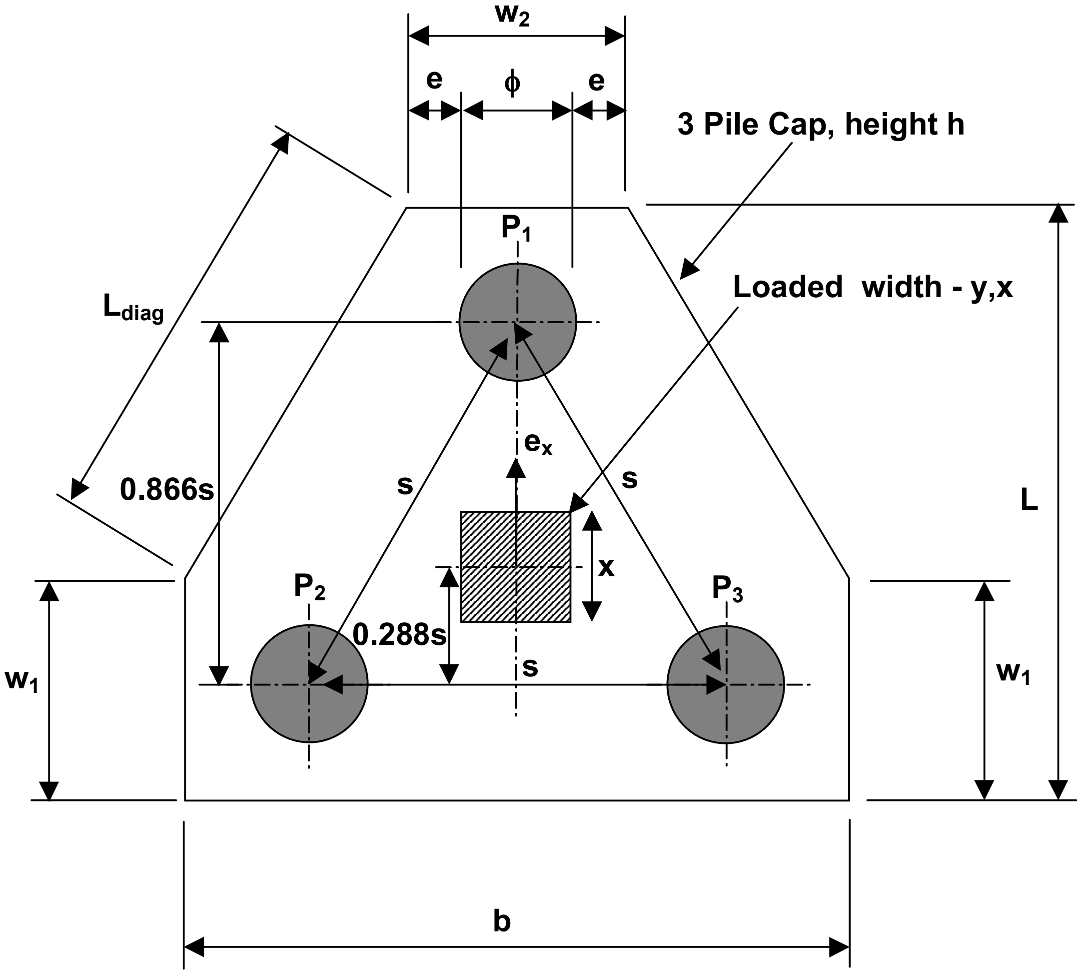
RC PILE CAP DESIGN (BS8110:PART1:1997)



Pile Cap Design – Truss Method

Design Input - 3 Piles - No Eccentricity

Number of piles;	N = 3
ULS axial load;	F_{uls} = **1500.0** kN
The ultimate load per pile is;	$F_{uls\_pile} = F_{uls}/3$ = **500.0** kN
Characteristic axial load;	F_{char} = **1000.0** kN

The characteristic load per pile is; $F_{char\_pile} = F_{char}/3 =$ **333.3** kN

Pile diameter; $\phi =$ **250** mm

Pile spacing; s = **750** mm

Pile cap overhang; e = **150** mm

Overall length of pile cap; $L = \sin(60) \times s + \phi + 2 \times e =$ **1200** mm

Overall width of pile cap; $b = s + \phi + 2 \times e =$ **1300** mm

Width at pile parallel to length, L; $w_1 = \phi + 2 \times e =$ **550** mm

Width at pile parallel to overall width, b; $w_2 = \phi + 2 \times e =$ **550** mm

Overall height of pile cap; h = **450** mm

Diagonal length of sides; $L_{side\_diag} = \sqrt{((L-w_1)^2 + ((b-w_2)/2)^2)} =$ **750** mm

Dimensions of loaded area; x = **300** mm

y = **300** mm

Cover

Concrete grade; $f_{cu} =$ **40.0** N/mm^2

Nominal cover; $c_{nom} =$ **40** mm

Tension bar diameter; $D_t =$ **16** mm

Link bar diameter; $L_{dia} =$ **12** mm

Depth to tension steel; $d = h - c_{nom} - L_{dia} - D_t/2 =$ **390** mm

Pile Cap Forces

Compression within pile cap; $F_c = F_{uls}/(3 \times \sin(\theta)) =$ **747.1** kN

Tension within pile cap; $F_t = F_c \times \cos(\theta) / (2 \times \cos(30)) =$ **320.5** kN

Compression In Pile Cap - Suggested Additional Check

Check compression diagonal as an unreinforced column, using a core equivalent to pile diameter

Compressive force in pile cap; $P_c = 0.4 \times f_{cu} \times \pi \times \phi^2/4 =$ **785.4** kN

PASS Compression

Cl. 3.8.4.3

Tension In One Truss Member

Characteristic strength of reinforcement; $f_y =$ **500** N/mm^2

Partial safety factor for strength of steel; $\gamma_{ms} =$ **1.15**

Required area of reinforcement; $A_{s\_req} = F_t /(1/\gamma_{ms} \times f_y) =$**737** mm^2

Provided area of reinforcement; $A_{s\_prov} = A_{st} =$ **1005** mm^2

Tension in truss member; $P_t = (1/\gamma_{ms} \times f_y) \times A_{s\_prov} =$ **437.1** kN

PASS Tension

Cl. 3.11.4.2

Max / Min Areas of Reinforcement - Considering A Strip Of Cap

Minimum required area of steel; $A_{st\_min} = k_t \times A_c =$ **293** mm^2

Maximum allowable area of steel; $A_{st\_max} = 4\ \% \times A_c =$ **9000** mm^2

Area of tension steel provided OK

Cl. 3.12.6 & Table 3.25

Beam Shear

Check shear stress on the sections at distance ϕ / 5 inside face of piles.

Cl. 3.11.4.3 & fig. 3.23

Applied shear stress

Applied shear force; $V = F_{uls} / 3 =$ **500.0** kN

Min effective width of pile cap along plane of shear; $b_v = \min(b_{v1} , b_{v2} , 3 \times \phi) =$ **750** mm

Design shear stress; $v = V / (b_v \times d) =$ **1.71** N/mm^2

Allowable shear stress; $v_{allowable} = \min ((0.8\ N^{1/2}/mm) \times \sqrt{(f_{cu})}, 5\ N/mm^2) =$ **5.00** N/mm^2

Shear stress - OK

Cl. 3.4.5.2

Design concrete shear strength

From BS8110-1:1997 Table 3.8;

$v_{c\_25} = 0.79 \times r^{1/3} \times \max(0.67, (400\ mm/d)^{1/4}) \times 1.0\ N/mm^2 / 1.25 =$ **0.56** N/mm^2

Shear enhancement (Cl. 3.4.5.8 and fig. 3.5); $v_c = v_{c\_25} \times (\min(f_{cu}, 40\ N/mm^2) / 25\ N/mm^2)^{1/3} =$ **0.66** N/mm^2

$a_v = \min(2 \times d, \max((s / sqrt(3) - \phi / 2 + \phi / 5 - x / 2), 0.1mm)) =$ **208** mm

Enhanced shear stress; $v_{c\_enh} = \min(v_{allowable} , 2 \times d \times v_c / a_v) =$ **2.46** N/mm^2

Concrete shear strength - OK, no links reqd.

Table 3.16

Note: If no links are provided, the bond strengths for **PLAIN** bars must be used in calculations for anchorage and lap lengths.

Cl. 3.12.8.3

Local Shear At Concentrated Loads (Cl 3.7.7)

Total length of inner perim. at edge of loaded area; $u_0 = 2 \times (x + y) =$**1200** mm

Assumed average depth to tension steel; $d_{av} = d - D_t =$ **374** mm

Max shear effective across perimeter; $V_p = F_{uls} =$ **1500.0** kN

Stress around loaded area; $v_{max} = V_p / (u_0 \times d_{av}) =$ **3.34** N/mm^2

Allowable shear stress; $v_{allowable} = \min((0.8\ N^{1/2}/mm) \times \sqrt{(f_{cu})}, 5\ N/mm^2) =$ **5.00** N/mm^2

Shear stress - OK

Cl. 3.4.5.2

Clear Distance Between Bars In Tension (Cl 3.12.11.2.4)

Maximum / Minimum allowable clear distances between tension bars considering a strip of cap

Actual bar spacing;

$spacing_{bars} = \max(0mm, (b_{ccs} - n_{surfaces} \times (c_{adopt} + L_{dia}) - D_t)/(L_{nt} - 1) - D_t) =$**92** mm

Maximum allowable spacing of bars; $spacing_{max} = \min((47000\ N/mm)/f_s, 300\ mm) =$ **192** mm

Minimum required spacing of bars; $spacing_{min} = h_{agg} + 5\ mm =$ **25** mm

Bar spacing OK

Clear Distance Between Face Of Beam And Tension Bars (Cl 3.12.11.2.5)

Distance to face of beam; $Dist_{edge} = c_{adopt} + L_{dia} + D_t/2 =$ **60** mm

Design service stress in reinforcement; $f_s = 2 \times f_y \times A_{s\_req} / (3 \times A_{s\_prov} \times \beta_b) =$ **244.4** N/mm^2

Max allowable clear spacing; $Spacing_{max} = \min((47000 \text{ N/mm})/f_s, 300 \text{ mm}) =$ **192**

mm

Max distance to face of beam; $Dist_{max} = Spacing_{max}/2 =$ **96** mm

Max distance to beam edge check - OK

Anchorage Of Tension Steel

Anchorage factor; $\phi_{factor} =$**35**

Type of lap length; lap_type =**"tens_lap"**

Type of reinforcement; reft_type = **"def2_fy500"**

Minimum radius; $r_{bar} =$ **32** mm

Minimum end projection; $P_{bar} =$ **130** mm

Minimum anchorage length or lap length req'd; $L_{table\ 3.27} = \phi_{factor} \times D_t =$ **560** mm

Check anchorage length to cl. 3.12.9.4 (b); $L_{cl.\ 3.12.9.4} = 12 \times D_t + d/2 =$ **387** mm

Required minimum effective anchorage length; $L_a = \max(L_{table\ 3.27}, L_{cl.\ 3.12.9.4}) =$ **560** mm

Check minimum radius required on bend

Note that the bars must extend at least 4D past the bend

Force per bar at bend; $F_{bt} = F_t / L_{nt} =$ **64.1** kN

Edge bar centres; $s_{ext} = c_{adopt} + D_t =$ **56** mm

Edge maximum allowable bearing stress; $f_{bt\_max\_ext} = 2 \times f_{cu} / (1 + 2\times(D_t / s_{ext}))$ = **50.91**

N/mm^2

Internal bar centres; $s_{int} = spacing_{bars} + D_t =$ **108** mm

Internal maximum allowable bearing stress; $f_{bt\_max\_int} = 2 \times f_{cu} / (1 + 2\times(D_t / s_{int}))$ = **61.71**

N/mm^2

Design max allowable bearing stress; $f_{bt\_max} = \min(f_{bt\_max\_ext}, f_{bt\_max\_int}) =$ **50.91** N/mm^2

Minimum radius required; $r_{min} = \max(r_{bar}, F_{bt} / (f_{bt\_max} \times D_t)) =$ **78.7** mm

Minimum radius of bend required = 79 mm