Sapatas - Exemplo 1

SAPATAS

Neste exemplo, será dimensionada uma sapata utilizando como base a Norma ACI318-19, comparando o cálculo manual dela os resultados obtidos pelo TQS:

Dados:

Max axial service

$N1 := 300.8 \cdot kip$ $\quad Mx1 := 5.2 \cdot kip \cdot ft$ $\quad Mz1 := 0 \cdot kip \cdot ft$

$Vx1 := 0 \cdot kip$ $\quad Vz1 := 0 \cdot kip$

Max moment service

$N2 := 287.0 \cdot kip$ $\quad Mx2 := 109.1 \cdot kip \cdot ft$ $\quad Mz2 := 0 \cdot kip \cdot ft$

$Vx2 := 0 \cdot kip$ $\quad Vz2 := 0 \cdot kip$

Max factored axial

$Nu1 := 394.5 \cdot kip$ $\quad Mux1 := 7.2 \cdot kip \cdot ft$ $\quad Muz1 := 0 \cdot kip \cdot ft$

$Vux1 := 0 \cdot kip$ $\quad Vuz1 := 0 \cdot kip$

Max factored moment

$Nu2 := 312.3 \cdot kip$ $\quad Mux2 := 264.6 \cdot kip \cdot ft$ $\quad Muz2 := 0 \cdot kip \cdot ft$

$Vux2 := 0 \cdot kip$ $\quad Vuz2 := 0 \cdot kip$

Tensão Admissível no solo: 3,5 lb/ft² ou 24,306 psi

f_y: 60 ksi

f_c: 4 ksi

c: 3 in

Densidade do concreto: 150 lb/ft³

Pilar: 24 in x 24 in

Sapata:

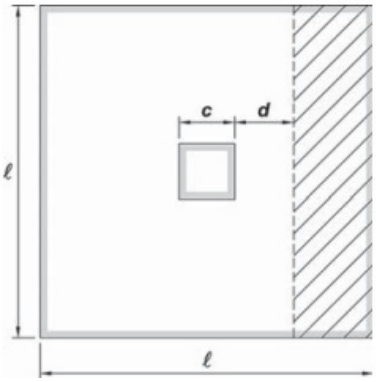
D: 10,5 ft

L: 10,5 ft

h_f: 25 in

q_u: 3,616 kip/ft²

Cortante:



$$V_n = V_c \rightarrow V_s = 0$$

$$d_b = \#6 = 0{,}75\ in$$

$$s = 10\ in$$

$$d = 25 - 3 - 0{,}75 = 21{,}25\ in$$

$$\rho_w = \frac{L}{s} \cdot \frac{d_b}{L \cdot d} = 0{,}003$$

$$\emptyset V_c = \emptyset \cdot 8 \cdot \lambda \cdot \rho_w^{\frac{1}{3}} \cdot \sqrt{f_c} \cdot b \cdot d = 0{,}75 \cdot 8 \cdot 1 \cdot \sqrt[3]{0{,}003} \cdot \sqrt{4000} \cdot 10{,}5 \cdot 12 \cdot 21{,}25 = 146{,}30\ kips$$

$$\emptyset V_{c,limite} = 5 \cdot 0{,}75 \cdot \sqrt{f'_c} \cdot b \cdot d = 5 \cdot 0{,}75 \cdot \frac{\sqrt{4000}}{1000} \cdot 10{,}5 \cdot 12 \cdot 21{,}25 = 635{,}02\ \ kips \rightarrow \emptyset V_{c,limite} \geq \emptyset V_c$$

$$\rightarrow OK!!$$

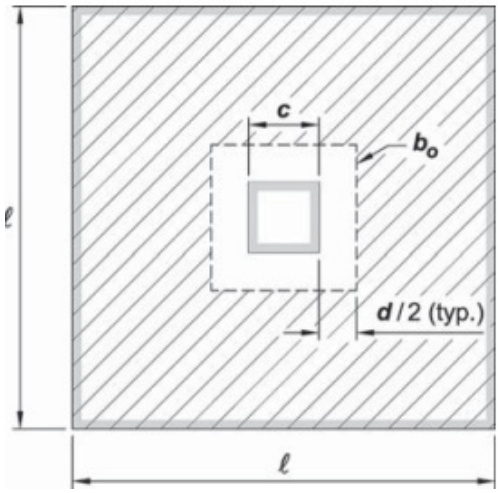
$$V_u = \left(\frac{L}{2} - \frac{a}{2} - d\right) \cdot b \cdot q_u = \left(\frac{10{,}5 \cdot 12}{2} - \frac{24}{2} - 21{,}25\right) \cdot 10{,}5 \cdot 12 \cdot \frac{3{,}616}{144} = 94{,}13\ kips$$

$$V_u \leq \emptyset V_c \rightarrow OK!!$$

TQS:

Sentido	Seção (in)		Força (kip)		Aviso
	ds	bs	Atuante	Limite	
X+	20.648"	125.984"	94.74	143.12	OK
X-	20.648"	125.984"	94.74	143.12	OK
Y+	19.896"	125.984"	94.74	139.63	OK
Y-	19.896"	125.984"	94.74	139.63	OK

Punção:



$$b_o = 4 \cdot (c + d) = 4 \cdot (24 + 21{,}25) = 181\ in$$

$$v_{c1} = 4 \cdot \lambda \cdot \sqrt{f_c} = 253\ psi v_{c1} = 4 \cdot \lambda \cdot \sqrt{f_c} = 253\ psi$$

$$v_{c2} = \left(2 + \frac{4}{\beta}\right) \cdot \lambda \cdot \sqrt{f_c} = 379{,}5\ psi$$

$$v_{c3} = \left(2 + \frac{\alpha \cdot d}{b_o}\right) \cdot \lambda \cdot \sqrt{f_c} = 423{,}50\ psi$$

$$v_{c1} \rightarrow OK!!$$

$$\emptyset V_c = \emptyset \cdot v_{c1} \cdot b_o \cdot d = 0{,}75 \cdot \frac{253}{1000} \cdot 181 \cdot 21{,}25 = 729{,}83\ kips \rightarrow 189{,}75\ lb/in^2$$

$$V_u = q_u \cdot [(a)^2 - (c + d)^2] = 3{,}616 \cdot \left[110{,}25 - \left(\frac{24 + 21{,}25}{12}\right)^2\right] = 347{,}25\ kips \rightarrow 90{,}28\ lb/in^2$$

$$V_u \leq \emptyset V_c \rightarrow OK!!$$

TQS:

Seção (in)		Tensão (lb/in²)		Aviso
ds	b0	Atuante (vu)	Limite (ϕvc)	
20.256"	178.583"	111.15	192.81	OK

Esmagamento:

$$B_n = \sqrt{\frac{A_2}{A_1}} \cdot 0{,}85 \cdot f_c \cdot A_1 = 5{,}25 \cdot 0{,}85 \cdot 4000 \cdot 576 = 10281\ kips$$

$$B_n = 2 \cdot \left(0{,}85 \cdot f'_c \cdot A_1\right) = 3916\ kips$$

$$Na\ sapata: \emptyset B_n = 0{,}65 \cdot 3916 = 2545{,}4\ kips \geq B_u(394{,}5\ kips) \rightarrow OK!!$$

$$No\ pilar: \emptyset B_n = 0{,}65 \cdot 1958 = 1272{,}7\ kips \geq B_u(394{,}5\ kips) \rightarrow OK!!$$

TQS:

Posição	Áreas (ft²)		Força (kip)		Aviso
	A1	A2	Atuante	Limite	
pilar	4.01	16.02	398.71	1359.71	OK
sapata	4.01	16.02	398.71	2719.43	OK

Flexão:

M_{ux}: 363,572 kip.ft - dx=21,625 in

M_{uy}: 339,317 kip.ft - dy=20,875 in

$$\emptyset M_n = M_u$$

$$a = \frac{A_s \cdot f_y}{0{,}85 \cdot f'_c \cdot b} = \frac{A_s \cdot 60}{0{,}85 \cdot 4 \cdot 10{,}5} = 0{,}17 A_s$$

$$A_{s,x} = \frac{M_u}{0{,}9 \cdot f_y \cdot (d - \frac{a}{1})} = \frac{363{,}572 \cdot 12}{0{,}9 \cdot 60 \cdot (21{,}625 - \frac{0{,}17 A_s}{2})} = 3{,}54\ in^2$$

$$A_{s,y} = \frac{M_u}{0{,}9 \cdot f_y \cdot (d - \frac{a}{1})} = \frac{339{,}317 \cdot 12}{0{,}9 \cdot 60 \cdot (20{,}875 - \frac{0{,}17 A_s}{2})} = 3{,}67\ in^2$$

$$A_{s,min} = \rho \cdot A_g = 0{,}0018 \cdot 25 \cdot 10{,}5 \cdot 12 = 5{,}67\ in^2$$

$$A_{s,min} \geq A_s \rightarrow A_{s,min}!!$$

Detalhamento:

Adotado #6 - 0,44 in²

$$Número\ de\ Barras: \frac{5{,}67}{0{,}442} = 12{,}82 \rightarrow 13\ barras \rightarrow s = \frac{10{,}5 \cdot 12}{13} = 9{,}69\ in \rightarrow Adotado\ 9\ in\ e\ 14\ barras$$

$$A_{s,efetivo,xy} = 14 \cdot 0{,}442 = 6{,}20\ in^2$$

TQS:

Sentido	Momentos (kip-ft)		Armaduras (in²)					
	M_{sd}	M_{min}	d	As_{calc}	$As_{calc,corr}$	$As_{min,rho}$	$As_{min,crit}$	As_{nec}
X	342.61	0.00	20.632"	4.17	4.17	5.45	0.23	5.45
Y	342.61	0.00	19.880"	4.32	4.32	5.45	0.23	5.45

Sentido	Armaduras				
	As_{det} (in²)	$As_{det/s}$ (in²/ft)	Nø	Ø (in)	c/ (in)
X	6.22	0.59	14	0.752"	9.055"
Y	6.22	0.59	14	0.752"	9.055"

Comprimento de Ancoragem:

$$\ell_d = \left(\frac{3}{40} \cdot \frac{f_y}{\lambda \cdot \sqrt{f'_c}} \cdot \frac{\psi_t \cdot \psi_e \cdot \psi_s \cdot \psi_g}{\left(\frac{c_b + K_{tr}}{d_b}\right)}\right) \cdot d_b = \left(\frac{3}{40} \cdot \frac{60000}{1 \cdot \sqrt{4000}} \cdot \frac{1 \cdot 1 \cdot 0{,}8 \cdot 1}{\left(\frac{3{,}5 + 0}{0{,}75}\right)}\right) \cdot 0{,}75 = 12{,}2\ in$$

$$\ell_{d,prov} = \frac{10{,}5 \cdot 12}{2} - 24 - cover = 36\ in \geq 12\ in \rightarrow OK!!$$

Arranques:

Comprimento dos arranques do pilar:

$$A_{s,dowel} = 0{,}005 \cdot A_g = 0{,}005 \cdot 24^2 = 2{,}88\ in^2$$

$$\ell_{dc1} = \frac{f_y \cdot \psi_r}{50 \cdot \lambda \cdot \sqrt{f'_c}} \cdot d_b = \frac{60000 \cdot 1}{50 \cdot 1 \cdot \sqrt{4000}} \cdot 0{,}75 = 14{,}23\ in$$

$$\ell_{dc2} = 0{,}0003 \cdot f_y \cdot \psi_r \cdot d_b = 0{,}0003 \cdot 60000 \cdot 1 \cdot 0{,}75 = 13{,}5\ in$$

$$Adotado\ \ell_{dc1} \rightarrow 14{,}23\ in$$

$$\ell_{sc1} = 0{,}0005 \cdot f_y \cdot d_b = 0{,}0005 \cdot 60000 \cdot 0{,}75 = 22{,}5\ in$$

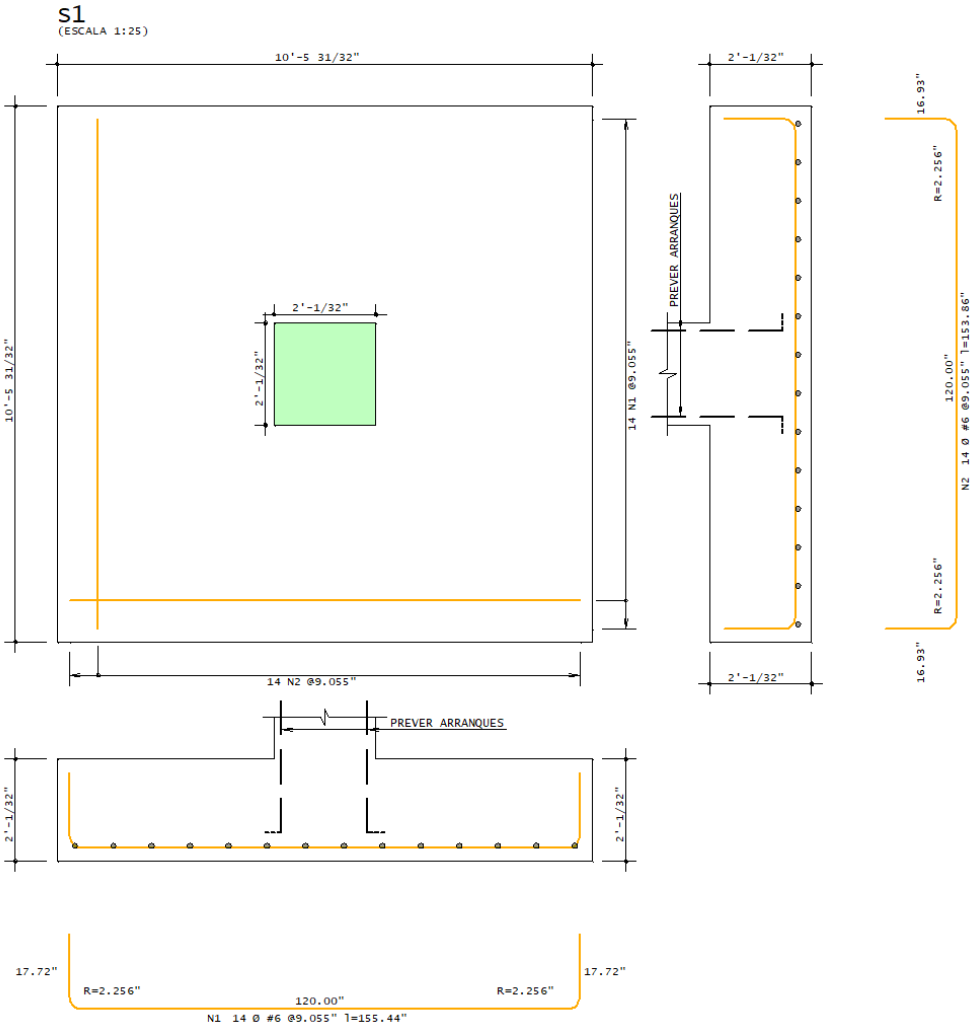
$$\ell_{sc2} = 12\ in$$

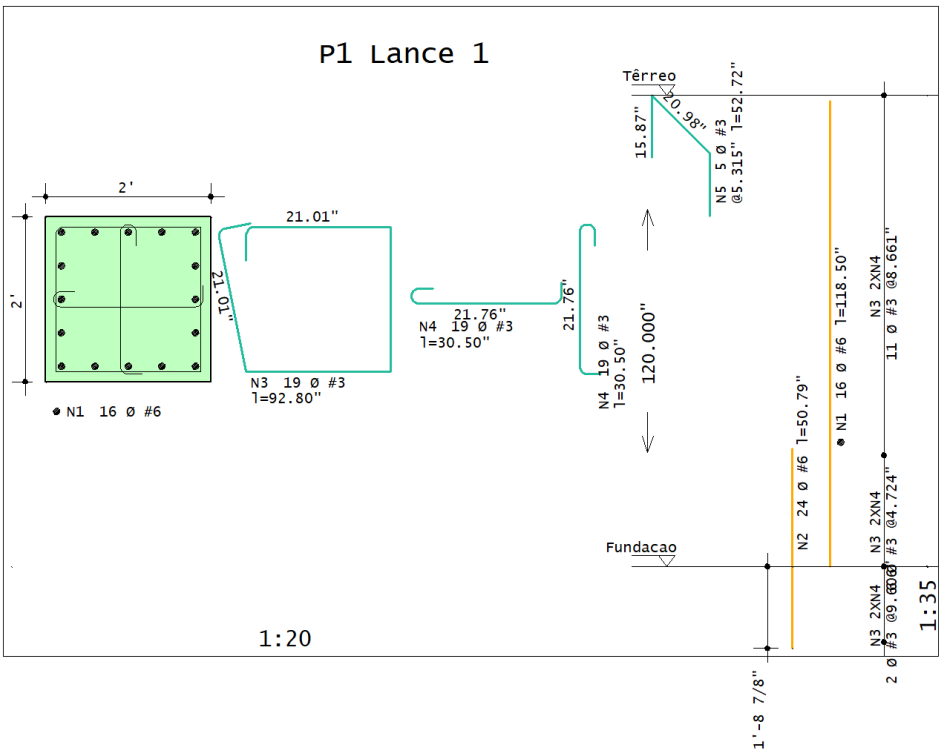
$$Adotado\ \ell_{sc1} \rightarrow 22{,}5\ in$$

Comprimento total:

$$\ell_{dc1} + \ell_{sc1} = 14{,}23 + 22{,}5 = 36{,}73\ in$$

TQS:





Conclusões:

Em geral se observam que os resultados são semelhantes apresentando apenas pequenas diferenças. O detalhamento final do TQS obedece às medidas necessárias pela Norma ACI318-19.