ستركشر اول

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FIRST YEAR CIVIL

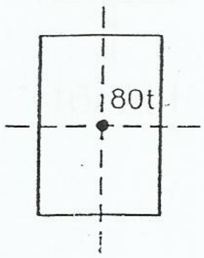
STRUCTURAL ANALYSIS

NORMAL STRESSES (2)

2010 / 2011

Example (1):

For the shown section draw the normal stress distribution due to the shown loads, where the dimention of the section is (30x60cm)



straining actions

$N = -80t$

$M_x = 0.0$

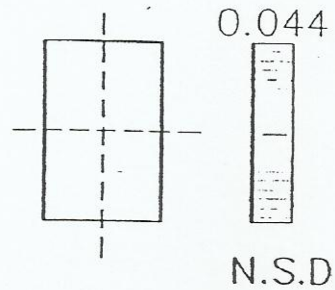
$M_y = 0.0$

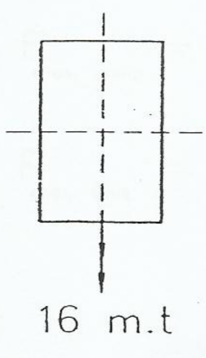
إذا لم يحدد
إشارة (N)
نعتبرها Comp.

Prop. of area

$A = 30x60 = 1800\ cm^2$

$$F = \pm \frac{N}{A} = \frac{-80}{1800} = -0.044\ t/cm^2$$





straining actions

$N = 0.0$

$M_x = 1600\ cm.t$

$M_y = 0.0$

Prop. of area

$$I_x = \frac{30x60^3}{12} = 540000\ cm^4$$

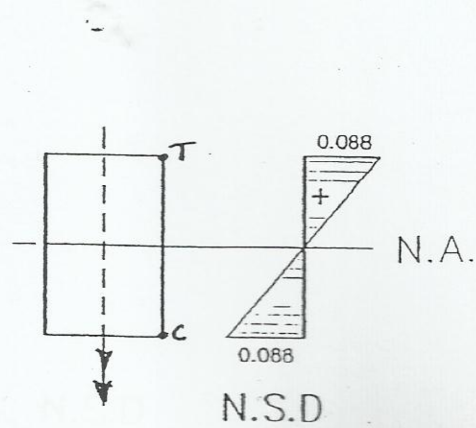
neutral axis.

N.A = X − axis

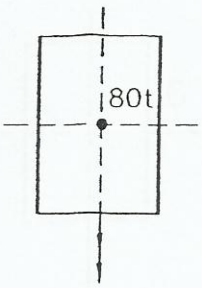
$$F = \pm \frac{M_x}{I_x}(y)$$

$$F_{max.\ comp.} = \frac{-1600}{540000}(30) = -0.088\ t/cm^2$$

$$F_{max.\ tens.} = \frac{+1600}{540000}(30) = +0.088\ t/cm^2$$



NORMAL STRESSES (2)



16 m.t

straining actions

$N = -80t$

$M_x = 1600$ cm.t

$M_y = 0.0$

$$e_y = \frac{M_x}{N} = 20 \text{ cm}$$

Prop. of area

$A = 30 \times 60 = 1800 \text{ cm}^2$

$$I_x = \frac{30 \times 60^3}{12} = 540000 \text{ cm}^4$$

$$i_x^2 = \frac{I_x}{A} = 300 \text{ cm}^2$$

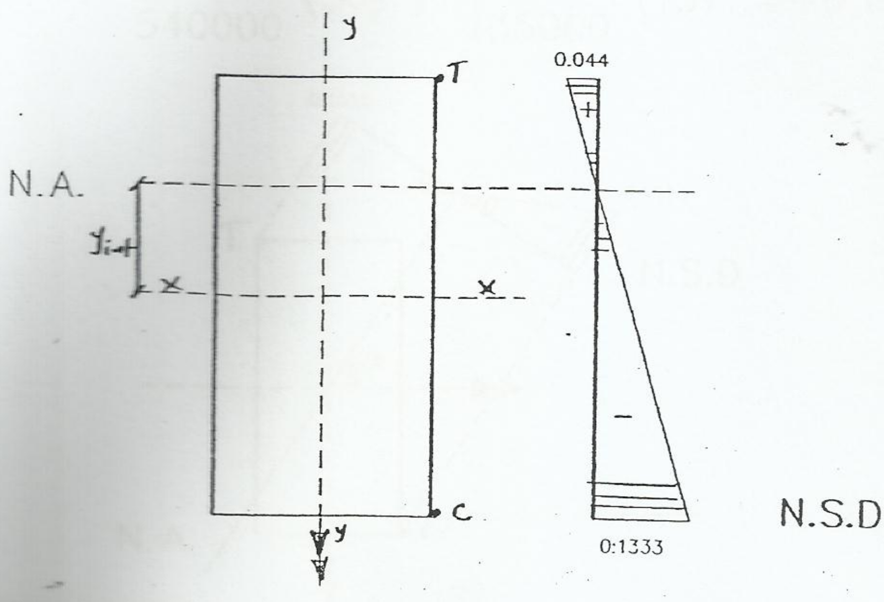
neutral axis.

$$y_{int} = \frac{i_x^2}{e_y} = 15 \text{ cm}$$

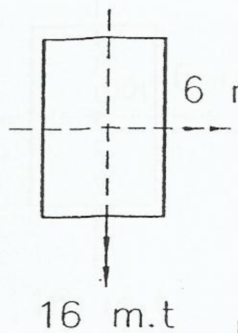
$$F = \pm \frac{N}{A} \pm \frac{M_x}{I_x}(y)$$

$$F_{max.\ comp.} = \frac{-80}{1600} - \frac{1600}{540000}(30) = -0.133 \text{ t/cm}^2$$

$$F_{max.\ tens.} = \frac{-80}{1600} + \frac{1600}{540000}(30) = +0.044 \text{ t/cm}^2$$



NORMAL STRESSES (3)



straining actions

$N = 0.00$

$M_x = 1600 \text{ cm.t}$

$M_y = 600 \text{ cm.t}$

Prop. of area

$$I_x = \frac{30 \times 60^3}{12} = 540000 \text{ cm}^4$$

$$I_y = \frac{60 \times 30^3}{12} = 135000 \text{ cm}^4$$

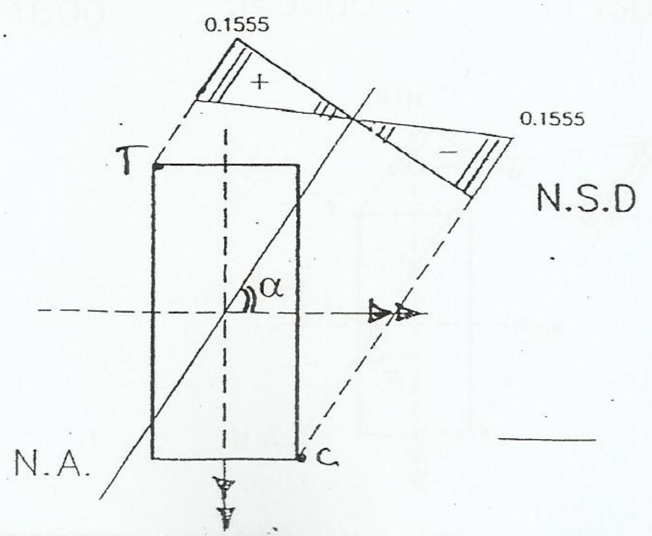
neutral axis.

$$\tan\alpha = \frac{\dfrac{M_y}{I_y}}{\dfrac{M_x}{I_x}} = 1.5 \qquad \alpha = 56.3$$

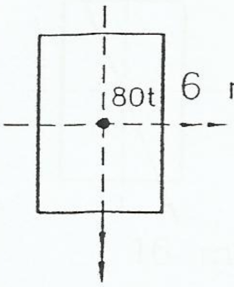
$$F = \pm \frac{M_x}{I_x}(y) \pm \frac{M_y}{I_y}(X)$$

$$F_{max.\,comp.} = -\frac{1600}{540000}(30) - \frac{600}{135000}(15) = -0.155 \text{ t/cm}^2$$

$$F_{max.\,tens.} = +\frac{1600}{540000}(30) + \frac{600}{135000}(15) = +0.155 \text{ t/cm}^2$$



NORMAL STRESSES (4)



straining actions

$N = -80t$

$M_x = 1600 \ cm.t$

$M_y = 600 \ cm.t$

$$e_y = \frac{M_x}{N} = 20 \ cm$$

$$e_x = \frac{M_y}{N} = 7.5 \ cm$$

Prop. of area

$A = 30x60 = 1800 \ cm^2$

$$I_x = \frac{30x60^3}{12} = 540000 \ cm^4$$

$$I_y = \frac{60x30^3}{12} = 135000 \ cm^4$$

$$i_x^2 = \frac{I_x}{A} = 300 \ cm^2$$

$$i_y^2 = \frac{I_y}{A} = 75 \ cm^2$$

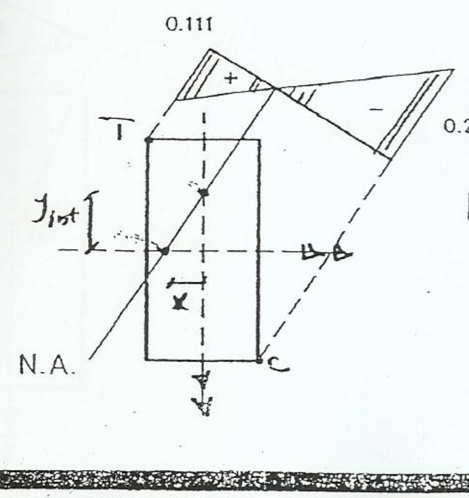
neutral axis.

$$y_{int} = \frac{i_x^2}{e_y} = 15 \ cm \qquad X_{int} = \frac{i_y^2}{e_x} = 10 \ cm$$

$$F = \pm \frac{N}{A} \pm \frac{M_x}{I_x}(y) \pm \frac{M_y}{I_y}(X)$$

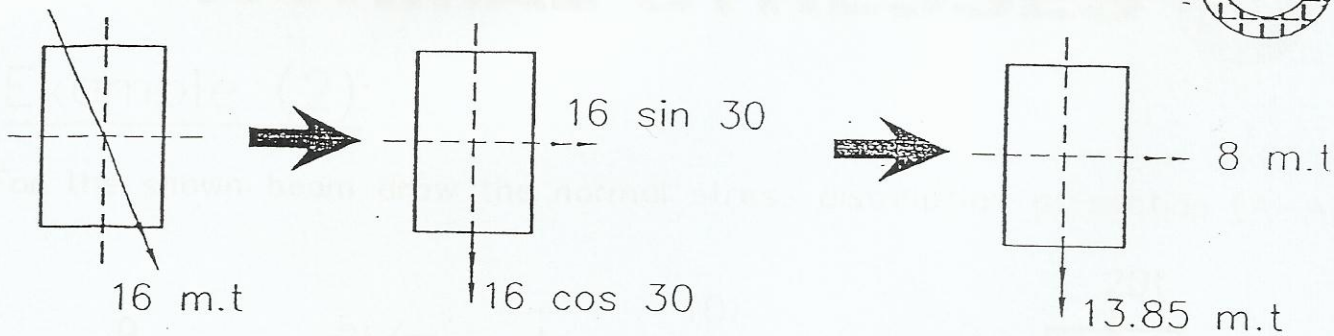
$$F_{max.\ comp.} = \frac{-80}{1600} - \frac{1600}{540000}(30) - \frac{600}{135000}(15) = -0.20 \ t/cm^2$$

$$F_{max.\ tens.} = \frac{-80}{1600} + \frac{1600}{540000}(30) + \frac{600}{135000}(15) = +0.111 \ t/cm^2$$



N.S.D

NORMAL STRESSES



<u>straining actions</u>

$N = 0.00$

$M_x = 1385 \text{ cm.t}$

$M_y = 800 \text{ cm.t}$

<u>Prop. of area</u>

$$I_x = \frac{30 \times 60^3}{12} = 540000 \text{ cm}^4$$

$$I_y = \frac{60 \times 30^3}{12} = 135000 \text{ cm}^4$$

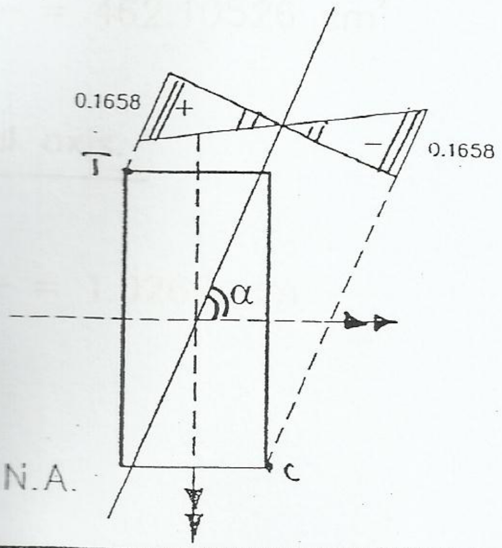
<u>neutral axis.</u>

$$\tan\alpha = \frac{\dfrac{M_y}{I_y}}{\dfrac{M_x}{I_x}} = 2.309 \qquad \alpha = 66.586$$

$$F = \pm \frac{M_x}{I_x}(y) \pm \frac{M_y}{I_y}(X)$$

$$F_{\text{max. comp.}} = -\frac{1385}{540000}(30) - \frac{800}{135000}(15) = -0.1658 \text{ t/cm}^2$$

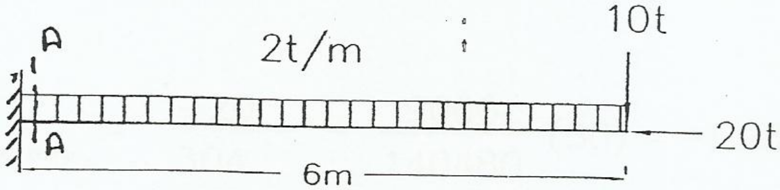
$$F_{\text{max. tens.}} = +\frac{1385}{540000}(30) + \frac{800}{135000}(15) = +0.1658 \text{ t/cm}^2$$

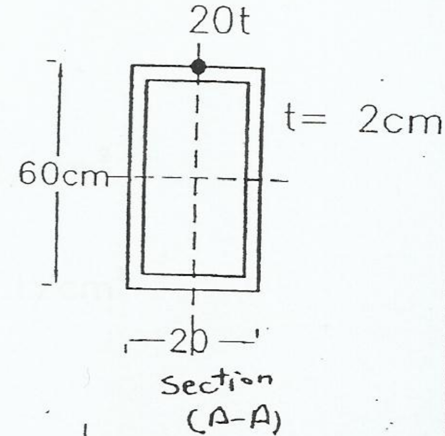


N.S.D

Example (2):

For the shown beam draw the normal stress distribution at section (A–A)





1) straining actions

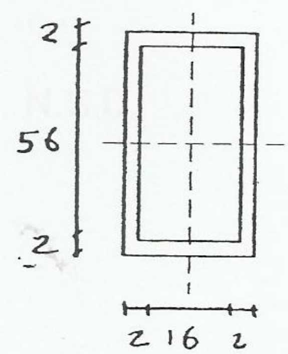
$N = -20\ t$

$M_x = 2x6x3+10x6-20x0.3=90m.t = 9000cm.t$

$e_y = \dfrac{M_x}{N} = 450\ cm$ $M_y = 0.0$ آخر امتحان

2) Prop. of area

$A = 20x60-16x56 = 304\ cm^2$



$I_x = \dfrac{20x60^3}{12} - \dfrac{16x56^3}{12} = 140480\ cm^4$

$i_x^2 = \dfrac{I_x}{A} = 462.10526\ cm^2$

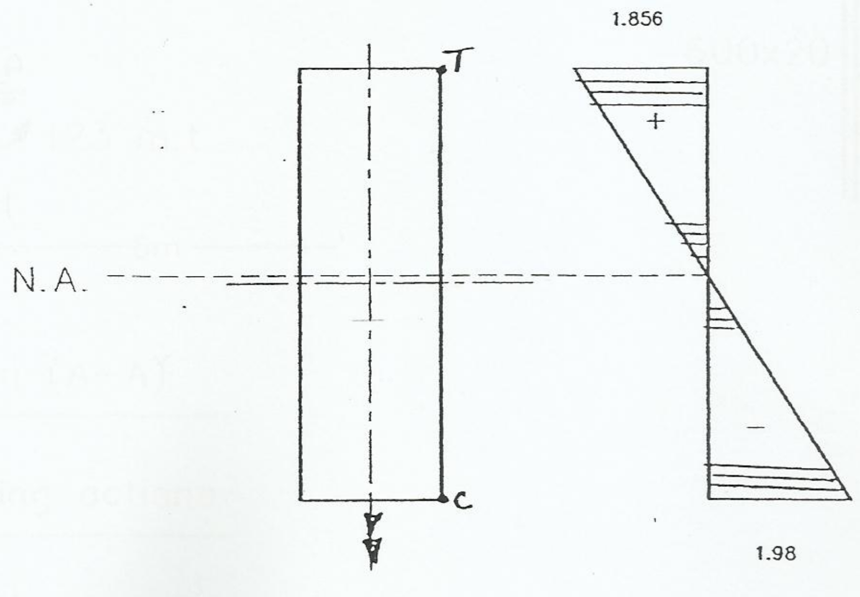
3) neutral axis.

$y = \dfrac{i_x^2}{e_y} = 1.0269\ cm$

$$F = \pm \frac{N}{A} \pm \frac{M_x}{I_x}(y)$$

$$F_{max.\ comp.} = \frac{-20}{304} - \frac{9000}{140480}(30) = -1.98 \quad t/cm^2$$

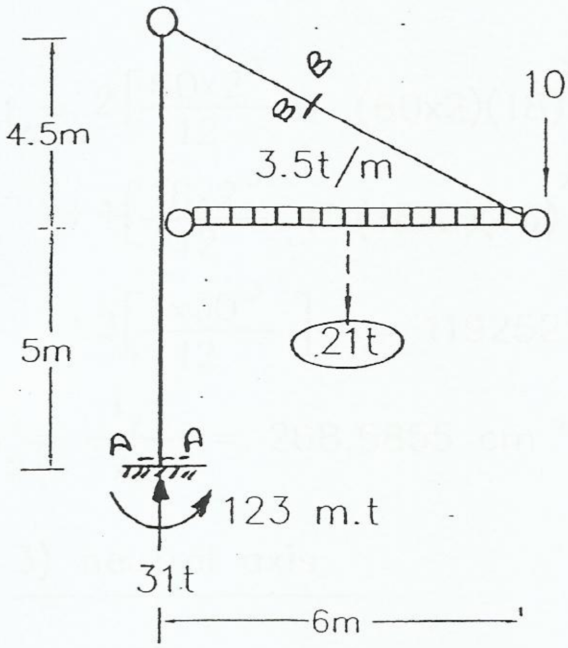
$$F_{max.\ tens.} = \frac{-20}{304} + \frac{9000}{140480}(30) = +\ 1.856 \quad t/cm^2$$

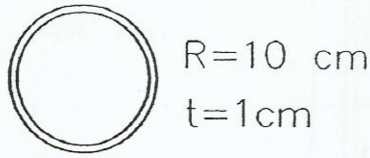


N.S.D

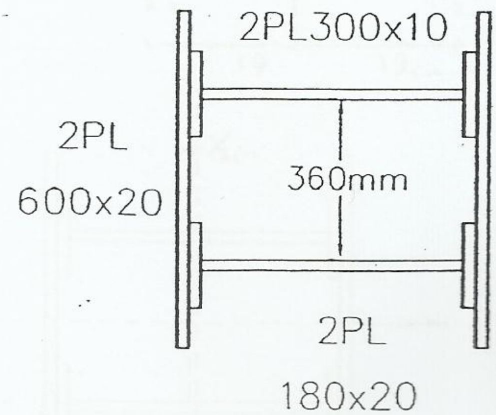
Example (3):

For the shown frame draw the normal stress distribution at section (A&B)





sec. (B−B)



sec. (A−A)

a) section (A−A)

1) straining actions

$N = -31t$

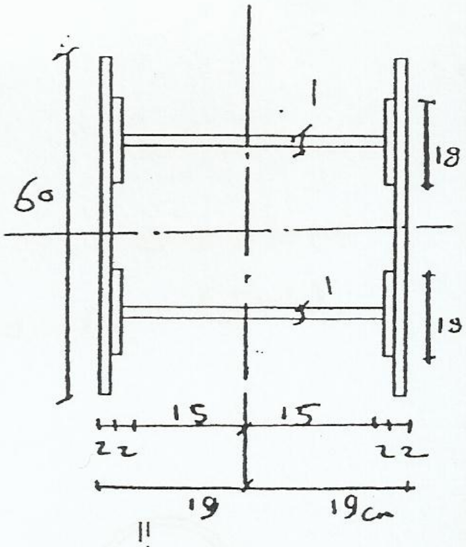
$M_x = 0.0 \longrightarrow$

$M_y = 123m.t = 12300 \text{ cm.t} \longrightarrow$

$e_x = \dfrac{M_y}{N} = 396.7742 \text{ cm}$

2) Prop. of area

$$A = 2(60\times2)+4(18\times2)+2(30\times1)=444 \ cm^2$$

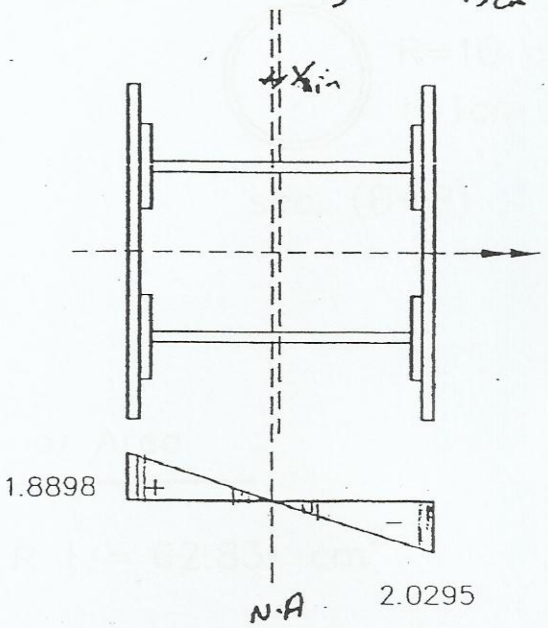


$$I_y = 2\left[\frac{60\times2^3}{12} + (60\times2)(18)^2\right]$$
$$+4\left[\frac{18\times2^3}{12} + (18\times2)(16)^2\right]$$
$$+2\left[\frac{1\times30^3}{12}\right] = 119252 \ cm^4$$

$$i_y^2 = \frac{I_y}{A} = 268.5855 \ cm^2$$

3) neutral axis.

$$X = \frac{i_y^2}{e_x} = 0.677 \ cm$$



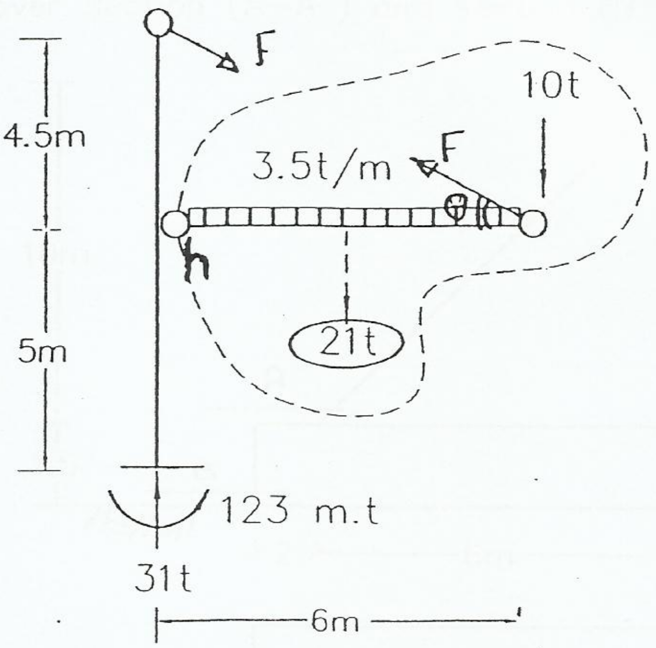
$$F = \pm\frac{N}{A} \pm \frac{M_y}{I_y}(X)$$

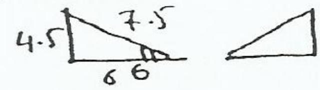
$$F_{max.\ comp.} = \frac{-31}{444} - \frac{12300}{119252}(19) = -2.0295 \ t/cm^2$$

$$F_{max.\ tens.} = \frac{-31}{444} + \frac{12300}{119252}(19) = +1.8898 \ t/cm^2$$

b) section (B–B)

Sec (B.B) in Link member
[illegible] Link

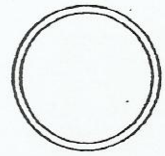




$\sum M_{h_R} = 0.0$

$(21)(3) + 10(6) - F\sin\theta\,(6) = 0.0$

$\therefore F = +34.166\,t$ (tens.)



sec. (B–B)

1) straining actions

$N = +34.166\ t$

$M_x = 0.0$

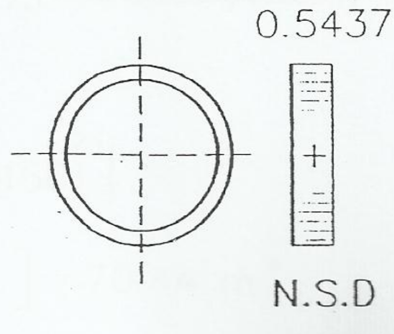
$M_y = 0.0$

} Link member

2) Prop. of Area

$A = 2\pi R t = 62.831\ cm^2$

$$F = \pm\frac{N}{A} = \frac{+34.166}{62.831} = +0.5437\ t/cm^2$$

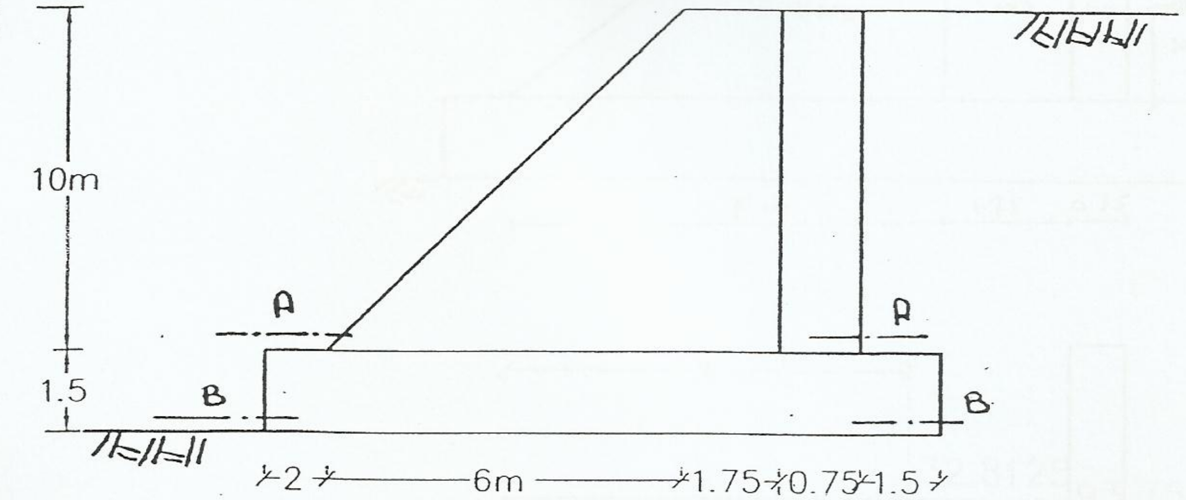


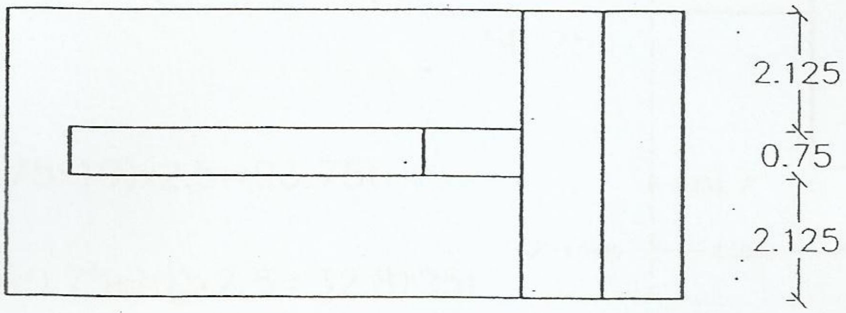
N.S.D

Example (4):

فى حاله وجود soil

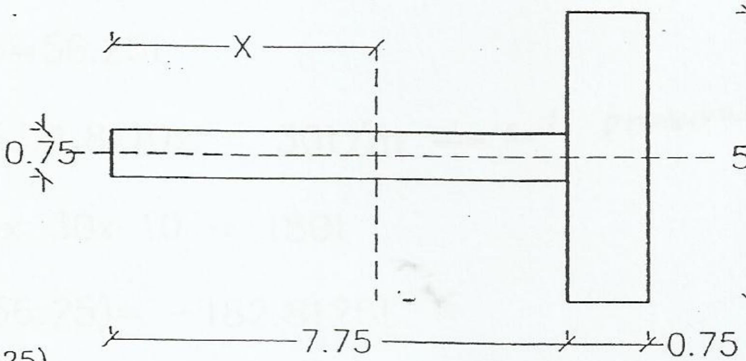
For the shown etaining wall draw the normal stress distribution over section (A–A) and section (B–B)





a) section (A–A)

Prop. of Area



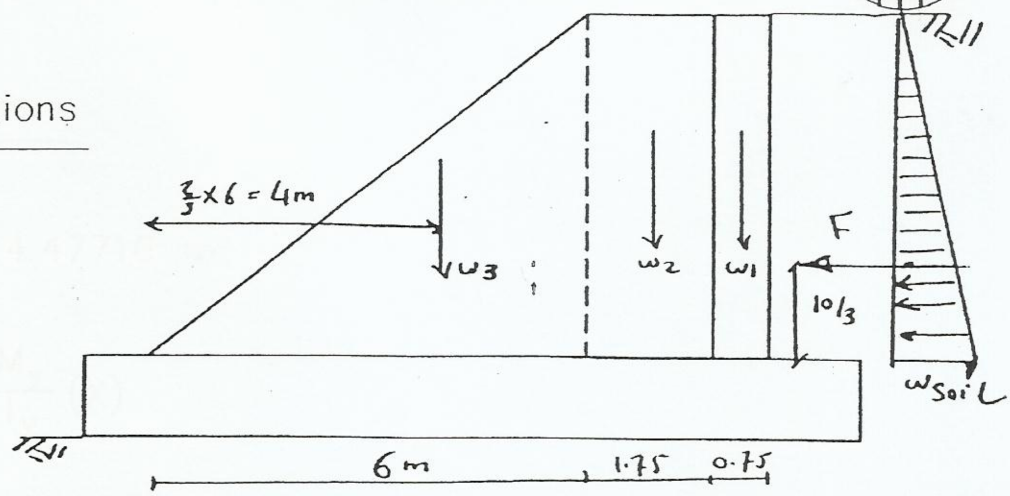
$$\overline{X}=\frac{(7.75\times0.75)\times3.875+(5\times0.75)(8.125)}{(7.75\times0.75)+(5\times0.75)}=5.54166\ m$$

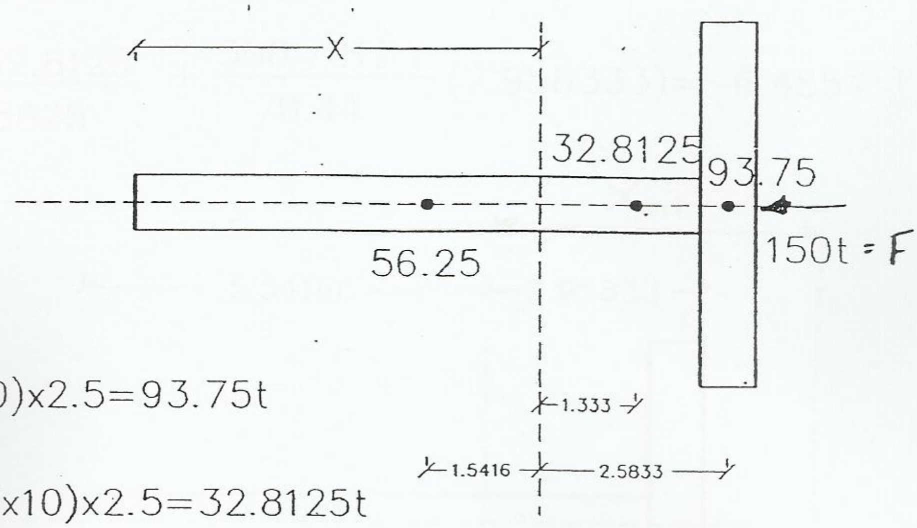
$$I_y=\left[\frac{0.75\times7.75^3}{12}+(7.75\times0.75)(3.875-5.54166)^2\right]$$

$$+\left[\frac{5\times0.75^3}{12}+(5\times0.75)(8.125-5.54166)^2\right]=70.44\ m^4$$

$$\therefore i_y^2=\frac{I_y}{A}=7.36627\ m^2$$

2) straining actions





$W_1 = (5x0.75x10)x2.5=93.75t$

$W_2 = (1.75x0.75x10)x2.5=32.8125t$

$W_3 = (0.5x6x10x0.75)x2.5=56.25t$

$W_{soil} = K x \gamma x h x B = 0.33x1.8x10x5= 30t/m$ → soil pressure

$F = 0.5 x w X h = 0.5x 30x 10 = 150t$

$N = -(93.75+32.8125+56.25)= -182.8125t$

$M_x = 0.0$

$M_y = (93.75x2.583333)+(32.8125x1.333)-(56.25x1.54166)$

$-(150)(10/3)= -300.78125$ m.t

$e_x = \frac{M_y}{N} = 1.645299$ m

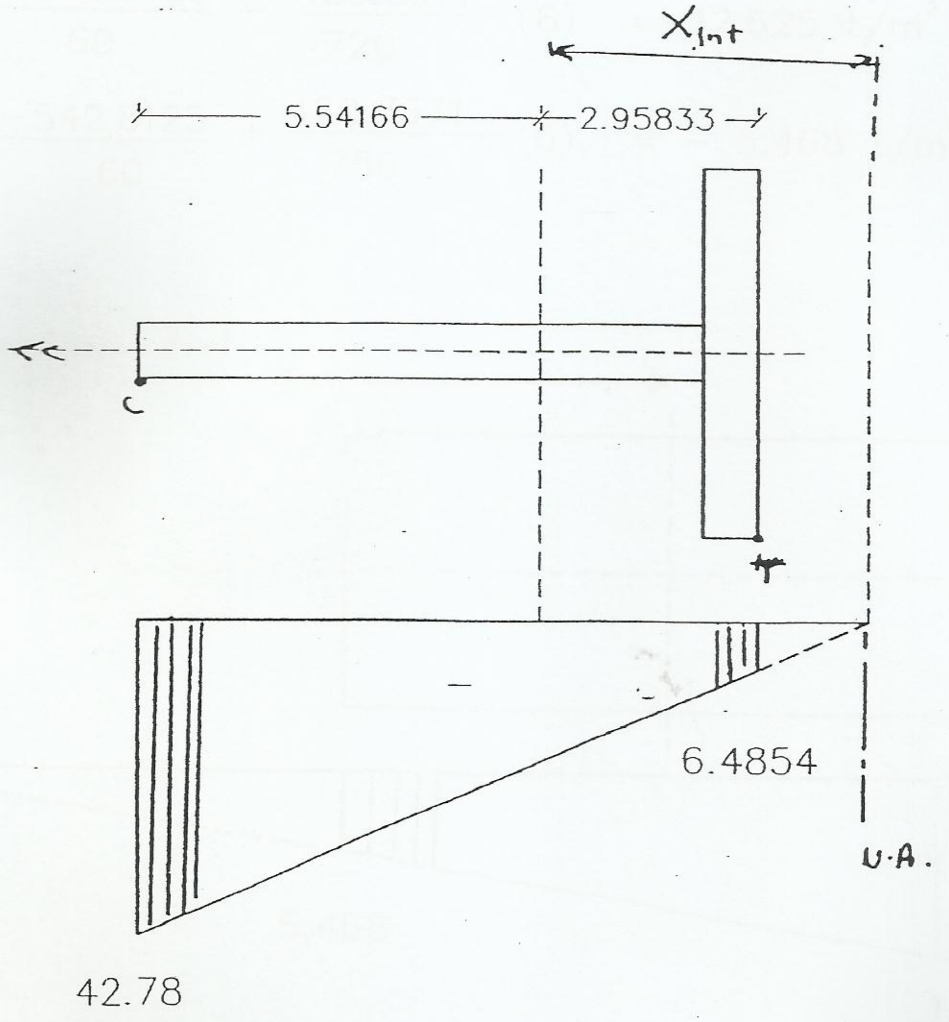
3) neutral axis.

$$X_{int} = \frac{i_y^2}{e_x} = 4.47716 \text{ m}$$

$$F = \pm \frac{N}{A} \pm \frac{M_y}{I_y}(X)$$

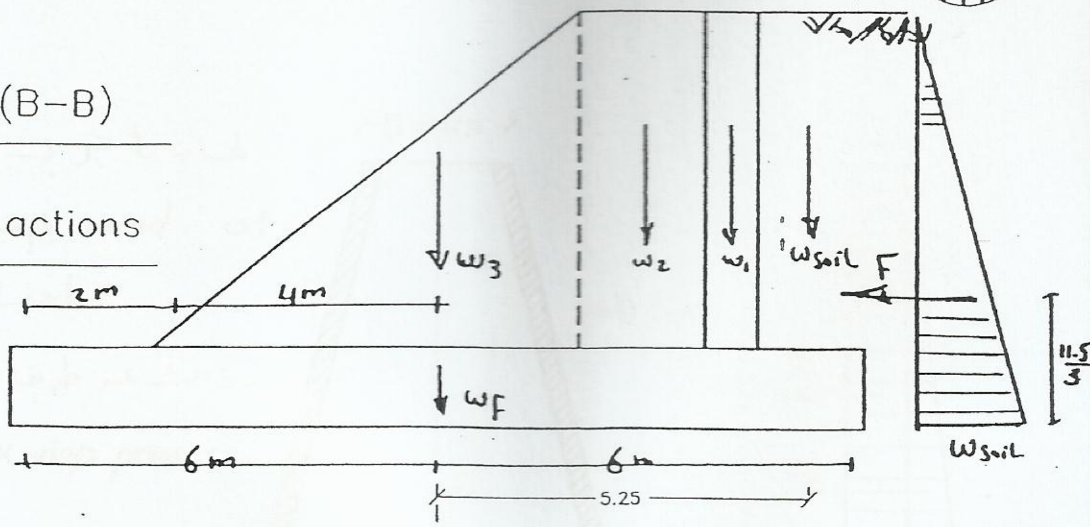
$$F_{max.\ comp.} = \frac{-182.8125}{9.5625} - \frac{300.78125}{70.44}(5.54166) = -42.78 \text{ t/m}^2$$

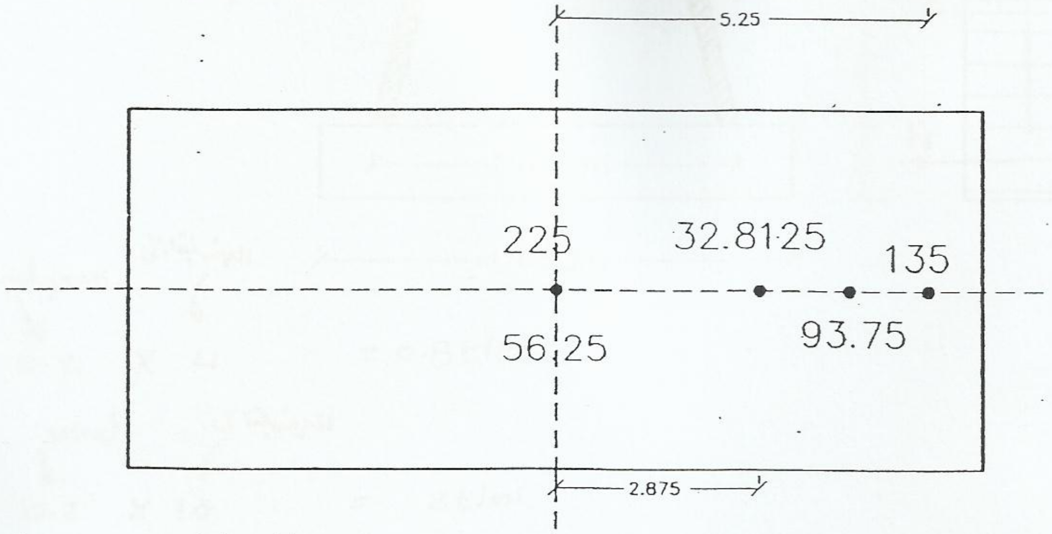
$$F_{max.\ tens.} = \frac{-182.8125}{9.5625} + \frac{300.78125}{70.44}(2.958333) = -6.4854 \text{ t/m}^2$$



b) Section (B–B)

1) straining actions





$W_F = (12 \times 5 \times 1.5)(2.5) = 225t$

$W_{soil} = (1.5 \times 5 \times 10)(1.8) = 135t$ → وزن ال soil

$W_{soil} = K \times \gamma \times h \times B = 0.33 \times 1.8 \times 11.5 \times 5 = 34.5\ t/m$ → soil pressure

$F = 0.5 \times w \times h = 0.5 \times 34.5 \times 11.5 = 198.375\ t$

$N = -(93.75 + 32.8125 + 56.25 + 225 + 135) = -542.8125t$

$M_x = 0.0$

$M_y = (93.75 \times 4.125) + (32.8125 \times 2.875) + (135 \times 5.25) - (198.375 \times 11.5/3)$

$M_y = 429.3671\ m.t$ ⟶

$e_x = \frac{M_y}{N} = 0.791\ m$

$A = (12 \times 5) = 60 \ m^2$

$I_y = \left[\dfrac{5 \times 12^3}{12}\right] = 720 \ m^4$ $\qquad i_y^2 = \dfrac{I_y}{A} = 12 m^2$

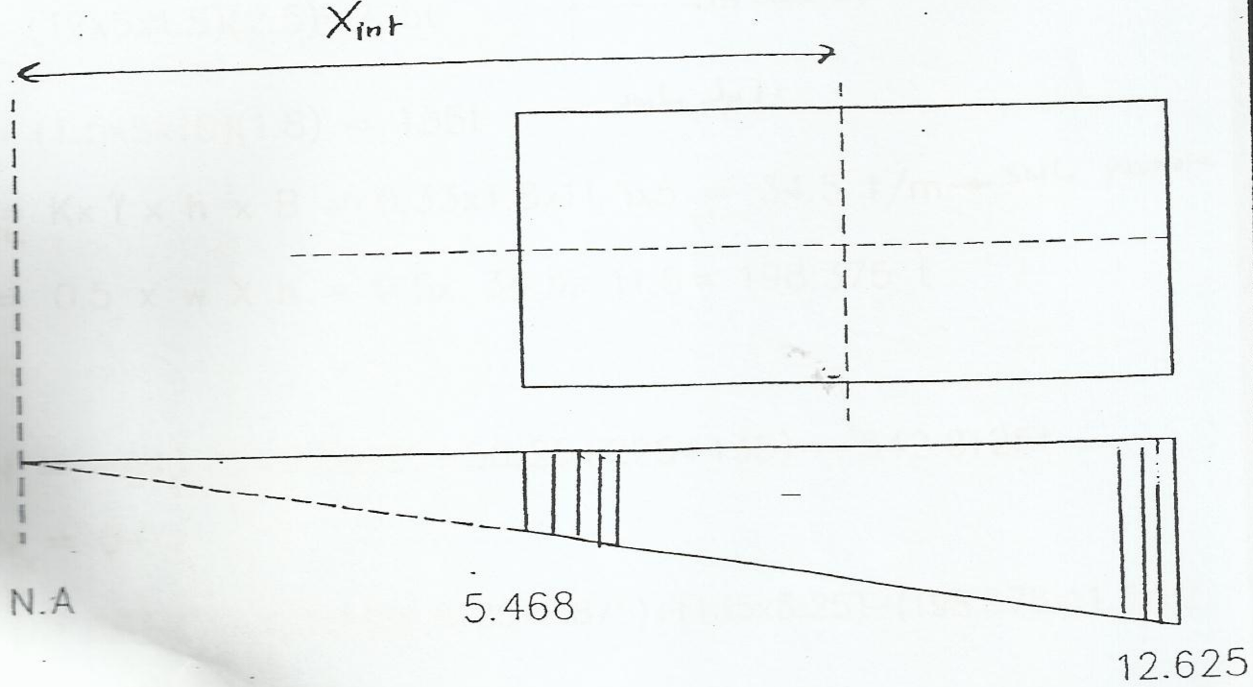
3) neutral axis.

$$X_{int} = \frac{i_y^2}{e_x} = 15.17 \ m$$

$$F = \pm \frac{N}{A} \pm \frac{M_y}{I_y}(X)$$

$$F_{max.\ comp.} = \frac{-542.8125}{60} - \frac{429.3671}{720}(6) = -12.625 \ t/m^2$$

$$F_{max.\ tens.} = \frac{-542.8125}{60} + \frac{429.3671}{750}(6) = -5.468 \ t/m^2$$

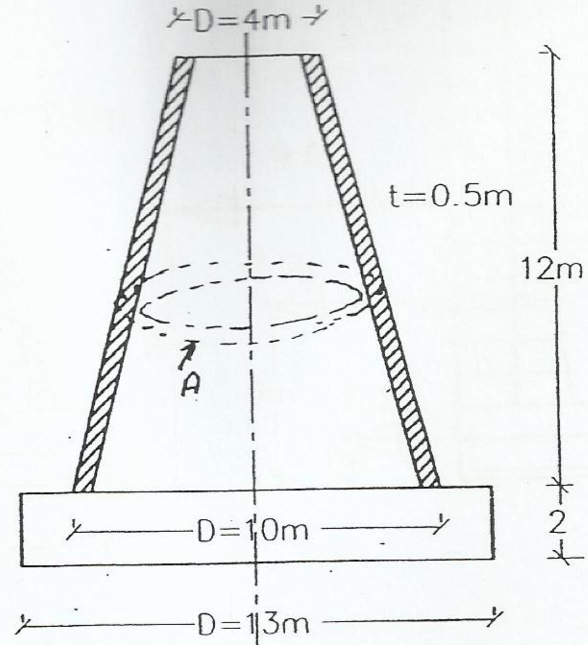


Example (5):

For the shown circular chimney draw the normal stress distribution over section (A–A)

$\gamma_{R.C} = 2.5 t/m^3$

wind intensity$=0.2t/m^2$



٨ لحساب وزن المدخنة (أو لحساب وزن أى مخروط ناقص عامة)

$weight = A\ h.\gamma$

$A \rightarrow$ مساحة المقطع فى منتصف القطاع

$h \rightarrow$ الارتفاع الكلى للمدخنة

لحساب المساحة (المقطع عبارة عن حلقة)

نصف القطر الخارجى = (نصف القطر الخارجى عند أسفل المدخنة + نصف القطر الخارجى عند أعلى المدخنة) / 2

نصف القطر الخارجى $= \frac{2+5}{2} = 3.5$

نصف القطر الداخلى = نصف القطر الخارجى − السمك

$= 3.5 - 0.5 = 3m$

$A = \pi(3.5)^2 - \pi(3)^2 = 10.21\ m^2$

$weight = \underset{A}{(10.21)}\underset{h}{(12)}\underset{\gamma}{(2.5)} = 306.3\ t$

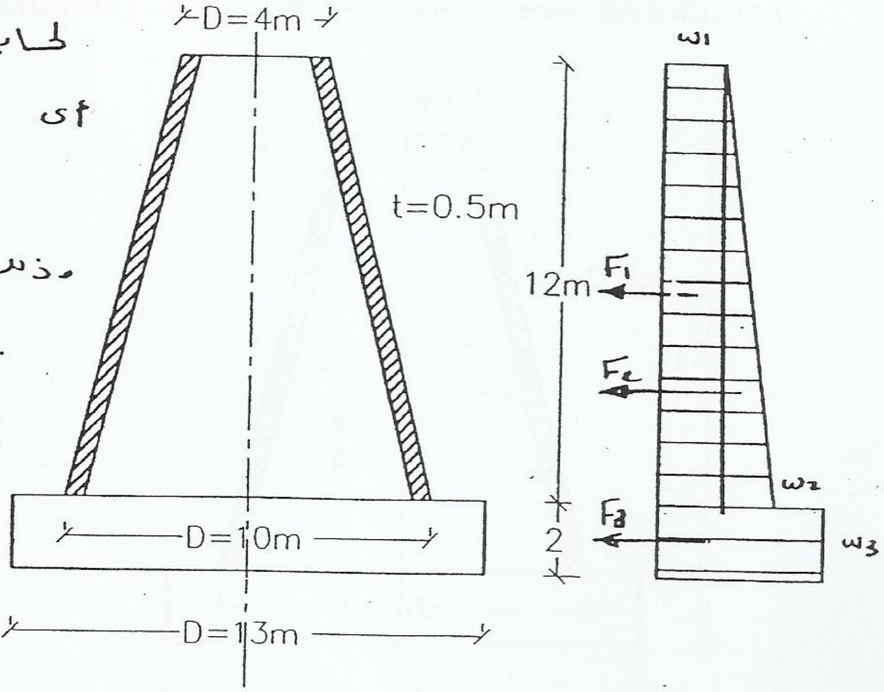
لحساب تأثير الـ wind

الـ wind يتم تحويلها إلى

uniform Load

وذلك عن طريق ضرب الـ

العرض X wind press.



wind press.   العرض المقابل

$w_1 = 0.2 \times 4 = 0.8\, t/m'$

wind   العرض المقابل

$w_2 = 0.2 \times 10 = 2\, t/m'$

$w_3 = 0.2 \times 13 = 2.6\, t/m'$

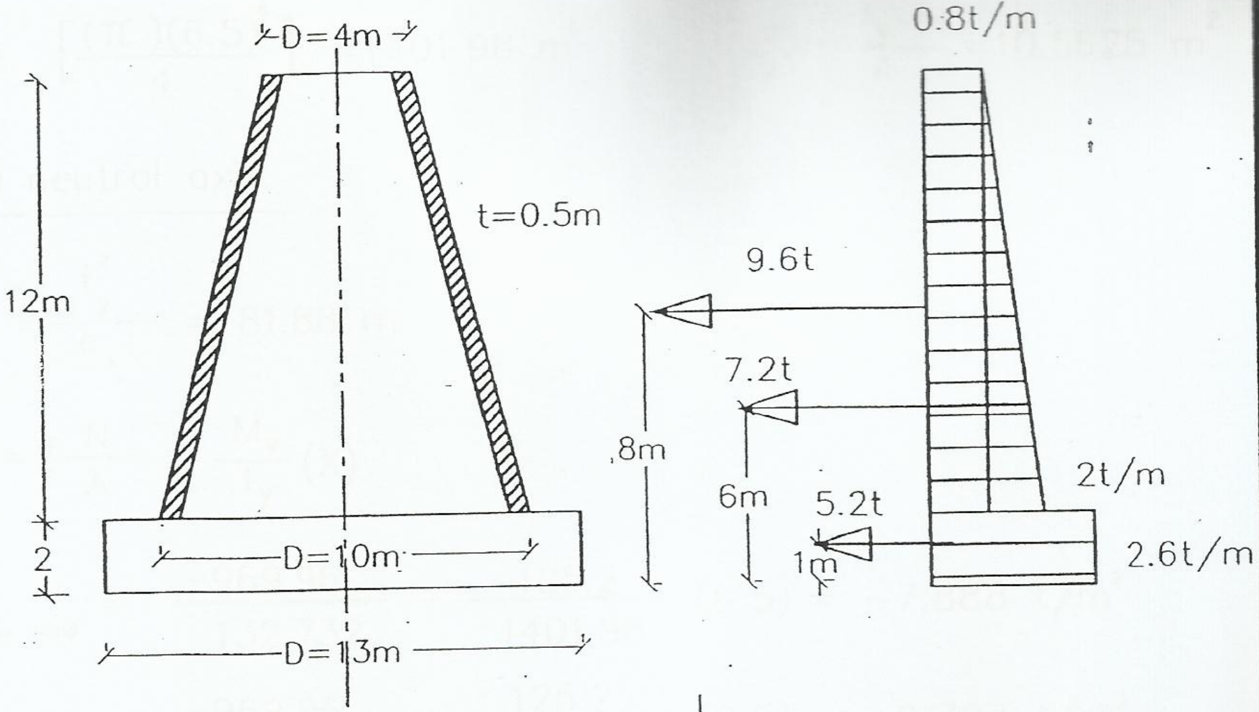
وبعد ذلك يتم التعامل مع الـ (distributed Load) ويتم تحويلها إلى Force

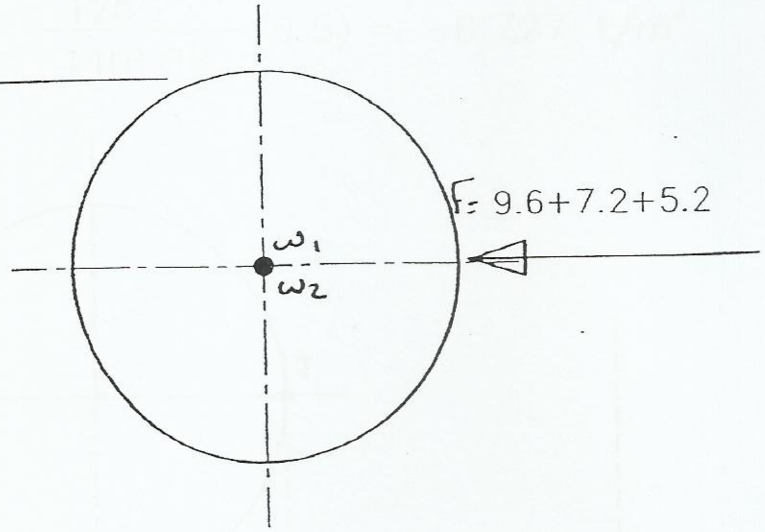
$F_1 = w_1 h = 0.8 \times 12 = 9.6\, t \longrightarrow 8m = (\overset{h/2}{6}+2)$ على ارتفاع

حمل مثلث

$F_2 = (w_2 - w_1)\frac{h}{2} = (2-0.8)\left(\frac{12}{2}\right) = 7.2\, t \longrightarrow 6m = (\overset{h/3}{4}+2)$ على ارتفاع

$F_3 = w_3 h = 2.6 \times 2 = 5.2\, t \longrightarrow \overset{h/2}{1m}$ على ارتفاع





1) straining actions

$N = W_1 + w_2$

$w_1 =$ weight of chimney $= 306.3t$

$w_2 =$ weight of foundation $= (\pi)(6.5)^2(2)(2.5) = 663.66\ t$

$N = -(306.3+663.66) = -969.96\ t$

$M_x = 0.0$

$M_y = 9.6x8+7.2x6+5.2x1 = 125.2\ m.t$

$e_x = \frac{M_y}{N} = 0.129\ m$

$$A = (\pi)(6.5) = 132.732 \ m^2$$

$$I_y = \left[\frac{(\pi)(6.5)^4}{4}\right] = 1401.98 \ m^4 \qquad i_y^2 = \frac{I_y}{A} = 10.5625 \ m^2$$

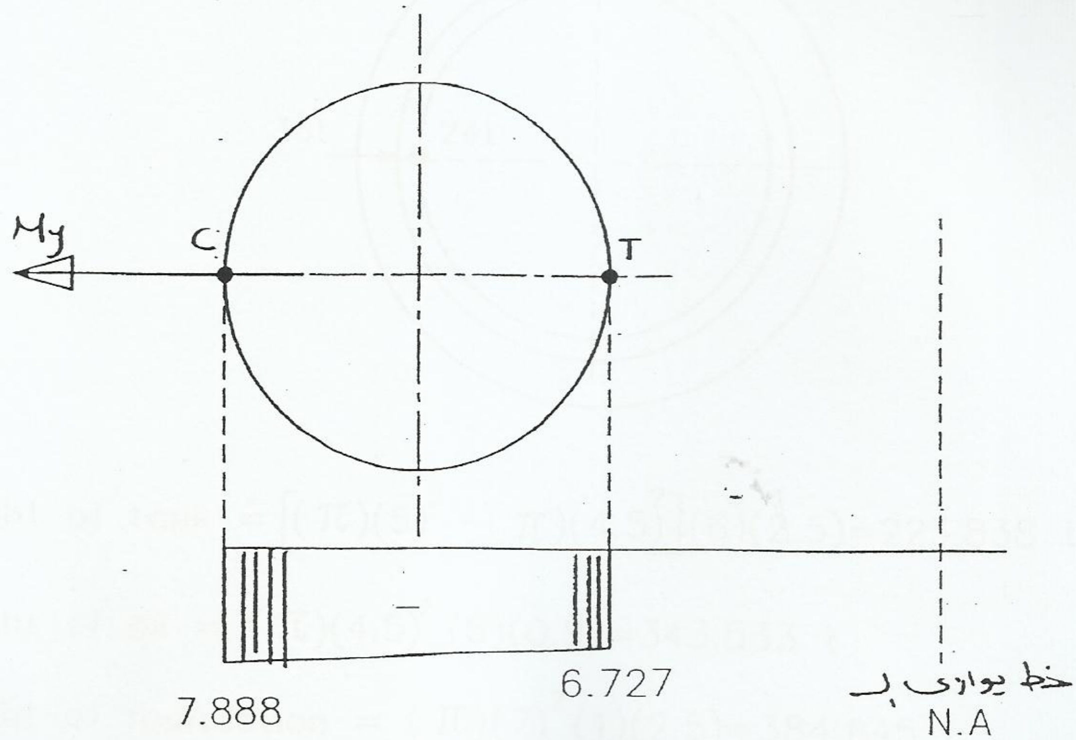
3) neutral axis.

$$X = \frac{i_y^2}{e_x} = 81.88 \ m$$

$$F = \pm \frac{N}{A} \pm \frac{M_y}{I_y}(X)$$

$$F_{max.\ comp.} = \frac{-969.96}{132.732} - \frac{125.2}{1401.98}(6.5) = -7.888 \ t/m^2$$

$$F_{max.\ tens.} = \frac{-969.96}{132.732} + \frac{125.2}{1401.98}(6.5) = -6.727 \ t/m^2$$

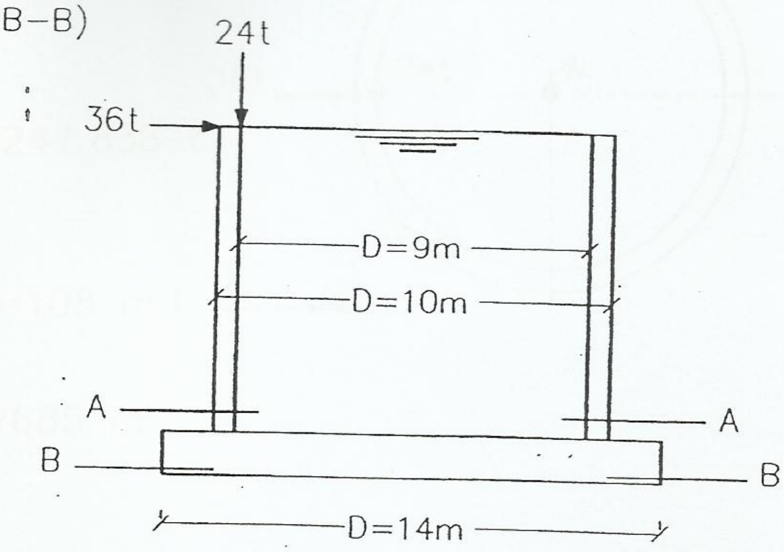


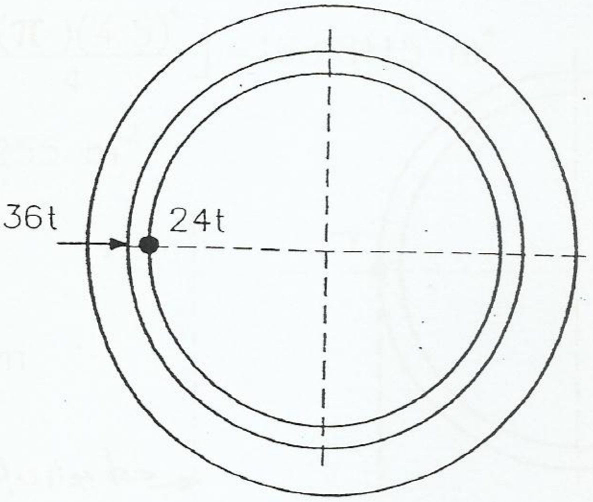
Example (5):

For the shown circular water tank draw the normal stress distribution over section (A–A & B–B)

$\gamma_{R.C} = 2.5 t/m^3$

$\gamma_{oil} = 0.9\ t/m^3$





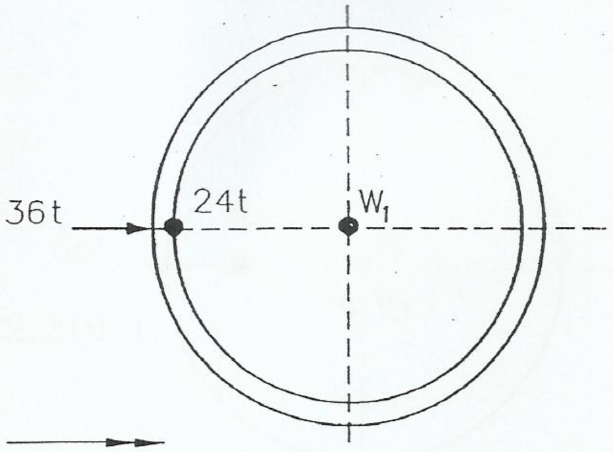
w_1 = weight of tank $= \left[(\pi)(5)^2 - (\pi)(4.5)^2\right](6)(2.5) = 223.838$ t

w_2 = weight of oil $= (\pi)(4.5)^2(6)(0.9) = 343.533$ t

w_3 = weight of foundation $= (\pi)(7)^2(1)(2.5) = 384.845$ t

a) section (A–A)

1) straining actions



$$N = -(24+w_1) = -247.838\ t$$

$$M_x = 0.0$$

$$M_y = 36x6 - 24x4.5 = 108\ m.t$$

$$e_x = \frac{M_y}{N} = 0.4357685\ m$$

2) prop. of Area

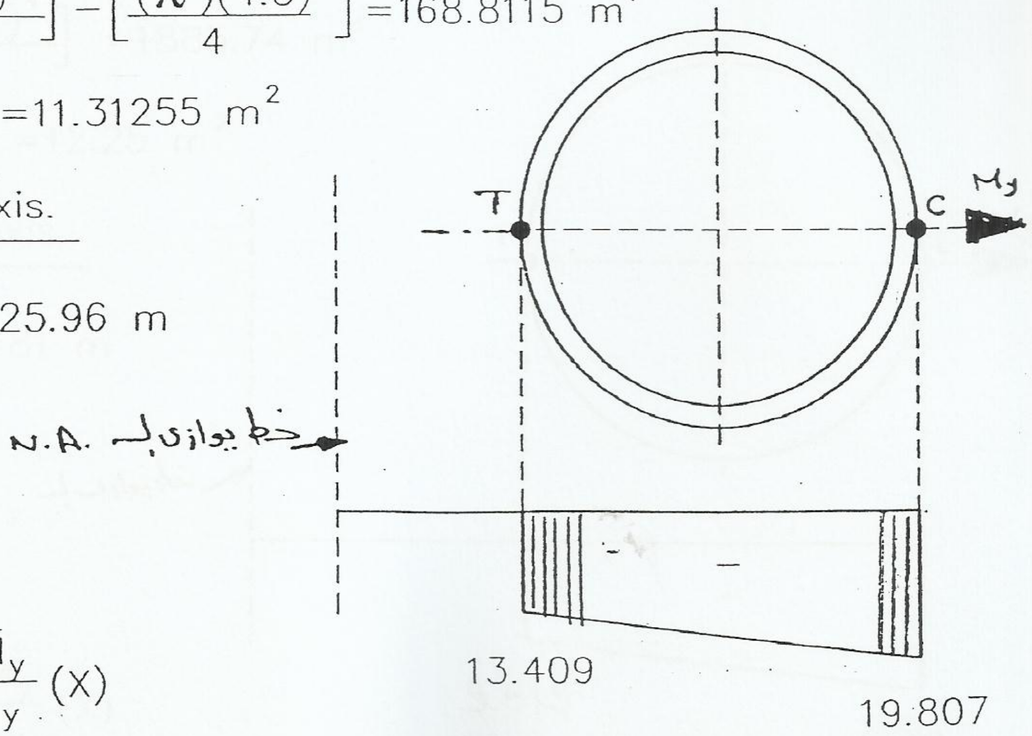
$$A = (\pi)(5)^2 - (\pi)(4.5)^2 = 14.9225\ m^2$$

$$I_y = \left[\frac{(\pi)(5)^4}{4}\right] - \left[\frac{(\pi)(4.5)^4}{4}\right] = 168.8115\ m^4$$

$$i_y^2 = \frac{I_y}{A} = 11.31255\ m^2$$

3) neutral axis.

$$X_{int} = \frac{i_y^2}{e_x} = 25.96\ m$$



$$F = \pm\frac{N}{A} \pm \frac{M_y}{I_y}(X)$$

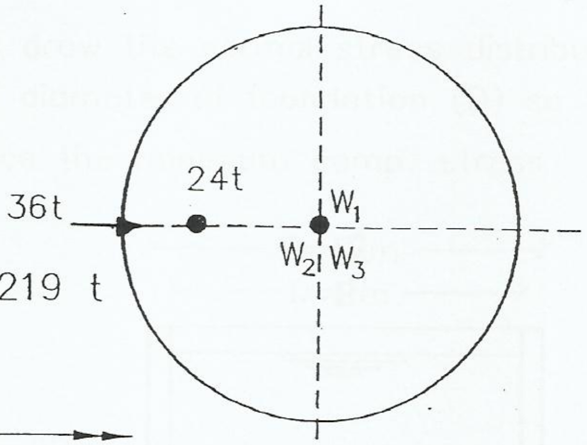
$$F_{max.\ comp.} = \frac{-247.838}{14.9225} - \frac{108}{168.8115}(5) = -19.807\ t/m^2$$

$$F_{max.\ tens.} = \frac{-247.838}{14.9225} + \frac{108}{168.8115}(5) = -13.409\ t/m^2$$

NORMAL STRESSES

a) section (A–A)

1) straining actions



$N = -(24+w_1+w_2+w_3) = -952.219$ t

$M_x = 0.0$

$M_y = 36 x 7 - 24 x 4.5 = 144$ m.t

$e_x = \dfrac{M_y}{N} = 0.1512257$m

2) prop. of Area

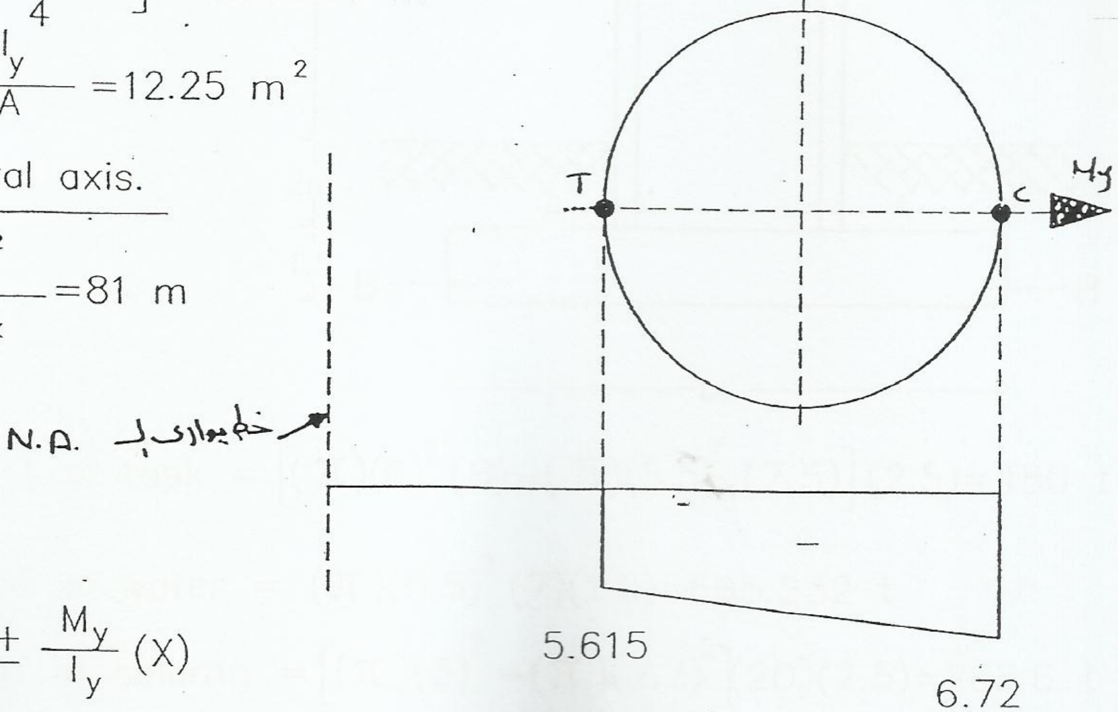
$A = (\pi)(7)^2 = 153.938$ m^2

$I_y = \left[\dfrac{(\pi)(7)^4}{4}\right] = 1885.74$ m^4

$i_y^2 = \dfrac{I_y}{A} = 12.25$ m^2

3) neutral axis.

$X_{inr} = \dfrac{i_y^2}{e_x} = 81$ m



$F = \pm \dfrac{N}{A} \pm \dfrac{M_y}{I_y}(X)$

$F_{max.\ comp.} = \dfrac{-952.219}{153.938} - \dfrac{144}{1885.75}(7) = -6.72$ t/m^2

$F_{max.\ tens.} = \dfrac{-952.219}{153.938} + \dfrac{144}{1885.75}(7) = -5.651$ t/m^2

Example (7):

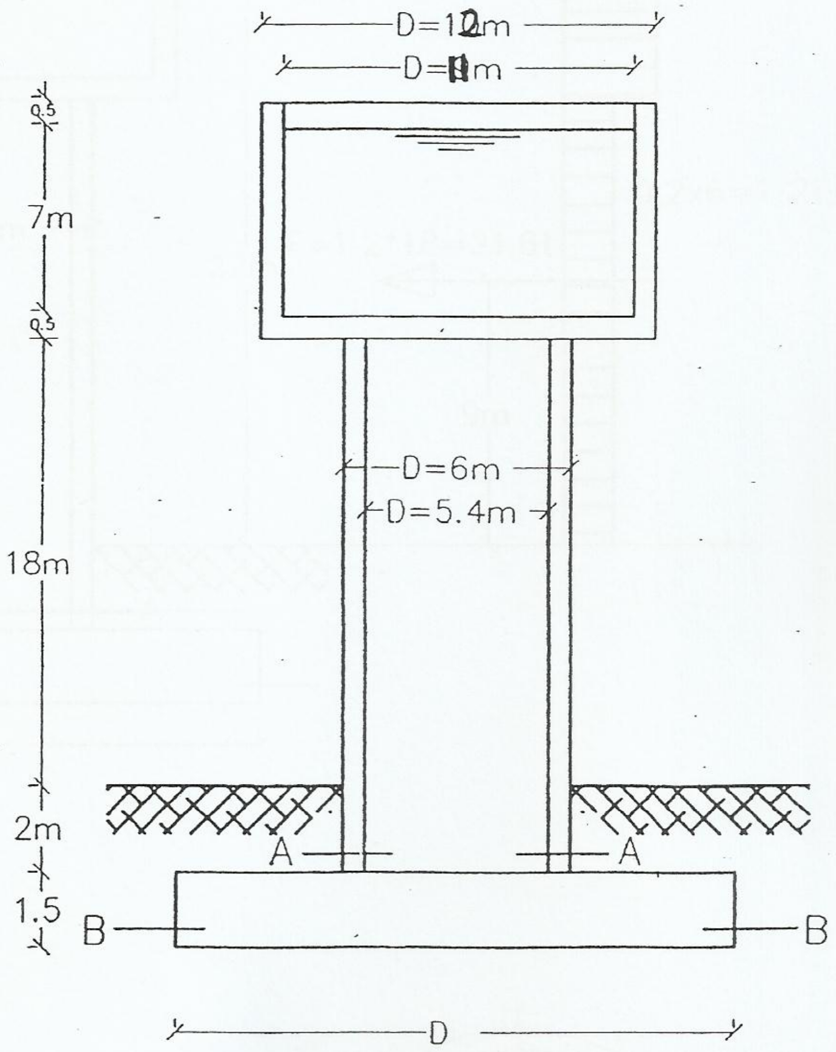
For the shown circular water tank draw the normal stress distribution over section (A–A). then find the diameter of foundation (D) so that the maximum comp. stress = twice the minimum comp. stress.

$\gamma_{water} = 1\ t/m^3$

$\gamma_{R.C} = 2.5\ t/m^3$

$\gamma_{soil} = 2.0\ t/m^3$

wind intensity $= 0.2\ t/m^2$



$w_1 =$ weight of tank $= \left[(\pi)(6)^2(8) - (\pi)(5.5)^2(7.5)\right](2.5) = 480\ t$

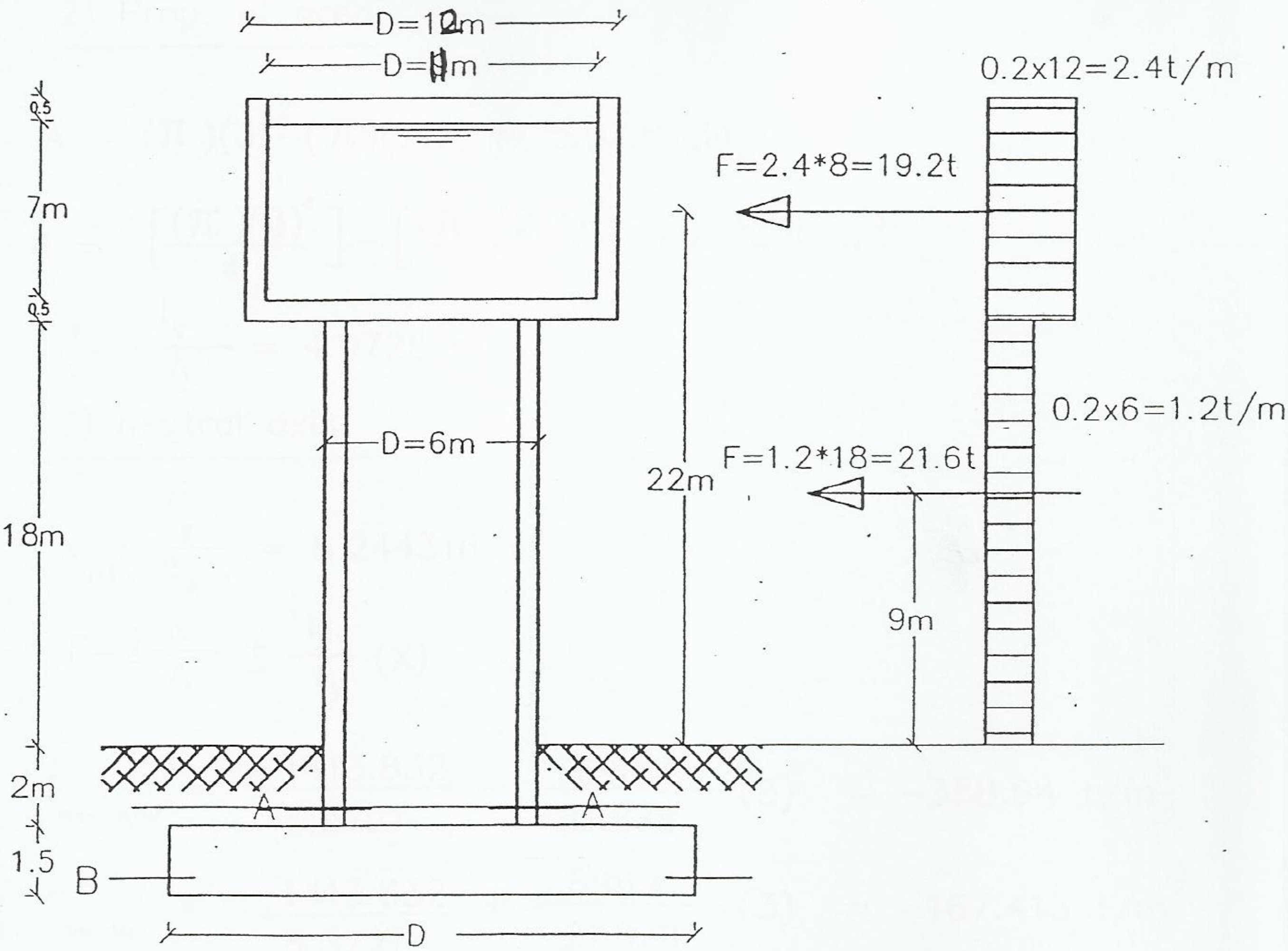
$w_2 =$ weight of water $= (\pi)(5.5)^2(7)(1.0) = 665.232\ t$

$w_3 =$ weight of column $= \left[(\pi)(3)^2 - (\pi)(2.7)^2\right](20)(2.5) = 268.6\ t$

$w_4 =$ weight of soil $= \left[(\pi)(D/2)^2 - (\pi)(3)^2\right](2)(2.5) = 268.6\ t$

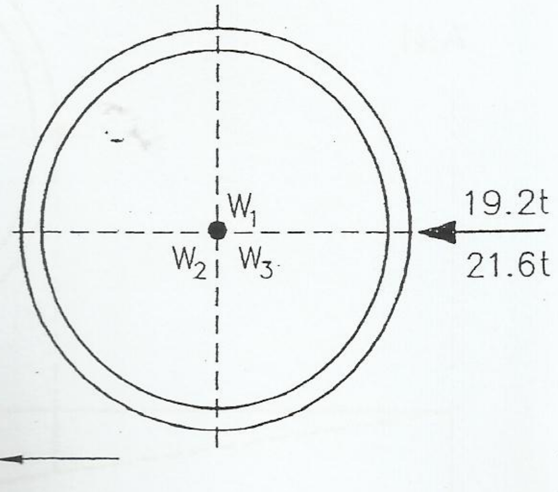
$w_4 =$ weight of soil $= 3.927D^2 - 141.3717$

$w_5 =$ weight of foundation $= (\pi)(D/2)^2(1.5)(2.5) = 2.945243\ D^2$



a) section (A–A)

1) straining actions



$N = W_1 + W_2 + W_3 = -1413.832$ t

$M_x = 0.0$

$M_y = 19.2*24 + 21.6*11 = 698.4$ m.t

$e_x = \frac{M_y}{N} = 0.4939766$ m

2) Prop. of area

$$A = (\pi)(3)^2 - (\pi)(2.7)^2 = 5.3721234 \text{ m}$$

$$I_y = \left[\frac{(\pi)(3)^4}{4}\right] - \left[\frac{(\pi)(2.7)^4}{4}\right] = 21.878 \text{ m}^4$$

$$i_y^2 = \frac{I_y}{A} = 4.0725 \text{ m}^2$$

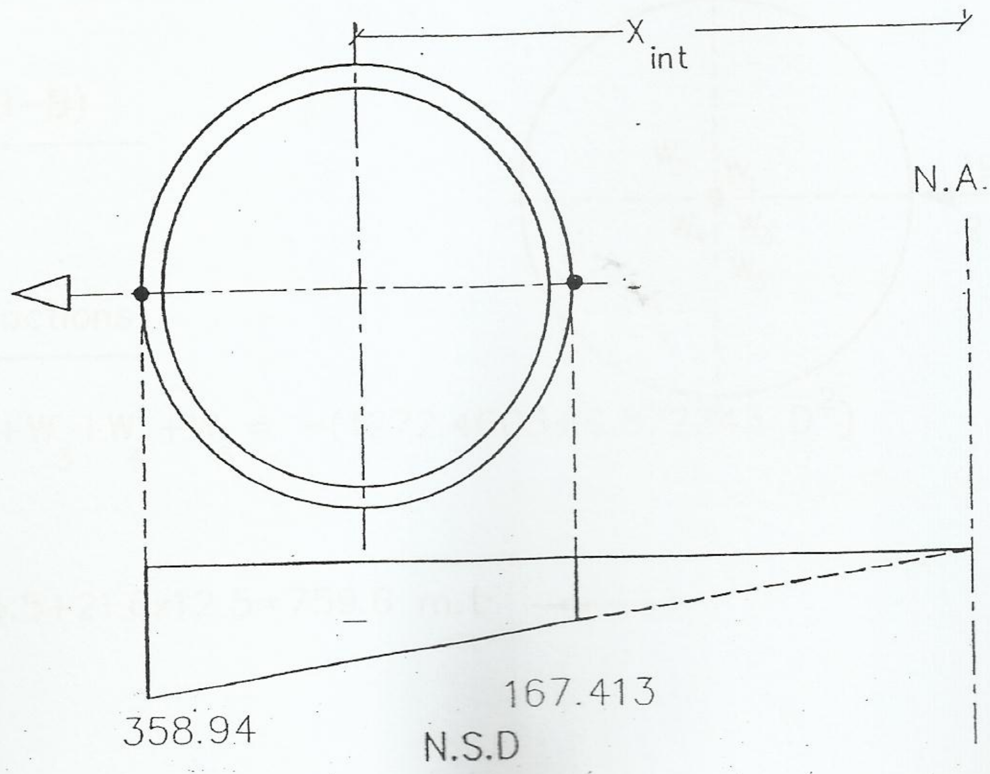
3) neutral axis.

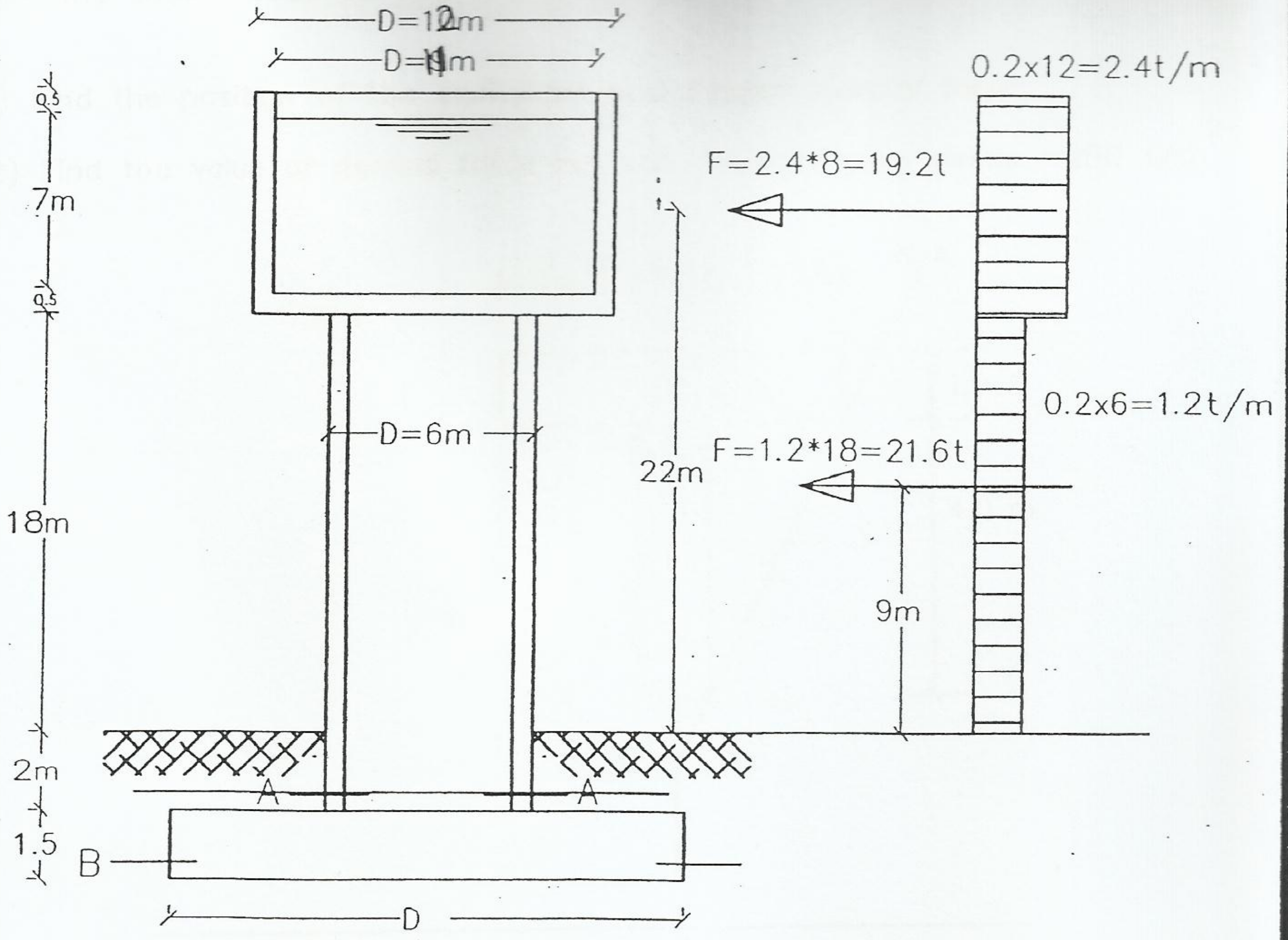
$$X_{int} = \frac{i_y^2}{e_x} = 8.244316$$

$$F = \pm \frac{N}{A} \pm \frac{M_y}{I_y}(X)$$

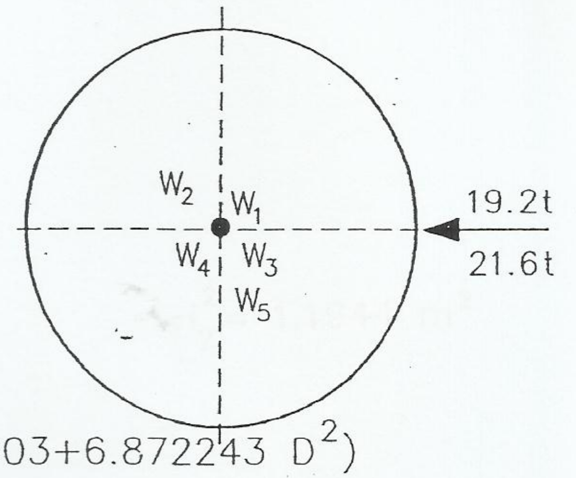
$$F_{max.\ comp.} = \frac{-1413.832}{5.3721} - \frac{698.4}{21.878}(3) = -358.94 \text{ t/m}^2$$

$$F_{max.\ tens.} = \frac{-1413.832}{5.3721} + \frac{698.4}{21.878}(3) = -167.413 \text{ t/m}^2$$





b) section (B–B)



1) straining actions

$N = W_1 + W_2 + W_3 + W_4 + W_5 = -(1272.4603 + 6.872243\ D^2)$

$M_x = 0.0$

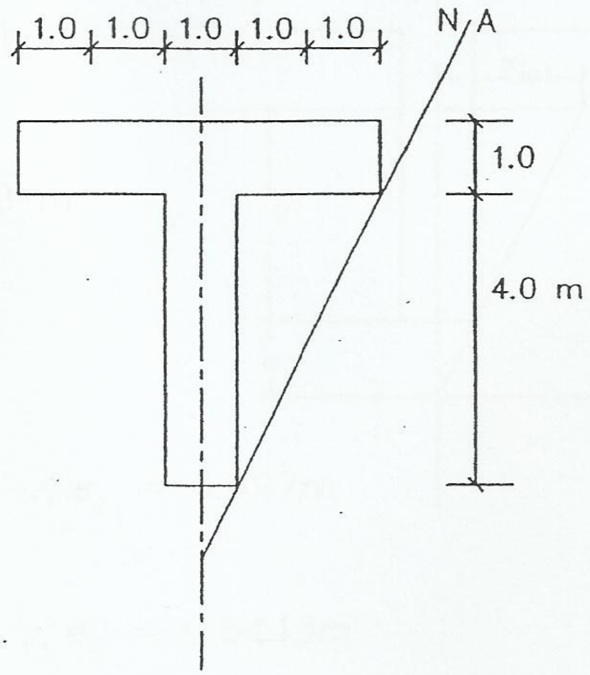
$M_y = 19.2 \times 25.5 + 21.6 \times 12.5 = 759.6$ m.t

PROBLEM (8)

For the shown cross section if the N.A. as shown

1) Find the position of the equivalent compression noraml force.

2) Find the value of normal force so that the maximum stress $=250\ t/m^2$



$$A = 4+5 = 9\ m^2$$

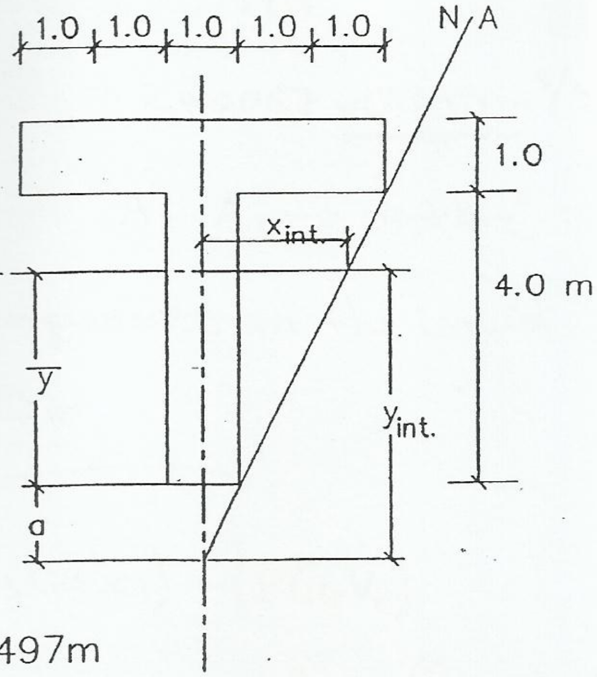
$$\bar{y} = \frac{5x4.5 + 4x2}{9} = 3.388\ m$$

$$I_y = \left[\frac{(1)(5)^3}{12} + \frac{(4)(1)^3}{12}\right] = 10.75\ m \qquad i_y^2 = 1.1944\ m^2$$

$$I_x = \left[\frac{(5)(1)^3}{12} + (5)(1.11)^2\right] + \left[\frac{(1)(4)}{} + (4)(1.388)^2\right] = 19.6388\ m^4$$

$$i_x^2 = 2.182\ m^2$$

where (N.A.) is given, then $X_{int.}$ & $y_{int.}$ are given



$$\frac{0.5}{a} = \frac{2.5}{4+a} = \frac{X_{int.}}{y_{int.}}$$

$\therefore a = 1$ m

$y_{int.} = \bar{y} + a = 4.388$ m

$X_{int.} = 2.1944$ m

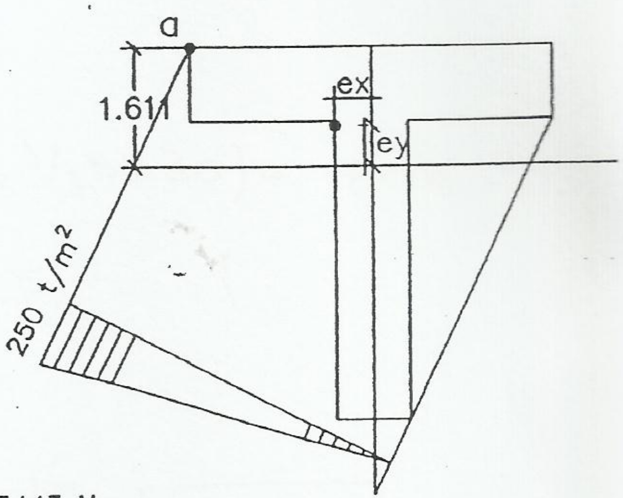
$$y_{int.} = 4.388 = \frac{i_x^2}{e_y} \qquad \therefore e_y = 0.497\text{m}$$

$$X_{int.} = 2.194 = \frac{i_y^2}{e_x} \qquad \therefore e_x = 0.5443\text{m}$$

(e_x & e_y) is the position of the equivalent compression noraml force.

$$F_a = -\frac{N}{A} - \frac{M_x}{I_x}.y - \frac{M_y}{I_y}.x$$

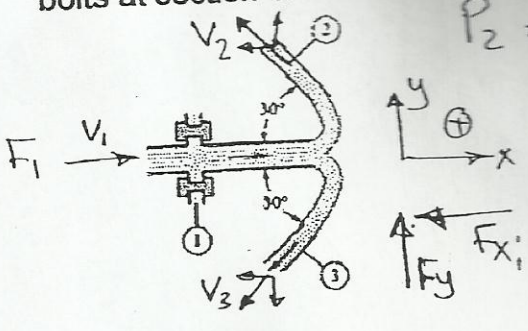
$$F_a = -\frac{N}{A} - \frac{(N)(e_y)}{I_x}.y - \frac{(N)(e_x)}{I_y}.x$$



$$-250 = -\frac{N}{9} - \frac{0.497\ N}{19.6388} \times 1.611 - \frac{0.5443\ N}{10.75} \times 2.5$$

$\therefore N = 987.77$ t

11/3-15 Water at 12°C exits to the standard sea-level atmosphere through the split nozzle in Fig. Duct areas are $A_1 = 0.022\ m^2$ and $A_2 = A_3 = 0.0078\ m^2$. If $p_1 = 174$ k Pa (absolute) and the flow rate is $Q_2 = Q_3 = 240\ m^3/hr$, compute the force on the flange bolts at section 1.



$P_2 = P_3 = \text{Zero}$ Patm

$Q_2 = Q_3 = \frac{240}{60 \times 60} = 0.067\ m^3/s$

$P_1 = 174 - 101 = 73\ KPa$

$Q_1 = Q_2 + Q_3 = 2 * 0.067 = 0.133\ m^3/s$

$A_1 = 0.022 m^2 \quad A_2 = A_3 = 0.0078 m^2$

* Let F_x, F_y are the force components on the liquid

∴ Apply Momentum equ. in X-Dir

$\Sigma F_x = \rho Q_f V_f - \rho Q_i V_i$

$F_1 - F_x = (-\rho Q_2 V_2 \cos 30 - \rho Q_3 V_3 \cos 30) - (\rho Q_1 V_1)$

$(73 \times 10^3 * 0.022) - F_x = -1000 \times 2 (0.067 * 8.59 \cos 30)$

$- 1000 (0.133 * 6.05)$

$\boxed{F_x = 3400\ N}$

$V_1 = \frac{Q_1}{A_1} = 6.05\ m/s$

$V_2 = V_3 = \frac{Q_2}{A_2} = 8.59\ m/s$

* Apply Momentum equ. in Y-Dir

$F_y = (\rho Q_2 V_2 \sin 30 - \rho Q_3 V_3 \sin 30) - \text{zero}$

but since $V_2 = V_3 \quad Q_2 = Q_3$

$\rightarrow F_y = 0$

∴ Force of liquid on nozzle $= \vec{F_x} = \boxed{3400\ N}$

$\rightarrow$ Force/bolt $= \frac{F_x}{\text{No. of bolts}}$