RESEARCH ARTICLE OPEN ACCESS

"Numerical Analysis and Validation of Octagonal Castellated Steel Beams with Circular and Octagonal Ring Stiffeners"

Rajeev Kumar Singh *, Prof. L.P. Shrivastava **
**(Department of Civil Engineering, CSVTU Bhilai India*
*** (professor, Department of Civil Engineering, CSVTU Bhilai India)*

ABSTRACT
Steel structure are employed in heavy industrial building to provide good strength and also carry tones of loads safely. Recently uses of castellated beam with different profile is increasing due to its good vertical bending stiffness, high weight ratio and high strength. The objective of the thesis is to strengthen the castellated beam with the application of extended plate and circular and hexagonal stiffener. The virtual CAD model of the I section beam is prepared with the help of standard sectional profile of IPE 140. FEM results guide us to the find out the stress and deflections in the existing parent beam and validate the result with experimental result. In order to reach the most optimum design of beam, several models in the form of different profile castellated were tested on the basis of ultimate strength and the most optimum design was selected. Based on the satisfaction of different factors in the form of load bearing capacity, stress induced and deflection the optimum selection of beam was performed.
The result obtained by ANSYS software is compared with the experimental result to validate the result of I Beams. In these two different approaches the boundary condition for analysis is same and other parameter is also kept at constant.
effectiveness of heat exchanger.
KEYWORD: CAD (computer aided design), FEM (Finite Element Method)

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I. INTRODUCTION

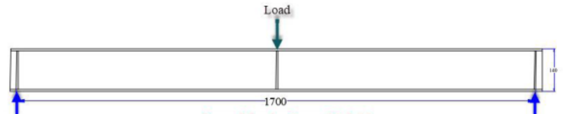
The use of steel cellular beams has been growing due to their commercial and visual advantages. Typically, these beams are produced from hot-rolled steel I-sections, and its webs are cut and welded making higher members with regular circular or hexagonal openings along their length. Researchers are always trying to improve the materials property and practices of design and construction. One of the major improvement occurred in built-up structural members in the mid-1930, an engineer from the Argentina, developed a castellated beam.

Castellated beams are a structural members, which are made by trimming a rolled beam along its center and then reassembled the two halves by welding so that the overall depth of beam is increased by 50% for improved structural performance under the bending. Since the II World War many attempt have been made by civil engineers to find new ways to decrease the cost and increase the utility of steel structures. Due to boundaries on minimum allowable deflection, the high strength property of structural cannot always be utilized to best advantage. As a result several new methods aimed at increasing stiffness of steel member, without any increase in weight of steel required. Castellated beam is one of the best option instead of solid beam.

II. BASIC OBJECTIVE OF RESEARCH WORK

The basic objective of the work is to find out the nature of beam under action of point load in the mid span of castellated beam and also to determine the amount of deflection and stresses generated in the beam. The specimen is prepared with the built up section of IPE 140 and four different beam has prepare with adding the stiffener plate and also adding the support plate around the circular and hexagonal profile. The basic objectives are:

- Find out the nature of castellated beam under the action of point load at mid span.
- Compare the result of parent beam with optional built up beam.
- Find out the load bearing capacity of each beam or the maximum load carrying capacity of the beam
- Validate the result obtained by FEA with experimental result.
- Propose a suitable beam for the same boundary condition.

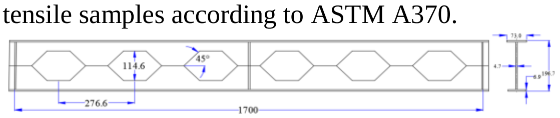


Parent I Section Beam CBC-00

III. METHODOLOGY

Experimental Analysis

The experimental specimen [1] is prepared by using IPE 140 beam as a parent section for fabrication of four specimens of large opening castellated beam in shape of hexagonal. The parameters of IPE 140 kept same as web thickness 4.7 mm flange thickness as 6.9 mm and width is 73 mm while the span is maintain at 1700 mm. the web of beam is cut by plasma cutter in zigzag way to form the required profile of hexagon and then re-join the two halves together by using electrode welding process. The expansion plate is added in the specimen CBC-02 and other two beam is formed by adding stiffener with expansion plate. The material properties were found from tension tests on flat tensile samples according to ASTM A370.

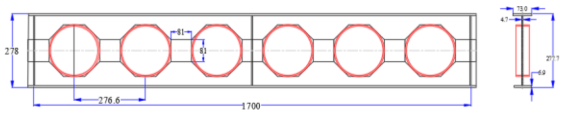


This exertion based on using two types of stiffener plate of octagonal and circular rings that it will located all around octagonal web opening to prevent failures due to Vierendeel failure and web-post-buckling. The angle of cut is maintain at 450 to form the hexagonal and further it extended as octagonal profile by adding expansion plate of 81x81 mm size with circular and hexagonal stiffener plate.

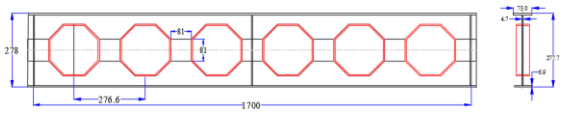
FEM analysis of Castellated Beam

Modeling & Boundary Condition

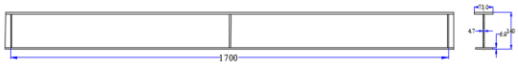
The basic geometry of I beam modeled in ANSYS Structure Analysis workbench with given parameter. The basic sketch of I beam is created in sketcher workbench and extruded it about 1700 mm span.



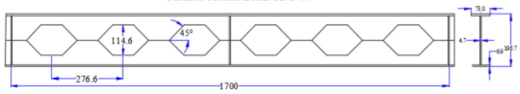
Castellated Beam with Expansion Plate & Circular Stiffener (CBC-02)



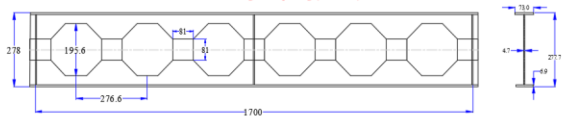
Castellated Beam with Expansion Plate & Octagonal Stiffener (CBC-02)



Parent I Section Beam CBC-00

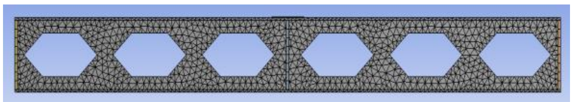


Castellated Beam with Hexagonal opening (CBC-01)



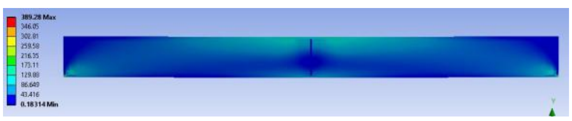
Castellated Beam with Expansion Plate (CBC-02)

Meshing is one of the key terms of structure analysis due to it's directly influence on the result of analysis. Choice of element types and meshing node data is greatly depend upon the geometry and way of modeling of machine parts, if the body is simple with no curvature then brick or rectangular element may use to mesh otherwise we need to move with parabolic element with curvature.

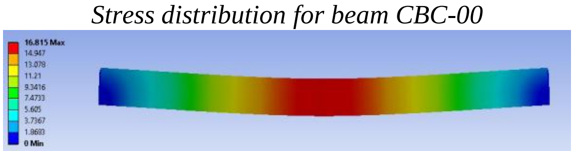


Solution

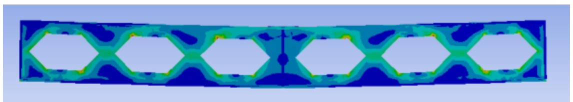
This is the major phase of the FEA, and here the solution of the object is achieved in the form of Max Von Mises Stress and Deflection. The stress distribution and the magnitude of deflection have been shown in Figure below.



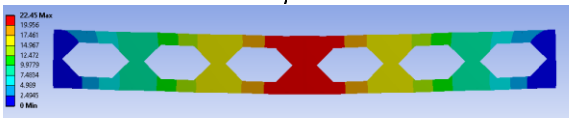
Stress distribution for beam CBC-00



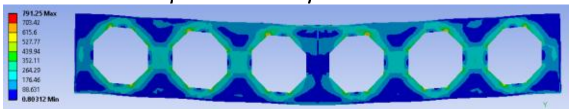
Deflection plot for beam CBC-00



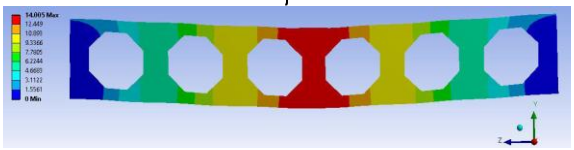
Stress Plot for CBC-01



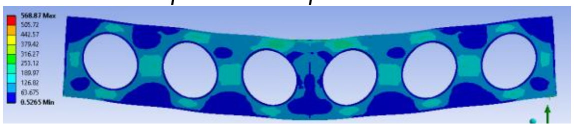
Deflection Plot for CBC-01



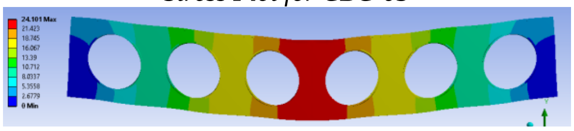
Stress Plot for CBC-02



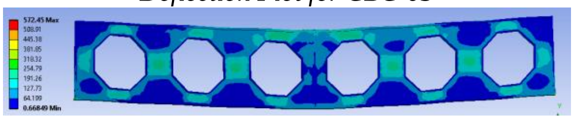
Deflection Plot for CBC-02



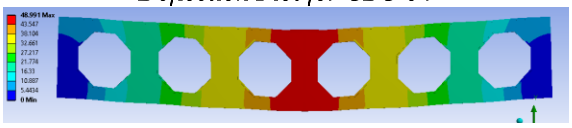
Stress Plot for CBC-03



Deflection Plot for CBC-03



Deflection Plot for CBC-04



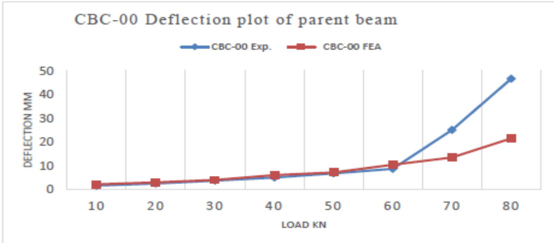
Deflection Plot for CBC-04

Post Processing

The post processing is concern about the data analysis which is found by the solution method. The outcome by the solution is define that the deflection of the beam is increases with increase of load. The ultimate load of CBC-02 of about 120.0 KN increased as 51% and 37% when compared with ultimate load of CBC-00 and CBC-01 respectively. In the web-post buckling, the lower compressed parts try to move away from the longitudinal plane of the web while the tensioned parts tend to remain in the starting position. This mode of failure occurs usually in inelastic rule with an important yielding of the section. In general, increasing the height of castellation beam causes the web-post buckling failure which as a results lead to rapid failure.

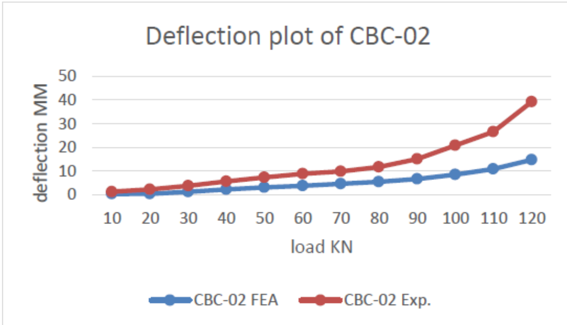
IV. RESULT & DISCUSSION

Stress and deflection are being calculated for the existing model of parent beam. For yield strength of I beam is 2.79×108 N/m2, it is found that induced stress is 3.89x108 N/m2, corresponding deflection is 16.85 mm. the amount of stress is maximum and beyond the limit of yield point but is observed that the maximum stress is developed on the top face of the beam where one extra plate provided to apply the load and it's not a part of beam analysis and rest of beam is under limit stress zone.



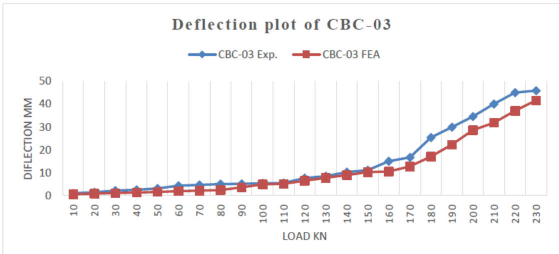
Comparative Analysis of Deflection of parent beam

Stress and deflection are being calculated for the CBC-01 castellated hexagonal profile I beam model. The deflection plot of experimental method is higher as compare to FEA method.

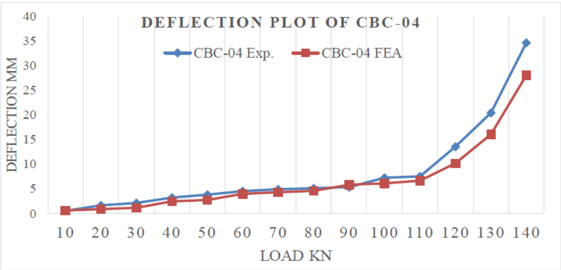


Comparative Analysis of Deflection of CBC-02

Similarly the comparison of CBC-02, CBC-03 and CBC-04 are given below.



Comparative Analysis of Deflection of CBC-03



Comparative Analysis of Deflection of CBC-04

V. CONCLUSION

The major advantages of castellated BEAM is their economy easy to use, easy to fabricate.

The relationship between the experimental and FEA analysis in shown vary good agreement almost all the segment of castellated beams except the last two or three point of loading condition. For example in the analysis of parent beam, the experimental analysis shown near about 47 mm deflection while the FEA result shows near about 22 mm deflection. Similarly in all cases there is different value in last two or three iteration due to two different approaches of same problem. But the overall nature of the beam and curve behavior is same and it follow each other.

Finally we may conclude that the castellated beam with extended plate and circular and octagonal stiffener will improve the overall ultimate strength of the beam with same boundary condition.

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