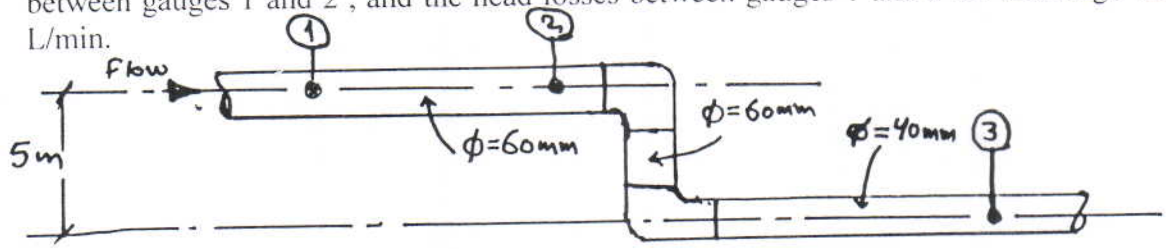
University Of Technology
Building and Construction Eng. Dept.
Final Exam 2014/2015 (1^{st} Attempt)

Subject :HY.Structures — Class:3^{rd}
Branch :Water & Dams — Time : 3 Hours
Examiner : Dr.J.S.Maatooq — Date :13 / 6/ 2015

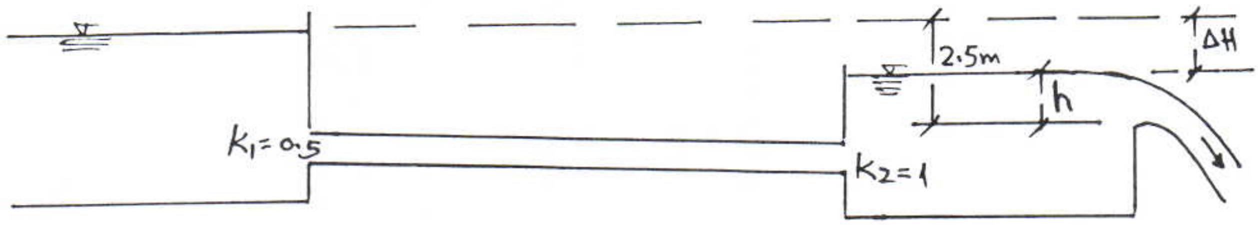
Notes : - Attempt all Questions

Q1] Answer "Two" of the following :-

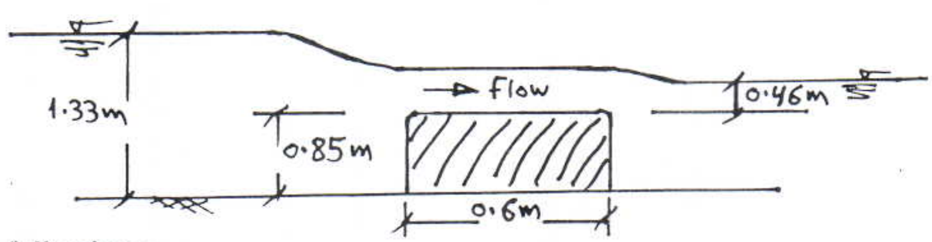
(A) For the simple pipe system shown in figure below , the pressures are ; P1=14kPa , P2=12.5kPa , and P3=10kPa . Neglect the minor losses and determine the head loss between gauges 1 and 2 , and the head losses between gauges 1 and 3 for discharge 420 L/min.



(B) The flow over weir from a second reservoir as shown in figure below is calculated by ; $Q = 0.4\sqrt{2g}\,Bh^{3/2}$. The pipe line length 40m and its diameter is 100mm , the crest length B=0.25 . Calculate the discharge and the head of flow over a weir crest , use f=0.024



(C) The flow over a broad crested weir as shown in figure below . Calculate a unit discharge by using a general equation and by Ranga-Raju equation . Also show is the flow modular or non-modular ? . (use $A^*/A=0.86$, and $Vo^2/2g=0.12$)



Q2] Answer "Two" of the following :-

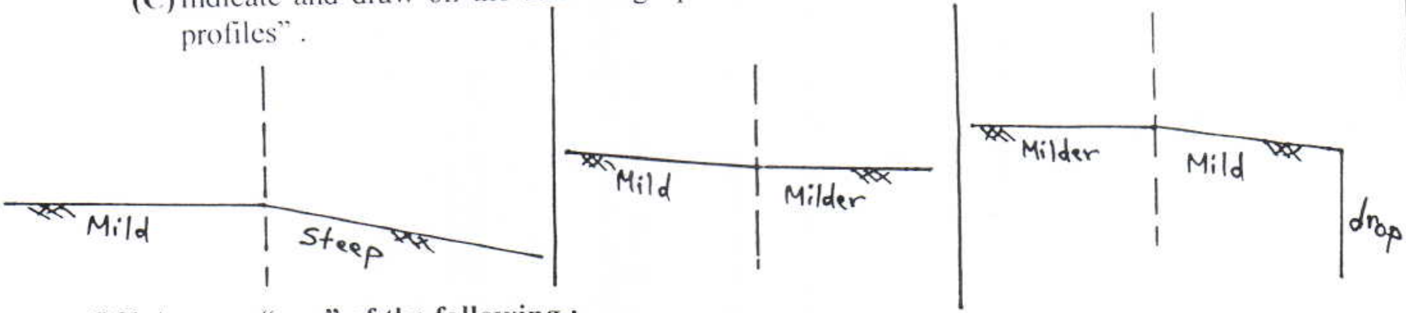
(A) A flow rate of $2.1m^3/s$ is to be carried in an open channel at velocity 1.3m/s . Determine the cross section for 1:1 side slope , and a required bed slope for the following normal depths :-

a) The same bottom width .

b) The half of bottom width .

(B) A rectangular channel 2m wide has a flow of $2.4m^3/s$ at a depth 1m . Determine if a critical depth occurs at a section where a hump of Δz 20cm height is installed across a channel bed ? . If need to constrict the width of a channel so as a critical depth to occur , compute the constriction width . (Use $\Delta z_{crit} = E - E_{min}$)

(C) Indicate and draw on the following open channels systems the possible "water surface profiles".



Q3| Answer "one" of the following :-

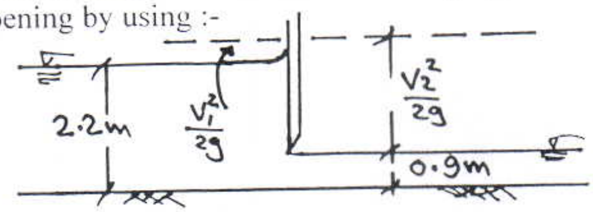
(A) The depth of runoff over a car parking is 5cm , flows towards 100m length open rectangular concrete lining (n=0.013) drain . If the bank top edge of the drain considered as a sharp crested suppressed weir its crest width along the length of drain . Determine the bottom width required for drain for a flow depth 0.7m, use $S_0 = 0.002$. (assume $P = 0$)

(B) For flow under sluice gate shown in figure below , neglect the effect of velocity approach and calculate the unit discharge and gate opening by using :-

a) Energy balance equation

b) Sluice gate equation

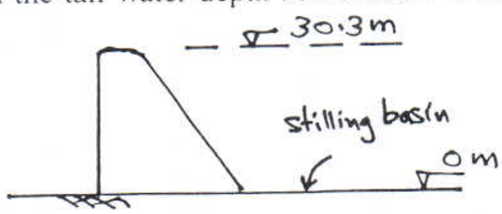
(use Cc=0.62)



Q4| Answer "one" of the following :-

(A) A maximum discharge $5700 m^3/s$ and a maximum total head 19.5m over a 18m height Ogee crested spillway. If the ratio of total head to the design head is 1.3m , determine the crest length , and the discharge at a design head .

(B) The discharge over 30.3m wide Ogee crested spillway is $417.5 m^3/s$, for the ratios $L/y2=4.4$, and $Tw/y1=14.5$, find ; the suitable type of stilling basin , the length of stilling basin , and the tail water depth . Also show is the hydraulic jump submerged or free ? .



Q5| Answer "one" of the following :-

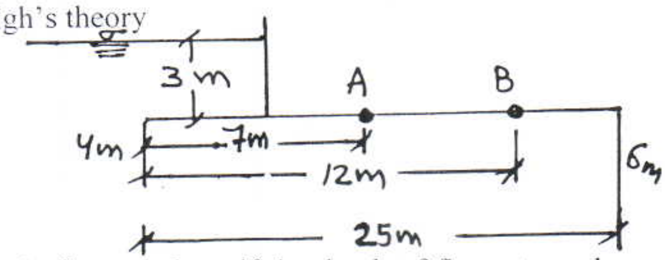
(A) For Barrage floor shown in figure . .Use Bligh's theory and find :-

a) Average hydraulic gradient and creep coefficient .

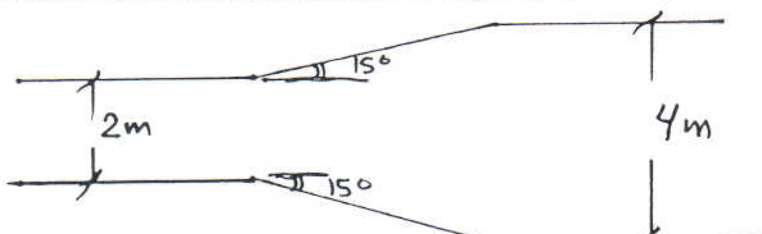
b) Uplift Pressure at points A and B

c) Safe thickness of floor at points A and B

(use $\gamma_c = 24 kN/m^3$)



(B) For rectangular expansion transition shown in figure below, if the depth of flow at canal before transition is 1m . Find the depth of flow at end of transition for $Q=5m^3/s$, and the length of transition for a constant bed level along a transition . (use Ce=0.3)



********* **Hard Luck** *********

Water & Dams Branch

Hydraulic Structures Exam / 1st Attempt

Poblems Solutions

Q1 (A)

between 1 & 2:

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_{L(1-2)}$$

$$\frac{V_1^2}{2g} = \frac{V_2^2}{2g} \quad \& \quad Z_1 = Z_2$$

then :- $h_{L(1-2)} = \frac{P_1 - P_2}{\gamma} = \frac{14-12.5}{9.81} \approx \boxed{0.153\ m}$

between 1 & 3

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + Z_3 + h_{L(1-3)}$$

$$V_1 = \frac{Q}{A_1} = \frac{\left(\frac{420}{60*1000}\right)}{\frac{\pi}{4}\left(\frac{60}{1000}\right)^2} \simeq 2.48\ m/s$$

$$V_3 = \frac{Q}{A_3} = 5.38\ m/s$$

then :- $\frac{14}{9.81} + \frac{2.48^2}{2*9.81} + 5 = \frac{10}{9.81} + \frac{5.38^2}{2*9.81} + 0 + h_{L(1-3)}$

$\Rightarrow h_{L(1-3)} = \boxed{4.24\ m}$

Water & Dams Branch

Hydraulic Structures Exam / 1st attempt

Problems Solutions

Q1 (B)

$$2.5-h = f\frac{L}{D}\frac{V^2}{2g} + 0.5\frac{V^2}{2g} + 1\frac{V^2}{2g}$$

$$2.5-h = \frac{V^2}{2g}\left[0.024 * \frac{40}{0.1} + 0.5 + 1\right]$$

$$2.5-h = 11.1\frac{V^2}{2g} \quad \text{——— (1)}$$

also $Q = 0.4\sqrt{2*9.81} * 0.25\, h^{3/2}$

$Q = 0.443\, h^{3/2}$ & $Q = V.A = V * \frac{\pi}{4}(0.1)^2$

$\Longrightarrow Q = 0.00785\, V$

then $V^2 = 3184.7\, h^3$ ——— (2)

Put 2 in 1

$$2.5-h = \frac{11.1}{2*9.81}(3181.47)h^3$$

$\Longrightarrow 1801.74h^3 + h = 2.5 \Longrightarrow h \simeq \boxed{0.11\,m}$

& $Q = 0.443(0.11)^{3/2} = \boxed{0.0162\ m^3/s}$

Water & Dams Branch

Hydraulic Structures Exam / 1st attempt

<u>Problems Solutions</u>

Q_1 (c)

$h = 1.33 - 0.85 = 0.48\ m$

$H = 0.48 + 0.12 = 0.6\ m$

$0.8 * 0.6 = 0.48\ m$

$H_2 = 0.46\ m < 0.48\ m$; hence the flow is "Modular"

$$C_v = \left(\frac{H}{h}\right)^{1.5} = \left(\frac{0.6}{0.48}\right)^{1.5} = 1.398$$

$$C_d = \frac{\left[1.398^{2/3} - 1\right]^{0.5}}{0.385 * 1.398} * \frac{1}{0.86} \simeq 1.081$$

$$q = C_d\, C_v\, \frac{2}{3}\sqrt{\frac{2}{3} g}\ H^{3/2}$$

$$= 1.081 * 1.398 * \frac{2}{3}\sqrt{2/3 * 9.81} * (0.6)^{3/2}$$

$$\Rightarrow q = \boxed{1.2\ m^3/s/m}$$

by Ranga-Raju Eq.

$$\frac{0.48}{0.48 + 0.85} = \frac{\sqrt{3}\left(C_w^{1.5} - \frac{2}{3}\right)^{1/2}}{C_w} \Rightarrow C_w = 0.78$$

$$\Rightarrow q = 0.78\sqrt{9.81} * (0.6)^{1.5} \simeq \boxed{1.14\ m^3/s/m}$$

Water & Dams Branch

Hydraulic Structures Exam / 1st Attempt

Problems Solutions

Q2 (A)

$$Q = A \cdot V \quad \& \quad R = \frac{A}{P} = \frac{(b+y)y}{b+2y\sqrt{2}} = \frac{by+y^2}{b+\sqrt{6}\,y}$$

$$2.1 = 1.3\,(by+y^2) \Rightarrow \boxed{by+y^2-1.6154=0}$$

(a) If $y = b \Rightarrow y^2+y^2-1.6154=0$

$$\Rightarrow \boxed{y = 0.899\text{ m}} \quad \& \quad \boxed{b = 0.899\text{ m}}$$

(b) $y^2 + 2y^2 - 1.6154 = 0$

$$\Rightarrow \boxed{y = 0.734\text{ m}} \quad \& \quad \boxed{b = 1.468\text{ m}}$$

for (a)

$$R = 0.521 \quad \& \quad S = \frac{V^2 n^2}{R^{4/3}} = \frac{1.3^2\, n^2}{(0.521)^{4/3}}$$

$$\boxed{S = 4.03\, n^2}$$

for (b) $R = 0.6384 \Rightarrow \boxed{S = 3.074\, n^2}$

Water & Dams Branch

Hydraulic Structures Exam / 1st Attempt

<u>problems Solutions</u>

Q2 (B)

$$q = \frac{Q}{b} = \frac{2.4}{2} = 1.2 \ m^3/s/m$$

$$E = y + \frac{V^2}{2g} = y + \frac{q^2}{2gy^2} = 1 + \frac{1.2^2}{2*9.81*1^2} = \underline{1.07 \ m}$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} = 0.528 \ m \quad \& \quad E_{min.} = 1.5 y_c = \underline{0.792 m}$$

$$\text{then} \quad \Delta Z_{crit.} = E - E_{min.} = 1.07 - 0.792 \cong \boxed{0.28 \ m}$$

$\because \Delta Z < \Delta Z_{crit.}$ $\therefore$ y_c <u>does not occur over hump.</u>

$$\text{If} \quad E_{min.} = E = 1.07 = 1.5 y_c \implies \underline{y_c = 0.715 m}$$

$$\implies y_c = \sqrt[3]{\frac{\frac{Q^2}{B^2}}{9.81}} = 0.715 \implies \boxed{B = 1.26 m}$$

(Constriction width)

Q2 (C)