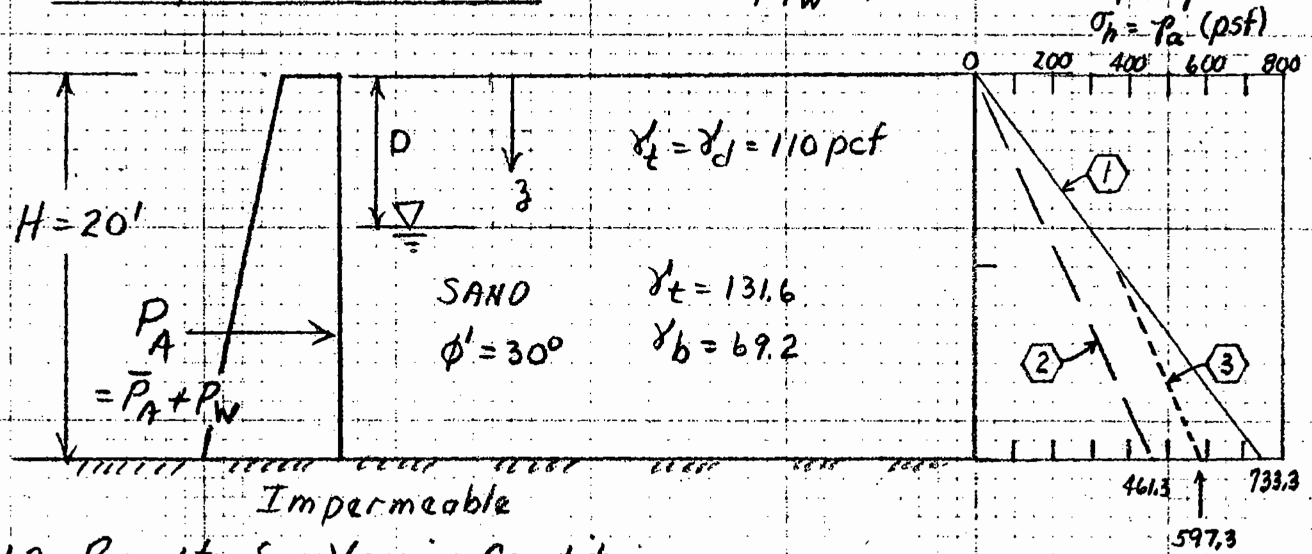
IV-5 LATERAL EARTH PRESSURES

Page No.

Part IV-5 LATERAL EARTH PRESSURES (p1/7) (Chapter 23)

1 COHESIONLESS SOIL: EFFECT OF VARYING WATER CONDITIONS (ACTIVE)

1.1 Example Problem (No wall friction, $\phi_w = 0$)



1.2 Results for Various Conditions

Case	Condition	$\bar{P}_A$ (kips/LF)	P_W (kips/LF)	P_A (kips/LF)	Notes	Note 1) All The Same
1.	Dry (D = 20')				1)	
2.	Submerged (D=0)				1) 2)	
3.	W.T. at D=10'				1) 2)	
4.	W.T. at D=0' Horizontal Drain				1) 3) 4)	
5.	W.T. at D=0' Vertical Drain				1) 3)	

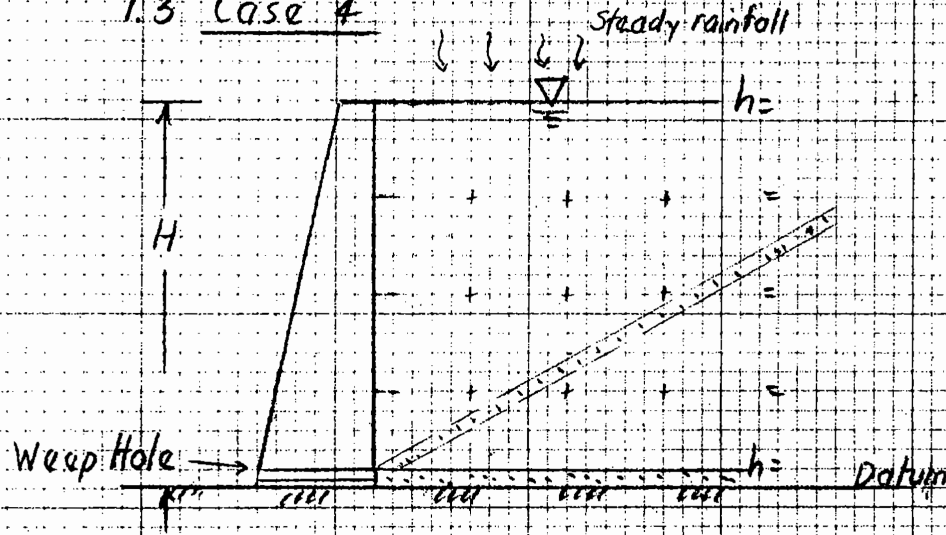
1) $\bar{P}_A = \frac{1}{2}\bar{\gamma} H^2 \{K_a = \tan^2(45 - \phi'/2)\}$ vs. Rankine Mohr circle vs. Coulomb

2) Conclude P_w very important 3) ∴ Need drainage to reduce P_w

4) Horizontal vs sloping drain ("value engineering")

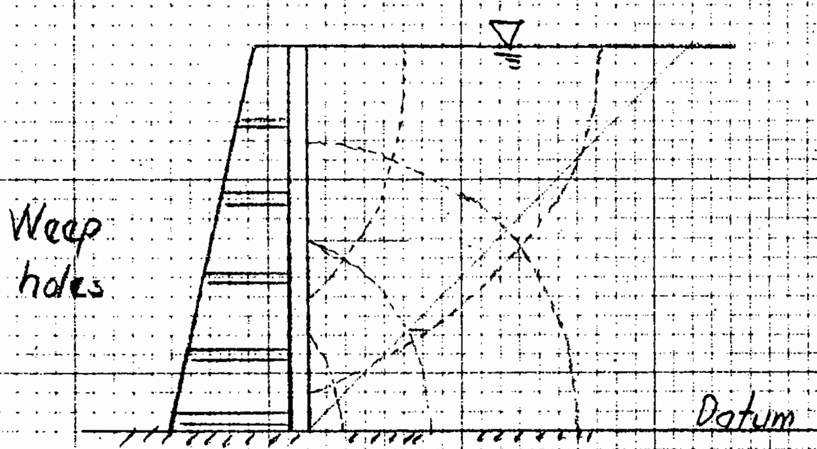
Part IV - 5 EARTH PRESSURES (p.2/7)

1.3 Case 4



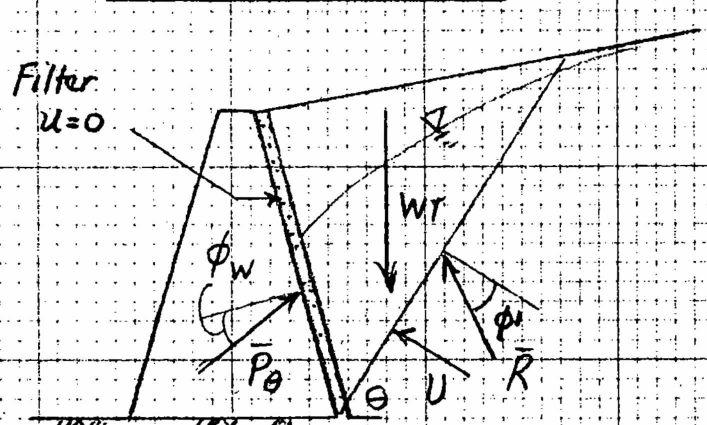
- Flow net
- $i =$ $u =$
- $\bar{\gamma} = \gamma_b + j =$
- $\bar{P}_A =$
- Sloping drain
- Rankine applies?

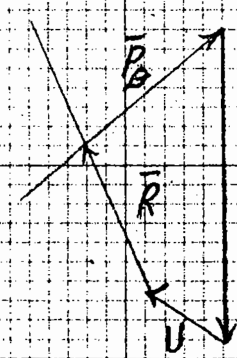
1.4 Case 5 (Ex 23.6)



- Boundary flow {equipotential
- Flow net
- Rankine applies?
- $\bar{P}_A =$
- $P_W =$

1.5 Coulomb - General





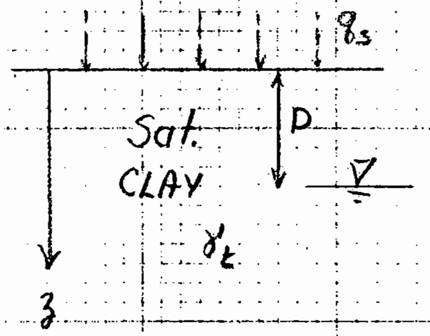
Vary $\theta \rightarrow \bar{P}_A$ maximum

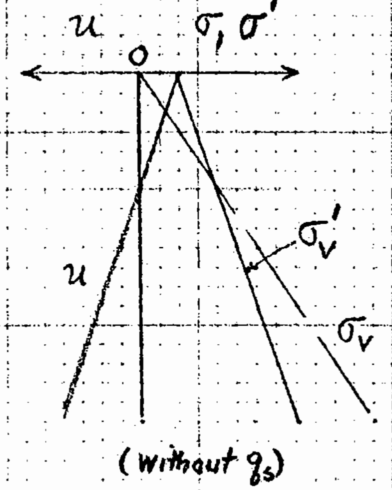
Part IV - 5 EARTH PRESSURES (p 3/7)

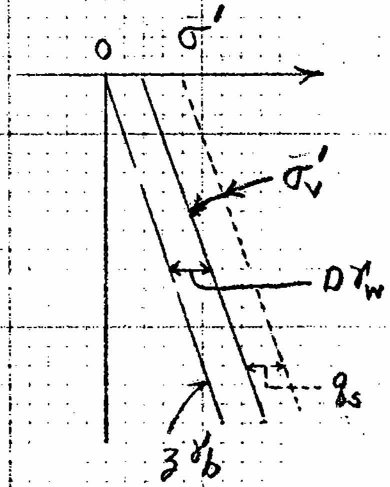
2. COHESIVE SOILS : RANKINE (Drained Shear)

2.1 Basic Relationships (Full capillarity; no evaporation)

(1) Vertical stresses

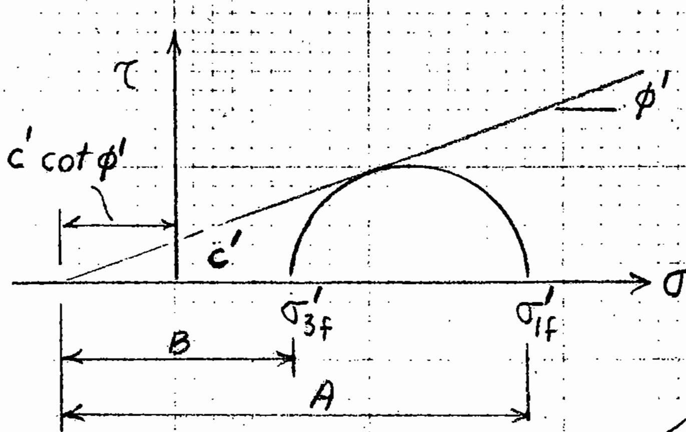






- $\sigma_v = z\gamma_t = z(\gamma_b + \gamma_w)$
- $u = (z - D)\gamma_w$
- $\sigma_v' = z\gamma_t - (z-D)\gamma_w = z\gamma_b + D\gamma_w$ (+ surcharge q_s)

(2) Effective stresses at failure



Define N_ϕ $[= (\sigma_1'/\sigma_3')_f$ for $c' = 0]$

$$N_\phi = \frac{1+\sin\phi'}{1-\sin\phi'} = \tan^2(45 + \phi'/2)$$

$$\frac{A}{B} = N_\phi = \frac{c'\cot\phi' + \sigma_{1f}'}{c'\cot\phi' + \sigma_{3f}'}$$

$$\sigma_{1f}' = \sigma_{3f}' N_\phi + c'\cot\phi'(N_\phi - 1)$$

$$\left\{ \begin{array}{l} (N_\phi - 1) = 2\tan\phi'\sqrt{N_\phi} \\ \sqrt{N_\phi} = \dfrac{\cos\phi'}{1-\sin\phi'} \end{array} \right.$$

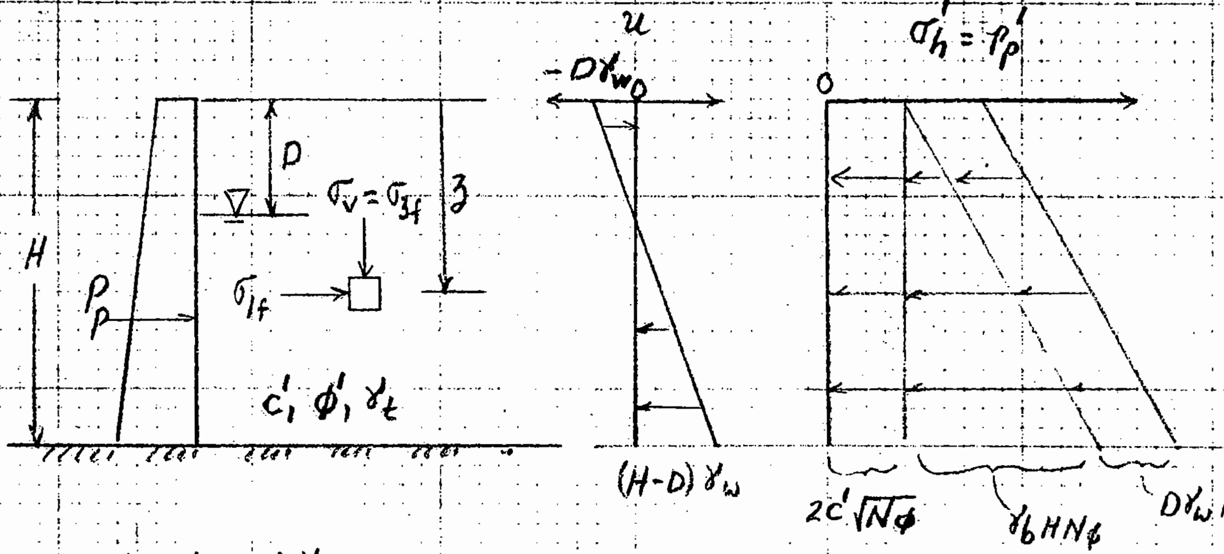
MEMORIZE

$$* \quad \sigma_{1f}' = \sigma_{3f}' N_\phi + 2c'\sqrt{N_\phi}$$

$$* \quad \sigma_{3f}' = \frac{\sigma_{1f}'}{N_\phi} - \frac{2c'}{\sqrt{N_\phi}}$$

2.2 Rankine Passive

(1) Mohr Circle solution



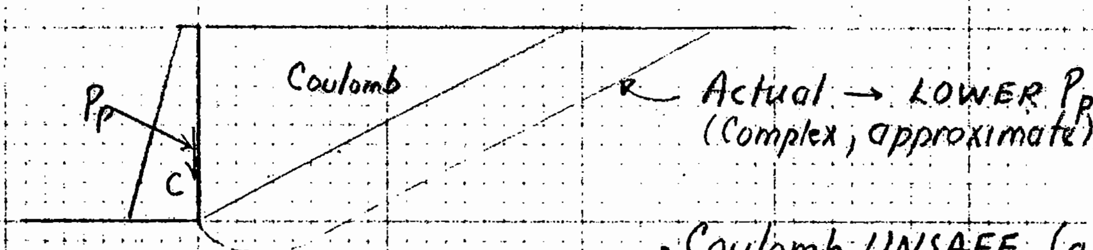
P_p not at $\frac{H}{3}$

- $u = (z-D)\gamma_w$
- $\sigma_v' = z\gamma_b + D\gamma_w$
- $p_p' = \sigma_h' = \sigma_v' N_\phi + 2c'\sqrt{N_\phi}$
- $\sigma_h = (z-D)\gamma_w + \sigma_h' = \underbrace{(z-D)\gamma_w}_{\text{Water}} + \underbrace{z\gamma_b N_\phi + D\gamma_w N_\phi}_{\text{Friction}} + \underbrace{2c'\sqrt{N_\phi}}_{\text{Cohesion}}$
- $P_p = \int_0^H \sigma_h \, dz$

(2) Coulomb for $\phi_w = 0$ (Ex. 23.7)

- Will this → same result? $\theta_{cr} =$

2.3 Coulomb Passive ($+\phi_w'$)

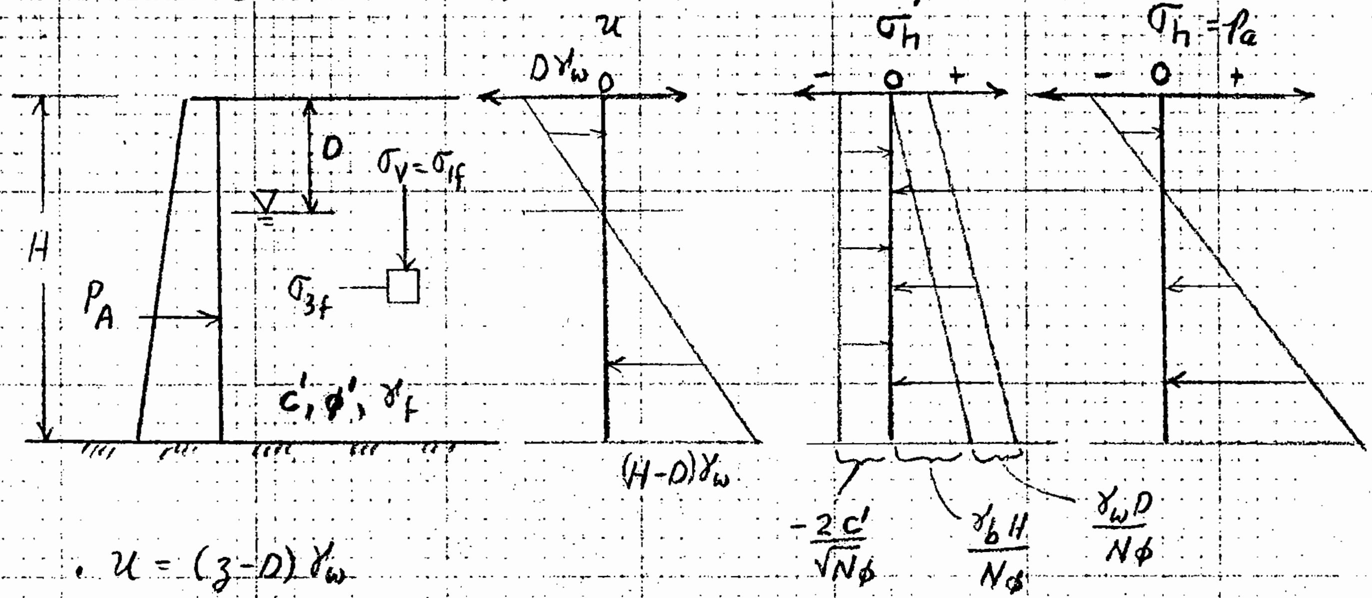


- Coulomb UNSAFE (as for sands)
- Rankine conservative

Part IV-5 EARTH PRESSURES (p 5/7)

2.4 Rankine Active (Full Capillarity)

(1) Mohr circle solution



- $u = (z-D)\gamma_w$
- $\sigma_v' = z\gamma_b + D\gamma_w$

$$\sigma_h' = \sigma_{3f}' = \frac{\sigma_{1f}'}{N\phi} - \frac{2c'}{\sqrt{N\phi}}$$

- $p_a' = \sigma_h' = \dfrac{\sigma_v'}{N\phi} - \dfrac{2c'}{\sqrt{N\phi}}$
- $\sigma_h = \underbrace{(z-D)\gamma_w}_{W} + \underbrace{\dfrac{z\gamma_b}{N\phi} + \dfrac{D\gamma_w}{N\phi}}_{F} - \underbrace{\dfrac{2c'}{\sqrt{N\phi}}}_{C} = p_a$

- $P_A = \int_0^H \sigma_h \, dz = \underbrace{\frac{1}{2}\gamma_w H^2 - \gamma_w D H}_{W} + \underbrace{\frac{1}{2}\frac{\gamma_b H^2}{N\phi} + \frac{\gamma_w D H}{N\phi}}_{F} - \underbrace{\frac{2c'H}{\sqrt{N\phi}}}_{C}$ { Does NOT act at $\frac{1}{3}H$

(2) Coulomb ($\phi_w = 0$)

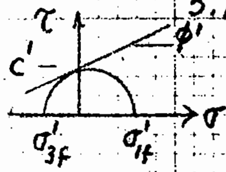
- Same result with $\theta_{cr} = 45 + \phi/2$ (but more complex)

(3) Warning

- Rankine UNSAFE due to tension crack problem

3. COHESIVE : ACTIVE : TENSION CRACKS

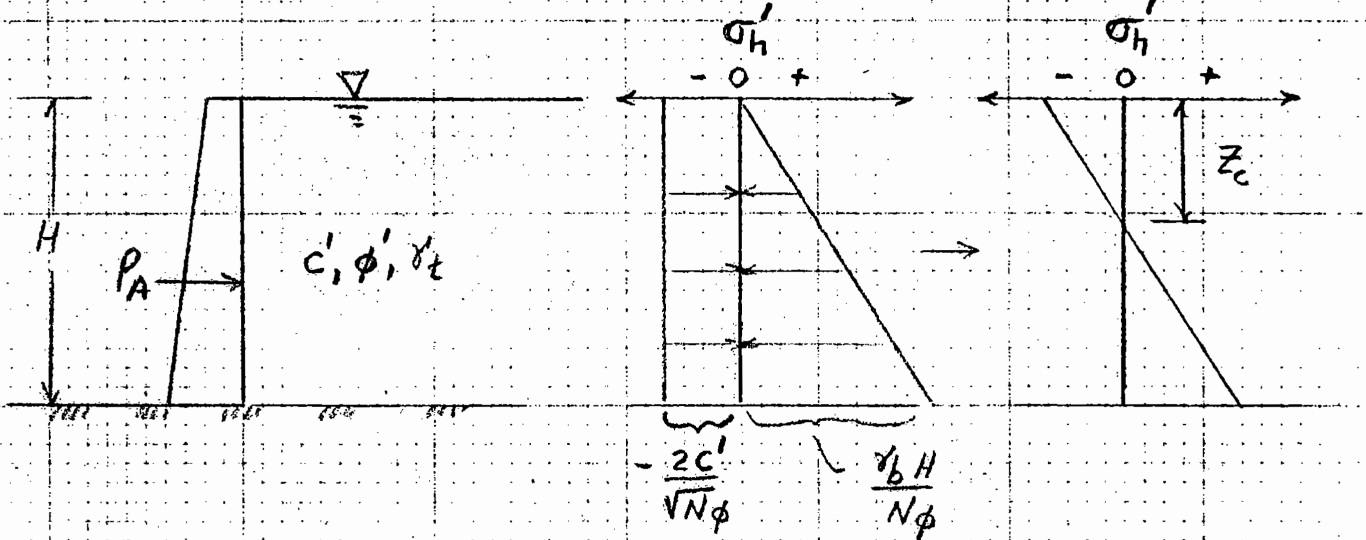
3.1 Basic Problems (NOTE: Text not very clear)



(1) Negative σ' - cannot sustain longtime within soil skelton
- cannot act at soil-wall interface

(2) Negative σ - cannot develop between soil & wall

3.2 Tension Crack Due To Negative σ'



$$\sigma_h' = \frac{z\gamma_b}{N\phi} - \frac{2c'}{\sqrt{N\phi}}$$

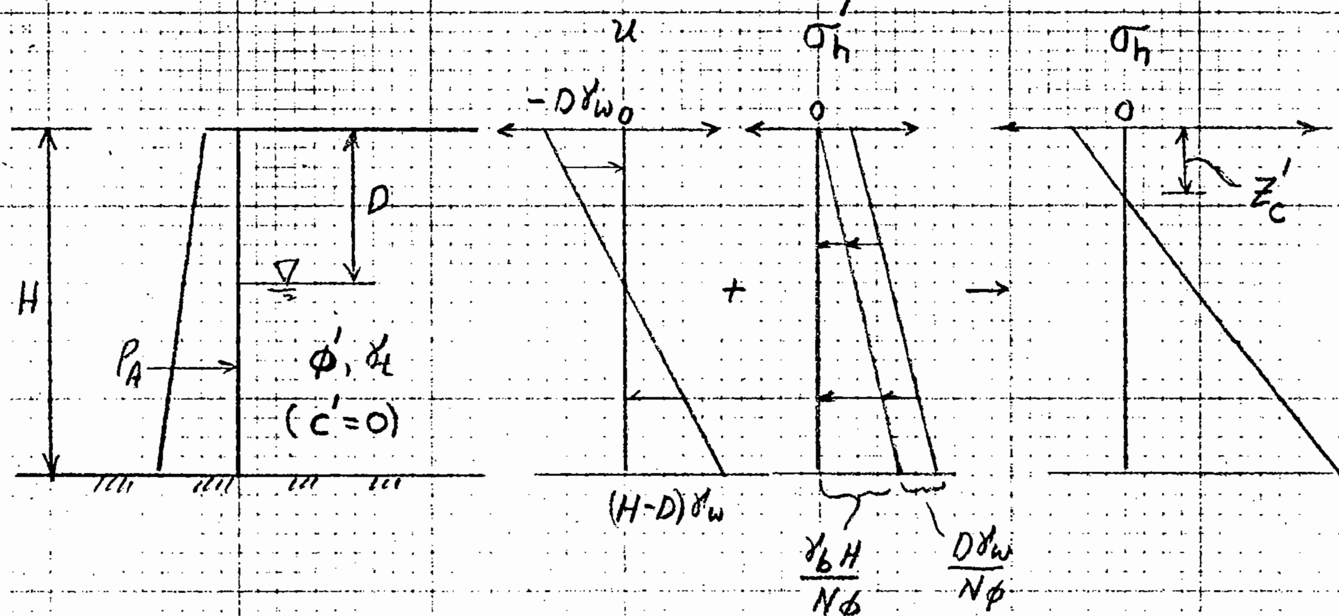
$$\therefore \sigma_h' = 0 \text{ at } z_c = \frac{2c'\sqrt{N\phi}}{\gamma_b}$$

$$\bar{P}_A = \underbrace{\frac{1}{2}\gamma_b\frac{H^2}{N\phi} - \frac{2c'H}{\sqrt{N\phi}}}_{\text{Rankine}} + \underbrace{\frac{2c'}{\sqrt{N\phi}}\frac{z_c}{2}}_{\text{Crack}} \rightarrow \frac{1}{2}\gamma_b\frac{(H-z_c)^2}{N\phi}\ {}^{*}$$

$$* \quad \frac{1}{2}\gamma_b\frac{H^2}{N\phi} - \frac{\gamma_b z_c H}{N\phi} + \frac{1}{2}\gamma_b\frac{z_c^2}{N\phi}$$

$$\frac{\gamma_b z_c H}{N\phi} \downarrow \frac{2c'H}{\sqrt{N\phi}} \qquad \frac{1}{2}\gamma_b\frac{z_c^2}{N\phi} \downarrow \frac{c'z_c}{\sqrt{N\phi}}$$

3.3 Tension Crack Due To Negative σ



$$\cdot\ \sigma_h = u + \sigma_h' = (z-D)\gamma_w + \frac{z\gamma_b}{N\phi} + \frac{D\gamma_w}{N\phi}$$

$$\therefore\ \sigma_h = 0 \Leftrightarrow Z_c'\left(\gamma_w + \frac{\gamma_b}{N\phi}\right) = D\gamma_w\left(1 - \frac{1}{N\phi}\right)$$

$$\rightarrow\ Z_c' = \frac{D\gamma_w(N\phi - 1)}{\gamma_b + \gamma_w N\phi}$$

$$P_A = \underbrace{\frac{1}{2}\gamma_w H^2 - DH\gamma_w}_{W} + \underbrace{\frac{1}{2}\frac{\gamma_b H^2}{N\phi} + \frac{DH\gamma_w}{N\phi}}_{F} + \underbrace{\frac{1}{2}D\gamma_w\left(1 - \frac{1}{N\phi}\right)Z_c'}_{TC}$$

NOTE: Sections 2 & 3 have used Rankine (Mohr circles) to obtain earth pressures on vertical walls. Same principles apply to sloping walls (HP #9)