Ixx
Linear

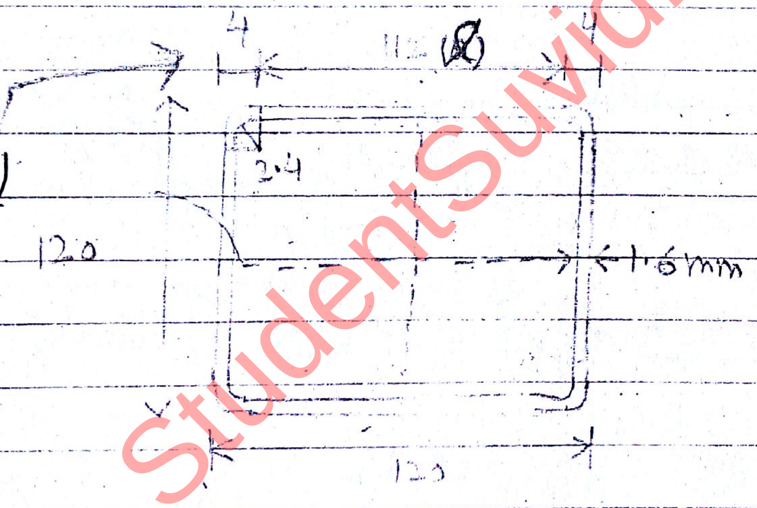
DSS [SECTION-D]

"COLD FRAMED SECTIONS"

Q1 Find the column section properties and allowable load for the column section shown in fig. The effective length of column is 3.0 m. Take $f_y = 235\ N/mm^2$.

Sol.

(2.4 + 1.6 = 4)



$\boxed{a = a' - t/2}$

$a = \frac{120}{2} - \frac{t}{2}$

$(a = 60) - t/2$

$(\ell = 112)$

$\left(a' = \frac{120}{2} = 60\right)$

Linear Properties :-

Radius of corner $= 2.4 + \frac{t}{2} \Rightarrow 2.4 + \frac{1.6}{2}$

$R = 3.2\,mm$

Length of corner $= 1.57R$ (Fix)

$= 1.57\,(3.2)$

$\ell' = 5.024\,mm$

$$I_{xx} = 2la^2 + 2\frac{l^3}{12} + \begin{pmatrix}\text{No. of}\\ \text{Corners}\end{pmatrix} \times \begin{pmatrix}\text{length of}\\ \text{Corner}\end{pmatrix} \times (a' - C_{xx})^2$$

Linear

$C_{xx} = 0.637R$ (Centre of gravity) (Fix)

$= 0.637(3.2)$

$= 2.038\ mm$

∴ Length of overall column section

$L = 4 \times 112 + 4 \times 5.024$

$= 468.1\ mm$

Area, A = length × thickness

$= 468.1 \times 1.6$

$= 748.96\ mm^2$

Linear :-

$$I_{xx} = 2a\left(\frac{a}{2}+R\right)^2 + 2\left(\frac{a^3}{12}\right) + 4\,l'\left(\frac{a}{2}+C_{xx}\right)^2$$

Formula (X)

$$\Rightarrow 2(112)(59.2)^2 + \frac{2(112)^3}{12} + 4(5.024)(58.038)^2$$

$(58.038) = (60-2)+0.038$

$\Rightarrow 108\,6885.58\ mm^3$

Actual :-

I_{xx} = (Linear I_{xx}) × thickness

$= 1086885.58\,(1.6)$

$= 1739016.92\ mm^4$

$$r = \sqrt{\frac{I_{xx}}{A}} \quad \text{(radius of gyration)}$$

$$= \sqrt{\frac{1739016.92}{748.96}}$$

$$= 48.18 \text{ mm}$$

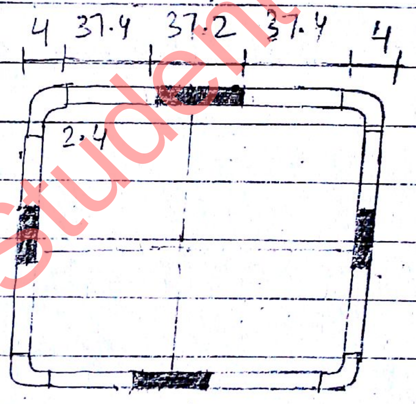
$$r = [\underline{4.8 \text{ cm}}]$$

$f = 0.6 f_y$ (allowable stress)

$$= 0.6(235)$$

$$= \underline{141 \text{ N/mm}^2}$$

To calculate the Form Factor, effective width and effective area of the section is required.



$$\left(\frac{112}{3} = 37.33\right)$$

$$\left(\frac{w}{t}\right)_{lim} = \frac{478}{\sqrt{f}} = \frac{478}{\sqrt{141}} = \underline{40.25}$$

$$\frac{w}{t} = \frac{112}{1.6} = \underline{70 > 40.25}.$$

i.e, $\frac{w}{t} > \left(\frac{w}{t}\right)_{lim}$

$$\frac{b}{t} = \frac{658}{\sqrt{f}}\left(1 - \frac{130}{\left(\frac{w}{t}\right)\sqrt{f}}\right)$$

$$= \frac{658}{\sqrt{141}}\left(1 - \frac{130}{70(\sqrt{141})}\right)$$

$$\frac{b}{t} = 46.75$$

or $b = 46.75\,t$

$= 46.75\,(1.6)$

$\therefore \boxed{b = 74.8}$ (effective width)

Shaded Portion

$A_{eff.} = A_{act} - 4(37.2 \times 1.6)$

$= 748.96 - 4(37.2 \times 1.6)$

$= 510.92\ mm^2$

(effective Area)

Form Factor :-

$$Q = \frac{A_{eff.}}{A}$$

$$= \frac{510.92}{748.96}$$

$[Q = 0.682]$

and $C_c = \sqrt{\frac{2\pi^2 E}{f_y}} = \sqrt{\frac{2(3.14)^2(2\times10^5)}{235}}$

$= 129.61$

E = modulus of Elasticity ($2\times10^5\ N/mm^2$)

$$\left(\frac{l}{r}\right)_{min.} = \frac{C_c}{\sqrt{Q}} = \frac{129.61}{\sqrt{0.682}} = \underline{157}$$

Actual, $\frac{l}{r} = \frac{3.0 \times 100}{4.8}$ (eff. length) / (rad. of gyration)

$$\Rightarrow \underline{62.5 < 157}$$

Hence,

$$f_{a_1} = \frac{12}{23} Q f_y - \frac{3}{23} \frac{(Q f_y)^2}{\pi^2 E} \left(\frac{Kl}{r}\right)^2$$

If $\frac{l}{r} < \left(\frac{l}{r}\right)_{min.}$ $\underline{(K=1)}$

But If $\frac{l}{r} \geq \left(\frac{l}{r}\right)_{min}$

then, $f_{a_1} = \frac{12}{23} \frac{\pi^2 E}{\left(\frac{Kl}{r}\right)^2}$ $\underline{(K=1)}$

$$f_{a_1} = \frac{12}{23}(0.682)(235) - \frac{3}{23} \frac{[(0.682)(235)]^2}{\pi^2 (2 \times 10^5)} (62.5)^2$$

$$= \underline{76.99 \ N/mm^2}$$

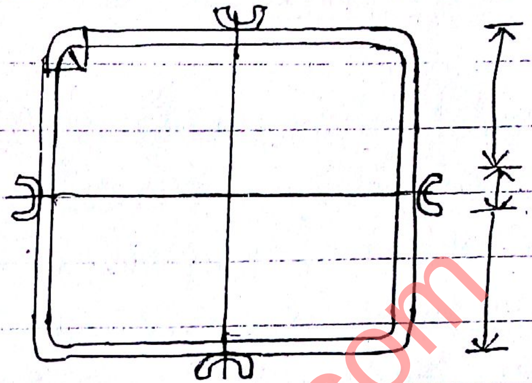
Now, Allowable load :-

$$= \boxed{f_{a_1} \times A_{act}}$$

$$= 76.99 \times 748.96$$

$$= \underline{57622 \ N} \text{ or } \underline{\text{"}57.6 \ KN\text{"}}$$ Ans

Note:- If we have to Design the column section with stiffners like this :-



If the Ratio $\frac{w}{t}$ Comes out to be ~~less than~~ more than 60, then effective design width is reduced & is given by :-

$$\frac{b_e}{t} = \frac{b}{t} - 0.10\left(\frac{w}{t} - 60\right)$$

and $b_e = ?$ (is to be Calculated)

For stiffner Design :-

one step extra besides the normal Q. steps

$$\left[I_{min.} = 1.83\, t^4 \sqrt{\left(\frac{w}{t}\right)^2 - \frac{27590}{f_y}} \right]$$

Do ↑ $\underbrace{\text{EX 16.3}}$ (S.K Duggal)

$$\boxed{I_{xx} = la^2 + \frac{l^3}{12} + \text{No. of Corners} \times \text{length of Corner} \times (a' - C_{xx})^2}$$

$a = 60 - \frac{t}{2} = a' - \frac{t}{2}$