



INVESTIGATION OF COMPRESSED EARTH BRICK CONTAINING CERAMIC WASTE

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ABSTRACT

This study presented experimental results on the use of ceramic waste as substitutes in the composition of laterite soil compressed bricks, better known as compressed earth brick (CEB). The use of ceramic waste was chosen because in recent years it can be seen landfills can no longer accommodate the growing of solid waste. Some examples of solid waste are glass, cans, plastic, paper and ceramic waste. Ceramics used in this study are ceramic rest that has been broken taken from the landfill and then crushed before mixing with the mixture of CEB. The main objective of this study was to investigate the physical and mechanical properties of compressed earth bricks containing waste ceramics and to determine the optimum percentage of waste ceramic in any mix of revenue compressed earth bricks. A total of 72 units of bricks were produced and used to test the density, water absorption, compressive strength and the initial rate absorption. The sample size utilize prototypes size of 100 mm x 50 mm x 40 mm. Laboratory tests conducted in accordance with the test procedures that were performed on brick CEB as specified in BS 3921: 1985 and MS 76: 1972. The experimental results shows that the ratio of ceramic waste 75% was the optimum value because it recorded the highest compressive strength with 33.6 N/mm² and the test of water absorption and initial rate absorption test were 17.2% and 1,634 kg / min / m² respectively.

Keywords: compressed earth brick, ceramic waste, soil replacement.

INTRODUCTION

Waste is materials resulting from an activity or process undertaken by humans, animals and even plants that can comes from industrial activities, municipal, animal husbandry and agriculture. It can be divided into sections such as solid waste, liquid waste and radioactive waste. Ceramics is one of the solid wastes that comes from human activities. Ceramics taken from the English word ceramic is derived from the Greek word, and simply refers to all forms of clay (Kingery *et al* 1976). Ceramic products made from natural materials consisting mainly of clay minerals. After certain process such as dehydration and combustion at a temperature between 700 ° C to 1000 ° C, the ceramic then have almost similar properties as clay. Therefore, it was predicted that ceramic can substitute clay in brick production. Ceramic or in Greek is called CERAMOS means objects made of clay. Therefore, all things produced from clay and then baked at a certain temperature levels are categorized as ceramics. However, the uses of modern terminology expand its use to include non-metallic inorganic materials (Kingery *et al* 1976).

Compressed earth bricks (CEB) provide faster, easier, economic, good strength and environmentally friendly system (Jayasinghe and Mallawaarachchi 2009) (Morel *et al.* 2007) (Muntohar 2011). It is economic because it does not require skilled labour for the installation. It can be installed as normal brick because it has the same size and shape as normal brick (Guettala *et al.* 2002). The raw material is mixed with stabilizers such as cement or lime and compacted under pressure of

20-40 kg / cm² using soil media. Brick wall is defined as one unit not exceeding 337.5 mm long, 225 mm wide and 112.5 mm high (MS76:1972). According to British standard, BS 3921: 1985 specification for brick and block brick, the size of the actual work for a brick is set to 215 mm x 102.5 mm x 65 mm. Compressed earth bricks (CEB) offers a sustainable construction, where it has been widely used in the construction of walls, roofs, gates and also for support (Oti *et al.* 2009) (Morel and Pkila 2002). CEB is produces by compressing the raw material which has been mixed with earth stabilizing agent such as cement using a special tool. The compress tools consists of a manual and a hydraulic pressure (Deboucha and Hashim 2011).

Looking at the potential of ceramics as clay substitution in producing bricks, this study was conducted involving experimental work on 72 bricks with different percentage of ceramic as clay replacement.

MATERIALS AND METHODS

72 pieces of bricks with a prototype size of 100mm x 50mm x 40mm was produced where ceramic replacement were 0%, 50%, 75% and 100%. The 0% replacement was treated as control specimen the brick consist of 100% laterite soil. All experiments were conducted in accordance with Standards BS 3921: 1985 and MS 76: 1972. Table 1 below shows the quantity of samples generated by the number of days and conducted experiments.

**Table-1.** Table of specimen.

Days	7 th				28 th			
% of Ceramic Waste Replacement	0	50	75	100	0	50	75	100
Compression Test	3	3	3	3	3	3	3	3
Water Absorption Test	3	3	3	3	3	3	3	3
IRA Test	3	3	3	3	3	3	3	3
Density Test								
Total	9	9	9	9	9	9	9	9
	36				36			

Material preparation

The dry laterite soil was crushed by using crushing machine as shown in Figure-1 and sieve until particle size of soil that pass 1.18mm. For cement, Ordinary Portland Cement was used. The ceramic waste in this study was collected from a factory located at Ayer Hitam namely as Clayton Ceramics Sdn. Bhd. The ceramic waste was cleaned from any impurities, then crushed using hammer into smaller size (see Figure 2) before it crushed again using crushing machine and sieve to get same particle size as laterite soil.

**Figure-1.** Crushing of laterite soil.**Figure-2.** Crushing of ceramic waste into smaller size before it can be crushed using crusher machine.**Preparation of sample**

Sample was prepared using mould box of 100mm x 50mm x 40mm as shown in Figure-3. In the production of samples, materials namely ceramic waste was mixed with cement and subsequently laterite soil prior to compress using compactor machines (Enerpac hand pump). Compaction is carried out with the capacity of 2000 psi pressure as shown in Figure-4. The quantity of water required for mixing is 330ml. On the other hand, the ratio of soil:cement used was 1:6.

After that, the sample was cured so that it hardens and dry. Compressed earth bricks sample is left with the preservation process based on the maturity of the concrete because there is no specialization of maturity for this type of brick. The samples were left in two different time periods of 7 days and 28 days. For the curing process, the brick samples were left in a sheltered area out of direct light from the sun and rain as shown in Figure-5. The curing process also aimed at maintaining the water content contained in the sample and avoiding the occurrence of evaporation of the water content to be uneven.

**Figure-3.** Mould for the brick.



Figure-4. Brick pressed using hydraulic jack.



Figure-5. Curing of specimen.

RESULT AND DISCUSSIONS

Laboratory tests were carried out on density, compressive strength, initial of water absorption rate and water absorption. Tests conducted and analyzed in accordance with standard BS 3921: 1985 and MS 76: 1972.

Density test

Figure-6 shows the average percentage density of each sample produced with control samples.

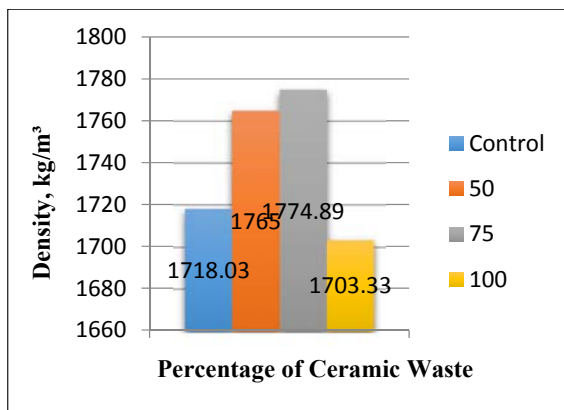


Figure-6. Graf density vs % of ceramic waste.

Based on the percentage obtained, a mixture of 75% ceramic material recorded the highest density of 1774.89 kg / m² while the lowest density was 1703.33 kg / m² with ceramic percentage of 100%. From the results obtained, it can be seen that the maximum ceramic

replacement percentage can be added was 75%. Beyond that, the density decreased dramatically.

Water absorption test

The test is conducted in accordance with stipulated by the standard BS 3921: 1985 and MS76: 1972. Figure-7 below shows the rate of water absorption for day 7 and 28.

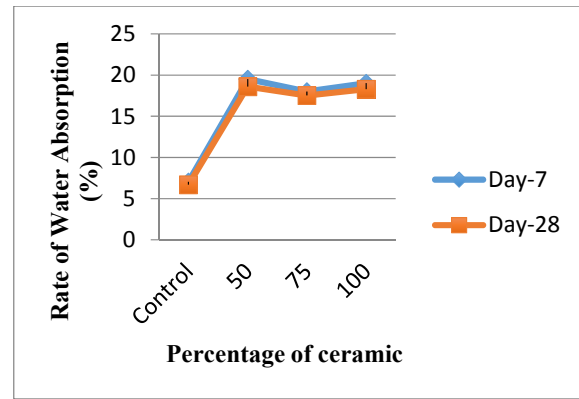


Figure-7. Graphic rate of water absorption versus % ceramic content in 7 and 28 days.

From Figure-7, the sample ceramic content of 50% recorded the highest readings for both period of 19:52% and 18.60%. The lowest water absorption was recorded for sample containing 75% of ceramic content of 18.1% and 17:52% for a period of 7 and 28 days. The results shows that between the samples with added ceramic, 75% ceramic recorded the lowest rate of water absorption.

Compression test

Compressive strength test was performed to determine the strength of bricks produced either sample has the same strength to control brick or higher and vice versa. The Figure-8 below shows the average compressive strength for all percentage.

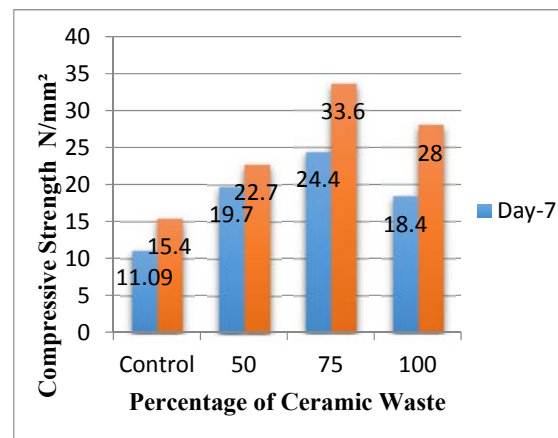


Figure-8. Graph compressive strength versus percentage content of ceramics at 7 and 28 days.



Based on the findings of the study, all ceramic mixture ratios recorded results higher than the control brick. For the highest reading for this test is a mixture of ceramic bricks containing 75% with the results of 24.4 N / mm and 33.6 N / mm for a period of 7 and 28 days. Beyond 75% ceramic replacement, the compressive strength decreased for both 7 and 28 days.

Initial rate absorption test

This experiment was conducted to know the rate of diffusion that occurs in the sample at the time of 60 seconds. The test is conducted in accordance with and mentioned by the standard BS 3921: 1985 and MS 76: 1972. Figure-9 shows the initial diffusion rate as a percentage of the mixture of ceramic substitutes on days 7 and 28.

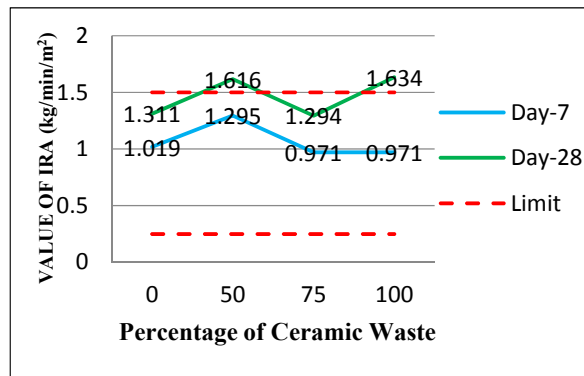


Figure-9. Content of the initial rate absorption for percentage of the sample at 7 and 28 days.

Based on the findings obtained, only the control brick and a sample that has a ceramic content 75%, is in the allowable range of IRA for two periods of 7 and 28 days.

CONCLUSIONS

Some conclusion can be drawn as follows:

- The compressed earth bricks containing ceramics recorded higher compressive strength than the control brick for all percentage.
- A positive influence on the water absorption in addition to the initial diffusion rate of the compressed earth bricks.
- The results obtained showed that the brick contains 75% waste ceramic materials brick is the optimum percentage compared to the other percentages. This percentage recorded the highest density and the highest compressive strength compared with control brick and the other percentage. While for water absorption test and initial rate absorption test, 75% of ceramic recorded the lowest value compared with the other percentage.

- It can be noted that when the percentage of ceramic increased, the brick density rate also increased. However, for the brick using 100% ceramic, the brick density is lower than the control specimen.

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