Experimental Investigation on Strength Properties of Waste Ceramic Aggregate Concrete

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Abstract—Concrete is the best construction material all around the world due to the plastic property which helps it to be casted and moulded into any desirable shape. Usage of concrete as increasing the materials used for concrete are also depleting fast due to the high usage in the era of modernization. Ceramic waste from the ceramic industries contributes as a major material for waste materials which cannot even decomposed on dumping. In the present study, ceramic aggregate waste is used as a partial replacement of natural coarse aggregate. The ceramic waste is chiseled to obtain aggregate of required size 20mm. The ceramic coarse aggregate is used as a partial replacement and replaced as according to mix proportions. Mix proportion of 1:1.73:2.88 with W/c ratio 0.48 for M20 Grade concrete and Mix proportion of 1:1.48:2.5 with W/c ratio 0.45 for M30 Grade Concrete was used for the present study. A total of 156 specimens are casted which consists of 72 Cube, 36 Cylinders and 36 Prisms. The test results obtained are compared and studied with the conventional reference concrete and conclusions are drawn from it for further use of ceramic waste aggregate for further use.

Key words: Cement, Ceramic Coarse Aggregate, Ceramic Aggregate Concrete, Strength Characteristics, Partial Replacement

I. INTRODUCTION

Concrete being an artificial construction material it is popular due to the uncommon quality it possesses among all the other construction materials used and the reason being the plastic state during the time of usage. The most widely used construction material all around the world is concrete due to the superior quality it possess to be cast into any desirable shape. It has emerged as a dominant construction material due to its long lasting strength and durability which as an important need for the present situation.

As concrete is a vital material in every construction activity, It plays an important role in the present scenario of construction industry. Concrete's characteristics makes it most appropriate for wide use in infrastructural development.

Research and Study on the recycled aggregates has already been started and recycling has found to be one of the better options for conserving natural resources. The strength of constituents used in preparation of concrete comprises the complete strength of concrete. The complete problem of the shortage of aggregates cannot be solved by the use of secondary aggregates but it could be relieved to a certain extent.

A. Need for Present Research

With increasing population in developing countries pollution free environment and economy are of prime importance to meet the necessary human needs in the construction industry. Hence waste aggregates which play an essential role in the production of a new type of concrete are required to fulfil demand of aggregates. Waste materials are generally generated from demolishing and industrial waste. This type of waste can be dumped anywhere in low laying areas but now a days dumping areas are very limited because of the increasing land cost in urban region. Pollution due to the disposal of waste influences the surrounding and nearby areas of the dumping areas.

II. MATERIAL USED

A. Cement:

Cement is an ultrafine powder, when it is mixed with water it undergoes chemical change and allows to harden & set.

Cement has the capability of uniting masses which are of solid matter together thereby producing a material which is mechanically strong. The principal constituent of Cement is lime, silica and alumina & they are called complex compounds.

B. Fine Aggregate (FA):

Sand: Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete.
For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete.

C. Coarse Aggregate (CA):

Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

D. Ceramic Coarse Aggregate (CCA):

Ceramic Coarse aggregate was collected from waste dump. Insulator bushes were used as a ceramic coarse aggregate as insulator bushes can be crushed down to a size of 4.75mm-20mm.

E. Water:

Locally available tap water is used. As per I.S:456-2000 15%-25% of the total volume of concrete is consumed by water 15%-25% of water content makes concrete to be in workable conditions. Water plays an important role in concrete as it is important constituent of concrete. Water should be from all kinds of impurities and contamination material and organic matter.

III. PROPERTIES OF MATERIALS USED

Property	Cement	F.A	C.A	Ceramic
Sp. Gravity	3.12	2.67	2.72	2.50
Bulk Density (kg/m^3)	-	1642	1460	1188

Fineness (%)	2.3	3.83	4.91	5.12

Table 1: Properties

A. *Mix Design*

Mix design is carried out by using Indian standard codes i.e. IS 456-2000, & IS 10262-2009. In my dissertation work I am using M20 & M30 grade conventional concrete & the mix details are as follows.

M20 Grade	Cement (Kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (lts)
Quantity	399	690	1147.59	191.5
Proportions	1	1.73	2.88	0.48

Table 2: M20 Details

M30 Grade	Cement (Kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (lts)
Quantity	438.1	654.4	1135.1	197.1
Proportions	1	1.49	2.59	0.45

Table 3: M30 Details

1) Mix Designations for M20 & M30 Grade concrete:

a) Nomenclature of Mixes for M20 Grade Concrete

Sl. No.	Mix Designation	Mix Details				
		Cement	F.A	Coarse Aggregate		Water
				Natural Coarse aggregate	Ceramic Coarse aggregate	
01	CM20	100%	100%	100%	0%	100%
02	CC-M1	100%	100%	90%	10%	100%
03	CC-M2	100%	100%	80%	20%	100%
04	CC-M3	100%	100%	70%	30%	100%
05	CC-M4	100%	100%	60%	40%	100%
06	CC-M5	100%	100%	50%	50%	100%

b) Nomenclature of Mixes for M30 Grade Concrete

Sl. No.	Mix Designation	Mix Details				
		Cement	F.A	Coarse Aggregate		Water
				Natural Coarse aggregate	Ceramic Coarse aggregate	
01	CM30	100%	100%	100%	0%	100%
02	CC-M6	100%	100%	90%	10%	100%
03	CC-M7	100%	100%	80%	20%	100%
04	CC-M8	100%	100%	70%	30%	100%
05	CC-M9	100%	100%	60%	40%	100%
06	CC-M10	100%	100%	50%	50%	100%

IV. EXPERIMENTAL SETUP

Specimen name	Specimen size	Number of specimens
Cube	150 mm x 150 mm x 150 mm	72
Cylinders	150 mm diameter and 300 mm height	36
Prisms	100 mm x 100 mm x 500 mm	36

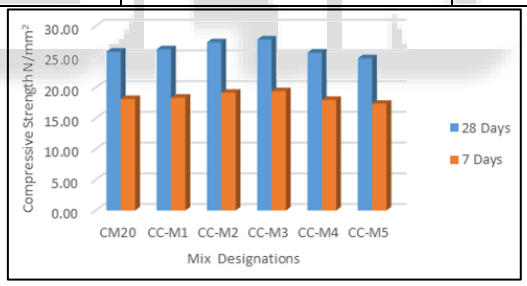

Fig. 1: Compreesive strength for M20 Grade Concrete

V. RESULTS AND DISCUSSION

A. *Cubes:*

The specimen of the concrete is tested for 7 days & 28 days in order to determine the initial strength for 7 days and final strength for 28 days. The cubes are tested in compressive testing machine, the results are shown below.

B. *Compressive Strength Test Results:*

MIX ID M20 Grade	Average strength in N/mm²	
	7 days	28 days
CM20	18.13	25.83
CC-M1	18.35	26.23
CC-M2	19.15	27.36
CC-M3	19.40	27.83
CC-M4	17.99	25.69
CC-M5	17.37	24.78

Table 4: Compressive Strength Test Results:

MIX ID M30 Grade	Average strength in N/mm²	
	7 days	28 days
CM30	25.58	36.48
CC-M6	25.94	36.91
CC-M7	27.07	38.51
CC-M8	27.61	39.09
CC-M9	25.40	36.55
CC-M10	24.45	35.10

Table 5: Compressive Strength Test Results:

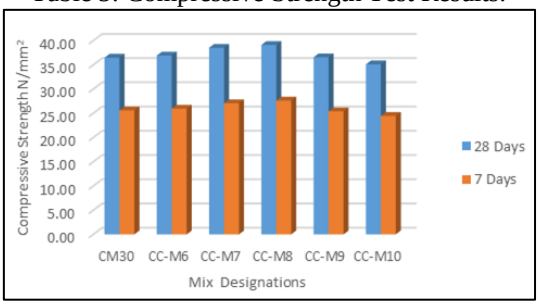

Fig. 2: Compreesive strength for M30 Grade Concrete

C. Cylinders:

The split tensile strength testing was done for 28 days in order to find the strength of cylinder, the results are shown below.

1) Split Tensile Strength Test Results:

MIX ID M20 Grade	28 Days Average strength in N/mm^2
CM20	2.6
CC-M1	2.63
CC-M2	2.78
CC-M3	2.82
CC-M4	2.64
CC-M5	2.55

Table 6: Split Tensile Strength Test Results:

MIX ID M30 Grade	28 Days Average strength in N/mm^2
CM30	2.8
CC-M6	2.85
CC-M7	2.99
CC-M8	3.04
CC-M9	2.82
CC-M10	2.79

Table 7: Split Tensile Strength Test Results:

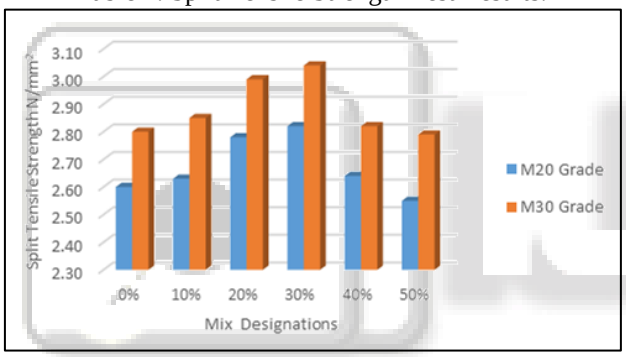

Fig. 3: Split Tensile Strength Test Results:

D. Prisms:

The Flexural strength testing was done for 28 days in order to find the strength of Prisms, the results are shown below

1) Flexural Strength Test Results:

MIX ID M20 Grade	28 Days Average strength in N/mm^2
CM20	4.5
CC-M1	4.56
CC-M2	4.72
CC-M3	4.83
CC-M4	4.54
CC-M5	4.37

Table 8: Flexural Strength Test Results:

MIX ID M30 Grade	28 Days Average strength in N/mm^2
CM30	5.62
CC-M6	5.69
CC-M7	5.83
CC-M8	5.99
CC-M9	5.64
CC-M10	5.48

Table 9: Flexural Strength Test Results:

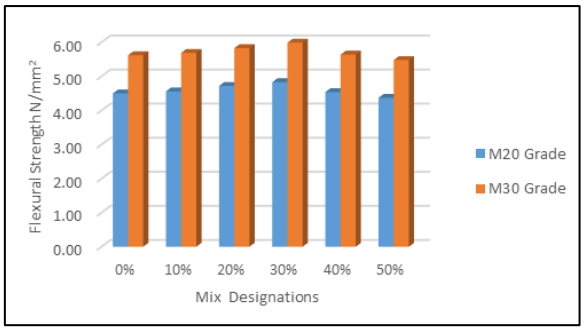

Fig. 4: Flexural Strength Test Results

VI. Discussion

1) With the addition of Ceramic Coarse aggregate upto certain percentage the strength values are noticed to increase and later decrease with more addition in CCA.
2) The strength increase with the addition of ceramic coarse aggregate is noticed from 10-20% replacement, the final strength increase is noticed with a replacement of 20-30% of CCA.
3) M20 Grade concrete Mix designation CC-M1, CC-M2 & CC-M3 which is 10%, 20% & 30% replacement of CCA shows higher strength values then Conventional reference Mix CM20.
4) M30 Grade concrete Mix designation CC-M6, CC-M7 & CC-M8 which is 10%, 20% & 30% replacement of CCA shows higher strength values then Conventional reference Mix CM30.
5) As the percentage of ceramic coarse aggregate increases the slump value and compaction value decreases when compared to conventional concrete.

VII. Conclusion

The following conclusions were made based on experimental study:

1) Properties of Ceramic Coarse Aggregate such as Impact value, Crushing Value, Elongation Index, and Water Absorption are slightly higher than those for Natural Coarse aggregate. However all values are in the range of 30-45%, hence ceramic waste aggregate can be safely used in concrete composition as alternative material for coarse aggregate.
2) In both the Grades of M20 & M30 Concretes Compressive strength of CC-M4 mix was found to be almost equal to Conventional mix CM20 which makes it desirable mix for replacement as Conventional mix strength can be attained with 40% replacement of CCA.
3) The Strength in both the Grades of M20 & M30 Concretes was found to increase at 10% replacement of Ceramic Coarse Aggregate with increase of 1.21% - 1.55% for 7 & 28 days Compressive strength, 1.15% for 28 days Split Tensile strength and 1.33% for Flexural strength. These Percentages were found to increase when compared with Conventional Reference Concrete mix.
4) The Strength in both the Grades of M20 & M30 Concretes was found to increase at 30% replacement of Ceramic Coarse Aggregate with increase of 5.63% - 7.74% for 7 & 28 days Compressive strength, 8.46% for 28 days Split Tensile strength and 7.33% for

Flexural strength. These Percentages were found to increase when compared with Conventional Reference Concrete mix.

5) 40% Replacement of Ceramic Coarse aggregate was found to be ideal and optimistic mix & and an alternate for Conventional concrete as strengths for Compression, Split tensile & Flexure nearly equal to Conventional reference concrete were achieved using this Mix proportion.
6) For Plain Cement Concrete 50% Replacement of Ceramic Coarse Aggregate can be used as there is less decrease in strength characteristics of Compressive, Split tensile & Flexure tests.

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