EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF COLD FORMED STEEL LIPPED CHANNEL SECTION COLUMN

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Abstract: **Cold-formed steel is also called as light gauge steel sections. CFS section is widely used structural elements in India. One of the great advantages of cold-formed steel (CFS) is the immense flexibility that the material affords in forming cross-section. Whereas, the low strength-to-weight ratio of hot rolled steel members leads to increase in overall load on structure as compared with cold-formed steel sections which having high strength-to-weight ratio. The paper presents a review of experimental and analytical investigation of cold –formed steel lipped channels with perforated welded webs and flanges under buckling. In the experimental investigation three varying thicknesses and varying dimensions were tested under a compression behavior using UTM and IS811-1987. The analytical investigation is carried out by using CUFSM. The load carrying capacity and deflection of column compared with theoretical and experimental results. Research project aims to provide which section is economical, more load carrying capacity and lesser deflection.**

Keywords: **Channel section, Cold formed steel, Universal Testing Machine, Conventional finite strip method, welding.**

1. INTRODUCTION.

Cold-formed steel is the common term for products made by rolling or pressing steel into semi-finished or finished goods at relatively low temperatures. Cold-formed steel goods are created by the working of steel billet, bar, or sheet using stamping, rolling, or presses to deform it into a usable product. The strength of elements used for design is usually governed by buckling. The construction practices are more similar to timber framing using screws to assemble stud frames .Cold-formed steel members have been used in buildings, bridges, storage racks, grain bins, car bodies, railway coaches, highway products, transmission towers, transmission poles, drainage facilities, firearms, various types of equipment and others.

Properties of cold formed steel section

1. High strength and stiffness
2. Ease of prefabrication and mass production
3. Economy in transportation and handling
4. Non combustibility
5. Recyclable material.

2. LITERATURE REVIEW

Karren and Winter [1967] found that the pressure of the rolls and aging after strectcher straightening cause roll-formed members to exhibits significant increase in strength in the flats adjacent to corners , and is confirmed by Macadam[1967b].The phenomenon is not observed in press-braked members.

Uribe and Winter [1970] investigated the cold -forming effects of thin-walled members.Their work included a statistical study of the as-formed strength of joist chord sections , a study of the strength of flexural members and buckling of columns of bisymmetrical sections subject to local buckling.

Hlavacek [1968] looked into the effects of cold –waving of a steel sheet .Thus is sometimes done before press-braking or cold-rolling in order to increase the yield strength ,with the sheet flat at initial and final stages .

Zinchy and Moreau [1971] presented test results on angle, channel, welded box and cruciform sections, all of which involve 90°cold –formed corners.Test results confirm the validity of the American Iron and Steel Institute (AISI) specification [1977].

Chajes, Britvec and Winter [1963] started by studying the effects of the simplest kind of cold-straining, namely one-dimensional stretching, and attributed these effects to three phenomena strain-hardening, strain –aging and the Bauschinger effects.

Clarke and Hancock (1994) proposed and validated a simple design procedure for the cold-formed tubular frames. The possible provisions off the American Iron and steel Institute load and Resistance Factor Design specification are proposed.

Wei-Wen Yu and LaBoube (1997) presented cold-formed steel structures during the numerous research projects have been conducted at the University of Missouri-Rolla. The purpose of these investigations had been to study the structural strength of cold-formed steel members, connections, and structural systems. Some of the research findings have been used in the development of the AISI specification for the design of cold-formed steel structural members. ASCE specification for the Design of cold-formed stainless steel structural members.

Elkersh (2010) studied the behavior of bolted cold formed steel frame apex connections under pure moment. The study was performed on portal frame rafter with double C cold formed sections. A total of 10 rafter sections as part of portal frames were used in the study. The study aimed to investigate the effect of different factors on both the frame capacity and connection failure mode. The effects of variable bolt pitches, thickness of gusset plates, effect of bearing or hole deformation around the bolt were investigated. A parallel theoretical study was carried out using the same boundary conditions and the results were compared with the experimental ones. The compatibility between the results was good. The flexural failure of the connected sections was always the critical. Failure modes which have been evaluated include local buckling of the gusset plate and web of the channels, lateral torsional buckling of the channels and bearing due to bolt-hole elongation. High tensile steel was used for both cold-formed section and hot rolled gusset plate to investigate both of the failure and the capacity.

Sabbagha etal (2011) carried out analytical investigation on ductile moment-resisting frames using cold formed steel. The potential use of cold-formed steel sections (CFS sections) in moment-resisting frames (MRFs) for seismic applications were investigated. The main limitation of CFS sections were the low out-of-plane stiffness of their thin-walled elements which leads to low ductility. In earthquake resistant MRFs, the beams were designed to provide considerable ductility, whereas the other elements are mainly limited to their elastic range. The performance of a new shape of CFS beam with curved flanges were examined analytically and compared with that of conventional shapes. The proposed beam–column connections include through plates which potentially limit the out-of-plane action of the forces transferred through the connections. The behavior of both individual CFS beam sections and CFS beam–column connections were studied by means of finite element analysis (FEA). The results of the analyses show that the new beam cross sections and connections exhibit a good ductile behavior, something which cannot be achieved by conventional cold-formed frame element.

Vothetal (2012) carried out numerical study and design of T-type branch plate-to-circular hollow section connections. A numerical finite element parametric study were presented on the behavior of transverse or longitudinal T-type plate-to-CHS connections loaded under branch plate tension or compression, to evaluate the suitability of current international design recommendations and the effect of boundary conditions and chord length on such connections. Finite element modeling and analysis techniques used in the parametric study were validated by comparison with previously tested experimental results. A total of 120 connections with wide-ranging values of geometric properties were modeled and analyzed using commercially available software. An analysis of the effect of chord length determined that, to exclude the influence of chord end boundary conditions, an effective chord length of at least eight times and four times the chord diameter, for thin and thick walled chords respectively, should be used for experimental and numerical studies. Evaluation of current CIDECT partial design strength functions indicated general conservatism and under-utilization of branch tension-only connection capacity. Partial design strength functions, determined through regression analysis of numerical finite element results and existing international experimental data, are hence proposed with lower bound reduction factor.

3. CUFSM ANALYSIS.

Conventional FSM, e.g., CUFSM, provides a method to examine all the instabilities in a cold-formed steel member under uniform longitudinal stresses (axial, bending, warping torsion, or combinations thereof). Additionally, the newly developed constrained finite strip method (cFSM) is implemented in CUFSM. When the signature curve of the conventional FSM is not able to provide distinct minima that correspond to local and distortional buckling mode, cFSM becomes essential for accurately determining the buckling modes.

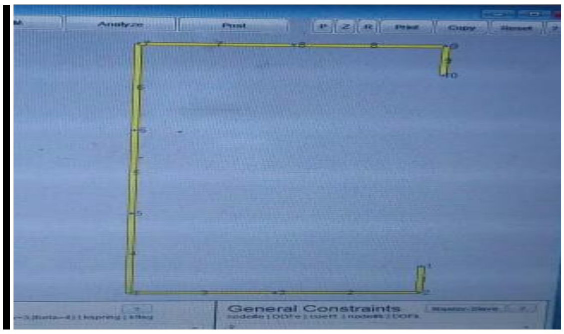
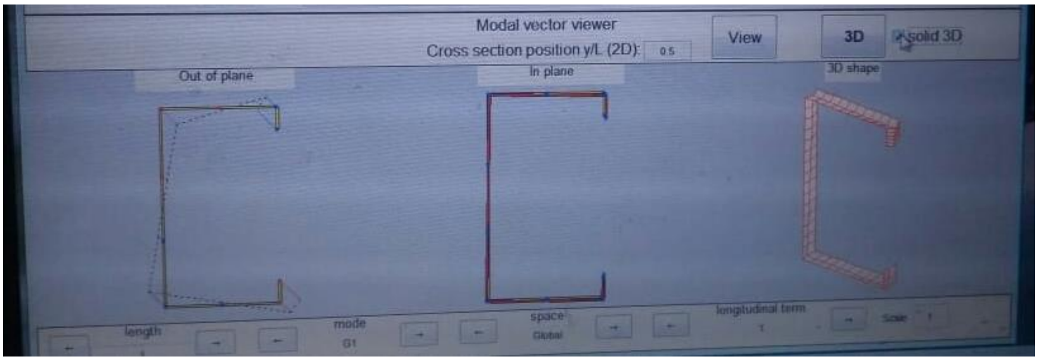


Figure 1 .General Constrained



Cross section position y/L (2D): 0.5

Figure 2. Cross Section Position

4. EXPERIMENTAL ANALYSIS

Experimental analysis is done for three varying thicknesses and three varying dimensions for a cold formed channel section by using Universal Testing Machine. The specimen is placed in a vertical position in the UTM. Two point load set up in UTM during testing is shown below.

Figure3.placing of specimen in UTM

Figure 4.Buckling Behavior of specimen due to load

Table 1.CLC For Flange (1mm)

LOAD (KN)	DEFLECTION (mm)	
	With plate	Without plate
2	0.6	0.3
4	0.9	0.5
8	1.2	0.8
10	1.8	1.1

Table 2.CLCFor Web (1mm)

LOAD (KN)	DEFLECTION (mm)	
	With plate	Without plate
2	0.8	0.5
4	1.0	0.9
8	1.4	1.2
10	2.1	1.5

Table3.CLC for Flange (1.5mm)

LOAD (KN)	DEFLECTION (mm)	
	With plate	Without plate
10	0.2	0.1
20	0.4	0.2
30	0.7	0.5
40	1.2	1.0

Table4.CLC for Web (1.5mm)

LOAD (KN)	DEFLECTION (mm)	
	With plate	Without plate
10	0.8	0.6
20	1	0.10
30	2.6	2.2
40	3.4	3.1
50	5	4.5
60	7	5.3

Table5.CLC for Flange (2mm)

LOAD (KN)	DEFLECTION (mm)	
	With plate	Without plate
10	0.4	0.2
20	1.0	0.8
30	1.3	1.1
40	1.6	1.3
50	1.85	1.7
60	2.15	2.0

Table6.CLC for Web (2mm)

LOAD (KN)	DEFLECTION (mm)	
	With plate	Without plate
10	0.8	0.3
20	1.2	0.9
30	1.4	1.3
40	1.82	1.5
50	2.2	2.0
60	4.4	3.6

4.1. COMPARSION GRAPH

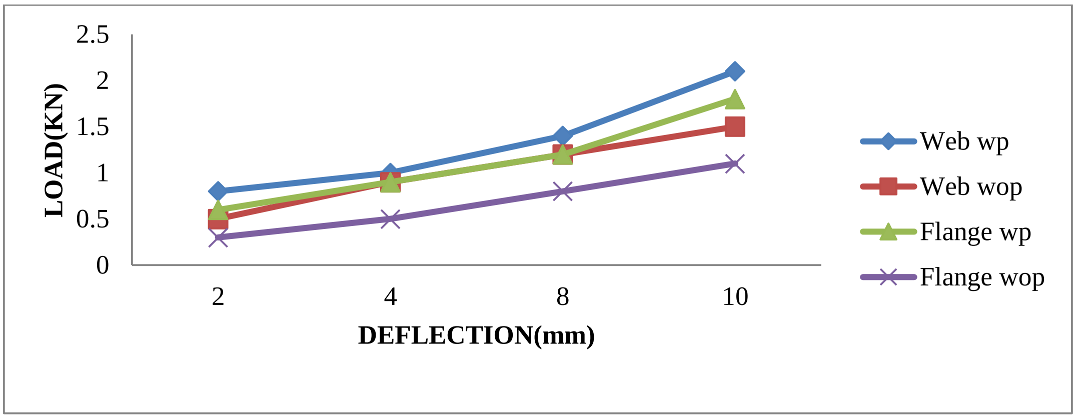


Figure5.CLC for 1mm web and flange

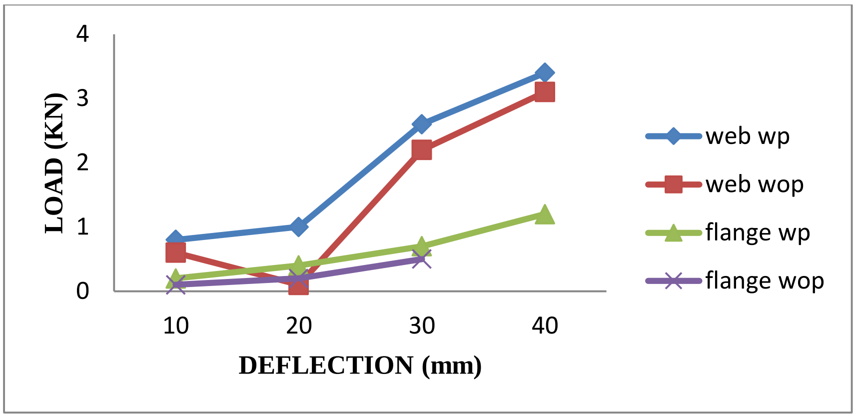


Figure6.CLC for 1.5 mm web and flange

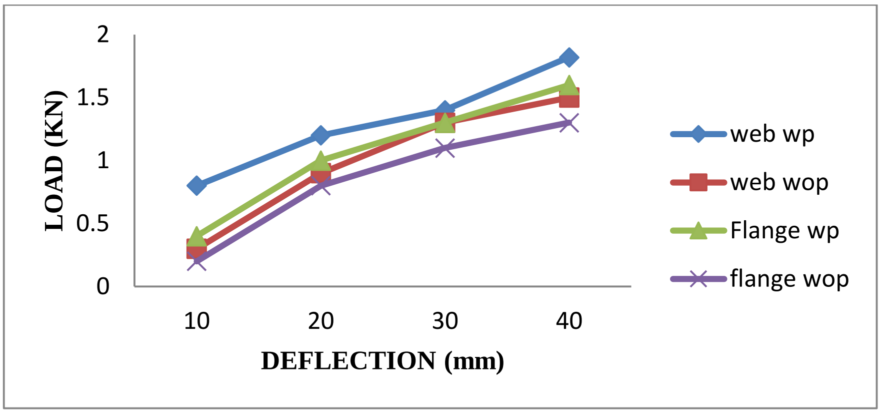


Figure7.CLC for 2mm web and flange

4.2. COUPON TEST

Tensile **coupon tests** are commonly carried out to determine the material properties of metallic materials in research and industry .It is used to determine the tensile load.

Figure 8.Cuopon Test Material

4.3. GRAPHICAL PRESENTATION OF COUPON TEST

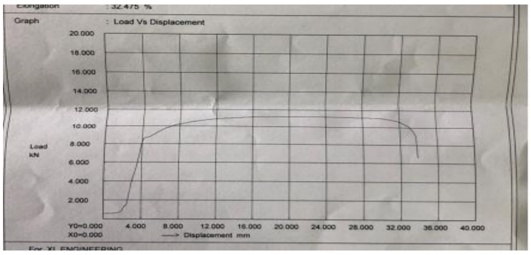


Figure9. CLC for 1.5 mm

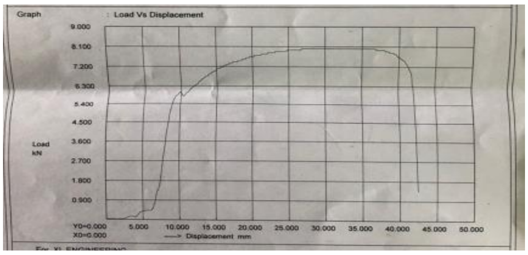


Figure 10. CLC for 1mm

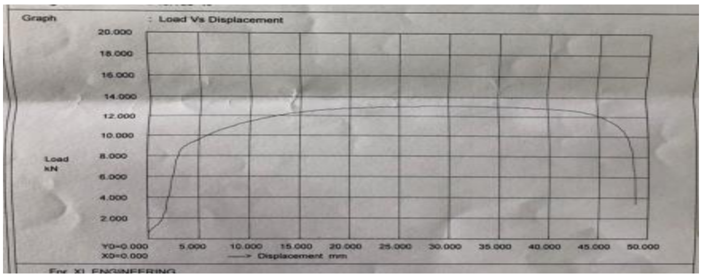


Figure 11.CLC for 2mm

5. THEORETICAL ANALYSIS

By using IS811-1987 design the compressive stress for cold formed lipped channel section. Here the column with both ends are pinned. The design strength is obtained for three varying thicknesses and varying dimensions.By the formula of

Non dimensional effective slenderness ratio

$$\lambda = \sqrt{(f_y / f_{cc})}$$

$$f_{cc} = (\pi^2 E) / (KL/r)^2$$

Design compressive stress

$$f_{cd} = \frac{f_y / \gamma_{m0}}{\Phi + (\Phi^2 - \lambda^2)^{0.5}}$$

Design strength

$$P_d = A_c \times f_{cd}$$

Table7.values obtained from codal provision and design

Thickness(mm)	Area (mm²)	Compressive stress(N/mm²)	Design strength(N)
CLC 1	298	234.68	75.520×10^3
CLC 1.5	174	225.03	39.05×10^3
CLC 2	298	198.13	59.04×10^3

6. BUCKLING BEHAVIOR OF CLC SECTIONS

Figure 11. CLC 1mm

Figure 12.CLC 1.5mm

Figure13. CLC 2mm

7. CUFSM RESULT

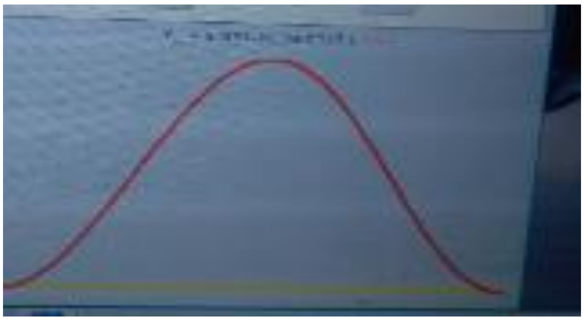


Figure14. CUFSM result

8. CONCLUSION

- The Buckling behavior of mild steel cold formed section with 3varying thicknesses and varying dimensions are analytical investigated using CUFSM.
- The web and flange plate are welded together with the specimens to increase the load carrying capacity.
- The difference is investigated between for the channel section with and without plate.
- Deflection is increased with decrease in thicknesses of section.
- The load carrying capacity is increases with increase in thickness of the section.
- Load carrying capacity is increased for the plate are welding together of the section. Deflection is decreased for the increase thicknesses and plate welded.

REFERENCES

[1] B. W. Schafer, “Review: The Direct Strength Method of cold formed steel member design,” Journal of Constructional Steel Research, vol. 64, no. 7-8, pp. 766–778, 2008.

[2] Direct Strength Method (DSM) Design Guide, Committee on Specifications for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute, January, 2006.

[3] I. El-Sheikh, E. M. A. El-Kassas, and R. I. Mackie, “Performance of stiffened and unstiffened cold-formed channel members in axial compression,” Engineering Structures, vol. 23, no. 10, pp. 1221–1231, 2001.

[4] T. H. Miller and T. Pekoz, “Load-eccentricity effects on cold formed steel lipped-channel columns,” Journal of Structural Engineering, vol. 120, no. 3, pp. 805–823, 1994.

[5] Young and J. Yan, “Finite element analysis and design of fixed ended plain channel columns,” Finite Elements in Analysis and Design, vol. 38, no. 6, pp. 549–566, 2002.

[6] B. Young and K. J. R. Rasmussen, “Behavior of cold-formed singly symmetric columns,” Thin-Walled Structures, vol. 33, no. 2, pp. 83–102, 1999.

[7] Young and J. Yan, “Channel columns undergoing local, distortional, and overall buckling,” Journal of Structural Engineering, vol. 128, no. 6, pp. 728–736, 2002.

[8] J. Dejin and C. Shaofan, “Inelastic torsional-flexural buckling of cold-formed open sections under eccentric load,” in Proceedings of the 7th International Specialty Conference on Cold-Formed Steel Structures, St. Louis, Mo, USA, 1984.

[9] H. T. Nguyen and S. E. Kim, “Buckling of composite columns of lipped-channel and hat sections with web stiffener,” Thin-Walled Structures, vol. 47, no. 11, pp. 1149–1160, 2009.