Effect of glass wool fibres on mechanical properties of concrete

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***Abstract*— The present trend in concrete technology is towards increasing the strength and durability of concrete to meet the demands of the modern construction world at lower cost. These factors can be achieved in concrete by adding natural or synthetic fibre. In the case of Glass Fibre reinforced Concrete, strength of the concrete is increased, but at higher cost. Hence, research has to be done to provide an alternative use of fiber glass. In the present study, Glass wool fibre is added to the concrete to increase the strength as compared to the conventional concrete at lower cost. The strength parameters of concrete such as compressive strength and tensile strength were studied by varying the percentage of fibre from 0.025% to 0.075% of the weight of concrete.**

***Keywords*— Compressive strength, Glass wool fibre, Tensile strength, Synthetic fibre**

I. INTRODUCTION

Concrete is the most widely used construction material and has most desirable properties like high compressive strength, stiffness and durability under usual environmental factors. Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. These properties can be improved by the use of fibers in the concrete. It has been revealed that concrete reinforced with a permissible amount of fibre acquires better performance in compression, flexure, toughness and energy absorption, in which case the degree of improvement relies on the types of fibres. Experiments have been carried out by several authors using fibres of glass, carbon, asbestos, polypropylene etc. Griffiths et al [1] conducted study to investigate the mechanical properties of glass fibre reinforced polyester polymer concrete. Sorousshian et al [2] reported the results of an experimental study on the relative effectiveness of different types of steel fibre in concrete. Babu et al [3] investigated the addition of the glass fibres and concluded that there is increase in the compressive strength upto 1% by volume at higher fibre percentages and the strength decrease if the fibre content is increased significantly. Barros et al **[4]** investigated the tensile behavior of GFRC specimens at 28 days of age. It was observed that fracture energy of cement based materials is significantly increased by adding glass fibre to the mix composition. Swami et al [5] has been established that discrete metallic (steel) fibers when added in certain percentage to the concrete improve the strength properties as well as crack resistance and ductility. Urooj Masood et al [6] studied the durability criteria of mixed fiber reinforced concrete to acids and salt resistance. The investigation was carried out with different proportions of mixed percentages of alkaline resistant glass fibers and steel fibers in total fiber content percentages.

II. MATERIALS USED

FRC comprises two components; namely the matrix component considered as the conventional concrete and the fibre component. The compositions of the concrete matrix component consist of cement, aggregate & water. The fibre component consists of glass wool fibres added to the concrete matrix.

A. Cement

Ordinary Portland cement of 53 grades available in local market is used in the investigation. The cement used has been tested for various proportions as per IS: 4031-1988 and found to be conforming to various specifications of IS: 12269-1987. The specific gravity was 3.15 and the fineness was 3200 cm^2/gm.

B. Coarse Aggregate

Crushed stone metal with a maximum size of 12.5 mm from a local source conforming to IS: 383-1970 was used. The specific gravity was found to be 2.7.

C. Fine aggregate

Fine aggregate can be natural or crushed. Locally available river sand passing through 4.75 mm IS sieve and it conforms to zone II (As per IS 383 – 1970). The specific gravity and fineness was found to be 2.6 and 2.63.

D. Glass wool fibre

Glass Wool is manufactured by the fusion of a mixture of natural sand and recycled glass at 1450 °C, the glass that is produced is converted into fibers. In the present study the amount of fibre to be added in a concrete mix is measured as a percentage of the total weight of the concrete. The fibres with the modulus of elasticity of 55 GPa, specific gravity 2.68 aspect ratio of 125 is used.

III. MIX COMPOSITION

The experimental investigation was carried out to study the properties of M20 grade concrete. The mix was designed as per IS 10262-1984 [7]. To study the effect of glass wool fibres on the strength of concrete the % of fibres is varied from 0.025% to 0.075% by total weight of concrete. The Table I shows the quantity of materials obtained based on the design mix.

TABLE I
QUANTITY OF MATERIALS USED

S.No	Materials	Quantities per cubic metre of concrete (kg)
1	Cement	383
2	Fine Aggregate	546
3	Coarse Aggregate	1188
4	Fibres	
	0.025%	5.3
	0.05%	10.585
	0.075%	15.88

IV. METHODOLOGY

A. Workability

In the present study the workability tests were performed using standard sizes of Slump moulds as per IS: 1199 -1999 to determine the workability of the glass wool fibre reinforced concrete. The Fig.1 shows the slump cone test performed to find workability of the mix.

Fig. 1 Slump test performed

B. Test specimens

A total of 80 specimens were casted of which, 36 cube of size 150mm x 150mm x150mm for compression test and 36 cylinders of size 100mm X 200mm for split tensile test were prepared for different % of glass wool fibres. The specimens without fibres are considered as control specimens & with fibre are considered as glass wool fibre reinforced concrete. All the specimens were cured and tested for 7, 14 & 28 days. The Fig.2 shows the some of the specimens casted.

Fig.2 Specimens casted

C. Compression Strength test

The compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications concrete is used primarily to resist compressive stress. The compression test was conducted on cube specimens cured for 7, 14 & 28 days. The test cubes were removed from the moist storage 24 hours before testing. The top and bottom bearing plates of the compression testing machine were wiped and cleaned before the placement of the specimen. After ensuring the connection between, the cube specimen was placed on the lower bearing plate keeping the center alignment by the screwed guides on the bearing plate. The load was applied until the concrete specimens failed and the ultimate load was noted.

D. Split tensile strength test

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. In this test, in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses developed in the specimen. The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The test specimens shall consist of concrete cylinder of 150mm diameter and 200mm long. The same compression test machine is used for finding tensile strength. It consists of applying a compressive line load along a concrete cylinder placed with its axis horizontal between the compressive platens. Due to the compression loading, a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis.

V. RESULTS AND DISCUSSIONS

A. Effect of glass wool fibres on workability

For fiber glass wool percentages of 0.025, 0.05, 0.075 by weight, the workability is determined by slump value. Higher

percentages of fiber beyond 0.075 percent require super plasticizer. At 1% fiber content balling has occurred and mix was not in a workable condition with a W/C ratio of 0.5.

B. Compression strength

The Table II shows the results obtained from compression strength test. It is observed that with increase in fiber percentage, the compressive strength also increases with age. At the age of 7 days with maximum of 0.075 percentage fiber the compressive strength is 5.15% in excess over the strength of control mix and for 14 days & 28 days the percentage of strength increase is found to be 13.13% & 15.68% respectively. It was observed that, the formation of cracks is more in the specimens without glass wool fibres, whereas it is minimum in the specimens with the maximum of 0.075% of fibre. It shows that the presence of fibres in the concrete act as the crack arrestors.

TABLE II
COMPRESSIVE STRENGTH OF SPECIMENS AT DIFFERENT FIBRE CONTENT

S.No	% of fibre	Compressive strength in N/mm^2		
		7 days	14 days	28 days
1	0	15.34	20.71	29.426
2	0.025	15.60	21.10	30.22
3	0.05	15.96	22.76	32.315
4	0.075	16.13	23.43	34.04

C. Split tensile strength

The Table III shows the results obtained from split tensile strength test. It is observed that with increase in fiber percentage, the split tensile strength also increases with age. At the age of 7 days with maximum of 0.075 percentage of fiber the split tensile strength is 20.41% in excess over the strength of the control mix and for 14 days & 28 days the percentage of strength increase is found to be 25.17% & 29% respectively.

TABLE III
TENSILE STRENGTH OF SPECIMENS AT DIFFERENT FIBRE CONTENT

S.No	% of fibre	Compressive strength in N/mm^2		
		7 days	14 days	28 days
1	0	2.45	2.94	3.3
2	0.025	2.67	3.275	3.8
3	0.05	2.86	3.395	3.89
4	0.075	2.95	3.68	4.257

The following Fig. 3 & 4 shows the increase in the tensile & compressive strength with respect to the % of fibre.

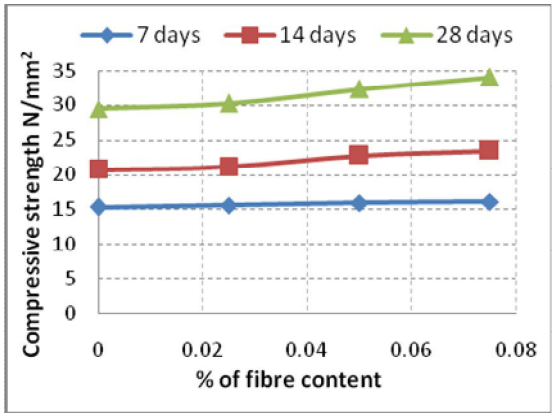

Fig. 3 Compressive strength vs % of fibre content

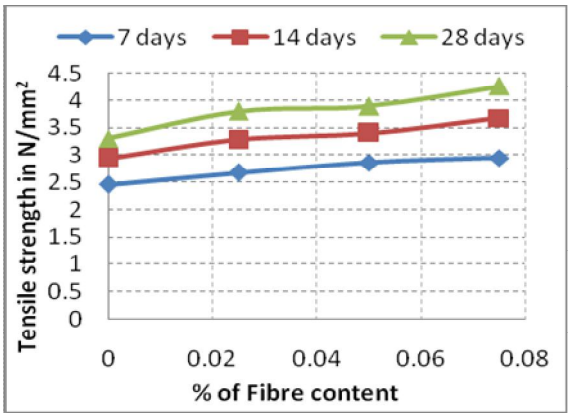

Fig. 4 Tensile strength vs % of fibre content

VI. CONCLUSION

Based on the present experimental investigation conducted and the analysis of test results, the following conclusions are drawn.

- Higher percentages of Glass wool fibers greater than one percentage affect the workability of concrete, and may require the use of super plasticizers (workability agents) to maintain the workability.
- As the percentage of fibre content by total weight of the concrete increases from 0.025%-0.075% the compressive strength of the concrete also increases from 5.15% to 15.68% at 28 days.
- Also from the split tensile strength test it was found that, the strength at 28 days increases by 20.41% to 29% due to the addidtion of glass wool fibres varying from 0.025%-0.075%.

- The flexural strength of glass wool fibre concrete is also found have a maximum increase of 30.26% at 0.075% of fibre content.
- It was observed that, the percentage increase in the strength of glass wool fibre reinforced concrete increases with the age of concrete.
- Also it was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibres than the glass wool fibre reinforced concrete.
- It shows that the presence of fibres in the concrete acts as the crack arrestors.
- The ductility characteristics have improved with the addition of glass wool fibers. The failure of fibre concrete is gradual as compared to that of brittle failure of plain concrete.

ACKNOWLEDGMENT

The authors wish to place on record the help provided by the management and the academic teaching and non teaching faculties of Vickram college of Engineering, in the completion of this study.

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