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# Repair and Strengthening of a Damaged RC Beam using Carbon FRP sheets

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**Abstract**: many reinforced concrete elements such as beams are deteriorated due to many reasons like spalling of concrete and excessive deflection, environmental stresses, etc.so an alternate technique for strengthening or repair of such elements are necessary. The carbon reinforced polymer sheets are quite effective measure for such damages. This paper investigates the flexural strength of normal RC beams and the beams wrapped with CFRP sheets. Totally 6 beams were casted and its load carrying capacity are checked. Then those damaged beams after testing are retrofitted by CFRP sheets and its failure load was once again checked.

**Keywords**: damaged beams, CFRP, strength, failure load

## I. INTRODUCTION

Concrete structures can be deteriorated due to over-loading, earthquakes, fire, spalling, environmental stresses, blast loading, mistakes in design calculations, corrosion of reinforcement and improper concrete mix design. Serious damage may lead to structural failure demanding costly repair and huge loss of lives. Therefore it is necessary to increase the service life and load carrying capacity of damaged original structures. Also it is important to study the behaviour of damaged RC members, since it involves huge cost to demolish and reconstruct them. In such occasions, it is better to use repair and rehabilitation which is most commonly used.

Complete replacement of the existing structure is very costly so the retrofitting and strengthening of existing reinforced concrete structures has become one of the best method. In recent years, it is necessary to find strengthening techniques suitable in terms of low cost and fast processing time. Externally bonded FRP (fibre reinforced polymer) has emerged as a new structural strengthening technology for strengthening the reinforced concrete elements.

Compared to other alternatives CFRP plates offer many advantages such as thin light weight, non-corrosive competitive and repair of structural members. It has higher strength to weight ratio, durable, less labour and equipment's required for installation, ease in handling and can be virtually delivered by any length. While its cost is higher than that of other techniques their easier handling in the field makes them cost co.

The main objective of this experimental study to carry out to investigate the flexural performance of damaged RC beams strengthened with CFRP plates for different damage degree. Basically the technique involves gluing fibre reinforced polymer to the surface of the concrete.

This work is the study of the behaviour of the concrete beams retrofitted with carbon FRP using experiments and finite element modelling.

## II. EXPERIMENTAL SETUP

### A. *Details of RC beam*

The part of the investigations deals with reinforced concrete beams strengthened in bending. The CFRP sheets are bonded with fibres oriented along the longitudinal axis of the beam. The experimental results are presented, analysed, compared and discussed.

The experimental work consist of six reinforced concrete beam specimens .All beams had the same dimensions and reinforcement by M20 grade concrete. The beams had rectangular cross section with 230mmϕ x 230 mm x 700mm. Beams were design to avoid shear failure, in which the beams were reinforced by four bars (8mm diam.) 2-bars at the top and 2-bars at the bottom of the cross section with 10 mm. diam. at 250 mm c/c

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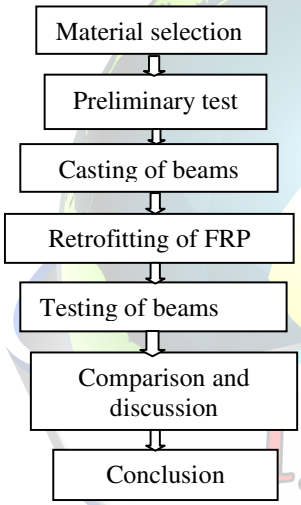
stirrups. The reinforcement details of the columns are given in fig. 1.

The materials in concrete consisted of

- coarse aggregate maximum size of 20 mm sieve and retained on 10mm sieve,
- locally available river sand
- 53 grades Portland cement.

The specimens were compacted by a tamping rod for good compaction.

*B. Methodology:*




*C. casting of beams:*

The beams were casted by using mould specimens. Specimens were filled using concrete and compacted using tamping rod after 24 hr. mould was removed and place specimen in a water tank for 28 days. The test beam specimens were divided into three groups. Group I-7 days, Group II-14 days Group III-28days. These beams were tested for their flexural strength on days accordingly.

## III. TESTING PROCEDURE

*A. **Surface preparation of concrete:*** The behaviour of beams strengthened with CFRP system is highly dependent on the proper surface preparation of the beams. An improperly surface preparation can result deboning of CFRP and beam surface. The concrete or repaired surface to which CFRP system is to be applied should be free from dust, oil, dirt, curing compound, exiting matter and any other matter. This matter can interfere with bonding of CFRP to the beam.

*B. **Test procedure and Instrumentation**:* All the beams were tested under simply supported condition. The testing was done under two point loading using the Universal Testing Machine of 600 KN capacity. Each beam was instrumented with dial gauge to observe the midspan deflection. The deflections were recorded for each incremental load of 5 KN. All the beams were tested up to the failure of beam in a single load cycle. The crack pattern was observed during the testing. The beam testing set up is show in fig

*C. **Results and explanations:***

*Before retrofitting:*

The experimental results are as follows for the casted beam before retrofitting i.e., beams without wrapping the carbon FRP sheets..,

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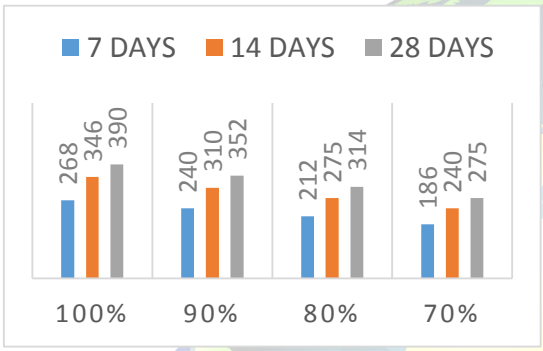
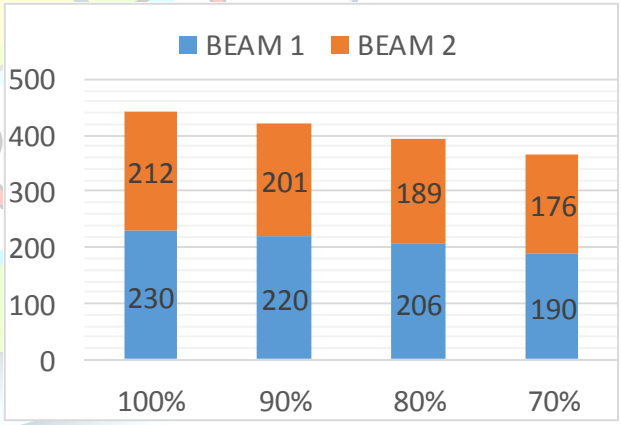
| TEST | MAX.LOAD | 90% | 80% | 70% |
|---|---|---|---|---|
| 7 DAYS | 268 KN | 240 KN | 212 KN | 186 KN |
| 14 DAYS | 346 KN | 310 KN | 275 KN | 240 KN |
| 28 DAYS | 390 KN | 352 KN | 314 KN | 275 KN |




The bar chart for the respected values of after retrofitting is as follows:

*After retrofitting:*

The normal beams are tested in UTM machine and then cracks are noted. The NITTOBOND is applied on the cracks and the CFRP sheets are wrapped on it. Then once again the beams are checked for its strength and the values are obtained as follows:




| B.NO. | M.LOAD | 90% | 80% |
|---|---|---|---|
| 1 | 230 KN | 220 KN | 206 KN |
| 2 | 212 KN | 201 KN | 189 KN |
| 3 | 209 KN | 196 KN | 187 KN |

*Material testing:*

The specimens are tested in UTM machine as shown in fig. and there values are then noted correctly.,

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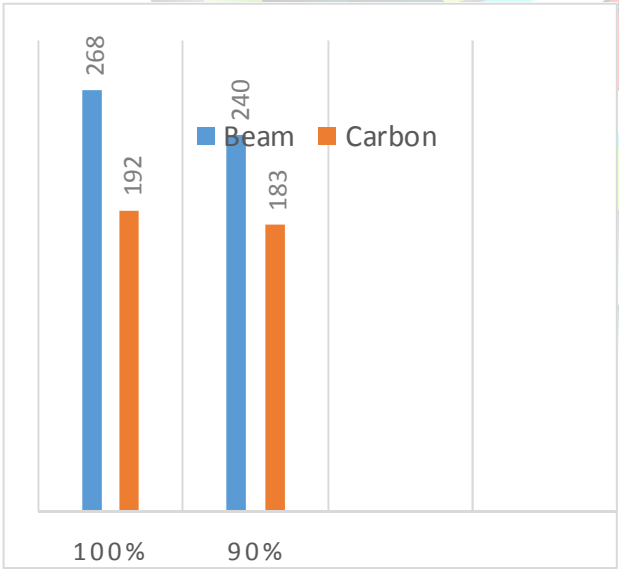
**comparison**:

In order to evaluate the effectiveness of using CFRP plates to strengthened damaged beams, a series of beams were designed, cast, damaged for different damage degree and then tested up to the failure. The values are compared as follows:




## IV. CONCLUSION

In this experimental investigation the flexural behaviour of reinforced concrete beams externally strengthened by CFRP sheets are studied. From the test results and calculated strength values of beams, the following conclusions are drawn:

- The deflections of the beams are minimized due to full wrapping technique around all the four sides of the beam.
- The initial cracks in the strengthened beams appear at a higher load compared to the un-strengthened beam.
- The flexural strength and ultimate load capacity of the beams improved due to external strengthening of beams.
- The strengthening of beams using carbon fibre sheets is found to be more effective in improving the flexural strength and ultimate load capacity of beams.
- The ultimate load capacity of the beams strengthened using carbon fibre sheets is increased by 125% when compared to that of normal beam.
- Even though the beams retrofitted with CFRP sheets have the maximum ultimate load capacity, the cost of the material is high.
- Retrofitting using CFRP sheets is least recommended since its cost is high and increase in ultimate load capacity is less.
- The bonding between the FRP sheet and the concrete is intact up to the failure of the beam which clearly indicates the composite action due to FRP sheets.

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