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Use of the Spent Bleaching Earth from Palm Oil Industry in Non Fired Wall Tiles

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ABSTRACT

Currently, abundant wastes from the palm oil refining process have been generated which are hard to handle. Spent Bleaching Earth (SBE) is the solid waste from this process and leads the cost of elimination to the company. This study aims to utilize the SBE as the alternative material in the non-fired wall tiles. The main raw materials used in non-fired wall tiles consist of laterite soil, fluvial sand, and Portland cement. The experimental formulas have been conducted and divided into 3 groups by varying the percentage of the SBE in main raw materials. The specimens of material mixture have been produced by uniaxial pressing at 100 bars, dimensions in 50x100x8 mm. These specimens are sprayed with water and cured in the air for 7 days. After that, bending strength and water absorption test of these specimens has been performed. It can be concluded that the best formula with the percentage of laterite soil, fluvial sand, Portland cement, and SBE are 60.94%, 13.125%, 22.5%, and 3.435%, respectively. Its bending strength and %water absorption are 0.68 MPa and 5.64%. Material costs of specimen are approximately $0.00276 USD /100g. Furthermore, the comparison of curing period between 7 days and 30 days has been performed. The 30 days of curing period can improve the bending strength of the specimen, but there is no effect on water absorption.

Keywords*: spent bleaching earth, non-fired wall tiles, wastes utilization*

1. INTRODUCTION

Oil palm is one of the high potential crops for producing edible oil and renewable energy, because its yield is higher than the other oil crops (i.e. soybean and rapeseed oil) as much as 4 times [1]. Thailand is one of the world leading palm oil producers. It is a distant third ranked producer of palm oil after Indonesia, Malaysia [2]. There are 15 refineries in Thailand with the maximum capacities of 2.5 million tonnes production per year. Utilization of the current capacity is estimated at 70% [3]. However, the refinery process has generated the abundant wastes. Managing and recycling industrial waste has been increasing interested during the past two decades. It pursuits many manufacturers attempt to tackle this problem with the major reasons for reducing disposal costs and social responsibility [4]. Spent Bleaching Earth (SBE) is solid waste which

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generated from refining palm oil process [5]. Bleaching earth is used to remove colour, phospholipids, oxidized products, metals and residual gums from the oil. It also absorbs approximately 0.5% by weight of the oil in the process. It is usually disposed of in landfills and leads the high cost of disposal to the manufacturers. Therefore, valorization this solid waste as the valuable materials is needed [6].

There are the researchers studying on recycling this solid waste (SBE) in various products. Sophonpong, et al (2007) has utilized SBE wastes as the materials in cement-clay bricks. The experiment shows that 1:1 ratio of cement and SBE is the appropriate formula. Its compressive strength is higher than the others and can pass the TIS standard [7]. Wangrakdiskul, et al (2008) have studied the possibility of producing non fired wall tiles using laterite soil, fluvial sand and Portland cement. The result shows that water absorption property of specimens can pass the standard of TIS 614-1986. However, the bending strength of specimens just cannot pass this standard [8]. Tee (2010) has investigated the result of using SBE in concrete. This study indicates that the ratio of SBE: cement with 50:50 gives the higher compressive strength than that of ratio 60:40. However, the spent bleaching earth shows lower early strength gain. Recommendation for further study, SBE should be used as the new material of lightweight composite products for the construction field [9]. Similarly, Chong Ann (2010) also studies the cement replacement with SBE in concrete products. The result shows that the 30% spent bleaching earth mixtures achieved higher compressive and flexural strength than 40% spent bleaching earth mixture [10]. In the other aspects, SBE has been used as briquette material. It can be summarized that the SBE waste is feasible for feedstock in briquetting [5]. In addition, valorization of SBE has been performed for using as feedstock in lubricant and biodiesel industries [5], [6].

In this study, we aims to investigate the feasibility of recycling SBE waste from the refining process of the studied company in non-fired wall tiles. It can be described in the following section.

2. EXPERIMENTAL DETAILS

2.1Materials

Raw materials used in this study are composed of four major types; Portland cement, fluvial sand, laterite clay, and SBE waste. Their properties can be described as follows.

2.1.1 Portland Cement

Portland cement type I or Ordinary Portland Cement Type I meeting the requirements of TIS 15 Part 1-2547 has been used in this experiment [11].

2.1.2 Fluvial Sand

Fluvial sand has the good quality for construction materials. During weathering process, sand particles have been polished with each other; the fragile particles are came off and left only the hardness and durable particles. Therefore, fluvial sand has round shape of particle, which appropriate for being the compound of concrete [12].

2.1.3 Laterite Soil

Generally, laterite soil can be found in the tropical area on the earth. It is the red tropical soil which has iron oxide rich and derived from rock weathering under oxidizing and leaching conditions [13]. This material is easily acquired and inexpensive. Thailand is one of tropical countries also having abundant laterite soil which can be employed to produce the related products for building, i.e. concrete, interlocking block.

2.1.4 Spent Bleaching Earth (SBE)

Bleaching earth is a type of clay mostly contains silica, followed by alumina. This mineral-rich substance is processed and used for its absorbing, bleaching, and filtering properties. After industrial used, it is called

Spent Bleaching Earth (SBE) and disposed in the plant [14]. The studied company also used 12 tons of bleaching earth per day and left out approximately 15 tons per day. For utilizing wastes, this research aims to study the feasibility of using SBE waste as the alternative material in non-fired wall tiles.

2.2Experimental Procedure

The raw materials as mentioned in the previous section have been prepared for producing the specimens. Three groups of formulas have been conducted, all of them consist of 17 formulas (see table I, II, and III). The based formula No. 1_0 is obtained from Wangrakdiskul, et al [8]. Thirty pieces of specimens are produced for each formula. However, formulas between no. 1_5 to no. 1_11 have not been done. Because the formula no 1_12 shows that the result of physical properties is not good. It could be explained in the following section.

Table 1. Composition formulas of varying %SBE by weight in laterite soil (Group I)

No.	%Fluvial Sand	%Portland Cement	%Laterite Soil	%SBE	% of SBE in 62.5% of Laterite Soil
1_0	15	22.5	62.5	0	
1_1	15	22.5	59.38	3.12	5%
1_2	15	22.5	56.25	6.25	10%
1_3	15	22.5	53.1	9.38	15%
1_4	15	22.5	50	12.5	20%
1_5	15	22.5	43.7	18.8	30%
1_6	15	22.5	37.5	25	40%
1_7	15	22.5	31.25	31.25	50%
1_8	15	22.5	25	37.5	60%
1_9	15	22.5	18.8	43.7	70%
1_10	15	22.5	12.5	50	80%
1_11	15	22.5	6.25	56.25	90%
1_12	15	22.5	0	62.5	100%

Table 2. Composition formulas of varying %SBE by weight in Portland cement (Group II)

No.	%Fluvial Sand	%Portland Cement	%Laterite Soil	%SBE	% of SBE in 22.5% of Portland cement
2_1	15	16.87	62.5	5.63	25%
2_2	15	11.25	62.5	11.25	50%

Table 3. Composition formulas of varying %SBE by weight in fluvial sand (Group III)

No.	%Fluvial Sand	%Portland Cement	%Laterite Soil	%SBE	% of SBE in 15% of Fluvial sand
3_1	11.25	22.5	62.5	3.75	25%
3_2	7.5	22.5	62.5	7.5	50%

Eight steps of experimental procedures are illustrated in Fig. 1. Bending strength and water absorption in step 6 have been conducted in accordance with TIS 614-1986 and calculated by the formulas as expressed in Eq. (1) and Eq. (2).

$$B = \frac{3PL}{2bd^2} \qquad \text{Eq. (1)}$$

Where

B = bending strength (MPa)

P = the maximum load applied to break a specimen (N)

L = span length of beam supporting specimen (mm)

b = width of specimen (mm)

d = thickness of specimen (mm)

$$\%\text{Water absorption} = \frac{(W_w - W_d)*100}{W_d} \qquad \text{Eq. (2)}$$

Where

W_w = wet weight of specimen after placed in boiling water for five hours then soaked in room temperature water for 24 hours (g)

W_d = dry weight of specimen (g)

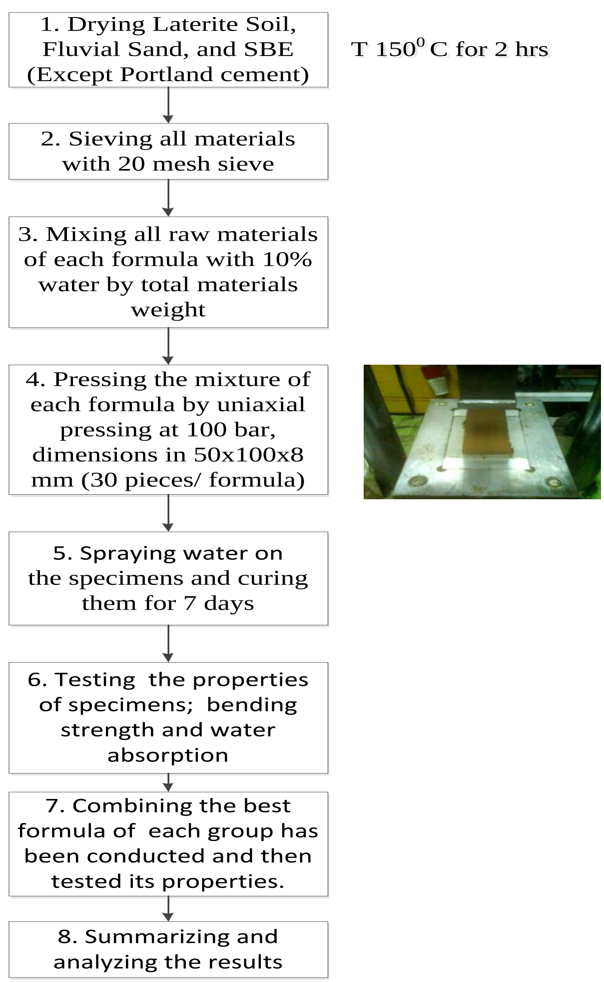

Figure 1. The experimental procedure

After testing all specimens of each formula, the results have been analysed and summarized by statistical analysis which will be described in the following section.

3. RESULTS AND DISCUSSION

The physical properties of this experimental testing have been divided into three groups in accordance with the group's formula. Table 4, 5 and 6 have illustrated the bending strength and water absorption of group 1, 2 and 3, respectively.

3.1 Physical Properties of Group 1

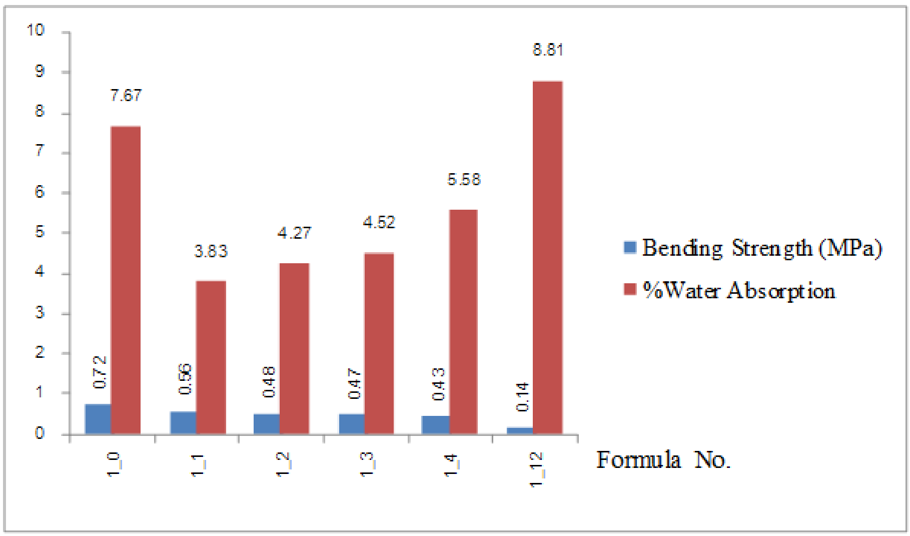

Figure 2. Bending strength and water absorption of group 1

According to Fig.2, the formula No.1_0 has been conducted as the basic formula in the comparison with other trial formulas. The results show that bending strength of specimens tend to decrease as the percentage of SBE increase. On the contrary, water absorption of them has decreased as the increase of %SBE. The best formula is No.1_1. Its bending strength is very closer to the basic formula. Additionally, its water absorption is lower than the basic formula. The aim of this research is to find out the formula that gives the high bending strength and low water absorption.

3.2 Physical Properties of Group 2

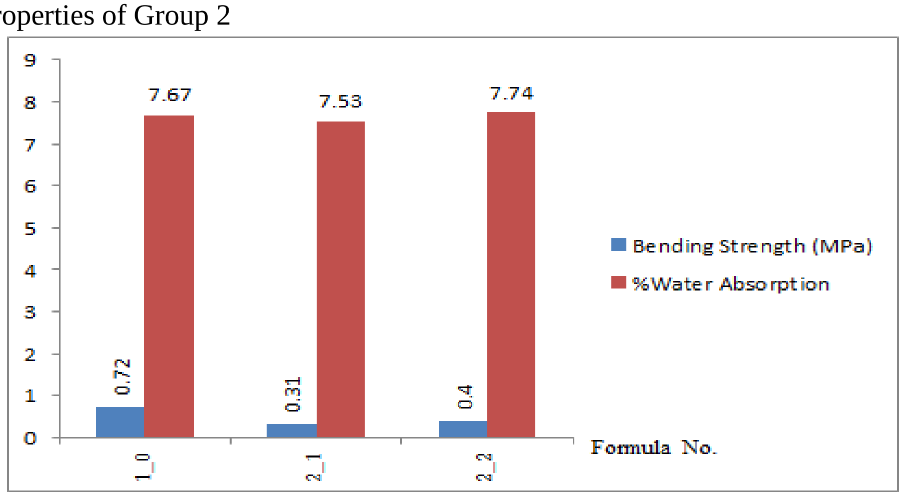

Figure 3. Bending strength and water absorption of group 2

Physical properties of group 2 have been illustrated in Fig. 3. SBE waste has been varied the percentage composition and replaced in Portland cement. The results show that bending strength and water absorption of each formula are not difference. However, bending strength of all formulas in group 2 is lower than that of the basic formula (No.1_0). Therefore, this is not an attractive result and further study will not be performed.

3.3 Physical Properties of Group 3

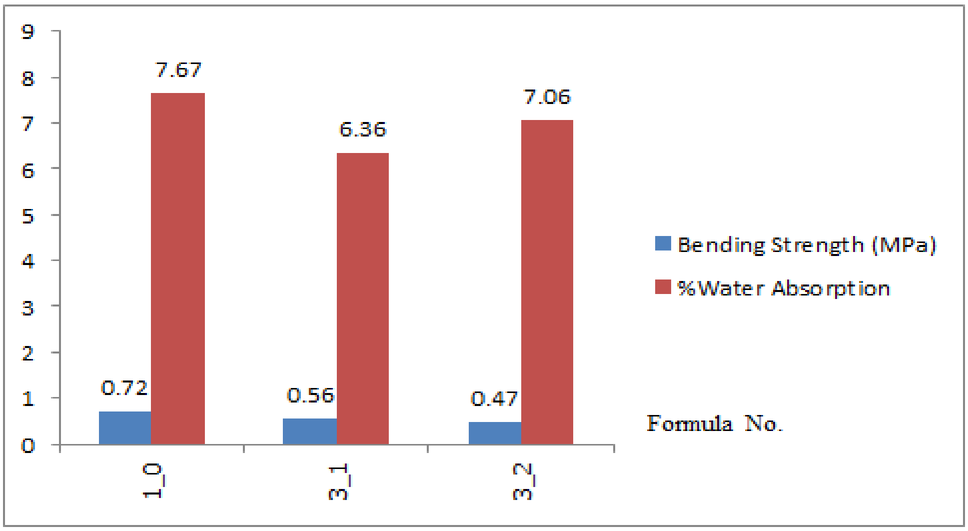

Figure 4. Bending strength and water absorption of group 3

Fig.4 has showed the physical properties of group 3. It is similar to the result of group 1. Bending strength tend to decrease when %SBE increase in replacement of fluvial sand. On the other hand, water absorption of them has decreased as the increase of %SBE. The best formula is No.3-1. Because bending strength is very closer to the basic formula. Furthermore, its water absorption is lower than that of the basic formula.

3.4 Combining the best formula of group 1 and group 3 and testing the physical properties

Comparison of the formula No.1_1 and No.3_1 has been combined and averaged the mid- point composition. Therefore, formula No.1_1+3_1 has been conducted as shown in table IV. The physical properties of specimens comparing to curing period (7 and 30 days) are indicated in Fig. 5.

Table 4. Composition formulas of combining of group 1 and 3

No.	%Fluvial Sand	%Portland Cement	%Laterite Soil	%SBE
1_1+3_1	13.125	22.5	60.94	3.435

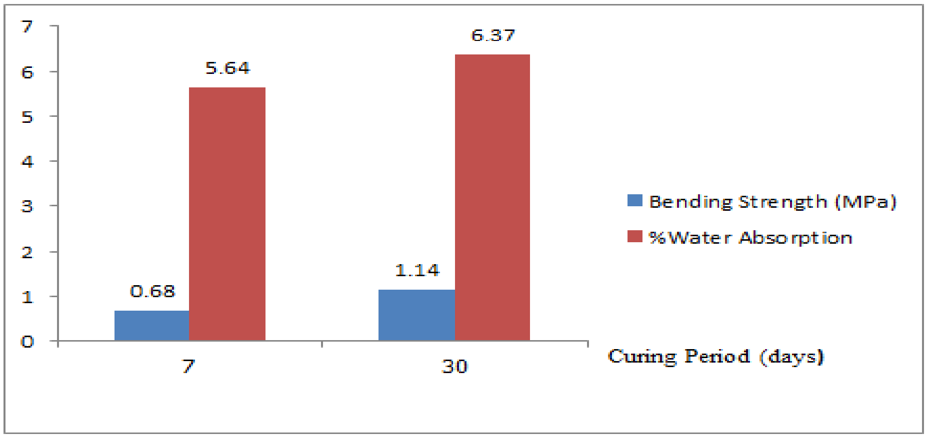

Figure 5. Bending strength and water absorption at different curing period of formula No. 1_1+3_1

According to Fig.5, bending strength of formula No.1_1+3_1 at 7 days of curing period is closer to the basic formula. In addition, at 30 days of curing period it gives the higher bending strength. However, water absorption of two curing periods is not difference and lower than that of the basic formula.

3.4 Statistical Analysis

Experimental design should be performed along with the experiment for confirmation and verifying the outcome [15]. In this study, one way ANOVA has been used for analysing the effect of raw material changed on the physical properties. P-values of hypothesis testing with a 0.05 significance level of the experiment are illustrated in Table V.

Table 5. One way ANOVA test with a 0.05 significance level of varying raw materials on physical properties of each group.

	p-value	
Group	Bending Strength	Water Absorption
1	0	0
2	0	0.48
3	0	0.018

According to table V, p-values of bending strength for all experimental groups are less than 0.05. This means that replacement of SBE waste into main raw materials has an effect on bending strength. Similarly, p-values of water absorption of experimental groups are also less than 0.05 except group 2. It can be summarized that replacement of SBE into laterite soil and fluvial sand has an effect on water absorption. Meanwhile, replacement of SBE waste in Portland cement has not affected the water absorption property.

4. CONCLUSION

The results in the previous section can be summarized that utilizing SBE waste for the alternative materials of non-fired wall tiles may be feasible. The formula No.1_1+3_1 is the best which bending strength is closer to the basic formula. In addition, it can be concluded that SBE waste can fill up between the particles of laterite soil and of fluvial sand. Therefore, the water absorption is less than that of basic formula. Materials costs of all materials per 1000 g. and the best formula are 0.08996 THB ($0.00276 USD) per 100 g. of the test specimen which are shown in table VI and VII, respectively.

Table 6. Materials Costs of the experiment

Raw Material	THB/ 1000 g
Fluvial Sand	0.235
Portland Cement	3
Laterite Soil	0.318
SBE	0

Table 7. Materials costs of the best formula (No.1_1+3_1)

	%By weight (g)	Costs of Materials (THB)
Fluvial Sand	13.125	0.00308
Portland Cement	22.5	0.06750
Laterite Soil	60.94	0.01938
SBE	3.435	0
	100 g.	0.08996 THB ($0.00276 USD)

Note: $1 USD = 32.62 THB

Water absorption of the best formula is approximately close to the TIS 614-1986 standard. However, bending strength of the specimens is low and less than the standard as shown in table VIII. Therefore, adjusting the composition of raw materials to improve the bending strength property should be investigated. For example, increasing the composition of Portland cement may enhance the bending strength property.

Table 8. Comparison the physical properties of the best formula with TIS 614-1986

		Bending Strength (Mpa)	%Water absorption
TIS 614-1986 Standard		20	6
Formula No.1_1+3_1	7 days curing period	0.68	5.64
	30 days curing period	1.14	6.37

Additionally, the new texture of specimens has been designed by modifying the press mold, although the bending strength could not pass the standard. It is illustrated in Fig. 6. In the future, if bending strength of products can meet TIS 614-1986, it can response the customers who want to use the ecofriendly products which need not to fire.

Figure 6. The texture of a test specimen

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