Biaxial bending

Rectangular columns in biaxial bending · EN 1992-1-1 §5.8.9, §6.1 · UK NA / PN-EN

Reference	NAE-RC-042 · 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

Check of a rectangular reinforced concrete column under an axial force with design moments about both axes: the criteria of 5.8.9(3) for when a separate check in each direction is enough, the uniaxial moment resistances at NEd by strain compatibility, and the interaction (5.39).

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 of width b and nh bars (corners included) on each face of width h, as in RC-008. MEd,y bends the section in the plane of h (about the axis parallel to b), MEd,z in the plane of b. The design moments are entered with second order effects included, from RC-008 for each axis; imperfections need only be included in the direction where they have the most unfavourable effect (5.8.9(2)). Slenderness ratios λy / λz from the effective lengths entered, i = h / √12 and b / √12; in (5.38b) each eccentricity is taken relative to the side in its direction: ey = MEd,z / NEd over b and ez = MEd,y / NEd over h. Uniaxial resistances MRd,y and MRd,z at NEd by strain compatibility (parabola-rectangle concrete of 3.1.7(1) with the strain limits of 6.1(5), bars elastic-plastic, concrete displaced by the bars deducted; bisection on the strain state). (5.39) with NRd = Ac fcd + As fyd and a = 1.0, 1.5, 2.0 at NEd / NRd = 0.1, 0.7, 1.0, interpolated linearly. Compression only (NEd > 0). Concrete classes up to C50/60, fyk ≤ 500 MPa. Detailing to 9.5 as in RC-008.
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 (biaxial bending).
- 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

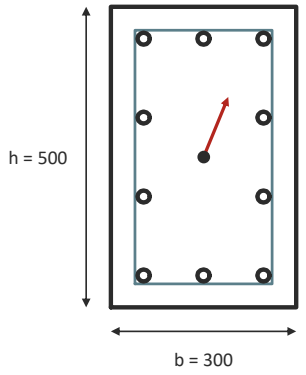
	National Annex		**UK NA (BS EN)**	
Table 3.1	Concrete strength class		**C32/40**	
3.2.2	Reinforcement characteristic yield strength (≤ 500 MPa)	f_{yk}	**500**	MPa
	Section width b	b	**300**	mm
	Section depth h	h	**500**	mm
4.4.1	Nominal cover to links	c_{nom}	**35**	mm
	Link diameter	φ_w	**8**	mm
	Bar diameter	φ	**20**	mm
	Bars on each face of width b (corners included)	n_b	**3**	
	Bars on each face of width h (corners included)	n_h	**4**	

Inputs · design actions

ULS, second order effects included

	Design axial force (compression)	N_{Ed}	**1500**	kN
	Design moment in the plane of h (either sign)	$M_{Ed,y}$	**150.0**	kNm
	Design moment in the plane of b (either sign)	$M_{Ed,z}$	**60.0**	kNm
5.8.3.2	Effective length for bending in the plane of h	$l_{0,y}$	**3500**	mm
5.8.3.2	Effective length for bending in the plane of b	$l_{0,z}$	**3500**	mm
	Inputs valid and consistent			**OK**

Your section, to scale · MEd,y bends it in the plane of h, MEd,z in the plane of b · the arrow shows the resultant eccentricity



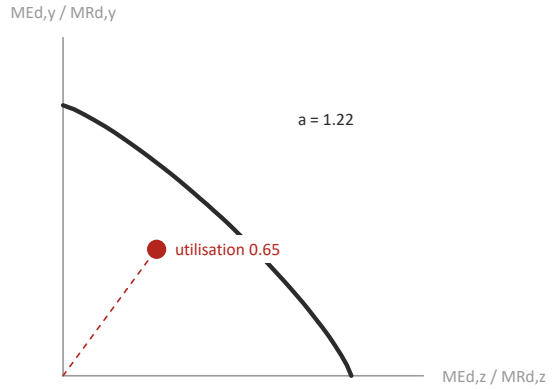
e_z 100 · e_y 40 mm

10 × ϕ20 · links ϕ8

Results

Biaxial interaction (5.39)	**0.65**	OK
Uniaxial MEd,y / MRd,y	**0.47**	OK
Uniaxial MEd,z / MRd,z	**0.32**	OK
Axial force NEd / NRd,max	**0.38**	OK
Biaxial check needed (5.8.9(3))	**Yes**	**Required**

Interaction (5.39) · (MEd,y / MRd,y)^a + (MEd,z / MRd,z)^a = 1 for the a at NEd · design point (red)



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
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	f_{cd}	18.13	MPa	
3.2.7	Design yield strength	f_{yd}	434.8	MPa	
	Gross area b h	A_c	150000	mm²	
	Number of bars 2 nb + 2 (nh − 2)	n	10		
	Reinforcement area	A_s	3142	mm²	
6.1(5)	Axial resistance (uniform strain εc2 = 0.002)	$N_{Rd,max}$	3920	kN	
6.1	Axial force NEd ≤ NRd,max	N_{Ed}	1500	kN	OK

Calculation · when a biaxial check is needed, 5.8.9(3)

(5.14)	Slenderness in the plane of h l0,y √12 / h	λ_y	24.2		
(5.14)	Slenderness in the plane of b l0,z √12 / b	λ_z	40.4		
(5.38a)	λy / λz		0.60		
(5.38b)	Eccentricity along h ez = MEd,y / NEd	e_z	100.0	mm	
(5.38b)	Eccentricity along b ey = MEd,z / NEd	e_y	40.0	mm	
(5.38b)	(ey / beq) / (ez / heq) (no moment: ∞ shown as 9999)		0.667		
5.8.9(3)	λ ratio within 0.5 to 2 and eccentricity ratio ≤ 0.2 or ≥ 5		not met		**Biaxial**

Calculation · resistances and (5.39) (see the Interaction sheet)

6.1	Moment resistance in the plane of h at NEd	$M_{Rd,y}$	**320.3**	kNm	
6.1	Neutral axis depth from the compressed face (check: N = NEd)	x_y	297	mm	
6.1	Moment resistance in the plane of b at NEd	$M_{Rd,z}$	**185.2**	kNm	
6.1	Neutral axis depth from the compressed face (check: N = NEd)	x_z	175	mm	

5.8.9(4)	NRd = Ac fcd + As fyd	N_{Rd}	4086	kN	
5.8.9(4)	NEd / NRd		0.367		
5.8.9(4)	Exponent a (1.0 at ≤ 0.1, 1.5 at 0.7, 2.0 at 1.0, linear)	a	1.223		
(5.39)	(|MEd,y| / MRd,y)^a + (|MEd,z| / MRd,z)^a		**0.648**		
(5.39)	Interaction ≤ 1		0.648		**OK**

The moments are design values about each axis, second order effects and the imperfection included (RC-008 for each axis). Where (5.38a) and (5.38b) are met, the uniaxial checks are enough (5.8.9(3)); the interaction (5.39) is shown anyway. Detailing is not checked here: use RC-008.

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Uniaxial resistances at NEd · 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. Bisection on the strain state s (0 to 1: x = s D; 1 to 2: whole section compressed, uniform strain at s = 2) until N = NEd, for each axis; with the bars symmetrical N rises with s, so the root is unique.

Bending in the plane of h

step	s low	s high	x (mm)	zc (mm)	N (kN)	M (kNm)
1	0.000000	2.000000	500.0	500.0	3072.7	164.4
2	0.000000	1.000000	250.0	250.0	1075.8	333.5
3	0.500000	1.000000	375.0	375.0	2194.0	267.3
4	0.500000	0.750000	312.5	312.5	1650.4	309.9
5	0.500000	0.625000	281.3	281.3	1330.6	331.6
6	0.562500	0.625000	296.9	296.9	1495.2	320.6
7	0.593750	0.625000	304.7	304.7	1573.9	315.2
8	0.593750	0.609375	300.8	300.8	1534.9	317.9
9	0.593750	0.601563	298.8	298.8	1515.1	319.2
10	0.593750	0.597656	297.9	297.9	1505.2	319.9
11	0.593750	0.595703	297.4	297.4	1500.2	320.3
12	0.593750	0.594727	297.1	297.1	1497.7	320.4
13	0.594238	0.594727	297.2	297.2	1499.0	320.3
14	0.594482	0.594727	297.3	297.3	1499.6	320.3
15	0.594604	0.594727	297.3	297.3	1499.9	320.3
16	0.594666	0.594727	297.3	297.3	1500.1	320.3
17	0.594666	0.594696	297.3	297.3	1500.0	320.3
18	0.594681	0.594696	297.3	297.3	1500.0	320.3
19	0.594681	0.594688	297.3	297.3	1500.0	320.3
20	0.594681	0.594685	297.3	297.3	1500.0	320.3
21	0.594683	0.594685	297.3	297.3	1500.0	320.3
22	0.594683	0.594684	297.3	297.3	1500.0	320.3
23	0.594683	0.594684	297.3	297.3	1500.0	320.3
24	0.594683	0.594684	297.3	297.3	1500.0	320.3
25	0.594684	0.594684	297.3	297.3	1500.0	320.3
26	0.594684	0.594684	297.3	297.3	1500.0	320.3
27	0.594684	0.594684	297.3	297.3	1500.0	320.3
28	0.594684	0.594684	297.3	297.3	1500.0	320.3
29	0.594684	0.594684	297.3	297.3	1500.0	320.3
30	0.594684	0.594684	297.3	297.3	1500.0	320.3
31	0.594684	0.594684	297.3	297.3	1500.0	320.3
32	0.594684	0.594684	297.3	297.3	1500.0	320.3
33	0.594684	0.594684	297.3	297.3	1500.0	320.3
34	0.594684	0.594684	297.3	297.3	1500.0	320.3
35	0.594684	0.594684	297.3	297.3	1500.0	320.3
36	0.594684	0.594684	297.3	297.3	1500.0	320.3
37	0.594684	0.594684	297.3	297.3	1500.0	320.3
38	0.594684	0.594684	297.3	297.3	1500.0	320.3
39	0.594684	0.594684	297.3	297.3	1500.0	320.3
40	0.594684	0.594684	297.3	297.3	1500.0	320.3

41	0.594684	0.594684	297.3	297.3	1500.0	320.3
42	0.594684	0.594684	297.3	297.3	1500.0	320.3
43	0.594684	0.594684	297.3	297.3	1500.0	320.3
44	0.594684	0.594684	297.3	297.3	1500.0	320.3
45	0.594684	0.594684	297.3	297.3	1500.0	320.3
46	0.594684	0.594684	297.3	297.3	1500.0	320.3
47	0.594684	0.594684	297.3	297.3	1500.0	320.3
48	0.594684	0.594684	297.3	297.3	1500.0	320.3
49	0.594684	0.594684	297.3	297.3	1500.0	320.3
50	0.594684	0.594684	297.3	297.3	1500.0	320.3
51	0.594684	0.594684	297.3	297.3	1500.0	320.3
52	0.594684	0.594684	297.3	297.3	1500.0	320.3
53	0.594684	0.594684	297.3	297.3	1500.0	320.3
54	0.594684	0.594684	297.3	297.3	1500.0	320.3
55	0.594684	0.594684	297.3	297.3	1500.0	320.3
56	0.594684	0.594684	297.3	297.3	1500.0	320.3
57	0.594684	0.594684	297.3	297.3	1500.0	320.3
58	0.594684	0.594684	297.3	297.3	1500.0	320.3
59	0.594684	0.594684	297.3	297.3	1500.0	320.3
60	0.594684	0.594684	297.3	297.3	1500.0	320.3

Bending in the plane of b

step	s low	s high	x (mm)	zc (mm)	N (kN)	M (kNm)
1	0.000000	2.000000	300.0	300.0	3077.7	92.4
2	0.000000	1.000000	150.0	150.0	1078.2	200.2
3	0.500000	1.000000	225.0	225.0	2226.2	152.3
4	0.500000	0.750000	187.5	187.5	1702.0	177.0
5	0.500000	0.625000	168.8	168.8	1399.1	189.2
6	0.562500	0.625000	178.1	178.1	1554.8	183.0
7	0.562500	0.593750	173.4	173.4	1478.1	186.1
8	0.578125	0.593750	175.8	175.8	1516.8	184.5
9	0.578125	0.585938	174.6	174.6	1497.5	185.3
10	0.582031	0.585938	175.2	175.2	1507.2	184.9
11	0.582031	0.583984	174.9	174.9	1502.4	185.1
12	0.582031	0.583008	174.8	174.8	1499.9	185.2
13	0.582520	0.583008	174.8	174.8	1501.1	185.2
14	0.582520	0.582764	174.8	174.8	1500.5	185.2
15	0.582520	0.582642	174.8	174.8	1500.2	185.2
16	0.582520	0.582581	174.8	174.8	1500.1	185.2
17	0.582520	0.582550	174.8	174.8	1500.0	185.2
18	0.582520	0.582535	174.8	174.8	1500.0	185.2
19	0.582527	0.582535	174.8	174.8	1500.0	185.2
20	0.582531	0.582535	174.8	174.8	1500.0	185.2
21	0.582531	0.582533	174.8	174.8	1500.0	185.2
22	0.582531	0.582532	174.8	174.8	1500.0	185.2
23	0.582531	0.582532	174.8	174.8	1500.0	185.2
24	0.582532	0.582532	174.8	174.8	1500.0	185.2
25	0.582532	0.582532	174.8	174.8	1500.0	185.2

26	0.582532	0.582532	174.8	174.8	1500.0	185.2
27	0.582532	0.582532	174.8	174.8	1500.0	185.2
28	0.582532	0.582532	174.8	174.8	1500.0	185.2
29	0.582532	0.582532	174.8	174.8	1500.0	185.2
30	0.582532	0.582532	174.8	174.8	1500.0	185.2
31	0.582532	0.582532	174.8	174.8	1500.0	185.2
32	0.582532	0.582532	174.8	174.8	1500.0	185.2
33	0.582532	0.582532	174.8	174.8	1500.0	185.2
34	0.582532	0.582532	174.8	174.8	1500.0	185.2
35	0.582532	0.582532	174.8	174.8	1500.0	185.2
36	0.582532	0.582532	174.8	174.8	1500.0	185.2
37	0.582532	0.582532	174.8	174.8	1500.0	185.2
38	0.582532	0.582532	174.8	174.8	1500.0	185.2
39	0.582532	0.582532	174.8	174.8	1500.0	185.2
40	0.582532	0.582532	174.8	174.8	1500.0	185.2
41	0.582532	0.582532	174.8	174.8	1500.0	185.2
42	0.582532	0.582532	174.8	174.8	1500.0	185.2
43	0.582532	0.582532	174.8	174.8	1500.0	185.2
44	0.582532	0.582532	174.8	174.8	1500.0	185.2
45	0.582532	0.582532	174.8	174.8	1500.0	185.2
46	0.582532	0.582532	174.8	174.8	1500.0	185.2
47	0.582532	0.582532	174.8	174.8	1500.0	185.2
48	0.582532	0.582532	174.8	174.8	1500.0	185.2
49	0.582532	0.582532	174.8	174.8	1500.0	185.2
50	0.582532	0.582532	174.8	174.8	1500.0	185.2
51	0.582532	0.582532	174.8	174.8	1500.0	185.2
52	0.582532	0.582532	174.8	174.8	1500.0	185.2
53	0.582532	0.582532	174.8	174.8	1500.0	185.2
54	0.582532	0.582532	174.8	174.8	1500.0	185.2
55	0.582532	0.582532	174.8	174.8	1500.0	185.2
56	0.582532	0.582532	174.8	174.8	1500.0	185.2
57	0.582532	0.582532	174.8	174.8	1500.0	185.2
58	0.582532	0.582532	174.8	174.8	1500.0	185.2
59	0.582532	0.582532	174.8	174.8	1500.0	185.2
60	0.582532	0.582532	174.8	174.8	1500.0	185.2

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)