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Experimental Study and Comparison of Test Results on Fiber Reinforced Concrete

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***Abstract*—In the present work, an attempt is made to investigate the compressive strength, Split tensile and flexural strength of concrete made with fiber reinforced concrete by using hooked end steel fibers, For this investigation, the cube and cylinder are cast of standard size and the beam specimens of 100 mm in width, 100 mm in depth, and 500 mm in length are cast, Steel fibers are varied from 0.0 % up to 1 % volume fraction. All the beam specimens are tested under two-point loading up to failure, and failure load, are recorded concisely and precisely.**

***Keywords*—Shear Strength; Beams; Steel Fibers; Concrete; SFRNSC.**

I. INTRODUCTION

Reinforced concrete members are normally designed for the limit state of collapse in flexure rather than in shear. Shear failure, which in reality, occurs under the combined action of shearing forces and bending moments, characterized by very small deflection and lack of ductility. This failure is many times, sudden and without any warning. For this reason, shear failure is considered very undesirable and is usually avoided. The problem of shear behaviour and ultimate shear strength of reinforced concrete beams was examined many years ago. Several tests were carried out and various models were developed to describe the failure behaviour of reinforced concrete beams under shear forces. Many suggestions are based on the cube strength of concrete, which still remain the key parameter in design principles of many countries. The research in the high strength concrete fields showed that cube strength is less important than fracture energy for the description of the material behaviour of structural elements. It is well known that use of steel fibers raises the ductility of concrete and the fractured energy. This phenomenon is transferable to the shear strength of concrete. In failure modes the addition of Fibers in a suitable percentage and geometry produces a significant increase in shear strength and in some cases can also change the failure mode from shear to flexure. Also the addition of fibers can partially substitute transverse stirrups and have the same effect in terms of shear strength. They also make easy manufacture of critical portions of R.C.Structures as well as allow highly effective control of the concrete cracking process particularly in low force levels. The SFRNSC (Steel fiber reinforced natural sand concrete) is a composite material made of cement, fine and coarse aggregates and discontinuous discrete steel fibers. In tension SFRNSC fails only after the steel fiber breaks or pulled out of the cement matrix. The composite nature of SFRNSC is responsible for its properties in freshly mixed and hardened state. The SFRNSC possess many excellent dynamic performances such as high resistance to explosion and penetration as compared to traditional concrete. The mechanical properties of SFRNSC are influenced by the type of fiber, aspect ratio, and volume fraction of fibers and the size of the aggregates.

The test specimens were cast using cement, fine aggregate, coarse aggregate, water, and Hooked steel fibers. The materials, in general, confirmed to the specifications laid down in the relevant Indian Standard codes. For grading of fine and coarse aggregate, sieve analysis was carried out. Ordinary portland cement of 53-grade confirming to IS 12269:1987 was used throughout the experimental work. The maximum size of coarse aggregate used was 20 mm along with 12.5 mm of same parent rock in 60-40 % fraction. Locally available Krishna river sand was used as fine aggregate. The specific gravity of sand was 2.85 and fineness modulus was 2.7.Hooked end steel fibers of length 60 mm and diameter 0.75 mm were used throughout the experimental work.

II. CONCRETE MIX DESIGN

The concrete mixes were designed in accordance with the I.S. code method of concrete mix design. The concrete mix was prepared for M-20,M-25 and M-30 grade of concrete. The water-cement ratio was kept at 0.50,0.48 and 0.42 respectively to enhance the workability of mix throughout experimental work. The mix proportion is given in Table I.

Table I Mix Proportion

All weights are in kilograms

Material	M20	M25	M30
Cement	372	413.33	442.85
Natural sand	679.88	649.43	630.29
Coarse aggregate	1236.99	1233.09	1226.13
Water	186	186	186
Water / Cement ratio	0.50	0.45	0.42
Cement/F.A/C.A ratio	1:1.83:3.33	1:1.57:2.98	1:1.42:2.76

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III. Test Specimens

Total 45 beams were cast. The span of the beam has been kept constant at 450 mm with 25 mm overhangs on either side of the support. All beams were rectangular in cross section with 100 mm width. Standard cubes of size 150 mm x 150 mm x150 mm were cast with each mix to know the compressive strength of concrete and cylinders of size 150 mm in diameter and 300 mm in height were cast with each mix to know the split tensile strength of concrete.

IV. Test Procedure

After 28-days curing period, the beam specimens were removed from the curing tank and both sides of the beams were white-washed to aid observations of the crack development during testing. All the beams were tested to failure under two-point loading test set-up as shown in Fig 1. After 28 days curing period, the cube specimens were tested for compressive strength and cylinder specimen were tested for split tensile strength

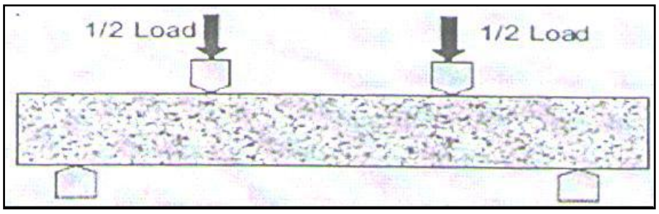

Figure1: Two point loading set up for flexural test

V. Results And Discussion

The results obtained from experimental investigation are tabulated as given below. From the results obtained, the effects of various parameters on concrete are analyzed and discussed below

1) Compressive strength Test:

Table II Compressive strength of SFRNSC

Fiber aspect ratio	Fiber volume fraction %	28 Days compressive strength of SFRNSC (MPa)		
		M20	M25	M30
0	0.0	22.51	28.14	33.18
80	0.25	23.26	30.29	33.85
80	0.50	25.26	33.25	35.7
80	0.75	28.81	35.55	37.85
80	1.0	33.41	39.78	42

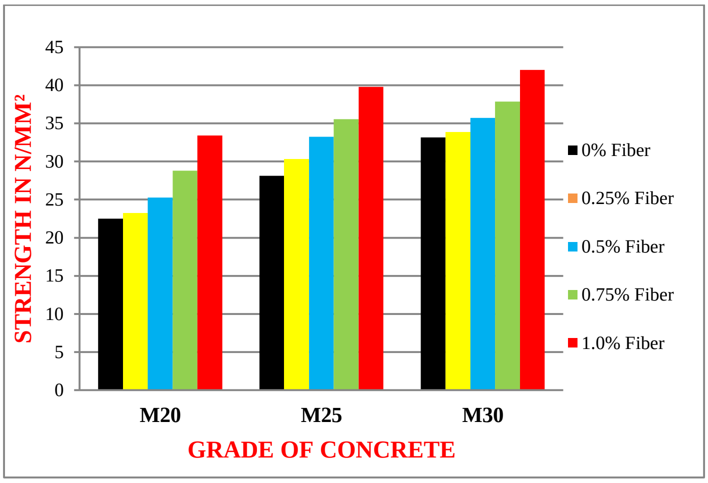

Figure 2: Variation of Compressive Strength V/s % Volume Fraction of Fibers.

2) Split Tensile Strength

Table III Split tensile strength of SFRNSC

Fiber aspect ratio	Fiber volume fraction %	28 Days Split tensile strength of SFRNSC (Mpa)		
		M20	M25	M30
0	0.0	4.10	4.53	5.23
80	0.25	4.22	4.62	5.30
80	0.50	4.48	4.79	5.42
80	0.75	4.74	5.07	5.56
80	1.0	4.9	5.31	5.92

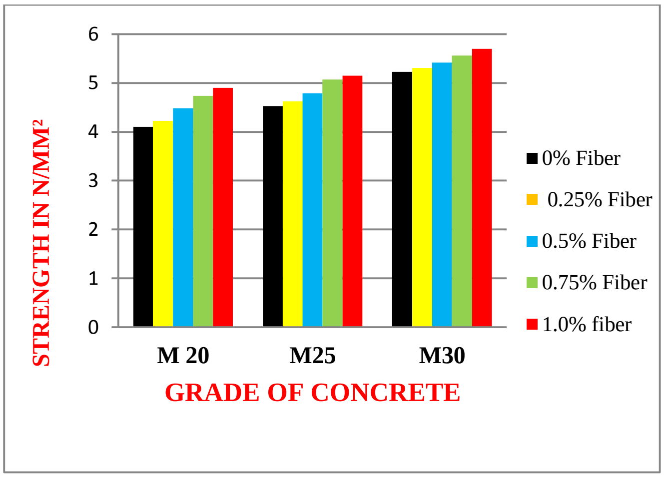

Figure 3: Variation of Split Tensile Strength V/s % Volume Fraction of Fibres.

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3)Flexural Strength

TABLE IV FLEXURAL STRENGTH OF SFRNSC

Fiber aspect ratio	Fiber volume fraction %	28 Days flexural strength of SFRNSC (MPa)		
		M20	M25	M30
0	0.0	4.15	4.35	5.12
80	0.25	4.32	4.61	5.50
80	0.50	5.29	5.52	6.18
80	0.75	5.45	5.87	6.38
80	1.0	5.9	6.2	6.7

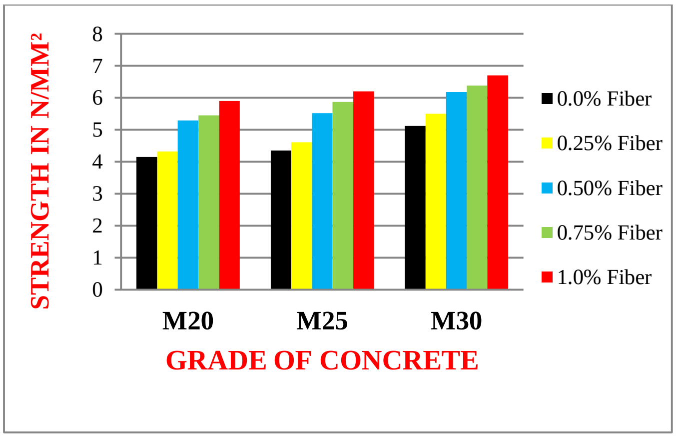

Figure 4: Variation of Flexural Strength V/s % Volume Fraction of Fibers.

VI. CONCLUSION

Based on the test results following conclusions can be drawn,

1. The significant increase in compressive, split tensile strength and flexural strength is observed with the addition of hooked end steel fibers in plain concrete. However, this increase depends on addition of amount of fiber content. The optimum percentage is found to be 1%.
2. There was increase in compressive strength by 41.36% , increase in split tensile strength by 17.21%, increase in flexural strength by 30.86% in concretes of all grades due to addition of 1% fiber volume fraction.
3. The addition of steel fibers also increased, decreased crack width, crack spacing and sizes, increased deformation capacity and also changed the mode of brittle failure to ductile.
4. The increase in compressive stress is marginal as compared to flexural and split tensile strength.
5. Considering the workability and effect of fiber, to get the designed degree of workability, the use of super plasticizer is essential.

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