

Experimental Study on Glass Fiber Reinforced Concrete Moderate Deep Beam

V.R.Rathi¹, A.V.Ghogare², S.R.Nawale³

Associate Professor, Department of Civil Engineering, Pravara Rural Engineering College, Loni, Maharashtra, India¹

P.G.Student, Department of Civil Engineering, Pravara Rural Engineering College, Loni, Maharashtra, India²

Assistant Professor, Department of Civil Engineering, Sanjivani College of Engineering, Kopergaon, Maharashtra, India³

Abstract: In this study, the result of glass fiber reinforced moderate deep beam with and without stirrups have been presented. Six tee beams of constant overall span and depth 150mm, 200mm, 250mm, 300mm with span to depth (L/D) ratios of 4, 3, 2.4, & 2 and glass fibers of 12mm cut length and diameter 0.0125mm added at volume fraction of 0%, 0.25%, 0.50%, 0.75% & 1%. The beams were tested under two point loads at mid span. The results showed that the addition of glass fiber significantly improved the compressive strength, split tensile strength, flexural strength, shear stress and ductility of reinforced moderate deep beam without stirrups.

Keywords: glass fiber, compressive strength, split tensile strength, flexural strength, shear stress.

I. INTRODUCTION

An attempt has been made through this work to understand the shear stress & flexural strength response of moderate deep beams under fibrous matrix as they predominantly fail under shear. and their strength is likely to be controlled by shear rather than flexure provided with nominal amount of longitudinal reinforcement. A. Avci reported that in his paper [1] Flexural strength of the polymer composite increases with increase in polyester and fiber content. A very little works have been reported on shear strength [2] and flexural deformational behaviour of fibrous Reinforced Cement Concrete moderate deep beams Moderate deep are shear predominant members and generally fail in brittle shear mode.

Concrete has disadvantage that it fails in brittle manner. The fibers can make failure mode more ductile by increasing the tensile strength of concrete. As a result a structural performance can be improved. Researchers all over the world are attempting to develop [3,5] high performance concretes by using fibers and other admixtures in concrete up to certain proportions. The addition of glass fibers to a reinforced concrete beam is known to increase its shear strength and if sufficient fibers are added, a ductile shear failure can be suppressed in favour of more ductile behaviour. The use of glass fibers is particularly attractive if conventional stirrups can be eliminated, which reduces reinforcement congestion.

The principle reason for incorporating fibers into a concrete is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. G.Appa Rao reported in his paper the shear strength [4] of deep beam decreases as the size of beam increases.

There are only few studies reporting results on the behavior of beams reinforced with a new type of glass Fibrillated mesh fibers. This fiber has a higher modulus of elasticity and an optimized geometry to enhance the bond between the fiber and the concrete matrix, which leads to an increase in the toughness properties of concrete. If sufficient fibers are added, a brittle failure can be suppressed in favor of more ductile behavior. The increased strength and ductility [6] of fiber-reinforced beams. In this work, an attempt is made to incorporate glass fibers in concrete to produce a desired material having appropriate compressive strength, flexural strength and split tensile strength.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014

II. EXPERIMENTAL PROGRAMME

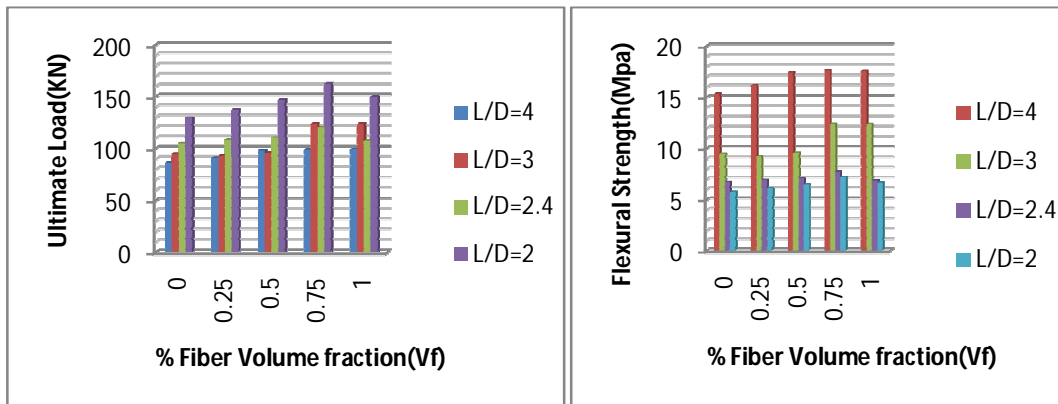
Test Materials: Mix design of M25 grade of concrete is carried out using IS method [7,8,9]. Ordinary Portland Cement (OPC) of 43 grade, natural river sand of fineness modulus 4.175 and 20mm coarse aggregate were used. The concrete mix was in proportion of 1: 1.272: 2.766 by weight and water cement ratio of 0.43 kept constant for all beam. Glass fibers of 12mm cut length and diameter 0.0125mm were used. The workability of glass fiber reinforced concrete mixtures was maintained by adjusting the dosage of super plasticizer admixture to offset the possible reduction in slump. For each series of beams, three cubes (150X150X150) mm and three cylinders (150mm diameter, 300mm high) as control specimen were casted. Cubes were tested for crushing strength at 28 days and cylinder were tested for splitting tensile strength at 28 days.

Specimen Details: Our Tests were carried out on six tee beams, simply supported on constant effective span of 600mm and width of 150mm under two point concentrated symmetrical loading.

There were four series of beams having different depths of 150mm, 200mm, 250mm, 300mm and Glass fibers [6] were added at volume fraction of 0%, 0.25%, 0.50%, 0.75% & 1%. All beams provided with anchor bars of 2-8 mm, bottom steel of 2-10mm of grade Fe500 and only beam of 0% fiber volume fraction were provided with 8mm stirrups of grade Fe250. The beam notation "D150" denotes the beam having overall depth 150mm.

Testing Procedure: The beams were tested under two point concentrated loading at their mid span in a universal testing machine. A dial gauge was fixed at bottom of beam to measure mid span deflection at interval of 0.5mm and corresponding load were noted. The loading at which first crack and ultimate crack appeared was noted. The pattern and propagation of cracks was noted, up to failure of beam.

III. RESULTS AND DISCUSSION



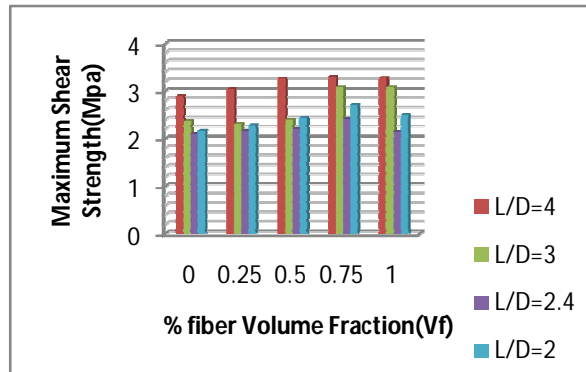
(a)

(b)

International Journal of Innovative Research in Science, Engineering and Technology

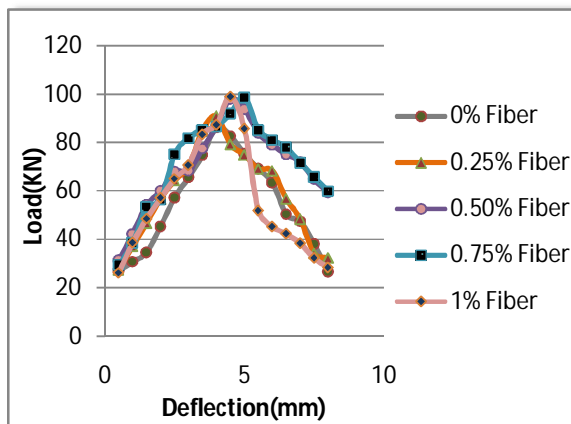
(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014

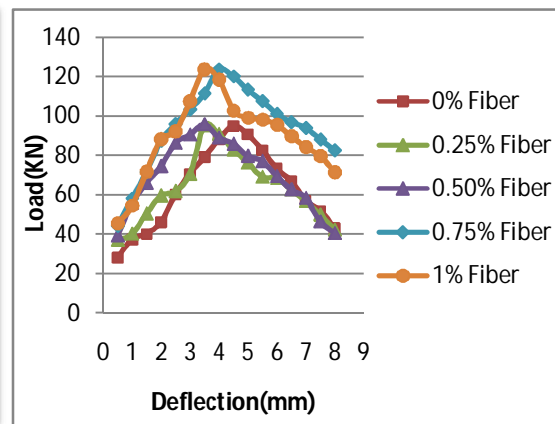


(C)

Fig. 1. (a) Ultimate crack load Vs % Fiber Volume Fraction (b) Flexural strength Vs % Fiber Volume Fraction (c) Shear Stress Vs % Fiber Volume Fraction.



(a)

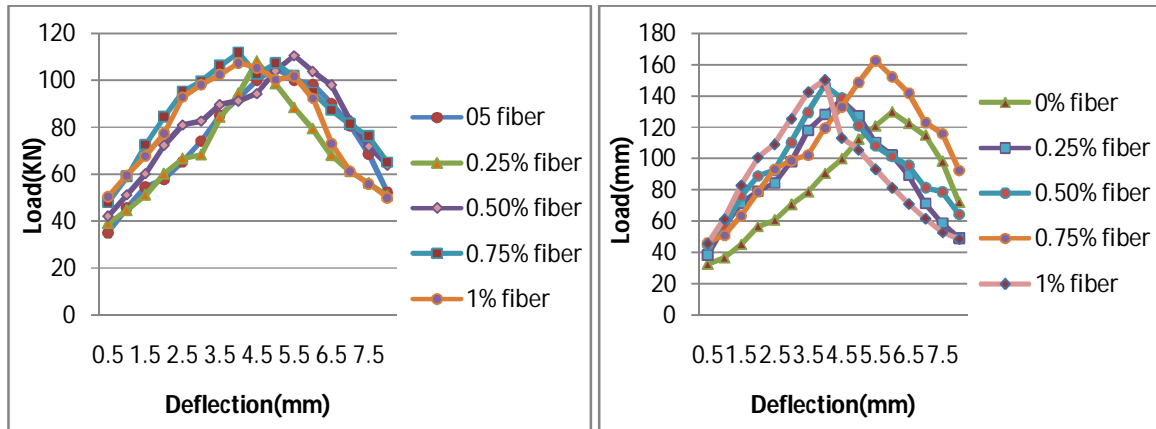


(b)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014



(c)

(d)

Fig.2: (a) load Vs % Deflection (L/D=4). (b) Load Vs % Deflection (L/D=3) . (c) Load Vs % Deflection (L/D=2.5). (d) Load Vs % Deflection (L/D=2)

Discussion of Crack Patterns and Mode of Failure:

The complete failure of the beam was observed to occur in one of the following ways as shown in fig.5:(i) The beams were collapsed by flexure with a flexural crack near to mid-span. This type of failure was observed in beams of L/D =4, L/D =3 series. (ii) The diagonal tension failure, observed in the majority of the beams of L/D =2.4, L/D =2 series, was indicated by splitting of beam in the direction of a line joining the inner edge of the support to the outer edge of the loading plate. Beam of series L/D =2.4 mainly failed in flexure-shear mode. While beams of series L/D =2 failed in pure shear mode.

The shear compression failure was indicated by crushing of the strut like portion of the concrete between two adjacent parallel diagonal cracks Fig.6 accompanied by splitting of the concrete along the plane of the diagonal cracks. Greater diagonal crack spacing's [10] were found in larger beams and hence resulted in wider shear cracks width and was followed by crushing and bursting in the web. This type of failure observed in some of beams of series L/D=2.



(a)



(b)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014



(C)

Fig.3: Crack Patterns (a) Beam of glass fiber 1% (L/D=3). (b) Normal beam of L/D=2.4. (c) Normal beam of L/D=2.

IV.CONCLUSION

Following conclusion are drawn on the result discussed in the previous chapter,

- 1) The increase in average compressive strength for GFRC is found 24.73 %. Compared to PCC. The maximum compressive strength is achieved with 0.75% fiber volume fraction.
- 2) The increase in split tensile strength is found 11.88 %. The maximum split tensile strength achieved with glass fibers having volume fraction 0.75 %.
- 3) The flexural strength for L/D=4 of moderate deep beam increases is 14.93% by inclusion of 0.75% glass fiber and for L/D=3 it increases is 30.25% by inclusion of 0.75% glass fiber, and for L/D=2.4 and 2 average increment is about 20.04 % by inclusion of 0.75% glass fiber.
- 4) The shear stress of moderate deep beam increases by 21.19% by inclusion of 0.75% glass fiber which helps to reduce stirrup requirement.
- 5) The increase in ductility for L/D=4 and 2 of moderate deep beam is found 4.76 %, and 4.81% respectively by inclusion of 0.50% glass fiber and The increase in ductility for L/D= 3 and 2.5 is found 3.72 % and 10.45% by inclusion of 0.75% glass fiber.
- 6) The ultimate load carrying capacity of moderate deep beam is observed to be maximum with 0.75% volume fraction for L/d ratio 2.4 & 2 but decrease again to 1% fiber volume fraction.
- 7) Balling effect and Heterogeneity in the concrete is observed with higher volume fraction such as 0.75% & 1% volume fraction of Glass fiber.
- 8) Overall observation of this study shows that it advantageous to use 0.75% of Glass fibers which gives satisfactory results in all conducted tests for concrete Grade M25.

REFERENCES

- [1] A. Avci, H. Arikani, A. Akdemir [25 August 2003] "Fracture behavior of glass fiber reinforced polymer composite", Cement and Concrete Research 34 (2004), pp. 429-434.
- [2] Ashour A.F. "Flexural and shear capacities of concrete beams with GFRC", Construction and Materials 20 (2006), pp.1005-1015.
- [3] Chandramouli K., Srinivasa Rao P. Pannirselvam N. Seshadri Sekhar T. and Sravana P. " Strength Properties Of Glass Fiber Concrete", ARPN Journal of Engineering and Applied Sciences, Vol. 5, No.4, April 2010.
- [4] G.Appa Rao and K.Kunal [16 June 2009]. "Strength & Ductility of RC deep beam" Journal of Structural engg. Vol. 36, No. 6, pp.393-400.
- [5] Frederick T. Wallenberger, James C. Watson, and Hong Li. "Glass Fiber"(2001) ASM International, ASM Handbook, Vol.21: Composites.
- [6] Ata El-kareim S. Soliman , Mostafa abdel-megied Osman "Efficiency of using discrete fibers on the shear behavior of R.C. beams", in Shams Engineering Journal (2012), www.Sciencedirect.com.
- [7] IS10262-1982, Recommended Guidelines for Concrete Mix Design, Bureau of Indian Standards.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014

- [8] **IS 456:2000**, “Plain and Reinforced Concrete Code of Practice”, fourth revision, Bureau of Indian Standards (BIS 2000).
- [9] **Shetty M.S.**, “Concrete Technology, Theory and Practice”, S. Chand & Company, New Delhi.
- [10] **M.Zakaria,T,Ueda, Z.Wu and L.Meng** /Journal of Advanced concrete Technology Vol. 7, No.1,pp.79-96,2009.
- [11] **C. Turki , B. Kechaou , D. Tréheux , Z. Fakhfakh , M. Salvia** [17 February 2004] Fretting behavior of unidirectional glass fiber–epoxy composites, influence of electric charge effects./ wear 257 (2004),pp.531-538.
- [12] **Deju Zhu, Mustafa Gencoglu, Brazin Mobasher**, “Flexural impact behavior of AR glass fabric reinforcement composites”, Cement and Concrete Composites 31 (2009), pp.379-387.

Table 1: Compressive strength and split tensile strength Test Results

Cement :sand: coarse aggregate	Water cement ratio	Fiber volume fraction (%)	Average compressive strength (N/mm ²)	Average split tensile strength (N/mm ²)
1:1.272: 2.766	0.43	0	28.14	3.03
1:1.272: 2.766	0.43	0.25	31.25	3.01
1:1.272: 2.766	0.43	0.50	33.33	3.34
1:1.272: 2.766	0.43	0.75	35.10	3.39
1:1.272: 2.766	0.43	1	29.32	3.32

Table 2: Average flexural strength and Maximum shear stress

Sr. No.	Span-depth ratio(L/D)	% Fiber volume fraction(Vf)	Average flexural strength (N/mm ²)	Maximum shear stress (N/mm ²)
1	4	0	15.33	2.89
2	4	0.25	16.16	3.03
3	4	0.50	17.43	3.26
Sr. No.	Span-depth ratio(L/D)	% Fiber volume fraction(Vf)	Average flexural strength (N/mm ²)	Maximum shear stress (N/mm ²)
4	4	0.75	17.62	3.30
5	4	1	17.53	3.28
6	3	0	9.49	2.37
7	3	0.25	9.23	2.31
8	3	0.50	9.57	2.39
9	3	0.75	12.37	3.09
10	3	1	12.35	3.09
11	2.4	0	6.72	2.10
12	2.4	0.25	6.92	2.16
13	2.4	0.50	7.07	2.20
14	2.4	0.75	7.71	2.41
15	2.4	1	6.86	2.14
16	2	0	5.76	2.16
17	2	0.25	6.09	2.28

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 3, March 2014

18	2	0.50	6.52	2.44
19	2	0.75	7.22	2.71
20	2	1	6.67	2.50

Table 3: ductility of moderate deep beam

Span-Depth Ratio (L/D)	% Fiber Volume Fraction(Vf)	Deflection at First Crack Load Dc, (kN)	Deflection at Ultimate Crack Load Du, (kN)	Ductility= (Du/Dc)
4	0	2.00	4.62	2.31
	0.25	2.12	4.85	2.28
	0.50	2.48	5.48	2.20
	0.75	1.56	5.26	2.05
	1	3.02	4.50	1.49
3	0	2.40	4.52	1.88
	0.25	2.58	3.54	1.37
	0.50	2.30	3.58	1.55
	0.75	2.16	4.22	1.95
	1	2.10	3.50	1.66
2.4	0	2.26	4.56	2.01
	0.25	3.00	4.58	1.53
	0.50	2.52	4.54	1.80
	0.75	2.50	5.56	2.22
	1	3.00	4.30	1.43
2	0	3.20	5.32	1.66
	0.25	3.28	5.68	1.73
	0.50	3.56	6.20	1.74
	0.75	3.85	6.50	1.68
	1	3.26	5.60	1.71