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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF SAND BY CERAMIC WASTE IN CONCRETE

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ABSTRACT

With the ever increase in the demand of river sand and decrease in its availability, there is an immediate need for finding suitable alternatives which can replace sand partially or at a high proportion. Many research study investigates the effect of several waste products such as Glass sheet powder, Incinerated Sewage sludge, foundary bed waste, crushed rock flour, building demolition waste in the partial replacement of river sand. Utilization of Ceramic waste is one of the active research area that encompass the effectiveness of replacement in all the aspects of construction materials. It is very essential to develop eco-friendly concrete from ceramic waste. This paper deals with the experimental study on the mechanical strength properties of M25 grade concrete with the partial replacement of sand by using ceramic waste. In order to analyze the mechanical properties such as compressive, split tensile, flexural strength, the samples were casted with 10%, 20%, 30%, 40%, 50% replacement of sand using ceramic waste and tested for different periods of curing like 7 days, 14 days and 28 days. The optimum of percentage addition of Ceramic waste is analyzed considering the requirements of mechanical properties of concrete

Key words: Ceramic wastes, Partial replacement, Eco-friendly, Behavioural study.

INTRODUCTION

Concrete is a composite material composed of gravels or crushed stones (coarse aggregate), sand (fine aggregate) and hydrated cement (binder). It has been in use for over a century in all construction works. A variety of new materials in the field of concrete technology have been developed during the recent past with the ongoing demand of construction industries to meet the functional, strength, economical and durability requirements. Indian ceramic production is 100 Million ton per year. India ranks in the top 3 list of countries in terms of tile production in the world. The production during 2011-12

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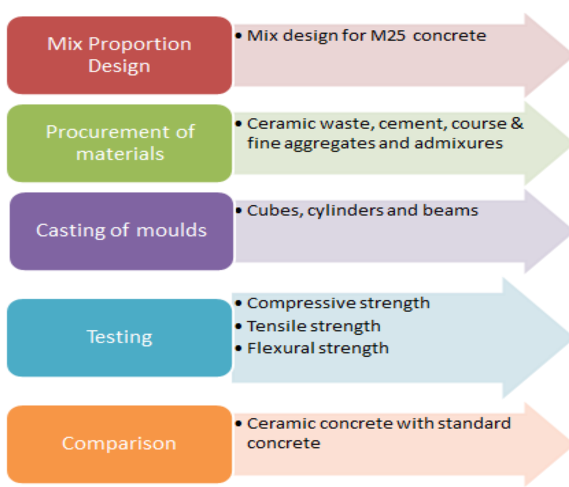
stood at approximately 600 million square meters. This huge production of ceramic tiles is due to the boom in housing sector coupled by government policies fuelling strong growth in housing sector. In the ceramic industry, about 15% to 30% waste material is generated from the total production. Although the reutilization of ceramic wastes has been practiced, the amount of wastes reused in that way is still negligible. Hence, the need for its application in other industries is becoming absolutely vital. Construction industry can be the end user of all ceramic wastes and in this way can contribute to solve this environmental problem.

Objectives of the study

- To effectively utilize the waste material from ceramic industries in concrete
- To replace the fine aggregates with various percentage 10, 20, 30, 40, 50% of ceramic waste in M25 concrete
- To conduct the mechanical strength tests for concrete with the partial replacement of fine aggregate by ceramic waste
- To study the effect of compressive, split tensile, flexural strength characteristic properties of ceramic waste in concrete

Methodology



Characteristics of materials used

Ceramic wastes

Ceramic waste is available from large ceramic factories, ceramic product manufacturing units and from everyday construction activities. Traditional ceramics, such as bricks, roof and floor tiles, other construction materials, and technical ceramics, such as porcelain are usually highly heterogeneous due to the wide compositional range of the natural clays used as raw materials. Approximately 300 kg of wastes from a Indian ceramic company (RAK Ceramics Pvt. Ltd., Chennai) was crushed with a tampering rod manually to make the ceramic aggregate. Thus, by using this system to crush ceramic wastes is possible to obtain coarse aggregates, fine aggregates and ceramic powder that after sieving (IS 4.75 mm sieve) can be used without additional work and with minimal cost implications.

Cement

Cement may be prescribed as material with adhesive and cohesive properties which make it capable of bonding material fragments into a compact whole. The most commonly used cement in construction today is Portland cement and hence Ordinary Portland Cement of 53 grades has been selected for the investigation. It is dry, powdery and free of lumps. The cement according to the Indian specification must satisfy the IS code IS:8122- 1989 (reaffirmed 1999).

Table 1: Physical properties of (OPC) cement

Property	IS Code (IS : 8112 – 1989)
Specific gravity	3.15
Consistency	30
Initial setting time	30 minimum
Final setting time	540 maximum

Coarse aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. Machine crushed angular granite metal of 20 mm nominal size from the local source was used as coarse aggregate. It was free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate chosen for Concrete was typically angular in shape, well graded, and smaller than maximum size suited for conventional concrete. The physical properties of coarse aggregate were investigated in accordance with IS 383 -1963.

Fine aggregate

Fine aggregate is an essential component of concrete. Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. The natural fine aggregates are the river sand which is the most commonly used natural material for the fine aggregates that is used, but the recent social factor that created a shortage of the material created a great problem in the construction sector. For the studies the river sand of Zone-II is used in all the references.

Table 2: Physical properties of aggregate

Property	Fine aggregate	Coarse aggregate	
		20 mm	10 mm
Fineness modulus	3.35	3.54	3.19
Specific gravity	2.63	2.78	2.69
Bulk density (g/cc)	1753	1741	1711
Water absorption (%)	1.2	1.83	1.35

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it gives the strength to cement concrete, the quantity and quality of water are required to be looked into very carefully. Potable tap water free from any injurious amounts of oils, acids, alkalies, sugar, salts and organic materials available in the laboratory with pH value of 7.0 ± 1 and confirming to the requirements of IS: 456 -2000 was used for mixing concrete and curing the specimens as well.

Experimental investigations

Mix design

Mix proportioning for a concrete of M25 is as follows:

1. Stipulation for proportion

a. Grade designation : M 25

b. Type of cement : OPC 43 grade conforming to IS 8112

c. Maximum nominal size of aggregate : 20 mm

d. Minimum cement content : 320 kg/m^3

e. Maximum water-cement ratio : 0.55

f. Workability (slump) : 100 mm

g. Exposure condition : Severe (for reinforced concrete)

h. Method of concrete placing : Pumping

i. Degree of supervision : Good

j. Type of aggregate : Crushed angular aggregate

k. Maximum cement content : 450 kg/m³

l. Chemical admixture : Super plasticizer

Test data for materials

a) Cement used : OPC 43 grade conforming to IS 8112

b) Specific gravity of cement : 3.15

c) Chemical admixture : Super plasticizer conforming to IS 9103

d) Specific gravity of :

1) Coarse aggregate : 2.78,

2) Fine aggregate : 2.63

Mix proportion

Cement = 350 kg/m³

Water = 140 kg/m³

Fine aggregate = 591 kg/m³

Coarse aggregate = 1140 kg/m³

Admixture = 7 kg/m³

Water-cement ratio = 0.4

Compressive strength

Compressive strength test is the most common test conducted on concrete, because it is the desirable characteristic properties of concrete are quantitatively related to its compressive strength. Compressive strength was determined by using Compression Testing Machine (CTM) of 2000 kN capacity. The compressive strength of concrete was tested using 150 mm x 150 mm x 150 mm cube specimens. The test was carried out by placing a specimen between the loading surfaces of a CTM and the load was applied until the specimen fails. Two test specimens were cast for each proportion and used to measure the compressive strength for each test conditions and average value was considered. The average value of compressive strength of 2 specimens for each category at the age of 7 days, 14 days and 28 days are shown below.

Fig. 1: Compressive strength testing set up

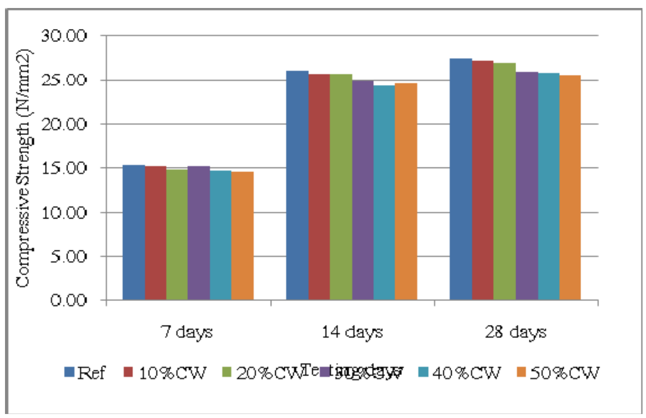


Fig. 2: Comparison of compressive strength

There is a consistency in the compressive strength of concrete with inclusion and increase in the percentage of ceramic waste sand. The compressive strength was achieved upto 30% replacement of fine aggregate with ceramic waste sand beyond which the addition of waste reduces the strength due to lack of moisture

Tensile strength

Knowledge of tensile strength of concrete is of great importance. Tensile strength was determined using Universal Testing Machine (UTM). The split tensile strength of concrete was tested using 100 mm x 200 mm cylinder specimens and carried out by placing a specimen between the loading surfaces of a UTM and the load was applied until the failure of the specimen. Two test specimens were cast for each proportion and used to measure the tensile strength for each test conditions and average value was considered. The average values of 2 specimens for each category at the ages of 7 days, 14 days and 28 days are shown in the Fig. 3.

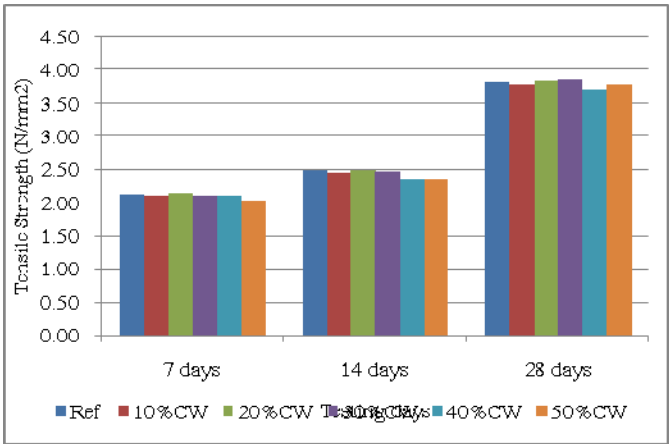


Fig. 3: Comparison of tensile strength

The increase in the tensile strength of various concrete mixtures over plain concrete is also tabulated in Fig. 3. There is a considerable improvement in the tensile strength of concrete with inclusion and increase in the percentage of ceramic waste sand up to 30%.

Flexural strength

Flexural strength is a measurement that indicates the resistance of a material to deformation when placed under a load. The values needed to calculate flexural strength are measured by experimentation, with rectangular samples of the material placed under load in a 2 point loading testing setup. The strength of a material in bending, expressed as the stress on the outermost fibres of a bent test specimen, at the instant of failure. Prism specimens were tested for flexural strength. The tests were carried out confirming to IS: 516-1959 (8). The specimens are tested under two-point loading. The average value of 2 specimens for each category at the age of 7 days, 14 days and 28 days is shown in Fig. 5.

The increase in strength of various concrete mixtures over the plain concrete is also shown in the Fig. 5. There is consistency in the flexural strength of concrete with the inclusion and increase in the percentage of ceramic waste sand upto 30%. However the flexural strength remained constant for almost all the mixtures.

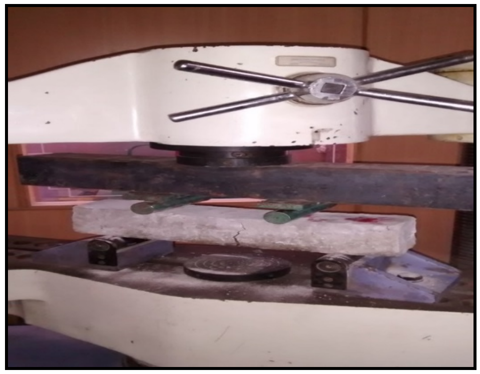


Fig. 4: Flexural strength testing set up

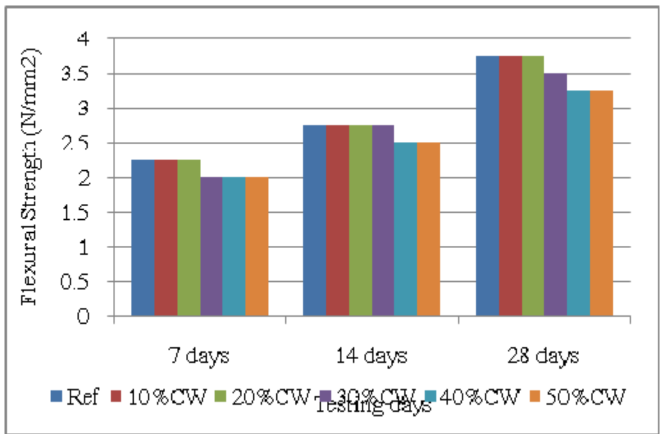


Fig. 5: Comparison of flexural strength

CONCLUSION

(i) The test results shows clearly that the ceramic waste can be used as a replacement materials for river sand in concrete

(ii) The concrete with 10 and 20% replacement satisfies the compressive strength of M25 grade however higher the percentage addition of ceramic waste reduces the strength of normal concrete

(iii) The tensile strength of 10, 20, 30% replacements at 14 days shows the consistency in attaining the required range.

(iv) Hence the replacement of river sand using 30% ceramic waste in concrete gives the required strength and can be considered as optimum percentage.

Further it can be analyzed with replacement of higher percentage of ceramic wastes.

(v) Further increase in the percentage addition of ceramic waste, reduces the mechanical properties of concrete.

REFERENCES

1. M. Veera Reddy, Investigations on Stone Dust and Ceramic Scrap as Aggregate Replacement In Concrete, Int. J. Civil Struct. Engin., **1(3)**, 661-666 (2010).
2. César Medina, M. I. Sánchez de Rojas, Moisés Frías and Andrés Juan, Using Ceramic Materials in Ecoefficient Concrete and Precast Concrete Products, Spain (2010).
3. C. Medina Martínez, M. I. Guerra Romero, J. M. Morán del Pozo and A. Juan Valdés, Use of Ceramic Wastes in Structural Concrete, 1st Spanish National Conference on Advances in Materials Recycling and Eco-Energy Madrid, 12-13 Nov. (2009).
4. M. Shahul Hameed and A. S. S. Sekar, Properties of Green Concrete Containing Quarry Rock Dust and Marble Sludge Powder as Fine Aggregate, ARPN J. Engg. Appl. Sci., **4(4)**, 83-89 (2009).
5. İ. B. Topçu and M. Canbaz, Utilization of Crushed Tile as Aggregate in Concrete, Iranian J. Sci. Technol., Transaction B, Engg., **31(B5)**, 561-565 (2007).
6. IS 2386-1963, Method of Test for Aggregate for Concrete, Bureau of Indian Standards, New Delhi.
7. IS 516-1959, Method of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi.
8. IS 383-1970, Specifications for Coarse and Fine Aggregate from Natural Source of concrete", Bureau of Indian Standards New Delhi.
9. IS 12269-1987, Specifications for 53 Grade Ordinary Portland Cement", Bureau of Indian Standards, New Delhi.
10. IS 10262-2009, Recommended Guidelines for Concrete Mix Design", Bureau of Indian Standards, New Delhi.
11. IS 456-2000, Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards New Delhi.

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