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Experimental And Theoretical Analysis Of Cold Formed Z- Section And Built Up Channel Section

A.Jayaraman[1], K. Tamil Selvan[2], R.Mounika[2], s.b.prasath[3]

1, 3-Assistant Professor, Department of Civil, Bannari Amman Institute of Technology, Sathymangalam, Erode, Tamilnadu, India.

2-PG Student, Department of Civil, Bannari Amman Institute of Technology, Sathymangalam, Erode, Tamilnadu, India.

Abstract

Now days most of the industry looks forward to the low construction cost and same time strength & safe of structures. The cold formed steel members are widely used in the constructionof all type of structures. Particularlyforrailway coaches, residential building, commercial building, agricultural storage bin, transportation field, transmission line tower and industrial buildings. This paper presents a studied on behaviour and economical of cold formed steel (CFS) section using in Different cross sectional area but weight of both the section is same and both cross sectional area is same but weight of both the section is different. Main focus of these studied which type of cold formed section is more economical and high strength and more load carrying capacity are studied. Over all two different cross sectionZ –Shape (110 x 45 x2) and built up channel section (60 x 60 x 4) mm is 3.50 kg /m are carried out. The theoretical data are calculated using Indian Standard code IS 801-1975 and the section properties of the specimens are obtained using IS 811-1975. The sections are designed under uniformly distributed loading with simply supported condition. The theoretical results are verified using ANSYS V11 software. The studies expose that the theoretical , experimental and numerical investigations Z –Shape section have high bending strength, high load caring capacity, deflection and minimum local buckling& distortional buckling compare to the built up channel section by different cross sectional area but same weight of section

***Key words*: Cold formed steel, built up channel section, ANSYS, bending strength, deflection**

I.INTRODUCTION

The light gauge cold formed steel sections are defined as structural elements cold formed of shapes in cold – rolling machines or press brakes or bending brake operations from carbon or low – alloy steel sheets or strips or flats. The thickness of such members usually range from 0.378mm to about 6.35mm, even though steel plates as thick as 25 .4mm may be cold formed into structural shapes. These thin steel sections are called cold formed as their manufacturing process of forming steel sections remains in a cold state .these are also known as cold rolled steel sections against hot rolled steel sections. There are four types of moment resistant connections are used in cold formed steel section by single row of screws using beam column connecter at the junction (C1), double row of screws using beam column connector at the junction (C2), angle plate along with beam column connector at the junction single row screws (C 3) and double row of screws (C 4). Finally concluded that, the moment resistant connection of C3 and C4 are maximum moment capacity compare with other type of connections (C1 & C2) in both the experiential and numerical investigation. (1) This paper reported that behaviour of cold formed section by with cover plate and without cover plates attached at the top flanges in cold formed section. Determination of pure bending strength and non-dimensional slenderness ratio in cold formed steel section by cover plates attached to the top flange and without cover plates at the top flanges. Finally concluded less buckling resistance and improve the non-dimensional slenderness ratio in cold formed section without cover plate at the top flanges section compare with cover plates attached at top flanges in cold formed sections. (2) The cold formed steel section are used in different way of connection such as back to back column member connection ,face to face box connection , moment resistant connection , stiffened connection , un stiffened connection and beam to beam and column to column splice connection. Another one method the strength is developed in cold formed section by composite method such as wooden pads, timber planks etc... The carrying capacity is increased in composite section of cold formed section compare with conventional cold formed steel sections. (3) The cold section is light weight and low cost materials compare with conventional steel section. Now a day's most of the industrial structures recently widely developed cold formed section due to light weight and minimum base shear and best seismic performance. Developed splice connection in industrial steel structures in beam to beam connection, column to column connection, bottom chord member and top chord member. In this type of moment resistant splice connection is best seismic performance minimum base shear and maximum load carrying capacity and minimum distortional buckling compare with ordinary cold formed section.

II. AIM OF THE STUDY

The main aim of the study provides which section is economical, high bending strength, more load carrying capacity and high flexural strength by analysis of theoretical and numerical investigation.(4)

III.EXPERIMENTAL INVESTIGATION

The experimental investigation of cold formed steel section in different section.

CASEI:Different cross sectional area but weight of both the section is same

CASE I:

Different cross sectional area but weight of both the section is same

Theoretical investigations of ZED Lipped equal flange section(110 x 45 x2) mm is 3.50 kg /m and built up channel section (60 x 60 x 4) mm is 3.50 kg /m

3.1 Materials

3.1.1 Light gauge steel physical properties: The rolled steel sheet is used. Thephysical properties of light gauge steel section given in Table 1.The properties taken from the Indian Standard code IS 800-2007

3.2Theoretical investigationsofZED Lipped equal flange section (110 x 45 x2) mm

The rolled steel sheet is used. The channel sectional properties of light gauge steel section (given in Table 2.The properties taken from the Indian Standard code IS 811-2007

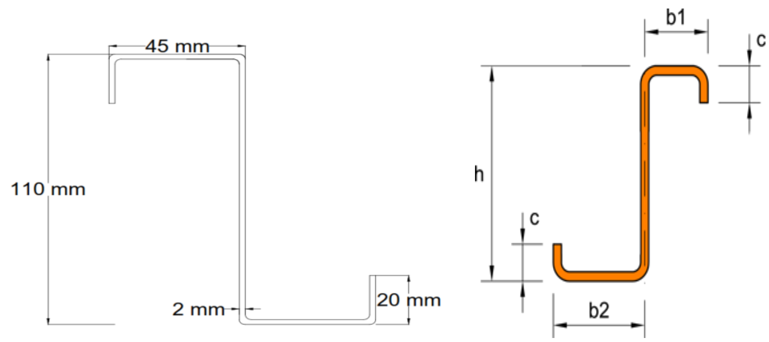
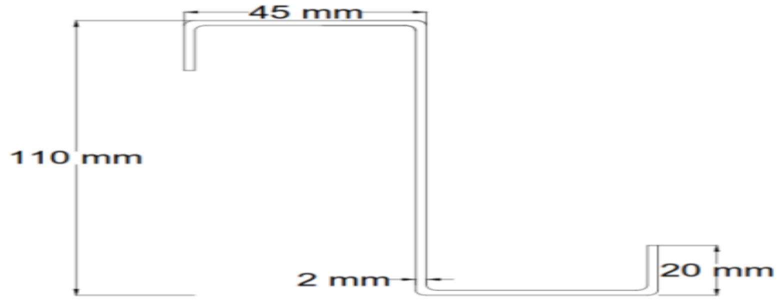


Table 2. Properties of (110 x 45 x2) mmlight gauge steel Channel section

Area	446 mm^2
Elastic Section modulus (zex)	14.7 x 10^3 mm^3
plastic Section modulus (pzx)	5.22 x 10^3 mm^3
Moment of inertia of section xx direction (Ixx)	811 x 10^3 mm^4
Moment of inertia of section yy direction (Iyy)	23 x 10^3 mm^4
Radius of gyration (rx)	13.8 mm

3.2.1 Slenderness ratio (λ): The Slenderness ratio value is given in table 4



Slenderness ratio

$$(\lambda) = \frac{Effectivelength}{Radiousofgyration\ (rmin)}$$

Table 4. Slenderness ratio

Effectivelength (mm)	Slenderness ratio (λ)
1000	72.46
2000	144.92
3000	217.39
4000	289.85
5000	362.31

The slenderness ratio of flexural member as percode IS800-1985 provide 300 mm for compression flange of a beam against lateral torsional buckling, so using this channel section (110 x45 x2) mm only up to 4 mfor construction field.

3.2.2Moment of resistance ofZED Lipped equal flange section (110 x 45 x2) mm

Moment resistance = MR = (Zxx) x (Fb)

$\frac{L^2 x\ Zxc}{d\ x\ Iyc}$= 1611.05

$\frac{\pi^2 x\ E\ x\ cb}{235}$= 8399.66

$0.18\ \frac{\pi^2 x\ E\ x\ cb}{235} =$ 1511.93

$0.9\ \frac{\pi^2 x\ E\ x\ cb}{235}$ = 7559.694

$\frac{L^2 x\ Zxc}{d\ x\ Iyc} > 0.18\ \frac{\pi^2 x\ E\ x\ cb}{235} < 0.9\ \frac{\pi^2 x\ E\ x\ cb}{235}$

Therefore IS 801 -1975 provide the basic design stress

Basic design stress = Fb = $\frac{2}{3} fy - \frac{fy^2}{2.7\ x\pi^2\ xExcb}\ (\frac{L^2 x\ Zxc}{d\ x\ Iyc})$ = 144.66 N / mm^2

fy = yield stress in cold form steel

$Z_{xx=}$ section modulusZed section

E = Young's modulus of steel

Cb = bending coefficient = 1

Moment of resistance (MR) = 2.12 x 10^6 Nmm

3.2.3 Load caring capacity (p) of ZED Lipped equal flange section (110 x 45 x2) mm

Moment resistance (MR) =$\frac{wl^2}{8}$

Maximum Load (p) = 16.96 kN / m

3.2.4Actual shear stressZED Lipped equal flange section(110 x 45 x2) mm

Maximum shear = $\frac{Wl}{2}$ = 8.48 kN / m Actual shear stress = $\frac{V}{2bd}$ = 20 N/mm^2

3.2.5 Allowable stresses in web of beam

Shear stresses in webs – The maximum permissible average shear stresses (Fv), on the gross area of a flat web shall not exceed (0.4 x fy)

$\frac{h}{t}$ =53 , $\frac{1425}{\sqrt{fy}}$ = 92.95 N/mm^{2}for$\frac{h}{t}$<$\frac{1425}{\sqrt{fy}}$

Fv = $\frac{396\sqrt{fy}}{\frac{h}{t}}$ = 114.5.2 N / mm^2

3.2.6Actual bending stress: $f$bw' = $0.6fy[\frac{y-t}{y}]$= 135N / mm^2

3.2.7 Allowable bending stress: fb=$0.6fy$= 141 N/mm².

Hence safe in bending stress

3.2.8Check for deflection of ZED Lipped equal flange section(110 x 45 x2) mm

The actual deflection (Δ) and Permissible deflection is given in table 5.

Actual deflection (Δ)= $\frac{5Wl^4}{384\ EI}$

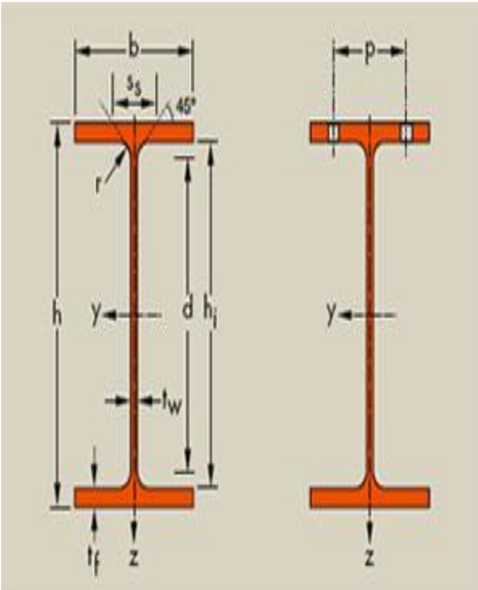
Permissible deflection = $\frac{span}{325}$

Table 5. Deflection

Effectivelength (mm)	Actual Deflection (Δ) (mm)	Permissible deflection (Δ) (mm)
1000	2.44	3.07
2000	3.92	6.15
3000	198.03	9.230
4000	625.56	12.30
5000	1326.67	15.38

3.3 Theoretical investigationsof builtupchannel section (60 x 60 x4) mm

The rolled steel sheet is used. The built up channel sectional properties of light gauge steel section (given in Table 3). The properties taken from the Indian Standard code IS 811-2007.



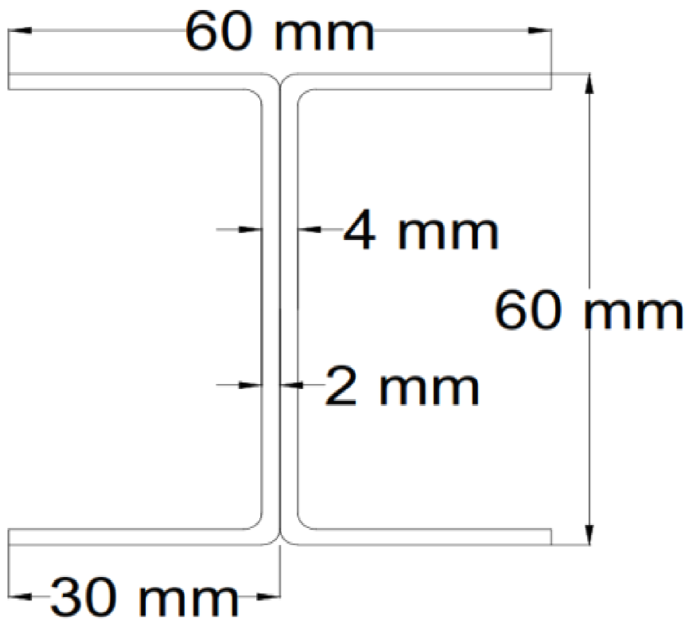
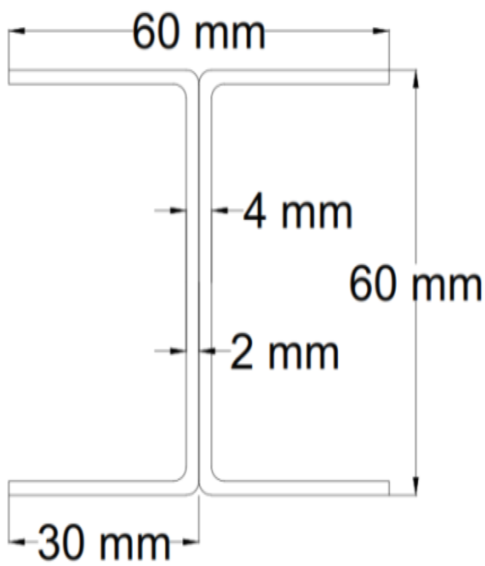


Table 3. Properties of light gauge steel built up Channel section (60 x60 x4) mm

Area	446 mm^2
Elastic Section modulus (zex)	8.133 x 10^3 mm^3
plastic Section modulus	0.925 x 10^3 mm^3
Moment of inertia of section xx direction (Ixx)	244 x 10^3 mm^4
Moment of inertia of section yy direction (Iyy)	70.22 x 10^3 mm^4
Radius of gyration (minimum)	9.44

3.3.1 Slenderness ratio (λ): The Slenderness ratio value is given in table 4



Effectivelength (mm)	Slenderness ratio (λ)
1000	105.93
2000	211.86
3000	317.80
4000	423.72
5000	530.00

Slenderness ratio

$(\lambda) = \frac{Effectivelength}{Radiousofgyration\ (rmin)}$

Table 6. Slenderness ratio

The slenderness ratio of flexural member as per IS Code 800-1985 provide 300 mm for compression flange of a beam against lateral torsional buckling ,so this channel section (30 x60 x1.6) mm using only up to 2 m for construction field.

3.3.2 Moment of resistance of builtupchannel section (60 x 60 x4) mm

Moment resistance = MR = (Zxx) x (Fb)

$\frac{L^2 x\ Zxc}{d\ x\ Iyc} = 3860.72$

$\frac{\pi^2 x\ E\ x\ cb}{235} = 8399.66$

$1.8\ \frac{\pi^2 x\ E\ x\ cb}{235} = 15119.3$

$0.36\ \frac{\pi^2 x\ E\ x\ cb}{235} = 3023.82$

$\frac{L^2 x\ Zxc}{d\ x\ Iyc} > 0.36\ \frac{\pi^2 x\ E\ x\ cb}{235} < 1.8\ \frac{\pi^2 x\ E\ x\ cb}{235}$

Therefore IS801 -1975 provide the basic design stress

Basic design stress = Fb = $\frac{2}{3} fy - \frac{fy^2}{5.4\ x\pi^2\ xExcb}\ (\frac{L^2 x\ Zxc}{d\ x\ Iyc})$ = 136.66 N / mm^2

fy = yield stress in cold form steel

Z_{xx} = section modulus Zed section

E = Young's modulus of steel

Cb = bending coefficient = 1

Moment of resistance (MR) = 1.11 x 10^6 Nmm

3.3.3 Load caring capacity (p) of built up channel section (60 x 60 x4) mm Moment resistance (MR) = $\frac{wl^2}{8}$

Maximum Load (p) = 8.80 kN / m

3.3.4 Actual shear stress built up channel section (60 x 60 x4) mm)

Maximum shear = $\frac{wl}{2}$ = 4.40 kN / m

Actual shear stress = $\frac{V}{2bd}$ = 9.16 N/mm^2

3.3.5 Allowable stresses in web of beam

Shear stresses in webs – The maximum permissible average shear stresses (Fv), on the gross area of a flat web shall not exceed (0.4 x fy)

$\frac{h}{t}$ =15 , $\frac{1425}{\sqrt{fy}}$ = 92.95 N/mm^{2}for $\frac{h}{t}<\frac{1425}{\sqrt{fy}}$

Fv = $\frac{396\sqrt{fy}}{\frac{h}{t}}$ = 202.35 N / mm^2

3.3.6 Actual bending stress:

*f*bw' = $0.6fy[\frac{y-t}{y}]$ = 131 N / mm^2

3.3.7 Allowable bending stress:

*f*b = $0.6fy$ = 141 N/mm^2.

Hence safe in bending stress.

3.3.8Check for deflection of built up channel section (60 x 60 x4) mm)

The actual deflection (Δ) and Permissible deflection is given in table 7 Actual deflection (Δ) = $\frac{5Wl^4}{384\ EI}$

Permissible deflection = $\frac{span}{325}$

Table 7. Deflection

Effectivelength (mm)	Actual Deflection (Δ) (mm)	Permissible deflection (Δ) (mm)
1000	7.42	5.070
2000	59.2	8.150
3000	296.03	12.305
4000	821.56	14.520
5000	1427.67	17.285

IV EXPERIMENTAL PROCEDURE

Theoretical investigation, experimental analysis and software analysis is done by light gauge cold formed steel Z – section(**110 x 45 x2) mm** and built up channel section(**60 x 60 x4) mm)** in different cross sectional area but weight of both the section is same. The theoretical data are calculated using Indian Standard code IS 801-1975& IS 811-1975 is used. The theoretical results of the Z – shape section, load caring capacity, moment resistanceand shear resistance is 92.72 %, 51.88 %and 54.2 % higher than the built up channel section. Allowable stress in web of the beam, actual deflection and bending stress in web is same in both the section. The numerical(using ANSYS) and experimental investigationthe bending moment, torsional moment, deformation and shear stress are maximum in built channel section compare with the Zee shape section.

V RESULT AND DISCUSSION

Experimental investigation of cold formed steel Z- Shape and built up channel sectionsexperimental set up are given Figure 5.1 and 5.2.

Figure 5. 1 & 5.2 Experimental set up for Z – Shaped cold formed steel sections(110 x 45 x2), formed built up channel sections(60 x 60 x4) mm)

The Experimental investigations and theoretical investigations cold formed Z –Shape and built up channel section different cross sectional area but weight of both the section is sameobtainable in Table1.

Types of sections	Section properties	Theoretical investigations of cold formed steel sections per meter of span**per meter of span**	Experimental investigations of cold formed steel sections per meter of span**per meter of span**
Cold formed steel Z – Shape section **(110 x 45 x2)**	Load carrying capacity in kN	16.96	8.80
	Moment resistance in kNm	2.21	1.10
	Permissible Deflection in mm	15.38	18
	Shear capacity in kN	20	7.5
Cold formed Built up channel Shape section. **(60 x 60 x4) mm)**	Load carrying capacity in kN	8.80	5.5
	Moment resistance in kNm	1.11	0.6875
	Permissible Deflection in mm	17.285	21
	Shear capacity in kN in kN	9.16	14.2

5.1 Load carrying capacity of Cold formed Z – Shape(110 x 45 x2) and Built up channel section(60 x 60 x4) mm)

Load carrying capacity of Cold formed steel Z – Shape section and Built up channel Shape section shown in Figure 6.And Table 5. The Z – Shape cold form steel section load carrying capacity is 92.72 %

and 60 % higher than built up channel section in both theoretical and experimental investigations per meter of span.

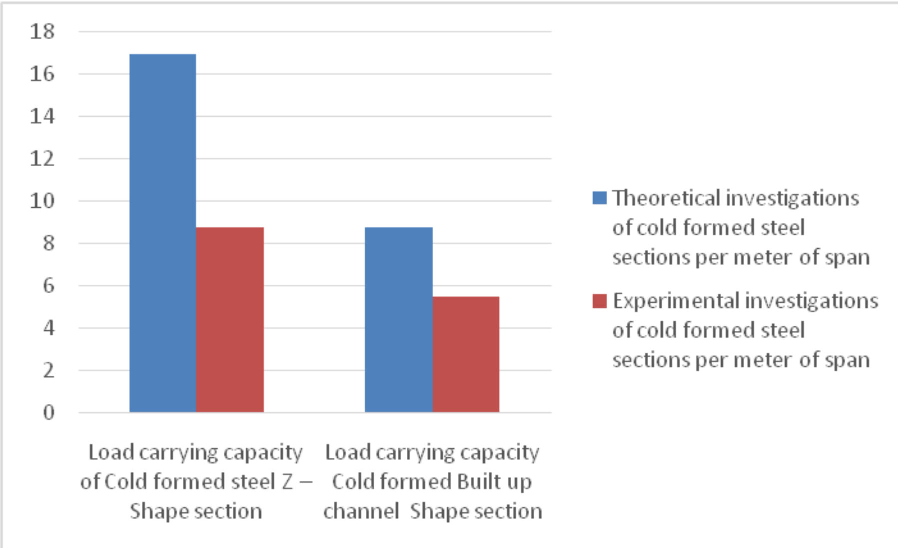


Figure .6 Load carrying capacity of Cold formed steel Z – Shape section(110 x 45 x2) and built up channel Shape section per meter of span

5.2 Moment resistanceof Cold formed Z – Shape(110 x 45 x2) and Built up channel section(60 x 60 x4) mm)

Moment resistance of capacity of Cold formed steel Z – Shape section and Built up channel Shape section shown in Figure 7 and Table 5. The Z – Shape cold form steel section moment of resistance is 52.72 % and 60 % higher than built up channel section in both theoretical and experimental investigations per meter of span.

5.3 Deflection of **Cold formed Z – Shape(110 x 45 x2) and Built up channel section(60 x 60 x4) mm)**

Deflection ofcold formed steel Z – Shape section and built up channel Shape section shown in Figure. 8 and Table 5. The Z – Shape cold form steel section deflection is 67.90 % and 26.76 % higher than built up channel section in both theoretical and experimental investigations per meter of span.

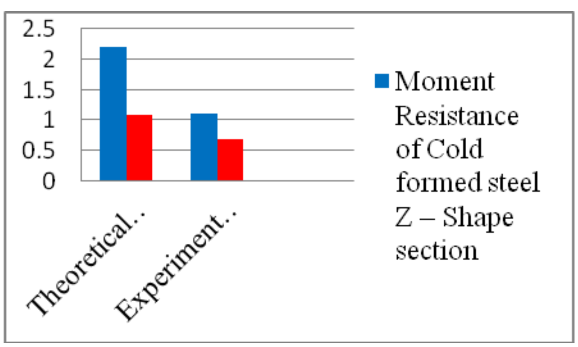


Figure.7 Moment Resistance of Cold formed steel Z – Shape section (110 x 45 x2) and built up channel Shape section(60 x 60 x4) mm) per meter of span

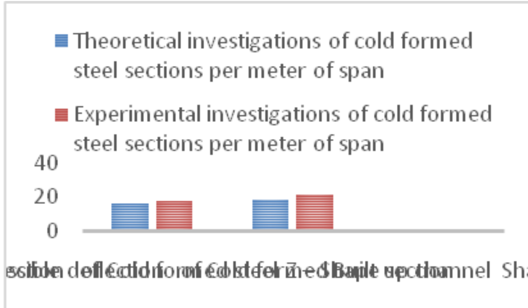


Figure. 8 Permissible Deflection of Cold formed steel Z – Shape section(110 x 45 x2) and built up channel Shape section(60 x 60 x4) mm) per meter of span

5.4 The numerical (using ANSYS) investigations Cold formed steel Z – Shape section (110 x 45 x2)and built up channel Shape section (60 x 60 x4) mm) per meter of span

The bending moment, deflection and shear capacity of cold formed steel Z – Shape section (110 x 45 x 2) per meter of span shown in figures 9.

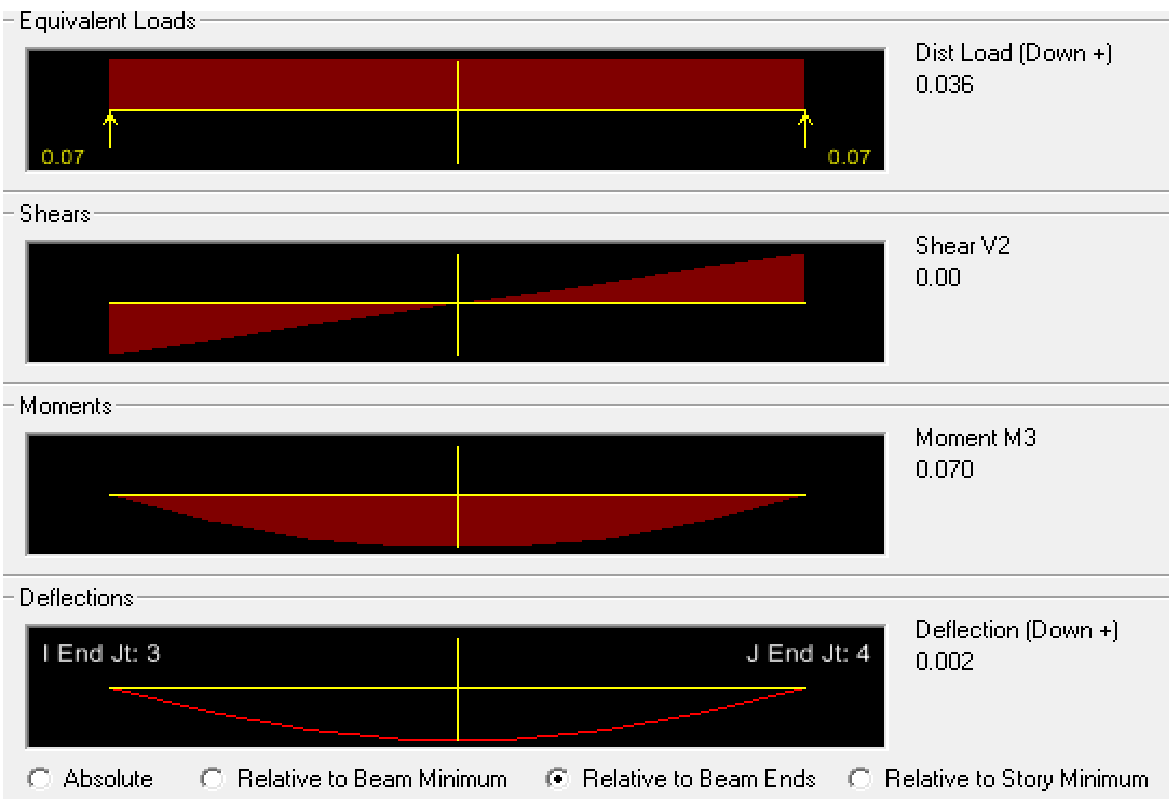
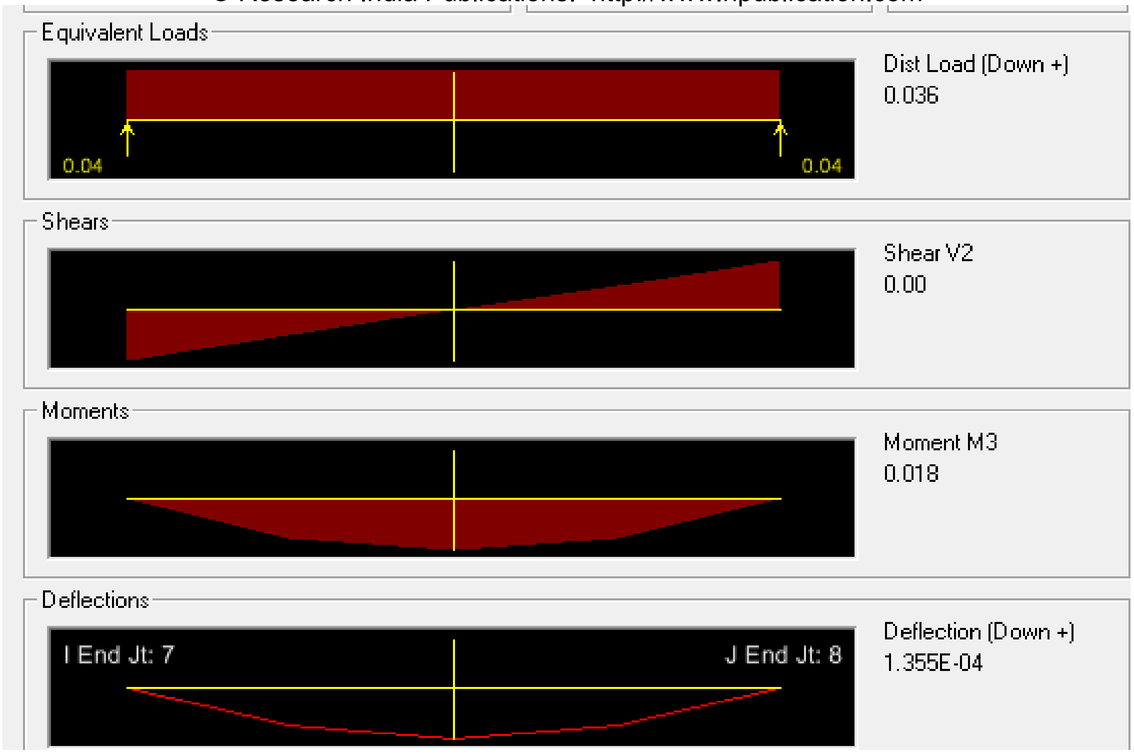


Figure .9 the numerical (using ANSYS) investigations Cold formed steel Z – Shape section (110 x 45 x2)

The bending moment, deflection and shear capacity of cold formed steel Z – Shape section (**60 x 60 x4) mm)** per meter of



Spans shown in Figures .10

Figure .10 the numerical (using ANSYS) investigations Cold formed steel Z – Shape section（60 x 60 x4) mm)

From the figure 10 & 11 The Z – Shape section（110 x 45 x 2) is 74.28 % and 56.2% higher bending moment resistance and deflection compare with built up channel section per meter of span.

VI CONCLUSIONS

The final results the theoretical , experimental and numerical investigations of Z- Shaped section is high load carrying capacity , moment of resistance and high deflection compare with built up channel section in per meter of span.

- Z – Shape cold form steel section load carrying capacity is 92.72 % and 60 % higher than built up channel section in both theoretical and experimental investigations
- The Z – Shape cold form steel section moment of resistance is 52.72 % and 60 % higher than built up channel section in both theoretical and experimental investigations.
- Z – Shape cold form steel section deflection is 67.90 % and 26.76 % higher than built up channel section in both theoretical and experimental investigations.
- The numerical investigations also Z – Shape cold form steel section is higher load carrying capacity and deflection.

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