Print Calculation Sheet

Pile Cap 1

(IS-456:2000, Including Amendment 1)
PILE ARRANGEMENT

Column Dimensions

Column Shape : Rectangular

Column Length - X (Pl) : 0.250 m

Column Width - Z (Pw) : 0.250 m

Pedestal

Include Pedestal : No

Pedestal Shape : N/A

Pile Cap Geometrical Data

Pile Cap Length P_{CL} : 1.900 m

Pile Cap Width P_{CW} : 1.900 m

Initial Pile Cap Thickness t_I : 0.780 m

Pile Geometrical Data

Pile spacing P_s : 1.200 m

Pile Edge distance **e** : 0.350 m

Pile Diameter d_p : 0.400 m

Pile Capacities

Axial Capacity P_P : 250.000 kN

Lateral Capacity P_L : 100.000 kN

Uplift Capacity P_U : 80.000 kN

Material Properties

Concrete f_{ck} : 25000.004 kN/m^2

Reinforcement f_y : 415000.070 kN/m^2

Concrete Cover

Bottom Clear Cover CC_B : 0.050 m

Side Clear Cover CC_S : 0.050 m

Pile in Pile Cap PC_P : 0.050 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.

Applied Loads - Service Stress Level						
Load Case	F_x (kN)	F_y (kN) Downwards is negative Upwards is positive	F_z (kN)	M_x (kNm)	M_z (kNm)	Code
101	0.000	-500.000	0.000	0.000	0.000	-

Applied Loads - Strength Level						
Load Case	F_x (kN)	F_y (kN) Downwards is negative Upwards is positive	F_z (kN)	M_x (kNm)	M_z (kNm)	Code
102	0.000	-750.000	0.000	0.000	0.000	-

Pile Cap size (in investigated direction) **H** : 1.900 m

Pile Cap size (in investigated perpendicular direction) **B** : 1.900 m

PILE CAP DESIGN CALCULATION

Self Weight Calculation

Self Weight : 70.393 kN

Pedestal Weight : 0.000 kN

Soil Weight : 0.000 kN

Extra weight for Surcharge : 0.000 kN

Buoyancy Reduction : 0.000 kN

Maximum Pile Reactions For Service Load Cases

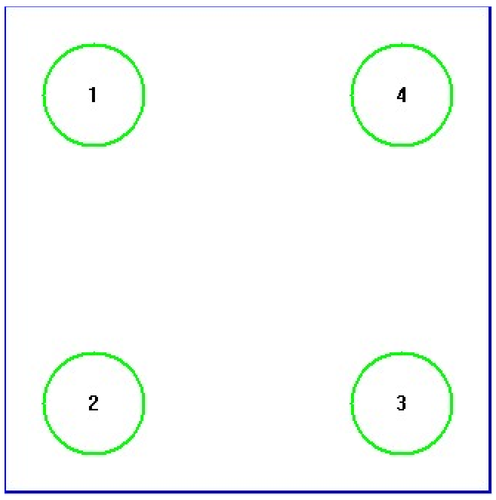
Reaction Type	Load case No.	Pile No.	X Coord. (m)	Z Coord. (m)	Reaction (kN)	Allowable (kN)	Capacity Chk
Axial	101	1	-0.600	-0.600	-142.598	250.000	Pass
Lateral	N/A	N/A	N/A	N/A	0.000	100.000	Pass
Uplift	N/A	N/A	N/A	N/A	0.000	80.000	Pass

Maximum Pile Reactions For Ultimate Load Cases

Total number of piles **N** = 4

Critical Load Case = 102

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.



Pile No.	Arrangement		Reaction		
	X (m)	Z (m)	Axial (kN)	Lateral (kN)	Uplift (kN)
1	-0.600	-0.600	-205.098	0.000	0.000
2	-0.600	0.600	-205.098	0.000	0.000
3	0.600	0.600	-205.098	0.000	0.000
4	0.600	-0.600	-205.098	0.000	0.000

Reinforcement Calculation for Pile Cap

Maximum bar size allowed along length : Ø16

Maximum bar size allowed along width : Ø16

Bending Moment At Critical Section : -182.232 kNm (About Z-axis)

Bending Moment At Critical Section : -182.232 kNm (About X-axis)

Pile Cap Thickness **t** : 0.780 m

Selected bar size along length : Ø12

Selected bar size along width : Ø12

Selected bar spacing along length : 115.00 mm

Selected bar spacing along width : 115.00 mm

Pile Cap Thickness Check

Calculated Thickness (t) : 0.780 m

Check for Moment (About Z-axis)

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

Critical Load Case : 102

Moments in pilecap due to individual pile reactions alone

Pile No.	Moment about x_1-x_1(kNm)	Moment about x_2-x_2(kNm)
1	-97.420	0.000
2	-97.420	0.000
3	0.000	-97.420
4	0.000	-97.420

x1-x1 and x2-x2 are two sections parallel to the YZ plane on either side of the pedestal

Governing moment (M_u)after deducting the moments due to selfweight and surcharge = -182.232 kNm

Effective Depth(d) = $h_{cap} - (P_{id} + cc + 1.5 \times d_b)$ = 0.662 m

Depth of neutral axis for balanced section(x_u) = $\frac{700 \times d}{1100 + 0.87 f_y}$ = 0.317 m

As Per IS 456 2000 ANNEX G,G-1.1 C

Ultimate moment of resistance (M_{ulim}) = $0.36 \times f_{ck} \times b \times X_u \times (d - 0.416 \times X_u)$ = 2874.765 kNm

We observed M_u <= M_{ulim} hence singly reinforced and under reinforced section can be used.

Check for Moment (About X-axis)

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

Critical Load Case : 102

Moments in pilecap due to individual pile reactions alone

Pile No.	Moment about z_1-z_1(kNm)	Moment about z_2-z_2(kNm)
1	-97.420	0.000
2	0.000	-97.420
3	0.000	-97.420
4	-97.420	0.000

z1-z1 and z2-z2 are two sections on either side of the pedestal in the XY plane

Governing moment (M_u)after deducting the moments due to selfweight and surcharge = -182.232 kNm

We assume singly reinforced and under reinforced section

Effective Depth(d) = $h_{cap} - (P_{id} + cc + 1.5 \times d_b)$ = 0.662 m

Depth of neutral axis for balanced section(x_u) = $\frac{700 \times d}{1100 + 0.87 f_y}$ = 0.317 m

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We observed M_u <= M_{ulim} hence singly reinforced and under reinforced section can be used.

Check for One Way Shear (In YZ Plane)

(As per Clause No. 34.2.4.1(a), Amendment 1, shear at deff/2 distance from column face)

Critical Load Case = 102

Pile No.	Shear Force x_1-x_1(kN)	Shear Force x_2-x_2(kN)
1	-187.645	0.000
2	-187.645	0.000
3	0.000	-187.645
4	0.000	-187.645
TOTAL	-375.291	-375.291

x1-x1 and x2-x2 are two sections parallel to the YZ plane on either side of the pedestal

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 Force for One-Way Action = V_u = -356.989 kN

As Per IS 456 2000 ANNEX B,B-5.1 and Clause No 34.2.4.2

Design Shear Stress (T_v) = $\frac{V_u}{B \times d}$ = -283.820 kN/m^2

Allowable Shear Stress (T_c) = min (SEF x Tc1, Tc max) = 2666.388 kN/m^2

Where T_{c1} = $\frac{0.85 \times \sqrt{0.8 \times f_{ck}}}{6 \times \beta} \times \left(\sqrt{1 + 5 \times \beta} - 1\right)$ = 290.000 kN/m^2

$T_{c\,max}$ as per Table 20 = 3100.000 kN/m^2

Shear Enhancement Factor(SEF) as per IS 456 2000 Clause 40.5.1, Fig 24 = 9.194

Note- If the shear enhancement Factor is not considered from Global Setting option, then this SEF would be considered as 1

Where Beta = $max\left[\frac{0.8 \times f_{ck}}{6.89 \times p_t}, 1\right]$ = 20.177

and percentage of steel required (p_t) = $\frac{100\ A_{st}}{B \times d}$ = 0.144

Here T_v <= T_c Hence, safe.

Check for One Way Shear (In XY Plane)

(As perClause No. 34.2.4.1(a), Amendment 1, shear at deff/2 distance from column face)

Critical Load Case = 102

Pile No.	Shear Force z_1-z_1(kN)	Shear Force z_2-z_2(kN)
1	-187.645	0.000
2	0.000	-187.645
3	0.000	-187.645
4	-187.645	0.000
TOTAL	-375.291	-375.291

z1-z1 and z2-z2 are two section on either side of the pedestal in the XY plane

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 force (V_u) = -356.989 kN

As Per IS 456 2000 ANNEX B,B-5.1 and Clause No 34.2.4.2

Design Shear Stress (T_v) = $\frac{V_u}{B \times d}$ = -283.820 kN/m^2

Allowable Shear Stress (T_c) = min (SEF x Tc1, Tc max) = 2666.388 kN/m^2

Where T_{c1} = $\frac{0.85 \times \sqrt{0.8 \times f_{ck}}}{6 \times \beta} \times \left(\sqrt{1+5 \times \beta} - 1\right)$ = 290.000 kN/m^2

T_{cmax} as per Table 20 = $\frac{0.85 \times \sqrt{0.8 \times f_{ck}}}{6 \times \beta} \times \left(\sqrt{1+5 \times \beta} - 1\right)$ = 3100.000 kN/m^2

Shear Enhancement Factor(SEF) as per IS 456 2000 Clause 40.5.1, Fig 24 = 9.194

Note- If the shear enhancement Factor is not considered from Global Setting option, then this SEF would be considered as 1

Where Beta = $max\left[\frac{0.8 \times f_{ck}}{6.89 \times p_t}, 1\right]$ = 20.177

and percentage of steel required (p_t) = $\frac{100\ A_{st}}{B \times d}$ = 0.144

Here T_v <= T_c Hence, safe.

Check for Two Way Shear

Critical Load Case = 102

Pile No.	Two-way Shear at column face (kN)
1	-202.834
2	-202.834
3	-202.834
4	-202.834

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

Design Two-Way Shear force = -757.448 kN

As Per IS 456 2000 Clause 31.6.2.1

Two Way Shear Stress(T_v) = $\frac{V_t}{b_0 \times d}$ = -308.797 kN/m^2

Where,perimeter of critical section(b_0) = $2 \times (b + h + 2 \times d)$ **or** $2 \times (b + h)$ = 3.672 m

As Per IS 456 2000 Clause 31.6.3.1

Allowable shear stress = $K_s \times T_c$ = 1250.000 kN/m^2

Where,k_s = $min\left[(0.5 + \beta_c),\ 1\right]$ = 1.000

Ratio of shorter to longer dimension(β_c) = = 1.000

and,T_c = $0.25 \times \sqrt{f_{ck}}$ = 1250.000 kN/m^2

T_v < K_sT_c Hence, Safe.

Punching Shear Check for Corner Piles

Pile No.	Shear Force (kN)
1	-205.098
2	-205.098

Pile No.	Shear Force (kN)
3	-205.098
4	-205.098

Governing reaction (P_{Cr}) = maximum of (P_i, P_j,... P_n) = 205.098kN

Pile Edge distance (P_e) = 0.350m

$d_{critical}$ = $\frac{P_{cr}}{min[\{T_{c\,punch}\theta.(P_d + d) + 2p_e\}, \{T_{c\,shear}.\, length\ of\ Shear\ line\}]}$ = 0.186m

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

Calculation of Maximum Bar Size

Along Length

Selected maximum bar size = Ø 16 mm

Bar diameter corresponding to max bar size(d_b) = 16.000 mm

As Per IS 456 2000 Clause No 26.2.1

Development Length(l_d) = $\frac{0.87 \times d_b \times f_y}{4 \times \tau_{bd}}$ = 0.645 m

Available Development Length(l_{db}) = $0.5 \times (B - b) - C_s$ = 0.775 m

l_{db} >l_d. Hence, safe.

Along Width

Selected maximum bar size = 16 mm

Bar diameter corresponding to max bar size(d_b) = 16.000 mm

As Per IS 456 2000 Clause No 26.2.1

Development Length(l_d) = $\frac{0.87 \times d_b \times f_y}{4 \times \tau_{bd}}$ = 0.645 m

Available Development Length(l_{db}) = $0.5 \times (H - h) - C_s$ = 0.775 m

l_{db} >l_d. Hence, safe.

Selection of Reinforcement

Along Length

Critical Load Case : 102

As Per IS 456 2000 Clause 26.5.2.1

Note - "Area of Steel required" reported here is the larger value between the calculated area of steel and minimum steel required as per code stipulation

Minimum Area of Steel (A_{stmin}) = $0.12\% \times B \times h_{cap}$ = 1778.400 mm2

As Per IS 456 2000 ANNEX G,G-1.1 b

Area of steel required (A_{sq}) = $0.5 \times \left(\frac{f_{ck}}{f_y}\right) \times \left(1 - \sqrt{1 - \frac{4.5977 \times M_u}{f_{ck} \times b \times d^2}}\right) \times b \times d$ = 1778.400 mm2

Area of steel provided (A_{st}) = 1809.558 mm2

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

Minimum spacing allowed (S_{min}) = 40 + d_b = 52 mm

Selected Bar Size = 12 mm

Selected spacing (S) = 115.00 mm

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

Along Width

Critical Load Case : 102

As Per IS 456 2000 Clause 26.5.2.1

Note - "Area of Steel required" reported here is the larger value between the calculated area of steel and minimum steel required as per code stipulation

Minimum Area of Steel (A_{stmin}) = $0.12\% \times B \times h_{cap}$ = 1778.400 mm2

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