Experimental Analysis of Glass Fiber Concrete by Destructive and Non-Destructive Methods

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Abstract - The engineering strength properties of hardened concrete like compressive strength, flexural strength and split tensile strength are often improved by adding admixtures. These correctives will improved by proper grading by weight and correct natural process. The demand for glass fiber is increasing within the Indian market thanks to high construction activities and conjointly because fiber glass offers versatile form and style. It's an inexpensive and cost-efficient material compared to alternative reinforcement materials. A series of compressive strength, flexural strength and split by destructive and non-destructive methods enduringness take a look at square measure conducted with varied percentage of glass fiber.

Key Words: grading, natural, inexpensive, enduringness, destructive, non- destructive

1. INTRODUCTION

1.1 General

Concrete is that the most generally used artificial material. It plays a crucial role within the world of applied science. It is a hardened mass obtained from a combination of cement, sand, gravel & water in definite proportions. These ingredients are mixed along to create a plastic mass which can be molded in any form. This plastic mass hardens on setting and that we get plain cement concrete. This hardening is caused by chemical change between water and cement and it continues for an extended time. Concrete grows stronger with the rise in age.

Fiber concrete, a comparatively new material, may be a concrete created primarily of hydraulic cements, aggregates and distinct reinforcing fibers. Glass fiber concrete is one in all the foremost versatile building materials obtainable to architects and engineers. This concrete consists in the main of cement, sand and alkali resistant glass fibers. GRC is a thin, high strength concrete with several applications in construction. Fiber within the cement based mostly matrix acts as crack constraint that restricts the expansion of flaws in the matrix, preventing these from enlarging below load into cracks that eventually cause failure. Prevention of propagation of cracks originating from internal flaws may end up in improvement in static and dynamic properties of the matrix. A significant

Advantage of victimization fiber concrete besides reducing permeability and increasing fatigue strength is that fibers addition improves the toughness or residual load carrying ability when the primary crack, this concrete is known as fiber concrete.

Present investigation was conducted to review the result of addition of fiber on the compressive strength, split strength and strength properties of the concrete.

2. MATERIAL PROPERTIES & ANALYSIS SETUP

2.1 General

Concrete combine style is that the method of finding the proper proportions of cement, sand, and aggregates for concrete to attain target strength in structures. The concrete combine style involves varied steps, calculations, and laboratory testing to search out the proper combine proportions. This method is sometimes adopted for structures that need higher grades of concrete like M-30 and higher than and large construction comes wherever the amount of concrete consumption is big. Benefits of concrete combine style square measure that it provides the proper proportions of materials, therefore creating the concrete construction economical in achieving the required strength of structural members. Because the amount of concrete needed for large constructions is huge, the economy within the variety of materials like cement makes the project construction economical.

2.2 Material properties:-

1.) Cement: - OPC 53 grade confirming as per IS 8112:1983 cement is employed for the experiment. The various check has been conducted on cement as per IS 4031:1998. Consistency of cement determined at 31%. The fineness of cement determined 91%. Initial setting time and final setting time of cement found 30 and 600 minutes.

2.) Course aggregate: - Crushed stone locally available is used in concrete. Coarse aggregate as per IS 383:2016 were used. The specific gravity of 20 mm size aggregate found 2.872 and Specific gravity of 10mm size were found 2.826. Impact value of aggregate obtained 9.52.

3.) Fine aggregate: - Locally available river sand (Narmada sand) used for mix design. The test is conducted as per IS specification. Fine aggregate found grading zone (ii) confirming as per IS 383:2016. The specific gravity of river sand was found 2.636 (gm/cc) & water absorption 1.254. Fineness modulus of sand is 2.86.

4.) fly Ash (class F):- Fly ash is a group of materials that can vary significantly in composition. It is residue left from burning coal, which is collected on an electrostatic precipitator or in a bag house. It mixes with flue gases that result when powdered coal is used to produce electric power.

5.) Glass fiber (AR):- Glass fiber of 10-12 mm size has been used in this experiment. As all the physical property has been shown in table no.1.1.

Table 1.1 (Physical properties of AR- glass fiber)

Item	Value
Specific gravity	2.68
Elastic modulus (Gpa)	72
Diameter (micron)	14
Length(mm)	10-12
Tensile strength(Mpa)	1700
Strain at failure (in %)	2.4

2.3 Mix design

Step 1 Determining the Target Strength for MixProportioning

F'ck = fck + 1.65 x S

Where,

F'ck = Target average compressive strength at 28 days

Fck = Characteristic compressive strength at 28 days

S = Assumed standard deviation in N/mm2 = 5 (as per table -3.1)

= 30 + 1.65 x 5.0 = 38.25 N/mm2

Note: Under control conditions if Target average compressive strength is achieved then at field, the probability of getting compressive strength of 30 MPa is very high.

Assumed standard deviation of IS 10262- 2009 has been mentioned in the table No. 3.1:-

Step 2 — Selection of Water-Cement Ratio:-

From Table 3.2, Maximum water-cementations (w/cm) ratio = 0.50

Note: Do not start with w/cm ratio above 0.50, even though the other desired results like Strength, workability could be achieved.

Minimum cement content, maximum water-cement Ratio and minimum grade of concrete for different exposures with normal weight aggregates of 20 mm nominal maximum size has been taken reference and made form IS 456 code.

Step 3 — Selection of Water Content

Maximum water content for 20 mm aggregate = 186 Kg (for 25 to 50 slump)

We are targeting a slump of 100mm, we need to increase water content by 3% for every 25mm above 50 mm i.e. increase 6% for 100mm slump

I.e. Estimated water content for 100 Slump = 186+(6/100) X 186 = 197 liter

Water content = 197 liters

Maximum water content per cubic meter of concrete for nominal maximum size of aggregate has been made by the reference of is 10262- 2009 which has been mentioned in table no3.3.

Step 4 – Calculation of Cementations Content

Water-Cement Ratio = 0.50

Water content from Step – 3 i.e. 197 liters

Cement Content = Water content / "w-cm ratio" = (197/0.50) = 394 kgs

From Table 5 of IS 456,

Minimum cement/cementations content for moderate exposure condition = 300 kg/m3

394 kg/m3 > 300 kg/m3, hence, OK.

As per clause 8.2.4.2 of IS: 456

Maximum cement content = 450 kg/m3, hence ok too.

Step 5: Proportion of Volume of Coarse Aggregate and Fine Aggregate Content

From Table 3.4, Volume of coarse aggregate corresponding to 20 mm size and fine aggregate (Zone I) = 0.60

*Volume of coarse aggregate per unit volume of total aggregate for different zones of fine aggregate has been made with the reference of IS 10262-2009.

Note 1: In the present case water-cement ratio is 0.5.So there will be no change in coarse aggregate volume i.e. 0.60.

Note 2: In case the coarse aggregate is not angular one, then volume of coarse aggregate may be required to be increased suitably based on experience.

Step 6: Estimation of Concrete Mix Calculations

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1 m3

As cement is partially replaced by fly ash, initially we will go for 20% replacement.

Earlier in Step 4 we got cement content of 394 kg/cum ,20% of it replaced by fly ash i.e. ~79 kg of fly ash and cement content of 315 kg/cum, keeping cementations content of 394 as arrived in STEP 4.

b) Volume of cement = (Mass of cement / Specific gravity of cement) x (1/1000)

= (315/3.15) x (1/1000) = 0.100 m3

c) Volume of fly ash = (Mass of fly ash / Specific gravity of cement) x (1/1000)

= (79/2.2) x (1/1000) = 0.036 m3

d) Volume of water = (Mass of water / Specific gravity of water) x (1/1000)

= (197/1) x (1/1000) = 0.197 m3

e) Total Volume of Aggregates = 1- (b+c+d) =1- (0.1+0.036+0.197) = 0.667 m3

f) Mass of coarse aggregates = d X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000 = 0.667 X 0.60 X 2.80 X 1000 = 1121 kgs/m3

Here we are taking: - 60 percent of 20 mm coarse aggregates that is = 1121x60%=672.60kgs.

And 40 percent of 10 mm coarse aggregates that is =

1121x40%=448.40kgs.

g) Mass of fine aggregates = d X Volume of Fine Aggregate X Specific Gravity of Coarse Aggregate X 1000 = 0.667 X 0.40 X 2.70 X 1000 = 720 kgs/m3

3 Results

3.1 Compression Test

Compressive strength of concrete without and with glass fibers was tested on 7 days and 28 days. With increase in fiber content an increase in compressive strength was observed. Increase in strength was observed at 0%, .4%, .8% and 1.2% of glass fibers in 7days and 28 days. A comparison graph and table has shown below.

Table 3.1

Sample	Fiber	7 days average	28 days average
1.	0%	18.55	37.77
2.	0.4%	20.78	35.58
3.	0.8%	21.34	36.53
4.	1.2%	22.26	38.12

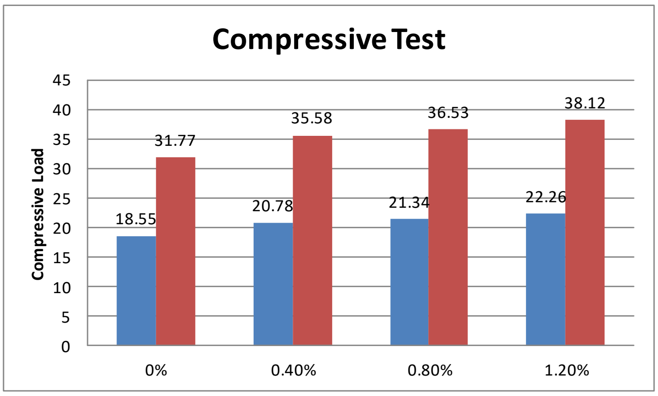

Fig 3.1

3.2 Split Tensile test

Split tensile test of concrete without and with glass fibers was tested on 7 days and 28 days. With increase in fiber content an increase in compressive strength was observed. Increase in strength was observed at .4%, .8% and 1.2% of glass fibers in 7days and 28 days. The split tensile test values of various mixes with different fiber percentages has been shown in graph and table form.

Table 3.2

Sample	Fibre	7 days average	28 days average
1.	0%	1.49	2.54
2.	0.4%	1.65	2.69
3.	0.8%	1.76	2.92
4.	1.2%	1.95	3.38

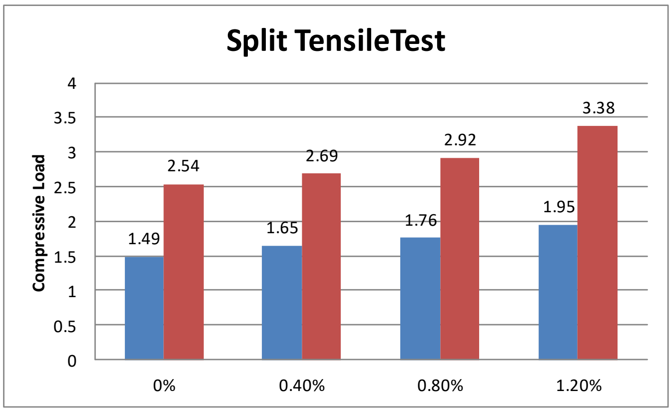

Fig 3.2

3.3 Flexural Strength Test

Flexural strength of concrete without and with glass fibers was tested on 7 days and 28 days. With increase in fiber content an increase in compressive strength was observed. Increase in strength was observed at .4%, .8% and 1.2% of glass fibers in 7days and 28 days. The Flexural tensile test values of various mixes with different fiber percentages has been shown in graph and table form.

Table 3.3

Sample	Fiber	7 days average	28 days average
1.	0%	1.49	2.54
2.	0.4%	1.65	2.69
3.	0.8%	1.76	2.92
4.	1.2%	1.95	3.38

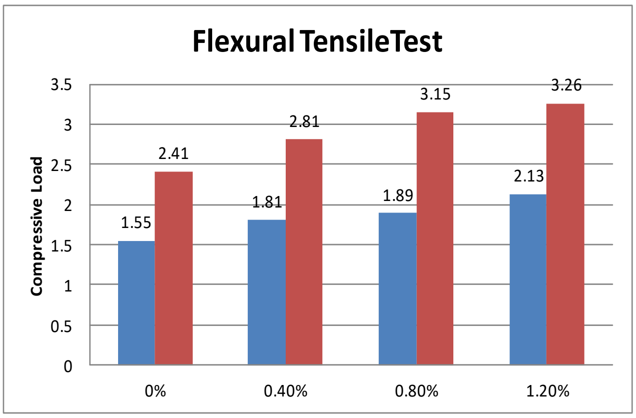

Fig 3.3

3.4 Rebound hammer Test

Rebound hammer without and with glass fibers are tested at the ages of 7 days and 28 days. Compressive strength results obtained by rebound hammer test were in good correlation with destructive compression test i.e. testing performed on compression testing machine..

Table 3.4

Sample	Fiber	7 days average			28 days average		
		Cube	Beam	Cylinder	C	B	Cy
1.	0%	18.70	19.85	21.22	30.32	32.85	33.65
2.	0.4%	23.40	23.85	24.25	33.12	35.72	36.92
3.	0.8%	24.97	26.61	28.22	35.25	38.15	39.25
4.	1.2%	28.93	30.32	32.25	37.15	40.05	42.15

3.5 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 39- 48 m/s i.e. the range for good to excellent quality of concrete as per IS 13311(Part 1) -1992.

Table 3.5

Fiber	28 days average		
	Cube	Beam	Cylinder
0%	39.83	41.83	43.76
0.4%	41.51	42.30	44.83
0.8%	41.96	43.16	45.26
1.2%	42.40	43.76	45.86

4 Conclusions

1. It is observed that the compressive strength of concrete gets increased upto 20% with Glass fiber at the age of 28 days as compared to plain concrete.
2. It is observed that the Flexural strength of concrete gets increased up to 28.45% as compared at the age of 28 days to plain concrete.
3. It is also observed that the split Tensile strength of concrete gets increased increases up to 35.25% with Glass fiber at the age of 28 days as compared to plain concrete.
4. From above discussion, it is observed that addition of glass fiber to concrete increases compressive strength, flexural strength and split tensile strength test result of glass fiber reinforced concrete at the age of 28 days.
5. Workability of concrete after adding the glass fiber is not much affected initially, but the workability decreases rapidly in those concrete mix which having more percentage of glass fiber.
6. It concludes that on adding glass fiber in concrete within limit it will increase its compressive strength.
7. Glass fiber increases the tensile strength by controlling the occurrence of micro cracks into macro cracks. The use of glass fiber imparts strength to concrete and durability.

5 References

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