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Concrete Ceramic Waste Slab (CCWS)

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ABSTRACT

The main focus of this research is to study the strength of concrete with ceramic waste as coarse aggregate. The sources of ceramic waste are obtained from the industrial in Malaysia. Presently, in ceramics industries the production goes as waste, which is not under going the recycle process yet. In this study an attempt has been made to find the suitability of the ceramic industrial wastes as a possible replacement for conventional crushed stone coarse. Experiment were carried out to determine the strength of concrete with ceramic waste coarse aggregate to compare them with the conventional concrete made (with crushed stone coarse aggregate). The properties of the aggregate were also compared. The results show, compressive strength of concrete with ceramic waste coarse aggregate was 85%-100% which indicates that the result is comparable to conventional concrete.

Keyword: Ceramic Waste; Conventional Concrete; Compressive Strength.

INTRODUCTION

The possible effects of recycled aggregate upon concrete properties such as workability, strength and durability have been discussed in several paper [1-3]. In ceramic industry, about 15%-30% production goes as waste. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant to biological, chemical, and physical degradation forces. As the ceramic waste is piling up everyday, there is a pressure on ceramic industries to find a solution for its disposal [1]. The conventional crushed stone aggregate reserves are depleting fast, particularly in some desert regions of the world [4]. Developments of concrete with non-conventional aggregates such waste aggregate was used in concrete to improve the properties of concrete and to reduce cost [1]. Akhtaruzzaman and Hasnat [5] studied the use of crushed brick as a 100% replacement of coarse natural aggregates in concrete. The crushed brick particles had an unit weight, a bulk specific gravity (SSD) and a water absorption value of 953kg/m3, 1.93% and 11.2%, respectively. The resulting concrete had an unit weight between 2000 kg/m3 and 2080 kg/m3 and a compressive strength between 13.8MPa and 34.5MPa. It was found that the tensile strength of brick concrete was higher than that of normal concrete by about 11%. Chi Sun Poon and Dixon Chan [6] studied to produce paving blocks prepared with 25% crushed clay brick that satisfied the compressive strength requirement for paving blocks (Grade B) prescribed by ETWB of Hong Kong for trafficked area. Padmini *et al.* [7], who used a fractional factorial experimental design method, studied the relative influence of different parameters on the strength of concrete using low-strength bricks as aggregates. The brick aggregates were derived from bricks with compressive strengths between 6MPa and 13MPa.

The development of concrete properties was observed by substitution of crushed stone coarse aggregate with crushed wasted ceramic. Compressive strength was unchanged when ceramic wastes are used partially to replace conventional crushed stone course. To reduce the amount of ceramic wastes deposited in landfill or anywhere and help the natural resources, recycling of the ceramic wastes for use aggregate in concrete has been investigated. The main objective of this research is to study the performance of concrete with ceramic waste.

EXPERIMENTAL PROGRAMME

The principal target of this experimented program is to determine the contribution of the waste aggregate type to the improvement of the strength behavior of the confined concrete. The experimental program also comprises the following two stages:

I. To characterizes the ceramic waste aggregate and compare with crushed stone coarse aggregate.
II. To study the behavior of fresh and hardened concrete with ceramic waste coarse aggregate and compare the respective properties with conventional concrete.

MATERIALS

Ceramic Waste As Coarse Aggregate

The big ceramic waste, such as flowerpot, tiles and sanitary ware were broken into small pieces about 5mm – 40mm sizes by a hammer. These small pieces are then fed into vibrator sieved to get the required 14mm-20mm size. Figure 1, show the sample of ceramic waste coarse aggregates.

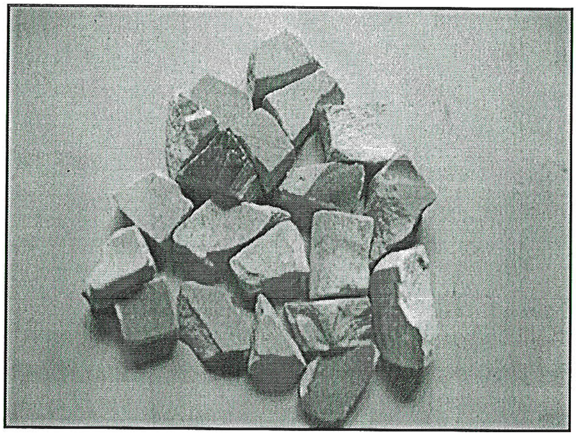

Figure 1. Ceramic waste coarse aggregate.

Other Concrete Mix Components

Conventionally, concrete crushed stone was used as coarse aggregate and river sand as fine aggregate. Coarse aggregate is usually gravel or crushed stone. The sizes range from the ¼ inch up to the maximum size permitted for the job. River sand as fine aggregate consists of particles ¼ inch or less in size. Crushed stone and river sand are commonly use as aggregates in concrete to provide higher volume at lower cost. Ordinary Portland cement, locally available river sand and natural crushed stone aggregate of maximum size 20mm were used in the conventional concrete.

Mix Proportions

The constituents used were divided into different fractions to determine the mix proportions that would yield the targeted compressive strength at a test age of 28 days. The optimum mix proportions included the coarse aggregate, sand, cement and water to yield a cubic meter of concrete. Three ceramics waste coarse aggregate were designed by the volumetric method with different water-cement ratio (0.65, 0.55 and 0.45). Three others conventional concretes mixes were designed with crushed stone coarse aggregate. The volume of individual ingredients was the same in both the ceramic waste coarse aggregate concrete and conventional concrete mixes. The mix proportions of the sample are presented in Table 1.

Table 1 Mix proportion of sample.

Mix	Water/Cement Ratio	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Mix	Water/Cement Ratio	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)
M1	0.65	920 (river sand)	995 (crushed stone)	M4	0.55	890 (river sand)	965 (ceramic waste)
M2	0.65	920 (river sand)	995 (ceramic waste)	M5	0.45	853 (river sand)	924 (crushed stone)
M3	0.55	890 (river sand)	965 (crushed stone)	M6	0.45	853 (river sand)	924 (ceramic waste)

Mix Proportion for M1 and M2 = 1:3.23:3.50
Mix Proportion for M3 and M4 = 1:2.58:2.80
Mix Proportion for M5 and M6 = 1:2.02:2.19
*(C: FA: CA)

PROCEDURE

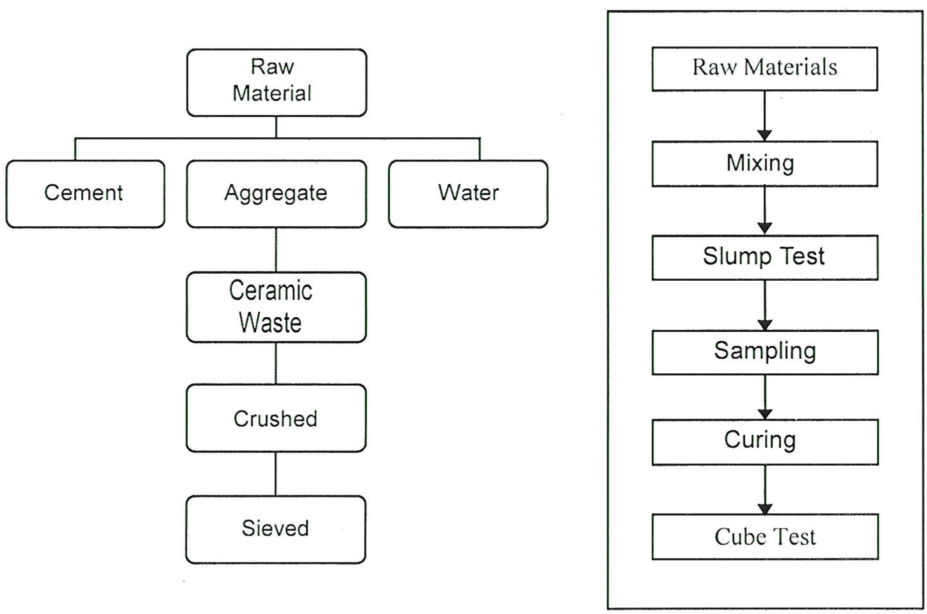

Figure 2. Flow chart of the raw material process and concrete mixing process.

Figure 2, indicates the flow chat of the whole process of raw material and concrete mixing process. Concrete ingredients consist of raw materials that are aggregate, Portland cement and water. The aggregate are divided into two types that are coarse aggregate and fine aggregate. The coarse aggregate consist of ceramic waste and crushed stone where as fine aggregate consist of the sand. The ratio for each model was based on volumetric method. The measurement used in this research is kilogram/ meter cube (kg/m^3).

The coarse aggregate for ceramic waste materials like flowerpot are crushed to small pieces by a hammer. These small pieces are then fed into the vibrator sieved to get the required 14mm - 20mm size.

The raw materials i.e. water; Portland cement and aggregate were mixed. After the mixing process, the entire models were measured using the slump test. Then, the concrete mixtures were sampled in the cube mold with size 150mm x 150mm x 150mm and 100mm x 100mm x 100mm (for cross sectional area). For every mix proportions, six samples were made. After a day, the samples were opened from the mold and then were cured in the water. All of the desirable properties of concrete are improved by proper curing process. The concrete which is moist was cured for 28 days. After 28 days, the cube test was carried out using the Universal Testing Machine (UTM) to measure the strengthening for each cube.

RESULT AND DISCUSSION

The ceramics waste coarse aggregate satisfied the aggregate requirements used for concrete. From observation, it was obvious that the particles shape analysis of ceramic waste coarse aggregate has different particles shape with the crushed stone normal concrete. The surface texture of the ceramic waste aggregate was found smoother than the crushed stone aggregate. The specific gravity for ceramic waste is 2.38 whereas for crushed stone is 2.63. The maximum size for both, ceramic waste and crushed stone are the same i.e. 20mm. The water absorption for ceramic waste is 1.45% whereas for crushed stone is 1.25%. In general, ceramic waste aggregate showed the properties closed to those of natural crushed stone aggregate.

The properties of Concrete Ceramic Waste Slab (CCWS) are presented in Table 2. The results presented in the table are the average of six tests. Fresh CCWS is less cohesive and workable compared to conventional concrete because high water absorption of ceramic waste. However, the slump test result is still in designed range that is between 30mm – 60mm.

Table 2 Properties of ceramic waste coarse aggregate and conventional concrete at 28 days.

Mix	w/c	Conventional Concrete				Mix	w/c	Concrete Ceramic Waste Slab			
		Cement Content (kg/m^3)	Slump Test (mm)	Compressive Strength (MPa)	Density (kg/m^3)			Cement Content (kg/m^3)	Slump Test (mm)	Compressive Strength (MPa)	Density (kg/m^3)
M1	0.65	285	100	11.59	2305.19	M2	0.65	285	40	15.64	2142.20
M3	0.55	345	50	27.33	2222.22	M4	0.55	345	20	23.51	2035.56
M5	0.45	422	40	30.34	2237.04	M6	0.45	422	15	30.16	2074.07

The compressive strength for Concrete Ceramic Waste Slab (CCWS) varied from 15MPa - 30MPa. As far as strengths are concerned, the basic trend in the behavior of CCWS is not significantly different from that of conventional crushed stone aggregate concrete. From the table, CCWS has lower density compared to conventional concrete.

Concrete Ceramic Waste Slab (CCWS) was fabricated by mixing the composition of cement and ceramic waste. The ceramic waste will act as coarse aggregate in the mixture. This slab can be used as landscape product such as table, chair, drain caver and many others. CCWS can be transformed into useful product and they are applicable for the range of parameter and material used. The sample of CCWS product presented at Figure 3.

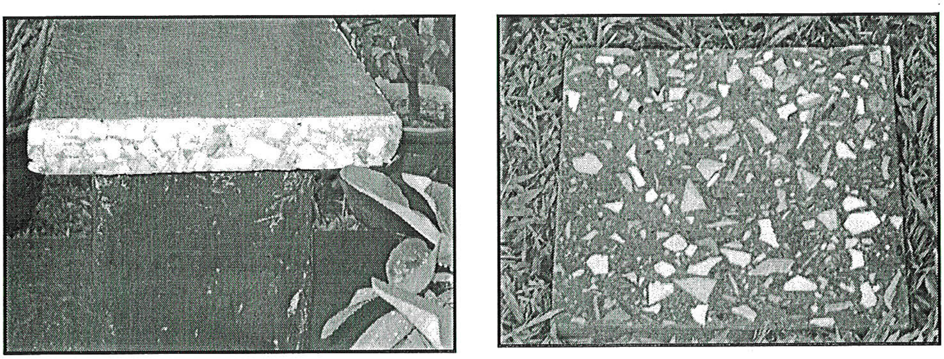

Figure 3. Example of Concrete Ceramic Waste Slab (CCWS).

CONCLUSION

From the test result and discussion, the following conclusions are drawn from the study on ceramics waste coarse aggregate; they are applicable for the range of parameters and materials in this study. Ceramics waste can be transformed into useful coarse aggregate. The properties of Concrete Ceramics Waste Slab (CCWS) are within the range of the values of concrete-making aggregate and they are not significantly different from those of conventional concrete. This research work is the basic for further experiment on normal concrete with the use of ceramics waste.

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