

FLEXURAL FAILURE PREDICTION OF CASTELLATED BEAMS USING EXPERIMENTAL INVESTIGATION

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ABSTRACT

Castellated beams are those beams which have openings in their web portion. Castellated beams are fabricated by cutting the web of hot rolled steel (HRS) I section into zigzag pattern and thereafter rejoining it over one another. Use of castellated beams is become very popular now a day due to its advantageous structural applications. This is due to increased depth of section without any additional weight, high strength to weight ratio, as well as their lower maintenance and painting cost. The principle advantage of castellated beam is increase in vertical bending stiffness, ease of service provision and attractive appearance. However one consequence of presence of web opening is the development of various local effects. The openings made in the webs are of generally hexagonal, diamond, rectangular or square in shape. By studying the different research paper it found that castellated beams with hexagonal, rectangular or square opening mostly fails due to shear stress concentration at the corner of opening, so our objective of this paper is to provide new web opening shape sinusoidal opening to avoid failure of castellated beam due to shear stress concentration at the corner of opening. From the experimental results, it is concluded that, moment carrying capacity of new sinusoidal web opening shape castellated beam is more as compare to castellated beam with hexagonal and rectangular web opening due shear stress redistribution at corner.

Keywords: *Castellated beam, Circular web opening, Hexagonal web opening, Sinusoidal web opening, shear stress concentration, Bending Moment Carrying capacity.*

INTRODUCTION

Castellation is a process of fabricating 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 web resists shear forces, while the flanges resist most of the bending moment experienced by the beam. Beam theory shows that the I shaped sections is a very efficient form for carrying both bending and shear loads in the plane of the web.

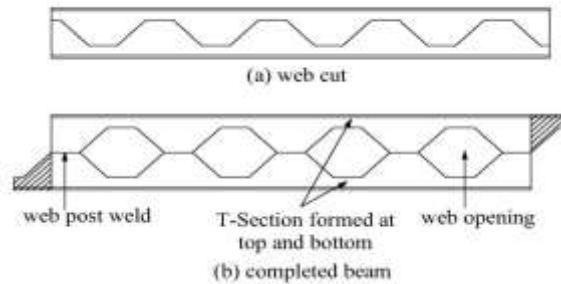


Figure 1 Fabrication Process

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. Although there are many advantages to using castellated beam, the one disadvantage is fabrication cost. The extra cost of cutting and welding the web is usually the deciding factor for their feasibility. Castellated beams are more popular in areas where the cost of steel is high and labor costs are low. The use of castellated beams in Europe has existed ever since the adoption of the fabrication process developed by Litzka Stahlbau of Bavaria, Germany (Boyer 1964). The design concept for castellated beams is based on typical beam limit states, but the presence of web openings and welds can cause other modes of failure. The potential modes of failure associated with castellated beams are:

- | | |
|---------------------------------|----------------------------------|
| 1. Flexural Failure Mechanism | 4. Weld Rupture at Web Post |
| 2. Lateral-Torsional Buckling | 5. Shear Buckling of Web Post |
| 3. Vierendeel Bending Mechanism | 6. Compression Web Post Buckling |

EXPERIMENTAL PROGRAMME

ISMB 150 section is selected as the parent section for fabricating castellated beam. The castellated beams are fabricated such that the depth of the beam is 1.5 times the original depth. Thickness of flange is 8 mm, thickness of web is 5 mm, depth of opening is 150 mm, and length of the beam is 1700 mm. Universal testing machine (UTM) of 1000 kN capacity is used for testing the castellated beam. The specimen was supported at two ends and it is properly fixed at the ends.

Details of Models

Table.No.1

Sr.No.	Name	Specification	No.
1	I _p	Parent section without castellation	3
2	I _H	Section with hexagonal web opening	3
3	I _{S1}	Section with sinusoidal web opening with fillet radius equal to 1/4 th	3
4	I _{S2}	Section with sinusoidal web opening with fillet radius equal to 1/6 th	3
5	I _{S3}	Section with sinusoidal web opening with fillet radius equal to 1/8 th	3

Measurement Technique

All specimens were loaded by two point load applied at L/3 distance from both ends slowly until buckling. The load corresponding to the failure of specimen is noted. The experimental set up is shown below. ISMB 150 solid section was also tested to determine the deflection.

RESULTS AND DISCUSSION

From experiment we have plotted the graph of load V/s deflection for different web opening castellated beams.



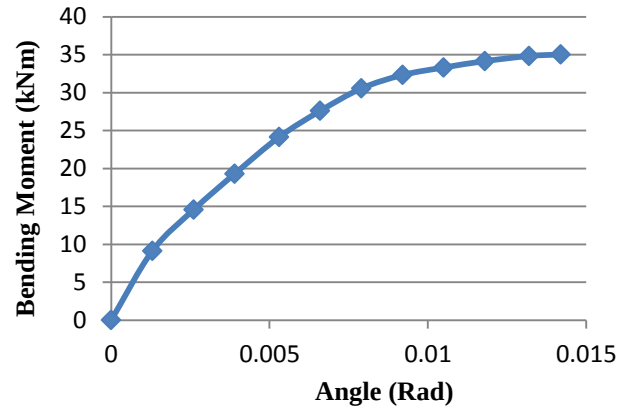
Figure 2 Testing Arrangement of Castellated Beams



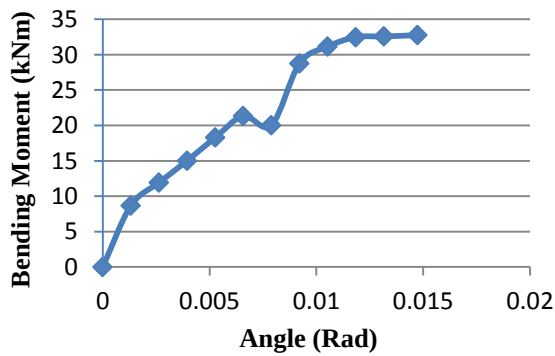
Figure 3 Shear Stress Redistribution In I_{S1}



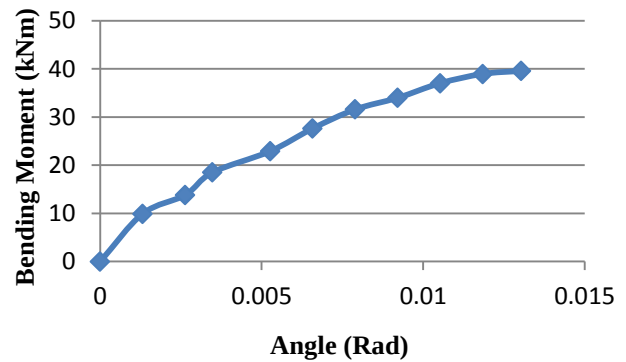
Figure 4 Flexural Buckling of I_{S1}



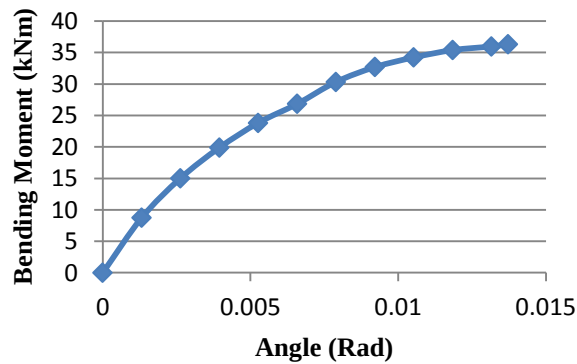
Graph 1 BM Carrying Capacity of I_p V/s Angle



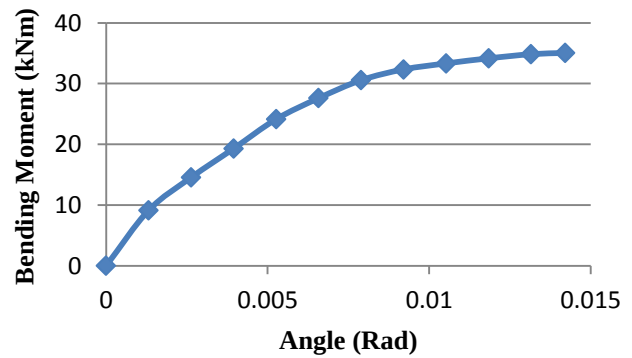
Graph 2 BM Carrying Capacity of I_H V/s Angle



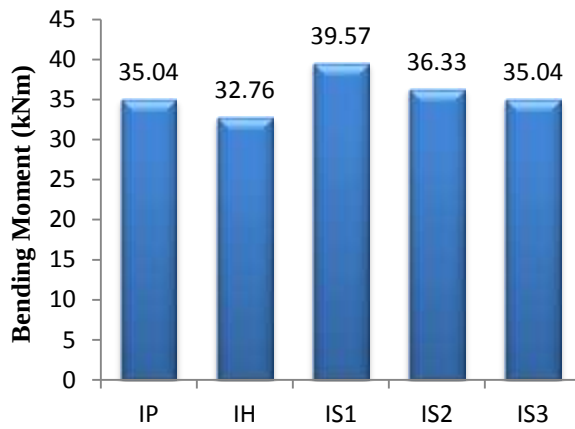
Graph 3 BM Carrying Capacity of I_{S1} V/s Angle



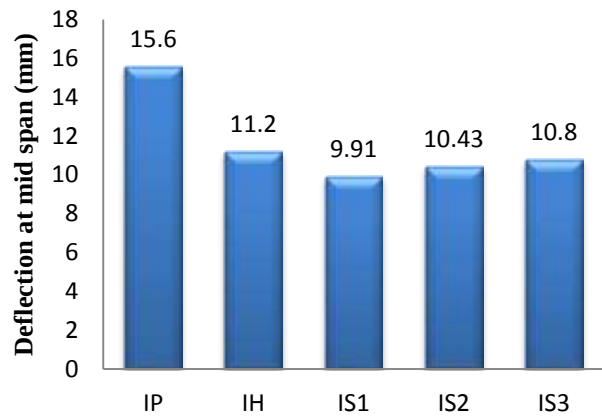
Graph 4 BM carrying capacity of I_{S2} V/s Angle



Graph 5 BM carrying capacity of I_{S3} V/s Angle



Graph 6 Comparison of BM carrying capacity of tested beam specimens



Graph 7 Comparison of Deflection of tested beam specimens

CONCLUSIONS

1. Bending moment carrying capacity of castellated beam with sinusoidal web opening is more as compare to castellated beam with hexagonal opening.
2. Bending moment carrying capacity of I_{S1} compare to I_H is 20.77% more, that of I_{S2} compare to I_H is 10.89% more and of I_{S3} compare to I_H is 6.94% more.
3. The castellated beam with sinusoidal web opening has as good structural performances as compare to hexagonal openings in the form of the stresses distribution, shear capacity and failure mode.
4. Castellated beams with Sinusoidal web opening have higher shear capacity than that with hexagonal web opening.
5. Experimental analysis shows that shear stress get easily redistributed at the fillet corner of sinusoidal web opening castellated beams.
6. Hexagonal web opening castellated beam have lower shear capacity due to shear stress concentration at corner of opening
7. Sinusoidal web opening castellated beams shows less deflection as compare hexagonal web opening.
8. Deflection of I_{S1} compare to I_H is 11.51 % less, that of I_{S2} compare to I_H is 6.87% less and of I_{S3} compare to I_H is 3.57% less.
9. Comparing the results of all sinusoidal web opening castellated beams it is found that a castellated beam with sinusoidal web opening with fillet radius equal to $1/4^{\text{th}}$ of opening shows better performance compare to castellated beam with sinusoidal web opening with fillet radius equal to $1/6^{\text{th}}$ and $1/8^{\text{th}}$ of opening in both bending moment and deflection .

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