Flexural Behavior of Reinforced Concrete Strengthened With CFRP Sheets

[1] R.Mohan Babu [2] P.Vijaya Kumar [3] M.Muneeswaran, [4] S.Annamalai

Department of Civil, VEL Tech Engineering College, Avadi, Chennai, India

ABSTRACT: Six reinforced concrete beams strengthened in flexure using carbon fiber reinforced polymer (CFRP) laminates subjected to different loads were tested. The main goal is to examine the effect of initial load and load history on the ultimate strength of strengthened RC beams by externally bonded CFRP laminates. Externally bonded CFRP strips help in improving the structure performance by reducing deflection and cracking and increasing ultimate strength. The ultimate capacity of the strengthen beam is controlled by either compression, crushing of concrete, rupture of CFRP and flexural cracking induced de-bonding at concrete-CFRP interface .three beams strengthened with CFRP wraps at bottom were tested with different width . It was observed that the CFRP wraps resulted in significantly increasing the stiffness and ductility of the RC beams along with increasing load carrying capacities of the reinforced concrete beams. Comprehension of performance of strengthening structures will allow for more precise designs that will balance safety and cost. Six beams strengthened with CFRP wraps at tension zone were tested with different width/layers .

I. INTRODUCTION

Reinforced concrete structures have enabled the vast world-wide construction of infrastructures. Strengthening of RC structure may be required due to modifications in design standards/codes or in usage of structure. Therefore, all these may result in a need to strengthen an existing or new structure. Many construction methodologies that are being practised are of importance now but they were ignored previously, resulting in distress and hence require strengthening. Since 1980, engineers have been investigating a means of post-strengthening Reinforced and pressurised concrete members via the bonding to their surfaces of fibre reinforced plastic sheets. This method, potentially useful for both strengthening

Weak structures whose capacity is insufficient, or for repairing damaged structures, has many advantages compared to conventional methods. The Canadian Armed Forces, with operations overseas in support of the United Nations, sees the potential of this technology as a fast and effective method of increasing the capacity of existing roadway bridges or buildings; Four point bending flexural test are conducted on four concrete control beams with externally bonded carbon fibre reinforced polymer sheets/ fabric. The effectiveness of externally bonded CFRP on the flexural strength of the concrete beam is studied

The objective of this investigation is to study the effectiveness of CFRP sheets or fabric supplied by fibre reinforced system in increasing the flexural strength of the concrete. The objective is achieved by conducting following tasks

- To perform Flexural testing of concrete beam strengthened with different layers of CFRP
- To calculate the effect of different layers of CFRP sheets
- To evaluate the failure mode

II. RESEARCH SIGNIFICANCE

The research aim to study the effect of mechanical bonding for the CFRP laminates with the concrete substrate to enhance the flexural beam capacity using different width CFRP laminate surface. How CFRP improves the bonding capacity of the beam.

III. MATERIALS AND METHODS

Materials used in the project are listed below .Initially the materials were collected and batched for casting beam and cube. Curing is done by immersing the casted materials and after 28 days test were conducted

1) Cement
2) Sand
3) Coarse aggregate
4) Steel

5) CFRP

Table –properties of cement

Grade of concrete	M20
Specific gravity	3.15
Mix design	0.5:1:1.42:3.4
7 Days strength	15 N/mm^2
28 days strength	22 N/mm^2

Table-properties of fine aggregate

Sieve analysis	Lies in zone 2
Specific gravity	2.5
Apparent specific gravity	2.8
Moisture content	1.88

Table-properties of coarse aggregate

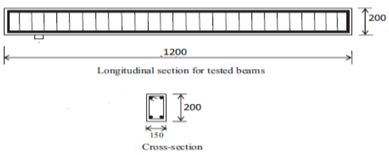
Specific gravity	2.62
Apparent specific gravity	2.70
Aggregate impact value	18.7%

Table- Properties of CFRP

Materials	Property	Values
CFRP LAMINATES	Sheet form	Uni-directional
	Yield strength(MPa)	1315
	Modulas of elasticity (GPa)	165
	Thickness	0.18
	Tensile stength(MPa)	1685
	Density (g/cm$^{3)}$	1600
EPOXY ADHISEIVE	Modulus of elasticity (GPa)	3
	Tensile strength(MPa)	55

Four point bending flexural tests are conducted up to failure on two concrete control beams .The CFRP fabric is a stitched unidirectional sheet of 0.18 mm thick. The length, breadth and depth (l*b*d) of all concrete beams is kept as 150mm*200mm*1200mm. Each concrete beam is reinforced with 6 mm dia steel bars for tension and 6 mm dia for stirrups at a spacing of 200 mm center to center spacing for shear reinforcement .The flexural span of all beams is kept as 1000 mm

The concrete control beams are designated as CB Three beams strengthened with different layouts of CFRP sheets designated as CFP 1,CFP 2,CFP 3, Three beams strengthened with different layer of CFRP sheets



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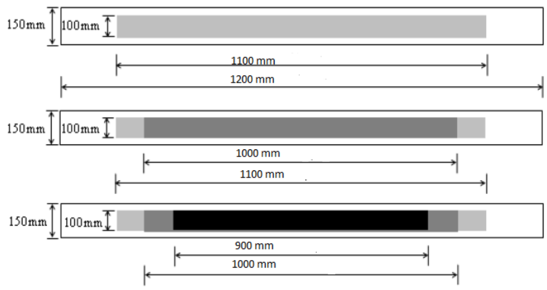
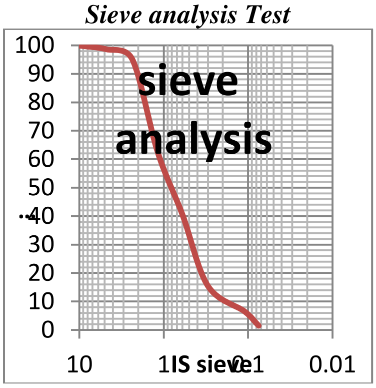


IV. RESULTS AND DISCUSSIONS

The following test results were found to calculate the mix design used for the project

Sieve analysis Test



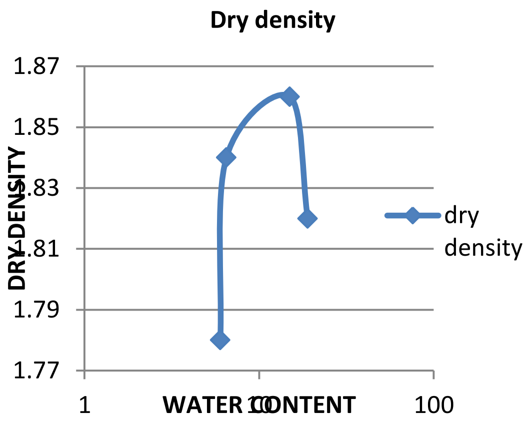
Specific gravity results

Weight of the sample =2000g
Weight of the saturated
+ surface dry = 500 g (C)
Weight of pycnometer +sample
+water =1820g (A)
Weight of the pycnometer
+ water = 1514g (b)
Weight of the oven dry sample
=480 g(D)
Specific gravity = d /(c-(a-b))*100
480/(500-(1820-1514) =2.5

Specific gravity test for coarse aggregate

Weight of the sample = 1000
Weight of the vessel = 3360 (A)
Weight of the vessel + water = 2750 (B)
Weight of the sample + saturated dry = 980 (C)
Weight of oven dry = 972 (D)
Specific gravity = D/(C-(AB))
972/(980-(3360-2750)) = 2.62

Moisture content results



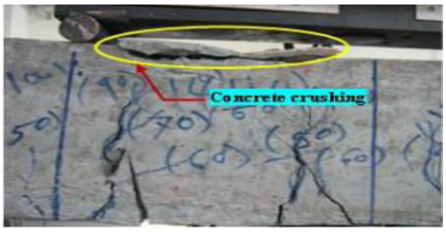
Mix design

Water	Cement	Fine	Coarse
0.5	1	1.4	3.4

Flexural Behavior Results

S.NO	EXPERIMENTAL LOAD(Kn)		DEFLECTION(mm)		Ductility index
	CRTICAL	ULTIMATE	CRITICAL	ULTIMATE	
CB	12.5	40.3	1.9	6	3.15
CFP 1	14.5	62	2.5	6.6	2.64
CFP 2	17.6	69.7	2.6	6.3	2.56
CFP 3	20.7	75.9	2.8	6.5	2.32

IV. EVALUVATING FALIURE MODE CONVENTIONAL BEAM



TWO LAYERED CFRP

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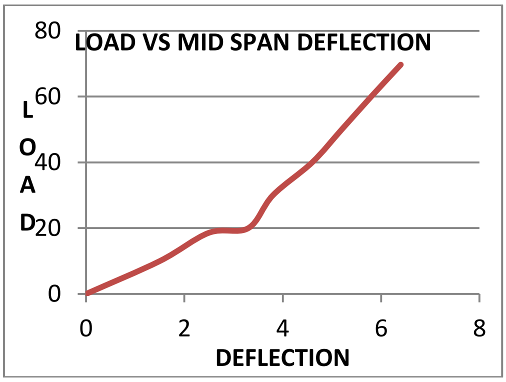
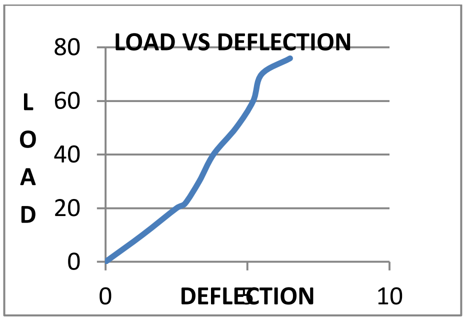
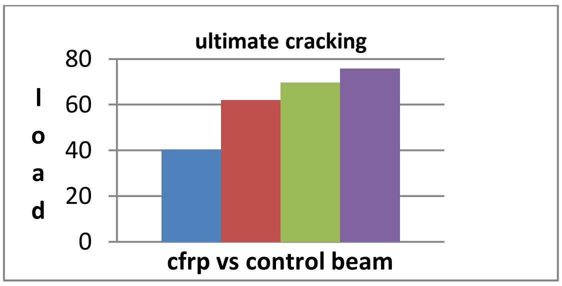


THREE LAYER CFRP



V. CONCLUSIONS

Based the graph shown in the FIG .we have concluded that beams externally strengthened by CFRP bonded by epoxy resin shown significantly increase in the flexural capacity and also in the ductility index.



The result of the experimental study indicates that externally bonded CFRP laminates can be used effectively to strengthen the reinforced concrete beams. Regarding the effect of number of layers, an increase in stiffness and flexural strength is achieved with the increase of CFRP layers. All the strengthened beams didn't show any inter-layer de-lamination in any cases. Regarding the effect of transverse edge strip, significant improvement in flexural strength was noted and the de-bonding of laminates occurred just before the final failure.

REFERENCES

[1] Almusalam TH, Alsayed SH. Structural behavior of reinforced concrete beams strengthened by bonded steel or GFRP plates. In: Proceedings of the first international conference on composites in infrastructures, Tucson, Arizona; 1996. p. 786–99.

[2] Lamanna Anthony J et al.. Flexural strengthening of reinforced concrete beams using fasteners and fiber-reinforced polymer strips. ACI Struct J 2001;98(3).

[3] Alagusundaramoorthy P, Harik IE, Choo CC. Flexural behaviour of R/C beams strengthened with carbon fiber-reinforced polymer plates and steel. J Compos Construct 2003;7(4):292–301.

[4] Ashour AF, El-Refaie SA, Garrity SW. Flexural strengthening of RC continuous beams using CFRP laminates. Cement Concrete Compos 2004;26(7):765–75.

[5] Ahmed Ehsan, Sobuz Habibur Rahman, Sutan Norsuzailina Mohamed. Flexural performance of CFRP strengthened RC beams with different degrees of strengthening schemes. Int J Phys Sci 2011;6(9):2229–38.

[6] Jumaat MZ, Rahman MM, Alam MA. Flexural strengthening of RC continuous T beam using CFRP laminate: a review. Int J Phys Sci 2010;5(6):619–25.

[7] Sobuz HR, Ahmed E. Flexural performance of RC beams strengthened with different reinforcement ratios of CFRP laminates. Key Eng Mater Trans Technol Publ 2011;471–472:79–84.

[8] Yao J, Teng JG. Plate end de-bonding in FRP-plated RC beams— I: experiments. Eng Struct 2007;29:2457–71.

[9] Anthony Lamanna, Flexural strengthening of reinforced concrete beams with mechanical fastened FRP strips. Ph.D., University of Wisconsin, Madison, 2002.

[10] Sayed-Ahmed EY, Bakay R, Shrive NG. Bond strength of FRP laminates to concrete: State-of-the-Art review. Electron J Struct Eng 2009;9.

[11] Sharif A, Al-Sulaimani FJ, Basunbul IA, Baluch MH. Strengthening of initially loaded reinforced concrete beams using FRP plates. ACI Struct J 1994;91(2):160–8.

[12] Sharif Alfarabi, Al-Sulaimani GJ, Basunbul IA, Baluch MH, Ghaleb BN. Strengthening of initially loaded reinforced concrete beams using FRP plates. ACI Struct J 1994;91(2):160–8.

[13] Spadea G, Bencardino F, Swamy RN. Structural behavior of composite RC beams with externally bonded