International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 8, August 2017, pp. 1730–1737, Article ID: IJCIET_08_08_187
Available online at http://http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=8&IType=8
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

A STUDY ON PROPERTIES OF CONCRETE WITH CERAMIC WASTE REPLACED FOR FINE AGGREGATE

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ABSTRACT

The continuous reduction of natural resources and the environmental hazards posed by the disposal of Construction and Demolition (C&D) waste has reached alarming proportion such that the use of C&D waste in concrete manufacture is a necessity than a desire. Hence the fine aggregate can be replaced fully or partially by materials like M-sand, quarry dust, saw dust, rice husk ash, ceramic waste etc in concrete. Ceramic waste may be used as an alternative for natural sand. The aim of this project is to determine the strength characteristics of recycled aggregates for application in concrete, with ceramic aggregates as an alternative material to fine aggregate in concrete. A total of three batches of concrete mixes of grade M20 were designed using various percentages (0%, 25%, 50% and 75%) of ceramic waste replaced for fine aggregates. From the results it is concluded that utilization of ceramic waste in concrete is more effective in strength as well as economic aspects.

Keywords: Compressive strength, Flexural strength, Marble waste, Mix design, Split tensile strength

Cite this Article: Dr. K. Ramadevi, A Study on Properties of Concrete with Ceramic Waste Replaced for Fine Aggregate, International Journal of Civil Engineering and Technology, 8(8), 2017, pp. 1730–1737.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=8

1. INTRODUCTION

At present the cost of fine aggregate is very high leading to an increase in total cost. Also fine aggregate is a natural resource which should be preserved. C&D wastes contribute the highest percentage of wastes worldwide (75%). Furthermore, ceramic materials contribute the highest percentage of wastes within the C&D wastes (54%) [1]. This waste of ceramic industries dumped at nearby places resulting in environmental pollution causing effect to habitant and agricultural lands [2]. The advancement of concrete technology can reduce the consumption of natural resources [3]. To avoid this situation, fine aggregate can be replaced fully or partially by materials like M-sand, quarry dust, saw dust, rice husk ash, ceramic waste etc in Concrete.

In this project it is aimed to use ceramic waste in various percentages to replace fine aggregate in concrete.

2. CERAMIC WASTES AS AN AGGREGATE

Ceramic is non-metallic solid which is inorganic, produced by the action of heat and subsequent cooling. The structure of ceramic materials may be crystalline or partly crystalline, or amorphous (e.g., a glass). Since most common ceramics are available in crystalline form, the term ceramic is often referred to inorganic crystalline materials.

The earliest ceramics made by humans were pottery objects, including 27,000 year old figurines, made from clay, either by itself or mixed with other materials, hardened in fire. Then glazing and heating of ceramics is done to create a coloured and smooth surface. Ceramics now include domestic, industrial and building products and a wide range of ceramic art. In the 20th century, new ceramic materials were developed for use in advanced ceramic engineering; for example, in semiconductors.

3. SOURCES OF CERAMIC WASTE

Various products of ceramic wastes include sanitary ware, floor tiles, wall tiles, roof tiles, ceramics from refractory and vitrified clay tiles [4]. Ceramic waste may come from two sources:

- The first source is the ceramics industry, and this waste is classified as non-hazardous industrial waste (NHIW). According To Integrated National Plan on Waste 2008-2015, NHIW is all waste generated by industrial.
- The second source of ceramic waste is associated with construction and demolition activity. For this project work, ceramic waste from Construction Demolition Waste is used. Ceramic waste was collected from Scrap yard in KCT Campus as shown in Fig1.

Figure 1 Ceramic waste from C&D waste

Coimbatore city municipal corporation says that population of the city is 10.09 lakhs and the quantity of garbage generated is 601 MT/day. In that about 2% of ceramic waste are included.

4. OBJECTIVES

- To replace fine aggregate in concrete by using ceramic waste in various proportions (0%, 25%, 50% and 75%)
- To cast and test the specimens for determining compressive strength, split tensile strength, flexural strength and modulus of elasticity of control mix and ceramic mix.
- To compare the test results and to find the optimum percentage of ceramic waste to be used in concrete.

5. MATERIALS USED

The materials used are cement (OPC of grade 53), river sand, coarse aggregate, ceramic waste and potable water available in the campus. The collected waste ceramic tiles were crushed into aggregates using Jaw crusher available in the laboratory (Fig. 2).

Figure 2 Ceramic waste aggregate

6. TESTS ON PROPERTIES OF MATERIALS USED

The physical properties of the materials were determined and the results are presented in the following topics.

6.1 Sieve Analysis Test

Sieve Analysis is done to determine Fineness modulus of aggregates. In this test fineness modulus is determined which is an index number which generally indicates the mean size of coarse or fine the particles. If the fineness modulus value of the aggregate is more, it implies that it is coarser and lesser value implies that it is finer.

6.2. Specific Gravity Test

Specific gravity is the ratio between the weight a given volume of a material at a standard temperature in air of to the weight of an equal volume of distilled water at the same stated temperature in air.[5] The specific gravity of fine-grained soil is determined by pycnometer method as per IS: 2720 (Part III/Sec 1) – 1980. IS:2386 (Part III)-1963[6]

6.3. Water Absorption Test

It is the ratio of weight of water absorbed to the weight of dry sample expressed as a percentage [7]. It will not include the amount of water adhering to the surface of the particles. The results of the tests are presented in Table 1.

Table 1 Physical properties of river sand and marble waste aggregate

S.no	Property	River sand	Ceramic waste aggregate	Reference
1	Specific gravity	2.7	2.3	IS 2386 - Part3
2	Water absorption	1.7	0.3	IS 2386 - Part3
3	Fineness modulus	2.66	3.29	IS2386 - Part1

7. CONCRETE MIX DESIGN

Concrete mix design for M25 grade is done as per IS: 10262 – 2009[8]. Batching details of the concrete mix are presented in Table 2 and the results of concrete mix design are tabulated in Table 3.

Table 2 Batching details

Aggregate	Batch Number		
	Batch 1	**Batch 2**	**Batch 3**
Natural fine Aggregate (%)	75	50	75
Ceramic Waste (%)	25	50	25

Table 3 Mix proportions for various percentages of fine aggregates

Materials	W/c	Cement	Fine Aggregate	Coarse aggregate
Mix Proportion for control mix				
Ratio	0.5	1	1.34	2.83
Kg/m^3	186	414	552	1173
Mix design for 25% replacement of ceramic waste				
Ratio	0.5	1	1.38	2.83
Kg/m^3	186	394	551	1173
Mix design for 50% replacement of ceramic waste				
Ratio	0.5	1	1.38	2.83
Kg/m^3	186	394	544.3	1173
Mix design for 75% replacement of ceramic waste				
Ratio	0.5	1	1.25	2.83
Kg/m^3	186	394	495.4	1173

8. EXPERIMENTAL INVESTIGATIONS

Three numbers of cube specimens of size 150 mm for Compressive strength test, cylinder specimens of size 150 mm dia and 300 mm length for Spilt Tensile strength test and prism specimens of size 100 x 100 x 500 mm for Flexural Strength test were cast and tested at 7 days and 28 days respectively after curing.

8.1. Slump Test

The consistency and degree of workability of fresh concrete is determined using slump test. The apparatus consists of a conical mould with a base plate. The mould is kept over the base plate and filled with the freshly mixed concrete of desired grade in three layers; each layer is tamped 25 times with a tamping rod of standard dimensions. After leveling the concrete, the mould is lifted upwards carefully and the concrete subsides. This depth of subsidence is termed as slump, and is measured in to the nearest 5 mm if the slump is <100 mm and measured to the nearest 10 mm if the slump is >100 mm[9]. The results of Slump test are shown in Table 4.

Table 4 Slump test results

Test	Control Mix	25%	50%	75%
Slump value (mm)	45	40	50	60

8.2. Cube Compressive Strength Test

Compressive test is the most common test used to test the hardened concrete specimen test. Concrete cube specimens of size 150 mm with various percentages of recycled aggregate were cast, cured and tested after 7th day and 28th day in the compression testing machine until failure. The compressive strength is calculated by the formula given below.

$$\text{Compressive strength} = \frac{P}{A}$$

Where,

P= Compressive Load in N

A= Area in mm^2

The test results are shown in Fig. 3.

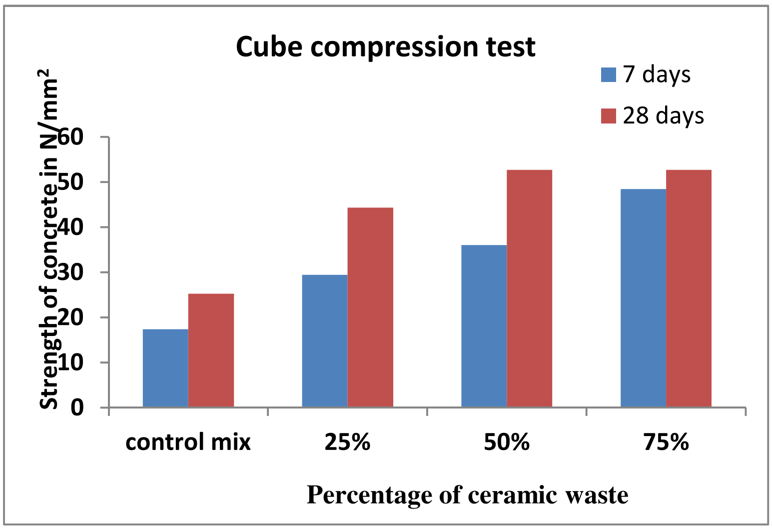

Figure 3 Cube compressive strength test results

8.3. Split Tensile Strength Test

The cylinders are placed in the compression testing machine and load is applied as similar to the cube. The cylinder is placed horizontally and the test is performed. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded. The tensile strength is calculated using the formula below.

$$\text{Split tensile strength} = \frac{2P}{\pi l d}$$

Where,

P = compressive load on cylinder

l= length of the cylinder = 300 mm

d= diameter of the cylinder = 150 mm

The test results are shown in Fig. 4.

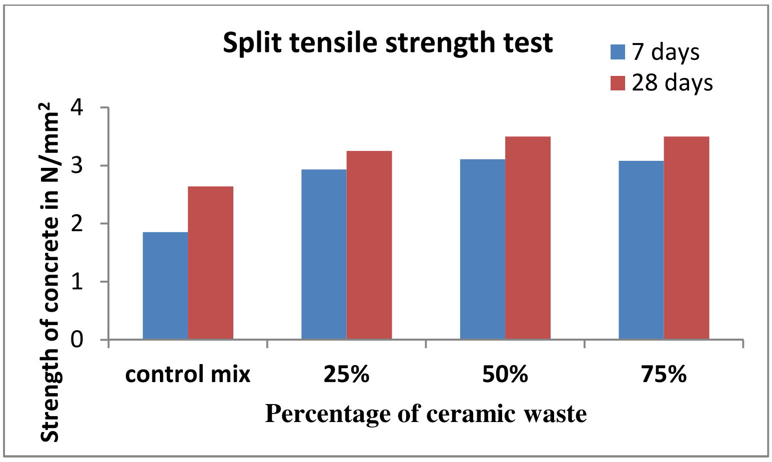

Figure 4 Split tensile strength test results

8.4 Cylinder Compressive Strength Test

Cylinder specimen size 300 mm height 150 mm diameter are used for compressive test with various mix proportion such as 25%, 50%, 75% after 28 days curing. The cylinders specimens are placed vertically on the platform of compression testing machine. The load is applied continuously and uniformly without shock at the rate of 315 kN/min. The loading is continued until the specimen fails. The test results are shown in Figure 5.

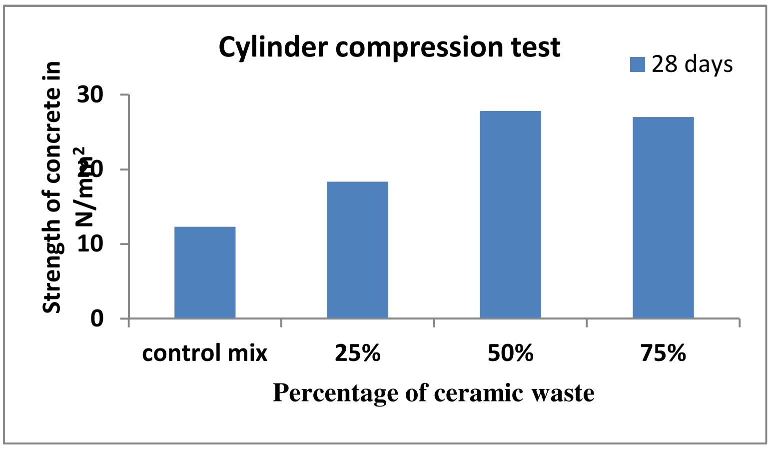

Figure 5 Cylinder compression test results

8.5 Flexural Strength Test

Prism specimen size 100 mm height 100 mm depth and 500 mm length are to be used for flexural strength test by various mix proportion such as 25%, 50%, 75%. The test results are shown in Fig. 6.

The flexural strength (f_b) is calculated using the following formula.

$$f_b = \frac{p\,l}{b\,d^2} \quad (if\ a > 13.3\ cm) \quad , \quad f_b = \frac{3\,p\,a}{b\,d^2} \quad (if\ a < 13.3\ cm)$$

Where,

f_b= flexural strength value (MPa)

b= breath of beam (mm), d= height of beam (mm)

a= shorter length of beam (mm)

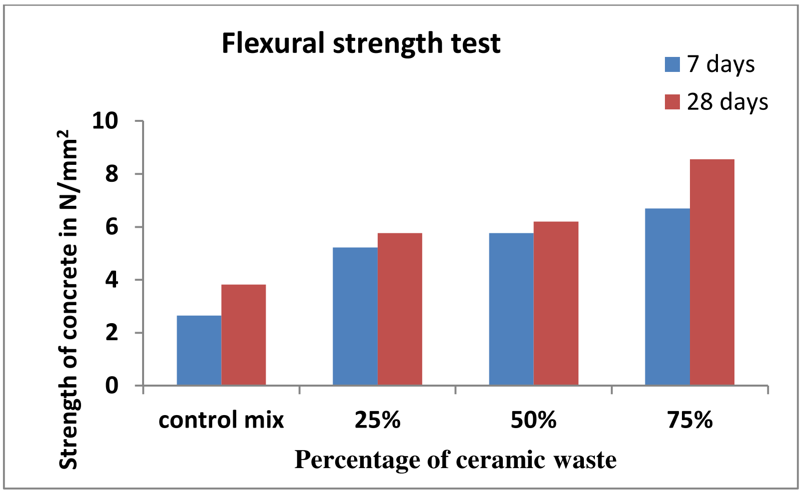

Figure 6 Flexural strength test results

9. CONCLUSION

- The cube Compressive strength, Split tensile strength, Flexural strength value of control mix are 25.27 N/mm^2 , 2.64 N/mm^2 , 3.82 N/mm^2 respectively.
- For 25% replacement of fine aggregate by ceramic waste, the cube Compressive strength, Split tensile strength, Flexural strength values are 44.33N/mm^2 , 3.25 N/mm^2 , 5.77 N/mm^2 respectively.
- For 50% replacement of fine aggregate by ceramic waste, the cube Compressive strength, Split tensile strength, Flexural strength values are 52.71 N/mm^2 , 3.5N/mm^2 , 6.2 N/mm^2 respectively.
- For 75% replacement of fine aggregate by ceramic waste, the cube Compressive strength, Split tensile strength, Flexural strength values are 52.71 N/mm^2, 3.5 N/mm^2, 8.55 N/mm^2 respectively.
- From this result it is inferred that strength gradually increases with the increase in replacement percentage of ceramic waste aggregate [10].
- It was noted these 50% replacement of ceramic waste gain strength and give better results than other percentage and control mix.
- It is concluded that ceramic waste may be used in concrete up to 50% there by it improves the strength as well as saves the natural resources.
- From this results it is inferred that 50% replacement by ceramic waste gain more strength and gives better result. Beyond 50% replacement the strength decreased. The strength loss may be due to increase in consumption of water to improve workability.

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