Comparative Study of Deflection of Fiber Reinforced and Non-Fiber Reinforced Concrete Beams

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Abstract - *Cement mortar and concrete are the most widely used construction materials. It is difficult to point out another material of construction which is as versatile as concrete. It is the material of choice where strength, durability, impermeability, fire resistance and abrasion resistance are required. Many of the complex behaviors of cement concrete are yet to be identified and employed advantageously and economically. The behavior of concrete with respect to shrinkage, creep, fatigue, bond, fracture mechanism and polymer modified concrete, fibrous concrete are some of the areas of active research.*

The main aim of this study is to compare the deflection between non-fiber reinforced beam and fiber reinforced beams (Steel FRC, Glass FRC and Combination of both (HFRC)).
In the present work, comparative studies on compressive strength and homogeneity are carried out. The results shows that Steel Fiber Reinforced Beam have better Deflection and Compressive Strength values.

Key Words: Fiber reinforced concrete, Glass fiber, Steel fiber, Hybrid fiber, Deflection, Compressive strength, Ultrasonic Pulse Velocity.

1. INTRODUCTION

Concrete is an environmental – friendly material and used as construction material due to its many advantages such as high compressive strength, availability of ingredients at a reasonable cost, give aesthetic appearance and resistance to fire and weathering. Plain concrete possess a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in concrete and its poor tensile strength is due to propagation of such micro cracks, eventually leading to brittle fracture of the concrete. As Concrete is exposed to different environmental conditions, to withstand the environmental effects the properties of conventional concrete had to be increased. This may be achieved by introducing admixtures or fiber to concrete.

1.1 Fiber Reinforced Concrete

Fiber reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed fibers. Adding Fibers to concrete greatly increases the toughness of the material. The use of fibers also alters the behavior of the fiber matric composite after it has cracked, thereby improving its toughness.

It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. Fiber is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fiber is often described by a convenient parameter called aspect ratio. Aspect ratio of fiber is the ratio of its length to its diameter. Fibers help to improve the post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eliminate temperature and shrinkage cracks.

1.2 Glass Fibers

Glass fiber is a material made from extremely fine fibers of glass. Fiber Glass is a light weight, extremely strong and a robust material. The material is far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favourable when compared to metals. Glass fibers can be easily formed using moulding processes. The stiffness of Glass Fiber is lower than that of other reinforcement fibers, but it possesses the distinct advantage of combining a very high strength with very low density.

By the addition of Glass Fibers we can observe a reduction in bleeding of concrete mixes. Glass Fibers are characteristic for their high strength, good temperature and corrosion resistant. Glass Fibers also give anti-rust properties to the concrete.

1.3 Steel Fibers

Steel Fiber is one of the most commonly used fiber. The steel fiber is likely to get rusted and loose some of its strength. But investigations have shown that rusting of fibers take place only at the surface. Use of steel fiber makes significant improvements in flexural, impact and fatigue strength of the concrete. It has been extensively used in various types of structures, particularly overlays of roads, airfield pavements and bridge decks. Thin shells and plates have also been constructed using steel fibers. Different types of Steel Fibers are used in concrete but the recently introduced steel fiber by name Dramix glued steel fiber have proved to be very effective type of steel fibers. The beneficial influence of steel fibers in concrete depends on many factors such as type, shape, length, cross-section, strength, fiber content, bond strength, matrix strength, mix design and mixing of concrete.

1.3 Hybrid Fibers

HFRC is achieved when two or more types of fibers are used in the same concrete mixture, this gives maximum strength to the concrete. HFRC helps exploiting benefits of each of the fibers being used. The hybrid fiber system enchance the performance of the composite both in fresh and harden concrete. There are different combinations of fibers like polypropylene and nylon fibers, glass and steel fibers, steel and polypropylene fibers, etc.. The addition of more fibers into the concrete mixtures make it more homogenous and isotropic in nature. The polypropylene and nylon fibers are found to be suitable to increase the impact strength. It is observed that the use of a combination of both metallic and non-metallic type of fibers help in improving concrete properties.

2. MATERIALS AND METHODOLOGY

2.1 Materials

The materials selected for this experimental study includes normal natural coarse aggregates, manufactured sand as fine aggregate, cement, fibers (Dramix glued steel fibers and chopped strand glass fiber) and portable drinking water. The physical and chemical properties of each ingredient as considerable role in the desirable properties of concrete like strength, workability, etc.

Cement: Ordinary portland cement, 43 Grade, Zuari cement by brand name conforming to IS 8112:2013 is used for investigation throughout.

S.NO	Particulars	Experimental Values	Suggested Values as per IS 8112:2013
1.	Specific Gravity	3.14	3.10 – 3.15
2.	Normal Consistency	29 %	30 – 35%
3.	Setting Time a) Initial b) Final	 160 minutes 310 minutes	 >30 minutes <600 minutes

Table -1: Physical properties of cement

Fine Aggregates: Manufactured sand has been used for the present investigation. M-Sand is crushed aggregates produced from hard granite stone which is cubically shaped with grounded edges, washed and graded with consistency to be used as a substitute of river sand. It should be passed through IS sieve 4.75 mm. It should have fineness modulus 2.5 – 3.5 and silt contents should not be more than 4%.

S.NO	Particulars	Experimental Value
1.	Specific Gravity	2.1
2.	Moisture Content	7.066 %

Table -2: Physical properties of fine aggregates

Coarse Aggregates: It should be hard, strong, dense, durable and clean. It must be free from alkalis, vegetable matters and other deleterious substances. It should be roughly cubical in shape. Flaky pieces should be avoided. It should confirm to IS 2838(I). Coarse Aggregate used are of two sizes 20 mm maximum size and 12.5 mm minimum size.

S.NO	Particulars	Experimental Value
1.	Specific Gravity	2.778
2.	Water absorption	0.25 %

Table -3: Physical properties of coarse aggregates

Water: Water should be free from acids, oils, alkalis, vegetables or other organic impurities. The PH value of water should be between 6 and 8.

Steel Fibers:

Type	Dramix glued
Length, L (mm)	35
Diameter, d (mm)	0.55
Aspect ratio (l/d)	65

Table -4: Properties of steel fibers

Glass Fibers:

Type	Chopped strand
Length, L (mm)	12
Diameter, d (mm)	0.022
Aspect ratio (l/d)	545

Table -5: Properties of glass fibers

Percentage of fibers in mix: The proportion of fiber used in concrete mix is at percentage 1% and for this proportion equal quantity (50% of each) of fibers are added in the mix.

Mix Designation of Concrete	Percentage of Fiber added in overall concrete mix (%)	Steel Fibers by Volume of Concrete (%)	Glass Fibers by Volume of Concrete (%)
RCC Beam	0	0	0
SFRC Beam	1	1	0
GFRC Beam	1	0	1
HFRC Beam	1	0.5	0.5

Table -6: Percentage variation of fibers in mix.

2.2 Methodology

Reinforcement Details: Eight Reinforced Concrete Beams were cast and tested under point load. All specimens were designed according to IS 456:2000. Out of eight beams, two were Reinforced beams, two were Glass Fiber Reinforced beams, two were Steel Fiber Reinforced beams and two were Hybrid beams. Dimensions of the beam are shown in Figure-1.

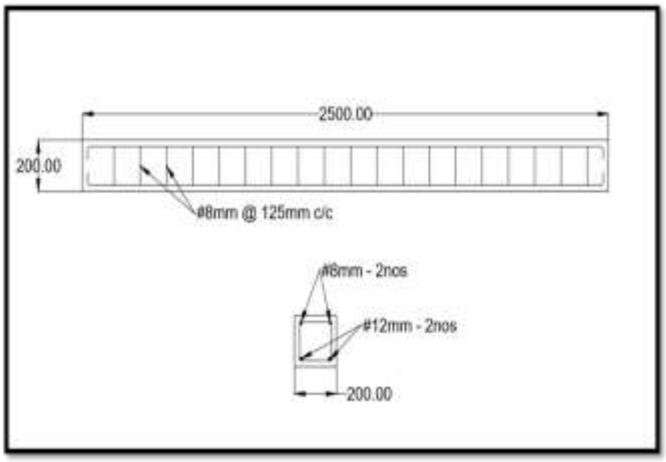

Figure 1. Reinforcement Details

Mix Design: The mixture proportioning was done according to IS 10262:2009 and with conforming to IS 456:2000. The target strength for mix proportioning for M25 Grade concrete was 30.77 N/mm^2.

Materials	Quantity		Ratio
Cement	72 kg		1
Fine Aggregate	72 kg		1
Coarse Aggregate		Total	
a) 20 mm b) 12 mm	86.4 kg 57.6 kg	144kg	2
Water	36 kg		0.5

Table -7: M25 concrete mix proportion

3. RESULTS AND DISCUSSIONS

The cube and cylindrical members which were casted using different combinations of steel and glass fibers were tested. The cubes were tested for compressive strength in the compression testing machine of capacity 2000 kN. The cylindrical members were tested for quality and homogeneity of concrete using ultrasonic pulse velocity test and the eight beams were tested for deflection using specially prepared loading frame.

3.1 Compressive Strength Test

Figure 2. Concrete Member in Compression Testing Machine

Sample	Load (kN)	Compressive Strength (MPa)
RCC - 1	661.3	29.39
RCC – 2	680.75	30.26
SFRC - 1	951.7	42.30
SFRC - 2	983.5	43.71
GFRC - 1	868.2	38.59

GFRC - 2	766.9	34.08
HFRC – 1	911.85	40.53
HFRC - 2	876.05	38.94

Table -8: Compressive Strength Test Results

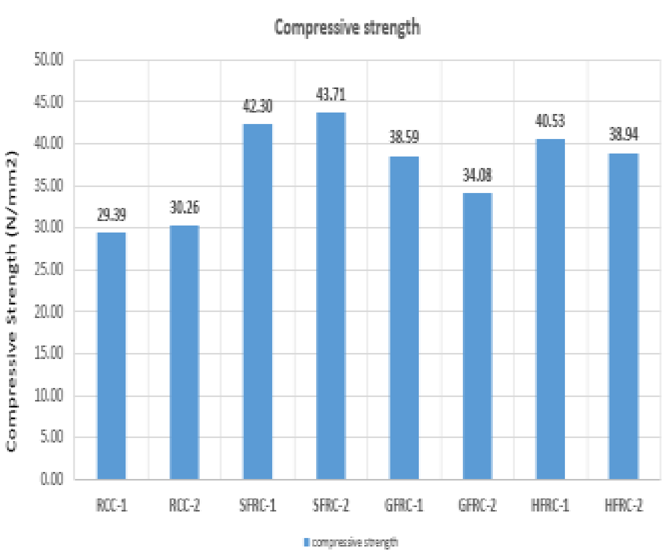

Figure 3. Graph of Compressive Strength Test

To study the 28 days Compressive Strength of concrete mixes, two concrete cubes for each fiber type were cast and tested in a Compression Testing Machine. The cube specimens of size 150x150x150 mm were casted and cured for 28 days. From Figure-3 we can observe that, fiber reinforced concrete members have comparatively higher compressive strength than that of non-fiber reinforced concrete members. We can also observe that in fiber reinforced concrete members, Steel Fiber Reinforced Concrete has highest Compressive Strength.

3.2 Ultrasonic Pulse Velocity Test

Figure 4. Ultrasonic Pulse Velocity Test for Cylindrical members

Sample	Time (μs)	Velocity (m/s)	Quality of Concrete
RCC	68.10	4416.33	Good
SFRC	67.93	4418.00	Good
GFRC	69.86	4295.00	Good
HFRC	65.30	4594.00	Excellent

Table -9: Ultrasonic Pulse Velocity Test Results

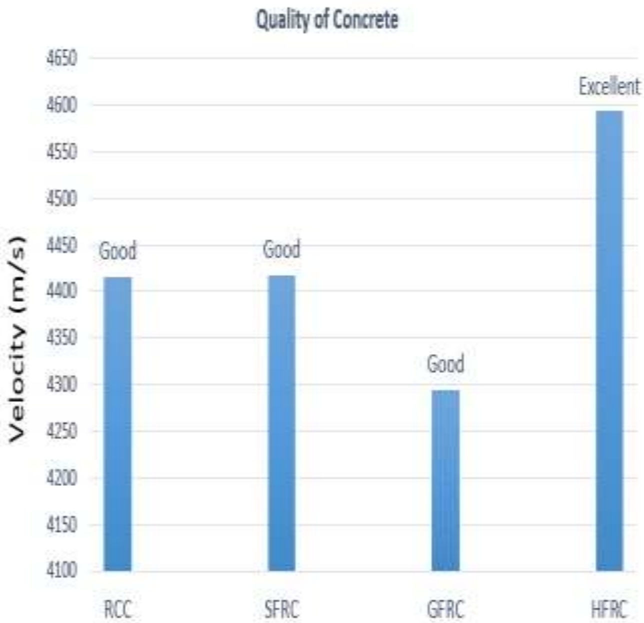

Figure 5. Graph of Ultrasonic Pulse Velocity Test

An Ultrasonic Pulse Velocity Test is a non-destructive test to check the quality of concrete. The cylindrical members (150 mm diameter and 300 mm depth) were cast and cured for 28 days.

This test is conducted by passing a pulse of ultrasonic through cylindrical moulds and measuring the time taken by pulse to get through the structure. Higher Velocities indicate good quality and continuity of the material, while slower velocities indicate concrete with many cracks or voids. From Figure-5 we can observe that the quality of concrete for fiber reinforced and non-fiber reinforced members are good, while for Hybrid Fiber reinforced members (HFRC) the quality of concrete is excellent.

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3.3 Deflection Test

Figure 6. Beam on Loading Frame

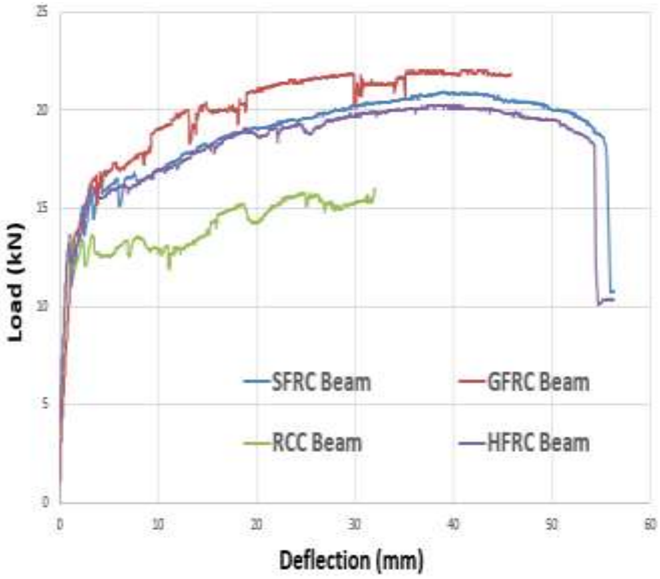

Figure 7. Graph of Deflection of Beams

Flexural Testing of the simply supported beam was carried out under the specially prepared loading frame. Loading setup was constructed in the existing reaction bed at laboratory to test the beam by applying point load at the center of the beam in the transverse direction. All beams are tested as Simply Supported beams in 200 tons capacity steel testing frame made up of rolled steel joists, the beam having a span of 2500 mm and 200 mm width and depth. The load was applied in increments of 1 kN/s until fracture load was obtained.

From Figure-7 we can observe that fiber reinforced concrete beams give better performance when compared to non-fiber reinforced beam. The maximum peak load was taken by Glass fiber Reinforced Concrete Beam (GFRC), maximum deflection was taken by Steel Fiber Reinforced Concrete Beam (SFRC). Hybrid Fiber Reinforced Concrete Beam (HFRC) and Steel Fiber reinforced Concrete Beam (SFRC) sustained for longer duration before fracture.

4. CONCLUSIONS

From the study conducted on strengthening of concrete beam using fibers, the following conclusions were drawn:

- The Fiber Reinforced Concrete (FRC) of all types have shown improvement in terms of ultimate load and deflection.
- From the study it is shown that, by the addition of fibers the compressive strength of concrete increases.
- The crack formation is very small in fiber reinforced member compared to non-fiber reinforced member.
- The quality of concrete for fiber reinforced and non-fiber reinforced members were good, while for Hybrid Fiber reinforced members (HFRC) the quality of concrete was excellent.

REFERENCES

[1] K. Mogileswar and B. Veni, "Experimental Investigation on Hybrid Fibers Reinforced Concrete (M25) and its Effects on properties of Strength and Durability", International Research Journal of Engineering and Technology (ITJET), volume 05, Issue 06, June-2017.

[2] E. Arunakanthi and J. D. Chaitanya Kumar, "Experimental Studies on Fiber Reinforced Concrete (FRC)", International Journal of Civil Engineering and Technology (IJCIET), volume 07, Issue 05, September-October 2016.

[3] J. D. Chaitanya Kumar, G. V. S. Abhilash, P. Khasim Khan, G. Manikanta Sai and V. Taraka Ram, "Experimental Studies on Glass Fiber Concrete", American Journal of Engineering research (AJER), volume 05, Issue 05, 2016.

[4] C. Selin Ravikumar and T. S. Thandavamoorthy, "Glass fiber Concrete: Invertigation on Strength and Fire resistant Properties", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), volume 09, Issue 03, September-October 2013.

[5] V. Gokulnath, Dr. B. Ramesh and V. Rajesh, "Influence of M-sand on the Compressive Strength of M30 Grade Steel Fiber Reinforced Safe Compacting Concrete', International Journal of Pure and Applied Mathematics, volume 119, No. 17, 2018.

[6] IS 8112:2013, Specification for 43 grade Ordinary Portland Cement.

[7] IS 456:2000, Plain and Reinforced Concrete-Code of Practice.

[8] IS 10262:2009, Guidelines for Concrete Mix Design Proportioning.

[9] IS 13311-Part 1-1992, Methods of Non-Destructive Concrete, Part 1-Ultrasonic Pulse Velocity.

[10] IS 516:1959, Method of Tests for Strength of Concrete.

[11] M. S. Shetty, "Concrete Technology" (Text Book).

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