Utilization of vegetable oil refinery activated carbon-bleaching earth as an additive to the production of low-density facing bricks

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Abstract. Incorporating industrial wastes and recyclable materials as additives and/or alternatives in raw materials of concrete bricks is an approach used by environmentalists to convert wastes to reusable materials. Facing bricks are aesthetic material that can be installed in the internal or external walls of houses or buildings. Spent Activated Carbon-Bleaching Earth (SACBE) is an industrial waste generated from the physical refining process of vegetable oil. SACBE is commonly disposed or buried in dedicated landfills. SACBE has no significant utilization and causes environmental hazards upon disposal. The study is designed to find the most effective and efficient mixture ratio of cement facing bricks with SACBE. The paper also investigates the physical and mechanical properties of the SACBE mixture. Three sets of mixtures with varying amount of SACBE in 800 mL, 900 mL, and 1 L of water were created. The volume of sand in the original ratio was substituted with 0% SACBE up to 30% SACBE in increments of 5%. Cement, sand, SACBE, and water were mixed accordingly to the different ratios and air dried in 7 days. Analysis of the results showed that as the percentage of SACBE increases, the density of the facing bricks decreases while the volume of water has no concrete effect on density. The water absorbed in varying amounts of water with the same percentage of SACBE decreased for most samples while the compressive strength is lower for the 900 mL across all samples. Results showed that the 30% SACBE mixture in 1 L of water is the optimum mixture of SACBE. This mixture exhibits higher compressive strength while having lowest density and minimum water absorption compared to other mixtures.

Keywords: Spent Bleaching earth, Facing bricks, Activated carbon, Low density material
1. Introduction
Spent Activated Carbon-Bleaching Earth (SACBE) is a solid industrial waste from the physical refining process in the edible oil industry. It is usually disposed of and/or buried in landfills [1]. In the Philippines, the Department of Environment and Natural Resources (DENR) classified SACBE as hazardous waste due to its slow decomposition and spontaneous combustion on exposure to air [2][1,3]. After the refining process, SACBE absorbs a high percentage of residual oil (~20-40%) [4] and leaves the refining process between 80°C-120°C and if disposed in landfills may spontaneously combust once exposed to atmospheric oxygen [1]. Thus, handling and disposing of SBE is a fire risk, source of environmental regulatory concerns, and additional operating expenses [5]. Moreover, the high generation of SACBE with no significant use could cause environmental hazards and pollution in groundwater.

The current trend in the manufacture of concrete bricks is to use recycled materials as additional or alternative materials in concrete mixture due to higher public awareness about ecological sustainability and environmental damage of the usual earth materials[6]. Conventional clay bricks utilizes earth-based materials such as clay, shale, and sand. The addition of industrial waste but similar earth materials like clay, shale, and sand may help curve depletion of natural resources and provide a safe disposal for industrial waste [7,8]. Facing brick is made up of cement, sand, and water. As this kind of bricks is not used to support loads, the sand is often replaced by other materials.

Due to similar composition with materials used in facing bricks, SACBE can be used as an additive to brick mixtures. This study aimed to utilize SACBE as an additive in the production of facing bricks. Consequently, the properties of the mixtures such as compressive strength, density, and water absorption were compared to concrete facing bricks without SACBE.

The study is conducted by using SACBE provided by a chosen research partner, an edible oil refining company in the Philippines. Finding the optimum mixture ratio of SACBE is encouraging to both government and the oil refining company as this may present an innovative way of disposing SACBE. The product is limited in using Spent Activated Carbon-Bleaching Earth (SACBE) as an additive in manufacturing of cement facing bricks and determining properties essential to its primary use. The results of the study are relevant only to the company, which supplies SACBE.

2. Methodology
The schematic diagram of the research is presented in Figure 1.

2.1 Collection of raw materials
SACBE was sourced from Mt. Makiling International Oil, Inc., an edible oil refinery in the Philippines. Dried SACBE from the oil company was sieved using 200 mesh. Sand after undergoing 100 degree Celsius drying for moisture removal, commercial cement and water were all mixed in the laboratory room of Casal Building, T.I.P. Manila.

2.2 Preparation of mixture
Cement and sand are usually mixed in ratio of 1:6. Sand is replaced by SACBE in volume percentage from 0 to 30 in increments of 5. Preliminary tests showed addition of greater than 30% volume
percentage of SACBE will not generate a solid functional brick. The facing brick with 0% SACBE was considered as the control and standard for the experiment. To enable comparative results and consider the oil content of SACBE, the amount of water was varied in 800 mL, 900 mL, and 1000 mL. The molds for the bricks have dimensions of 114 mm x 64 mm x 16 mm. There were 63 samples produced for the research.

2.3 Drying of samples
The samples were air dried for 7 days to monitor its solid form and compressive strength. The samples were weighed to record its initial weight needed to determine the facing bricks water absorption rate.

2.4 Testing

2.4.1 Test for water absorption.
After the bricks were air-dried for 7 days, it was subjected to water curing. The facing bricks were boiled in water at 100 degrees Celsius for 2 hours and then immersed at room temperature water for 24 hours then reweighed. The difference in the initial and final mass is the amount of water absorbed. The data obtained is recorded with a total of 3 trials per percentage of SACBE mixture created at different amounts of water.

2.4.2 Testing for compressive strength.
Subsequently, 3 trials per percentage ranging from 0% up to 30% of the seven days air-dried brick samples were tested using the Universal Testing Machine (DIGIMAX C0019/Y) located at A-105 Ground Floor, Arlegui Building, T.I.P. Quiapo, Manila to determine its compressive strength.

2.5 Analysis of data
Test results from water absorption, density, and compressive strength were analyzed, tabulated, plotted and compared to standards. The sample with 0% SACBE served as the standard value of comparison while the 30% SACBE was set as the limit.

3. Results and discussion

3.1. Results on density
The average density of the facing bricks produced at different rate of SACBE and volume of water in the mixture ratio are shown in Figure 3.1. The 0% SACBE was used as the standard in comparing the tests result. Variation in the amount of sand and water recorded a fluctuating graph for the density of the facing bricks. The results fluctuated between 1500 kg/m$^3$ to 1700 kg/m$^3$ for the 800 mL-SACBE mixture. The same trend was observed for the 900 mL – SACBE mixture. However, the difference in the values for the 1000 mL-SACBE mixture was as high as 400 kg/m$^3$. The decrease and increase in the density of the facing bricks was from 10% to 17% of the standard value of 1562 kg/m$^3$. There was no observable trend in the density of the bricks when SACBE and the volume of water were varied. The 900 mL water – 20% SACBE mixture represents the highest density of 1834 kg/m$^3$ while the 1000 mL water – 30% SACBE mixture represents the lowest density of 1421 kg/m$^3$. 
3.2. Result on water absorption

The amount of water absorbed determined the additional load the bricks carried during weathering. Figure 3.2 illustrates the water absorption of facing bricks produced at different percent SACBE and amount of water. Variation in percentage of SACBE with variation in water showed a decrease for the 900 mL samples compared to other samples. Both 800 mL and 1 L samples registered higher amount of water absorbed with the 800 mL-25% sample mixture posting the maximum amount of water absorbed among samples and the minimum recorded with.

Figure 3.1 Density of SACBE-facing bricks vs. %v/v SACBE with different volumes of water

Figure 3.2 Percent Water Absorbed of SACBE-facing bricks vs. %v/v SACBE with different volumes of water
3.3. Result on compressive strength

The compressive strength of facing bricks produced at different percentage SACBE and volume of water is shown in Figure 3.3. The 0 % SACBE was used as the standard for comparing compressive strengths. All standards posted higher compressive strength compared to SACBE containing mixtures and volume of water. The 10% SACBE in 800 mL posted the highest compressive strength at 0.8667 kPa while the 30% SACBE in 900 mL recorded the lowest compressive strength at 0.37 kPa. The compressive strengths of SACBE mixtures fluctuated with variations of SACBE content. The difference in compressive strength varies from 14% to 25%. The load each mixture can withstand before buckling also fluctuates within the different percentage of SACBE. The load ranges from 8% to 30% of the standards reading. The compressive strength decreases with the addition of SACBE in place of sand due to the texture and property of SACBE compared to sand. Clays and activated carbon are softer compared to sand.

![Figure 3.3 Compressive Strength of SACBE-facing bricks vs %v/v SACBE with different volumes of water](image)

4. Conclusion

The results showed that the density of the mixture decreases with increase in SACBE, the lowest posted by the 1L-30% SACBE mixture. Lower density materials mean less additional weight load when used in buildings. The amount of water absorbed determines the additional load, bricks will have to carry during weathering. Bricks samples with 800-mL water have the maximum water absorption capacity equivalent to 19.6% of its original weight. It is preferred that bricks absorbed less water so as not to put on more load to carry for roofed housing. Generally, bricks with SACBE tend to absorbed more water compared to the standards. The compressive strength of the samples decreased with every increase in the percentage of SACBE in the bricks compared to 0%SACBE. There is no significant difference within the set of mixtures as generally, they all have lowered compressive strengths compared to the standards.

Regardless of the volume of water, the density of the facing bricks is indirectly proportional to the percentage of SACBE added. While choosing the optimum mixture, considerations were confined to less dense material, lower absorption of water and higher compressive strength. Thus, the 30%
SACBE is the optimum amount which can be added to the sand-cement mixture. This mixture displays the highest compressive strength and load while having the lowest density compared to other mixtures results.

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