Experimental Study of Cfs of Different Sections

S. Sudha · Mr. G. E. Arunkumar, M.E
*1 Asst. prof. Department of Civil Eng, Erode Sengunthar Engineering college, Thudupathi, Erode, TamilNadu, India.
Mr. S. Boobathiraja, M.E.,
*2 Asst..prof, Department of Civil Eng., Erode Sengunthar Engineering college, Thudupathi, Erode, TamilNadu, India.
V. Mathankumar
*3 UG Student, Department of Civil Eng., Erode Sengunthar Engineering college, Thudupathi, Erode, TamilNadu, India
M. Preethi
*4 PG Student, Department of Civil Eng ,Erode Sengunthar Engineering college, Thudupathi, Erode, TamilNadu, India

Abstract: - *Cold formed steel purlins are the widely used structural elements in India. Practically 'Z' sections are provided, where the span of the roof purlins is sloped and the length of the span is maximum. The objective of this investigation is to study the behaviors of cold formed steel 'Z' and "C" purlin sections.To determine the maximum load carrying capacity of the specimens and then study the possible modes of failure of the members. The Effective Width Method (i) ignores inter-element (e.g., between the flange and the web) equilibrium and compatibility in determining the elastic buckling behavior, (ii) incorporation of competing buckling modes, such as distortional buckling can be awkward, (iii) cumbersome iterations are required to determine even basic member strength, and (iv) determining the effective section becomes increasingly more complicated as attempts to optimize the section are made, e.g., folded-in stiffeners add to the plates which comprise the section and all plates must be investigated as being potentially partially effective. The Effective Width Method is a useful design model, but it is intimately tied to classical plate stability, and in general creates a design methodology that is different enough from conventional (hot rolled) steel design that it may impede use of the material by some engineers in some situations.*

***Key Words**: Cold formed steel, C purlin, Z purlin, Effective width methods, Load carrying capacity.*

1. COLD FORMED STEEL

Cold-formed steel products find extensive application in modern construction in both low-rise and high rise steel buildings. In Today's scenario of rising cost of steel, it is most essential to use such products that provide optimum utilization such as least possible weight without compromising on the strength and custom lengths and punches for faster application and installation. Cold Roll Formed sections are the perfect replacement for the heavy, unviable traditionally formed sections. Cold-formed sections hold a superior edge in comparison to other traditionally produced sections.

The thickness of steel sheet used in cold formed construction is usually 1 to 3 mm. Much thicker material up to 8 mm can be formed if pre-galvanised material is not required for the particular application. The yield strength of steel sheets used in cold-formed sections is at least 280 N/mm^2. Galvanizing (or zinc coating) of the preformed coil provides very satisfactory protection against corrosion in internal environments. A coating of 275 g/m^2 (total for both faces) is the usual standard for internal environments. This corresponds to zinc coating of 0.04 mm.

The design of cold-formed members differs from that of conventional steel structures and therefore need special considerations. In most cases cold-formed members exhibit complex behaviour governed by interacting local and global stability phenomena. Conventional design approaches lead in these cases usually to a conservative design since the complex behaviour can only be approximated from the safe side. Also, the calculations easily become very time consuming, while the gain – i.e. savings on mass – is not always proportional with the efforts.

1.1 MANUFACTURING METHODS

Cold forming is the term used to describe the manufacture of products by forming material in the cold state from a strip or sheet of uniform thickness, the main methods used are

- Folding
- Press-braking and
- Rolling.

1.2 LIPPED CHANNEL SECTION (C SECTION)

C section steel processed from the hot coil, thin-wall light weight, excellent cross-section, high strength, compared with the traditional channel, the same material strength can save 30%.

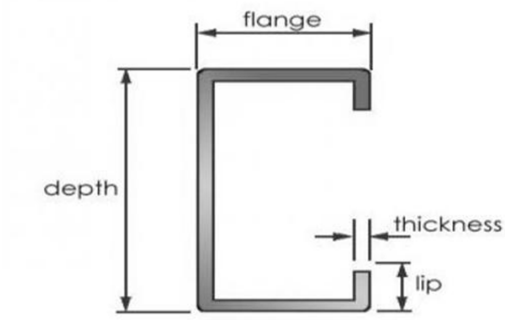

Fig 1: C section

Widely used for steel building purlin, wall beam, can also be combined into lightweight roof truss, brackets and other architectural elements. In addition, is available in column, beam and arm for light industry machinery manufacturing.

1.3 Z SECTION

Z Section Steel as a kind of common thin-walled cold-formed steel, Z section steel comes with 1.6-3.0mm in thickness and 120-350mm in height. It is manufactured by hot rolling. This product usually finds its application in large span steel structure workshop.

Fig 2: Z section

1.4 MAIN CHARACTERISTICS OF COLD-FORMED THIN-WALLED MEMBERS

The unique properties of thin-walled cold-formed C-section members originate from three factors

- The fabrication process
- The small thickness and
- High slenderness of the elements of the cross-section.

Cold-formed members are fabricated at room temperature, by introducing big plastic deformations to the base material. The most widely used fabrication technique used is cold roll forming. This technique uses rolled-up steel stripes feeded to 6-15 pairs of rolls – depending on the complexity of the cross-section to be made, that progressively form the stripe in the desired shape.

- Sections produced this way may be almost of arbitrary shape, but there are some common properties that helps identify them.
- Cold-formed sections have the same thickness in all their plates and usually the same radii in all edge regions,
- Plate thickness is usually not bigger than 3.50 mm,
- Width-to-thickness ratios of stiffened plates are usually between 80 and 250.

1.5 CONVENTIONAL COLD FORMED STEEL SECTION TYPES

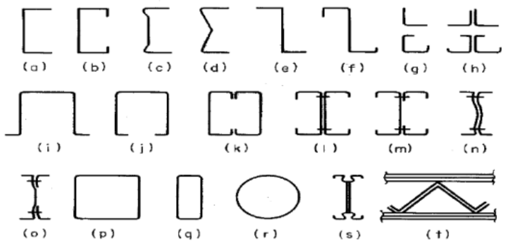

Fig 3: Commonly used cold formed sections

The use of cold formed steel structures is increasing rapidly around the world. The main use of cold formed steel members is found in the construction of residential and other low rise buildings such as commercial, industrial and institutional buildings. Some of the commonly used cold formed section types are given in fig.

1.6 ADVANTAGES OF COLD FORMED STEEL SECTIONS

- ✓ Better strength to weight ratio.
- ✓ High rigidity due to use of High Tensile Steel saves weight and hence, cost.
- ✓ Flexibility in thickness and custom lengths can be offered.
- ✓ Complex geometrical shapes can be produced.
- ✓ Closer tolerances of the produced sections.
- ✓ Better consistency and accuracy are achieved.
- ✓ Smoother and Better surface finish.
- ✓ Sections directly from Galvanized or Color Coated coils can be formed.
- ✓ On-line cutting and custom punching increases production speed and cost.

- ✓ Better and consistent chemical and mechanical properties achieved.

2. THEORETICAL INVESIGATION

2.1 DESIGN METHODS

- Effective width method
- Direct strength method

2.1.1 EFFECTIVE WIDTH METHOD

Currently the design of thin walled cold formed steel members for local buckling relies on the effective width approach. This powerful empirical method has been used successfully since the inception of the cold formed steel design specification in the 1940's and continues to be used in the design of a variety of thin walled structures. The method allows for the strength reduction due to local plate buckling by using a reduced (or effective) width for each element of a member.

Where the flat width of an element is reduced for design purposes, the reduced design width *b* is termed as the effective width or effective design width.

2.1.2 DIRECT STRENGTH METHOD

This is a design methodology that has been adopted by the North American Cold-Formed Steel Specification as an alternative method to the traditional effective width design approach. The DSM does not require effective width calculations or iterations, but instead uses gross properties and the elastic buckling behaviour of the cross-section to predict the member strength. With the assistance of computer software, this design procedure is applicable to cold-formed steel prismatic members with virtually any cross- section configuration and will result in a more reliable and realistic design. Research work has extended this design method to perforated members such as studs with web openings or rack structural members with patterned cut outs.

2.2 MODES OF FAILURE

There are three basic modes of buckling for cold-formed members.

- ➢ Local buckling
- ➢ Distortional buckling
- ➢ Flexural-Torsional buckling

2.2.1 LOCAL BUCKLING

Local buckling, a mode involving plate flexure alone without transverse deformation of the line or lines of intersection of adjoining plates.

2.2.2 DISTORTIONAL BUCKLING

Distortional buckling, a mode of buckling involving buckling of flange and web at same wavelength, resulting a change in cross-sectional shape excluding local buckling.

2.2.3 FLEXURAL-TORSIONAL BUCKLING

Flexural-Torsional buckling, sometimes also called torsional-flexural, a mode in which compression members can bend and twist simultaneously without change of cross-sectional shape.

The difference of these three buckling modes under compression and bending and comparison of these buckling modes by means of critical buckling stresses and halve-wavelength as shown below.

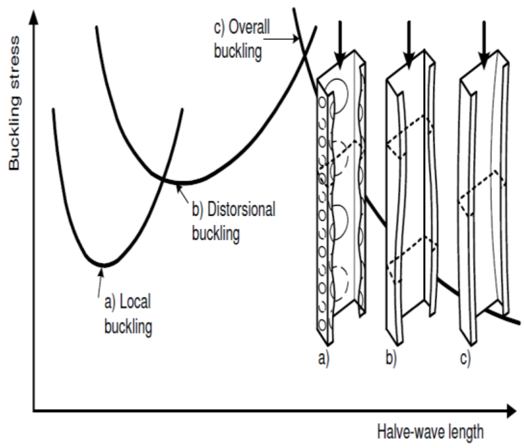

Fig 4: Difference of these three buckling modes

2.3 DESIGN OF THE SECTION

2.3.1 PROPERTIES OF LIPPED CHANNEL SECTION

Data

Span (L)	=	1500mm
Width of flanges	=	70mm
Depth of the section	=	150mm
Width of lips	=	25mm
Grade of steel	=	st42
Yield strength	=	240MPa
Elastic modulus	=	2.05×10^{5}MPa

TO FIND OUT THE EFFECTIVE SECTION MODULUS

Table 1: Properties of lipped channel section

ELEMENTS	A_i (mm^2)	y_i (mm)	$A_i y_i$ (mm^3)	$I_g + A_i y_i^2$ (mm^4)
Top lip	47.04	62	2916.48	2258+180822
Compression flange	133.28	74	9862.72	43+729841.3
Web	290.08	0	0	529493+0
Tension flange	133.28	-74	-9862.72	43+729841.3
Bottom lip	47.04	-62	-2916.48	2258+180822
∑	650.72	0	0	2355422

Second moment of area of effective section

$I_{zr}' = 235.54 \times 10^4$ mm^4

Second moment of area of gross section

$I_{zr} = 232.1 \times 10^4$ mm^4

Effective section modulus $Z_{zr} = 31.364 \times 10^3$ mm^3

2.3.2 PROPERTIES OF COMPLEX EDGE STIFFENED SECTION

Data

Span (L) = 1500mm

Width of flanges = 81mm

Depth of the section = 95mm

Width of lips = 29.5mm

Width of lips = 20.6mm

Grade of steel = st42

Yield strength = 240MPa

Elastic modulus = 2.05×10^5MPa

TO FIND OUT THE EFFECTIVE SECTION MODULUS

Table 2: Properties of complex edge stiffened section

ELEMENTS	A_i (mm^2)	y_i (mm)	$A_i y_i$ (mm^3)	$I_g + A_i y_i^2$ (mm^4)
Extra top lip	38.416	69	2651	12.3+182899
Top lip	53.9	82.75	4460.23	3397+369084
Compression flange	154.84	96.5	14942.1	49.56+1441909
Web	378.28	0	0	1174213+0
Tension flange	154.84	-96.5	-14942.1	49.56+1441909
Bottom lip	53.9	-82.75	-4460.23	3397+369084
Extra bottom lip	38.416	-69	-2651	12.3+182899
∑	872.6	0	0	5168915

Second moment of area of effective section

$I_{zr}' = 516.89 \times 10^4$ mm^4

Second moment of area of gross section

$I_{zr} = 486.33 \times 10^4$ mm^4

Effective section modulus $Z_{zr} = 50.4 \times 10^3$ mm^3

2.3.3 PROPERTIES OF LIPPED Z SECTION

Data

Span (L) = 1500mm

Width of flanges = 75mm

Depth of the section = 200mm

Width of lips = 16mm

Grade of steel = st42

Yield strength = 240MPa

Elastic modulus = 2.05×10^5MPa

TO FIND OUT THE EFFECTIVE SECTION MODULUS

Table 3: Properties of lipped Z section

ELEMENTS	A_i (mm^2)	y_i (mm)	A_iy_i (mm^3)	I_g+ A_i y_i^2 (mm^4)
Top lip	29.4	91.5	2690.1	551.25+246144.15
Compression flange	143.08	99	14165	46+1402327.08
Web	388.08	0	0	1267857.36+0
Tension flange	143.08	-99	-14165	46+1402327.08
Bottom lip	29.4	-91.5	-2690.1	551.25+246144.15
∑	733.04	0	0	4565993.26

Second moment of area of effective section

$I_{zr}' = 456.59 \times 10^4$ mm^4

Second moment of area of gross section

$I_{zr} = 427.3 \times 10^4$ mm^4

Effective section modulus $Z_{zr} = 43.2 \times 10^3$ mm^3

The above sections are designed based on the effective width method.

3. APPLICATIONS OF COLD FORMED STEEL

In building construction, cold-formed steel products are mainly used as structural members, diaphragms and coverings for roofs, walls and floors.

They have been grouped into the major areas of:

- Compression members
- Distortional and element buckling
- Corrugated and curved panels
- Flexural members and purlins
- Torsion and distortion
- Web crippling
- Connections and fasteners
- Mechanical properties
- Composite and plasterboard construction
- Storage racks.

4. RESULTS

The design results of above sections are as follows.

Table: Results of channel section

SECTIONS	EFFECTIVE WIDTH OF AN ELEMENTS (mm)				P_b (kN)
	Web	Flanges	Lips	Extra lips	
Lipped channel section	109.2	58.8	19.8	-	258
Complex edge stiffened section	110.5	62.13	19.45	15.59	442
Lipped Z section	111.24	59.84	11	-	250

CONCLUSIONS

The cold forming operation increases the yield point and ultimate strength of the steel sections. As compared with thicker hot-rolled shapes, more economical design can be achieve for relatively light loads and / or short spans.

REFERENCES

[1] Atis Dandens, Janis Kreilis, Guntis Andersons. "Properties of cold-formed steel sections". 3rd International Conference. pp no: 166-170.

[2] Cheng Yu, Weiming Yan (2011). "Effective Width Method for determining distortional buckling strength of cold-formed steel flexural C and Z sections". Journal of Thin-Walled Structures. Vol no. 49, pp no: 233–238.

[3] Haiming Wang, Yaochun Zhang (2009). "Experimental and numerical investigation on cold-formed steel C-section flexural members". Journal of Constructional Steel Research. Vol no. 65, pp no: 1225-1235.

[4] Karunakaran M and Helen Santhi M (2013). "FE Analysis of Hollow Flanged Cold-Formed Steel 'Z' Beams". International Journal of Civil Engineering and Applications. Vol no. 3, pp. 1-6.

[5] Vijayasimhan M, Marimuthu V, Palani G.S. and Rama Mohan Rao P (2013). "Comparative Study on Distortional Buckling Strength of Cold-Formed Steel Lipped Channel Sections". Research Journal of Engineering Sciences. Vol no. 2, pp no : 10-15.