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Strength and Durability of Sand Cement Brick Containing Recycled Concrete Aggregate (RCA) and Waste Fired Clayed Brick (FCB) As Partial Sand Replacement Materials

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Abstract: The use of burnt clayed brick (FCB) and recycled coarse aggregate (RCA) in cementitious materials aids in the reuse of clay brick waste from construction and demolition works. In fact, concrete manufacturing expanded in lockstep with the Malaysian economy's expansion. The purpose of this study is to determine the strength and durability of sand cement brick containing recycled concrete aggregate (RCA) and waste fired clayed brick (FCB) as partial sand replacement materials. According to the findings, a brick containing 0% RCA and 2% FCB has the best compressive strength, while a brick containing 15% RCA and 6% FCB has the lowest water absorption when compared to other mix designs and is the best mix design for water absorption. Lastly, it is steadily applicable the RCA and FCB as second sources of natural coarse aggregate and can reduce waste of concrete aggregate and FCB.

Keywords: Fired clayed brick, recycled concrete aggregate, sand cement brick

1. Introduction

Sand cement brick was commonly used as a construction material in civil engineering. Almost all infrastructure needs sand cement brick. This is because this concept was successfully used in Malaysian construction, where sand cement bricks were used in almost all residential and commercial structures. In masonry structures, a sand cement brick is a block that contains fine aggregate and cement content. According to Ismail & Yaacob (2010) [1], cement and brick were the most commonly used building materials in Malaysia due to their ease of availability and low cost of production. However, as the market for sand cement brick grows, so does the use of natural resources. As a result of this issue, natural resources for making sand cement bricks are becoming limited due to high energy consumption. Aside from that, due to insufficient brick supply, the market price of brick has risen sharply. This is due to the fact that manufacturers, especially in Malaysia, were limited in their ability to obtain natural resources for brick production. The retail price of brick would increase as a result, affecting low-cost structures.

In this research, many researchers claimed that loose of strength and durability after being exposed to high temperatures for a period of 10 to 15 days, and must be replaced with new fire bricks every two weeks or more [2-3]. As a result, the FCB is an industrial solid waste that must be properly disposed of, revealing a broken (FCB). In this case, it has shown that fire clay brick (FCB) could contribute to environment and can be sustain in the civil industry and together could apply the recycle waste of fire clay brick that can be implement in sustainable development.

This study was going to focus on developing sand cement bricks that contained RCA and FCB waste, with design replacements of RCA and FCB of %, 15%, 30%, and 45% respectively. Aside from that, the water cement ratio that has

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been used in this study is 0.6. According to BS EN 772-1: 2011, [4] the sand cement brick mould dimension is 213 mm in length, 101 mm in width, and 63 mm in depth was conducted. After the tests were finished, the data has been analyses to determine the optimum percentage of sand cement mixture replacement.

2. Materials and Methods

The strength and durability of cement sand brick containing RCA and FCB as partial sand replacement materials were investigated in the laboratory, which include sieve analysis, density, compressive strength, and water absorption had been analyzed.

2.1 Materials

In this study, Ordinary Portland Cement (OPC), recycled concrete aggregate (RCA), and fired clayed brick (FCB) is being used.

2.2 Methods

RCA and FCB mixtures designed according to the British Standard specifications (BS-5628-3) [5]. The sand and cement brick were designed according to Malaysian Standard (MS 76: 1972) if the compressive force value did not exceed 7 N/mm2. [6-8] The ratio of water used in the brick mix design is 0.6. The study prepared 70 samples which are 30 samples for compressive strength test, 30 water absorption test, and 10 samples for density test. The brick was 215 mm long, 103 mm wide, and 65 mm. The brick sample were tested for density, compression strength test, and water absorption test. The number of specimens to be tested are 70 samples of the whole testing.

3. Results and Discussion

Equations The data obtained from the material and specimen testing is used to determine the optimum percentage of mix designations between recycle coarse aggregate and fired clayed brick in sand cement brick. An investigation was conducted based on the percentage replacement of RCA and FCB as a partial replacement of NA in sand cement brick under 7 days and 28-day curing conditions respectively. For each mixture, the w/c ratio of 0.6 was readily consistent. After the testing has been completed, the data was collected, recorded, analyses and discussed in this chapter. While, the results were presented in the form of tables and graphs to be easily understood. All of the experimental results and investigations of compressive strength, density, and water absorption between control and RCA and FCB replacement sand in sand cement brick.

3.1 Density

This test was utilised in this study to determine the density of sand cement bricks including RCA and FCB as a partial replacement in sand cement bricks. It can be concluded that, mix designation for RCA 15% for combination FCB in 2% is the highest and the mix designation for RCA 45% for the combination in 6% is the lowest in results for density test. By dividing the mass, in kg, and the volume, in m3, the density of sand cement brick specimens was calculated. Control sand cement bricks had a density of 2110.714 kg/m3. The density of sand cement brick without added FCB was constant between 15% to 30% and 45% of RCA in brick, but it is become lower after FCB is being replaced with 2%, 4% and 6%. It was also demonstrated that increasing the RCA as a partial replacement for fine aggregates in brick boosted the density value. [9]

The density of the brick mixes was influenced by the density of the control and replacement mixtures for 28 days, as shown in Figure 1. After adding FCB to the brick, the density began to decrease. It can be stated that raising the percentage combination of RCA and FCB replacement for within 7 days and 28 days reduces the density values of the sand cement brick mixture for both tests. Figure 1 shows the results of density test after 7 days while Figure 2 shows the results of density test after 28 days.

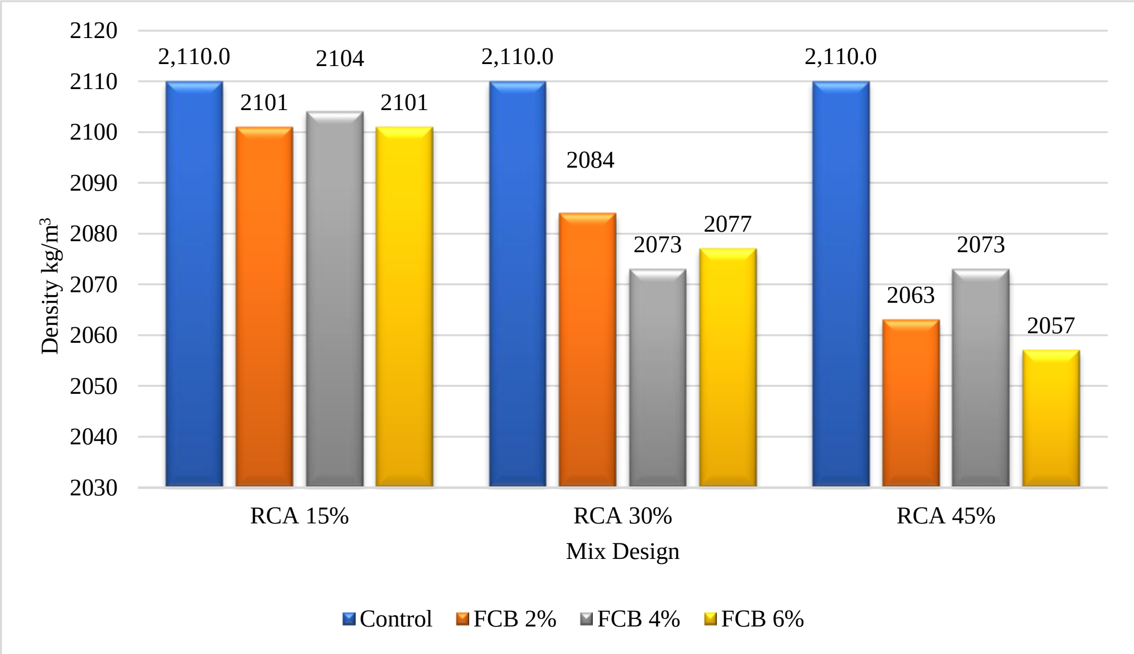

Fig. 1 - Density for 7 days

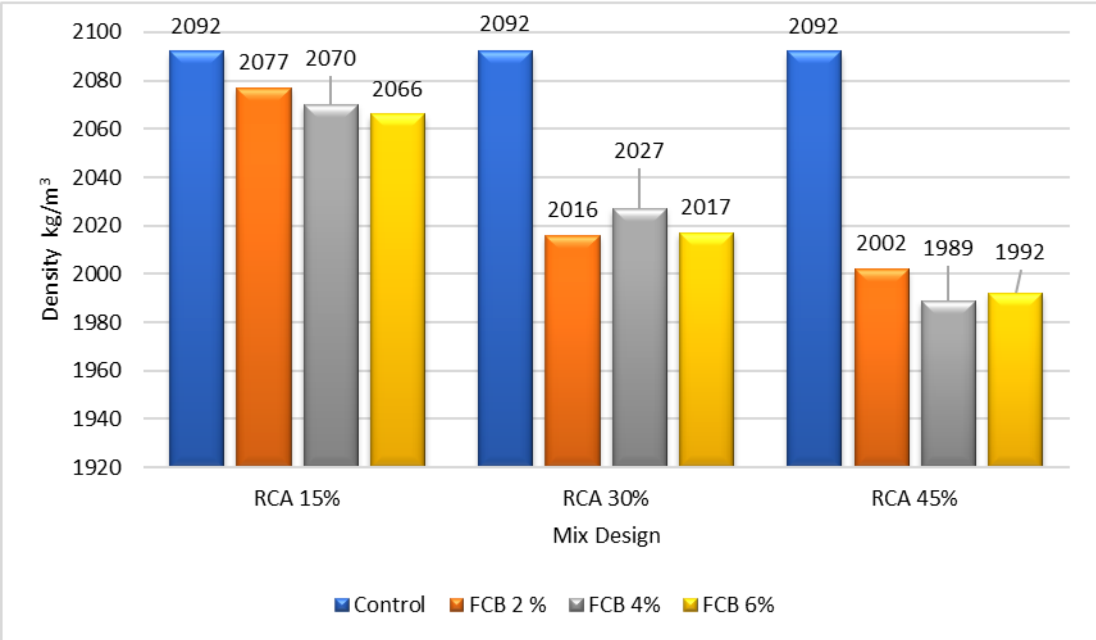

Fig. 2 - Density 28 days

3.2 Compressive Strength Test

The purpose of the testing was to determine the strength of a standard sand cement brick (control) and a sand cement brick containing various replacement percentages of RCA and FCB. The compressive strength of brick (control) and modified brick was evaluated based on these findings. According to British standards, the sand cement brick's ultimate strength must be greater than 7 N/mm2. [10-11] As illustrated in Figure 3, the negative value of average compressive strength of brick indicates that it was lower than control sand, while the positive value indicated that it was higher than control brick. The bigger the compressive strength differential between brick modified (RCA and FCB) and control brick, the better the ratio of RCA and FCB in sand cement brick [12]. According to the graph, the combination of RCA 30% replacement and FCB 2% replacement was the most effective when compared to other combinations.

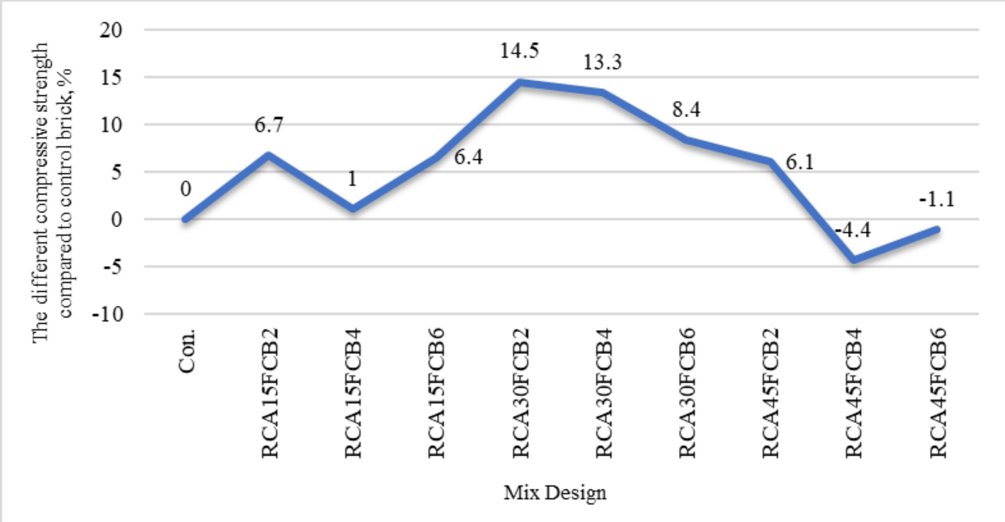

Fig. 3 - The difference in compressive strength between the test and control bricks, %

3.3 Water Absorption Test

The goal of the experiment was to compare the regular sand cement brick (control) and a sand cement brick with varied replacement percentages of RCA and FCB. The water absorption of brick (control) and modified brick was evaluated based on these findings. The minimum and maximum value of water absorption was -0.12% (minimum) to 2.17% respectively. The below value of minimum rate of percentage of average water absorption of brick implies that absorbing water in brick was extremely difficult, whereas the positive average suggested that absorbing water in brick was quite effective [13-15]. The difference in water absorption between brick modified (RCA and FCB) and control bricks was used to estimate the optimum RCA and FCB ratio in sand cement brick. Figure 4 shows percentages different of water absorption compared to control brick, %. Based on the results of the analysis, a brick comprising 15 percent RCA and 6% FCB was shown to be the best mix design, with the most decreased value of water absorption when compared to other mix designs.

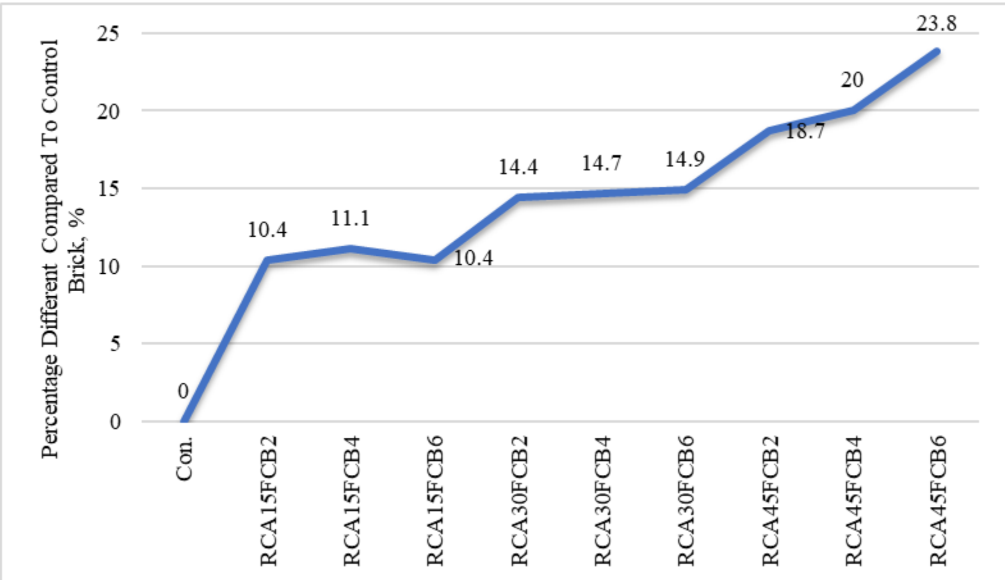

Fig. 4 - Percentage different of water absorption compared to control brick, %

4. Conclusions

In conclusion, for brick improvements, there are many research studies that have been done to increase the strength, and durability of brick itself. Some of the improvements that have been done are by conduct more tests for difference percentages of replacement of RCA and FCB. Therefore, experiment with various water cement ratios when building sand cement brick to find the best mix percentage for RCA and FCB in sand cement brick. Last recommendations are to develop ratio of sand cement brick until find the best one. For this study, the aim was to conclusive the strength and durability of cement sand brick that containing RCA and FCB as partial sand replacement material.

This study shows the physical characteristic of brick will occur to the compressive strength of brick as more FCB added. Therefore, the addition of FCB also not a huge contribution to the data obtained of compressive strength test. Overall, the ratio of the best mix designation for compressive strength test is 30%-RCA and 2%-FCB whereas 15%-RCA and 6%-FCB is for water absorption test.

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