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Section A

Subject Hydraulic Engineering

Question #2

Numerical

Given:-

⇒ Wide of channel = 3m

⇒ Discharge = Q = 12 m^3/sec

Req:-

⇒ Critical depth

⇒ minimum specific energy

⇒ alternate depth

Sol:- As

critical depth:-

Discharge per unit width

$q = Q/b = 12/3$

$q = 4 \ m^3/sec$

For rectangular channel

$h_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{4^2}{9.81}\right)^{1/3}$

$h_c = 1.18m$

Minimum specific Energy

For rectangular channel

$E_c = \frac{3}{2} h_c = \frac{3}{2} \times 1.18$

$E_c = 1.77m$

The alternate depth :-

$E > E_c$, There are two possible depth for a given specific energy

$E = h + \frac{v^2}{2g}$ where $v = \frac{Q}{A} = \frac{q}{h}$

(for rectangular channel)

$$E = h + \frac{q^2}{2gh^2}$$

$$4 = h + \frac{0.8155}{h^2}$$

$$h = 4 - \frac{0.8155}{h^2}$$

For the section* subcritical solution the first term, associated with potential energy dominates.

Iteration (from e.g. $h=4$)

gives $h = 3.98m$.

For the supercritical solution, the second term, associated with kinetic energy dominates

$$h = \sqrt{\frac{0.8155}{4-h}}$$

Iteration (from e.g. $h=0$)

gives $h = 0.4814m$

So alternate depth are 3.85 m and 0.4814 m.

Assignment #02

QNO1:- Numerical

ANS:-

Sol:- As first we find the Froude number.

$$Fr = \frac{v}{\sqrt{gy}} = \frac{6\ m/s}{\sqrt{9.81 \times 0.4}}$$

$$Fr = 6.0671$$

so the flow is supercritical

Alternate depth:-

As we know that

$$E = y + \frac{v^2}{2g}$$

$$= 0.1 + \frac{6^2}{2 \times 9.81}$$

$$= \boxed{1.935\ m}$$

The alternate depth for $E = 1.935\ m$ yields. $\boxed{Y_{alternate} = 1.93\ m}$

QNO 2:- Numerical

ANS #2:-

Given:-

velocity $= V_1 = 2\ m/s$.

depth $= y_1 = 3\ m$

Elevation $\Delta Z = 60\ cm = 0.6\ m$

down step $= 15\ cm = 0.15\ m$

Solution:-

As we know that

$E_1 = y_1 + \frac{v_1^2}{2g}$

$= 3 + \frac{(2)^2}{2 \times 9.81}$

$\boxed{E_1 = 3.20\,m}$

Now $E_2 = E_1 - \Delta Z$

$= 3.20 - 0.6$

$\boxed{E_2 = 2.60\,m}$

Also

$E_2 = y_2 + \frac{q^2}{2g\,y_2^2}$

$2.60 = y_2 + \frac{(6)^2}{2 \times 9.81 \cdot y_2^2}$

$\boxed{y_2 = 2.24\,m}$

$\Delta y = y_2 - y_1$

$= 2.24 - 3$

$\boxed{\Delta y \;\; -0.76\,m}$

So water surface drops 0.16 m

For a downward step of 15 cm or 0.15 m we have

$E_2 = E_1 - \Delta Z$

$= 3.20 - (-0.15)$

$\boxed{E_2 = 3.35\,m}$

Now $y_2 = 3.17\,m$

$\Delta y = y_2 - y_1$

$= 3.17 - 3$

$\boxed{\Delta y = 0.17\,m}$

So water surface rises $= 0.02\,m$

The maximum upset possible before affecting upstream water surface level is for

$y_2 = y_c$

$y_c = \sqrt[3]{\frac{q^2}{g}} =$

$= \sqrt[3]{\frac{(6)^2}{9.81}}$

$\boxed{y_c = 1.54\,m}$

Assignment #03

Q No 1:-

Given:-

$y_1 = 3.6 m$

$b = 3.9 m$

$y_2 = 0.9 m$

Sol:-

As we know that

$E_1 = E_2$

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

Also

$$Q = A_1 V_1 = A_2 V_2 \qquad \because b = b_1 = b_2$$

$$b_1 y_1 \cdot v_1 = b_2 y_2 \cdot v_2$$

$$b y_1 \cdot v_1 = b y_2 \cdot v_2$$

$$y_1 v_1 = y_1 v_2$$

$$v_2 = \frac{y_1}{y_2} \times v_1$$

$$v_2 = \frac{3.6}{0.9} \times v_1$$

$$\boxed{v_2 = 4 v_1} \rightarrow (2) \text{ put in eq (1)}$$

$$y_1 + \frac{v_1^2}{2g} = y_2 + \frac{v_2^2}{2g}$$

$$3.6 + \frac{v_1^2}{2(9.81)} = 0.9 + \frac{(4v_1)^2}{(2)9.81}$$

$$3.6 + \frac{v_1^2}{2g} = 0.9 + \frac{16 v_1^2}{2g}$$

$$\frac{v_1^2}{2g} - 16\frac{v_1^2}{2g} = 0.9 - 3.6$$

$$\frac{v_1^2 - 16 v_1^2}{2g} = -2.7$$

$$-15\frac{v_1^2}{2g} = -2.7$$

$$\sqrt{v_1^2} = \sqrt{\frac{2.7 \times 2(9.81)}{15}}$$

$V_1 = 1.879$ m/sec. put in eq (ii)

$V_2 = 4V_1$
$= 4(1.879)$ ⇒ $V_2 = 7.516$ m/sec

As
$Q_1 = A_1 V_1 = b y_1 \cdot V_1$
$= 3.9 \times 3.6 \times 1.879$

$Q_1 = 26.38$ m³/sec

$Q_2 = A V_2 = b \cdot y_2 \times V_2$
$= 3.9 \times 0.9 \times 7.516$

$Q_2 = 26.38$ m³/sec

$Q = Q_1 = Q_2 = 26.38$ m³/sec.

1) **Froud number** → At upstream side

$$F_{r1} = \frac{V_1}{\sqrt{g y_1}} = \frac{1.879}{\sqrt{9.81 \times 3.6}} = 0.31$$

sub-critical flow

2) **Froud number:-** ⇒ At downstream side

$$F_{r2} = \frac{V_2}{\sqrt{g y_2}} = \frac{7.516}{\sqrt{9.81 \times 0.9}} = 2.52$$

super critical flow