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Experimental Analysis of Epoxy Bonded Beams with GFRP Laminates

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Abstract: ***External wrapping or retrofitting of polymer sheets are used in concrete and reinforced concrete structures is an increasing trend present. This paper evaluates the flexural behavior of beams retrofitted externally with GFRP laminates. Experimental plan deals with static experimental analysis. Reinforced beams of sizes 200×250×3500mm are casted for a grade of M35. Reinforced beams are externally retrofitted with E-glass fiber polymers. Beams are epoxy bonded to the GFRP laminates. Beams are tested under monotonic two point concentrated loading. Load – Deflection characteristics, crack pattern and failure characteristics of beam are analyzed.***

Keywords: retrofitting, GFRP laminates, numerical analysis, experimental analysis.

I. INTRODUCTION

Reinforcement in beams is provided to resist against tension caused by different loads. Different types of steel bars of different diameters are provided in tension and compression zone of the beam. IS 456 provides the clear information related to the design of reinforced concrete beam. Other than reinforcement, polymers are used in concrete to increase ductile characteristics of the structure. Most common methods adopted in using polymers are either using fiber polymers mixing in concrete or external retrofitting with fiber reinforced polymer laminates. Externally retrofitted FRP laminates provide extra strength of reinforced concrete beam to withstand against failure. In this study FRP laminates are bonded to the external surface of beam using epoxy adhesive. Both the values are compared and results are plotted.

II. MATERIALS

A. Cement

Ordinary Portland cement of 53 grade is used, chemical composition of cement is done using XRF analysis and shown in table 1

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COMPOSITION	***OPC (%)***
SiO_2	14.03
Al_2O_3	2.68
Fe_2O_3	2.57
CaO	42.81
MgO	0.67
SO_3	0.40
Na_2O	0.26
K_2O	0.32
Mn_2O_3	0.2
TiO_2	0.00
Cl	0.00

Table 1: chemical composition of cement

B. Fine and coarse aggregate

River sand of passing through 4.75mm sieve is used as fine aggregate. Coarse aggregate of 12mm is chosen. Super plasticizer is used for the through mixing and flow ability of the concrete and stone dust is also used.

C. Mix design

Design mix proportions are 1:1.72:2.51:0.36 is used for preparing the test specimen. Stone dust is taken as 5% of weight of the cement. Mix proportion of the concrete is shown in table2. All components of design mix are given kg/m^3.

Cement	Fine Aggregate	Coarse Aggregate	water	Stone dust
440	770	1104.4	158.4	22

Table 2: Mix proportions

D. Reinforcement details

Two bars of 12mm diameter are used in tension zone and 8mm bars are used as shear reinforcement with spacing of 100mm. GFRP laminates of thickness 3mm are used for external retrofitting RC beam.

III. TESTS CONDUCTED

Casted beams were tested under two point loading using two point loading frame. Deflections in beam are measured by using dial gauges of accuracy 0.01mm. Crack width of the beam is measured using detection microscope of least count 0.02. Curvature is measured using dial gauges fixed at the compression side of the beam.

Loading of beam is steadily increasing up to failure. Crack development is tested during testing.

IV. TEST RESULTS

A reference reinforced concrete beam and GFRP laminated beams were tested for first crack load, deflection at first load, ultimate load and deflection at ultimate load, ductility characteristics and no of cracks developed. Reference beam is designated as RCB and GFRPEB is the designation for the epoxy bonded beam. Test values are tabulated in Table 3.

Comparative graph of RCB and GFRPEB is shown in fig 1and fig 2

Beam designation	First crack load (KN)	Deflection at first crack (mm)	Ultimate load (KN)	Deflection at ultimate load (mm)
RCB	16.21	1.66	58.88	41.21
GFRPEB	28.23	4.11	76.77	58.33

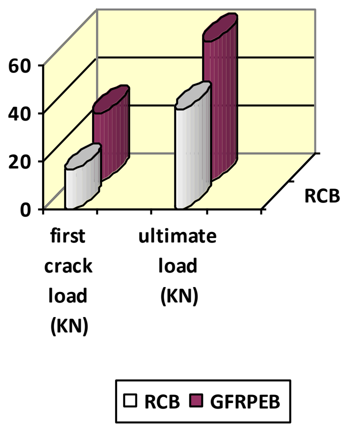


FIG 1: FIRST CRACK AND ULTIMATE LOAD OF RCB AND GFRPE

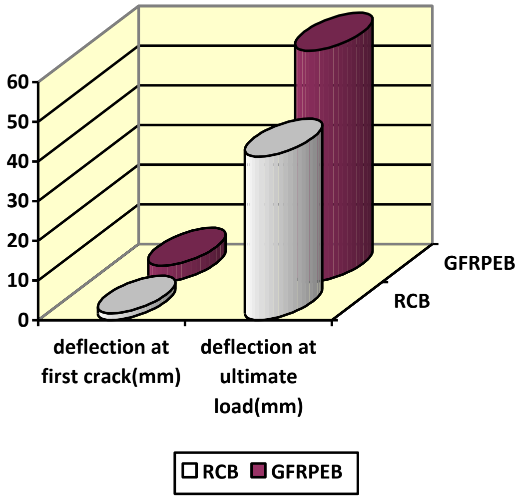
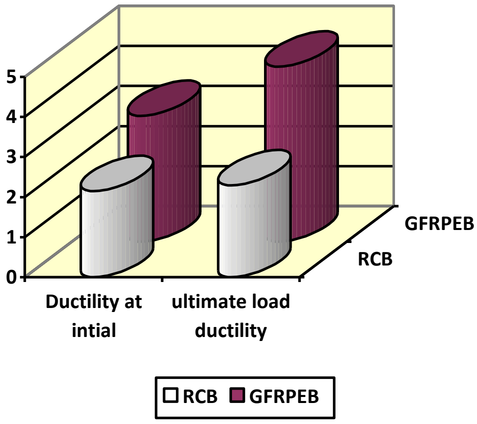


Fig 2: Deflection of RCB and GFRPEB

Ductility characteristics of RCB and GFRPEB is compared and plotted in Fig 3.



V. DISCUSSIONS

- It is evident from the test results that first cracking is occurring at very early load for reference beam compared to laminated beam. Crack load has difference of nearly 28%.
- Deflection characteristics of RCB and GFRPEB show a difference of 33% though deflection characteristics are high for GFRPEB, but load bearing capacity is high.
- GFRPEB is more ductile compared to RCB. Laminates are increasing the load carrying capacity as well as ductility.

VI. CONCLUSION

From the experimental results following inferences can be drawn

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- Laminated beams exbhit high strength and ductility When both beams are compared. This could b due to adhesive action of bonding and high strength of GFRP laminates.
- Thickness of GFRP laminate has a big impact on increase in strength.
- These types of beams can be used in a place of high corrosion concentrations where strength of the beam reduces due to corrosion.

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