

Retaining wall

Cantilever retaining walls · EN 1997-1 §9, EN 1992-1-1 · UK NA (DA1) / PN-EN (DA2*)

Reference	NAE-RC-011 · 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) · BS EN 1997-1:2004 with UK NA (DA1) · PN-EN 1997-1:2008 with NA in Ap2:2010 (DA2, bearing DA2*)
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

A reinforced concrete cantilever retaining wall on a spread base: earth pressure on the virtual back, sliding, eccentricity and drained bearing resistance of the base (EN 1997-1 Annex D), and the bending and shear reinforcement of the stem, heel and toe (EN 1992-1-1).

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

Vertical stem of constant thickness on a level base, level backfill to the top of the stem with a uniform surcharge q , cohesionless drained soils ($c' = 0$), no water pressure and no passive resistance in front of the toe. The front ground $D - t_b$ above the toe acts as weight on the toe (unit weight of the foundation soil), in equilibrium and in the toe design, factored like the other weights. Rankine pressure on a vertical virtual back through the heel: active K_a (wall free to rotate) or at rest $K_0 = 1 - \sin \phi'$ (normally consolidated backfill; overconsolidation and compaction pressures, 9.5.2 and 9.5.5, are outside the scope). The soil above the heel acts with the wall. Partial factors: UK NA DA1, combination 1 (A1+M1+R1) and 2 (A2+M2+R1); PL NA (Ap2:2010, Table NA.2) DA2 (A1+M1+R2: $\gamma_{R,v} = 1.4$, $\gamma_{R,h} = 1.1$) with the bearing resistance from characteristic actions (DA2*). Each set is checked for four load arrangements: weights unfavourable ($\times \gamma_G$) or favourable ($\times 1.0$), each with and without the surcharge over the heel; the lateral surcharge acts in all. Sliding uses favourable weights. Bearing to Annex D (strip, horizontal base, drained, $c' = 0$) with $B' = B - 2e$; the base pressure is linear, with partial contact at either end; $|e| \geq B/2$ is rejected and $|e| > B/3$ is outside this simplified method (6.5.4). The heel and toe are designed for the envelope of the cases; where a case reverses the bending (tension on the other face) the reinforcement result is flagged, because only the main face is designed here. Main-bar spacing to 9.6.3 / 9.3.1.1(3); distribution bars, anchorage of the stem bars, the base joint, cracking, overall stability (DA3 in PL), settlement and frost are outside the scope.

The second-generation EN 1997-1:2024 and EN 1992-1-1:2023 are not yet implemented.

Further reading and independent cross-check

- The Concrete Centre, How to design concrete structures using Eurocode 2: Foundations / retaining walls.
- Bond et al., Decoding Eurocode 7.
- The Concrete Centre, RC Spreadsheets v4, TCC62 Retaining wall (licensed product) can be used as an independent cross-check.

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About NA Engineering

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Disclaimer

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Revision history

v1.0 29 Oct 2026 · First issue

Project
Element
Date

Job no.
Made by
Checked

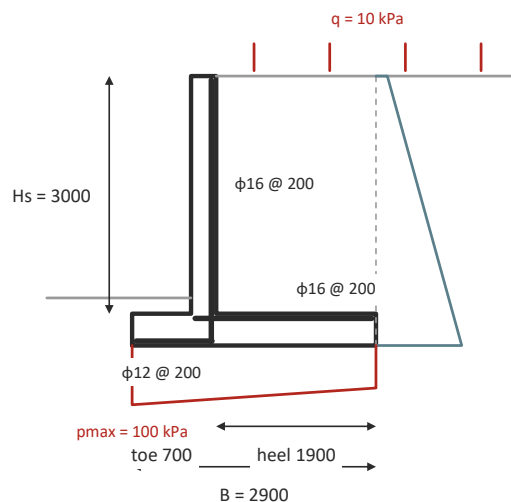
Inputs · geometry and reinforcement
Shaded cells only

	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
8.2(2)	Maximum aggregate size	d_g	20	mm
	Stem height above the base (retained height)	H_s	3000	mm
	Stem thickness	t_s	300	mm
	Base thickness	t_b	400	mm
	Toe length (in front of the stem)	B_t	700	mm
	Heel length (behind the stem)	B_h	1900	mm
D.4	Depth of the base underside below the front ground	D	600	mm
4.4.1	Nominal cover	c_{nom}	50	mm
	Stem bars, rear face: diameter	φ_{st}	16	mm
	Stem bars: spacing	s_{st}	200	mm
	Heel bars, top face: diameter	φ_{he}	16	mm
	Heel bars: spacing	s_{he}	200	mm
	Toe bars, bottom face: diameter	φ_{to}	12	mm
	Toe bars: spacing	s_{to}	200	mm

Inputs · soil and loads
Characteristic values

	Backfill: unit weight	γ	19.0	kN/m ³
	Backfill: angle of shearing resistance	φ'_k	30.0	°
	Earth pressure		Active Ka	K0: normally consolidated
	Foundation soil: unit weight (also over the base for q')	γ_f	19.0	kN/m ³
6.5.3(10)	Foundation soil: angle of shearing resistance (critical state)	φ'_f	30.0	°
	Surcharge on the backfill (variable)	q	10.0	kPa
	Unit weight of reinforced concrete	γ_c	25.0	kN/m ³
	Inputs valid and consistent			OK

Your wall, to scale · earth pressure on the virtual back (set 1) · base pressure, case 1a



Results

Sliding $H_d / R_{h,d}$ (worst set)	0.84		OK
Bearing $V_d / R_{v,d}$ (worst case)	0.77		OK
Eccentricity $ e / B$ (worst case; limit of this method 1/3)	0.100		OK
Reinforcement stem, heel and toe (largest moment)	61.0	kNm/m	OK

UK: both combinations of DA1, each with arrangements (a) to (d); PL: DA2 with all four and the bearing resistance from characteristic actions (DA2*). FAIL takes precedence over the reverse-bending warning. "I Reverse bending": a case puts the heel bottom or the toe top in tension; reinforce that face too (not designed here).

Calculation · geometry and weights (per metre run)

Base width $B = \text{toe} + \text{stem} + \text{heel}$	B	2900	mm
Height of the virtual back $H_s + t_b$	H	3.400	m
Stem $\gamma_c t_s H_s$	W_s	22.5	kN/m
Base $\gamma_c B t_b$	W_b	29.0	kN/m
Soil over the heel $\gamma B_h H_s$	W_{soil}	108.3	kN/m
Front ground over the toe $\gamma_f B_t (D - t_b)$	W_{front}	2.7	kN/m
Total weight W	W	162.5	kN/m
Moment of the weights about the toe $\Sigma W x$	$\Sigma W x$	273.3	kNm/m

Calculation · EN 1997-1 (GEO)

A.3.3.4	Resistance factor, bearing $\gamma_{R,v}$ (UK DA1: 1.0; PL DA2: 1.4)	$\gamma_{R,v}$	1.00	
A.3.3.4	Resistance factor, sliding $\gamma_{R,h}$ (UK DA1: 1.0; PL DA2: 1.1)	$\gamma_{R,h}$	1.00	
A.3	Set 1: partial factors $\gamma_G, \text{unfav} / \gamma_Q / \gamma_{\phi'}$		1.35 / 1.5 / 1.0	
(2.4.6.2)	Set 1: design ϕ' of the backfill $\arctan(\tan \phi' / \gamma_{\phi'})$	ϕ'_{d1}	30.00	°
Rankine	Set 1: earth pressure coefficient $K_a = (1 - \sin \phi') / (1 + \sin \phi')$, or	K_1	0.333	
	Set 1: thrust of the soil $K \gamma H^2 / 2$ (at $H/3$)	P_{G1}	36.6	kN/m
	Set 1: thrust of the surcharge $K q H$ (at $H/2$)	P_{Q1}	11.3	kN/m
6.5.3	Set 1: horizontal design force $\gamma_G P_G + \gamma_Q P_Q$	H_{d1}	66.4	kN/m
6.5.3(10)	Set 1: base friction $\tan \delta_d = \tan \phi' / \gamma_{\phi'}$ (cast in place)	$\tan \delta_1$	0.577	
(6.3a)	Set 1: sliding resistance $W \tan \delta_d / \gamma_{R,h}$ (weights 1.0, no surcharge)	R_{h1}	93.8	kN/m
D.4	Set 1: bearing factors N_q / N_{γ} ($\phi' / \gamma_{\phi'}$)		18.40 / 20.09	

Set 2 (A2 + M2 + R1) is the UK DA1 combination 2; under the PL annex it is shown for information only and is not used in the results.

A.3	Set 2: partial factors $\gamma_G, \text{unfav} / \gamma_Q / \gamma_{\phi'}$		1.0 / 1.3 / 1.25	
(2.4.6.2)	Set 2: design ϕ' of the backfill $\arctan(\tan \phi' / \gamma_{\phi'})$	ϕ'_{d2}	24.79	°
Rankine	Set 2: earth pressure coefficient $K_a = (1 - \sin \phi') / (1 + \sin \phi')$, or	K_2	0.409	
	Set 2: thrust of the soil $K \gamma H^2 / 2$ (at $H/3$)	P_{G2}	44.9	kN/m
	Set 2: thrust of the surcharge $K q H$ (at $H/2$)	P_{Q2}	13.9	kN/m
6.5.3	Set 2: horizontal design force $\gamma_G P_G + \gamma_Q P_Q$	H_{d2}	63.0	kN/m
6.5.3(10)	Set 2: base friction $\tan \delta_d = \tan \phi' / \gamma_{\phi'}$ (cast in place)	$\tan \delta_2$	0.462	
(6.3a)	Set 2: sliding resistance $W \tan \delta_d / \gamma_{R,h}$ (weights 1.0, no surcharge)	R_{h2}	75.0	kN/m
D.4	Set 2: bearing factors N_q / N_{γ} ($\phi' / \gamma_{\phi'}$)		10.43 / 8.71	
6.5.3	Sliding, set 1 $H \leq R_h$	H_{d1}	66.4	kN/m
6.5.3	Sliding, set 2 (UK)	H_{d2}	63.0	kN/m

Calculation · load cases: bearing, base pressure, heel and toe

Case 1a / 1b: set 1 with arrangement (a) or (b); 2a / 2b: set 2 (UK only). Pressure linear between the contact limits; heel and toe actions at the stem faces.

	Case 1a: vertical load $1.35 W + 1.5 q B_h$	V_{1a}	247.8	kN/m
	Case 1a: moment about the toe $1.35 \Sigma W x + 1.5 q B_h x_h - \gamma_G P_G$	M_{1a}	339.6	kNm/m
6.5.4	Case 1a: eccentricity $B/2 - M/V$ (+ towards the toe)	e_{1a}	0.080	m
6.5.4	Case 1a: effective width $B' = B - 2 e $ (PL: characteristic, DA2*)	B'_{1a}	2.741	m

(D.2)	Case 1a: bearing resistance $B' (q' N_q i_q + \frac{1}{2} \gamma_f B' N_\gamma i_\gamma) / \gamma R, \gamma, i_q$	R_{v1a}	870.4	kN/m
	Case 1a: contact from / to (m from the toe)		0.000 – 2.900	m
	Case 1a: pressure at the start of contact	p_{a1a}	99.5	kPa
	Case 1a: pressure at the end of contact	p_{b1a}	71.4	kPa
	Case 1a: heel moment at the stem (+ tension on top)	M_{he1a}	50.4	kNm/m
	Case 1a: heel shear at the stem	V_{he1a}	47.2	kN/m
	Case 1a: toe moment at the stem (+ tension at the bottom)	M_{to1a}	19.3	kNm/m
	Case 1a: toe shear at the stem	V_{to1a}	54.3	kN/m
	Case 1b: vertical load $1.0 W + 0.0 q B_h$	V_{1b}	162.5	kN/m
	Case 1b: moment about the toe $1.0 \Sigma Wx + 0.0 q B_h x_h - \gamma G PG \uparrow$	M_{1b}	188.4	kNm/m
6.5.4	Case 1b: eccentricity $B/2 - M/V$ (+ towards the toe)	e_{1b}	0.290	m
6.5.4	Case 1b: effective width $B' = B - 2 e $ (PL: characteristic, DA2*)	B'_{1b}	2.319	m
(D.2)	Case 1b: bearing resistance $B' (q' N_q i_q + \frac{1}{2} \gamma_f B' N_\gamma i_\gamma) / \gamma R, \gamma, i_q$	R_{v1b}	382.1	kN/m
	Case 1b: contact from / to (m from the toe)		0.000 – 2.900	m
	Case 1b: pressure at the start of contact	p_{a1b}	89.7	kPa
	Case 1b: pressure at the end of contact	p_{b1b}	22.4	kPa
	Case 1b: heel moment at the stem (+ tension on top)	M_{he1b}	54.0	kNm/m
	Case 1b: heel shear at the stem	V_{he1b}	42.9	kN/m
	Case 1b: toe moment at the stem (+ tension at the bottom)	M_{to1b}	17.3	kNm/m
	Case 1b: toe shear at the stem	V_{to1b}	47.4	kN/m
	Case 1c: vertical load $1.35 W + 0.0 q B_h$	V_{1c}	219.3	kN/m
	Case 1c: moment about the toe $1.35 \Sigma Wx + 0.0 q B_h x_h - \gamma G PG$	M_{1c}	284.0	kNm/m
6.5.4	Case 1c: eccentricity $B/2 - M/V$ (+ towards the toe)	e_{1c}	0.155	m
6.5.4	Case 1c: effective width $B' = B - 2 e $ (PL: characteristic, DA2*)	B'_{1c}	2.590	m
(D.2)	Case 1c: bearing resistance $B' (q' N_q i_q + \frac{1}{2} \gamma_f B' N_\gamma i_\gamma) / \gamma R, \gamma, i_q$	R_{v1c}	698.0	kN/m
	Case 1c: contact from / to (m from the toe)		0.000 – 2.900	m
	Case 1c: pressure at the start of contact	p_{a1c}	99.9	kPa
	Case 1c: pressure at the end of contact	p_{b1c}	51.4	kPa
	Case 1c: heel moment at the stem (+ tension on top)	M_{he1c}	51.4	kNm/m
	Case 1c: heel shear at the stem	V_{he1c}	44.0	kN/m
	Case 1c: toe moment at the stem (+ tension at the bottom)	M_{to1c}	18.9	kNm/m
	Case 1c: toe shear at the stem	V_{to1c}	52.8	kN/m
	Case 1d: vertical load $1.0 W + 1.5 q B_h$	V_{1d}	191.0	kN/m
	Case 1d: moment about the toe $1.0 \Sigma Wx + 1.5 q B_h x_h - \gamma G PG \uparrow$	M_{1d}	244.0	kNm/m
6.5.4	Case 1d: eccentricity $B/2 - M/V$ (+ towards the toe)	e_{1d}	0.172	m
6.5.4	Case 1d: effective width $B' = B - 2 e $ (PL: characteristic, DA2*)	B'_{1d}	2.555	m
(D.2)	Case 1d: bearing resistance $B' (q' N_q i_q + \frac{1}{2} \gamma_f B' N_\gamma i_\gamma) / \gamma R, \gamma, i_q$	R_{v1d}	573.7	kN/m
	Case 1d: contact from / to (m from the toe)		0.000 – 2.900	m
	Case 1d: pressure at the start of contact	p_{a1d}	89.3	kPa
	Case 1d: pressure at the end of contact	p_{b1d}	42.4	kPa
	Case 1d: heel moment at the stem (+ tension on top)	M_{he1d}	53.0	kNm/m
	Case 1d: heel shear at the stem	V_{he1d}	46.1	kN/m
	Case 1d: toe moment at the stem (+ tension at the bottom)	M_{to1d}	17.6	kNm/m
	Case 1d: toe shear at the stem	V_{to1d}	48.9	kN/m
	Case 2a: vertical load $1.0 W + 1.3 q B_h$	V_{2a}	187.2	kN/m
	Case 2a: moment about the toe $1.0 \Sigma Wx + 1.3 q B_h x_h - \gamma G PG \uparrow$	M_{2a}	239.8	kNm/m
6.5.4	Case 2a: eccentricity $B/2 - M/V$ (+ towards the toe)	e_{2a}	0.169	m
6.5.4	Case 2a: effective width $B' = B - 2 e $ (PL: characteristic, DA2*)	B'_{2a}	2.562	m
(D.2)	Case 2a: bearing resistance $B' (q' N_q i_q + \frac{1}{2} \gamma_f B' N_\gamma i_\gamma) / \gamma R, \gamma, i_q$	R_{v2a}	292.7	kN/m
	Case 2a: contact from / to (m from the toe)		0.000 – 2.900	m
	Case 2a: pressure at the start of contact	p_{a2a}	87.1	kPa
	Case 2a: pressure at the end of contact	p_{b2a}	42.0	kPa
	Case 2a: heel moment at the stem (+ tension on top)	M_{he2a}	50.8	kNm/m
	Case 2a: heel shear at the stem	V_{he2a}	44.1	kN/m
	Case 2a: toe moment at the stem (+ tension at the bottom)	M_{to2a}	17.1	kNm/m
	Case 2a: toe shear at the stem	V_{to2a}	47.5	kN/m
	Case 2b: vertical load $1.0 W + 0.0 q B_h$	V_{2b}	162.5	kN/m

	Case 2b: moment about the toe $1.0 \Sigma Wx + 0.0 q B h x h - \gamma G PG \uparrow$	M_{2b}	191.6	kNm/m	
6.5.4	Case 2b: eccentricity $B/2 - M/V$ (+ towards the toe)	e_{2b}	0.270	m	
6.5.4	Case 2b: effective width $B' = B - 2 e $ (PL: characteristic, DA2*)	B'_{2b}	2.359	m	
(D.2)	Case 2b: bearing resistance $B' (q' N q i q + \frac{1}{2} \gamma f B' N y i y) / \gamma R, v, i q$	R_{v2b}	210.7	kN/m	
	Case 2b: contact from / to (m from the toe)		0.000 – 2.900	m	
	Case 2b: pressure at the start of contact	p_{a2b}	87.4	kPa	
	Case 2b: pressure at the end of contact	p_{b2b}	24.7	kPa	
	Case 2b: heel moment at the stem (+ tension on top)	M_{he2b}	51.7	kNm/m	
	Case 2b: heel shear at the stem	V_{he2b}	41.4	kN/m	
	Case 2b: toe moment at the stem (+ tension at the bottom)	M_{to2b}	16.8	kNm/m	
	Case 2b: toe shear at the stem	V_{to2b}	46.2	kN/m	
	Case 2c: vertical load $1.0 W + 0.0 q B h$	V_{2c}	162.5	kN/m	
	Case 2c: moment about the toe $1.0 \Sigma Wx + 0.0 q B h x h - \gamma G PG \uparrow$	M_{2c}	191.6	kNm/m	
6.5.4	Case 2c: eccentricity $B/2 - M/V$ (+ towards the toe)	e_{2c}	0.270	m	
6.5.4	Case 2c: effective width $B' = B - 2 e $ (PL: characteristic, DA2*)	B'_{2c}	2.359	m	
(D.2)	Case 2c: bearing resistance $B' (q' N q i q + \frac{1}{2} \gamma f B' N y i y) / \gamma R, v, i q$	R_{v2c}	210.7	kN/m	
	Case 2c: contact from / to (m from the toe)		0.000 – 2.900	m	
	Case 2c: pressure at the start of contact	p_{a2c}	87.4	kPa	
	Case 2c: pressure at the end of contact	p_{b2c}	24.7	kPa	
	Case 2c: heel moment at the stem (+ tension on top)	M_{he2c}	51.7	kNm/m	
	Case 2c: heel shear at the stem	V_{he2c}	41.4	kN/m	
	Case 2c: toe moment at the stem (+ tension at the bottom)	M_{to2c}	16.8	kNm/m	
	Case 2c: toe shear at the stem	V_{to2c}	46.2	kN/m	
	Case 2d: vertical load $1.0 W + 1.3 q B h$	V_{2d}	187.2	kN/m	
	Case 2d: moment about the toe $1.0 \Sigma Wx + 1.3 q B h x h - \gamma G PG \uparrow$	M_{2d}	239.8	kNm/m	
6.5.4	Case 2d: eccentricity $B/2 - M/V$ (+ towards the toe)	e_{2d}	0.169	m	
6.5.4	Case 2d: effective width $B' = B - 2 e $ (PL: characteristic, DA2*)	B'_{2d}	2.562	m	
(D.2)	Case 2d: bearing resistance $B' (q' N q i q + \frac{1}{2} \gamma f B' N y i y) / \gamma R, v, i q$	R_{v2d}	292.7	kN/m	
	Case 2d: contact from / to (m from the toe)		0.000 – 2.900	m	
	Case 2d: pressure at the start of contact	p_{a2d}	87.1	kPa	
	Case 2d: pressure at the end of contact	p_{b2d}	42.0	kPa	
	Case 2d: heel moment at the stem (+ tension on top)	M_{he2d}	50.8	kNm/m	
	Case 2d: heel shear at the stem	V_{he2d}	44.1	kN/m	
	Case 2d: toe moment at the stem (+ tension at the bottom)	M_{to2d}	17.1	kNm/m	
	Case 2d: toe shear at the stem	V_{to2d}	47.5	kN/m	
6.5.2	Case 1a: bearing $V \leq R_v$	V	247.8	kN/m	OK
6.5.2	Case 1b: bearing $V \leq R_v$	V	162.5	kN/m	OK
6.5.2	Case 1c: bearing $V \leq R_v$	V	219.3	kN/m	OK
6.5.2	Case 1d: bearing $V \leq R_v$	V	191.0	kN/m	OK
6.5.2	Case 2a: bearing $V \leq R_v$	V	187.2	kN/m	OK
6.5.2	Case 2b: bearing $V \leq R_v$	V	162.5	kN/m	OK
6.5.2	Case 2c: bearing $V \leq R_v$	V	162.5	kN/m	OK
6.5.2	Case 2d: bearing $V \leq R_v$	V	187.2	kN/m	OK

Calculation · EN 1992-1-1 (STR)

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 (flexure)	α_{cc}	0.85	NDP sheet
6.2.2(1), 6.4.4(1)	Coefficient 0.18 / γ_c	$C_{Rd,c}$	0.120	NDP sheet
Table 3.1	Characteristic cylinder strength	f_{ck}	32	MPa
Table 3.1	Mean tensile strength	f_{ctm}	3.02	MPa
3.1.6(1)	Design compressive strength $\alpha_{cc} f_{ck} / \gamma_c$	f_{cd}	18.13	MPa
3.2.7	Design yield strength	f_{yd}	434.8	MPa
5.6.3	Limit on K without compression bars ($\xi \leq 0.45$)	K'	0.167	
8.2(2)	Minimum clear gap $\max(\phi; d_g + 5; 20)$	a_{min}	25	mm
	Stem: moment at the base $\gamma G K \gamma H s^3/6 + \gamma Q K q H s^2/2$ (worst s	M_{st}	61.0	kNm/m
	Stem: shear at the base	V_{st}	53.5	kN/m

	Stem: effective depth $t - c - \phi/2$	d	242	mm	
	Stem: $K = M / (b d^2 f_{ck})$	K	0.033		
3.1.7(3)	Stem: lever arm $d (1 - 0.4\xi) \leq 0.95 d$	z	230	mm	
	Stem: A_s required $M / (f_{yd} z)$	$A_{s,req}$	610	mm ² /m	
(9.1N)	Stem: $A_{s,min} \max(0.26 f_{ctm}/f_{yk}; 0.0013) b d$	$A_{s,min}$	381	mm ² /m	
	Stem: A_s provided $1000 \pi \phi^2 / (4 s)$ (rear face)	$A_{s,prov}$	1005	mm ² /m	
(6.2)	Stem: $V_{Rd,c}$ (no links)	$V_{Rd,c}$	131.3	kN/m	
9.6.1(1), 9.3.1.1(3)	Stem: maximum bar spacing	s_{max}	250	mm	
	Stem: bending $A_{s,prov} \geq \max(A_{s,req}; A_{s,min})$	A_s	1005	mm ² /m	OK
(6.2)	Stem: shear $V_{Ed} \leq V_{Rd,c}$	V_{Ed}	53.5	kN/m	OK
9.6.1(1), 9.3.1.1(3)	Stem: spacing $\leq s_{max}$, clear gap $\geq a_{min}$, $A_s \leq 0.04 A_c$	s	200	mm	OK
	Heel: largest moment, tension on top (envelope)	M_{he}	54.0	kNm/m	
	Heel: largest reverse moment (tension at the bottom)	$M_{he,rev}$	0.0	kNm/m	
	Heel: largest shear	V_{he}	47.2	kN/m	
	Heel: effective depth $t - c - \phi/2$	d	342	mm	
	Heel: $K = M / (b d^2 f_{ck})$	K	0.014		
3.1.7(3)	Heel: lever arm $d (1 - 0.4\xi) \leq 0.95 d$	z	325	mm	
	Heel: A_s required $M / (f_{yd} z)$	$A_{s,req}$	383	mm ² /m	
(9.1N)	Heel: $A_{s,min} \max(0.26 f_{ctm}/f_{yk}; 0.0013) b d$	$A_{s,min}$	538	mm ² /m	
	Heel: A_s provided $1000 \pi \phi^2 / (4 s)$ (top face)	$A_{s,prov}$	1005	mm ² /m	
(6.2)	Heel: $V_{Rd,c}$ (no links)	$V_{Rd,c}$	158.7	kN/m	
9.3.1.1(3)	Heel: maximum bar spacing	s_{max}	250	mm	
	Heel: bending $A_{s,prov} \geq \max(A_{s,req}; A_{s,min})$	A_s	1005	mm ² /m	OK
(6.2)	Heel: shear $V_{Ed} \leq V_{Rd,c}$	V_{Ed}	47.2	kN/m	OK
9.3.1.1(3)	Heel: spacing $\leq s_{max}$, clear gap $\geq a_{min}$, $A_s \leq 0.04 A_c$	s	200	mm	OK
	Toe: largest moment, tension at the bottom (envelope)	M_{to}	19.3	kNm/m	
	Toe: largest reverse moment (tension on top)	$M_{to,rev}$	0.0	kNm/m	
	Toe: largest shear	V_{to}	54.3	kN/m	
	Toe: effective depth $t - c - \phi/2$	d	344	mm	
	Toe: $K = M / (b d^2 f_{ck})$	K	0.005		
3.1.7(3)	Toe: lever arm $d (1 - 0.4\xi) \leq 0.95 d$	z	327	mm	
	Toe: A_s required $M / (f_{yd} z)$	$A_{s,req}$	136	mm ² /m	
(9.1N)	Toe: $A_{s,min} \max(0.26 f_{ctm}/f_{yk}; 0.0013) b d$	$A_{s,min}$	541	mm ² /m	
	Toe: A_s provided $1000 \pi \phi^2 / (4 s)$ (bottom face)	$A_{s,prov}$	565	mm ² /m	
(6.2)	Toe: $V_{Rd,c}$ (no links)	$V_{Rd,c}$	159.4	kN/m	
9.3.1.1(3)	Toe: maximum bar spacing	s_{max}	250	mm	
	Toe: bending $A_{s,prov} \geq \max(A_{s,req}; A_{s,min})$	A_s	565	mm ² /m	OK
(6.2)	Toe: shear $V_{Ed} \leq V_{Rd,c}$	V_{Ed}	54.3	kN/m	OK
9.3.1.1(3)	Toe: spacing $\leq s_{max}$, clear gap $\geq a_{min}$, $A_s \leq 0.04 A_c$	s	200	mm	OK

Heel and toe: envelope of the load cases at the faces of the stem (shear at the face is conservative; 6.2.1(8) allows d from the face). $V_{Rd,c}$ assumes the bars are anchored beyond the section (6.2.2(1)). Base spacing uses the $2h \leq 250$ mm limit for the region of maximum moment (9.3.1.1(3)). Distribution bars, the stem-base joint and the anchorage of the stem bars are for the designer to detail.

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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