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Experimental Study on Strength and Durability Behaviour of Concrete by Partial Replacement of Cement with Tile Powder

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Abstract - **Concrete is the widely used material in construction around the world and cement, a major constituent of concrete is being costly and only moderately available, researches or experiments are conducted to study the variations in the strength characteristics of concrete by replacement of cement partially or fully by cheaper or locally available materials . Ceramic waste powder is settled by alleviation and then dumped away which results in environmental pollution, in addition to forming dust in summer and menacing both agriculture and public health. Therefore, utilization of the ceramic waste powder in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. In this research study the cement has been replaced by ceramic waste powder accordingly in the range of 10% 15%, 20% by weight of M30 grade. Concrete mixtures were produced, tested and compared in terms of compressive strength & split tensile strength to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. Test for durability is also carried out and compared with conventional concrete. This research work is concerned with the experimental investigation on strength & durability of concrete and optimum percentage of the partial replacement by replacing cement via 10%, 15%, 20%, of ceramic waste. Keeping all this view, the aim of the analysis is to study the performance of concrete while replacing the ceramic waste with different proportions in concrete.**
Keywords: **Strength, Durability Behaviour, Concrete, Partial Replacement, Cement with Tile Powder**

I. INTRODUCTION

In India numbers of waste materials are produced by different manufacturing companies, thermal power plant, municipal solid wastes and other wastes. Solid as well as liquid waste management is one of the biggest problems of the whole world. Disposal of waste in to the land causes serious impact on environment. Now a day's large amount of tile powder is generated in tile industries with an impact on environment and humans. By using the replacement materials offers cost reduction, energy savings and few hazards in the environment. Partial or full replacement of cement in concrete with another suitable material will provide a means of reducing the cost of construction materials. Over the last few decades, replacement is done by locally available raw materials such as industrial, agricultural or domestic waste such as fly ash, blast furnace slag, silica fume, rice husk, oil palm shell, coconut shell, corn cob, tobacco waste, bamboo leaf, sugarcane baggage, groundnut shell, egg shell. The search for a new and viable alternative is important for conservation of natural resources and reduction in the manufacturing cost.

In India ceramic production is 100 million ton per year. The tile industry has about 15% to 30% waste material generated from the total production. The tile waste which is dumped in land filling and pit or vacant spaces causes the environmental pollution which is dangerous for human health. This waste is not recycled in any form at present. However, the tile waste is durable, hard and highly resistant to biological, chemical, physical degradation forces. The tile waste which is dumped in land filling and pit or vacant spaces causes the environmental and dust pollution which is dangerous for human health. As the ceramic waste is piling up every day, there is a pressure on tile industries to find a solution for its disposal.

II. MATERIALS

Cement: In this work the Ordinary Portland Cement 53 grade was used. Cement is affine, grey powder. It is mixed with water and materials such as sand, aggregate to make mortar and concrete. The cement and water forms a paste that binds the other materials together.

Coarse Aggregate: Locally available crushed stones confirming to graded aggregate of nominal size of 20mmas per IS 383-1970 are adopted. The physical properties of coarse aggregate like specific gravity, gradation and fineness modulus are tested.

Fine Aggregate: Locally available river sand confirming to grading zone II of nominal size 1.18 mm as per IS 383-1970.

Ceramic Tile Powder: The ceramic powder is obtained from the industrial by – products or as the solid waste dumped in any major city. As the ceramic in landfill it takes thousands of years to degradable and cause land pollution. So some of not recycled ceramic can be converted into ceramic powder and used as cement replacement. The usage of ceramic in the form of powder is better than using it as fine or coarse aggregate. The tile dust is obtained from RAK ceramics. The specific gravity of tile dust is found to be 2.62 and the fineness is found to be 7.5%.

III. EXPERIMENTAL PROGRAM

The aim of the experimental program is to compare the

properties of concrete made with andwithout ceramic powder,used as partial cement replacement. The basic tests cared out on materials used for casting concrete samples are discussed in this chapter, followed by a brief description about mix design and curing procedure adopted In this research work the Ordinary Portland Cement 53 grade, coarse aggregate with nominal size of 20mm are adopted. Various tests were conducted to check the properties of the coarse aggregate and some of the tests include the specific gravity, water absorption, fineness modulus, crushing strength tests etc. the natural sand is used as the fine aggregate in this study. Various tests were conducted for fine aggregate also to find out the finest of sand, specific gravity of sand etc. Colorless, odorless potable fresh water was used for mixing the concrete.

Here ceramic powder is used as partial cement replacement for making the concrete specimens. The test for cement was carried out to find the specific gravity, fineness, water absorption, Setting time and consistency. Initial and final setting time is founded with and without the replacement of ceramic tile powder in cement by Vicat apparatus. The percentage replacement for cement by tile powder was done in the proportion of 0, 10, 15 and 20.

After the various tests done on the materials the concrete is prepared through batching. The selected materials are properly weighed and mixed as per the design mix proportion of 1:1.57:2.57 for M30 grade concrete, the water cement ratio used in the work is 0.45, which is obtained from the IS 10262. The concrete was cast in the form of cubes and cylinders with 0%, 10%, 15% and 20% replacement of cement by Ceramic tile powder. To find out the workability of concrete the slump test was carried out in the fresh concrete mix.

After 24 hours, the specimen is removed from the cube and cylinder mould and cured. The compression and split tensile test was carried out in 7, 14 and 28 days using compression testing machine, and the durability test such as sorptivity test, water absorption test and chloride resistant tests are also done.

IV. TESTS ON HARDENED CONCRETE

A. Compressive Strength Test

The casted cubes on control mix and tile powder mixed concrete are given a curing of 28 days, after which they were tested for compression as per IS 10262 1983.

$Fc=Pmax/A$

where, Fc -compressive strength

Pmax -maximum load that cube sustained

B. Split Tensile Strength Test

Cylinders are casted on control mix and tile powder added concrete and given a curing of 28 days. Tensile strength test was determined as per IS 10262 1983.

The split tensile strength is given by:

$Ft= 2P/(\pi dl)$

Where Ft- indirect tensile strength,
P = maximum load sustained by the specimen
d = diameter of the specimen
L = length of the specimen

V. DURABILITY TEST

A. Water Absorption Test

This test helps to determine the water absorption of specimens. The absorption is due to permeability characteristics of concrete which reduces the durability of concrete.

1. Procedure

1. After 28 days continuous curing the specimen should oven dry for 24 hours**,**Weighing it (a).
2. Immersing it in water for 24 hour , and weighing it again (b).
3. The increase in weight as a percentage of the original weight is expressed as its absorption (in %)
4. Water Absorption, percent=(a-b)/b*100
   where,
   a=wet mass of unit in kg
   b=dry mass of unit in kg

B. Sorptivity Test

Sorptivity gives capillary action of water. The sorptivity can be determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used of the test fluid.

1. Procedure

1. After 28 days continuous curing the specimen should oven dry for 24 hours after non-absorbent colour sealing doing on outer periphery of cylinder and weight of this cylinder (W1).
2. The specimen should kept in water where the height of specimen immersed only 5mm, and after 30 min the weight of specimen measured nearest to 1gm (W2)
3. Surface water of the specimen was wiped off with a dampened tissue and each weighting operation was completed within 30 second.

Sorptivity, $S = I / t^{0.5}$

Where;
S= sorptivity in mm,
t= elapsed time in minute.
$I= \Delta W / Ad$
ΔW= change in weight = W2-W1
W1 = Oven dry weight of cylinder in grams
W2 = Weight of cylinder after 30 minutes capillary suction of water in grams.
A= surface area of the bottom side through which water is penetrated.
d= density of water

C. Chloride Resistance Test

1. Procedure

For long term durability of concrete structures, it is essential that the environmental factors capable of adversely affecting their service life can be given proper consideration. Chemical attack by aggressive water is one of the factors responsible for damage to concrete. Procedure for chloride test is as follows:

1. Concrete cubes of size 150mm were cast and cured for 28 days.
2. After 28 days of curing the cubes were taken out and dried.
3. Initial dry weight of the cubes was found.
4. The chloride solution has been prepared by adding 3.5% sodium chloride (NaCl) in distilled water.
5. This solution is stirred well so that the sodium chloride salts get dissolved in the solution. Then, the cubes were immersed in a chloride solution.
6. After 28days the cubes were taken out from the chloride solution.
7. The surfaces of the cubes were cleaned. The final dry weight of the specimens was found.
8. The differences in the initial dry weight and final dry weight of the specimen were found.
9. Percentage loss in mass and percentage loss in compressive strength of concrete cubes were found.

VI. RESULTS AND DISCUSSIONS

TABLE I COMPRESSIVE STRENGTH RESULTS

% of Ceramic Tile Powder	7 Days N/mm^2	14 Days N/mm^2	28 Days N/mm^2
0%	25.39	27.73	30.45
10%	26.13	28.20	32.17
15%	27.04	29.15	34.84
20%	23.76	25.54	29.09

The above chart represents the strength of the cube in 7 days, 14 days, and 28 days for both conventional concrete and replacement of cement in concrete by different ratios of ceramic tile powder. It is observed that if the curing time increases then the strength of concrete is also increases. From the observation the 15% replacement of the Ceramic Tile powder gains strength more than the conventional concrete.

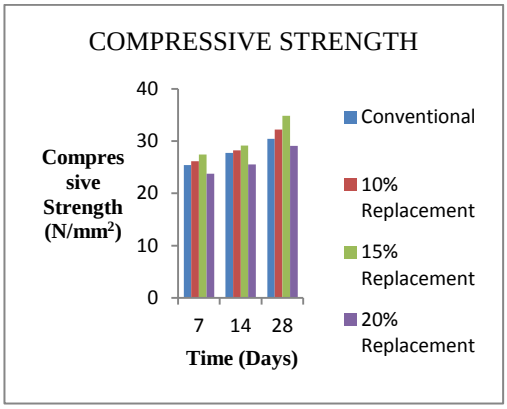

Fig. 1 Compressive Strength

TABLE II SPLIT TENSILE TEST RESULTS

% of Ceramic Tile Powder	7 Days N/mm^2	28 Days N/mm^2
0%	2.48	2.97
10%	2.82	3.57
15%	3.18	3.78
20%	2.26	2.51

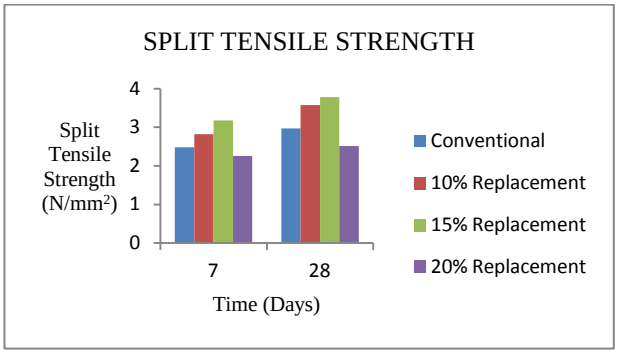

Fig. 2 Split tensile Strength

The above chart shows variation in split tensile strength of both conventional and tile powder mixed concrete cylinders with different proportions. The result shows that ultimate strength is obtained at 15% replacement of cement with tile powder

TABLE III WATER ABSORPTION TEST

S. No.	% 0f Ceramic Tile powder	Original weight (kg)	Final weight (kg)	Water absorption (%)
1	10	2.577	2.602	0.97
2	15	2.537	2.557	0.788
3	20	2.540	2.562	0.866
4	0	2.452	2.482	1.22

Water absorption test shows that normal concrete have greater water absorption compared to the tile powdered mixed concrete. Also it is found that 15 percent replacements give least water absorption

TABLE IV TEST RESULTS OF SORPTIVITY TEST

S. No.	% 0f Ceramic Tile powder	Original weight (kg)	Final weight (kg) (after 30 minute)	Sorptivity
1	10	0.913	0.925	4.42
2	15	0.886	0.892	2.91
3	20	0.867	0.873	4.09
4	0	0.898	.912	5.08

From this test it is determined that the percentage of sorpitivity is maximum for normal concrete when compared to others. Also it is found that 15 percent replacement give least sorpitivity

A. Chloride Resistance Test

TABLE V PERCENTAGE LOSS IN MASS OF CONCRETE

Mix	Weight before immersion (W1)	Weight after immersion (W2)	Loss % in mass	Average loss % in mass
Conventional concrete	8.20	8.11	1.098	1.279
	8.12	8.01	1.355	
	8.30	8.18	1.446	
10% replacement by tile powder	8.30	8.24	.723	0.862
	8.00	7.93	.875	
	8.10	8.02	.988	
15% replacement by tile powder	8.45	8.39	.952	0.803
	8.17	8.10	.987	
	8.30	8.14	.731	
20% replacement by tile powder	8.40	8.32	.710	0.893
	8.10	8.02	.856	
	8.20	8.23	.843	

From the chloride resistance test it is determined that the percentage loss in mass is maximum for conventional concrete when compared to others. Also it is found that 15 percent replacement give least percentage loss in mass of concrete.

TABLE VI PERCENTAGE LOSS IN COMPRESSIVE STRENGTH

Mix	Before immersion strength (S1)	After Immersion Strength (S2)	% Loss In Compressive Strength	Average loss % in Compressive strength
conventional concrete	32.31	30.45	5.757	5.308
	32.89	31.22	5.078	
	32.62	30.96	5.089	
10% replacement by tile powder	35.96	34.31	4.588	3.523
	36.09	35.53	1.522	
	36.81	35.81	4.428	
15% replacement by tile powder	36.96	35.52	3.89	2.59
	37.08	36.53	1.48	
	37.81	36.90	2.40	
20% replacement by tile powder	36.21	35.32	2.457	2.74
	36.32	35.23	3.00	
	36.93	35.90	2.78	

From the chloride resistance test it is determined that the percentage loss in compressive strength is maximum for conventional concrete when compared to others. Also it is found that 15 percent replacement give least percentage loss in compressive strength of concrete.

VII. CONCLUSION

This study was carried to obtain the results, test conducted on the tile powder modified cement concrete mix, in order to ascertain the influence of tile powder on the characteristic strength and durability of concrete.

1. It was found that Strength increment of specimens of tile powder mixed concrete was more compared to control mix.
2. The compressive strength of concrete decreases, when the addition of dosage is more than 15%.The results show if 20% replacement of cement by ceramic tile powder will affect the strength of concrete.
3. The compressive strength and split tensile strength shows the optimum increase in strength is from 15 % replacement of tile powder in concrete
4. Water absorption test shows that tile powder mixed concrete have less water absorption.
5. Sorpitivity test says that the tile powder mixed concrete have less sorpitiviy as compared to ordinary concrete
6. Chloride résistance test shows the tile powder mixed concrete have high resistance to chloride attack compare to conventional concrete
7. By doing this project we could gave a contribution to the society by making the environment more eco friendly by utilizing the ceramic waste scientifically.
8. Thus by adopting replacement method we can overcome problems such as waste disposal crisis. Utilization of tile powder and its application for the sustainable development of the construction industry is the most efficient solution and also address the high value application of such waste.
9. By using the replacement materials offers cost reduction and can overcome few environmental hazards.

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