An Experimental Study of Retrofitting and Re-Strengthening of a Member

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Abstract

Worldwide, retrofitting is used largely to repair and re-strengthen RC structural members. Retrofitting is the modification of an existing structure by adding new technologies or features to older systems. There are so many existing structures that need reconstruction, but complete replacement of structures becomes costly and time-consuming. Hence, retrofitting becomes an efficient option. Retrofitting is the most commonly used technique to repair or re-strengthen the structure. This paper presents an experimental study of the retrofitting and re-strengthening of RC members using various fibre materials externally and a comparison between a control specimen and a retrofitted specimen for ultimate load capacity. In this experimental study, we cast RC members and tested them after retrofitting with CFRP, GFRP, and CFRP with Carbon Laminate.

Keywords: **Retrofitting, RC member, CFRP, CFRP, Carbon Laminate, Ultimate Load Capacity, Strengthening.**

1. INTRODUCTION

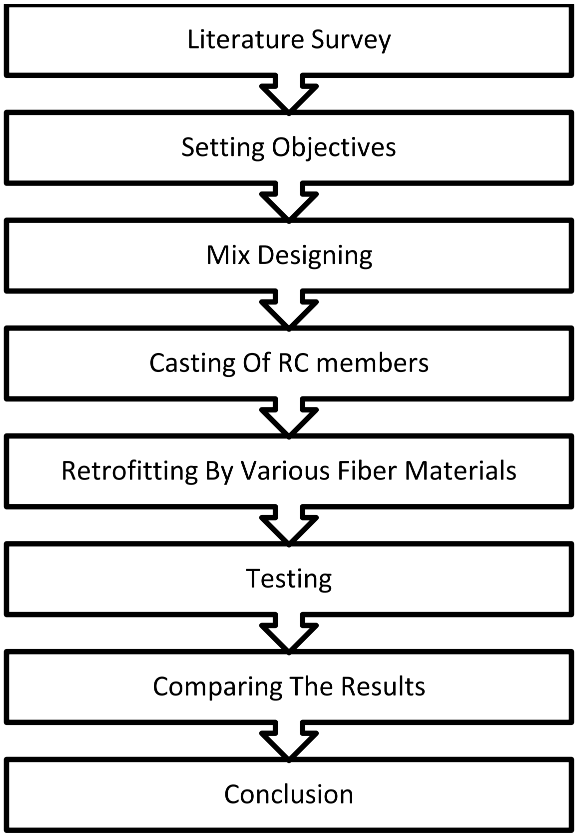
Repair and rehabilitation are one of the biggest challenges to the civil engineering field. Structures deteriorate because of natural disasters, reinforcement corrosion, poor construction quality, etc. For such conditions, retrofitting has become an efficient option for rehabilitation and repair. Existing structures also become safer as retrofitting improves the ultimate load capacity of existing structures.

FRP is nowadays widely implemented. FRP composite materials have recently been developed and studied for repair. FRP is a composite material made of a polymer matrix reinforced with fibres. There are various fibres such as CFRP, GFRP, PFRP, SFRP, COIR FIBRE SHEET etc. FRP is widely used because of its properties, as it is light in weight, corrosion resistant, high strength, easy to transport and install, etc.

Retrofitting using FRP materials is easy and cost-effective as compared to other traditional methods of retrofitting. Beams are the critical structural members subjected to bending, torsion, and shear in all types of structures. Similarly, columns are also used as various important elements, subjected to axial load combined with/without bending, and are used in all types of structures. Therefore, extensive research work is being carried out throughout the world on the retrofitting of concrete beams and columns with externally bonded FRP composites [2].The conventional strengthening methods of reinforced concrete structures attempt to compensate for the lost strength by adding more material around the existing sections [1].

The main objective of this study is to understand the behaviour of RC structural members after being strengthened with various fibres such as CFRP, GFRP, and CFRP with Carbon Laminate.

2. METHODOLOGY



3. MATERIALS

The grade of concrete used for casting RC members was M30 (1:0.75:1.5). The cement was Ordinary Portland Cement of grade 53 (JK Super Cement), crushed sand retained on 4.75 mm sieve and aggregate passing through 12 mm sieve. The water to cement ratio was 0.5. For reinforcement, 12 mm, 10 mm and 8 mm diameter bars are used. The following materials were used in this experimental study: CFRP, GFRP, and Carbon Laminate.

4. CASTING OF RC MEMBERS

4.1 Beam Casting

The moulds of the beam having a length of 1000mm with cross sectional dimension of 150mm X 150mm are prepared from wooden planks. Three moulds are prepared to have the same size as the beam. The beam has 2 bars of 12mm Ø at top as a compression reinforcement, 2 bars of 10mm Ø at bottom as a tension reinforcement and for stirrups 8mm Ø bars are provided at a spacing of 140 mm c/c. The beam was cast for M30 grade (1:0.75:1.5). Three beams were cast, one as a control specimen and the other two for retrofitting. Beams were cured for 14 days.

4.2 Column Casting

The moulds of the column have a length of 700mm with a cross sectional dimension of 150mm x 150 mm are prepared from wooden planks. For the column two identical moulds are prepared. The column has 4 bars of 12mm Ø bars and for stirrups, 8mm Ø bars are provided at a spacing of 140mm c/c. The columns were cast for the M30 grade (1:0.75:1.5). Two columns were cast, one as a control specimen and the other one for retrofitting. Columns were cured for 14 days.

Fig.1: Casting of the RC member

5. RETROFITTING OF RC MEMBERS

A three wrap method is used for the beam. And for columns, the four-side wrapping method is used. RCmembers were retrofitted after 40 days from casting.

5.1 Materials for Retrofitting

Glass Fibre

Carbon Fibre

Carbon Laminate

Epoxy primer

Epoxy putty

VCOBOND EPBL-5920

VCOBOND EPF-5910

VCOBOND EPB-5160

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5.2 Material application

a) CFRP with Carbon laminates beam application procedure.

Mix VCOBOND EPBL-5920 parts A and B with a proportion of 1:1/2. Add half the bag of filler to the above mixture and stir thoroughly. Apply this putty over the beam bottom to level the surface. Mix VCOBOND EPF-5910 parts A and B with a proportion of 1:1/2. Add half the bag of filler and stir thoroughly. Apply this putty over a surface to paste carbon laminate. Paste carbon laminate having a size of 900 x 50 mm over putty at the centre of the beam. Cut carbon fibre as per the required size. Mix VCOBOND EPB-5160 parts A and B with the proportion of 1:1/2. Apply this mixture to the beam bottom and sides of the beam with the help of a roller or brush. Apply carbon fibre to the mixture, finely removing all wrinkles. Reapply the mixture to the carbon fibre. The surface should be flat with no air bubbles.

Fig.2: Retrofitting of the beam using CFRP with Carbon Laminate

b) GFRP beam application procedure.

Firstly, cut glass fibre as per the required size. Mix VCOBOND EPB-5160 parts A and B with a proportion of 1:1/2. Apply this mixture on the beam bottom and sides of the beam with the help of a roller or brush. Apply glass fibre to the mixture, finely removing all wrinkles. Reapply the mixture to the fibre. The surface should be flat with no air bubbles.

Fig.3: Retrofitting of beam using GFRP

c) CFRP application procedure on the column.

Firstly, cut carbon fibre as per the required size. Drilling two holes at a certain distance for fasteners. Mix VCOBOND EPB-5160 parts A and B with a proportion of 1:1/2. Apply this mixture on all four sides of the column. Apply carbon fibre to the mixture, finely removing all wrinkles. Reapply the mixture to the carbon fibre. Place fasteners into drilled holes to seal the overlapping joints. Reapply the mixture to the fasteners. The surface should be flat with no air bubbles.

Fig-4: Retrofitting of a column using CFRP

6. TESTING

The control beams and columns as well as retrofitted beams and columns were tested for flexural strength. The UTM set up was used for testing. A central point load was given. The control specimens were tested after curing for 14 days. And retrofitted specimens were tested 15 days after retrofitting.

For beams

The beams were supported by the roller bearings. The beams were placed, leaving 150 mm from both ends, and the remaining part was divided into two equal parts. Then the central load was applied by the load cell. The ultimate load was taken at which the load on the control unit returned back.

For columns

The columns were placed vertically in UTM and central point load was given by load cell. The ultimate load was taken same as that of beams.

Fig.5: Testing of RC members

7. RESULTS

For Beams

The control specimen had an ultimate load capacity of 79 KN. The beam strengthened with GFRP had an ultimate load capacity of 120 KN, which increased by 51% compared to that of the control beam. The beam strengthened by using CFRP with carbon laminate had an ultimate load capacity of 132 KN, which increased by 67% compared to that of the control specimen.

For Columns

The ultimate load capacity of the control specimen is 370 KN. The ultimate load capacity of a column strengthened with CFRP is 448 KN, which is an increase of 21% over that of the control specimen.

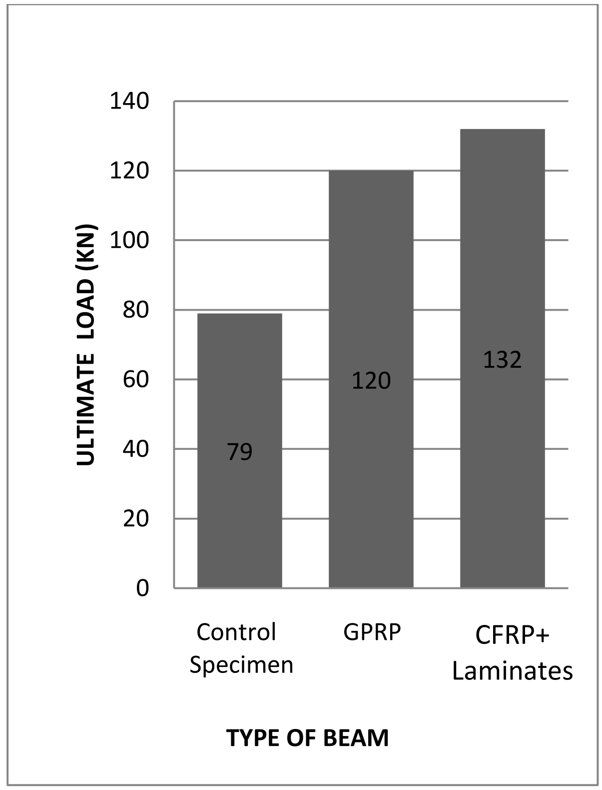

Fig.6: Beam loading graph

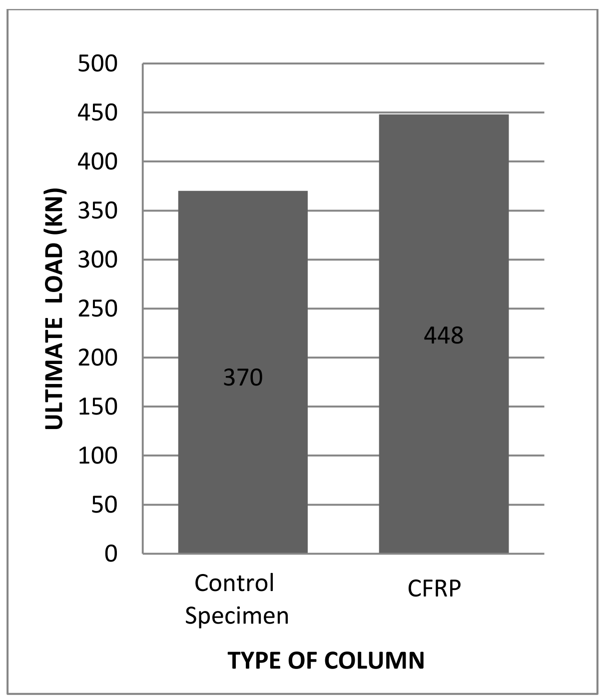

Fig.7: Column loading graph

8. CONCLUSION

In this experimental study, the behaviour of RC structural members retrofitted with CFRP, GFRP, and CFRP with carbon laminate is studied. From the test results and calculated strength values, the following conclusions were made:

• Deflection of beams minimized due to the wrapping of various fibre materials.

• The flexural strength and ultimate load capacity of RC members improved due to external strengthening of RC members.

• The ultimate load capacity of the beam by using CFRP with carbon laminate is increased by 67%.

• The ultimate load capacity of a beam strengthened with GFRP is increased by 51%.

• Even though the beam retrofitted by using CFRP with carbon laminate has the maximum ultimate load capacity, it has proved to be uneconomical.

• Beam strengthening using GFRP is more economical than using CFRP as it costs only Rs.300/sq.m and increases ultimate load capacity by 51%.

• The ultimate load capacity of a column strengthened with CFRP increased by 21%.

• The strength of a column retrofitted with CFRP is increased as compared to an un-strengthened column.

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