International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 10, October-2018

Flexural behaviour of RCC beam reinforcement with GFRP bar and steel bar

T. SureshBabu[1], Avinash Buchi[2]

1 Professor&head of Civil engineering department, Visvodaya engineering college, kavali,india
2 M. Tech Schlor, Civil engineering department, Visvodaya engineering college,kavali,india.

Abstract - The experimental study of flexural behaviour of RCC beams reinforcement with glass fiber reinforced polymer (GFRP) bars and steel bars. A total four RCC beams were tested. The size of beam is (1.5x0.15x0.15) m. Two beams were used reinforcement as GFRP bars in tension zone with M20 and M25 grade of concrete and remaining two beams with steel bars as reinforcement in tension zone with M20 and M25 grade of concrete. The test is conducted on universal testing machine under two-point loading with simply supported condition. The glass fiber reinforced polymer has low elasticity and lower stiffness than the steel reinforcement. The failure of GFRP bar is linear. Experimental results indicates the load deflection for the beam specimen's and crack pattern of the beams.

Keywords - flexural behaviour, deflection, crack pattern, load –deflection, GFRP bar

I. INTRODUCTION

Fiber-reinforced polymer (FRP) plays an essential role in upgrading and restoration of reinforced concrete structural elements (RC) as external reinforcements. Further progress in these areas is widespread. Several researchers have conducted theoretical and practical examinations or on the reinforced concrete beams and columns wrapped with carbon fibers and glass reinforced polymer composites (e.g., CFRP and GFRP) adapted to measure the effectiveness. Several practical applications worldwide prove that the glass fiber reinforced polymer (GFRP) bars is used as reinforcement in several concrete structure and bonding process laminates or FRP sheets to the outer surfaces are a systematic process of strengthening and enhancing the load-bearing samples of reinforced concrete. These are structurally weak and renovated or deteriorated materials are used as reinforcing the outer plate, carbon fiber and glass fiber reinforced polymer composite materials have found favor in particular engineers. Later, a period of time researchers began to work on Hybrid FRP (GFRP and CFRP combination).

Fiber-reinforced polymer (FRP'S) is used most often for the reinforcement of concrete structures subject to corrosion, due to the high strength to weight strength, outstanding corrosion resistance and good non-magnetization properties. Although in concrete reinforced by fibers of dissimilar materials comprise conventional steel reinforced concrete structures as their linear stress-strain relationship to failure. Moreover, the FRP low elastic modulus affects the resulting reduction of the bending strength or stiffness fiber reinforced cracked concrete samples later, and therefore, high deformations under the conditions of service.

The standard type of glass fiber used is glass fiber is E glass fiber, alumino borosilicate which is less than 1 percent of alkali oxides, primarily useful for plastic material reinforced with glass. And another type of glasses fibers used are glass (Alkali lime glass with small without boron oxide), a E-CR glass (electrical or chemical resistance and lime silica glass alumino less than 1 percent alkali metal oxides more acid resistance), C glass (alkali lime glass with more boron oxides B_2O_3, having discontinuous fibers or insulating), D glass (borosilicate glass, use constant low di-electric) , R (aluminosilicate glass and without magnesium oxide and calcium oxide with mechanical necessity as reinforcement)

Pure silica SiO_2 means silicon dioxide. It is refrigerated fused quartz glass without a true melting point, and it is also used as fiberglass. However, it has the disadvantage that only works with higher temperatures. This lower temperature required work reports and other additional substances are as fluxing agents (components means low melting point). Ordinary Glass (lime alkali) and also known as soda-lime glass name. It is crushed and ready to be hung, called cullet glass, and it was the original glass of the type used for fiberglass. E glass is free from alkali metals, and it was the initial glass formation is the application for the formation of continuous filaments. Currently, it's fiberglass production in the world. In addition, it is the largest single consumer of boron minerals worldwide. It has the ability to attack chloride ion and a low quality option for marine applications. S-glass ("S" means "strength") has high strength product strength (modulus). Accordingly, it is a main and epoxy composite aircraft. The same substance is known under the name R-glass ("R" means "reinforcement") in Europe. C-glass ("C" stands for "chemical resistance") and T-glass ("T" stands for "insulation") is a North American glass form C and are more resistant to chemical attack. C-Glass and Glass T both are often added to the insulation class of blown fiberglass.

Abid Alam et al. (2015) have conducted an experimental testing of RCC beam of size100X100X500mm with different grade of concrete mix M20, M30 grade of concrete. The glass fibres of 0.02% by volume fraction of concrete were used. The compressive strength is concrete show a marginal increase on addition of fibres to concrete mixes. Increased strength was reported as 26.6% and 25.78% for M20 and M30 grade of concrete. However further addition of fibres improves average strength up to 7% for M20 grade and 8.8% for M30 grade of concrete. The tensile strength of concrete also shows an increasing trend. For M20 & M30 grade of concrete increased tensile strength were observed to be 24.7% and 26.10%.

Patil et al. (2013) studied experimentally and analytically RC deep beams subjected to two-point loading with three different L/D ratios (1.5, 1.6, 1.71) using non-linear FEM. The results between FEM and experimental were made in terms of strength, flexural strain and deflection of concrete beams. It was found that the smaller the span/depth ratio, the more pronounced was the deviation of strain pattern at mid-section of the beam. As the depth of the beam increases the variation in strength, flexural stress and deflection were found to be more in case of experimental work as compared to the non-linear FEM.

II. METHODOLOGY FOR EXPERIMENTAION

A. Materials and its testing

The various materials used in the mix design cement (OPC), fine aggregates, coarse aggregates and potable water. The experiment results for cement, fine aggregates and coarse aggregates

A.1 Cement

The cement used in the experimental investigation is ordinary Portland cement (OPC) of Ultra-tech brand. The physical properties procured as per IS:4031-1968.

A.2 Fine aggregate

The sand is free from clay matter, organic impurities, and silt and sand is sieved on 4.75mm sieve. The physical properties like fineness modulus, specific gravity, moisture content, bulk density are tested as procedure in IS:2386.

A.3 Coarse aggregate

The maximum size of coarse aggregate used is 20mm which is local available.

Table 1: Test results of materials

S.NO	Materials	Contents
1	Cement used	Opc53 grade (ultra tech)
2	Specific gravity of coarse aggregate (20mm)	2.627
3	Specific gravity of fine aggregate	2.224
4	Specific gravity of cement	3.15
5	Water absorption of coarse aggregates	1.41%
6	Water absorption of fine aggregates	0.5%

B. Mix design

The mixing of materials are weighed exactly with their proportions and thoroughly mixed in their dry condition before water is added. The prepared mix was then immediately used for casting RCC beamsas per **IS 10262-2009** code, has been used for the design of M20 grade concrete mix

B.1 Selection of water cement ratio for M25 grade of concrete

From IS 456 maximum water cement ratio = 0.55
From IS 10262; 1982 adopt water cement ratio = 0.5
0.5 < 0.55, hence ok

B.2 Selection of water content

From IS 10262; 2009 maximum water content
for 20 mm aggregates = 186 kg

B.3 Calculations for cement content

Water Cement Ratio (W/C) = 0.5
Estimated water content (50 -75 slump) = 180 lit
Cement content = 382 kg/ m3
382 kg/m3 > 310 kg/m3, hence it is satisfied

Table 2: Mix Proportion of M25Grade concrete

Water	Cement	Fine aggregate	Coarse aggregate
180	382	460.5	1211.9
0.5	1	1.20	3.17

Table 3: Mix Proportion of M20 Grade concrete

Water	Cement	Fine aggregate	Coarse aggregate
180	360	533.84	1224.07
0.5	1	1.48	3.40

III. EXPERIMENTAL PROGRAM

A. General

The present investigation is aimed to study the flexural behaviour of RCC beam made with different reinforcement bars (steel bar and GFRP bar) with M20 and M25 grade of concrete.

A.1 Preparation of test specimens

Total four beams were casted with size of length1.5m, width 0.15m and depth 0.15m (1.5x0.15x0.15) m. One beam with steel bar as reinforcement in tension zone with M20 grade of concrete. One beam with GFRP bars as reinforcement in tension zone with M20 grade of concrete. One beam with steel reinforcing bar in tension zone with M25 grade of concrete. One beam with GFRP bars as reinforcement in tension zone with M25 grade of concrete. The beams are cured for 28 days and tested under standard condition on 28th day

A.2 Beam details

Table 4 details of beam specimen

S.NO	Grade of concrete	Testing of beam for days	Reinforcement bar	Longitudinal reinforcement		Stirrups diameter(mm)
				Top(mm)	Bottom(mm)	
1	M20	28	Steel	8	12	6
2	M20	28	GFRP	8	12	6
3	M25	28	Steel	8	12	6
4	M25	28	GFRP	8	12	6

A.3 Beams curing after 28 day

The beam is cured for 28 days. After completion of curing beam is to be tested

Fig 1 RCC beam with M20 grade (1) and GFRP beam with M20 grade (2)

Fig 2 RCC beam with M25 grade (1) and GFRP beam with M25 grade (2)

B. Test procedure and test set up

The schematic arrangement of the test set up is shown in fig.3. the beam is subjected to a two pointloading with a clear span of 1350mm. The beam loaded under simply supported condition. The load is gradually applied on the beam by using universal testing machine (UTM). The deflection of the tested beam is measured with the help of dial gauge; it is placed at the mid span of the beam. The results are observed on the dial gauge.

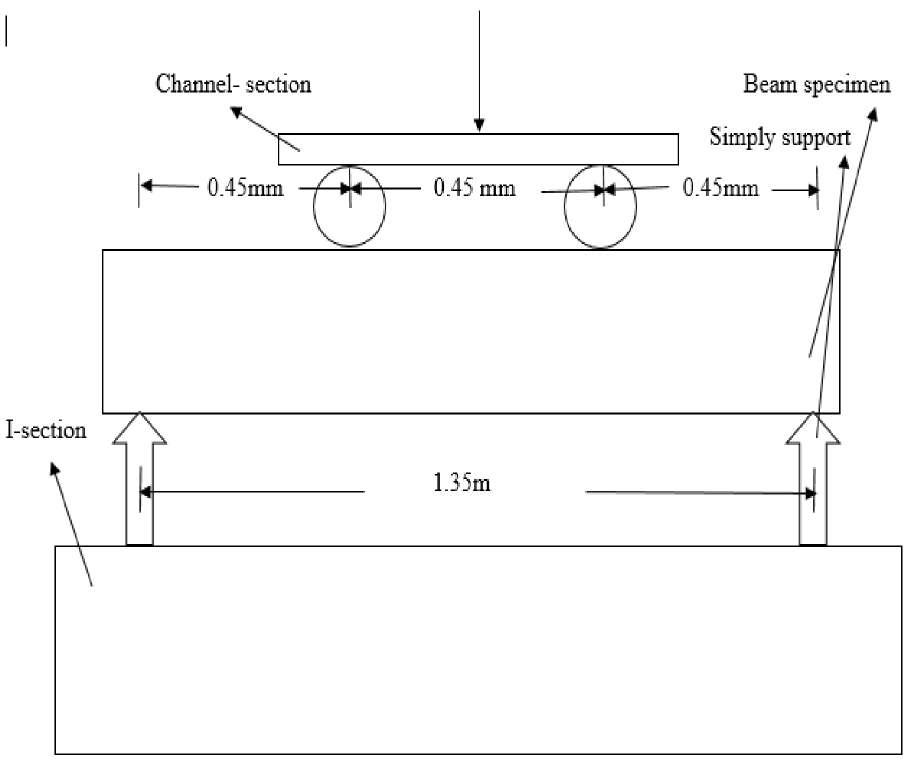

Fig 3 loading diagram

IV.RESULTS AND DISCUSSION

A. Load deflections:

The mid span deflection of the beam specimen is observed by using dial gauge is placed at the mid span of the beam. load to mid span deflection values are calculated for different loads. The load-deflection curves are for different beam is given below

B. Results

B.1 ***Load vs deflection graph for RCC beam with M20 grade of concrete***

The maximum load carrying capacity of the RCC beam with M20 grade of concrete is 92.7 KN and corresponding maximum deflection is 9.1mm as shown in figure 4.

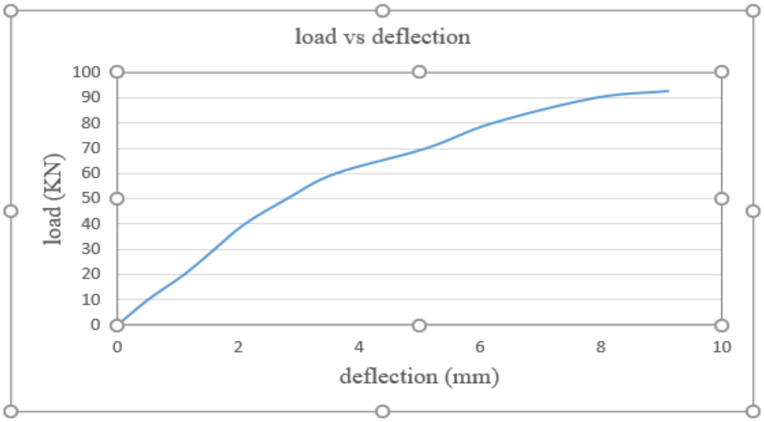

Fig 4 Load vs deflection curve for RCC beam with M20 grade of concrete

B.2*Load vs deflection graph for GFRP beam with M20 grade of concrete*

The maximum load carrying capacity of the GFRP beam with M20 grade of concrete is 88.1 KN and corresponding maximum deflection is 10.4 mm as shown in figure 5.

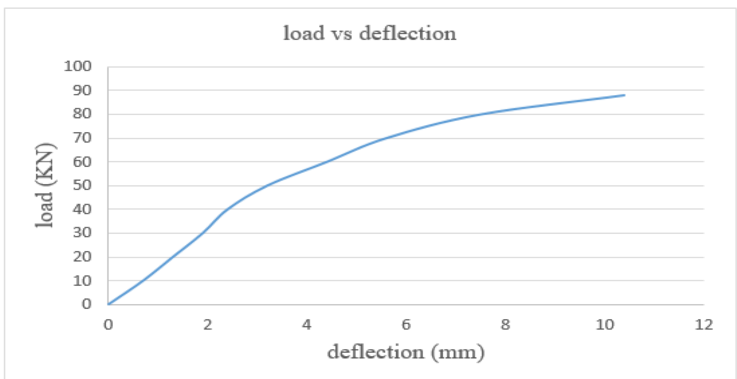

Fig 5 Load vs deflection curve for GFRP beam with M20 grade of concrete

B.3*Load vs deflection graph for RCC beam with M25 grade of concrete*

The maximum load carrying capacity of the RCC beam with M20 grade of concrete is 97.7 KN and corresponding maximum deflection is 8.3 mm as shown in figure 6.

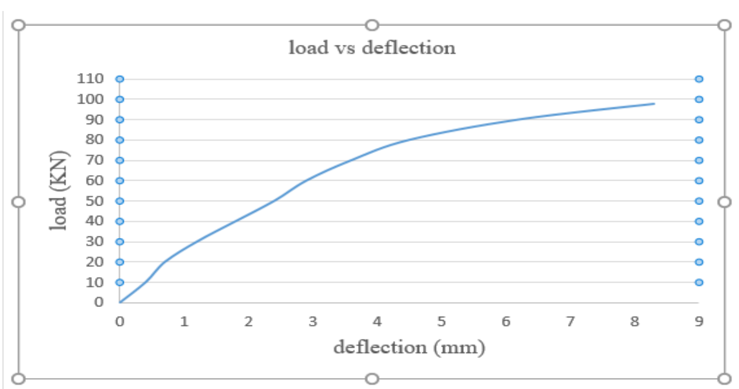

Fig 6 Load vs deflection curve for RCC beam with M25 grade of concrete

B.4*Load vs deflection graph for GFRP beam with M25 grade of concrete*

The maximum load carrying capacity of the RCC beam with M20 grade of concrete is 91.5 KN and corresponding maximum deflection is 9.2 mm as shown in figure 7.

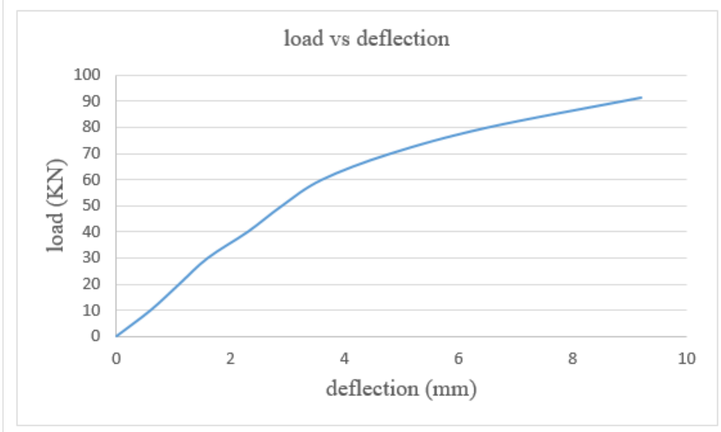

Fig 7 Load vs deflection curve for GFRP beam with M25 grade of concrete

C. Ultimate load carrying capacity of the beam:
The ultimate load taken by each of the beam was observed. Beyond this load the beam takes no load and failure occurs. The load at which first crack is developed was also noted for each beam. Table 6.5shows ultimate load carrying capacity and initial crack load for each beam. Figure 8 shows the comparison of ultimate load carrying capacity of the RC beam and GFRP beam with M20 and M25 grade of concrete

Table 4 Ultimate load carrying capacity of the beams

S.NO	Specimen	Grade of concrete	Initial crack load (KN)	Ultimate load (KN)
1.	RC beam with steel bar (A)	M20	18.2	92.7
2.	RC beam with GFRP bar (B)	M20	10.6	88.1
3.	RC beam with steel bar (C)	M25	20.7	97..7
4.	RC beam with GFRP bar (D)	M25	13.3	91.5

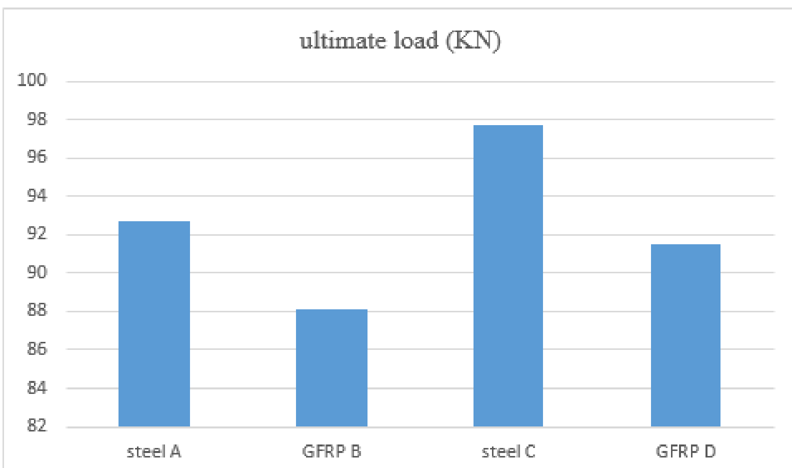

Fig 8 ultimate load carrying capacity for RCC beams with steel and GFRP bar

C. Crack pattern:

Mainly shear cracks were developed from near the supports and widened up to top of the beam as the load increased. At failure the concrete in compression region crushed. The cracks continued to widen as the load increased. The crack increase from tension zone to compression zone. Fig 9 shows crack pattern for beam specimens

Fig 9 Crack pattern for beam specimens

V. CONCLUSION

1. The RCC beam with M20 grade of concrete has ultimate load carrying capacity is 4 percent more than the GFRP beam.
2. The comparison between GFRP beam and RCC beam with M25 grade of concrete the ultimate load carrying capacity of GFRP beam is 6 times less than RCC beam
3. The ultimate deflections for RC beam is 15 percent less than the GFRP beam with M20 grade of concrete.
4. For M25 grade concrete with GFRP bar the deflections are 10 percent more than the RCC beam.
5. crack initiation is early in GFRP beam due to low modulus of elasticity of GFRP bar when compared to RC beam.
6. stress strain curve of GFRP bar increases linearly up to peak load and fails after elongation where as steel bar after yield enters in strain hardening state and fails.
7. As per IS 456-2000 clause 23.2, the deflection of the beam specimens is within the permissible limits
8. The use of GFRP bar in concrete structures as a replacement of steel bar proves to be cheaper, corrosion resistance, high tensile strength to weight ratio

REFERENCES

Abid Alam.Md, Imran Ahmad, Fazlur Rehman (2013)"Experimental Study On Properties Of Glass Fiber Reinforced Concrete" International Journal Of Engineering Trends And Technology, (Ijett) – Volume 24 Number 6- pp- 297-301. (2013)

Deshmukh S.H, Bhusari J. P Zende A. M (2012) "Effect of Glass Fibres on Ordinary Portland Cement Concrete", IOSR Journal of Engineering, Vol. 2, PP:1308-1312

Hamoush, S. A., Ahmad, S. H. (1990), Debonding of Steel Plate-Strengthened Concrete Beams, Journal of Structural Engineering, ASCE, 116(2), 356-371.

Hussain, M., Sharif, A., Basunbul, I.A., Baluch, M.H., Al- Sulaimani, G. J., (1995), Flexural Behaviour of Pre-cracked RC Beams Strengthened Externally by Steel Plates, ACI Structural Journal, 92(1), 14-22.

Jayajothi, P., Kumutha, R., Vijai, K. (2013), Finite Element Analysis of FRP Strengthened RC Beam using Ansys, Asian Journal of Civil Engineering, 14(4), 631-642

Patil, S. S., Shaikh, A. N., Niranjan, B. R., (2013), Experimental and Analytical Study on Reinforced Concrete Deep Beam", International Journal of Modern Engineering Research, 3 (1), 45-52.

Ritchie, P.A., Thomas, D.A., Le-Wu, L., Connelly, G.M (1990), External Reinforcement of Concrete Beams using Fiber Reinforced Plastics, ACI Structural Journal, 88(4), 490-50

Srinivas.T, N.V Ramana Rao (2015) "study on flexural behavior of RCC Beam containing high volume fly ash". ISOR journal of mechanical and civil engineering,e-ISSN:2278-1684,volume 12 (July-aug 2015**).**

Shirsath, P M Yeole (2015)"Effect Of Glass Fiber On The Strength Of Rcc Beam". International Journal of Modern Trends In Engineering And Research, Volume 2, pp-757-762.

Viradiya, S. R., Vora, T. P. (2014), Comparative Study of Experimental and Analytical Results of FRP Strengthened beams in Flexure, International Journal of Research in Engineering and Technology, 3(4), 555-561.

ACI Committee 440. ACI 440.1R-03, Guide for the design and construction of concrete reinforced with FRP bars. Farmington Hills, Mich., USA: American Concrete Institute (ACI); 2003.

ACI Committee 440. ACI 440.3R-04, Guide test methods for fiber-reinforced polymers (FRPs) for reinforcing or strengthening concrete structures. Farmington Hills, Mich., USA: American Concrete Institute (ACI); 2004.