Experimental Investigation on Mechanical Properties of Polypropylene Fibre Reinforced Concrete

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Abstract— A concrete has strong in compression and weak in tension, impact and flexure. To increase these properties we have add some addition to concrete like fibres. Fibres are giving some additional tensile and impact strength to concrete. In this investigation we are adding fibres like polypropylene with a fibre dosage of 0.5%, 1%, 1.5% were dispersed into the concrete of mix design M30 grade. The results are compared with conventional concrete so that here increasing the fibre dosage in concrete randomly increasing compressive strength, tensile strength flexure strength and bond strength.so finally while using fibres in concrete we are going to transfer brittle failure to ductility property.

Key words: Fibre Reinforced Concrete, Polypropylene, Compressive Strength, Split Tensile Strength, Flexural Strength

I. INTRODUCTION

Concrete is the most widely used construction material in this world. Generally concrete has low ductility,tensile and impact resistance on bridge decks, Aircrafts etc., hence polypropylene fibres are added with concrete mix. Due to an increasing use of FRC (fibre-reinforced concrete) in construction like bridge decks and military industries against impact loads, these concretes are important role in human life. Adding fibres to concrete increases its ductility, tensile strength, flexural strength and resistance against dynamic and impact loads. The aspect ratio (L/d) and volume fraction (Vf) are important fibres parameters in FRC. When cracks are initiated in FRC, the fibres bear the applied loads, when the load increases the fibres tend to transmit the excess stresses to the matrix. If these stresses exceed the fibre-matrix bond strength, which in turn is influenced by fibre properties the fracture process may lead to fibres pullout or rarely rupture of the fibres. Thus, fibre reinforced concretes are more ductile than other concretes.

It was reported that polypropylene fibes were effective in improving strength properties of the concrete.. The main objective of this project is to study the mechanical properties of fibre reinforced concrete with mix proportion of fibres for M30 grade concrete and comparing with the conventional concrete and to know the optimum percentage of addition of fibres to concrete and finding maximum ratios.

II. EXPERIMENTAL STUDY

The experimental investigation was focused on the effect of various fibre dosages on mechanical properties of FRC. Mix proportion was designed using IS 10262-2009 and IS 456-2000 with mean target strength of 38.25 MPa (M30) for control mix.

Ordinary Portland cement (type 1) was used in this study. A coarse aggregate with a maximum nominal size of 19 mm and a fine aggregate with a fineness modulus of 3.4 were used in the experiment. Polypropylene fibres were used; their geometry and apparent shape are shown in Fig. 1 and their properties are listed in Table 1. Super plasticizer of SP-430 was used to adjust the workability of mixtures.

Fig. 1: Polypropylene fibres

Fibre	Diameter (µm)	Specific Gravity	Modulus of Elasticity (GPa)
Polypropylene	20-400	0.9-0.95	3.5-10

Table 1: Physical Properties of polypropylene fibres

Crushed granite stones of size 20 mm and 10 mm were used as coarse aggregate and river sand was used as fine aggregate. The bulk specific gravity in oven dry condition and water absorption of the coarse aggregate 20 mm and 10mm were 2.58 and 0.3% respectively. The bulk specific gravity in oven dry condition and water absorption of the sand were 2.62 and 1% respectively.

A. Mix Design

In this study, water cement ratio of 0.5 was adopted for M30 grade concrete and polypropylene of 0.5%, 1%, 1.5% volume fractions were used

Constituents	Content KG/ m^3 of concrete
Cement	394.32
Fine aggregate	623.45
Coarse aggregate	1097.81
Water content	197.16
Fibres	
0.5%	11.56
1%	23.12
1.5%	34.69
Super plasticizer	9.38

Table 2: Content of mix proportions used

III. TEST METHOD

A. Details of specimen preparation

Cubes of size 150 mm were used to evaluate the compressive strength of PFRC. Cylinders of size 150 mm x 300 mm were used to determine the split tensile strength. Flexural strength of PFRC was evaluated using 100 mm x 100 mm x 500 mm beams. Steel moulds were used for

casting the specimens. Concrete was poured in mould in 3 layers and each layer was vibrated for 15 s after placing it on the vibrating table for proper compaction. Smooth surface was ensured by properly levelling the surface of the specimen. Specimens were removed from the moulds after 24 hrs of casting and immersed in clean water for 28 days. Specimens were prepared for fibre dosages of 0.50%, 1.00% and 1.50% of volume of concrete in addition to samples of control mix. Three specimens were prepared for each test and average value was obtained.

Fig. 2: Compressive strength

Fig. 3: Split tensile strength

Fig. 4: Flexure set up

Fig. 5: Bond set up

IV. RESULTS AND DISCUSSION

A. Compressive Strength

Compressive strength is the capacity of material to with stand loads tending to reduce size. The compressive strength of concrete cube of size (15cmx15cmx15cm) for dosage of fibre 0.5%,1%,1.5% is given by following table 2 for the curing period of 28 days

Fibre Dosage (%)	Compressive strength after 28 days	% Growth
PCC	39.53	-
0.50%	39.64	0.28
1.00%	40.73	3.04
1.50%	41.04	3.82

Table 3: Compressive strength of PFRC at 28 days curing

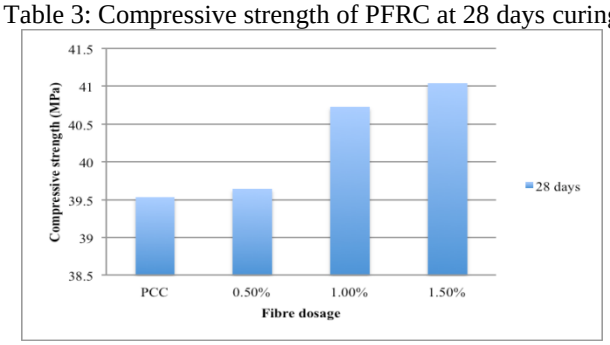

Fig. 6: Compressive strength of PFRC at 28 days curing

By observing the table readings we can say that, with the increase in dosage of fibre and with curing period of concrete the compressive strength of concrete cube increases. The maximum compressive strength concrete cube from test data is 41.04 N/mm2 at a curing period 28 days for a dosage of 1.5% of fibre and it can be represented from the fig 3 and it represents at 1.5% of fibre dosage the compressive strength of fibre reinforced concrete cube increased.

B. Split Tensile Strength

Fibre Dosage(%)	Split tensile strength after 28 days	% Growth
PCC	3.06	-
0.50%	3.12	1.96
1.00%	3.21	4.90
1.50%	3.31	8.17

Table 4: Split tensile strength of PFRC at 28 days curing

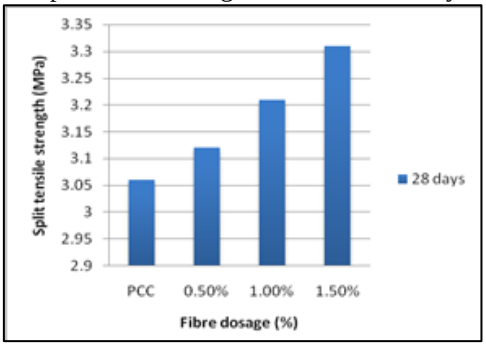

Fig. 7: Compressive strength of PFRC at 28 days curing

From the table observation we can say that with increase of fibre dosage and curing period fibre reinforced concrete the split tensile strength of fibre reinforced concrete increased. The maximum split tensile strength of fibre reinforced concrete is 3.31N/mm^{2}and is occurred at 1.5% dosage of fibre at a curing period of 26 days. The graphical representation of split tensile strength of PFRC and various

dosage of fibre content is given in fig4 for curing period 28 days.

C. Flexural Strength

Tensile strength of fibre reinforced concrete is estimated by using flexural strength of fibre reinforced concrete. It calculates an unreinforced concrete beam or slab to resist failure occurred under bending.

Fibre dosage (%)	Flexural strength after 28 days	% Growth
PCC	4.16	-
0.50%	4.23	1.68
1.00%	4.26	2.40
1.50%	4.37	5.05

Table 5: Flexural strength of PFRC at 28 days curing

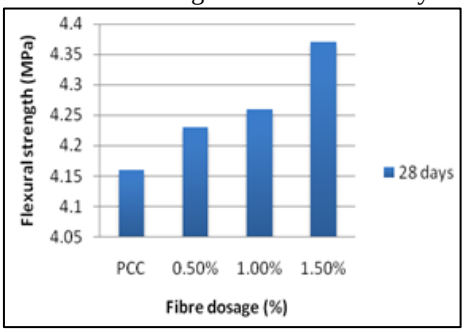

Fig. 8: Flexure strength of PFRC at 28 days curing

From the table observation we can say that with increase of fibre content and curing period of PFRC the flexural strength of PFRC increased. The maximum Flexural strength of PFRC is 4.37N/mm2 and occurred at fibre dosage 1.5% and for a curing period of curing period of 28 days. The graphical representation of flexural strength of PFRC and various dosage of fibre content is given in fig4 for curing period 28 days.

D. Bond Strength

The amount adhesion between concrete and steel is calculated by using bond strength. It measures the amount strength required to separate the bonded layers each other.

Fibre dosage (%)	Bond strength after 28 days	% Growth
PCC	10.02	-
0.50%	10.03	0.10
1.00%	10.06	0.40
1.50%	9.93	-0.90

Table 6: Bond strength of PFRC at 28 days curing

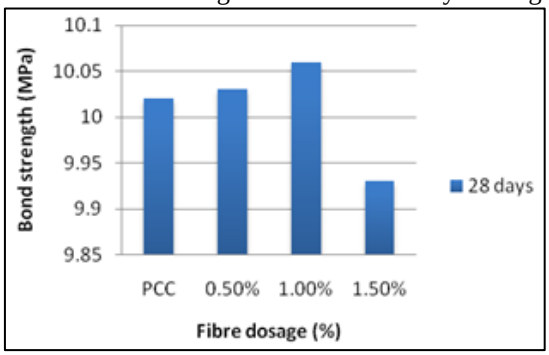

Fig. 9: Bond strength of PFRC at 28 days curing

By analysing the graph it is clear that with increase in fibre content in PFRC up to certain limit only bond strength PFRC increased and it gets maximum value for a dosage of fibre up to 1.0% only at a curing period of 28 days

V. CONCLUSIONS

Based on the results of this experimental investigation, the following conclusions can be drawn:

1) Polypropylene fibers were found to be effective in improving compressive strength, split tensile strength, flexural strength and bond of the concrete compared to OPC.
2) Compressive strength of concrete increased with increase in fiber dosage and the maximum strength attained for a fiber dosage of 1.50%.
3) Tensile strength of concrete slightly increased with increase in fiber dosage and the maximum Flexural& split tensile strength attained for a fiber dosage of 1.50%.
4) Bond strength of concrete increased with increase in fiber dosage and the maximum strength attained for a fiber dosage of 1.0%.

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