The Asian Review of Civil Engineering
ISSN: 2249-6203 (P) Vol.7 No.2, 2018, pp.20-23

DOI: https://doi.org/10.51983/tarce-2018.7.2.2264

Comparative Study on Castellated Beam for Circular and Hexagonal Opening Using ANSYS

K. Sriman Narayanan[1], N. Arun Prakash[2] and B. Anupriya[3]
[1&2]UG student, [3]Associate Professor, Department of Civil Engineering,
Arasu Engineering College, Kumbakonam, Tamil Nadu, India
E-Mail: srimanalone@gmail.com, prakash.arun349@gmail.com, anupriyarajavignesh@gmail.com

Abstract **- A beam with number of regular openings in its web is called castellated beam. Nowadays cost reduction and strength goes hand in hand. In that perspective this paper presents an overview of recent research on castellated beam for circular and hexagonal web openings. The castellated beams are well accepted for industrial buildings, power plant and multi storey buildings. Castellated beam gain its advantage due to its increased depth of section without any additional weight. The research paper gives details about the load vs. Deflection comparison for castellated beam for circular & hexagonal opening. The beam is analysed using Finite Element Analysis (ANSYS 18.2).Two point load is applied and stress distribution is studied for circular and hexagonal openings. Through the vierendeel analysis it is clear that stress concentration occurs near the perforations which reduce the shear carrying capacity and stability of the beam. Stress concentrations are more in circular opening than in hexagonal section. Hence hexagonal opening is preferred than circular opening for the further study and it is also found that castellated beams are mostly tend to fail in web buckling.**

Keywords: **Castellated Beam, Circular Opening, Hexagonal Opening, Stress Distribution, Vierendeel Effect**

I. INTRODUCTION

Steel structure building are becoming more and more popular due to their many advantages such as the better satisfaction with the flexible architectural, durability, strength, design, low inclusive cost and environmental protect as steel is manufacture to precise and uniform shapes[1]. Many attempts have been made by structural Engineers to find new ways to decrease the cost of steel structures. Due to limitations on maximum allowable deflections, the high strength properties of structural steel cannot always be utilized to best advantage. As a result several new methods have been aimed at increasing the stiffness of steel members without any increase in weight of the steel required. Castellated beams were one of these solutions [2].

Castellated beams are fabricated from wide flange I-beams. The web of the section is cut by flame along the horizontal x-x axis along a “Zigzag” pattern as shown in the Figure 1.

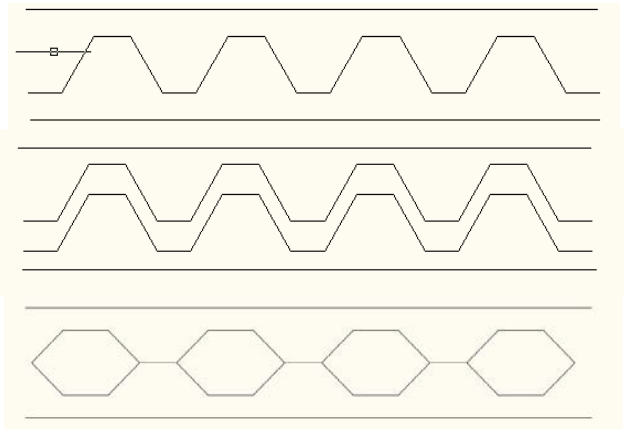

Fig. 1 Castellated Beam- Hexagonal Opening

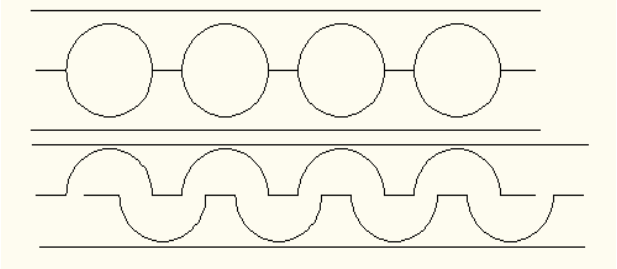

Fig. 2 Castellated Beam- Circular Opening

The two halves are then welded together to produce a beam of greater depth with hexagonal opening in the web. The resulting beam has a larger section modulus and greater bending rigidity than the original section without an increase in weight. However, the presence of the holes in the web will change the structural behavior of the beam from that of plain webbed beams [6][7]. Figure 2 shows castellated beam with circular opening.

II. INVESTIGATION OF CASTELLATED BEAM

A. Castellation Process

Castellated beams are fabricated from wide flange I-beams. Two sections ISMB 150 is selected and fabricated such that depth of the beam is increased to 1.5 times the original depth. The increased depth of the section is indicated as IC 225 and respectively [1].

B. Advantage and Limitations of Castellated Beams

Advantages

1. The castellated beams are well accepted for industrial buildings, power plant and multi storey buildings as they have cheap labour cost [9].
2. In terms of structural performance, the operation of splitting and expanding of rolled sections help to increase the section modulus of the beams.
3. Increased load carrying capacity of the beam [3].

Limitations

Stress concentrations occur near the perforations and the shear carrying capacity is reduced by making perforations near the neutral axis.

C. Objective of the Study

The main focus of the study is to compare the stress concentration on circular and hexagonal opening and to study the effectiveness of the section. [12]

III. FINITE ELEMENT ANALYSIS

Finite Element Analysis is widely used by the engineers to do analysis of the structure and solve any real engineering problems. In this paper, a three dimensional (3D) finite element model is developed using ANSYS for IC 225 Two point load is applied and various finite element models and von mises stresses are developed. Stress concentration of the beam is studied [10][11].

To carry out the study Rolled steel I section of ISMB 150 is selected for a span length of 3.2m. The web of the section is cut along the horizontal x-x axis along a “Zigzag” pattern as shown in the Fig. 1. The two halves are then welded together such that depth of the beam is increased to 225 mm. The increased depth is indicated as IC 225. Table I represents the specimen detail of IC 225. The sectional properties are same for both hexagonal and circular opening. [8][9]

TABLE I SPECIMEN DETAIL (IC 225)

Specimen Detail	IC225
Length (m)	3.2
Thickness of flange t_f (mm)	7.5
Thickness of the web t_w (mm)	5
Breath of the web b_w (mm)	80
Height of the web opening HW (mm)	150

Figure 3 represents the load application of castellated beam for hexagonal opening. Two point loads is applied for a span length of 3.2 m.

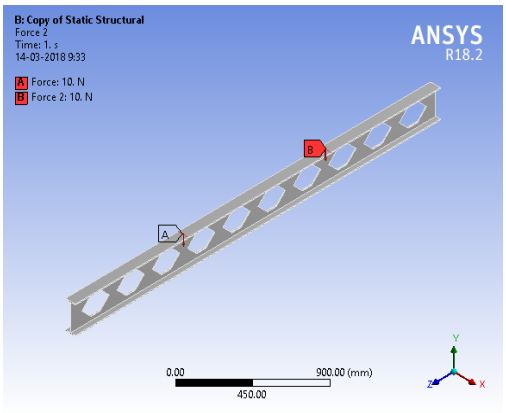

Fig. 3 Load Application of CB- hexagonal Opening

Figure 4 represents the stress distribution of castellated beam for hexagonal opening. Stress concentration occurs along the hole opening along the shear zone.

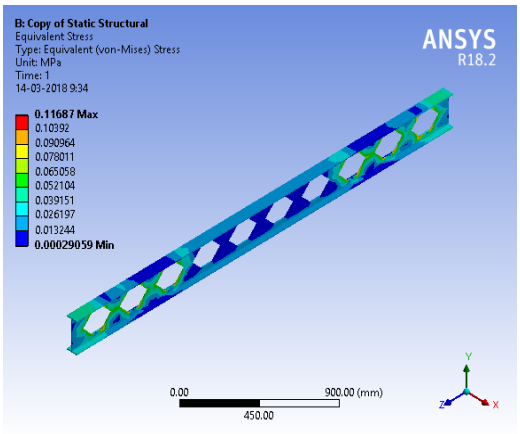

Fig. 4 Stress distribution of CB-Hexagonal Opening

Figure 5 represents the deflection of castellated beam for hexagonal opening. As load increase deflection of castellated beam increases.

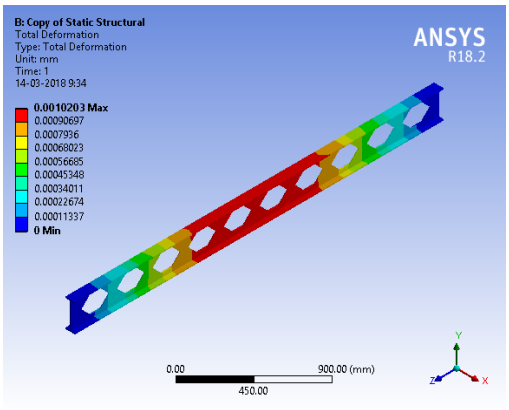

Fig. 5 Deflection of CB- Hexagonal Opening

Our main objective is to study the stress concentration of castellated beam for hexagonal and circular opening. Figure 6 represents the load application of castellated beam for circular opening.

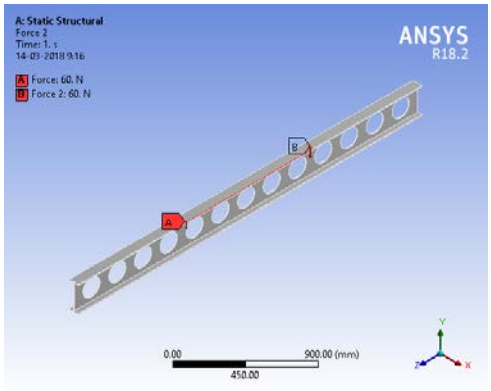

Fig. 6 Load Application CB- Circular Opening

Figure 7 represents the stress distribution of castellated beam for circular opening. While compared to hexagonal opening stress concentration are more for circular opening since in circular opening, area of solid portion is less.

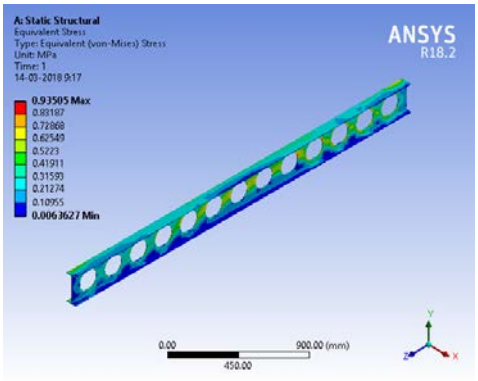

Fig. 7 Stress distribution of CB-Circular Opening

Figure 8 represents the deflection of castellated beam for circular opening. Deflection for circular opening is higher when compared to hexagonal opening. Since deflection is higher stability of the beam reduces which reduces the load carrying capacity.

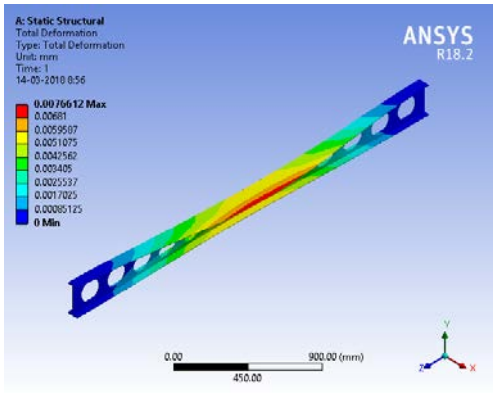

Fig. 8 Deflection of CB -Circular Opening

IV. RESULTS AND DISCUSSION

Figure 9 represents the load Vs deflection for circular and Hexagonal opening. For 60kN load deflection for circular opening was 0.02mm and for hexagonal opening observed deflection was 0.006mm. In hexagonal opening stress concentration was along the shear zone, while in circular opening stress concentration was along the whole length of beam. The observed deflection was also higher in circular opening.

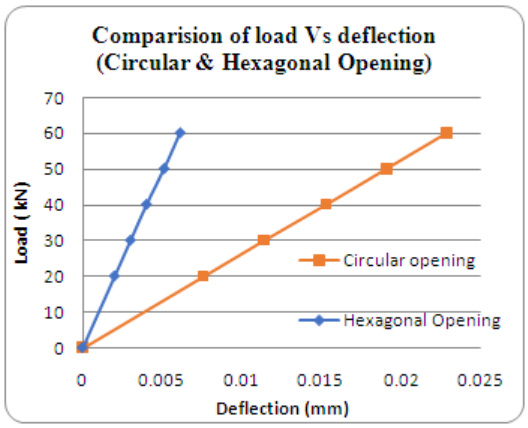

Fig. 9 Comparison of load Vs deflection of CB
(Hexagonal and Circular opening)

V. CONCLUSION

From the results obtained it was observed that stresses are distributed across the web opening along the shear zone and shear failure is more near the holes than in the solid web of the castellated beam. Stress concentrations are more in circular opening than in hexagonal opening. When comparing fabrication of hexagonal and circular opening, in hexagonal opening no portion of the part is wasted the whole portion was effectively utilised. But in circular opening while fabricating some portion was wasted. Hence the study concludes hexagonal opening is the more effective than circular opening.

VI. FUTURE WORK

The study illustrates the stress concentration and stability of the beam is more critical for circular opening. Hence future work is carried out to improve the stability and load carrying capacity of hexagonal for circular opening.

REFERENCES

[1] B. Anupriya and K. Jagadeesan, "Strength Study on Castellated Beam", *International Journal of Engineering Research & Technology*, Vol. 2, No. 12, Dec. 2013, ISSN: 2278- 0181.

[2] M. R. Wakchaure, A.V. Sagade and V. A. Auti, "Parametric Study of Castellated Beam With Varying Depth of Web Opening", *International Journal of Scientific and Research Publications*, Vol. 2, No. 8, August 2012, ISSN 2250-3153.

[3] Komal S. Bedi and P. D. Pachpor, "Moment and Shear Analysis of Beam with Different Web Openings", *International Journal of Engineering Research & Applications*, Vol.1, No. 4, pp. 1917-1921, 2012. ISSN: 2248-9622.

[4] M. R.Wakchaure and A.V. Sagade, "Finite Element Analysis of Castellated Steel Beam", *International Journal of Engineering and Innovative Technology*, Vol. 2, No. 1, July 2012, ISSN: 2277-3754.

[5] N. K. Chhapkhane, Shashikant and R. Kamble, "Analysis of Stress Distribution in Castellated Beam using Finite Element Method and Experimental Techniques", *International Journal of Mechanical Engineering Applications Research*, Vol. 3, No. 3, Aug-Sep 2012, ISSN: 2249- 6564.

[6] P. D. Pachpor and Sharda P. Siddh, "Finite Element Analysis of Steel Beam with Web Opening of Different Shapes", *International Journal of Science and Advanced Technology*, Vol. 1, No. 5, July 2011, ISSN: 2221- 8386.

[7] J. Sabarishand and V. Biju, "Web Buckling of Castellated Beams", *Proc. of the National Conference*, 2011.

[8] Sharada P. Siddh, P. D. Pachpor, "Finite Element Analysis of Steel Beam With Web Opening of Different Shapes", *International Journal of Science and Advanced Technology*, Vol. 1, No. 5, July 2011, ISSN 2221-8386.

[9] H. Showkati, "Lateral – Torsional Buckling of Castellated Beams", *Iranian Journal of Science & Technology, Transaction B, Engineering*, Vol. 32, No. B2, pp. 153-156, 2008.

[10] J.P.Boyer, "Castellated Beams – New Developments", *Proc. of the AISC National Engineering Conference*, Omaha, Nebraska, May, 1964.

[11] Codes Referred: IS 800 – 2007 and Hand Book for the Design of Castellated Beams, *Oxford Publications*.

[12] N. Subramanian, "Design of Steel Structures", *Oxford Publication*.