	Project details				
mpa The Concrete Centre	**V1.2 Stocky perimeter column in internal environment**	Calculated by	**MM**	Job no.	**V1**
		Checked by	**CIEG**	Sheet no.	**1/14**
		Client	**TCC**	Date	**Nov 2026**

Example

The 325 x 325 mm perimeter column shown in Figures V1.2.1 and V1.2.2 is in the internal environment and supports three suspended floors and the roof of an office block. It is to be designed at ground floor level where the clear height is 3.0 m about the z-direction and 3.325 m about the y-direction. A 30 minutes fire resistance is required. C30/37 concrete is used.

From first order analysis:

Load case 1:

N_{Ed} = **1101.5 kN**
M_{02y} = **89.6 kNm**
M_{02z} = **12.5 kNm**

Load case 2:

N_{Ed} = **1072.1 kN**
M_{02y} = **68.7 kNm**
M_{02z} = **11.0 kNm**

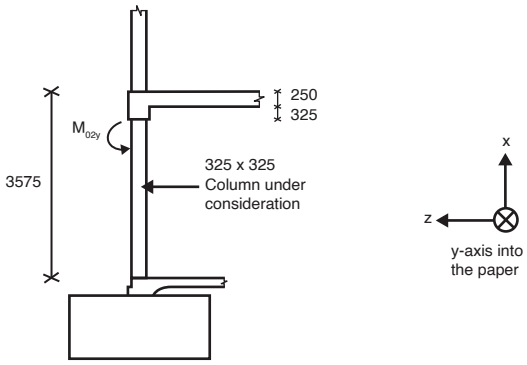


Figure V1.2.1: Perimeter column (internal environment)

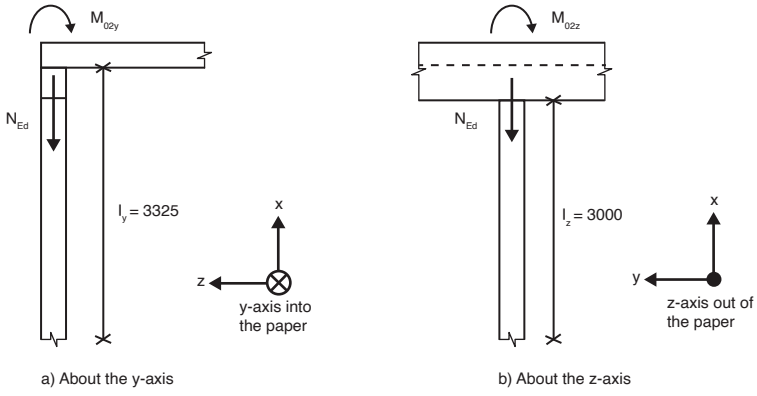


Figure V1.2.2: Actions on the perimeter column in the y- and z-axes

	Project details				
mpa The Concrete Centre	**V1.2 Stocky perimeter column in internal environment**	Calculated by	**MM**	Job no.	**V1**
		Checked by	**CIEG**	Sheet no.	**2/14**
		Client	**TCC**	Date	**Nov 2026**

General notes:

This worked example is intended to show a hand calculation for the design of a stocky column using column design charts. It also checks the cover required for durability, bond and fire.

The loads and moments in this worked example are given for two load combinations. In practice, all column load combinations should be considered one by one.

All calculations are carried out in a spreadsheet format where the outcome is not rounded and it is the unrounded value that is used in any further calculation.

This worked example is based on the versions of the codes of practice, guidance documents and publications as noted in the List of References. The user is responsible for ensuring that they use the latest version of the documents.

Abbreviations

General:	Cl.	Clause
	F.	Formula
	Fig.	Figure
	WE	Worked example
Codes of practice:	EC2-1-1	BS EN 1992-1-1:2023 [1]
	EC2-1-2	BS EN 1992-1-2:2023 [2]
	NA EC2-1-1	NA to BS EN 1992-1-1:2026 [3]
	PD 6687	PD 6687:2026 [4]
Guidance documents:	V1. How to	V1 - How to: Stocky columns [5]
	WE V1.1	Stocky edge column [6]

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **3/14**
		Client **TCC**	Date **Nov 2026**

V1.2.1 Column effective length

Effective length:

$l_0 = kl$ — NA EC2-1-1: Cl. NA.4.113

a) About the y-axis

l = clear column height = 3325 mm

k = effective length factor for braced column: The column is in condition 3 at top* and bottom (assumed pinned support) = 1.00 — NA EC2-1-1: Table NA.9

$\therefore l_{0y} = 3325 \times 1$ = **3325 mm**

b) About the z-axis

l = column length = 3000 mm

k = effective length factor for braced column: The column is in condition 1 at top** and condition 3 at bottom (assumed pinned) = 0.90 — NA EC2-1-1: Table NA.9

$\therefore l_{0z} = 3000 \times 0.9$ = **2700 mm**

V1.2.2 Determine first order end moments: M_{01}, M_{02} and M_{0Ed}

Note:

The first order end moments are denoted M_{01} and M_{02} and include the unfavourable effects of imperfections and the position of loads. $|M_{02}| > |M_{01}|$. M_{0Ed} is the maximum first order moment due to the fundamental load combination, also including the effect of imperfections. — EC2-1-1: Cl.3.2.1 & NA EC2-1-1: Cl. NA.4.114

$M_{01} = M_{btm} + e_i|N_{Ed}|$ — EC2-1-1: Fig. O.1

$M_{02} = M_{top} + e_i|N_{Ed}|$ — EC2-1-1: Fig. O.1

where:

The effect for imperfections, e_i:

$e_i = \theta_i l_0/2$ — EC2-1-1: F. (7.5)

where:

column inclination, θ_i:

$\theta_i = \alpha_h \alpha_m/200$ — EC2-1-1: F. (7.1)

reduction coefficient for height, α_h:

$0.4 \le \alpha_h = 2/l^{0.5} \le 1.0$ — EC2-1-1: F. (7.2)

a) About the y-axis

$l^{\dagger} = 3325/1000$ = 3.325 m — EC2-1-1: Cl. 7.2.1.2 (3)

$2/l^{0.5} = 2/(3.325)^{0.5}$ = 1.1 — EC2-1-1: F. (7.2)

$\therefore \alpha_h$ = 1.0 — EC2-1-1: F. (7.2)

$\therefore$ use simplification‡: $\theta_i = 1/200$ = 0.005 — EC2-1-1: Cl. 7.2.1.2 (5b)

$\therefore e_{iy} = 0.005 \times 3325/2$ = **8.3 mm**

(Alternatively, use simplification: $e_i = l_0/400^{\S}$) — EC2-1-1: Cl. 7.2.1.2 (5a)

---

* The slab is 250 mm deep and is shallower than the overall dimension of the column (325 mm). However, because the slab restrains the column on one side only, the top cannot be considered as condition 2. The value of k lies within the range $0.85 < k < 1$, with $k = 1$ being the most conservative. — NA EC2-1-1: Cl. NA.4.113

** The total depth of the beam downstand and slab is 575 mm, which is deeper than the overall dimension of the column i.e. 325 mm. — NA EC2-1-1: Cl. NA.4.113

† The length 'l' is the actual column height.

‡ The simplification corresponds to $\alpha_h = 1.0$ (refer to EC2-1-1 Cl. 7.2.1.2 (5b)).

§ In this case, the simplification gives an accurate estimation of e_{iy} and e_{iz} because $\alpha_h = 1.0$ for a column of $l \le 4$ m.

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **4/14**
		Client **TCC**	Date **Nov 2026**

b) About the z-axis

$l^{\dagger} = 3000/1000$	=	3.0 m	EC2-1-1: Cl. 7.2.1.2 (3)
$2/l^{0.5} = 2/(3)^{0.5}$	=	1.2	EC2-1-1: F. (7.2)
$\therefore \alpha_h$	=	1.0	EC2-1-1: F. (7.2)
$\therefore$ use simplification[‡]: $\theta_i = 1/200$	=	0.005	EC2-1-1: Cl. 7.2.1.2 (5b)
$\therefore e_{iz} = 0.005 \times 3325/2$	=	**6.8 mm**	
(Alternatively, use simplification: $e_i = l_0/400$[§])			EC2-1-1: Cl. 7.2.1.2 (5a)

Summary of first order end moments (including imperfections)

Load case 1:

$M_{01y} = 0 + 8.3 \times \lvert 1101.5 \rvert/1000$	=	**9.2 kNm**
$M_{01z} = 0 + 6.8 \times \lvert 1101.5 \rvert/1000$	=	**7.4 kNm**
$M_{02y} = 89.6 + 8.3 \times \lvert 1101.5 \rvert/1000$	=	**98.8 kNm**
$M_{02z} = 12.5 + 6.8 \times \lvert 1101.5 \rvert/1000$	=	**19.9 kNm**

Load case 2:

$M_{01y} = 0 + 8.3 \times \lvert 1072.1 \rvert/1000$	=	**8.9 kNm**
$M_{01z} = 0 + 6.8 \times \lvert 1072.1 \rvert/1000$	=	**7.2 kNm**
$M_{02y} = 68.7 + 8.3 \times \lvert 1072.1 \rvert/1000$	=	**77.6 kNm**
$M_{02z} = 11 + 6.8 \times \lvert 1072.1 \rvert/1000$	=	**18.2 kNm**

Maximum first order moment including the effect of imperfections, M_{0Ed}:

$M_{0Ed} = C_m M_{02}$ EC2-1-1: F. (O.14)

where:

$C_m = 0.6 + 0.4 r_m \geq 0.4$ EC2-1-1: F. (O.15)

To find r_m, first check if $|M_{02}| < 0.05\, N_{Ed}\, h$ EC2-1-1: F. (O.16)

a) About the y-axis

For load case 1:

$0.05 N_{Ed} h = 0.05 \times 1101.5 \times 325/1000$	=	17.9 kNm	
$\lvert M_{02y} \rvert = 98.8$ kNm > 17.9 kNm			
$\therefore r_{my} = M_{01y}/M_{02y} = 9.2/98.8$	=	0.09	EC2-1-1: F. (O.16)
$\therefore C_m = 0.6 + 0.4 \times 0.09 \geq 0.4$	=	0.64	
$\therefore M_{0Edy} = 0.64 \times 98.8$	=	**62.9 kNm**	

For load case 2:

$0.05 N_{Ed} h = 0.05 \times 1072.1 \times 325/1000$	=	17.4 kNm	
$\lvert M_{02y} \rvert = 77.6$ kNm > 17.4 kNm			
$\therefore r_{my} = M_{01y}/M_{02y} = 8.9/77.6$	=	0.11	EC2-1-1: F. (O.16)
$\therefore C_m = 0.6 + 0.4 \times 0.11 \geq 0.4$	=	0.65	
$\therefore M_{0Edy} = 0.65 \times 77.6$	=	**50.1 kNm**	

b) About the z-axis

For load case 1:

$\lvert M_{02z} \rvert = 19.9$ kNm > 17.9 kNm			
$\therefore r_{mz} = M_{01z}/M_{02z} = 7.4/19.9$	=	0.37	EC2-1-1: F. (O.16)
$\therefore C_m = 0.6 + 0.4 \times 0.37 \geq 0.4$	=	0.75	
$\therefore M_{0Edz} = 0.75 \times 19.9$	=	**14.9 kNm**	

For load case 2:

$\lvert M_{02z} \rvert = 18.2$ kNm > 17.4 kNm			
$\therefore r_{mz} = M_{01z}/M_{02z} = 7.2/18.2$	=	0.40	EC2-1-1: F. (O.16)
$\therefore r_{mz} = \max(0.37, 0.4)$	=	0.40	
$\therefore C_m = 0.6 + 0.4 \times 0.4 \geq 0.4$	=	0.76	
$\therefore M_{0Edz} = 0.76 \times 18.2$	=	**13.8 kNm**	

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **5/14**
		Client **TCC**	Date **Nov 2026**

Summary of maximum first order end moments M_{0Ed} (including imperfections)

Load case 1:

M_{0Edy} = **62.9 kNm**

M_{0Edz} = **14.9 kNm**

Load case 2:

M_{0Edy} = **50.1 kNm**

M_{0Edz} = **13.8 kNm**

V1.2.3 Concrete cover

Nominal cover, c_{nom}:

$c_{nom} = c_{min} + \Delta c_{dev}$ EC2-1-1: F. (6.1)

where:

$c_{min} = \max(c_{min,dur} + \Sigma\Delta c, c_{min,b}, 10\text{ mm})$ EC2-1-1: F. (6.2)

where:

$c_{min,dur}$ = minimum cover due to environmental conditions

Assuming XC1 using C30/37 concrete, BS 8500-1: Table A.1

$c_{min,dur}$ = 15 mm BS 8500-1: Table A.3

$\Sigma\Delta c$ = sum of applicable reductions and additions = 0 mm EC2-1-1: Cl. 6.5.2.1

Assuming maximum aggregate size = 20 mm < 32 mm,

$c_{min,b}$ = minimum cover due to bond = bar diameter EC2-1-1: Table 6.5

Assuming 16 mm main bars and 8 mm links

$\therefore c_{min,b}$ = 16 mm to main bars

$\therefore c_{min,b} = 16 - 8$ to links = 8 mm

say, $c_{min,b}$ to links = 10 mm

$\therefore c_{min} = \max(15 + 0, 10, 10)$ = **15 mm**

Δc_{dev} = allowance in design for deviation

Assuming no measurement of cover, Δc_{dev} = 10 mm EC2-1-1: Table 6.7

$\therefore c_{nom}$ to links = 15 + 10 = **25 mm**

$\therefore$ Provide a nominal cover to links of 25 mm

V1.2.4 Fire resistance

Note:

In this WE, Method B using Annex D of EC2-1-2 is used to check the fire resistance. For a 0.5 hour fire resistance, Table D.2 is used. The column reinforcement area and hence, the axial resistance N_{Rd} is unknown at the start of the column calculation. Hence, conservatively, the degree of utilisation $\mu_{fi} = |N_{Ed,fi}|/N_{Rd}$ is assumed to be 0.7. It is required to check the modified mechanical reinforcement degree, ω_{mod} at the end of the calculation.

Using Method B i.e. Annex D of EC2-1-2

$l_{0,fi}/l_0 = (l_{0,fi}/l)/(l_0/l)$

l_{0y}/l (as before from Section V1.2.1) = 1.00

l_{0z}/l (as before from Section V1.2.1) = 0.90

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **6/14**
		Client **TCC**	Date **Nov 2026**

For a ground floor column, $l_{0,fi}/l$	=	0.70*	EC2-1-2: Cl. 6.3.1 (5)
$\therefore$ max $l_{0,fi}/l_0 = 0.7/0.9$	=	**0.78**	
$\therefore$ $l_{0,fi} > 0.7\ l_0$			
For minimum column dimension b = 325 mm, minimum number of reinforcing bars for fire in the tensile and compressive side for columns with $l_{0,fi} \geq 0.7l_0$			
For $\omega_{mod} \leq 0.5$	=	3	EC2-1-2: Table D.1
For $0.5 \leq \omega_{mod} \leq 1.0$	=	3	EC2-1-2: Table D.1
Use minimum 3 bars per face			
Check the modified mechanical reinforcement degree at end of calculation			
Degree of utilisation:			
μ_{fi} (assumed)	=	0.70	EC2-1-2: Cl. 4.7 (2)
Assuming 8 mm stirrups and 12 mm main reinforcment:			
Axis distance of the main reinforcing steel bars:			
$a = 25 + 8 + 12/2$	=	**39 mm**	
$a \geq 1.5\phi_{sl} = 1.5 \times 12 = 18$ $\therefore$ OK			EC2-1-2: Cl. D.2 (9)
$a \approx 40$ mm			
First order eccentricity of the axial forces in fire:			
$e_0 = M_{0Ed,fi}/N_{Ed,fi}$			EC2-1-2: Cl. 6.3.2.2 (2b)
Assuming that the ratio $M_{0Ed,fi}/N_{Ed,fi} = M_{0Ed}/N_{Ed}$:			
Load case 1:			
N_{Ed}	=	1101.5 kN	
max M_{0Ed} = max(62.9, 14.9)	=	62.9 kNm	
$\therefore$ $e_0 = 62.9 \times 1000/1101.5$	=	**57 mm**	
Load case 2:			
N_{Ed}	=	1072.1 kN	
max M_{0Ed} = max(50.1, 13.8)	=	50.1 kNm	
$\therefore$ $e_0 = 50.1 \times 1000/1072.1$	=	**47 mm**	
Conservatively consider the maximum e_0	=	**57 mm**	
$l_{0,fi}/l_0$ = (as before)	=	0.78	
Conservatively use table for $l_{0,fi} = 1.0l_0$:			
For R30, $\mu_{fi} = 0.7$, b = 300 mm (conservatively) and a = 40 mm:			
For $e_0 = 20$ mm $\quad l_{0,max}$	=	4.4 m	EC2-1-2: Table D.2
For $e_0 = 0.5b = 162.5$ mm $\quad l_{0,max}$	=	3.8 m	EC2-1-2: Table D.2
Interpolating between values for $e_0 = 57$ mm, $\quad \mathbf{l_{0,max}}$	=	**4.2 m**	EC2-1-2: Cl. D.2 (10)
l_0 under ambient conditions (from Section V1.2.1) = 3.325 m (max) < $l_{0,max}$			
$\therefore$ Fire (using Method B) OK			EC2-1-2: Cl. D.2 (1)
$\therefore$ c_{nom} = 25 mm to stirrups OK (subject to confirming utilisation)			

* For a braced structure, EC2-1-2 states that the effective length of a column in the fire condition, $l_{0,fi}$ may be taken as 0.5l for an intermediate floor and 0.7l for a top floor. For the column in this WE, which is assessed at the ground floor level, it is assumed that there is sufficent rotational rigidity in the fire condition and it is conservatively assumed that $l_{0,fi}$ equals 0.7l, same as a top floor.

	Project details	Calculated by MM	Job no. V1
mpa The Concrete Centre	**V1.2 Stocky perimeter column in internal environment**	Checked by CIEG	Sheet no. 7/14
		Client TCC	Date Nov 2026

V1.2.5 Check slenderness, λ

Slenderness ratio:

$\lambda = l_0/i$ — EC2-1-1: F. (O.8)

where:

i = radius of gyration = $(I_c/A_c)^{0.5} = h/12^{0.5}$ for rectangular sections — EC2-1-1: Cl. O.5 (1)

$\therefore$ i = $325/12^{0.5}$ = 94 mm*

a) About the y-axis

$\therefore \lambda_y = 3325/94$ = **35.4**

(Alternatively, use How to simplified equation of $\lambda = 3.46 l_0/h$ for rectangular sections) — V1. How to: Fig V1.1

b) About the z-axis

$\therefore \lambda_z = 2700/94$ = **28.8**

(Alternatively, use How to simplified equation of $\lambda = 3.46 l_0/h$ for rectangular sections) — V1. How to: Fig V1.1

V1.2.6 Limiting slenderness, λ_{lim}

Note:

The column is subject to biaxial bending and the slenderness is checked separately in each principal plane of bending.
*EC2-1-1 Cl. 7.4.4 (3) states that for the biaxial check, imperfections should be considered in one direction only where they have the most unfavourable effect. However, to determine whether a column is stocky or slender in each direction, imperfections are considered about both the y- and z-axes**.*

EC2-1-1: Cl. O.6 (2)

a) About the y-axis

$\lambda_{lim} = 20ABC/n^{0.5}$ — EC2-1-1: F. (O.12)

where:

A = (default value) = 0.7 — EC2-1-1: Cl. O.6 (1)

$B = (1 + 2\omega)^{0.5}$ — EC2-1-1: Cl. O.6 (1)

where:

$\omega = A_s f_{yd}/(A_c f_{cd})$ — EC2-1-1: Cl. O.6 (1)

Assuming 3H12 per face (i.e. 8H12 total):

$f_{yd} = 500/1.15$ = 435 MPa

$f_{cd} = 30/1.5 \times 1 \times 1$ = 20.0 MPa† — EC2-1-1: F. (5.3) & F. (5.4)

$A_s = 8 \times 113$ = 905 mm²

$\omega = (905 \times 435)/(325 \times 325 \times 20)$ = 0.19

$\therefore B = (1 + 2 \times 0.19)^{0.5}$ = 1.17

(Alternatively, use How to look-up tables) — V1. How to: Table V1.9

$C = 1.7 - r_m$ — EC2-1-1: Cl. O.6 (1)

---

* Applicable to both the y- and z-directions because the column section is square and b = h.

** In this WE, should imperfections be excluded from the calculation of M_{02} about the z-axis, a smaller slenderness limit is obtained. This is because M_{02} without imperfections < $0.05N_{Ed}h$, and consequently, in such a case, r_m should be taken as 1 (see EC2-1-1 F. (O.12)).

† Conservatively ignoring the benefit from confinement. For an example of how to calculate $f_{cd,c}$ refer to WE V1.1).

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **8/14**
		Client **TCC**	Date **Nov 2026**

For the smallest λ_{lim}, use the largest value for r_m (i.e. smallest value of C)

r_{my} = max(0.09, 0.11) = **0.11**

$\therefore$ C = 1.7 – (0.11) = 1.6

For the smallest λ_{lim}, use the largest value for N_{Ed} (and hence n)

$n = |N_{Ed}|/(A_c f_{cd})$ EC2-1-1: Cl. O.6 (1)

$\therefore$ n = max(1101.5, 1072.1) x 1000/(325 x 325 x 20) = 0.52

$\therefore \lambda_{lim,y} = 20 \times 0.7 \times 1.6 \times 1.3/0.52^{0.5}$ = **36.0**

(as opposed to using the default value of B of 1.1: $\lambda_{lim,y}$ = 33.8)*

35.4 < 36.0 i.e. $\lambda < \lambda_{lim}$

$\therefore$ Second order effects may be ignored EC2-1-1: Cl. O.6 (1)

$\therefore$ M_2 = second order moment = **0**

b) About the z-axis

$\lambda_{lim} = 20ABC/n^{0.5}$ EC2-1-1: F. (O.12)

where:

A = (default value) = 0.7 EC2-1-1: Cl. O.6 (1)

B = (as before from Section V1.2.6 a)) = 1.17 EC2-1-1: Cl. O.6 (1)

$C = 1.7 - r_m$ EC2-1-1: Cl. O.6 (1)

$\therefore$ C = 1.7 – (0.4) = 1.3

$\therefore \lambda_{lim,z} = 20 \times 0.7 \times 1.17 \times 1.3/0.52^{0.5}$ = **29.6**

(as opposed to using the default value of B of 1.1: $\lambda_{lim,z}$ = 27.8)*

28.8 < 29.6 $\therefore \lambda < \lambda_{lim}$

$\therefore$ Second order effects may be ignored EC2-1-1: Cl. O.6 (1)

$\therefore$ M_2 = second order moment = **0**

V1.2.7 Design moments

$M_{Ed} = \max\{M_{0Ed} + M_2; M_{02}; |M_{01} - 0.5M_2 - 2|N_{Ed}|e_i|\}$ EC2-1-1: F. (O.13)

where:

M_2 (as before from Section V1.2.6) = 0

$\therefore M_{Ed} = \max\{M_{0Ed}; M_{02}; |M_{01} - 2|N_{Ed}|e_i|\}$

* In this WE, calculating the value of B results in a larger slenderness limit than if the default value of 1.1 is used.

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **9/14**
		Client **TCC**	Date **Nov 2026**

a) About the y-axis

For load case 1:

From before: N_{Ed} = 1101.5 kN

M_{01y} = 9.2 kNm

M_{02y} = 98.8 kNm

M_{0Edy} = 62.9 kNm

e_{iy} = 8.3 mm

$\therefore M_{Ed} = \max\{62.9; 98.8; |9.2 - 2 \times |1101.5| \times 8.3/1000|\}$ = 98.8 kNm

Check that $M_{Ed} \geq M_{Ed,min}$ EC2-1-1: Cl. 8.1.1 (5)

$M_{Ed,min} = \pm N_{Ed} e_{d,min}$ EC2-1-1: F. (8.1)

where:

$e_{d,min} = \max[h/30, 20\text{ mm})$

$= \max[325/30, 20\text{ mm}]$ = 20 mm

$\therefore M_{Ed,min} = \pm 1101.5 \times 20/1000$ = 22.0 kNm

$\therefore M_{Ed}$ = **98.8 kNm**

For load case 2:

From before: N_{Ed} = 1072.1 kN

M_{01y} = 8.9 kNm

M_{02y} = 77.6 kNm

M_{0Edy} = 50.1 kNm

e_{iy} = 8.3 mm

$\therefore M_{Ed} = \max\{50.1; 77.6; |8.9 - 2 \times |1072.1| \times 8.3/1000|\}$ = 77.6 kNm EC2-1-1: Cl. 8.1.1 (5)

Check that $M_{Ed} \geq M_{Ed,min}$ EC2-1-1: F. (8.1)

$M_{Ed,min} = \pm N_{Ed} e_{d,min}$

$\therefore M_{Ed,min} = \pm 1072.1 \times 20/1000$ = 21.4 kNm

$\therefore M_{Ed}$ = **77.6 kNm**

$\therefore$ Maximum M_{Edy} (including imperfections) = 98.8 kNm

b) About the z-axis

For load case 1:

From before: N_{Ed} = 1101.5 kN

M_{01z} = 7.4 kNm

M_{02z} = 19.9 kNm

M_{0Edz} = 14.9 kNm

e_{iz} = 6.8 mm

$\therefore M_{Ed} = \max\{14.9; 19.9; |7.4 - 2 \times |1101.5| \times 6.8/1000|\}$ = 19.9 kNm EC2-1-1: Cl. 8.1.1 (5)

Check that $M_{Ed} > M_{Ed,min}$ EC2-1-1: F. (8.1)

$M_{Ed,min} = \pm N_{Ed} e_{d,min}$

where:

$e_{d,min} = \max[h/30, 20\text{ mm})$

$= \max[325/30, 20\text{ mm}]$ = 20 mm

$\therefore M_{Ed,min} = \pm 1101.5 \times 20/1000$ = 22.0 kNm

$\therefore M_{Ed}$ = **22.0 kNm**

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **10/14**
		Client **TCC**	Date **Nov 2026**

For load case 2:

From before: N_{Ed} = 1072.1 kN

M_{01z} = 7.2 kNm

M_{02z} = 18.2 kNm

M_{0Edz} = 13.8 kNm

e_{iz} = 6.8 mm

$\therefore M_{Ed} = \max\{13.8; 18.2; |7.2 - 2 \times |1072.1| \times 6.8/1000|\}$ = 18.2 kNm — EC2-1-1: Cl. 8.1.1 (5)

Check that $M_{Ed} > M_{Ed,min}$ — EC2-1-1: F. (8.1)

$M_{Ed,min} = \pm N_{Ed} e_{d,min}$

$\therefore M_{Ed,min} = \pm 1072.1 \times 20/1000$ = 21.4 kNm

$\therefore M_{Ed}$ = **21.4 kNm**

$\therefore$ **Maximum M_{Edz} (including imperfections) = 22.0 kNm***

V1.2.8 Design using charts

$d = 325 - 25 - 8 - 12/2$ = 286 mm

$d/h = 286/325$ = 0.88

a) About the y-axis

The critical moment = $M = M_{Edy}$ = 98.8 kNm

The corresponding axial force, N = 1101.5 kN

$N_{Ed}/(bhf_{cd}) = 1101.5 \times 1000/(325 \times 325 \times 20)$ = **0.52**

$M_{Ed}/(bh^2f_{cd}) = 98.8 \times 10^6/(325 \times 325^2 \times 20)$ = **0.14**

Conservatively using column design chart for d/h = 0.85: — V1. How to: Fig. V1.10

$A_s/(bhf_{cd})$ = 0.00015 mm^2/N

$\therefore A_s = 0.00015 \times 325 \times 325 \times 20$ = **317 mm^2**

$A_s/2$ (at one face only) = 158 mm^2

> *Note:*
>
> *A_s in the design charts refers to the total area of vertical reinforcement bars at two opposite column faces.*

Check minimum steel:

$A_{s,min} = \max\{0.1N_{Ed}/f_{yd}, 0.002A_c\}$ — EC2-1-1: Table 12.3

$A_{s,min} = \max\{0.1 \times 1101.5 \times 1000/435, 0.002 \times 325 \times 325\}$ = 253 mm^2

$\therefore$ Try 3H12 per face (339 mm^2)

i.e. 8H12 total (905 mm^2)

b) About the z-axis

By inspection 3H12 per face is OK

$\therefore$ Try 3H12 per face (339 mm^2)

i.e. 8H12 total (905 mm^2)

* The maximum moments about the y- and the z- axes both correspond to the same load case 1.

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **11/14**
		Client **TCC**	Date **Nov 2026**

V1.2.9 Check for biaxial bending

Note:

Biaxial bending checks may be omitted if F. (7.29) and F. (7.30) are satisfied, i.e.:
$0.5 \le \lambda_y/\lambda_z \le 2.0$ and
$e'_y/e'_z \le 0.2$ or $e'_y/e'_z \ge 5.0$

EC2-1-1: Cl. 7.4.4 (4)
EC2-1-1: F. (7.29)
EC2-1-1: F. (7.30)

$\lambda_y/\lambda_z = 35.4/28.8 = 1.23$

$\therefore$ **Formula (7.29) is satisfied**

The dimensionless eccentricities about both axes are:

$e'_z = M_{Edz}/|N_{Ed}b|$ EC2-1-1: Cl. 7.4.4 (4) & Fig. 7.5
$= 22 \times 1000/(1101.5 \times 325) = 0.06$

$e'_y = M_{Edy}/|N_{Ed}h|$ EC2-1-1: Cl. 7.4.4 (4) & Fig. 7.5
$= 98.8 \times 1000/(1101.5 \times 325) = 0.28$

$\therefore e'_y/e'_z = 0.28/0.06 = 4.48$

$\therefore$ **Formula (7.30) is <u>not</u> satisfied**

$\therefore$ **Biaxial bending should be taken into account** EC2-1-1: Cl. 7.4.4 (5)

Check if the following simplified criterion is satisfied: EC2-1-1: Cl. 8.1.1 (8)

$(|M_{Edz}|/M_{Rdz,N})^{a_N} + (|M_{Edy}|/M_{Rdy,N})^{a_N} \le 1.0$ EC2-1-1: F. (8.2)

where:

a_N is dependent on N_{Ed} and the axial concrete capacity, $N_{Rd,0}$ EC2-1-1: Cl. 8.1.1 (8)

$N_{Rd,0} = A_c f_{cd} + A_s f_{yd}$ EC2-1-1: F. (8.3)

$A_c = 325 \times 325 = 105{,}625$ mm^2

$\therefore N_{Rd,0} = (105{,}625 \times 20 + 905 \times 435)/1000 = 2506$ kN

$|N_{Ed}|/N_{Rd,0} = 1101.5/2506 = 0.4$

$\therefore a_N = 1.3$ EC2-1-1: Cl. 8.1.1 (8)

$N/(bhf_{cd})$ (as before from Section V1.2.8) $= 0.52$

$A_{s,prov}/(bhf_{cd}) = 679/(325 \times 325 \times 20) = 0.00032$ mm^2/N

Conservatively using design charts for d/h = 0.85, for $A_s/bhf_{cd} = 0.03\%$: How to: Fig. V1.10

$M_{Rd}/(bh^2 f_{cd}) = 0.162$

$\therefore M_{Rdz,N} = M_{Rdy,N}$
$= 0.162 \times 325 \times 325^2 \times 20/10^6 = 111$ kNm

$\therefore (|M_{Edz}|/M_{Rdz,N})^{a_N} + (|M_{Edy}|/M_{Rdy,N})^{a_N}$
$= (|22|/111)^{1.3} + (|98.8|/111)^{1.3} = \mathbf{0.98}$
< 1.0

$\therefore$ Formula (8.2) is satisfied and <u>no</u> further checks are required.

$\therefore$ **Biaxial bending OK**

Note:

EC2-1-1 Cl. 7.4.4 (3) states that for the biaxial check, imperfections should be considered in one direction only where they have the most unfavourable effect (see WE V1.1). This calculation is conservative because both M_{Edy} and M_{Edz} include the effect of imperfections. Because the column utilisation < 1, refinement to the biaxial interaction equation is deemed unneccesary.

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **12/14**
		Client **TCC**	Date **Nov 2026**

V1.2.10 Links

Minimum link bar diameter = 0.25ϕ = 0.25 x 12 = 3.0 mm — EC2-1-1: Table 12.3

∴ Use 8 mm diameter stirrups

At intermediate region, maximum spacing = $s_{max,col}$ = 20ϕ ≤ min{h, b, 300 mm} — EC2-1-1: Table 12.3

∴ $s_{max,col}$ = 20 x 12 = 240 mm ≤ min{325, 325, 300 mm} = 240 mm

At the end regions, maximum spacing = 0.6$s_{max,col}$ — EC2-1-1: Table 12.3

= 0.6 x 240 = 144 mm

over a length of 325 mm

For simplicity, use a spacing of 125 mm over the entire column height

Number of legs:

Bars are at 123.5 mm cc i.e. <150 mm. Therefore, no need to restrain bars in face — EC2-1-1: Cl. 12.6 (3)

V1.2.11 Confirm fire resistance assumptions are correct

The modified mechanical reinforcement degree:

$\omega_{mod} = 2 \min(A_{s0}, A_{s1}) f_{yd}/(A_c f_{cd})$ — EC2-1-2: Cl. D.2 (3)

where:

$A_{s0} = A_{s1}$ = 3 x 113 = 339 mm² — EC2-1-2: Cl. D.2 (5)

∴ ω_{mod} = 2 x 339 x 435/(325 x 325 x 20) = 0.14

0.1 < 0.14 < 1.0, ∴ OK — EC2-1-2: Cl. D.2 (4)

∴ ω_{mod} is within the limits to use Annex D

From EC2-1-2 Table D.1:

For ω_{mod} ≤ 0.5, minimum no. of bars for b = 325 mm = 3 — EC2-1-2: Table D.1

∴ provided number of bars per face (= 3) is OK

Calculate the degree of utilisation:

$\mu_{fi} = |N_{Ed,fi}|/N_{Rd}$ — EC2-1-2: F. (6.6)

To find $N_{Ed,fi}$:

For fire, use the accidental design situation — EC0-1: Table 5.1

Using F. (8.12) and (8.15): — EC0-1: Table A.1.3

$N_{Ed,fi} = G_k + \psi_{1,1} Q_{k,1}$ (or $\psi_{2,1} Q_{k,1}$) + $\psi_{2,2} Q_{k,2}$ — EC0-1: F. (8.15)

where:

ψ_1 for category B: office = 0.5 — NA EC0-1: Table NA.2

ψ_1 for category H: inaccessible roof = 0 — NA EC0-1: Table NA.2

From analysis, $N_{Ed,fi}$ = 693.2 kN

Note:

N_{Rd} in EC2-1-2 F. (6.6) is different from $N_{Rd,0}$ (found in Section V1.2.9) and is defined as the column's design axial resistance at ambient temperature including second order effects and an initial eccentricity equal to the eccentricity of $N_{Ed,fi}$. The code also notes that the first order eccentricity under fire conditions can be assumed as equal to that in ambient temperature design (refer to Note in Cl. 6.3.2.2).

Reference is made to the column design chart used for the ULS design reproduced in Fig. V1.2.3. If on this column chart a straight line (denoted by 2) is drawn passing through the origin and the plotted point for the applied N_{Ed} and M_{Ed} (denoted by 1), any point on this line represents values for N and M with the same eccentricity as that for the ambient condition. N_{Rd} (denoted by 4) can be read off the chart from the intersection of this line with the N-M curve for the provided reinforcement (denoted by 3).

mpa The Concrete Centre	Project details **V1.2 Stocky perimeter column in internal environment**	Calculated by **MM**	Job no. **V1**
		Checked by **CIEG**	Sheet no. **13/14**
		Client **TCC**	Date **Nov 2026**

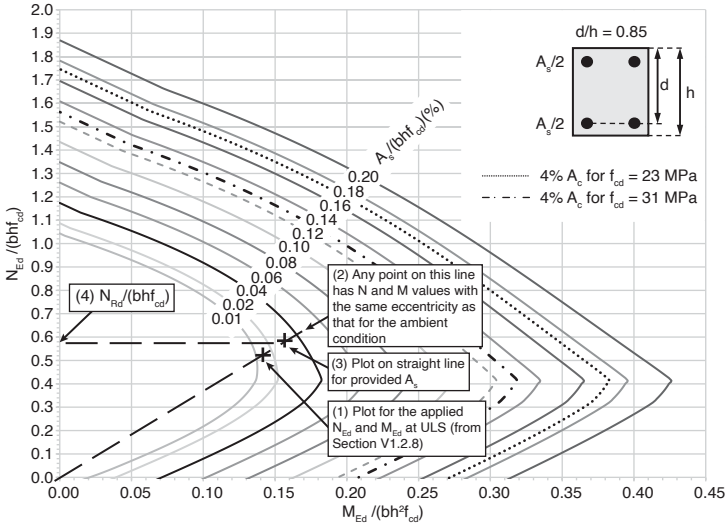


Figure V1.2.3: Assessing N_{Rd}

$A_{s,prov}/(bhf_{cd})$ = (as before from Section V1.2.9) = 0.00032

Conservatively using design charts for d/h = 0.85, for $A_s/(bhf_{cd})$ = 0.03%:

$N_{Rd}/(bhf_{cd})$ = 0.56

$\therefore N_{Rd} = 0.56 \times 325 \times 325 \times 20/1000$ = 1183 kN

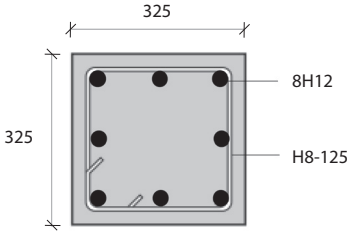
V1. How to: Fig. V1.10

$\therefore \mu_{fi} = 693.2/1183$ = **0.6**

$\therefore$ The assumption for fire of $\mu_{fi} = 0.7$ is conservative

$\therefore$ Fire check OK

V1.2.12 Design summary



Concrete: C30/37, c_{nom} = 25 mm to links

Figure V1.2.4: Design summary for perimeter column

	Project details				
mpa The Concrete Centre	**V1.2 Stocky perimeter column in internal environment**	Calculated by	**MM**	Job no.	**V1**
		Checked by	**CIEG**	Sheet no.	**14/14**
		Client	**TCC**	Date	**Nov 2026**

List of references

[1] British Standards Institution. (2023) BS EN 1992-1-1:2023 Eurocode 2 – Design of concrete structures. Part 1-1: General rules and rules for buildings, bridges and civil engineering structures. London, BSI.

[2] British Standards Institution. (2023) BS EN 1992-1-2:2023 Eurocode 2 – Design of concrete structures. Part 1-2: Structural fire design. London, BSI.

[3] British Standards Institution. (2026) NA to BS EN 1992-1-1:2023 UK National Annex to Eurocode 2: Design of concrete structures. Part 1-1: General rules and rules for buildings, bridges and civil engineering structures. London, BSI.

[4] British Standards Institution. (2026) PD 6687:2026 Background paper to the National Annexes to BS EN 1992-1-1:2023, BS EN 1992-1-2:2023 and BS EN 1992-4:2018. London, BSI.

[5] MPA The Concrete Centre. (2026) How to design concrete structures using Eurocode 2 (second generation). V1 - How to: Stocky Columns. London, TCC.

[6] MPA The Concrete Centre. (2026) Worked Examples to Eurocode 2 (second generation). WE V1.1 - Stocky edge column. London, TCC.

Revision number	Revision date	Notes
1.0	Nov 2026	First publication

At the time of publication, work on the second generation of Eurocodes and supporting documents is ongoing. Where possible, this worked example has been developed based on the standards that have been published to date, but in some instances, the relevant documents have not yet been finalised and so anticipated values are included and clearly noted as such. Amendments are planned for all of the Eurocodes ahead of the March 2028 date of adoption and users are advised to ensure they are referring to the latest version of a standard or publication.

The Concrete Centre acknowledges and appreciates the support given by many individuals, companies and organisations forming part of the Concrete Industry Eurocode 2 Group (CIEG) in the preparation of this worked example.

The Concrete Centre provides material, design and construction guidance to help professionals maximise concrete's structural, aesthetic and sustainability potential through effective design and specification.

The Concrete Centre is part of the Mineral Products Association, the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and industrial sand industries.

www.mineralproducts.org

Published by The Concrete Centre

1st Floor, 297 Euston Road
London NW1 3AD

www.concretecentre.com



Ref: TCC/03/77
ISBN 978-1-908257-61-1
First published November 2026
Price code: N
© The Concrete Centre

All advice or information from MPA The Concrete Centre is intended for use in the UK only by those who will evaluate the significance and limitations of its contents and take responsibility for its use and application. No liability (including that for negligence) for any loss resulting from such advice or information is accepted by MPA The Concrete Centre or its subcontractors, suppliers or advisors. Readers should note that publications from MPA The Concrete Centre are subject to revision from time to time and they should therefore ensure that they are in possession of the latest version.

eurocode
second generation