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To Study The Effect of Ceramic Waste as Fine Aggregate to The Properties of Concrete

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Abstract: This study was focus on partial replacement of ceramic waste as fine aggregate in production of concrete. This study is to identify whether the replacement of ceramic waste as fine aggregate can meet the requirement the standard of concrete for construction or have similar with natural fine aggregate. This research is study the properties of the ceramic waste in concrete mix and to identify the optimum percentage of ceramic waste as partial replacement of fine aggregate in concrete production based on the data from previous studies. The percentage replacement of ceramic waste are 10.00 %, 20.00 %, 30.00 %, 40.00 %, and 50.00 %. Meanwhile, experiments that carried out on the specimen are slump test and compressive strength test at age 7 days and 28 days.

Keywords: Concrete, Partial Replacement, Ceramic Waste, Fine Aggregate, Previous Studies, Slump Test, Compressive Strength Test

1. Introduction

Concrete is the second most used material in the world after water and it forms the built environment and can also be recovered as recycled aggregate. Every year an estimated 33 billion tons of concrete are produced globally. That means more than 1.7 billion truckloads per year, or around 6.4 million truckloads per day, or more than 3.8 tons per person per year in the world. In Malaysia, residential area or construction industry produces waste which contributes largely to solid waste. Generally, solid waste material results from the construction of wok waste material or residual building renovations such as stone, wood, iron, cement and other waste materials. . This research will concentrate on the ceramic wastes collected from the construction industry and residential area. According to Sharifah Meryam et al. (2009) [1], in Malaysia there are various ventures in promoting the re-use of waste through the National Campaign Recycling however the amount recycled is still small. This study focus on the properties of ceramic waste in concrete mix and identify the optimum percentage of ceramic waste as a fine aggregate.

1.1 Concrete

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Generally, concrete is a combination of four elements which are coarse aggregate, fine aggregates, water and cement. Type of cement that is commonly use is Portland cement, which is mix with water and react as binder to coarse and fine aggregate due to chemical reaction of cement and water [2]. Concrete can be used for various construction works such reinforced concrete, pre-cast concrete and masonry units. Concrete for slab, shear wall must have minimum compressive strength of 25 MPa and above. While for non-structural, the compressive strength less than 25 MPa is suitable. It is important to identify the proportion and the amount of each material that will be mix in production of concrete. This is because the quality of concrete will be effect by the design amount of its mixture. Concrete has a high demand as construction materials because of the economical use. It is also inexpensive and widely available around the globe compared to steel, polymers and other construction materials.

1.2 Fine aggregate

Fine aggregate is the essential ingredient in concrete that consist of natural sand and crushed stone as shown in Figure 1. All the rock that pass through 4.75 mm sieve and retain on 0.075 mm is describe as fine aggregate. Other material that are used for fine aggregates include sand, sulky, stone screening, burnt clays, cinders, fly ash, etc. Mining and sand quarry are the main sources that provide the most desirable fine aggregate grading depend on type of work needed and maximum size of fine aggregate. The quality and density of fine aggregate strongly influence the hardened properties in concrete [3]. In the terms of concrete mix, fine aggregate plays vital role that act as structural filler that would occupies most of volume of the concrete mixture. In addition, fine aggregates provide dimensional stability to the mixture and influence elastic modulus. Fine aggregates also should be in dry condition before the test being conduct.

Figure 1: Natural fine aggregate

1.3 Ceramic waste

In accordance with the source of raw materials, ceramic waste may be separated in two categories. The first is all the fired waste generated by the structural ceramic factories that produce their products using only red pastes, such as bricks, blocks and roof tiles. The second is all the waste that is fired from ceramics of stone walls, tiles of floors and sanitary facilities. Nevertheless, white pastes are more commonly used by these manufacturers and are much greater in quantity. The ceramic waste was graded according to the production process in each group. Ceramics are classified into the following sectors which is wall tiles, floor tiles, toiletry, bricks or tiles for the roof, refractory materials for domestic and ornamental purposes, professional ceramic and ceramic materials.

2. Methodology

The general program of this study is to produce a green concrete by focusing on partial replacement of the ceramic waste as fine of aggregate in concrete production. This chapter describe the method used to evaluate properties of ceramic waste in concrete mix. The flow chart, experimental and the standard referred in conducting tests are presented based on method used by previous researchers. Later data from the previous study were recorded and analyzed. At the end of this study, the conclusion are made taking into account the experimental results and related factors. Figure 2 show the flow chart to ensure the sequence of work on track.

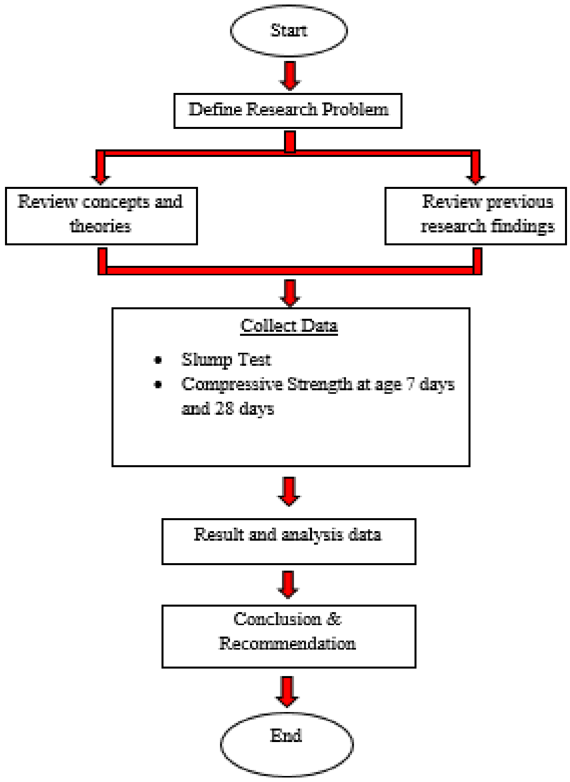

Figure 2: Flow chart of methodology

2.1 Experimental

For this study, the concrete was tested in laboratory. This replacement analysis will be carried out by using slump test and compressive strength test.

2.1.1 Slump Test

Slump test is performed to evaluate fresh concrete consistency. Indirectly, it is a way to check whether the right amount of water has been added to the concrete mix. The test is performed according to BS EN 12350-2 (2002) (Fresh concrete testing).

2.1.2 Compressive strength

Compression test is a test in which a material experiences opposing forces pushing the specimen from opposite sides inward or otherwise being compressed, squashed, crushed or flattened [4]. Compression test is to assess a material's action or reaction when undergoing a compressive load by measuring basic variables such as pressure, stress, and deformation. In this study, all the method procedure following (British Standard EN12390, 2002).

3. Results and Discussion

3.1 Slump test

This method is used to determine the workability of the fresh concrete. The high of workability concrete provide easier to handling, compaction and finishing for the worker to do the construction.

The result of slump test with different percentage of ceramic waste used on previous studies are show in Table 1 below.

Table 1: Result of slump test

References	Ratio (%)	Slump value (mm)
(Hitesh et al., 2015) [5]	10	75
	20	60
	30	48
	40	40
	50	31
(Suraya et al., 2017) [6]	10	50
	20	40
	30	35

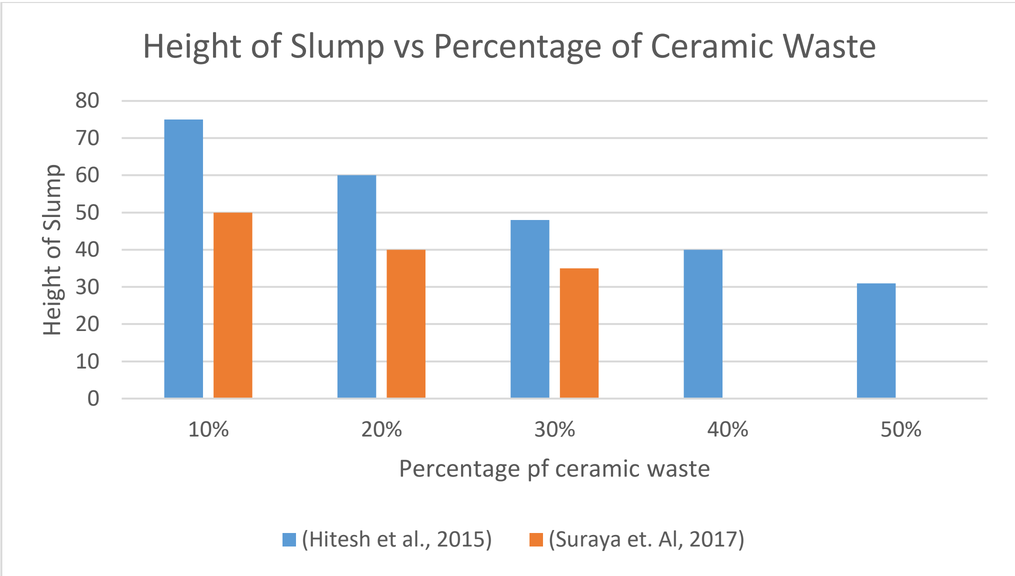

Figure 3: Bar chart for slump test

Based on the bar chart shown in Figure 3, the trend of the slump height decrease when the percentage of replacement of ceramic waste increase. Hitesh et al. (2017) [5] mentioned that the 10.00 % of replacement ceramic waste is the highest slump value which is 75 mm. Otherwise, Suraya et al. (2017) [6] state that the height of the slump at 10.00 % replacement of ceramic waste is 50 mm which is lower than study done by Hitesh et al. (2017) [5].

In addition, both researches agree that partial replacement of natural aggregate with ceramic waste will reduce the height of the slump value. The slump test was designed within range of 30 mm to 60 mm. The result of the two researchers is therefore appropriate, while the 10.00 % replacement of ceramic waste in study done by Hitesh et al. (2015) did not achieve the proposed range at the height of the slump design and the degree of workability is high state. According to Table 1, the reaction of ceramic waste toward water very high. It can be assumed that the higher the percentage of replacement of the ceramic waste, the higher the reactivity of ceramic waste with water. Based on the bar chart on Figure 3, the trend of workability will decrease when the replacement of ceramic waste increase. This is because characteristics of ceramic waste is very reactive with water.

3.2 Compressive Strength Test

3.2.1 Age at 7 days

In concrete manufacturing, compressive strength is very significant. This is because the function of the concrete is to withstand the loading of the structures. Thus, the higher the compressive strength, the higher the loading that can afford. Compressive strength of concrete is the main subject of the study and related to the correlation between the waste materials used and the strength of concrete produced in different percentages of replacement. The compressive data from the two researcher tabulated in Table 2 and Figure 4 show the comparison of the strength of concrete in different replacement of fine aggregate at 7 days.

Table 2: Result of compressive sstrength at age 7 days

References	Ratio (%)	Compressive strength (MPa)
(Hitesh et al., 2015) [5]	10	25.66
	20	27.40
	30	28.60
	40	26.13
	50	25.26
(Suraya et al., 2017) [6]	10	28.50
	20	29.10
	30	26.20

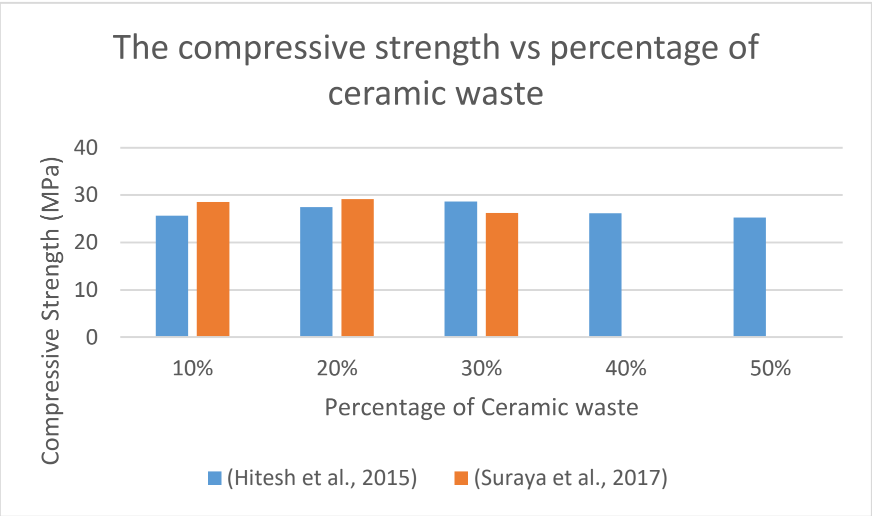

Figure 4: Bar chart of compressive strength at age 7 days

According to the data above, the ceramic waste replacement obtained higher result for compressive strength. From data collected study done by Hitesh et al. (2015), the optimum percentage of replacement was 30.00 % replacement which is 28.60 MPa. Meanwhile, the study done by Suraya et al. (2017) state that the optimum percentage of replacement was 20.00 % replacement which is 29.10 MPa where higher than data from Hitesh et al. (2015). Hitesh et al. (2015) state that the compressive strength of the concrete at 7 days increase when the percentage of ceramic waste increase but until 30.00 % of ceramic waste only and the compressive strength decrease at 40.00 % of replacement. Suraya et al. (2017) show that the compressive strength increase when the percentage of ceramic waste increase but up to 20.00 % only and the strength of the concrete become lower at 30.00 % of replacement. All of the percentage of the ceramic waste for both researchers more than the minimum value of the compressive strength at 7 days by following the article by Civiology (2017) [7] which is 17 N/mm^2 for grade concrete M25.

3.2.2 Age at 28 days

The result of the compressive strength test with different percentage of ceramic waste for age 28 days shown in Table 3 below. The percentage ceramic waste used by Hitesh et al. (2015) for this test are 0.00 %, 10.00 %, 20.00%, 30.00 %, 40.00 %, 50.00 % and Suraya et al. (2017) used are 10.00 %, 20.00 %, 30.00 % for the percentage of ceramic waste. Based on the bar chart shown in Figure 5, Hitesh et al. (2015) state that the trend of the compressive strength test increase when the percentage ceramic waste increase until 40.00 % then declined at 50.00 %. However, the result from Suraya et al. (2017) show that the trend of the graph for compressive strength decrease when the percentage of ceramic waste increase. From this study, the maximum value for the ratio of ceramic waste are at 40.00 % and 10.00 % for the study done by Hitesh et al. (2015) and Suraya et al. (2017) respectively while the minimum value for the ratio of the ceramic waste for the study done by Hitesh et al. (2015) is 50.00 % and for the study done by Suraya et al. (2017) is 30.00 %.

Table 3: The compressive sstrength at age 28 days

References	Ratio (%)	Compressive strength (MPa)
(Hitesh et al., 2015) [5]	10	37.44
	20	39.73
	30	39.13
	40	45.20
	50	31.00
(Suraya et al., 2017) [6]	10	37.80
	20	35.80
	30	34.10

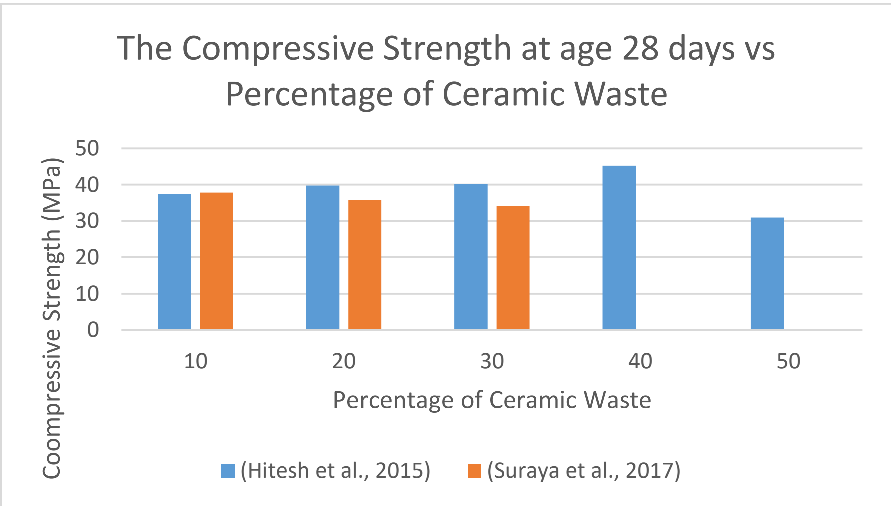

Figure 5: Bar Chart of compressive Strength at 28 days

3.3 Best ratio

The best ratio for the study done by Hitesh et al. (2015) is 40.00 % of ceramic waste. This is because the slump value for 40.00 % of ceramic waste is 40 mm which is it show in the range between 30 mm to 60 mm. 40.00 % of ceramic waste is the best ratio because the value of compressive strength is higher than the others which is 45.20 MPa. The best ratio for the study done by Suraya et al. (2015) is 10.00 % because due to some reason. First, the height of the slump at 10.00 % ceramic waste is 50 mm which is the value in the range between 30 mm to 60 mm. Lastly, the compressive strength for this ratio is 37.80 MPa which is the highest value compare to another ratio.

4. Conclusion

This chapter is discuss about the conclusion and recommendation of the whole project based on data analysis and discussion. After collecting data of from previous study about laboratory test including slump test and compressive strength of ceramic waste replacement of fine aggregate in concrete production. The conclusion can be summarized as follows:

According to the data analysis and conclusion made above, the conclusion that can be made are

1. The workability of concrete decrease when the percentage pf ceramic waste decrease. This is because ceramic waste very reactivity to water. The value of slump test from the both researcher can be accepted because in range between 30 mm to 60 mm except 10.00 % study done by researcher 1

2. When the percentage of ceramic waste increase, the compressive strength at age 7 days increase until 40.00 % but decrease at 50.00 % while the study done by researcher 2 show that the higher the percentage of the ceramic the higher the compressive strength at age 7 days but decrease at 30.00 %.

3. Data from study done by researcher 1 show the compressive strength increase up to 40.00 % but decrease at 50.00 % when the percentage of the ceramic increase, while study done by researcher 2 show when the percentage of ceramic waste increase, the compressive strength also decrease. This was due to increase of ceramic waste would reduce the strength of the concrete

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