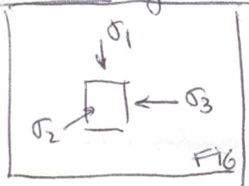
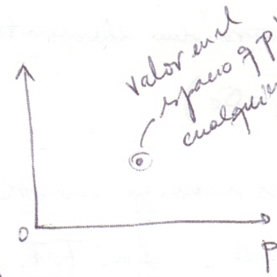
Trayectoria de Tensiones: (clase 2).

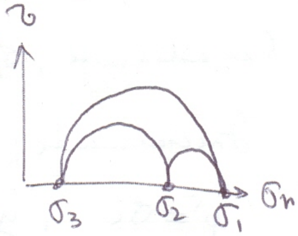
- **Notación general**:



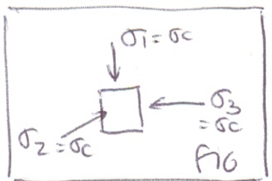
$$p' = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3}$$

$$q = \frac{\sigma_1 - \sigma_3}{2}$$





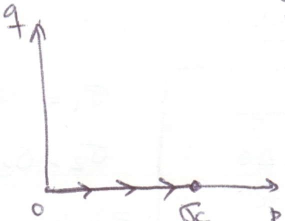
- **Compresión Hidrostática** (Isotrópica)

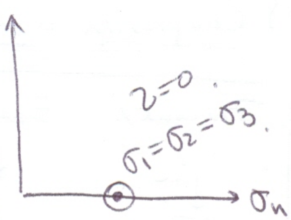


$\sigma_1 = \sigma_2 = \sigma_3 = \sigma_c$

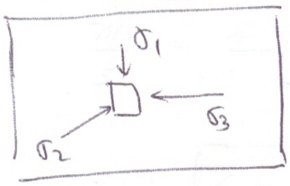
σ_c = presión confinamiento

$p = \sigma_c$, $q = 0$.





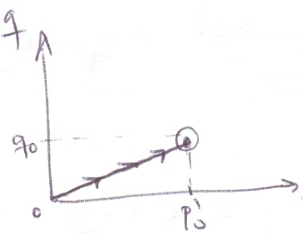
- **Compresión anisotrópica**:

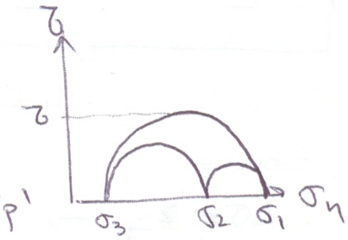


$\sigma_1 \neq \sigma_2 \neq \sigma_3$ ($\sigma_1 > \sigma_2 > \sigma_3$)

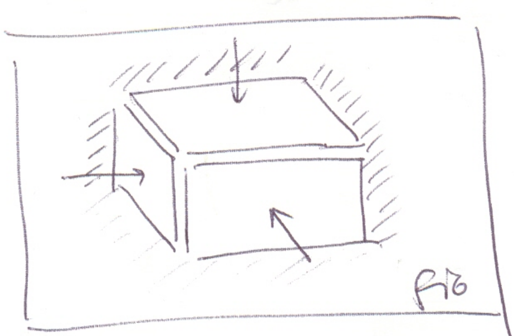
$$p'_0 = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3}$$

$$q_0 = \frac{\sigma_1 - \sigma_3}{2}$$





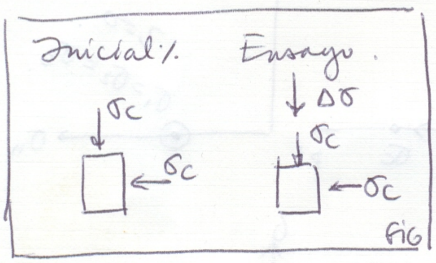
En suelos, generalmente, se utiliza la convención $\sigma_2 = \sigma_3$ ya que la mayoría de los ensayos simplifican la situación real. Sólo se tiene compresión radial. (la excepción a la regla la cumple el ensayo triaxial verdadero en el cual se producen esfuerzos independientes en una masa de suelos cúbica)



Tomando la suposición anterior, para explicar las trayectorias de Tensiones, se tomará un elemento de suelo cilíndrico donde $\sigma_2=\sigma_3$. (en adelante, $\sigma_3 = \sigma_c$)

Inicialmente, se realiza consolidación isotrópica drenada. i.e. $p'=\sigma_c$, $q=0$. Las T.T. posibles están dadas como sigue:

·) <u>Compresión axial</u>:



$$\sigma_1 = \sigma_c + \Delta\sigma$$

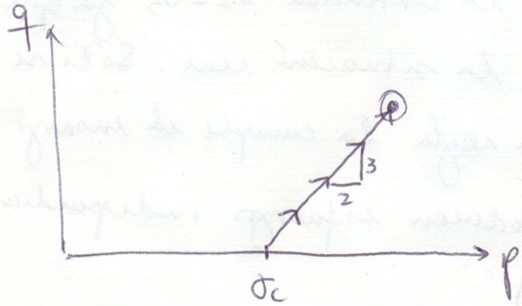
$$\sigma_2 = \sigma_3 = \sigma_c$$

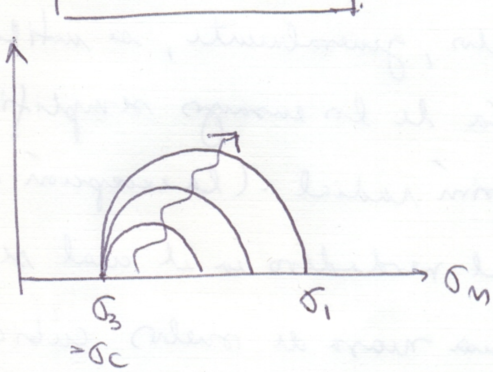
$$\Rightarrow p' = \frac{\sigma_1+\sigma_2+\sigma_3}{3} = \frac{\sigma_c+\Delta\sigma+2\sigma_c}{3} = \sigma_c + \frac{\Delta\sigma}{3}$$

$$\wedge\ q = \frac{\sigma_1-\sigma_3}{2} = \frac{\sigma_c+\Delta\sigma-\sigma_c}{2} = \frac{\Delta\sigma}{2}.$$

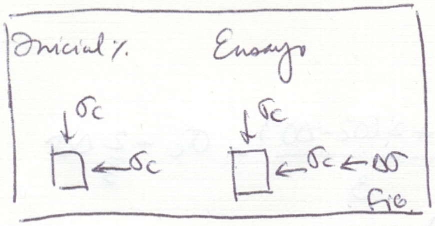
Concepto:

$$\Delta\sigma = 2q \Rightarrow p' = \sigma_c + \frac{2q}{3} \Rightarrow \boxed{q = \frac{3}{2}(p'-\sigma_c)}$$





·) Compresión radial:



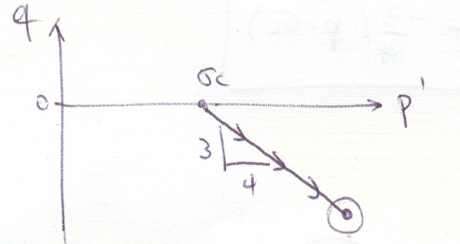
$\sigma_1 = \sigma_c$

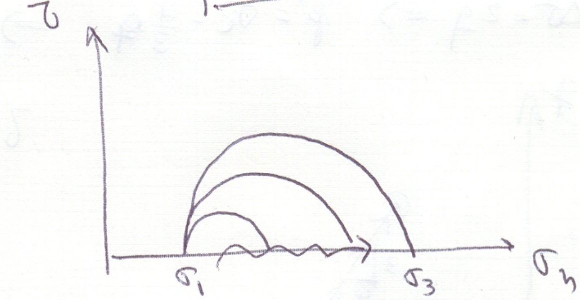
$\sigma_2 = \sigma_3 = \sigma_c + \Delta\sigma.$

$$\Rightarrow p' = \frac{\sigma_c + 2\sigma_3}{3} = \frac{\sigma_c + 2(\sigma_c + \Delta\sigma)}{3} = \sigma_c + \frac{2}{3}\Delta\sigma$$

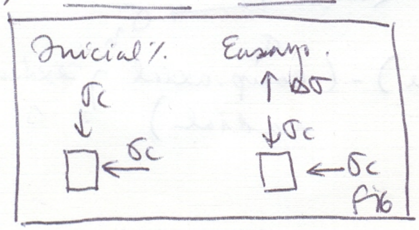
$$\wedge\ q = \frac{\sigma_c - (\sigma_c + \Delta\sigma)}{2} = -\frac{\Delta\sigma}{2}$$

Con esto: $\Delta\sigma = -2q. \Rightarrow p' = \sigma_c - \frac{4}{3}q \Rightarrow \boxed{q = -\frac{3}{4}(p - \sigma_c).}$





·) Extensión axial



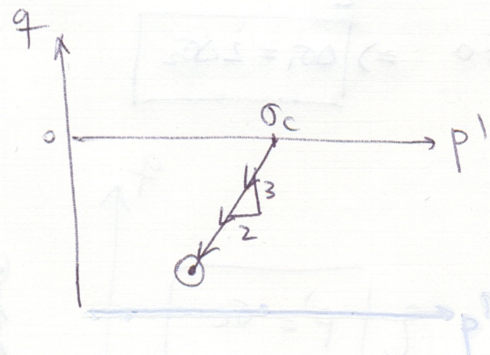
$\sigma_1 = \sigma_c - \Delta\sigma$

$\sigma_3 = \sigma_2 = \sigma_c$

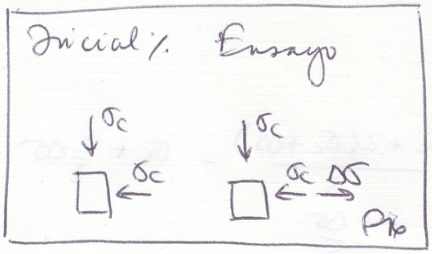
$$\Rightarrow p' = \frac{\sigma_1 + 2\sigma_3}{3} = \frac{(\sigma_c - \Delta\sigma) + 2\sigma_c}{3} = \sigma_c - \frac{\Delta\sigma}{3}$$

$$\wedge\ q = \frac{(\sigma_c - \Delta\sigma) - \sigma_c}{2} = -\frac{\Delta\sigma}{2}$$

Con esto: $\Delta\sigma = -2q \Rightarrow p' = \sigma_c + \frac{2}{3}q. \Rightarrow \boxed{q = \frac{3}{2}(p - \sigma_c)}$



·) <u>Extensión radial</u> :



$\sigma_1 = \sigma_c$

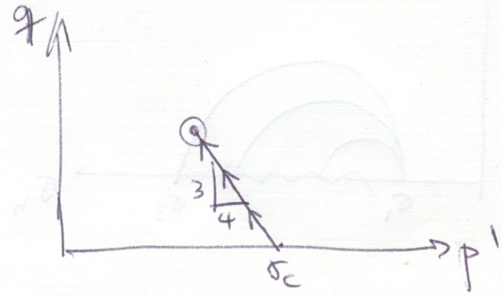
$\sigma_2 = \sigma_3 = \sigma_c - \Delta\sigma$

$\Rightarrow p' = \dfrac{\sigma_1 + 2\sigma_3}{3} = \dfrac{\sigma_c + 2(\sigma_c - \Delta\sigma)}{3} = \sigma_c - \dfrac{2}{3}\Delta\sigma$

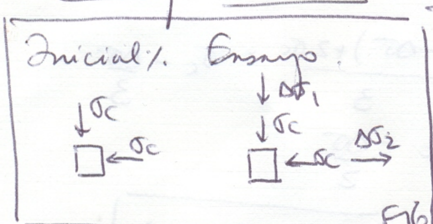
$\wedge\ q = \dfrac{\sigma_c - (\sigma_c - \Delta\sigma)}{2} = \dfrac{\Delta\sigma}{2}$

Con esto:

$\Delta\sigma = 2q \Rightarrow p' = \sigma_c - \frac{4}{3}q \Rightarrow \boxed{q = -\frac{3}{4}(p' - \sigma_c)}$



·) <u>Ensayo a tensión media cte.</u> (p = cte) - (comp. axial y extensión radial)



$\sigma_1 = \sigma_c + \Delta\sigma_1$

$\sigma_2 = \sigma_3 = \sigma_c - \Delta\sigma_2$

$\Rightarrow p' = \dfrac{\sigma_1 + 2\sigma_3}{3} = \dfrac{\sigma_c + \Delta\sigma_1) + 2(\sigma_c - \Delta\sigma_2)}{3} = \sigma_c + \left(\dfrac{\Delta\sigma_1 - 2\Delta\sigma}{3}\right.$

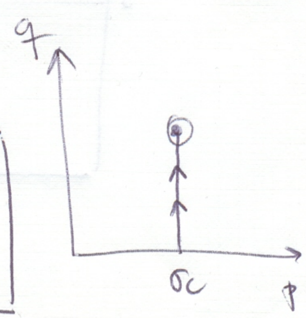
$\wedge\ q = \dfrac{\sigma_1 - \sigma_3}{2} = \dfrac{\Delta\sigma_1 + \Delta\sigma_2}{2}$

para que p' sea cte $\Rightarrow \dfrac{\Delta\sigma_1 - 2\Delta\sigma_2}{3} = 0 \Rightarrow \boxed{\Delta\sigma_1 = 2\Delta\sigma_2}$

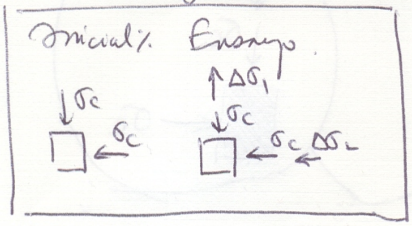
Luego: $p' = \sigma_c$

$\wedge\ q = \dfrac{2\Delta\sigma_2 + \Delta\sigma_2}{2} = \dfrac{3\Delta\sigma_2}{2}$

Si $\Delta\sigma_2 = \Delta\sigma \longrightarrow \begin{matrix}\Delta\sigma_1 = 2\Delta\sigma \\ \Delta\sigma_2 = \Delta\sigma\end{matrix} \Bigg\}\ \boxed{\begin{matrix} p' = \sigma_c \\ q' = \dfrac{3\Delta\sigma}{2}\end{matrix}}$



·) Ensayo a tensión media cte. (ext. axial y comp. radial)



$$\sigma_1 = \sigma_c - \Delta\sigma_1$$

$$\sigma_3 = \sigma_2 = \sigma_c + \Delta\sigma_2$$

$$\Rightarrow p' = \frac{\sigma_1 + 2\sigma_3}{3} = \frac{\sigma_c - \Delta\sigma_1 + 2(\sigma_c + \Delta\sigma_2)}{3} = \sigma_c - \frac{(\Delta\sigma_1 - 2\Delta\sigma_2)}{3}$$

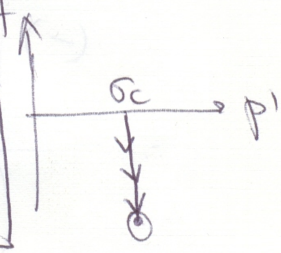
$$\Rightarrow q = \frac{(\sigma_c - \Delta\sigma_1) - (\sigma_c + \Delta\sigma_2)}{2} = \frac{-(\Delta\sigma_1 + \Delta\sigma_2)}{2}$$

Pero para que $p' = \text{cte} \Rightarrow \frac{\Delta\sigma_1 - 2\Delta\sigma_2}{3} = 0 \Rightarrow \boxed{\Delta\sigma_1 = 2\Delta\sigma_2}$

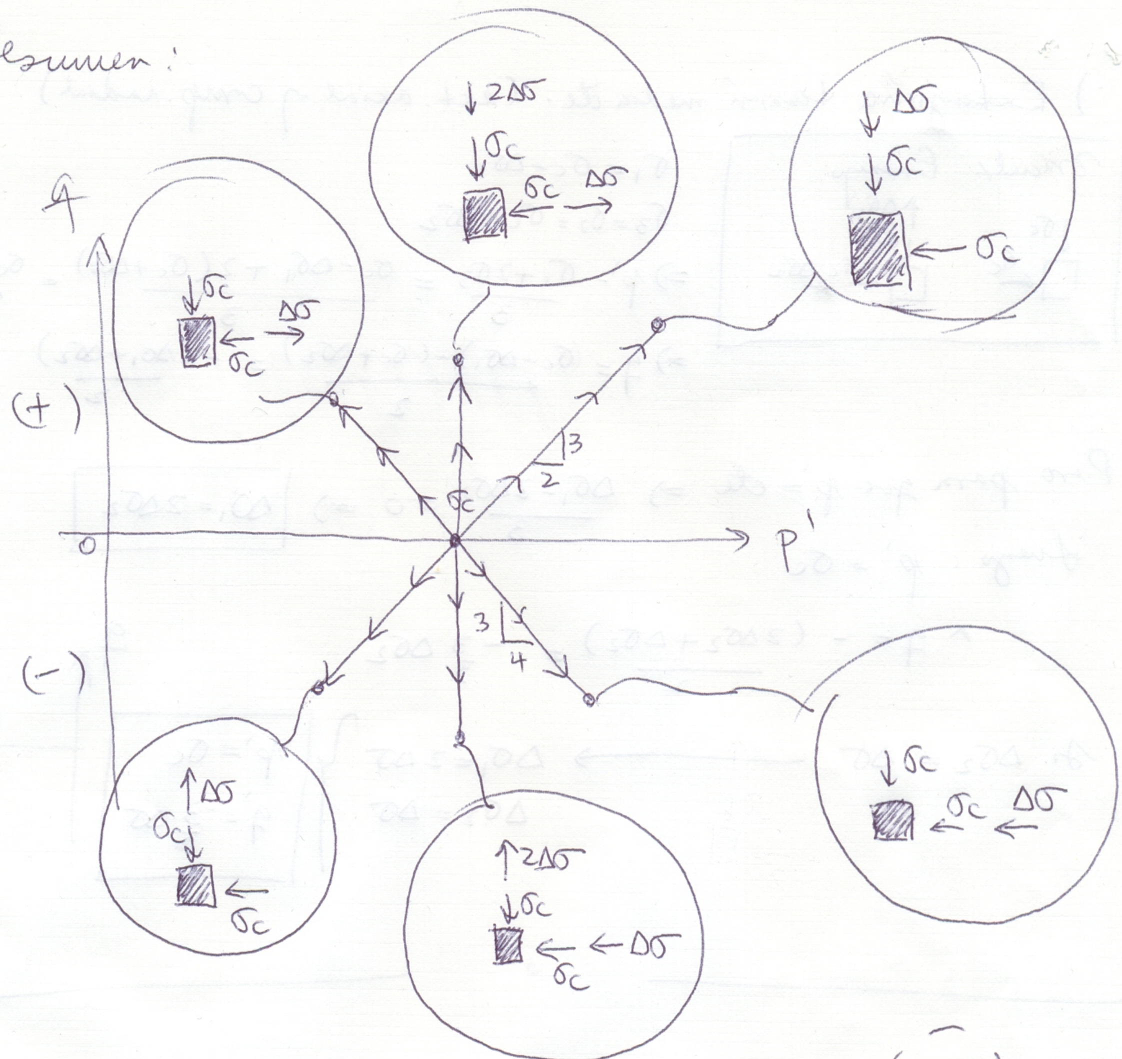
Luego: $p' = \sigma_c$

$$\wedge\ q = -\frac{(2\Delta\sigma_2 + \Delta\sigma_2)}{2} = -\frac{3}{2}\Delta\sigma_2$$

Si $\Delta\sigma_2 = \Delta\sigma \longrightarrow \left.\begin{array}{l}\Delta\sigma_1 = 2\Delta\sigma \\ \Delta\sigma_2 = \Delta\sigma\end{array}\right\} \boxed{\begin{array}{l} p' = \sigma_c \\ q' = -\frac{3}{2}\Delta\sigma \end{array}}$



En Resumen:



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