Study on Partial Replacement of Fine Aggregate in Concrete Using Ceramic Wastes

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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 studies investigates the effect of several waste products such as Glass sheet powder, Incinerated Sewage sludge, foundry bed waste, crushed rock flour, building demolition waste in the partial replacement of river sand. It is very essential to develop eco-friendly concrete from ceramic waste. In the ceramic industry, about 15% to 30% waste material is generated from the total production. Hence, the need for its application in other industries is becoming absolutely vital. 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 strength, the samples were casted with 15%, 20%, 25%, 30%, 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, Behavioral study.

I.INTRODUCTION

In this project we use the ceramic waste materials by replacing partially with cement in the concrete. ceramic wastes is an inorganic, nonmetallic, solid material comprising metal, nonmetal or metalloid atoms primarily held in ionic and covalent bonds. In India ceramic production is 100 million tons per year. In this ceramic industry, about 15% - 30% production goes as waste. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant of biological, chemical and physical degradation this leads to serious environmental and dust pollution, occupation of vast area of land. The advancement of concrete technology can reduce the consumption of natural resources. They have forced to focus on recovery, reuse of natural resources and find other alternatives. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment. Ceramic materials are the mixture of clay, powder and water shaping into desired forms. The principle waste coming into the ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing. It is estimated that 15% to 30% waste are produced from total raw material used, and although a portion of this waste may be utilized on-site, such as for excavation pit refill, The disposals of these waste materials acquire large land areas and remain scattered all around, spoiling the aesthetic of the entire region. It is very difficult to find a use of ceramic waste produced. Ceramic waste can be used in concrete to improve its strength and other durability factors. Ceramic waste can be used as a partial replacement of cement or as a partial replacement of fine aggregate sand as a supplementary addition to achieve different properties of concrete.

II. OBJECTIVE

- To effectively utilize the waste material from ceramic industries in concrete
- To replace the fine aggregates (M-sand) with various percentage 20%, 25%, 30% 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 characteristic properties of ceramic waste in concrete

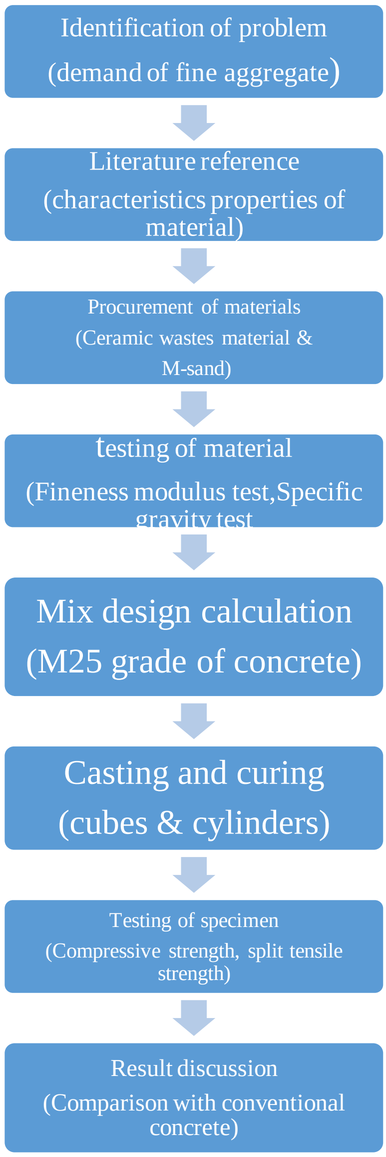
III LITERATURE REVIEW

G. Sivaprakas, v. Saravana kumar and lakhi jyoti saikia, "Experimental Study on Partial Replacement of Sand by Ceramic Waste in Concrete"(2016) says clearly that the ceramic waste can be used as replacement materials for river sand in concrete. 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. The tensile strength of 10, 20, 30% replacements at 14 days shows the consistency in attaining the required range. Hence the replacement of river sand using 30% ceramic waste in concrete gives the required strength and can be considered as optimum percentage

C.Karthik and S.Ramesh Kumar, "Experimental Investigation on Concrete with Ceramic Waste as A Partial Replacement of Fine Aggregate"(2016) Ceramic wastes are the main problem of tile industries and from demolition buildings. The aim of this investigation was the utilization of ceramic waste collected from dressing and polishing of metal or non-metal compounds in concrete as fine aggregate. The use of ceramic waste in concrete as positive effects on the environment and obtaining lower costs. In this experimental investigation, concrete mix M25 has been used. The concrete with ceramic waste as a partial replacement of fine aggregate are used and

the results have been evaluated. The properties of ceramic waste fine aggregate concrete are not significantly different from those of conventional concrete. The compressive strength and split tensile strength of concrete made using ceramic waste up to 30% replacement of fine aggregate, the strength increases.

*Dr. M.Swaroopa Rani, "A Study on Ceramic Waste Powder"(2016)*The study shows that the addition of the industrial wastes improves the physical and mechanical properties..The Compressive Strength of M40 grade concrete increases when the replacement of cement with ceramic waste is up to 10% by weight of cement, and further replacement of cement with ceramic powder decreases the compressive strength.



III. METHODOLOGY

IV. MATERIAL INVESTIGATION

1 Cement

The cement used should confirm IS specifications. There are several types of cements available commercially in the market of which Portland cement is very common and it is well known and available everywhere. PPC 43 grade was used for this study. The physical properties of the cement tested according to standard procedure confirm to the requirement of IS 12269:1989. The physical properties of the cement are listed in the table 1

Table1 Physical Properties of Cement

S.No	Characteristiceramic wastes	experimental values
1	Standard Consistency	31%
2	Fineness of cement as retained on 90 micron sieve	5%
3	Initial setting time	35 minutes
4	Final setting time	520 minutes

2 Fine Aggregate

Locally available river sand passing through 4.75mm sieve conforming to the recommendation of IS 383:1970 is used. Specific Gravity of fine aggregate is found and the particle size distribution is listed below in the Table 2

Table2 Particle Size distribution for fine aggregate

Weight of fine aggregate =1000 grams

Sieve Size	Weight Retained (grams)	Cumulative percentage retained	Cumulative percentage passing
4.75mm	0	0	0
2.36mm	11	1.1	98.9
1.18mm	231	23.1	76.9
600micron	342	34.2	65.8
300micron	257	25.7	74.3
150micron	157	15.7	84.3
75micron	2	0.2	99.8
Pan	0	100	0

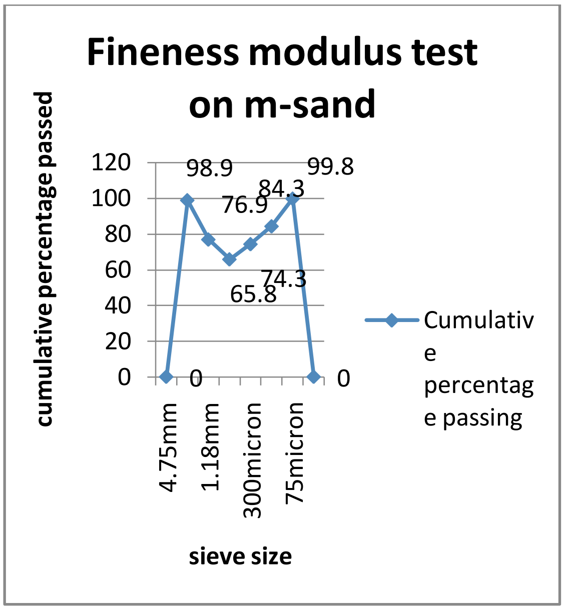


Figure 1 Sieve Analysis for Fine Aggregate

From the sieve analysis results fine aggregate is graded to Zone IV

3 Coarse Aggregate

Coarse aggregate to be used for production of concrete must be strong, impermeable, durable and capable of producing a sufficient workable mix with minimum water cement ratio to achieve proper strength. Locally available coarse aggregate retaining on 4.75 mm sieve is used. Specific Gravity of coarse aggregate was found and the particle size distribution for coarse aggregate is listed below in Table 3

Table 3 Particle Size Distribution for Coarse Aggregate

Weight of coarse aggregate = 3000 grams

Sieve Size	**Weight Retained (grams)**	**Cumulative percentage retained**	**Cumulative percentage passed**
40mm	0	0	100
20mm	1598.00	46.74	53.26
16mm	793.50	73.55	26.45
12.5mm	343.70	88.55	11.45
10mm	231.11	92.29	7.71
4.75mm	33.69	98.88	1.12

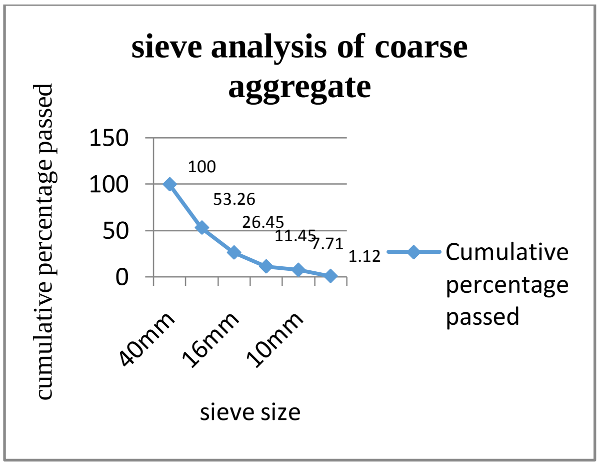


Figure 2 Sieve Analysis for Coarse Aggregate

From the sieve analysis results nominal size of coarse aggregate is 20mm

4 Water

The quality of mixing water for concrete has a visual effect on the resulting hardened concrete. Impurities in water may interfere with the setting time of cement and will adversely affect the strength and durability of concrete with copper slag. Fresh and clean water which is from organic matter silt, oil, and acid material as per standards is used for casting the specimens. Water that is piped from the public supplies is used.

5 Ceramic Wastes

A ceramic is an inorganic compound, non-metallic, solid material comprising metal, non-metal or metalloid atoms primarily held in ionic and covalent bonds. This article gives an overview of ceramic materials from the point of view of materials science. The ceramic wastes are used as partial substitute for fine aggregate. The fraction of 4.75mm is used.

Table 4 Chemical Composition of ceramic

Sl.no.	**Chemical constitution**	**Ceramic powder (wt %)**
1	SiO_2	68.41
2	Al_2O_3	24.96
3	Fe_2O_3	0.94
4	CaO	0.63
5	MgO	0.19
6	P_2O_5	0.17
7	K_2O	2.80
8	Na_2O	1.65
9	TiO_2	0.55
10	ZrO_2	0.08
11	Others	0.12

V. TEST ON MATERIALS

Table 5 Test results

MATERIALS	SPECIFIC GRAVITY	CONSISTENCY	FINENESS	IMPACT TEST
Cement	3.15	31%	5%	
Ceramic wastes	2.73			
Fine aggregate	2.68			
Coarse aggregate	2.74			6.20 %

VI CONCRETE MIX DESIGN

Mix design calculations

A.1 Target Strength for Mix Proportion

$f'_{ck} = f_{ck} + 1.65 \times S$

Where,

f'_{ck}= Target average compressive strength at 28 days

f_{ck} = Characteristic compressive strength at 28 days

S = Assumed standard deviation in N/mm^2 = 5 (as per table -1 of IS 10262-2009) $= 30 + 1.65 \times 5.0 = 38.25\ N/mm^2$

A.2 Selection of Water – cement ratio

From table 5 of IS 456 the water cement ratio is adopted as 0.4

Hence w/c=0.4

Percentage of ceramic replacement	Cement content Kg/m^3	Fine aggregate Kg/m^3	Coarse aggregate Kg/m^3	Ceramic wastes Kg/m^3
0%	468	685	1121	0
15%	468	582.25	1121	102.75
20%	468	548	1121	137
25%	468	513.75	1121	171.25

A.3. Water Content

From table 2 of IS 10262 the maximum water content for 20mm aggregate is 176 litre

Water content = 186 litre

A.4 Cement Content

w/c ratio = 0.4

Therefore cement = 186/0.4 = 468 kg/m^3

A.5 Volume of Aggregates

From table 3 of IS 10262

Volume of coarse aggregate = 0.61

Volume of fine aggregate = 1-0.61=0.39

A.5 Mix Calculations

a) Volume of Concrete = 1 m^3
b) Volume of Cement = (437.7/3.15)/1000 = 0.138 m^3
c) Volume of water = 0.186 m^3
d) Volume of aggregate = 1-0.138-0.186 = 0.676 m^3
e) Mass of Coarse aggregate = 0.676*0.61*2.65*1000 = 1121 kg/ m^3
f) Mass of Fine aggregate = 0.676*0.39*2.65*1000 = 685 kg/ m^3

Cement	= 468 kg/ m^3
Water	= 186 kg/ m^3
Fine Aggregate	= 685 kg/ m^3
Coarse Aggregate	= 1121 kg/ m^3
Water Cement ratio	= 0.45

Table 6 Mix design

VII TEST ON CONCRETE

1 TEST ON FRESH CONCRETE

1.1 SLUMP CONE TEST

Table 7 Slump Cone test Values for CS replacement

Percentage of Ceramic waste replacement	Slump Value in mm
Nominal Mix	95
15%	85
20%	80
25%	80
30%	75

1.2 COMPACTION FACTOR TEST

Table 8 Compaction Factor Values for ceramic replacement

Percentage of Ceramic wastes replacement	Compaction Factor value in %
Nominal Mix	0.92
15%	0.93
20%	0.95
25%	0.96
30%	0.96

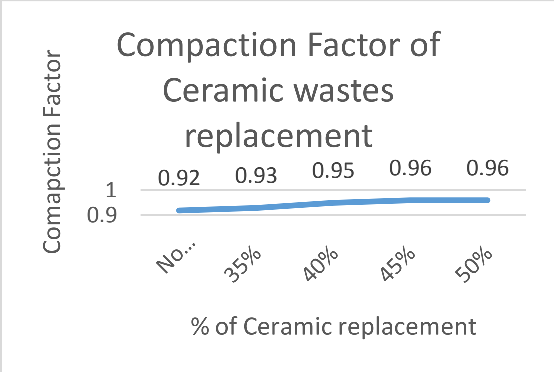


Figure 3 Compaction Factor of CS replacement

2 TEST ON HARDENED CONCRETE

2.1 COMPRESSIVE STRENGTH TEST

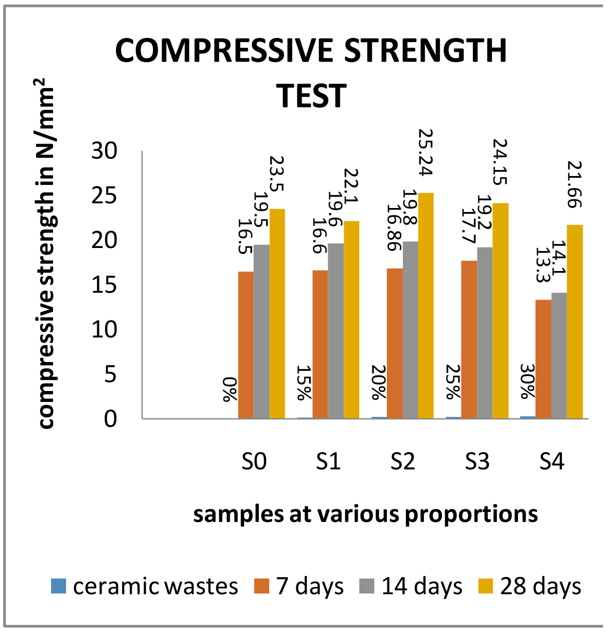
Table 9 Compressive strength Test on Conventional Concrete

Conventional Concrete	Compressive strength at 7 days N/mm^2	Compressive strength at 14 days N/mm^2	Compressive strength at 28 days N/mm^2
C1	16.5	19.5	23.5
C2	18.8	21.5	25.5

Table 10 Compressive strength Test on ceramic wastes replacement

Percentage replacement of ceramic wastes	Compressive strength at 7 days N/mm^2	Compressive strength at 14 days N/mm^2	Compressive strength at 28 days N/mm^2
15%	16.6	19.6	22.1
20%	16.86	19.8	25.24
25%	17.7	19.2	24.15
30%	13.3	14.1	21.66

Figure 4 Compressive strength of Conventional Concrete



From the graph it is obtained that the compressive strength of the CERAMIC WASTES replaced concrete is found to be high at a replacement of **20%** and hence this value is found to be the optimum value

2 SPLIT TENSILE STRENGTH

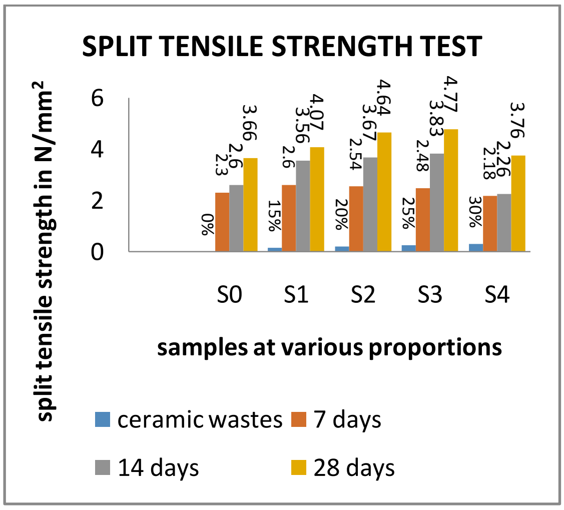
Table 12 Tensile Strength test on conventional concrete

Conventional Concrete	Tensile strength at 7 days N/mm^2	Tensile strength at 14 days N/mm^2	Tensile strength at 28 days N/mm^2
C1	2.3	2.6	3.66
C2	2.4	3.3	4.2

Table 11 Tensile Strength test on ceramic wastes replacement

Percentage replacement of Ceramic wastes	Tensile strength at 7 days N/mm^2	Tensile strength at 14 days N/mm^2	Tensile strength at 28 days N/mm^2
15%	2.6	3.56	4.07
20%	2.54	3.67	4.64
25%	2.48	3.83	4.77
30%	2.18	2.26	3.76

Figure 5 Tensile Strength of Ceramic replaced Concrete



VIII CONCLUSION

i. The test results show clearly that the ceramic waste can be used as replacement materials for m-sand in concrete.

ii. The concrete with 15 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 15, 20, 25, 30% replacements at 14 days shows the consistency in attaining the required range.

iv. Hence the replacement of m-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.

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