PILE CAP DESIGN

British code(BS 8110-97)

Pile Cap 0

PILE ARRANGEMENT

Pedestal

Include Pedestal	:	Yes	
Pedestal Shape	:	Rectangular	
Pedestal Height (Ph)	:	1.200	m
Pedestal Length - X (Pl)	:	0.450	m
Pedestal Width - Z (Pw)	:	0.450	m

Pile Cap Geometrical Data

Pile Cap Length P_{CL}	:	4.232	m
Pile Cap Width P_{CW}	:	4.232	m
Initial Pile Cap Thickness t_I	:	1.300	m

Pile Geometrical Data

Pile spacing P_s	:	2.250	m
Pile Edge distance **e**	:	0.525	m
Pile Diameter d_p	:	0.750	m

Pile Capacities

Axial Capacity P_P	:	900.000	kN
Lateral Capacity P_L	:	100.000	kN
Uplift Capacity P_U	:	100.000	kN

Material Properties

Concrete f'_c	:	30000.005	kN/m^2
Reinforcement f_y	:	460000.077	kN/m^2

Concrete Cover

Bottom Clear Cover CC_B	:	0.075	m
Side Clear Cover CC_S	:	0.100	m
Pile in Pile Cap PC_P	:	0.100	m

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.

Load Case	F_x (kN)	F_y (kN) Downwards is negative Upwards is positive	F_z (kN)	M_x (kNm)	M_z (kNm)
101	0.000	-3500.000	0.000	0.000	0.000
201	0.000	-3500.000	0.000	0.000	0.000

Pile Cap size (in investigated direction) **H**	:	4.232	m
Pile Cap size (in investigated perpendicular direction) **B**	:	4.232	m

PILE CAP DESIGN CALCULATION

Self Weight Calculation

Self Weight : 581.911 kN

Pedestal Weight : 6.075 kN

Soil Weight : 0.000 kN

Extra weight for Surcharge : 0.000 kN

Buoyancy Reduction : 0.000 kN

Pile Reactions for ultimate load cases

Total number of piles **N** = 5

Critical Load Case : **201**

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.

	Arrangement		Reaction		
Pile No.	X (m)	Y (m)	Axial (kN)	Lateral (kN)	Uplift (kN)
1	-1.591	-1.591	-817.597	0.000	0.000
2	-1.591	1.591	-817.597	0.000	0.000
3	0.000	0.000	-817.597	0.000	0.000
4	1.591	-1.591	-817.597	0.000	0.000
5	1.591	1.591	-817.597	0.000	0.000

Reinforcement Calculation for Pile Cap

Maximum bar size allowed along length : # 32 mm

Maximum bar size allowed along width : # 32

Bending Moment At Critical Section : -1994.908 kNm (About Z-axis)

Bending Moment At Critical Section : -1994.908 kNm (About X-axis)

Pile Cap Thickness **t** : 1.300 m

Selected bar size along length : # 16

Selected bar size along width : # 16

Selected bar spacing along length : 110.00 mm

Selected bar spacing along width : 110.00 mm

Pile Cap Thickness Check

Calculated Thickness (t) = 1.300m

Check for Moment (Along Length)

Critical load case for thickness is reported only when required thickness is more than the given minimum thickness

Critical Load Case : 201

Pile No.	Moment along x_1-x_1(kNm)	Moment along x_2-x_2(kNm)
1	-1116.797	0.000
2	-1116.797	0.000
3	-7.120	-7.120
4	0.000	-1116.797
5	0.000	-1116.797

Effective Depth = $h_{cap} - (P_{id} + cc + 1.5 \times d_b)$ = 1.077 m

Governing moment (M_u) = = -1994.908 kNm

K = $\frac{M_u}{B \times d^2 \times f_{cu}}$ = 0.014

K <= 0.156. hence, safe

Check for Moment (Along Width)

Critical load case for thickness is reported only when required thickness is more than the given minimum thickness

Critical Load Case : 201

Pile No.	Moment along y_1-y_1(kNm)	Moment along y_2-y_2(kNm)
1	-1116.797	0.000
2	0.000	-1116.797
3	-7.120	-7.120
4	-1116.797	0.000
5	0.000	-1116.797

Effective Depth = $h_{cap} - (P_{id} + cc + 1.5 \times d_b)$ = 1.077 m

Governing moment (M_u) = = -1994.908 kNm

K = $\frac{M_u}{B \times d^2 \times f_{cu}}$ = 0.014

K <= 0.156. Hence, safe

Check for One Way Shear (Along Length)

Pile No.	Shear Force x_1-x_1(kN)	Shear Force x_2-x_2(kN)
1	-765.574	0.000
2	-765.574	0.000
3	0.000	0.000
4	0.000	-765.574
5	0.000	-765.574
TOTAL	-1531.149	-1531.149

Design Shear Force for One-Way Action = V_u = -1419.235 kN

Design Shear Stress for One-Way Action V = $\frac{V_u}{B \times d}$ = -311.418 kN/m^2 BS 8110-1997 Eqn 3

Allowable Shear Stress for One-Way Action VC1 = $min\left[0.8\sqrt{f_{cu}}, 5\right]$ = 4381.781 kN/m^2 BS 8110-1997 sec 3.4.5.2

We Observe V < V_{c1}

Shear strength considering enhanced shear

Vide Table 3.8 note 2 , the values of parameters

V1 = $min\left[\frac{100\ A_{s,reqd}}{BD}, 3\right]$ = 0.159 BS 8110-1997 Table 3.8

V2 = $max\left[\frac{400}{d}, 1\right]$ = 1.000 BS 8110-1997 Table 3.8

V3 = $min\left(\frac{f_{cu}\ ,\ 40}{25}\right)^{\frac{1}{3}}$ = 1.200 BS 8110-1997 Table 3.8

Design concrete shear stress: V_c = $\frac{0.79 \times (v_1)^{\frac{1}{3}} \times (v_2)^{\frac{1}{4}} \times (v_3)}{1.25}$ = 363.727 kN/m^2 BS 8110-1997 Table 3.8

Length Traversed by shear failure plane :av_x = $|X_{min}| - 0.3 \times d_p - \frac{b}{2}$ = 1.141 m BS 8110-1997 Table 3.8

As av_x <= 2.0xEffective Depth (d)

Enhanced Shear Strength V_{ce} = $2.0 \times d \times \frac{V_c}{A_v}$ = 686.665 kN/m^2

We Observe V < V_{ce} hence safe

Pile Spacing (P_s) <= 3x Effective Depth (d_p)

V <= V_{ce} hence Safe

Check for One Way Shear (Along Width)

Pile No.	Shear Force y_1-y_1(kN)	Shear Force y_2-y_2(kN)
1	-765.574	0.000
2	0.000	-765.574
3	0.000	0.000
4	-765.574	0.000
5	0.000	-765.574
TOTAL	-1531.149	-1531.149

Design Shear Force for One-Way Action = V_u = -1419.235 kN

Design Shear Stress for One-Way Action V = $\frac{V_u}{B \times d}$ = -311.418 kN/m^2 BS 8110-1997 Eqn 3

Allowable Shear Stress for One-Way Action VC1 = $min\left[0.8\sqrt{f_{cu}}, 5\right]$ = 4381.781 kN/m^2 BS 8110-1997 Eqn 3.4.5.2

We Observe V < V_{c1}

Shear strength considering enhanced shear

Vide Table 3.8 note 2 , the values of parameters

V1 = $min\left[\frac{100\ A_{s,reqd}}{BD}, 3\right]$ = 0.159

V2 = $max\left[\frac{400}{d}, 1\right]$ = 1.000 BS 8110-1997 Table 3.8

V3 = $min\left(\frac{f_{cu}\ ,\ 40}{25}\right)^{\frac{1}{3}}$ = 1.200

Design concrete shear stress: V_c = $\frac{0.79 \times \left(v_1\right)^{\frac{1}{3}} \times \left(v_2\right)^{\frac{1}{4}} \times \left(v_3\right)}{1.25}$ = 363.727 kN/m^2 BS 8110-1997 Table 3.8

Length Traversed by shear failure plane :av_z = $|Z_{min}| - 0.3 \times d_p - \frac{b}{2}$ = 1.141 m

As av_z <= 1.5xEffective Depth(d)

Enhanced Shear Force V_{ce} = $2.0 \times d \times \frac{V_c}{A_v}$ = 686.665 kN/m^2

We Observe V < V_{ce} hence safe

P_s <= $3d_p$

V <= V_{ce}. hence Safe

Check for One Way Shear

Pile No.	Shear Force x_1-x_1(kN)	Shear Force x_2-x_2(kN)
1	-765.574	0.000
2	-765.574	0.000
3	0.000	0.000
4	0.000	-765.574
5	0.000	-765.574
TOTAL	-1531.149	-1531.149

Design Shear for One-Way Action = S_{OL} = -1419.235 kN

V = = -311.418 kN/m^2

$$\frac{V_u}{B \times d}$$

VC1 = $min\left[0.8\sqrt{f_{cu}}, 5\right]$ = 4381.781 kN/m^2

We Observe V < V_{c1}

V1 = $min\left[\frac{100\ A_{s,reqd}}{BD}, 3\right]$ = 0.159 BS 8110-1997 Table 3.8

V2 = $max\left[\frac{400}{d}, 1\right]$ = 1.000 BS 8110-1997 Table 3.8

V3 = $min\left(\frac{f_{cu}\ ,\ 40}{25}\right)^{\frac{1}{3}}$ = 1.200 BS 8110-1997 Table 3.8

V_c = $\frac{0.79 \times (v_1)^{\frac{1}{3}} \times (v_2)^{\frac{1}{4}} \times (v_3)}{1.25}$ = 363.727 kN/m^2 BS 8110-1997 Table 3.8

av_x = $|X_{min}| - 0.3 \times d_p - \frac{b}{2}$ = 1.141 m

As av_x < 1.5d

V_{ce} = $2.0 \times d \times \frac{V_c}{A_v}$ = 686.665 kN/m^2

P_s <= $3d_p$ and V <= V_{ce} hence Safe

Check for Two Way Shear (Along Length)

Pile No.	Two-way Shear at column face (kN)	Two-way Shear at critical distance (kN)
1	-817.597	-817.597
2	-817.597	-817.597
3	0.000	0.000
4	-817.597	-817.597
5	-817.597	-817.597
TOTAL	-3130.744	-2701.984

Design Shear Force for Two-Way Action at column face V_u = -3130.744 kN

Design Shear Force for Two-Way Action at critical dist V_{u1} = -2701.984 kN

Design Shear Stress for Two-Way Action at critical dist V_{max} = $\frac{V_u}{2 \times (b+h) \times d}$ = -1383.504 kN/m^2

Allowable Shear Stress for Two-Way Action at critical dist = $min\left[0.8\sqrt{f_{cu}}, 5\right]$ = 4381.781 kN/m^2

Pile Spacing p_s = = 2250.000 m

Pile Diameter d_p = = 750.000 m

Here P_s <= $3d_p$

We observe V_{max} <= V_{C1} hence safe

Beta=0.5, Deformed Bar:Type 2

Calculation of Maximum Bar Size

Along Length

Bar diameter corresponding to max bar size (d_b) = 32.000 mm Beta=0.5, Deformed Bar:Type 2

Development Length(l_d) = $\frac{0.87 \times d_b \times f_y}{4 \times \beta \times \sqrt{f_c'}} =$ = 1.461 m

Allowable Length(l_{db}) = $0.5 \times (B - b) - C_s$ = 1.791 m

l_{db} >l_dHence, safe

Along Width

Bar diameter corresponding to max bar size(d_b) = 32.000 mm

Development Length(l_d) = $0.5 \times (B - b) - C_s$ = 1.461 m

Allowable Length(l_{db}) = $0.5 \times (H - h) - C_s$ = 1.791 m

$l_{db} > l_d$. Hence, safe

Selection of Bottom and Top Reinforcement

Top reinforcement is provided same as bottom reinforcement

Along Length

Critical Load Case : 201

Minimum Area of Steel(A_{stmin}) = 7151.235 mm2

Calculated Area of Steel(A_{st}) = 7151.235 mm2

Area of steel provided($A_{stprovided}$) = 7151.235 mm2

A_{stmin}<= $A_{stprovided}$, Steel area is accepted.

Minimum spacing allowed (S_{min}) 40 + d_b = 56.00 mm

Bar type selected = # 16

Selected spacing (S) = 110.00 mm

S_{min}<= S <= 450 mm and selected bar size < selected maximum bar size. The reinforcement is accepted.

S_{min}<= S <= 450 mm and selected bar size < selected maximum bar size. The reinforcement is accepted.

Along Width

Critical Load Case : 201

Minimum Area of Steel (A_{stmin}) = 7151.235 mm2

Calculated Area of Steel (A_{st}) = 7151.235 mm2

Area of steel provided ($A_{stprovided}$) = 7151.235 mm2

A_{stmin}<= A_{st}, Steel area is accepted.

Minimum spacing allowed (S_{min}) 40 + d_b = 56.00 mm

Bar type selected = # 16

Selected spacing (S) = 114.73 mm

S_{min}<= S <= 450 mm and selected bar size < selected maximum bar size. The reinforcement is accepted.

S_{min}<= S <= 450 mm and selected bar size < selected maximum bar size. The reinforcement is accepted.

Print Calculation Sheet