Available online at www.elixirpublishers.com (Elixir International Journal)

Civil Engineering

Elixir Civil Engg. 96 (2016) 41666-41668

ISSN: 2229-712X

Effect of Varying Aspect Ratio of Steel Fibres on Strength of Concrete

Zahid Bashir Bhat[1], Muneeb Anwar Shah[2], Irfan Latief[3] and Sahil Bashir[4]
[1]Lecturer, Department of Civil Engineering, NIT Srinagar, India..
[2]Civil Engineering Graduate, NIT Srinagar, India.
[3]Department of Civil Engineering, KITE Polytechnic Rangret.
[4]Project Specialist, Ericsson, J&K India.

ARTICLE INFO

Article history:
Received: 8 June 2016;
Received in revised form:
13 July 2016;
Accepted: 18 July 2016;

Keywords
Ductility,
Steel fibres,
Aspect Ratio,
Compressive strength,
Splitting tensile strength,
Flexural strength.

ABSTRACT

Crimped steel fibres with varying aspect ratio in the range of 30-60 were added in M-20 Concrete specimens. The fibre percentage chosen for study was 1% by volume. The concrete specimens were tested for 7 day, 14 day and 28 day compressive strength, flexural strength and splitting tensile strength and the results obtained were compared with those of normal concrete mix without fibres. The results concluded that the addition of 1% fibres with an aspect ratio of 50 leads to maximum improvement in early as well as long term compressive strength, split tensile strength and flexural strength of concrete.

I. Introduction

Plain concrete has two major deficiencies, a low tensile strength and a low strain at fracture. The tensile strength of concrete is very low because plain concrete normally contains numerous micro cracks. It is the rapid propagation of these micro cracks under applied stress that is responsible for the low tensile strength of the material, eventually leading to brittle fracture of concrete. In past attempts have been made to impart improvements in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying restraining techniques. Although both methods provide tensile strength to concrete members, they how ever do not increase inherent tensile strength to concrete itself. It has been found that the addition of small closely spaced and uniformly dispersed fibers to concrete would act as crack arresters and would substantially improve it's static and dynamic properties. This type of concrete is known as "Fiber Reinforced Concrete" (F.R.C.)

F.R.C. can be defined as "A composite material consisting of a mixture of cement, mortar or concrete and discontinuous, discrete uniformly dispersed suitable fibers ".The new generation technology utilizes discrete fiber from 19mm to 64mm in length. The fibers are randomly throughout the concrete matrix providing for better distribution of both internal and external stresses by using a three dimensional network. The Primary role of fibers in hardened concrete is to modify the cracking mechanism. The cracks are smaller in width thus reducing the permeability of concrete and the ultimate cracking strain of concrete is enhanced. Un-reinforced concrete will separate at a crack, reducing the load carrying ability to zero across the crack. The fibers are capable of Carrying a load across the crack.

The presence of micro-cracks at the mortar aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by in inclusion of fibers in the mix. The fiber helps to transfer the loads at the internal micro-cracks. Such a concrete is called as Fiber Reinforced Concrete. Thus the fiber reinforced concrete is a composite material essentially consisting of conventional concrete or mortar reinforced by random dispersal of short, discontinuous and discrete fine fibers of specific geometry. The fibers can be imagined as an aggregate with an extreme deviation in shape from the rounded smooth aggregate. The fibers interlock and entangle around aggregate particles and considerably reduce the workability while the mix becomes more cohesive and less prone to segregation. [1]

In contract to reinforcing bars in reinforced concrete which are continuous and carefully placed in the structure to optimize their performance, the fibers are discontinuous and are generally randomly distributed throughout the concrete matrix. As the result, the reinforcing performance of steel fibers, for example, is inferior to that of reinforcing bar. In addition, the fibers are likely to be considerably more expensive than the convectional steel rods. Thus fibers reinforced concrete is not likely to replace conventional reinforced concrete. [2]

However the addition of fibers to the brittle cement and concrete materials can offers a convenient, particle and economical method of overcoming their inherent deficiencies of poor tensile and impact strengths and enhances many of the structural properties of the basic materials such as fracture toughness, flexural strength and resistance to fatigue impact, thermal shock or spalling.

Essentially, fiber act as crack arrestor restricting the development of cracks and thus transforming an inherently brittle matrix i.e. Portland cement with its low tensile and impact resistance, into a strong composite with superior crack resistance, improved ductility and distinctive post-cracking behavior prior to failure.[3]

Tele:
E-mail address: zahidbashirbhat@gmail.com

In this research, crimped steel fibres are added to concrete with dosage of 1% by volume and aspect ratio was varied in the range of 30-60. Concrete specimens with varying aspect ratio were tested for compressive strength, splitting tensile strength and flexural strength. The results obtained were compared with results of normal M-20 concrete mix without fibres and it was found that maximum increase in compressive strength, splitting tensile strength and flexural strength at 7 days age, 14 days age and 28 days age occurred for concrete mix containing 1% fibres by volume having an aspect ratio of 50.

II. Materials Used

2.1. Cement and Aggregates

Khyber ordinary Portland cement of 43 grade confining to IS 8112 [4] was used throughout the work. Fine aggregates used throughout the work comprised of clean river sand with maximum size of 4.75mm conforming to zone II as per IS383-1970 [5] with specific gravity of 2.6. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 20mm IS sieve and retained on 4.75mm IS sieve with specific gravity of 2.7.

2.2. Steel Fibres

1% Steel fibres by volume in the aspect ratio range of 30-60 were added to study the behavioural characteristics of concrete. Fig. 1 shows Crimped Steel fibres used.

III. Experimental Investigation

3.1. Mix Proportion

The concrete mix design was proposed by using IS 10262 [6]. The grade of concrete used was M-20 with water to cement ratio of 0.5.

3.2. Test on Fresh Concrete

The workability of all concrete mixtures was determined through compaction factor test. The ratio of weight of concrete filled cylinder without compaction to the weight of the cylinder after full compaction was reported as compaction factor. Fig. 2 shows the equipment for compaction factor test. The compaction factor test was performed according to IS 1199-1959 [7].

3.3. Tests on hardened Concrete

From each concrete mixture, cubes of size 150mm x 150mm x 150mm, 150mm x 300mm cylinders and 500mm x 100mm x 100mm beams were casted for the determination of compressive strength, splitting tensile strength and flexural strength respectively. The concrete specimens were cured under normal conditions as per IS 516-1959 [8] and were tested at 7 days, 14 days and 28days for determining compressive strength as per IS 516-1959 [9], splitting tensile strength as per IS 5816-1999 [10] and flexural strength as per IS516-1959[11].

IV. Results and Discussion

4.1. Fresh concrete

The compaction factor of all the mixtures is represented in TABLE 1. Decrease in compaction factor was observed in fresh concrete samples containing fibres as compared to compaction factor of normal concrete. The variation of compaction factor with varying fibre content is depicted in Fig. 3.

4.2. Hardened concrete

4.2.1. Compressive strength

The compressive strength tests are presented in TABLE 2. Compressive strength tests, splitting tensile strength tests and flexural strength tests were carried out at 7, 14 and 28 days. The maximum compressive strength measured was 65%, 49% and 43% more than that of reference mix at 7 days, 14 days and 28 days respectively, corresponding to concrete mix containing 1% fibre by volume.

4.2.2Splitting tensile strength

The splitting tensile strength tests are presented in TABLE 3. Splitting tensile strength witnessed an increase of 85%, 92% and 70% at 7, 14 and 28 days of age respectively, corresponding to concrete mix containing 1% fibre by volume.

4.2.3Flexural strength

The flexural strength tests are presented in TABLE 4. Flexural strength witnessed an increase of 122%, 55% and 63% at 7, 14 and 28 days of age respectively, corresponding to concrete mix containing 1% fibre by volume. However, maximum increase of 141%, 105% and 207% in flexural strength at the age of 7, 14 and 28 days was obtained on fibre addition of 2% by volume. Fig.4, 5, 6 present the compressive strength, splitting tensile strength and flexural strength of all mixtures at 7, 14 and 28 days.

Fig 1. Crimped steel fibres.

Fig 2. Compaction factor test.

TABLE 1. Compaction factor of concrete specimens.

Aspect Ratio	W/C ratio	Compaction factor
0	0.5	0.86
30	0.5	0.85
40	0.5	0.82
50	0.5	0.77
60	0.5	0.7

TABLE 2 . Compressive strength results.

Aspect Ratio	Average compressive strength (N/mm^2)		
	7 days	14 days	28 days
0	11.51	16.35	22.17
30	16.54	20.82	26.52
40	19.07	24.40	31.78
50	21.6	26.60	33.60
60	17.42	20.64	27.68

TABLE 3 . Split tensile strength results.

Aspect Ratio	Average splitting tensile strength (N/mm^2)	
	7 days	14 days	28 days
0	1.12	1.48	2.15
30	1.82	2.56	3.4
40	2.07	2.97	3.75
50	3.2	3.8	4.5
60	2.4	3.12	3.8

TABLE 4 . Flexural strength results.

Aspect Ratio	Average flexural strength (N/mm^2)		
	7 days	14 days	28 days
0	2.01	3.13	3.92
30	3	4.28	5.62
40	3.47	4.86	6.38
50	4.8	5.84	8.24
60	4.1	4.92	7.2

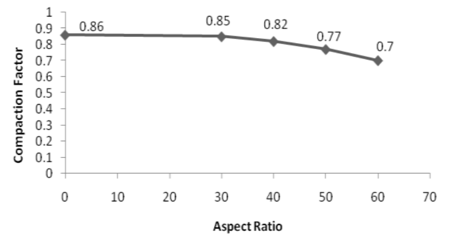

Fig.3 Variation of compaction factor with Aspect Ratio

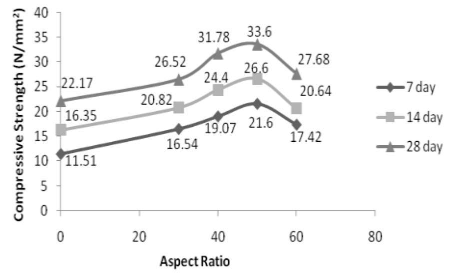

Fig.4 Variation of compressive strength with Aspect Ratio

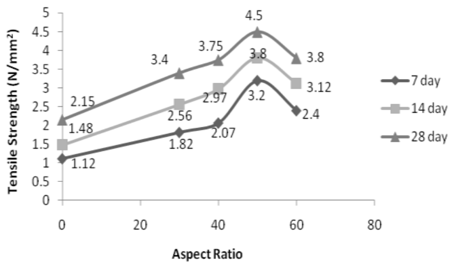

Fig.5 Variation of Split Tensile strength with Aspect Ratio

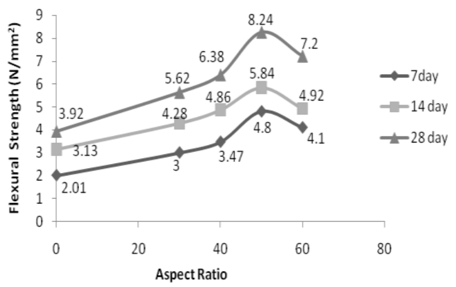

Fig.6 Variation of Flexural Strength with Aspect Ratio

V. Conclusions

On the basis of results obtained, following conclusions can be drawn:

1. The unconventional mix of 1 : 1.33 : 2.73 with an aggregate size of 10mm and 20mm in the ratio of 0.4 : 0.6, sand of zone-ii, 1% steel fibres with an aspect ratio of 50 and water cement ratio of 0.5 can be used wherever the target strength of 33.60 MPa is required.
2. The addition of steel fibres at 1% by volume with an aspect ratio of 50 causes maximum enhancement in early as well as long term compressive strength of concrete. The extent of improvement with respect to reference mix at 7, 14 and 28 days was observed to be 87%, 62% and 51% respectively.
3. The addition of steel fibres at 1% by volume with an aspect ratio of 50 causes a considerable improvement in early as well as long term split tensile strength of concrete. The extent of improvement with respect to reference mix at 7, 14 and 28 days was observed to be 185%, 156% and 200% respectively.
4. It has been observed that due to the presence of fibres as reinforcement inside the matrix of concrete beam, mode of failure of concrete changed from brittle to ductile in unreinforced *and* reinforced cases, respectively.
5. The percent increase in Split tensile strength and Flexural Strength is more as compared to increase in Compressive Strength.
6. The increase in flexural strength at optimum dosage of 1% with an aspect ratio of 50 was 138%, 86% and 210% at the age of 7, 14 and 28 days respectively.

References

[1].Colin D. Johnston, “Fiber reinforced cements and concretes” Advances in concrete technology volume 3 – Gordon and Breach Science publishes – 2001.

[2].Perumalsamy N. Balaguru, Sarendra P. Shah, ‘‘Fiber reinforced cement composites’’ , Mc Graw Hill International Editions 1992.

[3].Arnon Bentur & Sidney Mindess, ‘‘Fiber reinforced cementitious composites’’ Elsevier applied science London and Newyork 1990.

[4].43 Grade Ordinary Portland Cement – Specification. IS 8112:1989, Bureau of Indian Standards, New Delhi.

[5].Specification for Coarse and Fine Aggregates from Natural Sources for Concrete. IS: 383-1970, Bureau of Indian Standards, New Delhi.

[6].Recommended Guidelines for Concrete Mix Design. IS: 10262-1982, Bureau of Indian Standards, New Delhi.

[7].Methods of Sampling and Analysis of Concrete. IS: 1199-1959, Bureau of Indian Standards, New Delhi.

[8].Methods of Tests for Strength of Concrete. IS: 516-1959, Bureau of Indian Standards, New Delhi.

[9].Methods of Tests for Strength of Concrete. IS: 516-1959, Bureau of Indian Standards, New Delhi.

[10].Splitting Tensile Strength of concrete – Methods of test. IS 5816:1999.

[11].Methods of Tests for Strength of Concrete. IS: 516-1959, Bureau of Indian Standards, New Delhi.