NATIONAL UNIVERSITY OF SINGAPORE

CE5312 – RIVER MECHANICS

(Semester I: AY2016/2017)

Time Allowed: 2.5 Hours

INSTRUCTIONS TO CANDIDATES

1. Please write your student number only. **Do not write your name**.
2. This assessment paper contains **FIVE** questions and comprises **FOUR** printed pages.
3. Answer **ALL** questions. All questions DO NOT carry equal marks.
4. Please start each question on a new page.
5. This is an "OPEN BOOK" assessment.
6. Programmable calculators are NOT allowed for this exam.

Question 1 [15 marks]

A long and straight channel has a rectangular cross section (10-m wide and 3 m-deep) and a constant slope S_0=1/1000. The channel surface gives a Manning's coefficient n=0.05. It is controlled by a sluice gate at the downstream end. Assume steady flow in this question. A discharge of Q=20m^3/s is established at the sluice gate.

(a) What is the water depth far upstream from the gate? (5 marks)

(b) The gate opening is 0.3m. Determine the water depth before the sluice gate. Use a contraction coefficient C_v=0.6. (5 marks)

(c) Sketch the surface profile from the gate upstream. (5 marks)

Question 2 [15 marks]

A prismatic long and straight canal eventually discharges into a large lake. You can assume the canal has a wide rectangular cross section and the effect of bottom slope and bed friction can be neglected. The flow in the canal at a reference time t=0 is steady and uniform at a depth of 4 m and a velocity of 1 m/s. A sluice gate located 4km upstream from the exit to the lake is fully opened before t=0, but is suddenly closed at t=0.

(a) Use method of characteristics to illustrate the development of the flow disturbance caused by the gate closing in the downstream canal before the influence reaches the lake. Graphically identify regions with uniform depth and non-uniform depth. Discuss the traveling of the leading and trailing edges of non-uniform region. (8 marks)

(b) What is the water depth at x=600m and t=100 s? (4 marks)

(c) When will the influence reaches the lake? (3 marks)

Question 3 [15 marks]

A dam holds water in a very long rectangular channel. In the upstream direction from the dam (x<0), water depth is initially h=8m. The channel is dry in the downstream direction from the dam (x>0). An earthquake starts to make the dam slide to downstream immediately at a uniform velocity U_d=1m/s Through calculations to sketch the surface profile at t=100 seconds. Your calculation should determine the locations of the leading and trailing edge of uniform-flow region(s), and 1 point within the non-uniform region.

Question 4 [30 marks]

In this question, we study open-channel flow through a patch of artificial vegetation in an experimental current flume. As shown in the figure below, an array of 500 cylinders with diameter D=1.0cm is placed inside the test section to mimic emerged aquatic vegetation, e.g. mangrove roots. All cylinders are vertical and emergent, and you can assume that they are uniformly placed over the whole flume. The flume is 5m long, 1-m wide, and 0.7-m deep. A sharp-crested weir controls the outflow. The weir height is 0.4 m, and the water level is 0.1m above the weir crest. The flume bottom is horizontal and the flow is steady.

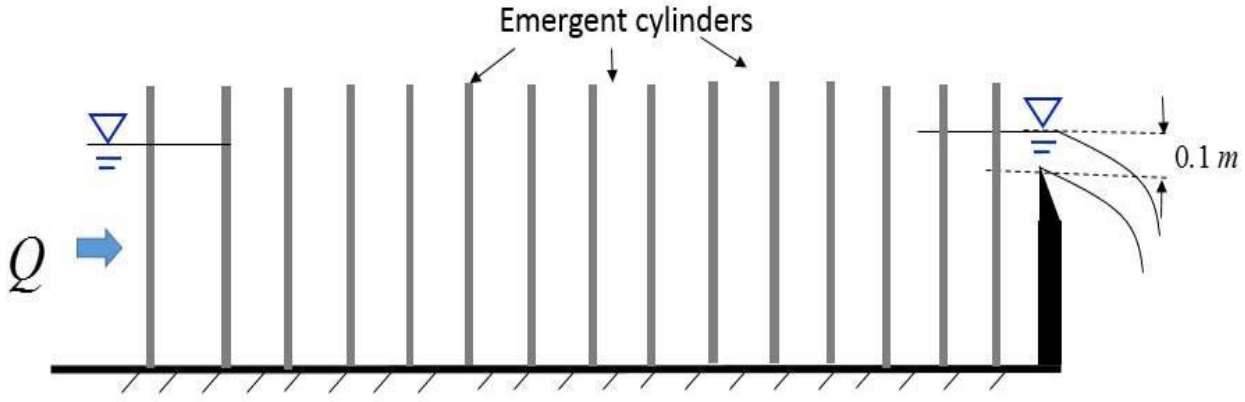


Fig. Q4

(a) Determine the total discharge in this flume. (5 marks)

(b) Sketch the surface profile. (5 marks)

The flow resistance due to each cylinder is given as:

$$F_D = C_D \rho V^2 h D$$

where C_D=1 is the drag coefficient, ρ=1000kg/m^3 is water density, h is the water depth and D is the diameter of the cylinder. It is observed that the difference between water depths at the two ends of the flume is very small, so you can approximately take the average water depth in the flume as 0.5m.

(c) Estimate the small difference between the water depths at the two ends of the flume. You can neglect the frictions on the channels' side walls.

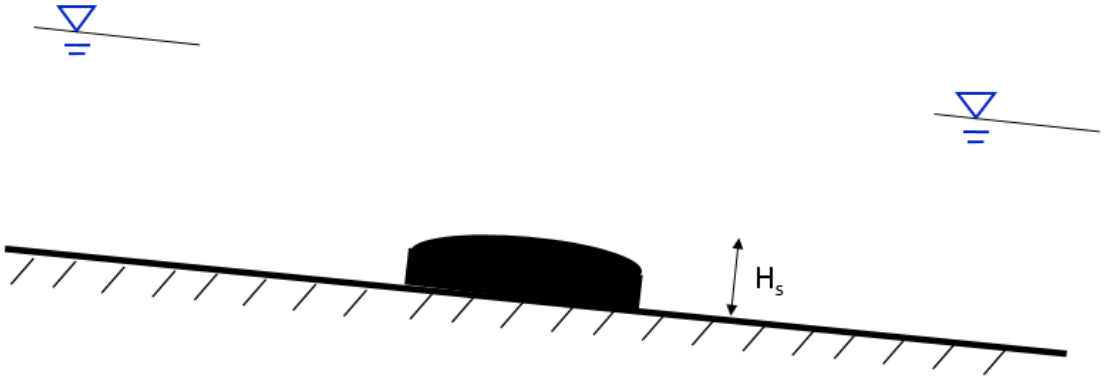
(10 marks)

(d) In many applications, the flow resistance of aquatic vegetation is usually represented by a Manning's coefficient. What is the Manning's coefficient for the artificial vegetation patch in the flume? Again, you can neglect the frictions on the sidewalls of the flume.

(10 marks)

Question 5 [25 marks]

Here we consider the flow over a step in a very long and straight open channel. The channel has a very wide rectangular cross section. Far upstream and downstream from the step, the flow is steady and uniform with a water depth of 5 meters and a discharge of 20m^2/s per unit channel width. The height of the step is H_s=2 m.



(a) Determine the water depth at the top of the step. (7 marks)

(b) Determine the water depth before the step. (7 marks)

(c) Sketch the surface profile of this flow. (11 marks)

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