$T_3 = 38.6$ kN

Joint B

$V_2 = T_3 \sin \alpha_3$

$V_2 = 27.29$ kN

$\underline{H_2 = T_3 \cos \alpha_3 = 27.29 \text{ kN}}$

CHAPTER 2

1. $\sigma = \rho gh = 1020 \times 9.81 \times 5000 = 50\ \text{MN/m}^2$

2. $A_1 = 1.767\text{E-4};\ A_2 = 3.142\text{E-4};\ A_3 = 7.069\text{E-4}$

$\sigma_1 = 283\ \text{MN/m}^2;\ \sigma_2 = 159.1\ \text{MN/m}^2;\ \sigma_3 = 70.73\ \text{MN/m}^2$

$$\delta = (283 \times 0.2 + 159.1 \times 0.3 + 70.7 \times 0.5) \times \frac{1\text{E}6}{2\text{E}11}$$

$\underline{\delta = 6.984\text{E-4m} = 0.698\ \text{mm}}$

3. $$\delta = \left(\frac{283 \times 0.2}{2\text{E}11} + \frac{159.1 \times 0.3}{7\text{E}10} + \frac{70.7 \times 0.5}{1\text{E}11}\right) \times 1\text{E}6$$

$\underline{\delta = 1.318\ \text{mm}}$

4. $$u = \frac{W\ell}{A_1 E}\left(\frac{d_1}{d_2}\right)$$

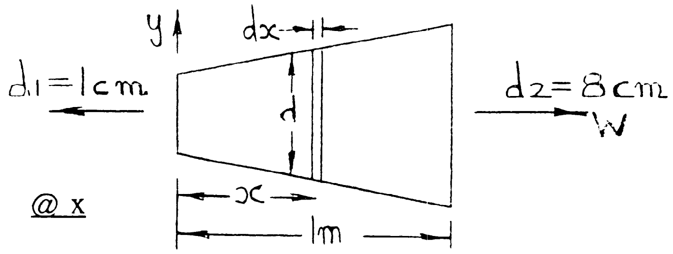
$$A_1 = \frac{\pi \times (1\text{E} - 2)^2}{4} = 7.854\text{E}-5\ \text{m}^2$$

$$u = \frac{0.1\text{E}6 \times 1}{7.854\text{E}-5 \times 2\text{E}11} \times (0.125)$$

$= 7.958\text{E-4 m}$

$u = 0.796\ \text{mm}$

Proof of formula for problem 4



@ x

$d = 1\text{E-2} + 7\text{E-2}\ x$

d = 1E-2 (1 + 7x)

@ x

$$\sigma = \frac{W}{\pi d^2} = \frac{W \times 4}{\pi \times [1E-2(1 + 7x)]^2}$$

$$\sigma = \frac{12732\ W}{(1 + 7x)^2}$$

@x

$$\epsilon = \frac{12732\ W}{(1 + 7x)^2 \times 2E11}$$

$$\epsilon = \frac{6.366E-8W}{(1 + 7x)^2}$$

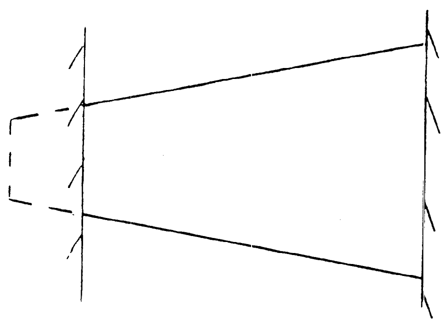
$$\delta u = \frac{6.336E-8W\ \delta x}{(1 + 7x)^2}$$

$$u = 6.366E-8W \int \frac{1.dx}{(1 + 7x)^2}$$

$$= 6.366E-3 \left[\frac{-1}{7\ (1 + 7x)}\right]_0^1 = -9.094\ [0.125 - 1]$$

$$u = 7.96E-4m$$

5.



Free expansion = $\alpha \ell T$ = 15E-6 x 1 x 10 = 1.5E-4m

From solution to problem 4,

$$1.5E\text{-}4 = 7.96E\text{-}4 * \left[\frac{W_T}{0.1E6}\right]$$

$\therefore \underline{W_T = 18844N}$

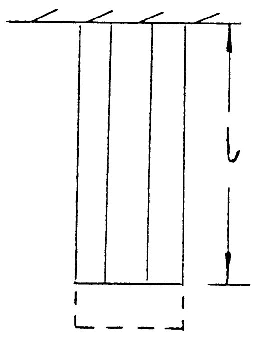
@ smaller end,

$$\sigma = \frac{-18844}{7.854E-5} = -240 \text{ MN/m}^2$$

6. $W = (\rho_c A_c + \rho_s A_s) g\ell$

$= (0.896 + 0.1572) \times 9.81 \ \ell$

$\underline{W = 10.332 \ \ell}$



Compatibility

$\delta_c = \delta_s$

$\ell \times \epsilon_c = \ell \times \epsilon_s$

$\frac{\sigma_c}{E_c} = \frac{\sigma_s}{E_s}$ or $\underline{\sigma_c = 0.5\sigma_s}$

From 1

σ_c is design criterion

ie $\underline{\sigma_c = 30}$ & $\underline{\sigma_s = 60}$

Equilibrium

$W = \sigma_c A_c + \sigma_s A_s$

or $10.332 \ \ell = (30 \times 1E\text{-}4 + 60 \times 0.2E\text{-}4) \ 1E6$

$\therefore \underline{\ell = 406.5 \text{ m}}$

7. Average stress in copper = 15 MN/m^2

$\therefore$ Average strain = $\dfrac{15E6}{1E11}$ = 1.5E−4

δ = 1.5E-4 x 406.5 = 0.06098 m

= 60.98 mm

Check

σ_{AV} (steel) = 30 MN/m^2

ϵ_{AV} (steel) = 1.5E - 4

δ = 15E-4 x 406.5 = 0.061 m

8. W = (100 000 + (7860 - 1020) x 8E-4 ℓg)

W = 100 000 + 53.68 ℓ ———— 1

but W = σA = 200 E6 x 8E-4

= 160 000 N ———— 2

Equating 1 and 2

160 000 = 100 000 + 53.68 ℓ

ℓ = 1118 m

9. $\delta_1 = \delta_2$

$2\,\ell\,\epsilon_1 = \ell\,\epsilon_2$

$$2\,\frac{\sigma_1}{E_1} = \frac{\sigma_2}{E_2}$$

or $\sigma_1 = \dfrac{\sigma_2\,E_1}{2E_2}$ ———— 1

$F_1\,\ell = W\,(\ell - x)$

$$F_1 = \frac{W(\ell - x)}{\ell}$$

$$\sigma_1 A_1 = \frac{W(\ell - x)}{\ell}$$

$$\sigma_1 = \frac{W(\ell - x)}{A_1 \ell} \qquad \text{———————} \quad 2$$

$$F_1 + F_2 = W$$

$$\sigma_1 A_1 + \sigma_2 A_2 = W$$

$$\therefore \frac{W(\ell - x)}{A_1 \ell} * A_1 + \sigma_1 * \frac{2E_2 * A_2}{E_1} = W$$

$$\therefore \frac{W(\ell - x)}{\ell} + \frac{W(\ell - x)}{A_1 \ell} * \frac{2 * 3E}{E} * 0.5\ A_1 = W\ 1$$

$$\therefore (\ell - x)\ [1 + 3] = \ell$$

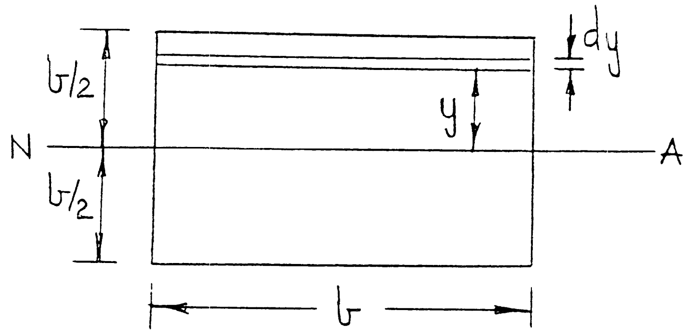
$$4\ell - 4x = \ell$$

$$4x = 3\ell$$

$\underline{x = 0.75\ell}$

CHAPTER 3

$$I_{NA} = \int_{-b/2}^{+b/2} b.dy.y^2$$

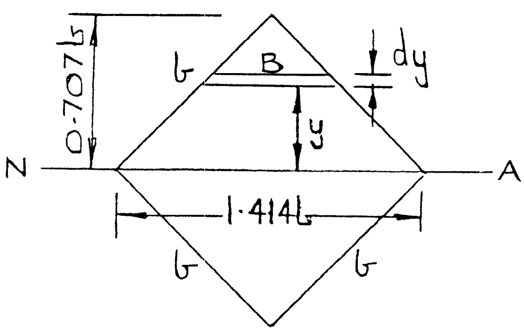


1a. $$= b\left[\frac{y^3}{3}\right]_{-b/2}^{b/2}$$

$$I_{NA} = \frac{b^4}{12}$$

b. From similar triangles

$$\frac{1.414b}{0.707b} = \frac{B}{0.707b-y}$$



or $2(0.707b - y) = B$

$$I_{NA} = \int_{-.0707b}^{0.707b} B.dy.y^2$$

$$= 2\int_{0}^{0.707b} 2(0.707b - y)y^2\,dy$$

$$= 2\int_{0}^{0.707b} (1.414\,by^2 - 2y^3)\,dy$$

$$= 2\left[\frac{1.414by^3}{3} - \frac{2y^4}{4}\right]_0^{0.707b}$$

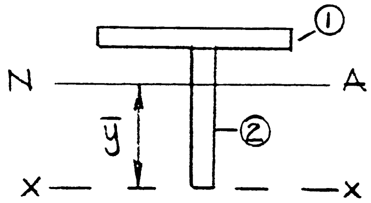
$$I_{NA} = 2b^4\,(0.1666 - 0.1249)$$

$$I_{NA} = \frac{b^4}{12}$$

2a.

Section	a	y	ay	ay^2	i_o
1 2	8 5	10.5 5	84 25	882 125	0.67 41.67
Σ	13	-	109	1007	42.34

$\bar{y} = \dfrac{\Sigma ay}{\Sigma a} = 8.38 \text{ cm}$



$I_{xx} = \Sigma ay^2 + \Sigma i_o = 1049.3$

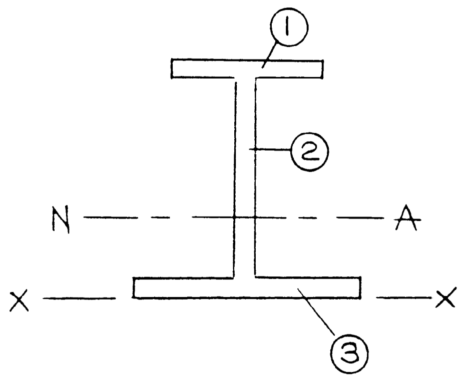
$I_{NA} = I_{xx} - y^{-2}\, \Sigma a = 1049.3 - 8.382 \text{ x } 13$

$I_{NA} = 136.4 \text{ cm}^4 = 1.36\text{E-}6\text{m}^4$

2b.

Section	a	y	ay	ay^2	i_o
1 2 3	8 12 20	14.5 8 1	116 96 20	1682 768 20	0.67 144 6.67
Σ	40	-	232	2470	151.34

$\bar{y} = \dfrac{232}{40} = 5.8 \text{ cm}$



$I_{xx} = 2470 + 151.34 = 2621.34$

$I_{NA} = 2621.34 - 5.8^2 \text{ x } 40$

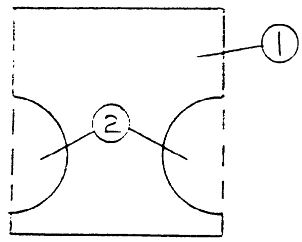
$I_{NA} = 1275.7 \text{ cm}^4 = 1.276 \text{ E-5 m}^4$

2c. $I_{NA} = \dfrac{11 \text{ x } 14^3}{12} - \dfrac{\pi \text{ x } 10^4}{64}$

$I_{NA} = 2024 \text{ cm}^4 = 2.024 \text{ E-5m}^4$

2d.

Section	a	y	ay	ay^2	u_o
1 2	154 -78.54	7 6	1078 -471.2	7546 -2827.4	2515.3 -490.9
Σ	75.46	-	606.8	4718.6	2024.4



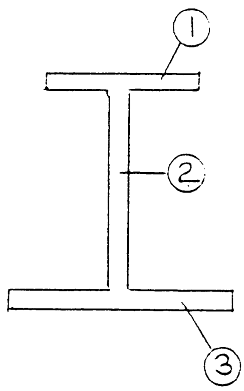
$$\bar{y} = \frac{606.8}{75.46} = 8.04 \text{ cm}$$

$$I_{XX} = 4718.6 + 2024.4 = 6743 \text{ cm}^4$$

$$I_{NA} = 1865 \text{ cm}^4 = 1.865\text{E-5 m}^4$$

3. <u>First case</u>

Section	a	y	ay	ay^2	i_o
1 2 3	2E-3 1E-3 4E-3	0.13 0.07 0.01	2.6E-4 7E-5 4E-5	3.38E-5 4.9E-6 4E-7	6.7E-8 8.33E-7 1.33E-7
Σ	7E-3	-	3.7E-4	3.91E-5	1.03E-6



$$\bar{y} = \frac{3.7\text{E}-4}{7\text{E}-3} = 0.0529$$

$$I_{XX} = 3.91\text{E-5} + 1.03\text{E-6} = 4.013\text{E-5m}^4$$

$$I_{NA} = 2.054\text{E-5 m}^4$$

<u>Second case</u>

$$I_{NA} = \frac{0.1 \times 0.14^3}{12} - \frac{0.09 \times 0.1^3}{12}$$

$$= 2.287\text{E}-5 - 7.5\text{E}-6 = \underline{1.537\text{E}-5\text{m}^4}$$

$$\% \text{ reduction} = \frac{2.054 - 1.537}{2.054} \times 100\% = 25\%$$

CHAPTER 4

1. $w = \rho g A = 2400 \times 9.81 \times 4 = 94176$ ——— 1

$$M_{max} = \frac{w\ell^2}{8}$$

$$\therefore w = \frac{8M_{max}}{\ell^2} = 8M_{max}/\ell^2$$ ——— 2

$$\frac{\sigma}{y} = \frac{M_{max}}{I}$$

$$M_{max} = \frac{\sigma * I}{y} = \frac{1E6 \times 1.333}{1} = 1.333E6$$ ——— 3

Substituting 3 into 2

$w = 10.667E6/\ell^2$ ——— 4

Equating 1 and 4

$\underline{\ell = 10.64 \text{ m}}$

2. $\bar{y} = 1.026$

$I_{NA} = 1.279$

$M_{max} = 1.2466E6$

$w = 9.973E6/\ell^2 = 2400 \times 9.81 \times 3.8037$

$\underline{\therefore \ell = 10.55 \text{ m}}$

3. $\bar{y} = 0.974$

$I_{NA} = 1.279$

$$M_{max} = \frac{1E6 \times 1.279}{0.974} = 1.313E6$$