Experimental Study on Strength Properties of Polypropylene Fiber Reinforced Concrete

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***Abstract*—This paper focuses on experimental study in the behaviour of polypropylene fibre reinforced concrete. The polypropylene fibres were mixed into the concrete in the form of reinforcement into the concrete with uniform orientation of the fibres. The tests on the concrete were conducted before and after by adding polypropylene fibres into the concrete in different contents, i.e.; 1.6%, 1.7%, 1.8% of the cement mass. It was observed that the composite with 1.6% of polypropylene fibre demonstrated the highest compressive, flexural and split tensile strengths when compared to the other contents of fibres. The optimum result acquired Fibre reinforced concrete is fixed to accomplish additional flexure strength in the concrete beam.**

***Index Terms*—Polypropylene fibre, Tensile Strength, Flexural behaviour, Fibre reinforced Concrete.**

I. INTRODUCTION

Recent studies are being made in the field of Fibre reinforced concrete in order to improve the property of concrete. In general, various types of fibres like steel fibres, carbon fibres, and glass fibres are being used. Natural fibres such as coconut, flax, hemp, jute and linen are used as reinforcement in the concrete. Synthetic fabrics include polypropylene, polyester, acrylic, nylon, rayon, acetate, spandex, Lastex, orlon and Kevlar. Generally Synthetic fibres are more durable than most natural fibres and will readily pick-up different dyes. In addition, many synthetic fibres offer consumer-friendly functions such as stretching, waterproofing and stain resistance. Sunlight, moisture, and oils from human skin cause all fibres to break down and wear away. Compared to other types of fibres such as steel, natural or glass fibres these synthetic fibres i.e., fibre are cheap, they do not shrink, they last longer than natural fibres, they dry quickly, they need little or no ironing, they are resistant to chemicals. Synthetic fibres are more durable than natural fibres. Synthetic less expensive and readily available. Fibre content can be part of total weight/mass of composite or the percentage of any ingredient of the concrete. Synthetic fibres benefit the concrete in both plastic and hardened state. educed plastic settlement cracks.

- Reduced plastic shrinkage cracks.
- Lowered permeability.

II. MATERIALS USED CEMENT

Cement used in this investigation was 53 Grade Ordinary Portland cement confirming to IS: 12269 [18]. The specific gravity of cement was 3.2. Initial and final setting time for the was 35 minutes and 560 minutes.

Course And Fine Aggregate

Aggregates are inert mineral material used as filler in concrete which occupies 70% to 85 % volume. Sand passing through 4.75mm IS sieve conforming to grading zone III of IS 383:1970 was used. Its specific gravity is 2.74. Locally available stone aggregate of size 20 mm passing and retained in 19 mm, was used and the specific gravity and fineness modulus for the same are 2.74 and 2.47as per IS: 2386- 1968 Part III. Both the Aggregates compiled with the requirements of IS: 383-1970.

Polypropylene Fibre

Used as secondary reinforcement, polypropylene fibres help reduce shrinkage and control cracking. To use these fibres, concrete mix design does not have to be Saltered, and no special equipment or slump modifications are required, even for pumping. Only two things must be determined: how much fibre to add and what length of fibre to use. Polypropylene fibres are manufactured in small bundles. During the mixing operation, the movement of aggregate shears these bundles into smaller bundles and individual fibres. If the jobsite is more than a 30- minute drive, the fibres should be added at the site.

Polypropylenefibre

Fibre Length

In fibre-reinforced concrete, cracks can open only if the tensile stresses in the concrete exceed the tensile strength or the pull-out strength of the fibres. The longer the fibres are, the stronger the bond between fibres and paste is and thus the greater the fibre pull-out strength is. If fibres are too long, uniform distribution of the fibres becomes difficult. Longer fibres can be used when larger aggregates are present to shear the bundles of fibre apart. Short fibres are used with small or lightweight aggregate.

Polypropylene fibres tend to hold the concrete mix together. In hardened concrete, polypropylene fibres act as crack arresters. Like any secondary reinforcement, the fibres tend to stop cracks from propagating by holding the concrete together so cracks cannot spread wider or grow longer. However, since polypropylene fibres are distributed throughout the concrete, they are effective close to where cracks start at the aggregate-paste interface. The length of pp fibre has 12mm, density as 0.91g/cm3, Tensile strength as 360MPa and 6denier thick fibre.

Aim

The main aim of this project is to evaluate the compressive strength of polypropylene fiber reinforced concrete (PPFRC) blocks and to study the effect of polypropylene fibers on the strength and performance of concrete. The project focuses on comparing the compressive strength of conventional concrete blocks with PPFRC blocks by conducting standard compression tests.

Need of the project

The increasing demand for durable and sustainable construction materials has led to the development of advanced concrete technologies. Conventional reinforced concrete structures often face durability problems due to corrosion of steel reinforcement, shrinkage cracking, and environmental exposure. By adding polypropylene fibers to concrete, the material becomes stronger and more resistant to cracking. The fibers act like small reinforcements inside the concrete and help in controlling both micro and macro cracks. This project is also needed to study the effect of different fiber sizes (6 mm and 12 mm) on the strength of concrete blocks. By comparing these, we can find out which fiber size gives better performance and can be used in construction. In addition, there is a need to develop cost-effective and long-lasting construction materials. Even though fibers slightly increase the initial cost, they reduce maintenance and repair costs in the long run.

Objectives

1.To understand the properties of polypropylene fibers and their effect on concrete performance.

2.To develop a suitable mix design for PPFRC with proper proportion of materials.

3.To evaluate the effect of fibers on the workability of fresh concrete.

4.To determine and analyse the compressive strength of PPFRC specimens.

III. TEST CONDUCTED ON SPECIMEN

A. Compressive Strength

The cube specimens were tested in the compression testing machine with the capacity of 200 tones. The upper / bearing surface of the machine is cleaned and kept free from the other loose particles and the; load is applied constantly at increased rate until the specimen got broken. The 7- & 28-days strength of cubes with various proportions of polypropylene fiber is compared below for M25 grade concrete.

The compressive strength test of Polypropylene Fiber Reinforced Concrete (PPFRC) blocks is carried out to determine how much load the block can withstand before failure. This test is very important because it helps in checking the strength and quality of the blocks used in construction. The compressive strength test is conducted to determine the load-carrying capacity and strength of Polypropylene Fiber Reinforced Concrete (PPFRC) blocks. In this test, concrete cube specimens of size 150 mm × 150 mm × 150 mm are used. After casting, the blocks are cured in water for specific curing periods such as 7 days, 14 days, and 28 days. After the required curing period, the blocks are removed from the curing tank and their surfaces are cleaned properly. The standard Indian Standard (IS) for the compressive strength testing of concrete blocks, including those reinforced with fibers, is IS 2185-1 (2005).

The specimen is then placed in the Compression Testing Machine (CTM) in such a way that the load is applied uniformly on the opposite faces of the cube. The load is applied gradually and continuously until the block fails or cracks. The maximum load at failure is noted and the compressive strength of the block is calculated by dividing the load by the cross-sectional area of the cube. This test helps in evaluating the strength and performance of the PPFRC blocks and comparing it with conventional concrete blocks.

Calculations:
Compressive strength = Maximum load/ Area

Compressive Testing

B. Split Tensile Strength Test

Split tensile strength was evaluated as per the test procedure given in Indian Standards IS.5816. In order to evaluate the splitting tensile strength of polypropylene fibre reinforced concrete, all the cylinder specimens were subjected to split tensile strength test in a 2000 kN digital compression testing machine. Specimens of 150 mm diameter, 300 mm height were placed in the machine in a horizontal manner in between the two parallel steel strips one at top and another at the bottom such that the load shall be applied along 300 mm length. The load was applied without shock and increased continuously at a nominal rate within the range of 1.2 N/mm2/min to 2.4N/mm2/min until the specimen failed. The maximum load applied to the specimen was recorded and the split tensile strength of the specimen was calculated at 28 days for M25 grade concrete.

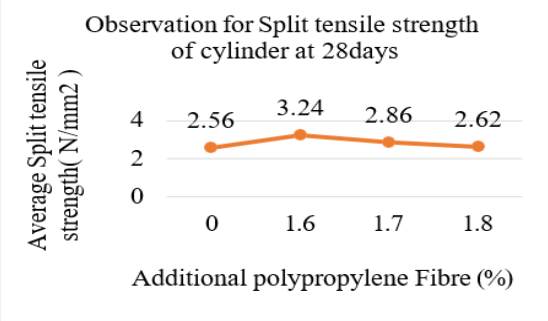
Calculations:
The split tensile strength of the specimen calculated from the following formula

$Tsp = (2P/ (\pi dL))$

Were,
P = maximum load in tonne L = length of the specimen
D = dia of the specimen


Split tensile testing on cylinder

Split tensile Strength (N/mm^2)	
	28days
Conventional	2.56
1.6% of polypropylene fibre	3.24
1.7% of polypropylene fibre	2.86
1.8% of polypropylene fibre	2.62



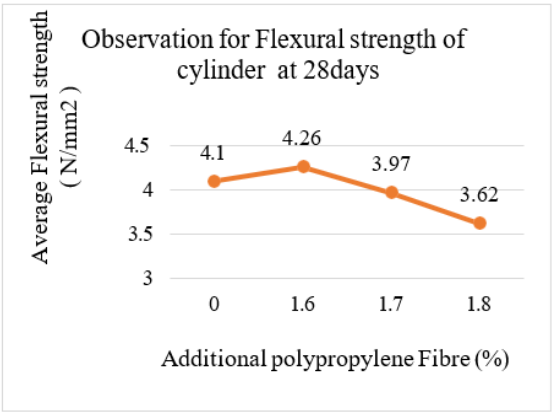
C. Flexural Strength Test

The beam specimens were tested in the universal resting machine to obtain the flexural strength of the beam casted with the polypropylene fibre reinforcement. The 28 days flexural strength of beams at M25 grade concrete with various proportions of polypropylene fibres, the flexural strength of the specimen was calculated using the bending equation.

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

Flexural test in UTM

Flexural Strength (N/mm^2)	
	28days
Conventional	4.10
1.6% of polypropylene fibre	4.26
1.7% of polypropylene fibre	3.97
1.8% of polypropylene fibre	3.73



IV. CONCLUSION

Based on the experimental investigation, the following conclusions have been drawn;Optimum result of high compressive strength, split tensile strength and flexural strength has been achieved in 1.6% of polypropylene fibre in the concrete and thus that fibre has ability to reduce the cracks, shrinkage in the concrete.

V. FUTURE WORK

a. Effect of coated PP fibre of higher diameter and higher length.
b. Will investigate the mechanical and structural properties of PP fibre reinforced self-compacting concrete.
c. Incorporating higher amounts of supplementary cementitious materials such as fly ash and slag.
d. Incorporating the nano particles with PP- FRC such as nano calcium carbonate and nano silica and study the mechanical properties and fracture.
e. To be study the creep performance of PP- FRC.
f. An investigation on fire exposed properties of PP-FRC including the effect of PP fibres on mitigating explosive spalling.

VI. AREAS OF APPLICATION

a. Pavements,
b. Drive ways,
c. Overlay patch repair,
d. Thin concrete,
e. Plastering,
f. Renders

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