Sapatas - Exemplo 2

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:

$ND := 120 \cdot kip$ $MxD := 240 \cdot kip \cdot ft$ $MzD := 0 \cdot kip \cdot ft$

$NLL := 100 \cdot kip$ $MxLL := 100 \cdot kip \cdot ft$ $MzLL := 0 \cdot kip \cdot ft$

$Numax := \max(1.4 \cdot ND, 1.2 \cdot ND + 1.6\ NLL)$ $Numax = 304\ kip$

$Muxmax := \max(1.4 \cdot MxD, 1.2\ MxD + 1.6 \cdot MxLL)$ $Muxmax = 448\ kip \cdot ft$

Tensão Admissível no solo: 4,0 lb/ft² ou 27,778 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:

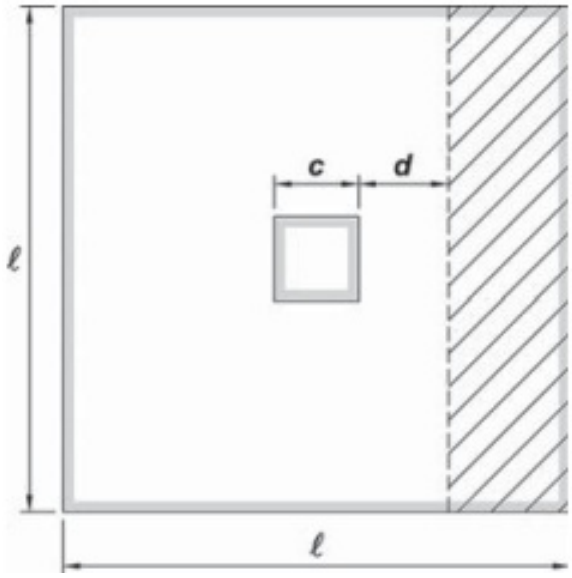
D: 10,5 ft

L: 10,5 ft

h_f: 35 in

q_u: 3,265 kip/ft²

Cortante:



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

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

$$s = 7\ in$$

$$d = 35 - 3 - 0{,}75 = 31{,}25\ in$$

$$\rho_w = \frac{L}{s} \cdot \frac{d_b}{L \cdot d} = 0{,}002$$

$$\emptyset V_c = \emptyset \cdot 8 \cdot \lambda \cdot \rho_w{}^{\frac{1}{3}} \cdot \sqrt{f_c} \cdot b \cdot d = 0{,}75 \cdot 8 \cdot 1 \cdot \sqrt[3]{0{,}002} \cdot \sqrt{4000} \cdot 10{,}5 \cdot 12 \cdot 31{,}25 = 188{,}25\ kips$$

$$\emptyset V_{c,limite} = 5 \cdot 0{,}75 \cdot \sqrt{f'_c} \cdot b \cdot d = 5 \cdot 0{,}75 \cdot \frac{\sqrt{4000}}{1000} \cdot 10{,}5 \cdot 12 \cdot 31{,}25 = 933{,}85\ \ kips \rightarrow \emptyset V_{c,limite} \geq \emptyset V_c \rightarrow OK!!$$

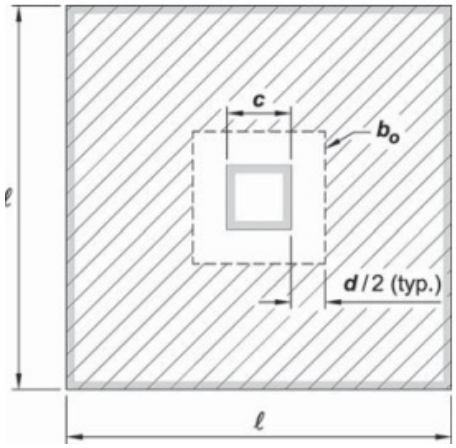
$$V_u = \left(\frac{L}{2} - \frac{a}{2} - d\right) \cdot b \cdot q_u = \left(\frac{10{,}5 \cdot 12}{2} - \frac{24}{2} - 31{,}25\right) \cdot 10{,}5 \cdot 12 \cdot \frac{3{,}265}{144} = 56{,}42\ kips$$

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

TQS:

Sentido	Seção (in)		Força (kip)		Aviso
	ds	bs	Atuante	Limite	
X+	30.593"	125.984"	49.30	189.60	OK
X-	30.593"	125.984"	49.30	189.60	OK
Y+	29.967"	125.984"	49.30	187.00	OK
Y-	29.967"	125.984"	49.30	187.00	OK

Punção:



$$b_o = 4 \cdot (c + d) = 4 \cdot (24 + 31{,}25) = 221\ in$$

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

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

$$v_{c3} = \left(2 + \frac{\alpha \cdot d}{b_o}\right) \cdot \lambda \cdot \sqrt{f_c} = 484{,}21\ psi$$

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

$$\emptyset V_c = \emptyset \cdot v_{c1} \cdot b_o \cdot d = 0{,}75 \cdot \frac{253}{1000} \cdot 221 \cdot 31{,}25 = 1310{,}46\ kips \rightarrow 189{,}75\ lb/in^2$$

$$V_u = q_u \cdot [(a)^2 - (c + d)^2] = 3{,}265 \cdot \left[110{,}25 - \left(\frac{24 + 31{,}25}{12}\right)^2\right] = 290{,}75\ kips \rightarrow 42{,}10\ lb/in^2$$

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

TQS:

Seção (in)		Tensão (lb/in²)		Aviso
ds	b0	Atuante (vu)	Limite (ϕvc)	
31.256"	222.520"	45.04	192.81	OK

Esmagamento:

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

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

$$Na\ sapata: \emptyset B_n = 0{,}65 \cdot 3916 = 2545{,}4\ kips \geq B_u(304\ kips) \rightarrow OK!!$$

$$No\ pilar: \emptyset B_n = 0{,}65 \cdot 1958 = 1272{,}7\ kips \geq B_u(304\ kips) \rightarrow OK!!$$

TQS:

Posição	Áreas (ft²)		Força (kip)		Aviso
	A1	A2	Atuante	Limite	
pilar	4.01	16.02	311.20	1359.71	OK
sapata	4.01	16.02	311.20	2719.43	OK

Flexão:

M_{ux}: 267,40 kip.ft - dx=31,625 in

M_{uy}: 267,40 kip.ft - dy=30,875 in

$$\emptyset M_n = M_u$$

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

$$A_{s,x} = \frac{M_u}{0{,}9 \cdot f_y \cdot (d - \frac{a}{1})} = \frac{267{,}40 \cdot 12}{0{,}9 \cdot 60 \cdot (31{,}625 - \frac{0{,}17 A_s}{2})} = 1{,}89\ in^2$$

$$A_{s,y} = \frac{M_u}{0{,}9 \cdot f_y \cdot (d - \frac{a}{1})} = \frac{267{,}40 \cdot 12}{0{,}9 \cdot 60 \cdot (30{,}875 - \frac{0{,}17 A_s}{2})} = 1{,}93\ in^2$$

$$A_{s,min} = \rho \cdot A_g = 0{,}0018 \cdot 35 \cdot 10{,}5 \cdot 12 = 7{,}94\ in^2$$

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

Detalhamento:

Adotado #6 - 0,44 in²

$$N\acute{u}mero\ de\ Barras: \frac{7{,}94}{0{,}442} = \rightarrow 18\ barras \rightarrow s = \frac{10{,}5 \cdot 12}{18} = 7\ in \rightarrow Adotado\ 7\ in\ e\ 19\ barras$$

$$A_{s,efetivo,xy} = 19 \cdot 0{,}442 = 8{,}40\ in^2$$

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	267.40	0.00	31.632"	2.68	2.68	7.94	0.23	7.94
Y	267.40	0.00	30.880"	2.74	2.74	7.94	0.23	7.94

Sentido	Armaduras				
	As_{det} (in^2)	$As_{det/s}$ (in^2/ft)	Nø	Ø (in)	c/ (in)
X	8.44	0.80	19	0.752"	6.299"
Y	8.44	0.80	19	0.752"	6.299"

Comprimento de Ancoragem:

$$\ell_d = \left(\frac{3}{40}\cdot\frac{f_y}{\lambda\cdot\sqrt{f'_c}}\cdot\frac{\psi_t\cdot\psi_e\cdot\psi_s\cdot\psi_g}{\left(\frac{c_b+K_{tr}}{d_b}\right)}\right)\cdot d_b = \left(\frac{3}{40}\cdot\frac{60000}{1\cdot\sqrt{4000}}\cdot\frac{1\cdot1\cdot0{,}8\cdot1}{\left(\frac{3{,}5+0}{0{,}75}\right)}\right)\cdot 0{,}75 = 12{,}2\ in$$

$$\ell_{d,prov} = \frac{10{,}5\cdot12}{2} - 24 - cover = 36\ in \geq 12in \rightarrow OK!!$$

Arranques:

Comprimento dos arranques do pilar:

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

$$\ell_{dc1} = \frac{f_y\cdot\psi_r}{50\cdot\lambda\cdot\sqrt{f'_c}}\cdot d_b = \frac{60000\cdot1}{50\cdot1\cdot\sqrt{4000}}\cdot 1 = 18{,}97\ in$$

$$\ell_{dc2} = 0{,}003\cdot f_y\cdot\psi_r\cdot d_b = 0{,}003\cdot60000\cdot1\cdot1 = 18\ in$$

$$Adotado\ \ell_{dc1} \rightarrow 18{,}97\ in$$

$$\ell_{sc1} = 0{,}0005\cdot f_y\cdot d_b = 0{,}0005\cdot60000\cdot1 = 30\ in$$

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

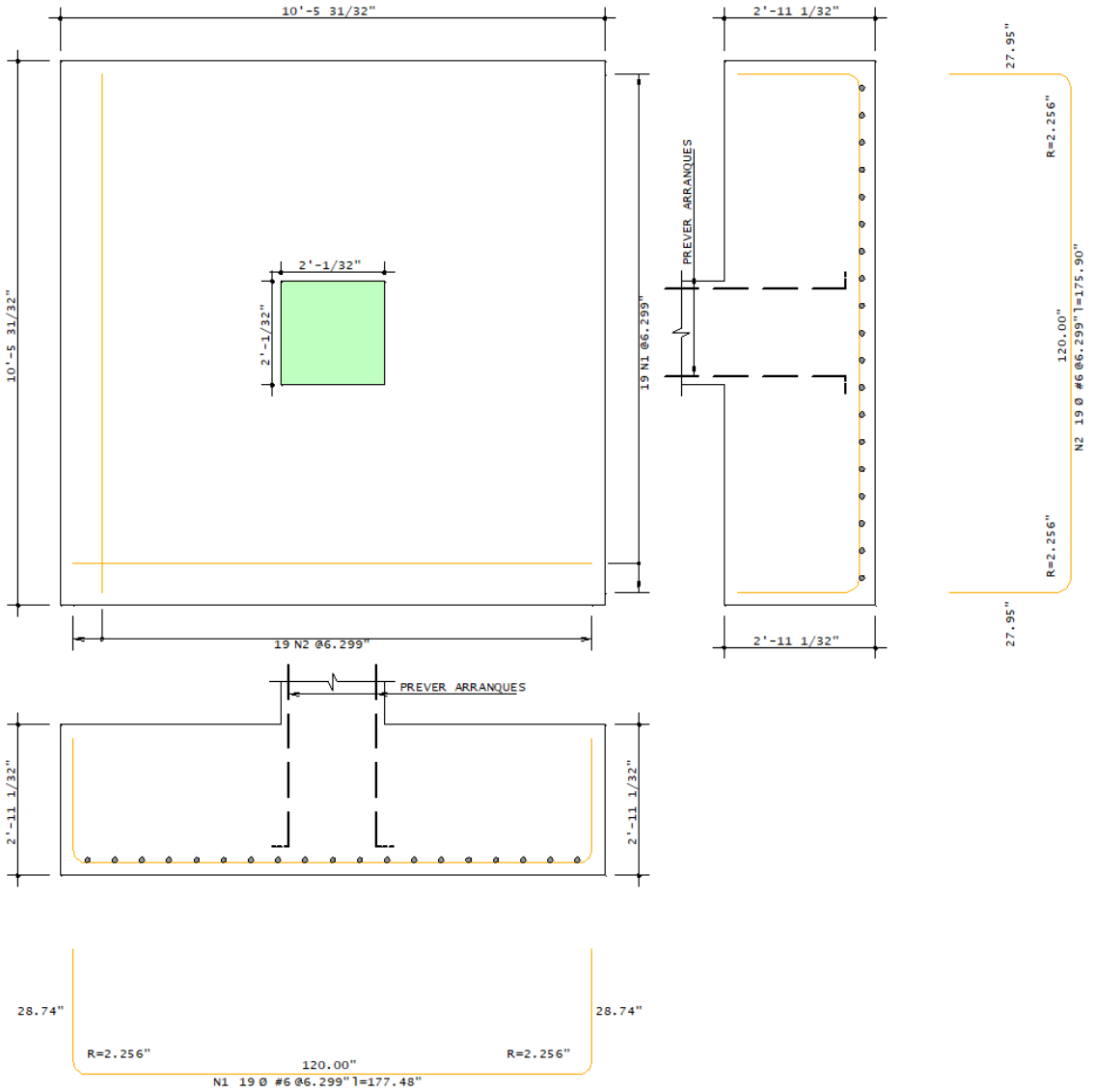
$$Adotado\ \ell_{sc1} \rightarrow 30\ in$$

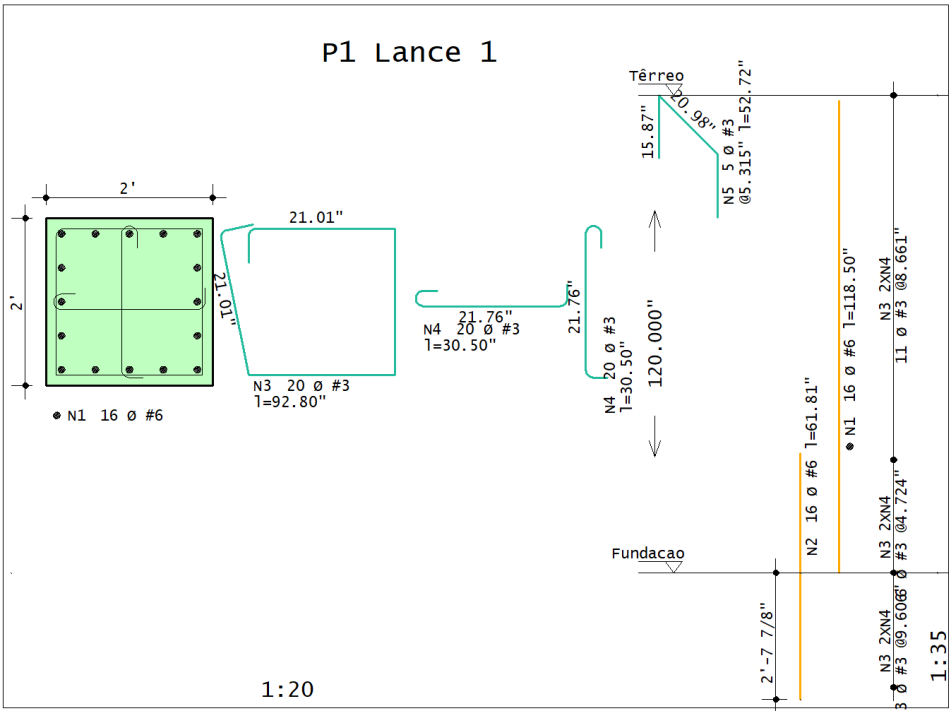
Comprimento total:

$$\ell_{dc1} + \ell_{sc1} = 18 + 30 = 48\ in$$

TQS:

S1
(ESCALA 1:25)





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.