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AN EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF COARSE AGGREGATE BY WASTE CERAMIC TILES REINFORCED WITH GLASS FIBERS

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ABSTRACT

Due to the increasing demand of construction material and degradation of environment, there is need to explore alternative construction material from industrial as well as household waste and recyclable materials. Ceramic tiles are often dumped as waste material after it becomes useless. But it can be recycled and can be used as a construction material in present world which is seeking for alternative construction materials which are economical, environment friendly as well as provides same quality as that of a normal aggregate made of stones. Glass fiber are material consisting of numerous extremely fine fibers of glass. Glass fiber-reinforced concrete consists of high-strength glass fiber embedded in a cementitious matrix. The inclusion of fiber reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. An experimental investigation of compressive strength, split tensile strength, and Flexural strength will be undertaken by partial replacement of coarse aggregate by waste ceramic tiles, fiber reinforced with glass fiber.

Keywords: Ceramic tiles; Glass fiber

I. Introduction

Concrete is a durable and versatile construction material. Experience has shown that concrete is vulnerable production. For this it is necessary to understand the influence of components on the behaviour of concrete and to produce a concrete mix within closely controlled tolerances.

Construction and Demolition (C&D) wastes contribute the highest percentage of wastes worldwide (75%). Furthermore, ceramic materials contribute the highest percentage of wastes within the C&D wastes (54%). The current option for disposal of ceramic wastes is landfill. This is due to unavailability of standards, avoidance of risk, lack of knowledge and experience in using ceramic wastes in construction [1].

The nature of construction industry, especially the concrete industry, is such that ceramic wastes can be used safely with no need for dramatic change in production and application process. On one hand, the cost of deposition of ceramic waste in landfill will be saved and, on the other, raw materials and natural resources will be replaced, thus saving energy and protecting the environment [2]. Durability is one of the most important properties of

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concrete from the standpoint of safety, as well as for economic and environmental reasons [3]. Here this study deals only with the variation of aggregates used in concrete construction. Waste ceramic tiles are used in the study for partially replacing coarse aggregate.

The addition of discrete fiber reinforcement to a concrete matrix leads to an increased flexural strength, post-cracking capacity, impact resistance and energy absorption capacity . Commercially available short fibers are available from different materials, including steel, glass and carbon. The selection of fiber material, its geometry and the material properties should be appropriate for the intended application and ensure chemical compatibility with the binder. Glass fibers are relatively inexpensive, lightweight and have high tensile strength. Studies have shown that the addition of glass fibers in concrete can control shrinkage cracking, improve the flexural and tensile strengths[4].Glass fiber are material consisting of numerous extremely fine fibers of glass. Research in glass fiber reinforced concrete resulted in the development of an alkali resistance fibers high dispersion that improved long term durability. Here in this study we are using alkali resistant glass fibers.

II. EXPERIMENTAL INVESTIGATION

Concrete is a composite building material formed by the combination of cement, fine aggregate, coarse aggregate and water in a particular way that is designed to meet the job on hand with regard to desired workability, strength, durability and economy. Materials used and their properties are tested according to IS Specifications [5, 6, 7, 8]. M30 grade concrete mix is the prepared according to IS 10262:2009 [9]

Compressive strength, split tensile strength, and flexural strength of M30 grade concrete and concrete containing 10%, 15%, 20%, 25%, 30% of ceramic tiles which replaces coarse aggregate are experimentally investigated. Compression test is the most common test conducted on hardened concrete. The compressive test is carried out on specimens cubical in shape having a size of 150x150x150mm. The compression tests were conducted after 7 days, 28 days. The test was conducted according to IS specifications [10].

Fig 1. Test setup for compressive strength and split tensile strength respectively.

A standard test cylinder of concrete specimen of size 300mm x 150mm is used to determine the split tensile strength. The test is done using compression testing machine [10]. Replacement of ceramic tiles will improve the tensile strength of concrete. Test setup for compressive strength and split tensile strength respectively shown in figure1.

Fig 2. Test setup for flexural strength

Flexural strength is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 100 x 100 mm x 500mm concrete beams with a span length of at least three times the depth. Fig 2. Shows the test setup for flexural strength of concrete [10].

Compressive strength split tensile strength and flexural strength of the concrete containing 25% of ceramic tiles which replaces natural coarse aggregate and then addition of glass fiber at various % to the optimum mix (25%) are experimentally investigated.

III. RESULTS AND DISCUSIONS

From the experiments, the result obtained shows that the compressive strength was increasing as the replacement of natural coarse aggregate with ceramic tile increase up to 25%. The increase in strength is shown in table I and its graphical representation in fig 3. The strength was 35.5 N/mm^2 on 7 day test and 49.6 N/mm^2 on 28 day test. Further replacement shows the decrease in the compressive strength.

Table I. Compressive strength of concrete at various % of coarse aggregate replacement (N/mm^2)

Cube designation	Compressive strength (N/mm^2)	
	7 day	28 day
M30	23.5	38.2
10%	29.7	42.6
15%	30.8	44.4
20%	32	45.8
25%	35.5	49.6
30%	27.5	40.8

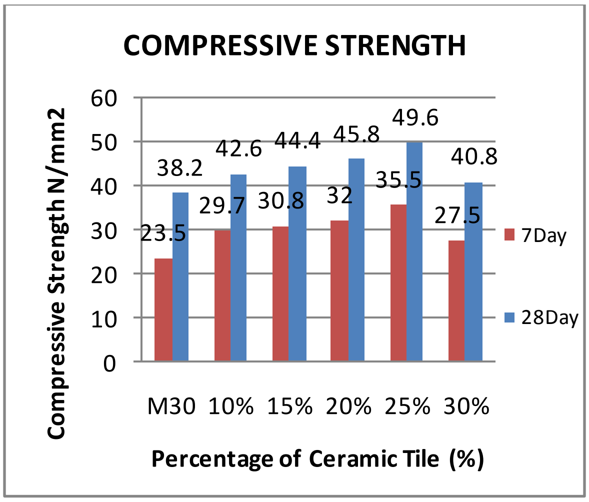

Fig 3. Graphical representation of compressive strength at 7day and 28day .

The compressive strength increased by 29.8 % on 28 day test. Ceramic aggregates are used in a pre saturated state, thus providing water for cement hydration, which results in increase in compressive strength [11]. The reduction in strength after optimum % is due to the decrease in strength of the paste with an increase in replacement ratio [12]. There was an increase in the compressive strength of concrete with longer curing periods.

Similarly for the split tensile strength, the increase in strength is shown in table II and its graphical representation in fig 4. Split tensile strength at 7day was found to be 2.54 N/mm^2 and at 28 day it was 3.4 N/mm^2. Further increase in replacement of coarse aggregate results in decrease of Split tensile strength of the concrete.

Table II. Split tensile strength of concrete at various % of coarse aggregate replacement. (N/mm^2)

Cylinder designation	Split tensile strength (N/mm^2)	
	7 day	28 day
M30	1.55	2.4
10%	2.29	2.75
15%	2.37	2.9
20%	2.46	3.1
25%	2.54	3.4
30%	2.15	2.6

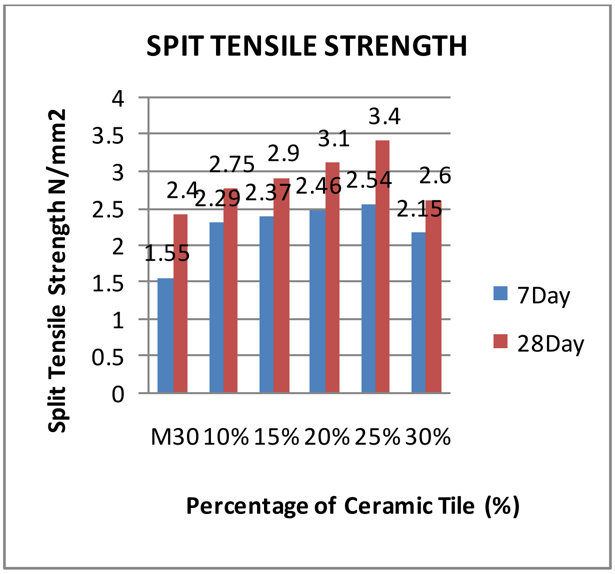

Fig 4. Graphical representation of split tensile strength at 7day and 28day

There was an increase of split tensile strength 41.6 % on 28 day test on comparing with control mix concrete.

In case of flexural strength, the strength was decreasing by the replacement of coarse aggregate with ceramic tiles. For M30 grade concrete the strength at 7day is 3.2 N/mm^2 and 5.6 N/mm^2 at 28 day. At the 25% the result obtained is 4 N/mm^2 at 7 day and 4.8 N/mm^2 at 28 day. Result shows the gradual decrease in flexural strength.

Table III shows the flexural strength behavior of coarse aggregate replaced ceramic concrete the variation in strength is graphically shown in fig 5.

Table III. Flexural strength of concrete at various % of coarse aggregate replacement. (N/mm^2)

Beam designation	Flexural strength (N/mm^2)	
	7 day	28 day
M30	3.2	5.6
10%	5	5.8
15%	4.8	5.5
20%	4.4	5.3
25%	4	4.8
30%	3.2	4.2

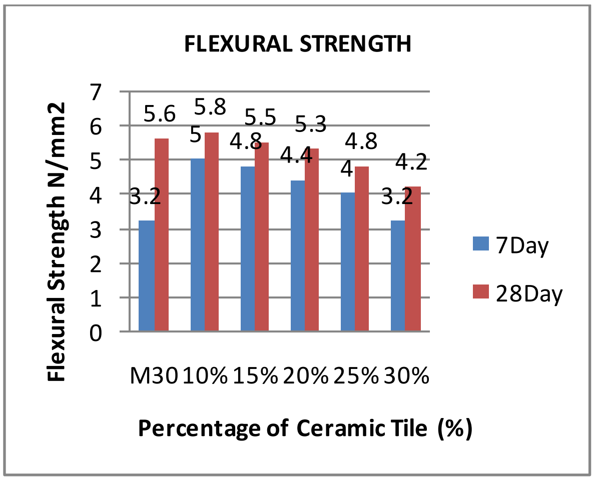

Fig 5. Graphical representation of flexural strength at 7day and 28day

The rate of flexural strength was decreasing by the replacement of natural coarse aggregate with ceramic tiles, strength decreases by 16.6%. Use of ceramic tile on substitution of natural coarse aggregate for concrete production had a negative influence on flexural strength By the addition of glass fibers to the optimum % replacement of natural coarse aggregate (25%), compressive strength, split tensile strength and flexural strength increases. The variation in compressive strength and split tensile strength is shown in table IV and table V respectively. The respective graphs are figure 6 and figure 7.

Table IV. Compressive strength of concrete by addition of glass fiber to optimum % replacement of natural coarse aggregate. (N/mm^2)

Cube designation	Compressive strength (N/mm^2)	
	7 day	28 day
25%	35.5	49.6
0.2%	36	49.8
0.4%	38.6	50.6
0.6%	40.4	54.8
0.8%	42.6	55.2

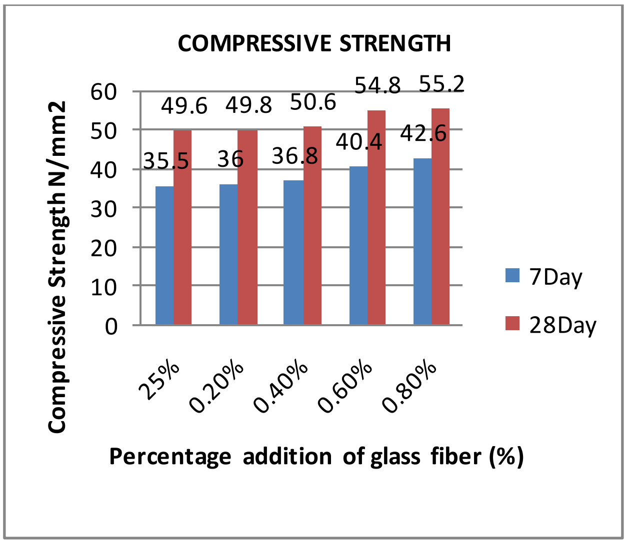

Fig 6. Graphical representation of compressive strength at 7day and 28day by addition of glass fiber

Optimum strength reached by the addition of .8% of glass fiber to concrete and the strength at 28 day strength 55.2 N/mm^2. Increase of compressive strength at 28 day by the addition of glass fiber was 44.5%. The addition of polymeric materials with cement, during hydration, enabled polymer film formation to occur which resulted in a co-matrix under which the polymer was intermingled with cement hydrate the presence of polymer particles in the dispersion is restricted to the capillary force at the interface of the aggregate and the bulk polymer-cement phase [13]. It was reported that polymer concrete is stronger than cement based concrete. Therefore, polymer concrete is used in many applications like box culvert, hazardous waste disposal site liner, trench lines, floor drains, pavements and bridges [6] .

Table IV. Split tensile strength of concrete at various % of coarse aggregate replacement. (N/mm^2)

Cylinder designation	Split tensile strength (N/mm^2)	
	7 day	28 day
25%	2.54	3.45
0.2%	2.57	3.54
0.4%	2.63	3.65
0.6%	2.68	3.7
0.8%	2.75	3.9

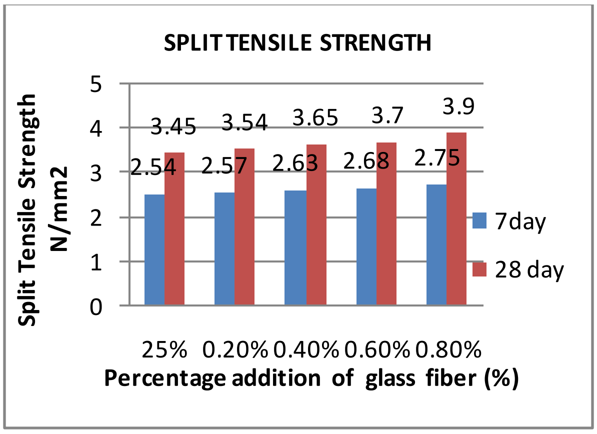

Fig 7. Graphical representation of split tensile strength at 7day and 28day by addition of glass fiber

Optimum strength reached by the addition of .8% of glass fiber to concrete. The strength at .8% was 3.9 N/mm^2 at 28 days curing. Increase of split tensile strength at 28 day by the addition of glass fiber was 51.7%.

This behaviour can be attributed to improvements of the properties (thickness and modulus of elasticity) of the interfacial transition zone (ITZ) between ceramic aggregate/paste with respect the ITZ gravel/paste [4].

The flexural strength variation in concrete is tabulated in Table VI and fig 8 shows the strength variation.

Table VI. Flexural strength of concrete by addition of glass fiber to optimum % replacement of natural coarse aggregate (N/mm^2)

Beam designation	Flexural strength (N/mm^2)	
	7 day	28 day
25%	4	4.8
0.2%	4.1	5.65
0.4%	3.95	5.5
0.6%	4.3	5.83
0.8%	4.54	6.03

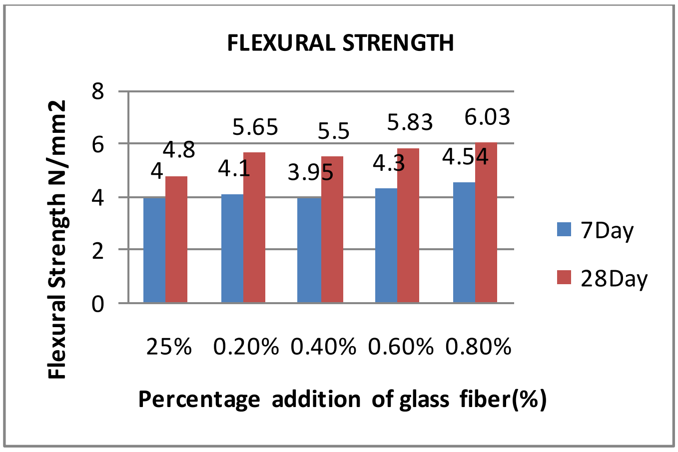

Fig 8. Graphical representation of flexural strength at 7day and 28day by addition of glass fiber

Addition of glass fiber increases the flexural strength and strength at 28 day is 6.03 N/mm^2, and the rate of increase of flexural strength is 7.6%.

The addition of fibers had negligible influence on the initial stiffness of the response, but resulted in significantly higher peak loads as the fiber dosage increased, irrespective of the aggregate type [11].

CONCLUSION

Plain concrete is a brittle material with low tensile strength and strain capacity. Experimental investigation on compressive strength and split tensile strength is conducted to find out the optimum strength of concrete by partially replacing natural coarse aggregates by ceramic tiles which is then reinforced with glass fibers.

From the results obtained from the study it is clear that the mechanical properties will be improved by the partial replacement of coarse aggregate with ceramic tile up to 25%. The result also showed that addition of glass fiber into ceramic concrete had little influence in the mechanical properties of concrete while the workability decreases with an increase of fiber content.

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