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EFFECT OF DIFFERENT TYPES OF STEEL FIBER ON THE SPLIT TENSILE STRENGTH OF SFRC CYLINDRICAL SPECIMENS

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ABSTRACT

In this study, effect of aspect ratio (l/d), volume fraction (V_f) and fiber type on the split tensile strength of steel fiber reinforced concrete (SFRC) was investigated. Different types of steel fiber i.e. hooked end fiber of aspect ratio 60 and 75 and crimped rounded steel fiber of aspect ratio 75 were used. These fibers were added in the concrete mix at 0.75%, 1.00%, 1.25% and 1.5% by volume of concrete. Standard cylindrical concrete specimens were casted of grade M20 with particular fiber type and at particular volume fraction. After 28 days of curing, these specimens were tested and split tensile strength was determined. It was found that with the inclusion of steel fibers and with the increase in V_f and l/d there was significant increase in split tensile strength. Moreover, crimped round fiber shows better result as compare to hooked end fiber at same l/d up to 1.25% V_f. At V_f= 1.5%, strength of crimped round fiber reduces due to the formation of balls because of improper mixing of crimped round fiber with the concrete mix due to its shape.

***Keywords*: Aspect Ratio, Split Tensile Strength, Steel Fiber Reinforced Concrete, Volume Fraction**

1. INTRODUCTION

Concrete is a composite material made of cement, aggregate (coarse & fine) and water. Concrete is strong in compression but very weak in tension. At failure concrete shows brittle failure. To overcome these disadvantages steel reinforcement is added. Steel reinforcement provides tensile strength to concrete but is unable to resist the micro cracks. These micro cracks with due course of time becomes large and cause structure to fail. To avoid the formation of micro cracks fibers are added into the concrete. These fibers are in variety of types. Some of them are glass fibers, steel fibers, synthetic fibers and natural fibers. Out of all steel fibers are best suited. The advantages of steel fibers are that it do not allow micro cracks to occur. Bekaert (1991) suggested to mechanisms which showed how steel fibers are able to resist micro cracks. With the addition of steel fibers there is minor increase in compressive strength but flexural and split tensile strength are significantly improved.Post peak behavior of concrete is improved with the addition of steel fibers thereby, increasing the ductility of concrete.

The aspect ratio and volume fraction of steel fiber also effect the properties of concrete. Higher the aspect ratio and volume fraction provide better spilt tensile and flexural strength but workability of concrete suffers with higher aspect ratio and volume fraction. Fiber with different shape also increases the strength properties of concrete for example hooked-end fiber are better than straight fibers and crimped fibers provide better strength than hooked-end fibers. This is due to the fact that crimped fibers provide better anchorage than hooked-end fibers.

Main disadvantage of SFRC is, addition of steel fibers effects the workability of concrete. And as the aspect ratio and volume fraction increases mixing of the steel fibers with concrete becomes difficult. This leads to the entanglement of fibers. This is called balling effect of fibers. This balling effect can be reduced with the addition of admixture but up to certain extend.

II EXPERIMENTAL STUDY

1.1. Material used

Concrete of grade M20 was prepared for which ordinary Portland cement of 53 grade conforming to IS 12269 was used. Specific gravity of cement was determined as 3.15. Coarse aggregate of size 16mm were used having fineness modulus 7.41, conforming IS 383-1970. Fine aggregate were used of zone II with specific gravity 2.64 and fineness modulus 2.91, conforming IS 383-1970. Portable water was used for the experimentation.

Table 1- Mix proportion

Cement	Fine Aggregate	Coarse Aggregate	Water/Cement
1	1.78	2.95	0.55

In this experiment, three types of steel fibers were used namely, hooked end fibers of aspect ratio 60 &75 and crimped round fiber used of aspect ratio 75.Properties of steel fiber is denoted in table 2

Table 2- Properties of steel fiber

	Hooked end (75)	Crimped (75)	Hooked end (60)
Length (l) (mm)	60.0	60.0	50
Diameter (d) (mm)	0.8	0.8	0.58
Aspect Ratio (l/d)	75	75	60
Tensile Strength (MPa)	1250	1250	1250

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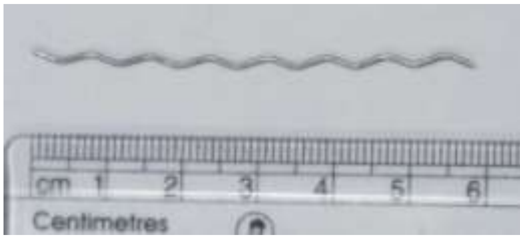
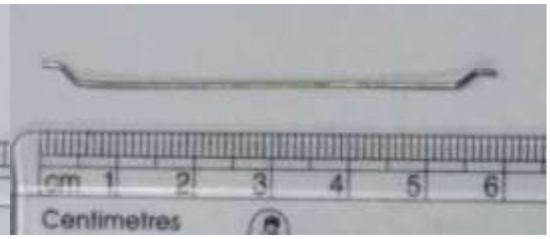
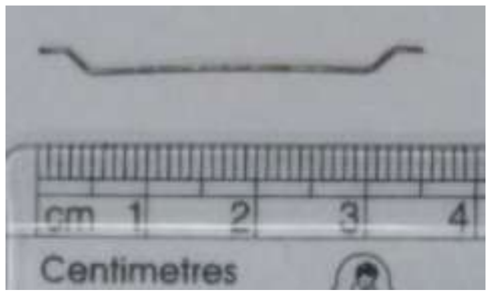
Hooked-end fiber of aspect ratio 75 and 60 is represented as HE 75/60 and HE 60/50. Crimped rounded fiber is represented as CR 75/60.





CR 75/60 HE 75/60



HE 60/35

Figure 1- Images of the Fiber Used

1.2. Experimental methodology

For split tensile strength test, cylindrical specimen of dimensions 150 mm diameter and 300 mm height were cast for M20 grade concrete. The concrete was reinforced with particular type of steel fiber with dosage varying from 0.75%, 1.00%, 1.25% and 1.5% by volume of concrete. Table 3 shows the weight of steel fiber added for particular volume fraction.

Table 3- weight of steel fiber to be added according to volume fraction.

Volume Fraction (V_f)	0.75%	1.00%	1.25%	1.5%
Weight (grams) of steel fiber to be added in one cylinder	312	416	520	624

After 24 hours of casting, the specimens were demoulded and were transferred to the curing tank where they were allowed to cure for 28 days. After the completion of 28 days of curing the specimens were tested under compression testing machine. For each average value three cylinders were tested. In total 39 cylinders were casted including plain concrete cylinders. Split tensile strength was calculated by following formula.

Split Tensile strength (MPa) = $\frac{2P}{\pi DL}$

Where, P = Failure load (N).

D = diameter of the cylinder = 300 mm.

L = Length of the cylinder = 150 mm.

Figure 2- Specimen under Split Tensile Test

II RESULTS AND DISCUSSIONS

The results obtained after the spilt tensile test are reported below. Table—shows the average split tensile strength of M20 grade plain concrete (without steel fiber). The results obtained by SFRC specimens having particular fiber type and particular volume fraction are reported in table 4.

Table 4- Average value of split tensile strength of plain concrete specimen.

Split tensile strength (MPa)	Average Split tensile strength (MPa)
1.98	1.90
1.85	
1.88	

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Table 5- Average value of split tensile strength of SFRC specimens.

Volume Fraction (V_f) (%)	Hooked-end (l/d=60)		Hooked-end (l/d=75)		Crimped (l/d=75)	
	Average Load (kN)	Split Tensile Strength (N/mm^2)	Average Load (kN)	Split Tensile Strength (N/mm^2)	Average Load (kN)	Split Tensile Strength (N/mm^2)
0.75	141.66	2.00	176.67	2.49	208.67	2.94
1	186.67	2.64	226.7	3.21	271.67	3.84
1.25	235	3.32	266.6	3.77	278.33	3.94
1.5	265	3.68	321	4.54	275	3.89

Value taken in this study are average of three specimens.

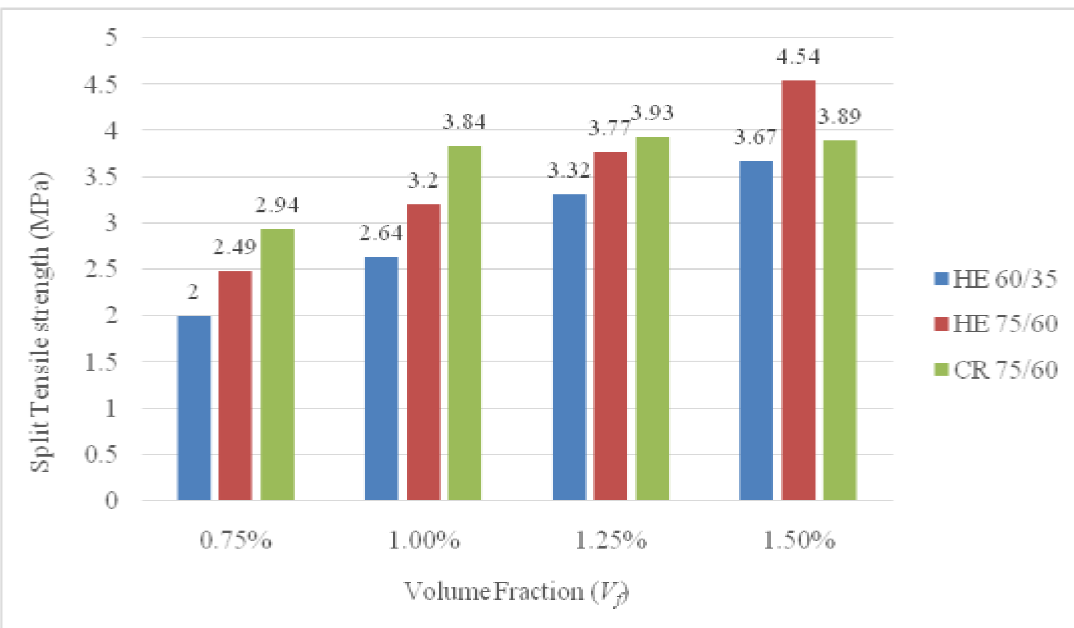

Figure 3- Variation of split tensile strength of different SFRC specimens at different volume fractions.

From the above bar chart it is evident that, as the aspect ratio increases there is significant increase in split tensile strength. With the change in aspect ratio from 60 to 75 of hooked-end fiber there is increase of 24.5% at 0.75% $V_f$and 23.7% at 1.5% V_f. This is because HE 75/60 has a higher length as compare to the HE 60/35 which helps in making better bond with the concrete.

In case of type of fiber, CR 75/60 shows increase in split tensile strength by 18% at 0.75% V_f and 4.24% at 1.25% V_f as compare to the hooked-end fiber. This is due to the fact that crimped round provide better anchorage as compare to the hooked-end fiber. But at 1.5% V_f value of split tensile strength of CR 75/60 reduces to 17% as compare to HE 75/60. This is because at 1.5% V_f crimped fiber start entangling with each other to form balls, this is also called balling effect. Such balls of fibers are removed from the mix thereby decreasing the fiber dosage. Since the effective fiber dosage gets reduced that's why value of split tensile strength is reduced.

III CONCLUSION

From the above discussion following conclusions are drawn:

1) With increase in aspect ratio the there is significant improvement in split tensile strength.
2) With increase in volume fraction split tensile strength increases.
3) Shape of the fiber play vital role in the increase in strength parameter. For example in the above case despite having same aspect ratio crimped round fiber showed better result as compare to hooked end fibers.
4) From results it is evident that steel fiber are quite beneficial in increasing the tensile strength of concrete. However, entanglement of fibers resulting in improper mixing (balling effect) is the major disadvantage of the steel fibers. This problem can be settled by using admixtures but up to certain volume fraction.
5) Due to this balling effect the effective dosage of the fiber is reduced and therefore strength of crimped fiber at 1.5% V_f is reduced.

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