Column design

Rectangular columns · EN 1992-1-1 §5.8, §6.1, §9.5 · UK NA / PN-EN

Reference	NAE-RC-008 · 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)
National Annex	Selectable: UK NA to BS EN 1992-1-1 or Polish NA to PN-EN 1992-1-1
Issued	30 October 2026

What it does

Ultimate limit state design of a rectangular reinforced concrete column under an axial force and a bending moment about one axis: slenderness, imperfections, second order effects by the nominal curvature method, and the resistance from an N-M interaction curve worked out by strain compatibility, with the detailing rules for columns.

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

Rectangular section, bars of one size symmetrical about both axes: nb bars on each face parallel to b and nh bars (corners included) on each face parallel to h. Bending about one axis, with h in the plane of bending; check the other axis with a second copy (swap b with h and nb with nh, and enter the moments, bracing and effective length of that axis) and biaxial bending to 5.8.9 separately. End moments only: loads between the ends of the column are outside the scope. Compression only (NEd > 0). The aspect ratio b/h or h/b is at most 4 (9.5.1). Isolated member: imperfection $\theta_i = \theta_0 \alpha_h$ with $\theta_0 = 1/200$ and $\alpha_m = 1$ (5.2(5), (6)). Slenderness limit from (5.13N) with A, B and C from the inputs; effective length l_0 from the user (5.8.3.2). Second order moment by nominal curvature (5.8.8) with c = 10, or 8 for a constant first order moment (5.8.8.2(4)). The entered end moments exclude imperfections: the imperfection moment NEd ei is added at both ends in the direction of M02; where it is not smaller than M02 the moments are taken as due to imperfections and C = 0.7. Resistance by strain compatibility: parabola-rectangle concrete of 3.1.7(1) with the strain limits of 6.1(5) (0.0035 at the compressed face, 0.002 at 3h/7 once the whole section is compressed), bars elastic-plastic, the concrete displaced by the bars deducted; MRd at NEd by bisection on the strain state (60 steps). Concrete classes up to C50/60, $f_{yk} \le 500$ MPa. Link spacing to 9.5.3; the 0.6 reduction near beams, slabs and laps is the user's to apply.
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: Columns.
- The Concrete Centre, Worked Examples to Eurocode 2: Volume 1.
- The Concrete Centre, RC Spreadsheets v4, TCC53 Column design (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	30 Oct 2026 · First issue

Project		Job no.	
Element		Made by	
Date		Checked	

Inputs · section

Shaded cells only

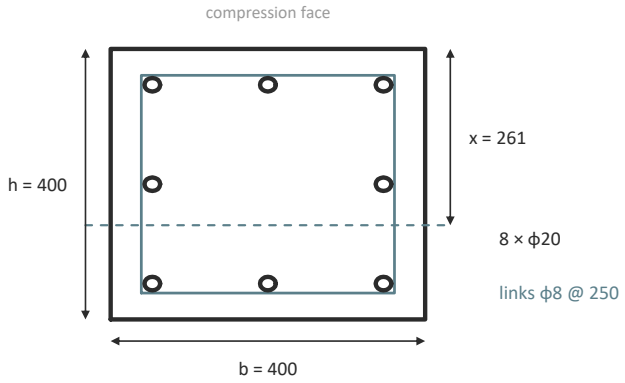
	National Annex		**UK NA (BS EN)**	
Table 3.1	Concrete strength class		**C32/40**	
3.2.2	Reinforcement characteristic yield strength (≤ 500 MPa)	f_{yk}	**500**	MPa
8.2(2)	Maximum aggregate size	d_g	**20**	mm
	Section width (perpendicular to the plane of bending)	b	**400**	mm
	Section depth (in the plane of bending)	h	**400**	mm
4.4.1	Nominal cover to links	c_{nom}	**35**	mm
	Link diameter	φ_w	**8**	mm
9.5.3	Link spacing	s_w	**250**	mm
9.5.3(6)	Cross-ties on the intermediate bars		**Corner bars only**	
9.5.2(1)	Bar diameter	φ	**20**	mm
	Bars on each face parallel to b (top and bottom)	n_b	**3**	
	Bars on each face parallel to h (corners included)	n_h	**3**	

Inputs · actions and length

ULS design values

	Design axial force (compression)	N_{Ed}	**1800**	kN	
5.8.8.2(2)	Larger first order end moment |M02|	M_{02}	**60.0**	kNm	
5.8.8.2(2)	Smaller end moment M01 (negative in double curvature)	M_{01}	**20.0**	kNm	
5.8.3.1	Bracing		**Braced**		
5.2(5)	Clear height of the column (for αh)	l	**5000**	mm	
5.8.3.2	Effective length	l_0	**4250**	mm	0.5l to 1.0l braced
5.8.4	Effective creep ratio	φ_{ef}	**1.50**		
5.8.8.2(4)	Curvature factor (10; 8 for a constant moment)	c	**10**		
	Inputs valid and consistent				**OK**

Your section, to scale · compression face on top · neutral axis at the resistance for NEd (dashed)

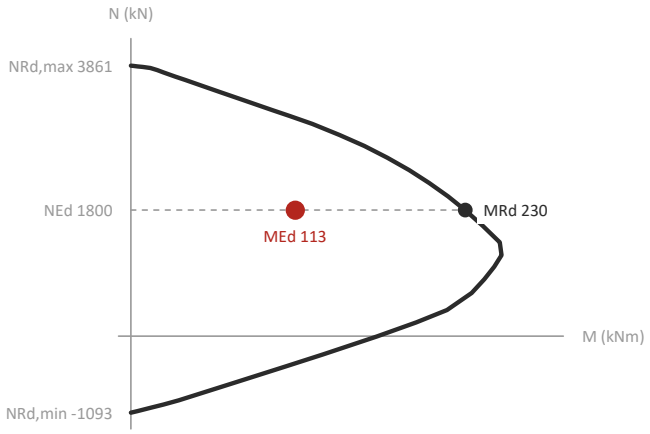


Results

	Bending at NEd MEd / MRd	**0.49**	**OK**

	Axial force NEd / NRd,max		**0.47**		**OK**
	Design moment (with second order effects when slender)	M_{Ed}	**113.0**	kNm	**! Slender**
	Detailing (bar size, areas, spacing, links) · As provided	A_s	**2513**	mm²	**OK**

N-M interaction curve · design point (red) · resistance at NEd



Calculation · materials and section

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
9.5.2(1)	Minimum diameter of longitudinal bars	φ_{min}	12	mm	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 αcc fck / γc (η = 1)	f_{cd}	18.13	MPa	
3.2.7	Design yield strength	f_{yd}	434.8	MPa	
3.2.7(4)	Modulus of elasticity of reinforcement	E_s	200000	MPa	
	Gross area b h	A_c	160000	mm²	
	Number of bars 2 nb + 2 (nh − 2)	n	8		
	Reinforcement area	A_s	2513	mm²	
	Centre of the corner bars from the face c + ϕw + ϕ/2	d_1	53	mm	
5.8.8.3(2)	Radius of gyration of the bars about the centroid	i_s	127.3	mm	
	Mechanical reinforcement ratio As fyd / (Ac fcd)	ω	0.377		
(5.13N)	Relative axial force NEd / (Ac fcd)	n	0.620		

Calculation · slenderness and design moment

5.8.3.2	Radius of gyration h / √12	i	115.5	mm	
(5.14)	Slenderness l0 / i	λ	36.8		
(5.13N)	A = 1 / (1 + 0.2 ϕef)	A	0.769		
(5.13N)	B = √(1 + 2ω)	B	1.324		
(5.13N)	Moment ratio M01 / M02	r_m	0.333		
(5.13N)	C = 1.7 − rm (braced); 0.7 unbraced or M02 ≤ NEd ei (imperfecti	C	1.367		
(5.13N)	Slenderness limit 20 A B C / √n	λ_{lim}	35.3		
5.2(5)	αh = 2 / √l, 2/3 ≤ αh ≤ 1 (l in m)	α_h	0.894		
(5.1)	Inclination θi = θ0 αh αm, θ0 = 1/200, αm = 1	ϑ_i	0.00447		
(5.2)	Eccentricity from imperfections θi l0 / 2	e_i	9.5	mm	
5.8.8.2(2)	End moments with imperfections M02 + NEd ei	$M_{02'}$	77.1	kNm	
5.8.8.2(2)	M01 + NEd ei	$M_{01'}$	37.1	kNm	
6.1(4)	Minimum eccentricity max(h / 30; 20 mm)	e_0	20.0	mm	

(5.36)	Kr = (nu − n) / (nu − nbal) ≤ 1, nu = 1 + ω, nbal = 0.4	K_r	0.774		
(5.37)	β = 0.35 + fck/200 − λ/150	β	0.265		
(5.37)	Kϕ = 1 + β ϕef ≥ 1	K_φ	1.397		
5.8.8.3(2)	Effective depth h/2 + is	d	327.3	mm	
(5.34)	Curvature Kr Kϕ εyd / (0.45 d)	$1/r$	1.60E-05	1/mm	
(5.33)	Second order eccentricity (1/r) l0² / c	e_2	28.8	mm	
(5.31)	Second order moment NEd e2 (slender columns only)	M_2	51.9	kNm	
(5.32)	Equivalent first order moment 0.6 M02 + 0.4 M01 ≥ 0.4 M02	M_{0e}	61.1	kNm	
5.8.8.2	Design moment max(M0e + M2; M02; M01 + M2/2; NEd e0)	M_{Ed}	**113.0**	kNm	

Calculation · resistance (see the Interaction sheet)

6.1(5)	Axial resistance in compression (uniform strain εc2 = 0.002)	$N_{Rd,max}$	3861	kN	
6.1	Axial resistance in tension −As fyd	$N_{Rd,min}$	-1093	kN	
	Largest sampled moment on the curve (scale of the chart)	M_{max}	255.1	kNm	
6.1	Neutral axis depth with N = NEd (bisection, Interaction sheet)	x	261	mm	
6.1	Axial force at that depth (check: = NEd)	N	1800.0	kN	
6.1	Moment resistance at NEd	M_{Rd}	**230.0**	kNm	
6.1	Axial force NEd ≤ NRd,max	N_{Ed}	1800	kN	**OK**
6.1	Moment MEd ≤ MRd	M_{Ed}	113.0	kNm	**OK**

Calculation · detailing (9.5)

(9.12N)	Minimum reinforcement max(0.10 NEd / fyd; 0.002 Ac)	$A_{s,min}$	414	mm²	
9.5.2(3)	Maximum reinforcement 0.04 Ac (outside laps)	$A_{s,max}$	6400	mm²	
8.2(2)	Minimum clear gap max(ϕ; dg + 5; 20)	a_{min}	25	mm	
	Clear gap along b (b − 2d1)/(nb − 1) − ϕ	a_b	127	mm	
	Clear gap along h (h − 2d1)/(nh − 1) − ϕ	a_h	127	mm	
9.5.3(1)	Minimum link diameter max(6; ϕ / 4)	$\varphi_{w,min}$	6.0	mm	
9.5.3(3)	Maximum link spacing min(20 ϕ; b; h; 400)	$s_{cl,tmax}$	400	mm	
9.5.3(6)	Largest clear distance from a free bar to a restrained bar	s_{free}	127	mm	Corners and tied bars restrained
(9.12N)	Reinforcement As ≥ As,min	A_s	2513	mm²	**OK**
9.5.2(3)	Reinforcement As ≤ As,max	A_s	2513	mm²	**OK**
9.5.2(1)	Bar diameter ϕ ≥ ϕmin	φ	20	mm	**OK**
8.2(2)	Clear gaps min(ab; ah) ≥ a_min		127	mm	**OK**
9.5.3(1)	Link diameter ϕw ≥ ϕw,min	φ_w	8	mm	**OK**
9.5.3(3)	Link spacing s ≤ s_cl,tmax	s	250	mm	**OK**
9.5.3(6)	Every bar within 150 mm of a restrained bar	s_{free}	127	mm	**OK**

Not in the detailing status: reduce the link spacing by 0.6 within a distance equal to the larger dimension of the column above and below a beam or slab, and at laps of bars over 14 mm, with at least three links in the lap length (9.5.3(4)). φmin: UK NA 12 mm, PL NA.6 6 mm.

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N-M interaction · strain compatibility, EN 1992-1-1 §6.1

Parabola-rectangle of 3.1.7(1), (3.17): εc2 = 0.002, εcu2 = 0.0035, n = 2, fcd = αcc fck / γc, no tension. Strain limits of 6.1(5), Fig. 6.1: 0.0035 at the compressed face while x ≤ h; once the whole section is compressed, 0.002 at 3h/7 from that face, down to the uniform 0.002. Bars elastic-plastic, Es = 200 GPa, horizontal branch (3.2.7(2)b); the concrete displaced by the bars is deducted at the concrete stress at each bar centre. zc: depth in compression, min(x, h). M about the centroid of the gross section, compression positive.

	x (mm)	zc (mm)	N (kN)	M (kNm)
1	tension	0	-1092.7	0.0
2	4	4	-1069.2	4.7
3	12	12	-1022.3	13.7
4	20	20	-975.3	22.5
5	30	30	-916.6	33.0
6	40	40	-662.5	71.8
7	50	50	-429.0	107.0
8	60	60	-259.9	132.3
9	80	80	-4.8	169.2
10	100	100	197.7	196.4
11	120	120	372.9	217.6
12	140	140	616.5	234.5
13	160	160	812.4	243.3
14	180	180	991.0	250.2
15	200	200	1157.3	255.1
16	220	220	1340.3	253.9
17	240	240	1575.4	242.1
18	260	260	1792.7	230.4
19	280	280	1996.0	218.3
20	300	300	2188.0	205.4
21	320	320	2370.9	191.6
22	340	340	2546.1	176.7
23	360	360	2712.9	160.8
24	380	380	2873.7	143.6
25	400	400	3030.5	124.9
26	420	400	3140.1	109.5
27	440	400	3227.8	97.2
28	480	400	3358.5	78.9
29	540	400	3486.2	61.0
30	600	400	3568.4	49.6
31	700	400	3653.6	37.7
32	800	400	3705.4	30.5
33	1000	400	3764.0	22.5
34	1200	400	3795.7	18.1
35	1600	400	3827.1	13.4
36	2400	400	3842.5	8.1
37	4000	400	3851.6	4.5
38	10000	400	3857.9	1.7
39	uniform	400	3861.1	0.0

The table draws the curve. MRd at NEd below: bisection on the strain state s (0 to 1: x = s h; 1 to 2: t = 2 − s, whole section compressed

step	s low	s high	x (mm)	zc (mm)	N (kN)	M (kNm)
1	0.000000	2.000000	400.0	400.0	3030.5	124.9
2	0.000000	1.000000	200.0	200.0	1157.3	255.1
3	0.500000	1.000000	300.0	300.0	2188.0	205.4
4	0.500000	0.750000	250.0	250.0	1686.0	236.3
5	0.625000	0.750000	275.0	275.0	1946.4	221.4
6	0.625000	0.687500	262.5	262.5	1818.8	228.9
7	0.625000	0.656250	256.3	256.3	1753.1	232.6
8	0.640625	0.656250	259.4	259.4	1786.2	230.8
9	0.648438	0.656250	260.9	260.9	1802.6	229.8
10	0.648438	0.652344	260.2	260.2	1794.4	230.3
11	0.650391	0.652344	260.5	260.5	1798.5	230.1
12	0.651367	0.652344	260.7	260.7	1800.5	230.0
13	0.651367	0.651855	260.6	260.6	1799.5	230.0
14	0.651611	0.651855	260.7	260.7	1800.0	230.0
15	0.651733	0.651855	260.7	260.7	1800.3	230.0
16	0.651733	0.651794	260.7	260.7	1800.1	230.0
17	0.651733	0.651764	260.7	260.7	1800.1	230.0
18	0.651733	0.651749	260.7	260.7	1800.0	230.0
19	0.651733	0.651741	260.7	260.7	1800.0	230.0
20	0.651733	0.651737	260.7	260.7	1800.0	230.0
21	0.651733	0.651735	260.7	260.7	1800.0	230.0
22	0.651733	0.651734	260.7	260.7	1800.0	230.0
23	0.651734	0.651734	260.7	260.7	1800.0	230.0
24	0.651734	0.651734	260.7	260.7	1800.0	230.0
25	0.651734	0.651734	260.7	260.7	1800.0	230.0
26	0.651734	0.651734	260.7	260.7	1800.0	230.0
27	0.651734	0.651734	260.7	260.7	1800.0	230.0
28	0.651734	0.651734	260.7	260.7	1800.0	230.0
29	0.651734	0.651734	260.7	260.7	1800.0	230.0
30	0.651734	0.651734	260.7	260.7	1800.0	230.0
31	0.651734	0.651734	260.7	260.7	1800.0	230.0
32	0.651734	0.651734	260.7	260.7	1800.0	230.0
33	0.651734	0.651734	260.7	260.7	1800.0	230.0
34	0.651734	0.651734	260.7	260.7	1800.0	230.0
35	0.651734	0.651734	260.7	260.7	1800.0	230.0
36	0.651734	0.651734	260.7	260.7	1800.0	230.0
37	0.651734	0.651734	260.7	260.7	1800.0	230.0
38	0.651734	0.651734	260.7	260.7	1800.0	230.0
39	0.651734	0.651734	260.7	260.7	1800.0	230.0
40	0.651734	0.651734	260.7	260.7	1800.0	230.0
41	0.651734	0.651734	260.7	260.7	1800.0	230.0
42	0.651734	0.651734	260.7	260.7	1800.0	230.0
43	0.651734	0.651734	260.7	260.7	1800.0	230.0
44	0.651734	0.651734	260.7	260.7	1800.0	230.0
45	0.651734	0.651734	260.7	260.7	1800.0	230.0
46	0.651734	0.651734	260.7	260.7	1800.0	230.0
47	0.651734	0.651734	260.7	260.7	1800.0	230.0
48	0.651734	0.651734	260.7	260.7	1800.0	230.0
49	0.651734	0.651734	260.7	260.7	1800.0	230.0

50	0.651734	0.651734	260.7	260.7	1800.0	230.0
51	0.651734	0.651734	260.7	260.7	1800.0	230.0
52	0.651734	0.651734	260.7	260.7	1800.0	230.0
53	0.651734	0.651734	260.7	260.7	1800.0	230.0
54	0.651734	0.651734	260.7	260.7	1800.0	230.0
55	0.651734	0.651734	260.7	260.7	1800.0	230.0
56	0.651734	0.651734	260.7	260.7	1800.0	230.0
57	0.651734	0.651734	260.7	260.7	1800.0	230.0
58	0.651734	0.651734	260.7	260.7	1800.0	230.0
59	0.651734	0.651734	260.7	260.7	1800.0	230.0
60	0.651734	0.651734	260.7	260.7	1800.0	230.0

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 γc	2.4.2.4(1)	**1.5**	**1.4**	Persistent & transient. UK NA: recommended; PL: NA.2, Table NA.2
Partial factor, reinforcement γs	2.4.2.4(1)	**1.15**	**1.15**	UK NA: recommended; PL: NA.2, Table NA.2
αcc (compression in flexure / axial)	3.1.6(1)	**0.85**	**1**	UK NA: 0.85; PL: recommended (NA.9)
αcc,pl (plain concrete, compression)	12.3.1(1)	**0.6**	**0.8**	UK NA Table NA.1: 0.6; PL: recommended (NA.9)
αcc (shear and punching)	3.1.6(1)	**1**	**1**	UK NA: 1.0 for other phenomena; PL: recommended (NA.9)
αct (design tensile strength)	3.1.6(2)	**1**	**1**	Recommended value in both annexes
CRd,c numerator (CRd,c = value / γc)	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
vRd,max factor (vRd,max = factor · ν · fcd)	6.4.5(3)	**0.5**	**0.4**	UK NA: 0.5 ν fcd; PL: recommended value (NA.9), 0.4 ν fcd since EN 1992-1-1 AC:2010 (PN-EN 1992-1-1:200
kmax (vEd ≤ kmax · vRd,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
ϕlarge (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 ≤ cot θ ≤ 2.0
k1 (x/d limit, δ ≥ k1 + k2 xu/d)	5.5(4)	**0.4**	**0.44**	UK NA for fyk ≤ 500 MPa; PL: recommended (NA.9)
k2 (x/d limit, εcu2 = 0.0035)	5.5(4)	**1**	**1.25**	UK NA: 0.6 + 0.0014/εcu2; PL: 1.25(0.6 + 0.0014/εcu2)
Upper limit on the (310/σs) factor (0 = none)	7.4.2(2)	**1.5**	**0**	UK NA Table NA.5 Note 5: (310/σs) or (500/fyk)(As,prov/As,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
ϕmin (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
k1 (concrete stress, characteristic; XD, XF, XS)	7.2(2)	**0.6**	**1**	UK NA: recommended; PL: NA.5, k1 = 1.0
k2 (concrete stress, quasi-permanent; linear cı	7.2(3)	**0.45**	**0.45**	Recommended value in both annexes (UK NA; PL NA.9)
k3 (steel stress, characteristic)	7.2(5)	**0.8**	**0.8**	Recommended value in both annexes (UK NA; PL NA.9)
k4 (steel stress, imposed deformation)	7.2(5)	**1**	**1**	Recommended value in both annexes (UK NA; PL NA.9)