International Journal of Scientific & Engineering Research Volume 10, Issue 5, May-2019
ISSN 2229-5518

Seismic Performance and Dynamic Impact Resistant Behaviour of Hollow Structural Steel Connections

seena K A, Bhavya c

Abstract— The paper presents seismic performance and dynamic impact resistant behavior of hollow structural steel connections. Numerical analysis on hollow structural steel connections was carried out through ANSYS16.1 software. Ductile behaviour of steel structures depends on mechanical properties of steel materials and steel structures are designed so that plastic deformations occur on beams particularly in beam-to-column connections under cyclic loads. The purpose of this study is to prevent local buckling effects to occur under bending in welded connections of hollow sections. The strain distribution, load displacement curves, failure modes of the joints are analysed and also determine the sufficient stiffness and the deformation occurred on the model by varying beam-column shape. Dynamic behaviour under impact loading and seismic performance on the best model was carried out. After studying the behaviour of different types of hollow sections the efficient model was suggested for its better behaviour.

Index Terms— Ansys 16.1,Deformation Ductile behavior, Hollow sections,impact load, Seismic performance,Deformation,Finite element analysis

1 Introduction

The two most important features of steel in a structure designed using steel construction are ductility and energy absorp-tion capacity under cyclic loading. In ductile structures, seismic energy is absorbed by plastic hinges before the occurrence of collapse mechanism. The feature of steel to cause large deformation without break and its high strength makes the material an ideal material for structures to be built in earthquake zones.

Most of the steel structures in India are made of conventional steel sections (such as angle, channel and beam sections) and were designed by conventional work stress methods. However, new hollow steel sections (such as square and rectangular hollow sections) are gaining popularity in recent steel constructions due to a number of advantages.The architectural and structural advantages of tubular sections have prompted their wide use in industrial building, offshore platform and buildings, halls, bridges, barriers,masts, towers, offshore and special applications, such as glass houses, radio telescopes, sign gantries, parapets, cranes

A Hollow Structural Section (HSS) is a type of metal profile with a hollow tubular cross section. HSS members can be circular, square, or rectangular sections, although other shapes are available, such as elliptical. HSS, especially rectangular sections, are commonly used in welded steel frames where members experience loading in multiple directions. Square and circular HSS have very efficient shapes for this multiple-axis loading as they have uniform geometry along two or more cross-sectional axes, and thus uniform strength characteristics. This makes them good choices for columns. They also have excellent resistance to torsion.

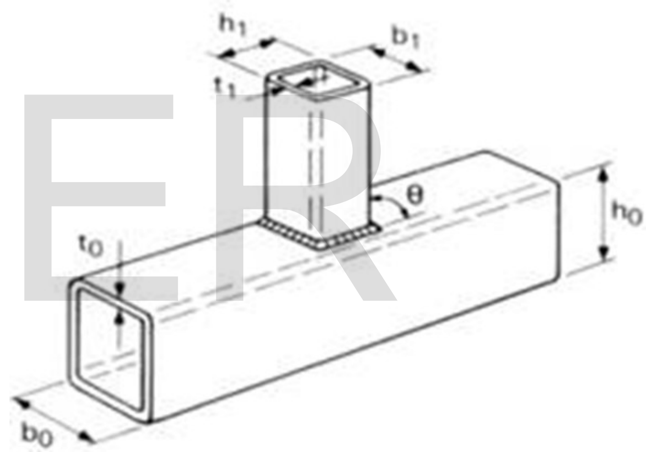


Fig.1: T-joint with Hollow Steel Structure

2 OBJECTIVES

The main purpose of this analysis is to study the behaviour of varying shape of beam-column joint in steel hollow section

- To study the behavior of beam-column joint in steel hollow section with and without endplate
- To determine the sufficient stiffness and deformation of connections.
- To study the behavior of seismic performance of beam-column joint
- To find the dynamic behaviour of T-joint under impact loading of varyingshape
- To detetermine the behaviour impact loading varying thickness and length of endplate
- Comparing the result and to suggest an efficient model for its better behaviour

3 LITERATURE REVIEW

Deniz Bayraktar, Zeki Ay et al. Conducted a study of "Ex-

- *Seena K A is currently pursuing masters degree program in structural engineering in Thejus engineering college, Kerala Technical University,India, E-mail: seenakanto99@gmail.com*
- *Bhavya C is currently working as assistant professor in civil engineering department at Thejus engineering college, Kerala Technical University,India*

perimental and numerical study on moment-rotation relations of welded end-plate tubular connections" The purpose of this study is to prevent local buckling effects to occur under bending in welded connections of circular hollow sections. Local deformations occurred on the connections were prevented in all specimens with end-plate of various sizes and thicknesses and stiffness values. The plate thickness to be used could be taken as larger than column wall thickness and two times smaller than beam wall thickness because deformations occurred on the plate remained within the acceptable limits.

Shao Yong-Boa, Lie Seng Tjhen et al.conducted a study on "Hysteretic behaviour of square tubular T-joints with chord reinforcement under axial cyclic loading" Experimental test and finite element analysis are carried out on reinforced and un-reinforced square tubular T-joints subjected to quasi-static cyclic loads. The enclosed area of the hysteretic curves of the reinforced T-joint is larger than that of the un-reinforced specimen because the chord reinforcement can prevent the fracture failure as well as improving the bearing capacity.The failure performance of the reinforced and unreinforced specimens also show that a T-joint with chord reinforcement is more advantageous in resisting seismic action.

J. Yang, Y.B. Shao et al. conducted a study on"Experimental study on fire resistance of square hollow section (SHS) tubular T-joint under axial compression" The main purpose of this paper is to study the fire resistance and failure mode of the square hollow section (SHS) T-joint at elevated temperatures under axial compression. The experimental results show that the the final failure mode of both specimens is local buckling on the chord surface near the brace/chord intersection ,there is no clear global deformation on the T-joint surfaces.

Jarmo Havulaa, Marsel Garifullin et al.carried out a study on "Moment-rotation behaviour of welded tubular high strength steel T joint" This paper is to present experimental results dealing with the welded in-plane moment-loaded HSS joints. Twenty tests on square hollow section T joints were performed to observe their moment-rotation relationship, studying the following parameters: (1)bending resistance (2) rotational stiffness(3) ductility.The required ductility was achieved by all specimens, even when using welds smaller than full-strength fillet welds.

Gilberto Martinez-Saucedo,Jeffrey A. Packer et al.studied about "Gusset Plate Connections to Circular Hollow Section Braces under Inelastic Cyclic Loading" Braces are commonly used to provide lateral stiffness and strength to steel framed buildings subjected to wind or earthquake loading. hollow structural sections represent a very good solution due to their excellent structural properties in compression. slotted hollow structural section connections are popular in seismic zones but the hollow section is typically reinforced with steel cover plates to increase the net area at the critical location to avoid premature fracture under tension loading cycles

Hongfei Chang, Zhen Guo et al.conducted a study of "Experimental study on the axial compressive strength of vertical inner plate reinforced square hollow section T-joints" To evaluate the influence of vertical inner plate reinforcement on the compression behaviour of square hollow section joints, four T-joints with and without such reinforcement were tested experimentally and simulated numerically.The strain distribution, load displacement curves, compressive strength as well as the failure modes of the joints are analysed. The failure of the vertical inner plate reinforced T-joints is dominated by two modes, flange yielding and web buckling.

Fadden and Cormick et al. studied the ability of HSS-to-HSS moment connections to form stable plastic hinges under large cyclic inelastic deformations. A parametric study of 133 HSS beams was done for the determination of limiting depth-thickness (h/t) and width-thickness (b/t) ratios based on a finite element model calibrated to experimental results. The effect of the beam width-to-column width ratio (β) and beam depth was considered for the unreinforced connections also. From the study it was understood that, unreinforced and external diaphragm HSS-to-HSS moment connections are not adequate in developing the full moment capacity of the beam member.

4 VALIDATION

Ansys workbench 16.1 software was used for the validation and it was done with the Circular hollow section profiles of Ø219.1mmwith a wall thickness of 5mmwere used for columns and of Ø168.3 mm with a wall thickness of 4 mm for beams. The column and beam lengths were set at 1960 mm and 980 mm, respectively. it was aimed to prevent local deformations likely to occur on columns under bending in particular and to increase the stiffnes and capacity of joints with the end-plate (stiffening plate) to be attached to the joint.The maximum load value obtained after analysis was compared with the journal values as shown in table 1.

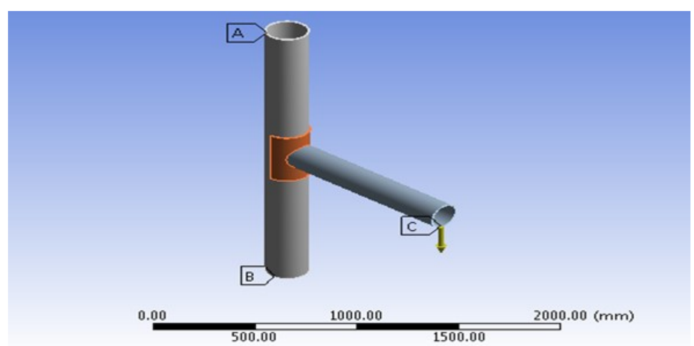


Fig.2: Loading diagram of numerical model used in validation

Table 1: Results comparison

Results	Maximum load ((kN)
From FEA	28.1
From journal	26

Percentage difference	8.07%

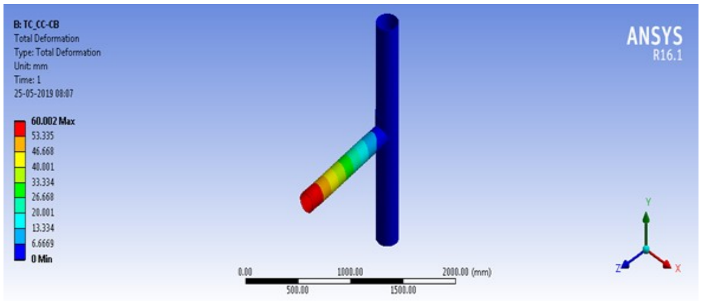


Fig.3: Total deformation of beam-column joint

5 FINITE ELEMENT ANALYSIS

A non-linear static analysis was done in ansys workbench 16.1 software for castellated beams and columns. The same area and material in the validation process was used for finite element analysis of beams. Two more shapes square ,circle and rectangular were considered in the case of beam-column joint. By keeping the area as constant in all shapes of beam-column joint were analysed. In case of columns both ends was fixed and lateral loading was applied in beam.So the study includes finite element analysis of;

- The behaviour of varying shape of beam-column joint in steel hollow section
- To determine the sufficient stiffness and deformation of connections.
- To study the behavior of seismic performance of beam-column joint.
- The dynamic behaviour of T-joint under impact loading of varyingshape

Steel was modelled with the element SOLID 186, three dimensional 20-node element having 3 degrees of freedom at each node and yield strength f_y=310MPa. The size of the beam and column are taken in As per IS 1161:1998(STEEL TUBES FOR STRUCTURAL PURPOSES –SPECIFICATION) and IS : 4923 – 1997(HOLLOWSTEEL SECTIONS FORSTRUCTURAL USE-SPECIFICATION)
Square Column(195x195x5)
Square Beam(125x125x5)
Rectangular Beam(145x82x4.8)

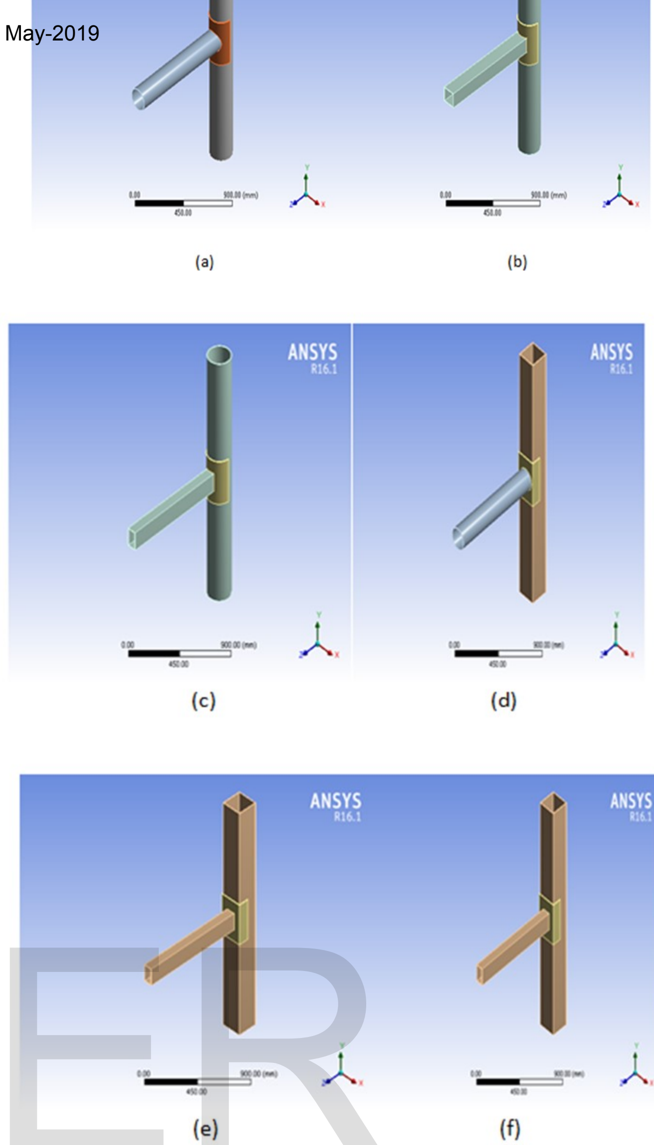
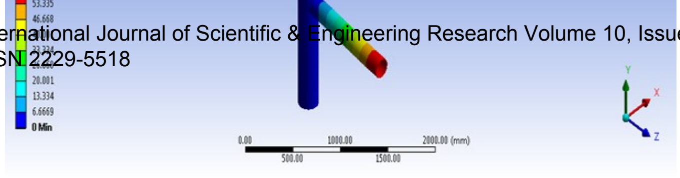
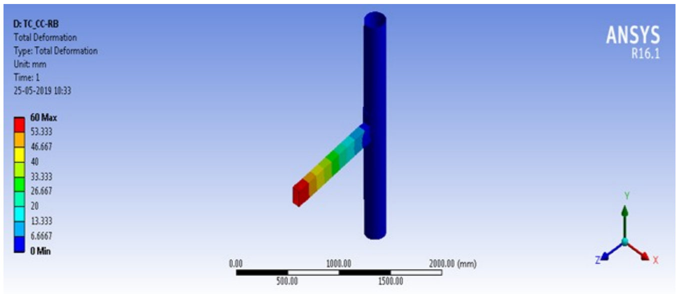


Fig.4: (a) CC-CB(b) CC-SB (c)CC-RB (d) SC-CB (e)SC-SB (f)SC-RB (CC-Circular column,CB-Circular beam,SB-Square beam,SC-Square column,RC-Rectangular column,RB-Rectangular beam)

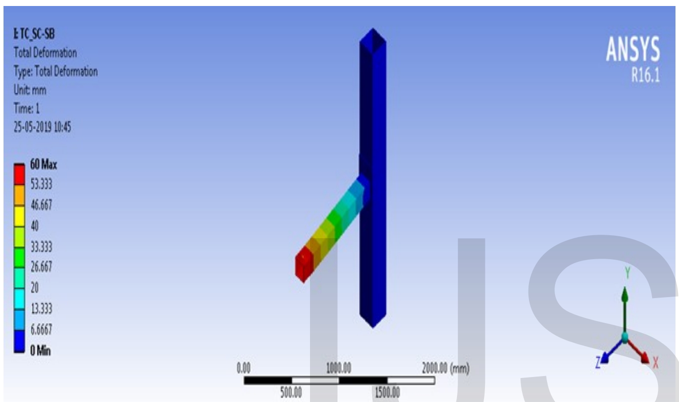
6 RESULTS



(a)

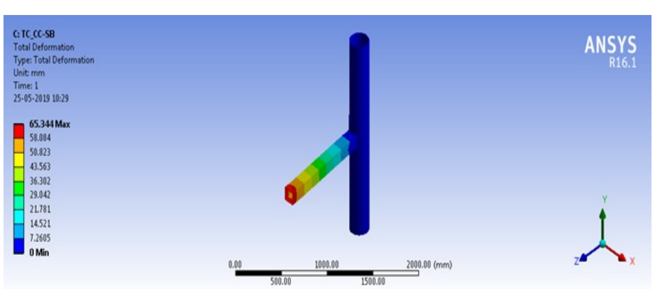


(b)

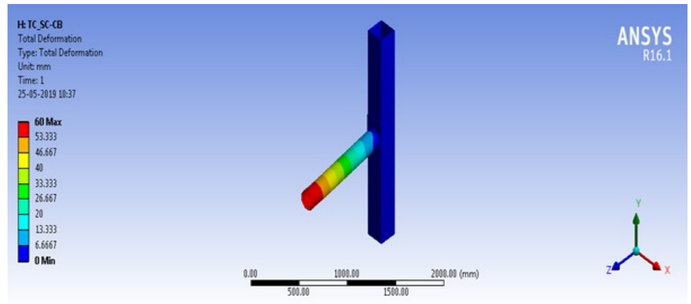


(c)

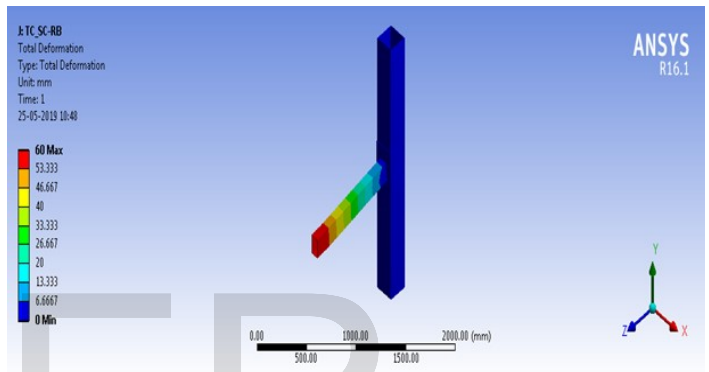
Fig.5: Total deformation of (a) CC-CB (b) CC-SB (c) CC-RB (d)SC-CB (e) SC-SB (f) SC-RB



(d)



(e)



(f)

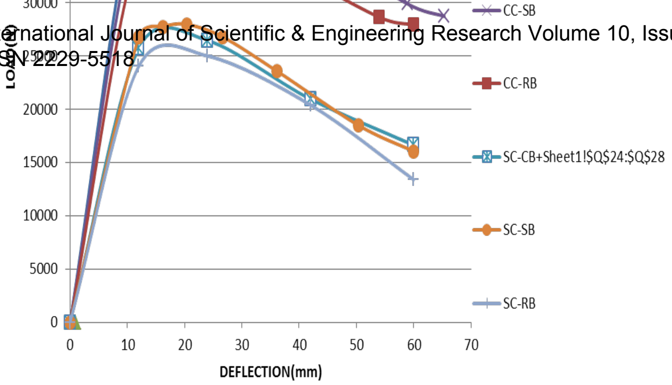
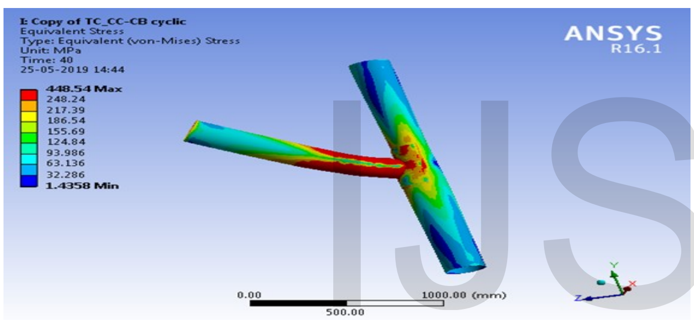


Fig.6: Load deformation graph for varying shape

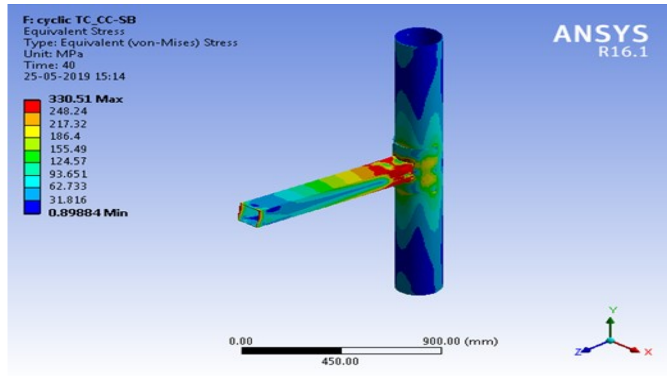
Maximum load can taken in Circular Column and Circular beam.Load carrying capacity 3.9% increase in Circular Column and Circular Beam compared to Circular Column and Square Beam.

4 seismic analysis

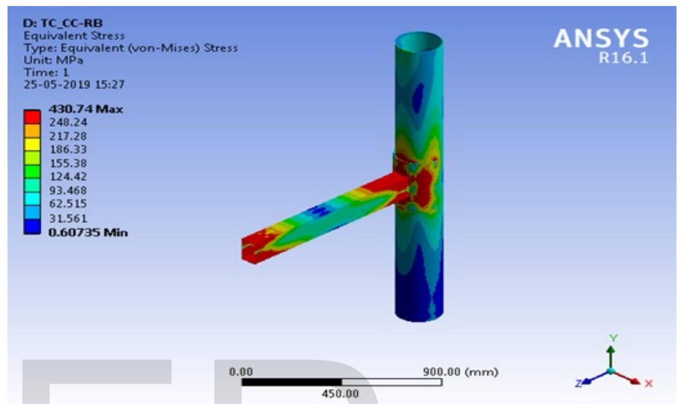
Sesmic analysis is done in varying shape of beam-column joint.Loading can be done in the joint ACT protocol.



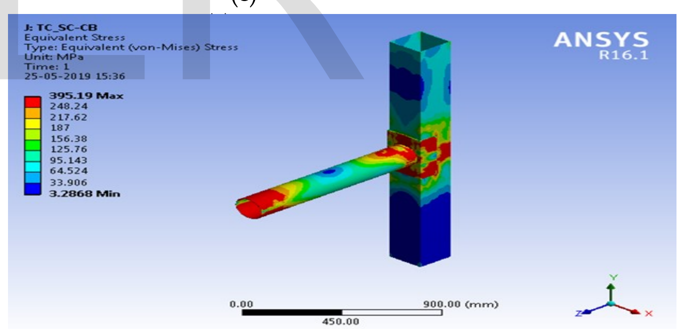
(a)



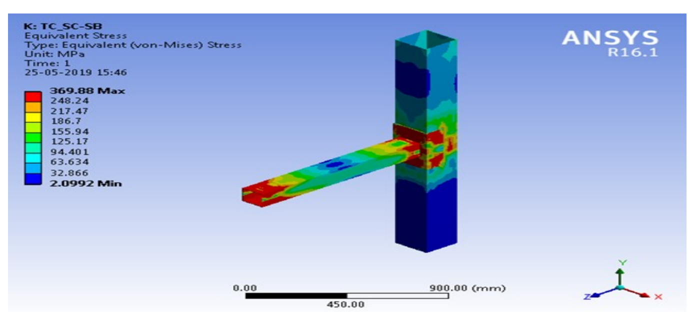
(b)



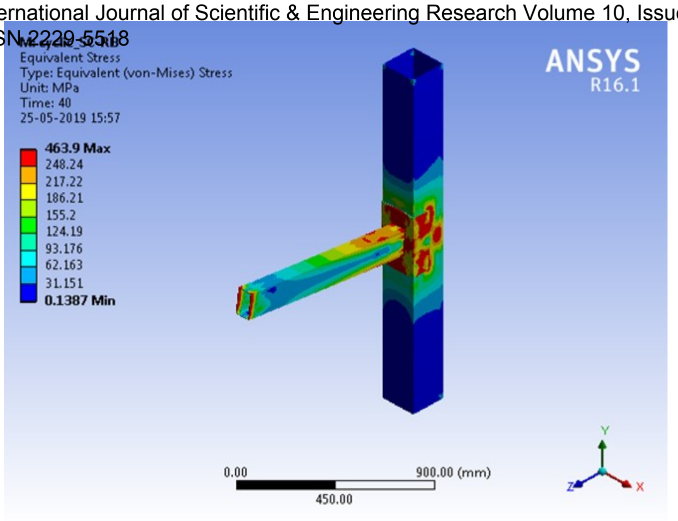
(c)



(d)



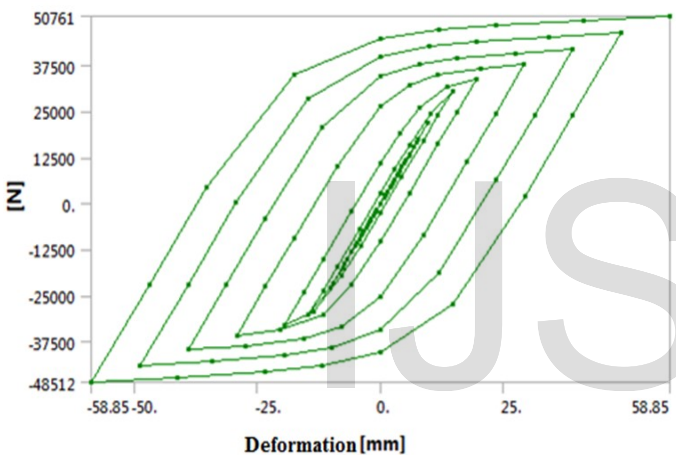
(e)



(f)

Fig.7: Equivalent stress diagram (a) CC-CB (b) CC-SB (c) CC-RB (d)SC-CB (e) SC-SB (f) SC-RB

Maximum load can taken in Circular Column and Circular beam 50.761 kN,Maximum moment capacity-49.748kNm



7 CONCLUSION

Numerical study on stiffness and seismic behaviour of Beam-Column Joint of HSS members for varying shapes studied using finite element software ANSYS WORKBENCH 16.1.

1. The deformation of HSS beam column joints without connection is higher than that with connections
2. Different shape of Beam-Column (Square, Circular and Rectangular) maximum lateral load is taken in Circular section
3. Load carrying capacity 3.9% increase in Circular Column and Circular Beam compared to Circular Column and Square Beam.
4.Maximum load carrying capacity 42.008 kN in Circular Column and Circular Beam
5.Load carrying capacity in Square Column and Square Beam is 27.979KN
6. Moment capacity 49.748KNm in Circular column Circular beam and 34.89KNm Circular column Square beam

To reduce the stress concentration and to increase the strength steel encased in concrete method can be used. Both composite beams and columns with partial encasement and full encasement were analysed. Both the methods improved the load carrying capacity of the member. Elliptical shape of web opening showd more load carrying capacity in both partially encased and fully encsed condition.

REFERENCES

[1] **Deniz Bayraktar, Ilyas Devran Celik,(2016)** "Experimental and numerical study on moment-rotation relations of welded end-plate tubular connections" Journal of Constructional Steel Research 126 (16) 63–73

[2] **Shao Yong-Boa, Lie Seng Tjhen, (2011)** "Hysteretic behaviour of square tubular T-joints with chord reinforcement under axial cyclic loading"

[3] **Lei Zhu, Yan Zhao, Shuwen Li, Yuxing Huang(2014)** "Numerical analysis of the axial strength of CHS T-joints reinforced with external stiffeners" Journal Of Structural Engineering

[4] **LiT,ShaoYB,ZhangJC(2010)**Studyonstaticstrengthoftubularjointsreinforcedwithverticalinnerplate.EngMech;27(4):133–40

[5] **Jarmo Havulaa, Marsel Garifullinb, Markku Heinisuob(2018)** "Moment-rotation behaviour of welded tubular high strength steel T joint" Journal Of Engineering Structures

[6] Gilberto Martinez-Saucedo1, Jeffrey A. Packer(2008) "Gusset Plate Connections to Circular Hollow Section Braces under Inelastic Cyclic Loading"

[7] Pengfei Cui, Yanzhi Liu(2018) "Dynamic behaviour of square tubular T-joints under impact loadings"

[8] Matthew Fadden, Jason McCormick(2010) "Large-Scale Testing of Hollow Structural Sections for Seismic Applications"

[9] Dhruv, S.Agarwal and C.AnkitChatwani (2015) The economic and structural analysis of hollow structural sections,International Journal on Recent and Innovation Trends in Computing and Communication, vol. 3,

[10] J. Lee , H.M. Goldsworthy a, E.F. Gad(2010)Blind bolted T-stub connections to unfilled hollow section columns in lowrise structures,,Journal of Constructional Steel Research 66 981-992,