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Design of RC Beam and Column Joint by Application CFRP & GFRP

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Abstract—The beam column joint is the crucial zone in a reinforced concrete moment resisting frame. It is subjected to large forces during severe ground shaking and its behavior has a significant influence on the response of the structure. The assumption of joint being rigid fails to consider the effects of high shear forces developed within the joint. The shear failure is always brittle in nature which is not an acceptable structural performance especially in seismic conditions. The revisions of Indian code provisions have necessitated strengthening of several existing structure in country.

Keywords: - Deflection, Flexure , fiber reinforced polymers , Design of RC -Beam columns joint, epoxy

I. INTRODUCTION

Strengthening of existing structures has become a major part of construction activity in our country. Many civil engineering structures are no longer safe due to increased load specifications in the design codes. Such structure must be strengthened in order to maintain their serviceability. Strengthening refers to the reconstruction or renewal of any part of an existing building to provide better structural capacity like higher strength and ductility than the original building. Procedure for Paper Submission. Strengthening of existing structures has become a major part of construction activity in our country. Many civil engineering structures are no longer safe due to increased load specifications in the design codes. Such structure must be strengthened in order to maintain their serviceability. Strengthening refers to the reconstruction or renewal of any part of an existing building to provide better structural capacity like higher strength and ductility than the original building. Procedure for Paper Submission. In RC buildings, beam-column joints are subjected to large forces during severe ground shaking and its behavior has a significance influence on the response of the structure. Hence beam-column joint is the crucial zone in a reinforced concrete moment resisting frame. The revisions of Indian code provisions have necessitated strengthening of several existing structure in country. [2]

A *Importance of RC beam-column joint:*

In the analysis of reinforced concrete moment resisting frames the joints are generally assumed as rigid. In Indian practice, the joint is usually neglected for specific design with attention being restricted to provision of sufficient anchorage for beam longitudinal reinforcement. This may be acceptable when the frame is not subjected to earthquake loads. There have been many catastrophic failures reported in the past earthquakes, in particular with Turkey and Taiwan earthquakes occurred in 1999, which have been attributed to beam-column joints. The poor design practice of beam column joints is compounded by the high demand imposed by the adjoining flexural members (beams and columns) in the event of mobilizing their inelastic capacities to dissipate seismic energy. Unsafe design and detailing within the joint region jeopardizes the entire structure, even if other structural members conform to the design requirements. Since past three decades extensive research has been carried out on studying the behavior of joints under seismic conditions through experimental and analytical studies. Various international codes of practices have been undergoing periodic revisions to incorporate the research findings into practice. [3], [9].

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II. METHODOLOGY & INVESTIGATION

A Experimental work:

The experimental work consists of the testing eight reinforced concrete interior beam-column joint specimens. The columns had a cross section of 150 mm x 150 mm with an overall length of 750 mm and the beams had a cross section of 150 mm x 150 mm with an overall length of 750 mm. The cantilever length of 300 mm on either side of the column. The column was reinforced with 4 numbers of 10 mm diameter tor steel bars and the beam was reinforced with 2 numbers of 10 mm diameter tor steel bars each as tension and compression reinforcement. The lateral ties in the columns of the specimens were 6 mm diameter bars with the spacing of 90 mm c/c. Beams had double legged stirrups of 6 mm diameter mild steel bar at 90 mm c/c. [2]

B. Factors affecting bond strength:

The significant parameters that influence the bond performance of the reinforcing bar are confinement, clear distance between the bars and nature of the surface of the bar. Confinement of the embedded bar is very essential to improving the bond performance in order to transfer the tensile forces. The relevant confinement is obtained from axial compression due to the column and with reinforcement that helps in arresting the splitting cracks. Joint horizontal shear reinforcement improves anchorage of beam bars . But, there is an upper bound to the beneficial effects of confinement. At this limit, maximum bond strength is attained beyond which the crushing of concrete in front of the rib portion of the deformed bar occurs. Research indicates better bond performance when the clear distance between the longitudinal bars is less than 5 times the diameter of the bar 13. As expected, the deformed bars give better performance in bond. The behavior of the reinforcing bar in bond also depends on the quality of concrete around the bar.

C .Material properties:

In this paper two type of material used Carbon fibre 1)reinforced polymer (CFRP)
 2)Glass fibre reinforced polymer (GFRP)

Fig. 1 Shows carbon fiber

Each carbon filament thread is a bundle of many thousand carbon filaments. A single such filament is a thin tube with a diameter of 5–8 micrometers and consists almost exclusively of carbon. The earliest generation of carbon fibers (e.g. T300, and AS4) had diameters of 7–8 micrometers. Later fibers (e.g. IM6) have diameters that are approximately 5 micrometers. Carbon fiber is an extremely lightweight reinforcing fiber derived from the element carbon.
The carbon atoms are bonded together in crystals , The crystal alignment gives the fiber high strength-to-volume ratio.CARBON FIBRE +PLASTIC RESIN=CFRP

TABLE I MATERIAL PROPERTIES OF CFRP

Name	CFRP
Technical data of fiber	230 gsm
Modulus of elasticity	240kN/mm^2
Tensile strength	5650MPa to531GPa
Total wt of sheet in maim direction	230 g/m^2
Density	1.7g/cm^3
Ultimate strain %	1.55
Color	Back
Thickness for static density wt/density	0.117mm

Materials Properties Glass fibre reinforced polymer (GFRP):

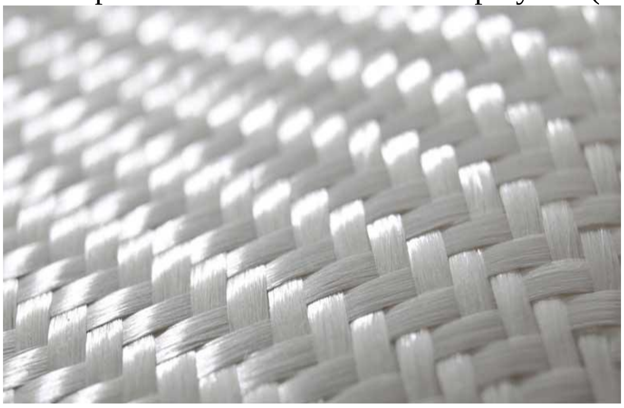

Fig. 2 Shows Glass fiber

Fiberglass or GFRP , is a fibre reinforced polymer made of a plastic matrix reinforced by fine fibers of glass. Fiberglass is a lightweight, extremely strong, and robust materials. The plastic matrix may be epoxy, thermosetting plastic.
Common uses of fiberglass include high performance aircrafts , boats, automobiles, baths, hot tubs, water tanks, roofing, pipes, cladding, casts, Surfboards, and external door skins.

TABLE II MATERIAL PROPERTIES OF GFRP

Name	GFRP
Technical data of fiber	E-Glass,900gsm
Modulus of elasticity	73kN/mm^2
Tensile strength	3400 N/mm^2
Total wt of sheet in maim direction	9000 g/m^2
Density	2.6g/cm^3
Ultimate strain %	4.5
Color	Black
Thickness for static density wt/density	0.342mm

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D. Application Procedure of GFRP & CFRP Wrapping:

1. Grinding the surface from joint up to 150 mm and to get an even surface. All projections are grounded off.
2. Apply embraced Primer to be prepared concrete surface area. Work site must be thoroughly ventilated during the application of chemicals.
3. Mix the two packed MBrace Saturant two packs and apply to the primed concrete specimen using brush.
4. The fibre sheet must be cut before application of MBrace Saturant into prescribed sizes using scissors or cutters.
5. On the saturant fix the sized glass fibre carbon fibre sheets and roll in the beam longitudinal direction . [2]

III TEST SETUP

The specimens were fixed on universal testing machine such that the both ends of column were fixed by UTM. The projections of beam length 300 mm on either side of the column were fixed by proving ring attached with hydraulic jacks. The experimental programme consist of rehabilitation using glass fibre reinforced polymer (GFRP) and carbon fibre reinforced polymer (CFRP) .[2]

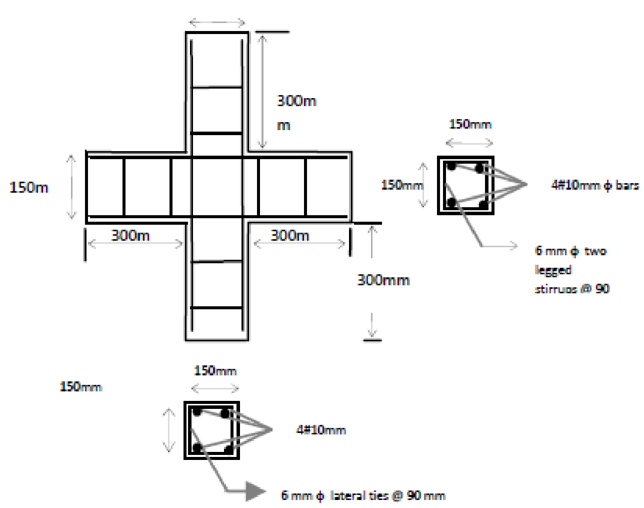

Fig. 3 Shows reinforce detail.

Fig. 4 Test arrangement for Virgin Specimen.

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Fig. 5 Test arrangement for Rehabilitated specimen.

A Graphs and result for CFRP: The loads and the corresponding deflections on virgin and rehabilitated specimens were plotted on graphs. These results were obtained by conducting load test on virgin specimens and rehabilitated specimens. The graphs are plotted based on loads and deflections of both the specimens.[2]

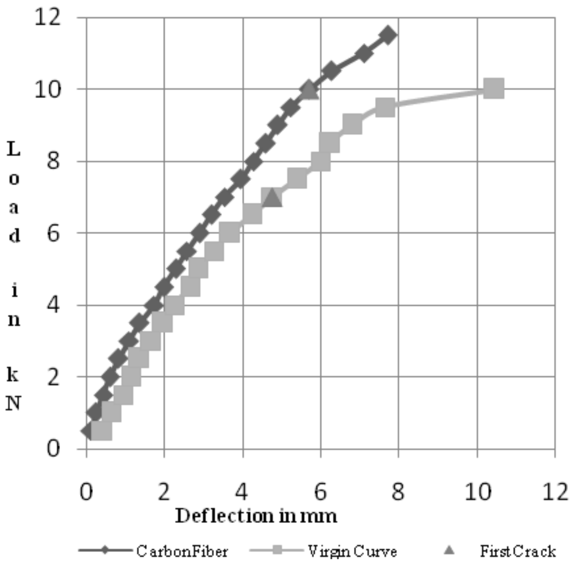

Fig. 6 Load Deflection Curve for CSP 1

B Load Study:

With reference to the test results, the load on virgin specimens at first crack stage is compared to the load on carbon fibre specimens at first crack stage. It is observed that the load carrying capacity of carbon fibre specimens are increased when compared to the virgin specimens. From these values the percentage of increase in load carrying capacity of carbon fibre specimens over virgin specimens are tabulated following table.

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TABLE III YIELD POINTS OF THE CARBON FIBRE SPECIMENS

Sample No	Load at First crack (kN)		Percentage increase In strength
	Virgin Specimen	Carbon fibre Specimen	
CSP 1	7.0	10.0	42.86
CSP 2	4.5	8.5	88.89
CSP 3	6.5	10.0	53.85
CSP 4	5.5	7.5	36.36

C Graphs and result for GFRP:

The loads and the corresponding deflections on virgin and rehabilitated specimens were plotted on graphs. These results were obtained by conducting load test on virgin specimens and rehabilitated specimens. The graphs are plotted based on loads and deflections of both the specimens.[2]

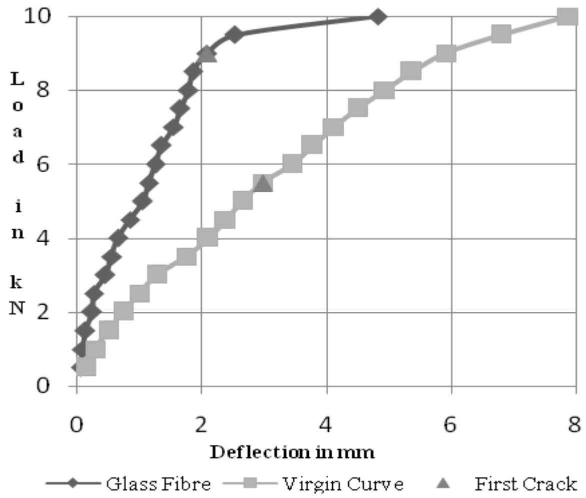

Fig. 7 Load Deflection Curve for GSP 1

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Yield points of the carbon fibre specimens:

D Load Study:

With reference to the test results, the loads on virgin specimens at first crack stage are compared to the loads on glass fibre specimens at first crack stage. It is observed that the load carrying capacity of glass fibre specimens are increased when compared to the virgin specimens. From these values the percentage of increase in load carrying capacity of glass fibre specimens over virgin specimens are tabulated in following table.

TABLE IV Yield points of the glass fibre specimens:

Sample No.	Load at first crack (kN)		Percentage increase in strength
	Virgin Specimen	Carbon Fibre Specimen	
GSP 1	5.5	9.0	63.63
GSP 2	7.5	9.5	26.67
GSP 3	8.0	8.5	6.25
GSP 4	6.0	9.0	50.00

E Casting Procedure:

In this paper cast specimen with mix design M20 .Total eight specimen cast and after 28 days strength test specimen of load and deflection study of vergin specimen CFRP & GFRP.These three comparision of load & deflection study with help of universal testing machine.

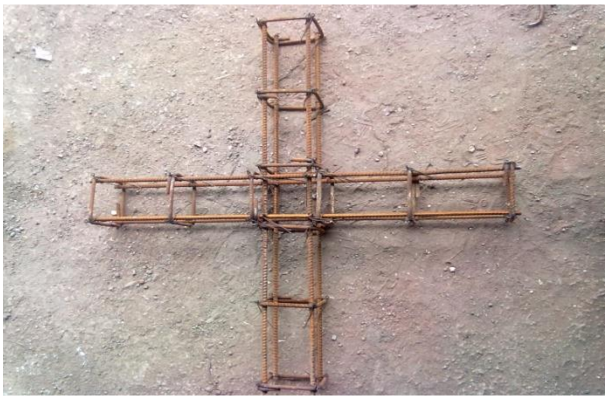

Fig. 9 Reinforcement details for test specimen.

Fig. 10 Casting specimen with mold.

IV ADVANTAGES

1. In numerous environmental conditions, like when exposed to salts or moisture, GFRC & CFRC is likely to function better.
2. Relatively light in weight its installation is fast and comparatively simple.
3. GFRC & CFRC has the characteristics to be cast into almost any shape.

4. GFRC consists of materials that are unlikely to burn. The concrete takes the role of a thermal regulator while exposed to fire and protects the materials from the flame heat.
5. GFRC & CFRC is thin and strong, with weight being 75% to 90% less compared to solid concrete. Less weight facilitates easy and rapid installation, and also decreases the load applied on the structure. The light weight and tough material also minimizes the transportation expenditures, permits flexibility in design, and reduces the impact on environment.
6. Superior strength enhances the ability to endure seismic loads.
7. GFRC & CFRC is less vulnerable to weather effects and more resistant to freeze thaw than the normal concrete.
8. Limitless opportunities for architectural expression.
9. Surface can be left uncoated.
10. Naturally Friendly to the Environment.
11. Disaster Resistant. [2]

V CONCLUSION

Based on the experimental investigations carried out on the virgin and rehabilitated beam-column joint specimens using GFRP and CFRP wrapping, the following conclusions were drawn.

1. The rehabilitation technique using wrapping system for the damaged R.C.C interior beam – column joints have proved to be effective.
2. The rigidity and ultimate load carrying capacity of the restored beam was improved with decrease in deflections.
3. Both glass and carbon composite materials can be efficiently used for rehabilitation of reinforced concrete joints. [2]
4. Joints can exhibit enhanced performance for different reinforcement detailing and damage states.
5. Considerable increase in yield load can be achieved by use of glass and carbon reinforced polymer materials.
6. Considerable increase in first crack load can be achieved by using glass and carbon reinforced polymers.
7. Tests on rehabilitated specimens suggest that FRP not only restores its original strength but also considerable enhancement in its yield load and initial stiffness.
8. The rehabilitated specimens are stiffer than the virgin specimen and the crack widths in the rehabilitated specimens are relatively less.

REFERENCES

[1] Antonopoulos C.P., and Triantafillou T.C.,(February 2002): Analysis of FRP-strengthened RC Beam-Column Joints, Journal of Composites for Construction, Vol. **6**, No. 1.
[2] V.Ravindra & R.V.Ramkrishna, "Experimental investigation on Rehabilitation of reinforced Cement concrete interior Beam-column joints using CFRP and GFRP sheets", International Journal of Engineering Science and Technology (IJEST),vol 2, page no 875-881.
[3] Prof. A. Meher Prasad & Dr.S.R.Uma, "Seismic Behavior of Beam Column Joints in Reinforced Concrete Moment Resisting Frames". Document No: IITK-GSDMA-EQ31-Vol 1. page no 2-5
[4] Engindeniz M., Kahn L.F., Zureick A.H., (March-April 2005): Repair and strengthening of reinforced concrete beam-column joints state of the art, ACI Structural Journal, V. **102**, No. 2, pp. 187-197.
[5] Syed Altaf Husain, V. Pandurangadu, K. Palani Kumar, "Machinability of glass Fibre reinforced material", 12WCEE2000, page no- 4-10.
[6] Faza SS, Ganga Rao HVS.,(1994) : Fibre composite wrap for rehabilitation of concrete structures. Proceedings of the Materials Engineering Conference 804, ASCE pp. 1135-1139.
[7] Geng Z.J., Chajes M.J., Chou T.W., and Pan D.Y.C.,(1998). The Retrofitting of Reinforced Concrete Column-to-Beam Connections, Composites Science and Technology Vol. **58**, pp. 1297-1305.

Volume 02, Issue 08, [August– 2015] **ISSN (Online):2349–9745 ; ISSN (Print):2393-8161**

[8] Granata P.J., and Parvin A.,(2001): An Experimental Study on Kevlar Strengthening of Beam-Column Connections, Composite Structures Vol. **53,** pp. 163-171.
[9] Geetha , "An Experimental Study on behavior of RC beam column joint Strengthened using different composite material". IJEST vol 3, page no 65-68.
[10] LAU Shuk Lei, (August 2005) : Rehabilitation of reinforced concrete beam-column joints using glass fibre reinforced polymer sheets, M.Phil. Thesis, the University of Hong Kong, 154 pp.
[11] Meier U., (1987a) Proposal for a carbon fibre reinforced composite bridge across the State of Gibraltar at its narrowest site, Proceedings of the Institution of Mechanical Engineers, 201(B2), pp. 77-78.
[12] N. Attari, S. Amziane and M. Chemrouk, "strength and ductility of reinforced concrete beam-column joint strengthening by hybrid F.R.P. & G.F.R.P sheets", APFIS, page no-88-90.
[13] Meir U., (1992): Carbon Fibre Reinforced Polymers: Modern Materials in Bridge Engineering, Strvctvrak /Engineering International, International Association for Bridge and Structural Engineering, Switzerland, pp. 7-11.
[14] Mukherjee A., and Joshi M.,(2005): FRPC Reinforced Concrete Beam-Column Joints under Cyclic Excitation, Composite Structures, Vol.**70**, pp. 185-199.
[15] Nanni A., (Ed.)., (1993): Fibre-Reinforced-Plastic (FRP) Reinforcement for Concrete Structures, Properties and Applications. Elsevier Science Publisher.
[16] Pantelides C.P., Gergely J., Reaveley L.D., and Nuismer R.J., (1997): Rehabilitation of Cap Beam-column Joints with Carbon Fibre Jackets, Proc.,3rd Int. Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures, Sapporo, Japan, Japan Concrete Institute, Tokyo, Vol. **1**, pp. 587-595.

