



Department: Civil Engineering
Level: (4)
Semester: Fall
Subject: Engineering Hydraulics
Subject code: CIE 401

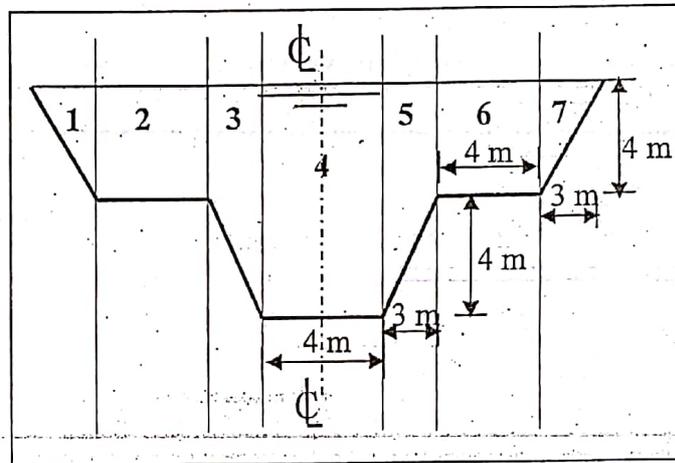
Date: 16/1/2018
Time allowed: 3 Hours
Full marks: 60 marks
No. of pages: Two Pages

Question (I): (15 Marks)

The following figure is a cross section of an open channel. This cross section is divided into 7 sectors as shown in figure. The Manning coefficient (n) and mean velocity (V_{mean}) corresponding to each sector is shown in the table. **It is required to:**

- Calculate the geometric elements for the cross section. (3 Marks)
- Calculate the mean velocity for the whole cross section. (2 Marks)
- Calculate the values of energy and momentum coefficients. (4 Marks)
- Calculate the equivalent Manning coefficient using Horton and Einstein formula; (2 Marks)
- Calculate the bed slope of the channel. (2 Marks)
- Classify the flow according to Froude number. (2 Marks)

Sec	n	V_{mean} (m/sec)
1	0.013	1.5
2	0.025	1.4
3	0.013	1.2
4	0.025	1.6
5	0.013	1.2
6	0.025	1.4
7	0.013	1.5

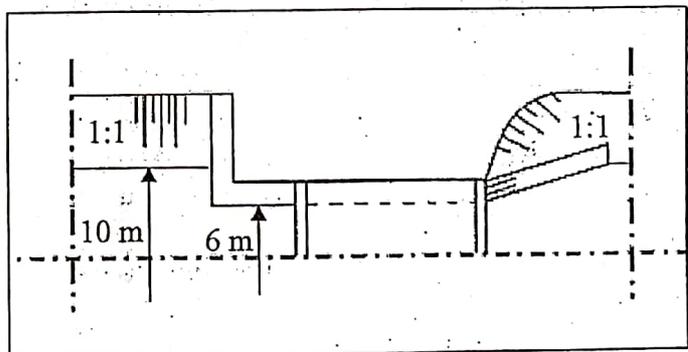


Question (II): (15 Marks)

- (a) Define the following terms: (4 Marks)
- Specific energy
 - Specific energy curve
 - Specific discharge curve
 - Control section

(b) It is proposed to build a bridge, of span equals 6 m, across a channel of 10 m bed width, 1:1 side slope, 3 m water depth and carries a discharge of $25 \text{ m}^3/\text{sec}$ as shown in figure. **It is required to:** (11 Marks)

- Calculate the water depth in the bridge location.
- The maximum height of hump which may be installed in the bridge location to produce critical depth here.
- What occurs for the water depth in the bridge location, if the channel bed is constricted to 2.8 m?
- How can the water levels before and after the transition remain the same? (compute the value of a transition)

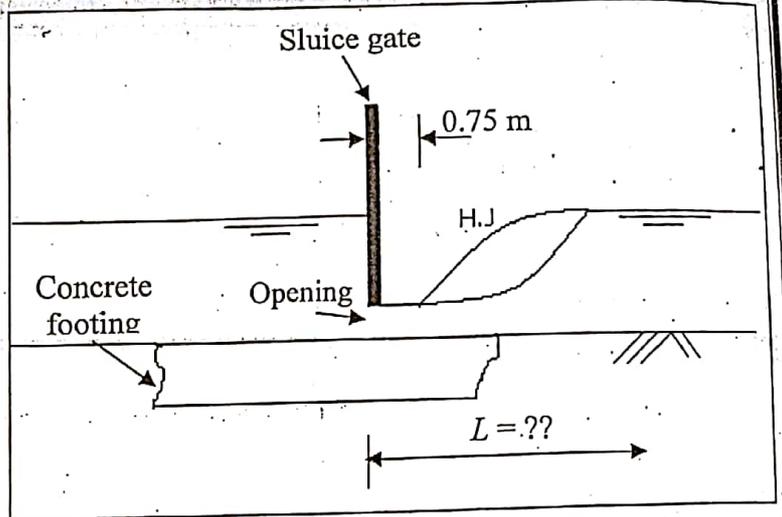


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Question (III): (15 Marks)

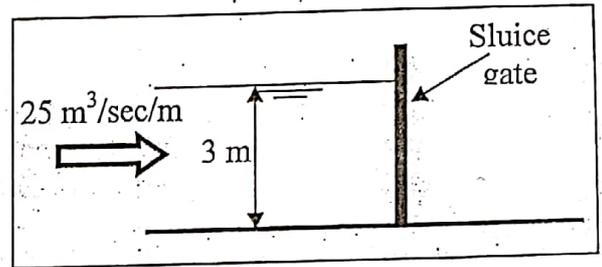
(a) The figure shows a hydraulic jump formed in a horizontal smooth rectangular open channel, the bed width is 10 m and the initial depth is 2 m. The discharge passing is $185.3 \text{ m}^3/\text{sec}$. **It is required to: (7 Marks)**

- (i) Calculate the sequent depth.
- (ii) Classify the hydraulic jump.
- (iii) What is critical value of length (L)?
- (iv) If the gate opening is equal to initial depth of jump, what is the gate opening required to produce oscillating jump if sequent depth remains constant?



(b) For the shown figure, **it is required to:**

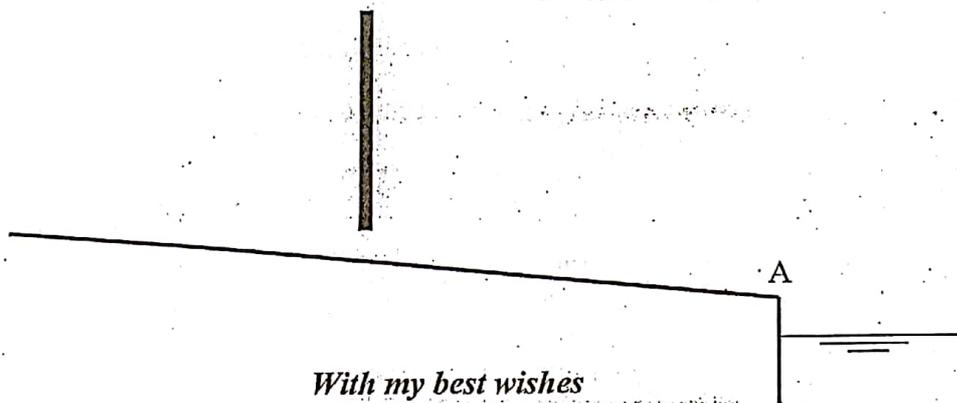
- (i) Calculate the specific force on the sluice gate if the water flow rate is $5 \text{ m}^3/\text{sec}/\text{m}$. Re-calculate the specific force if the water is static. (4 Marks)
- (ii) Draw a general relationship between specific force and water depth. (2 Marks)
- (iii) What occurs if the sluice gate is suddenly opened? (2 Marks)



Question (IV): (15 Marks)

- (a) Deduce an expression to calculate the shear stress on the wetted perimeter in case of steady uniform flow. (3 Marks)
- (b) Deduce an expression to calculate the horizontal distance of any G.V.F using direct step method. (3 Marks)
- (c) A lined rectangular channel shown in the following figure, carries a discharge of 200 cfs, its width is 10 ft, its slope is 0.001 and $n = 0.02$. If a regulator is installed across the channel which raises the water level at the gate location to a depth of 6.0 ft. **It is required to:**

- (i) Sketch the water surface profile for the channel if critical slope is 0.0072. (4 Marks)
- (ii) Calculate the horizontal distance from point (A) to a location in the channel whose water depth is equal to normal depth (take three sections only in the direct step method) (5 Marks)



With my best wishes
 Assoc. prof. Dr./ Hamdy El-Ghandour

Solution of Final exam

Question (I) 15

(i) $T = (3+4+3) \times 2 + 4 = \underline{24 \text{ m}}$

$y = 4+4 = \underline{8 \text{ m}}$ (3)

$P = (5+4+5+2) \times 2 = \underline{32 \text{ m}}$

$A = 0.5 \times 3 \times 4 \times 2 + 4 \times 4 \times 2 + (0.5 \times 3 \times 4 + 4 \times 3) \times 2 + 4 \times 8 = \underline{112 \text{ m}^2}$

$R = A/P = 112/32 = \underline{3.5 \text{ m}}$

$D_{\text{mean}} = A/T = 112/24 = \underline{4.67 \text{ m}}$

(ii) $V_m = \frac{\sum_{i=1}^7 V_i A_i}{A_T} = \frac{12 \times 1.5 + 32 \times 1.4 + 36 \times 1.2 + 32 \times 1.6}{112} = \underline{1.4 \text{ m/s}}$ (2)

(iii) $\alpha = \frac{\sum_{i=1}^7 V_i^3 A_i}{V_m^3 A_T} = \frac{12 \times 1.5^3 + 32 \times 1.4^3 + 36 \times 1.2^3 + 32 \times 1.6^3}{1.4^3 \times 112} = \underline{1.04}$ (2)

$\beta = \frac{\sum_{i=1}^7 V_i^2 A_i}{V_m^2 A_T} = \frac{12 \times 1.5^2 + 32 \times 1.4^2 + 36 \times 1.2^2 + 32 \times 1.6^2}{1.4^2 \times 112} = \underline{1.02}$ (2)

(v) $n_{eq} = \frac{\left[\sum_{i=1}^7 P_i n_i^{2/3} \right]^{3/2}}{P_T^{2/3}} = \left[\frac{5 \times 0.013 \times 4 + 4 \times 0.025 \times 3}{32} \right]^{3/2} = \underline{0.018}$ (2)

(v) $V_m = \frac{1}{n} R^{2/3} S^{1/2} \rightarrow 1.4 = \frac{1}{0.018} \times (3.5)^{2/3} S^{1/2} \rightarrow \underline{S = 0.000134}$ (2)

(vi) $Fr = \frac{V}{\sqrt{g D_{\text{mean}}}} = \frac{1.4}{\sqrt{9.81 \times 4.67}} = 0.2 < 1$ subcritical flow (2)

Question II 15

(14)

(a) Specific energy: مجموع الطاقات متوسطة إلى قاع المجرى المائي

Specific energy curve: عبارة عن علاقة بين عمق الماء على المحور الرأسي وبين specific energy على المحور الأفقي. يستخدم لإيجاد alternative depths

Specific discharge curve: عبارة عن علاقة بين عمق الماء على المحور الرأسي وبين specific discharge على المحور الأفقي. يستخدم لإيجاد alternative depths

Control section: هو عبارة عن قطاع يكون التقعر عنده في القناة الحرة أو قريباً منها أو يمكن التحكم في السرعات خلاله

(b) $b = 10\text{ m}$, $z = 1$, $y_1 = 3\text{ m}$, $Q = 25\text{ m}^3/\text{sec}$

$$A_1 = b y_1 + z y_1^2 = 10 \times 3 + 1 \times 3^2 = 39\text{ m}^2 \quad (1)$$

$$T_1 = b_1 + 2 z y_1 = 10 + 2 \times 1 \times 3 = 16\text{ m}$$

$$Fr_1 = \frac{V_1}{\sqrt{g D_{\text{mean}}}}, \quad D_{\text{mean}} = \frac{A_1}{T_1} = \frac{39}{16} = 2.44\text{ m} \quad (1)$$

$$\therefore Fr_1 = \frac{25/39}{\sqrt{9.81 \times 2.44}} = 0.13 < 1 \rightarrow \text{The flow is subcritical.}$$

check of choking :-

(1)

$$E_1 = E_c \rightarrow 3 + \frac{25^2}{2 \times 9.81 \times 39^2} = 1.5 \sqrt[3]{\frac{q^2}{g}}$$

$$q_c = 8.95\text{ m}^3/\text{sec}/\text{m} \rightarrow b_{\text{min}} = \frac{25}{8.95} = \underline{\underline{2.8\text{ m}}}$$

(2)

∴ There is no choking

$$(i) E_1 = E_2 \rightarrow y_1 + \frac{Q^2}{2gA_1^2} = y_2 + \frac{Q^2}{2gy_2^2} \quad (2)$$

$$3 + \frac{25^2}{2 \times 9.81 \times 392} = y_2 + \frac{(25/6)^2}{2 \times 9.81 \times y_2^2}$$

$$19.62 y_2^3 - 59.25 y_2^2 + 17.36 = 0$$

$$y_2 = 2.91 \text{ m}$$

$$(ii) E_1 = E_c + \Delta z_c \quad (2)$$

$$3.02 = 1.5 \sqrt[3]{\frac{(25/6)^2}{9.81}} + \Delta z_c$$

$$\Delta z_c = 1.21 \text{ m}$$

(iii) If bed width is constricted to 2.8 m, critical flow occurs in Bridge location

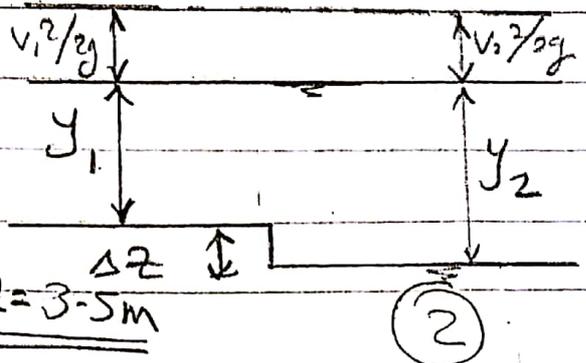
$$\text{then } y_2 = y_c = \sqrt[3]{\frac{Q^2}{g}} = \sqrt[3]{\frac{(25/2.8)^2}{9.81}} \approx 2 \text{ m}$$

iv) Depression is installed in Bridge location

$$V_1^2/2g = V_2^2/2g \Rightarrow V_1 = V_2$$

$$\frac{Q}{A_1} = \frac{Q}{A_2} \Rightarrow \frac{25}{39} = \frac{25/6}{y_2}$$

$$\frac{25}{39} = \frac{25/6}{y_2} \rightarrow y_2 = 6.5 \text{ m} \rightarrow \Delta z = 3.5 \text{ m}$$



(3)

Question III 15

(a) (i) $\frac{y_2}{y_1} = \frac{1}{2} (\sqrt{1 + 8Fr_1^2} - 1)$

$Fr_1 = \frac{v_1}{\sqrt{gy_1}} = \frac{(185.3/2 \times 10)}{\sqrt{9.81 \times 2}} = 2.091$

(2)

$y_2 = \frac{2}{2} (\sqrt{1 + 8 \times 2.091^2} - 1) = \underline{\underline{5m}}$

(ii) $Fr_1 = 2.091 \rightarrow$ The Jump is Weak (1)

(iii) $Fr_1 < 4.5 \rightarrow L_j = 6.9(y_2 - y_1) = 6.9(5 - 2) = 20.7m$

(2)

$\therefore L = 0.75 + 20.7 = 21.45m$

(iv) oscillating jump occurs when $2.5 < Fr_1 \leq 4.5$

take $Fr_1 = 3$

(2)

$\therefore \frac{y_2}{y_1} = \frac{1}{2} (\sqrt{1 + 8Fr_1^2} - 1) \rightarrow \frac{5}{y_1} = \frac{1}{2} (\sqrt{1 + 8 \times 3^2} - 1)$

\therefore gate opening $= y_1 = \underline{\underline{1.33m}}$

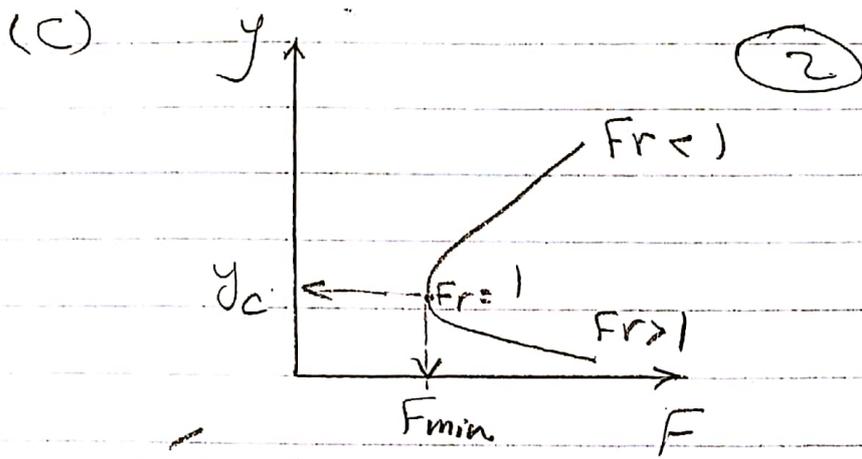
(b) $F = \frac{\gamma y^2}{2} + \frac{\gamma q^2}{gy}$, take $\gamma = 1 \text{ t/m}^3$

(4)

$F = \frac{1 \times 3^2}{2} + \frac{1 \times 5^2}{9.81 \times 3} = 5.35 \text{ t/m}^2$

if the water is static $F = 4.5 \text{ t/m}^2$

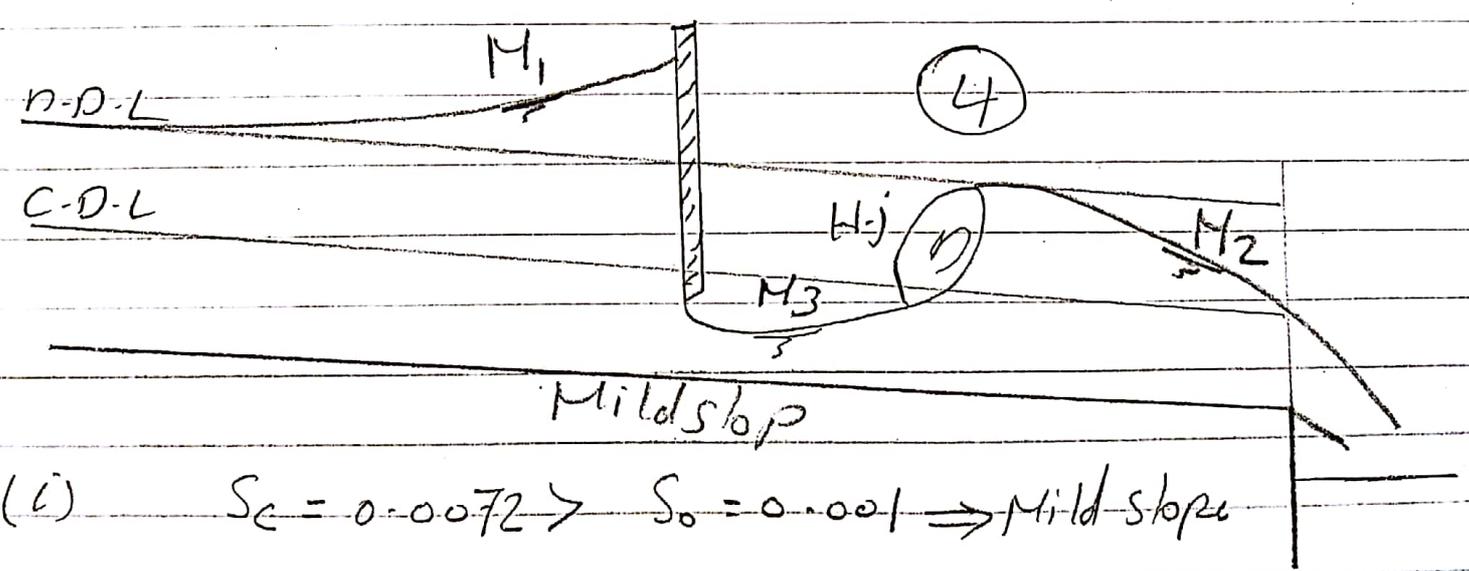
(4)



(d) تكون موجة Surge خلف البوابة ثم تتبدأ في الخلة في اتجاه اليمين.

Question IV

- (a) انظر الكتاب ص 135 (3)
- (b) انظر المحاضرات (3)
- (c) $Q = 200 \text{ ft}^3/\text{sec}$, $b = 10 \text{ ft}$, $s = 0.001$, $n = 0.02$



(i) $S_c = 0.0072 > S_0 = 0.001 \Rightarrow \text{Mild slope}$

y	A	R	$R^{4/3}$	V	$V^{2/3}g$	E	ΔE	S_F	\bar{S}_F	I
2.32	23.2	1.58	1.85	8.62	1.15	3.47		7.2×10^{-3}		
3.5	35	2.05	2.62	5.71	0.5	4.0	-0.53	2.24×10^{-3}		4.72×10^{-3}
4.75	47.5	2.44	3.28	4.21	0.28	5.03	-1.03	9.736×10^{-4}		1.6×10^{-3}

(5)

$$y_c = \sqrt[3]{\frac{q^2}{g}} = \sqrt[3]{\frac{20^2}{32.2}} = 2.32 \text{ ft}$$

$$200 = 10 y_n \left(\frac{1.49}{0.02} \right) \left(\frac{10 y_n}{10 + 2 y_n} \right)^{2/3} (0.001)^{1/2} \rightarrow y_n = 4.75$$

$$S_F = \frac{V^2 n^2}{2.22 R^{4/3}}$$

$$\Delta X = \frac{\Delta E}{\Delta S}$$

$$L = \frac{\Delta X_1}{\Delta S_1} + \frac{\Delta X_2}{\Delta S_2} = \frac{-0.53}{(0.001 - 4.72 \times 10^{-3})} + \frac{-1.03}{(0.001 - 1.6 \times 10^{-3})}$$

$$= 142.47 + 1716.67 \approx 1575 \text{ ft}$$

(6)