Experimental Analysis of Fiber Reinforced Concrete Made Up of M20 Concrete

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Abstract— The project deals with the topic "Fiber Reinforced concrete" using Steel. The inclusion of fiber reinforced in concrete, mortar and cement paste can enhancement of engineering properties of the basic materials such as fracture, toughness, flexure strength and resistance to fatigue, impact, thermal shock or swelling. Fiber reinforced concrete is ordinary concrete containing discontinuous, discrete fibers of short length and small diameter fiber in concrete serve as crack arrestor by applying pinching forces at crack tips, thus delaying the appearances of crakes and creating a stage of slow crack propagation. The ductility of the composite is increased many fold, compared to the un-reinforced matrix, with a corresponding increase in strength. Fiber reinforced is likely to be used in preference to conventional reinforced or pre-stressed concrete, if these properties can be exploited in conjunction with advantages in construction or fabrication techniques example. The inclusion of reinforcement as an integral part of the fresh concrete or the manufacture of thin sheet products. In this project, steel fiber is used in different percentages.

Keywords: Fiber Reinforced Concrete, M20 Concrete

I. Introduction

Concrete is a composite material containing hydraulic cement, water, coarse aggregate and fine aggregate. The resulting material is a stone like structure which is formed by the chemical reaction of the cement and water. This stone like material is a brittle material which is strong in compression but very weak in tension. This weakness in the concrete makes it to crack under small loads, at the tensile end. These cracks gradually propagate to the compression end of the member and finally, the member breaks. The formation of cracks in the concrete may also occur due to the drying shrinkage. These cracks are basically micro cracks. These cracks increase in size and magnitude as the time elapses and the finally makes the concrete to fail. The formation of cracks is the main reason for the failure of the concrete. To increase the tensile strength of concrete many attempts have been made. One of the successful and most commonly used method is providing steel reinforcement. Steel bars, however, reinforce concrete against local tension only. Cracks in reinforced concrete members extend freely until encountering are bar. Thus need for multidirectional and closely spaced steel reinforcement arises. That cannot be practically possible. Fiber reinforcement gives the solution for this problem So to increase the tensile strength of concrete a technique of introduction of fibers in concrete is being used. These fibers act as crack arrestors and prevent the propagation of the cracks. These fibers are uniformly distributed and randomly arranged. This concrete is named as fiber reinforced concrete. The main reasons for adding fibers to concrete matrix is to improve the post-cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material. The initial researches combined with the large volume of follow up research have led to the development of a wide variety of material formulations that fit the definition of Fiber Reinforced Concrete.

II. Fibre reinforced concrete:

Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. So we can define fiber reinforced concrete as a composite material of cement concrete or mortar and discontinuous discrete and uniformly dispersed fiber. Fabre is discrete material having some characteristic properties. The fiber material can be anything. But not all will be effective and economical. Some fibers that are most commonly used are:

1) Steel Fibers-Steel fiber is one of the most commonly used fiber. Generally round fibers are used. The diameter may vary from 0.25 to 0.75mm.The steel fiber sometimes gets rusted and lose its strength. But investigations have proved that fibers get rusted only at surfaces. It has high modulus of elasticity. Use of steel fibers makes significant improvements in flexure, impact and fatigue strength of concrete. It has been used in various types of structures.
2) Glass Fibers-Glass fiber is a recently introduced fiber in making fiber concrete. It has very high tensile strength of 1020 to 4080Mpa. Glass fiber concretes are mainly used in exterior building façade panels and as architectural precast concrete. This material is very good in making shapes on the front of any building and it is less dense than steel.
3) Carbon Fibers -Use of carbon fiber is not a developed process. But it has considerable strength and young's modulus. Also investigations have shown that use of carbon makes the concrete very durable. The study on the carbon fibers is limited. Mainly used for cladding purpose.
4) Natural Fibers -Natural fibers are low cost and abundant. They are nonhazardous and renewable. Some of the natural fibers are bamboo, jute, coconut husk, elephant grass. They can be used in place of asbestos. It increases toughness and flexural strength. It also induces good durability in concrete.
5) Disposal of non-biodegradable materials is a serious problem. It creates environmental problems. Reusing is the best option to reduce the waste. These NBD materials are non-corrosive, resistant to chemical attack, light in weight, easy to handle. NBD materials – fiber

plastic, jute plastic, polythene, disposal glass, cement bags.

6) Studies conducted so far, proved that the short and discrete, small fibers can improve the flexural load carrying capacities and impact resistance for nonferrous fibers.

A. PROPERTIES OF FRC

Properties of concrete is affected by many factors like properties of cement, fine aggregate, coarse aggregate. Other than this, the fiber reinforced concrete is affected by following factors:

1) Type of fiber
2) Aspect ratio
3) Quantity of fiber
4) Orientation of fiber

1) Type of fiber:

A good fiber is the one which possess the following qualities:-

- Good adhesion within the matrix.
- Adaptable elasticity modulus (sometimes higher than that of the matrix)
- Compatibility with the binder, which should not be attacked or destroyed in the long term
- An accessible price, taking into account the proportion within the mix
- Being sufficiently short, fine and flexible to permit mixing, transporting and placing
- Being sufficiently strong, yet adequately robust to withstand the mixing process.

2) Aspect ratio:-

Aspect ratio is defined as the ratio of length to width of the fiber. The value of aspect ratio varies from 30 to 150. Generally the increase in aspect ratio increases the strength and toughness till the aspect ratio of 100. Above that the strength of concrete decreases, in view of decreased workability and reduced compaction. From investigations it can be found out that good results are obtained at an aspect ratio around 80 for steel fibers. Keeping that in view we have considered steel hooked end fibers with aspect ratio of 80 (Length 60 mm and D diameter 0.75 mm).

3) Fiber quantity:

Generally quantity of fibers is measured as percentage of cement content. As the volume of fibers increase, there should be increase in strength and toughness of concrete. Regarding our fiber, we hope that there will be an increase in strength, with increase in fiber content. We are going to test for percentages of 1.0, 2.0 and 3.0.

4) Orientation of fiber:

The orientations of fibers play a key role in determining the capacity of concrete. In RCC the reinforcements are placed in desired direction. But in FRC, the fibers will be oriented in random direction. The FRC will have

III. THE MIX PROPORTION

Water	Cement	Fine Aggregate	Coarse Aggregate
191.58	383.16 kg	567.09 kg	1278.88 kg
0.50	1	1.48	3.34

Proportioning the concrete mix for the type of job in hand is an essential part of any quality assurance plan. This can be done effectively with proper understanding of properties of constituent materials of concrete. Increase in water demand has to be compensated by increasing cement content to maintain the same water-cement ratio. Their particle size distribution helps in higher packing density, which enhances the durability of concrete. Proportioned mixes shall be in line with IS 456 recommendations. Final mix shall be arrived at only through trials in the laboratory followed by full-scale trials at site.

A. Mix Design for M20 Grade Concrete

IS method:-

1) Design Data:-

Characteristic compressive strength = 20 N/mm^2
Maximum size of aggregate = 20mm
Degree of workability = 0.90 C. F.
Degree of control = Good
Type of exposure = Mild

2) Test data for materials:-

Specific gravity of cement =3.15
Specific gravity of coarse aggregate = 3.08
Target strength:-
Fck = Fck + 1.65 S
S = 4.0 N/mm^2
Fck = 20+ 1.65 x 4.0
= 26.60 N/mm^2

3) Selection of water-cement ratio:-

Water-cement ratio = 0.45
This is lower than the maximum value of 0.65 prescribed for mild exposure.

4) Selection of sand and water conten:-

For 20mm maximum size of aggregate and sand confirming to grade zone II water content per cubic meter of concrete =186kg. And sand content as % of total aggregate by absolute volume= 35%.

For change in value of w/c ratio, compacting factor, sand belonging to zone II the following adjustment is required.

Absolute volume of sand = 35-3.5= 31.5 %
Required water content = 186+5.58 = 191.6 /m^3

a) Determination of Cement content:
W/C ratio = 0.45
Water = 191.60 liters
Cement = 191.60/0.45
= 452.78kg/m^3

5) Determination of coarse aggregate contents:-

Maximum size of aggregate = 20mm
Amount of entrapped air in the wet concrete is 2%
V = [W+(C/Sc) + (Fa/P.SFa)]*[1/1000]
Fa = 625.28 kg
Ca= 1359.73kg/cu.m

B. Mix proportion:-

Water	Cement	Coarse Aggregate	Fine Aggregate
191.6	452.78 kg	1359.73 kg	625.28
0.45	1	3.00	1.38

1) Mix proportion and test results for trial mix.

Is present work, following mix proportion and taken as trial mix for M25 concrete and their test results is are tabulated table 4.5.

Mix design 1:1.38:3.00 w/c = 0.45

Sr. no.	7 days comp. strength	Avg.	28 days comp. strength N/mm^2	Avg. N/mm^2
1 2 3	25.59 26.60 26.32	26.33 N/mm^2	34.55 37.82 34.55	35.64

Table 1: Compressive strength for (1:1.38:3.00) proportion

Trial mix

Since mix gives comp. strength greater than the required strength mix proportion 1:1.38:3.00 was used in the present work for achieving required compressive strength on safe side.

Proportion and test results for trial mix

In present work, following mix proportion had taken as trial mix for M25 grade concrete and their test results are tabulated in table below.

Design = 1:1.28:3.12 w/c ratio = 0.42

2) Casting Process

a) Casting of Cubes:-

Steel fibers were used. Proportion of fiber content was varied in 0.1%, 2.0%, and 3.0% on volume basis.

Six cubes were casted for each % of fiber. Therefore total 54 of 150mm x 150mm x 150mm cubes were casted for fiber. Table vibrator was used for the purpose of vibration and compaction. 7 days and 28 days curing process was done and then the cubes were tasted.

b) Casting of Beams for Flexural Strength:-

Simultaneously with cube, beam of size 100mm x 100mm x 450mm was casted. For each % of fibre, 12 beams were casted for 28 days flexural strength result. Table vibrator was used for vibration purpose.

c) Casting of Cylinder for Compressive Strength:-

Simultaneously, 12 cylinders were casted of size 150mm dia and 300 mm height for each % of steel fibre for 7 days and 28 days comp. strength.

Sr.no.	Beam size (BxDxL)mm	Fiber volume	Remark
1.	100x100x450	1,2,3 %	

Table 2: details of beam

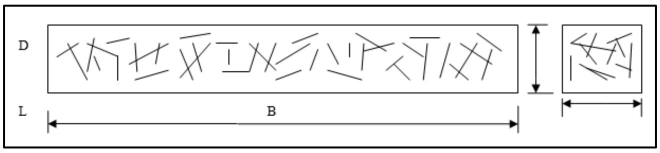

Fig. 1: Details of Beam for Fiber Reinforced Concrete

- Testing process :-
- Testing of cubes :-
  All the cubes were tested under compressive strength testing machine of 200 ton capacity under gradually applied load.
- Testing of beam :-
- flexural strength :-
  All beams were tested by two symmetrically loaded concentrated loads in universal testing machine of 100 ton capacity. The load was applied at uniform rate was measured at an increment of 50 kg

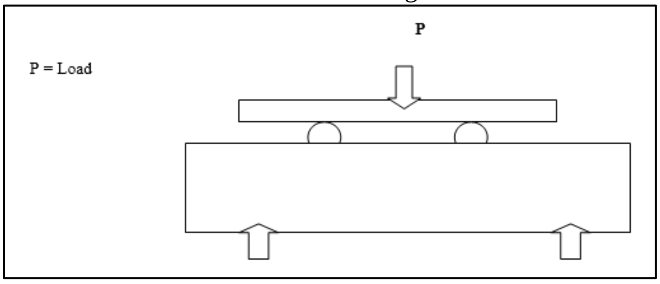

Fig. 2: Beam Test Set Up for Flexural Strength

IV. RESULTS AND DISCUSSION

The results were observed in three categories as compressive strength and flexural strength. Which are some properties of conventional concrete. Tables and charts shows the results

A. Compressive Strength of Plain Concrete

For M20 Trial mix

Sr. no.	7 days comp. strength	Avg.	28 days comp. strength N/mm^2	Avg. N/mm^2
1 2 3	15.75 16.30 16.9O	16.32 N/mm^2	21.55 21.80 22.05	21.82

Table 3

B. Compressive strength results of FRC cube: -

For M20 Concrete:-

Sr. no.	% of fibre	7 days comp. strength		28 days comp. strength	
		Comp. Strength N/mm2	Avg. comp. Strength N/mm2	Comp. Strength N/mm2	Avg. comp. Strength N/mm2
1	1 %	16.20 17.05 17.95	17.06	22.55 22.85 23.15	22.85
2	2 %	16.90 17.45 17.90	17.42	23.10 22.90 23.35	23.12
3	3 %	17.50 18.05 18.55	18.03	24.15 23.85 24.90	24.30

Table 4

C. Compressive strength of FRC cube in 28 days

For M20 grade concrete:-

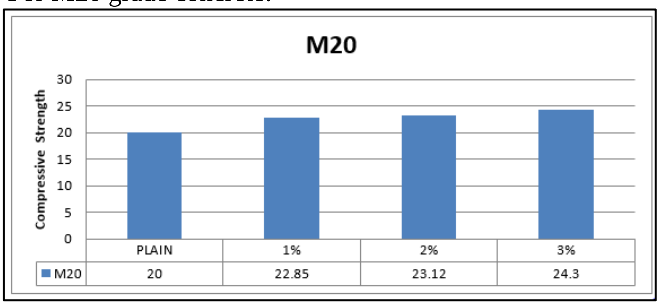

Chart 1

D. Compressive Strength Results of FRC Cylinder

For M20 Concrete

Sr no.	% of fiber	7 days comp. strength		28 days comp. strength	
		Comp. Strength N/mm2	Avg. comp. Strength N/mm2	Comp. Strength N/mm2	Avg. comp. Strength N/mm2
1	1 %	17.20 18.05 18.95	18.06	23.55 23.85 24.15	23.85
2	2 %	17.90 18.45 18.90	18.42	24.10 23.90 24.35	24.12
3	3 %	18.50 19.05 19.55	19.03	25.15 24.85 25.90	25.3

Table 5

E. Compressive strength of FRC cylinder in 28 days

For M20 grade concrete:-

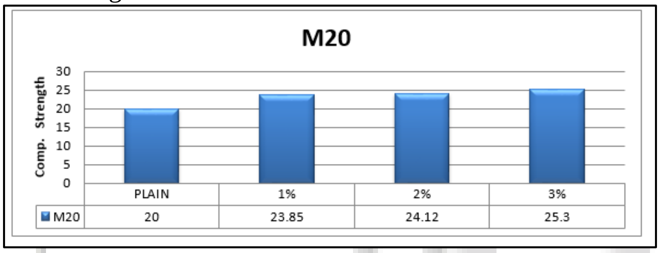

Chart 2

F. Flexural Strength Comparison Chart:-

Flexural Strength result for plain concrete

Sr. no.	Grade of concrete	Comp. Strength for 28 days N/mm2
1	M20	3.13

Table 6

G. Flexural Strength of FRC Beam In 28 Days

For M20 concrete:-

sr. no.	% of fiber	Load in kg	Load in N	PL/bd2	Avg.
1	1%	1060 1120 1190	10398.6 10987.2 11673.9	3.74 3.96 4.20	3.96
2	2 %	1190 1210 1250	11673.9 11870.1 12262.5	4.20 4.27 4.41	4.29
3	3 %	1270 1290 1320	12458.7 12654.9 12949.2	4.48 4.56 4.66	4.56

Table 7

H. Flexural strength of FRC cylinder in 28 days

For M20 grade concrete:

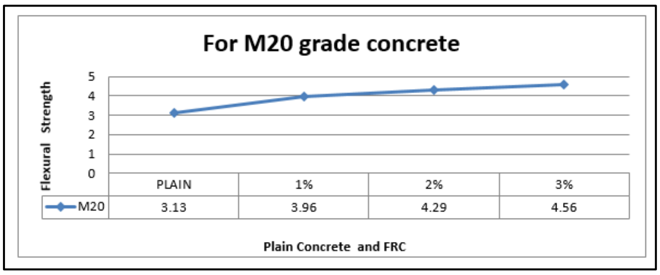

Chart 3

V. CONCLUSION

1) Compressive strength:-

Major effect of fiber inclusion is concerned with crack development. With the low fiber concentration that are normally used in cement concrete (from 1 to 3% by volume), the strain at which the matrix cracks is very little different from that observed in plain cements or in concretes. However, once cracking has started, the fibers act as crack stoppers and also absorb a significant amount of energy.

2) Steel fiber:-

In steel fiber it was observed that there was slight difference in 7 days comp. Strength of various steel percentage when compared with plain concrete.

For 28 days comp. strength than 3%, it has shown increment.

It was observed that in all cubes, surface steel fibers were corroded, however the inner fibers were free from corrosion.

3) Flexural strength:-

Fiber reinforcement of concrete upto the full depth or the tension zone will slightly increase the strength and significantly improve the ductility of the concrete under bending stresses.

4) Steel:-

Flexural strength for steel fiber was observed to increase with the percentage of steel. The increase for 3% steel fiber was 38.45% as compared to plain concrete.

It was found to be less as compared to the flexural strength of crimped end fibers. It was found that for crimped end fibers with 1.5% fiber content the flexural strength was 1.4 times of that of plain concrete and at 3% fiber content by volume, the strength was found to be 3 times of that of plain concrete.

REFERENCES

[1] ACI committee 544, "state of the Art Report on Fiber Reinforced concrete ", ACI Journal, Nov 1973, pg. 730-741.
[2] Ashour S.A, Hasanain G.S. and Wafa F.F., "Shear behavior of Fiber Reinforced concrete beams", ACI Structural journal, vol- 89, no-2, Mar-Apr 1992, pg. 176-184.
[3] ACI journal, "Measurement of properties of FRC July 1978, pg. No.-283-281.
[4] A.K. Sharma, "shear strength of steel fiber reinforced concrete beams", ACI journal; July-Aug 1986, pg.624-628.

[5] Ambuja technical literature series “fiber reinforced concrete”.
[6] B.P. Hughes and N.I Fattahi, “Flexural testing of fiber-reinforced cement part beams”. Concrete journal, June 1976. Pg.21-24.
[7] Baggott R.S and A.E.S Abdul-Monem, “influence of fiber parameters on compressive deformation of steel fiber reinforced cements”, proceedings of RILEM - 17.1992.
[8] G.Shimizu and P. Jorillo Jr, “CocosNucifera fiber reinforced cement based composite part 1 and part 2.
[9] H. Savastano Jr. and V. Agopyan, “Transition zone of hardened cement paste and vegetable fiber”, proceedings of Rilem-17, 1992.

