

(A High Impact Factor, Monthly, Peer Reviewed Journal) Visit: <u>www.ijirset.com</u>

Vol. 8, Issue 5, May 2019

Retrofitting of Flexural Member using GFRP 300

Rohit Kumar¹, Shubham Anand², Suraj Gundeti³, Shubham Jathar⁴, Nilesh Baglekar⁵

B. E Student, Department of Civil Engineering, MITAOE, Pune, Maharashtra, India. 1,2,3,4

Assistant Professor, Department of Civil Engineering, MITAOE, Pune, Maharashtra, India⁵

ABSTRACT: The stock of existing road bridges in India exhibit insufficient performance, both in terms of structural safety and functionality. The infrastructure simply doesn't fulfil the demands of the common public. The infrastructure development is also taking at a breathtakingly slow pace. This makes it important for the structural engineers to look for new ideas for fast and smooth recovery of the old structural members. A review of the available literature has disclosed that there are numbers of retrofitting methodologies available. Among them, an efficient and effective method of repairing damaged structures in the applications of Fibre Reinforced Polymer (FRP) Concrete. The report presents the result of experimental investigation of material properties of GFRP sheet with epoxy laminates and its response to various loads, bonding behaviour on the retrofitted concrete RCC beams due to flexural loading. The result indicates that the GFRP can be used for retrofitting works and loss in strength of the structural members can be regained even up to more than 100%.

KEYWORDS: Flexural, Bond stress, Strengthening, GFRP sheet, Retrofitting.

I. INTRODUCTION

In India, the growing number of deteriorated concrete bridge decks has highlighted the need for research on new highperformance construction material for the rehabilitation of transportation infrastructure. The growing number of traffic demands has put a strain on the traffic condition of the metros of the country as there is poor infrastructure that hardly meets the demands of the common people. And the existing infrastructure is too old to be replaced without causing upheaval in the public order. To solve this problem, there is a growing interest to strengthen the old structural entities like the bridge decks or any flexural member. In this context, the use of GFRP has proven to impart strength to the structural members. Fibre reinforced polymer decks have a great potential in refurbishment and replacement of concrete and steel girders in existing bridges. The project is based on analysing the flexural members by four-point load test for newly constructed flexural members and in the damaged flexural members and comparing the results between the use of GFRP and without the use of GFRP.

PROBLEM STATEMENT

In India, the growing number of deteriorated concrete bridge decks has highlighted the need for research on new highperformance construction material for the rehabilitation of transportation infrastructures. The relatively oldage of most existing bridges and the increasing traffic demands have also risen the needs for upgrading methods with a focus on minimizing traffic disruption. Fibre reinforced polymer decks have a great potential in refurbishment and replacement of concrete and steel girders in existing bridges. These decks/girders offer superior properties such as high strength and stiffness-to-weight-ratio, superior fatigue and corrosion resistance and enhanced durability.

OBJECTIVES

- To study the feasibility of using GFRP 300 as a retrofit or construction material for flexure member (in strength aspect).
- To know the material property (GFRP) and strength of the material.
- To prepare a comparative analysis of flexural member with GFRP300 and without GFRP300.



(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: <u>www.ijirset.com</u>

Vol. 8, Issue 5, May 2019

II. RELATED WORK

MATERIAL PROPERTIES OF GFRP.

Tensile Test on GFRP sheet.

The maximum stress that a material can withstand while being stretched or pulled before failing or breaking is its tensile strength. The epoxy resin laminated glass Fibre reinforced polymer sheet was cut into the required dimension using a cutter. The tensile test was carried out on a universal testing machine. The test specimens were prepared having thickness is 0.016mm, their gauge length is 0.09m and width is 0.03m as shown in fig. No 1. The specimen was tested in UTM and the setup as shown in fig. no. 2. They were tested under the ultimate load of failure and failure of the specimen is shown in fig. no. 3. The four specimens were subjected to tensile test and their values were recorded as shown in Table no. 1 and comparative results of samples are represented graphically in fig. no. 4.



Fig -1:Specimen Details







Fig - 3: Failure of Specimen

Sr. No.	Sample	Gauge Length(m)	Width(m)	Thickness(m)	Peak load (KN)	Tensile Strength (MPa)
1	Sample 1	0.09	0.03	0.016	7.352	15.316
2	Sample 2	0.09	0.03	0.016	7.016	14.616
3	Sample 3	0.09	0.03	0.016	7.276	15.158
4	Sample 4	0.09	0.03	0.016	6.792	14.15

Table -1: Tensile Test Observation



Fig - 4: Comparison between samples.

Bond Shear Strength Between Concrete and Laminated GFRP Sheet.

Epoxy resin laminated GFRP sheets are being successfully used for strengthening of existing RCC and prestressed concrete (PC) structures. It is the means for the transfer of stresses between concrete and epoxy resin laminated GFRP



Failure surface

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 5, May 2019

sheets in order to develop composite action. Three specimens are prepared for testing, each specimen consisted of three cubes of 150mm X 150 mm and joined together through epoxy resin laminated sheet. The specimen prepared for double shear failure is tested on UTM and load is applied on the top surface of the middle cube (C2) as shown in fig. no.5. Fig. no. 6 shows the failure of the bond between the concrete surface and epoxy laminated GFRP sheet. These specimens were subjected to load and their values were recorded as shown Table no. 2 and comparative results of different sample is represented graphically in fig. no.7.



Fig - 5: Specimen Setup for double shear failure.



Fig - 6: Failure Specimen

Table – 2: Bond Shear Strength Test Observations. Shear Sr. No. Sample Area(mm^2) Peak load (N) Bond Strength (MPa) 1 Sample 1 45000 17724 0.393 2 Sample 2 45000 18276 0.406 3 Sample 3 45000 17013 0.378

Bond Strength (MPa) 0.41 0.405 (edW) 0.395 STRENDTH 0.39 0.385 0.38 0.375 BOND 0.37 0.365 0.36 Sample 1 Sample 2 Sample 3 SAMPLE

Fig - 7: Comparison Between Samples.

ANALYSIS OF FLEXURAL MEMBER.

Flexural Test & Shear Test on Beams.

Flexural test & shear test on RCC beam is conducted using four-point load test. The configuration of the four-point load test is shown in Fig No 8. For achieving a pure bending four-point test were performed. Twelve RCC beams were cast having the size of 700 X 150 X150 mm & grade of concrete is M30. Out of which six beams are designed to be weak in shear and other six beams are designed to be weak in flexure. These beams are tested for flexural and shear loading with and without retrofitting with GFRP.



(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: <u>www.ijirset.com</u>

Vol. 8, Issue 5, May 2019

Four-Point Load.

Four-point test load is conducted on Universal Testing Machine. The sample is placed on two supporting pins which are a set distance apart and two loading pins placed at an equal distance from the centre. These two loadings are lowered from above at a constant rate until the sample fails. Four-point load test setup is as shown in fig. No. 8.



Fig 8: Four-Point Load Test Setup.

RCC Beam for Retrofitting.

This study presented the result of the experimental investigation of GFRP strengthened concrete RCC beams due to flexural loading. For this purpose, 12 RC beams were cast in two groups, each group containing 6 beams. The specimens of the first group were designed to be weak in flexure and strong in shear, whereas specimens of the second group were designed just in an opposite manner i.e., the beams were designed to fail in shear and remain strong in flexure.

Test for Shear.

In each group, out of the six beams, two beams were taken as a control specimen which is tested for ultimate load at failure. Other two beams were damage under 75% of ultimate load and the remaining two beams were damage under 90% of the ultimate load for both groups. Then, the weakened specimens were retrofitted using GFRP strips which were wrapped in the perpendicular direction of the failure plane (i.e., the developed cracks at 45°). These samples were tested on UTM by four-point load test as shown in fig. no. 9. The result of damage beams and retrofitted beams were compared.



Fig 9: Four Point Load Test on Retrofitted Beam with GFRP in Shear Failure.



(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: <u>www.ijirset.com</u>

Vol. 8, Issue 5, May 2019

Table -3: Observations for Retrofitting up to 75% of Damaged RCC Beams in Shear Failure.

		Ultimate	Load without GFRP	Load After
Sr. No.	Sample	Load	(75% of UL)	Retrofitting
1	Sample 1	53.964 KN	40.268 KN	41.948 KN
2	Sample 2	53.964	41.948 KN	62.984 KN

Table -4: Observations for Retrofitting up to 90% of Damaged RCC Beams in Shear Failure.

			Load without GFRP	Load After
Sr. No.	Sample	Ultimate Load	(90% of UL)	Retrofitting
1	Sample 1	53.964 KN	48.58 KN	62.096 KN
2	Sample 2	53.964	48.576 KN	48.836 KN

Test for Bending.

In each group, out of the six beams, one beam was taken as a control specimen which is tested for ultimate load at failure. Other two beams were damage under 60% of ultimate load and the remaining three beams were damage under 90% of the ultimate load for both groups. Then, the weakened specimens were retrofitted using GFRP strips which were wrapped in U-shape. These samples were tested on UTM by four-point load test as shown in fig. no 10. The result of damage beams and retrofitted beams were compared.



Fig 10: Four Point Load Test on Retrofitted Beam with GFRP in Bending Failure.

 Table -5: Observations for Retrofitting of 60% of Damaged RCC Beams in Bending Failure.

		Ultimate	Load without GFRP (60%	Load After
Sr. No.	Sample	Load	of UL)	Retrofitting
1	Sample 1	60.288 KN	37.124 KN	76.084 KN
2	Sample 2	60.288 KN	37.676 KN	74.756 KN

Table -6: Observations for Retrofitting of 90% of Damaged RCC Beams in Bending Failure.

		Ultimate	Load without GFRP (90%	Load After
Sr. No.	Sample	Load	of UL)	Retrofitting
1	Sample 1	60.288 KN	53.108 KN	82.396 KN
2	Sample 2	60.288 KN	53.124 KN	67.804 KN
3	Sample 3	60.288 KN	53.172 KN	80.460 KN



(A High Impact Factor, Monthly, Peer Reviewed Journal) Visit: <u>www.ijirset.com</u> Vol. 8, Issue 5, May 2019

COMPARATIVE RESULT OF RETROFITTING RCC BEAM



Fig. 11: Comparative results of retrofitting RCC beam.

III. EXPERIMENTAL RESULTS

- Average tensile strength of the epoxy-laminated GFRP sheet was found to be 14.81 MPa from table no.1.
- The bond strength between concrete and epoxy-laminated GFRP sheet in double shear was found to be 0.392 MPa from table no.2.
- In shear, regain in the strength of the retrofitted beam was observed to be 9.53% at 75% damage of the ultimate load. Similarly, at 90% damage of the ultimate load, the regain in strength was observed to be 2.79% from table no. 3 and table no. 4.
- In bending, the regain in the strength of the retrofitted beam was observe to be 25.224% at 60% damage of the ultimate load. Similarly, at 90% damage of the ultimate load, the regain in strength was observed to be 27.66% from table no.5 and table no. 6.

IV. CONCLUSION

- As expected, an increase in the strength was achieved in both shears and bending when GFRP was used for retrofitting of the flexural member.
- It was found that GFRP can be used for retrofitting works and loss in strength of the structural members can be regained even up to more than 100% as shown graphically in fig. no. 11.

REFERENCES

- [1]. Claudio Modena, Giovanni Tecchio, Carlo Pellegrino "Retrofitting and Refurbishment of Existing Road Bridges.", Dept of Civil, Environment, Agricultural Engineering, University of Padova, Italy, vol.- 4.2 June 2012
- [2]. Hayes, M. D Ohanehi, D. Lesko, J. J Cousins, T. E., and Witcher "Performance of tube and plate Fiberglass composite bridge deck," Journal of Composites for Construction, ASCE, vol.- 4(2), pp- 48-55, May 2000.
- [3]. Hoa, S. V., Xie, M AND Xio, "Repair of steel reinforced concrete with carbon/epoxy composites," Advanced Composite Materials in Bridges and Structures, pp -573-580, 1996,



(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: <u>www.ijirset.com</u>

Vol. 8, Issue 5, May 2019

- Johansen, G. E. Wilson, R. J. Roll, F Gaudini, "Design and construction of long span FRP pedestrian bridges" Building to Last Structures Congress – Proceedings, ASCE, pp-46-50,1997,
- [5]. NANNI, "Concrete repair with externally bonded FRP reinforcement," Concrete International, vol.- 17(6), pp -22-26,1995.
- [6]. Rudy Djamaluddin, Mufti Amir Sultan, Rita Irmawati, and Hino Shinichi. Jacsit" Bond Characteristics of GFRP Sheet on Strengthened Concrete Beams due to Flexural Loading" International Journal of Engineering and Technology, Vol.-7(2), April 2015.
- [7]. T.P. Meikandaan "The study of Glass Fiber Reinforced Polymer (GFRP) flats under flexural behavior in reinforced concrete beams" Vol. 1(3), February 2017.
- [8]. Sachin Raveendran, Dr.Sreemahadevan Pillai "Experimental Evaluation of the strength of Damaged RCC Beam Repaired using Steel Mesh at 45° and Modified mortar" International Research Journal of Engineering and Technology (IRJET) Vol. 5 Issue: 6, June-2018.
- [9]. Alaa M. Morsy, El-Tony M. El-Tony, Mohamed El-Naggar," Flexural repair/strengthening of pre-damaged R.C. beams using embedded CFRP rods" Vol. - 54, pp - 1175-1179, 2015.
- [10]. T.P.Meikandaan, Dr.A.Ramachandra Murthy "Flexural Behaviour of RC Beam Wrapped with GFRP sheets" International Journal of Civil Engineering And Technology ,vol. 8,pp 452-469,2017
- [11]. Mehmet Mustafa Onal , "Strengthening Reinforced Concrete Beams with CFRP and GFRP"Hindawi Publishing Corporation Advances in Materials Science and Engineering ,Article ID 967964,Volume 2014.
- [12]. Narayan Tiadi, B. S. Tyagi, Siddharth Jain,"Retrofitting of RC Continuous Beam with Glass FRP Sheet"International Research Journal of Engineering and Technology (IRJET), vol. 5 Issue 5, pp - 3563,2018.