International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 06 | June 2019 www.irjet.net p-ISSN: 2395-0072

Comparison of RC Beam-Column Joint with GFRC Beam-Column Joint using Software ANSYS

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Abstract - *Beam-column joint is the weakest link in a reinforced concrete moment resisting frame. The function of a beam-column joint in a frame is to transfer the loads and moments at the ends of the beams into the columns. Joints are subjected to large forces during severe ground shaking & its behavior has a significant influence on the response of the structure. Retrofitting of the damaged joints is difficult, so it should be designed and detailed properly so that there won't be any failure. This study is focused on the comparison of RC beam-column joint with GFRC beam-column joint. Glass fiber reinforced concrete (GFRC) is a material made of extremely fine fibers of glass mixed with concrete. A specimen of reinforced concrete corner beam-column joint is taken from a G+2 building and designed with steel reinforcement and meshed and loaded. The same beam-column joint is molded by GFRC by assigning the material properties to the joint in the software and analyzed. The static analysis of the both RC & GFRC corner beam-column joint using ANSYS is done. The value of the corresponding deformations and shear stress is obtained. The maximum values obtained for deformations for both the joints are compared for the conclusion.*

Key Words: Beam-column joint, ETABS, Solid works, ANSYS, Static analysis, Deformations.

1. INTRODUCTION

The joint between beam and column are the most critical component in a reinforced concrete structure. The performance of beam-column joint is influenced by many parameters such as material used, column load, and arrangement of reinforcement in column and beam. The RC structure is separated to an individual structure component including column-beam element, wall element. Compressive strength of concrete, detailing of beam-column joints and workmanship play an important role in assessing the seismic performance under seismic loading. Beam-column joint is defined as the zone of intersection between beams and columns with the functional requirement which enable the adjoining members to develop and sustain their ultimate capacity. This study focuses on the design, testing corner beam-column joint. A specimen of reinforced concrete (RC) exterior beam-column joint is taken from a G+2 building and designed with steel reinforcement and meshed. The static analysis of the corner beam-column joint using ANSYS is done. The value of deformation is obtained. The same beam-column joint is molded by GFRC by assigning the material properties to the joint in the software and analyzed. The static analysis of the both RC & GFRC corner beam-column joint using ANSYS is done. The maximum values obtained for deformations for both the joints are compared for the conclusion.

1.1 TYPES OF BEAM-COLUMN CONNECTION

The joint is defined as the Portion of column within the depth of the deepest beam that frames into the column. In a moment resisting frame there are three types of joints such as interior joint, exterior joint and corner joint. Interior joint condition is said when four beams frame into the vertical faces of a column, the joint is called as an interior joint. Meanwhile Exterior joint condition is when one beam frames into a vertical face of the column and two other beams frame from perpendicular directions into the joint, then the joint is called as an exterior joint. Comer joint condition is when a beam each frames into two adjacent vertical faces of a column, then the joint is called as a comer joint.

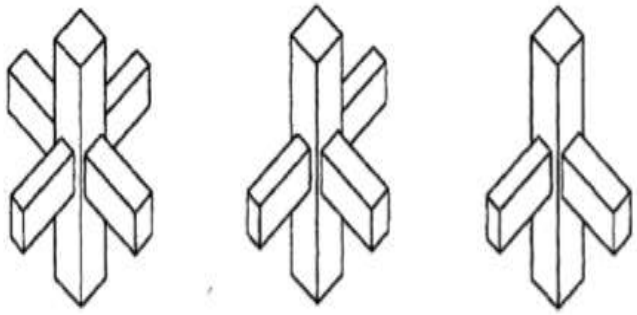

Fig -1: a) Interior Joint b) Exterior Joint c) Corner Joint

1.2 GFRC MATERIAL

Glass fiber also called as fiberglass. It is a material made of extremely fine fibers of glass. Fiberglass is lightweight, extremely strong and robust material. Although the strength properties are somewhat lower than the carbon fiber and it

is less stiff. The material is typically far less brittle and the raw materials are much less expensive.

Fig -2: Glass fiber

2. MODELING

A two-Storey plan of 24mx24m of a building is analyzed in ETABS and one of the Corner joint is chosen and modeled using software SOLID Works. The model is imported to ANSYS for the further analysis. The analysis of beam-column joint with RC material & GFRC material is done using software ANSYS. The material properties for GFRC are taken from journal.

Design details of beam column joint

1. Material
M20 grade concrete, Fe415 steel
2. Beam size
Depth=450mm
Width=350mm
Slab thickness=100mm
Beam span=6m
3. Column size
Depth=450mm
Width=350mm
Column length=3m
4. Loading
Total dead load due to slab, brick & plaster acting on each floor of the structure is 13.8 KN/m.
Seismic load is applied based on IS 1893-2002.

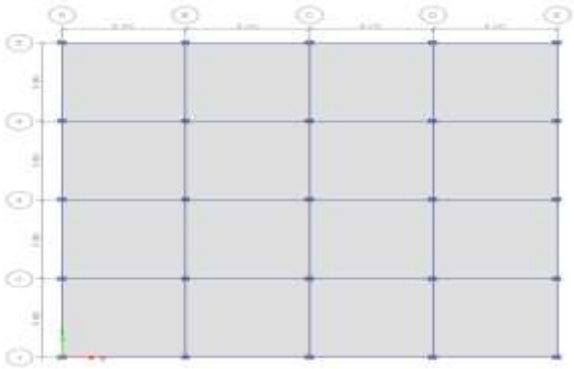

Fig -3: ETAB building Plan.

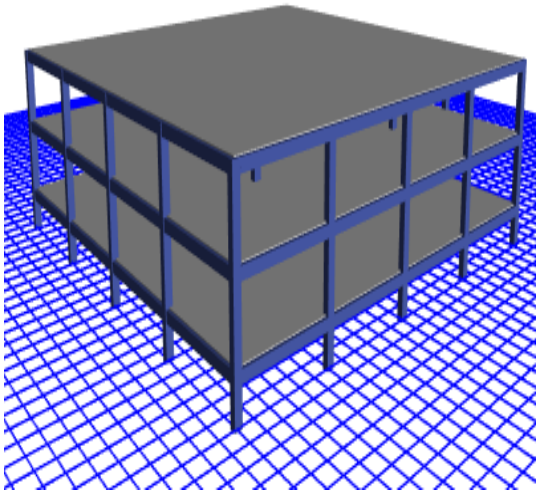

Fig -4: ETAB model of building.

2.1 MODELING OF BEAM-COLUMN JOINT USING SOFTWARE SOLID WORKS

Column reinforcement

- Length=3000mm
- Cover=40mm
- 8 numbers of 16mm dia bar.
- Stirrup of 8mm at 255mm spacing.

Beam reinforcement

- Length=6000mm
- Cover=25mm
- 3 numbers of 16mm dia bar
- Stirrup of 8mm at 175mm spacing.

Beam is positioned to the column at distance of 150 mm to the column width.

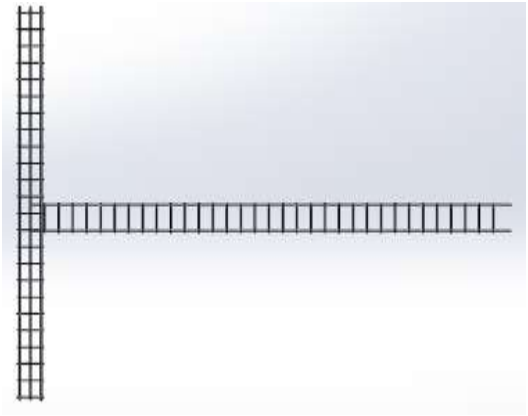

Fig -5: Reinforcement view of beam-column joint in solid works.

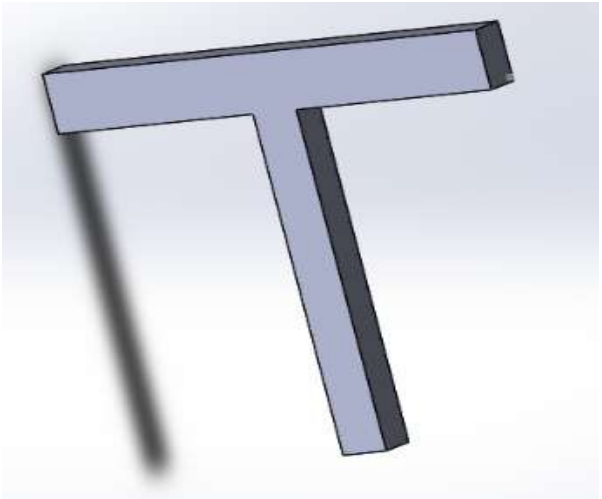

Fig -6: Beam-column joint model done in solid works.

3. Analysis using software ANSYS

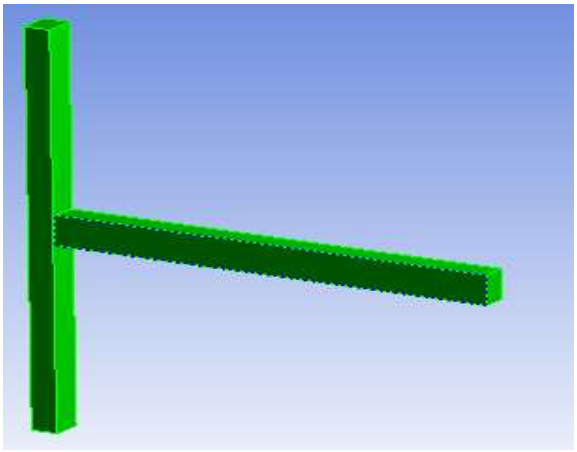

Fig -7: Beam-column joint model in ANSYS.

Table -1: Properties of Concrete

Density	2300 Kg/m^3
Young's Modulus	3x10^{10} Pa
Poisson's Ratio	0.18
Bulk Modulus	1.5625x10^{10} Pa
Shear Modulus	1.2712x10^{10}Pa
Tensile Ultimate Strength	5x10^6 Pa
Compressive Ultimate Strength	4.1x10^{7}Pa

Table -2: Properties of structural steel

Density	7850Kg/m^3
Young's Modulus	2x10^{11} Pa
Poisson's Ratio	0.3
Bulk Modulus	1.6667x10^{11} Pa
Shear Modulus	7.6923 x10^{10}Pa
Tensile Yield Strength	2.5 x10^8 Pa
Compressive Yield Strength	2.5 x10^8 Pa
Tensile Ultimate Strength	4.6x10^8 Pa

Table -3: Properties of Glass Fiber reinforced Concrete

Density	2300Kg/m^3
Young's Modulus	8.5x10^{10}Pa
Poisson's Ratio	0.18
Bulk Modulus	4.427x10^{10}Pa
Shear Modulus	3.6017x10^{10}Pa
Tensile Yield Strength	2.5x10^7 Pa
Compressive Yield Strength	4.1x10^{7}Pa.
Tensile Ultimate Strength	5x10^6 Pa

Table -4: Properties of Meshing

Relevance Centre	Coarse
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Centre	Coarse
Nodes	12557
Elements	6782

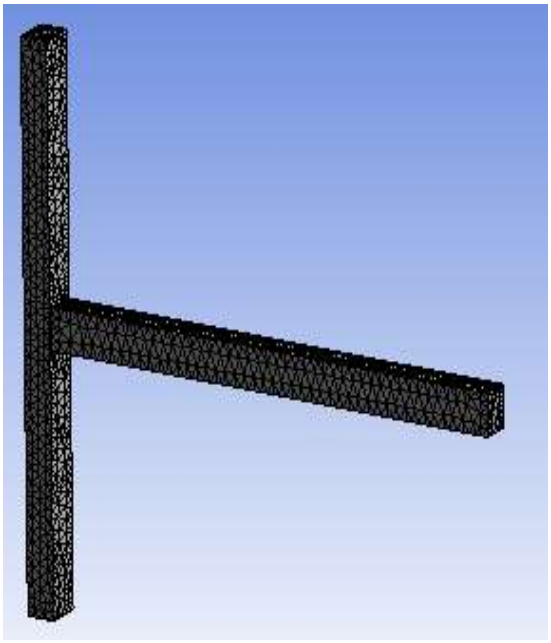

Fig -8: Meshed model.

3.1 Total deformation

A uniformly distributed load of 10 N/mm & 20 N/mm is applied vertically on the beam as force for both RC & GFRC beam-column joint. And the total deformations are obtained for the beam-column joint.

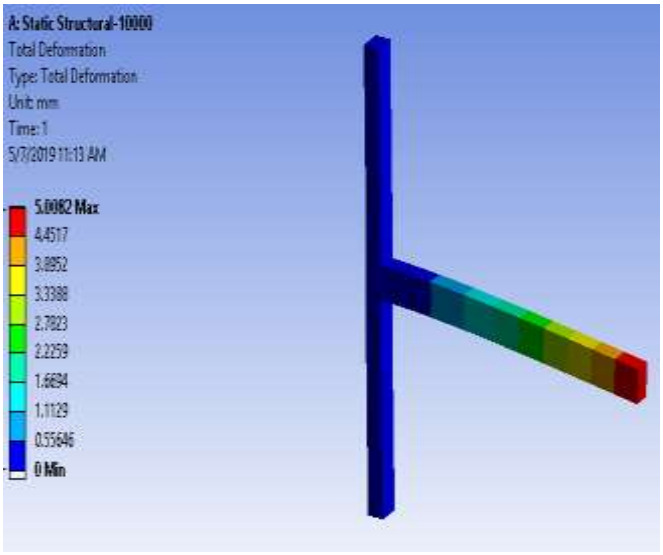

Fig -9: Total deformation for RC beam-column joint at 10 N/mm.

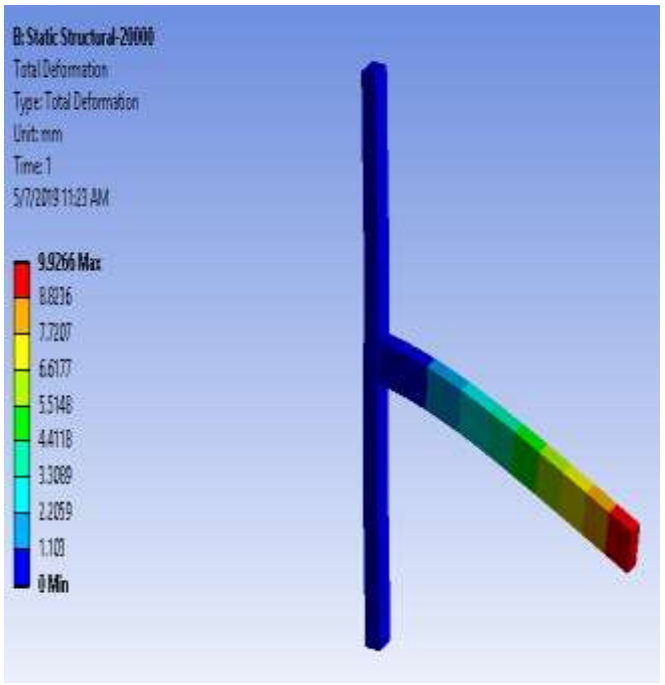

Fig -10: Total deformation for RC beam-column joint at 20 N/mm.

3.2 Deformations obtained for GFRC beam-column joint.

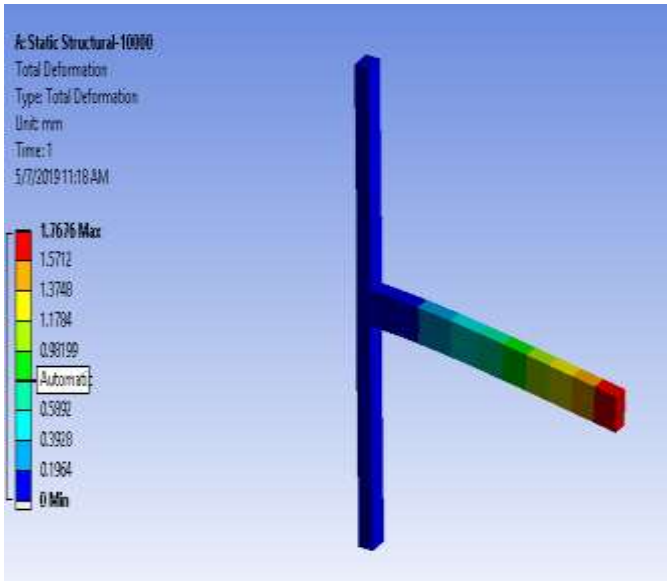

Fig -11: Total deformation for GFRC beam-column joint at 10 N/mm.

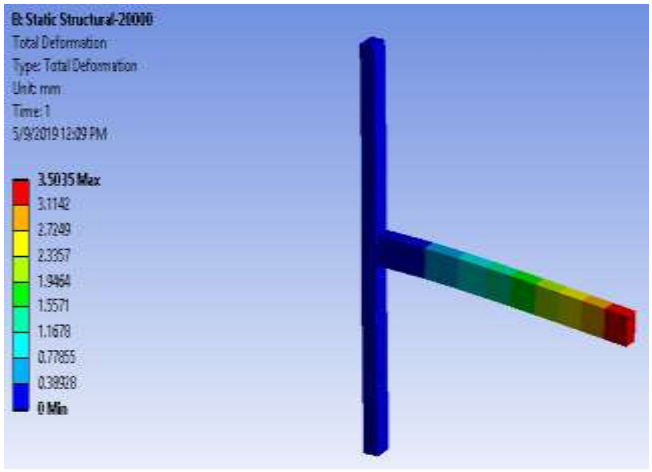

Fig -12: Total deformation for GFRC beam-column joint at 20 N/mm.

4. RESULTS AND DISCUSSION:

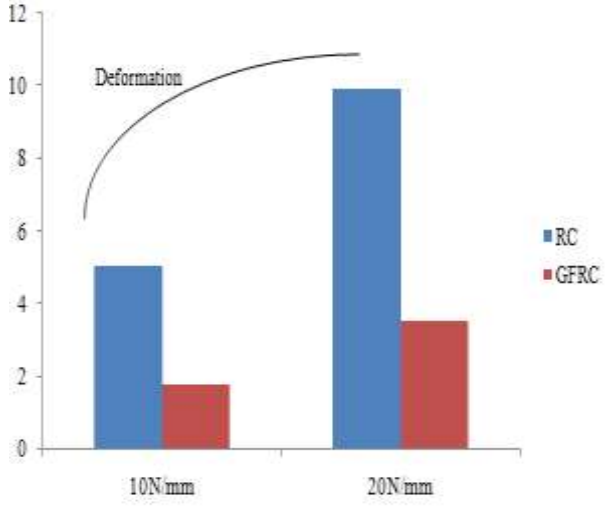

Fig -13: Graphical representation of deformation of the beam column joint corresponding to load.

Table -5: Comparison of RC & GFRC beam-column joint.

S.NO	Load in N/mm	Deformation in mm	
		RC	GFRC
1	10	5.0082	1.7676
2	20	9.9266	3.5035

5. CONCLUSIONS

The following conclusions are drawn from the present work:

- A two story plan was analyzed under seismic condition in ETAB to obtain a proper reinforcement detailing of beam & column for the purpose of modeling of beam-column joint.
- The beam-column joint was modeled in software called solid works. The model was imported to ANSYS for further analysis of both RC & GFRC beam-column joint.
- A uniformly distributed load of 10 N/mm & 20N/mm was applied vertically on the beam and it was observed that compared to RC beam-column joint the deformations obtained for GFRC beam-column joint was much lesser.
- Hence, from the present work it can be concluded that the deformations in the joint can be reduced by up to 4-6% when GFRC is used.

6. FUTURE SCOPE OF WORK

In the present work only the corner beam column joint is considered.

- The material used is Glass fiber reinforced concrete.
- The corner beam column joint is modeled in software solid works.
- The static analysis of the corner beam column joint using ANSYS is done.

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