

## ***“Analytical Investigation on Energy Absorption Transfer from Tensile to Compression Reinforcement in RC Exterior Beam Column Joint”***

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### ***Abstract***

*The beam column joint has been an area of research for the past couple of decades. In this study, the beam column joint was studied for monotonic loading and the interaction between the load increment and the stress developed in the tension and compression reinforcements was determined, this was observed that even the compression reinforcement plays a role in the load carrying capacity of the beam column joint under monotonic loading. It has been observed that as the diameter of the tension reinforcement increases, the load carried by the compression steel reduces. This also implies ductility of the tension reinforcement plays a major role in the load carrying capacity of the beam column joint.*

***Keywords:*** - ANSYS, Exterior joint, Energy absorption, Finite Element

### **INTRODUCTION**

The analysis of RC moment resisting frames the junctions are generally assumed as rigid. In Indian practice, the beam column joints are usually ignored for definite design with attention being constrained to give 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. A beam column joint defined by the Indian code is the portion of the column within the depth of the deepest beam that frames into the column. This area has been under research over the past

couple of decades. Using finite element software provides us the opportunity to understand the behaviour of RCC beam column joints. This study uses ANSYS software to investigate the beam column joint. The current study aims at determining the variation of stress developed in steel as the load is applied in increments.

### LITERATURE REVIEW

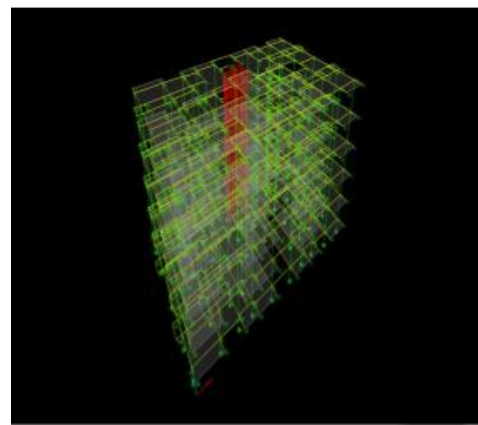
It has been observed from past, many experimental researches have been carried out on exterior beam column joint to Study its exact behaviour under various parameters. Some of the very important parameters are enlisted below:

S.S.Manekari and S.S.Patil [1] used finite element modeling to model and analyze a beam column joint. With the help ANSYS, a model for corner as well as exterior beam column joint was analyzed with the application of monotonic load. The parameters varied were the end conditions, viz., fixed end conditions, hinged end conditions; also the stiffness of the joint was also varied and the parameters determined from the analysis were deflection, maximum stress and minimum stress. The results show that with increase in load the deflection, maximum stress and minimum stress increases; also the

displacement, minimum stress and maximum stress vary nonlinearly with change in stiffness.

### ANALYTICAL PROCEDURE

A G+5 storey building was modeled using ETABS and from the results the most critical external beam column joint was selected. Fig. 1 shows the model in ETABS. After the critical exterior joint was selected, the forces were scaled to one fourth the value in order to experimentally verify the solution obtained from ANSYS for the load deflection characteristics.



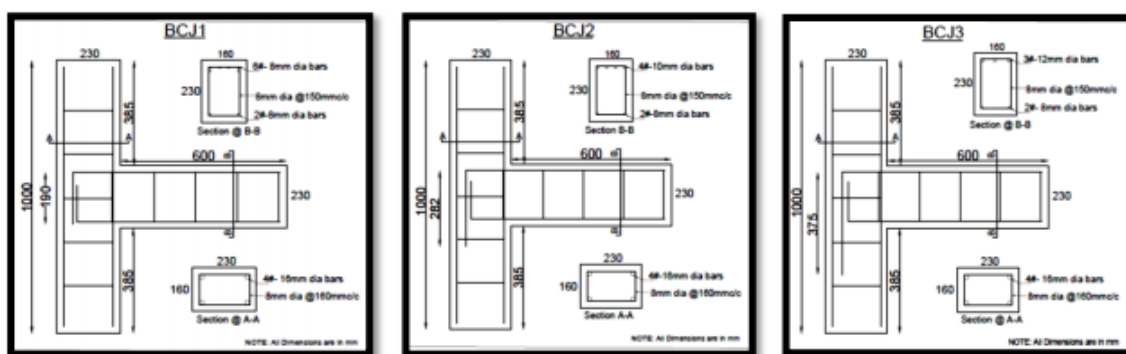
**Figure 1: ETABS model of G+5 structure**

The six beam-column joints which were analysed in the CAD lab of Civil Engineering Dept. research Centre at MSRIT were modelled and run using ANSYS. Each joint was designed as per IS 456: 2000 and detailed as per SP34: 1987. All the six beam-column joints had identical beam and column sizes. The

beams were 160 mm wide and 230 mm deep and the columns are 230 mm by 160 mm. The column height was fixed to 1000mm and the beam length was fixed at 600mm. The 28-day cube strength of concrete was taken as 42.85 N/mm<sup>2</sup>. The yield stress in steel was considered to be 500 N/mm<sup>2</sup>.

The details of the specimen can be seen in **fig 2**. And **Table 1** provides us details of all the six specimens.

ANSYS was used to model the beam column joint using Link 180 element for reinforcement and Concrete 65 element for concrete. The column was considered to be fixed and a constant axial load of 130 kN, which was the calculated working load, was applied at the top of the column. The column was fixed at the top and the bottom. The load at the beam was applied at a distance of 100 mm from the free end of the cantilever portion, in incremental proportions.



(2) 8 mm dia Longitudinal bar  
Longitudinal bar

(3) 10 mm dia Longitudinal bar

(4) 12mm

**Figure (2), (3) & (4) : Reinforcement details of BCJ**

**Table 1: Details of Reinforcement**

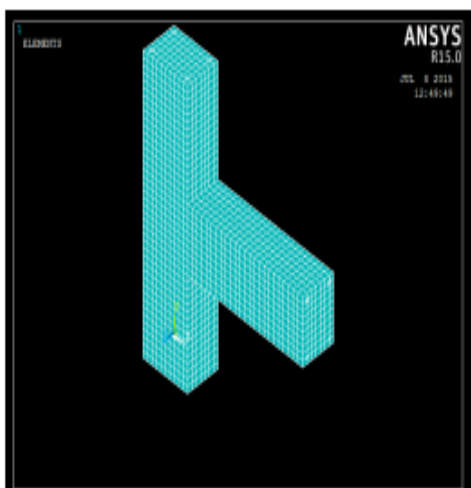
Specimen	Set No.	Column Reinf.	Beam Reinforcement	
			Longitudinal	Shear
BCJ 1	1	4 Nos-16 $\phi$	6 Nos - 8 $\phi$	8mm@ 100c/c
BCJ 2	1	4 Nos-16 $\phi$	4 Nos - 10 $\phi$	8mm@ 100c/c
BCJ 3	1	4 Nos-16 $\phi$	3 Nos - 12 $\phi$	8mm@ 100c/c
BCJ 4	2	4 Nos-16 $\phi$	6 Nos - 8 $\phi$	8mm@ 150c/c
BCJ 5	2	4 Nos-16 $\phi$	4 Nos - 10 $\phi$	8mm@ 150c/c
BCJ 6	2	4 Nos-16 $\phi$	3 Nos - 12 $\phi$	8mm@ 150c/c

Even though the load can be applied at the centroid of the structure, the loads are applied at the respective points in order to simulate the actual behaviour of the beam-column joint. The models were analysed applying monotonic load in the downward direction. The mesh size was fixed at 25mm. A total of 6 beams were analysed. Figure.5 shows the concrete meshed model and Figure.6 shows the reinforced steel.

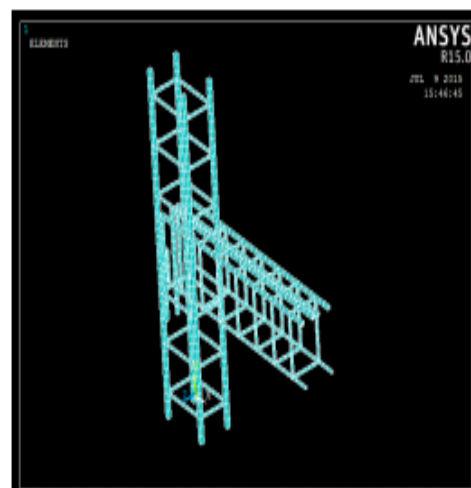
### RESULTS AND DISCUSSION

It was seen that from Figure.7, as the load was incremented the tensile stress developed by the tensile steel also increased. The ultimate stress of 500 N/mm<sup>2</sup> for the tensile steel was attained at a load of 40 kN. Also it was observed that when the load was incremented in steps

the compressive steel had a small gradual increase in the stress, as the tensile steel reached its ultimate stress due to strut effect the load gets transferred to the compressive steel. The compressive steel reaches its ultimate stress value at a load of 60kN. From this it was understood that both compressive and tensile steel play a role in the load carrying capacity. The load v/s deflection plot for any element gives us the energy absorbed by the element. Similarly, in this study the Load v/s Stress in steel was plotted and it was observed that the results obtained were a loop. This loops given us the energy absorbed by the longitudinal reinforcement. Fig shows the plot of the energy absorbed as the reinforcement was varied.



**Figure: - 5 concrete meshed model Figure.**



**Figure: - 6 Reinforced steel model**

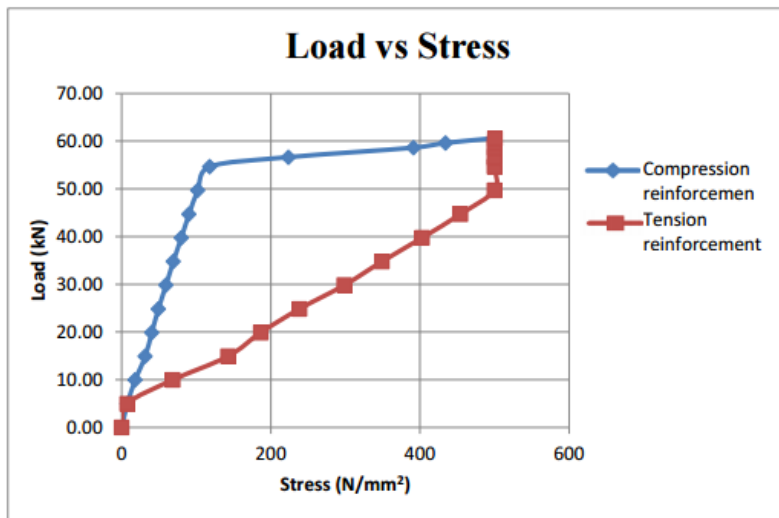


Figure.7: Load v/s Stress plot for BCJ 1

Table: 2 Energy Absorbed by Steel

Specimen	Area under Plot(x 10 <sup>3</sup> mm <sup>2</sup> )
BCJ 1	12245.8
BCJ 2	12803.09
BCJ 3	12716.79
BCJ 4	13513.48
BCJ 5	14114.48
BCJ 6	14051.09

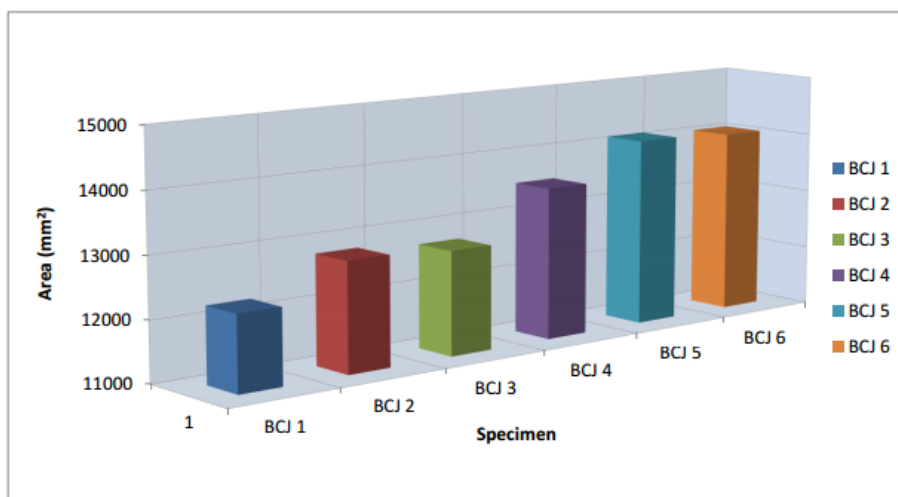


Figure.8: Energy Absorbed by Reinforcement

## CONCLUSIONS

- It was seen that a new approach can be used to determine the energy absorbed by the reinforcement in a beam column joint
- It was observed that even the compression reinforcement plays a role in the load carrying capacity of the beam column joint.
- It was seen that as the diameter of the tension reinforcement increases, the load carried by the compression steel reduces. This also implies ductility of the tension reinforcement plays a major role in the load carrying capacity of the beam column joint.
- It was seen that the area under the loop increases for BCJ 2 by 4.36% when compared to BCJ 1 and increases for BCJ 3 by 3.72% compared to BCJ 1. Similarly, for BCJ 5 there was an increase by 4.26% compared to BCJ 4 and for BCJ 6 it was found to be 3.98% greater than BCJ 4.

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