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International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Comparative Study of Hexagonal Opening of Castellated Beam

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A B S T R A C T

The castellated beam is manufactured from its parent solid I beam by cutting it in a zigzag pattern and again joining it by welding, therefore the depth of the beam increases. Hence, due to the increase in depth of beam load carrying capacity of the parent I section is increased with the same quantity of material. The increase in depth of the castellated beam leads to web post-buckling and lateral torsional buckling failure. In this study the IS 800:2007 is used for the designing of the castellated beams by using the parent section ISMB150 with different openings with the same length. The Experimental investigation on the castellated beam is done with a different opening under two-point loading. The comparative study is done for the sections of this castellated beam that are tested for two-point loading under a universal testing machine. The deflection at the Centre of the beam and various failure patterns are studied. Castellated beams with hexagonal openings of 45° offer more load-carrying capacity. The openings considered in the experimental study are standard hexagonal shapes like 30°, 45° and 60°. Castellated beams are by and large furnished with hexagonal openings in the web portion. In any case, in structural applications, the suitable size and shape of openings in the web are constantly a significant issue of concern.

Keywords: *I Section ISMB150, Hexagonal Castellated beam, IS code*.

1. Introduction

A beam with a perforated web is called a castellated beam. It is an open web beam made up of a single rolled wide flange beam section and is formed by flame cutting the beam section in the predetermined pattern and re-joining the segment by welding to produce a regular pattern of holes in the web. The beam section obtained in such a way can be even 50% dipper than the original section. By increasing the depth, the section modulus is increased by about 2.25 times the section modulus of the original beam section. A beam with various ordinary openings in its web is known as a castellated beam. Castellated beams have been utilized in a wide variety of uses, for example, rooftop bars and rafters in both straightforward range and cantilever development, floor beams of unbending casings, pipe spans, girts and other extraordinary applications. They likewise show the interesting appearance and the utilization of the web holes. Indeed, even the expanded profundity is on occasion worthwhile on account of spandrels or other exceptional design highlights. The economy of the castellated beam is one of their most important advantages. Be that as it may, the effectiveness and economy of the castellated beam have been well set up and, for beams on most spans carrying medium to heavy loads, their utilization merits thought.

The exhibition of such beams has been viewed as just for vertical loads. Hot rolled steel light ISMB 150 with openings in the web was tested to failure. The beams were at the ends simply supported and subjected to a concentrated load applied at the mid-span. The openings considered in the experimental study are standard and non-standard hexagonal shapes. Castellated beams are by and large furnished with hexagonal openings in the web portion. In any case, in structural applications, the suitable size and shape of openings in the web are constantly a significant issue of concern. Research work completed in advancing sizes of the castellated beam, with hexagonal openings has detailed that castellated beam flop principally by nearby disappointment modes and stress focuses on opening edges.

The use of castellated beams with hexagonal openings is very common in recent years because of the simplicity of their fabrication. Castellated beams are fabricated by cutting the flange of a hot rolled steel I beam along its center line and then welding two halves so that the overall beam depth gets increased for more efficient structural performance against bending. Castellated beams with hexagonal openings have found widespread use, primarily in buildings, because of great savings in materials and construction costs. The research studies report that the use of beams with hexagonal openings requires a smaller amount of steel material, and it is also superior to cellular beams from the cost point of view.

2. Procedure

Types of castellated beams:

Castellated beams are generally classified based on the type or shape of perforations made in the web of the specimen's beam. Based on the shape of the opening the various types of castellated beams are shown figure.

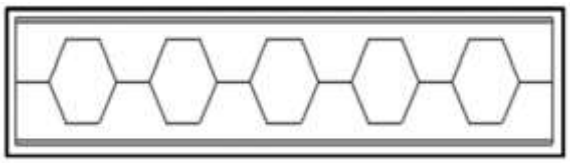

Fig. 1 - Castellated Beam with Hexagonal Shaped Opening

Methodology:

[Analysis and Design of Castellated Beam as Per IS 800:2007]

This chapter describes the methodology of this project the main topics included in this chapter are the study of material, selection of suitable sections, section properties, fabrication of test specimens, and testing of specimens.

1. Study of material - The study of material is about gaining general ideas and knowledge about the materials used in the project. It also includes the study of the terms involved in the project. It consists of the general study of steel, properties, advantages, applications and castellation techniques details etc

2. Selection of suitable section - The suitable section selection is nothing but identifying the most suitable section of beam required for the project from the literature reviewed. The section is designed and analysed by the limit state method. ISMB150 is selected as a parent section for fabricating castellated beams.

3. Process of fabrication of castellated beam -The fabrication of a castellated beam is a comparatively simple series of operations when adequate handling section on the side only.

I) Cutting- This is the first step of the process of fabrication. In this process, the web of a rolled section is cut in a Zigzag pattern, generally with advanced cutting systems in conjugation with CNC-controlled cutting heads. On small scale, it is done with the help of a Gas Cutter.

Fig 2 - 30° Hexagonal cutting of castellated beam

II) Welding- Lastly welding of the web post back together at the high points is carried out with an automated submerged arc welding process.

Fig 3 - Welding of castellated beam

III) Grinding –

Grinding is used to finish work pieces that must show high surface quality (e.g., low surface roughness) and high accuracy of shape and dimension. As the accuracy in dimensions in grinding is of the order of 0.000025 mm, in most applications it tends to be a finishing operation and removes comparatively little metal, about 0.25 to 0.50 mm depth. However, there are some roughing applications in which grinding removes high volumes of metal quite rapidly.

Fig 4 - Grinding of the castellated beam.

IV) Colouring – It's the last part of the castellation of the entire beam because it is good finishing and attractive surface of this beam. It is also helping the easy naming of the beams with help of a marker.

Fig 5 - Colouring of castellated beam

4. Testing of specimen

1. Parent shape web openings having 1.7490m length of each specimen.
2. Hexagonal shape web openings angle of opening is 30° having 1.7490 m length.
3. Hexagonal shape web openings angle of opening is 45° having 1.7490 m length.
4. Hexagonal shape web openings angle of opening is 60° having 1.7490m length.

5. Method of testing specimen

By two points loading in Universal Testing Machine

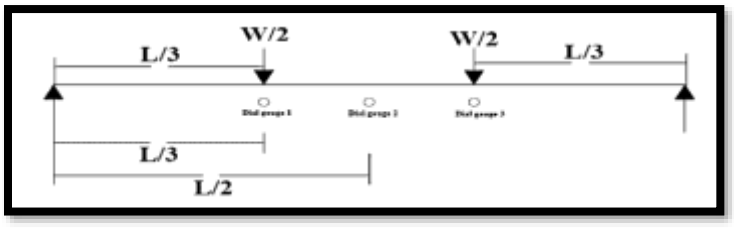

Fig 6 - Testing of the castellated beam

6. Experimental program

ISMB150 section was chosen as the parent element for manufacturing castellated beams. The Castellated beams are fabricated such that the depth of the beam is 1.5 times the original depth of 225mm. The thickness of the flange is 8 mm, the thickness of the web is 5 mm, the depth of the opening is 150 mm, and the length of the beam is 1750 mm. A universal testing machine (UTM) is used for testing the castellated beam. The below figures show the schematic diagram of the parent section, castellated steel Beam with a hexagonal opening used for the analysis.

Fig 7 - Before Cutting Parent Section Marking

Fig 8 - Testing of Hexagonal 30° Castellated Beam

3. Experimental Results

Table 1 - Experimental Result obtained Parent section Length of Specimen= 1.7490 M

Sr. No.	Load (kN)	Deflection(mm)	Remark
1	0	0	
2	10	1.2	
S3	20	2.5	
4	30	3.4	
5	40	4.0	
6	50	5.5	
7	60	6.7	
8	70	7.3	
9	75.6	8.5	Failure

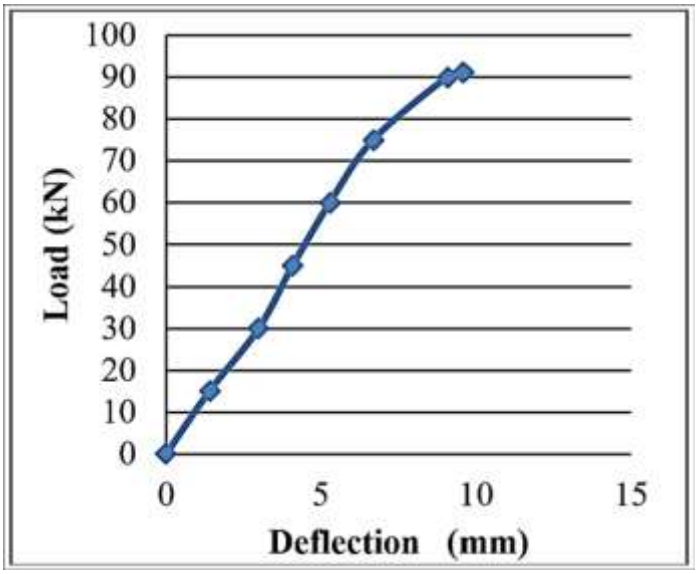

Fig 9 - Load Vs Deflection for Parent section

From Fig. 9 and table no.1, it is concluded that the parent section takes a maximum load of 75.6 kN and the deflection at this load is 8.5 mm. For this load and deflection beam fails.

Table 2 - Experimental Result Obtained Section with Hexagonal opening angle of opening is 300.

Length of Specimen= 1.7490M

Sr. No.	Load (kN)	Deflection(mm)	Remark
1	0	0	
2	15	1.1	
3	30	1.9	
4	45	3	
5	60	3.8	
6	75	4.5	
7	90	5.3	
8	91.2	6.2	Failure

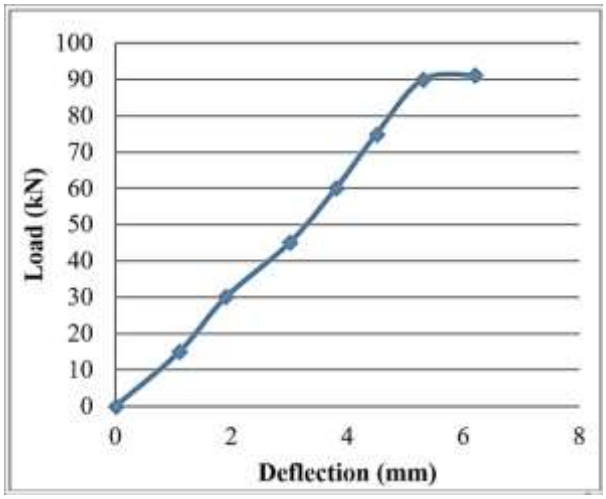

Fig - 10 Load Vs Deflection Hexagonal web opening angle of opening is 30^0

From Fig.10 and Table no.2, it is concluded that the Hexagonal 30^0 section takes a maximum load of 91.2 kN and the deflection at this load is 6.2 mm. For this load and deflection beam fails.

Table 3 - Experimental Result Obtained Section with a hexagonal opening angle of opening is 45^0

Length of Specimen= 1.7490 M

Sr. No.	Load(kN)	Deflection(mm)	Remark
1	0	0	
2	10	0.1	
3	20	0.6	
4	30	1.2	
5	40	1.8	
6	50	2.4	
7	60	3	
8	70	3.8	
9	80	4.7	
10	90	5.9	
11	100.2	8.8	Failure

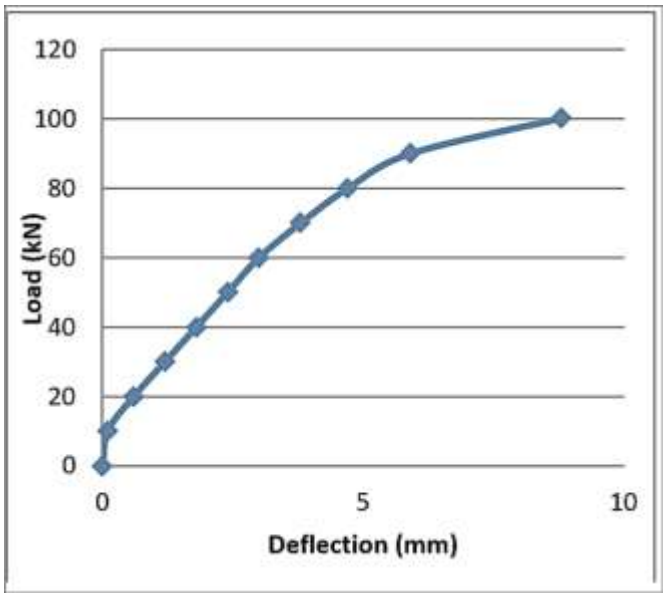

Fig - 11 Load Vs Deflection Hexagonal web opening angle of opening is 45^0

From Fig.11 and table no. 3 it is concluded that the Hexagonal 45^0 section takes a maximum load of 100.2 kN and the deflection at this load is 8.2 mm. For this load and deflection beam fails.

Table - 4 Experimental Result Obtained Section with a hexagonal opening angle of opening is 60^0

Length of Specimen= 1.7490 M

Sr. No.	Load (kN)	Deflection(mm)	Remark
1	0	0	
2	10	2.1	
3	20	3.5	
4	30	4.4	
5	40	6.5	
6	50	8.2	
7	60	9.1	
8	70	10.7	
9	80	11.9	
10	86.7	13.1	Failure

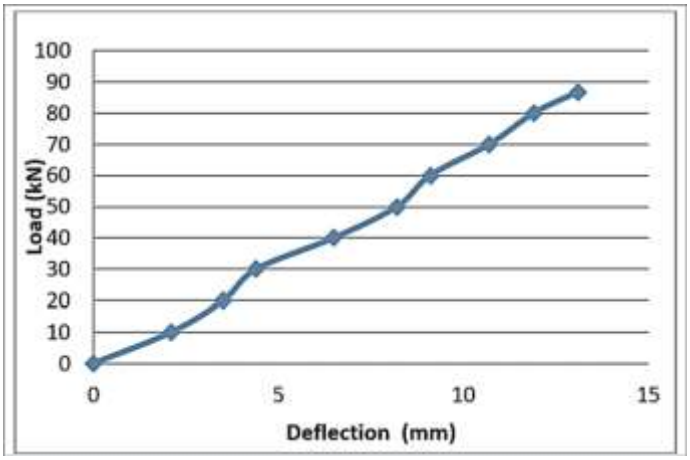

Fig - 12 Load Vs Deflection Hexagonal web opening angle of opening is 60^0

From Fig. 12 and Table no. 4, it is concluded that the Hexagonal 60^0 section takes a maximum load of 86.7 kN and the deflection at this load is 13.1 mm. For this load and deflection beam fails.

4. Future Scope

This research is extended by considering the different lengths of the opening, the height of the opening, and the changing depth of the beam. By considering the above dimensional variation, it can be possible to find the optimum load-carrying capacity of a castellated beam. Comparative study of different shapes opening experimentally Result and Software Result.

5. Conclusion & Discussion

- Hexagonal opening 30^0, 45^0 and 60^0 shows a larger load-carrying capacity as compared to a Parent element.
- Compared to Hexagonal openings, 45^0 Hexagonal openings gain more load-carrying capacity as compared to hexagonal openings 30^0 and 60^0
- Experimentation shows that hexagonal opening 60^0 after failure mode has more deflection other than hexagonal opening 30^0 and 60^0
- Analytically after castellation more M.I. and depth beam than parent element ISMB150

Acknowledgements

I am grateful to all of those with whom I have had the pleasure to work on this project work. My team member, Family members have provided me with extensive personal and professional guidance and taught me a great deal about both scientific research and life in general.

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