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An Experimental Investigation on Strengthening of Reinforced Concrete Beam Using Glass Fiber Reinforced Polymer Composites

R. Elanchezhiyan[1], K.Thiyagu[2], C.Hema[3]

Assistant Professor, Department of Civil Engineering, Muthayammal College of Engineering, Rasipuram, Tamil Nadu, India[1,2]

Assistant Professor, Department of Civil Engineering, Bharath University, Chennai, Tamil Nadu, India[3]

ABSTRACT: The maintenance, repairing and rehabilitation of structural members, is perhaps one of the most critical problems in civil engineering applications. Glass Fiber Reinforced Polymer (GFRP) application is very effective way to repair and strengthen structures. The reinforced concrete beams of externally bonded epoxy resin with GFRP sheets were tested to failure by using a symmetrical two point concentrated static loading system. The beams were casted for this experimental test program. In SET I three beams were casted weak in flexure, out of this beam one is controlled beam and other two beams were strengthened using continuous Glass Fiber Reinforced Polymer (GFRP) sheets in flexure. The strengthening of the beams was carried out with different amount and configurations of GFRP sheets. Experimental data on ultimate load, deflection and failure modes of each of the beams were obtained. The effects of number of GFRP layers and its orientation on the ultimate load carrying capacity and failure mode of the beams are investigated.

KEYWORDS: Glass Fiber, Reinforced Polymer (GFRP), Epoxy resin

I. INTRODUCTION

The studies on Effects of Glass Fiber Reinforced Polymer Composites are reported on literature [1],[2],[3] and [4]. Strengthening is accomplished by either reducing the magnitude of forces or by enhancing the member's resistance. The strengthening techniques are enlarging the section, bonded reinforcement at externally, post-tensioning work, and supplemental supports may be used to achieve improved strength and serviceability. The durability studies of glass fiber reinforced polymers are reported in [6]. [5] Carried out investigation on Glass Fiber Reinforced Concrete Moderate Deep Beam. Finally they reported, addition of glass fiber significantly improved, shearstress and ductility of reinforced moderate deep beam without stirrups. In this paper, strengthening of reinforced concrete beam is carried out by using Glass Fiber Reinforced Polymer composites. The flexural and shear behaviour of reinforced concrete beams strengthened with varying configuration and layers of GFRP sheets. And also the effect of the number of GFRP layers and its orientation on the strength and ductility of beams are investigated.

II. MATERIAL USAGE AND ITS PROPERTIES

- Cement (Ordinary Portland Cement – OPC-53 Grade)
- Fine aggregate (It passes through 2.36mm IS sieve)
- Coarse aggregate (Maximum size of 20 mm is used)
- Water (Clean potable water conforming to IS 456-2000 was used)
- Reinforcement (HYSD 12mm φ- Longitudinal Reinforcement and Mild steel bar Stirrups 6mmφ bars)

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- Concrete (Mix Proportion of M25 grade concrete used)

Reinforcement Materials (Glass Fibers):

Normally, fiber is a material made into a long filament with a diameter generally in the order of 10 tm. The aspect ratio of length and diameter can be ranging from thousand to infinity. The functions of the fibers are to carry the load and provide strength, thermal stability, stiffness, and other structural properties in the FRP. Glass fibers are also available as thin sheets, called mats. A mat which is made by both long continuous and short fibers (e.g., discontinuous fibers with a length between 25 and 50 mm) arranged in random and bonded together. The width of such mats is variable between 5 cm and 2 m, their density being roughly 0.5 kg/m^2.

III. MATRIX MATERIALS

The matrix serves to bind the fibers together, transfer loads to the fibers. The matrix has a strong influence on several mechanical properties of the composite such as strength, shear and compression.

Epoxy resins are relatively low molecular weight pre-polymers capable of being processed under a variety of conditions. Epoxy resins are characterized by the presence of a three-membered ring containing two carbons and an oxygen (epoxy group or epoxide or oxirane ring).

IV. EXPERIMENTAL STUDY

The experimental study consists of casting reinforced concrete (RC) beams. In- SET I three beams were casted weak in flexure, out of which one is controlled beam and other two beams were strengthened using continuous glass fiber reinforced polymer (GFRP) sheets as weak in flexure. The strengthening of the beams is done with varying configuration and layers of GFRP sheets. Experimental data on ultimate load, deflection and failure modes of each of the beams were obtained.

The dimensions of all the specimens are identical. The cross sectional dimensions of the beams are 250 mm by 200 mm and length is 2300 mm. In SET I beams 2, 12 mm φ bars are provided as the main longitudinal reinforcement and 6 mm φ bars as stirrups at a spacing of 75 mm centre to centre.

Test Procedure:

The specimens were tested using loading frame(two point loading system).The specimen was placed over the two steel rollers bearing leaving 150 mm from the ends of the beam. The remaining 2000 mm was divided into three equal parts of 667 mm .Two point loading arrangement are done and .Loading was done by hydraulic jack of capacity 100 KN. Three number of dial gauges were used for recording the deflection of the beams. One dial gauge was placed just below the centre of the beam and the remaining two dial gauges were placed just below the point loads to measure deflections.

V. FLEXURAL STRENGTHENING OF BEAM

The beams were tested for their ultimate strengths. In SET I three beams (F1, F2 and F3) weak in flexure are tested. The beam F1 is taken as controlled beam. It has less load carrying capacity when compared to that of the externally strengthened beams using GFRP sheets. In SET I beams F2 is strengthened only at the soffit of the beam and F3 is strengthened up to the neutral axis of the beam along with the soffit of the beam.

Testing of Specimens:

The GFRP strengthened beam and the control beams were tested to find out their ultimate load carrying capacity. It was found that the control beams F1 is failed in flexure and showing that the beams were deficient in flexure In SET I beam F2 failed due to fracture of GFRP sheet in two pieces and then flexural-shear failure of the beam took place. Beam F3 failed due to delamination of the GFRP sheet after that fracture of GFRP sheet took place and then flexural-shear failure of the beam. In SET I beams F2 and F3, GFRP rupture and flexural-shear kind of failure was prominent when strengthening was done using both the wrapping schemes.

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Table 1: Ultimate load and Nature of failure of SET I beam

Beams weak in flexure (SET I beams)	Load at initial crack(KN)	Ultimate load (KN)	Nature of Failure
F1	30	76	Flexure failure
F2	36	105	GFRP rupture +Flexure – Shear failure
F3	Not visible	114	GFRP rupture +Flexure – Shear failure

Load and Deflections of specimens:

The use of GFRP sheet had effect in delaying the growth of crack formation. In SET I when both the wrapping schemes were considered it was found that the beam F3 with GFRP sheet up to the neutral axis along with the soffit had a better load deflection behaviour when compared to the beam F2 with GFRP sheet only at the soffit of the beam. The graphs comparing the mid-span deflection of flexure deficient beams and their corresponding control beams which is following,

Beam F1: At the load of 30 KN initial cracks started coming on the beams. Further with increase in loading propagation of the cracks took place. The beam F1 failed completely in flexure which is sshown in the figure.1.

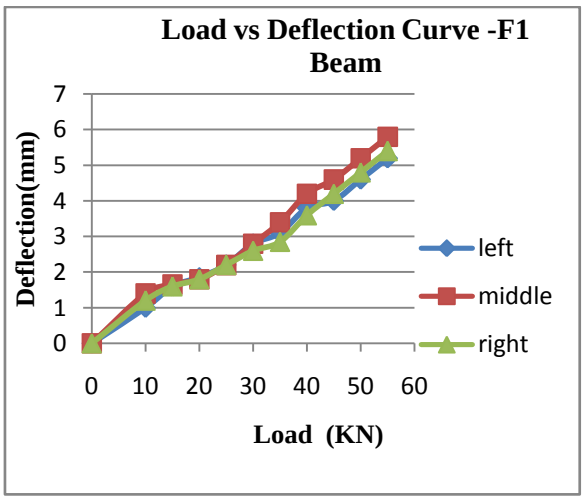

Figure1: Load Vs Deflection of Beam F15

Beam F2: Figure.2 shows at the load of 36 KN initial cracks started coming on the beams. Initial cracks started at a higher load in beam F2 compared to beam F1. Further with increase in loading propagation of the cracks took place. The beam F2 failed in flexural shear. Beam F2 carried a higher ultimate load compared to beam F1.

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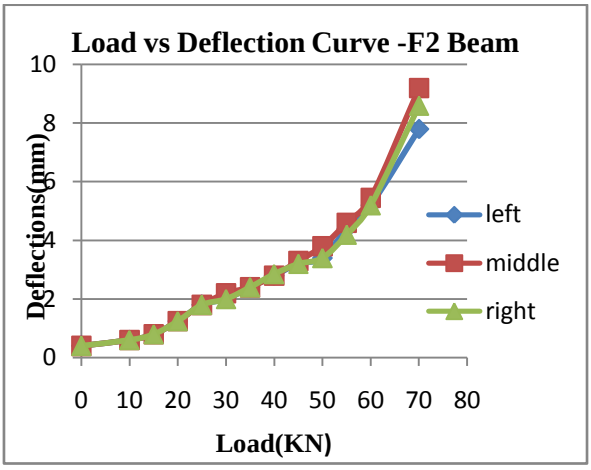

Figure 2 : Load Vs Deflection of Beam F2

Beam F3: Initial cracks are not visible on the beams. Further with increase in loading propagation of the cracks took place but it had poor visibility of cracks due to the covering of the GFRP sheet were shown in figure.3. The beam F3 also failed in flexural shear like beam F2 but beam F3 carried a higher ultimate load compared to both beam F1 and F2.

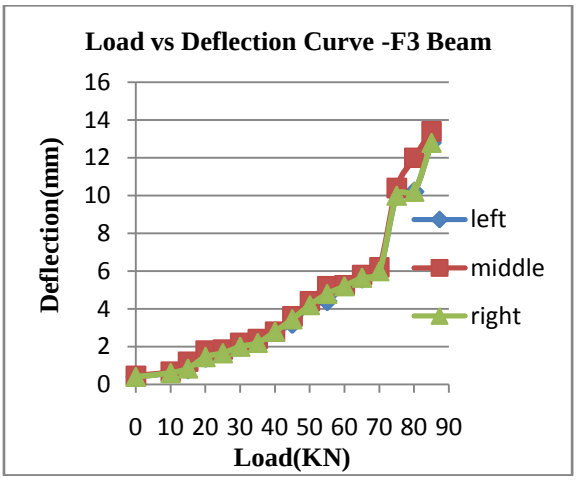

Figure 3 : Load Vs Deflection of Beam F3

From the load and deflection of data of SET I beam F1, F2 and F3, load vs. deflection curve is plotted for all the three beams were shown in figure.4. From this load vs. deflection curve, it is clear that beam F1 has lower ultimate load carrying capacity compared to beams F2 and F3. Beam F1 had also undergone higher deflection compared to beams F2 and F3 at the same load. Beam F2 had higher ultimate load carrying capacity compared to the controlled beam F1 but lower than beam F3. Beam F3 had higher ultimate load carrying capacity compared to the beams F1 and F2. Both the beams F2 and F3 had undergone almost same deflection up to 65 KN load. After 65 KN load beam F3 had undergone same deflection as beam F2 but at a higher load compared to beam F2. The deflection undergone by beam F3 is highest. Beam F2 had undergone higher deflection than beam F1.

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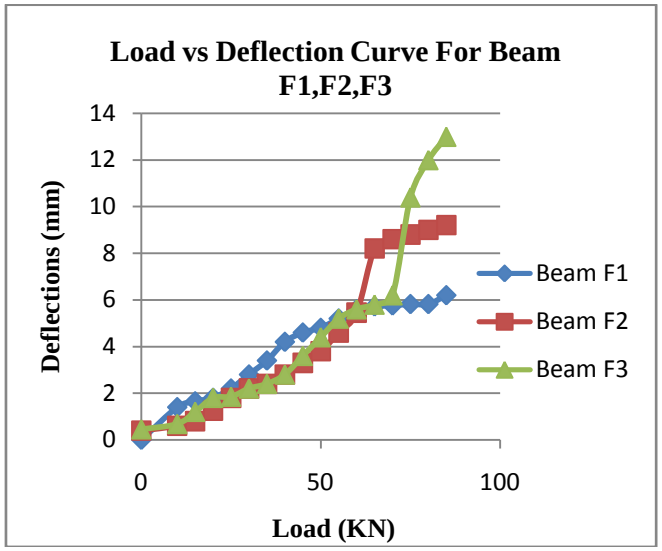

Figure 4: Load Vs Deflection of Beam F1,F2,F3

VI. CONCLUSION

In this paper, the experimental investigations the flexural behaviour of reinforced concrete beams strengthened by GFRP sheets are studied. In SET I, three beams were casted in weak in flexure. Initial flexural cracks appear at a higher load by strengthening the beam at soffit. The ultimate load carrying capacity of the strengthen beam F2 is 33 % more than the controlled beam F1. Load at initial cracks is further increased by strengthening the beam at the soffit as well as on the two sides of the beam up to the neutral axis from the soffit. The ultimate load carrying capacity of the strengthen beam F3 is 43 % more than the controlled beam F1 and 7 % more than the strengthen beam F2. Flexural strengthening up to the neutral axis of the beam increases the ultimate load carrying capacity.

REFERENCES

[1] Avinash Gornale, S Ibrahim Quadri, S MehmoodQuadri, Syed MdAkram Ali, Syed Shamsuddin Hussaini,**"**Strength Aspects of Glass Fibre Reinforced Concrete**"** International Journal of Scientific & Engineering Research, Volume 3, Issue no.7., 2012

[2] Deshmukh S.H., Bhusari J. P, Zende A. M.,**"**Effect of Glass Fibres on Ordinary Portland cement Concrete**"** IOSR Journal of Engineering, Vol. 2(6) pp: 1308-1312, 2012

[3] Kavita S Kene, Vikrant S Vairagade and Satish Sathawane,"Experimental Study on Behavior of Steel and Glass Fiber Reinforced Concrete Composites**"** Bonfring International Journal of Industrial Engineering and Management Science, Vol. 2, Issue no.4, pp.125-130,2012

[4] LiaqatA.Qureshi, Adeel Ahmed,"An Investigation On Strength Properties Of Glass Fiber Reinforced Concrete" International Journal of Engineering Research & Technology (IJERT), Vol. 2, Issue no. 4, pp.2567-2572, 2013

[5] Rathi. V.R.,Ghogare. A.V, Nawale. S.R.,**"**Experimental Study on Glass Fiber Reinforced Concrete Moderate Deep Beam" International Journal of Innovative Research in Science Engineering and Technology Vol. 3, Issue. 3, pp.10639-10645, 2014

[6] SrinivasaRao.P, Chandra Mouli K and Dr. T. SeshadriSekhar,**"**Durability studies on glass fiber reinforced concrete "Journal of civil engineering science : An International Journal, vol 1 no 1-2, pp.37-42, 2012