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Comparative Study of Different Web Openings in Castellated Beam by Using Ansys Software

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Abstract - The use of castellated beams has become very popular due to its beneficial structural applications as engineers are actively seeking to improve building materials and properties. Castellated beams are those beams whose webs open in part. Castalized beams are manufactured by cutting a web of hot rolled steel (HRS) I sections in a zigzag pattern and then joining them on top of each other. The use of castellated beams has become very popular nowadays due to its beneficial structural applications. This is due to the increased depth of section without any additional load, higher strength to weight ratio, their low maintenance and painting cost. The main advantages of lattice beams are increased vertical bending stiffness, ease of service provision and attractive appearance. However one consequence of the appearance of web openings is the development of various local influences. In this research, we have suggested an Indian Standard Code based method for the design of castellated beams. So the first objective of this research is to investigate the performance of castellated beams designed by IS code method against that designed by British standard method. The performance study is based on the deflection, load carrying capacity of the lattice beam. We compare the castellated beam design by the IS code method to the conventional castellated beam design by British Standard based on their load carrying capacity. The opening is generally provided in the shape of the web hexagonal, rectangular, diamond or square. By studying various research papers found on lattice beams with hexagonal, rectangular or square openings that mostly fail due to shear concentration at corner openings, the second aim of this research is to provide new web openings that can be protected from lattice failure. There is a sinusoidal opening to escape beam due to shear stress concentration at the corner of the opening. The study of this project is based on the deflection, load carrying capacity of the new sinusoidal opening shape casted beam as compared to castellated beam with hexagonal web opening.

Key Words: Castellated beam, fabricated, Strength, Stress, IS code.

1. INTRODUCTION

Castellation is a process of fabricating a section with improved section properties from virgin rolled section by increasing depth ultimately improving moment of inertia. There by increase in moment of resistance and controlled on deflection. Thisprocess 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 2 underneath ultimately reducing the depth of the floor system

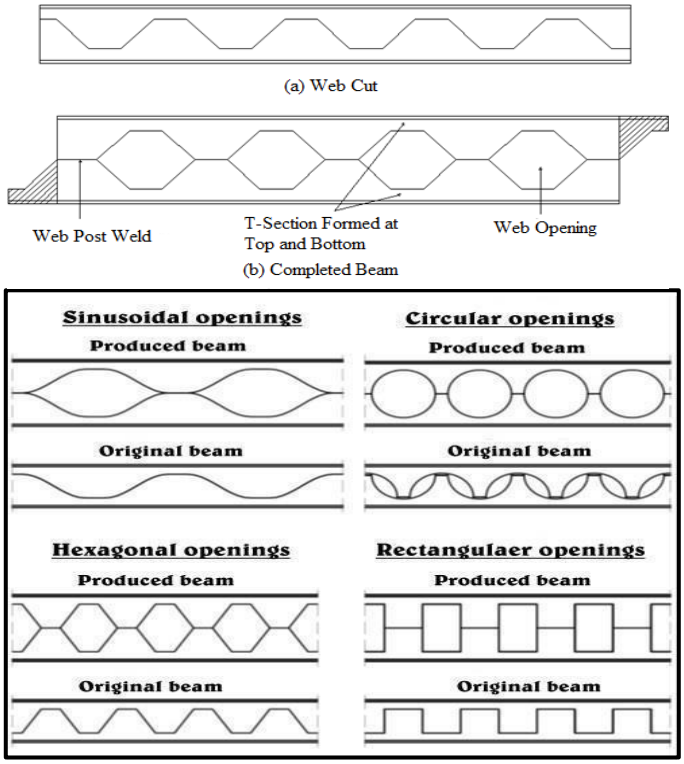


Figure 1.1 Fabrication Process

1.1 ANSYS

ANSYS is a finite element analysis (FEA) software package. It uses a preprocessor software engine to create geometry. Then it uses a solution routine to apply loads to the meshed geometry. Finally it outputs desired results in post- processing. Finite element analysis was first developed by the airplane industry to predict the behavior of metals when Formed for wings. Now FEA is used throughout almost all engineering design including

mechanical systems and civil engineering structures. ANSYS is used throughout industry in many engineering disciplines. This software package was even used by the engineers that investigated the World Trade Center collapse in 2001

1.2ADVANTAGES

1. Increase in depth d results increase in moment of inertia, increases momentcarrying capacity of Castellated Beam up to 50% of the original capacity.

2. The length of the castellated beam can be extended up to 90 ft.

3. It has a high stiffness-to-weight ratio

4. Installation is fast and easy as the span of the beam is longer.

5. Same section can be used for longer span after castellation which covers more column free area.

6. Since, webs of beams are perforated AC ducts, Plumbing lines, Electric wiringcan be easily passed through it which otherwise have hampered the headroom.

7. Improve aesthetic view of the ceiling.

8. Tapered and curved section can be easily fabricated.

9. Optimum use of material there by saving in material.

10. Innovative and ecofriendly structure.

11. Proves economical as castellated section gives 50% more moment of resistance

12. The overall cost of the structure will be reduced as castellated beams are more economical.

13. Castellated beam requires low maintenance

14. Handling of the beam is easy due to the lighter weight

15. Installation is fast and easy as the span of the beam is longer.

16. It minimizes the floor vibration issues

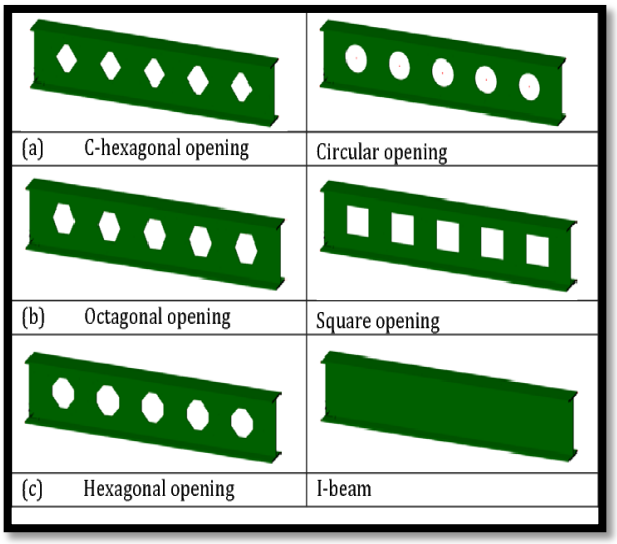
1.3 DISADVANTAGES

a) As web is perforated and not uniform shear carrying capacity of beam reduces.

b) Shear concentration will be there at re-entering corners in case of rectangular and hexagonal patterns and may be a cause of failure.

c) Loss of web material in case of castellated beam with circular sections.

d)High skilled labour is required.



1.4 LIMITATIONS

There are a number of possible failure modes for castellated beams, which are as follows

•Vierendeel Mechanism:

Vierendeel bending is caused by the need to transfer the shear force across the opening to be consistent with the rate of change of bending moment, in the absence of local or overall instability, hexagonal castellated beams have two basic modes of plastic collapse, depending on the opening geometry. The failure is dependent on the presence ofa shear force of high magnitude in the holes through span

•Lateral Torsional Buckling of the web:

Non-compsosite castellated beams are more susceptible to lateral-torsional buckling than composite beams due to lack of lateral support to the compression flange. The lateral torsional buckling behaviour of castellated beams is similar to that of plain webbed beams. The holes had a significant influence on lateral torsional buckling behavior.

•Rupture of welded joints in the web:

Rupture of a welded joint in a web-post can result when the width of the web-post or length of welded joint is small. This mode of failure is caused by the action of the horizontal shearing force in the web-post, which is needed to balancethe shear forces applied at the points of contra flexure at the ends of the upper I section.

2.OBJECTIVE

•The aim of the present work is designing of castellated beam based on IS Code.

•In the present work we have developed the IS 800-2007 Code based methodology for designing of castellated beam for hexagonal web opening. From the observation of past result, it is found that castellated beam with hexagonal web opening fails due to shear stress concentration at the corner of hexagonal web opening.

•To avoid this concentration of shear stress at the corner of hexagonal web opening we suggest the new web opening pattern Sinusoidal web opening form by filleting the corner of hexagonal web opening in castellated beams.

•The main focus of the research work is to introduce web opening so that the deflection is minimize and shear failure is controlled.

•In this beam section the depth of original section is increase by 1.5 times of original depth, due to increase of the section moment of inertia and moment of resistance is also increase.

•The main objective this project for to study analytical shear strength deflection properties of newly introduced opening section i.e. diagonal rectangular section.

3. SCOPE OF PROJECT

While designing a power plant structure or multi storied building, the traditional structure steel framing consists of beam and girder with solid web. This hinder provision of pipeline and air conditioning duct. Electrical wiring required for satisfactory functioning for which structure put up. The re-routing structure and additional cost required is unnecessary

One of the greatest advantages of castellated beams are their integration possibilities Castellated beams let facility owners run their utilities directly through web openings. This design opportunity saves several inches of height per floor Beam opening scan also be used as installation conduits for sprinkler piping. HVAC piping, and other utility systems

The future of architectural design relies on this type of structural integration. The use of castellated beams in office buildings may create new solutions for tenants and managers alike Meanwhile, the integration installation capabilities created by castellated beams is creating new opportunities for office building designers.

The installation of conduits within beam depth is advantageous across other building designs, too. Medical buildings, for example, include a variety of data lines and gas lines. Typical construction often requires these lines to be installed, or even relocated, once the project is complete. Castellated steel beams eliminate this need. creating environments conducive to full service integration.

Castellated beams are quickly becoming industry standard options for long lasting ,cost- efficient designs. If you haven't yet, consider their inclusion in your projects.

3.1 PROBLEM STATEMENT

Due to limitation on minimum allowable deflection, the high strength properties steel cannot always be utilized to best advantages. As result several new method aimed at increases in weight of steel required, Castellated beam is one of the best solution. While designing a power plant structure or multi storied building, the traditional structure steel framing consists of beam and girder with solid web. This hinder provision of pipeline and air conditioning duct. Electrical wiring required for satisfactory functioning for which structure put up. The re-routing structure and additional cost required is unnecessary.

3.2 RESEARCH METHODOLOGY

The experimental investigation in this research involves fabrication of castellated beams. To fabricate the castellated beam section ISMB 150 are selected. the beam is cut along its web in a definite pattern and then rejoined together to get an increased depth (50%) of castellated beam with different opening (hexagonal, sinusoidal and diagonal rectangular opening) indicates the Increased depth of Castellated beam. The theoretical design to made as per the Indian code 800 2007 To check the shear strength of different openings. The beam is loaded till its failure and shear strength to study. The beam is tested for 225mm depth for different web openings, hence Single beam will be casted for each type of section. Therefore totally three numbers of beams will be fabricated. The beams will be undergone two point loading until its failure. Analysis will be made with IS code method and ANSYS software. Stress distribution and failure modes for three different web openings will be studied. Finally, experimental results will be compared with the parent section

3.3 EXPECTED OUTCOME:

Our aim is to study flexural behavior of castellated beam for different shape of opening and optimize the shape of opening by using ANASYS software, so that for shape of opening the load carrying capacity is more and the deflection is less.

The expected outcome of this project is to introduce the new shape i.e. the rectangular diagonal shape which can give the better properties than previous shapes.

4. RESEARCH METHODOLOGY

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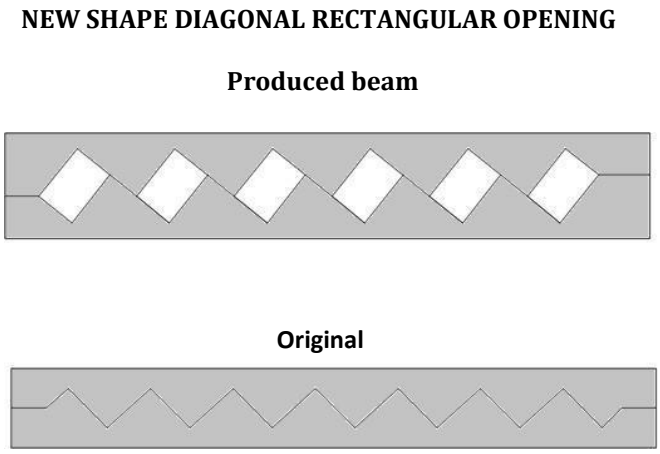


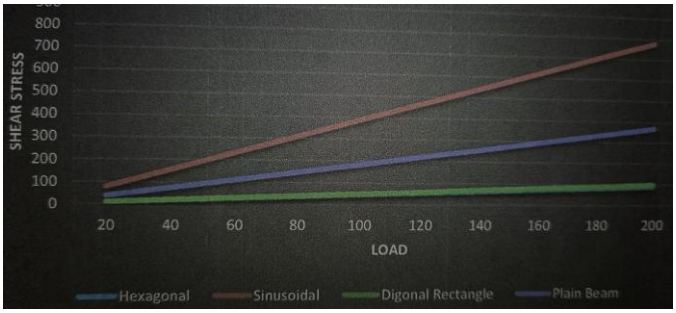
Figure 3.1 Diagonal Rectangular Opening With Fabrication Process

Together to get an increased depth (50%) of castellated beam with different opening (hexagonal, sinusoidal and diagonal rectangular opening) indicates the Increased depth of Castellated beam. The theoretical design to made as per the Indian code 800 2007 To check the shear strength of different openings. The beam is loaded till its failure and shear strength to study. The beam is tested for 225mm depth for different web openings, hence Single beam will be casted for each type of section. Therefore totally three numbers of beams will be fabricated. The beams will be undergone two point loading until its failure. Analysis will be made with IS code method and ANSYS software. Stress distribution and failure modes for three different web openings will be studied. Finally, experimental results will be compared with the parent section

5. RESULTS

Table- 1 Loads Versus Shear stress For all Beam.

Sr No.	Load (KN)	Shear Stress In Parent Beam (N/mm^2)	Shear Stress In Beam With Hexagonal Opening (N/mm2)	Shear Stress In Beam With Sinusoidal Opening (N/mm2)	Shear Stress In Beam With Daigonal Rectangular Opening (N/mm2)
1	20	36.76	9.021	77.77	9.87
2	40	73.52	18.043	155.55	19.755
3	60	110.28	27.064	233.33	29.632
4	80	147.04	36.085	311.11	39.51
5	100	183.8	45.106	388.89	49.387
6	120	220.56	54.128	466.66	59.265
7	140	257.32	63.149	544.44	69.142
8	160	294.08	72.17	622.22	79.02
9	180	330.84	81.191	699.99	88.897
10	200	367.6	90.213	777.77	98.775

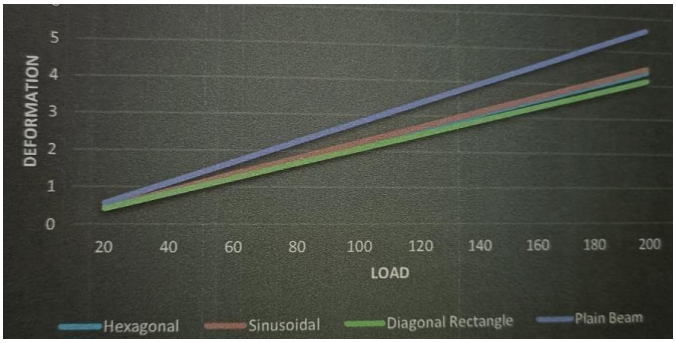


Graph 1 -Loads Versus Shear Stress For all Beam

From this graph between load and shear stress for the load of 200KN the beam with hexagonal web opening gives minimum shear stress i.e. 90.123 N/mm as compared to other beams.

Table- 2 Loads Versus Deflection For all Beam.

Sr No.	Load (KN)	Deflectionof Parent Beam (mm)	Deflectionof Beam With Hexagonal Opening (mm)	Deflection of Beam With Sinusoidal Opening (mm)	Deflection of Beam With Daigonal Rectangular Opening (mm)
1	20	0.56	0.438	0.449	0.412
2	40	1.12	0.87	0.89	0.825
3	60	1.68	1.31	1.35	1.238
4	80	2.25	1.754	1.79	1.651
5	100	2.81	2.19	2.24	2.063
6	120	3.37	2.63	2.69	2.476
7	140	3.94	3.06	3.146	2.889
8	160	4.5	3.5	3.59	3.302
9	180	5.06	3.94	4.04	3.714
10	200	5.63	4.38	4.49	4.127



Graph 2 -Loads Versus Deflection For all Beam

From this graph between load and deflection for the load of 200KN the beam with diagonal rectangular web opening gives minimum deflection i.e. 4.127mm as compared to other beams.

CONCLUSION

1) The load carrying capacity of castellated beam with diagonal rectangular web opening is more as compared to other beams.

2) The beam with diagonal rectangular web opening gives minimum deflection as compared to other beams.

3) The shear stress generation in the beam with diagonal rectangular web opening is comparatively less.

4) The castellated beam with diagonal rectangular web opening give better structural performances as compared to other castellated beam.

5) It is observed from software analysis of castellated beams, diagonal rectangular web opening gives better results as compared to other castellated beams.

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