2. DESIGN OF STABLE CHANNELS

KENNEDY'S THEORY

- Design Steps

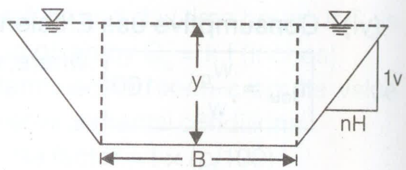
(i) $\boxed{V_0 = 0.55\,m y^{0.64}}$ where, V_o = Critical velocity
y = Trial depth
m = Critical velocity ratio

(a) $\boxed{m = \dfrac{V}{V_0}}$ where, V = Actual mean velocity.

m = 1 → For standard particles of upper Baridoab.
m = 1 to 1.2 → For Coarser Sediments.
m = 0.7 to 1.0 → For finner particles.

(b) y = 1 m → when $0 \le Q \le 20$ m³/sec.
y = 2 m → when $20 \le Q \le 40$ m³/sec.
y = 2.5 m → when $40 \le Q \le 80$ m³/sec.
y = 3.0 m → when $80 \le Q \le 100$ m³/sec.

(ii) $\boxed{A = \dfrac{Q}{V_o}}$ and $\boxed{A = (B + ny)y}$ → Get 'B'



where, A = Area, (m²)
Q = Discharge (m³/sec)
V_o = Critical velocity.

(iii) $\boxed{P = B + 2y\sqrt{n^2 + 1}}$

(iv) $\boxed{R = \dfrac{A}{P}}$ where, R = Hydraulic mean depth.

(v) $\boxed{V = C\sqrt{RS}}$

(a) $$C = \dfrac{23 + \dfrac{0.00155}{s} + \dfrac{1}{N}}{1 + \left(23 + \dfrac{0.00155}{s}\right)\dfrac{N}{\sqrt{R}}}$$

(b) $\boxed{\dfrac{1}{3500} \le S \le \dfrac{1}{5000}}$

(vi) If $\boxed{V \simeq V_0}$ then O.K.

LACEY'S THEORY

- Design Steps:

(i) $\boxed{V = \left[\dfrac{Qf^2}{140}\right]^{1/6}}$ where, V = Velocity in m/s
Q = Discharge in cumec (m³/sec)
f = Silt factor

(a) $\boxed{f = 1.76\sqrt{d_{mm}}}$ where d_{mm} = dia in 'mm'.

(ii) $\boxed{R = \dfrac{5}{2}\cdot\dfrac{V^2}{f}}$

(iii) $\boxed{P = 4.75\sqrt{Q}}$ and $\boxed{P = B + 2y\sqrt{n^2 + 1}}$ → Get equation (i) where, P = Perimeter

(iv) $\boxed{A = \dfrac{Q}{V}}$ and $\boxed{A = (B + ny)y}$ → Get equation (ii) where, A = area.

Solve equation (i) and (ii) get B and y.

(v) $\boxed{S = \dfrac{f^{5/3}}{3340 \cdot Q^{1/6}}}$ where S = bed slope.

(vi) $\boxed{\text{Lacey regime scour depth} = 1.35\left(\dfrac{q^2}{f}\right)^{1/3}}$

LINDLEY'S THEORY

$\boxed{V = 0.567 \cdot y^{0.57}}$, $\boxed{V = 0.274 \cdot B^{0.355}}$ and $\boxed{B = 7.76 y^{1.61}}$

LINING OF CANALS

(a) Annual Benefits

$\boxed{\text{Total annual benefits} = mR_1 + PR_2}$

where R_1 = Irrigation water sold to the cultivator at a rate ₹R_1/cumec.
m = Cumec of water is saved by lining the canal annually.
R_2 = Rate of maintenance cost in rupees per year.
P = % (fraction) of saving achieved in maintenance cost by lining the canal.
≃ 0.4.

(b) Annual Costs

$$\text{Total annual cost of lining} = \frac{C}{y} + \frac{C}{2}\left(\frac{r}{100}\right)$$

where, C = Capital expenditure required on lining

y = Life of lining

$\frac{C}{y}$ = Annual depreciation charge in rupees

r = Rate of interest (%)

$\frac{C}{2}\left(\frac{r}{100}\right)$ = Annual Interest

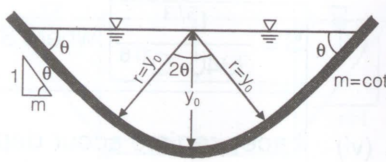
(c) $$\text{Benifit cost ratio} = \frac{mR_1 + PR_2}{\frac{C}{y} + \frac{C}{2}\left(\frac{r}{100}\right)}$$

DESIGN OF LINED CANALS

A. Triangular Section

- Used when

$Q \leq 150$ cumec



(i) $A = y^2(\theta + \cot\theta)$

(ii) $P = 2y(\theta + \cot\theta)$

(iii) $R = \frac{A}{P} = \frac{y}{2}$ where, A = Area (m²)

y = Central depth = Radius of circle

θ = Angle

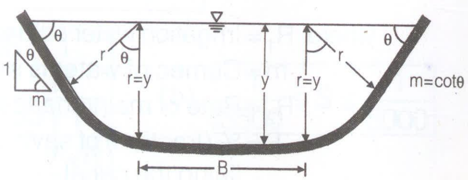
R = Hydraulic mean depth.

B. Trapezoidal Section

$A = By + y^2(\theta + \cot\theta)$

$P = B + 2y(\theta + \cot\theta)$

$R = \frac{A}{P}$



SEDIMENT TRANSPORT MECHANICS

(i) Du-Bois Formula

$$q_b = k_b \cdot \tau_0(\tau_0 - \tau_c)$$

where, q_b = Bed load (volume) transported in m³ per second per unit width of channel.

τ_o = Average shear stress on the channel boundary. (N/m²)

τ_c = Minimum shear stress required to move the grain called shear stress. (N/m²)

k_b = A constant depending upon the grain size & given as.

$$k_b = \frac{0.178}{(d)^{3/4}}$$ where d is effective grain dia in mm

(ii) Shield's Formula

$$\frac{q_b}{q} = \frac{\gamma \cdot d(S_s - 1)}{10(\tau_0 - \tau_c)}$$ where, $\frac{q_b}{q}$ = Load carrying capacity.

q_b = Bed load transported in m³/sec.

S_s = Specific gravity of the bed grain.

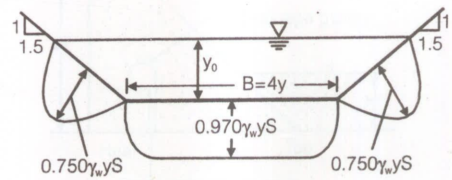
q = Discharge per unit width in m²/s

γ = Unit weight of fluid in kN/m³.

d = Dia of bed grain in meter.

DESIGN OF UNLINED CANAL

(i) $\tau_0 = \gamma_w RS$



where, S = Channel longitudinal slope

R = Hydraulic mean depth

τ_0 = Tractive stress (shear stress) at the channel bottom when water flows through the channel.

(ii) $\boxed{\tau_0' = 0.75\gamma_w RS}$

where, τ_0' = Average tractive stress at the channel side.

γ_w = Unit weight of water in kN/m^3.

(iii) For No Sediment Movement

$\boxed{\tau_0 \le \tau_c}$ where, τ_c = Critical tractive stress.

(iv) At Channel Bottom

$$\boxed{\tau_c = 0.056\gamma_w \cdot d(S_s - 1)}$$

where, γ_w = Unit weight of water (kN/m^3)

d = Dia of sediments.

S_s = Specific gravity of sediments $\simeq$ 2.65

$$\boxed{\tau_c = \frac{\gamma_w \cdot d}{11}} \text{ at } G = 2.67.$$

(v) At Channel Side

$$\boxed{\tau_c' = \tau_c\sqrt{1 - \frac{\sin^2\theta}{\sin^2\phi}}}$$

where, θ = Sides slope angle

ϕ = Angle of repose of soil.

(vi) For No Scouring

$\boxed{\tau_0 \le \tau_c}$ → For no scouring from channel bottom.

→ $\boxed{d \ge 11RS}$

$\boxed{\tau_0' \le \tau_c'}$ → For no scouring from channel sides.

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