International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

Analysis Of Retrofitted Reinforced Concrete Shear Beams Using Carbon Fiber Composites

NAVEEN.K
PG Student, Department of Civil Engineering, PRIST University,
Thanjavur, Tamil Nadu, India.

ABSTRACT

Fiber Reinforced Polymer (FRP) is a relatively new class of composite material manufactured from fibers and resins and has proven efficient and economical for the development and repair of new and deteriorating structures in civil engineering. FRP composite materials possess superior mechanical properties. It includes impact resistance, strength, stiffness, flexibility and ability to carry loads. To meet up the requirements of advanced infrastructure, new innovative materials/ technologies in construction industry has started to make its way. Any technology or material has its limitations. To meet the new requirements, new technologies have to be invented and put to use. With structures becoming old and the increasing bar corrosion, old buildings have started to demand additional retrofits to increase their durability and life. Use of FRP for confinement has proved to be effective retrofitting and strengthening application.

INTRODUCTION

Strengthening of reinforced concrete (RC) structures using externally bonded Fibre reinforced polymer (FRP) composites is an effective method of improving the structural performance under both service and ultimate load conditions. It is a rather simple and economical approach to meet the increased load carrying capacity for a structure. The use of lay-up FRP composites under increased load conditions reveals a reduced deflection and smaller crack widths. Also, the use of composites offers several advantages like ease of bonding to curved or irregular surfaces, lightweight/ease of application and fibre flexibility to orient in a desired direction for strengthening. Furthermore, its high stiffness, high fatigue strength and good durability make it an excellent choice for infrastructure strengthening. Compared to traditional methods used for infrastructure strengthening that involve partial or complete shutting down of facilities, strengthening involving FRP laminates is less time consuming and does not involve large displacements of the resources.

Various RC structural elements such as beams, slabs and columns can be strengthened using externally bonded FRP sheets. In recent years several studies have been conducted to investigate the flexural strengthening of RC members. However, few have concentrated on shear strengthening. The importance of shear strengthening may be considered even more critical than that of flexural strengthening since shear failures occur without advance warning (i.e. sudden) and are more catastrophic compared to flexural failures that are generally progressive in nature and provide ample warning of failure.

FIBRE REINFORCED POLYMER COMPOSITE MATERIALS

FRP composite materials consist of fibres embedded in or bonded to a matrix with distinct interfaces between them. In this form, both fibres and matrix retain their physical and chemical identities, but they produce a combination of properties that cannot be achieved with either of the constituents acting alone. In general, fibres are the principal load carrying members, while the surrounding matrix keeps them in the desired location and orientation, acts as a load transfer medium between them, and protects them from environmental effects. Commercially, the principal fibres come in various types of glass and carbon as well as aramid. Other fibres, such as boron, silicate carbide and aluminium oxide, are in limited usage. All fibres can be incorporated into a matrix either in continuous lengths or in discontinuous (chopped) lengths. A polymer used as a matrix, is defined as a long chain molecule containing one or more repeating units of atoms, joined together by strong covalent bonds. Polymers are divided into two broad categories: thermoplastics and thermosets. Among the thermoset polymeric materials, epoxies and polyesters are widely used, mainly because of the ease of processing.

EXPERIMENTAL PROGRAMME

Numerous research works has been done on beams strengthened using FRP composites. However only few works have been done using CFRP composites. This project aims at studying the effectiveness of using CFRP(S) for strengthening of beams failing in shear. RC beams failing in shear were taken for study and they were rehabilitated using the following FRP composites using **hand lay-up** technique:

- Carbon Fibre Continuous Tow [CFRP(C)] Composite
- Carbon Fibre Scrap [CFRP(S)] Composite
- Glass Fibre [GFRP] Composite
- Hybrid combination of CFRP(C) and GFRP composite- [H-CF(C)-GFRP]
- Hybrid combination of CFRP(S) and GFRP composite- [H-CF(S)-GFRP]
- Hybrid combination of CFRP(C) and CFRP(S) composite- [H-CF(C)-CF(S)RP]

The FRP composites listed above were bonded to the sides and bottom of the RC beams in the form of U-wraps as discussed by **Zhicago Zhang, 2005** as shown in Figure (1).

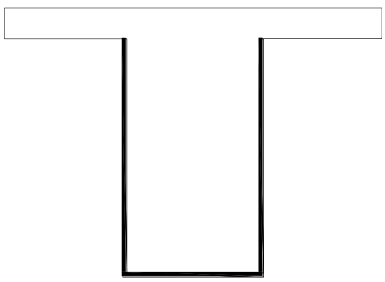


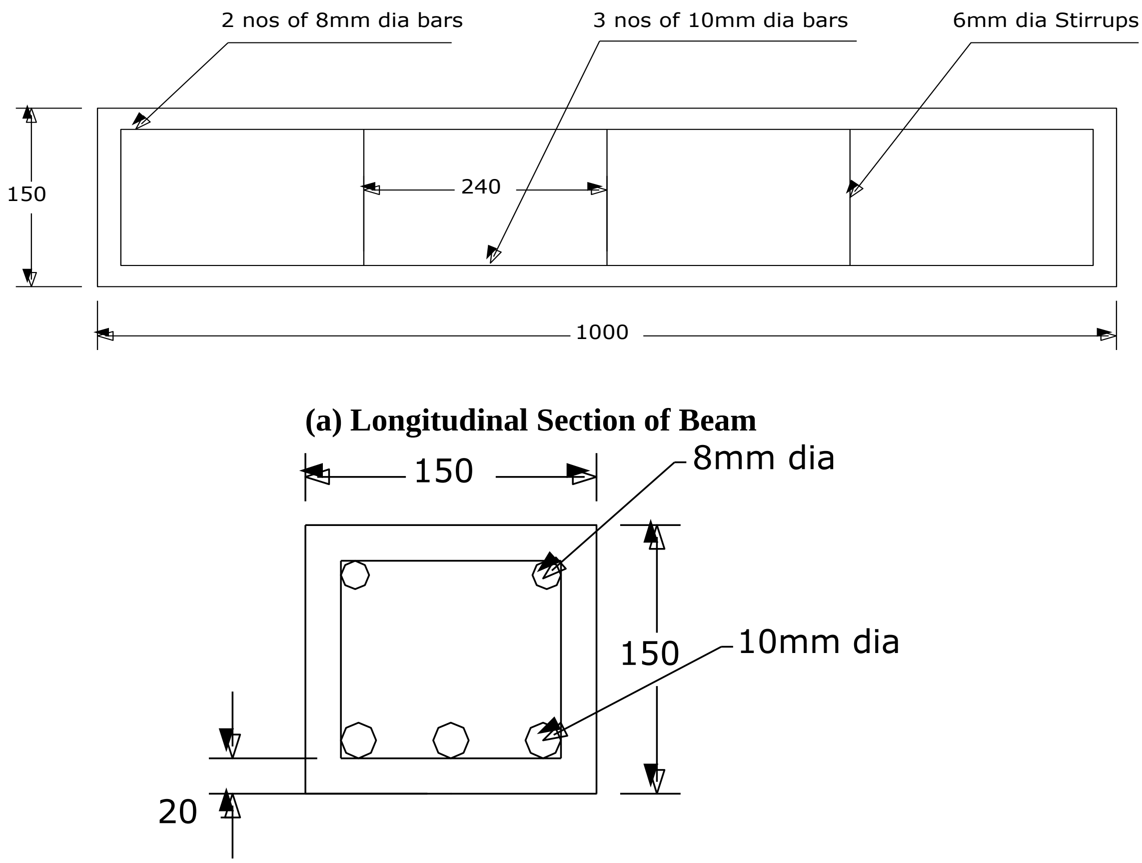
Figure (1) U-Wrap

Epoxy resin was used for bonding the fibres to the beams. The behaviour of CFRP(S) treated beams were compared with those of their control beams (beams tested to failure without

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

treatment) and those treated using other composites.

Fourteen beams of size 150 × 150 × 1000mm were taken for study as shown in figure (2). Two beams were used as control beams and twelve beams were rehabilitated using FRP composites. As per requirements 3 nos. of 10mmdia bars were provided on tension side. In order to hold the stirrups, 2nos. of 8mm diameter rods were provided on the compression side also. In order to introduce shear failure in the beams, the spacing of stirrups was increased to 250mm.



(a) Longitudinal Section of Beam

(b) Transverse Section of Beam

Figure (2) Reinforcement Details of Beam

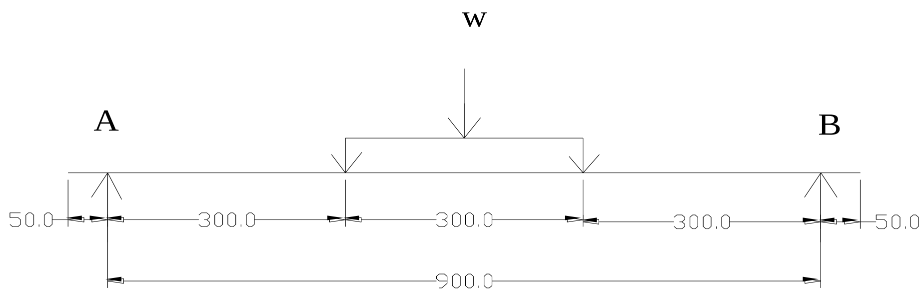
MATERIALS USED FOR CASTING BEAMS

- **Cement**: Ordinary Portland Cement (OPC)-53 grade was used for the investigation.
- **Fine Aggregate**: Sand passing through IS 4.75 mm sieve conforming to zone II as per IS standard specifications. Specific gravity of fine aggregate was 2.63
- **Coarse aggregate**: Crushed granite aggregate passing through IS 20mm sieve and retained on IS 10mm sieve were used. Specific gravity of coarse aggregate was 2.78
- **Steel**: Tor steel of Fe 415 grade was used as longitudinal reinforcement where as mild steel Fe 250 was used as transverse reinforcement.

- **Mix proportion**: The mix proportion of **1: 1.58: 3.46** with W/C ratio of **0.55** was used for casting of all the beams. The average compressive strength of concrete was found to be 29.11 N/mm^2.

TEST SETUP AND TESTING PROCEDURE FOR BEAM SPECIMENS

The RC beams were subjected to four-point loading over an effective span of 900 mm as shown in Figure (3). The loading frame of fifty tonnes capacity was used for the testing of beams. The deflectometer was fixed at the centre span of the beam. Initially the deflectometer reading was set to zero. The load was increased in the order of 0.1 tonnes. The deflection readings were noted accordingly. The beams to be rehabilitated were initially loaded to 75% of the ultimate load (**virgin beams**) and then subsequently rehabilitated using FRP composites. The control beams were taken as the reference beams and the various parameters were compared with those of the rehabilitated beams. Experimental setup for the beam is shown in Figure (4).



All dimensions are in mm

Figure (3) Experimental Setup of Beams

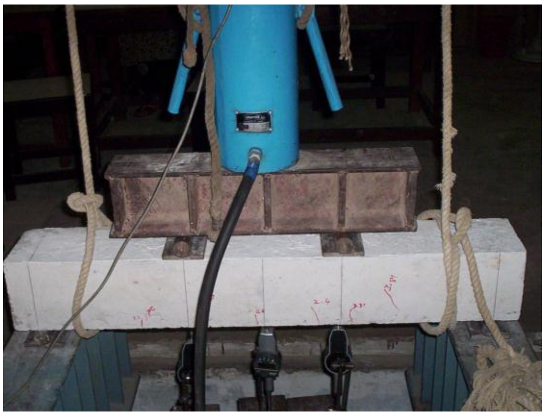


Figure (4) Experimental Arrangement for the Beams

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

RESULTS AND DISCUSSION

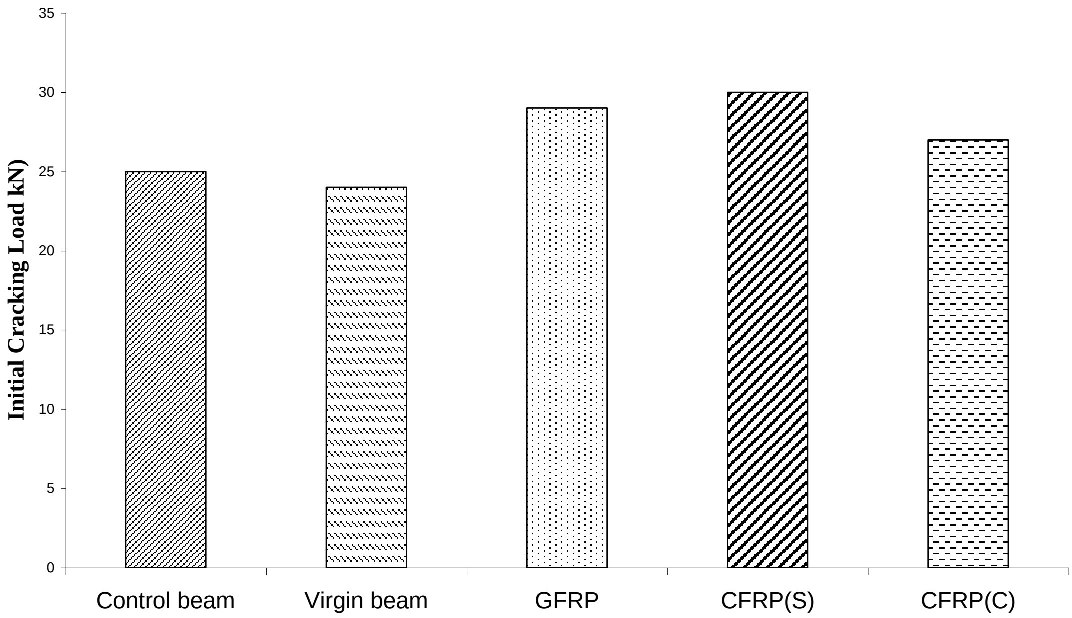


Figure (5.1) Initial Cracking Load for Control, Virgin and Beams Rehabilitated Using Monolithic FRP Composites

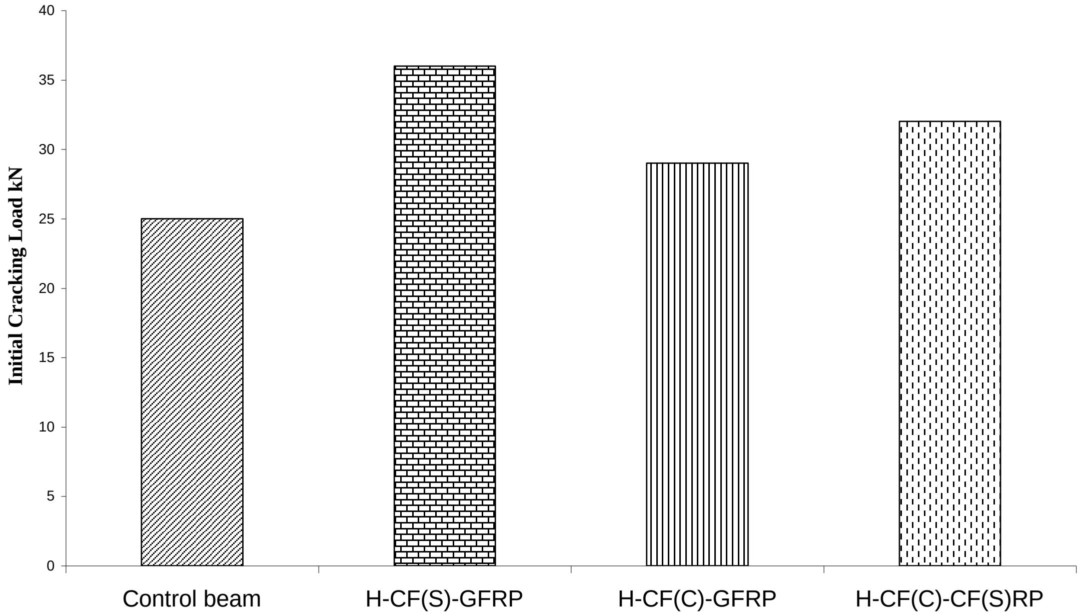


Figure (5.2) Initial Cracking Load for Control and Beams Rehabilitated Using Hybrid FRP Composites

International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

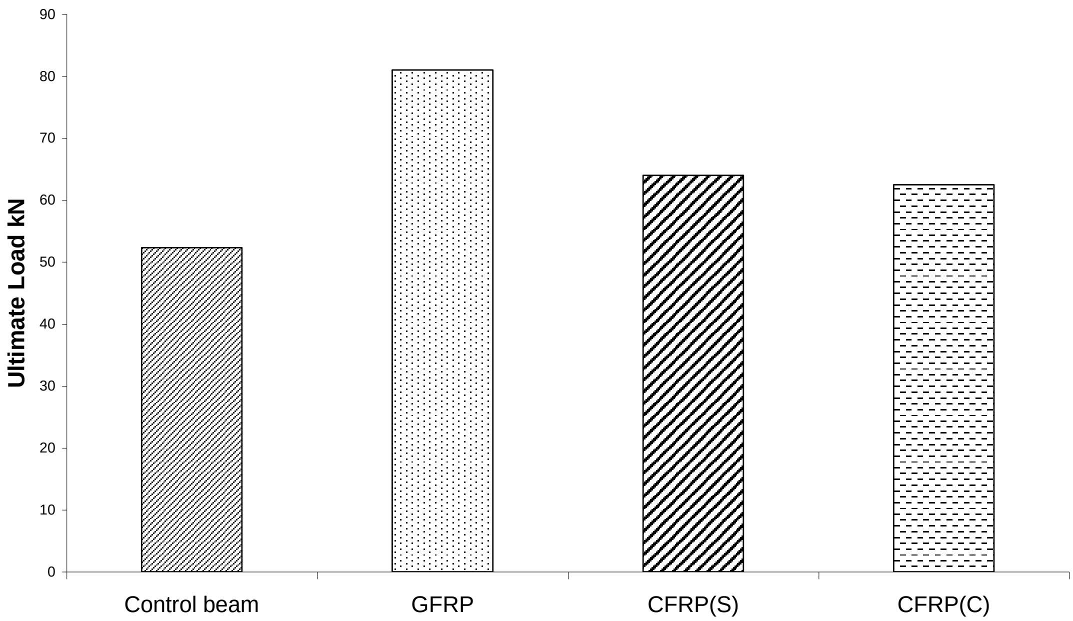


Figure (5.3) Ultimate Load for Control and Beams Rehabilitated Using Monolithic FRP Composites

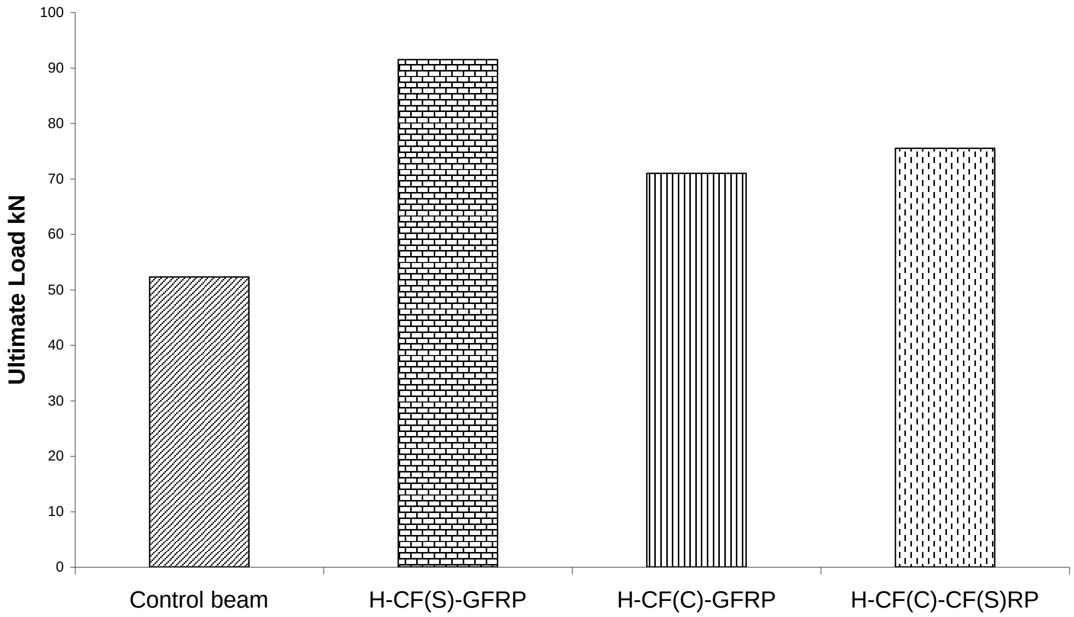


Figure (5.4) Ultimate Load for Control and Beams Rehabilitated Using Hybrid FRP Composites

CONCLUSION

- All the treated beams showed better performance when compared with control beams.
- In monolithic treated beams, GFRP treated beams showed enhanced initial and ultimate loads compared to other monolithic treated beams.
- CFRP(S) treated beams showed enhanced deflection ductility and energy absorption value

compared to other monolithic fibres treated beams.

- Stiffness at yield and ultimate loads for CFRP(C) treated beams showed an increase in value compared to other monolithic fibres treated beams.
- In hybrid treated beams, H-CF(S)-GFRP treated beams showed enhanced initial and ultimate loads compared to other hybrid treated beams.
- H-CF(S)-GFRP treated beams showed enhanced deflection ductility and energy absorption value compared to other hybrid fibres treated beams.
- Stiffness at yield load for H-CF(S)-GFRP treated beams showed decrease in value compared to other hybrid treated beams. Stiffness at ultimate loads for H-CF(S)-GFRP treated beams showed increase in value compared to other hybrid treated beams.
- Hence CFRP(S) could be effectively used both as monolithic as well as hybrid composites for treatment of beams failing in shear.

REFERENCES

1. Ahmed Khalifa, William J.Gold, Antonio Nanni and Abdel Aziz (1998) “Contribution of Externally Bonded FRP to Shear Capacity of RC Flexural Members” Journal of Composites for Construction, Vol. 2, No. 4, pp. 195-202.
2. Anders Carolin and Bjorn Täljsten (2005) “Experimental Study of Strengthening for Increased Shear Bearing Capacity” Journal of Composites for Construction, Vol. 9, No. 6, Dec., pp. 488-496.
3. Cao S.Y, Chen J.F., Teng J.G., Hao Z, Chen J.,(2005)“ Debonding in RC Beams Shear Strengthened with Complete FRP Wraps” Journal of Composites for Construction, Vol. 9, No.5, pp. 417-428.
4. Ghani Razaqpur A., Burkan O. Isgor, Greenaway S. and Alistair Selley (2004)” Concrete Contribution to the Shear Resistance of Fiber Reinforced Polymer Reinforced Concrete Members” Journal of Composites for Construction, Vol. 8, No. 5, pp. 452-460.
5. Guido Camata, Enrico Spacone, Riadh Al-Mahaidi and Victor Saouma (2004) “Analysis of Test Specimens for Cohesive Near-Bond Failure of Fiber-Reinforced Polymer-Plated Concrete” Journal of Composites for Construction, Vol. 8, No. 6, pp. 528-538.
6. Prodromos D. Zararis and George Ch. Papadakis (2001) “Diagonal Shear Failure and Size Effect in RC Beams without Web Reinforcement” Journal of Structural

Engineering, Vol. 127, No. 7, pp. 733-742.

7. Raghu A. (2000) "An assessment of In-situ Reinforced Concrete Joists" ASCE Structures Congress, Vol. 100, pp. 1-15.