FLUID MECHANICS–II
HDRAULIC JUMP
UNIT – IV

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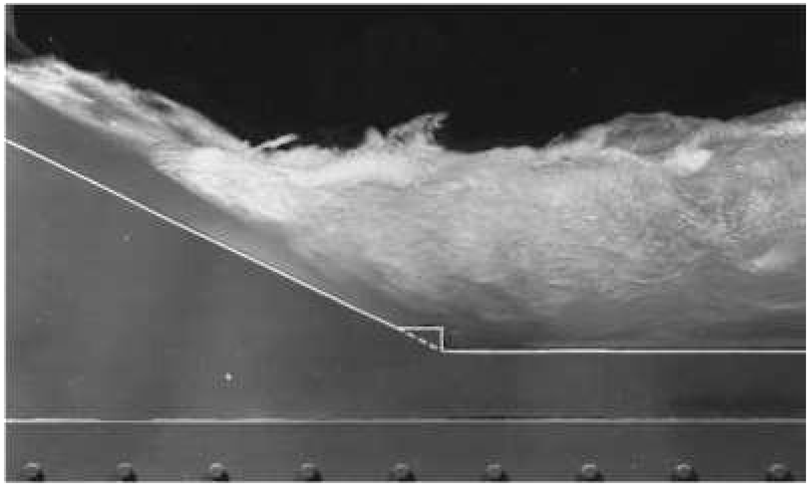
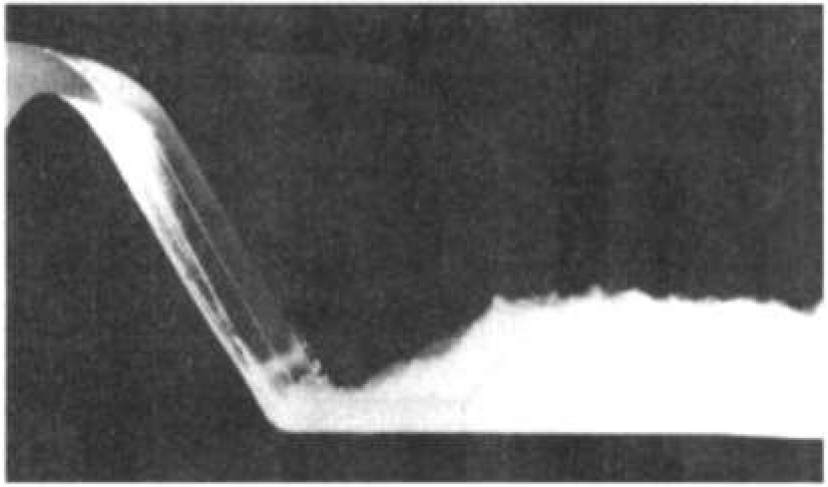
Hydraulic jump



Hydraulic jump formed on a spillway model for the Karna-fuli Dam in Bangladesh.



Rapid flow **and** hydraulic jump on a dam

Characteristics of R.V.F

- A ***rapid variation of flow depth and velocity*** occurs in short reach of channel
- R.V.F occurs in small reach so ***friction force is quite small compared to other forces and may be neglected***.
- ***Velocity coefficient, alpha and momentum coefficients, beta*** are ***greater than unity*** and ***difficult to ascertain accurately***
- In R.V.F, the ***flow pattern and velocity distribution is complicated***

Determination of alpha and beta

Rehbock assumed a linear velocity distribution and obtained

$$\alpha = 1 + \varepsilon^2$$

$$\beta = 1 + \frac{\varepsilon^2}{3}$$

and for logarithmic velocity distribution.

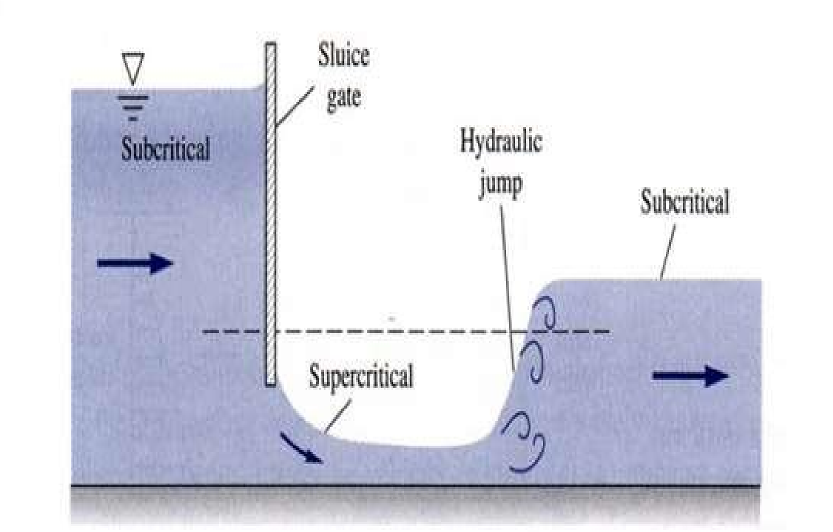
$$\alpha = 1 + 3\varepsilon^2 - 2\varepsilon^3$$

$$\beta = 1 + \varepsilon^2$$

in which $\varepsilon = \left\{ \frac{V_{max}}{\overline{V}} - 1 \right\}$, V_{max} is the maximum velocity and $\overline{V}$ is the mean velocity

Hydraulics Jump or Standing Wave

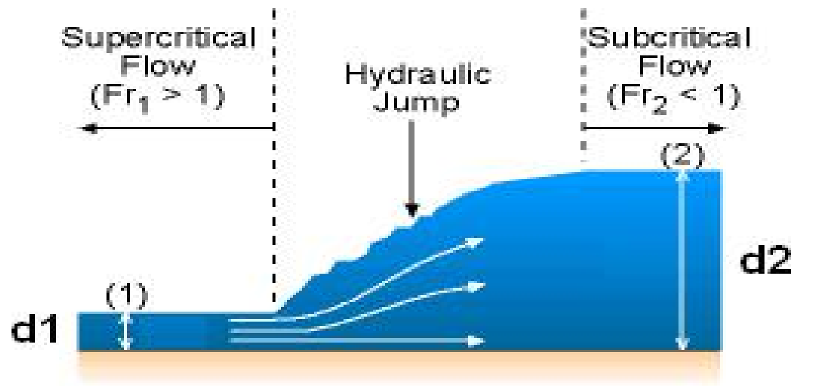
Hydraulics jump is local non-uniform flow phenomenon *resulting from the change in flow from super critical to sub critical*.



Flow under a sluice gate accelerates from subcritical to critical to supercritical and then jumps back to subcritical flow

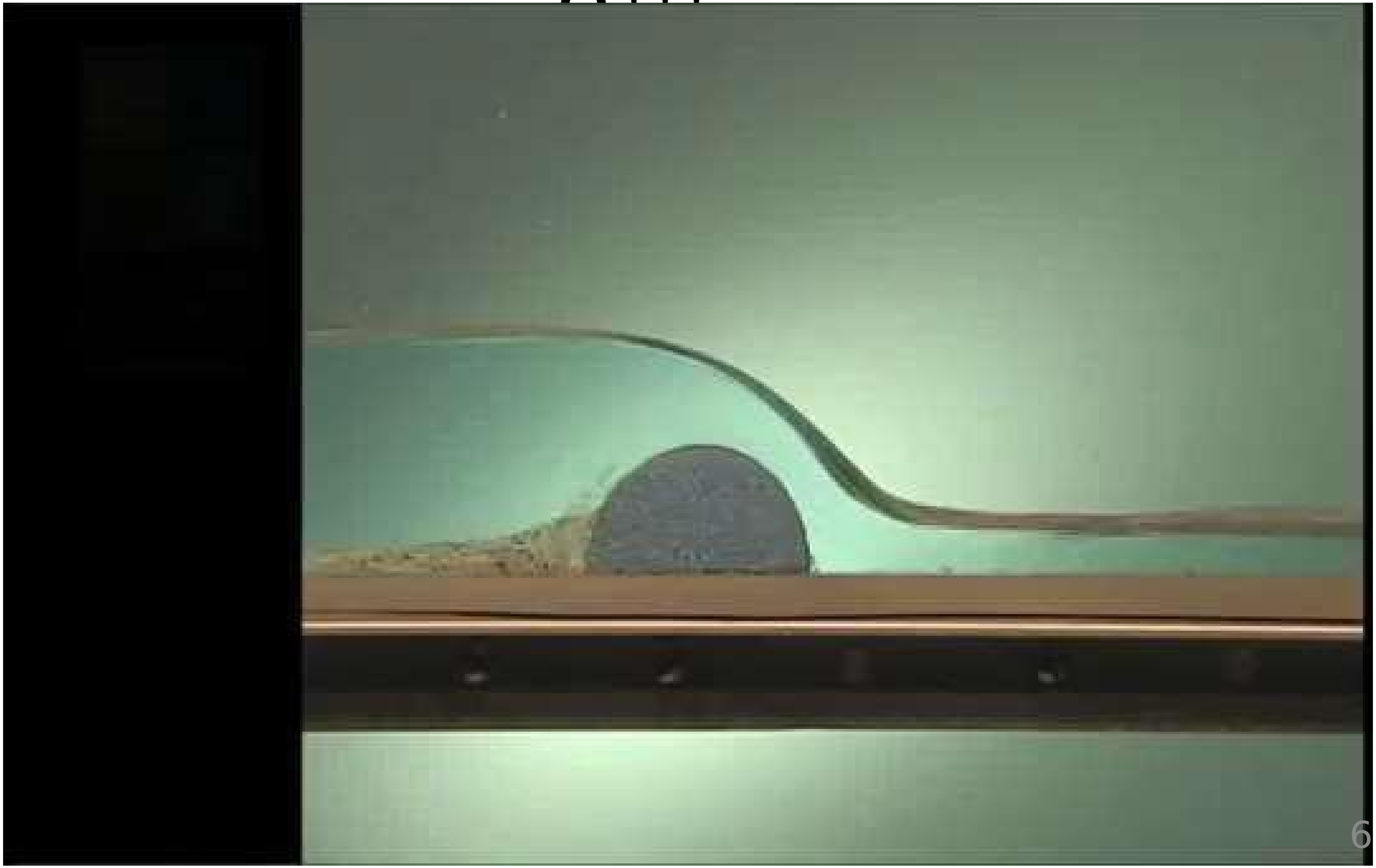
The Hydraulic jump there is discontinuity in the surface characterized by a steep upward slope of the profile accompanied by lot of turbulence and eddies. The eddies cause energy loss.

The depth before and after the hydraulic jump are known as conjugate depths or sequent depths.

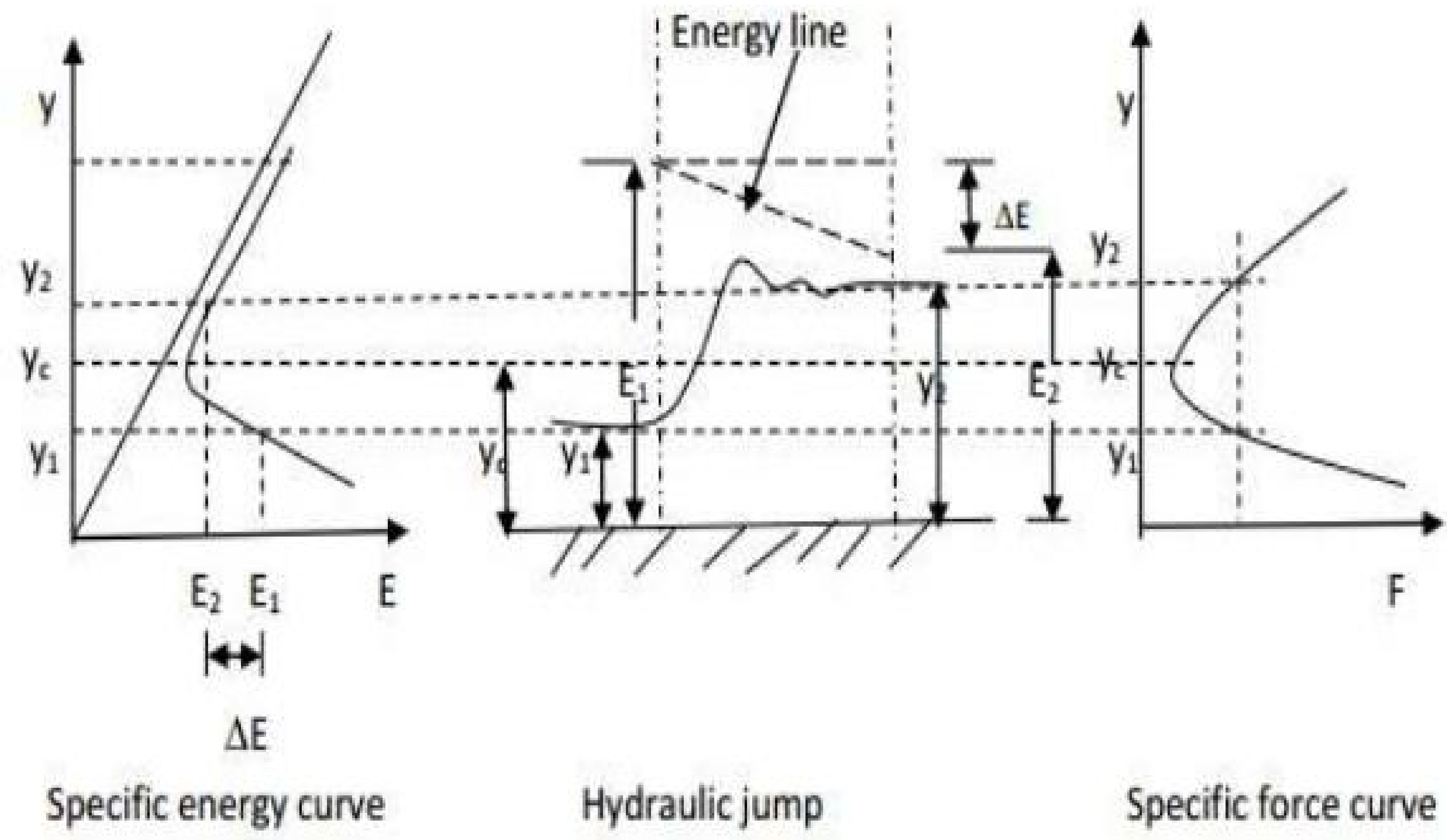


Froude Numbers and Fluid Depths across a Hydraulic Jump

Vide o!!!



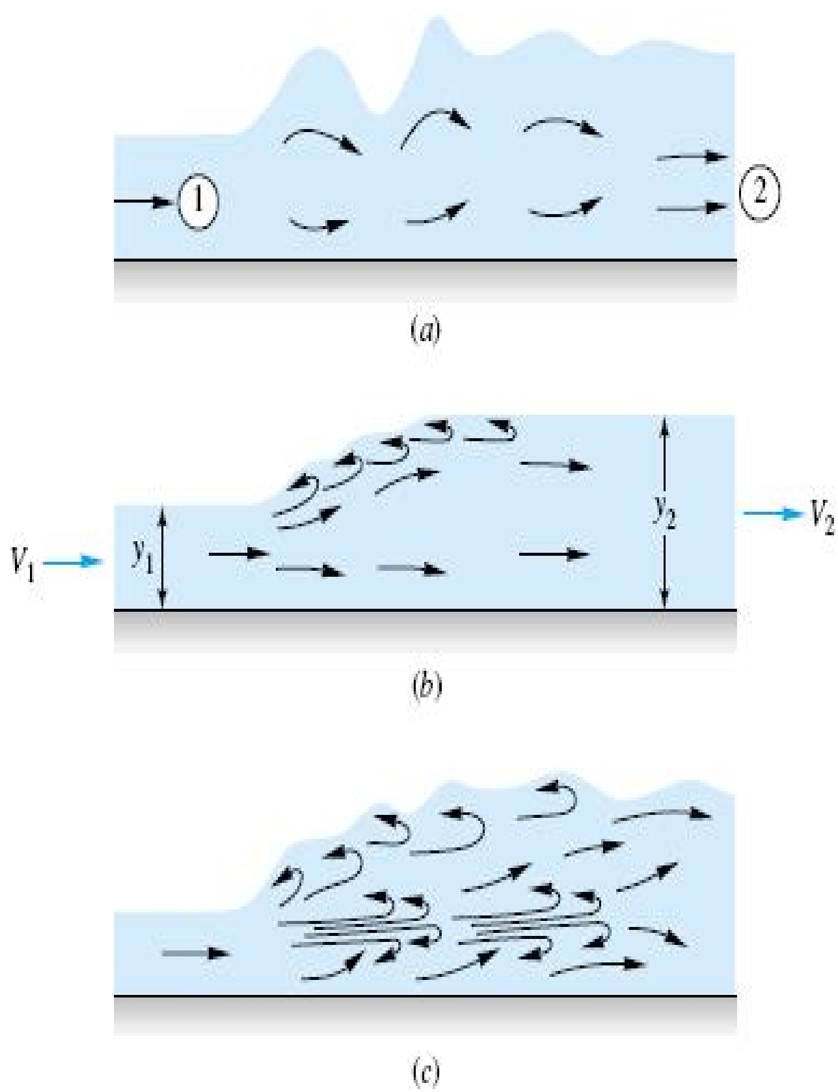
Specific Energy and specific force curves for Hydraulic Jump

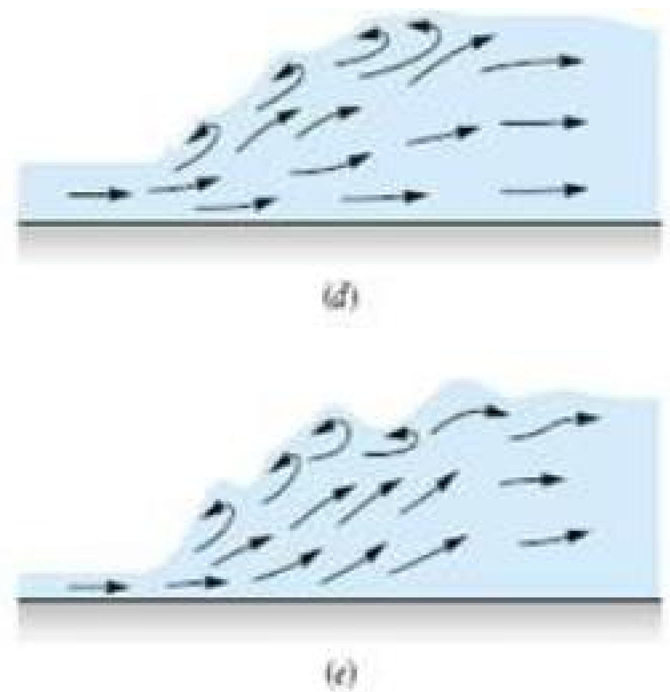


Uses of Hydraulic Jump/Practical applications

- As an energy dissipater, to dissipate the excess energy of flowing water downstream of hydraulic structure such as spillway and sluice gates
- Mixing of chemical
- Aeration of stream polluted by biodegradable waste
- Raising the water level in the channel for irrigation
- Desalination of seawater
- efficient operation of flow measurement flumes

Classification of Hydraulic jump
1.Based on Froude number





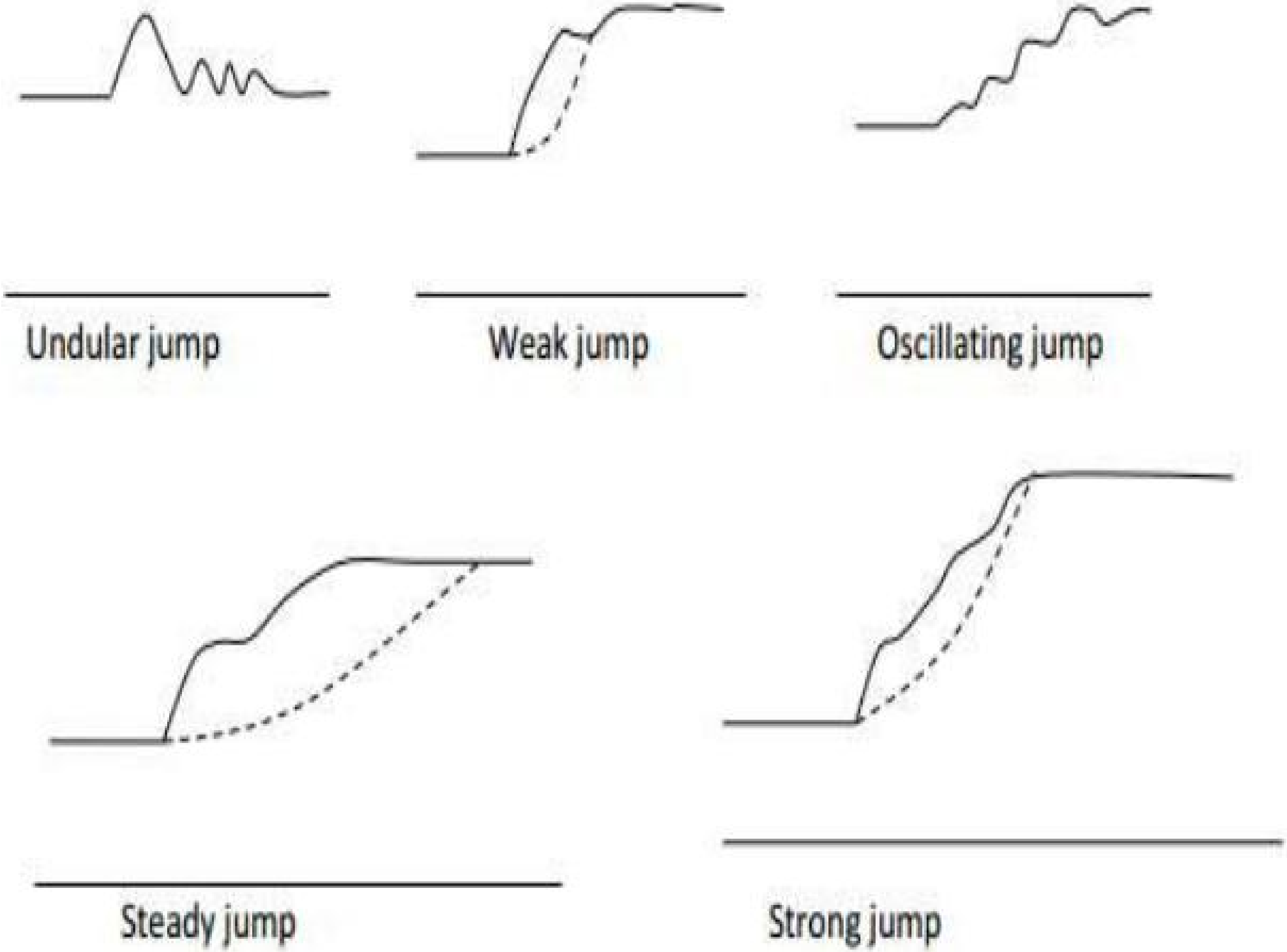
Classification of hydraulic jumps:

(a) Fr =1.0 to 1.7: undular jumps;

(b) Fr =1.7 to 2.5: weakjump;

(c) Fr =2.5 to 4.5: oscillating jump;

(d) Fr =4.5 to 9.0: steadyjump;


Undular jump
Weak jump
Oscillating jump
Steady jump
Strong jump

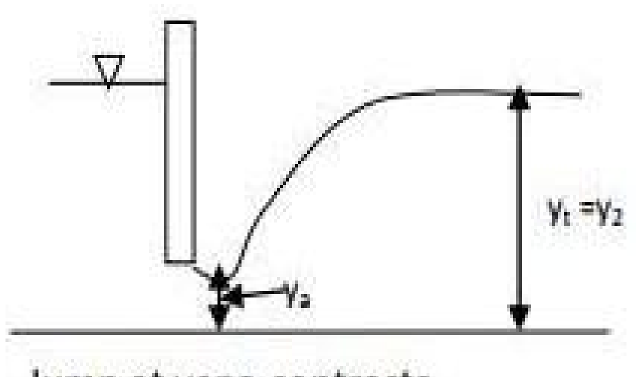
Classification of Hydraulic jump

- $F_{r1} < 1.0$: Jump impossible, violates second law of thermodynamics.
- $F_{r1} = 1.0$ to 1.7: Standing-wave, or *undular, jump* about $4y_2$ long; low dissipation, less than 5 percent.
- $Fr1 = 1.7$ to 2.5: Smooth surface rise with small rollers, known as a *weak jump*; dissipation 5 to 15 percent.
- $F_{r1} = 2.5$ to 4.5: Unstable, *oscillating jump*; each irregular pulsation creates a large wave which can travel downstream for miles, damaging earth banks and other structures. Not recommended for design conditions. Dissipation 15 to 45 percent.
- $F_{r1} = 4.5$ to 9.0: Stable, well-balanced, *steady jump*; best performance and action, insensitive to downstream conditions. Best design range. Dissipation 45 to 70 percent.
- $F_{r1} > 9.0$: Rough, somewhat intermittent *strong jump*, but good performance. Dissipation 70 to 85 percent.

2.Based on Tail water depth

- **The depth downstream of a hydraulic structure is called tailwater depth.**
  yt = tailwater depth, ya = Depth at the vena-contracta, y2 = sequent depth to ya

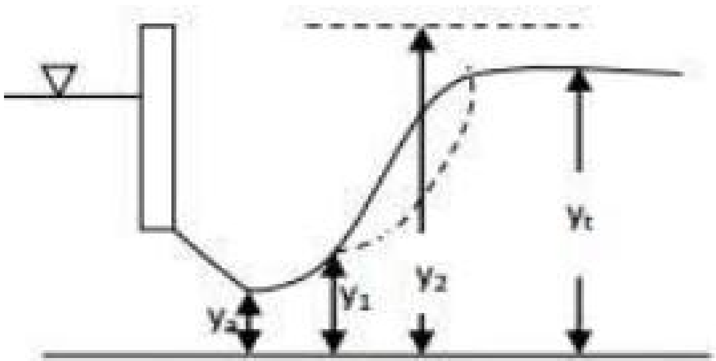
1) **Free jump**: The jump with **yt equal to or less than y2** is called free jump. When **yt = y2**, a free **jump will form at the vena-contracta.**



Jump at vena-contracta

2)Repelled jump:

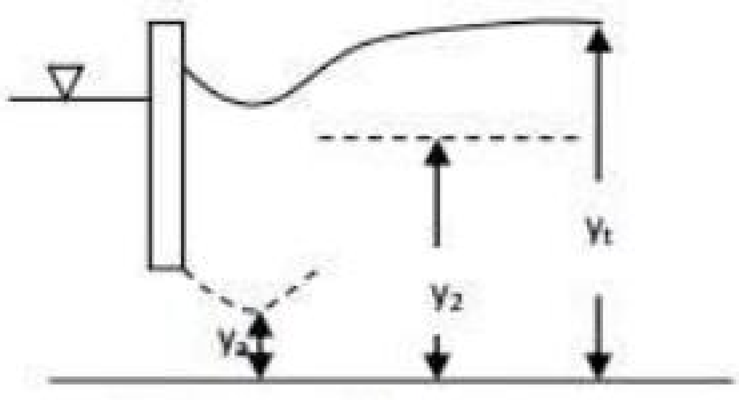
- If **$y_t < y_2$**, the jump is repelled downstream of the vena-contracta through an M3 curve (or may be H3). The **depth at the toe of the jump is larger than ya**. Such a jump is called a repelled jump.



Repelled jump

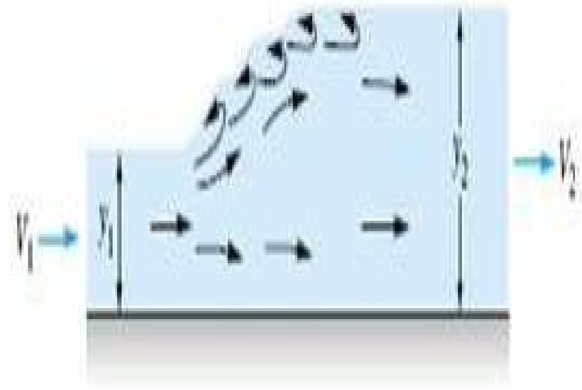
3) Submerged jump:

- If **yt > y**2, the jump **is no longer free but gets drowned out**. Such a jump is called **drowned jump or submerged jump**. ***The loss of energy in a submerged jump is smaller than that in a free jump***



Submerged jump

Jump Variables



- **Conjugate depth**=**y_1 and y_2**
- **Height of jump(hj)=y_2–y_1**
- **Length of jump(Lj)**

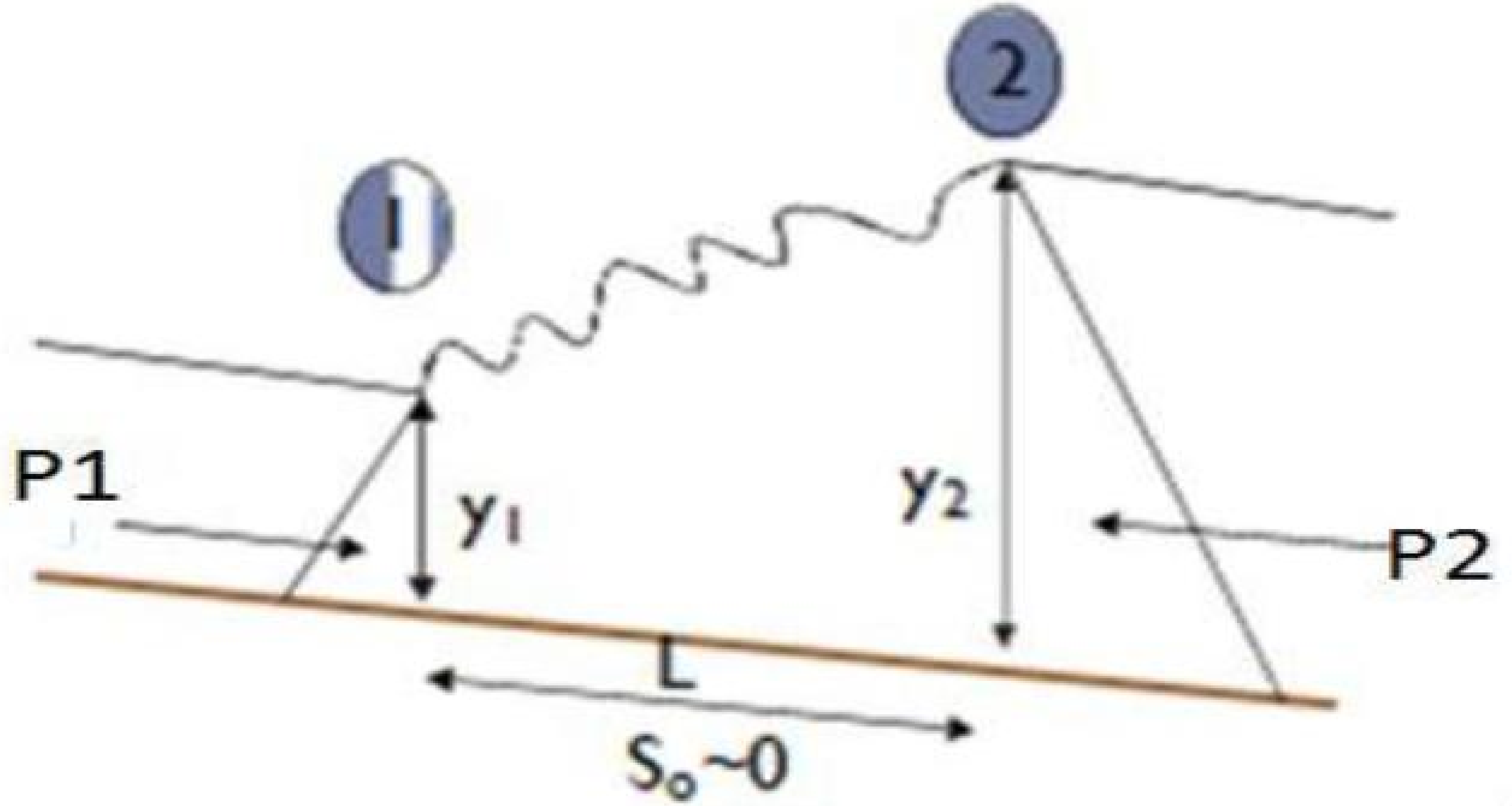
It is the distance measured from front face of hump to a point on surface immediately downstream of roller.

Experimentally,

For rectangular channel, **Lj**=(5 **to** 7)***hj=**6**hj**

- **Efficiency of jump** = **E_2/E_1** where E_2 = specific energy after jump and E_1 = specific energy before jump
- **Power dissipated by the jump**= $\gamma Q(\Delta E)$

Equation for Conjugate Depths



Assumptions

- Loss of head due to friction is negligible
- The flow is uniform and the pressure distribution is hydrostatic before and after the jump
- Channel is horizontal hence the weight component in the direction is neglected
- The momentum correction factor is unity.
- The flow is steady

Hydraulic Jump in a retangular channel

Equation for Conjugate Depths

The momentum equation for the jump is given by

$$P_1 - P_2 + W\sin\theta - F_f = \rho Q(V_2 - V_1)$$

For a short reach of prismatic channel, $\theta = 0$ and friction force, F_f can be neglected.

$$P_1 - P_2 = \rho Q(V_2 - V_1)$$

a. Expression for sequent depth

Consider unit width of the channel. The discharge per unit width $q = V_1y_1 = V_2y_2$

$P_1 = \gamma A_1\overline{x_1} = \gamma(1.y_1).\frac{y_1}{2} = \frac{1}{2}\gamma y_1^2$ and $P_2 = \gamma A_2\overline{x_2} = \gamma(1.y_2).\frac{y_2}{2} = \frac{1}{2}\gamma y_2^2$

Substituting the values of P_1 and P_2

$$\frac{1}{2}\gamma y_1^2 - \frac{1}{2}\gamma y_2^2 = \rho q(V_2 - V_1)$$

From continuity equation: $q = y_1 V_1 = y_2 V_2$

$V_1 = q/y_1$, $V_2 = q/y_2$

Substituting the values of V_1 and V_2

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

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

$$\frac{2q^2}{g} = y_1y_2(y_1 + y_2) \quad \text{(I)}$$

Equation for Conjugate Depths

$$\frac{2q^2}{g} = y_1 y_2 (y_1 + y_2) \qquad \text{(I)}$$

Dividing both sides by y_1 and simplifying

$$y_2^2 + y_1 y_2 - \frac{2q^2}{g y_1} = 0$$

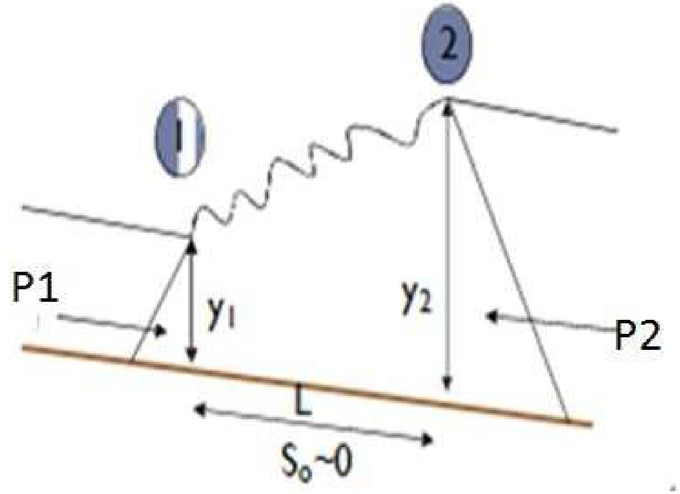
Solving for y_2

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

As negative root is not possible

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

This is the relationship between conjugate depths



Equation for Conjugate Depths

Conjugate depths in terms of Froude number

Substituting $q = y_1 V_1$

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

Multiplying numerator and denominator by 4, we get

$$y_2 = -\frac{y_1}{2} + \sqrt{\left(\frac{y_1}{2}\right)^2 \left(1 + \frac{8V_1^2}{g y_1}\right)}$$

Since, $\frac{V_1^2}{g y_1} = F_{r1}^2$

$$y_2 = \frac{y_1}{2}\left(-1 + \sqrt{1 + 8F_{r1}^2}\right)$$

Similarly

For y_1

$$y_1 = -\frac{y_2}{2} + \sqrt{\left(\frac{y_2}{2}\right)^2 + \frac{2q^2}{g y_2}} \text{ and } y_1 = \frac{y_2}{2}\left(-1 + \sqrt{1 + 8F_{r2}^2}\right)$$

The above equation is known as Belanger momentum equation.

Energy loss in a jump

c. Expression for energy loss in terms of conjugate depths (Analysis using specific energy)

$$\Delta E = E_1 - E_2$$

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

From continuity $V_1 = q/y_1$, $V_2 = q/y_2$

$$= \left(y_1 + \frac{q^2}{2gy_1^2}\right) - \left(y_2 + \frac{q^2}{2gy_2^2}\right)$$

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

Substituting $\frac{q^2}{g} = \frac{1}{2}y_1 y_2(y_1 + y_2)$ from eq. (i)

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

??

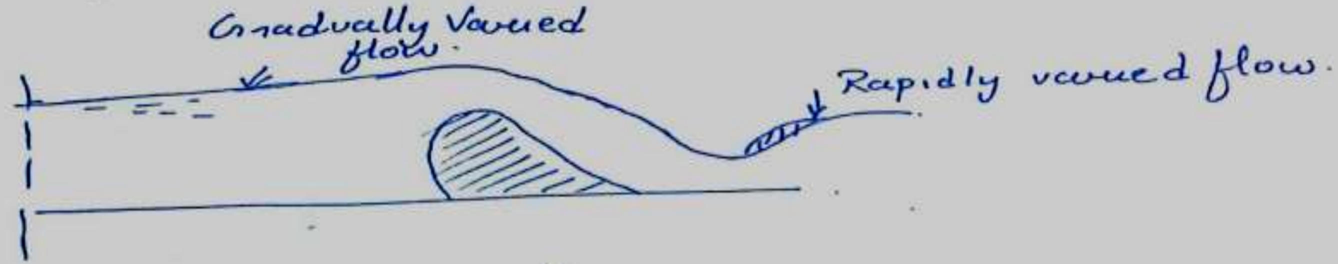
SOLVE

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

THANK YOU

GRADUALLY VARIED FLOW
(G.V.F)

If the depth of flow in a channel changes gradually over a long length of the channel, the flow is said to be gradually varied flow and is dennoted by GVF

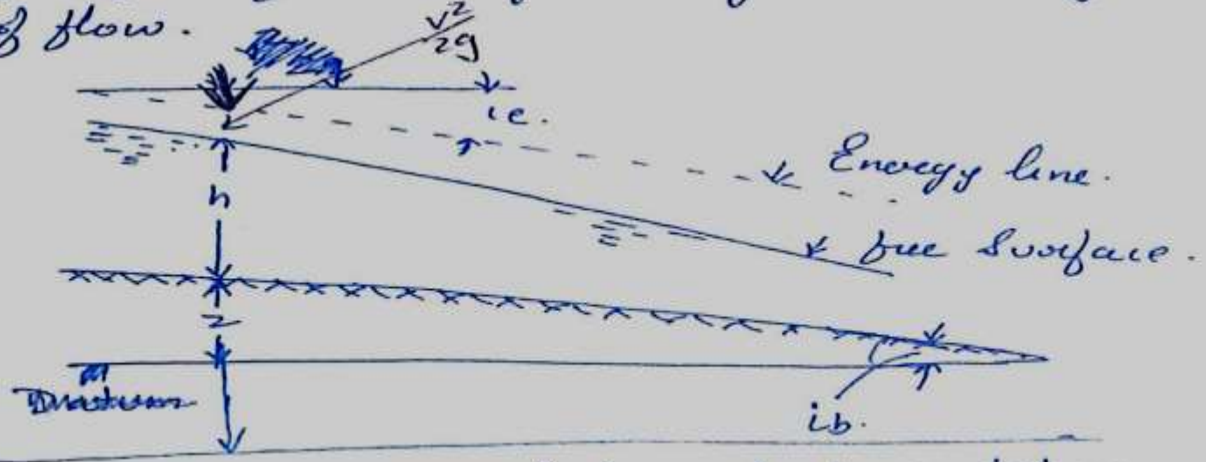


Equation of gradually varied flow.

Before deriving an equation for gradually varied flow, the following assumptions are made.

1) Bed slope of channel is small.
2) The flow is steady and hence Q is constant
3) Accelerative effect is negligible hence hydrostatic pressure distribution prevails over channel crosssection.
4) Energy Roughness co-efficient is constant for the length and it does not depend on depth of flow.
5) The formulae, such as chezy's formula, manning formula, which are applicable for uniform flow are also applicable for gradually varied flow. for determining slope of Energy line

Consider a rectangular channel having gradually varied flow. The depth of the flow is gradually decreasing in the direction of flow.



Z = height of bottom of channel above datum.

h = depth of flow.

V = mean velocity of flow.

i_b = slope of channel bed.

i_e = slope of Energy line

b = width of channel.

Q = discharge through channel.

The energy equation at any section is given by. Bernoulli's Equation.

$$E = Z + h + \frac{V^2}{2g}$$

- Differentiating this the Energy Equation w.r.t x, where x is measured along the bottom of the channel along the direction of flow.

$$\frac{dE}{dx} = \frac{dz}{dx} + \frac{dh}{dx} + \frac{d}{dx}\left(\frac{v^2}{2g}\right) \qquad -(1)$$

$$\frac{d}{dx}\left(\frac{v^2}{2g}\right) = \frac{d}{dx}\left(\frac{Q^2}{A^2 \times 2g}\right)$$

Note
$$\left[v = \frac{Q}{A} = \frac{Q}{b \times h} \right]$$

$$= \frac{d}{dx}\left(\frac{Q^2}{b^2 h^2 \times 2g}\right) = \frac{Q^2}{b^2\, 2g}\frac{d}{dx}\left(\frac{1}{h^2}\right)$$

[Q, b, g are constant].

$$= \frac{Q^2}{b^2 \times 2g}\frac{d}{dh}\left[\frac{1}{h^2}\right]\frac{dh}{dx}.$$

$$= \frac{Q^2}{b^2 \times 2g}\left[-\frac{2}{h^3}\right]\frac{dh}{dx}$$

$$= -\frac{2Q^2}{b^2 \times 2g\, h^3}\frac{dh}{dx}$$

$$= -\frac{Q^2}{b^2 h^2 \times g h}\frac{dh}{dx} \qquad \left[\frac{Q}{bh} = v\right].$$

$$\frac{d}{dx}\left(\frac{v^2}{2g}\right) = -\frac{v^2}{gh}\frac{dh}{dx}$$

Substituting the value of $\frac{d}{dx}\left(\frac{V^2}{2g}\right)$ in equation (1)

$$\frac{dE}{dx} = \frac{dz}{dx} + \frac{dh}{dx} - \frac{V^2}{gh}\frac{dh}{dx}$$

$$\frac{dE}{dx} = \frac{dz}{dx} + \frac{dh}{dx}\left[1 - \frac{V^2}{gh}\right]$$

$$\frac{dE}{dx} = -i_e = \text{slope of energy line}$$

$$\frac{dz}{dx} = -i_b = \text{slope of bed of channel.}$$

-ve sign with i_e and i_b is taken as with the increase of x, the value of E and Z decreases.

Substituting the value of $\frac{dE}{dx}$ and $\frac{dz}{dx}$

$$-i_e = -i_b + \frac{dh}{dx}\left[1 - \frac{V^2}{gh}\right]$$

$$i_b - i_e = \frac{dh}{dx}\left[1 - \frac{V^2}{gh}\right].$$

$$\frac{dh}{dx} = \frac{i_b - i_e}{\left[1 - \frac{V^2}{gh}\right]}$$

$$F_e = \frac{V}{\sqrt{gh}}$$

$$(F_e)^2 = \frac{V^2}{gh}$$

$$\frac{dh}{dx} = \frac{i_b - i_e}{\left[1 - (F_e)^2\right]}$$

$$\frac{dh}{dx} = \frac{i_b - i_e}{[1-(F_e)^2]}$$

As h is the depth of flow and x is the distance measured along the bottom of the channel hence $\frac{dh}{dx}$ represents the variation of the water depth along the bottom of channel.

(i) When $\frac{dh}{dx} = 0$, h is constant or depth of the water above the bottom of channel is constant Means free surface of water is parallel to the bed of the channel.

(ii) $\frac{dh}{dx} > 0$ or $\frac{dh}{dx} = +ve$. It means the depth of the water increases in the direction of flow.
And profile of water so obtained is called <u>back water curve</u>.

(iii) $\frac{dh}{dx} < 0$ or $\frac{dh}{dx} = -ve$, It means that depth of water decreases in the direction of flow.
The profile so obtained is called ~~back water~~.
<u>drop down curve</u>.

Problem 16.43
Pg 792

Find the Rate of Change of depth of water in a rectangular channel of 10m wide and 1.5m deep, when the water is flowing with a velocity of 1m/s. The flow of water through the channel of bed slope 1 in 4000, is regulated in such a way that energy line is having a slope of .00004.

⑥

Given

Width of Channel $b = 10m.$

$h =$ 1.5m

$V = 1 m/s.$

$i_b = \frac{1}{4000} = .00025$

$i_e = .00004$

Rate of change of depth of water $= \frac{dh}{dx}.$

$$\frac{dh}{dx} = \frac{(i_b - i_e)}{\left(1 - \frac{V^2}{gh}\right)} = \frac{.00025 - .00004}{\left(1 - \frac{1 \times 1}{9.81 \times 3}\right)}$$

$$= \frac{.00021}{.966}$$

$$\frac{dh}{dx} = .000217$$

Problem 16.44
Pg 792

Find the slope of the free ~~surface~~ water. (9)
Surface in a Rectangular channel of width 20m having depth of flow 5m. The discharge through the channel is 50 m^3/s. The bed of the channel is having slope of 1 in 4000. Take the value of Chezy Constant C=60.

Given

$b = 20m$

$h = 5m$

$Q = 50 m^3/s$.

$i_b = \frac{1}{4000} = .00025$

Chezy's Constant $C = 60$.

The discharge, Q is given by $Q = V \times Area$.

$$Q = AC\sqrt{mi}$$

$A =$ Area of flow $= b \times h = 20 \times 5 = 100 m^2$.

$$m = \frac{A}{P} = \frac{100}{b+2h} = \frac{100}{20+2\times5} = \frac{100}{30} = \frac{10}{3}$$

$i = i_e$ = slope of Energy line

The slope is determined by chezy's formula.

$$50 = 100 \times 60\sqrt{\frac{10}{3} i_e}$$

$$i_e = \left(\frac{50}{10954.45}\right)^2 = 0.0000208$$

The slope of free water surface $= \frac{dh}{dx}$

$$\frac{dh}{dx} = \frac{i_b - i_e}{1 - \frac{V^2}{gh}} = \frac{0.00025 - 0.0000208}{1 - \frac{V^2}{9.81 \times 5.0}}$$

$$V = \frac{Q}{A} = \frac{50}{b \times h} = \frac{50}{20 \times 5} = 0.5$$

$$\frac{dh}{dx} = \frac{0.00025 - 0.0000208}{1 - \frac{0.5 \times 0.5}{9.81 \times 5}}$$

$$\frac{dh}{dx} = 0.00023$$

BACK WATER CURVE AND AFFLUX

Consider the flow over a dam as shown in figure.
The depth of water is rising in the direction of flow.
[If there had not been obstruction in the path of flow of water,
The depth of water would have been constant as shown
by dotted line parallel to the bed of the channel]
⇒ Due to obstruction the water level rises and it has
maximum depth from the bed at some section.

Let h_1 = depth of water at point, where water start rising up

h_2 = maximum height of Rising water from bed

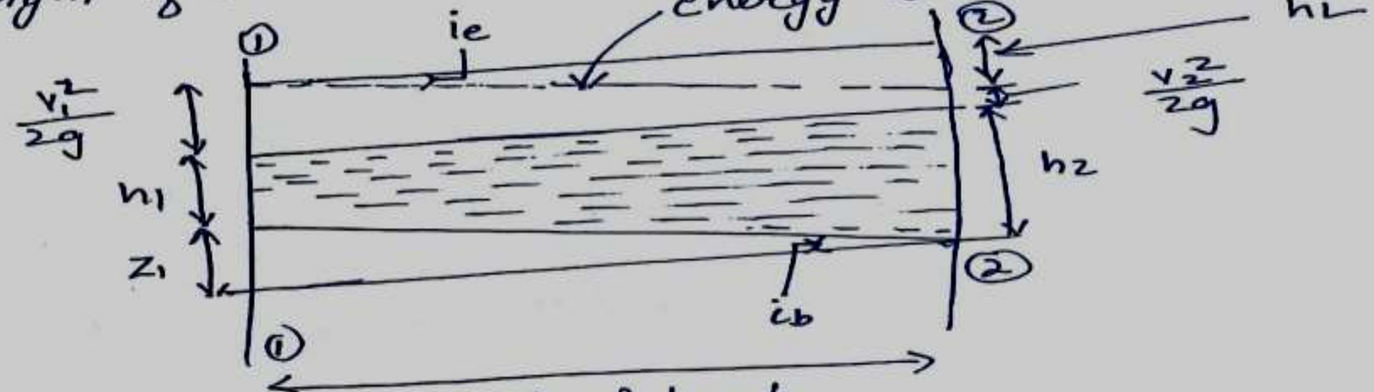
$(h_2 - h_1)$ = <u>Afflux</u>

The maximum increase in the water level due to obstruction in the path of flow of water

And the Profile of Rising water is known as <u>Back-Water Curve</u>.

Expression for the length of Back Water Curve.

Consider the flow of water through a channel in which depth of water is rising. Let the two section 1-1 and 2-2 are at such a distance that distance b/w them represents the length of back water curve.



Length of back water Curve.

h_1 = depth of flow at section 1-1

V_1 = velocity of flow at section 1-1

h_2 = depth of flow at section 2-2.

V_2 = Velocity of flow at section 2-2.

i_b = bed slope.

i_e = energy line slope.

L = Length of back water curve.

Applying Bernoullis equation at section 1-1 and 2-2.

$$Z_1 + h_1 + \frac{V_1^2}{2g} = Z_2 + h_2 + \frac{V^2}{2g} + h_L$$

To find h_L and Z_1 [Note $\tan i_e = \frac{h_L}{L}$; $h_L = i_e \times L$

$\tan i_b = \frac{Z_1}{L}$; $Z_1 = i_b \times L$ [ie and ib are taken minimum]

Also Z_2 at Section 2-2 is Zero. $[Z_2 = 0]$

$$i_b \times L + h_1 + \frac{V_1^2}{2g} = h_2 + \frac{V_2^2}{2g} + i_e \times L$$

$$i_b \times L - i_e \times L = \left(h_2 + \frac{V_2^2}{2g}\right) - \left(h_1 + \frac{V_1^2}{2g}\right)$$

$$L(i_b - i_e) = E_2 - E_1$$

[Note $E_2 = h_2 + \frac{V_2^2}{2g}$

$E_1 = h_1 + \frac{V_1^2}{2g}$]

[Length of Back Water Curve]

$$L = \frac{E_2 - E_1}{i_b - i_e}$$

Note. ⇒ The value of ie is Calculated Using Mannings and Chezy's formulae.

Problem 16.45
Pg 795

Determine the length of the back water curve caused by an afflux of 2.0 m in the Rectangular channel of Width 40m and depth 2.5m. The slope of the bed is given as 1 in 11000. Take manning's constant N = 0.03

h2=4.5m

Given

$b = 40m$

Afflux $(h_2 - h_1) = 2.0m$

$h_1 = 2.5m$

$i_b = \frac{1}{11000} = .0000909$

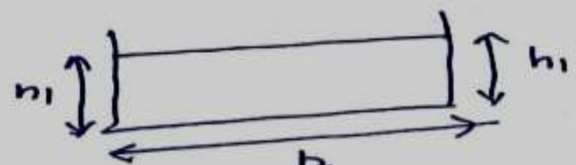
$N = 0.03$

Area of flow at section 1-1 = $b \times h_1 = 40 \times 2.5 = 100 m^2$.

Wetted Perimeter " " 1-1 = ~~$m_1 = \frac{A_1}{P_1}$~~

$P_1 = b + 2h_1$

At Section 1-1



$P_1 = b + h_1 + h_1 = b + 2h_1 = 40 + 2 \times 2.5$
$= 45 m$

hydraulic Mean depth, $m_1 = \frac{A_1}{P_1} = \frac{100}{45} = 2.22m$

Mannings formulae.

$$V = C\sqrt{mi}$$

Put [According to manning formulae.

$$C = \frac{1}{N} m^{\frac{1}{6}}$$

$$V = \frac{1}{N} m^{\frac{1}{6}} m^{\frac{1}{2}} \cdot i_b^{\frac{1}{2}}.$$

$$\boxed{V = \frac{1}{N} m^{\frac{2}{3}} i_b^{\frac{1}{2}}}$$

∴ Velocity at section 1-1

$$V_1 = \frac{1}{N} m_1^{\frac{2}{3}} i_b^{1/2}.$$

$$= \frac{1}{.03} (2.22)^{\frac{2}{3}} (.0000909)^{1/2}$$

$$V_1 = 0.54 \text{ m/s}.$$

Specific energy at section 1-1 $= E_1 = h_1 + \frac{V_1^2}{2g} = 2.5 + \frac{0.54^2}{2 \times 9.81}$

$$= 2.5148 \text{ m}.$$

Now

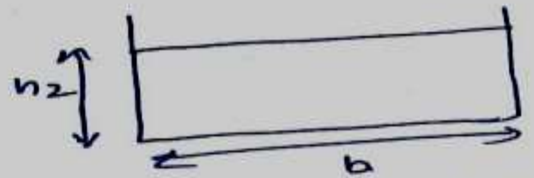
$$Q_1 = Q_2$$

$$V_1 A_1 = V_2 A_2.$$

$$V_2 = \frac{V_1 A_1}{A_2} = \frac{0.54 \times 100}{b \times h_2} = \frac{0.54 \times 100}{40 \times 4.5} = 0.3 \text{ m/s}.$$

$$A_2 = b \times h_2 = 40 \times 4.5 = 180 \text{ m}^2$$

At Section 2-2.



$P_2 = b + 2h_2 = 40 + 2\times4.5 = 49m$

$m_2 = \frac{A_2}{P_2} = \frac{180}{49} = 3.673m$

$E_2 = h_2 + \frac{V_2^2}{2g} = 4.5 + \frac{0.3^2}{2\times9.81} = 4.504m$

Now to find value of ie.
& we need to find Vav, hav, mav

$V_{av} = \frac{1}{N}(m_{av})^{\frac{2}{3}} \times ie^{1/2}$.

$h_{av} = \frac{h_1 + h_2}{2} = \frac{2.5 + 4.5}{2} = 3.5m$.

~~$V_{av} = \frac{V_1 A_1}{}$~~

$V_{av} = \frac{\text{Discharge}}{(\text{Area})_{av}} = \frac{V_1 A_1}{A_{av}} = \frac{V_1 \times b \times h_1}{b \times h_{av}}$

$= \frac{V_1 \times h_1}{h_{av}} = 0.\frac{54\times2.5}{3.5}$

$V_{av} = 0.3857 m/s$.

$$m_{av} = \frac{m_1 + m_2}{2} = \frac{2.22 + 3.673}{2} = 2.9465$$

Now Subsituting values.

$$V_{av} = \frac{1}{N} (m_{av})^{\frac{2}{3}} \, i_e^{1/2}.$$

$$0.3857 = \frac{1}{0.03} (2.9465)^{\frac{2}{3}} \times i_e^{1/2}.$$

$$i_e = 0.00003167$$

Now we can calculate length of Back water Curve

$$L = \frac{E_2 - E_1}{i_b - i_e} = \frac{4.504 - 2.518}{0.0000909 - 0.00003167}$$

~~= 1.9892~~

$$L = 33584.3 \text{ m.}$$

HYDRAULIC JUMP

HYDRAULIC JUMP

PREPARED BY:
Nirali Padhiyar

INTRODUCTION

In an open channel when rapidly flowing stream abruptly changes to slowly flowing stream, a distinct rise or jump in the elevation of liquid surface takes, this phenomenon is known as hydraulic jump.

The hydraulic jump converts kinetics energy of rapidly flowing into potential energy.

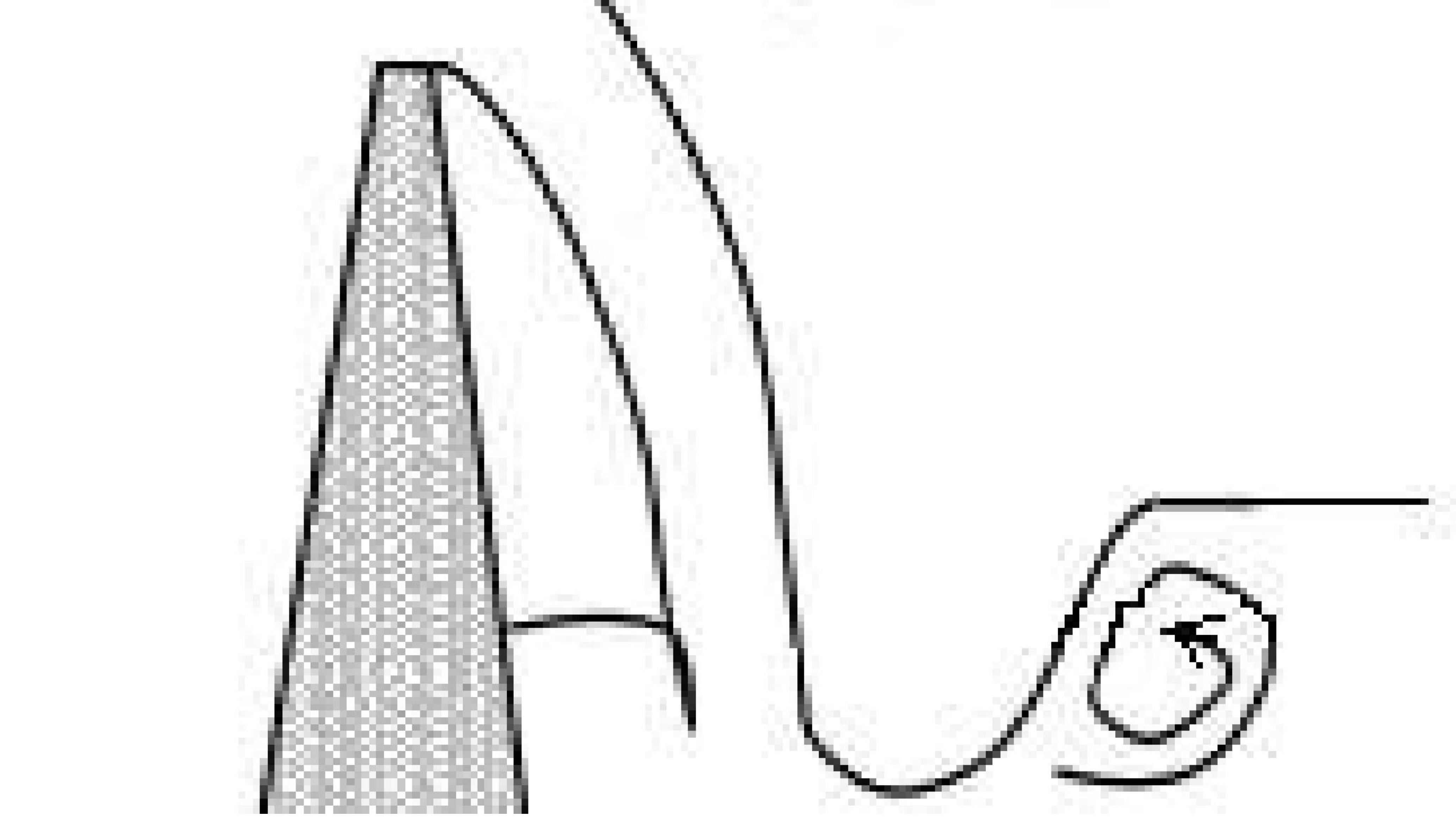
Due to this there is a loss of kinetic energy

The hydraulic jump is also known as a standing wave because it is, in essence, a wave which

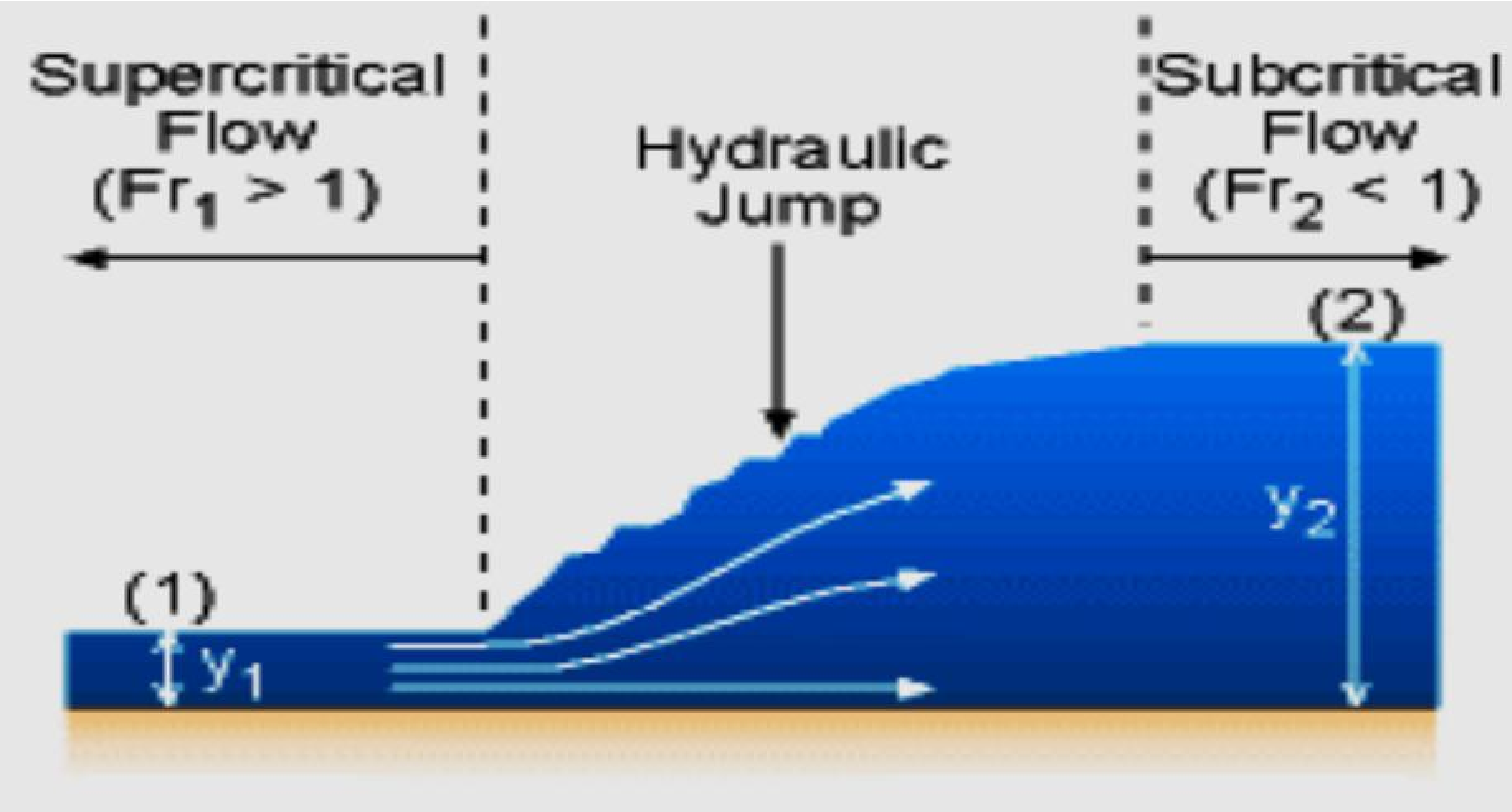
Is stationary (at stand-still) at one place.

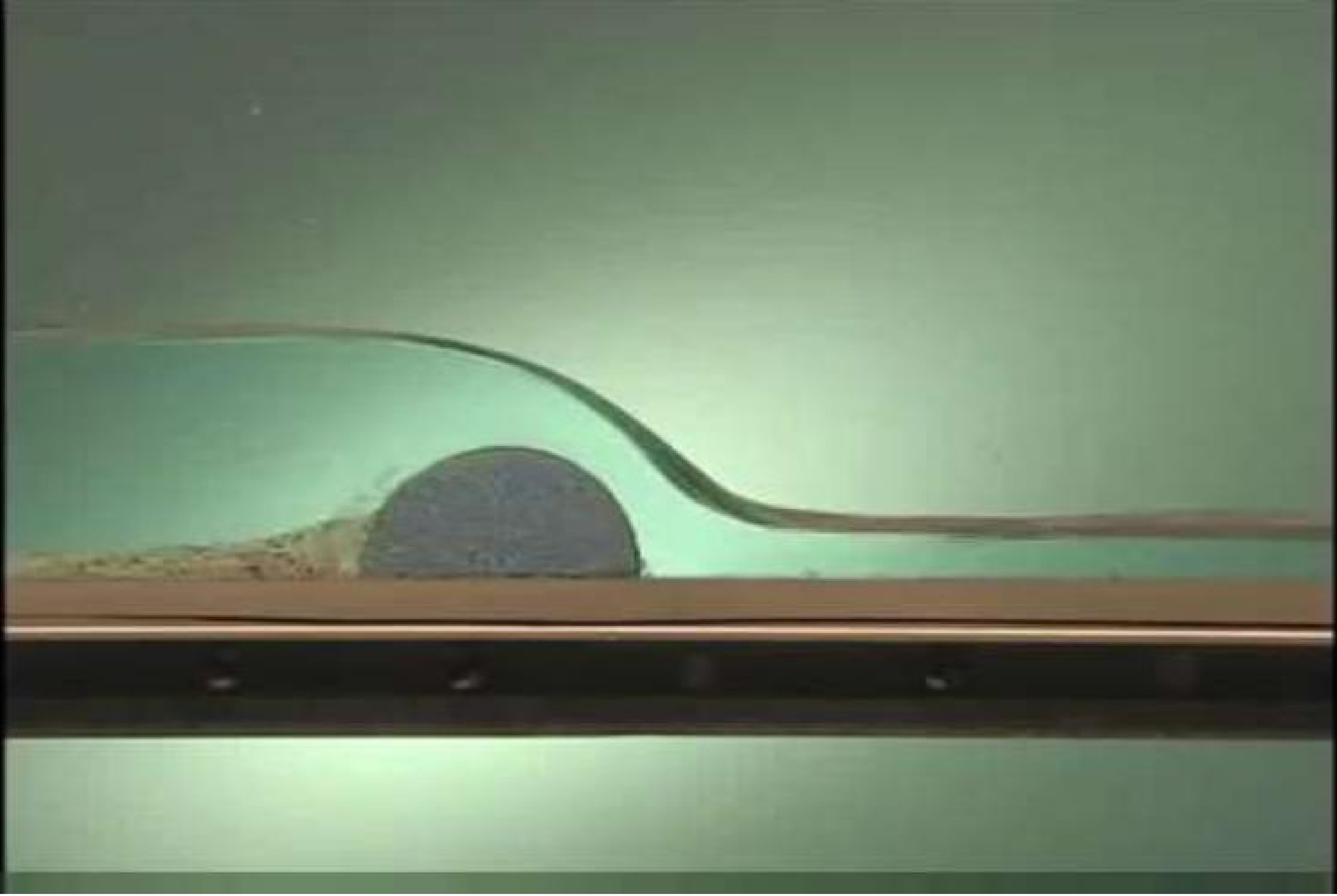
''The rise of water level, which takes place due to the transformation of the supercritical flow to the subcritical flow''.

After a Dam



Hydraulic jump at the end of a spillway …


Supercritical
Flow
(Fr1 > 1)
Hydraulic
Jump
Subcritical
Flow
(Fr2 < 1)
(2)
y2
(1)
y1



Critical flow : A critical flow is one in which specific energy is minimum. A flow corresponding to critical depth is also known as critical flow.

Subcritical flow : The flow is subcritical (or streaming or tranquil) when the depth of flow in a channel is greater than the critical depth. In this type of flow, Fr<1.

Supercritical flow : The flow is supercritical (or shooting or torrential) when the depth of flow in a channel is less than the critical depth. In this case, Fr>1.

Froud Number

The Froud Number is theratio between fluid inertial forces and fluid gravitational forces.

$$Fr = \frac{\text{flow velocity}}{(\text{acceleration of gravity}) \text{x} (\text{force of inertia})}$$

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

V= velocity, D= depth, g= gravitational constant

When the froud number is less than the velocity at which wave moves is greater then the flow velocity and waves can travel up stream (tranquil, subcritical).
When the froud number exceeds 1, wave do not flow up stream, (shooting, or supercritical).

So, froud number of 1 represent the critical flow

EFFECTS

Actually the hydraulic jump usually acts as the energy dissipater. It clears the surplus energy of water.

Due to the hydraulic jump, may noticeable disturbances are created in the following water like eddies, reverse flow.

Usually when the hydraulic jump takes place, the considerable amount of air is trapped in the water. That air can be helpful in removing the wastes in the streams that are causing pollution.

APPLICATIONS

Usually hydraulic jump reverses the flow of water. This phenomenon can be used to mix chemicals for water purification.

Hydraulic jump usually maintains the high water level on the down stream side. The water level can be used for irrigation purposes.

Hydraulic jump can be used to remove the air from water supply and sewage lines to prevent the air locking.

THANK YOU

THANK YOU