FLEXURAL RETROFITTING OF RCC BEAM USING BFRP

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Abstract - *This work deals with the experimental study of RCC beams retrofitted with Basalt Fiber Reinforced Polymer (BFRP). 5 RCC beams were casted. The dimension of the beam is 1200 X 200 X 150 mm. In these two beams were taken as the control beam. The ultimate load of the controlled beam is taken. The other beams were weakened by applying 65% of the ultimate load of the control beam. Then these weakened beams are retrofitted with BFRP. The wrapping of the beam is done in the multiple layer. The load given as One Point load. Load deflection behavior, first crack load, ultimate load, failure mode and crack pattern were analyzed. The results indicated that BFRP wraps improved the ultimate load carrying of the member and then restored the stiffness of the member.*

***Key Words*: Retrofitting, BFRP, Epoxy resin, wrapping, Preloading**

1. INTRODUCTION

Retrofitting is the technique of bringing back the original strength and stiffness back to the member. This method is applicable for both horizontal and vertical members in the structures. The deterioration of the structures is caused due to reduction in durability which is caused by poor selection of the materials and improper design. Accidents like fire and natural calamities like storm, cyclone and earthquake also reduce the strength of the structure.

In recent years, retrofitting by bonding of fiber reinforced polymer (FRP) fabrics, plates or sheets on the concrete surface has become very popular. The wide acceptance of FRP is due to its inherent advantages like it has high strength to-weight ratio, high tensile strength, good fatigue resistance, corrosion resistance characteristics, less labour and equipment required for installation, ease in handling, higher ultimate strength, lower density than steel. In this paper RCC Beams were retrofitted using BFRP. Usually beams are retrofitted for enhancing shear capacity, flexural strength, torsional resistance. FRP's are wrapped on the available surface of the beam to enhance required strength. Practically only three sides of the beam are available for wrapping since the fourth side is constructed monolithic with the slab and it is inside the slab. There i specific wrapping pattern for enhancing flexure, shear and torsional capacity of beams. In this paper retrofitting was done to enhance the total load carrying capacity of the beam

2. MATERIALS

The concrete used for casting the beams is M20 grade. The materials used includes cement, fine aggregate, coarse aggregate, Epoxy Resin, Hardener and Basalt Fiber Reinforced Polymer. The materials used are of good quality.

Tests for cement and aggregates were taken and then these materials were used

2.1. CEMENT

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. The cement used is the ordinary Portland cement of grade 53 conforming to IS 12269-1987. The grade of concrete used is M20

2.2 FINE AGGREGATE

Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and Fine aggregate density strongly influence the hardened properties of the concrete. The size of the fine aggregate ranges from 4.75mm to 75 Micron. Fine aggregate used for concrete varies in four zone from zone I to zone IV according to IS 383-2016. The sand used is river sand.

2.3. COARSE AGGREGATE

Coarse aggregate is the natural material which is obtained from the rock. They are the essential component in the concrete. The size of the coarse aggregate greatly varies from 4.75 mm to 50 mm. The size of the aggregate normally used for concreting is 20 mm. The coarse aggregate used was crushed Angular aggregate

2.4. REINFORCEMENT

Reinforcement is one in which steel is embedded into the concrete structure to resist forces and to add strength to the member. Generally concrete is strong in compression and weak in tension because concrete is brittle material. In order to take over the tension in the concrete steel is introduced into the concrete .in this beam. It was found that the bars had average yield strength of 390 N/mm2. Thus use of the bar specimen as reinforcement was safe. Fe 415, 12 mm diameter bars were used for the longitudinal reinforcement

@ 100 mm spacing and 8mm diameter bars for stirrups and it is placed @ 200 mm spacing.

2.5. EPOXY RESIN

It is the medium which is used to improve the binding property of FRP and concrete to improve the strength and stiffness of the member. High adhesive strength and mechanical property can also be enhanced by using the high electrical insulation and good chemical resistance. The resin and hardener used here are Araldite LY 564 is a low-viscosity epoxy resin. Hardener HY 560 is based on polyamines in the` proportion of 10:1.

2.6. PROPRETIES OF BFRP

Table -1: PROPERTIES

Properties	BFRP
Monofilament diameter(m)	15
Chopped length	18
Density	2650
Young's modulus	93-110
Tensile strength	4150-4800
Ultimate elongation	3.1

3. BEAM DESIGNATION

Totally 5 beams were casted. All the beams are of the same size 1200 X 200 X 150 mm. The beams which are subjected to ultimate load (Full load) are taken as the control beam. They were named as CB-01 and CB-02. For the remaining beams after the application of the load epoxy resin coating is given along with the wrapping of the BFRP sheets. The beam which is provided with single layer of wrapping is designated as BFRP – 01. The beam is which is wrapped with two layers of BFRP sheets is named as BFRP – 02 and the beam with three layers of BFRP sheets is named as BFRP – 03

4. EXPERIMENTAL SETUP

Two beams where taken as the control beam. The load applied to the beam is single point load. One of two control beams are allowed to take over the ultimate load. The load is applied on to the control beam with the help of UTM of capacity 750kN. The load at which the first crack occur is noted down and the ultimate load of the beam is also noted down. Then for the remaining beams preloading i.e. 65% of the ultimate load of the control beam is applied. The beam is weakened. Then epoxy resin along with the hardener is applied on to the surface of the beam at the ratio of 10:1. Then BFRP sheets were wrapped on to the beam on single layer, double layer and triple layer basis. Then this beam is subjected to loading. The ultimate load is noted down and the results were tabulated for further uses.

5. RETROFITTING OF RCC BEAM

After the application of the desired load, the surface of the beam for applying the epoxy resin is prepared. All the loose particles in the beam are removed with the help of sand paper. Then it is cleaned with waste clothes to remove all dirt and dust particles present in it. Then the epoxy resin (Araldite LY 564) and the hardener (Hardener HY 560) is mixed carefully and thoroughly in the ratio of 10:1 respectively. Then this mix is applied on the concrete surface. Then BFRP sheet is placed on this epoxy coat on the basis of single, double and triple layer and bonding is ensured by rolling a roller on the upper surface of the BFRP sheets. The work was carried out under room temperature

6. RESULT

The ultimate load and the first crack occurrence for the control beam and the BFRP wrapped beams are noted down. It is found that the both the control beams provided the same value for both ultimate load and the first crack load. The Basalt Fiber Reinforced polymer (BFRP) wrapped beams showed an increasing value in the first crack load and in the ultimate load.

Table- 2: First crack occurrence load and ultimate load

Description	Occurrence of first crack (KN)	Mean	Percentage increase	65% of ultimate load	Ultimate load (KN)	Mean	Percentage increase
CB-01	5.5	5.5	-	-	26	26	-
CB-02	5.5		-	-	26		-
BFRP-01	6	6	9.09	16.9	29.5	29.5	13.46
BFRP-02	7.5	7.5	36.36	16.9	32.5	32.5	25
BFRP-03	8.0	8.0	45.45	16.9	36.5	36.5	40.38

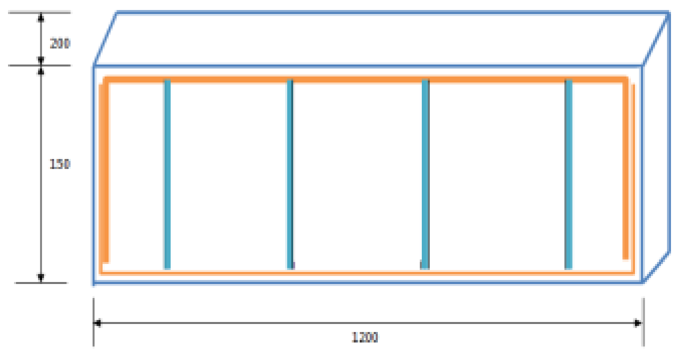

Fig -1: Table for first crack load and ultimate load

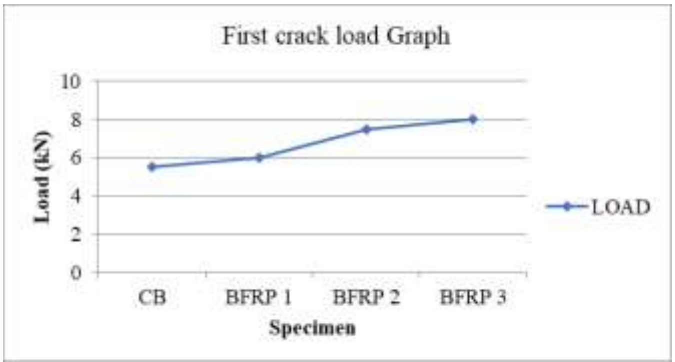

Fig -2: First crack occurrence graph

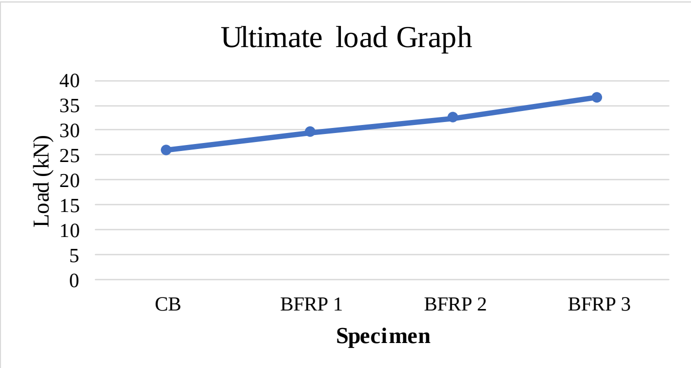

Fig -3: Ultimate load graph

7. CONCLUSIONS

1. The ultimate load and the crack occurrence load for control beam and for the BFRP wrapped beams where clearly examined and studied in this study. The crack pattern of the various beams is also studied in this study

2. Singly wrapped BFRP beam showed an increasing value in the occurrence of first crack and in the ultimate load when compared with the values of the control beam. The percentage increase in the values is found to be about 9.09% and 13.46% respectively.

3. Doubly wrapped BFRP beam showed an alarming rise in the value of ultimate load and the first crack load when it is compared with the control beam. The value is found to increase by 36.36% for first crack and 25% for ultimate load than the results of the control beam. This indicates the increase in the strength and the stiffness of the member

4. Triply wrapped BFRP beam showed an increased value in ultimate load and the first crack occurrence load when compared with the control beams. The percentage increase in the values is found to be about 45.45% for first crack and 40.38% for ultimate load when it is compared with the control beams

REFERENCES

[1] Jasmin S.P., Retrofitting of RCC Beams Weak in Shear with BFRP Wraps" International Journal of Engineering Science Invention (IJESI), vol. 07, no. 04, 2018, pp 81-8

[2] P. Bhuvaneshwari., Strengthening of Shear Deficient Reinforced Concrete Beams Retrofitted with Cement-based Composites "Jordan Journal of Civil Engineering, Volume 9, No. 1, 2015

[3] Rushikumar D Patel., Nikhil L Landage2., Retrofitting of Simply Supported Beam by BFRP and AFRP Wrapping "International Advanced Research Journal in Science, Engineering and Technology Vol. 6, Issue 8, August 2019

[4] P. Polu Raju., Experimental Evaluation of Retrofitted Concrete Beams Using CFRP and GFRP "International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 04, No 06 SPL, October 2011, pp. 812-818

[5] Hee Sun Kim, Yeong Soo Shin, Flexural Behavior Of Reinforced Concrete (RC) Beams Retrofitted With Hybrid Fiber Reinforced Polymers (Fraps) Under Sustaining Loads, Composite Structures, 93, 2011, 802-811

[6] IS 456-2000, Code of Practice For Plain And Reinforced Concrete, Indian Standards Institutions

[7] IS 10262-2009, Guidelines For Concrete Mix Design Proportioning, Bureau Of Indian Standards