EFFECT ON CONCRETE STRENGTH DUE TO ADDTION OF FIBER

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ABSTRACT

Concrete is most widely used construction material in the world. Fiber reinforced concrete (FRC) is a concrete in which small and discontinuous fibers are dispersed uniformly. The fibers used in FRC may be of different materials like steel, G.I., carbon, glass, aramid, asbestos, polypropylene, jute etc. The addition of these fibers into concrete mass can dramatically increase the compressive strength, tensile strength, flexural strength and impact strength of concrete. FRC has found many applications in civil engineering field. Based on the laboratory experiment on fiber reinforced concrete (FRC), cube and cylinders specimens have been designed with steel fiber reinforced concrete (SFRC) containing fibers of 0% and 0.5% volume fraction of hook end Steel fibers of 53.85, 50 aspect ratio. Comparing the result of FRC with plain M20 grade concrete, this paper validated the positive effect of different fibers with percentage increase in compression and splitting improvement of specimen at 7 and 28 days, analyzed the sensitivity of addition of fibers to concrete with different strength.

Keyword: *Compressive Strength, Fiber Reinforced Concrete, Split Tensile Strength, Steel Fibers.*

I. INTRODUCTION

CEMENT concrete is characterized by brittle failure, the nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibers (steel, glass, synthetic and natural) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc.

Fibre Reinforced Concrete (FRC)

Concrete is the most widely used structural material in the world with an annual production of over seven billion tons. For variety of reasons, much of this concrete is cracked. The reason for concrete to suffer cracking may be attributed to structural, environmental or economic factors, but most of the cracks are formed due to the inherent weakness of the material to resist tensile forces. Again, concrete shrinks and will again crack, when it is restrained. It is now well established that steel fiber reinforcement offers a solution to the problem of cracking by making concrete tougher and more ductile. It has also been proved by extensive research and field trials carried out over the past three decades, that addition of fibers to conventional plain or reinforced and prestressed concrete members at the time of mixing/production imparts improvements to several properties of concrete, particularly those related to strength, performance and durability. The weak matrix in concrete when reinforced with fibers, uniformly distributed across its entire mass, gets strengthened enormously, thereby rendering the matrixto behave as a composite material with properties significantly different from conventional concrete.

II . LITERATURE SURVEY

Presently, a number of laboratory experiments on mechanical properties of SFRC have been done. [Shah Surendra and Rangan], in their investigations conducted uni-axial compression test on fiber reinforced concrete specimens. The results shown the increase in strength of 6% to 17% compressive strength, 18% to 47% split tensile strength, 22% to 63% flexural strength and 8% to 25% modulus of elasticity respectively. [Byung Hwan Oh] in their investigations, the mechanical properties of concrete have been studied, these results shown the increase in strength of 6% to 17% compressive strength, 14% to 49% split tensile strength, 25% to 55% flexural strength and 13% to 27% modulus of elasticity respectively. [Barrows and Figueiras]in their investigations the mechanical properties of concrete have been studied. These results shown the increase in strength of 7% to 19% compressive strength, 19% to 48% split tensile strength, 25% to 65% flexural strength and 7% to 25% modulus of elasticity respectively. [Chen S. investigated the strength of 15 steel fiber reinforced and plain concrete ground slabs. The slabs were 2x2x0.12m, reinforced with hooked end steel fibers and mill cut steel fibers. [Dwaraknath and Nagaraj] predicted flexural strength of steel fiber concrete by these parameters such as direct tensile strength, split cylinder strength and cube strength. James and Beaudoin stated that the minimum fiber volume dosage rate for steel, glass and polypropylene fibers in the concrete matrix was calculated approximately 0.31%, 0.40% and 0.75%. Patton and Whittaker investigated on steel fiber concrete for dependence of modulus of elasticity and correlation changes on damage due to load. Rossi et. al , analyzed that the effects of steel fibers on the cracking at both local level (behavior of steel fibers) and global level (behavior of the fiber/cement composite) were dependent to each other. Sener et. alcalibrated the size effect of the 18 concrete beams under four-point loading. Swami and Saad], had done an investigation on deformation and ultimate strength of flexural in the reinforced concrete beams under 4 point loading with the usage of steel fibers, where consists of 15 beams (dimensions of 130x203x2500mm) with same steel reinforcement (2Y-10 top bar and 2Y-12 bottom bar) and variables of fibers volume fraction (0%, 0.5% and 1.0%). Tan et. al [9] concluded some investigation on the shear behavior of steel fiber reinforced concrete. Six simply supported beams were tested under two- point loading with hooked steel fibers of 30mm long and 0.5mm diameter, as the fiber volume fraction increased every 0.25% from 0% to 1.0%. Vandewalle had done a similar crack behavior investigation, which based on combination of five full scale reinforced concrete beams (350x200x3600mm) with steel fibers (volume fraction of 0.38% and 0.56%).In his investigation, the experimental results and theoretical prediction on the crack width was compared.

III. CHARACTERISTICS

In comparison to conventional reinforcement, the characteristics of fiber reinforcement are that:

1. The fibers are generally distributed throughout a cross-section, whereas steel bars are only placed where needed.
2. The fibers are relatively short and closely spaced, whereas the steel bars are continuous and not as closely placed.
3. It is generally not possible to achieve the same area of reinforcement with fibers as with steel bars.
4. It is much tougher and more resistant to impact than plain concrete.

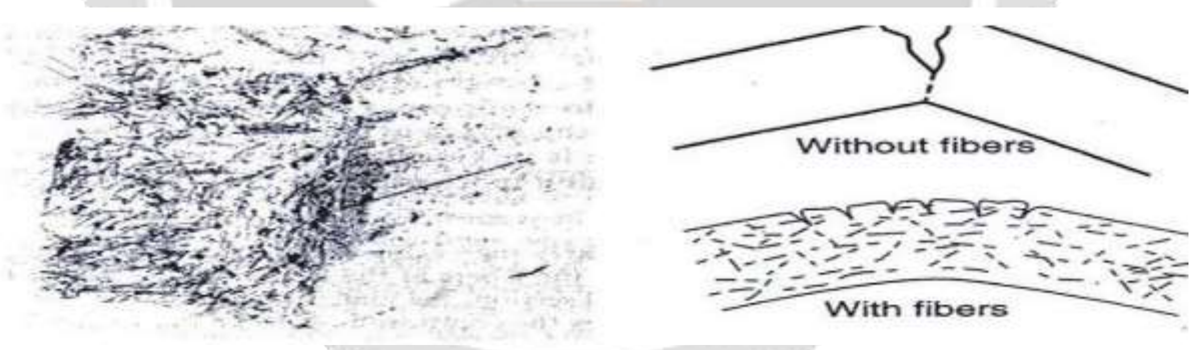

Fig. 1 Failure mechanism and the effect of fibers

The fibers are not added to improve the strength, though modest increases in strength may occur. Rather, their main role is to control the cracking of FRC, and to alter the behavior of the material once the matrix has cracked, bybridging across these cracks and so providing some post-cracking ductility.

IV MATERIAL

A] Materials and Properties

The materials selected for this experimental study includes normal natural coarse aggregate, manufactured sand as fine aggregate, cement, superplasticizer, both end hooked steel fiber and portable drinking water. The physical and chemical properties of each ingredient has considerable role in the desirable properties of concrete like strength and workability.

B] Cement

The cement used for this project work is Portland slag cement. It gives low heat of hydration.

Table I: Physical Properties of Cement

Brand of cement	OPC
Initial setting time (in mins)	147
Final setting time (in mins)	325
Specific gravity	2.91
Standard consistency	34%

V. EXPERIMENTAL PROGRAM

Material Used
Cement, sand, coarse aggregate, water, steel and glass fibers were used for this study.

Cement:
The cement used was Ordinary Portland cement (43 Grade) with a specific gravity of 3.15. Initial and final setting time of the cement was 20 min and 227 min, respectively. Ordinary Portland cement of 43 grade was used, conforming to I.S-8112- 1989

Sand:
Good quality river sand was used as a fine aggregate. Locally available sand, confirming to zone II with specific gravity 2.45, water absorption 2% and fineness modulus 3.18, conforming to I.S. – 383-1970
Coarse aggregate: Crushed granite stones of maximum 20 mm size having specific gravity of 2.67, fineness modulus of 7.10, conforming to IS 383-1970

Water:
Potable water was used for the experimentation.
Fibers: In this work, effects on strength of concrete with two hook end steel fibers at low volume fraction were studied.

Mild steel:
Mild steel wire form, Hook end 35 mm and 50 mm length having density of 7.85 g/cm3 and minimum tensile strength as 345 MPa, at 0.5% by volume of concrete collected from Stewols Pvt. Ltd. Nagpur, Maharashtra, India, were used. The different aspect ratios adopted were 53.85 and 50 with diameter of fibers 0.93 and 0.7 mm respective.

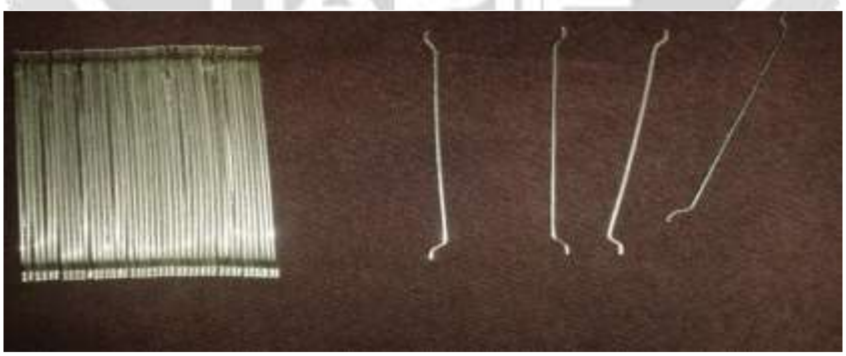

Fig.2 Mild steel used

The mixture proportioning was done according the Indian Standard Recommended Method IS 10262- 2009[20] and with reference to IS 456-2000 [19]. The target mean strength was 26 MPa for the OPC control mixture, the total binder content was 383 Kg/m3, fine aggregate was taken 672 Kg/ m3 and coarse aggregate was taken 1100 Kg/m3. The water to binder ratio was kept constant as 0.5. The total mixing time was 5 minutes; the samples were then casted and left for 24 hrs before demoulding. They were then placed in the curing tank until the day of testing cement, sand and coarse aggregate were properly mixed together in the ratio 1:1.75:2.87 by weight before water was added and properly mixed together to achieve homogenous material. Water absorption capacity and moisture content were taken into consideration. Cube and cylindrical moulds were used for casting. Compaction of concrete in three layers with 25 strokes of 16 mm rod was carried out for each layer. The concrete was left in the mould and allowed to set for 24 hours before the specimens were demoulded and placed in curing tank. The specimens with and without fiber were cured in the tank for 7 and 28days.

Table 2: Details of Quantity of Constituent Materials

Material	Quantity	Proportion
Cement	383 Kg/ m3	1
Sand	672 Kg/ m3	1.75
Coarse Aggregates (20 mm)	1100 Kg/ m3	2.87
Water	192 Kg/ m3	0.5

have been performed to determine the mechanical properties such as compressive strength and splitting tensile-strength of concrete mix with steel fibers 0%, 0.5% by volume of concrete.

VI. RESULTS AND DISCUSSIONS

In the present investigation an attempt has been made to determine the effect of fiber by examining the slump, compressive strength, split tensile strength. For that cubes, cylinders were casted using fibers.
The mixing was done using a pan mixer. The compression test and splitting tension test were conducted by the same.

A. Compressive Strength Test
The test performed on, compression testing machine, which has a capacity up to 200 Tones. The compressive strength was calculated as follows:
Compressive strength (MPa) = Failure load / cross sectional area.

Fig.3 Compressive Strength Test

B. Split Tensile Strength Test
The test was conducted as per IS 5816:1999 For tensile strength test, cylindrical specimens of dimension 100 mm diameter and 200 mm length were cast. The specimens were demoulded after 24 hours of casting and were

transferred to curing tank where in they were allowed to cure for 7 and 28days. In each category, three cylinders were tested and their average value was reported [10].

The split tension test was conducted using digital compression machine having 2000 kN capacity

Split tensile strength was calculated as follows:

Spilt Tensile strength (MPa) = 2P / π DL

Where, P = Failure Load (kN)

D = Diameter of Specimen (100 mm)

L = Length of Specimen (200 mm)

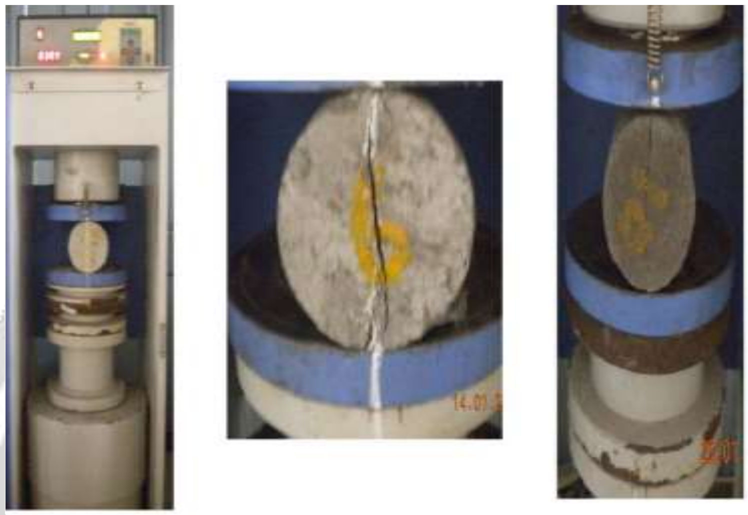

Fig.4 Compressive Strength Test

Table 3: Details of Quantity of Constituent Materials

Design -ation	Fibre Kg/m^3	Average compressive strength (N/mm^2)			Average split tensile Strength (N/mm^2)		Average modulus of rupture (N/mm^2)	
		3rd	7th	28th	7th	28th	7th	28th
CM 1	0	19.3	25.3	35.3	1.65	2.25	3.2	5.2
MS1	20	20.4	26.3	36.4	2.34	3.07	4.0	6.4
MS2	25	22.3	28.3	39.4	2.63	3.25	4.2	7.2
MS3	30	24.4	30.4	40.7	2.83	3.78	5.2	8.0

(i) Compressive strength

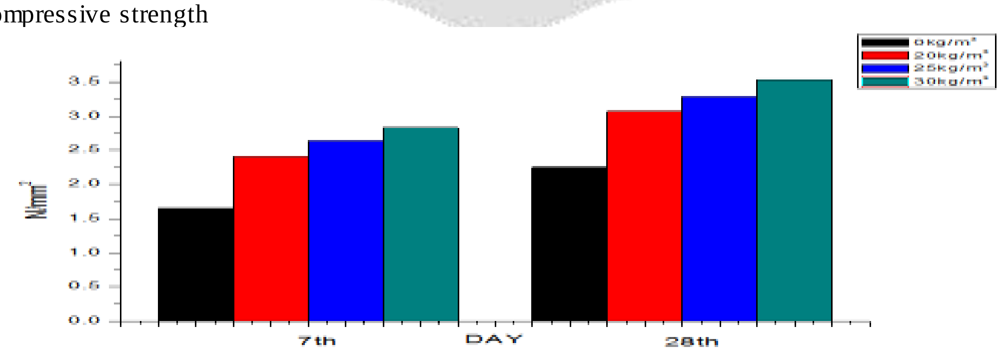

Fig.5 Compressive Strength

(ii) Split tensile strength

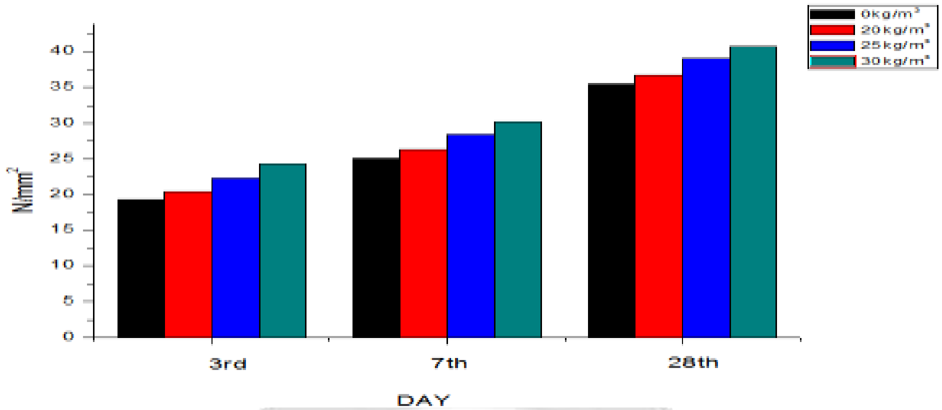

Fig.6 Split tensile strength

From the test results of compressive strength, split tensile strength and, it can be seen that, in the presence of steel fiber there is an increase in compressive strength, split tensile strength. The crack formation is also very small in fiber specimen compared to the non fiber specimens.

VII. CONCLUSIONS

The findings of the above studies indicate that the addition of steel fibers to concrete improve not only the stren gth characteristics but also the ductility. Research over the years have shown that fiber reinforcement has sufficient strength and ductility to be used as a complete replacement to conventional steel bars in some types of structures; foundations, walls, slabs. The technology that is available today has made is possible to consider fiber reinforcement without the use of conventional steel bars in load carrying structures.

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