Retrofitting Of a Flexural Member Using GFRP Polymer

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ABSTRACT

There is a considerable number of existing reinforced concrete structures in India that do not meet current design standards because of inadequate design and construction or need structural upgrading to meet new seismic design requirements. Inadequate performance of this type of structures is a major concern from public safety standpoint. This paper presents an experimental research program aimed at developing a retrofitting technique that utilizes locally available high strength, lightweight, corrosion resistance advanced composites for retrofitting existing reinforced concrete beams of frame structures in India. The proposed technique consists of applying Glass Fiber Reinforced Polymer Laminates (GFRP) to the bottom surface and sides of the concrete beam to increase its stiffness and flexural strength. A total of nine full scale reinforced concrete beams were constructed, tested under three points loading representing full dead and live loads and then unloaded to dead load. Under this dead load the beams were retrofitted with GFRP and then loaded till failure.

INTRODUCTION

Retrofitting

Refers to the addition of new technology or features to older systems. Retrofitting of an existing building can often times be more cost-effective than building a new facility. Since buildings consume a significant amount of energy (40 percent of the nation's total energy consumption), particularly for heating and cooling (32percent), and because existing buildings comprise the largest segment of the built environment, it is important to initiate energy conservation retrofits to reduce energy consumption and the cost of heating, cooling, and lighting buildings. But conserving energy is not the only reason for retrofitting existing buildings. it Improves the indoor environmental quality, reducing mold ,decreasing moisture penetration, and all will result in improving the occupant health and productivity. when deciding on a retrofit, consider upgrading for safety ,security and accessibility, at the same time. There are some unique aspects for retrofit of historic buildings and must be given special consideration. Designing the major renovations and retrofits for existing buildings to include sustainability initiatives will reduce environmental impacts ,operation costs and, can increase the building durability ,adaptability, , and resiliency.

The Concrete is made with Portland cement and is relatively strong in compression but weak in tension, and it has a little resistance to cracking and tends to be brittle. The weakness in tension can be overcome by man Performance Enhancement of Concrete Structures using Natural Fiber Composites.

Conventional methods that is already available. Fibre Reinforced Polymers (FRP) are been extensively used as external wraps for the structural strengthening and rehabilitations of buildings. In particular its application is been in the area of masonry and concrete structures. retrofitting activity and Strengthening generally by using synthetic fibres such as aramid /glass/carbon/ is becoming popular all over the world. The Extensive research is done across the world during the last 30 years are so as led to better understanding about the properties and behavior of FRPs under different conditions, and more extensive use of FRPs is likely to seen in the coming years. Synthetic fibres are non-made fibres resulting from research and development in the petrochemical and textile industries. The various synthetic fibres include - acrylic, aramid, carbon, glass, etc.., But using these synthetic fibres is as costlier and chances for applicability in rural areas are remote.

CLASSIFICATION OF RETROFITTING:

Retrofitting of concrete structures :

a) Reinforced concrete jacketing

b) Steel plate bonding and jacketing

c) plate bonding and jacketing

Retrofitting of masonary structures

a) Stitching of cracks

b) Grouting with cement or epoxy

c) Use of CFRP

Materials used in retrofitting

1 CFRP Strips

2 Epoxy adhesives

3 Glass and Carbon Fabrics

CFRP: Carbon Fiber Reinforced Polymer

CFRP U-channels with aggregate coating and an anchorage system consisting of a lipped channel section with intermittent closed loops were found to provide improved composite action between the CFRP reinforcement and concrete. These CFRP channels also ensured adequate strength and ductility before failure. Possible modes of failure of the beams are discussed, as is the effect of the design parameters on the failure mode and the failure load.

CFRP ie The carbon fibre reinforced polymer also increases the shear strength of reinforced concrete mix by wrapping the fibers around the section that to be strengthen. As Wrapping around the sections can also enhance the ductility of the section, generally it increases the resistance to collapse under the earthquake loading comes on structure. 'The seismic retrofit' is the major application in earthquake-prone areas, as it is more economical than other methods. Carbon fibre is generally used at many applications due to it's unique and special properties. The major advantages of carbon fibre over the traditional materials like steel, aluminium, wood and plastics are as :

- It posses High stiffiness and strength
- It is Lightweight
- It posses Corrosion resistance
- X-ray transparency is there in CFRP
- Low CTE (Coefficient of Thermal Expansion)
- Chemical resistivity
- It have good Thermal and electrical conductivity

GFRP : Glass Fiber reinforced Polymer:

FRP rebar have increasing commercial value mainly because it provide good resistant to corrosive agents and it does not let concrete to rust or weaken. GFRP rebar is a variant of FRP. GFRP fiberglass rebar is one of the most developed types of fiber made of composite materials that can be used in various civil engineering applications. GFRP reinforcement is being accepted widely due to its favorable properties like electromagnetic neutrality, high strength-to-weight ratio, corrosion-resistance, and ease of installation.

Advantages of GFRP Rebar: Glass fiber reinforced polymer rebar is now a days a high value-added construction product. GFRP is generally a cost-effective construction material that it has the full potential to increase the life of structures where the corrosion can have a huge economic and environmental impact.some of the advantages of using GFRP rebar in various applications:

- The constituents of GFRP include vinyl ester resin of high-quality corrosion resistant that increases the lifespan of a concrete structure.
- As compared with the traditional reinforcement material, GFRP rebar is one fourth the weight of steel with twice the tensile strength of steel.
- The GFRP rebar is non-conductive to electricity and heat and making it as an ideal choice for facilities like power generation plants and scientific installations.
- It is a cost-effective product as compared with epoxy-coated or stainless steel.

- It is generally invulnerable to chloride ions and other chemical elements.
- It is also manufactured in custom lengths, bends, and shapes.
- The installation process of GFRP rebar is very convenient coupled with its property of being easily to cut and machined.
- Glass fibre reinforced polymer is transparent to electrical field and radio frequencies
- A project reinforced with GFRP rebar is maintenance free, enabling builders to avoid rehabilitation cost.

MATERIALS AND METHODS

Concrete of M20 Grade is used

Steel of FE 415 is used and 12mm and 8 mm bars are used

FRP Sheets with epoxy adhesive is used and CFRP Sheets are used in retrofitting of beam and comparision is made between two sheets.

Manufacturing of beam

There are total nine number of beams were tested under three point bending. The beams were divided into two groups.

For group RF, focus was on flexural behaviour, and

for group B focus was on shear behaviour.

For group RF, three beams were used as control beams.

The other beams were retrofitted and loaded until flexural cracks appeared and. Two different thickness (3mm and 6mm) of Glass Fibre Reinforced Polymer were used, with three equal beams for each length., the retrofitted beams are loaded until failure and the results are compared with the control beams.

For group RS, three beams (retrofitted with 6mm thick GFRP) and three beams (retrofitted with 3mm thick GFRP) are used as control beams, and its flexural strength is compared with the normal beam.

Construction of beams

The beams have a rectangular cross-section. The beams in group RF are designed to have insufficient flexural strength, compression and obtain a pure flexural failure. They have tension reinforcement and the steel bars were tied together with stirrups of about 100 mm c\c reinforcement along the beam. The beams in group RS have the same geometry, but were casted with a larger longitudinal reinforcement ratio and a reduced shear reinforcement ratio and in order to obtain pure diagonal shear cracks without development of the flexural cracks. The beams have tension and were tied with stirrups, compression reinforcement. In all the beams, about 15 mm of the clear concrete cover is provided to the main flexural reinforcement. This cover avoid the splitting bond failure. The beams cured for six months before they were tested

Detail of beam : The details of beam used in retrofitting are as follows:

Grade of concrete used = M 20 (1:15:3)

Size of coarse aggregate = 20mm

Water cement ratio = 0.5

Size of beam :150*150*700

Testing Performed

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For group RF, three beams were used as control beams.

The other beams were retrofitted and loaded until flexural cracks appeared and. Two different thickness (3mm and 6mm) of Glass Fibre Reinforced Polymer were used, with three nominally equal beams for each length. Finally, the retrofitted beams were loaded until failure and the results were compared with the control beams.

For group RS, three beams(retrofitted with 3mm thick GFRP) and three beams(retrofitted with 6mm thick GFRP) were used as control beams, and its flexural strength is compared with normal beam.

Testing of control beams;

The beams were tested in three point bending. This load case was chosen because it gives constant maximum moment and zero shear in the section between the loads, and constant maximum shear force between support and load. The moment was linearly varying between supports and load. The load was applied at points dividing the length into three equal parts as shown in Fig. Steel plates were used under the loads to distribute the load over the width of the beam

RESULTS AND DISCUSSION

The beams in group RF were taken and retrofitted them with GFRP materials as shown in Fig. The soffit of the beam was retrofitted with material laminates 150 mm wide and of two different thick layer, say 3 mm (series beam2), 6 mm (series beam3) and 520 mm as shown in Fig. The laminate was positioned at the centre of the beam width. The laminate was applied when the beams were subjected to a negative moment corresponding to their own dead weight. This implies a small prestressing effect which could be obtained by a jack in the case of on-site repair.

In order to ensure correct application of the external strengthening materials, it was considered necessary to improve the concrete surface characteristics on the contact areas to be bonded. The surface preparation was done according to the manufacturer's instruction. It included removing the cement paste, grinding the surface by using a disc sander, and removing the dust generated by surface grinding using an air blower. After that the epoxy 520 mm 300 mm material 100 mm adhesive was applied to both the material and the concrete surface. Finally the material plates were applied to the beams.

Testing of retrofitted beams

After 28 days curing at ambient temperature the beams were retested under three point bending until failure occurred. The tests were performed using the same setup as described before.

Average Flexural strength for three beam retrofitted are as follows:

Beam 1			Beam 2			Beam 3		
σ 1	σ 2	σ 3	σ 1	σ 2	σ 3	σ 1	σ 2	σ 3
13.33 N/mm^2	13.87 N/mm^2	13.5 N/mm^2	15.11 N/mm^2	15.64 N/mm^2	16 N/mm^2	17.24 N/mm^2	17.42 N/mm^2	16 N/mm^2
σ avr = 13.57 N/mm^2			σ avr = 15.58 N/mm^2			σ avr = 16.88 N/mm^2		

Table no. 3

RESULT

So , Increase in flexural strength of beam retrofitted with different layers of epoxy resins (in %) are as follows

For Beam with Retrofitted with 3mm thick layer,

$$\frac{15.58-13.57}{13.57} \times 100 = 14.81\%$$

For Beam with Retrofitted with 6mm thick layer,

$$\frac{17.48-13.57}{13.57} \times 100 = 24.44\%$$

CONCLUSION

In the last decade, innovative technologies have been developed using Fiber Reinforced Polymer (FRP) as strengthening and repair of masonry structures. Bond of FRP to substrate is crucial for the effectiveness of the technique especially to masonry substrate, which can have a wide variability. Few contributions are available concerning debonding problems on masonry. The above study shows that:

- The strength of a concrete member gets increase by about 14.81% when 3mm thick GFRP laminate sheet is used.

- The strength of a concrete member gets increase by about 24.44% when it is wrapped with 6mm thick GFRP laminate sheet..

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REFERENCES

1. Ai-hui, Z., Wei-Liang, J., & Gui-bing, L. Behaviour of preloaded RC beams strengthened with CFRP laminates. Journal of Zhejiang University Science A 2006; 436-444.

2. Ashour, AF., El-Refaie, S.A., and Garrity, SW. Flexural strengthening of RC continuous beams using CFRP laminates. Cement & Concrete Composites 2004; 26: 765- 775.

3. Esfahani, M., Kianoush, M., & Tajari, A. Flexural behaviour of reinforced concrete beams strengthened by CFRP sheets. Engineering Structures 2007; 29: 2428-2444.

4. Pham, H., & Al- Mahaidi, R. Experimental investigation into flextural retrofitting of reinforced concrete bridge beams using FRP compoistes. Composite Structures 2004; 66: 617-625.

5. Camata, G., Spacone, E., & Zarnic, R. Experimental and nonlinear finite element studies of RC beams strengthened with FRP plates. Composites: Part B 2007; 38: 277-288.