrease in the strength of Portland cement bricks [29].

Referring to the physical requirements of Portland cement brick, the more cavities that arise due to the cement hydration process, the lower the compressive strength [32]. The denser the coarse aggregate arrangement, the greater the value of compressive strength. The higher the compression value of an aggregate, the smaller the value of the porch. Hydration reactions occur when cement is added by water. Hydration reactions that produce various kinds of chemical compounds [33]. The mechanism of the hydration reaction of the cement components is as follows [33]:



Tricalcium silicate compounds (C₃S) and dicalcium silicate (C₂S) are the most dominant parts in providing cement properties, these two compounds occupy 70-80% of cement. C₂S have a large effect on cement hardening, especially before reaching the age of 14 days. C₃S affects cement hardening after more than 7 days and gives final strength. Hydration reactions (1) and (3) take place very quickly in minute order, while reactions (2), (4) and (5) can take place slowly in the order of weeks. Therefore maximum cement hardening can reach 28 days [33].

3.4 Examination of Physical Appearance Results

The result of examination of the physical appearance in the brick product shown in Table 5.

Table 5. Differences Physical Appearance of Brick With Quality Standard of SNI 03-0349-1989

Brick Code	Field		Unity	Lateral	
	Rift	Smoothness		Sharpness	Strength
A	not cracked	Smooth	Elbow	Sharp	Strong
B	not cracked	Smooth	Elbow	Sharp	Strong
C	not cracked	Smooth	Elbow	Sharp	Strong
D	not cracked	Smooth	Elbow	Sharp	Strong
E	not cracked	Smooth	Elbow	Sharp	Strong
F	cracked	Less-Smooth	Elbow	Not-Sharp	Not-Strong
G	cracked	Less-Smooth	Elbow	Not-Sharp	Not-Strong
SNI 03-0349-1989	not cracked	Smooth	Elbow	Sharp	Strong

Some quality requirements for a brick. Quality requirements tests are based on SNI 03-0691-1996 [13] namely: the outward visibility of the brick, a brick should have a flat surface, no cracks and defects, the corners and ribs are not easily trimmed with the strength of fingers.

Seven bricks produced with different compositions fulfilling the requirements of physical appearing properties according to standard SNI 03-0349-1989, all of the bricks have flat surface area, smooth surfaces and many ribs are not cracked, but ribs for bricks have higher SBE contents (13.76% & 27.52%) are cracked. The brick containing SBE granules is about 13.76% and 27.52%) has an uneven surface area and less smooth surface, because it is has oil in it and it can be affected to hidrate reaction between cement and water are not running so well. It impacted into solid and surface of the brick field could be cracked.

According to SNI 03-0691-1996 standards [13], the brick must have a minimum nominal thickness of 60 mm with a tolerance of $\pm 8\%$. The concrete brick produced in this study is suitable with SNI 03-0691-1996 and provisions of SNI 030348-1989 [14].

Table 6. Differences Between The Measured Result of The Brick Dimension and Quality Standard of SNI 03-0349-1989

Brick Code	Length (cm)		Width (cm)		Thick (cm)	
	Results	SNI	Results	SNI	Results	SNI
A	29.7	30	14.7	15	8.9	9
B	29.9	30	14.8	15	8.8	9
C	29.8	30	14.7	15	8.9	9
D	29.8	30	14.9	15	8.9	9
E	29.7	30	14.8	15	8.7	9
F	29.6	30	14.6	15	8.8	9
G	29.5	30	14.6	15	8.7	9

There are differences in size in seven bricks product, but the difference is not significant (Table 6). This is because SBE granules used as a filler can be distribute and fill the cavity between the sand causing the brick becomes more solid so that the surface of the concrete brick becomes flat and not cracked. In Table 3 can be seen, dimension of concrete bricks product have not significant differences. The condition is due to the way of making concrete brick manually so as to obtain concrete brick with a density that is not uniform. Because the density of the pores in the brick will greatly affect the density of the concrete brick composition.

Spent bleaching earth (SBE) grading analysis has been carried out by other researchers [34] and testing SBE fine aggregate gradation and determining the ideal minimum and maximum limits based on the ASTM C33 standard "Standard Specification for Concrete Aggregates".

Table 7. SBE Degradation Test Results

Sieve Size (mm)	Weight on Hold Amount (g)	Weight	
		%	% Cumulative
4.75	34.5	3.45	3.45
2.38	200.5	20.05	23.5
1.19	137.6	13.76	37.26
0.60	94.3	9.43	46.69
0.30	48.9	4.89	51.58
0.15	363.5	36.35	87.93
0.075	117.0	11.7	99.63
Pan	3.7	0.37	100
Total	1000		

Source; M. L. Ashari, D. Dermawan, R. B. Sunarya. 2017

Spent Bleaching Earth gradation has an SBE grain size distribution pattern that is generally in the ideal maximum and minimum range according to the ASTM C33 standard "Standard Specification for Concrete Aggregates". However, in sieves with a size of 0.3 mm the percentage of SBE passes reached 48.42% which indicates that SBE has a very fine grain size [34].



Fig 4 Printing Tool Brick



Fig. 5 Compressive Strength Test Equipment



Fig. 6 Image of BRICK SBE

4. CONCLUSIONS

SBE can be used as a fine aggregate substitute in making brick based on the results of the ASTM C33 gradation analysis. Variation treatment of SBE in making brick has an effect on dry weight, compressive strength and absorption of brick against water. Brick containing SBE has a lighter dry weight than the brick does not contain normal SBE or brick. The compressive strength decreases along increase in the amount of SBE used and vice versa the absorption of brick with respect to water increasing along with the increase in the number of SBE on making brick. The maximum compressive strength of the brick containing SBE of 2.75% with an average value of compressive strength of 8.95 MPa, dry weight of 7.80 kg and its absorption to water 1.26%. While brick has an average weight of 5.76 kg and the absorption rate of brick for water is 4.42%.

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