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An Experimental Investigation of a High-Density Concrete with Waste Ceramic Tiles Used as an Aggregate

Ritu Arya[1], Dr. Parikshit Joshi[2], Dr. Chaitanya Mishra[3]
[1]PG–Scholar, [2]Associate Professor, [3]HOD & Associate Professor, Department of Civil Engineering, Oriental University, Indore, INDIA

Abstract: The use of waste material as aggregates in civil engineering applications is beneficial and increasingly desirable because it reduces the environmental impact and economic cost of mining, processing, and transportation operations. Therefore, this study focused on establishing the effect of crushed tile on the compressive strength of concrete.
In this research investigation, ceramic waste tile waste was substituted for natural coarse aggregate in concrete to varying degrees from (0, 10, 20, and 30%), and the M-20 graded concrete was used to produce high density concrete. After 3, 7, and 28 days of the curing process, few number of new concrete mould were casted and evaluated about the Compressive Strength and Split Tensile Strength. The findings of these results showed that 35% replacement of naturally made coarse aggregate with the ceramic tile aggregate which contributes the higher compressive strength to produce the high-density concrete in construction industry.
Keywords: Ceramic Tile Aggregate (CTA), aggregates, concrete, Curing Process, Compressive strength, Split tensile strength, High density concrete.

I. INTRODUCTION

Throughout the world, rapid industrial expansion contributes to significant problems, including the extensive depletion of naturally formed aggregates and the fabrication of large amounts of debris from civil engineering and demolition activities in the construction field. Using garbage is a technique to decrease this problem and, at the same time, high-density concrete can be produced. All countries produce a significant amount of waste each year, with construction and demolition debris accounting for the largest part (75%). In addition, ceramic materials account for 54% of the waste generated during the construction and demolition process. Waste made from ceramic is very strong, rigid, and incredibly resistant to the forces of biological, chemical, and physical deterioration. When specific gravity is considered, ceramic tile aggregate is hard, has smooth and rough side material, and is much less in weight than the typical pattern of stone aggregates. In addition to being cost effective, using broken ceramic tile waste or aggregate in concrete will also be beneficial to the environment.

II. MATERIALS & ITS PROPERTIES

1) *Cement:* It is fine dust, when combined with water, allowed for setting and further hardening, can be used to join separate pieces of solid material to create a mechanically robust substance. The most often used type of cement is regular Portland cement, grade 53, according to IS:12269. The Specific Gravity, Setting Time and Standard Consistency test were done on cement to determine its quality.

Table 1: Properties of Cement particles

Property	Values
The normal consistency of Cement	30%
Initial setting time of Cement	42 minutes
7days compressive strength	22.1 MPa
28days compressive strength	43.4 MPa

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2) *Fine Aggregate:* Sand that is virtually riverbed pure with easily accessible locally is utilized as fine aggregate. The phrase "fine aggregate" refers to fractions with a size between 4.75 mm and 150 microns. Each and every time minimum void ratio is targeted or satisfied by sand particles; greater void ratio necessitates by mixing more water. According to Indian criteria, the sand in the current study is in zone I. The fineness of particular product, the specific gravity, and water absorption tests are performed on the fine aggregates.
3) *Material Properties:*

Table 2: Properties of cement

SL No.	Particulars	Readings
01	Specific gravity	3.15
02	Setting time of cement Initial setting time Setting time of cement	30 Mins 285 Mins

Table 3: Properties of sand

Sl. No.	Particulars	Readings
01	Fineness modulus	02.545
02	Maximum size	02.56 mm
03	Specific gravity	02.25
04	Water absorption	1%

Table 4: Properties of the Coarse Aggregate (C.A.)

Sl. No.	Particulars	Observations
01	Fineness modulus	2.28
02	Maximum size	20 mm
03	Specific gravity	2.38
04	Water absorption	0.8%

Fig. 1: Ceramic tiled aggregates broken pieces.

Table 5: The Physical properties of ceramic tiled aggregates

S. No.	Particulars	Obtained Values
01	Specific gravity	2.42
02	Impact value	26%
03	Water absorption	12.4%

Table 6: Comparison of the Properties of Ceramic Tiled Vs Normal Aggregates

Sl. No.	Particulars	Normal Aggregates	Ceramic Tile Aggregates
01	Shape	Angular	Flakiness
02	Texture	Rough	Entire perimeter rough other than top surface
03	Specific gravity	2.68	2.42
04	Impact value	15%	26%
05	Water absorption	0.6%	12.3%

The test concrete cube samples or specimens are examined after three, seven, and twenty-eight days of cure. The concrete cube samples are examined after 03, 07, and for 28 days' curing process. The concrete cubes were set up on compression testing machine and maximum load is applied and it has been recorded. At this load, specimen's resistance/weight withstanding capacity to the load increases cracks and no further load can be withstanding. Similarly, the split tensile tests on the cubes are carried out with the help of a tensile test apparatus and the values are noted for further evaluation.

III. METHODOLOGY FOR MIX PROPORTION

The effects of a waste ceramic tile aggregate (C.T.A) on high density concrete workability.

The slump value for various water-cement ratios as a function of the effect of the broken or waste ceramics tile aggregate contents on workability of fresh concrete mixes. The broken, damaged or waste ceramics tiles and water with a proper water/cement ratio were used as two separate bases for the data interpretation and for evaluation.

As can be seen, an increase in the water cement ratio decreases the workability of a fresh concrete. Additionally, as the quantity of tile and coarse aggregate grows, the slump value drops.

This decline may be caused by discarded ceramic tile aggregates having a more angular shape and by tiles absorbing more water. Overall, the samples' slump is altering, and this shift happens in the range of 0 to 10 millimeters with respect to water cement ratio.

IV. THE EFFECT OF WASTE CERAMIC TILED AGGREGATES ON CONCRETE DENSITY

The density is an indication of perfect concrete stability and degree of solidity. The load bearing capacity of the concrete has been observed and tested after various process. It will enhance the overall strength of the material.

So that the maximum load can be calculated and according to the optimum weight the construction process can be carried out through this kind of Projects.

Fig. 2: Testing model of the casted cube the waste ceramic tile casted cube

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Table 7: The Mix Proportion of Tested Samples

% Replacement of CTA	Cement (Kg/m^3)	sand (F.A.) (Kg/m^3)	Aggregate (C.A.) (Kg/m^3)	ceramic tile aggregate (Kg/m^3)
0%	383.2	721.99	1099.66	-
10%	383.2	721.99	989.7	94.7
20%	383.2	721.99	879.73	189.4
30%	383.2	721.99	769.76	284.1

Observations for M20 grade concretes with 0%, 10%, 20% & 30% replacement of Coarse Aggregate with the C.T.A. for 03,07 and 28days with WCR taken as 0.50.

V. RESULTS & DISCUSSION

1) Parameter 1: Compressive Strength Results

Observations for M20 grade concretes with 0%, 10%, 20% & 30% replacement of Coarse Aggregate with the C.T.A. for 03,07 and 28days with WCR taken as 0.50.

Table 8: Compressive Strength Results (MPa)

S. NO.	% Replacement of Tile Aggregate	03 DAYS	07 DAYS	28 DAYS
1	0%	17.86	22.15	28.49
2	10%	16.22	18.67	24.04
3	20%	16.88	19.55	23.95
4	30%	18.86	23.24	32.03

The M20 grade of concrete with overall 0%, 10%, 20% and 30% replacements of C.T.A and their compressive strength at 03, 07 and for 28 days

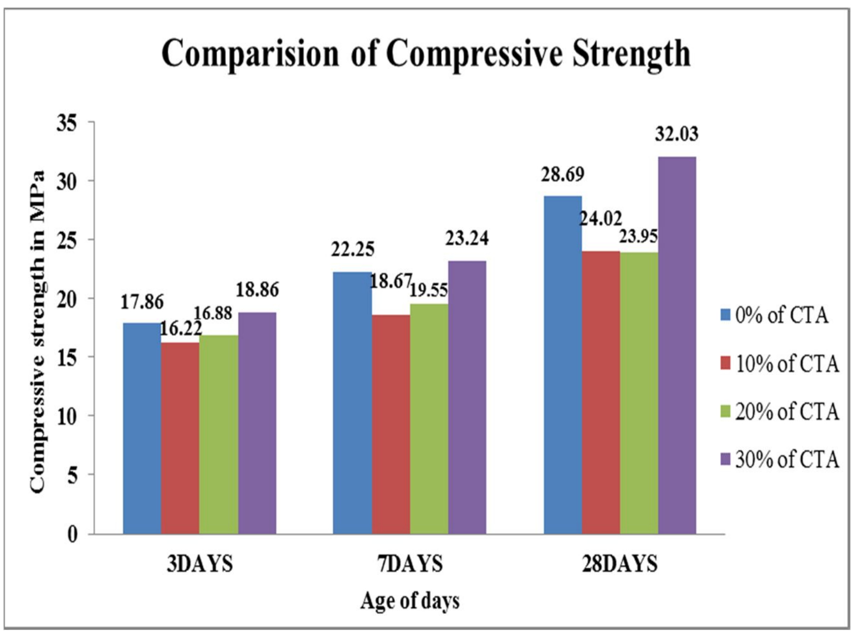

Fig. 3: Bar chart representation of compressive strength

2) *Parameter 2: Split Tensile Strength Results*

Table 9: Split Tensile Strength Results

S. NO.	% Replacement of Tile Aggregate	03 DAYS	07 DAYS	28 DAYS
1	0%	2.63	3.43	4.38
2	10%	2.46	3.98	4.38
3	20%	2.6	3.81	4.44
4	30%	2.57	3.89	4.61

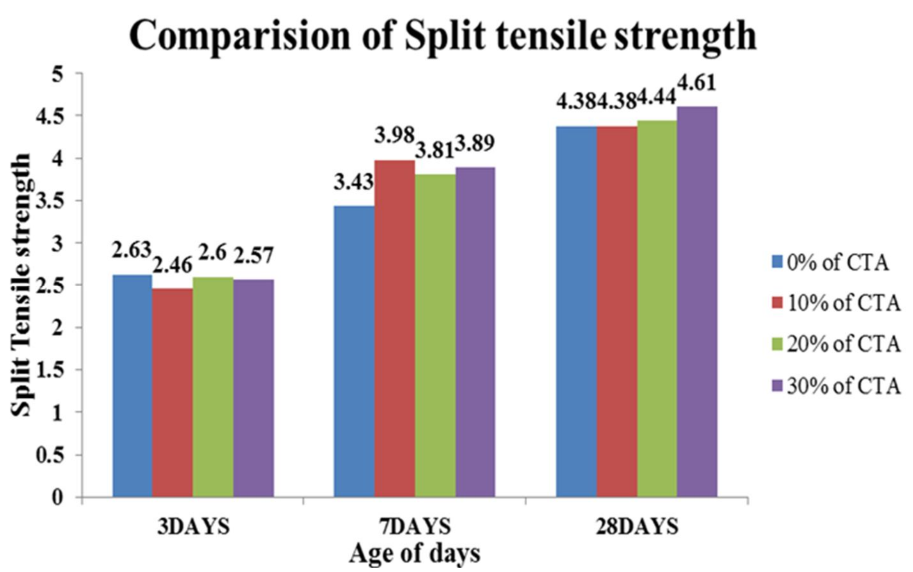

Fig 4: The comparison chart of split tensile strength.

VI. CONCLUSIONS

Since this kind of the material wastes are day by day gradually rising with enormous growth in the population and in the urban development, research on the use of waste to produce high density concrete in construction materials is crucial. The usage of tiles gathered from demolished structures and trash derived from the tile businesses was the primary goal of this inquiry for recycling the waste.

The following Conclusions are made under the experimental investigation of use of ceramic tile aggregate.

1) When coarse aggregate is used to replace 30% of the ceramic tile aggregate (C.T.A.), the maximum compression strengths are achieved.
2) When coarse aggregate is substituted for 30% of the ceramic tile aggregate, the maximum tensile strength is attained.
3) For replacement of 10% & 20% of C.T.A., the compressive strength value and split tensile strengths are not enhanced. When compared to regular concrete, the strength varies only slightly. The best outcome is achieved when coarse aggregate replaces C.T.A. by 30%.
4) Finally, the proper use of ceramic tiled aggregates can lead to optimum use of natural materials.

VII. FUTURE SCOPE

The list of points is taken under the ceramic tile investigation, which are as follows:

1) Use of waster ceramic tile as a partial replacement of cement, sand & aggregate in concrete.
2) Experimental investigation of cracks in concrete with use of waster ceramic tile & bacteria.
3) Small Model Construction such as Water tank, Beam & Column etc with the use of waste ceramic tile.
4) Software and Experimental comparison with the use of waste ceramic tile in multistorey building.

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