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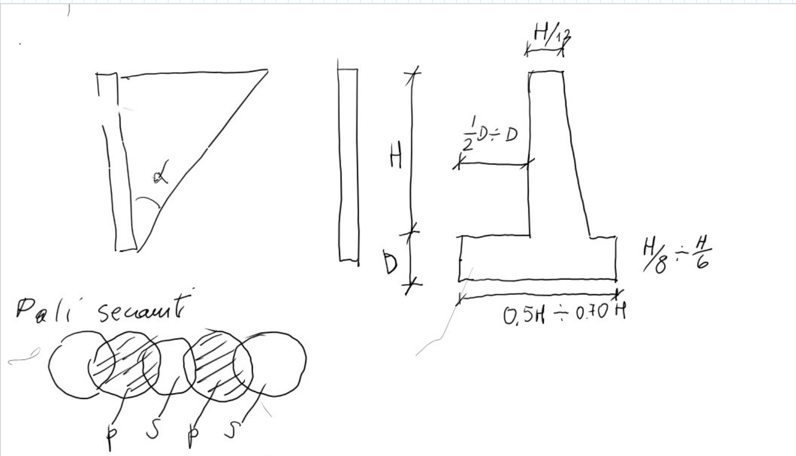
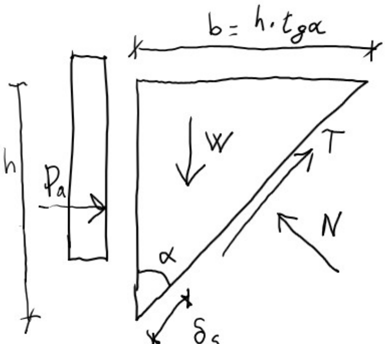




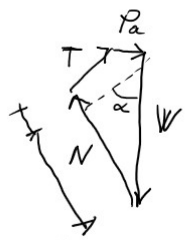
$$L_e - L_i = 0$$

$$L_e = W\,\delta_{V_w} - P_a \cdot \delta h_a$$

$$L_i = T \cdot \delta_s$$

$$T = \tau \cdot \frac{h}{\cos\alpha} = (c + \sigma \tan\varphi) \cdot \frac{h}{\cos\alpha} = \frac{ch}{\cos\alpha} + \frac{\sigma \cdot tg\varphi \cdot h}{\cos\alpha}$$

$$\frac{h}{\cos\alpha} = \frac{b}{\sin\alpha} \rightarrow b = h \cdot tg\alpha$$



$$W = \frac{1}{2} h^2 tg\alpha = \frac{1}{2} h^2 \frac{\sin\alpha}{\cos\alpha}$$

$$N = \frac{\sigma \cdot h}{\cos\alpha}$$

$$T = \frac{\tau\, h}{\cos\alpha}$$

$$N = W \sin\alpha + P_a \cdot \cos\alpha$$

$$W \cdot \delta V_w - P_a \cdot \delta h_a - \underbrace{\left[\frac{ch}{\cos\alpha} + \overbrace{\frac{\sigma\, tg\varphi \cdot h}{\cos\alpha}}^{N}\right]}\delta_s = 0$$

$$W \cdot \delta V_w - P_a \cdot \delta h_a - T\,\delta_s = 0$$

$$W \cdot \cancel{\delta_s} \cdot \cos\alpha - P_a \cdot \cancel{\delta_s} \cdot \sin\alpha - \cancel{\delta_s}\frac{ch}{\cos\alpha} - W \cdot \sin\alpha\, tg\varphi \cdot \cancel{\delta_s} - P_a \cdot \cos\alpha\, tg\varphi\, \cancel{\delta_s} = 0$$

$$\frac{\delta h}{\sin\alpha} = \frac{\delta V_w}{\cos\alpha} = \delta_s$$

$$\delta_h = \delta_s \cdot \sin\alpha$$

$$\delta V_w = \delta_s \cdot \cos\alpha$$

$$P_a\,(\cos\alpha\, tg\varphi + \sin\alpha) = W\cos\alpha - \frac{ch}{\cos\alpha} - W \cdot \sin\alpha\, tg\varphi$$

$$P_a\,(\cos\alpha\, tg\varphi + \sin\alpha) = \frac{1}{2} h^2 \frac{\sin\alpha}{\cos\alpha} \cdot \cos\alpha - \frac{1}{2} h^2 \frac{\sin\alpha}{\cos\alpha} \cdot \sin\alpha \cdot tg\varphi - \frac{ch}{\cos\alpha}$$

$$= \frac{\frac{1}{2} h^2 \sin\alpha\,(\cos\alpha - tg\varphi \cdot \sin\alpha) - ch}{\cos\alpha}$$

$$P_a = \frac{\frac{1}{2} h^2 \sin\alpha \cdot (\cos\alpha - tg\varphi \sin\alpha) - ch}{\cos\alpha \cdot (\cos\alpha\, tg\varphi + \sin\alpha)} \quad \begin{matrix}) f(\alpha) \\ ) g(\alpha) \end{matrix}$$

$$\rightarrow \frac{\partial P_a}{\partial \alpha}$$

$$D\frac{f(x)}{g(x)} = \frac{f'(x) \cdot g(x) - f(x) \cdot g'(x)}{g(x)^2}$$

$$f'(\alpha) = \cos\alpha\,(\cos\alpha - tg\varphi \sin\alpha) + \sin\alpha\,(-\sin\alpha - tg\varphi \cos\alpha) \rightarrow \underbrace{\cos^2\alpha - \sin^2\alpha}_{\cos 2\alpha} - 2\underbrace{tg\varphi \sin\alpha\cos\alpha}_{tg\varphi \sin 2\alpha} = 0$$

$$\cos^2\theta - \sin^2\theta = \cos 2\theta$$

$$2\sin\theta\cos\theta = \sin 2\theta$$

$$f'(\alpha) = \cos 2\alpha - tg\varphi \sin 2\alpha$$

$$g'(\alpha) = -\sin\alpha\,(\sin\alpha + tg\varphi\cos\alpha) + \cos\alpha\,(\cos\alpha - tg\varphi \sin\alpha) \rightarrow \underbrace{-\sin^2\alpha + \cos^2\alpha}_{\cos 2\alpha} - \underbrace{2\,tg\varphi \sin\alpha \cdot \cos\alpha}_{tg\varphi \sin 2\alpha} = 0$$

$$\frac{\partial P_a(\alpha)}{\partial \alpha} = 0 \qquad \frac{f'(\alpha)\, g(\alpha) - f(\alpha)\, g'(\alpha)}{g^2(\alpha)} = 0 \rightarrow f'(\alpha) = g'(\alpha)$$

$\cos 2\alpha$ $\qquad$ $tg\varphi \sin 2\alpha$

$$\frac{\partial P_a(\alpha)}{\partial\alpha}=0 \qquad \frac{f'(\alpha)g(\alpha)-f(\alpha)g'(\alpha)}{g^2(\alpha)}=0 \rightarrow \frac{f'(\alpha)}{f(\alpha)}=\frac{g'(\alpha)}{g(\alpha)}$$

(A) $f(\alpha)=g(\alpha)$ Denominatori si eguagliano, t=tg(phi)

$$\sin\alpha \cancel{\cos\alpha} - t\cdot \sin^2\alpha = \sin\alpha \cancel{\cos\alpha} + t\cos^2\alpha$$

$$t(\sin^2\alpha+\cos^2\alpha)=0$$

$$\| \sin^2\alpha+\cos^2\alpha=1 \|$$

$$t=0 \rightsquigarrow tg\varphi=0 \rightarrow \varphi=0+k\pi,\ k\in\mathbb{Z}$$

(B) $\cos 2\alpha = tg\varphi \sin 2\alpha$

$$tg\varphi=\frac{\cos 2\alpha}{\sin 2\alpha} \rightarrow \tan\varphi=\frac{1}{\tan 2\alpha} \Longleftrightarrow \tan 2\alpha=\frac{1}{\tan\varphi}$$

$$\| \frac{1}{\tan\theta}=cotg\theta$$

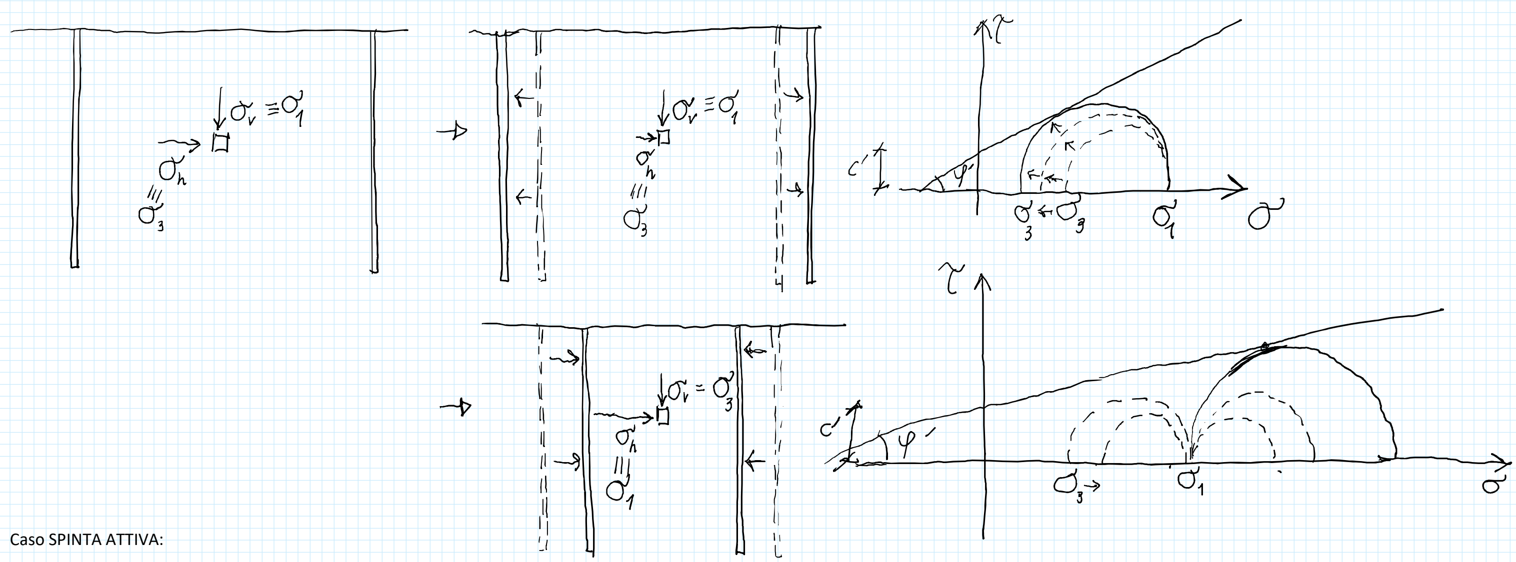
$$tg\left(\frac{\pi}{2}\pm\alpha\right)=\mp cotg\alpha$$

$$\tan 2\alpha = cotg\varphi$$

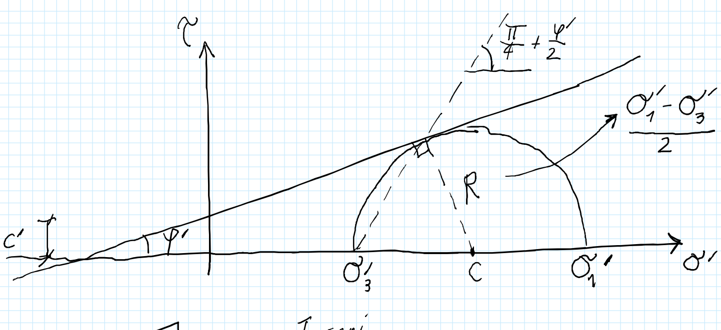
$$cotg\varphi = tg\left(\frac{\pi}{2}-\varphi\right)$$

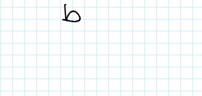
$$\tan 2\alpha=\tan\left(\frac{\pi}{2}-\varphi\right) \rightarrow 2\alpha=\frac{\pi}{2}-\varphi \rightsquigarrow \boxed{\alpha=\frac{\pi}{4}-\frac{\varphi}{2}} \quad \left(+\frac{k\pi}{2};\ k\in\mathbb{Z}\right)$$

Vero solo dal punto di vista matematico



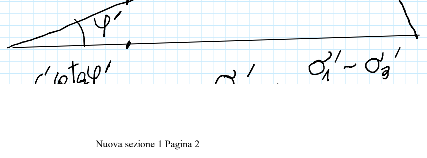
Caso SPINTA ATTIVA:





T. seni

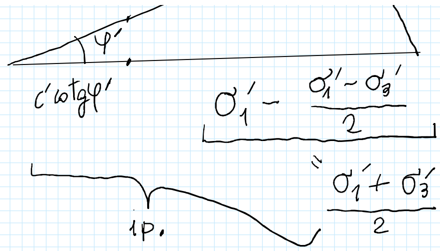
$$\frac{c'}{\sin\varphi'}=\frac{b}{\cos\varphi'} \longrightarrow b=\frac{c'}{tg\varphi}=c'\cdot cotg\varphi$$



T. seni

$$\frac{R}{\sin\varphi'}=ip \longrightarrow \frac{\sigma_1-\sigma_3}{2}=ip\cdot\sin\varphi$$

$$\sigma_1'-\sigma_3' \quad \left[c'cotg\varphi' + \frac{\sigma_1'+\sigma_3'}{\ldots}\right]\sin\varphi'$$



$$\frac{R}{\sin\varphi'} = 1p \longrightarrow \frac{\sigma_1 - \sigma_3}{2} = 1p \cdot \sin\varphi$$

$$\frac{\sigma_1' - \sigma_3}{2} = \left[c' \cot g\,\varphi' + \frac{\sigma_1' + \sigma_3'}{2}\right] \sin\varphi'$$

$$\frac{1}{2}\sigma_1' - \frac{1}{2}\sigma_3' = c' \cdot \underbrace{\cot g\,\varphi'}_{= \frac{1}{tg\,\varphi'} = \frac{\cos\varphi'}{\sin\varphi'}} \cdot \sin\varphi' + \frac{1}{2}\sigma_1' \sin\varphi' + \frac{1}{2}\sigma_3' \sin\varphi$$

$$\cancel{\tfrac{1}{2}}\sigma_1' - \cancel{\tfrac{1}{2}}\sigma_1' \sin\varphi' = \cancel{\tfrac{1}{2}}\sigma_3' + \cancel{\tfrac{1}{2}}\sigma_3' \sin\varphi' + 2c' \cos\varphi'$$

$$\sigma_1'(1 - \sin\varphi') = \sigma_3'(1 + \sin\varphi') + 2c' \cos\varphi'$$

$$\sigma_1' = \frac{1 + \sin\varphi'}{1 - \sin\varphi'}\sigma_3' + 2c' \frac{\cos\varphi'}{1 - \sin\varphi'}$$

$$\sigma_3' = \sigma_1' \frac{(1 - \sin\varphi')}{(1 + \sin\varphi')} - 2c \frac{\cos\varphi'}{1 + \sin\varphi'}$$

$$\tan\left(\frac{x}{2}\right) = \frac{\sin x}{1 + \cos x} \quad (\text{Formula di bisezione della tangente})$$

$$\sin\left(\frac{\pi}{2} - \beta\right) = \cos\beta \quad (\text{Formule di riduzione al primo quadrante})$$

$$\cos\left(\frac{\pi}{2} - \beta\right) = \sin\beta$$

$$\sigma_3' = \sigma_1' \cdot \frac{(1 - \sin\varphi') \cdot (1 - \sin\varphi')}{(1 + \sin\varphi')(1 - \sin\varphi')} - 2c' \cdot \frac{\sin\left(\frac{\pi}{2} - \varphi'\right)}{1 + \cos\left(\frac{\pi}{2} - \varphi'\right)}$$

$$= \sigma_1' \frac{(1 - \sin\varphi')^2}{1 - \sin^2\varphi'} - 2c \tan\left(\frac{\frac{\pi}{2} - \varphi'}{2}\right)$$

$$= \sigma_1' \frac{(1 - \sin\varphi')^2}{\cos^2\varphi'} - 2c \tan\left(\frac{\pi}{4} - \frac{\varphi'}{2}\right)$$

$$\left(\frac{1 - \sin\varphi}{\cos\varphi}\right)^2 = \left(\frac{1}{\cos\varphi} - \frac{\sin\varphi}{\cos\varphi}\right)^2 = (\sec\varphi - tg\,\varphi)^2$$

$$= \sigma_1' \left[\frac{1 + tg^2 \frac{\varphi}{2}}{1 - tg^2 \frac{\varphi}{2}} - \frac{2 \cdot tg\, \varphi/2}{1 - tg^2 \varphi/2}\right]^2 - 2c\, tg\left(\frac{\pi}{4} - \frac{\varphi'}{2}\right)$$

$$\tan(A - B) = \frac{\tan A - \tan B}{1 + \tan A \cdot \tan B}; \quad tg\,\frac{\pi}{4} = 1$$

$$= \sigma_1' \left[\frac{1 - 2tg\, \varphi/2 + tg^2 \varphi/2}{1 - tg^2 \varphi/2}\right]^2 - \ldots$$

$$= \sigma_1' \left[\frac{(1 - tg\,\varphi/2)^{\cancel{2}}}{(1 + tg\,\varphi/2)\cancel{(1 - tg\,\varphi/2)}}\right]^2 - \ldots$$

$$= \sigma_1' \left[\frac{tg\frac{\pi}{4} - tg\,\varphi/2}{1 + tg\,\pi/4 \cdot tg\,\varphi/2}\right]^2 - \ldots$$

$$\sigma_3' = \sigma_1' \tan^2\left(\frac{\pi}{4} - \frac{\varphi'}{2}\right) - 2c' \underbrace{\tan\left(\frac{\pi}{4} - \frac{\varphi'}{2}\right)}_{\sqrt{K_A}} \Longrightarrow \boxed{\sigma_3' = \sigma_1' K_A - 2c'\sqrt{K_A}}$$

Caso SPINTA PASSIVA

$$K_p = tg^2\left(\frac{\pi}{4} + \frac{\varphi'}{2}\right)$$

$$\sigma_{h_p}' = K_p \cdot \sigma_{v_0}' + 2c \cdot \sqrt{K_p}$$