RESEARCH PAPER | Engineering | Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

Reinforced Concrete Beam Strengthening With Fibre Reinforced polymer

KEYWORDS: RC Beam, Strengthening, Deflection, Load

Patel Karankumar
PG student, Marwadi education foundation, Rajkot.

Prof. Dipesh Rathod
Assistant professor Civil Engineering Department, Marwadi education foundation, Rajkot.

Prof. Tarak Vora
Associate professor Civil Engineering Department, Marwadi education foundation, Rajkot.

ABSTRACT The current paper reviews existing design guidelines for strengthening beams in shear with fibre reinforced polymer (FRP) sheets. Fiber reinforced polymer materials are continuing to show great promise for using strengthening reinforced concrete structures.

I.INTRODUCTION

In recent years repair and retrofit of existing reinforced concrete structures such as buildings, bridges, etc., it does have been the major problem today in Civil Engineering. The primary reason for strengthening of structures includes upgrading of its resistance to withstand estimated loads, increase in the load carrying capacity for higher loads, such as due to increased perceived risk from seismic excitations, eliminating premature failure due to inadequate detailing, restoration of lost load carrying capacity due to corrosion or other types of degradation caused by aging, etc. Procedure for Paper Submission

The strengthening of concrete structures with externally bonded reinforcement is generally done by using either steel plates or Fibre Reinforced Polymer (FRP) laminates. Fibre reinforced polymers many beneficial characteristics over steel including excellent corrosion resistance, non-magnetic, non-conductive, generally resistant to chemicals, good fatigue resistance, low coefficient of thermal expansion, and high strength to weight ratio as well as being light weight.FRPs also possesses a high specific stiffness such as cost effectiveness, low density (one-quarter that of steel), resistance to electrochemical deterioration and low maintenance cost. And an equally high specific strength in the direction of fibre alignment.

Recently, this method has been applied to strengthen such structures as column, beams, walls, slabs, etc. The use of external CFRP reinforcement may be classified as flexural strengthening, improving the ductility of compression members, and shear strengthening. It is well known that reinforced concrete beams strengthened with externally bonded fiber-reinforced polymer (FRP) to the tension face

can exhibit ultimate flexural strength greater than its original strength.

II. RC BEAM WRAP WITH GFRP SHEET

T.Manikandan & G.Balaji ponraj made their research in gfrp sheet wrap with reinforced concrete structure. For that study they used M 20 grade concrete and HYSD 415 steel reinforcement bars. They used epoxy resin as a binding material used for fibre polymer sheet bind with RC beam.

Table 1 Properties of FRP
(T.Manikandan & G.Balaji ponraj)

PROPERTIES	E-GLASS
Density of fiber	2.6 x lO-5N/mm3
Fiber thickness	0.3mm
Tensile strength	3450N/mm2

The tests were carried out on ten simply supported reinforced concrete beams with square cross section of 150 x 150 x 1000 mm. The beams were strengthened with external U wraps bonded to tension side. The GFRP sheet is contributes to withstand the deboning action. In this out of ten beams two were controlled specimen, two beams were treated as continuous U jacketed wraps, two beams were treated as partially U jacketing wraps, remaining four beams were treated and GFRP strips were bonded at different spacing.

The load carried by tested beams for all groups of beams at initial and ultimate load levels. The initial load was taken at which the deflection of the control beams was measured at above 35% of their ultimate load. The initial crack for the control beams was about 12 kN and the corresponding deflection at the level was about 0.35 mm.

COMPARISON OF LOAD VS DEFLECTION

In this study increase load capacity of wrapped beam upgrading strength of the beam due to GFRP lamination. The capacity of the load carrying of the GFRP laminated beam compared with controlled specimen.

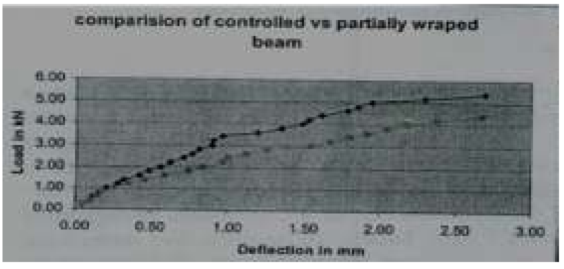

FIG. 1 comparison of controlled VS partially wrapped beam
(T.Manikandan . G.Balaji ponraj)

Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

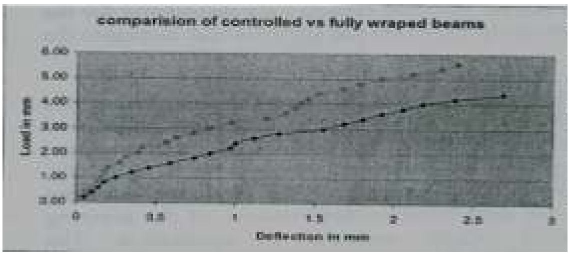

FIG.2 comparison of controlled VS fully wrapped beam (T.Manikandan . G.Balaji ponraj)

M. A. A. Saafan was also experimented on the contribution of GFRP sheet in the increase load carrying capacity of reinforced concrete beam. He studied about flexural and shear load carrying capacity of Reinforced concrete beam with GFRP sheet.
A total number of 20 singly reinforced concrete beams (100×150×1050 mm) were cast. All beams were reinforced With two lower bars allowing for an effective depth of 130 mm. the beam is divided into following category for the testing.
Group C: comprised six control beams without strengthening.
Group CF: comprised six control beams with flexural strengthening.
Group S: comprised eight beams with different schemes of shear strengthening.

After this study, he concluded that the glass fibre material is easily available and economical material that has good physical property can withstand failure of reinforced concrete beam in shear loading. After application of the GFRP sheet on beam part the crack patterns has been changed, cracks were not developed at that beam portion where GFRP sheet wrapped.

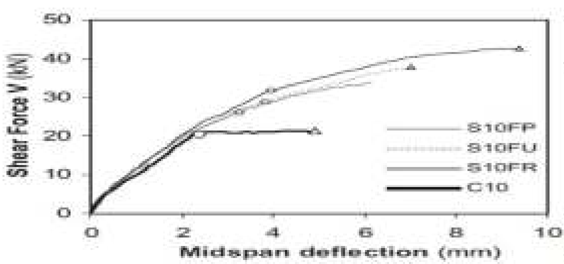

FIG. 3 load vs deflection curve for shear strengthened beam (M. A. A. Saafan)

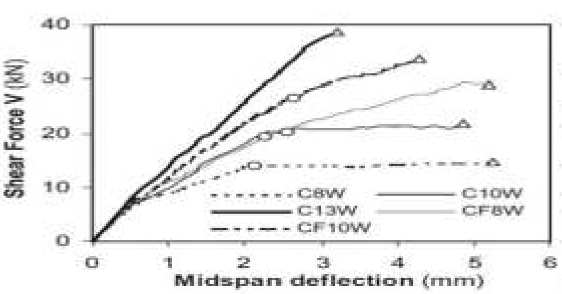

FIG. 4 Load-deflection curves for control beams with web reinforcement (M. A. A. Saafan)

S. Deepa Raj & R.S. Surumi were also studied about the application of GFRP sheet wrapping for strengthening of reinforced concrete for increase the load carrying capacity of beam. the beam specimens were tested on a beam testing machine with load controlling capabilities, The beam specimens were simply supported with a span of 1200mm. The beam specimens were tested for two- point load. They were made 12 number of beam specimen

They tested the beam in shear loading for different angle for application of GFRP sheet on the beam for 450 and 900. This below table is shows the load and ratio of increase on reinforced concrete beam specimen.

Table 2: First crack load and ultimate load of the beam specimens (S. Deepa Raj & R.S. Surumi)

Beam designation	First crack load	Ultimate load	Ultimate shear			
	Load (kN)	Ratio of increase	Load (kN)	Ratio of increase	Load (kN)	% increase
CB	83.39	-	161.87	-	80.94	-
BR90E	142.25	1.71	235.44	1.45	117.72	45.44
BR45E	122.63	1.47	220.73	1.36	110.37	36.36
BS90E	147.15	1.76	259.97	1.61	129.99	60.60
BS45E	166.77	2.00	279.59	1.73	139.80	72.72
BS90E125	166.77	2.00	294.3	1.82	147.15	81.80
BS45E125	127.53	1.53	245.25	1.52	122.63	51.51
BS90E100	161.87	1.94	284.89	1.76	142.45	75.99
BS45E100	152.06	1.82	274.68	1.70	137.34	69.68
BS90E75	147.15	1.76	240.35	1.48	120.18	48.48
BS45E75	176.58	2.12	299.21	1.85	149.61	84.84
BUW	93.2	1.12	215.82	1.33	107.91	33.32

III. RC BEAM WRAP WITH CFRP SHEET

I. A. Bukhari, R. L. Vollum, S. Ahmad and J. Sagaseta have been research in the strengthening of reinforced concrete beam with fibre polymer sheet specially used by carbon fibre sheet for strengthening. concrete beam Fibre reinforced polymer composites are mostly used for strengthening concrete structures because they have many advantages over conventional strengthening methods the majority of tests have been carried out on simply supported beams without steel stirrups strengthened with complete side wrap, U-wrap or full wrapping of the section with carbon fibre reinforced polymer sheet.

In this study, they made seven two-span, continuous RC beams with a rectangular cross-section of 152 mm x 305 mm and shear span-to-depth ratio (l/d) of 2.85 were tested. The effective depth to the steel reinforcement was 267 mm. Three 16 mm diameter bars were provided at the top and bottom of each beam. The yield strength of the reinforcement was 494 MPa. The corresponding flexural failure load of the beams is around 500 kN. Steel stirrups provided for protection of beam force in reinforced concrete beam at 130 mm center to center distance. Beam C1 was a control specimen so was not strengthened. The remaining tests investigated the contribution of different arrangements of CFRP to the shear capacity of the beams. The beams were not reinforced with internal stirrups within the central shear pans as the aim was to compare the efficiency of different arrangements of CFRP.
Rectangular sections of reinforced concrete beam were tested since the aim was to compare the response of

Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

continuous reinforced concrete beams with that of simply supported rectangular sections tested by others. one beam specimen was fully wrapped and was to determine the influence of the CFRP anchorage length. Specimen reinforced concrete beam C-4 was designed to simulate the reduced anchorage in an up stand beam. The CFRP sheet was 0.34 mm thick. The elastic modulus of the carbon fibres was 234.5 GPa and the ultimate tensile strength was 3450 MPa.

EXPERIMENTAL RESULT AND DISCUSSION

In this study, researcher had concluded strengthening Continuous RC beams in shear with CFRP sheet can be highly effective and that the contribution of the CFRP depends on its configuration and orientation. C1 beam which is taken as controlled beam that was not wrapped with CFRP sheet Beam C1 failed at total load of 250 kN. as a result of a shear-tension failure.

Beam C2 was strengthened with CFRP sheets measuring 304.8 mm by 304.8 mm, which were applied in the middle of each of the internal shear spans as shown in Figure 3. The beam failed in shear at total load of 384.7 kN, which is 54% greater than the control beamC1.

Beam C5 was strengthened with a similar configuration of CFRP sheets to beam C2, but the sheets were fully wrapped rather than being side wrapped. A shear crack appeared at the mid-height of the beam near the central support at a load of 384.7 kN. Clicking sounds were heard in the CFRP sheet whether load reached 403.9 kN. The failure load of C5 was 452 kN which is 81% greater than the control beam C1 and 27% greater than beam C2.

Beam C3 is complete side strengthened with CRFP sheet wrapping as shown in figure 3. Breaking sounds were heard as the load was increased and at 365.4 kN de-lamination occurred between the concrete and CFRP sheet under one of the load points. The beam was failed at 423.2 kN, which is 69% greater than the control beam C1.

Beam C4 was strengthened throughout the length of the shear span as in beam C3 but the CFRP sheets were only positioned within the tensile (i.e. upper) half of the beam depth as shown in Figure 3. The beam failed at 384.7 kN, which is 54% greater than the control beam C1.

Similarly C6, 304.8 mm wide CFRP sheets were wrapped with the main fibres oriented almost perpendicular to the angle of the shear cracks at an angle of 458 to the longitudinal axis of the beam as shown in Figure 3. Beam C6 failed at a load of 480.9 kN, which is 92% greater than C1

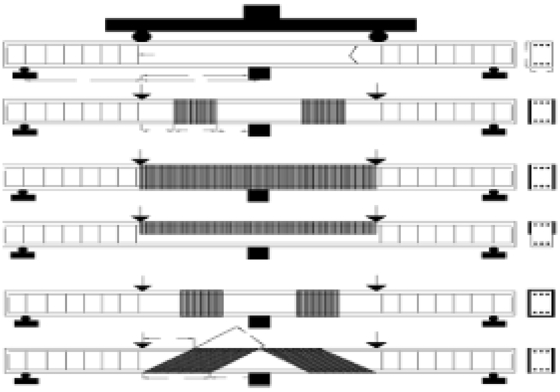

FIG.3 Beam configuration details (I. A. Bukhari, R. L. Vollum, S. Ahmad and J. Sagaseta)

R. Balamuralikrishnan & C. Antony Jeyasehar also investigated CFRP strengthening for the reinforced concrete beam. The test program consisted of casting and testing of ten

Beams, of which two were control beams, all having size of 150x250x3200 mm and designed as the beams of under reinforced section, reinforced with 2-12 # at bottom, 2–10 # at top using 6mm dia. stirrups @ 150 mm c/c. The beams were cast using M 20 grade concrete and Fe 415 grade steel.

They used material Ordinary Portland cement, natural river sand and the crushed granite of maximum size 20 mm were used. High yield strength deformed (HYSD) bars of 12 and 10 mm diameter with mean strength of 512 N/mm2 were used as longitudinal reinforcement and 6 mm diameter mild steel bars were used for internal links. The elastic modulus of the concrete is 2.4x104 N/mm2. In this study they were casted reinforced concrete beam in three category CB1, RB1,RB3. Where CB1 is the controlled beam specimen, RB1 is the single layer CFRP sheet wrapped beam and RB3 is the double layer CFRP sheet wrapped beam.

They concluded that with application of one layer of CFRP sheet strength was increased up to18- 20% for double layer strength was increased 40-45 % strength of the control beam specimen. In this study CPRP strengthened beam gives appreciable ductility when compared to control beam. All the beams strengthened with CFRP fabric in single layer and two layers experience flexural failures. None of the beams exhibit premature brittle failure..

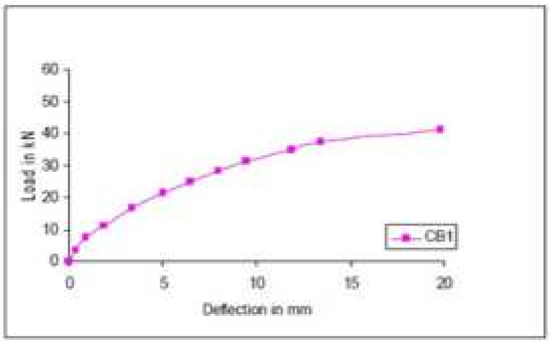

FIG.5 Load-Deflection Curves for CB1 (Static Loading) (R. Balamuralikrishnan & C. Antony Jeyasehar)

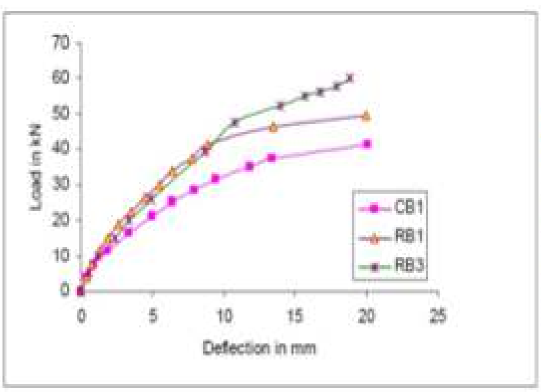

FIG. 6 Load deflection Curve for Control Beam and CFRP Strengthened Beams in Single and Double Layers (Static Loading)
R. Balamuralikrishnan & C. Antony Jeyasehar

Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

IV. CONCLUSION

The following conclusions were made from this Study:

- U-wrapping strengthening pattern of GFRP sheet contributed 35% increase the carrying capacity with compared to controlled beam of the ultimate load.

- Strengthening of CFRP sheet on reinforced concrete beam at angle of 450 is very effective because of its perpendicular to the shear cracks. In flexural, application of single layer of CFRP sheet at bottom shows 18-20% and, application of double layer of CFRP sheet at bottom shows 40-45% % strength of the control beam specimen.

REFERENCE [1]Flexural Behavior of RC Beams Strengthened with Carbon Fiber Reinforced Polymer (CFRP) Fabrics R. Balamuralikrishnan,* and C. Antony Jeyasehar. | [2]Shear strengthening of reinforced concrete beams using near surface mounted glass fibre reinforced polymers Deepa Raj*a and R.S. Surumib | [3] Shear Strengthening of Reinforced Concrete Beams Using GFRP Wraps .M. A. A. Saafan. | [4] Strengthening Of RC Beam Using GFRP WrapsT.Manikandan. G.Balaji ponraj [5] Shear strengthening of reinforced concrete beams with CFRP . A. Bukhari*, R. L. Vollum†, S. Ahmad* and J. Sagaseta | [6] Shear performance of RC member strengthened with externally bonded FRP wraps AHMED KHALIFA1, ABDELDJELIL BELARBI2 And ANTONIO NANNI3 | [7] Experimental Response of RC Beams Strengthened in Shear by FRP Sheets E. Grande, M. Imbimbo* and A. Rasulo