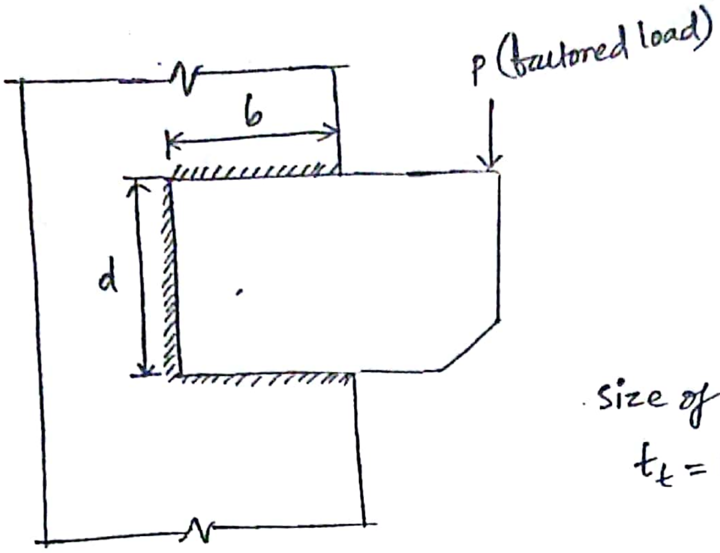
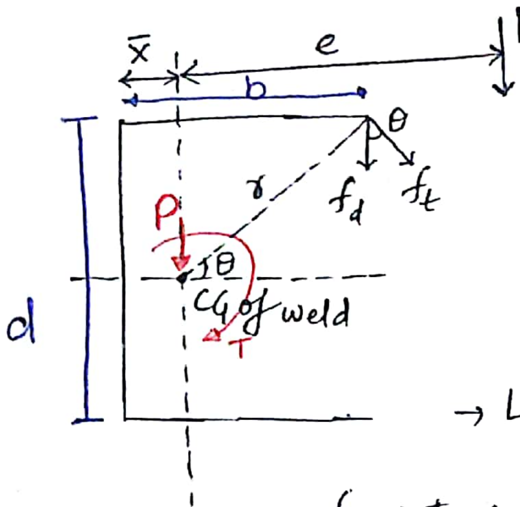
→ Eccentric Connection using welding :

Case I : Fillet weld subjected to direct load & Torsional moment



size of weld → S

$t_t = KS = 0.7S$



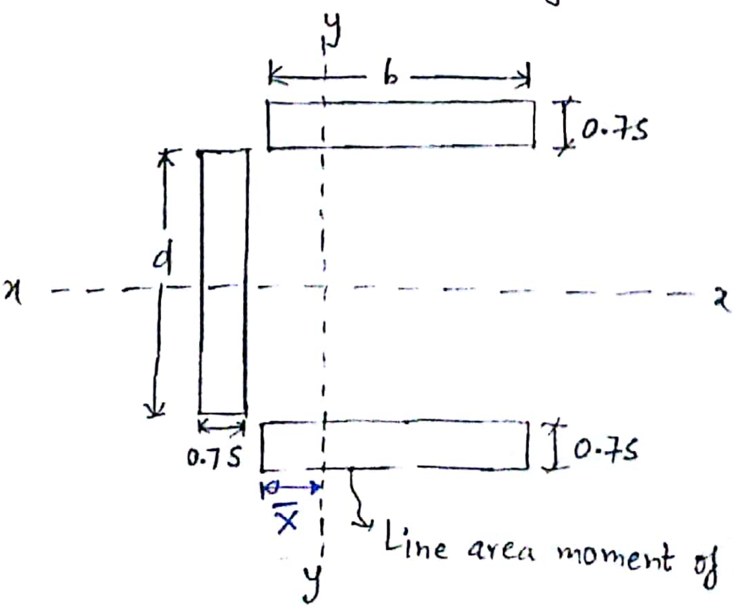
f_d → direct shear stress

$$f_d = \frac{P}{d \times t_t + 2bt_t} = \frac{P}{(d+2b) \times 0.7S}$$

→ Line of action of f_d is parallel to direct load

f_t → Torsional shear stress

$$f_t = \frac{Tr}{J}, \quad T = Pe$$



Line area moment of inertia about its own axis is neglected.

$J \rightarrow$ Polar moment of inertia

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

$$I_{xx} = 2b \times 0.75s \times \left(\frac{d}{2}\right)^2 + 0.75s \times \frac{d^3}{12}$$

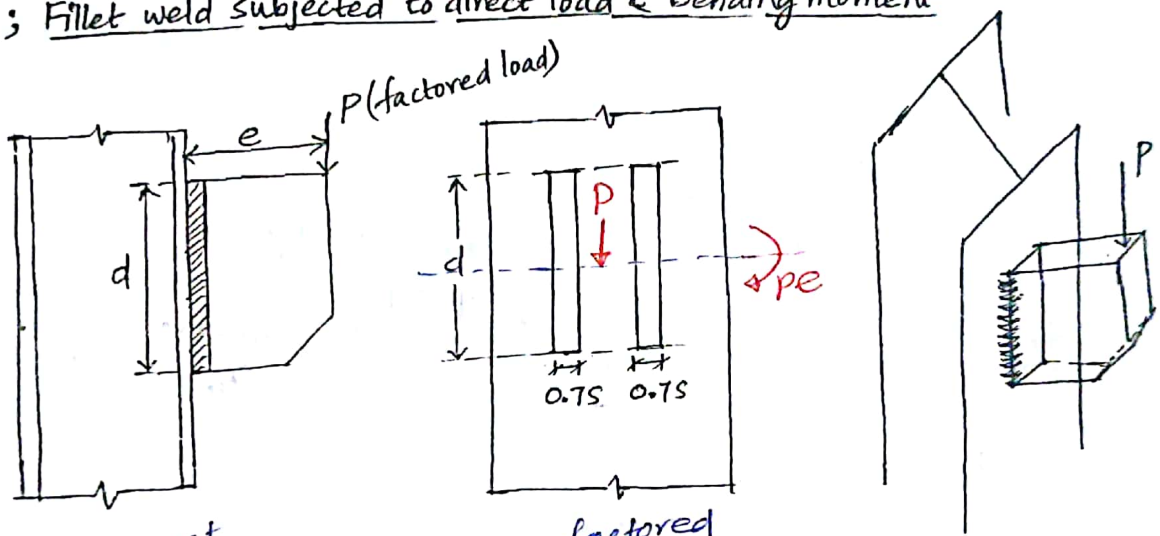
$$I_{yy} = 2\left(0.75s\frac{b^3}{12} + 0.75sb\left(\frac{b}{2} - \bar{x}\right)^2\right) + d \times 0.75s \times \bar{x}^2$$

→ Direction of f_t will be ~~tan~~ perpendicular to the line joining C.G. of weld with the point under consideration, and it will be in the same sense as that of the applied moment (P e)

$f_r \rightarrow$ resultant shear stress

$$\rightarrow \boxed{f_r = \sqrt{f_a^2 + f_t^2 + 2 f_a f_t \cos\theta} \le \frac{f_u}{\sqrt{3}\,\gamma_{mw}}}$$

Case II ; Fillet weld subjected to direct load & Bending moment



$q \rightarrow$ direct shear stress in weld due to factored load 'P' ; $q = \frac{P}{2 d t_t}$

$$q = \frac{P}{2 \times 0.75 d}$$

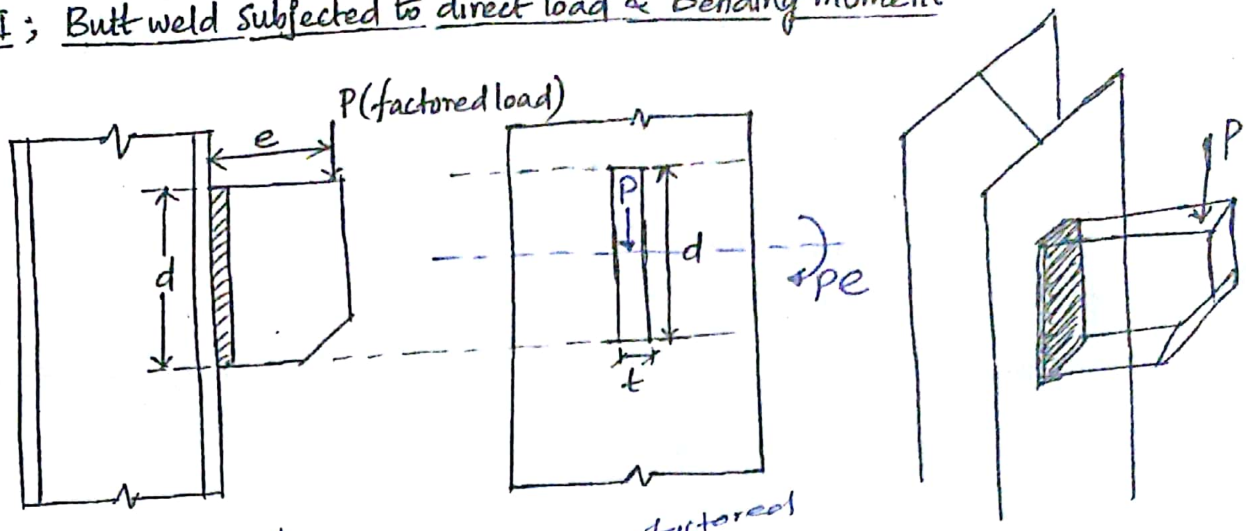
$f_a \rightarrow$ normal stress in weld due to bending moment (Pe)

$$f_a = \frac{My}{I} = \frac{Pe \times \frac{d}{2}}{2 \times \frac{0.75 d^3}{12}}$$

$f_e \rightarrow$ equivalent stress , $f_e \ngtr f_{wd} \Rightarrow f_e \le f_{wd}$

$$\rightarrow \boxed{f_e = \sqrt{f_a^2 + 3q^2} \le \frac{f_u}{\sqrt{3}\,\gamma_{mw}}}$$

Case III ; Butt weld subjected to direct load & Bending moment



$q \rightarrow$ direct Shear stress on weld due to factored load P

$$q = \frac{P}{dt}$$

$f_b \rightarrow$ Bending stress

$$f_b = \frac{My}{I} = \frac{Pe \times \frac{d}{2}}{\frac{td^3}{12}}$$

$f_e \rightarrow$ equivalent stress

$$\rightarrow \boxed{f_e = \sqrt{f_b^2 + 3q^2} \leq \frac{f_y}{\gamma_{mo}}}$$

For safety, $f_e \not> \frac{f_y}{\gamma_{mo}}$ where $\gamma_{mo} = 1.1$

→ f_e as calculated above should not exceed the values allowed for the parent metal

Note :-

→ from maximum distortion energy theory in 2D.

$$\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2 \leq f_y^2$$

for butt weld ; $\sigma_x = f_b$, $\tau_{xy} = q$, $\sigma_y = 0$

$$\therefore \boxed{\sqrt{f_b^2 + 3q^2} \leq f_y}$$

Note → For design depth of bracket plate is adopted using the following relation ;

i) for Butt weld ;

$$\boxed{d = \sqrt{\frac{6M}{tf_b}}} \; ; \; f_b = \frac{f_y}{\gamma_{mo}} \qquad \gamma_{mo} = 1.1$$

For fillet weld;

$$d = \sqrt{\frac{6M}{2t_t f_{wd_1}}}$$

; $f_{wd_1} = \frac{0.8 f_u}{\sqrt{3}\gamma_{mw}}$ & $t_t = 0.7S$

A reduced value of about 80% should be used to account for the effect of direct shear force