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Experimental Analysis on Concrete by Partial Replacement of Fine Aggregate with Powdered Ceramic Tile

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ABSTRACT

Concrete is the most versatile material in building industry. River Sand is scarcely available now and other alternative materials are being tried. Ceramic tiles are widely used in construction industry in which about 25% becomes waste. This investigation deals about replacing sand partially with 10%, 20%, 30% and 40% of waste powdered ceramic tile in concrete. The test results for M30 grade concrete with water cement ratio of 0.4 and partial replacement by 30% shows an increase of 13% and 15% respectively in compressive and flexural strength. For 40% replacement of sand with ceramic tile, the compression and flexural strength are at par with conventional concrete. The result leads to the effective utilization of ceramic tile waste thus by reducing the disposal and environmental problems.

Keywords: *Ceramic Tile, Fine Aggregate, Compressive Strength, Flexural Strength.*

1. INTRODUCTION

Concrete plays a major role in the construction industry. This paper is concerned with the scarcity of natural resources and its effect on the environment. Globally India is ranked third in the production of ceramic tiles. 25% of ceramic tile is wasted during the production, transportation, and usage. Ceramic tile waste is found as an effective alternate and supplementary material in concrete as a replacement for fine aggregate which is getting costlier nowadays.

Ceramic tile waste is found as an effective alternate and supplementary material in concrete with the optimum replacement of 40%. (Hitesh Kumar, et al., Aug 2015) [8].The optimum percentage of concrete with ceramic tile waste for coarse and fine aggregate is 10% & 20% (Hemnath Kumar ch.et al., June 2015) [9]. The optimum value of ceramic tile waste replacement in concrete with water cement ratio 0.5 is 30% (Md Daniyal, et al., 2015) [10]. Tile powder concrete has increased the durability, compression & flexural strength of M30 grade concrete by 30% replacement (Ponnapatti, et al., 2015) [11]. Replacement of ceramic powder and marble dust powder with fine aggregate in concrete by 30% by weight of M20 grade concrete has same characteristic strength. Beyond 30% of ceramic waste and 20% of marble powder the strength decreases. (Abdullah Anwar, et al., 2015) [12]. Ceramic powder has very good pozzolonic reactivity. Optimum percentage of ceramic powder for replacement is 20-30% as cementations material (Jay Patel, et al., 2014) [14]. The concrete mixes containing recycled ceramic waste aggregate achieves strength up to 95% compared to the conventional concrete (A. Mohd Mustafa Al Bakri, et al., 2008) [17].

This paper utilizes the powdered ceramic waste as the replacement material of fine aggregate in concrete. In this investigation, the strength and flexural parameters of partially replaced concrete with powdered ceramic tile waste were studied.

2. MATERIALS

2.1 Cement

Ordinary Portland Cement (OPC) of grade 53 was used in this investigation. The OPC used is confirming to IS12269: 2013. Initial setting time and final setting time are 30 minutes and 9 hrs. 45 minutes respectively. The specific gravity of cement is 3.15.

2.2 Fine Aggregate

Fine aggregate was obtained from the local source and falls under zone III. Fine aggregate is confirming to IS 383: 1970. It passes through 4.75 mm size of IS sieve having a specific gravity of 2.67.

2.3 Coarse Aggregate

Coarse aggregate was obtained from local sources graded from 20 mm to 10 mm. It is confirming IS 383: 1970. The fraction of 20 mm to 10 mm coarse aggregate was in a ratio of 60:40. Both sized aggregates were sieved separately. Specific gravity and water absorption of 20mm and 10mm aggregates are 2.74 & 0.5% and 2.74 and 1.0% respectively.

2.4 Ceramic Tile Waste

Ceramic tiles waste were obtained from a local warehouse and powdered. Figure 1 shows the powdered ceramic tile waste. Its bulk density and water absorptions are 2.35 gm/cc and 0.45% respectively.

Fig. 1 Ceramic Tile Powder

Table I shows that ceramic wastes contain 12% more Silicon dioxide content than fly ash which is favorable for replacement as fine aggregate. Potassium oxide and Sodium oxide content are higher by 4.50 % and 1% when compared to Fly ash.

Table I: Comparison of Chemical Composition of Ceramic Tile and Fly Ash

S.No.	Oxides	Chemical composition in %	
		Ceramic Tile	Fly ash
1	SiO_2	64.92	53.39
2	Al_2O_3	25.19	61.07
3	Fe_2O_3	0.7	13.05
4	TiO_2	0.7	0
5	CaO	0.36	6.33
6	MgO	0.55	5.49
7	K_2O	4.50	0
8	Na_2O	2.57	1.59

2.5 Superplasticizer

Super plasticizer Glenium SKY8233 was used. It is a synthetic super plasticizer based on modified Polycarboxylic ether. It confirms to IS 9103: 1999. It is a light brown liquid instantly dispersible in water. It can yield up to 25% reduction of water, thereby reducing permeability and increasing strength. Table II shows the properties of super plasticizer.

Table II: Properties of Glenium SKY8233 (Superplasticiser)

Aspect	Light Brown Liquid
Relative Density	1.08±0.01 at 25°C
pH	≥6
Chloride ion content	< 0.2%

2.6 Water

Potable drinking water was used for mixing and curing. The water-cement ratio adopted is 0.4.

3. PREPARATION OF SPECIMENS

3.1 Proportioning

The quantity of cement, fine and coarse aggregates, ceramic tile wastes, water and Super plasticiser for each batch of proportions were prepared. Here M30 concrete mix is designed as per IS 10262 – 2009 code. The designed mix proportion of M30 concrete is 1:2.52:3.21.

3.2 Mixing of Concrete

The mixing of concrete is done by mixer machine.

3.3 Moulds

The concrete specimens were cast using the cube moulds of size 150mm x150mm x 150mm and beam moulds of size 100mm x 100mm x500mm.

3.4 Curing

After 24 hours, the beams and cubes were demoulded and placed in the curing tank for curing at 27ºC ±3ºC for and 7 days and 28 days.

4. TESTS ON SPECIMENS

4.1 Compressive Strength of Concrete

The figure 2 shows the cube loaded in the compression testing machine. Compressive strength test was carried out on 150x150x150mm size cubes. The load is applied gradually till failure.

Ultimate Compressive strength = P/A
Where P = Total load applied in N
A= Area of the cube

Fig. 2: Compressive Strength Test

4.2 Flexural Test

Figure 3 shows the prism loaded in the universal testing machine. Test for modulus of rupture is carried out on the Standard beams of size 100mm x 100mm x 500mm. The beam should be tested on a span of 400mm by applying a single point load at the centre of the beam supported on steel rollers. The first crack was noted and the load was applied till failure.

Ultimate Flexural strength = PL/bd^2
Where,
P = Total load applied on the beam (N)
L = Supported length (cm)
b = Width of specimen (cm)
d = Depth of beam (cm)

Fig 3: Standard Beam Test for Flexure

5. M-30 CONCRETE MIX DESIGN

5.1 Mix Proportions

The various proportions for different percentage replacement of ceramic tile waste are given in Table III below.

Table III: Mix Proportioning Per Cubic Meter of Concrete

MIX NAME	CW in % kg/m3	C kg/m3	FA kg/m3	CA20 kg/m3	CA12 kg/m3	W kg/m3	SP kg/m3
CW0	0	355	896	456	684	142	7.1
CW1	10	355	886	456	684	142	7.1
CW2	20	355	876	456	684	142	7.1
CW3	30	355	866	456	684	142	7.1
CW4	40	355	856	456	684	142	7.1

Note: CW – Ceramic tile Waste. C- Cement, FA – Fine Aggregate, CA20 – 20mm Coarse aggregate mix, CA12 – 12mm Coarse aggregate mix, W- Water in Kilogram, SP – Super Plasticizer.

6. RESULTS AND DISCUSSIONS

6.1 Workability

Workability of concrete made using waste ceramic tiles was determined at different replacement level. The results are shown in graphical form in figure 4 for visual observation. It is evident from the figure that workability of concrete made using ceramic waste decreased with increase in replacement level.

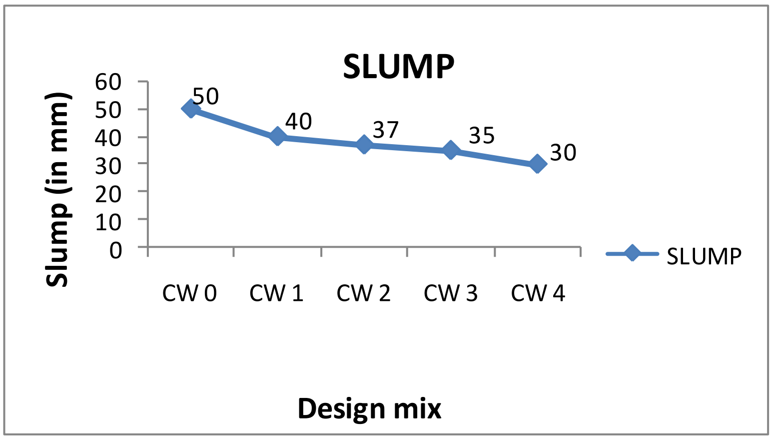

Fig 4: Variation in Slump for Design Mix Proportion

6.2 Compressive Strength

From the figure 5 given below, the compressive strength of concrete made using 10% replacement level reduced when compared to conventional concrete. There was an increase in compressive strength from 10% replacement up to 30% and then decreases to 40% replacement level. The compressive strength increased up to 13.43%. From the results, it is inferred that 30% of replacement is the optimal replacement.

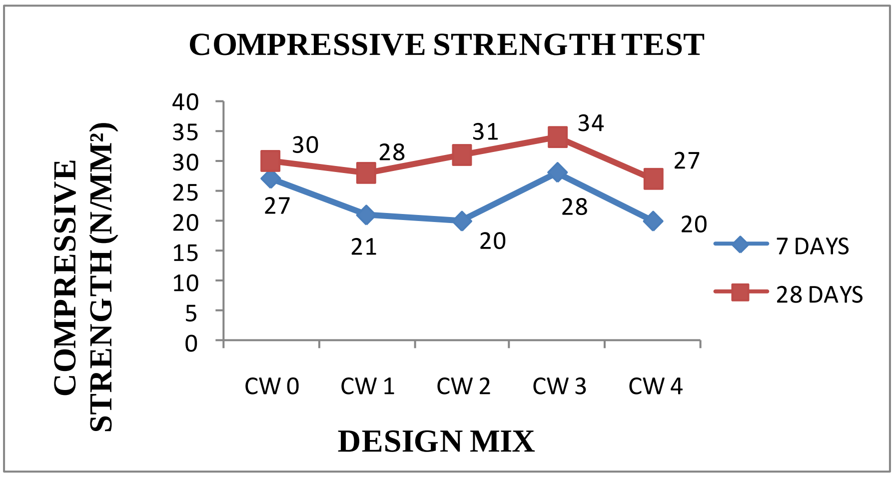

Fig.5: Variation in Compressive Strength for Design Mix Proportion

6.3 Flexural Test

7 and 28 days flexural strength results of the beam specimens are shown in figure.6.

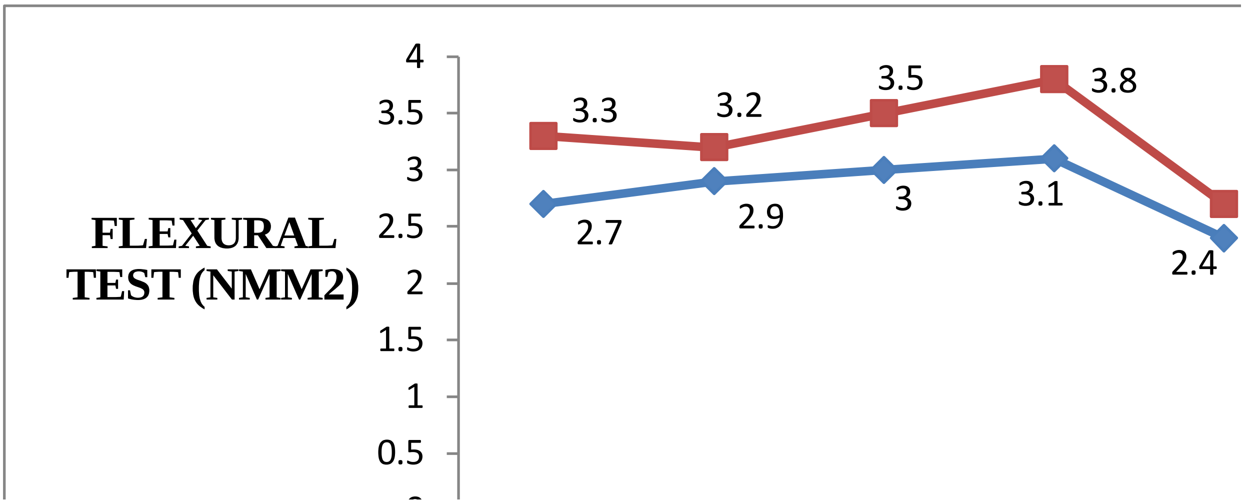

Fig.6 Variation of Flexural Strength for Design Mix Proportion

For 7 days test, the flexural strength increases gradually from 10% to 30% and reduces at 40% of powdered ceramic tile waste replacement. For 28 days the flexural strength increases gradually from 10% to 30% and reduced abruptly for 40% powdered ceramic tile waste replacement.

7. CONCLUSION

- Using waste powdered ceramic tiles as partial replacement of fine aggregate, workability decreased with increase in replacement level.
- The optimal replacement level of fine aggregate with powdered ceramic waste was found to be 30%.
- The 40% replacement was a marginally less compressive strength with that of conventional concrete.
- The compressive strength increased up to 13.43% and the flexural strength increased up to 15.55% at 30% replacement level compared to conventional concrete.
- Powdered ceramic waste can be effectively used in concrete by reducing the environmental problem.

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