Experimental Investigation of Eccentrically Loaded Cold-Formed Steel Built-Up Columns

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Abstract— This paper deals with the study of behaviour of cold-formed steel built-up columns both experimentally and numerically. An attempt has been made in this study to check the maximum load carrying capacity of cold-formed steel channel section connected face to face using lacings subjected to eccentric loading. The channel sections are placed at different spacing varying from 25mm to 50mm and the effect of spacing in the load carrying capacity were studied. The present study also aims to check the failure pattern at the maximum load bearing capacity of the built-up columns.

Key words: Cold-formed steel built-up columns, lacing connection, buckling behaviour, experimentally

I. Introduction

Cold-formed steel structures are widely used in the construction of buildings other than their usage in car bodies, railway coaches, transmission towers, transmission poles, drainage facilities and bridge construction. Cold-formed sections are relatively used for carrying lighter loads or short span members. Unusual shapes can be manufactured through which favourable strength-to-weight ratios can be obtained. Load carrying panels and decks can be used for roof, floor and wall construction which are capable of withstanding not only the normal loads but also the transverse shear loads. The depth of the cold-formed framing members used in construction usually range from 51mm to 305mm. The thickness of these material range from 1.22 mm to 6.35 mm. Sometimes the thickness may even go up to 12.7 mm. The cold-formed plate sections of thickness of 19 mm to 24 mm can be used as primary framing members in buildings up to six stories height. The cold-formed sections are manufactured using three methods. 1. Cold Roll forming, in which the steel is rolled in to sheets using pairs of rolls. This method is widely used for the production of building components. 2. Press brake, in which sections like angles, channels and Z-sections are made by pressing the sheet over the dyes prepared for a particular section. 3. Bending brake operation. This paper deals with the experimental and numerical investigation of cold-

formed steel built-up columns with channel sections connection in face-to-face position using lacings. The maximum load carrying capacity and their failure pattern were observed for varied spacing between the channel sections.

II. Literature review

The past works in the area of cold-formed steel built-up columns include the testing of columns with channel sections in back-to-back position with battens as connecting elements (1) (2), testing of various shapes like channel sections and Z sections with stiffeners (3) (6), testing of built-up columns with both welded and bolted connections (4), and experimental investigation of hot-rolled steel with laced connections (5). The comparisons were made between the maximum load bearing capacity of various specimens.

III. Specimen fabrication

In this experimental investigation a total of six specimens were investigated. All the six specimen are placed in face-to-face position with lacings as lateral system. The dimensions and the slenderness ratio of all the six specimens are given below.

SPECIMEN NAME	SLENDERNESS RATIO	LENGTH (mm)
2C60x2-25	63.45	1250
2C60x2-50	63.45	1250
2C80x2-25	47.5	1250
2C80x2-50	47.5	1250
2C100x2-25	45.45	1500
2C100x2-50	45.45	1500

Table 1: Slenderness ratio and dimensions

In the above table the name indicate two square channel sections of same dimensions connected together by lacings with a spacing of 25mm and 50mm. For e.g., the specimen 2C60x2-25 indicates the built-up column with two square channel sections of 60x60x2mm dimension with a spacing of 25mm between them. The slenderness ratio was limited between 45 and 65. The specimens of channel section 60 mm and 80 mm were provided a length of 1250 mm while the 100 mm specimens were provided with a height of 1500 mm. The lacings for the columns were made from the same material of the column. The lacings were welded to the channel sections. The width of the lacings was taken as 50 mm. The end plates were provided at the top and bottom of the columns which were also given a width of 50 mm. An image of the specimens before testing is shown below.

Fig. 1: Specimens of different dimensions after fabrication

IV. Experimental Set-up

The specimens were tested in a column testing frame with a capacity of 50 tonnes. The specimen was placed above the loading jack. The top end was given pinned condition and the bottom end was fixed. The loading was given eccentrically at a distance of 25 mm from the centre of the specimen at the top. The eccentric load was given using a circular rod attached to a plate. All the specimens were welded with plates at the top and bottom in order to distribute the load applied. The size of the plates depended on the dimension of the specimen and the thickness was 8 mm. LVDTs and deflectometers were used to measure the deflection at the bottom, 1/3rd height from bottom and at the midpoint of the column. The experimental set-up of a specimen is shown below.

Fig. 2: Experimental set-up in laboratory

V. Observation and Results

The testing was carried out on each specimen and the ultimate load of each specimen was recorded along with the deflections. Using the ultimate load and the corresponding deflection of each specimen graphs were plotted. The graphs showing load vs. deflection curve for all specimens is given below.

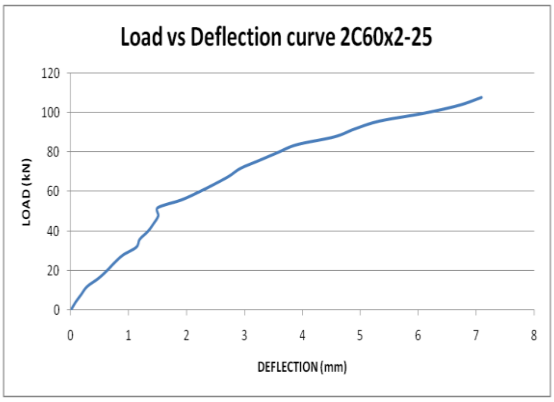

Fig. 3: Load vs. Deflection curve of 2C60x2-25

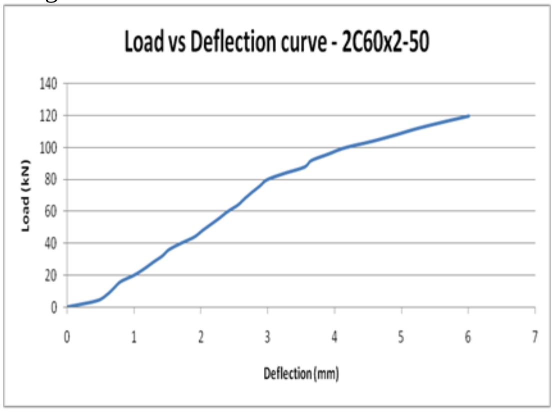

Fig. 4: Load vs. Deflection curve of 2C60x2-50

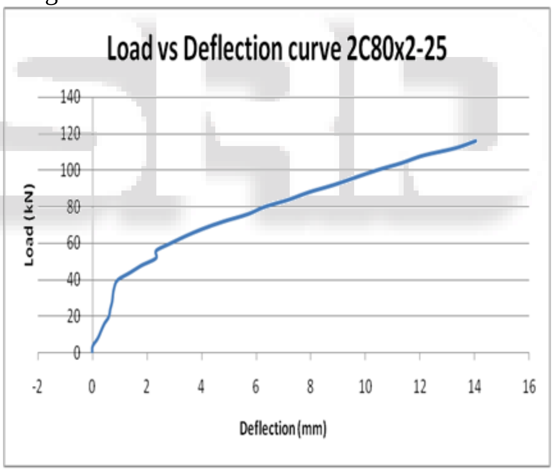

Fig. 5: Load vs. Deflection curve of 2C80x2-25

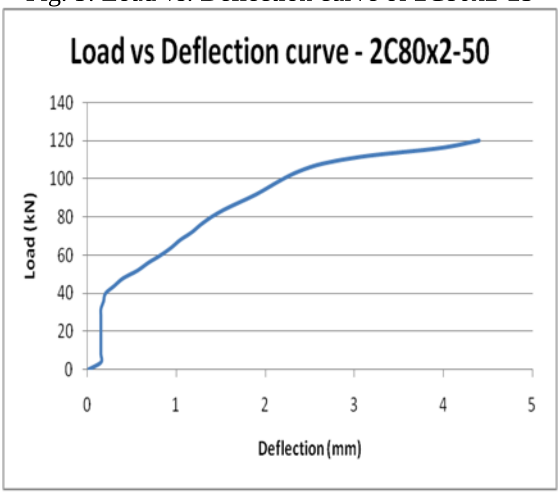

Fig. 6: Load vs. Deflection curve of 2C80x2-50

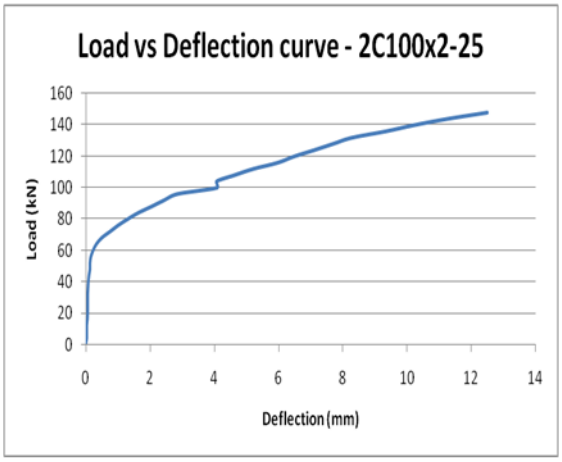

Fig. 7: Load vs. Deflection curve of 2C100x2-25

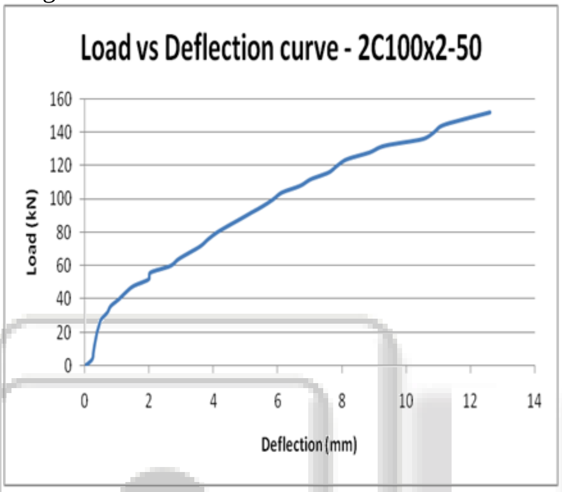

Fig. 8: Load vs. Deflection curve of 2C100x2-50

The overall deflection of the specimen varied between 6mm to 14mm. From the graph it was observed that as the spacing between the channel sections were increased the load bearing capacity of the specimen increased. The variations of load bearing capacity of the specimens are shown below

Specimen	Spacing (mm)	Load bearing capacity (kN)
60x60x2 Channel section	25	108
	50	120
80x80x2 Channel section	25	116
	50	120
100x100x2 Channel section	25	148
	50	152

Table 2: Maximum load bearing capacity of all specimens

A. Failure Pattern:

All the built-up columns showed a similar failure pattern. The top and bottom ends of the specimen buckled and were distorted. A prominent lateral bulge was obtained in the channel section below the point of eccentric loading. The end plate at the top and few lacings in the top were distorted from their position. A slight bending of the column was seen in the centre at the maximum load of each specimen. The failure patterns of the specimens are shown below.

Fig. 9(a), (b): Failure patterns of 2C80x2-25

Fig. 9 (b):

Fig. 10: Failure pattern of 2C80x2-50


Fig. 11: Failure pattern of 2C100x2-25

VI. Conclusion

The following conclusions were obtained from the experimental study,

1) The maximum load bearing capacity of the specimen with the same dimensions increases with the increase in spacing between the channel sections.
2) The 50 mm spaced specimens showed an increase in load carrying capacity of 3% to 11% when compared with 25 mm spaced specimens of the same dimension respectively.
3) The increase in load bearing capacity was due to the increase in the length of the lacings used for connection as the spacing was increased.
4) The failure pattern obtained was lateral bulging at the top and bottom end with a slight buckling throughout the specimen. Only the end plates and the lacings at the top were affected. Due to eccentric loading the channel section just below the point of loading showed more bulging and the column buckled along the direction of the same channel section.

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