Parametric Study of Cold Form Channel Section with and Without Stiffener under Pure Torsion

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Abstract - *The progress in the construction has lead to light weight construction that has enhanced the significance of the light gauge steel sections in the construction industry. The sections are open in nature but the load carrying capacity is enhanced using less thickness of the steel. The steel sheets of .8 to 3 mm are roll and the sections are prepared. This improves the section modulus of the section which ultimately improves the load carrying capacity of the section. Due to its open in nature the shear centre and the centroid of the section does not match which leads to the development of the torque forces in the section even under flexural loading. The eccentricity develops torsional moment in the section and this fallout in the distortional buckling in succession with the flexural failure. In this dissertation work we have studied the effect of the torsional loading on the light measure channel section. Five different specimens of the channel section where considered with in addition to without lip, v-stiffeners and rectangular stiffeners for deriving the ultimate moment carrying capacity and angle of rotation of the section. The analysis and design of the channel section was done using code is 801-1975 while the analytical work was carried out using finite element method with ABAQUS software. Further the experimental validation was done using true length specimen and setup was prepared for the pure torsion loading. The results of this experimental investigation indicated that the torsional capacity of the light gauge channel section is enhanced by using different stiffener and lips.*

Key Words: (Channel Section, Stiffeners, Torsion, ABAQUS Software)

1 INTRODUCTION

In recent decades the interest of the building sector is tending towards the lightweight construction so as to overcome the faults of the last decades. The Major advantage of CFS beams over hot rolled beams is to be found in the relative thickness of the material from which the sections are formed. This will lead to having highly effective in terms of weight and efficient member and structures. However, the promising advantages of the thin walls can only be partially obtained. To obtain these advantages, the designer must be aware of the importance associated with thin-walled members and their effects on analysis and design. The most important of these phenomena is local buckling.

In most frequent applications purlins, floor joists and wall studs, the loading and restraint are both continuous, both of which are self-equilibrating to some extent so that the tendency to wind is greatly reduced. Rational methods of analysis in these situations are exceedingly complicated and design usually proceeds on the foundation of test consequences. In this study, continuous restraint is not considered and attention is confined to cases where light gauge steel members are free of charge to twist between discrete points of restraint.

1.1 Effects of perforations

In practice, perforations are either pre-punched or punched onsite on the cold formed sections, to pass through conduits, utility ducts, etc. The presence of perforations in a structural member has often created a number of problems and drawbacks and complicates the design process. In general, the effect of perforations made specifically for fasteners such as bolts, screws, etc. On the overall strength of a structure may be neglected as holes are filled with material.

However, any other openings perforations generated and not filled with replacement material creates a reduced cross sectional area and cross sectional properties and this should be taken into account in any analysis. The effect of perforations on the structure is examined by testing and analysis. Leading design rules for cold formed steel members with perforations are largely based on empirical formulae which have been developed by numerous researchers in the past, and are limited to certain perforation sizes, shapes, orientations, and positions. These limitations have created a number of problems and can decrease the reliability of cold formed steel sections in the construction industry. The results of the investigations of cold formed steel structural members with perforations, previously conducted by various researchers, have found that a concentrated load that may potentially cause deformation of the structure is applied over perforations.

1.2 Failure modes in light gauge steel section

✓ **Local Buckling**

When an element buckles locally it does not necessarily mean that this element will collapse or loss its ability to carry loads. In fact, a plate can be allowed to take a considerably increased load beyond initial buckling before any danger of collapse occurs. This is because the deflections due to buckling are accompanied by stretching of the middle surface of the plate. It is not always possible for practical reasons to allow some elements of a structure to buckle, but if stable buckles can be tolerated, a considerable gain follows in structural efficiency. The effective width of the plate element is the function of the ratio of yield strength to the critical stress of local buckling.

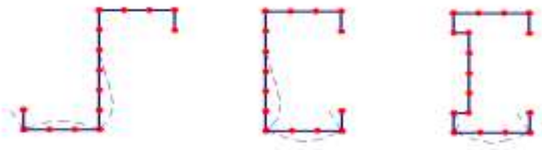

Fig - 1 Local Buckling

✓ Distortional Buckling

Distortional buckling occurs only in the structural members of open cross-sections. This buckling is characterised by the distortion of the cross-section of the structural member. The half-wavelength of the distortional buckling mode is typically several times larger than the largest characteristic dimension of the cross-section. Local buckling may interacts with the distortional mode, and the interaction reduces the capacity of cold-formed steel member.

Fig - 2 Distortional buckling

1.3 Lateral Torsional Buckling

The buckling of a strut in compression or a beam in bending is called Euler buckling or lateral-torsional buckling; Lateral-torsional buckling usually occurs when a rigid body is bent to twist and translates to have lateral movements but do not have deformation in shape of cross-section. Roof purlins and sheeting rails, in most cases, are restrained against lateral movement by roof or wall cladding, which reduce the possibility of lateral-torsional buckling, but do not necessarily eradicate the problem.

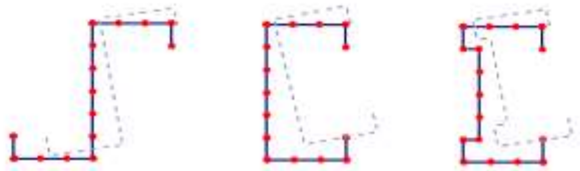

Fig - 3 Lateral Torsional buckling

2 LITERATURE REVIEW

2.1 Mohammed H. Serror, Emad M. Hassan and Sherif A. Mourad, et.al. 2016. The turning round capacity of cold-formed steel (CFS) beam has been evaluate through experimental study. Studies on different structural levels have been performing. At the ingredient level, different profile slenderness ratios have been measured, and dissimilar part shapes have been investigate by rising the number of flange bends: C-section and curved-section, which represent an infinite number of flange bends. At the association level, a web bolt moment opposed to type of association using through plate has been adopted. In web bolted relations without out-of-plane stiffeners, premature web buckling results in early loss of strength. Hence, out of- plane stiffeners have been examine to delay web and flange buckling and to produce relatively high moment power in addition to ductility. The experimental results have been compared with numerical results obtained by the authors in paperwork. The consequences revealed that rising the number of flange bends will not in all luggage enhance the behaviour. Meanwhile, the use of out-of-plane stiffeners can increase the seismic energy dissipation, the instant strength and the ductility, when compare with the case without stiffeners.

2.2 D. S. Yerudkar, G. R. Vesmawala, 2015. The aim of this report is to give a assessment of the improvement in field of cold formed steel sections. Particular emphases are given to the study of strength and behaviour of different cold shaped steel sections with flange or web stiffeners. Cold formed steel members can be plain in simple application, but if provide with flange or web stiffeners, their presentation and resistance to local, distortional and lateral torsional buckling improve. The idea behind cold-formed steel member is to use shape rather than thickness to hold load. Due to the fairly easy method of manufacturing, a big digit of different configurations can be shaped to fit the demands of optimized design for both structural and economical purposes. The direct strength method makes a more formal allowance for post-buckling and is evidently more appropriate when local buckling is important. It would seems that perhaps this would be an appropriate time to create a link between stipulation and computer packages, with exact study using accepted packages specified as complying with the plan code.

2.3 Hong-Xia Wana and Mahen Mahendran, 2015. The let Steel beam (LSB) is a cold-formed high strength steel channel section complete of two torsion ally rigid closed flanges and a slender web. Due to its mono-symmetric individuality, its centroid and shear centre perform not agree. The LSBs can be used in earth systems as joists or bearers and in this application they are often subjected to slanting loads that are practical away as of the shear centre. Hence they are often subjected to combined bending and torsion actions. Earlier research on LSBs has concerted on their bending or shear behaviour and strength, and only incomplete investigate has been undertaken on their combined bending and torsion behaviour. So in this research a series of nine experiments was first conduct on LSBs subject to combined bending and torsion. Three LSB section were experienced to collapse under eccentric load at mid-span, and appropriate results were obtain from seven tests. A special test rig was used to simulate two different eccentricities and to provide accurate simple boundary situation at the supports. Finite element models of tested LSBs were developed using ANSYS, and the final strengths, failure modes, and load–displacement curves were obtain and compare with equivalent test outcome. Finite element analysis decided well with test outcome and hence the urbanized model was used in a parametric study to examine the effects of load locations, eccentricities, and spans on the combined bending and torsion behaviour of LSBs. The communication between the final bending and torsional instant capacity was studied and a simple design rule was future. This paper presents the details of the tests, finite element analyses, and parametric study of LSBs subject to combined bending and torsion, and the results.

3 METHODOLOGY

3.1 Problem statement

The channel section with and without lips, V-stiffeners and rectangular stiffener is considered for the study. The size of the specimen is 100mmx40mmx2mm and the lip dimension is 40mmx2mm. Design is to be carried out using IS 801-1975 and analytically the finite element analysis was carried out using the ABAQUS software. The torsional capacity of the different channel section was determined on the bases of the moment carrying capacity and Angle of rotation.

3.2 Cold form channel section

Cold-formed steel structures are steel structural products that are made by bending flat sheets of steel at ambient temperature into shapes which will support more than the flat sheets themselves. They have been produced for more than a century since the first flat sheets of steel were produced by the steel mills. However, in recent years, higher strength materials and a wider range of structural applications have caused a significant growth in cold-formed steel relative to the traditional heavier hot-rolled steel structural members. Cold-formed steel members have been widely used in building applications as the secondary cladding and purlin applications as well as the primary applications as beams and columns of industrial and housing systems. Consumption rate of cold-formed steel products is growing steadily.

4 EXPERIMENTAL AND ANALYTICAL WORK

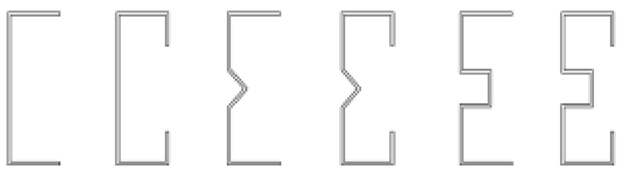

Fig - 4 Specimens of cold formed steel channel section for the experimental work

Fig - 5 Experimental Performance

5 RESULTS AND ANALYSIS

5.1 Analytical Load Carrying Capacity C Without Lip

- **C Without Lip**

Table - 1.C Without Lip

Description	Load
C Without Lip	26.140

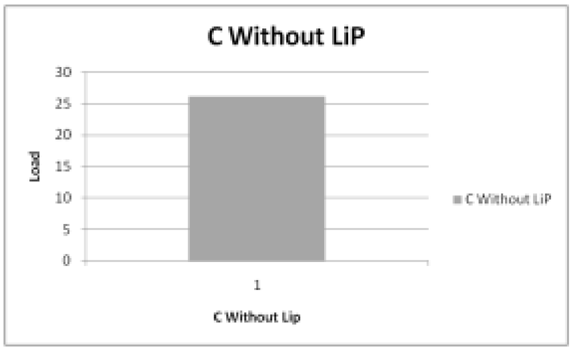

Chart - 1:C Without Lip

- **C With Lip**

Table - 2.C With Lip

Description	Load
10	28.34
20	29.65
30	29.98
40	30.10

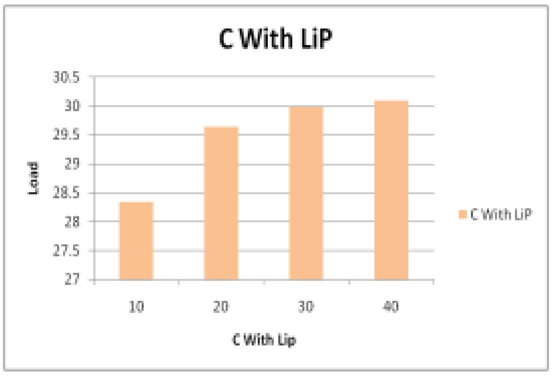

Chart - 2: C With Lip

5.2 Analytical Load Carrying Capacity C with V stiffener with & without Lip

➢ **C With V Stiffener**

Table - 3. C With V Stiffener

Description	Load
15 X 10	29.01
15 X 20	30.48
15 X 30	31.59
20 X 10	28.36
20 X 20	28.99
20 X 30	29.78
25 X 10	27.64
25 X 20	28.14
25 X 30	27.49
30 X 10	31.25
30 X 20	30.58
30 X 30	30.05

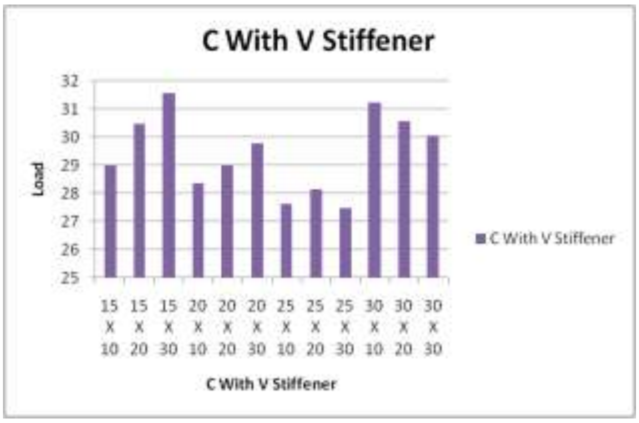

Chart - 3: C With V Stiffener

Table - 4. C With V Stiffener

Description	Load
35 X 10	26.35
35 X 20	27.95
35 X 30	29.37
40 X 10	28.37
40 X 20	27.10
40 X 30	29.37
45 X 10	30.87
45 X 20	31.68
45 X 30	28.39
50 X 10	29.54
50 X 20	27.61
50 X 30	28.24

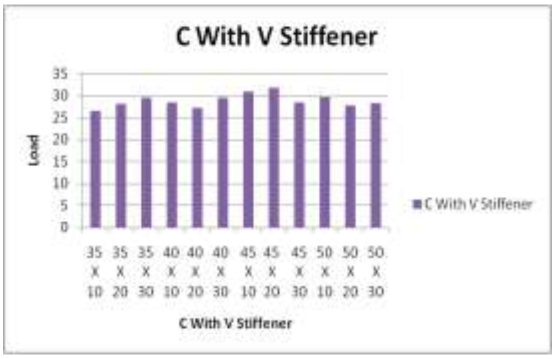

Chart - 4: C With V Stiffener

➢ **C With V Stiffener with 10mm Lip**

Table - 5. C With V Stiffener With Lip (10 mm)

Description	Load
15 X 10	29.15
15 X 20	28.34
15 X 30	30.17
20 X 10	26.67
20 X 20	28.26
20 X 30	29.36
25 X 10	28.19
25 X 20	28.99
25 X 30	29.47
30 X 10	30.87
30 X 20	31.54
30 X 30	30.05

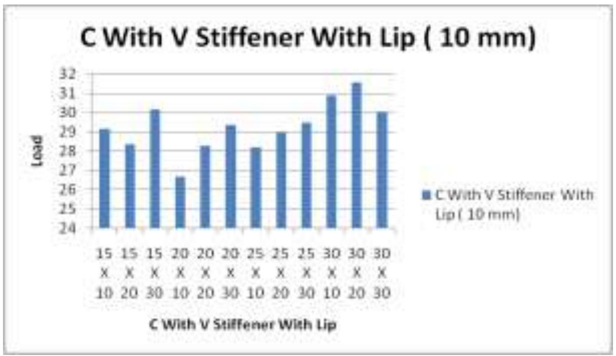

Chart - 5: C With V Stiffener With Lip(10mm)

Table - 6. C With V Stiffener With Lip (10 mm)

Description	Load
35 X 10	27.36
35 X 20	28.61
35 X 30	30.27
40 X 10	28.14

40 X 20	28.97
40 X 30	30.61
45 X 10	29.48
45 X 20	29.89
45 X 30	30.35
50 X 10	28.45
50 X 20	30.87
50 X 30	29.45

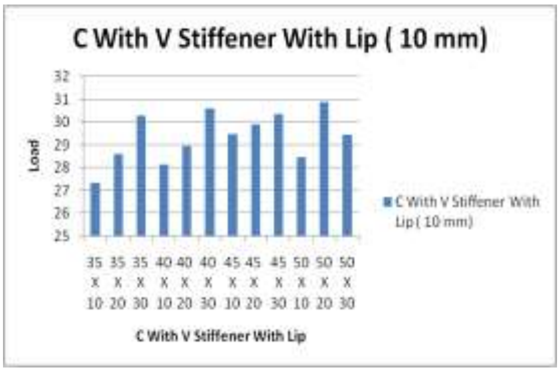

Chart - 6: C With V Stiffener With Lip (10mm)

➢ **C With V Stiffener with 20 mm Lip**

Table - 7.C With V Stiffener With Lip (20mm)

Description	Load
15 X 10	27.64
15 X 20	28.23
15 X 30	29.34
20 X 10	29.37
20 X 20	28.34
20 X 30	28.97
25 X 10	30.24
25 X 20	29.81
25 X 30	28.54
30 X 10	29.82
30 X 20	30.33
30 X 30	31.57

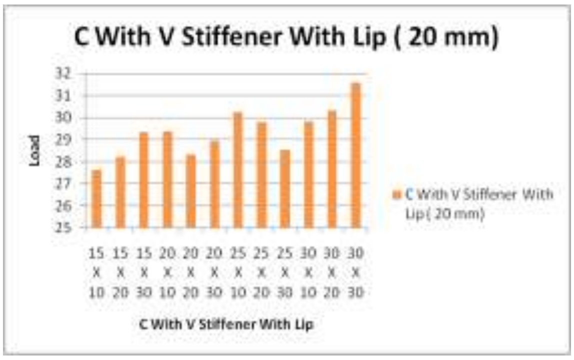

Chart - 7: C With V Stiffener With Lip (20 mm)

Table - 8. C With V Stiffener With Lip (20 mm)

Description	Load
35 X 10	30.2
35 X 20	29.34
35 X 30	28.64
40 X 10	29.87
40 X 20	29.1
40 X 30	28.64
45 X 10	28.34
45 X 20	28.2
45 X 30	27.64
50 X 10	29.31
50 X 20	28.94
50 X 30	27.18

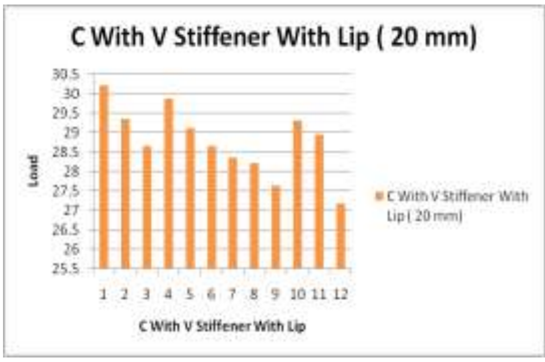

Chart - 8: C With V Stiffener With Lip (20 mm)

➢ **C With V Stiffener with 30 mm Lip**

Table - 9.C With V Stiffener with Lip (30 mm)

Description	Load
15 X 10	27.64
15 X 20	27.99
15 X 30	28.64
20 X 10	28.37
20 X 20	29.15
20 X 30	29.99
25 X 10	29.34
25 X 20	30.14
25 X 30	30.05
30 X 10	29.76
30 X 20	28.64
30 X 30	28.12

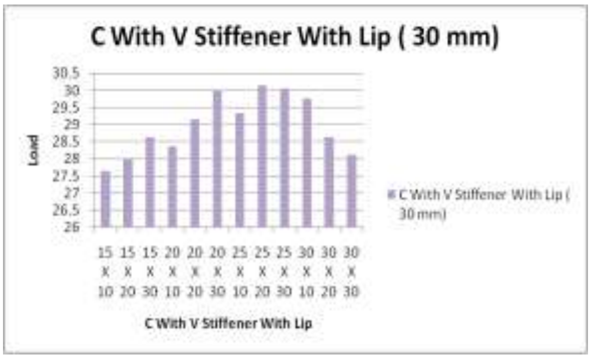

Chart - 9:C With V Stiffener with Lip (30 mm)

Table - 10.C With V Stiffener With Lip (30 mm)

Description	Load
35 X 10	29.99
35 X 20	29.16
35 X 30	28.67
40 X 10	27.2
40 X 20	28.52
40 X 30	27.61
45 X 10	29.25
45 X 20	29.45
45 X 30	29.1
50 X 10	30.12
50 X 20	29.35
50 X 30	28.64

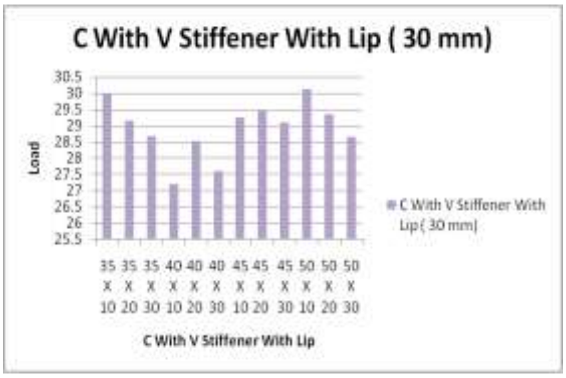

Chart - 10:C With V Stiffener with Lip (30 mm)

5.3 C With Rec. Stiffener With & Without Lip

➢ **C With Rec. Stiffener without Lip**

Table - 11.C With Rec. Stiffener Without Lip

Description	Load
15 X 10	26.94
15 X 20	27.72
15 X 30	28.34
20 X 10	27.25
20 X 20	28.61
20 X 30	29.87
25 X 10	30.14
25 X 20	29.67
25 X 30	28.58

30 X 10	27.81
30 X 20	28.52
30 X 30	29.63

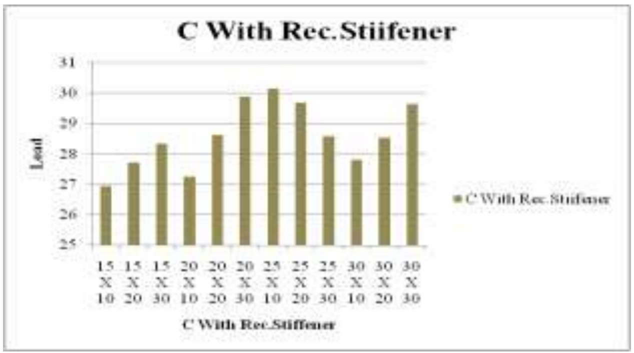

Chart - 11: C With Rec. Stiffener

Table - 12. C With Rec. Stiffener without Lip

Description	Load
35 X 10	30.15
35 X 20	29.89
35 X 30	29.61
40 X 10	30.05
40 X 20	29.81
40 X 30	29.32
45 X 10	29.97
45 X 20	30.21
45 X 30	29.36
50 X 10	30.01
50 X 20	29.94
50 X 30	29.78

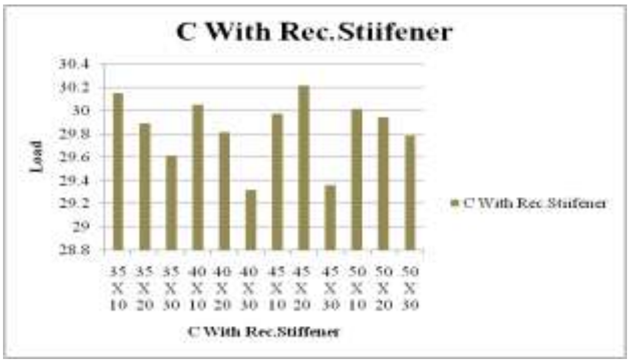

Chart - 12: C With Rec. Stiffener without Lip

➢ **C With Rec. Stiffener with Lip (10mm)**

Table - 13. C With Rec. Stiffener With Lip (10 mm)

Description	Load
15 X 10	27.31
15 X 20	28.64
15 X 30	29.36
20 X 10	29.78
20 X 20	29.99
20 X 30	29.64
25 X 10	27.69

25 X 20	28.31
25 X 30	29.34
30 X 10	26.85
30 X 20	27.69
30 X 30	28.54

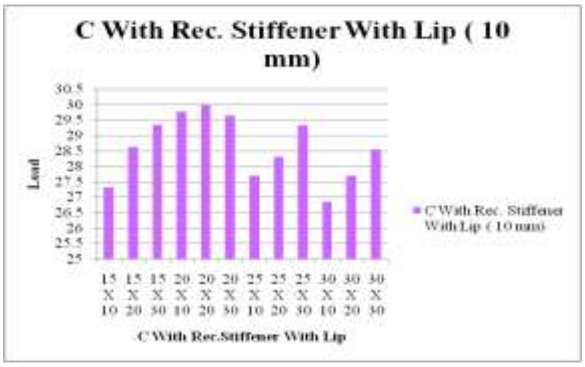

Chart - 13: C With Rec. Stiffener With Lip (10 mm)

Table - 14.C With Rec. Stiffener With Lip (10 mm)

Description	Load
35 X 10	27.31
35 X 20	27.94
35 X 30	28.85
40 X 10	28.76
40 X 20	29.24
40 X 30	29.64
45 X 10	28.61
45 X 20	27.98
45 X 30	28.61
50 X 10	27.12
50 X 20	28.86
50 X 30	29.23

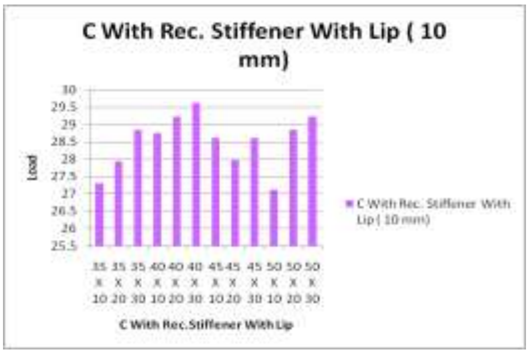

Chart - 14: C With Rec. Stiffener With Lip (10 mm)

- **C With Rec. Stiffener with Lip (20mm)**

Table - 15.C With Rec. Stiffener with Lip (20 mm)

Description	Load
15 X 10	27.13
15 X 20	27.87
15 X 30	28.31
20 X 10	27.69
20 X 20	28.61
20 X 30	29.2
25 X 10	28.34
25 X 20	28.59
25 X 30	29.18
30 X 10	28.95
30 X 20	29.18
30 X 30	30.51

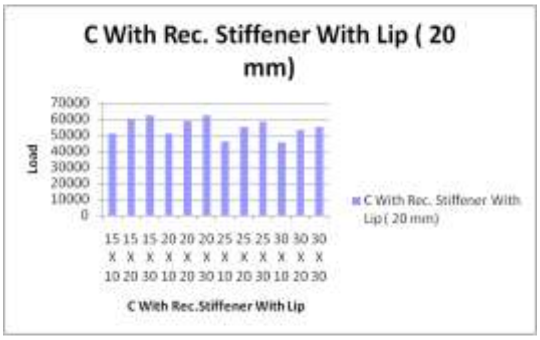

Chart - 15: C With Rec. Stiffener With Lip (20 mm)

Table - 16.C With Rec. Stiffener with Lip (20 mm)

Description	Load
35 X 10	30.14
35 X 20	29.95
35 X 30	29.64
40 X 10	29.37
40 X 20	28.94
40 X 30	28.73
45 X 10	29.43
45 X 20	28.14
45 X 30	27.54
50 X 10	29.81
50 X 20	28.94
50 X 30	28.37

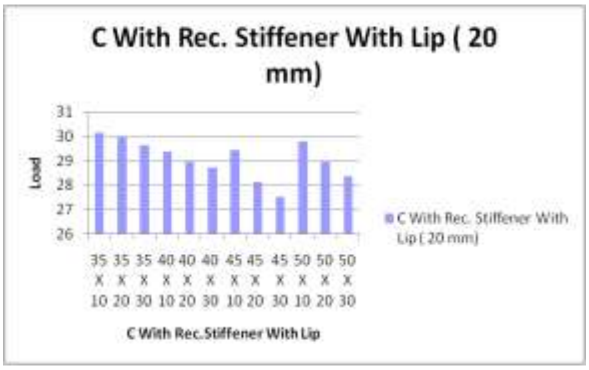

Chart - 16: C With Rec. Stiffener With Lip (20 mm)

- **C With Rec. Stiffener With Lip (30 mm)**

Table - 17.C With Rec. Stiffener with Lip (30 mm)

Description	Load
15 X 10	29.61
15 X 20	29.45
15 X 30	28.31

20 X 10	28.34
20 X 20	28.96
20 X 30	30.24
25 X 10	29.91
25 X 20	28.8
25 X 30	27.41
30 X 10	28.91
30 X 20	29.17
30 X 30	30.15

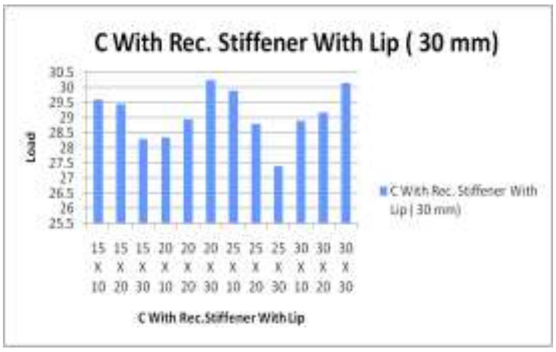

Chart - 17: C With Rec. Stiffener with Lip (30 mm)

Table - 18. C With Rec. Stiffener with Lip (30 mm)

Description	Load
35 X 10	27.36
35 X 20	27.91
35 X 30	28.48
40 X 10	28.37
40 X 20	28.61
40 X 30	29.14
45 X 10	28.42
45 X 20	29.67
45 X 30	30.54
50 X 10	29.76
50 X 20	30.78
50 X 30	30.91

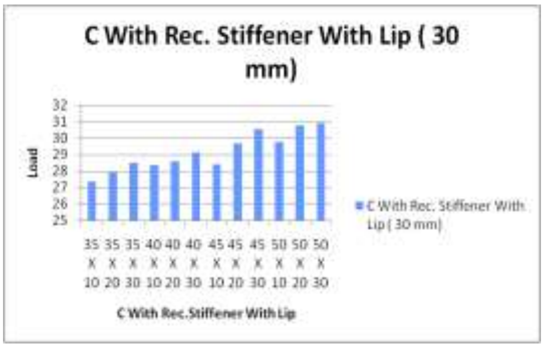

Chart - 18: C With Rec. Stiffener with Lip (30 mm)

5.4 Comparison of Analytical and Experimental Results

Table - 19. Comparison of Analytical and Experimental

Sr. No	Content	Abaqus	Experimental
1	C Without Lip	26.14	23.6
2	C With Lip	29.65	25.8
3	C With V Stiffener Without Lip	31.59	26.1
4	C With V Stiffener With Lip	28.97	27.7
5	C With Rectangular Stiffener Without Lip	29.87	29.2
6	C With Rectangular Stiffener With Lip	29.2	30.4

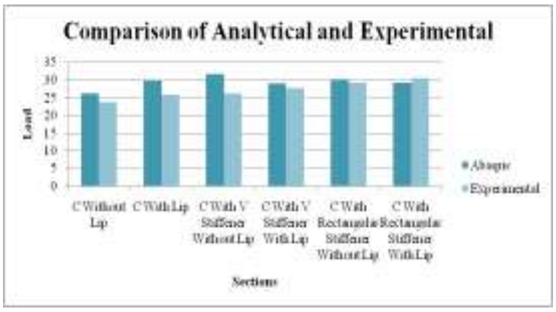

Chart - 19: Comparison of Analytical and Experimental

6 CONCLUSIONS

These studies are the current fire resistance guidelines are very restrictive in applications and cannot be used under performance-based codes. The following points are conducted from the analysis results and discussion.

a. The C section with lip Section in which Load carrying capacity of more for 40 mm lip is 30.10 & load carrying capacity less for 10mm lip is 28.34.
b. The C section with V stiffener without lip in which Load carrying capacity of more in this table is 31.68 of 45 X 20mm size stiffener & less is 26.35 of 35 X 10mm size stiffener.
c. The C section with V stiffener with 10mm, 20mm, 30mm lip. In which 20mm lip Stiffener Carrying more capacity than 10mm and 30m. Load carrying capacity of more in this table is 31.57 of 30 X 30mm size stiffener & less is 27.64 of 15 X 10mm size stiffener.
d. The C section with Rectangular stiffener without lip in which Load carrying capacity of more in this table is 30.21 of 45 X 20 mm size stiffener & less is 26.94 of 15 X 10mm size stiffener.
e. The C section with Rectangular stiffener with10mm, 20mm and 30mm lip. In which 30mm lip is more load carrying than 10mm, 20mm lip. Load carrying capacity of more in this graph is 30.91of 50 X 30 mm size stiffener & less is 27.36 of 35 X 10 mm size stiffener.

f. The C section with Double V stiffener without slip in Load carrying capacity of more in this table is 28.97of 20 X 20 mm size stiffener & less is 27.61 of 15 X 10 mm size stiffener.
g. The C section with Double V stiffener with 10mm, 20mm, 30mm lip. In which 30mm lip section carrying more load. The 30mm lip Load carrying capacity of more in this table is 29.2 of 15 X 10 mm size stiffener & less is 26.2 of 15 X 10 mm size stiffener.
h. The C section with Double Rectangular stiffener without lip. Load carrying capacity of more in this table is 30.02 of 25 X 30 mm size stiffener & less is 26.43 of 15 X 10 mm size stiffener.
i. The C section with Double Rectangular stiffener with 10mm, 20mm, 30mm lip. Load carrying capacity of more of 30mm lip in this Load carrying capacity of more in this table is 30.31 of 25 X 30 mm size stiffener & less is 26.94 of 15 X 10 mm size stiffener

7 REFERENCES

[1] Arvin Patrick Yu, Dr. Bernardo A. Lejano, “Investigation of the Strength of Cold-Formed Steel C-Section in Compression”, Research Congress 2014.

[2] B. P. Gotluru, B.W. Schafer and T. Pekoz, "Torsion in Thin-Walled Cold-Formed Steel Beams", Thin-Walled Structures, Vol- 37, pp-127–145, 2000.

[3] Chong Ren, “Structural Behaviour Of Cold-Formed Steel Purlin-Sheeting Systems Under Uplift Loading”, 2012.

[4] D. S. Yerudkar, G. R. Vesmawala, “Strength And Behavior Of Cold Formed Steel Stiffened Sections Under Interaction Of Local, Distortional And Lateral Torsional Buckling: A Review”, International Journal Of Civil And Structural Engineering Research, ISSN 2348-7607, Vol. 3, Issue 1, Pp-234-250, 2015.

[5] Hancock. G. J., Kwon. Y. B, and. Stephen Bemard E “Strength Design Curves for Thin-Walled Sections Undergoing Distortional Buckling”, Journal of Constructional steel and Research, Vol. 31 (2-3), Pp 169-186, 1994.

[6] Hong-Xia Wana and Mahens Mahendran, "Bending and Torsion of Hollow Flange Channel Beams", Engineering Structures, Vol. 84, pp-300–312, 2015.

[7] Mohammed H. Serror, Emad M. Hassan and Sherif A. Mourad, "Experimental Study on the Rotation Capacity of Cold-Formed Steel Beams", Journal of Constructional Steel Research, vol. 121, Pp. 216–228, 2016.

[8] Murat Pala, "Genetic Programming-Based Formulation for Distortional Buckling Stress Of Cold-Formed Steel Members", Journal of Constructional Steel Research, Vol-64, pp-1495–1504, 2008.

[9] Pedro B. Dinis and Dinar Camotim, "Post-Buckling Behaviour and Strength of Cold-Formed Steel Lipped Channel Columns Experiencing Distortional/Global Interaction", Computers and Structures, Vol - 89, Pp – 422 – 434, 2011.

[10] R. Kandasamy, R. Thenmozhi, L. S. Jeyagopal, “Flexural-Torsional Buckling Tests Of Cold-Formed Lipped Channel Beams Under Restrained Boundary Conditions”, International Journal of Engineering and Technology (IJET), Vol - 6 No 2 Apr-May 2014.

[11] Zhou Feng and Lu Li, "Experimental Study On Hysteretic Behavior Of Structural Stainless Steels Under Cyclic Loading", Journal of Constructional Steel Research, Vol. 122, pp-94–109, 201.