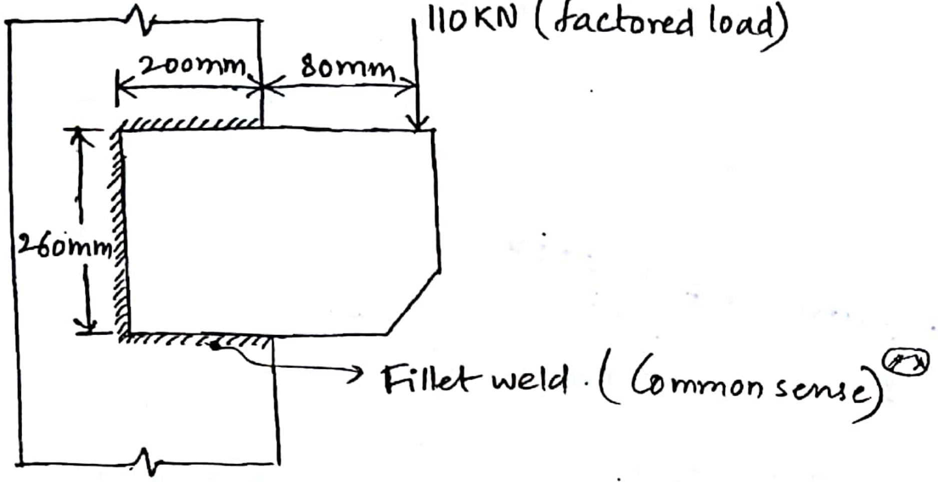
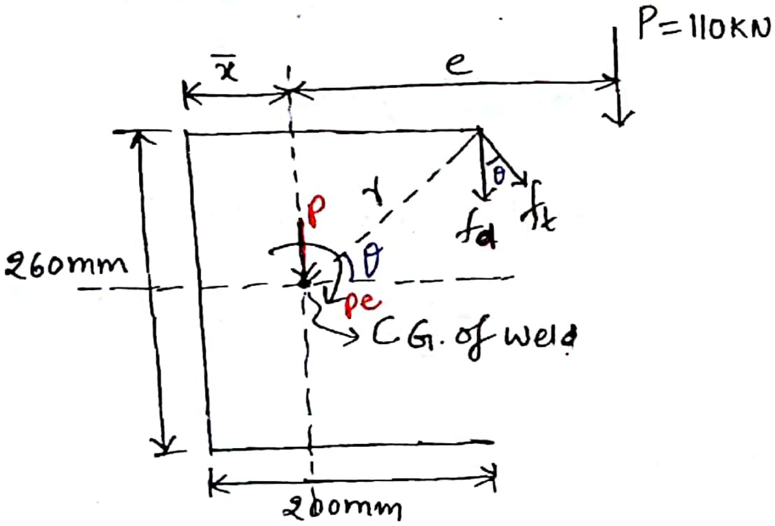
Q:- A bracket plate is welded to the flange of a column section ISHB:300 as shown in the figure. Calculate the size of the weld required to support a factored load of 110 KN. Assume shop welding & Fe 410 grade steel.



Sol:-



$t_t \rightarrow$ effective throat thickness

$$\bar{X} = \frac{2\times 200\times t_t\times 100 + 260\times t_t\times 0}{2\times 200\times t_t + 260\times t_t} = 60.61\text{mm}$$

$$e = 80+200-60.61 = 219.39\text{mm}$$

$\rightarrow$ f_d = direct shear stress.

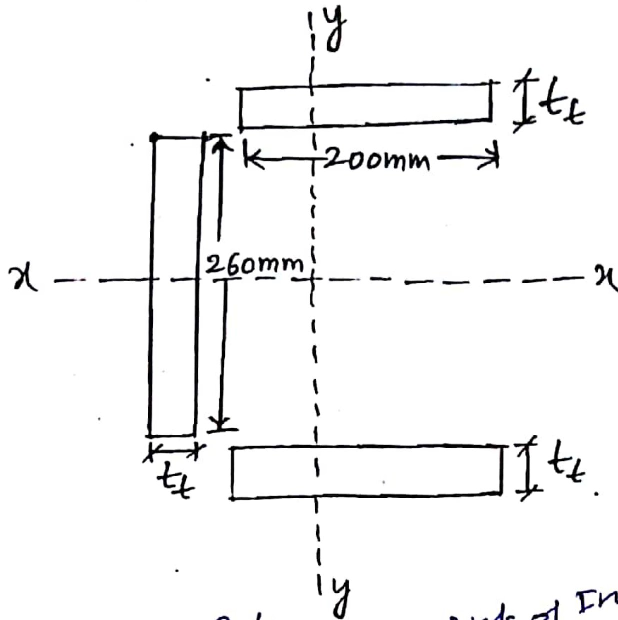
$$\therefore f_d = \frac{P}{260\times t_t + 2\times 200 t_t} = \frac{110\times 10^3}{660 t_t}\ \text{N/mm}^2$$

$\rightarrow f_t$ = Torsional shear stress.

$$\therefore f_t = \frac{Tr}{J}$$

$$T = Pe$$

$$r = \sqrt{130^2 + (200-60.61)^2} = 190.603\,mm$$



$J \rightarrow$ polar moment of Inertia

$$J = I_{xx} + I_{yy}$$

$\frac{260}{2}$

$$I_{xx} = 2 \times 200 \times t_t \times 130^2 + \frac{t_t \times 260^3}{12} = 822.467 \times 10^4\, t_t\ mm^4$$

$$I_{yy} = 2 \times \left(t_t \times \frac{200^3}{12} + 200 \times t_t\,(100-60.61)^2\right) + 260 \times t_t \times 60.61^2 = 290.91 \times 10^4\, t_t\ mm^4$$

$$f_t = \frac{Per}{J}$$

$$\therefore J = (822.467 + 290.91) \times 10^4\, t_t\ mm^4 = 1113.377 \times 10^4\, t_t\ mm^4$$

$$\therefore f_t = \frac{110 \times 10^3 \times 219.39 \times 190.603}{1113.377 \times 10^4\, t_t} = \frac{413.139}{t_t}\ N/mm^2$$

$f_r \rightarrow$ resultant shear stress

$$f_r = \sqrt{f_a^2 + f_t^2 + 2 f_a f_t \cos\theta}$$

$$f_r = \sqrt{\left(\frac{110 \times 10^3}{660\, t_t}\right)^2 + \left(\frac{413.139}{t_t}\right)^2 + 2 \times \frac{110 \times 10^3}{660 \times t_t} \times \frac{413.139}{t_t} \times \frac{139.39}{190.603}} = \frac{546.96}{t_t}$$

for safety ; $f_r \not> f_{wd}$ $\qquad \left[f_{wd} = \frac{f_u}{\sqrt{3}\,\gamma_{mw}} \right]$

$$f_r \leq \frac{f_u}{\sqrt{3}\,\gamma_{mw}}$$

$\gamma_{mw} = 1.25 \rightarrow$ for shop welding

$$\rightarrow \frac{546.96}{t_t} \leq \frac{410}{\sqrt{3}\times 1.25}$$

we should not round of t_t but we can roundoff 'S'

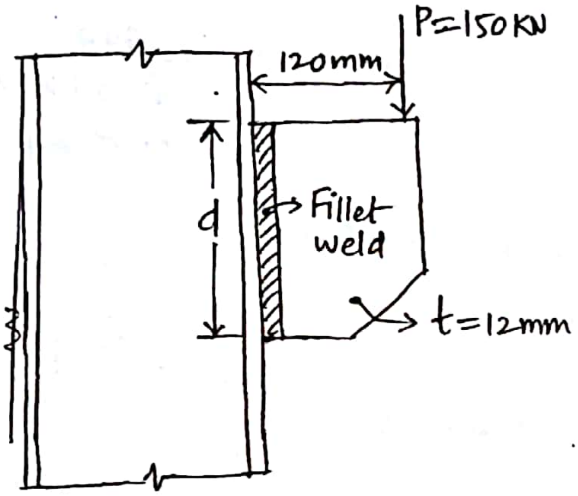
$$t_t \geq 2.89\,mm$$

$$\therefore 0.7S \geq 2.89\,mm$$

$$S \geq 4.126\,mm$$

$\therefore$ Adopt, size (s) of fillet weld = $\underline{\underline{5mm}}$

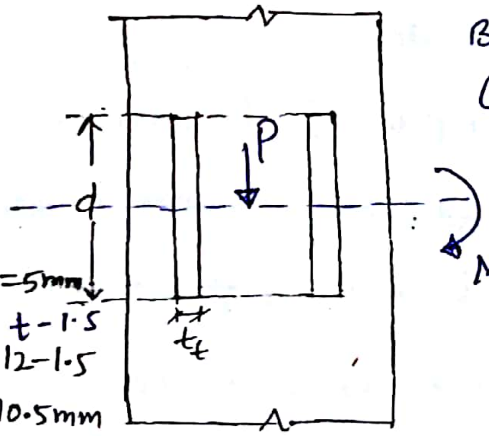
3) A bracket plate 12mm thick is used to transmit a factored load of 150KN at an eccentricity of 120mm from the column flange as shown fig, Design the shop fillet weld on two sides. Grade of steel is Fe410



Sol: Given that;

$P = 150\,KN$

$e = 120\,mm$



Bending moment $(M) = Pe$

$= 150\times10^3\times120$

$= 18\times10^6\,N\,mm$

minimum size of weld for 12mm plate = 5mm

maximum size of weld for 12mm plate $= t-1.5 = 12-1.5 = 10.5\,mm$

$\therefore$ let us adopt weld size $(S) = 6\,mm$

effective throat thickness $(t_t) = 0.7\times S = 0.7\times6 = 4.2\,mm$

$\rightarrow$ let us adopt 'd' by ;

$$d = \sqrt{\frac{6M}{2t_t f_{wd}}}$$ (follow this, for finding d)

where; $f_{wd} = \frac{0.8 f_u}{\sqrt{3}\gamma_{mw}}$, $\gamma_{mw} = 1.25 \rightarrow$ for shop weld

$$\therefore d = \sqrt{\frac{6 \times 150 \times 10^3 \times 120 \times \sqrt{3} \times 1.25}{2 \times 4.2 \times 0.8 \times 410}} = 291.32 \text{mm}$$

let us adopt, $d = 295$mm

Now check the safety of weld

$q \rightarrow$ direct shear stress

$$q = \frac{P}{2dt_t} = \frac{150 \times 10^3}{2 \times 295 \times 4.2} = 60.531 \text{ N/mm}^2$$

$f_a \rightarrow$ axial stress due to bending

$$f_a = \frac{My}{I} = \frac{150 \times 10^3 \times 120 \times \frac{295}{2}}{2 \times 4.2 \times \frac{295^3}{12}} = 147.74 \text{ N/mm}^2$$

$f_e \rightarrow$ equivalent stress

$$\therefore f_e = \sqrt{f_a^2 + 3q^2} = \sqrt{147.74^2 + 3 \times 60.531^2} = 181.161 \text{N/mm}^2$$

for safety; $f_e \ngtr f_{wd}$

$$f_e \leq \frac{f_u}{\sqrt{3} \times \gamma_{mw}} = \frac{410}{\sqrt{3} \times 1.25} = 189.371 \text{ N/mm}^2$$

$\therefore$ Safe.

Alternatively

$$q = \frac{P}{2dt_t} = \frac{150 \times 10^3}{2 \times 4.2d} = \frac{17.85 \times 10^3}{d} \text{ MPa}$$

$$f_a = \frac{My}{I} = \frac{18 \times 10^6 \times \frac{d}{2}}{2 \times 4.2 \times \frac{d^3}{12}} = \frac{12.857 \times 10^6}{d^2} \text{ MPa}$$

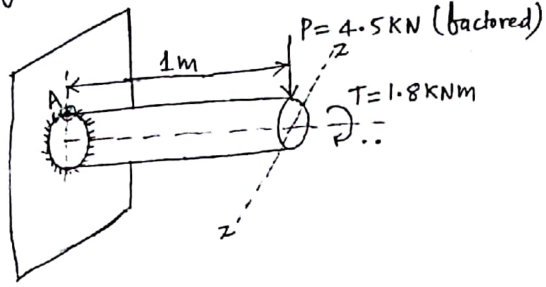
$$f_e = \sqrt{f_a^2 + 3q^2} = f_{wd} = \frac{f_u}{\sqrt{3}\gamma_{mw}}$$

$$\frac{(12.857 \times 10^6)^2}{d^4} + \frac{3 \times (17.85 \times 10^3)^2}{d^2} = \left(\frac{410}{\sqrt{3} \times 1.25}\right)^2$$

solve by iteration using calculator.

$$\left[f_{wd} = \frac{f_u}{\sqrt{3}\gamma_{mw}} \right]$$

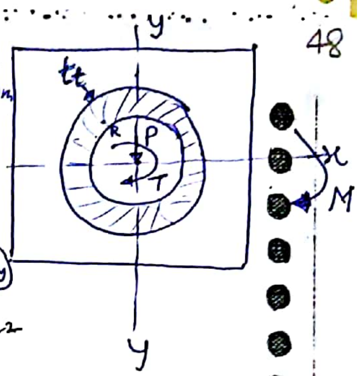
Q:- A 120mm diameter and 6mm thick pipe is fillet welded to a 8mm plate. It is subjected to a vertical factored load of 4.5KN at 1m from the welded end & a factored twisting moment of 1.8 KNm as shown in figure. Design the joint assuming shop welding & steel of grade Fe410.



Sol:- Given that; P= 4.5KN , factored bending moment (M)= P.e = 4.5×1 = 4.5 KNm

Direct twisting moment (T)= 1.8KNm

e = 1m



→ let us assume throat thickness as 't_t'

$I_{xx} + I_{yy} = J$ - - - ($I_{xx} = I_{yy}$)

→ Polar moment of Inertia (J) = $(2\pi r t_t) r^2$

∴ Moment of Inertia (I_{xx}) -about x-x $= \frac{J}{2}$

$= \pi r^3 t_t$

→ At the point of maximum bending stress, the shear stress due to Torsion acts horizontally in Transverse direction whereas direct shear is in vertical direction.

→ Direct shear stress (f_d) $= \frac{P}{2\pi r t_t} = \frac{4.5\times10^3}{\pi\times120\times t_t} = \frac{11.937}{t_t}$ N/mm²

→ shear stress due to torsion or Torsional shear stress (f_t) $= \frac{Tr}{J} = \frac{1.8\times10^6\times60}{2\pi\times60^3\times t_t} = \frac{79.577}{t_t}$ N/mm²

∴ Resultant shear stress (q) $= \sqrt{f_d^2+f_t^2} = \frac{80.467}{t_t}$ N/mm²

f_a → Axial stress due to bending

$f_a = \frac{My}{I_{zz}} = \frac{4.5\times10^3\times1\times10^3\times60}{\pi\times60^3\times t_t} = \frac{397.887}{t_t}$ N/mm²

f_e → equivalent stress

$f_e = \sqrt{f_a^2+3q^2}$

$f_e = \frac{421.587}{t_t}$ N/mm²

$\left[f_{wd} = \frac{f_u}{\sqrt{3}\,\gamma_{mw}} \right]$

$\gamma_{mw} = 1.25$ for shop weld

for safety; $f_e \ngtr f_{wd}$

$f_e \le \frac{f_u}{\sqrt{3}\,\gamma_{mw}}$

$\frac{421.587}{t_t} \le \frac{410}{\sqrt{3}\times1.25}$

$t_t \geq 2.226\,mm$

$0.7S \geq 2.226\,mm$

$S \geq 3.180\,mm$

∴ let us ~~adopt~~ Provide weld of size $(S) = 4\,mm$

→ Imp. points;

→ The effective throat thickness of a fillet weld depends upon "Angle between fusion faces"

→ Fillet weld is designed to resist shear and we design it for minimum thickness which is throat thickness. So it will be weakest section.

Note→ ~~whenever thickness is~~ For square edge weld. thickness of plate ≤ ~~6a~~ less than equal to 6mm, max^m size is equal to 't' i.e. cross criteria is not checked