Diseño de fundaciones

MURO: F4X

$$\sigma_{suelo\_estatico} := 8 \ \frac{kgf}{cm^2} \qquad \sigma_{suelo\_sismico} := 10 \ \frac{kgf}{cm^2}$$

1. Dimensiones elementos

Propiedades y esfuerzos de muro:

Dimensiones zapata:

$$L_{muro} := 6.76 \ m$$

$$L_{zap} := 60 \ cm + L_{muro} + 60 \ cm = 7.96 \ m$$

$$e_{muro} := 25 \ cm$$

$$B_{zap} := 140 \ cm$$

$$\gamma_H := 2.5 \ \frac{tonnef}{m^3}$$

$$H_{zap} := 200 \ cm$$

$$N_{zap} := \gamma_H \cdot B_{zap} \cdot L_{zap} \cdot H_{zap} = 55.72 \ tonnef$$

2. Esfuerzos de ETABS

$$N_{PP} := -415.9831 \ tonnef \qquad M_{PP} := -176.3241 \ tonnef \cdot m \qquad V_{PP} := 26.6489 \ tonnef$$

$$N_{SC} := -118.0962 \ tonnef \qquad M_{SC} := -20.3411 \ tonnef \cdot m \qquad V_{SC} := -1.0577 \ tonnef$$

$$N_{SX} := 216.7196 \ tonnef \qquad M_{SX} := 522.4481 \ tonnef \cdot m \qquad V_{SX} := 27.6026 \ tonnef$$

$$N_{SY} := 157.9424 \ tonnef \qquad M_{SY} := 59.8586 \ tonnef \cdot m \qquad V_{SY} := 8.2291 \ tonnef$$

3. Combinaciones

3.1. Combinaciones estáticas

Combinación 1 (PP)

$$N_{est1} := N_{zap} + |N_{PP}| = 471.703 \ tonnef \qquad V_{est1} := V_{PP} = 26.649 \ tonnef$$

$$M_{est1} := M_{PP} = -176.324 \ tonnef \cdot m$$

$$l := \frac{L_{zap}}{6} = 1.327 \ m \qquad e := \left| \frac{M_{est1}}{N_{est1}} \right| = 0.374 \ m \qquad L' := 3 \cdot \left(\frac{L_{zap}}{2} - e \right) = 10.819 \ m$$

$$\sigma_{est1} := \text{if } e < l$$
$$\qquad \left\| \max \left(\frac{N_{est1}}{B_{zap} \cdot L_{zap}} + \frac{6 \cdot M_{est1}}{B_{zap} \cdot L_{zap}^2}, \frac{N_{est1}}{B_{zap} \cdot L_{zap}} - \frac{6 \cdot M_{est1}}{B_{zap} \cdot L_{zap}^2} \right) \right. = 5.425 \ \frac{kgf}{cm^2}$$
$$\text{else if } e = l$$
$$\qquad \left\| \frac{2 \ N_{est1}}{B_{zap} \cdot L_{zap}} \right.$$
$$\text{else}$$
$$\qquad \left\| \frac{2 \ N_{est1}}{B_{zap} \cdot L'} \right.$$

<u>Factores de seguridad</u> $\mu := 0.4$

$F_D := V_{est1} = 26.649 \ \textit{tonnef}$ $F_R := N_{est1} \cdot \mu = 188.681 \ \textit{tonnef}$ $\boxed{FS_D := \dfrac{\left|F_R\right|}{\left|F_D\right|} = 7.08}$

$M_V := M_{est1} + V_{est1} \cdot H_{zap} = -123.026 \ \textit{tonnef} \cdot \textit{m}$

$M_R := N_{est1} \cdot \dfrac{L_{zap}}{2} + M_{est1} = 1701.054 \ \textit{tonnef} \cdot \textit{m}$ $\boxed{FS_V := \dfrac{\left|M_R\right|}{\left|M_V\right|} = 13.827}$

$\boxed{chequeo\left(FS_D\right) = \text{``CUMPLE''}}$

$\boxed{chequeo\left(FS_V\right) = \text{``CUMPLE''}}$

<u>Combinación 2 (PP+SC)</u>

$N_{est2} := N_{zap} + \left|N_{PP}\right| + \left|N_{SC}\right| = 589.799 \ \textit{tonnef}$ $V_{est2} := V_{PP} + V_{SC} = 25.591 \ \textit{tonnef}$

$M_{est2} := M_{PP} + M_{SC} = -196.665 \ \textit{tonnef} \cdot \textit{m}$

$l := \dfrac{L_{zap}}{6} = 1.327 \ \textit{m}$ $e := \left|\dfrac{M_{est2}}{N_{est2}}\right| = 0.333 \ \textit{m}$ $L' := 3 \cdot \left(\dfrac{L_{zap}}{2} - e\right) = 10.94 \ \textit{m}$

$\sigma_{est2} := \text{if } e < l$
$$\left\| \max\left(\dfrac{N_{est2}}{B_{zap} \cdot L_{zap}} + \dfrac{6 \cdot M_{est2}}{B_{zap} \cdot L_{zap}{}^2}, \dfrac{N_{est2}}{B_{zap} \cdot L_{zap}} - \dfrac{6 \cdot M_{est2}}{B_{zap} \cdot L_{zap}{}^2}\right)\right.$$
$\quad\quad \text{else if } e = l$
$$\left\| \dfrac{2 \ N_{est2}}{B_{zap} \cdot L_{zap}} \right.$$
$\quad\quad \text{else}$
$$\left\| \dfrac{2 \ N_{est2}}{B_{zap} \cdot L'} \right. \qquad = 6.623 \ \dfrac{\textit{kgf}}{\textit{cm}^2}$$

$\boxed{\sigma_{est} := \max\left(\sigma_{est1}, \sigma_{est2}\right) = 6.623 \ \dfrac{\textit{kgf}}{\textit{cm}^2}}$ $\boxed{resistencia\left(\sigma_{suelo\_estatico}, \sigma_{est}\right) = \text{``CUMPLE''}}$

<u>Factores de seguridad</u> $\mu := 0.4$

$F_D := V_{est2} = 25.591 \ \textit{tonnef}$ $F_R := N_{est2} \cdot \mu = 235.92 \ \textit{tonnef}$ $\boxed{FS_D := \dfrac{\left|F_R\right|}{\left|F_D\right|} = 9.219}$

$M_V := M_{est2} + V_{est2} \cdot H_{zap} = -145.483 \ \textit{tonnef} \cdot \textit{m}$

$M_R := N_{est2} \cdot \dfrac{L_{zap}}{2} + M_{est2} = 2150.736 \ \textit{tonnef} \cdot \textit{m}$ $\boxed{FS_V := \dfrac{\left|M_R\right|}{\left|M_V\right|} = 14.783}$

$\boxed{chequeo\left(FS_D\right) = \text{``CUMPLE''}}$

$\boxed{chequeo\left(FS_V\right) = \text{``CUMPLE''}}$

3.2. Combinaciones sísmicas

Combinación 3,1 (PP+SX)

$$N_{sis} := N_{zap} + |N_{PP}| + N_{SX} = 688.423 \ \boldsymbol{tonnef} \qquad V_{sis} := V_{PP} + V_{SX} = 54.252 \ \boldsymbol{tonnef}$$

$$M_{sis} := M_{PP} + M_{SX} = 346.124 \ \boldsymbol{tonnef \cdot m}$$

$$l := \frac{L_{zap}}{6} = 1.327 \ \boldsymbol{m} \qquad e := \left| \frac{M_{sis}}{N_{sis}} \right| = 0.503 \ \boldsymbol{m} \qquad L' := 3 \cdot \left(\frac{L_{zap}}{2} - e \right) = 10.432 \ \boldsymbol{m}$$

$$\sigma_{sis31} := \text{if } e < l$$
$$\left\| \max \left(\frac{N_{sis}}{B_{zap} \cdot L_{zap}} + \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}^2}, \frac{N_{sis}}{B_{zap} \cdot L_{zap}} - \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}^2} \right) \right.$$
$$\text{else if } e = l$$
$$\left\| \frac{2 \, N_{sis}}{B_{zap} \cdot L_{zap}} \right.$$
$$\text{else}$$
$$\left\| \frac{2 \, N_{sis}}{B_{zap} \cdot L'} \right.$$

$$= 8.519 \ \frac{\boldsymbol{kgf}}{\boldsymbol{cm^2}}$$

Factores de seguridad $\qquad \mu := 0.4$

$$F_D := V_{sis} = 54.252 \ \boldsymbol{tonnef} \qquad F_R := N_{sis} \cdot \mu = 275.369 \ \boldsymbol{tonnef} \qquad \boxed{FS_D := \frac{|F_R|}{|F_D|} = 5.076}$$

$$M_V := M_{sis} + V_{sis} \cdot H_{zap} = 454.627 \ \boldsymbol{tonnef \cdot m}$$

$$M_R := N_{sis} \cdot \frac{L_{zap}}{2} + M_{sis} = 3086.046 \ \boldsymbol{tonnef \cdot m} \qquad \boxed{FS_V := \frac{|M_R|}{|M_V|} = 6.788}$$

$$\boxed{chequeo\left(FS_D\right) = \text{``CUMPLE''}}$$

$$\boxed{chequeo\left(FS_V\right) = \text{``CUMPLE''}}$$

Combinación 3,2 (PP-SX)

$$N_{sis} := N_{zap} + |N_{PP}| - N_{SX} = 254.984 \ \textit{tonnef} \qquad V_{sis} := V_{PP} - V_{SX} = -0.954 \ \textit{tonnef}$$

$$M_{sis} := M_{PP} - M_{SX} = -698.772 \ \textit{tonnef} \cdot \textit{m}$$

$$l := \frac{L_{zap}}{6} = 1.327 \ \textit{m} \qquad e := \left|\frac{M_{sis}}{N_{sis}}\right| = 2.74 \ \textit{m} \qquad L' := 3 \cdot \left(\frac{L_{zap}}{2} - e\right) = 3.719 \ \textit{m}$$

$$\sigma_{sis32} := \text{if } e < l \\
\left\| \max\left(\frac{N_{sis}}{B_{zap} \cdot L_{zap}} + \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}^2}, \frac{N_{sis}}{B_{zap} \cdot L_{zap}} - \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}^2}\right) \right. \\
\text{else if } e = l \\
\left\| \frac{2 \ N_{sis}}{B_{zap} \cdot L_{zap}} \right. \\
\text{else} \\
\left\| \frac{2 \ N_{sis}}{B_{zap} \cdot L'} \right. = 9.796 \ \frac{\textit{kgf}}{\textit{cm}^2}$$

Factores de seguridad $\qquad \mu := 0.4$

$$F_D := V_{sis} = -0.954 \ \textit{tonnef} \qquad F_R := N_{sis} \cdot \mu = 101.993 \ \textit{tonnef}$$

$$M_V := M_{sis} + V_{sis} \cdot H_{zap} = -700.68 \ \textit{tonnef} \cdot \textit{m}$$

$$M_R := N_{sis} \cdot \frac{L_{zap}}{2} + M_{sis} = 316.062 \ \textit{tonnef} \cdot \textit{m}$$

$$FS_D := \frac{|F_R|}{|F_D|} = 106.945$$

$$FS_V := \frac{|M_R|}{|M_V|} = 0.451$$

$$chequeo\left(FS_D\right) = \text{"CUMPLE"}$$

$$chequeo\left(FS_V\right) = \text{"REDISEÑAR"}$$

Combinación 4,1 (PP+0.75(SC+S))

$$N_{sis} := N_{zap} + |N_{PP}| + 0.75 \cdot |N_{SC}| + 0.75 \cdot N_{SX} = 722.815 \ \textit{tonnef}$$

$$M_{sis} := M_{PP} + 0.75 \cdot M_{SC} + 0.75 \cdot M_{SX} = 200.256 \ \textit{tonnef} \cdot \textit{m}$$

$$V_{sis} := V_{PP} + 0.75 \cdot \left(V_{SC} + V_{SX}\right) = 46.558 \ \textit{tonnef}$$

$$l := \frac{L_{zap}}{6} = 1.327 \ \textit{m} \qquad e := \left|\frac{M_{sis}}{N_{sis}}\right| = 0.277 \ \textit{m} \qquad L' := 3 \cdot \left(\frac{L_{zap}}{2} - e\right) = 11.109 \ \textit{m}$$

$$\sigma_{sis41} := \text{if } e < l$$
$$\left\| \max\left(\frac{N_{sis}}{B_{zap} \cdot L_{zap}} + \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}{}^2}, \frac{N_{sis}}{B_{zap} \cdot L_{zap}} - \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}{}^2}\right) \right.$$
$$\text{else if } e = l$$
$$\left\| \frac{2 \, N_{sis}}{B_{zap} \cdot L_{zap}} \right.$$
$$\text{else}$$
$$\left\| \frac{2 \, N_{sis}}{B_{zap} \cdot L'} \right. \qquad = 7.841 \ \frac{\textit{kgf}}{\textit{cm}^2}$$

Factores de seguridad $\mu := 0.4$

$$F_D := V_{sis} = 46.558 \ \textit{tonnef} \qquad F_R := N_{sis} \cdot \mu = 289.126 \ \textit{tonnef} \qquad FS_D := \frac{|F_R|}{|F_D|} = 6.21$$

$$M_V := M_{sis} + V_{sis} \cdot H_{zap} = 293.371 \ \textit{tonnef} \cdot \textit{m}$$

$$M_R := N_{sis} \cdot \frac{L_{zap}}{2} + M_{sis} = 3077.06 \ \textit{tonnef} \cdot \textit{m} \qquad FS_V := \frac{|M_R|}{|M_V|} = 10.489$$

$$chequeo\left(FS_D\right) = \text{``CUMPLE''}$$

$$chequeo\left(FS_V\right) = \text{``CUMPLE''}$$

Combinación 4,2 (PP+0.75(SC-S))

$$N_{sis} := N_{zap} + \left| N_{PP} \right| + 0.75 \cdot \left| N_{SC} \right| - 0.75 \cdot N_{SX} = 397.736 \; \boldsymbol{tonnef}$$

$$M_{sis} := M_{PP} + 0.75 \cdot M_{SC} - 0.75 \cdot M_{SX} = -583.416 \; \boldsymbol{tonnef \cdot m}$$

$$V_{sis} := V_{PP} + 0.75 \cdot \left(V_{SC} - V_{SX} \right) = 5.154 \; \boldsymbol{tonnef}$$

$$l := \frac{L_{zap}}{6} = 1.327 \; \boldsymbol{m} \qquad e := \left| \frac{M_{sis}}{N_{sis}} \right| = 1.467 \; \boldsymbol{m} \qquad L' := 3 \cdot \left(\frac{L_{zap}}{2} - e \right) = 7.539 \; \boldsymbol{m}$$

$$\sigma_{sis42} := \text{if } e < l \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad = 7.536 \; \frac{\boldsymbol{kgf}}{\boldsymbol{cm}^2}$$
$$\left\| \max \left(\frac{N_{sis}}{B_{zap} \cdot L_{zap}} + \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}^{\;2}}, \frac{N_{sis}}{B_{zap} \cdot L_{zap}} - \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}^{\;2}} \right) \right.$$
$$\text{else if } e = l$$
$$\left\| \frac{2 \, N_{sis}}{B_{zap} \cdot L_{zap}} \right.$$
$$\text{else}$$
$$\left\| \frac{2 \, N_{sis}}{B_{zap} \cdot L'} \right.$$

Factores de seguridad $\qquad \mu := 0.4$

$$F_D := V_{sis} = 5.154 \; \boldsymbol{tonnef} \qquad \qquad F_R := N_{sis} \cdot \mu = 159.094 \; \boldsymbol{tonnef} \qquad \boxed{FS_D := \frac{\left| F_R \right|}{\left| F_D \right|} = 30.87}$$

$$M_V := M_{sis} + V_{sis} \cdot H_{zap} = -573.109 \; \boldsymbol{tonnef \cdot m}$$

$$M_R := N_{sis} \cdot \frac{L_{zap}}{2} + M_{sis} = 999.571 \; \boldsymbol{tonnef \cdot m} \qquad \boxed{FS_V := \frac{\left| M_R \right|}{\left| M_V \right|} = 1.744}$$

$$\boxed{chequeo \left(FS_D \right) = \text{“CUMPLE”}}$$

$$\boxed{chequeo \left(FS_V \right) = \text{“CUMPLE”}}$$

<u>Combinación 5,1 (0.6PP +SX)</u>

$$N_{sis} := 0.6 \ N_{zap} + 0.6 \ |N_{PP}| + N_{SX} = 499.741 \ \boldsymbol{tonnef}$$

$$M_{sis} := 0.6 \ M_{PP} + M_{SX} = 416.654 \ \boldsymbol{tonnef \cdot m}$$

$$V_{sis} := 0.6 \cdot V_{PP} + V_{SX} = 43.592 \ \boldsymbol{tonnef}$$

$$l := \frac{L_{zap}}{6} = 1.327 \ \boldsymbol{m} \qquad e := \left|\frac{M_{sis}}{N_{sis}}\right| = 0.834 \ \boldsymbol{m} \qquad L' := 3 \cdot \left(\frac{L_{zap}}{2} - e\right) = 9.439 \ \boldsymbol{m}$$

$$\sigma_{sis51} := \begin{array}{l} \text{if } e < l \\ \left\| \ \max\left(\dfrac{N_{sis}}{B_{zap} \cdot L_{zap}} + \dfrac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}{}^2}, \dfrac{N_{sis}}{B_{zap} \cdot L_{zap}} - \dfrac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}{}^2}\right) \right. \\ \text{else if } e = l \\ \left\| \ \dfrac{2 \ N_{sis}}{B_{zap} \cdot L_{zap}} \right. \\ \text{else} \\ \left\| \ \dfrac{2 \ N_{sis}}{B_{zap} \cdot L'} \right. \end{array} \Bigg| = 7.303 \ \frac{\boldsymbol{kgf}}{\boldsymbol{cm}^2}$$

<u>Factores de seguridad</u> $\mu := 0.4$

$$F_D := V_{sis} = 43.592 \ \boldsymbol{tonnef} \qquad F_R := N_{sis} \cdot \mu = 199.897 \ \boldsymbol{tonnef} \qquad FS_D := \frac{|F_R|}{|F_D|} = 4.586$$

$$M_V := M_{sis} + V_{sis} \cdot H_{zap} = 503.838 \ \boldsymbol{tonnef \cdot m}$$

$$M_R := N_{sis} \cdot \frac{L_{zap}}{2} + M_{sis} = 2405.625 \ \boldsymbol{tonnef \cdot m} \qquad FS_V := \frac{|M_R|}{|M_V|} = 4.775$$

$$chequeo\left(FS_D\right) = \text{“CUMPLE”}$$

$$chequeo\left(FS_V\right) = \text{“CUMPLE”}$$

Combinación 5,2 (0.6PP-SX)

$$N_{sis} := 0.6 \; N_{zap} + 0.6 \; \left| N_{PP} \right| - N_{SX} = 66.302 \; \textbf{\textit{tonnef}}$$

$$M_{sis} := 0.6 \; M_{PP} - M_{SX} = -628.243 \; \textbf{\textit{tonnef}} \cdot \textbf{\textit{m}}$$

$$V_{sis} := 0.6 \cdot V_{PP} - V_{SX} = -11.613 \; \textbf{\textit{tonnef}}$$

$$l := \frac{L_{zap}}{6} = 1.327 \; \textbf{\textit{m}} \qquad e := \left| \frac{M_{sis}}{N_{sis}} \right| = 9.475 \; \textbf{\textit{m}} \qquad L' := 3 \cdot \left(\frac{L_{zap}}{2} - e \right) = -16.486 \; \textbf{\textit{m}}$$

$$\sigma_{sis52} := \text{if } e < l \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad = -0.575 \; \frac{kgf}{cm^2}$$
$$\left\| \max \left(\frac{N_{sis}}{B_{zap} \cdot L_{zap}} + \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}{}^2} , \frac{N_{sis}}{B_{zap} \cdot L_{zap}} - \frac{6 \cdot M_{sis}}{B_{zap} \cdot L_{zap}{}^2} \right) \right.$$
$$\text{else if } e = l$$
$$\left\| \frac{2 \, N_{sis}}{B_{zap} \cdot L_{zap}} \right.$$
$$\text{else}$$
$$\left\| \frac{2 \, N_{sis}}{B_{zap} \cdot L'} \right.$$

Factores de seguridad $\qquad \mu := 0.4$

$$F_D := V_{sis} = -11.613 \; \textbf{\textit{tonnef}} \qquad F_R := N_{sis} \cdot \mu = 26.521 \; \textbf{\textit{tonnef}} \qquad \boxed{FS_D := \frac{\left| F_R \right|}{\left| F_D \right|} = 2.284}$$

$$M_V := M_{sis} + V_{sis} \cdot H_{zap} = -651.469 \; \textbf{\textit{tonnef}} \cdot \textbf{\textit{m}}$$

$$M_R := N_{sis} \cdot \frac{L_{zap}}{2} + M_{sis} = -364.36 \; \textbf{\textit{tonnef}} \cdot \textbf{\textit{m}} \qquad \boxed{FS_V := \frac{\left| M_R \right|}{\left| M_V \right|} = 0.559}$$

$$\boxed{chequeo \left(FS_D \right) = \text{"CUMPLE"}}$$

$$\boxed{chequeo \left(FS_V \right) = \text{"REDISEÑAR"}}$$

$$\boxed{\sigma_{sis} := \max \left(\sigma_{sis31} , \sigma_{sis32} , \sigma_{sis41} , \sigma_{sis42} , \sigma_{sis51} , \sigma_{sis52} \right) = 9.796 \; \frac{kgf}{cm^2}}$$

$$\boxed{resistencia \left(\sigma_{suelo\_estatico} , \sigma_{est} \right) = \text{"CUMPLE"}}$$

4. Chequeo parrilla

Momento lado corto

$$M1 := \dfrac{\sigma_{sis} \cdot \left(\dfrac{B_{zap}}{2}\right)^2 \cdot 1 \; m}{2} = 23.999 \; tonnef \cdot m$$

Momento Lado Largo

$$M2 := \dfrac{\sigma_{sis} \cdot \left(\dfrac{L_{zap} - L_{muro}}{2}\right)^2 \cdot 1 \; m}{2} = 17.632 \; tonnef \cdot m$$

Propiedad de la Sección de Zapata

$$W := \dfrac{1}{6} \cdot 1 \; m \cdot H_{zap}^2 = 0.667 \; m^3$$

Propiedad de la Sección de Zapata

$$W := \dfrac{1}{6} \cdot 1 \; m \cdot H_{zap}^2 = 0.667 \; m^3$$

$$\dfrac{M1}{W} = 3.6 \; \dfrac{kgf}{cm^2}$$

$$\dfrac{M2}{W} = 2.645 \; \dfrac{kgf}{cm^2}$$

$$\text{if } \dfrac{M1}{W} < 7 \; \dfrac{kgf}{cm^2}$$
$$\left\| \text{“No necesita parrilla”} \right.$$
$$\text{else}$$
$$\left\| \text{“Necesita Parrilla”} \right.$$

= "No necesita parrilla"

$$\text{if } \dfrac{M2}{W} < 7 \; \dfrac{kgf}{cm^2}$$
$$\left\| \text{“No necesita parrilla”} \right.$$
$$\text{else}$$
$$\left\| \text{“Necesita Parrilla”} \right.$$

= "No necesita..."