COMPUSOFT, An international journal of advanced computer technology, 6 (7), July-2017 (Volume-VI, Issue-VII)

ISSN:2320-0790

An International Journal of Advanced Computer Technology

# AN EXPERIMENTAL STUDY ON DISTORTIONAL BUCKLING STRENGTH OF THE COLD FORMED STEEL COLUMNS WITH INWARD LIP

**V.YOGESHWARAN, M.BOOPATHI and J.SRISINDHU**
Department of Civil Engineering, Rathinam Technical Campus, Eachanari,
Coimbatore – 21

Abstract: The aim of this study is the distortional buckling strength of open thin walled cold formed steel column with inward lip under axially compression with hinged end condition. This study gives a very wide knowledge about the cold formed steel necessity & its requirement in various applications in different fields. It also gives the knowledge about the various modes of failures of cold formed steel members, like local buckling, distortional buckling and flexural - torsional buckling. To study the distortional buckling of the open thin walled section, the section made partially closed by providing spacers which connects the lip of open section at different intervals. Four specimens were fabricated with the uniform thickness of 1.6 mm having a yield stress of 350 Mpa. One control specimen i.e. without spacers and other three specimens with spacers by varying the numbers were tested. The spacers are connected to the column by self-tapping screws.

Keywords: Keywords: strength, forming, cold working and strength of material.

## 1. Introduction

Thin-walled cold-formed steels are widely used in many branches of mechanical industry and civil engineering. Recently, an increasing interest for improving these profiles with regard to their shapes and manufacturing can be noticed. The primary advantages of cold-formed steel are light weight, high strength and stiffness, uniform quality, ease of prefabrication and mass production, economy in transportation and handling, fast and easy erection and installation, its flexibility in forming different cross-section shapes. However, this flexibility makes the selection of the most economical section difficult for a particular situation. Cold-formed steel structural members may lead to an economic design than hot-rolled members because of their superior strength to weight ratio and ease of construction. In particular, light gauge cold-formed channels are commonly used as wall studs and chord members of roof trusses in steel frame housing and industrial buildings. One of the advantages of cold-formed steels is that the strength to weight ratio is much higher than that of common hot-rolled shapes, thus it reduce the total weight of structures. Therefore the cold-formed steel members are considered to be economical for low-rise buildings

## 2. MATERIALS AND METHODS

**Cold formed steel** - In building construction, there are primarily two types of structural steel: hot-rolled steel shapes and cold-formed steel shapes. The hot-rolled steel shapes are formed at elevated temperatures while the cold-formed steel shapes are formed at room temperature. Cold-formed steel structural members are shapes commonly manufactured from steel plate, sheet or strip material. The manufacturing process involves forming the material by either press-braking or cold roll-forming to achieve the desired shape.

**Methods of forming - a) Cold roll forming**
The method of cold roll forming has been widely used for the production of buckling components such as individual structural members and some roof, floor, and wall panels and corrugated sheets.


Fig.1 – Cold roll forming

Sections made from strips up to 36 in. (915 mm) wide and from coils more than 3000 ft. (915 m) long can be produced most economically by cold roll forming. The machine used in cold roll forming consists of pairs of rolls which progressively from strips into the final required shapes. A simple section may be produced by a few as six pairs of rolls. However, a complex section may require as many as 15 sets of rolls. Roll set up time may be several days. The speed of the rolling process ranges from 20 to 300 ft. /min (6 to 92 m/min). The usual speed is in the range of 75 to 150 ft. /min (23 to 46 m/min). At the finish end, the completed section is usually cut to required lengths by an automatic cutoff tool without stopping the machine. Maximum cut lengths usually between 20 and 40 ft. (6 and 12 m). As far as the limitations for thickness of material are concerned, carbon steel plate as thick as ¾ in. (19mm) can be roll formed successfully and stainless steels have been roll-formed in thicknesses of 0.006 to 0.30 in. (0.2 to 7.6 mm)

**b) Press breaks forming**

The press brake operation may be used under the following conditions: The section is of simple configuration, the required quantity is less than about 300 linear ft. / min (91.5 m / min), The section to be produced is relatively wide [usually more than 18 in (457mm)] such as roof sheets and decking units. The equipment used in the press brake operation consists essentially of a moving top beam and a stationary bottom bed on which the dies applicable to the particular required product are mounted. Simple sections such as angles, channels and Z-sections are formed by press brake operation from sheet, strip, plate, or bar in not more than two operations. More complicated sections may take

Table1. Section properties

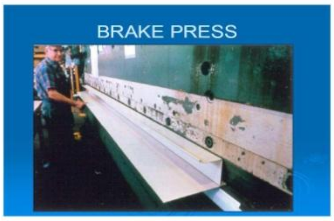



Fig. 2 – Press break forming

## ANALYSIS OF OPEN THIN WALLED COLUMN

CUFSM is software which is used to do the elastic buckling analysis for a section. From this analysis the length of the specimen was selected based on the buckling plot. The section properties are also obtained by using CUFSM.

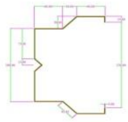


Fig 3. Sectional view of column

**Input in CUFSM**

The specimen details like node points were given to the CUFSM as shown in the following CUFSM window.

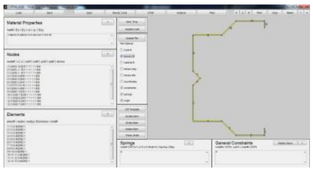


Fig 4. Input window in CUFSM

**Geometric Properties**

After the input, the section properties were obtained by using the CUFSM.

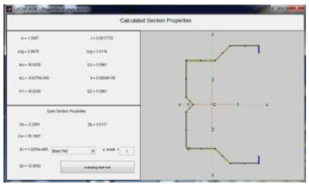
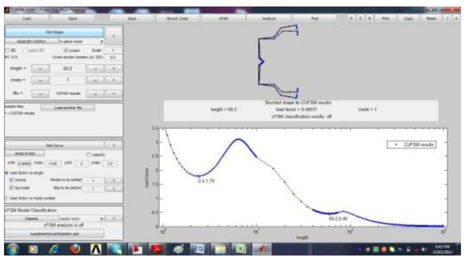


Fig 5: Section properties

The CUFSM software is American unit based software which gives, the corresponding values in SI unit system is for section properties given in Table.1

**Buckling plot:**

The buckling plot i.e. curve obtained by plotting half wavelength and load factor is obtained from CUFDM by performing elastic buckling analysis. A curve obtained showing local & distortional buckling is shown in Fig 6 and 7 respectively.



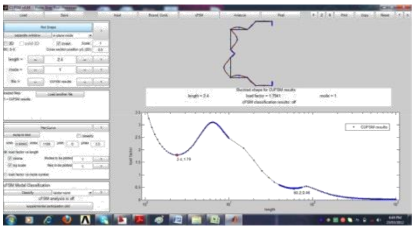


Fig 7. Distortional Buckling

Hence from the buckling plot the length of the specimen is chosen in such a way that the major mode of failure will be distortional buckling. Hence, for the project work the length of the specimen is taken as 1600 mm after performing elastic buckling analysis.

**Experimental Investigation:**

Totally four specimens were fabricated with intermediate web stiffener with uniform thickness of 1.6 mm. The experiment is carried out using 100T capacity loading set up. This program involves fabrication and testing of 4 specimens. The details of the specimens are as follows.

``CONTROL SPECIMEN- CFS-C-1-S-0

| Sl. No. | Property | Notation | Value | Unit |
|---|---|---|---|---|
| 1 | Gross area of the section | A | 864.966 | $mm^2$ |
| 2 | Moment of inertia about XX axis | Ixx | $7.01x10^6$ | $mm^4$ |
| 3 | Moment of inertia about YY axis | Iyy | $2.43 x10^6$ | $mm^4$ |
| 4 | St. venant's torsion constant | J | 738.103 | $mm^4$ |
| 5 | Yield stress of material | $f_y$ | 248 | $N/mm^2$ |
| 6 | Warping constant | Iw | $9.02 x10^9$ | $mm^6$ |
| 7 | Radius of gyration about XX axis | $r_x$ | 90.00 | mm |
| 8 | Radius of gyration about YY axis | ry | 53.01 | mm |
| 9 | Centre of gravity about "xx" axis | Xcg | 51.397 | mm |
| 10 | Shear centre about "xx" axis | Xs | 61.768 | mm |

SPECIMEN WITH 1 SPACERS- CFS-C-1-S-1

SPECIMEN WITH 2 SPACER- CFS-C-1-S-2

SPECIMEN WITH 3 SPACERS- CFS-C-1-S-3

Where,
CFS- Cold Formed Steel, C-Column, S-Spacers

The experimental arrangement is as shown in the following fig 8. A 500 KN capacity loading Hydraulic Jack and 100 Ton capacity Toad Cell are used to test all the specimens. The load is applied at the centroid of the column. The deflection in the X and Z direction and the axial deformation in Y direction are measured by using deflectometers.

Fig 8. Specimen before testing

Fig 9. Experimental Setup

Fig 10. Position of deflectometer

**RESULTS AND DISCUSSION**

**Specimen 1 - control specimen - CFS-C-1-S-0:**

The specimen was placed in the setup and the load was given gradually with the help of 500 KN hydraulic jack. The ultimate load carrying capacity was found to be 134 KN and the mode of failure was flexural torsional buckling as shown in figure.11. Local buckling occurred at the lip 280 mm above from the bottom. Local buckling occurred at the top web 60 mm below from the top. The specimen started rotating at 132 KN.

Fig 11. Mode of Failure CFS-C-1-S-0

Fig 12. Local Buckling in the web

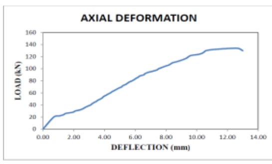


Fig 13. Load Vs Axial Deformation Graph for CFS-C-1-S-0

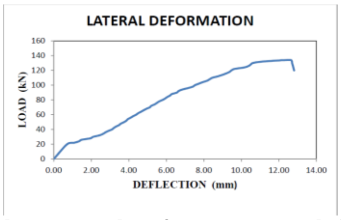



Fig 14.Load Vs Lateral Deformation Graph for CFS-C-1-S-0

**Specimen-2 - single spacer – CFS –C-1-S-1:**

The specimen was placed in the set up and the load was given gradually with the help of 500 KN hydraulic jack. The load carrying capacity was found to be 138 KN and the mode of failure was found to be as flexural-torsional buckling. . The top portion of the specimen buckled inwards at the height of 650 mm below from the Top support of the specimen. . The bottom portion of the specimen buckled outward at the height of 300 mm from the bottom support.

Fig 15. Failure mode of CFS-C-1-S-1

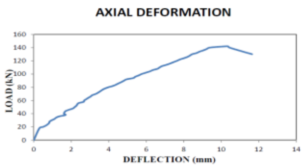



Fig 16. Load Vs Axial Deformation Graph for CFS-C-1-S-1

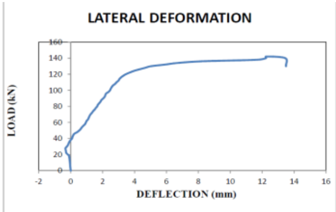



Fig 17. Load Vs Lateral Deformation Graph for CFS-C-1-S-1

**SPECIMEN-3 - Double spacer – CFS - C-1-S-2:**

The specimen was placed in the setup and the load was given gradually with the help of 500 KN hydraulic jack. The ultimate load carrying capacity was found to be 143 KN. The failure mode was distortional buckling there was no deformation in the spacer. The local buckling occurred in the lip at the height of 270 mm from the bottom support of the specimen.

Fig 18. Failure mode of CFS-C-1-S-2

Fig 19. Local buckling in the lip at the botto

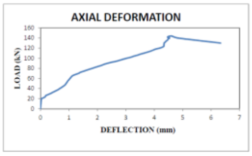



Fig.20 Load Vs Axial Deformation Graph For CFS-C-1-S-2

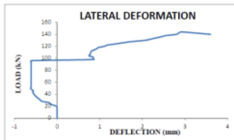



Fig.21 Load Vs Lateral Deformation Graph for CFS-C-1-S-2

**SPECIMEN-4 - three spacer -CFS-C-1-S-3:**

The specimen was placed in the set up and the load was given gradually with the help of 500 KN hydraulic jack. The ultimate load carrying capacity was found to be 148 KN. The failure mode was flexural-torsional buckling. The local buckling occurred in the lip at the height of 700 mm from the bottom support of the specimen. The local buckling occurred in the web of the specimen at the height of 30 mm below the top support of the specimen. The specimen rotated at the load of 140 KN. There was no deformation in the spacers.

Fig 22 Failure mode of CFS – C – 1 – S – 3

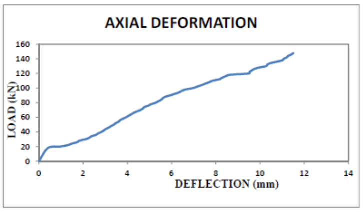


Fig 23 Load Vs Axial Deformation Graph For CFS-C-1-S-3

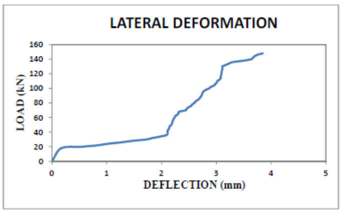



Fig.24 Load Vs Lateral Deformation Graph for CFS-C-1-S-3

Fig.25 Failure modes of specimens

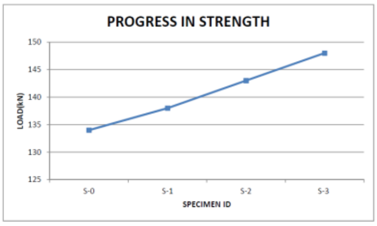



Fig 26. Progress strength of Buckling

The values derived from the experimental results are shown the table 2.

| Sl.No | Specimen | Experimental load (KN) | Mode of Failure |
|---|---|---|---|
| 1 | CFS-C-1-S-0 | 134 | Flexural – torsional buckling |
| 2 | CFS-C-1-S-1 | 138 | Flexural – torsional buckling |
| 3 | CFS-C-1-S-2 | 143 | Distortional buckling |
| 4 | CFS-C-1-S-3 | 148 | Flexural – torsional buckling |

Table 2. Experimental Results

## IV. **CONCLUSION**

The behavior of open walled cold formed steel columns under axial compression was studied in experimentally and its failure mode is observed. The mode of failure observed in control specimen was flexural torsional buckling. From this it is concluded that geometry of the section plays an important role in distortional buckling.

The load carrying capacity of specimen with one spacer i.e. CFS-C-1-S-1 was 138 KN. It was 2.98 % higher than control specimen. The mode of failure was flexural torsional buckling. The lateral and the axial deflection curve is obtained from the reading taken from the deflectometer.

The load carrying capacity of specimen with two spacers i.e. CFS-C-1-S-2 was found as 143 KN and it is 6.71 % higher than control specimen. There has no failure observed in the spacer sides. The failure mode was distortional buckling at the bottom (below the spacer).

The load carrying capacity of the specimen with three spacers i.e. CFS-C1-S-3 was found to be 148 KN. This load is 10.44 % higher than the control specimen. The axial and lateral deflection was studied. This specimen rotated when the load was applied. So the failure mode was flexural-torsional buckling.

The experimental result shows that the buckling strength is improved by providing spacer at different intervals.

## REFERENCES

[1]. B.C Punmia "Design of steel structures" (2007) Laxmi Publications (p) ltd.
[2]. Indian Standard code of practice for cold formed steel (IS:801-1975)
[3]. B.W. Schafer &Pekoz local and distortional buckling of cold formed steel
[4]. "R.S Talikoti, K.M. Bajoria" "New approach to improving distortional strength of intermediate length thin walled open section-2005"
[5]. Ben Young and Kim J.R. Rasmussen "Design of lipped channel-1998"
[6]. Godoy, L. A. , E. J. Barbero, and I. Raftoyiannis, Interactive Buckling Analysis of Fiber-Reinforced
[7]. Effects of pump recycling technique on stimulated Brillouin scattering threshold: A theoretical model," Optics. Express, Vol. 18, No. 21, pp. 22339-22347.
[8]. Particle swarm optimization on threshold exponential gain of stimulated Brillouin scattering in single mode fibers," Optics. Express, Vol. 19, No. 3, pp. 1842-1853.
[9]. Schafer, B.W. Distortional buckling of cold-formed steel columns. American Iron And steel institute-2000 Brillouin Linewidth Characterization in Single Mode Large Effective Area Fiber through the Co-Pumped Technique," International Journal of Electronics, Computer and Communications Technologies (IJECCT), Vol. 1(1), pp. 16-20.