A Comparative Assessment on Crack Propagation Behaviour of Concrete Using Recron 3S Fibre

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Abstract: ***Cracks in concrete are the most undesirable due to Plastic shrinkage and drying shrinkage causes structural failures as well as decay in Load bearing capacity of concrete. So, there is a vital importance in improving the Crack Resistance of structural elements in order to increase the durability and life span. In view of that, Fiber-reinforced concrete (FRC) containing fibrous material has the potential to increase the structural integrity. Recron fiber is made up of Polypropylene as majority portion which has excellent tensile strength among all the synthetic fibers. This study mainly concentrates on the Fresh and Hardened properties of M25 Grade Concrete along with the Assessment of Crack Propagation studies in terms of Crack Mouth Opening Displacement (CMOD. Properties will be analyzed by maintaining the Fiber Aspect Ratio (L/D) ratio as 200 with the Random orientation for different dosages of fiber of lengths 12.5 mm and 25 mm. Polypropylene fibers will be added in concrete with different dosages viz., 0.5, 0.75 and 1.0% to the total volume of concrete. Beams will be casted for flexural strength test. Seven beams will be tested; one normal beam without polypropylene fiber and six beams with polypropylene fiber will be casted and a flexural strength test will be conducted. Compressive Strength, Flexural strength and Crack Propagation behavior in terms of width measurement are monitored during the test.***

Keywords: Poly Propylene Fiber, Crack Propagation, Recron 3S Fiber, Concrete with Fibers

1. Introduction

Concrete is a composite material made up mostly of particles or aggregate fragments embedded in a binding medium (such as a Portland cement and water mixture). The aggregate fragments are often a blend of fine and coarse aggregate.

Simple concrete has extremely little resistance to cracking, very little ductility, and very low tensile strength. Concrete naturally contains internal microcracks, and these microcracks spread throughout the material, causing brittle fracture. This is the reason for the concrete's low tensile strength. It has long been known that adding tiny, uniformly distributed fibers to concrete will significantly enhance both its static and dynamic qualities while also acting as a crack arrester. Fiber Reinforced Concrete is the name given to this kind of concrete.

1.1 Polypropylene Fibers (Recron 3S)

Recron 3s fiber, another name for polypropylene fiber, was employed as a secondary reinforcement material. In addition to strengthening resistance against impact, abrasion, and water penetration, it stops shrinkage fractures. It not only homogenizes the concrete but also enhances its ductility, flexural strength, compressive strength, and energy absorption capacity.

The concrete mix is typically held together by polypropylene fibers. This lowers the rate of bleeding by delaying the coarse aggregate's settlement. Reduced plastic shrinkage cracking results from a slower bleeding rate, which also slows down drying. Polypropylene fibers serve as crack arresters in hardened concrete. The fibers, like any secondary reinforcement, work to keep the concrete together, preventing cracks from getting bigger or longer. Nonetheless, because polypropylene fibers are dispersed throughout the concrete, they work best along the aggregate-paste interface, which is where cracks first appear.

1.2 Crack Propagation Behaviour of Concrete

The term "crack propagation" refers to the process of a crack on a certain surface becoming wider, longer, or more numerous. One or more of the following may contribute to the formation of a crack: the application of additional loads; thermal stresses; concentrations of stress; and repeated cycles of shrinkage and expansion. A structure's ability to support loads can be severely reduced by crack formation, which can happen to a range of materials, including concrete, wood, and metal. Crack growth is another name for crack propagation.

The Crack Mouth Opening Displacement (CMOD) is known to be a good indicator of fracture properties that characterize the concrete materials It is however often difficult to determine Crack Tip Opening Displacement (CTOD) as it is linked to the details of constitution of the micro cracked zone. However CTOD is related to the crack mouth opening displacement (CMOD). The interrelationship between CMOD and CTOD is complex mainly due to the considerable extent of the micro cracked zone in front of the crack tip.

2. Objectives of Investigation

The main objectives of current experimental investigation are

1) Investigating the effect of Recron 3S fibre on Fresh Properties of Concrete.

2) Assessment of Compressive strength, Flexural Strength with the varying dosage of Recron 3S Fibers in Concrete.
3) Investigating Crack propagation behaviour of concrete by CMOD Test.

3. Methodology

This experimental research is conducted to determine the strength and flexural behavior of the polypropylene fiber reinforced beams. Polypropylene fibers were being added in concrete with different dosages viz., 0.5, 0.75,1 and 1.5% to the total volume of concrete of grade M25 for two different recron3s fibers of length 12mm and 25mm. Compressive Strength, Flexural strength and the cracking pattern were monitored during the test. The results indicated that the addition of polypropylene fibers in concrete significantly increased the strength and load carrying capacity of beams with different cracking patterns.

3.1 Materials

Cement: Cement is the main ingredient in manufacturing of concrete. The characteristics of concrete will b greatly affected by changing the cement content. The cement used in this project is Ordinary Portland cement of 53 grade confirming to IS 12269 – 1987.

Fine Aggregate: Aggregates of size ranges between 0.075mm – 4.75mm are generally considered as fine aggregates. In this experimental work natural river sand was used as a Fine Aggregate. The fine aggregates are selected as per IS-383 specifications.

Coarse Aggregate: Aggregates of size more than 4.75mm are generally considered as coarse aggregate. The maximum size of coarse aggregate used in this experimental is 20 mm. A good quality of coarse aggregates is obtained from nearest crusher unit.

Recron 3S Fiber: Chopped Polypropyene fibers of 12 mm and 25 mm are used as an admixture in concrete.

Chart 1: Recron 3S Fiber 1 Kg Pack

Chemical Admixture: For Better Workability Conplast SP 430 was Used as a Chemical Admixture.

Table 1: Material Test Results

Material	Specific Gravity	Bulk Density	Water Absorption
Cement	3.15	-	-
Fine Aggregate	2.66	1602	1%
Coarse Aggregate	2.84	1700	0.5%
Recron 3S	1.36	0.9 g/cm^3	1.1%

Table 2: Mix Quantities for M25 Grade

Material	Quantity (Kg/m^3)
Cement	328
Fine Aggregate	618
Coarse Aggregate	1296
Water	148 Lit
SP Dosage	0.3%
W/C Ratio	0.45

3.2 Proportioning of Trial Mixes

The values for cement, fine aggregate, coarse aggregate are adopted from the mix design ratio whereas the amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed "volume fraction" (Vf). Vf typically ranges from 0.1 to 3%. The aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio

Table 3: Mix Proportion details

Mix	Cement	Fine aggregate	Coarse aggregate	Fibre (12mm)	Fibre (24mm)
Control	100%	100%	100%	0%	0%
Trial 1	100%	100%	100%	0.50%	0%
Trial 2	100%	100%	100%	0.75%	0%
Trial 3	100%	100%	100%	1%	0%
Trial 4	100%	100%	100%	1.50%	0%
Trial 5	100%	100%	100%	0%	0.50%
Trial 6	100%	100%	100%	0%	0.75%
Trial 7	100%	100%	100%	0%	1%
Trial 8	100%	100%	100%	0%	1.50%

4. Results and Discussions

In this chapter the results are tabulated by calculating Fresh and Hardened properties of concrete. The Compressive Strength and Flexural strength is the main properties for determining the concrete strength. In this the strength properties are calculated by adding polypropylene fiber of 24mm and 12mm length at different proportions of 0.5%, 0.75%, 1% and 1.5%. The Crack Propagation behavior of Concrete was investigated by CMOD Test. The detailed tabulations and graphs are presented as follows.

4.1 Workability of Concrete:

The Slump Cone method is used to assess the workability of concrete. The slump was between 25 and 100mm.

Table 4: Slump Obtained

Mix	Fiber Length	Slump (mm)
Control Mix	-	72
Trial 1	25 mm	68
Trial 2		65
Trial 3		58
Trial 4		50
Trial 5	12 mm	65
Trial 6		62
Trial 7		60
Trial 8		55

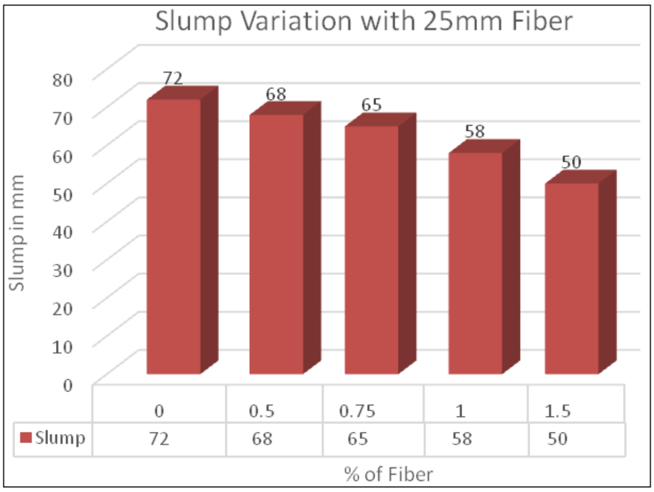

Chart 2: Variation of Slump with 25 mm Fiber

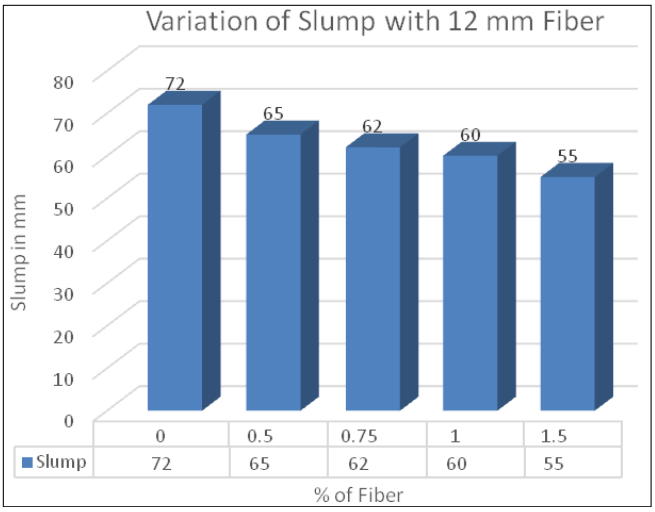

Chart 3: Variation of Slump with 12 mm Fiber

4.2 Compressive Strength

Compressive strength is determined by crushing the cube's surface, which is why it's also known as crushing strength. Here are the test results for 7 days, 28 days, and so on.

Table 5: Compressive strength after 7 & 28 Days (25 mm Fiber)

Mix	Compressive strength (N/mm^2)	
	7 days	28 days
Control Mix	21.1	32.4
Trial 1	21.8	33.6
Trial 2	22.2	34.1
Trial 3	23.5	**36.2**
Trial 4	19.4	29.8

Table 5: Compressive strength after 7 & 28 Days (12 mm Fiber)

Mix	Compressive strength (N/mm^2)	
	7 days	28 days
Control Mix	21.1	32.4
Trial 5	20.7	31.9
Trial 6	21.1	32.4
Trial 7	22.4	34.4
Trial 8	18.4	28.3

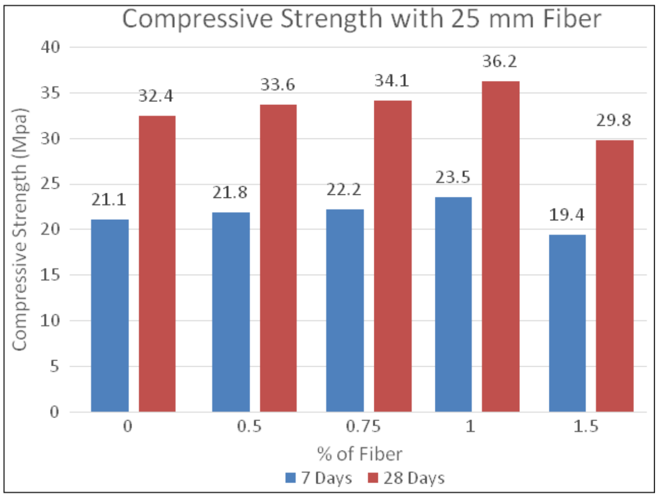

Chart 4: Compressive Strength with 25 mm Fiber

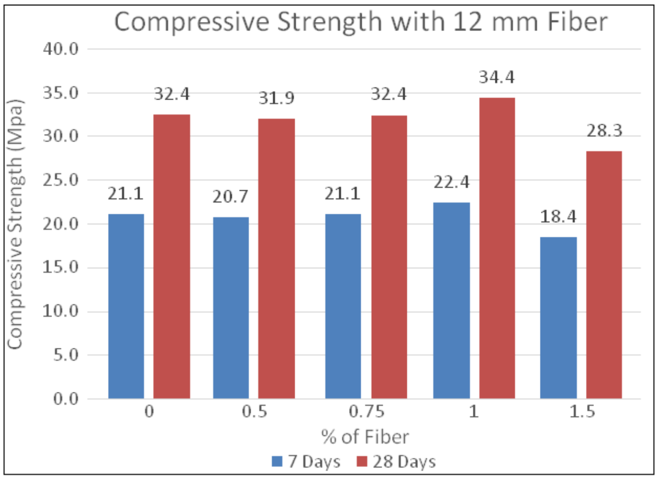

Chart 5: Compressive Strength with 12 mm Fiber

4.3 Flexural Strength

Flexural strength is obtained by applying crushing load on the beam surface. Flexural strength of concrete is calculated by casting 750 mm x 150mm x 150mm beams. The test results are presented here for the flexural strength of 7 Days and 28 days of testing.

Table 6: Flexural strength after 7 & 28 Days

Fibre	Trial Mix	Percentage of fiber (%)	7 Days Flexural Strength (N/mm^2)	28 Days Flexural Strength (N/mm^2)
-	Control Mix	0%	2.66	4.1
25 mm	Trial 1	0.5	3.63	5.58
	Trial 2	0.75	3.89	5.98
	Trial 3	1	4.18	6.43
	Trial 4	1.5	3.77	5.8
12 mm	Trial 5	0.5	3.12	4.81
	Trial 6	0.75	3.23	4.97
	Trial 7	1	3.41	5.24
	Trial 8	1.5	3.26	5.01

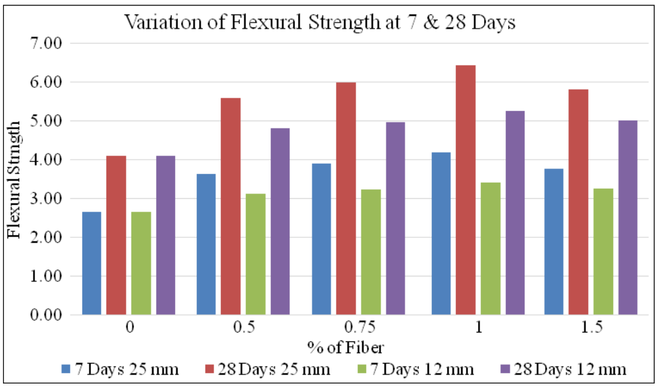

Chart 5: Flexural Strength at 7 Days and 28 Days

5. Crack Propagation Studies

Cracks in concrete are the most undesirable due to Plastic shrinkage and drying shrinkage causes structural failures as well as decay in Load bearing capacity of concrete. So, there is a vital importance in improving the Crack Resistance of structural elements in order to increase the durability and life span.

5.1 Average Crack Length

Table 7: Average Crack length of Beam Specimens

Fibre	Trial Mix	Percentage of fiber (%)	Crack Length (mm)
-	Control Mix	0%	95
25 mm	Trial 1	0.5	80
	Trial 2	0.75	76
	Trial 3	1	68
	Trial 4	1.5	60
12 mm	Trial 5	0.5	78
	Trial 6	0.75	70
	Trial 7	1	64
	Trial 8	1.5	55

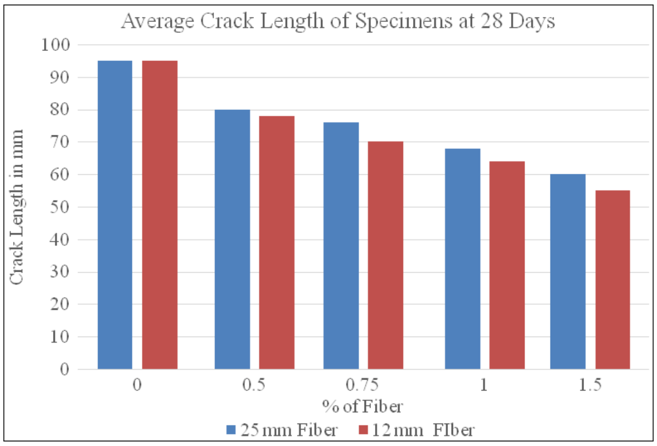

Chart 6: Average Crack Length of Specimens at 28 Days

5.2 Crack Mouth Opening Displacement

The Crack width was measured on the maximum of Two faces of failure for each Cube and Beam Specimens. The Width was measured in terms of Crack Mouth Opening Displacement and the Results Were Tabulated. The Specimens with 12 mm Fiber Given Lesser Crack Widths When Compared to Specimens Width 25 mm Fiber.

Table 8: Average Crack Widths of Specimens after 28 Days

Fibre	Trial Mix	Percentage of fiber (%)	Average Crack Width (mm)
-	Control Mix	0%	2.5
25 mm	Trial 1	0.5	1.8
	Trial 2	0.75	1.3
	Trial 3	1	1
	Trial 4	1.5	0.9
12 mm	Trial 5	0.5	1
	Trial 6	0.75	0.8
	Trial 7	1	0.6
	Trial 8	1.5	0.5

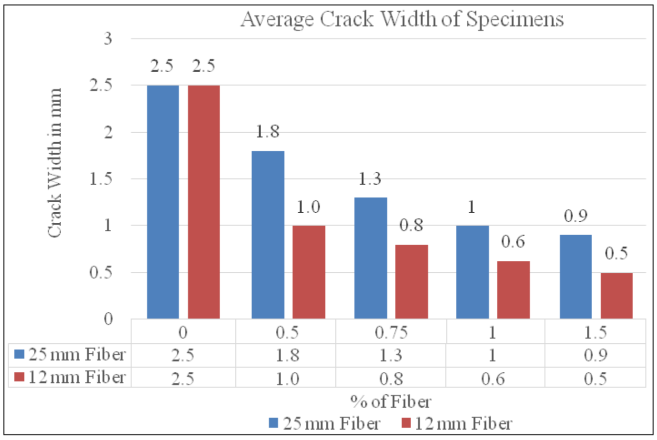

Chart 7: Average Crack Width

Chart 8: Measuring CMOD using Crack Width Comparator

6. Conclusions

1) The fibers were partially soluble in water and forming white color in water. So that the immersion of fiber in water was good.
2) All the Trials achieved their Desired results in both Compression and Flexural Strength Point of View.
3) The Workability of Concrete was effected with the addition of Fiber. There is a reduction of Slump was observed for both 25 mm and 12 mm Fiber.
4) Concrete with 12 mm Fiber given better Workability when Compared to Concrete with 25 mm Fiber.
5) The addition of polypropylene fibers increased the flexural strength of the concrete compared to a control mix. There is also a significant gain in strength with age up to 28 days.
6) Maximum Compressive of 36.2 Mpa was Achieved for Concrete with 25 mm Recron Fiber at 1% Dosage i.e., Trial 4.

7) Concrete with 25 mm Recron Fiber Shown Better Results in Compressive Strength when compared with Specimens with 12 mm Fiber.
8) A Higher value of 28-day flexural strength as 6.428 N/mm2 was obtained at 1% of 25 mm polypropylene fiber content in concrete.
9) It was observed that the Crack Formation was reduced when compared with the controlled mix.
10) From the crack propagation studies it was observed that the crack width formation was less in the 12mm fibered concrete when compared to 25 mm fibered concrete.
11) It was also observed that the Specimens with 12 mm Fiber Displayed Lesser Crack lengths and Crack length was decreased with increase in the fiber content.
12) The Optimum Percentage of Fiber was 1% of Recron Fiber of 12 mm Size in Concrete.

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