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Subject : Hydraulics Engineering

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Mid Term Exam

Question No: 01

(A) Let Suppose a rectangular channel discharge R litre/sec of water into a 8m wide apron with zero slope. Mean velocity is R - 200 lt/sec calculate

1- Height of hydraulic Jump (In unit of meter)

2- Power absorbed due to hydraulic Jump (In unit of kw).

Solution

Given data:

Channel width = b = 8m

Discharge, Q = 7875 lit/sec

= 7.875 m³/sec

Mean velocity => v = Q - 200

= 7875 - 200

= 7675 lt/sec

= 2339.93 m/sec

As we know

$Q = qb$

$q = Q/b$

$= \frac{7.875}{8} = 0.984 \; m^2/sec$

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

$$y_c = \left(\frac{0.984}{9.81}\right)^{1/3} = 0.4646 m$$

As it is rectangular section

$Q = qb \longrightarrow (i)$

$Q = AV \longrightarrow (ii)$

eq (i) and (ii) comparing

$qb = AV$

$qb = ybv$

$q = yv$

$v_c = q/y_c$

$$v_c = \frac{0.984}{0.4646}$$

$v_c = 2.117$ m/sec

$\therefore v > v_c$ Supercritical flow

<u>Height of Hydraulic Jump on the upstream:-</u>

Side:- As $Q = AV$

$Q = byv$

$y_1 = Q/v_1 b$

$$y_1 = \frac{7.875}{2334.93 \times 8} = 0.0004006 \text{ m}$$

(3)

$$y_2 = -\frac{y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2yv_1}{g}}$$

Putting values

$$y_2 = -\frac{0.0004206}{2} + \sqrt{\frac{(0.0004206)^2}{4} + \frac{2(0.0004206 \times 2339.93}{9.81}}$$

$y_2 = 22.59$

$\Delta y = y_2 - y_1$

$= 22.59 - 0.0004206$

$\Delta y = 22.58$

$\Delta E = E_1 - E_2$

As we know

$A_1 V_1 = A_2 V_2$

$by_1 v_1 = by_2 v_2$

$v_2 = y_1 v_1 / y_2$

$$v_2 = \frac{0.0004206 \times 2339.83}{22.59}$$

$v_2 = 0.0545\ m/sec$

$$\Delta E = E_1 - E_2 = \left(y_1 + \frac{v_1^2}{2g}\right) - \left(y_2 + \frac{v_2^2}{2g}\right)$$

$$= \left(0.0004206 + \frac{(2339.83)^2}{2 \times 9.81}\right) - \left(22.59 + \frac{0.0545^2}{2 \times 9.81}\right)$$

$= 278213.84$

(Q) (ii)

Power Absorbed:-

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

$$\Delta P = 1000 \times 9.81 \times 7.875 (278013.84$$

$$\boxed{\Delta P = 2.13428 \times 10^{10}}$$

Question No# 02
"B"

A sluice gate controls the flow in channel of width 4m. If discharge is R ft³/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.

Ans:-

<u>Given Data</u>:

$b = 4m$

$Q = 7875 \ ft^3/sec = \frac{7875}{(3.28)^3}$

$Q = 223.16 \ m^3/sec$

$y_1 = 2.9m$

$y_2 = 1.1m$

Let Specific Energy ~~of upstream~~ and downstream side :-

$E_1 = E_2$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g} \longrightarrow (1)$$

As we know that

$Q = A_1V_1 = A_2V_2$

$b y_1 v_1 = b_2 y_2 v_2$

$$V_2 = \frac{y_1 V_1}{y_2}$$

$$V_2 = \frac{2.9\, V_1}{1.1}$$

$$V_2 = 2.636 V_1$$

Put the values in eq (i) and eq (ii)

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

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

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

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

$$35.31 = 5.948 V_1^2$$

$$\sqrt{V_1^2} = \sqrt{\frac{35.31}{5.948}}$$

$$\boxed{V_1 = 2.436}$$

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

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

$$2.9 + \frac{2.436^2}{2 \times 9.81} = 1.1 + \frac{V_2^2}{2 \times 9.81}$$

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

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

(8)

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

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

$$35.316 = V_2^2 - 5.937$$

$$V_2^2 = 35.316 + 5.937$$

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

$$V_2 = 6.428 \text{ m/sec}$$

Using Froude No to determine type of flow

Upstream side:-

$$Fr_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{2.436}{\sqrt{9.81 \times 2.9}} = 0.4568 < 1$$

(Sub critical flow)

Downstream side:-

$$Fr_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{6.428}{\sqrt{9.81 \times 1.1}} = 1.955 > 1$$

(Supercritical flow)

Question No#02 Part 'A'

What is the minimum height (in unit of meter) of broad creisted weir if it is to functional 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:-

Given Data:-

$y = 1.8m$

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

$Q = \frac{7875}{3.28^3} = 223.16 \; m^3/sec$

Req-data:-

Minimum height (P) of weir = ?

As

$Q = AV$

$V = \frac{Q}{A} = \frac{Q}{by} = \frac{223.16}{20.12 \times 1.8} = 6.140 \ m/sec$

$V = 6.140 \ m/sec$

$\because q = Q/b$

$q = \frac{223.16}{20.12}$

$q = 11.09$

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

$y_c = \left(\frac{11.09}{9.81}\right)^{1/3}$

$y_c = 2.317 m$

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 :-

$E_1 = E_2$

$$y_1 + \frac{V_1^2}{2g} = \frac{V_2^2}{2g} + y_2 + P$$

$$1.8 + \frac{6.14^2}{2\times9.81} = \frac{4.767}{2\times9.8} + 2.317 + P$$

$$3.721 = 3.475 + P$$

$$P = 0.245 m$$

Question No# 2 "B" (12)

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

__Ans:-__

__Given Data:-__

$b = 2.8m$

$d = 1.5m$

$H_1 = 5m$

$H_2 = 5 + 1.5 = 6.5m$

$H = 5 + 0.6 = 5.6m$

$Cd = 0.7875$

__Required__

$Q = ?$

Scanned with CamScanner

Discharge through Submerged Portion:-

$Q = Cd \times b \times (H_2 - H) \times \sqrt{2gH}$

$Q = 0.7875 \times 2.8 (6.58 - 5.6) \times \sqrt{2 \times 9.81 \times 5.6}$

$Q_1 = 20.737 \ m^3/sec$

Discharge of Free Portion:-

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

$Q_2 = \frac{2}{3} (0.7875) \times 2.8 \sqrt{2 \times 9.81} \left[5.6^{3/2} \ 5^{3/2} \right]$

$Q_2 = \boxed{13.44 \ m^3/sec}$

Total Discharge:-

$Q = Q_1 + Q_2$

$Q = 20.737 + 13.44$

$\boxed{Q = 34.168 \ m^3/sec}$

Question No #03

(A)

The diameter of water pipe as suddenly enlarged from R-200m to R+3000 mm the rate of flow through is 0.95 m³/sec and the pressure in the larger pipe is R+800 N/m².

Calculate:-

1) The loss of head due to sudden enlargement.

2) The Power lost due to sudden enlargement

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

Answer:-

Given Data

$P_2 = R + 800 = 7875 + 800 = 8675\ N/m^2$

$d_1 = R - 200 = 7875 - 200 = 7675\ mm$

$= 7.675\ m$

$d_2 = R + 3000 = 7875 + 3000 = 10875\,mm$

$= 10.875\,m$

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

$= \frac{\pi}{4} (7.675)^2 = 45.92\,m^2$

$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} (10.875)^2 = 92.407\,m^2$

$Q = 0.95\,m^3/sec$

$\therefore Q = AV$

$V = Q/A$

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

$V_1 = 0.0206\,m/sec$

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

$V_2 = 0.01028$

Headloss due to sudden enlargement:

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

$= \left(1 - \frac{45.927}{92.407}\right)^2 \times \left(\frac{0.206 - 0.01028}{2 \times 9.81}\right)^2$

$= 0.253001 \times 0.00000542$

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

Power lost due to sudden enlargement

$P = \rho g Q h_c$

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

$\boxed{P = 0.0127 W}$

Pressure in the smallest Pipe:-

Apply Bernouli's equation

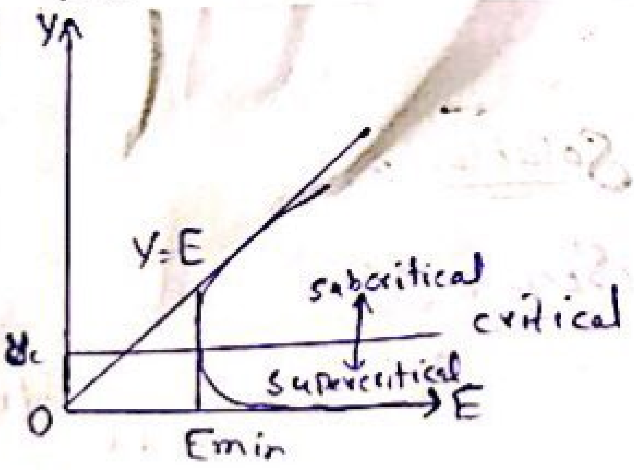
$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_c$$

$$\frac{8675}{1000 \times 9.81} + \frac{(0.0306)^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{(0.01622)^2}{2 \times 9.81} + 1.37 \times 10^{-6}$$

$P_2 = 8175.14 \, N/m^2$

Question No# 03 (B)

(17)



What does this blue curve indicate. How is obtained. Explain the above figure fro each and every point of view.

Answer..

The above graph is plot b/w dep flow (y) and Specific energy (E)
It is made from three degree polynomic equation which shows us the different Specific energy for the depth flow which may be either

i) Sub critical
ii) Critical
iii) Super Critical

Specific energy is used to clarify the meaning of the term in an open Channel.

Total energy = Potential energy + Kinetic energy

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

$= \omega h + \frac{1}{2} \frac{\omega}{g} v^2 \quad m = \frac{\omega}{g}$

ignoring "ω" 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 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 (a) 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 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