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Study on Strength and Durability Properties of Polypropylene and Carbon Fiber Reinforced Concrete Composite

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Abstract: ***Concrete is the most widely utilized "manmade" material globally for construction in many developing countries in all types of civil engineering works. Also, concrete is an environmental - friendly material and in areas of growing environment – related awareness that is of prime importance. The weakness of concrete is due to the presence of micro cracks at mortar aggregate interface. To overcome the existing problems addition of fibers in the concrete has been come in to practice. In fiber reinforced concrete the fibers are added to the concrete mix so that those are discontinuous fibers will be uniformly distributed in the mix and improve the concrete properties in all directions. In this research paper, an attempt is made to use fibers only .The experimental investigation consisting of casting and testing of compression tests were conducted on 150x150x150mm cube and 150mmx300mm, cylindrical specimens using test method that gave the complete compressive strength, split tensile test using with and without fiber.The strength and durability properties are carried out for various mix designations and compared with normal conventional concreteIn present project work M25 grade considered and the polypropylene (PP) fiber at 0.5,1 ,1.5 ,2 and 2.5% volume fractions and carbon fibers at 1, 1.5, 2,2.5 and 3% volume fractions are introduced into fiber-reinforced. Based on the results will find the superior crack resistance, improved tensile strength. The proposed sample will be tested at 7 days, 21 days and 218days age of curing. These results will show whether the FRC is suitable for proper confinement or not for structures subject to extreme load conditions.***

Keywords: Polypropylene, Carbon fibers, Compressive tensile strength, Flexural strength, Impact strength.

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 fibres are 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.

Some of the benefits include;

1) Reduced plastic settlement cracks.
2) Reduced plastic shrinkage cracks.
3) Lowered permeability.
4) Increased impact and abrasion resistance.

It is also expected that the final outcome of the project will have an overall beneficial effect on the utility of fiber concrete in the field of civil engineering construction work.

Following parameters influences behavior of the fibre concrete, so these parameters are kept constant for the experimental work

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Thus, the scope of the project can be summarized as:

a) To obtain Mix proportions of Control concrete by IS method.
b) To perform the specific gravity test, sieve analysis and slump test under Indian Standard methods.
c) To conduct compressive strength, split tensile test using with and without fibre as per Indian Standard methods.

Ajeeth kumar et.al, carried out the experimental study in the behavior of polypropylene fiber reinforced concrete. The polypropylene fibers were mixed into the concrete in the form of reinforcement into the concrete with uniform orientation of the fibers. The tests on the concrete were conducted before and after by adding polypropylene fibers 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 fiber demonstrated the highest compressive, flexural and split tensile strengths when compared to the other contents of fibers. The optimum result acquired Fiber reinforced concrete is fixed to accomplish additional flexure strength in the concrete beam.

Bhaskar Dhiman et.al, reviewed attempts to study various applications and future trends of CFRP for structural applications worldwide. Through literature, we found CFRP significantly increases the life of structures, strengthened infrastructure, and minimized the maintenance requirements. Discrepancy related to tensile and compressive strengths of CFs observed in a significant amount. Therefore, integrated efforts may be used in the CFRP area to reduce the existing gap between theoretical and practically calculated tensile strengths, and work should be done to improve the compressive behavior of carbon fibers.

Deore et.al, studied the experimental investigation was performed to evaluate the strength of concrete, in which natural sand was partially replaced with waste foundry sand (WFS). Percentages of fibers were added with respect to weight of cement. Tests were performed for 30% replacement of sand by WFS with various percentages (0.25%, 0.50%, 0.75% and 1.0%) of carbon fiber for M30 grade concrete at different curing periods (3, 14 and 28 days). The maximum flexural strength 6.05 Mpa (3 days), 7.35 Mpa (14 days), 9.05 Mpa (28 days) were obtain at 30% replacement of sand by WFS with 0.75% carbon fiber addition in concrete. The optimal use of 30% WFS with 0.75% carbon fiber has a better mechanical property. The crack formation is very small in fiber specimen compare to the non fiber specimens. Higher amount carbon fiber decreases the bonding in the concrete with results in strength degradation.

II. MATERIALS USED

A. Cement

Cement used in this investigation was 43 Grade Ordinary Portland cement confirming to IS 8112/1989. The specific gravity of cement was 2.7. Initial and final setting time for the was 35 minutes and 560 minutes.

B. 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 2.6. 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 2.7 and 2.53 as per IS: 2386- 1968 Part III. Both the Aggregates compiled with the requirements of IS 383-1970.

C. Polypropylene (PP) Fiber and Carbon Fiber Property

Table 1 shows the properties of the Polypropylene (PP) Fiber and Carbon Fiber.

Table 1: Polypropylene (PP) Fiber and Carbon Fiber Property

Properties	Polypropylene	Carbon
Density	0.91g/cc	1.65g/cc
Length	12mm	10mm
Diameter	18 microns	7 microns
Aspect Ratio	666.67	1428.57

D. Water

Potable water which is available in laboratory is used for casting of specimen and as well as curing of specimen as per IS 456-2000.

E. Percentage Variation of Fibers in Mix

The proportions of fibers used in concrete mix percentage of polypropylene (PP) fiber at 0.5,1, 1.5, 2 and 2.5% volume fractions and carbon fibers at 1, 1.5, 2, 2.5 and 3% are added. Table 2 shows the details of the tested specimen designation.

Table 2: Specimen Designation

PP Fiber Content by Volume (%)	Carbon Fiber Content by Volume (%)	Specimen Designation
0%	0%	Conv
0.5%	1.0%	Mix-1
1.0%	1.5%	Mix-2
1.5%	2.0%	Mix-3
2.0%	2.5%	Mix-4
2.5%	3.0%	Mix-5

F. Concrete Mix Design for M25 Concrete (IS 10262:2009)

Stipulation for mix proportioning

Table 3: Stipulation for mix proportioning

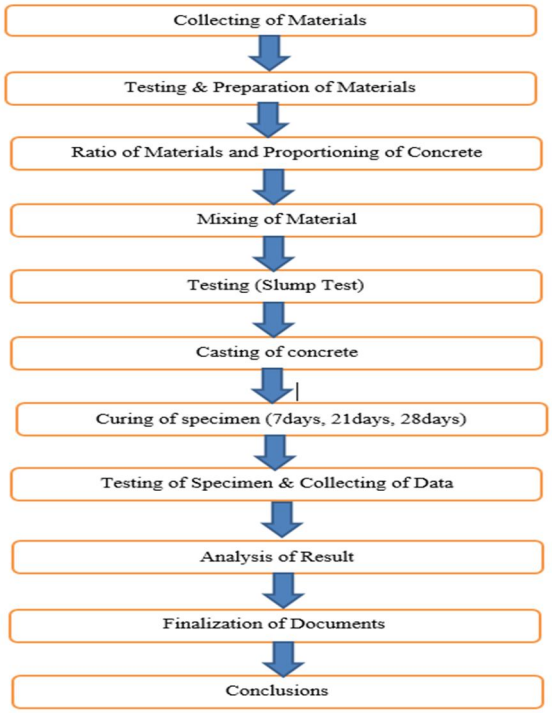
S.No	Content	Mix Proportion
1	Grade destination	M25
2	Type of cement	OPC 43 Grade
3	Maximum nominal size of aggregate	20mm
4	Minimum cement content	300kg/m^3
5	Workability	75mm
6	Exposure condition	Severe
7	Method of concrete placing	Normal
8	Degree of supervision	Good
9	Type of aggregate	Crushed angular aggregate
10	Maximum cement content	450kg/m^3

III. METHODOLOGY

A preliminary study on compressive strength, tensile strength and flexural using different proportions of fibers resulted in a varying ratio of the Polypropylene (PP) and Carbon fiber percent by volume of concrete. In the present study, experimental concrete cubes of size 150mm x 150mm, in thickness of 150mm and cylinder of diameter 150mm and height of 300mm, both with PCC (plain concrete) and fiber reinforced concrete with experimental fibers were cast and tested for compression, tensile for 7 and 28 days of curing. A concrete beam of size 150mm x 150mm x 500 mm were casted and tested for flexural strength after 7 ,21 and 28 days. fiber reinforced concrete can be in general produced using conventional concrete practice, though there are obviously some important differences. The basic problem is to introduce a sufficient volume of uniformly dispersed to achieve the desired improvements in mechanical behaviour, while retaining sufficient workability in the fresh mix to permit proper mixing, placing and finishing. The performance of the hardened concrete is enhanced more by fibers with a higher aspect ratio, since this improves the fiber-matrix bond. On the other hand, a high aspect ratio adversely affects the workability of the fresh mix. In general, the problems of both workability and uniform distribution increase with increasing fiber length and volume. fiber reinforced concrete can be placed adequately using normal concrete equipment.

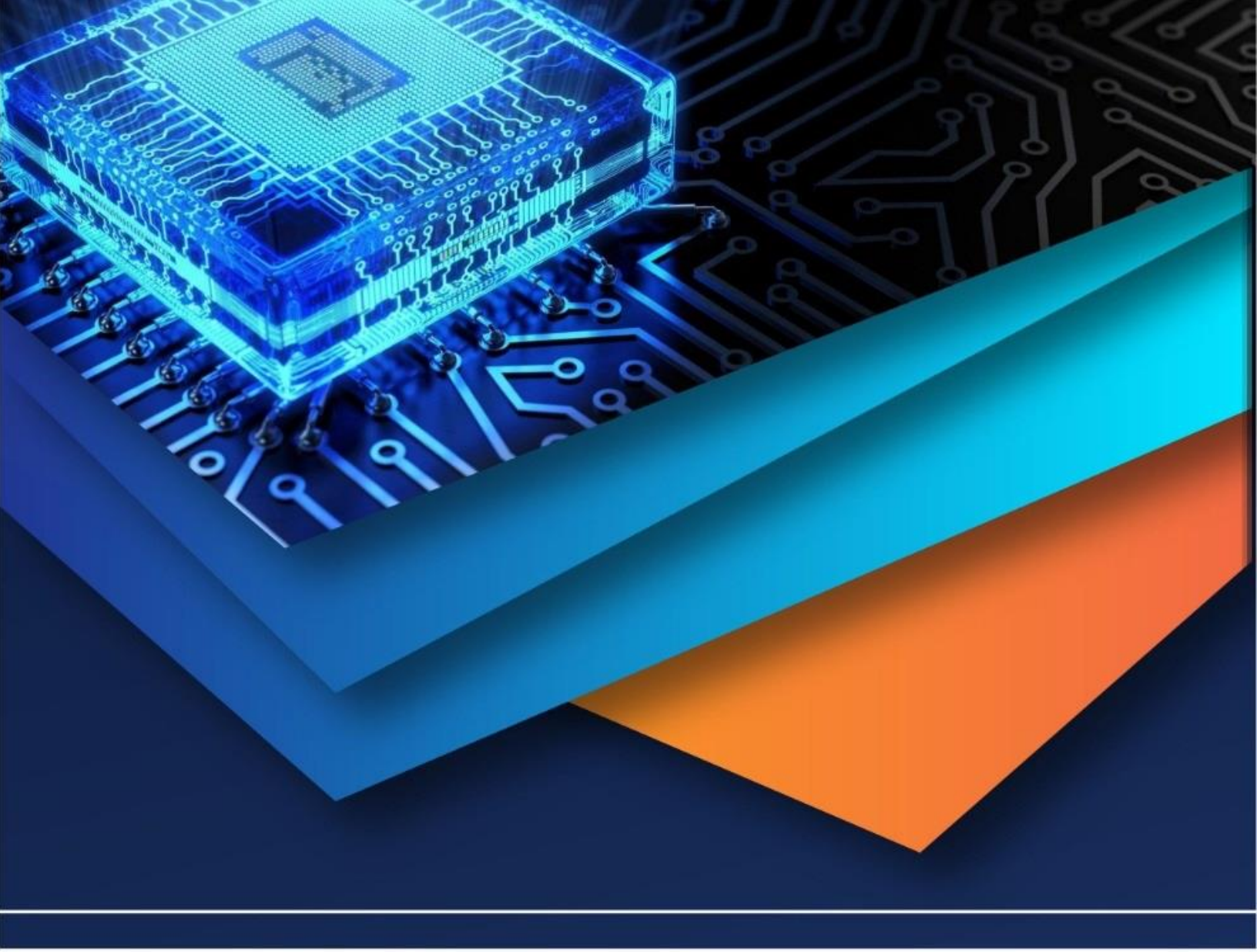
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It appears to be very stiff because the fibers tend to inhibit flow; however, when vibrated, the material will flow readily into the forms. It should be noted that water should be added to fiber reinforced concrete mixes to improve the workability only with great care, since above a w/c ratio of about 0.5, additional water may increase the slump of the fiber reinforced concrete without increasing its workability and place ability under vibration. The finishing operations with fiber reinforced concrete are essentially the same as for ordinary concrete, though perhaps more care must be taken regarding workmanship.



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