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Analysis of Exterior Beam Column Joint Using ANSYS

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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 building is designed in STAAD. Pro V8i and an exterior beam column joint is considered. This joint is modelled in NX CAD and imported to ANSYS to analyse it to derive the shear stress and the corresponding deformation.***

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.

Dr. R Prabhakara, Harish R, Nambiyanna B, (2015)[1] carried out a study to determine the effect of the diameter of longitudinal reinforcement of the beam on the strength, deformation and ductility in the beam-column joint using ANSYS. It was seen that the load carrying capacity and the deformation increases as the diameter of reinforcement in the beam increases.

Dr. Suraj. N. Khante, Aniket V. Nemade (2015)[2] carried out analytical study on conventional and nonconventional reinforcement near the joint. Behaviour of these two specimens studied by plotting and calculating, Load-displacement curves, ductility factor, cumulative energy dissipation, stiffness behaviour. It is observed that provision of cross diagonal reinforcement bars increased the ultimate load carrying capacity and ductility of joint in the upward and downward loading condition.

Thomas H.K.Kang and Mitra N. (2012)[3] proved that the increasing development length, head thickness, head size and decreasing joint shear demand gives better beam-column joint performance.

K.R. Bindhu and K.P. Jaya (2010)[4] in this paper the performance of exterior beam column joints with non-conventional reinforcement detailing was examined experimentally and numerically. The following conclusions are arrived from this study. The test specimens with diagonal confining bars have shown better performance, exhibiting higher strength with minimum cracks in the joint. All the specimens failed by developing tensile cracks at interface between beam and column. The joint region of specimens of group B is free from cracks except some hair line cracks which show the joints had adequate shear resisting capacity. The specimens detailed as per IS: 456 with diagonal confining bars had improved ductility and energy absorption capacity than specimens detailed as per IS 456:2000.The displacement ductility is increased considerably for the non-conventionally detailed specimens. From the analytical study it is observed that the provision of cross diagonal reinforcement increased the ultimate load carrying capacity and ductility of joints in the both upward and downward loading conditions.

Murty, C.V.R., Rai, D.C., Bajpai, K.K. and Jain, S.K. (2003)[5] have tested the exterior beam column joint subject to static cyclic loading by changing the anchorage detailing of beam reinforcement and shear reinforcement. It was reported that the practical joint detailing using hairpin-type reinforcement is a competitive alternative to closer ties in the joint region.

Scott, R. H. (1992)[6] performed studies by varying the reinforcement pattern using bent up, bent down and U-bars. It was observed that the U-bars show highest load carrying capacity while the bent up and bent down bars fail due to pull out.

Over the past 30 years, researches has been conducted on beam column joint and until now a clear picture is not derived and studies are still on its way.

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.

3.1 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

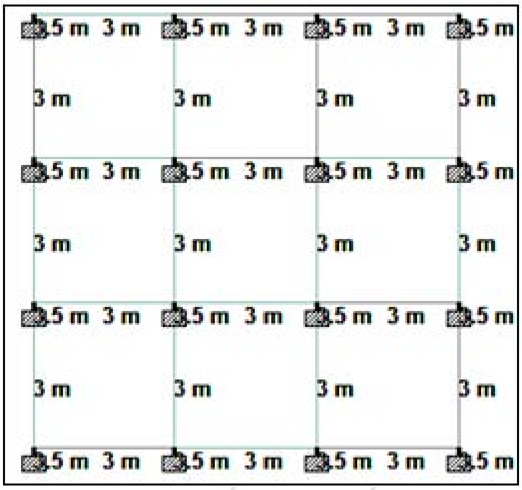

Figure 1: Building Plan

3.2 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.

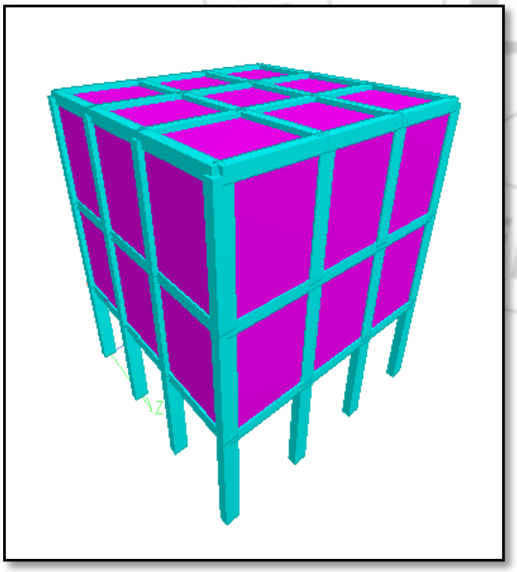

Figure 2: STAAD.Pro V8i model of building

3.3 Modelling Using NX CAD

The detail design result of the G+2 building is extracted from the STAAD.Pro V8i .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

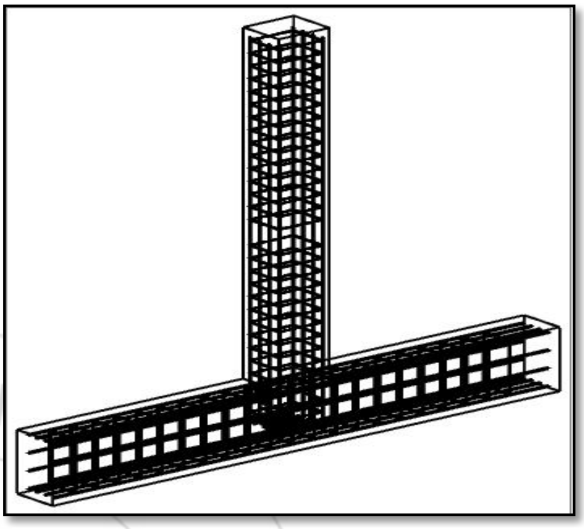

Figure 3: Isometric view of exterior beam column joint

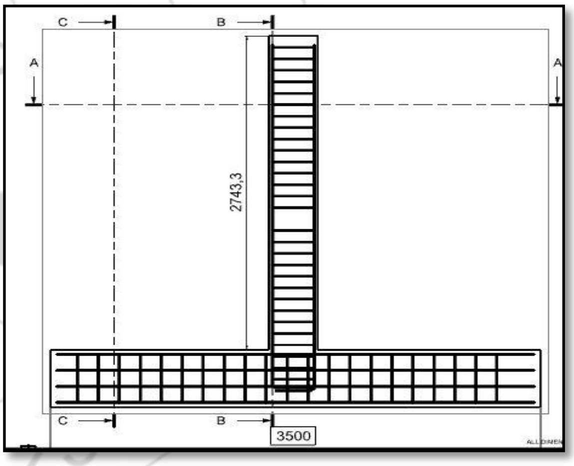

Figure 4: Detailing of Exterior beam column joint

4. Analysis Using ANSYS

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

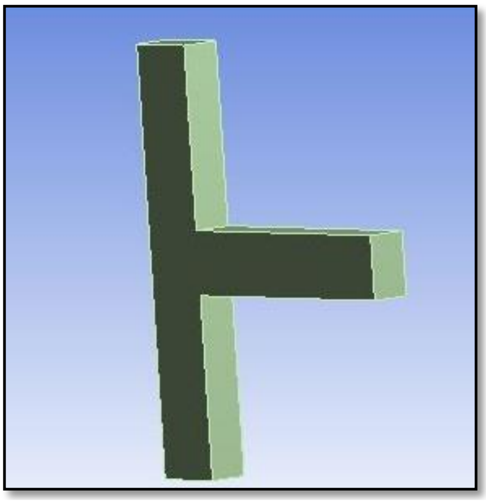

Figure 5: Imported model

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

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

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

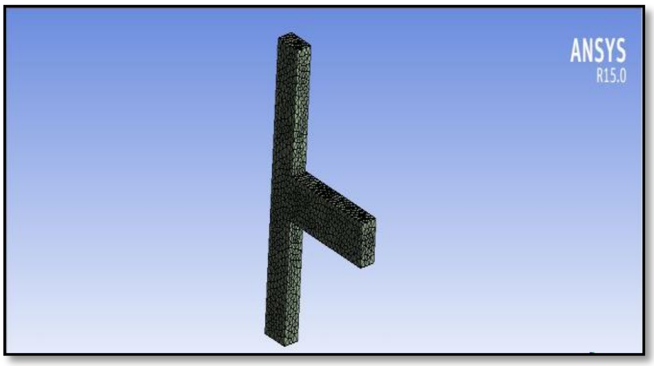

Figure 6: Meshed model

5. Results and Discussions

The static analysis of the exterior beam column joint using ANSYS 15 is done. The value of the shear stress and the corresponding deformation is obtained.

5.1 Shear Stress

The maximum value of the shear stress obtained from the static analysis is 4.27MPa, this value is within the safe limits so no cracks will be formed and hence the joint will be safe under the seismic action.

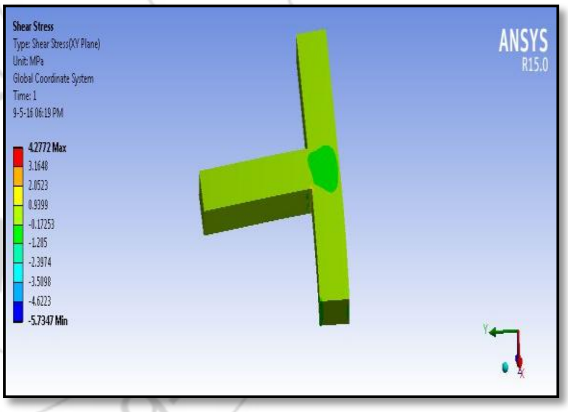

Figure 7: Shear Stress

5.2 Shear Deformation

The maximum deformation value obtained is 0.48mm which is affordable and this deformation does not affect the exterior beam column joint in a critical way.

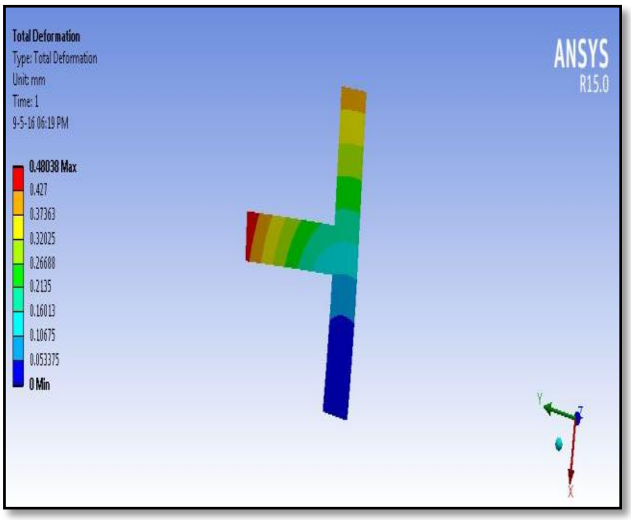

Figure 8: Shear Deformation

6. Conclusions

The conclusion drawn out from the work is listed below

- The maximum value of shear stress in the analysed exterior beam column joint is 4.27MPa is within the permissible limit
- The maximum value of deformation obtained is 0.48mm.

7. Future Scope

The future scope includes:

- In the present work only the exterior beam column joint is considered; the work can be done for interior and corner joints as well.
- The material in the beam column joint can be changed and analysed.
- The exterior beam column joint can be modelled in software such as CATIA.

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