

# An Experimental Study on Partial Replacement of OPC with Silica Fume and Coarse Aggregate with Waste Ceramic Tiles

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**Abstract**— The main focus of this research is to study the strength of concrete with waste ceramic tile as coarse aggregate and silica fume as cement. Increased construction activity and continuous depends on conventional materials of concrete making are leading to scarcity of the materials and increased construction cost. In this study an attempt has been made to find the suitability of waste ceramic tile coarse aggregate and silica fume as a possible substitute for conventional aggregate and cement in concrete. The both ceramic tile industry and quartz industry are known to generate large amount of waste each year. So for a huge part is used in landfills. Re-using these wastes in concrete could be a within situation. So I prefer ceramic tile waste and silica fume to increase strength and stability of concrete.

**Key words:** Ceramic Tiles, Silica Fume, Dumping, Stability

## I. INTRODUCTION

Concrete is a composite material composed of aggregate bonded together with the fluid cement which hardens over time. Most use of the term concrete refers to Portland cement concrete or to concrete made with other hydraulic cements. In Portland cement concrete and other hydraulic cement concrete, when aggregate is mixed together with dry cement and water, they form a fluid mass that is easily molded into shape. The cement reacts chemically with water and other ingredient to form hard matrix which binds all the materials together into a durable stone-like material that has many uses.

Silica fume is a by-product in the production of silicon alloys such as ferro-chromium, ferro-manganese, calcium silicon etc, which also creates environment pollution and health hazard. In recent past, there has been considerable attempts for improving the properties of concrete with respect to strength and durability especially in aggressive environment. Leaving the waste materials to the environment directly can cause environmental problem. Hence reuse of waste material from industries has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste. Silica fume is also known as micro silica or condense silica fume, is used as an artificial pozzlanic admixture. It is a material resulting from reduction of quartz with coal in an electric is furnace in the manufacture as silicon or ferrosilicon alloy.

### A. Waste Ceramic Tiles

Aggregate impact about 70% to 75% of volume to concrete. In this aspect consumption of waste tiles or broken tiles as coarse aggregate in concrete manufacturing can be a new scientific sobriety in the field of sustainable concrete. By using these wastes instead of conventional material would be preserving the natural resources, but also solving the

problem of disposal of waste, which has become a national problem.

## II. EXPERIMENTAL SETUP

In this stage collection of materials required and data required for the mix design are obtained by sieve analysis and specific gravity. Sieve analysis is carried out from various fine aggregate (FA) and coarse aggregate (CA) samples and the samples which suits the requirement is selected. Specific gravity tests are carried out for fine and coarse aggregate. The various materials used were tested as per Indian standard specification.

### A. Materials:

Raw materials required for the concreting operations of present work are cement, fine aggregate, coarse aggregate, ceramic waste and water.

#### 1) Cement:

Cement is used as binding material in the concrete where the strength and durability re significant important. The ordinary Portland cement of 53 grades conforming to IS: 12269-1987 is used to manufacture the concrete. Also some tests were conducted such as consistency test, setting time test, specific gravity test.

Property	IS Code(IS 8112:1989)
Specific gravity	3.15
Consistency	30
Initial setting time	55min
Final setting time	9hr 30minutes

Table 1: Properties of cement

#### 2) Aggregate:

The size of aggregates used is 20mm and the grain size of sand is used. The aggregate tests are performed and results are as follows.

##### a) Fine aggregate:

It consists of small angular or grounded grains of silica (SiO<sub>2</sub>) and is formed by decomposition of sand stone under the effect weathering agencies. The size which is less than 4.75mm is called as fine aggregate. River sand is used as fine aggregate conforming to the requirements of IS 383. Before using that, it can be properly cleaned by sieving and washing to eliminate the impurities.

##### b) Coarse aggregate:

Coarse aggregate may be in the form of irregular broken stones or naturally occurring rounded gravel. Materials which are large to be retained on 4.75mm sieve size called as coarse aggregate. It acts as a main filler, and forms the main bulk of concrete. Of which the materials adhere in the form of film. Aggregates balance the shrinkage and volume changes of concrete conforming to IS: 383 are used.

Property	Fine aggregate	Coarse aggregate
Fineness modulus	2.40	6.50

Specific gravity	2.60	2.602
Crushing strength	-	20.50
Water absorption (%)	1.60	1.8

Table 2: Physical properties of aggregates

3) *Water:*

Water plays an important role in mixing, laying, and compaction, setting and hardening of concrete. Water influences the strength development and durability of concrete. Ordinary drinking water can be used for preparing concrete. Guidance to examine the suitability of the available water for construction can be obtained from the following specified data in IS 456-2000. The pH value of water should be generally not be less than 6.

Property	Regarding values
Specific gravity	2.35
fineness	7
Impact strength	18.5%
Crushing strength	22.75%
Water absorption	4.5%

Table 3: Waste Ceramic tiles:

4) *Silica fume:*

The size of silica fume is less than 1 micron dia, the specific gravity is 2.2 and the bulk density was 430 Kg/ m<sup>3</sup>.

B. *Design Mix:*

The concrete is designed for M30 grade by using the procedure as per Indian standard (IS10262:2009). This proportion is used to prepare the samples. The mix proportions are shown in table.

	W	C	FA	CA
By weight in kg/m <sup>3</sup>	128	320	598.4	1081.6
By Volume (m <sup>3</sup> )	0.40	1	1.18	3.38

Table 4: Design mix proportions

concrete type	Waste ceramic tile	Silica fume
C0	0% replacement	0% replacement
C1	15% replacement	15% replacement
C2	35% replacement	15% replacement
C3	40% replacement	15% replacement

Table 5: Replacement proportions for various concrete

III. EXPERIMENTAL SETUP

A. *Experiment Methodology:*

The evaluation and partial replacement of waste ceramic tile for coarse aggregate and silica fume for cement are done by using concrete testing. The ingredients of concrete is added and the test is conducted. In this experiment we replace the waste ceramic tiles for coarse aggregate partially in the percentage of 15%, 35%, 40%, and cement replace with silica fume 15%. The replaced concrete is compared with the normal concrete. For this cube samples of size 150mm\*150mm\*150mm are casted for each percentage of replaced concrete and normal concrete. The size of cylinder 150mm\*300mm. The cubes and cylinders are prepared. After 24 hours the samples are remolded and they are cured in the curing tank for 7 and 28 and 56 days.

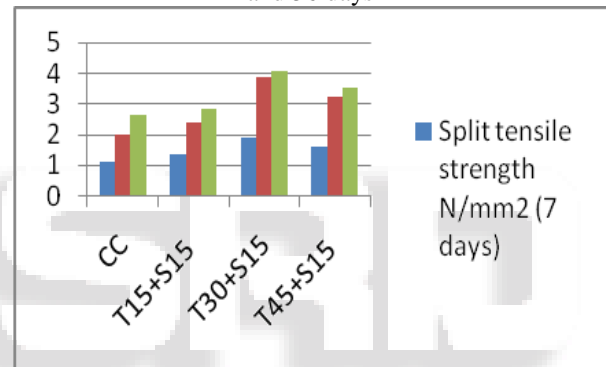
IV. MECHANICAL PROPERTIES

A. *Split Tensile Strength Test:*

Tensile strength of the concrete is estimated by using Split tensile strength of concrete. It is one of the failure condition of concrete at which the concrete gets crack after application of load and it is calculated by using standard cylindrical specimen which gets the longitudinal cracks after application of load in testing and the test results are placed in table3 for 7, 28 and 56 days curing period for different dosages of replacement materials (WCT& SF) that is 15%, 30% and 45% of WCT and 15% of silica fume kept constant.

Specimen designation	Split tensile strength N/mm <sup>2</sup> (7days)	Split tensile strength N/mm <sup>2</sup> (28days)	Split tensile strength N/mm <sup>2</sup> (56days)
CC	1.07	1.98	2.6
T15+S15	1.35	2.4	2.8
T30+S15	1.9	3.86	4.07
T45+S15	1.6	3.24	3.53

Table 6: values of split tensile strength at the age of 7, 28 and 56 days



Graph 1: Tensile strength of cubes at different ages

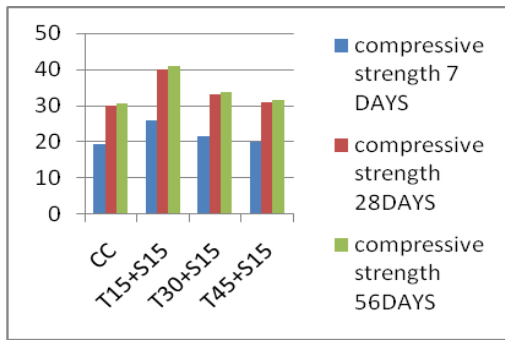
From the above graphical representations it has been seen that the split tensile strength of partially replaced concrete is gradually increased up to the dosage of 30% ceramic tiles and 15% of silica fume but from here it is observed that the value of split tensile strength was decreased from here, and it is higher when compared with conventional concrete.

B. *Compressive Strength Test:*

The compressive strength of cubes are tested by using the compressive testing machine by applying the load at the rate of 30N/mm<sup>2</sup> per minute. The average test result values are tabulated and comparative studies were made on the both normal and partially replaced concrete cubes of 15%, 30%, 45% as waste ceramic tile and 15% of silica fume.

Specimen designation	Compressive Strength N/mm <sup>2</sup> (7 days)	Compressive Strength N/mm <sup>2</sup> (28days)	Compressive Strength N/mm <sup>2</sup> (56days)
CC	19.5	30	30.7
T15+S15	26	40	40.8
T30+S15	21.45	33	33.7
T45+S15	20.15	31	31.5

Table 7: Compressive strength values for 7, 28 and 56 days curing



Graph 2: Compressive strength of cubes at different ages

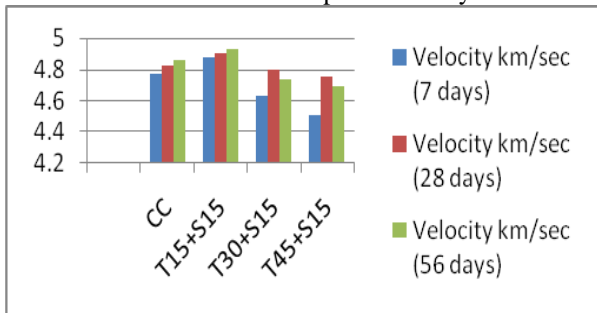
The table results and graphical representations shows that the results of compressive strength of conventional concrete and compressive strength of ceramic tile and silica fume added to conventional concrete. As it can be seen that the compressive strength increased by increasing when the materials (ceramic tiles and silica fume) added to conventional concrete. Maximum compressive strength occurs for maximum dosage of 15% of waste ceramic tiles and 15% of silica fume with 26MPa, 40MPa and 40.8 Mpa for 7, 28, and 56 days respectively.

C. Ultrasonic Pulse Velocity Test:

Ultrasonic pulse velocity test of partially replaced concrete is estimated by using power transmitted through the concrete member it calculates an unreinforced concrete beam or slab to find the quality of concrete by using velocity of power waves. Ultrasonic pulse velocity test was expressed as velocity of power waves.

Specimen designation	Velocity km/sec (7 days)	Velocity km/sec (28 days)	Velocity km/sec (56 days)
CC	4.77	4.82	4.86
T15+S15	4.88	4.90	4.93
T30+S15	4.63	4.80	4.74
T45+S15	4.51	4.75	4.69

Table 8: values of ultrasonic pulse velocity test results



Graph 3: Comparison of ultrasonic pulse velocity with conventional concrete

The table results and graphical representation shows that the values of ultrasonic pulse velocity and comparison with the values of conventional concrete. As we observe the results of partially replaced concrete is higher when compare to conventional concrete up to the dosage of 15% of ceramic tiles and 15% of silica fume. From here the results of partially replaced concrete was decreased but, these values are higher when mpared with conventional concrete. The maximum strength was obtained at the dosages of 15% of ceramic tiles and 15% of silica fume as 4.88MPa, 4.99MPa, 4.93 MPa for 7, 28 and 56 days respectively.

V. CONCLUSION

Based on the results of this experimental investigation, the following conclusions can be drawn:

- 1) Waste ceramic tiles and silica fume are more effective in improving the mechanical properties of concrete compared to conventional concrete.
- 2) Compressive strength increased by increasing when the materials (waste ceramic tiles and silica fume) added to conventional concrete. Maximum compressive strength occurs for maximum dosage of 15% of waste ceramic tiles and 15% of silica fume with 26MPa, 40MPa and 40.8 Mpa for 7, 28, and 56 days respectively.
- 3) Split tensile strength gradually increased up to the dosage of 30% of ceramic tiles and 15% of silica fume. From here the split tensile strength was decreased by increasing the materials as silica fume and ceramic tiles in the place of coarse aggregate and cement. But, these values are more than the conventional concrete. Maximum split tensile strength occurs for dosage of 30% of ceramic tiles and 15 % of silica fume with 1.9MPa 3.86MPa and 4.07MPa for 7, 28 and 56 days.
- 4) Split tensile strength of partially replaced concrete is gradually increased up to the dosage of 30% ceramic tiles and 15% of silica fume but from here it is observed that the value of split tensile strength was decreased from here, and it is higher when compared with conventional concrete.
- 5) The table results and graphical representation shows that the values of ultrasonic pulse velocity and comparison with the values of conventional concrete. As we observe the results of partially replaced concrete is higher when compare to conventional concrete up to the dosage of 15% of ceramic tiles and 15% of silica fume.
- 6) From here the results of partially replaced concrete was decreased but, these values are higher when compared with conventional concrete. The maximum strength was obtained
- 7) at the dosages of 15% of ceramic tiles and 15% of silica fume as 4.88MPa, 4.99MPa, 4.93 MPa for 7, 28 and 56 days respectively.

However, further study is suggested to understand the effect of on the strength of the concrete.

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