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Section :- "B"

Semister :- 6^{th}

Subject Name :- Hydraulic Engineering

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Question No: 01

(A) Let suppose a rectangular channel discharge R lit/sec of water into a 8m wide apron with zero slope. Mean velocity is R-220ft/sec calculate

1. Height of hydraulic Jump (In unit of Meter)
2. Power absorbed due to hydraulic Jump (In Unit of KW)

Answer No 01 (A)

Sol::

Given that

Channel width = $b = 8m$

Discharge, $Q = 7847$ lit/sec

$= 7.847 \; m^3/sec$

Mean velocity $\Rightarrow v = Q - 200$

$= 7847 - 200$

$= 7647$ ft/sec

$= 2331.402$ m/ses

As we know

$Q = q b$

$q = Q/b$

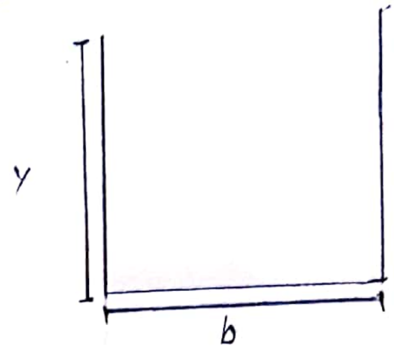
$= \frac{7.847}{8} = 0.9808 \; m^2/sec$

(2)

$$Y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

$$= \left(\frac{0.98087}{9.81}\right)^{1/3} = \boxed{0.464138m}$$

As it is rectangular section



$$Q = qb \rightarrow (i)$$
$$Q = AV \rightarrow (ii)$$

eq, (1) and (2) comparing

$$qb = AV$$
$$q\cancel{b} = Y\cancel{b}V$$
$$q = YV$$
$$V_c = q/Y_c$$
$$= \frac{0.98087}{0.464138}$$
$$V_c = \boxed{2.1133\ m/sec}$$

$\therefore V > V_c$ super critical flow.

Height of hydraulic jump on the upstream side.

As
$$Q = AV$$
$$Q = bYV$$
$$Y_1 = Q/V_1 b$$
$$Y_1 = \frac{7.847}{2331.402 \times 8} = 0.0004207\ m$$

③

$$Y_2 = \frac{-Y_1}{2} + \sqrt{\frac{Y_1^2}{4} + \frac{2YV_1}{g}}$$

Putting the values

$$Y_2 = \frac{-0.0004207}{2} + \sqrt{\frac{(0.0004207)^2}{4} + \frac{2(0.0004207)(2331.402)}{9.81}}$$

$$Y_2 = 21.59$$

$$\Delta y = Y_2 - Y_1$$

$$= 21.59 - 0.0004207$$

$$\Delta Y = 21.589$$

$$\Delta E = E_1 - E_2$$

As we know

$$A_1 V_1 = A_2 V_2$$

$$b y_1 v_1 = b y_2 v_2$$

$$V_2 = Y_1 V_1 / Y_2$$

$$V_2 = \frac{0.0004207 \times 2331.402}{21.59}$$

$$V_2 = 0.0454 \text{ m/sec}$$

$$\Delta E = E_1 - E_2 = \left(Y_1 + \frac{V_1^2}{2g}\right) - \left(Y_2 + \frac{V_2^2}{2g}\right)$$

$$\Rightarrow \left(0.0004207 + \frac{(2331.402)^2}{2 \times 9.81}\right) - \left(21.59 + \frac{(0.0454)^2}{2 \times 9.81}\right)$$

$$= 277013.84$$

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(4)

Power Absorbed:

$$\Delta P = \rho g Q (E_1 - E_2)$$

$$\Delta P = 1000 \times 9.81 \times 7.847 \, (277013.84)$$

$$\Delta P = 2.132426778 \times 10^{10}$$

Question No # 01
"B"

A sluice gate controls the flow in channel of width 4m. If the discharge is R ft^3/sec and the upstream and downstream water depth is 2.9m and 1.1m respectively. Calculate the downstream velocity.
Also state the type of flow at upstream and downstream side using any equation.

"B"

Answer No # 01

Given Data:

$b = 4m$

$Q = 7847 \, ft^3/sec = \frac{7847}{(3.28)^3}$

$Q = 222.373 \, m^3/sec$

$Y_1 = 2.9 \, m$

$Y_2 = 1.1 \, m$

Let Specific energy at upstream &

Down stream side :-

$E_1 = E_2$

$$Y_1 + \frac{V_1^2}{2g} = Y_2 + \frac{V_2^2}{2g} \rightarrow (1)$$

As we know that

$$Q = A_1 V_1 = A_2 V_2$$

$$b y_1 V_1 = b y_2 V_2$$

$$V_2 = \frac{Y_1 V_2}{Y_2}$$

$$V_2 = \frac{2.9\, V_2}{1.1}$$

$$\boxed{V_2 = 2.636 V_1}$$

Put the values in eq, (2) & eq, (1)

$$2.9 + \frac{V_1^2}{2 \times 9.81} = 1.1 + \frac{(2.636 V_1)^2}{2 \times 9.81}$$

$$2.9 - 1.1 = \frac{6.948 V_1^2}{19.62} - \frac{V_1^2}{19.62}$$

$$1.8 = \frac{6.948V_1^2 - V_1^2}{19.62}$$

$$1.8 \times 19.62 = 6.948V_1^2 - V_1^2$$

$$35.316 = 5.948\,V_1^2$$

$$\sqrt{V_1^2} = \sqrt{\frac{35.316}{5.948}}$$

$$\boxed{V_1 = 2.4366}$$

Now put the value of "V_1" in eq (1)

$$Y_1 + \frac{V_1^2}{2g} = Y_2 + \frac{V_2^2}{2g}$$

$$2.9 + \frac{2.4366^2}{2g} = 1.1 + \frac{V_2^2}{2g}$$

$$2.9 + \frac{5.937}{2g} = 1.1 + \frac{V_2^2}{2g}$$

$$2.9 - 1.1 = \frac{V_2^2}{2g} - \frac{5.937}{2g}$$

$$1.8 = \frac{V_2^2 - 5.937}{2g}$$

$$1.8 \times 2 \times 9.81 = V_2^2 - 5.937$$

$$35.316 = V_2^2 - 5.937$$

$$V_2^2 = 35.316 + 5.937$$

$$\sqrt{V_2^2} = \sqrt{41.253}$$

$$\boxed{V_2 = 6.4228 \, m/sec}$$

Using Froud No to determine type of Flow.

Up stream Side :-

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{2.4366}{\sqrt{9.81 \times 2.9}} = 0.4568 < 1$$

sub critical flow

Down stream Side :-

$$Fr_2 = \frac{V_2}{\sqrt{g y_2}} = \frac{6.4228}{\sqrt{9.81 \times 1.1}} = 1.955 > 1$$

(supercritical flow)

Question No # 02 "A"

What is the minimum height (In unit of meter) of broad crested weir if it is to function critical depth on the crest.

If water flows along a rectangular channel at a depth of 1.8m with a discharge of R ft^3/sec. the channel width is 66 ft.

Answer No # 02 "A"

Given Data :-

$Y = 1.8\,m$

$b = 66' \Rightarrow \frac{66}{3.28} = 20.12$

$Q = \frac{7847}{3.28^3} = 222.37\ m^3/sec$

Required Data :

minimum height (P) of weir

As

$Q = AV$

$v = \frac{Q}{A} = \frac{Q}{bY} = \frac{222.37}{20.12 \times 1.8} = 6.140\ m/sec$

$V = 6.140\ m/sec$

As we know that

$\because q = Q/b$

$q = \frac{222.37}{20.12}$

$q = 11.05$

$Y_c = \left(\frac{q^2}{g}\right)^{1/3}$

$Y_c = \left(\frac{11.05^2}{9.81}\right)^{1/3}$

$Y_c = 2.317\ m$

Also

$v = \sqrt{gY} \Rightarrow \sqrt{gY_c}$

$= \sqrt{9.81 \times 2.317}$

$\boxed{V_c = 4.767\ m/sec}$

Now According to specific energy.

$$E_1 = E_2$$

$$Y_1 + \frac{V_1^2}{2g} = \frac{V_2^2}{2g} + Y_c + P$$

$$1.8 + \frac{6.14^2}{2\times 9.81} = \frac{4.767^2}{2\times 9.81} + 2.317 + P$$

$$3.721 = 3.475 + P$$

$$\boxed{P = 0.245m}$$

Question No # 02 "B"

An orifice is in one side of large tank is rectangular in shape. 2.8 m board and 1.5 m deep. The water level on one side of the orifice is 5 meter above its top edge. The water level on the other side of the orifice is 0.6m below its top edge. calculate the discharge through the orifice if coefficient of discharge is cd = 0. R

Answer No # 02 "B"

Given data

$b = 2.8m$

$d = 1.5m$

$H_1 = 5m$

$H_2 = 5+1.5 = 6.5m$

$H = 5+0.6 = 5.6m$

$cd = 0.7847$

Required ?

$Q = ?$

Discharge through submerged Portion

$Q_1 = cd \times b \times (H_2 - H) \times \sqrt{2gH}$

$Q = 0.7847 \times 2.8 \times (6.5 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$

$Q_1 = 20.727 \ m^3/sec$

Discharge of free Portion.

$Q_2 = \frac{2}{3} cd \times b \sqrt{2g} \left[H^{3/2} - H_1^{3/2}\right]$

$Q_2 = \frac{2}{3} (0.7847) \times 2.8 \sqrt{2 \times 9.81} \times \left[5.6^{3/2} - 5^{3/2}\right]$

$= 13.441 \ m^3/sec$

Total Discharge.

$Q = Q + Q_2$

$Q = 20.727 + 13.441$

$Q = 34.168 \ m^3/sec$

Question No # 03

(A)

The diameter of water Pipe os suddenly enlarged from R − 200 mm to R+ 3000 mm the rate of flow through is 0.95 m^3/sec and the Pressure in the larger Pipe is R+ 800 N/m^2

calculate

1) The loss of Head due to sudden enlargement.

2) The Power lost due to sudden enlargment

3) The Pressure in the smaller Pipe (If the Pipe is horizontal).

Answer No # 03

(A)

Given data

$p_1 = R + 800 = 7847 + 800 = 8647\ N/m^2$

$d_1 = R - 200 = 7847 - 200 = 7647\ mm$

$= 7.647\ m$

$d_2 = R + 3000 \Rightarrow 7847 + 3000 = 10847$ mm

$A_1 = \frac{\pi}{4} d_1^2$

$= \frac{\pi}{4}(7.647)^2 = 45.927\ m^2$

$A_2 = \frac{\pi}{4} d_2^2 \Rightarrow \frac{\pi}{4}(10.847)^2 = 92.407\ m^2$

$Q = 0.95\ m^3/sec$

$\therefore\ Q = AV$

$V = Q/A$

$V_1 = Q_1/A_1 \Rightarrow \frac{0.95}{45.927}$

$V_1 = 0.0206$ m/sec

$V_2 = Q_2/A_2 \Rightarrow \frac{0.95}{92.407}$

$V_2 = 0.01028$

Head loss due to the sudden enlargement

$h_L = \left(1 - \frac{A_1}{A_2}\right)^2 \times \frac{(V_1 - V_2)^2}{2g}$

$= \left(1 - \frac{45.927}{92.407}\right)^2 \times \frac{(0.0206 - 0.01028)^2}{2 \times 9.81}$

$= 0.253001 \times 0.00000542$

$h_L = 1.37 \times 10^{-6}$

Power lost due to sudden enlargment

$P = \rho g Q h_c$

$P = 1000 \times 9.81 \times 0.95 \times 1.37 \times 10^{-6}$

$\boxed{P = 0.0127\ W}$

Pressure in the smallest Pipe

Apply Bernouli's equation.

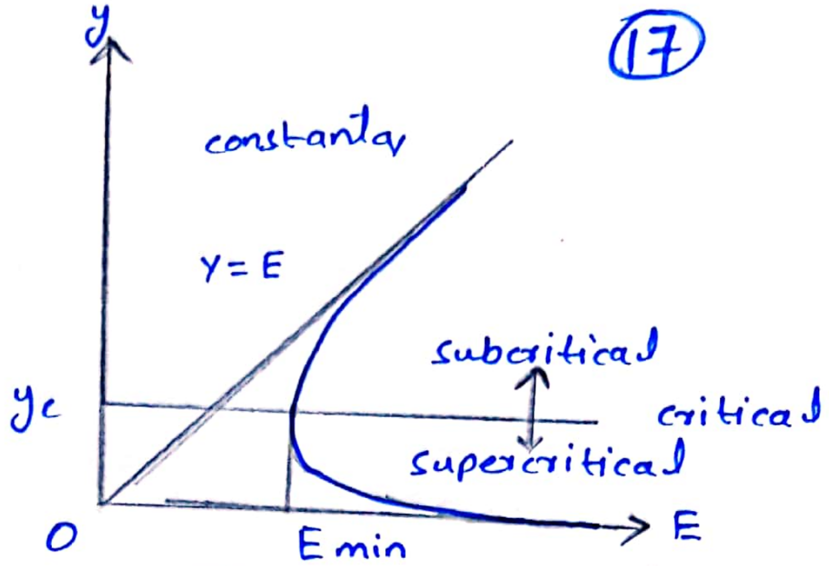
$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_c$$

$$\frac{8647}{1000 \times 9.81} + \frac{(0.0206)^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{(0.01028)^2}{2 \times 9.81} + 1.37 \times 10^{-6}$$

$\boxed{P_2 = 8647.14\ N/m^2}$

Question No # 03 (B)

(17)



what does this blue curve indicate. How it is obtained. Explain the above figure from each and every point of view.

Answer

The above graph is plot between depth flow (y) and Specific Energy(E). It is made from Three degree Polynomail equation which shows us the different specific energy for the depth flow which may be either

(i) subcritical
(ii) critical
(iii) Super critical

specific energy is used to clarify. The meaning of the terms in an open channel.

Total energy = Potential energy + kinetic energy

$T.E = mgh + \frac{1}{2} mv^2$ $\quad \because w = mg$

$= wh + \frac{1}{2} \frac{w}{g} v^2$ $\quad m = \frac{w}{g}$

ignoring "w" weight of water

$T.E = h + \frac{v^2}{2g}$

$T.E = Y + \frac{v^2}{2g} \rightarrow (1)$

As we know

$Q = VA$

$V = Q/A$ Taking square on b/s

$V^2 = Q^2/A^2$

Put v^2 in $\rightarrow$ eq (1)

$E = Y + \frac{Q^2}{A^2 2g}$ eq $\rightarrow (2)$

Let suppose the channel is Rectangular

$A = Y \times b \rightarrow (x)$

$Q = 2b \rightarrow (y)$

Putting value of (x) and (y) in (2)

$$E = y + \frac{Q^2}{y^2 b^2 2g}$$ (Putting x)

$$E = y + \frac{q^2}{y^2 2g}$$ (Putting y)

$$E - y = \frac{q^2}{y^2 2g} \Rightarrow y^2 (E-y) = \frac{q^2}{2g}$$

$$(E-y)\,y^2 = \text{constant}$$

As "q" and "g" are constant

critical depth is the flow depth corresponding to minimum specific energy.

$y > y_c \Rightarrow$ sub critical flow.
$y = y_c \Rightarrow$ critical flow.
$y > y_c \Rightarrow$ Super critical flow.