Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 5, May -2017

STRENGTHNING OF REINFORCED CONCRETE ELEMENT USING GFRP AND REFOR-TEC

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ABSTRACT: *In the last two decades there were very frequent cases of occurrence of earthquake. Which causes the moderate/severe damage to the reinforced concrete structure repair and rehabilitating is a process whereby an existing structure is enhanced to increase the probability that the structure will survive for a long period of time and also against earthquake forces. This can be accomplished through the addition of new structural elements, the strengthening of existing structural elements and/or the addition of base isolators in this study an experimental study is carried out to investigate the performance of structure element after the damage and increase the structure element capacity using the two kind of material and find the optimum results.*

Keywords*: Strengthening, Glass fiber, one layer – two layer, Refor-tec with varying layers (UHPFRCC)*

I. INTRODUCTION

A Structure repair and rehabilitating is a process whereby an existing structure is enhanced to increase the probability that the structure will survive for a long period of time and also against earthquake forces. This can be accomplished through the addition of new structural elements, the strengthening of existing structural elements and/or the addition of base isolators. Deterioration of concrete and corrosion of embedded reinforcement structure might make the R.C.C structure structurally deficient. Corrosion can be controlled to some extent by fixing of chloride or protective coating.

Additional strength may be needed to allow for higher loads to be placed on the structure. This is often required when the use of the structure changes and a higher load carrying capacity is needed. This can also occur if additional mechanical equipment filing systems, planters, or other items is being added to a structure. The majority of structural strengthening involves improving the ability of the structural element to safely resist one or more internal forces caused by loading: flexure, shear, and torsion. Typical strengthening techniques such as section enlargement, externally bonded reinforcement post-tensioning, and supplemental supports may be used to achieve improved strength and serviceability.

Development of different techniques became very necessary in order to find the optimum behaviour for the strengthening cementations composite material. These advanced techniques include metallic grid reinforced surface coatings; shortcrete overlay and externally bonded fiber reinforced polymers (FRP), ultra-high fiber reinforced concrete (UHFRC) and ultra-high performance fiber reinforced cementations composites (UHPFRCC).

The purpose of this research is to investigate the flexural and behavior of reinforced concrete beams strengthened with varying configuration and layers of GFRP sheets and Refor-tec layers.

II. AIM OF RESEARCH

This study aims to develop and execute novel technique over existing technique for strengthening of RC Structure.

To know the performance and strengthening of the retrofitted beam used glass and jacketing of beam.

After knowing the advantages and disadvantages of existing technique we will used the UHPFRCC investigate the performance of the column and shear wall.

III. EXPERIMENTAL PROGRAM

1: Test Specimen

Notations for RC Beams, dimensional details and number of wraps considered are presented in Table 1. GFRP and Refortec was used to confine the beam specimens. Fig. 1 shows the cross-sections and dimensions of the beam specimens tested. [1]

Table:1 specification of the beam and specimen number

Name	Length (mm)	Width (mm)	Depth (mm)	Wrapping(mm)	No of beam
B1C	1500	150	250	Nil	3
B2G1	1500	150	250	Single	3
B3G2	1500	150	250	Double	3
B4R30	1500	150	250	30	3
B5R40	1500	150	250	40	3
B6R50	1500	150	250	50	3

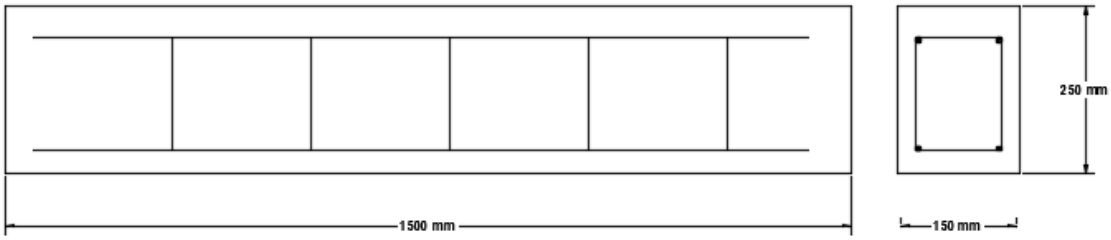

Fig.1 cross section of the specimen

2: Material properties

2.1 Concrete

Casting of all beam is carried out by using the M25 grade of concrete mix. Concrete mix proportion is selected after mix design is water: cement: send: aggregate, 0.49:1:1.88:3.13 respectively. The quantities of ingredients, used in the concrete mixes are shown in Table 2

Table:2 ingredients of concrete mix (1m3)

Ingredients	Quantities
Cement	380 kg/m3
Send	716 kg/m3
20mm aggregates	714 kg/m3
10mm aggregates	476 kg/m3
Water	186 kg/m3

2.2 Glass Fiber

It also known as composite fibre system is a non-intrusive structural strengthening technique that increase the load carrying capacity and ductility of reinforced concrete member without causing distress or destruction to the existing concrete. This technique adopting in two types of systems:

1: Uni-directional E-glass fibres 2: Bi-directional E-glass fibres

In present investigation the Uni-directional E-glass fiber sheets is used as show in fig.2 The properties of GFRP sheet are presented in Table 3. The resin system used to bond the glass fabrics over the columns is an epoxy resin made of two

parts, resin and hardener. Fig. 2 Shows GFRP sheet in roll form and defines the direction of layers of fibers which are more in longitudinal direction as compared to that for the transverse direction. [1]


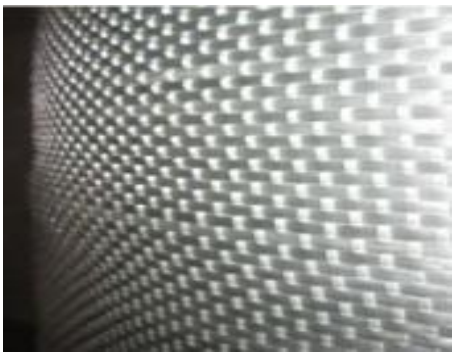

Fig. 2. GFRP Sheet (a) Sheet roll and (b) Unidirectional GFRP sheet

Table:3 properties of glass fibre

Appearance	Weight	Elasticity	Width of sheet	Tensile strength
White	900 gsm	74,500 N/sq.mm	500mm	1975Gpa

2.3 REFOR-Tec

It is a tri-component cement based product of the REFOR-tec series, which combines the self levelling rheology with exceptional physical-mechanical properties and ductility



Fig .2 ingredients of refortec

Table:4 typical values of refortec

Elastic modules	Compressive strength	Tensile strength	Flexure strength	Ductility	Temperature resistance
33Gpa	65-280Mpa	6-12Mpa	13-80Mpa	8-25	800-1000 °C

3. Casting of beam

Total 18 no. of beam rectangular beam having c/s 150mm X 250mm X 1500mm with 4 – no 12 mm bars and 8 mm stirrups having 100mm c/c distance have been cast. Concrete is prepared in the concrete mixture machine of one cement bag capacity and vibration is done after the casting of the beam for free up the voids in the concrete. The selection of bars and stirrups were made after the calculation according to the IS 456:2000 and for refortec additional layering (30- 40 - 50 mm) applied after the curing of concrete new formwork according to the need.

Fig.3 a) reinforcement b) formwork with cage c) concrete beam d) curing of concrete

4. Wrapping of layers

After the casting of the beam the beam was put in the curing for the 28 days, after the completion of 28 days curing period treatment of beam surface is given buy the some kind of putty to achieve the void free surface than epoxy is made by base and curing agent with the ratio of the 1:2 (curing : base) were mixed by hand continuously before use that epoxy is called saturate and primer. Special attention was taken by the installers to eliminate any voids between the FRP laminates and the concrete surfaces.[1]

Fig. 4 After application of the primer and saturant, GFRP sheet .

5. REFOR-tec layering

After the casting of the beam the beam was put in the curing for the 28 days, after the completion of 28 days curing period treatment of beam surface is given buy the some kind of putty to achieve the void free surface.
New formwork is made according to the dimension (30 - 40 – 50 mm) and places the beam in formwork. Vertical mixer is used to mixing of the component A, B & C. minimum 8-10 minutes required for the mixing of the components after the mixing the material placed in the newly formwork .after the 24 hours of the casting formwork is

removed and sent to the 7 days of curing and after the completion of the curing period tests are performed in laboratory.

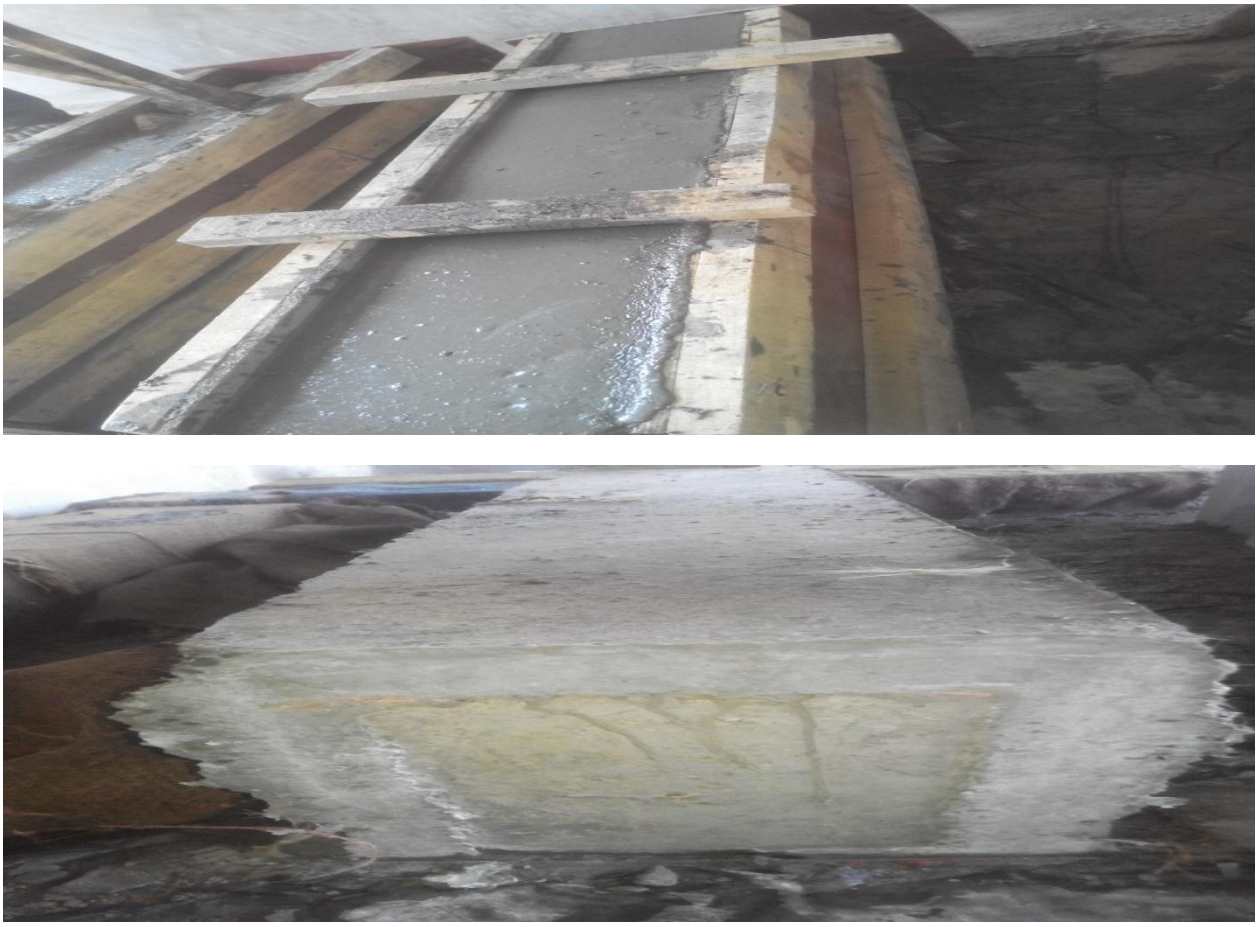

Fig .5 placing of material and final geometry of the beam after the layering

IV. TEST PROCEDURE

The beam is to be set to test after the 28 days of curing, application of GFRP and REFOR tec layering after that4 point load test are carried out for flexure strength of the beam. The two point load is applied by the jack and the capacity of the frame 500KN. Test setup is showing in fig.6 beam with parallel steel surface plate resting on the two support to ensure that the load is equally transforming to the beam and counterattacking the eccentricity the load is applied at the 10 KN rate.

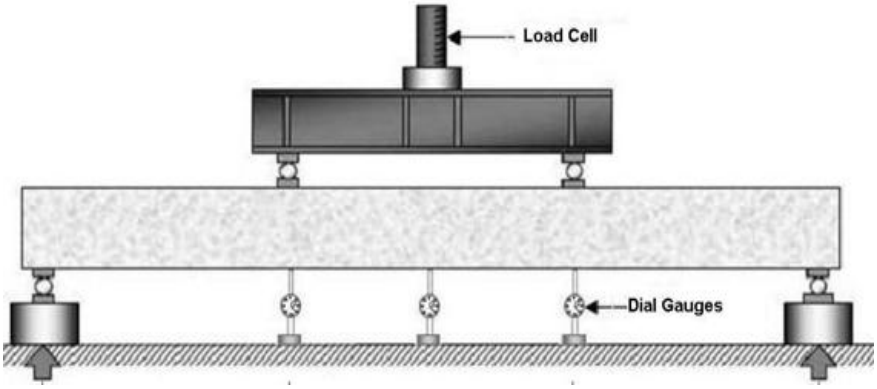

Fig. 6 Experimental set up for testing [2]

V. RESULT AND DISCUSSION

Sets of beams were tested for their ultimate strengths. The beams B1C were taken as the control beams. It was observed that the beams B1C had less load carrying capacity when compared to that of the externally strengthened beams using GFRP sheets. In B2GA, B3G2 beams are strengthened only at the soffit of the beam.

Deflection behavior and the ultimate load carrying capacity of the beams were noted. The ultimate load carrying capacity of all the beams along with the nature of failure is given in Table 5.

Table .5 ultimate load, nature of failure and crake occurrence load detail

SR NO.	TYPE OF BEAM	BEAM NOTETION	Load at initial crack (KN)	Ultimate load (KN)	Nature of failure
1	Beam weak in flexure	B1C	70	115	Flexure
2	Beam weak in flexure	B2G1	90	143	GFRP rupture + flexure
3	Beam weak in flexure	B3G2	112	158	GFRP rupture + flexure
4	Beam weak in flexure	B4R30	130	175	Flexure
5	Beam weak in flexure	B5R40	148	192	Flexure
6	Beam weak in flexure	B6R50	166	218	Flexure

After the testing of all the specimens the load and deflection results show the critical value in compare to the normal beams the load deflection graph are listed below:

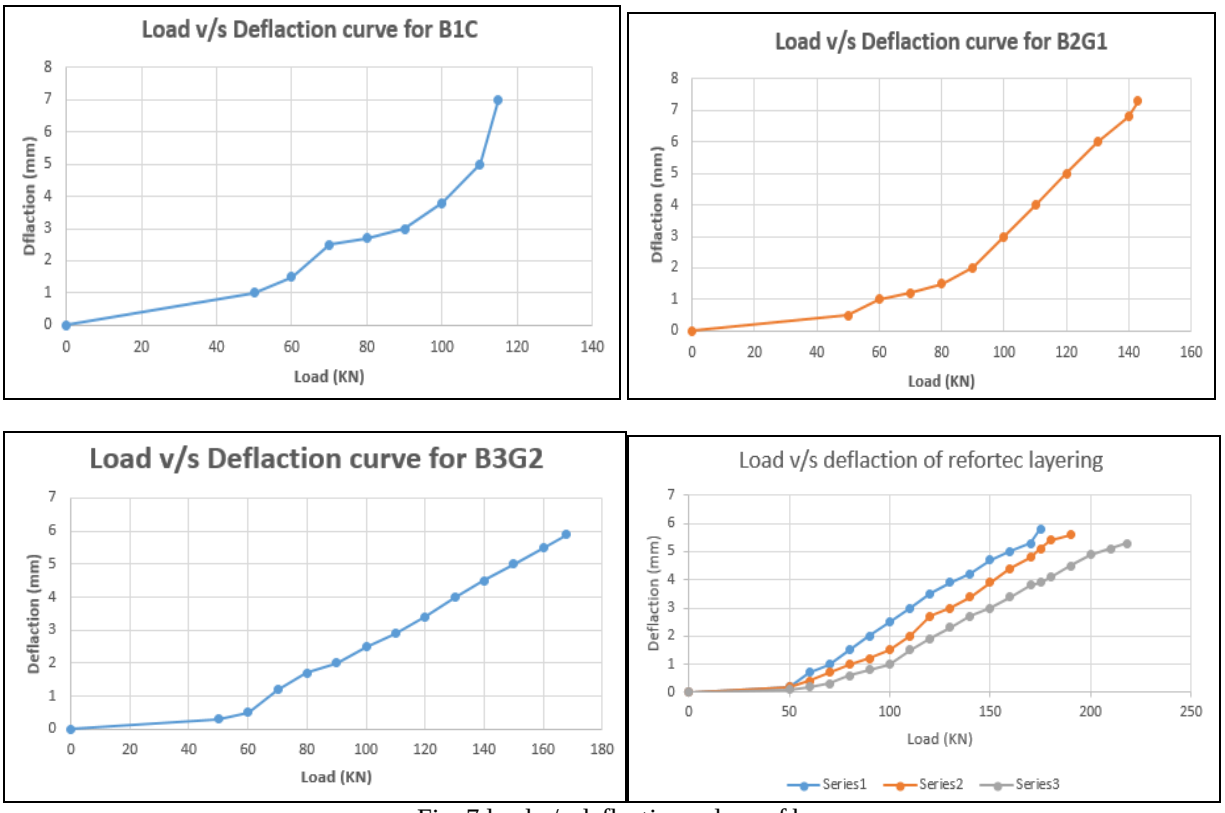

Fig. 7 load v/s deflection values of beams

VI. CONCLUSION

In this experimental investigation the flexure behaviour of reinforced concrete beam strengthened by Refor-tec layers and GFRP sheets are studied. Total 6 different case of reinforced concrete beams carried for studied. From the test results and calculated strength values the conclusion is determine as below:

The experimental results clearly show that Refor-tec layering and GFRP wrapping can achieve and increase the structure element performance in terms of flexure loading and increase the strength.

Percentage of the failure of the beam is 70 % to 174% for beam with Refor-tec layers.

Increasing layers and wrapping number increase the strength. However increasing strength is not depend on the wrapping of GFRP sheets layers.

Higher ultimate caring capacity is achieved by Refor-tec 50mm layers.

To enhance overall performance of RC elements confinement with Refor-tec and GFRP is recommended for strengthen purpose with different type of pattern and layers it increase the capacity of the elements and life service of the structure.

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