NATIONAL UNIVERSITY OF SINGAPORE

FACULTY OF ENGINEERING

EXAMINATION FOR

(Semester I: 2013-2014)

CE5312 - RIVER MECHANICS

Nov/ Dec 2013 - Time allowed: 2.5 hours

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains **FOUR(4)** questions and comprises **FIVE(5)** printed pages.
2. Answer ALL **FOUR(4)** questions.
3. All questions carry equal marks.
4. This is an "**OPEN BOOK**" examination.

Question 1

Water is released into a rectangular canal at a constant rate dQ/dt such that the flow is a maximum at 350 m^3/sec in 50 minutes. The canal has a width B of 10 m. The initial water depth in the canal is 3 m and the water is initially stationary. Assume that the canal is horizontal and neglect bed friction.

(a) The point of release is at $x=0$ and if $q=Q/B=Uh$ where U and h are the cross-sectional average flow velocity and water depth respectively, show that at the time t, the release rate at $x=0$ is given by

$$\frac{dq}{dt}=a=\frac{d(Uh)}{dt}=\frac{d(Uc^2)}{gdt}=\frac{2}{g}c(U+c)\frac{dc}{dt}$$

State your assumptions clearly. [4 marks]

(b) Show that the location x_S and time of occurrence t_S of the first surge is

$$x_S=\frac{(U+c)_0^2}{3\left.\frac{dc}{dt}\right|_0}=\frac{2c_0(U_0+c_0)^3}{3ga} \quad , \quad t_S=\frac{x_S}{U_0+C_0}$$

[4 marks]

(c) What is the water depth and velocity at $x=0$ at the time $t=t_S$? [10 marks]

(d) What is the water depth and velocity at $x=1500\ m$ at the time $t=t_S$? [7 marks]

Question 2

A 10 m wide canal is 12 km long and discharges water from a large reservoir into the sea. The initial steady state flow depth h_0 is 3 m and the uniform velocity U_0 is 1.5 m/s. Vertical gates are provided just downstream of the reservoir and just upstream of the canal mouth with the sea. Assume that the canal bed is horizontal and flow resistance is negligible as a first approximation.

The gates are suddenly closed completely simultaneously.

(a) Describe the resulting disturbances arising from the sudden closures of the gates? [2 marks]

(b) At 15 minutes after closure, what are the water depths at the upstream gate and the downstream gate? Show your working equations clearly. [8 marks]

(c) At 15 minutes after closure, what is the water depth and discharge at 4 km downstream of the gate at the reservoir? [8 marks]

(d) When will the disturbances created by the action of the two gates meet? Where does this take place? [4 marks]

(e) At the instance the disturbances meet, what is the total volume of water between the two gates? [3 marks]

Question 3

The bed of a mountain river consists of boulders of d_{84}=415 mm and the mean water depth y=1 m.

(a) Calculate the flow rate per unit width if the bed slope is S=2% and the measured Manning's coefficient n=0.05, assuming that the river is a wide rectangular channel. [5 Marks]

(b) Give the unit of n; [5 Marks]

(c) If the bed shear stress can be expressed as $\tau_b = \frac{f}{8}\rho V^2$, where $f = f(\mathrm{Re}, \frac{k_s}{y})$ is the dimensionless friction coefficient with $k_s \sim d_{84}$ being the physical bed roughness, find the theoretical relationship between n and f. [5 Marks]

(d) For a rough bed, the friction coefficient can be calculated by using the following formula based on Nikuradse's experiment: $\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{k_s}{12y}\right)$; estimate the value of n based on the information provided and compare it to the measured n=0.05; explain the possible reasons that may cause the difference. [5 Marks]

(e) For relatively small value of k_s / h (i.e., <0.1), the friction coefficient f can be further simplified to the following form: $f = 0.113\left(\frac{k_s}{y}\right)^{1/3}$; discuss how n will vary during the flood season when the flow rate increases over 10 times. [5 Marks]

Make and state any assumption you think valid when you answer the above questions.

Question 4

A river flow passes through a bridge with a group of bridge piers. The river is 100 m wide and 2 m deep with the bed slope of S=0.15% and Manning's coefficient of n=0.03. The bridge piers have the sum width of 25m in transverse direction.

(a) Calculate the water depth at the bridge location. [10 Marks]

(b) During a flood period, the incoming flow rate becomes 10 times larger; find whether the bridge piers will cause water blockage or not. [7 Marks]

(c) Sketch the water surface profile upstream of the bridge during the flood and estimate the water depth 100m from the bridge (hint: use 1 computational step for such estimation). [8 Marks]

- END OF PAPER -