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# Analytical Study On Cold Formed Steel Section In Different Type Of Section

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**ABSTRACT**
Cold formed steel (CFS) which are also known light gauge steel section, are fabricated by using steel sheet.CFS are manufactured by punching and rolling of steel sheets at low temperatures i.e. room temperature. Generally the thickness of steel sheet used for fabricating CFS is usually 1 mm to 3 mm. Maximum thickness no sheet can be used up to 12 mm in which pre-galvanized material are not required for the particular application. Normally, sheets used to making CFS have yield strength of 280 N/mm$^2$, although there is a trend to use steels of higher strengths, and as low as 230 N/mm$^2$. Manufacturing of CFS require steel sheet coils of 1.0 to 1.25 m width, which is laid longitudinally with appropriate width as per requirement and then feed them into a series of roll forms. These rollers, containing female and male dies, which are arranged in pair and move in opposite direction so that as the steel sheet is feed through them and shape is gradually altered to the required profile. The number of pairs of rollers will depend on the complexity of the cross section shapes. At the end of the rolling stages a flying shearing machine cuts the member into desired shape. The main aim is to analyze the various section of CFS with correspondence to specific hot rolled section and compare their various properties like strength- to- weight ratio. It can be done by changing the orientation of element in CFS and increasing its moment of inertia value by increasing the area on flange part.
**KEYWORDS:** *Cold formed Steel (CFS), flexural, torsional buckling, distortional buckling, Hot rolled steel.*

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## I. INTRODUCTION

Cold-Form Steel Structure concept originated during World War II in 1960's in the United States and made available in India in late 90's. During World War II, it is known as Pre-fabricated building. Later on which became a household need and was mass produced by hundreds of thousands to meet a requirement for inexpensive and standardized shelter. Which require no extraordinary aptitudes, these structures are gathered with just hand instruments and with no more prominent exertion could be promptly disassembled and moved and re-raised elsewhere. The scientific term Cold-Form Steel buildings came into being in the 1960's. The structures were "Cold Form Steel" since like their predecessors they depended upon standard building outlines for a predetermined number of off the rack designs.

Cold forming increases the yield strength of steel, it enhance the mean yield stress by 15%-30%. This 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. For purpose of design, the yield stress may be regarded as having been enhanced by a minimum of 15%. Some of the main advantages of CFS as compared with their hot-rolled counterparts are as follows:

a) CFS has high strength to weight ratio.
b) Being light in weight it is easily transportable.
c) Pre-galvanized or pre-coating metals are formed, so that high resistance to corrosion can be achieved.
d) Cross sectional shapes are framed to close resistances and these can be reliably rehashed for whatever length of time that required.
e) Cold rolling can be utilized to deliver any covered shape to any needed length.
f) Pre-stirred or pre-covered metals can be shaped, with the goal that high protection from consumption, other than an appealing surface complete, can be accomplished.

g) All regular jointing techniques, (i.e. riveting, cotter joints, welding and knuckle joints) can be utilized.
h) High quality to weight proportion is accomplished in frosty moved items.
i) They are normally light making it simple to transport and erect.
j) It is conceivable to uproot the material far from the impartial hub in request to upgrade the heap conveying limit (especially in pillars).
k) There is no restriction to the kind of cross area that can be framed. Some ordinary cold formed.

## II. OBJECTIVE

The objective of this study is to build up a general plan strategy for Cold formed steel auxiliary individuals with openings. Cold-formed steel pillars and segments are regularly produced with apertures. For instance, in low and midrise development, openings are pre punched in auxiliary structures to suit the section of utilities in the dividers and roofs of structures

Utilized for showing the ideas with suitable modifications fitting to Indian undoubtedly it is hard to belief about any industry in which CFS items don't exist in one form or the other. They are utilized in engine vehicles, railroads, flying machines, horticultural machinery, electrical hardware, stockpiling racks and house hold apparatuses etcetera. In these sections, the foundation hypothesis administering the outline of CFS elements is displayed in a rundown shape. Plans of frosty framed steel areas are deal with in IS: 801-1975 which is presently due under amendment. Without a suitable Limit State Code in India, the Code of Practice for CFS is use in the U.K. (BS 5950, Part 5). It is seen from writing work that the exploratory examination on behavior of icy shape steel in twisting, clasping and furthermore relative investigation such work with hot moved steel area With the diverse investigations in view of the bars and segments of various CFS segment increment in stack conveying limit, avoidance limit and firmness as contrast with individual hot moved steel area.

## III. MATERIALS AND METHODS

A forging section where punching or pressing is done comprises of die block which have two component male and female over which work piece is positioned in such a way that desired shape is obtained. Then steel sheet is feed in to die and desired shape is obtained. While forging bending is come over both the side i.e. compressive and tensile side both these forces resist the bending so the bending angle has to keep increases as compare to desired bending angle as if this is not done the residual stress which is left in material tries or let the material to regain its original shape. While bending sheet metal length is stretches. The bend deductions the amount the sheet will stretch when bent, as it is measured from the outside edges of the bend. The bend radius indicates the inside radius So this lead to conclusion that bending of CFS depend on material type, property and bending angle.

**Chemical Composition of Sheet Used**

| Element | Composition |
|---|---|
| Iron, Fe | 68 |
| Chromium, Cr | 17-19 |
| Manganese, Mn | 7.50-10 |
| Nickel, Ni | 4-6 |
| Silicon, Si | ≤ 1 |
| Nitrogen, N | ≤ 0.25 |
| Carbon, C | ≤ 0.15 |
| Phosphorous, P | ≤ 0.060 |
| Sulfur, S | ≤ 0.030 |

**Mechanical Properties of Sheet**

| Properties | Metric |
|---|---|
| Density | 7.7 gm/cc |
| Tensile Strength | 515 MPa |
| Yield Strength | 275 MPa |
| Compressive Yield Strength | 170 Mpa |
| Compressive Ultimate Strength | 310 MPa |
| Elastic Modulus | 207 GPa |
| Poisson’s Ratio | 0.27-0.30 |
| Elongation at break | 40% |

## IV. DESIGN CALCULATION

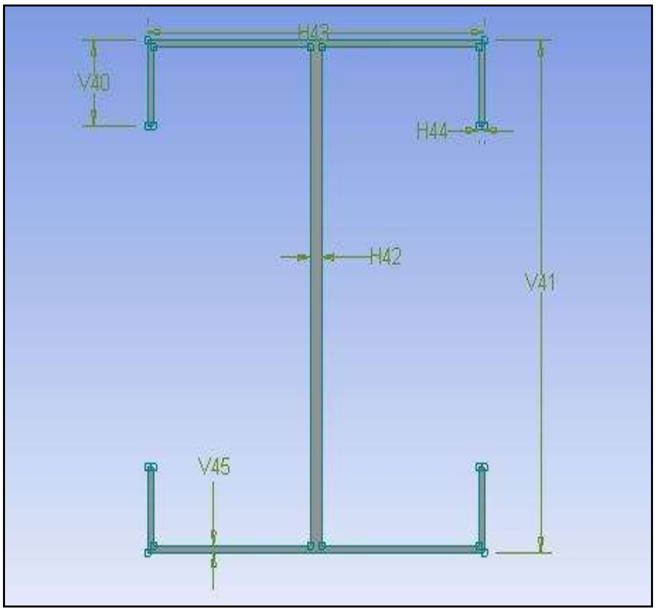


**Fig. First Specimen (Beam having I Section with Lip)**

Dimension of first specimen is described below:-
Thickness of web (t) =4mm, Width of flange (B) =120 mm
Thickness of lip ($B_L$) =2mm, Depth of lip ($D_{L)}$ =25 mm
Depth of section (D) =150mm
Thickness of flange ($t_f$) =2mm
Load it has taken experimentally =5.36 kN
Yield strength ($f_y$)=240MPa
Moment of Inertia about X-axis i.e. $I_{xx}$= $10.38\times10^6$ $mm^4$

**i) Limiting stress for stiffened web in buckling**

$$p_0 = \{1.13 - 0.0019\frac{D}{t}\sqrt{\frac{f_y}{280}}\} \times p_y$$

and $p_y = \frac{240}{1.15}$ =208.7N/mm$^2$

$$p_0 = \{1.13 - 0.0019\frac{150}{4}\sqrt{\frac{280}{280}}\} \times 208.7$$

=218 N/mm$^2$

Which is equal to the maximum stress in the flange in compression i.e. 218 N/mm$^2$

**ii) Effective width of flange portion**

$$h = \frac{B_2}{B_1}$$

$B_1$ =60-2×2-4 = 52mm
$B_2$ =150-2×2 =146 mm

a) Buckling coefficient $K_1$

$K_1 = 5.4 - \frac{1.4h}{0.6+h} - 0.02h^3$

$= 5.4 - \frac{1.4(5.34)}{0.6+5.345} - 0.02(5.34)^3$

= 1.1 or 4 (minimum)

$K_1 = 4$

b) Elastic critical stress

$p_{cr} = 185.28\times10^3.K.(t/b)^2$

t =4 mm, K =4, b =$B_1$ =52 mm

$p_{cr} = 13.175\times10^2$ N/mm$^2$

$f_c/p_{cr} = 218/(13.175\times10^3) = 0.0165 < 0.123$

$b_{eff}/b = 1$ so $b_{eff} = 52$ mm

This means, the full section is effective in bending.

So Moment of Inertia about X-axis i.e. $I_{xx} = 10.38\times10^6$ mm$^4$

**iii) Moment of resistance of beam**

$M_r$ of the restrained beam is

$M_{cx} = Z_{xr}\times p_y$

$=115.1\times10^3\times208.7$

$= 24.02\times10^6$Nmm or 24.02 kNm

$M_{cx}$ = 24.02 kNm> 16.47 kNm

**iv) Shear resistance of beam**

a) Shear yield strength, $p_v$

1. $p_v = 0.6p_y$

2. $=0.6208.87 = 125.22$ N/mm$^2$

b) Shear buckling strength, $q_{cr}$

3. $q_{cr} = (1000t/D)^2 = \{(1000\times4)/150)^2$

4. =493.82 N/mm$^2$

**Check for deflection**

A coefficient of 1/48 is used to take in account of span

$\delta_{max} = 1/48 \times wl^3/EI$

$= (1\times 5.36\times1000^4)/(48\times10.36\times10^6\times2.05\times10^5)$

= 7.55 mm

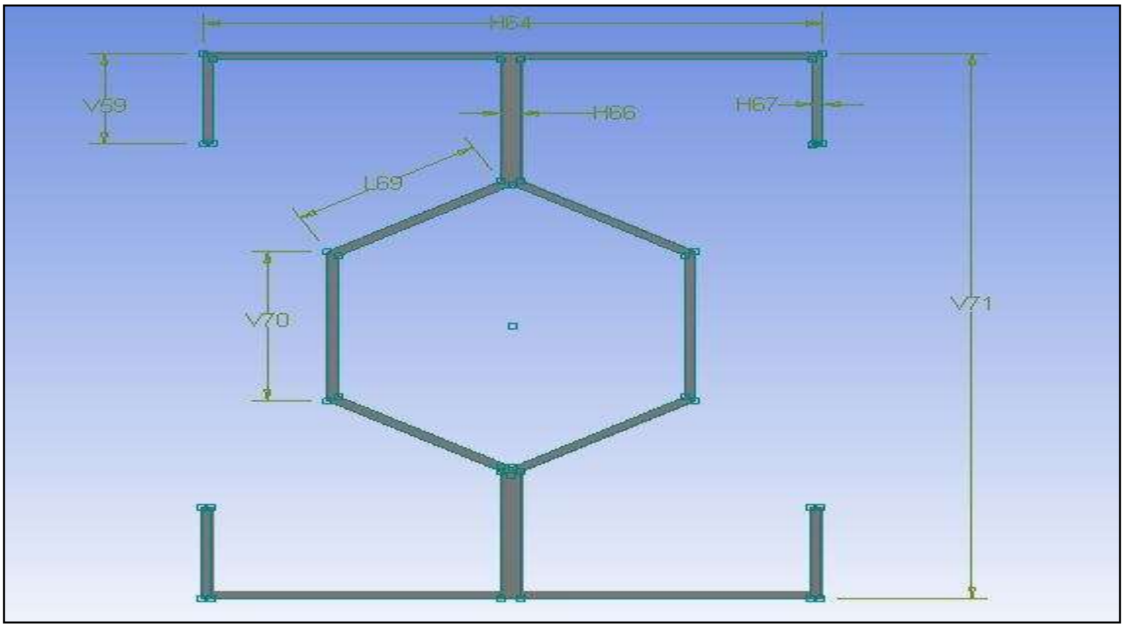


**Fig. Second Specimen(Beam having I Section With Hollow Hexagon)**

Dimension of second specimen is described below:-
Thickness of web =4mm
Width of flange =120mm
Thickness of lip =2mm
Depth of lip =25mm
Depth of section =150mm
Thickness of flange =2mm
Thickness of hexagon =2mm
Outer length of hexagon (L69, V70) =41mm
Yield strength ($f_y$)= 240 MPa
Load (w) =6.276 kN
Moment of Inertia about X-axis i.e. $I_{xx}$= $11.54\times10^6$ mm$^4$

**i) Limiting stress for stiffened web in buckling.**

$$p_0 = \{1.13 - 0.0019\frac{D}{t}\sqrt{\frac{f_y}{280}}\} \times p_y$$

and $p_y = \frac{240}{1.15}$ =208.7N/mm$^2$

$$p_0 = \{1.13 - 0.0019\frac{150}{4}\sqrt{\frac{280}{280}}\} \times 208.7$$

=218 N/mm$^2$

Which is equal to the maximum stress in the flange in compression i.e. 218 N/mm$^2$

**ii) Effective width of flange portion**

$$h = \frac{B_2}{B_1}$$

$B_1$ =60-2×2-4 = 52mm
$B_2$ =150-2×2 =146 mm

a) Buckling coefficient $K_1$

$$K_1 = 5.4 - \frac{1.4h}{0.6+h} - 0.02h^3$$

$$= 5.4 - \frac{1.4(5.34)}{0.6+5.345} - 0.02(5.34)^3$$

= 1.1 or 4 (minimum)

$K_1$ =4

b) Elastic critical stress

$p_{cr}=185.28\times10^3.K.(t/b)^2$
t =4 mm, K =4, b =$B_1$ =52 mm
$p_{cr}$ =$13.175\times10^2$ N/mm$^2$
$f_c/p_{cr}$ = 218/($13.175\times10^3$) =0.0165<0.123
$b_{eff}/b$ =1 so $b_{eff}$ =52 mm
This means, the full section is effective in bending.
So Moment of Inertia about X-axis i.e. $I_{xx}$= $11.54\times10^6$ mm$^4$

**iii) Moment of resistance of Beam**

$M_r$ of the restrained beam is,

$M_{cx} = Z_{xr}\times p_y$
=$126.1\times10^3\times208.7$
= $26.31\times10^6$Nmm or 26.31kNm
$M_{cx}$ = 26.31kNm> 16.47 kNm

**iv) Shear resistance of Beam**

a) Shear yield strength, $p_v$

$p_v = 0.6p_y$
=0.6×208.87 = 125.22 N/mm$^2$

b) Shear buckling strength, $q_{cr}$

$q_{cr}= (1000t/D)^2 = \{(1000\times4)/150)^2$
$=493.82\ N/mm^2$

c) Check for deflection

A coefficient of 1/48 is used to take in account of span

$$\delta_{max}= 1/48 \times wl^3/EI$$
$$= (1\times6.276 \times1000^4)/(48\times11.54\times10^6\times2.05\times10^5)$$
$$= 6.45\ mm$$

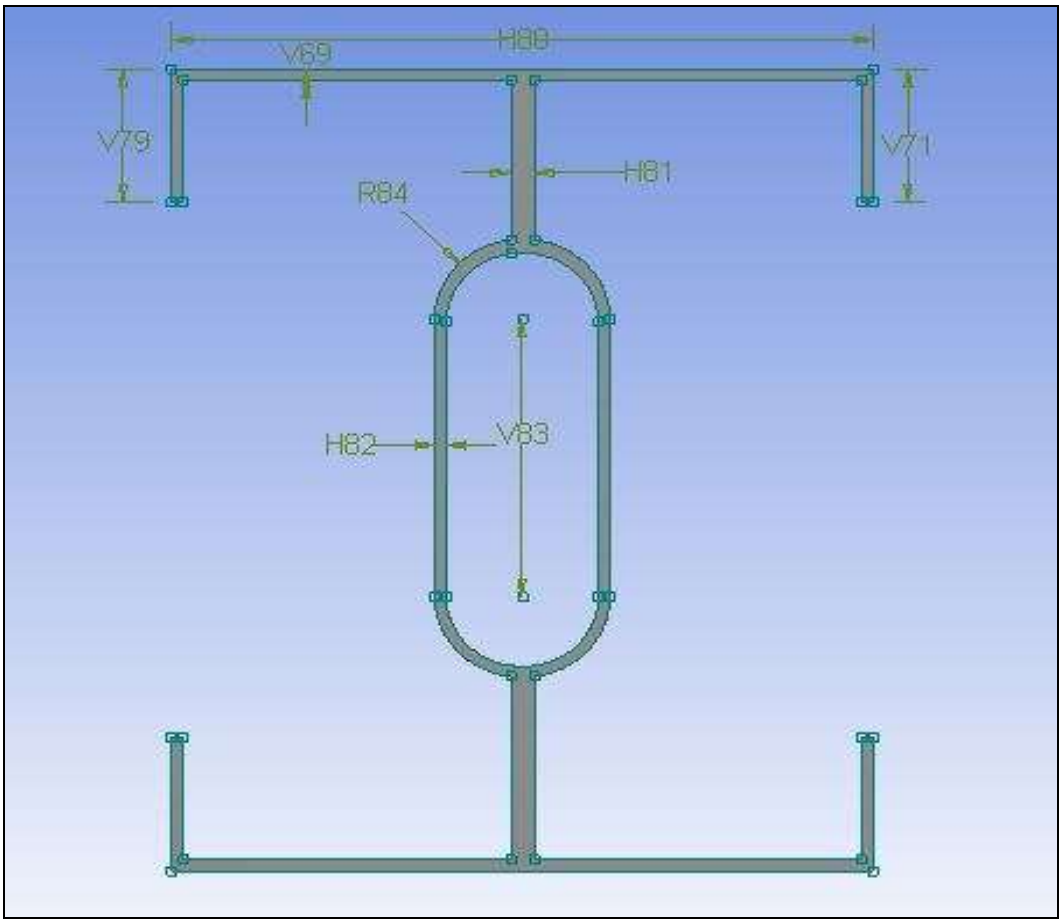


**Fig. Third Specimen(Beam having I Section With Hollow Oval)**

Dimension of third specimen is described below:-
Thickness of web =4mm
Width of flange =120mm
Thickness of lip =2mm
Depth of lip =25mm
Depth of section =150mm
Thickness of flange =2mm
Thickness of oval =2mm
Load it has taken experimentally =8.041kN
Yield strength ($f_y$)= 240 MPa
Moment of Inertia about X-axis i.e. $I_{xx}= 10.95\times10^6\ mm^4$

**i) Limiting stress for stiffened web in buckling.**

$p_0 = \{1.13 - 0.0019\frac{D}{t}\sqrt{\frac{f_y}{280}}\} \times p_y$

and $p_y = \frac{240}{1.15} = 208.7 N/mm^2$

$p_0 = \{1.13 - 0.0019\frac{150}{4}\sqrt{\frac{280}{280}}\} \times 208.7$

$= 218 N/mm^2$

Which is equal to the maximum stress in the flange in compression i.e. 218 $N/mm^2$

**ii) Effective width of flange part**

$h = \frac{B_2}{B_1}$

$B_1 = 60-2\times2-4 = 52mm$

$B_2 = 150-2\times2 = 146$ mm

**a) Buckling coefficient $K_1$**

$K_1 = 5.4 - \frac{1.4h}{0.6+h} - 0.02h^3$

$= 5.4 - \frac{1.4(5.34)}{0.6+5.345} - 0.02(5.34)^3$

$= 1.1$ or 4 (minimum)

$K_1 = 4$

**b) Elastic critical stress**

$p_{cr} = 185.28\times10^3.K.(t/b)^2$

t =4 mm, K =4, b =$B_1$ =52 mm

$p_{cr} = 13.175\times10^2 N/mm^2$

$f_c/p_{cr} = 218/(13.175\times10^3) = 0.0165 < 0.123$

$b_{eff}/b = 1$ so $b_{eff} = 52$ mm

This means, the full section is effective in bending.

So Moment of Inertia about X-axis i.e. $I_{xx} = 10.38\times10^6 mm^4$

**iii) Moment of resistance of beam**

$M_r$ of restrained beam is

$M_{cx} = Z_{xr}\times p_y$

$= 117.1\times10^3\times208.7$

$= 24.43\times10^6$Nmm or 24.43kNm

$M_{cx} = 24.43kNm > 16.47$ kNm

**iv) Shear resistance of beam**

a) Shear yield strength, $p_v$

$p_v = 0.6p_y$

$= 0.6208.87 = 125.22 N/mm^2$

b) Shear buckling strength, $q_{cr}$

$q_{cr} = (1000t/D)^2 = \{(1000\times4)/150)^2$

$= 493.82 N/mm^2$

**v) Check for deflection**

A coefficient of 1/48 is used to take in account of span $\delta_{max} = 1/48 \times wl^3/EI$

$= (1\times8.041\times1000^4)/(48\times10.95\times10^6\times2.05\times10^5)$

$= 5.95$ mm

## V. RESULT

From the above result in which analysis is done on beam one by one, in this segment we compare the value of all three sections.

**Combine Load and Deflection Value based on Experiment**

| **Deflection (mm)** | | | **Load (kN)** |
|---|---|---|---|
| **Simple I section** | **I with hollow Hexagon** | **I with hollow Oval** | |
| 0 | 0 | 0 | 0 |
| 4.19 | 4.05 | 3.6 | 0.98 |
| 5.48 | 4.47 | 3.75 | 1.96 |
| 6.01 | 4.85 | 3.82 | 2.94 |
| 6.75 | 5.1 | 3.95 | 3.92 |
| 7.86 | 5.56 | 4.1 | 4.90 |
| 7.92 | 6.11 | 4.45 | 5.36 |
| | 6.76 | 4.88 | 5.884 |
| | 6.93 | 5.18 | 6.276 |
| | | 5.45 | 6.864 |
| | | 5.62 | 7.845 |
| | | 5.95 | 8.041 |

Table represent deflection value with respect to corresponding load result based on experiment by which combine graph is made in which variation of deflection is shown with increase in load on UTM And graph is shown below which represent load Vs deflection curves and analysis on graph is done based on this curve.

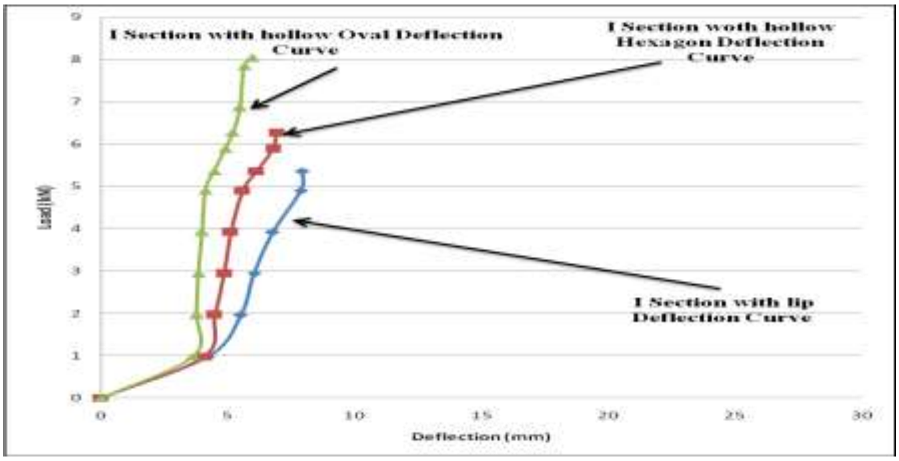


**Fig. Load Vs Deflection Curve**

## VI. CONCLUSION

From the above examination between sections following conclusion can be drawn while keeping all the dimension same of both hot rolled steel section and CFS sections, weight per unit length of CFS sections is half the value hot rolled steel section which make cold formed steel section more economical. Moment of inertia value of hollow hexagon is more which leads to increase in cost of fabrication then other two sections. And value of other two sections are approx. same. Similarly the value of equivalent stress of Simple I section is more as compare to other two sections, and hollow oval section have least stress value among all three section. Among all three sections oval section is best and economical since it has less Moment of Inertia value means less cost for fabricating it, high load carrying capacity then other two, and deflect less as compare to other two. Conclusion regarding all three specimens is described below like load bearing capacity, deflection and other:-

1. I Section with lip where no modification is done like change in shape or size have less bearing capacity and deflect high as comparison to other two specimen.
2. I Section with hollow hexagon in web portion have more load carrying capacity then first simple and deflect less than first sample.
3. I Section with hollow oval in web portion have more load carrying capacity then other two specimen and deflect less as compare to other two specimen.
4. Be seeing the weight and deflection graph it is clear that weight are not playing any major rule for reducing the deflection value.
5. From the above two example of column it is clear that keeping area and weight same we can increase the compressive strength of section by changing its orientation or shape of member throughout the section.

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