

An Experimental Study to Compare the Strength Characteristics of Concrete using Polypropylene Fiber and Polyester Fiber Admixtures

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ABSTRACT: This paper outlines an experimental study that compares the strength characteristics of polymer fiber concrete to the plain cement concrete. However the fiber polymers may serve as admixtures, which might result in certain changes in concrete, like low rate of water absorption, high-range water reduction, greater strength and goodness in elasticity. The parameters of investigation included fresh properties of different fiber reinforced concrete, compressive strength, split tensile strength and flexural strength. Various tests conducted on the standard concrete specimens with polypropylene and polyester fiber as admixtures in varying percentages, **0%, 0.3%, 0.5%, 0.7%, 0.9%, and 1.1%** of the total weight of the cement.

KEYWORDS: Polymer reinforced concrete, polypropylene fiber, polyester fiber, Compressive strength, Flexural Strength, Split tensile strength.

I. INTRODUCTION

Cement strong in compression but weak in tension and tends to be brittle. Because of the load and environmental changes, microcracks appear in cement products. Therefore cement based materials have low tensile strength and cause brittle failure. The weakness in tension can be overcome by the use of sufficient volume fractions of certain fibers. In order to improve the mechanical properties of concrete it is good to mix cement with fiber, which have good tensile strength, adding fibers to concrete greatly increases the toughness of the material. Thereby improving its toughness. Incorporation of polyester and polypropylene materials in concrete significantly improves its plastic settlement, thermal and shrinkage strains, and stress concentrations imposed by external restraints. Concrete develops micro cracks with curing and these cracks propagate rapidly under applied stress resulting in low tensile strength of concrete. Hence the addition of fibers improves the strength of concrete and these problems can be overcome by the use of Polypropylene and Polyester fibers in concrete. Application of Polypropylene and Polyester fibers provides strength to the concrete while the matrix protects the fibers.

Polyester is a synthetic fiber extracted from coal, air, and petroleum. Developed in a 20th century in the laboratory, polyester fibers are formed from a chemical reaction between an acid and alcohol. In this reaction, two or more molecules combine to make a large molecule whose structure repeats throughout its length. Polyester fibers can form very long molecules that are very stable and strong. Polyester is used in the manufacture of many products, including clothing, home furnishings, industrial fabrics, computer and recording tapes, and electrical insulation. Polyester has several advantages over traditional fabrics such as cotton. It does not absorb moisture, but does absorb oil; this quality makes polyester the perfect fabric for the application of water, soil, and fire resistant finishes. Its low absorbency also

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makes it naturally resistant to stains. Polyester clothing can be preshrunk in the finishing process, and thereafter the fabric resists shrinking and will not stretch out of shape.



Fig: 1.1 Polyester Fibers

Polypropylene and polyester fibers can't provide the primary reinforcement in a concrete pavement because of relatively low modulus and strength values when compared with steel fibers. Polypropylene fibers are used to provide secondary reinforcement, or the encouragement of a desired material behaviour such as decreased plastic and shrinkage cracking and improved toughness. Polypropylene fibers have been widely used in structural applications since the late 1950's and more recently in paving applications. Several manufacturers have been selling the fibers to improve the concrete's resistance to the formation of plastic shrinkage cracking and as secondary reinforcement as a replacement. Polypropylene fibers are mainly three different forms, they are monofilament polypropylene fibers, Multifilament polypropylene fibers and Fibrillated polypropylene fibers. Monofilament fibers having single strand and uniform cross sectional area. Multifilament fiber consists of number of continuous strands. Fibrillated fibers are manufactured fibers are in the form of tapes or films.



Fig: 1.2 Polypropylene Fibers

This is an environmental friendly approach in the field of pavement construction as almost all sorts of polymer waste can be recycled and used as a reinforcing admixture in the concrete pavement polymeric fibers normally used are polypropylene & polyester it should be 100% virgin synthetic fiber size 12mm long and 0.45mm diameter. It shall be mixed at the rate of 0.3%, 0.5%, 0.7%, 0.9%, and 1.1% by weight of cement.

The primary role of fibers in cementations composite is to control cracking, increase the tensile strength, toughness and to improve the deformation characteristics of the composite. The performance of FRC depends on the type of the fibers used. Inclusion of polypropylene fibers reduces the water permeability, increases the flexural strength due to its high modulus of elasticity. In the post cracking stage, as the fibers are pulled out, energy is absorbed and cracking is reduced. Polypropylene fibers are resistant to most chemical attacks. Its melting point is high (about 165 degrees centigrade). So that it can withstand a working temperature, as (100 degree centigrade) for short periods without detriment to fiber properties. Polyester is a state of art reinforcing material which is used to increase the strength in a variety of

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applications like automotive battery, paper, filtration fabrics, and asbestos cement sheets, cement based pre-cast products and for improving quality of construction.

This is an environment friendly approach in the field of pavement construction as almost all sorts of polymer waste can be recycled and used as a secondary reinforcing admixture in the concrete pavements. Polymers waste produced in large quantities is non biodegradable; they can lead to cause environmental issues. Instead of disposing it, we can efficiently make use of its properties in the pavement construction.

II. LITERATURE REVIEW

S.A Kanalli, Ramu Palankar, Bharath Kumar, Praveen Kumar, Prakash S.K in Comparative study of polymer fibre reinforced Concrete with conventional concrete pavement, International Journal of Research in Engineering and Technology has shown the difference between the strengths of concrete with polypropylene and conventional concrete. Kolli.Ramujee, "strength properties of polypropylene fiber reinforced concrete" international journal of innovative research in science, engineering and technology showed the mechanical properties of the polyester and polypropylene fibers and also shows the strength properties of the polypropylene fiber.

III.METHODOLOGY

A preliminary study on compressive, tensile and flexural strengths using different proportions of polypropylene and polyester fibers resulted in a varying ratio of fiber dosage of 0.2% by weight of cement. In the present study, experimental concrete cubes of size 150mm x 150mm x 150mm and cylinder of diameter 150mm and height of 300mm, both with PCC (plain concrete) and FRC (fiber reinforced concrete) were cast and tested for compression, tensile for 7 and 28 days of curing. The short term compressive strength test was carried out to study if there is any reduction in strength due to possible degradation of the fibers in the concrete's alkaline environment. A concrete beam of size 150mm x 150mm x 700 mm were cast and tested for flexural strength after 28 days.

- Cement: Ordinary Portland Cement (53 grade) with a specific gravity of 3.12 was used for this experimental investigation. No significant variations were observed in the trends of the experimental results. Hence, 53-grade ordinary Portland cement was used in construction work.
- Fine Aggregate: Locally available sand having a density of 1483 kg/m³ and fineness modulus of 3.417 was used. The specific gravity was found to be 2.65 the fine aggregate was found to be confirming to zone-II as per Is 383:1970.
- Coarse Aggregate: Natural granite aggregate having a density of 1520 kg/m³ and fineness modulus (FM) of 9.343 was used which is available in local quarries. The specific gravity was found to be 2.85 and the aggregate passing from IS Sieve 20mm and retaining on IS Sieve 12.5mm was used.
- Water: Locally available water, which is free from the concentration of acid or organic substances, was used for mixing the concrete.
- Fiber: Fiber is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fiber is the ratio of its length to its diameter. The typical aspect ratio ranges from 30 to 150. Fibers may generally be classified into two: organic and inorganic. Inorganic fibers include steel fibers and glass fibers, whereas organic fibers include natural fibers like coconut, sisal, wood, bamboo, jute, sugarcane, etc. and synthetic fibers based on acrylic, carbon, polypropylene, polyethylene, nylon, and polyester.
- Polypropylene Fiber: Polypropylene is one of the cheapest and abundant available polymers. Polypropylene fibers are resistant to most chemical attacks. Its melting point is high. So that it can withstand a working temperature, as (100 degree centigrade) for short periods without detriment to fiber properties.
- Polyester Fiber: Polyester is a state of art reinforcing material which is used to increase the strength in a variety of applications like automotive battery, paper, filtration fabrics, and asbestos cement sheets, cement based pre-cast products and for improving quality of construction.

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Design stipulation:

- Characteristic compressive strength - 20 N /mm²
- Max size of aggregate - 20 mm (angular)
- Degree of workability - 0.9 compacting factor
- Degree of quality control - good
- Type of exposure - mild
- Type of aggregate - crushed angular
- Type of compaction - vibration

Test data for materials:

- Cement used OPC - 53 grade
- Specific gravity of cement - 3.12
- Specific gravity of fine aggregate - 2.65
- Specific gravity of coarse aggregate - 2.85
- Bulk density of sand - 1483 kg/m³
- Bulk density of coarse aggregate - 1520 kg/m³
- Fineness modulus of sand - 3.417
- Grading Zone of sand - Zone II

Design of concrete mix:

- Target mean strength (f) - $f_{ck} + t.s = 20 + (1.65 \times 4) = 26.6 \text{ N/ mm}^2$
- Water-cement ratio - 0.47
- Water content - 186kg/m³
- Sand content (ρ) - 31.5%

Table 1 shows obtained mix design calculated as per the standards. The standards are considered from IS 456: 2000. The third row of the table represents the different weights of the material in ratio and the water content in percentage weight of cement. The mixing of concrete is done by weigh batching using electronic weighing machine.

Table 1: Mix Design

Water	Cement	Fine Aggregate	Coarse Aggregate
186 lit	395kg	629.23 kg	1185.01 kg
0.47069	1	1.59129	2.994428

IV.RESULTS

The table below indicates the results of compressive, flexural and split tensile strengths for nominal concrete specimens.

Table 2: Strength of nominal mix concrete

Compressive strength (N/mm ²)		Split tensile strength (N/mm ²)	Flexural strength(N/mm ²)
7 days	28 days	28 days	28 days
16.31	24.36	3.175	3.62

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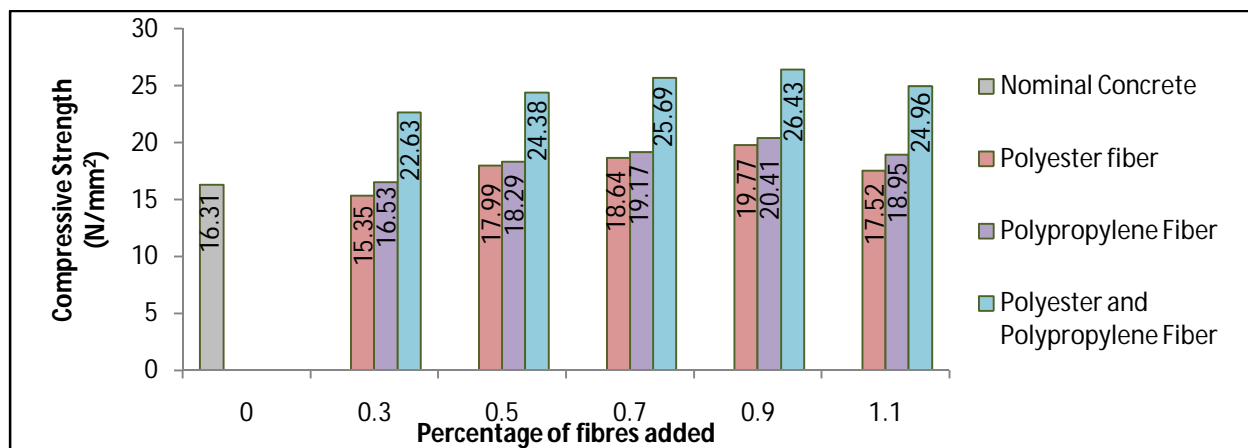
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The following table indicate the results of compressive strength of cubes with addition different percentages of fibers.

Table 3: Compressive Strength of Cubes

S. No	Name of Fibers	% of fibers added	Compressive strength (N/mm ²)	
			7 days	28 days
1	Polyester fiber	0.3	15.35	30.32
		0.5	17.99	33.21
		0.7	18.64	34.06
		0.9	19.77	35.22
		1.1	17.52	32.75
2	Polypropylene fiber	0.3	16.53	31.55
		0.5	18.29	33.67
		0.7	19.17	34.08
		0.9	20.41	36.08
		1.1	18.95	34.87
3	Polypropylene and Polyester fibers (in equal proportions)	0.3	22.63	34.62
		0.5	24.38	36.16
		0.7	25.69	36.85
		0.9	26.43	37.54
		1.1	24.96	36.24

The results above are obtained by testing the concrete for compression in compression testing machine. The analysis of the above results can be done through the following graphical representations. Graph 1 represents the compressive strengths of cubical specimens mixed with different percentage of polymers cured for 7 days.



Graph 1: Compressive strength of cubes for 7 days

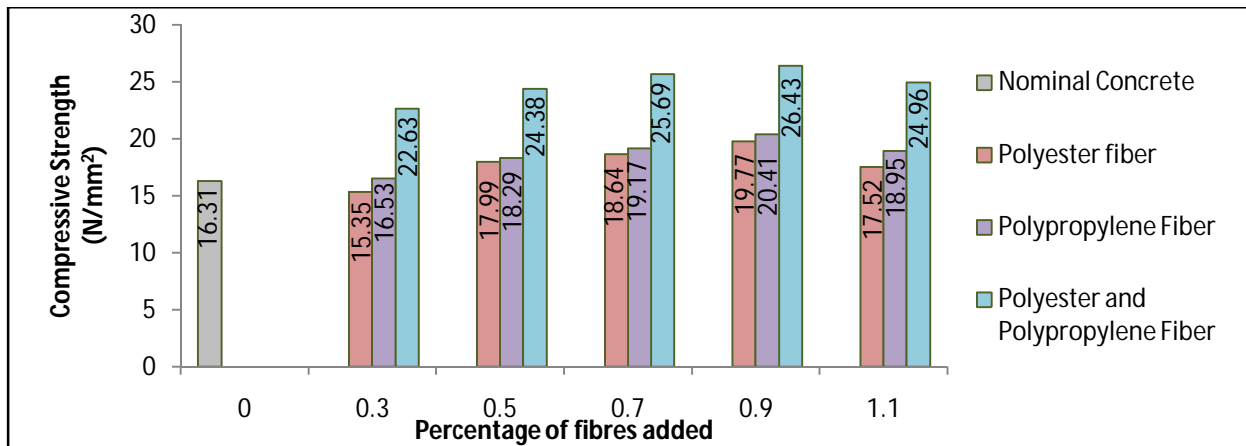
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Graph 2 represents the compressive strengths of cubical specimens mixed with different percentage of polymers for 28 days. The graphical representation is the comparative report between concrete mixed with polymer fiber admixtures and nominal concrete.



Graph 2: Compressive strength of cubes for 28 days

Test results for split tensile strength of concrete:

The following table indicate the results of split tensile strength of cylinders with addition different percentages of fibers as mentioned below.

Table 4: Split Tensile Strength of Cylinders

S. No	Fibers	% of fiber added	Split tensile strength (N/mm ²)	
			7 days	28 days
1	Polyester fiber	0.3	2.2	2.99
		0.5	2.8	3.00
		0.7	3.075	3.035
		0.9	3.435	3.85
		1.1	3.25	3.38
2	Polypropylene fiber	0.3	2.12	3.05
		0.5	2.65	3.135
		0.7	2.635	2.95
		0.9	3.485	3.235
		1.1	3.1	2.89
3	Polypropylene and Polyester fibers (in equal proportions)	0.3	2.95	3.12
		0.5	3.08	3.195
		0.7	3.145	3.24
		0.9	3.685	3.58
		1.1	3.21	3.25

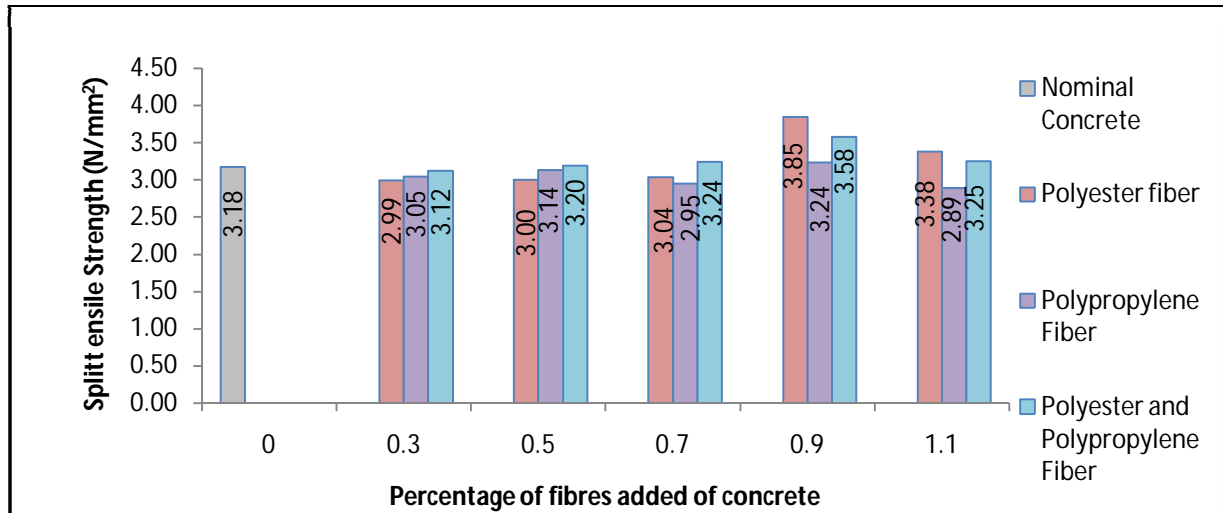
The results above are obtained by testing the concrete for split tensile strength in compression testing machine. The analysis of the above results can be done through the following graphical representation. Graph 3 represents the compressive strengths of cylindrical specimens mixed with different percentage of polymers cured for 28 days.

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Graph 3: Splitting tensile strength of cylinders for 28 days

Test results for flexural strength of concrete:

The following table indicate the results of flexural strength of beams with addition different percentages of fibers as mentioned below. It is observed that there is a considerable increase in flexural strength up to 0.9% of poly ester, poly propylene and the mixture of both polymers and decreased for further increase in the quantity of polymers.

Table 5: Flexural Strength of Beams

S. No	Fibers	% of fiber added	Flexural strength (N/mm ²)	
			Load (kN)	28 days
1	Polyesterfiber	0.3	235.265	3.328
		0.5	242.866	3.435
		0.7	269.606	3.814
		0.9	279.469	3.953
		1.1	268.268	3.795
2	Polypropylene fiber	0.3	242.241	3.427
		0.5	259.296	3.668
		0.7	249.469	3.529
		0.9	261.227	3.695
		1.1	258.289	3.654
3	Polypropylene and Polyester fibers (in equal proportions)	0.3	264.326	3.739
		0.5	270.606	3.828
		0.7	275.674	3.899
		0.9	279.140	3.949
		1.1	267.958	3.790

The results above are obtained by testing the concrete for flexural strength in compression testing machine. The analysis of the above results can be done through the following graphical representation. Graph 4 represents the

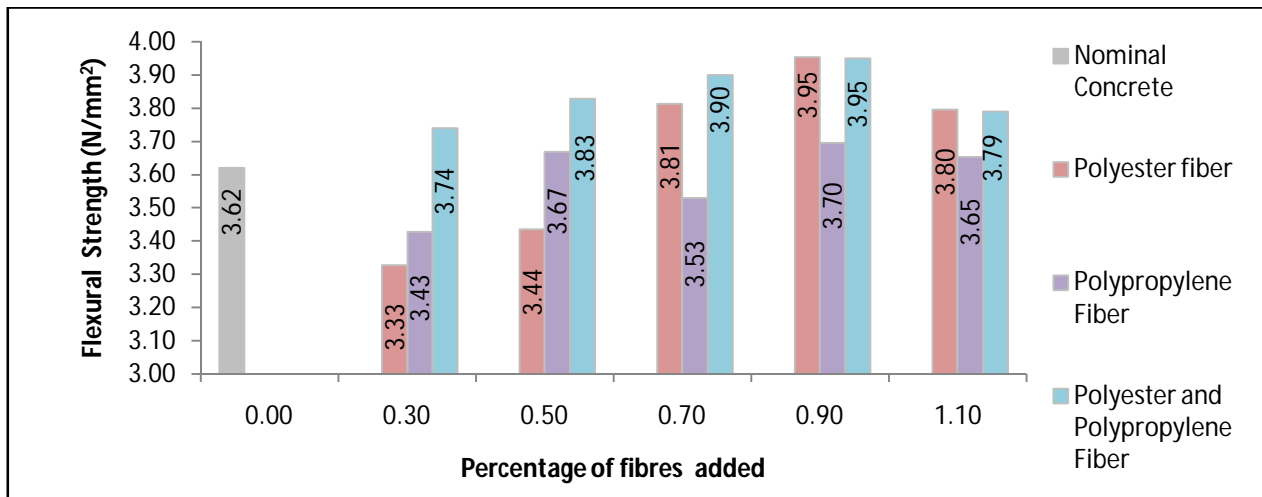
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flexural strengths of specimen casted in the form of beams mixed with different percentage of polymers cured for 28 days.



Graph 4: Flexural strength of beams for 28 days

V. CONCLUSION

Higher compressive strength is obtained at 0.9 % of polyester fiber, 0.9% of polypropylene fiber and 0.9% of polyester and polypropylene fiber added to concrete. Higher split tensile strength is obtained at 0.9 % of polyester fiber, 0.9% of polypropylene fiber and 0.9% of polyester and polypropylene fiber added to concrete. Higher Flexural Strength is obtained for 0.9 % of polyester fiber, 0.9% of polypropylene fiber and 0.9% of polyester and polypropylene fiber added to concrete.

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