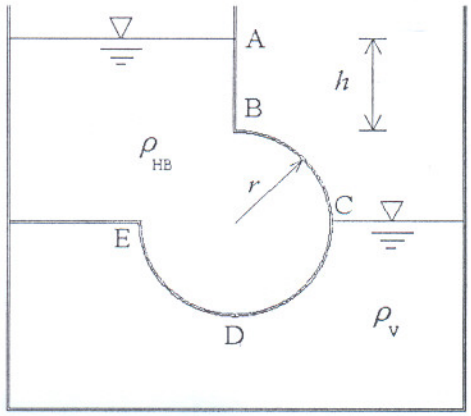
ISPIT IZ HIDROMEHANIKE 11.11.2010.

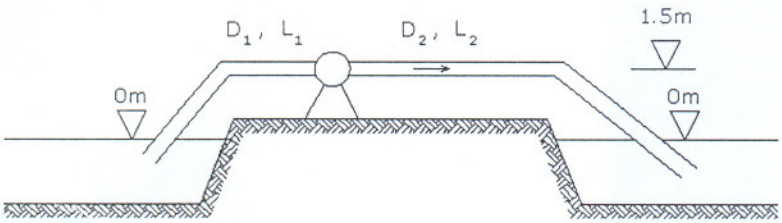
1) Odredite horizontalnu i vertikalnu komponentu sile kojom hidrotehnički beton djeluje na oplatu od točke A do točke E. Potrebno je i nacrtati vertikalne i horizontalne komponente dijagrama rasporeda tlakova po konturama od točke A do točke E.

Zadano: $\rho_{HB} = 2500 kg/m^3$; $\rho_V = 1000 kg/m^3$; $r = 4.5 m$; $h = 6 m$. (20 bodova)



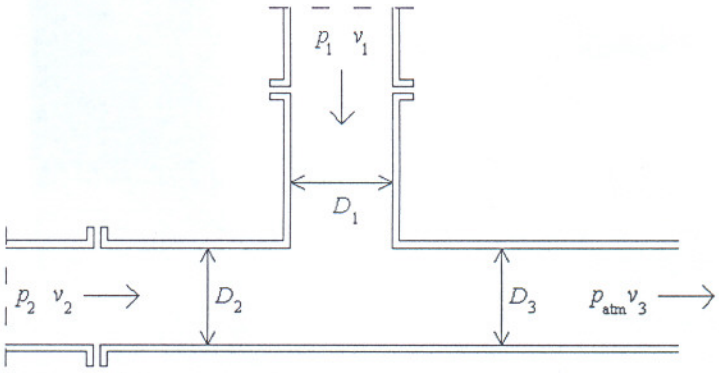
2) Za sistem na slici treba proračunati snagu pumpe koja ostvaruje tečenje vode iz lijevog rezervoara u desni i nacrtati energetsku i piezometarsku liniju. Također je potrebno odrediti minimalni tlak u cjevovodu i označiti mjesto gdje se pojavljuje. (25 bodova)

Zadano je: $D_1 = 100$ mm ; $D_2 = 60$ mm ; $Q = 0.015 m^3/s$; $L_1 = 10$ m ; $L_2 = 15$ m ; $\nu = 1.01*10^{-6} m^2/s$; $\varepsilon = 0.2$ mm; $\zeta_{UL} = 0.7$; $\zeta_{KOLJ} = 0.15$; $\eta_P = 0.8$



3) Potrebno je odrediti ukupnu silu kojom voda djeluje na račvu položenu u horizontalnoj ravnini. Težinu vode zanemariti.

Zadano je: $D_1 = 0.3$m ; $D_2 = D_3 = 0.5$m ; $p_1 = p_2$ (u osima cijevi) = 4.0kPa ; $v_1 = 4$m/s ; $v_2 = 2$ m/s. (20 bodova)



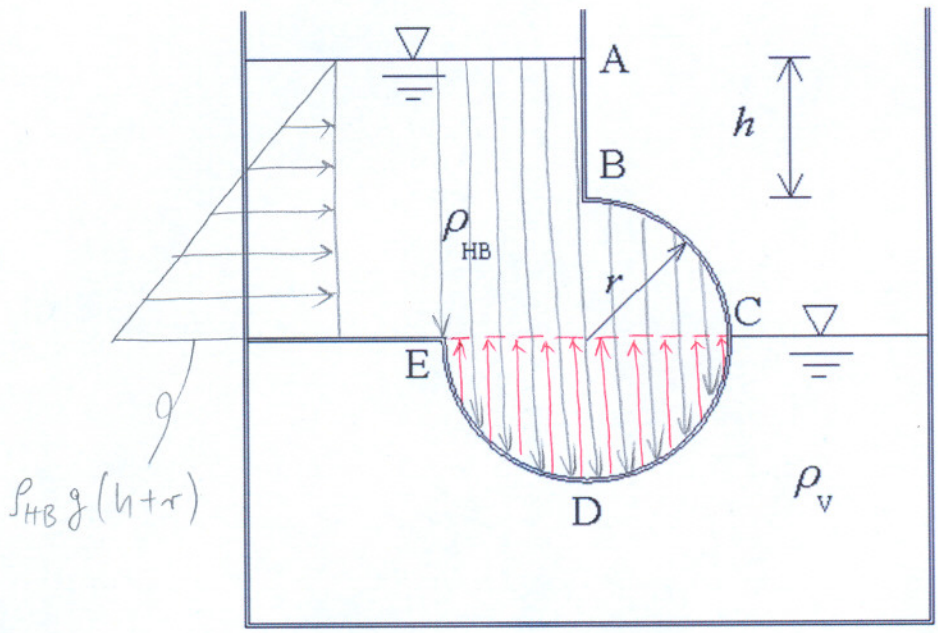
4) Hidraulički model preljeva izrađen je u mjerilu $\lambda = 140$. Uz pretpostavku zanemarivanja viskoznih djelovanja potrebno je odrediti koje će se brzine i protoci pojaviti u prirodi ako su na modelu izmjerene sljedeće vrijednosti: $v_m = 0.8$ m/s; $Q_m = 0.09 m^3/s$. (20 bodova)

TEORIJA (15 bodova) :

1. Što je to strujna linija?
2. Napišite Darcyjev zakon i objasnite članove.
3. Napišite i objasnite zakon održanja količine gibanja.
4. Riječima i grafički opišite Arhimedov zakon.

Obavezno riješiti 1. i 2. zadatak

(1)



— Rezultantni dijagram djelovanja hidrotehničkog betona A-E

— Rezultantni dijagram djelovanja vode A-E

$$F_{AE}^{y} = -\rho_{HB} \cdot g \left[(h+r) \cdot r + \frac{3}{4} r^2 \pi \right] + \rho_V \cdot g \left[\frac{r^2 \pi}{2} \right]$$

$$= -2{,}5 \cdot 9{,}81 \left(10{,}5 \cdot 4{,}5 + \frac{3}{4} \cdot 4{,}5^2 \pi \right) + 1 \cdot 9{,}81 \left(\frac{4{,}5^2 \pi}{2} \right)$$

$$= -2328{,}97 + 312{,}04$$

$$= -2016{,}93 \ kN$$

$$F_{AE}^{x} = \rho_{HB} \cdot g \cdot (h+r)^2 \cdot \frac{1}{2}$$

$$= 2{,}5 \cdot 9{,}81 \cdot 10{,}5^2 \cdot \frac{1}{2}$$

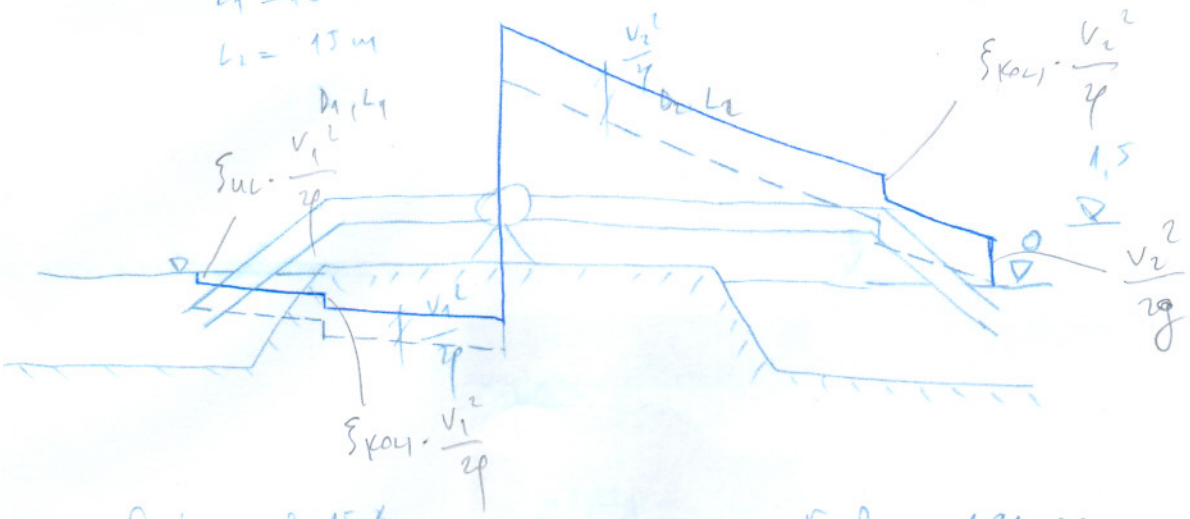
$$= 1351{,}94 \ kN$$

(2)

$Q = 0{,}015\ m^3/s$

$L_1 = 10\ m$

$L_2 = 15\ m$



$$v_1 = \frac{Q \cdot 4}{D_1^2 \pi} = \frac{0{,}015 \cdot 4}{0{,}1^2 \cdot \pi} = 1{,}91\ m/s \quad ; \quad Re_1 = \frac{v_1 \cdot D_1}{\nu} = \frac{1{,}91 \cdot 0{,}1}{1{,}01 \cdot 10^{-6}} = 1{,}9 \cdot 10^5$$

$$v_2 = \frac{Q \cdot 4}{D_2^2 \pi} \cdot \frac{0{,}015 \cdot 4}{0{,}06^2 \cdot \pi} = 5{,}3\ m/s \quad ; \quad Re_2 = \frac{v_2 \cdot D_2}{\nu} = \frac{5{,}3 \cdot 0{,}06}{1{,}01 \cdot 10^{-6}} = 3{,}1 \cdot 10^5$$

$$\frac{\varepsilon}{D_1} = \frac{0{,}2}{100} = 0{,}002 \rightarrow \lambda_1 = 0{,}025$$

$$\frac{\varepsilon}{D_2} = \frac{0{,}2}{60} = 0{,}003 \rightarrow \lambda_2 = 0{,}022$$

$$H_p = \frac{v_1^2}{2g}\left(\zeta_{ul} + \zeta_{kol} + \lambda_1 \frac{L_1}{D_1}\right) + \frac{v_2^2}{2g}\left(\zeta_{kol} + \lambda_2 \frac{L_2}{D_2} + 1\right)$$

$$H_p = 0{,}186\,(0{,}7 + 0{,}15 + 2{,}5) + 1{,}43\,(0{,}15 + 6{,}75 + 1)$$

$$= 0{,}62 + 11{,}3$$

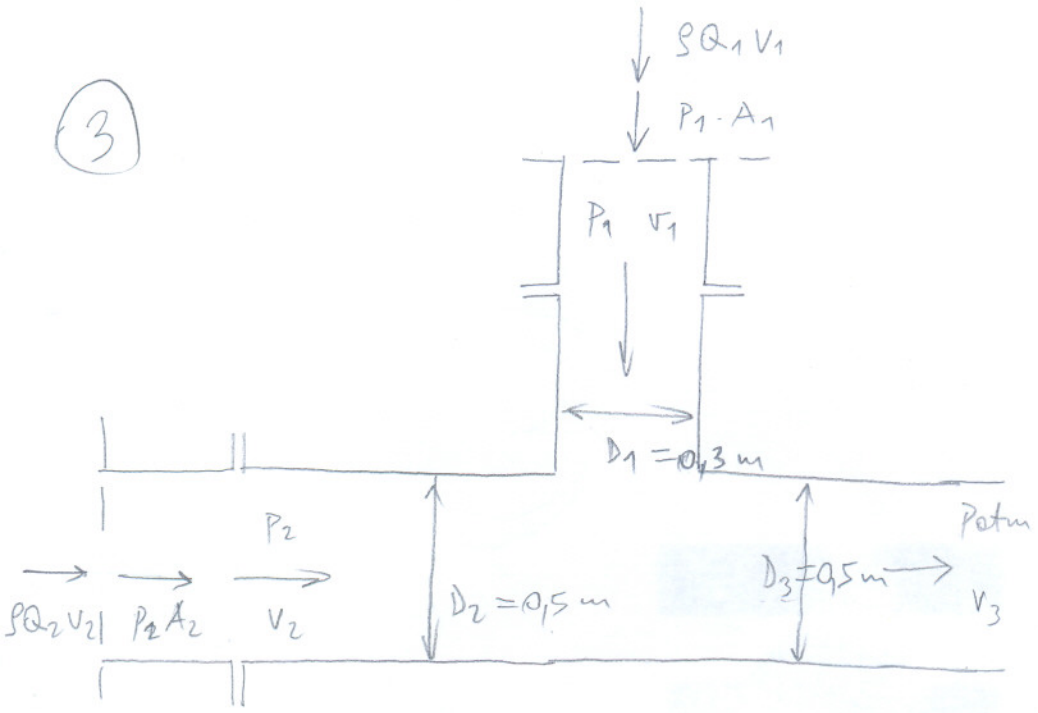
$$= 11{,}92\ m$$

$$N_p = \frac{\rho g Q H_p}{\eta} = 2{,}19\ kW$$

$$p_{min} = \left(0 - \frac{v_1^2}{2g}\left(\zeta_{ul} + \zeta_{kol} + \lambda_1 \frac{L_1}{D_1} + 1\right) - 15\right) \cdot \rho \cdot g = -2{,}306 \cdot \rho \cdot g$$

$$= -22{,}62\ kPa \quad \text{(injred pumpe)}$$

(3)



$P_1 = P_2 = 4\ kPa$

$V_1 = 4\ m/s$

$V_2 = 2\ m/s$

$$Q_1 = A_1 \cdot v_1 = \frac{D_1^2 \pi}{4} \cdot V_1 = \frac{0,3^2 \pi}{4} \cdot 4 = 0,283\ m^3/s$$

$$Q_2 = A_2 \cdot V_2 = \frac{D_2^2 \pi}{4} \cdot V_2 = \frac{0,5^2 \pi}{4} \cdot 2 \quad 0,393\ m^3/s$$

$$Q_3 = Q_1 + Q_2 = 0,676\ m^3/s$$

$$V_3 = \frac{Q_3}{A_3} = \frac{4 \cdot 0,676}{0,5^2 \pi} = 3,44\ m/s$$

$$F_{RAC}^{X} = +\rho Q_2 V_2 + p_2 A_2 - \rho Q_3 V_3$$

$$= 0,393 \cdot 2 + 4 \cdot 0,196 - 0,676 \cdot 3,44$$

$$= -0,755\ kN$$

$$F_{RAC}^{Y} = -0,283 \cdot 4 - 4 \cdot 0,071 = -1,416\ kN$$

(4)

$\lambda = 140$

$v_m = 0{,}8\ m/s$

$Q_m = 0{,}09\ m^3/s$

$Fr_p = Fr_m$

$$\frac{v_p}{\sqrt{g \cdot L_p}} = \frac{v_m}{\sqrt{g \cdot L_m}} \rightarrow \frac{v_p}{v_m} = \sqrt{\frac{L_p}{L_m}} = \sqrt{\lambda} = \sqrt{140} = 11{,}83$$

$v_p = v_m \cdot 11{,}83$

$= 0{,}8 \cdot 11{,}83$

$= 9{,}47\ m/s$

$$\frac{Q_p}{Q_m} = \frac{A_p \cdot v_p}{A_m \cdot v_m} = \frac{A_p}{A_m} \cdot \frac{v_p}{v_m}$$

$$\frac{Q_p}{Q_m} = \lambda^2 \cdot \sqrt{\lambda}$$

$Q_p = \lambda^2 \cdot \sqrt{\lambda} \cdot Q_m$

$= 140^2 \cdot \sqrt{140} \cdot 0{,}09\ m^3/s$

$= 208{,}19\ m^3/s$