1

PVC $\varnothing = 70\ mm \Rightarrow r = 35\ mm$

$C = 150$

$L = 200\ m$

$Q = 18000\ L\,h^{-1}$

F. Hazen-Williams:

$$\boxed{v = 0{,}849\, C R^{0{,}63}\, j^{0{,}54}}$$

j → p.c. un

1) a) $v = ?$

$$Q = A \cdot v \Rightarrow v = \frac{Q}{A}$$

$$A = \pi \left(\frac{70 \times 10^{-3}}{2}\right)^2 = 3{,}85 \times 10^{-3}\ m^2 = 0{,}00385\ m^2$$

$$\Rightarrow v = 18000\ \cancel{dm^3} \times \frac{10^{-3}\ m^3}{1\ \cancel{dm^3}}\ h^{-1} \Big/ 3{,}85 \times 10^{-3}\ m^2$$

$$v = \frac{18000 \times \cancel{10^{-3}}}{3{,}85 \times \cancel{10^{-3}}}\ \frac{m^3}{m^2} \cdot h^{-1}$$

$$v = \frac{18 \times 10^3}{3{,}85}\ m \cdot \frac{1}{\cancel{h}} \cdot \frac{1\cancel{h}}{3600\ s} = 1{,}298$$

$$\approx 1{,}3\ m\,s^{-1}$$

b) p.c. unit.

$$v = 0{,}849\ C R^{0{,}63} \cdot j^{0{,}54}$$

j → p.c. unit.

$$1{,}3 = 0{,}849 \cdot 150 \times 0{,}0175^{0{,}63} \cdot j^{0.54}$$

$$R\,(\text{raio hid.}) = \frac{r}{2} = \frac{0{,}035}{2} = 0{,}0175\ m$$

$$\Leftrightarrow j^{0{,}54} = 0{,}1306 \Leftrightarrow \left(j^{\cancel{0{,}54}}\right)^{1/\cancel{0{,}54}} = 0{,}1306^{1/0{,}54}$$

$$\Leftrightarrow j = 0{,}023\ m \cdot m^{-1}$$

c) $L = 200\ m$

$$J = j \times L = 0{,}023 \times 200 = 4{,}6\ m$$

② Poucas singularidades $\Rightarrow$ 2º método : Simplificado

$\downarrow$ assumir que as p.c. sing. tomam um valor em % de J (perdas de c. contínuas)

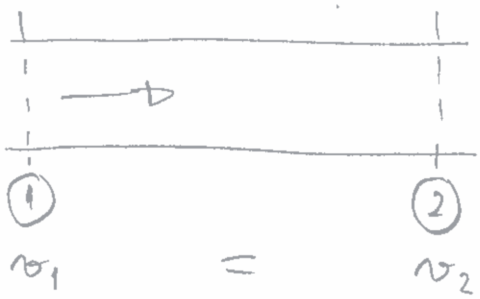
p. ex.: 15%

$$\Sigma h_s = 0{,}15 \times 4{,}6 = 0{,}69\,m$$

Perda de carga total (H):

$$H = J + \Sigma h_s = 4{,}6 + 0{,}69 = 5{,}29\,m$$

③ a) $\frac{p_1}{\gamma} = 36\,m$; tubo horizontal



$\frac{p_2}{\gamma} = ?$

$v_1 = v_2$ pq. ϕ é =

(lei da continuidade $A_1 v_1 = A_2$ logo $A_1 = A_2$; $\phi_1 = \phi_2$)

$\Delta N = 0$ (pq. o tubo é horizontal)

$z_1 = z_2$

$\downarrow$

O desnível é zero

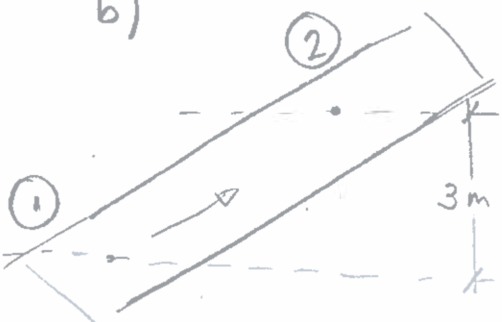
Aplicando a Eq. Bernoulli :

$$H_1 = H_2 + \Delta H_{1-2}$$

$$\frac{p_1}{\gamma} + \cancel{\frac{v_1^2}{2g}} + \cancel{z_1} = \frac{p_2}{\gamma} + \cancel{\frac{v_2^2}{2g}} + \cancel{z_2} + \Delta H_{1-2}$$

$$36 = \frac{p_2}{\gamma} + 5{,}29\,m \Rightarrow \frac{p_2}{\gamma} = 30{,}7\,m$$

b)



$\frac{p_1}{\gamma} = 36\,m$, tubo inclinado c/ $\Delta N = 3\,m$

$\frac{p_2}{\gamma} = ?$

Eq. Bernoulli :

$$H_1 = H_2 + \Delta H_{1-2}$$

$$\frac{p_1}{\gamma} + \cancel{\frac{v_1^2}{2g}} + z_1 = \frac{p_2}{\gamma} + \cancel{\frac{v_2^2}{2g}} + z_2 + \Delta H_{1-2}$$

$$36 + 0 = \frac{p_2}{\gamma} + 3 + 5{,}29$$

$$\Leftrightarrow \frac{p_2}{\gamma} = 27{,}7\,m$$

EXERC. II

$\Delta H = J' + \Sigma h_s$

$J' = J \times F$

PVC
Utilizámos a f. H-W
p/ calcular J

$L = 200 m$

$N = 100$ saídas → igual/espaçadas $\Rightarrow l_0 = 1$ → $\beta = 1{,}85$, $n = 100$ ⇓ $F = 0{,}356$

$\Delta H = ?$

$J = 4{,}6 m$

$J' = 4{,}6 \times 0{,}356 = 1{,}64 m$

$\Sigma h_s = \% J'$

$\Sigma h_s = 0{,}20 \times 1{,}64 = 0{,}32 m$

↓

> * pq. cd. saída introduz uma perda de carga singular (20% - redes médias)

* do q/ c/ Q contínuo

$\Delta H = 1{,}64 + 0{,}32 = \boxed{1{,}96 m}$

III

$L = 50\,m$

PVC

$\varnothing = 50\,mm$

$\frac{p}{\gamma}_{aspersor} = 20\,m$

$h_{cana} = 2\,m$

$\eta = 70\%$

$H_{mt} = ?$

$P_e = ?$

$P_b = ?$

$H_1 = H_2 + \Delta H - H_{mt}$

$H_1 \begin{cases} v_1 = 0 & \text{(res. gds. dims.)} \\ \frac{p_1}{\gamma} = 0 & \text{(pr. atm)} \\ z_1 = 0 & \text{(referencial)} \end{cases}$

$H_2 \begin{cases} v_2 = \text{desprezar} \\ \frac{p_2}{\gamma} = 20\,m & \text{(alt. piez. aspersor)} \\ z_2 = 4+2 = 6\,m \end{cases}$

Cálculo das perdas de carga entre ① e ②: (ΔH)

F. H-W (aspersão)

$$\boxed{v = 0{,}849\, C R^{0{,}63} j^{0{,}54}}$$

$v = Q/A = 0{,}0017 / 0{,}001963 = 0{,}849\ m\,s^{-1}$

$Q = 6\,m^3 h^{-1} \times \frac{1h}{3600} = 0{,}0017\ m^3 s^{-1}$

$A = \pi \left(\frac{50 \times 10^{-3}}{2}\right)^2 = 0{,}001963\ m^2$

$C = 150$ (PVC)

$R = \frac{r}{2} = \frac{25}{2} = 12{,}5$

$0{,}849 = 0{,}849 \cdot 150 \cdot 0{,}0125^{0{,}63} \times j^{0{,}54}$

$\Leftrightarrow j = 0{,}0155\ m\,m^{-1}$

$J = j \times L = 0{,}0155 \times 50 = 0.776\,m$

$\Sigma h_s = 0.15 \times 0{,}776 = 0{,}1164\ m$

$\hookrightarrow \Delta H = J + \Sigma h_s = 0.776 + 0.1164 = 0{,}89\,m$

Eq. Bernoulli:

alt. manométrica total (H_{mt}):

$0+0+0 = 0 + 20 + 6 + 0{,}89 - H_{mt} \Leftrightarrow H_{mt} = 27\,m$

$$Pe = Q \gamma H_{mt} = 0.0017 \times 9800 \times 27 = 450 W$$

$$\gamma = \rho \cdot g = 1000 \times 9{,}8 \ N m^{-3}$$

$$P_b = \frac{Pe}{\eta} = \frac{450}{0{,}7} = 645 W$$