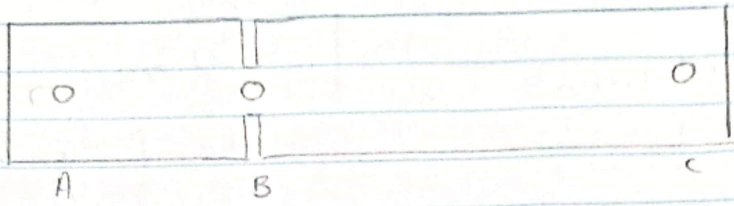
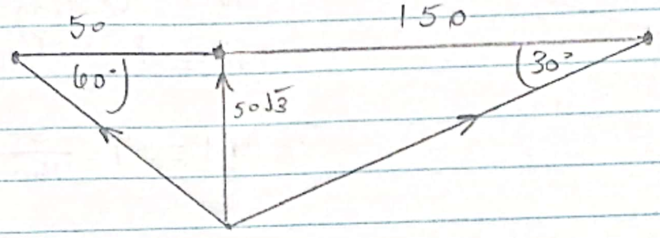
# Beam Calcs



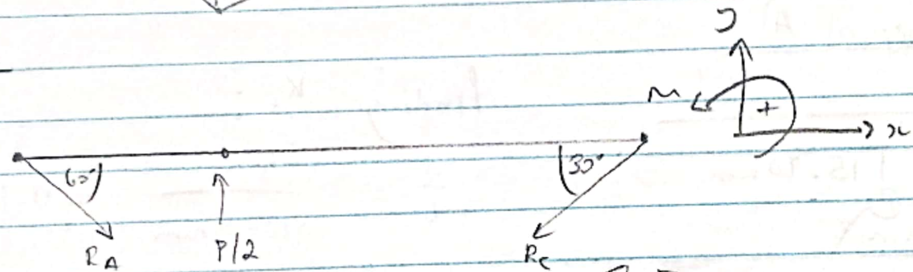

Assumptions:

→ due to bearing nut, $P/2$ force is experienced by the beam

→ geometry remains constant during loading, negligible change in angles upon loading




* FBD




$\sum F_y = 0$,

$$\frac{P}{2} = R_A \sin 60^\circ + R_c \sin 30^\circ$$

$$\therefore P = 2\left(R_A \frac{\sqrt{3}}{2} + R_c \frac{1}{2}\right)$$

$$\therefore P = \sqrt{3} R_A + R_c$$

$\sum F_x = 0$

$$R_A \cos 60^\circ = R_c \cos 30^\circ$$

$$\therefore \frac{R_A}{\cancel{2}} = R_c \frac{\sqrt{3}}{\cancel{2}}$$

$$\therefore R_A = R_c \sqrt{3}$$

$$\therefore P = \sqrt{3}\left(R_c \sqrt{3}\right) + R_c$$

$$= 3R_c + R_c$$

$$P = 4R_c$$

$$\therefore R_c = P \cdot \frac{1}{4}$$

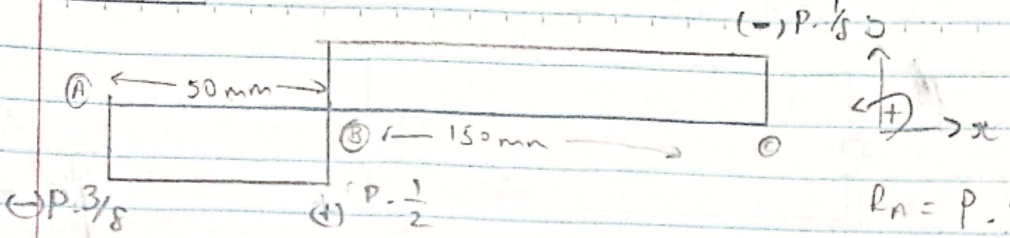
$$\therefore R_A = P \cdot \frac{\sqrt{3}}{4}$$

hence:

$$R_{A,y} = P \cdot \frac{\sqrt{3}}{4} \cdot \sin 60^\circ = P \cdot \frac{\sqrt{3}}{4} \cdot \frac{\sqrt{3}}{2} = P \cdot \frac{3}{8} \text{ N}$$

$$R_{c,y} = P \cdot \frac{1}{4} \cdot \sin 30^\circ = P \cdot \frac{1}{4} \cdot \frac{1}{2} = P \cdot \frac{1}{8} \text{ N}$$

* SFD

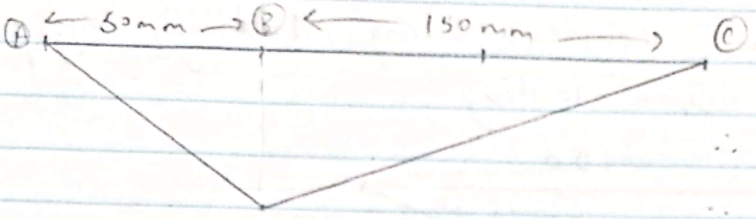



$R_A = P \cdot 3/8 \ (-)$

$R_B = P \cdot 1/2 \ (+)$

$R_C = P \cdot 1/8 \ (-)$

* BMD

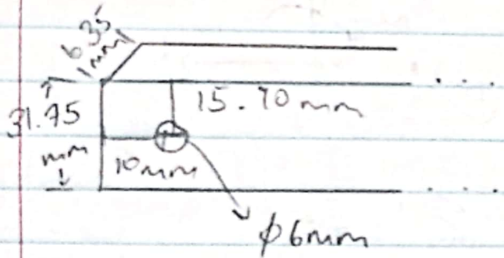



$\therefore$ max bending at B

$\therefore M = P \cdot \frac{3}{8} N \times 0.05 m$

$\therefore M = P \cdot \frac{3}{160} Nm$

* stresses at A




finding $K_t$:

$\frac{d}{b} = \frac{6mm}{31.75mm} = 0.189 \simeq 0.2$

$\therefore K_t \simeq 5.5$ (considering "pin loaded hole")

finding $\sigma_{max}$:

$\sigma_{max} = K_t \cdot \sigma_{nom}$

$\sigma_{nom} = \frac{P}{(b-d)h}$

$= \frac{P \cdot 3/8 \ N}{(31.75mm - 6mm)(6.35mm)}$

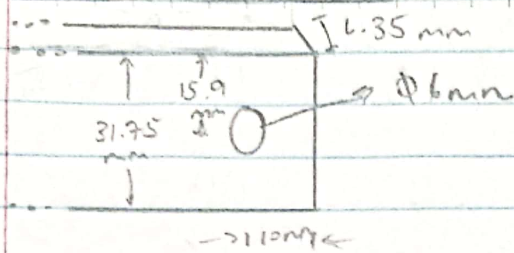
$= 0.00229 \cdot P \ MPa$

$\therefore \sigma_{max} = 5.5 \times 0.00229 \cdot P \ MPa$

$= 0.0126 \times P \ MPa$

7mm A4

* stresses at C




finding $K_t$:

$$\frac{d}{w} = \frac{6mm}{31.75mm} = 0.1889 \simeq 0.20$$

$\rightarrow K_t \simeq 5.5$ ("pin loaded hole")

finding $\sigma_{max}$:

$$\sigma_{max} = K_t \cdot \sigma_{nom}$$

$$\sigma_{nom} = \frac{P}{(w-d)h}$$

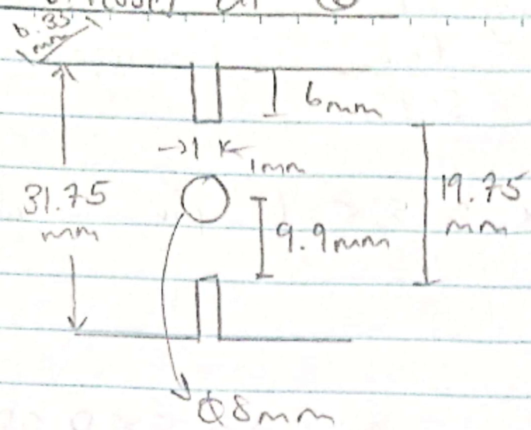
$$= \frac{P \cdot 1/8 \ N}{(31.75mm - 6mm)(6.35mm)}$$

$$= 0.00076.P \ MPa$$

$$\therefore \sigma_{max} = 5.5 \times 0.00076P \ MPa$$

$$= 0.0042P \ MPa$$

* stresses at (B)




considering "hole":

$R_B = P/2 \ N$

$\frac{d}{b} = \frac{8mm}{19.75mm} = 0.405 \simeq 0.40$

$\therefore K_t \simeq 2.25$ ("unloaded hole")

$\therefore \sigma_{max} = K_t \cdot \sigma_{nom}$

$\therefore \sigma_{nom} = \frac{P}{(b-d)h}$

$= \frac{P \cdot 1/2 \ N}{(19.75mm - 8mm)(6.35mm)}$

$= 0.0067 \cdot P \ MPa$

$\therefore \sigma_{max} = 2.25 \times 0.0067P$

$= 0.01508P \ MPa$ (axial)

$\frac{d}{b} = \frac{8mm}{19.75mm} = 0.405 \simeq 0.40$

$M_B = P \cdot \frac{3}{160} \ Nm$

$\frac{d}{h} = \frac{8mm}{6.35mm} = 1.26 \simeq 1.25$

$\therefore K_t \simeq 1.25$

$\sigma_{max} = K_t \cdot \sigma_{nom}$

$\sigma_{nom} = \frac{6M}{(b-d)h^2}$

$= \frac{6(P \cdot 3/160 \ Nm)}{(19.75mm - 8mm)(6.35mm)^2}$

$= 1507.8P \ Pa$

$\therefore \sigma_{max} = 1.25 \times 1507.8P \ Pa$

$= 1884.74P \ Pa$

$= 1.88P \ MPa$ (bending)

7mm A4

considering "notch":

$R_B = P/2$ N

Assumption

$\rightarrow$ approximate notch of radius $r \Rightarrow r = 6$mm

$\therefore \frac{r}{h} = \frac{6\text{ mm}}{19.75\text{ mm}} = 0.303 \simeq 0.30$

$\therefore \frac{H}{h} = \frac{31.75\text{ mm}}{19.75\text{ mm}} = 1.607 \simeq 1.60$

$\therefore K_t = 1.8$

$\therefore \sigma_{max} = 1.8 \times \sigma_{nom}$
$= 0.00718P$ MPa (axial)

$\therefore \sigma_{max} = K_t \cdot \sigma_{nom}$

$\Rightarrow \sigma_{nom} = \frac{P}{bh}$

$= \frac{P \cdot 1/2\text{ N}}{6.35\text{ mm} \times 19.75\text{ mm}}$

$= 0.00398P$ MPa

$M_B = P \cdot \frac{3}{160}$ Nm

$\therefore \frac{r}{h} = \frac{6\text{ mm}}{19.75\text{ mm}} = 0.303 \simeq 0.30$

$\frac{H}{h} = \frac{31.75\text{ mm}}{19.75\text{ mm}} = 1.607 \simeq 1.60$

$\therefore K_t = 1.5$

$\therefore \sigma_{max} = 1.5\sigma_{nom}$
$= 68.1P$ MPa (bending)

$\therefore \sigma_{max} = K_t \cdot \sigma_{nom}$

$\therefore \sigma_{nom} = \frac{6M}{bh^2}$

$= \frac{6(P \cdot 3/160\text{ Nm})}{(6.35\text{ mm})(19.75\text{ mm})^2}$

$= 45419.7P$ Pa

$= 45.42P$ MPa

7mm A4

* superimpose to find total stress concentration at B:

$$\sigma_{max} = \sigma_{max,\,axial,\,hole} + \sigma_{max,\,bend,\,hole} + \sigma_{max,\,axial,\,notch} + \sigma_{max,\,bend,\,notch}$$

$$= 0.01508P + 1.88P + 0.02718P + 68.1P$$

$$= 70P$$