Experimental study on Cold form steel column

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Abstract :Open cold-formed steel sections such as C, Z, Hat and rack sections are relatively small because of their simple forming procedure and easy connections but they suffer from buckling modes due to their mono-symmetric, point symmetric nature, high plate slenderness, eccentricity of shear center to centroids and low torsional rigidity. An innovative tiny bracing system is proposed to reduce or avoid distortional buckling and also the effect of lipping compared to the tiny bracing will be investigated. Finite strip analysis is carried out to determine the load and the location of the bucking modes. Both analytical and experimental study on the C section will be compared. Simple C sections with and without Lips are tested to understand the different buckling modes and the failure loads are compared with the analytical solutions.

Index Terms -BUCKLING MODES, C Section , CUFSM,FINITE STRIP METHOD

I. INTRODUCTION

In steel construction, there are two main families of structural members. One is the familiar group of Hot-Rolled Steel (HRS) sections and other is Cold Formed Steel (CFS) members. The cold-formed steel members are widely used in various fields such as building construction, bridge Construction, storage racks, highway products, drainage facilities, grain bins, transmission towers, car bodies, railway coaches, and various types of equipment. Cold-formed steel structural members may lead to a more economic design than hot-rolled members as a result of their high strength to weight ratio, ease of construction and suitability for a wide range of applications. The thickness of steel sheets or strip generally used in cold-formed steel structural members ranges from 0.4mm to about 6.4 mm. Steel plates and bars as thick as 1 in 25 mm can be cold-formed successfully into structural shapes. The materials used in cold-formed thin-wall members have to satisfy certain criteria to be suitable for cold-forming and usually also for galvanizing. The yield strength is normally in the range of 220 to 350 N/mm^2, but also some high-strength sheet steels with yield strength of over 500 N/mm^2 are used in some cases due to practical reasons i.e. transportation, handling etc., limit the range of thickness of the material used in profiled sheeting.

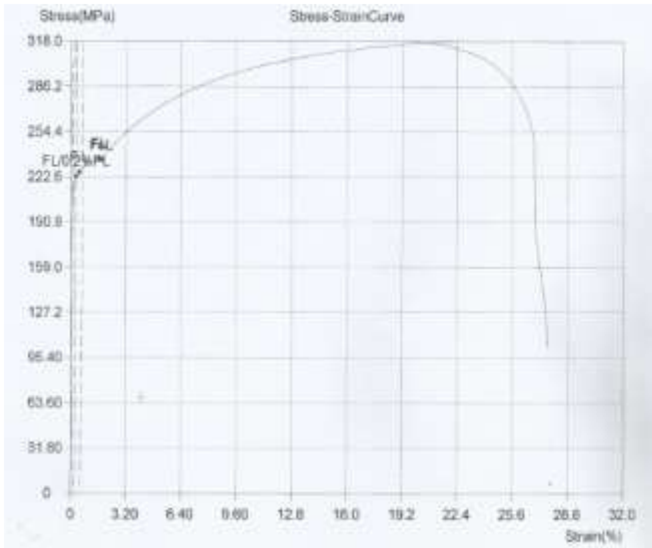
II. PRELIMINARY TEST

The coupon test Specimen details are as follows.The test piece has a width 'b' of 50mm and gauge length 'Lt' of 240mm. However, if the nominal thickness 'a' is not greater than 2mm, the test piece may have a width of 11.5mm and a gauge length 'lo' of 90mm. The ends of the test piece metal held in suitable grips in the testing machine in such a way that the centre line of pull coincides with the longitudinal axis of the test piece.

The parallel length is kept between "Lo + b/2 & Lo + 2b".

A. Coupon Specimens

Fig. 1. Coupon test specimens



B. Coupon Test

Data:
Length of plate =240mm
Width of plate = 50mm
Thickness of plate = 2mm

TABLE I. COUPON TEST RESULT

S. no	Property	Values
1	Yield stress	250N/mm^2
2	Young's modulus	2x10^{5}N/mm^2
3	Tangent modulus	2.22x10^{4}N/mm^2
4	Ultimate stress	350N/mm^2
5	Elongation	27%

III. NUMERICAL INVESTIGATION

Many numerical software are available to predict the structural behavior of thin walled structural members subjected to different actions. Since last few decades, many researchers have simulated cold formed steel using various software packages. Most of them use Finite Element Analysis (FEA) and Finite Strip Analysis (FSA) techniques. These numerical analyses predict accurate results if the loading, boundary conditions and relevant mechanical properties are modeled correctly. In this analysis the finite strip models developed to determine the load capacity and to investigate the buckling behavior of cold-formed steel compression members.

A. CUFSM Programme

CUFSM is FSM based analysis package for exploring elastic buckling behavior of thin-walled members. CUFSM calculates buckling stresses, buckling loads, and also shows buckling modes of arbitrarily shaped thin-walled members. CUFSM was originally developed to support research on the behavior and design of cold-formed steel members with variety of different types of longitudinal stiffeners.

B. Boundary Conditions

The specimens of 1m length and 4 mm thickness of 'channel' and 'hat' sections are modeled and analysed for the strength performance. It was found that good simulation results could be obtained by using the element (mesh) size of approximately 2.5x2.5 mm (length by width) for the web, flanges and lips. The ends of the specimens are simply supported with hinges and rollers. The bearing length of 100mm is kept on either side of the specimen.

C. *Buckling modes of Channel Section*

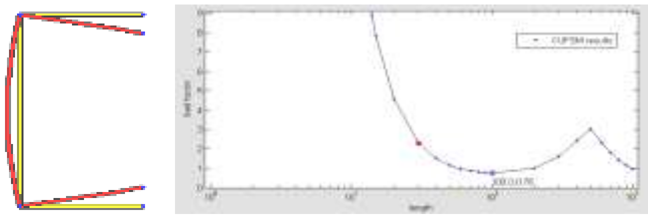


Fig.II . Local buckling

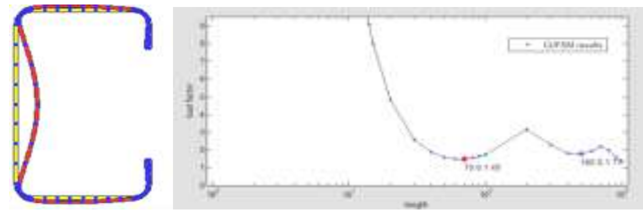


Fig.III.Distortional buckling

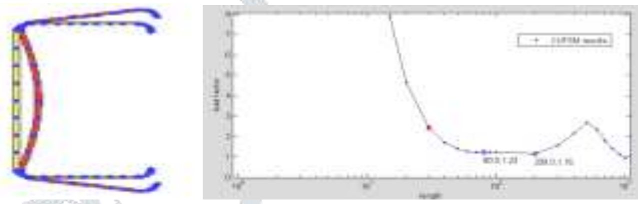


Fig.IV.Global buckling

D. LOAD OBTAINED FROM NUMERICAL INVESTIGATION

TABLE II. CUFSM ANALYSIS RESULT

SPECIMEN DIMENSION (mm)	LOAD OBTAINED(KN)
80x50x0x1.5	44.83
80x50x15x1.5	111.59
90x40x0x1.5	68.75
90x40x20x1.5	94.65
110x30x0x1.5	39.85
110x30x0x1.5	105.61
110x30x20x1.5	65.76
110x30x20x1.5	130.06

IV.

IVEXPERIMENTAL INVESTIGATIONS

In this eight specimens are tested under axial load which includes column with lip, without lip and bracing . The section properties like yield stress, young modulus and elongation are determined by the coupon test .The length and cross section differ for the specimens with fixed thickness. The experiment is carried out by using 500kN capacity of loading frame setup

A.. Methodology

The columns are prepared initially. It is ensured that the steel column are of free from rust to get the clear view of deflection and all. The schematic procedure of the experiment of cold form column is as follows.

- Initially the Cold formed steel column is placed under the loading frame with its position.
- Strain variations in the cross section is observed at midpoint of the column.
- We do the measurement at mid-span and the strain gauges are fixed in the lateral direction to column.
- The strain indicators can be fine tuned for zero at starting. Similarly auto adjustments for deflection measurements are made.
- Now, loading is done and deflections are tabulated
- Similarly the experiment is repeated with all the specimen and the load with respect to deflection is tabulated.

Fig. V. Experimental setup

Fig. VI. Specimens after loading

C. Load and deflection obtained from the test

TABLE III. LOAD OBTAINED

SPECIMEN DIMENSION (mm)	LOAD OBTAINED(KN)
80X50X0X1.5	51.8
80X50X15X1.5	115.58
90X40X0X1.5	64.76
90X40X20X1.5	97.64
110X30X0X1.5	44.83
110X30X0X1.5	109.67
110X30X20X1.5	68.75
110X30X20X1.5	149.46

D. Buckling mode of specimen

SPECIMEN 1: P_1L_0
Breadth of flange (b_f) = 50mm
Thickness of plate (t) = 1.5mm
Span (L) = 80mm

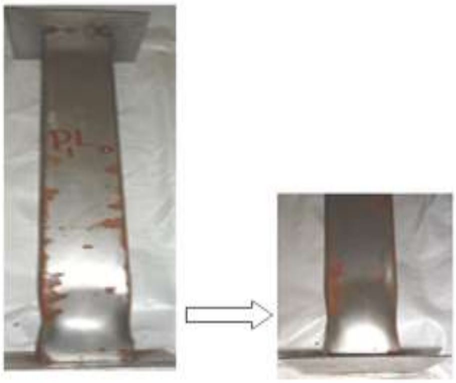


Fig. VII. Specimen P_1L_0 buckling mode

SPECIMEN 2: P_1L_1
Breadth of flange (b_f) = 50mm
Depth of the flange =15mm
Thickness of plate (t) = 1.5mm
Span (L) = 80mm

Fig. VIII. Specimen P_1L_1 buckling mode

SPECIMEN 3: P_2L_0
Breadth of flange (b_f) = 40mm
Thickness of plate (t) = 1.5mm

Span (L) = 90mm

Fig. IX. Specimen P_2L_0 buckling mode

SPECIMEN 4: P_2L_1
Breadth of flange (b_f) = 40mm
Depth of the flange =20mm
Thickness of plate (t) = 1.5mm
Span (L) = 90mm

Fig. X. Specimen P_2L_1 buckling mode

SPECIMEN 5: P_3L_0
Breadth of flange (b_f) = 30mm
Thickness of plate (t) = 1.5mm
Span (L) = 110mm

Fig. XI. Specimen P_2L_0 buckling mode

SPECIMEN 6: P_3L_0B
Breadth of flange (b_f) = 30mm
Thickness of plate (t) = 1.5mm
Span (L) = 110mm

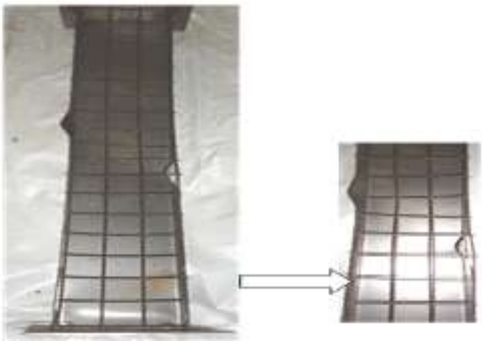


Fig. XII. Specimen P_2L_0B buckling mode

SPECIMEN 7: P_3L_1
Breadth of flange (b_f) = 30mm
Depth of the flange =20mm
Thickness of plate (t) = 1.5mm
Span (L) = 110mm

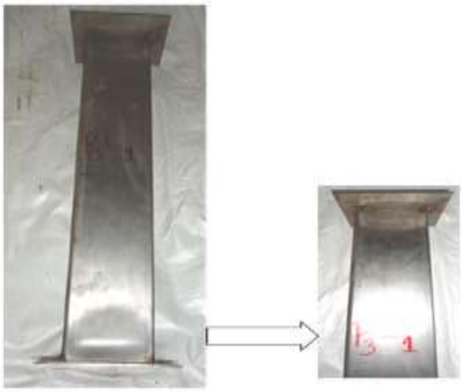


Fig. XIII Specimen P_2L_1 buckling mode

SPECIMEN 8: P_3L_1B
Breadth of flange (b_f) = 30mm
Depth of the flange =20mm
Thickness of plate (t) = 1.5mm
Span (L) = 110mm

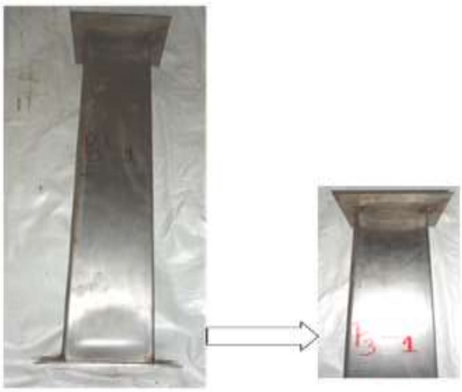


Fig. XIV Specimen P_2L_1B buckling mode

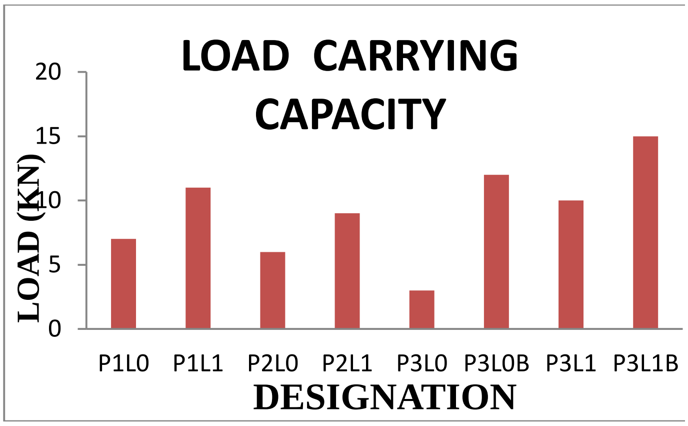


Fig. XV. Load carrying capacity of the cold formed steel colum

V. DISCUSSIONS

TABLE VI. COMPARISION TABLE

DIMENSION(mm)	LOAD OBTAINED FROM CUFSM(KN)	LOAD OBTAINED FROM EXPERIMENT (KN)
80X50X0X1.5	44.83	51.8
80X50X15X1.5	111.59	115.58
90X40X0X1.5	68.75	64.76
90X40X20X1.5	94.65	97.64
110X30X0X1.5	39.85	44.83
110X30X0X1.5	105.61	109.67
110X30X20X1.5	65.76	68.75
110x30x20x1.5	130.06	149.46

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The above comparison table shows that there was similar deflection with respect to the given load. The behavior of the braced column performed well when compared to the other column.

VI. RESULTS

- From preliminary study, it has been observed that many section fails under local or distortional buckling before global buckling failure. So, it is recommended to review the section for modification so that local and distortional buckling can be delayed.
- From literature review findings, it is recommended here to include Direct Strength Design Approach as an alternative design solution.
- From the finite strip analysis, it has been observed that, buckling of cold formed steel compression member is not only governs by global/elastic buckling, but it is governs by all three types of buckling. i.e., Local, Distortional and Global buckling.
- Local buckling occurred in all the eigth specimens. Distortional buckling occurred only in the specimen P_3L_0 due to the absence of lip and slenderness of the specimen.
- The column with lip and bracing performed well under axial load when compared to the column with out lip and bracing.

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