Experimental Study on Properties of Concrete by Using Ceramic Materials

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ABSTRACT

This paper generalizes the results of study on concrete using ceramic materials as partial replacement for fine and coarse aggregate. The attempt has been made to compare, the 7 days and 28 days compressive strength, splitting tensile strength and flexural strength of ceramic concrete with the normal concrete of M25 grade with maintaining the water cement ratio 0.45. The objective of this study is to develop concrete with good strength, less porous, less capillarity, eco-friendly concrete. For this purpose, the experiment has been carried out on M25 grade of concrete, using ceramic materials as partial replacement in different percentage 0%, 10%, 20%, 30% to the weight of fine and coarse aggregate.

Key words: *ceramic concrete, fine aggregate, coarse aggregate,partial replacement, water cement ratio.*
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INTRODUCTION

Generally in design of concrete mix, cement, fine aggregates and coarse aggregates are using from long back, which plays a crucial role in designing of a particular grade of concrete. But now a days there is a scarcity in aggregates. So, some new materials which are locally available for low cost have to introduce for replacing the fine aggregates, coarse aggregates and as well as cement to get the same strength as that these basic materials can give. So, we have to search for different materials to reduce the quantity of basic natural materials in the concrete mix without changing any mix design procedure and considerations. Use of cheaper material without loss of performance is very crucial to the growth of developing countries. We cannot replace the whole basic material in the concrete, but we can replace with other materials to some extent.

In the present world, huge amount of solid wastes are obtaining from manufacturing units and demolitions of construction from human daily habitats. Some researchers are working on solid waste as partial replacing substances based on the locally available waste materials like crushed plastic, Stone dust, over burnt bricks, M – sand, glass powder, coconut shells, waste tires, slag, fly ash produced from industries, broken glass pieces, rice husk ash, coconut shell ash, etc., to use them in concrete to partially replace the basic materials. And studies have been going on to preserve the natural basic aggregates and to promote use of the recycled aggregates to the next level in the concrete mix and to reuse the solid waste from construction again as a material in the concrete to decrease the land fill of solid waste and decrease the scarcity of natural aggregates like gravel and sand. Huge usage of ceramic tiles and other ceramic for architectural appearance, the productions of which are drastically increased. As 30 to 40% of the total production from manufacturing units is solid waste. So, we selected these waste tiles as a replacement material to the basic natural aggregate.

NEED FOR CERAMIC MATERIALS IN CONCRETE

Indian ceramic production is 100 Million ton per year. In the ceramic industry, about 15%- 30% waste material generated from the total production. 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. The Ceramic industries are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. Utilization of Ceramic waste and its application are used for the development of the construction industry, Material sciences. It is the possible alternative solution of safe disposal of Ceramic waste. Use of ceramic materials brings positive effect to the environment. Waste tiles can be used to replace some of the aggregates in a concrete mixture. This contributes to reducing the unit weight of the concrete. This is useful in applications requiring non-bearing light weight concrete, such as concrete panels used in facades, foot bath.

OBJECTIVES

The objective of this work is to develop concrete with good strength, less porous, less capillarity so that durability will be reached. For this purpose it requires the use of different pozzolanic materials like rice husk ash, ground granulated blast furnace slag, and silica fume. So the experiment carried out;

- To study the properties of M25 grade of ceramic concrete.
- To save the natural aggregate by using ceramic waste.
- To investigate the increase in the strength of concrete and better bonding between the aggregate and cement paste.
- To minimize the environment hazards by utilizing wastages

PROPERTIES OF CERAMIC CONCRETE

Workability

Slump cone test was performed on fresh concrete, for all mixes having different percentages of replacing materials, Slump values are not changing when waste crushed tiles are replaced in place of coarse aggregate. But, increase in percentage of tile powder in place of fine aggregate leads to the increase in slump value. Maximum slump is obtained for 20% mix i.e., when 20% of fine aggregate replaced by the tiles powder. In case of combinations also slump value is increasing. From the experiments clearly observe that the workability is increasing for all mixes at different percentages of replacing materials. There is a huge change in slump value when only tile powder was replaced in place of fine aggregate. So, here tile powder is acting like admixtures, which are used to produce RMC mix.

Strength

The strength of the concrete depends on a number of factors including the properties and proportions of the constituent materials, degree of hydration, rate of loading, and method of testing and specimen geometry. The properties of the constituent materials which affect thestrength are: the quality of fine and coarse aggregates, the cement paste and the paste aggregate bond characteristics, i.e. properties of the interfacial transition zone. These, in turn, depend on the macro- and microscopic structural features including total porosity, pore size and shape, pore distribution and morphology of the hydration products, plus the bond between individual components.

MATERIALS USED

- Cement: Ordinary Portland Cement, 53 Grade.
- Fine aggregate: Locally available river sand.
- Coarse aggregate: Locally available crushed blue stones conforming to graded aggregate of nominal size 20mm and 10mm.
- Ceramic materials: crushed tiles and ceramic powder.
- Water: Potable water.

MATERIAL PROPERTIES

Cement

Ordinary Portland Cement (53 Grade) was used for casting all the specimens. To produce high performance concrete, the utilization of high strength cements is necessary. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement.

Table 1. Properties of Cement

S. No.	Properties	Values
1	Fineness Of Cement	7.5%
2	Grade Of Cement	53
3	Specific Gravity	3.15
4	Initial Setting time	30 min
5	Final Setting Time	600 min

Fine Aggregate

Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.

Table 2. Properties of Fine Aggregate

S. No.	Properties	Values
1	Specific Gravity	2.65
2	Fineness Modulus	2.25

Coarse Aggregate

The coarse aggregate with 20 mm nominal size and 10mm size having specific gravity 2.72 was used. The impact value is 20.44%. And the water absorption of the coarse aggregate is 0.38%.In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

Table 3. Properties of Coarse Aggregate

S. No.	Properties	Values
1	Specific Gravity	2.72
2	Size of Aggregate	Passing Through 12.5 mm Sieve
3	Fineness Modulus	5.96

Ceramic materials

The amount of ceramic tile waste on earth is enough for use as a coarse and fine aggregate in concrete. Ceramic tile is produced from natural materials sintered at high temperatures. There are no harmful chemicals in tile. Waste tiles cause only the hazard of pollution. Wherever some parts of tiles are used in cotto as flooring and also flooring in different types of structures use differently like tennis courts, walkways, cycling paths and gardens as a ground material. So due to such reasons waste tiles are stored in factory fields because of their economic value. Nevertheless, every year approximately 250,000 tons of tiles are washed out, while 100 million tiles are used for repairs. Ceramic waste can be transformed into useful Fine and Coarse aggregate. It has been calculated that about 30% of the daily production in the ceramic industry left as a waste. This waste is not recycled in any form at present. Ceramic tiles possess a broad range of properties, and certain tiles are better suited for some installations than others. Few tiles are fitted for all types of installations; consequently, good knowledge of the properties is essential for the consumer to achieve the desired and look forward value of the tile. Because so many tile installations are built around or near water, and because due to porous materials it can soak up the moisture and dock unwanted organisms, absorption is one of the most important properties, that is because, in wet-area applications, it can involve health and safety issues, and in exterior applications, it can initiate important freeze/thaw damage .Ceramic waste can be separated in two categories in compliance with the origin of raw materials. The first one are all fired waste generated by the ceramic factories that use only red paste to manufacture their products, such as brick, blocks and roof tiles. The second one is all ignited waste manufactured in stoneware ceramic such as wall, floor tiles and sanitary ware. The ceramic industry is comprised of thefollowing sub-sectors like wall and floor tiles, sanitary ware, bricks and roof tiles, stubborn materials and ceramic materials for domestic and ornamental.

Table 4: chemical properties of ceramic waste

MATERIALS	CERAMIC POWDER (%)
SiO_2	63.29
Al_2O_3	18.29
Fe_2O_3	4.32
CaO	4.46
MgO	0.72
P_2O_5	0.16
K_2O	2.18
Na_2O_2	0.75
SO_3	0.10
CL	0.005
TiO_2	0.61
SrO_2	0.02
Mn_2O_3	0.05
L.O.I	1.61

MIX DESIGN

The concrete mix design was done DOE method. The following mix proportion was arrived as shown

Table 5. Mechanical Properties and Specimen Details

S. No.	Shape of the Specimen	Properties to be Studied	No. of Specimens	Days of Testing	Size of Specimen
1	Cube	Compressive Strength	21	28 Days	150x150 x150mm
2	Cylinder	Split Tensile Strength	21	28 Days	150mm dia, 300mm high
3	Prism	Flexural Strength	21	28 Days	100x100 x500mm

Quantities of the ingredients required for 1 cum cement concrete (M25)

cement	Fine aggregate	Coarse aggregate	water
422.543	524.64	1166.53	194.37

Ratio = 1 : 1.24 : 2.76 : 0.46

PERCENTAGES OF F.A AND C.A REPLACED

Table 6.replacement percentage

Mix	Fine Aggregate (%)		Coarse Aggregate(%)	
	Sand	Tiles Powder	C.A	Crushed Tiles
A0	100	0	100	0
A1	100	0	90	10
A2	90	10	70	30
A3	90	10	100	0
A4	80	20	80	20
A5	80	20	90	10
A6	70	30	80	20
A7	70	30	70	30

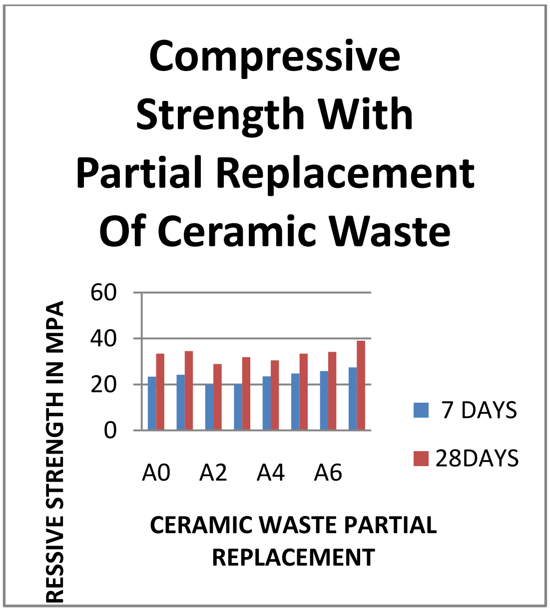
TEST RESULTS

Compressive strength

Table 7. Compressive Strength

SL.NO	Mix	Average Compressive Strength (Mpa)	
		7 days	28 days
1	A0	23.42	33.41
2	A1	24.20	34.55
3	A2	19.88	28.90
4	A3	20.10	31.88
5	A4	23.50	30.48
6	A5	24.78	33.41
7	A6	25.80	34.20
8	A7	27.41	39.04

Fig 1. Compressive strength at 7 & 28 Days



Ultrasonic pulse velocity test

It is a Non-Destructive method of testing on harden concrete to measure the quality of the concrete. The test was conducted following the procedure and specifications given in IS1311 part 1: 1992. As per Table 2 of IS1311 part 1: 1992, the quality grade of the concrete with respect to the velocity of the pulse traveled in the concrete as follows.

Table 8 : quality grading of concrete

Sl.no	Velocity (km/sec)	Quality
1	Above 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	Below 3.0	Doubtful

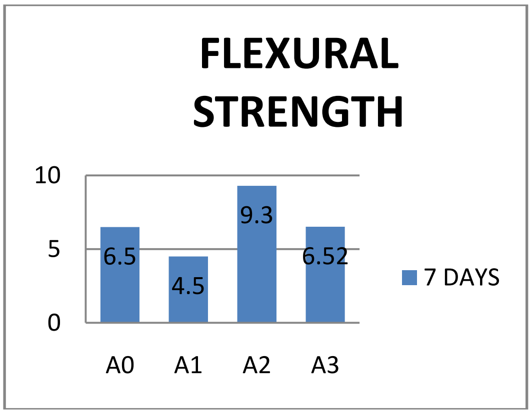
Table 9 : ultrasonic pulse velocity test results

Mix	Velocity (km/sec)		Concrete quality grading
	7 days	28 days	
A0	4.77	4.82	Excellent
A1	4.74	4.73	Excellent
A2	4.75	4.72	Excellent
A3	4.78	4.90	Excellent
A4	4.71	4.82	Excellent
A5	4.67	4.89	Excellent
A6	4.68	4.86	Excellent
A7	4.65	4.79	Excellent

Flexural strength

Flexural tensile strength, also determines as modulus of rupture is explained as the material ability to resist deformation under load or in other words load at which the concrete members may crack. It is determined by the standard testing specimens of 500x100x100mm over a span under symmetrical two point load.

Fig2:flexuralstrength



CONCLUSION

With the experimental studies conducted the following conclusions can be drawn:

- Ceramic waste initially there is decrease of 23.32% in compressive strength of 7days when partially replacement of 10%, but after that while replacing 20% there is increase of 5.48% and with 30% there is increase of 14.56% increases respectively in initial compressive strength with respect to normal concrete mix. The reason behind this is that the ceramic waste (sand) behaves as micro filler in concrete. When the ceramic waste replaced as 10% the amount of micro filler is not enough to exhibit required strength but further increase in amount of ceramic waste (sand) fill more voids in concrete mix due to which the compressive strength increased.
- Ceramic waste initially there is decrease 16.20% in compressive strength of 28days when partially replacement of 10%, but after that while replacing 20% there is increase of 4.2% and with 30% there is increase of 14.42% increases respectively in final compressive strength with respect to normal concrete.
- Initially there is decrease by 39.49% in flexural strength (28days) when partially replacement of 10%, but after that while replacing 20% there is increase of 8.57% and with 30% there is increase of 33.40% increases respectively in flexural strength with respect to normal concrete.

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