Print Calculation Sheet

PILE CAP DESIGN

US Code (ACI 318-14) - English

Pile Cap 1

PILE ARRANGEMENT

Footing Geometrical Data

Pedestal

Include Pedestal : Yes

Pedestal Shape : Rectangular

Pedestal Height (Ph) : 4.000 ft

Pedestal Length - X (Pl) : 3.000 ft

Pedestal Width - Z (Pw) : 3.000 ft

Pile Cap Geometrical Data

Pile Cap Length $\mathbf{P_{CL}}$: 7.000 ft

Pile Cap Width $\mathbf{P_{CW}}$: 7.000 ft

Initial Pile Cap Thickness $\mathbf{t_I}$: 2.500 ft

Pile Geometrical Data

Pile spacing $\mathbf{P_s}$: 4.000 ft

Pile Edge distance $\mathbf{P_e}$: 1.500 ft

Pile Diameter $\mathbf{P_d}$: 0.896 ft

Pile Capacities

Axial Capacity $\mathbf{P_P}$: 60.000 kip

Lateral Capacity $\mathbf{P_L}$: 40.000 kip

Uplift Capacity $\mathbf{P_U}$: 40.000 kip

Material Properties

Concrete $\mathbf{f'_c}$: 648.000 kip/ft^2

Reinforcement $\mathbf{f_y}$: 8640.000 kip/ft^2

Concrete Cover

Bottom Clear Cover $\mathbf{CC_B}$: 0.250 ft

Side Clear Cover $\mathbf{CC_S}$: 0.250 ft

Pile in Pile Cap $\mathbf{PC_P}$: 0.500 ft

Loading applied at top of cap

For the loads shown in this table, the sign convention is the same as that for JOINT LOADS in STAAD.Pro when global Y is the vertical axis.

Service Level Combinations

Load Combination Number	Load Combination Title	Load Case Multiplier	Self Weight Factor	Code
1	LOAD CASE 1	1.00	1.00	-

Strength Level Combinations

	Load Combination Title			Code

Load Combination Number		Load Case Multiplier	Self Weight Factor	
1	LOAD CASE 1	1.00	1.00	-

Applied Loads - Service Stress Level					
Load Case	F_x (kip)	F_y (kip) Downwards is negative Upwards is positive	F_z (kip)	M_x (kip-ft)	M_z (kip-ft)
1	2.730	-2.170	2.730	70.420	-70.420

Applied Loads - Ultimate Stress Level					
Load Case	F_x (kip)	F_y (kip) Downwards is negative Upwards is positive	F_z (kip)	M_x (kip-ft)	M_z (kip-ft)
1	2.730	-2.170	2.730	70.420	-70.420

PILE CAP DESIGN CALCULATION

Self Weight Calculation

Self Weight : 18.375 kip

Pedestal Weight : 5.400 kip

Soil Weight : 18.200 kip

Extra weight for Surcharge : 0.000 kip

Buoyancy Reduction : 0.000 kip

Maximum Pile Reactions for service load cases

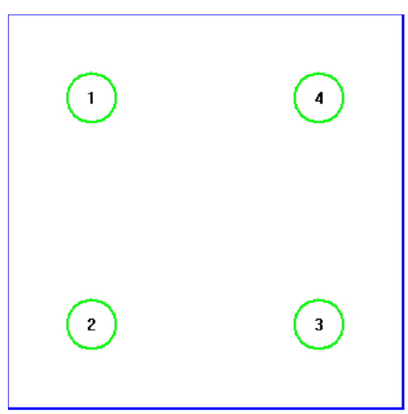
Reaction Type	Load case No.	Pile No.	X Coord. (ft)	Z Coord. (ft)	Reaction (kip)	Allowable (kip)
Axial	1	3	2.000	2.000	-33.077	60.000
Lateral	1	1	-2.000	-2.000	0.965	40.000
Uplift	1	1	-2.000	-2.000	11.005	40.000

Maximum Pile Reactions for Ultimate Load Cases

Governing Load Case : 1

This is the load case for which the pilecap depth required is the maximum. If there are multiple load cases for which the same maximum depth is required, then the load case with the highest axial load (absolute value) is considered as the critical load case.

Total number of piles **N** : 4



Pile No.	Arrangement		Reaction		
	X (ft)	Z (ft)	Axial (kip)	Lateral (kip)	Uplift (kip)
1	-2.000	-2.000	0.000	0.965	11.005
2	-2.000	2.000	-11.036	0.965	0.000
3	2.000	2.000	-33.077	0.965	0.000
4	2.000	-2.000	-11.036	0.965	0.000

Reinforcement Calculation for Pile Cap

Maximum bar size allowed along length :	# 6	
Maximum bar size allowed along width :	# 6	
Bending Moment At Critical Section :	-11.596	kip-ft (About Z-axis)
Bending Moment At Critical Section :	-11.596	kip-ft (About X-axis)
Pile Cap Thickness **t** :	2.500	ft
Selected bar size along length :	# 7	
Selected bar size along width :	# 7	
Selected bar spacing along length :	11.02	in
Selected bar spacing along width :	11.02	in

Pile Cap Thickness Check

Critical Load Case : **1**

Two Way Shear Check For Pile Reactions

Critical Load Case : 1

Note: C_W = Column or Pedestal Width

C_L = Column or Pedestal Length

Pile No.	Pile Reactions Contributing Two-way Shear (kip)
1	2.411
2	-2.417
3	-7.245
4	-2.417

Note: A value of 0.0 in the pile reaction contribution table signifies that the pile is located completely inside the punching shear boundary.

Punching shear force is calculated per CRSI method (Punching Shear = Applied Load + Self Weight - Pile reaction inside punching perimeter)

According to ACI-318-14 Clause No. 8.4.4.2, an additional factor is added to account for the moment effect

Design Shear for Two-Way Action	=	S_t	=	30.225	kip
Beta	=	$\frac{C_L}{C_W}$ *or* $\frac{P_L}{P_W}$	=	1.000	
b_0	=	$2 \times (C_L + C_w + 2 \times d)$ *or* $2 \times (C_L + C_w)$	=	12.000	ft
ACI 318 - 14 Table 22.6.5.2, (b) : V_{C1}	=	$\lambda \times \left(2 + \frac{4}{\beta}\right) \times \sqrt{f'_c} \times b_0 \times d$	=	1173.667	kip
ACI 318 - 14 Table 22.6.5.2, (c) : V_{C2}	=	$\lambda \times b_0 \times d \times \left(2 + \frac{40 \times d}{b_0}\right) \times \sqrt{f'_c}$	=	1491.536	kip
ACI 318 - 14 Table 22.6.5.2, (a) : V_{C3}	=	$4 \times \lambda \times b_0 \times d \times \sqrt{f'_c}$	=	782.445	kip
V_C	=	minimum of (V_{C1}, V_{C2}, V_{C3})	=	782.445	kip

S_t <= 0.75 V_C. hence, safe

Check for One-way Shear in YZ Plane(Shear Line Parallel to Width)

Critical Load Case : 1

Pile No.	Shear Force x_1-x_1(kip)	Shear Force x_2-x_2(kip)
1	0.000	0.000
2	0.000	0.000
3	0.000	0.000
4	0.000	0.000
TOTAL	0.000	0.000

Note: A value of 0.0 in the pile reaction contribution table signifies that the position of the pile with respect to the one-way shear line is such that this pile does not contribute to the shear force. The reason is either the pile is located completely inside the zone bounded by the one-way shear line, or, it is on the other side of the pedestal / column.

Design Shear for One-Way Action (Shear Line Parallel to Width) = S_{OL} = 1.997 kip

Width of Shear Area = b_w = 7.000 ft

$V_C = 2 \times b_w \times d \times \sqrt{f_c^{'}}$ = 223.987 kip

S_{OL} <= 0.75 V_C. Hence, safe

Check for One-way Shear in XY Plane(Shear Line parallel to Length)

Critical Load Case : 1

Pile No.	Shear Force z_1-z_1(kip)	Shear Force z_2-z_2(kip)
1	0.000	0.000
2	0.000	0.000
3	0.000	0.000
4	0.000	0.000
TOTAL	0.000	0.000

Note: A value of 0.0 in the pile reaction contribution table signifies that the position of the pile with respect to the one-way shear line is such that this pile does not contribute to the shear force. The reason is either the pile is located completely inside the zone bounded by the one-way shear line, or, it is on the other side of the pedestal / column.

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$V_C = 2 \times b_w \times d \times \sqrt{f_c^{'}}$ = 223.987 kip

S_{OL} <= 0.75 V_C. Hence, safe

Punching Shear Check for Corner Piles

Pile No.	Shear Force (kip)
1	11.005
2	-11.036
3	-33.077
4	-11.036

Governing reaction (P_C) = maximum of (P_i, P_j,... P_n) = 33.077 kip

Pile Edge distance (P_e) = 1.500 ft

Effective Depth (d) = 1.656 ft

$$d_1 = \frac{P_{cr}}{\lambda \times \emptyset \times 4 \times \sqrt{f_c^{'}} \left[\frac{\pi}{4} \times (P_d + d) + 2\ P_e\right]} \ or \ \frac{P_{cr}}{\lambda \times \emptyset \times 4 \times \sqrt{f_c^{'}} \left[\frac{\pi}{4} \times \ (P_d) + 2\ P_e\right]} = 0.228 \text{ ft}$$

$$d_2 = \frac{R_{cr}}{\lambda \times \Phi \times 2 \times \sqrt{f_c}^{'} \times length\ of\ shear\ line} = \quad = 0.270 \text{ ft}$$

$d_{critical}$ = maximum of (d_1, d_2) = 0.270 ft

d > = $d_{critical}$. Hence, safe.

Calculation of Maximum Bar Size

Along Length (Along global X)

Selected maximum bar size = # 6

Bar diameter corresponding to max bar size (d_b) = 0.750 in

Required development length for bars... = $\frac{d_b \times f_y}{25 \times \lambda \times \sqrt{f_c^{'}}}$ = 2.236 ft

Along Width (Along global Z)

Selected maximum bar size = # 6

Bar diameter corresponding to max bar size (d_b) = 0.750 in

Required development length for bars = $\frac{d_b \times f_y}{25 \times \lambda \times \sqrt{f_c^{'}}}$ = 2.236 ft

Selection of Reinforcement

Along Length (Along global X)

Critical Load Case : 1

Moments in pilecap due to individual pile reactions alone

Pile No.	Moment about x_1-x_1(kip-ft)	Moment about x_2-x_2(kip-ft)
1	5.503	0.000
2	-5.518	0.000
3	0.000	-16.539
4	0.000	-5.518

Governing moment (M_{tl})after deducting the moments due to selfweight and surcharge = $\frac{max(M_{t1},\ M_{t2})}{0.9}$ = -11.596 kip-ft

dBeta = $\begin{cases} 0.85, & f_c' \leq 4000psi \\ \max\left[0.65, 0.85 - \frac{0.05}{1000}(f_c' - 4000psi)\right], & f_c' > 4000psi \end{cases}$ = 0.650

Maximum Reinforcement Ratio (R_{max}) = $\frac{0.85 \times 87000 \times dbeta \times f_c^{'}}{1.33 \times f_y \times (87000 + f_y)}$ = 0.0184

Minimum Reinforcement Ratio (R_{min}) = 0.0018

Calculated Reinforcement Ratio (R) = 0.0024

Note - Calculated Reinforcement Ratio reported here is the larger value between the Calculated Reinforcement Ratio and minimum steel ratio required as per code stipulations

R_{min}<= R <= R_{max}, R is accepted.

Minimum spacing allowed (S_{min}) = 1.5 x d_b = 2 in

Selected Bar Size = # 7

Provided Number of Bars = 8

Provided spacing (S) = 11.02 in

S_{min}<= S <= 18 inch and selected bar size < selected maximum bar size. The reinforcement is accepted.

Along Width (Along global Z)

Critical Load Case : 1

Moments in pilecap due to individual pile reactions alone

Pile No.	Moment about z_1-z_1(kip-ft)	Moment about z_2-z_2(kip-ft)
1	5.503	0.000
2	0.000	-5.518
3	0.000	-16.539
4	-5.518	0.000

Governing moment (M_{tl})after deducting the moments due to selfweight and surcharge = $\frac{max(M_{t1},\ M_{t2})}{0.9}$ = -11.596 kip-ft

dBeta = $\begin{cases} 0.85, & f_c' \le 4000psi \\ \max\left[0.65, 0.85 - \frac{0.05}{1000}(f_c' - 4000psi)\right], & f_c' > 4000psi \end{cases}$ = 0.650

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Minimum spacing allowed (S_{min}) = 1.5 x d_b = 2 in

Selected Bar Size = # 7

Provided Number of Bars = 8

Provided spacing (S) = 11.02 in

S_{min}<= S <= 18 inch and selected bar size < selected maximum bar size. The reinforcement is accepted.

Pedestal Design

Pedestal at Support No.	Axial Capacity Ratio, Critical Load Case, Location	Flexural Capacity Ratio	% of Main Steel	Main Reinforcement	Links
1	0.004, 1, Bottom	0.122	1.020	4-#7 + 24-#6	#3 @ 11.81inches

Pedestal Size

Pedestal Shape = Rectangular

Dimension Along Global X = 36.000 inches

Dimension Along Global Z = 36.000 inches

Longitudinal Reinforcement Details

Area of Longitudinal Bars = 13.058 sq.inches

Number of Bars and Bar Dia = 4-#7 + 24-#6

Longitudinal Steel Percentage = 1.020

Bar arrangement sequence on each side along Global X = 1 # 7 + 6 # 6 + 1 # 7

Bar arrangement sequence on each side along Global Z = 1 # 7 + 6 # 6 + 1 # 7

Flexure - Governing Load Case Details

Governing Load Case Number = 1

Critical Location = Bottom

Axial load = 10.945 kip

Moment about X axis = 88.164 kip-ft

Moment about Z axis = -88.164 kip-ft

Resultant moment = 124.682 kip-ft

Moment Capacity = 1020.574 kip-ft

= 45.000 degrees

Angle of inclination of Neutral Axis
with respect to local Z

Serial No.	P (kip)	M (kip-ft)	Strength Reduction Factor (Φ)
1	-705.157	0.000	0.900
2	-704.624	1.115	0.900
3	-674.402	58.696	0.900
4	-572.998	237.294	0.900
5	-425.175	471.829	0.900
6	-242.171	724.821	0.900
7	-37.166	971.858	0.900
8	210.645	1226.399	0.900
9	488.590	1454.082	0.899
10	607.423	1483.554	0.855
11	715.102	1498.596	0.816
12	835.102	1515.063	0.782
13	946.128	1519.022	0.751
14	1047.966	1510.771	0.724
15	1164.662	1499.704	0.699
16	1274.479	1477.966	0.677
17	1375.914	1445.803	0.657
18	1518.815	1432.450	0.650
19	1673.581	1424.005	0.650
20	1818.268	1405.673	0.650
21	1970.803	1376.411	0.650
22	2110.095	1338.857	0.650
23	2235.042	1295.744	0.650
24	2365.859	1241.525	0.650
25	2484.864	1182.883	0.650
26	2590.844	1122.695	0.650
27	2701.170	1051.857	0.650
28	2888.066	909.693	0.650
29	3059.070	753.177	0.650
30	3200.216	602.760	0.650
31	3315.689	463.658	0.650
32	3412.832	331.891	0.650
33	3482.460	229.249	0.650
34	3529.263	157.462	0.650
35	3555.494	119.548	0.650
36	3575.310	102.231	0.650
37	3591.994	87.730	0.650
38	3605.505	74.911	0.650
39	3617.241	63.672	0.650
40	3626.483	53.756	0.650
41	3634.579	44.941	0.650
42	3641.096	37.246	0.650
43	3646.872	30.344	0.650
44	3655.503	19.129	0.650
45	3661.388	10.792	0.650
46	3665.160	4.986	0.650
47	3667.272	1.464	0.650
48	3668.056	0.041	0.650
49	3668.058	0.000	0.650

Shear - Governing Load Case Details

Critical Load Case for Shear Along X = 1

Critical Load Case for Shear Along Z = 1

Shear force along X = 2.730 kip

Shear force along Z = 2.730 kip

Transverse Stirrups Details

Rebar Links = #3 @ 11.81 inches

No. of Legs in X direction = 8

No. of Legs in Z direction = 8

Material Take Off

Footing Reinforcement

Direction	Size	Number	Total Length (ft)	Weight (lb)
Along X on Bottom	#7	8	52.00	106.29
Along Z on Bottom	#7	8	52.00	106.29
Along X on Top	N/A	N/A	N/A	N/A
Along Z on Top	N/A	N/A	N/A	N/A

Pedestal Reinforcement

Type	Size	Number	Total Bar Length (ft)	Weight (lb)
Main Steel 1 (Vertical)	#6	24	156.00	234.31
Main Steel 2 (Vertical)	#7	4	29.13	59.53
Transverse Steel (Ties)	#3	6	67.00	25.19
Internal Steel (Ties)	#3	72	228.00	85.73

Total Reinforcement Weight : 617.34 lb

Concrete

-	Length (ft)	Width (ft)	Thickness (ft)	Volume (ft^3)
Footing	7.00	7.00	2.50	122.50
Pedestal	3.00	3.00	4.00	36.00

Total Concrete Volume : 158.50 ft^3

Formwork

Footing : 70.00 ft^2
Pedestal : 48.00 ft^2
Total : 118.00 ft^2

Soil Excavation

Pit Depth : 6.00 ft
Pit Slope (a : b) : 1 : 1 (Assumed)
Side Distance, s : 0 (Assumed)
Excavation Volume : 1086.00 ft^3
Backfill Volume : 932.00 ft^3