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Experimental Study of Polypropylene Fibre Concrete

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Abstract*— *An experimental work investigation was carried out the behavior of polypropylene fibre reinforced concrete. Experimental program consisted of compressive strength test on polypropylene fibre reinforced concrete. Normally, the fibres are added to increase the crack resistance and tensile strength. **This investigation deals with the addition of polypropylene fibres in concrete. Experimental work have been conducted for workability test , strength test and durability test on concrete of M30 grade with 0%, 0.2%, 0.4%, and 0.6% by volume of concrete. This study consisted of compressive strength test by comparing the results, the optimum amount of fibre was found to be 0.6%.**

Keywords: Aspect ratio, Compressive Strength, Polypropylene Fibres Reinforced concrete

I. INTRODUCTION

Concrete is the most widely used construction material has several desirable properties like high compressive strength, stiffness and durability under usual environmental factors. At the same time concrete is brittle and weak in tension.

Plain concrete has two deficiencies, low tensile strength and a low strain at fracture. These shortcomings are generally overcome by reinforcing concrete. Normally reinforcement consists of continuous deformed steel bars or pre-stressing tendons.

The advantage of reinforcing and pre-stressing technology utilizing steel reinforcement as high tensile steel wires have helped in overcoming the incapacity of concrete in tension but the ductility magnitude of compressive strength.

Fibre reinforced concrete (FRC) is a concrete made primarily of hydraulic cements, aggregates and discrete reinforcing fibres. FRC is a relatively new material. This is a composite material consisting of a matrix containing a random distribution or dispersion of small fibres, either natural or artificial, having a high tensile strength.

Due to the presence of these uniformly dispersed fibres, the cracking strength of concrete is increased and the fibres acting as crack arresters. Fibres suitable of reinforcing concrete having been produced from steel, polypropylene and organic polymers. Many of the current applications of FRC involve the use of fibres ranging around 1% by volume of concrete.

Recent attempts made it possible to incorporate relatively large volumes of steel, polypropylene and synthetic fibres in concrete. Results of tensile tests done on concretes with polypropylene, polypropylene and steel fibres indicate that with such large volume of aligned fibres in concrete, there is substantial enhancement of the tensile load carrying capacity of the matrix.

This may be attributed to the fact fibres suppress the localization of micro-cracks into macro-cracks and consequently the apparent tensile strength of the matrix increases.

II. MATERIAL PROPERTIES

A. *Cement*

Ultra tech OPC 53 grade was used for this investigation. The specific gravity of cement is 3.17.

B. *Fine aggregate*

Local clean river sand conforming to grading zone was used. The sand is sieved using 4.75 mm sieve to remove all the pebbles. Fine aggregate having a specific gravity of 2.63 and fineness modulus of 2.94 was used.

C. *Coarse Aggregate*

The size of crushed hard blue granite of size 20 mm angular aggregate was used is passed through 12.5 mm and retained on 10mm with the specific gravity of 2.63 and fineness modulus of 2.94.

D. *Polypropylene fibre*

Polypropylene fibre is a synthetic hydrocarbon polymer. There are several major benefits from using polypropylene fibre most of these were highlighted earlier some of the others are as follows:

- Used as secondary reinforcement, plastic fibers help reduces shrinkage and control cracking.
- Polypropylene fibers have been used in precast concrete products including pipe, paving blocks, wall panels, septic tanks, burial vaults, and utility buildings.
- Cast-in-place applications have ranged from retaining walls, and earth - sheltered, dome-shape homes to all types off at work streets, sidewalks, drive ways, parking areas, floor slabs, and even barge deck overlays and helicopter pads.

III. PROPERTIES OF POLYPROPYLENE

Density **-**0.92 g/cm^3, Tensile strength is 550-700 MPa, Elastic modulus 70-80 GPa, Elongation at Break **is** 10-45% Softening Point is 773 to 860 degree Celsius, Melting point 130 to171 degree Celsius.

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Figure 1. Polypropylene Fibre

Based on the physical properties of material and tested as per IS: 4031-1996, IS: 383-1970, M_{30} grade concrete mix was designed as per IS: 10262-2009.

Water	Cement	Fine Aggregate	Coarse Aggregate
0.38	1	1.23	2.19

Table 1 Mix Proportion

IV. LITERATURE SURVEY

Allan and Kukacka (1995) reported that compressive and flexural strengths were not consistently affected by incorporation of fibres. Fibres did not significantly change the residual compressive strength of air entrained grouts subjected to freeze-thaw cycles. Jong-Pil Wona study(2008) evaluated the effects of synthetic and steel fibres on the bond properties of high-strength concrete and fibre-reinforced polymer (FRP) reinforcing bars. Katrin Habel(2006) studied about the Development of the mechanical properties of an Ultra-High Performance Fibre Reinforced Concrete. Bryan (2003)studied for obtaining the stress versus crack opening (r–w) response of steel fibre reinforced concrete through a uniaxial tension test. Houssam (1999) reported about the durability characteristics of concrete columns confined with advanced composite materials. Ronald F. Zollo (1997) studied rhetorical discussion on the Subject of fibre-reinforced concrete, FRC. This investigation deals with the addition of polypropylene fibres in concrete. Experimental work have been conducted for workability test , strength test and durability test on concrete of M30 grade with 0%, 0.2%, 0.4%, and 0.6% by volume of concrete. This study consisted of compressive strength test by comparing the results, the optimum amount of fibre was found to be 0.6%.

V. RESULTS AND DISCUSSION

A. *Workability test*

Slump cone test is the most commonly used method of measuring consistency. It doesn't measure all factors contributing to workability. It is used as a control test and gives an indication of uniformity of batches. Compacting factor test is more precise and sensitive than the slump cone test. This test gives an idea for degree of compaction and adopted to find the workability of concrete where aggregate size does not exceed 20mm and the mixes are comparatively dry. From both test workability is not getting affected by influence of fibres table2.

Table 2 Slump and Compaction factor

Fibre (%)	Slump in mm	Compaction factor
0	82	0.98
0.2	86	0.98
0.4	85	0.97
0.6	86	0.97

B. *Compressive Strength*

Concrete specimens are tested to fine its compressive strength, for 7 days and 28 days. The other tests like split tensile and flexural strength was determined for concrete mixes after 28 days curing. As per IS: 516-1999. Test results are shown in table 3.

The compressive strength of test cubes was measured for reference and PFRC concrete mixes for 7 and 28 days, for water cement ratio of 0.6 and 0.4, 0.4, and 0.6% of Polypropylene fibre. The increase in compressive strength with respect to age and for different percentage of Polypropylene fibre are plotted in the form of graphs shown in fig. From the test results it was observed that the maximum compressive strength is obtained for mixes with 0.6% Polypropylene fibre. While testing it was also observed that the pieces of concrete did not spall off as they were held intact by the fibres.

Table 3 Compressive strength N/mm^2

Fibre (%)	Strength after 7 days curing	Strength after 28 days curing
0	24	34.5
0.2	24.5	36.5
0.4	26	38.5
0.6	25	39.5

C. *Split Tensile and Flexural strength*

Tests were carried out conforming to IS: 516-1999 and IS: 5816-1999 to obtain the splitting tensile strengths and flexural strength for various concrete mixtures. The results of splitting tensile strengths and flexural strength of concrete at the age of 28 days were presented in table 4. Fig 2 and 3 shows split and flexural strength test

Figure 2. Split Tensile Test

Figure 3. Flexural testing for Beam

Table4 Split and Flexural strength N/mm^2 after 28 days curing

Fibre (%)	Split Tensile strength	Flexural Strength
0	3	6.10
0.2	3.25	6.15
0.4	3.38	7.35
0.6	4	7.70

D. Permeability Test

Figure 4 shows permeability test and conducted as IS:3085-1965. Test results are shown in table5 and shows that the penetration of water in concrete reduced as the content of mineral admixtures in the concrete was increased at the mentioned quantities. It can be seen that the voids were decreasing with increasing compressive strength. There exists a linear relation between the two parameters.

Figure 4. Water Permeability Testing

Table 5 Permeability test result

Fibre (%)	Depth of penetration(mm)
0	7.36
0.2	7.12
0.4	6.78
0.6	6.26

E. Acid Resistance Test

The Acid resistance test is conducted by using sulphuric acid at a concentration of 3% dilution. From the results shown in table 6, it is found that the resistance of concrete to sulphuric acid in the mix with mineral admixtures is far greater than that of control mix. Figure 5 shows concrete specimen after acid curing. Adding FRRP to the normal concrete the porosity of the concrete is reduced this is the main reason for decrease in weight loss.

Figure 5 Polypropylene fibrous Concrete Cube after curing in H_2SO_4

Table 6 Polypropylene fibrous Concrete Cube after curing in H_2SO_4

Fibre %	Strength after 7 days (N/mm2)	Strength after 28 days (N/mm2)
0	22	31.5
0.2	22.5	33.5
0.4	22	35.5
0.6	23	35

VI. CONCLUSIONS

The following conclusions are drawn from this investigation.

1. Compression strength, split tensile strength and flexural strength of concrete specimen got increased with the addition of Polypropylene fibre. The optimum strength was attained with 0.6% addition of fibre by weight of cement. Compressive strength by 39.5 N/mm^2. Split tensile strength by 4 N/mm^2 and flexural strength is 7.7 N/mm^2 for 0.6% of polypropylene fibre
2. Water permeability of FRC is low when compared to the control mix concrete. It is seen that there is a decrease in the absorption of water after 28 days in FRC. Thus the Durability will be good.
3. FRC resistance towards sulphuric acid is high when compared to the control mix concrete. This would result in a better resistance to corrosion of reinforcement as in the case of RCC structures.

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