International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 2 ǁ 2022 ǁ PP. 81-95

Experimental Investigation of RC Elements with Synthetic Wraps

Kallam Venkata Reddy[1], Dr. Meikandan[2], Mrs. M Hema Priya [2]
[1] *Final Year, B.Tech; Dept. of Civil Engineering,*
[2] *Professor, Department of Civil Engineering,*
Bharath Institute of Higher Education and Research, Selaiyur, Chennai, Tamilnadu, India.

ABSTRACT:-
The use of composite materials for the strengthening of structural elements is being practiced throughout the world. Despite of its higher cost, the strength of the Hybrid Fiber Reinforced Polymer (HFRP) is more and it induces fragile behavior at or close to failure. This fragile behavior is not recommended for structures in seismic regions. The present study is oriented towards the evaluation on the contribution of the external reinforcement provided to concrete beams by hybrid FRP laminates. A combination of one-way glass (GFRP) and carbon fibers (CFRP) as well as a bi- directional and unidirectional hybrid glass/carbon fabric were used as HFRP laminates. The performance of such materials in term of compression and flexural behavior along with mode of failure is investigated. An experimental program on a total of nine concrete beams reinforced with hybrid configurations of reinforcement were tested up to failure in two points bending under static loading condition. Except three other three beams were strengthened by CFRP & GFRP sheets, loads were applied up to the failure of specimens. The crack pattern was recorded & deflection was observed at failure load. The cylinder tensile split test and cube compression tests were also performed to compare the conventional and HFRP reinforced concretes. The results of such tests revealed that the HFRP enhanced the strength and flexural behavior of concrete. The failure pattern on various zones of concrete beams were demarcated and analyzed.
Keywords: HFRP, Beam, CFRP sheets, GFRP sheets, Deflection, Static loading, Failure pattern

---

Date of Submission: 02-02-2022 Date of acceptance: 16-02-2022

I. INTRODUCTION

Nowadays, Fiber Reinforced Polymer (FRP) composite materials have become an attractive solution for the repair and strengthening of structures, particularly in concrete structures. This is due to the numerous advantages of these materials, namely their good behavior towards corrosion, their lightness and their better strength. However, the external strengthening of reinforced concrete beams using FRP was established as an efficient way to increase their strength, in both shear and in flexure. This strengthening method does have some inconveniences. As a consequence, when FRPs are used for flexural strengthening of beams reinforced with conventional steel, the reinforcement may yield before the FRP starts contributing to any supplementary strength capacity of the beam with at the end a brittle and a fragile failure. Consequently, it would be difficult to obtain a significant increase in the ductility or in the stiffness for the beam. In seismic zones, the ductility of reinforced concrete elements is an important design criterion and a number of solutions have been put forward to improve such a structural quality, such as: Confinement concrete up-to the compression zone this method is only practicable for beams without slab floors. We have studied the strengthening of beams with strips in glass fiber reinforced plastics (GFRP, CFRP); they have concluded that the bonding of GFRP and CFRP strips reduces considerably the crack widths at all the levels of loading. They have also indicated that the use of GFRP strips reduces the ductility of beams showed that bonding FRP fabrics or sheets to the sides of beams improves their shear strength recently we have studied experimentally and analytically the cases of CFRP and GFRP strengthening of beams; they have deduced that the contact surface of the strengthening material increases the ductility. Use of hybrid FRP laminates, which consist of a combination of carbon and glass fibers fabrics, or a hybrid fabric HFRP. We are introduced in this study, a new Hybrid bidirectional fabric braided with carbon and glass fibers at control bending moment of beam. 100mm width and 400mm length of CFRP and GFRP laminates were attached to the beams to find the strengthening in the aim of increasing both their ultimate strength capacity and their ductility.

Hybrid Fiber Reinforced Polymer Composite:

The use of externally bonded Fiber Reinforced Polymer (FRP) systems has been proven to be an effective technique to rehabilitate and strengthen deficient and deteriorated structural members. The FRP materials are known to have high stiffness, high strength to weight ratio, resistance to corrosion and ease of installation. In this external strengthening technique, the materials are attached to the tension side of RC beams or girders to carry the tensile stresses by means of the epoxy adhesive In general, the FRP plates are bonded to the soffit of the beams and the sheets are attached at anchorage zones to provide a locking mechanism that would increase the load carrying capacity of the structural member. It should be noted that the externally bonded systems were produced in the early 1940s in which steel plates were bonded to bridge girders to carry extra tensile forces introduced by the increasing number of users and vehicles. However, the introduction of FRP materials showed better performance than the conventional methods due to the several mechanical advantages of the FRP materials. Many experimental programs and numerical studies investigated different strengthening techniques in which multiple arrangements of FRP plates and sheets were used and experimentally investigated the performance of 3 continuous high-strength reinforced concrete beams externally strengthened with CFRP and GFRP sheets. They also developed an analytical model based on moment curvature that was able to predict the response and load carrying capacity of the tested specimens with reasonable accuracy. It was concluded that as the number of CFRP sheets increases, the load carrying capacity of the tested specimens increases, while the moment redistribution and ductility decrease along with a decrease in the CFRP ultimate strain at failure. Similarly, for the specimens strengthened with GFRP sheets, test results showed that by increasing the number of GFRP sheets, the moment redistribution and ductility would decrease without a significant increase in the load-carrying capacity.

AIM, SCOPE AND LITERATURE REVIEW AIM

- To find efficiency of Glass/Carbon FRP to increase the flexural strength of the beam and its effects to resist the shear failure.
- To increase the strength of the failure beam based on the formation of the cracks using CFRP and GFRP wrapping

SCOPE

- The scope of this research was to study the feasibility of beneficial utilization of fibers in strengthening of RC beams.
- Its effects in Seismic Strengthening of Structural elements
- To compare the load and behavior of GFRP/CFRP laminated beam with control one.

OBJECTIVES

- To compare the load and behavior of Fiber laminated beam with control one.
- To find its resistivity under compressive load in tensile and shear zone of the beam.
- To analyses the type of cracks in each loads with that of the control one.

II. LITERATURE REVIEW

Megha Puri et al (2019), the present experimental study is done on the behavior of reinforced concrete beams strengthened by CFRP sheets. Five reinforced concrete (RC) beams having same reinforcement detailing were casted and tested. From the test results, the following conclusions are drawn: The ultimate load carrying capacity of all the strengthen beams were enhanced as compared to the Control Beam CB. In case of strengthened beams initial cracks appeared at higher load.

Prashant. P et al (2019), Two sets of reinforced concrete (RC) beams, in SET I three beams weak in flexure and in SET II three beams weak in shear were casted and tested. When the beam is not strengthen it failed in flexure but after strengthening the beam in flexure, then flexure-shear failure of the beam takes place which is more dangerous than the flexural failure of the beam as it does not give much warning before failure. There-fore it is recommended to check the shear strength of the beam and carry out shear strengthening along with flexural strengthening if required. Flexural strengthening up to the neutral axis of the beam increases the ultimate load carrying capacity, but the cracks developed were not visible up to a higher load.

Karamjot Singh et al (2017), Based on the test results presented in this study the following conclusions can be drawn. The inclusion of FRP on concrete surface provides better crack control and deformation characteristic of beams. Both the first crack strength and ultimate strength in shear increase in both series of setups. More significant increase was found for the Vinyl Ester Bonded GFRP fiber reinforced beams i.e., series-B because of their increased resistance to propagation of cracks. Shear strength increases with increasing of fiber content. The theoretical prediction of ultimate shear strength on the basis of methods used in the study gives results close to the observed values in most of the beams tested.

Poonam C et al (2017), in this experimental investigation the flexural and shear behavior of reinforced concrete beams strengthened by GFRP or CFRP sheets are studied. Two sets of reinforced concrete (RC) beams, in SET I and SET II total sixteen beams were casted and tested. From the result and calculated strength values using ANSYS, the following conclusions are drawn. FRP composites are promising materials, presenting several advantages over traditional materials for both new construction and rehabilitation: strength, lightness, ease of application, durability under aggressive environments and low maintenance. Firstly it is observed that load at initial cracks was increased for all strengthened beams.

M. Velumani et al (2017), from this study concluded that, CFRP has a high tensile strength, a high modulus and is also light in weight and easy to handle. Although, CFRP applications are gaining popularity in seismic retrofitting, their long-term behavior is still not very well known. While strengthening of the buildings with CFRP several layers of epoxy based adhesives are used. Those layers of materials as well as CFRP wrapped concrete may therefore be affected by different stress levels and environmental changes. FRP composite materials have experienced a continuous increase of use in structural strengthening and repair applications around the world, in the last decade. In addition, when the FRP was compared with steel materials, it was found that it provided unique opportunities to develop the shapes and forms to facilitate their use in construction.

Harishankar N et al (2017), Beams retrofitted using epoxy binder and glass fiber showed more increase in ultimate load carrying capacity. It showed an increase of 64% than that of control beam. When sisal fiber and epoxy binder was used, the increase was 30%. Beams retrofitted with cement matrix composite and glass fiber showed a 33% increase, while the beams retrofitted with cement matrix composite and sisal fiber showed a 25% increase than the control beams. In beams retrofitted with epoxy binder, failure occurred by complete stretching and breaking of fiber sheets. Thus the tensile strength of fiber was fully transferred to the beams, which explains the increase in ultimate load carrying capacity. In beams retrofitted with cementations binder, failure occurred either by spelling of composite layer or by cracking of them layer.

Jasmin S et al (2015), the workability of hybrid fiber reinforced concrete decreased with the increase in percentage of fiber addition. The compressive strength of fiber reinforced concrete with 0.2% glass fiber and 0.5% nylon fiber had high strength than other proportions. Percentage increase in 7th day compressive strength is 18% and 28th day compressive strength is 15%. The splitting tensile strength and flexural strength of hybrid fiber reinforced concrete increase up to 0.5% addition of nylon fiber and then decreased. The load deflection characteristics of the hybrid fiber reinforced beam specimens were better than control mix.

Jagadish B.M. et al (2015), Fiber's elasticity plays an important role in increasing stiffness and this has led to decrease of deflection. By using GFRP as strengthening material so that the load carrying capacity of RC member increases. The strength carrying capacity is depending on bonding between GFRP and concrete surface. For the analytical study, ANSYS software is used this software gives the results of above tests which is almost similar to experimental study. So, this software may be used to study the behavior of heavy structure.

Stephen Jebamalai Raj J et al (2015), the finite element model results show good agreement with observations and data from the experimental full- scale beam tests. This numerical study can be used to predict the behavior of reinforced concrete beam strengthened with FRP more precisely by assigning appropriate material properties to develop design rules for strengthening RC member using FRP. The results are performed in this study indicate that significant increase in the flexural strength can be achieved by bonding CFRP sheets to the tension face of high strength reinforced concrete beams. It was found that for all strengthened experimental beams of the tensile steels strains were always higher than the CFRP strains when compared with the FEA program. When compared with the experimental results the failure should increasing value but there was not a significant difference between both the results.

Kannan R et al (2015), in this experimental investigation the shear behavior of RC beams strengthened by GFRP sheets are studied. The test results illustrated in the present study showed that the external strengthening with GFRP sheets can be used to increase the shear capacity of RC beams, but the efficiency varies depending on the test variables such as fiber orientations, wrapping schemes and number of layers. Based on the experimental results, the Following conclusions are drawn externally bonded GFRP sheets can be used to enhance the shear capacity of RC beams. The test results confirm that the strengthening technique of FRP system can increase the shear capacity of RC beams. Increasing the number of layers of FRP sheets, the shear capacity also increases. The initial cracks in the strengthened beams are formed at a higher load compared to the ones in the control beam.

Ratan kharatmol et al (2014), The CFRP wrapped at tension side gives better strength as compared to CFRP wrapped at two parallel sides but gives less strength as compared to CFRP wrapped at three sides. CFRP wrapped at three sides gives higher strength but as the CFRP composite is costly it increasing the cost of construction so from an economic point of consideration CFRP wrapped at tension side to the beam is desirable.

Khaled Galal, et al [2011] they conducted an experiment and analytical study on the tested full-scale GFRP reinforced concrete masonry beams and auxiliary prisms. Compression tests conducted on masonry prisms conducted using conventional concrete cinder blocks demonstrated that the CSA S303.1-4 [2004a] slightly overestimate the actual compressive resistance of the masonry assemblage parallel to its bed joints. Cross-sectional nominal flexural capacity and stiffness of the reinforced concrete masonry beams significantly improve as the internal GFRP reinforcement ratio increased.

G.B. Kim,G.B et.al [2010] studied and presented a design orientated conclusions are deduced from the experimental, analytical and parametric studies. Anchors in GFRP reinforced GFRC behave and exhibit a pull-out mode of failure as expected form steel or FRP reinforced plain concrete. The pull-out resistance in GFRP is slightly greater in GFRC than in plain concrete. The flexural capacity and deformations of GFRP-reinforced GFRC elements can be predicted by FEA provided the tensile properties of the GFRC are determined and modeled correctly.

Reda Taha,M.M et.al [2010] their objective of the experiments was to assess the significance of creep in the epoxy adhesive and whether such creep might allow the FRP strip to unload overtime. Slip movements at the ends of the FRP strips were also monitored. The work described herein indicates that assessment of the long-term effects of strengthening a beam with externally applied FRP should include to the effect of creep in the epoxy layer joining the FRP to the concrete.

M.J.Roth,M.J et.al(2010), presented the results of a study on the mechanical behavior of the newly developed ultrahigh-strength, glass fiber reinforced concrete(UHSGFRC)material are presented. Third point bending experiments direct tension experiments and finite element analysis where used to study the materials responses under various loading conditions: and an understanding of the tensile failure characteristics and their relationship to flexural response was developed.

Mady M A et al (2009), A studied to full scale exterior reinforced concrete beam column joints where constructed and tested to failure under stimulated seismic load conditions. One specimen was reinforced with conventional steel bars stirrups and the other one was reinforced with GFRP bars and stirrups based on the experimental results they concluded that GFRP bars and stirrups can be used as reinforcement in the beam column joints subjected to seismic loading conditions. The GFRP bars where capable of resisting tension-compression cycles with no problems.

K.H.Tan,K.H, et al (2009), they carry out an analytical and experimental investigations on glass FRP-strengthened RC beams under the combined effect of sustained loading and tropical weathering. They concluded that FRP-strengthened RC beams under sustained loads exhibited larger deflections and crack widths when subjected to tropical weathering at the same time. They showed smaller deflections and crack width when strengthened with a higher FRP reinforcement ratio. Both the strength and ductility of beams under sustained loads decreased with the longer weathering periods. However, beams with, more FRP laminates showed less degradation in strength and ductility.

Pannirselvam N et.al (2008), Studied and presented a general regression Neural network (GRNN)based computational model for predicting the yield load, Ultimate load, Yield deflection, Ultimate deflection, Deflection ductility and energy ductility of such beams. The GRNN model can provide an easy and low error alternative to the traditional regression and finite element techniques of modeling. The strength of GFRP plated beams was higher than corresponding unplanted beams.

Sing-Ping Chiew et al (2007), conducted an experiment and conducted that by bonding GFRP laminates to the tension face of flexural RC beams, both strength and stiffness of the beams can be increased. The strengthening ratio increases linearly with the increase of the axial rigidity of the external GFRP laminates. In contrast, the variation of bond length in the shear span has little effect as long as larger than 0.56 the interfacial debonding is progressively activated with the increase of the external load from below the loading point toward the end of the laminate.

K. Balasubramianian, et.al (2007), conducted an experimental investigation to evaluate the performance of the GFRP wraps used fo retrofitting of the beams and columns and concluded that, the performance of the RC beams was found to be improved after retrofitting using RP wrapping. But the performance of both CFRP and GFRP were almost similar. In case of the shear strengthening, the RC beams provided with CFRP wrap along the entire span was found to be better among the various methods of carbon fiber wrap that were investigated.

SUMMARY OF LITERATURE

We have referred the various research papers on experimental study of reinforced concrete elements strengthened by FRP sheets. The purpose of this research is based on the investigation of the use of carbon fibers and glass fibers bonded on the surface of structural members to enhance the strength of reinforced concrete elements.

III. MATERIALS AND METHODS

GENERAL

This chapter presents the details of the various materials used in the investigation preparation of the test specifications, repair methodology adopted and the testing procedure.

MATERIALS USED

Cement (OPC53): The grade of cement is required to confirm the BIS specification IS: 122269-1987 with a designed strength for 28 days being a minimum of 53mpa (or) 530kg/sq.cm.

Table-3.2.1 properties of cement:

Fineness	Consistency	Setting time of cement
97%	34%	31.5 (minutes)

Fine aggregate:

River sand passing through 2.36mm IS sieve conforming to IS 383 was used as fine aggregate.

Table-3.2.2 properties of fine aggregate:

Specific gravity of fine aggregate	Sieve analysis	
	(CU)	(CC)
2.57	4	2.25

Coarse aggregate:

The coarse aggregate of maximum size 20mm confirming to IS 383 was used.

Table-3.2.3 properties of coarse aggregate

Impact test	Abrasion test
7.59%	19.24%

Concrete:

In this experiment we were used M30 grade concrete as per (IS 10262:2009 & IS 456:2000).

Table-3.2.4 properties of concrete:

Slump test	Compaction test	VEE BEE
46mm	0.81	2 sec

Mix proportion of concrete (M30)

MIX DESIGN M30 GRADE DESIGNED AS PER (IS 10262:2009 & IS 456:2000)

Table-3.2.5 mix proportion of concrete (1m^3):

Water	Cement	Fine aggregate	Coarse aggregate
186 L/m^3	413 Kg/m^3	752 Kg/m^3	1062 Kg/m^3
0.45	1	1.82	2.57

RCC Beam Design:

In the present investigation five beams were cast for testing under flexural static loading. The overall dimensions and the details of the reinforcement of the beam are given below Figure.

Length = 1500 mm

Breadth = 100 mm

Depth = 200 mm

Clear cover = 20 mm

Effective cove = 25mm

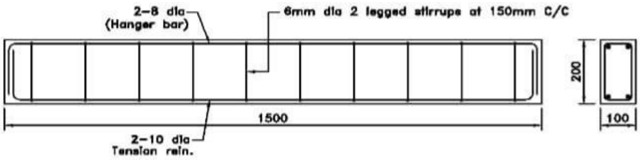


Figure-1 Reinforcement details of RCC Beam

3.3 CASTING OF SPECIMEN (BEAM):
Altogether we were casted six beams of size 1500mm*100mm*200mm*.

Fig-2 MOULD

Fig-3 Oil applied to moulds

Fig-4 COVER

Fig-5 Placing Reinforcement

Fig-6 FILLING THE CONCRETE

Fig-7 VIBRATING

3.4 CASTING OF CUBES AND CYLINDERS:
Altogether we were casted the cubes of size 150mm X 150mm X 150mm and cylinders of size150mm dia. X 300mm height.

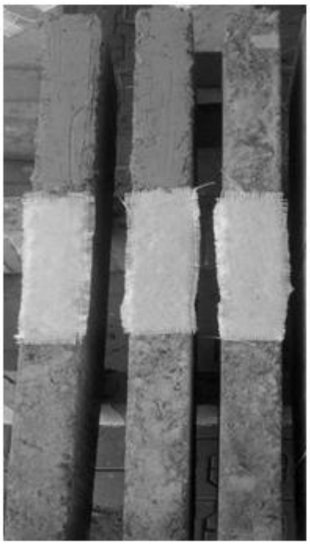
EPOXY RESIN:

Epoxy is a thermosetting epoxide polymer that cures [polymerizes and cross links] when mixed with a catalyzing agent are “hardener”. Most common epoxy resins are produced from a reaction between epichlorohydrin and bisphenol-

A. Epoxies are known for their excellent adhesion, resistance to moisture chemical and heat resistance, good to excellent mechanical properties and very good electrical insulating properties, but almost any property can be modified. They are suitable for production of composite material in the civil engineering field. The epoxy pre-polymer is usually a viscous fluid, with viscosity depending on the polymerization degree.

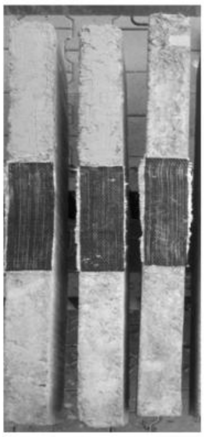
BEAM WRAPPED WITH GFRP STRIPS (100mm Width, 400mm long strip of GFRP) (Control Bending Moment):

Before bonding the fiber on the beam, the concrete beam surfaces are abraded to remove the weak layer of dry cement paste at the surface and expose the hard concrete through a smooth surface. The surfaces are then cleaned with an air nozzle and finally wiped off to remove any dust or loose particles that might hinder perfect bonding. The bonding of one or more layers of fabric onto the concrete surface is performed in accordance with the following procedure. First, the concrete surfaces are coated with a uniformly thick layer of adhesive for the even impregnation of the surface. The fibers, cut at the desired size (100mm width, 400mm long strip), is then applied on the fresh resin using a flexible roller to make sure that the adhesive fully penetrates into the open spaces of the fabric and, conversely, that the fibers was firmly pressed onto the fresh resin without folding or stretching excessively.



BEAM WRAPPED WITH CFRP STRIPS:

A second layer of adhesive is then immediately applied on top of the fabric to obtain a uniform layer of bonded surface reinforcement. The second adhesive layer is applied with a trowel without excessive pressure and movements in the direction of the fibers. The process is repeated as further layer of CFRP strip over the GFRP strip are added on top of moist adhesive coating.



IV. EXPERIMENTAL INVESTIGATION

4.1 FLEXURAL TEST ON CONTROL BEAMS:

The beam specimens were casted and tested as per Indian Standards two point loading test in the given below. The load deflection response of beams during the test was graphically represented.

4.1.1 CONTROL BEAM (CB1):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
5	0.224	0.104
15	0.151	0.16
20	0.074	0.223
25	0.212	0.286
30	0.342	0.345
35	0.466	0.463
40	0.575	0.577
45	0.727	0.683
50	0.847	0.783
55	0.946	0.933
60	1.063	1.038
65	1.088	1.129
70	1.229	1.243
75	1.351	1.362

Table-1 Flexural Test results

Fig-1 Crack patterns on Control Beam after Flexural test

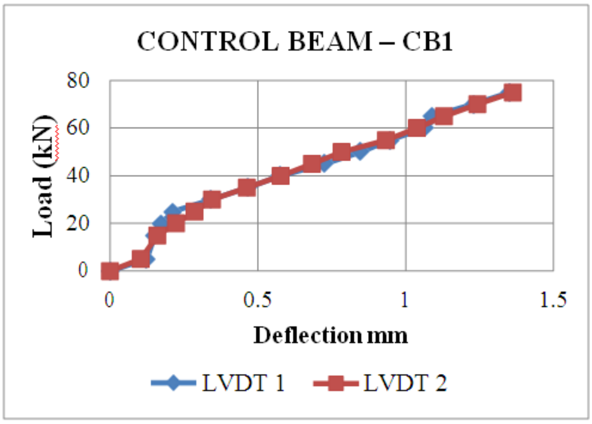


Fig-2 Load Deflection response of Beam specimen (CB1)

4.1.2 CONTROL BEAM (CB2):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
5	1.107	0.346
10	1.186	0.464
15	1.206	0.518
20	1.308	0.65
25	1.449	0.8
30	1.529	0.936
35	1.623	1.041
40	1.672	1.204
45	1.91	1.393

50	2.071	1.613
55	2.244	1.815
60	2.409	2.022
65	2.644	2.313
70	2.912	2.613
75	2.992	2.715

Table-2 Flexural Test results

4.1.3 CONTROL BEAM (CB3):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
5	1.475	0.563
10	1.522	0.6549
15	1.663	0.792
20	1.782	0.918
25	1.828	1.003
30	1.963	1.098
35	2.109	1.234
40	2.261	1.372
45	2.461	1.558
50	2.571	1.67
55	2.732	1.822
60	2.956	2.029
65	3.203	2.15
70	3.355	2.328
75	3.487	2.498

Table-3 Flexural Test results

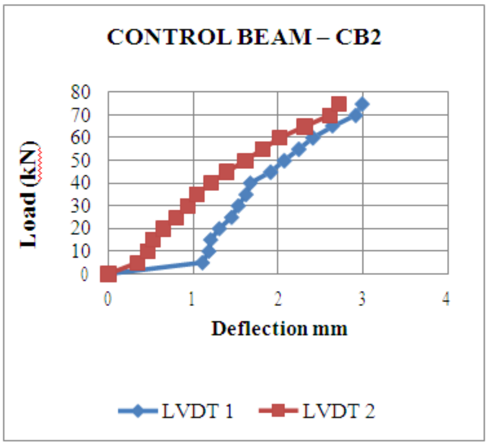


Fig-3 Load Deflection response of Beam specimen (CB2)

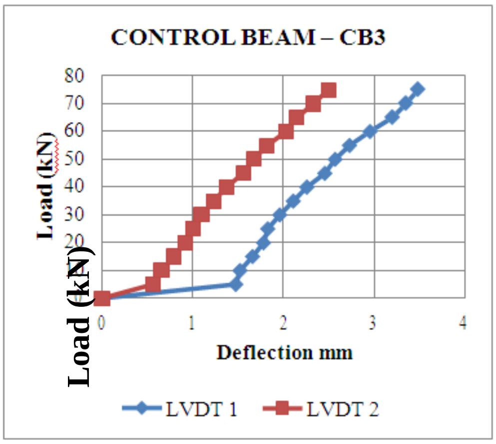


Fig-4 Load Deflection response of Beam specimen (CB3)

4.2 FLEXURAL TEST ON BEAM

(100mm width- 400mm length at middle of span):

The beam specimens were casted and tested as per Indian Standards two-point loading test in the given below. The beams were laminated with GFRP and CFRP by pasting them on Bending Moment zone with 100mm width and 400mm length strip. The load deflection response of beams during the test was graphically represented.

4.2.1 CONTROL BENDING MOMENT (CBM100-1):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
5	1.502	1.988
10	1.912	2.307
15	2.294	2.607
20	2.742	2.971
25	3.214	3.409
30	3.668	3.845
35	4.072	4.251
40	40503	4.669
45	4.939	5.105
50	5.419	5.557
55	5.921	6.026
60	6.557	6.505
65	7.092	7.011
70	7.755	7.565
75	8.432	8.242
80	8.958	8.658
85	9.723	9.250

Fig-5 Crack pattern on Beams wrapped with CFRP and GFRP after flexural test

Table -4 Flexural Test results

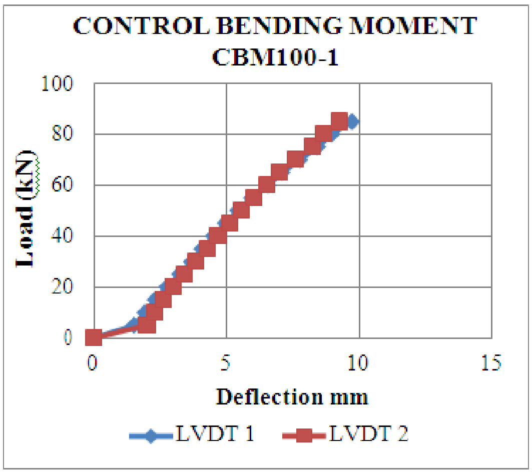


Fig-6 Load Deflection response of Beam specimen (CBM100-1)

4.2.2 CONTROL BENDING MOMENT (CBM1002):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
5	0.798	2.097
10	1.172	2.455
15	1.475	2.699
20	1.846	3.037
25	2.324	3.474
30	2.871	3.913
35	3.429	4.341
40	3.886	4.709

45	4.216	5.066
50	4.564	5.476
55	5.709	6.098
60	6.236	6.526
65	7.216	7.185
70	8.732	9.134
75	9.245	9.250
80	10.110	9.898

Table-5 Flexural Test results

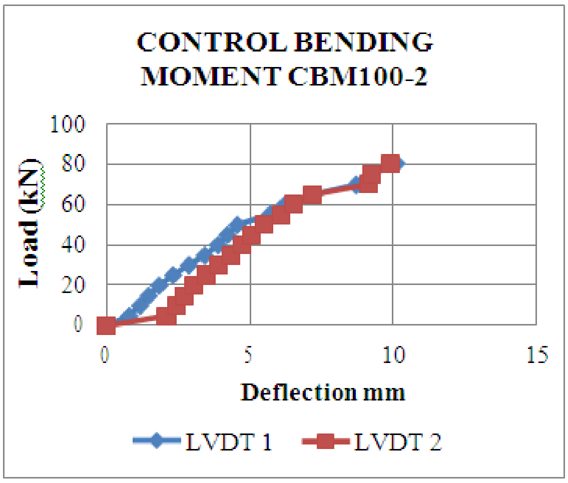


Fig-7 Load Deflection response of Beam specimen (CBM100-2)

4.2.3 CONTROL BENDING MOMENT (CBM100-3):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
5	2.386	1.952
10	2.85	2.61
15	3.08	2.622
20	3.323	2.897
25	3.725	3.338
30	4.396	4.128
35	4.655	4.467
40	5.463	5.068
45	5.642	5.37
50	6.22	5.917
55	6.857	6.37
60	7.506	6.69
65	7.707	7.18
70	8.599	7.942
75	9.232	8.951
80	9.670	9.421
85	10.120	9.980
90	10.335	10.125

Table-6 Flexural Test results

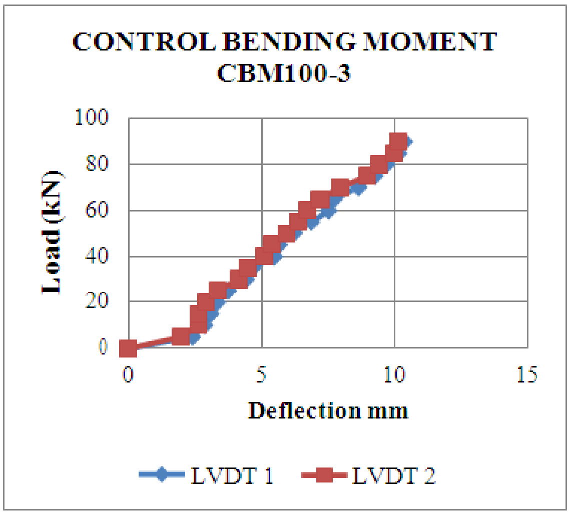


Fig-8 Load Deflection response of Beam specimen (CBM100-2)

4.3 FLEXURAL TEST ON BEAM

(100mm width- 1200mm length at bottom full of beam): The beam specimens were casted and tested as per Indian Standards two-point loading test in the given below. The beams were laminated with GFRP and CFRP by pasting them at bottom full of beam with 100mm width and 1500mm length strip. The load deflection response of beams during the test was graphically represented.

4.3.2 BOTTOM FULL (BFB1):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
05	2.513	2.378
10	3.043	2.772
15	3.474	3.081
20	4.023	3.558
25	4.537	4.011
30	5.151	4.575
35	5.394	4.829
40	5.958	5.285
45	6.578	5.771
50	7.208	6.379
55	8.036	7.075
60	8.806	7.747
65	9.195	8.099
70	11.427	10.082
7.5	11.935	10.305
80	12.025	10.815
85	12.505	11.015
90	12.805	11.500

Fig-9 Crack pattern on Beams wrapped with CFRP and GFRP after flexural test
Table-6 Flexural Test Test-results

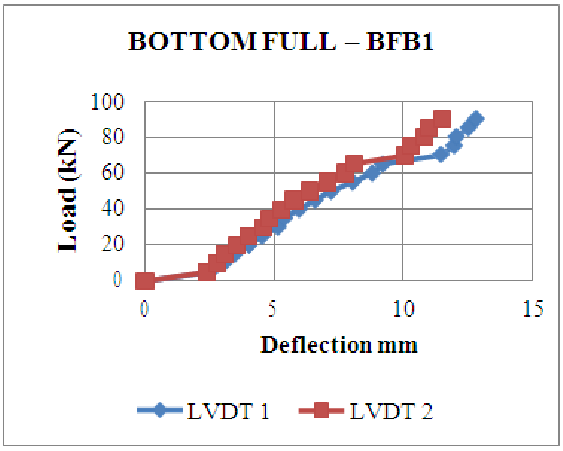


Fig-10 Load Deflection response of Beam specimen (BFB1)

4.3.2 BOTTOM FULL (BFB2):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
5	1.935	1.421
10	2.253	1.731
15	2.618	2.119
20	3.143	2.56
25	3.599	2.867
30	4.182	3.32
35	4.599	3.686
40	5.18	4.242
45	5.459	4.568
50	6.06	5.172
55	6.523	5.619
60	7.079	6.204
65	7.785	6.951
70	8.502	7.798
75	9.596	8.776
80	10.025	9.252
85	10.505	9.854

Table-7 Flexural Test results

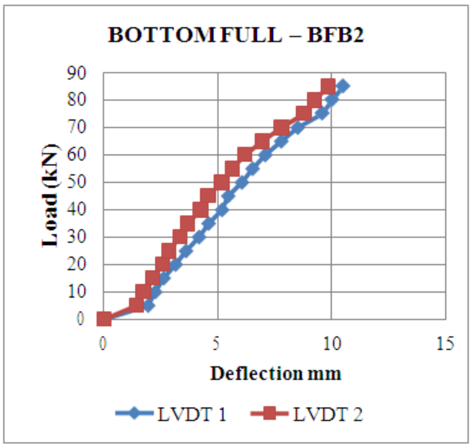


Fig-11 Load Deflection response of Beam specimen (BFB2)

4.3.3 BOTTOM FULL (BFB3):

Load in KN	LVDT1 in mm	LVDT2 in mm
0	0	0
5	2.142	1.999
10	2.349	2.181
15	2.767	2.547
20	3.031	2.786
25	3.556	3.267
30	3.871	3.534
35	4.356	3.949
40	4.789	4.319
45	5.317	4.774
50	5.649	5.071
55	6.498	5.697
60	6.823	5.97
65	7.449	6.498
70	8.214	7.149
75	8.914	7.805
80	10.835	9.57
85	11.125	10.230
90	11.650	10.750
95	11.950	11.200

Fig-8 Flexural Test results

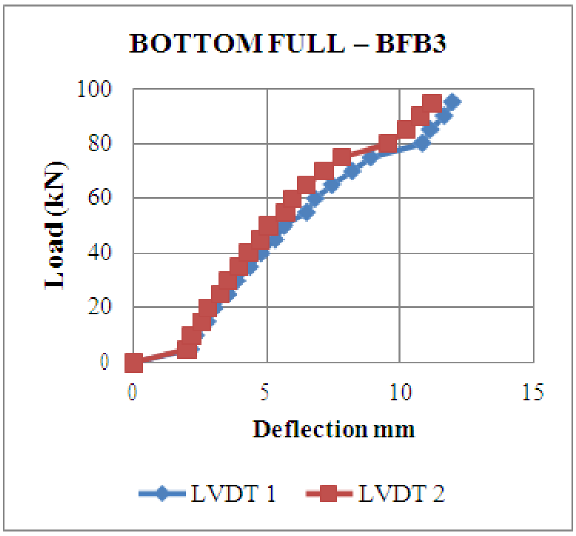


Fig-12 Load Deflection response of Beam specimen (BFB3)

V. CONCLUSION:

The conclusion arrived based on test result are as follows:

- Control Beam: the structure failed at 75KN with maximum deflection of 3.6mm.
- Beam wrapped with 100mm width and 400mm length of CFRP/GFRP laminates at control bending moment: the structure failed at 85KN with maximum deflection of 10.5mm.
- Beam wrapped with 100mm width and 1200mm length of CFRP/GFRP laminates at bottom: the structure failed at 90KN with maximum deflection of 13.1mm.
- Comparing to control beam the capacity of 100mm width, 400mm length wrapped at control bending moment of beam increased by 13.33% (OR) 10KN.
- Comparing to control beam the capacity of 100mm width, 1200mm length wrapped at bottom of beam increased by 20%
- Comparing to wrapped beam at control bending moment the capacity of wrapped beam at bottom is

increased by 6.67% (or) 5KN.

- The FRP wrapped specimens showed improvement in the ultimate load.
- When compared to control beam the beam which is wrapped at control bending moment is better.
- When compared to beam wrapped at control B.M the beam which is wrapped at bottom full is better.
- Flexural load carrying capacity of beams increases with FRP wraps than control beams.
- The strength of beams also increases with FRP wraps than control beam.

REFERENCES:

[1]. Amir mirmiran (1999), “Strength and Ductility of Hybrid FRP Concrete Beam-Columns High strength-to-weight ratio and resistance to electro-chemical corrosion”, Journal of construction and building materials, Vol. 38(2), pp.174-183.

[2]. Abdul K. Azad, Ibrahim Y.Hakeem, (2000), “Flexural behavior of hybrid concrete beams RCC with ultra-high performance concrete”, Journal of civil & Environmental engineering, Vol. 49, pp. 128-133.

[3]. Attar N., Amziane S. And Chemrouk M. (2008), “A great emphasis is placed on Developing an innovative strengthening method with hybrid fiber reinforced plastics”, Journal of construction and building materials, Vol. 28(10), pp. 906-913.

[4]. Aravindan S, "Experimental studies on fibre reinforced concrete from industrial waste", Journal of scientific research 12, 1738-1744, 2013.

[5]. Chitra Ganapathy, Balasubramaniun and Murgeshwaran. (2006), “Effect of wrapping reinforced concrete columns within carbon fiber(scarp) composites”, 5th Asian symposium on polymers in concrete, India, pp.623-631.

[6]. Chandra Sekhar Rao, "An investigation on confined fibre reinforced concrete beams under flexure", International Journal of Advanced Structures and Geotechnical Engineering, 2, 6- 10, 2013.

[7]. Deifalla A. and Ghobarah A. (2000), “Full Torsion Behavior of RC Beams Wrapped with FRP”, Journal of The Higher Institute of Engineering, El Shorouk Academy, Egypt ASCE.9(3), pp. 157-166.

[8]. Eether Thanon Dawood, Mahyuddin Ramli, (2012) “Mechanical properties of high strength flowing concrete with hybrid fibers”, Journal of construction and building material. Vol. 28, pp.193-200.

[9]. Eslami A. (1996), “Effect of FRP wrapping in seismic performance of RC buildings with and without special detailing”, Journal of construction and building materials. Vol. 29(1), pp. 30- 40.

[10]. Ewha Womans U. (2002), “New hybrid beam reinforced and ultra high performance concrete”, Journal of cement and concrete research, Vol. 54, pp. 36-42.

[11]. Ferier.E (2003), “strengthening systems of RC beams”, Journal of cement and concrete research, USA, pp.1-10.

[12]. Giovanni A. Plizzari, " Flexural behaviour of RC beams in fibre reinforced concrete", Composites: Part B 43, 2930–2937, 2012.

[13]. Giuseppe Campione (2007), “Ductility of Reinforced Concrete Members Externally Wrapped with Fiber-Reinforced Polymer Sheets”, Journal of construction & building management, Vol. 108(4), pp. 216- 226.

[14]. Jay G. Sanjayan, "Critical parameters of nylon and other fibres for spalling protection of high strength concrete in fire", Materials and Structures 44: 599–610, 2011.

[15]. Mark Adom-Asamoah, " Flexural and shear behaviour of reinforced concrete beams made from recycled materials", Journal of Ghana Institution of Engineers, 6(1), 57-66, 2009.

[16]. Mettu Bhaskara Rao "Study of the behavior of GFRP – RC beams under shear", International Journal of Engineering Trends and Technology (IJETT) - Volume4 Issue7, 2013.

[17]. Murali G, "Experimental investigation on fibre reinforced concrete using waste materials", International Journal of Engineering Research and Applications, 2, 278-283, 2012.

[18]. Oudah F, El-Hacha R. A new ductility model of reinforced concrete beams strengthened using fiber reinforced polymer reinforcement. Composites: Part B 2012.

[19]. P.S. Song, "Strength properties of nylon- and polypropylene- fiber - reinforced concretes", Cement and Concrete Research 35 (2005) 1546– 1550, 2004.

[20]. Pey-Shiuan Song, "Investigating Mechanical Properties of Steel- Nylon Hybrid FiberReinforced Concrete by Using Experimental Design", journal of C.C.I.T., vol.42, no.1, 2013 [21] Rashid Hameed, "Flexural behaviour of reinforced fibrous concrete beams", International Journal of Engineering Research and Applications, 13, 19-28, 2013.