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#1504075

CE, BUET

Open channel Flow

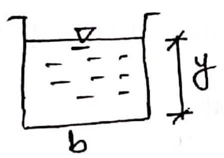
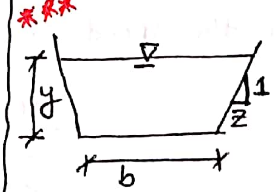
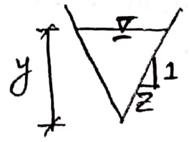
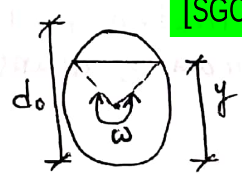
* open channel Flow / Free Flow ⇒ It may be defined as the flow of water with a free surface (subjected to atmospheric pressure)

* difference between open channel flow & pipe flow ⇒

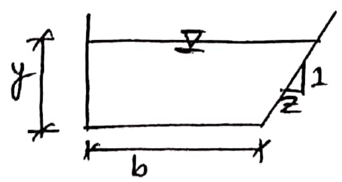
itas-14

open channel Flow	pipe Flow
Flow occurs due to gravity	Flow occurs due to difference in pressure
Flow occurs with a free surface	Normally flowing full without a free surface
Cross section of OCF can be rectangular, trapezoidal, triangular, circular, or perabolic	Cross section of pipe is generally round
Example ⇒  open channel Flow	Example ⇒  pipe Flow

* b = bottom width
  T = Top width
  y = water height
  P = wetted perimeter
  R = Hydraulic Radius = A/P
  D = Hydraulic depth = A/T

Rectangle	Trapezoidal	Triangle	Circular
	*** 		[SGCL] 
$T = b$	$T = b + 2yz$	$T = 2yz$	$T = d_o \sin(\omega/2)$
$P = b + 2y$	$P = b + 2y\sqrt{1+z^2}$	$P = 2y\sqrt{1+z^2}$	$P = \frac{\omega d_o}{2}$
$A = by$	$A = (b + yz)y$	$A = y^2 z$	$A = (\omega - \sin\omega)\frac{d_o^2}{8}$

$\omega = 2\cos^{-1}\left(1 - \frac{2y}{d_o}\right)$ (VVI)



⇒ $T = b + yz$
⇒ $P = b + y + y\sqrt{1+z^2}$
⇒ $A = \frac{1}{2} * y * (b + b + yz)$

- Renold number, $Re = \frac{\bar{u} R}{\upsilon}$ $\left[\upsilon = 10^{-6}\ m^2/s\right]$

$Re < 500 \longrightarrow$ Laminar flow

$500 \le Re \le 12500 \longrightarrow$ Transitional Flow

$Re > 12,500 \longrightarrow$ Turbulant Flow

- Fraude number, $F_r = \sqrt{\frac{\text{Inertia Force}}{\text{Gravity Force}}} = \frac{\bar{u}}{\sqrt{gD}}$ $\left[F_r = \frac{\bar{u}}{c}\right]$ $\therefore c = \sqrt{gD}$

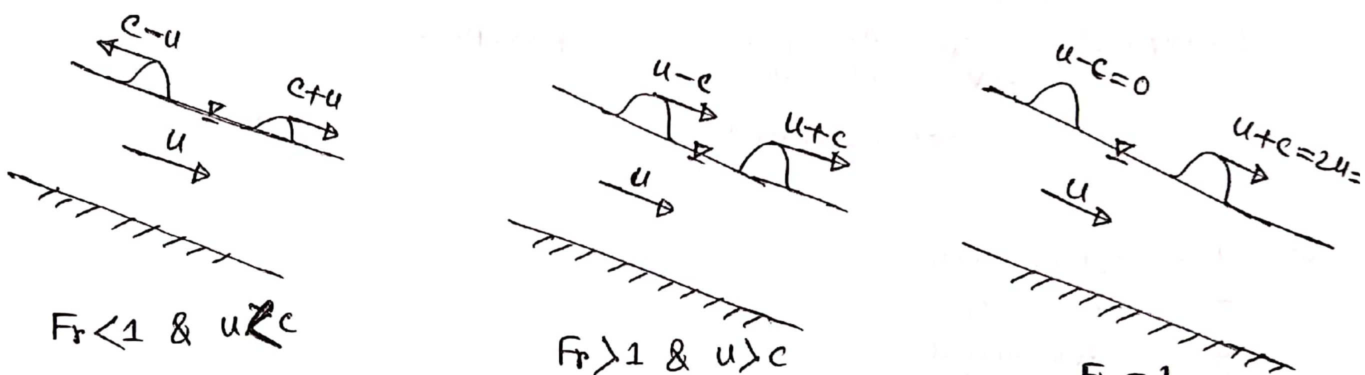
$F_r < 1 \longrightarrow$ subcritical

$F_r = 1 \longrightarrow$ critical

$F_r > 1 \longrightarrow$ super critical

- Discharge per unit width, $q = \frac{Q}{d} = \bar{u} h$

-



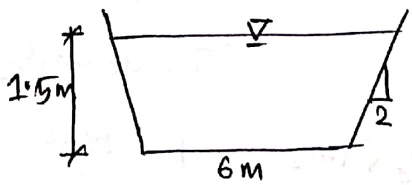
$F_r < 1$ & $u < c$
sub critical

$F_r > 1$ & $u > c$
super critical

$F_r = 1$
$u = c$
critical

- A trapezoidal channel has a bottom width of 6 m & side slope of 2:1. Compute the discharge & determine the state of flow if depth of flow is 1.5 m & the mean velocity of flow is ~~1.5 m~~ 2.3 m/s. If Elementary waves are created in the channel. Determine the speed of the wave fronts upstream & downstream.

Soln



Given,
$b = 6\ m$
$z = 2$
$y = 1.5\ m$
$\bar{u} = 2.3\ ms^{-1}$

Top width, $T = b + 2yz = 12\ m$

Wetted perimeter, $P = b + 2y\sqrt{1+z^2} = 12.71\ m$

Area, $A = (b + yz)y = 13.5\ m^2$

$\therefore$ Hydraulic Radius, $R = A/P = 1.07\ m$

$\therefore$ Hydraulic depth, $D = A/T = 1.125\ m$

$\therefore$ Discharge, $Q = A\bar{u} = 31.05\ m^2$ (Ans)

$\therefore$ Renold number, $Re = \frac{\bar{u}R}{\nu} = \frac{2.3 \times 1.07}{10^{-6}} = 2.4 \times 10^{6} > 12,500$

So, Turbulent Flow.

$\therefore$ Froude number, $F_r = \frac{\bar{u}}{\sqrt{gD}} = 0.69 < 1$

So, sub critical Flow.

$\{ c = \sqrt{gD} = 3.3\ ms^{-1}$

$\therefore$ speed of wave fronts upstream $= c - \bar{u} = 1\ ms^{-1}$ (Ans)

$\therefore$ " " " " down stream $= c + \bar{u} = 5.6\ ms^{-1}$ (Ans)

$$\bar{u} = \frac{\int u\,dz}{h} = \frac{\Sigma u \Delta z}{h}$$

$$q = \int u\,dz = \Sigma u \Delta z$$

$$\alpha = \frac{\int u^3 dz}{\bar{u}^3 h} = \frac{\Sigma u^3 \Delta z}{\bar{u}^3 h}$$

$$\beta = \frac{\int u^2 dz}{\bar{u}^2 h} = \frac{\Sigma u^2 \Delta z}{\bar{u}^2 h}$$

② In a wide channel the velocity varies along a vertical as $u = 1 + \frac{3z}{h}$, where h is the depth of flow & u is the velocity at a distance from the channel bottom.

ⓐ compute the discharge per unit width

ⓑ Determine the state of flow

ⓒ $\frac{\alpha - 1}{\beta - 1} = ?$

if $h = 5m$

Solⁿ

$$\bar{u} = \frac{\int u\,dz}{h} = \frac{\int_0^h \left(1 + \frac{3z}{h}\right) dz}{h} = \frac{\int_0^5 \left(1 + \frac{3z}{5}\right) dz}{5} = 2.5\ ms^{-1} \text{ Ans}$$

ⓐ

$\therefore q = \bar{u}h = 2.5 \times 5 = 12.5\ ms^{-1}$ Ans

ⓑ $Re = \frac{\bar{u}R}{\nu} = 12.5 \times 10^{6} > 12,500$ So, Turbulent Flow

$F_r = \frac{\bar{u}}{\sqrt{gD}} = \frac{2.5}{\sqrt{9.8 \times 5}} = 0.36 < 1$ So, sub critical Flow

From Wide Channel, R ⟶ y

D ⟶ y

ⓒ $\alpha = \dfrac{\int u^3 dz}{\bar{u}^3 h} = \dfrac{\int_0^5 \left(1+\frac{3z}{5}\right)^3 dz}{(2.5)^3 \times 5} = 1.36$

$\beta = \dfrac{\int u^2 dz}{\bar{u}^2 h} = \dfrac{\int_0^5 \left(1+\frac{3z}{5}\right)^2 dz}{(2.5)^2 * 5} = 1.12$

$\therefore \dfrac{\alpha - 1}{\beta - 1} = 3$ Ans

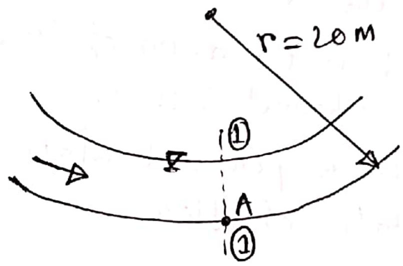
Pressure distribution in curvilinear Flow

Total pressure head $= h\left(1 \pm \frac{u^2}{rg}\right)$

" " $= \rho g h\left(1 \pm \frac{u^2}{rg}\right)$ $\boxed{\gamma = \rho g}$

For concave Flow ⟶ (+)
For convex " ⟶ (−)

③ A spillway flip bucket has a radius of curvature of 20m. If the Flow depth at section 1-1 is 3m & discharge per unit width is 66 m²/s. Compute pressure at A.



Soln

Given that,
$r = 20m$
$h = 3m$
$q = 66\ m^2/s$

$q = \bar{u} h$
$\Rightarrow 66 = \bar{u} \times 3$
$\Rightarrow \bar{u} = 22 m/s$

pressure, $P = \rho g h\left(1 + \frac{u^2}{rg}\right)$ [∵ concave]
$= 1000 \times 9.81 \times 3\left(1 + \frac{22^2}{20 \times 9.81}\right)$
$= 102030\ N/m^2$ Ans

Proof that, most of the flow in nature are turbulent.

Let, $u = 1 ms^{-1}$
$R = 1$
$\nu = 10^{-6}\ m^2/s$

proof $Re = \dfrac{\bar{u} R}{\nu} = \dfrac{1 \times 1}{10^{-6}} = 10^6 > 12,500$

∴ so, natural Flows are turbulent.

Bernoulli's eqⁿ

For a perfect incompressible Liquid following in a continuous stream, the total energy of a particle remains the same, while the particle moves from one point to another.

$$Z_1 + \frac{V_1^2}{2g} + \frac{P_1}{\gamma} = Z_2 + \frac{V_2^2}{2g} + \frac{P_2}{\gamma} + h_f$$

***

Darcy Weisbach Formulae / Darcey's Formulae

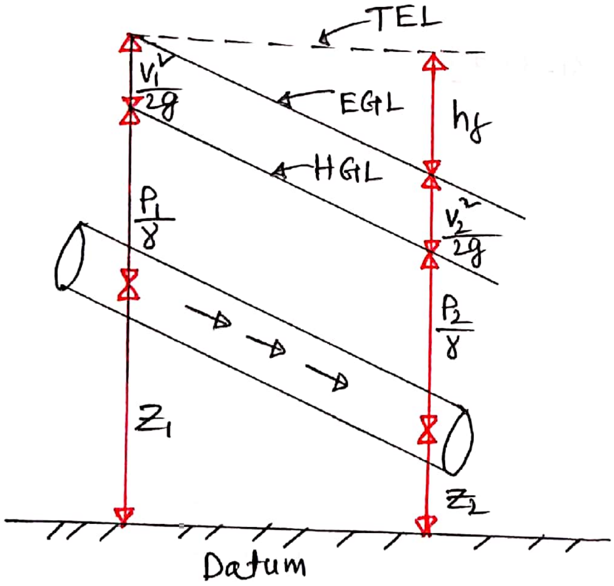
Darcey's Formulae for loss of head in pipes,

$$h_f = 4f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

h_f = loss of head due to friction
f = friction co-efficient = 0.01
L = Length of pipe
D = Dia of "
V = velocity of water in the pipe

*****

Hydraulic Grade Line (HGL) & Total Energy line



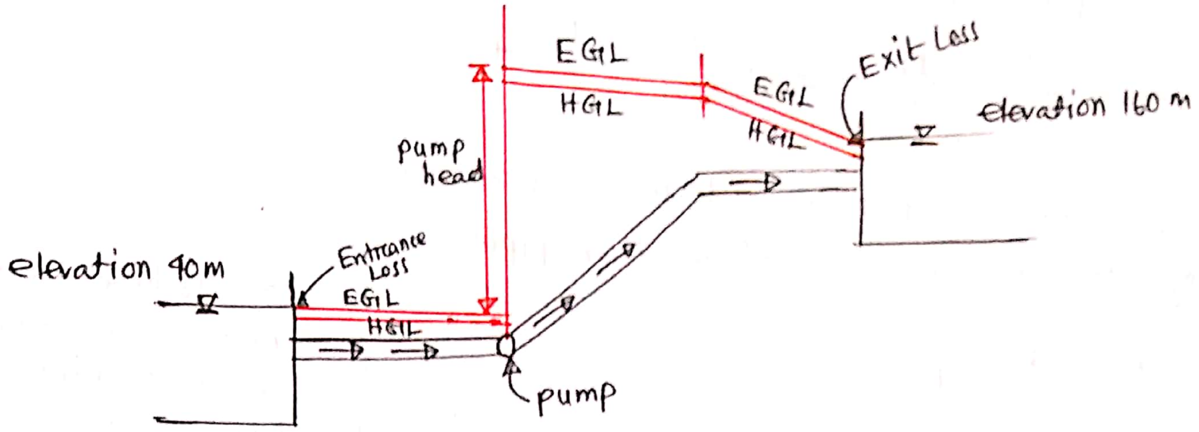
HGL ⇨ If the pressure head at different section of the pipe are plotted to a scale as vertical ordinates, then joint by straight line which is reffered to as HGL

$HGL = Z + \frac{P}{\gamma}$ (It is defined as the line which gives the sum of Pressure head, Datum head of flowing fluid in a pipe)

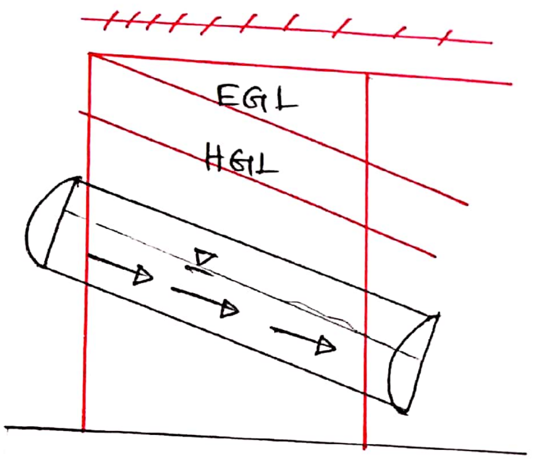
TEL ⇨ if the pressure head & velocity head at different section of the pipe are plotted to a scale as vertical ordinate above the assume datum, the joint by straight line which is refferred as TEL.

$$TEL = Z + \frac{P}{\gamma} + \frac{V^2}{2g}$$

*** Draw HGL & EGL for the following Figure ⇒ [G-669, B-216]



*** Draw HGL & EGL ⇒ [B-258, G-669]



*** Write Bernoulli's eq^n for the following conditions (considering two points on a single pipe line)

(i) with friction & horizontal

(ii) without friction & horizontal

(iii) with friction & Inclined

Sol^n

Bernoulli's eq^n ⇒ $Z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = Z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_f$

(i) For horizontal, $Z_1 = Z_2$

$$\therefore \boxed{\frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_f}$$

(ii) without friction, $h_f = 0$

For horizontal, $Z_1 = Z_2$

$$\therefore \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + \frac{V_2^2}{2g}$$

(iii) with friction & inclined,

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_f + h_L$$

h_L = Local head loss

*** (8) Water flowing a pipe of 70 mm diameter under a gauge pressure of 3.5 kg/cm² and with a mean velocity of 1.5 m/s. The pipe is 7m above the datum line. Neglecting friction, determine total head of water.

Soln Total head $= Z + \frac{V^2}{2g} + \frac{P}{\gamma} = 7 + \frac{1.5^2}{2\times 9.81} + \frac{3.5\times 100^2}{1000}$

$\gamma = 1000$ kg/m³

$= 42.11$ m [redacted] Ans

*** (c) A pipe lying a head of 525 m one end P & other end Q at elevation is 580 m. Dia of pipe at P & Q are 50 mm & 70 mm. Discharge, Q = 70 L/s if pressure at P is 100 KN/m² then Find pressure at Q when head loss is 1 m. water is flowing from P to Q.

Soln

$$V_P = \frac{0.070}{1.96\times 10^{-3}} = 35.71 \text{ m/s}$$

$$V_Q = \frac{0.070}{3.85\times 10^{-3}} = 18.18 \text{ m/s}$$

$A_P = \pi/4 \, (50/1000)^2 = 1.96\times 10^{-3}$ m²

$A_Q = \pi/4 \, (70/1000)^2 = 3.85\times 10^{-3}$ m²

$Q = 0.070$ m³/s

$$Z_P + \frac{V_P^2}{2g} + \frac{P_P}{\gamma} = Z_Q + \frac{V_Q^2}{2g} + \frac{P_Q}{\gamma} + h_f$$

$$\Rightarrow 525 + \frac{35.71^2}{2\times 9.81} + \frac{100}{9.81} = 580 + \frac{18.18^2}{2\times 9.81} + \frac{P_Q}{9.81} + 1$$

$\Rightarrow P_Q = 22.98$ KN/m² Ans

***

(Y) Define Froude number. A Rectangular channel has a bottom width of 10 m & depth of flow is 1 m. Discharge of the channel is 2·6 m^3/s. Determine the state of flow.

Soln

Froude number ⇒ The Froude number is a dimensionless parameter measuring the ratio of Inertia force divided by gravitational force.

Q wide channel

When the width of a rectangular channel is very large compared to depth i.e. $b \gg h$ ($b \geq 10h$), the sides of the channel have no influence on the velocity distribution in the central region. Such a channel is known as wide channel. For wide channel,

$$R = A/P = \frac{bh}{b+2h} \approx \frac{bh}{b} \approx h$$

***

Q Uniform flow, ununiform flow, steady flow, unsteady Flow ---

***Q Define specific energy. From dimensionless specific Energy curve for Rectangular channel, Find Y_c. [B-379] ⑤

**Q Draw a typical non-dimensional specific Energy curve for triangular Channel section for a given discharge. write its applicability? [B-232]

A Specific Energy

Specific Energy at a channel section may be defined as the energy measured with respect to the channel bottom.

$$\text{Specific Energy, } E = d\cos\theta + \alpha \cdot \frac{V^2}{2g}$$

if $\theta \approx 0°$

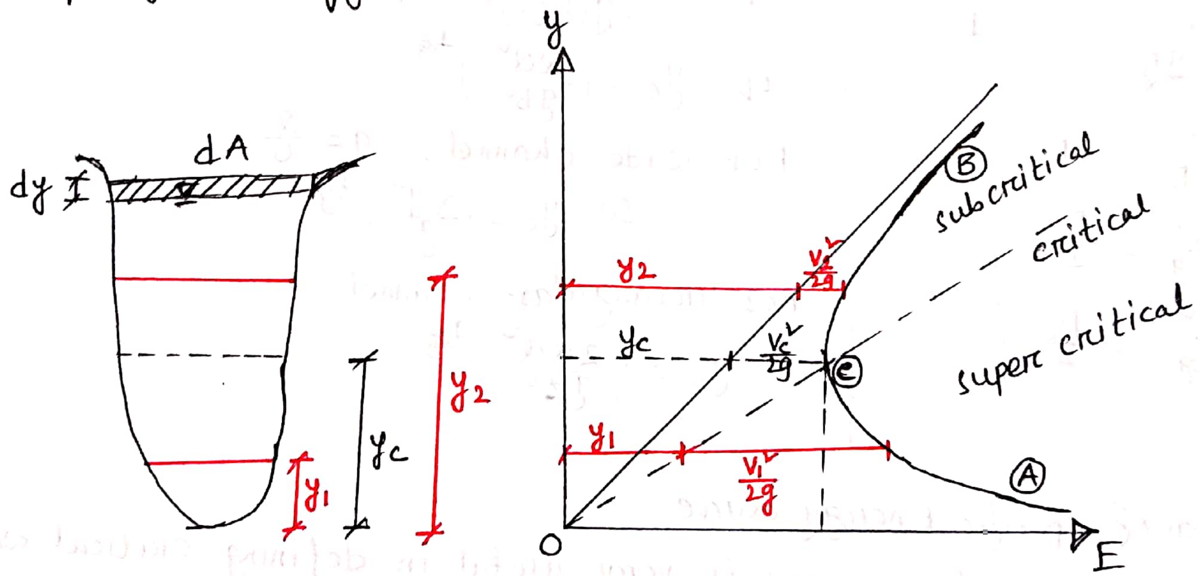
$$E = y + \alpha \cdot \frac{V^2}{2g}$$

$$= y + \alpha \cdot \frac{Q^2}{2gA^2} \qquad \therefore E = f(y)$$

***

A Specific Energy Curve

When depth of flow is plotted against the specific energy for a given channel section & discharge, the obtained graph is called specific Energy curve.



Specific curve has 2 limbs (CA & CB).

At limb CA, $y \to 0$, $\frac{u^2}{2g} \to \alpha$, $E \to \infty$

so, the limb CA approaches the E axis asymptotically toward the right.

At limb CB, $y \to \infty$, $\frac{u^2}{2g} \to 0$, $E \to h$

so, the limb CB approaches the line op which Equation is $\boxed{E = h}$

* E–h curve always in the right side of 45° line.
* For all point ~~of~~ on E–h curve except c, there are two values of h for a particular E.
* At point c, Energy is minimum, Flow is critical.

Characteristics of critical Flow ⇒

* discharge is maximum for given specific Energy.
* Specific Energy is minimum for a given discharge.
* Specific Force is minimum for a given " .
* Velocity head is equal to half of hydraulic depth (
* Froude number is equal to unity ($F_r = 1$).

⇒ For critical Flow,

$$F_r = 1$$

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

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

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

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

$$\Rightarrow \boxed{\alpha \cdot \frac{V_c^2}{2g} = \frac{D_c}{2}}$$

*** For Rectangular channel,

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

$$\Rightarrow \alpha \cdot \frac{Q^2}{2gA^2} = \frac{D_c}{2}$$

$$\Rightarrow \alpha \cdot \frac{Q^2}{2g(by_c)^2} = y_c \qquad [A = by_c]$$

$$\Rightarrow y_c = \left(\frac{\alpha Q^2}{gb^2}\right)^{1/3}$$

For wide channel, $q = \frac{Q}{b}$

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

*** For Triangular channel,

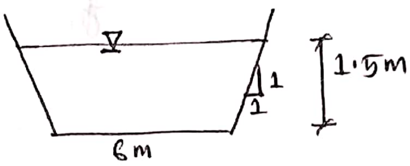
$$y_c = \left(\frac{2\alpha Q^2}{gz^2}\right)^{1/5}$$

***
Application of specific Energy curve.

The concept of specific Energy is very useful in defining critical water depth & in the analysis of open channel Flow. While the total Energy energy in a real fluid flow always decreases in the downstream direction the specific energy is constant for a uniform flow and can either decreases or increase in a varied flow, since the elevation of the bed of the channel relative to the elevation of the energy line, determines the specific energy.

*** (a) A trapezoidal channel has a bottom width of 6m & side slope 1:1. The depth of flow is 1·5m at a discharge of 15 m^3/s. Determine specific energy in terms of head of water.

Soln



$b = 6$ m
$z = 1$
$y = 1.5$ m
$Q = 15\ m^3/s$

$\therefore A = (b + yz)y = 11.25\ m^2$

Again, $Q = AV \Rightarrow 15 = 11.25 \times V \Rightarrow V = 1.33$ m/s

$\therefore E = y + \frac{V^2}{2g} = 1.5 + \frac{1.33^2}{2 \times 9.81} = 1.59$ m Ans

*** (b) Calculate the specific Energy of the trapezoidal channel 2h:1v & Q = 2700 L/s, b = 6m & depth = 1·5m

Soln

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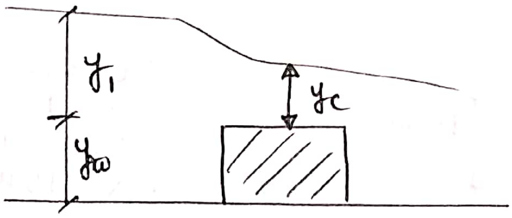
Flow measurement

*** Instrument used in Flow measurement [B-263]

Board crested weir



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

$$y_1 = y_c + \frac{V_c^2}{2g}$$
$$= y_c + \frac{y_c}{2}$$
$$= 3/2\, y_c$$

$$Q = 1.705\, b\, y_1^{1.5}$$

(2) A board crested weir is built in a rectangular channel of width 2m. The height of the weir crest about the channel bed is 1.2 m & the head over the weir is 0.80 m. Calculate Discharge.

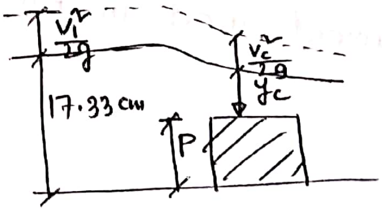
Soln

$$Q = 1.705\, b\, y_1^{1.5}$$
$$= 1.705 \times 2 \times 0.8^{1.5}$$
$$= 2.44 \text{ m}^3/\text{s} \quad \text{Ans}$$

$b = 2$ m
$y_\omega = 1.2$
$y_1 = 0.8$ m

*** (20) BWDB

Determine the height of broad crested weir (P) from the given data. Width of flume = 25 cm, Actual discharge = 7020.5 cm^3/s. Ignore head loss.



Soln

$$y_c = \sqrt[3]{\frac{\alpha Q^2}{g b^2}} = \sqrt[3]{\frac{1 \times 7020.5^2}{981 \times 25^2}}$$
$$= 4.316 \text{ cm}$$

$$y_1 = 3/2\, y_c = 6.47 \text{ cm}$$

$$\therefore 17.33 = P + y_1$$

$$\Rightarrow \boxed{P = 10.86 \text{ cm}} \quad \text{Ans}$$

- Chezy Formulae, $U = C\sqrt{RS}$
- Manning Formulae, $U = \frac{1}{n} R^{2/3} \sqrt{S}$ $\quad \therefore C = \frac{1}{n} R^{1/6}$
- Darcy Formulae, $U = \sqrt{\frac{8g}{f}} \sqrt{RS}$ $\quad \therefore C = \sqrt{\frac{8g}{f}}$

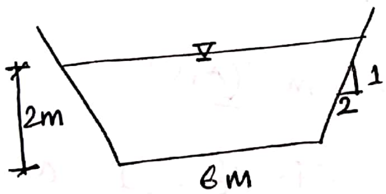
C = chezy's constant
n = manning's n / manning Roughness co-efficient
f = ~~fact~~ friction factor

- $n = 0.047\, d_{50}^{1/6}$

- Factor affecting manning's n ⇒
  - Roughness of the surface
  - vegetation
  - Channel irregularity
  - channel alignment
  - silting & scouring
  - obstruction
  - stage & discharge
  - suspended material & ~~Load~~ bed Load

(22) A open channel lined with concrete ($d_{50} = 1.5$ mm) is laid on slope of 0.1%. The channel ~~width~~ is trapezoidal with b = 6 m, s = 2, depth of flow 2m. Compute Q, chezy's C, friction factor.

Soln



S = 0.1 % = 0.001
b = 6 m
z = 2
y = 2 m

$n = 0.047\, d_{50}^{1/6} = 0.047\,(1.5\times10^{-3})^{1/6} = 0.0159$

$A = (b+yz)y = 20\ m^2$

$P = b + 2y\sqrt{1+z^2} = 14.94$ m

Discharge, $Q = \frac{1}{n} R^{2/3} \sqrt{S} * A$

$= \frac{1}{0.0159} * \left(\frac{20}{14.94}\right)^{2/3} * \sqrt{0.001} * 20$

$= 48.32\ m^3/s$ (Ans)

$\therefore C = \frac{1}{n} R^{1/6} = 0.0159 * \left(\frac{20}{14.94}\right)^{1/6} = 66.02\ m^{1/2} s^{-1}$ Ans

$\therefore C = \sqrt{\frac{8g}{f}} \Rightarrow f = 0.018$ Ans

For Wide Channel, R ⟶ h

Normal depth

(a) Wide channel,

* by manning Formulae,

$$h_n = \left(\frac{nq}{\sqrt{s}}\right)^{3/5}$$

* By chezy's Formulae,

$$h_n = \left(\frac{q}{C\sqrt{s}}\right)^{2/3}$$

(b) other channel

$$Q = \frac{1}{n} R^{2/3} s^{1/2} * A$$

$$\Rightarrow A_n R_n^{2/3} = \frac{Qn}{\sqrt{s}}$$

$A_n R_n^{2/3}$ is known as section factor

(Q2) A wide channel with $S_0 = 0.0025$ Carries a discharge of 3 m^2/s. Compute the normal depth and velocity —

(i) using the manning's formulae when $n = 0.020$

(ii) using chezy's formulae when $c = 45\ m^{1/2} s^{-1}$

Soln

(i) $h_n = \left(\frac{nq}{\sqrt{s}}\right)^{3/5} = \left(\frac{0.020 \times 3}{\sqrt{0.0025}}\right)^{3/5} = 1.12\,m$ (Ans)

v = 1/n*R^(2/3)...

$q = Vh \Rightarrow 3 = V * 1.12 \Rightarrow V = 2.69\ m/s$ (Ans)

(ii) $h_n = \left(\frac{q}{C\sqrt{s}}\right)^{2/3} = \left(\frac{3}{45\sqrt{0.0025}}\right)^{2/3} = 1.21\,m$ (Ans)

$q = Vh \Rightarrow 3 = V \times 1.21 \Rightarrow V = 2.48\ m s^{-1}$ (Ans)

(26) For a triangular channel width side slope of 2:1, a longitudinal slope of 0.0016, $n = 0.015$, determine the normal depth if $Q = 10\,m^3/s$

Soln

$$A_n R_n^{2/3} = \frac{Qn}{\sqrt{s}}$$

$$\Rightarrow 2y^2 * \left(\frac{y}{\sqrt{5}}\right)^{2/3} = \frac{10 \times 0.015}{\sqrt{0.0016}}$$

$$\Rightarrow y_n = 1.55\,m \text{ Ans}$$

$A = y^2 z = 2y^2$

$P = 2y\sqrt{1+z^2} = 2y\sqrt{5}$

$R = \frac{2y^2}{2y\sqrt{5}} = \frac{y}{\sqrt{5}}$

q = 1/n*R^(2/3)*...
=> 30/h = 1/n*h^(2/3)*...

***** 28

A wide channel having $n = 0.026$, $S_0 = 0.0028$, calculate the normal depth & velocity of flow if the channel discharge is $30\ m^2/s$

Sol^n

$$y_n = \left(\frac{nq}{\sqrt{S}}\right)^{3/5} = 5.02\ m$$

$$q = uh \Rightarrow 30 = u \times 5.02 \Rightarrow u = 5.9\ ms^{-1}$$ (Ans)

*** 26

open channel that is 12m wide. The channel slope is $S = 0.0028$. if the velocity is 6 m/s, find depth of flow. [n = 0.013]

Sol^n

$$u = \frac{1}{n} R^{2/3} \sqrt{S}$$

$$\Rightarrow 6 = \frac{1}{0.013} * \left(\frac{by}{b+2y}\right)^{2/3} * \sqrt{0.0028}$$

$$\Rightarrow \boxed{y = 2.55\ m}$$

*** 2ⓤ

The value of Dimensionless effective stress is 0.045. Find

(i) effective velocity

(ii) The value of incipient depth of a wide river channel with the bed sediment size of 0.2 mm with longitudinal river bed slope of 0.0001? Assume, any value. [B-134]

Sol^n

Computation of normal & critical slope

* Normal slope, $Q = \frac{1}{n} R^{2/3} \sqrt{S} \times A$

$$\Rightarrow S_n = \frac{n^2 Q_n^2}{A_n^2 R_n^{4/3}}$$ [A, P, B need to calculate with y_n]

* critical slope, $$S_c = \frac{n^2 Q^2}{A^2 R^{4/3}}$$ [A, P, B need to calculate with y_c]

(29) A Rectangular channel has a bottom width of 6 m, $\alpha = 1.12$ & $n = 0.02$

(i) for $h_n = 1$ m, $Q = 11$ m³/s determine the normal slope

(ii) Determine the critical slope for $Q = 11$ m³/s

(iii) Determine the critical slope for $h_n = 1$ m

Soln

(i) $h_n = 1$ m, $Q = 11$ m³/s

$A = bh = 6 \times 1 = 6$ m², $P = b + 2h = 6 + 2\times 1 = 8$ m

$\therefore R = A/P = 6/8 = 0.75$ m

$$\therefore S_n = \frac{n^2 Q_n^2}{A_n^2 R_n^{4/3}} = \frac{0.02^2 \times 11^2}{6^2 \times (0.75)^{4/3}} = 0.002 \text{ (Ans)}$$

(ii) $Q = 11$ m³/s

$$\therefore h_c = \sqrt[3]{\frac{\alpha Q^2}{g b^2}} = \sqrt[3]{\frac{1.12 \times 11^2}{9.81 \times 6^2}} = 0.73 \text{ m}$$

$A = b h_c = 6 \times 0.73 = 4.38$ m, $P = b + 2h_c = 7.46$ m

$\therefore R = A/P = 0.59$m

$$S_c = \frac{n^2 Q^2}{A^2 R^{4/3}} = \frac{0.02^2 \times 11^2}{4.36^2 \times (0.58)^{4/3}} = 0.0053 \text{ (Ans)}$$

(iii) $h_n = h_c = 1$ m

$A = bh = 6 \times 1 = 6$ m², $P = b + 2h = 8$ m

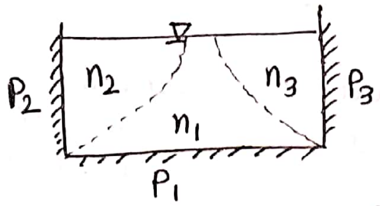
$\therefore R = A/P = 0.75$ m

$$V_n = V_c = \sqrt{\frac{g D_c}{\alpha}} = \sqrt{\frac{g h_c}{\alpha}} = \sqrt{\frac{9.81 \times 1}{1.12}} = 2.96 \text{ m/s}$$

$\therefore Q = A V_c = 6 \times 2.96 = 17.76$ m³/s

$$S_c = \frac{n Q^2}{A^2 R^{4/3}} = \frac{0.02^2 \times 17.76^2}{6^2 \times 0.75^{4/3}} = 0.0051 \text{ (Ans)}$$

Channel selection with composite Roughness



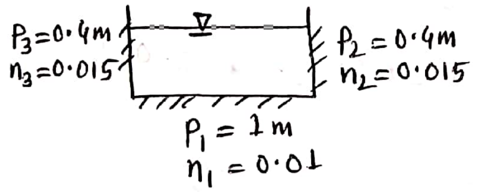
$$n = \left(\frac{P_1 n_1^{3/2} + P_2 n_2^{3/2} + P_3 n_3^{3/2}}{P}\right)^{2/3}$$

where, P_1 = bottom perimeter

P_2, P_3 = side perimeter

(b) The side of a laboratory flume are made of glass ($n = 0.01$) and the bottom is made of wood ($n = 0.015$). The Flume is rectangular with $b = 1$ m and is laid on a slope of 0.001. Compute the discharge in the flume if $h_n = 0.4$ m

Soln



$\therefore P = P_1 + P_2 + P_3 = 1.8$ m

$\therefore A = 1 \times 0.4 = 0.4$ m^2

$\therefore R = P/A = \frac{0.4}{1.8} = 0.222$ m

$$n = \left(\frac{P_1 n_1^{3/2} + P_2 n_2^{3/2} + P_3 n_3^{3/2}}{P}\right)^{2/3} = 0.013$$

$$\therefore Q = \frac{1}{n} R^{2/3} \sqrt{S} * A$$

$$= \frac{1}{0.013} * (0.222)^{2/3} * \sqrt{0.001} * 0.4$$

$= 0.36$ m^3/s (Ans)

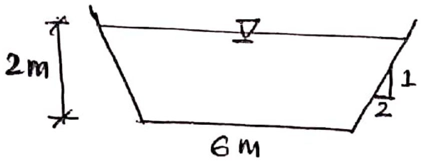
Lined / Unlined math

Q2) An irrigation canal is trapezoidal with ~~width~~ bottom width of 6 m. Side slope of 2H : 1V and depth of flow of 2 m. The Longitudinal slope of the canal is 0.0005, considering uniform flow. compute discharge Carried by ~~channel~~ canal if

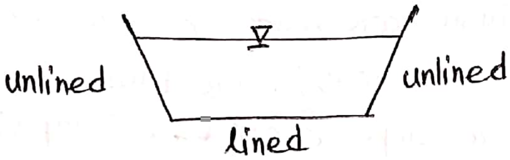
(i) when only the bottom is lined
(ii) when only the sides are lined

Given,
$n = 0.025$ for unlined part
$n = 0.013$ for lined part

Soln



(i)



$$P n^{3/2} = P_1 n_1^{3/2} + P_2 n_2^{3/2} + P_3 n_3^{3/2}$$

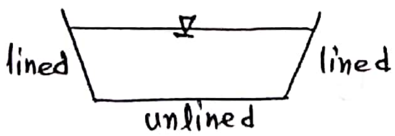
$$\Rightarrow (6+2\times2\sqrt{1+2^2})\, n^{3/2} = 6 * 0.013^{3/2} + 2 * \sqrt{1+2^2} * 0.025^{3/2}$$

$$\Rightarrow n = 0.0206$$

$$\therefore Q = \frac{1}{n} R^{2/3} \sqrt{S} * A = \frac{1}{0.0206} \times \left[\frac{(6+2\times2)2}{6+2\times2\sqrt{1+4}}\right]^{2/3} * \sqrt{0.0025} \times [(6+2\times2)2$$

$$= 26.36 \text{ m}^3/\text{s}$$ Ans

(ii)



$$(6+2\times2\sqrt{1+4}) \times n^{1.5} = 6\times0.025^{1.5} + 2\times(2\sqrt{1+4})\times0.013^{1.5}$$

$$\Rightarrow n = 0.0183$$

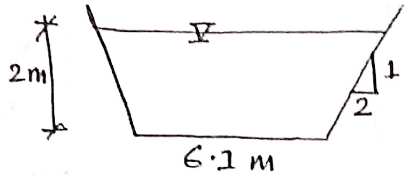
$$\therefore Q = \frac{1}{n} R^{2/3} \sqrt{S} * A$$

$$= 29.68 \text{ m}^3/\text{s}$$ Ans

Hydraulic component (N)

* For manning formula, $N = \frac{2y}{3A}\left[5T - 2R\frac{dP}{dy}\right]$
* For chezy Formula; $N = \frac{y}{A}\left[3T - R\frac{dP}{dy}\right]$

(20)



Calculate N for the shown trapezoidal channel section.

Sol^n

$T = b + 2yz$
$= 14.1$ m

$P = b + 2y\sqrt{1+z^2}$
$= 15.04$ m

$\therefore \frac{dP}{dy} = 2\sqrt{1+z^2}$
$= 2\sqrt{5}$

$A = (b + yz)y$
$= 20.2\ m^2$

using chezy's Formula,

$$N = \frac{y}{A}\left[3T - R\frac{dP}{dy}\right]$$
$$= \frac{20}{20.2}\left[3\times 14.1 - \frac{20.2}{15.04} * 2\sqrt{5}\right]$$
$$= 3.59 \text{ (Ans)}$$

using manning Formulae,

$$N = \frac{2y}{3A}\left[5T - 2R\frac{dP}{dy}\right]$$
$$= 3.86 \text{ (Ans)}$$

Cross sectional mean velocity

- Hydraulically smooth surface ($\frac{K_s u^*}{\nu} \le 5$)

$$\frac{u}{u^*} = 5.75 \log\left(\frac{3.64\, u^* R}{\nu}\right)$$

- Transition Regime ($5 < \frac{K_s u^*}{\nu} < 70$)

$$\frac{U}{u^*} = 5.75 \log\left(\frac{12.2 R}{K_s + 3.35 \frac{\nu}{u^*}}\right)$$

- Hydraulically Rough surface ($\frac{K_s u^*}{\nu} \geq 70$)

$$\frac{U}{u^*} = 5.75 \log\left(\frac{12.2 R}{K_s}\right)$$

u^* = Shear/friction/drag velocity
$= \sqrt{gRS_o}$ (Any channel)
$= \sqrt{ghS_o}$ (wide channel)

K_s = Roughness height
$\nu = 10^{-6}\ m^2/s$

~~Chez~~

(22) A Rectangular channel is 6 m wide and laid on a slope of 0.25%. The channel is made of concrete ($K_s = 2$ mm) and carries water at a depth of 0.50 m. Compute the mean velocity of flow.

Sol^n

$K_s = 2mm = 0.002\ m$ $\quad S = \frac{0.25}{100} = 0.0025$

$R = A/P = \frac{6 \times 0.5}{6 + 2 \times 0.5} = 0.429\ m$

$u^* = \sqrt{gRS} = \sqrt{9.81 \times 0.429 \times 0.0025} = 0.1025\ m/s$

$\therefore \frac{K_s u^*}{\nu} = \frac{0.002 \times 0.1025}{10^{-6}} = 205 > 70$

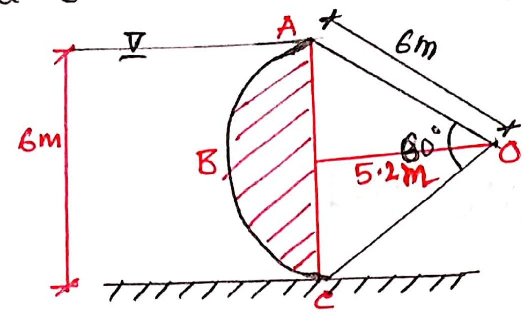
So, the boundary is hydraulically rough

$\therefore \frac{U}{u^*} = 5.75 \log\left(\frac{12.2 R}{K_s}\right)$

$\Rightarrow U = 5.75 \log\left(\frac{12.2 \times 0.429}{0.002}\right) * 0.1025$

$= 2.014\ m/s$ Ans

*** (22) Find out the horizontal & verticle force for the following figure ⇒



Soln

Horizontal Force, $F_H = PA = \gamma h_{cg} * A$ → For unit width

$= 9.81 \times \left(\frac{6}{2}\right) * (6 \times 1)$

$= 176.58$ KN **Ans**

Vertical Force, $F_V = \gamma h A_{ABC}$

$= 9.81 \times 1 \times 3.25$

$= 31.88$ KN **Ans**

$\left\{ A_{ABC} = \frac{60}{360} \times \pi \times 6^2 - \frac{1}{2} \times 6 \times 5.2 \right.$

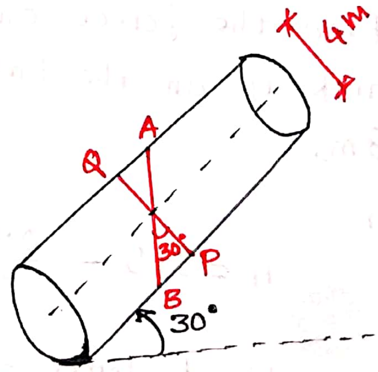
$= 3.25\ m^2$

Extra

F_H acts at a distance from top $= \frac{2}{3} * H = \frac{2}{3} \times 6 = 4$ m

F_V " from point O $= \frac{r \sin\theta}{\theta_{rad}} = \frac{r \sin 30°}{30 \times \frac{\pi}{180}} = 5.73$ m

** (26) Determine of a pipe is 4ft. Angle of inclination, θ = 30°. The pressure in the centre of pipe = 5 psi, Determine the pressure of top & bottom.



Soln

$OA = OB$, $OP = OQ = 2$ m

$\therefore OB = \frac{OP}{\cos 30°} = 2.31'$

$\therefore P_A = 5 - \gamma h = 5 - \frac{62.4 \times 2.31}{144} = 4$ psi **Ans**

$\therefore P_B = 5 + \gamma h = 5 + \frac{62.4 \times 2.31}{144} = 6$ psi **Ans**

*** (28)

If co-efficient of dynamic viscosity, $\mu = 1\ N\,sec/m^2$ and velocity distribution, $V = 0.9y - y^2$. Determine the shear stress if $y = 0.45$

Soln

$V = 0.9y - y^2$

$\Rightarrow \frac{dv}{dy} = 0.9 - 2y$

$= 0.9 - 2 \times 0.45 \quad [\because y = 0.45]$

$= 0$

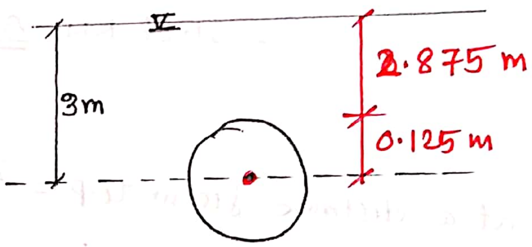
Shear stress, $\tau = \mu \frac{dv}{dy}$

$= 1 \times 0$

$= 0$ (Ans)

*** (29) Find the resultant force on one side of a 25 cm diameter vertical circular plate standing at the bottom of 3 m pool of water.

Soln



Resultant Force $= \gamma h A$

$= 9810 \times 2.875 \times \left[\frac{\pi}{4}(0.250)^2\right]$

$= 1384.45\ N$ (Ans)

$\gamma = \rho g$
$= 1000 \times 9.81$
$= 9810$

*** Same as 29

(30) Find the force on the circular disk of 25 mm diameter circular disk is on the base of a swimming pool of depth 2.5 m, width 3 m.

Soln $h = 2.5 - \frac{0.025}{2} = 2.488\ m$

Resultant force $= \gamma h A$

$= 9810 \times 2.488 \times \frac{\pi}{4}(0.025)^2$

$= 11.98\ N$ Ans

***(29)** Calculate the velocity of a trapezoidal section if discharge is $11.25\ m^3/s$, slope 1:1, bottom width is 6 m & depth of flow is 1.5 m.
1:2

Soln

$A = (b + yz)y = (6 + 1.5 \times 2) \times 1.5 = 13.5\ m$

$\because Q = AV$

$\Rightarrow 11.25 = 13.5 \times V$

$\Rightarrow V = 0.833\ m s^{-1}$ (Ans)

***(26)** Find the discharge of pipe if velocity of fluid through the pipe is 20 m/s & dia of the pipe is 18 cm?

Soln

$A = \pi/4 (0.18)^2 = 0.025\ m^2$

$\therefore Q = AV = 20 \times 0.025 = 0.51\ m^3/s$ (Ans)

specific gravity problem

***(27)** A wood of 5 kg floats in water; if the wood contains 60% of its volm at the time of floating. Then, find out the specific gravity of this method. [B-50]

Soln

***(30)** Calculate the hydraulic head for a quick condition soil. It's thickness 1.5 m, specific gravity 2.67 & void ratio = 0.67? [B-293]

Soln

Hydraulic Head = Hydraulic Gradient* thickness
= (Gs-1)/(1+e)*t

Ans: 1.5m

channel design BCS

*** BWDB

- Best Hydraulic section ⇒ A channel section that conveys the maximum discharge for a given area is known as the best hydraulic section.

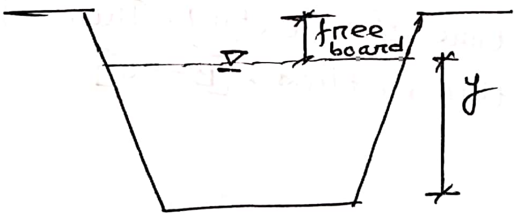
- A channel may be lined or unlined, may or may not carry sediment. We consider 3 types of channel ⇒

  * Rigid boundary ~~or~~ non erodible
    ⇒ channel carry clear water with little or no sediment
  * Mobile boundary or erodible
    ⇒ Erossions take place but no siltation
  * Alluvial channel
    ⇒ channel carry sediment with both scour & sediment.

- Free board in ~~a~~ canal

The top of the ~~channel~~ canal bank has to be maintained higher than water depth level to allow for waves and possible fractuation in supply.

The vertical distance between the top of canal banks and the full supply level of the canal is known as freeboard. Larger free boards are recommended for canal carrying larger discharge.



free board ⇒ 5–30% of flow depth

- Why free board is provided ⇒
  * For wave due to wind
  * possible fractuation in supply
  * At bend elevation is higher at outer face
  * Sudden rainfall may increase the channel.
  * Tride & Hydraulic jump may increase the level.

- Natural used in channel design ⇒
  * Concrete
  * Stone or brick masonary
  * Steel
  * Cast iron
  * Glass
  * plastic
  * Geotexile.

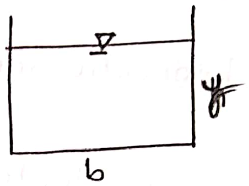
BCS Canal lining ⇒ It is the process of reducing seepage loss of irrigation water by adding an impermeable layer to the edge of trench.

BCS Why lining is provided? (Advantages)

* permit the ~~velocity~~ water to flow at high velocity i.e. discharge increase
* Decreases seepage & perculation losses
* Reduce cost of maintenance & operation
* Ensure the stability of the channel section

*** Most efficient Rectangular channel

Area, $A = by \Rightarrow b = Ay^{-1}$



perimeter, $P = b + 2y$

$= Ay^{-1} + 2y$

$\therefore \frac{dp}{dy} = -Ay^{-2} + 2$

For minimum perimeter, $\frac{dp}{dy} = 0$

$\Rightarrow -Ay^{-2} + 2 = 0$

$\Rightarrow A = 2y^2$

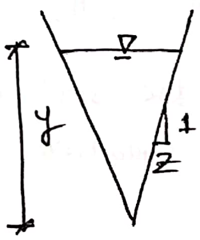
$\Rightarrow by = 2y^2$

$\therefore \boxed{b = 2y}$

*** So, The best Hydraulic Rectangular section is one-half of a square.

*** Most efficient trianglar channel.

Area, $A = y^2 z \Rightarrow y = (A/z)^{1/2}$



perimeter, $P = 2y\sqrt{1+z^2}$

$= 2 \times \sqrt{A/z} \times \sqrt{1+z^2}$

$= 2\sqrt{A} \sqrt{1/z + z}$

$\Rightarrow P^2 = 4A(1/z + z)$

$\Rightarrow 2P\frac{dp}{dz} = 4A(1 - 1/z^2)$

For minimum perimeter, $\frac{dp}{dz} = 0$

$$\Rightarrow 1 - \frac{1}{z^2} = 0$$

$$\Rightarrow z = 1$$

Area of triangular channel, $A = y^2 z = y^2$

Area of Rectangular channel, $A = by = 2y \times y = 2y^2$

*** $A_{triangular} = \frac{1}{2} * A_{rectangular}$

So, Best hydraulic section of triangle is half of Rectangle.

W. For Best hydraulic section,

Rectangle $\Rightarrow b = 2y$, $R = y/2$

Triangle $\Rightarrow z = 1$, $R = \frac{y}{2\sqrt{2}}$

Trapezoid $\Rightarrow b = 2y(\sqrt{1+z^2} - z)$
$z = 1/\sqrt{3}$, $R = y/2$

BCS The choice of material depends mainly on the

* Availability of the material
* Cost of the material
* The purpose of construction
* The methed of construction

Procedure for designing a channel with best hydraulic channel – (when Q, n, S are given)

1. Compute the section factor for uniform flow computation by using manning's equation,

$$AR^{2/3} = \frac{nQ}{\sqrt{S}}$$

2. From best hydraulic section criteria, calculate y.
3. Check that velocity is less than maximum velocity.
4. Check froude number & check
5. Draw figure with proper free board.

Design of channel by best hydraulic section

Q2) A trapezoidal channel chan carrying $25\,m^3/s$ is built with a slope of 1 in 1500. It has side slope 1:1. Design the most efficient section if $n = 0.0135$

Soln For best section (Trapezoidal), ~~$Z \neq 1$~~ & $b = 2y\left(\sqrt{1+z^2} - z\right)$

$$\therefore A = (b + yz)y$$
$$= \left(2y\left(\sqrt{1+1} - 1\right) + y \times 1\right) \times y \quad [\text{given}, z = 1]$$
$$= 2y^2(\sqrt{2} - 1) + y^2$$

$$\therefore A R^{2/3} = \frac{nQ}{\sqrt{S}}$$

$$\Rightarrow \left[2y^2(\sqrt{2}-1) + y^2\right] \times \left(\frac{y}{2}\right)^{2/3} = \frac{0.0135 \times 25}{\sqrt{1/1500}}$$

$$\Rightarrow y = 2.49\ m$$

$$\therefore b = 2.06\ m$$

$$A = 11.33\ m^2$$

check

permissible velocity, $V = \frac{Q}{A} = \frac{25}{11.33} = 2.21\ m/s$

Froude number, $F_r = \frac{u}{\sqrt{gD}} = \frac{2.21}{\sqrt{9.81 \times 1.61}}$

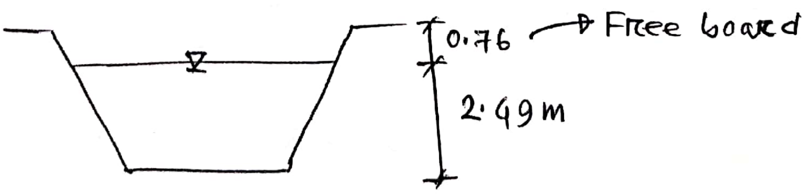
$$= 0.56 < 0.6 \quad \text{~~or 1~~}$$

~~so, subcritical flow~~

$$D = \frac{11.33}{2.06 + 2 \times 2.49 \times 1} = 1.61$$

Add a free board of 0.76 m

Total depth $= 2.49 + 0.76 = 3.25$



(32)

A Rectangular section is built of rough unsized timber. If given a drop of 2m in a km. what will be the width & depth for the most effective section. ($Q = 1.1\ m^3/s$, $n = 0.011$)

Ans

For most effective section, $b = 2y$

So, $A = by = 2y^2$

$$AR^{2/3} = \frac{nQ}{\sqrt{S}}$$

$$\Rightarrow 2y^2 \left(\frac{y}{2}\right)^{2/3} = \frac{0.011 \times 1.1}{\sqrt{2/1000}}$$

$$\Rightarrow y = 0.56\ m$$

$\therefore b =$

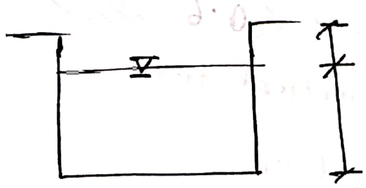
Check

permissible velocity, $V = \frac{Q}{A} =$ $\{ A =$

Froude number, $Fr = \frac{u}{\sqrt{gD}} =$ < 0.6 (OK) $\{ D = A/T =$

Add a free board of 0.14 m

$\therefore$ Total depth $= 0.56 + 0.14 = 0.70\ m$



Design of Rigid boundary / Non-erodible / Lined channel

BC(30) Design a concrete lined channel to carry a discharge of 350 cumec by a slope of 1 in 5000. The side slope of the channel is 1.5 : 1 & manning's n = 0.014. Assuming, limiting velocity in the channel as 2 m/s.

Soln

For trapezoidal channel, $b = 2y(\sqrt{1+z^2} - z)$
$= 0.606y$ $[\because z = 1.5]$

$\therefore A = (b + yz)y = (0.606y + y \times 1.5)y$
$= 2.106y^2$

$\therefore AR^{2/3} = \frac{nQ}{\sqrt{S}}$

$\Rightarrow 2.106y^2 * \left(\frac{y}{2}\right)^{2/3} = \frac{0.014 \times 350}{\sqrt{1/5000}}$

$\Rightarrow y = 8.06$ m

$\therefore b = 4.88$ m

Check

~~$V = \frac{Q}{A} = \frac{350}{136.81} =$~~

$Fr = \frac{u}{\sqrt{gD}} = \frac{2}{\sqrt{9.81 \times 4.71}} = 0.29 < 0.60$ (OK)

$A = 136.81$ m²

$D = \frac{A}{T} = \frac{136.81}{29.06} = 4.71$ m

* channel type (ex triangular, trapezoidal) উল্লেখ থাকলে, ঐ type হিসেবেই math করব
* channel type না দেওয়া থাকলে, $Q < 55$ m³/s ⇒ Triangular
  $Q > 55$ m³/s ⇒ Trapezoidal হবে
* সাধারণত max. permissible velocity 2 ms⁻¹ হয়, প্রশ্নে permissible velocity উল্লেখ থাকলে ঐটা নিয়েই করব কিন্তু না দেওয়া থাকলে 2 ms⁻¹ ধরে আমরা ঐটা নিয়ে করব
* Main check দিতে Fr এর $Fr < 0.6$ must হতে হবে

(98) Design a lined channel to carry 30 m^3/s on a slope of 1 in 1600. The side slope is to be maintained at 1.25 H : 1 V and the lining is expected to give a value of n equal to 0.014.

Soln

$Q = 30\ m^3/s < 55\ m^3/s$ so, Triangle channel selection

$Z = 1.25$, $A = y^2 Z = 1.25\ y^2$

$$A R^{2/3} = \frac{nQ}{\sqrt{S}}$$

$$\Rightarrow 1.25 y^2 * \left(\frac{y}{2\sqrt{2}}\right)^{2/3} = \frac{0.014 \times 30}{\sqrt{1/1600}}$$

$$\Rightarrow y = 3.44\ m$$

check

max. permissible velocity, $V = \frac{Q}{A} = 2.03\ m/s$

$$F_r = \frac{u}{\sqrt{gD}} = \frac{2.03}{\sqrt{9.81 \times 1.43}} = 0.54 < 0.6 \quad \text{(OK)}$$

$T = 2yz = 10.32$

$D = A/T = 1.43$

** Design a surface Drainage channel in non Alluvial soil to carry a discharge of 12 m^3/s with a velocity of 1 m/s. Assume, side slope 0.5 : 1, bed slope 1 : 6000, manning's n = 0.0225

Soln

(06) A trapezoidal channel lined with concrete ($n = 0.013$) on a slope of 1 in 3600 carries discharge of 100 m^3/s. Determine the section dimensions of the channel if $b = 6$ m, side slope = 1 : 1

Soln

$$A = (b + yz)y = (6+y)y$$

$$AR^{2/3} = \frac{nQ}{\sqrt{S}}$$

$$\Rightarrow (6+y)y \times \left\{ \frac{(6+y)y}{6+2y\sqrt{1+1}} \right\}^{2/3} = \frac{0.013 \times 100}{\sqrt{1/3600}}$$

$$\Rightarrow y = 4.24 \text{ m}$$

Check

permissible velocity, $V = \frac{Q}{A} = \frac{100}{(6+4.24) \times 4.24} = 2.3$ m/s

$$Fr = \frac{u}{\sqrt{gD}} = \frac{2.3}{\sqrt{9.81 \times 7.24}} = 0.27 < 0.6$$

(OK)

| $D = 7.24$

Mobile boundary / Erodible

Alluvial channel design

* A channel transporting the same type of material as that comprising the channel perimeter
* such a channel can be stable only when sediment inflow into channel is equal to sediment outflow i.e the channel cross section & bottom slope don't change due to erosion & deposition.

***## Regime channel

* A channel said to be ~~regime~~ in a regime when it has adjusted its shape & slope to an equillibrium condition.
* A channel is said to be in a state of regime if the flow is such that silting & scouring need no special attention.

*** BC ## Comparision between Kenedy's theory & Lacey's theory

Kenedy's theory	Lacey's Theory
consider a trapezoidal section	consider a shaped section
channel to be in a state of true regime	channel is a combination of initial & final regime
has not given any importance on bed width & depth ratio	establish a relationship between bed & width

Lacey's Equation (given, Q & d)

* silt factor, $f_s = 1.76\sqrt{d}$ → mm
* slope of channel, $S = 3\times10^{-4} f_s^{5/3} Q^{-1/6}$

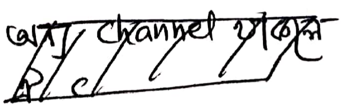
$$\frac{f_s^{5/3}}{3340 Q^{1/6}} = S$$

* Hydraulic Radius, $R = 0.47\left(\frac{Q}{f_s}\right)^{1/3}$
* wetted perimeter, $P = 4.75\sqrt{Q}$

Assume, $z = 0.5$

Area, $A = PR$

$P = b + 2y\sqrt{1+z^2}$, $A = (b+yz)y$



এভাবে ২৫, y, b বের করো,

Check ⇒ $V = 10.8 R^{2/3} S^{1/3} < 2\ ms^{-1}$

$Fr < 0.6$

BCS BCS

(৬৬) Design a regime channel for a discharge of 50 cumec and silt factor 1.1, using Lacey's theory.

Sol^n

d দেওয়া থাকলে, $f_s = 1.76\sqrt{d}$

silt factor, $f_s = 1.1$

Slope of channel, $S = 3\times10^{-4} f^{5/3} Q^{-1/6}$
$= 3\times10^{-4}(1.1)^{5/3} * (50)^{-1/6}$
$= 0.000183$

Hydraulic radius, $R = 0.47\,(Q/f_s)^{1/3} = 1.68$

wetted perimeter, $P = 4.75\sqrt{Q} = 33.59$

let, $z = 0.5$

$\therefore A = PR = 1.68 \times 33.59 = 56.43$

$P = b + 2y\sqrt{1+z^2}$
$\Rightarrow 33.59 = b + 2y\sqrt{1+0.5^2}$
$\therefore b = 33.59 - 2y\sqrt{1+0.5^2}$ ——(1)

$A = (b+yz)y$
$\Rightarrow 56.43 = (b+0.5y)y$
$\Rightarrow 56.43 = (33.59 - 2y\sqrt{1+0.5^2} + 0.5y)y$
$\Rightarrow y = 1.86$ m
$\therefore b = 29.43$

Check

$U = 10.8 R^{2/3} S^{1/3} = 0.87\ ms^{-1} < 2\ ms^{-1}$ (OK)

$F_r = \frac{U}{\sqrt{gD}} = \frac{0.87}{\sqrt{9.81 \times \frac{56.43}{31.29}}} = 0.21 < 0.6$ (OK) | $T = 31.29$ m

* $F_r < 0.6 \Rightarrow$ এই check ok হয়, হওয়া বাধ্যতামূলক
* $U < 2ms^{-1} \Rightarrow$ এটা fullfill না করলেও চলবে।

(৬৭) Design a Lacey's channel to carry 5 m³/s through 0.5 mm sand.

Sol^n

Same as (৬৬)

***(69) BWDB

The river ganga flows bank full rate of 2500 m^3/s. Find (i) Hydraulic Geometry (ii) Scour depth (Bed material size is 0.15 mm)

Soln

(i)

Silt factor, $f_s = 1.76\sqrt{0.15} = 0.68$

Slope of the channel, $S = 3\times10^{-4}\,(0.68)^{5/3}\,(2500)^{-1/6} = 4.29\times10^{-5}$

Hydraulic Radius, $R = 0.47\,(Q/f_s)^{1/3} = 7.25$ m

Wetter perimeter, $P = 4.75\sqrt{2500} = 237.5$ m

Let, $z = 0.5$

$A = PR = 1721.88\ m^2$

$P = b + 2y\sqrt{1+z^2}$

$\Rightarrow 237.5 = b + 2y\sqrt{1+0.5^2}$

$\Rightarrow b = 237.5 - 2y\sqrt{1+0.5^2}$ —(1)

$A = (b+yz)y$

$\Rightarrow 1721.88 = (b+0.5y)y$

$\Rightarrow 1721.88 = (237.5 - 2y\sqrt{1+0.5^2} + 0.5y)y$

$\Rightarrow y = 7.68$ m

$\therefore b = 220.33$ m

Check

$V = 10.8\,R^{2/3}\,S^{1/3} = 1.41\ ms^{-1} < 2\ ms^{-1}$ (OK)

$T = 228.01$ m

$D = \frac{1721.88}{228.01} = 7.55$

$Fr = \frac{V}{\sqrt{gD}} = \frac{1.41}{\sqrt{9.81\times7.55}} = 0.16 < 0.6$ (OK)

(ii) Scour depth $= R = 7.25$ m Ans

(65)

Hydraulic jump

- In any open channel, when a supercritical flow is made to change abruptly to subcritical flow, the result is an abrupt rise of the water surface. This feature is known as hydraulic jump.

Application of Hydraulic jump

- ✓* To dissipate excessive energy to prevent scouring
- * To rise the water level ~~for~~ on downstream ~~from~~ for irrigation & water distribution purpose.
- * To reduce the uplift pressure under a structure by increasing weight on its apron.
- * To mix the chemical for water purification or waste water treatment
- ✓* To aerate water for city water supply
- ✓* To remove air pocket from water supply line.
- ✓* To increase the decharge of a sluice gate by holding back tail water.

Type of jump

1. (i) $F_r = 1$ ⇒ No jump (Flow is critical)
2. (ii) $F_r = 1 - 1.7$ ⇒ undular jump
3. (iii) $F_r = 1.7 - 2.5$ ⇒ weak jump
4. (iv) $F_r = 2.5 - 4.5$ ⇒ oscillating jump
5. (v) $F_r = 4.5 - 9$ ⇒ steady jump
6. (vi) $F_r > 9$ ⇒ strong jump

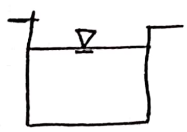
Jump Type depends on Fr1

U WOS

Momentum eqn

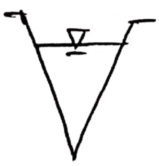
$$\underbrace{\frac{Q^2}{gA_1} + \bar{z}_1 A_1}_{F_1} = \underbrace{\frac{Q^2}{gA_2} + \bar{z}_2 A_2}_{F_2}$$

(For any type of channel)



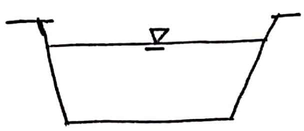
$\bar{z} = y/2$

$A = by$



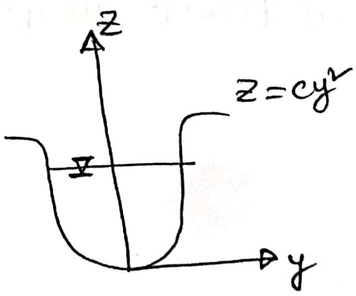
$\bar{z} = y/3$

$A = y^2 z$



$\bar{z} = \frac{y}{6}\left(\frac{3b+2yz}{b+yz}\right)$

$A = (b+yz)y$



$\bar{z} = \frac{2y}{5}$

$A = \frac{4}{3}\sqrt{\frac{y^3}{c}}$

(i) $\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{8F_{r1}^2+1} - 1\right)$ [For Rectangular channel]

বা, $\frac{y_1}{y_2} = \frac{1}{2}\left(\sqrt{8F_{r2}^2+1} - 1\right)$ ["]

y_1 = upstream height / Initial depth

y_2 = downstream height / sequent depth

$F_{r1} = \frac{V_1}{\sqrt{g y_1}}$, $F_{r2} = \frac{V_2}{\sqrt{g y_2}}$

(ii) $\frac{L_j}{y_1} = 9.75 (F_{r1} - 1)^{1.01}$

L_j = Length of the hydraulic jump

(iii) Head loss / Energy Loss in jump, $h_L = \Delta E = E_1 - E_2$

(Energy Dissipation)

$= \frac{(y_2 - y_1)^3}{4 y_1 y_2}$ [For Rectangle]

$E_1 = y_1 + \frac{V_1^2}{2g}$

$E_2 = y_2 + \frac{V_2^2}{2g}$

(iv) Relative head loss / Energy loss $= \frac{h_L}{E_1} = 1 - \frac{E_2}{E_1}$

(v) Efficiency $= \frac{E_2}{E_1}$

$= \frac{(1+8F_{r1}^2)^{3/2} - 4F_{r1}^2 + 1}{8F_{r1}^2 (F_{r1}^2 + 2)}$ [For Rectangular channel]

(v) Height of the jump, $h_j = y_2 - y_1$

Relative height of the jump $= \frac{h_j}{E_1}$

$= \frac{\sqrt{8F_{r1}^2+1} - 3}{F_{r1}^2 + 2}$ [For Rectangular]

(vi) Power dissipation $= \gamma Q h_L$

(a) Horizontal Rectangular channel, $b = 6m$, $y_1 = 0.52m$, $V_1 = 15.2\ m/s$ if hydraulic Jump form in the channel. Determine,

(I) Type of jump? (II) $y_2 = ?$ (III) $Fr_2 = ?$ (IV) efficiency of the jump (V) Relative height of the jump (VI) $L = ?$ (VII) Relative Energy loss? (VIII) Horse power dissipation?

Soln

(I) $Fr_1 = \frac{V_1}{\sqrt{g h_1}} = \frac{15.2}{\sqrt{9.81 \times 0.52}} = 6.73$

So, steady jump.

(II) $\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{8Fr_1^2+1} - 1\right) \Rightarrow \frac{y_2}{0.52} = \frac{1}{2}\left(\sqrt{8 \times 6.73^2 + 1} - 1\right)$

$\therefore y_2 = 4.70\ m$ Ans

(III) $\frac{y_1}{y_2} = \frac{1}{2}\left(\sqrt{8Fr_2^2+1} - 1\right)$ অথবা, $Fr_2 = \frac{V_2}{\sqrt{g y_2}} =$

$\Rightarrow Fr_2 = 0.52$ Ans (0.25)

(IV) $E_1 = y_1 + \frac{V_1^2}{2g} = 0.52 + \frac{15.2^2}{2 \times 9.81} = 12.30\ m$

$E_2 = 4.70 + \frac{\left\{\frac{(6 \times 0.52) \times 15.2}{6 \times 4.70}\right\}^2}{2 \times 9.81} = 4.84\ m$

$\therefore \frac{E_2}{E_1} = \frac{4.84}{12.30} = 39.35\%$

(VII) ~~(V)~~ Head / Energy Loss, $h_L = E_1 - E_2 = 7.46\ m$

Relative head loss $= \frac{h_L}{E_1} = \frac{7.46}{12.30} = 60.65$ (Ans)

(V) Realative height of the jump $= \frac{h_j}{E_1} = \frac{y_2 - y_1}{E_1} = 33.98\%$ (Ans)

(VI) $\frac{L_j}{y_1} = 9.75(Fr_1 - 1)^{1.01} \Rightarrow L_j = 29.05\ m$ Ans

(VIII) power dissipation $= \gamma Q h_L = (1000 \times 9.81) \times (6 \times 0.52 \times 15.2) \times 7.46$

$= 3470611.62\ W = 4652.29\ H.P$ Ans

BUET (80) BWDB

The sequent & initial depth ratio of a hydraulic jump in a rectangular channel is 16·48. Find the Froude number at the beginning of jump & type of jump.

Soln

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

$\Rightarrow 16{\cdot}48 = \frac{1}{2}\left(\sqrt{8F_r^2+1} - 1\right)$

$\Rightarrow F_{r1} = 12 > 9$; strong jump.

BWDB (81) A rectangular channel 6 m wide, discharge 1200 L/sec of water into a 6 m wide apron with zero slope with a mean velocity of 16 m/s. What is the height of the jump?

Soln

$Q = AV \Rightarrow 1{\cdot}2 = (6 \times y_1) \times 16 \Rightarrow y_1 = 0{\cdot}0125$ m

$\therefore F_{r1} = \frac{V_1}{\sqrt{g y_1}} = \frac{16}{\sqrt{9{\cdot}81 \times 0{\cdot}0125}} = 45{\cdot}69 > 9$ so, strong jump

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

$\Rightarrow y_2 = 0{\cdot}801$ m

$\therefore$ Height of jump $= y_2 - y_1 = 0{\cdot}801 - 0{\cdot}0125$
$= 0{\cdot}789$ m Ans

(82) A Horizontal trapezoidal channel width b=6m, S=2 carries a discharge of 120 m³/s. If the upstream depth of flow is 1 m. Compute the downstream depth that will create a hydraulic jump.

Soln

$$F_1 = \frac{Q^2}{gA_1} + \bar{z}_1 A_1 = \frac{Q^2}{g[(b+yz)y]} + \left\{\frac{y}{6}\left(\frac{3b+2yz}{b+yz}\right)\right\}\left\{(b+yz)y\right\}$$

$$= \frac{120^2}{9{\cdot}81[(6+1\times 2)1]} + \left\{\frac{6}{6}\left(\frac{3\times 6+2\times 1\times 1}{6+1\times 1}\right)\right\}\left\{(6+1\times 2)1\right\}$$

$\simeq 187{\cdot}15$

$$F_2 = \frac{120^2}{9.81\,[(6+y\times1)y]} + \left\{\frac{y}{6}\left(\frac{3\times6+2y\times1}{6+1\times2}\right)\right\}\left\{(6+y\times2)y\right\}$$

$\therefore F_1 = F_2$

$\Rightarrow y_2 = 5.14\ m$ Ans

$\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{8F_{r1}^2+1} - 1\right)$ এই সূত্র দিয়ে এই math করা যাবে না। এটি শুধু Rectangular channel এর জন্য

* Relative head loss :

$$E_1 = y_1 + \frac{V_1^2}{2g} = 1 + \frac{\left(\frac{120}{8}\right)^2}{2\times9.81} = 12.47\ m$$

$A_1 = 8\ m^2$

$A_2 = 83.68\ m^2$

$$E_2 = 5.14 + \frac{\left(\frac{120}{83.68}\right)^2}{2\times9.81} = 5.24\ m$$

$$h_L = E_1 - E_2 = 7.23\ m$$

$$\therefore \frac{h_L}{E_1} = 57.98\ \%$$ Ans

(82) Horizontal parabolic channel, $y_1 = 0.5\,m$, $Q = 10\ m^3/s$, $y^2 = 4z$,

$y_2 = ?$

Soln

$y^2 = 4z$

$\Rightarrow z = \frac{1}{4}y^2$ $\quad [\because z = cy^2]$

$= 0.25\,y^2$

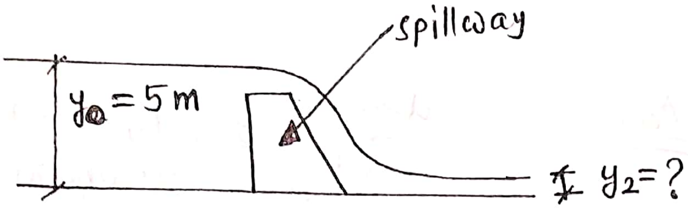
$$F_1 = \frac{Q^2}{gA_1} + \bar{z}_1 A_1 = \frac{Q^2}{g\left(\frac{4}{3}\sqrt{y^3/c}\right)} + \left(\frac{2y}{5}\right) * \left(\frac{4}{3}\sqrt{y^3/c}\right)$$

$= 11.086$

$$F_2 = \frac{10^2}{9.81 * \frac{4}{3}\sqrt{y^3/0.25}} + \frac{2y}{5} * \frac{4}{3}\sqrt{y^3/0.25}$$

$\therefore F_1 = F_2 \Rightarrow y_2 = 2.45\ m$ Ans

(86) Discharge 2.5 m³/s per width of spillway flow for occuring the hydraulic jump. what should be the value of y_2. [B-52]



Soln

$Q = A.V \Rightarrow 2.5 = (1 \times 5) V \Rightarrow V = 0.5 \ ms^{-1}$

$\therefore F_{r1} = \frac{V}{\sqrt{g y_0}} = \frac{0.5}{\sqrt{9.81 \times 5}} = 0.071$

(88) Spillway height = 40 m
Design Energy head = 2.5m (H_d)
Co-efficient of discharge = 0.738

Energy loss = ?
Relative Energy loss = ?
velocity after Jump ?

Soln

$q = \frac{2}{3} C_d \sqrt{2g} \ H_d^{3/2}$

$= \frac{2}{3} \times 0.738 \times \sqrt{2 \times 9.81} * (2.5)^{3/2}$

$= 8.614 \ m^2/s$

(22)

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

$$\Rightarrow 40 + 2.5 = y_1 + \frac{\left(\frac{8.614}{y_1}\right)^2}{2 \times 9.81} \quad [\because q = uy]$$

$$\Rightarrow y_1 = 0.3 \text{ m}$$

$$F_1 = \frac{V_1}{\sqrt{g y_1}} = \frac{8.614/0.3}{\sqrt{9.81 \times 0.3}} = 16.74$$

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

$$\Rightarrow y_2 = 6.95 \text{ m}$$

Calculation is wrong but process is correct.

$$h_L = \frac{(y_2 - y_1)^3}{4 y_1 y_2} = 5.3 \text{ m}$$

$$\therefore \frac{h_L}{E_1} = \frac{5.3}{42.32} = 12.5\%$$

$$E_1 = y_1 + \frac{V_1^2}{2g} = 0.3 + \frac{(8.614/0.3)^2}{2 \times 9.81} = 42.32 \text{ m}$$

$$h_L = E_1 - E_2$$

$$\Rightarrow 5.3 = 42.32 - \left(y_2 + \frac{V_2^2}{2g}\right)$$

$$\Rightarrow V_2 = 24.29 \text{ m/s}$$

E1 = y1 + v1^2/2*g = 0.3 + (8.61/0.3)^2/2*9.81 = 42.28 m

E2 = y2 + v2^2/2*g = 6.95 + (8.61/6.95)^2/2*9.81 = 7.03 m

Energy Loss = E1 - E2 = 42.28 - 7.03 = 35.25 m

Relative Energy Loss = (E1 - E2)/ E1 = 83.27%

Q. Peak Demand ? (B-233)

Q. Water hydrology? (B-226)

Q. Draw a typical Hydrograph showing diff. segment. (B-294)

Q. Draw & Define unit hydrograph & write its function. (B-261)

Q. Write down the methods of finding average rainfall & drainage basin. (B-373)

** Hydrology ⇒ The science which deals with the occurance, circulation & distribution of water of the earth & earth's atmosphere

objectives
* Estimation of water resources
* study of processes such as precipitation
* study ~~at~~ of Problems such as flood.

Hydrologic circle
The various aspects of water related to the earth can be explained in terms of a circle known as hydrologic circle.

catchment area / Drainage area / Drainage Basin / watershed ***
The area of land draining into stream or a water course at a given location is known as catchment area.

Rainfall (P) & runoff (R) Relation

[redacted] L = P - R

L = Losses (water not available to run off due to infiltration, evaporation, transpiration & surface storage)

**Rainfall/Precipitation = P
**Runoff = R

(8C) A small catchment of 150 ha area received a rainfall of 10.5cm in 90 min due to a storm. At outlet, the stream draining the ~~catmen~~ catchment was dry before storm and experienced a runoff lasting for 10 hrs with an average discharge of 1.5 m³/s. The stream was again dry after the runoff event.

(a) What is the amount of water which has not available to runoff due to combined effect of infiltration, evaporation & Transpiration?

(b) What is the ratio of run off to precipitation?

Soln

(a) $P = 150 \times 10^4 \, m^2 * \frac{10.5}{100} m = 157500 \, m^3$

$R = 1.5 \times (10 \times 3600) = 54,000 \, m^3$

$\therefore L = P - R = 103,500 \, m^3$ Ans

(b) $\frac{Runoff}{Rainfall} = \frac{54,000}{157,500} = 0.343$ Ans

$\frac{Runoff}{Rainfall}$ = run off co-efficient

Forms of precipitation:

* Rain → size = 0.5 mm – 0.6 mm
* *** Snow ⇒ Consists of ice crystals which usually combine to form flakes
* Drizzle ⇒ A fine sprinkle of numerous water droplets of size < 0.5 mm & intensity 1 mm/hr

*** Evaporation

It is the process in which a liquid changes to the gaseous state at the free surface, below the boiling point through the transfer of heat energy.

The rate of evaporation depends on =

* vapour pressure
* Air & water temperature
* Wind speed
* Atmospheric pressure
* Quality of water
* Size of water body

Water Harvesting

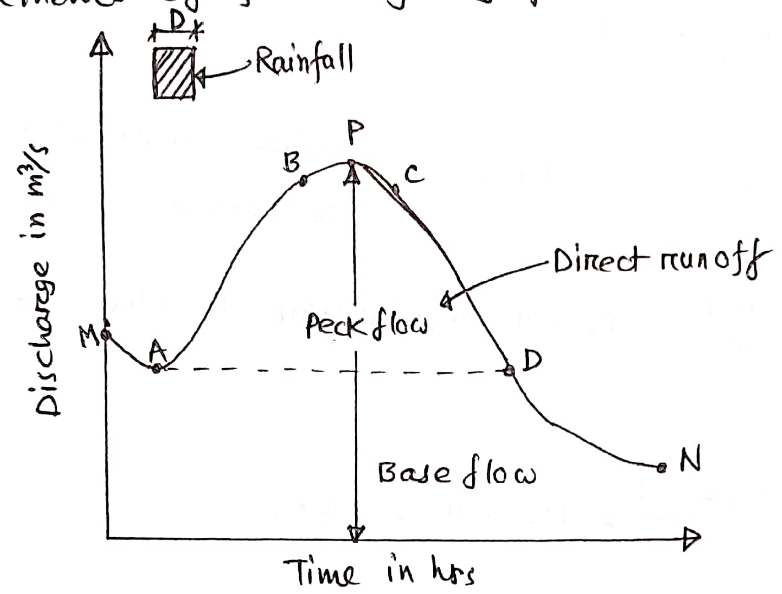
It is the process of collecting and concentrating runoff water from a runoff area into run-on area, where the collected water is either directly applied to the cropping area and stored in the soil profile for immediately use by the crop.

Water Harvesting
↓
* Rain water Harvesting
* Flood water Harvesting

** Hydrograph

It is a graphical representation of discharge in a stream plotted against time chronologically.

** Elements of flood Hydrograph



MA = Base flow recession
AB = rising limb
BC = crest segment
CD = falling limb
DN = Base flow recession
point B & C = inflection point

Fig: Elements of flood hydrograph.

*** Factor affecting runoff / Flood hydrograph ⇒

(i) Physical factors

(a) Basin characteristics
* shape * size * slope * elevation * nature of valley

(b) Infiltration characteristics
* Land use & cover * soil type & geological conditions

(c) channel characteristics
* cross section * Roughness

(ii) Climate factors

(a) precepitation, intensity, duration, magnitude of storm
(b) Initial Loss
(c) Evapotranspiration.

Effective Rainfall / Excess Rainfall

It is part of the rainfall that becomes direct runoff at the outlet of the watershed.

Hyetograph

A hyetograph is a plot of the intensity of rainfall against the time interval. It is usually represented as a bar chart.

*** (86)

Here is a zone precipitation is occur 9 cm & run off is 5 cm. Rainfall Data is provided below with respect to time ⇒

(B-51) (H-42)

Time (hr)	1	2	3	4	5	6
Rainfall (cm)	0.4	2.2	4	2.2	1.4	0.9

Infiltration Index, ϕ - index $= \frac{P-R}{t_e}$

t_e = duration of excess rainfall

Soln

1st trial,

Total infiltration $= P-R = (11.1 - 5) = 6.1$ cm

$t_e = 6$ hr

$\therefore \phi - \text{Index} = \frac{P-R}{t_e} = \frac{6.1}{6} = 1.02$ cm/hr > The rainfall value of 1st & 6th hr

2nd trial,

$\phi - \text{Index} = \frac{6.1 - 0.4 - 0.9}{4} = 1.2$ cm/hr (OK)

$\therefore \phi - \text{Index} = 1.2$ cm/hr (Ans)

*** (89)

Rainfall of magnitude 3.8 cm and 2.8 cm occuring on two consecutive 4-h duration on a catchment of area 27 km² produced the following hydrograph of flow at the outlet of the catchment. Find rainfall excess & ϕ index.

Rainfall

Time (hr)	-6	0	6	12	18	24	30	36	42	48	54	60	66
flow (m³/s)	6	5	13	26	21	16	12	9	7	5	5	4.5	4.5

Runoff

Soln

Base flow = 5 m³/s

Time (hr)	0	6	12	18	24	30	36	42	48
DRH (m³/s)	0	8	21	16	11	7	4	2	0

Interval time

Total direct runoff vol^m = (8+21+16+11+7+4+2) * (6×3600)

= 14,90,400 m³

Runoff depth = $\frac{\text{Runoff vol}^m}{\text{Runoff catchment area}} = \frac{1490400}{27\times10^6} = 5.52$ cm

(rainfall excess) Ans

Total rainfall = (3.8 + 2.8) = 6.6 cm

Duration = (4 + 4) = 8 hr

∴ ϕ – Index = $\frac{6.6 - 5.52}{8}$ = 0.135 cm/hr (Ans)

Check

Total loss in 4 hr rainfall = 0.135×4 = 0.54 cm < rainfall (3.8 cm & 2.8 cm) (OK)

(8b) In a 180 min storm, the following intensities of rainfall were observed in successive 30 min intervals: 3.3, 3.6, 9, 6.6, 0.6 & 0.9 cm/hr. Assume, the ϕ-index value to be 2 cm/hr, catchment Area 3 km²

(i) Total vol^m of run off
(ii) Total vol^m of infiltration
(iii) Duration of rainfall excess

Sol^n

ϕ-index = 2 cm/hr = 1 cm/30 min

Time from start (min)	30	60	90	120	150	180
Rainfall in 30 min (cm)	1.65	1.8	4.5	3.3	0.3	0.45
Infiltration in 30 min (cm)	1	1	1	1	0.3	0.45
Runoff in 30 min (cm)	0.65	0.8	3.5	2.3	0	0

(i) Total runoff = (0.65 + 0.8 + 3.5 + 2.3) = 7.25 cm

Total runoff vol^m = $\left(\frac{7.25}{100}\right) \times (3\times10^6)$ = 217500 m³ (Ans)

(ii) Total vol^m of infiltration = $\left(\frac{1+1+1+1+0.3+0.45}{100}\right) * (3\times10^6)$

= 142500 m³ (Ans)

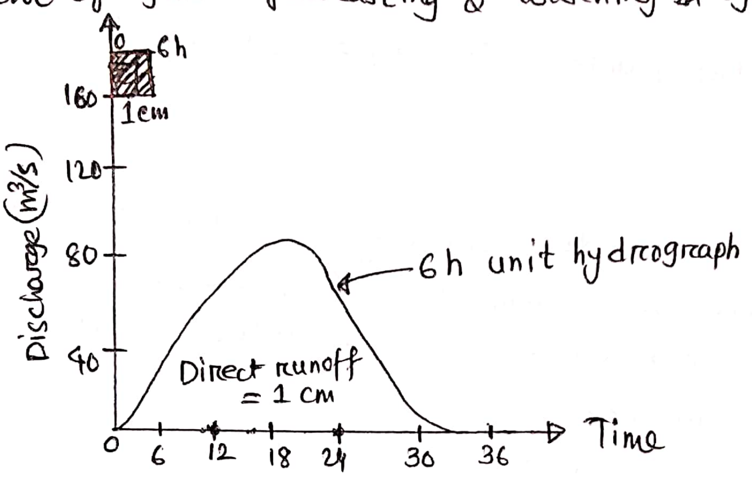
(iii) Duration of rainfall excess = (30 + 30 + 30 + 30) = 120 min (Ans)

Unit Hydrograph

A unit hydrograph is defined as the hydrograph of direct runoff resulting from one unit depth (1 cm) of rainfall excess occuring uniformly over the basin and at a uniform rate for a specified duration (D hrs).

Function/uses of unit hydrograph

* The development of flood hydrographs for extreme rainfall magnitudes for use in the design of hydraulic structures.
* Extension of flood flow records based on rainfall records.
* Development of flood forecasting & warning system based on rainfall.



S-Curve/S hydrograph

It is a hydrograph produced by a continuous effective rainfall at a constant rate for an infinite percoid.

(Q) The peak of flood hydrograph due to a 3h duration isolated storm in a catchment is 270 m^3/s. The total depth of rainfall is 5.9 cm. Assuming an avg. infiltration loss of 0.3 cm/hr & a constant base flow of 20 m^3/s (a) estimate the peak of the 3-h unit hydrograph of this catchment.

(b) If the area of catchment is 567 km^2, determine the base width of the 3-h unit hydrograph by assuming it to be triangular in shape.

Flood hydrograph = DRH + Base flow

Soln

$$\phi\text{-index} = \frac{P-R}{t} \Rightarrow 0.3 = \frac{5.9-R}{3}$$

$$\Rightarrow R = 5 \text{ cm}$$

Unit Hydrograph= DRH/Runoff height

∴ Runoff/Rainfall excess = 5 cm

Peak of DRH $= (270-20) = 250\ m^3/s$

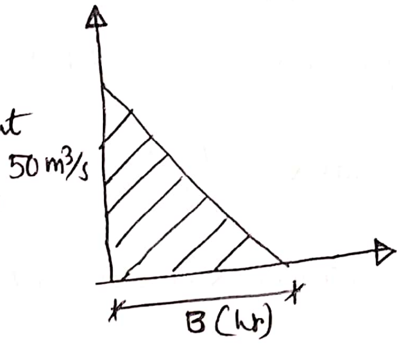
$\therefore$ peak of 3 h unit hydrograph $= \frac{250}{5} = 50\ m^3/s$ Ans

(b) let, Base width = B in hours

$\therefore$ Vol^m represented by the area of UH = Area of catchment * 1 cm

$\therefore \frac{1}{2} * 50 * (B \times 3600) = 567 \times 10^6 * \left(\frac{1}{100}\right)$

$\Rightarrow$ **B = 63 hrs** Ans



BWDB
***
(50) The value of peak of a 6h flood hydrograph is 35 m³/s and constant base flow is 10 m³/s. If the rainfall depth is 3.25 cm and infiltration rate is 0.125 cm/hr. Determine, peak of 6-h unit hydrograph & runoff co-efficient.

Sol^n ϕ-index $= \frac{P-R}{t}$ $\Rightarrow 0.125 = \frac{3.25-R}{6}$

$\Rightarrow R = 2.5$ cm

Runoff / Rainfall excess = 2.5 cm

Peak of DRH $= 35-10 = 25\ m^3/s$

$\therefore$ peak of 6-h unit hydrograph $= \frac{25}{2.5} = 10\ m^3/s$ (Ans)

Runoff co-efficient $= \frac{2.5}{3.25} = 0.77$ (Ans)

*** (51) The hourly ordinates of 6-h unit hydrograph for a particular basin is 36 cumec. The flood peak due to 6-h storm was 130 cumec. The constant base flow is 6 cumec and avg. storm loss 6 mm/hr. Determine the depth of storm rainfall and the streamflow at successive 3 hr interval. Assume, the wall surface.

Sol^n

Peak of DRH $= 130-6 = 124\ m^3/s$

Peak of UH $= 36\ m^3/s$

$$\text{peak of 6-h UH} = \frac{\text{peak of DRH}}{\text{Rainfall excess}}$$

$$\Rightarrow 36 = \frac{124}{\text{Rainfall excess}}$$

$\Rightarrow$ Rainfall excess = 3.44 cm

$\therefore$ ϕ-index $= \frac{P-R}{t} \Rightarrow 6 = \frac{P-3.44}{6} \Rightarrow P = 7.04$ cm

$\therefore$ Storm Rainfall depth = 7.04 cm (Ans)

Check:

Direct Runoff = 36 × 3.44 = 123.84 m^3/s

[1 cm → 36
3.44 cm → 36×3.44 = 123.84]

$\therefore$ Stream flow = 123.84 + 6 = 129.84 m^3/s (Ans)

— o —

Irrigation

* Define ⇒ Evaporation, Evapotranspiration, Sodium absorption Ratio, [B-266]
BCS * Delta & Duty of crop.
BCS * Define consumptive use of water. What are the factor affecting consumptive use. [B-395]
BCS * What are the water logging? Explain in brief the measure adopted for controlling water logging. [G-603]
BCS * principle causes & effects of water logging.
BCS * Leaching requirement? [B-400]
BCS * What is SAR? Discuss the effect of salt on plant growth.
BCS * Furrow irrigation & sprinkler irrigation? which one is preferred in BD?
BCS * what are different form of soil water? Show them in case of Sandy soil & silty Loam soil with a diagram.
BCS * "All the waters are not fit for irrigation crops" – Explain it.
BCS * Electrical conductivity of water in irrigation.

* Short note ⇨ water logging, Losses in irrigation cannal, Berms & counter Berms (GI-602), Lining of irrigation canal, Balancing depth, ill effect of irrigation

gache pani dewa

Irrigation ⇨

Irrigation is the artificial means to supply water to plant for its growth & maturity.

when irrigation is required?

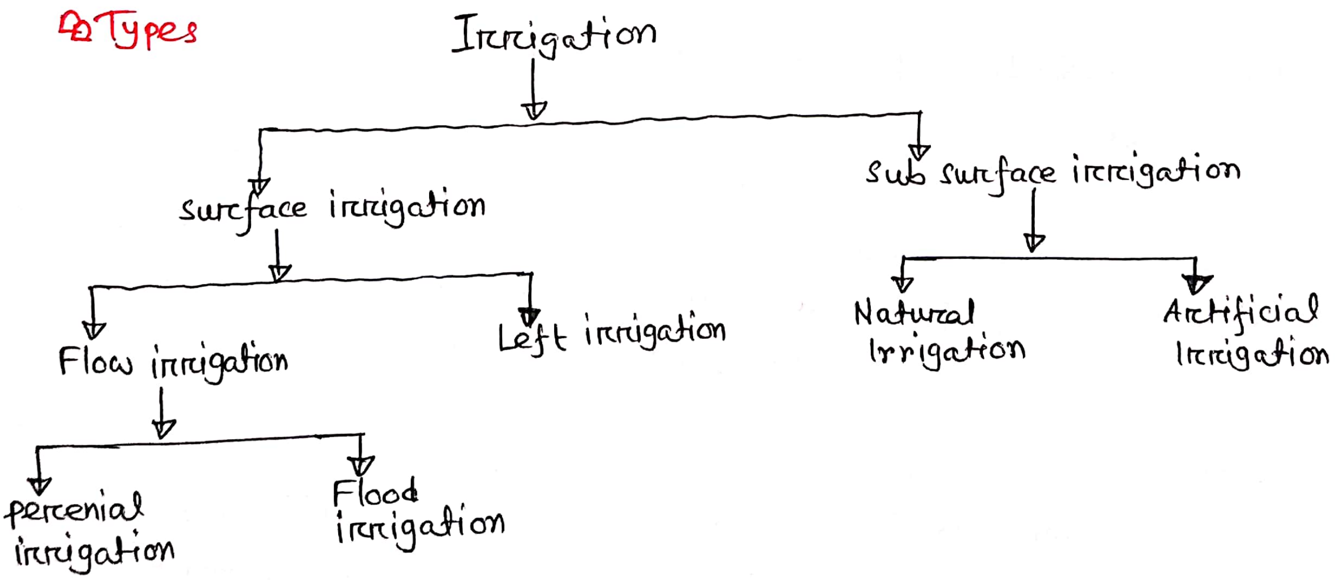
irrigation is required when rainfall is insufficient for plant growth & maturity.

* Amount of rainfall is lower than plant requirement
* if the amount of rainfall is sufficient but spatial distribution is not as per requirement.
* Sometimes, rainfall is suffient, spatial distribution is also good but temporal distribution is not good as per requirement.

objective of irrigation ⇨

* ensure enough moisture essential for plant growth
* Cool the soil & atmosphere to provide a suitable surrounding
* Dilute & washout harmful salt
* provide crop insurance against short duration of drought.
* Reduce hazards of soil piping.

Types

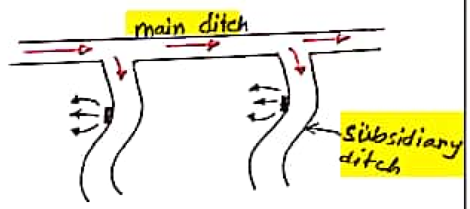
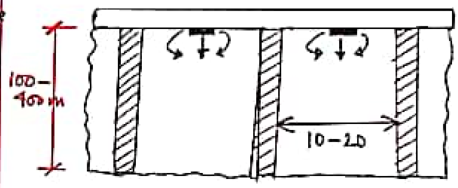
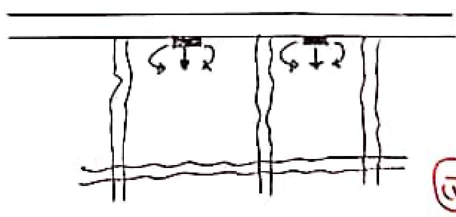


Irrigation methods ⇨

BCS

* free flooding
* Basin flooding
* Border "
* check "
* Furrow irrigation
* Sprinkler "
* Drip "

(Furrow, Sprinkler) কোনটা better BD তে?

	Advantage	Disadvantage	Figure
Free Flooding / ordinary flooding / wild flooding	* low initial cost * suitable for rolling land i.e, irregular Topography * Suitable to all medium to fine texture soil.	* efficiency is low * loss of land as ditches are excavated in the field. * Suitable where irrigation water is abundant and inexpensive. * non-uniform distribution of water	
2017-18 Border flooding	* low maintenance cost * uniform distribution & high water application efficiency * suitable for soil having high infiltration rate * Requires less labour.	* High initial cost * loss of irrigation land because of border. * Requires proper surface leveling.	
Check flooding	* effective leaching * high efficiency * max. use of seasonal rainfall * low evaporation loss	* not applicable for soil having high infiltration capacity * labour cost high * Soil crusting * unsuitable for crops that can't accomodate inundation.	

(21)

	Advantage	Disadvantage	
basin flooding	* effective leaching * high efficiency * max. use of seasonal rainfall * less water loss	* initial cost is very high * soil crusting * unsuitable for crops that can't accomodate inundation	
Furrow irrigation	* less evaporation loss * suitable for row crops.	* very high initial cost * salt accumulation in the ridges * Little water near down-slope end	
Sprinkler irrigation	* no seepage losses * no surface run off * no cultivation area is lost * land leveling is not required.	* at high temp. evaporation loss take place. * high wind distort sprinkler pattern. * not suitable to crop requiring larger depth of irrigation * very costly system	* In this method, water is applied to the soil in the form of form of spray through a network of pipes and pumps → permanent system → Semi-permanent system → portable system
Drip irrigation	* greater crop yield * suitable for widely spaced plants * Reduce weed growth * run off loss and percolation loss min.	* high initial cost * wind erosion can harm the pipe. * Saving in energy requirement as operate on much lower line pressure.	* It is the latest field irrigation Tegnique. Irrigation water is applied by using small diameter plastic Lateral lines This is being used for small

④ Identify types of irrigated water

***① Sodium Absorption Ratio (SAR)

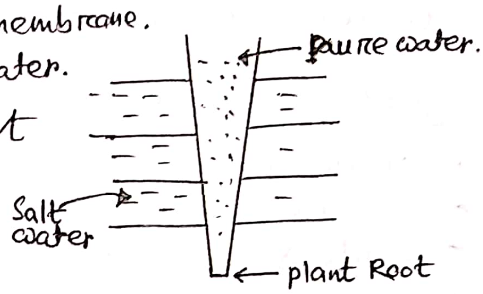
The proportion of sodium ions present in the soils is generally measured by a factor called SAR.

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

SAR = 0–10 → Low sodium water → S_1
SAR = 10–18 → Medium " " → S_2
SAR = 18–26 → High " " → S_3
SAR = > 26 → very high " " → S_4

***What is the problem if the irrigation water is saline?

Plant roots act as a semi-permeable membrane. In the plant cell, there is almost pure water. and other side highly concentrates salt solution.



Due to osmosis, the pure water within the roots will start flowing out of the roots toward solution.

The plant will die due to ~~water/solut~~ lack of water.

* using poor water, special consideration,,
  - use ~~gps~~ gypsum when SAR > 20 and $\frac{Mg}{Ca} > 3$.
  - If $\frac{Cl}{SO_4} > 20$, use phosphorus fertilizer.
  - 20% extra seed may be
  - Leaving the field fallow during rainy season.
  - Be, Si, Fe, heavy metal ⇒ Expert decision.

***⑪ Electrical Conductivity (EC)

EC is a measure of salt content in a given water sample.

EC = 100–250 micro mhos/cm → Low conductivity water → C_1
EC = 250–750 " → Medium " " → C_2
EC = 750–2250 " → High " " → C_3
EC = > 2250 " → very high " " → C_4

micrometer hos / cm = µm hos/ cm
millimeter hos/ cm = mm hos/cm
meter hos /cm = m hos/ cm

(iii) Sodium percentage (SP)

$$SP = \frac{Na^+}{Na^+ + Mg^{2+} + K^+ + Ca^{2+}}$$

(iv) Exchangeable sodium percentage (ESP)

$$ESP = \frac{\text{Exchangeable sodium}}{\text{Total exchangeable cation / cation exchangeable capacity}} * 100$$

me = m.eq = m. equivalent

A Unit converstion ⇒

me/L = (mg/L) / EW

$$\Rightarrow me/L = \frac{ppm}{\text{equivalent weight}}$$

$$\Rightarrow ppm = 640 \times EC\ (mS/cm)$$

[mS/cm = mmhos/cm]

$$\Rightarrow atm = 0.36 \times EC\ (mS/cm)$$

(32) ***

(a) What is the classification of irrigation water having the following characteristics: Concentration of Na, Ca & Mg are 22, 3 & 1.5 milli-equivalents per liter respectively and the electrical conductivity is 200 μmhos/cm at 25°C?

(b) What problem might arise in using this water on fine textured soil?

(c) What remedies do you suggest to overcome this trouble?

Soln

(a)

$$SAR = \frac{Na^+}{\sqrt{\frac{Mg^{2+} + Ca^{2+}}{2}}} = \frac{22}{\sqrt{\frac{3+1.5}{2}}} = 14.67 \longrightarrow \text{medium sodium water} \longrightarrow S_2$$

EC = 200 micro mhos/cm ⟶ low salinity water ⟶ C_1

$C_1 - S_2$ water

(b) problems ⟶

* Soil becomes Less permeable.
* Start crushing when dry.
* become plastic & sticky when wet.
* it's pH increases towards that of alkaline soil.

(c) Remedy ⇒ Add gypsum ($CaSO_4 \cdot 2H_2O$) to the soil or water.

(Q) Express 8300 ppm of sodium salt concentration in mmhos/cm, μmhos/cm & mhos/cm

Sol^n

ppm = 640 * EC

⇒ 8300 = 640 * EC

∴ EC = 12.97 mmhos/cm (Ans)

$= 12.97 \times 10^3$ μmhos/cm (Ans)

$= \frac{12.97}{10^3}$ mhos/cm (Ans)

(Q8) Express 2300 ppm sodium chloride salt concentration in me/L of water.

Sol^n

Equivalent weight of NaCl = 23 + 35.45 = 58.45

$$me/L = \frac{ppm}{\text{Equivalent weight}} = \frac{2300}{58.45}$$

= 39.45 me/L (Ans)

Time Requirements of crops

Ⓐ Cropping pattern in Bangladesh

* Kharif-I (March - July) ⇒ Aush is planted.
* Kharif II (July - December) ⇒ Aman is planted.
* Rabi (Nov - April) ⇒ Boro, wheat etc.

Ⓐ Crop period ⇒ The time period that elapses from the instant of its sowing to the instant of its harvesting. (sowing to harvesting)

Ⓐ Base period ⇒ The time between the first watering of a crop at the time of its ~~sto~~ sowing to its last watering before harvesting. (1st watering to harvesting)

Crop period ≥ Base period

*** BCS

Ⓐ ~~Duty~~ Delta ⇒ The total depth of water required by a crop ~~by~~ to come to maturity is called its delta (Δ). unit ⇒ cm or m

*** BCS

Ⓐ Duty ⇒ It may be defined as the area ~~required~~ irrigated for full growth of a given crop by supply of unit discharge (1 m³/s) continuously during the entire base period of that crop. unit ⇒ $\frac{ha}{cumec}$ $\left(\frac{\text{Area}}{\text{discharge}}\right)$

Duty depends on ⇒

* Type of crop
* Type of soil.
* climate & season
* useful rainfall
* Efficiency of cultivation method.

Importance of Duty ⇒

It helps us in designing an efficient canal irrigation system.
* If we know the area to be irrigated and their duties, we can calculate the discharged required for desiging the channel. D=A/Q
* if we know the total available water at the head of main canal & overall duty for all crop. we can calculate the area to be irrigated.

How we can improve duty?

* Canal should be lined to reduce transmission Load.
* Canal should be nearest to the irrigated area.
* Land should be properly ploughed.
* Good quality of water should be used for irrigation.
* Rotation of crops should be practised.

Relation between Delta & Duty

B = Base period

$$\Delta = 864 \frac{B}{D}$$

Δ → cm
B → day
D → ha/cumec

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

(13) if rice requires about 10 cm depth of water at an average interval of about 10 days and the crop period for rice is 120 days Find out the delta for rice?

Soln

$$\Delta = \frac{120}{10} \times 10 = 120 \text{ cm} \quad \text{Ans}$$

(14) Find the delta for a crop when its duty is 864 ha/cumec on the field, base period of this crop is 120 days.

Soln $$\Delta = 864 \frac{B}{D} = 864 \times \frac{120}{864} = 120 \text{ cm} \quad \text{Ans}$$

(64) A channel is to be designed for irrigating 5000 ha in kharif crop & 4000 ha in Rabi crop. The water requirement for Kharif and Rabi are 60 cm & 20 cm respectively. The base period for Kharif is 3 weeks & for Rabi is 4 weeks. Determine the discharge of the channel for which it is to be designed.

Soln

Discharge required for Kharif ⇒

$$\Delta = 864 \frac{B}{D} \Rightarrow 60 = 864 \times \frac{3\times7}{\frac{5000}{Q_K}} \Rightarrow Q_K = 16.53\ m^3/s$$

Discharge required for Rabi ⇒

$$\Delta = 864 \frac{B}{D} \Rightarrow 20 = 864 \times \frac{4\times7}{\frac{4000}{Q_R}} \Rightarrow Q_R = 3.31\ m^3/s$$

∴ Design Discharge for the channel = ~~(16.53 + 3.31) = 19.84 m³/s~~ Ans

= 16.53 m^3/sec
(max. value)

BCS Water Logging

A Land is said to be water logged when its productivity gets affected and when the root zone of the plants get flooded with water by the high water table.

BCS Causes of water logging

* Irregular or flat topography
* over & Intensive irrigation
* seepage of water
* Inadequate natural drainage
* Excess rainfall

BCS Result of water Logging

* Land becomes ill aerated which reduce plant growth & finally reduce the crop yield.
* Normal operations such as tilling, ploughing can't be easily carried out in wet soil.
* water logging also Leads to salinity.
* water loving plants like grass, weeds grow quickly in water Logged Land and affect the growth of the crops.

BCS Measures for controlling of water logging

* Lining of canal & water courses
* Reducing the intensity of irrigation
* By introducing crop rotation
* By optimum use of water
* By improving natural drainage.

BCS Leaching

Leaching is the process of dissolving the salts and removing them from the desired soil layer by the downward movement of water.

Leaching requirement of a soil

* To Leach out excess salts, water is applied in a quantity more than the normal requirement of the crop to avoid accumulation of salts. This becomes necessary when the irrigation water contains soluble salts or the soil is already saline in nature.
* This excess water will flow down beyond the root zone of the crop and washed down the excess salt.
* This excess water which is required to meet the Leaching needs is generally expressed as the percentage of the total irrigation water.

Leaching Requirement,

$$LR = \frac{\text{Depth of water drained out per unit area}}{\text{Depth of irrigation water applied per unit area}}$$

$$\Rightarrow LR = \frac{D_d}{D_i} = \frac{D_i - C_u}{D_i} = \frac{C_i}{C_d} = \frac{EC_i}{EC_d} = \frac{EC_i}{2EC_e}$$

D_d = Depth of water drained out per unit area

D_i = Depth of irrigation water applied per unit area

C_u = Consumptive use of water

C_i = Salt content in irrigation water

C_d = Salt content in drainage water

EC_i = Electrical conductivity in irrigation water

EC_d = " " in drainage water

EC_e = " " in saturated soil extract

(26) Estimate the Leaching requirement when electrical conductivity (EC) value of a saturated extract of soil is 10 micro mhos/cm at 25% reduction ~~the~~ in the yield of a crop. The EC of irrigation water is 1·2 m mhos/cm. What will be the required depth of water to be applied to the field if consumptive use requirement of the crop is 80 mm?

Soln

$$LR = \frac{EC_i}{2EC_e} \times 100\% = \frac{1.2}{2 \times 10} \times 100\% = 6\%$$

Again, $LR = \frac{D_i - C_u}{D_i}$ ⇒ $0.06 = \frac{D_i - 80}{D_i}$ ⇒ $D_i = 85.1$ mm

Ans

(27) A tile drainage system draining 12 ha, flows at a design capacity for two days, following a storm. If the system is designed using a drainage co-efficient (DC) of 1·25 cm/day. How many cubic metres of water will be removed during this period? DC= 1.25/100 m/day

Soln 0.0125*12*10000 m^3/day = Volm / 2

volm of water entering the drain/day $= \frac{1.25}{100} \times 12 \times 10^4 = 1500\ m^3/day$

volm of water removed during 2 days $= 1500 \times 2 = 3000\ m^3$

(Ans)

BCS (10)

Determine the size (dia) of a tile at the outlet of a 6 ha drainage system, if the DC is 1 cm/day and the tile grade is 0·3%. Assume, the regusity co-efficient for the tile drain material as 0·011.

Soln

$$Q = \frac{1}{100} \times (6 \times 10^4)$$
$$= 600\ m^3/day = 0.00694\ m^3/s$$

$n = 0.011$
$S = 0.3\% = 0.003$
For circular,
$A = \frac{\pi}{4} D^2$
$P = \pi D$
$\therefore R = D/4$

$$\therefore Q = \frac{1}{n} R^{2/3} \sqrt{S} * A$$

$$\Rightarrow 0.00694 = \frac{1}{0.011} \times \left(\frac{D}{4}\right)^{2/3} \times \sqrt{0.003} \times \frac{\pi}{4} D^2$$

⇒ $D = 0.1315$ m Ans

Cross drainage work

A cross draining work is a structure which is constructed at the crossing of a canal and a natural drain to dispose of draining water without interrupting the canal supplies.

(Q) If the flow rate is 113 cusec & Area is 5 ha. What is the time required for irrigation if dewatering in irrigated land 10.92 cm?

Soln

volm of irrigated water = $\frac{10.92}{100} \times (5\times10^4) = 5460\ m^3$

$Q = 113$ cusec

$\therefore Q = \frac{Volm}{t} \Rightarrow t = 48.32$ sec Ans

WHP = Q*H/76   Q = L/s
H = m

* Water Horse power, $WHP = \frac{QH}{3960}$

Shaft/Brake Horse power, $BHP/SHP = \frac{WHP}{E}$

Q → gpm
H → ft

$1 ft^3 = 7.48$ gallon
1 gallon = 3.785 L

(Q2) A pump lifts 93600 L of water per hour against a total head of 21 m. compute the WHP. If the pump has an efficiency of 72%. What size prime mover is required to operate the pump. If a direct drive electric motor having an efficiency 80% is used to operate the pump, Compute the cost of electrical energy in a month of 30 days. If pump is operated for 12 hrs. daily for 30 days. The cost of energy is 20 paisa/day.

Soln

$Q = 93600$ L/hr
$= \frac{93600/3.785}{60}$ gpm
$= 412.15$ gpm

$H = 21\times3.28 = 68.88'$

$WHQ = \frac{QH}{3960} = \frac{412.15\times68.88}{3960} = 7.17$ Ans

$SHP = \frac{7.17}{0.72} = 9.96$ Ans

Killowatt input to motor $= \frac{9.96\times0.746}{motor\ effi.} = 9.29$ KW

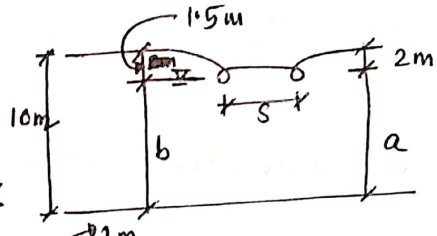
Total Energy/month $= 9.29\times(12\times30) = 3343.57$ KWh

$\therefore$ Cost/month $= 3343.57\times\left(\frac{20}{100}\right) = 668.71$ tk Ans

***(49) Determine the spacing of the tile drain from the data - Annual rainfall = 100 cm, Drainage co-efficient = 1% to be drained in 24 hr. Depth of impervious layer from Land to surface = 10 m, depth of drain below Land surface = 2m. permeability of soil = 10^{-4} cm/sec, Depth of WT below Land = 1.5 m. [G-606]

Soln

let, longitudinal Length of drain = 1m



Runoff per second, $Q = \dfrac{\frac{100}{100} \times \frac{1}{100} \times S \times 1}{24 \times 60 \times 60} = \dfrac{S}{8.64 \times 10^6}$

(100 cm → $\frac{100}{100}$; 1% → $\frac{1}{100}$; 1m → 1)

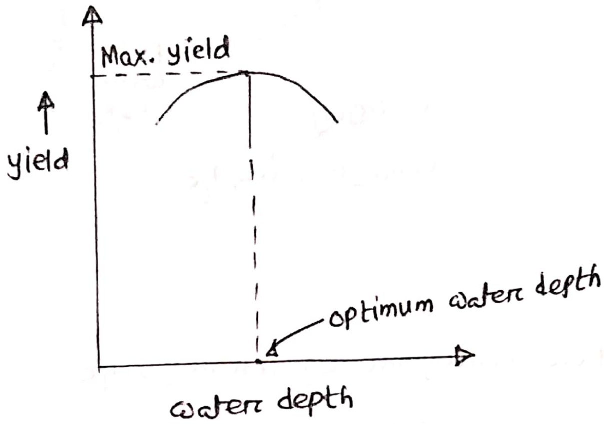
We know, $S = \dfrac{4K(b^2 - a^2)}{Q} \Rightarrow S = \dfrac{4 \times 10^{-4} (8.5^2 - 8^2)}{\frac{S}{8.64 \times 10^6}} \Rightarrow \boxed{S = 169 \text{ m}}$ Ans

BCS

State the necessary of Drainage. Discuss briefly some of the important field investigations necessary for drainage work.

Optimum irrigation water depth

The quantity of water at which the yield is maximum is called the optimum irrigation water depth.



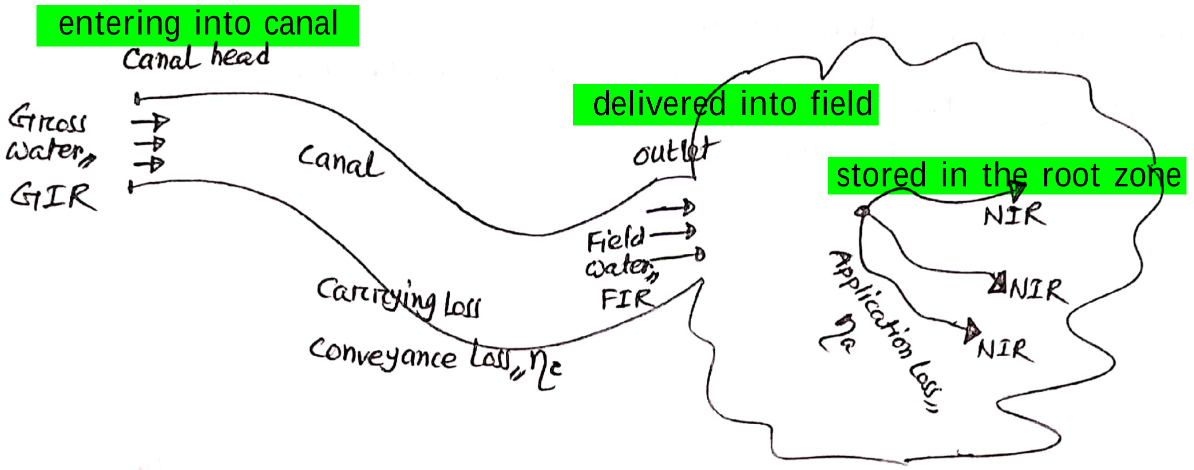
BWDB

(58) A canal commands an irrigation area of 400 ha. The duty of water on the field during the peak period is 220 ha/cumec. Determine, the drainage discharge of the canal at the off take if the water loss in canal is 30% ?

Soln

$$\text{Duty} = \frac{\text{Area}}{\text{Discharge}} \Rightarrow 220 = \frac{400}{\text{Discharge}} \Rightarrow \text{Discharge} = 1.82\ m^3/s$$

$$\therefore \text{Design Discharge} = \frac{1.82}{0.70} = 2.6\ m^3/s \text{ Ans}$$



Water conveyance efficiency, η_c

$$\eta_c = \frac{\text{Water delivered into fields from outlet of channel}}{\text{water entering into channel at its starting point}} * 100\% = \frac{FIR}{GIR}$$

Water application efficiency, η_a

$$\eta_a = \frac{\text{water stored in the root zone of the crop}}{\text{water delivered into the field}} * 100\% = \frac{NIR}{FIR}$$

Water storage efficiency, η_s

$$\eta_s = \frac{\text{water stored in the root zone of the crop during irr}^n}{\text{Water needed in the root zone prior to irrg}^n} * 100\% =$$

*additional needed

Water distribution efficiency, η_d

$$\eta_d = \left(1 - \frac{d}{D}\right) * 100\%$$

D = mean depth of water stored during irrigation

d = Average of the absolute values of deviations from the mean

(56) 1 cumec of water is pumped into a farm distribution system. 0.8 cumec is delivered to a turnout, 0.9 Km from the well. Compute the conveyance efficiency / on farm efficiency.

Soln

$$\eta_c = \frac{0.8}{1} * 100\% = 80\% \text{ Ans}$$

(57) 10 cumec of water is delivered to a 32 ha field for 4 hrs. Soil probing after the irrigation indicates that 0.3 metre of water has been stored in the root zone. Compute the water application efficiency.

NIR = 0.3 m
FIR = 10*(4*3600)/32*10^4 m
Ans = NIR / FIR

Soln

$$\text{Input} = 10 \times (4 \times 3600) = 144000 \text{ m}^3$$

$$\text{output} = 0.3 \times (32 \times 10^4) = 96,000 \text{ m}^3$$

$$\eta_a = \frac{96000}{144000} = 66.67\% \text{ (Ans)}$$

(59) The depth of penetrations along the length of ~~boundary~~ border strip at points 30 m apart were probed. Their observed values are 2, 1.9, 1.8, 1.6 & 1.5 m. Compute the water distribution efficiency.

Soln

$$\text{Mean depth, } D = \frac{2+1.9+1.8+1.6+1.5}{5} = 1.76 \text{ m}$$

$$d = \frac{|2-1.76| + |1.9-1.76| + |1.8-1.76| + |1.6-1.76| + |1.5-1.76|}{5} = 0.168 \text{ m}$$

$$\eta_d = (1 - d/D) * 100\% = 90.5\% \text{ Ans}$$

BUET

(60) *** A stream of 130 L/s was diverted from a canal and 100 L/s were diverted to the field. An Area of 1.6 ha was irrigated in 8 hours. The effective depth of root zone was 1.7 m. The runoff loss in the field was 420 m³. The depth of water penetration varied Linearly from 1.7 m at the head end of the field to 1.1 m at the tail end. Available moisture holding capacity of the soil is 20 cm per metre depth of soil. It is required to determine η_c, η_a, η_s and η_d. Irrigation was started at a moisture extraction Level of 50% of the available moisture.

(i) $\eta_e = \frac{100}{130} = 77\%$ (Ans)

(ii) Water supplied $= 100 \times (8 \times 60 \times 60) = 2880\ m^3$

Runoff Loss $= 420\ m^3$

Water stored in the root zone $= (2880 - 420) = 2460\ m^3$

$\therefore \eta_a = \frac{2460}{2880} = 85.4\%$ (Ans)

(iii) Moisture holding capacity (WHC) of soil $= 20\ cm/m * 1.7m$
$= 34\ cm$

Available moisture $= 34 \times 50\% = 17\ cm$

water needed in the root zone

$\therefore$ Additional water required in root zone $= (34 - 17) = 17\ cm$

$\therefore V_{sfm} = \frac{17}{100} \times (1.6 \times 10^4) = 2720\ m^3$

$\therefore \eta_s = \frac{2460}{2720} = 90\%$ Ans

(iv) $D = \frac{1.7 + 1.1}{2} = 1.4\ m$

$d = \frac{|1.7 - 1.4| + |1.1 - 1.4|}{2} = 0.3$

$\therefore \eta_d = \left(1 - \frac{0.3}{1.4}\right) = 78\%$ (Ans)

BUET

(62) A canal commands an irrigation area of 350 ha, the peak field irrigation requirement is 9mm/day. Determine the design discharge of canal at the outlet, water loss 25%.

Soln

Total water requirement $= \frac{9}{1000 \times 3600 \times 24} * (350 \times 10^4) = 0.364\ m^3/s$

$\therefore$ Design Discharge $= \frac{0.364}{0.75} = 0.485\ m^3/s$ (Ans)

BCS

Consumptive use (Cu) or Evapotranspiration

* The total amount of water used by plant in transpiration & evaporation from adjacent soil or from plant Leaves in any specified time.
* Consumptive use is the sum of two terms — Transpiration & Evaporation

Transpiration

* water being passed entering plants roots & used to build plant tissue.
* water being passed through leaves of plant into the atmosphere.
* Transpiration affected by climate factor, soil factor, plant factor

BCS

Evaporation

Water evaporating from adjacent soil, water surface and surface of Leaves of the plant.

plant leaves

Effective Rainfall (Re)

Precipitation falling during the growing period of a crop that available to meet the evapo-transpiration need of the crop is called effective rainfall.

$$R_e = R - R_f - D_f$$

R = precipitation
R_f = surface runoff
D_f = Deep percolation

BCS

factor affecting consumptive use ⇒

* Evaporation which depends on humidity.
* Mean monthly temperature.
* Monthly precipitation in Area.
* Wind velocity in Locality.
* Soil & Topography.
* Sunlight hours.
* Growing season of crops & cropping pattern
* Irrigation practices & method of irrigation.

Evaporation
monthly precipitation
monthly temperature
sunlight hours
soil and topography
wind velocity
crop pattern
method of irrigation

- Consumptive irrigation requirement, $CIR = C_u - R_e$
- Net irrigation Requirement, $NIR = CIR +$ water loss
- Field irrigation Requirement, $FIR = NIR +$ application Loss $= \frac{NIR}{\eta_a}$
- Gross irrigation Requirement, $GIR = FIR +$ conveyance Loss $= \frac{FIR}{\eta_c}$

(40) Determine NIR of jowar crop, assuming that water is not required for any other purpose except that of fulfilling the evapo-transpiration needs of the crops.

Dates	Cu (mm)	Re (mm)	NIR
Oct 16–31	37	30.8	6.2
Nov 1–30	84.2	20.4	63.8
Dec 1–31	154.9	6.7	148.2

Sol^n

NIR = 218.2 mm Ans

Note water loss না থাকলে, CIR = NIR

* Estimation of consumptive use, Cu

$$C_u = \frac{KP}{40}\left[1.8t + 32\right]$$ (t → °C)

$$= \frac{KP}{40} * t$$ (t → K)

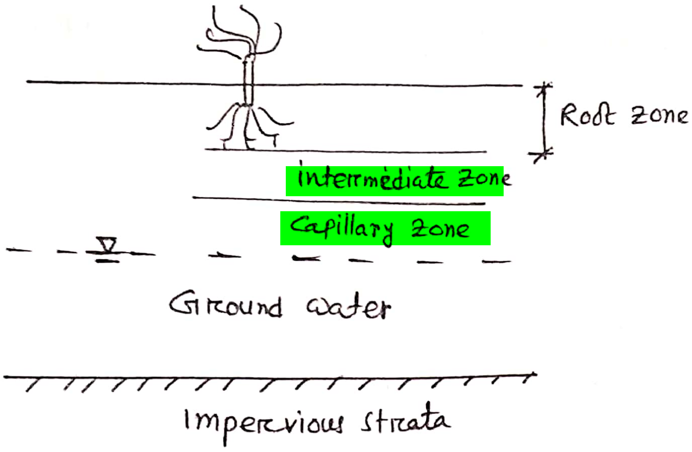
} Blaney – criddle method

* Class A pan evaporation method,

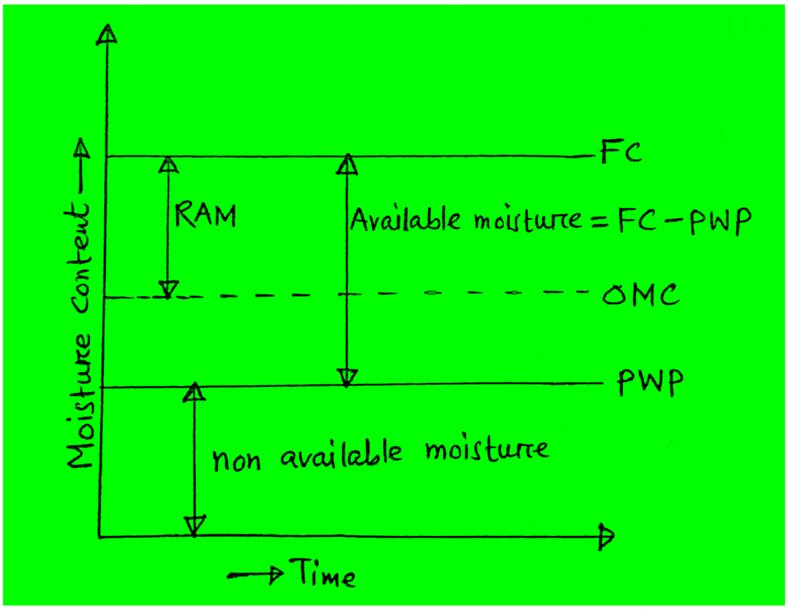
$$C_u = K E_p$$

Soil moisture - Irrigation Relationship ⇨

The water above the WT is known as soil moisture.



VVI for any Math



RAM = FC - OMC
= 80% of Available moisture (AW)

Field capacity (FC)

The field capacity is the amount of water content of a soil after free drainage has taken place for a sufficient period.

$$FC = \frac{\text{wt of water retained in a certain vol}^m \text{ of soil}}{\text{wt of same vol}^m \text{ of dry soil}} \times 100\%$$

Permanent wilting point (PWP)

Permanent wilting point is that water content at which plant can no longer extract sufficient water for its growth

Available moisture = FC − PWP

Readily available moisture, RAM = 80% of Available moisture = FC - OMC

[redacted]

Always, RAM hobe, RAM= FC - OMC

W depth of water, $d_w = \frac{\gamma_d}{\gamma_w} * d * (FC - OMC/MC)$

↳ d = depth of soil
depth of root zone

** (92) After How many days (Irrigation frequency) will you supply water to soil in order to insure sufficient irrigation of the given crop if

**kono point dewa thakle, oi point niye korbo.. Otherwise, RAM diye korbo

(i) FC of the soil = 28%
(ii) PWP = 13%
(iii) Dry density of soil = 1.3 g/cc
(iv) Effective depth of root zone = 70 cm
(v) Daily consumptive use = 12 mm

Soln

Available moisture (AM) = FC − PWP = 28% − 13% = 15%

∴ RAM = 80% of AM = 12%

[redacted]

RAM = FC - OMC

Depth of water $= \frac{\gamma_d}{\gamma_w} \times d \times (FC - OMC)$

$= \frac{1.3}{1} * 0.70 *$ [redacted] 12%

$= 0.1092$ m

No of ~~daily~~ days $= \frac{0.1092}{0.012} \approx 9$ days (Ans)

*** (92) Determine the field capacity of a soil for the following data =

(i) Depth of root zone = 1.8 m (ii) Existing moisture = 8%
(iii) Dry density of soil = 1450 Kg/m³
(iv) Quantity of water applied to soil = 650 m³
(v) water lost due to deep perculation & evaporation = 10%
(vi) Area to be irrigated = 1000 m²

[G-592]

Soln water wasted = 650 × 10% = 65 m³

Water used to rise MC to FC = 650 − 65 = 585 m³

Depth of water to rise MC to FC $= \frac{585}{1000} = 0.585$

RAM=FC-OMC/MC (94)

$0.585 = \frac{1450}{1000} \times 1.8 \times (FC - MC)$ → 8%

⇒ **FC = 30.4%** Ans

*** (96) The FC & MC at the time of irrigation are 27% and 19%. The root zone depth is 100 cm. The apparent specific gravity is 1.3 and root zone depth is 100 cm. The apparent specific gravity is 1.3 and root zone depth is 100 cm. The apparent specific gravity is 1.3 and root zone depth is 100 cm.

The apparent specific gravity is 1.3 and root zone depth is 100 cm. The apparent specific gravity is 1.3 with a flow of 60 L/s. Determine the time required to irrigate 2 ha with a flow of 60 L/s if water application losses are taken to be 20%? [G-593]

Soln

[redacted]

RAM = FC - MC
= 27 - 19

Depth of water stored in the root zone, $d_\omega = \frac{1.3}{1} \times 1 \times$ [redacted] (27-19)%
= [redacted] 0.104 m

Discharge, $Q = 60 - 0.2 \times 60 = 48$ L/s $= 0.048\ m^3/s$

water depth= 0.048/(2*10^4)
= 2.4*10^-6 m/s

[redacted]

Time req. = 0.104/...
=43333.33 s

Ans

40th BCS

(98) A sandy loam soil holds water at 140 mm/m between FC & PWP. The root zone of the crop is 30 cm and allowable depletion of water is 35%. The daily water use by the crop is 5mm/day. The area to be irrigated is 60 ha & water can be diverted at 28 Lps. The surface irrigation application efficiency is 40%. There are no rainfall & ground water contribution. Determine – [WRE-omera-51]

(i) Allowable depletion depth between irrigations
(ii) Frequency of irrigation
(iii) Net application depth of water
(iv) volm of water required
(v) Time to irrigate 4 ha plot.

Root zone depth = 0.3 m

∴ moisture holding capacity of root zone = $140 \times 0.3 = 42$ mm

(a) allowable depletion = 35%

∴ Allowable depletion depth = $42 \times 35\% = 14.7$ mm (Ans)

(ii) Rate = $\frac{\text{depth}}{\text{time}}$ ⇒ $5 = \frac{14.7}{\text{time}}$ ⇒ time = $2.94 \approx 3$ days

∴ Frequency of irrigation = 3 day (Ans)

(iii) Net depth of water = $5 * 3 = 15$ mm (Ans)

(iv) $E = \frac{NIR}{FIR}$ ⇒ $0.4 = \frac{15}{FIR}$ ⇒ FIR = 37.5 mm (Ans)

(v) vol^m of water required = $0.0375 * (60 \times 10^4) = 22500\ m^3$ Ans

(vi) For 4 ha irrigation,

vol^m of water = $0.0375 * (4 \times 10^4) = 1500\ m^3$

$Q = \frac{vol^m}{t}$

⇒ $28 \times 10^{-3} = \frac{1500}{t}$

⇒ $t = 14.88$ hr Ans

- **Gross command area (GCA)**
  It is the total area, bounded within the irrigation boundary of a project. It includes the culturable as well as unculturable area.
- **Culturable/cultivable command Area (CCA)**
  It includes all land of GCA on which cultivation is possible.

  CCA = 80% * GCA

(98) The GCA for a distributary is 6000 ha, 80% of which is culturable. The intensity of irrigation for Rabi season is 50% and Kharif season is 25%. If the average duty at the head of the distributory is 2000 ha/cumec for Rabi season & 900 ha/cumec for Kharif season. Find out the discharge required at the head of the distributary from average demand consideration.

Soln

GCA = 6000 ha, CCA = 80% x 6000 = 4800 ha

Area to be irrigated in Rabi season = 4800 x 50% = 2400 ha
Area to be irrigated in Kharif " = 4800 x 25% = 1200 ha

Water reqn at the head of distributory in Rabi season $= \frac{2400 \text{ ha}}{2000 \text{ ha/cumec}} = 1.2$ Cumec

" " " " in Kharif " $= \frac{1200}{900} \approx 1.33$ cumec

Design Discharge = 1.33 cumec Ans

(99) The CCA of a water-course is 1200 ha. Intensity of sugarcane and wheat crops are 20% & 40% respectively. The duties for the crops at the head of the watercourse are 730 ha/cumec and 1800 ha/cumec. Find – (a) the discharge of required at the head of the water course
(b) Determine the design discharge at the outlet, assuming a time factor equal to 0.8.

Soln

Area to be irrigated under sugar cane = 1200 x 20% = 240 ha
" " " " Wheat = 1200 x 40% = 480 ha

Discharge for sugarcane $= \frac{240}{730} = 0.329$ cumec

" " Wheat $= \frac{480}{730} = 0.271$ cumec

Discharge reqⁿ at the head of water course $= (0.329 + 0.271) = 0.6$ cumec (Ans)

Sugarcane ১২ মাস পানি দেওয়া লাগে
আর wheat 6 মাস " " "

(b) Design Discharge $= \frac{0.6}{0.8} = 0.75$ cumec (Ans)

(99) At a place, the transpiration of the rice takes 16 days and total depth of water required by the crop is 60cm on the field. During the transpiration period of 16 days, rain starts falling and about 10 cm of rain is being utilised to fulfill the rice demand. Find the duty of the irrigation water required for rice during transplantation period.

(a) Assuming, 25% losses of water in water courses, Find the duty of water at the head of water course.

(b) Also Find duty for 15% losses at the head of the water course.

Solⁿ

Depth of water required for transplantation of rice $= (60-10) = 50$ cm

$\therefore$ Duty $= 864 \frac{B}{\Delta} = 864 \times \frac{16}{50} = 276.5$ ha/cumec

(a) For 25% losses, Duty $= 0.75 \times 276.5 = 207.4$ ha/cumec (Ans)

(b) For 15% " , Duty $= 0.85 \times 276.5 = 235.03$ ha/cumec (Ans)

40th BCS

(96) A pump is installed on a well to left water and to irrigate rice crop, sown over 3 ha of land. If duty of rice is 864 ha/cumec on the field & pump efficiency is 48%. Determine the minimum required input (HP) of the pump, if the lowest well water level is 8 m below the highest portion of the field. Assume, negligible field channel.

Solⁿ

Discharge required for rice for fulfilling duty demand $= \frac{3}{864}$

$= \frac{1}{288}$ cumec

Volᵐ of water lifted per second $= \frac{1}{288}$ m^3

wt of " " " " $= \frac{1}{288} \times 9.81 = 0.0341$ KN/sec

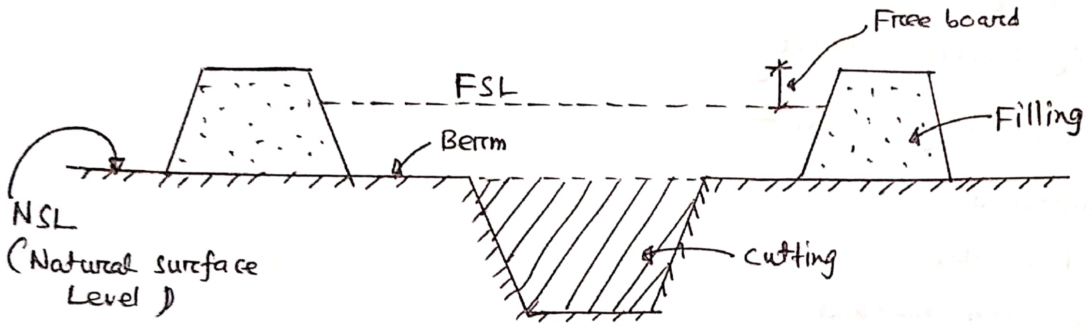
Min. Static Lift of pipe $= 8$ m

Work done = 0.0341 × 8 = 0.273 KNm/sec
= 0.273 KWatt

∴ output of pump = $\frac{0.273 \times 10^3}{746}$ = 0.37 H.P

∴ Input of pump = $\frac{0.37}{0.48}$ = 0.77 H.P (Ans)

Cross section of irrigation channel



Berm

The narrow strip of the Land at the ground level between the inner toe of the bank and top edge of the cutting is Known as berm

purpose ⇨
* provide a bigger waterway.
* provide scope for future widening of canal.
* protect the bank from erosion.

Flood

- Write down the four types of flood normally occurs in Bangladesh. [B-]
- What structural measures are taken to prevent the city from flood?
- The Lowest floor including the basement of any building Located in flood prone area shall not be Located below the design flood Level Complying few requirement, what are those? [B-250]
- Write down the total international river in Bangladesh and which river come from India & Myammar. [B-274]
- What are the condn of flood in BD? What measures can be taken to prevent flood? [B-328]
- BCS Design flood? Explain the various methods for estimating the design flood of a catchment. [B-397]
- BCS Explain principle cause of flood & possible remedial measures for flood mitigration. [B-398]
- BCS Short notes ⇒ watershed management, Flood plain zonning, Artesian aquifer, Design flood, Flood control, Flood prevention, Flood protection, Flood management, Flood proofing.
- BCS Discuss the advantages & ill-effects of Embankment as a measure for flood management.
- BCS Flood? Design flood? State the various causes of flood.

Flood

BCS
Flood is a natural phenomena and it is water related disaster. If an area goes under water and even remains so far sometimes then it is called inundation. When this inundation causes demage to property, disrupts communication and bring harmful effects then it is called flood.

BCS
Causes of flood –

* Geographical Location & climate pattern
* Exeessive rainfall
* melting of ice
* The influences of tides & cyclones
* Reduction of river capacity

BCS
Method of estimating flood –

* Rational method
* Emperical Formulae
* Unit Hydrograph method
* Flood frequency studies

Rational Method

$$Q_p = CIA$$

Q_p = peak discharge / ~~Runoff~~ (m^3/s)

C = Co-efficient of runoff

$$= \frac{\text{Total runoff vol}^m}{\text{Total rainfall vol}^m}$$

i = intensity of rainfall

$$= \frac{\text{depth of rainfall}}{\text{time}}$$

* Kirpich Equation,

Time of concentration, $t_c = 0.01947 L^{0.77} S^{-0.385}$

t_c (min)

L → Length of travel time (m)

S → catchment slope.

(92) An urban area has a runoff co-efficient of 0.3 and an area of 0.85 km^2. The slope of the catchment is 0.006 & maximum Length of the travel of water is 950m. The max. depth of rainfall along with durations for a 25 year return period are given below:

Duration (min)	5	10	20	30	40	60
Depth of rainfall (mm)	17	26	40	50	57	62

Estimate the required peak flow rate for the catchment for a 25 yr return period.

Soln

$t_c = 0.01947 L^{0.77} S^{-0.385} = 0.01947 \times (950)^{0.77} (0.006)^{-0.385} = 27.4$ min

From table, depth of rainfall = 47.4 mm

$\therefore$ rainfall intensity, $i = \frac{47.4}{27.4}$ mm/min $= 2.883 \times 10^{-5}$ m/s

Peak flow rate, $Q = CIA = 0.3 \times 2.883 \times 10^{-5} \times (.85 \times 10^6) = 7.35\ m^3/s$ Ans

*** (60) Rain water: Area of roof 20 m^2, rainfall intensity 10mm/day, run off co-efficient 0.8 given, what will be the quantity?

Soln

$i = 10$ mm/day $= \frac{1}{8640000}$ m/s

$Q = CIA$

$= 0.8 \times \frac{1}{8640000} \times 20$

$= 1.852 \times 10^{-6}\ m^3/s$ Ans

*** (62) Rainfall intensity is 2.4 m/year, Run off co-efficient is 0.7. Find out the minimum catchment area for the daily water demand is 15 Lpcd of 7 people

Soln

$Q = 15 \times 7$ L/day $= 1.215 \times 10^{-6}\ m^3/s$

$i = 2.4$ m/yr =

$Q = CIA$

$\Rightarrow 1.215 \times 10^{-6} = 0.7 \times \frac{2.4}{365 \times 24 \times 3600} \times A$

$\Rightarrow \boxed{A = 22.81\ m^2}$ (Ans)

** (63) A storm with 10 cm precipitation has direct runoff 60,000 m^3/s in a 10 Km^2 catchment area. Calculate Rainfall & Runoff co-efficient. [B-51]

i = 10 cm (Let)

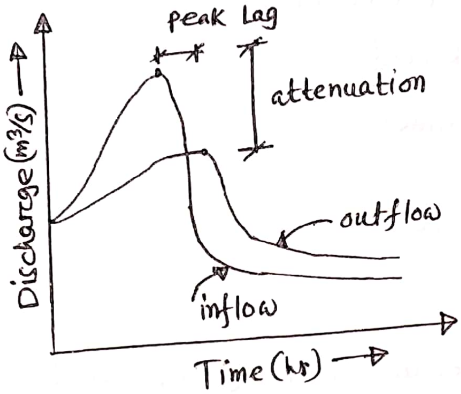
*** (64) The value of total direct run off volm of catchment 6×10^3 m^3. If rainfall depth is 8 cm & 0.5 is the run off co-efficient. Determine, the catchment area in Km^2?

$$Q = C*i*A$$

$$Volm = C*h*A \qquad [i = h/t]$$

Attenuation

The peak of the outflow hydrograph will be smaller than that of the inflow hydrograph. This reduction in the peak value is called attenuation.



Chance Flood

If a flood of a given magnitude occurs with an average frequency of 100 years, then there exist $\frac{1}{100} \times 100 = 1\%$ chance and is called 1 % chance flood.

Probability of occurance & exceedance, P ⇒

The probability of occurance of a flood equal to or greater than 100 years.

$$P = \frac{1}{100} = 0.01 \; ; \quad F = 100$$

Probability of non-occurance

$$q = 1 - P = 1 - \frac{1}{F}$$

*** (68) 170 floods have occured in 120 years of record. it is desired to find out the chance of flood having a frequency of 1000 years?

Soln

Flood in one year $= \frac{170}{120}$

" " 1000 " $= \frac{170 \times 1000}{120}$

∴ chance ~~of~~ for 1000 years frequency flood $= \dfrac{1}{\frac{170 * 1000}{120}} * 100\%$

$= 0.07\%$ (Ans)

*** Design flood
Flood adopted for the design of a structure.

*** Structural measure for controlling flood

* Storage & detension reservoir
* Levees (Flood embankment)
* Flood ways (new channel)
* Channel improvement
* Watershed management

Risk & Reliability

The probability of occurrance of an event at least once over period of n successive year is called the risk ($\bar{R}$)

$$\bar{R} = 1-(1-P)^n$$
$$= 1-(1-\tfrac{1}{T})^n$$

T = Return period
Probability, $P = 1/T$

Reliability, $Re = 1-\bar{R}$

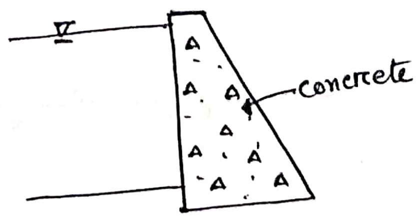
*** (bq) A bridge has an expected life of 25 years and is designed for a flood magnitude of return period 100 years.
(i) What is the risk of this hydrologic design?
(ii) If 10% risk is acceptable, what return period will have to be adopted?

Soln

(i) $\bar{R} = 1-(1-p)^n = 1-(1-\frac{1}{100})^{25} = 22.2\%$ Ans

(ii) $\bar{R} = 1-(1-p)^n \Rightarrow 0.10 = 1-(1-\tfrac{1}{T})^{25} \Rightarrow T = 237.78$ years (Ans)

Flood walls ⇒ Mansonry structures used to confine the river in a manner similliar to Levee is known as flood walls



*** Flood plain ⇒ The total area which is affected by a flood is called flood plain.

Flood routing

Flood routing is the technique of determining the flood hydrograph at a section of a river by utilizing the data of flood flow at one or more upstream sections.

- Reservior Routing
- Channel Routing

Flood ways

Flood ways are natural channel, into which a part of the flood will be diverted during high stages of flood.

BCS

Levees / Dikes / Flood Embankment

These are earthen banks constructed parallel to the course of the river to confine it to a fixed course and limited cross sectional width.

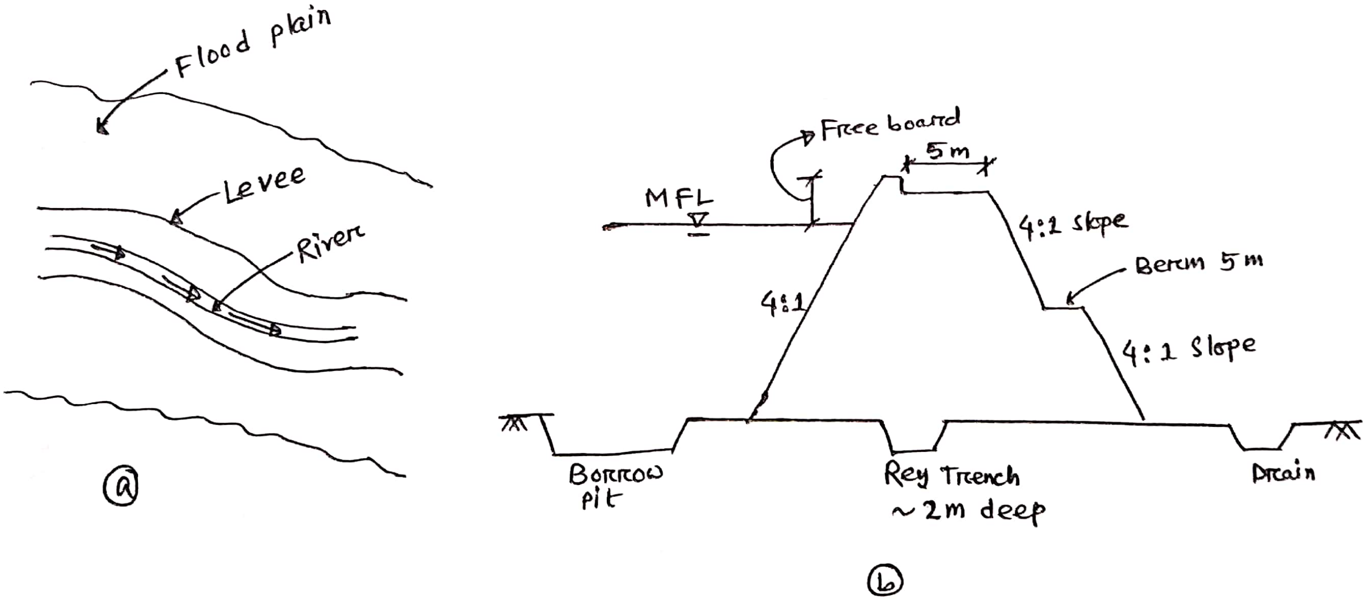


Fig: A typical Levee ⓐ plan ⓑ cross section.

Flood and Its Management

- Disaster is a natural or human , caused phenomenon, which causes serious disruption of the functioning of a community or a society causing widespread human, material, economic and environmental losses which elicited the ability of the affected community, society to cope using its resources.
- Floods are a common feature in the Bangladesh that occur every year in many parts of the country.
- Floods are natural phenomena and it is water related disaster

What is Flood?

- If an area goes under water and even remains so far some time then it is called inundation
- When this inundation causes damage to property and like disrupts communication and bring harmful effects then it is called flood.
- This is a major problem in Bangladesh
- A flood occurs when the Geomorphic Equilibrium in the river system is disturbed because of intrinsic or extrinsic factors or when a system crosses the geomorphic threshold.
  - (a) Flooding in a river due to aggradation of river bed (intrinsic)
  - (b) Flooding in a river due to heavy rainfall (extrinsic)
- Floods in major cities especially during rainy season are proving too disastrous not only to the environment but also have serious implications for human life and property.

Types of Floods:

- Flash floods
- River floods
- Coastal Floods
- Urban Flood

- **According to their duration flood can be divided into different categories:**
  - **Slow-Onset Floods:** Slow Onset Floods usually last for a relatively longer period, it may last for one or more weeks, or even months.
  - **Rapid-Onset Floods:** Rapid-Onset Floods last for a relatively shorter period, they usually last for one or two days only.

- ❖ **Flash Floods:** Flash Floods may occur within minutes or a few hours after heavy rainfall, tropical storm, failure of dams or levees or releases of ice dams. And it causes the greatest damages to society.

Flash Flood:

- ➢ Flash floods happen in a short time, they have a great volume of water, and are local floods.
- ➢ The runoff of intense rain results in high flood waves.
- ➢ Flash floods result in failure of dams and more.
- ➢ It usually happens in desert areas and mountain regions.
- ➢ They are a threat in steep land, high runoff rates, thunderstorms, and narrow streams.

River Flood:

- ➢ River floods are caused by melting of snow and precipitation over large areas.
- ➢ They take place in rivers.
- ➢ Floods in large rivers take hours to days.
- ➢ The ground conditions effects the runoff.

Coastal Flood:

- ➢ Coastal floods are caused by tides, storms, tropical cyclones, or tsunamis.
- ➢ These floods happen in the ocean and affects the general public and maritime interests along the coastline.
- ➢ These are caused by heavy surf, tidal piling, and storm surges,
- ➢ Other factors are tidal cycles, behaviors of the storm, river or stream runoff, no offshore reefs or other barriers, and high winds.

Urban Flood:

- ➢ Urban floods are when the land is turned from fields or woods into roads and parking lots. Since this happens it can't absorb the rainfall.
- ➢ During the urban floods all the streets become rivers and basements become full of water, they are death traps.
- ➢ Ice Jam is floating ice that adds up at a man-made or natural area and stops the flow of water. This causes the area to flood.

Causes of Floods:

- ➢ Silting in the river bed
- ➢ Inadequate capacity within the banks
- ➢ River bank erosion
- ➢ Flow obstruction and change in the river course

- Common floods in the main and tributary rivers
- Poor natural drainage
- Cyclones
- Retardation of flow and back water effect
- Heavy rainfall

Natural Factors:

- Due to bank erosion
- Earthquake loosening the soil
- High runoff or rise in the water level
- Silting of river bed due to bank erosion
- High discharge of water due to rain shifting river courses
- Landslides
- Falling of the trees
- Flash flood due to high discharge in the main river
- Obstruction of the natural drainage
- High precipitation
- High runoff

Man-made Factors:

- Due to dams, embankments and bunds construction
- Decrease in bank height
- Decrease in vegetative cover due to deforestation
- Construction activities in the river bed
- Breaking of bunds constructed on the tributary river for irrigation purposes
- Rapid urbanization which causes pressure on the drainage system
- Inadequate drainage capacity and urbanization in the low lying areas

Main causes of floods may be summarized as follows:

- excessive rainfall leading to run-off in excess of safe channel conveyance capacity;
- deterioration of drainage channel by natural siltation, shoal formation, or obstructions;
- drainage congestions due to faulty or unplanned development activities and encroachment on flood plains;
- effect of construction of embankments, causing increases in flooding elsewhere;
- deforestation in upper catchment areas;
- flat topography of the country which slows drainage rate;
- rise in sea level due to monsoon wind;

- coincidence of peak flow of major rivers causing congestion at confluences;
- failure of water retaining structures, dams etc.;
- tidal surges and sea waves; and
- Global climate change.

Ill effects of flood:

- Damage crops in the field and disrupt normal agricultural cycle
- Cause death to live stock.
- Render thousands homeless
- Pose serious threats to nutrition
- Causes various diseases.
- disrupts communication etc
- Human Loss
- Property Loss
- Affects the Major Roads
- Disruption of Air / Train / Bus services
- Spread of Water-borne Communicable Diseases
- Communication Breakdown
- Electricity Supply Cut off
- Economic and Social Disruption
- Increase in Air / Water Pollution
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Major floods occurred in Bangladesh:

- Bangladesh is a country with many rivers. Flooding in this area is common and necessary so it could fertilize from deposits of fresh alluvium.
- Fresh alluvium is soil that is deposited by moving water.
- In the fall of 1974 flooding was extended over one half of the country and stayed this way for over a month.
- At least 1,200 people had died in the floods and 27,500 died from diseases and starvation. 425,000 houses were destroyed and destroyed agriculture.
- The cost of damages were 325.9 million in U.S.
- 36 million were affected by this huge flood.

<u>Damages from a flood event depend on the following factors</u>:

- location (urban and rural areas need to be treated separately);
- depth (growth stage of crops is to be considered);
- duration (paddy can tolerate submergence for few days);
- timing (crop calendar is important here); and
- extents of flooding.

<u>Planning for disaster management</u>:

a. Pre-disaster mitigation: This includes measures to reduce the impact of or prevent a flood event. Examples range from structural measures to public education.
b. Pre-disaster preparedness: At this stage a response plan for the flood is developed in advance; a warning system for flood is installed and the people responsible for preparedness are trained; the institutional mechanism for implementation is specified.
c. Response to disaster: This includes activities which are undertaken during and immediately after flood, such as emergency aid, evacuation to pre-designated shelters, flood fighting; and assistance and taking measures for minimizing secondary damage and recovery operations.
d. Post-flood recovery: At this stage support is provided for a return to vital life-support system to minimum operation levels, which is continued until the community returns to normal life.

These stages are however inter-related.

<u>Options for flood damage mitigation:</u>

Measures that can be adopted for flood damage mitigation can be classified into two categories~

(i) direct or structural measures and
(ii) Indirect or non-structural measures

<u>Structural measures for flood control</u>

Structural measures can be divided into six categories:

- storage reservoir or detention basins for impounding of excess runoff;
- retarding basin to lower the level of flooding downstream:
- levees and flood walls to confine flood waters within areas immediately adjacent to the rivers or sea:

- improvement of channel capacity by channel improvement and removing obstructions to flow;
- floodway or flood diversion through by-passes aimed at diversion of excess flows causing flood; and
- watershed management.

Non-structural Methods:

Broadly, there are seven types of non-structural measures~

- flood forecasting and warnings;
- flood-fighting;
- flood-proofing;
- rescheduling of reservoir operations;
- evacuation and post flood recovery programs;
- flood insurance; and
- flood plain zoning.

Conclusion:

- Flooding is a natural phenomenon, which can not be prevented .
- Complete flood control is not in the interests of most Bangladeshi farmers.
- The flood control measures and policies should be direct to mitigation of flood damage rather than flood prevention.
- To minimize flood losses, the following steps may be taken.

i) increasing the forecast lead time by strengthening the flood and warning system through the installation of effective equipment for collection of hydrological and meteorological data and through adequate training for related personnel:

ii) setting up an efficient system for the dissemination of flood warning;

iii) encouraging the introduction of zoning laws, especially in urban areas and areas covered by newly-built water-control structures;

iv) education of the public about flood hazards, especially through the development of flood-risk maps;

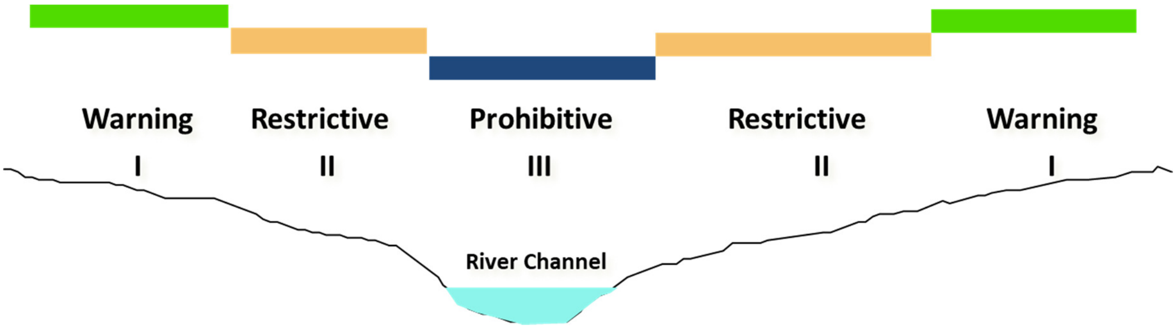
v) the inclusion of disaster relief and preventive health measures in development programs;

vi) the maintenance of an effective infrastructure for emergency relief operations;

vii) where reservoirs have been constructed its operational pattern may be properly designed and monitored so that artificial flood is not created at downstream locations;

viii) where embankments/polders have been constructed, its maintenance is essential to have it effective during flood events. Involvement of local people in planning, design, construction and maintenance of new embankments must be ensured.

Flood Plain Zoning



Flood Plain Zoning: Concept

- An important non-structural measure.
- Regulates land use in flood plains to restrict damage by floods.
- Involves demarcation of zones in flood plains compatible with flood risks involved.

Flood Plain Zoning: Zone Regulation

Priority - I

Activity limited to water levels corresponding to 100 years flood frequency and drainage congestion for 50 years rainfall.

Flood frequency 100 yr
Rainfall Frequency 50 yr

Priority - II

Activity limited to levels corresponding to 25 years flood frequency and drainage congestion for 10 years rainfall frequency.

Priority – III

Less economic and community activity in areas vulnerable to frequent floods.

The main reasons for the failure of any flood management policy are:

- lake of adequate funds for undertaking mitigation, warning recovery and preparedness program ; thus ad-hoc measures are taken only when flood arrives,
- Often difficult to implement long term program and sustain them as the pressure fades away after occurrence of a disaster;

- Flood problems are technically complex and prediction of next occurrence of a major event is difficult; and
- Inter-government and inter-organizational management problem that undermines concerned and integrated to a flood event.

<u>List of possible impacts on water resources system of Bangladesh:</u>

1. Reduction of water in the Brahmaputra River would affect the followings:
    - Change in morphology (Bank erosion and Deposition)
    - Water holding capacity of the Beels in the NW region
    - Ground water storage
    - Recharge of wetlands and ground water
    - Inflow to the Padma and lower Meghna
    - Tidal propagation in the lower Meghna, Meghna and Padma
    - LLP irrigation
    - Navigation
    - Open fisheries
    - Forestry
    - Industry
2. Reduction of flow of the Teesta and Other rivers in the NW region:
    - Agriculture in the NW region (Teesta Barrage: Present 111,000 ha, Phase II 408,000 ha)
3. Increased salinity intrusion in the lower Meghna:
    - Agriculter in the SE and SC regions
    - Haors in the NE region
    - Forestry
    - Fresh water fisheries
4. Draining of wetlands:
    - Fish, bird and wildlife habitats
    - Aquatic plants
    - Biodiversity
5. Water scarcity would effect the following major irrigation projects:
    - Teesta barrage project in NW region
    - Chandpur and Meghna-Dhonagoda project in the SE region

- Bhola and Barisal projects in the SC region
- GK project in SW region (already afftected by the Farrakka diversion)

6. Risk of catastrophic flood
    - Flooding due to water release during high rainfall
    - Flooding due to failure of dam
7. Intensification of adverse impacts in the long term by climate change

River Training

BCS ① River training? its objectives?

BCS ② Name important types of river training method and indicate the purpose for which each type is adopted.

BCS ③ Give a typical plan & sections of a guide bank & discuss it design procedure step by step. [G-601]

BCS ④ Short notes ⇒ Berms & counter Berms, Balancing depth, Water losses in irrigation canal, ill effect of irrigation

BCS ⑤ What are cut-offs? How are they artificially induced? What are the advantages & disadvantages? [B-262]

BCS ⑥ What is spur? Explain the different type of spur based on their alignment with neat sketch. [G-722]

⑦ How does the groynes protect the river bank from erosion or Breaking? [B-10]

⑧ Draw the plan & cross section of meander & braided river? [B-258]

Others

① What are the factors acting on gravity dam? [B-85]

② Draw the cross section of the dam to protect a city? [B-10]

③ What is water dam? Write down a purpose of constructing a dam. [B-252]

④ Differentiate ⇒ (i) Dam & Embankment [B-324]
(ii) Bridge & culvert. [B-349]

⑤ Sketch the Fig. ⇒ (i) Aqueduct section
(ii) plan of silt excluder [B-52]
(iii) Shaft spillway

⑥ sketch flow profile ⇒
(i) Mild slope - Milder slope
(ii) Milder slope - Steeper slope
(iii) Steeper slope - Mild slope
(iv) Horizontal slope to vertical slope
[B-379]