International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.5., 2015
(Sept.-Oct.)

RESEARCH ARTICLE

ISSN: 2321-7758

EXPERIMENTAL STUDY ON FRACTURE PARAMETERS OF STEEL FIBRE REINFORCED CONCRETE WITH VARIOUS ASPECT RATIO

ANJU DOMINIC[1], AHSANA FATHIMA[2], ANUMOL V. BASHEER[3]

[1,3] PG Student, Department of Civil Engineering, Indira Gandhi Institute of Engineering and Technology , Kerala, India,

[2] Assistant Professor, Department of Civil Engineering, Indira Gandhi Institute of Engineering and Technology , Kerala, India,

ANJU DOMINIC

AHSANA FATHIMA

ANUMOL V. BASHEER

ABSTRACT

Concrete is characterized by brittle failure, the nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibers (steel, glass, synthetic and natural) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc. The objective of the study is to determine and do the comparative study of the fracture properties of concrete containing no fibers and concrete with fibers, as well as the comparison on the effects of different type and aspect ratio of fibers on fracture properties of concrete. Three-point bending test on notched prisms with a/W (notch depth/beam depth) ratio equal to 0.4 was used. Notch is provided by inserting a metal strip of required thickness during casting. Fracture properties of normal concrete, is compared with steel fiber reinforced concrete. Effect of variation of type steel fiber is analyzed by using hooked end and crimped roll end steel fibers. of same aspect ratio. And for evaluating the effect on variation of aspect ratio of fibers, crimped steel fibers of aspect ratios 26.67,50,60 are used..

Key Words: SFRC, Steel Fibers, fracture parameters, aspect ratio

1. INTRODUCTION

Concrete is characterized by brittle failure causing complete loss of loading capacity, once failure is initiated. This characteristic which limits the application of the material can overcome by the inclusion of a small amount of short randomly distributed fibres (steel, glass, synthetic and natural). This can be practiced among others that remedy weaknesses of concrete, such as low crack resistance, high shrinkage cracking, low durability, etc. Well dispersed fibers in the concrete act to bridge the crack that develop in concrete. The incorporation of fibers 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.

Fracture is the separation of a component into, at least, two parts. A material fractures when sufficient stress and work are applied on the atomic level to break the bonds that hold atoms together. Failures have occurred for many reasons, including uncertainties in the loading or environment, defects in the materials, inadequacies in design and deficiencies in construction or maintenance. Failure of a structure occurs due to catastrophic growth of cracks causing localization of stresses. The fracture energy is one of the important material properties for the design of large concrete structures. The inclusion of fibers increases the toughness of concrete. The magnitude of improvement in toughness is strongly influenced by the fiber orientation and resistance of fibers to pullout, which in turn is governed primarily by the aspect ratio and other factors, such as shape or surface texture.[4]

2. FRACTURE PARAMETERS

2.1 Fracture Energy

Fracture energy is defined as the consumed energy divided by newly generated fracture surface or it can also be defined as the energy absorbed to create a unit area of the fracture surface. Fracture energy was measured through a three point bending test of notched concrete beams. The configuration of beam was 100 x 100 x 500 mm. the ratio of span to depth was 5. The ratio of notch depth to depth of beam was 0.4.

Fracture energy is determined as below

$$G_f = \frac{W_{0+mg\delta_{max}}}{A_{lig}} \qquad 1.1$$

Where,

W_0 = area under the load deflection curve (Nm)

Mg = self wt of the beam between supports (kg)

δmax = maximum displacement (m)

Alig = fracture area=[W(B-a)] (m^2)

B,W =width and height of beam

a = depth of notch

2.2 Fracture Toughness

The critical stress intensity factor (K_{IC}) was in the past being used to represent the fracture toughness.

Fracture toughness is determined as below:

$$K_{IC} = 6Y M_{max} \frac{\sqrt{a}}{BW^2} \qquad 1.2$$

Where,

Y = Function of geometry

M_{ma} =M_1+M_2

M_1 = B.M due to the maximum applied load

M_2 = B.M due to self weight of beam

B = Width of beam

W = depth of beam

a = notch depth

Several expressions have been proposed for the geometry function Y. The function used here is the compliance function proposed by Brown and Srawley (1966)

$Y(a/w)= A_0+A_1(a/w)+A_2(a/w)^2+ A_3(a/w)^3+ A_4(a/w)^4$

Where,

A_i = coefficients listed in table 3.6, for a specimen in three point bending.

Table 3.6 Values of Coefficients A_i for Three Point Bend Specimen[6]

Span/Depth	A_0	A_1	A_2	A_3	A_4
8	+1.96	-2.75	+13.66	-23.98	+25.22
4	+1.93	-3.07	+14.53	-25.11	+25.80
5	+1.9375	-2.99	+14.3125	-24.827	+25.655

3. EXPERIMENTAL DETAILS

3.1 Casting of Specimen

The experimental programme was carried out to evaluate the fracture properties of fiber reinforced concrete. Required quantities of cement, fine aggregate and coarse aggregate, were first mixed thoroughly in a drum type mixer for a period of 2 minutes and then water and super plasticizer has been added. For SFRC, steel fibers were dispersed by hand in the mixture to achieve a uniform distribution throughout the concrete, which was mixed for a total duration of 5 minutes. All mixes were tested for workability using slump cone apparatus. However, addition of fibers reduced the workability of concrete and hence the dosage of super plasticizer was adjusted to maintain the workability between 80-100mm for all the mixes. Central notch is provided by inserting a metal strip of 1mm thickness and 4cm depth during casting.

Fig -1: Notched beam for fracture testing

BEAM DESIGNATION		FRACTURE ENERGY (Nm)	FRACTURE TOUGHNESS $(\times 10^5 \frac{N}{m^{3/2}})$
M30		109.51	7.39
CR26.7	0.5%	124.22	8.13
	1%	197.85	8.76
CR50	0.5%	161.14	8.45
	1%	325.07	12.52
CR60	0.5%	201.33	9.39
	1%	383.26	13.15
HK50	0.5%	153.21	8.76
	1%	221.35	9.39
HK60	0.5%	173.78	8.76
	1%	312.70	10.06

3.2 Testing Procedure

Stable three-point bend test were done on prismatic notched beam specimens as recommended by RILEM TC-50.Test were performed in 30T Shimadzu UTM. Central deflection was measured using a dial gauge of least count 0.01 mm. The test setup for experimental study is shown in Fig.4.

Fig -2: Test setup for fracture test

4. RESULTS AND DISCUSSIONS

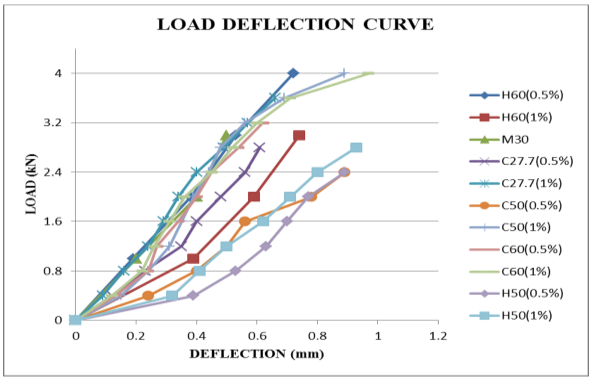

Chart -1: Load- Deflection Diagram

From the above results it is clear that fracture energy and toughness of concrete can be improved with the addition of steel fibers. Fracture energy of concrete specimen reinforced with 0.5% volume fraction crimped steel fiber gives 13.43% improvement in fracture energy than normal M30 concrete. And the fracture energy has improved to 150% and 183% of normal concrete for aspect ratios 50 and 60 respectively. Concrete reinforced with hooked end steel fibers also shows similar improvement in fracture parameters. From the above results it is clear that crimped roll end steel fibers provide more fracture energy to the specimen than hooked end steel fibers. Fracture toughness also improved with increase in aspect ratio of steel fibers. The increase in amount of fibers from 0.5% to 1% volume fraction also caused improvement in fracture energy and toughness. The magnitude of improvement in toughness is strongly influenced by the aspect ratio and other factors, such as shape or surface texture and volume of fibers added.

4. CONCLUSIONS

Fracture parameters of normal M30 concrete and concrete reinforced with 0.5% and 1% of hooked end fibers of aspect ratio 50, 60 and crimped steel fibers of aspect ratios 26.7, 50 and 60 are calculated. Following conclusions are made from the study,

- Fiber addition improves the strength parameters of concrete. This may be due to the high energy absorbing capacity of fibers.
- Fracture properties show an increasing variation with an increase in fiber content from 0.5%to 1% due to the crack resisting property of steel fibers.
- Waved geometry of crimped fibers provide more locking with concrete matrix and thus improvement in fracture energy and toughness is obtained.
- The fracture properties of concrete have improved with increase in aspect ratio of fiber added.

REFERENCES

[1]. Y.C. Guo , J.H. Zhang , G. Chen , G.M. Chen a, Z.H. Xie *"Fracture behaviours of a new steel fiber reinforced recycled aggregate concrete with crumb rubber"* Construction and Building Materials, Vol.54, PP32–39, (2014)

[2]. X. X. Zhang, M. Abd Elazim,. G.Ruiz, *"Influence Of Loading Rate On The Fracture Behaviour of Steel Fiber-Reinforced Concrete",* International Journal for impact Engineering, Vol.71, (2014)

[3]. Misba Gul, Alsana Bashir, Javed A Naqash, *"Study of Modulus of Elasticity of Steel Fiber Reinforced Concrete"* International Journal of Engineering and Advanced Technology (IJEAT), Volume-3, Issue-4,PP 2249 – 8958,(April 2013)

[4]. Bencardino F, Rizzuti L, Spadea G, Swamy R, "Experimental evaluation of fiber reinforced concrete fracture properties" Composites Part B: Engineering, Vol.41, PP17–24, (2010)

[5]. Deepa Joseph, Geethakumari B., Shyam Prakash V., "Experimental study on fracture parameters in cement mortar" International conference on technological trends, Dept. of CE., CET Trivandrum.(2010)

[6]. Bhushan L. K., "Fracture mechanics and structural concrete", first edition, Longman Scientific and Technical.