.

1.0 DESCRIPTION:

BEARING PRESSURES FOR RECTANGULAR FOOTINGS WITH BIAXIAL UPLIFT.

Purpose

The purpose of this calculation sheet is to solve for design parameters of a footing, which will result in easie design of footing. The footing is subject to axial load and bearing (biaxial moment). The footing can have a portion of their footing area that does not act in bearing.

The parameters calculated are:

- Combined Forces and Moment at centroid of footing.
- Soil bearing pressure.
- Maximum bearing pressure.
- Bearing pressure at remaining foundation corners.
- Location of line of zero presure.
- Percentage of footing area acting in bearing.
- Factors of Secury (Overturning and Sliding).

Assumptions

The following assumptions are made in the derivation of the results presented in this calculation sheet:

- The foundation is rectangular.
- The foundation behaves as a rigid body.
- The foundation has a planar stress distribution, and the location of zero pressure is therefore linear.
- The bearing pressure can only be compressive in nature, and there are no tensile bearing stresses.

Referees

- "*Bearing Pressures For Rectangular Footings With Biaxial Uplift*" by Kenneth E. Wilson. Journal of Brid Engineering / February 1997.

Materials

- Steel Reinforcing Bars $f_y := 4200 \frac{kgf}{cm^2}$ $E := 2039 \frac{kgf}{cm^2}$

- Concrete $f_c := 400 \frac{kgf}{cm^2}$ $E_c := 15100 \cdot \sqrt{f_c \cdot \frac{kgf}{cm^2}}$ $\gamma_c := 2.40 \frac{tonnef}{m^3}$

- Soil $q_{all} := 3.1 \frac{kgf}{cm^2}$ $E_{soil} := 360 \frac{kgf}{cm^2}$ $\gamma_{soil} := 1.85 \cdot \frac{tonnef}{m^3}$

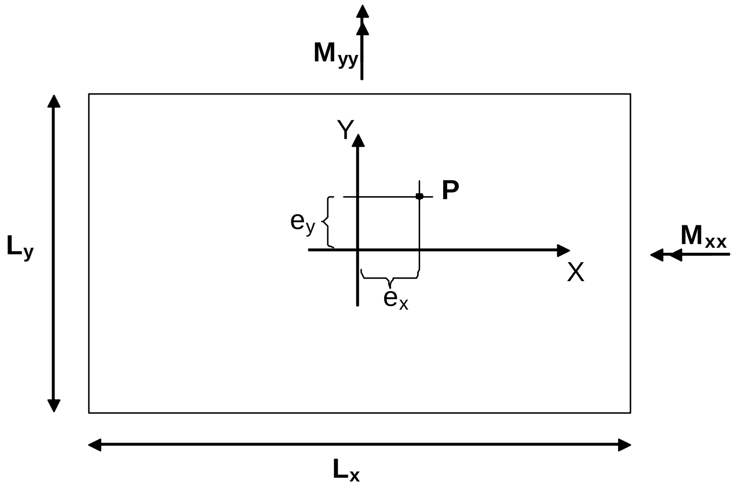
$c := 0 \frac{kgf}{cm^2}$ $\phi := 33deg$

$\nu_{soil} := 0.30$

$FSsliding_{all} := 1.3$ $FSOT_{all} := 1.4$ $\%InContact_{all} := 50\%$

.

2.0 INPUT DATA:



Length along X axis	$L_x := 15m$
Length along Y axis	$L_y := 3m$
Footing centroid	$CG_x := 0m$
	$CG_y := 0m$
Finish grade level	$Grade := 4064.300m$
Top of pedestal level	$TOP := 4065.110m$
Bottom of footing level	$BOF := Grade - 1.7m$
Thickness of footing	$FootingThickness := 0.8m$
	$FootingWeight := \gamma_c \cdot FootingThickness \cdot L_x \cdot L_y$
Soil thickness above footing	$SoilAboveFooting := Grade - BOF - FootingThickness$
	$SoilWeight := \gamma_{soil} \cdot SoilAboveFooting \cdot L_x \cdot L_y$

Total No of pedestals on the footing	$NoOfPedestal := 3$
Total No of loads	$NoOfLoad := 8$
Total No of load combinations	$NoOfComb := 29$

Pedestal coordinates

Pedestal No.	Joint No.	Coordinates [m] X	Y
1	1979	-6,00	0,00
2	1998	0,00	0,00
3	1981	6,00	0,00

Relocated footing centroid and pedestals

New pedestal coordinates:

$i := 0 .. NoOfPedestal - 1$

Case #1

$$XY_{i,1} := XY_{i,1} - \frac{CG_x}{m}$$

$$XY_{i,2} := XY_{i,2} - \frac{CG_y}{m}$$

Case #2

$L_{x.2} := L_y$ $\quad L_{y.2} := L_x$ $\quad CG_{x.2} := CG_y$ $\quad CG_{y.2} := CG_x$

Relocated footing centroid and pedestals

Loads on pedestal

Load	Joint No.	Forces [tonf]			Moments [tonf-m]	
		P	Vx	Vy	Mxx	Myy
DL	1979	-12,13	-0,59	0,31	-0,91	0,00
LL	1979	-1,71	-0,09	0,09	-0,28	0,00
ELx	1979	17,79	7,26	0,08	-0,17	0,00
ELy	1979	-3,04	-0,14	2,98	-13,85	0,00
WLx	1979	-1,68	-0,65	-0,01	0,01	0,00
WLy	1979	2,51	0,38	-2,74	12,95	0,00
SL	1979	-23,97	-1,32	1,22	-3,85	0,00
CL	1979	-3,27	0,02	0,36	-0,83	0,00
DL	1998	-12,43	0,00	0,31	-0,91	0,00
LL	1998	-1,72	0,00	0,09	-0,28	0,00
ELx	1998	0,00	14,22	0,06	0,00	0,00
ELy	1998	-2,75	-0,03	3,02	-14,06	0,00
WLx	1998	0,10	-1,31	-0,01	0,00	0,00
WLy	1998	4,69	0,03	-2,42	11,45	0,00
SL	1998	-24,12	-0,01	1,23	-3,86	0,00
CL	1998	-0,23	0,24	0,02	-0,07	0,00
DL	1981	-12,13	0,59	0,31	-0,91	0,00
LL	1981	-1,71	0,09	0,09	-0,28	0,00
ELx	1981	-17,79	7,26	-0,01	0,16	0,00
ELy	1981	-3,01	0,12	2,98	-13,85	0,00
WLx	1981	1,60	-0,66	0,00	-0,01	0,00
WLy	1981	2,48	-0,36	-2,74	12,96	0,00
SL	1981	-23,97	1,31	1,23	-3,85	0,00
CL	1981	-0,15	0,08	0,01	-0,04	0,00

Note : a) joint numbers are SAP2000 model nodes.
b) for establishing coordinates of the pedestals refer to previous page.
c) footing, pedestal and soil weight are not included.

Combination factors

Comb	Loads							
	DL	LL	ELx	ELy	WLx	WLy	SL	CL
1	1,00							
2	1,00	1,00						
3	1,00						1,00	
4	1,00				1,00			
5	1,00					1,00		
6	1,00		1,00					
7	1,00			1,00				
8	1,00		-1,00					
9	1,00			-1,00				
10	1,00	0,75			0,75		0,75	
11	1,00	0,75				0,75	0,75	
12	1,00	0,75	0,75				0,75	
13	1,00	0,75		0,75			0,75	
14	1,00	0,75	-0,75				0,75	
15	1,00	0,75		-0,75			0,75	
16	0,60				1,00			
17	0,60					1,00		
18	0,60		1,00					
19	0,60			1,00				
20	0,60		-1,00					
21	0,60			-1,00				
22	1,00	1,00						1,00
23	1,00						1,00	1,00
24	0,75	0,75			0,75		0,75	0,75
25	0,75	0,75				0,75	0,75	0,75
26	0,75	0,75	0,75				0,75	0,75
27	0,75	0,75		0,75			0,75	0,75
28	0,75	0,75	-0,75				0,75	0,75
29	0,75	0,75		-0,75			0,75	0,75

where,

DL : dead load
LL : live load
CL : crane load
WL : wind load
EL : earthquake load

Pedestal data

$$NoOfForce := cols(MatrixLoad) \qquad NoOfCoord := cols(XY)$$

$$\begin{aligned} MatrixXY := \; & \text{for } i \in 0 .. NoOfComb - 1 \\ & \quad \text{for } j \in 0 .. NoOfCoord - 1 \\ & \quad\quad \text{for } k \in 0 .. NoOfPedestal - 1 \\ & \quad\quad\quad MatrixXY_{i+NoOfComb \cdot k, j} \leftarrow XY_{k,j} \end{aligned}$$

$$\begin{aligned} Comb_{AUX} := \; & \text{for } k \in 0 .. NoOfPedestal - 1 \\ & \quad Comb_{AUX_{k,0}} \leftarrow Comb \end{aligned}$$

$$\begin{aligned} MatrixComb := \; & \text{for } i \in 0 .. NoOfComb - 1 \\ & \quad \text{for } k \in 0 .. NoOfPedestal - 1 \\ & \quad\quad MatrixComb_{i+NoOfComb \cdot k} \leftarrow \left(Comb_{AUX_{k,0}}\right)_i \end{aligned}$$

$$\begin{aligned} CombFactor_{AUX} := \; & \text{for } k \in 0 .. NoOfPedestal - 1 \\ & \quad CombFactor_{AUX_{k,0}} \leftarrow CombFactor \end{aligned}$$

$$\begin{aligned} MatrixCombFactor := \; & \text{for } i \in 0 .. NoOfComb - 1 \\ & \quad \text{for } j \in 0 .. NoOfLoad - 1 \\ & \quad\quad \text{for } k \in 0 .. NoOfPedestal - 1 \\ & \quad\quad\quad MatrixCombFactor_{i+NoOfComb \cdot k, j} \leftarrow \left(CombFactor_{AUX_{k,0}}\right)_{i,j} \end{aligned}$$

$$\begin{aligned} CombLoad_{AUX} := \; & \text{for } k \in 0 .. NoOfPedestal - 1 \\ & \quad CombLoad_{AUX_{k,0}} \leftarrow CombFactor \cdot submatrix[MatrixLoad, NoOfLoad \cdot k, NoOfLoad \cdot (k + 1) \end{aligned}$$

$$\begin{aligned} MatrixCombLoad := \; & \text{for } i \in 0 .. NoOfComb - 1 \\ & \quad \text{for } j \in 0 .. NoOfForce - 1 \\ & \quad\quad \text{for } k \in 0 .. NoOfPedestal - 1 \\ & \quad\quad\quad MatrixCombLoad_{i+NoOfComb \cdot k, j} \leftarrow \left(CombLoad_{AUX_{k,0}}\right)_{i,j} \end{aligned}$$

$$\begin{aligned} MatrixLoad := \; & MatrixLoad \leftarrow stack\left(MatrixComb^T, MatrixXY^T, MatrixCombLoad^T\right) \\ & MatrixLoad \leftarrow MatrixLoad^T \\ & csort(MatrixLoad, 0) \end{aligned}$$

- Combined loads at the pedestals

Case #1		Coordinates [m]		Forces [tonf]			Moments [tonf-m]	
Comb	Joint No	X	Y	P	Vx	Vy	Mxx	Myy
1	1998	0,00	0,00	-12,43	0,00	0,31	-0,91	0,00
1	1981	6,00	0,00	-12,13	0,59	0,31	-0,91	0,00
1	1979	-6,00	0,00	-12,13	-0,59	0,31	-0,91	0,00
2	1998	0,00	0,00	-14,16	0,00	0,40	-1,18	0,00
2	1981	6,00	0,00	-13,84	0,68	0,40	-1,18	0,00
2	1979	-6,00	0,00	-13,84	-0,69	0,39	-1,18	0,00
3	1981	6,00	0,00	-36,09	1,90	1,54	-4,76	0,00
3	1979	-6,00	0,00	-36,10	-1,91	1,53	-4,76	0,00
3	1998	0,00	0,00	-36,55	-0,01	1,54	-4,77	0,00
4	1979	-6,00	0,00	-13,81	-1,24	0,30	-0,90	0,00
4	1998	0,00	0,00	-12,33	-1,31	0,30	-0,91	0,00
4	1981	6,00	0,00	-10,53	-0,08	0,31	-0,92	0,00
5	1979	-6,00	0,00	-9,62	-0,21	-2,44	12,05	0,00
5	1981	6,00	0,00	-9,65	0,23	-2,43	12,05	0,00
5	1998	0,00	0,00	-7,75	0,03	-2,11	10,54	0,00
6	1981	6,00	0,00	-29,92	7,85	0,30	-0,75	0,00
6	1998	0,00	0,00	-12,43	14,22	0,37	-0,91	0,00
6	1979	-6,00	0,00	5,66	6,67	0,38	-1,07	0,00
7	1979	-6,00	0,00	-15,17	-0,74	3,28	-14,76	0,00
7	1998	0,00	0,00	-15,18	-0,03	3,33	-14,96	0,00
7	1981	6,00	0,00	-15,14	0,71	3,29	-14,76	0,00
8	1998	0,00	0,00	-12,43	-14,23	0,24	-0,91	0,00
8	1979	-6,00	0,00	-29,92	-7,85	0,23	-0,74	0,00

$k := 0 .. NoOfPedestal \cdot NoOfComb - 1$

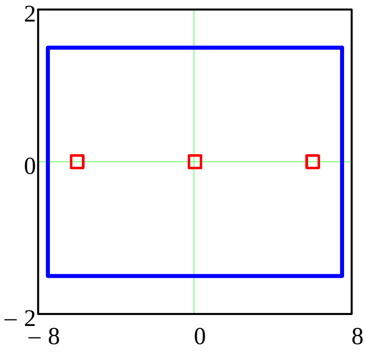
Case #1

$$XY_{foot} := \begin{pmatrix} 0.5 \cdot L_x & 0.5 \cdot L_y \\ -0.5 \cdot L_x & 0.5 \cdot L_y \\ -0.5 \cdot L_x & -0.5 \cdot L_y \\ 0.5 \cdot L_x & -0.5 \cdot L_y \\ 0.5 \cdot L_x & 0.5 \cdot L_y \end{pmatrix}$$

Case #2

$$XY_{foot.2} := \begin{pmatrix} 0.5 \cdot L_{x.2} & 0.5 \cdot L_{y.2} \\ -0.5 \cdot L_{x.2} & 0.5 \cdot L_{y.2} \\ -0.5 \cdot L_{x.2} & -0.5 \cdot L_{y.2} \\ 0.5 \cdot L_{x.2} & -0.5 \cdot L_{y.2} \\ 0.5 \cdot L_{x.2} & 0.5 \cdot L_{y.2} \end{pmatrix}$$

Pedestal data



.

3.0 CALCULATIONS:

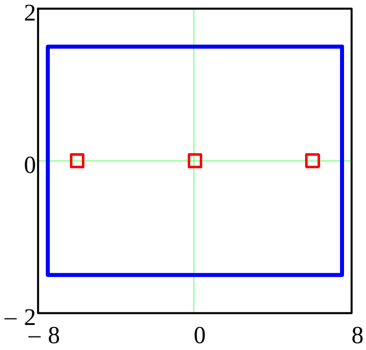
Calculations

The footing dimensions must be assigned as L_x **and** L_y **such that** $\frac{e_y}{L_y} < \frac{e_x}{L_x}$

- Pedestal positions

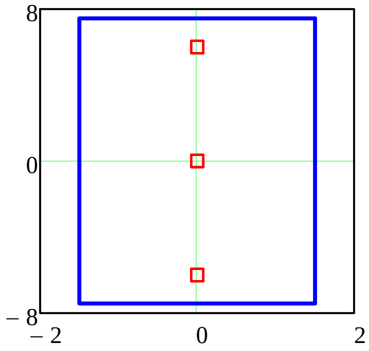
Case #1

$X := X \cdot m$ $\qquad Y := Y \cdot m$



Case #2 (90 degrees rotation about axes Z)

$X_2 := -Y$ $\qquad Y_2 := X$



- Forces (axial loads, shears and moments) acting on the pedestals

$P_o := P_o \cdot tonnef \quad V_{ox} := V_{ox} \cdot tonnef \quad V_{oy} := V_{oy} \cdot tonnef \quad M_{ox} := M_{ox} \cdot tonnef \cdot m \quad M_{oy} := M_{oy} \cdot tonnef \cdot m$

$j := 0 .. NoOfComb - 1$

- Axial force at centroid of footing

$$P_j := \sum_{i = 0 + NoOfPedestal \cdot j}^{NoOfPedestal \cdot (j+1) - 1} P_{o_i} + (FootingWeight + SoilWeight) \cdot CombFactor_{j,0}$$

- Shear along X axis at centroid of footing

$$V_{x_j} := \sum_{i = 0 + NoOfPedestal \cdot j}^{NoOfPedestal \cdot (j+1) - 1} V_{ox_i}$$

- Shear along Y axis at centroid of footing

$$V_{y_j} := \sum_{i = 0 + NoOfPedestal \cdot j}^{NoOfPedestal \cdot (j+1) - 1} V_{oy_i}$$

- Moment about X axis at centroid of footing

$$M_{xx_j} := \sum_{i = 0 + NoOfPedestal \cdot j}^{NoOfPedestal \cdot (j+1) - 1} M_{ox_i} + \sum_{i = 0 + NoOfPedestal \cdot j}^{NoOfPedestal \cdot (j+1) - 1} \left(P_{o_i} \cdot Y_i\right) \cdots$$
$$+ \sum_{i = 0 + NoOfPedestal \cdot j}^{NoOfPedestal \cdot (j+1) - 1} \left[V_{oy_i} \cdot (TOP - BOF)\right]$$

- Moment about Y axis at centroid of footing

$$M_{yy_j} := \sum_{i=0+NoOfPedestal\cdot j}^{NoOfPedestal\cdot(j+1)-1} M_{oy_i} + \sum_{i=0+NoOfPedestal\cdot j}^{NoOfPedestal\cdot(j+1)-1} \left(P_{o_i}\cdot X_i\right) \cdots$$
$$+ \sum_{i=0+NoOfPedestal\cdot j}^{NoOfPedestal\cdot(j+1)-1} \left[V_{ox_i}\cdot(TOP - BOF)\right]$$

Case #2 (90 degrees rotation about axes Z)

$P_{2_j} := P_j \quad V_{x.2_j} := -V_{y_j} \quad V_{y.2_j} := V_{x_j} \quad M_{xx.2_j} := M_{yy_j} \quad M_{yy.2_j} := -M_{xx_j}$

- Corners in bearing

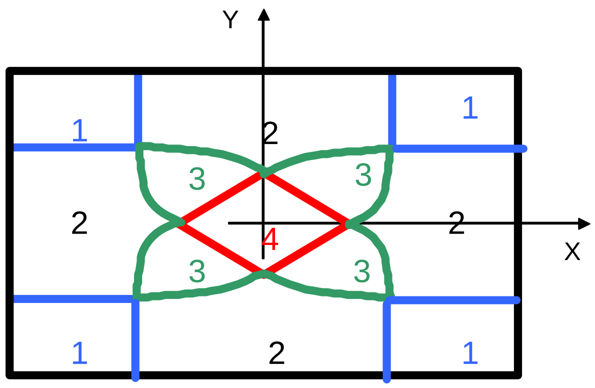
Case #1

$$e_{x_j} := \left|\frac{M_{yy_j}}{P_j}\right| \qquad e_{y_j} := \left|\frac{M_{xx_j}}{P_j}\right|$$

Case #2 (90 degrees rotation about axes Z)

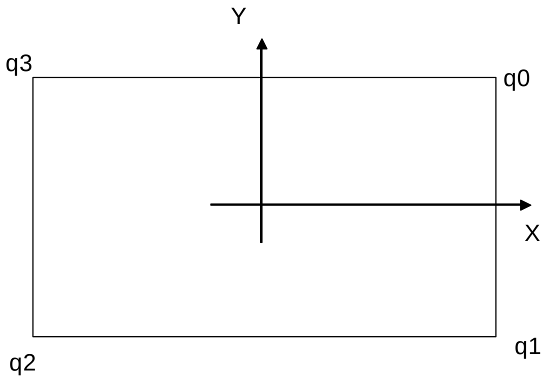
$$e_{x.2_j} := \left|\frac{M_{yy.2_j}}{P_{2_j}}\right| \qquad e_{y.2_j} := \left|\frac{M_{xx.2_j}}{P_{2_j}}\right|$$

$$Check_j := if\left(\left|\frac{e_{y_j}}{L_y}\right| < \left|\frac{e_{x_j}}{L_x}\right|, "Case\ \#1", "Case\ \#2"\right)$$



$$
NBC_j := \left|
\begin{array}{l}
b(a) \leftarrow \dfrac{\dfrac{1}{6} - \dfrac{a^2}{6} + \dfrac{a^3}{12}}{1 - a + \dfrac{a^2}{3}} \\
tope_y \leftarrow b\left(4 \cdot \dfrac{e_x}{L_x}\right) \cdot L_y \\
tope_x \leftarrow b\left(4 \cdot \dfrac{e_y}{L_y}\right) \cdot L_x \\
tope_{y.2} \leftarrow b\left(4 \cdot \dfrac{e_{x.2}}{L_{x.2}}\right) \cdot L_{y.2} \\
tope_{x.2} \leftarrow b\left(4 \cdot \dfrac{e_{y.2}}{L_{y.2}}\right) \cdot L_{x.2} \\
\text{if } \left|\dfrac{e_{y_j}}{L_y}\right| < \left|\dfrac{e_{x_j}}{L_x}\right| \\
\quad \left|
\begin{array}{l}
3 \text{ if } e_{x_j} \le tope_{x_j} \wedge e_{y_j} \le tope_{y_j} \wedge e_{y_j} > -\dfrac{L_y}{L_x} \cdot e_{x_j} + \dfrac{L_y}{6} \\
4 \text{ if } e_{y_j} \le -\dfrac{L_y}{L_x} \cdot e_{x_j} + \dfrac{L_y}{6} \\
1 \text{ if } e_{y_j} \ge \dfrac{L_y}{4} \wedge e_{x_j} \ge \dfrac{L_x}{4} \\
2 \text{ otherwise}
\end{array}
\right. \\
\text{otherwise} \\
\quad \left|
\begin{array}{l}
3 \text{ if } e_{x.2_j} \le tope_{x.2_j} \wedge e_{y.2_j} \le tope_{y.2_j} \wedge e_{y.2_j} > -\dfrac{L_{y.2}}{L_{x.2}} \cdot e_{x.2_j} + \dfrac{L_{y.2}}{6} \\
4 \text{ if } e_{y.2_j} \le -\dfrac{L_{y.2}}{L_{x.2}} \cdot e_{x.2_j} + \dfrac{L_{y.2}}{6} \\
1 \text{ if } e_{y.2_j} \ge \dfrac{L_{y.2}}{4} \wedge e_{x.2_j} \ge \dfrac{L_{x.2}}{4} \\
2 \text{ otherwise}
\end{array}
\right.
\end{array}
\right.
$$

- Bearing pressures



$A := L_x \cdot L_y$

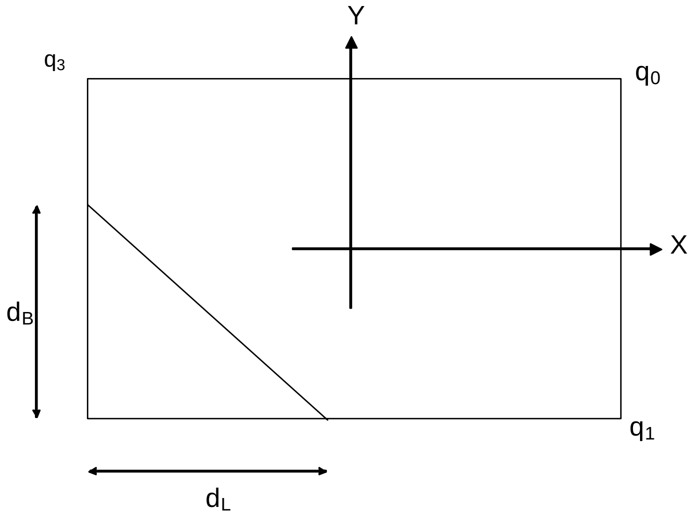
FOUR CORNERS IN BEARING

$$
q_{4CB} := \text{for } j \in 0..\text{NoOfComb}-1
$$

$$
\begin{aligned}
&\text{if } \left|\frac{e_{y_j}}{L_y}\right| < \left|\frac{e_{x_j}}{L_x}\right| \\
&\quad q_{4CB_{0,j}} \leftarrow \frac{P_j}{A}\cdot\left(1+\frac{6\cdot e_{x_j}}{L_x}+\frac{6\cdot e_{y_j}}{L_y}\right) \\
&\quad q_{4CB_{1,j}} \leftarrow \frac{P_j}{A}\cdot\left(1+\frac{6\cdot e_{x_j}}{L_x}-\frac{6\cdot e_{y_j}}{L_y}\right) \\
&\quad q_{4CB_{2,j}} \leftarrow \frac{P_j}{A}\cdot\left(1-\frac{6\cdot e_{x_j}}{L_x}-\frac{6\cdot e_{y_j}}{L_y}\right) \\
&\quad q_{4CB_{3,j}} \leftarrow \frac{P_j}{A}\cdot\left(1-\frac{6\cdot e_{x_j}}{L_x}+\frac{6\cdot e_{y_j}}{L_y}\right) \\
&\text{otherwise} \\
&\quad q_{4CB_{0,j}} \leftarrow \frac{P_{2_j}}{A}\cdot\left(1+\frac{6\cdot e_{x.2_j}}{L_{x.2}}+\frac{6\cdot e_{y.2_j}}{L_{y.2}}\right) \\
&\quad q_{4CB_{1,j}} \leftarrow \frac{P_{2_j}}{A}\cdot\left(1+\frac{6\cdot e_{x.2_j}}{L_{x.2}}-\frac{6\cdot e_{y.2_j}}{L_{y.2}}\right) \\
&\quad q_{4CB_{2,j}} \leftarrow \frac{P_{2_j}}{A}\cdot\left(1-\frac{6\cdot e_{x.2_j}}{L_{x.2}}-\frac{6\cdot e_{y.2_j}}{L_{y.2}}\right) \\
&\quad q_{4CB_{3,j}} \leftarrow \frac{P_{2_j}}{A}\cdot\left(1-\frac{6\cdot e_{x.2_j}}{L_{x.2}}+\frac{6\cdot e_{y.2_j}}{L_{y.2}}\right)
\end{aligned}
$$

$$
\%A_{4CB_j} := 100\%
$$

THREE CORNERS IN BEARING



Given

$$\frac{0.5\cdot(d_y - Ly)\cdot\left[\frac{0.5\cdot d_x^{2}\cdot(Ly - d_y)^{2}}{d_x\cdot(Ly - d_y) + Lx\cdot d_y}\right] + \left[0.5\cdot Ly - \frac{5}{8}\cdot(Ly - d_y)\right]\cdot\left[\frac{\frac{1}{3}\cdot d_x^{2}\cdot(Ly - d_y)^{2}\cdot\frac{Ly - d_y}{d_y}}{d_x\cdot(Ly - d_y) + Lx\cdot d_y}\right] - \cdots}{\left[\frac{0.5\cdot d_x^{2}\cdot(Ly - d_y)^{2}}{d_x\cdot(Ly - d_y) + Lx\cdot d_y}\right] + \left[\frac{\frac{1}{3}\cdot d_x^{2}\cdot(Ly - d_y)^{2}\cdot\frac{Ly - d_y}{d_y}}{d_x\cdot(Ly - d_y) + Lx\cdot d_y}\right] + \left[\frac{Ly\cdot d_x\cdot(Ly - d_y)\cdot\left(Lx - Ly\cdot\frac{d_x}{d_y}\right)}{d_x\cdot(Ly - d_y) + Lx\cdot d_y}\right] + \left[\frac{0.5\cdot L_y\cdot(Lx\cdot d_y - \cdots}{d_x\cdot(Ly \cdots}\right.}$$

$$\frac{0.5\cdot\left[-Lx + d_x + \frac{4}{3}\cdot(Ly - d_y)\cdot\frac{d_x}{d_y}\right]\cdot\left[\frac{0.5\cdot d_x^{2}\cdot(Ly - d_y)^{2}}{d_x\cdot(Ly - d_y) + Lx\cdot d_y}\right] + \left[-0.5\cdot Lx + \frac{3}{8}\cdot(Ly - d_y)\cdot\frac{d_x}{d_y}\right]\cdot\left[\frac{\frac{1}{3}\cdot d_x^{2}\cdot(Ly - d_y)^{2}\cdot\frac{Ly \cdots}{\cdots}}{d_x\cdot(Ly - d_y) + Lx \cdots}\right.}{\left[\frac{0.5\cdot d_x^{2}\cdot(Ly - d_y)^{2}}{d_x\cdot(Ly - d_y) + Lx\cdot d_y}\right] + \left[\frac{\frac{1}{3}\cdot d_x^{2}\cdot(Ly - d_y)^{2}\cdot\frac{Ly - d_y}{d_y}}{d_x\cdot(Ly - d_y) + Lx\cdot d_y}\right] + \left[\frac{L_y\cdot d_x\cdot(L \cdots}{d_x\cdot(\cdots}\right.}$$

$0cm < d_x < Lx$

$0cm < d_y < Ly$

$eqn_3(Lx, Ly, d_x, d_y, ex, ey) := Find(d_x, d_y)$

$$q_{3CB}(Lx, Ly, d_x, d_y, N, ex, ey) := \left| \begin{array}{l} \begin{pmatrix} d_{x3} \\ d_{y3} \end{pmatrix} \leftarrow eqn_3(Lx, Ly, d_x, d_y, ex, ey) \\ K \leftarrow \dfrac{Lx \cdot d_{x3} \cdot d_{y3} \cdot (Ly - d_{y3}) +}{d_{x3}{}^2 \cdot (Ly - d_{y3})^2 \cdot \left(\frac{1}{3} + \frac{1}{6} \cdot \frac{d_{y3}}{Ly}\right) + (Lx \cdot d_{y3} - Ly \cdot d_{x3}) \cdot \left[\frac{1}{2} \cdot (Lx \cdot d_{y3} + Ly \cdot d\right.} \\ q_{3CB} \leftarrow K \cdot \dfrac{N}{A} \cdot \begin{bmatrix} 1 \\ \dfrac{d_{y3} \cdot (Lx - d_{x3})}{d_{x3} \cdot (Ly - d_{y3}) + Lx \cdot d_{y3}} \\ 0 \\ \dfrac{d_{x3} \cdot (Ly - d_{y3})}{d_{x3} \cdot (Ly - d_{y3}) + Lx \cdot d_{y3}} \end{bmatrix} \end{array} \right.$$

$$\%A_{3CB}(Lx, Ly, d_x, d_y, ex, ey) := \left| \begin{array}{l} \begin{pmatrix} d_{x3} \\ d_{y3} \end{pmatrix} \leftarrow eqn_3(Lx, Ly, d_x, d_y, ex, ey) \\ \%A_{3CB} \leftarrow \dfrac{A - 0.5 \cdot d_{x3} \cdot d_{y3}}{A} \end{array} \right.$$

$$q_{3CB} := \text{for } i \in 0..3$$

$$\quad \text{for } j \in 0..NoOfComb - 1$$

$$\quad\quad \text{if } NBC_j = 3$$

$$\quad\quad\quad \text{if } \left|\frac{e_{y_j}}{L_y}\right| < \left|\frac{e_{x_j}}{L_x}\right|$$

$$\quad\quad\quad\quad q_{aux} \leftarrow q_{3CB}(L_x, L_y, 1 \cdot mm, 1 \cdot mm, P_j, e_{x_j}, e_{y_j})$$

$$\quad\quad\quad\quad q_{i,j} \leftarrow q_{aux_{i,0}}$$

$$\quad\quad\quad \text{otherwise}$$

$$\quad\quad\quad\quad q_{aux} \leftarrow q_{3CB}(L_{x.2}, L_{y.2}, 1 \cdot mm, 1 \cdot mm, P_j, e_{x.2_j}, e_{y.2_j})$$

$$\quad\quad\quad\quad q_{i,j} \leftarrow q_{aux_{i,0}}$$

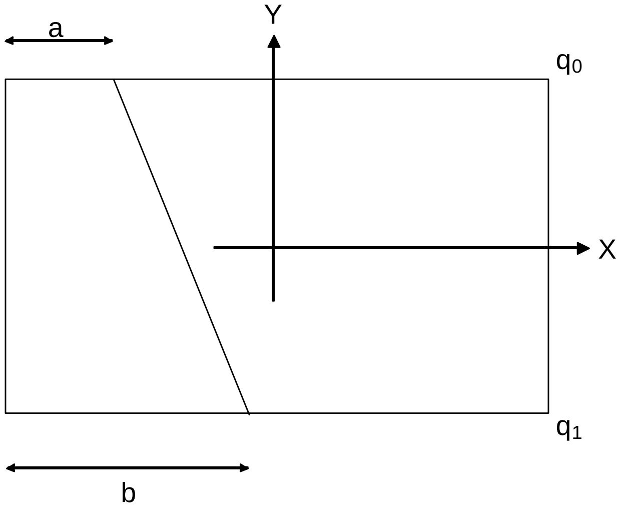
$$\quad\quad \text{otherwise}$$

$$\quad\quad\quad q_{aux} \leftarrow (0 \ \ 0 \ \ 0 \ \ 0)^T \cdot \frac{kgf}{cm^2}$$

$$\quad\quad\quad q_{i,j} \leftarrow q_{aux_{i,0}}$$

$$
\%A_{3CB} := \begin{array}{l} \text{for } j \in 0..NoOfComb - 1 \\ \quad \left| \begin{array}{l} \text{if } NBC_j = 3 \\ \quad \left| \begin{array}{l} \%A_j \leftarrow \%A_{3CB}\left(L_x, L_y, 1mm, 1mm, e_{x_j}, e_{y_j}\right) \text{ if } \left|\dfrac{e_{y_j}}{L_y}\right| < \left|\dfrac{e_{x_j}}{L_x}\right| \\ \%A_j \leftarrow \%A_{3CB}\left(L_{x.2}, L_{y.2}, 1mm, 1mm, e_{x.2_j}, e_{y.2_j}\right) \text{ otherwise} \end{array} \right. \\ \%A_j \leftarrow 0\% \text{ otherwise} \end{array} \right. \end{array}
$$

TWO CORNERS IN BEARING



Given

$$\frac{\frac{Ly}{6}\cdot\left[\frac{0.5\cdot Ly\cdot(Lx-b_2)\cdot(b_2-a_2)}{L_x-a_2}\right]+\frac{Ly}{4}\cdot\left[\frac{\frac{1}{6}\cdot Ly\cdot(b_2-a_2)^2}{L_x-a_2}\right]}{\left[\frac{0.5\cdot Ly\cdot(Lx-b_2)^2}{Lx-a_2}\right]+\left[\frac{0.5\cdot Ly\cdot(Lx-b_2)\cdot(b_2-a_2)}{Lx-a_2}\right]+\left[\frac{\frac{1}{6}\cdot Ly\cdot(b_2-a_2)^2}{Lx-a_2}\right]} - ey = 0\cdot cm$$

$$\frac{\left(\frac{a_2}{2}-\frac{b_2}{6}+\frac{Lx}{6}\right)\cdot\left[\frac{0.5\cdot Ly\cdot(Lx-b_2)^2}{Lx-a_2}\right]+\left(\frac{Lx}{2}-\frac{b_2-a_2}{3}\right)\cdot\left[\frac{0.5\cdot Ly\cdot(Lx-b_2)\cdot(b_2-a_2)}{Lx-a_2}\right]+\left(\frac{Lx}{2}-\frac{b_2-a_2}{4}\right)\cdot\left[\frac{1}{6}\cdot\right.}{\left[\frac{0.5\cdot Ly\cdot(Lx-b_2)^2}{Lx-a_2}\right]+\left[\frac{0.5\cdot Ly\cdot(Lx-b_2)\cdot(b_2-a_2)}{Lx-a_2}\right]+\left[\frac{\frac{1}{6}\cdot Ly\cdot(b_2-a_2)^2}{Lx-a_2}\right]}$$

$0cm < a_2 < Lx$

$0cm < b_2 < Lx$

$eqn_2(Lx, Ly, a_2, b_2, ex, ey) := Minerr(a_2, b_2)$

$$q_{2CB}(Lx,Ly,a_2,b_2,N,ex,ey) := \begin{array}{|l} \begin{pmatrix} a_2 \\ b_2 \end{pmatrix} \leftarrow eqn_2(Lx,Ly,a_2,b_2,ex,ey) \\ K \leftarrow \dfrac{2\cdot Lx\cdot(Lx-a_2)}{Lx^2 - Lx\cdot a_2 - Lx\cdot b_2 + \frac{1}{3}\cdot\left(a_2{}^2 + a_2\cdot b_2 + b_2{}^2\right)} \\ q_{3CB} \leftarrow K\cdot\dfrac{N}{A}\cdot\begin{pmatrix} 1 \\ \dfrac{Lx-b_2}{Lx-a_2} \\ 0 \\ 0 \end{pmatrix} \end{array}$$

$$\%A_{2CB}(Lx,Ly,a_2,b_2,ex,ey) := \begin{array}{|l} \begin{pmatrix} a_2 \\ b_2 \end{pmatrix} \leftarrow eqn_2(Lx,Ly,a_2,b_2,ex,ey) \\ \dfrac{A - 0.5\cdot(a_2+b_2)\cdot Ly}{A} \end{array}$$

$$q_{2CB} := \text{for } i \in 0..3$$
$$\quad \text{for } j \in 0..NoOfComb - 1$$
$$\quad\quad \text{if } NBC_j = 2$$
$$\quad\quad\quad \text{if } \left|\frac{e_{y_j}}{L_y}\right| < \left|\frac{e_{x_j}}{L_x}\right|$$
$$\quad\quad\quad\quad q_{aux} \leftarrow q_{2CB}(L_x, L_y, 1\cdot mm, 1\cdot mm, P_j, e_{x_j}, e_{y_j})$$
$$\quad\quad\quad\quad q_{i,j} \leftarrow q_{aux_{i,0}}$$
$$\quad\quad\quad \text{otherwise}$$
$$\quad\quad\quad\quad q_{aux} \leftarrow q_{2CB}(L_{x.2}, L_{y.2}, 1\cdot mm, 1\cdot mm, P_{2_j}, e_{x.2_j}, e_{y.2_j})$$
$$\quad\quad\quad\quad q_{i,j} \leftarrow q_{aux_{i,0}}$$
$$\quad\quad \text{otherwise}$$
$$\quad\quad\quad q_{aux} \leftarrow (0\ \ 0\ \ 0\ \ 0)^T\cdot\frac{kgf}{cm^2}$$
$$\quad\quad\quad q_{i,j} \leftarrow q_{aux_{i,0}}$$

$$\%A_{2CB} := \text{for } j \in 0..NoOfComb-1$$

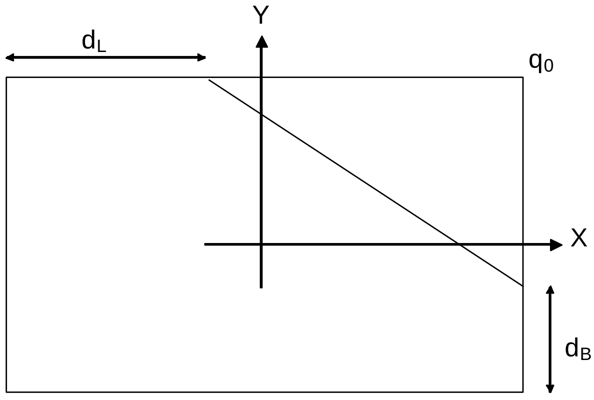
$$\quad \text{if } NBC_j = 2$$

$$\quad\quad \%A_j \leftarrow \%A_{2CB}\left(L_x, L_y, 1mm, 1mm, e_{x_j}, e_{y_j}\right) \text{ if } \left|\frac{e_{y_j}}{L_y}\right| < \left|\frac{e_{x_j}}{L_x}\right|$$

$$\quad\quad \%A_j \leftarrow \%A_{2CB}\left(L_{x.2}, L_{y.2}, 1mm, 1mm, e_{x.2_j}, e_{y.2_j}\right) \text{ otherwise}$$

$$\quad \%A_j \leftarrow 0\% \text{ otherwise}$$

ONE CORNERS IN BEARING



$d_{y1_j} := 4 \cdot e_{y_j} - L_y \quad d_{x1_j} := 4 \cdot e_{x_j} - L_x \quad d_{y1.2_j} := 4 \cdot e_{y.2_j} - L_{y.2} \quad d_{x1.2_j} := 4 \cdot e_{x.2_j} - L_{x.2}$

$$
q_{1CB} := \text{for } j \in 0..NoOfComb - 1
$$

$$
\begin{aligned}
&\text{if } \left|\frac{e_{y_j}}{L_y}\right| < \left|\frac{e_{x_j}}{L_x}\right| \\
&\quad q_{1CB_{0,j}} \leftarrow \frac{1.5 \cdot P_j}{\left(L_y - 2 \cdot e_{y_j}\right) \cdot \left(L_x - 2 \cdot e_{x_j}\right)} \\
&\quad q_{1CB_{1,j}} \leftarrow 0 \frac{kgf}{cm^2} \\
&\quad q_{1CB_{2,j}} \leftarrow 0 \frac{kgf}{cm^2} \\
&\quad q_{1CB_{3,j}} \leftarrow 0 \frac{kgf}{cm^2} \\
&\text{otherwise} \\
&\quad q_{1CB_{0,j}} \leftarrow \frac{1.5 \cdot P_{2_j}}{\left(L_{y.2} - 2 \cdot e_{y.2_j}\right) \cdot \left(L_{x.2} - 2 \cdot e_{x.2_j}\right)} \\
&\quad q_{1CB_{1,j}} \leftarrow 0 \frac{kgf}{cm^2} \\
&\quad q_{1CB_{2,j}} \leftarrow 0 \frac{kgf}{cm^2} \\
&\quad q_{1CB_{3,j}} \leftarrow 0 \frac{kgf}{cm^2}
\end{aligned}
$$

$$\%A_{1CB} := \begin{aligned}&\text{for } j \in 0..NoOfComb-1\\ &\quad \left| \begin{array}{ll} \dfrac{0.5\cdot\left(L_y - d_{y1_j}\right)\cdot\left(L_x - d_{x1_j}\right)}{A} & \text{if } \left|\dfrac{e_{y_j}}{L_y}\right| < \left|\dfrac{e_{x_j}}{L_x}\right| \\ \dfrac{0.5\cdot\left(L_{y.2} - d_{y1.2_j}\right)\cdot\left(L_{x.2} - d_{x1.2_j}\right)}{A} & \text{otherwise} \end{array}\right.\end{aligned}$$

- Bearing pressure at remaining foundation corners

$$q_{bearingCorner} := \left| \begin{array}{l} \text{for } i \in 0..3 \\ \quad \text{for } j \in 0..NoOfComb-1 \\ \quad\quad \left| \begin{array}{ll} q_{aux_{i,j}} \leftarrow q_{3CB_{i,j}} & \text{if } NBC_j = 3 \\ q_{aux_{i,j}} \leftarrow q_{4CB_{i,j}} & \text{if } NBC_j = 4 \\ q_{aux_{i,j}} \leftarrow q_{1CB_{i,j}} & \text{if } NBC_j = 1 \\ q_{aux_{i,j}} \leftarrow q_{2CB_{i,j}} & \text{if } NBC_j = 2 \end{array}\right. \\ \text{for } j \in 0..NoOfComb-1 \\ \quad \left| \begin{array}{l} \text{if } \left|\dfrac{e_{y_j}}{L_y}\right| < \left|\dfrac{e_{x_j}}{L_x}\right| \\ \quad \left| \begin{array}{l} q_{0,j} \leftarrow q_{aux_{0,j}} \\ q_{1,j} \leftarrow q_{aux_{1,j}} \\ q_{2,j} \leftarrow q_{aux_{2,j}} \\ q_{3,j} \leftarrow q_{aux_{3,j}} \end{array}\right. \\ \text{otherwise} \\ \quad \left| \begin{array}{l} q_{0,j} \leftarrow q_{aux_{1,j}} \\ q_{1,j} \leftarrow q_{aux_{2,j}} \\ q_{2,j} \leftarrow q_{aux_{3,j}} \\ q_{3,j} \leftarrow q_{aux_{0,j}} \end{array}\right. \end{array}\right. \\ q \end{array}\right.$$

- % of footing in contact with soil

$$\%InContact := \text{for } j \in 0..NoOfComb-1 \quad \begin{array}{|l} \%A_j \leftarrow \%A_{3CB_j} \text{ if } NBC_j = 3 \\ \%A_j \leftarrow \%A_{4CB_j} \text{ if } NBC_j = 4 \\ \%A_j \leftarrow \%A_{1CB_j} \text{ if } NBC_j = 1 \\ \%A_j \leftarrow \%A_{2CB_j} \text{ if } NBC_j = 2 \end{array}$$

- Maximum bearing pressure

$$q_{BearingMax} := \text{for } j \in 0..NoOfComb-1 \quad q_{BearingMax_j} \leftarrow \max\left(q_{bearingCorner}^{\langle j \rangle}\right)$$

- Overburden

$$overburden := \frac{FootingWeight + SoilWeight}{L_x \cdot L_y}$$

- Sliding

Sliding of foundations in response to design earthquake forces is usually very limited (fractions of a centimeter) and is typically considered as positive behavior. Sliding of foundations limits forces introduced into the structure, and therefore need not be checked. However, sliding of non anchored equipment and other nonstructural items could cause damage and should be checked.

FSsliding = 2
= 1.5 (typically on *Soil Reports*)

$$FSsliding_j := \begin{array}{|l} \text{if } \left|\frac{e_{y_j}}{L_y}\right| < \left|\frac{e_{x_j}}{L_x}\right| \\ \quad \begin{array}{|l} \min\left[\frac{P_j \cdot \tan\left(\frac{2}{3}\cdot\phi\right) + \left(\%InContact_j \cdot L_x \cdot L_y\right)\cdot(0.80c)}{\sqrt{\left(V_{x_j}\right)^2 + \left(V_{y_j}\right)^2}}, 100\right] \text{ if } \sqrt{\left(V_{x_j}\right)^2 + \left(V_{y_j}\right)^2} \neq 0 \\ 100 \text{ otherwise} \end{array} \\ \text{otherwise} \\ \quad \begin{array}{|l} \min\left[\frac{P_{2_j} \cdot \tan\left(\frac{2}{3}\cdot\phi\right) + \left(\%InContact_j \cdot L_{x.2} \cdot L_{y.2}\right)\cdot(0.80c)}{\sqrt{\left(V_{x.2_j}\right)^2 + \left(V_{y.2_j}\right)^2}}, 100\right] \text{ if } \sqrt{\left(V_{x.2_j}\right)^2 + \left(V_{y.2_j}\right)^2} \neq 0 \\ 100 \text{ otherwise} \end{array} \end{array}$$

- Overturning

Overturning of foundations in response to design earthquake loads is to be checked on an allowable stress basi using allowable stress load combinations. A factor of safety of 1.0 should be used considering only 90% of the dead load for resistance. The 0.9 factor accounts for uncertainty of the dead load and upward vertical accelerati

FSOT	= 1.2	==> 25% of the soil compressed under the foundation
	= 1.5	==> 50% of the soil compressed under the foundation
	= 2.0	==> 75% of the soil compressed under the foundation
	= 3.0	==> 100% of the soil compressed under the foundation

$$FSOT_{x_j} := \begin{cases} \begin{cases} \min\left(\dfrac{P_j \cdot L_y}{2 \cdot M_{xx_j}}, 100\right) & \text{if } P_j \cdot M_{xx_j} > 0 \\ \min\left(-\dfrac{P_j \cdot L_y}{2 \cdot M_{xx_j}}, 100\right) & \text{if } P_j \cdot M_{xx_j} < 0 \\ 100 & \text{otherwise} \end{cases} & \text{if } \left|\dfrac{e_{y_j}}{L_y}\right| < \left|\dfrac{e_{x_j}}{L_x}\right| \\ \text{otherwise} \\ \begin{cases} \min\left(\dfrac{P_{2_j} \cdot L_{y.2}}{2 \cdot M_{xx.2_j}}, 100\right) & \text{if } P_j \cdot M_{xx.2_j} > 0 \\ \min\left(-\dfrac{P_{2_j} \cdot L_{y.2}}{2 \cdot M_{xx.2_j}}, 100\right) & \text{if } P_{2_j} \cdot M_{xx.2_j} < 0 \\ 100 & \text{otherwise} \end{cases} \end{cases}$$

$$FSOT_{y_j} := \begin{cases} \begin{cases} \min\left(\frac{P_j \cdot L_x}{2 \cdot M_{yy_j}}, 100\right) & \text{if } P_j \cdot M_{yy_j} > 0 \\ \min\left(-\frac{P_j \cdot L_x}{2 \cdot M_{yy_j}}, 100\right) & \text{if } P_j \cdot M_{yy_j} < 0 \\ 100 & \text{otherwise} \end{cases} & \text{if } \left|\frac{e_{y_j}}{L_y}\right| < \left|\frac{e_{x_j}}{L_x}\right| \\ \begin{cases} \min\left(\frac{P_{2_j} \cdot L_{x.2}}{2 \cdot M_{yy.2_j}}, 100\right) & \text{if } P_{2_j} \cdot M_{yy.2_j} > 0 \\ \min\left(-\frac{P_{2_j} \cdot L_{x.2}}{2 \cdot M_{yy.2_j}}, 100\right) & \text{if } P_{2_j} \cdot M_{yy.2_j} < 0 \\ 100 & \text{otherwise} \end{cases} & \text{otherwise} \end{cases}$$

- Results

$q_{max} := \max(q_{BearingMax})$

$\%InContact_{min} := \min(\%InContact)$

$FSsliding_{min} := \min(FSsliding)$

$FSOT_{x.min} := \min(FSOT_x)$

$FSOT_{y.min} := \min(FSOT_y)$

Calculations

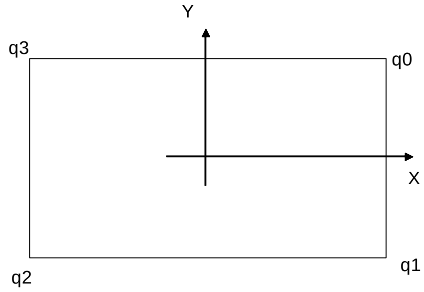
Pedestal coordinates

Pedestal No.	Joint No.	Coordinates [m] X	Y
1	1979	-6,00	0,00
2	1998	0,00	0,00
3	1981	6,00	0,00

Forces and Moment at centroid of footing seal

Comb	Forces [tonf]			Moments [tonf-m]	
	P	Vx	Vy	Mxx	Myy
1	124,63	0,00	0,92	-0,41	0,00
2	119,49	-0,01	1,19	-0,57	0,00
3	52,58	-0,02	4,61	-2,73	0,00
4	124,65	-2,63	0,91	-0,43	13,09
5	134,31	0,05	-6,98	17,11	-0,09
6	124,64	28,74	1,05	-0,10	-141,35
7	115,84	-0,05	9,90	-19,63	0,08
8	124,63	-28,75	0,80	-0,72	141,35
9	133,42	0,04	-8,06	18,82	-0,08
10	66,75	-1,98	3,88	-2,29	9,82
11	73,99	0,02	-2,04	10,87	-0,06
12	66,73	21,55	3,98	-2,04	-106,02
13	60,14	-0,05	10,62	-16,69	0,06
14	66,73	-21,58	3,79	-2,50	106,01
15	73,33	0,02	-2,85	12,15	-0,06
16	74,80	-2,62	0,54	-0,27	13,09
17	84,46	0,05	-7,35	17,28	-0,09
18	74,78	28,75	0,68	0,07	-141,35
19	65,99	-0,05	9,53	-19,47	0,08
20	74,78	-28,75	0,43	-0,56	141,35
21	83,57	0,04	-8,42	18,98	-0,08
22	115,84	0,34	1,58	-0,54	19,59
23	48,93	0,32	5,00	-2,69	19,59
24	32,85	-1,73	3,94	-2,16	24,51
25	40,10	0,28	-1,98	11,00	14,63
26	32,84	21,80	4,04	-1,91	-91,33
27	26,24	0,21	10,68	-16,56	14,75
28	32,84	-21,32	3,85	-2,38	120,70
29	39,43	0,28	-2,79	12,27	14,63

Bearing pressure at remaining foundation corners and Maximum Bearing pressure



Comb	NBC	Bearing Corner [tonf/m²]				
		q0	q1	q2	q3	qmax
1	4	2,79	2,75	2,75	2,79	2,79
2	4	2,68	2,63	2,63	2,68	2,68
3	4	1,29	1,05	1,05	1,29	1,29
4	4	2,91	2,87	2,63	2,67	2,91
5	4	3,74	2,22	2,22	3,75	3,75
6	4	4,03	4,02	1,51	1,52	4,03
7	4	3,45	1,70	1,70	3,45	3,45
8	4	4,06	3,99	1,48	1,55	4,06
9	4	3,80	2,13	2,13	3,80	3,80
10	4	1,50	1,29	1,47	1,67	1,67
11	4	2,13	1,16	1,16	2,13	2,13
12	4	2,52	2,33	0,45	0,63	2,52
13	4	2,08	0,59	0,60	2,08	2,08
14	4	2,54	2,31	0,43	0,65	2,54
15	4	2,17	1,09	1,09	2,17	2,17
16	4	1,79	1,77	1,53	1,56	1,79
17	4	2,64	1,11	1,11	2,65	2,65
18	4	2,92	2,92	0,40	0,41	2,92
19	4	2,33	0,60	0,60	2,33	2,33
20	4	2,94	2,89	0,38	0,43	2,94
21	4	2,70	1,01	1,01	2,70	2,70
22	4	2,77	2,72	2,38	2,42	2,77
23	4	1,38	1,14	0,79	1,03	1,38
24	4	1,04	0,85	0,42	0,61	1,04
25	4	1,25	0,27	0,53	1,51	1,51
26	2	1,64	1,46	0,00	0,00	1,64
27	2	0,63	0,00	0,00	2,68	2,68
28	2	2,05	1,77	0,00	0,00	2,05
29	4	1,29	0,20	0,46	1,55	1,55

$$q_{max} = 4.06 \frac{tonnef}{m^2}$$

$$q_{net} := q_{all} + \gamma_{soil} \cdot (SoilAboveFooting + FootingThickness) \qquad q_{net} = 34.14 \frac{tonn}{m^2}$$

Footing in contact with soil, Sliding and Overturning Factors of Safety

Comb	NBC	%InContact	Factor of Safety		
			Sliding	OTx	OTy
1	4	100,00	54,54	100,00	100,00
2	4	100,00	40,69	100,00	100,00
3	4	100,00	4,61	100,00	28,93
4	4	100,00	18,12	100,00	71,42
5	4	100,00	7,77	100,00	11,77
6	4	100,00	1,75	100,00	6,61
7	4	100,00	4,73	100,00	8,85
8	4	100,00	1,75	100,00	6,61
9	4	100,00	6,69	100,00	10,64
10	4	100,00	6,20	51,00	43,70
11	4	100,00	14,63	100,00	10,21
12	4	100,00	1,23	49,16	4,72
13	4	100,00	2,29	100,00	5,41
14	4	100,00	1,23	39,96	4,72
15	4	100,00	10,39	100,00	9,05
16	4	100,00	11,28	100,00	42,86
17	4	100,00	4,64	100,00	7,33
18	4	100,00	1,05	100,00	3,97
19	4	100,00	2,80	100,00	5,08
20	4	100,00	1,05	100,00	3,97
21	4	100,00	4,01	100,00	6,60
22	4	100,00	29,04	100,00	44,36
23	4	100,00	3,95	27,25	18,74
24	4	100,00	3,09	22,77	10,05
25	4	100,00	8,09	20,56	5,47
26	2	94,17	0,60	25,79	2,70
27	2	62,41	0,99	13,34	2,38
28	2	76,21	0,61	20,71	2,04
29	4	100,00	5,69	20,22	4,82

$\%InContact_{min} = 62.41\ \%$

$FSsliding_{min} = 0.60$

$FSOT_{x.min} = 13.34$

$FSOT_{y.min} = 2.04$

.

4.0 RESULTS:

Maximum Bearing pressure	$\text{if}\left(\max\left(q_{BearingMax}\right) \geq q_{net}, \text{"X"}, \text{"ok"}\right) = \text{"ok"}$
Footing in contact with soil	$\text{if}\left(\min(\%InContact) < \%InContact_{all}, \text{"X"}, \text{"ok"}\right) = \text{"ok"}$
Sliding Factor of Safety	$\text{if}\left(\min(FSsliding) < FSsliding_{all}, \text{"X"}, \text{"ok"}\right) = \text{"X"}$
Overturning Factor of Safety	$\text{if}\left(\min\left(FSOT_x\right) < FSOT_{all}, \text{"X"}, \text{"ok"}\right) = \text{"ok"}$
	$\text{if}\left(\min\left(FSOT_y\right) < FSOT_{all}, \text{"X"}, \text{"ok"}\right) = \text{"ok"}$

.

5.0 SKETCHES: