Universiti Malaysia PAHANG

# HYDRAULICS

## NON - UNIFORM FLOW IN OPEN CHANNEL

### TOPIC 3.3

by

Nadiatul Adilah Ahmad Abdul Ghani
Faculty of Civil Engineering and Earth Resources
nadiatul@ump.edu.my



Universiti Malaysia PAHANG

## NON -UNIFORM FLOW IN OPEN CHANNEL

3.3

- Control Section

## 3.3 : Control Section

- ❖ A section where a certain relationship can be established between flowrate and water level, Q and h
- ❖ It also controls the flow so that it can prevent the changes of flow types from happening (critical flow, subcritical & supercritical)
- ❖ Gauge station – to get flow rating curve which represents the 'flowrate' vs 'depth' relationship for the channel.



### 3.3.1 Control point

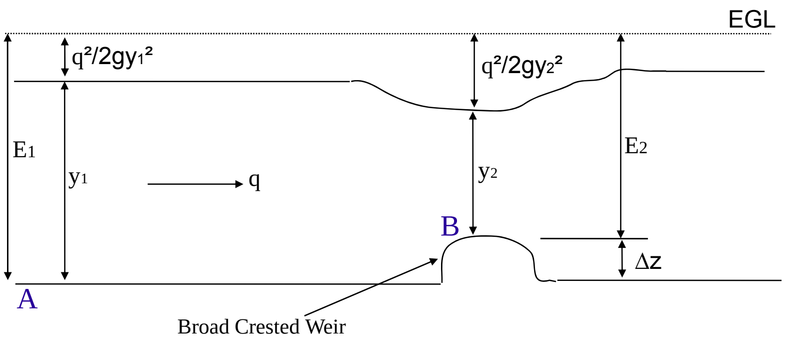
- ❖ Point where depth of steady flow can be determined due to grade change, dam, weir, etc.

Examples;

- ❖ The change of slope from mild to steep
- ❖ Free drop
- ❖ Entrance point from reservoir to steep channel
- ❖ Outlet point from steep channel to reservoir
- ❖ Flow over weir

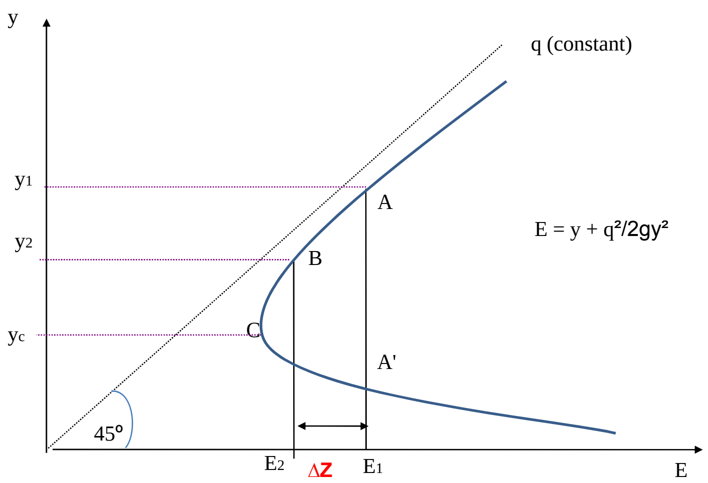
## a) Presence of Broad Crested Weir

A rectangular channel with width b (constant along the channel) flows with q m³/s/m. Assume this channel's slope is 0 degree (flat) and no roughness coefficient (subcritical flow).






## SED for Presence of Broad Crested Weir



# $E1 = E2 + \Delta Z$

note:- $\Delta Z$ = height of Broad crested weir

$$y1 + v1^2/2g = y2 + v2^2/2g + \Delta Z$$

or $E2 = E1 - \Delta Z$

From that figure, depth of water flow become lesser from point A to point B,

Specific Energy at point A, E1 > E2 (at point B)

If $y2 = yc$ ; $E2 = Emin$ ;

Therefore

$$\Delta z = \Delta zc$$

(critical flow and this broad crested weir represent as control point)



- If the weir increase more than before, specific energy will be decreased and water depth, y2 become lower until one point (point C). **Specific energy, E2 become minimum and y2 turn to yc. At this point, $\Delta z = \Delta zc$, flow is critical and weir known as control point.**

- If the height of weir increase greater than ($\Delta z > \Delta zc$), E-y curve for same q can not be used because minimum point for this curve is achieved and E2 < Emin. Therefore, for E2 and water depth above weir is constant, yc so $\Delta z$ move to right side from point C. At this point, E1 not enough for same q.

  $E1' = Emin + \Delta z$

- In this condition, **total flow at point A cannot flow over weir but maintain at the back of the weir**. This condition called '**choke**' and water depth at the upstream is increase. The depth at the upstream called backwater situation. At the downstream of the weir supercritical flow will be happened.

## EXAMPLE 3.6:

Water flows uniformly at $15 m^3/s$ in a rectangular channel with 3 m width and 2.5 m depth. If broad crested weir is constructed, calculate the minimum height of this weir which can cause critical flow above the weir (critical depth).

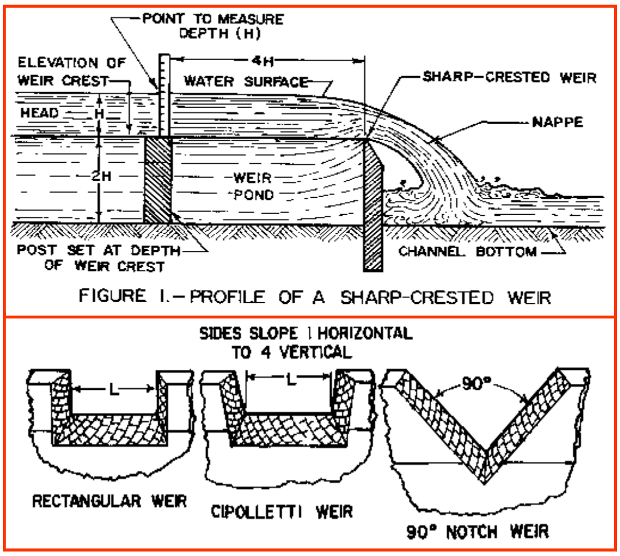
**Solution:-**

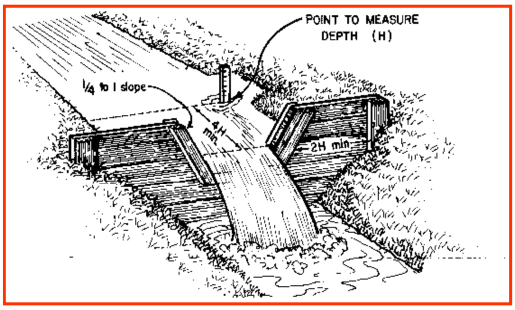
$$E_1 = E_{min} + \Delta Z_c$$
$$= 1.5\, y_c + \Delta Z_c$$

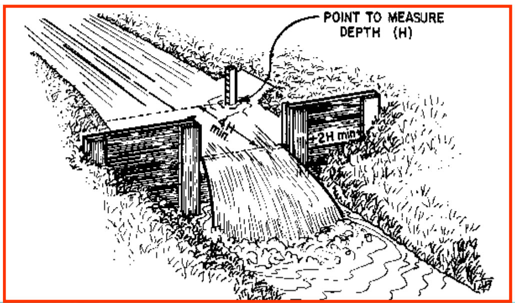
(Answer: $y_c$ = 1.367m, $E_1$ = 2.704m , ΔZ = 0.655m)



## Examples of Weirs



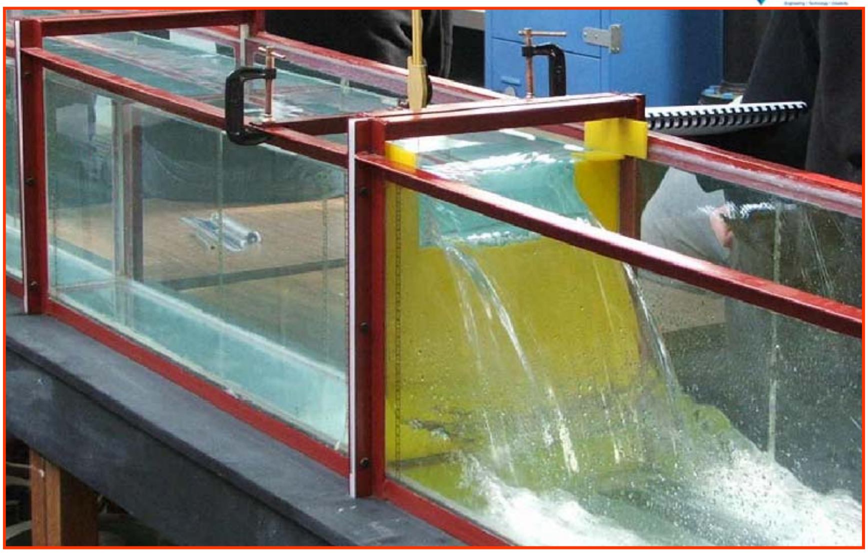






Universiti Malaysia PAHANG



## b) Change of channel's width (Narrowing channel)

The similar concept like weir will be applied in this topic but the relationship between q-y is used because the width of channel will be changed and q also.

For same Q :

$Q = q1b1 = q2b2$

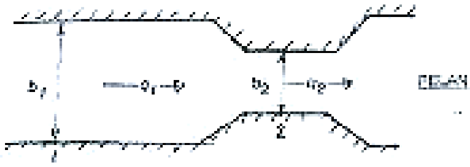
$q1 = Q/b1$

$q2 = Q/b2$

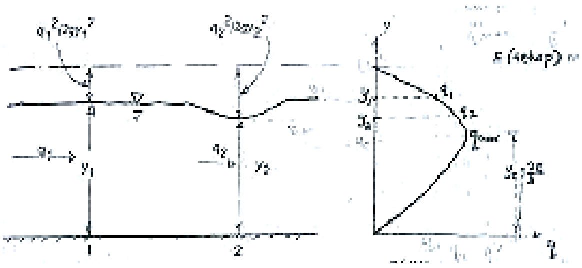
$b2 < b1$ therefore $q2 > q1$



**Plan**



**Side plan**



At critical point, b2 become minimum and q is maximum at same specific energy.

When the channel's become smaller, E1 do not enough to support q so E1 need to increase for achieve suitable specific energy, E' for critical depth yc'. Therefore, the depth at upstream, y1 increase for E'.

$y1' + q1^2/2gy1^{2\prime} = E'$

$y1' + Q^2/2gb1^{2\prime}y12' = E'$

where $E' = 1.5yc$ and

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

$= \sqrt[3]{(Q^2/b'2g)}$




Therefore,

if E' > E1, b' < bmin and specific energy at upstream E' = 1.5y'c

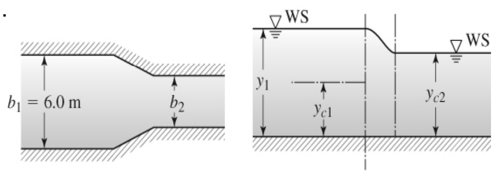
If control situation happened, the structure will be controlled flow at upstream and this structure called venturi flume.

## Example of flume



## EXAMPLE 3.7:

A 6.0 m rectangular channel carries a discharge of 30 $m^3/s$ at a depth of 2.5 m. Determine the constricted channel width that produces critical depth.




(a) (b)

**Solution:**

$$E = y + \frac{q^2}{2gy^2} = 2.5 + \frac{5^2}{2*9.81*2.5^2} = 2.70m$$

$$E = E_{min} = \frac{3}{2}y_c \Rightarrow y_c = 1.80m$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} \Rightarrow q = \sqrt{gy_c^3} = 7.56\ m^2/s$$

$$b_2 = Q/q = 30/7.56 = 3.07m$$

## EXAMPLE 3.8:

The water flows uniformly at 16.5 $m^3/s$ in a rectangular channel with 3.0 m width and 1.8 m depth. If one part of the channel was narrowing, calculate the maximum width of narrowing that can obtain critical water depth.

(Answer : $b_{max}$ = 2.819m)



# Lecturer Information (Authors)

Pn. Nadiatul Adilah bt Ahmad Abdul Ghani
Dr Nor Azlina bt. Alias
Pn. Wafty bt. Abd Rahman
Dr. Jacqueline Isabella