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HYDRAULICS

NON - UNIFORM FLOW IN OPEN CHANNEL

TOPIC 3.2

by

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Communitising Technology

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NON -UNIFORM FLOW IN OPEN CHANNEL

3.2

- Determination of critical depth by various methods

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3.2 : DETERMINATION OF CRITICAL DEPTH BY VARIOUS METHODS

Three methods available

1. Algebraic/Trial and Error Method
2. Graphical Method
3. Design Chart

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EXAMPLE 3.4:

a) A wide and straight river was flows with 3.5m³/s/m flow rate. What is the value of critical depth? If normal depth is 4.6m, calculate the Froude number for this flow rate. (Type of flow: sub critical or supercritical). Calculate the critical slope if Manning's Coefficient is 0.035.

b) Refer to question (a), calculate the depth (y_2) for the same specific energy. What is Froude number for this condition?

*For (b), there are 2 solutions; trial and error and graphical method

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Solution Example 3.4 (a):

$q = 3.5 m^3/s/m$

$y_c = \sqrt[3]{(q^2/g)}$

$= \sqrt[3]{[(3.5^2)/9.81]}$

$=$ **1.08m** (answer)

At normal depth, $y = 4.6m$,

Flow Velocity, $v = q/y = 3.5/4.6 = 0.76 m/s$

Froude Number at $y = 4.6$,

$Fr = v/\sqrt{(gy)}$

$= 0.76/\sqrt{(9.81)(4.6)}$

$=$ **0.113** (answer)

Note: **Fr < 1.0**, therefore , flow in this river is **subcritical flow**

From Manning Formula:

$Q = AR^{(2/3)}\sqrt{S} / n$

Note:-

for a rectangular channel, q= Q/b; for a very wide channel, R = y

Therefore;

$q = y^{(5/3)}S^{(1/2)}/n$

At critical flow in Non-Uniform flow;-

$q = y_c^{(5/3)}S_c^{(1/2)}/n$

$S_c = (q_n/y_c^{(5/3)})^2$

$= [3.5 \times 0.035 / (1.08)^{(5/3)}]^2$

$=$ **0.012 or 1/86** (answer)

Solution Example 3.4 (b):

Specific Energy for y_1 = 4.6

E = $4.6 + (3.5)^2/19.62\,(4.6)^2$ = 4.63m

but

E = $y_2 + q^2/(2gy_2^2)$

Where as y_2 = depth at the same specific energy

THERE ARE 2 METHODS:-

Trial & Error Method

y_2 should be in supercritical flow, therefore, the value of y_2 is smaller than y_c.

If y_2 >>>> ;E <<<<

Graphical Method

Graph 'y' vs 'E = $y + (3.5)^2/19.62\,(y)^2$'

E = $y + 0.624/y^2$

y = 0 – 5 meter

y = 0.383 m

EXAMPLE 3.5:

A rectangular channel with 3m width flows water at 12m³/s flow rate when Froude number is 0.8. Determine the depths (y_1 and y_2) for the same flow rate and specific energy.

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Solution Example 3.5:

Q	=	$12 m^3/s$
V	=	Q/A
	=	$12/3y_1$
	=	$4/y_1$

If

Fr	=	0.8 (subcritical flow)
$v/\sqrt{(gy_1)}$	=	0.8
$(4/y_1)/\sqrt{(9.81y_1)}$	=	0.8
y_1	**=**	**1.366m** **(depth for subcritical flow, y_1)**

Specific Energy;-

E_1	=	$y_1 + q^2/2gy_1^2$
	=	$1.366 + (4)^2/2(9.81)(1.366)^2$
	=	1.803m

Solution Example 3.5:

Calculation for y_2 at the same flow rate and specific energy

E_1	=	E_2
	=	$y_2 + q^2/2gy_2^2$
1.803	=	$y_2 + 0.815/y_2^2$

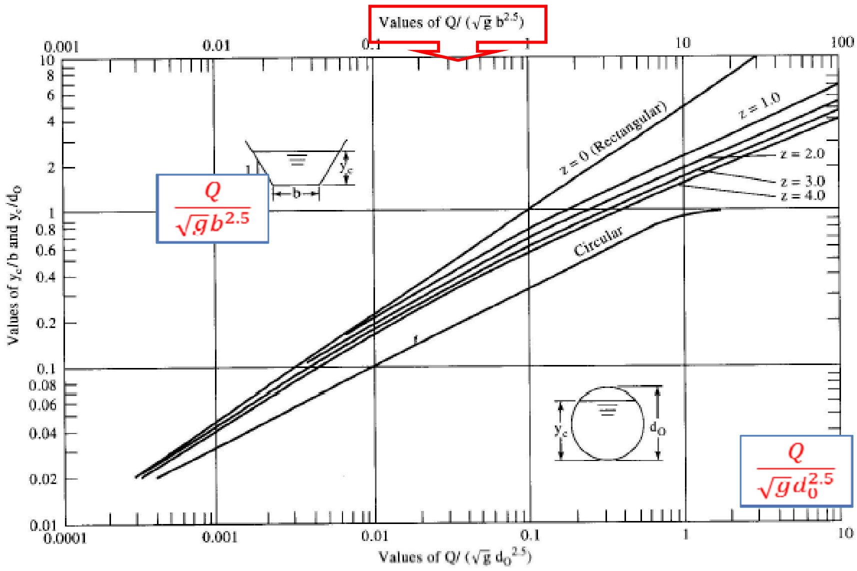
Critical depth, y_c	=	$(q^2/g)^{(1/3)}$
	=	$(4^2/9.81)^{(1/3)}$
	=	1.177m (as a reference for trial & error method)

- **Algebraic /Trial & Error Method**:-

Y_2	E = 1.803
1	1.82
1.01	1.81
1.02	1.8

y_2 = 1.02 m **(depth at supercritical flow)**

Curve for determining critical depth



Curve for determining critical depth

FIG. 4-1. Curves for determining the critical depth.

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