Exterior Beam Column Joint: An Assessment

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ABSTRACT

In a multi-storied building, the beam-column joint is one of the most critical regions. Usually the beam-column joint was considered as rigid frames. Various researchers over the past years indicated that the joint is not rigid. Now it is also stated that instead of the failure in beam and column, failure can also occur in joint; hence joint must be considered as a structural member. The Indian standards define a joint as the portion of the column within the depth of the deepest beam that frames into the column. In framed structures the bending moment and shear forces are maximum at the junction area. So, beam column joint is one of the failure zones. Among the beam column joints, the exterior joint is more critical. The exterior beam column joint have been a study for about 30 years since now. Still there are many more to be understood. In the present work a joint is one of the failure zones. The paper concluded that the joint enlargement as shown in the Fig: 2.2.1 is a very effective method to reduce the shear stress transmission in the joint panel and hence effective in preventing the damage. There has been also change in the failure mode with the relocation of the plastic hinge from the face of the beam to the face of the enlarge section. The model is well explain with the strut and tie model.

KEYWORDS: Exterior beam column joint, lateral loads, STAAD. Pro V8i, NX CAD, ANSYS

1. INTRODUCTION

Beam column joint is an important component of a reinforced moment resisting frame and should be designed and detailed properly, especially when the frame is subjected to seismic forces. As soon as lateral loads i.e.; seismic forces, comes into picture it will become a critical problem. This problem has not been completely solved till date.

Bakir and Boduroglu (1991) proposed a model for the prediction of the shear strength of the beam-column joints. The paper considers the three new parameters for the first time to predict the shear strength of the joint. These parameters are beam longitudinal reinforcement ratio, beam-column joint aspect ratio and the influence of stirrups ratio. It concluded that beam longitudinal reinforcement ratio has positive effect on the joint shear strength. Because the influence of beam longitudinal reinforcement ratio is taken into account, the proposed equation predicts that the joint shear strength is proportional to (hb/ho)αβγβ. The paper also concluded that the column axial load has no effect on the shear strength but the high column axial load and high column longitudinal reinforcement is required to prevent the column failure.

Park and Mosalman (1993) given a shear strength model of the exterior beam-column joints without shear reinforcement, which can be useful in required confinement reinforcement to prevent the shear damage.

Muhseen and Umemura (1995) proposed a model to estimate the strength of the interior beam-column joint with consideration of the confinement reinforcement and axial force. The proposed model is similar to the current ACI and AJI codes with little modification in the effective area of the joint panel and considering the confinement due to axial force in the column and confinement reinforcement in the joint core. None of the codes has considered the confinement effect in the estimation of the shear strength of the beam-column joint.

Pimanmasa and Chaimahawaneb (1997) present paper to prevent the beam-column joints by enlarging the joint area.

2. OBJECTIVES

1. To design a G + 2 building in STAAD.Pro V8i
2. To Model one exterior beam column joint in NX CAD
3. To statically analyse this exterior beam column joint in ANSYS.
3. Methodology
The design of a G+2 building is done using STAAD.Pro V8i. From the design an exterior beam column joint is selected and modelled using NX CAD, Importing this model to ANSYS 15. Meshing is then carried out followed by static analysis of the exterior beam column joint and solved for the results.

Building Plan and Dimensions
Building having a plan area of 9m × 9m and floor height 3.5m with slab thickness 100mm situated in seismic zone V is selected.

Modelling and Design of Building
A G+2 building of plan as shown in figure 1 is modelled and designed using STAAD. ProV8i. End beam column joint in the first floor is selected for the further proceedings.

Modelling Using NX CAD
The detail design result of the G+2 building is extracted from the STAAD. ProV8i. The column and beam concrete design and detailing are considered for modelling.

| Table 1: Beam and column properties |
|-------------------------------------|
| Beam Size | 300×350 |
| Length of Beam | 3000mm |
| Column Size | 300×500 |
| Length of Column | 3500mm |
| Material | concrete |
| Column Cover | 40mm |
| Beam Cover | 25mm |

4. Analysis Using ANSYS
The beam column joint modelled in NX CAD is imported to ANSYS for analysis.

| Table 2: Properties of Concrete |
|---------------------------------|
| Density | 2300Kgm$^3$ |
| Coefficient of thermal expansion | 1.4E-05 |
| Young’s Modulus | 3E+10 Pa |
| Poisson’s Ratio | 0.18 |
| Bulk Modulus | 1.5625E+10 Pa |
| Shear Modulus | 1.2712E+10 Pa |
| Tensile Ultimate Strength | 5E+06 Pa |
| Compressive Ultimate Strength | 4.1E+7 Pa |
### Table 3: Properties of structural steel

| Property                     | Value          |
|------------------------------|----------------|
| Density                      | 7850 Kgm$^3$   |
| Coefficient of thermal expansion | 1.2E-05       |
| Young's Modulus              | 2E+11 Pa       |
| Poisson’s Ratio              | 0.3            |
| Bulk Modulus                 | 1.6667+11 Pa   |
| Shear Modulus                | 7.6923 +10 Pa  |
| Strength Coefficient         | 9.2 E+08 Pa    |
| Ductility Coefficient        | 0.213          |
| Tensile Yield Strength       | 2.5 E+08 Pa    |
| Compressive Yield Strength   | 2.5 E+08 Pa    |
| Tensile Ultimate Strength    | 4.6E +08 Pa    |
| Compressive Ultimate Strength| 0 Pa           |
| Strength Exponent            | -0.106         |
| Ductility Exponent           | -0.47          |
| Cyclic Strength Coefficient  | 1E+09 Pa       |
| Cyclic Strain Hardening Exponent | 0.2   |

### Table 4: Properties of Meshing

| Property                      | Value          |
|------------------------------|----------------|
| Relevance Centre             | Coarse         |
| Initial Size Seed            | Active Assembly|
| Smoothing                    | Medium         |
| Transition                   | Fast           |
| Span Angle Centre            | Coarse         |
| Minimum Size                 | 0.610460mm     |
| Maximum Force size           | 61.0460mm      |
| Maximum Size                 | 122.090mm      |
| Nodes                        | 1479715        |
| Elements                     | 945288         |

**Figure 6:** Meshed model

### 5. Conclusions

The objective of the present study was defined as. In order to achieve first objective a family of multi-storeyed plane frame with varying building-height, storey-height, base-width, number of bays, column and beam dimensions and grade of concrete were selected. The selected building models were analysed and design according to IS 456:2000 using commercial software STAAD. Pro. Results were analysed to find out the effect of all the above parameters on the shear force demand of critical beam-to-column joints. Also an effort has been made to detect the location of the critical joint in the multi-storeyed framed building. To achieve the objective an innovative joint reinforcement scheme is developed and modelled in finite element software ANSYS v13.0. Beam-column joints with conventional joint reinforcement were also modelled to compare the results of the proposed model. These models were analysed for nonlinear static behaviour. Result were presented how the new approach is effective in reducing the shear demand of the joints and hence can be used to solve the problem of congestion in the beam-column joints.

### References

[1] Rajagopal, S. and Prabavathy, S. (2013). Investigation on the Seismic behavior of the Exterior Beam-column joint using T-type mechanical anchorage with hair-clip bar. Journal of King Saud University-Engineering Sciences.

[2] Thomas H.K.Kang and Mitra N. (2012). Prediction and performance of Exterior Beam-Column Connections with the headed bars subjected to load reversal. Engineering Structures 41(2012) 209-217.

[3] Pimanmas, P. and Chaimahawan, P. (2011). Cyclic shear resistance of Expanded Beam-Column Joint. Procedia Engineering 14(2011) 1292-1299.

[4] Pimanmas, P. and Chaimahawan, P. (2010). Shear Strength of Beam-Column Joint with Enlarged Joint area. Engineering Structure. 32(2010) 2529-2545.

[5] Pantazopoulou, S. J. and Bonacci, J. F. (1994). On earthquake resistant reinforced concrete frame connections. Canadian Journal of Civil Engineering, 21, 307-328.

[6] Rots, J. G. and Blaauwendraad. J. (1989). Crack models for concrete: Discrete or smeared? Fixed, multidirectional or rotating? Heron, 34:1, 334–344.

[7] Will, G. T., Uzumeri, S. M. and Sinha, S. K. (1972). Application of finite element method to analysis of reinforced concrete beam-column joints. In Proceeding of Specialty Conference on Finite Element Method in Civil Engineering, CSCE, EIC, Canada, 745-766.

[8] Hegger, J., Sherif, A. and Roesser, W. (2004). Nonlinear Finite Element Analysis of Reinforced Concrete Beam-Column Connections. ACI Structural Journal, 101:5, 601-614.

[9] Lowes, L. N., Altoontash, A. and Mitra, N. (2005). Closure to “Modeling reinforced concrete beam-column joints subjected to cyclic loading” by L. N. Lowes & A. Altoontash. Journal of Structural Engineering, ASCE, 131:6, 993–994

[10] Noguchi, H. (1981). Nonlinear finite element analysis of reinforced concrete beam-column joints. In IABSE Colloquium, Delft, the Netherlands, 639–653.

[11] LaFave, J. M. and Shin, M. (2005). Discussion of “Modeling reinforced concrete beam-column joints subjected to cyclic loading” by L. N. Lowes & A. Altoontash. Journal of Structural Engineering, ASCE, 131:6, 992–993.

[12] Baglin, P. S., and Scott, R. H. (2000). Finite element modeling of reinforced concrete beam-column connections, ACI Structural Journal, 886-894.