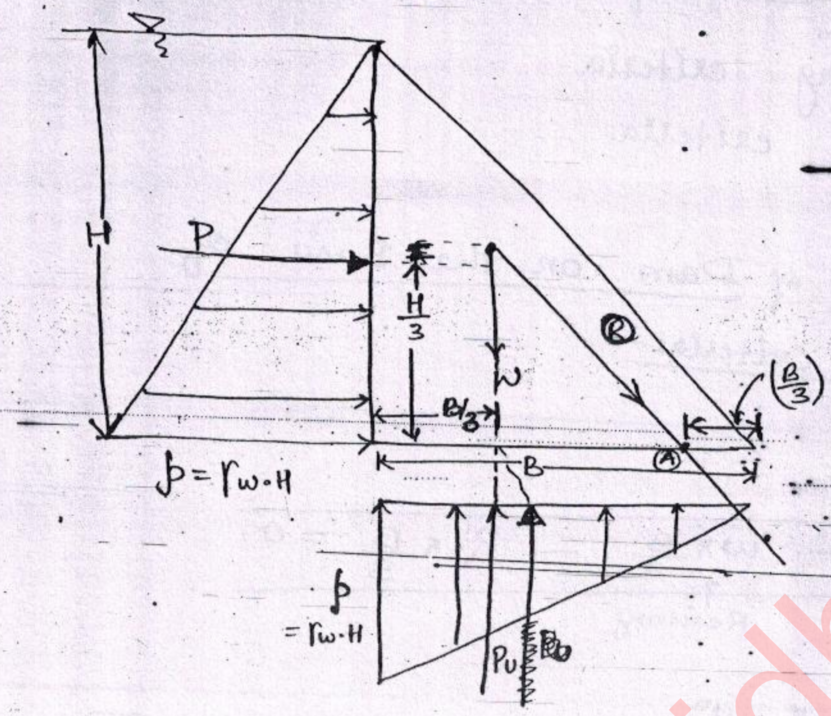
⇒ ELEMENTARY PROFILE OF DAM



→ Elementary profile of the dam is the theoritical profile which is subjected to self wt, water pr and uplift pr. [Note:- Tail water is assumed to be absent].

- If the reservoir is empty the resultant force passes thru the inner $\frac{1}{3}$rd point of the base.

i.e

$$R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2} \Rightarrow \Sigma F_x = 0$$

$$\Sigma F_y = W.$$

$$\therefore \boxed{R = W}$$

[Acts at $\frac{B}{3}$ from Heel.].

- in Reservoir full condition, resultant force passes thru outer $\frac{1}{3}$rd point of the base

$$R = \sqrt{\Sigma F_x - \Sigma F_y}$$

$$\Sigma F_x = P$$

$$\Sigma F_y = W - P_U$$

[$\frac{B}{3}$ from toe.]

- The elementary profile of the Dam is used to calculate the minimum width of the Dam on the Basis of
  - overturning criteria
  - sliding criteria.

1) Minimum Width of Dam on the Basis of overturning criteria:-

$$\Sigma M_A = 0$$

$$\underbrace{-P\left(\frac{H}{3}\right)}_{\text{overturning}} + \underbrace{W \times \frac{B}{3}}_{\text{Resisting}} - P_U \times \frac{B}{3} = 0.$$

$\hookrightarrow P = \frac{1}{2} \cdot \gamma_w \cdot H^2$

$W = \gamma_c \cdot (\frac{1}{2} B \cdot H)(1)$

$G_c = \frac{\gamma_c}{\gamma_w}$

$\hookrightarrow W = \frac{G_c \cdot \gamma_w \cdot BH}{2}$.

$\hookrightarrow P_U = \frac{1}{2} p \cdot B \cdot C$

$= \frac{1}{2} \cdot \gamma_w \cdot H \cdot B \cdot C.$

$$\Rightarrow -\frac{\gamma_w \cdot H^2}{2} \cdot \frac{H}{3} + \frac{G_c \cdot \gamma_w \cdot B \cdot H}{2} \cdot \frac{B}{3} - \frac{\gamma_w \cdot H \cdot B \cdot C}{3} \cdot \frac{B}{3} = 0$$

$$-H^2 + G_c B^2 - B^2 C = 0$$

$$B^2 (G_c - B) = H^2$$

$$\boxed{B = \frac{H}{\sqrt{G_c - 1}}}$$

C = uplift intensity factor

$$B = \frac{H}{\sqrt{G_c - C}}$$

for (B) to be minimum

$C = 0.$

$$B_{min} = \frac{H}{\sqrt{G_c}}$$

$$B_{min} = \frac{H}{\sqrt{2.4}}$$

$$\boxed{B_{min} = 0.64\,H}$$

↳ Minm Width using Overturning criteria.

↳ H = Height of Dam = Height of water in Dam which is decided based on capacity.

(II) MINIMUM WIDTH ON THE BASIS OF SLIDING CRITERIA:-

for No sliding,

$$f \geq \Sigma F_H$$

$$\mu \cdot \Sigma F_V \geq \Sigma F_H$$

$$\mu \cdot (W - P_U) \geq \Sigma F_H.$$

$$\mu \cdot (W - P_U) \geq P$$

$$\mu \left(\frac{G_c \cdot \gamma_w \cdot B \cdot H}{2} - \frac{\gamma_w \cdot B \cdot H \cdot C}{2} \right) \geq \frac{\gamma_w \cdot H^2}{2}.$$

$$\mu (G_c \cdot B - BC) \geq H.$$

$$B \mu (G_c - C) \geq H$$

$$\boxed{B \geq \frac{H}{\mu (G_c - C)}}$$

for B to be min.

$c = 0$, $\mu = 0.7$

$G_c = 2.4$

$$B_{min} = \frac{H}{0.7 \times 2.4}$$ $\boxed{B_{min} = 0.595\, H}$

↳ on the basis of sliding

⇒ Minimum Width is adopted as the Max^m of the values calculated from overturning & sliding criteria.

Note → If in question some value of c is given, than also the min^m width is calculated using c=0. Thats the absolute min^m width.

⇒ PRINCIPAL & SHEAR STRESSES IN ELEMENTARY PROFILE OF DAM :-

(1) Reservoir full condition

(a) $\boxed{\text{At toe}}$.

$$\sigma_{VT} = \frac{\Sigma F_V}{B}\left(1 + \frac{6e}{B}\right)$$

$$\Sigma F_V = W - P_U$$

$$\Sigma F_V = \frac{G_c \cdot \gamma_w \cdot B \cdot H}{2} - \frac{\gamma_w \cdot BHC}{2}.$$

$$\bar{x} = \frac{B}{3} \Rightarrow e = \frac{B}{2} - \frac{B}{3} = \frac{B}{6},$$

$$\sigma_{VT} = \frac{\gamma_w \cdot BH}{2}\left(\frac{G_c - C}{B}\right)\left[1 + 6 \times \frac{B}{6} \times \frac{1}{B}\right]$$

$$\boxed{\sigma_{VT} = \gamma_w \cdot H\,(G_c - C)}$$ vertical stress at toe

$$\sigma_T = \sigma_{VT} \cdot \sec^2\alpha - p_2 \tan^2\alpha .$$

$$p_2 = \gamma_w \cdot H_2 = 0$$ as tail water is absent in elementary profile analysis.

$$\tan\alpha = \frac{B}{H}.$$

$$\sigma_T = \gamma_w \cdot H \cdot (G_c - C)\left(1 + \frac{B^2}{H^2}\right) - 0\left(\frac{B}{H}\right).$$

$$\sigma_T = \gamma \cdot H \cdot (G_c - C)\left(1 + \frac{B^2}{H^2}\right).$$

$$\left\{B = \frac{H}{\sqrt{G_c - C}}\right\}$$

$$\sigma_T = \gamma \cdot H\,(G_c - C)\left(1 + \frac{1}{(G_c - C)}\right)$$

at toe

$$\boxed{\sigma_T = \gamma_w \cdot H\,(G_c - C + 1)}$$

Major principal stress when Reservoir is full. for elementary profile.

SHEAR STRESS:-

$$q_T = (\sigma_{VT} - p_2)\tan\alpha$$

$$q_T = (\gamma_w \cdot H\,(G_c - C) - 0)\,\frac{B}{H}$$

$$\boxed{q_T = \gamma_w \cdot B \cdot (G_c - C)}$$

or

$$\boxed{q_T = \gamma_w \cdot H \cdot \sqrt{G_c - C}}$$

Shear at toe, for elementary profile, when reservoir is full at toe.

(b) AT HEEL

Vertical stress

$$\sigma_{VH} = \frac{\Sigma F_V}{B}\left(1 - \frac{6e}{B}\right).$$

$$= \frac{\gamma_w \cdot H \cdot B (G_C - C)}{2 \times B}\left(1 - \frac{6}{B} \times \frac{B}{6}\right).$$

$$\boxed{\sigma_{VH} = 0}$$

Vertical stress at heel in full condition at heel = zero.

Major principal stress

$$\sigma_H = \sigma_{VH} \cdot \sec^2\phi - p_1 \cdot \tan^2\phi.$$

$$\boxed{\sigma_H = 0}$$

$\tan\phi = 0 \longrightarrow$ as slant section is not there on upstream side.

Shear stress

$$q_H = (\sigma_{VH} - p_1)\tan\phi$$

$$\boxed{q_H = 0}$$

(ii) RESERVOIR ~~FULL~~ EMPTY CONDITION

(a) AT HEEL

$$\sigma_{VH} = \frac{\Sigma F_V}{B}\left(1 + \frac{6e}{B}\right)$$

$$\Sigma F_V = W = \frac{G_C \cdot \gamma_w \cdot BH}{2} \quad ; \quad e = \frac{B}{6},$$

$$\sigma_{VH} = \frac{G_C \cdot \gamma_w \cdot BH}{2}\left(1 + \frac{6}{B} \times \frac{B}{6}\right)$$

$$\boxed{\sigma_{VH} = G_C \cdot \gamma_w \cdot H}$$

⇒ Major principal stress

$$\sigma H = \sigma VH \sec^2\phi - p_1 \tan^2\phi.$$

$$\phi = 0 \quad ; \quad p_1 = \gamma w \cdot H = 0.$$

$$\sigma H = G_c \cdot \gamma w \cdot H \, (1+0) - \gamma w \cdot H \, (0)$$

$$\boxed{\sigma H = G_C \cdot \gamma w \cdot H}.$$

Note:- the vertical stress and major principal stress are equal because there is no horizontal forse as reservoir is empty

⇒ SHEAR FORCE

$$q_H = (\sigma v H - p_1) \tan\phi$$

$$\boxed{q_H = 0}$$

(b) AT TOE

$$\sigma_{VT} = \frac{\Sigma F_V}{B}\left(1 - \frac{6e}{B}\right)$$

$$\Sigma F_V = W = \frac{\gamma w \cdot G \cdot B \cdot H}{2} \quad ; \quad e = B/6$$

$$\sigma_{VT} = \frac{G_C \cdot \gamma w \cdot B \cdot H}{2 \cdot B}\left(1 - 6 \times \frac{B}{6} \times \frac{1}{B}\right)$$

$$\boxed{\sigma_{VT} = 0}$$

⇛ Major principal stress

$$\sigma_T = \sigma_{VT} \cdot \sec^2\alpha - p_2 \tan^2\alpha$$

$$p_2 = 0.$$

$$\tan\alpha = \frac{B}{H}.$$

$$\sigma_T = 0\left(1 + \frac{B^2}{H^2}\right) - 0\left(\frac{B}{H}\right)^2$$

$$\boxed{\sigma_T = 0}$$

⇛ SHEAR STRESS

$$q_T = (\sigma_{VT} - p_2)\tan\alpha$$

$$= (0 - 0)\frac{B}{H}$$

$$\boxed{q_T = 0}$$

⇛ SUMMARY :

	HEEL		TOE	
	Rfull	Rempty	Rfull	Rempty.
σ_V	0	$G_c \cdot \gamma_w \cdot H$	$\gamma_w \cdot H \cdot (G_c - C)$	0
σ	0	$G_c \cdot \gamma_w \cdot H$	$\gamma_w \cdot H \cdot (G_c - C + H)$	0
q.	0	0	$\gamma_w \cdot H \cdot \sqrt{G_c - C}$	0

Note :- In obj $\boxed{G_c \cdot \gamma_w \cdot H = \frac{2 \cdot W}{B}}$