Experimental Investigation on Flexural Behaviour of Polypropylene Fiber Reinforced Concrete

K. Manikandan[1], S. Arulkesavan[2]
[1, 2] Department of Civil Engineering
[1, 2] The kavery Engineering College, Mecheri.

Abstract- *This thesis presents a series of tests for characterizing the structural behavior of fiber reinforced concrete beams subjected to Flexural loading. The experimental program involves a polypropylene fiber. As a reference, plain concrete and conventionally reinforced concrete specimens have also been casted and tested in the laboratory as per Indian standards. The ultimate shear carrying capacities of the beams are calculated. The study confirms that the shear crack resistance of the material is greatly enhanced by the fibers. Fibers reduced the crack width to approximately a fifth of that in beams with stirrups. The use of steel fibers raises the ductility and fracture energy of concrete. Addition of steel fibers to concrete improves its post cracking behavior in tension. The shear resistance increased with increasing aspect ratio of fibers and volume fraction of fibers.*

Keywords- Crack Resistance, Strength characteristics, Compressive Strength, Tensile Strength, Flexure Strength

I. INTRODUCTION

The purpose of this work is to present the results of a study carried out to characterize the structural behavior of FRC beams under shear loading, considering fibers of different materials (steel and polymeric). Further, the study aims to evaluate the ability of predicting the ultimate shear capacity through code provisions or by correlations with results from other tests. At the same time, it is verified whether the design methods can be extrapolated to polypropylene fiber reinforced concrete (PFRC).

According to experimental results, the shear strength of simply supported beams is significantly affected by the compressive strength of concrete, the ratio of tensile reinforcement, the shear span to depth ratio (a/d), and size of beam.

The shear strength of concrete beams mainly depends on the following variables:

- Depth of members or size effect.
- Shear span to effective depth a/d or moment to shear ratio
- Longitudinal Reinforcement or dowel action,
- Axial Force,
- The tensile strength of concrete

Crushing strength of beam web,

- Yielding of stirrups,
- The aggregates sizes leading to aggregate interlocking
- Failure of Tension chord
- Failure of Stirrups anchorage
- Serviceability failure due to excessive crack width at service load.

II. METHODOLOGY AND EXPERIMENTAL INVESTIGATIONS

The main objective of this paper is as below:

1) To study the physical properties of material required for concrete (Polypropylene fiber, fine Aggregate, Coarse Aggregate, Cement,)
2) To find out the Concrete mix design as per IS 10262 : 2009
3) To investigate the Strength parameter such as compressive Strength, flexural strength, indirect tensile strength and bond Capacity of Conventional Concrete at 7,14 and 28-days.
4) To compare the result of PFRC Concrete with Conventional Concrete.

III. MATERIAL PROPERTIES

A. Cement

Cement is the most important ingredient in concrete. One of the important criteria for the selection of cement is its ability to produce improved microstructure in concrete. The most commonly used cement is called normal Portland cement. Concrete made with this cement is tested for standard strength after a curing period of 28 days. Normal Portland cement can be used to produce fiber-reinforced concrete. The properties of cement like Consistency, initial setting time, final setting time and specific gravity were studied and the obtained results were as shown in Table 1.

Test	Result obtained	As per IS 4031-1998
Consistency	33	--
Initial setting time	90 minutes	Not less than 30 min.
Final setting time	5 hours	Not more than 600 min.
Specific gravity	3.15	--

B. Fine Aggregates

The material smaller than 4.75mm size is called fine aggregate. Natural sands are generally used as fine aggregate. The particle size distribution of fine aggregate was determined from sieve analysis and the experimental results carried out to find other properties of fine aggregate are given. IS sieve ranging from 4.75mm to 150 micron were used to conduct the sieve analysis and fineness modulus was found out. From the sieve analysis results, it is found that the fine aggregate confirms to Zone II and is designated as fine sand. All tests are carried out as per IS: 383-1970 as shown in Table 2.

S.No	Descriptions	Result
1	Specific gravity	2.68
2	Fineness modulus	3.33
3	Gradation Zone	II

C. Coarse Aggregates

The material retained on 4.75mm sieve is termed as coarse Aggregate. Crushed stone and natural gravel are the common material used as coarse aggregate for concrete. Coarse aggregate are obtained by crushing various types of granites, schist, crystalline and lime stone and good quality sand stones. When high strength concrete is required a very fine grained granite perhaps the best aggregate. Concrete made with sand stone aggregate give trouble due to cracking because of high degree of shrinkage. Graded crushed hard blue granite jelly of 20mm size available in and around Dharmapuri was used. The grading of aggregate conformed to the requirement as per IS: 383-1970 as shown in Table 3.

S.No	Descriptions	Result
1	Fineness modulus	8.02
2	Impact Value	34.38%
3	Crushing Value	31.67%
4	Elongation Value	40.44%
5	Flakiness index	36.22%
6	Water Absorption	1.1%

D. Fiber properties

Metallic fibers are made of either steel or stainless steel. The polymeric fibers in use include acrylic, aramid, carbon, Nylon, polyester, polyethylene and Polypropylene fibers. Glass fiber is the predominantly used mineral fiber. Various types of organic and inorganic naturally occurring fibers such as cellulose are also being used to reinforce the cement matrix.

E. Mix Proportion for M_{20} Concrete

Table 4: Mix Proportions

Water (liter)	Cement (kg/ m3)	Fine Aggregate (kg/ m3)	Coarse Aggregate (kg/ m3)
0.50	1	1.48	3.00
191.6	383	569.94	1151.81

F. Properties of Fresh Concrete

Table 5: Properties of fresh Concrete

S.No	Descriptions	Result
1	Slump Value	130 mm
2	Compaction Factor	0.96

G. Concrete Specimen Specification

Table 6: Concrete Specimen Specification

S.No	Descriptions	Size of Specimen
1	Cube Size	150 mm X 150 mm X 150 mm
2	Cylinder	150 mm Dia & 300 mm Height
3	Beam	500 mm X 100 mm X 100 mm

IV. EXPERIMENTAL STUDY ON HARDENED CONCRETE

A. Compressive Strength of Concrete

Compressive strength is one of the important properties of concrete. Concrete cubes of size 150x150 x150mm were cast with and without rubber. After 24 hours the specimen were demoulded and subjected to water curing. After 7,14 and 28 days of curing, the three cubes were taken and allowed to dry and tested in compressive strength testing machine. The specimens were tested according to IS 516-1964 the rate of loading was about 14 N/mm^2 per minute and ultimate load was noted

Fig 1: Compressive Strength Test

Table – 7: Compressive Strength of Concrete

Specimen	Compressive Strength in N/mm^2		
	7th days	14th days	28th days
I	11.56	17.92	20.59
II	16.29	20.29	21.51
III	12.00	19.26	21.03

B. Split Tensile Strength

Tensile strength is indirect way of finding the tensile strength of concrete by subjecting the cylinder to a compressive force. Cylinder of size 150mm diameter and 300mm long were cast with and without rubber.After24 hours the specimen were demoulded and subjected to water curing. After 7,14 and 28days of curing, the curing three cylinders were taken and allowed to dry and tested in UTM by placing the specimen horizontal. The ultimate loads of the specimen were noted.

Fig. 2: Split Tensile Strength Test

Table – 8: Split Tensile Strength of Concrete

Specimen	Split Tensile Strength in N/mm^2		
	7th days	14th days	28th days
I	1.2	1.69	2.25
II	1.69	2.54	2.89
III	1.27	2.19	2.54

C. Flexural Strength

The flexural strength of concrete of beam of size 500x100x100mm were cast with and without rubber. After 24hours the specimen were demoulded and subjected to water curing. After 3, 7,14and 28days of curing, the curing three beams were taken and allowed to dry and tested in UTM. The two point load in applied to specimen and slow rate till the specimen fails.

Fig. 3: Flexural Strength Test

Table – 9: Flexural Strength of Concrete Beams

Specimen	Flexural Strength in N/mm^2		
	7th days	14th days	28th days
I	11.56	17.92	20.59
II	16.29	20.29	21.51
III	12.00	19.26	21.03

V. RESULTS AND DISCUSSION

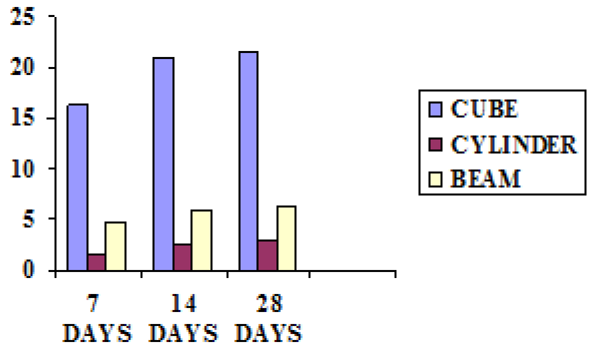

Fig 4: 5 % of PFRC

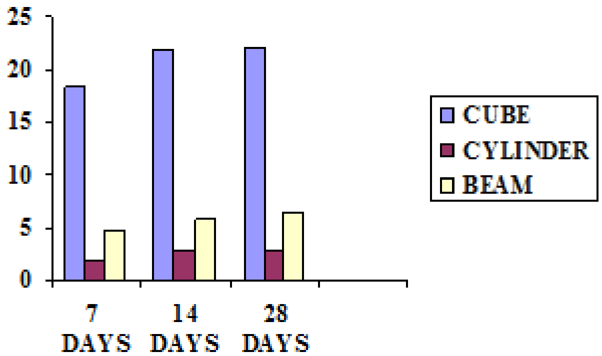

Fig 5. 10 % of PFRC

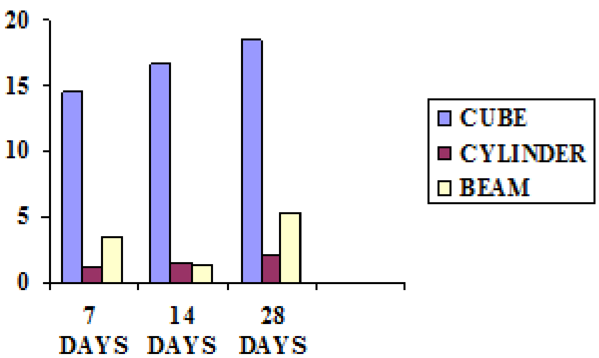

Fig 6: 15 % of PFRC

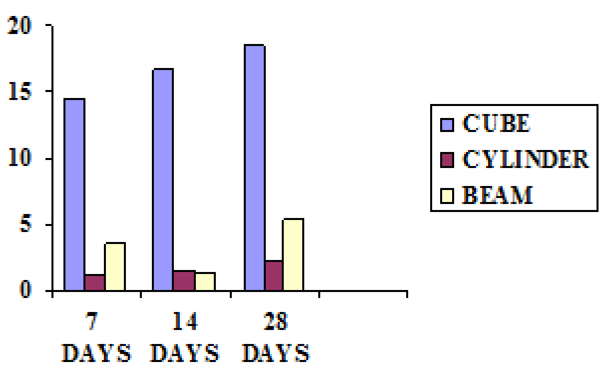

Fig 7: 13.5 % of PFRC

VI. CONCLUSION

The following conclusions were drawn with in the limitations of experimental investigation

- It has been observed that the incorporation of fibers to the mix increases the material toughness both in tension and compression, as represented by the toughness indexes of the Indain standards. The toughness increases results in higher shear strength of the concrete and better deformability, i.e. the deflection at maximum load is significantly higher for FRC beams than plain concrete specimens.
- The compressive strength increase only marginally due to fiber incorporation in concrete.
- First crack occurs earlier in PFRC when compared to Ordinary Concrete.
- In PFRC beams, the maximum load increased by approximately 20% of the plain concrete.
- The length and width of the crack is reduced due to the incorporation of fibers in the concrete.

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