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STUDY OF STRENGTH OF CONCRETE USING POLYPROPYLENE FIBER

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Abstract: The effects of adding different amounts of polypropylene fibers to high strength concrete are the subject of this research. To investigate its impacts on compressive, tensile, and flexural strength under various curing conditions, an experimental program was conducted. The primary goal of the research program is to determine the ideal polypropylene fiber concentration by examining the effects of a variety of fiber mixes, including those with contents of 1%, 1.5%, and 2%. The mechanical properties of concrete, notably cube compressive strength, split tensile strength, and flexural strength, were investigated on concrete specimens at varying age levels. A thorough analysis was done to determine the curing conditions Half of the concrete examples were allowed to cure naturally in the open air, while the other half were kept inside a curing tank. When the curing specimens grew stronger throughout the course of the day, the concrete specimens initially exhibited notable strength despite their uneven curing. There was a noticeable improvement in the flexural, tensile, and compressive strengths. Nonetheless, it was strongly advised that more research be done to fully comprehend the mechanical characteristics of fiber-reinforced concrete.

Index Terms – Concrete, mix design, polypropylene fiber, compressive, tensile, and flexural strength

1.0 INTRODUCTION

Synthetic fiber composed of the polymer polypropylene is called polypropylene fiber. It is renowned for being adaptable, strong, and impervious to abrasion, chemicals, and dampness. Because of its advantageous qualities, polypropylene fibers are employed in many different industries for a wide range of purposes. Here is a brief rundown of polypropylene fiber. For a structure to last the length of its service life with little maintenance, it must be able to resist weathering, chemical assault, abrasion, and other degrading processes in addition to stress. Although concrete has numerous advantages in terms of its mechanical qualities and cost-effectiveness when building, its brittleness is a major drawback for earthquake and other applications that call on the material's flexible behavior. But now that PFRC, or polypropylene fiber-reinforced concrete, has been developed, a technological foundation for overcoming these shortcomings has emerged. This research presents a review of the effects of polypropylene (PP) fibers on the workability, compressive strength, tensile strength, and fresh and hardened concrete. There are many applications for polypropylene fiber in the production of concrete mixtures, such as self-compacting concrete and stiff pavement. The polypropylene concrete that had been shaped into 12 cylinders, 12 beams, and 24 cubes was tested for split tensile and compressive strengths after 7 days.

2.0 NEED OF THE STUDY

Understanding the properties, structure, and behaviour of polypropylene fibers contributes to advancements in material science. This includes research into its mechanical, thermal, and chemical properties, as well as its potential applications. Polypropylene Fibers are widely used in the textile industry for manufacturing various types of fabrics. Researching these fibers aids in the creation of novel textile products as well as the improvement of fabric performance, durability, and quality. Concrete is frequently reinforced with polypropylene fibers to increase its durability, strength, and resistance to cracking. Research in this area focuses on optimizing fibre characteristics and concrete mix designs for better performance.

Studying polypropylene fibres is essential for advancing various fields, including material science, textiles, construction, environmental science, medicine, and packaging, leading to innovations in product development, sustainability, and performance.

3.0 METHODOLOGY

3.1 Materials required

a) Cement: - 43 grades of regular Portland cement are used.

b) Fine Aggregate: - Well graded and normally weight zone II is used.

c) Coarse Aggregate: - Gravel that has been graded properly is typically utilized as coarse aggregate. Aggregate sizes used are 20 mm (Comprising 70% of the total weight of the aggregate) and 10 mm (30 % of the total weight of the aggregate).
d) Polypropylene fiber: – Polypropylene fibers added to concrete enhance its durability by reducing cracking and increasing impact resistance. They improve the overall toughness and longevity of concrete structures, particularly in harsh environmental conditions.

3.2 Mix Design

The proportions of the different ingredients must be set to give the strength and durability qualities required for the design of an M25 grade concrete mix. A concrete mix that normally possesses a compressive strength of 25 (MPa) after 28 days of curing is referred to as M25 grade concrete. This is a general overview of the M25 grade concrete mix design procedure. It is significant to remember that mix design procedures can change depending on regional norms, the availability of resources, and particular project needs. Ensuring the successful design of M25 grade concrete mixes can be achieved by consulting pertinent codes and guidelines and getting advice from knowledgeable concrete technologists.

Table 4.1: Proportion for M25

Cement	Fine aggregate	Coarse aggregate	Water
395 kg/m3	757 kg/m3	1023 kg/m3	197 kg/m3
1	1.86	3.29	0.42

3.3 Casting of specimen

Concrete can be strengthened, made more durable, and resistant to cracking by adding polypropylene fibers. The basic procedure for adding polypropylene fibers to concrete to reinforce it is as follows:
1) Concrete Mix Design: Begin with a carefully thought-out concrete mix that satisfies the necessary durability and strength requirements. Cement, aggregates, water, and any required admixtures should all be included in this combination.
2) Selection of material Polypropylene Fibers: Prior to choosing the material and proportion of polypropylene fibers, ascertain the desired qualities of the concrete. The fibers have varying sizes, are shaped, and are stretched. Usually, the dosage falls between 0.1% and 1% of the concrete's volume.
3) Mixing: Add the polypropylene fibers to the concrete mixture while it is still mixing. Make sure the fibers are well distributed throughout the mixture to produce consistent reinforcing.
4) Batching: Measure the correct number of polypropylene fibers according to the desired dosage and add them to the concrete mixer along with other ingredients.
5) Mixing Procedure: Mix the concrete thoroughly according to standard procedures, ensuring that the polypropylene fibers are uniformly distributed and well-dispersed within the mixture.
6) Testing: Test the fiber-reinforced concrete to determine its strength characteristics. It is common practice to do tests for compressive, flexural, and split tensile strengths.
7) Curing: After casting the concrete specimens, follow appropriate curing procedures to promote hydration and strength development. Adequate curing is essential for achieving optimal concrete properties.
8) Evaluation and Optimization: Utilizing testing and observation, assess the fiber-reinforced concrete performance.
9) Quality Control: To guarantee consistency and dependability in the functioning of the fiber-reinforced concrete, implement quality control procedures at every stage of the production process

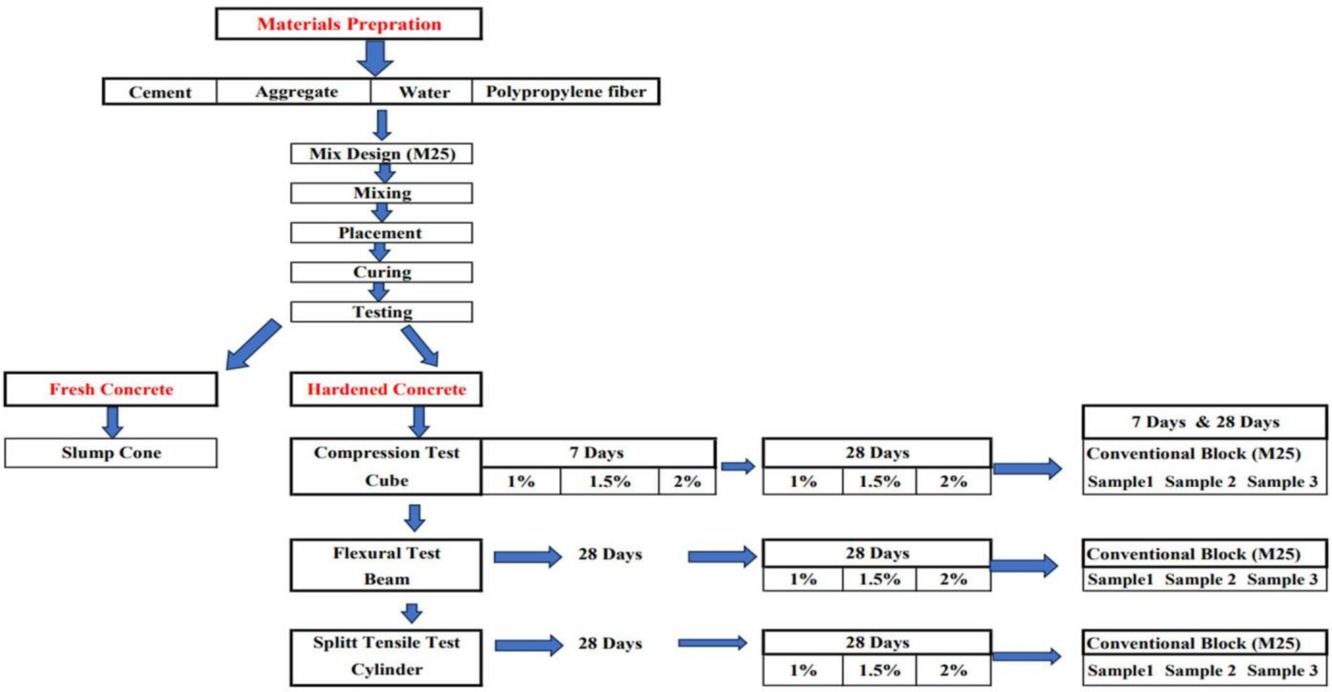


fig 3.1: Flow chart of methodology

4.0 Laboratory Experiments: -

4.1 Test on fresh concrete

The slump cone test and other experimental tests on freshly mixed concrete are essential for determining the consistency and workability of concrete mixtures. Here are some additional experimental tests commonly conducted alongside or instead of the slump cone test. To guarantee that concrete mixes fulfil required performance standards in terms of workability, strength, durability, and other attributes, these experimental investigations are helpful to concrete producers, engineers, and contractors. To attain the intended results in a variety of building projects, they are essential in optimizing concrete mix designs and construction techniques.

4.2 Test on hardened concrete

Testing hardened concrete is essential for assessing its mechanical properties. Here are details on some common tests, including flexural, compression, and split tensile tests. These tests help ensure the structural integrity and durability of concrete in construction applications. Always follow standard procedures and safety protocols during testing.

4.2.1 Compressive test procedure

The test procedure followed IS 516:1979 guidelines. The specimen's concrete mixture was filled into 150 x 150 x 150 mm steel moulds. After that, the concrete was allowed to cure for seven and twenty-eight days in a curing tank. After the healing period, the specimen was taken out of the healing tank and cleaned. The weight and size of the sample were accurately noted. The specimen area (A) has been calculated based on its dimensions. The test is typically conducted using a compression testing machine, also known as a universal testing machine (CTM) or a concrete testing machine. This machine compresses a cylindrical or cubic object till it breaks.

Calculations: The compressive strength (fc) is calculated by dividing the total load supported by the specimen (Pmax) by the area of its cube cross-section (A).

Fc =A / Pmax

4.2.3 Split test procedure

The tensile strength of concrete is ascertained using the split tension test. Typically, this entails pushing a cylindrical specimen between two opposing generators until its diameter cracks. In compliance with IS 516:1979 methodology, the concrete mix sample was cast using steel moulds measuring 150 mm in diameter and 300 mm in height. After the specimen was cured in a tank for seven and twenty-eight days, respectively, its weight and measurements were measured exactly. The specimens were held horizontally on the loading surface of a 200-ton hydraulic compression testing machine, and loads were progressively raised until the specimens failed. The last load was then recorded. One can use to determine the specimen's splitting tensile strength.

$$T = \frac{2P}{\pi \mathrm{LD}}$$

Where, T = Split tensile strength, MPa
P = maximum applied load that the testing apparatus indicates
D = specimen diameter, in millimeters
L= specimen length, in mm

4.2.3 Flexural test procedure

In accordance with IS 516:1979 guidelines, the specified test method was implemented. Steel moulds measuring 500x100x100 mm were utilized for casting the samples, adhering to the concrete mix and sample preparation outlined in section 3.4.1. Following casting, the specimens underwent curing for durations of 7 and 28 days within a curing tank. Precise measurements of sample dimensions and weight were meticulously recorded, with all samples falling within the weight range of 12.5 to 12.8 kg. The testing apparatus featured two 38-mm-diameter rollers upon which the specimens were positioned, ensuring the rollers were appropriately spaced to maintain a 400-mm distance between them. Two identical rollers at the third point of support on the span made it easier to apply load.

Great care was taken to identify the fracture's position when the specimen failed. The specimen's flexural stress or modulus was determined using equation a, where 'a' denotes the distance—which must to be greater than 133 mm—between the fracture line and the closest support.

$$\text{Flexural Stress} = \frac{WL}{BD^2}$$

Where, W = load applied
B = Width of the beam
D = beam depth
L= beam length

When the fracture occurs in the middle third of the span length and the deviation is less than 5% of the entire span length, the modulus of rupture is determined using the following procedure.

$$\text{Flexural Stress} = \frac{3Wa}{BD^2}$$

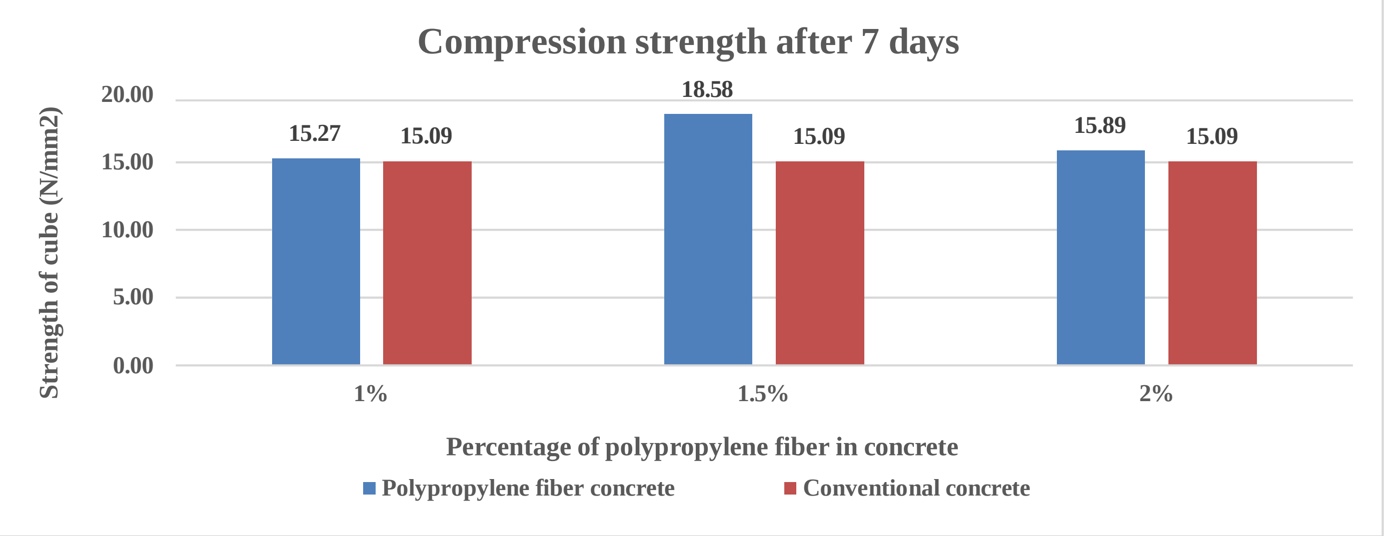
5.0 RESULTS AND DISCUSSION

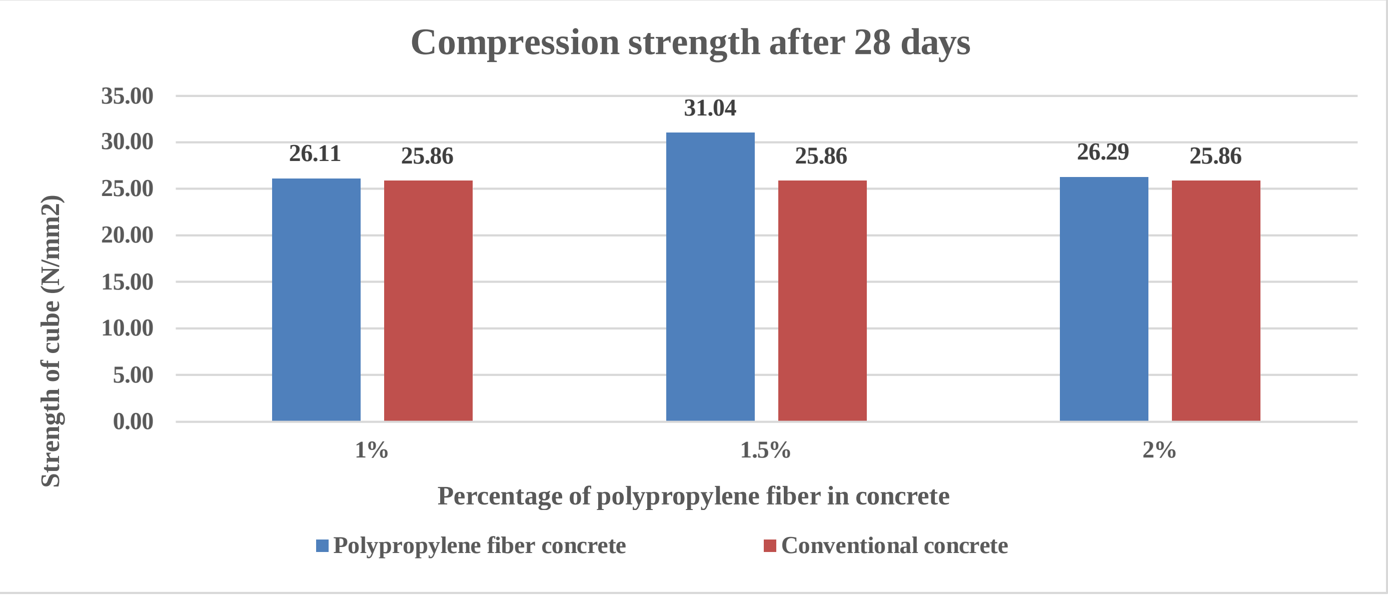
5.1 Compressive test results

Table 5.1: Compression test result

Percentage of adding fiber	Nos	7 Days test (N/mm^2)	Average	28 Days test (N/mm^2)	Average
0%	1	15.42	**15.09**	25.45	**25.86**
	2	15.32		26.89	
	3	14.52		25.23	
1%	1	14.53	**15.27**	25.86	**26.11**
	2	15.59		25.52	
	3	15.69		26.96	
1.5%	1	17.23	**18.58**	31.44	**31.04**
	2	18.96		30.56	
	3	19.56		31.12	
2%	1	16.52	**15.89**	25.53	**26.29**
	2	15.23		26.78	
	3	15.91		26.56	

The following results, which were tested over, show the compressive strength of concrete containing polypropylene fiber at the suggested replacement levels of 1%, 1.5%, and 2% for M25 grade concrete.





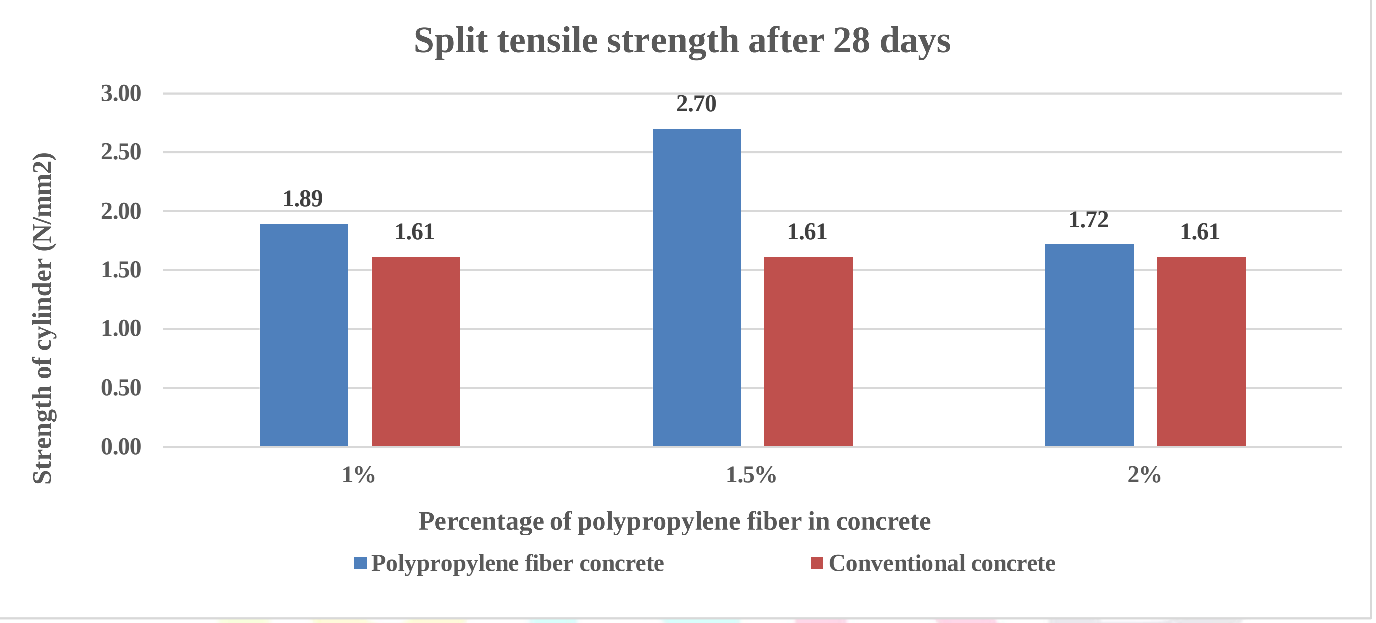
From the table 5.1 it is observed that the compression test at 7 & 28 days result 18.58 N/mm2 & 31.04 N/mm2 respectively 1.5 percentage inclusion of polypropylene fiber which is greater than 14.47% for 7 days & 15.88% for 28 days compare to all mix ratio of concrete.

5.2 Split tensile test results

Table 5.2: Split tensile test result

Percentage of adding fiber	Nos	28 Days (N/mm^2)	Average
0%	1	1.63	1.61
	2	1.65	
	3	1.56	
1%	1	1.96	1.89
	2	1.88	
	3	1.84	
1.5%	1	2.56	2.70
	2	2.42	
	3	3.12	
2%	1	1.63	1.72
	2	1.59	
	3	1.93	

The data below illustrates the split tensile strength of concrete containing polypropylene fiber, evaluated at various intervals of 7 and 28 days.



From the table 5.2 it is observed that the split tensile test at 28 days is 2.70 N/ mm2 at 1.5 percentage inclusion of polypropylene fiber which is greater than 30% compare to all mix ratio of concrete.

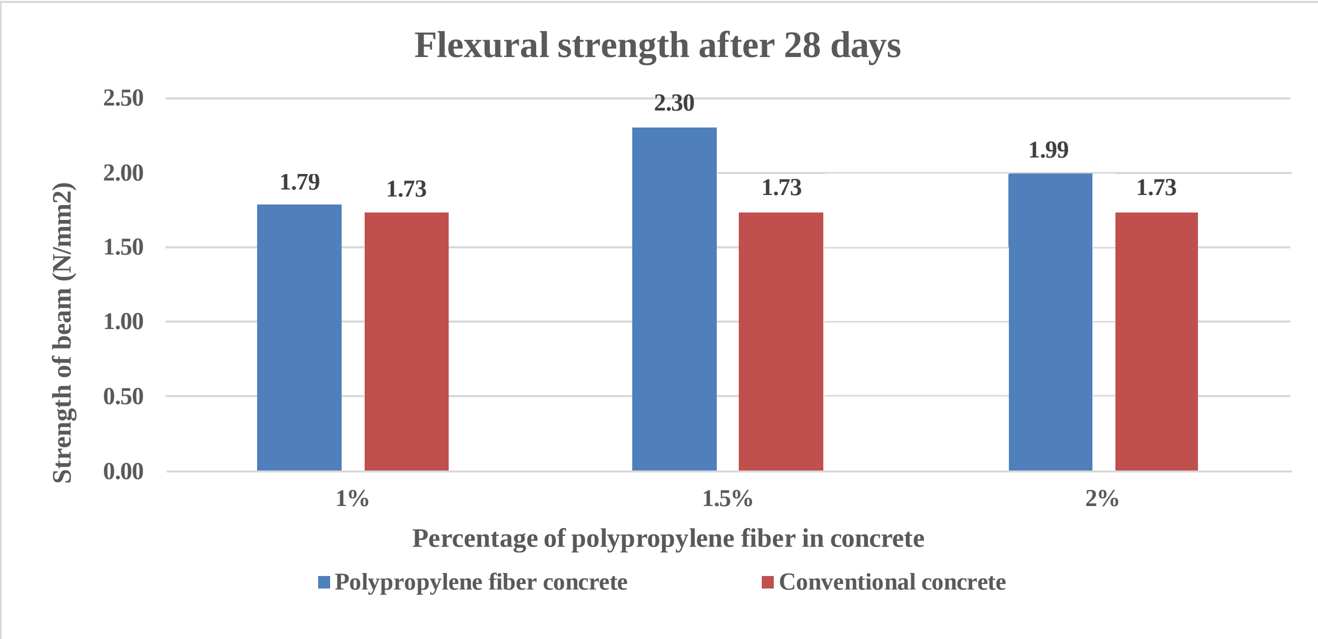
5.3 Flexural test results

Table 5.3: Flexural test result

Percentage of adding fiber	Nos	28 Days (N/mm^2)	Average
0%	1	1.77	1.73
	2	1.91	
	3	1.52	

1%	1	1.88	**1.79**
	2	1.95	
	3	1.53	
1.5%	1	2.15	**2.30**
	2	2.28	
	3	2.48	
2%	1	1.85	**1.99**
	2	1.94	
	3	2.17	

The presence of polypropylene fibers as evidenced by the considerable differences observed in the results of flexural tests conducted at 28 days between polypropylene fibers and conventional concrete. An overview of possible contents is provided below



From the table 5.3 it is observed that the flexural test at 28 days is 2.30 N/ mm2 at 1.5 percentage inclusion of polypropylene fiber which is greater than 15% compare to all mix ratio of concrete.

6.0 CONCLUSION

An experimental study was conducted on cubes, cylinders, beam, for compressive, split tensile strength, flexural test respectively by mixing various percentages of polypropylene fiber. Based on the investigation the following conclusions are made.

1. The Inclusion of Polypropylene fiber in concrete improves structural performance of concrete compared to conventional concrete.
2. When compared to conventional concrete with a 1.5% polypropylene fiber content by weight of cement in the concrete, the compression strength of polypropylene fiber concrete increased by 16.68%
3. The flexural strength of Polypropylene fiber concrete increased by 25.21% compared to normal concrete with 1.5% content of Polypropylene fiber by weight of cement in the concrete.
4. Compared to regular concrete with a 1.5% polypropylene fiber content by weight of cement in the concrete, the split tensile strength of polypropylene fiber concrete increased by 40.37%.

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