Performance Analysis Of Retrofitted Beam Column Joint By Using FEM

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Abstract - *A Beam, Column and Joint is selected from the structure, and to be modeled in FEA software. With the help of finite element analysis, the model of Beam Column Joint is properly modeled by assigning properties and after that proper meshing is done on the model. Further, by applying proper loading the Beam-Column Joint is analyzed. Finally, by Analyzing the model results like Stress, Strain distribution also the total Deformation the strength is calculated and which is within the limit and structure performance is analyzed well. Retrofitting of currently used buildings has come into question with the determination of buildings' performance levels due to earthquake force effect. In this sense, lots of retrofitting techniques have been applied for the retrofitting of current buildings beam column joint In recent years, For strengthening and rehabilitation of existing structures Fiber Reinforced Polymer (FRP) composites have their advantage over traditional materials. The advantages such as corrosion resistance, light weight, high-strength to weight ratio, and high efficiency in construction encourage civil engineers to use this material*

Key Words: **Shear, Torsion, Buckling, Beam Column Joint, shear strength, Strain ,Reinforced Concrete Structure, CFRP and ANSYS.**

1. INTRODUCTION

The maintenance, rehabilitation and upgrading of structural members, are perhaps one of the most crucial problems in civil engineering applications. Moreover, a large number of structural components such as beams, columns and beam column joint constructed in the past using the older design codes in different parts of the world. Beams, columns and Beam-column joint deformations and strength affect the overall performance and load carrying capacity of reinforced concrete structures making them susceptible to progressive collapse due to failure of one or more beam-column joints under gravity and earthquake loadings. Therefore, retrofitting of beams, columns and beam column joints is needed to maintain structural safety and reliability. Retrofitting of currently used buildings has come into question with the determination of buildings' performance levels due to earthquake force effect. In this sense, lots of retrofitting techniques have been applied for the retrofitting of current buildings. Columns, beams, joints In recent years, For strengthening and rehabilitation of existing structures Fiber Reinforced Polymer (FRP) composites have their advantage over traditional materials. The advantages such as corrosion resistance, light weight, high-strength to weight ratio, and high efficiency in construction encourage civil engineers to use this material. Effective lateral confinement is provided by FRP jackets to the concrete beams, columns and joints that can improve their compressive strength, flexure strength and ultimate axial strain. Retrofitting with FRP materials provides successful solutions for strengthening, repairing, adding ductility, rapid execution, long-term durability, and consequently lower lifecycle costs.

Ilki, Demir and Comert [1] Studied on the retrofit of RC joints with FRP composites. This paper explains about typical failure modes of RC beam-column joints. The most common FRP retrofitting schemes and contribution of the FRP retrofitting to behaviour of exterior beam column joint is examined. For the study large scale structural tests on retrofitting beam column joints built with low strength concrete and plain bars by FRP sheets is done. It is found that FRPs can contribute significantly to the performance of RC joints against various deficiencies. The need for standard code of practise in the field of FRP retrofitting is pointed out from this study

Subramani, Krishnan, Saravanan, and Thomas [2] Studied The Finite element method (FEM) has become a staple for predicting and simulating the physical behavior of complex engineering systems. The details of the finite element analysis of beam column joints retrofitted with carbon fibre reinforced polymer sheet (CFRP)carried out using the package FEA are presented in this paper

Ali and Gayathri [3] Studied investigated on the behaviour of RC beam column joint retrofitted with various thicknesses of CFRP and GFRP Sheets. Beam column joint of a G+3 story building is considered. CFRP and GFRP sheets of varying thickness are considered. Analytical study for the model is done using FEA software and the results are discussed. Result shows that retrofitting using CFRP will give 50% more strength (Von-Mises stress) as compared to GFRP.

Vijaya, Shivakumaraswamy, Ravikiran [4] Studied Retrofitting of existing structures using Fiber reinforced polymer (FRP) technique. Different types of FRP sheets such as (CFRP) Carbon Fiber Reinforced polymer, (GFRP) Glass Fiber Reinforced Polymer, (AFRP) Aramid Fiber Reinforced Polymer sheets to strengthen the beam-column joint

1.1 CARBON FIBRE REINFORCED POLYMER

Carbon fiber-reinforced polymer, carbon fiber-reinforced plastic or carbon fiber-reinforced thermoplastic (CFRP, CRP, CFRTP) or often simply carbon fiber, or even carbon), is an extremely strong and light fiber reinforced polymer which contain carbon fiber.

The reinforcement will give the CFRP its strength and rigidity; measured by stress and elastic modulus respectively. Unlike isotropic materials like steel and aluminium, CFRP has directional strength properties. The properties of CFRP depends on the layouts of the carbon fiber and the proposition of the carbon fibers relative to the polymer

Despite its high initial strength to weight ratio,a degree limitation of CFRP is its lack of a definable endurance limit. This means theoretically that stress cycle failure cannot be ruled out. While steel and many other structural metals and alloys do have estimate fatigue endurance limits, the complex failure modes of composites mean that the fatigue failure properties of CFRP for critical cyclic load applications, engineers may need to design in considerable strength safety margins toprovide suitable component reliability over its life service.

ADVANTAGE FOR CFRP

- High tensile strength
- High strength to weight ratio
- Low weight to volume ratio
- Excellent fatigue behavior
- Quick application

CFRP composite was able to strengthen the shear capacity as well as the ductility of beam column joint.

2.0 OBJECTIVES

- In order to increase the strength and stiffness of beam column joint by using carbon fibre reinforced polymer.
- In order to reduce the failure on beam column joint like Cracking, under seismic load
- The use of carbon fiber reinforced polymer into joint will enhance the strength and stiffness

3.0 FINITE ELEMENT MODELLING

3.1 Element Types

The finite-element analysis of bare and strengthened beam-column joints first require modeling of the joints with the dimensions and properties corresponding to beam-column joints tested in the experiment. In this section, modeling, including meshing, details of beam-column joints, is presented. The finite-element program ANSYS Workbench Version 12 is used for this purpose. The element details of each material are presented subsequently.

Concrete: To model the concrete an eight-node solid element, Solid65, is used. This solid element has eight nodes with three degrees of freedom at each node with translations in the nodal x, y, and z directions. Plastic deformation, cracking in three orthogonal directions and crushing capability can be utilized by the element.

Reinforcing Steel: Discrete modeling is used for reinforcement steel by defining the element between the nodes in the performed meshes. The steel for the finite-element model was assumed to be an elastic–perfectly plastic material with identical properties in tension and compression.

Link8 element is used to model the steel reinforcement. Two nodes are required for this element. Each node has three degrees of freedom, which are translations in the nodal x, y, and z directions. Depending upon the applications, the element may be saw as truss element, a cable element, a reinforcing bar and a bolt. The three-dimensional spar element is having two nodes and each node having three translational degrees of freedom.

SOLID 45 is a 3-dimensional element is used to model isotropic solid problems. It has eight nodes, with each node having three translational degrees of freedom in the nodal X, Y & Z directions. This element may use to analyze high deflection, high strain, plasticity and creep problems. It has no real constants

4. METHODOLOGY , ANALYSIS AND RESULT

ANSYS is a finite element analysis tool for structural analysisand explicit studies. ANSYS offers an easy and flexible platform for performing analysis of structures or models with great accuracy. ANSYS consists of two working platforms called APDL and workbench among which workbench provides more automated options for the analysis operations.

This is usually done using numerical approximation in structural analysis is the Finite Element Method

This chapter deals with the parametric study. The parametric study is analyzed by using software's like ANSYS 16 The parametric study focuses on the analysis of the structure and after which analysis of exterior Beam Column joint carried out using FEM software, this study has carried out for concluding the importance of Beam Column joint strength and its behavior on the structure.

Table -1: Different material properties used in Ansys

Material s	Concrete	Steel
Density (kg/ m3)	2300	7850
Elastic Modulus (Mpa)	25000	200000
Poisson's ratio	0.15	0.30
Fck (Mpa)	25	-
Fy (Mpa)	-	Fe 500
Element used	SOLID 65	LINK 8

Table -2: Reinforcement Schedule For BCJ

TYPE OF MODEL	Column	Beam
Retrofitted	CFRP	CFRP
CS SIZE (mm)	400 X 400	230 X 450
Length of model (mm)	3000	2400
Longitudinal Steel	4 Nos T16 mm	4 Nos T16 mm
Lateral Ties	8mm @ 300mm c/c	8mm @ 300mm c/c

Table -3: Properties of CFRP Sheets

FRP SHEETS	CFRP
MODULUSOF ELASTICITY (E)	23000 Mpa
POISSONS RATIO	0.22
ULTIMATE TENSILE STRENGTH	3500 Mpa
SHEAR MODULUS (G)	3270 Mpa

Table -4 : Details of retrofitted on model used in Ansys

FRP SHEETS	CFRP
MODULUS OF ELASTICITY (E)	23000 Mpa
POISSONS RATIO	0.22
Thickness Of CFRP Sheets	1.12 mm
No of Layer Wrapped	02

4.1 Procedure and boundary condition

- A BCJ is modeled by using ANSYS
- BCJ having M25 grade of concrete used
- After selection of the BCJ the geometric model (concrete and steel) is Prepared by taking proper dimensions and assigning properties to the model After that retrofitting
- The above model is retrofitted by CFRP in Ansys meshing is done in Ansys
- applying the boundary condition for column

  (both ends are fixed fixed).
- The boundary condition for beam (one end are fixed other is free).
- Apply the load center of the edge of the beam and analysis is carried out
- Above figure shows the geometry of the BCJ model prepared for the analysis.
- Following figure shows The Geometry of selected retrofitted BCJ model

Firstly the geometry of Beam Column Joint is modeled in ANSYS v16 software.

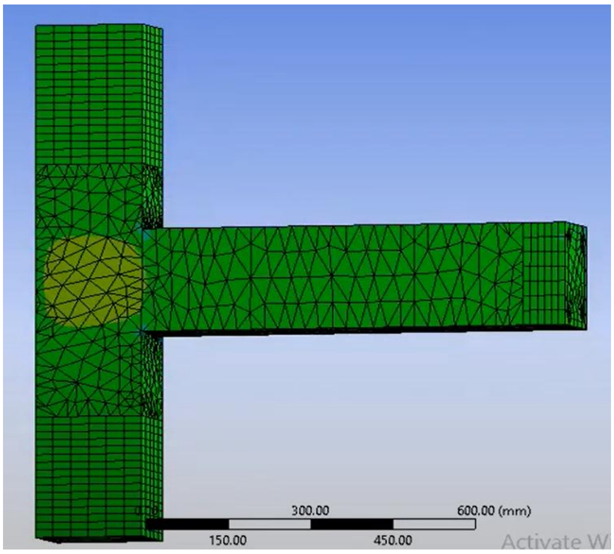

Figure No 4.1 : The Geometry of selected retrofittedBCJ model

Reinforcement :

Following fig 4.2 shows Reinforcement details of Retrofitted BCJ

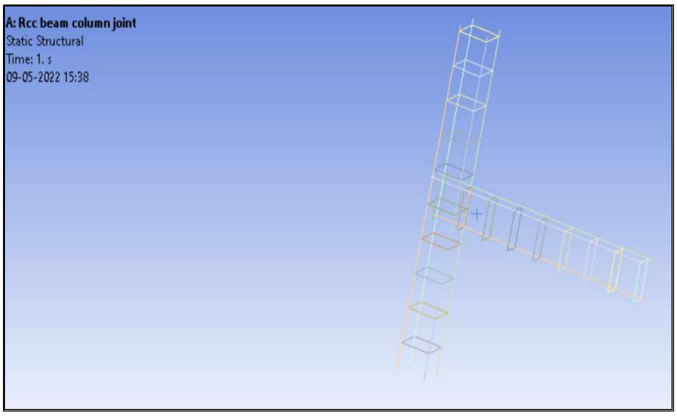

Figure No. 4.2 : Reinforcement details of Retrofitted BCJ

Meshing:

After the model in ANSYS v16 and after giving proper properties the model is run for the Meshing. Following fig.4.3 shows the Meshed model of Beam-ColumnJoint

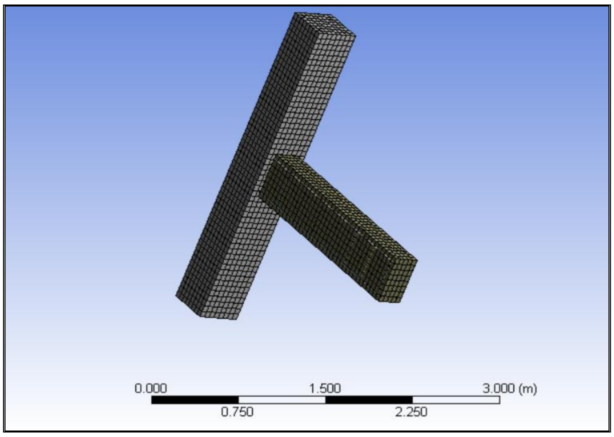

Figure No 4.3 : Meshing of BCJ model

The loading applied on BCJ model the static remote load for the analysis of the BCJ as following table

Table No 5 : Remote force of BCJ

Nos	Loading (Y) (downward) in N
1	200000
2	300000
3	400000
4	500000
5	600000

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After that detail analysis of retrofitted BCJ like total deformation ,maximum principal elastic strain ,shear stress ,normal stress, shear elastic strain , equivalent elastic strain, shown in below.

The Total Deformation obtained is tabulated in the Table.6 with the values and according to fig.4.4 the Joint shows safer values.

Fig. No. 4.4 : Total Deformation of BCJ Solution Total Deformation

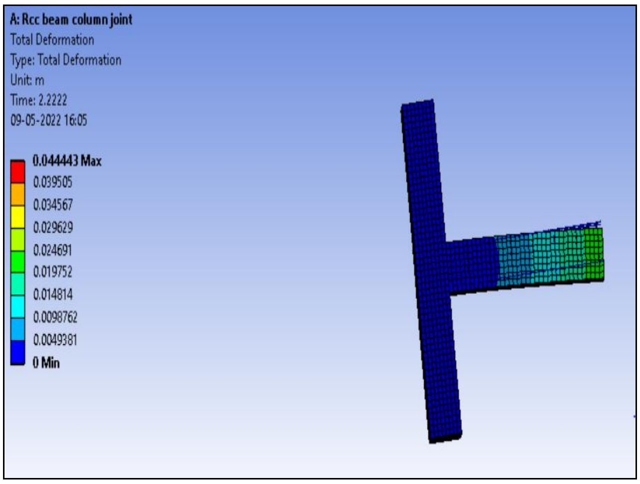


Table -6: Total Deformation

Time [s]	Minimum [m]	Maximum [m]
1.	0.	4.4443e-002

The Normal Elastic Strain obtained is tabulated in the Table.7 with the values and according to fig.4.5 the Joint shows safer values.

Fig. No. 4.5 : Normal Elastic Strain of BCJ Solution Normal Elastic Strain

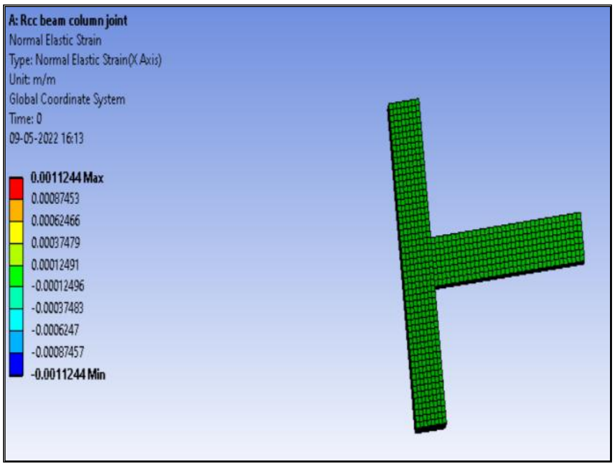


Table -7: Normal Elastic Strain

Time [s]	Minimum [m/m]	Maximum [m/m]
1.	-1.1244e-003	1.1244e-003

The Normal stress obtained is tabulated in the Table.7 with the values and according to fig.4.6 the Joint shows safer values.

Fig. No. 4.6 : Normal Stress of BCJ Solution normal Stress

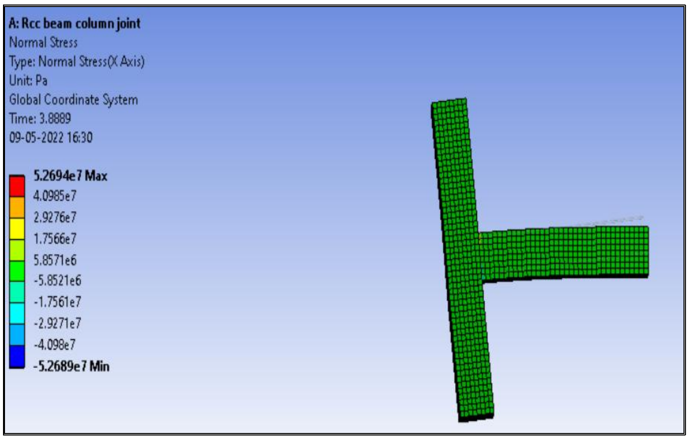


Table -7: Normal stress

Time [s]	Minimum [Pa]	Maximum [Pa]
1.	-5.2689e+007	5.2694e+007

The von Mises Stress obtained is tabulated in the Table.8 with the values and according to fig.4.7 the Joint shows safer values.

Fig. No. 4.7 : von Mises Stress of BCJ Solution von Mises Stress

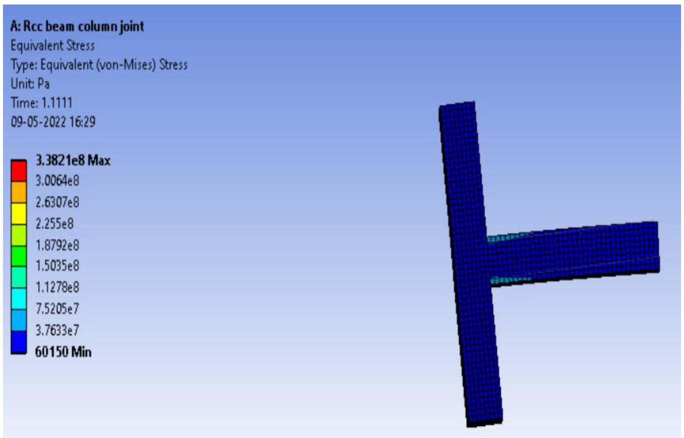


Table -8: Equivalent (von Mises)Stress

Time [s]	Minimum [Pa]	Maximum [Pa]
1.	60150	3.3821e+008

The Shear Elastic Strain obtained is tabulated in the Table.9 with the values and according to fig.4.78the Joint shows safer values

Fig. No. 4.8 : Shear Elastic Strain of BCJ Solution Shear Elastic Strain

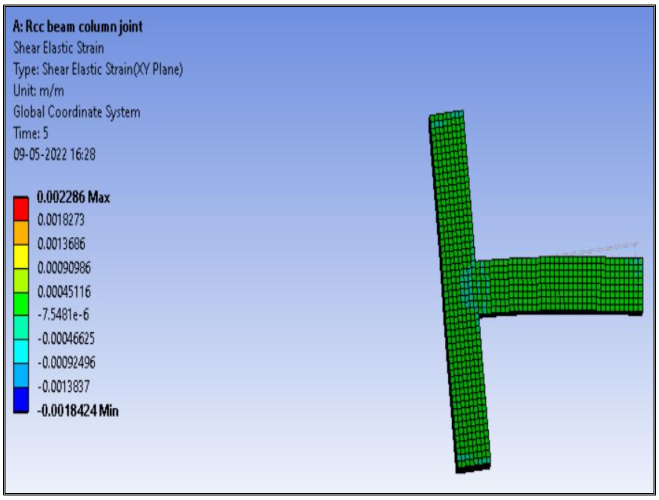


Table -9: Shear Elastic Strain

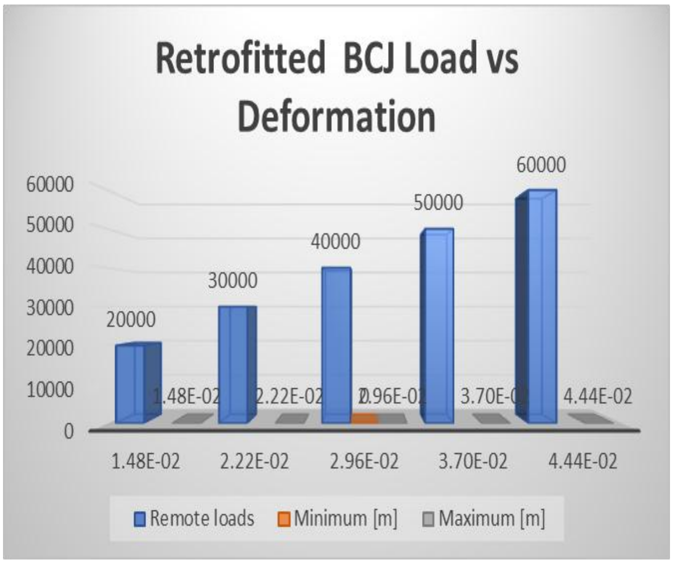
Time [s]	Minimum [m/m]	Maximum [m/m]
1.	-1.8424e-003	2.286e-003

4.2 Load vs Deformation of Retrofitted BCJ

The following table shows applied remote loadsvs Respective minimum and maximum deformationof Retrofitted Beam column joint

Time [s]	Remote loads [N]	Minimum [m]	Maximum [m]
1.	20000		1.4814e-002
2.	30000		2.2221e-002
3.	40000	0.	2.9629e-002
4.	50000		3.7036e-002
5.	60000		4.4443e-002

Fig No. 4.9 : Load vs Deformation for Retrofitted BCJ



5 Conclusion

- As we see that the fig 4.9 shows the Load vs Deformation for Retrofitted BCJ as we seen that the load increases the deformation increases. the minimum deformation for 60KN loading is 0 and maximum deformation for loading 60KN is 0.044443 m which is safe and with in limit

- the analysis of the reinforced concrete structure by estimating forces and based on these forces the design is to be carried out, After that study focused on the use of Finite Element Analysis to observe behavior of External Beam Column Joint. Further it was aimed to perform detail analysis of Beam Column Joint in FEA Software to analyze the stress, strain distribution pattern. By study of Finite Element Analysis, it is observed that computer simulation offers proper potential to understand the behavior of beam column joint under various loading. Detailed analysis is performed for Beam Column Joint for stability of joint under consideration, and according to fig 4.4 it shows that maximum deformation of BCJ 0.044443 m which safe and within limit and fig 4.6 and 4.7 shows the maximum Normal stress and von Mises stresses is 5.2694e+007 Pa and 3.3821e+008 Pa respectively and Normal & Shear elastic Strain of BCJ is 1.1244e-003 and 2.286e-003 under 60 kN loading the values within limit and joint is safe

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REFERENCES

[1] **N. Ganesan., P.V. Indira.,** and Ruby Abraham., Steel fibre reinforced high performance concrete Beam-column joints subjected to cyclic loading. ISET Journal of Earthquake Technology., Vol. 44, No. 3-4, Sept.-Dec. 2007, pp. 445–456.

[2] **A. Ilki, C. Demir and M. Comert (2013)** "Retrofit of RC joints with FRP composites", Istanbul Technical University, Turkey, https:// www. researchgate. Net / publication / 259364431

[3] **Vijaya,s., b.Shivakumaraswamy, and k. V. Ravikiran.** "Numerical modeling on behavior of reinforced concrete exterior beam- column joint retrofitte with externally bonded fiber reinforced polymer (frp)". International journal of research in engineering and technology 3 (2014).

[4] **Vijaya,s., b.Shivakumaraswamy, and k. V. Ravikiran.** "Numerical modeling on behavior of reinforced concrete exterior beam- column joint retrofitte with externally bonded fiber reinforced polymer (frp)". International journal of research in engineering and technology 3 (2014).

[5] **Mrs. S. M. Kulkarni, Dr. Y.D. Patil** A State-of-art Review On Reinforced Concrete Beam-column Joints. Journal Of Information,Knowledge And Research In, ISSN: 0975 – 6744., Vol.2, Nov11- oct12, pp.94-98

[6] **IS 456-2000, "Indian Standard Plain and Reinforced Concrete-Code of Practise"** , Bureau of Indian Standards ,New Delhi