King Saud University
Collage of Engineering
Civil Engineering Department

CE 441, CE 447

Water supply and drainage systems

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Tutorial No.3

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Problem 1

Given: D_1= 350 mm P_1= 120 psi V_1= 6 m/s

D_2= 150 mm P_2 ?

No friction head loss, h_L= 0

Solution

$$\text{Bernoulli's equation: } \frac{P_1}{\gamma}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}+Z_2+h_L$$

The pipe is horizontally connected ➔ $Z_1 = Z_2$

To find V_2 using continuity equation:

$$Q_1 = Q_2$$
$$V_1 A_1 = V_2 A_2$$

$V_1 (\pi D_1^2)/4 = V_2 (\pi D_2^2)/4$

$V_2 = (D_1^2/ D_2^2) V_1 = (0.35^2/ 0.15^2) (6) = 32.7$ m/s

$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}$$

$$\frac{120}{1.43}+\frac{6^2}{2(9.81)}=\frac{P_2}{1.43}+\frac{(32.7)^2}{2(9.81)}$$

P_2 = 45 psi

Problem 2

Given: P_1= 350 kpa Z_1= 0

P_2 ? Z_1= 9 m h_L= 150 kpa

Solution

$$\frac{P_1}{\gamma}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\gamma}+\frac{V_2^2}{2g}+Z_2+h_L$$

There is no change in velocity head ➔ $V_1= V_2$

$$\frac{P_1}{\gamma}+Z_1=\frac{P_2}{\gamma}+Z_2+h_L$$

h_L= 150 kpa = (150/ 9.81) m

$$\frac{350}{9.81}+0=\frac{P_2}{9.81}+9+\frac{150}{9.81}$$

$P_2 = 111.71$ kpa

Problem 4 (equivalent length)

<u>Solution</u>

(a)

pipe in series ➔

$Q_{eq} = Q_1 = Q_2 = Q_3$

$h_{f\,eq} = h_{f\,1} + h_{f\,2} + h_{f\,3}$

$K_e = K_1 + K_2 + K_3$

pipe in Parallel ➔

$Q_{eq} = Q_1 + Q_2 + Q_3$

$h_{f\,eq} = h_{f\,1} = h_{f\,2} = h_{f\,3}$

$$\left(\frac{1}{K_e}\right)^{0.54}=\left(\frac{1}{K_1}\right)^{0.54}+\left(\frac{1}{K_2}\right)^{0.54}+\left(\frac{1}{K_3}\right)^{0.54}$$

Hazen-Williams equation

$h_f = K\,Q^{1.85}$,where $K=\frac{10.7L}{C^{1.85}D^{4.87}}$

$$\left(\frac{1}{K_e}\right)^{0.54}=\left(\frac{(140)^{1.85}(0.1)^{4.87}}{10.7(174)}\right)^{0.54}+\left(\frac{(80)^{1.85}(0.15)^{4.87}}{10.7(274)}\right)^{0.54}+\left(\frac{(100)^{1.85}(0.2)^{4.87}}{10.7(366)}\right)^{0.54}$$

$$\left(\frac{1}{K_e}\right)^{0.54} = 5.6\,(10^{-3}) + 7.28\,(10^{-3}) + 0.0166 = 0.029$$

$K_e = 678.2$

To find equivalent length

$$678.2=\frac{10.7L_{eq}}{(100)^{1.85}(0.3)^{4.87}} \quad => \quad L_{eq} = 903 \text{ m}$$

(b)

$h_f = K\,Q^{1.85}$

$h_f = 678.2\,(0.19)^{1.85} = 31.4$ m

(c)

$$h_f = K\,Q^{1.85} \quad \Rightarrow \quad Q = \left(\frac{h_f}{K}\right)^{\frac{1}{1.85}}$$

where $h_{f\,1} = h_{f\,2} = h_{f\,3}$

$$Q_1 = \left(\frac{31.4}{1/(5.6(10^{-3}))^{1.85}}\right)^{0.54} = 0.036 \text{ m}^3/\text{s}$$

$$Q_2 = \left(\frac{31.4}{1/(7.28(10^{-3}))^{1.85}}\right)^{0.54} = 0.047 \text{ m}^3/\text{s}$$

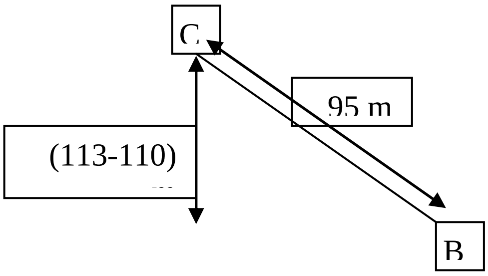
$$Q_3 = \left(\frac{31.4}{1/(0.0166)^{1.85}}\right)^{0.54} = 0.107 \text{ m}^3/\text{s}$$

Problem 5

Solution

$$\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_E}{\gamma} + \frac{V_E^2}{2g} + Z_E + h_{LAE}$$

$$Z_E = 110 + \frac{(113-110)}{95}(30) = 110.95 \text{ m}$$



$$h_{f\,AE} = h_{f\,AB} + h_{f\,BE}$$

$$= K_{AB}\,Q^{1.85} + K_{AB}\,Q^{1.85} \quad , \quad K = \frac{10.7L}{C^{1.85}D^{4.87}}$$

$$= \left[\frac{10.7(140)}{(120)^{1.85}(0.15)^{4.87}} + \frac{10.7(30)}{(120)^{1.85}(0.2)^{4.87}}\right](0.015)^{1.85}$$

$$= [2195.14 + 115.88]\,(0.015)^{1.85}$$

$$= 0.98 \text{ m}$$

$$\frac{70}{1.43} + 100 = \frac{P_E}{1.43} + 110.95 + 0.98$$

P_E = 52.9 psi