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Comparative Study On Flexural Behavior Of Cold Formed Steel Channel Sections Using Is And AISI Codes

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Abstract: Cold formed steel is the light gauge steel produced from high strength Cooled Rolled (CR) steel sheet by the process of brake pressing .This paper deals with the flexural behavior of cold formed steel channel sections. All the calculations are made by considering the load as uniformly distributed. The first part of the study is theoretical investigation of flexural properties of various channels such as moment of resistance ,load carrying capacity, web crippling and the aim of this part is to economize the design by comparing the various codes to obtain different strength. The second part of this study is experimental and analytical study. The Direct Strength Method (DSM) was newly developed method and an alternative to the effective width method for the design of cold formed steel channel sections. Experimentally the buckling behavior is identified by Universal Testing Machine (UTM) under fixed edge conditions. The ultimate strength and other properties of the members between local and overall buckling were studied experimentally and theoretically. In this project Finite Element Analysis (FEA) is carried out by the software ANSYS 12.0.Then the comparative study is made between theoretical, experimental and analytical study. From this study we concluded that the experimental results compare reasonably well with theoretical prediction. Then the comparisons are made between experimental study with FEA. All the analysis are made as per IS 811-1975 and AISI-S100-2007 codal reference.

Keywords: CR, DSM, UTM, FEA, ANSYS, CFS, PSTRES, AISI

1. INTRODUCTION

1.1. General:

In steel construction hot- rolled members and cold formed member are the two families of structural members. Even though cold formed structural members were less familiar it has a growing importance relative to the traditional heavier hot-rolled steel structural members. Cold-formed steel (CFS) structural members are made by bending the flat thin sheet of thickness 0.4mm to 0.7mm at a room temperature by press braking operation to get the desired strength to weight ratio, versatility, very small thickness, non-combustibility with appropriate measures and ease of production makes the CFS useful in many situations where high strength is required with low member weight. At present these member are widely used as a construction materials and out of all possible cross sections C and Z are frequently used as flexural members either individually or as built-up configuration with edge lips.The reason for edge lip and internal stiffener is to resist compression, and consequently the actions become structurally efficient. However in India, the potential of cold formed steel structures is not well exploited in spite of several favorable conditions and world-class researchers in the area of cold formed steel structures. Nevertheless the changing economic scenario in India appears to hold great promise for cold formed steel structures.

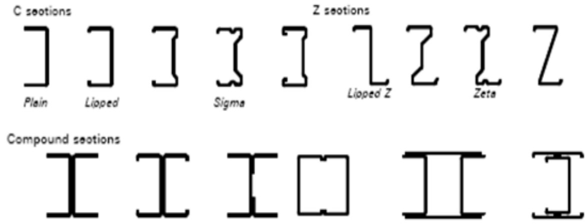

Fig 1.1 various cross sections of cold formed steel sections.

1.2 Advantages of cold formed sections:

Cold forming has the effect of increasing the yield strength of steel, the increase being the consequence of cold working well into the strain-hardening range. These increases are predominant in zones where the metal is bent by folding. The effect of cold working is thus to enhance the mean yield stress by 15% - 30%. For the purpose of design, the yield stress may be regarded as having been enhanced by a minimum of 15%.

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- High load resistance for a given section depth.
- Long span capability (up to 10m) and dimensional accuracy.
- Long term durability and free from long term creep and shrinkage.
- Lightness, which is important for buildings in poor ground conditions.

2 .CODE BOOK COMPARISON ON FLEXURAL BEHAVIOR OF COLD FORMED STEEL CHANNEL

The flexural behavior of cold formed steel mainly influenced by moment of resistance ,load carrying capacity &web crippling etc. that The research project aims to provide which code of practice given more economical, high bending strength, more load carrying capacity and high flexural strength in compared various channel (C,I,Z,Hat) also to found best channel for design by usig IS&AISI

2.1AISI METHOD
2.1.1 Moment of resistance

Mn = Fc Sf …. eq 2.1

2.1.2Shear strength

Vn Vn = Aw Fv

For $h/t \le \sqrt{Ekv/Fy}$

Fv = 0.60Fy …. eq 2.2

2.1.3Combined bending &shear strength

$\sqrt{(\Omega bm^2/Mnxo)+(\Omega vV^2/vn)}$ ….eq 2.3

2.1.4Web crippling strength

$Pn=Ct^2Fy\sin\theta\left(1-C_R\sqrt{R/t}\right)\left(1+C_N\sqrt{N/t}\right)\left(1-C_h\sqrt{h/t}\right)$ ….eq 2.4

2.2 IS METHOD
2.2.1 Moment of resistance

Mn = Fc Sf ….eq 2.5

2.2.2Shear strength

Vn Vn= Aw Fv ….eq 2.6

For $h/t \le \sqrt{Ekv/Fy}$

Fv = 0.60Fy

2.2.3 Combined bending&shear strength

$=\sqrt{(fhwIFbw)^2 - t\,(fv/Fv)^2}$ ….eq 2.7

2.2.4 Web crippling strength

PMax = 70 t'' [98 + 4.20(h/t)-0.022(N/t) (h/t) – 0.011 (h/t)] X [1.33-0.33 (Fy/2 320)] (Fy/2 320) ….eq 2.8

Tab 1 –comparision of flexural behavior

s. no	Size of specimen	length	Moment of Resistance		Load carrying Capacity		Shear strength		Combined bending Shear		Web crippling		Deflection
		mm	ISI	AISI	ISI	AISI	ISI	AISI	ISI	AISI	ISI	AISI	Mm
1	100X40X2 (C sec)	600	2.81	2.81	62.4	62.4	22.04	33.07	0.88	0.94	6.37	3.29	1.01
2	90x40x2 (I sec)	600	2.4	2.4	53.3	53.3	19.8	29.76	0.77	0.8	54.9	62.8	1.11
3	100x80x15x2 (Hat section)	600	3.47	3.47	77.11	77.11	22.04	33.07	0.9	1	54.4	61.9	0.87
4	120x45x20x2 (Z section)	600	4.49	4.49	99.78	99.78	26.46	39.68	0.74	0.8	52.3	68.4	0.83

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FIG 2.1 Moment of resistance

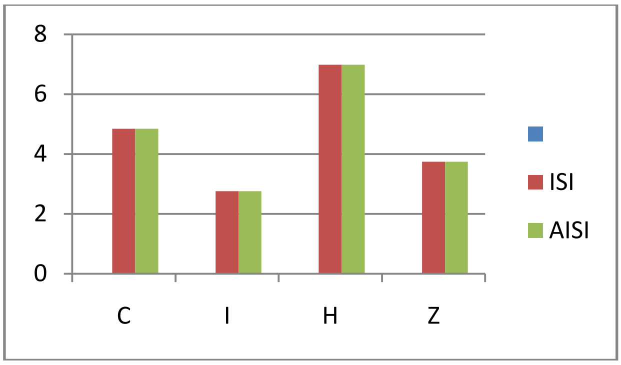

FIG 2.3 Load carrying capacity

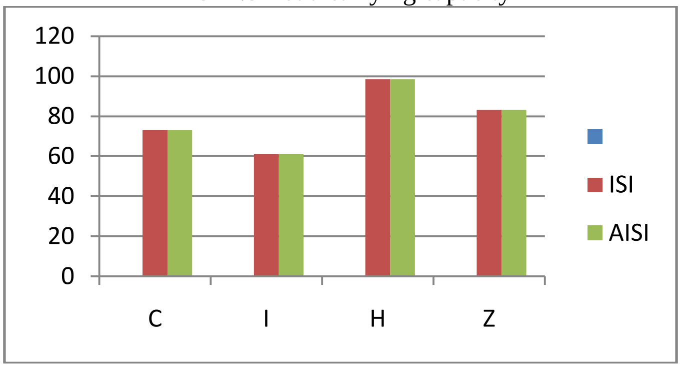

FIG 2.5 Shear strength

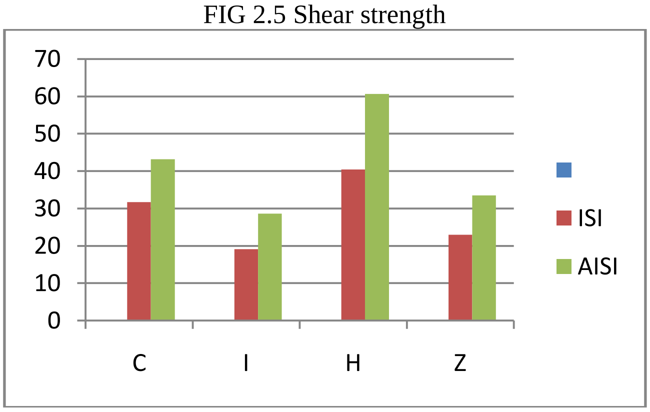

FIG 2.2 Combined bending &shear strength

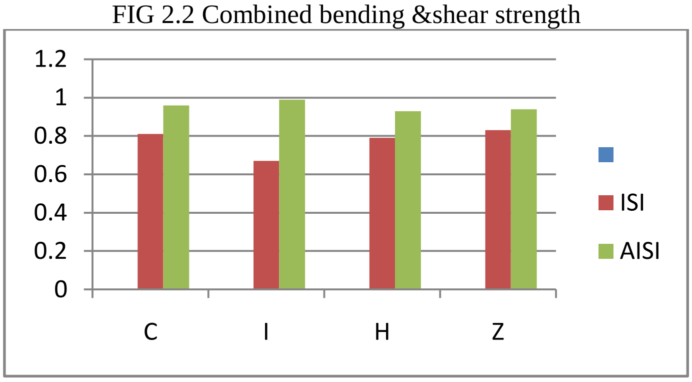

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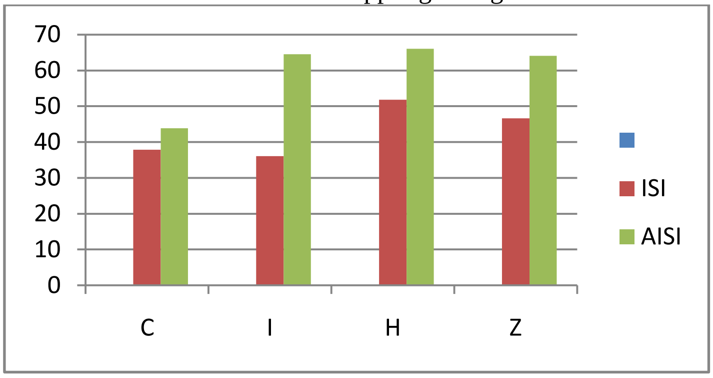
FIG 2.4 Web crippling strength



2.3 Conclusion of comparison

In conclusion of this comparision of code book has to be the moment of resistance is to be same AISI code books have a high load carrying capacity, shear strength ,web crippling strength is compare to Indian standard. In conclusion of the part is to be AISI design has to be more economical .based on the shapes , hat shape section have a high moment of resistance compared other channels.so that hat channel is more economical&best for design compared other channels

3. EXPERIMENTAL INVESTIGATION

An experimental study is carried out to investigate the mode of failure, especially distortional buckling, and the ultimate load carrying capacity of cold-formed steel C-sections &I section under major axis bending

3.1 Material properties

Density of steel (ρ)	7850 kg / m^3
Modulus of elasticity ,E	2 x 10^5 N / mm^3
Poisson ratio	0.3
Modulus of rigidity , G	0.769 x 10^5 N / mm2

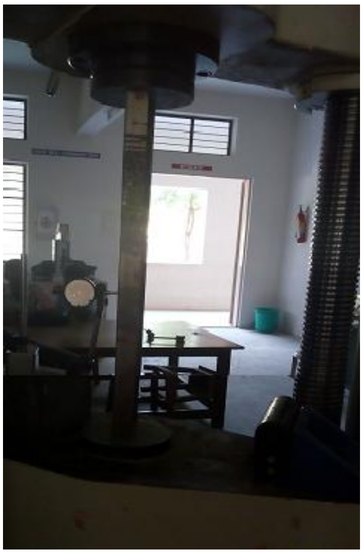


Fig 3.1 experimental setup

3.2 Test procedure & material used :

The required size of specimens are to be taken in correct manner for testing Care has been taken while placing the specimen on the supports by releasing lower head then to fix their position, so as to achieve precise distribution of load The centre portion of the specimen are marked while the dial gauges are fixed at that point Before applying a load , to set zero on the scale &check all their criterias for operation,The dial gauges are adjusted to take initial reading The load was applied gradually in a controlled manner in increments of 2kN by hand pumping of the manually operated hydraulic jack .The loading was monitored through a high accuracy load cell with a sensitivity of 1kN.The specimen tends to show the buckling mode of failure such as local and distorstional when it receives the stress more than its yield stress .After the ultimate load on cold formed steel section buckle is noted carefully.Also to be noted that the

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displacement of the specimen are to be shown accurately by the dial gauge Then repeated the process for different sections such as C section & I section with varying dimensions to finding ultimate load carrying capacity of the specimen finally the graph is to be drawn into load vs displacement and that are to be tabulated as follows.

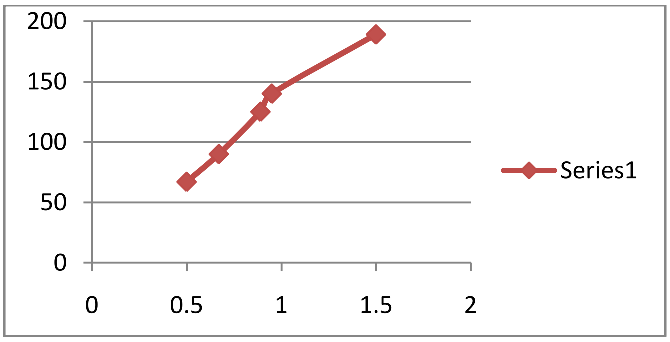

Fig : 3.1 load –displacement curve

Tab 3.1- load test results

s.no	Speciemen Size (mm)	TEST Load KN	ISI	AISI	Test/ISI	Test /AISI
1	100x50x2	67	43.3	52.43	1.55	1.28
2	100x60x2	90	76.5	81.8	1.18	1.1
3	90x50x2	125	119.4	121.5	1.05	1.03
4	90x40x2	140	127.8	136	1.09	1.09
5	80x60x2	189	169.7	175.4	1.11	1.14

3.3 buckling test results

The maximum buckling capacity of the column (*Ptest*) was the largest axial load applied to the column when failure occurred. The nominal loads of the columns(*Pn*) were calculated in accordance with AISI&ISI Specification.The test results of the C&I shaped channel sections were compared to the previous experimental results The main pattern of interest was an increase in the (*Ptest*/*Pn*) ratio for thicker material, which means the AISI-2001 Specification becomes more conservative for thicker c shaped channel section. The tests of the I-shaped orientation were done to see if
there is a significant change in the maximum axial buckling capacity of the column with a change in orientation the I-shaped orientation the overall trend of an increase in the (*Ptest*/*Pn*) ratio with an increase in member thickness remains true. It can be seen that
many of the I-shaped channel sections are unconservative while all of the rectangular columns have a conservative value.

4.ANLYTICAL INVESTIGATION

4.1 Finite element method :
General: Today, finite element method enjoys a position of predominance among the computational methods to occur in this century, within only a few decades this technique has evolved from one with initial application in analysis of aircraft structure and in structural engineering to a widely utilized and richly varied computational approach. The basic concept of finite element method is discritization of a structure into finite number of elements, connected at finite number of points called nodes. The material properties and the governing relationships are considered over these elements and expressed in terms of nodal displacement at nodes. An assembly process duly considering the loading and constraints results in a set of equations governing the structural response, which are established through the application of appropriate variation principle. Solutions of these equations give the response of the structure.

4.1.1 MERITS OF FINITE ELEMENT METHOD
The systematic generality of finite element procedure makes it a powerful and versatile tool for a wide range of problems. Thus, flexible, general-purpose computer programs can be developed and can be applied to various problems with little or no modification. FEM can be easily interpreted in physical terms. As well it has a strong mathematical base. Hence, finite element method can be easily applied to any problem with a proper knowledge of the physical system under consideration and can be solved to a greater accuracy by the application of proper mathematical tool. Non-homogenous continuum can also be dealt with by merely assigning different properties to different elements. It is

even possible to vary the properties within an element according to the polynomial applied. Finite element method accommodates complex geometry with ease and is capable of handling non-linear and time dependent system

4.1.2 DEMERITS OF FINITE ELEMENT METHOD

The solution obtained from FEM can be realistic if and only if the material properties are known precisely.The major drawback of FEM is sensitivity of the solution on the geometry of the element such as type, size, number, shape and orientation of elements used.The computer programs of FEM require relatively a large computer memory and time.FEM Programs yield a large amount of data as results. It is very difficult to separate out the require results from the pile of numbers.

4.2 ANSYS - INTRODUCTION

ANSYS is a commercial FEM package having the capabilities ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. It is available in modules. Each module is applicable to specific problem. For example, Ansys/Civil is applicable to Civil structural analysis. Similarly Ansys/Flotran is CFD software applicable to Fluid Flow. The advantage of Ansys compared to other competitive software's is , its availability as bundled software of pre, post and a Processor. Typical Ansys program includes

3 stages.

- Pre-Processing
- Solution
- Post-Processing

Procedure for Eigenvalue Buckling Analysis

Eigenvalue buckling analysis generally yields un conservative results, and should usually not be used for design of actual structures. The procedure of eigenvalue buckling analysis is as follows.

- Building the model.
- Obtaining the static solution.
- Obtaining the eigenvalue buckling solution.
- Expanding the solution.
- Reviewing the results.

1. Building the model

The Model is built is either through Bottom up Approach or Top down Approach and should be meshed with appropriate elements. Proper material and geometric properties (Real properties) should be supplied. Finally Boundary conditions should be supplied.

2. Obtaining the Solution

The following should be followed to obtain proper solution Prestress effects [PSTRES] must be activated. Eigenvalue buckling analysis requires the stress stiffness matrix to be calculated.

Unit loads are usually sufficient (that is, actual load values need not be specified). The eigenvalues calculated by the buckling analysis represent buckling load factors. Therefore, if a unit load is specified, the load factors represent the buckling loads. All loads are scaled. Eigenvalues represent scaling factors for all loads. If certain loads are constant (for example, self-weight gravity loads) while other loads are variable (for example, externally applied loads), we need to ensure that the stress stiffness matrix from the constant loads is not factored by the eigenvalue solution. One strategy that we can use to achieve this end is to iterate on the eigen solution, adjusting the variable loads until the eigenvalue becomes 1.0 (or nearly 1.0, within some convergence tolerance). Design optimization could be useful in driving this iterative procedure to a final answer

S.NO	SPECIEMEN	TEST	ANSYS	ISI	AISI	TEST/ANSYS
1	100X50X2	235	215	206	225	1.45
2	100X60X2	175	159	1137	168	1.08

3. Obtaining the Eigen value buckling Solution:

After executing the program for static solution, again solution should be changed to Eigen Buckling and extraction technique should be specified.

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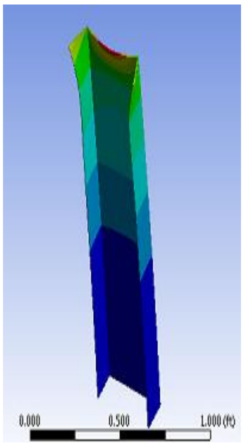
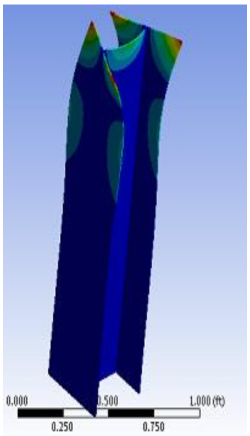
4. Expanding the Solution:
Solution should be expanded to obtain the critical buckling loads.

5. Reviewing the results:

Results can be reviewed through /post1. Through result summary critical buckling in the form of natural frequencies can be viewed. By using the read set option for different critical loads, deflection and stress patterns can be viewed.





4.CONCLUSION

To study the flexural behaviour of cold-formed channel sections with simple lips was considered for the present analytical study. Four point bending test setup is simulated by FE model developed using ABAQUS software to investigate the distortional buckling behaviour under pure bending. The behaviour of cold-formed steel channel sections with lips under major axis bending was studied numerically using Finite element method and the results were compared with the predicted moment capacities using different international codes.

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