# Comparative Study on Behaviour of Hot and Cold Formed Steel Sections Under Flexure

Ms. A. Rosana Begum,
PG Student
Department of Civil Engineering
University College of Engineering-BIT Campus
Trichirappalli, Tamilnadu,India

Dr. S. Evany Nithya,
Assistant Professor
Department of Civil Engineering
University College of Engineering-BIT Campus
Trichirappalli, Tamilnadu,India

***Abstract*:- Cold-formed steel is also known as light gauge steel. Cold Formed Steel (CFS) is used in the different field of our daily life; in the home, the shop, the factory, the office, the car, the petrol station. Cold-formed steel is a basic component in construction of lightweight prefabricated structures like stud frame panels, trusses and portal frames. The Cold formed steel term itself make it different from hot rolled steel due to difference in manufacturing methods. Typically columns, beams and angles etc. are different globally. At room temperature cold formed steel members are formed by bending flat sheets. Cold formed steel sections mainly created using two methods those are break press through and rolling. Hot rolled steel members are precasted. Therefore cold formed steel sections can be easily available at any place where hot rolled sections are not available. The cold formed steel components can be used for larger and complex structures. The thickness of cold formed steel sheets or strip are generally ranges from 0.4 mm to 6.4 mm. The Comparison of cold formed steel section and Hot rolled steel section of equal cross sectional area is done in this research paper. Primarily the hot rolled sections are selected from IS 800:2007 Steel Tables and cold formed sections are selected from IS 811:1987. The sections are selected based on the moment capacity and effective span of the sections by analyze software STAAD.Pro. The analytical results are compared with theoretical results according to IS 801:1975 and IS 800:2007. The chosen effective Sections were experimentally tested under flexure in universal testing machine. Simultaneously, ultimate flexure strength of cold formed members and hot rolled members has been investigated. The validation of results is done by preparing finite element model in ABAQUS software for hot roll and cold formed sections. From experimental work studied flexure behavior of hot rolled steel and cold formed sections.***

## I. INTRODUCTION

Steel is used for many applications in construction of Industrial building. In building construction, there are primarily two types of structural steel hot-rolled steel shapes and cold-formed steel shapes. The hot-formed steel shapes are formed at elevated temperatures while the cold- formed steel shapes are formed at room temperature. Cold- formed steel structural members are shapes commonly manufactured from steel plate, sheet are strip material. The manufacturing process involves forming the material by either press-breaking or cold roll- forming to achieve the desired shape.

Press- breaking is often used for protection of small quantity of simple shapes. Cold roll- forming is the most widely used method for production of roof, floor and wall panels. It is also used for the production of structural components such as Cees, Zees and hat sections. Sections can usually be made from sheet up to 60 inches (1.5m) wide and from coils more than 3,000 feet (1,000m) long.

The thickness of material that can be formed generally ranges between 0.004 inches (0.10mm) upto 0.312 inches (7.7mm), although heavy duty cold forming mills can handle steel up to 3/4 inch (19mm) thick. Cold –formed steel in either flat plates or coils is the primary raw material for a wide range of industries. We are surrounded by applications, in washing machines, filing cabinets, storage systems, heating under ventilation and cars. About 40 % of the sheet steel protection is used in the construction industries, in cladding, light structural frames and components such as purlins and lintels. The steel sheets can be cold- formed into many different shapes and forms by a variety of manufacturing processes.

### *A. PROPERTIES OF CFS*

Generally, the grades of carbon steel and high strength low alloy steel used for cold- formed steel products are characterized by two main properties: The yield point and tensile strength. Other important properties are ductility, hardness and weld ability. The yield point of the steels commonly used for cold- forming ranges from 33 to 55ksi (230 to 380 MPa), and may be higher. Tensile strength and ductility are important because of the way they relate to form ability, and because of the local deformation demands of bolted and other types of connection. In members that include bolted connection or that, because of special design, may be subject to high stress concentrations, the tensile strength often must be taken into account. The ratio of tensile strength to yield strength for cold- formed steel commonly ranges from 1.2- 1.8.However steels with a lower ratio can be used for specific applications.

### *B. PROFILES OF CFS*

There are two major types of cold-formed steel products: structural shapes and panels. Of the former, there are a variety of shapes produced. They include open sections, closed sections, and built-up sections, such as Cee sections, zee sections, double channel I beams with stiffened flanges, hat sections with and without intermediate stiffeners, box sections, U sections and others. These are used in buildings for such structural functions as eave struts, purlins and grits as well as joists and studs and other components. Generally, the depth of cold-formed individual framing members range from 2 to 12 inches (50 to 300mm) and the thickness of the material range from 0.035 to about ¼ inches (0.90 to 6.4mm).

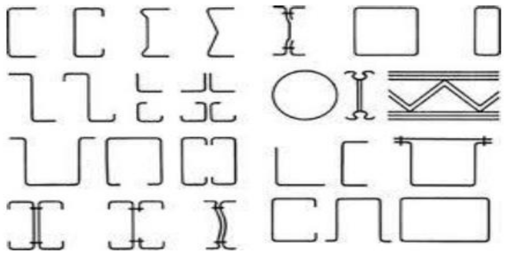


Fig.1 Various Shapes ofCold formed Sections

*C. STRUCTURAL PERFORMANCE OF A CFS*

Cold-formed steel sections tend to be more sensitive to local buckling effects than typical hot rolled sections. Cross sections are generally stiffened to improve resistance to local buckling. The structural behaviour of cold-formed steel can be distinguished from hot rolled section are relatively stocky and thick compared to cold-formed steel sections, whilst cold-formed sections are comparatively thin and slender, sections can be visualized as series of plates connected at the corners. When the steel plates are subjected to compression buckling is likely to occur in the plane of the plate. The tendency to buckle increases as the breadth to thickness ratio of the plate increases. Compressive forces develop in the section either as a result of direct compression in columns and struts or flexural compression in beams. The geometry of the cross section and the position of bends are used to stabilize the section against local buckling effects. Intermediate stiffeners may also be used where the distance between the corners is relatively large to increase the stability D. Behaviour aspects of steel sections

The buckling of cold-formed steel sections can be described by local, distortional and flexural-torsional modes. Local buckling is characterized by internal buckling of the elements of the sections in which there is no relative movement of the nodes.

Shear: A beam can fail due to violation of its shear design strength.

Flexure: Several possible risk modes must be considered. A beam can fail by reaching (fully plastic).

- Lateral torsional buckling (LTB), elastically or inelastically
- Flange local buckling (FLB), elastically or inelastically.
- Web local buckling (WLB), elastically or inelastically

If the maximum bending stress is less than the proportional limit when buckling occurs, the failure is elastic. Otherwise, it is inelastic.

The compressive flange of a beam behaves like an axially loaded column. Thus, in beams covering long spans the compression flange may tend to buckle. However, this tendency is resisted by the tensile flange to certain extent. The overall effect is a phenomenon known as lateral torsional buckling, in which the beam tends to twist and displace laterally. Lateral torsional buckling may be prevented by,

- Using lateral supports at intermediate points.
- Using torsionally strong sections (e.g., box sections).
- Using I-sections with relatively wide flanges.

The hot-rolled steel sections are thin-walled sections consisting of a number of thin plates. When normal stresses due to bending and/or direct axial forces are large, each plate (for example, flange or web plate) may buckle locally in a plane perpendicular to its plane. In order to prevent this undesirable phenomenon, the width-to-thickness ratios of the thin flange and the web plates are limited by the code.

## II. MATERIALS PROPERTIES

The properties of structural steel result from both its chemical composition and its method of manufacture, including processing during fabrication. The tensile coupon test was done to determine the mechanical properties are derived from minimum values specified in the relevant product standard.

### *A. Yield strength*

It is the most common property that the designer will need as it is the basis used for most of the rules given in design codes. In European Standards for structural carbon steels (including weathering steel ), the primary designation relates to the yield strength, e.g. S425 steel is a structural steel with a specified minimum yield strength of 425 N/mm².

### *i. Hot rolled steels*

For hot rolled carbon steels, the number quoted in the designation is the value of yield strength for material up to 16 mm thick. Designers should note that yield strength reduces with increasing plate or section thickness (thinner plate is worked more than thick plate and working increases the strength). minimum yield strengths and the minimum tensile strength.

### *ii. Cold formed steels*

There is a wide range of steel grades for steels suitable for cold forming. Minimum values of yield strength and tensile strength are specified in the relevant product standards.

### *B. Toughness*

It is in the nature of all materials to contain some imperfections. In steel these imperfections take the form of very small cracks. If the steel is insufficiently tough, the 'crack' can propagate rapidly, without plastic deformation and result in a 'brittle fracture'. toughness of steel and its ability to resist brittle fracture are dependent on a number of factors

### *C. Ductility*

Ductility is a measure of the degree to which a material can strain or elongate between the onset of yield and eventual fracture under tensile loading as demonstrated in the figure below. The various standards for the grades of steel insist on a minimum value for ductility so the design assumptions are valid and if these are specified correctly the designer can be assured of their adequate performance.

### *D. Weldability*

All structural steels are essentially wieldable. However, welding involves locally melting the steel, which subsequently cools. The cooling can be quite fast because the surrounding material.

### E. Other Mechanical Properties of Steel

Other mechanical properties of structural steel that are important to the designer include:

- Modulus of elasticity, E = 200,000 N/mm²
- Shear modulus, G = E/[2(1 + ν)] N/mm², often taken as 81,000 N/mm²
- Poisson's ratio, ν = 0.3
- Coefficient of thermal expansion, α = 12 x 10-6/°C (in the ambient temperature range).

## III. CHOOSING OF TRIAL SECTIONS

The sections are selected based on the moment capacity and effective span of the sections. The section moment capacity under flexure are compared based on the bending moment given by analyze software STAAD.Pro. by assuming constant live load 10KN/m for various channel and angle sections for span 1.5m, 2m and 2.5m under fixed end conditions. The effective sections are selected based on the moment resistance comparison. After doing all the structural analysis of our structure, we have designed it to find out the suitable sections for beams and to calculate its moment capacity. Similarly, moment capacity of the other sections are analyzed and listed, based on various types of trial sections.

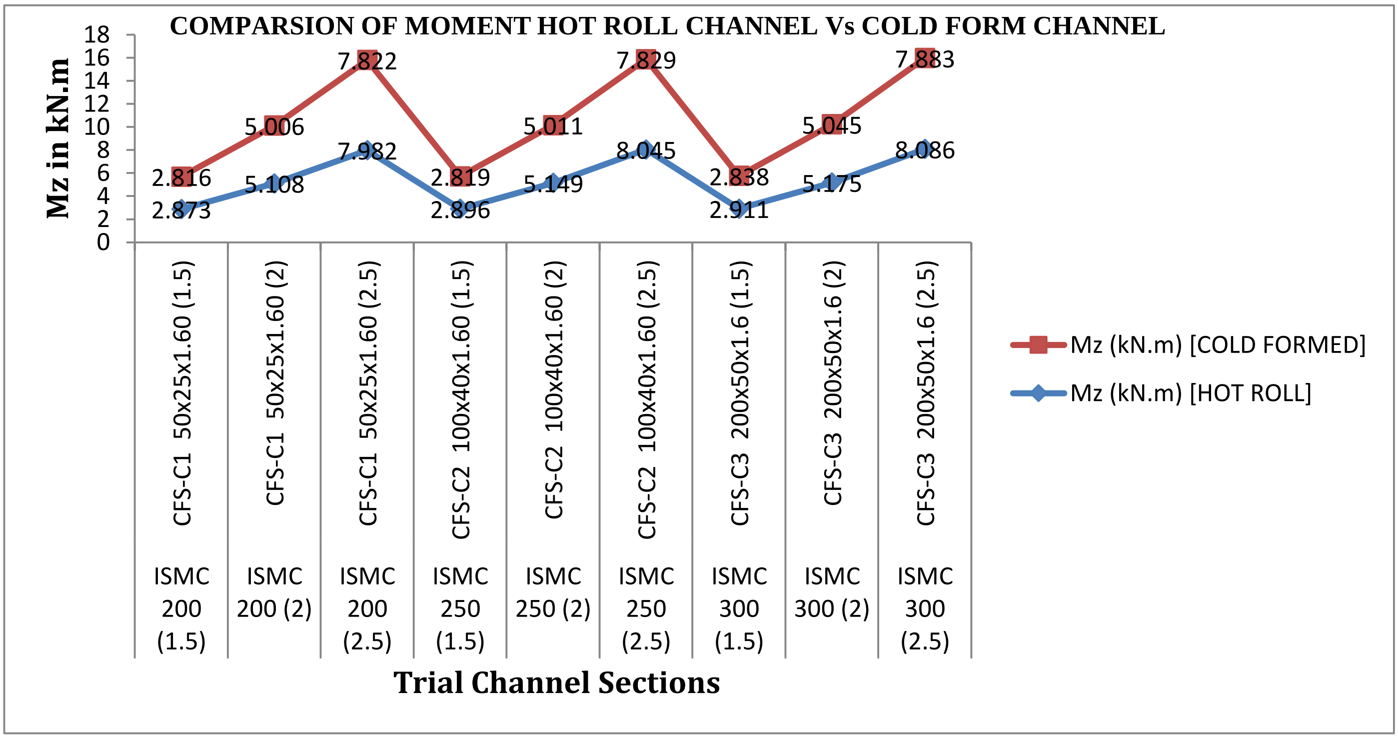
Table 1 Moments for Hot Rolled Channel Sections

| SPAN (m) | LOAD (kN/m) | ROLLED SECTIONS | WEIGHT N Per m | Max. MOMENT Mz (kN.m) |
|---|---|---|---|---|
| 1.5 | 10 | ISMC 200 | 221 | 2.873 |
| 2.0 | | | | 5.108 |
| 2.5 | | | | 7.982 |
| 1.5 | 10 | ISMC 250 | 304 | 2.896 |
| 2.0 | | | | 5.149 |
| 2.5 | | | | 8.045 |
| 1.5 | 10 | ISMC 300 | 358 | 2.911 |
| 2.0 | | | | 5.175 |
| 2.5 | | | | 8.086 |

TABLE 2 Moments for Cold Formed Channel Sections

| SPAN (m) | LOAD (kN/m) | COLD FORMED SECTIONS | WEIGHT N Per m | Max. MOMENT Mz (kN.m) |
|---|---|---|---|---|
| 1.5 | 10 | CFS-C1 50x25x1.60 | 11.70 | 2.816 |
| 2.0 | | | | 5.006 |
| 2.5 | | | | 7.822 |
| 1.5 | 10 | CFS-C2 100x40x1.60 | 21.70 | 2.819 |
| 2.0 | | | | 5.011 |
| 2.5 | | | | 7.829 |
| 1.5 | 10 | CFS-C3 200x50x1.60 | 88.80 | 2.823 |
| 2.0 | | | | 5.018 |
| 2.5 | | | | 7.841 |

Fig 2 COMPARSION OF MOMENT HOT ROLL CHANNEL Vs COLD FORM CHANNEL



| SPAN (m) | LOAD (kN/m) | ROLLED SECTIONS | WEIGHT N Per m | Max. MOMENT Mz (kN.m) |
|---|---|---|---|---|
| 1.5 | 10 | ISA 35x35x5 | 26 | 2.820 |
| 2.0 | | | | 5.013 |
| 2.5 | | | | 7.832 |
| 1.5 | 10 | ISA 50x50x5 | 23 | 2.823 |
| 2.0 | | | | 5.018 |
| 2.5 | | | | 7.841 |
| 1.5 | 10 | ISA 65x65x5 | 49 | 2.826 |
| 2.0 | | | | 5.024 |
| 2.5 | | | | 7.850 |

Table 3 Moments for Hot Rolled Angle Sections

| SPAN (m) | LOAD (kN/m) | COLD FORMED SECTIONS | WEIGHT N Per m | Max. MOMENT Mz (kN.m) |
|---|---|---|---|---|
| 1.5 | 10 | CFS-A1 30x30x1.6 | 7.10 | 2.815 |
| 2.0 | | | | 5.004 |
| 2.5 | | | | 7.818 |
| 1.5 | 10 | CFS-A2 50x50x1.6 | 19.10 | 2.816 |
| 2.0 | | | | 5.006 |
| 2.5 | | | | 7.822 |
| 1.5 | 10 | CFS-A3 60x60x1.6 | 23.10 | 2.817 |
| 2.0 | | | | 5.007 |
| 2.5 | | | | 7.824 |

Table 4 Moments for Cold Formed Angle Sections

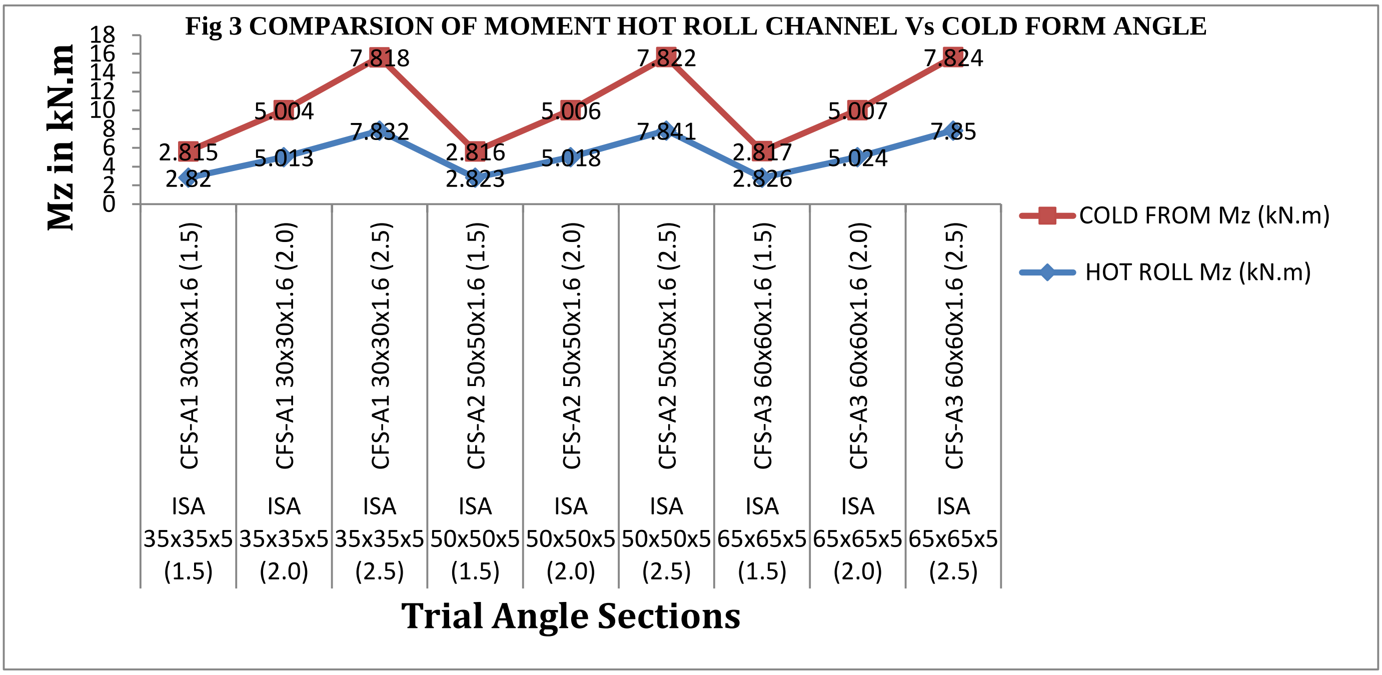


Fig 3 COMPARSION OF MOMENT HOT ROLL CHANNEL Vs COLD FORM ANGLE

*Selection of safer section from the trial sections:*

i. While comparing results obtained from STAAD.Pro analysis maximum bending of selected Channel Sections under given loading and span conditions up to 8.086KN.m. for hot rolled sections and for cold formed sections 7.883KN.m.

ii. While comparing results obtained from STAAD.Pro analysis maximum bending of selected Angle Sections under given loading and span conditions up to 7.85KN.m. for hot rolled sections and for cold formed sections 7.824KN.m.

iii. The resulting tables and graphs shows that Moment carrying capacity of hot roll and cold formed sections with different spans under 10KN/m live load condition, hot roll and cold formed Channel Sections offers 23% more moment of resistance when compared to hot roll and cold formed Angle Sections. Channel sections are likely to give more moment carrying capacity compared to angle sections.

iv. From the above result obtained ISMC 200 and ISMC 250 are selected from hot roll sections and corresponding comparison are made with CFS-C1 50x25x1.60 and CFS-C2 100x40x1.60 for Span 1.5m, 2.0m, 2.5m under fixed support condition for further and analysis flexure strength both experimentally and analytically.

## IV. THEORECTICAL ANALYSIS

### A. Determination of moment capacity of Hot Rolled Channel section:

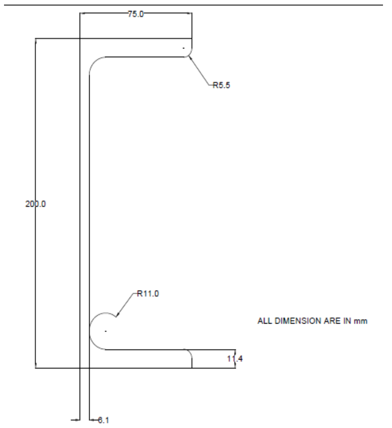


Fig 4 Hot Rolled section ISMC 200

Choose trial section ISMC 200 @221 N/m from IS 800-2007. [Limit State Method]

Sectional Properties:
h=200mm; $b_f$=75mm; $t_f$=11.4mm; $t_w$=6.1mm
$C_y$=21.7mm; $I_{xx}$=1819.3x$10^4$ $mm^4$; $I_{yy}$=140.4x$10^4 mm^4$;
$Z_{xx}$=181.9x$10^3 mm^3$; $Z_{yy}$=26.3x$10^3 mm^3$; $r_1$=11 mm
$A_w$ = 200*6.1= 1220$mm^2$
$A_f$ = 2($b_f$-$t_w$)*$t_f$ =1570.92$mm^2$.
Aw<Af. Therefore equal area axis lies outside of web
Plastic Section modulus:
$\overline{Z} = (2b_f * t_f + 2t_f * t_w – ht_w) / 4t_f$
Z = 13.8mm
Zpz = bf * tf (h-tf) + tw x (h/2 – tf) 2
Zpz = 209.137x103mm3
Zpy = htw (z ‾tw/2) + (z –tw)2tf + (bf –z)2 tf
Zpy = 56.48x103mm3
Section Classification:
ε= (250/fy) 0.5 = 1
For channel section; b/ tf =6.5< 9.4
d / tw = 42.32 < 84
Hence the section is plastic.
Moment Resistance capacity for ISMC 200 @221 N/m is given by:
Design bending strength Md = βb*Zp*fbd
βb = 1.0 for plastic and compact section
Zp = Plastic section modulus of section
fbd = Design bending stress = (χLT * fy) / γmo
fbd = 203.12 N/mm2
Design bending strength Md = βb*Zp*fbd
Md= 42.48 KN.m
Therefore Maximum Design Bending Strength given by trial section ISMC 200 @221 N/m is 42.48KN.m

### B. Determination of moment capacity of Built up Cold Formed Channel section as per IS 801-1975:

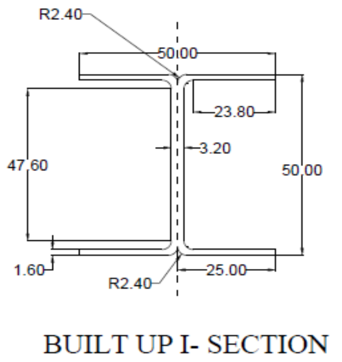


Fig 5 Cold formed steel Section

Choose trial section CFS-C1 50mm x 25mm x 1.6mm @ 11.17 N/m from IS 811-1987
Sectional Properties:
h=50mm; b=50mm; $t_f$=1.6mm; $t_w$=1.6mm; A = 320$mm^2$
$C_y$=25 mm; $I_{xx}$=1.27x$10^5$ $mm^4$; $I_{yy}$=3.34x$10^4 mm^4$;
$Z_{xx}$=5.08x$10^3 mm^3$; $Z_{yy}$=1.33 x$10^3 mm^3$;
$r_{xx}$ = 19.93mm; $r_{yy}$ = 10.23mm; leff = 1.25m
Aw = 50*1.6= 80$mm^2$
Af = 2(bf-tw)*tf =154.88$mm^2$.
Aw<Af. Therefore equal area axis lies outside of web
Plastic Section modulus:
$\overline{Z}$ = (2bf * tf + 2tf * tw – htw) / 4tf
$\overline{Z}$ = 1.6 mm
Zpz = bf * tf (h-tf) + tw x (h/2 – tf) 2
Zpz = 11368.19$mm^3$
Zpy = htw (z ‾tw/2) + (z –tw)2tf + (bf –z)2 tf
Zpy = 938.04$mm^3$
Slenderness ratio (λ):
Slenderness ratio (λ) = leff / $r_{min}$
λ = 122.18 < 300
The slenderness ratio for flexural member as per IS Code provide 300 mm for compression flange of a beam against lateral torsional buckling, so in this channel section (50mm x 25mm x1.6mm) up to 2.5m (limit state method)

Allowable shear stress on the beam:
As per IS 801-1975 from clause 6.2
Max. Allowable compression stress on flat unstiffened element:
[ w/t ] < [530 / {fy} 0.5]
= 31.25 < 33.52
Hence the section safe against shear stress.
Bending Moment (BM) of channel section:
Maximum Bending Moment = fb x Zxx
fb = lateral buckling stress in cold form steel ;
Zxx = section modulus channel section.
Maximum lateral buckling stress:
As per IS 801-1975, clause 6.3 given by
Maximum lateral buckling stress is determined by

$$F_b = 2/3 f_y – f_y^2/5.4 * \pi^2 * E * c_b\ (A)$$

$F_b$ = 166.66N/$mm^2$
Maximum Bending Moment = fb x Zxx
M = 18.83 kN.m
Moment of resistance of channel section:
As per IS 801-1975, clause 6.3 given by

The elastic lateral buckling moment capacity is determined for a channel section bent in the plane of the web and loaded through shear centre, this is

$$M_E = \frac{\pi 2 * A * E * h * C_b}{2\,\lambda^2}\ [1+ (1/20\{\lambda * t/h\})]0.5$$

$$M_E = 45.32 \text{ kN.m}$$

Therefore Maximum Design Bending Strength given by trial channel section 50mm x 25mm x 1.6mm @ 11.17 N/m is 14.06 KN.m

Table 5 Theoretical Load Calculation for Selected Sections

| S.NO | TRIAL SECTIONS | EFF. LENGTH IN m | FEM (ABAQUS IN kN) |
|---|---|---|---|
| 1. | ISMC 200 | 0.75 | 294.15 |
| 2. | ISMC 200 | 1.00 | 180.80 |
| 3. | ISMC 200 | 1.25 | 155.41 |
| 4. | CFS-C1 50x25x1.60 | 0.75 | 291.31 |
| 5. | CFS-C1 50x25x1.60 | 1.00 | 169.13 |
| 6. | CFS-C1 50x25x1.60 | 1.25 | 110.15 |

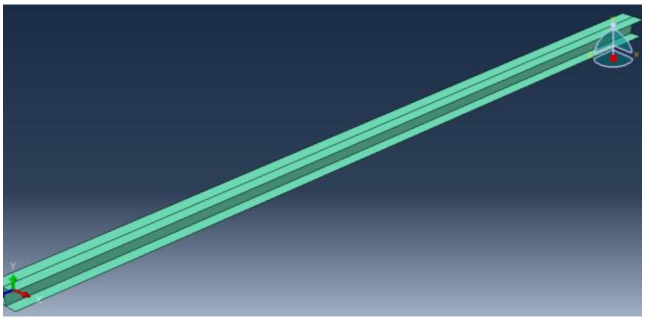


Fig 5 Typical Model Created in ABAQUS

*Element and Assembly*

The channel specimen was assembled with the ends at both the ends as shown in Figure. Assembly was such that the centroid of the cold formed channel section element coincides as well in the near cold formed channel section. Based on the mesh convergence study a mesh size of 20 x20 was selected.

## IV. FINITE ELEMENT MODELING

The flexure behavior of channel beam specimens was studied by modeling the angle sections using the Finite element package ABAQUS_6.11 part module. In order to apply a pressure loading concentric with the center of the channel specimen with rotation and displacement for one end and encaster for other end. The channels were modelled using shell element for cold formed steel and solid element for hot rolled steel.

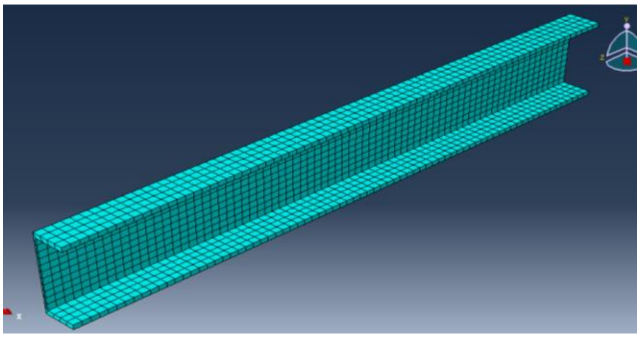


Fig 6 Typical Meshing Created in ABAQUS

*Boundary Condition and Loading*

For the case of loaded beams, the rigid plates were assembled in such a way that the centroid of plate coincided with that of the cross section. The models were analysed for fixed support conditions for a length of 1.5m, 2m, 2.5m. The boundary conditions were defined on the channel edges.

Fixed end condition – All the rotational and translational degrees of freedom were restrained at both the ends except the translational degree of freedom in the axial direction at top end.

Displacement Controlled Loading (DCL) – Load was applied in the form uniformly distributed axial displacement on the channel edges. This type of loading was required to study the post buckling range.

*Validation of the Model*

The model was validated using the experimental results on the fixed-ended beam specimens, subjected to concentrated loads. Finite element modeling was done using the ABAQUS software and the input parameters were also given [2]. The model results given in Table II were found to be harmonized with the experimental study data.

**Table 6 Load Capacity using FEM**

| S.NO | TRIAL SECTIONS | EFF. LENGTH IN m | MOMENT RESISTANCE IN kN.m | FLEXURAL LOAD CAPACITY IN kN |
|---|---|---|---|---|
| 1. | ISMC 200 | 0.75 | 42.48 | 226.56 |
| 2. | ISMC 200 | 1.00 | 42.48 | 169.92 |
| 3. | ISMC 200 | 1.25 | 42.48 | 135.94 |
| 4. | CFS-C1 50x25x1.60 | 0.75 | 45.32 | 241.70 |
| 5. | CFS-C1 50x25x1.60 | 1.00 | 38.86 | 155.44 |
| 6. | CFS-C1 50x25x1.60 | 1.25 | 30.67 | 98.14 |

## V. EXPERIMENTAL INVESTIGATION

A total of twelve simple beam tests were carried out. The nominal section sizes were CFS-C1 50x25x1.60, for cold formed and ISMC 200 for hot-rolled specimen were examined. The geometric properties of each specimen have been taken from IS 800 and IS 811. The symmetrical central-point simply-supported bending test arrangement is shown in Fig.. The span of the beams was fixed at 1100 mm and testing was displacement-controlled at a rate of 3.0 mm/min. Fixed support conditions were achieved by means of base plate. The specimens extended approximately 50 mm beyond each end support. Steel plates (50mm wide and 10 mm thick) were also employed at the points of support and load introduction. For each specimen, two strain gauges were adhered to the tensile. End rotations and midspan deflections were recorded digitally throughout the tests by means of LVDTs.

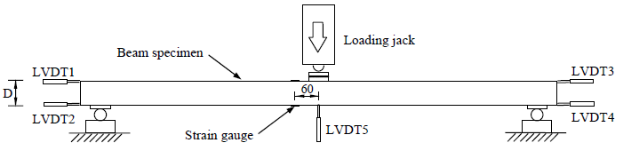


Fig 7 Load Set up

### A. Tensile Coupon Tests

The basic stress-strain properties of the investigated hot-rolled and cold-formed sections were obtained through tensile coupon tests. These tests were conducted in accordance with EN10002-1 [20]. For each thickness CFS and RHS specimens, one flat parallel coupon was machined from the face opposite the weld. The location of the flat and corner tensile coupons extracted from the hot-rolled and cold-formed beam sections for this study.

Fig 8 Experimental setup

## VI. RESULTS AND DISCUSSION

### A. EXPERIMENTAL RESULTS

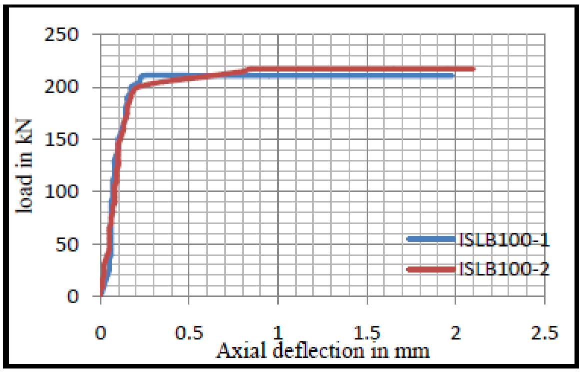


Chart 1- Load Vs Axial deflection for Hot Roll Section

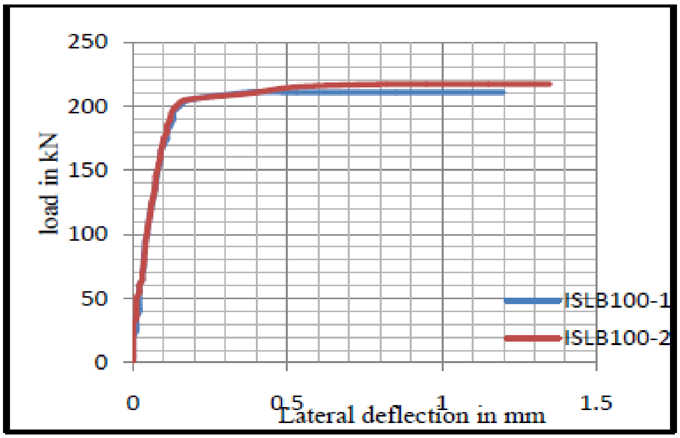


Chart 2- Load Vs Lateral deflection for Hot Roll Section

The chart shows distinct elastic, elasto-plastic zones with some strain hardening phase and then constant deformation, chart 1 and 2 shows linear variation from 0 kN to 200 kN for axial deflection and lateral deflection till it reaches to deflection of 0.2 mm then it changes its slope. Now, rate of change of deflection is more than rate of change of load from 215 kN to 217 kN.

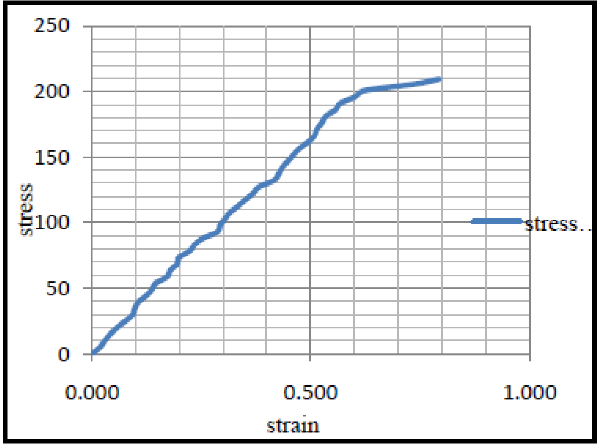


Chart 3- Stress Vs Strain graph for Hot Roll Section

Similarly stress vs. Strain graph shows linear proportionality up to 200 N/mm$^2$ stress, then slope of the line changes as section changes elastic state to elasto-plastic state.

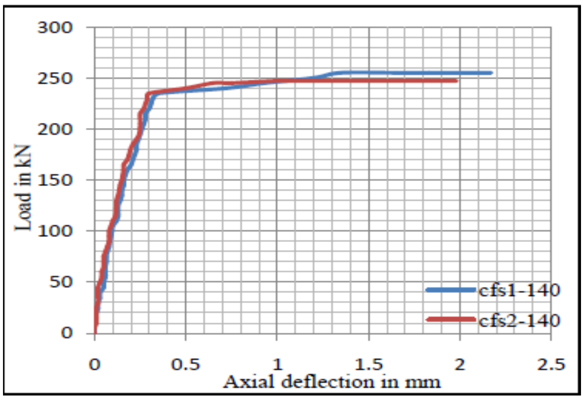


Chart 4- Load Vs Axial deflection for Cold formed Section

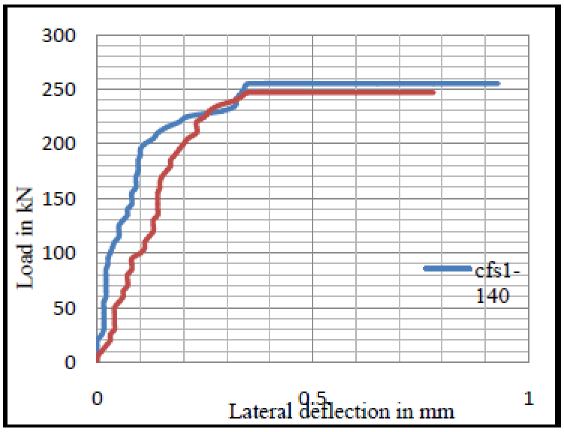


Chart 5- Load Vs Lateral deflection for Cold Form Section

In chart4 it is seen that section shows linear behavior till it reaches 200 kN load with 0.29 mm axial deformation. Then it changes state from elastic state to plastic state at 200 kN to 255 kN. It shows more rate of change of deflection than rate of change of load.

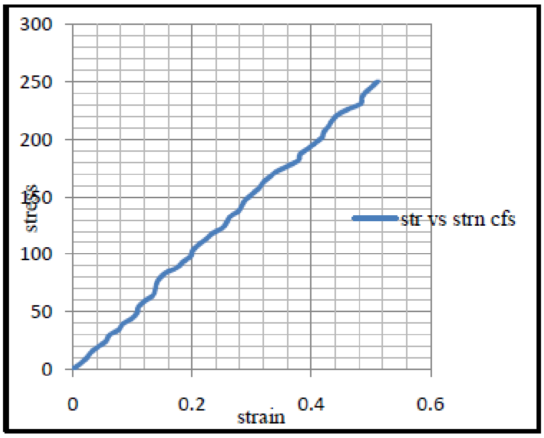


Chart 6- Stress Vs Strain graph for Cold Form Section

Stress vs. strain graph shows linear proportionality up to the ultimatestress. As it is cold formed section, it remains in elastic state up to the failure load. The maximum stress value obtained is 250.98 N/mm$^2$ for strain value 0.512

## B. FINITE ELEMENT METHOD RESULTS

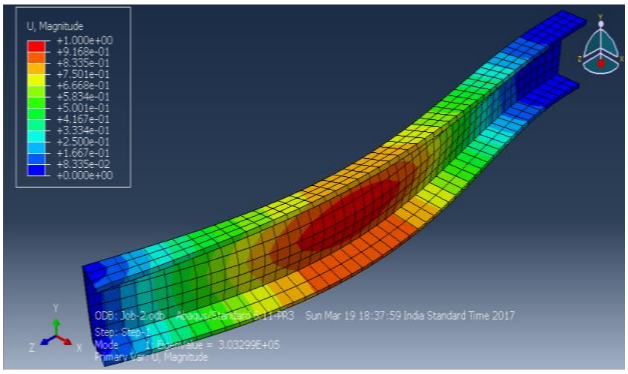


Fig 9 Bending Shape of Hot roll Section

The maximum deflection investigated from ABAQUS software is 2.002 mm with ultimate load 254.78 kN. The maximum stress is observed near fix end support; within the effective length of the column, uniform stress distribution observed is shown in green colour, which causes bending of the section. o

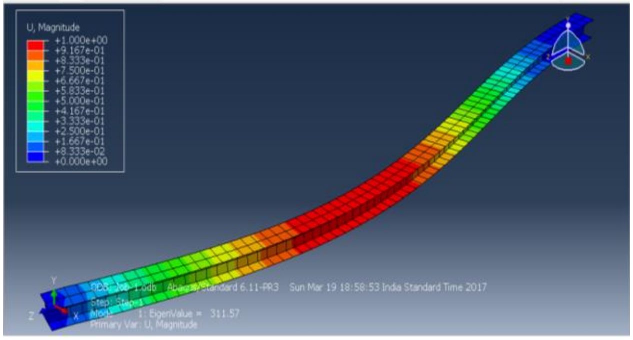


Fig 10 Bending Shape of Cold Form Section

In figure it is observed that failure of cold formed steel section is irregular, it shows convex and concave failure pattern and it fails near the support. The deflection obtained from ABAQUS is 1.89mm with ultimate buckling load 269.41 kN.

| Specimen Tested | | Experimental | FEM | % Error |
|---|---|---|---|---|
| Axial deflection (mm) | ISMC 200 | 2.00 | 1.98 | 1 |
| | CFS-C1 50x25x1.6 | 1.89 | 1.823 | 3.54 |
| Lateral deflection (mm) | ISMC 200 | 1.025 | 1.001 | 2.34 |
| | CFS-C1 50x25x1.6 | 0.92 | 0.89 | 3.26 |
| Stress (N/mm$^2$ ) | ISMC 200 | 210.15 | 220.85 | 5.09 |
| | CFS-C1 50x25x1.6 | 230.85 | 238.24 | 3.2 |
| strain | ISMC 200 | 0.896 | 0.924 | 3.02 |
| | CFS-C1 50x25x1.6 | 0.684 | 0.754 | 9.28 |

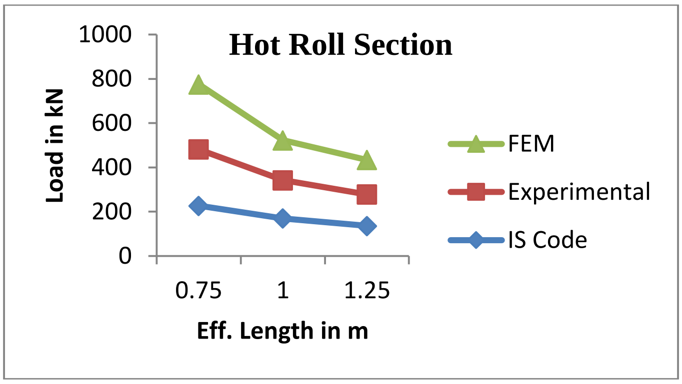
Table 7 Coupon Test Results

Coupon test was preformed for the hot roll and cold formed sections to find the actual behavior of materials for the given load condition the material preformed was completely analyzed. From the table experimental values from coupon tests and ABAQUS software values are nearly equal with much less error so software gets validated.

The deflection values are less in cold formed steel but at the same time the stress and strain value is nearly increased about 5-9% compared with hot rolled sections. The bending of sections during stress strains relationship is taken as a pure bending.

Table 8 Comparison of Flexural Capacity

| Sections | Eff. Length in m | IS Code | Experimental | FEM |
|---|---|---|---|---|
| ISMC 200 | 0.75 | 226.56 | 254.78 | 294.15 |
| ISMC 200 | 1.00 | 169.92 | 172.16 | 180.80 |
| ISMC 200 | 1.25 | 135.94 | 142.18 | 155.41 |
| CFS-C1 50x25x1.60 | 0.75 | 241.70 | 269.41 | 291.31 |
| CFS-C1 50x25x1.60 | 1.00 | 155.44 | 162.21 | 169.13 |
| CFS-C1 50x25x1.60 | 1.25 | 98.14 | 102.69 | 110.15 |



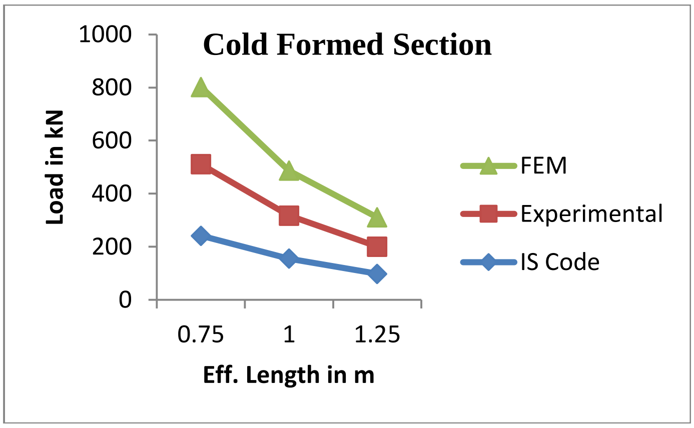


Table 9 Flexural capacity comparison from experimental results

| Sections | Area in mm$^2$ | Eff. Length in m | Flexural Capacity | % of increase in capacity |
|---|---|---|---|---|
| ISMC 200 | 2821 | 0.75 | 254.78 | 5.74 |
| CFS-C1 50x25x1.60 | 320 | 0.75 | 269.41 | |
| ISMC 200 | 2821 | 1.00 | 172.16 | -5.77 |
| CFS-C1 50x25x1.60 | 320 | 1.00 | 162.21 | |
| ISMC 200 | 2821 | 1.25 | 142.18 | -27.77 |
| CFS-C1 50x25x1.60 | 320 | 1.25 | 102.69 | |

## VII. CONCLUSION

It can be interpreted that the cold formed steel sections shows 5.74 % more load carrying capacity as compared to hot rolled sections below the span range upto 1.5m with fixed support conditions. At the same time if the span range exceeds above 1.5m the flexural capacity of cold formed section reduces compared to hot rolled sections. It also shows little variation in axial deflection of both cold formed steel section and hot rolled steel section. The stress distribution of hot rolled steel section is much uniform throughout the length, on the contrary cold formed steel section shows distinct variation in stress distribution. The finite element software ABAQUS gives results nearer to experimental results up to 13 % for load carrying capacity calculation. While comparing failure pattern, hot rolled steel member shows bending failure and cold formed steel shows distortional local buckling failure

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