

Pile cap

Reinforced concrete foundations · truss model, EN 1992-1-1 §6.2, §6.5, §9.8.1 · UK NA / PN-EN

Reference	NAE-RC-007 · version 1.0
Standards	BS EN 1992-1-1:2004 with UK NA · PN-EN 1992-1-1:2008 with Polish NA (NDP sources listed on the NDP sheet) · EN 1990 load combination by the user
National Annex	Selectable: UK NA to BS EN 1992-1-1 or Polish NA to PN-EN 1992-1-1
Issued	29 October 2026

What it does

Pile cap on two piles in line or four piles in a rectangle under one central column: pile loads against the working capacity, tension ties from the truss (strut-and-tie) model, shear across the cap with the $2d/av$ enhancement near the piles, and the concrete stress at the column face.

How to use

1. Open the Calculation sheet and select the National Annex.
2. Fill in the shaded input cells. Everything else is calculated.
3. Read the Results block; every step below it quotes its clause. Print or save as PDF for your calculation package.

Scope and limitations

Axial column load only, column central on the cap, piles of equal diameter at the corners of the pile group. Truss of depth d from the column centre to the pile centres, ties over the pile lines (TCC How to: Foundations, the established UK method): $T = N I / (4d)$ for two piles, $N I / (8d)$ per tie for four piles, with N the column load plus the factored weight of the cap (conservative). Bars of each tie are placed within $3D$ over the pile line (9.8.1(3)) and anchored past the pile centre (check separately). Shear is checked across the whole cap on a section at $D/5$ inside the pile faces with the $2d/av$ enhancement over $3D$ -wide bands on the piles ($av \geq 0.5d$) and $VEd \leq 0.5 b d v fcd$ (6.2.2(6)). The column face is checked to 6.4.5(3). Punching of a single pile or of the column outside the pile group and moments or eccentric pile loads are not covered. Pile capacity is the working (SLS) value from the pile designer. Concrete classes up to C50/60. The second-generation EN 1992-1-1:2023 is not yet implemented.

Further reading and independent cross-check

- The Concrete Centre, How to design concrete structures using Eurocode 2: Foundations (pile caps).
 - The Concrete Centre, Worked Examples to Eurocode 2: Volume 1.
 - The Concrete Centre, RC Spreadsheets v4, TCC82 Pile caps (licensed product) can be used as an independent cross-check.
- NA Engineering is not affiliated with The Concrete Centre or CIRIA; their publications are referenced for information only.

About NA Engineering

NA Engineering is a structural engineering consultancy delivering structural design, reinforced concrete modelling and detailing, and steel detailing for residential, commercial, infrastructure, energy and refurbishment projects. We share tools like this one because good engineering should be transparent: every formula here is visible and referenced. If you need a design, a check or a full detailing package, talk to us.

Website	naengineering.uk
Email	adrian@naengineering.uk
Phone	+48 505 844 422
LinkedIn	linkedin.com/company/naengineering

Disclaimer

This spreadsheet is provided free of charge, as is, for use by competent engineers. It does not replace engineering judgement. The user is responsible for the input, for checking that the method suits the element being designed and for verifying the results. NA Engineering accepts no liability for any loss arising from its use. Sheets are password-protected and the workbook structure is locked so that the formulas and the NA Engineering details cannot be changed; only the shaded input cells can be edited.

Revision history

v1.0	29 Oct 2026 · First issue
------	---------------------------

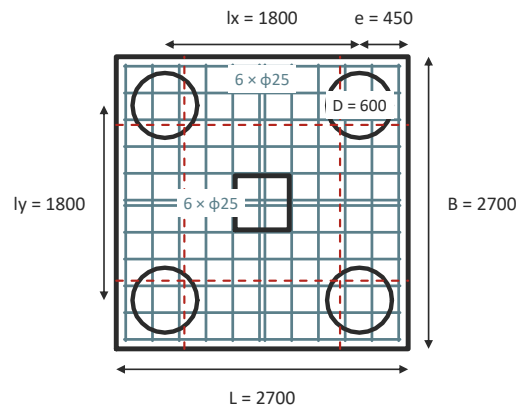
Project
Element
Date

Job no.
Made by
Checked

Inputs · geometry
Shaded cells only

	National Annex		UK NA (BS EN)	
Table 3.1	Concrete strength class		C32/40	
3.2.2	Reinforcement characteristic yield strength (≤ 500 MPa)	f_{yk}	500	MPa
	Number of piles		4 piles	
	Pile diameter	D	600	mm
	Pile spacing in x ($\geq 2D$)	l_x	1800	mm 3D typical
	Pile spacing in y (4 piles; $\geq 2D$)	l_y	1800	mm
	Pile centre to the edge of the cap	e	450	mm D/2 + 150 recommended
	Cap depth	h	1100	mm
	Column dimension in x	c_x	500	mm
	Column dimension in y	c_y	500	mm
4.4.1	Cover to the tie bars, from the pile head (≥ 40)	c_{nom}	75	mm
8.2(2)	Maximum aggregate size	d_g	20	mm
	Ties in x (lower layer): bar diameter	φ_x	25	mm
	Ties in x: bars over each pile line	n_x	6	
	Ties in y (upper layer, 4 piles): bar diameter	φ_y	25	mm
	Ties in y: bars over each pile line	n_y	6	

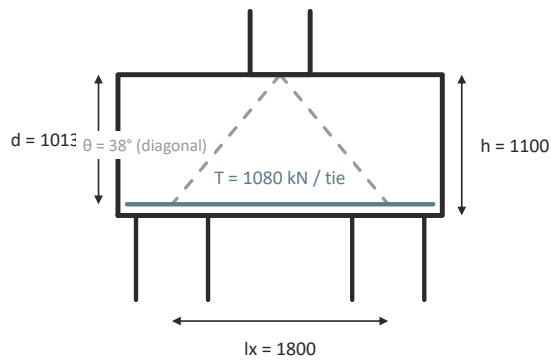
Your pile cap in plan, to scale · tie bars over the pile lines (blue) · shear sections at D/5 inside the pile faces (dashed)


Inputs · loads
Column loads at the top of the cap

	Column load, permanent	G_k	2400	kN
	Column load, variable	Q_k	900	kN
EN 1990 A1.2(B)	Partial factor, permanent	γ_G	1.35	
EN 1990 A1.2(B)	Partial factor, variable	γ_Q	1.50	
	Pile working capacity (characteristic load)	P_{allow}	1500	kN From the pile designer
	Inputs valid and consistent			OK

Section along x, to scale · struts (grey) from the column centre to the piles, tie (blue) at the bars · 4 piles: projection of the diagonal truss

N = 4861 kN



Results

Pile load, characteristic N / P_{allow}	N_{pile}	0.58	OK
Ties in x $A_{s,req} / A_{s,prov}$	$A_{s,x}$	0.84	OK
Ties in y $A_{s,req} / A_{s,prov}$	$A_{s,y}$	0.86	OK
Shear across the cap, x V_{Ed} / V_{Rd}		0.65	OK
Shear across the cap, y V_{Ed} / V_{Rd}		0.66	OK
Column face $v_{Ed} / v_{Rd,max}$		0.41	OK
Truss geometry $\cot \theta = x_p / d$		1.27	OK
Column face to the nearest pile face / 2d		0.31	n/a: shear across the cap
Edge projection beyond the pile face		150 mm	OK

Punching is not calculated here. Piles within 2d of the column face: the shear across the cap at the pile faces (with the $a_v / 2d$ enhancement) and the column-face check carry it (TCC How to: Foundations). Piles further out leave room for a punching failure around the column inside the pile group: check it separately to 6.4. A shallow cap (struts flatter than about 27°) makes the truss model unreliable: deepen the cap. Anchor the tie bars beyond the pile centres with a full anchorage length (bends allowed, 8.4) and provide side and top bars (9.8.1(4)) and starter bars to the column. For two piles, transverse bars are nominal: not designed here.

Calculation · geometry and pile loads

	Number of piles	n	4	
	Cap length $l_x + 2e$	L	2700	mm
	Cap width (2 piles: $2e$; 4 piles: $l_y + 2e$)	B	2700	mm
	Self weight of the cap $25 \text{ kN/m}^3 \cdot L \cdot B \cdot h$	W_c	200.5	kN
	Pile load, characteristic $(G_k + Q_k + W_c) / n$	$N_{pile,k}$	875.1	kN
EN 1990 (6.10)	Design column load $\gamma_G G_k + \gamma_Q Q_k$	N_{Ed}	4590.0	kN
	Design load on the truss $N_{Ed} + \gamma_G W_c$	N	4860.6	kN
	Design pile reaction N / n	P_{Ed}	1215.2	kN

Calculation · truss and ties

2.4.2.4(1)	Partial factor, concrete	γ_c	1.50	NDP sheet
2.4.2.4(1)	Partial factor, reinforcement	γ_s	1.15	NDP sheet
3.1.6(1)	Coefficient on compressive strength (shear)	α_{cc}	1.00	NDP sheet
6.2.2(1), 6.4.4(1)	Coefficient $0.18 / \gamma_c$	$C_{Rd,c}$	0.120	NDP sheet
6.4.5(3)	Factor on v_{fcd} for $v_{Rd,max}$		0.50	NDP sheet
Table 3.1	Characteristic cylinder strength	f_{ck}	32	MPa
Table 3.1	Mean tensile strength	f_{ctm}	3.02	MPa
	Effective depth, x ties $h - c - \phi_x / 2$	d_x	1013	mm
	Effective depth, y ties $h - c - \phi_x - \phi_y / 2$	d_y	988	mm
	Mean effective depth (2 piles: d_x)	d	1000	mm
	Column centre to pile centre in plan	x_p	1273	mm

	Strut inclination $\cot \theta = x_p / d$	$\cot \theta$	1.27	
6.4.2	Column corner to the nearest pile face (4 piles: diagonal)	s	619	mm
3.2.7	Design yield strength	f_{yd}	434.8	MPa
	Tie force in x (2 piles: $N l_x / 4d_x$; 4 piles: $N l_x / 8d_x$ per tie)	T_x	1080.1	kN
	Required area per x tie T / f_{yd}	$A_{s,req,x}$	2484	mm ²
	Provided per x tie $n_x \pi \phi_x^2 / 4$	$A_{s,prov,x}$	2945	mm ²
8.2(2)	Minimum clear gap between bars $\max(\phi_x; \phi_y; d_g + 5; 20)$	a_{min}	25	mm
9.8.1(3)	Band for the x ties ($\leq 1.5D$ each side of the piles, inside the cover)	b_x	1263	mm
8.2(2)	x bars fit in the band $n_x \phi_x + (n_x - 1) a_{min}$		275	mm
	Tie force in y, per tie $N l_y / 8d_y$ (4 piles)	T_y	1107.5	kN
	Required area per y tie T / f_{yd}	$A_{s,req,y}$	2547	mm ²
	Provided per y tie $n_y \pi \phi_y^2 / 4$	$A_{s,prov,y}$	2945	mm ²
9.8.1(3)	Band for the y ties (as for x)	b_y	1263	mm
8.2(2)	y bars fit in the band $n_y \phi_y + (n_y - 1) a_{min}$		275	mm

Calculation · column face, 6.4.5(3)

(6.6N)	Strength reduction factor $0.6(1 - f_{ck}/250)$	ν	0.523	
3.1.6(1)	Design strength for shear $\alpha_{cc} f_{ck} / \gamma_c$	f_{cd}	21.33	MPa
6.4.5(3)	Maximum punching stress $v_{max} \nu f_{cd}$	$\nu_{Rd,max}$	5.581	MPa
(6.53)	Stress at the column face $N_{Ed} / (2(c_x + c_y) d)$	$\nu_{Ed,0}$	2.295	MPa

Calculation · shear across the cap, x direction

6.2.2(6)	Column face to the section at $D/5$ inside the pile face $l_x/2 - c/4$	$a_{v,x}$	470	mm
6.2.2(6)	av used ($\geq 0.5d$)	$a_{v,x}$	506	mm
	Shear on the section $n/2 \cdot P_{Ed}$	$V_{Ed,x}$	2430.3	kN
6.2.2(1)	Reinforcement ratio $(n/2) A_{s,tie} / (b d)$	$\rho_{l,x}$	0.0022	
(6.2)	Basic resistance $\max(CR_{d,c} k (100 \rho f_{ck})^{1/3}; v_{min})$	$\nu_{Rd,c,x}$	0.344	MPa
	Width with enhancement (3D bands over the piles)	$b_{enh,x}$	2700	mm
6.2.2(6)	Resistance $\min(d(b_{enh} \nu_{Rd,c} \max(1; 2d/av) + (b - b_{enh}) \nu_{Rd}, V_{Ed,x})$	$V_{Rd,x}$	3758.5	kN
(6.2)	Shear, x direction $V_{Ed} \leq V_{Rd}$	$V_{Ed,x}$	2430.3	kN

Calculation · shear across the cap, y direction (4 piles)

6.2.2(6)	Column face to the section at $D/5$ inside the pile face $l_y/2 - c/4$	$a_{v,y}$	470	mm
6.2.2(6)	av used ($\geq 0.5d$)	$a_{v,y}$	494	mm
	Shear on the section $n/2 \cdot P_{Ed}$	$V_{Ed,y}$	2430.3	kN
6.2.2(1)	Reinforcement ratio $(n/2) A_{s,tie} / (b d)$	$\rho_{l,y}$	0.0022	
(6.2)	Basic resistance $\max(CR_{d,c} k (100 \rho f_{ck})^{1/3}; v_{min})$	$\nu_{Rd,c,y}$	0.346	MPa
	Width with enhancement (3D bands over the piles)	$b_{enh,y}$	2700	mm
6.2.2(6)	Resistance $\min(d(b_{enh} \nu_{Rd,c} \max(1; 2d/av) + (b - b_{enh}) \nu_{Rd}, V_{Ed,y})$	$V_{Rd,y}$	3687.0	kN
(6.2)	Shear, y direction $V_{Ed} \leq V_{Rd}$	$V_{Ed,y}$	2430.3	kN

The section at $D/5$ inside the pile face and the 3D band rule follow TCC How to: Foundations: bands 1.5D each side of each pile line, clipped by the cap edge and half way between the pile lines; within them the shear resistance is enhanced by $2d/av$ (not below 1), equivalent to $\theta = av/2d$ of 6.2.2(6). The pile load is the design reaction including the cap weight (conservative).

Prepared with NA Engineering calculation tools · naengineering.uk · adrian@naengineering.uk. Free for use by competent engineers; see the About sheet for scope and disclaimer.

Nationally Determined Parameters

Values used by the Calculation sheet for the selected National Annex. Sources: UK NA to BS EN 1992-1-1:2004, Table NA.1; PN-EN 1992-1-1:2008, Załącznik krajowy NA. Edit only if your project specifies different values.

Parameter	Clause	UK NA	PL NA	Notes
Partial factor, concrete γ_c	2.4.2.4(1)	1.5	1.4	Persistent & transient. UK NA: recommended; PL: NA.2, Table NA.2
Partial factor, reinforcement γ_s	2.4.2.4(1)	1.15	1.15	UK NA: recommended; PL: NA.2, Table NA.2
α_{cc} (compression in flexure / axial)	3.1.6(1)	0.85	1	UK NA: 0.85; PL: recommended (NA.9)
α_{cc} (shear and punching)	3.1.6(1)	1	1	UK NA: 1.0 for other phenomena; PL: recommended (NA.9)
α_{ct} (design tensile strength)	3.1.6(2)	1	1	Recommended value in both annexes
CRd,c numerator (CRd,c = value / γ_c)	6.2.2(1), 6.4.4(1)	0.18	0.18	Recommended value in both annexes
k1 (axial stress term, punching)	6.4.4(1)	0.1	0.1	Recommended value in both annexes
$v_{Rd,max}$ factor ($v_{Rd,max} = \text{factor} \cdot v \cdot f_{cd}$)	6.4.5(3)	0.5	0.4	UK NA: 0.5 v fcd; PL: recommended value (NA.9), 0.4 v fcd since EN 1992-1-1 AC:2010 (PN-EN 1992-1-1:2008)
kmax ($v_{Ed} \leq k_{max} \cdot v_{Rd,c}$ at u1)	6.4.5	2	1.5	UK NA 6.4.5(3): 2 vRd,c. PL: no limit in PN-EN 1992-1-1:2008; 1.5 (A1:2014 recommendation) applied conse
ϕ_{large} (large bar threshold, mm)	8.8(1)	40	32	UK NA: 40 mm; PL: 32 mm recommended (NA.9)
cot θ upper limit (variable strut)	6.2.3(2)	2.5	2	UK NA: 2.5 (1.25 with axial tension); PL: NA.4, $1 \leq \cot \theta \leq 2.0$
k1 (x/d limit, $\delta \geq k_1 + k_2 x_u/d$)	5.5(4)	0.4	0.44	UK NA for $f_{yk} \leq 500$ MPa; PL: recommended (NA.9)
k2 (x/d limit, $\epsilon_{cu2} = 0.0035$)	5.5(4)	1	1.25	UK NA: $0.6 + 0.0014/\epsilon_{cu2}$; PL: $1.25(0.6 + 0.0014/\epsilon_{cu2})$
Upper limit on the (310/ σ_s) factor (0 = none)	7.4.2(2)	1.5	0	UK NA Table NA.5 Note 5: (310/ σ_s) or (500/ f_{yk})($A_{s,prov}/A_{s,req}$) ≤ 1.5 ; PL: none
L/d not to exceed 40 K (1 = applies)	7.4.2(2)	1	0	UK NA Table NA.5 Note 6; not in EN text
ϕ_{min} (longitudinal bars in columns, mm)	9.5.2(1)	12	6	UK NA: 12 mm; PL: NA.6, 6 mm
k3 (crack spacing)	7.3.4(3)	3.4	3.4	Recommended value in both annexes
k4 (crack spacing)	7.3.4(3)	0.425	0.425	Recommended value in both annexes