EAH225 HYDRAULICS
Open Channel Flow

Assignment Due Date : **17 Mac 2009**

1. A trapezoidal concrete channel has a uniform flow depth of 2 m. The bottom channel width is 5 m and the side slope 1:2. The Manning's roughness coefficient is 0.015 and the channel bed slope is 0.001. Compute the flow velocity, discharge, Froude Number, and type of flow under the given flow condition.

   Kedalaman aliran seragam di dalam satu saluran konkrit berbentuk trapezoid adalah 2 m. Lebar dasar saluran adalah 5 m dan cerun sisi 1:2. Nilai pekali kekasaran Manning adalah 0.015 dan cerun dasar saluran adalah 0.001. Kira halaju, luahan, Nombor Froude dan jenis aliran dalam saluran tersebut.

   (10 marks)

2. If the flow discharge in Q1 is 60 m^3/s, calculate the uniform flow depth.

   Jika luahan bagi soalan (1) adalah 60 m^3/s, kira kedalaman aliran seragam.

   (10 marks)

3. The water level during flood for a compound channel in Figure 1 exceeds the bankfull depth of 2.5 m. The Manning's roughness coefficient for main channel and flood plain are 0.025 and 0.050 respectively. Compute the flood discharge if the water level in the main channel is 4 m. The compound channel bed slope is 0.001.

   Paras air bagi saluran majmuk dalam Rajah 1 melebihi paras tebing penuh iaitu 2.5 m sewaktu banjir berlaku. Pekali kekasaran Manning bagi saluran utama dan dataran banjir masing-masing adalah 0.025 dan 0.050. Kira luahan jika kedalaman aliran dalam saluran utama adalah 4 m. Cerun saluran adalah 0.001.

   (10 marks)

4. If the flow discharge in Q3 is 750 m^3/s, calculate the flow depth in the main channel.

   Jika luahan bagi saluran majmuk dalam soalan (3) adalah 750 m^3/s, kira kedalaman aliran di dalam saluran utama.

   (20 marks)

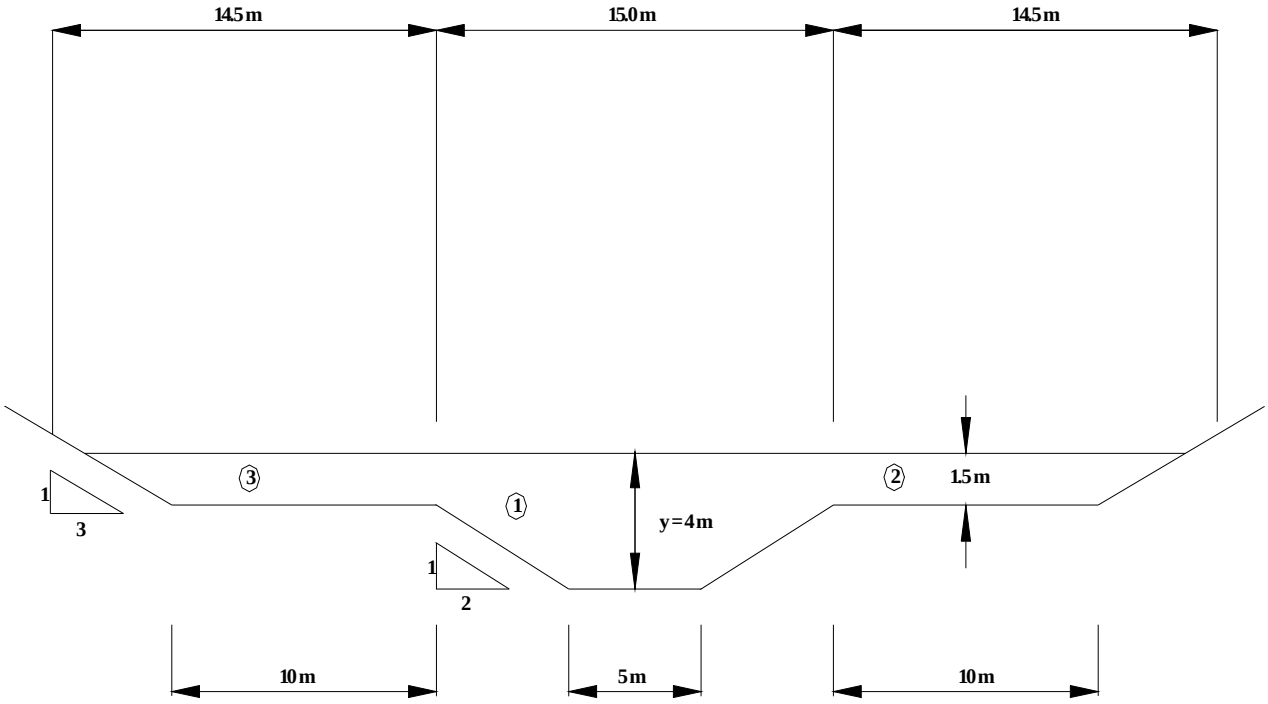

Figure 1

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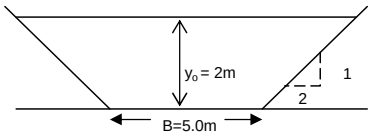
1



Given:

B	=	5	m
S_o	=	0.001	
n	=	0.015	
y_o	=	2	m

Solution :

v = $\frac{1}{n} R^{2/3} S_o^{1/2}$

Q = (A) x (v)

A = $(B+Ny_o)y_o$ = $(5+2y_o)y_o$ = 18.0 m^2

P = $B+2y_o\sqrt{1+N^2}$ = $5+2(2)\sqrt{1+2^2}$ = 13.944 m

Therefore,

R = A/P = 1.2909

v = 1.17 m/s

Q = 21.08 m^3/s

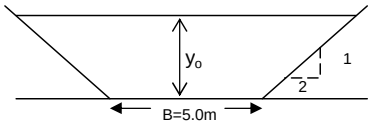
Froude Number, $Fr_1 = \left(\frac{Q^2 B}{gA^3}\right)^{1/2}$

$= \left(\frac{(45^2 \times 5)}{9.81 \times (18)^3}\right)^{1/2}$

= 0.197 (< 1)

Therefore, **Subcritical flow**

2



Given:

B	=	5	m
S_o	=	0.001	
n	=	0.015	
Q	=	60	m^3/s

Solution :

A = $(B+Ny_o)y_o$ = $(5+2y_o)y_o$

P = $B+2y_o\sqrt{1+N^2}$ = $5+2y_o\sqrt{1+2^2}$ = $5+4.47y_o$

y_o (m)	A (m^2)	P (m)	R (m)	v m/s	Q (m^3/s)
1.00	7.0	9.47	0.739	1.723	12.06
2.00	18.0	13.94	1.291	2.499	44.99
3.00	33.0	18.42	1.792	3.110	102.63
2.310	22.2	15.33	1.450	2.700	60.00

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3 S_o = 0.001

n_1 = 0.025 n_2 = 0.050

Main channel : A_1 = (4 x 5) + 2 x (0.5 x (4+1.5) x 5)

= 47.5 m^2

P_1 = 2 x $(2.5^2 + 5^2)^{0.5}$ +5

= 16.18 m

R_1 = (A_1/P_1)

= 2.9357

V_1 = $\frac{1}{n} R^{2/3} S_o^{1/2}$

Q_1 = Av

= 123.185 m^3/s

Floodplain : A_2 = (10 x 1.5) + (0.5 x 4.5 x 1.5)

= 18.375 m^2

P_2 = 10 + $(4.5^2 + 1.5^2)^{0.5}$

= 14.74 m

R_2 = (A_2/P_2)

= 1.2463

V_2 = $\frac{1}{n} R^{2/3} S_o^{1/2}$

Q_2 = AV

= 13.459 m^3/s

Q_2 = Q_3

Therefore, Q = Q_1 + 2 x Q_2

= 150.103 m^3/s

4 Q = 750 m^3/s

Solution :

Main channel : A_1 = (y_o x 15) + (0.5 x (15 + 5) x 2.5)

= 25 + 15y_o m^2

P_1 = 2 x $(2.5^2 + 5^2)^{0.5}$ +5

= 16.18 m

R_1 = (A_1/P_1)

V_1 = $\frac{1}{n} R^{2/3} S_o^{1/2}$

Q_1 = Av

Floodplain : $A_2 = (10 \times y_o) + (0.5 \times 3x\ y_o \times y_o)$

$= 10y_o + 1.5y_o^2$

$P_2 = 10 + y_o\sqrt{1+3^2}$

$= 10 + 3.162y_o$

$R_2 = (A_2/P_2)$

$V_2 = \frac{1}{n} R^{2/3} S_o^{1/2}$

$Q_2 = AV$

$Q_2 = Q_3$

y_o = above bankfull depth

y_o (m)	A_1 (m^2)	P_1 (m)	R_1 (m)	V_1 m/s	Q_1 (m^3/s)	A_2 (m2)	P_2 (m)	R_2 (m)	V_2 m/s	Q_2 (m^3/s)	Total Q (m^3/s)
5.00	100.0	16.18	6.180	4.260	425.99	87.5	25.81	3.390	1.427	124.9	675.76
5.50	107.5	16.18	6.644	4.470	480.56	100.4	27.39	3.664	1.503	150.9	782.34
6.00	115.0	16.18	7.107	4.676	537.73	114.0	28.97	3.935	1.576	179.7	897.12
5.352	105.3	16.18	6.507	4.409	464.14	96.5	26.92	3.584	1.481	142.9	749.94

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Therefore, total depth for main channel = 2.5 + 5.35 =**7.85m**