RETROFITTING OF RC BEAM ELEMENTS USING FIBRE REINFORCED POLYMER (FRP) MATS

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ABSTRACT: Now a days it is common observation that structures are unable to offer service as much as they are expected as per design. This is often as a result of deterioration of the concrete and reinforcements caused by environmental factors and therefore the widespread application of deicing salts, or as a result of an increase in applied loads. The Retrofitting will be used as an cost-effective solution to the replacement of these structures and is commonly the sole feasible option. Fibre reinforced Polymers (FRP) mats are well suited to the current application as a result of their high strength-to-weight ratio, good fatigue properties, and wonderful resistance to corrosion. A lot of analysis has been done on the FRP as reinforcement in concrete beams. However, the number of analysis conducted on FRP as a mat & laminate; is sort of less. So within this paper, impact of FRP on RC beams as a retrofitting material and comparative impact of laminates with mats having equivalent area has been studied.
Keywords: concrete, replacement, FRP, strength-to-weight ratio, mat, laminate.

I. INTRODUCTION

An increasing range of concrete structures have reached the top of their service life, either attributable to deterioration of the concrete and reinforcements caused by environmental factors and therefore the widespread application of deicing salts, or attributable to associate increase in applied loads. These deteriorated structures could also be structurally deficient or functionally obsolete, and most are currently in serious want of in depth rehabilitation or replacement. Strengthening may be used as a cost-effective alternative to the replacement of these structures and is usually the sole possible solution. Fibre reinforced Polymers (FRP) mats or laminates are well suited to the current application owing to their high strength-to weight ratio, good fatigue properties, and wonderful resistance to corrosion. Their application in the civil engineering structures has been growing quickly in recent years becoming an effective and promising answer for strengthening deteriorated concrete members. As a result of FRPs being quickly and simply applied, their use minimizes traffic disruption and labour costs and might cause important savings within the overall costs of a project.

II. LITERATURE REVIEW

Yasmeen Taleb Obaidat , Susanne Heyden, et al. studied the behavior of structurally damaged full-scale reinforced concrete beams retrofitted with CFRP laminates in shear or in flexure. Carlo Pellegrino and Mira Vasic aimed to assess some common design models for the prediction of the shear capacity of RC beams strengthened with externally bonded FRP composites. Hidenori Murakami and Jack Y. Zeng examined he strength and ductility of slurry infiltrated mat concrete (SIMCON) tension members were investigated both experimentally and analytically to construct a mechanical model for simulating tensile force–displacement relationships. Hee Sun Kim and Yeong Soo shin reported experimental studies of re-inforced concrete beams with new hybrid fibre re-inforced polymer system containing CFRP & GFRP.

III. EXPERIMENTAL INVESTIGATION

A preliminary experimental study was conducted to see the optimum volume fraction of fiber mat. Five laminates of size 100×20×500mm3 were cast(shown in Fig. (1).) with totally different volume fractions (Vf), say 1%, 2%,3%,4% and 5%.Among these test results it is found that Vf = 5% gives better performance with regard to ultimate load (U.L) and stiffness. Every mat has 4 or 5 layers of fibers as per Vf and therefore the individual fibers square measure warranted with low viscosity synthetic resin that ought to not have an effect on the voids between the individual fibers for achieving excellent cement grout. Then the fiber mats were kept within the mould and were grouted; the cement slurry was mixed in a mortar mixer with super plasticizer for increasing workability with reduced w/c ratio and to possess adequate fluidness so as to facilitate construction of specimens. Hence care has been taken in selecting the constituent materials supported based on different trail mix. Mix ratio of the cement suspension is given below:
Sand /cement – 1:1
Water/cement ratio– 0.30
Super plasticizers / Cement - 0.025

Fig. (1). Laminates with Vf 1%,2%,3%,4% & 5%

IV. MIX PROPORTION

Based on numerous trials the mix proportion obtained is 1:2.19:2.92 at 0.35 water/cement ratio for M25 grade

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concrete. Conplast 430 is used as super plasticizer. Specimen's sizes Beams of size (100 x 200 x 1200 mm3) were casted using M 25 grade concrete. The beams are stressed up to the level at which they stopped taking further load and then retrofitted with FRP laminates & mats. The glass fibre mat is shown in Fig. (3).

V. RETROFITTING PROCESS

The test procedure consists of

5.1. The retrofitting is carried out by two process:

i. By casting laminates of 20mm thickness and attaching them to the beams.

ii. Directly pasting the fibre mat to the beam surface.

5.2. The beams are under reinforced section, reinforced with 2-10 # at bottom, 2–8 # at top using 6mm dia stirrups @ 120 mm c/c (Fig. 2). M 22 concrete and Fe 415 grade Steel are used. The laminates with volume fraction 5% were made total length of 1000mm and left for curing for 28 days. The soffit of the beams was sand blasted to get rid of the surface laitance and then blown freed from mud dust using compressed air when surface preparation, the adhesive elements were mixed in the ratio of 1:3 more quantity being the epoxy resin and the remaining hardener and totally applied to the surface using a trowel. The laminates already casted were placed over the beam and are being held in position by dead weights for 24 hours.

VI. PROPERTIES OF GFRP

Different properties of Glass fibre mat are shown in the below table 1

Material	Density (KG/M3)	Longitudinal tensile modulus	Tensile strength (MPA)
GFRP mat	1600-2000	20-55	400-1800

Table. (1). Different properties of glass fibre mat

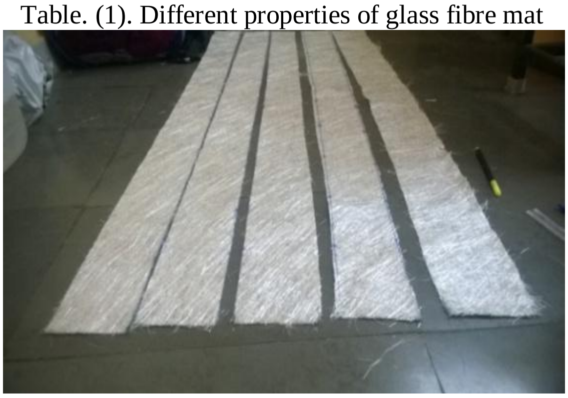

Fig. (2). Glass fibre mat

VII. TESTS CONDUCTED

These are the following tests that are conducted in laboratory for finding out different parameters.

7.1. Flexural strength

The deflections are noted using deflection meter and the single point loading is applied at the centre using UTM Fig (5). Deflections are noted at L/2 and L/4 from the end.

Fig. (3) UTM for flexure strength testing

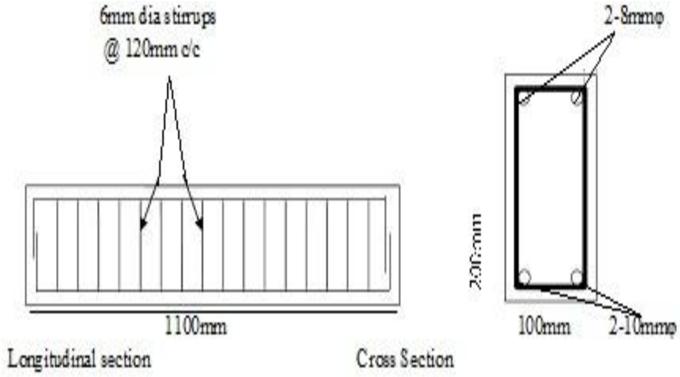

Fig. (4). Longitudinal and Cross Section of beam

Fig. 5.(1). Application of Epoxy Fig. 5(2). Pasting of Mat
Fig. 5(3). Pasting of Laminate

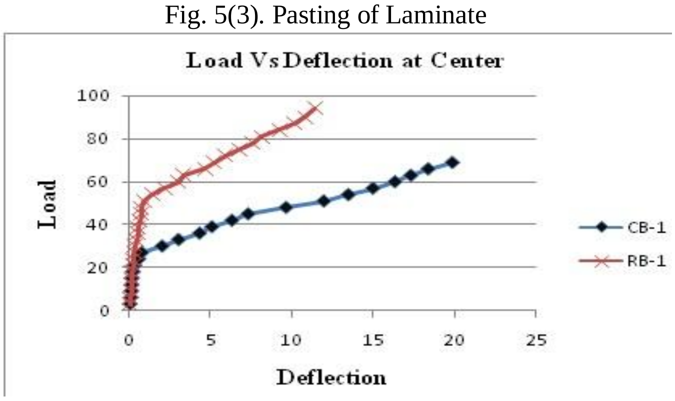

Fig 6.(1) Load deflection curve at the center of the beam for RB-1

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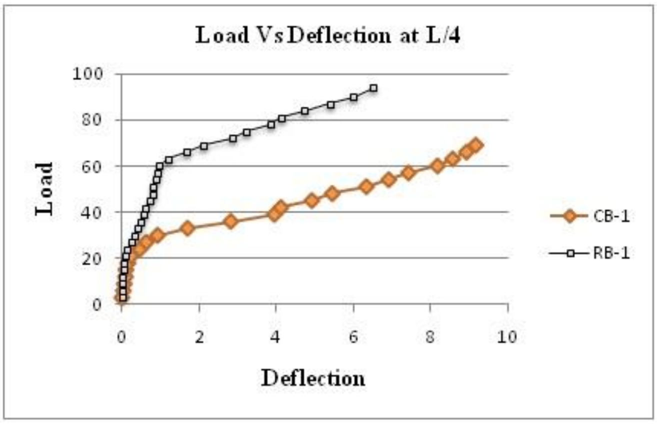

Fig 6.(2) Load deflection curve at L/4 from support of the beam for RB-1

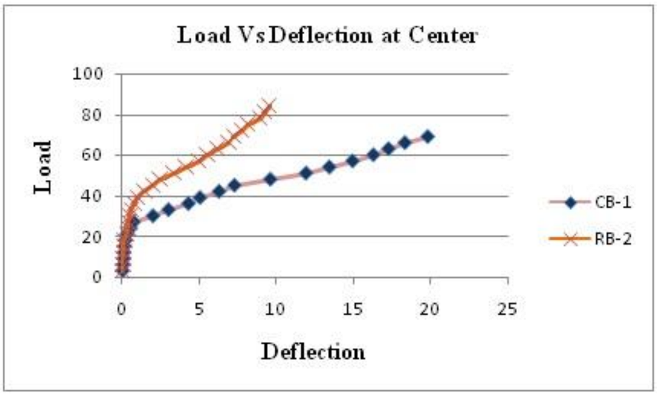

Fig 6.(3) Load deflection curve at the center of the beam RB-2

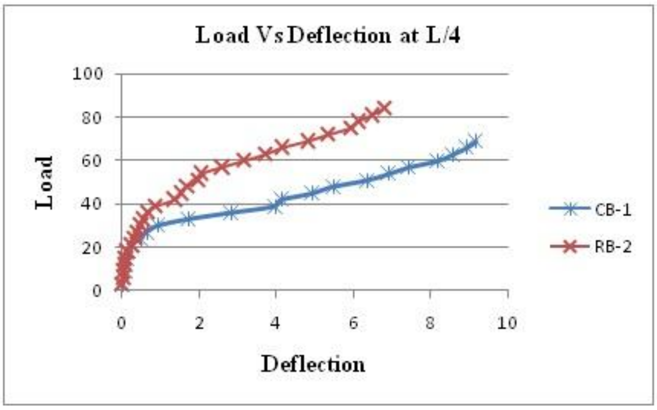

Fig 6.(4) Load deflection curve at L/4 from the support of the beam RB-2

S.no	Beam Detail	First Crack Stage		Service Stage		Yield Stage		Ultimate Stage	
		Load	Deflection	Load	Deflection	Load	Deflection	Load	Deflection
1	CB-1	33	3.002	42	6.278	57	14.948	70	19.82
2	RB-1	32	0.419	61	5.96	83	8.863	95	11.39
3	RB-2	30	0.533	53	3.853	68	4.69	85	9.54

Table. (2). Different Stages of loadings and corresponding deflections

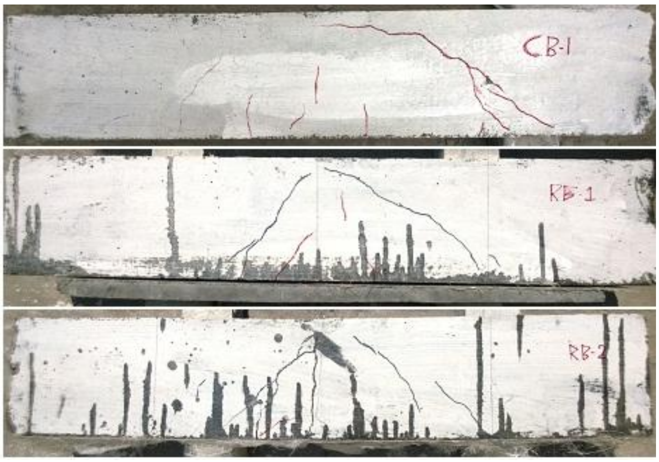

Fig. (7). Crack patterns of the beams after the loading/

VIII. CONCLUSION

1. The fibre laminates properly bonded to the tension face of RC beams can enhance the flexural strength substantially. Load carrying capacity of retrofitted beam was significantly improved as compared to fresh beams.
2. The strengthened beams with laminates exhibit an increase in flexural strength of 26.31% for laminates having volume fraction 5 %.
3. The strengthened beams with mats exhibit an increase in flexural strength of 17.64 % for laminates having volume fraction 5 %.
4. Comparing beam applied with laminates & beam applied with fibre mats having equivalent area, laminates have taken 11.76% more load than mats.
5. At any given load level, the deflections are reduced significantly thereby increasing the stiffness for the strengthened beams. At ultimate load level of the control specimens, the strengthened beams exhibit a decrease of deflection up to 42.53 % for laminates and 51.86 % for mats.
6. All the beams strengthened with both mats and laminates with optimum volume fraction 5 % experience flexural failures. None of the beams exhibit premature brittle failure.
7. A flexible epoxy system will ensure that the bond line does not break before failure and participate fully in the structural resistance of the strengthened beams.

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