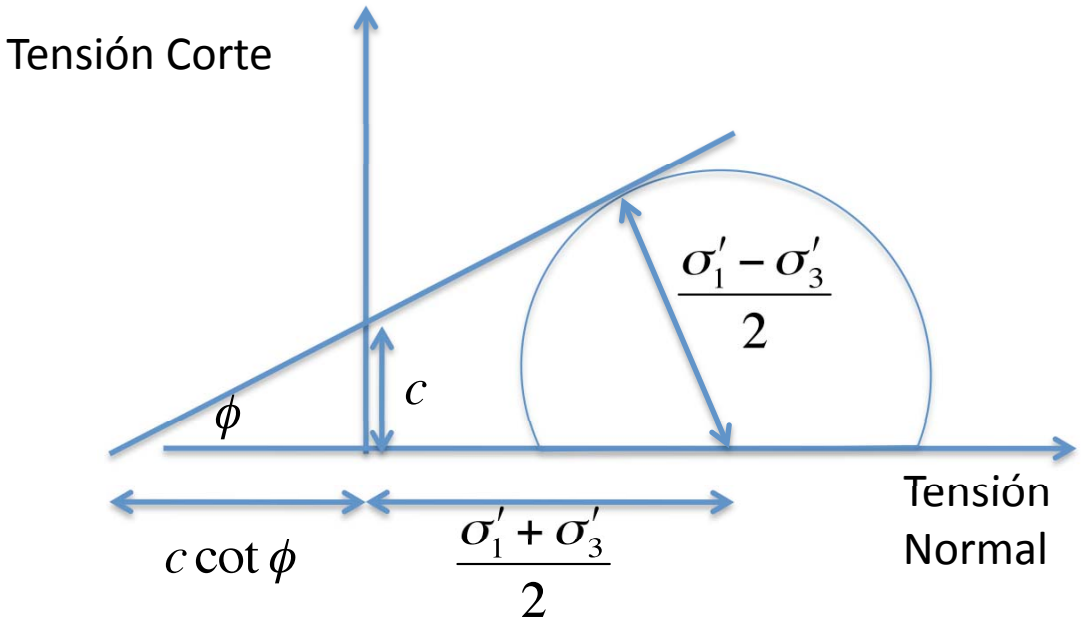
Presión Lateral de Suelo

Círculo de Mohr



$$sen\phi = \frac{(\sigma_1' - \sigma_3')/2}{c\cot\phi + (\sigma_1' + \sigma_3')/2}$$

$$\sigma_1' = \sigma_3' \frac{1 + sen\phi}{1 - sen\phi} + \frac{2c\cos\phi}{1 - sen\phi}$$

$$\sigma_1' = \sigma_3' \tan^2\left(45° + \frac{\phi}{2}\right) + 2c\tan\left(45° + \frac{\phi}{2}\right)$$

$$\sigma_1{}' = \sigma_3' N_\phi + 2c\sqrt{N_\phi}$$

$$\sigma_1{}' = \sigma_3' N_\phi \qquad c = 0$$

Equilibrio Elástico

- Empuje de Suelo en Reposo
  - K_0 varía hasta 1.0 (suelos preconsolidados). Depende de la razón de preconsolidación
  - Asociado a condición de deformación 0, y un estado elástico.

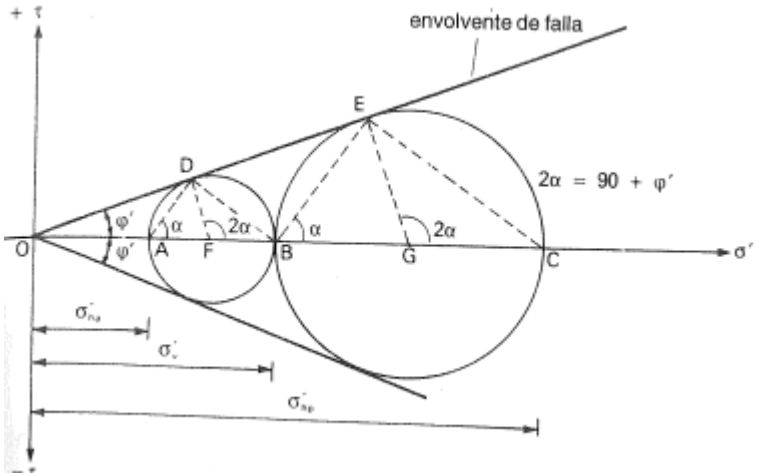
$$K_0 = \frac{\sigma'_h}{\sigma'_v}$$

$$K_0 = 1 - sen\phi \qquad \text{(Jaky, 1944)}$$

$$K_0 = K_{0(nc)}\sqrt{R_c}$$

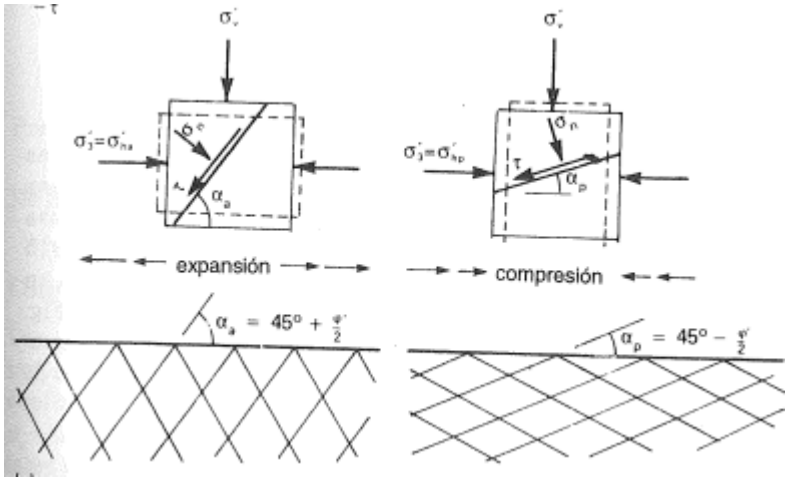
Equilibrio Plástico

- EMPUJE ACTIVO Y PASIVO
  - Activo: cuando $\sigma_h < \sigma_v$; K_A; expansión lateral; Tramo OA
  - Pasivo: cuando $\sigma_h > \sigma_v$; K_P; contracción lateral; Tramo OC



Equilibrio Plástico

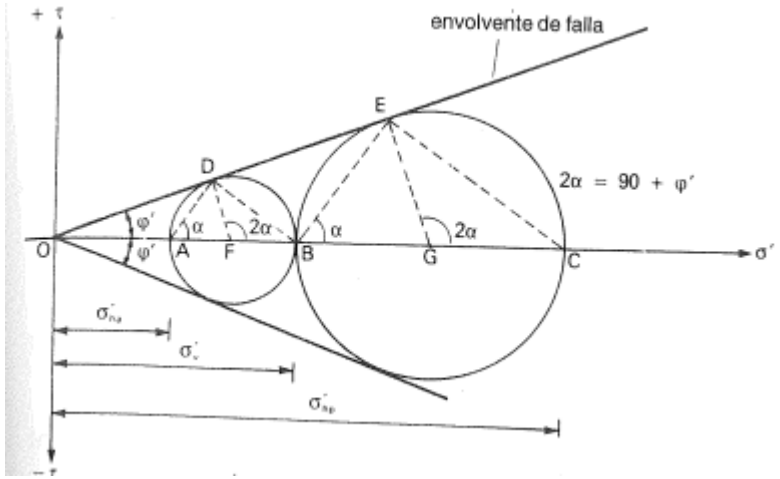
- EMPUJE ACTIVO Y PASIVO
  - Activo: $\alpha_a = \frac{1}{2}(2\alpha) = \frac{1}{2}(90° + \phi)$
  - Pasivo: $\alpha_p = \frac{1}{2}(180 - 2\alpha) = \frac{1}{2}(180 - (90° + \phi)) = 45° - \frac{\phi}{2}$



Equilibrio Plástico - Rankine

Suelo No Cohesivo

Empuje Activo



$$\sigma'_v = \gamma z \;\; ; \;\; \sigma'_h$$

$$\frac{\sigma'_1}{\sigma'_3} = N_\phi = \tan^2\left(45° + \frac{\phi}{2}\right)$$

$$K = \frac{\sigma'_h}{\sigma'_v} = \frac{OA}{OB} = \frac{OF - AF}{OF - FB} = \frac{1 - AF/OF}{1 + FB/OF}$$

$$AF = FB = FD$$

$$FD/OF = sen\phi$$

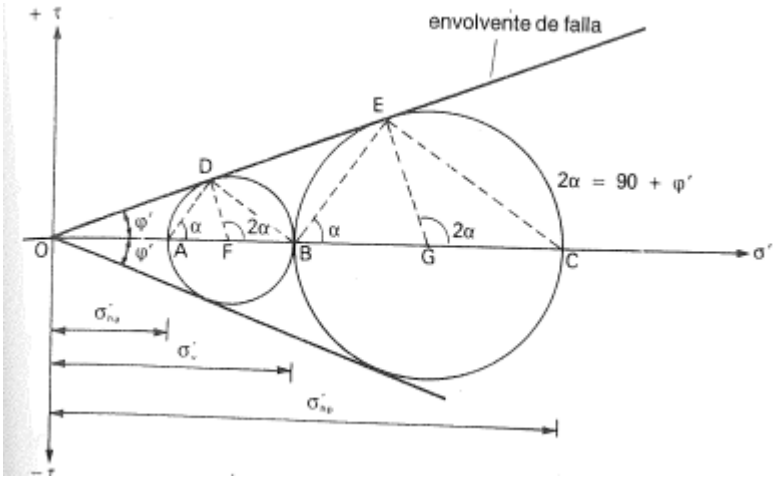
$$K_A = \frac{1 - sen\phi}{1 + sen\phi}$$

$$K_A = \frac{\sigma'_h}{\sigma'_v} = \frac{1}{N_\phi} = \tan^2\left(45° - \frac{\phi}{2}\right)$$

Equilibrio Plástico - Rankine

Suelo No Cohesivo

Empuje Pasivo

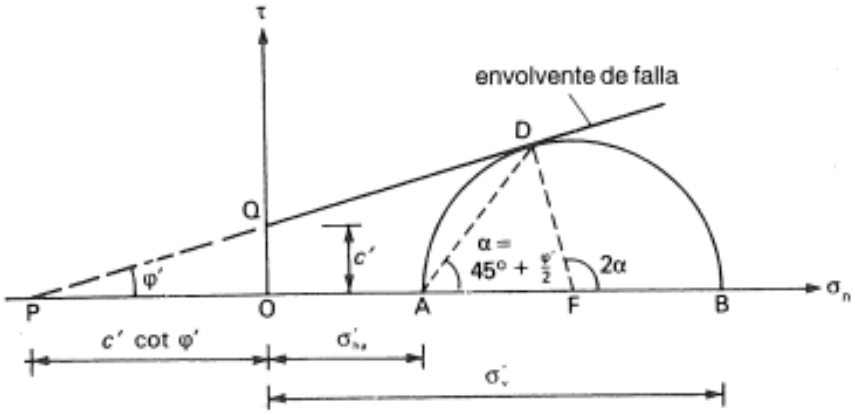


$$K_P = \frac{1 + sen\phi}{1 - sen\phi}$$

$$K_P = \frac{\sigma'_h}{\sigma'_v} = N_\phi = \tan^2\left(45° + \frac{\phi}{2}\right)$$

Equilibrio Plástico - Rankine

Empuje Suelo Cohesivo (Bell, 1915)



Equilibrio Plástico - Rankine

Empuje Activo-Suelo Cohesivo (Bell, 1915)

$$\frac{PA}{PB} = \frac{c'\cot\phi + \sigma'_{ha}}{c'\cot\phi + \sigma'_{v}} = \frac{PF - AF}{PF + BF} = \frac{1 - FD/PF}{1 + FD/PF} = \frac{1 - sen\phi}{1 + sen\iota} = K_A$$

$$\sigma'_{ha} = K_A\sigma'_{v} + (K_A - 1)c'\cot\phi$$

$$(K_A - 1)c'\cot\phi = c'\frac{1 - sen\phi - (1 + sen\phi)}{1 + sen\phi}\frac{\cos\phi}{sen\phi}$$

$$= -2c'\sqrt{\frac{1 - sen\phi}{1 + sen\phi}} = -2c'\sqrt{K_A}$$

$$\Rightarrow \sigma'_{ha} = K_A\sigma'_{v} - 2c'\sqrt{K_A}$$

Equilibrio Plástico - Rankine

Empuje Pasivo-Suelo Cohesivo (Bell, 1915)

$$\Rightarrow \sigma'_{ha} = K_P \sigma'_v + 2c'\sqrt{K_P}$$

Caso sin drenado

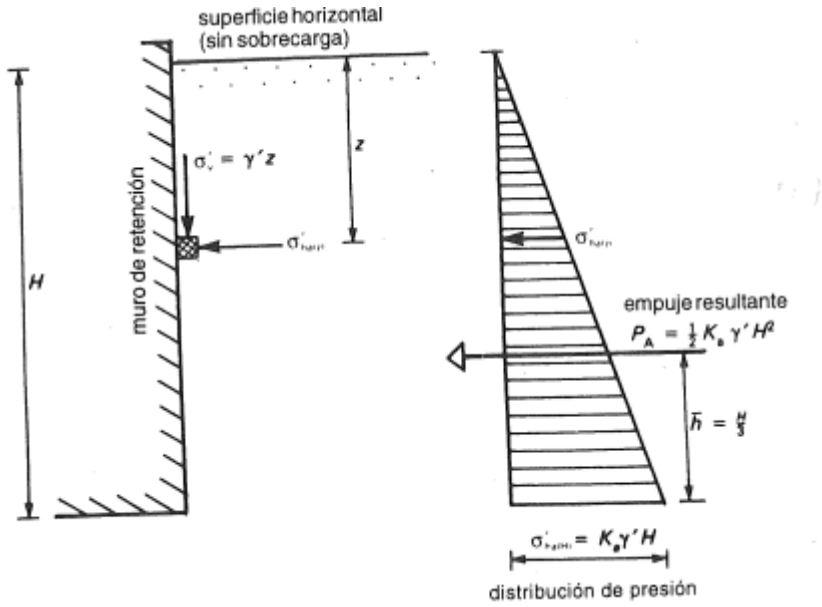
$$\phi_u = 0$$

$$K_A = K_P = 1$$

$$\Rightarrow \sigma'_{ha} = \sigma'_v - 2c'_u$$

$$\Rightarrow \sigma'_{hp} = \sigma'_v + 2c'_u$$

Presión Lateral Sobre Muro



$$\sigma'_{ha} = K_A \gamma' z$$

γ'= peso unitario efectivo

= γ (sobre el nivel freático)

= γ_{sat}-γ_w (bajo nivel freático)

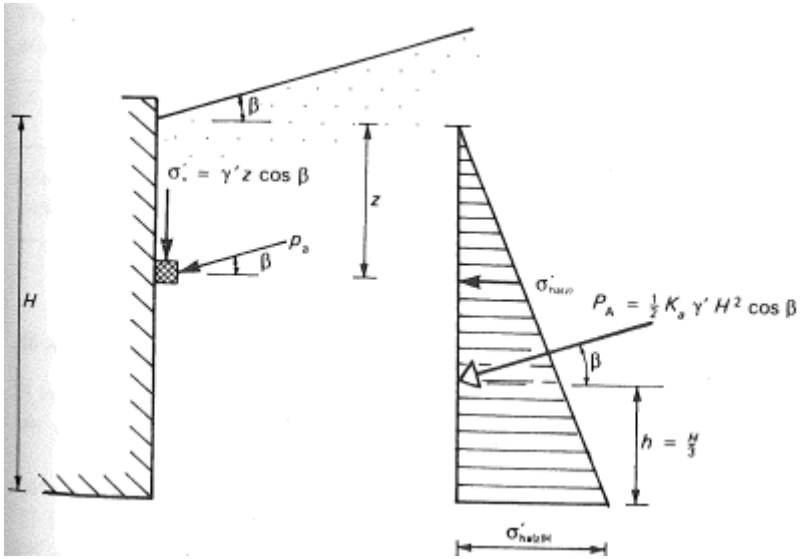
$$P_A = \frac{1}{2}\sigma'_{ha} H = \frac{1}{2} K_A \gamma' H^2$$

$$\bar{h} = \frac{1}{3} H$$

P_A : Empuje activo resultante

Presión Lateral Sobre Muro

Efecto pendiente de terreno



$$\sigma'_{ha} = K_A \sigma'_v \cos\beta$$

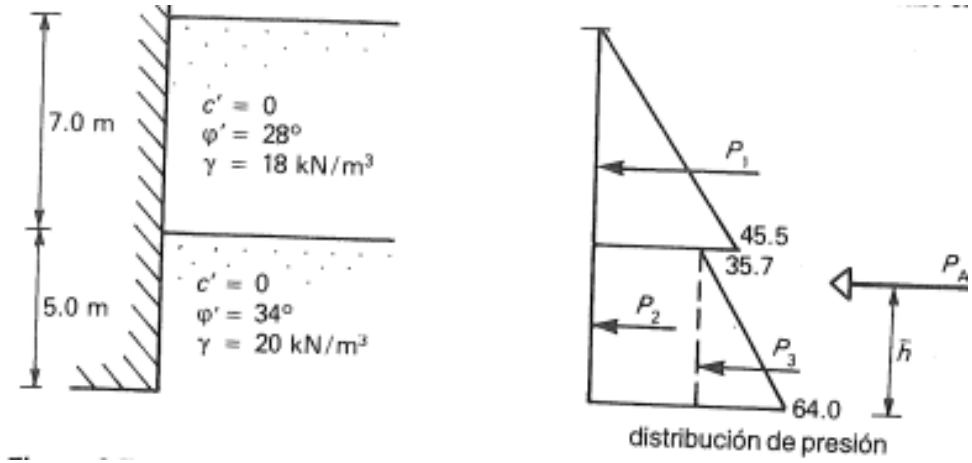
$$\sigma'_{hp} = K_P \sigma'_v \cos\beta$$

$$K_A = \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}$$

$$K_P = \frac{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}} = \frac{1}{K_A}$$

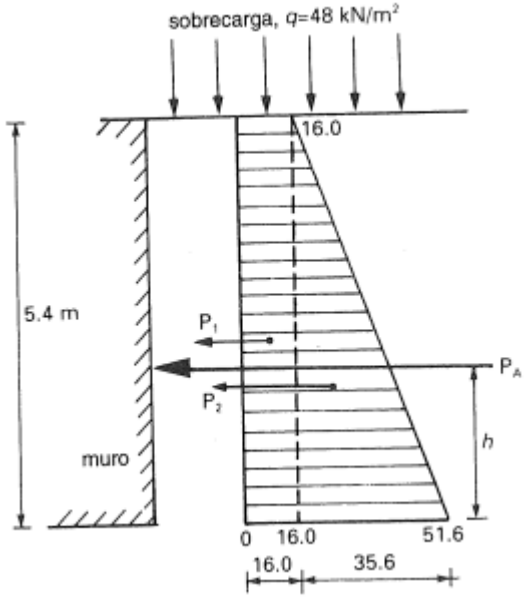
Presión Lateral Sobre Muro

Efecto suelo estratificado



Presión Lateral Sobre Muro

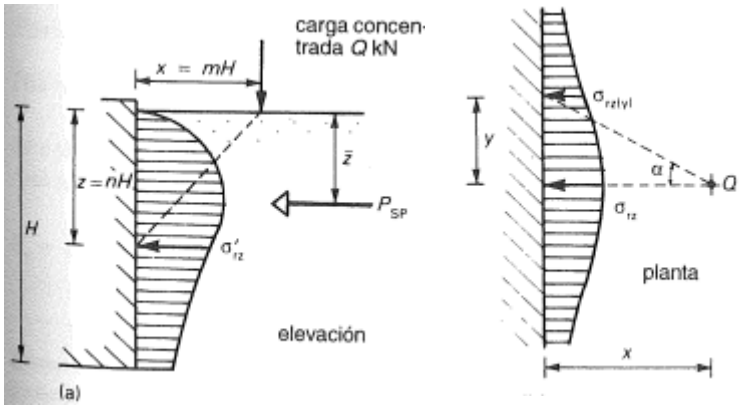
Efecto sobrecarga Repartida



$$\sigma'_v = \gamma' z + q$$

$$\sigma'_h = K_A(\gamma' z + q)$$

Efecto carga puntual



$$\sigma'_{rz} = \frac{1.77 Q m^2 n^2}{H^2 (m^2 + n^2)}$$ Vertical

$$m < 0.4 \Rightarrow m = 0.4$$

$$\sigma'_{rz(y)} = \sigma'_{rz} \cos^2(1.1\alpha)$$ Horizontal

Presión Lateral Sobre Muro

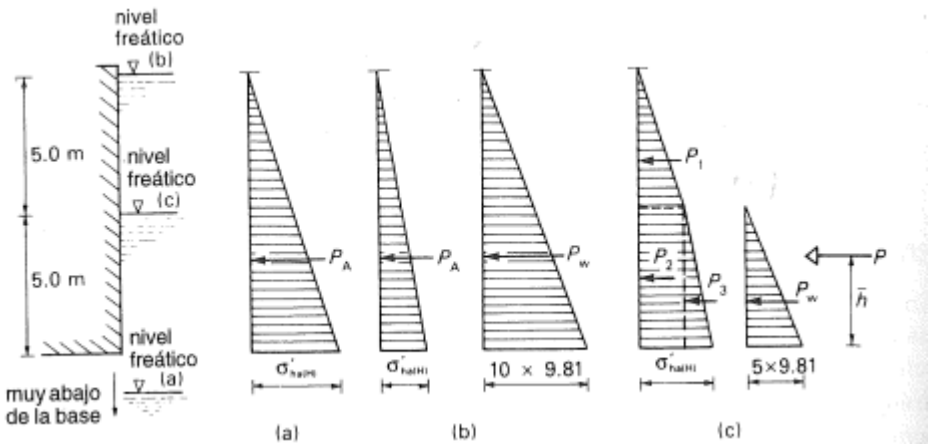
Efecto nivel freático

$$\sigma'_{ha} = K_A(\gamma'_{sat} - \gamma_w)z$$

$$\sigma'_{hp} = K_P(\gamma'_{sat} - \gamma_w)z$$

$$p_w = \gamma_w$$

$$P = P_{suelo} + P_w$$



Presión Lateral Sobre Muro

Drenado – suelo cohesivo

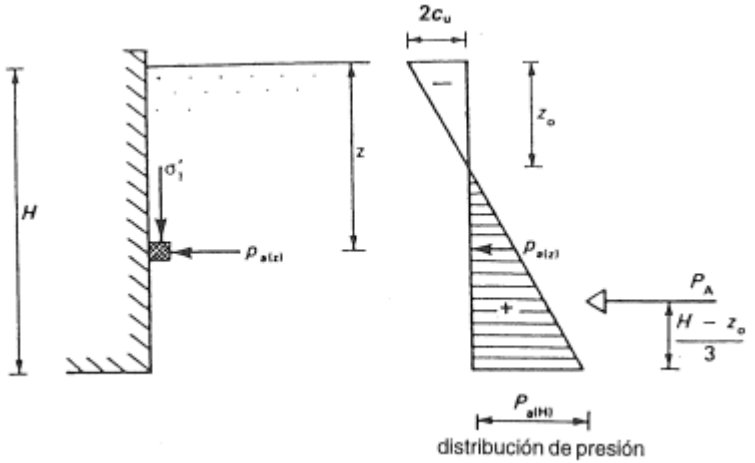
$$\sigma'_{ha} = K_A \sigma'_v - 2c'\sqrt{K_A}$$

$$\sigma'_{hp} = K_P \sigma'_v - 2c'\sqrt{K_P}$$

No drenado

$$\sigma'_{ha} = \sigma'_v - 2c_u$$

$$\sigma'_{hp} = \sigma'_v + 2c_u$$



Presión Lateral Sobre Muro

No Drenado – sobrecarga

$$\sigma'_v = \gamma z + q \qquad \phi_u = 0$$

$$\sigma'_{ha} = \sigma'_v + q - 2c_u$$

$$\sigma'_{hp} = \sigma'_v + q + 2c_u$$