HYBRID FIBRE REINFORCED CONCRETE RESEARCH

B. Suvarna Babu[1], M. Hanuma[2], D. Prakash[3], S. Lavanya[4]
[1,2,3,4] Assistant Professor, St Peters Engineering College, Secunderabad, TS

Abstract — The main purpose of this work is to study the behaviour of concrete both in fresh state and hardened state by combing the stainless steel fibers (hooked end) and polypropylene fibers in it. We have added two types of fibres in concrete, so it is named as hybrid fibre reinforced concrete (HFRC). In general cement concrete is weak in tension; to enhance the tensile strength in concrete we have adopted fibers. By incorporating short closely distributed and evenly dispersed fibers to concrete, it will enhance the strength properties of concrete and these fibers also act as crack resistor. Hybrid fibers are added to the concrete in volume fraction i.e. 0.25%, 0.50%, 0.75%, 1% respectively. Concrete of M40 grade was adopted based up on Indian standard code of mix and design. Tests were conducted on specimens to study the effect of hybrid fibers in various fractions in hardened concrete. Performance of HFRC under loading was found to improve significantly compared with normal concrete. Undoubtedly these hybrid fibers improve the mechanical properties of concrete. Test results have proven that Hybrid fibers will enhance the compression, flexural and split tensile strength parameters of concrete.

Keywords— **Stainless Steel Fibres, Polypropylene Fibres, HFRC**

INTRODUCTION

Concrete is widely used construction material in the world. Concrete is feasible to prepare and handle. Concrete is quasi brittle material, in general concrete is good in compression and weak in tension, in order to improve the tensile strength reinforcing bars were provided to it, Even though concrete is affected by micro cracks. When concrete is subjected to loading these micro cracks will propagate and causes failure. The idea of using fibers in construction is not new; use of fibers as reinforcing materials was started in ancient times. In olden days natural fibers are used in construction as reinforcing materials. As technological advances have taken, manmade fibers came in to existence. These artificial fibers are found to be stronger than the natural fibers, they also have numerous benefits. Major advantage is they easily blend with concrete, and they won't get decay. By adding steel fibers and polypropylene fibers to concrete will arrest crack propagation, and also improve the flexural tensile strength and toughness of concrete. Hybrid fibers do not show negative impact on concrete. Hybrid fibers also improve the durability nature of concrete, life of concrete structure will also get enhance. Fibres won't get decay because we are using stainless steel fibres (hooked end) and polypropylene fibres made of polymerisation of chemical compounds. Fibre Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers [1]. Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Fibre-reinforcement is mainly used in shotcrete, but can also be used in normal concrete. Fibre-reinforced normal concrete are mostly used for on-ground floors and pavements, but can be considered for a wide range of construction. Low modulus of fiber such as polypropylene is unlikely to give strength improvement, but it help in the absorption of large energy and gives greater degree of toughness and resistance to concrete. High modulus fibers such as steel impart strength and stiffness to the concrete.

EXPERIMENTAL PROGRAM

A. Materials Used

Fibers

Shaktiman MSH 8060 hooked end steel fibers were used in the study to increase tensile strength of concrete. Specifically it is designed for reinforcement of concrete. Diameter of fiber is 0.75mm; length of fiber 60mm, aspect ratio (L/D) 80 is used. Polypropylene fibre (short-cut strands of very fine denier monofilament) is added to the concrete during batching. Shape of the hooked end steel fibre and polypropylene fibre is shown in Figure 1 and their property is given in Table 1.

Cement

Ordinary Portland cement (OPC) 53 grade confining to IS: 12269[2] was used in this experimental study. Initial and final setting time was 180 and 325 minutes, respectively tested according to IS: 4031[3]. Specific gravity of cement was tested and was found to be 3.12.

Figure 1: Hooked End Steel Fibres And Polypropylene Fibres

TABLE 1: Properties of hooked end steel and Polypropylene fibers

Fiber length	60mm	10-12mm
Thickness	0.75mm	35-40 µ
Aspect ratio	80	……
Tensile strength	1200 N/mm^2	670 N/mm^2
Shape	Hooked end	Fibrillated

Aggregates

Fine aggregate collected from natural river bed is used. Fine Aggregates which passes through 4.75mm sieve is used. Specific gravity of fine aggregate of Zone-2 was tested as per IS: 2386[4] and resulted as 2.62 and Fine Modulus of 3.15, the coarse aggregate was taken as a combination of 20mm (60%) and 10mm (40%) as per IS code. Specific gravity of coarse aggregate was tested and resulted as 2.73 and fineness modulus as 7.05,

Water

Portable water was used confining to IS 456 2000[5] for casting and curing of specimens.

Super plasticizer

To improve the workability of concrete Conplast SP- 430 super plasticizer is used.

B. Concrete Mix Proportion

Concrete of M40 was designed confining to IS 10262[6]. Water cement ratio is taken as 0.4.
Mix proportion of M40 grade is given below in Table 2

TABLE 2: Concrete Mix Proportioning

Cement (Kg/m^3)	F.A (Kg/m^3)	C.A (Kg/m^3)	Water (litre/m^3)
420	671.25	1190	160
1	1.59	2.83	0.4

C. Mixing and casting

After doing all the mix design, material quantities are calculated. As per the calculated values materials has to take for mixing extra wastage should also considered in the calculations. Prior to mixing, moulds have to be cleaned and oil must be applied inside the moulds. Concrete mixture was batched by hand mixing. After mixing all the materials like C.A, F.A, cement then fibers are to be dispersed in the mix uniformly and water has to be added to the mix shown in Figure 2. Concrete mixing should be done rigorously and uniformly. After completion of mixing, concrete has to be poured in to moulds, after that tamping must done uniformly. So the air voids in the fresh concrete gets eliminated. If it is not done properly it leads to formation of voids and later decreases the strength of hardened concrete. Precaution must be taken while mixing the concrete because steel fibers are sharp in nature they can cause damage or injury. Over tamping must be avoided because it leads to the problems of segregation and bleeding. After 24 hours demoulding should be done, and specimens have to be cure for 28 days.

Figure 2: steel and polypropylene fibers mixing with aggregates & cement before adding water to mix

Specimen details

1. For compressive strength test 150mm X 150mm X 150mm cubes are used.
2. For split tensile strength test 150mm X 300mm cylinders are used.
3. For flexural strength test 100mm X 100mm X 500mm prisms are used.

For each proportion 3 specimens were cast.

RESULTS AND DISCUSSION

Test on fresh concrete

Slump cone test

Workability of Fresh concrete for various proportions of fibres was evaluated using slump cone test. Values were given in Table 3.

TABLE 3: Results for Slump Cone Test

Sl. No.	Specimen	Concrete Slump (mm)
1	Normal Concrete	100
2	H.F.R.C 0.25%	96
3	H.F.R.C 0.5%	93
4	H.F.R.C 0.75%	87
5	H.F.R.C 1%	82

Test on hardened concrete

Compressive strength

Concrete cubes casted and cure were tested under compressive testing machine (CTM) of capacity of 1000KN for 3 days, 7 days, and 28 days respectively. Cubes must place properly under CTM before testing and cubes testing are shown in Figure 3. Compressive strength results are given in table 4.

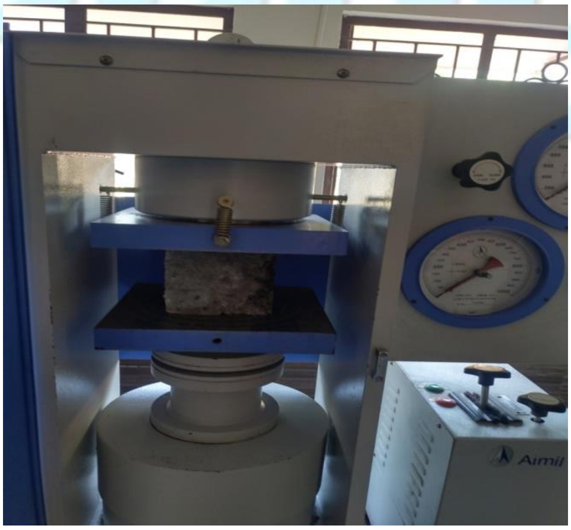

Figure 3: cube test under CTM

TABLE 4: Average Compressive Strength of Concrete with fibres and without fibres (N/mm^2)

S.NO	Days	Average Compressive Strength of Concrete with fibers and without fibers (N/mm^2)				
		Normal Concrete	H.F.R.C 0.25%	H.F.R.C 0.5%	H.F.R.C 0.75%	H.F.R.C 1.0%
1	3	22.3	24.6	26.8	29.5	32
2	7	37.86	41.66	45.58	49.23	52.88
3	28	57.66	61.36	65.06	68.76	72.46

Split tensile strength

Cylinders casted and cure were tested under CTM of capacity of 1000KN. Cylinders were placed in horizontal direction under CTM. Wooden strip has to place on top and bottom edges of cylinder. Cracking is a form of tensile failure, splitting tests are well known as indirect tests used for determining the tensile strength of concrete. Testing was shown in figure 4. Results were shown in table 5.

Figure 4: Cylinders testing under CTM

TABLE 5: Split tensile strength results

S.No	Days	Split tensile strength at 28 days (N/mm^2)				
		Normal Concrete	H.F.R.C 0.25%	H.F.R.C 0.5%	H.F.R.C 0.75%	H.F.R.C 1.0%
1	28	3.85	3.93	4.02	4.15	4.23

Flexural strength

Prisms casted were tested after 28 days under universal testing machine (UTM). Flexural test was conducted to observe bending behaviour of concrete. Test was performed confining to IS: 516[7]. Testing is shown in figure 5 and flexural results were shown in table 6.

PERCENTAGE INCREASE IN STRENGTH

Compressive strength

TABLE 7: Percentage Increased in compression strength

Sl. No	Type of Concrete	Percentage Increased		
		3 days	7 days	28 days
1	H.F.R.C 0.25%	10.31	10.03	6.41
2	H.F.R.C 0.5%	20.17	20.40	12.84

3	H.F.R.C 0.75%	32.28	30.03	19.25
4	H.F.R.C 1%	43.50	39.67	25.66

Figure 5: Beams testing under Flexural Testing Machine

Split tensile strength

TABLE 8: Percentage Increase in split tensile strength

Sl. No	Type of Concrete	Percentage Increase
		28 Days
1	H.F.R.C 0.25%	2.25
2	H.F.R.C 0.5%	4.45
3	H.F.R.C 0.75%	7.80
4	H.F.R.C 1%	10

Flexural strength

TABLE 9: Percentage Increase in Flexural strength

Sl. No	Type of Concrete	Percentage Increase
		28 Days
1	H.F.R.C 0.25%	12.4
2	H.F.R.C 0.5%	21.25
3	H.F.R.C 0.75%	35.6
4	H.F.R.C 1%	41.5

GRAPHS

The following graphs were plotted for compressive strength of concrete for 28 days, 7 days, 3 days Shown in Figures 6to8, similarly graph was plotted for flexural strength of concrete for 28 days shown in Figure 9, and similarly graph was plotted for split tensile strength of concrete for 28 days shown in Figure 10.

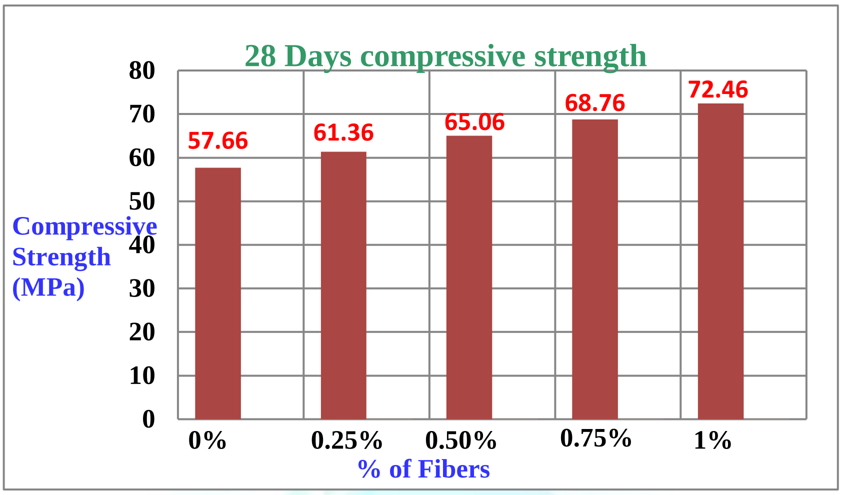

Figure 6: Compressive strength for 28 days

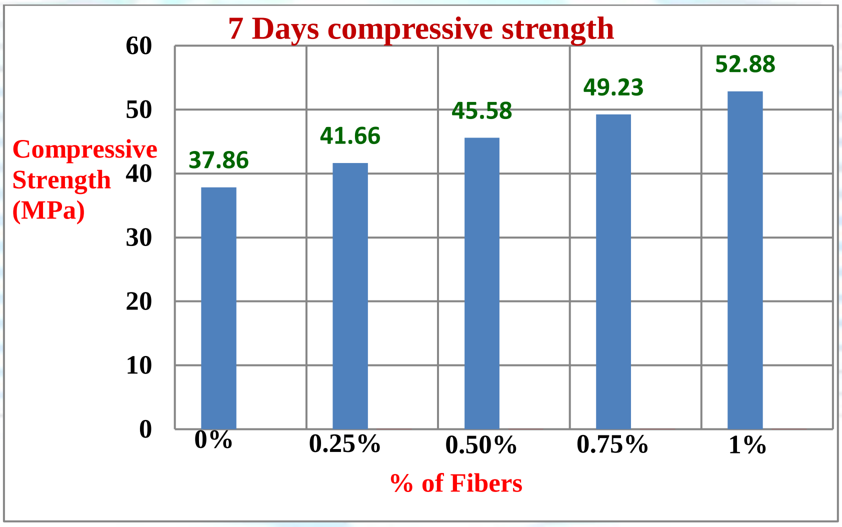

Figure 7: Compressive strength for 7 days

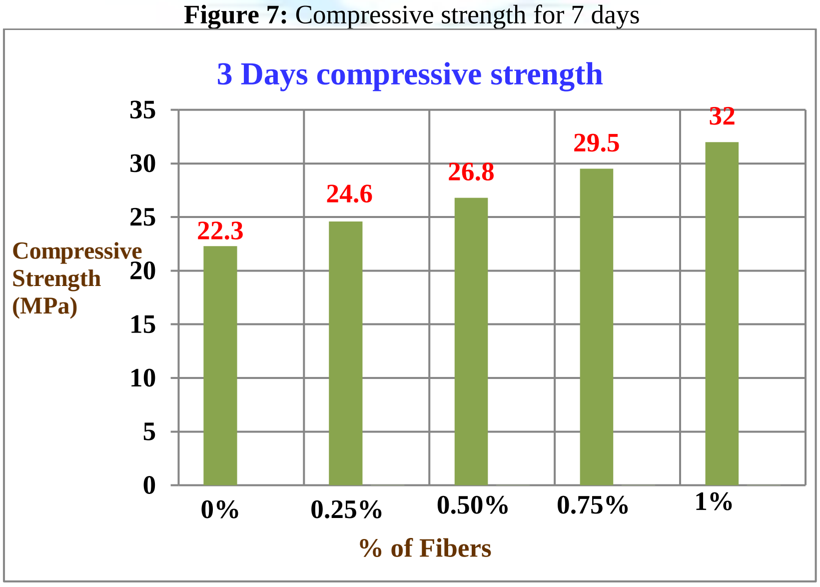

Figure 8: Compressive strength for 3 days

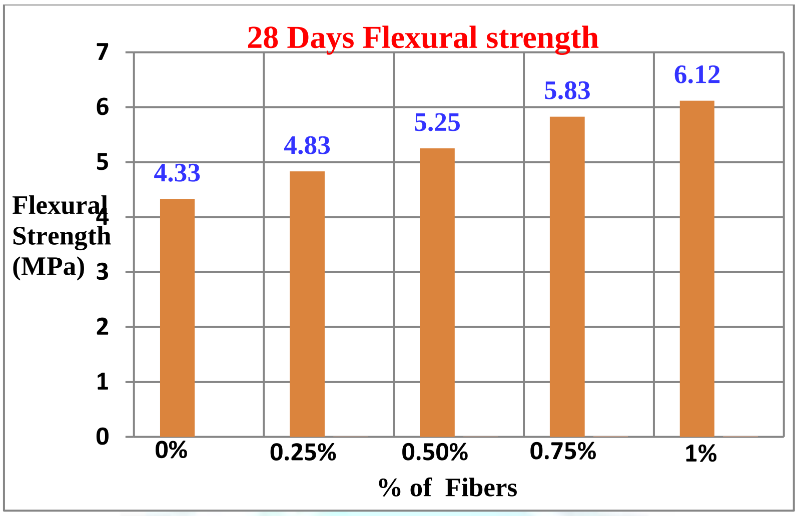

Figure 9: Flexural strength for 28 days

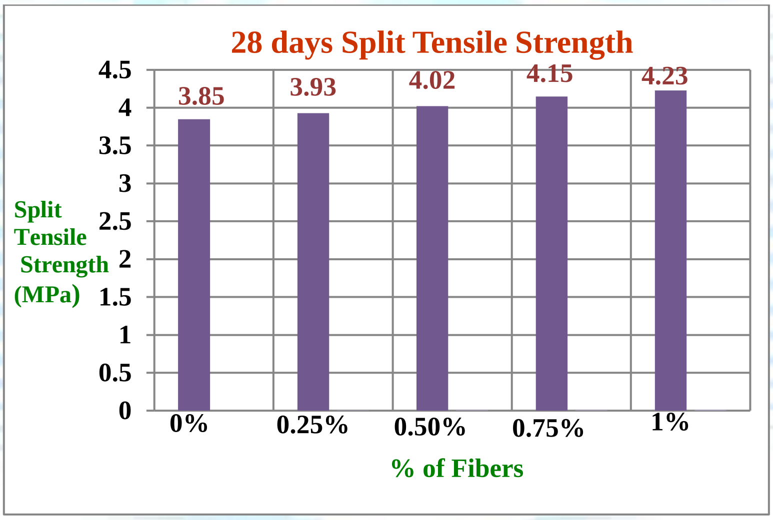

Figure 10: Split Tensile strength for 28 days

CONCLUSION

Based upon the experimental work performed on Hybrid Fibre Reinforced Concrete (HFRC) by combination of two materials namely Steel Fibres and Polypropylene Fibres the following conclusions are drawn

1. In HFRC the compressive strength was found to increase well while compared to normal concrete, especially for fibres proportion of 1% the strength was found to increase for 3 days, 7 days, and 28 days respectively. By adding hybrid fibres to concrete shows a large variation in compressive strength of concrete.
2. Flexural strength of concrete was also increased by adding the hybrid fibres to concrete, flexural test was performed on 28 day specimen, for normal concrete and HFRC (0.25%, 0.5%, 0.75%, 1%), it was observed that flexural strength increases linearly with % of fibres, higher the % of fibres relatively higher the flexural strength.
3. Split tensile strength of HFRC compared to normal concrete was found to be increased linearly.
4. For fresh concrete slump values decreases for HFRC compared with Normal concrete, in workability Aspect normal concrete shows better results than HFRC.
5. By adding hybrid fibres to concrete, it improves the crack resistance, ductility and toughness of concrete.
6. In this work we found that hybrid fibres controls the crack initiation well compared with normal concrete.

ACKNOWLEDGEMENTS

We would like to thank "Andhra Loyola Institute of Engineering And Technology", "DVR&DR.HS MIC College of Technology", and "Vignan's Lara Institute of Technology & Science", for providing the platform to conduct this study and the entire civil engineering department for generously allowing us to avail their lab facilities for conducting experiments.

REFERENCES

[1] Mohankar, R. H., et al. "Hybrid fibre reinforced concrete." *International Journal of Science, Engineering and Technology Research (IJSETR)* 5.1 (2016): 1-4.
[2] IS: 12269-1987, Indian standards ordinary Portland cement,53 grade, specification.
[3] IS: 4031-1968, Test methods for ordinary Portland cement, Bureau of Indian Standards.
[4] IS: 2386-PART-3, method of test for aggregate for concrete, part-3: specific gravity, density, voids, absorption and bulking[CED 2: Cement and Concrete].
[5] IS 456. Indian standard plain and reinforced concrete code of practice (Bureau of Indian Standards), New Delhi; 2000.
[6] IS 10262-2009. Indian standard concrete mix proportioning – guidelines (Bureau of Indian Standards), New Delhi; 2009
[7] IS: 516. "Indian standard methods of tests for strength of concrete." *Bureau of Indian Standards* (1959).
[8] D V Srikanth,Nageshwar K Rao,Vijayasree. Optimization of Process Parameters of Abrasive Jet Machining on Epoxy Glass Fiber Composite, IJSAE ONLINE JOURNALS,Vol 3.Issue-10,Pages-4577-4587.