EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE WITH ADDITION OF CHOPPED GLASS FIBER

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ABSTRACT - *All concrete structures crack to some extent, due to shrinkage and tension. This paper was attempted to investigate the effect of glass fiber on the compressive strength, split tensile strength and tensile strength (flexural strength) properties of the concrete. In this study the effect of addition of glass fibers on compressive strength, split tensile strength, flexural strength of concrete has been studied experimentally. Glass fibers were added with varying percentages from 0.3%, 0.5%, and 0.7% of total binder content. Rebound hammer test and ultrasonic pulse velocity (UPV) tests were also studied. The strength predicted from the rebound hammer has been compared with the one achieved experimentally. The quality of concrete assessed using UPV has been correlated with the strength and quality of the concrete. Maximum strength gain was achieved at fiber content of 0.7% at both curing ages of 7 and 28 days. Besides, concretes with glass fibers have shown better results than concrete with no fibers.*

Key Words: **Compressive Strength Split Tensile Strength, Flexural Strength, Rebound hammer And Glass Fiber.**

INTRODUCTION

Concrete is the most widely used artificial material. It plays an important role in the world of civil engineering. It is a hardened mass obtained from a mixture of cement, sand, gravel & water in definite proportions. These ingredients are mixed together to form a plastic mass which can be moulded in any shape. This plastic mass hardens on setting and we get plain cement concrete. This hardening is caused by chemical reaction between water and cement and it continues for a long time. Concrete grows stronger with the increase in age.

Plain cement concrete has good compressive strength but very low tensile strength. To improve the tensile strength of concrete, some sorts of fibers are used. These fibers take up the tensile stresses developed in the structure and decrease the brittle behavior of concrete. One can control the properties of concrete by mixing ingredients very carefully. The properties of concrete depend upon the type of ingredients and their proportions. Admixtures are the most important factor which affects the workability of concrete.

Fiber reinforced concrete (FRC), a relatively new material, is a concrete made primarily of hydraulic cements, aggregates and discrete reinforcing fibers [1]. Glass fiber reinforced concrete is one of the most versatile building materials available to architects and engineers [4]. This concrete is composed principally of cement, sand and alkali resistant glass fibers. GRC is a thin, high strength concrete with many applications in construction [4]. Fiber in the cement based matrix acts as crack arrester, which restricts the growth of flaws in the matrix, preventing these from enlarging under load into cracks, which eventually cause failure [9]. Prevention of propagation of cracks originating from internal flaws can result in improvement in static and dynamic properties of the matrix [9]. A major advantage of using fiber reinforced concrete besides reducing permeability and increasing fatigue strength is that fibers addition improves the toughness or residual load carrying ability after the first crack, this concrete is known as glass fiber reinforced concrete (GFRC) [11].

Present investigation was conducted to study the effect of addition of glass fiber on the compressive strength, split tensile strength and tensile strength (flexural strength) properties of the concrete.

MATERIALS USED

The material properties used in concrete were determined in laboratory as per relevant Indian standards. Portland pozzolanic cement, accessible in market, was used in this investigation confirming to various designation of IS: 1489 (Part 1) – 1991. The specific gravity of cement was 2.65. Locally available river sand was used as fine aggregate lying under zone-I (IS: 383-1970) with specific gravity and fineness modulus as 2.60 and 2.95 respectively. Locally available coarse aggregates of 20 mm nominal size were used with specific gravity and fineness modulus as 2.70 and 6.99 respectively.

METHODOLOGY

A total of 72 specimens were cast containing cubes, beams and cylinders and were tested at the curing age of 7 days and 28 days. The water cement ratio used was kept constant as 0.40 for all the mixes. The mix proportion used in the study was chosen as 1:1:2 arbitrarily without designing the mix. Glass fibers were added in concrete in 3 different proportions as 0.3%, 0.5%, and 0.7% of total binder content. Increase in fiber concrete decreased the workability of concrete so Sicca based super plasticizer was added to keep the concrete within workable limits.

After specified curing age, the compressive strength of cubes, split tensile strength of cylinders and flexural tensile strength of beams were tested as per guidelines of standard IS: 516-1959. For compressive strength, 24 cubes of size 150×150×150 mm were cast. Testing was done on compression testing machine as shown in Figure 1. At each age strength was calculated after taking average of strength of 3 specimens as per the relation:-

Compressive strength (N/mm^2) = load / area

Figure 1: Test Setup for Compressive Strength

For testing split tensile strength, the specimens of 200 mm length and 100 mm diameter was used. Total 24 cylinders were cast and the specimens were tested in same compression testing machine (Figure 2). At each age, strength was calculated after taking average of strength of 3 specimens as per the relation:-

Split tensile strength (N/mm^2) **=** $2P / \pi DL$

Where P = failure load

D = Diameter of cylinder = 100 mm

L= Length of cylinder = 200 mm

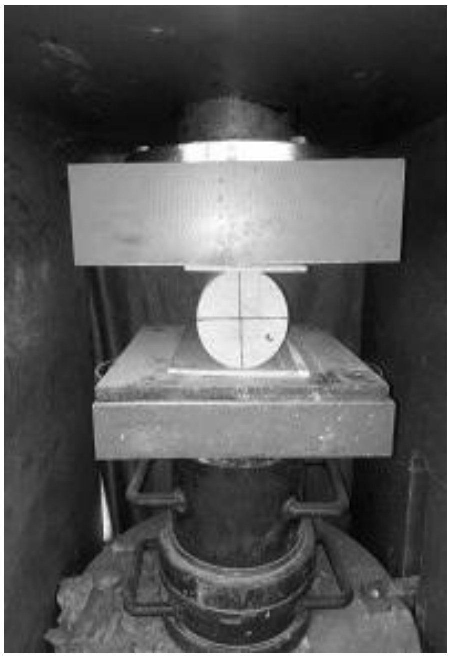

Figure 2: Test Setup for Split Tensile Strength

Flexural strength is also a measure of tensile strength of concrete. For testing, total 24 beams of size 500×100×100 mm were. The flexural strength specimens was tested under four point loading according to IS: 516-1959. Effective span of beam was 450 mm. Average of 3 specimens were tested at each age to obtain the flexural strength. Test setup is as shown in Figure 3. Flexural strength was calculated as per the relation:-

Flexural strength (N/m^2) = $p\,l / bd^2$
Where,
p = failure load
l = c/c distance 500mm
b = width of the specimen = 100 mm
d = depth of the specimen = 100mm

Figure 3: Test Setup for Flexural Strength

At curing age of 28 days, rebound hammer test was also conducted on 12 samples each of cubes, cylinders and beams (Figure 4).

Figure 4: Test Setup for Rebound Hammer

Ultrasonic pulse velocity test was also conducted on samples at curing age of 28 days. In ultrasonic pulse velocity method, velocity was calculated in m/s. It is non-destructive test which involves measurement of the time of travel of electronically generated mechanical pulses through the concrete (Figure 5). The pulses can be generated by an electro acoustic transducer. The instrument used is called “Soniscope”. The ultrasonic pulse velocity measurement may be used to find:

a) Uniformity of the concrete.
b) Quality of the concrete or concrete strength.
c) Presence of cracks, voids, defects due to fire and frost.
d) Modulus of elasticity

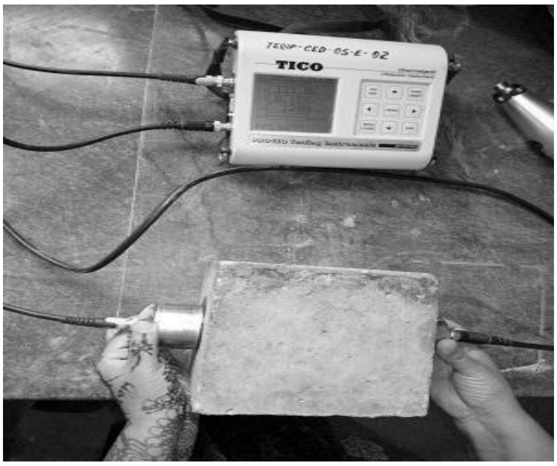

Figure 5: Test Setup for Ultrasonic Pulse Velocity

RESULTS AND DISCUSSION

Compressive Strength Test

Compressive strength of concrete without and with glass fibers was tested at the age of 7 days and 28 days. With increase in fiber content an increase in compressive strength was observed, at both curing ages. Maximum increase in strength was observed at 0.7% of glass fibers with strength at 28 days curing age as 40.62 N/mm^2. The compressive strength values of various mixes with different fiber percentages and at different curing ages is as shown in Table 1.

Table 1: Effect of Glass Fibers on Compressive Strength of Concrete Mixes.

Sr. No.	Glass Fiber	Compressive Strength (N/mm^2)	
		7 days	28 days
1	0%	23.36	33.85
2	0.3%	24.99	35.96
3	0.5%	25.92	38.69
4	0.7%	26.81	40.62

Percentage increase in compressive strength of various mixes as compare to mix with 0% glass fibers is shown in Figure 6.

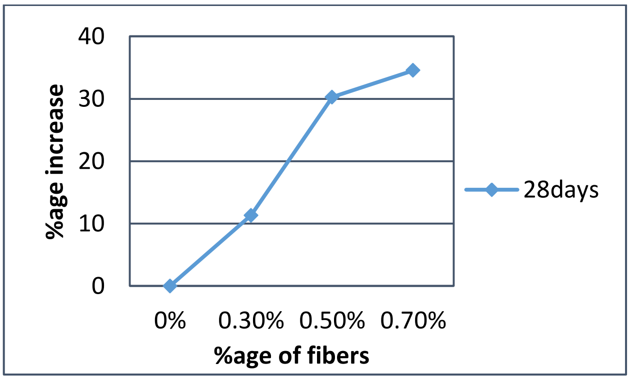

Figure 6: Percentage increase in compressive strength w.r.t. glass fiber content.

Split Tensile Strength

Split tensile strength of concrete without and with glass fibers are tested at the ages of 7 days and 28 days. Similar to compressive strength results, maximum increase in strength was observed at 0.7% of glass fibers with strength at 28 day curing age as 5.05 N/mm^2. The split tensile strength values of various mixes with different fiber percentages and at different curing ages is as shown in Table 2.

Table 2: Effect of Glass Fibers on Split Tensile Strength of Concrete Mixes.

Sr. No.	Glass Fiber	Split Tensile Strength (N/mm^2)	
		7 days	28 days
1	0%	2.25	3.25
2	0.3%	2.65	3.81
3	0.5%	2.79	4.53
4	0.7%	3.22	5.05

Percentage increase in split tensile strength of various mixes as compare to mix with 0% glass fibers is shown in Figure 7.

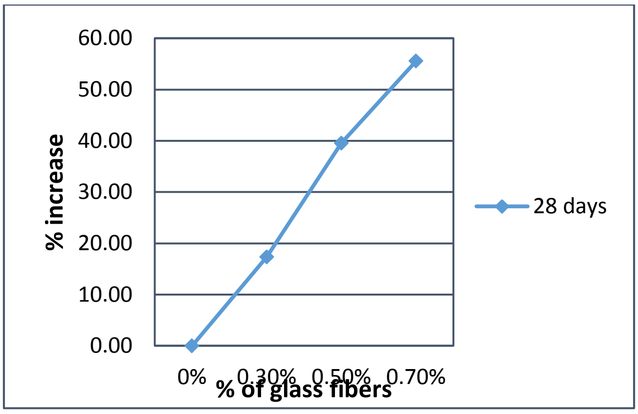

Figure 7: Percentage Increase in Split Tensile Strength w.r.t. Glass Fiber.

Flexural Strength

Flexural strength of concrete without and with glass fibers are tested at the ages of 7 days and 28 days. Similar to compressive strength results, maximum increase in strength was observed at 0.7% of glass fibers with strength at 28 day curing age as 7.80 N/mm^2. The flexural strength values of various mixes with different fiber percentages and at different curing ages is as shown in Table 3.

Table 3: Effect of Glass Fibers on Flexural Strength of Concrete Mixes.

Sr. No.	Glass Fiber	Flexural Strength (N/mm^2)	
		7 days	28 days
1	0%	3.86	5.70
2	0.3%	4.76	6.58
3	0.5%	5.63	7.27
4	0.7%	6.30	7.80

Percentage increase in flexural strength of various mixes as compare to mix with 0% glass fibers is shown in Figure 8.

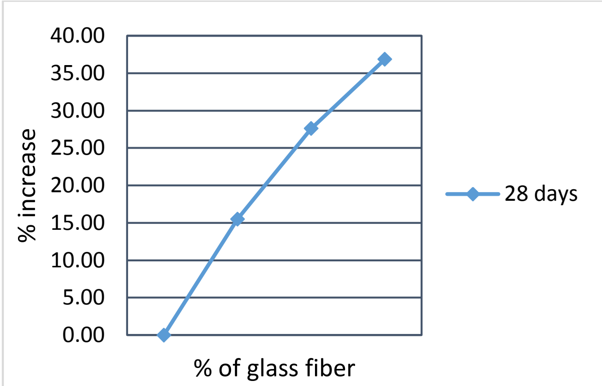

Figure 8: Percentage Increase in Flexural Strength w.r.t. Glass Fiber.

Rebound Hammer Test:

Rebound hammer without and with glass fibers are tested at the ages of 28 days. Compressive strength results obtained by rebound hammer test were in good correlation with destructive compression test i.e. test performed on compression testing machine. Maximum percentage different between rebound hammer and destructive testing (compression testing machine) values are given in table 5.1.9 as per IS: 13311(Part 2) -1992.

Table 4: Rebound Numbers for various concrete mixes.

Sr.No.	Glass Fiber	Rebound Number		
		Cubes	Beams	Cylinders
1	0%	22.46	22.42	23.04
2	0.3%	23.80	22.67	23.89
3	0.5%	24.67	23.60	25.42
4	0.7%	25.91	26.54	26.17

Table 5: Comparison between Rebound Number (Strength by Average Curve) and Destructive Testing (Compression Testing Machine)

Sr.No.	% of glass fiber	0%	0.3%	0.5%	0.7%
1	Average rebound value	22.46	23.80	24.67	25.91
2	Strength by average curve N/mm^2	18.23	20.76	21.9	23.87

3	Destructive strength(Compression testing machine) N/mm^2	33.85	35.96	38.69	40.62
4	% difference between average curve and destructive strength N/mm^2	-0.86	-0.73	-0.76	-0.70

Ultrasonic Pulse Velocity Test

Ultrasonic pulse velocity (USPV) results were in correlation with the strength results. Value of ultrasonic pulse velocity increased with increase in glass fiber content. USPV values for the concretes lied in the range of 3983- 4586 m/s i.e. the range for good to excellent quality of concrete as per IS 13311(Part 1) -1992.

Table 6: Ultrasonic Pulse Velocity value for various concrete mixes.

Sr.No.	Glass Fiber	Ultrasonic pulse velocity		
		Cubes	Beams	Cylinders
1	0%	3983.33	4183.33	4376.66
2	0.3%	4151.66	4230	4483.33
3	0.5%	4196.66	4316.67	4526.67
4	0.7%	4240.00	4376.66	4586.67

CONCLUSION

In this limited experimental investigation test programme tests were conducted on the hardened properties of the concrete. Non-destructive tests were also conducted to assess the properties of the hardened concrete like strength and homogeneity on the basis of rebound hammer and ultrasonic pulse velocity respectively. On the basis of the study following conclusions have been drawn.

- In the concrete mixes, addition of glass fibers can be reduced in bleeding.
- With increase of fiber content, the concrete mix gets harsher and less workable.
- It can be concluded in general that concrete with glass fibers are shown better results than concrete with no fibers.
- With increase in glass fiber content in concrete the compressive strength, flexural strength and split tensile strength of concretes increased.
- Maximum strength gain was achieved at fiber content of 0.7% at both curing ages of 7 and 28 days.
- At 0.7% glass fiber content, increase in strength w.r.t. reference mix (0% fiber content) was approximately 20% more in compression test, 56% more in case of split tensile test and 37% more in case of flexural strength test.
- At 0.7% glass fiber content, increase in compressive strength are approximately 35% more than the strength of reference mix (0% fiber content).
- Compressive strength results obtained by rebound hammer test were in good correlation with destructive compression test i.e. test performed on compression testing machine. Maximum percentage different between rebound hammer and destructive compression strength value are approximately -0.70.
- Ultrasonic pulse velocity (USPV) results were in correlation with the strength results. Value of ultrasonic pulse velocity increased with increase in glass fiber content. USPV values for the concretes lied in the range of 3983-4586 m/s i.e. the range for good to excellent quality of concrete as per IS 13311(Part 1) -1992.

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