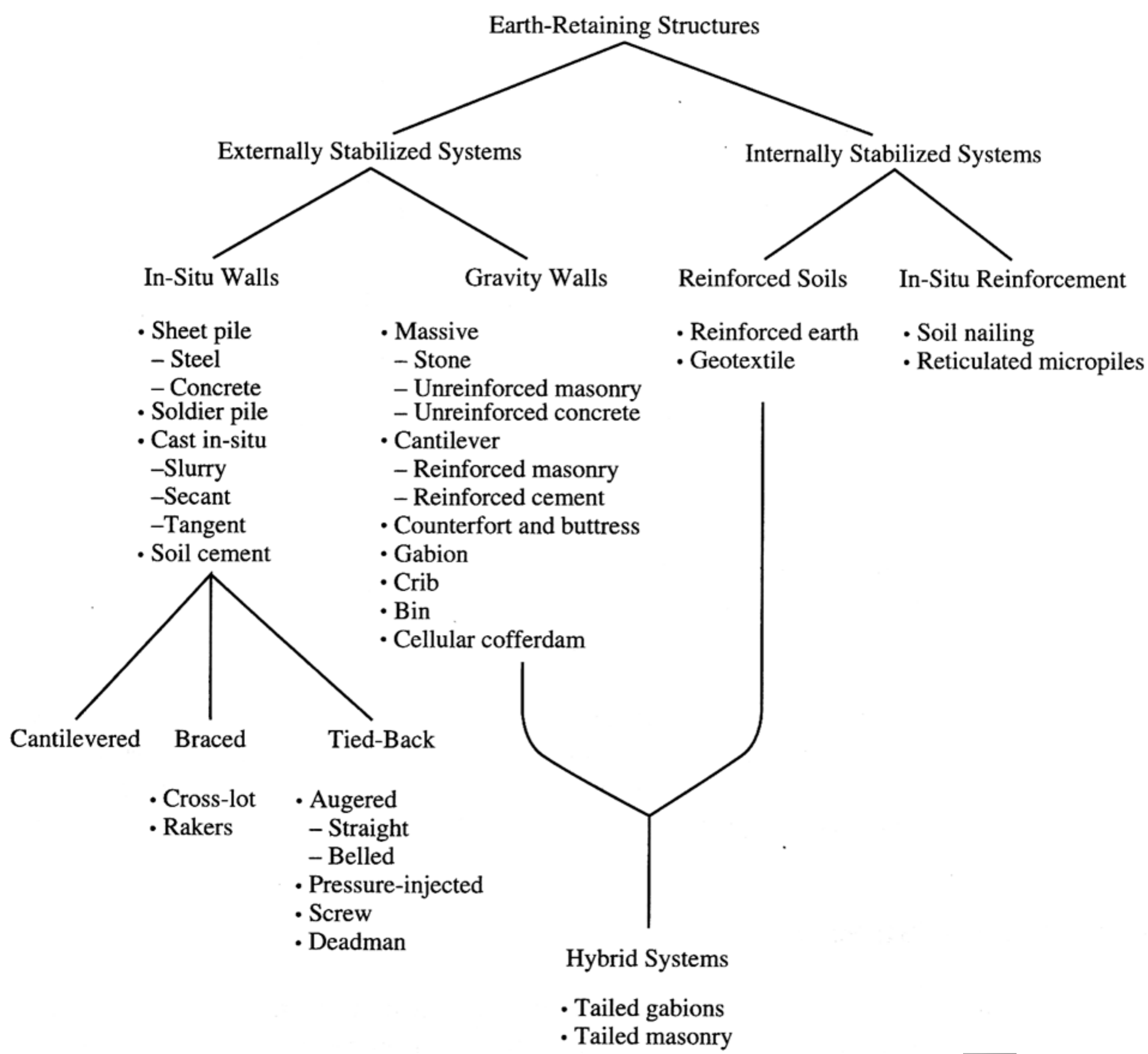
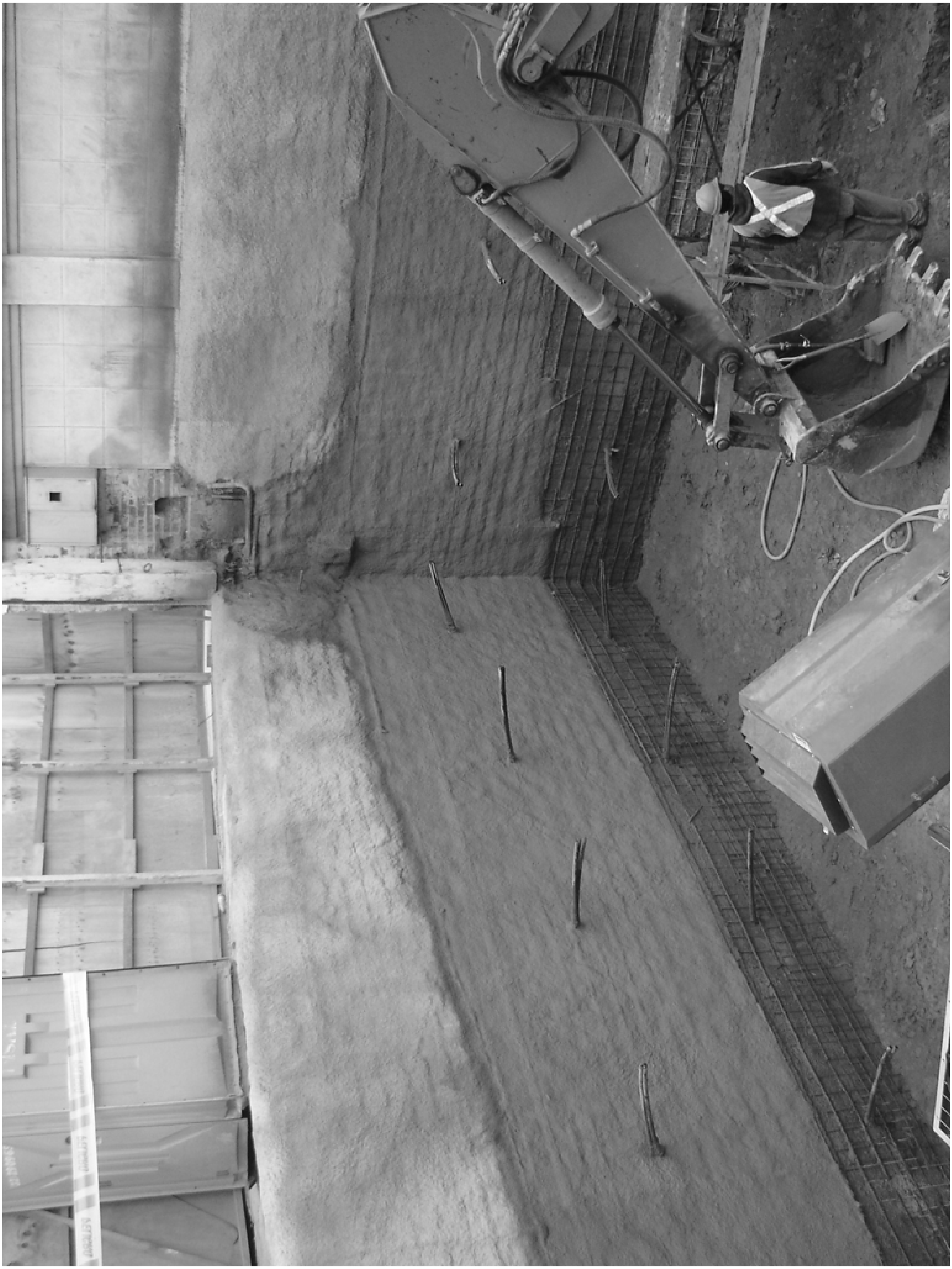
Empujes y Muros de Contención

Prof.: Ricardo Moffat

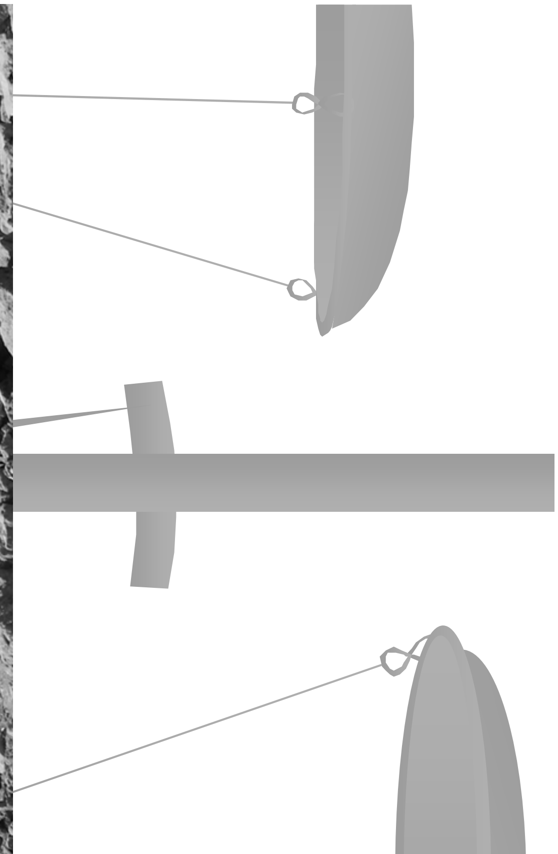
Tipos de muros

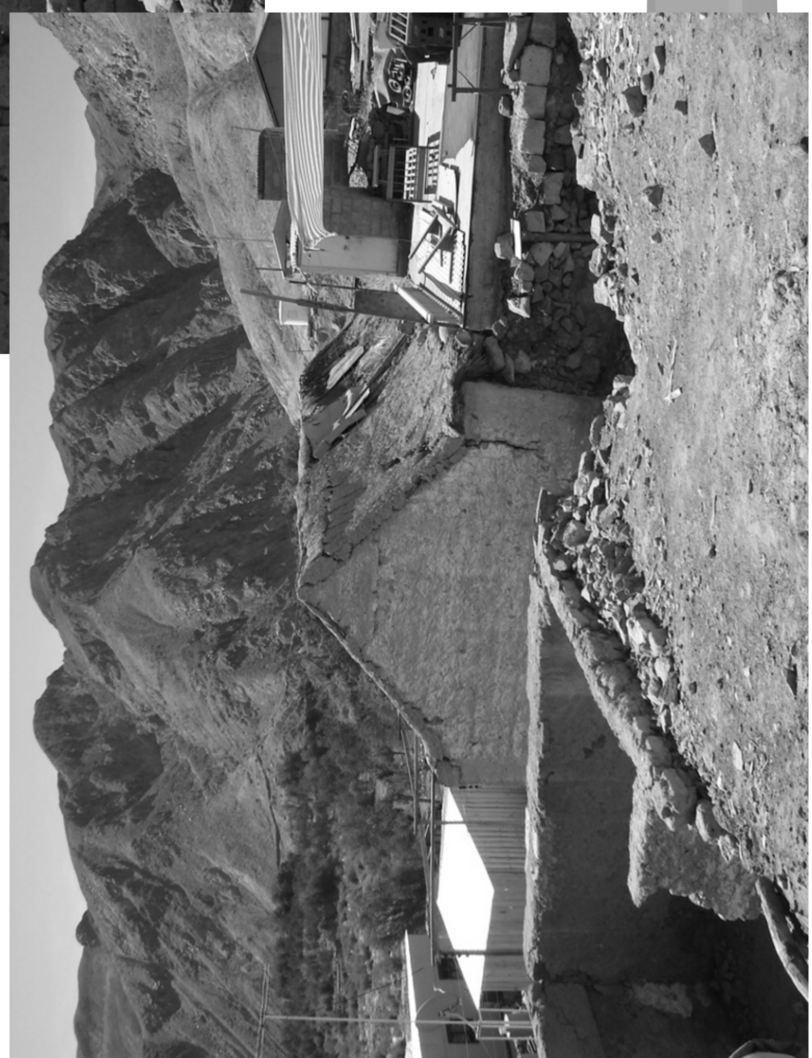


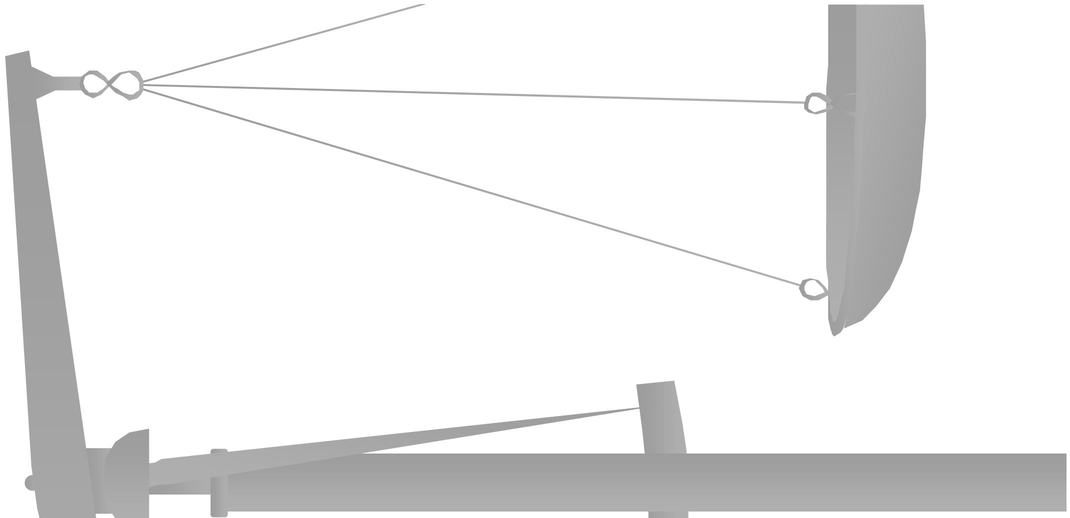


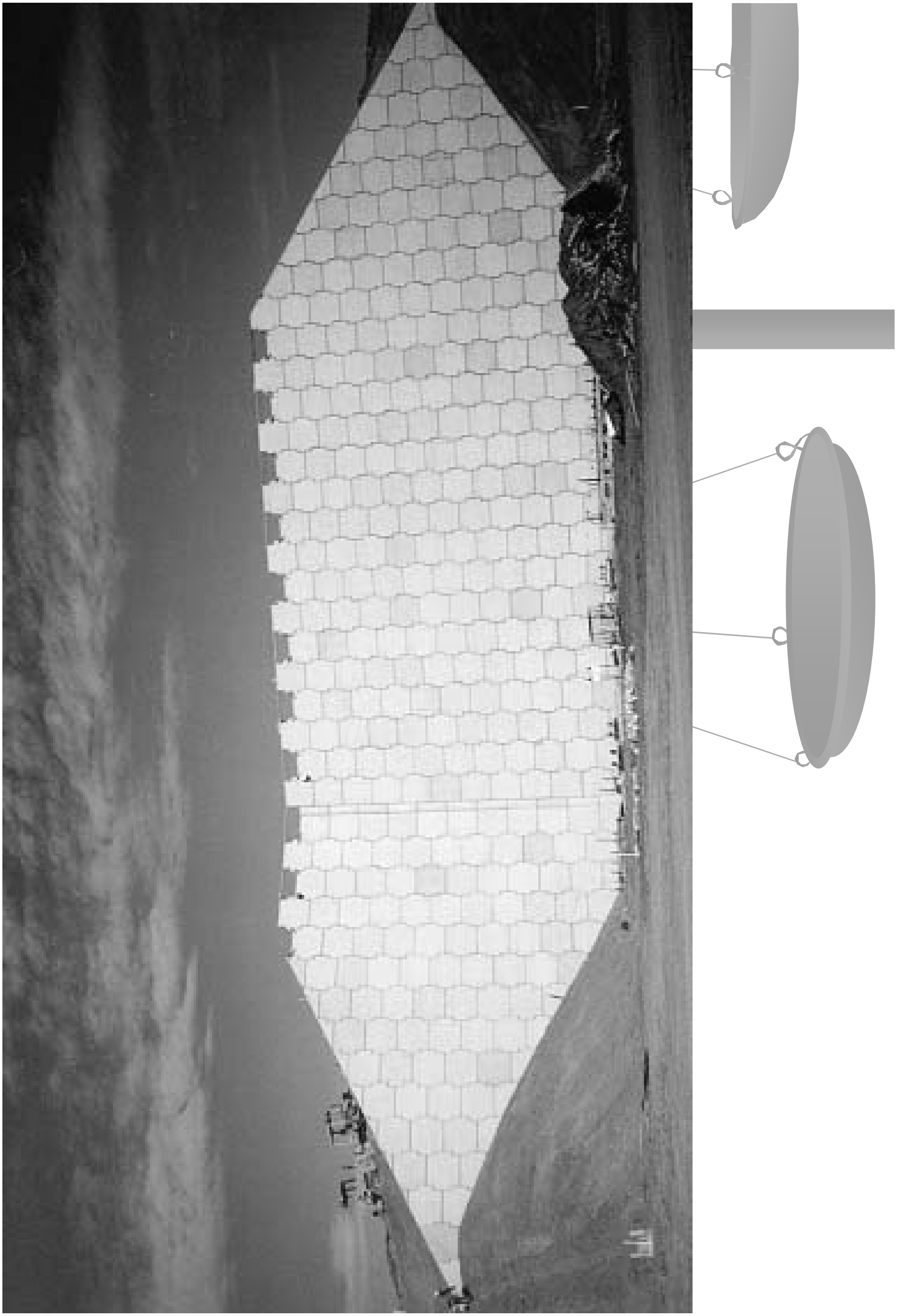

Anclajes

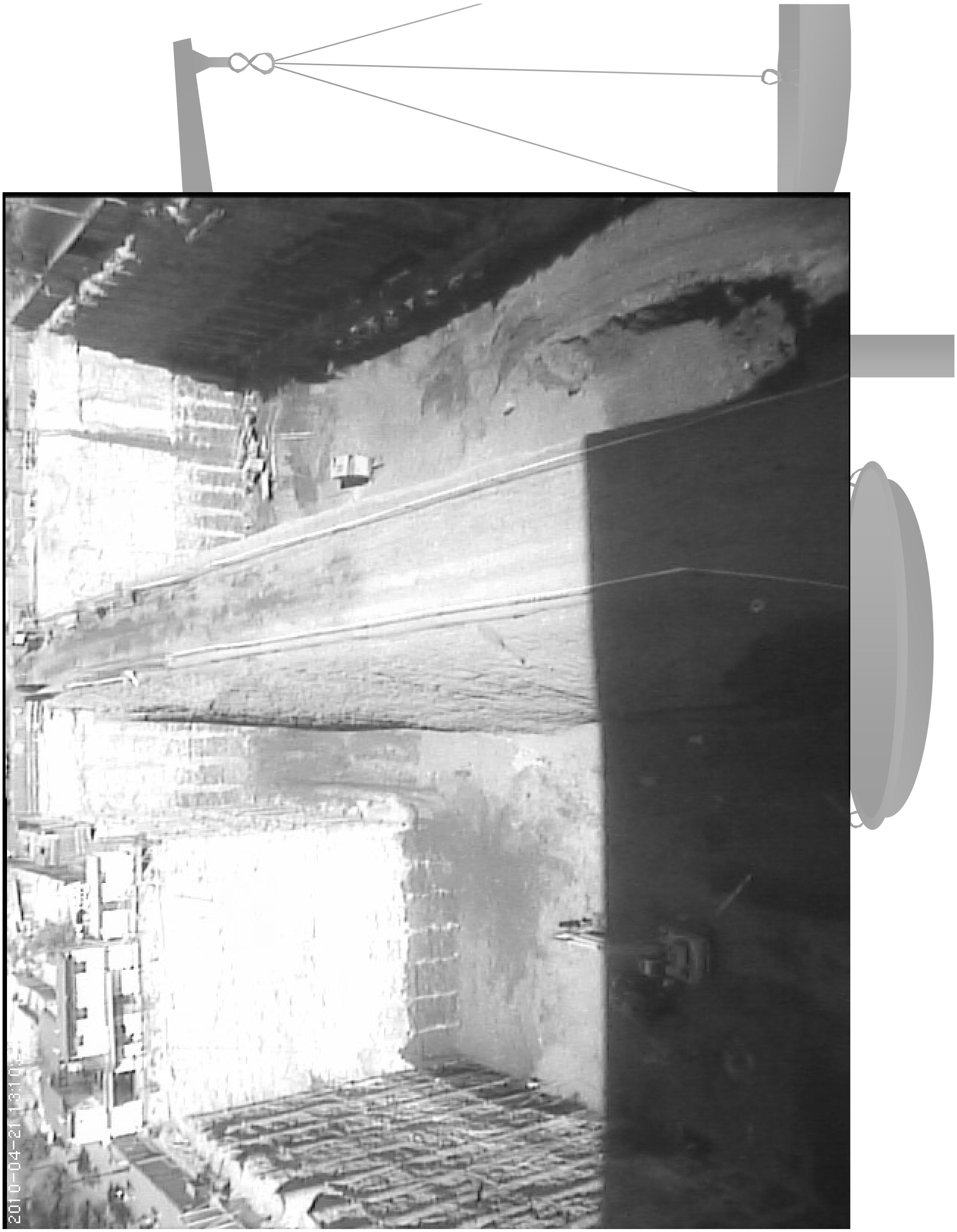

KOMATSU
ASALCO S.A.









Consideraciones de construcción

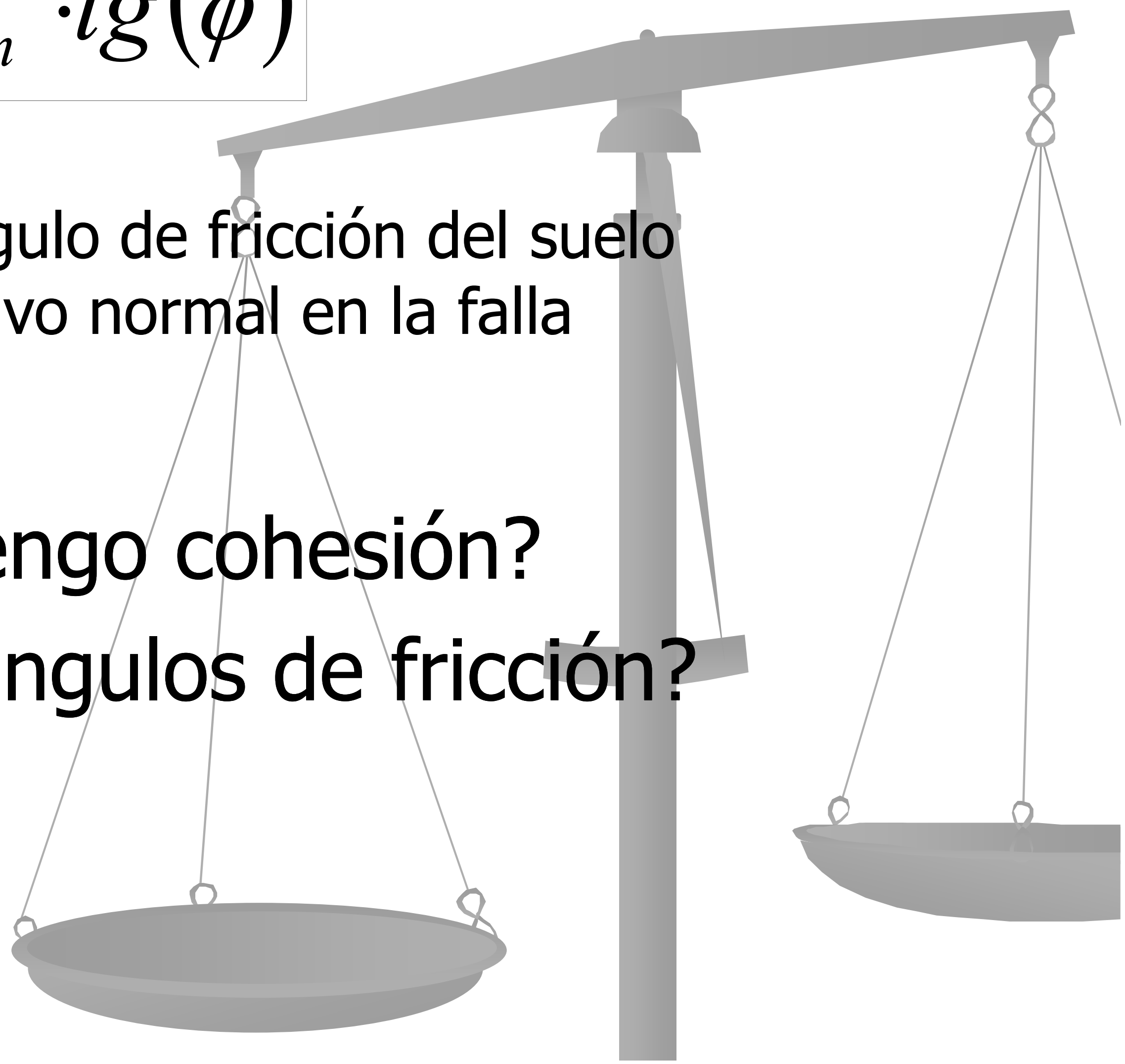
- Material de relleno
- Materiales de filtro y drenaje
- Colocación y compactación de rellenos

Parámetros de diseño

- Parámetros de resistencia al corte
- Parámetros de deformación

Parámetros de resistencia al corte

$$\tau_f = c` + \sigma_n ` \cdot tg(\phi)$$



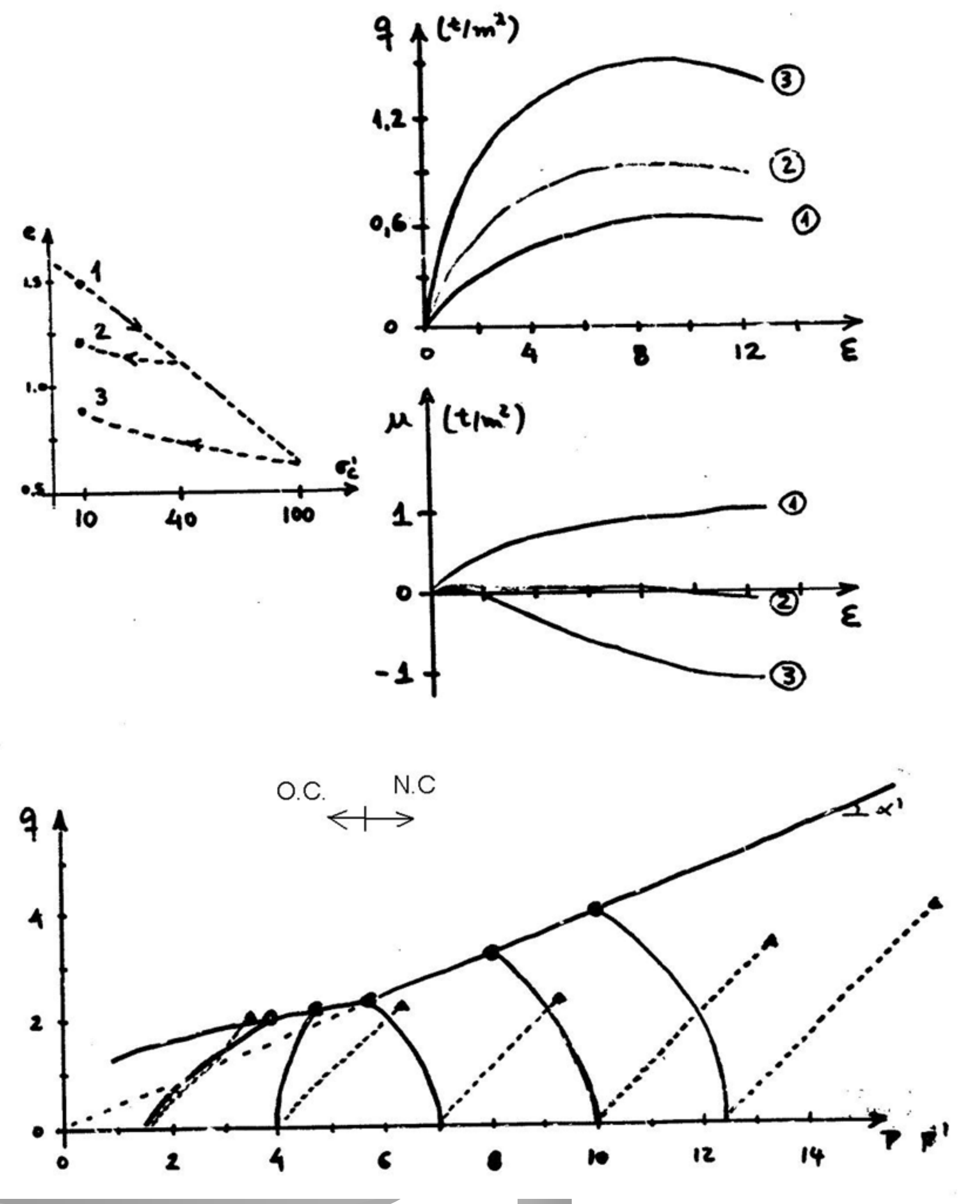
$c´, \phi´$: cohesión y ángulo de fricción del suelo

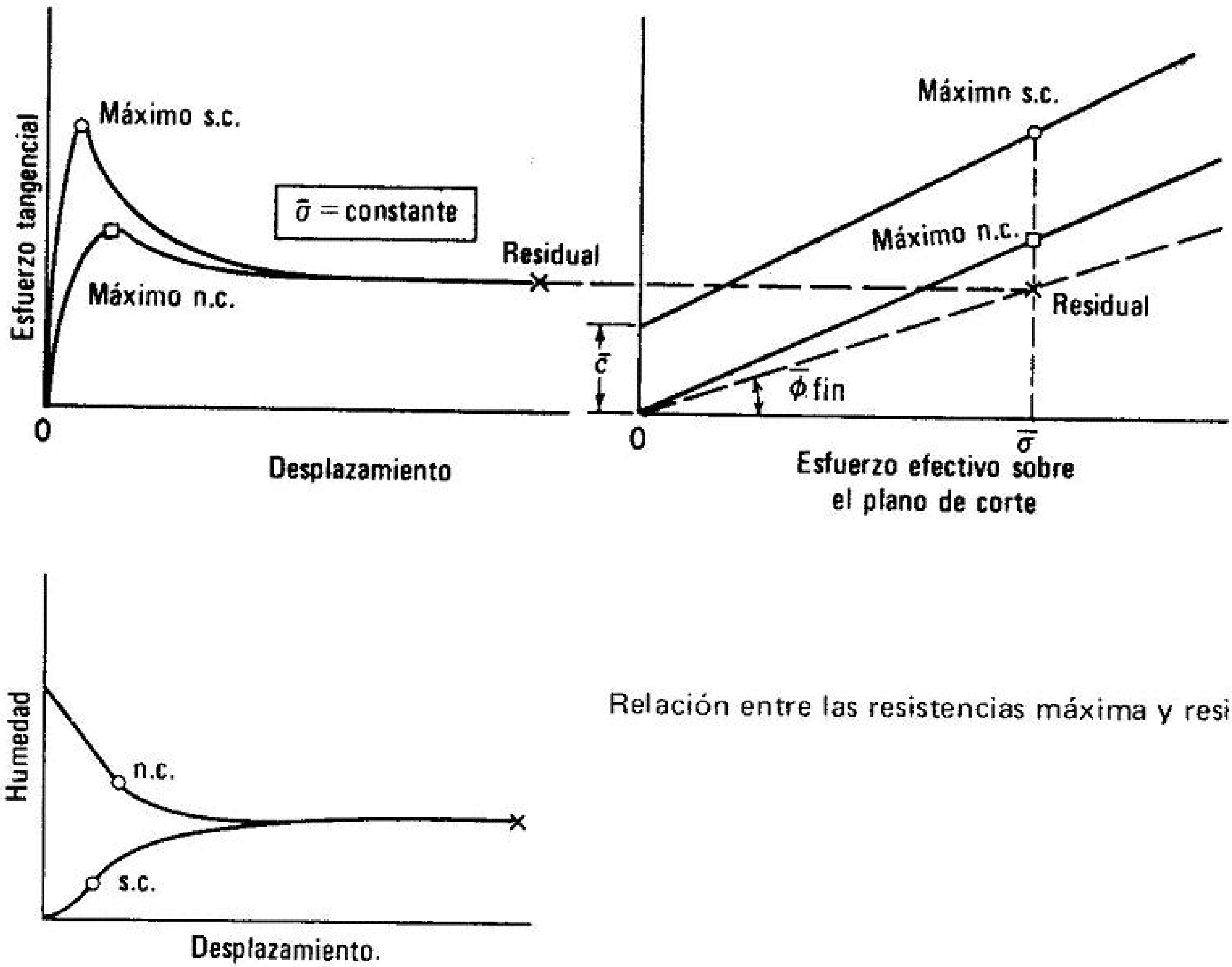
$\sigma_n´$: Esfuerzo efectivo normal en la falla

- ¿En que casos tengo cohesión?
- ¿Existen varios ángulos de fricción?

Suelos cohesivos

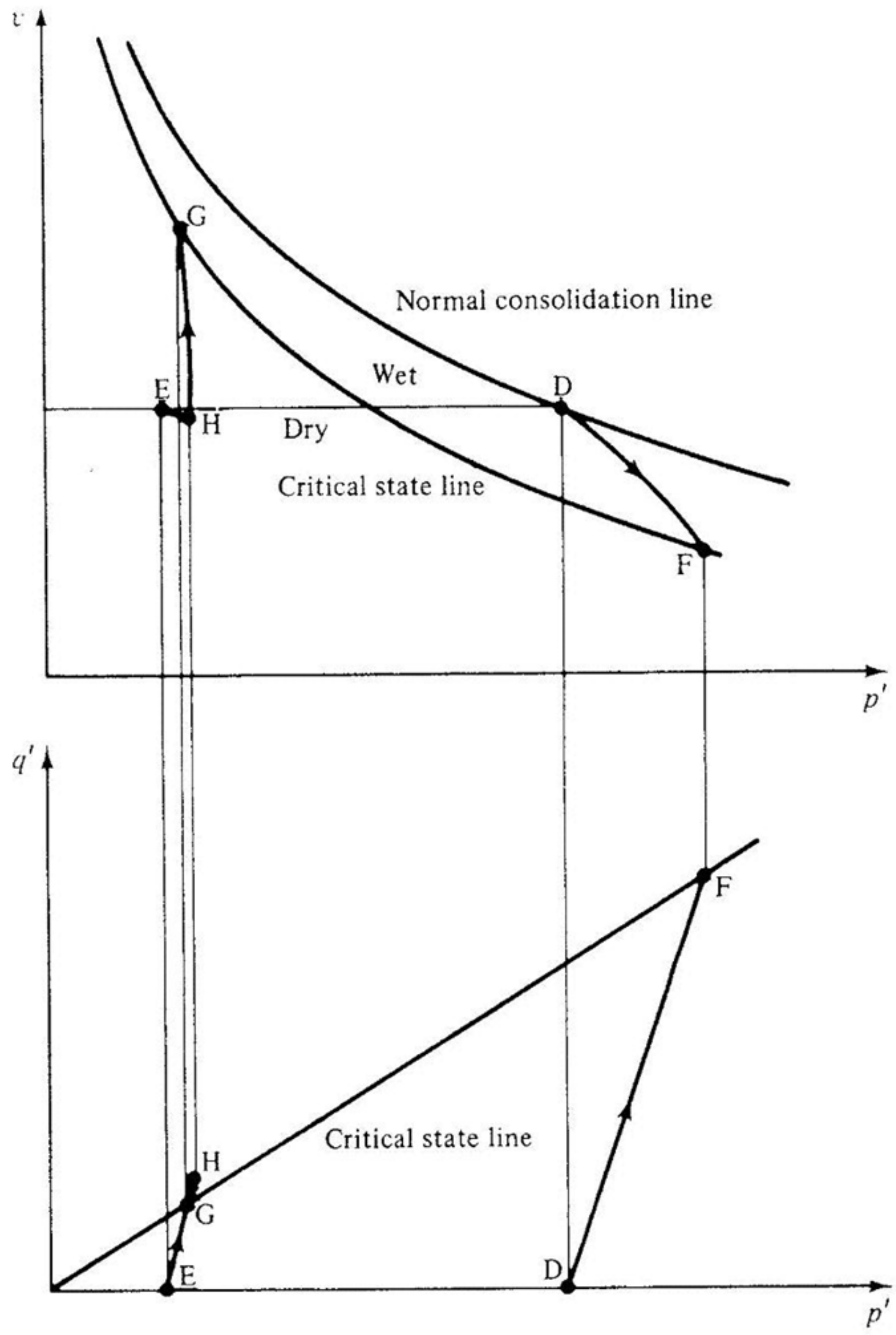
- Arcilla Pre-consolidada



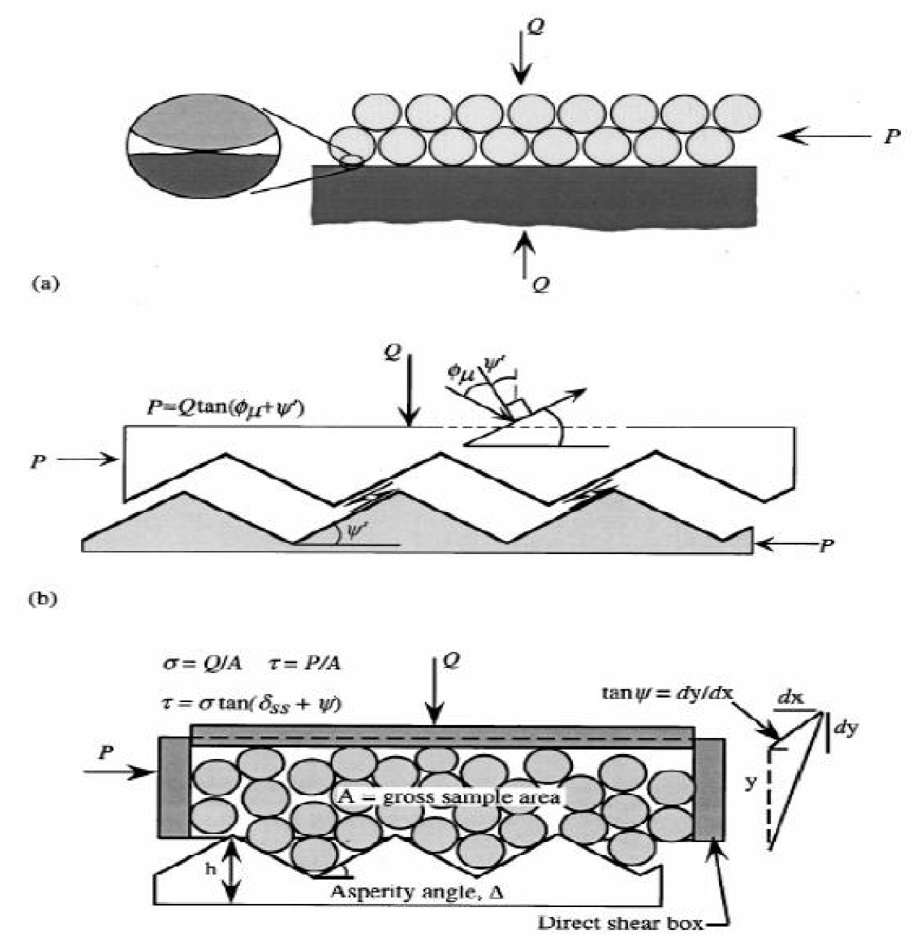


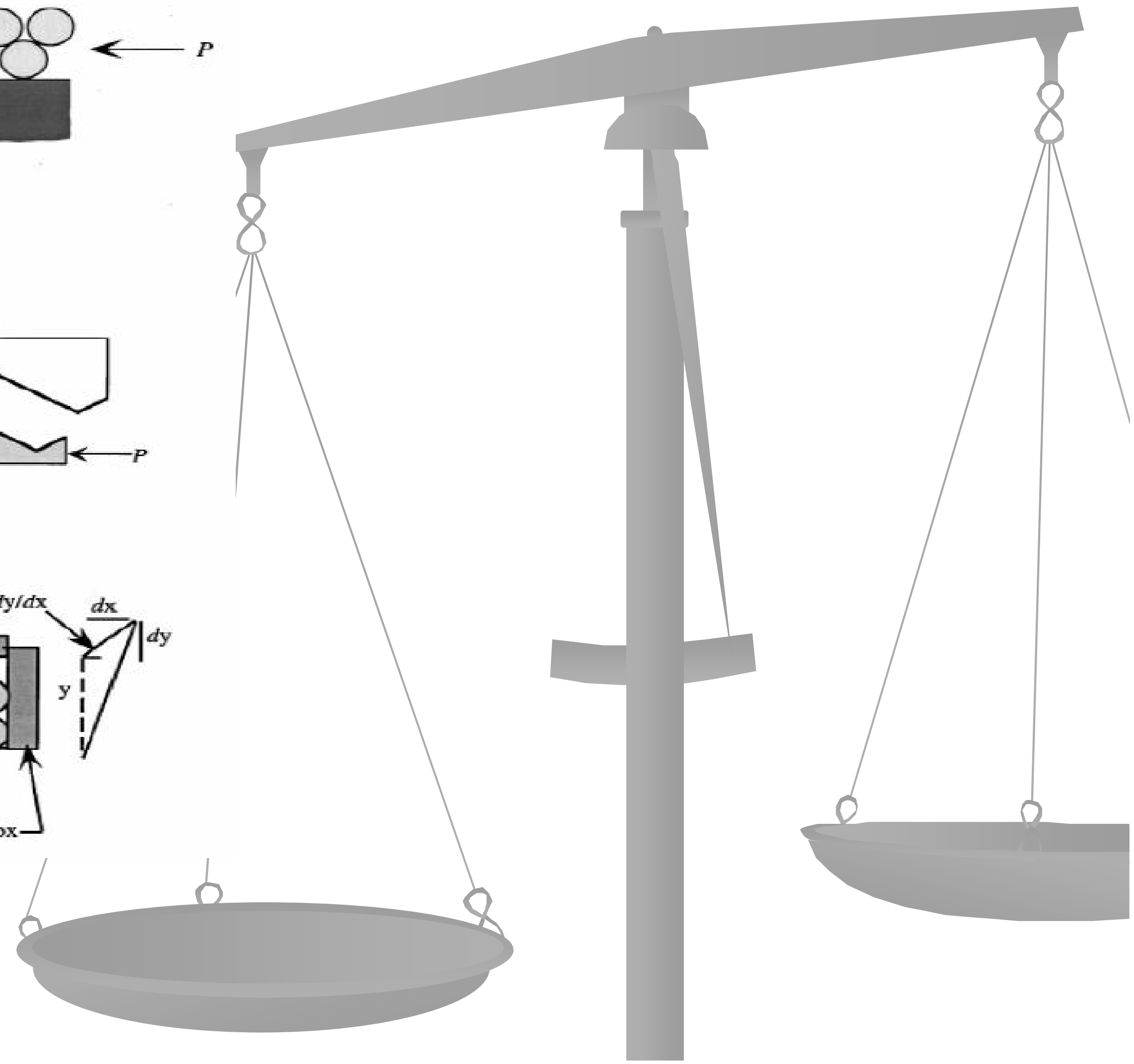
Relación entre las resistencias máxima y residual.

Comparación ensayo drenado NC y OC

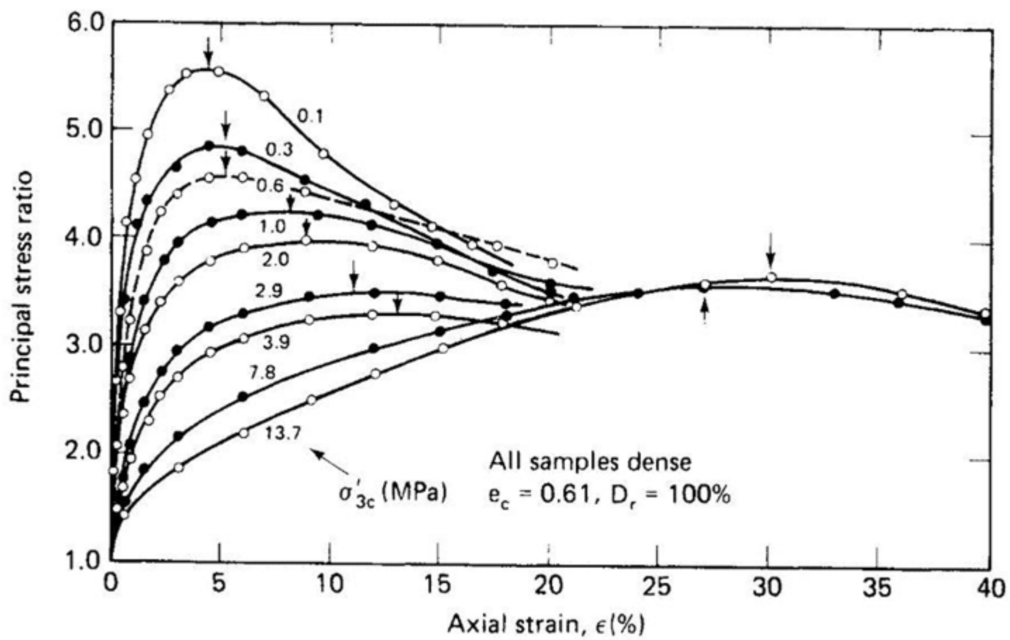


Arenas densas

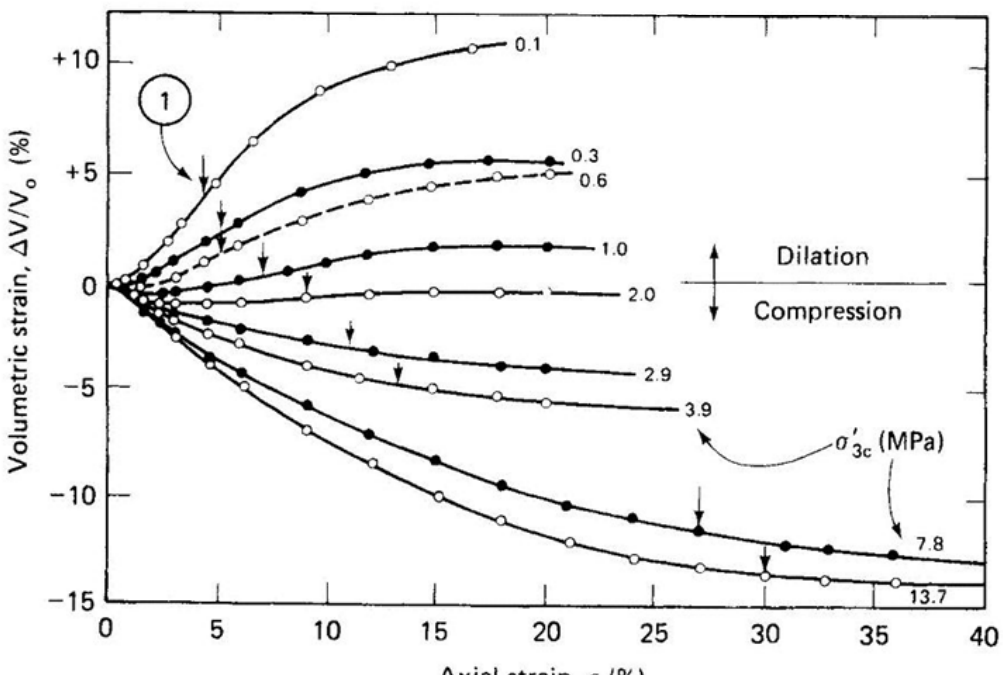




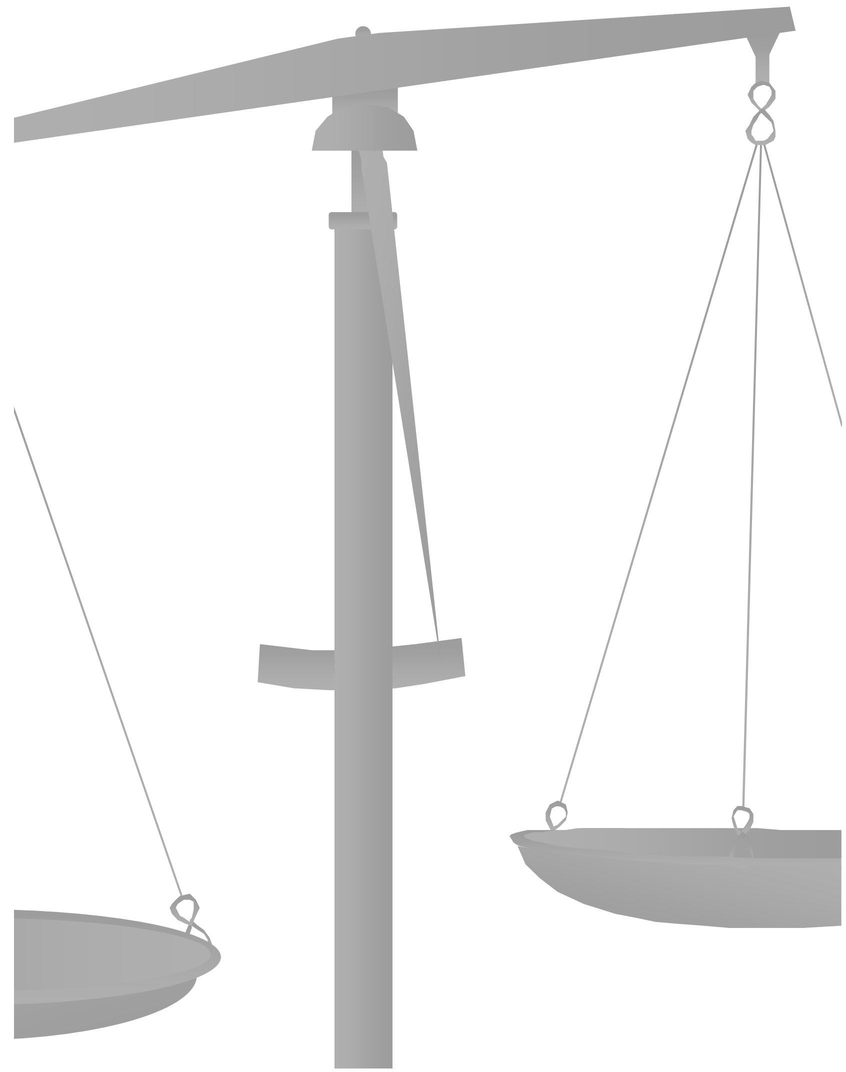
Arena densa, ensayos triaxiales drenados

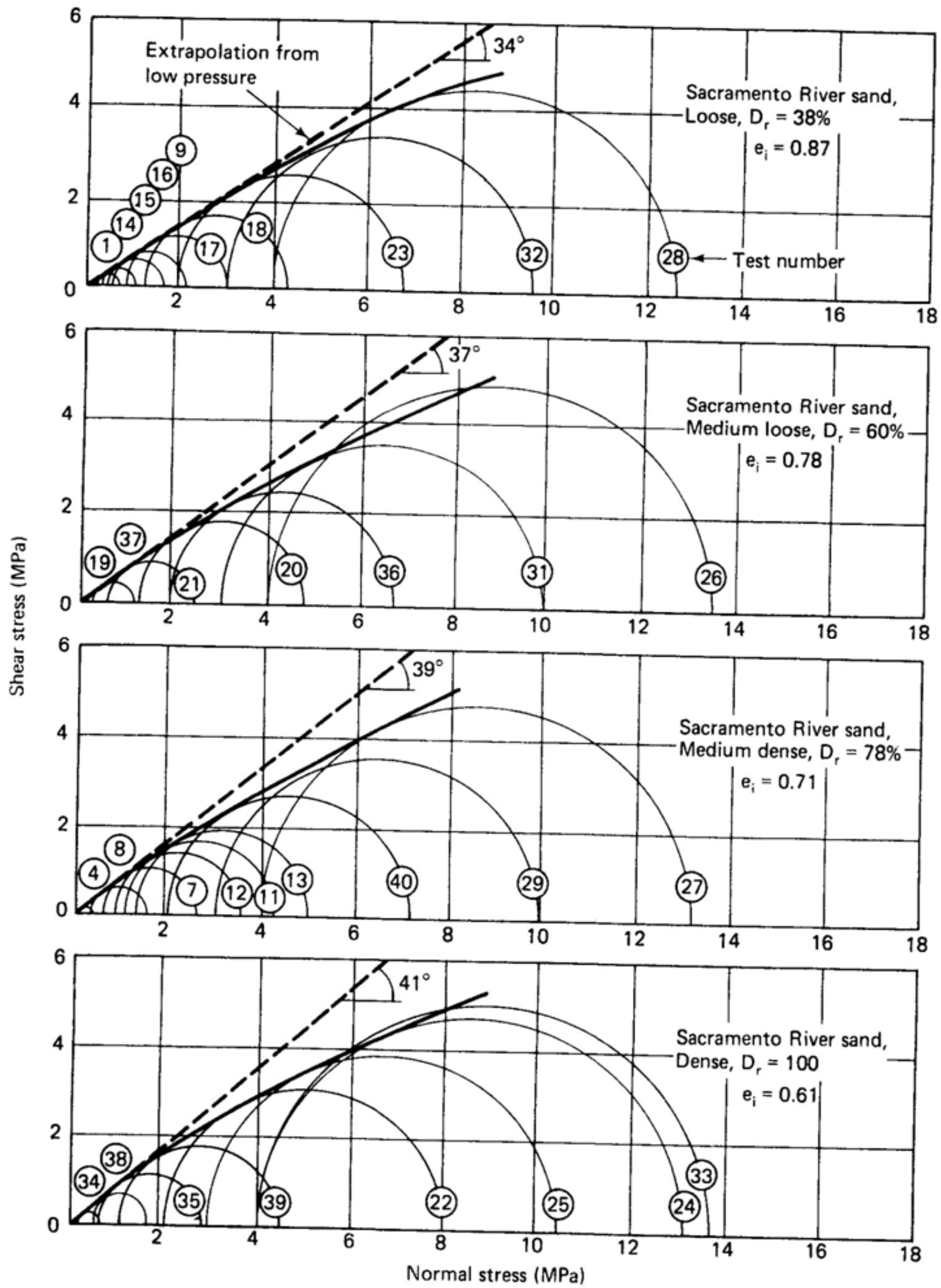


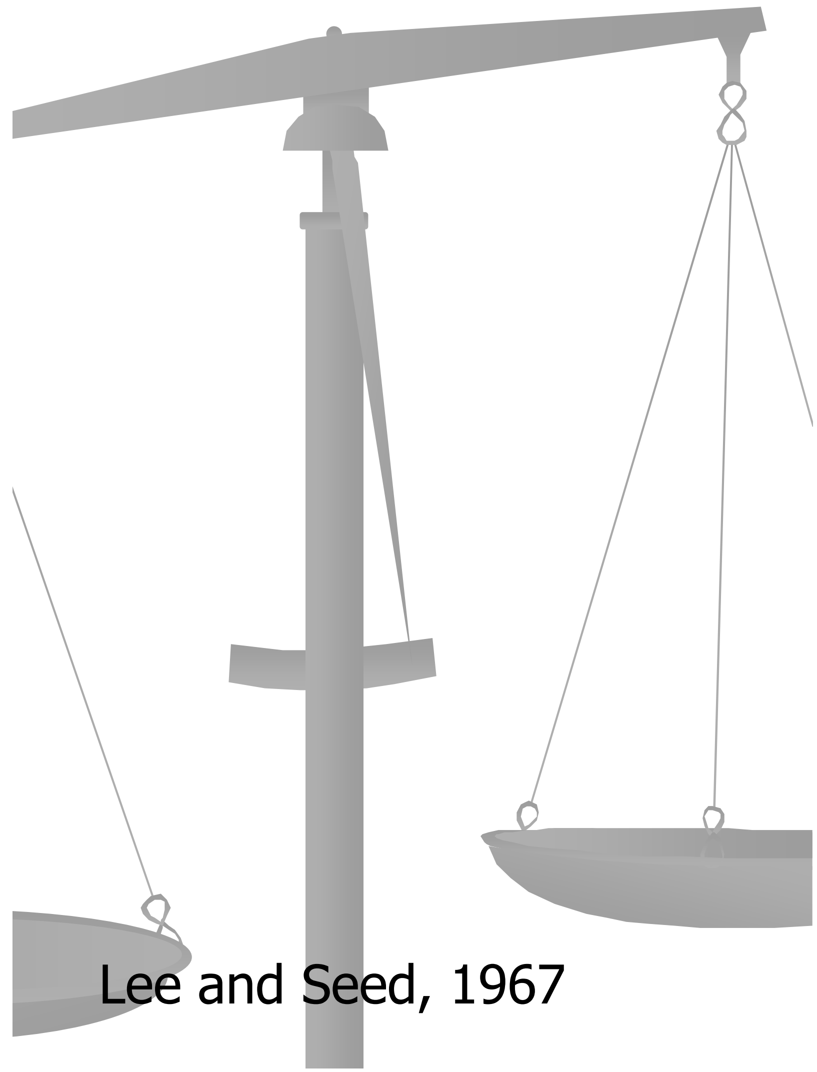
(a)



(b)

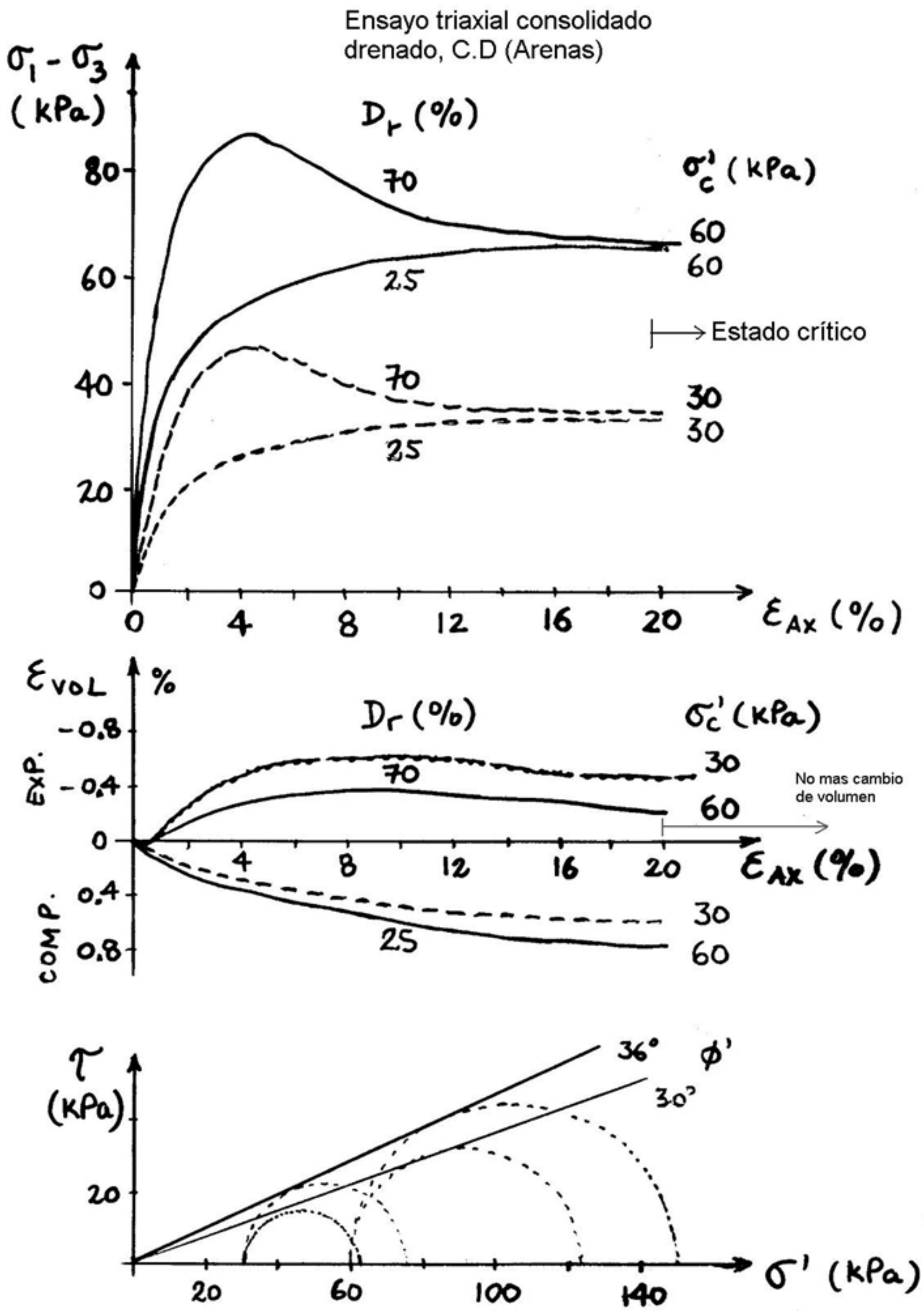


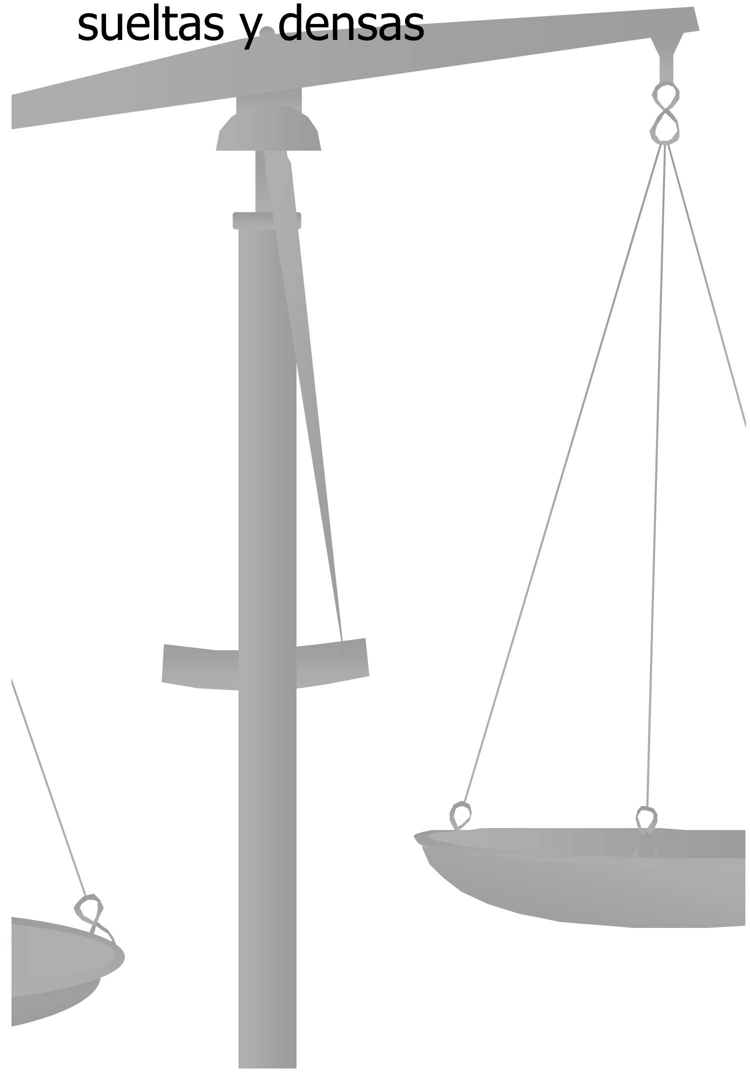




Lee and Seed, 1967

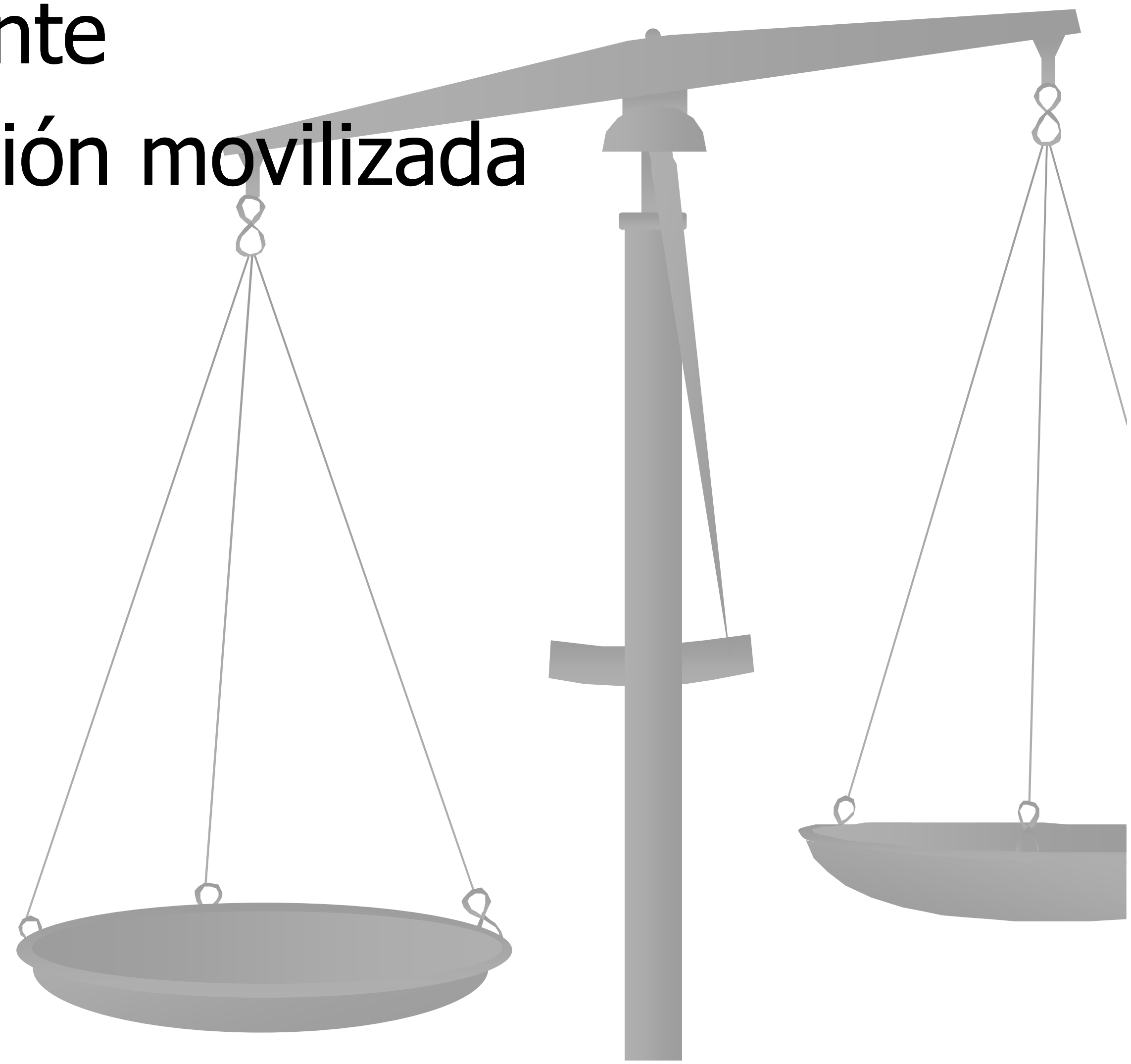
Comportamiento drenado de arenas sueltas y densas





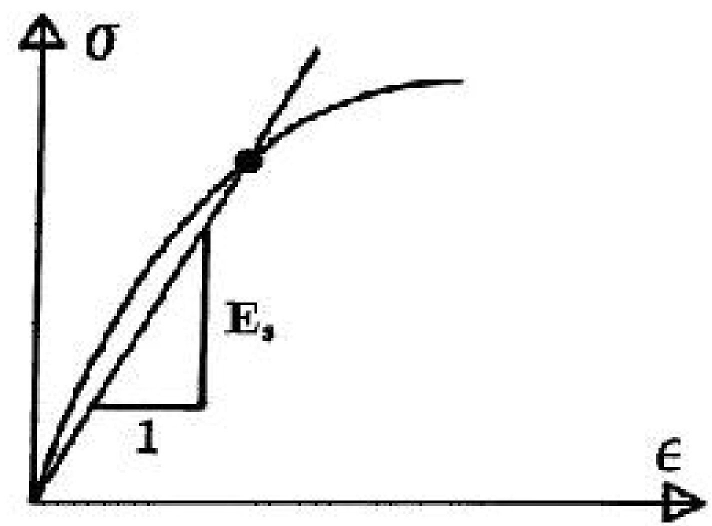
Otros conceptos

- Cohesión aparente
- Cohesión y fricción movilizada

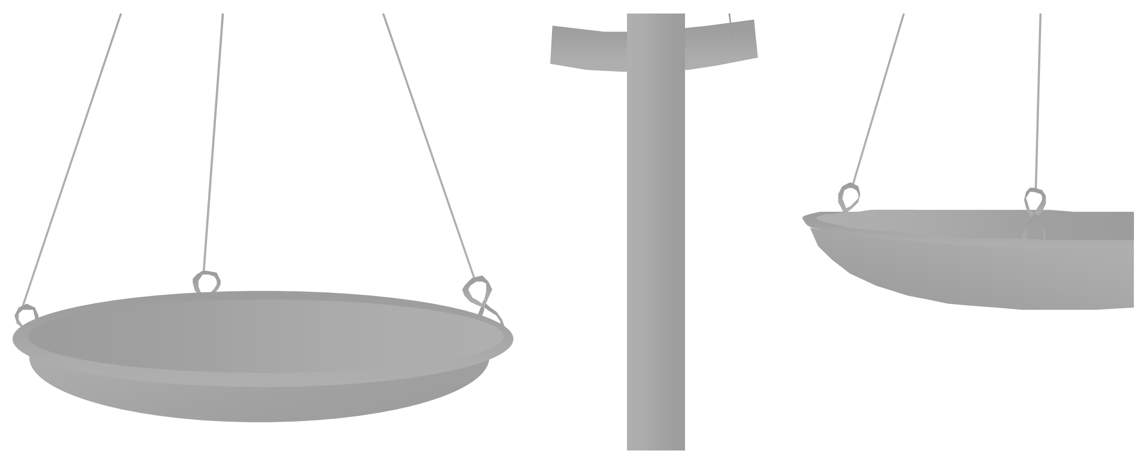


Parámetros de deformación

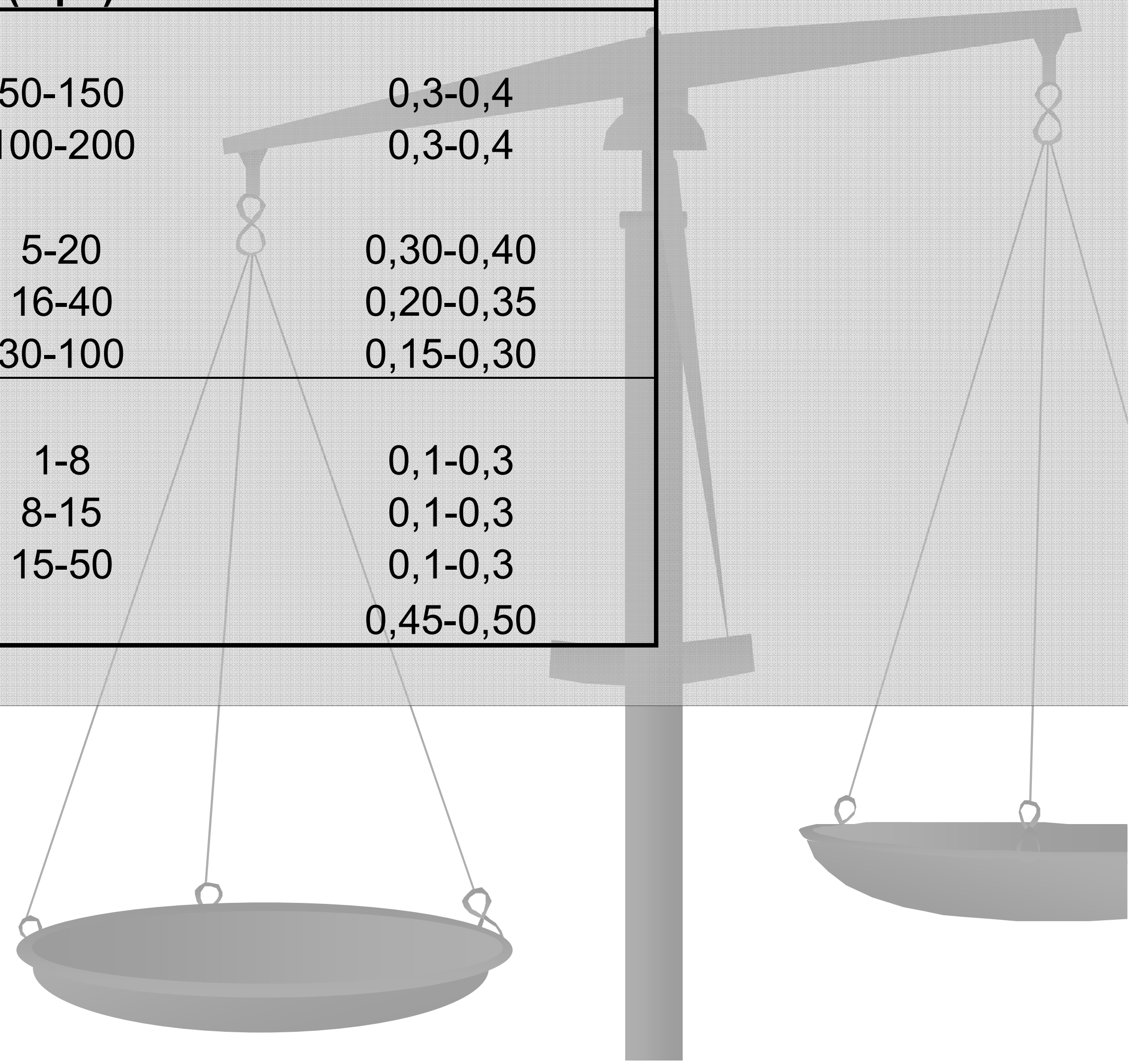
Se asume comportamiento elástico para el cálculo de las deformaciones instantáneas, el módulo de deformación se estima de la curva esfuerzo-deformación.



Ejemplo: $$S = q \cdot B \cdot \left(\frac{1-\nu^2}{E_s} \right) \cdot I_w$$



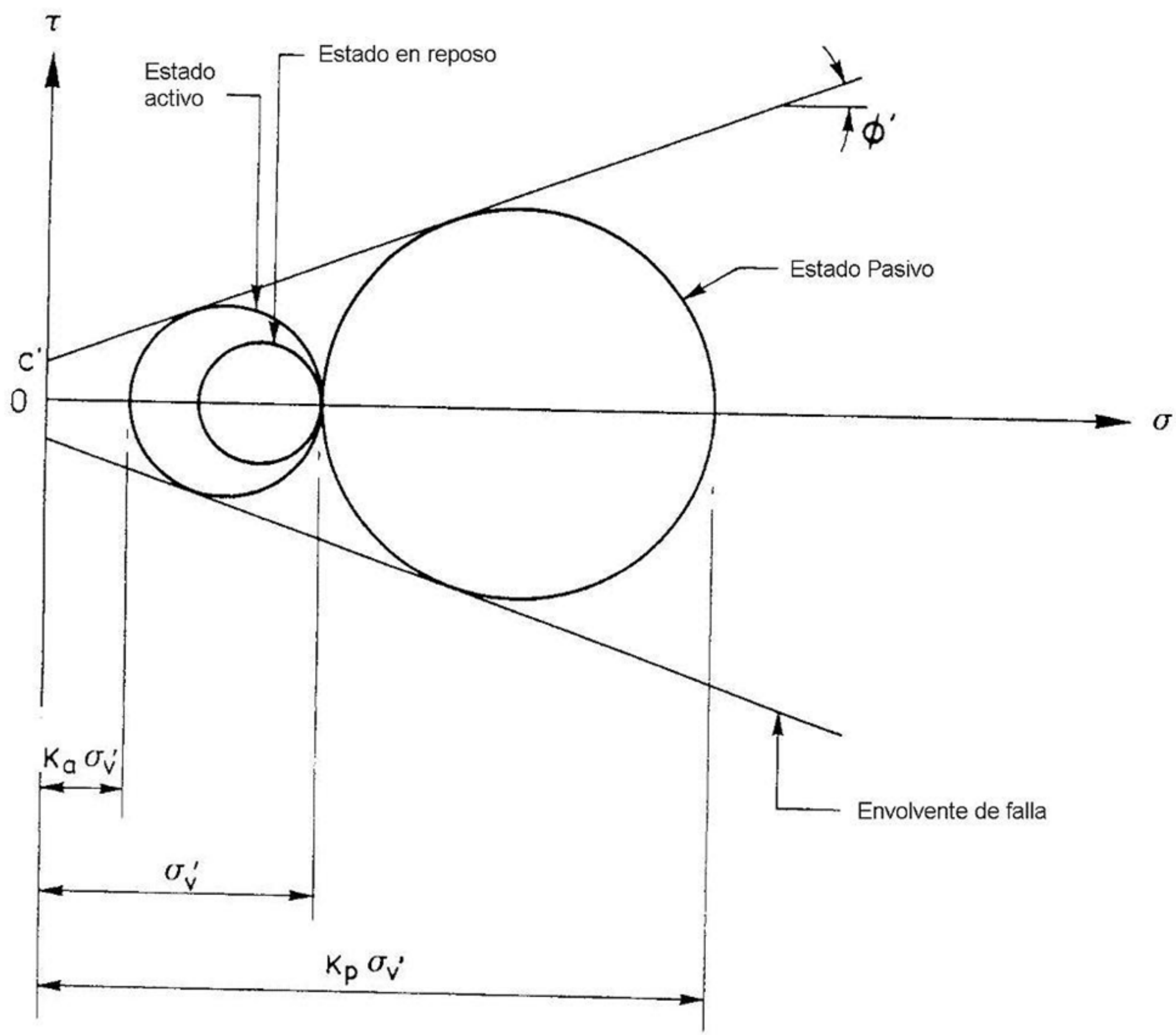
Tipo de Suelo	Estado	Módulo de Young (Mpa)	Coef. De Poisson
Grava-arenosa			
	Suelta	50-150	0,3-0,4
	Densa	100-200	0,3-0,4
Arena			
	Suelta	5-20	0,30-0,40
	Media	16-40	0,20-0,35
	Densa	30-100	0,15-0,30
Arcilla			
	Blanda	1-8	0,1-0,3
	Media	8-15	0,1-0,3
	Dura	15-50	0,1-0,3
	Saturada		0,45-0,50

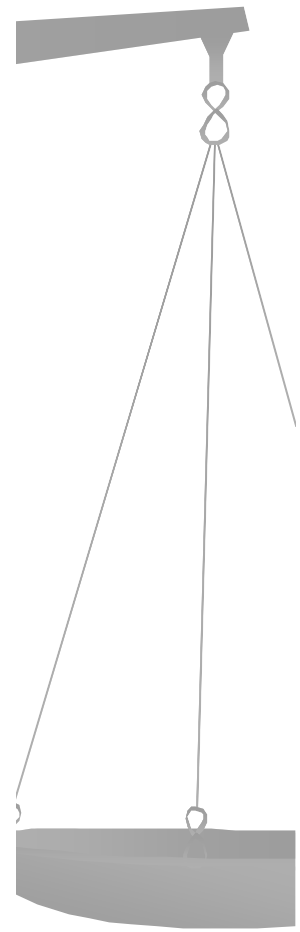


Empuje de Suelos

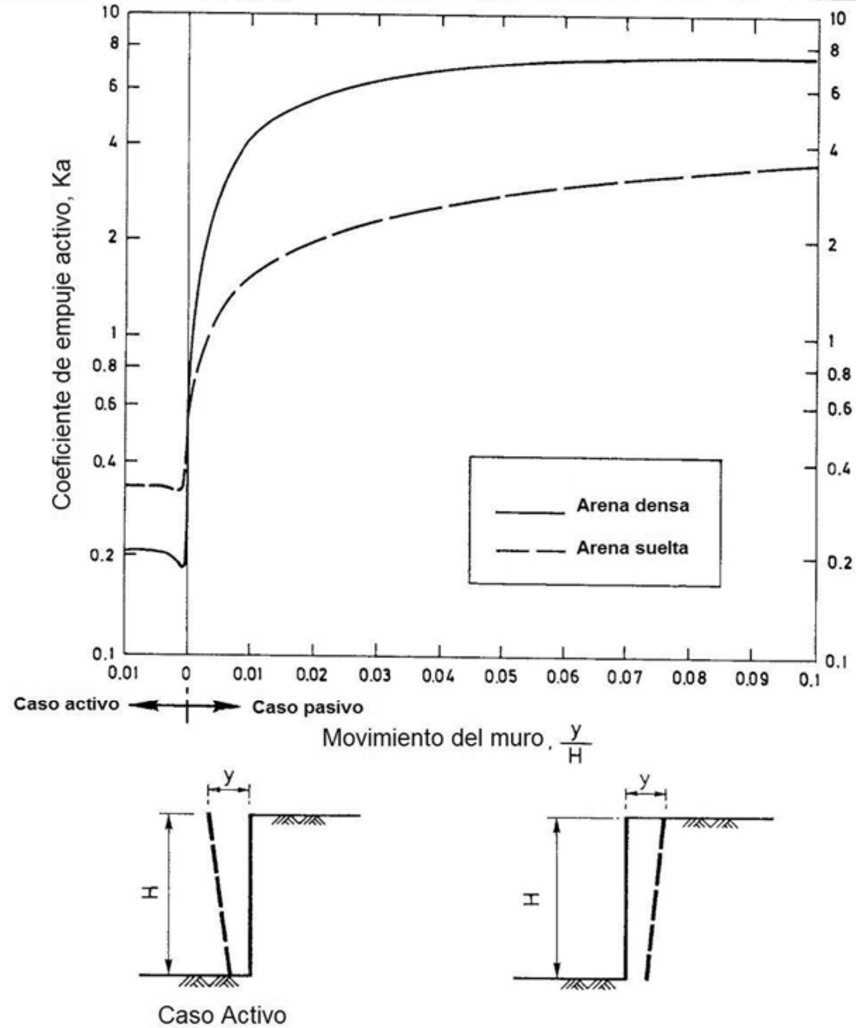
- Empujes Estáticos
- Empujes de agua
- Empujes dinámicos

Teoría de Rankine



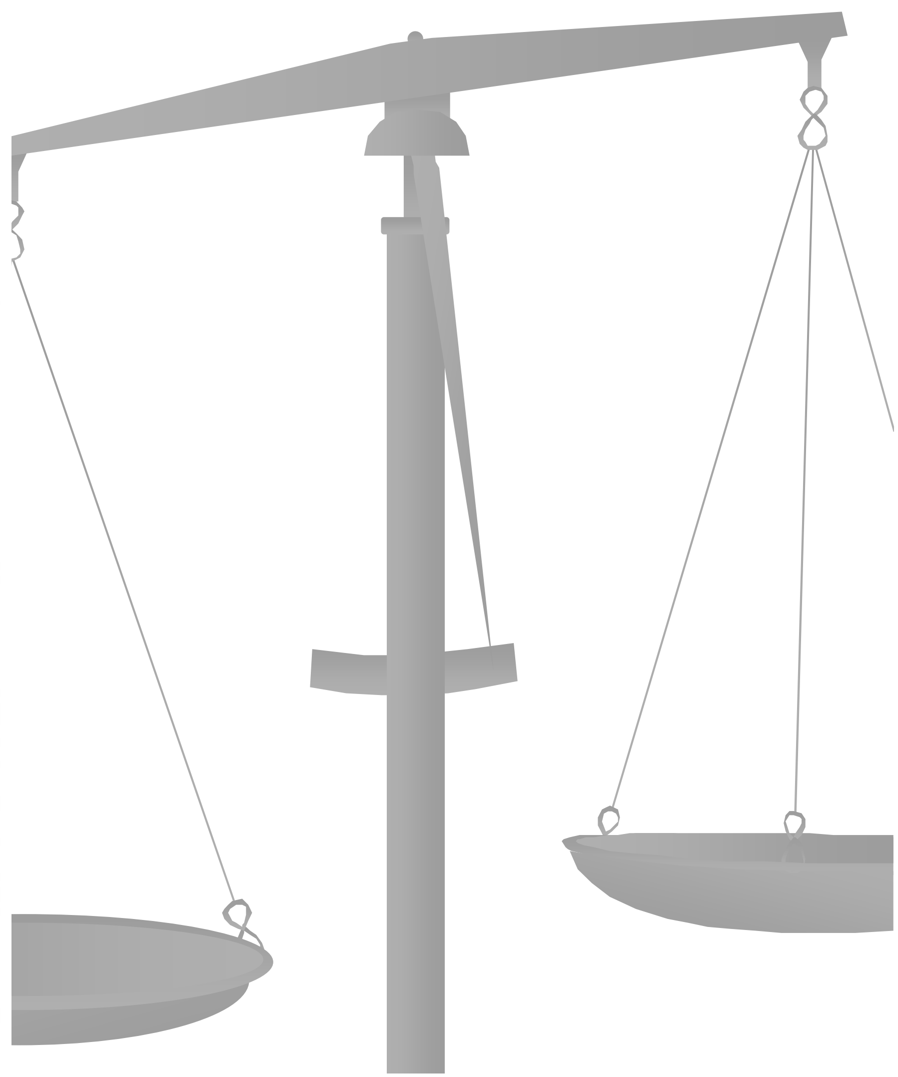


Desplazamientos Vs. Empuje



Tipo de suelo	Mov. necesario para la falla, $\frac{y}{H}$	
	Caso Activo	Caso Pasivo
Dense sand	0.001	0.02 – 0.06
Loose sand	0.005	0.06 – 0.35
Stiff clay	0.01	0.02
Soft clay	0.02	0.04

Obs.: 1) Figura basada en el "Canadian Geotechnical Society (1985) y Rowe &Peaker (1965)
2) Sólo para muros rígidos con Ko menor que 1.0.

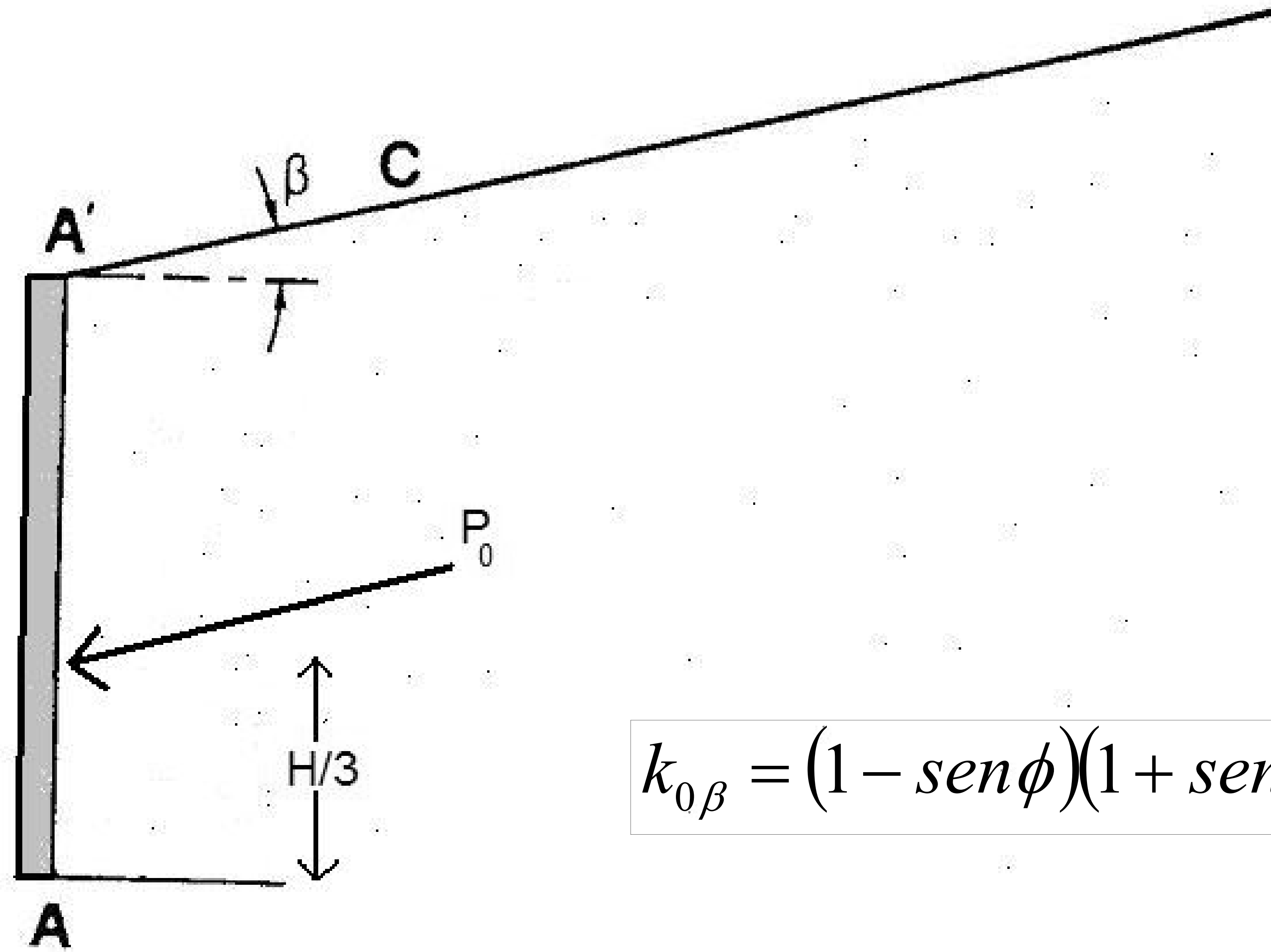


Empuje en reposo

$$\boxed{k_0 = 1 - sen\phi}$$

Jaky (1944)

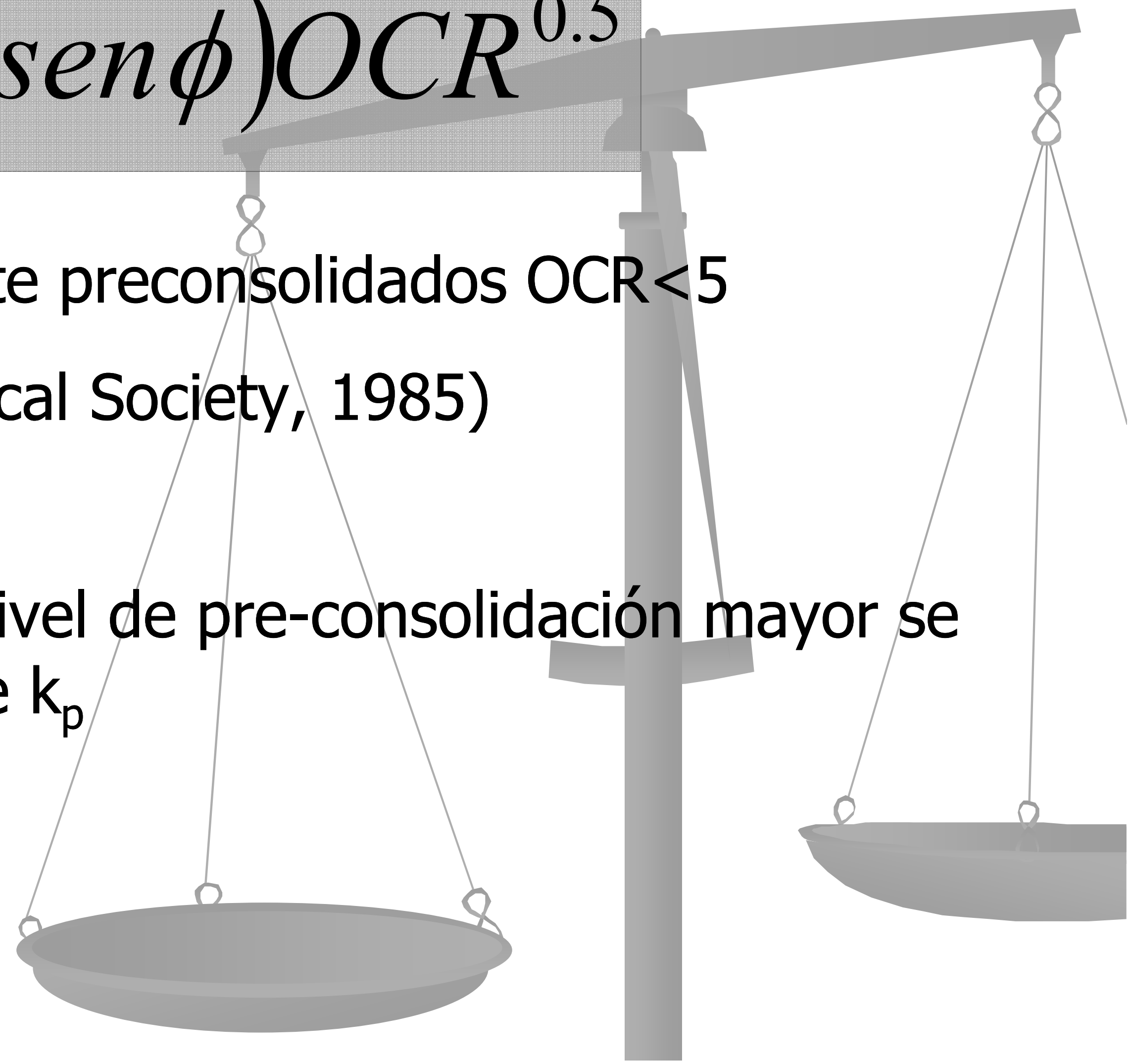
- Ecuación válida para suelos normalmente consolidados que no han presentado deformaciones laterales.



$$k_{0\beta} = (1 - sen\phi)(1 + sen\beta)$$

$$k_{0,OC} = (1 - sen\phi) OCR^{0.5}$$

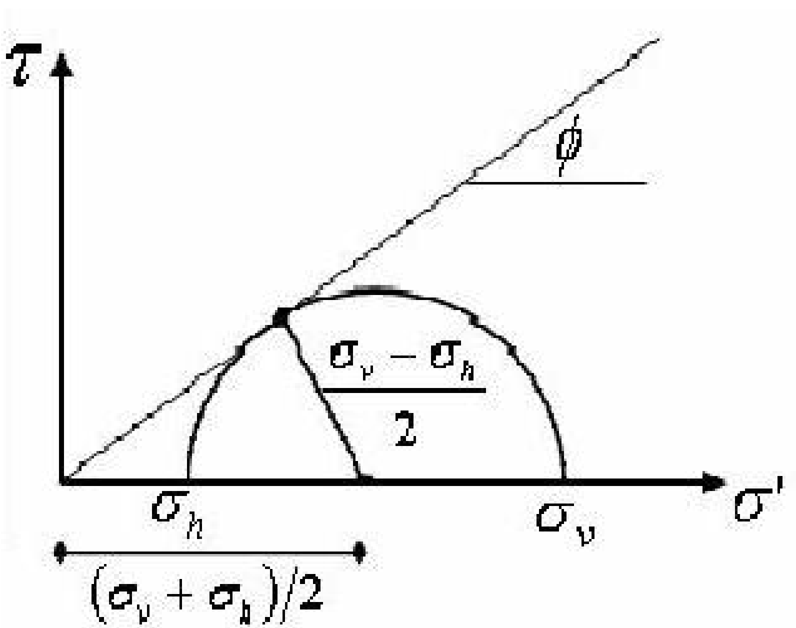
- Para suelos levemente preconsolidados OCR<5
- (Canadian Geotechnical Society, 1985)
- Para suelos con un nivel de pre-consolidación mayor se recomienda el uso de k_p

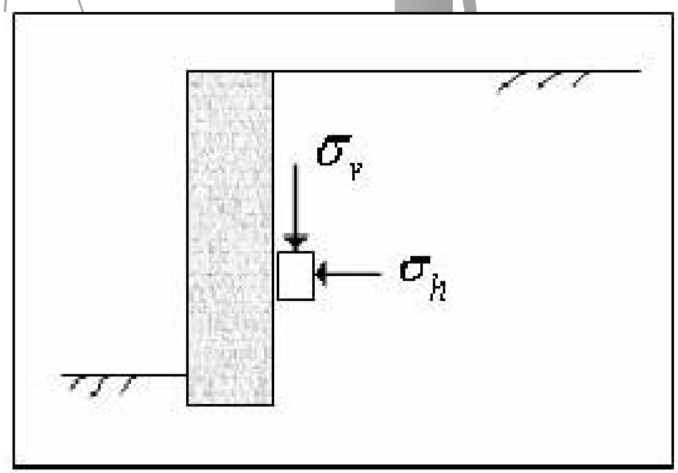


Empuje activo

$$k_a = \frac{1 - sen\phi}{1 + sen\phi} = \tan^2\left(45 - \frac{\phi}{2}\right)$$

- Coeficiente de empuje activo derivado de la teoría de Rankine.



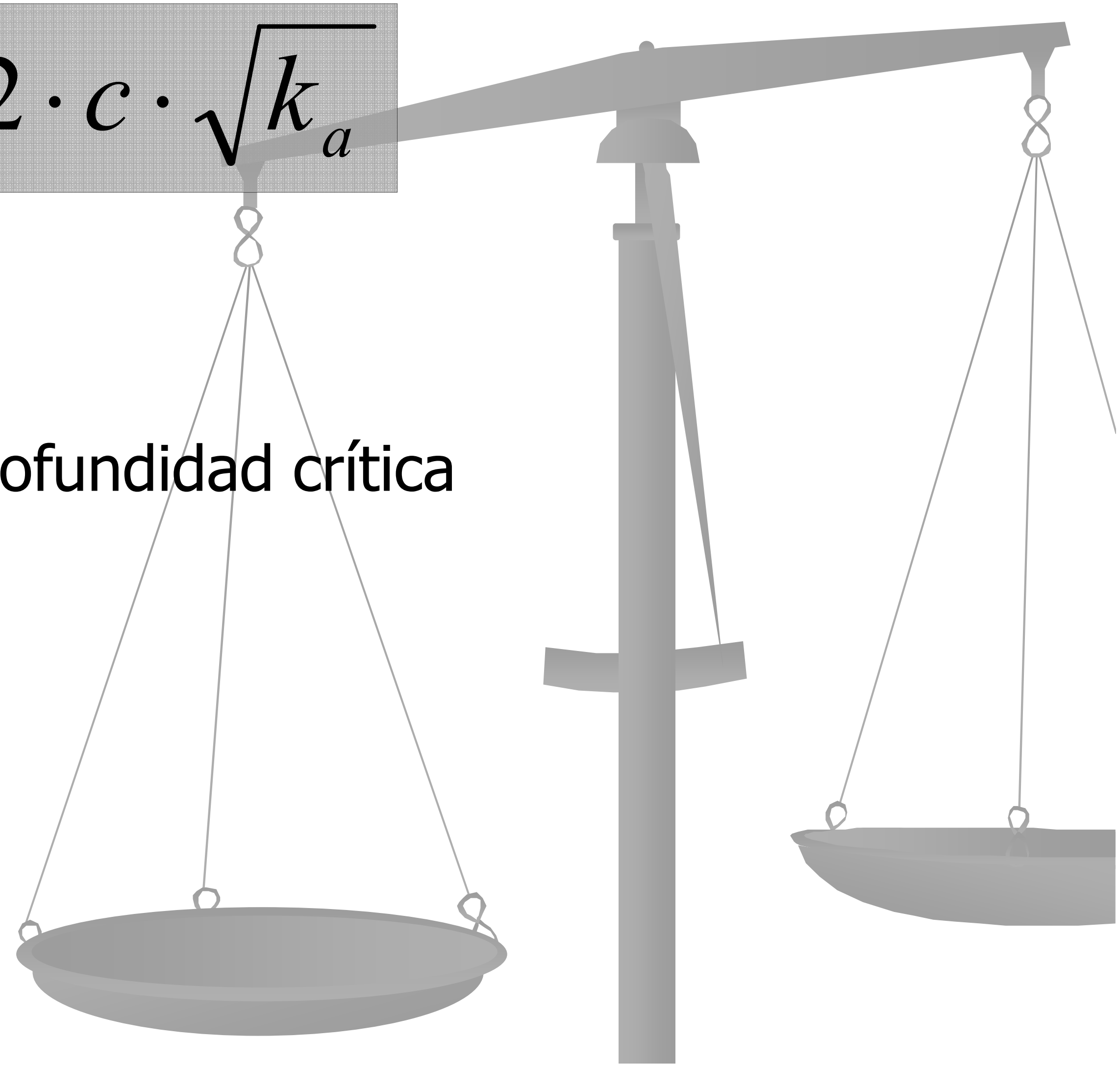


Suelos cohesivos

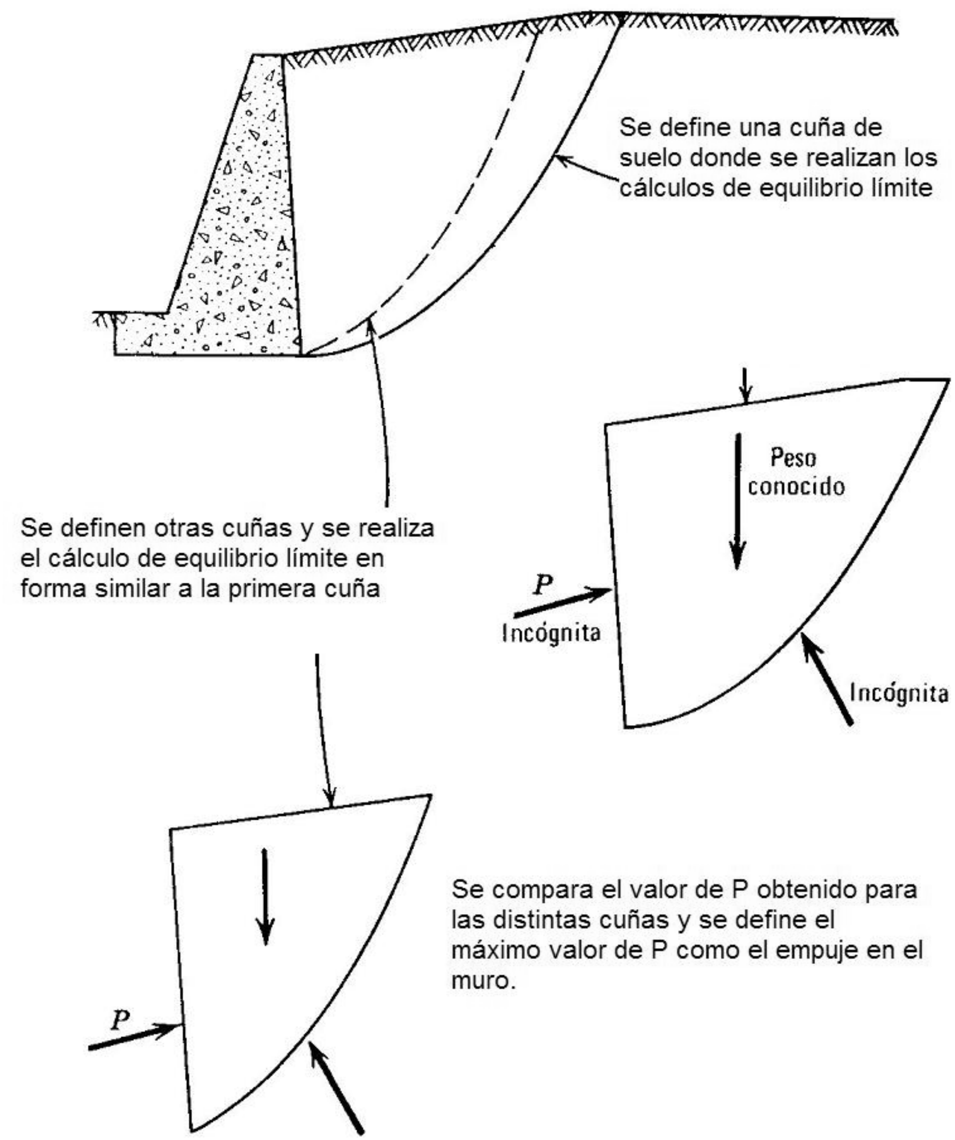
$$P_a = k_a \cdot \gamma \cdot z - 2 \cdot c \cdot \sqrt{k_a}$$

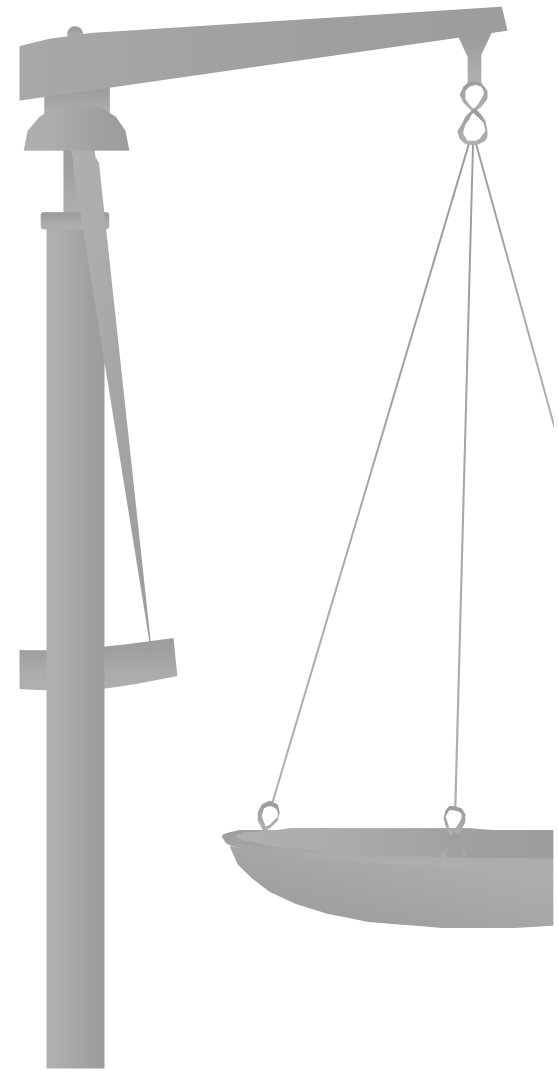
$$z_0 = \frac{1}{\gamma}\left(\frac{2c`}{\sqrt{k_a}} - q\right)$$

Profundidad crítica



Método de la cuña (Coulomb)





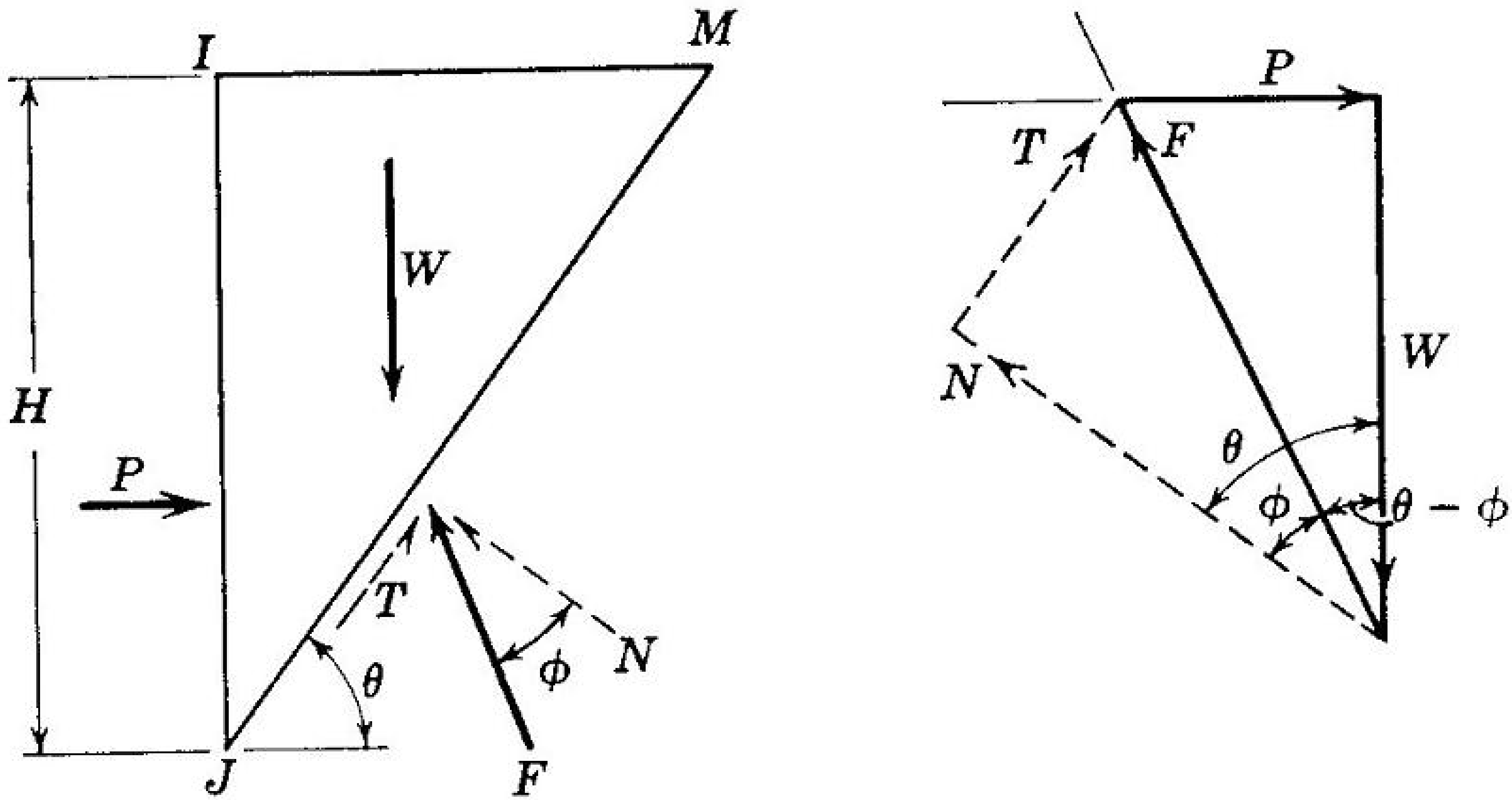
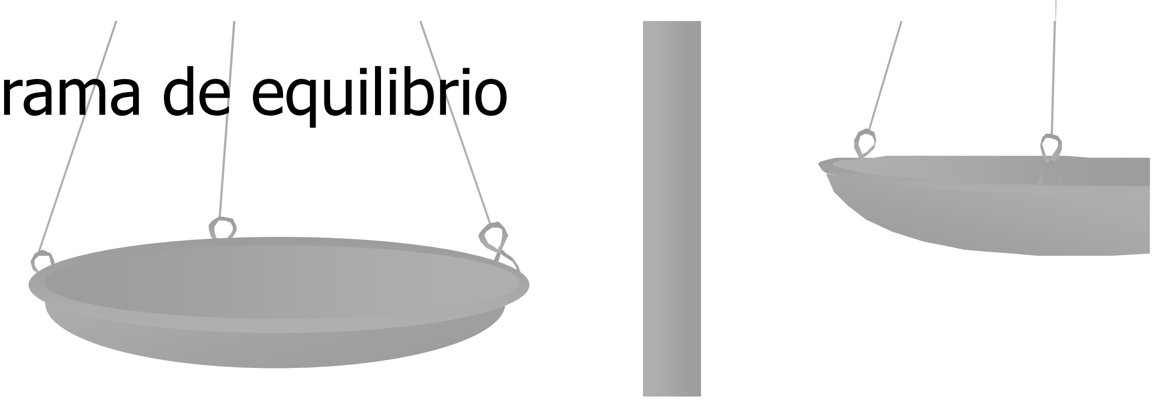
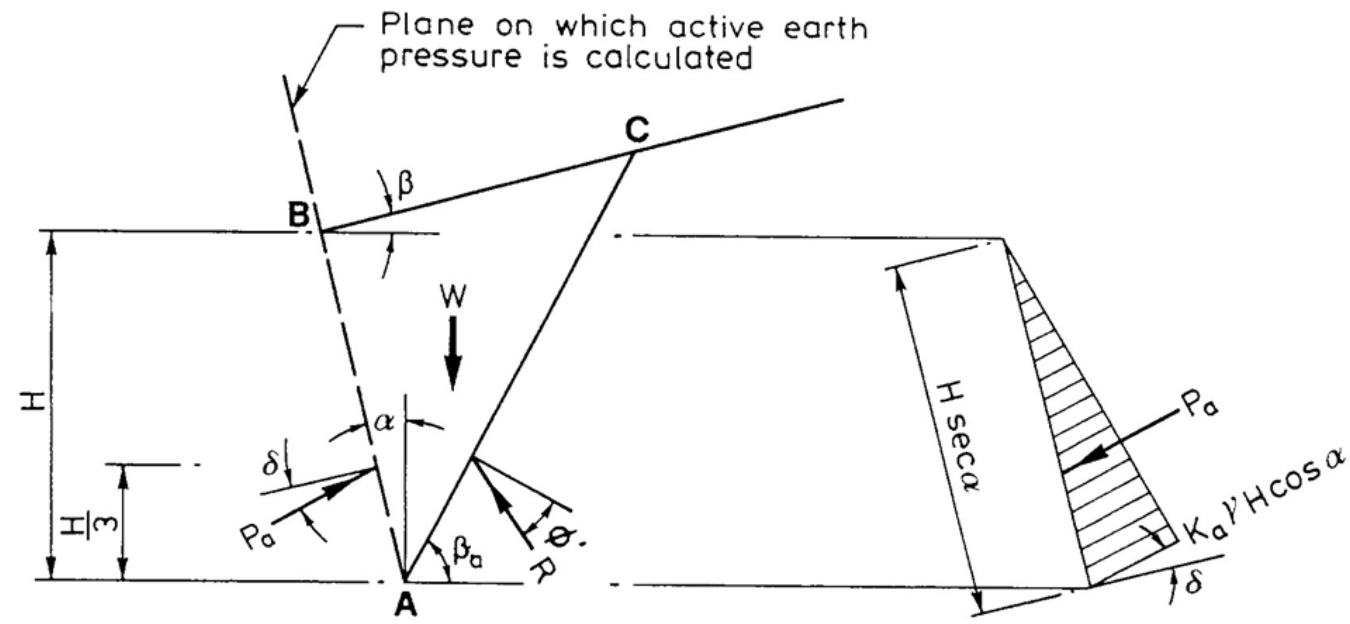


Diagrama de equilibrio



Empuje activo según Coulomb

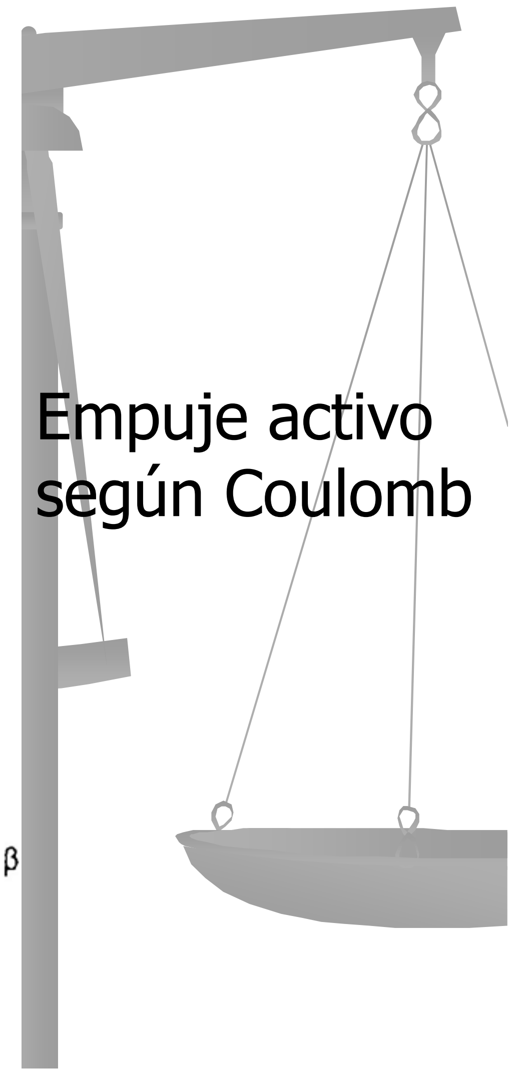


$$P_a = 0.5 K_a \gamma H^2$$

$$\text{where} \quad K_a = \frac{\cos^2(\phi' - \alpha)}{\cos^2\alpha \cos(\delta + \alpha)\left[1 + \sqrt{\dfrac{\sin(\phi' + \delta)\sin(\phi' - \beta)}{\cos(\delta + \alpha)\cos(\beta - \alpha)}}\right]^2}$$

$$\cot(\beta_a - \beta) = \sec(\phi' + \delta + \alpha - \beta)\sqrt{\frac{\sin(\phi' + \delta)\cos(\delta + \alpha)}{\sin(\phi' - \beta)\cos(\beta - \alpha)}} - \tan(\phi' + \delta + \alpha - \beta)$$

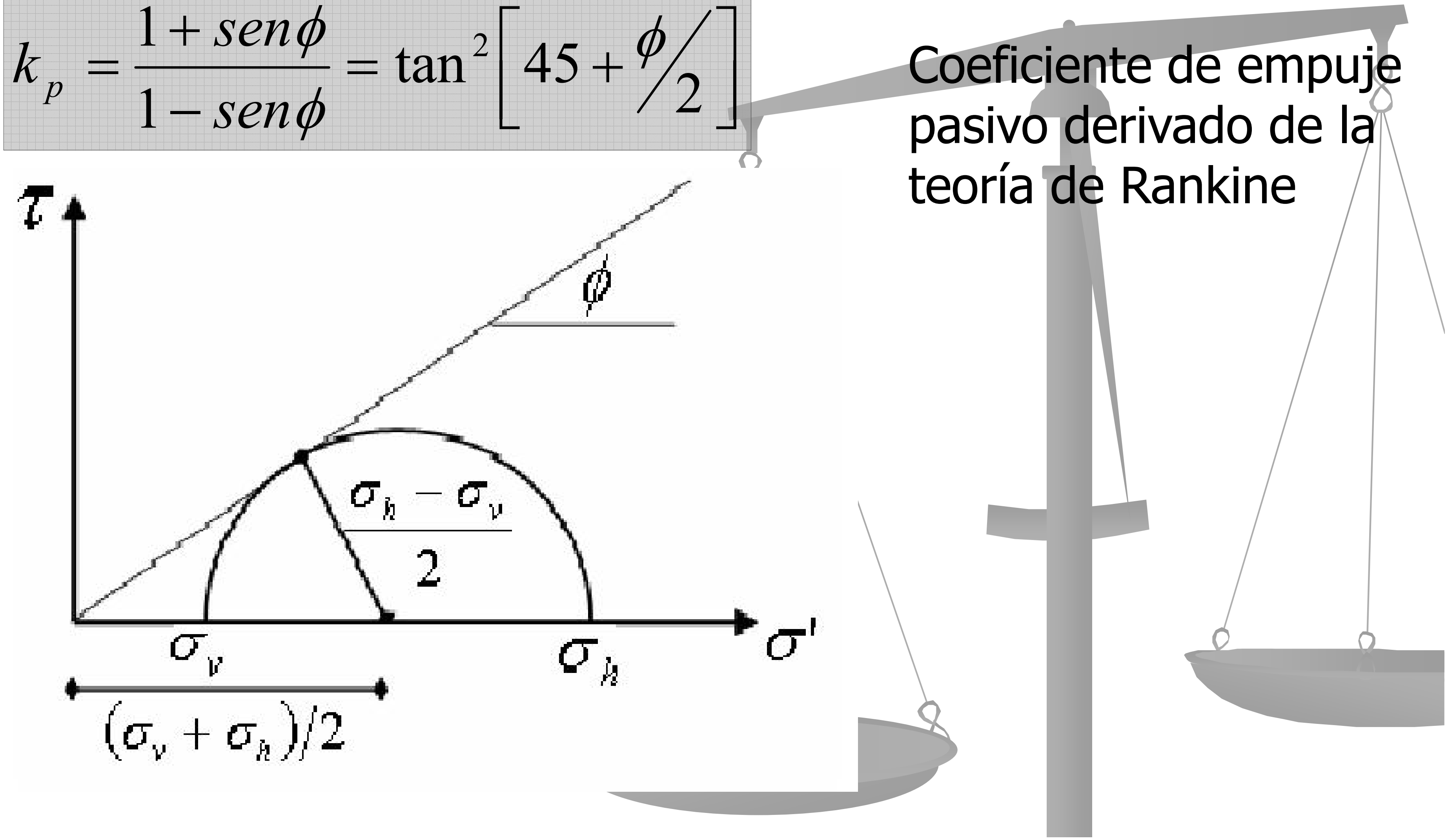
For $\alpha = 0$ and $\delta = \beta$, K_a = Rankine's value given in Figure 15 (a).



Empuje Pasivo

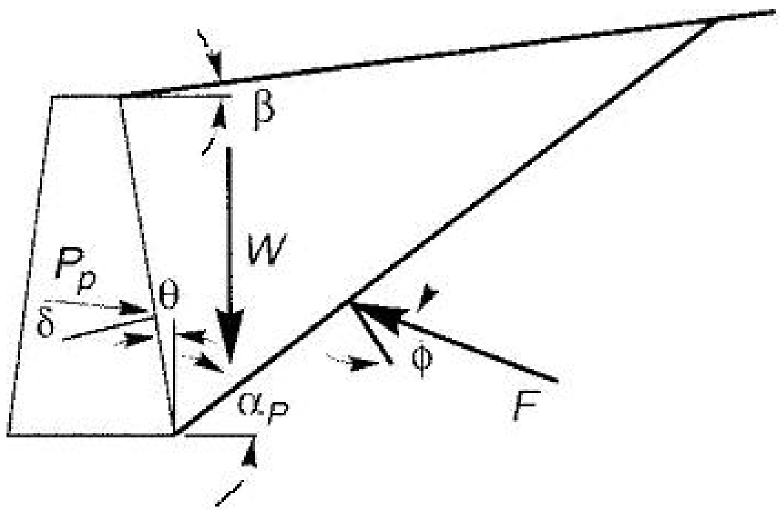
$$k_p = \frac{1 + sen\phi}{1 - sen\phi} = \tan^2\left[45 + \frac{\phi}{2}\right]$$

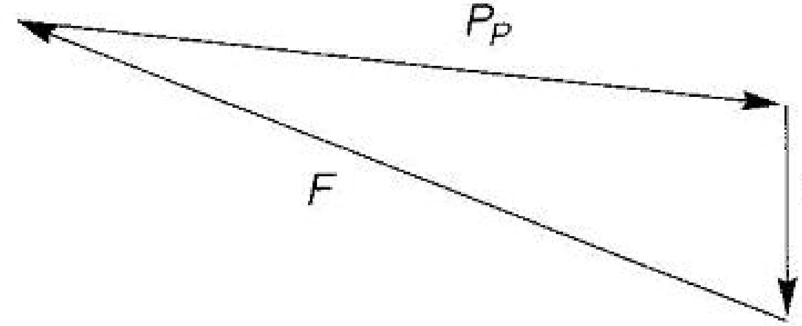
Coeficiente de empuje pasivo derivado de la teoría de Rankine



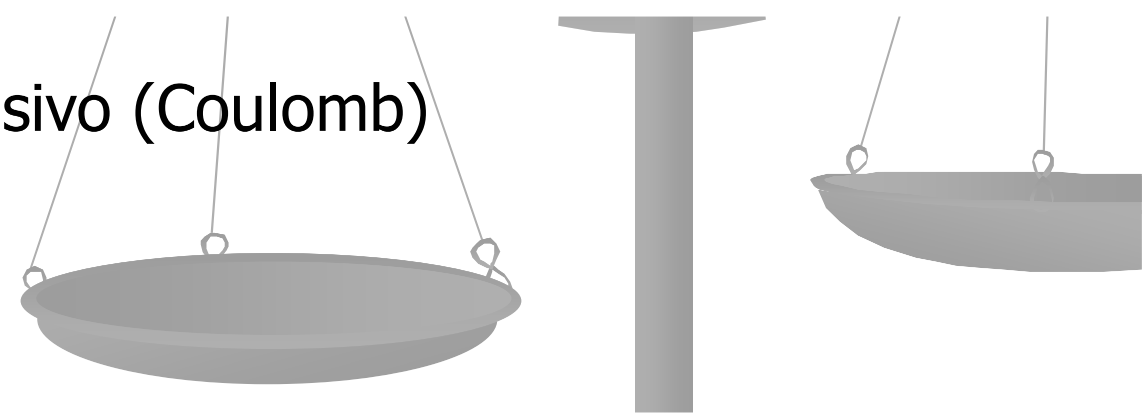
$$P_P = \tfrac{1}{2} K_P \gamma H^2$$

$$K_P = \frac{\cos^2(\phi+\theta)}{\cos^2\theta \cos(\delta-\theta)\left[1+\sqrt{\dfrac{\sin(\delta+\phi)\sin(\phi+\beta)}{\cos(\delta-\theta)\cos(\beta-\theta)}}\right]^2}$$



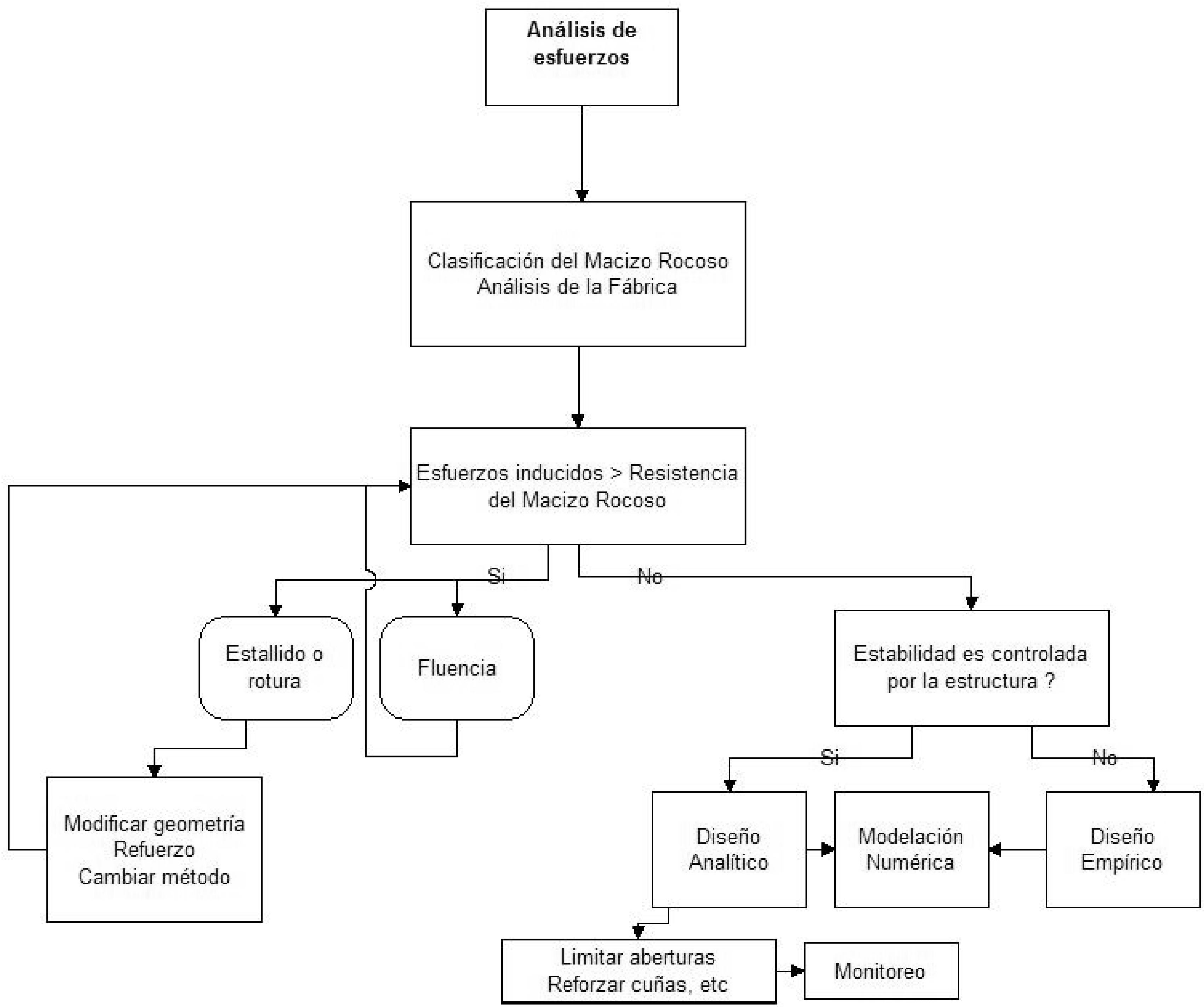


Empuje Pasivo (Coulomb)



Empuje de Rocas

- ¿Es válido lo empleado en suelos?


Análisis de esfuerzos
Clasificación del Macizo Rocoso
Análisis de la Fábrica
Esfuerzos inducidos > Resistencia del Macizo Rocoso
Si
No
Estallido o rotura
Fluencia
Modificar geometría
Refuerzo
Cambiar método
Estabilidad es controlada por la estructura ?
Si
No
Diseño Analítico
Modelación Numérica
Diseño Empírico
Limitar aberturas
Reforzar cuñas, etc
Monitoreo

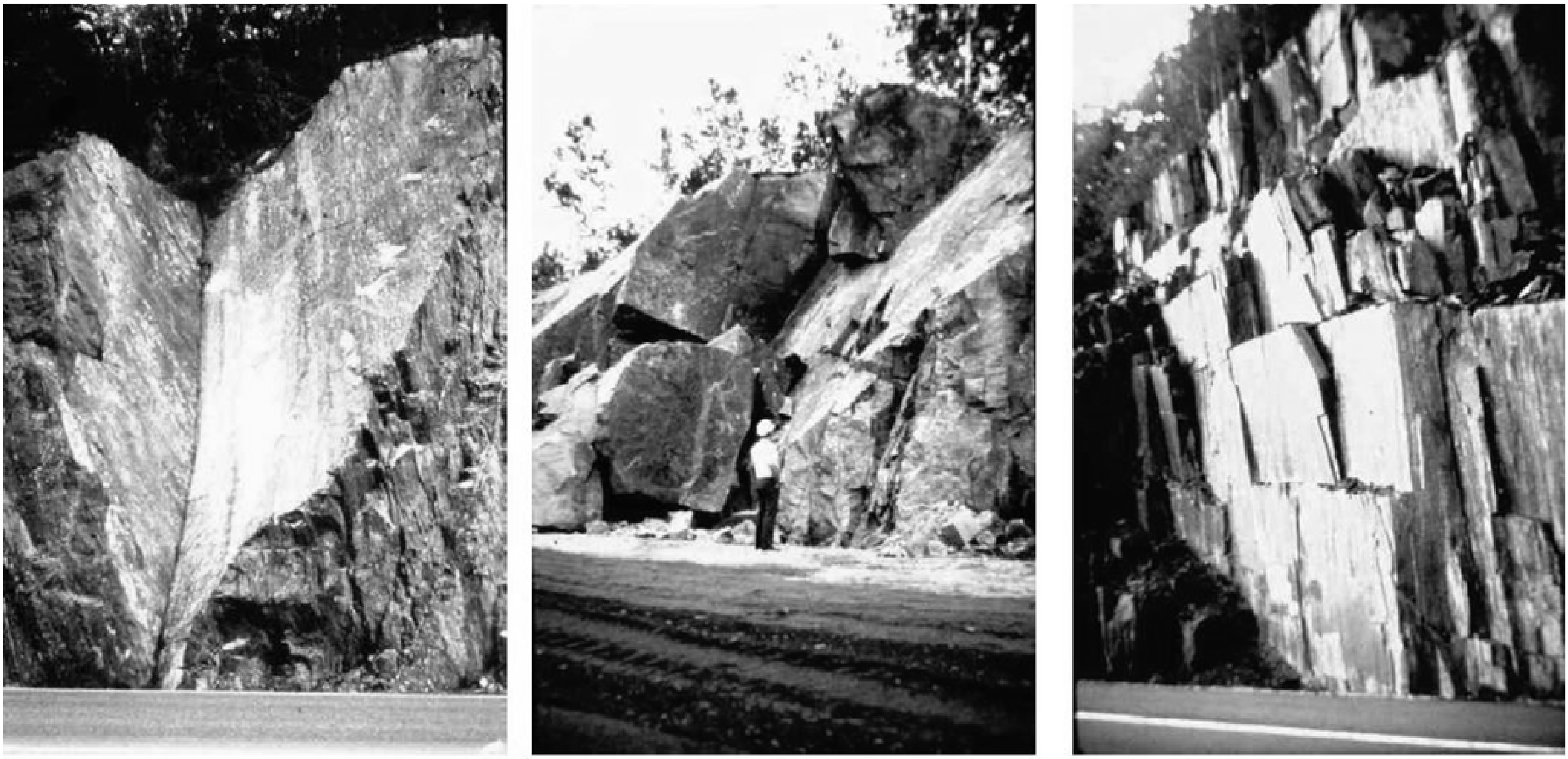
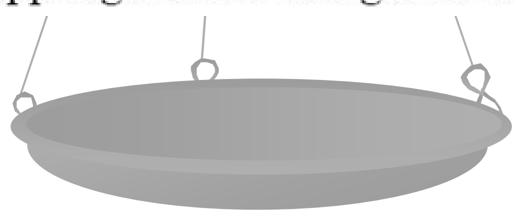
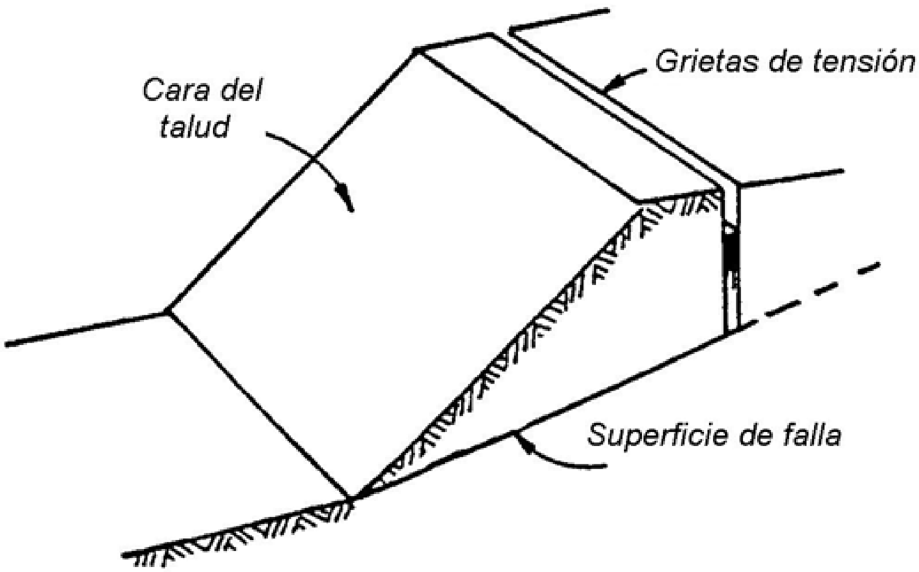
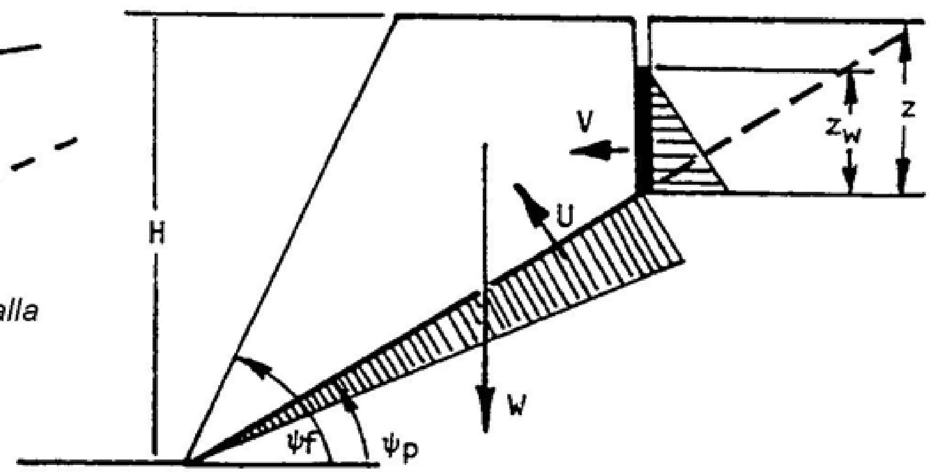


Figure 3. Example of wedge, planar, and toppling failures along road cuts.

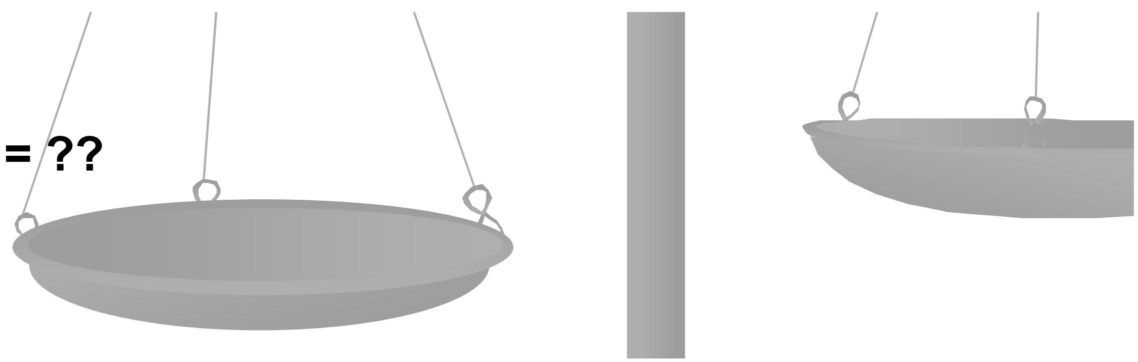


Análisis 2-D de falla plana

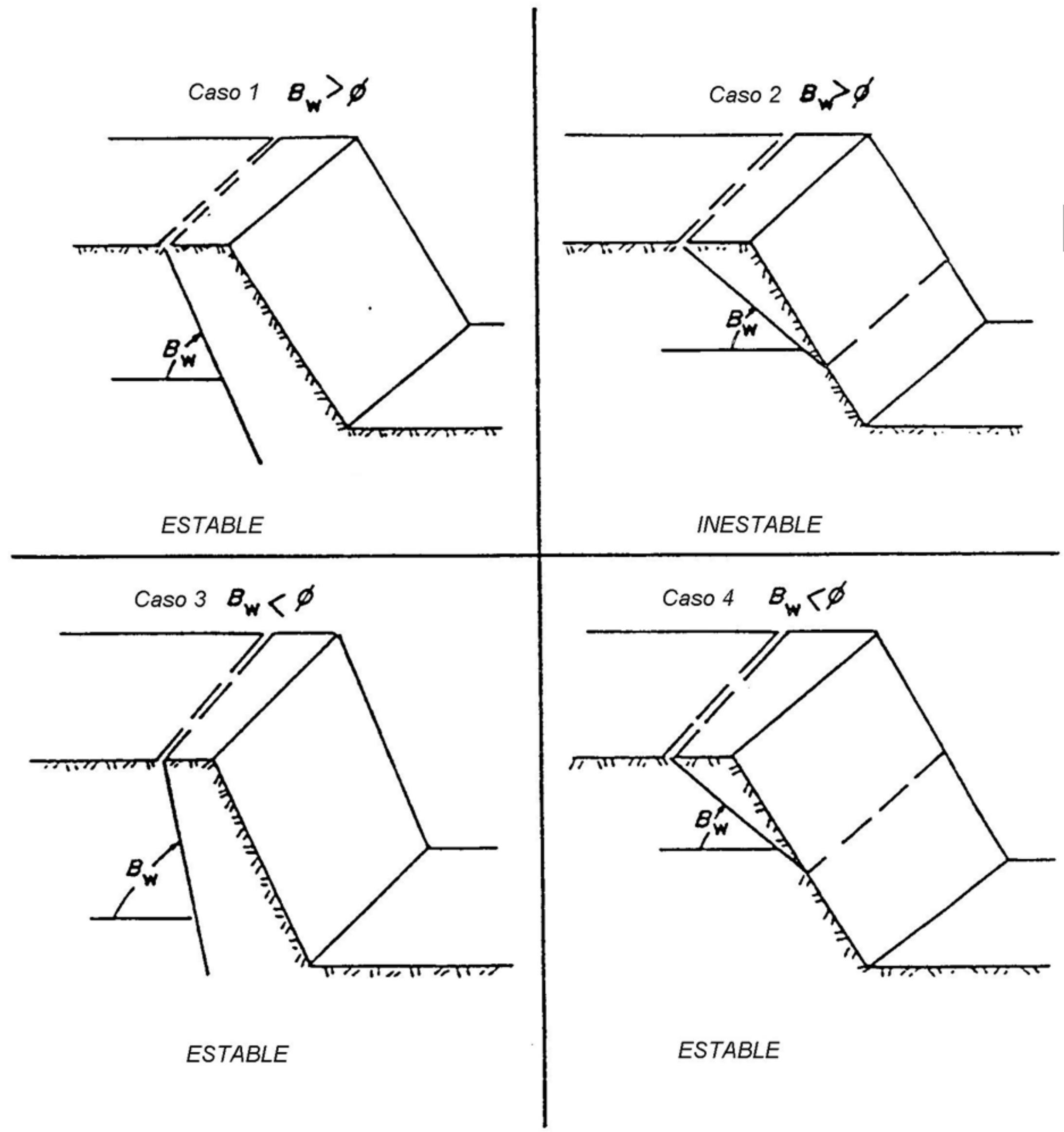


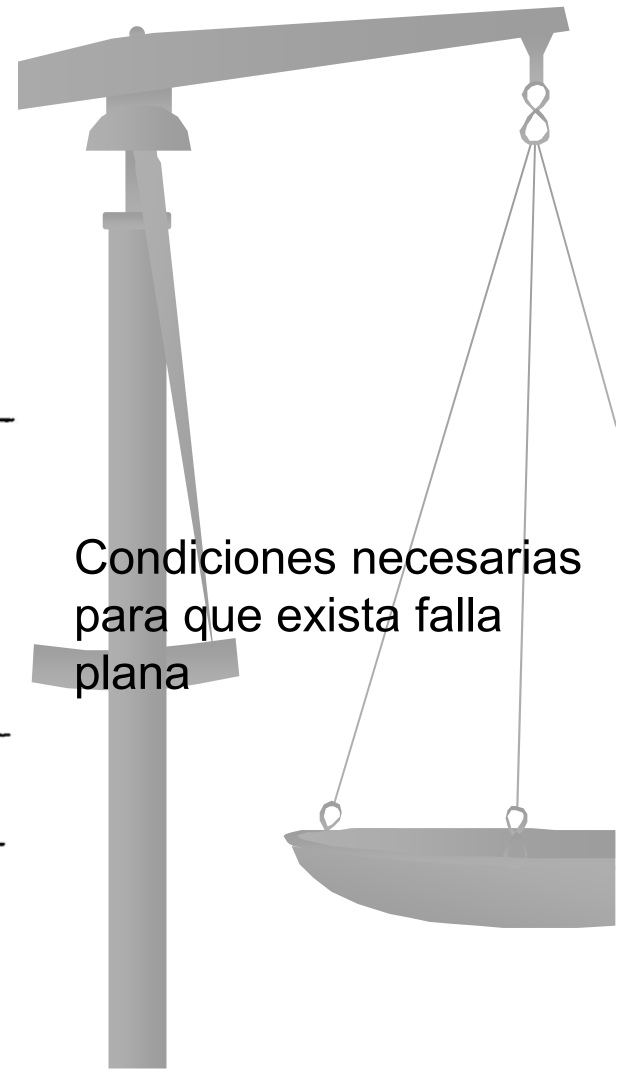


Análisis Mohr-Coulomb. F.S. = ??



Falla plana





Condiciones necesarias para que exista falla plana


AGA


TOYOTA

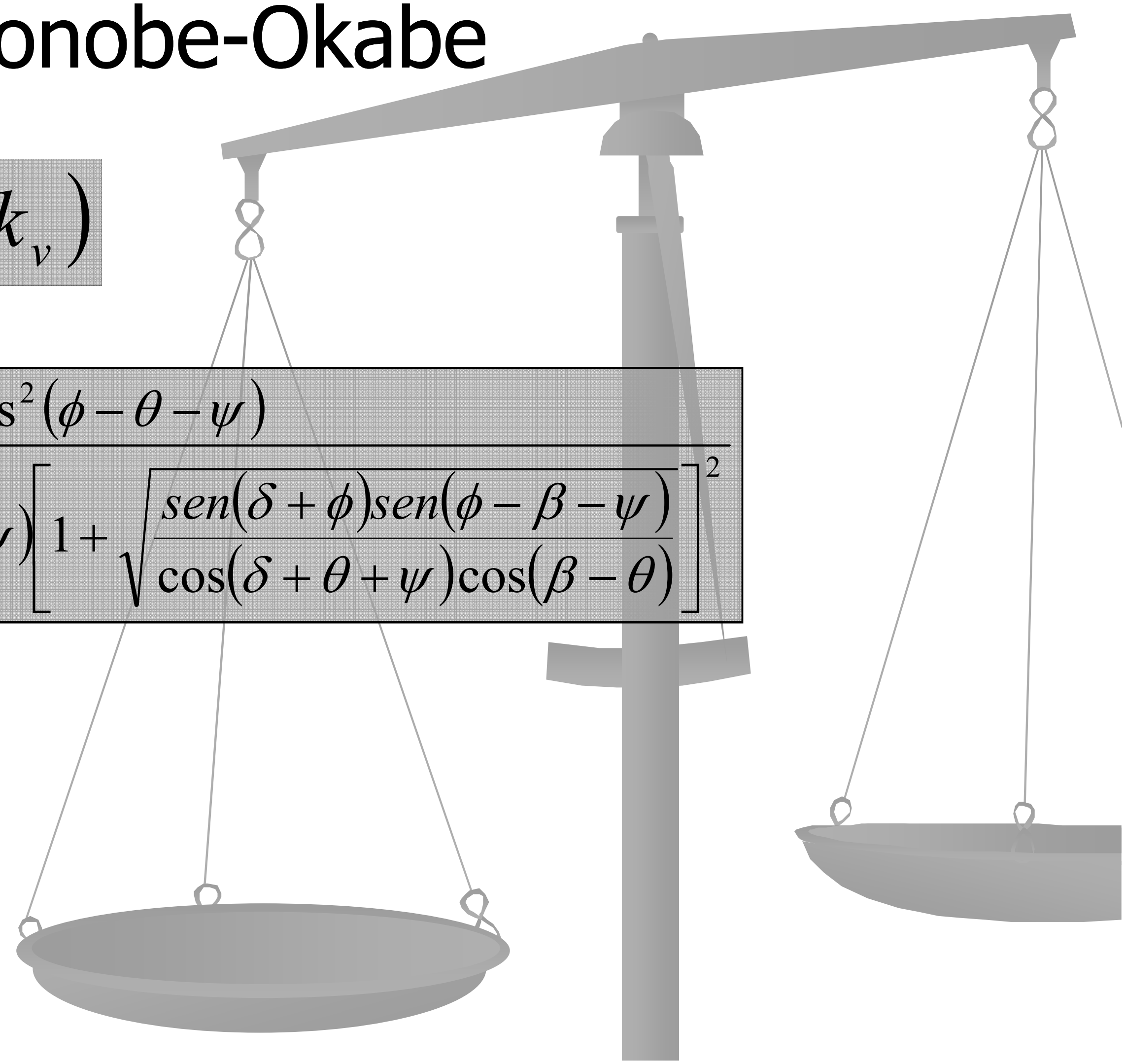
Empujes Sísmicos

- Método de Mononobe-Okabe

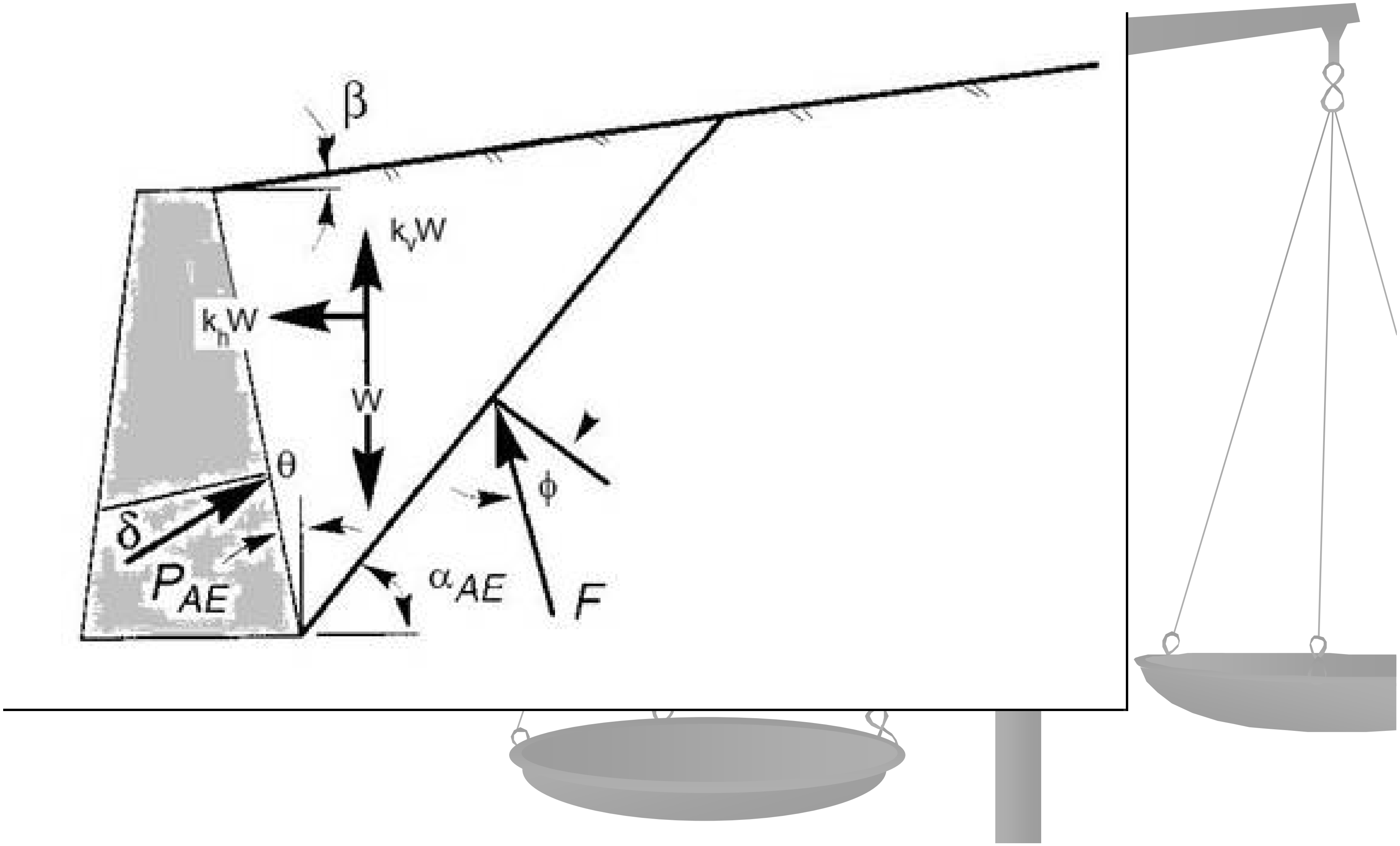
$$P_{act} = \tfrac{1}{2} K_{AE} \gamma H^2 \left(1 - k_v\right)$$

$$K_{AE} = \frac{\cos^2(\phi - \theta - \psi)}{\cos\psi \cos^2\theta \cos(\delta + \theta + \psi)\left[1 + \sqrt{\dfrac{sen(\delta + \phi) sen(\phi - \beta - \psi)}{\cos(\delta + \theta + \psi)\cos(\beta - \theta)}}\right]^2}$$

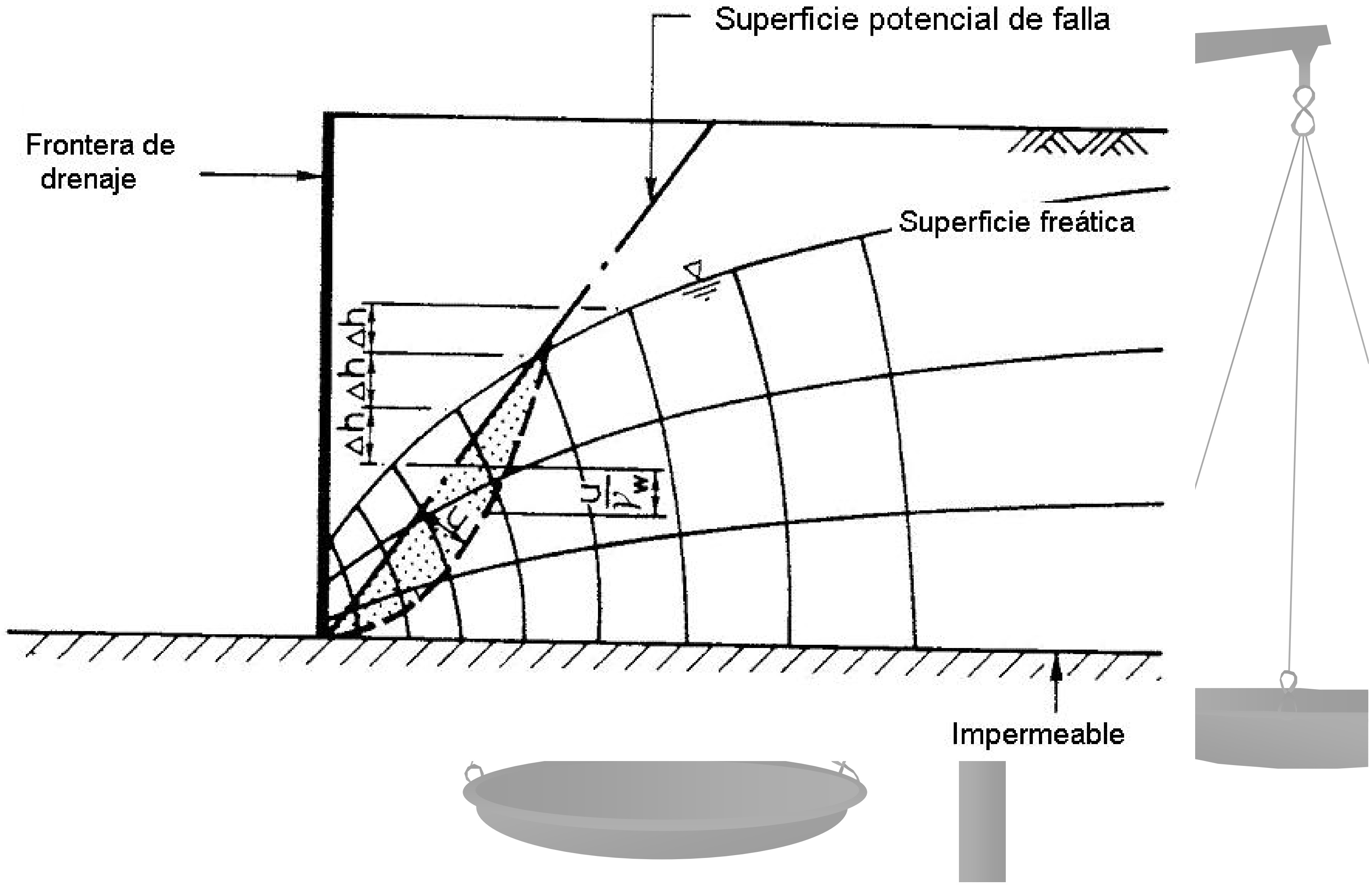
$$\psi = \arctan\left(\frac{k_h}{1 - k_v}\right)$$

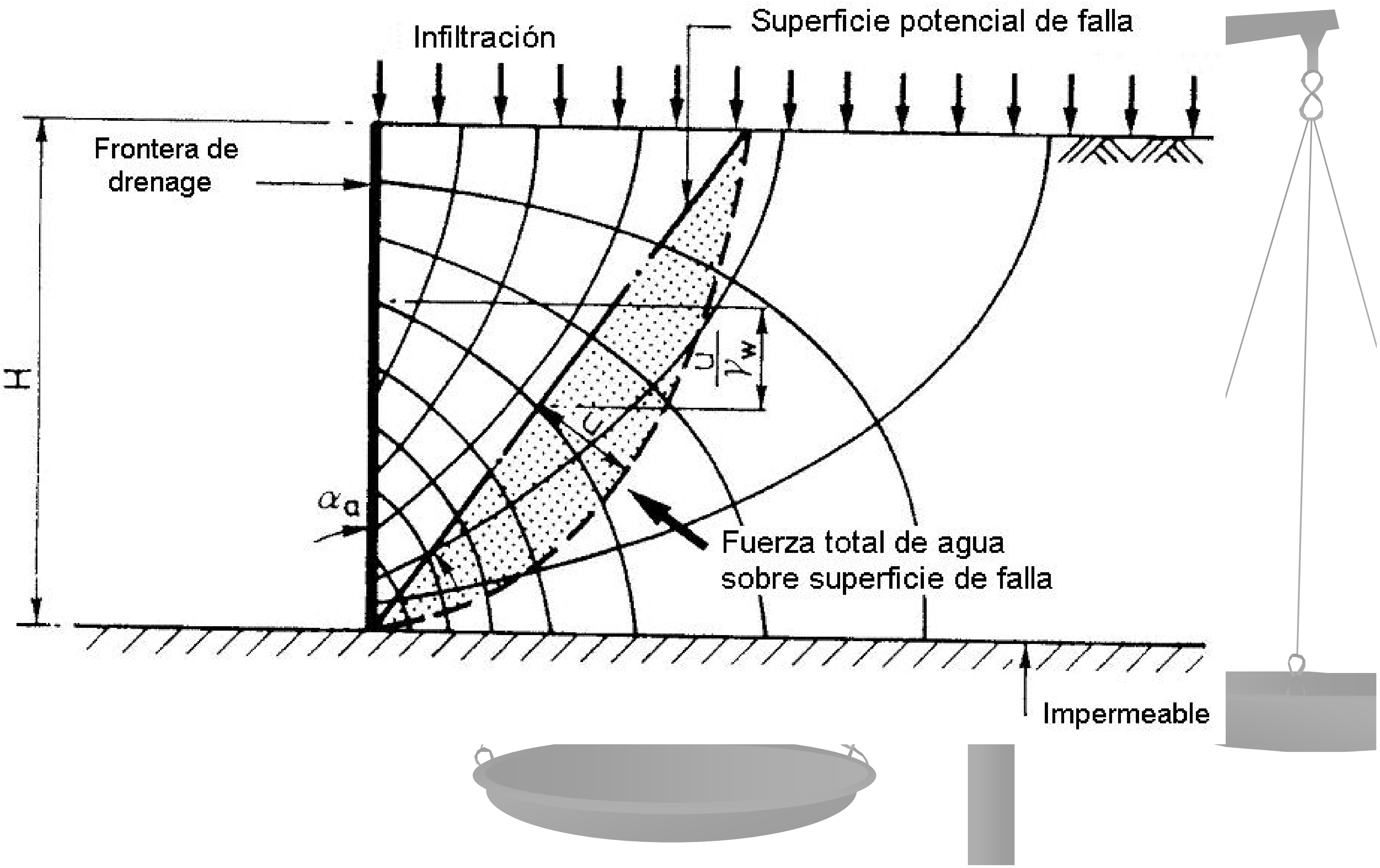


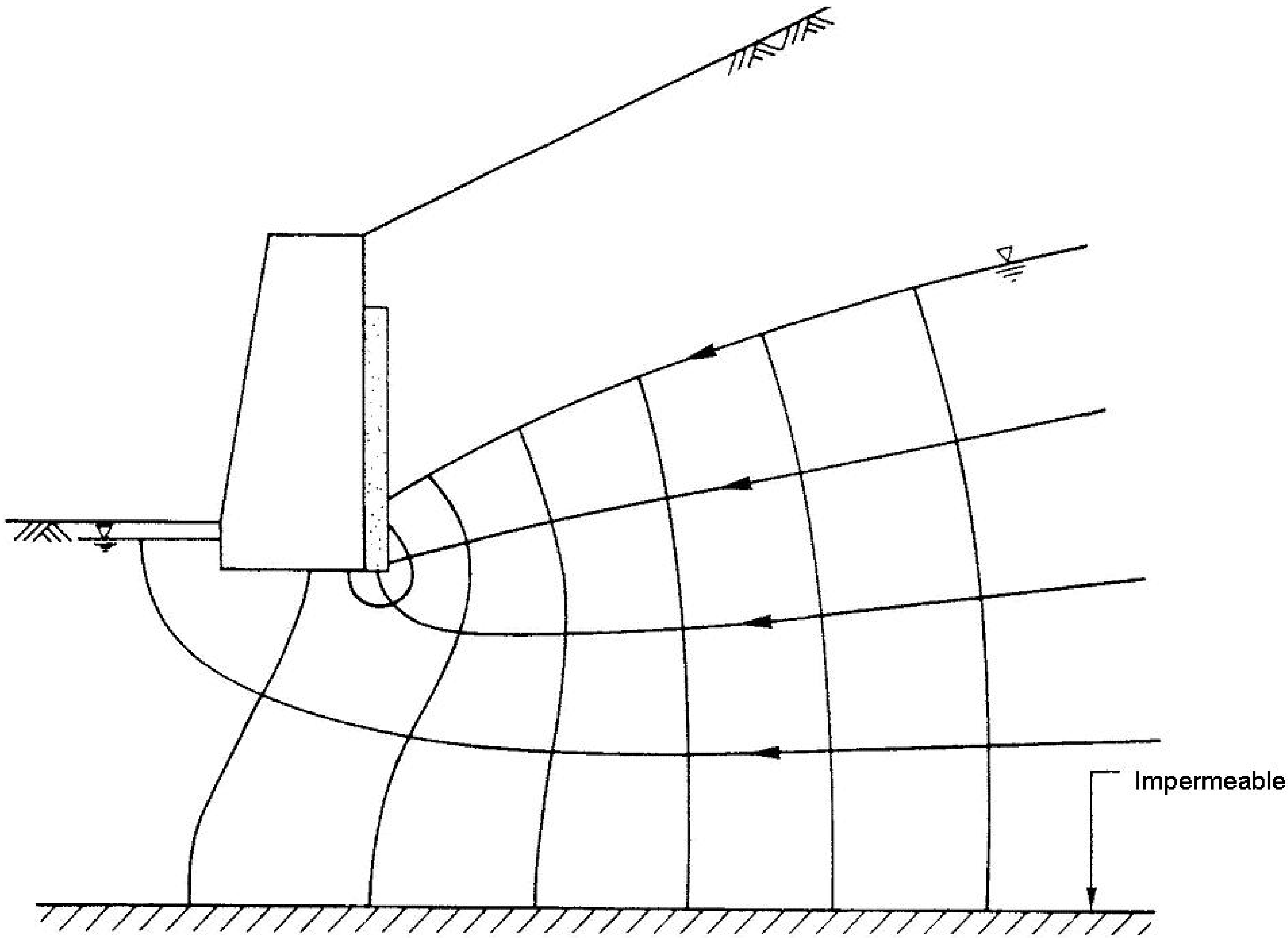
$$P = P_{est} + \Delta P$$

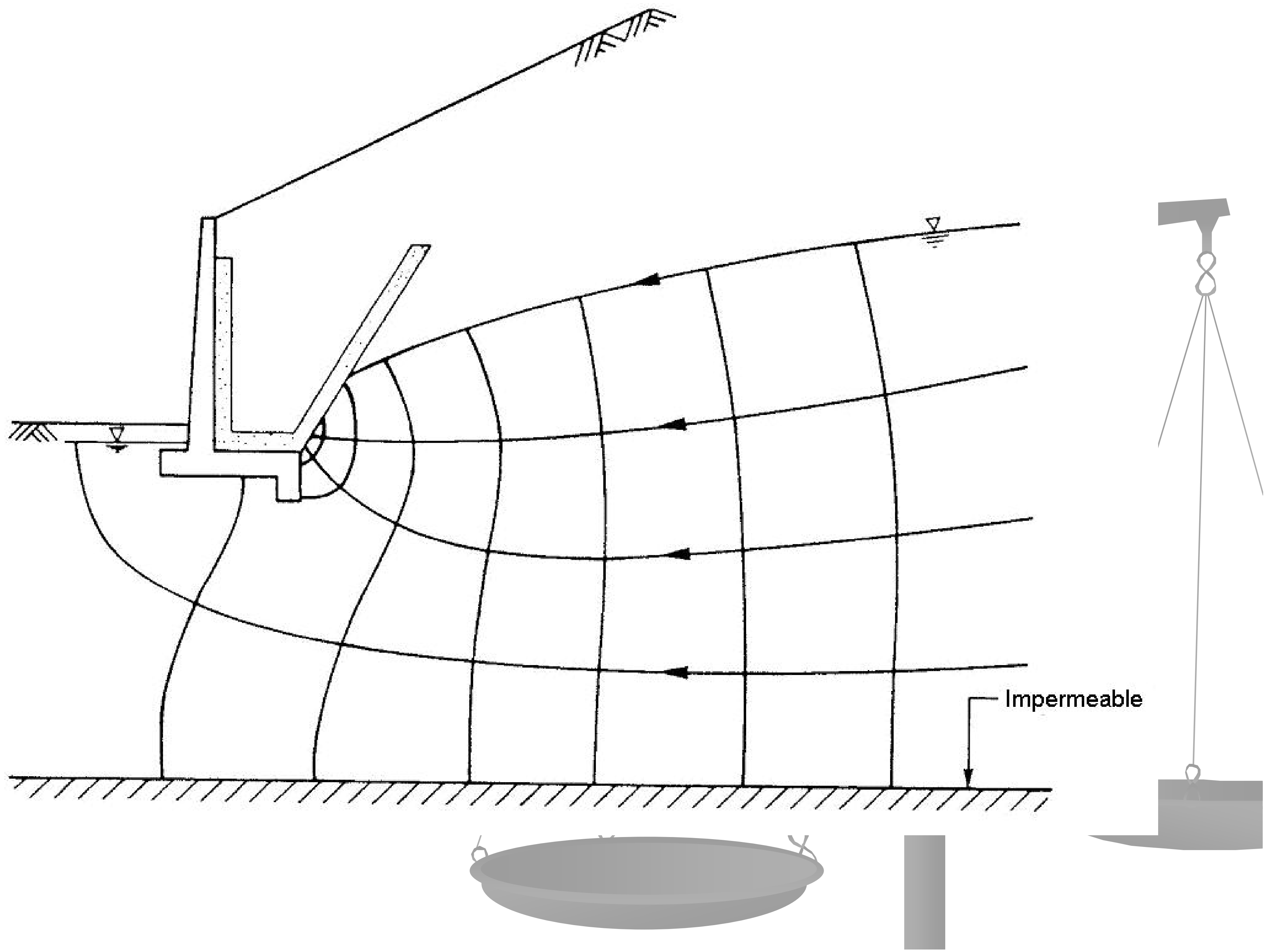


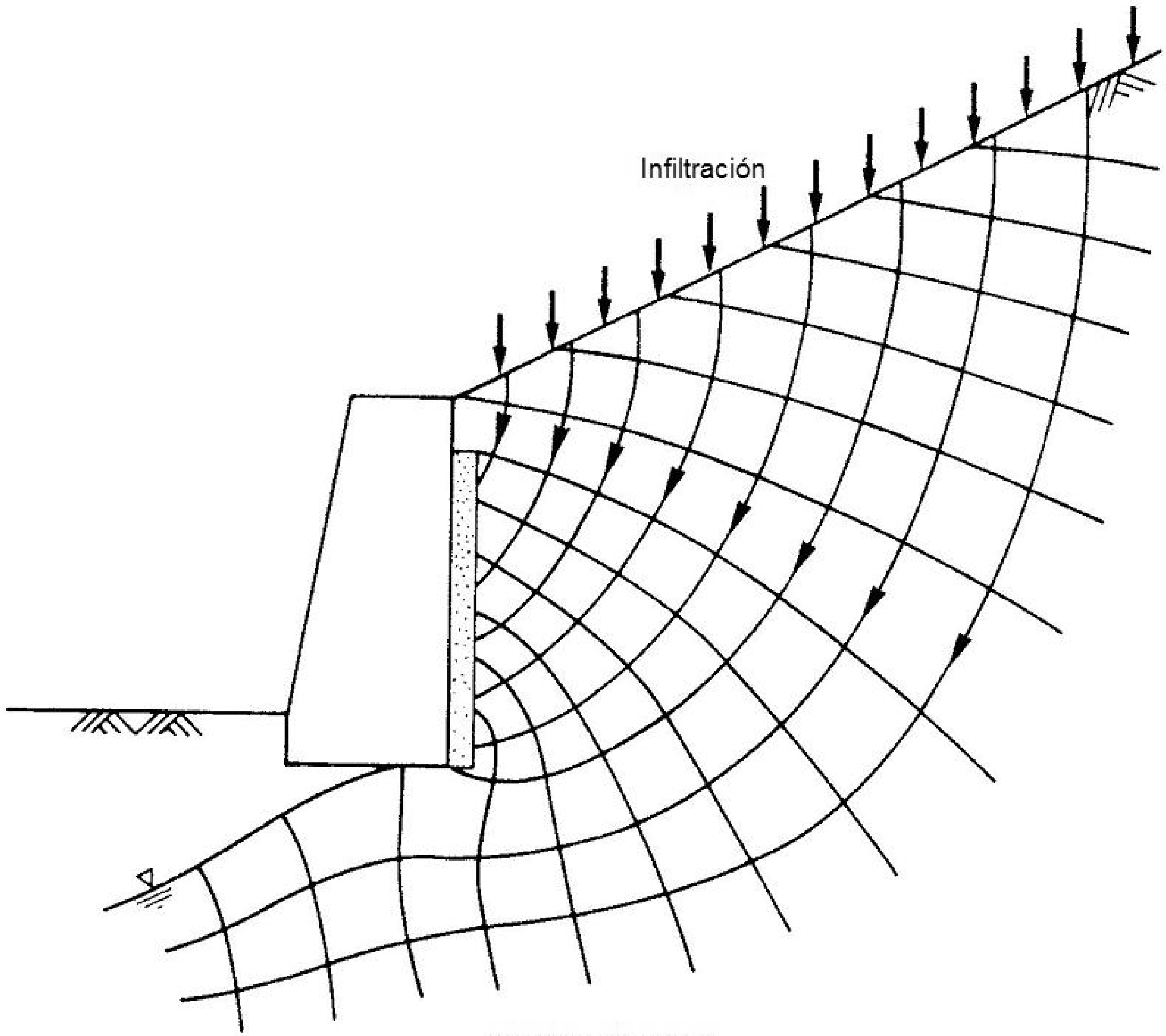
Efecto del agua en muros



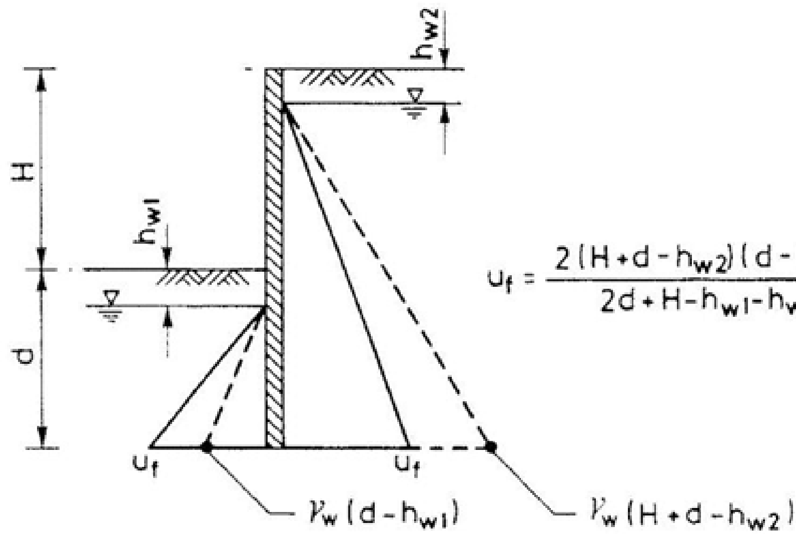

Infiltración
Superficie potencial de falla
Frontera de drenage
H
$\frac{u}{\gamma_w}$
u
α_a
Fuerza total de agua sobre superficie de falla
Impermeable


Impermeable


Impermeable

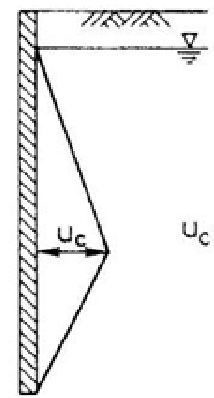


Muro gravitacional



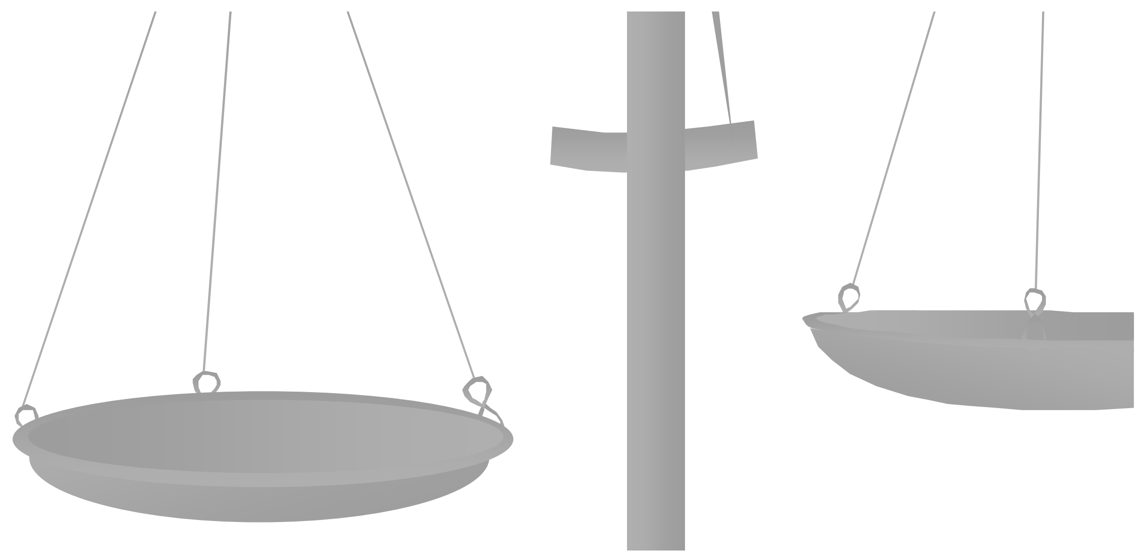
$$u_f = \frac{2\,(H + d - h_{w2})\,(d - h_{w1})}{2d + H - h_{w1} - h_{w2}}\,\gamma_w$$

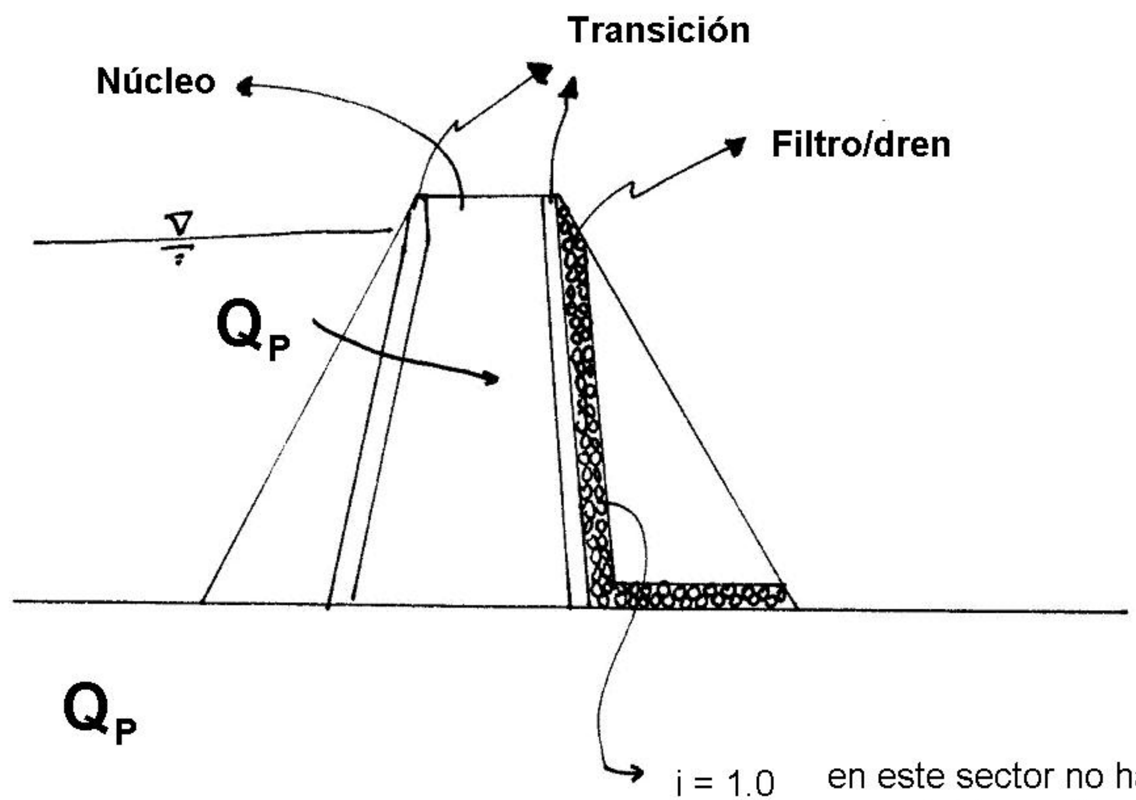
Presión de agua total a través de un tablestacado

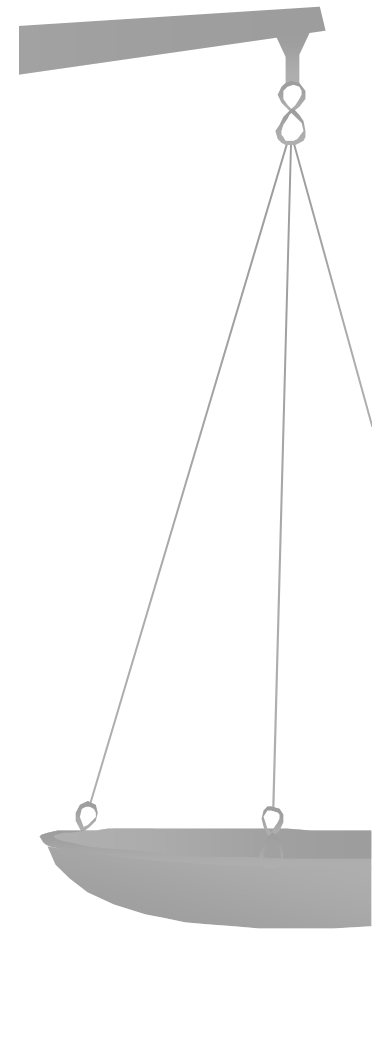


$$u_c = \frac{2\,(H + h_{w1} - h_{w2})\,(d - h_{w1})}{2d + H - h_{w1} - h_{w2}}\,\gamma_w$$

Presión de agua neta a través del tablestacado







Q_P

en este sector no hay p.p, => Δh es sólo debido a la diferencia de altura.

$$Q_{dren} = k\,A\,i$$

Necesito asegurar $Q_{dren} \geq Q_P$

Usualmente se diseña $Q_{dren} \approx 100\,Q_P$