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An Experimental Study on Strengthening of Reinforced Concrete Beam using Glass Fiber Reinforced Polymer Composites

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Abstract

Objective: This work deals with the experimental investigation on the study the effect of glass fiber reinforced polymer composite sheets in RC beam. **Methods/Statistical analysis:** An experimental setup is placed the specimens on the loading frame for flexure and shear behavior of RC beams. **Findings:** Determining the load, deflection and failure mode of each beams and their results (beam F2, F3) are compared with controlled concrete beam (F1). The beam F2 has initial flexuralcracks appeared at higher load than beam F1. The ultimate load carrying capacity of beam F2 is 35%, which is higher than beam F1. **Applications/Improvements:** The beam with GFRP sheets up to neutral axis of beam, which is increasing the ultimate load carrying capacity.

Keywords: Epoxy Resin, Flexure, Glass Fiber Reinforced Polymer (GFRP), Two Point Static Loading System

1. Introduction

The glass fiber reinforced polymer composites are advantages in the strengthening done by reduction of magnitude of forces and maximizing the member's resistance[1,2,3,4]. The strengthening techniques are carried out by section enlargement, external bonded reinforcement, post-tensioning work, and supplemental supports. In this study external bonded reinforcement used to achieve improved strength and serviceability. The durability studies of the glass fiber reinforced polymers are carried out investigation on glass fiber reinforced concrete moderate deep beam[5,6]. Finally they reported, addition of glass fiber in moderate deep beam, it improved strength, shear stress and ductility at without using stirrups in deep beam. In this paper, strengthening of reinforced concrete beam is carried out by using glass fiber reinforced polymer composites[7]. The reinforced concrete beam in flexure, strengthened with different configuration and different layers of GFRP sheets. Finally the effect on strength and ductility of beam is obtained.

2. Material usage and its Properties

The materials used in the specimens for this study are

- 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)
- Concrete (Mix Proportion of M25 grade concrete used)

2.1 Reinforcement Materials (Glass Fibers)

Normally, fiber is a long filament with a diameter of 10 tm. The ratio of length to diameter is called as aspect ratio. It can be ranging from thousand to infinity. The fiberscan improve strength, thermal stability, stiffness, and carrying the excess load. Glass fiberscan also use asmats. It is made by long continuous and short fibers (e.g., fibers with discontinuous length between 25 to 60 mm) which is randomly arranged and bonded together. The width of mats is varying from 5 cm to 2 m, and its density is 0.5 kg/m^2.

2.2 Matrix Materials

The matrix materials used to bind the fibers with proper orientation and configurations, and also load transfer to the fiber. The matrix materials have mechanical properties such as strength, shear and compression.

2.2.1 Epoxy Resin

Epoxy resin is the structure of three member ring, which contains two carbons and one oxygen. The molecular weight of epoxy resin is very low for pre-polymers under various conditions.

3. Methods

The experimental study is carried out by two point loading system. In this report, three beams are tested for flexure. One for are with deflection of controlled concrete beam. Controlled beam and other two beams are casted and strengthend by applying GFRP on two beams in flexure mode. The strengthening of beam is done by different amount and different configurations of GFRP sheets provided. The application of ultimate load acting on the beam, the deflection and mode of failure each beam obtained. Finally the results are compared with deflection of controlled concrete beam.

The dimensions of all the specimens are denoted below and which is identically arranged. The cross sectional dimensions of the beams are 1500 × 250 × 250 mm. The two numbers of 12 mm diameter bars are provided for main longitudinal reinforcement and 6 mm diameter bars are provided for stirrups at a spacing of 80 mm centre to centre distance.

3.1 Test Procedure

The specimens were placed over the steel rollers in two point loading system. The bearing spacing at their ends is 150mm. The remaining length 1200mm is divided by three equal parts at each 400 mm. The load is applied by hydraulic jack at capacity 100 KN. Finally, the deflection is measured by dial gauges which fixed at three places just below the beam.

4. Results and Discussions

4.1 Failure of the Specimens

The beams were tested for finding their ultimate strength. In this study, the three beams were tested namely F1, F2, F3 at weak in flexure mode. The beam F1 was controlled beam. It carried lesser load than other two beams F2, F3. The beam F2 was strengthened at only so fit of the beam. Then beam F3 was strengthened up to neutral axis of the beam F3.

Three beams were tested and found out their ultimate load carrying capacity which is presented in Table 1. From the Table 1, it may be found that beam F1 was failed at earlier stage, the beam F2 was failed by the influence of flexural and shear failure; as a result GFRP sheets broke down by two pieces and the beam F3 was failed, when GFRP sheets were delaminated.

4.2 Load and Deflections of the Specimens

The GFRP sheets were used to delay the formation of cracks. As a result, the beam F3 with GFRP sheets provided upto neutral axis of the beam, which carried heavy load-deflection behaviour compared to the beam F2 with

Table 1. Nature of Failure and Ultimate Load of Beams (F1, F2, F3)

Beams tested in flexure mode	Initial cracking Load(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

GFRP sheet provided at only so fit of the beam. The graphs comparing the mid-span deflection of flexure deficient beams and their corresponding control beams follows:

4.2.1 Beam F1

The relationship between the load and deflection of beam F1 is shown in Figure 1. From the Figure 1, it was found that at the load of 30 KN, initial cracks was formed on beam F1, after increasing the load simultaneously, crack formation took place. Finally, the beam F1 failed in flexure.

4.2.2 Beam F2

The relationship between the load and the deflection of beam F2 is shown in Figure 2. At the load of 36 KN, initial cracks was formed on beam F2 and the initial cracks started on beam F2 at high load compared to beam F1. Further, as load increases, the beam F2 was failed in flexure-shear.

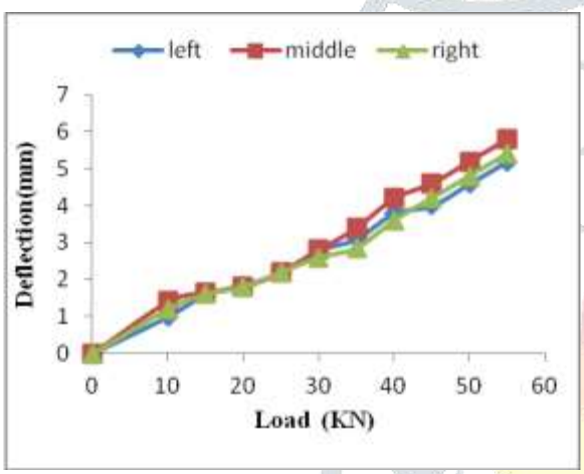

Figure 1. Relationship between load and deflection of beam F1.

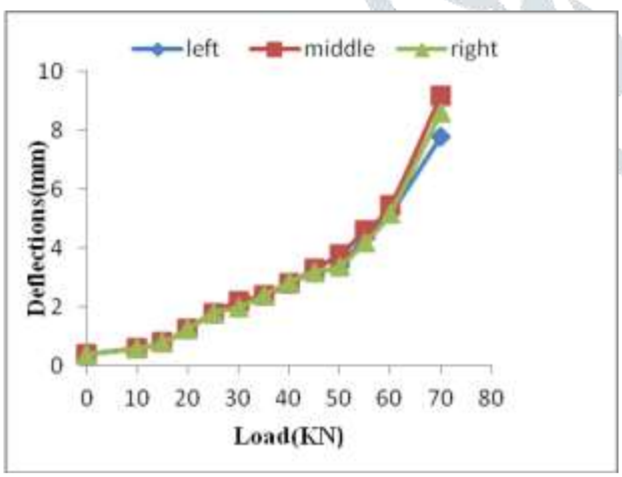

Figure 2. Relationship between load and deflection of beam F2.

4.2.3 Beam F3

The application of load acting on beam F3 and their deflection is shown in Figure 3. The initial cracks were not visible on beam F3. After increasing a load, crack took place with poor visibility, is due to GFRP sheets covered over beam F3. The beam F3 was also failed in flexure-shear, but it took place at higher ultimate load than beam F1 and F2.

4.2.4 Comparison of Load and Deflection ofBeam F1, F2, F3

The comparison of load and deflection observed on beams F1, F2, and F3 is shown in Figure 4. The beam F1 has lower ultimate load carrying capacity than F2, and F3. F1 has higher deflection than F2, and F3. The beam F2 has higher load carrying capacity than F1 but lower than F3. The beam F3 has higher load carrying capacity than F1, and F2. Further, it may observed that the deflection of beam F2, and F3 has same magnitude at a load of 65 KN. The beam F3 maintained the same deflection for an increasing load. The deflection of beam F3 and F2 is higher than beam F1.

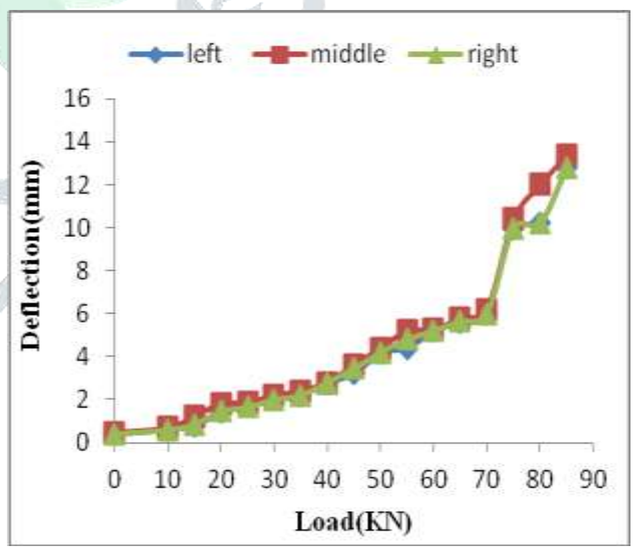

Figure 3. Relationship between load and deflection of beam F3.

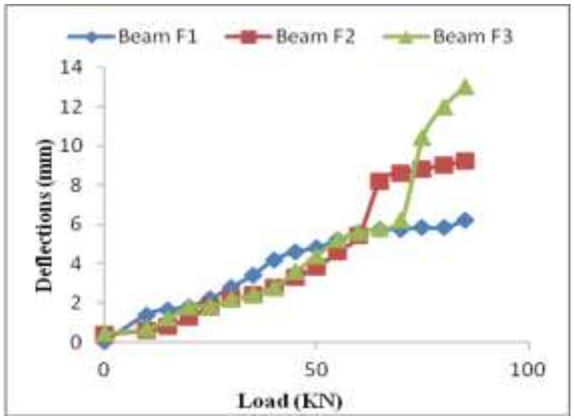

Figure 4. Relationship between load and deflection of beam F1, F2, F3.

5. Conclusions

In this study, the beam F2 has initial flexural cracks appeared at higher load than beam F1. The ultimate load carrying capacity of beam F2 is 35%, which was higher than beam F1. Further, for an increasing load, the beam F2 failed in flexure-shear. In beam F3, the ultimate load carrying capacity is found to be 45%, which is higher than beam F1 and 10% higher than beam F2. Finally, the strengthening of beam with GFRP sheets upto neutral axis of beam, leads to increase the ultimate load carrying capacity.

6. References

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