Flexural Behaviuor of concrete beams Reinforced with Glass Fibre Polymer

Sumant U. Ladole
(M.E. STRUCTURE)
Email ID: ladole.sumant@rediffmail.com
Prof Ram Meghe Institute of Technology & Research, Badnera,Amravati.

Abstract

Corrosion of steel reinforcement is one of the main problem facing the construction industries throughout the world. Many method's have been used to minimize the problem but they lead's to failure. Thus more durable reinforcement due to its non corrodible characteristic. This paper presents the flexural behavior of concrete beam each measuring (500 x 100 x 100) mm and Reinforced with direct roving glass fiber. The performance of their flexural strength and split tensile strength of beam and cylinder, have been observed However, the performance of Glass Fiber Reinforced Polymer (Directing roving glass fiber) reinforced concrete beam improved slightly.

1. Introduction

The alarming problem of steel corrosion in reinforced concrete structure leads to the requirement for more durable concrete and corrosion resistant reinforcement to be used for structures where the risk of concrete is by the incorporation of pozzolainic material such as slag, silica, fume and fly ash in the concrete mix . As for durable reinforcement, stainless steel is one of the options. However the cost of stainless steel is very expensive compared to carbon steel. Thus the search for less expensive and more durable reinforcement continues.

In last two decades researchers explore the possibility of using fiber reinforced polymer (FRP) materials to be used as concrete reinforced polymer(FRP) materials to be used as concrete reinforced cement .The FRP is made up of continuous fiber filaments embedded in resin matrix to from various types of shapes such bars ,structure section ,plates ,and fabric.

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Now,a days the GFRP available in market is in various form compared with conventional steel. The GFRP offer more benefits such as high tensile strength to weight ratio corrosion free , light weight ,non magnetic, and non conductive . However despite those benefits the GFRP bars have low elastic modulus and behave elastically up to near failure. These two characteristics may affect the behavior of concrete beams reinforced with such reinforcement, i.e. the stiffness and mode of failure .As from the structural point of view the stiffness is an important aspect to be considered since it affects the load carrying capacity of the member and the deflection at service load.

This paper presents the suitability of GFRP to replace the conventional steel as the main tensile reinforcement. The short term flexural behavior of concrete beam reinforced with GFRP polymer was investigated. The behavior of the GFRP reinforced concrete beam was compared with the beam reinforced with conventional concrete beams. The effect of stainless steel mesh as shear reinforcement on the flexural performance of the GFRP reinforced concrete beam was also studied.

2. Methodology

Glass fiber reinforced concrete Beam Were Cast and Tested to failure. The overall Dimension of reinforced concrete beam Tested Were (500x100x100) MM

Table 1.Physical Properties of Direct roving Glass Fibers

Sr. No.	**Property**	**Value**
1	Length	Continuous in length
2	Appearance	White in Roving forms
3	Density of Glass Fiber	2.60 gm/cc
4	Fiber tensile strength	(2-4) Gpa
5	Modulus of Elasticity	72 Gpa
6	Available Tex	2400 gm/km

Dosages used: Number of roving increased as (0,2,3,4,5,6,7) in each mix, as kept constant throughout the mix and grade of concrete changes from (M-15 to M-40) as a continuous fiber.

2.1 Mix Design of Concrete

ACI method and IS 10262 [19] method of mix design was used for mix design of [M-15 to M-40] grade of concrete. The quantity of ingredient materials and mix proportions as per design is as wider.

Table 2: Quantity of Materials per Cubic meter of concrete: Grade M-15

Material	Proportion by weight	Weight in Kg/m^3
Cement	1	345.24
F.A.	1.67	573.786
CA (20mm) 60%	2.11	727.275
CA(l0mm)40%	1.41	484.85
Water	0.55	191.60

2.2 Specimen Details

Table 3: Schedule of Specimen Preparation

Sr. No	Mix Design	W/C ratio	Fiber Content As a No.of Rovings	No. of specimen for Flexure test on (28days)	Split tensile strength on (28days)
1	Ml M-15	0.55	0,2,3,4,5 6,7	8	8
2	M2 M-20	0.50	0,2,3,4,5 6,7	8	8
3	M3 M-25	0.50	0,2,3,4,5 6,7	8	8

4	M4 M-30	0.45	0,2,3,4,5 6,7	8	8
5	M5 M-35	0.45	0,2,3,4,5 6,7	8	8
6	M6 M-40	0.40	0,2,3,4,5 6,7	8	8

2.4 Preparations of Specimen

2.4.1 Measurement of Ingredients

All cement, sand, coarse aggregate (20mm, 10mm) measured with Digital balance.

The direct roving glass fibers are measured with no. of roving as respect to length of each specimen.

2.4.2 Mixing of concrete

The ingredients are thoroughly mixed over a G. I. sheet. The sand, cement and aggregate are measured accurately and were mixed in dry state for normal concrete. Similarly for glass fibers reinforced concrete, the required quantity of glass fibers (0, 2, 3, 4, 5, 6, and 7) measured with no. of roving's as respect to length of each specimen is equal to length of each roving placed at a failure pattern and bottom surface.

The required roving of glass fibers is then uniformly distributed over bottom surface of mould of specimen in rigid wooden frame so formed a reinforcement case of a roving in tension position .Concrete mix containing CA, FA, cement and roving glass fibers hence known as Glass fiber reinforced concrete with special case.

2.4.3 Placing of Concrete

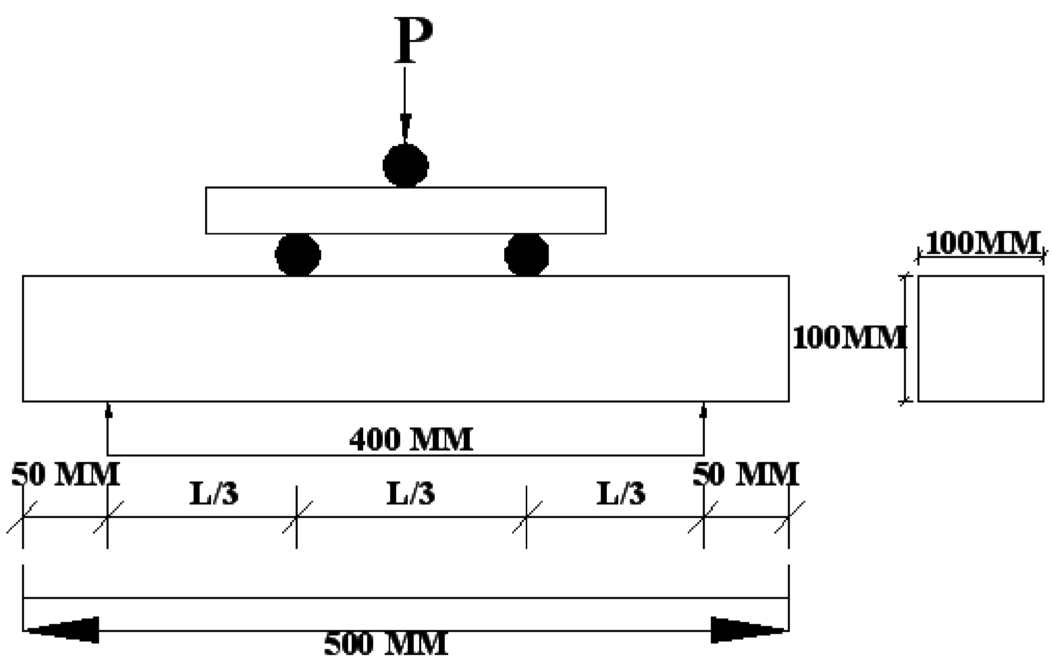
The fresh concrete was placed in the moulds by trowel. It was ensured that the representative volume was filled evenly in all the specimens to avoid segregation, accumulation of aggregates etc. While placing concretes, the compaction in vertical position was given to avoid voids in moulds.

2.4.5 Test Conducted On Hardened Concrete: Confirming to IS 516-1959 1211

In present study flexural test on beams, split test,on plain and Glass fiber reinforced concrete (GFRC) with varying fraction were carried out on number of samples. The experimental set up for various tests are described below.

The results of flexural strength is shown in Table 4 and relation with flexural strength with respect to fiber content and are shown in Figure

2.4.6Flexural test on plain Concrete and GFRC



TWO POINT LOADING SETUP IN FLEXURE TEST

FIG.1

Standard beams of size 100 x 100 x 500 mm were supported symmetrically over a span of 400mm and subjected two points loading till failure of the specimen. The deflection at the center of the beam is measured with sensitive dial gauge on UTM.

ISSN 2229-5518

3. Result and discussion

3.1 Flexural strength Test on Beam:

Flexural strength is obtained for various fiber volume fractions (no. of roving 0 to 7) and results are presented in Table 4. The variation of flexural strength with respect to fiber volume fraction is shown in table 4.

Table 4.Comparison of Flexural strength of 28 days on beam

Fiber content (no. of roving) / Mix Design	Comparison of Flexural strength of 28 days on beam	0	2 (0.10%)	3 (0.15%)	4 (0.20%)	5 (0.25%)	6 (0:30%)	7 (0.35%)
[M-15]	Flexural strength(MPa)	4.5	4.52	4.55	4.69	4.75	4.8	4.9
	% variation in Flexural strength over normal concrete		2.16	4.05	4.66	5.26	6.25	8.16
[M-20]	Flexural strength(MPa)	4.75	4.83	4.94	4.98	5.20	5.3	5.4
	% variation in Flexural strength over normal concrete		2.17	3.83	4.61	8.65	11.57	12.03
[M-25]	Flexural strength(MPa)	5.00	5.18	5.31	5.42	5.62	5.79	5.81

	% variation in Flexural strength over normal concrete		2.24	5.83	7.74	11.10	13.64	13.84
[M-30]	Flexural strength(MPa)	6.28	6.42	6.75	6.96	7.12	7.21	7.30
	% variation in Flexural strength over normal concrete		2.32	8.14	9.79	11.23	13.74	13.91
[M-35]	Flexural strength(MPa)	7.62	7.98	8.10	8.26	8.53	8.68	8.86
	% variation in Flexural strength over normal concrete		2.44	8.19	9.81	11.67	13.78	13.99
[M-40]	Flexural strength(MPa)	8.50	8.74	8.94	9.21	9.56	9.78	9.92
	% variation in Flexural strength over normal concrete		2.74	4.92	7.70	11.08	13.08	14.13

Table 4 shows that initially the value of flexural strength get increases with increases in no. of roving as volume of fiber content at the age of 28 days by 14.13 %of M-40 grade of concrete over normal concrete.

Figure no. 2 shows the graph of flexural strength increases with increases in percentage of fiber contain. It is observed from these figures that deformation is linear with respect to the flexural load up to first crack.

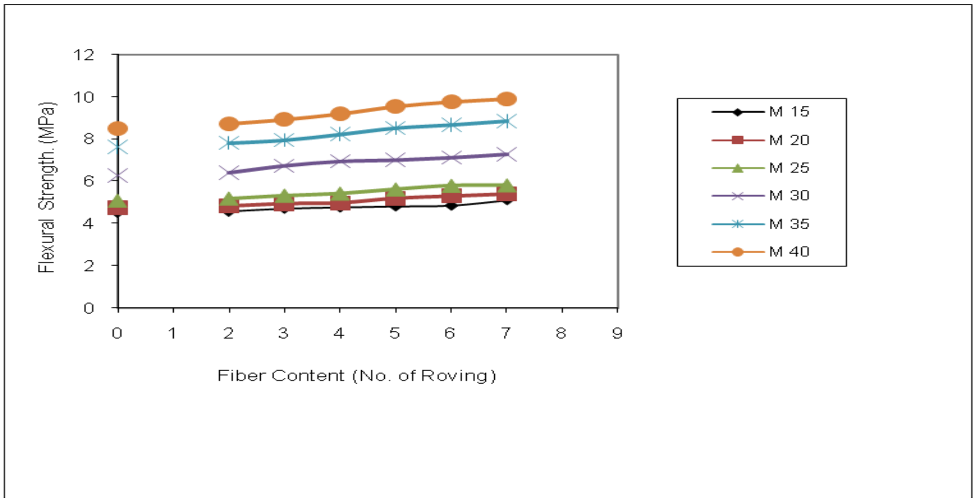


Fig. 2 Graph Shows Comparison of Flexural Strength verses Fiber content

Table 5 Split tensile Strength on cylinder, MPa

Fiber content (no.of rovings)	0	2 (0.10%)	3 (0.15%)	4 (0.20%)	5 (0.25%)	6 (0.30%)	7 (0.35%)
(M-15)	0.72	0.73	0.74	0.75	0.76	0.765	0.78
(M-20)	0.95	0.96	0.97	0.975	0.98	0.99	1.01
(M-25)	1.41	1.42	1.43	1.44	1.45	1.46	1.50
(M-30)	1.52	1.521	1.522	1.525	1.53	1.55	1.56
(M-35)	1.846	1.847	1.85	1.89	1.91	1.92	1.925
(M-40)	2.18	2.19	2.20	2.205	2.212	2.232	2.310

From Table 5 The 28 days split tensile strength initially increase for the fiber Volume fraction-varying from 0to7 no: of roving as in volume fraction 0.35% for 28 days. The maximum increase in split tensile strength is 2% than normal concrete for M40 grade of concrete for FRC at 28 days.

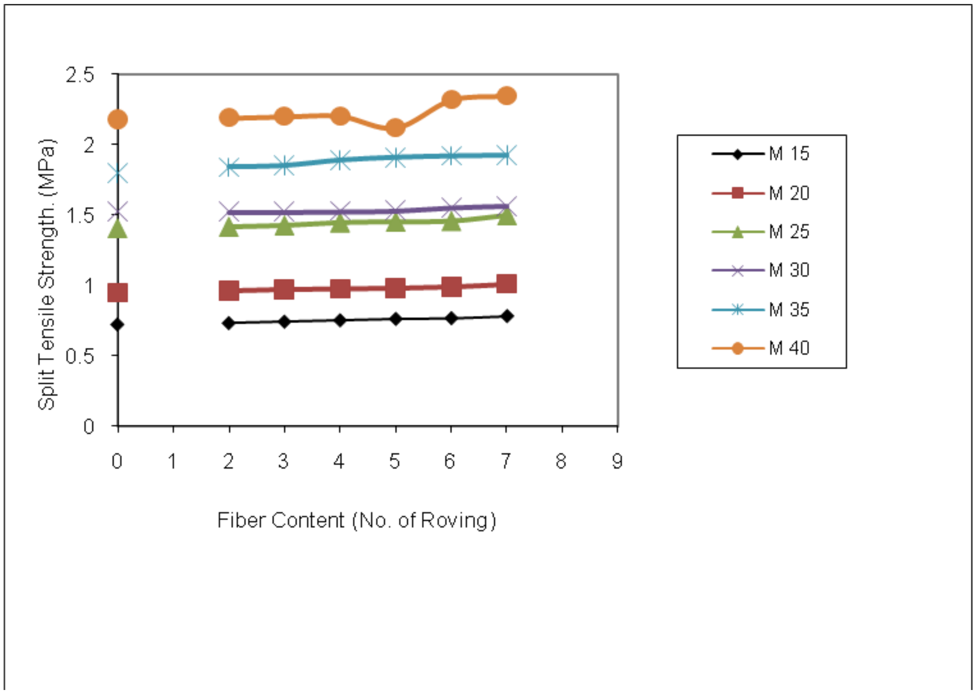


Fig 3: Variation of Split Tensile Strength at the age of 28 days w. r. t. increasing in percentage of Fiber Volume Fraction for M 15 to M 40

4. CONCLUSIONS

Following are the conclusion based on the result discussed in the paper.

1. The maximum flexural strength & split tensile strength achieved are 14.13% & 2.30%. at 28 days with 7 No. of roving as (0.35% of volume fraction) of Glass Fibre content respectively.
2. Elastic constants of GFRC are obtained by various methods. Empirical expressions for modulus of elasticity i.e. static and dynamic have been developed in terms of fibre volume fraction of GFRC. The values of modulus of elasticity are excellent agreement with those of law of mixtures.
3. In general, the significant improvement in various strengths is observed with the inclusion of Glass fibers in the plain concrete. However, maximum gain strength of concrete is found to depend upon the amount of fiber content. The optimum fiber content to impart maximum gain in strength varies with type of the strength.

4. While testing plain cement concrete cube spalling of concrete is observed. However it is not observed in GFRC different specimens due to fibers.
5. Flexural strength of GFRC is increase with increasing no. of roving of direct roving glass fiber as there is 14.13 % increase in flexural strength than normal concrete upto only 0.35% of fiber content as in the form of roving as 7 numbers.
6. It is found that crack width in GFRP is comparatively less than that of the plain cement concrete.
7. The split tensile strength at 28 days of curing observed to be increasing marginally.
8. In all fiber content mode of failure was changed from brittle to ductile failure when subjected to bending
9. Arrangement of this fiber means Roving is useful as increasing strength of plain concrete more attention in Flexural strength.

References

[1] Hans W. Reinhardt, Markus Kruger, Christian J. Grobe "Concrete prestressed with textile fabric" Journal of advanced concrete technology ,vol no.3, November 2003, PP. 231-239.

[2] B. Zastrau, L. Leepenies, M. Richter "On the multiscale modeling of textile reinforced concrete" technische mechanik, Band 28, Heft 1, (2008), Manuskripteingang 31. August 2007, pp. 53-63.

[3] Joao Mariano Laredo Dos Reis "Mechanical characterization of fiber reinforced polymer concrete" Materials Research, Vol. 8, No. 3, 2005, pp.. 357-360.

[4] Yuvraj M. Ghugal, Santosh B. Deshmukh "Performance of alkali resistant glass fiber reinforced concrete" Journal of Reinforced Plastics and Composites, published on January 9, 2006, pp .301-320.

[5] Scott Robert John Bumpus, "Experimental setup and testing of fiber reinforced composite structure"B.E. University Victoria 2002, pp. 120-125.

[6] Marie-Laure Dano ,Guy Gendron, Francois Maillette, BenoIt Bissonnette 'Experimental characterization of-damage in random short glass fiber reinforced composite' journal of Thermoplastic Composite Materials, Vol. 19, No. 1, 2006, pp. 79-96

[7] T. Sekar Member 'Fiber reinforced concrete from industrial waste fibers a feasibility study' IE(I) journal —CV vol 84 February 2004, pp. 78-88.

[8] M. Valle, 0. Buyukozturk 'Behavior of fiber reinforced high strength concrete under direct shear' ,Mechanics of Solids in Brazil 2007, pp. 56-60.

[9] J.M.L. Reis 'Fracture toughness of fiber reinforced polymer concrete' Mechanics of solids ,Brazil 2007, pp. 66-75.

[10] M.R.Garcez , L.C.Meneghetti, L.C.P. Silva Filho, J.L. Campagnolo ,'A comparative study of reinforced concrete beams strengthened with glass, carbon aramid fibers' International conference of durability of building materials and components, April 2005, Pp. 17-20.

[11] D. R. moore and A. cervenka 'Future requirements in the characterization of continuous fiber-reinforced polymeric composites', Pure AppI.chem,vol-74, No.4, 2000, pp. 601-628.

[12] B. Mobasher, 'Modeling of cement based composites laminates'

[13] David Roylance , 'Introduction to composites', Polymer Engineering and science, vol -16, March 24-2000, PP. 344-352.

[14] MIL handbook, 'Plastic matrix composites with continuous fiber reinforcement' 754 AR 19 Sept 1991, pp. 345-445

[15] J.P. J.G. Ferrejra and F.A.B. Branco 'The use of glass fiber reinforced concrete as a structural material' Experimental Techniques ,May-June 2007, pp. 45-56.

[16] H. Cypers, J. Wastiels, P. Van Itterbeek, E.De Bolster 'Durability of glass fiber reinforced composite' CompTest, 2004, pp. 23-35.

[17] Ghugal, Y. M. "Effects of Steel Fibers on Various Strengths of Concrete", ICI Journal, 4(3), pp. 23-29.

[18] I.S.456-2000, "Indian Standard Code of Practice for Plain and Reinforced Concrete, (fourth Revision)", Bureau of Indian Standard, New Delhi, 2000, pp. 1-45.

[19] I.S.10262-1982, "Indian Standard Recommended Guidelines for Concrete Mix Design", Bureau of Indian Standard, New Delhi, 1983, pp. 1-5.

[20] l.S.383-1970, "Code of Practice for Plain and Reinforced Concrete, (Third Revision)", Bureau of Indian Standard, New Delhi, 1970, pp. 1-6.

[21] I.S.516-1975, "Method of Tests For Strength of Concrete", Bureau of Indian Standard, New Delhi, pp. 1-25.

[22] I.S. 13311 (Part 1): 1992, "Non Destructive Testing of Concrete- Methods of Test, Ultrasonic Pulse Velocity", Bureau of Indian Standard, New Delhi, pp. 1-5.

[23] I.S. 13311 (Part 2): 1992, "Non Destructive Testing of Concrete- Methods of Test, Rebound Hammer", Bureau of Indian Standard, New Delhi, pp. 1-5.

[24] Neville A.M., "Properties of Concrete", ELBS Edition of P Edition, Longman Group, U.K. Ltd., 1981, pp. 1-30.

[25] Hannant Di., "Fibre Cements and Fibre Concretes", John Wiley and sons, New York, USA. 1978, pp. 779. -