International Journal of Scientific Research & Engineering Trends
Volume 1, Issue 6, Nov-2015, ISSN (Online): 2395-566X

Experimental Investigation on Hybrid Fibre Reinforced Concrete Beams

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

K. Rushi Kesava Reddy
Department of Civil Engineering
JNTU University Anantapuram, India
Siddharth Engineering College,
Puttur, India
Email: rushi.civil282@gmail.com

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

***Abstract* – The normal conventional concrete has less compressive and tensile strength so to enhance the performance of the concrete some kinds of fibres are added to the concrete gain required strength. This research work presents the effect of fibres on high strength rein forced concrete beams with and without fibres. The study parameters for the investigation included ultimate load, ultimate deflection and flexural strength. The fibers used in the investigation are steel fibres and polyolefin fibers. Fibers are added to the concrete not only to increase tensile strength but also to control the crack and to change the behavior of cracked material by bridging across the cracks.**

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

I. Introduction

Concrete is relatively a brittle material and has serious short-coming of poor toughness. Plain concrete possesses a very low tensile strength, limited ductility and little resistance of cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to propagation of such micro cracks, eventually leading to brittle fracture of the concrete.

In plain concrete and brittle materials, structural cracks (micro cracks) develop even before loading, particularly due to drying shrinkage or other causes of volume changes. The width of these initial cracks seldom exceeds a few microns

It has been recognized that the addition of small, closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its dynamic properties. This type of concrete is known as fiber reinforced concrete.

Addition of randomly distributed fibers improves concrete structural characteristics flexural strength, ductility and flexural toughness etc. which depend upon fibre type, size, aspect ratio and volume fractions of the fibres used. Recent years have seen considerable interest in the fibre hybridization – particularly combinations of metallic and non-metallic fibres. For optimal behaviour, different types of metallic and non-metallic fibres have been combined. The mechanical properties such as compressive strength, flexural strength and flexural toughness etc was improved.

Fibre reinforced concrete may be defined as a composite materials made with Portland cement, aggregate and incorporating discrete discontinuous fibres. Plain, unrestrained concrete is brittle material with a low tensile strength and a low strain capacity. The role of randomly distributed discontinuous fibres is to bridge across the crack that develops in future.

The development of such micro cracks is the main cause of in elastic deformation in concrete. It has been recognized that the addition of small closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. Several forms of fibre such as steel and polypropylene have been tried and these are available in variety of shapes, sizes and thickness. These fibres are used either jointly called as hybrid fibre. The addition of fibers reduces immediate deflection, long-term deflection and crack width of beam two kinds of fibers have been used in concrete mix that is steel and polyolefin fibers since the now no single fiber reinforced Concrete could exhibit perfect mechanical properties.

Fibre reinforced cement and concrete materials (FRC) have been developed progressively since the early work by Romualdi and Batson in the 1960s. By the 1990s, a wide range of fibre composites and FRC products were commercially available and novel manufacturing techniques were developed for use with high fibre content. In parallel with the commercial development of FRC materials and products, an extensive research programmed was undertaken to quantify the enhanced properties of FRC materials and more specifically to allow comparisons to be made between various types of fibres. Fibre reinforced concrete (FRC) is a composite material consisting of cement, sand, coarse aggregate, water and fibres. In this composite material, short discrete fibres are randomly distributed throughout the concrete mass. The behavioral efficiency of this composite material is far superior to that of plain concrete and many other construction materials of equal cost. Due to this benefit, the use of FRC has steadily increased during the last two decades and its current field of application includes: airport and highway pavements, earthquake-resistant and explosive-resistant structures, mine and tunnel linings, bridge deck overlays, hydraulic structures, rock-slope

International Journal of Scientific Research & Engineering Trends
Volume 1, Issue 6, Nov-2015, ISSN (Online): 2395-566X

stabilization, etc. Concrete is relatively a brittle material and has serious short-coming of poor toughness. The term high strength concrete is generally used for concrete with compressive strength higher than 41MPa (6000psi). The addition of randomly distributed fibres improves concrete structural characteristics Fiber reinforced concrete (FRC) is a composite material consisting of cement, sand, coarse aggregate, water and fibres the main purpose of steel and synthetic fibers is used to resist cracks forming in the concrete structures.

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. Production of Hybrid Fibre Reinforced Concrete Beams

Fibre reinforced concrete is a type of concrete that includes fibrous substance that increases its structural strength and cohesion. Fibre reinforced concrete has small distinct fibres that are homogeneously dispersed and oriented haphazardly. Fibres are natural fibres and artificial fibres, namely steel fibers and polyethylene fibers. The characteristics of fiber reinforced concrete are changed by the alteration of quantities of concretes, plain Portland cement concrete is a brittle material the strength concrete in tension is much lower than the compression. Growing crack in plain concrete can very soon lead to failure.in the presence of reinforcement the tensile load is transfer to the steel. An alternative to increasing the load carrying capacity of concrete in tension is the addition of fibres. Well-dispersed fibres in the concrete act to bridge the cracks developed in concrete. The incorporation of fibres in a cement matrix leads to an increase in the toughness and tensile strength, and an improvement in the cracking and deformation characteristics of the resultant concrete.

Fibres are usually in concrete to control plastic shrinkage cracking and drying shrinkage cracking. 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 cannot replace moment resisting or structural steel reinforcement. The amount of fibres added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibres) termed volume fraction typically ranges from 0.5 to 1%.

Some recent research indicated that using fiber 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. The results also pointed out that the micro fibers is better in impact resistance compared with the longer fiber.

IV. Properties of Fibres are Used

Table 1: Properties of Fibers used

Fiber Properties	**Fiber Details**	
	Polyolefin	**Steel**
Length (mm)	48	38
Shape	straight	hooked
Size / Diameter (mm)	1.22×0.732mm	0.5mm
Aspect Ratio	39.34	60
Density (kg / m3)	920	7850
Young's Modulus (GPa)	6	210
Tensile strength (MPa)	550	530
Tensile strength (MPa)	530	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 hybrid fibre reinforced concrete beams 0.5% and 1% of steel and polyolefin fibres 70%(steel fibres)-30%(polyolefin 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.

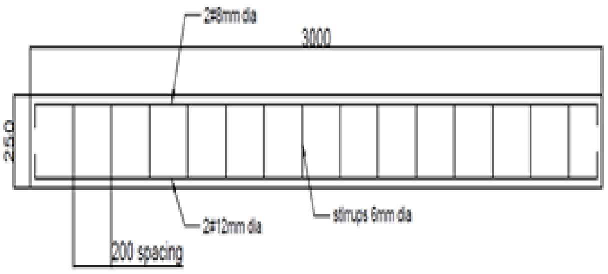

Fig.1. specimen details

International Journal of Scientific Research & Engineering Trends
Volume 1, Issue 6, Nov-2015, ISSN (Online): 2395-566X

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).

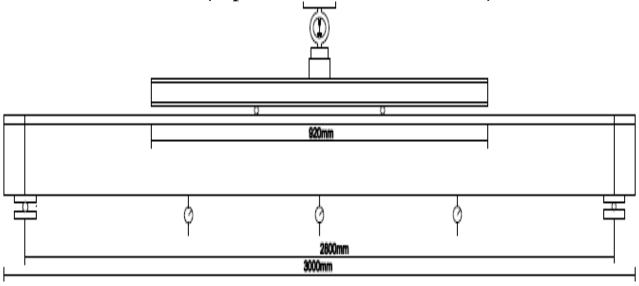

Fig.2. Loading setup of the beams.

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.

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.

Fig.3. loading setup

Table 3: Ultimate Load Yield Load Data of the Beam

Specimen Name		Control	0.5% Beam	1% Beam
Volume fraction	Steel		0.35	0.7
	polyolefin		0.15	0.3
	Total		0.5%	1%
Yield load		37	43	40
Yield deflection		26.045	24.075	23.0
Ultimate load		56.19	71.43	61.43
Ultimate deflection		73	78	75

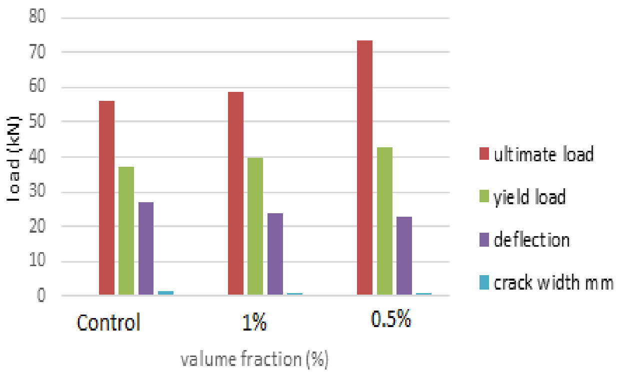

Fig.4. Ultimate load, yield load,deflection & max crack width

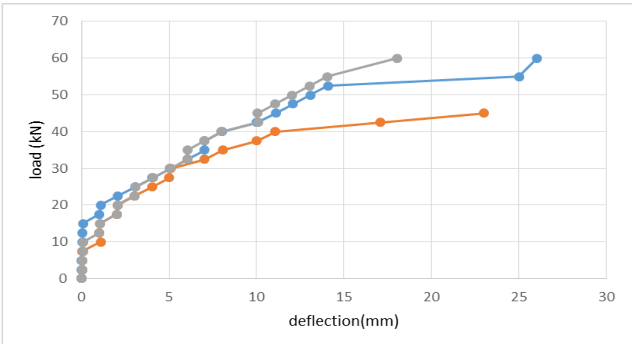

Fig.5. load deflection behavior of mid span all the beams

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: 5

Finding W/c +p =1/2 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

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 K.Kartheek Babu Match and also thank to financial support Mr.K.Rushi Kesava Reddy 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] G.C. Hoff, Use of steel fiber reinforced concrete in bridge decks and pavements, Steel Fiber Concrete, Elsevier Applied Sciences Publishers Ltd., 1986, 67-108

[2] P.N. Balaguru, and S.P. Shah, Fiber reinforced cement composites (McGraw International Edition, New York, 1992).

[3] C.X. Qian and P.Stroven, Development of hybrid polypropylene steel fiber reinforced concrete, Cement and Concrete Research, 30, 2000, 63 – 69.

[4] Y. Wu, J. Li and K. Wu, Mechanical Properties of Fiber Reinforced Concrete at Low Fiber Volume Fraction, Cement and Concrete Research, 30, 2003, 27-30.

[5] B. Mobasher and C.Y. Li, Mechanical properties of hybrid cement based composites, *ACI Materials Journal*, *93(3)*, 1996, 284 – 292.

[6] N. Banthia and M. Sappakittipakron, Toughness enhancement in steel fiber reinforced concrete through fiber hybridization, *Cement and Concrete Research*, *37*, Sep. 2007, 1366-1372.

[7] Y.M. Ghugal, Effects of steel fibers on various strength of concrete, *Indian Concrete Institute Journal*, *4(3)*, 2003, 23-29.

[8] S.C. Patodi and J.D. Rathod, Performance evaluation of ECC as a material for repair and retrofit, International Journal of 3R’s, *1(3)*, 2010, 102 – 111.

[9] IS 456, Plain and reinforced concrete – Code of practice, *Bureau of Indian Standards*, New Delhi, 2000, 603-608.

[10] N.K. Bairagi and C.D. Modhera, Shear strength of FRC’, *Indian Concrete Journal*, *1(4)*, 2000, 47-52.

[11] Ahmed H. Ghallab.,” Flexural behaviour of Polypropylene Fibres Reinforced Concrete beams”, HFBRC journal, 2005.

[12] Balaguru, P. N., Narahari, R., and Patel, M.” Flexural Toughness of Steel Fiber Reinforced Concrete”, ACI Materials Journal, Vol. 89, No. 6Nov-Dec 1992, pp. 541-54.

[13] Eswari.S. Ragunath .P.N., and Suguna.K.,” Ductility Performance of Hybrid Fibre Concrete”, American journal of applied sciences, Proceedings, 2008,pp.1257 – 1262.

[14] Lars Kutzing.,” Influence Of Fibres on the Improving of Ductility of High Performance Concrete (HPC)”, Universitat Leipzig 2007.

[15] Nagarkar.P.K.,Tambe.S.K.,andPazare .D.G.,”Study of Fibre Reinforced Concrete”, International symposium on Fibre Reinforced Concrete, Proceedings, vol.1, Dec16-19,1987, pp.2.131-2.142.

AUTHOR PROFILE

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

K. Rushi Kesava Reddy
M.Tech., Assistant Professor, SSN Engineering College, Kurnool Road, Ongole.
Pin Code: 523001
Phone No.: +91-9494034146

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