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COMPARISON STUDY ON LATERAL LOADING BEHAVIOR OF COLD FORM STEEL COLUMNS AND HOT ROLLED STEEL COLUMNS

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Abstract: Cold-formed steel columns are increasingly applied in engineering recently. This study focusses on the performance evaluation of two limbed built-up cold-formed steel (CFS) columns under lateral loading. Specimens of built-up columns were fabricated into two limbed and three limbed rectangular columns. Two nonlinear finite element (FE) models were modelled for two limbed and three limbed columns each and its behavior under lateral loading was observed. Tests were conducted for two different values of slenderness. Later hot rolled steel columns were modelled using ISMB100 with different slendernesses. The load carrying capacity of cold form steel (CFS) columns were compared with hot rolled steel (HRS) columns.

***Index Terms* - Built up box sections, Cold Form Steel (CFS), Finite element modelling, Hot Rolled Steel (HRS), Lateral Loading**

1.INTRODUCTION

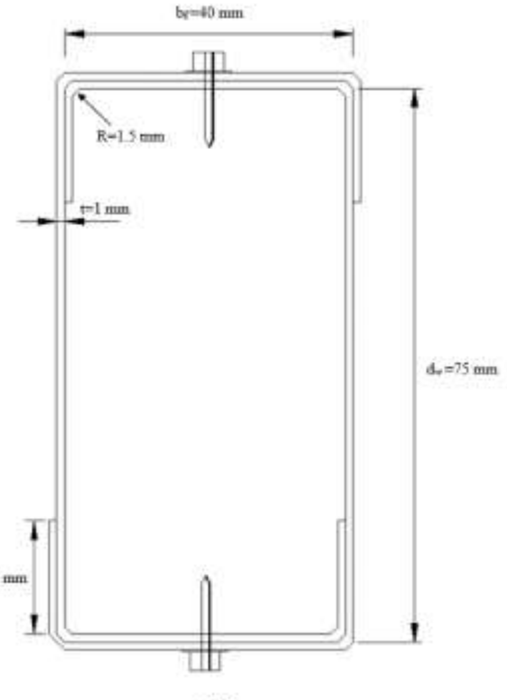
The use of Cold-Formed Steel systems has significantly increased all over world where traditional structural practices have been dominating the construction sector. CFS goods are created by the working on thin steel sheets using stamping, rolling or presses to deform the steel sheets into required product which are usable. The manufacturing of CFS products can be done at the room temperature with the use of rolling/pressing. The yield strength and ultimate strength of the steel section which is formed by cold pressing are increased. In comparison to the hot rolled section with the cold rolled sections, CFS have more moment of inertia, stability, section modulus, therefore the load carrying capacity and moment resisting capacity are higher.

A journal by Krishanu Roy et al. [8] presented an experimental investigation on Experimental and numerical investigations on the axial capacity of cold-formed steel built-up box sections. In this literature axial load carrying capacity of built up box sections and channel sections were conducted and the results were observed. The dimensions of a box section from this journal is used in this paper and is made in to two limbed and three limbed columns.

Lateral loading was done on the built up multiple limbed columns. The load bearing capacity of cold form steel columns are then compared with hot rolled steel columns.

2. SPECIMEN DESIGN

The columns used for analysis are made up of either two limbed or three limbed box sections. Multilimbed models were used so that it can improve the stiffness of the columns; since cold form steel sections are very light in weight as well as the columns modelled were hollow. The built-up box sections are formed by two identical lipped channels connected at their flanges with screws. These built up box sections are further joined using screws and made in to two limbed or three limbed structures. For a single built up box section total length of flange ($\boldsymbol{bf}$)is 40 mm. Total depth of the web ($\boldsymbol{dw}$) is 75 mm. The total width of the lip (C) is 15mm and the nominal thickness of the channel section (t) is 1mm. These built up sections were connected and made into two limbed and three limbed structures based on their symmetry using bolt embedments. Two box sections were connected to form two limbed columns and three box sections were connected to form three limbed columns. The built-up columns were subdivided into two different column heights: short columns of 0.5 m height and slender columns of 1.5 m height.



(a) B75

Fig-1: Geometrical Cross Section of a Single Box Section [8]

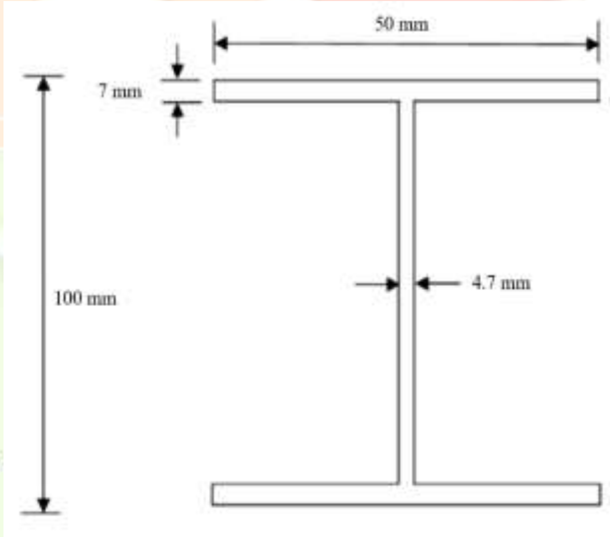


Fig-2: Geometrical Cross Section of I Section

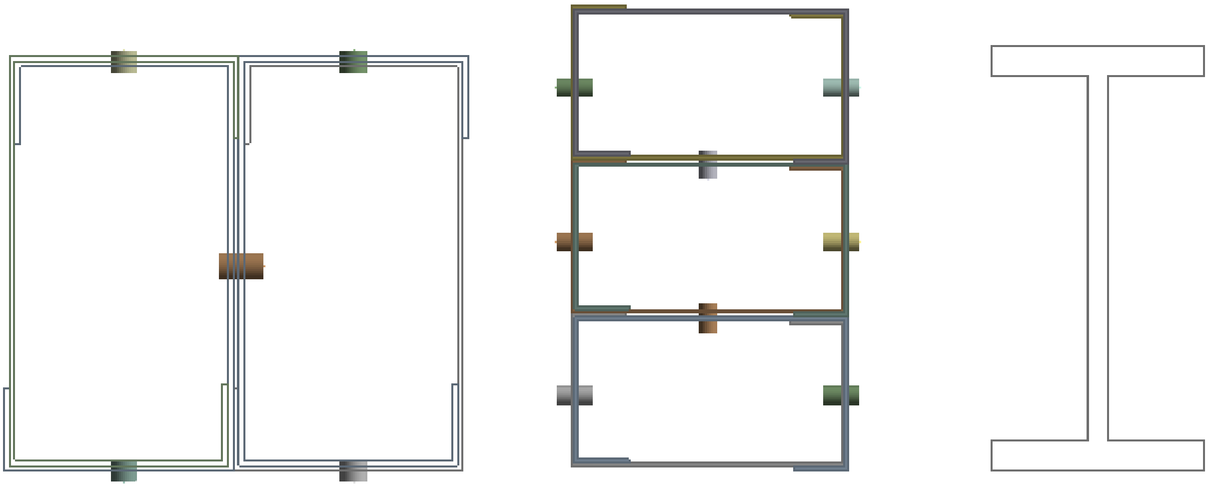
Mild steel columns were used as conventional columns. ISMB 100 sections were made so as to compare with CFS models on the basis of lateral loading capacity. These columns were made in two heights similar to CFS columns which are 500 mm and 1500 mm. ISMB 100 sections were made with depth of column (D) as 100 mm, flange thickness (B) as 50 mm, thickness of flange (T) as 7 mm and thickness of web (t) as 4.7 mm.

2.1 Specimen Labelling

CFS represents cold form steel sections. BS represents built up section. 2L or 3L indicates two limbed or three limbed sections. LL in sections indicates that the section is subjected to lateral loading. RECT, T or L represents the shape of the cross section of the column. The numbers 500 and 1500 represents the height of the column.

3 MODELLING

The ANSYS 16.1 software was used to model all the specimens for nonlinear analysis. The models were connected using bolt embedments. Fastener size of 5 mm was used at a longitudinal screw spacing of 100 mm. All columns were loaded under displacement control. Pin-pin boundary condition was applied to the finite element models. Lateral loading of columns was done in the x-axis.



(a) (b) (c)

Fig-3: Geometrical Cross Sections of (a) 2 Limbed columns, (b) 3 Limbed columns, (c) I section

4 RESULTS AND DISCUSSIONS

There are two specimens each for two limbed as well as three limbed structures which are designed as cold form steel structures. Models were designed in rectangular cross sections. Each model varies in its height. Lateral loading was done on these columns further finding total deformation and force reaction for each model. Results are obtained after analysis and graphs are plotted.

HRS columns were made so as to compare with the CFS sections. Three specimens of ISMB 100 are made in the same slendernesses of CFS specimens. The specimens were axially loaded. The load bearing capacity of two limbed and three limbed CFS columns were compared for corresponding height of the HRS columns.

4.1 Two Limbed Columns

Models are made using two identical limbs. Two columns of two different heights were designed and its behaviour under lateral loading was studied.

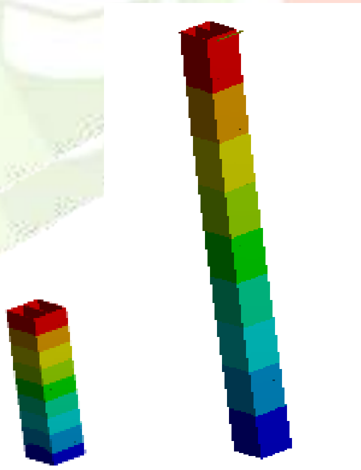


Fig-3: Geometrical Cross Sections of 2 Limbed columns

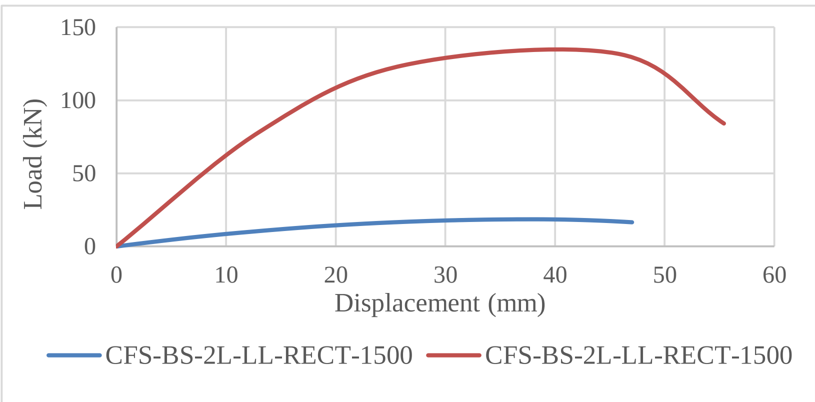


Chart -1: Load Deflection curve for 2 Limbed Columns

The column CFS-BS-2L-LL-RECT-500 having 500 mm height performs far better than the model CFS-BS-2L-LL-RECT-1500.

4.2 Three Limbed Columns

Models are made using three identical limbs. Two columns of two different heights were designed and its behaviour under lateral loading was studied.

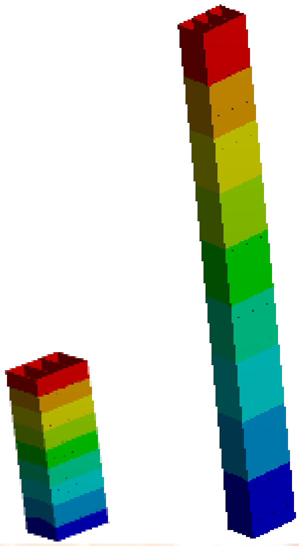


Fig-3: Geometrical Cross Sections of 3 Limbed columns

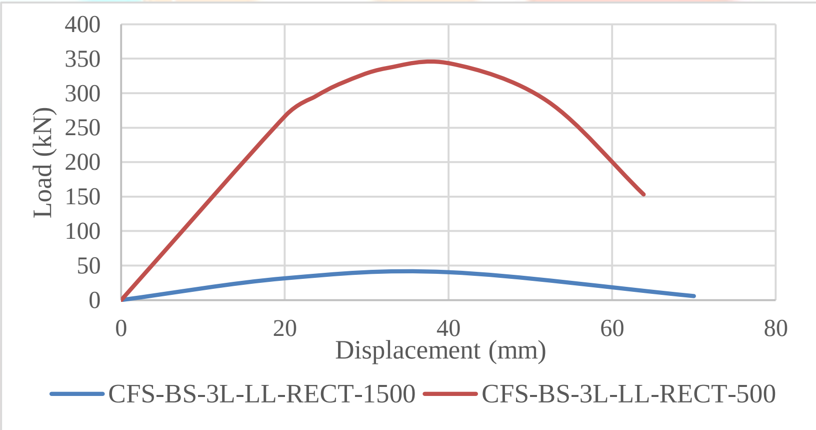


Chart -2: Load Deflection curve for 3 Limbed Columns

The column CFS-BS-3L-LL-RECT-500 having 500 mm height performs far better than the model CFS-BS-3L-LL-RECT-1500.

4.3 I Section Columns

Models are made using ISMB 100.

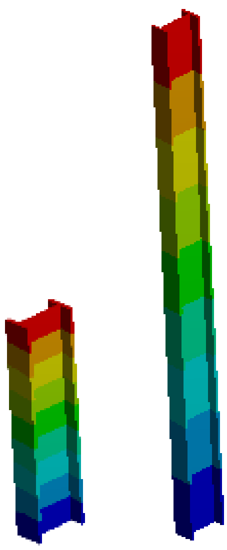


Fig-3: Geometrical Cross Sections of I Section columns

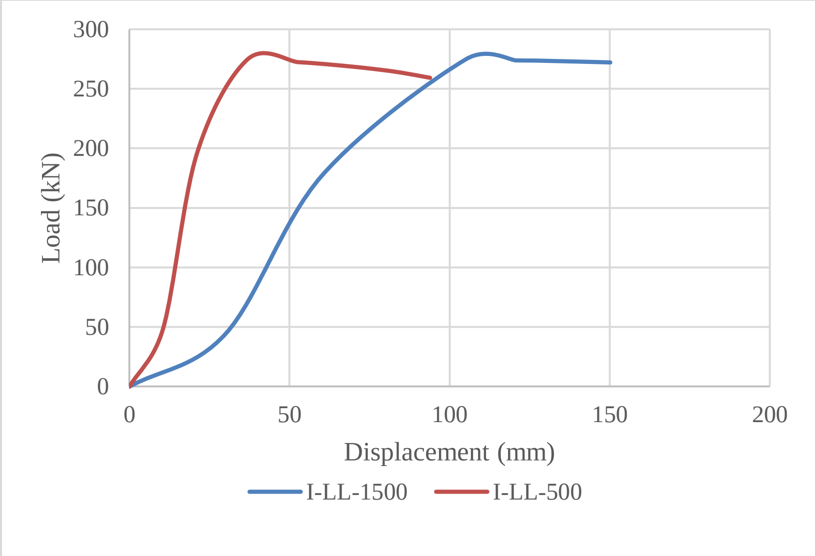


Chart -3: Load Deflection curve for I Section Columns

The columns I-LL-500 and I-LL-1500 carries almost similar ultimate load but the value of deflection both columns undergo is very different. The columns having 1500 mm height deforms to a greater extent when comparing to the other column.

4.4 Comparison Study of Columns

A comparison study of load bearing capacity of all the cold form steel columns and hot rolled steel columns for different heights were done and graphs of columns are drawn.

Table -1: Lateral Loading

SPECIMEN	ULTIMATE LOAD (kN)	ULTIMATE DEFLECTION (mm)	STIFFNESS (kN/mm)
CFS-BS-2L-RECT-500	132.02	45.62	2.89
CFS-BS-2L-RECT-1500	18.566	38.24	0.49
CFS-BS-3L- RECT-500	342.8	40.272	8.51
CFS-BS-3L- RECT-1500	40.245	40.017	1.01
I-500	274.76	38.86	7.07
I-1500	274.67	105.08	2.61

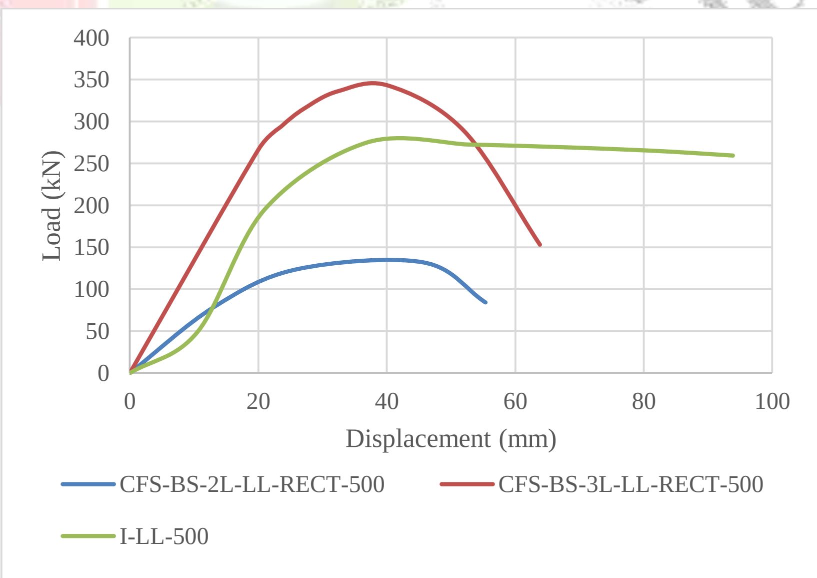


Chart -4: Load Deflection curve for Columns of height 500 mm

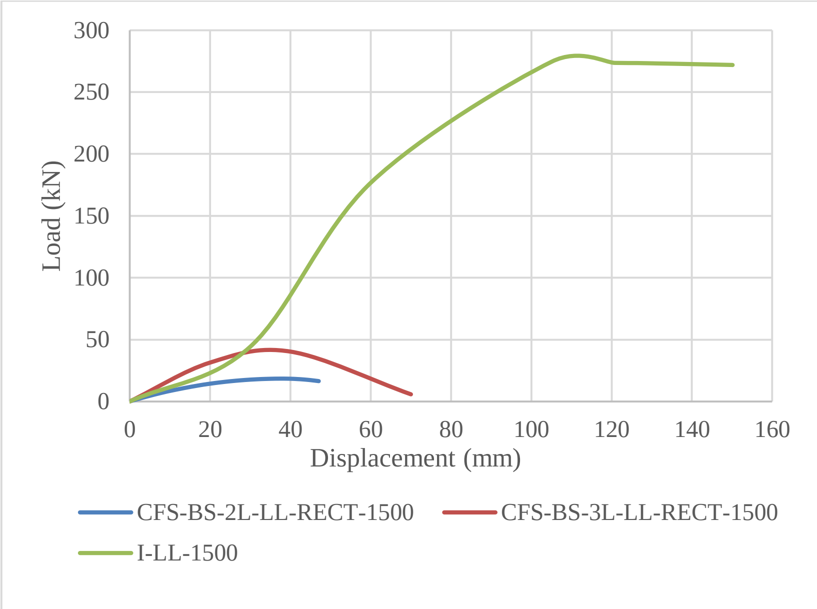


Chart -5: Load Deflection curve for Columns of height 1500 mm

For 500 mm sections, CFS-BS-3L- RECT-500 withstand maximum lateral loading which is in fact the model which take maximum load out of all sections undergoing lateral loading. This column also has the maximum stiffness. CFS-BS-2L-RECT-500 takes lowest amount of load out of all 500 mm sections.

For 1500 m sections, I-1500 takes the maximum load which is far greater than all other members with 1500 mm height. It also has the highest stiffness value. It can take the same amount of ultimate load that the 500 mm columns can take.

5 CONCLUSIONS

From the analysis of comparing the lateral loading capacity of cold form steel sections over hot rolled steel sections, the sections show wide range of difference in terms of load bearing capacity. For 500 mm columns, Cold Form Steel columns withstand maximum lateral load and has a good stiffness value. In case of 1500 mm columns, Hot Rolled Steel columns withstand maximum load and also has the highest amount of stiffness. From the above analysis, by modelling different columns with different number of limbs, it is observed that the load bearing capacity increases when the number of limbs increases. It is also evident that as the number of limbs increases, stiffness value of columns also increases. For smaller heights cold form steel performs almost similar to hot rolled steel columns. However, if we require to build the columns having low weight, we can opt cold form steel as cold form steel columns are very much lighter than hot rolled steel columns.

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