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An Experimental Study on the Structural Behavior of Reinforcement Beam by Using Polypropylene Fiber

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Abstract

Polypropylene Fiber Reinforced Concrete is an embryonic construction material which can be described as a concrete having high mechanical strength, Stiffness and durability. By utilization of Polypropylene fibers in concrete not only optimum utilization of materials is achieved but also the cost reduction is achieved. This paper presents a comprehensive review on various aspects Polypropylene Fiber Reinforced Concrete concerning the behavior, applications and performance. In addition, the density of polypropylene is the lowest of any fiber available, super-tenacity polypropylene fibers have been prepared that exceed the strength of all commercial fibers - including the much more expensive nylons .Polypropylene fibers also excel in other important physical properties, such as toughness, resilience, permeability, chemical resistance, and abrasion resistance, strength.

Keywords

Polypropylene fiber, Stiffness, Strength, Abrasion Resistance.

I. Introduction

Polypropylene fiber is a long chain of synthetic polymer composed of stereo regular Isotactic polymer. They are gaining in significance due to the low price of the raw polymer material and their high alkaline resistance. They are available indifferent forms like mono filament or fibrillated manufactured in a continuous process by extrusion of polypropylene homo polymer resin and filament possesses all the outstanding properties associated with the polymer. Being lightest amongst fibers, polypropylene yields higher length of fabric, than any other commercial fiber. It has high tensile strength, wrinkle and abrasion resistance. Several different types of short discrete fibers have been used to reinforce concrete. The choice of fibers varies from synthetic organic materials such as polypropylene or carbon, synthetic inorganic such as steel or glass, natural organic such as cellulose or sisal to natural inorganic asbestos. Short discrete steel, glass, polyester and polypropylene fibers are most commonly being used as reinforcement to the FRC. The selection of the type of fibers is guided by the properties of the fibers such as diameter, specific gravity, young's modulus, tensile strength etc. and the extent these fibers affect the properties of the cement matrix. Fibrillated polypropylene fibers are slit and expanded into an open network thus offering a larger specific surface area with improved bond characteristics and applications in several structures of parking areas, drive ways, industrial floorings, water and other chemical storage tanks, walkways, pavements, roof screeds, mosaic flooring, structural concrete and also in pre-cast slabs.

II. Objective and Scope

Conduct experimental investigation for measurement of workability of Polypropylene Fiber Reinforced Concrete.

- Conduct experimental and analytical investigation to characterize principle mechanical properties of PPFRC.

For the mechanical properties, the following tests are conducted to study the effect of amount of fibers and the length of fibers on the compressive, tensile and flexure strength and the associated straining capacity.

- Compressive Strength of concrete cubes.
- Split Tensile Strength of concrete cylinders
- Flexure Strength of concrete beams

III. Literature Review

Antonio Nanni.al (1988), concluded that the splitting –tension test could be used to determine the tensile strength of fiber reinforced concrete commonly obtained with static flexural test.

Bhal and Jain.al (1999), experiments to study behavior of concrete in compressive strength when it is subjected to elevated temperature and discusses some of the important factors affecting compressive strength.

Clinton Pereira.al (2009), conducted each application it needs to be determined which type of fiber is optimal in satisfying the concrete application.

Christopher et al (2007), have been advocated to reduce the potential for plastic shrinkage cracking in concrete through mixture proportioning, curing methods, or the use of fiber reinforcement.

Gregor Fischer.al (2004), discussed brittle matrices, such as plain mortar and concrete, lose their tensile load-carrying capacity almost immediately after formation of the first matrix crack.

Isabel Padron et al (1990), investigated the serviceability of Portland cement concrete and of reinforced concrete structures is closely associated with their ability to resist and control cracking.

S. K. Singh.al (2010), studied about polypropylene fibers are actually man-made development in the petrochemical and textile industries. synthetic fibers resulted from research and concrete after which strength starts reducing with further increment in fiber ratios.

Saeed Ahmed et al (2006), found that the behavior of concrete in flexure seems to be identical with polypropylene fiber reinforced concrete as that in tensile strength.

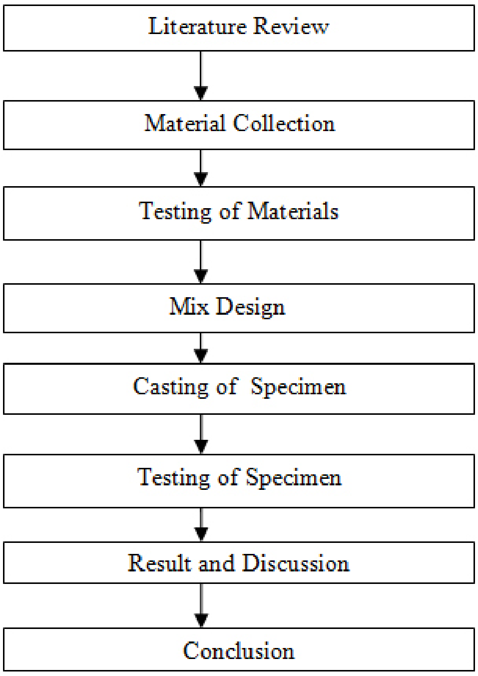
Vikrant et al studied the effect of length of fiber on the split tensile strength of fiber reinforced concrete and observed that, the split tensile strength of fiber reinforced concrete was dependent on length of fiber used.

ZiadBayasi et al,(1993) ,studied the effect of length and volume fraction of polypropylene fiber on the flexural behavior of PPFRC by characterizing the post-peak flexural resistance under four point loading.

IV. Summary Of Reports

- It is observed that most fibers were used to study the performance of concrete with steel fibers and polypropylene fibers.
- Comparison of cost analysis of concrete with different types of fibers was not reported to suit use in construction site for civil engineers, builders and public use.
- It was found that there was no report about the relation between cube compressive strength and cube compressive strength for fibrous concrete.

V. Methodology



VI. Materials Used

1. Cement

Ordinary Portland cement of grade 43 conforming to IS specifications is used to cast the test specimen. Cement is a material, generally in powder form, that can be made into a paste usually by the addition of water and, when melded or poured, will set into a solid mass. Numerous organic compounds used for adhering, or fastening materials, are called cements, but these are classified as adhesives, and the term cement alone means a construction materials. It is a bluish-gray powder obtained by finely grinding the clinker made by strongly heating an intimate mixture of calcareous and argillaceous mineral.

Table. 1: Properties of cement

S.no	Properties	Cement
1.	Specific gravity	3.10
2.	Fineness modulus	0.3
3.	Initial setting time	30 min
4.	Final setting time	600 min

2. Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is good gradation of aggregates. Good quality river sand was used as a fine aggregate. The material whose particles are of size as are retained on I.S Sieve 4.75mm is termed as coarse aggregate. The size of coarse aggregate depends upon the nature of work. The coarse aggregate used in this experimental investigation are of 20mm size crushed angular in shape. The fine aggregate used in this experimental investigation was natural river sand Sieve 4.75mm passed particles are fine aggregate.

Table. 2: Properties of coarse aggregate

S.no	Properties	Coarse aggregate
1.	Specific gravity	2.75
2.	Fineness modulus	6.23
3.	Water absorption	0.5%

Table. 3: Properties of coarse aggregate

S.no	Properties	Fine aggregate
1.	Shape	Angular particle
2.	Gradation zone	Zone II
3.	Specific gravity	2.63
4.	Fineness modulus	2.75

3. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

4. Steel

Rebar short for reinforcing bar, also known as reinforcing steel and reinforcement steel is a common steel bar or mesh of steel wires commonly used as a tension device in reinforced concrete and reinforced masonry structures, to strengthen and hold the concrete in compression. The surface of the rebar may be patterned to form a better bond with the concrete

5. Polypropylene fiber

This is available in two forms, monofilament fibers and film fibers. Monofilament fibers are produced by an extrusion process through the orifices in a spinneret and then cut to the desired length. The newer film process is similar except that the polypropylene is extruded through a die-that produces a tubular or flat film. This film is then slit into tapes and uniaxially stretched. These tapes are then stretched over carefully designed roller pin systems which generate longitudinal splits and these can be cut or twisted to form various types of fibrillated fibers. The fibrillated fibers have a net-like physical structure. The tensile strength of the fibers is developed by the molecular orientation obtained during the extrusion process. The draw ratio (final length/initial length), a measure of the extension applied to the fiber during fabrication, of polypropylene fibers is generally about eight. The term fibrillated (screen) fiber derives from the manufacturing method used. The term collated means that the fibrillated fibers are bundled together, usually with some type of water soluble glue which will break up or dissolve in the fluid concrete mixture.

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Fig.1: Polypropylene fiber

Table.4:Properties of polypropylene fiber

S.no	Properties	Test data
1.	Diameter(D) ,mm	0.0445
2.	Length (l),mm	6.20
3.	Aspect Ratio (l/D)	139.33
4.	Tensile strength Mpa	308
5.	Specific gravity	1.33

VII. Mix Design

Table. 5: Concrete mix design

Concrete mix design quantities	
Grade of concrete	M30
Type of cement	OPC 53
Size of coarse aggregate	20 mm
Workability	80mm
Exposure condition	Severe
Degree of supervision	Good
Cement content	450 Kg/m^3

Table. 6: Result of mix proportion

Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)	Water (lit/m^3)
340	739.8	1210	154
1	2.35	3.5	0.45

VIII. Analysis of Concrete Properties

For strength studies the cubes specimens are of the size of 150mm x150mm x 150 mm. The cylinder specimens are of the size of 150 mm x 300 mm. M30 grade concrete was prepared with and without fiber. The concrete is then filled in the mould then the specimens are compacted by the hand and table vibrator. After 24 hours the specimens are de- moulded and kept immersed in water for 28 days.

Fig.2: Casting of Specimens

IX. Experimental Study on Beam

The concrete mixes were filled in the Beam moulds after laying the reinforcements with the required cover and compacted effectively by using damping rod. The beams of dimension 1500 x150 x 150 mm were casted for each design mixes.

X. Load Deflection Behavior

Beam specimens were prepared for finding the flexural behavior of beam. The beam is gradually loaded by increasing the load level by increment of 1.5 KN, up to failure. The Deflection readings measured at the mid span of the beam are recorded. The Load Vs deflection curves are drawn.

XI. Mode Of Failure

The beam is subjected to load up to failure of the beam. As the load level is increased further, the crack is developed on the beam. The concrete was crushed and spalling down

Fig. 3:Test set up of beam

Fig 4: Mode of failure of RC beam

XII. Testing Of The Specimens

A. Compressive Strength

Compressive strength is most important property of the hardened concrete. The concrete cubes were casted, cured and tested accordance with IS standard 7 and 28 days highest compressive strength value is which is obtained for M30 grade by adding of polypropylene fiber in concrete when compared to the conventional mix.

Compressive Strength, f_c = P/A N/mm².

Where, P=Load at failure in N

A=Area subjected to compression in mm².

Fig..5: Testing setup for compressive strength

1. Comparison Of Test Result By Table

Table 7 : Compressive Strength Test Result

Grade of Concrete	Adding Percentage of polypropylene fiber (%)	Cube Compressive strength (N/mm²)	
		7 days	28 days
M30	Conventional	27.51	33.75
	0.5	27.97	34.61
	1	29.00	34.87
	1.5	29.72	35.42
	2	30.57	36.50

2. Comparison Of Test Result By Graph

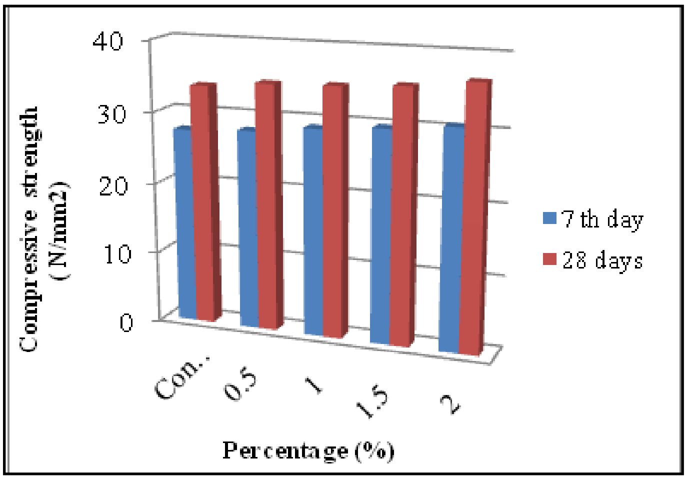

Fig. 6 : Days testing result

B. Split Tensile Strength

After curing of Cylinder specimens they are placed in testing machine. The load is applied on the cylinder specimens. The cylinder specimen is failed at ultimate load which is noted from dial gauge reading.

Split Tensile Strength, f_{sp} =2P / LD N/mm²

Where, P =Load at failure in N

L =Length of the Specimen in mm

D =Diameter of the Specimen in mm

Fig.7: Testing setup for split tensile strength

1. Comparison of Test Result By Table

Table 8: Split Tensile Strength Test Result

Grade of Concrete	Adding Percentage of polypropylene fiber (%)	Cylinder Split Tensile strength (N/mm²)	
		7 days	28 days
M30	Conventional	2.13	3.67
	0.5	2.37	3.81
	1	2.83	4.27
	1.5	3.09	4.75
	2	3.47	5.05

2. Comparison of Test Result By Graph

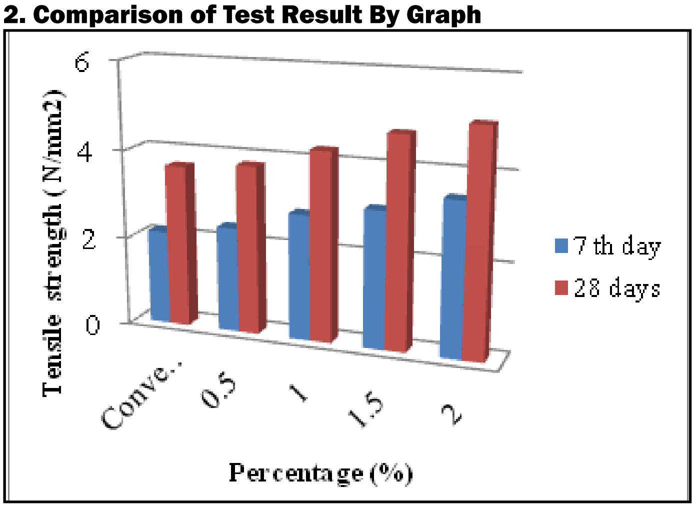

Fig.8: Days testing result

C. Flexural Strength

Flexural strength teat was conducted after 28 days the concrete beams were fabricated and UTM was used for this test. Prepared one beam of conventional and another one is added 2% of polypropylene fiber materials. Flexural strength, also known as modulus of rupture, bending strength or fracture strength a

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mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at terms of stress, here given the symbol calculated using the following formula:
The flexural strength when a >133 mm for 100 mm specimen,
f_{fb}= Pa / bD^2
The flexural strength when a < 133 mm for 100 mm specimen,
f_{fb}= 3Pa / bD^2
Where ,B= measured width of specimen in mm
D= measured depth in mm of the specimen at the point of failure.
a= distance of the crack from the nearer support in mm
P= maximum load in N applied to the specimen.

Fig.9: Testing setup for flexural strength

1. Comparison of Test Result By Table

Table 9 : Flexural Strength Test Result

Cycle No	Max Load (KN)	Maximum deflection (mm)	
		Conventional concrete beam	**Polypropylene fiber reinforced concrete beam**
1	7.5	1.05	1.43
2	15.0	2.54	2.76
3	22.5	4.15	4.41
4	30.0	5.83	6.72

2. Comparison Of Test Result By Graph

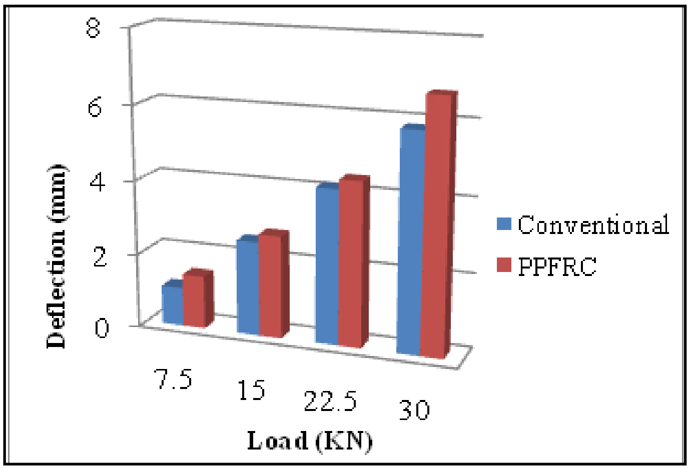

Fig.10: Comparison load carrying capacity for beam

XIII. Conclusion

Due to several advantages of Polypropylene fiber materials used for structural behavior and strengthening, the use of Polypropylene fiber has becoming popular. This paper makes a comparative study between the load carrying capacity of an RCC beam and other beams with polypropylene fiber added. An experiment study will carry out to study the change in the structural behavior of R.C.C. beams Reinforced with Polypropylene fiber, to enhance the Flexural capacity of the beams.

- To compute the flexural strength of concrete beam using Polypropylene fiber materials given better results compared to the conventional beam.
- The strengthening with Polypropylene fiber materials in the beam was found more effective in improving the ultimate load carrying capacity of beams.
- By adding fibers in the concrete, compression strength increased by 33% after addition of 0.5% polypropylene (by weight of cement) and 1% steel (by volume of concrete) fiber for M30 mix design.
- The tensile strength increment was about 40% for polypropylene fiber added concrete in comparison to conventional concrete.
- The flexural strength has increased by 52% for polypropylene fiber added concrete in comparison to conventional concrete.
- The first crack load capacity of polypropylene fiber with beam is 50% increased compared to conventional type of concrete.
- The ultimate load of polypropylene fiber with beam is 13% increased compared to conventional concrete.
- The highlight of this beam observed in this study was mainly in regard to its increased load carrying capacity due to their better performance.

An overall conclusion can be stated that the polypropylene fiber reinforced concrete section performed well in the flexural especially the ultimate load capacity and deflection.
However, both behaviors were greatly influenced by the shape and arrangement of the reinforcement in the concrete beam. Thus, the application of the section as an alternative to the conventional steel reinforcement in the concrete beam could be accepted. Improvement in the bonding behavior of the reinforcement by providing rougher surface with make the reinforcement beam more competitive and practicable to replace the conventional steel reinforcement in the concrete structures.

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