A Comparison Study on Mechanical Properties by Using Polyesters and Polypropylene Fiber Concrete

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***Abstract*—Right now, concrete is used in the greatest volume of construction projects, and the near future, there won't be any other options available. It is necessary to develop better quality concrete that will survive longer and have increased mechanical qualities to extend the service life of any structure since enormous volumes of concrete are being utilised for new construction work. It is not possible to change its innately breakable nature or the requirement for any concrete structure's tensile strength. Fiber-reinforced concrete (FRC) appears to be a feasible substitute under these circumstances. The practical application of polyester and polypropylene fibre (pp) as secondary reinforcement in concrete to alter its brittle properties is the main topic of this research paper. The M40 grade of concrete was employed in this investigation. As a result, different proportions of polyester and polypropylene fibre were added to the concrete. such as 0.32, 0.37, 0.42, and 0.47 by the concrete's weight, in that order. To investigate the usage of polyester and polypropylene fibre in concrete, a series of controlled lab tests were conducted. For compressive and flexural strength, only the basic concrete mix is evaluated in the first sample. The second sample is evaluated for compressive strength and flexural strength again after 0.32, 0.37, 0.42, and 0.47%, respectively, of polypropylene fibre, are added to the concrete mix. The polyester and polypropylene fibres were tested in the third concrete sample in the same way. which demonstrates how adding fibre to concrete can raise its quality.**

Keywords— Polyester Fibre, Fiber Reinforcement, Fibres, Polypropylene Fibre, Compressive Strength, Flexural Strength, Optimum Percentage, Split Tensile Strength.

I. INTRODUCTION

Because of its strength, adaptability, and durability, concrete is one of the most commonly used building materials. However, traditional concrete does have its limitations, including susceptibility to cracking and low tensile strength. In recent years, researchers and engineers have been exploring innovative ways to enhance concrete's properties through the incorporation of various fibres. Polyester and polypropylene are particularly promising among these fibres as additions to enhance concrete performance.

Polyester and polypropylene fibres are synthetic materials commonly used in various industries due to their excellent mechanical properties, chemical resistance, and affordability. When incorporated into concrete, these fibres act as reinforcement, mitigating cracking and improving tensile strength, ductility, and durability.

Polyester fibres, derived from polyethene terephthalate (PET), offer several advantages when used in concrete. These fibres are known for their high tensile strength, resistance to alkalis and acids, and low water absorption rate. When mixed into concrete, polyester fibres help control shrinkage cracking by distributing stress more evenly throughout the material. Additionally, they enhance the flexural and impact resistance of concrete structures, making them suitable for a wide range of applications, including pavements, overlays, and precast elements.

Polypropylene fibres are another popular choice for reinforcing concrete. These fibres, made from polypropylene resin, offer excellent resistance to chemical attacks, moisture, and abrasion. In concrete, polypropylene fibres improve toughness and reduce plastic shrinkage cracking, particularly in applications such as industrial floors, shotcrete, and architectural elements. Furthermore, they enhance the freeze-thaw resistance of concrete, making it suitable for harsh environmental conditions.

II. MATERIALS USED

A. M40 Design mix concrete

To make a proper mix of fibre-reinforced concrete, the following materials are to be used:

1. Cement

The local market provided the 53 grade of Ordinary Portland Cement (OPC), Ultratech brand, which was used in this investigation. When water is added to cement, an artificial substance that is often found in powder form, it can be transformed into a paste that solidifies when it is poured or moulded.

Table No 1 Physical Properties of OPC

No	Properties	Value
1	Specific Gravity	3.11
2	Normal Consistency	28%

3	Initial Setting time	60min
4	Final Setting time	280 min
5	Bulk Density	835-1655 kg/m^3
6	Soundness	2.5mm
7	Fineness	330 kg/m^2

2. Sand

Granular material that occurs naturally is called fine aggregate. Particles of mineral and finely divided rock are collected to make sand. In continental inland environments and non-tropical coastal environments, silica (SiO2), typically quartz, is the primary component of sand. It is the most prevalent weather-resistant mineral. It is a fine aggregate that is utilised in mortar and concrete. Sand is a mixture of mineral particles that are left over after rocks break down. Only the size of the grains or particles distinguishes sand from gravel; clays, on the other hand, include biological components. When water currents flow across dry regions and separate sand from organic material, the grains of the sand are typically quite consistent in size. Typically, riverbeds and dunes created by wind are the sources of commercial sand.

3. Coarse Aggregate

For this experiment, crushed stone aggregate with particles smaller than 20 mm was utilized. According to IS 2386:1963 (PART 3), the coarse aggregate's specific gravity was determined to be 2.89. Aggregates, or immovable granular elements like gravel, sand, or crushed stone mixed with water and standard Ordinary Portland Cement, are the main ingredients of concrete. The aggregate must be well-cleansed and comprise strong, hard particles devoid of absorbed chemicals and other fine particles that could stop concrete from degrading to be combined into a concrete mix. Aggregates come in two primary varieties: fine and coarse. Between 60 and 75 per cent of the volume of concrete is composed of aggregates. The remaining coarse aggregate in concrete is mostly composed of crushed stone, with gravel making up the majority of the coarse aggregate. Twenty-millimetre coarse aggregate was employed in this investigation.

4. Fiber

Polyester and polypropylene were the types of fibre employed in this investigation. The surface of these fibres is hydrophobic. By adding these fibres as reinforcement, concrete's permeability and shrinkage resistance are reduced, and its tensile and compressional strengths are strengthened. Polyester and polypropylene (PP) fibres were used in this investigation.

a) Polypropylene fibre: Polypropene, or PP, is another name for polypropylene fibre-reinforced concrete, or PFRC. It is a synthetic fibre that is made from propylene and is utilized in many different industries, including buildings. These fibres are typically utilised in concrete to control soaking and plastic shrinkage-related cracking. Additionally, they lessen the permeability of the concrete, which lessens water seepage. Polypropylene fibre is nonpolar and partly crystalline, and it is a member of the polyolefin family. Though it is a stronger and more heat-resistant substance, it shares many of the same qualities as polyethene. It is a strong, white substance that is very resistant to chemicals. Propylene gas is converted to polypropylene by adding a catalyst, such as titanium chloride. Polypropylene fibre exhibits strong resistance to acids, alkalies, and organic solvents, along with good heat-insulating qualities.

Figure 1. Polypropylene Fiber

b) Polyester fibre: For precast constructions, polyester fibres are utilised in fibre-reinforced concrete (FRC). Polyester micro and macro fibres are added to cement concrete to improve toughness and, when appropriately constructed, to give greater resistance against the formation of plastic shrinkage fractures in comparison to welded wire fabric. In this work, the mechanical qualities of cement concrete pavement are improved by the use of polyester fibre as reinforced material.

Figure 2. Polyester Fiber

Table No 2 Physical Properties of Fiber

No	**Properties**	**Polyester Fiber**	**Polypropylene Fiber**
1	Shape	Triangular	Triangular
2	Cost Length (mm)	12	12
3	Dia (Micron)	30-35	34
4	Specific Gravity	1.34	0.91
5	Melting Point (Degree. c)	250-265	160-165
6	Tensile Strength (kg/cm2)	4000-6000	4000-6000
7	Alkali Resistance	Very Good	Very Good
8	Electrical Conductivity	Low	Low

9	Thermal Conductivit y	Low	Low
10	Acid and salt Resistance	Excellent	Excellent

5. Water

The water used to make concrete ought to be pure, drinkable, and devoid of contaminants. It is generally advised to use potable water when mixing concrete. Hazardous materials or excessive levels of contaminants that could negatively impact the concrete's qualities shouldn't be present in the water. For concrete, the water-to-cement ratio was 0.40.

6. Superplasticizer Admixture

A class of additives called superplasticizers is added to concrete to enhance workability and efficiency. Another name for them is high-range water reducers. To reduce the amount of water required to obtain a specific workability level without compromising the strength or longevity of the concrete, these ingredients are used with the mixture.

Table No 3 M40 design mix proportion

No.	Material	Quantity
1.	Cement	415 kg/m³
2.	Water	166 kg/m³
3.	Fine Aggregate	803 kg/m³
4.	Coarse Aggregate- 20mm	719 kg/m³
5.	Coarse Aggregate- 10mm	383 kg/m³
6.	Chemical Admixture	3.53 kg/m³
7.	W/C ratio	0.40

A. Test of specimens

Concrete cubes, cylinders, and beams were cast and tested following IS code specifications. The M40 concrete mix was used, and the percentages of fibres ranged from 0% to 0.32%, 0.37%, 0.42%, and 0.47%. The following were utilized: 150 mm x 150 mm x 150 mm nominal concrete cubes, 150 mm diameter and 300 mm long concrete cylinders, and 150 mm x 150 mm x 700 mm nominal concrete beams. When the specimens were cast, a mixture of fibres was added to the concrete, making sure that the fibres were evenly dispersed throughout the mixture. To look for differences in split tensile, compressive, and flexural strength, tests were performed on concrete cubes with varying fibre percentages. Nine beams of M40 mix, nine cylinders, and three sets of nine cubes were cast without fibres. Afterwards, distinct sets of cylinders, beams, and cubes were cast with different fibre content ratios of 0.42%, 0.37%, 0.42%, and 0.47%. After that, the specimens were moved into a curing tank to undergo the necessary tests and curing times.

1. *Compressive strength of concrete cube*

Concrete cubes measuring 150 x 150 x 150 mm were measured for compressive strength following IS516. The cube and the loading frame were not separated by any packing material. With no shock, the load was introduced gradually. Cubes were tested for compressive strength at 7, 14, and 28 days of curing. The results are graphically represented in Figure 3 and summarized in Table 5.

2. *Splitting tensile test of concrete*

The splitting tensile strength of 150 mm diameter and 300 mm length cylinders was tested by IS 5816. To make sure that all of the cylinders were in the same plane, symmetric lines were drawn on them. The strength of splitting tensile was assessed following 7, 14, and 28 days of curing. Table 6 displays the results that have been tabulated, whereas Figure 4 displays the data as a graphical representation.

3. Flexural Strength of Concrete

According to IS516, the flexural strength of the beam (150 mm x 150 mm x 700 mm) cast is calculated at 7, 14, and 28 days of curing age, respectively. There is neither shock nor vibration when the load is supplied gradually. The beams' flexural strength was assessed after 7, 14, and 28 days of cure. Table 7 presents the tabulated results, whereas Figure 5 shows the graphical depiction of the data.

IV. Results and Discussions

A. *Compressive Strength of cube test results*

Table No 4: Normal Concrete

M40 Concrete	Compressive Strength
7 days	34 .42 N/mm²
28 days	47.06 /mm²

Table No 5: Compressive result (N/mm²)

Fibres	0.32%	0.37%	0.42%	0.47%
Polyester	53.65	55.19	56.88	54.13
Polypropylene	55.53	57.05	58.91	56.18

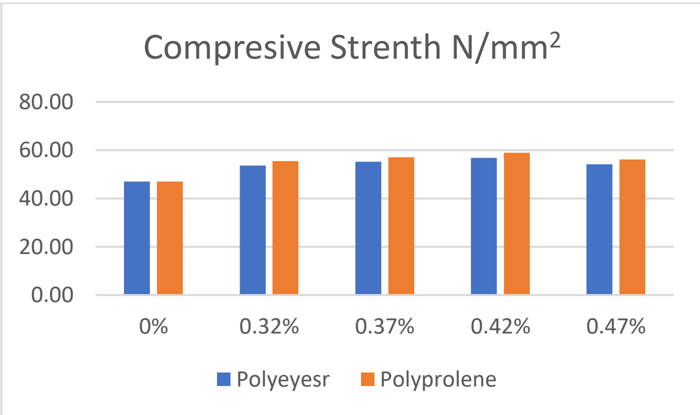

Figure 3.

The 28-day compressive strength of the cube for normal concrete is obtained as 47.06N/mm². From the above table, it is understood that for all percentages of Polyester and Polypropylene fibres, The optimum result in both fibres at 0.42% fibres added in concrete. The result was an increase of 20.86 % compressive strength with added 0.42% Polyester and Polypropylene fibres in concrete.

B. *Split tensile strength of cylinder test result*

Table No 6: Split tensile result(N/mm²)

Fibres	0.32%	0.37%	0.42%	0.47%
Polyester	4.75	5.04	5.42	5.12
Polypropylene	4.31	4.69	4.89	4.77

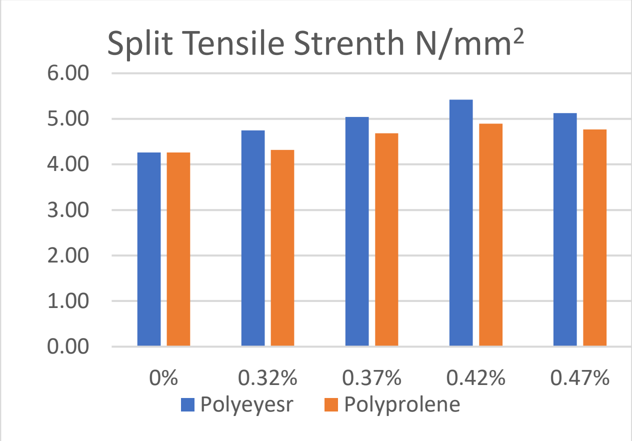

Figure 4.

The 28-day Split tensile strength of the cylinder for normal concrete is obtained as 4.26 N/mm². From the above table, it is understood that for all percentages of Polyester and Polypropylene fibres, The optimum result in Polyester and Polypropylene fibre at 0.42% fibres added in concrete. The result was an increase of 27.23% Split tensile strength with added 0.42% Polyester and Polypropylene fibres in concrete.

C. *Flexural strength of beam test result*

Table No 7: Flexural Strength of beam result (N/mm²)

Fibres	0.32%	0.37%	0.42%	0.47%
Polyester	6.88	6.97	8.06	7.37
Polypropylene	5.74	6.05	7.10	6.15

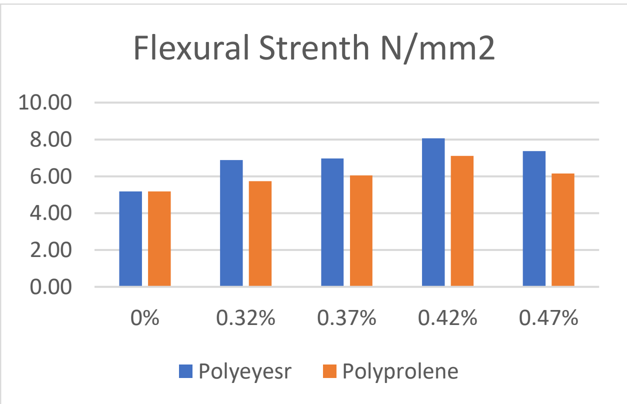

Figure 5.

The 28-day Flexural strength for normal concrete is obtained as 5.18 N/mm². From the above table, it is understood that for all percentages of Polyester and Polypropylene fibres, The optimum result in Polyester and Polypropylene fibre at 0.42% fibres added in concrete. The result was an increase of 37.06% in Flexural strength with added 0.42% Polyester and Polypropylene fibres in concrete.

D. Cost Comparison

When M40 grade concrete was used, fibre was added to the concrete in proportion to the weight of the concrete. Then we find that 0.42% of fibre increases compressive, split tensile and flexural strength. Hence it can be said that when 0.42 percent fiber is added in concrete. Then there is an increase in all three strengths. And making fibre-reinforced concrete is 8 to 10 % more expensive than normal concrete.

V. CONCLUSIONS

The addition of fibre from synthetic to concrete is studied. Fibres added to concrete are polyester and polypropylene fibres are added in 0.32%, 0.37%,0.42% and 0.47% with 0.40 water-cement ratio and compression, split tensile, and flexural test is conducted. The summarised points that the experimental study revealed after polyester and polypropylene fibre are added are:

- The addition of Polyester and Polypropylene Fibers showed a maximum rise of 58.91 N/mm² in compressive strength at 0.42%, which is 20.86% more than the Standard concrete mix.
- A Concrete with Polyester and Polypropylene Fiber has a rise of 5.42 N/mm² in Split tensile strength at 0.42%, 27.23% more than the normal concrete tensile result.
- In the flexural strength concrete with Polyester and Polypropylene fibre has risen to 8.06 N/mm² at 0.42%, 37.06% more than the normal concrete flexural result.
- Based on research results 8 to 10% cost increase compared to normal concrete.

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