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Study Using Different Fibres in Fibre Reinforced Concrete

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Abstract: The most widely used man-made materials in the construction industry are concrete. It is a combination of cemeteries, water, compounds and various types of admixtures to a certain extent. New concrete has plastic properties, which means that before casting it it behaves like plastic but over time, it becomes harder as rock. These hardening structures occur due to the chemical reaction between water and cement, it hardens over a long period of time.

From the last century onward, the strength of the RCC structures was largely based on the round steel bars, which were readily available in the market. Over time, these items have also changed in appearance, structure, and power. For example, Pozzolana cement is used in place of conventional cement and TMT bars are applied in place of stainless steel.

Energy testing methods are based on Indian standards. Test equipment provides complete results after examination of cubes, cylinders and beams, which are inserted and stored in water for treatment for 28 days continuously.

Concrete structures, either in the 1970s or later made of high-strength steel-reinforced steel, have replaced concrete structures and structures with various additives in cement and admixtures with their acceleration or deceleration capacity. Now, instead of steel bars, steel fibers, polypropylene, natural polymers etc. are used. The reasons for the demands are many, but as a building engineer, we have to think hard and architecture by using building materials. In anticipation of long-term sustainability, we need to be able to meet needs.

I. INTRODUCTION

The main goal is the production of concrete that is not only based on the strength of the concrete, and there are many other factors such as preference for low absorption, high durability. Therefore, to meet the above expectations, we need to add synthetic materials and super plasticizer with a low water content. The use of fibers such as polypropylene fiber and steel fiber is multifaceted, highly efficient and the best material for the production of efficient concrete. Now a day, one of the best applications in various fields of reinforced fiber concrete construction, which has been gaining popularity due to its positive effect on various concrete structures

A variety of fiber materials other than steel, glass or other natural fibers have been developed and used in the industry to build reinforced fiber concrete. These fibers are classified as synthetic fibers, SNFRC editing. Synthetic fibers are man-made from R&D in the textile and petrochemical industries. Types of fiber that can be used in concrete matrices such as aramid, carbon, acrylic, nylon, polythene, polyester and polypropylene. Reinforced concrete concrete is a mixture that contains water, cement, composite and non-breakable fibers of various shapes and sizes.

II. CONTENT

Fiber reinforced concrete (FRC) is a type of boon in the field of engineering in the form of physical and chemical parameters. So in our present study we are going to put our great diligence in study of SFRC and PPFRC which can be made as partial replacement of cement simultaneously achieving required strength testing on mortar cubes.

Steel fibers & Polypropylene fibers are mainly used with concrete for the production of FRC. We are going to use the fibers in different percentage i.e. 0%, 1%, 2%, 3% to the weight of concrete and study the 28 days splitting tensile, compressive strength, and flexural strength of concrete with maintaining the w/c ratio having variation between 0.35-0.50. We have used ordinary portland cement 53 grade.

Different materials that are used for this study are given below for the strength evaluation of concrete using different pozzolanic material, fiber and super plasticizer.

A. Materials

1) Cement

For the experiment OPC – 53 grade is used.

The different properties of the cement are shown below:

a) Fineness – 340 m^2/kg
b) Specific gravity- 2.96
c) Initial setting time - 90 min
d) Final setting time – 190 min

2) *Fine Aggregate:* For this study, the Zone-II sand (Mahanadi river ,situated in Raipur,Chattisgarh-India) was used, over which the sieve analysis is performed using the various sieve sizes IS 10mm, IS 4.75mm, IS 2.36mm, IS 1.18mm, IS 600µ, IS 300µ, IS 150µ) based on IS 383:1963.

3) *Properties of Fine Aggregate:* Some important properties of fine aggregates are in Table 1

Table 1: Properties of Fine Aggregates

Properties	Results Obtained
Specific Gravity	2.65
Water absorption	0.65%
Fineness Modulus	2.48

4) *Coarse Aggregate:* 20 mm as the maximum size of coarse aggregate was considered. The IS 383:1970 has been used to calculate the mix proportion of coarse aggregate, with IS 10 mm sieve size as 60% and with IS 20 mm sieve size as 40%.

5) *Properties of Coarse Aggregate:* The properties of coarse aggregates are presented in Table 2

Table 2: Properties of Coarse Aggregates

Properties	Results Obtained
Specific Gravity	2.67
Water absorption	0.61%
Fineness Modulus	4.01

6) *Fibers:* In this project work, Steel & Polypropylene fiber was used. In different weight fraction (0%, 1%, 2%, 3%) to concrete it was used.

III. STRENGTHS OF SPECIMENS

Table containing compressive strengths for Nominal Mix:

Table 3 : Compressive Strength for Nominal Mix

Compressive Strength(N/Sqmm) of 0% Fiber Grade M40		
	Observed C.S.	Avg. C.S.
Sample M1	37.4	38.78
Sample M2	36.8	
Sample M3	38.1	
Sample M4	40.8	
Sample M5	41.1	

Five samples of conventional concrete have taken for testing. The compressive strength of all cube samples given in the above table. When no fibers added in concrete, the strengths came accordingly and related to 40MPa after 28 days.

Table 4 is showing compressive strength for steel fiber with mix of conventional concrete.

Table 4: Compressive Strength for Steel Fiber Mix

Compressive strength(N/sqmm) of 1%, 2% and 3% Steel Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample CS1.1	52.2	52.74	53.1	54.34	55.6	55.66
	Sample CS1.2	54.8		54.8		55	
	Sample CS1.3	53.2		54		54	
	Sample CS1.4	52.5		55		57.5	
	Sample CS1.5	50.9		54.8		56.2	
60	Sample CS2.1	53.3	53.4	54.8	56.94	56	58.12
	Sample CS2.2	52.1		54.5		55.8	
	Sample CS2.3	54.4		58		58	
	Sample CS2.4	55.1		58		60.2	
	Sample CS2.5	52.1		59.4		60.6	

For different aspect ratios i.e. 50 and 60, with mixing of 1%, 2% and 3% steel fibers added. The results found were more compressive strength as compared with conventional concrete. For more steel fiber mixing (3%), more strength observed on aspect ratio 60 whereas in case of minimum percentage of steel fiber i.e. 1%, compressive strength minimum compressive strength 52.74MPa came out.

Table 5 is telling about the compressive strength of polypropylene fiber mix reinforced concrete.

Table 5: Compressive Strength for Polypropylene fiber Mix

Compressive strength(N/sqmm) of 1%, 2% and 3% Polypropylene Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample CP1.1	38.8	41.32	48.8	47.02	49.4	49.2
	Sample CP1.2	40.4		44.4		50.8	
	Sample CP1.3	41.5		49.5		43.5	
	Sample CP1.4	42.4		44		57.8	
	Sample CP1.5	43.5		48.4		44.5	
60	Sample CP2.1	40.5	45.28	44.8	50.98	49.4	54.48
	Sample CP2.2	45.5		50.4		45.4	
	Sample CP2.3	48.9		53.6		60.1	
	Sample CP2.4	43.5		52.2		55.4	
	Sample CP2.5	48		53.9		62.1	

30 samples have been taken for polypropylene fiber mixes. Five samples of each percentage taken out. When 1% of polypropylene fiber added, 41.32MPa compressive strength got on Compressive Testing Machine for aspect ratio 50. Similarly for aspect ratio 60, compressive strength 45.28MPa measured.

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Table 6 presented to show the flexural strength of nominal mix.

Table 6: Flexural Strength for Nominal Mix

Flexural Strength(N/Sqmm) of 0% Fiber Grade M40		
	Observed F.S.	Avg. F.S.
Sample MF1	7.4	7.62
Sample MF2	7.8	
Sample MF3	7	
Sample MF4	7.8	
Sample MF5	8.1	

For M40 Grade of concrete, 5 samples have been taken. The observed flexural strengths were approximately to achieve target strength. So, the average flexural strength of all observed strength is 7.62MPa.

Table 7 having Flexural strength for steel reinforced concrete mix.

Table 7: Flexural Strength for Steel fiber Mix

Flexural strength(N/sqmm) of 1%, 2% and 3% Steel Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample FS1.1	8.9	8.54	8.5	9.18	10.5	10.62
	Sample FS1.2	8.1		8.4		10.2	
	Sample FS1.3	9.1		9.4		11.2	
	Sample FS1.4	8.4		9.8		11.4	
	Sample FS1.5	8.2		9.8		9.8	
60	Sample FS2.1	8	8.58	8.9	9.622	11.5	11.54
	Sample FS2.2	8.2		9.5		9.4	
	Sample FS2.3	8.1		9.4		12	
	Sample FS2.4	9.2		10.2		12.4	
	Sample FS2.5	9.4		10.11		12.4	

As similar to compressive strength, here again 30 samples collected and measured their respective strengths with 1%, 2% and 3% steel fibers by volume. The flexural strength for steel fibers is more than conventional concrete flexural strength.

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Table 8 is showing results after 28 days of flexural strength for polypropylene fiber mix.

Table 8: Flexural Strength for Polypropylene fiber Mix

Flexural strength(N/sqmm) of 1%, 2% and 3% Polypropylene Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample FP1.1	36.5	37.76	39.5	39.18	40.1	41.4
	Sample FP1.2	36.5		37.8		40.5	
	Sample FP1.3	40		38.4		42.7	
	Sample FP1.4	38.2		40		41.8	
	Sample FP1.5	37.6		40.2		41.9	
60	Sample FP2.1	40.5	40.14	39	42.18	32.8	44.26
	Sample FP2.2	42.5		45.5		34.9	
	Sample FP2.3	36.4		40		50.8	
	Sample FP2.4	40.2		43.2		51	
	Sample FP2.5	41.1		43.2		51.8	

Here, after mixing of polypropylene fibers with conventional concrete, the flexural strengths are higher than steel fibers. If we talk about 1% addition of polypropylene fibers, we achieved 37.76MPa flexural strength for aspect ratio 50.

Similarly, for aspect ratio 60, this value is 40.14MPa. Whereas for same aspect ratio, 44.26MPa at 3% addition of polypropylene fibers.

Table 9 is presenting the split tensile strength after 28 days for conventional concrete.

Table 9: Split Tensile Strength for Nominal Mix

Spit Tensile Strength(N/Sqmm) of 0% Fiber Grade M40		
	Observed F.S.	Avg. F.S.
Sample MT1	2.9	3.56
Sample MT2	3.1	
Sample MT3	3.4	
Sample MT4	4.2	
Sample MT5	4.2	

For split tensile strength, cylinders were casted and tested in Compression Testing Machine after 28 days. The minimum and maximum values of split tensile strength were noted 2.9MPa and 4.2MPa respectively.

Split tensile strength for steel fiber with different percentages are presented in Table 10.

Table 10: Split Tensile Strength for Steel Fiber Mix

Split Tensile strength(N/sqmm) of 1%, 2% and 3% Steel Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample TS1.1	3.2	3.26	4.1	4.36	5.2	5.16
	Sample TS1.2	3		4.1		4.2	
	Sample TS1.3	2.9		4.3		5.4	
	Sample TS1.4	3.4		4.2		5.4	
	Sample TS1.5	3.8		5.1		5.6	
60	Sample TS2.1	2.9	3.36	6	4.76	4.5	5.28
	Sample TS2.2	3.2		3.5		5.6	
	Sample TS2.3	3.1		3.5		5.8	
	Sample TS2.4	3.4		5.2		5.9	
	Sample TS2.5	4.2		5.6		4.6	

In case of steel fiber addition, 5 samples of aspect ratio 50 with 1%, given 3.26MPa average split tensile strength, for 2% the average strength is 4.36MPa and for 3% the average strength is 5.16MPa whereas for aspect ratio 60 with 1% steel fibers, the average strength is 3.36MPa and with 2% fibers, average strength is 4.76MPa and the maximum strength is 5.28MPa with 3% addition of steel fibers. These values show that the split tensile strength of steel fibers is more durable than conventional concrete.

Table 11 is presenting the split tensile strength of polypropylene reinforced concrete after 28 days.

Table 11: Split Tensile Strength for Polypropylene fiber Mix

Split Tensile strength(N/sqmm) of 1%, 2% and 3% Polypropylene Fiber Grade M40							
Aspect Ratio		1%	Avg.	2%	Avg.	3%	Avg.
50	Sample TP1.1	4.2	4.16	4.5	5.3	5.1	5.76
	Sample TP1.2	2.4		4.5		5.1	
	Sample TP1.3	4.5		5.6		5.2	
	Sample TP1.4	4.5		5.8		6.2	
	Sample TP1.5	5.2		6.1		7.2	
60	Sample TP2.1	4.8	5.5	4.8	5.98	4.6	6.58
	Sample TP2.2	5.1		5.2		8	
	Sample TP2.3	5.6		6.2		6.1	
	Sample TP2.4	5.8		6.4		6.8	
	Sample TP2.5	6.2		7.3		7.4	

If we compare the strengths of both steel and polypropylene fibers with conventional concrete, we get polypropylene fibers shows maximum split tensile strength. At 1% polypropylene fiber mixing with conventional concrete, the average value is 4.16MPa, and for 2% and 3%, 5.3MPa and 5.76MPa respectively for aspect ratio 50. For aspect ratio 60 and 1% mixing of polypropylene fibers, the strength is 5.5MPa, 2% mixing of polypropylene fibers, the strength is 5.98MPa and lastly, for 3% mixing of polypropylene fibers, the strength is 6.58MPa.

IV. RESULTS

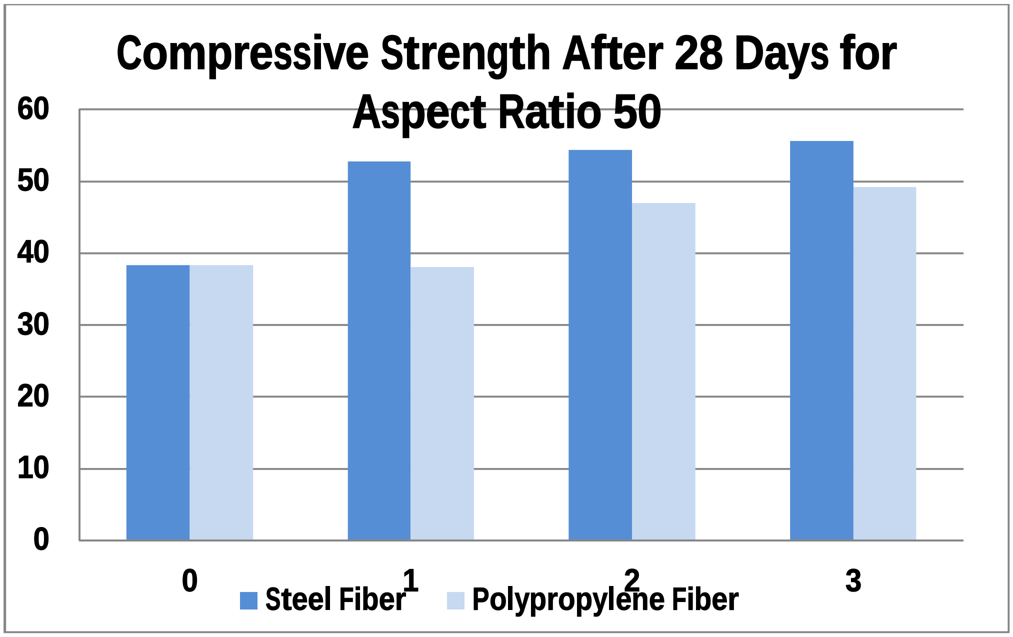

Figure 1: Compressive strength after 28 days for Aspect Ratio 50

Figure 1 is showing the compressive strength results after 28 days. After addition of steel fibers, compressive strength values increases as compared to polypropylene fibers. After addition of fibers with 1%, 2% and 3% small changes are coming in steel fiber whereas in case of polypropylene fiber, maximum changes are coming after 1% to 2%. In case of 2% and 3% polypropylene addition, a small change is there. If we compare between steel fiber and polypropylene fiber at 1%, 27% of total strength increased on addition of steel fiber.

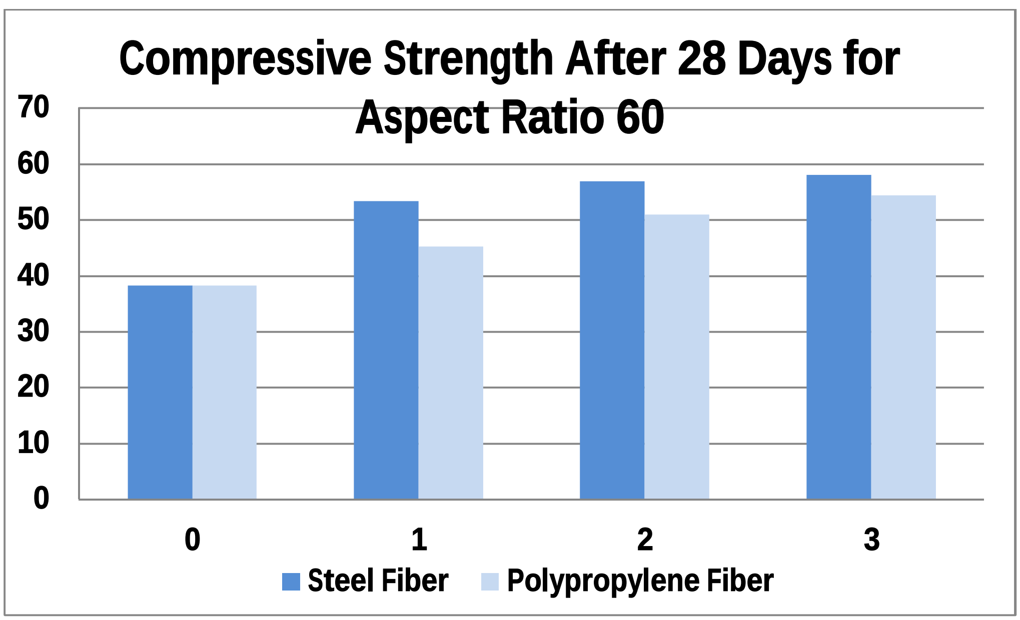

Figure 2: Compressive strength after 28 days for aspect ratio 60

Figure 2 is comparison between compressive strength results after 28 days for aspect ratio 60. For steel fibers, changes are very slow as compared to polypropylene fibers. On addition of 1% steel fiber, strength increased with 28% whereas in case of polypropylene fiber, strength increased 15% for same percentage. If we compare the changes in 1% to 2%, the strength gained approximately 6% for steel fibers and for polypropylene fiber, it is 11%.

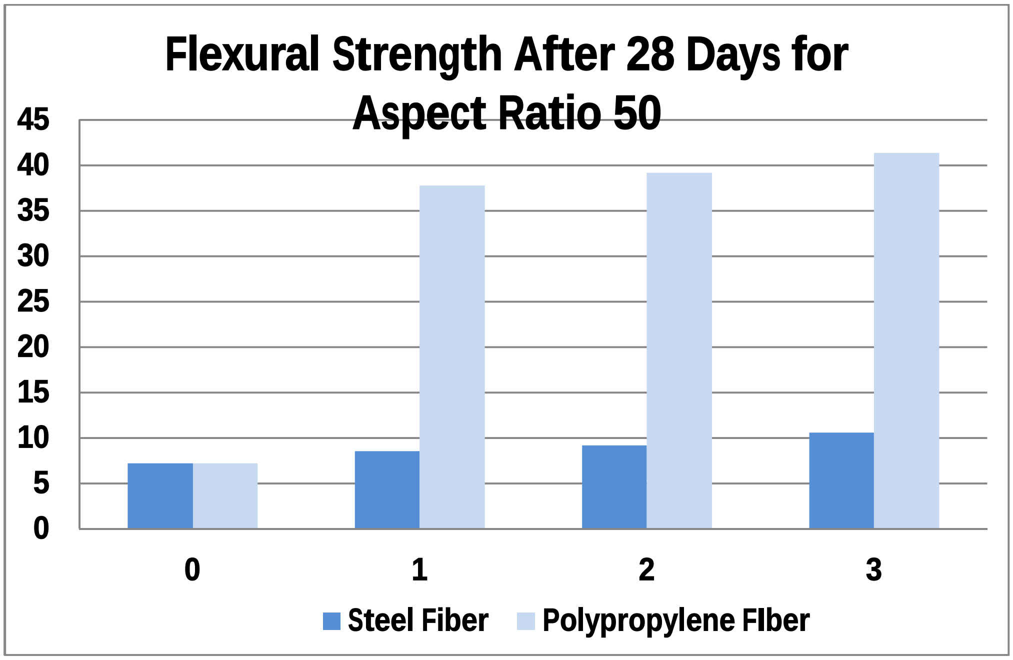

Figure 3: Flexural strength after 28 days for aspect ratio 50

Figure 3 is showing a big change in flexural strength in polypropylene fibers with respect to steel fibers. At 1% mixing of fibers, strength of steel fiber concrete was 15% whereas strength of polypropylene fibers was 80%. In case of 2% mixing of fibers, 21% gained for steel fibers, and 81% gained for polypropylene fibers. Similarly for 3% addition of fibers, steel fiber strength increased 32% whereas 83% strength increased for polypropylene fibers with respect to conventional concrete.

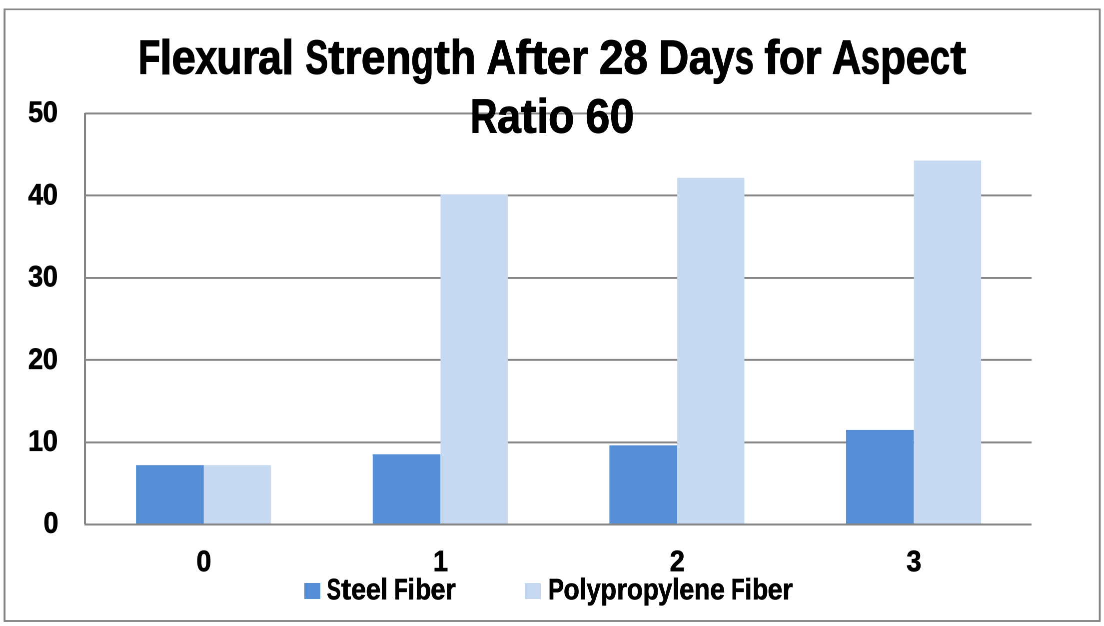

Figure 4: Flexural strength after 28 days for aspect ratio 60

From figure 4, the obtained results are very clear that after 3% addition of polypropylene fibers, the increased strength is 83.5% with respect to nominal concrete. Gained strength between 2% to 3% in polypropylene fibers is 4% whereas for steel fibers these changes are 16% for same. A comparison of steel and polypropylene fibers at 1% is 78.5%, at 2% is 77% and at 3% is 73%. The graphical presentation and analysis shows that a small change in strength is totally depend on percentages of fibers.

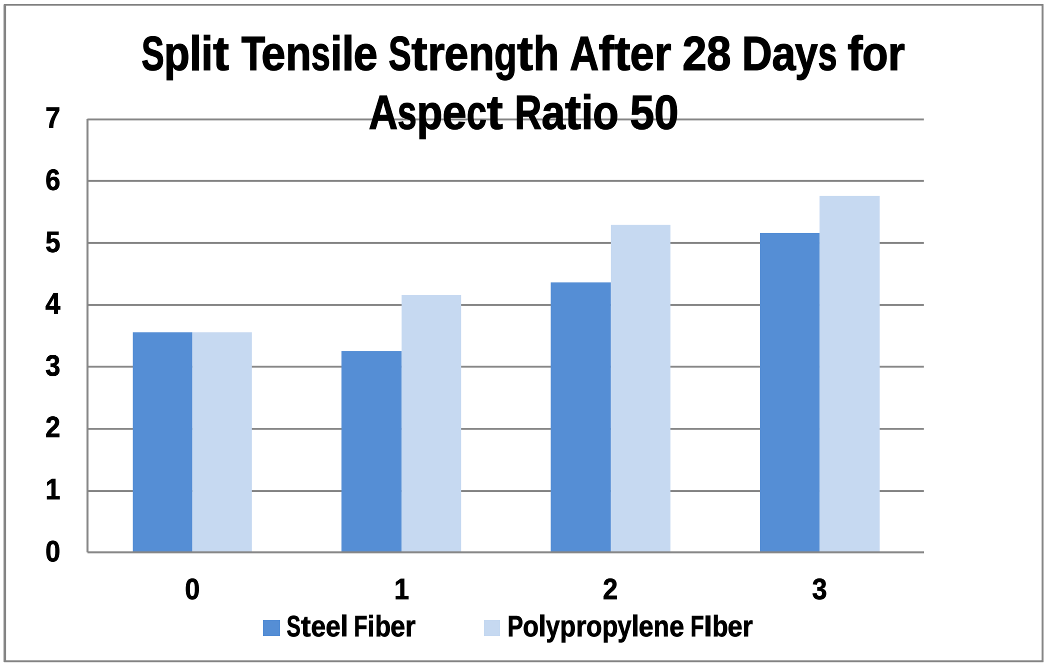

Figure 5: Split Tensile strength after 28 days for aspect ratio 50

Figure 5 is telling the strength of steel fibers at 1% with conventional concrete i.e. fiber free is decreased with 9% whereas for polypropylene fibers, strength increased with 14%. Split tensile strength comparison between 1% and 2% of steel fibers is showing 25% change whereas in polypropylene fibers 21%.

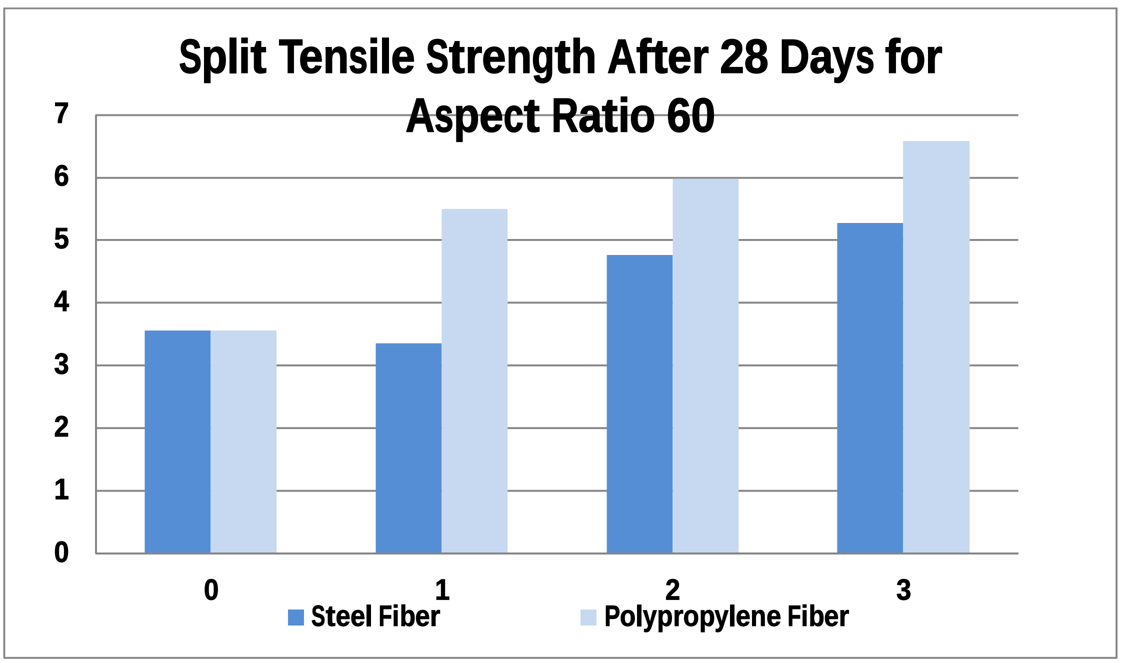

Figure 6: Split Tensile strength after 28 days for aspect ratio 60

Figure 6 is a comparison between split tensile strengths of steel and polypropylene fibers. At 1% of steel fiber addition, 6% strength decreased whereas at 2% addition of same, strength increased 25% with respect to conventional concrete. In polypropylene fiber mixing with conventional concrete, strength increased at 1% is 35% and at 2% is 40%. At 3% for both, polypropylene fibers are showing 13% more capable to check the strength as compared to steel.

V. CONCLUSION

In this present study with the stipulated time and laboratory set up afford has been taken to enlighten the use of so called fiber reinforced concrete in accordance to their proficiency. It was concluded that:

1) With the use of superplasticizer, it is possible to get a mix with low water to cement ratio to get the desired strength.
2) In case of ordinary portland cement with the use of steel fiber, the 28 days compressive strength at 3% fiber content the result obtained is maximum.
3) When polypropylene fiber mixed with nominal concrete, it shows compressive strength is less than steel i.e. 11%.
4) After mixing of fibers (i.e. steel & polypropylene) with by 1%,2% and 3%, the compressive strengths increases gradually. Which means slightly changes comes by increasing the percentage fibers for both aspect ratios.
5) As shown in graphs for aspect ratios i.e. 50 and 60, compressive strength changes maximum limit in aspect ratio 60. This shows if the length of fibers is more, then compressive strengths will be more.
6) When there is no mixing of fibers, no changes will come in any strength.
7) Maximum flexural strength is coming in polypropylene, it means for casting of beams is helpful by using the polypropylene fibers.
8) The orientations of fibers also giving a good result for polypropylene fibers. Because as compared to steel, it is more flexible and able to resist the uniformly distributed loads.
9) The flexural strength for aspect ratio 60 and polypropylene fibers is showing a long gap between steel and polypropylene fibers.
10) If we compare the split tensile strength, for the aspect ratio 50, it is 10% variation between steel and polypropylene. Whereas for aspect ratio 50, it is approximately 20% variation in same.
11) Polypropylene fibers will be more effective in tensile zone because they have property of plasticity.
12) The null hypothesis in T-Test for compressive strength with aspect ratios 50 and 60 for steel and polypropylene fibers shows that values 0.0011 and 0.020 which is showing the results obtained by tests is correct.
13) The value 0.0009 for split tensile strength is there in T-Test, it is more effective to show that samples taken for these test are accurate.
14) The statistical technique i.e. T-Test for steel and polypropylene fiber of aspect ratio 50 and 60 in case of compressive strength are 1.23×10^{-6} and 8.64×10^{-5}. The result came from these are showing that assumed hypothesis is null hypothesis and the result is best i.e. 95% true.
15) The approximated characteristic strength values for sample in split tensile strength for steel and polypropylene and aspect ratio 50 and 60 is 0.000479 and 9.68×10^{-5}. It gives the result assurance is more than 95%.

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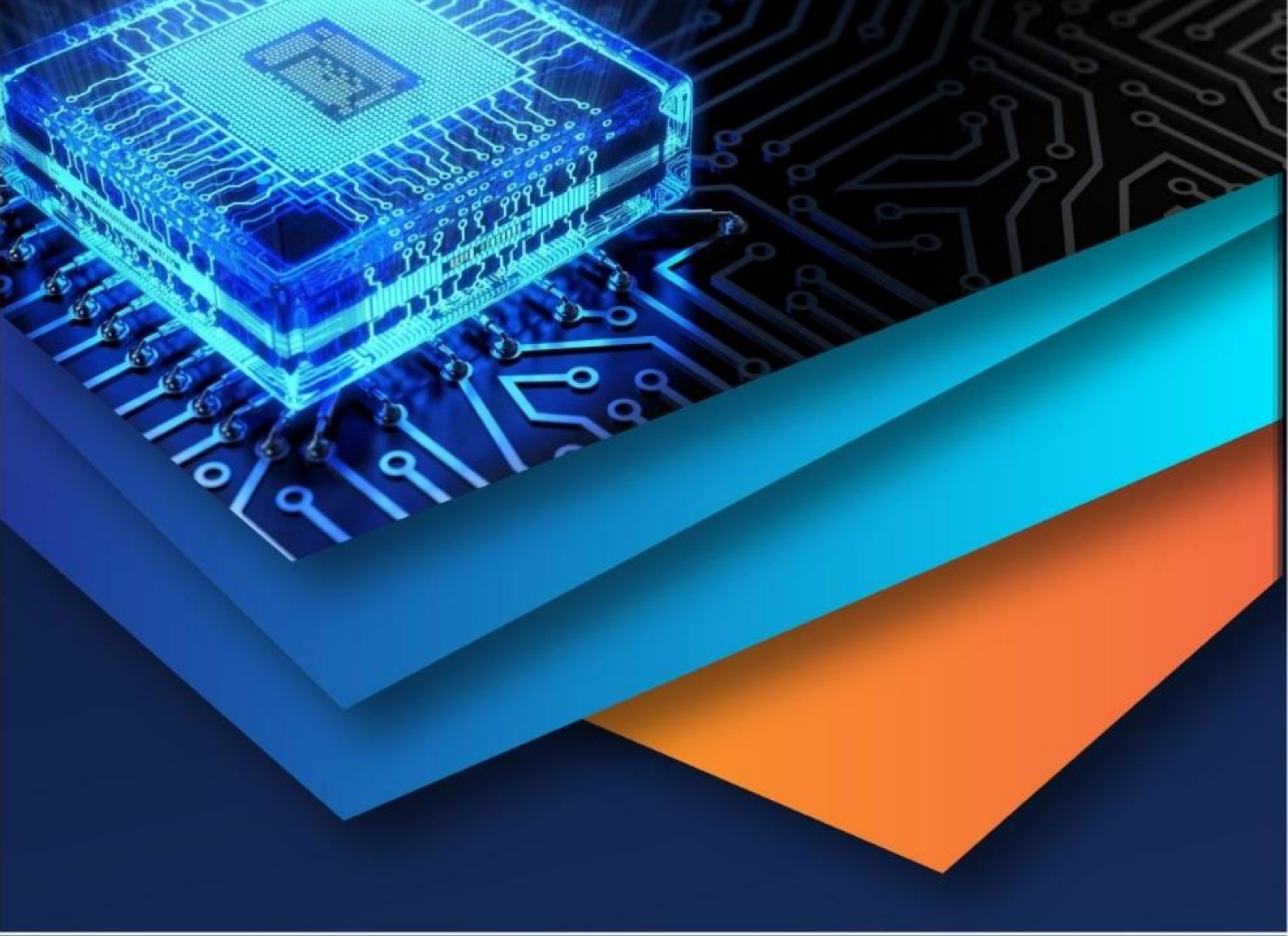

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