GX702

Ollscoil na hÉireann, Gaillimh

SUMMER EXAMINATION 2000

FOURTH CIVIL ENGINEERING EXAMINATION

HYDRAULICS II (EH405)

Examiners: Prof. P.E. O'Connell
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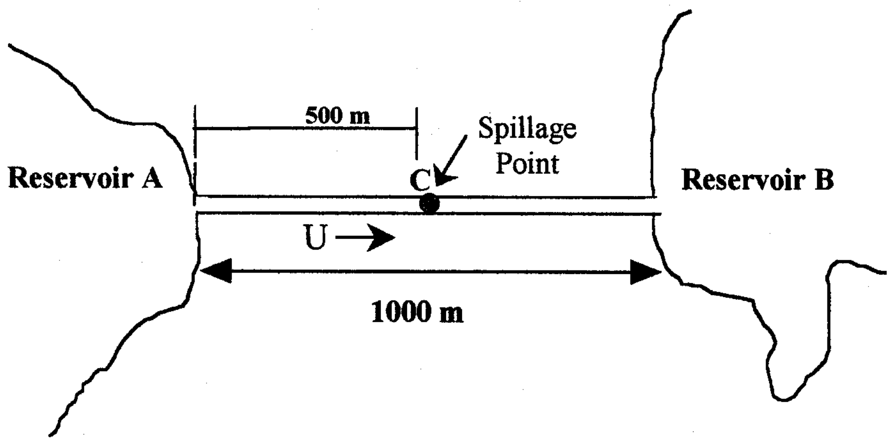
Mr. A.M. Cawley

Time allowed: **Two Hours.**

Attempt any four other questions

1. A uniform service channel connects two large reservoirs. At point **C** midway between the two reservoirs an incident occurs in which an instantaneous slug of pollutant is released causing the concentration at **C** to immediately rise to 100 mg/l. The connecting reservoirs are very large and the pollutant concentration in these reservoirs can be assumed to be constant over time at a background concentration of 0.0 mg/l. The flow in the service channel is from Reservoir A to B at a steady uniform velocity of 1m/s..



(a) Given that the objective is to model the spread and fate of the pollutant in the service channel, derive the governing equation for this problem and detail any assumptions made in the derivation.

Using a finite difference solution scheme of your choice present the above governing equation in finite difference form.

(15 marks)

(b) Using a time step $\Delta t = 50$sec, a spatial step $\Delta x = 100$m, a dispersion coefficient of 2 m^2/s an a first order decay rate of $0.2 day^{-1}$:

(i) Construct the finite difference domain.

(ii) Present the initial conditions and the boundary conditions for this problem.

(iii) Compute the pollutant concentration throughout the finite difference domain for one single time step.

(10 marks)

2. **(a)** (i) List the desirable features of a site to be used for streamflow gauging by a dilution method. How do these features contrast with those required for current meter gauging?

(6 marks)

(ii) What is the principle requirement of a substance used as a tracer for streamflow gauging by a dilution method.

(5 marks)

(iii) 2,000g of tracer was injected instantaneously into a stream and the following concentrations (g/m^3) were found in samples recovered some distance downstream at five minute intervals:

0.0 0.4 2.9 7.6 15.8 30.7 43.1 49.0 50.8 49.6 46.8

42.2 37.3 31.7 26.6 21.8 17.8 14.0 10.8 8.2 6.0

The sampling interval was then increased to 15 minutes and the following concentrations were found

3.0 1.2 0.4 0.4

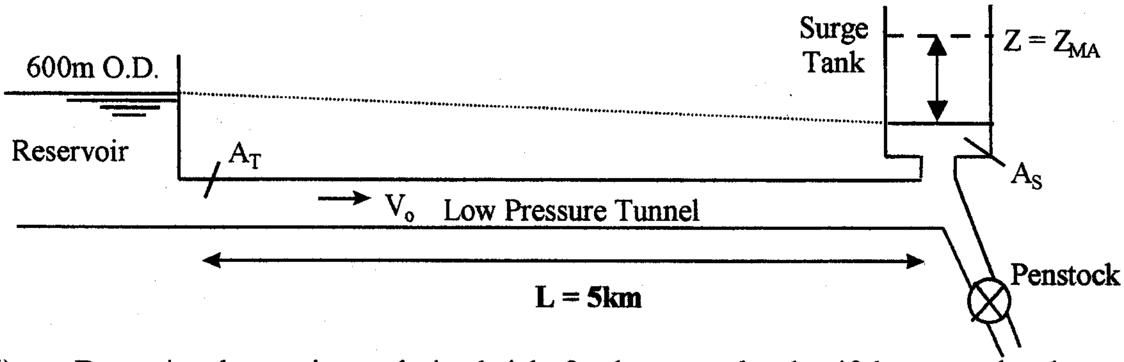
Estimate the flow in the stream to the nearest 0.1 m^3/s.

(6 marks)

(b) Explain briefly the importance of stage, or water level measurement in the estimation of the discharge of a river. In selecting a site for a stage-discharge flow gauging station what is the most important consideration other than the security and durability of the gauge?

(8 marks)

3. **(a)** A simple surge chamber is to be included upstream of a penstock to protect a low pressure conveyance tunnel as shown in the accompanying diagram. The low-pressure tunnel is to be 5km long, 2m in diameter and will convey water at an operating flow rate of 4cumec.



(i) Determine the maximum design height for the surge chamber if the surge chamber diameter is 10m and energy losses can be neglected.

(ii) Indicate briefly how you would solve the above design problem with energy losses included.

(13 marks)

(b) Describe the various steps involved in assessing a "Run of the River" site for hydropower development.

(12 marks)

4. A computer package was used to analyse the simple pipe network described in the accompanying diagram and in Table 1. The computer results after the third iteration are given in Table 2. In the analysis a constant friction factor of f = 0.022 was used and all shock losses ignored.

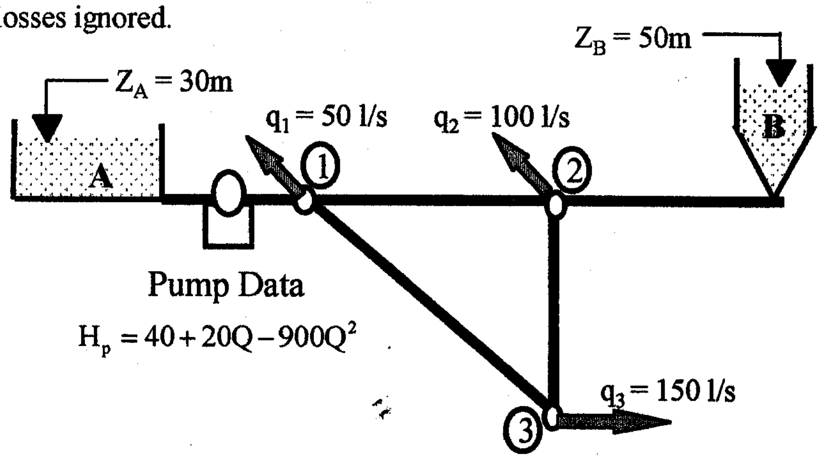


Table 1 – Pipe information

Pipe Number	Head Node	Tail Node	Length (m)	Diameter (mm)	Elevation (m)
1	A	1	300.0	250.0	Node 1 22
2	1	2	200.0	200.0	Node 2 20
3	1	3	250.0	200.0	Node 3 24
4	2	3	150.0	200.0	Node A 27
5	B	2	200.0	250.0	Node B 4.0

Table 2 Computer Results after Iteration 3

Pipe Number	Discharge (cumec)	Head Loss (m)
1	0.17296	16.7120
2	0.04926	2.7578
3	0.07370	7.7170
4	0.07630	4.9626
5	0.12704	22.930

Node Number	Piezometric Head (m)
1	29.82355
2	27.06569
3	22.10309

(i) Check the above computer solution for errors and comment on the convergence and accuracy of the solution.

(10 marks)

(ii) Based on the above results, comment on the adequacy of the pipe network.

(5 marks)

(iii) Using the linear matrix method assemble the solution matrix for this problem using the results in Table 2 as the initial values. Indicate how you would complete the solution.

(10 marks)

5. (a) The mass and momentum conservation equations for unsteady flow in pipes subject to water hammer are, in terms of head, h, and velocity v

$$v\frac{\partial h}{\partial x}+\frac{\partial h}{\partial t}+\frac{C_o^2}{g}\frac{\partial v}{\partial x}+v\mathrm{Sin}(\theta)=0$$

$$g\frac{\partial h}{\partial x}+\frac{\partial v}{\partial t}+v\frac{\partial v}{\partial x}+\frac{f}{2D}v|v|=0$$

Derive the corresponding characteristic equations, and show that the speed of a pressure wave through the pipe can be taken as C_o.

What factors influence the speed of a pressure wave in a pipeline?

(12 marks)

(b) Using the characteristic equations derived in (a), calculate the variation in head at the closed end of a horizontal pipe, which has an open end subjected to a periodic pressure head wave given by

$$h(t)=4+2\sin\left(\frac{\pi t}{4}\right)$$

Assume that C_o = 1,100 m/s, f = 0.015 and the pipe diameter is D=0.4m. Note that calculations for <u>two time steps</u> only are required and results are not required for interior points of the pipe. The pipeline is 2,200m long.

(13 marks)