EAH 225 HYDRAULICS

Open Channel Flow Test

1. Design a rectangular channel with the following data:

   Discharge, $Q = 5.75\ m^3/s$

   Channel slope, $S_o = 0.012$

   Manning's $n = 0.017$

   Normal depth, y_o = half of the width of the channel (B/2)

   Check the velocity and Froude number requirements.

(10 Marks)

2. A rectangular channel with a width of 4 m has a depth of 2.5 m at flow rate12 m^3/s. Draw a specific energy diagram for the given flow condition and determine whether the flow is subcritical or supercritical?

(10 Marks)

EAH 225 HYDRAULICS

OPEN CHANNEL FLOW TEST SOLUTION

1. Rearrange the Manning equation:

$$AR^{2/3} = \frac{nQ}{S^{1/2}}$$

Values of parameters for the Right Hand Side (RHS) are known:

RHS = $0.017 * 5.75 / (0.012)^{1/2} = 0.892$

Now we know that y = B/2, express the flow area (A) and the hydraulic radius (R) in terms of channel width (B):

$A = By = B^2/2$

$P = B + 2y = 2B$

$R = A/P = B/4$

Therefore, Left Hand Side (LHS) is given as:

LHS = $AR^{2/3} = B^2/2 * (B/4)^{2/3}$ = RHS = 0.892

Therefore,

B = **1.76 m**

and

y = 1.76/2 m = **0.88 m**

Checking velocity and Froude Number requirements:

$$V = \frac{1}{n} R^{2/3}\ S_O^{1/2}$$

$$R = \frac{B}{4} = 0.44m$$

$$V = \frac{1}{0.017}\ (0.44)^{2/3}\ (0.012)^{1/2} = \mathbf{3.728\ m/s}$$

$$F_r = \frac{V}{\sqrt{\text{gy}}} = \frac{3.728}{\sqrt{(10)(0.88)}} = \mathbf{1.257}$$

Since **V is between 0.6 m/s and 4 m/s** for a concrete channel, the computed dimensions are OK.

Fr > **1.13,** the design is OK

2. $E_s = y + \frac{Q^2}{2gA^2}$ (Velocity Head)

Rewrite as:

$$E_s = y + \frac{q^2}{2gy^2}$$

where unit discharge = q = Q/B

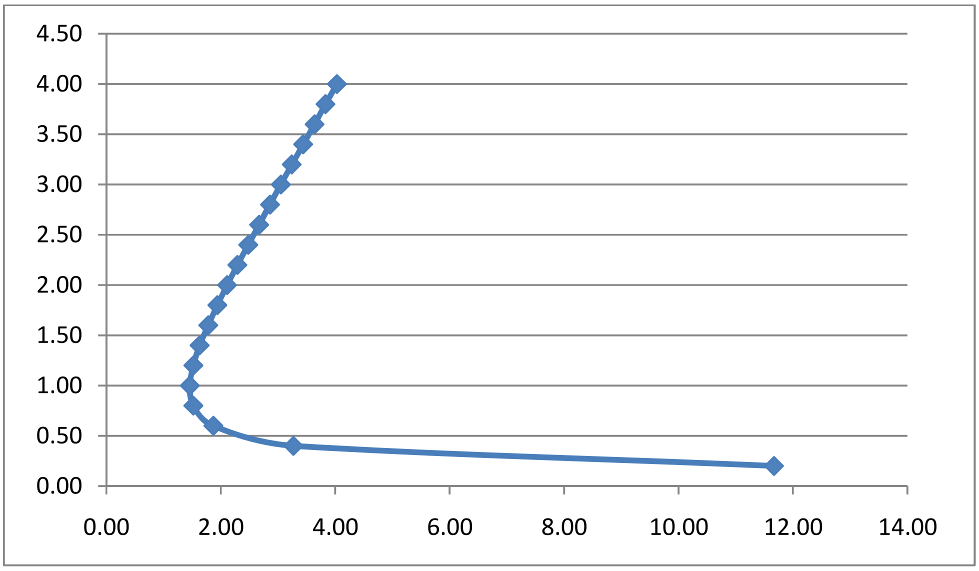
The advantage of using unit discharge is that we avoid using B and relate q directly to y:

q = 12/4 = 3 m^2/s

Set up a table and compute the velocity head and specific energy for every 0.2m depth increment:

y (m)	Velocity Head (m)	E_s (m)
0.20	11.47	11.67
0.40	2.87	3.27
0.60	1.27	1.87
0.80	0.72	1.52
1.00	0.46	1.46
1.20	0.32	1.52
1.40	0.23	1.63
1.60	0.18	1.78
1.80	0.14	1.94
2.00	0.11	2.11
2.20	0.09	2.29
2.40	0.08	2.48
2.60	0.07	2.67
2.80	0.06	2.86
3.00	0.05	3.05
3.20	0.04	3.24
3.40	0.04	3.44
3.60	0.04	3.64
3.80	0.03	3.83
4.00	0.03	4.03

y (m)



E_s

Explicit computation

For critical flow,

$$\frac{q^2}{g y_c^3} = 1$$

Or

$$y_c = \sqrt[3]{\frac{q^2}{g}}$$

$$y_c = \sqrt[3]{\frac{3^2}{9.81}} = 0.971 \text{ m}$$

Since the flow depth is 2.5 m > 0.971 m, the flow is **subcritical.**