JACKETING OF BEAM- COLUMN JOINT USING FRP COMPOSITES

[1]V.Mohanalakshmi, [2]Prof.R.Jagadeesh Kumar,[3]Prof.L.Agnes Preethi, [4]Prof.A.Sasikumar[5]Prof.V.Soundara Rajan

1PG Student, Civil Engineering Department, K.S.R. college of Engineering, Tiruchengode, Tamil Nadu, India.
2, 3,4, 5 Assistant Professor, Civil Engineering Department, Jansons Institute ofTechnology, Coimbatore, Tamil Nadu, India.

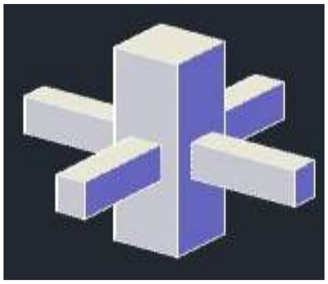
Abstract: According to Indian Standard codal provisions for earthquake considerations it has been found that many structures located in seismically active zones are not capable of withstanding seismic waves.Moreover the seismic behaviour of the existing buildings is affected due to design deficiency, construction deficiency, additional loads, additionalperformance demand, etc.During recent Earthquakes it is observed that the principal cause of collapse of many moment-resisting frame buildings is because ofthe Shear failure ofbeam – column joints.In a view of improving the seismic performance of existing structures,enormous number of research works have been carried out to developvarious strengthening and rehabilitation techniques.During future seismic activities Retrofitting processreduces the vulnerability of damage of an existing structure. It aims to strengthen a structure to satisfy the necessities of the current codal provisions for seismic design. In recent years it has been found that among various retrofitting methods, seismic retrofit with FRP materials has gained notable acceptance. Retrofitting with FRP materials is now extensively being used as a seismicretrofitting method and it is a technicallysound and cost effective repairing technology. In this paper, it has been reviewed the possibilities and methods in practice for wrapping the beam column joints.This paper also summarizes the scope and uses of FRP materials such as carbon Fibre Reinforced Polymer (CFRP) and Glass Fibre Reinforced Polymer(GFRP).

***Keywords*:Retrofitting, beam – column joint, seismic activity, CFRP, GFRP.**

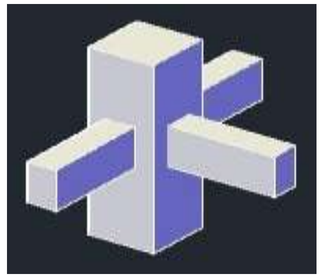
I. INTRODUCTION

During recent years, earthquakes of varying magnitude, causing broad damage to life and property. The seismic behavior of the existing buildings is generally affected by their original structural inadequacies, material degradation due to aging and alterations carried out during use over time. The main types of damage in reinforced concrete structures due to earthquake are cracking in tension zone, diagonal cracking in the core and loss of concrete cover, bursting of stirrups at outside and buckling of main reinforcement. Therefore, it is necessary to upgrade the existing undamaged or damaged buildingswith seismic strengthening Techniques. It increases the seismic resistance of an existing building so that it becomes safer during the occurrence of further seismic waves. Different Techniques have been used in the years to reinstate the structural integrity of the member by restoring or increasing its strength. Researchers across the globe are studying on the retrofitting techniques those are advantageous and most cost effective.

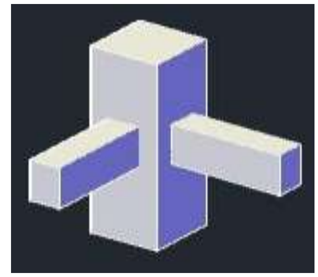
In RCC buildings the portion of column which is common to the beams at their intersection are called beam-column joints. The constituent materials of joints have limited force carrying capacity and limited strength.Beam column jointsbeing the lateral and vertical load resisting memberswhich are severely damaged during earthquake,when the forces that applied are larger than the resisting capacity of joints. Beam – Columnjoints are the weakest link in RC moment resisting frame. The prime reason behind it failure is the inadequate shear strength of the joints, and this is occurred due to the insufficient and inadequate detailed reinforcement in the joint region. Damage must be avoided by using different techniques during construction stages because repairing of damaged joints is very difficult after it appears. Generally column should be stronger then beam in earthquake resisting frame. The behavior of beam column joints are influenced by two major factors like exposure conditions such as exterior and interior and the nature of load coming over the structure – i.e. intensity of earthquake. The various types of beam column joints based on the exposure condition are shown in figure 1.



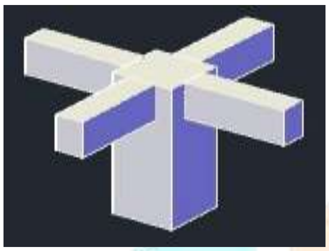
a) Interior



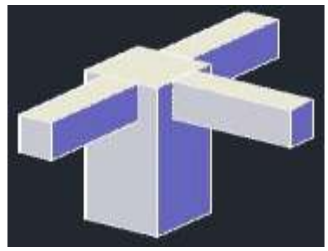
b) Exterior



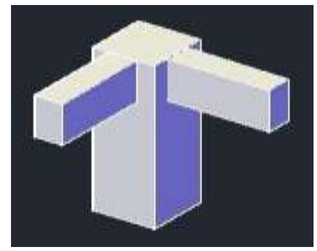
c) Corner



d) 'Roof'- interior



e) 'Roof'- Exterior



f) 'Roof'- Corner

Fig 1: Types of Beam- Column Joints

Fibre materials are used to strengthen a variety of reinforced concrete elements to enhance the flexural, shear and axial load carrying capacity of elements. Fibre Reinforced polymer composite (FRPC) materials have been successfully used in the construction of new structures and in rehabilitation of existing structures. FRPCs are non-metallic. Therefore, they are resistant to corrosion. They have high strength to weight ratio. The major constituents ofFRP are the fibre and the resin. The commonly used types of FRP are: i) Carbon Fibre Reinforced Polymer (CFRP), ii) Glass Fibre Reinforced Polymer (GFRP), iii) Aramid Fibre Reinforced Polymer (AFRP).

II. MATERIAL PROPERTIES

2.1 Carbon Fibre Reinforced Polymer (CFRP)

Carbon Fibre-reinforced polymer is an extremely strong and light Fibre reinforced polymer which contains carbon Fibre. Carbon fibres are created when polyacrylonitrilefibres, Pitch resins, or Rayon are carbonized (through oxidation and thermalpyrolysis) at high temperatures. It is expensive but commonly used wherever high strength and rigidity is required. TheCarbon Fibre-Reinforced Polymer (CFRP) materials have a highpotential for manufacturing effective strengthening systems toincrease the flexural or shear strength of RC beams. The CFRPmaterials have a very low weight to volume ratio, are immuneto corrosion, and possess high tensile strength.

2.2 Glass Fibre Reinforced Polymer (CFRP)

Glass Fibre is a material consisting of numerous extremely fine Fibres of glass. Glass Fibre is commonly used as an insulating material. Glass Fibre is also used as a reinforcing agent for many polymer products; to form a very strong and light Fibre-reinforced polymer(FRP) composite material called glass-reinforced plastic (GRP), popularly known as "Fibreglass". With reference to internet source the thermal and mechanical properties of Carbon Fibre and Glass Fibre are shown in Table.1 and Figure 2 and 3 shows the CFRP and GFRP.

Table.1.Thermal and Mechanical properties of Carbon Fibres and Glass Fibres

S. No	Properties	Glass Fibre	Carbon Fibre
1	Tensile Strength (MPa)	1380-2070	3950
2	Density (g/m^3)	2.59	1.77
3	Tensile Strain (%)	1.4	1.4
4	Elongation at Break (%)	3-4	1.5
5	Linear Coefficient of Thermal Expansion ($10^{-6}/k$)	-0.1	-0.1
6	Tensile Modulus (GPa)	72.45	238
7	Ply Thickness (inches)	0.038	0.064

Fig.2.CFRP

Fig.3.GFRP

III. JACKETING OF BEAM – COLUMN JOINT

3.1 Earlier researches based on CFRP as wrapping material

Gia Toai Truong et al. (2017), has carried out various retrofit methods for concrete columns such as steel jacketing, carbon Fibre reinforced polymer (CFRP) wrapping, concrete jacketing with non-shrinkage mortar, and new concrete jacketing with amorphous metallic Fibre (AMF) reinforced concrete. Two different retrofit strategies were applied to the control specimens: partial retrofit in the plastic hinge zone, mainly aiming at increasing deformability, and full retrofit in the entire range of columns, aiming at increasing both shear strength and deformability. The test results showed that the retrofitted specimens presented ductile failure mode and enhancement in the dissipated energy and the damping ratio, but the effect differed for each retrofit method.

Naveeena et.al. (2016), the exterior beam column joint is strengthened or retrofitted to enhance their strength and stiffness. An analytical model is proposed to predict the shear capacity strengthened with carbon fibre reinforced polymer (CFRP).The axial load were applied at the column top of the surface and held constant during the test. The free end of the beam subjected to cyclic loading. Two specimen one is unstrengthened and another is strengthened specimen with CFRP were modelled and analysed. An effective re-habitation strategy is in order to increase the ductility of the beam column joint and transfer the failure mode to beam or delay the shear failure mode. The specimens are then loaded with step by step load increment procedure to stimulate the cyclic loading in testing. The stress and deformation results were evaluated and compared their results with strengthened and unstrengthened specimen. The numerical result shows that the beam column joint strengthened with CFRP can increase their structural stiffness, strength and energy dissipation capacity.

Muhammad N.S. Hadi et al. (2014), has carried out retrofitting on exterior beam–column joints using segmental circular concrete covers together with Carbon Fibre Reinforced Polymer (CFRP). They modify the columns of beam–column joints before wrapping with CFRP. That glued concrete covers work well together with the existing concrete. The result shows that the application of CFRP on the modified circular sections improved its effectiveness.

S. H. Alsayed et al. (2010), epoxy-bonded CFRP sheets have been used with different scheme such as control, strengthened, repaired specimens at the joints for the upgrading the shear strength and ductility of exterior beam-column joints. The author compared the results of different scheme through hysteretic loops, load-displacement envelopes, joint shear distortion, ductility, and stiffness degradation and found that CFRP sheets are very effective in improving shear resistance and deformation capacity of the exterior beam-column joints and delaying their stiffness degradation.

IV. JACKETING OF BEAM – COLUMN JOINT USING GFRP

4.1 Earlier researches based on GFRP as wrapping material

Mariselvam et al. (2015), have carried out the experimental investigation on seismic behavior of beam column joint using Glass Fibre Reinforced polymer (GFRP) wraps. Four numbers of exterior beam column joint were cast and tested under lateral loading. The performances of the specimens are compared in terms of lateral load versus displacement curves. Out of four specimens one was control specimen and the remaining three specimens were wrapped with 1 layer, 2 layers, and 3 layers of GFRP. Result shows that GFRP specimen posses more load carrying capacity than the control specimen.

Ganesh Kumar et al. (2015), have carried out an experimental investigation to study the effect of hybrid Fibres on the strength and behavior of High performance concrete beam column joints subjected to cyclic load. Crimped steel Fibres and Glass Fibres were used in hybrid form. The combination of 0.75% volume fraction of steel Fibres and 0.33% volume fraction of Glass Fibres gave better performance with respect to energy dissipation capacity and stiffness degradation than the other combinations.

Tara Sen et al. (2013), carried out the study of failure modes, flexural strengthening effect on ultimate load and load deflection bonded externally with JFRP, CFRP and GFRP, wrapped in configuration in single layer, along the entire length of the beam in full wrapping and strip wrapping technique. The results depicted that JFRP, CFRP and GFRP, strengthening improved the ultimate flexural strength of the RC beams. FRP strengthening displayed highest deformability index has huge potential as a structural strengthening material.

V. CONCLUSION BASED ON PAPER REFERRED

From the review of literature collection it is observed that the strengthening/retrofitting plays a very vital role to improve the ductility of the failure structure. From all these paper it is found that CFRP and GFRP sheets are being very effective in improving the shear resistance and deformation capacity of the exterior and interior beam-column joints and delaying their stiffness degradation during seismic activities. For strengthening the beam column joint small thickness of CFRP or GFRP sheet cause of mechanical debonding, so it can be reduced by improving the thickness of sheet or implementation of additional layer of sheets .CFRP and GFRP wrapping on beam column joint increases the ultimate flexural strength of the structure and considerably reduces the shear failure.

VI. FUTURE SCOPE

There is a wide scope for research and to learn more about the beam column joint. In all research papers the author has not used steel plates at the joint for the strengthening of beam column joint. So, using steel plates with different scheme at the joint we can also improve the shear resistance and deformation capacity of the exterior and interior beam-column joints and delaying their stiffness degradation.

The carbon and glass fibres can also be used for retrofitting of beams and columns.

It can be used as a hybrid fibre of various percentages to enhance the load carrying capacity.

CFRP material has advantages in the various fields such as Aerospace Engineering where it is used in wings and fuselage component of airplane and Automotive Engineering where it is used in high end automobile racing vehicles in body panel due to increase strength and decrease weight.

It also used in laptop cases, audio components, musical instruments etc.

VII. ACKNOWLEDGMENT

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