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Experimental Study on Behaviour of Cold-Formed Steel Castellated Beam

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Abstract - *Castellated beams are the beam which has openings in its web portion. The advantage in castellated beams it causes less in whole weight of the structure because of usage cold-formed steel and so usage of steel is lesser. Study on behaviour of cold-formed I section castellated beam with hexagonal openings and with stiffener plate along the web portion and cover plate over flange are carried out. Beams are analysed whelp of Abaqus by changing the position of stiffener plates over the beam*

Key Words*: *Castellated beam, Cold-formed, Stiffened plate, I-section

1. INTRODUCTION

Steel is an alloy of iron and carbon that is widely used in construction and other application due to its hardness and tensile strength. Cold-formed Steel Section or Light Gauge Steel Sections are used as purlins, floor decks, roof sheeting and prefab panels. Cold-formed steel sections tend to be more sensitive to local bucking than hot rolled sections. Castellated beam studied is in the form of I-section. The main application of castellated beam is for increasing depth 1.5 than actual depth of the beam and also openings are used for electrical conduits.

2. STUDY FROM PREVIOUS LITERATURES

From the literature study it is understood that, research on cold-formed steel (CFS) castellated beam with hexagonal openings is limited. For a flexural member subjected to light and moderate load, castellated beam section with thin flange and web may be sufficient even if the openings are provided in the web portion. Also, the stiffeners can also be provided along the web between the intervals of opening in castellated beams. Hence the present study is an attempt to perform a systematic study on the parameters and behaviour of cold-formed steel castellated beam I section with hexagonal openings in the web by providing stiffeners.

3. SPECIMEN SPECIFICATIONS

Castellated beams with hexagonal openings are same in depth of beam, depth of openings and length of the beam as shown in Table I. Dimensions of the beam are shown in Fig.1 and Fig.2. Specification which differs from one another are by providing stiffener plates parallel, perpendicular along web, providing cover plate over the flange and also thickness of material varies from 1.6 mm and 2 mm as show in Table 1.

Table -1: Specimen specification

S.no	L (mm)	D (mm)	D_o (mm)
1	1050	225	150

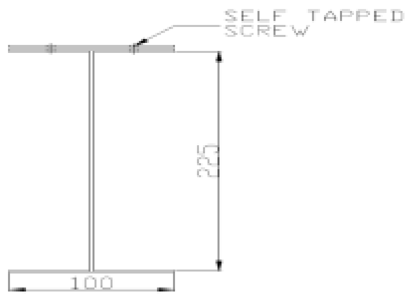

Fig-1: Cross sectional view

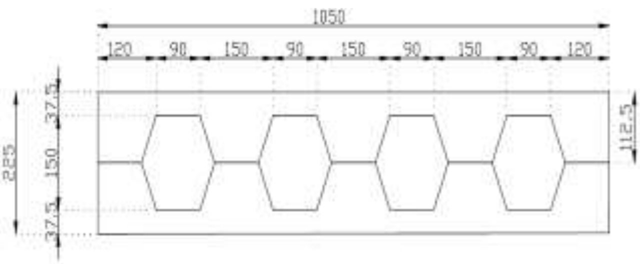

Fig-2: Longitudinal sectional view

Table-2: Details of the Specimen

Beam ID	Specification
CB1	Castellated beam with 1.6 mm thickness without any stiffeners.
CB2	Castellated beam with 2 mm thickness without any stiffeners.
CB3	Castellated beam 1.6 mm thickness with stiffener plates perpendicular along web.
CB4	Castellated beam with 2 mm thickness with stiffener plates perpendicular along web.
CB5	1.6mm Thickness is used, stiffener plates are kept parallel along the web portion of the beam.

CB6	2mm Thickness is used, stiffener plates are kept parallel along the web portion of the beam.
CB7	1.6mm Thickness is used, perpendicular stiffener plates are used along the web and cover plate is kept over the flange and connected using bolt.
CB8	2mm Thickness is used, perpendicular stiffener plates are used along the web and cover plate is kept over the flange and connected using bolts.

4. NUMERICAL ANALYSIS

The numerical analysis a technique for obtaining approximate solutions for the engineering problems. By the steps involving linear analysis and incorporating results from linear to nonlinear analysis for which ultimate load and critical moment is obtained.

4.1 Solid Modeling

The modelling is done using ABAQUS 6.13. Each part is to be created and welded separately as shown in Fig.3. The dimensions of the solid model created are same as the dimensions in Table 1 and also as specimen as in Table 2.

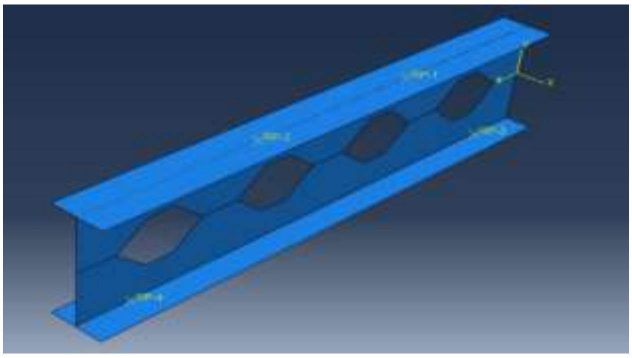

Fig-3: Finite element model of beam

4.2 Element Type

The element chosen for finite element model plays a vital role in the prediction of behavior of the structure. Every single element are defined by separate parts then assembled together. From the numerical study it is finalized that element 3D deformable shell is used.

4.3 Material Properties

The Young's modulus E is given as 2.1x105 N/mm2 The Poisson's ratio is given as 0.33. The yield stress of the material is 250Mpa. Thickness of section is assigned to 1.6 and 2 mm.

4.4 Meshing

The 3D Finite element model always requires mesh generation techniques. Depending upon the mesh sizes analyses time varies to run the process. This figure represents the modeling of the specimen with meshing size 50 mm. Top and bottom flange and web with hexagonal openings and stiffener plates are created by separate parts; those parts are welded together by means of tie constraint. The nodes are selected and tie connections are applied. As shown in Fig 4

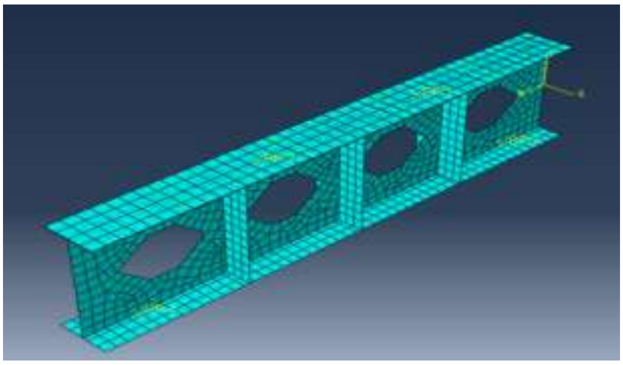

Fig-4: Meshing of a castellated beam

4.5 Providing Boundary Conditions

Boundary conditions are provided in the model based on the supports to be incorporated in the finite element model by selecting the nodes restraining the displacement. In our model the castellated beam is analyzed by simply supported end condition. So that displacement components Ux, Uy, and Uz are selected one end and displacement components Ux and Uy are restrained at another end

4.6 Applying Loads

Loads are applied by selecting the nodes on which load should be applied. In our case two point load method is used to analyze the castellated beams. Load is applied over 1/3 distance of beam. Loading part and boundary conditions are shown in Fig 5.

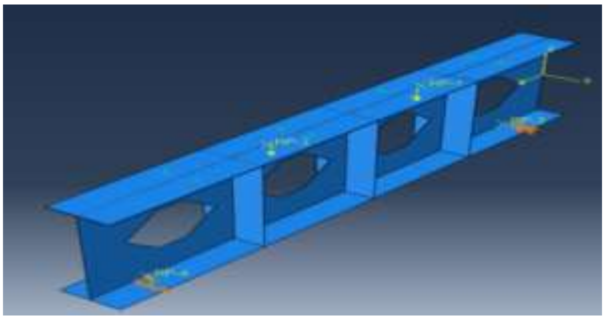

Fig.5: Load and Boundary conditions on beam

4.7 Linear Analysis

In this stage problem is subjected to static linear analysis. The errors and warnings are identified at this stage. After nullifying those errors, the solution process gets completed and the various deformations are studied.

4.8 Non-Linear Analysis

Analysis is carried by keeping the step procedure type as statics and risks. NLGEOM option is activated. Maximum number of increments kept as 100 with arc length increment 0.5 and estimated total arc length as 1.0. Deformed state of castellated beam is shown in Fig.6 and graph obtained also shown in Fig.7

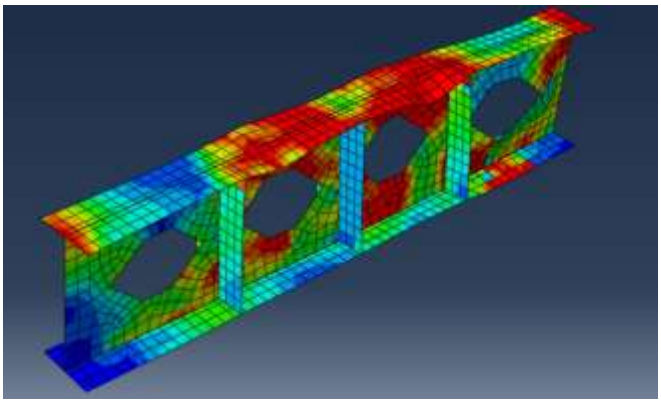

Fig-6: Deformed state of castellated beam

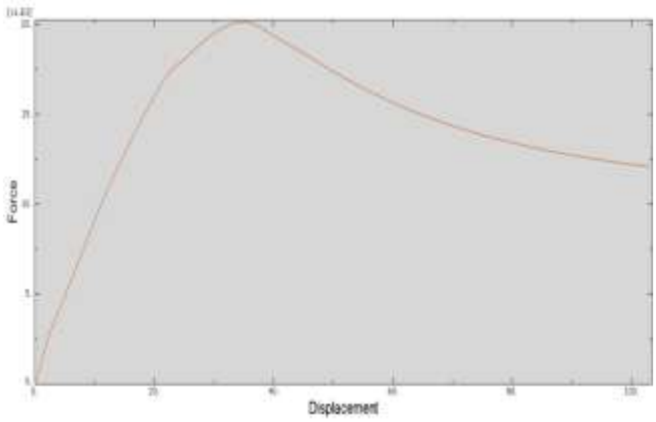

Fig-7 : Graph obtained from Abaqus for CB8

5. COMPARISON OF RESULTS

The results obtained from the numerical analysis of castellated beam CB1, CB2, CB3, CB4, CB5, CB6, CB7 and CB8 are compared below in Chart-1 and Table 3.

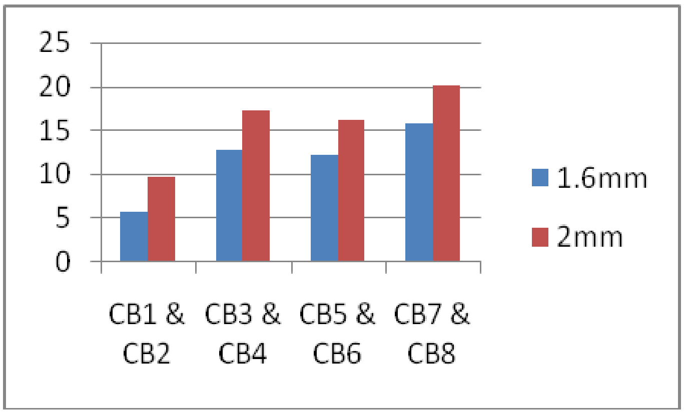

Chart-1: Comparison of results

Table-3: Comparison of results with ultimate load and moment

Beam ID	Ultimate Load (kN)	Ultimate Moment (kN-m)
CB1	5.8	2.03
CB2	9.8	3.43
CB3	12.8	4.48
CB3	17.2	6.02
CB5	12.3	4.31
CB6	16.1	5.635
CB7	15.8	5.53
CB8	20.1	7.035

6. CONCLUSION

From the past literature investigation, the behaviour of castellated beams were mostly done for hot rolled section. In this paper, experimental study of castellated beam was carried out for cold-formed section. In numerical analysis the section is observed that local buckling occurs for castellated beam with stiffener plates under the two point loading. Cover plate needed to be provided above flange and its to be connected with self tapped screw connections so the load carrying capacity of the beam increases. Perpendicular stiffener plates withstand more load than parallel according to numerical analysis.

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