Name Saqib Ahmad

ID 7798

Section A

Semester 6th

Paper mid-term

Subject Hydraulics Engineering

Teacher Sir Fawad

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QNo (01)
Part (A)

Let suppose a rectangular channel discharge R Litre/sec of water into a 8m wide apron with zero slop. Mean velocity is R-220 ft/sec

Calculate
① Height of hydralic jump (in unit of meter)
② Power absorbed due to hydralic jump (in unit of KW)

① Height of hydrolic jumpse

As "q" is discharge per unit width

Discharge = 7798 Lit/sec = 7.798 m³/sec
Width of apron = 8m
Mean velocity = 7798 - 220 = 7578 ft/sec

$$= \frac{7578}{3.28} = 2310.36 \text{ m/sec}$$

$$q = Q/b$$

$$q = \frac{7.798}{8} = \boxed{0.9747 \text{ m}^2/\text{sec}}$$

⇒ As critical dpth (y_c) is

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

$$y_c = \left(\frac{(0.9747)^2}{9.81}\right)^{1/3} = \boxed{y_c = 0.459 \text{m}}$$

⇒ Critical velocity :-

$$\text{As} \quad q = vy$$

$$v = q/y$$

$$V_c = q/y_c$$

$$V_c = \frac{0.9747}{0.459}$$

$$\boxed{V_c = 2.123 \text{ m/sec}}$$

As $V_1 > V_c$
super - critical flow

⇒ **Water Depth on upstream side is :-** (of hydraulic jump)

$$Q = AV$$
$$Q = (by) \cdot v$$

$$y = \frac{Q}{vb}$$

$$y_1 = \frac{Q}{V_1 \cdot b} = \frac{7.798}{2.123 \times 8}$$

$$\boxed{y_1 = 0.4591 m}$$

By using formula

$$y_2 = \frac{-y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2y_1 V_1^2}{g}}$$

$$y_2 = -\frac{0.459}{2} + \sqrt{\frac{(0.459)^2}{2} + \frac{2(0.459)(2.12\,\mathrm{?})^2}{9.81}}$$

$$y_2 = -0.229 + \sqrt{0.105 + 0.421}$$

$$\boxed{y_2 = 0.516\,m}$$

⇒ **<u>Difference in depths:</u>**

$$\Delta y = y_2 - y_1$$

$$\Delta y = 0.516 - 0.4591$$

$$\boxed{\Delta y = 0.057}$$

⇒ As.

$$\Delta E = E_1 - E_2$$

Also, $Q_1 = Q_2$

$$A_1 V_1 = A_2 V_2$$

$$b_1 y_1 V_1 = b_2 y_2 V_2$$

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

$$V_2 = \frac{0.459 \times 2310.36}{0.516}$$

$$\boxed{V_2 = 2055.145}$$

⇒ $\Delta E = E_1 - E_2$

$$\Delta E = \left(y_1 + \frac{V_1^2}{2g}\right) - \left(y_2 + \frac{V_2^2}{2g}\right)$$

$$E_1 - E_2 = 0.4591 + \frac{(2310.36)^2}{2 \times 9.81} - \left(0.516 + \frac{(2055.14)^2}{2 \times 9.81}\right)$$

$$E_1 - E_2 = 272057.71 - 215270.66$$

$$\boxed{E_1 - E_2 = 56787.04\,m}$$

⇒ **Power Dissipation in hydralic Jump :-**

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

$$\Delta P = (1000)(9.81)(7.798)(56787.04)\,W$$

$$\Delta P = 4344116565$$

$$\boxed{\Delta P = 434416.565\,KW}$$

(Part B)

Data

Channel width (b) = 4m
Discharge = 7798 ft³/sec
Height of upstream side = 2.9m
Height of downstream side = 1.1 m

① Downword stream velocity:-

As specific Energy is

$E_1 = E_2$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \frac{V_2^2}{2g} \longrightarrow ①$$

Also from Discharge

$Q = AV$

$\Rightarrow A_1V_1 = A_2V_2$

$\cancel{b_1}y_1 V_1 = \cancel{b_2}V_2 y_2$

$y_1V_1 = y_2V_2$

$$V_2 = \frac{y_1V_1}{y_2}$$

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

$\boxed{V_2 = 2.63V_1} \longrightarrow ②$ put in eq ①

$$2.9 + \frac{V_1^2}{2g} = 1.1 + \frac{(2.63V_1)^2}{2g}$$

$$\Rightarrow \quad 2.9 + \frac{V_1^2}{2g} = 1.1 + \frac{6.91}{2g}$$

$$\Rightarrow \quad \frac{V_1^2}{2g} - \frac{6.91V_1^2}{2g} = 1.1 - 2.9$$

$$\Rightarrow \quad -\frac{5.91V_1^2}{2g} = -1.8$$

$$\Rightarrow \quad 5.91V_1^2 = 1.8 \times 2 \times 9.81$$

$$\sqrt{V_1^2} = \sqrt{\frac{1.8 \times 2 \times 9.81}{5.91}}$$

$$\boxed{V_1 = 2.44 \, m/sec}$$

$\Rightarrow$ Put in eq ②

$$\boxed{V_2 = 2.63 \, V_1}$$

$$V_2 = (2.44)\,2.63$$

$$\boxed{V_2 = 6.41 \, m/sec}$$

Type of flow using Froude Number

① On upstream side:

$$Fr_1 = \frac{V_1}{\sqrt{g y_1}}$$

$$Fr_1 = \frac{2.44}{\sqrt{9.81 \times 2.91}} = 0.45$$

$0.45 < 1$ (sub-critical flow)

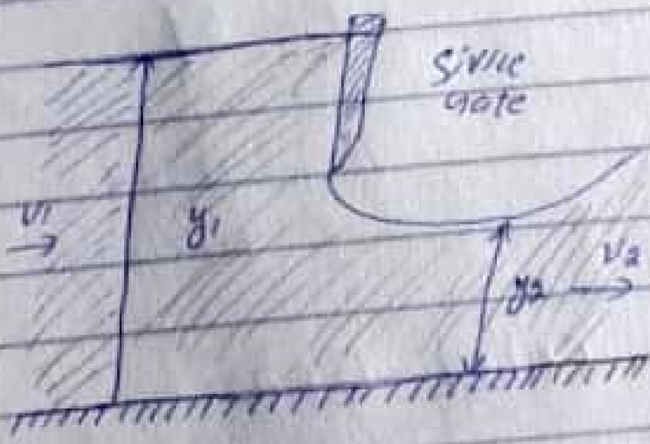
(2) On Down stream side:

$$Fr_2 = \frac{V_2}{\sqrt{g y_2}}$$

$$Fr_2 = \frac{6.41}{9.81 \times 1.1}$$

$1.95 > 1$ super-critical flow

Diagrammatically:



QNo (03)
part (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 66ft.

Data:

Depth of channel = 1.8m
Discharge = 7798 ft^3/sec = 220.98 m^3/sec
Width of channel = 66ft = 20.12 m
P = weir height =

Solution

As $Q = AV$

$$V = Q/A = \frac{Q_1}{by}$$

$$V_1 = \frac{220.98}{20.1 \times 1.8} = 6.11 \ m/sec$$

⇒ Critical Depth:-

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

As $q = Q/b$

$$q = \frac{220.98}{20.12} = \boxed{10.98 \ m^2/sec}$$

$$\Rightarrow \quad y_c = \left(\frac{(10.98)^2}{9.81}\right)^{1/3}$$

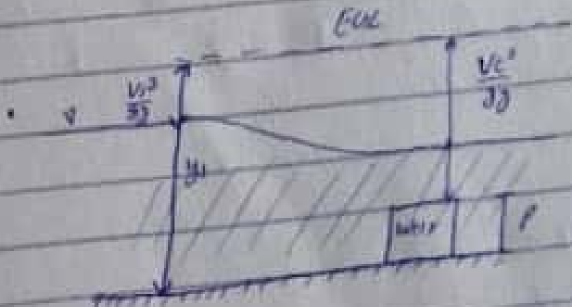
$$\boxed{y_c = 2.305\,m}$$

Also

$$V = \sqrt{g y_c}$$

$$V_c = \sqrt{9.81 \times 2.305}$$

$$\boxed{V_c = 4.755\ m/sec}$$



From the figure

$$\frac{V_1^2}{2g} + y_1 = \frac{V_c^2}{2g} + y_c + P$$

$$\frac{(6.11)^2}{2 \cdot 9.81} + 1.8 = \frac{(4.755)^2}{2 \times 9.81} + 2.305 + P$$

$$1.902 + 1.8 = 1.152 + 2.305 + P$$

$$3.702 = 3.457 + P$$

$$P = 3.702 - 3.457$$

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

The weir height 0.245 measured from the channel bed.

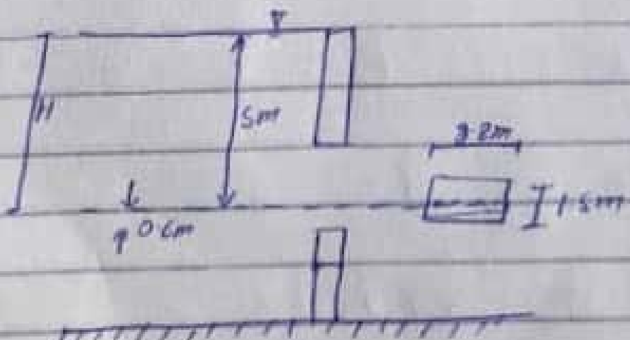
QNo(2) part(B)

An orifice in one side of large tank is rectangular in shape 2.8m broad and 1.5m deep. The water level on one side of the orifice is 5 meters above its top edge. The water level on the other side of the orifice is 5 meters 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

__Given data:-__

Breadth = 2.8m
Depth = 1.5m
Water level on one side (above its top edge. H_1 = 5m
Water level on other side = 5m + 1.5 = H_2 = 6.5m
cd = 0.7798
H = 5.6m
Discharge = ?

__Solution__



As by using formula

⇒ Discharge through submerged portion:

$Q_1 = cd \times b \times (H_2 - H_1) \times \sqrt{2gh}$

$Q_1 = 0.7798 \times 2.8\ (6.5 - 5.6) \times \sqrt{2(9.81)(5.6)}$

$Q_1 = 8.173 \times 2.8\ (6.5 - 5.6)$

$\boxed{Q_1 = 20.595\ m^3/sec}$

Discharge through Free portion:

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

$Q_2 = \frac{2}{3}(0.7798) \times 2.8 \sqrt{2 \times 9.81} \times [5.6^{3/2} - 5^{3/2}]$

$Q_2 = 0.5198 \times 12.40 \times (13.25 - 11.18$

$Q_2 = 13.34\ m^3/sec$

Total Discharge:

$Q_T = Q_1 + Q_2$

$Q_T = 20.595 + 13.34$

$\boxed{Q_T = 33.935\ m^3/sec}$

QNo (03)
part (A)

The diameter of a water pipe as suddenly enlarged from R-200mm to R+3000mm, the rate of flow through is 095 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 horizontel

Given Data

$d_1 = R - 200mm$

$d_1 = 7798 - 200 = 7598\ mm$

$d_2 = R + 3000mm$

$d_2 = 7798 + 3000 = 10798\ mm$

Flowrate $(Q) = 0.95\ m^3/sec$

Pressure in larger pipe $= R + 800\ N/m^2$

$= 7798 + 800 = 8598\ N/m^2$

Solution

① The Loss of Head due to sudden enlargement:

$\Rightarrow d_1 = 7598mm = 7.598m$

$A_1 = \frac{\pi}{4}(7.598)^2 = 45.317\ m^2$

$\Rightarrow d_2 = 10798\ mm = 10.798\ m$

$A_2 = \frac{\pi}{4}(10.798)^2 = 91.52\ m^2$

As $\Rightarrow Q = AV$

$V = Q/A$

$V_1 = \frac{0.95}{45.317} = \boxed{0.020\ m/sec}$

$\Rightarrow V_2 = \frac{Q}{A_2}$

$\Rightarrow V_2 = \frac{0.95}{91.52} = \boxed{0.010\ m/sec}$

By formula of sudden Enlargement

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

$h_e = \left(1 - \frac{45.31}{91.52}\right)^2 \times \frac{(0.020 - 0.010)^2}{2 \times 9.81}$

$h_e = (1 - 0.495)^2 \times (5.09 \times 10^{-6})$

$h_e = (0.255) \times (5.09 \times 10^{-6})$

$\boxed{h_e = 1.298 \times 10^{-6}\ m}$

(b) Power lost due to sudden Enlargement:-

$\Rightarrow P = \rho g Q h_e$

$P = (1000)(9.81)(0.95)(1.298 \times 10^{-6})$

$\boxed{P = 0.0120\ W}$

(c) Pressure in the smaller pipe :-

By using Bernoullis Equation

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

$$\Rightarrow \frac{P_1}{(1000)(9.81)} + \frac{(0.020)^2}{2 \times 9.81} = \frac{8598}{1000 \times 9.81} + \frac{(0.010)^2}{2 \times 9.81} + 1.398 \times 10^{-6}$$

$$\Rightarrow \frac{P_1}{9810} + 0.0000203 = 0.8764 + 5.09 \times 10^{-6} + 1.298 \times 10^{-6}$$

$$\frac{P_1}{9810} = 0.8763$$

$$\boxed{P_1 = 8593.34 \ N/m^2}$$

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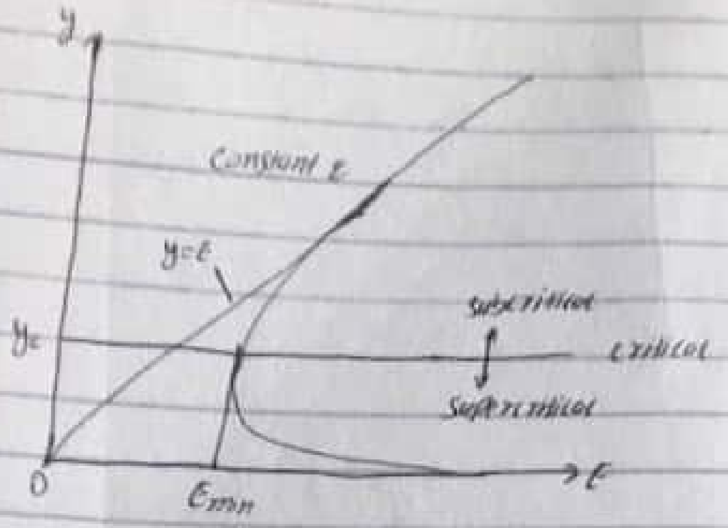
Q No (3)
Part (B)



What does this blue curve indicates. How it is obtained. Explain the above Figure from each and every point of view.

Answer

First we define Specific Energy as " Specific Energy is a parameter that can be used to clarify the meaning of super critical, sub critical and critical flow in an open channel "

Critical depth:-

critical depth is the depth corresponding to minimum specific energy.

↳ $y > y_c$, $E > E_{min}$ (Sub critical flow)
↳ $y = y_c$, $E = E_{min}$ (critical flow)
↳ $y < y_c$, $E < E_{min}$ (Super critical flow)

In the three degree polynomial equation it can be use to prepare a plot of specific Energy "E"