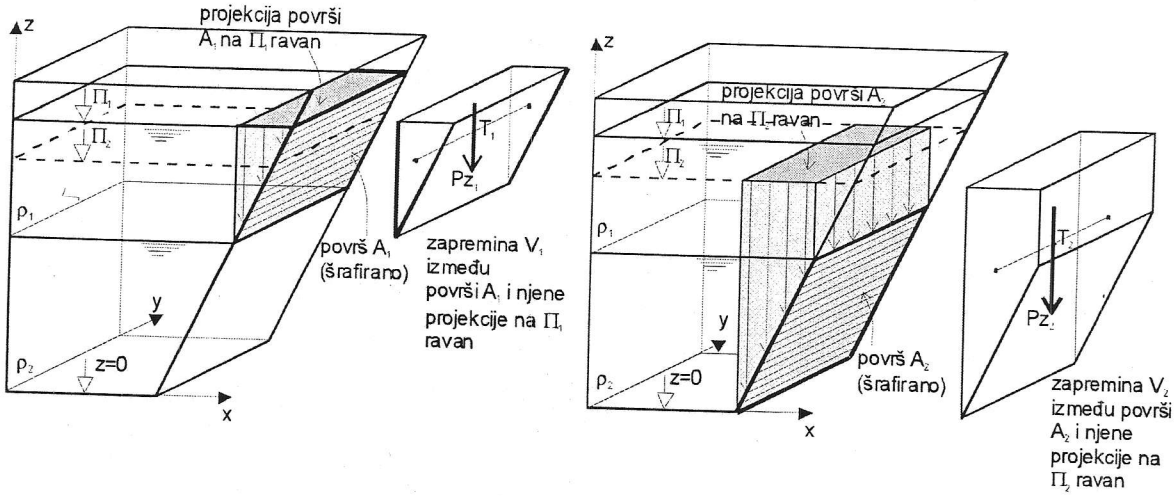
Vežba H3 - VERTIKALNA KOMPONENTA HIDROSTATIČKE SILE

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:

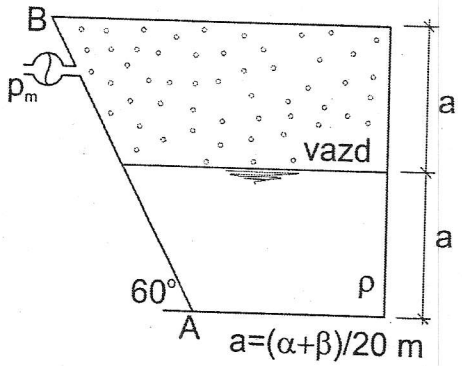
1. Uočiti površ na koju se traži vertikalna sila.
2. Izdeliti površ na onoliko delova sa koliko je različitih fluida u kontaktu.
3. Za svaki fluid proveriti da li Π ravan preseca površ na dva dela. Ako preseca, delove ispod i iznad Π ravni posmatrati odvojeno.
4. Za svaki od delova:
   - **tečnost:**
   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

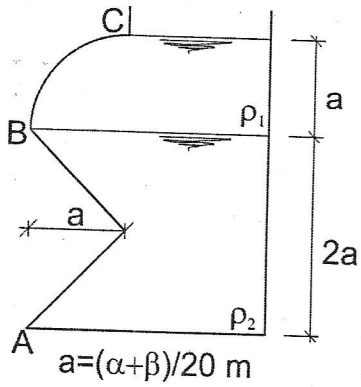
Zatvoren sud ispunjen je vodom (ρ=1 kg/dm^3) i vazduhom. Ukoliko je pritisak na manometru, p_m=-0.9(α+β) kPa, odrediti intenzitet, smer i mesto delovanja vertikalne komponente hidrostatičke sile na zid AB, koji ima širinu 1.5m u ravni upravnoj na crtež.



ZADATAK 3.2

U otvorenom sudu, nalaze se dve tečnosti poznatih gustina [ρ_1=(1-α/25) kg/dm^3 i ρ_2=(1+α/25) kg/dm^3]. Potrebno je odrediti intenzitet, smer i mesto delovanja vertikalne komponente hidrostatičke sile na zid ABC, koji ima širinu 2m u ravni upravnoj na crtež.

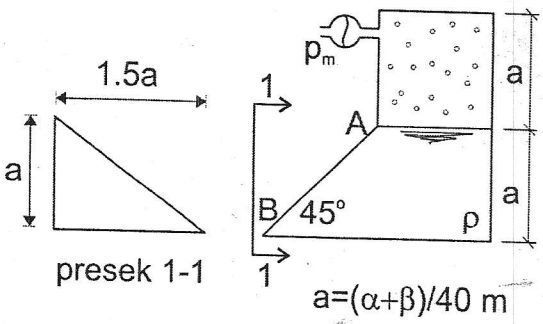
Napomena: Svaku komponentu i njenu pripadajuću zapreminu skicirati posebno.



ZADACI KOJI SE OCENJUJU NA NAREDNOM ČASU

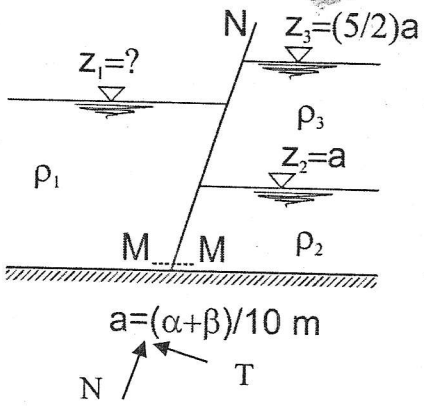
ZADATAK 3.3

Zatvoren sud ispunjen je vodom (ρ=1 kg/dm^3) i vazduhom. Ukoliko je pritisak na manometru, p_m=8(α+β) kPa, odrediti intenzitet, smer i mesto delovanja ukupne hidrostatičke sile na revizioni poklopac AB, trougaonog oblika, čiji je izgled dat u preseku 1-1.

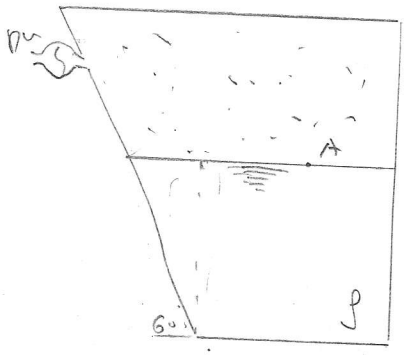


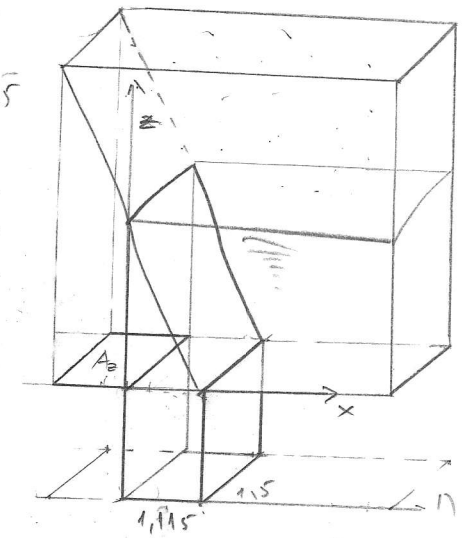
ZADATAK 3.4

Pregrada MN, koja sa horizontalom zaklapa ugao od 60°, razdvaja tri tečnosti. Nivoi tečnosti sa desne strane zida, ρ_2 i ρ_3, su poznati (skica), dok je nivo tečnosti ρ_1 nepoznat [ρ_1=1.1 kg/dm^3, ρ_2= (1.2+α/25) kg/dm^3, ρ_3= (1-α/25) kg/dm^3]. Odrediti nepoznati nivo tečnosti z_1, iz uslova da nema normalne sile u preseku M-M pregrade, odn. da je suma sila u pravcu pregrade jednaka nuli. U ravni upravnoj na crtež, pregrada MN ima širinu (α+β)/7 m. Zanemariti debljinu pregrade i njenu sopstvenu težinu. Odrediti presečne sile N, T i M u preseku M-M.



3.11





$a = \frac{l + P}{2a}$

$a = 1,935$

$\rho = 1000 \text{ kg/m}^3$

$p_{manz} = -34830 \text{ Pa}$

$L = 1,5 \text{ m}$

$z_A = 1,935$

$p_A = p_m = -34830 \text{ Pa} = p_{vac}$

$\frac{p_A}{\rho g} + z_A = n \Rightarrow n = -1,615 \text{ m}$

$1,935 = \frac{b\sqrt{3}}{2} \Rightarrow b = 2,23 \text{ m}$

$\frac{b}{2} = 1,115$

$V_1 = \frac{b}{2} \cdot a : 2 \cdot L \Rightarrow V_1 = 1,618 \text{ m}^3$

$V_2 = 1,115 \cdot 1,5 \cdot (-A) = 1,115 \cdot 1,5 \cdot 1,615 \Rightarrow V_2 = 2,7 \text{ m}^3$

$\Rightarrow V_{12} = V_1 + V_2$

$V_{12} = 4,32$

$P_{z_1} = \rho g V_{12} \Rightarrow P_{z_1} = 42379,2 \text{ N}$

$x_1 = \frac{1}{3} \cdot \frac{b}{2} \Rightarrow x_1 = 0,372$

$x_2 = \frac{1}{2} \cdot \frac{b}{2} \Rightarrow x_2 = 0,557$

$x_T = \frac{V_1 x_1 + V_2 x_2}{V_{12}} \Rightarrow x_T = 0,487 \text{ m}$

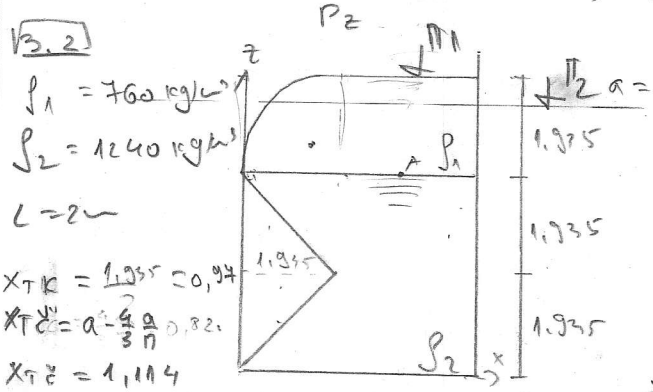
$A_z = \frac{b}{2} \cdot L \Rightarrow A_z = 1,67 \text{ m}^2$, $P_z = p_{vaz} \cdot A_z \Rightarrow P_{z_2} = -58166,1 \text{ N}$

$P_z = P_{z_1} + P_{z_2} \Rightarrow P_z = -15786,9 \text{ N}$

$x_{T\,vaz} = -\frac{b}{2} \cdot \frac{1}{2} \Rightarrow x_{T,az} = 0,557$

$x = \frac{P_{z_1} \cdot x_T - P_{z_2} \cdot x_{T\,vaz}}{P_z} \Rightarrow x = 0,745 \text{ m}$

3.2



$\rho_1 = 760 \text{ kg/m}^3$

$\rho_2 = 1240 \text{ kg/m}^3$

$L = 2 \text{ m}$

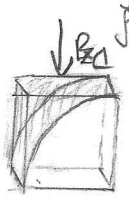
$x_{T\,K} = \frac{1,935}{3} = 0,97$

$x_{T\,\check{C}} = a - \frac{4}{3}\frac{a}{\pi} = 0,821$

$x_{T\,\check{C}} = 1,114$

$\frac{p_A}{\rho_1 g} + z_A = n_1 \Rightarrow p_A = 14426,58 \text{ Pa}$

$\frac{p_A}{\rho_2 g} + z_A = n_2 \Rightarrow n_2 = 5,056 \text{ m}$



$V_K = L \cdot a^2 \Rightarrow V_K = 2 \cdot 1,935^2$

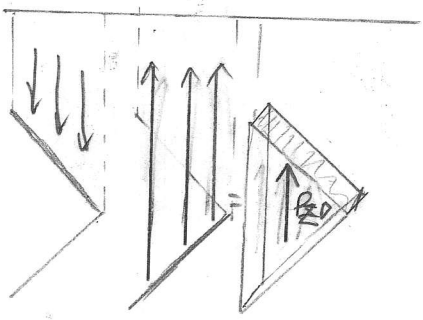
$V_K = 7,49 \text{ m}^3$

$V_{\check{C}} = L \cdot \frac{a^2 \pi}{4} \Rightarrow V_{\check{C}} = 5,88 \text{ m}^3$

$x_T = \frac{x_K V_K - x_{\check{C}} V_{\check{C}}}{V_P}$ $V_P = V_K - V_{\check{C}} = 1,61 \text{ m}^3$

$P_{ZK} = \rho_1 \cdot g \cdot V \Rightarrow P_{ZK} = 12003,52 \text{ N}$

$x_{TK} = 0,44 \text{ m}$



$V_D = \frac{2a \cdot a}{2} \cdot L = 7,48 \text{ m}^3$

$P_{ZD} = \rho_2 \cdot g \cdot V_D \Rightarrow P_{ZD} = 9098,7 \text{ N}$

$x_{T_D} = \frac{a}{3} = 0,645$

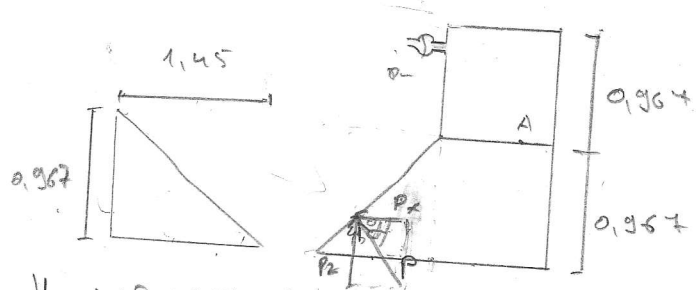
$P_x =$

$P_z = P_{ZK} - P_{Z\check{C}} \Rightarrow P_z = 78986,18 \text{ N}$

$x = \frac{P_{ZK} \cdot x_{TK} - P_{Z\check{C}} \cdot x_{T\check{C}}}{P_z}$

$x = 0,676 \text{ m}$

3.3



$\rho = 1000\ kg/m^3$

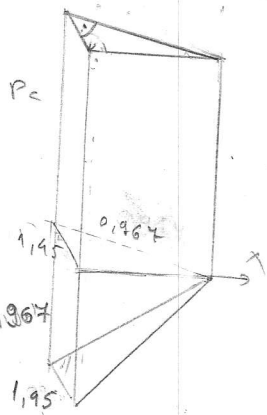
$p_m = 309600\ Pa$

$a = 0,967$

$p_A = p_m$

$\frac{p_A}{\rho g} + z_A = H$

$\Rightarrow H = 32,53 m$



$V_\Delta = 1,45 \cdot 0,967 \cdot \frac{0,967}{3} \Rightarrow V_\Delta = 0,452 m^3$

$V_\square = \frac{0,967 \cdot 1,45}{2} \cdot (32,53 - 0,967) = 22,13 m^3$

$V = 22,582 m^3$

$P_z = \rho \cdot g \cdot V \Rightarrow P_z = 221529,42 N$

$P_{z\Delta} = \rho g V_\Delta = 4434,12 N$

$P_{z\square} = \rho g V_\square = 217095,3 N$

$x_{T\Delta} = \frac{1}{4} \cdot 0,967 = 0,242 m$

$x_{T\square} = \frac{1}{3} 0,967 = 0,322 m$

$x_T = \frac{x_{T\Delta} P_{z\Delta} + x_{T\square} P_{z\square}}{P_z} \Rightarrow x_T = 0,320 m$

$P_x = P_T \cdot A$

$z_T = \frac{1}{3} \cdot 0,967 \Rightarrow z_T = 0,322$

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

$P_T = 315960,48 Pa$

$A = \frac{0,967 \cdot 1,45}{2}$

$A = 0,701 m^2$

$P_x = 315960,48 \cdot 0,701$

$P_x = 221488,3 N$

$I_{yy} = \frac{1}{36} \cdot 0,967^3 \cdot 1,45 = 0,036 m^4$

$e = \frac{-\rho g I_{yy}}{P_x} \Rightarrow e = -0,0001613 m$

$z_{Px} = z_T + e \Rightarrow z_{Px} = 0,3204 m$

$P = \sqrt{P_x^2 + P_z^2} \Rightarrow P = 313260,83 N$

$tg\alpha = \frac{P_z}{P_x} = \frac{221529,42}{221488,3} \Rightarrow \alpha \approx 45°$

✓

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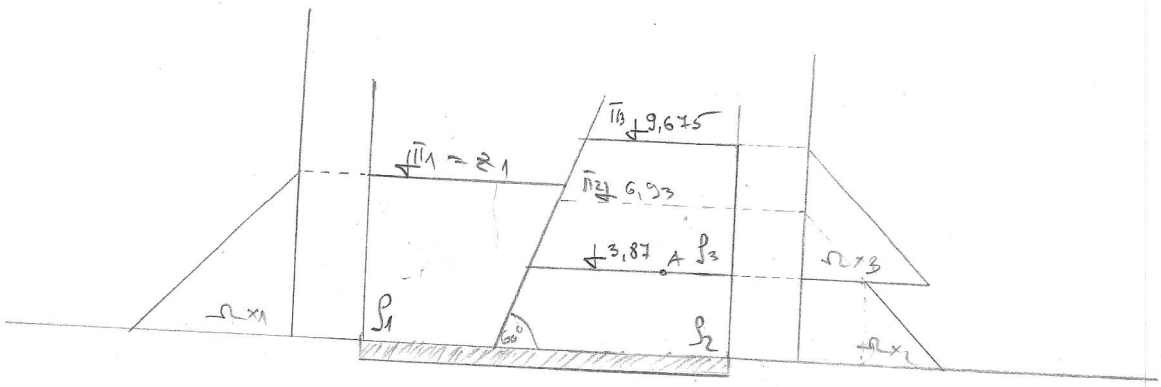
3.41



$\rho_1 = 1100\ kg/m^3$
$\rho_2 = 1440\ kg/m^3$
$\rho_3 = 760\ kg/m^3$
$L = 5,53\ m$

$\frac{P_A}{\rho_3 \cdot g} + z_A = \bar{\Pi}_3 \Rightarrow P_A = 43279,76\ Pa$

$\frac{P_a}{\rho_2 \cdot g} + z_A = \bar{\Pi}_2 \Rightarrow \bar{\Pi}_2 = 6,93\ m$

- ХОРИЗОНТАЛНА КОМПОНЕНТА

$P_{x_3} = \rho_3 g L \cdot \Omega x_3 \Rightarrow P_{x_3} = 760 \cdot 9,81 \cdot 5,53 \cdot (9,675 - 3,87)^2/2 \Rightarrow \boxed{P_{x_3} = 69467,82\ N}$

$z_{Px_3} = \frac{1}{3}(9,675 - 3,87) + 3,87 \Rightarrow z_{Px_3} = 5,805\ m$

$\Omega x_2 = (\bar{\Pi}_2 + \bar{\Pi}_2 - z_A) : 2 \cdot z_A \Rightarrow \Omega x_2 = 19,33\ m^2 = A_2$

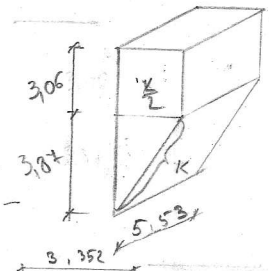
$P_{x_2} = \rho_2 \cdot g \cdot L \cdot \Omega x_2 \Rightarrow \boxed{P_{x_2} = 1510040,11\ N}$

$z_{Px_2} = \frac{z_{Px_{21}} \cdot A_{21} + z_{Px_{22}} \cdot A_{22}}{A_2} \Rightarrow z_{Px_2} = \frac{\frac{1}{2} \cdot 3,87 \cdot (3,87 \cdot (6,93 - 3,87)) + \frac{1}{3} \cdot 3,87 \cdot (3,87)^2 : 2}{19,33}$

$\Rightarrow z_{Px_2} = 1,69\ m$

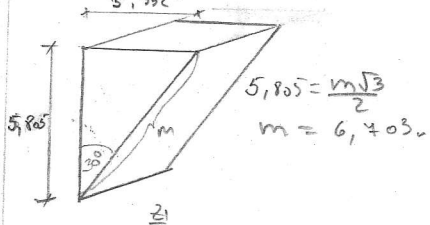
$P_{x_1} = \rho_1 g L \Omega x_1 = \rho_1 g \cdot L \cdot \frac{z_1^2}{2} \Rightarrow \boxed{P_{x_1} = 29834,115 z_1^2}, \quad z_{Px_1} = \frac{z_1}{3}$

- ВЕРТИКАЛНА КОМПОНЕНТА



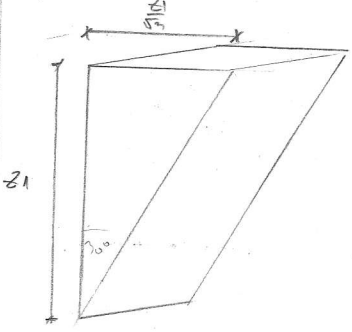
$3,87 = \frac{K\sqrt{3}}{2}$
$K = 4,47\ m$
$\frac{K}{2} = 2,234$

$V_\nabla = \frac{3,87 \cdot 2,234}{2} \cdot 5,53 = 23,91\ m^3$
$V_\square = 2,234 \cdot 3,06 \cdot 5,53 = 37,78\ m^3$
$V_2 = V_\nabla + V_\square = 61,71\ m^3$
$P_{z_2} = \rho_2 g \cdot V_2 \Rightarrow \boxed{P_{z_2} = 871740,144\ N}$
$x_2 = \frac{(\frac{1}{3} \cdot 2,234) \cdot 23,91 + (\frac{1}{2} \cdot 2,234) \cdot 39,6}{63,51}$
$x_2 = 0,977\ m$



$5,805 = \frac{m\sqrt{3}}{2}$
$m = 6,703\ m$

$V_3 = \frac{5,805 \cdot 3,352}{2} \cdot 5,53 = 53,49\ m^3$
$P_{z_3} = \rho_3 g \cdot V_3 \Rightarrow \boxed{P_{z_3} = 401036,72\ N}$
$x_3 = \frac{K}{2} + \frac{3,352}{3} \Rightarrow x_3 = 3,351$



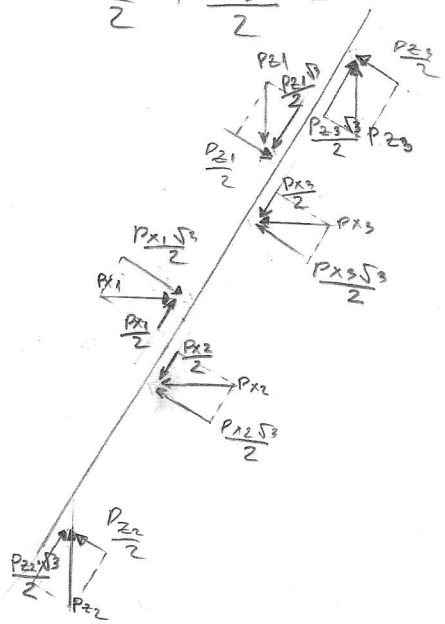
$V_1 = \frac{z_1^2}{2\sqrt{3}} \cdot 5,53 \Rightarrow V_1 = 1,596 \cdot z_1^2$

$P_{z_1} = \rho_1 g \cdot V_1 \Rightarrow \boxed{P_{z_1} = 17226,47\ z_1^2}$

$x_1 = \frac{1}{3} \frac{z_1}{\sqrt{3}} = 0,192 z_1$

$\sum N = 0$

$$\frac{P_{z2}\sqrt{3}}{2} - \frac{P_{x2}}{2} + \frac{P_{x1}}{2} - \frac{P_{x3}}{2} - \frac{P_{z1}\sqrt{3}}{2} + \frac{P_{z3}\sqrt{3}}{2} = 0$$



$754949,101 - 755020,055 + 14918,556 \cdot z_1^2 - 14918,5575 z_1^2 - 347337,91 + 347307,99 = 0$

$-100,865 + ? = 0$

$\sum T = 0$

$$\frac{P_{z2}}{2} + \frac{P_{x2}\sqrt{3}}{2} + \frac{P_{x3}\sqrt{3}}{2} + \frac{P_{z3}}{2} = \frac{P_{x1}\sqrt{3}}{2} + \frac{P_{z1}}{2}$$

$$2545728,436 = 2539,69 \cdot z_1^2 + 8613,23 \cdot z_1^2$$

$$\Rightarrow \boxed{z_1 = 8,59\,m}$$

$P_{x1} = 2201624,025\,N$

$P_{z1} = 1271108,49\,N$