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Experimental Study on Load Carrying Capacity of Cold Formed Steel Built-up Column

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Abstract : The cold formed steels are best alternative to the hot rolled sections in the present situation but still the usage of built-up columns are still under the research. The structural behavior and stability of columns have been studied by many researchers. This paper states the experimental and numerical analysis of a cold formed open and closed built-up column section. The columns were connected using bolted connection. For the finite element modeling ABAQUS 6.10 software was used. Geometrical and non-linearties are included in the model and the nodes are taken from AutoCAD and are imported in ABAQUS. A linear elastic buckling analysis was performed to obtain the buckling loads and associated buckling modes. A non-linear ultimate strength analysis has been carried out to know the ultimate axial load capacity and experimental investigation results were compared.
Keywords : Cold Formed Steel, Built-up Cold Formed Steel, Connectors, Types of Buckling, ABAQUS.

1. Introduction

Cold-formed steel sections have been used in the construction industry for more than 40years.The popularity of these sections has been increased in recent years due to their various application and quick fabrication.

1.1 Built-up section:

The built-up section is formed by the combination of two channel sections connected back to back using bolted or welded connection. According to research conducted the Back to back I section is used for strengthening external frame columns while Box section is used to support long beam.

1.2 Connections:

The connection may be bolt or weld. Bolts are usually hexed head and used with washers.

1.3 Types of Buckling:

Buckling are classified into different types local, distortional, flexural, flexural-tensional buckling. It basically depends on cross section geometry and the support condition.

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2. Literatue Review

In detail Jia-huizhang, Benyoungn (2015), Non-linear finite element analysis to investigate the behavior of cold-formed steel built-up columns with stiffeners. And comparing the results of DSM and ABAQUS.Yuanqi li, Zuyanshen, (2014), to determine the axial load capacity of a built-up box section members composed of two C-section connected by screws. Also the spacing of the fasteners was summarized in the paper. The experimental investigations of the built-up box sections were compared with the numerical analysis. M. Anbarasu, P. Bharath Kumar, S. Sukumar, (2014), the theoretical (DSM) and numerical investigation (FEM) were carried for a battened column section. And concluded by stating that the axial strength of the member decreased with the increase of overall slenderness ratio.Gabor jakab, (2009),the structural arrangement of C-sections in a back-to-back facing, structural joints are done by bolts. The numerical mode of different type of failures such as local, distortional, flexural failure were obtained and compared with the experimental results. The details of the section considered for the current study has been shown in fig.1

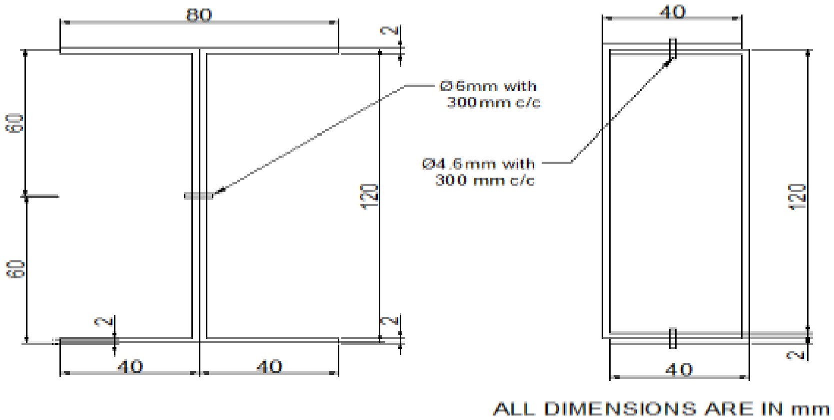

Fig. 1 Proposed Built-up Open and Closed Section

3. Design Methodology

Experimental study has been carried out to determine the ultimate load carrying capacity of the column section and to examine the Failure mode of the deflected specimen. Numerical Analysis has been made using ABAQUS software. It automatically evaluates the axial load capacity of such models and create test reports. This tool can also serve as a basis for more accurate design of cold-formed steel structures and have a potential of replacing the traditional models composed of column elements. Fig.2 shows the methodology of design.

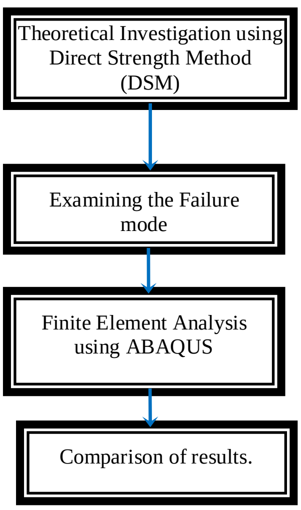

Fig. 2 Methodology

4. Experimental Investigation

Experimental Investigation are conducted to examine the behavior and mode of failure of the built-up section.

4.1 Material properties:

As per IS 1608 2005 part I prescribed, totally three specimens were fabricated. Tensile test has been conducted in universal tensile machine of 400 kN capacity. Test setup is shown in the Fig.3 Stress Vs Strain plots are drawn.

Fig. 3. Test setup for Coupon test

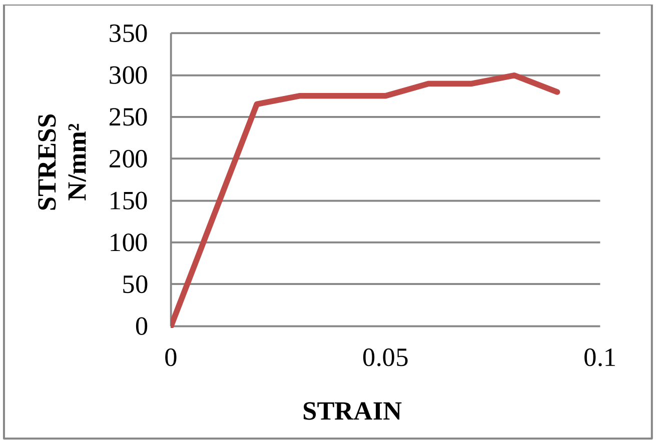

Fig. 4 Stress Vs Strain curve

Table 1 Test results of coupon test

S.No	Ultimate Load (Kn)	Yield Stress (N/mm²)	Young's Modulus (N/mm²)(10^5)
1	22.5	277	1.98
2	21.6	266	2.06
3	23.5	251	2.08

4.2 Test specimen:

The specimens were taken from the locally available cold formed sheets. CFS sheets of 2mm thick were used. Single CFS sheets were bended as a channel section. In the specimen BS-BB the channel section were connected back to back. And in BS-TT the channel section connected toe to toe. The Specimen was connected using bolted connection along the mid span. The spacing of the bolts was provided as 300 mm c/c. To apply the load uniformly, base plate of 6 mm thickness was provided to the column sections.

4.3 Test setup:

The column specimen was tested by using loading frame machine of capacity of 200 tonnes. The end condition was provided as simply supported. The deflection of the specimen is noted using the dial gauge1 attached at the mid span for measuring the displacement. And the axial shortening was measured by the dial gauge2 at the bottom support. The axial load has been applied to the column from bottom using hydraulic jack.

4.4 Failure mode:

The column get deflected after applying the axial load over it. For every instant of loading, the deflection is noted in both the dial gauge. The failure mode of the column after the ultimate loading was examined. The failure mode observed was local and flexural buckling The failure mode of BS-Toe to Toe is shown in Fig.6

Fig. 6 Tested specimen (BS-TT)

The failure mode of BS-Back to Back is shown in Fig.7

Fig. 7 Tested specimen (BS-BB)

5. Results and Discussion

The finite element non linear analysis done by ABAQUS software has been used to simulate the experimental structural behavior. The engineering stress and strain obtained from the coupon tests were used to calculate the true stress and strain. The geometric imperfections were also included in the analysis by using a linear perturbation. The main purpose of the perturbation analysis was to establish probable buckling modes of the column. The section is properly made and they are meshed independently. The ABAQUS results are shown in Fig 8 - Fig 11. Figure captions show a type of various section analyzed.

5.1Analysis of Open Built-up Section.

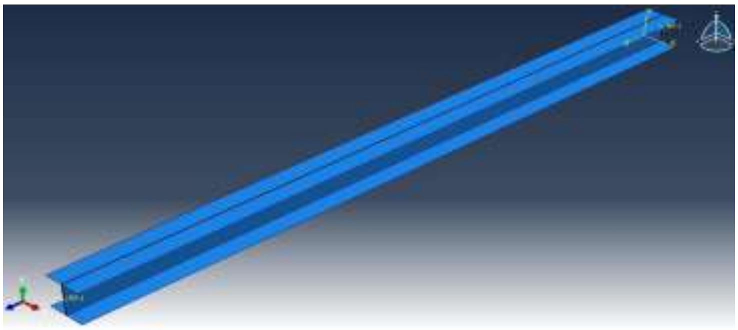

Fig. 8 Modal of the section

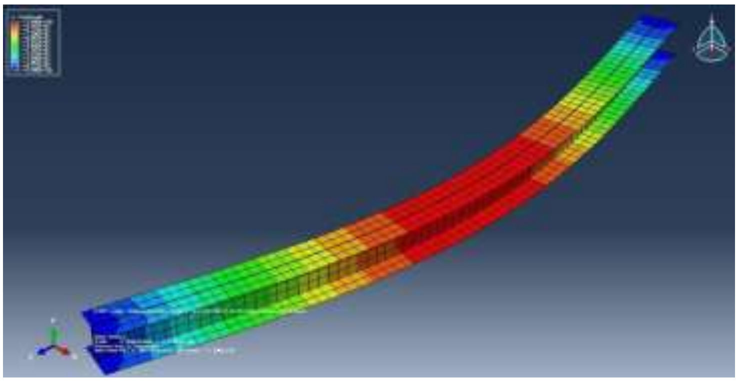

Fig. 9 Deflected BS-BB-L1700-T2

5.1 Analysis of Closed Buit-up Section

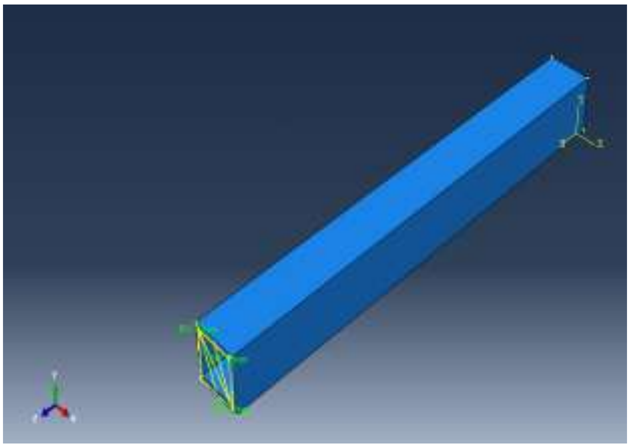

Fig. 10 Modal of the section

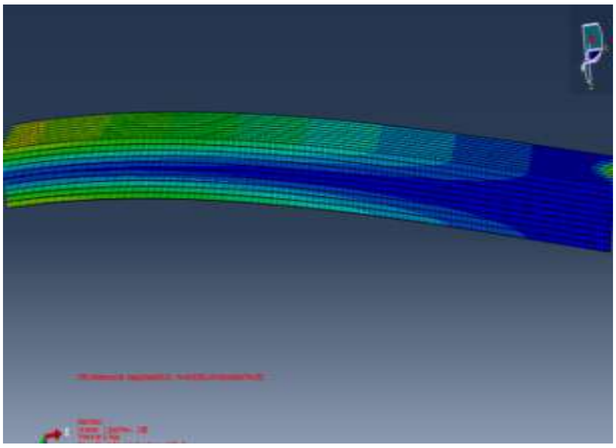

Fig. 11 Deflected BS-TT-L1700-T2

6. Conclusion

This paper has proposed that while evaluating the load carrying capacity of open and closed cold formed section. It has been stated that, the closed built-up column carries more load than the open built-up section. Also for the increase in thickness of the section the load carrying capacity increases. The column with slenderness ratio greater than 140 is set to be slender column. And the initial buckling mode will be local bucking and carry over by flexural buckling at the mid span. While comparing the results of P_{EXP}/P_{FEM} it shows 1.12 ratio difference. The Fig. 12 shows the load vs deflection curve of built-up section for the dial gauage fitted at the mid span to find deflection.

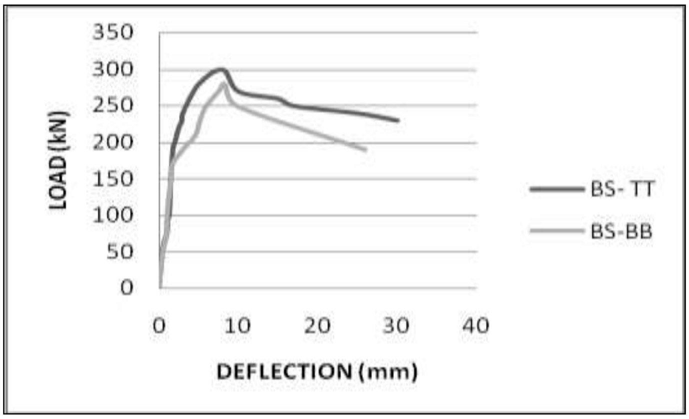

Fig. 12 Load Vs Deflection curve

Table 2 Comparison of built-up open and closed section

Specimen	**Size (mm)**	**P_{EXP} (kN)**	**Failure mode**	**P_{FEM} (kN)**	**P_{EXP}/P_{FEM} (kN)**
BS-BB	120X 40X2	280	F+L	250	1.12
BS-TT	120X 40X2	300	L	270	1.11

P_{EXP} – Ultimate load (Experimental), P_{FEM} – Ultimate load (Finite Element Analysis)

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