UNIVERSITY OF SWAZILAND

Faculty of Health Science

Department of Environmental Health Sciences

Final Examination 2007

TITLE OF PAPER	:	WATER DISTRIBUTION AND SEWERAGE
COURSE CODE	:	EHS 544
DURATION	:	3 HOURS
MARKS	:	100
INSTRUCTIONS	:	READ THE QUESTIONS & INSTRUCTIONS CAREFULLY
	:	ANSWER FIVE QUESTIONS: QUESTION 1 AND 2 ARE MULTIPLE CHOICE
	:	EACH QUESTION CARRIES 20 MARKS
	:	NO PAPER SHOULD BE BROUGHT INTO NOR OUT OF THE EXAMINATION ROOM
	:	BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER

DO NOT OPEN THE QUESTION PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR.

172

QUESTION 1

Write true or false for the following statements;

a) The velocity of water in a pipe changes from the pipe boundary to the center of the pipe.

b) The velocity of flow in a pipe is highest in the center and lowest at the boundary

c) Changes in the diameter of a pipeline do not affect the velocity.

d) The flow rate is not affected by changes in pipe diameter.

e) When water in a pipeline flows it loses its potential energy into kinetic energy, however, this change do not result in an increased velocity head.

f) The term $p/\rho g$ stands for pressure energy in the total energy equation.

g) The total energy equation of a system is represented by $p/\rho g + v^2/2g + Z$ (excluding loses and addition of energy into the system)

h) The flow into a node is equal to the flow out of it.

i) The hydraulic gradient line stands for or represents the energy of a system minus loses of the energy along a pipeline.

j) The pressure head, velocity head, and elevation head together give the total head useful in the design of pipe network.

(20 Marks)

QUESTION 2

Write true or false for the following statements;

a) The relationship between pressure and head is utilized for pressure measurement in the manometer or liquid gauge.

b) The maximum gauge pressure of water that can be measured by means of a pyrometer tube 2m high is $19.62 \times 10^3 \, Nm^{-2}$

c) Except in nuclear processes, matter is neither created nor destroyed.

d) According to the principle of continuity of flow, the mass of fluid entering per unit time is equal to the mass of fluid leaving per unit time minus increase of mass of fluid in the control volume per unit time.

e) For the flow of a real fluid through a pipe or other conduit, the velocity will vary from wall to wall.

f) The continuity of flow equation is one of the major tools of fluid mechanics, providing a means of calculating velocities at different points in a system

g) The continuity equation can be applied to determine the relationship between the flow into and out of a junction.

h) For steady conditions, total inflow to a junction is equal to the total outflow from the junction.

i) In any fluid under gravitational attraction, pressure increases with increase in height.

j) For steady flow at any junction the algebraic sum of all the mass flow must be zero.

(20 marks)

QUESTION 3

A vertical sluice gate with an opening of 0.67 m produces a down stream jet depth of 0.40m when installed in a long rectangular channel 5.0 m wide conveying a steady discharge of 20.0m^3/s. Assuming that the flow downstream of the gate eventually returns to the uniform flow depth of 2.5m.

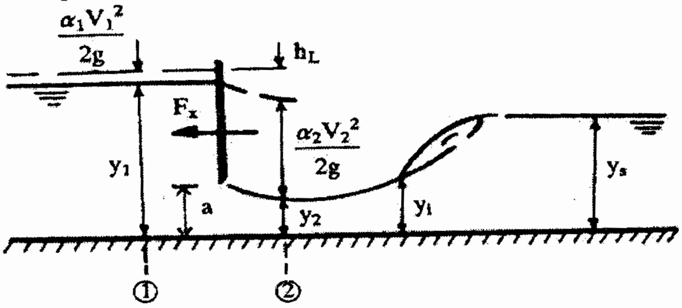


Fig. 1

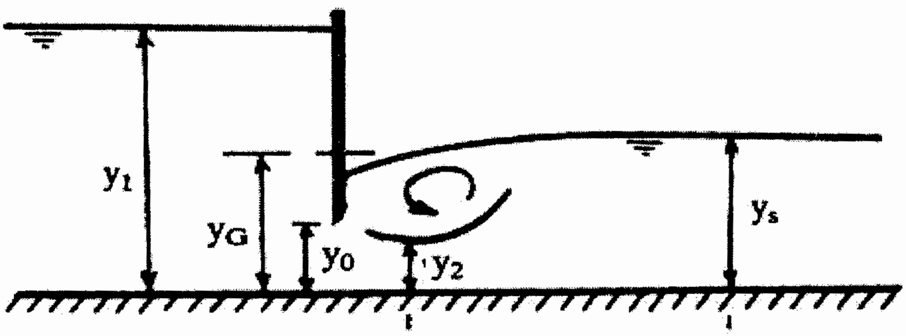


Fig. 2

a) Verity that that a hydraulic jump occurs. Assume $\alpha = \beta = 1.0$ (See fig.1)
(4 marks)

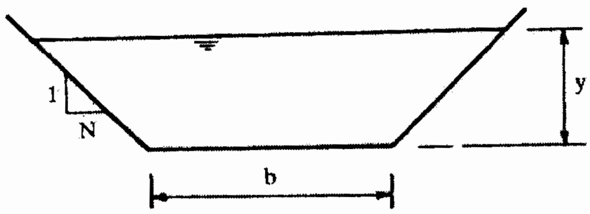
b) Calculate the head loss in the jump.
(2 marks)

c) If the head loss through the gate is $0.05\ V_j^2/2g$, calculate the depth upstream of the gate and the force on the gate.
(8 marks)

d) If the down stream depth is increased to 3.0 m analyze the flow conditions at the gate. (See fig.2)
(6 marks)

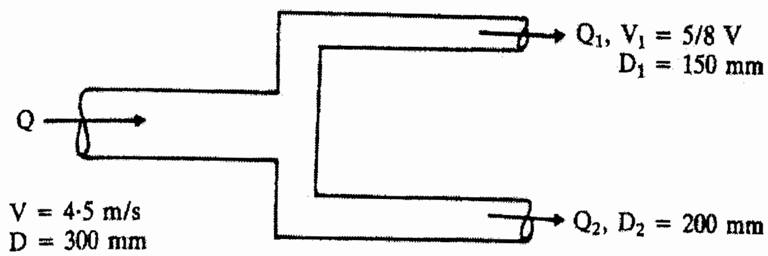
QUESTION 4

(a) A trapezoidal irrigation channel excavated in silty sand having a critical force on the horizontal of 2.4 N/m^2 and angle of friction 30^0 is to be designed to convey a discharge of $10m^3/s$ on the bed slope of 1: 10 000. The side slopes will be 1(vertically): 2 (horizontally). n =0.02. Determine the channel dimensions such that the mean velocity does not exceed 0.6m/s when conveying the discharge of 10 m^3/s.



(14 marks)

(b) A pipeline of 300 mm diameter carrying water at an average velocity of 4.5 m/s branches into two pipes of 150 mm and 200 mm diameters. If the average velocity in the 150 mm pipe is 5/8 of the velocity in the main pipeline. Determine the average velocity of flow in the 200 mm pipe and the total flow rate in the system in l/s.



Branching pipeline

(6 Marks)

QUESTION 5

(a) A vertical circular tank 1.25 m diameter is fitted with a sharp edged circular orifice 50 mm diameter in its base. When the flow of water into the tank was shut off, the time taken to lower the head from 2m to 0.75 m was 253 seconds. Determine the rate of flow in l/s through the orifice under a steady head of 1.5m.

(6 marks)

(b) A large rectangular orifice 0.40 m wide and 0.60m deep placed with the upper edge in a horizontal position 0.90 m vertically below the water surface in the vertical sidewall of a large tank, is discharging to the atmosphere.
Calculate the rate of flow through the orifice if its discharge coefficient is 0.65

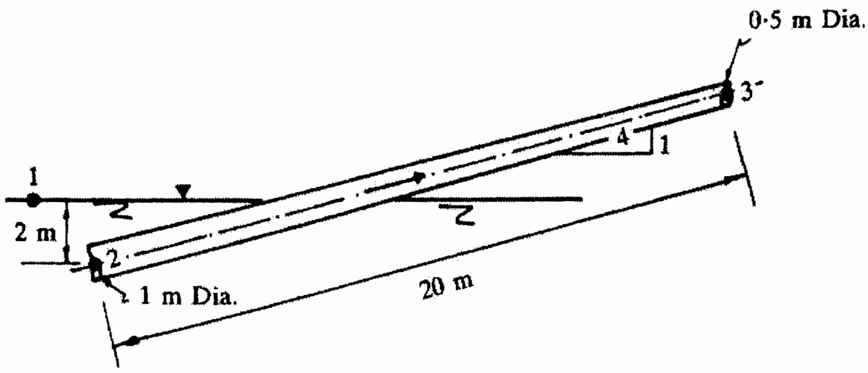
(4 marks

(c) Estimate the energy (head) loss along a short length of pipe suddenly enlarging from a diameter of 350mm to 700mm and conveying 300 liters per second of water. If the pressure at the entrance of the flow is 10^5 N/m^2, find the pressure at the exit of the pipe. What would be the energy loss if the flow were to be reversed with a contraction coefficient of 0.62?

(10 Marks)

QUESTION 6

(a) A drainage pump having a tapered suction pipe, discharges water out of a sump. The pipe diameters at the inlet and at the upper end are 1 m and 1.5 m respectively. The free water surface in the sump is 2m above the centre of the inlet and the pipe is laid at slope of 1:4 (1 vertical): 4 (along pipeline). The pressure at the top end of the pipe is 0.25 m of mercury below atmosphere and it is known that the loss of head due to friction between the two sections is 1/10 of the velocity head at the top section. Compute the discharge in l/s through the pipe if its length is 20 m. (See figure below)

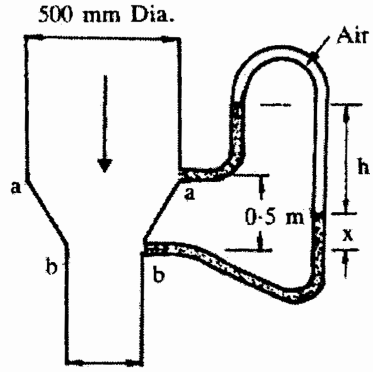


Flow through the suction pipe of a pump

(10 Marks)

177

(b) A 500 mm diameter vertical water pipeline discharges water through a constriction of 250 mm (See figure below). The pressure difference between the normal and constricted sections of the pipe is measured by an inverted U-tube. Determine (i) the difference in pressure between these two sections when discharge through the system is 600 l/s, and (ii) the manometer deflection, h, if the inverted U-tube contains air.



Flow through a vertical constriction

(10 Marks)

178

FORMULARS

1. $Cd = 0.61$ and $T = \int dt = \frac{ZA(H_1^{1/2} - H_2^{1/2})}{Cda\sqrt{2g}}$

2. $Q = 2/3\ Cd\ \sqrt{2g}\quad b(H_1^{3/2} - H_2^{3/2})$

3. $Y_i = Y_S/2\ (\sqrt{1+8\beta f_S^2} - 1)$

4. $F_S = V_S/\sqrt{gY_S}$

5. $(Y + V/2g) - (Y + V/2g)$

6. $\rho g y^2/2 + \rho q(V_1 - V_2) - \rho g Y_2^2/ F_X = 0$

7. $Y_G = Y_s\ \sqrt{1+2F_s^2}\ (1 - Y_S/Y_2)$
8. $Q = AV$

9. $Q = A/n\ R^{2/3}\ S_0^{1/2}$
10. $Y_i = Y_S/2\ (\sqrt{1+8\beta f_S^2} - 1)$

11. $F_S = V_S/\sqrt{gY_S}$

12. $10 \log_{10} [W/W_0]$
13. $W/W_0 = 10^{LW/10}$

14. L_W (Total) $= 10 \log (W_1/W_0 + W_2/W_0)$

15. $L_p = 10 \log (p_1/p_0)^2$
16. $L_p(\text{total}) = 10 \log (p_{total}/p_0)^2$

17. $W = \sum_{i=1}^{4} \frac{p^{2rms(1)}}{\rho C} S_i$, where $\rho C = 420$ rayls.

18. $I = \frac{W}{4\pi r^2}$

19. $I = \frac{p^2_{rms}}{\rho C}$ or $p_{rms} = (I\ \rho C)^{1/2}$

20. $\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g}$

21. $h = \frac{2\sigma \cos\theta}{r\rho g}$

22. $W = \rho g Q$

Additional formulae

$C_d = 0.61$ and $T = \int dt = \dfrac{2A\,(H_1^{1/2} - H_2^{1/2})}{C_d a\sqrt{2g}}$

$Q = 2/3\ C_d \sqrt{2g}\ b\ (H_1^{3/2} - H_2^{3/2})$

$Q = a_1 v_1 = a_1 v_2$

$P_1/\rho g + V_1^2/2g + P_1/\rho g + V_2^2/2g + (V_1 - V_2)^2/2g$

$h_L = (1/C_c - 1)^2\ V_1^2/2g$