University Of Technology
Building and Construction Eng. Dept.
Final Exam – 2013/2014 (1st Attempt)

Subject :Hydraulic Structures — Class:3rd year
Branch :Water and Dams — Time : 3 Hours
Examiner :Asst. Prof. Dr. Jaafar S. Maatooq — Date : 8 / 6/ 2014

Closed Book Exam

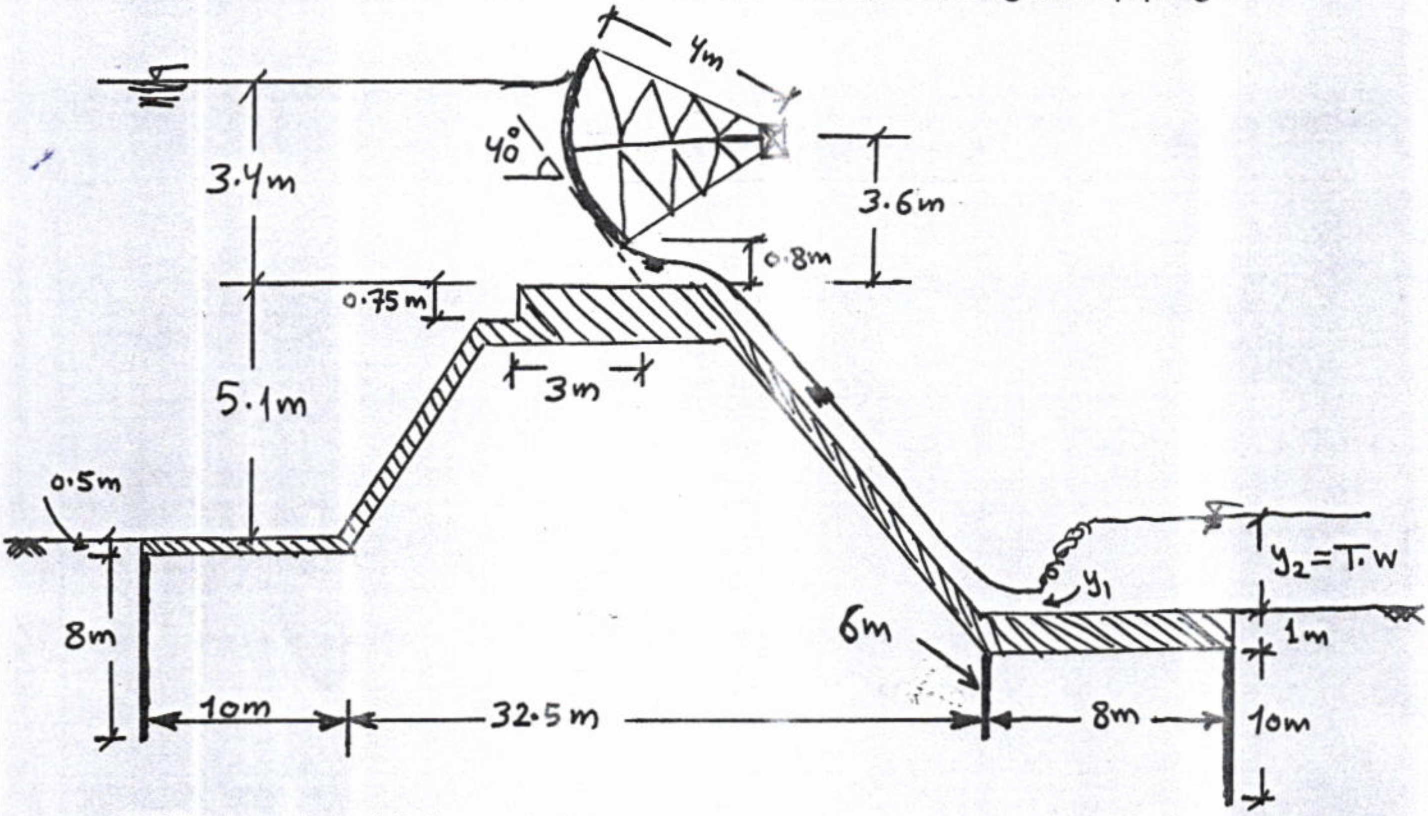
أجب عن (خمسة أسئلة) على أن يكون السؤال الأول من ضمنها

Q1] The regulator shown in Figure below has a width 5.5m . Give a solution for the following :-

a) If the design head is 3.4m , calculate the design discharge for controlled spillway crest .

b) If the gate is fully opened the spillway crest will be uncontrolled , the actual head become 1.3m , calculate the actual and design discharge for uncontrolled spillway crest .

c) At fully closed gate with U/S head over the crest 3.4m , use Khosla's method and find the uplift pressure head at key points of sheet piles and exit gradient . Also show which bed material be safe against piping .



Q2] Determine if 2.5m x 2.5m square edge reinforced concrete box culvert with roughness coefficient (Ke=0.2) is adequate to pass a discharge 20m³/s. The data help you for answer ;

- shoulder elevation El=32.5m ,
- culvert entrance invert El=30.5m ,
- culvert slope = 0.02 ,
- T.W =1.6m ,
- culvert length =60m .

***Q3]* Answer <u>One</u> of the following**

(A) The 0.3m diameter smooth galvanized iron pipe convey $Q=0.2m^3/s$, for $\upsilon=10^{-6}\ m^2/s$, C=110 . Find the head losses due to friction for 3000m distance of this pipe by using both Darcy-Weisbach and Hazen- William formulas .

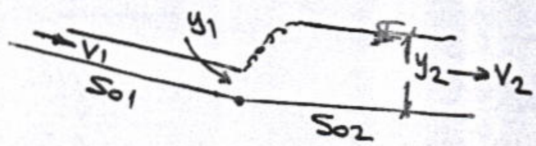
(B) Show that for a hydraulic jump in a rectangular channel the Froude number upstream Fr1 and downstream Fr2 are related by :

$$Fr2^2 = \frac{8Fr1^2}{[(1+8Fr1^2)^{0.5}-1]^3}$$

If the Fr2 after a jump is 0.36 show the type of this jump and suitable stilling basin that should be used with this jump .

Q4] A warped expansion transition is to be designed to connect 1.5 flume to trapezoidal channel ; bc=3m , yc=1.3m and zc=1.5 . If the difference in elevation between inverts of channel and flume is 0.3m and the flow depth at flume is 1.6m , use loss coefficient Ce=0.2 . Find the length of transition and ; bed width , side slope , and flow depth at mid section of transition .

Q5] Water flows in a wide finished concrete channel (n=0.012) as shown in Figure . If the upstream Froude number and depth are 4 and 0.05m respectively. Determine the So1 and So2 those need for uniform flow at both channels (note ; treat a hydraulic jump as a jump in horizontal surface).



Q6] Flow in a rectangular channel is at velocity 1.5m/s and depth 0.4m . Neglect the effect of approach velocity and determine the height of suppressed sharp-crested weir be installed into this channel to rise the water depth upstream of this weir 1.6m . (use Cd=0.7)

******** Good Luck ********

حل أسئلة المنشآت الهيدروليكية / المرحلة الثالثة

فرع المياه والسدود

Ans Q11

a)

$$Q = C_d C_1 G b \sqrt{2 g y_1}$$

$y_1 = 3.4\,m$

$b = 5.5\,m$

$G = 0.8\,m$

$P_1 = 0.75\,m$

$L = 3\,m$

$a = 3.6\,m$

$r = 4\,m$

$\frac{L}{P_1} = \frac{3}{0.75} = 4 \rightarrow$ from fig. 8.11 $\rightarrow C_1 = 1.05$

$\frac{a}{r} = \frac{3.6}{4} = 0.9$

$\frac{G}{r} = \frac{0.8}{4} = 0.2$ $\rightarrow$ from fig. 8.10 $\rightarrow C_d = 0.66$

$\frac{y_1}{r} = \frac{3.4}{4} = 0.85$

$$\therefore Q = 0.66 * 1.05 * 0.8 * 5.5 \sqrt{2 * 9.81 * 3.4} = \boxed{24.9\ m^3/s}$$

b)

$$Q = C_o L H_o^{3/2}$$

$H_o = 3.4\,m$

$\frac{P}{H_o} = \frac{5.1}{3.4} = 1.5$

from fig. 4 at $\frac{P}{H_o} = 1.5 \longrightarrow C_o = 3.9$

from fig. 6 $\frac{C_{inc.}}{C_{vet.}} = 0.995$

$\therefore C_{incl.} = 0.995 * 3.9 \simeq 3.88$

$\therefore Q_{des.} = 3.88 * 5.5 * 3.4^{3/2} = \boxed{133.8\ m^3/s}$ (design discharge)

for $H_e = 1.3\,m$

then $\frac{H_e}{H_o} = \frac{1.3}{3.4} = 0.38 \longrightarrow$ from fig. 5 $\longrightarrow \frac{C}{C_o} = 0.88$

$C = 0.88 * 3.88 = 3.414$

$$\therefore Q = 3.414 * 5.5 * 1.36^{3/2} = \boxed{29.78\ m^3/s}$$

c) U/S pile

from Fig. 9.6

$\frac{1}{\alpha} = \frac{8.5}{50.5} = 0.17$

$\phi_{C_1} = 100 - \phi_E \rightarrow \phi_E = 38\% \rightarrow \phi_{C_1} = 62\%$

$\phi_{D_1} = 24\% \rightarrow \phi_{D_1} = 100 - 24 = 76\%$

Corr. for thickness :

Total pressure drop = 14%

height of drop = 8.5 $\rightarrow$ Corr. $= \frac{14}{8.5} * t = 1.647 * 0.5 = 0.824\%$

then actual $\phi_{c_1} = 62 + 0.824 = 62.824\%$

D/s pile

$\frac{1}{\alpha} = \frac{10}{50.5} = 0.2$

$\phi_E = 42\%$ & $\phi_D = 28\%$

Corr. for thickness $= \frac{14}{11} \times 1 = 1.272\%$

$\therefore \phi_E = 42 - 1.272 = 40.73\%$

Corr. for intermediate pile:

① for U/S pile

$D = 6m$, $d = 8m$, $b_1 = 42.5$, $b = 50.5$

$\because D < d$ & $b_1 > 2*8 = 16m$ then Corr. at U/s pile neglected

② for D/S pile

$D = 6m$ $d = 10m$, $b_1 = 8m$, $b = 50.5m$

$\therefore C = \frac{19\sqrt{\frac{6}{8}}\,(10+6)}{50.5} = 5.21\%$

then $\phi_E = 40.73 - 5.21 = 35.52\%$

$\phi_D = 28 - 5.21 = 22.78\%$

U.P head at Key point will be:-

at $C_1 = 0.62824 * 8.5 = 5.34$ m

$D_1 = 0.76 * 8.5 = 6.46$ m

$E = 0.3552 * 8.5 = 3.02$ m

$D = 0.2278 * 8.5 = 1.94$ m

exit gradient :

$\alpha = \frac{b}{d} = \frac{50.5}{11} = 4.591$

$\lambda = \frac{1}{2}(1 + \sqrt{1 + 4.591^2}) = 2.849$

$G_e = \frac{8.5}{\pi * 11 * \sqrt{2.849}} = 0.146 \simeq \frac{1}{7}$

$\therefore$ Safe for fine Sand

Ans Q2|

for inlet control

Chart 8A → $\frac{Q}{B} = \frac{20}{2.5} = 8\ m^3/s/m$

→ $\frac{Hw}{D} = 1.18$ → $Hw = 1.18 * 2.5 = 2.95\ m$

∴ HW El. = 30.5 + 2.95 = 33.45 m Not o.k (overflow)

for outlet control

Chart 15A → H = 0.64 m

Chart 14A → $y_c = 1.8$ m

$h_o = \frac{1.8 + 2.5}{2} = 2.15$ use $h_o = 2.15$ > T.W

∴ $Hw = 2.15 + 0.64 - 60 * 0.02 = 1.59$ m

HW El. = 30.5 + 1.59 = 32.09 m o.k (Safe for outlet control)

Ans Q3|

(A)

$V = \frac{Q}{A} = \frac{0.2}{\frac{\pi}{4}(0.3)^2} = 2.83$

$R = \frac{VD}{\nu} = \frac{2.83 * 0.3}{10^{-6}} = 848826$

for smooth pipe:

$\frac{1}{\sqrt{f}} = 2\log(848826\sqrt{f}) - 0.8$

assume $f \simeq 0.012$ (trial & Error)

∴ $h_f = f\frac{L}{D}\frac{V^2}{2g} = 0.012 * \frac{3000}{0.3} \cdot \frac{2.83^2}{2*9.81} \simeq 49\ m$

by Hazen

$Q = 0.2 = 0.279 * 110 * 0.3^{2.63} * \frac{h_L^{0.54}}{3000^{0.54}}$ ⇒ $h_L \cong 94.3\ m$

Q3 B)

$$0.36^2 = \frac{8 F_{r_1}^2}{\left[(1+8F_{r_1}^2)^{0.5} - 1\right]^3} \simeq 0.13$$

$\Longrightarrow F_{r_1} \simeq 3.6$ ∴ Oscillating jump

Use stilling basin IV

Ans Q4)

$$L_T = 2.35(3-1.5) + 1.65 * 1.5 * 1.3 = 6.74 m$$

$$Z_x = 1.5 - 1.5\left(1 - \frac{\frac{6.74}{2}}{6.74}\right)^{\frac{1}{2}} = \underline{\underline{0.44}}$$

$$e = 0.8 - 0.26 * 1.5^{0.5} = 0.481$$

$$b_x = 1.5 + (3-1.5) * \frac{\frac{6.74}{2}}{6.74}\left[1 - \left(1 - \frac{\frac{6.74}{2}}{6.74}\right)^{0.481}\right]$$

$$= \underline{\underline{1.74\ m}}$$

Ans Q5)

$$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1+8F_{r_1}^2} - 1\right) \longrightarrow y_2 = 0.26\ m$$

$$V_1 = \sqrt{9.81 * 0.05} * 4 = 2.8\ m/s$$

$$V_1 y_1 = V_2 y_2 = q \longrightarrow V_2 = 2.8 * \frac{0.05}{0.26} = 0.538\ m/s$$

$$V_1 = \frac{1}{n} R^{2/3} S_{o_1}^{\frac{1}{2}} \longrightarrow S_{o1} = \frac{0.012^2 * 2.8^2}{(0.05)^{4/3}} = \underline{\underline{0.0613}}$$

$$S_{o2} = \frac{0.012^2 * 0.538^2}{0.26^{4/3}} = \underline{\underline{0.00025}}$$

Ans Q5

From continuity → $Q = V \cdot A = 1.5 * 0.4 b = 0.6 b$ m^3/s

$Q = \frac{2}{3}\sqrt{2g}\ C_d\, b\, H^{3/2}$

$= \frac{2}{3}\sqrt{2*9.81} * 0.7 * b * H^{3/2} = 2.067\, b H^{3/2}$

then: $0.6 b = 2.067\, b\, H^{3/2}$ → $H = \left(\frac{0.6}{2.067}\right)^{2/3}$

$= 0.438\ m$

$\therefore P = 1.6 - 0.438 = \boxed{1.16\ m}$