$$I_{NA} = \frac{0.2 \times 0.01^3}{12} + 0.2 \;\; 0.01 \times 0.1284^2$$

$$+ \frac{0.01}{3} (0.1234^3 + 0.1766^3)$$

$= 1.67E\text{-}8 + 3.297E\text{-}5 + 2.462E\text{-}5$

$I_{NA} = 5.76E\text{-}5 \ m^4$

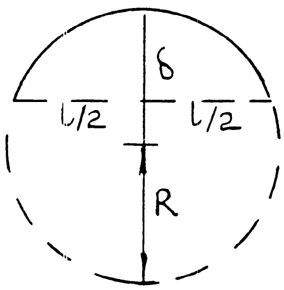
Now

$$\frac{M_e}{I} = \frac{E}{R}$$

$$\therefore R = \frac{EI}{M_e} = \frac{2 * 10^{11} * 5.76 * 10^{-5}}{142 * 10^3}$$

R = 81.1 m

From the properties of a chord



$(2R - \delta) * \delta = 2^2$

$162.2\delta - \delta^2 = 4$

neglecting δ^2

$\delta = 0.0247$ m

On removal of load, the total I has to be used.

Section	a	y	ay	ay^2	i_o
1 2	2E-3 4E-3	0.405 0.2	8.1E-4 8E-4	3.28E-4 1.6E-4	1.67E-8 5.333E-5
Σ	6E-3	-	16.1E-4	4.88E-4	5.335E-5

$$\bar{y} = \frac{16.1E-4}{6E-3} = 0.2683$$

$I_{xx} = 4.88E\text{-}4 + 5.34E\text{-}5$

$= 5.413E\text{-}4$

$I_{NA} = 5.413E\text{-}4 - 0.2683^3 \times 6E\text{-}3$

$I_{NA} = 1.094E\text{-}4 m^4$

$$R = \frac{EI}{M} = \frac{2 \times 10^{//} \times 1.094 \times 10^{-4}}{210 \times 10^3}$$

<u>R = 104.2 m</u>

$$\delta = \frac{4}{104.2 \times 2} = 0.019 \text{ m}$$

Residual deflection $= 0.247 - 0.019$

$= \underline{0.0055 \text{ m}}$

CHAPTER 10

1. $\sigma_{ypc} = \sigma_{yp}$

$p = \rho gh = 10006\ h = 0.01\ h$ MPa

$\sigma_1 = -p$

$$\sigma_2 = -\frac{pR}{2t} = -50p$$

$$\sigma_3 = -\frac{pR}{t} = -100p$$

Maximum principal stress theory

$-100\ p = -400$ or $p = 4 = 0.01\ h$

$\therefore h = 400$ m

Maximum principal strain

$\sigma_3 - \upsilon(\sigma_1 + \sigma_2) = \sigma_{ypc}$

$-100\ p - \upsilon(-p - 50\ p) = -400$

or $-85\ p = -400$

$\therefore p = 4.706 = 0.01\ h$

$h = 470$ m

Total strain energy theory

$p^2 + 2500\ p^2 + 10000\ p^2 - 0.6\ (50 + 100 + 5000)\ p^2 = 400^2$

or $9411\ p^2 = 400$

$p = 4.123 = 0.01\ h$

$\therefore h = 412.3$ m

Maximum shear stress theory

$\sigma_1 - \sigma_3 = \sigma_{yp}$

$- p + 100 p = 400$

or $p = 4.04 = 0.01 h$

$\therefore h = 404 m$

Shear Strain energy theory

$(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2 = 2\sigma_{yp}^2$

or $(49p)^2 + (99p)^2 + (50p)^2 = 2 * 400^2$

or $p = 4.666 = 0.01 h$

$\therefore h = 466.6 m$

2. $J = \dfrac{\pi \times (2E-2)^4}{32} = 1.571E-8 \ m^4$

$\tau = \dfrac{Tr}{J} = \dfrac{0.25E3 \times 1E-2}{1.571E-8} = 159.1 \ MPa$

$\sigma_1 = 159.1; \quad \sigma_2 = -159.1$

(a) Tresca

$\sigma_{yp} = 159.1 \times 2 = 318.3 \ MPa$

(b) Hencky-von Mises

$\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 = \sigma_{yp}^2$

$159.1^2 + 159.1^2 + 159.1^2 = \sigma_{yp}^2$

$\therefore \sigma_{yp} = 275.6 \ MPa$

(c) Tresca ratio $= \dfrac{159.1}{318.3} = 0.5$

Hencky-von Mises ratio $= \dfrac{159.1}{275.6} = 0.577$

3. $J = \frac{\pi \times 0.1^4}{32} = 9.817E\text{-}6m^4$

$$\frac{\tau}{r} = \frac{T}{J}$$

$$\therefore \tau = \frac{30 \times 10^3 \times 0.05}{9.817 \times 10^{-6}} = 152.8 \text{ MPa}$$

$\sigma_1 = 152.8 \quad \sigma_2 = -152.8$

$\sigma_1 - \sigma_2 = \sigma_{yp}$

$\underline{\therefore \sigma_{yp} = 305.6 \text{ MPa}}$

Due to M

$I = 4.909E\text{-}6m^4$

Now

$$\frac{\sigma_1}{y} = \frac{M}{I}$$

$\& \ \sigma_2 = 0$

Tresca

$\sigma_1 - \sigma_2 = 305.6$

$\sigma_1 = 305.6$

$$\therefore M = \frac{305.6 \times 10^6 \times 4.909 \times 10^{-6}}{0.05} = \underline{30 \text{ kN.m}}$$

Hencky-von Mises

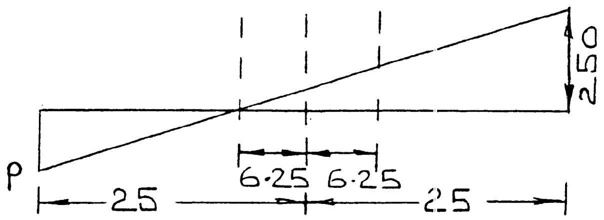
$\sigma_1^2 + \sigma_2^2 - \sigma_1 \sigma_2 = \sigma_{yp}^2$

$\sigma_1 = \sigma_{yp}$

<u>M = 30 kN.m</u>

CHAPTER 11

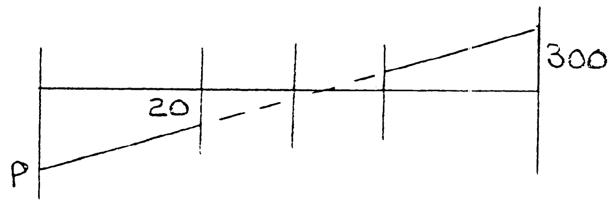
1.



$$\frac{P}{25 - 6.25} = \frac{250}{25 + 6.25}$$

$$P = \frac{250 \times 18.75}{31.25} = \underline{150 \text{ MPa}}$$

2.



$$\frac{300 + P}{50} = \frac{P - 20}{25 - 6.25}$$

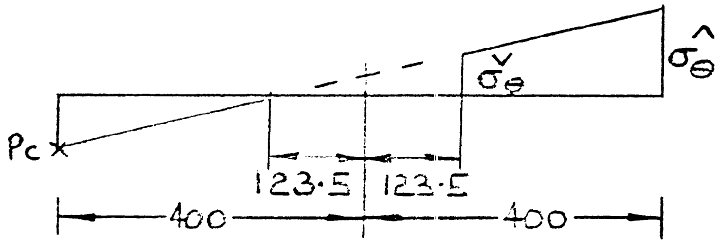
$(300 + P)\ 18.75 = (P - 20)\ 50$

$5625 + 18.75\ P = +\ 50\ P - 1000$

$6625 = 31.25\ P$

$\underline{P = 212 \text{ MPa}}$

3. <u>Steel Ring</u>



$$\frac{\sigma_{\theta max}}{400 + 123.5} = \frac{P_c}{400 - 123.5}$$

$\sigma_{\theta max}$ = 1.893 MP$_c$

For shaft

$\sigma_{\theta s}$ = - P$_c$

$$w_R = \frac{5E-2}{2E11} (1.893\ P_c + 0.3\ P_c) - 5.483E\text{-}13\ P_c$$

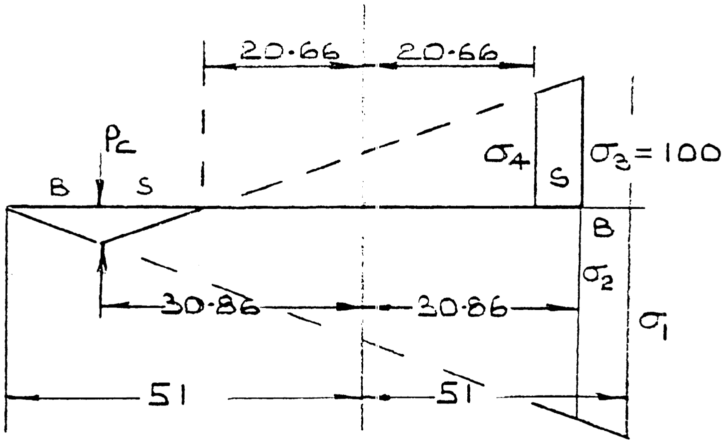
$$w_s = \frac{5E-2}{1E11} (-P_c + 0.35\ P) = -3.25E\text{-}13\ P_c$$

0.005E-2 = (5.483E-13 + 3.25 E-13) P$_c$

$\therefore$ P$_c$ = 57.25 MPa

$\sigma_{\theta max}$ = 108.3 MPA

4.



Outer Cylinder

$$\frac{\sigma_3}{30.86 + 20.66} = \frac{P_c}{30.86 - 20.66}$$

$$P_c = \frac{100 \text{ x } 10.2}{51.52} = \underline{19.8 \text{ MPa}}$$

Inner Cylinder

$$\frac{\sigma_2}{51 + 30.86} = \frac{-P_c}{51 - 30.86}$$

$$\therefore \sigma_2 = \frac{-81.86 \text{ x } 19.8}{20.14}$$

$\underline{\sigma_2 \quad = 80.48 \text{ MPa}}$

$$w_E = \frac{18E-2}{2E11} (100E6 + 0.3 \text{ x } 19.8E6) = 9.535E\text{-}5m$$

$$w_I = \frac{18E-2}{2E11} (-80.48E6 + 0.3 \text{ x } 19.8E6) = -6.709E\text{-}5 \text{ m}$$

$\underline{\delta = w_E - w_I = 1.624E\text{-}4 \text{ m} = 0.16 \text{ mm}}$

$$\frac{\sigma_1}{51 \text{ x } 2} = \frac{-19.8}{51 - 30.86}$$

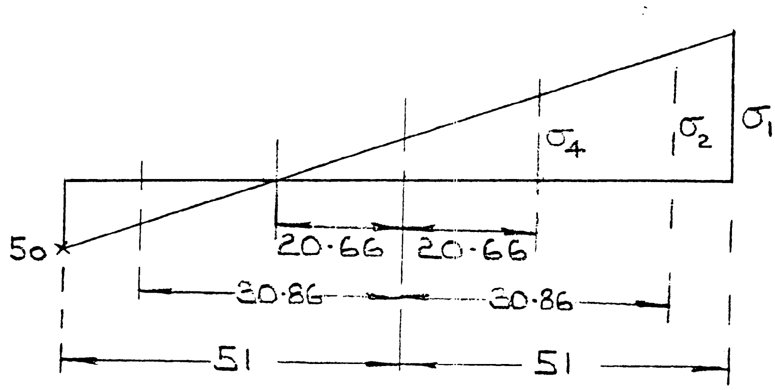
$\underline{\sigma_1 = -100 \text{ MPa}}$

5. $w_E = 9.535E\text{-}5$

$$w_I = \frac{18E-2}{1E11} (-80.48E6 + 0.4 \times 19.8E6) = -1.306E-4 \text{ m}$$

$\underline{\delta = 0.226 \text{ mm}}$

6.



$$\frac{\sigma_2}{30.86 + 20.66} = \frac{50}{51 - 30.86}$$

$\underline{\sigma_2 = 127.9 \text{ MPa}}$

σ_{max} (on internal surface of outer cylinder)

= $\underline{227.9 \text{ MPa}}$

7.