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Performance of Glass Fiber Reinforced Concrete

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Abstract*—In the present investigation, the compressive strength, flexural strength and workability of concrete containing varying proportions of glass fiber as replacement of fine aggregate is studied. The result of these parameters is compared to those of standard M30 grade concrete. The increase in compressive strength is nominal while the flexural strength increased significantly as expected with the increase in percentage of glass fiber. Also, significant reduction in the slump value of the glass fiber reinforced concrete was observed with increase in glass fiber content. The preliminary investigations reveal that the use of this industrial waste is not only improving the properties of concrete but also provides a safe and efficient means of disposal of such non-biodegradable wastes

***Index Terms*—Compressive Strength, Flexural Strength, Slump, Glass Fiber.**

I. Introduction

There has been an exponential rise in the use of concrete with the increase in infrastructural development. With this ever-increasing consumption of concrete, the fundamental natural ingredients which make the concrete, that is, fine and coarse aggregates are depleting at a very fast pace. This necessitates the use of alternate materials which can be added to cement, without lowering its performance. The better idea would be to add ingredients which can improve the performance of the same. In this regard, several researchers have worked on using materials like rice husk [1]-[2], sugarcane bagasse [3] and so on.In adding a new ingredient to the standard ingredients of concrete, one must bear in mind the short term and long term interaction of the ingredient with other elements, the effect on the compressive strength, flexural strength, workability, durability, permeability, tensile strength, bond and homogeneity. The requirements of performance also depend on many other factors like mixing, mixing time, transportation methods, placement, use of admixtures, curing methodologies, climatic factors.

In the present work, glass fibers, 25 micrometer in diameter and 5cm long are used for the preparation of standard M30 grade concrete by replacing fine aggregate by up to 1.5%. The fibers are available in huge quantities and are waste products of the glass manufacturing industries. Thus, use of such fibers not only increase the flexural strength of the concrete, but also pave the way for an easy disposal of the industrial waste. In addition to this, the fibers are known to arrest the plastic shrinkage and drying shrinkage cracking. The use of waste glass as aggregate for concrete has been attempted decades ago. Jones [4] attempted to use finely ground E-glass fiber and investigated the performance of glass fiber reinforced concrete subjected to accelerated tests.

The compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete made of alkali resistant glass fiber was studied by Chandramouli [5]. For fibers with high aspect ratios, it was observed that the workability reduced significantly. Osmani [6] discussed the use of GRP waste ground fiber, as replacement for fine aggregate in foamed concrete, increased strength with reduced weight. The fire resistance of the concrete was found to increase significantly.

II. Experimental Investigation

The material specifications for the concrete are as mentioned in Table I.

TABLE I. **Material Specification**

S.No.	Ingredient	Specifications	Remarks
1	Cement	• PPC 43 Grade • Specific gravity 3.15 • Fineness 4.0%	Confirming IS 4031-1988 & IS 1489-1991[7][8]
2	Coarse Aggregate	• Crushed angular • 20mm nominal size • Specific gravity 2.65 (By pycnometer test at 25^0C) • Fineness Modulus 6.05	Confirming IS 383-1970 [9]
3	Fine Aggregate	• River Sand • Confirming to Zone-III • Specific gravity 2.65 (By pycnometer test at 25^0C) • Fineness Modulus 2.77	Confirming IS 383-1970 [9]

The glass fiber used herein consists of 25 micrometer diameter and 5 cm long and has specific gravity of 1.2 at 25^0C. These fibers occupy high volumes; hence it is almost impractical to use them in quantities more than 2% of weight of fine aggregate. But even such small quantities can significantly alter the performance of concrete as discussed further. The mix design procedure for M30 grade concrete as mentioned in IS 10262-1982 was adopted for plain concrete subjected to moderate exposure and good degree of quality control. After necessary corrections and adjustments the ratio is found to be: 1:0.88:1.85. The water-cement ratio is 0.45. Samples of concrete with 0.0%, 0.5%, 0.7%, 0.9%, 1.2%, and 1.5% of fine aggregate replaced by glass fibers, randomly distributed were prepared. The compression testing samples

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were cast in cubes of 150 X 150 X 150 mm cast iron mould. The flexural members were cast in the standard 700 X 150 X 150 mm mould. The specimens were systematically placed in curing tanks after 24 hours for 7 and 28 days respectively. For each given percentage of glass fibers, six cubes and six beams were cast. Similarly, the workability for each of the given percentage of glass fiber is reported by taking the average of three slump test results. The Specimens were tested according to IS 516-1959 and IS 1199-1959.

III. Results & Discussions

In order to compare the results obtained by adding varying amounts of glass fiber, plain cement concrete with 0% of the fiber is also prepared with the same material. The results of the compressive strength after 7 days and 28 days of curing are as presented in Table-II

TABLE II.COMPRESSIVE STRENGTH

S.No.	% Glass Fiber	7 days (MPa)	28 days (MPa)
1	0.0	24.44	38.00
2	0.5	24.88	38.22
3	0.7	24.88	38.44
4	0.9	25.33	39.11
5	1.2	25.55	39.55
6	1.5	25.77	40.44

The results presented in table-1 indicate no significant changes in the compressive strength of concrete in both 7 and 28 days. As is well known, fibers cannot take compressive loads, this was expected. The most affected parameter by the addition of glass fiber is the flexural strength. The results of flexural strength after 28 days of curing subjected to two point load are presented in Table-III.

TABLE III. FLEXURAL STRENGTH

S.No.	% Glass Fiber	28 days (MPa)
1	0.0	4.1
2	0.5	4.5
3	0.7	4.8
4	0.9	5.0
5	1.2	5.2
6	1.5	5.3

From the table, it could be inferred that the flexural strength of beam with 1.5% glass fiber shows almost 30% increase in the strength compared to the beam with 0% glass fiber. This significant increment in flexural strength with increase in fiber content maybe due to the random orientation of fibers, the ability of the fiber to take up some part of the flexural load, good bonding between the fiber and concrete, a high length to diameter ratio which makes the fibers work like reinforcing agents.

The workability of the glass fiber concrete decreased significantly with increase in the percentage of fiber as shown in Table-IV.

TABLE IV.WORKABILITY

S.No.	% Glass Fiber	Slump Value (mm)
1	0.0	18
2	0.5	15
3	0.7	12
4	0.9	10
5	1.2	09
6	1.5	07

The reduction in slump with the increase in glass fiber content could be attributed to the hindrance offered to the aggregates by the fibers to freely slip past the adjoining aggregates due to their geometry.

IV.Conclusion

The present research work deals with the use of glass fiber in concrete which is obtained from the glass industry as a waste product. The work is in nascent stage but is promising, as the preliminary results satisfy the basic needs which the alternate material should fulfill in concrete. Though, as expected, the compressive strength of concrete did not increase much, the flexural strength showed almost 30% increase in strength compared to the beam with 0% fibers. The slump value decreased with increase in fiber content. The reasons for these behaviours are discussed. Thus, it can be concluded that the use of fiber glass in concrete, not only improves the properties of concrete and can do a small cost cutting, but also provides an easy outlet of the efficient disposal of this environmental hazard.

V. Future Scope

The durability aspects and the interaction of glass fiber with concrete in the micro-level are in progress. Also, analysis of the possibilities of formation of new complex chemical compounds is going on by the interaction of glass fiber with concrete.

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