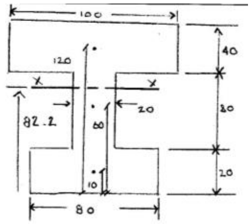
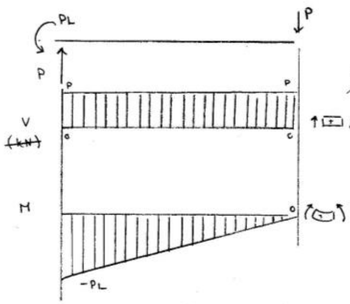
$$\bar{y} = \frac{\Sigma A_i y_i}{A} = \frac{80(20)(10) + 80(20)(60) + 40(100)(120)}{2(80)(20) + 40(100)} = 82.2\,mm$$



$$I_{xx} = \frac{80(20)^3}{12} + 80(20)(72.2)^2 + \frac{20(80)^3}{12} + 20(80)(22.2)^2 + \frac{100(40)^3}{12} + 100(40)(37.8)^2 = 16.28 \times 10^6\ mm^4$$

SFD & BMD apply to both Q1 and Q2 for determining the max. moment as a f^n of P.

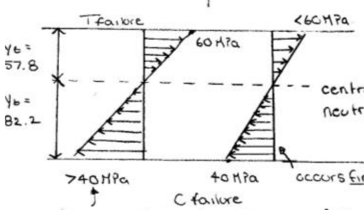


From BMD, find that Mmax is −PL.

−ve => hogging moment
T on top
C on bottom

$\sigma_{c\,max} = \sigma_{bottom\,max} = 40\,MPa$

$\sigma_{t\,max} = \sigma_{top\,max} = 60\,MPa$



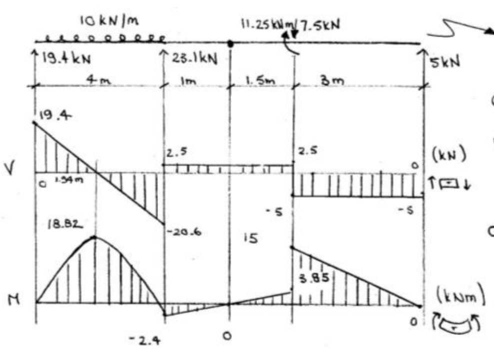
$\sigma_{failure}$ $\frac{\sigma_b}{y_b} = \frac{40}{82.2} = 0.487$ ← governs.

T failure $\frac{\sigma_t}{y_t} = \frac{60}{57.8} = 1.03$

since $\sigma = \frac{My}{I}$ and $M = PL$; $P = \frac{\sigma I}{yL}$

to kN

$$\therefore P_{max} = 0.487\left(\frac{16.28 \times 10^6}{1600}\right)\frac{1}{1000} = \underline{4.95\ kN}$$



Solve for reactions by breaking beam apart at Pin C.

Cross Section is symmetric.

$M_{des} = 1.9 \times M_{max}$
$= 1.9 \times 18.82$
$= 35.8\ kNm$

$\sigma_{all} = 8\,MPa$

$I = \frac{bd^3}{12} = \frac{(150)d^3}{12}$

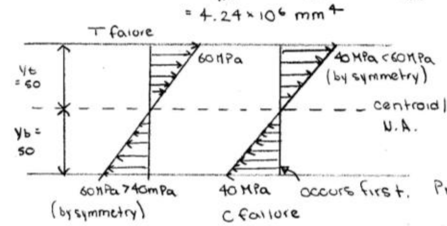
$y_{max} = \frac{d}{2}$

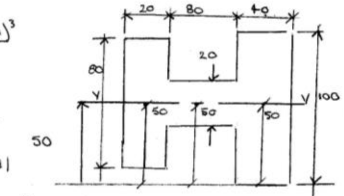
$$\sigma = \frac{My}{I} \Rightarrow \sigma_{all} = \frac{M_{des} \cdot y_{max}}{I}\ ;\ \underset{L.S.}{8\,MPa\ \left[\frac{N}{mm^2}\right]} = \frac{(35.8 \times 10^6\ Nmm)\left(\frac{d}{2}\ mm\right)}{\left(\frac{150\,d^3}{12}\ mm^4\right)}\ \underset{R.S.}{\left[\frac{N}{mm^2}\right]}$$

$$\therefore d = \sqrt{\frac{(35.8 \times 10^6)(12)}{2(150)(8)}} = \sqrt{179000} = 423\,mm \quad \therefore \text{Take } \underline{d = 425\,mm}$$

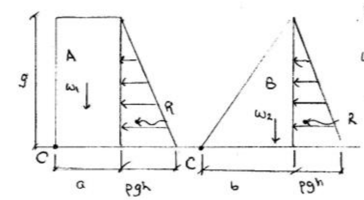
as d↑, σ↓, so round up to the nearest multiple of 25mm

$\bar{x} = 50\,mm$ $\quad I_{yy} = \frac{20(80)^3}{12} + \frac{80(20)^3}{12} + \frac{40(100)^3}{12}$
$= 4.24 \times 10^6\ mm^4$





Similarly, $P_{max} = \frac{40(4.24 \times 10^6)}{50(1600)} \frac{1}{1000} = \underline{2.12\ kN}$



$R = \frac{(\rho g h)}{2} \times 9 = \frac{(9.81)(1)(9)^2}{2} = 397.3\ kN/m$

$w_1 = \rho g V = (2.4)(9.81)(9)a = 211.9a\ /m$

$w_2 = \rho g V = \frac{1}{2}(2.4)(9.81)(9)b = 105.9b\ /m$

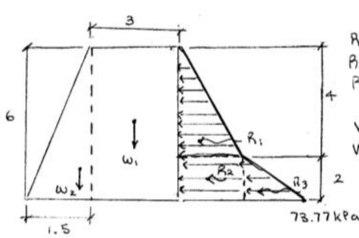
All forces act at the centroid of their respective shape.

$\circlearrowleft \Sigma M_{C_A} = 0$ $\quad R(3) - w_1\left(\frac{a}{2}\right) = 0$
$397.3(3) - \frac{211.9a^2}{2} = 0$
$a = \sqrt{\frac{397.3(3)(2)}{211.9}} = 3.35\,m$

$\therefore W = \rho g V = 2.4(9.81)(9)(3.35) = \underline{711\ kN/m}$

$\circlearrowleft \Sigma M_{C_B} = 0$ $\quad R(3) - w_2\left(\frac{2}{3}b\right) = 0$
$397.3(3) - 105.9b^2\left(\frac{2}{3}\right) = 0$
$b = \sqrt{\frac{397.3(3)(3)}{2(105.9)}} = 4.11\,m$

$\therefore W = \rho g V = \frac{2.4(9.81)(9)(4.11)}{2}$
$= \underline{435\ kN/m}$



$R_1 = 1/2(39.24)(4)(5) = 392.4\ kN$
$R_2 = (39.24)(2)(5) = 392.4\ kN$
$R_3 = (34.53)(2)(5)(1/2) = 172.7\ kN$

$W_1 = 2.4(9.81)(3)(6)(5) = 2119\ kN$
$W_2 = 2.4(9.81)(1.5)(6)(1/2)(5) = 529.7\ kN$

All forces act at the centroid of their respective shape.

$P_{4m} = \rho_w g h = 9.81(4) = 39.24\ kPa$
$P_{6m} = P_{4m} + \rho_s g h = 39.24 + 1.76(9.81)(2) = 73.77\ kPa$
$\Delta P = P_{6m} - P_{4m} = 34.53\ kPa$

$$F.O.S = \frac{\text{resistance}}{\text{overturning moment}} = \frac{2119(3) + 529.7(1)}{392.4(3.33) + 392.4(1) + 172.7(0.666)}$$

$= \underline{3.80}$