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INVESTIGATION ON ENCASED COLD FORMED STEEL BEAM BY VARYING CORRUGATION PROFILES

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ABSTRACT

The thin walled steel sections are more sensitive to local buckling when compared to hot rolled steel sections. Cross sections are generally stiffened to improve resistance to local buckling. The range of application of cold-formed steel structures is considerable and increasing. The bridges of today show the advancements in steel technology and design which have occurred over the last century. From the modest spans to the exciting cable stayed and suspension bridges, steel has a wide appeal. In this research study, design and optimization of encased cold formed corrugated steel beams has been modified for the various parameters such as length, breadth, depth of web, angle of corrugation, encased concrete steel section with corrugation. The comparison between analytical and numerical investigation design are carried by AISI-S100-2007, IS801:1975 and AS/NZS 4600:2005 standard codes with analysis of ANSYS 12.0 software, to found the optimum design of beams with various parameters to ultimate load carrying capacity of beam.

Keywords--Encased Beam, Ansys, AISI, local buckling, Cold Formed Steel.

I. INTRODUCTION

Cold-formed steel (CFS) is the common term for products made by rolling or pressing steel into semi-finished or finished goods at relatively low temperatures. Cold-formed steel goods are created by the working of steel billet, bar, or sheet using stamping, rolling (including roll forming), or presses to deform it into a usable product. Coldworked steel products, such as cold-rolled steel bar stock and sheet, are commonly used in all areas of manufacturing of durable goods, such as appliances or automobiles, but the phrase coldformed steel is most prevalently used to described construction materials. The use of cold-formed steel construction materials has become more and more popular since its initial introduction of codified standards in 1946. In the construction industry both structural and non-structural elements are created from thin gauges of sheet steel. The manufacturing of cold-formed steel products occurs at room temperature using rolling or pressing. Cold-formed steel members have been used in buildings, bridges, storage racks, grain bins, car bodies, railway coaches, highway products, transmission towers, transmission poles, drainage facilities, various types of equipment and others. These types of sections are cold-formed from steel sheet, strip, plate, or flat bar in roll forming machines, by press brake (machine press) or bending operations.

1.2Theoretical investigation of plane web CFS

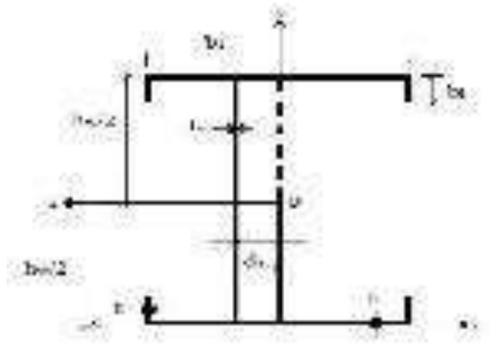


Fig -1 Plane Web CFS Beam

Computation of Basic Design Stress: Design Stress fb= 0.6fy

Computation of Effective Width

$$\frac{b}{t} \quad \frac{658}{\sqrt{fb}}\left[1-\frac{145}{\left(\frac{w}{t}\right)\sqrt{fb}}\right]$$

Determination of Moment of Inertia (I)

Moment of inertia = $\frac{BD3-(bd3)}{12}$

Determination of Centre of gravity (y)

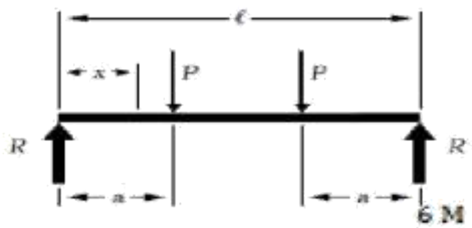
Centre of gravity y = $\frac{D}{2}$

Determination of section modulus (Z) Section modulus Z = $\frac{I}{y}$

Determination of Bending Moment (M)

Bending moment M = fb x Z

Determination of Load Carrying Capacity (W)



$$\frac{6\,M}{l}$$

Fig -2 Beam With Two Point Loading

Load carrying capacity w =6M/L

Check for web Shear

Max.average shear stress

$\frac{V}{2\,th}$: $\frac{h}{t}$ = 58 $< \frac{1425}{\sqrt{fy}}$ v $\frac{396\sqrt{fy}}{h/t}$

f =fv > Max. Avg.shear stress permissible compressive stress f bm = $\frac{W}{\left(\frac{h}{t}\right)^2}$

Check for Combined Bending and Shear Stress in

Web$\sqrt{}$ ($\frac{fbm}{f_{bm}}$)^2 + ($\frac{fv}{f_v}$)^2 ≤ 1

Maximum deflection at centre = $\frac{23\,WL^3}{648EI}$

1.3Design of Corrugated Web for Different Angles

Computation of Basic Design Stress : Design

Stress fb= 0.6fy

Determination of Centre of gravity of corrugated we(y)

yco sec =[$\frac{(bf.tf.yf)+\left(\frac{hw}{2}\right).tw.yw}{bf.tf+\left(\frac{hw}{2}\right)tw}$]

Moment of Inertia (I) = Itop flange +Iweb + Ibottom flange

Itop flange = ICG + A1 h1^2

Iweb = [(2btw x$\left(\frac{hr}{2}\right)^2$) + ($\frac{tw\,hr^3}{6\sin\emptyset}$)]

Ibottom flange = ICG + A3 h3^2

Section modulus Z = $\frac{I}{y}$

Bending moment M =fb xZ

Load carrying capacity W = $\frac{6M}{l}$

1.4Design of Corrugated Web for Varying Depth

Computation of Basic Design Stress

Design Stress fb= 0.6fy

Determination of Centre of gravity of corrugated we(y)

$$yco\ sec = \left[\frac{(bf.tf.yf)+\left(\frac{hw}{2}\right).tw.yw}{bf.tf+\left(\frac{hw}{2}\right)tw} \right]$$

Moment of Inertia (I) = Itop flange +Iweb + Ibottom flange

I top flange = ICG + A1 $h1^2$

$$Iweb = \left[\left(2btw\ x\left(\frac{hr}{2}\right)^2\right) + \left(\frac{tw\ hr^3}{6\sin\emptyset}\right)\right]$$

Ibottom fl_{ange} = ICG + A3 $h3^2$

Section modulus $Z = \frac{I}{y}$

Bending moment M =fb xZ

Load carrying capacity W = $\frac{6M}{l}$

1.5Encased Beam with Corrugated Web

Determination of Moment of Inertia of

Composite section(Iz) : Iz = Iza + Izc red

Izc red= reduced moment of inertia of concrete=Izcx$\frac{Ec}{Es}$

Design strength of Concrete

$$\beta_R = \frac{\text{Grade of concrete}}{\text{partial safty factor}}$$

Geometric properties

According to the plastic compressive zone

$$e_{pl} = \frac{2fya.tw.h1/2}{2fya.tw+2b1.\beta R}$$

Design strength of steel $f_{ya} = \frac{\text{yield strength of steel}}{\text{partial safty factor}}$

$\frac{2fya.tw.h1/2}{2fya.tw+2b1.\beta R}$: $I_{zc} = e_{pl}\ x \frac{(b-tw)^2}{12}$

$\frac{Ec}{Es}$: $E_c = 5000\sqrt{fck}$

$$\frac{BD^3-(bd^3)}{12}$$

Iza= moment of inertia of steel ,I_z= Moment of inertia of the composed section = Iza + Izc red

Centre of gravity $y = \frac{D}{2}$: $M_{pl,a} = \frac{fy\ xIz}{y}$

Determination of plastic moment (Mpl)

Mpl= Mpl,a - $\frac{2fya.tw(0.5.h1-ep1)^2}{2}$ + βR.2b1.ep1(0.5.ep1+0.5h1- ep1)

Load carrying capacity w = $\frac{6\ M}{l}$

1.6 Concrete Encased Trapezoidal Corrugated Web Steel Beam With Varying Angle of Corrugation.

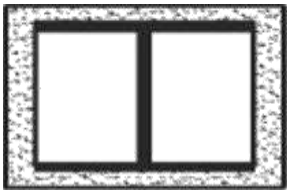


Fig -3 Encased Steel CFS Beam

Determination of Centre of gravity of corrugated web(y) yco sec = [$\frac{(bf.tf.yf)+\left(\frac{hw}{2}\right).tw.yw}{bf.tf+\left(\frac{hw}{2}\right)tw}$]

Moment of Inertia (I)= Itop flange +Iweb + Ibottom flange

Iz = Iza + Izc red Izc red= reduced moment of inertia

of concrete = Izc x : $\frac{Ec}{Es}$ E = 5000 $\sqrt{fck}$

Izc= epl x $\frac{(b-tw)^2}{12}$

Geometric properties according to the plastic

Compressive zone epl= $\frac{2fya.tw.h1/2}{2fya.tw+2b1.\beta R}$

Design strength of steel f ya = $\frac{\text{yield strength of steel}}{\text{partial safty factor}}$

Design strength of Concrete

$\beta_R = \frac{\text{Grade of concrete}}{\text{partial safty factor}}$

Full plastic moment for the steel section (Mpl,a)

Mpl,a= $\frac{fy\ xIz}{y}$

Plastic moment (Mpl)

Mpl= Mpl,a – $\frac{2fya.tw(0.5.h1-ep1)^2}{2}$ + βR.2b1.ep1(0.5.ep1+0.5h1- ep1)

1.7 Result and Discussion

Table -1 Normal I Section

Sl.no	Section	Moment ‘knm’	L ‘m’	Load ‘kn’
1.	100x150x2.5mm	5.636	1	33.81
2.	100x200x2.5mm	8.089	1	48.535
3.	100x150x3mm	6.70	1	40.20
4.	100x150x2mm	4.551	1	27.30

Table -2 Encased Beam with corrugated angles

Sl.N o	Section	Moment ‘KN.m’	L ‘m’	Load ‘KN’
1.	100x150x2.5mm	6.890	1	41.34

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2.	100x200x2.5mm	10.234	1	61.40
3.	100x150x3mm	7.426	1	44.55
4.	100x150x2mm	5.911	1	35.46

Table -.3 Normal Section Vs Various lengths

Sl.No	**Section**	**Moment ‘KNm’**	**L ‘m’**	**Load ‘KN’**
1.	100x150x2.5mm	5.636	1.5	22.54
2.	100x200x2.5mm	8.089	1.5	32.35
3.	100x150x3mm	6.70	1.5	26.82
4.	100x150x2mm	4.551	1.5	18.21

Table no.4 Encased Beam with varying depth of web

Sl. No	Section	Moment 'KNm'	L 'm'	Load 'KN'
1.	100x150x2.5mm	6.890	2	20.67
2.	100x200x2.5mm	10.234	2	30.70
3.	100x150x3mm	7.426	2	22.27
4.	100x150x2mm	5.911	2	17.73

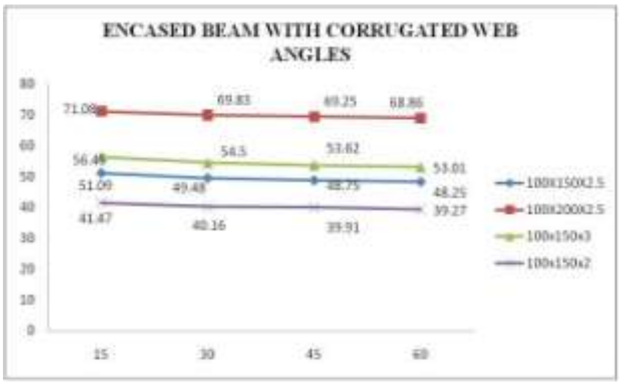

Fig -4 Comparison graphs for normal section and encased corrugated beams

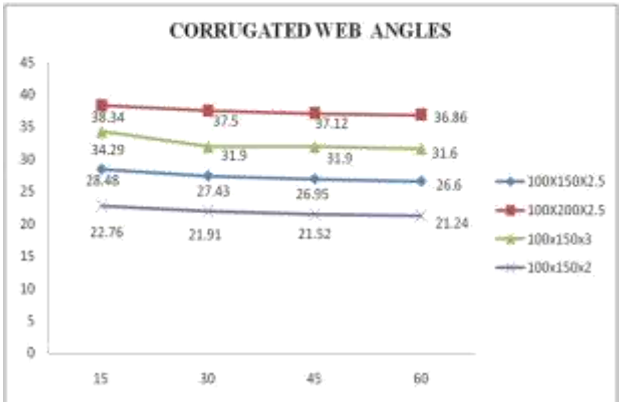

Fig -5 Normal Section with Encased Beam with varying angle

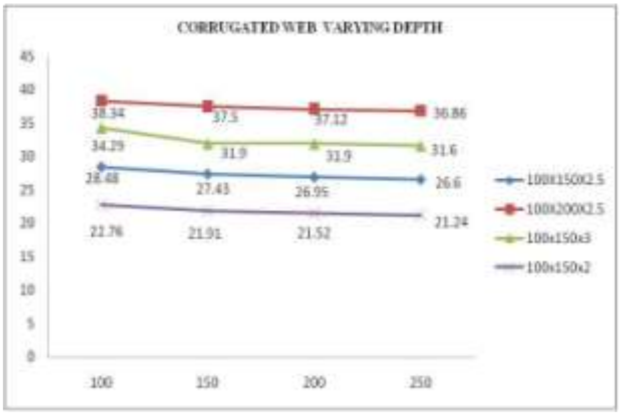

Fig -6 Normal Section Vs Various Depths

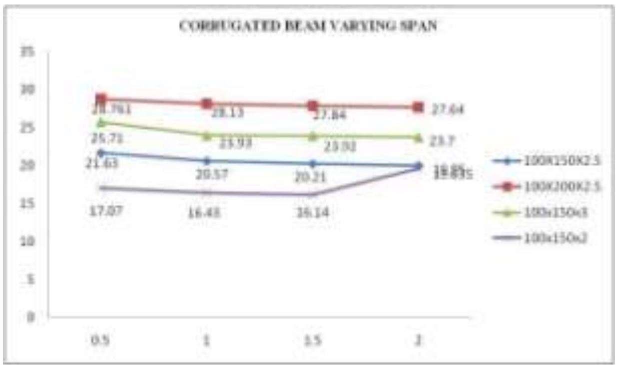

Fig -7 Normal Section Vs Varying encased beam Span

II.DISCUSSION

The theoretical study of all standard codes of normal section was found to be 48.35Kn.the graph shows a comparison between normal steel I section with various parameters are modified in encased steel beam as varying span, depth of web , angles of corrugation in these parameter the result is found to be the optimum section of varying span is 100x200x2.5 mm carries a maximum load of 32.35kN in 1.5m span and in Depth of web carries 100x200x2.5mm carries 30.70kN in 2m and angle section carries 61.40kN in 1m.it shows that the optimum design was found to be 100mmx 200mm x 2.5 mm carries maximum load carrying capacity of beam in all parameter.

III.CONCLUSION

Within the parametric study, due to increase in depth of web the load carrying capacity is also increases. Due to provision of corrugated web, the failure due to shear is completely eliminated. Due to provision of stiffeners at the loading point and support, bearing failure is avoided. Newly proposed warping constant can be used for all lipped section of trapezoidal corrugation I beam, which are in good agreement with theoretical and investigation. By laminating the top flange by, the overall buckling is reduced and the strength is increased by 1.5 times as that of normal steel. Within the parametric study, it was observed that the theoretical investigation AISI S-100:2007 and IS8011975 holds good agreement with theoretical investigation.

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