Experimental Study on Effect of Different Types of Steel Fibers on Properties of Concrete

Bodanki Venkat Rao[1], Anusuri Uma Maheswari[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Chaitanya Engineering College, Kommadi

Abstract- *Concrete is one of the world most widely used construction material. However, since the early 1800's, it has been known that concrete is weak in tension. Weak tensile strength combined with brittle behavior result in sudden tensile failure without warning. This is obviously not desirable for any construction material. Thus, concrete requires some form of tensile reinforcement to compensate its brittle behavior and improve its tensile strength and strain capacity to be used in structural applications. Historically, steel has been used as the material of choice for tensile reinforcement in concrete. Unlike conventional reinforcing bars, which are specifically designed and placed in the tensile zone of the concrete member, fibers are thin, short and distributed randomly throughout the concrete member. In this study, an experimental investigation is conducted to find the effect of different types of steel fibers on strength parameters of M40 and M60 grade concrete using fibers like straight fiber, crimped fiber and hooked fiber.*

Keywords- About crimped fiber, hooked fiber, straight fiber, steel fiber reinforced concrete.

I. INTRODUCTION

Concrete is most widely used in construction. Concrete undergoes brittle failure as concrete is weak in tension. To increase the tensile strength carrying capacity of concrete different types of fibers can be incorporated in concrete. Concrete containing steel fiber have been shown to have substantially improved resistance to brittle failure. In this thesis different types of steel fibers like straight fiber, crimped fiber and hooked fiber at varying percentages from 1% to 3%.

II. MATERIALS

The following are the materials used in this project.

A. Cement

OPC 53 grade cement was adopted. Specific gravity of cement was ascertained as 3.15 using pycnometer apparatus.

B. Fine Aggregate

Fine aggregate i.e. Sand confirming to Zone-III of IS: 383-1970, is used for concrete.

C. Coarse Aggregate

Coarse aggregate i.e. crushed stone chips of size 4.75 - 20 mm confirming to IS: 383-1970.

D. Water

Potable water free from impurities and deleterious materials was used for mixing and curing in this thesis.

E. Steel Fibers

In this experiment Straight Steel Fibers, Crimped Steel Fibers and Hooked Steel Fibers are used.

(i) Straight Steel Fibers:

These steel fibers are pieces of steel wires from 0.3 to 1.1 mm in diameter and having length of 50mm.

(ii) Crimped Steel Fibers:

These steel fibers are either made up of carbon steel or stainless steel. The length of this fiber is normally less than 150mm. The length to diameter ratio typically ranges from 30 to 100 mm.

(iii) Hooked Steel Fibers

These steel fibers can be used with any concrete mix. The length to diameter ratio typically ranges from 30 to 100 mm.

III. METHODOLOGY

All the materials are proportioned according to the required mix design and are mixed well in a concrete mixer. First cement and sand is mixed well until a uniform colour is obtained. Then coarse aggregate is added to the above

mixture. After that water and required type of steel fiber of required aspect ratio is added to the above mix. It is then mixed well for about 3 to 5 minutes.

IV. RESULTS & DISCUSSIONS

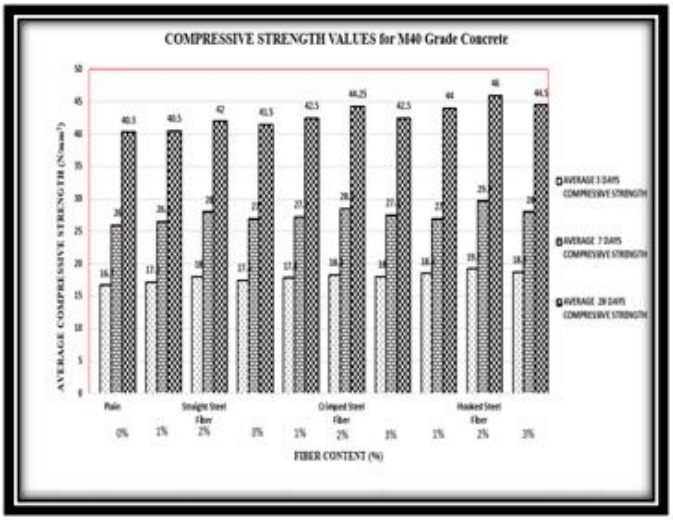
(a) Compressive Strength Test

In the present investigation the cubes were casted with steel fiber reinforcement, and tested. The dimensions of the cube are 150X150X150 mm in accordance to IS 456-2000. The casted cubes kept for curing and tested after 3days, 7days, and 28days and the capacity of concrete cube noted in KN .i.e force (P) by placing on any one side of the cube. The cross sectional area (A) of cube is 225cm2. . This work is carried out for grades of M40 & M60 at 3days, 7days and 28 days. The compressive strength is represented in N/mm2. The Mathematical representation of compressive strength σc =P/A.

Table 1: Compressive Strength for M40 grade concrete

(a) For M40 Grade Concrete

TYPE	FIBER CONTENT (%)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)		
		3 DAYS	7 DAYS	28 DAYS
Plain	0%	16.7	26.0	40.3
Straight Steel Fiber	1%	17.2	26.5	40.5
	2%	18.0	28.0	42.0
	3%	17.5	27.0	41.5
Crimped Steel Fiber	1%	17.8	27.2	42.5
	2%	18.3	28.5	44.25
	3%	18.0	27.5	42.5
Hooked Steel Fiber	1%	18.5	27.4	44.0
	2%	19.2	29.7	46.0
	3%	18.7	28.0	44.5

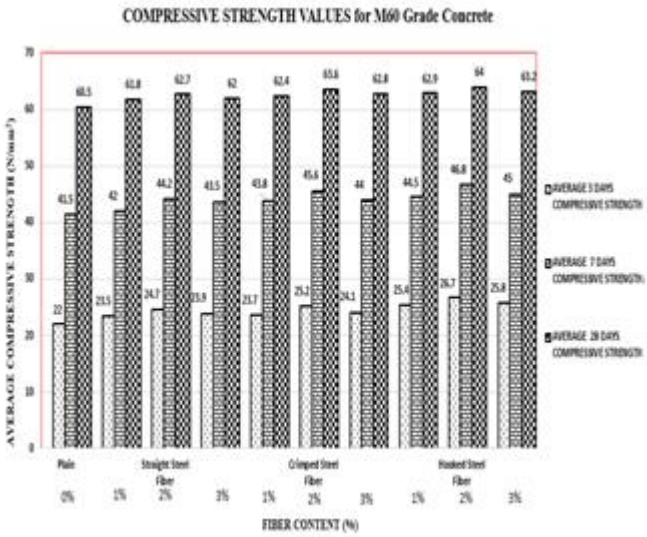


Graph 1: Compressive Strength for M40 grade concrete

Table 2: Compressive Strength for M60 grade concrete

(a) For M60 Grade Concrete

TYPE	FIBER CONTENT (%)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)		
		3 DAYS	7 DAYS	28 DAYS
Plain	0%	22.0	41.5	60.5
Straight Steel Fiber	1%	23.5	42.0	61.8
	2%	24.7	44.2	62.7
	3%	23.9	43.5	62.0
Crimped Steel Fiber	1%	23.7	43.8	62.4
	2%	25.2	45.6	63.6
	3%	24.1	44.0	62.8
Hooked Steel Fiber	1%	25.4	44.5	62.9
	2%	26.7	46.8	64.0
	3%	25.8	45.0	63.2



Graph 2: Compressive Strength for M60 grade concrete

(b) Split Tensile Strength Test

Generally the split tensile strength will be predicted by using cylinders of diameter 150mm and depth or height of 300m placing longitudinally and applying force by machine. This work is carried out for grades of M40 & M60 at 3days, 7days and 28 days.

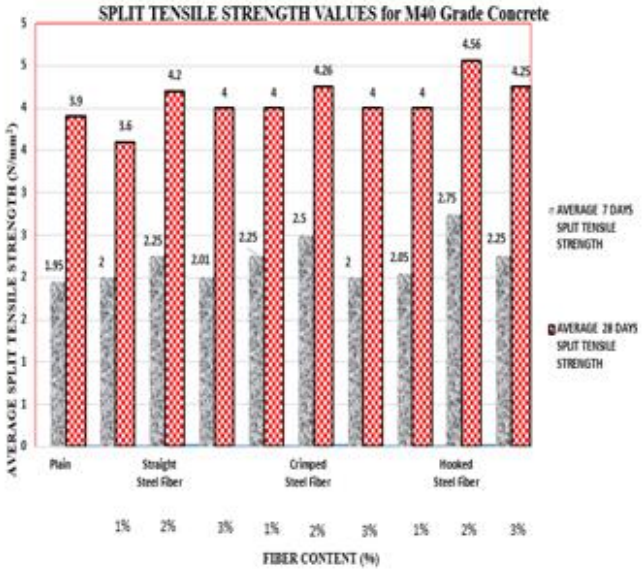
Split Tensile strength (MPa) = 2P / π DL, Where, P = failure load, D = diameter of cylinder,

L = length of cylinder

Table 3: Split Tensile Strength for M40 grade concrete

(a) For M40 Grade Concrete

TYPE	FIBER CONTENT (%)	AVERAGE 7 DAYS TENSILE STRENGTH (N/mm^2)	AVERAGE 28 DAYS TENSILE STRENGTH (N/mm^2)
Plain	0%	1.95	3.90
Straight Steel Fiber	1%	2.00	3.60
	2%	2.25	4.20
	3%	2.01	4.00
Crimped Steel Fiber	1%	2.25	4.00
	2%	2.50	4.26
	3%	2.00	4.00
Hooked Steel Fiber	1%	2.05	4.00
	2%	2.75	4.56
	3%	2.25	4.25

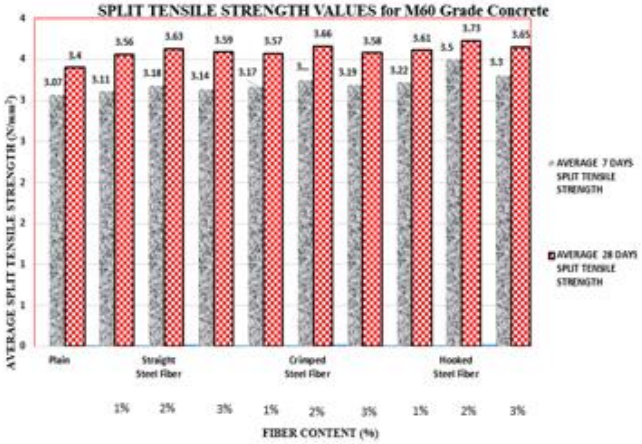


Graph 3: Split Tensile Strength for M40 grade concrete

Table 4: Split Tensile Strength for M60 grade concrete

(a) For M40 Grade Concrete

TYPE	FIBER CONTENT (%)	AVERAGE 7 DAYS TENSILE STRENGTH (N/mm^2)	AVERAGE 28 DAYS TENSILE STRENGTH (N/mm^2)
Plain	0%	3.07	3.40
Straight Steel Fiber	1%	3.11	3.56
	2%	3.18	3.63
	3%	3.14	3.59
Crimped Steel Fiber	1%	3.17	3.57
	2%	3.25	3.66
	3%	3.19	3.58
Hooked Steel Fiber	1%	3.22	3.61
	2%	3.50	3.73
	3%	3.30	3.65



Graph 4: Split Tensile Strength for M60 grade concrete

(c) Flexural Strength Test

Modulus of rupture was tested by prisms with dimension of (100x100x500) mm. The flexural strength (modulus of rupture) is calculated using the formula.

$M.O.R = 3PL /2BD^2$

Table 5: Flexural Strength for M40 grade concrete

(a) For M40 Grade Concrete

TYPE	FIBER CONTENT (%)	AVERAGE 3 DAYS FLEXURAL STRENGTH (N/mm^2)	AVERAGE 7 DAYS FLEXURAL STRENGTH (N/mm^2)	AVERAGE 28 DAYS FLEXURAL STRENGTH (N/mm^2)
Plain	0%	1.53	2.47	4.40
Straight Steel Fiber	1%	1.56	2.52	4.50
	2%	1.89	3.10	5.00
	3%	1.55	2.50	4.50
Crimped Steel Fiber	1%	1.58	2.52	4.70
	2%	1.78	3.28	5.20
	3%	1.60	3.10	5.12
Hooked Steel Fiber	1%	1.59	3.07	5.10
	2%	1.85	3.50	5.40
	3%	1.74	3.25	5.20

Table 6: Flexural Strength for M60 grade concrete

(a) For M60 Grade Concrete

TYPE	FIBER CONTENT (%)	AVERAGE 3 DAYS FLEXURAL STRENGTH (N/mm^2)	AVERAGE 7 DAYS FLEXURAL STRENGTH (N/mm^2)	AVERAGE 28 DAYS FLEXURAL STRENGTH (N/mm^2)
Plain	0%	1.89	3.65	5.42
Straight Steel Fiber	1%	1.92	3.69	5.55
	2%	1.97	3.74	5.68
	3%	1.94	3.70	5.57
Crimped Steel Fiber	1%	1.96	3.71	5.54
	2%	2.02	3.77	5.69
	3%	1.97	3.71	5.60
Hooked Steel Fiber	1%	2.01	3.76	5.65
	2%	2.15	3.85	5.76
	3%	2.00	3.75	5.64

V. CONCLUSIONS

In this study, different types of steel fibers were used to produce fiber reinforced concrete. The following conclusions were obtained from this study:

1) The 3,7 and 28 days compressive strength concrete with hooked steel fibers is maximum at a fiber percentage of 2%.
2) The 3, 7 and 28 days splitting tensile strength of concrete with hooked steel fibers is maximum at a fiber percentage of 2%.
3) The 3,7 and 28 days flexural strength of concrete with hooked steel fibers is maximum at a fiber percentage of 2%.
4) The optimum percentage of diff erent type of steel fiber was found to be 2 percentage. Hooked steel fibers at 2% addition to Concrete was found to be the most efficient mix.

REFERENCES

[1] Ganeshan N et al, (2007) „steel fibre reinforced high performance concrete for seismic resistant structure‟ Civil Engineering and construction Review, December 2007, pp 54-63
[2] Bhikshma V, Ravande Kishor and Nitturkar Kalidas (2005)," Mechanical properties of fibre reinforced high strength concrete „Recent advances in concrete and construction tech‟6-8 Jan 2005, Chennai, pp 23-33
[3] Balaguru P and Najm H (2004), "High-performance fibre reinforced concrete mixture proportion with high fibre volume fractions", Material Journal, volume 101, issue 4, July 1, 2004 pp281-286
[4] Ghavami, K., Rodrigues, C.and. Paciornik, S., "Bamboo: Functionally Graded Composite Material", Asian Journal of Civil Engineering (building & housing), Vol. 4. (2003), pp 1-10
[5] Tensing D,Jeminah and Jaygopal L S (2003) " Permeability studies on steel fibre reinforced concrete and influence of fly ash" National seminar on advance in construction materials,14-15 feb 2003.
[6] Madan S. K., Rajeshkumar G., and Sign S.P., "Steel Fibers as Replacement to Web Reinforcement for RCC Deep Beam in Shear", Asian journal of Civil Engineering Building and Housing), Vol. 8, No. 5 (2007), pp 479-489
[7] Damgir R.M.and Ishaque M.I.M (2003) "Effect of silica fume and steel fibre composite on strength properties of high performance concrete", proceedimg of the INCONTEST 2003, Coimbatore,10-12 sept 2003,pp281-286
[8] Raghuprasad .P.S, Ravindranatha (2003) "Experimental investigation on flexural strength of slurry infiltrated fibre concrete" proceedimg of the INCONTEST 2003, Coimbatore, 10-12 sept 2003, pp 403-408