STUDIES ON STRENGTH CHARACTERISTICS ON UTILIZATION OF WASTE MATERIALS AS COARSE AGGREGATE IN CONCRETE

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Abstract:

Depletion of natural resources is a common phenomenon in developing countries like India due to rapid urbanization and Industrialization involving construction of Infrastructure and other amenities. In view of this, people have started searching for suitable other viable alternative materials for concrete so that the existing natural resources could be preserved to the possible extent, for the future generation. In this process, different industrial waste materials such as fly ash, blast furnace slag, quarry dust, tile waste, brick bats, broken glass waste, waste aggregate from demolition of structures, ceramic insulator waste, etc. have been tried as a viable substitute material to the conventional materials in concrete and has also been succeeded. This paper describes the studies conducted on strength characteristics of concrete made with utilizing waste materials viz: ceramic tiles, ceramic insulator waste, and broken glass pieces. A total number of 24cubes, 24 cylinders and 24 beams were cast and tested for compressive strength, splitting tensile strength and flexural strength using industrial wastes and the results presented. It was found that, the concrete made of waste ceramic tile aggregate produced more strength in compression, split tensile and flexure than ceramic insulator scrap and broken glass material. This paper recommends that waste ceramic tiles can be used as an alternate construction material to coarse aggregate in concrete.

Keywords: concrete; ceramic tiles waste aggregate; glass waste aggregate; ceramic insulator waste aggregate

1. Introduction

Owing to liberalization, privatization, and globalization, the construction of important infrastructure projects like Expressways, Airports, nuclear plants etc in India is increasing year after year. Such developmental activities consume large quantity of precious natural resources. This leads to faster depletion of natural

resources on one side and manifold increase in the cost of construction of structures on the other side pose severe problem for the construction sector. This problem is very severe in developing countries like India.
In view of this, people have started searching for suitable other viable alternative materials which could be used either as an additive or as a partial replacement to the conventional ingredients of concrete so that the existing natural resources could be saved to the possible extent, and could be made available for the future generation. In this process, different industrial waste materials such as fly ash, blast furnace slag, quarry dust, tile waste, brick bats, broken glass waste, waste aggregate from demolition of structures, ceramic insulator waste, etc. have been tried as a viable substitute material to the conventional materials in concrete and has also been succeeded. Weihua Jin, Christian Meyer and Stephen Baxter (2000) suggested that the use of crushed waste glass as an aggregate in concrete has several advantages in terms of strength. If used in large quantities in compressibility products such as concrete masonry blocks, the solid waste disposal problem faced can noticeably be reduced [1]. R.M. Senthamarai, et.al.,(2005) suggested that the compressive, splitting tensile and flexural strengths of ceramic waste coarse aggregate are lower by 3.8, 18.2 and 6% respectively when compared to conventional concrete[2]. J.de Brito. A.S. Pereira, J.R. Correia (2005) suggested ceramic tile aggregates can be used in elements in which the primary requirement is not compressive strength. However, it can be used in members wherein tensile strength and abrasion resistance are of primary importance, such as for concrete pavement slabs[3].

Information regarding studies on concrete made with different wastes is available in different forms in a scattered manner, and has also not adequately reached the large volume of stakeholders engaged in the construction activities across the length and breadth of our country. Due to this, the effective utilization of potential industrial waste materials in concrete has not attained the expected level in India even today. Hence, there is a compulsion on the part of civil engineering community, to take appropriate strategies so that the consumption of such potential waste by the construction industries will be on rise day-by-day leading to a green environment which is of-course the need of the hour for our nation. This paper deals with the experimental studies made on compressive strength, split tensile strength and flexural strength of concrete made with industrial wastes ceramic insulator scrap, broken glasses and ceramic floor tiles.

2. Experimental Programme:

2.1 Material Properties

Ordinary Portland Cement 43 grade confirming to IS 8112 – 1989, [4], locally available river sand of specific gravity 2.506 and fineness modulus 2.583 confirming to IS 383-1970[5] and natural crushed stone aggregate of maximum size 12.5 mm with specific gravity 2.5 and fineness modulus 7.839 were used in the conventional concrete. The physical and mechanical properties of the materials were tested as per IS 2386 (Part I-VIII) -1960[6].

2.2 Properties of coarse aggregates

The properties of the coarse aggregates are given in Table 1. The surface texture of the ceramic tile aggregates was found to be smoother than that of crushed stone aggregate. The other properties of the coarse aggregates such as crushing, impact and abrasion values were found close to the natural crushed stone aggregate.

Table 1: Properties of Aggregates

Property	Stone	Ceramic	Glass	Tiles
Specific gravity	2.506	2.200	2.500	2.300
Fineness Modulus	7.839	7.854	7.863	7.951
Maximum size(mm)	12.5	12.5	12.5	12.5
Crushing Value (%)	22	27	31	27
Impact Value (%)	13	17	22	20
Abrasion Value (%)	20	23	27	24

2.3 Mix proportions

The mix proportion of 1:1.23:2.64 (cement: fine aggregate: coarse aggregate) by weight was arrived for M20 concrete with the conventional aggregates. It was found that, the minimum water content required for the mix is 201 litres per cubic meter of concrete as per IS 10262 -2009[7]. Keeping this water content as constant, mix proportions were arrived for the ceramic waste, crushed glass and broken tile wastes. The mix proportions for M20 grade concrete as per IS 10262 -2009[7] for various coarse aggregates are presented in Table 2.

Table 2: Mix proportions

Grade	w/c ratio (By weight)	Cement content (kg/m^3)	Mix Proportions (By volume) C:FA:CA
A	0.49	411.16	1:1.23:2.64
B	0.49	411.16	1:1.22:2.32
C	0.49	411.16	1:1.22:2.66
D	0.49	411.16	1:1.22:2.43

A – Controlled specimens
B – Ceramic insulator scraps (100%)
C - Crushed Glass (100%)
D- Tile waste (100%)

In the mix proportion for concrete using waste aggregates, the conventional stone aggregate was completely replaced by ceramic insulator scrap, broken tiles and broken glass.

Fig. 1a Broken Tile aggregate

Fig. 1b Broken glass pieces

2.4 Casting and Testing of specimen

Totally 72 specimens, (cubes, cylinders and beams, each 24 numbers) were cast to determine their compressive strength, split tensile strength and flexural strength after 7 days and 28 days of curing. For each mix, three cubes of size 100mm, three cylinders of size 100 mm diameter and 200 mm long and three beams of size 100 x 100 x 500mm were cast to determine the compressive strength, splitting tensile strength and flexural strength of the specimens at 7 days and 28 days. The specimens were demoulded after 24 hours of casting and cured at 27 ± 2 ° C until the test age. All the tests were conducted as per IS 516 – 1959.[8].

3. Results and Discussions

4.1. Compressive strength.

The compressive strength values varied from 4.763 MPa to 7.175 MPa for 7 days strength. Also, it varied from 15.66 MPa to 21.26 MPa for 28 days. It was found that, there was not much variation in the compressive strength of conventional concrete and crushed stone aggregate concrete. The strength of the concrete with different coarse aggregates is given in Table 3. The compressive strength of concrete cubes made with ceramic insulator and glass concrete were found to be 16% and 26.34 % lesser respectively than that of conventional concrete. The reasons may be due to smooth surface texture of these aggregates and poor bonding properties of the matrix with aggregates.

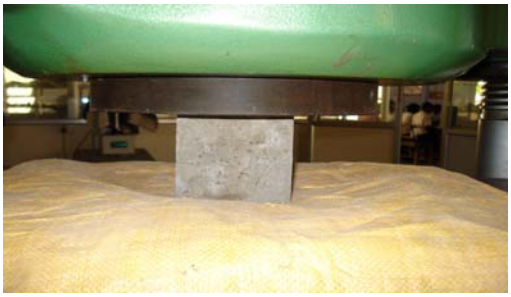

Fig 2. Compression Testing

4.2. Splitting tensile strength

The splitting tensile strength values varied from 0.790 MPa to 0.918 MPa at 7 days and 2.940 MPa to 3.244 MPa at 28 days. It was observed that, as far as the splitting strength is concerned, the concrete with broken tiles as coarse aggregate gave values nearer to that of conventional aggregate concrete. Similarly, the ceramic aggregate concrete gave the next higher strength.

Fig 3. Split tensile test

4.3 Flexural strength

The flexural strength results were found in the range of 8.699 MPa to 10.368 MPa for 7 days and it is from 13.945 MPa to 18.015 MPa for 28 days. From the results, it was observed that, the tile aggregate concrete can produce strength results similar to that of conventional aggregate concrete for both at 7 and 28 days. The results of the above tests were tabulated in Table 3.

Fig 4. Flexural Testing arrangement

Table 3: Comparison of Strength Results

Grade	Ave. Compressive Strength (MPa)		Ave. Splitting Tensile Strength (MPa)		Ave. Flexural Strength (MPa)	
	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
A	6.811	21.26	0.856	3.244	10.368	17.133
B	5.671	17.86	0.846	2.887	9.781	16.900
C	4.763	15.66	0.790	2.940	8.699	13.945
D	7.175	20.23	0.918	2.950	9.913	18.015

5. Conclusions:

Based on the studies conducted on strength characteristics of concrete made with utilizing waste materials, it was found that the concrete made of waste ceramic tile aggregate produced similar strength in compression, split tensile and flexure as conventional concrete. The compressive strength of concrete cubes made with ceramic insulator and glass concrete were found to be 16% and 26.34 % lesser respectively than that of conventional concrete. It was also found that the flexural strength and splitting tensile strength results were similar to that of compression strength test results. Hence, it can be seen that waste ceramic tiles can be used as an alternate construction material to coarse aggregate in concrete. Besides economical and strength criteria, concrete made from waste materials as aggregates, solves the disposal problem of these waste materials.

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