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Retrofitting of Reinforced Concrete Beams Using Carbon Fiber Composite Laminate and Glass Fiber Composite Laminate

KEYWORDS: CFCL, GFCL, Retrofitting

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ABSTRACT *Materials such as carbon fibre composite (CFC), aramid fibre composites (AFC), and glass fibre composites (GFC), can be used in the repairing and strengthening of aged concrete. In the present paper, experimental study is designed to investigate the flexural behaviour of reinforced concrete beams strengthened with CFRP GFRP laminates attached to the bottom of the beams, sides of the beams by epoxy adhesive subjected to transverse loading. The experiment consists of varying the fiber content; configuration and their performance in flexure were studied.*

From the test results it can be concluded that retrofitting with GFCL and CFCL provides a feasible rehabilitation technique for repair as well as strengthening. The paper also highlighted the beams failure modes due to the different level of strengthening scheme.

INTRODUCTION

The Fibre Reinforced Polymer (FRP) offer remarkable mechanical and fatigue properties as well as fracture strength and a relatively low crack propagation rate.

A quick and simple solution of rehabilitating these deteriorated concrete members is by wrapping them with FRP. A total of seven beams of span length 1500 span length having different CFRP and GFRP laminates configurations were tested in flexure by application of two point loading. Among these beam specimen's one beam is considered as control beam (unwrapped). The other six beams were loaded up to 70% of the ultimate load carried by the control beam and are then unloaded. These beams were retrofitted using different amount and configuration of Glass fibre composite laminates (GFCL) and Carbon fibre composite laminate (CFCL). These retrofitted beams were tested in flexure till failure and results are compared with control beam.

EXPERIMENTAL INVESTIGATION:

In this experimental work seven RCC beams were casted using M20 mix concrete and with two bars of 10mm diameter deformed steel reinforcing bars as bottom reinforcement and two 8mm diameter deformed steel reinforcing bars as top reinforcement. The shear reinforcement consists of 6mm diameter deformed steel reinforcing bars as closed stirrups spaced every 150mm c/c. All these beams were cured for 28 days. Among these beam specimen's one beam is the control beam (unwrapped) and remaining six beams were retrofitted as given below:

C - Control Beam with no FRP strengthening.

C_1 - beam with single layer GFRP laminates attached to the soffit of the beam.

C_2 - beam with two layers bidirectional GFRP laminate attached to the soffit of the beam.

C_3 - beam with single layer CFRP laminates attached to the soffit of the beam

C_5 - beam with single layer GFRP laminates wrapped around the sides (for half depth of beam) and the soffit of the beam.

C_4 - beam with single layer GFRP laminates wrapped around the sides and soffit of the beam.

C_6 - beam with both CFRP laminates attached to the bottom of the beam and GFRP laminates wrapped around the sides and the soffit of the beam.

TABLE 1: TEST RESULTS OF BEAMS AND FAILURE MODE

Beam Description	Different failure modes
C	Control beam failed in flexural crack
C_1	C_1 Beam failed due to delimitation
C_2	C_2 Beam failed due to delimitation
C_3	C_3 Beam failed in flexural crack
C_4	C_4 Beam failed due to fracture of GFCL
C_5	C_5 Beam failed due to delimitation of GFCL
C_6	C_6 Beam failed due to delimitation of GFCL

FIG 1: COMPARISION OF LOAD V/S DEFLECTION OF CONTROLLED BEAM WITH STRENGTHENED BEAMS

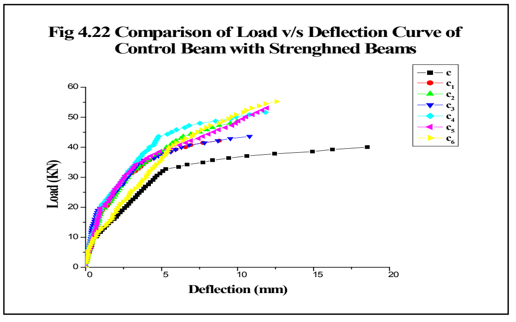

FIG 2: ULTIMATE LOAD ON BEAMS

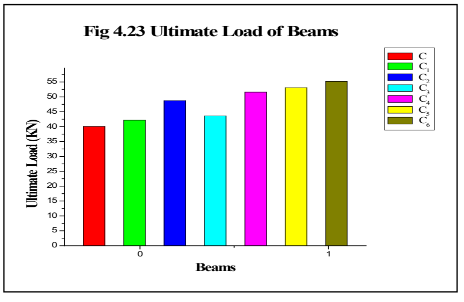

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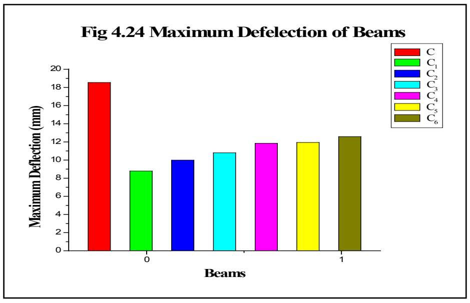
FIG 3: MAXIMUM DEFLECTION OF BEAMS



DISCUSSION AND CONCLUSIONS

Based on the experimental results the following Conclusions were made.

1) The increase in flexural strength of the retrofitted beam by using GFCL and CFCL with different configurations and equivalent fibre content (13.75 % to 48 %) were in the range of 5.44% to 38.1% in comparison with the flexural strength of control beam.
2) The flexural strength of the beam retrofitted using single layer GFCL for full depth and single layer CFCL at soffit is increased by 38.1% in comparison with the flexural strength of control beam this is because of increase bond of GFCL to concrete and high strength of CFRC sheet.
3) The wrapping of beam with single layer of CFCL at soffit increases the ductility by 22.84 % in comparison with wrapping the beam with one layer of GFCL at soffit.
4) The retrofitted beams possessed less ductility compared to the un-retrofitted beams. Hence retrofitted beams failed either by fracture of fibre or delamination of fibre sheets from concrete.
5) From the test results it can be concluded that retrofitting with GFCL and CFCL provides a feasible rehabilitation technique for repair and strengthening.
6) The cost of retrofitting of beams using FRP is quite expensive.
7) To achieve full capacity of laminate and to avoid failure by delamination, it is necessary to provide anchorage length for the fibres.

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