

BENJAMIN, CRAW

R 270

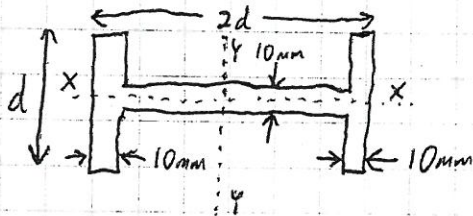
①④④

$$P = \frac{\pi^2 EI}{4L^2}$$

$$\text{LOAD} = 92 \text{ kN}$$

$$\text{LENGTH} = 6 \text{ m}$$

$$E = 200 \text{ GPa/m}^2 =$$



$$= \boxed{} + \boxed{} + \boxed{}$$

$$I_{yy} > I_{xx}$$

$$\therefore I_{xx} = \frac{30^3}{12}$$

$$= 2 \left(\frac{10 \times d^3}{12} \right) \times 10^{-12} + \left(\frac{(2d-20)10^3}{12} \right) \times 10^{-12}$$

$$I_{xx} = (1.67d^3 + 166.7d - 1666.7) \times 10^{-12}$$

FROM EULER

$$P = \frac{\pi^2 EI}{4L^2}$$

$$\therefore I = \frac{4PL^2}{\pi^2 E}$$

$$= \frac{4 \times 92 \times 10^3 \times 6^2}{\pi^2 \times 200 \times 10^9}$$

$$= \underline{\underline{6.72 \times 10^{-6}}}$$

$$\therefore (1.67d^3 + 166.7d - 1666.7) \times 10^{-12} = 6.72 \times 10^{-6}$$

$$1.67d^3 + 166.7d - 1666.7 = 6.72 \times 10^6$$

$$1.67d^3 + 166.7d \approx 6.73 \times 10^6$$

$$\underline{\underline{d^3 + 100d \approx 4.03 \times 10^6}}$$

STROTS

ST (13)

b) WITH THE UPPER END PINNED;

$$P = \frac{2\pi^2 EI}{L^2}$$

$$\therefore I = \frac{PL^2}{2E\pi^2}$$

$$= \frac{92 \times 10^3 \times 6^2}{2 \times 200 \times 10^9 \times \pi^2}$$

$$= \underline{\underline{0.84 \times 10^{-6} \text{ m}^4}}$$

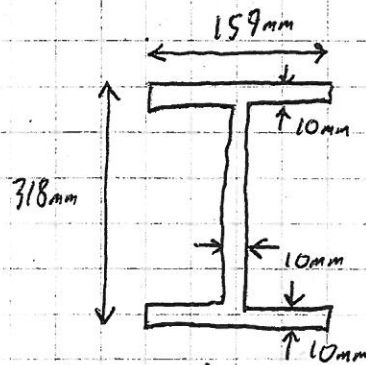
$$\therefore (1.67d^3 + 166.7d - 1666.7) \times 10^{-12} = 0.84 \times 10^{-6}$$

$$1.67d^3 + 166.7d - 1666.7 = 0.84 \times 10^6$$

$$1.67d^3 + 166.7d \approx 0.84 \times 10^6$$

$$\underline{\underline{d^3 + 100d \approx 0.50 \times 10^6}}$$

c) FOR PART A :



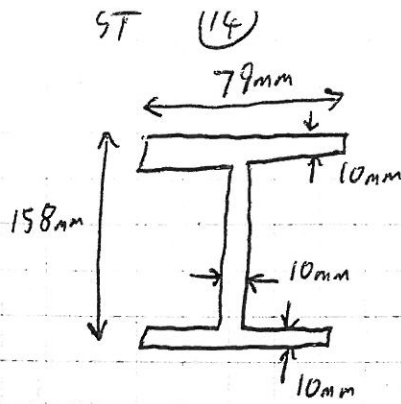
$$\therefore \text{AREA} = 2(159 \times 10) + (318 - 20) \times 10$$

$$= 6160 \text{ mm}^2$$

$$\therefore \text{STRESS} = \frac{\text{FORCE}}{\text{AREA}} = \frac{92 \times 10^3}{6160 \times 10^{-6}} = 14.9 \times 10^6 \text{ N/m}^2$$

$$= \underline{\underline{14.9 \text{ MN/m}^2}}$$

FOR PART B:



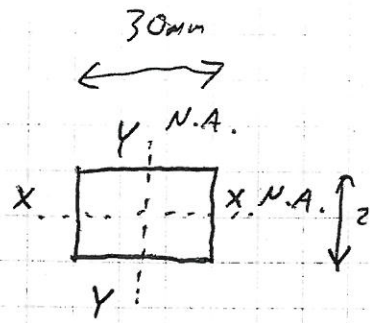
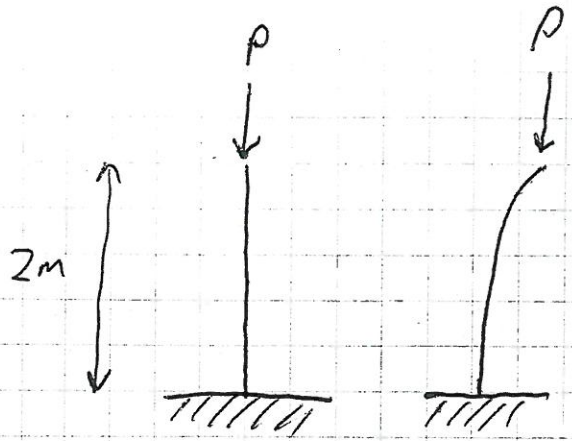
$$\begin{aligned} \text{AREA} &= 2(79 \times 10) + (158 - 20) \times 10 \\ &= \underline{\underline{2960 \text{ mm}^2}} \end{aligned}$$

$$\begin{aligned} \therefore \text{STRESS} &= \frac{\text{FORCE}}{\text{AREA}} = \frac{92 \times 10^3}{2960 \times 10^{-6}} = 31.1 \times 10^6 \text{ N/m}^2 \\ &= \underline{\underline{31.1 \text{ MN/m}^2}} \end{aligned}$$

ST (15)

REVISION:

(2)



$$E = 200 \text{ GPa}$$

$$= 200 \times 10^9 \text{ Nm}^{-2}$$

$$I_{xx} < I_{yy}$$

$$\therefore I_{xx} = \frac{BD^3}{12}$$

$$= \frac{(30 \times 20^3) \times 10^{-12}}{12}$$

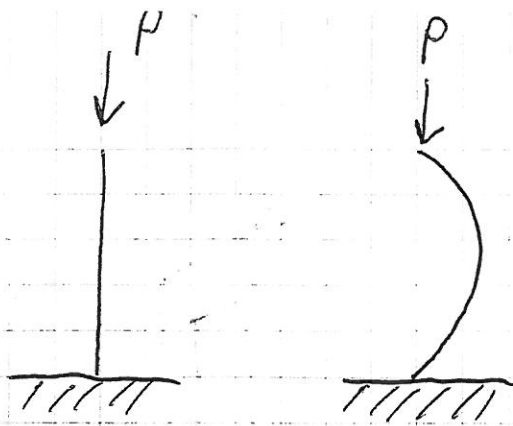
$$= \underline{\underline{2 \times 10^{-8} \text{ m}^4}}$$

$$F = \frac{\pi^2 EI}{4L^2}$$

$$= \frac{\pi^2 \times 200 \times 10^9 \times 2 \times 10^{-8}}{4 \times 2^2}$$

$$= \underline{\underline{2467 \text{ N}}}$$

3)

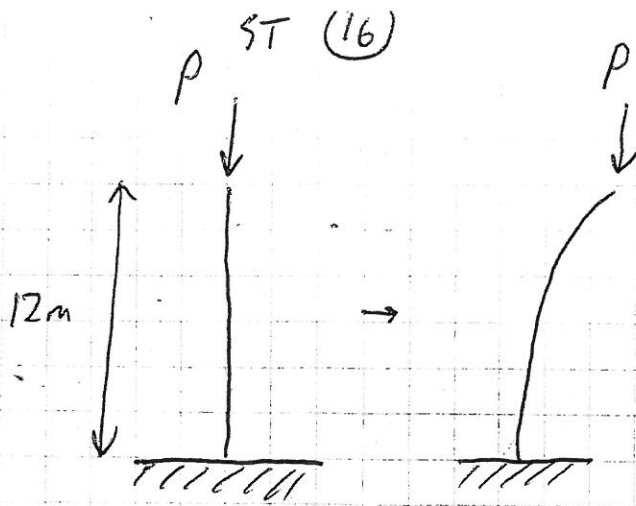


$$P = \frac{\pi^2 EI}{L^2}$$

$$= \frac{\pi^2 \times 200 \times 10^9 \times 2 \times 10^{-8}}{2^2}$$

$$P = \underline{\underline{9870 \text{ N}}}$$

④



I_{xx}

$\phi = 0.15m$

$$I_{xx} = I_{yy} = \frac{\pi d^4}{64}$$

$$I_{xx} = \frac{\pi \times 0.15^4}{64}$$

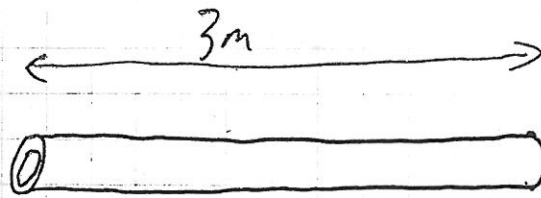
$$= 2.485 \times 10^{-5} m^4$$

$$P = \frac{\pi^2 EI}{4L^2}$$

$$= \frac{\pi^2 \times 205 \times 10^9 \times 2.485 \times 10^{-5}}{4 \times 12^2}$$

$$= \underline{\underline{87289 N}}$$

⑤



$$I_{yy} = I_{xx} = \frac{\pi d^4}{64}$$

$$= \left(\frac{\pi \times 50^4}{64} - \frac{\pi \times 30^4}{64} \right) \times 10^{-12}$$

$$= \underline{\underline{2.67 \times 10^{-7}}}$$

①

$$P = \frac{4\pi^2 EI}{L^2}$$

$$= \frac{4 \times \pi^2 \times 120 \times 10^9 \times 2.67 \times 10^{-7}}{3^2}$$

$$= \underline{\underline{140.5 \text{ kN}}}$$

②

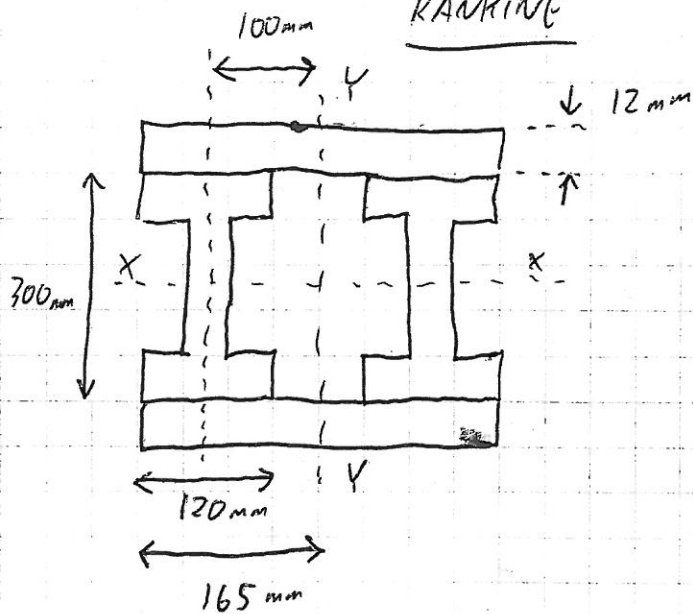
$$\text{or } \frac{\pi^2 EI}{l^2} \quad \text{WHERE } l = \frac{L}{2}$$

$$= \frac{\pi^2 \times 120 \times 10^9 \times 2.67 \times 10^{-7}}{1.5^2}$$

$$= \underline{\underline{140.5 \text{ kN}}}$$

RANKINE

①



EACH PART

$$\begin{aligned} I_{xx} &= 96 \times 10^{-6} \text{ m}^4 \\ I_{yy} &= 4.2 \times 10^{-6} \text{ m}^4 \\ A &= 6 \times 10^{-3} \text{ m}^2 \end{aligned}$$

} GIVEN.

④

XX

JOISTS : $I_{xx} = 2 \times 96 \times 10^{-6} = \underline{\underline{192 \times 10^{-6} \text{ m}^4}}$

PLATES : $I_{xx} = \frac{BD^3}{12}$

$$\begin{aligned} &= \left[\frac{330 \times 324^3}{12} - \frac{330 \times 300^3}{12} \right] \times 10^{-12} \\ &= \underline{\underline{192.8 \times 10^{-6} \text{ m}^4}} \end{aligned}$$

$$\begin{aligned} \therefore I_{\text{TOTAL}} &= 192 \times 10^{-6} + 192.8 \times 10^{-6} \\ &= \underline{\underline{384.8 \times 10^{-6} \text{ m}^4}} \end{aligned}$$

YY

FROM PARALLEL AXIS THEOREM:

$$(I_{NA} = I + Ah^2)$$

JOISTS:

$$I_{YY} = 2(4.2 \times 10^{-6} + 6 \times 10^{-3} \times 0.1^2)$$

$$= \underline{128.4 \times 10^{-6} \text{ m}^4}$$

PLATES:

$$I_{YY} = \frac{Bb^3}{12}$$

$$= 2 \left(\frac{12 \times 330^3}{12} \right) \times 1 \times 10^{-12}$$

$$= \underline{71.9 \times 10^{-6} \text{ m}^4}$$

$$\therefore \text{TOTAL } I_{YY} = (128.4 + 71.9) \times 10^{-6}$$

$$= \underline{200.3 \times 10^{-6} \text{ m}^4}$$

$$\therefore \text{since } I_{xx} = 384.8 \times 10^{-6} \text{ m}^4$$

$$I_{YY} = 200.3 \times 10^{-6} \text{ m}^4$$

$$\text{ie } I_{xx} > I_{YY}$$

GORDON RANKINE STRESS σ_R IS GIVEN WHEN K IS A MINIMUM, AND HENCE

$$\sigma_R = \frac{\sigma_y}{1 + a \left(\frac{L}{K} \right)^2}$$

$$\left(K = \sqrt{\frac{I}{A}} \right)$$

~~OR~~

$$\text{ie smallest } I = I_{YY} = \underline{200.3 \times 10^{-6} \text{ m}^4}$$

$$\therefore K = \sqrt{\frac{I}{A}} = \underline{200.3 \times 10^{-6}}$$

ST (20)

$$K = \sqrt{\frac{I}{A}}$$

$$\begin{aligned} \text{TOTAL AREA} &= 2 \times \text{JOISTS} + 2 \times \text{PLATES} \\ &= 2 \times 6 \times 10^{-3} + 2 \times (380 \times 12) \times 10^{-6} \\ &= \underline{\underline{19.92 \times 10^{-3} \text{ m}^2}} \end{aligned}$$

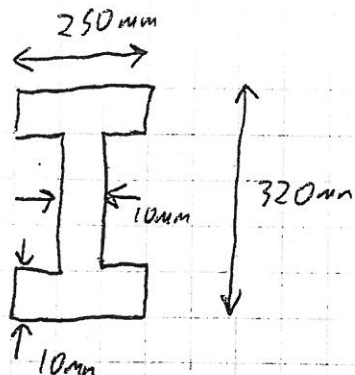
$$\begin{aligned} \therefore K &= \sqrt{\frac{200.3 \times 10^{-6}}{19.92 \times 10^{-3}}} \quad \left(\frac{\text{m}^4}{\text{m}^2} \right) \\ &= \underline{\underline{0.1 \text{ m}^2}} \end{aligned}$$

$$\begin{aligned} \therefore P_R &= \frac{\sigma_y A}{1 + \left(\frac{L}{K} \right)^2} \\ &= \frac{300 \times 10^6 \times 19.92 \times 10^{-3}}{1 + \frac{1}{7500} \left(\frac{7}{0.1} \right)^2} \\ &= \frac{5976000}{1.653} \\ &= \underline{\underline{3.62 \times 10^6 \text{ N}}} \end{aligned}$$

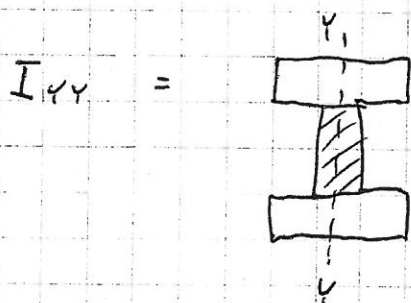
WITH FACTOR OF SAFETY :

$$\begin{aligned} P_{\text{max}} &= \frac{3.62 \times 10^6}{3} \\ &= \underline{\underline{1.205 \times 10^6 \text{ N}}} \end{aligned}$$

(2)



$$\begin{aligned}
 I_{xx} &= \frac{BD^3}{12} \\
 &= \left[\frac{250 \times 320^3}{12} - 2 \left(\frac{(125-5)(320-20)^3}{12} \right) \right] \times 10^{-12} \\
 &= \left(682.67 \times 10^6 - 540.0 \times 10^6 \right) \times 10^{-12} \\
 &= \underline{\underline{142.67 \times 10^{-6} \text{ m}^4}}
 \end{aligned}$$



$$\begin{aligned}
 I_{yy} &= \frac{BD^3}{12} \\
 &= \left[2 \left(\frac{10 \times 250^3}{12} \right) + \frac{300 \times 10^3}{12} \right] \times 10^{-12} \\
 &= \left(26041.7 \times 10^3 + 25000 \right) \times 10^{-12} \\
 &= \underline{\underline{26.07 \times 10^{-6} \text{ m}^4}}
 \end{aligned}$$

$\therefore I_{yy}$ is SMALLEST

$$P_R = \frac{\sigma_y A}{1 + a \left(\frac{L}{K} \right)^2}$$

$$I = 26.07 \times 10^{-6} \text{ m}^4$$

$$\therefore K = \sqrt{\frac{I}{A}}$$

$$= \sqrt{\frac{26.07 \times 10^{-6}}{(10 \times 250 \times 2 + 300 \times 10) \times 10^{-6}}}$$

=

$$\underline{\underline{57.09 \times 10^{-3} \text{ m}^4}}$$

$$A = (10 \times 250 \times 2 + 300 \times 10) \times 10^{-6}$$

$$= \underline{\underline{8.0 \times 10^{-3} \text{ m}^2}}$$

$$\therefore P_R = \frac{\sigma_y A}{1 + a \left(\frac{L}{K} \right)^2}$$

$$= \frac{325 \times 10^6 \times 8.0 \times 10^{-3}}{1 + \frac{1}{64000} \left(\frac{16}{57.09 \times 10^{-3}} \right)^2}$$

$$= \frac{2.6 \times 10^6}{2.23}$$

$$= \underline{\underline{1.17 \times 10^6 \text{ N}}}$$