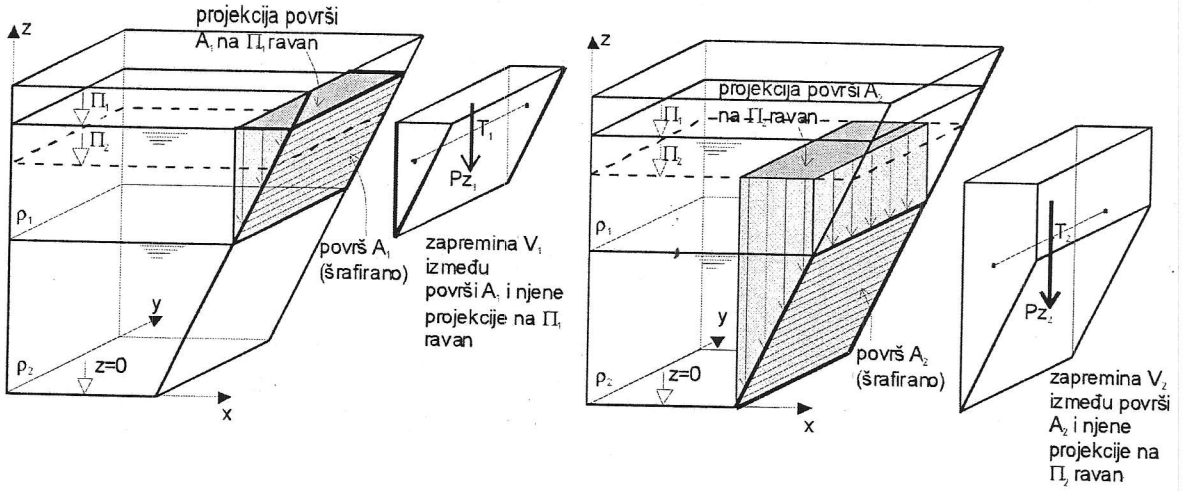
Vežba H3 - VERTIKALNA KOMPONENTA HIDROSTATIČKE SILE

Definicija: Vertikalna komponenta hidrostatičke sile kojom fluid deluje na površinu jednaka je težini fluida koji se može smestiti u zapreminu između površine i njene projekcije na pijezometarsku ravan (ravan gde je pritisak jednak nuli). Sila prolazi kroz **težište** navedene zapremine.



Postupak određivanja vertikalne komponente hidrostatičke sile:

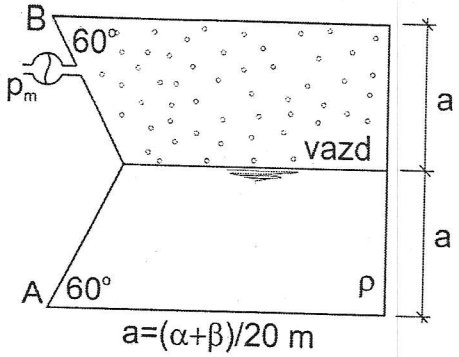
1. Uočiti površ na koju se traži vertikalna sila.
2. Izdeliti površ na onoliko delova sa koliko je različitih fluida u kontaktu.
3. Za svaki fluid proveriti da li Π ravan preseca površ na dva dela. Ako preseca, delove ispod i iznad Π ravni posmatrati odvojeno.
4. Za svaki od delova:
   - **tečnost:**
   a. projektovati površ na Π ravan;
   b. uočiti telo između površi i njene projekcije na Π ravan i odrediti mu zapreminu $\forall$;
   c. odrediti intezitet sile pomoću obrasca $\mathbf{Pz=\rho g \forall}$;
   d. odrediti mesto delovanja sile (težište zapremine $\forall$);
   e. odrediti smer sile analizirajući pritiske (ako je u fluidu pritisak pozitivan, smer sile je prema površi; a ako je negativan, sila je usmerena od konture).
   - **vazduh:**
   a. odrediti projekciju površi na horizontalnu ravan;
   b. odrediti površinu projekcije Az;
   c. sračunati pritisak u vazduhu p_{vaz};
   d. odrediti intezitet sile pomoću obrasca $\mathbf{Pz= p_{vaz} Az}$;
   e. odrediti mesto delovanja sile (težište površine Az);
   f. odrediti smer sile analizirajući pritiske.
5. Vektorski sabrati sve komponente vertikalne sile.

ZADACI ZA OVERU PRISUSTVA NA VEŽBAMA

(Napomena: slike kotirati u metrima, a ne u opštim brojevima)

ZADATAK 3.1

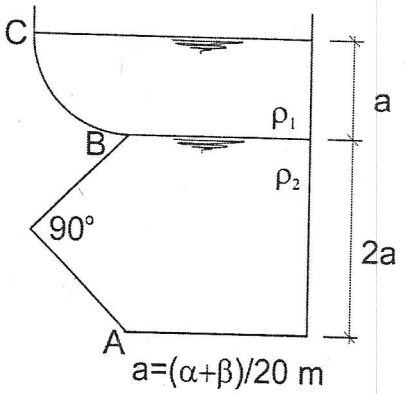
Zatvoren sud ispunjen je vodom (ρ=1 kg/dm^3) i vazduhom. Ukoliko je pritisak na manometru, p_m= -0.8(α+β) kPa, potrebno je odrediti intenzitet, smer i mesto delovanja vertikalne komponente hidrostatičke sile na zid AB, koji ima širinu 3m u ravni upravnoj na crtež.



ZADATAK 3.2

U otvorenom sudu, nalaze se dve tečnosti poznatih gustina [ρ_1=(1-α/20) kg/dm^3 i ρ_2=(1+α/20) kg/dm^3]. Potrebno je odrediti intenzitet, smer i mesto delovanja vertikalne komponente hidrostatičke sile na zid ABC, koji ima širinu 1.5m u ravni upravnoj na crtež.

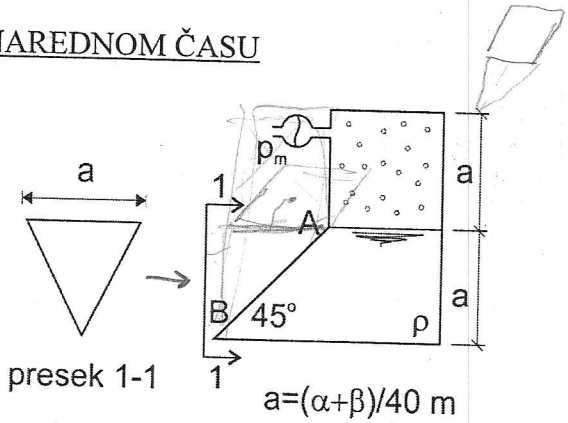
Napomena: Svaku komponentu i njenu pripadajuću zapreminu skicirati posebno.



ZADACI KOJI SE OCENJUJU NA NAREDNOM ČASU

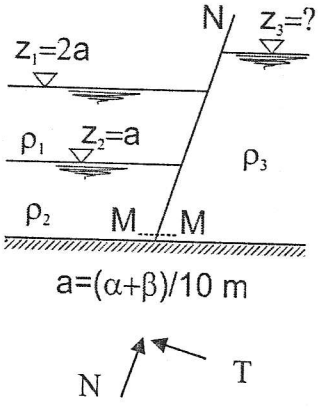
ZADATAK 3.3

Zatvoren sud ispunjen je vodom (ρ=1 kg/dm^3) i vazduhom. Ukoliko je pritisak na manometru, p_m=5(α+β) kPa, odrediti intenzitet, smer i mesto delovanja ukupne hidrostatičke sile na revizioni poklopac AB, oblika jednakokrakog trougla, čiji je izgled dat u preseku 1-1.

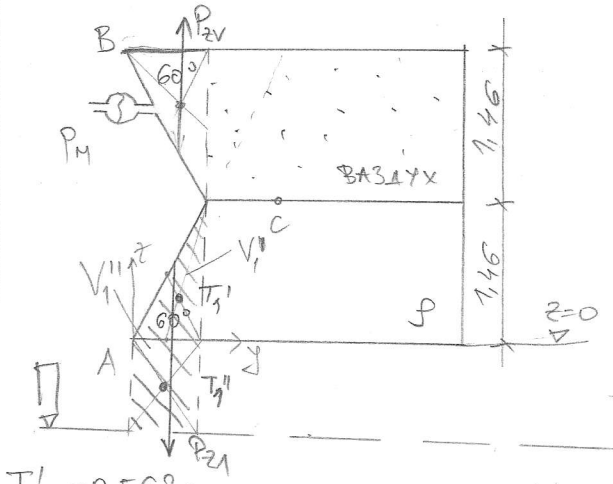


ZADATAK 3.4

Pregrada MN, koja sa horizontalom zaklapa ugao od 60°, razdvaja tri tečnosti. Nivo tečnosti sa desne strane zida, ρ_1 i ρ_2, su poznati (skica), dok je nivo tečnosti ρ_3 nepoznat [ρ_1=(1.2-α/30) kg/dm^3, ρ_2= (1.2+α/30) kg/dm^3, ρ_3 = 1.2 kg/dm^3]. Odrediti nepoznati nivo tečnosti z_3, iz uslova da nema transverzalne sile u preseku M-M, odn. da je suma sila upravnih na pravac pregrade u tom preseku jednaka nuli. U ravni upravnoj na crtež, pregrada MN ima širinu (α+β)/5 m. Zanemariti debljinu pregrade, i njenu sopstvenu težinu. Odrediti presečne sile N, T i M u preseku M-M.



(1)



$$P_{z1} = \rho g V_1 = 1000 \cdot 9{,}81 \cdot \frac{2{,}38+0{,}92}{2} \cdot 0{,}843 \cdot 3$$

$$\boxed{P_{z1} = 40935{,}66\ N}$$

$$V_1 = \frac{2{,}38+0{,}92}{2} \cdot 0{,}843 \cdot 3$$

$$\boxed{V_1 = 4{,}173\ m^3}$$

$$V_1' = \frac{0{,}843 \cdot 1{,}46}{2} \cdot 3 = 1{,}846\ m$$

$$V_1'' = 0{,}843 \cdot 0{,}92 \cdot 3$$

$$V_1'' = 2{,}327\ m$$

$T_{1x}' = 0{,}562\ m$

$T_{1x}'' = 0{,}422\ m$

$\rho = 1\ kg/dm^3$ $\quad a = \frac{d+D}{20} = 1{,}46$

$p_M = -23{,}36\ kPa$ $\quad L = 3\ m$

$$p_M = \rho g (\Pi - z_C)$$

$$\Pi = \frac{p_M}{\rho g} + z_C$$

$$\Pi = \frac{-23{,}36 \cdot 10^3}{1000 \cdot 9{,}81} + 1{,}46$$

$$\boxed{\Pi = -0{,}92\ m}$$

$$P_{zV} = p_V \cdot A_z = -23{,}36 \cdot 10^3 \cdot 3 \cdot 0{,}843$$

$$\boxed{P_{zV} = -59077{,}44\ N}$$

$$\frac{a\sqrt{3}}{2} = 1{,}46 \Rightarrow a = 1{,}686\ m$$

$$T_x = \frac{V_1' \cdot T_{1x}' + V_1'' \cdot T_{1x}''}{V} = \frac{1{,}846 \cdot 0{,}562 + 2{,}327 \cdot 0{,}422}{4{,}173}$$

$$\boxed{T_x = 0{,}484\ m}$$

$$P_z = 40935{,}66 - 59077{,}44 \Rightarrow \boxed{P_z = -18141{,}78\ N}$$

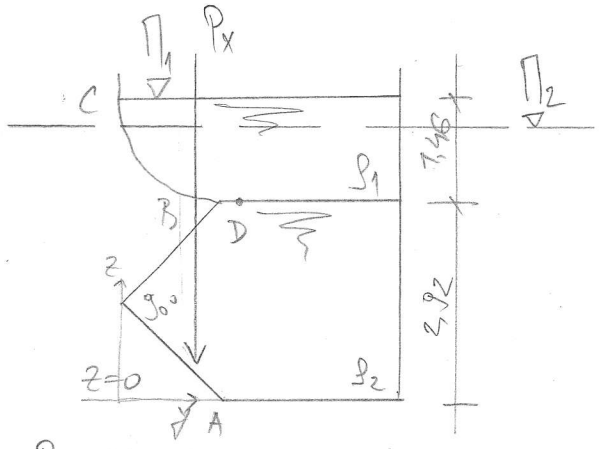
$$x = \frac{P_{z1} \cdot T_x - P_{zV} \cdot 0{,}562}{P_z} = \boxed{0{,}738\ m}$$

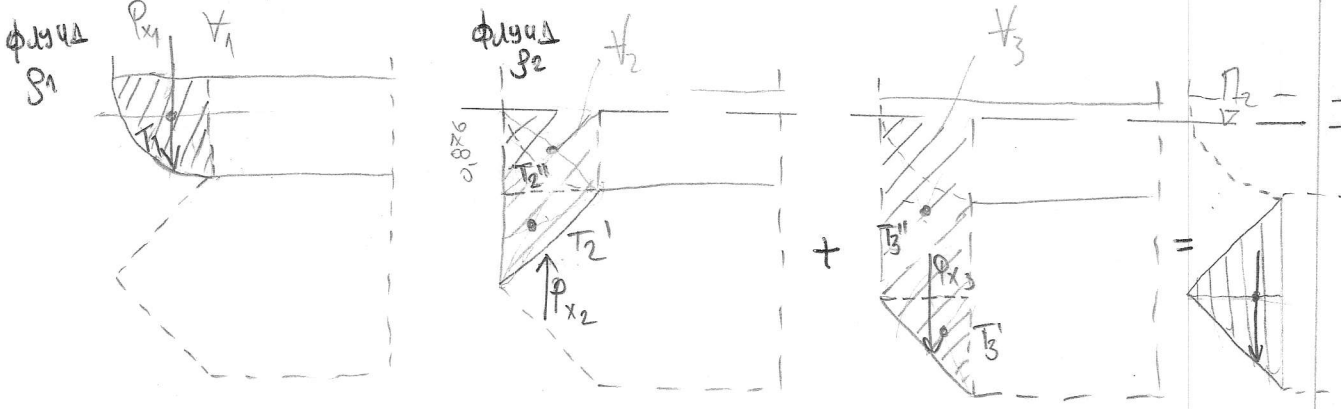
(2)

$a = \frac{\alpha + b}{20} = 1{,}46$ $\quad L = 1{,}5\,m$

$\rho_1 = 0{,}75\ kg/dm^3$

$\rho_2 = 1{,}25\ kg/dm^3$





$p_D = \rho_1 g (\Pi_1 - z_D)$

$p_D = 750 \cdot 9{,}81 (4{,}38 - 2{,}92)$

$\boxed{p_D = 10741{,}95\ Pa}$

$\Pi_2 = \frac{p_D}{\rho_2 g} + z_D$

$\Pi_2 = \frac{10741{,}95}{1250 \cdot 9{,}81} + 2{,}92$

$\boxed{\Pi_2 = 3{,}796\,m}$

$\boxed{\Pi_1 = 4{,}38\,m}$

$V_1 = \frac{1}{4}(r^2\pi \cdot L) = \frac{1{,}46^2 \cdot 3{,}14 \cdot 1{,}5}{4}$

$\boxed{V_1 = 2{,}511\,m^3}$

$V_2 = \frac{a+b}{2} \cdot h \cdot L = \frac{0{,}876 + 2{,}336}{2} \cdot 1{,}46 \cdot 1{,}5$

$\boxed{V_2 = 3{,}517\,m^3}$

$V_3 = \frac{3{,}796 + 2{,}336}{2} 1{,}46 \cdot 1{,}5$

$\boxed{V_3 = 6{,}714}$

$T_{x1} = \frac{4}{3}\frac{R}{\pi} = 0{,}619\,m$

$T_{x2}' = 0{,}487\,m$

$T_{x2}'' = 0{,}73\,m$

$T_{x3}' = 0{,}973\,m$

$T_{x3}'' = 0{,}73\,m$

$P_{x_1} = \rho_1 g V_1 = 750 \cdot 9{,}81 \cdot 2{,}511$

$\boxed{P_{x_1} = 18474{,}68\ N}$

$P_{x_2} = \rho_2 g V_2 = 1250 \cdot 9{,}81 \cdot 3{,}517$

$\boxed{P_{x_2} = 43127{,}21\ N}$

$P_{x_3} = \rho_2 \cdot g \cdot V_3$

$\boxed{P_{x_3} = 82{,}330{,}42\ N}$

$V_2' = 1{,}60\,m^3$

$V_2'' = 1{,}918\,m^3$

$V_3' = 1{,}60\,m^3$

$V_3'' = 5{,}116\,m^3$

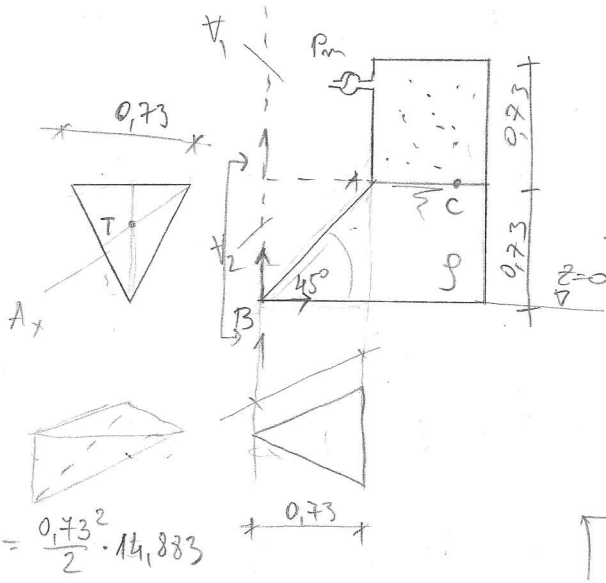
$T_{x2} = \frac{V_2' \cdot T_{x2}' + V_2'' \cdot T_{x2}''}{V_2} = \frac{1{,}60 \cdot 0{,}487 + 1{,}918 \cdot 0{,}73}{3{,}517} = \underline{0{,}619\,m}$

$T_{x3} = \frac{1{,}60 \cdot 0{,}973 + 5{,}116 \cdot 0{,}73}{6{,}714} = \underline{0{,}788\,m}$

$z_x = \frac{P_{x_1} \cdot T_{x_1} + P_{x_3} \cdot T_{x_3} - P_{x_2} \cdot T_{x_2}}{(P_{x_1} + P_{x_3} - P_{x_2})} = \frac{18474{,}68 \cdot 0{,}619 + 82330{,}42 \cdot 0{,}788 - 43127{,}21 \cdot 0{,}619}{57677{,}89}$

$\boxed{z_x = 0{,}860\,m}$

(3)



$$a = \frac{\alpha+15}{40} = 0,73$$

$$\rho = 1\ kg/dm^3$$

$$P_m = 5(\alpha+15) = 146\ kPa$$

$$\Pi = \frac{P_m}{\rho g} + z_c$$

$$\Pi = \frac{146.10^3}{1000.9,81} + 0,73$$

$$\boxed{\Pi = 15,613\ m}$$

$$A_x = \frac{0,73 \cdot 1,032}{2}$$

$$\boxed{A_x = 0,377\ m^2}$$

$$V_1 = \frac{0,73^2}{2} \cdot 14,883$$

$$\boxed{V_1 = 3,965\ m^3}$$

$$V_2 = \frac{1}{3} \cdot \frac{0,73^2}{2} \cdot 0,73$$

$$\boxed{V_2 = 0,065\ m^3}$$

$$\boxed{V = 4,030\ m^3}$$

$$P_T = \rho g (\Pi - z_T)$$

$$P_T = 1000.9,81(15,613 - 0,487)$$

$$\boxed{P_T = 148386,06\ Pa}$$

$$P_z = \rho g V = 1000 \cdot 9,81 \cdot 4,030$$

$$\boxed{P_z = 39534,30\ N}$$

$$\Phi_x = P_T \cdot A_x = 148386,06 \cdot 0,377$$

$$\boxed{P_x = 55941,54\ N}$$

$$e_z = -\frac{\rho g I_{yy}}{P_x}$$

$$I_{yy} = \frac{1}{36} \cdot 0,73^4 = 7,888.10^{-3}\ m$$

$$e_z = -\frac{1000 \cdot 9,81 \cdot 7,888.10^{-3}}{55941,54} \Rightarrow \boxed{e_z = -1,383.10^{-3}}$$

$$P_{ux} = \sqrt{P_x^2 + P_z^2} = \sqrt{55941,54^2 + 39534,30^2} \Rightarrow \boxed{P_{ux} = 68501,22\ N}$$

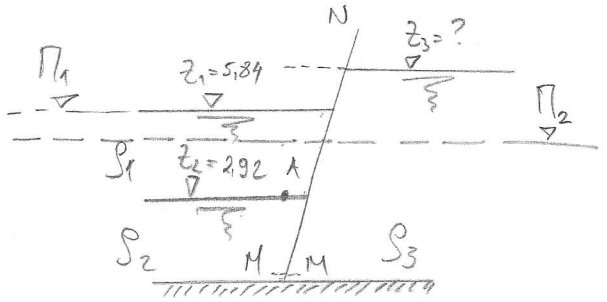
$$D(x,z) = \frac{2}{3}0,73 - 1,383.10^{-3} = \boxed{0,485}$$

$$D(x,z) = (0,487\ ;\ 0,485)$$

✓

④

$a = \frac{\alpha+5}{10} = 2,92\,m$ $\quad 60°$



$\rho_1 = 1,033\ kg/dm^3$ $\quad \rho_2 = 1,367\ kg/dm^3$

$\rho_3 = 1,2\ kg/dm^3$ $\quad z_3 = ?$

$MN = L = 5,84\,m$

$\Pi_1 = 5,84\,m$

$p_A = \rho_1 g (\Pi_1 - z_A)$

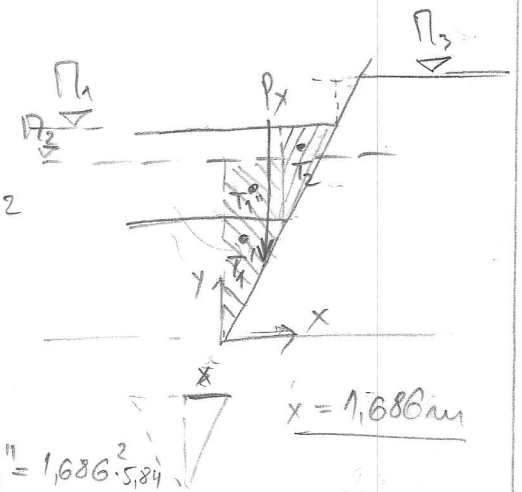
$p_A = 1033 \cdot 9,81 (5,84 - 2,92)$

$p_A = 29590,49\ Pa$

$\Pi_2 = \frac{p_A}{\rho_2 g} + z_A$

$\Pi_2 = \frac{29590,49}{1367 \cdot 9,81} + 2,92$

$\Pi_2 = 5,126\,m$



$x = 1,686\,m$

$T_{x_1}' = \frac{1}{3} 1,686 = 0,562\,m$

$T_{x_1}'' = 0,843\,m$

$T_{x_2} = 1,686 + \frac{1}{3} 1,686 = 2,248\,m$

$V_1' = 1,686 \cdot 2,92 \cdot 5,84$ $\quad V_1'' = 1,686^2 \cdot 5,84$

$V_1' = 28,751\,m^3$ $\quad V_1'' = 16,60\,m^3$ $\Rightarrow V_1 = 45,352\,m^3$

$V_2 = 1,686 \cdot 2,92 \cdot 5,84 \Rightarrow V_2 = 28,751\,m^3$

$P_{z_1}' = \rho_2 g V_1' = 1367 \cdot 9,81 \cdot 28,751 \Rightarrow P_{z_1}' = 385558,67\ N$

$P_{z_1}'' = 1367 \cdot 9,81 \cdot 16,60 \Rightarrow P_{z_1}'' = 222610,48\ N$

$\Big\} P_{z_1} = 608169,15\ N$

$P_{z_2} = 1033 \cdot 9,81 \cdot 28,751 \Rightarrow P_{z_2} = 291354,27\ N$

$x_{x_1} = \frac{28,751 \cdot 0,562 + 16,60 \cdot 0,843}{45,352} = 0,665\,m$

$P_z^{\Sigma} = 899524,02\ N$

$z_x = \frac{608169,15 \cdot 0,665 + 291354,87 \cdot 2,248}{899524,02} = 1,178\,m$

$p_{T_1}' = 1367 \cdot 9,81 (5,126 - 1,46)$

$\Omega_{x_1}' = 2,206 \cdot 2,92 = 6,441\,m^2$ $\quad z_{x_1}' = 1,46\,m$

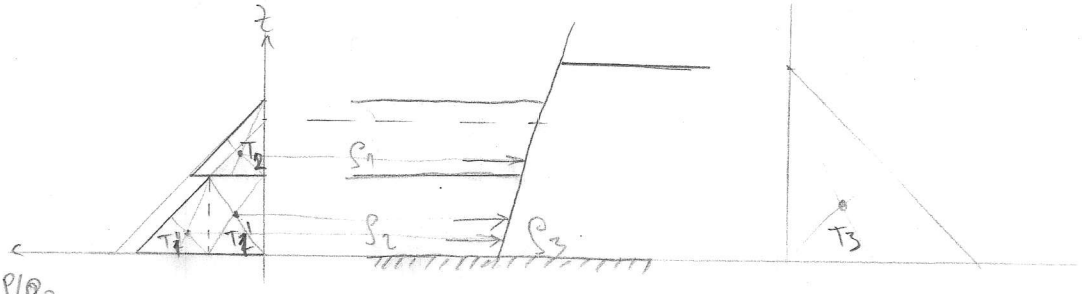
$p_{T_1}' = 49162,05\ Pa$

$\Omega_{x_1}'' = 4,263\,m^2$ $\quad z_{x_1}'' = 0,973\,m$

$p_{T_1}'' = 1367 \cdot 9,81 (5,126 - 0,973) \Rightarrow p_{T_1}'' = 55692,85$

$\Omega_{x_2} = 4,263\,m^2$ $\quad z_{x_2} = 3,893\,m$

$p_{T_2} = 1033 \cdot 9,81 (5,84 - 3,893) \Rightarrow p_{T_2} = 19730,37\ Pa$



p/ρg

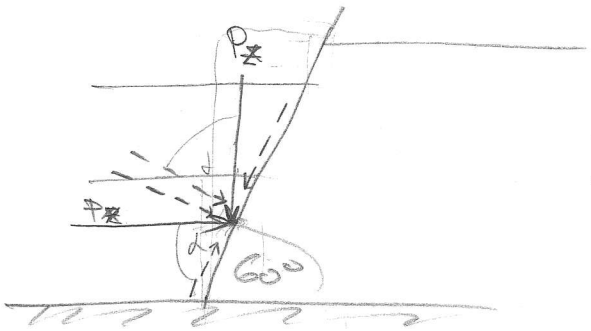
$P_{x_1}' = \rho_1 g \Omega' x_1' L = 1367 \cdot 9{,}81 \cdot 6{,}441 \cdot 5{,}84 \Rightarrow$ **$P_{x_1}' = 504433{,}21\ N$**

$P_{x_1}'' = 1367 \cdot 9{,}81 \cdot 4{,}263 \cdot 5{,}84 \Rightarrow$ **$P_{x_1}'' = 333861{,}01\ N$**

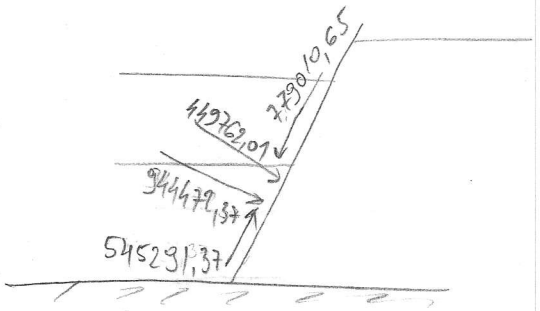
$P_{x_2} = 1033 \cdot 9{,}81 \cdot 4{,}263 \cdot 5{,}84 \Rightarrow$ **$P_{x_2} = 252288{,}53\ N$**

$P_x^L = 1090582{,}75\ N$

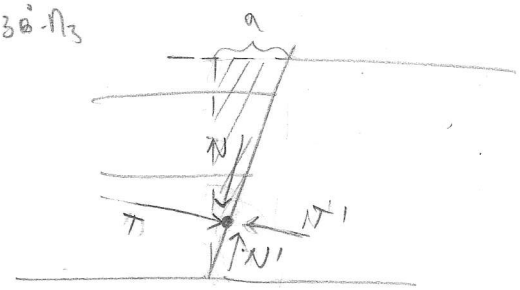
$$z_x = \frac{504433{,}21 \cdot 1{,}46 + 333861{,}01 \cdot 0{,}973 + 252288{,}53 \cdot 3{,}893}{1090582{,}75} \Rightarrow$$ **$z_x = 1{,}874\ m$**



$\Rightarrow$

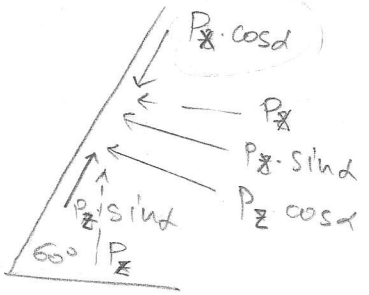


$a = tg30° \cdot \Pi_3$



$T = 1394{,}23\ kN$ ✓

$N = 233{,}72\ kN$



$T = P_x \sin\alpha + P_z \cos\alpha$

$1394{,}23 \cdot 10^3 = \frac{\sqrt{3}}{2} P_x + \frac{1}{2} P_z$

$P_z = \rho_3 g \Psi_3 = 1200 \cdot 9{,}81 \cdot \frac{\Pi_3^2 \cdot tg30°}{2} \cdot 5{,}84$

$P_z^D = 1984{,}97 \cdot \Pi_3^2 =$ **$697175{,}61\ N$**

$P_x = \rho_3 g \Omega x_3 \cdot L$

$P_x = 1200 \cdot 9{,}81 \cdot \frac{\Pi_3^2}{2} \cdot 5{,}84 \Rightarrow$

$P_x^D = 34374{,}24\ \Pi_3^2 =$ **$1207543{,}98\ N$**

$M = 0$

$N = P_x^D \cos\alpha - P_z^D \sin\alpha$

$1394230 = \frac{1}{2} 1984{,}97\ \Pi_3^2 + \frac{\sqrt{3}}{2} 34374{,}24\ \Pi_3^2$

$N^D = 0{,}2\ N \approx 0\ N$ ✓

$\Pi_3^2 = 35{,}126\ m$

$\Pi_3 = 5{,}927\ m$ ✓