



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 11, November 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

Experimental Investigation of Tapered Shape Castellated Beam

Mr. Amol J. Mehetre¹, Dr. R. S. Talikoti², Dr. N. U. Mate³, Mr. Pradip B. Sonawane⁴

Research Scholar, Department of Civil Engineering, AVCOE Sangamner, Maharashtra, India¹

Research Guide, Department of Civil Engineering, RHSCOE Management Studies & Research Nashik, Maharashtra, India²

Research Guide, Department of Civil Engineering, AVCOE Sangamner, Maharashtra, India³

P.G. Student, Department of Civil Engineering, AVCOE Sangamner, Maharashtra, India⁴

ABSTRACT Use of castellated beams is become very popular now days due to its advantageous structural applications. Castellated beams are those beams which has openings in its web portion. Castellated beams are fabricated by cutting the web of hot rolled steel (HRS) I section into zigzag pattern and thereafter re-joining it over one another. The openings made in the webs are of generally hexagonal, circular, diamond or square in shape. Therefore, considering structural performance of the beam, the size and shape of openings provided in the web are always an important issue of concern. There is lot of study has been done in optimizing sizes of castellated beams with hexagonal openings, and hence there is need to optimize the beams with other shaped openings. An efficiently designed pre-engineered building can be lighter than the conventional steel buildings by up to 30%. Lighter weight equates to less steel and a potential price savings in structural framework. A hangar is a closed structure to hold aircraft or spacecraft in protective storage.

In this paper we are work on a load deflection analysis of castellated beam with tapered section and compared it with load deflection analysis of castellated beam of prismatic section.

KEYWORDS: Castellated beam, Hexagonal opening, Sinusoidal opening, Tapered section, Prismatic section

I. INTRODUCTION

Castellated beam is defined as the beam in which increasing width of beam without increasing the self-weight of beam. Now a day castellated beam is a new technique. A castellated beam is fabricated from a standard steel I-shape by cutting the web on a half hexagonal line down the center of the beam. The two halves are moved across by one spacing and then rejoined by welding. This process increases the width of the beam and hence the major axis bending strength and stiffness without adding additional materials. Due to the opening in the web, castellated beams are more susceptible to lateral-torsional buckling. The main benefit of using a castellated beam is to increase its buckling resistance about the major axis. However, because of the openings in the web, castellated beam have complicated sectional properties, which make it extremely difficult to predict their buckling resistance analytically. In the Castellation process the fabrication of a section with improved section properties from virgin rolled section that is improving moment of inertia, improving depth. There by increase in moment of resistance and controlled on deflection. The name commonly used for a type of expanded beam is "Castellated Beam". By creating a regular pattern of holes in the web of standard rolled shape sections are expanding and such a beam is created. Fig 1 shows a fabrication process of tapered castellated beam. Steel is the material of choice for design because it is inherently ductile and flexible. It flexes under extreme loads rather than crushing and crumbling. Structural steels low cost, strength, durability, design flexibility, adaptability and recyclability continue to make it the material of choice in building construction. Fast construction lowers overhead expenses for construction management services. Steel is extensively used in the construction of industrial buildings of large spans with or without cranes (medium and heavy buildings), where the concrete construction is not feasible. This process increases the depth of the beam by approximately 50%, therefore increasing the strength and stiffness by about 20 to 30% without increasing the weight of the beam. Also the holes in the web allow ductwork to run through beams instead of underneath ultimately reducing the depth of the floor system. A typical beam limit state concept is used at the time of designing the castellated beam, but in present work there is various other failure should occurred due to various shape of web opening. That may be:

- A) Flexural Failure Mechanism
- B) Shear Buckling of Web Post
- C) Lateral-Torsional Buckling
- D) Rupture of the Welded Joint in a Web Post

E) Vierendeel Bending Mechanism

II. LITRATURE REVIEW

1. Wakchaure M. R; Sagade A.V; Auti V. A.

From the experimental testing, it is concluded that, Castellated steel beam behaves satisfactory for serviceability, up to maximum depth of opening 0.6D. Castellated beams has holes in its web, as holes incorporated various local effects in beams, increase in load causes beams to be failed in different failure mode, which resist them to take load up to their actual carrying capacity. So we cannot compare beams with different modes of failure directly for strength criteria. Due to the presence of holes in the web, the structural behavior of castellated steel beam will be different from that of the solid web beams. It make structure highly indeterminate, which may not analyzed by simple methods of analysis. So we have to design beam to avoid local effects, for improved performance of castellated beam. It is observed as depth of opening increases in Vierendeel effects is prominently observed at the hole corners, so by taking corrective measures (i.e corners should be rounded , provision of reinforcement) we can expect improvement in performance of beam.

2. Jinsha M. S. & Linda Ann Mathew

A pre engineered building (PEB) is a metal building that consist of light gauge metal standing seam roof panels on steel purlins spanning between rigid frames with light gauge metal wall cladding. it has a much greater vertical and horizontal deflection .The advantages of having a steel structure or building over traditional concrete are far too many. Primarily speed and quality of construction are the top two 18 benefits. Steel buildings are fire, quake and cyclone resistant – hence from a safety and longevity perspective, these buildings are timeless. Considering India has extreme weathers as a part of the other seasons, a steel building proves to be very energy efficient, especially when insulated, because of its low thermal mass. The changing perception to a long term perspective and willingness to invest in quality is working towards the growth of PEB in the Indian construction industry. Pre-engineered buildings are nothing but steel buildings in which excess steel is avoided by tapering the sections as per the bending moment's requirement.

3. C. M. Meera

Steel is a material which has high strength per unit mass. Hence it is used in construction of structures with large column-free space. Most of the Industrial Structures require this criterion. An Industrial Warehouse is a storage building and is usually characterized as single storey steel structures with or without mezzanine floors. The enclosures of these structures may be brick masonry, concrete walls or GI sheet coverings.

4. B. Anupriya, Dr. K. Jagadeesan

From the results obtained from ANSYS 14, 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. When vertical stiffeners are provided on the solid portion of the web, shear across the holes does not have any path to flow and hence shear strength across the holes decreases, so web starts to buckle leading to higher deflection. When stiffeners are provided diagonally in the direction of diagonal tension and diagonal compression (strut and tie action), truss 20 action takes complete along the diagonal members in the open web find smooth flow for the shear forces leading to lesser deflection Hence shear stiffeners provided on the opening of the web is effective than the solid portion. Also shear strength of castellated beam can be improved by introducing shear stiffeners (Diagonal Stiffeners) on the web opening along the shear zone

5. Saurabh A. Shah, Madhav B. Kumthekar

Pre-engineered Steel Buildings utilizes a combination of built-up sections, hot rolled sections and cold composed elements which provide the rigid steel frame work with a covering of single skin sheeting which is either integrated insulation or insulated sandwich panels for roofing and wall cladding. It is a concept which is designed to provide a consummate building envelope system to accommodate air tight, energy efficient, optimum in weight and cost and above all requisite designed as per utilizer's needs. These Pre-Engineered Steel Buildings can be fitted and modified with different structural attachments including mezzanine floors, canopies, fascias, interior partitions, crane systems etc. The building is made air-tight by utilization of special mastic beads, filler divests and trims. This is a very flexible building system and can be finished internally so that it accommodates the required function and accessorized externally to achieve captivating and distinctive architectural styles.

6. Resmi Mohan1 & Preetha Prabhakaran

There are many structures using steel as there constructional element. In order to decrease the cost of steel structures and increasing the stiffness of steel members, castellated beams have been developed. Castellated beams are

beams with holes in its web portion. Such beams are fabricated by cutting a zigzag pattern in its web portion and then welding together the two halves in such a way that the holes are formed in the web portion. Due to its availability and cheap labour cost, castellated beams were used in early 1950s in Europe. By splitting and then expanding the steel section modulus is increased. Presence of openings causes many failures modes in the web portions that are not visible in the solid webs. Web post buckling is one such failure. Such failures can be reduced by the introduction of stiffeners along the web opening.

III. OBJECTIVE & SCOPE OF WORK

The basic aim of this work is, by using IS code we can develop new methodology for designing of castellated beam. By using IS 800-2007 Code based methodology we can develop the procedure of designing of castellated beam for hexagonal web opening in this present work. It is found that from the observation of past result castellated beam fails due to shear stress concentration at the corner of hexagonal web opening. So just to avoid this Vierendeel failure i.e. concentration of shear stress at the corner of hexagonal web opening we suggest the new web opening pattern which is form by filletting the corner of hexagonal web opening that is Sinusoidal web opening in castellated beams.

IV. CASTING DETAILS

Sr. No	Symbol	Specification	No. of specimen	Fillet Radius (mm)
1	IH1	Section with hexagonal web opening(30 ⁰)	2	0
2	IH2	Section with hexagonal web opening(45 ⁰)	2	0
3	IH3	Section with hexagonal web opening(60 ⁰)	2	0
4	IS1	Section with sinusoidal web opening with fillet radius equal to 1/4th of opening	2	37.5
5	IS2	Section with sinusoidal web opening with fillet radius equal to 1/6th of opening	2	25
6	IS3	Section with sinusoidal web opening with fillet radius equal to 1/8th of opening	2	18.75

V. METHEDOLOGY

1. **Cutting of section-** It is the initial step of process of fabrication. In this step generally with the help of CNC-controlled cutting heads the web of a rolled section is cut in a zigzag pattern. It is also done with Gas Cutter when work is on small scale.
2. **Rearrangement of section-** By rearranging the two halves of the beam separated after cutting and form predetermined pattern of beam.
3. **Welding of a section-** By using automated submerged arc welding process the web post back together at the high points is carried out.

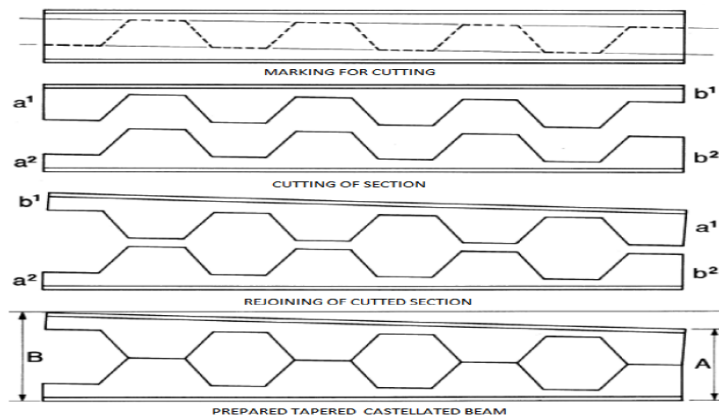


Fig. 1 Fabrication process of castellated beam.

Guidelines for Perforations in Web:

The perforations made in the web are greatly affecting the structural performance of the beam. Therefore, some logical and practical considerations need to be observed while providing perforations in the beam. Following are the general guidelines which are given by Euro code and some of them are based on the field or practical considerations. These standards in web perforations can be changed or modified without affecting the structural performance of the beam. These guidelines are as follows;

- $1.08 < \frac{5}{D_0} < 1.5$
- $1.25 < \frac{D}{D_0} < 1.75$
- $D_0 < 0.8 D$
- $E < 0.4 D_0$
- Width of end panel post $> 0.5 D_0$

VI. EXPERIMENTAL PROGRAM

Rectangular hot rolled section is selected as the parent section for fabricating castellated beam. The castellated beams are fabricated such that the depth of the beam at one face is 1.5 times the original depth while other face is 1.33 times of original depth. Thickness of flange is 5 mm, thickness of web is 10 mm, depth of opening is 150 mm, and length of the beam is 2000 mm. Universal testing machine (UTM) is used for testing the castellated beam. Below figures shows the schematic diagram of parent section, castellated steel beam with hexagonal opening used for the analysis..

The specimens were loaded in universal testing machine (UTM) of 1000 KN capacity. The specimen was supported at two ends. The specimen was loaded at its midpoint slowly until buckling. The load corresponding to the failure of specimen is noted. The experimental set up is shown in fig. 2 below. In this we describe the behavior of different web post and ultimate load carrying capacity of the beams under static loading conditions (single point load) and load- deflection curve. Their behavior throughout test to failure is described using recorded data of deflection the load carrying capacity.

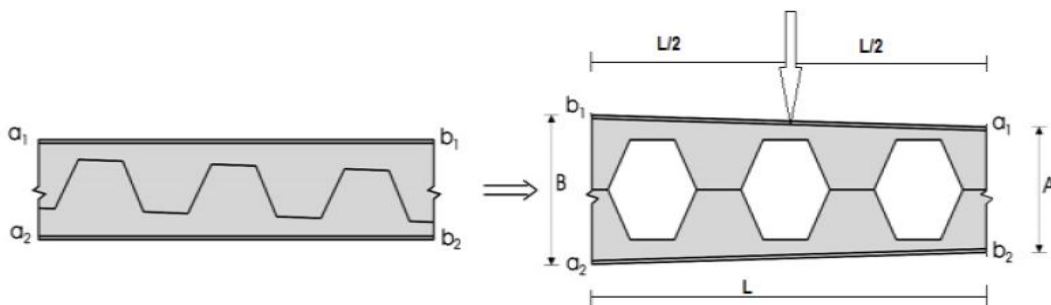


Fig. 2 Testing of castellated beam under UTM



Fig. 3 Testing of IS2 castellated beam under UTM



VII. EXPERIMENTAL RESULTS

Load	Deflection
30	0.5
40	0.9
50	1.3
60	1.7
70	2.3
80	2.6
90	3
100	3.6
110	4.4
120	5.8
126.46	8.2

Load Vs Deflection For Sinusoidal Section IS₁

Load	Deflection
30	0.5
40	0.8
50	1.2
60	1.6
70	1.8
80	2.2
90	2.8
100	3.4
110	4.6
120	6.3
123.6	8

Load Vs Deflection For Sinusoidal Section IS₂

Load	Deflection
30	0.47
40	0.62
50	0.98
60	1.37
70	1.86
80	2.4
90	2.95
100	3.47
110	4.98
120	6.87
125.3	7.42

Load Vs Deflection For Sinusoidal Section IS₃

Load	Deflection
30	0.2
40	1.2
50	1.7
60	2.1
70	2.6
80	3
90	3.7
100	4.7
110	6.3
115	8.7

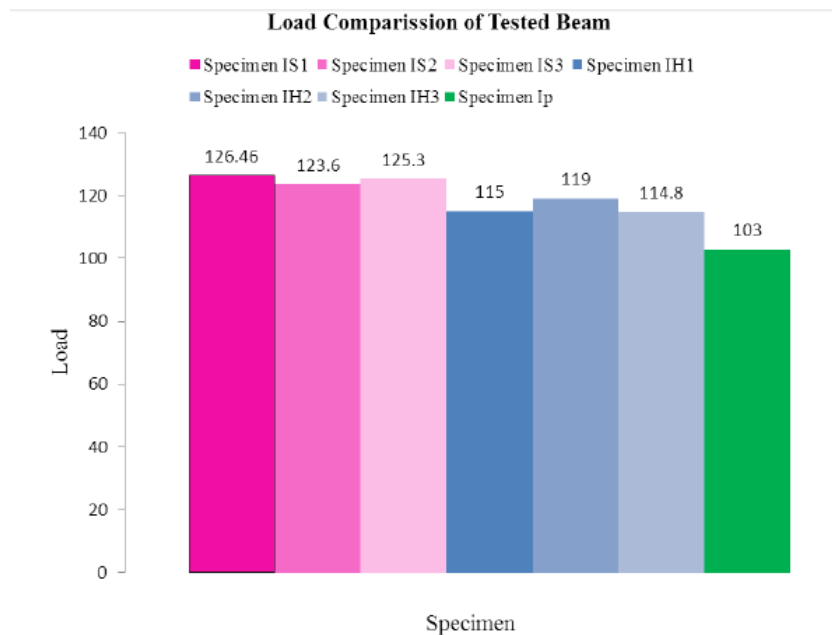
Load Vs Deflection For Hexagonal Section IH₁

Load	Deflection
30	0.4
40	0.8
50	1.5
60	1.9
70	2.3
80	2.6
90	3
100	3.4
110	4.1
119	5.3

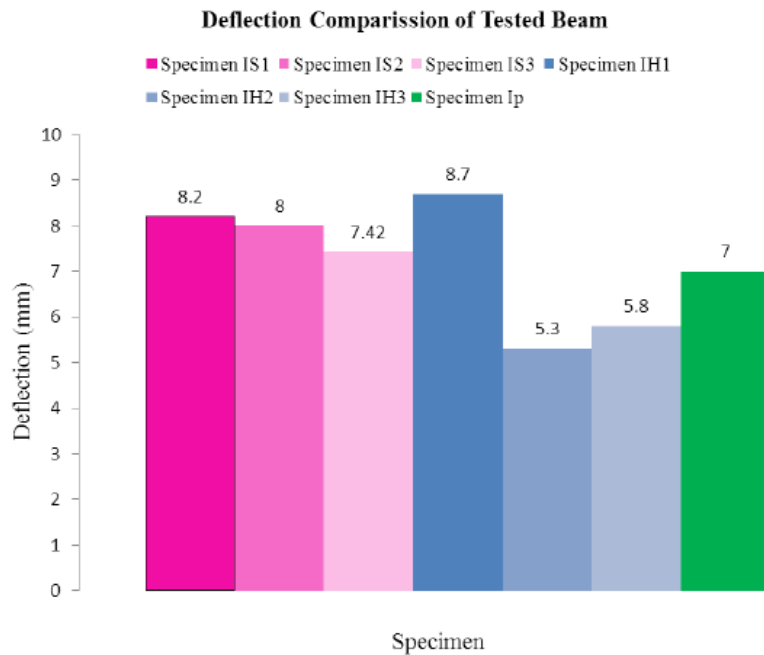
Load Vs Deflection For Hexagonal Section IH₂

Load	Deflection
30	0.2
40	0.5
50	0.9
60	1.4
70	2
80	2.7
90	3.5
100	4.3
110	5.4
114.8	5.8

Load Vs Deflection For Hexagonal Section IH₃



Graph 1: Load comparisons of tested beam



Graph 2: Deflection comparisons of tested beam

VIII. CONCLUSION

1. Load carrying capacity of castellated beam with sinusoidal web opening is more as compare to castellated beam hexagonal opening.
2. The Castellated beam with sinusoidal web opening has as good structural performances as that with hexagonal openings in forms of the stresses distribution, the shear capacity and failure mode, etc.
3. Also the Castellated beam with Sinusoidal web opening has a higher shear capacity than that with hexagonal web opening.
4. Sinusoidal web opening castellated beam has less deflection as compare hexagonal web opening castellated beam.
5. Experimental analysis shows that shear stress get easily redistributed at the fillet corner of Sinusoidal Web Opening Castellated Beams.
6. Load carrying capacity of IS1 compare to IP is 18.55% more, that of IS2 compare to IP is 16.66% more and of IS3 compare to IP is 17.79% more.
7. Deflection of IS1 compare to IP is 14.59 % less that of IS2 compare to IP is 12.5 % less and of IS3 compare to IP is 5.66 % less.

REFERENCES

- [1] Wakchaure M.R., Sagade A.V., Auti V. A., “Parametric study of castellated beam with varying depth of web opening”, International Journal of Scientific and Research Publications, Volume 2, Issue 8, August 2012 1 ISSN 2250-3153.
- [2] Jinsha M S, Linda Ann Mathew, “Analysis of Pre –Engineered Buildings”, International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391.
- [3] C. M. Meera, “Pre-Engineered Building Design Of An Industrial Warehouse”, International Journal Of Engineering Sciences & Emerging Technologies, June 2013. Issn: 2231 – 6604 Volume 5, Issue 2, Pp: 75-82 ©IJESET.
- [4] B.ANUPRIYA, Dr.K.JAGADEESAN, “Shear Strength Of Castellated Beam With And Without Stiffeners Using FEA (ANSYS 14)”, International Journal of Engineering and Technology (IJET) ISSN : 0975-4024 Vol 6 No 4 Aug-Sep 2014.
- [5] Saurabh A. Shah, MadhavB.Kumthekar, “An Overview of Pre-Engineered Building Systems in India”, Proceedings of 27th IRF International Conference, 24th May 2015, Pune, India, ISBN: 978-93-85465-17-8.
- [6] Resmi Mohan1, PreethaPrabhakaran, “Experimental Analysis To Compare The Deflection Of Steel Beam With And Without Web Openings”, IJRET: InternationalJournal of Research in Engineering and Technology e-ISSN: 2319-1163 | p-ISSN: 2321-7308



INNO SPACE
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details