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The Development of Sand Cement Brick Incorporating of Ceramic Tiles Waste

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Abstract: Brick is a form of masonry material used to construct walls, walkways, and other structures. Sand cement brick is porous, low mechanical strength, ductile and has poor crack resistance and to utilize the use of ceramic tiles waste in the development of sand cement brick. In this study, ceramic tiles waste is used as partial replacement of sand in the production of sand cement brick. The objective to be achieved for this study is to determine the suitable percentage of replacement and properties of sand cement bricks containing ceramic tiles waste as the partial replacement for fine aggregate. To process the CTW into smaller size, hammer and LA Abrasion machine was used. The mix consist of 40% and 50% ceramic tiles waste is partially replace sand to produce samples of 36 bricks with ratio of 1:3. Furthermore, the tests carried out on the sand cement brick samples are density tests, water absorption tests and compression strength tests. In conclusion, the optimum percentage replacement of Ceramic Tiles Waste with sand are 40%. As the higher percentage replacement, the higher compressive strength and water absorption.

Keywords: Brick, Ceramic Tiles Waste, Compressive Strength, Water Absorption

1. Introduction

Brick is a form of masonry material used to construct walls, walkways, and other structures. Several types of brick are used in construction such as clay brick and cement brick. Sand cement bricks are commonly utilized in low and medium cost residential construction as well as various commercial buildings in Malaysia. This is because high production rates of the brick as the brick is easy to produce and cheaper than the other brick[1]. Sand cement bricks are rarely used in building walls in comparison to clay bricks. This is because sand cement brick has poor strength to maintain the structure's loads This is in fact that sand cement brick also porous, ductile, has poor mechanical properties such as tensile strength, has poor crack resistance as well as brittle [2][3].

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Lately, there are many studies regarding production of brick by using waste material. As example, [4] used natural fiber such as oil palm fruit and pineapple eaves into the clay mixture. In other hand, [5] reused fly ash as base material for making fired bricks instead of clay. Other than that, a study by [6] used wasted glass from structural glass wall into the clay mixture in the process of brick development.

As a result, this study was carried out to make sand cement bricks by utilized ceramic tiles waste as partial replacement of the sand that act as a fine aggregate material in order to reduce industrial waste as well as to reduce the weakness of the brick. This is because by using recycled aggregates, especially ceramic, in new structural concrete is helpful from the standpoints of environmental preservation and natural resource conservation [7]. Ceramic tiles waste as shown in Figure 1 made from various materials such as ceramic, sand, water and lime. Ceramic tiles waste has been proven as an waste material that consist excellent attribute such as long-lasting, durable, and resistant to biological, chemical, and physical forces [8]. This has been proven by [9] as ceramic materials surpass metals on terms of increasing thermal strength, durability, density, and heat resistance. The aim of this research was to determine the optimum percentage of CTW replacement in the development of sand cement brick and to evaluate the physical and mechanical properties of sand cement brick incorporating ceramic tiles waste.

Figure 1: Ceramic Tiles Waste

2. Materials and Methods

2.1 Materials

Sand cement brick was made from various material such as sand, cement and water. In this study, the ceramic tiles waste was utilized as a sand replacement in the manufacturing of cement bricks. The ceramic tiles waste (CTW) were obtained from various places such as construction and garbage dumps site around Batu Pahat, Johor. Ceramic tiles waste were cleaned and dried before grinding. Next, Ceramic tiles waste were hammered to reduce into smaller size. Then, the CTW were grinded by using LA abrasion machine method. To obtain same range size with sand, CTW has gone through sieve analysis in range of 150 μm to 5 mm. The ratio of the brick mixture are 1:3 which 1 for cement and 3 for sand. The mould of size $215\ mm \times 103\ mm\ x\ 65\ mm$ are used in the making of brick. The brick were left for 1 day to allowed it to harden. The brick are put to curing in curing tank for a duration of 7 days and 28 days

2.2 Methods

This study used a 40% and 50% ceramic tiles waste as the replacement of sand in the production of brick. The mixture design of the brick was recorded in Table 1. Laboratory testing has been conducted once the brick reach 7 and 28 days. The bricks were dried in the oven after it reached 7 and 28 days of curing and measured its mass by weighing scale. The bricks were test in 3 different testing which is compression strength test, water absorption test and density test. The sample required for each testing were recorded in Table 2. For density test, it was conducted by measuring brick length, width and height and divided with the mass to get the volume. For water absorption, the bricks were immersed for a duration of 24 hours and then recorded its weight. For compression strength test, the brick of 7 and 28 days are test using compression strength machine to determine its strength before started to failure. The water cement ratio for the mix design was 0.6.

Table 1: Mix Design

Mix	Cement (Kg)	Sand (Kg)	Water (Kg)	CTW (Kg)	Remarks
M0	7.78	23.32	9.36	0	Control
M40	7.78	13.99	9.36	9.33	40% CTW
M50	7.78	11.66	9.36	11.66	50% CTW

Table 2: Sample for each test

Mix	Size (mm × mm × mm)	Number of Specimen		Curing Ages		Total Specimen
		Compressive Strength Test	Water Absorption Test	7 Days	28 Days	
M0	215×103×65	6	6	6	6	12
M40	215×103×65	6	6	6	6	12
M50	215×103×65	6	6	6	6	12

3. Results and Discussion

By using Microsoft Excel, the findings of laboratory testing in this utilization of ceramic tiles waste as a sand replacement in production of sand cement bricks are examined. The purpose of this data analysis was to determine the efficiency of the alternative materials utilized in accomplishing the study's goals.

3.1 Dry Sieve Analysis

Based on Figure 2, the line graph of CTW is almost similar to the sand. This is due to the ceramic tiles waste having similar range of size with the sand. This has been proven by [10] as the data obtained also stated that ceramic tiles waste has similar range of size with sand which is from m 5.0 to 0.075 mm and only ceramic tiles waste in that range are used as fine aggregate. Hence, this support the statement that CTW could be replacement material of sand as the size are almost similar.

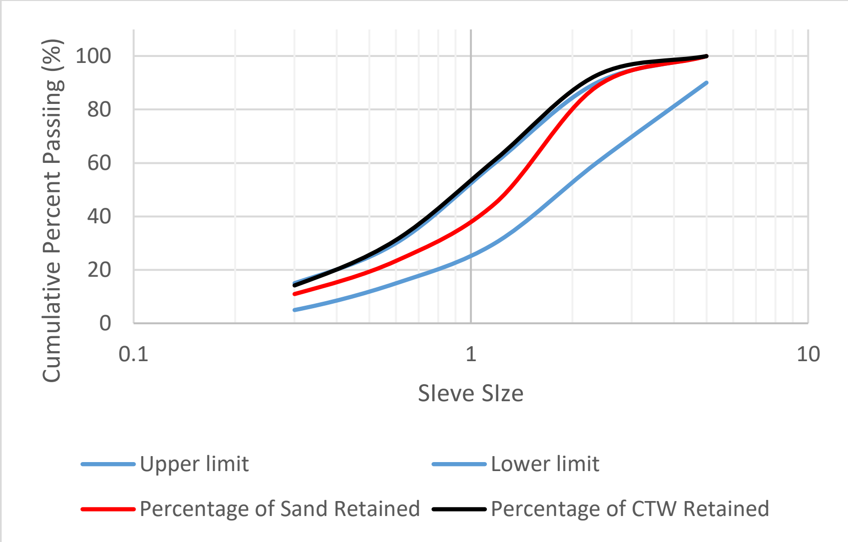

Figure 2: Graph of Dry Sieve Analysis

3.2 Density Test

It is essential for the determination of density of brick sample due to the different proportion of mixtures which resulting in different masses for every specimen. Table 3 shows the summary of brick density for each sample.

Table 3: Density of Brick

Sample	Days	Average Density (Kg/m^3)
Control	7	2121
	28	2128
40% CTW	7	2124
	28	2128
50% CTW	7	1966
	28	2011

Based on Figure 3, it can be observed that both 40% and 50 % CTW of 7 days curing has lower density than the control specimen. The decreased in density are 0.33% for CTW 40% while 7.3% for 50% CTW. For 28 days, the 40% CTW has similar density with the control which is 2128 kg/m^3. The 50% CTW showed decreased in density which 5.5% lower in density than the control specimen. It was clear that the higher the percentage of ceramic tiles waste mixed in the mixture, the lower the density of the brick.

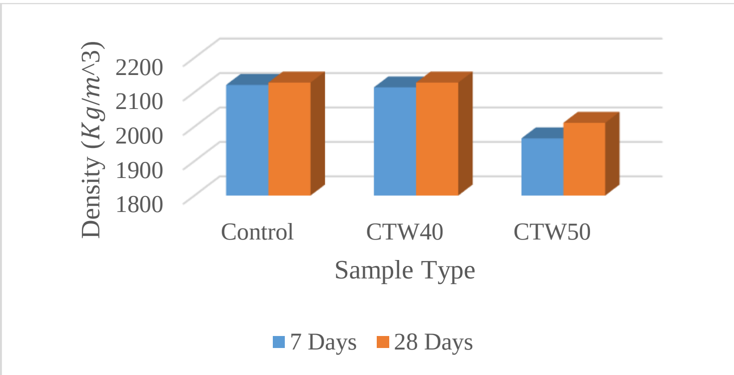

Figure 3: Density of brick

3.3 Compression Strength

Summary of compressive strength is shown in Table 4. As plotted in Figure 4, it can be observed that the compressive strength for both 7 days and 28 days of curing age for CTW 40% are slightly increased while strength for CTW 50% were slightly decreased than 40 % CTW. For 7 days curing age, CTW 40% strength are increased by 7.42% than the control specimen while CTW 50% strength are decreased by 6.87%. For 28 days, 40% CTW showed increasing of strength of 53.2 MPa while 50% CTW showed a decreased of strength than 40% CTW which the strength is 49.0 MPa. It is clear that the higher ceramic tiles waste content in the brick mixture, the lower strength of the brick. This is because the strength started to decline at 50 % CTW replacement.

Table 4: Compression Strength of Brick

Sample	Average Strength (MPa)	
	7 Days	28 Days
Control	36.4	43.7
CTW40	39.1	53.2
CTW50	33.9	49.0

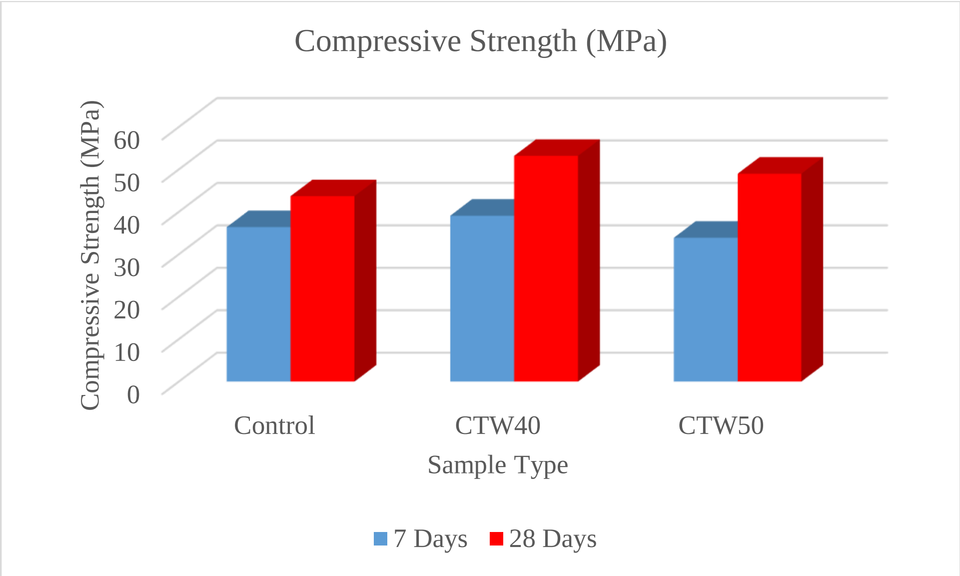

Figure 4: Compression strength of brick

3.4 Water Absorption Test

From Table 5 the water absorption for 40% CTW during 7 days are lower than control specimen which decreased by 4.8%. This result is contrast to the 50% CTW which the result of water absorption are higher than control specimen by 2.65%. For 28 days, both 40% and 50 % CTW showed higher water absorption than control specimen which at 7.29% and 7.61% respectively.

Table 3.5: Water absorption of Brick

Sample	Water Absorption (%)	
	7 Days	28 Days
Control	10.85	6.20
CTW40	6.05	7.29
CTW50	13.5	7.61

The water absorption increased as the higher percentage replacement are use in the mixture. This are showed in Figure 5 where the water absorption increased gradually for CTW 40% and CTW 50%. This is due to the water absorption property of sand cement bricks incorporating recycled fine aggregate raised the water absorption properties of bricks as stated by [1]. Previous study by [11] that the ceramic brick aggregates were found to have a significant water absorption.

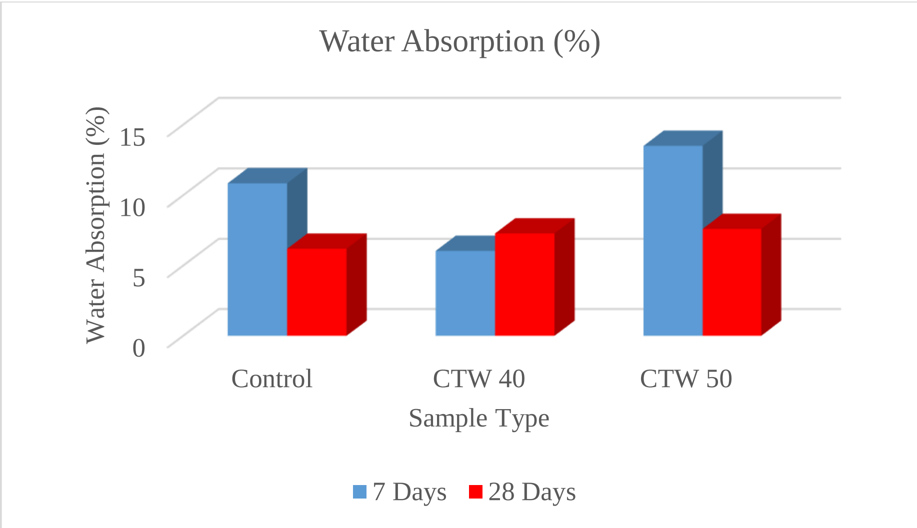

Figure 5: Water Absorption on Brick

4.0 Conclusion

Based on the findings of the study, sand cement bricks made from ceramic tiles waste have the capability to become better building materials available in the industry. The study proven that the increased of percentage replacement of ceramic tiles waste with sand, the lowered the compressive strength of the brick due to the higher water absorption of ceramic tiles waste. As a result, the use of ceramic tiles waste as a sand replacement in production of sand cement brick is appropriated at maximum content of 40% replacement.

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