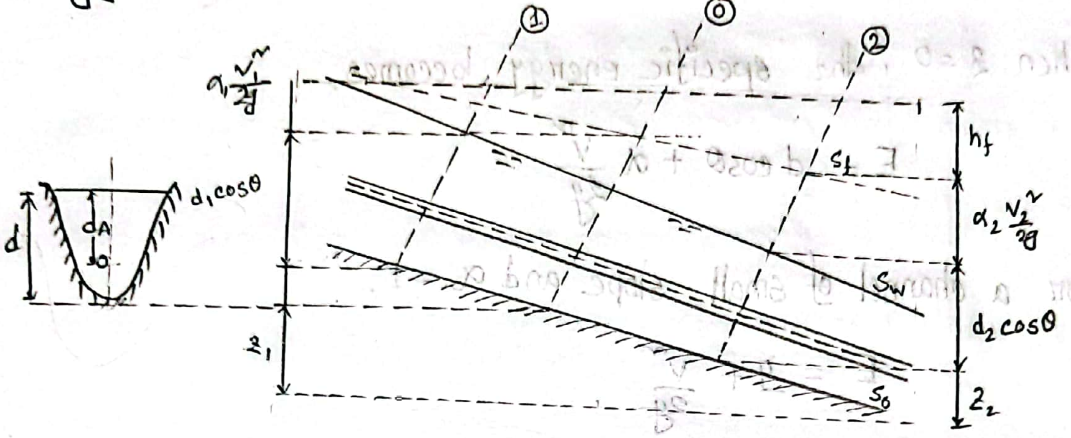
~~Eneg~~

channel

constant area

Energy and Momentum Principles :

Energy in open channel Flow :



$$H = z_A + d_A \cos\theta + \frac{V_A^2}{2g}$$

But, in case of gradually varied flow, $H = z + d\cos\theta + \alpha \frac{V^2}{2g}$

if, $\theta \approx 0$, then, $H = z + d + \alpha \frac{V^2}{2g}$.

in uniform flow, $S_f = S_W = S_0 = \sin\theta$

Now, $z_1 + d_1 \cos\theta + \alpha_1 \frac{V_1^2}{2g} = z_2 + d_2 \cos\theta + \alpha_2 \frac{V_2^2}{2g} + h_f$.

$$\Rightarrow z_1 + y_1 + \alpha_1 \frac{V_1^2}{2g} = z_2 + y_2 + \alpha_2 \frac{V_2^2}{2g} + h_f .$$

$\alpha_1 = \alpha_2 = 1$, $h_f = 0$

$$\therefore z_1 + y_1 + \frac{V_1^2}{2g} = z_2 + y_2 + \frac{V_2^2}{2g} = \text{constant}$$

This is Bernoulli energy equation.

Specific energy: Specific energy in a channel section is defined as the energy per pound of water at any section of a channel measured with respect to the channel bottom.

Thus, when $z = 0$, the specific energy becomes,

$$E = d\cos\theta + \alpha \frac{v^2}{2g}$$

or, for a channel of small slope and $\alpha = 1$,

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

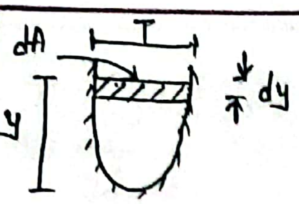
specific energy = depth of water + velocity head.

$$E = y + \frac{v^2}{2g}, \qquad Q = AV \quad \Rightarrow V = Q/A.$$

$$E = y + \frac{Q^2}{2gA^2}$$

[Prismatic channel এর discharge constant হলে specific energy শুধু depth of water এর উপর depend করে]

22.05.22



$$T \times dy = dA$$

$$\Rightarrow \frac{dA}{dy} = T$$

Prove that, for a given channel section specific energy is ~~les~~ minimum for critical state of flow.

Prove that, for a given channe section at critical state of flow froude number is unity

Let us consider a channel section with cross-sectional area A,
Discharge Q. and depth of flow y.

Specific energy, $E = y + \frac{V^2}{2g}$

$$E = y + \frac{Q^2}{2gA^2} \quad [\because V = Q/A]$$

Differentiating with respect to dy,

$$\frac{dE}{dy} = 1 + \frac{Q^2}{2g} \frac{d}{dy} \cdot (A^{-2})$$

$$\Rightarrow \frac{dE}{dy} = 1 + \frac{Q^2}{2g} \times \frac{dA}{dy} \times \frac{d}{dA} (A^{-2})$$

$$= 1 - \frac{2Q^2}{2gA^3} \cdot \frac{dA}{dy}$$

$$\Rightarrow \frac{dE}{dy} = 1 - \frac{Q^2}{gA^3} \times T \qquad \left[\because \frac{dA}{dy} = T \right]$$

$$\Rightarrow \frac{dE}{dy} = 1 - \frac{A^2 V^2 T}{gA^3}$$

$$\Rightarrow \frac{dE}{dy} = 1 - \frac{V^2 T}{gA}$$

We know, $D = \frac{A}{T}$. $\Rightarrow \frac{1}{D} = \frac{T}{A}$

$$\therefore \frac{dE}{dy} = 1 - \frac{V^2}{gD}$$

When, specific energy is minimum,

$$\frac{dE}{dy} = 0$$

$$\therefore 0 = 1 - \frac{V^2}{gD}$$

$$\Rightarrow \frac{V^2}{gD} = 1$$

$$\Rightarrow \frac{V}{\sqrt{gD}} = 1$$

$$\therefore F_r = 1$$

$$\frac{V^2}{gD} = 1$$

$$\Rightarrow \frac{V^2}{g} = D$$

$$\Rightarrow \frac{V^2}{2g} = \frac{D}{2}.$$

$$\alpha \frac{V^2}{2g} = \frac{D}{2}.$$

$\theta \rightarrow$

$$\alpha \frac{V^2}{2g} = \frac{D\cos\theta}{2}$$

At critical section, when θ

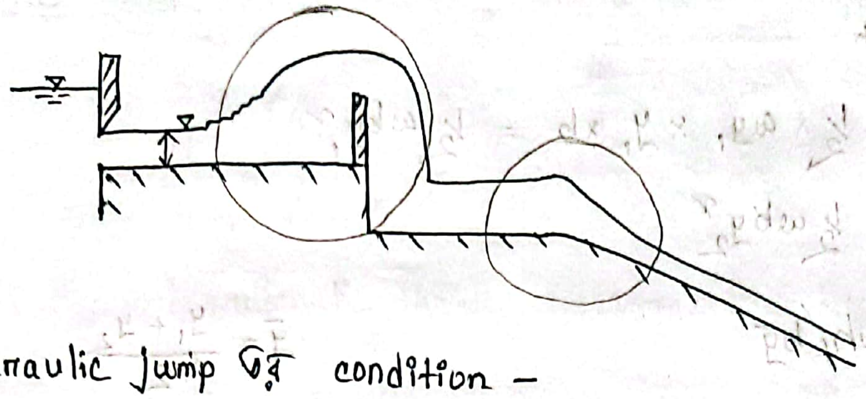
$$F_r = \frac{V}{\sqrt{\frac{gD\cos\theta}{2}}}.$$

$$V^2 = \frac{gD\cos\theta}{\alpha}$$

$$\Rightarrow V = \sqrt{\frac{gD\cos\theta}{\alpha}}$$

$$\Rightarrow \frac{V}{\sqrt{\frac{gD\cos\theta}{\alpha}}} = 1 = F_r$$

$$\Rightarrow F_r = \frac{V}{\sqrt{\frac{gD\cos\theta}{\alpha}}}.$$



flow depth less
Velocity ↑
Supercritical.

hydraulic Jump এর condition -

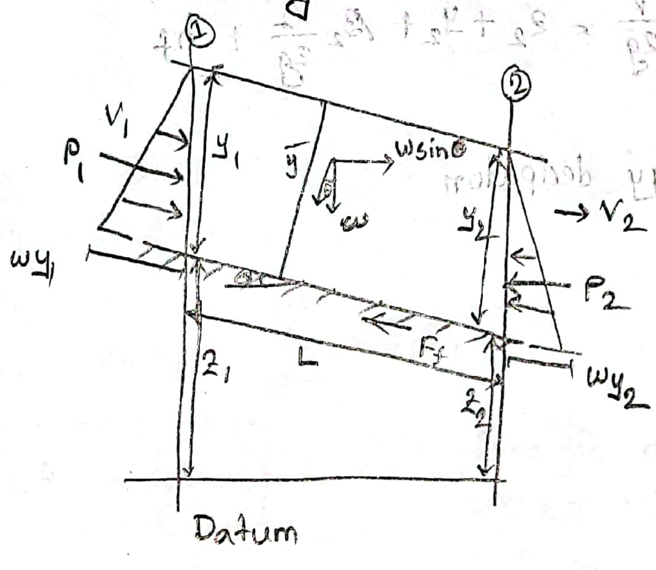
Supercritical to subcritical এ আসে

hydraulic fall - Subcritical to supercritical.

Momentum

$$\text{Momentum} = \frac{\beta w Q V}{g}$$

β = Correction coefficient



$$\frac{\beta_2 w Q V_2}{g} - \frac{\beta_1 w Q V_1}{g} = P_1 - P_2 + w\sin\theta - F_f$$

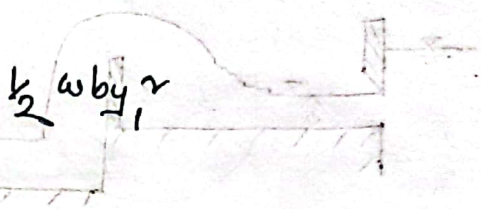
$P_1 = \beta_1' P_1'$

$P_2 = \beta_2' P_2'$

Change of momentum in

If width, b

$P_1 = \frac{1}{2} \times w y_1 \times y_1 \times b = \frac{1}{2} w b y_1^2$



$P_2 = \frac{1}{2} w b y_2^2$

$F_f = w h_f' b \bar{y}$ coefficient

$\bar{y} = \frac{y_1 + y_2}{2}$

$W = w b \bar{y} L$

momentum equation,

$$z_1 + y_1 + \beta_1 \frac{v^2}{2g} = z_2 + y_2 + \beta_2 \frac{V_2^2}{2g} + h_f'.$$

h_f' = internal energy decipaton

h_f = external loss

24.05.22

Specific force : $\frac{Q w \beta_2 V_2}{g} - \frac{Q w \beta_1 V_1}{g} = P_1 - P_2 + W\sin\theta - F_f$

$\Rightarrow \frac{Q w}{g}(\beta_2 V_2 - \beta_1 V_1) = P_1 - P_2 + W\sin\theta - F_f$

$\beta_1 = \beta_2 = 1$, $\theta = 0°$, $F_f = 0 \rightarrow$ যদি চ্যানেলের Bottom খুব কাছাকাছি হয়
এবং channel prismatic এবং channel bottom horizontal হয়।

$\frac{Q w}{g}(V_2 - V_1) = P_1 - P_2$

$P_1 = \frac{1}{2} w b y_1^2 = w \times \left(\frac{y_1}{2}\right) \times (b y_1) = w \bar{z} A_1$

Channel এর top থেকে centroid এর distance $y/2$

$P_2 = w \bar{z}_2 A_2$

$V_1 = Q/A_1$, $V_2 = Q/A_2$.

$\frac{Q w}{g}\left(\frac{Q}{A_2} - \frac{Q}{A_1}\right) = w \bar{z}_1 A_1 - w \bar{z}_2 A_2$

$\Rightarrow \frac{Q^2 w}{g A_2} - \frac{Q^2 w}{g A_1} = w(\bar{z}_1 A_1 - \bar{z}_2 A_2)$

$\Rightarrow \frac{Q^2}{g A_2} + \bar{z}_2 A_2 = \frac{Q^2}{g A_1} + \bar{z}_1 A_1$

$$\boxed{F = \bar{z}A + \frac{Q}{gA}}$$

Specific force (F); per unit wt. of water momentum ($\frac{Q}{gA}$)

Specific energy থেকে যেমন eqⁿ বের করা যায় তেমনি specific force থেকেও eqⁿ বের করা যায়।

$w\bar{z}A$ = per unit force এর momentum

Specific force curve :

কোনটার Depth কোনটার Depth এর alternate :

Prove that specific force is minimum at critical depth

Differentiating with respect to dy for minimum value,

$$\frac{dF}{dy} = \frac{d(\bar{z}A)}{dy} + \frac{Q^2}{g} \cdot \frac{d(A^{-1})}{dy}$$

$$\Rightarrow 0 = -\frac{Q^2}{gA^2} \cdot \frac{dA}{dy} + \frac{d(\bar{z}A)}{dy}$$ ⟶ water এর Area static moment ——— (1)

$\boxed{\bar{z} \downarrow A}$ $\bar{z}A$ → Static moment

$$d(\bar{z}A) = \left[\underbrace{A \times (\bar{z} + dy)} + \underbrace{T \cdot dy \cdot \frac{dy}{2}}\right]$$

full area এর Static moment   surface এর moment

$\boxed{\bar{z}A}$ → পুরো অংশের Static moment

$$= \left[A(\bar{z} + dy) + (dy)^2 \cdot \frac{T}{2}\right] - \bar{z}A$$

$$= A\bar{z} + A\,dy - \bar{z}A$$

$$= A\,dy$$

From (1) $\Rightarrow 0 = -\frac{Q^2}{gA^2} \cdot T + A$ $[d(\bar{z} \cdot A) = A\,dy]$

$$A = \frac{Q^2 T}{gA^2}$$

$$= \frac{A^2 V^2 \cdot T}{gA^2}$$

$\Rightarrow A = \frac{V^2 T}{g}$

$\Rightarrow \frac{V^2 T}{gA} = 1$

Hydraulic depth

$D = A/T$

$\frac{T}{A} = \frac{1}{D}$

$$\boxed{\frac{V^2}{gD} = 1}$$

$\frac{V^2}{g} = D$

$$\Rightarrow \boxed{\frac{V^2}{2g} = \frac{D}{2}}$$

On the other hand,

$$\frac{V}{\sqrt{gD}} = 1$$

$\Rightarrow F_r = 1$

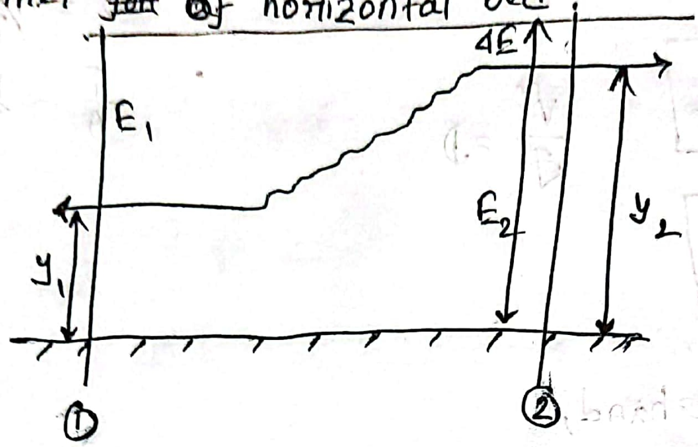
Show that for a given force, froude number is 1.

Force দিয়ে বলতে বললে Force

Energy " " " Energy

29.05.22

Ex-3.3. Derive a relationship betn initial depth & sequent depth for a hydraulic jump in a rectangular channel ~~for~~ of horizontal bed.



For momentum eqn,

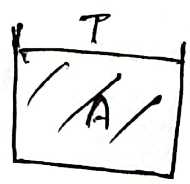
we know,

$$\frac{Q^2}{gA_1} + \bar{z}_1 A_1 = \frac{Q^2}{gA_2} + \bar{z}_2 A_2 \quad \text{--- (1)}$$

For rectangular channel, $Q = A_1V_1 = A_2V_2$, $A_1 = by_1$, $A_2 = by_2$.

$\bar{z}_1 = \frac{y_1}{2}$, $\bar{z}_2 = \frac{y_2}{2}$, $F_1 = \frac{V_1}{\sqrt{gy_1}}$, ~~$F_2 = \frac{V_2}{\sqrt{gy_2}}$~~ .

$$\Rightarrow F_1^2 = \frac{V_1^2}{gy_1}$$



$$(1) \Rightarrow \frac{A_1^2 V_1^2}{gA_1} + \bar{z}_1 A_1 = \frac{A_1^2 V_1^2}{gA_2} + \bar{z}_2 A_2$$

$D = \frac{A}{T}$

$y = \frac{A}{T}$.

$$\Rightarrow \frac{b^2 \cdot y_1^2 \cdot V_1^2}{g} + \frac{y_1}{2} \cdot by_1 = \frac{b^2 \cdot y_1^2 \cdot V_1^2}{g\, b\, y_2} + \frac{y_2}{2} \cdot by_2 .$$

?

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

$$\Rightarrow \frac{v_1^2}{g y_1} \cdot y_1^2 + \frac{y_1^2}{2} = \left(\frac{v_1^2}{g y_1}\right) \frac{y_1^3}{y_2} + \frac{y_2^2}{2}$$

$$\Rightarrow F_1^2 \cdot y_1^2 + \frac{y_1^2}{2} = F_1^2 \cdot \frac{y_1^3}{y_2} + \frac{y_2^2}{2}$$

Multiplying by $\cancel{\frac{y_2}{y_3}}$ $\frac{y_2}{y_1^3}$

$$\Rightarrow F_1^2 \cdot \frac{y_2}{y_1} + \frac{1}{2} \times \frac{y_2}{y_1} = F_1^2 + \frac{1}{2} \cdot \left(\frac{y_2}{y_1}\right)^3$$

Let, $y_2/y_1 = x$.

$$F_1^2 x + \frac{1}{2} \cdot x = F_1^2 + \frac{1}{2} x^3$$

$$\Rightarrow 2 \cdot F_1^2 x + x = 2F_1^2 + x^3$$

$$\Rightarrow x^3 - x - 2F_1^2 x + 2F_1^2 = 0$$

$$\Rightarrow x^3 - x^2 + x^2 - x - 2F_1^2 x + 2F_1^2 = 0$$

$$\Rightarrow x^2(x-1) + x(x-1) - 2F_1^2(x-1) = 0$$

$$\Rightarrow (x-1)(x^2 + x - 2F_1^2) = 0$$

Now, $x - 1 \neq 0 \Rightarrow x \neq 1$

$\Rightarrow y_2/y_1 \neq 1 \quad \therefore y_2 \neq y_1$

$$\therefore x^2 + x - 2F_1^2 = 0$$

$$x = \frac{-1 \pm \sqrt{1 - 4 \cdot 1 \cdot (-2F_1^2)}}{2 \cdot 1}$$

$$= \frac{-1 \pm \sqrt{1 + 8F_1^2}}{2}$$

$$\therefore x = \frac{\sqrt{1+8F_1^2} - 1}{2}$$

[depth is always +ve]

$$y_2/y_1 = \frac{1}{2}\left(\sqrt{1+8F_1^2} - 1\right)$$

Ex 3.7: Prove that at critical state of flow the discharge is maximum for a given specific energy.

→ We know, specific energy, $E = y + \frac{Q^2}{2gA^2}$

Differentiating w.r.to dy,

$$\frac{dE}{dy} = 1 + \frac{Q^2}{2g}(-2A^{-3})\frac{dA}{dy} + \frac{2Q}{2gA^2}\frac{dQ}{dy}$$

$$= 1 - \frac{Q^2}{gA^3}\frac{dA}{dy} + \frac{Q}{gA^2}\cdot\frac{dQ}{dy}.$$

At critical flow, $\frac{dE}{dy} = 0$, $\frac{dA}{dy} = T$, $\frac{T}{A} = \frac{1}{D}$.

$$\Rightarrow 0 = 1 - \frac{V^2A^2}{gA^3}\cdot T + \frac{Q}{gA^2}\cdot\frac{dQ}{dy}$$

$$\Rightarrow 0 = 1 - \frac{V^2}{gD} + \frac{Q}{gA^2}\cdot\frac{dQ}{dy}$$

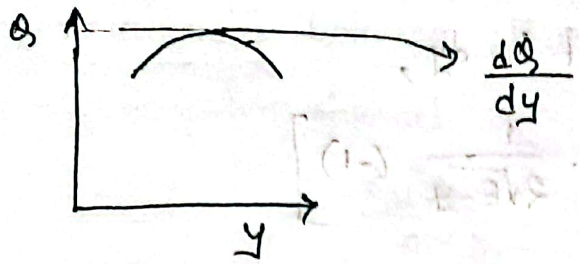
$Fr = \frac{V}{\sqrt{gD}} = 1$

$\therefore \frac{V^2}{gD} = 1$

$$\therefore \Rightarrow 0 = 1 - 1 + \frac{Q}{gA^2}\cdot\frac{dQ}{dy}$$

$$\therefore \frac{Q}{gA^2}\cdot\frac{dQ}{dy} = 0$$

$$\therefore \frac{dQ}{dy} = 0$$



From the above equation we can state that discharge is maximum for a given specific energy.

Ex. 3.31 Show that, at critical state of flow specific energy

Exercise head in a rectangular channel is equal to 1.5 times the depth of flow. Assuming zero slope at $\alpha = 1$.

We know, specific energy, $E = y + \frac{Q^2}{2gA^2}$

$$\Rightarrow \frac{Q^2}{2gA^2} = E - y$$

$$\Rightarrow Q^2 = 2gA^2(E-y)$$

$$\Rightarrow Q = A\sqrt{2g(E-y)}$$

For rectangular channel, $A = by$

Considering unit width i.e., $b = 1$, let $Q = q$.

$$q = y\sqrt{2g(E-y)}$$

Differentiating with respect to dy,

$$\frac{dq}{dy} = \sqrt{2g}\left[\sqrt{E-y} + y \cdot \frac{1}{2\sqrt{E-y}}(-1)\right]$$

$$\Rightarrow \frac{dq}{dy} = \sqrt{2g}\left[\sqrt{E-y} - \frac{y}{2\sqrt{E-y}}\right]$$

at critical flow, $\frac{dq}{dy} = 0$, $y = y_c$

$$\Rightarrow 0 = \sqrt{2g}\left[\sqrt{E-y_c} - \frac{y_c}{2\sqrt{E-y_c}}\right]$$

$$\Rightarrow 0 = \frac{2(E-y_c) - y_c}{2\sqrt{E-y_c}}$$

$$\Rightarrow 2E - 2y_c - y_c = 0$$

$$\Rightarrow 2E = 3y_c$$

$$\boxed{E = 1.5\, y_c}$$

31.05.22

The relationship between alternate and altern. depth y_1, y_2 in a rectangular channel

$$\frac{2y_1^2 y_2^2}{y_1+y_2} = y_c^3$$

We know, At critical flow, $F_n = 1$

$$\Rightarrow \frac{V_c}{\sqrt{gD}} = 1$$

$$\Rightarrow \frac{V_c^2}{gD} = 1$$

$$\Rightarrow V_c^2 = gD$$

$$\Rightarrow \frac{Q^2}{A_c^2} = gD$$ [for rectangular channel, $D = y_c$ & $A_c = by_c$]

$$\Rightarrow \frac{Q^2}{b^2 y_c^2} = g \cdot y_c$$

$$\Rightarrow y_c^3 = \frac{Q^2}{b^2 g} \quad \text{--- (1)}$$

Specific energy, $E = y_1 + \frac{Q^2}{2gA_1^2} = y_2 + \frac{Q^2}{2gA_2^2}$

$$\Rightarrow y_1 - y_2 = \frac{Q^2}{2g(by_2)^2} - \frac{Q^2}{2g(by_1)^2}$$

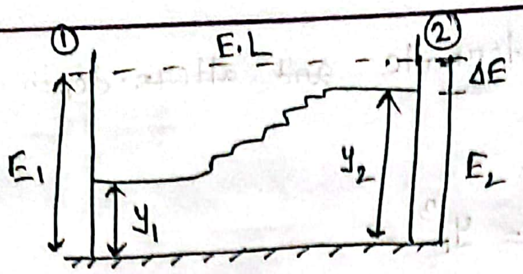
$$\Rightarrow y_1 - y_2 = \frac{Q^2}{2gb^2}\left(\frac{1}{y_2^2} - \frac{1}{y_1^2}\right)$$

$$= \frac{Q^2}{2gb^2}\left(\frac{y_1^2 - y_2^2}{y_1 y_2}\right)$$

$$\Rightarrow y_1 - y_2 = \frac{Q}{gb^2} \cdot \frac{(y_1-y_2)(y_1+y_2)}{2y_1y_2}$$

$$\Rightarrow 1 = y_c^3 \, \frac{y_1+y_2}{2y_1^2y_2^2}$$ [From (1)]

$$\therefore y_c^3 = \frac{2y_1^2y_2^2}{y_1+y_2}.$$



Prove that in a horizontal hydraulic jump, energy loss is

$$\Delta E = \frac{(y_2-y_1)^3}{4y_1y_2}$$

We know, specific force, $F = \frac{Q^2}{gA} + \bar{z}A$.

at section ① & ②, $\frac{Q^2}{gA_1} + \bar{z}_1 A_1 = \frac{Q^2}{gA_2} + \bar{z}_2 A_2$

For rectangular channel, $A_1 = by_1$, $A_2 = by_2$, $\bar{z}_1 = \frac{y_1}{2}$, $\bar{z}_2 = \frac{y_2}{2}$.

$Q = b \times q$

$$\frac{(bq)^2}{gby_1} + \frac{y_1}{2}\cdot by_1 = \frac{b^2q^2}{gby_2} + \frac{y_2}{2}\cdot by_2$$

$$\Rightarrow \frac{q^2}{gy_1} + \frac{y_1^2}{2} = \frac{q^2}{gy_2} + \frac{y_2^2}{2}$$

$$\Rightarrow \frac{q^2}{gy_1} - \frac{q^2}{gy_2} = \frac{y_2^2}{2} - \frac{y_1^2}{2}$$

$$\Rightarrow \frac{q^2}{g}\cdot\left(\frac{1}{y_1} - \frac{1}{y_2}\right) = \frac{1}{2}(y_2^2 - y_1^2)$$

$$\Rightarrow \frac{q^2}{g}\cdot\left(\frac{y_2-y_1}{y_1y_2}\right) = \frac{1}{2}\cdot(y_2-y_1)(y_2+y_1)$$

$$\Rightarrow \frac{q^2}{g} = \frac{1}{2}\cdot y_1y_2(y_1+y_2)$$

$$\Rightarrow \frac{q^2}{2g} = \frac{1}{4}(y_1+y_2)\,y_1y_2 \quad \text{———} ①$$

From specific energy equation,

$$E_1 - E_2 = \Delta E$$

$$\Rightarrow \Delta E = \left(y_1 + \frac{Q^2}{2gA_1^2}\right) - \left(y_2 + \frac{Q^2}{2gA_2^2}\right)$$

$$= (y_1 - y_2) + \frac{Q^2}{2g}\left(\frac{1}{A_1^2} - \frac{1}{A_2^2}\right)$$

$$= (y_1 - y_2) + \frac{q^2 b^2}{2g}\left(\frac{1}{b^2 y_1^2} - \frac{1}{b^2 y_2^2}\right)$$

$$\Rightarrow \Delta E = (y_1 - y_2) + \frac{q^2 b^2}{2gb^2} \cdot \left(\frac{1}{y_1^2} - \frac{1}{y_2^2}\right)$$

$$= (y_1 - y_2) + \frac{1}{4} \cdot y_1 y_2 (y_1 + y_2) \cdot \frac{y_2^2 - y_1^2}{y_1^2 y_2^2}$$

$$= (y_1 - y_2) + \frac{1}{4} y_1 y_2 (y_1 + y_2) \cdot \frac{(y_2 - y_1)(y_2 + y_1)}{y_1^2 y_2^2}$$

$$= (y_2 - y_1)\left\{-1 + \frac{1}{4} \cdot \frac{(y_1 + y_2)^2}{y_1 y_2}\right\}$$

$$= (y_2 - y_1)\left\{-1 + \frac{y_1^2 + y_2^2 + 2y_1 y_2}{4 y_1 y_2}\right\}$$

$$= (y_2 - y_1) \times \frac{-4y_1 y_2 + y_1^2 + y_2^2 + 2y_1 y_2}{4 y_1 y_2}$$

$$= (y_2 - y_1) \times \frac{y_2^2 - 2y_1 y_2 + y_1^2}{4 y_1 y_2}$$

$$\Delta E = \frac{(y_2 - y_1)(y_2 - y_1)^2}{4 y_1 y_2}$$

$$\Delta E = \frac{(y_2 - y_1)^3}{4 y_1 y_2}.$$

CamScanner

* 3.16 $$F = \frac{\frac{V}{\sqrt{gD\cos\theta}}}{\beta}$$

* 3.10 $$\frac{y_3}{y_2} = \sqrt{1 + 2F_2^2\left(1 - \frac{y_2}{y_1}\right)}$$

Condition

Chapter 4

Condition of critical Flow.

4.1 Condition –

(i)

(ii)

(iii)

(iv)

(v)

3rd. peria Flow at or near – unstable

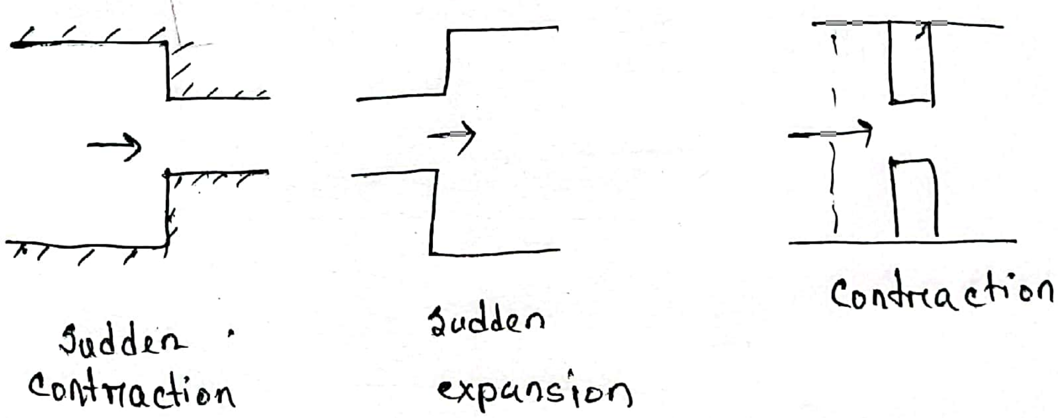
05.06.22

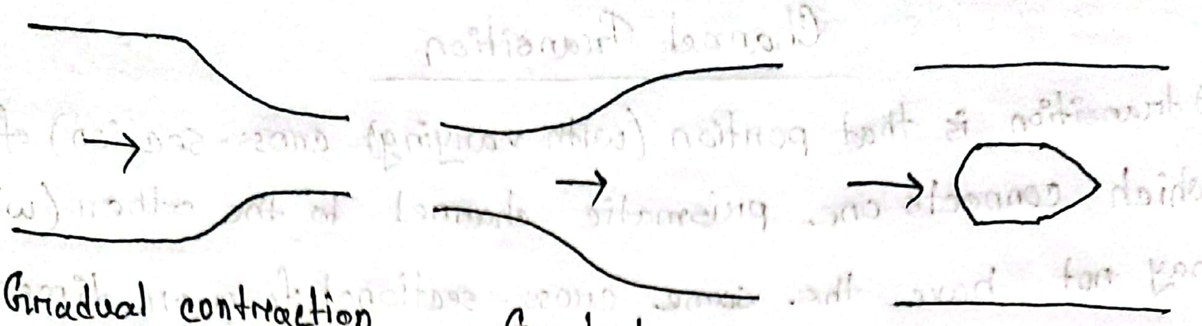
Channel Transition

- A transition is that portion (with varying cross-section) of the channel which connects one prismatic channel to the other (which may or may not have the same cross-sectional form or dimensions). The variation of the channel section may be caused either by reducing or ~~reduc~~ increasing the width or by raising or lowering the bottom of the channel.

Various channel transitions may be broadly classified as sudden and gradual transitions.

- Sudden transitions are those in which the channel of cross-sectional dimension occur in a relative short length.
- On the other hand,





functions which channel transitions are made to serve as;

i) Metering of flow

ii) Dissipation of energy

iii) Reduction or increase of velocities

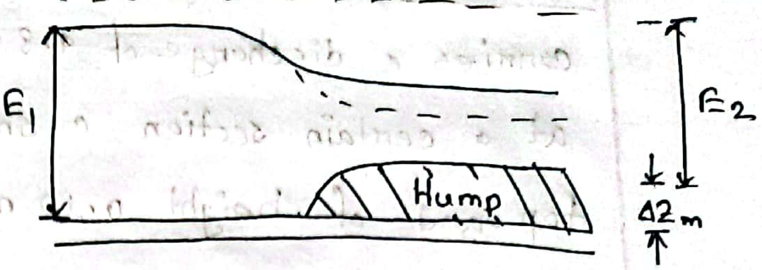
iv) Change in channel section or alignment with a minimum of energy dissipation and least disturbance in the flow regime.

[flow measure করবার জন্য আমরা channel transition use করি,]

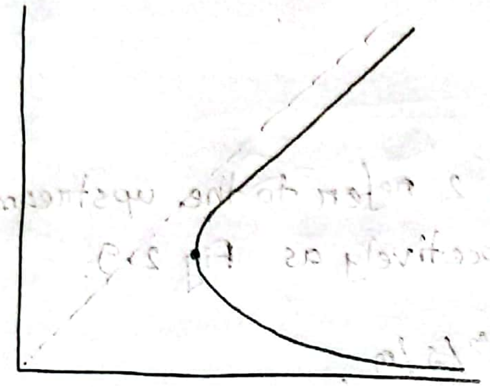
[Dam হবে direction across the river
Embankment direction along the river]

Channel with a Hump

a) Subcritical flow:



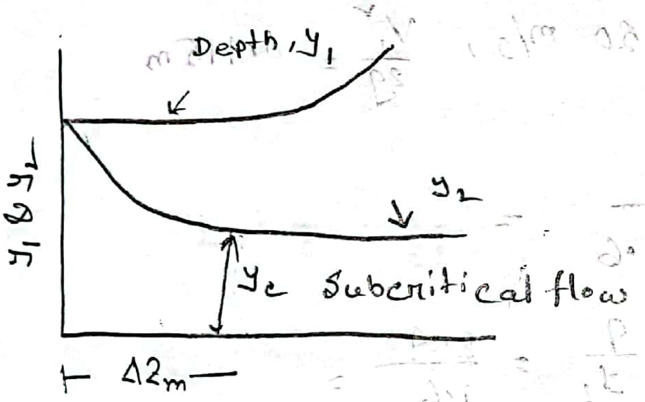
Channel bottom থেকে water level পর্যন্ত ⟂ specific energy



যখন Δz সর্বোচ্চ হবে,

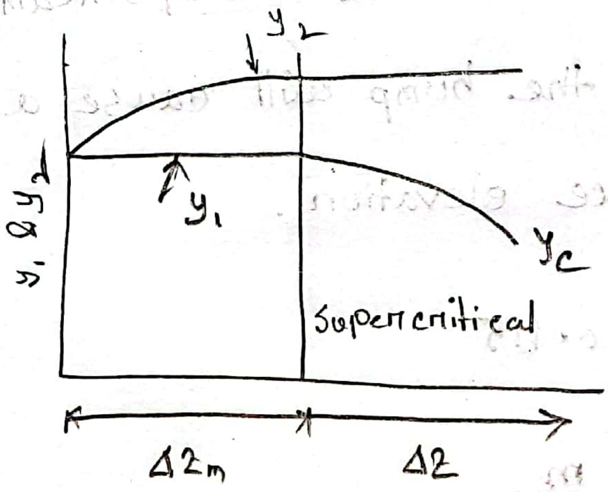
$E_2 = E_c$

$y_2 = y_c$



$\cancel{y_2 \downarrow}$ $\quad \Delta z \downarrow \quad Sp. E \uparrow$

b) Supercritical flow:



$y_2 = y_c$

$E_2 = E_c$

y_1 constant

E_1 constant

Ex. 2.10) A rectangular channel has a width of 2.0 m and carries a discharge of 4.8 m^3/s with a depth of 1.60 m. at a certain section a small, smooth hump with a flat top and of height 0.10 m is proposed to be built. Calculate the likely change in the water surface. Neglect the energy loss?

Soln: Let, the suffixes 1 and 2 refer to the upstream and downstream sections respectively as Fig 2.9.

$$q = \frac{4.80}{2} = 2.40 \ m^3/s/m.$$

$$V_1 = \frac{2.40}{1.6} = 1.50 \ m/s, \quad \frac{V_1^2}{2g} = 0.115 m$$

alternate, $V_1 = \frac{Q}{A_1} = \frac{4.8}{2 \times 1.6} =$

$$V_1 = \frac{q \cdot B}{B \cdot y_1} = \frac{q}{y_1} = \frac{2.4}{1.6} =$$

$F_1 = V_1 \sqrt{g y_1} = 0.379$, hence the upstream flow is subcritical and the hump will cause a drop in the water surface elevation.

$$E_1 = 1.60 + 0.115$$

$$= 1.715 \ m.$$

At section 2, $E_2 = E_1 - \Delta z = 1.715 - 0.10 = \cancel{1.16}$ 1.615 m

$$y_c = \left(\frac{(2.4)^2}{9.81}\right)^{1/3} = 0.837 \text{ m}.$$

$$E_c = 1.5 y_c = 1.256 \text{ m}.$$

The min sp. energy at section 2, $E_c < E_2$. the available sp. energy at the section. Hence $y_2 > y_c$ and the upstream depth y_1 will remain unchanged. The depth y_2 is calculated by solving the sp. energy relation.

$$y_2 + \frac{V_1^2}{2g} = E_2$$

i.e. $$y_2 + \frac{(2.4)^2}{2 \times 9.81 \times y_2^2} = 1.615$$

$$\frac{V_2^2}{2g} = \frac{(qB)^2}{2g A_2^2} = \frac{q^2 B^2}{2g B^2 y_2^2} = \frac{q^2}{2g \cdot y_2^2} = \frac{(2.4)^2}{2 \times 9.81 \times y_2^2}$$

Solving by ~~trait~~ trial and error, $y_2 = 1.481$.

07.06.2022

Section Factor :

$$\frac{V^2}{2g} = \frac{D}{2}$$

$$\Rightarrow \frac{Q}{2gA^2} = \frac{D}{2}$$

$$\Rightarrow \frac{Q^2}{g} = A^2 D$$

$$\Rightarrow \frac{Q}{\sqrt{g}} = \boxed{A\sqrt{D} = A\sqrt{\frac{A}{T}} = Z}$$

Problems 2.6, 2.7, 2.8 Subharamanyam] h.w
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Ven Te Chow

Problem 4.4: Prove that the critical depth and velocity for a rectangular channel are expressed by

$$y_c = \sqrt[3]{\frac{\alpha Q^2}{g b^2}}$$

$$V_c = \sqrt{\frac{g y_c}{\alpha}} = \sqrt[3]{\frac{Q g}{\alpha b}}$$

where, Q = discharge, b = channel width
α = energy coefficient.

i) For rectangular channel at critical flow :-

$$\frac{\alpha V_c^2}{2g} = \frac{D}{2} = \frac{y_c}{2}.$$

$$\Rightarrow \frac{\alpha V_c^2}{g} = y_c$$

$$\Rightarrow \frac{\alpha Q^2}{g A_c^2} = y_c$$

$$\Rightarrow \frac{\alpha Q^2}{g b^2 y_c^2} = y_c$$

$$\Rightarrow y_c^3 = \frac{\alpha Q^2}{g b^2}$$

$$\Rightarrow y_c = \sqrt[3]{\frac{\alpha Q^2}{g b^2}}.$$ [Proved]

Again, We know,

$$Q = A_c V_c$$

$$= b . y_c . V_c$$

$$y_c = \frac{Q}{b . V_c}$$

Again, $\frac{\alpha V_c^2}{g} = y_c$

$$\Rightarrow V_c^2 = \frac{y_c g}{\alpha}$$

$$V_c = \sqrt{\frac{y_c g}{\alpha}}.$$ [Proved].

and, $V_c^2 = \frac{y_c g}{\alpha}$

$\Rightarrow V_c^2 = \frac{\frac{Q}{bV_c} \cdot g}{\alpha}$

$\Rightarrow V_c^2 = \frac{Qg}{bV_c \alpha}$

$\Rightarrow V_c^3 = \frac{Qg}{b\alpha}$

$\therefore V_c = \sqrt[3]{\frac{Qg}{b\alpha}}$. [Proved]

$\boxed{\text{Problem 4.15}}$ A uniform flow of 300 cfs occurs at a depth of 5' in a long rectangular channel 10' wide. Compute the minimum height of a flat ~~of~~ top hump that can be built on the floor of the channel in order to produce critical depth.

What will the result, if the hump is lower or higher than computed height.

Sol^n: $\alpha = 1$

Given, $Q = 300\ ft^3/s$

$y_1 = 5'$, $b = 10'$ $\quad \Delta z_m = ?$

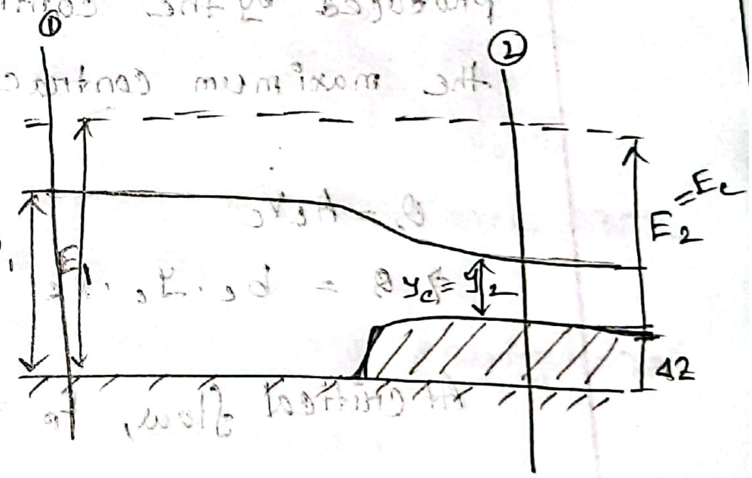
$$y_c = \sqrt[3]{\frac{Q^2}{gb^2}} = \sqrt[3]{\frac{300^2}{32.2 \times (10)^2}} = 3.03'$$

$$E_c = 1.5 \times y_c = 1.5 \times 3.03 = 4.55'$$

$$\therefore E_1 = y_1 + \frac{Q^2}{2gA_1^2} = y_1 + \frac{Q^2}{2g\, b^2 y_1^2}$$

$$= 5 + \frac{300^2}{2 \times 32.2 \times 10^2 \times 5^2}$$

$$= 5.56'$$



$E_2 = E_1 - \Delta z$

$\Rightarrow E_c = E_1 - \Delta z_m$

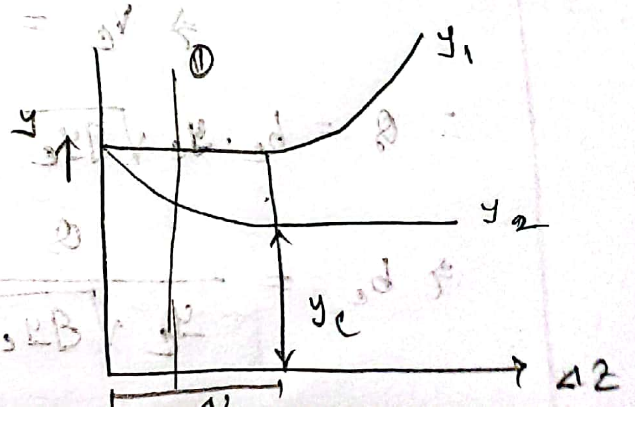
$\Rightarrow 4.55 = 5.56 - \Delta z_m$

$\Rightarrow \Delta z_m = 5.56 - 4.55 = 1.01'$

$$F_r = \frac{V_1}{\sqrt{gy_1}} = \frac{Q}{\sqrt{gy_1} \times A_1} = \frac{Q}{\sqrt{gy_1} \times b \times y_1} = \frac{300}{\sqrt{32.2 \times 5} \times 10 \times 5}$$

$= 0.47$

When, $\Delta z < \Delta z_m$



ⓐ Upstream depth will be constant.

(b) Downstream depth will be greater than critical depth.

(ii) When $\Delta z > \Delta z_m$

(a) Upstream depth will increase with the increase of height of hump.

(b) Downstream depth will be constant and equal to critical.

Problem — If the critical depth of the above ~~channel~~ problem is produced by the contruction of the channel what will be the maximum contracted width.

$Q = A_c V_c$

$\Rightarrow Q = b_c \cdot y_c \cdot V_c$

At critical flow, $F_r = 1$.

$$\Rightarrow \frac{V_c}{\sqrt{g y_c}} = 1$$

$$\Rightarrow V_c = \sqrt{g y_c}$$

$$\therefore Q = b_c \cdot y_c \sqrt{g y_c}$$

$$\Rightarrow b_c = \frac{Q}{y_c \sqrt{g y_c}} = \frac{300}{3.03 \sqrt{32.2 \times 3.03}} = 10.02.$$