Effective Width Calculation of Cold Formed Section as Per IS-801 and Comparison with AISI-2007

Prof. Mayuri D. Patil[1] Prof. Ashish S. Burakale[2]
[1]Assistant Professor [2]Head of Dept.
[1,2]Department of Civil Engineering
[1,2]Siddhivinayak Technical Campus, Shegaon, India

Abstract— Buildings built using cold-formed sections as primary members (frames) and secondary members (purlins) offers a viable alternative solutions for wide range applications of social sectors like housing, education etc. Design of cold formed sections has obvious complexity in view of buckling of sections vis-à-vis stress in the compression element, especially in flexure. In this study, using IS801 equations, effective section properties of C section are calculated for wide range of configurations with different b/t ratios for flange subjected to maximum allowable stress. These section properties are used to evolve optimum frame configurations for various wind zones of the country. Study also presents simple design tools and few standard cold formed sections having similar configuration but for thickness to be used for residential or community shelters for different wind zones. A recourse is made to compare the results with similar studies using AISI code.

Key words: b/t Ratio, Cold-Formed Steel (CFS), Effective Width, Flexural Strength, Slenderness Limits

I. Introduction

Cold form sections as primary members (frames) and secondary members (purlins) offer a wider range of applications in varying sectors like education, health, housing etc. CFS section has large flat width to thickness ratio and leading to buckling of element still CFS have following inherent characteristics,

- Flexibility in designs.
- Easy and fast manufacturing and erection.
- Ease in transportation and handling.
- Economical and light in weight.
- Low maintenance.
- Easy future expansion.

Methods of forming of cold formed sections are:

- Cold rolled forming operation.
- Press break operation.

In this study, usual stiffened CFS C-section with lips has been focused. Buckling of C-section element under axial compression and flexure as,

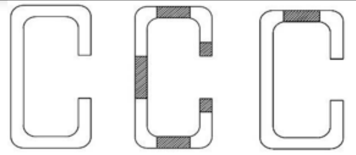

Fig. 1:Buckling of C-section elements.

II. Reference work

Adi Susila and Jimmy tan (2015)[1], has done his works on flexural strength performance and buckling mode prediction of cold-formed steel and conclude that,“ web stiffeners to the C-section not improve the bending capacity significantly, it just helps to reduced local buckling”.

Jun Ye (2016)[2], Jun ye indicates that, a methodology that would enable the development of optimized CFS beam sections with maximum flexural strength for practical applications and concluded that,“ CFS beam with the folded flanges rather than the conventional gives 57% increment in the flexural capacity, where both having the same thickness and same coil width”.

Ben Young (2005)[3], carried his work on behaviour of cold-formed high strength stainless steel sections. In this paper, author use cold formed high strength stainless steel section as a column and analysis is carried out with different sections and practical results are compared with the various countries codes.

Kim J. R. Rasmussen (2004)[4], author work on design of stiffened elements in cold-formed stainless steel sections. This paper tries to established strength equations for single stainless steel stiffened elements applicable to the range of alloys included in the american, australian, and european standards for stainless steel structures.

Y. B. Kwon (2006)[5], has worked for, the flexural strength of the sections and structural behavior of the connections including the moment-rotation relation, the yield, and ultimate moment capacity of the connections. He studied experimentally and compared with the numerical estimation.

D. Polyzois (1993)[6], he has done his work for web- flange interaction in cold-formed steel z-section columns. He come up with conclusion that, current AISI code overestimates 59% of web buckling in theoretical determination rather compared to the practical experimentation.

Derrick Y. Yap and Gregory Hancock (2008) [7], author has taken a specimen of cold-formed high-strength steel of 0.42 mm thickness and nominal yield stress of 550 mpa for compressive test. A new design methodology has been proposed by the author to improve the prediction of local buckling and distortional buckling.

M. Raizamzamani and M. Zain (2010)[8], author investigates the structural behavior of cold-formed steel channel columns (without or with stiffeners) subjected to axial thrust and proves that, the importance of edge and intermediate stiffener to show less deformation in terms of buckling.

S.A. Kakade (2014)[9], has done his work for various design methods for cold formed light gauge steel sections for compressive strength and concluded that, IS 801 is in working stress method and in MKS system. So full cross section of the member is not utilized. It is very essential to revise the code to the limit state method and in SI system.

Yin-hai Zhao (2015)[10], he carried his work on comparative analysis of different stiffening types (rectangular, V-shape, arc-shape) with their locations on the web and conclude that, the V-shape stiffener is the optimal choice and the effect of the rectangular stiffener is the worst and arc-shape stiffener is the second one.

III. DESIGN METHODOLOGY

A. Assumptions

The whole study has been concentrated on following assumptions,

1) C-section with lips is considered for analysis.
2) Section is predominantly in flexure.
3) Only compression flange shall undergo buckling.
4) Though compression flange undergoes buckling, shift in neutral axis towards tension flange is negligible. (Ref. fig.2)

B. Shifting of Neutral Axis

In case of flexure member only top flange buckle and area concentration shifts toward bottom tension fiber and neutral axis shifts downward with small amount of eccentricity (δ) as shown in following fig.2.

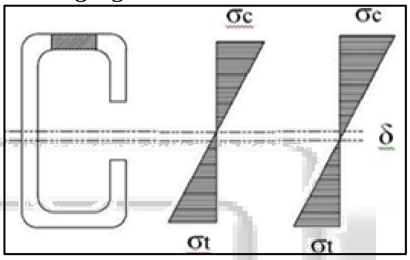

Fig. 2: Stress distribution and shifting of neutral axis

C. Data considered for analysis

Sections considered for calculation of gross and effective sectional properties as,

Web Depth	Flange Width	Lip Depth	Thickness
mm	mm	mm	mm
200	60	18	1.5 1.6 1.75 1.8 2.0 2.1 2.2 2.5
	65	20	
	70	22	
	75	24	
	80	26	
	85	28	
	90	30	
Internal radius of curvature (Ri) = 3mm			

Table 1: Configuration of sections

Buckled area (A') to be deducted for calculation of effective sectional properties,

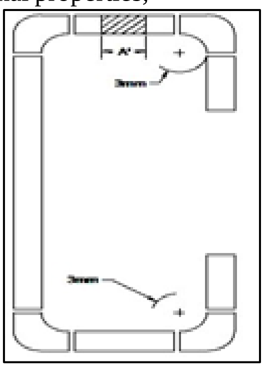

Fig. 3: Element for calculation of sectional properties

– Effective properties of C-sections are calculated as per IS: 801-1975 and AISI-2007.
– The structural parameters namely effective width to thickness, effective width to gross width, effective moment of inertia to gross moment of inertia are calculated for Indian codes IS:801-1975 and comparison are done with calculations as per AISI- 2007.
– The various combinations of respective parameters for observing quick access of design parameters are discuss further.

IV. ANALYSIS AND DISCUSSION

A. Graphical Representation

The below mention graphs shows graphical representation of parameters of Indian code IS: 801-1975 and compared with AISI-2007.

1) Graph for effective flange width to gross flange width versus flange width to thickness ratio for Indian standard code IS 801:1975 and AISI-2007.

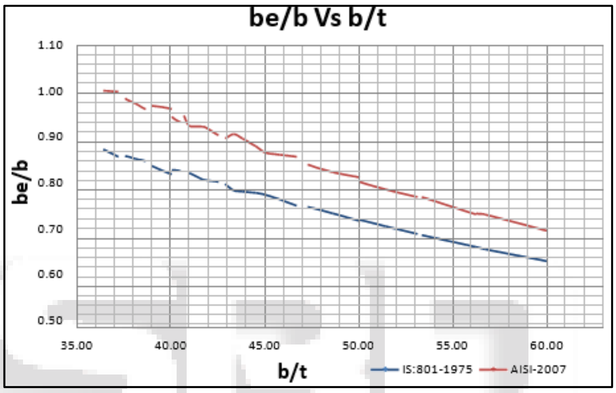

Fig. 4: b_e/b versus b/t for Indian and American code.

The value have been calculated as per the methodology explain in Indian code and American code and trend line equations are,

$$b_e/b = -0.010 * (b/t) + 1.230 \quad (1)$$

For Indian code and

$$b_e/b = -0.013 * (b/t) + 1.467 \quad (2)$$

For American code.

2) Graph for effective flange width to gross flange width versus flange width to thickness and effective moment of inertia to gross moment of inertia versus flange width to thickness ratio for Indian standard code IS 801-1975.

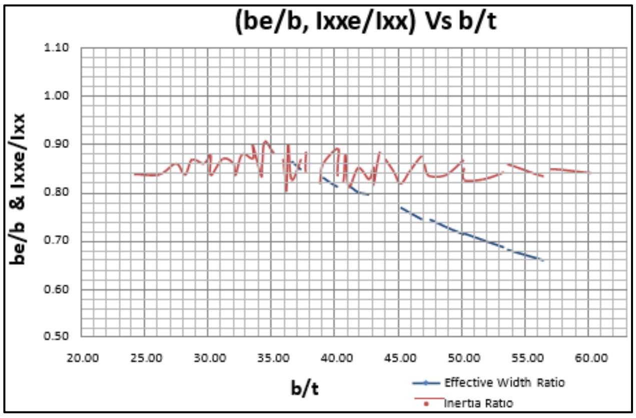

Fig. 5: b_e/b versus b/t and I_{xxe}/I_{xx} versus b/t for Indian code.

Similar graphical representation has been observed for effective flange width and effective moment of inertia as per American code AISI-2007.

For Indian code it found that, the section with maximum effective flange width and maximum moment of inertia is for b/t of 40 and about 0.82 times gross properties and shows nearly same variation for American code.

3) Graph for effective moment of inertia to gross moment of inertia versus effective flange width to gross flange width for Indian code IS 801-1975. Approximately similar results have found for American code AISI-2007.

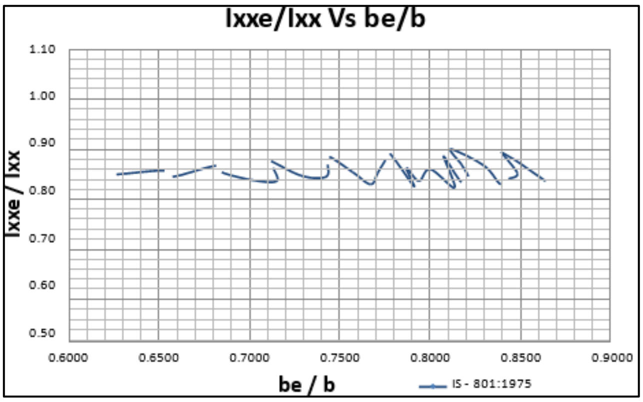

Fig. 6: I_{xxe}/I_{xx} versus be/b for Indian code.

For any value of effective flange width, effective moment of inertia varies from 0.8 to 0.9 for either Indian code or American code.

Standard cold formed section obtained from above analysis having similar configuration with varying thickness can be further used to optimize the below mention frame for residential or community shelters for different wind zones.

V. Frame Specifications

The diagrammatic representation of sample frame as,

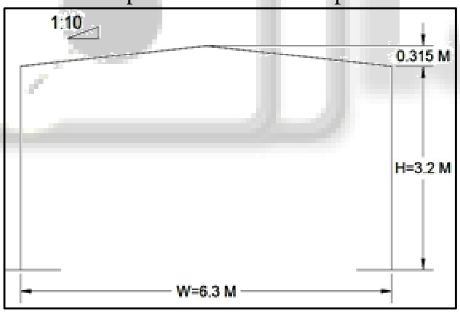

Fig. 7: Sample frame taken for analysis

The above sample frame is taken for different bay spacing and analyze for different wind zones of India tabulated as below,

Span	Height	Bay spacing	Basic wind velocity
M	M	M	M/S
6.3	3.2	1.0	
		1.1	
		1.2	33
		1.4	39
		1.6	44
		1.8	47
		2.0	50
		3.0	55
		3.5	
		4.0	
Roof Slope 1:10			

Table 2: Configuration of frames

VI. Observations and Conclusions

- Fig.4 shows that with increase in b/t ratio of flange, effective width decreases however values computed by AISI-2007 shows variation of approximately 10% on higher side.
- Though values of b/t varies from 35 to 60, the effective moment of inertia to gross moment of inertia is range bound.
- For any b/t ratio or be/b ratio, quick assessment of effective moment of inertia can be taken as 0.85 times gross moment of inertia for either Indian or American code.
- With the use of above study, we are still targeting to achieve same section with different thickness for frame to use under different wind zones.

Notations

- b - Gross flange width
- b_e - Effective flange width t - Thickness of section
- I_{xx} - Gross moment of Inertia
- I_{xxe} - Effective moment of Inertia
- W - Span of frame
- H - Height of frame
- A' - Buckled area of compression flange
- R_i - Internal radius of curvature
- δ - Shifting of Neutral Axis
- σ_c - Stress at compression fiber
- σ_t - Stress at tension fiber.

References

[1] Adi Susila and Jimmy Tan, "Flexural strength performance and buckling mode prediction of cold-formed steel (C section)", ELSEVIER, pp. 979 – 986, November 2015.

[2] Jun Ye, Iman Hajirasouliha, JurgenBecque and Kypros Pilakoutas, "Development of more efficient cold-formed steel channel sections in bending", ELSEVIER , pp.01 – 13, December 2015.

[3] Ben Young, and Wing-Man Lui, "Behavior of Cold-Formed High Strength Stainless Steel Sections", Journal of Structural Engineering, ASCE, pp.1738 - 1745 November 2005..

[4] Kim J. R. Rasmussen, Tim Burns, and Paul Bezkorovainy, "Design of Stiffened Elements in Cold-Formed Stainless Steel Sections", Journal of Structural Engineering , ASCE, pp.1764-1771, November2004.

[5] Y. B. Kwon, H. S. Chung, and G. D. Kim, "Experiments of Cold- Formed Steel Connections and Portal Frames", Journal of Structural Engineering, ASCE, pp.600-607, April2006.

[6] D. Polyzois, "Web-Flange Interaction In Cold-Formed Steel Z-Section Columns", Journal of Structural Engineering, ASCE, vol. 119, pp.2607 2628, September 1993.

[7] Derrick C. Y. Yap and Gregory J. Hancock, "Experimental Study of Complex High-Strength Cold-Formed Cross-Shaped Steel Section", Journal of Structural Engineering, ASCE, vol.134, pp.1322-1333, August 2008.

[8] M. Raizamzamani and M.Zain, "Numerical Investigation of Cold-Formed Steel Channel Columns Subjected To Axial Thrust", IEEE, pp. 292-297, December 2010.
[9] S.A.Kakade, B.A.Bhandarkar, S.K. Sonar, A.D.Samare, "Study of Various Design Methods for Cold Formed Light Gauge Steel Sections for Compressive Strength", International Journal of Research in Engineering and Technology, Volume: 03, June-2014.
[10] Yin-hai Zhao, "Comparative analysis of stiffening style of cold formed thin-walled channel steel members", IEEE, December 2015.
[11] R.Parnell(2010), "Vibration Performance of Lightweight Cold-Formed Steel Floors", Journal of Structural Engineering, ASCE, pp. 645 -653, Vol. 136, June, 2010.
[12] Ben Young (2008), "Design of Cold-Formed Steel Built-Up Closed Sections with Intermediate Stiffeners", Journal of Structural Engineering, Vol. 134, No. 5, ASCE.