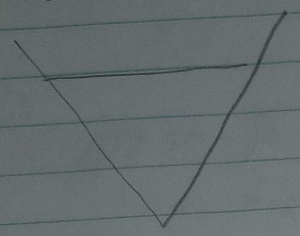
1 of

Foster Grubbs

Test 3 Problem 3

Purpose) - Design a triangular channel to be made of formed unfinished concrete to carry $5.75\ m^3/s$ of water when laid on a 1.2 percent slope

Drawings + Diagrams)



Sources) Mott R, Untener, J.A. "Applied Fluid Mechanics" 7th edition Pearson Education Inc. (2015)

Design Considerations)
- Incompressible Fluid
- Steady State
- Isothermal problem

Data + Variables)

$Q = 5.75\ m^3/s$

$S = 1.2\%$ slope $= 0.012$

$n = 0.017$

Foster Brubb

Test 3 Problem 3

Procedure + calculations

1) From the book, for designing an open channel's dimensions, you must use the following equation

$$\frac{nQ}{S^{1/2}} = AR^{2/3}$$

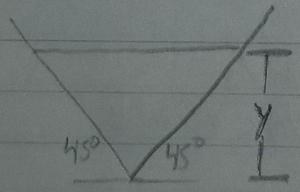
where $A = y^2$ and $R = 0.354y$ since we are designing a triangular channel

2) Plugging in known values into new equation

$$\frac{(0.017)(5.75\,m^3/s)}{(0.012)^{1/2}} = (y^2)(0.354y)$$

$$0.8923 = (y^2)(0.354y)$$

$$\boxed{y = 1.3609\,m}$$



Summary: the height of the triangle must be at least 1.3609 m.

Material: • concrete
- water

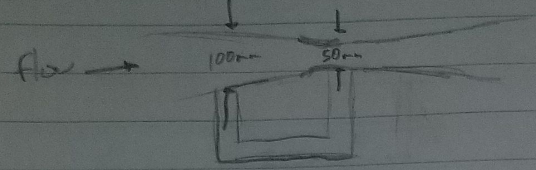
Analysis: After working and modifying one of the examples out of the book, this problem was much easier to solve

Foster Grubbs

Test 3 Problem 5

Purpose - calculate volume flow rate in a certain venturi meter.

Drawings + Diagrams



Sources

Mott, R. Untener, J.A. "Applied Fluid Mechanics", 7th edition, Pearson Education Inc. (2015)

Design Considerations

- Incompressible fluid
- Steady State
- Isothermal problem

Data + Variables

$D_1 = 100mm = 0.1m$

$D_2 = 50mm = 0.05m$

$T_w = 80°C$

$\Delta p = 55 kPa$

γ of water @ $80° = 9.53 kN/m^3$

$\nu = 3.6 \times 10^{-7} m^2/s$ (from table)

$C = 0.984$

Foster Gibbs

Test 3 Problem 5

Procedure and calculations

1) Given the diameter of both sections, the area can be calculated

$D_i = 0.1 m$ $\qquad$ $D_t = 0.05 m$

$A_i = \frac{\pi D_i^2}{4}$ $\qquad$ $A_t = \frac{\pi D_t^2}{4}$

$A_i = 0.00785 m^2$ $\qquad$ $A_t = 0.00196 m^2$

2) Velocity of flow calculation

$$v_1 = C\sqrt{\frac{2g(\Delta p)/\gamma}{(A_1/A_2)^2 - 1}}$$

$$= 0.984\sqrt{\frac{(2(9.81 m/s^2)(55 kPa))/(9.53)}{(0.00785 m^2/0.00196 m^2)^2 - 1}}$$

$$= 0.984\sqrt{\frac{113.232}{15}}$$

$$v_1 = 2.70 m/s$$

3) checking C

$$N_R = \frac{v_1 D_i}{\nu}$$

$$= \frac{(2.70 m/s)(0.1 m)}{3.6\times10^{-7} m^2/s}$$

$$N_R = 7.5\times10^5$$

$N_R > 2\times10^5$ ∴ C is correct

Foster Gubbs

Test 3 Problem 5

4) calculating Flow rate

$$Q = A_1 V_1$$

$$= (7.854 \times 10^{-3}\, m^2)(2.70\, m/s)$$

$$\boxed{= 2.12 \times 10^{-2}\, m^3/s}$$

Summary

The volume flow rate under the circumstances is $2.12 \times 10^{-2}\, m^3/s$

Materials

- Venturi meter
- Water

Analysis

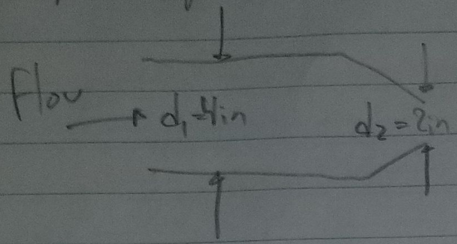
The Volume flow rate makes sense for this problem as it is a relatively small venturi tube.

Foster Grubbs

Test 3 Problem 6

Purpose - Calculate the force exerted by the water on the nozzle

Drawings & Diagrams



Sources

Mott, R, Untener, J.A. "Applied Fluid Mechanics" 7th edit
Pearson Education Inc. (2015)

Design Considerations

- Incompressible fluid
- Steady State
- Isothermal problem

Data & Variables

$d_1 = 4in = 0.3 ft$
$d_2 = 2in = 0.1\bar{6} ft$
$K = 0.12$
$V_2 = 80 ft/s$

$\rho = 1.94 lb/ft^3$
$\gamma = 62.4 lb/ft^3$
$g = 32.2 ft/s^2$

Foster Gubbs

Test 3 Problem 6

Procedure + Calculations

1) First, the area of both the pipe and nozzle must be calculated.

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \left(\frac{4}{12}\right)^2}{4}$$

$$A_1 = 0.0873 ft^2$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \left(\frac{2}{12}\right)^2}{4}$$

$$A_2 = 0.0218 ft^2$$

2) Knowing the area of the nozzle and the velocity of its exit, the flow rate at the nozzle can be calculated.

$$Q = AV$$
$$= (0.0218 ft^2)(80 ft/s)$$

$$Q = 1.745 ft^3/s$$

3) Since the fluid is incompressible, we can use the continuity equation to determine velocity in the tube.

$$A_1 V_1 = A_2 V_2$$

$$(0.0873 ft^2)(V_1) = (0.0218 ft^2)(80 ft/s)$$

$$V_1 = 19.977 ft/s$$

Foster Gubbles

Test 3 Problem 6

4) The equation for energy loss due to a sudden contraction is $h_L = k \times \frac{V_A^2}{2g}$

$$h_L = .12 \times \frac{80^2}{2 \times 32.2}$$

$$= .12 \times \left(\frac{6400}{64.4}\right)$$

$$= .12 \times 99.38$$

$$h_L = 11.925 \text{ ft}$$

5) Using the equation $\frac{P_A}{\gamma} + Z_A + \frac{V_A^2}{2g} - h_L = \frac{P_B}{\gamma} + Z_B + \frac{V_B^2}{2g}$

pressure in the hose can be calculated.

Rearranging the equation, we get

$$P_A = \cancel{P_B}^{0} + \gamma\left(\cancel{(Z_A - Z_B)}^{0} + \frac{(V_B^2 - V_A^2)}{2g} + h_L\right)$$

Z_A and Z_B are irrelevant to the equation

$$P_1 = \gamma\left(\frac{(V_B^2 - V_A^2)}{2g} + h_L\right)$$

$$= 62.4\left(\frac{(80 \text{ ft/s})^2 - (19.977 \text{ ft/s})^2}{2 \times 32.2 \text{ ft/s}^2} + 11.925 \text{ ft}\right)$$

$$P_1 = 6558.68 \text{ lb/ft}^2$$

Foster Grubbs

Test 3 Problem 6

6) The equation $F = \rho Q(v_2 - v_1) + p_1 A_1 - \cancel{p_2 A_2}$ can be used to calculate the force exerted by the water on the nozzle.

$$F = (1.94)(1.745\,ft^3/s)\left((-80\,ft/s) - (-19.977\,ft/s)\right) +$$
$$(6558.68\,lb/ft^2)(0.0873\,ft^2)$$

$$\boxed{F = 369.38\,lb}$$

Summary

The force exerted on the hose by the water is 369.38 lb.

Materials

- Hose
- Nozzle
- Water

Analysis