

# Effect of Waste Ceramic Tiles in Partial Replacement of Coarse and Fine Aggregate of Concrete

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**Abstract:** Concrete is a versatile engineering composite material made with cement, aggregates and admixtures in some cases. Due to the day by day innovations and developments in construction field, the global consumption of natural aggregates is very high and at the same time production of solid wastes from the demolitions and manufacturing units are also very high. Extensive use of concrete leads to the scarcity of natural aggregates. Because of this reasons the reuse of demolished construction wastes and solid waste from manufacturing came into the picture to reduce the solid wastes from demolition and manufacturing units and as well as to decrease the scarcity of natural basic aggregate. This papers is to study the suitability of waste crushed tiles in the concrete mix .In this experimental study, different mixes are casted, waste crushed tiles are used to partially replace the coarse aggregate by 10% and 20% and tiles powder is used to partially replace the fine aggregate by 10% and 20%. Both coarse and fine aggregates also partially replaced by these waste materials at different percentages. According to this total 9 types of mixes of M25 grade were prepared (Shown in TABLE 1). A brief study on workability and compressive strength for 7 and 28 days of all total 9 types of mixes has been carried out and observed that increase in tiles powder leads to the increase in strength and workability of concrete like Ready Mix Concrete (RMC). In all 9 types of mixes, maximum compressive strength is obtained for the mix having 20% of tile powder. For the combinations compressive strength is increased for all mixes and maximum compressive strength obtained for the mix having 10% of crushed tiles and 20% of tiles powder. The optimum percentage of coarse aggregate that can be replaceable by crushed tiles is 10%.

**Key Words:** Waste crushed tiles, tiles powder, fine aggregate, coarse aggregate, Ready Mix Concrete (RMC), Workability, Compressive strength.

## I. 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.

In the present study, to understand the behavior and performance of ceramic solid waste in concrete. The waste ceramic crushed tiles are used to partially replace coarse aggregate by 10% and 20% say A1 and A2 respectively and the waste ceramic powder used to partially replace the fine aggregates by 10% and 20% say A3 and A4 respectively. To understand the combined behavior of ceramic materials with partial replacement of coarse and fine aggregates at different compositions are also studied. For analyzing the suitability of these crushed waste tiles and tile powder in the concrete mix workability test, ultrasonic test along with compressive strength test after 7 and 28 days are conducted for all mixes. All these tests were discussed in the section “IV. EXPERIMENTAL PROGRAMM” below.

## II. MATERIALS USED

### A. Cement:

The ordinary Portland cement of 53 grade whose specific gravity of cement is 3.14, normal consistency of the cement was found as 28% and the initial and final setting times were found as 120 min and 238 min respectively was used.

### B. Coarse aggregate:

The coarse aggregate with 20 mm nominal 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%.

### C. Fine aggregate:

Locally available river sand is used. As per IS 383:1970, sand is confirming to Zone III. Specific gravity of the sand used is 2.69. And the water absorption value is 0.45%.

### D. Crushed Tiles:

Broken tiles were collected from the solid waste of ceramic manufacturing unit. Crushed them into small pieces by manually (Shown in Pic.1 of section VII) and by using crusher. And separated the coarse material to use them as partial replacement to the natural coarse aggregate. Specific gravity of the crushed waste tiles is 2.39. Impact value of these crushed tiles is 25.81%.

### E. Tiles powder:

From the crushed waste tiles, powder (Shown in Pic.2 of section VII) passed through 4.75 mm IS sieve to use as partial replacement to the fine aggregate. Specific gravity of tile powder is 2.63.

## III. MIX DESIGN

M25 grade of concrete was designed by following the specification given in the IS 10262: 2009. Water – Cement ratio (w/c) was selected as 0.50 based on conducting slump tests for different design trails. Mix proportion obtained for M25 mix is 1:2.29:4.12.

## IV. EXPERIMENTAL PROGRAM

Total 9 type of mixes were prepared by changing percentage of replacement by waste crushed tiles and tiles powder in coarse and fine aggregates respectively as shown in Table 1.

TABLE 1  
PERCENTAGES OF F.A AND C.A REPLACED

Mix	Fine aggregate (%)		Coarse aggregate (%)	
	Sand	Tiles powder	C.A	Crushed tiles
A0	100	0	100	0
A1	100	0	90	10
A2	100	0	80	20
A3	90	10	100	0
A4	80	20	100	0
A5	90	10	90	10
A6	90	10	80	20
A7	80	20	90	10
A8	80	20	80	20

Slump cone test was performed on all mixes to assess the workability of concrete for different percentages of

replacing materials. The results of workability are discussed in the section “A. Workability”. Concrete cubes having size of 150 x 150 x 150 mm were prepared for all mixes to test 3 samples of a mix at 7, 28 days. Ultrasonic pulse velocity test was performed on concrete cubes after completion of 7 and 28 days curing period to analyze the quality of harden concrete. The results of Ultrasonic pulse velocity results were discussed in the section “B. Ultrasonic pulse Velocity Test”. Compressive strength test is also conducted on cubes after 7 and 28 days curing period, for each mix 3 samples were tested. Compressive strength of each mix is taken as average of the 3 samples and discussed in the section “C. Compressive strength”.

### A. Workability:

Slump cone test was performed on fresh concrete, for all mixes having different percentages of replacing materials which are shown in Table 1 (A0 to A8). The slump value for different mixes are obtained as follows.

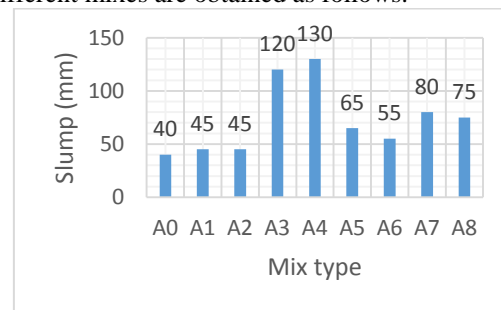


Fig. 1. Shows slump variation for different mixes.

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 A4 mix i.e., when 20% of fine aggregate replaced by the tiles powder. In case of combinations (A5 to A8) also slump value is increasing.

From the Fig.1 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.

### B. 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 2  
QUALITY GRADING OF CONCRETE

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

This test was performed on all cubes having different percentages of replacing materials after 7 and 28 days curing period. Ultrasonic wave was injected into the concrete cube by using the test apparatus (shown in Pic.3 of section VII) and measured the time travelled by the ultrasonic pulse in the concrete cube. The velocity of the ultrasonic pulse in the concrete was calculated by dividing the length of the concrete cube (150 mm) with time travelled by the ultrasonic pulse in the concrete specimen. Velocities of different concrete mixes (A0 to A8) were calculated and the values are as follows.

**TABLE 3**  
**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	4.90	Excellent
A6	4.68	4.89	Excellent
A7	4.64	4.86	Excellent
A8	4.65	4.79	Excellent

As per the Table 2 of IS1311 part 1: 1992, if the velocity of the pulse in the concrete is above 4.5 km/sec then the quality grade of the concrete is Excellent. After completion of testing, the velocity travelled by the ultrasonic pulse in all cubes is greater than 4.5 km/sec. So, finally concluded from the test is that the quality of all concrete mixes having different percentages excellent.

**C. Compressive Strength:**

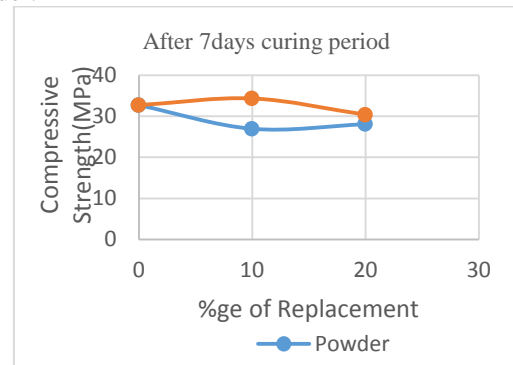
Compressive strength test was performed by using compression Testing Machine to find the 7 and 28 days compressive strength of the concrete. 3 samples from each mix were tested and average of these 3 is taken as the average compressive strength of each mix. The compressive strength results are as follows.

**TABLE 4**  
**COMPRESIVE STRENGTH RESULTS**

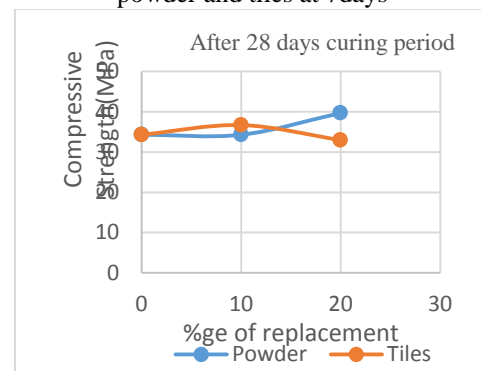
S.No	Mix	Average compressive strength (MPa)		Slump (mm)
		7 days	28 days	
1	A0	32.73	34.30	40
2	A1	34.36	36.69	45
3	A2	30.41	32.97	45
4	A3	26.97	34.30	120
5	A4	28.09	36.69	130
6	A5	26.72	38.72	65
7	A6	26.07	35.56	55
8	A7	35.19	39.16	80
9	A8	31.23	35.46	75

In the Table 4, A0 is the conventional concrete mix. 28 days compressive strengths of mixes having replacing material (A1 to A8) were increased when compared to the compressive strength of the conventional mix except A2.

When increasing tile percentages in the mixes (A1 and A2) to the 10%, compressive strength is increasing but when it is increased to 20% compressive strength is decreasing. So, optimum percentage of tiles addition is 10%. Maximum compressive strength obtained when 20% of fine aggregate was replaced with tile powder (A4). In case of combinations (A5 to A8), compressive strength is increasing for all mixes and maximum attained for A7 i.e., the mix having 10% of crushed tiles and 20% of tiles powder.



**Fig. 2.** Strength variation for different percentages of powder and tiles at 7 days



**Fig. 3.** Strength variation for different percentages of powder and tiles at 28 days

From Fig. 2&3 observed that, when fine aggregate is replaced by tiles powder the compressive strength is decreasing for 7 days curing period. But it is increasing for 28 days compressive strength. Means tiles powder leads to the increase in compressive strength after long period of curing.

**V. CONCLUSION**

After completion of all experimental program, we concluded that, crushed tiles can be used in placed of fine and coarse aggregate.

Based on workability test, the following observations were made.

- a. Increase in tiles powder leads to the increasing in workability of concrete
- b. Tile powder behaving like admixtures, which can be used to produce RMC mix.
- c. There are minor increases in workability when crushed tiles are replace in place of coarse aggregate.

Based on the Ultrasonic Pulse Velocity Test, we observed that the velocity travelled by the pulse in all mixes is



greater than 4.5 km/sec. So, quality of all concrete mixes is good.

Based on compressive strength test, the following observations were made.

- a. Maximum compressive strength is obtained when 20% of tiles powder was replaced in fine aggregate.
- b. When crushed tiles replacing in place of coarse aggregate, up to 10% compressive strength is increasing. But after that it is decreasing for 20%.
- c. In case of combinations, compressive strength is increasing in all cases.
- d. In combinations, maximum compressive strength is obtained for the mix having 20% of tiles powder and 10% of crushed tiles.

#### VI. FUTURE WORK

- a. We are going to calculate the 56 days compressive strength to analyze the strength variations of all concrete mixes after long period of curing.
- b. And we are going to increase the percentage of tiles powder above 20% to estimate the optimum percentage of tiles powder in replacement to the fine aggregate.

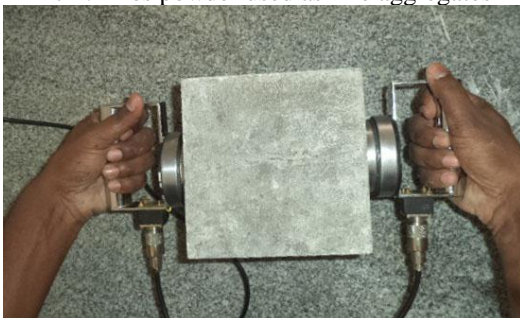
#### VII. PHOTOGRAPHS



Pic 1: Crushed tiles used as coarse aggregate



Pic 2: Tiles powder used as fine aggregates



Pic 3: Cubes under Ultrasonic pulse velocity test

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