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An Experimental Study on Mechanical Properties of Hooked Steel Fiberous Concrete

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ABSTRACT: Concrete being brittle is weak in tension. The addition of Steel Fibers in concrete have greatly progresses its Compressive Strength, Split tensile strength as well as Flexural Strength . The use of dissimilar types of Fibers & their orientation in the cement Concrete matrix have shown positive responses between the scholars. Fiber is easy available material. The crack failures can be reduced by means of the steel fibers in concrete. These fibers are thin, short and distributed randomly all over the concrete member of different aspect ratios (L/d ratio). Out of all different types of Fibers, steel Fibers are widely used because steel has high elasticity Modulus , high elongation, high tensile strength and the bond between steel and the Fiber is enormous. In This present experimental investigation was carried out to investigate the influence of steel Fibers on physical and mechanical properties of concrete, covering cold strained carbon steel Fibers of hooked end type having aspect ratio of 50 with diameter of 0.6mm and length 30mm with following percentages of 0.5%, 1%, 1.5% and 2.0% fraction is added to the concrete. Concrete is evaluated for compressive, split tensile and flexural strength at the ages of 7, 14 and 28 days, with the adding of 1.5% of Steel Fibers, test results show the maximum compressive Strength, split tensile Strength and flexural strength, it becomes the optimal value. Moreover, the results confirmed that the fibrous steel reinforced concrete reduce cracking and improves flexure.
Keywords: Compressive strength, Hooked steel fiber, aggregate and cement

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I. INTRODUCTION

In present scenario concrete is one of the most widely used materials in the construction field. Usually, it is associated with ordinary Portland cement which is the main Component for making concrete[1]. Cement offers excellent performance as a bind-ing material in concrete. So the demand for cement rises day by day due to development of infrastructure all over the world. On another hand, cement manufacturing Companies are increases from past decades to till now

The concrete without any Fibers will develop the cracks due to plastic shrink-age, drying shrinkage and other reasons of changes in volume of concrete[2]. The development of these micro cracks causes elastic deformation of concrete. Plain concrete is a brittle material and having the values of modulus of rupture and strain capacity is low. In order to meet the required values of flexural strength and enhances the strain capacity of the plain concrete, the Fibers are being used in normal concrete[3]. The adding of Fibers in the plain concrete will control the cracking due shrinkage and also reduce the bleeding of water.

Plain concrete processes a very low tensile strength, limited ductility, and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle failure of the concrete.The most widely accepted remedy to this flexural weakness of concrete is the conventional reinforcement with high strength steel. Restraining techniques are also used to. Although these methods provide tensile strength to members, they however do not increase the inherent tensile strength of concrete itself.

Fiber Reinforced Concrete

Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The fiber is often described by a convenient parameter called “aspect ratio”. The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150. 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. Within these different fibers that character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.

Effect of Fibers in Concrete

Fibers are usually used in concrete to control plastic. They also lower the permeability of concrete and thus reduce bleeding of water. Some types of Fibers produce greater impact, abrasion and shatter resistance in concrete. Generally Fibers do not increase the flexural strength of concrete, so it can not replace moment resisting or structural steel reinforcement. Some Fibers reduce the strength of concrete. The amount of Fibers added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and Fibers) termed volume fraction (Vf). Vf typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing Fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. Some recent research indicated that using Fibers in concrete has limited effect on the impact resistance of concrete materials.This finding is very important since traditionally people think the ductility increases when concrete reinforced with Fibers.

Objective of the Work:

- The main objective of the project is reduce the cracks in the concrete structures like precast beams, columns, pipes and many other concrete structures.
- By increasing the tensile strength we can reduce the cracks. Thereby, we can increase the strength in the concrete structures.
- By avoiding the cracks in buildings, they appear to be more appealing.

Scope of the project:

The main scope of project is the use of hooked steel fibers in concrete where the usage of normal steel reinforcement will be reduced. In uneven settlement of cement concrete roads the bottom portion will subjected to tension, but it is plain concrete so it can't tolerate these stresses therefore they may give cracks and finally it leads to the entire road failure. In that case we can increase the tensile strength of concrete by introducing steel fiber reinforced concrete.

II. MATERIALS AND METHODS

STEEL FIBERS

Steel fiber for reinforcing concrete is defined as short, discrete lengths of steel fibers with an aspect ratio (ratio of length to diameter) from about 20 to 100, with different cross-sections, and that are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the usual mixing procedures.

Properties of steel fibers

S.NO	PROPERTY	VALUES
1	Equivalent Diameter, mm	0.15 to 1.00
2	Specific Gravity, kg/m3	7840
3	Tensile Strength, MPa	345 to 3000
4	Young's Modulus, GPa	200
5	Ultimate Elongation, %	4 to 10
6	Thermal Conductivity,1%	2.74
7	Aspect Ratio	50 to 100

Hooked Steel Fibers

These are glued together in a row way. The big difference between loose and glued fibers is that the former is easy to block together and the latter is easy to disperse uniformly.In this study Hooked Steel bars were used.

Figure: Hooked Steel Fiber

Advantages

- Uniform distribution maximum the strengths of steel fibers.
- Three dimensional reinforcement avoid all cracks.
- Easy to use.
- Long service life.

Specifications:

- Diameter: 0.5 to 1.0mm.
- Length: 25 to 60mm.
- Aspect Radio: ≥42.
- Material: Low carbon steel; cold-drawn.

Tensile strength: more than 1100MPa

Table :Aspect Ratios of various hooked steel Fibers

Diameter (mm)	Length (mm)	Aspect Radio (L/D)	Tensile Strength (MPa)
0.5	25	50	≥1100
0.5	30	60	≥1100
0.5	35	70	≥1100
0.6	25	42	≥1100
0.6	30	50	≥1100
0.6	35	58	≥1100
0.75	30	40	≥1100
0.75	35	47	≥1100
0.75	60	80	≥1100
0.8	30	38	≥1100
0.8	35	44	≥1100
0.8	60	75	≥1100
0.9	50	56	≥1100
0.9	60	67	≥1100
1.0	50	50	≥1100
1.0	60	60	≥1100

Applications:

- Shotcrete.
- Airport runways and taxiways.
- Highway pavements.
- Precast.
- Equipment foundations.
- Blast resistant structures.

AGGREGATES

Aggregates are the important Component in concrete nearly 75 to 80% of volume is occupied. They give rigid skeleton structure to the concrete. Good gradations of aggregates are one of the most important factors for producing workable concrete.

COARSE AGGREGATE

The properties of the coarse aggregate used in a concrete mixture affect the modulus for a few reasons. One property is the Modulus of Elasticity of the coarse aggregate..

FINE AGGREGATE

River sand is used as a fine aggregate. The fine aggregates utilized were easily accessible from the local market. Fine aggregate can be classified as those particles which roughly pass the 4.75mm IS sieve and significantly retains on the 75micron sieve. Fine Aggregates having specific gravity value of 2.74

Properties of cement

S.No.	Description	Test Result / Specifications
1	Grade used	53
2	Fineness of the cement	93%
3	Consistency	30%
4	Time for Initial setting	30 min
5	Final setting time	10 hours
6	Specific gravity	3.15
7	Soundness	1mm

Properties aggregate

S.No	Description	Test Result
1	Sand zone	Zone- II
2	Specific gravity	2.62
3	Water absorption	0.8%

III. PREPARATION OF CUBES, CYLINDERS AND PRISMS

In this Steel Fiber reinforced concrete, Five different combinations were studied. At first one 100% of Cement used as binder material under adding of 0.5%, 1%, 1.5%, and 2% Steel Fiber, river sand as fine aggregate and conventional course aggregate was used, in course aggregate 80%of 20mm size aggregates and 20% of 10mm size aggregates was used and the Steel Fibers was used as an different percentages through weight of cement. After testing the physical properties and chemical Composition of ingredients, all ingredients are mixed together to prepare cubes (150 mm x 150 mm x 150 mm), cylinders (150mm width and 300mm height) and prisms (100mm x 100mm x 100mm) by provisions of IS 516.

The following aspects have to keep in notice while preparation of cubes and cylinders.

- Mixing of all the materials have been done in the laboratory at room temperature

- The Steel Fiber added before adding water in to the mix and the mix should be well mixed until the Fiber was mixed uniformly
- The binder, coarse aggregate, Steel Fiber and aggregates were mixed together by hand mixing. The mixing is allowed to continue for about 3 minutes.
- after proper mixing the fresh concrete is placed into the mounds into three layers and each layer is Compacted by using standard tamping rod allow for 25 blows then apply vibrate by using vibrating machine.
- Now strike off the excess quantity placed above the specimen then finish the surface smoothly and gently.
- Those specimens were kept in room temperature and these specimens were demoulded between 16 to 24 hours after casting.
- After casting, the concrete specimens were kept at room temperature and cured under water for 28 days.

Mechanical Tests On Steel Fiber Reinforced Concrete

The tests performed for finding the mechanical properties of Steel Fiber reinforced concrete and then brief test procedure are explained as follows.

Compressive Strength:

This test is conducted on three samples for each mix. The surface of the cubes is polished carefully using fine paper in order to remove irregularities. Characteristic Compressive Strength of S.FC is determined according to the guidelines of IS 516:1958, IS 456:2000.

The characteristic Compressive strength is calculated by the following formula

Compressive strength (fck) = load/(area) = p/a

Where P = Load at failure (N),

A = Cross-sectional area of specimen (mm2)

Split Tensile Test:

As from the guide-lines IS 516:1959 the split tensile strength of concrete is determined. And this test was done on the concrete specimens of length 300 mm and diameter 150 mm. Figure shows the specimen arrangement and the specimen after test respectively. Split-tensile strength of concrete. = 0.7Fck.The splitting tensile strength is calculated using the formula

$T = 2P/\pi LD$

Where,

T = Splitting tensile strength

P = Maximum applied load

L = Length in mm

D = diameter

Flexural Strength Test:

To conduct Flexural strength test, Prisms having specimens (100 mm × 100mm × 500 mm) was determined according to the guide-lines of IS 516by applying 2 point load as shown in the fig.

Flexural Testing of Specimen

The specimens were de-moulded after compeletion of 24 hours of casting and were shifted to curing tank where they were permitted to cure for 28 days. These flexural strength specimens were tested under 2 point loading according to I.S 516-1959, over an actual span of 500 mm on flexural testing machine. Load and corresponding deflections were recorded up to failure. In each category 3 no of prisms were tested and their average result is noted. The flexural strength was calculated as follows.

Flexural strength (MPa) = $(P \times L) / (B \times D^2)$

Where, P= Failure load

L = C/C distance between the support = 400mm

B= width of specimen = 100 mm

D= depth of specimen = 100 mm

Mix Proportion:

Mix proportion for the M30 grade of concrete mix is 1:1.54:2.62

Table Mix proportions

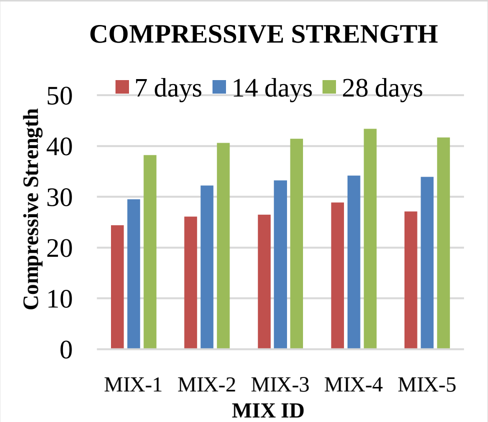
MIX	Cement (Kg/m^3)	S.F (%)	F.A (Kg/m^3)	C.A (Kg/m^3)	Water (Liters)	Steel Fiber(Kg/m^3)
Mix-1	437	0	673	1146	197	0
Mix-2	437	0.5	673	1146	197	2.185
Mix-3	437	1	673	1146	197	4.37
Mix-4	437	1.5	673	1146	197	6.555

Mix-5	437	2	673	1146	197	8.74

IV. RESULTS AND ANALYSIS

Compressive strength results

Mix Type	COMPRESSIVE STRENGTH (MPa)			AVG COMPRESSIVE STRENGTH(MPa)		
	7 days	14 days	28 days	7 days	14 days	28 days
MIX-1	24.8	29.1	38.1	24.4	29.5	38.2
	24.5	29.5	38.1			
	23.9	29.9	38.4			
MIX-2	25.6	31.9	39.9	26.1	32.2	40.6
	25.9	32.1	40.9			
	26.8	32.6	41			
MIX-3	26.6	33.0	41.1	26.5	33.2	41.4
	26.4	33.4	41.0			
	26.5	33.2	42.1			
MIX-4	28.5	34.2	43.7	28.9	34.2	43.4
	28.9	34.1	42.9			
	29.3	34.3	43.6			
MIX-5	27.2	33.7	42.0	27.1	33.9	41.7
	27.0	33.8	42.2			
	27.1	34.2	39.9			



Graph: Compressive strength results of Mixes

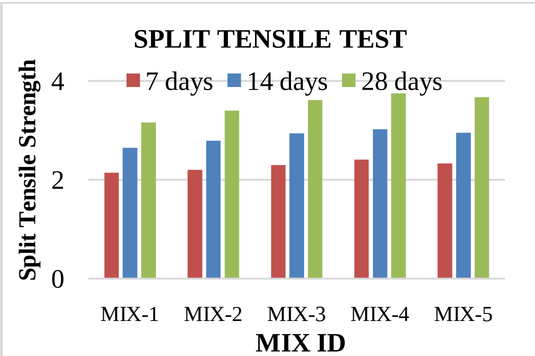
From the above graph represents the compressive strengths of Fiber reinforced concrete with different proportions of steel Fiber 0%, 0.5%, 1%, 1.5% and 2% respectively at the ages of 7, 14 and 28 days.

It was found that the average compressive strengths of 0.5% SF at the age of 7, 14 and 28 days has increased by 7%, 9.1 % and 6.28% respectively when compared with Mix-1, It was found that the compressive strength of 1% SF at the age of 7, 14 and 28 days has increased by 8.6%, 12.54% and 8.37% respectively when compared with Mix-1. It was found that the compressive strength of 1.5% SF at the age of 7, 14 and 28 days has increased by 18.4%, 16% and 13.6% respectively when compared with Mix-1, It was found that the compressive strength of 2% SF at the age of 7, 14 and 28 days has increased by 11%, 14.9% and 9.16% respectively when compared with Mix-1

SPLIT TENSILE STRENGTH

Split Tensile strength results

MIX TYPE	SPLIT TENSILE STRENGTH (MPa)			AVG SPLIT TENSILE STRENGTH(MPa)		
	7 days	14 days	28 days	7 days	14 days	28 days
MIX-1	2.07	2.62	3.05	2.14	2.65	3.16
	2.23	2.66	3.12			
	2.12	2.67	3.31			
MIX-2	2.21	2.8	3.40	2.2	2.79	3.4
	2.11	2.79	3.44			
	2.28	2.8	3.36			
MIX-3	2.42	2.77	3.51	2.3	2.94	3.61
	2.45	3.01	3.58			
	2.48	3.04	3.74			
MIX-4	2.45	3.00	3.5	2.41	3.02	3.75
	2.46	3.05	4.01			
	2.32	3.00	3.72			
MIX-5	2.5	2.95	3.65	2.33	2.95	3.67
	2.28	3.05	3.67			
	2.21	2.85	3.69			



Graph Split Tensile strength results of Mixes

From the above graph represents the Split strengths of Fiber-reinforced concrete with differentproportions of steel Fiber 0%, 0.5%, 1%, 1.5% and 2% respectively at the ages of 7, 14 and 28 days.

It was found that the average Split Tensile strengths of 0.5% SF at the age of 7, 14 and 28 days has increased by 2.8%, 5.3% and 7.6% respectively when compared with Mix-1, It was found that the compressive strength of 1% SF at the age of 7, 14 and 28 days has increased by 7.5%, 10.9% and 14.2% respectively when compared with Mix-1. It was found that the compressive strength of 1.5% SF at the age of 7, 14 and 28 days has increased by 12.61%, 13.9% and 18.7% respectively when compared with Mix-1, It was found that the compressive strength of 2% SF at the age of 7, 14 and 28 days has increased by 8.8%, 11.3% and 16.1% respectively when compared with Mix-1

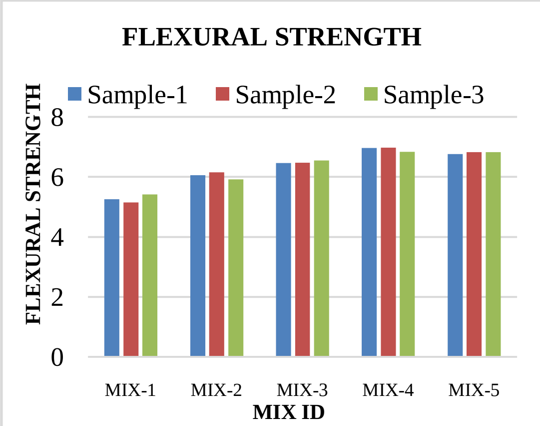
Flexural strength test results:

Table Flexural strength results

Mix Type	Trail	Flexural Strength (N/mm^2) for 28 days	Avg Flexural Strength(N/mm^2) 28 Days
MIX-1	1	5.26	5.28
	2	5.15	
	3	5.41	
MIX-2	1	6.06	6.04
	2	6.15	
	3	5.92	
MIX-3	1	6.46	6.5
	2	6.47	
	3	6.55	
MIX-4	1	6.96	6.92
	2	6.97	
	3	6.84	
MIX-5	1	6.76	6.8
	2	6.82	
	3	6.82	

From the graph represents the Flexural strengths of Fiber-reinforced concrete with different proportions of steel Fiber 0%, 0.5%, 1%, 1.5% and 2% of Sample-1, Sample-2, and Sample-3 respectively at the age 28 days.

It was found that the results of Flexural Tensile strengths of 0.5% SF at the age of 28 days has increased by 14.3% when compared with Mix-1, It was found that the results of compressive strength of 1% SF at the age of 28 days has increased by 23.1% when compared with Mix-1. It was found that the results of compressive strength of 1.5% SF at the age of 28 days has increased by 31% when compared with Mix-1, It was found that the results of compressive strength of 2% SF 28 days has increased by 28% when compared with Mix-1



Graph Flexural strength results

V. CONCLUSIONS

In the present study, the influence of adding of Steel-Fiber on the conventional concrete with Various proportions of steel Fiber such 0%, 0.5%, 1%, 1.5%, and 2%, of binding material by weight. Several mechanical properties for example Compressive strength, split-tensile strength test and flexural strength were studied in this work.

On the basis of experimental studies carried out and the analysis of test results, the following conclusions are drawn. The fibrous Steel concrete is start to attain supreme ultimate load carrying capacity and is firmer than the conventional concrete. It is perceived that the Compressive strength, split tensile strength and flexural strength for M30 grade of concrete.

1) When increase in steel-Fiberous content, mainly the mechanical properties are such as compressive strength, Split Tensile strength, &Flexural Strength improved gradually; particularly for Flexural strength and split tensilestrength, the steel-fiber reinforcement effect is clear.
2) Maximum Compressive strengths, split tensile strength and flexural strengths attained with 1.5% SteelFiber,28 days of with mix-4 of concrete
3) Mechanical properties of Compressive strength split tensile strength and Fexural strength results increased with increasing of age of concrete. These results were increased with increasing of Steel Fiber content up to 1.5% then decreasing gradually above 1.5% till 2.0%
4) Maximum increase in Compressive Strength obtained at Mix-4, 1.5% of Steel fiber is 43.4 MPa which is 13.6% more than the Control mix at the age of 28 days.
5) Maximum increase in Split Tensile Strength obtained at Mix-4, 1.5% of Steel fiber is 3.75 MPa which is 18.67% more than the Control Mix at the age of 28 days.

6) Maximum increase in Flexural Strength obtained at Mix-4, 1.5% of Steel fiber is 6.92 MPa which is 31% more than the Control Mix at the age of 28 days.
7) In Compressive strengths, under adding of steel Fibers 10% of Compressive strength gain attained to conventional concrete.
8) In Split tensile strength, under adding of steel Fibers 10-14% of Split Tensile strength gain attained to conventional concrete.
9) In Flexural strength, Under adding of steel Fibers 20-25% of Flexural strength gain attained to conventional concrete.
10) As well as under adding of fibrous Steel in the concrete effect the workability of concrete. Adding of 0.5%, 1%,1.5% and 2% steel fibers will decreases slump value. Introduce the suitable admixtures such as Super plasticizers to overcome This problem of workability and flow property of concrete

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