BEHAVIOUR OF COLD FORM STEEL UNDER POINT LOADING & STATICALLY DEFINING ITS LIMITATION

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Abstract - *Cold-formed steel is highly ductile, sustainable, and uninfluenced by insects, mold or decay. Different products are manufactured from Cold Formed Steel (CFS) are used in the different field of our on a daily basis life; in the home, the shop, the factory, the office, the car, the petrol station. These products have a lot of uses structural frame, building members. This investigation presents the analytical study and theoretical study of the behaviour of CFS sections. Analytical study of CFS section was done by using FEM software (ANSYS) workbench. Here Channel sections provided with different stiffeners with lips and without lips. One of the C-sections is provided with V stiffener and rectangular stiffener to increase the flexural strength. The analytical results are compared with experimental results according to IS 801:1975. The experimental, analytical and arithmetical investigation is on the interrelation between non-dimensional slenderness and pure bending strength of stiffened cold-formed steel as a construction material. Different types of stiffeners were incorporated to evaluate the deformation on flexural performance of C-sections it would be the predicted location for local and distortional buckling. The Application of the study to an extensive parametric study to investigate the Deflection, Equivalent Stress and Equivalent strain modes of specimens with different Stiffeners sizes. A nonlinear finite element model was developed and established against the test results in terms of failure buckling modes.*

Key Words: Cold Formed Steel, FEM, C-sections

1. INTRODUCTION

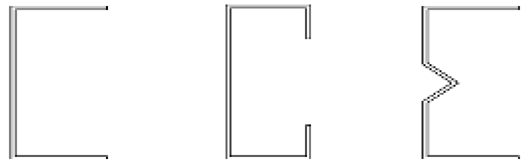
All over the world, applications of thin-walled sections have been a growing demand in all the engineering industry due to their low self-weight, high performance of structural systems with uniform quality, simple fabrication process and cost-effective in both transport erection. Cold-formed steel sections can be used effectively as a structural element in cases where hot-rolled sections or others are not efficient. The behaviour of the thin-walled section is governed by various parameters such as cross-sectional geometry and dimensions. The instabilities of thin-walled flexural members are local, distortional, flexural torsional buckling and their interaction between them. Cold formed steel are currently used for building construction especially non-load bearing partition, curved walls, etc due to its flexural strength and good presence. The cold formed steel enhances the mean yield stress by 15% to 30% as compared to hot rolled steel. In this paper detailed parametric and comparative study of cold formed steel sections by different codes is carried out for forecasting of flexural strength of beams.

The performance of cold-formed steel members is influenced by the material and sectional properties of the section it can be improved by a variety of ways. The behaviour of the cold-formed steel beam is generally improved by the presence of intermediate and edge stiffener stiffened elements or by making a closed profile. It can increase the strength and improve its overall behaviour. Subsequent are the proposed sections to be analyzed for the projects. Thin sheet steel products are extensively used in building industry, and vary from purlins to roof sheeting and floor decking.

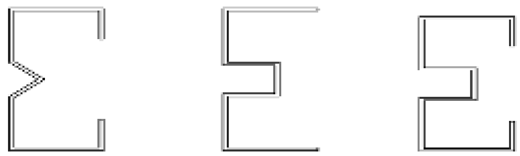
The modeling is done using the finite element program of ANSYS 18.1 Workbench version is used to analyse a finite element model which simulates the behaviour and strength of the cold-formed steel channel sections for various profiles along with three d/t ratio and boundary conditions. Numerical analysis is to be carried out for channel beam section by ANSYS-version 18.1 software.

1.1 Significance of Research

In this study the behaviour of channel section under point load is studied for different types of combinations of stiffeners with additional lip arrangement. Different types of stiffener with variation in size and shape under intense point loading are compared with its behaviour parameter as deflection, buckling under loading and failure load capacity.



Simple C Section C Section with Lip V Stiffener without Lip



V Stiffener with Lip | Rec. Stiffener without Lip | Rec. Stiffener with Lip

Fig-1: Typical view of channel sections

2. OBJECTIVES OF RESEARCH WORK

The objectives of this research work are to study:

- To carry out design and analysis of Cold form steel (channel section with and without stiffener, V stiffener and Rectangular stiffener) using IS 801 - 1975 manually.
- To analyse same sections using FEM based ANSYS software and determine the load carrying capacity and deflection for both with and without stiffeners.
- To optimize size of the web stiffener by considering different combinations of stiffener viz. V- stiffeners, Lips, and Rectangular stiffeners and validate using same length specimen taken for analytical work.
- To investigate behavior of a frame with cold form steel section and optimized cold form steel section with different stiffeners.

3. ANALYTICAL STUDY

The Channel Section of 100 X 40 X 2 mm is considered for the analytical purpose based on combinations. The lip for channel section is considered from 10mm to 30mm. Similarly different V stiffener and rectangular stiffener is considered. The section is calculated and judged on its behaviour under loading condition. The specimen is tested for the one point loading. Total length of specimen is 1000 mm. The supports are kept at the distance of 50mm from both the ends of the beam. The load is applied at the at the midspan. Numerical analysis is carried out for channel sections by ANSYS-version 18.1 software.

3.1 Material Properties

The material properties of Cold form steel are as follows.

Table-1 Material properties

Yield Strength	235 N/mm^2
Modulus of Elasticity	2x10^5 N/mm^2
Poisson ratio	0.3
Modulus of Rigidity	0.769x10^5 N/mm^2
The yield stress	250Mpa

3.2 Modelling and Meshing

Six models with defferent stiffeners such as simple channel sections with and without lips, V stiffener with and without lips, Rectangular section with and without lips used with 2mm thickness and length 1000mm. Both the ends are simply supported wth hinge and roller. The finite element programme of ANSYS 18.1 workbench is used develop finite element models, which aimed to simulate the behaviour and strength of cold form seel sections.

There are different type of meshing that is adaptive, proximity & curvature, curvature , proximity, uniform in which types adaptive type meshing are used for modelling analysis. In meshing relevance are three types coarse, medium and fine. The analysis of modelling fine type of relevance is used. No. of node system are applying on section.

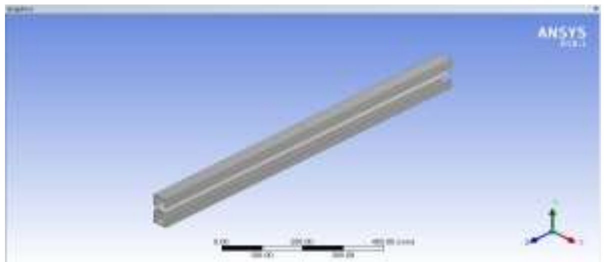


Fig-2: CFS section model

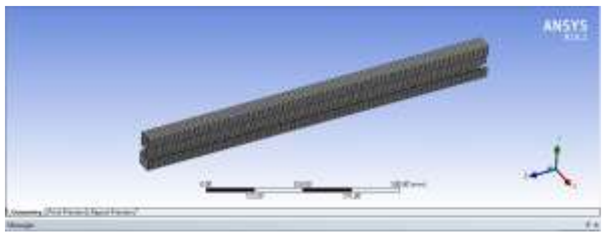


Fig-3: Meshing of channel section in ANSYS

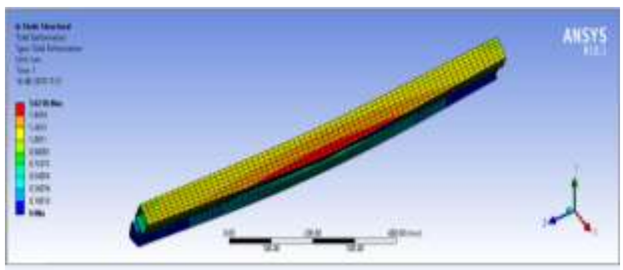


Fig-4: Deformation of channel section with rectangular stiffener

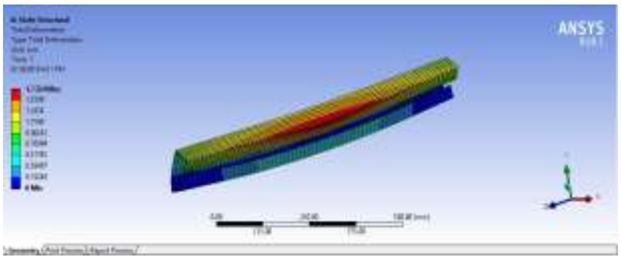


Fig-5: Deformation of C section providing with lips

3.3 Analytical results

For the analysis of results 6 different sections are used with or without stiffener and lip. In analysis we obtained deformation, stress and strain is given below.

Table-1: Deformations of Channel section with and without stiffeners

Details	Deformation (mm)	Strain	Stress (N/mm^2)
C Section Without Lip	3.01	0.0034	85.227
C Section With Lip	1.89	0.00344	63.559
C Section With V Stiffener Without Lip	2.6	0.00289	85.970
C Section With V Stiffener With Lip	3.6	0.00400	63.971
C Section With Rectangular Stiffener Without Lip	2.48	0.00276	78.125
C Section With Rectangular Stiffener With Lip	2.3	0.00256	70.754

Chart-1: Deformation

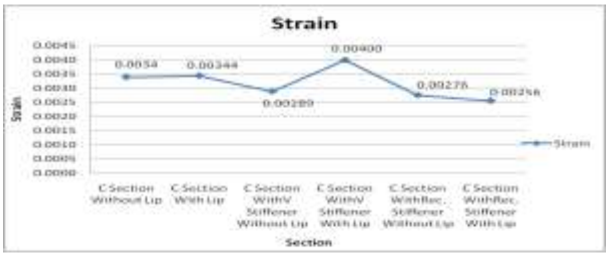


Chart-2: Strain

Chart-3: Stress

From analytical results observed optimum load carrying capacity, deformation, strain, stress of with and without stiffener and lip for channel section. Maximum deformation and strain for C section with v stiffener with lips 3.6 mm, 0.00400 respectively. Maximum stress for C section with v stiffener without lips 85.970 N/mm^2.

4. EXPERIMENTAL STUDY

The size of channel Section 100 X 40 X 2 mm is considered for the experimental purpose. The optimize size of lip for channel section is considered from 30mm The section is calculated and judged on its behaviour under loading condition. The specimen is tested for the one point loading. The length of beam considered for experimental as well as analytical is 1000mm. When the support will rest at 50mm from both sides support to support clear distance is 900mm. loading is done at l/2 distance one line loading which will generate the point load condition. The supports are kept at the distance of 50mm from both the ends of the beam. The load is applied at the midspan. The supports kept at certain overhang to avoid slip of specimen during the experimental work.

Fig-6: Experimental test setup

Fig-7: Test specimens

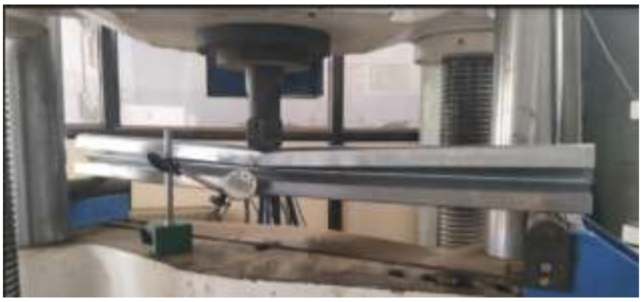


Fig-8: Channel section with stiffener failure pattern

Fig-9: Deformation of channel

4.1 Experimental results

The experimental testing is carried out on universal testing machine for different sections. This results shows the behaviour of CFS section after deformation.

Table-2: Deformation of sections under different load

Details	Load (KN)	Deformations (mm)
C Section Without Lip	25	2.95
C Section With Lip	30	3.02
C Section With V Stiffener Without Lip	30	2.56
C Section With V Stiffener With Lip	34.5	2.89
C Section With Rectangular Stiffener Without Lip	36.5	2.952
C Section With Rectangular Stiffener With Lip	42.25	3.06

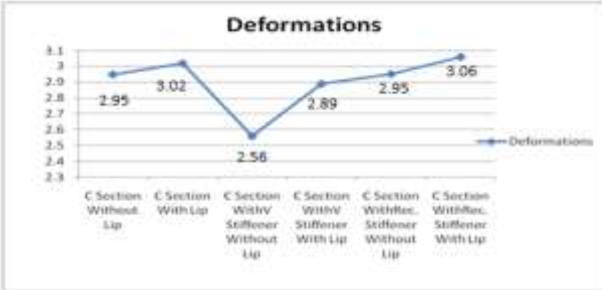


Chart-4: Deformation

The graph shows maximum deformation for rectangular stiffener with 30mm lip section is 3.06mm at maximum load 42.25 KN.

5. ANALYTICAL AND EXPERIMENTAL RESULTS COMPARISION

Comparison of experimental and analytical displacement for various channel section was plotted in Fig. The von mises stress and strain for the various profiles were noted at the time of failure load.

Table-3: Comaparision of channel section

Experimental			Analytical	
Details	Load (KN)	Deformations (mm)	Load (KN)	Deformations (mm)
C Section Without Lip	25	2.95	30	3.01
C Section With Lip	30	3.02		1.89
C Section With V Stiffener Without Lip	30	2.56		2.6
C Section With V Stiffener With Lip	34.5	2.89		3.6
C Section With Rec. Stiffener Without Lip	36.5	2.952		2.48
C Section With Rec. Stiffener With Lip	42.25	3.06		2.3

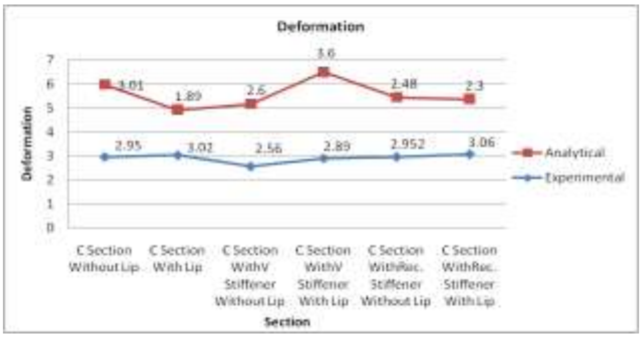


Chart-5: Comparision of experimental and analytical results

Comparison of Analytical & experimental study proved that experimental rectangular channel section with 30 mm lip carry 42.25 KN load, 3.06 mm deflection, strain 0.0034 and stress 89.51 N/mm2 is more than analytical rectangular channel section with 30mm lip.

6. CONCLUSIONS

The following conclusions can be made based upon the experimental results:

The parametric study was performed using finite element ANSYS analysis. The following detailed observations and conclusions can be made.

- The ANSYS results were generally in good agreement with the test results.
- It was observed that of the parameters varied in the test spacing between the analysis results and experimental results. As the load was increased the amount of deformation, stress and also strain increased.
- The load capacity of Sections was observed to decrease with the increase of width of beam, because local buckling occurred earlier.

The following conclusions can be made based upon the experimental results.

- Without stiffener with 30 mm lip channel section carry more loads is 30KN and its deformation is 3.02mm when compared to without stiffener with & lip
- V stiffener with 30 mm lip channel section carry more load 34.5 KN and its deformation is 2.89 mm as compared to V stiffener without lip
- Rectangular stiffener with 30 mm lip channel section carry more load 42.25 KN and its deformation is 3.06 mm as compared to rectangular stiffener without lip
- Stress strain curves and load deflection curves for all channel section are linear.
- The comparative study reveal that rectangular channel section have high load carrying capacity and maximum local buckling as compare to other section.

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