NUMERICAL STUDY ON BEHAVIOUR OF COLD-FORMED STEEL BUILT-UP BATTENED COLUMN

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Abstract - *The paper presents the study on Built up cold formed steel battened columns. Built-up CFS is usually a composition of normal CFS – C, Z or hat section to produce a new section. The section is connected by using bolt, screw or weld. According to research conducted the Back to back I section is used for strengthening external frame columns while Box Up is used to support long beam. This structural behavior and stability of columns have been studied by many researchers. In this work, the ultimate axial load carrying capacity of built-up column sections with battens is studied analytically. This study is based on the geometric limitations for structures as per (AISI 100-2007). The finite element model models were developed by using ANSYS 15.0 software. A linear elastic buckling analysis was performed to obtain the axial buckling loads and associated buckling shapes. Coupon Test for cold formed steel plates has been done as per IS: 1608-2005 in order to get the Yield Stress and Young's modulus. The theoretical study yet to be carried out by direct strength method (DSM) in AISI S100 – North American Specification for the Design of Cold formed steel structural members. Experimental Investigation will be carried out to validate the Numerical Analysis procedure. Comparison of results of Numerical, Theoretical and Experimental investigations will be made.*

Key Words*: *Built-up column, Cold-formed steel, ANSYS, buckling length

1. INTRODUCTION

Thin sheet steel products are extensively used in building industry, and range from purlins to roof sheeting and floor decking. Generally, these are available for use as basic building elements for assembly at site or as prefabricated frames or panels. These thin steel sections are cold-formed, i.e. their manufacturing process involves forming steel sections in a cold state (i.e. without application of heat) from steel sheets of uniform thickness. These are given the generic title Cold Formed Steel Sections. Sometimes they are also called Light Gauge Steel Sections or Cold Rolled Steel Sections. Cold-formed steel products are found in all aspects of modern life; in the home, the Shop, the factory, the office, the car, the petrol Station, the restaurant, and indeed in almost any imaginable location. The uses of these products are many and varied, ranging from "tin" cans to structural piling, from keyboard switches to mainframe building members. Nowadays, a multiplicity of widely different products, with a tremendous diversity of shapes, sizes, and applications are produces in steel using the cold forming process. Cold-formed steel products such as sections have been commonly used in the metal building construction industry for more than 40 years. The popularity of these products has dramatically increased in recent years due to their wide range of application, economy, and ease of fabrication, and high strength-to weight ratios. In market various shapes of these products are available C-sections are predominantly used in light load and medium span situations such as roof systems.

2. SURVEY FROM THE LITERATURES

An experimental investigation was conducted to study the behavior of built-up cold-formed steel studs and to assess the current design provisions of the North American Specification for the Design of Cold-Formed Steel Structural Members. The built-up studs in this study consisted of two C-sections oriented back-to-back forming an I-shaped cross-section. It was concluded that for thicker materials the modified slenderness ratio is not necessary when computing axial capacity, and therefore the designer can use the actual slenderness ratio of the built-up member. The existing design specifications pertaining to the modified slenderness ratio may be on the average conservative when designing thinner members

3 SPECIMEN SPECIFICATIONS

The dimensions of the proposed sections are selected based on the North American Specification for design of cold – formed steel structural member. Fig below shows the limitations in geometry of lipped channel section.

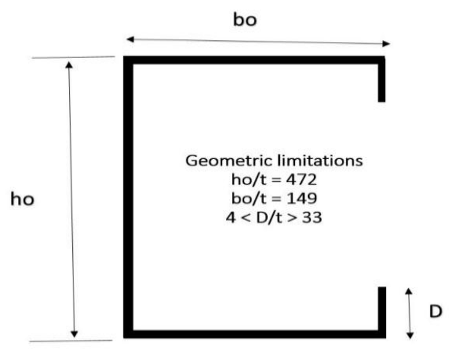


Figure 1 Geometric limitations

3.1 Details of specimen

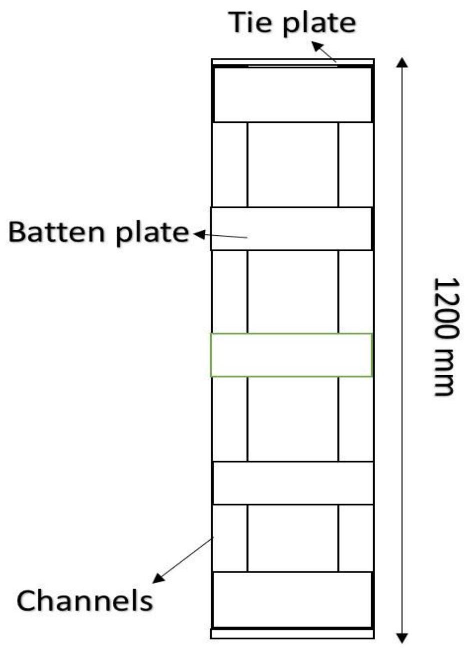
The dimensional properties for selected specimens are represented in Table 1 below.

Table 1 Dimensional properties of the specimens

Column ID	BC1	BC2	BC3	BC4
Thickness-t (mm)	1.6	1.6	2	2
Web-h_o (mm)	80	160	80	160
Flange b_o(mm)	30	60	30	60
Lip-d1(mm)	15	15	15	15
Spacing-s (mm)	30	55	30	55

The moment of inertia of major axis and minor axis are made equal by maintaining the corresponding spacing between the channels. Figure 2 shows the typical elevation and cross section of the column. The depth of batten plates and numbers has been chosen in such a way that the effective buckling length (L_z) about the minor axis of a single channel section varies from 150 to 400 mm.

The breadth of the batten plates was chosen such that the minimum overlap of battens on the flanges of the channel is satisfied. The specimens were labelled such that the specimen details could be identified from the label, as an example, the label "BC1-270" defines the specimen as shown in Figure 3.



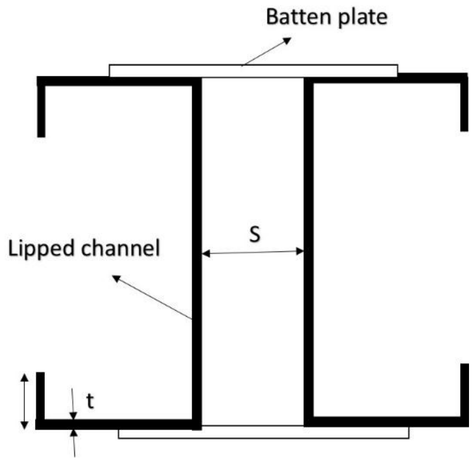


Figure 2: Typical elevation and cross section of the column

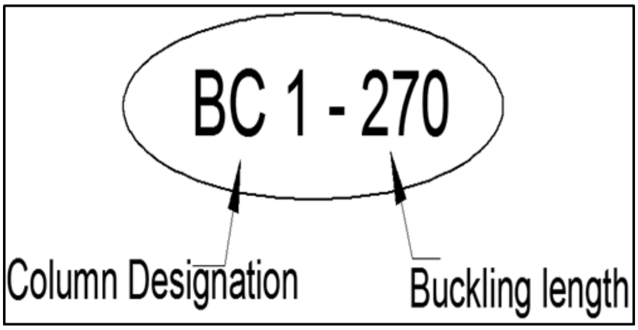


Figure 3 Specimen Labelling

4. NUMERICAL ANALYSIS

The numerical models were created using ANSYS software, which was also used to evaluate the ultimate capacity of pinned-ended cold-formed lipped channel built-up battened columns. The model was based on the sketch line dimensions of the cross-sections together with the base metal thickness. The residual stresses and the rounded corners of the channel sections were not included in the model. The numerical modelling involves linear and non-linear analysis. In the linear analysis, the sections were considered to have a perfect geometry in order to determine the probable buckling behaviour to examine the ultimate load and failure modes of the column.

4.1 Model Creation

The model was created using Geometry module in ANSYS software. Figure 4 shows the typical model generation of specimen BC1-270

4.2 End Conditions

The FEM simulation is carried out by making the boundaries as pinned with warping fixed ends. The modelling of pinned with warping fixed-ended boundary conditions were adopted by restraining the translational degree of freedom in the three directions x, y and z and also rotation along z-axis at the bottom end, whereas at the top, translation in x and y directions and rotation concerning z-axis were restrained. This is due to the load applied at the top end of the column.

4.3 Mesh generation

The mesh was generated using program controlled mesher. Figure 4 shows the typical mesh generation of a specimen in ANSYS.

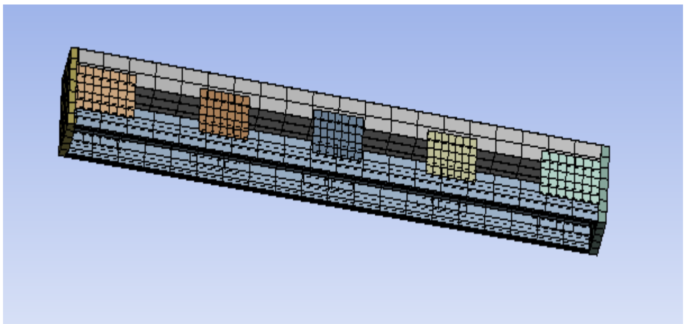


Figure 4 Typical mesh generation of a specimen

4.4 Application of load

Geometric Selection in ANSYS software was used for applying load to the column. At the top, axial compressive load is applied in the face of the end plate and it is distributed uniformly throughout the ends of specimen. The loading was applied with five numbers of steps to feed tabular data to get load deformation curve.

4.5 Linear analysis

Linear analyses (Elastic buckling analyses) has been carried out first to identify the critical load and its corresponding buckling modes. It is performed by keeping the stiffness of the structure remained unchanged and varying the density, Young's modulus and Poisson's ratio of the materials.

4.6 Non-linear analysis

Non-linear analysis has been performed by taking the values of multilinear isotropic hardening property of the material in ANSYS software. Minimum and maximum of 8 and 20 subsets has been provided for analysis respectively. The non-linear controls were changed to the Program controlled activity.

4.7 FEM Results

The following figures shows the Buckling modes, von-Mises stress, axial deformation and Load vs Deflection curves of the specimens.

4.7.1 Specimen BC1-150

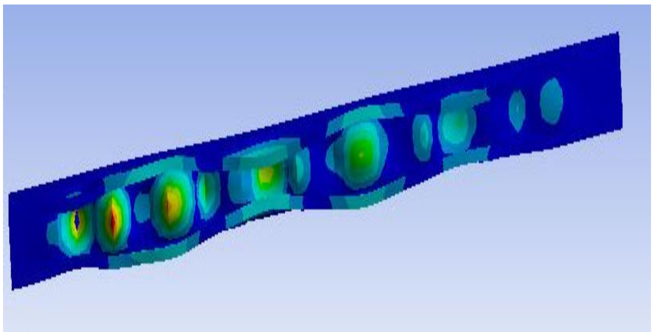


Figure 5 Failure mode of specimen BC1-150

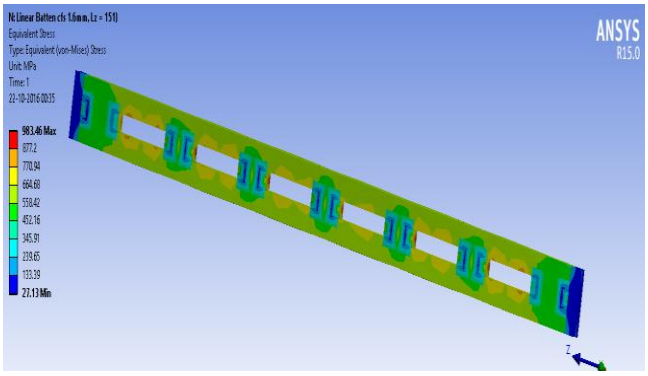


Figure 6 von-Mises stress of specimen BC1-150

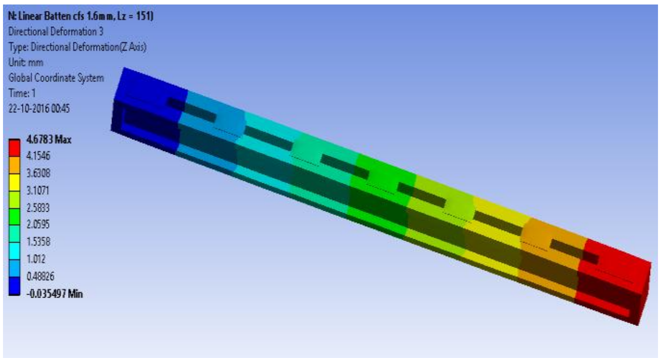


Figure 7 Axial Deformation of specimen BC1-150

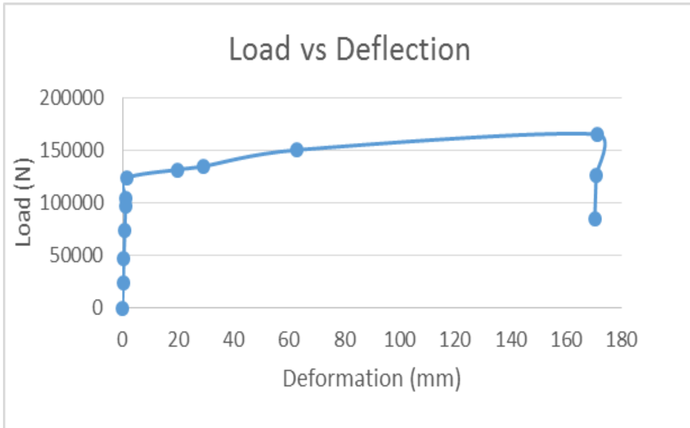


Figure 8 Load vs Deflection curve of BC1-150

4.7.2 Specimen BC2-200

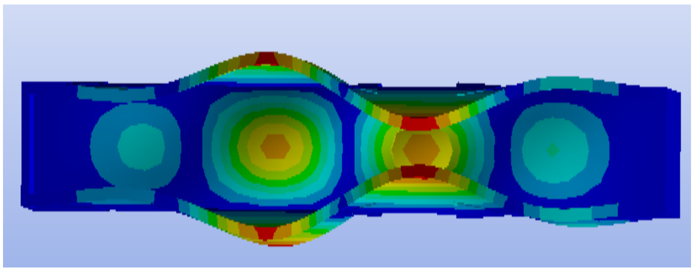


Figure 9 Failure mode of specimen BC2-200

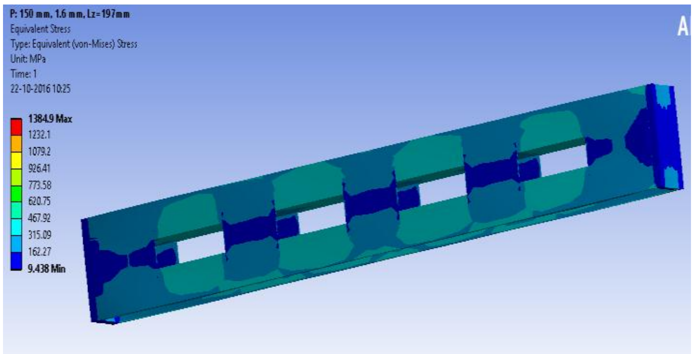


Figure 10 von-Mises stress of specimen BC2-200

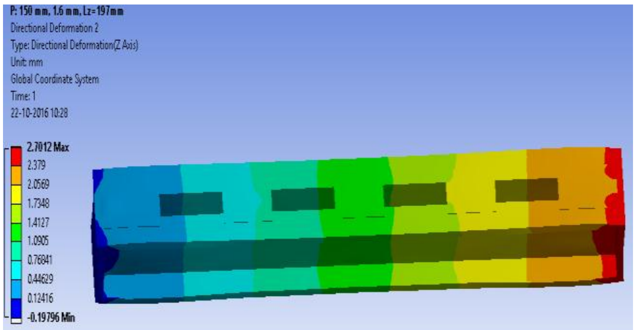


Figure 11 Axial Deformation of specimen BC2-200

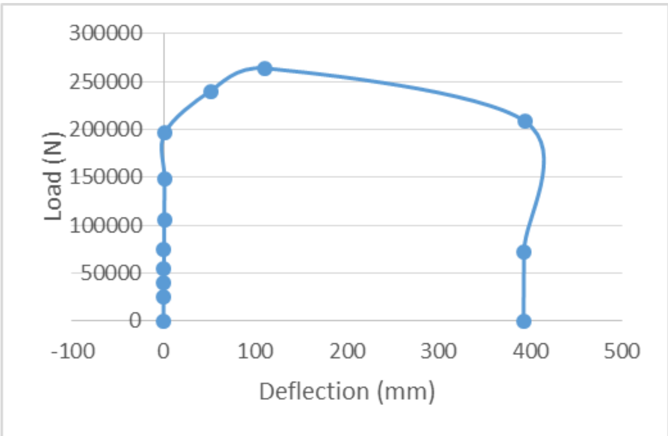


Figure 12 Load vs Deflection curve of BC2-200

4.7.3 SPECIMEN BC3-150

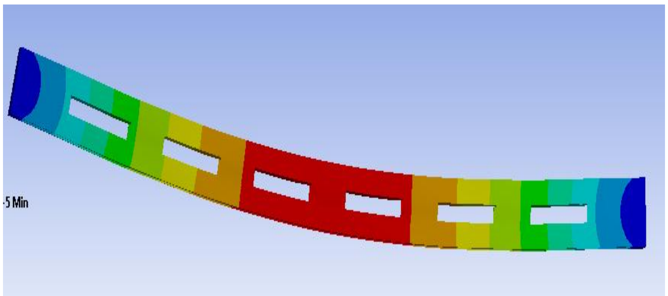


Figure 13 Failure mode of BC3-150

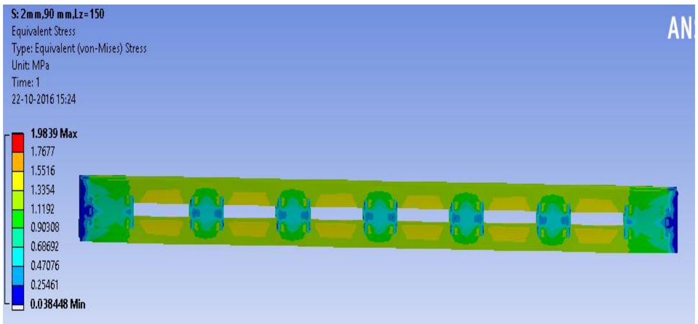


Figure 14 von-Mises stress of BC3-150

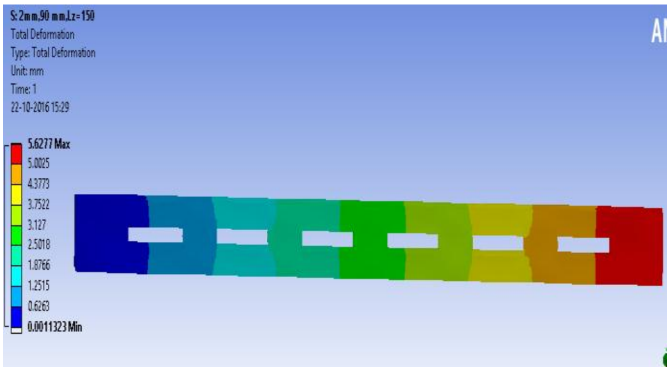


Figure 15 Axial Deformation of specimen BC3-150

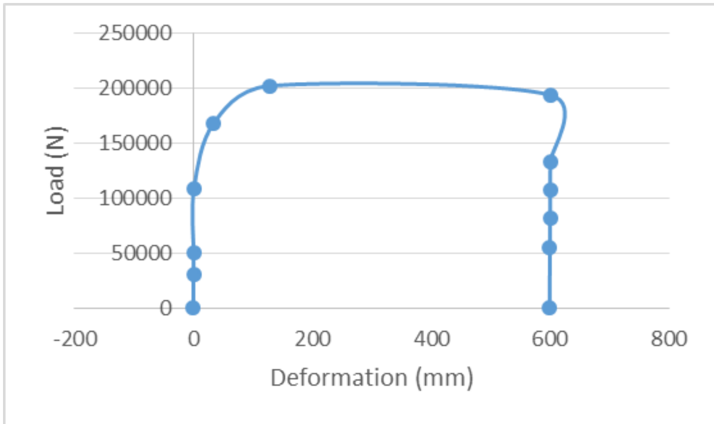


Figure 16 Load vs Deflection of BC3-150

5 RESULTS FROM THE ANALYSIS

The failure modes of the columns sections have been identified from the mode shapes given by ANSYS software. Table 2 shows the failure modes of the specimens.

Table 2 Failure modes of specimens

SPECIMEN	FAILURE MODE
BC1-150	L + D
BC2-200	L + D
BC3-150	L + D + F

5.1 Load Carrying Capacity

The load carrying capacity of the specimens has been found from the load deflection curve. Table 3 shows the load carrying capacity of the analysed specimens.

Table 3 Load carrying capacity of the specimens

SPECIMEN	LOAD CARRYING CAPACITY (kN)
BC1-150	165
BC2-200	272
BC3-150	208

6. CONCLUSION

The behavior of the cold formed steel built up battened columns have been studied numerically using FEM software ANSYS. The specimens were tried with different thickness of 1.6 and 2.0 mm. The load carrying capacity has been found from the load vs deflection curve. It has been found the load carrying capacity of the battened column is more when compared with normal built up column. Further the sections will be analysed by varying the number of battens and the load carrying capacity of the columns will be investigated experimentally and theoretically.

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