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Effect of Granite Powder and Crushed Ceramic Tiles on Properties of Concrete

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ABSTRACT

The fast and improved infrastructural development in India has demanded for large quantities of fine and coarse aggregates for concrete. Also , the ecological imbalance in the nature due to exploitation of natural fine and the coarse aggregates, there is much need to utilize the industrial and demolished construction waste in concrete as an initiative to replace the natural fine and coarse aggregate and also to maintain and develop a sustainable environment through the construction industry. In this experimental study, the effect of granite powder and crushed ceramic tiles as a partial replacement of fine and coarse aggregates respectively in concrete mixes is presented. The laboratory experiment was carried out on concrete M25 grade. Concrete produced from 10%, 20% and 30% replacement of sand with granite powder along with 10% replacement of coarse aggregate with crushed ceramic tiles and 10%, 20% and 30% replacement of coarse aggregate with crushed ceramic tiles along with 10% replacement of sand with granite powder and it is compared with normal concrete. The laboratory program includes workability, compressive strength, split tensile strength, flexural strength, water absorption, Rapid chloride ion penetration and sorptivity. From the experimental investigation, it was found that with the addition of granite powder and crushed ceramic tiles we could achieve good workability but decline in strength with increase in percentage replacement when compared with normal concrete. The optimum percentage of granite powder and crushed ceramic tiles were found to be 10% of the strength.

Keywords: *Granite powder, Crushed ceramic tiles, RCPT, Water absorption, Sorptivity.*

1. INTRODUCTION

The global consumption of natural fine and coarse aggregate is very high due to extensive use of concrete. The non-availability of sufficient quantity of these materials for making concrete is affecting the growth of construction industry in many parts of country. On the other hand waste disposal problem is becoming serious issue. In this present work, it is aimed at developing a new building material from industrial and demolished waste as partial replacement of fine and coarse aggregate in concrete.

Concrete is the most widely used construction material in the world. Concrete is a mixture of cement, aggregate (fine and coarse) and water in which aggregates constitute 60-80% of the total volume. The fast and improved infrastructural developments in India demand for large quantities of natural fine and coarse aggregate for concrete. Reduction in the fine and coarse aggregate creates ecological difficulties and therefore there is restriction on the usage and also an increase in costs are seemed. The raw materials used for the manufacture of concrete are depleting day by day and research is on for constant alternative methods and materials as partial replacement of fine and coarse aggregates.

In this investigation, granite powder and crushed ceramic tiles are chosen as alternative partial replacement of fine and coarse aggregate with the percentage replacement of 10%, 20% and 30% by weight of fine and coarse individually. The tests are conducted like Compressive, Flexural, Split, RCPT, Water absorption, Sorptivity and compared with normal concrete.

2. MATERIALS

2.1 CEMENT (OPC)

OPC 53 grade cement was used in this study. The physical properties of the cement were studied as per IS 12269-1987 and are shown in Table 2.1

Table 2.1 Properties of cement (53 grade OPC)

SL NO.	PROPERTIES	TEST RESULTS
1	Specific gravity	3.15
2	Normal consistency	28%
3	Initial setting time	110min
4	Final setting time	260min

2.2 COARSE AGGREGATE

The aggregate of particle size retained on 4.75 mm IS sieves are coarse aggregate and they should be free from debris of dirt, natural matters and dust. Table 2.2 gives the detailed physical properties of coarse aggregates.

Table 2.2 Properties of coarse aggregates

SL NO.	PROPERTIES	TEST RESULTS
1	Shape of aggregate	Angular
2	Specific gravity	2.688
3	Water absorption	0.2%
4	Bulk density	1450 kg/m3
5	Crushing value	27.6%
6	Impact value	26.6%

2.3 FINE AGGREGATE

M sand is used for the experimental work. Table 2.3 gives the detailed physical properties of sand that were obtained by conducting experiments in the laboratory.

Table 2.3 Properties of fine aggregate

SL NO.	PROPERTIES	TEST RESULTS
1	Specific gravity	2.69
2	Fineness modulus	3.40
3	Grading zone	Zone И
4	Bulk density	1670 kg/m3
5	Water absorption	2.10

2.4 GRANITE POWDER

Granite powder is procured from crushing of granite rocks, the chemical and mineral composition of granite is similar to that of natural aggregates. Table 2.4 gives the detailed physical properties of granite powder.

Table 2.4 Properties of granite powder

SL NO.	PROPERTIES	TEST RESULTS
1	Specific gravity	2.5
2	Fineness Modulus	2.43
3	Water absorption	1.2%

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2.5 CRUSHED CERAMIC TILES

Broken tiles were collected from the solid waste of ceramic flooring tiles from retail distributors. The waste tiles were crushed into small pieces by manually. The crushed tile aggregate wastes which are 20mm down size are used.

Table 2.5 Properties of crushed ceramic tiles

SL NO.	PROPERTIES	TEST RESULTS
1	Specific gravity	2.39
2	Impact value	12.5%
3	Water absorption	0.19%

3. MIX PROPORTIONING

Concrete mix design for M25 grade was prepared as per IS 10262-2009 Code

C: FA: CA=1:1.54:2.53

Cement = 437 kg / m3

Fine aggregate = 675 kg / m^3

Coarse aggregate = 1106 kg /m^3

Water = 197 kg /m^3

W/C ratio = 0.45

The percentage replacement of fine and coarse aggregate by granite powder and crushed ceramic tiles was 10 %, 20% and 30 % by its weight.

4. VARIABLES CONSIDERED IN THE EXPERIMENTAL INVESTIGATION

The experimental investigation comprises of 6 concrete types named as conventional concrete with 0% granite powder and 0% of crushed ceramic tiles indicated by notation R0, partially replaced concrete mixture with 10% granite powder and 10 % crushed ceramic tiles indicated by notation R2 , partially replaced concrete mixture with 20% granite powder and 10 % crushed ceramic tiles indicated by notation R3 , partially replaced concrete mixture with 10% granite powder and 20% crushed ceramic tiles indicated by notation R4 , partially replaced concrete mixture with 10% granite powder and 30% crushed ceramic tiles indicated by notation R5.

Table 4.1 Mix proportion for different concrete mixtures

NOTATION	CONCRETE MIX PROPORTION
R0	Conventional concrete
R1	10 , 10 (10% of granite powder + 10% of crushed ceramic tiles)
R2	20, 10 (20 of granite powder + 10% of crushed ceramic tiles)
R3	30, 10 (30% of granite powder + 10% of crushed ceramic tiles)
R4	10, 20 (10% of granite powder + 20% of crushed ceramic tiles)
R5	10, 30 (10% of granite powder + 30 % of crushed ceramic tiles)

5.2 CASTING AND CURING OF THE SPECIMEN

For every concrete mixture 150 mm×150mm×150mm cubes were casted to evaluate the compressive strength, 150mm×300 mm cylinder were casted to evaluate the split tensile strength, 100×100×500 prism were casted to evaluate the flexural strength and 100mm×50mm cylinders were casted to evaluate the water absorption, rapid chloride ion penetration and sorptivity test of the concrete specimen

After casting the specimens, the casted mould is kept for 24 hr at room temperature by covering the specimen with wet gunny bags. The specimen were demolded after 24 hr and then kept for water curing for 3,7 and 28 days.

6. TESTING AND DISCUSSION OF TEST RESULTS

In the present experimental investigation concrete of M25 grade was considered by using granite powder and crushed ceramic tiles by weight of concrete respectively.

6.1 SLUMP TESTS

The slump test was conducted for normal concrete as well as alternative partial replacement of granite powder and crushed ceramic tiles in percentage 10%, 20% and 30%.

Table 6.1 Slump test results

W/C RATIO	CONCRETE TYPE	SLUMP (mm)
0.45	R0	105
0.45	R1	100
0.45	R2	95
0.45	R3	90
0.45	R4	90
0.45	R5	85

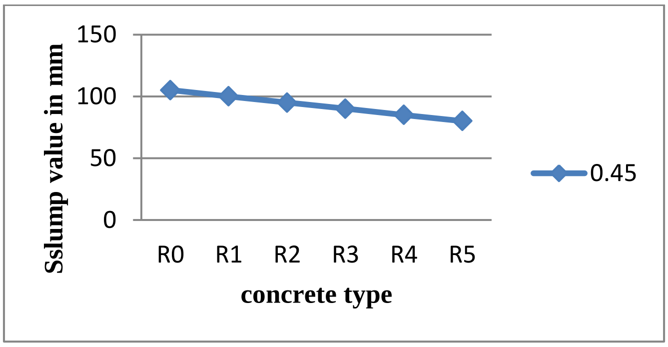

Figure 6.1 Variation of Slump for different concrete mixes

From the figure 6.1 it is observed that the falling in slump value was observed, due to inclusion of granite powder and crushed ceramic tiles which affect the workability of concrete. The obtained slump value is decreased as the percentage replacement increases.

6.2 COMPRESSIVE STRENGTH

The compressive strength tests for ordinary concrete and partially replaced concrete were conducted for 3, 7 and 28 days of curing period. Specimen of 150×150×150mm was cast and cured. After curing and later tested in CTM.

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Table 6.2 Compressive strength test results

CONCRETE TYPE	NO. OF SPECIMENS	COMPRESSIVE STRENGTH (Mpa)		
		3 DAYS	7 DAYS	28 DAYS
R0	12	22.4	36.6	56.4
R1	12	20.9	33.9	52.3
R2	12	20.6	33.4	51.4
R3	12	19.3	31.3	48.1
R4	12	18.5	30.1	46.3
R5	12	16.8	27.3	42

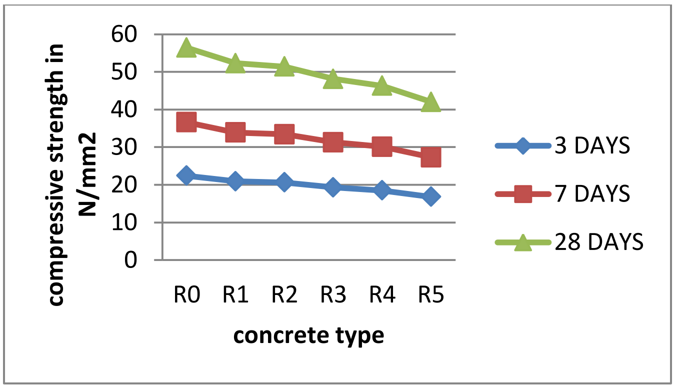

Figure 6.2 Compressive strength variation for different concrete type

Figure 6.2 shows the compressive strength of the concrete. A marginal reduction in the strength obtained due to the crushed ceramic tiles. This is due to an increase in the surface area caused due to flakiness of the crushed ceramic tiles which further leads to reduction in the strength of the concrete.

6.3 SPLIT TENSILE STRENGTH

Split tensile strength is determined to know the tensile behavior of concrete. Cylinder specimen of 150×300mm was cast and cured for 3, 7 and 28 days. After the sample was cured and later tested in CTM.

The split tensile of concrete is lesser when compared to the compressive strength due to different loading conditions.

Table 6.3 Split tensile strength test results

CONCRETE TYPE	NO. OF SPECIMENS	SPLIT TENSILE STRENGTH (Mpa)		
		3 DAYS	7 DAYS	28 DAYS
R0	12	2.08	3.38	5.21
R1	12	2.06	3.35	5.16
R2	12	1.98	3.21	4.95
R3	12	1.82	2.97	4.57
R4	12	1.72	2.80	4.32
R5	12	1.63	2.65	4.08

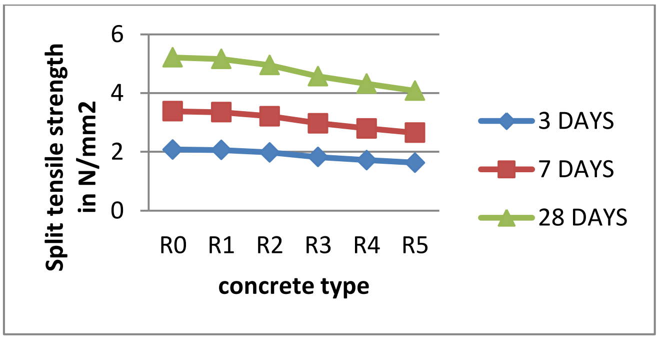

Figure 6.3 Split tensile strength variation for different concrete type

Figure 6.3 shows the split tensile strength of the concrete. Material composition plays a vital role on strength. Reduction in the strength obtained due to presence of impurities in the granite powder also the flakiness of the crushed ceramic tiles.

6.4 FLEXURAL STRENGTH

The flexural strength test was conducted as per IS 516:1959.100×100×500mm was cast and cured for 3, 7 and 28 days . After the sample was cured and later it is tested.

The beam is subjected to pure bending. Equal loads are applied at the distance of one-third from both sides of the beam supports.

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Table 6.4 Split tensile strength test

CONCRETE TYPE	NO. OF SPECIMENS	SPLIT TENSILE STRENGTH (Mpa)		
		3 DAYS	7 DAYS	28 DAYS
R0	12	2.08	3.38	5.21
R1	12	2.06	3.35	5.16
R2	12	1.98	3.21	4.95
R3	12	1.82	2.97	4.57
R4	12	1.72	2.80	4.32
R5	12	1.63	2.65	4.08

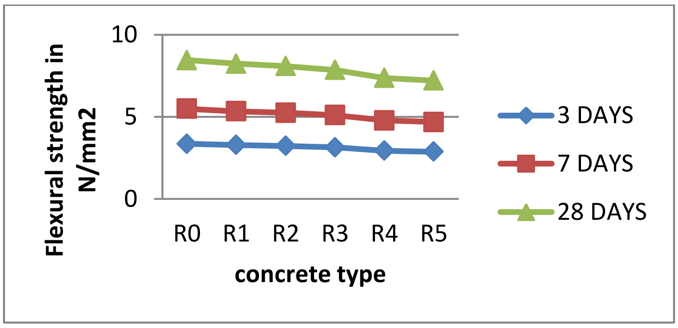

Figure 6.4 Flexural strength variation for different concrete type

Figure 7.4 shows the flexural strength of concrete**.** Reduction in the strength obtained as increase in the percentage replacement when compared to conventional concrete. This may due to increase in percentage of crushed ceramic tiles.

6.5 WATER ABSORPTION

100×50 mm cylinder cured for 28 days. Test results are shown below.

Table 6.5 Water absorption test results

CONCRETE TYPE	NO. OF SPECEMEN	DRY WGT (W1)	WET WGT (W2)	% WATER ABSORPTION
R0	4	1.012	1.038	2.569
R1	4	1.026	1.059	3.210
R2	4	1.028	1.062	3.307
R3	4	1.040	1.078	3.653
R4	4	1.058	1.098	3.740
R5	4	1.090	1.138	4.403

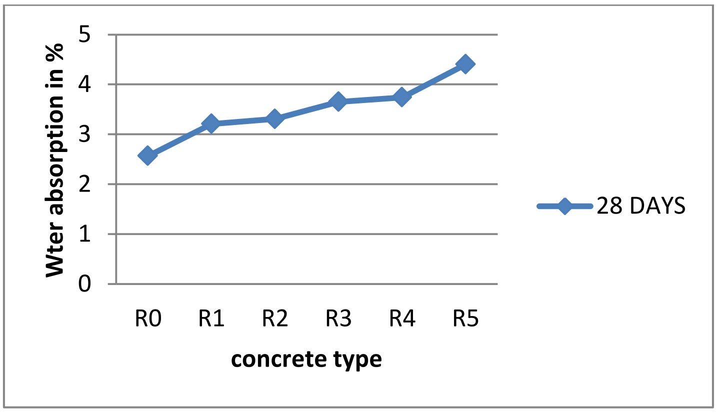

Figure 6.5 Water absorption for different concrete type

Figure 6.5 shows the water absorption test on concrete specimen. It is absorbed that water absorption of all concrete mixtures increase as increase in percentage replacement.

6.6 RAPID CHLORIDE ION PENETRATION

100×50 mm cylinder cured for 28 days. Test results are shows amount of charge passing in each concrete mixture.

Table 6.6 Rapid chloride ion penetration test results.

CONCRETE TYPE	W/C RATIO	CHARGE PASSING IN COULUMS	CHLORIDE PENETRATION RATE
R0	0.45	3210	Moderate
R1	0.45	2947	Moderate
R2	0.45	2804	Moderate
R3	0.45	2365	Moderate
R4	0.45	2115	Moderate
R5	0.45	1560	Low

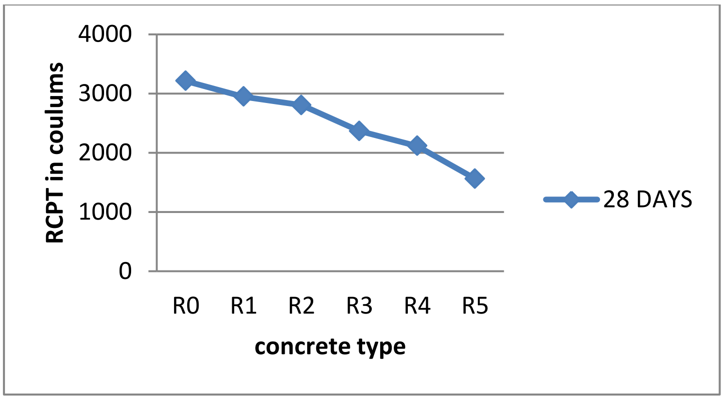

Figure 6.6 Rapid chloride ion penetration for different concrete type

Figure 6.6 Shows decrease in chloride ion permeability of increased replacement ratio. This is because of increased percentage of ceramic tiles which are resistant to moisture and having considerable durability.

6.7 SORPTIVITY

100×50 mm cylinder cured for 28 days. Test results are shown below. It is absorbed that sorptivity value of all concrete mixtures increase as increase in percentage

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Capacity of fluid to penetrate into the concrete microstructure is called as permeability.

Table 6.7 Sorptivity test results

CONCRETE TYPE	NO. OF SPECIMEN	DRY WGT (W1)	WET WGT (W2)	SORPTIVITY VALUE IN 10^-5
R0	4	1.012	1.010	2.320
R1	4	1.026	1.025	2.455
R2	4	1.028	1.027	2.562
R3	4	1.040	1.039	2.891
R4	4	1.058	1.056	2.986
R5	4	1.090	1.089	3.123

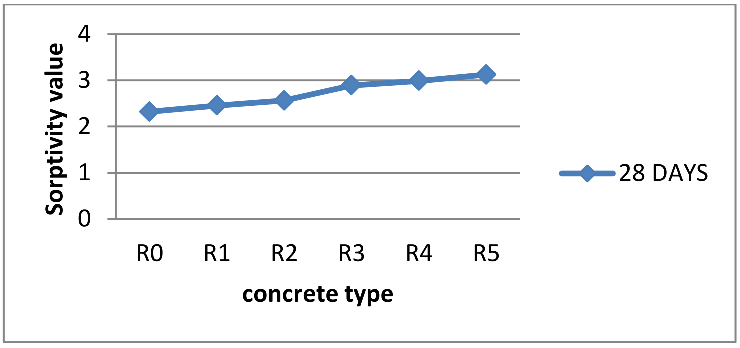

Figure 6.7 Sorptivity test for different concrete type

Figure 6.7 shows sorptivity value of the concrete mixtures. Concrete permeability has a close relationship with the characteristics of pore structure in cement and intensity of aggregate cement paste. Thus there is increase in permeability due to the presence of crushed ceramic tiles.

7 CONCLUSIONS

The following conclusions were drawn from the experimental investigations on compressive, split , flexural, RCPT , water absorption and sorptivity considering the environmental aspects also

1) For a given w/c ratio the partial replaced granite powder and crushed ceramic tiles concrete has shown lower slump than the conventional concrete and this may be due to the increase in water demand of granite powder and crushed ceramic tiles.
2) A marginal reduction in the mechanical properties like compressive , split and flexural strength has been noticed in the case of partially replaced concrete with granite powder and crushed ceramic tiles compared to conventional concrete and this may be due to flakiness of crushed ceramic tiles and also its low crushing strength.
3) From the study, it was found that 10% replacement in concrete by granite powder and crushed ceramic tiles was the optimum percentage, beyond which strength reduces.
4) The result of this study indicates that the reuse of granite powder and crushed ceramic tiles as 10% replacement for FA and CA in concrete is certainly feasible.
5) Granite powder used as fine aggregates has more influence on the concrete than the ceramic tiles because of chemical composition it is made of and works as admixture.
6) Water penetration depth of concrete mix containing 10% of granite powder and 10 % of crushed ceramic tiles is minimum indicating highly durable compared to other mixes. so, this concrete is suitable for use in adverse environment.
7) Reuse of waste in concrete helps to cope up with problems like disposal problems, environmental pollution, and scarcity of natural resources

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