International Journal of Scientific Research & Engineering Trends
Volume 2, Issue 2, March-2016, ISSN (Online): 2395-566X

Enhancing Flexural Capacity of Steel Fibre Reinforced High Strength Concrete Beams

N. Harsha Vardhan
Deportment of Civil Engineering,
Sathyabama University, Chennai, India
Email: harsha.nagineni33@gmail.com

K. Kartheek Babu
Deportment of Civil Engineering,
Sathyabama University, Chennai, India
Email: kartheek324@gmail.com

A. Annadurai
Deportment of Civil Engineering,
Sathyabama University, Chennai, India
Email : annadurai_1972@yahoo.co.in

***Abstract* – The steel fibres are generally used as a resistance of cracking and strengthen of concrete, in this study hooked end steel fibres of length 35mm with thickness of 0.5 mm diameter is used. In this program consist of tests on steel fibre reinforced high strength concrete (SFRHSC) beams were conducted under flexural loading. Steel fibre reinforced high strength concrete (SFRHSC)beams include two different volume fraction i.e. 1% and 2% the cross sectional dimensions and span of beams were fixed same for all types of beams. The specimens were conducted ultimate load, load deflection, ductility, crack load and characteristics of beams with and without steel fibres have been carried out and quantitative comparison was made on significant stages of loading. It was observed that one control beam is casted with HSC and two beams are casted with SFRHSC .these two beams are compared with control beam. It was concluded that SFRHSC beams showed enhanced properties compared to that of HSC beams. A modified procedure has been suggested to calculated the ultimate load, load deflection, ductility, crack load obtained in the experimental investigation was also compared with the all types of beams.**

***Keywords* – Flexural Strength, Steel Fiber Reinforced High Strength Concrete, Mechanical Properties, Steel Fibres.**

I. INTRODUCTION

Fibre reinforced concrete (FRC) is Portland cement concrete reinforced with more or less randomly distributed fibres. In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions.

It has been successfully used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. Fibre is a small piece of reinforcing material possessing certain characteristics properties. The principle reason for incorporating fibres into a cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. Plain concrete possesses 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 fracture of concrete. In the past, attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining techniques. Although both these methods provide tensile strength of concrete members, they however, do not increase the inherent tensile strength of concrete itself.

When loaded on plain concrete the micro cracks propagated and open up, and owing to the effect of the stress concentration, additional cracks form in the places of minor defects .the structural cracks precede slowly or by tiny jumps because they are retarders by various obstacles. The development of such micro cracks is the main cause of in elastic deformations in concrete. It has been recognized that the additional of small, closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its static and dynamic properties .this type of concrete is known as fibre reinforced concrete.

Lot of researches have been carried out on the properties of steel fiber reinforced high strength concrete beams, the results , volume dosage of steel fiber and the beam height on ultimate flexural behavior of steel fiber reinforced high-strength concrete beams are not completely appropriate for practical purposes. Therefore, the present study investigate the ultimate load, ultimate deflection ,crack load, volume dosage of steel fiber and the beam strength on flexural behavior of steel fibre reinforced high-strength concrete beams, which has great instruction in the design and applications of steel fiber reinforced high-strength concrete beams.

When steel fibers are added to high strength concrete, the increase in fiber volumetric ratio results in an increase in the compressive strength of the concrete and a considerable amount of increase in the tensile strength of the fiber reinforced specimens is observed in split cylinder tests (Mukesh Shukla (2011) Okay and Engin, (2012). However, when this addition exceeds a certain volumetric level, the increase in the strength becomes less (Song and Hwang, 2004; Mohammadi*et al*., 2008). Volumetric ratio of fiber also increases energy absorbing capacity in bending (Gao *et al*., 1997). Wang and Lee (2007) experimentally demonstrated that steel fiber reinforced concrete. As the volume content of the fiber increases, ductility under constant load increases in the diagrams. In other words, no difference is observed up to crack, but ductility increases afterwards with the increase in volume content of steel fibers (Rao and Seshu, 2005 ,Amithrana). In a research study, the effect of steel fibers on cracks in reinforced concrete beams was investigated and it was concluded that a steel fiber dosage of 30-40 kg/m^3 was appropriate to have an appreciable improvement on cracks (Altun*et al*., 2007). Dupont and Vandewalle (2002) and Paine *et al*. (2002) studied the contribution of steel fibers of reinforced concrete beams and determined that a steel fiber dosage of 1-2% by absolute volume was ideal from that aspect after having performed experiments.

II. PRODUCTION OF HIGH STRENGTH CONCRETE

The manufacture of high strength concrete is to more compressive strength lesser cracks but the water absorption will be more to reduce the water absorption will added some materials will grow to find its due to place in concrete construction for all the obvious benefits in the modern batching plants high strength concrete is produced in a mechanical manner of course one has been taken care about mix proportioning shape of aggregates, use of supplementary cementations materials, silica fume we are adding these materials the voids between the aggregates will be reduce but one of the defect is water absorption will be more to reduce the water absorption will be adding HRWR (high range water reduces).With the modern equipment's understanding the role of the constituent materials, production of high strength concrete has become a routine matter

III. FIBRE REINFORCED CONCRETE

Fibers are generally used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce 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, and so cannot replace moment resisting or structural steel reinforcement. The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed "volume fraction" (V_f). V_f typically ranges from 0.1 to 3%. The 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. If the fiber's modulus of elasticity is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increasing the aspect ratio of the fiber usually segments the flexural strength and toughness of the matrix. However, fibers that are too long tend to "ball" in the mix and create workability problems.

Some recent research indicated that using fibers in concrete has limited effect on the impact resistance of the materials. This finding is very important since traditionally, people think that ductility increases when concrete is reinforced with fibers. The results also indicated that the use of micro fibers offers better impact resistance to that of longer fibers.

1. Steel Fibre Reinforced Concrete

1.1 Introduction

The use of Steel Fiber Reinforced Concrete (SFRC) has received much attention in concrete industry as more research is being performed and more is being understood about its material properties and behavior. When steel fibers are added to high strength concrete, the increase in fiber volumetric ratio results in an increase in the compressive strength of the concrete and a considerable amount of increase in the tensile strength of the fiber reinforced specimens is observed in split cylinder tests.

1.2 Properties of Concrete Improved by Steel *Fibres*

i. Flexural Strength: Flexural bending strength can be increased of up to 3 times more compared to conventional concrete.

ii. Fatigue Resistance: Almost 1 1/2 times increase in fatigue strength.

iii. Impact Resistance: Greater resistance to damage in case of a heavy impact.

iv. Permeability: The material is less porous

v. Abrasion Resistance: More effective composition against abrasion and spalling.

vi. Shrinkage: Shrinkage cracks can be eliminated.

vii. Corrosion: Corrosion may affect the material but it will be limited in certain areas

1.3. Advantages of steel fibres

i. More ductile concrete with a high load bearing capacity-resulting in thinner slabs with equal or better performance than their mesh counter parts

ii. Efficiency crack control -3,200 fibres on average per Kg

iii. Durability –steel fibres slabs reinforce the structure through of the concrete

iv. Quick and Easy application – steel fibres can be added at the concrete plants or at the job site directly.

v. Efficiency & Cost effective –on average a draw mix slab will cost between 10-15% less than an equivalent mesh slabs.

1.4 Objectives

i. Increase the ultimate flexural strength of RC beam by using High Strength concrete (M60) grade and adding with the addition of steel fibres.

ii. Improve the resistance of conventionally reinforced structural members to cracking, deflection and other serviceability conditions, by utilizing the inherent material properties of fiber reinforced concrete.

iii. Steel fibers in different volumes have been added and the performances has been Compared.

iv. To study the effect of different proportions of steel fiber mixes.

International Journal of Scientific Research & Engineering Trends
Volume 2, Issue 2, March-2016, ISSN (Online): 2395-566X

IV. PROPERTIES OF FIBRES ARE USED

Fibre Properties	Steel Fibres
Length (mm)	35 mm
Shape	Hooked End
Size / Diameter (mm)	0.5 mm
Aspect Ratio	60
Density (kg / m3)	7850
Young's Modulus (GPa)	210
Tensile strength (MPa)	532

V. TESTS CONDUCTED AND RESULTS

An experimental programed was carried out to study the performance of HFRC beams with and without fibres, by Two-point loading. The beams of 150 mm x 250 mm in cross section and overall length of 3000mm provided with 3 nos. 1 beam was control beam without another 2 beams are steel fibre reinforced high strength concrete beams 1% and 2% of steel fibres in total volume of concrete in that beam 2 bars of 8mm ϕ on tension zone and 2 bars 12mm ϕ in compression zone and as the 6mm stripes were used.

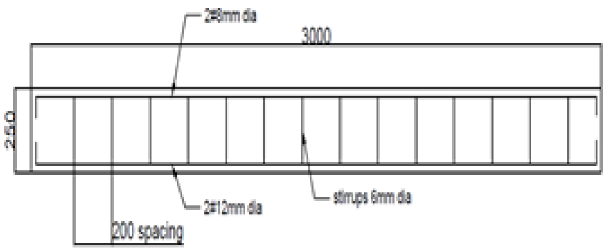

Fig.1. specimen details

Table 2: Specification of beam

Length of beam	3000 mm
Depth of beam	250 mm
Width of beam	150 mm
Steel bars	12mm,8mm
Stirrups	6mm dia @200 mm
Clear cover	25mm

1. Loading setup

The beams are testing after 28 days proper curing. The loading setup of the beam, was shown in the below figure. The pallets are arranged on beam with constant spacing, totally 28 pallets are arranged on compression side and tension side. These pallets arranged with a clear cover of 25mm on all sides (top and bottom both sides).

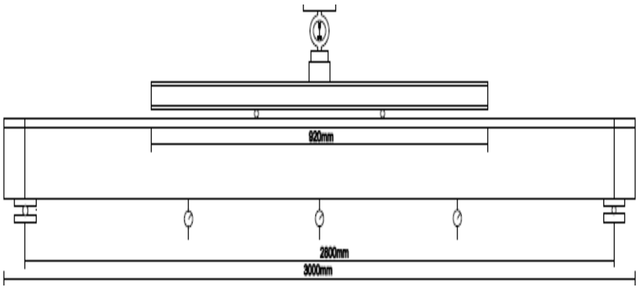

Fig.2. loading setup of the beams.

2. Testing Procedure

All the beams were tested, under two-point loading as per ASTM C 78, in a loading frame of 500 KN capacity and 100mm bearing was given on both ends, resulting in an effective test span of 2800mm as shown in (fig.2). The deflections were measured at mid span and load points using mechanical dial gauges of 0.01mm accuracy. Three dial gauges were setup on the tension side of the specimen under load points and center of the beam to measure slope at the ends. The strains at extreme fibres were measured using demountable mechanical strain gauge. The crack widths were measured using a demo gauge with a least count of 0.02mm.the pallets are placed at constant distance.

For the applying of loading proving ring is used with a capacity of 500KN and to measure displacement dial gauzes are used with an accurate of 0.2mm, the diagram of proving ring and dial gauzes was shown below. The strain and crack width can be measured by using the democ gauge the first crack and end crack can be measured The deflections can be measured at different load levels the crack development and propagation was measured during of the process of testing

Fig.3. loading setup

A total of 3 beams were casted and tested in this investigation to study the strength and load deflection behavior of the hybrid fiber reinforced concrete beams. The test results of the ultimate load, yield load, deflection and crack width as shown in figure below. Concrete mix for all beams are taken from the mix design as per the ACI codal provision, respectively.

International Journal of Scientific Research & Engineering Trends
Volume 2, Issue 2, March-2016, ISSN (Online): 2395-566X

Table: 3 Ultimate Load Yield Load Data of the Beam

Beam Designation	**Control beam**	**1% steel fibres**	**2% steel fibres**
Ultimate load (KN)	56.19	68.16	76.430
Yield load (KN)	37	39	43.000
Deflection (mm)	27	21.075	23.000
Crack width (mm)	1.18	1.047	1.185

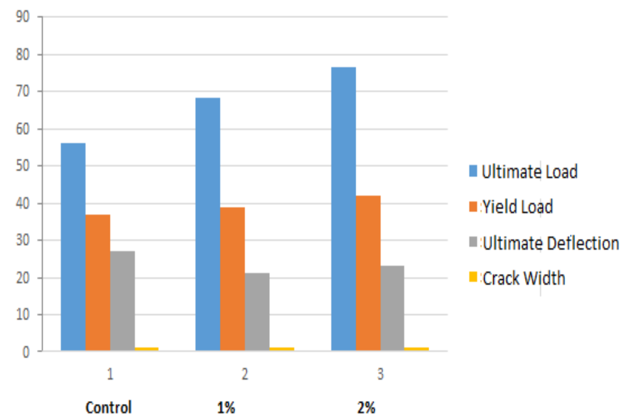

Fig.4. Ultimate load, yield load,deflection & max crack width

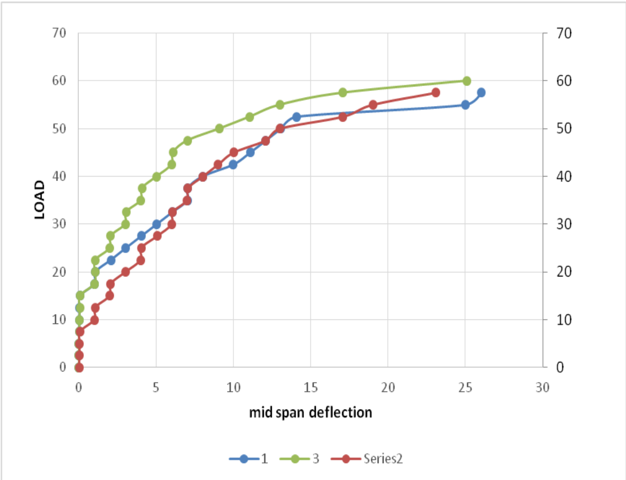

Fig.5. Load deflection behavior of mid span all the beams

VI. Conclusion

The hybrid fibre volume fraction of 0.5% with 70% - 30% steel polyolefin combine significantly improves the overall performance of high-strength reinforced concrete beams.

The increase in ultimate load was found to be 15.24% when compared to reference beam. The increase in ultimate deflection was found to be 22.03% when compared to reference beam

Appendix

MIX DESIGN

Step 1
Select slump and required strength
Fcr = (8702.34+1400)/0.9=11224.8psi

Step 2
Max size of aggregate = 1/2 in
Bulk specific gravity of aggregate =2.806
Water absorption = 0.39%
Dry Bulk density =95.50lb/ft3

Step: 3
Vol of Coarse aggregate = 0.68 (As per code provision)
Dry wt/yd3 of concrete = (0.68X95.50X27)
= 1753.38lb

Step: 4
Slump =1 to 2
C.A size =1/2 in
For this condition water content =295 lb/yd3 (As per code provision)
Entrapped air =2%
Voids of sand =[(1)-(106.8/(2.75X6.24)]X100=37.76%
The mixing water adjustment = (37.76-35) X8=+22.08 lb/yd3
Water content =295+22.08=317.08

Step: 5z1/2 in
11000=>0.29
11224=>X
12000=>0.26
X=0.283
For field convenient
(0.9X11224) =10101.6psi

Step: 6
Wt of cementations material = (317.08/0.283)=1120.42lb

Step: 7
Cement content/yd3 of concrete =1120.42 lb
Volumes/yd3 of all materials expect sand
Cement = [(1120)/ (3.15X62.4)] =5.69ft3
Coarse Aggregate = [1753.38/ (2.806X62.4)] =10.01ft3
Water =[317.08/62.4] =5.08ft3
Air = [0.02X27] =0.54ft3
Total =21.32ft3
Required sand Vol/yd3 = [27-21.32] =5.68ft3
= [5.68X62.4X2.75] =974.68lb

Material content:
Cement =1120.42 lb
Coarse Aggregate =1753.38 lb
Sand =974.68 lb
Water =317.08 lb

International Journal of Scientific Research & Engineering Trends
Volume 2, Issue 2, March-2016, ISSN (Online): 2395-566X

Adjustments:

Cement = 1120.42 lb

Coarse Aggregate = (1753.38) X [(1) + (0.39/100)] =1760.22 lb

Fine Aggregate = (974.68) X [(1) + (1.21/100)] =986.47 lb

Water = (317.08)-[(974.68) X (0.0638-0.0121)]-[(1753.38) X (0.0033-0.0039) =264.77 lb

As Per Indian Units:

Cement =661.04Kg/Cum

Coarse Aggregate =1038.52Kg/Cum

Fine Aggregate =582.01Kg/Cum

Water =184Kg/Cum

Mix for silica fume:

Mix 1	Cement	Silica Fume
8%	608.15	52.88

Mix 2	Cement	Silica Fume
9%	601.55	59.49

Mix for HRWR:

Mix 1	Water	HRWR
1.25%	175.74	8.26
Mix 2	Water	HRWR
1.5%	174.08	9.92

Compaction Mix:

Mix	Cement	F.A	C.A	Water	S.F	HRWR
#1	608.1	582.0	1038.5	175.7	52.8	826
#2	601.5	582.0	1038.5	174.0	59.4	9.92

ACKNOWLEDGMENT

First and foremost, I would express my sincere gratitude to our beloved Sponsor N.Harsha Vardhan M.Tech and also thank to financial support K.Kartheek Babu M.Tech for providing me the necessary facilities for the completion of my article for her constant support.

I also express my sincere thanks to my guide Mr.A.Annadurai (Ph.D.) and my counsellors for their constant guidance and supervision during the period of my project work.

Last but not least, I would like to thank my beloved parents for their encouragement and

REFERENCES

[1] ISSN (Online) 2319-183X, (Print) 2319-1821 Volume 1, Issue 1 (September 2012), PP. 043-048, "Experimental Study on Steel Fiber Reinforced Concrete".

[2] Dr. N. Ganesan& Dr. P.V.Indira, Behaviour of steel fiber reinforced high performance concrete members under flexure, Behavior of steel fiber reinforced high performance concrete members under flexural may2007, Vol no88

[3] M.s.Shetty concrete technology theory and practice .S.Chand Company New Delhi

[4] P.S. Song & S. Hwang, Mechanical properties of high strength steelfibre reinforced concrete, Construction and building material 18 2004, pp 669-673, 2004.

[5] *Mukesh Shukla. (*2011) Investigated the Behavior of Reinforced Concrete Beams with Steel Fibres under Flexural Loading.

[6] *Qiaoyan Guan(2012)* .In order to investigate the effect of longitudinal reinforcement ratio, volume dosage of steel fiber and the beam height on flexural behavior of steel fiber reinforced high-strength concrete beams,

[7] *Sreeja . M.D (2013).*This paper describes the influence of steel fibre distribution on the ultimate strength of concrete beams. An experimental & analytical investigation of the behavior of concrete beams

[8] B. R. Phanikumar (2009) Effect of lime and fly ash on swell, consolidation and shear strength characteristics of expansive clays: comparative study, Journal of Geomechanics and Geoengineering, 4(2), 175-181.

AUTHOR'S PROFILE

N. Harsha Vardhan
M.Tech., Assistant Professor, Civil Engineering Deportment,S.S.N Engineering College, Kurnool Road, Ongole.
Pin Code: 523001
Ph No: +91-9000339971

K. Kartheek Babu
M.Tech, Assistant Professor, Civil Engineering Deportment,S.S.N Engineering College, Kurnool Road, Ongole.
Pin Code: 523001
Ph No: +91-9966054997

A. Annadurai
M.Tech (Ph.D.), Associate Professor, Sathyabama University, Chennai.
Pin Code: 600119
Ph No: +91-9790434734