

Behaviour of the Cold Form Channel Section with and Without Stiffener under Pure Torsion

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ABSTRACT: The use of the cold form steel section in the building sectors is growing in day to day life. As they can be used as the individual members and are applicable in any size and shape. These shapes are open in nature they are designed with the consideration of the beam loading but at times it undergoes the torque as the shear centre and the centroid do not intersect. Up till now the flexure behaviour of the cold form steel is studied so in this paper the torsional behaviour of the cold form steel in the ABACUS software. The effect of the eccentric loading is studied on the beam designed as the flexural member. For the study the channel section is considered with the different stiffener. The study was conducted to observe the behaviour of the cold form channel section under pure torsion.

KEYWORDS: Horizontal Shear, cold form channel section, torsion, stiffeners.

I. 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 light weight and faster construction is the demand of the era. This has led to the increase in use of the cold form steel structure as they satisfy the demand of the light weight and faster construction. Though there are several advantages of the light gauge steel section they are partially obtained due to the unawareness of the designer about the behaviour of the section. Therefore it is necessary to study the behaviour of the light gauge section under loading which will help in achieving the good performance of the structure. The important points to be noted by the designer are that:

- The section is open in nature and as the shear centre lies out of the section it is difficult to match the centroid and the shear centre which lead to the torque in the section.
- The torsion factor of the section is directly proportional to the cube of the thickness of the section.
- The torque generated will induce the longitudinal stress additive to the primary stress.

This led the scope to understand the torsional behaviour of the cold form steel section its behaviour and capacity to sustained the eccentric loading. In this we will study the channel section with and without stiffener under pure torsion condition. This will help in understanding the behaviour of the cold form channel section with different stiffeners and its reduction the twisting moment. It is important in case of the overhang portion of the beams these parts of the beam undergo the same behaviour.

II. RELATED WORK

Dinar Camotim and Pedro Dinis[1], studied the distortional buckling of the lipped channel section under compression. They also studied the post buckling phenomenon of the channel section with the consideration of lip and without lipped section. Chong Ren, Xianzhong Zhao and Yiyi[2], Chen studied the buckling behavior of the partially restrained cold form steel Z purlins subjected to transverse disturbed uplift loading. They concluded the uplift loading causes the different distortions in the cross section of the purlin and also affects the post buckling behavior of the beam. Hence they introduced the new modified design curve for the buckling. Feng Zhou and Lu Li studied [3] the behavior of the stainless

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steel under the cyclic loading and they found that the stainless steel shows very good hysteresis behavior as the hysteresis graph for the section plump, stable and symmetric for the considered specimen.

This gives us the idea that the study of the behaviour of the cold form steel is completed in the flexure compression under cyclic loading but the gap study of the cold form steel under torsion. Though it undergoes the torsion effect in the flexural loading the capacity to handle the torsional load is important.

III. COLD FORM CHANNEL SECTION

Thin-walled, cold-formed steel sections are commonly used in the construction of modern industrial and residential buildings as sheeting and decking, purlins and sheeting rails, wall studs, storage racking and shelving. The most popular products are roof purlins and sheeting rails which account for a considerable proportion of cold-formed steel usage in buildings. Cold-formed roof purlins and sheeting rails are usually used as the intermediate members between the main structural frame and the corrugated roof or wall sheeting in buildings.

Trapezoidal sheeting is usually fixed to these members in order to enclose the building. The most common sections are the Z, channel and Σ shapes, which may be plain or have stiffened lips. The lips are small additional elements provided to a section to improve its efficiency under compressive loads.

A. LOCAL BUCKLING

Local buckling is characterised by ripples of relatively short half-wavelength of the order of magnitude of individual plate elements and the displacements are only perpendicular to plate elements while the fold lines remain straight. The possibility of such situation is only when the plates are under compression loading which is so called because the length of the buckles which form is similar to the dimensions of the cross-section rather than the length of the structural member. When an element buckles locally it does not necessarily mean that this element will collapse or lose 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.

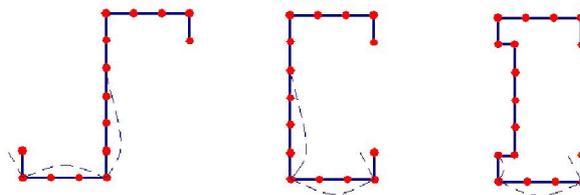


Fig. 1 Local Buckling

B. 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 interact with the distortional mode, and the interaction reduces the capacity of cold-formed steel member. The reason for the interaction of the distortional and local buckling is that the behaviour of post-distortional buckling is normally stable and in-plane deformations leads to membrane stresses becoming yield and failure in the member.

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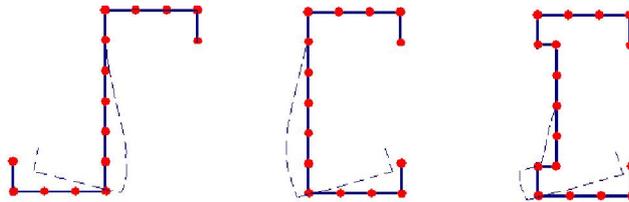


Fig. 2 Distortional Buckling

C. LATERAL TENSIONAL 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 translate 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. For example, under wind uplift, the unrestrained flange still has compression to produce lateral-torsional buckling. For short lengths of the member the first buckling mode is local, but for longer members lateral-torsional buckling occurs first. In cases of members with continuous restraint, the lateral-torsional buckling capacity reaches a minimum value over the finite length of the beam, whereas in the absence of restraint the buckling capacity decreases indefinitely with length.

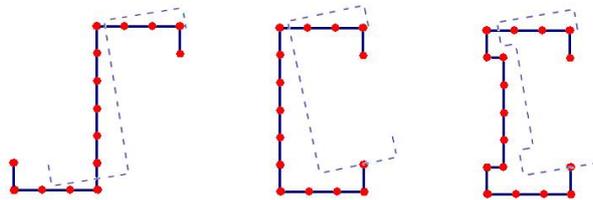


Fig. 3 Lateral Torsional Buckling

IV. TORSION BEHAVIOUR OF THE CHANNEL SECTION

Thin-walled, cold-formed steel has wide applications in building structures. In general, cold-formed steel beams have open sections where the centroid and shear center do not coincide. When a transverse load is applied away from the shear center it causes torque. Because of the open nature of the sections, this torque induces warping in the beam. The magnitude of the warping stresses can be as high as the bending stresses in some cases. If the beam is not continuously restrained against torsion and lateral movement, it may fail in non-uniform torsion, i.e. torsion combined with warping. Singly symmetric columns may fail either By Euler buckling about an axis perpendicular to the line of symmetry

By a combination of bending about the axis of symmetry and a twist this latter type of behaviour is known as torsional-flexural behaviour. Purely torsional and purely flexural failure does not occur in a general case. Cold formed sections are mainly formed with "open" sections and do not have high resistance to torsion. In general, when examining torsional behavior of thin walled sections, the total torsion may be regarded as being made up of two effects:

- St. Venant's Torsion or Pure Torsion - Produces shear stresses, which vary linearly through the material thickness.
- Warping Torsion - Produces in-plane bending of the elements of a cross section, thus inducing direct (i.e. Normal) stresses and the angle of twist increases linearly.

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V. RESULT USING ABACUS

For the study the channel section are considered with the different stiffeners. The size of the channel section is 100x40x2 mm of the galvanized steel material fe245. Five different cases are studied using the abacus software for the torsional capacity of the section. The channel sections are compared with the moment carrying capacity and the angle of the rotation. The angle of the rotation is measured on both the side of the section. The loading is done on the cantilever part of the section as shown in fig due to this type of loading the twisting moment is generated. The finite element analysis is nonlinear dynamic analysis which gives the actual performance of the element at the instance of the loading this helps us to forecast the behaviour of the member under loading.

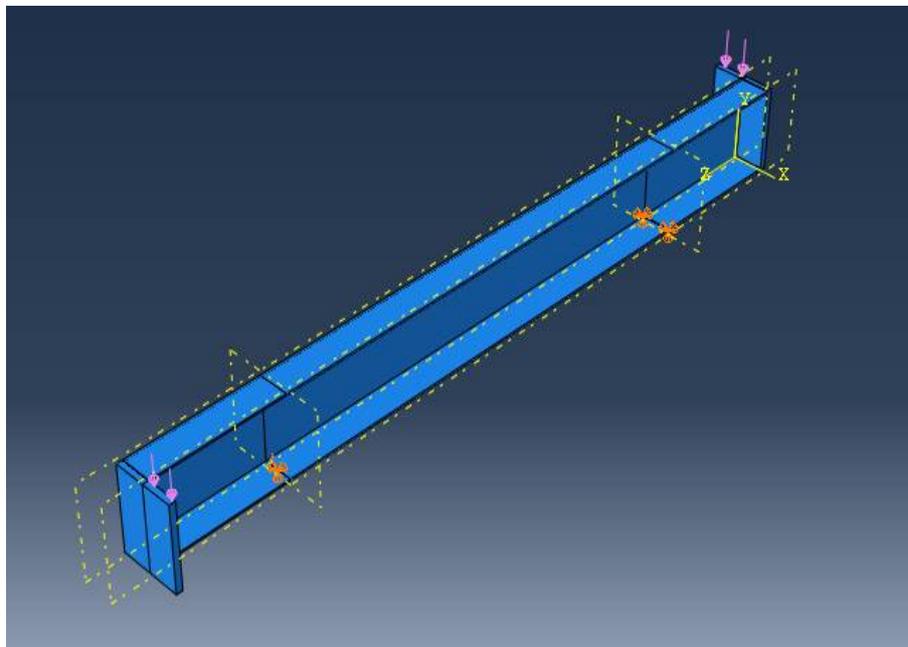


Fig. 4 Loading in Abacus

Table No.1 Comparison of moment carrying capacity and Angle of Rotation

Description	Moment Carrying Capacity	Angle Of Rotation
C without lip	16.29	21
C with lip	19.63	17
C with V stiffner	24.28	13.28
C with V stiffner and lip	23.63	10.65
C with Rectangular stiffner	32.6	6.56
C with Rectangular stiffner and lip	39.65	6.5

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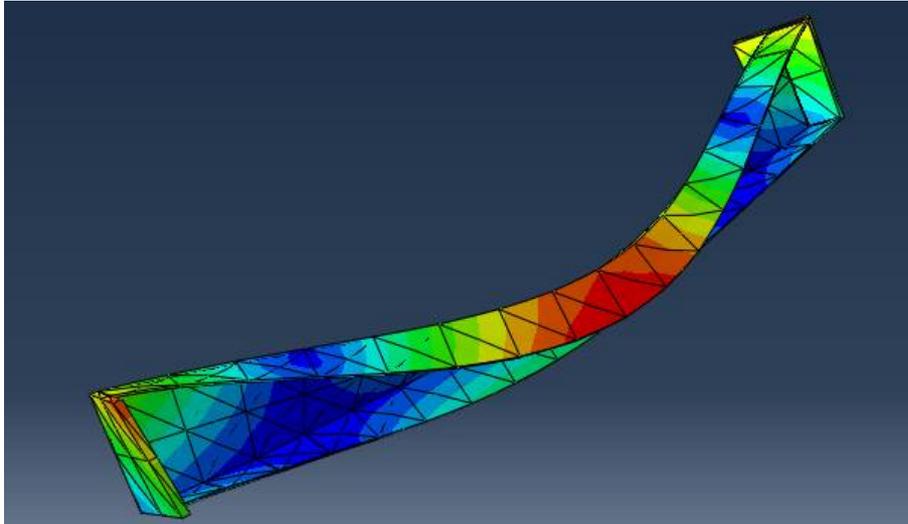


Fig. 5 Deformed shape From Abacus

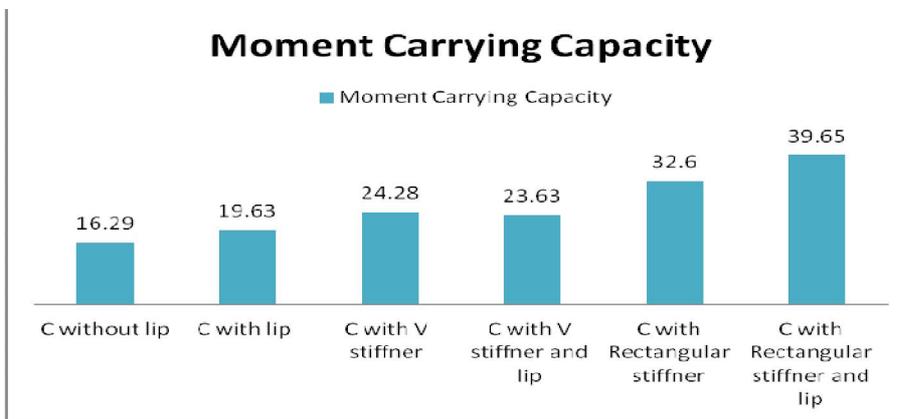


Fig. 6 Moment Carrying Capacity

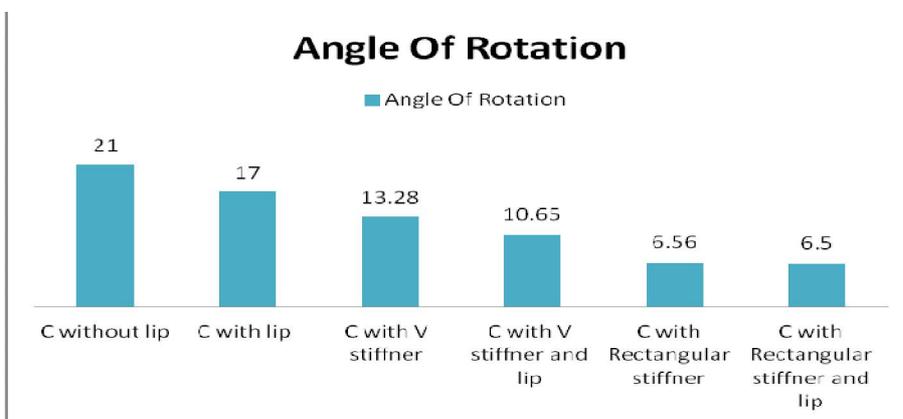


Fig. 6 Angle of Rotation

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VI. EXPERIMENTAL WORK

Five different beams are considered for the experimental investigation for the torsional capacity of the beam. The different stiffeners and lips are introduced to the beam to compare the increase in the torsional capacity of the beam. The loading was done using plates of the 10mm thickness on the either side of the opening as shown in the image further Pure torsion was developed as seen in the arrangements of the experimental work.



Fig. 7 Samples For Experimental Work



Fig. 8 Experimental Set Up

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Fig. 9 Rotation Of Beam After Loading



Fig. 10 Rotation Of Beam After Loading

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Table No.2 Comparison of moment carrying capacity and Angle of Rotation

Description	Moment Carrying Capacity	Angle Of Rotation
C with lip	18.43	29
C with V stiffener and lip	27.45	9
C with Rectangular stiffener	36.29	19
C with V stiffener	26.2	16
C without lip	14.91	28

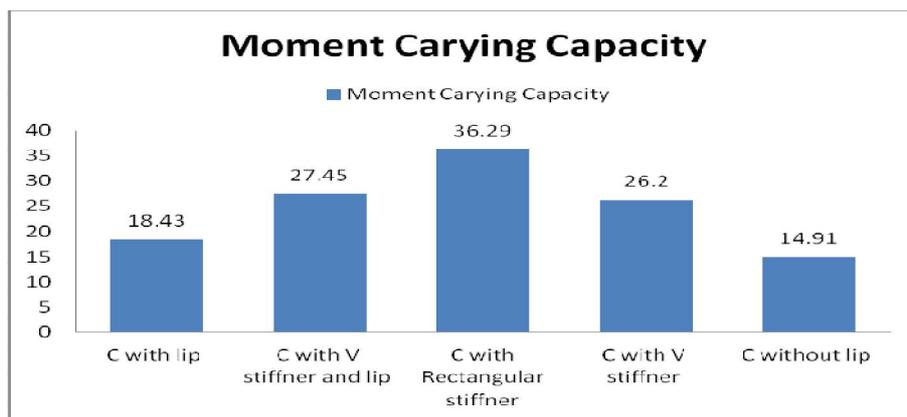


Fig. 11 Moment Carrying Capacity

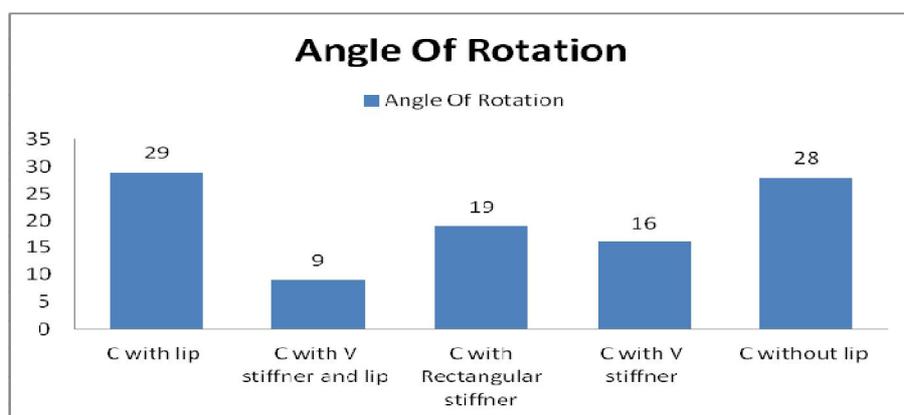


Fig. 12 Moment Carrying Capacity

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VII. CONCLUSION

The shear center and the centroid of the cold form steel channel section is never intersecting so there is induction of the torque under any flexure loading. The torsion capacity of the cold form is considerably increased up to 58% with different stiffeners. The angle of rotation is considerably reduced by 69% using different stiffness agents. The moment carrying capacity is increasing as the stiffeners are introduced but simultaneously the angle of the rotation is reduced. The experimental and the analytical results show the good agreement as the percentage error is within the limit less than 15%

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