Experimental and Analytical Investigation on Beam Column Joint Strengthening With GFRP Sheet

S.Bharathi, PG student of Structural Engg, Dhirajlal Gandhi College of Technology,Salem, Tamilnadu.
Mrs.M.Nithya, Assistant Professor of Civil Engg, Dhirajlal Gandhi College of Technology,Salem,Tamilnadu.

ABSTRACT

The common regions of intersecting elements are called joints. In Reinforced concrete buildings, the portion of columns that are common to beam at their intersections are called beam-column joints. Shear failure of beam-column joints is identified as the principal cause of collapse of many moment-resisting frame buildings during recent earthquakes.In this project, the efficiency and effectiveness of Glass Fiber-Reinforced Polymer (GFRP) sheets which increase the shear strength and ductility of seismically deficient beam-column joints have been studied. A brief review of literature has been carried out in following topics, behaviour of beam column joints under earthquake loading, effect of different types of fiber reinforced polymers, finite element modeling of fiber reinforced concrete. In this project, experimental study as well as analytical study has been done. In this project, two beam column joint specimens have been casted. The first specimen is considered as control specimen who is casted without GFRP wrapping. In the second specimen, before concreting, GFRP sheets pasted by epoxy adhesive are wrapped initially with reinforcement. The two specimens are checked for its load carrying capacity, load-deflection behaviour and cracking pattern. The comparison of results shows that GFRP sheets are very effective in improving shear resistance and deformation capacity of the corner beam-column joints and delaying their stiffness degradation. The corner as well as exterior beam-column joint is analyzed by using Ansys software with varying stiffness of beam-column joint. The behavior of exterior and corner beam-column joint subjected to cyclic loading is different. The results which will be obtained from the experiment and by software analysis will be characterized by plotting various graphs like load vs. deflection (deformations), Maximum stress and Stiffness variations. The failure modes and crack patterns are noted to get better understanding on the performance of beam column joints strengthened with GFRP sheets.

Keywords: GFRP Sheets, Ductility, Strength, Stiffness

I.INTRODUCTION

1.1 BEAM COLUMN JOINTS

The conduct of reinforced concrete moment resisting frame structures in late seismic tremors everywhere throughout the world has highlighted the outcomes of poor execution of beam column joints. Beam column joints in a reinforced concrete moment resisting frame are urgent zones for exchange of burdens viably between the interfacing components (i.e. beams and columns) in the structure. In the investigation of reinforced concrete moment resisting frames, the joints are expected to be inflexible. For satisfactory flexibility of beam column joints, utilization of firmly separated loops as transverse support was suggested in the ACI-ASCE Committee 352 report (ACI, 2002). Because of the clog of support, throwing of beam column joint will be troublesome and will prompt honeycombing in concrete. In Indian practice, the joint is normally disregarded for particular outline with consideration being limited to arrangement of adequate harbor for bar longitudinal reinforcement. Beam column joints have an urgent part in the basic trustworthiness of the structures. Along these lines, bar section joints must be intended to oppose earthquake impacts.

1.2 TYPES OF JOINTS IN FRAME

The joint is characterized as the segment of the section inside the profundity of the most profound column that edges into the segment. In a moment resisting frame, three sorts of joints can be recognized viz.

(1) Interior joint
(2) Exterior joint and
(3) Corner joint.

At the point when four bars outline into the vertical countenances of a column, the joint is called as an interior joint. When one beam frames into a vertical face of the column and two different bars outline from opposite headings into the joint, then the joint is called as an exterior joint. At the point when a column each casings into two neighboring vertical countenances of a segment, then the joint is called as a corner joint. The seriousness of strengths and requests on the execution of these joints calls for more prominent comprehension of their seismic conduct. These strengths create complex instruments including bond and shear inside the joint.

1.3 OBJECTIVES OF THE STUDY

The vast majority of the fortifying plans produced for beam-column joints so far have a restricted scope of relevance and constraints, while the utilization of FRP composites in reinforcing RC beam-column joints is still in its initial stage. Inquire about in FRP-reinforced joints is a long way from finish, and more research endeavors ought to be centered around this territory so as to build up a solid and material strengthening plan. Keeping in mind the end goal to give a crucial comprehension of the conduct of RC joints reinforced with FRPs, an extensive research programme is directed by the Department of Civil Engineering of The University of Hong Kong. Test studies were completed expecting to enhance the shear limit, flexibility limit and vitality dissemination limit of insufficient joints.Quasi-static cyclic burdens were connected to the sub-collections to reproduce the impact of seismic assaults. The target of the present research program is to build up a viable recovery framework for reinforcing and repairing lacking RC beam-column joints.

II. LITERATURE REVIEW

Uzmeri (1977) did exploratory review on the conduct of eight strengthened solid pillar section joints subjected to moderate load inversions mimicking seismic stacking. Factors were the amount and size of joint fortification and stress strain attributes of joint glass. He detailed that the presumption of inflexible bar section joints could give invalid outcomes. He recommended that the utilization of joint support with yield level may be undesirable for constrainment. He prescribed that joint stirrups ought to be reached out above and underneath the shaft glass at same dividing as in the joint for a separation of in any event a large portion of the center measurement to avert untimely disappointment in the segment simply above or beneath the pillar.

Balaguru*et al.* (1992) revealed the effects of a test examination on the flexural conduct of steel fiber fortified cement (SRC). The factors examined were fiber sorts, length and volume part and grid structure. They led test on tube shaped and crystal samples. Three fiber sorts, three fiber lengths, four fiber volume portions and four framework creations were assessed. In their outcomes they detailed that the amazing malleable conduct can be acquired utilizing fibrecontent in the scope of 1.5% volume division. Increment in fiber content outcomes in malleability and vitality assimilation limit. The post-top load-avoidance reactions were compliment and the strength files were higher. Snared end fiber would be advised to come about than folded and disfigured end steel fibres.

Arulraj(2010) had distributed the paper on Experimental Investigation on Behavior of Reinforced Concrete Beam Column Joints Retrofitted with GFRP-AFRP Hybrid Wrapping. In this paper an endeavor has been made to concentrate the conduct of strengthened solid bar segment joints retrofitted with glass carbon cross breed fiber sheets. Three outside strengthened solid pillar section joint samples (control) were thrown and tried to disappointment. Two samples had support points of interest according to code IS 456:2000. The other sample had support points of interest according to code IS 13920:1993. A pivotal load was connected on the segment. Push and force load was connected at the free end of the cantilever bar till disappointment. The fizzled two bar segment joint sample planned according to code IS 456:2000were retrofitted with GFRP-AFRP/AFRP-GFRP crossover fiber sheets wrapping to fortify the samples. The execution of the retrofitted bar section joints was contrasted and the control pillar segment joint samples and the outcomes are introduced. They inferred that the heap conveying limit of the fortified solid shaft segment joint sample retrofitted with GFRP-AFRP half breed sheet was observed to be 18.3 % more than the control samples. And furthermore they reasoned that the heap conveying limit of the strengthened solid pillar section joint sample retrofitted with AFRP-GFRP crossover sheet was observed to be 23.8 % more than the control samples.

III.METHODOLOGY

The structures are broke down utilizing diverse programming and distinctive advancements accessible. Yet, here in our venture composite component basic part is dissected utilizing the product called ANSYS. Regularly as in all different examination programming the structure is made and property is designated to the structure that you had made. At that point the heap is connected to the basic part as required. In all investigation programming the heaps are connected on the highest point of the individual from structure made or in the highest point of hubs that interface the R.C.C part you make where we get the outcome like twisting minute and shear force of the structure part made and it is the normal outcome we get in a wide range of examination programming.

Here in ANSYS programming there is a kind of examination technique called FEA (Finite Element Analysis) which is utilized to investigate the basic encircled part you made. Limited component examination (FEA) is the displaying of items and frameworks in a virtual domain, with the end goal of finding and explaining potential (or existing) auxiliary or execution issues. FEA is the down to earth use of the limited component strategy (FEM), which is utilized by specialists and researcher to scientifically show and numerically explain extremely complex auxiliary, liquid, and transcendentalism issues. FEA software can be used in an extensive variety of industries.

IV.ABOUT SOFTWARE

Ansys is examination programming which is utilized generally for investigation motivation behind structure and questions. It is not only just for the investigation procedure of building structure in common but also for the most part utilized as a part of the where territory can be used in an extensive variety of ventures, however most regularly is utilized as a part of the aeronautical, biomechanical and car enterprises.

4.1 TYPES OF ANALYSIS INCLUDE

Linear statics: direct examination with connected loads and requirements that are static .

Nonlinear statics and flow: nonlinear material definitions (versatility, flexibility, and so on.) and expansive dislodging (strains that surpass little displacement hypothesis that restrains a linear investigation approach) Normal modes: characteristic frequencies of vibration.

Dynamic response: loads or motions that vary with time and frequency

Buckling: critical loads at which a structure becomes unstable

Heat transfer: conduction, radiation and stage change. The Finite Element Analysis (FEA) is a numerical strategy for taking care of issues of designing and scientific material science. Valuable for issues with muddled geometries, loadings, and material properties where explanatory arrangements could not get. Limited component examination (FEA) has turned out to be typical as of late, and is currently the premise of a multibillion dollar for each year industry. Numerical answers for even exceptionally convoluted anxiety issues can now be acquired routinely utilizing FEA, and the strategy is important to the point that even starting medications of Mechanics of Materials, for example, these modules ought to framework its primary components. Disregarding the immense energy of FEA, the inconveniences of PC arrangements must be remembered when utilizing this and comparable strategies: they do not really uncover how the burdens are impacted by vital issue factors, for sample, materials properties and geometrical elements, and blunders information can create fiercely off base outcomes that might be ignored by the investigator.

V.MATERIAL COLLECTION

Concrete, natural fine aggregates, characteristic coarse aggregates, reused coarse aggregates, reused plastic coarse aggregates silica smoke, water and glass disfigured bars are to cast sample research. The physical properties of these materials are talked about in the accompanying segments.

5.1 CEMENT

All through the trial contemplate, Ordinary Portland Cement complying with IS: 8112 - 1989 was utilized. The physical and mechanical properties of the bond utilized are appeared in Table 1.

Physical property	Results
Fineness	2946 cm2/gm.
Normal Consistency	30%
Vicat initial setting time (minutes)	64
Vicat final setting time (minutes)	192
Specific gravity	3.10
Compressive strength at 3-days	23.86 MPa
Compressive strength at 7-days	37.01 MPa
Compressive strength at 28-days	45.73 MPa

Fig.1 Cement

5.2 FINE AGGREGATE

Locally accessible waterway sand adjusting to Grading zone II of IS: 383 –1970. Spotless and dry stream sand accessible locally will be utilized. Sand going through IS 4.75mm Sieve will be utilized for throwing every one of the samples.

Fig.2 Fine Aggregate

5.3 COARSE AGGREGATE

Locally accessible pounded blue rock stones adjusting to reviewed aggregate of ostensible size 12.5 mm according to IS: 383 – 1970. Pulverized rock aggregate with particular gravity of 2.77 and going through 4.75 mm sieve and will be utilized throughout for all samples. A few examinations presumed that greatest size of coarse aggregate ought to be limited in quality of the composite. Notwithstanding bond glue – total proportion, aggregate sort impacts concrete dimensional soundness.

Fig 3.Coarse Aggregate

5.4 WATER

Water utilized for blending and curing might be spotless and free from harmful measures of Oils, Acids, Alkalis, Salts, Sugar, Organic materials. Potable water is viewed as attractive for blending solid Mixing and curing Ocean water should not be allowed. The pH esteem might not be under 6.

Fig.4 Water

5.5 GLASS FIBRE

Glass fiber likewise called fiberglass. It is the material which is produced using amazingly fine strands of glass. Fiberglass is a lightweight, greatly solid, and strong material. In spite of the fact that quality properties are to some degree lower than carbon fiber and it is less solid, the material is ordinarily far less fragile, and the crude materials are substantially less costly. Its mass quality and weight properties are likewise extremely ideal when contrasted with metals, and it can be effectively framed utilizing shaping procedures. Glass is the most seasoned, and most natural, execution fiber. Filaments have been produced from glass since 1930s. Most broadly utilized class of strands in composites are those produced from E-glass. E-glass is a low soluble base borosilicate glass initially created for electrical protection applications. It was initially delivered financially for composite produce in 1940's, and its utilization now approaches 2 MT for each year around the world. A wide range of nations produce E-glass and its correct arrangement fluctuate as per the accessibility and creation of the neighborhood crude materials. It is made as consistent fibers in groups, or strands, each containing normally between 200 and2000 singular fibers of 10-30 µm widths.

Fig 5.Glass Fiber Reinforced Polymer

5.5.1 Properties of GFRP Materials

GFRP composites are a cutting edge development material, an other option to customary materials, for example, solid, steel and wood. Among numerous utilizations of FRP in common foundations, connect decks have got much consideration as a result of their light weight, high quality to-weight proportion, and consumption resistance. Different points of interest of FRP extension decks are the lessening in scaffold deck development time and increment in administration life. The engaging quality of FRP composites as development materials gets from a setof points of interest gathered from the tail or capacity of this material class through the synergistic mix of strands in a polymeric pitch network, wherein the fiber fortifications convey stack in predesigned bearings and the tar goes about as a medium to exchange worries between abutting filaments through attachment and furthermore gives insurance to the filaments. The choice of framework and support for manufacture of any composite item predominantly relies on upon the properties of matrix and reinforcement.

5.6 RESINS

An imperative issue in the make of composites is the choice of the ideal lattice in light of the fact that the physical and warm properties of the network fundamentally influence the last mechanical properties and also the assembling procedure. Keeping in mind the end goal to have the capacity to abuse the full quality of the fibres, the framework ought to have the capacity to build up a higher extreme strain than the fibres. The matrix not just coats the fibres and protects them from mechanical abrasion and substance assault, additionally exchanges worries between the fibres. Other critical parts of the lattice are the exchange of interlaminar and in-plane shear inside the composite, and the arrangement or horizontalsupport to the fibres against clasping when subjected to compressive burdens.

VI.TEST PROCEDURES

The chose stacking samples were proposed to deliver strengths that could initiate abnormal amounts of inelastic distortions experienced by the basic edges if there should arise an occurrence of seismic assault. The nominal moment capacity of beam of every sample was computed to decide the hypothetical yield load of beam. The moment capacity of beam depended on the arrangement given in BS 8110 (1997), by setting all the halfway security variables for material quality γm to one.

6.1 CYCLIC LOADING

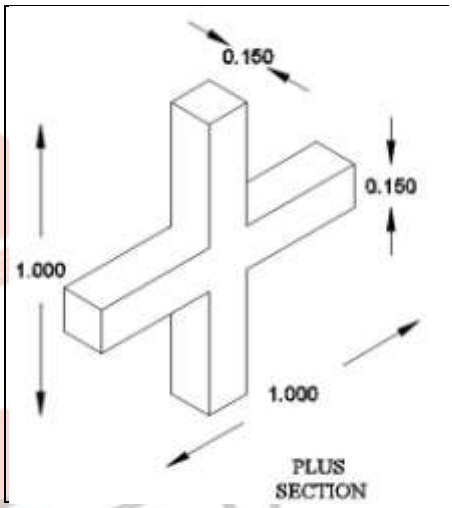


Fig.6 Dimension Of Plus Specimen

The beam-column joint specimen was tested in the self-reaction loading frame under reversed quasi-static cyclic load applied at the beam tip. The cyclic load was applied slowly to eliminate any dynamic effects and typically 5-8 hours were required to complete the loading test. There were two loading.

Procedures adopted under reversed cyclic load. The first phase was load controlled followed by the displacement-controlled in the second phase. In the first loading phase, the specimen was subjected to an increasing load up to that corresponding to 75% of its nominal moment capacity of beam *Mn*. The associated beam tip displacement was recorded and extrapolated to determine the displacement of beam tip Δy when the assumed first yield occurred.

Fig. 7Experimental Setup

6.2 LOADS-DISPLACEMENT RELATIONSHIPS

The load-displacement reactions of the specimens are talked about in this segment, including the hysteretic conduct, load carrying limit, strength and ductility. The productivity of the proposed recovery systems in enhancing the conduct of the inadequate samples can be assessed by looking at the conduct of the reference samples to that of the restored samples. The heap talked about in this area can be ordered into beam tip stack P and storey shear drive Vc. The beam tip load is the normal estimation of the connected load toward the finish of each beam.

The displacement examined in this segment can be characterized into beamtip removal Δ, storey drift proportion η and dislodging ductility factor μ. The beam tip removal is the uprooting at the purpose of stacking measured by LVDTs amid the test. It is the proportion of the relocation at the beam tip to the yield uprooting. Distinctive frameworks for the diagrams are utilized relying upon the way of the samples. The heap - storey float plot for the samples is communicated as far as story shear compel Vc and story float η. The story shear constrain Vc can be got from balance of minutes at different cross segments. The even response is the story shear constrain and can be acquired as taken after where P1 and P2 (with various signs) are the heaps connected separately at each of the bar tips and L band L mind the traverse lengths of bar and section individually, as showed .The sub-collection was composed in light of the suspicion that purposes of contra-flexure happen at mid-tallness of the stories and mid-traverse of the sounds. The sample was held set up by pivot underpins at the top and the base of the section which re-enacted the enunciation focuses. The proportional story relocation can be Calculated in light of pillar unbending revolution.

6.3 COMPRESSIVE STRENGTH TEST

Three indistinguishable samples are pounded at 7days and three indistinguishable samples are squashed at 28 days. The compressive quality is figured by partitioning the disappointment stack by normal cross sectional zone. The normal estimation of the three samples was taken as the compressive quality of the bunch. The compressive quality testing machine of limit 5000 KN is utilized for deciding the greatest compressive burdens conveyed by solid shapes. The compressive quality test machine which utilized as a part of all tests is appeared in Plate 3.7. At the test age the samples are removed from the curing tank and kept outside for 10 minutes. At that point one sample is set on the steel plate of the machine with the end goal that the sample is tried opposite to the throwing position. At that point the test is completed at the stacking rate of 5 kN/s indicated IS: 516 - 1959. Most extreme load on the sample was recorded as load at which sample neglected to take any further increment in load

Fig.8 Testing For Compressive Strength

6.4 SPLIT TENSILE TEST

The span of cylinders 300 mm length and 150 mm measurement are set in the machine with the end goal that heap is connected on the inverse side of the cylinder. Adjustments had been made and load is connected, till the sample breaks. The equation utilized for count.

Split tensile strength = 2P/ μdl

Fig.9 Split Tensile Test

Aside from the flexure test alternate techniques to decide the tensile strength of concrete can be comprehensively delegated (a) direct methods, and (b) indirect methods. The direct method experiences various troubles identified with holding the sample appropriately in the testing machine without presenting stress fixation, and to the utilization of uniaxial elastic load which is free from unconventionality to the sample.

VII.ANSYS RESULTS

7.1 FRAME WITHOUT GFRP

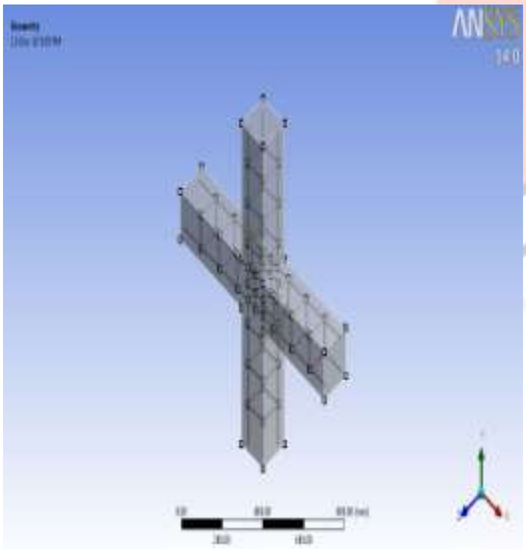


Fig.10 Reinforcement without GFRP in Ansys

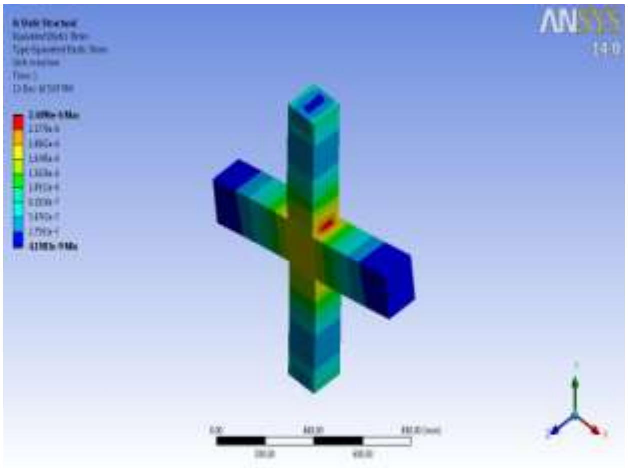


Fig.11Frame strain

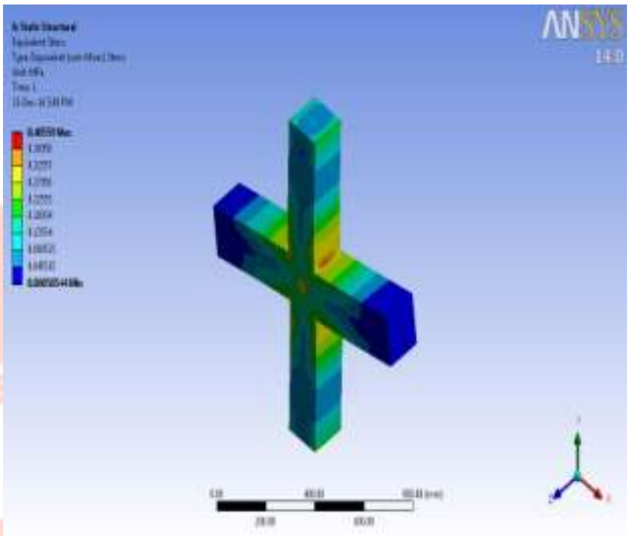


Fig.12Frame stress

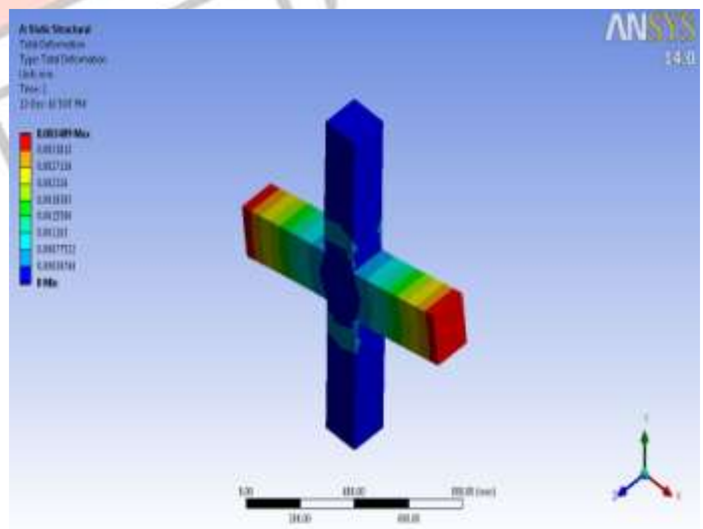


Fig.13Frame Deformation

7.2 FRAME SECTION WITH GFRP

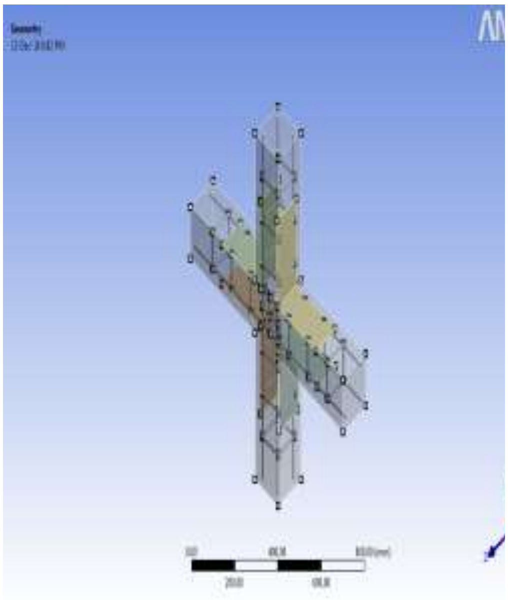


Fig.14Reinforcement with GFRP in ansys

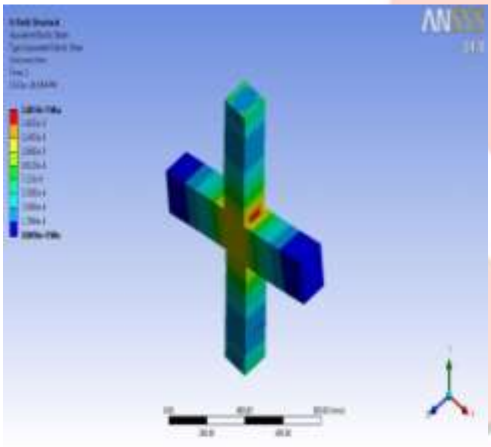


Fig.15 Frame strain

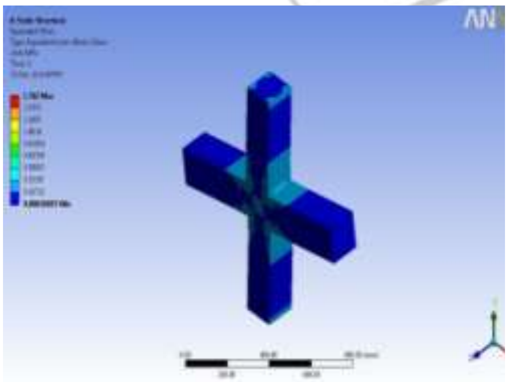


Fig.16Frame stress

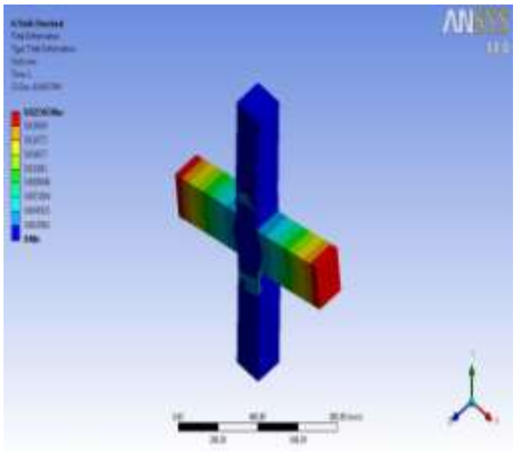
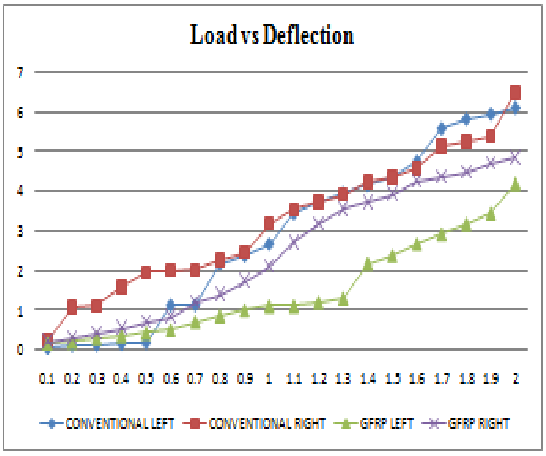


Fig.17Frame Deformation

VIII.EXPERIMENTAL RESULTS

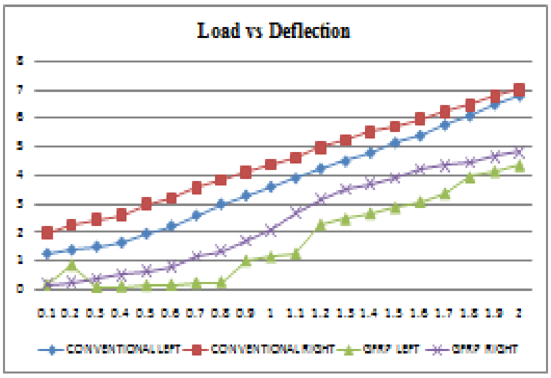
8.1 CYCLIC LOAD TESTING FOR (+) SECTION AT 28DAYS

Load		Deflection in mm			
LOAD	DIAL GUAGE	Conventional		GFRP	
		Left	Right	Left	Right
1	0.1	0.07	0.22	0.16	0.20
2	0.2	0.14	1.09	0.20	0.30
3	0.3	0.15	1.10	0.30	0.40
4	0.4	0.18	1.60	0.35	0.55
5	0.5	0.20	1.95	0.42	0.70
6	0.6	1.14	2.0	0.50	0.84
7	0.7	1.15	2.01	0.70	1.20
8	0.8	2.18	2.26	0.85	1.40
9	0.9	2.38	2.45	1.0	1.74
10	1.0	2.68	3.18	1.10	2.10
11	1.1	3.45	3.54	1.10	2.70
12	1.2	3.76	3.72	1.20	3.18
13	1.3	3.96	3.92	1.30	3.54
14	1.4	4.16	4.24	2.18	3.72
15	1.5	4.38	4.35	2.38	3.92
16	1.6	4.76	4.58	2.68	4.24
17	1.7	5.58	5.12	2.92	4.35
18	1.8	5.82	5.26	3.18	4.48
19	1.9	5.94	5.38	3.45	4.69
20	2.0	6.10	6.50	4.20	4.85



8.2 CYCLIC LOAD TESTING FOR (+) SECTION AT 14DAYS

LOAD		DEFLECTION IN MM			
DIAL GUAGE READING	LOAD IN KN	Conventional		GFRP	
		LEFT	RIGHT	LEFT	RIGHT
1	0.1	1.25	1.96	0.20	0
2	0.2	1.38	2.24	0.90	0.10
3	0.3	1.50	2.46	0.12	0.20
4	0.4	1.64	2.59	0.15	0.40
5	0.5	1.95	3.0	0.18	0.80
6	0.6	2.22	3.20	0.21	0.12
7	0.7	2.60	3.55	0.27	0.18
8	0.8	3.0	3.80	0.30	0.23
9	0.9	3.30	4.10	1.05	1.03
10	1.0	3.60	4.35	1.18	1.20
11	1.1	3.90	4.60	1.30	1.30
12	1.2	4.25	4.95	2.30	2.23
13	1.3	4.50	5.23	2.50	2.51
14	1.4	4.80	5.50	2.70	2.69
15	1.5	5.15	5.70	2.90	2.90
16	1.6	5.40	5.95	3.10	3.09
17	1.7	5.78	6.21	3.40	3.50
18	1.8	6.10	6.45	3.96	3.92
19	1.9	6.50	6.75	4.16	4.24
20	2.0	6.80	7.0	4.38	4.58



VIII.CONCLUSION

Beam-column joint in the moment resisting frame have traditionally been neglected in design process while the individual connected elements, that is, beam and column, have received considerable attention in design. Based on the studied dimensions of the beam–column joint and the considered defects along with the proposed GFRP strengthening configuration subjected to incrementally monotonic static loading, the following conclusions can be drawn:

- Using GFRP as a strengthening material led to increased ultimate capacity and decreased ductility compared to conventional beam column joints.
- The experimental results clearly demonstrate that GFRP wrapping can enhance the structural performance of RC beam column joint under static loading.
- Increasing the number of GFRP layers increase the axial compressive strengths of the beam column joint.
- The above test results show comparison of Control specimen has less load carrying capacity compared to GFRP layered specimen.
- The structural behavior of RCC beam column joint Corner type has been studied. , Experimental investigation has been carried out and the test results show that the structural behavior of Corner beam column joint model. From the test results, important parameters have been worked out such as strength, deflection in order to assess the seismic behavior of the beam column joint when earthquake load acting on structure.

REFERENCES

1) Abram, D. P. "Scale Relations for Reinforced Concrete Beam-Column Joints", ACI Journal, Vol. 79, No. 6, pp. 484-490, 1987.

2) Alexandor, and Dimitrios George Tsonos, "Cyclic Load Behaviour of Reinforced Concrete Beam Column Sub Assemblages of Modern

Structures", ACI Structural Journal, Vol. 104, No. 4, July-August, pp. 468-478, 2007.

3) Asha, P. and Sundararajan, R. "Evaluation of seismic resistance of exterior beam column joints with detailing as per IS 13920:1993", The Indian concrete journal, February, pp. 29-34, 2006.

4) Au, F. T. K., Huang, K. and Pam, H. J. "Diagonally- Reinforced Beam-Column Joints Reinforced Under Cyclic loading", Structures and Buildings, Vol. 158, pp. 21-40, 2005.

5) Balaguru, P., Narahari, R. and Patel, M. "Flexural Toughness of Steel Fibre Reinforced Concrete", ACI Structural Journal, Vol. 89, No. 6, November-December, pp. 541-546, 1992.

6) Hwang-Lee, Seismic design and detailing of exterior reinforced concrete beam-column joints. 13th world conference on earthquake engineering van couver, B.C., Canada, August'1-6, 2004.

7) Jachong, K. and Lafave, J.M. "Joint Shear Behaviour Prediction in RC Beam-Column Connections Subjected to Seismic Lateral Loading",The 14th World Conference on Earthquake Engineering, Beijing, China, 2008.

8) Kumar. V., Nautiyal B.D and Kumar.S, "A Study of Exterior Beam-column joints", The Indian Concrete journal, January, pp. 39-44, 1991.

9) Lee, D. L. N., Wight, J. K. and Hanson, R. D. "R.C Beam-Column Joints under Large Load Reversals", Journal of Structural Division, ASCE, Vol 103, No ST 12, pp. 2337- 2350, 1977.

10) Liang, X. and Montesinos, G.J.P. "Seismic Behaviour of Reinforced Concrete Column-Steel Beam Subassemblies and Frame Systems", Journal of Structural Engineering, ASCE, February 2004, PP. 310-319, 2004.

11) Mariselvam.T and Sakthieswaran.N "Experimental Investigation on GFRP Wrapped R.C Beam Column Joint." International Journal Of Engineering Research Vol-1, Issue-1, 2015.

12) Nawale.M.A., and Mehetre.A.J.,Kandekar.S.B., "Strengthening of RC Beam and Column Joint by Using CFRP & GFRP". International Journal of ScientificEngineering and Technology, vol-4, issue-9, pp. 457-460, September 2015.

13) NagumalliKedarNath and Jeyashree "Analytical study on reinforced concrete beam column joint wrapped with CFRP". Inernational Journal of Advanced Structures and Geotechnical Engineering.vol-5, No-2. ISSN 2319-5347,2016.

14) Pampanin, S., Calvi, G.M. and Moratti, M. "Seismic Behaviour of R.C. Beam-Column Joints Designed for Gravity Loads", 12th European Conference on Earthquake Engineering, paper reference 726, 2002.

15) Perumal, P. and Elangovan, G. "Correlation of Experimental and Theoretical Strength of Superplasticised Steel Fibre Reinforced Concrete", International Journal of Engineering Studies Vol. 1, No. 2, pp. 139–148, 2009.

16) Rajesh Prasad, D., Tso-b Chein, P., Paulus, I, Keh-Chyuan, T., Ker-Chun, L. and Chui-Hsin, C. "Experimental study on the dynamic response of gravity- designed reinforced concrete connections"Elsevier Journal of Engineering Structures, Vol. 27, pp. 75-87, 2005.