International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.11, pp 167-176, 2017

Study on Flexural Behaviour of RC Beams with Extra Addition of Glass Fibre and CFRP Composites under Flexural Loading

***Manikandan. T, K. Rajkumar,**

Structural Engineering/SBM College of Enggand Tech., Dindigul, Tamilnadu, India

Abstract : In our country many of the existing reinforced concrete structures are in need of repair or reconstruction, rehabilitation, because of deterioration due to various factors like corrosion, lack of detailing, failure of bonding between beam, column, slab, etc…Strengthening of existing reinforced concrete structures is necessary to obtain an expected life span and achieve specific requirements. The need for efficient rehabilitation and strengthening techniques of existing concrete structures has resulted in research and development of composite strengthening systems. Recent experimental and analytical research have demonstrated that the use of composite materials for existing structural components is more cost-effective and requires less effort and time than the traditional means. Carbon Fiber Reinforced Polymer (CFRP) composite has been accepted in the construction industry as a capable substitute for repairing and strengthening of RCC structures. During past two decades, much research has been carried out on flexural strengthening of reinforced concrete beams using different types of fiber reinforced polymers and adhesives. A detailed Literature review based on the previous experimental and analytical research on reinforced concrete beams is presented. Proposed method of strengthening the RC beam is decided based on the previous experimental and analytical research. Behaviors of reinforced concrete beams with externally bonded CFRP with various types of resins is investigated. Static load responses of all the beams under two point load method had evaluated in terms of flexural strength, crack observation, compositeness between CFRP fabric and concrete, and the associated failure modes.
Keywords : Carbon Fibre Reinforced Polymer, CFRP strengthened beam, Beam flexural behavior, CFRP laminates.

Introduction

The development of external bonding of High-strength Carbon fiber reinforced polymer (CFRP) composites is the potential technique over the steel plates in structural strengthening and upgrades of damaged or deteriorated members. Before the introduction of carbon fiber reinforced polymer strengthening technologies, one popular technique for upgrading reinforced concrete beams was the use of external epoxy-bonded steel plates. This method suffers deterioration problem caused by the corrosion of the steel. There is wide range of techniques available to repair or strengthen structurally deficient and functionally aged structures. One such technique is adding CFRP as external bonded reinforcement to the structure for upgrading reinforced concrete beams was the use of externally epoxy-bonded steel plates. Repair and strengthening of existing reinforced concrete structures is of great interest for extending their service life as well as for their rehabilitation. Repair of concrete structures can be classified as restoring the original structural shape and strengthening. There are different techniques available for retrofitting and strengthening of various reinforced concrete structural elements. The methods were developed due to different causes, such as inadequate maintenance, overloading of the RC member, corrosion of the steel reinforcement and other reasons

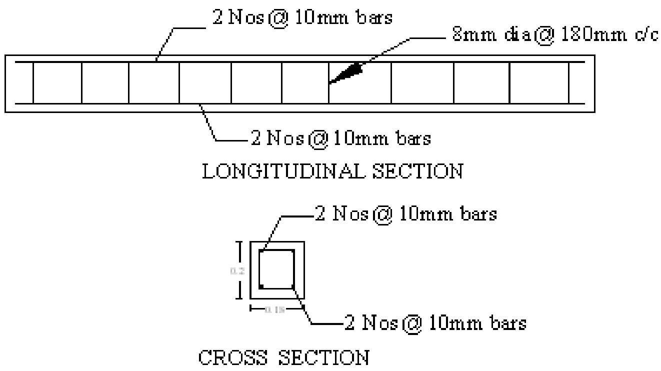

Fig 1. Reinforcement details for beam

Carbon fibres have the highest specific modulus & specific strength of all reinforcing fibre materials. Carbonfibres are not affected by moisture or variety of solvents, acids, bases. Fibre & composite manufacturing processes have been developed that are relatively inexpensive & cost effective.

Experimental Program

Bonding of CFRP composites with suitable epoxy adhesive on external surface of structures is the most versatile and widely used technique for strengthening RC beams. Generally, the soffit (bottom) bonding is done for flexural strengthening, while web bonding is preferred for shear strengthening.

Bonding of CFRP composites on beam webs is one of the highly effective methods, since it can provide both the shear and flexural enhancement for concrete beams. The use of lay-up CFRP composites under increased load conditions reveals a reduced deflection and smaller crack widths.

Also, the use of composites offers several advantages like ease of bonding to curved or irregular surfaces, lightweight/ease of application and fiber flexibility to orient in a desired direction for strengthening.

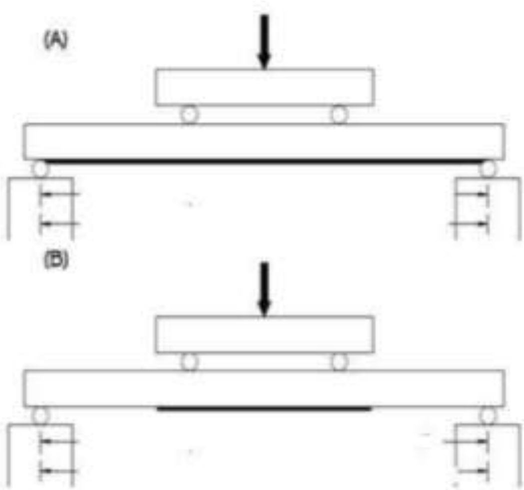

Fig 2. Wrapping scheme

Test Methods

The flexural behavior of the reinforced concrete beam is observed under two point loading. The test data are recorded and it will be interpreted for further comparison with CFRP wrapped beams. The reinforced concrete beam with glass fibre mixes is tested under the same loading conditions. The point at which the cracks occurred is noticed and the flexural strength of the beam is noted. The precracked beams are wrapped with CFRP laminates by using epoxy resins. Then the wrapped concrete samples are allowed to cure for one week. This concrete specimen is again tested with the same loading setup. The result data are tabulated, interpreted and the discussions are made based on the observed results. The test process of control beam and retrofitted beams are shown in figures.

Fig 3. Testing of control beam

Fig4. Deflection and Crack patterns observed in control beam under loading

Fig 5. CFRP partially wrapped on its tension zone

Fig 6. Crack patterns observed in partially wrapping beam

Fig 7. CFRP fully wrapped on its tension zone

Fig 8. Crack patterns observed in fully wrapping beam

Results

A result shows that as the addition of CFRP increases the strength.

Table 4.Load – Mid Span Deflection

Control Beam

Load	Left	Mid	Right
0	0	0	0
0.5	0.15	0.65	0.15
1	0.61	0.99	0.61
1.5	1.33	1.72	1.33

Ultimate load = 2 TON

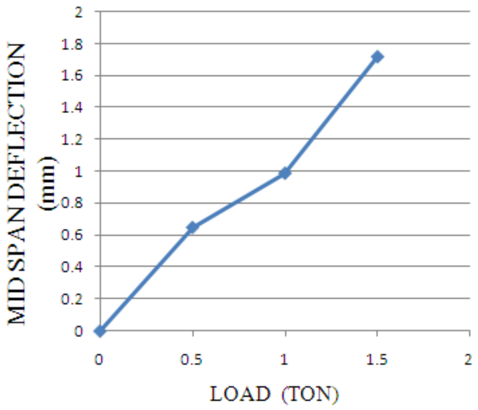

Fig 9. Load – Mid Span Deflection(CB)

Table 5.Load – Mid Span Deflection

PWB for Single Layer

Load	Left	Mid	Right
0	0	0	0
0.3	0.08	0.2	0.08
0.6	0.15	0.37	0.15
0.9	0.36	0.70	0.36
1.2	0.55	1.10	0.55
1.5	0.77	1.47	0.77
1.8	1.15	2.14	1.15
2.1	1.46	2.63	1.46
2.4	1.79	3.18	1.79
2.7	2.30	3.72	2.30
3	2.89	4.49	2.89
3.3	3.37	5.13	3.37
3.6	3.70	5.68	3.70
3.9	4.22	6.25	4.22
4.2	4.74	7.09	4.74
4.5	5.10	7.68	5.10

Ultimate load = 5.4 TON

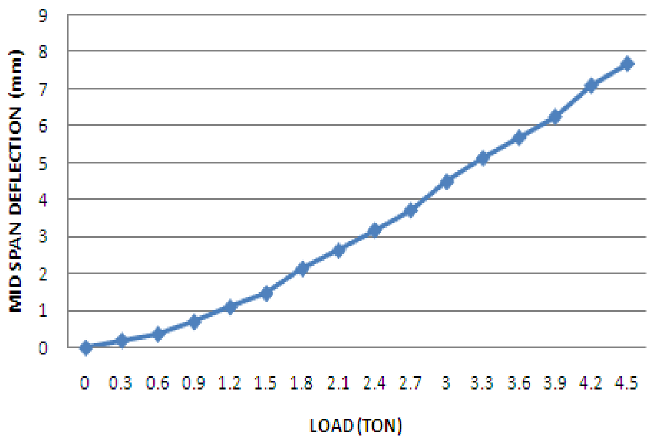

Fig 10. Load – Mid Span Deflection

(PWB for Single Layer)

Table 6.Load – Mid Span Deflection

PWB for Two Layers

Load	Left	Mid	Right
0	0	0	0
0.3	0.23	0.26	0.23
0.6	0.38	0.42	0.38
0.9	0.55	0.65	0.55
1.2	0.88	1.12	0.88
1.5	1.25	1.89	1.25
1.8	1.73	2.35	1.73
2.1	2.28	3.05	2.28
2.4	2.68	3.63	2.68
2.7	3.24	4.48	3.24
3	3.62	5.12	3.62
3.3	4.20	5.75	4.20
3.6	4.66	6.50	4.66
3.9	5.24	7.14	5.24
4.2	5.65	8.15	5.65

Ultimate load = 5.7 TON

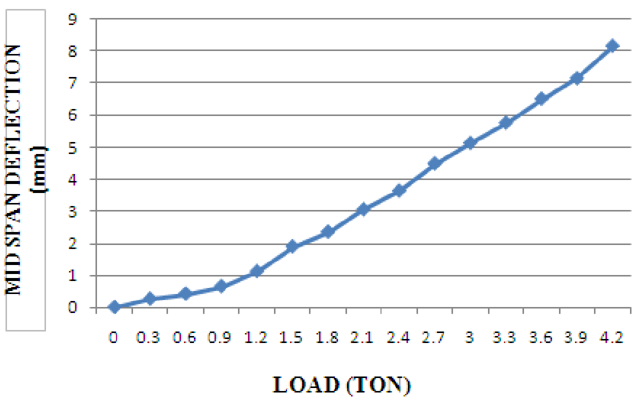

Fig 11. Load – Mid Span Deflection

(PWB For Two Layers)

Table 7.Load – Mid Span Deflection

PWB for Three Layers

LOAD	LEFT	MID	RIGHT
0	0	0	0
0.3	0.21	0.19	0.21
0.6	0.45	0.38	0.35
0.9	0.54	0.64	0.54
1.2	0.85	1.12	0.85
1.5	1.28	1.86	1.22
1.8	1.71	2.32	1.71
2.1	2.2	3.01	2.2
2.4	2.75	3.6	2.65
2.7	3.2	4.46	3.2
3	3.68	5.1	3.58
3.3	4.1	5.71	4
3.6	4.58	6.48	4.58
3.9	5.26	7.1	5.2
4.2	5.73	8.1	5.63

Ultimate Load-6.5 TON

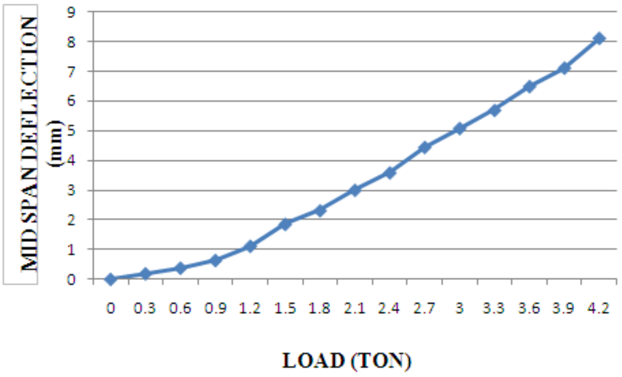

Fig 12. Load – Mid Span Deflection

(PWB For Three Layers)

Table 8.Load – Mid Span Deflection

FWB For Single Layer

LOAD	LEFT	MID	RIGHT
0	0	0	0
0.3	0.24	0.26	0.24
0.6	0.47	0.56	0.47
0.9	0.73	0.84	0.67
1.2	0.87	1.14	0.87
1.5	1.47	1.94	1.42
1.8	1.58	2.17	1.58
2.1	1.98	2.75	1.98
2.4	2.45	3.3	2.35
2.7	2.82	4.02	2.82
3	3.18	4.58	3.18
3.3	3.42	5.03	3.4
3.6	3.83	5.54	3.83
3.9	4.28	6.15	4.28

4.2	4.68	6.74	4.68
4.5	5.24	7.52	5.17
4.8	5.75	8.22	5.6

Ultimate Load-5.74 TON

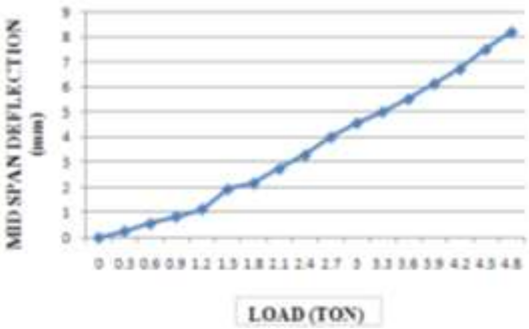

Fig 13.Load – Mid Span Deflection

FWB For Single Layer

Table 9.Load – Mid Span Deflection

FWB For Two Layers

LOAD	LEFT	MID	RIGHT
0	0	0	0
0.3	0.25	0.29	0.25
0.6	0.44	0.48	0.44
0.9	0.63	0.68	0.63
1.2	0.84	0.93	0.84
1.5	1.22	1.35	1.22
1.8	1.52	1.83	1.52
2.1	1.92	2.36	1.92
2.4	2.37	2.96	2.37
2.7	3.62	3.66	3.62
3	3.82	3.92	3.82
3.3	4.43	4.34	4.43
3.6	4.93	4.95	4.93
3.9	5.34	5.64	5.34
4.2	5.59	5.94	5.59
4.5	6.20	6.54	6.20
4.8	6.34	6.96	6.34
5.1	6.78	7.54	6.78
5.4	7.32	8.19	7.32

Ultimate Load- 6.3 TON

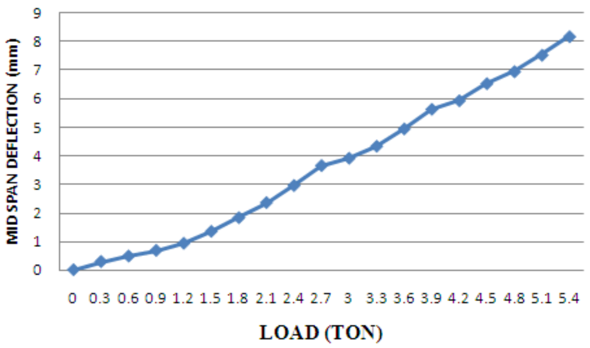

Fig 14.Load – Mid Span Deflection

FWB For Two Layers

Table 10.Load – Mid Span Deflection

FWB For Three Layers

LOAD	LEFT	MID	RIGHT
0	0	0	0
0.3	0.12	0.16	0.12
0.6	0.22	0.25	0.22
0.9	0.43	0.48	0.43
1.2	0.56	0.60	0.56
1.5	0.72	0.84	0.72
1.8	0.81	1.88	0.81
2.1	0.95	1.98	0.95
2.4	1.04	2.04	1.04
2.7	1.13	2.55	1.13
3	1.44	2.92	1.44
3.3	1.86	3.50	1.86
3.6	2.27	3.96	2.27
3.9	2.62	4.57	2.62
4.2	2.94	5.06	2.94
4.5	3.42	5.62	3.42

Ultimate Load-6.6 TON

Conclusion

Based on the results obtained from experiments, following conclusions are drawn. The external bonding of CFRP fabrics offers an externally effective means of strengthening Reinforced Concrete (RC) beams flexure.CFRP fabric property bonded to the tension face of RC beams can enhance the flexural strength substantially the strengthened beams exhibit an increase in flexural strength for 40 to 45 percent for three layers static loading respectively. A flexible system will ensure that bond line three layers CFRP strengthened beam does not break before failure and participate fully in structural resistant of the strengthened beams.

In flexural (FB) beams, the use of CFRP on the RC beam increased its ultimate load capacity.

It was found that the ultimate load bearing capacity of CFRP strengthened flexural beams with different reinforcement layouts were similar, while their failure mechanisms were different.

In this investigation CFRP strengthened beam gives appreciable strength and stability when compared to control beam.

References

1. AlaaMorsy and EI Tony Mahmoud (2013) Bonding Techniques for Flexural Strengthening of RC beams using CFRP laminates. Ain Shams Engineering Journal (2013) 4, 369 – 374.
2. Alferjani.M.B.S et al (2013) Use of Carbon Fiber Reinforced Polymer Laminate for strengthening reinforced concrete beams in shear.
3. Barros .J and Dias. S (2002) Shear strengthening of reinforced concrete beams with laminate strips of CFRP. Journal of Mechanics of Composite Materials and Structures.
4. Concrete Technology by A.M.Neville&J.J.Brooks, ADDISON-WESLEY, Concrete Tecnolgy by M.S.Shetty, S.CHAND & COMPANY LTD.
5. Ehsani and Saadatmanesh (1991) Extensive study into the reactions of RC beams strengthened with FRP under static loading. ASCEJ.Struct.Eng., vol.117 no. 11, pp.3417-3433.
6. Elchaiakani.M and Bambach.M.R (2007) Plastic mechanism analysis for circular hollow section (CHS) tubes strengthened using CFRP.
7. IS 456, (2000) Code of practice for reinforced concrete design, New Delhi: Bureau of Indian Standards, 2000.
8. IS 10262- 2009 Code of practice for Concrete Mix Proportioning, New Delhi: Bureau of Indian Standards, 2009.
9. IS 2386 (Part I – IV)-1963, “Methods of Test for Aggregates for Concrete”, Bureau of Indian Standards, 1963.
10. IS 516 – 1959 (Reaffifmed 1999). Edition 1.2 (1991-07) Methods of tests for strength of Concrete, Bureau of Indian Standards, 2002

*****