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Retrofitting of RC Element Beam

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Abstract - Structures with the passing of time they lose their strength because of many reasons like seismic activity, soil failure due to ground motion, arises problem like damaging of roof, foundation, walls, pillars, column and beams for these structures becomes statically unsafe and solution to these problem is Retrofitting. The structure performs normally during their life span but at the end of design period of structure, the structure may not be capable of taking load. Enhancement of performance of such buildings can be done by increasing strength and strength of building can be increased by process of Retrofitting. RCC buildings undergo three different R's name as Repair, Rehabilitation and Retrofitting. Experimental investigations on the flexural behaviour of RC beams strengthened using carbon fibre reinforced polymer (CFRP) fabrics are carried out. Externally reinforced concrete beams with epoxy-bonded CFRP sheets were tested to failure using a point load concentrated static loading system. The effect of CFRP fabric and its orientation technique on ultimate load carrying capacity and failure mode of the beams are investigated. A finite element model that is made by using ABAQUS software is used for the simulation of experiments and model gave compatible results with experiments.

Keywords – Retrofitting of Beam, CFRP, ABAQUS

INTRODUCTION

Retrofitting is defined as the process of modification of existing structures like buildings, bridges to make more resistant to seismic activity and other natural calamities. Structures with the passing of time they lose their strength because of many reasons like seismic activity, soil failure due to ground motion, arises problem like damaging of roof, foundation, walls, pillars, column and beams for these structures becomes statically unsafe and solution to these problem is Retrofitting. The structure performs normally during their life span but at the end of design period of structure, the structure may not be capable of taking load. Strengthening with Fiber Reinforced Polymers (FRP) composite materials in the form of external reinforcement is of great interest to the civil engineering community. The conventional strengthening methods of RCC structures attempt to compensate the lost strength by adding more material around the existing sections. The strengthening of concrete structures with externally bonded reinforcement is generally done by using either steel plates or Fiber Reinforced Polymer (FRP) Enhancement of performance of such buildings can be done by increasing strength and strength of building can be increased by process of Retrofitting. RCC buildings undergo three different R's name as Repair, Rehabilitation and Retrofitting. Repair is partial improvement of the degraded strength of a building after an earthquake.

Rehabilitation is a functional improvement, where Retrofitting means structural strengthening and enhancement of performance of deficient structural elements of a building to a pre-defined performance level whether or not an earthquake has occurred. **Repairs** the main purpose of repairs is to bring back the architectural shape of the building so that all services start working and the functioning of building is resumed quickly. Repair does not pretend to improve the structural strength of the building and can be very deceptive for meeting the strength requirements of the next earthquake. The actions will include the following:

- Patching up of defects such as cracks and fall of plaster.
- Repairing doors, windows, replacement of glass panes.
- Checking and repairing electric wiring.

Restoration This type of action must be undertaken when there is evidence that the structural damage can be attributed to exceptional phenomena that are not likely to happen again and that the original strength provides an adequate level of safety.

The main purpose of restoration is to carry out structural repairs to load bearing elements. It may involve cutting portions of the elements and rebuilding them or simply adding more structural material so that the original strength is more or less restored.

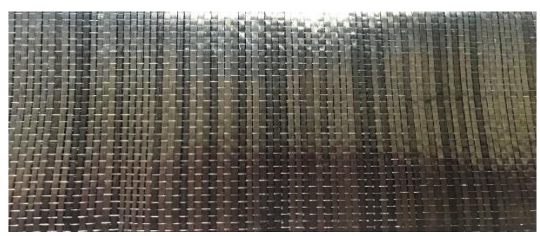

Figure 1 CFRP

Carbon Fiber Reinforced Polymer (CFRP) is an advanced non-metallic composite material made of a polymer resin reinforced with carbon fibers. It has many superior performances, such as high strength, lightweight, no corrosion and high fatigue resistance. Carbon fiber reinforced polymers are one the stiffest and lightest composite materials, they are much substantial than other conventional materials in many fields of applications. At present CFRP is being used for structural repair for damage structure for development of aircraft fuselage, automobile chassis, wind turbines (CFRP) materials have become increasingly popular in industry applications. It can be largely endorsed to the superior properties of CFRP, such as high strength-to-weight ratio, corrosion resistance and improved fatigue performance.

Table No 1: Mix design M25

Grade of concrete	Material	Quantity (kg / M^3)
M25 (1:1.88:2.82) (w/c ratio = 0.40)	Cement	394.325 Kg
	Coarse aggregate	1112.74 Kg
	Fine aggregate	742.02 Kg
	Water	157.73Litres

Table 2 Properties of CFRP

Type of fiber	Carbon Fiber
Fiber orientation	Unidirectional
Weight of fiber	400 g/mm^2
Density of fiber	1.80 g/cc
Fiber thickness	0.3 mm
Ultimate elongation (%)	1.5
Tensile strength	3400 N/mm^2
Tensile modulus	2300000 N/mm^2

Application of CFRP by Dry Application Method.

Cleaning

Clean all the tools and application equipment with immediately after use. Any uncured epoxy should be wiped up with a clean wetted with turpentine. Hardened material can only be removed mechanically.

Preparation

Review the project specifications and requirement in detail

Obtain all of the necessary equipment and tools plus material required

Repairs to concrete surface irregularities such as blowholes or voids must be made with a suitable repair mortar

The concrete surface must be brushed and air blasted to achieve a dust free condition and no loose particles should be present on surface.

Dry application process

The name of the dry application method comes from the state of fabric at the time it is applied inn its final position. For this process, sikadur-330 is normally used both as the substrate primer and as the fabric impregnating resin.

The dry application method is suitable for woven fabrics with an area weight of up to 430 g/m^2, dependent on the fiber type.

For the dry application of the CFRP sheet sikadur-330 is normally used for the resin priming coat and as the impregnating resin.

It is shorter at high temperatures and longer at low temperatures.

The greater the quantity is mixed, the shorter the pot life becomes. To obtain longer workability ay high temperatures, the mixed adhesive may be divided into portions. Another method is chill components A and B before mixing them.

The actual consumption, especially of the priming layer, is primarily dependent on the roughness of the substrate and the type and amount of FRP sheets to be impregnated.

Testing of beam specimen

- 28 days cured specimen were tested on universal testing machine at Nikhil Construction, Pune
- Among 12 beam specimen 3 beam are tested for maximum load capacity
- Remaining 9 beams are distressed by 60% of average ultimate load capacity of 3 control beam.
- Three beams are wrapped completely by CFRP, three are wrapped at middle and three are wrapped at bottom.

Comparison of Retrofitted beams and without retrofitted beams using CFRP from strength point of views.

- Beam wrapped completely sheet shows greater load carrying capacity than other beams.
- The ultimate load obtained for control beam is 75KN, completely wrapped beam has an ultimate load of 114.5KN, middle wrapped beam has an ultimate load of 104.93KN, bottom wrapped beam has an ultimate load of 89.98KN.
- Completely wrapped beam carries maximum load compared to other specimens

Figure 2 Beam wrapped completely

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Figure 3 Beam wrapped Middle

Figure 4 Beam wrapped Bottom

Figure 5 De-Bonding Failure

Technique	Load Carrying Capacity (kN)	Flexural Strength (N/mm^2)
Without Wrapping	75	23.33
Wrapped Completely	114.5	35.62
Wrapped at Middle	104.93	32.64
Wrapped at Bottom	89.98	23.20

Overall Results

Analysis of Beam on ABAQUS software

The results obtained from analysis were the stress carrying capacity of beam with CFRP increased 10-15% by wrapping the sheet at the bottom side of beam

The maximum stress without CFRP of beam obtained as 19.7 Mpa and maximum stress with CFRP was 27.4 Mpa.

The discretization is done for the clear representation of the contour. Stress contour and deflection are shown comparing the top to bottom side, figure shows that the total displacement of beam reduced by application of CFRP sheet

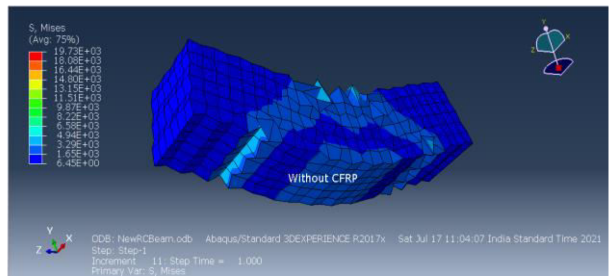

Figure 7 Beam Without CFRP

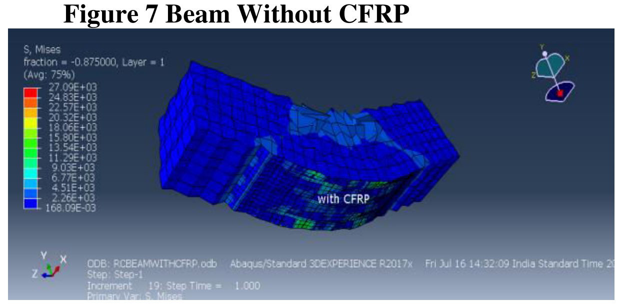

Figure 8 Beam with CFRP

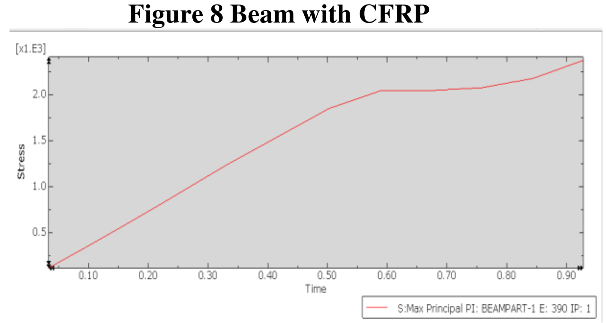

Figure 9 Control Beam Stress vs Time curve

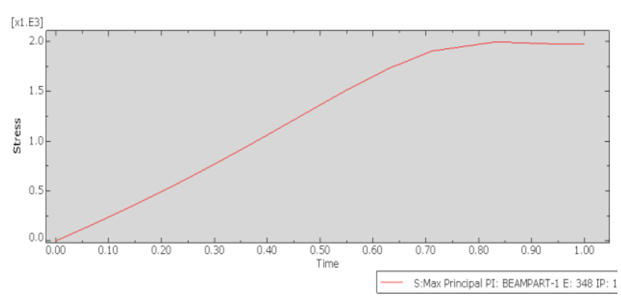

Figure 10 Beam with CFRP Result

From the above curves the stress vs time, without wrapping the CFRP with increment of time the stress carrying capacity of retrofitted beam shows more as compared to non-retrofitted beam.
The variation of curve is linear up to some point in first curve that is stress carrying capacity with respect to time is not more as compared to results obtained in second curve that is beam retrofitted with CFRP.

CONCLUSION

1. RC beam wrapped with CFRP completely U-shape showed increase in flexural strength by 52.66% compared to beam without wrapping.
2. It is observed that for beam wrapped at middle U-shape 1/3rd portion of beam increase flexural strength by 39.9% as compared to beam without wrapping.
3. Beam wrapped with CFRP at bottom side showed increment in flexural strength by 19.97% compared to beam without wrapping.
4. From the above results we can conclude that the beam with U-shape wrap, beam wrapped at middle U-shape and beam wrapped at bottom gives 8.36%, 34.86% and 52.66% more flexural strength respectively than that of beam without wrapping.
5. Flexural strength of beam wrapped with CFRP at bottom side is increased by 18.10% compared to beam without wrap when analyzed by finite element method.
6. By comparing experimental and analytical results of flexure strength of beam wrapped with CFRP at bottom side, it is observed that experimental results show 1.87% higher values than that of analytical results, hence analytical results obtained from Abaqus software for RC beam retrofitted using CFRP material showed compatible results with experimental results.
7. From present experimental work we can conclude that by using RC beam completely wrapped with CFRP gives effective results also, we can achieve better mechanical performance like strength and stiffness.

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