University of Johannesburg

Department of Civil Engineering Science

UNIVERSITY OF JOHANNESBURG

Urban Hydraulics 3A **July Examination** **July 2014**

EXAMINER
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Total marks: 100 points
Time: 180 minutes
Answer <u>all</u> questions

Calculators are allowed

Question 1

a) Sketch the hydraulic grade line (dashed line) and the total energy line (solid line) for two series pipes connecting two reservoirs. The first half of the connection pipes has a larger diameter than the second half. Include secondary losses at the inlet, outlet and where the diameter size changes. [5 marks]

b) Rewrite the Darcy-Weisbach equation in terms of Q rather than V, and solve for D. This is the equation required for determining the pipe diameter in practical pipeline design. [6 marks]

c) Two pipes, A and B are connected in series to link two reservoirs in a water supply system. Pipe A has a diameter of 350 mm, length of 3.4 km and roughness, $\varepsilon = 0.1$ mm, while pipe B has a diameter of 250 mm, length of 1.8 km and roughness, $\varepsilon = 1$ mm. If the flow rate is 100 ℓ/s, determine the equivalent length of pipe C with diameter of 310 mm and roughness, $\varepsilon = 0.4$ mm. [12 marks]

d) Describe briefly different methods used to mitigate surge in pipes. [6 marks]

Question 2

Using the Hardy Cross method with two iterations for the square loop shown in Figure Qn 2, calculate:

a) the flow rates in all the pipes. [20 marks]
b) the pressure heads at points B, C and D, if the pressure head at A is 70 m, and A, B, C and D have the same elevations. [6 marks]

All pipes are 1 km long and 300 mm in diameter, with roughness of 0.03 mm and kinematic viscosity of 1.14×10^{-6} m^2/s. Use Barr's equation in estimating your friction factors.

Formula Sheet Hydraulic Engineering 3A

$$z_1 + h_1 + \frac{V_1^2}{2g} + h_p = z_2 + h_2 + \frac{V_2^2}{2g} + h_f + h_s + h_t$$

$$Re = \frac{\rho V D}{\mu}$$

$$y_v = 14 \times \frac{D}{Re\sqrt{f}}$$

$$z_1 + h_1 + \frac{V_1^2}{2g} = z_2 + h_2 + \frac{V_2^2}{2g}$$

$$y_t = 184 \times \frac{D}{Re\sqrt{f}}$$

$$\frac{1}{\sqrt{f}} = 2\log\left(\frac{Re\sqrt{f}}{2.51}\right)$$

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon}{3.7D} + \frac{2.51}{Re\sqrt{f}}\right)$$

$$\frac{1}{\sqrt{f}} = 2\log\left(\frac{3.7D}{\varepsilon}\right)$$

$$\frac{V_p}{V_{max}} = \left(\frac{2y}{D}\right)^{1/n}$$

$$\frac{1}{\sqrt{f}} = -1.8\log\left[\left(\frac{\varepsilon}{3.7D}\right)^{1.11} + \frac{6.9}{Re}\right]$$

$$\alpha = 1 + 2.7f$$

$$h_f = \frac{fLV^2}{2gD}$$

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon}{3.7D} + \frac{5.74}{Re^{0.9}}\right)$$

$$D_h = \frac{4A}{P}$$

$$\left[\frac{fL}{D^5}\right]_e = \sum_{i=1}^{N}\left[\frac{fL}{D^5}\right]_i$$

$$\frac{1}{\sqrt{f}} = -2\log\left(\frac{\varepsilon}{3.7D} + \frac{5.129}{Re^{0.89}}\right)$$

$$h_s = K\left(\frac{V^2}{2g}\right)$$

$$L_{eq} = \frac{KD}{f}$$

$$Q_1 = 0.5Q_0 + 0.5A(H_{begin} - H_{end})$$

$$A = \frac{1}{KQ_0}$$

$$\left[\sqrt{\frac{D^5}{fL}}\right]_e = \sum_{i=1}^{N}\left[\sqrt{\frac{D^5}{fL}}\right]_i$$

$$NPSHA = H_{abs} + H_s - H_f - H_{sec} - H_{vap}$$

$$P = \frac{\rho g v H}{t} = \rho g Q H$$

$$P_a = \frac{\rho g Q H}{\eta}$$

$$\frac{Q_1}{Q_2} = \left(\frac{D_1}{D_2}\cdot\frac{N_1}{N_2}\right)$$

$$\frac{H_1}{H_2} = \left(\frac{D_1}{D_2}\cdot\frac{N_1}{N_2}\right)^2$$

$$\frac{P_1}{P_2} = \left(\frac{D_1}{D_2}\cdot\frac{N_1}{N_2}\right)^3$$

$$\frac{NPSHR_1}{NPSHR_2} = \left(\frac{N_1}{N_2}\right)^2$$

$$P = A\left[\frac{1-(1+i)^{-n}}{i}\right]$$

$$c = \sqrt{\frac{K}{\rho}}$$

$$PS = \frac{54EI}{D^3} \geq \frac{98950}{D}$$

$$\Delta h = \frac{\Delta p}{\rho g} = \frac{cV_0}{g}$$

$$\Delta h = \frac{\Delta p}{\rho g} = \frac{L}{g}\left(\frac{V_0}{\Delta t}\right)$$

$$\frac{\Delta Y}{D} = 100\left(\frac{D_L K P}{0.149PS + 0.061E'}\right)$$

$$c_e = \sqrt{\frac{1}{\rho\left(\frac{1}{K} + \frac{C_1 D}{TE}\right)}}$$

$$T = \frac{pD}{2fGJ}$$

$$C_D = \frac{1 - exp\left[-2K\tan\theta\left(\frac{H}{B}\right)\right]}{2K\tan\theta}$$

$$W = C_D \rho g B^2$$

$$W = C_C \rho g D^2$$

$$C_C = \frac{exp\left[2K\tan\phi\left(\frac{H}{D}\right)\right] - 1}{2K\tan\phi}$$

$$w = \frac{P(1+IM)}{A}$$

$$W_{total} = wLS_L$$

$$\sigma = \rho g h\frac{1+\sin\phi}{1-\sin\phi} + 2c\sqrt{\frac{1+\sin\phi}{1-\sin\phi}}$$

$$F = 2(pA + \rho QV)\sin\left(\frac{\theta}{2}\right)$$

$$L_e = L + 1.31D$$

$$Q = \frac{ND\sqrt{P}}{70}$$