

# Physical and Mechanical Properties of Compressed Earth Brick (CEB) Containing Sugarcane Bagasse Ash

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**Abstract.** The use of brick in construction is commonly used, especially in the construction of buildings and infrastructure. Various studies have been conducted to produce methods that can increase the strength of brick at the same time can reduce the cost of manufacturing bricks. In order to reduce cost of manufacturing, one of the solution applied was by using waste as part of bricks production materials. In this study, sugarcane bagasse (SuCaB) ash was used as a part of compressed earth brick (CEB) by replacing the quantity of cement for SuCaB ash. The study focused on the physical and mechanical properties of CEB containing SuCaB and the optimum percentage of SuCaB ash as partial cement replacement in CEB. There are 4 types of percentages used; 0%, 20%, 25% and 30% from cement content. All mixed use the same water content of 30% of cement content by weight and the ratio for cement: laterite soil used was 1: 6. A total of 72 specimen with size of 100mm x 50mm x 40mm was produced. The test conducted were Initial Rate Absorption Test (IRA), Density Test, Dimensions Test, Compression Test and Water Absorption Test. From the experimental results, the optimum SuCaB ash percentage as cement replacement in CEB was 20%. It recorded the highest compressive strength of 16.23 MPa at 28 days while for the Initial Rate Absorption test, it lies within the range specified. The density of CEB containing 20% of SuCaB shows slightly lower value where it decreased for about 0.4% from the control specimen. From this study, it can be concluded that waste materials such as sugarcane bagasse can be used as part of construction materials. However, further study needs to be conducted such as on the energy consumption, chemical properties and others to enhance the knowledge on this area before it can be applied into the brick production.

## 1 Introduction

Due to limited availability of natural resources and rapid urbanization, there is a shortfall of conventional building construction materials. On the other hand, energy consumed for the production of conventional building construction materials pollutes the air, water and land. Accumulation of unmanaged agro-waste, especially from the developing countries has an increased environmental concern [1]. Therefore, development of new technologies to recycle and convert waste materials into reusable material is critically importance for the protection of the environment and sustainable development of the society [2]. The need to conserve traditional building materials that are facing

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depletion has forced engineers to look for alternative materials. Recycling of such wastes by incorporating them into building materials is a practical solution to the pollution problem [3].

## 2 Literature

### 2.1 Compressed earth brick

Compressed Earth Brick (CEB) is combination from three different materials which is Ordinary Portland Cement, soil, and sand that mixed together with addition of water by compression method. It is faster, easier, less skill labor required, good strength, good insulation, less carbon emission, and environmental friendly product. CEB is claimed as a sustainable product that using local material to produce it. However, local soils give a difference performance on their physical and chemical properties such as strength, durability, thermal and water absorption rate. By UNESCO Chair Earthen Architecture (2010), clay laterite soil is suitable for the production of CEB. Since Malaysia has an equatorial climate, the most suitable soils use and easy found is the laterite soil [4].

### 2.2 Sugarcane bagasse fly ash

In the sugar industry, sugarcane bagasse is more related as the by-product in sugarcane mills. After the sugarcane is pressed to remove sucrose or known as table sugar, the residue is called as sugarcane bagasse which contains highly fibrous residue. After the sucrose removal, the bags is generated and its accumulation presents as a waste problem for the sugar industry. Requirement for economic and environmental friendly materials has extended an interest in natural fibers [5].

The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicellulose and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide ( $\text{SiO}_2$ ). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests [6]. Due to limited availability of natural resources and rapid urbanization, there is a shortfall of conventional building construction materials. Therefore, study has been conducted by many researchers on the use of agricultural waste as partial construction materials either cement, sand or aggregate [7-11].

## 3 Methodology

In this experimental work, a total of 72 brick specimens were produced for the seventh and 28<sup>th</sup> days. The specimen size was 100 mm x 50 mm x 40 mm. The percentage of SuCaB ash were 0%, 20%, 25% and 30% from cement content. The percentage were chosen based on literature review where beyond 30% replacement, it shows inefficiency to replace cement in normal concrete. All experiments were conducted in accordance with Standards BS 3921: 1985 and MS 76: 1972. Table 1 shows the summary of specimen that produced according to the testing day and types of test conducted.

**Table 1.** Summary of specimen.

Testing day SuCaB(%)	7 <sup>th</sup>				28 <sup>th</sup>			
	0	20	25	30	0	20	25	30
Test								
Compression	3	3	3	3	3	3	3	3
Water absorption	3	3	3	3	3	3	3	3
IRA								
Density	3	3	3	3	3	3	3	3
Total	9	9	9	9	9	9	9	9
	36				36			

### 3.1 Material procurement

#### 3.1.1 Laterite soil, cement and water

The dry laterite soil were crushed by using crushing machine and sieve until particle size of soil that past on 1.18mm. In this study, the cement used is Ordinary Portland Cement (OPC) while the water used was available in the laboratory confirming to the requirements of water for mixing and curing.

#### 3.1.2 Sugarcane bagasse (SuCaB) ash

The SuCaB was collected at stall in area Parit Raja, Johor. SuCaB was grinded until fine by using the particle size machine. The bagasse then placed inside electric control furnace and burnt at temperature of 450°C for 2 hours. After that, the ash obtained was grinded again by using planetary micro mill.

### 3.2 Production of CEB containing SuCaB as partial cement replacement

The brick manufacturing process is a critical element and should be given special attention. The materials used to produce these specimens were measured by volume. Figure 1 show the materials that has been weigh and ready to be mixed. Then the material must first be mixed thoroughly as shown in Figure 2 before pouring the water. The amount of water used was 600ml. After the mix has been thoroughly blend, it was put into a mold as shown in Figure 3. Hydraulic machine as in Figure 4 was used with the pressure of 2000 psi pressed onto the specimen. Figure 5 shows the process of pressing specimen to produces compressed earth brick (CEB).



**Figure 1.** Materials used to produce CEB.



**Figure 2.** Mix of materials.



**Figure 3.** Mold used to produce specimen.



**Figure 4.** Hydraulic Jack with pressure of 2000 psi.



**Figure 5.** Specimen subjected to pressure.

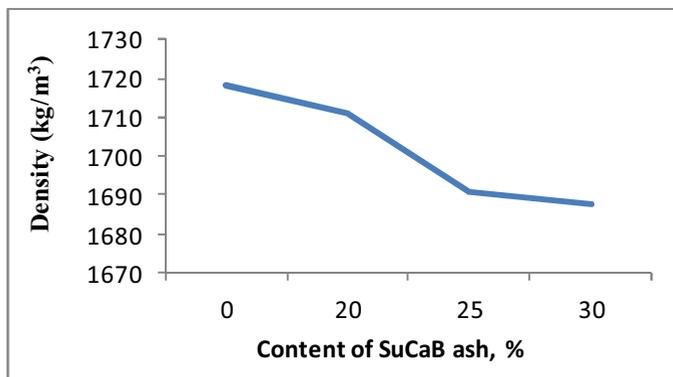
## 4 Data Analysis

### 4.1 Density test

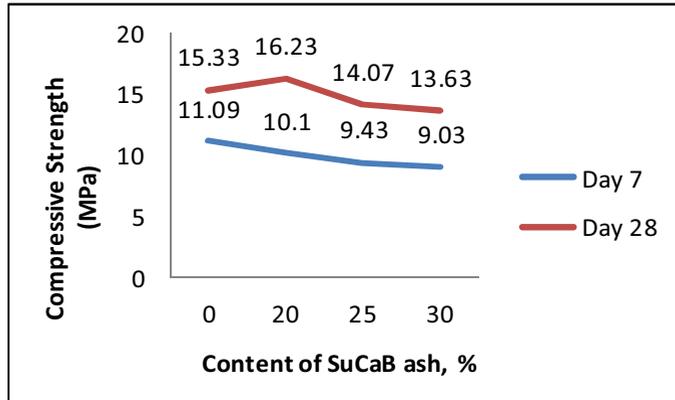
Figure 6 shows the density of bricks for all percentage. For control brick (0% SuCaB ash), the density recorded was 1718.03 kg/m<sup>3</sup>. For brick containing SuCaB ash of 20%, 25% and 30%, the density slightly decreased to 1710.76 kg/m<sup>3</sup> and 1690.73 kg/m<sup>3</sup> and 1687.69 kg/m<sup>3</sup> respectively. The lowest value was brick containing 30% SuCaB with a decreased of 1.76% compared with the control specimen. From this experimental results, it shows that the density of concrete containing sugarcane bagasse decreased as the percentage increased. This shows that the bagasse makes the bond between aggregate in the concrete weaker than the control specimen.

### 4.2 Compression test

Figure 7 shows the relationship between the compressive strength and percentage of SuCaB ash on the 7th and the 28th days. Specimen with 20% of SuCaB ash recorded the highest strength compared to other specimens of 16.23 MPa. From the results, it was found that the additional SuCaB ash reduced the strength of the CEB compared to the control brick as the brick become more porous with a higher percentage of SuCaB ash. The additional of exceed 20% of SuCaB ash weaken the bond strength between the brick interface materials. The optimal percentage of SuCaB ash observed was 20% with 16.23 Mpa compressive strength.



**Figure 6.** Density of concrete vs percentages of SuCaB ash.



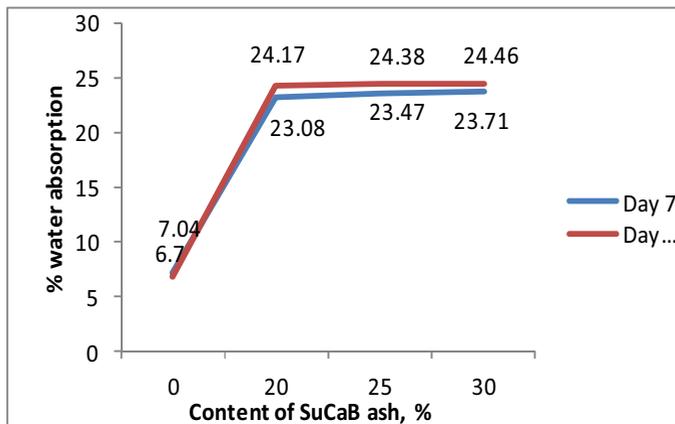
**Figure 7.** The relationship between the compressive strength and percentage of SuCaB ash on the 7th and the 28th days.

### 4.3 Water absorption test

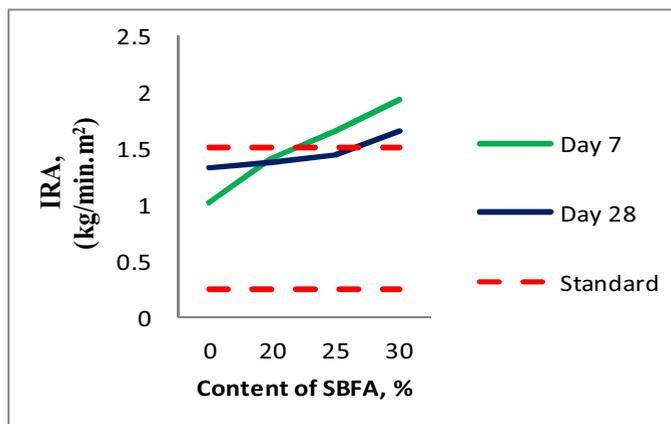
Based on Figure 8, the percentage of water content of specimens with 0% SuCaB ash is the lowest with 7.04% on day 7 and 6.04% on day 28 after being soaked for 24 hours. The percentage of water content increased dramatically in the percentage of 20% with 24.17% on day 7 and 23.08% on day 28. Then, it increase slightly on the percentage of 25% and 30% by value of 24.38% and 24.46% at day 7, 23.49% and 23.71% on day 28 respectively.

### 4.4 Initial rate absorption test

Based on Figure 9, the IRA of 20%, 25% and 30% of SBFA increased compared to control CEB specimen. For 0% and 20% of SuCaB ash, the IRA for 7 and 28 days were within the range specified. While the 25% of SuCaB ash on 28 days, which is within the standard, while the other percentage rest exceed the range of standards.



**Figure 8.** The relationship between the water absorption and percentage of SuCaB ash on the 7th and the 28<sup>th</sup> days.



**Figure 9.** The relationship between the IRA value and SuCaB ash on the 7th and the 28th days.

## 5 Conclusion

The results show that with the addition of SuCaB ash by 20% of cement content in CEB brick, the compressive strength increased compared with CEB without SuCaB ash. However, higher than that, the compressive strength started to decreased and it shows that the optimum content for SuCaB addition was at 20%. The density of CEB decreased with the increase of SuCaB ash content and thus light weight CEB can be produced with further research.

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