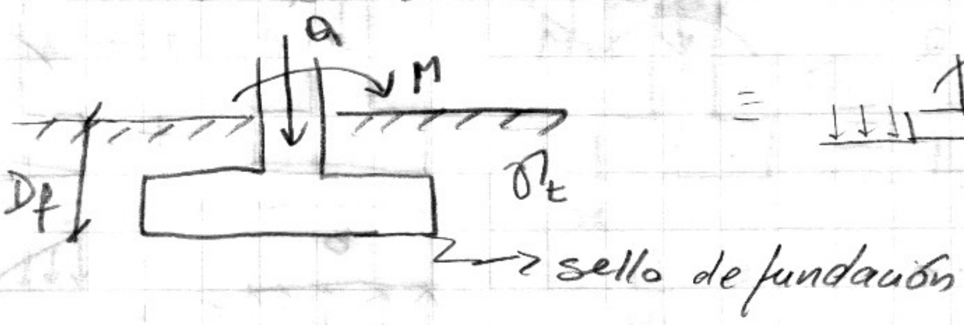
Clase Auxiliar N°2
Fundaciones CI52Q



- Capacidad de soporte (Vesic y Meyerhof)

$$q_{ult} = C \cdot N_c \cdot S_c \cdot i_c \cdot d_c \cdot t_c \cdot g_c \rightarrow \text{Cohesión}$$
$$+ 0{,}5 \cdot \gamma_t \cdot B \cdot N_\gamma \cdot S_\gamma \cdot i_\gamma \cdot d_\gamma \cdot t_\gamma \cdot g_\gamma \rightarrow \text{Resist. a corte}$$
$$+ q' \cdot N_q \, S_q \, i_q \cdot d_q \cdot t_q \cdot g_q \rightarrow \text{Sobrecarga}$$

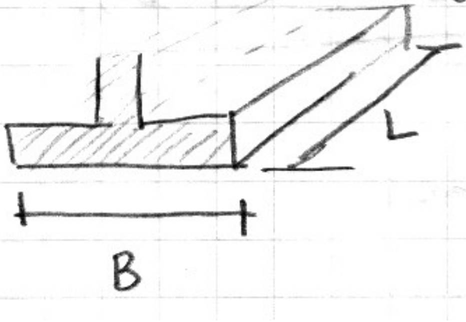
En general $q' = D_f \cdot \gamma_t$ (Sobrecarga)

Correcciones
s = forma de la zapata y excentricidad de la carga
i = inclinación de la carga
d = Enterramiento
t = Inclinación del sello de fundación

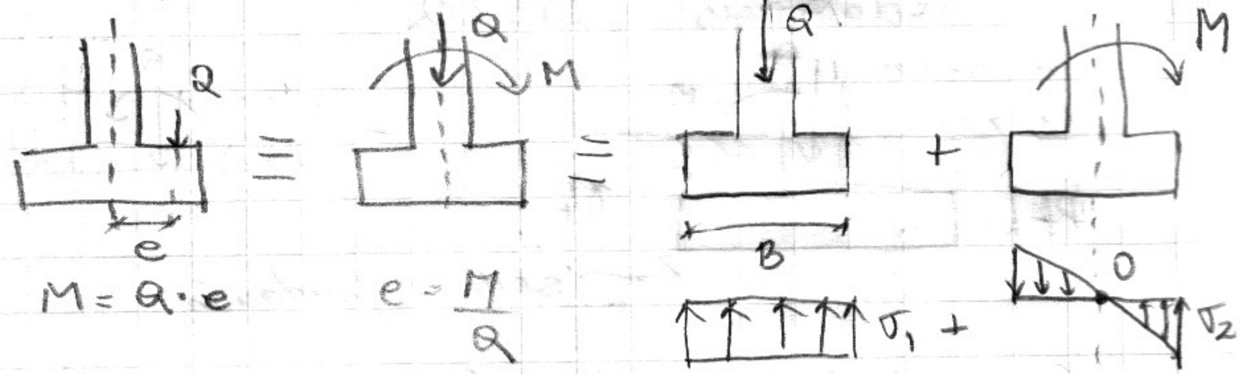
Si $L >> B$

$\frac{B}{L} \approx 0$ zapata corrida $\Rightarrow S_\gamma = S_c = 1$ (Strip)

$\frac{B}{L} \approx 1$ zapata cuadrada o zapata circular



- Caso zapata rectangular (Solicitación)



$M = Q \cdot e$ $\qquad$ $e = \dfrac{M}{Q}$

$\sigma = \sigma_1 + \sigma_2$ $\qquad$ $M = \sigma_2 \cdot r + \sigma_2 \cdot r$

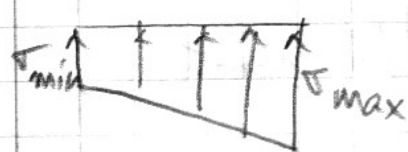
$M = 2\sigma_2 \cdot r$

Entonces $\sigma_1 = \dfrac{Q}{B \cdot L}$

$$M = \cancel{2}\left\{ \sigma_2 \cdot \frac{B}{\cancel{2}} \cdot L \cdot \frac{1}{\cancel{2}} \cdot \frac{\cancel{2}}{3}\frac{B}{2} \right\}$$

$$M = \frac{\sigma_2 \cdot B^2 \cdot L}{6}$$

$$\sigma_2 = \frac{6}{B^2} \cdot \frac{M}{L}$$

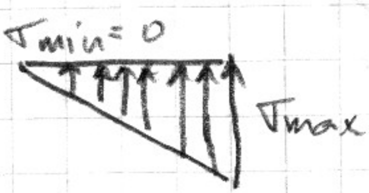


$$\sigma_{\substack{max \\ min}} = \frac{Q}{BL} \pm \frac{6}{B^2} \cdot \frac{M}{L}$$

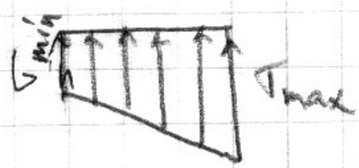
con $M = Q \cdot e$

$$\Rightarrow \boxed{\sigma_{\substack{max \\ min}} = \frac{Q}{BL}\left(1 \pm \frac{6 \cdot e}{B}\right)}$$

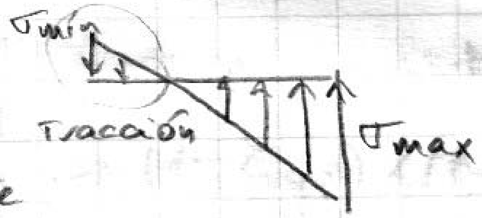
Si $e = \dfrac{B}{6}$

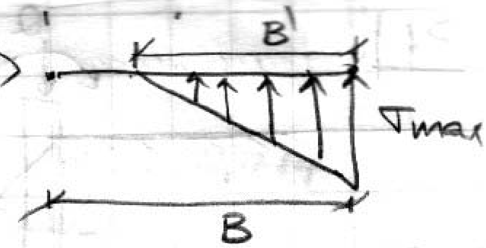


$e < \dfrac{B}{6}$.



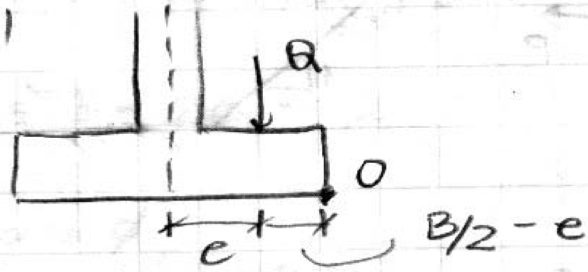
$e > \frac{B}{6}$





Suelo no resiste tracción

- Calculo de B'



$$\Sigma F_v = 0 \; : \; \sigma_{max} \cdot \frac{B' \cdot L}{2} = Q \Rightarrow \sigma_{max} = \frac{2Q}{B' \cdot L} \quad (1)$$

$$\Sigma M_o = 0 \; : \; \sigma_{max} \cdot \frac{B' \cdot L}{2} \cdot \frac{1}{3} B' = Q\left(\frac{B}{2} - e\right) \quad (2)$$

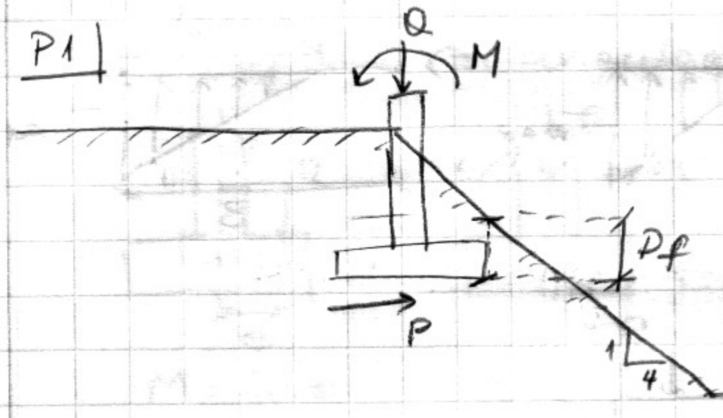
$$(1) \text{ en } (2) \quad B' = 3\left(\frac{B}{2} - e\right)$$

$$\therefore \quad \boxed{\sigma_{max} = \frac{2 \cdot Q}{3\left(\frac{B}{2} - e\right) \cdot L}} = q_{sol}$$

- Factor de seguridad

$$F.S. = \frac{q_{ult}}{q_{sol}} \left\{ \begin{array}{ll} F.S = 3 & \text{estático} \\ F.S = 2 & \text{sísmico} \end{array} \right.$$

P1



$Q = 600\,t$
$M = 300\ t\cdot m$
$P = 100\,t$
$c = 0{,}3\ t/m^2$
$\phi = 32^\circ$
$\gamma_t = 1{,}7\,t/m^3$
$L = 11\,m$

Solución

a) $D_f = 2{,}5\,m \Rightarrow e = \dfrac{M}{Q} = \dfrac{300}{600} = 0{,}5$

Para que no existan tracciones $\quad e \leq \dfrac{B}{6} \Rightarrow B \geq 3\,m$

·) Con $B = 3m$ $\quad \sigma_{max} = \dfrac{2\cdot Q}{B'\cdot L} = \dfrac{2\cdot 600}{3\cdot 11} = 36{,}4\,t/m^2$

$B' = 3\left(\dfrac{3}{2} - 0{,}5\right)$

$B' = 3$

· factores de capacidad de Vesic

$\phi = 32^\circ \quad N_c = 35{,}49$
$N_q = 23{,}18$
$N_\gamma = 30{,}21$
$N_\phi = 3{,}25$

· forma o excentricidad (Vesic y Meyerhof)

$S_c = 1 + (B'/L')/(N_q/N_c) = 1{,}278$

con $B' = B - 2\cdot e_B = 3 - 2\cdot 0{,}5 = 2\,m$

$L' = L - 2\cdot \cancel{e_L}^{0} = 11\,m$

$S_\gamma = S_q = 1 \quad \left(\text{strip } \dfrac{B}{L} \approx 0\right)$

ó $\dfrac{L}{B} > 3$ aprox

- inclinación de la carga

$$i_c = \zeta_{qi} - (1-\zeta_{qi})/(N_q - 1) = 0{,}714$$

$$i_q = \zeta_{qi} = \left[1 - P/(Q + B' \cdot L' \cdot c_a \cdot \cot \phi_a)\right]^m = 0{,}727$$

con $B' = B - 2e_B = 2$

$c_a = c$

$\phi_a = \phi$

$m = (2 + B/L)/(1 + B/L)$

$$i_\gamma = \left[1 - P/(Q + B' L' c_a \cdot \cot \phi_a)\right]^{m+1}$$

- Enterramiento

$$d_c = \zeta_{qd} - (1 - \zeta_{qd})/(N_q - 1) = 1{,}241$$

$$d_q = \zeta_{qd} = 1 + 2\tan\phi\,(1 - \sin\phi)^2 \cdot \frac{D_f}{B} = 1{,}23$$

$d_\gamma = 1$

- Inclinación del sello de fundación

$$t_c = t_\gamma = t_q = 1$$

- Talud

$$g_c = \zeta_{qg} - (1 - \zeta_{qg})/(N_q - 1) = 0{,}343$$

$$g_q = \zeta_{qg} = (1 - \tan\beta)^2 = 0{,}563$$

$$g_\gamma = (1 - \tan\beta)^2 \quad (\text{para } \phi \geq 0) = 0{,}563$$

$$\beta = \arctan\left(\frac{1}{4}\right) = 14^0$$

⇒ Multiplicando todo se tiene que

$$q_{ult} = \overset{c}{0{,}3} \cdot 35{,}4 \times 1{,}278 \times 0{,}714 \times 1{,}241 \times 1 \times 0{,}543$$

$$+ \; 0{,}5 \cdot \overset{\gamma}{1{,}7} \cdot \overset{B}{3} \cdot 30{,}21 \times 1 \times 0{,}683 \times 1 \times 1 \times 0{,}563$$

$$+ \; \underbrace{\underset{Df}{2{,}5} \times \underset{\gamma}{1{,}7}}_{q'} \times 23{,}18 \times 1 \times 0{,}727 \times 1{,}23 \times 1 \times 0{,}563$$

$$q_{ult} = 85{,}66 \; t/m^2$$

$$F.S = \frac{85{,}66}{36{,}4} = 2{,}4 \quad \underline{\text{No da !}}$$

- Si utilizamos $B = 4$ y $Df = 2{,}5$

⇒ $$\sigma_{máx} = \frac{q}{B \cdot L}\left(1 + 6\frac{e}{B}\right) = 23{,}86\, t/m^2$$

N_c, N_γ, N_q son iguales

	c	γ	q
s	1,418	1,0	1,0
i	0,724	0,685	0,736
d	1,180	1,00	1,173
t	1,0	1,0	1,0
g	0,543	0,563	0,563

⇒ $$q_{ult} = 94{,}5 \; t/m^2$$

$$F.S. = \frac{94{,}5}{23{,}86} = 3{,}96 > 3 \; \boxed{ok}$$ ✓

b) Si $B = 3m$ y $Df = 3m$, $L = 11$

$$\sigma max = \frac{q}{B \cdot L}\left(1 + 6 \cdot \frac{e}{B}\right) = 36,4\ t/m^2$$

Nc, Nγ y Nq iguales

	c	γ	q
s	1,278	1.0	1.0
i	0,714	0,683	0,727
d	1,289	1,0	1,276
t	1,0	1,0	1,0
g	0,543	0,563	0,563

$\Rightarrow$ $q_{ult} = 98,2\ t/m^2$

$$F.S = \frac{98,2}{36,4} = 2,7$$ No da

Si $B = 3m$ y $Df = 3,5m$, $L = 11$

$\sigma max = 36,4\ t/m^2$

Nc, Nγ y Nq iguales

	c	γ	q
s	1,278	1,0	1,0
i	0,714	0,683	0,727
d	1,337	1,0	1,322
t	1,0	1,0	1,0
g	0,543	0,563	0,563

$q_{ult} = 111,3\ t/m^2$

$$F.S. = \frac{111,3}{36,4} = 3,05 > 3$$ $\boxed{ok}$

c) Si $B = 3,5\,m$ y $D_f = 3,5\,m$

$$\sigma_{max} = \frac{Q}{B \cdot L}\left(1 + 6\frac{e}{B}\right) = 28,9\ t/m^2$$

N_c, N_γ y N_q son iguales

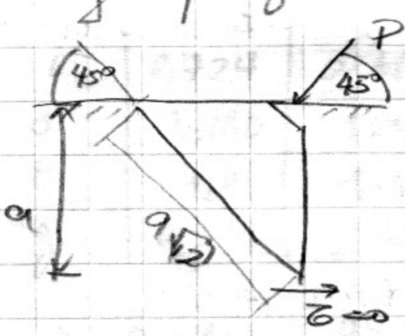
	c	γ	q
s	1,348	1,0	1,0
i	0,719	0,684	0,731
d	1,289	1,0	1,276
t	1,0	1,0	1,0
g	0,543	0,563	0,563

$$q_{ult} = 114,2\ t/m^2$$

$$F.S. = \frac{114,2}{28,9} = 3,95 > 3\ \boxed{ok}$$

P2)

a) En la zapata con base inclinada ya que no hay esfuerzo tangencial en el sello de fundación



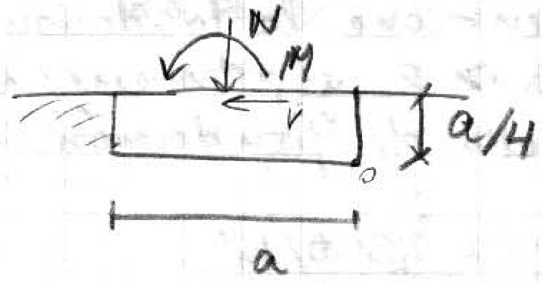
$$sen(45) = cos(45) = \frac{1}{\sqrt{2}}$$

b) Zapata con S.F. Inclinado ($L = 1\,m$)

$$\sigma_{max} = \frac{P}{a \cdot \sqrt{2}} = \frac{P}{1,41a}$$

zapata con sello de Fundación Horizontal

$$N = \frac{P}{\sqrt{2}}$$



$$M = \frac{a}{4} \times \frac{P}{\sqrt{2}} = r \cdot V$$

$$e = \frac{M}{N} = \frac{a}{4} > \frac{a}{6}$$

$$q_{max} = \frac{P/\sqrt{2}}{a}\left(\frac{4a}{3a - 6 \cdot a/4}\right) = \frac{P}{1{,}89a}$$

$\Rightarrow$ Zapata con S.F horizontal tiene q_{max} menor

c) S.F. Inclinado $c = 0,\ q' = 0,\ \phi = 35°$ (terzaghi)

$$q_{ult} = \left[0{,}5 \cdot \gamma \cdot a \cdot \sqrt{2}\right] N_\gamma \cdot t_\gamma = 0{,}5\sqrt{2} \cdot 11{,}5 \times \gamma a$$

$$q_{ult} = 8{,}1\ \gamma \cdot a$$

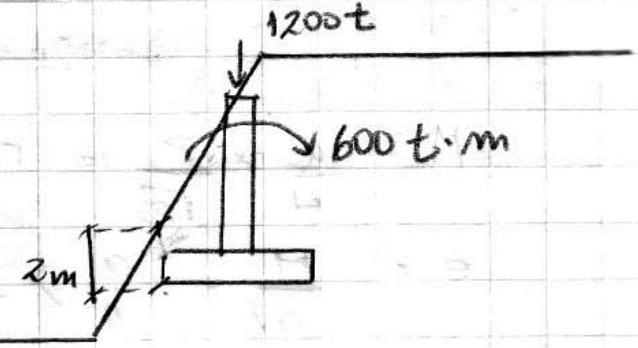
S.F. Horizontal $c = 0,\ \phi = 35°$ (terzaghi)

$$q_{ult} = 0{,}5 \cdot \gamma a \cdot N_\gamma + q' \cdot N_q$$
$$q_{ult} = 0{,}5 \cdot \gamma \cdot a \cdot 42{,}4 + \gamma \cdot \left(\frac{a}{4}\right) \times 41{,}4$$
$$= 21{,}2 \cdot \gamma a + 10{,}4\ \gamma a = 32\ \gamma \cdot a > 8{,}1\ \gamma a$$

$\therefore$ La zapata horizontal necesita mayor carga normal para llegar a la falla.

P3 | Dimensione la fundación indicada en la figura con F.S. ≥ 2 y para que no se produzca tracción en el sello de fundación.

Datos: $C = 0{,}5\ t/m^2$
$\phi = 40°$
$\gamma = 2\ t/m^3$
$L = 9\ m$



Solución $\quad e = \dfrac{M}{Q} = 0{,}5\ m$

· Para que no existan tracciones: $e \leq \dfrac{B}{6}$
$\Rightarrow B \geq 3\ m$

• Con $B = 3\ m$ y $D_f = 2\ m$
- solicitante:
$$\sigma_{Max} = \frac{Q}{BL}\left(1 + \frac{6 \cdot e}{B}\right) = 88{,}9\ t/m^2$$

- C. Soporte con Terzaghi

$$q_{ult} = C \cdot N_c \cdot S_c + 0{,}5 \cdot \gamma \cdot B \cdot N_\gamma \cdot S_\gamma + q' \cdot N_q\, S_q$$

zapata corrida $(L >> B)$
$$S_c = S_\gamma = S_q = 1$$

$$q_{ult} = 0{,}5 \times 95{,}7 + 0{,}5 \cdot 2 \times 3 \times 100.4 + \overbrace{2 \cdot 2 \cdot 81{,}3}^{D_f \cdot \gamma \cdot N_q}$$

N_q, N_c, y N_γ de la tabla para $\phi = 40°$

$$q_{ult} = 674{,}2\ t/m^2$$

$$F.S = \frac{q_{ult}}{q_{sol}} = \frac{674{,}2}{88{,}9} = 7{,}5 > 2 \text{ ok}$$

- C Soporte con Meyerhof

$$q_{ult} = C \cdot N_c\, S_c\, d_c\, i_c + 0{,}5 \cdot \gamma' \cdot B \cdot N_\gamma \cdot S_\gamma\, d_\gamma \cdot i_\gamma + q' \cdot N_q\, S_q \cdot d_\gamma\, i_\gamma$$

$N_c = 75{,}25$
$N_q = 64{,}1$
$N_\gamma = 93{,}6$
$N_\phi = 4{,}60$

Factores Meyerhof Tabla

- Factores de corrección Tabla 5.1 pag 146

$$S_c = 1 + 0{,}2 \cdot 4{,}6 \cdot (3 - 2 \cdot 0{,}5)/9 = 1{,}204$$
$$S_q = 1 + 0{,}1 \cdot 4{,}6 \cdot (3 - 2 \cdot 0{,}5)/9 = 1{,}102$$
$$S_\gamma = S_q = 1{,}102$$

carga no inclinada $\delta = 0 \Rightarrow i_c = i_q = i_\gamma = 1{,}0$

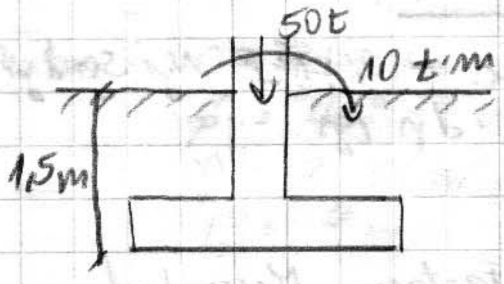
$$d_c = 1 + 0{,}2\,(4{,}60)^{1/2} \cdot 2/3 = 1{,}286$$
$$d_q = 1 + 0{,}1\,(4{,}60)^{1/2} \cdot 2/3 = 1{,}143$$
$$d_\gamma = d_q = 1{,}143$$

$$q_{ult} = 0{,}5 \times 75{,}25 \times 1{,}204 \times 1 \times 1{,}286 + 0{,}5 \times 2 \times 3 \times 93{,}6 \times 1{,}102 \times 1 \times 1{,}143 + 2 \times 2 \cdot 64{,}1 \times 1{,}102 \times 1 \times 1{,}143$$

$$q_{ult} = 743{,}9 \ t/m^2$$

$$F.S = \frac{743{,}9}{88{,}9} = 8{,}3 > 2 \text{ ok}$$

P4 | Para la fundación corrida de la figura, determinar el ancho B, de modo que el ancho en compresión sea igual al 80% del área de contacto (Normativa)



$\gamma = 1{,}8\ t/m^3$
$\phi = 30°$
$c = 0{,}8\ t/m^2$

Solución $A = B \cdot L$; 80% de $B \cdot L$

$$\Rightarrow A' = 0{,}8 \cdot B L$$

$$e = \frac{10}{50} = \frac{1}{5} = 0{,}2$$

Sabemos que $B' = 3\left(\frac{B}{2} - e\right)$

luego $0{,}8 \cdot B = 3\left(\frac{B}{2} - e\right) \Rightarrow B = 0{,}86$ $\boxed{B = 1\ m}$

b) Suponiendo que el largo de la zapata vale 5 m verifique el F.S.

- Terzaghi, zapata corrida $D_f = 1{,}5\ m$

$S_c = S_\gamma = S_q = 1$
$N_c = 37{,}2$
$N_\gamma = 19{,}7$
$N_q = 22{,}5$
} Tabla $\phi = 30°$

$$q_{ult} = 0{,}8 \times 37{,}2 + 0{,}5 \times 1{,}8 \times 1 \times 19{,}7 + 1{,}8 \times 1{,}5 \times 22{,}5 =$$

$$q_{ult} = 108{,}2\ t/m^2$$

$$\sigma_{max} = \frac{Q}{B \cdot L}\left(1 + \frac{6 \cdot e}{B}\right) = \frac{50}{1 \times 5}\left(1 + \frac{6 \cdot 0{,}2}{1}\right)$$

$\sigma_{max} = 22\ t/m^2$ (solicitante)

$$FS = \frac{108{,}2}{22} = 4{,}9 > 3\ \boxed{ok}$$

– Meyerhof ;

$\phi = 30°$ $N_c = 30{,}13$, $N_\gamma = 15{,}7$, $N_q = 18{,}4$ } Tabla. $N_\phi = 3$.

factores de corrección Tabla 5.1 pag 146.

Forma { $s_c = 1 + 0{,}2 \times 3 \times (1 - 2 \cdot 0{,}2)/5 = 1{,}072$
$s_q = 1 + 0{,}1 \cdot 3 \times (1 - 2 \cdot 0{,}2)/5 = 1{,}036$
$s_\gamma = s_q = 1{,}036$

carga no inclinada $i_c = i_\gamma = i_q = 1$ $(\delta = 0)$

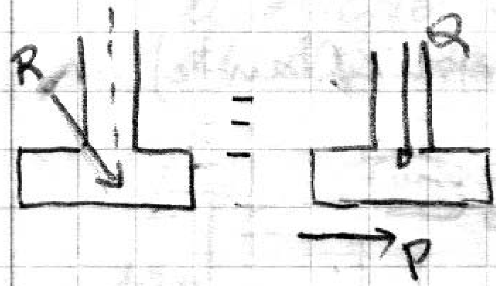
$d_c = 1 + 0{,}2\sqrt{3} \times 1{,}5/1 = 1{,}520$
$d_q = 1 + 0{,}1\sqrt{3} \cdot 1{,}5/1 = 1{,}260$
$d_\gamma = d_q = 1{,}260$

$q_{ult} = 0{,}8 \cdot 30{,}13 \cdot 1{,}072 \cdot 1 \cdot 1{,}520 +$
$0{,}5 \cdot 1{,}8 \cdot 1 \cdot 15{,}7 \cdot 1{,}036 \cdot 1 \cdot 1{,}260 +$
$1{,}5 \cdot 1{,}8 \cdot 18{,}4 \cdot 1{,}036 \cdot 1{,}26 \cdot 1$

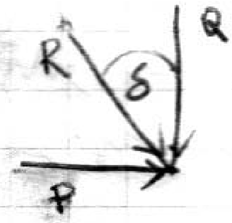
$q_{ult} = 122{,}6\ t/m^2$

$$FS = \frac{122{,}6}{22} = 5{,}6 > 3\ \boxed{ok}$$

Nota: En el caso que exista una carga inclinada



$$R^2 = Q^2 + P^2$$



$$R\cos\delta = Q$$

$$\cos\delta = \frac{Q}{R}$$

$$\delta = \arccos\left(\frac{Q}{R}\right)$$

Con δ se ingresa en Tabla 5.1 pag 146 de Meyerhof en (i) carga inclinada y se calculan i_c, i_γ, i_q