

Element design

Slabs, beams, shear, columns, indirect supports · EN 1992-1-1 · UK NA / PN-EN

Reference	NAE-RC-040 · 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

Six quick designs in one workbook, one tab each: a slab section, a rectangular beam, a T or L beam (bending with the x/d limit of the redistribution chosen, $A_{s,min}$, $A_{s,max}$, bars provided, deflection by span / depth and cracking by bar size or spacing), shear in a beam or slab, a symmetric rectangular column under N and M, and the hanger links of an indirect support.

How to use

1. Pick a tab: Slab, Rect beam, Tee beam, Shear, Column or Indirect.
2. Select the National Annex on that tab and fill in its shaded cells; each tab is independent.
3. Read the Results block; every step below it quotes its clause. Print or save as PDF for your calculation package.

Scope and limitations

Slab, Rect beam, Tee beam: one section with the design moment entered (hogging at a support or cantilever: tension at the top; a T beam then works as its web). Rectangular block $\lambda = 0.8$, $\eta = 1$ for bending, concrete up to C50/60, $f_{yk} 400 - 500$ MPa. $x/d \leq \min((\delta - k_1)/k_2; \epsilon_{cu}/(\epsilon_{cu} + \epsilon_{yd}))$ (5.5(4)), K' from it; above K' beams take compression steel at f_{sc} from the strain diagram ($|f_{sc}| \leq f_{yd}$) net of the concrete it displaces, slabs fail. With $\delta < 1$ the bars provided must keep $x \leq x_{lim}$. $A_{s,min}$ (9.1N) with b_t the web (flange in compression) or the mean width of the gross tension zone (flange in tension); $A_{s,max} 0.04 A_c$. Deflection by (7.16) with K from the section location (Table 7.4N), p on b_d (flanged: the concrete above the tension steel, Concise EC2 10.5.2), 0.8 for $b_{eff}/b_w > 3$, $7/l$ (flat slab 8.5/l) with brittle partitions, $310/\sigma_s$ with $\sigma_s = f_{yd}$ ($g_k + \psi_2 q_k$)/($\gamma_G g_k + \gamma_Q q_k$) $A_{s,req}/A_{s,prov}/\delta$, UK NA: $310/\sigma_s \leq 1.5$ and $l/d \leq 40$ K. ψ_2 from EN 1990 Table A1.1 (the same in both annexes). Cracking by Table 7.2N (bar size adjusted by (7.6N), $k_c = 0.4$, h_{cr} of the gross section) or Table 7.3N at the same σ_s , linear between rows. Shear: $V_{Rd,c}$ (6.2), variable strut $1 \leq \cot \theta \leq 2.5$ (UK) or 2.0 (PL), vertical links, $\sigma_{cp} = 0$; V_{Ed} at d for uniform load (6.2.1(8)). Column: two symmetric layers of bars, parabola-rectangle concrete (3.1.7(1)) under the strain limits of 6.1(5) for every neutral axis depth, steel found by bisection on the area with the neutral axis solved by strain compatibility for each trial; M_{Ed} includes second order effects. Indirect support: hanger links for the whole reaction within the zones of Figure 9.7. Torsion, fire, flange shear (RC-031), slenderness (RC-008, RC-037) and crack widths by calculation (RC-003) are separate sheets. 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: Beams, Slabs, Columns, Deflection, Crack control.
 - The Concrete Centre, Concise Eurocode 2.
 - The Concrete Centre, RC Spreadsheets v4, TCC11 Element Design (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.

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Disclaimer

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Revision history

v1.0	30 Oct 2026 · First issue
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Project
Element
Date

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Inputs · section

Shaded cells only · per metre width

	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
Annex C	Reinforcement ductility class		B	$\delta \geq 0.7$ (B, C) / 0.8 (A)
8.2(2)	Maximum aggregate size	d_g	20	mm
Table 7.4N	Section location		End span	Support: hogging, no l/d
	Slab thickness	h	250	mm
4.4.1	Cover to the main bars	c	25	mm
	Main bars: diameter	φ	12	mm
	Main bars: spacing	s	150	mm

Inputs · actions and serviceability

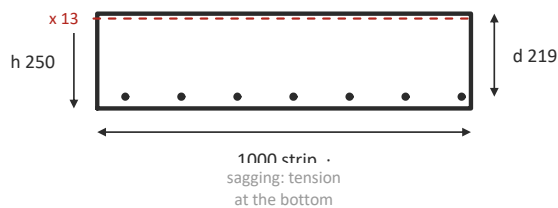
ULS moment; characteristic loads for as

	Design moment at the section (support, cantilever: hogging)	M_{Ed}	40.0	kNm/m
5.5(4)	Moment redistribution ratio (1.0 = none)	δ	1.00	
7.4.2	Span for l/d (cantilever: its length; flat slab: the longer span)	l	5.00	m
	Characteristic permanent load (any unit: only the ratio is used)	g_k	5.00	
	Characteristic variable load	q_k	3.00	
EN 1990 A1.2(B)	Partial factor, permanent	γ_G	1.35	
EN 1990 A1.2(B)	Partial factor, variable	γ_Q	1.50	
EN 1990 A1.1	Category of use (gives ψ_2)		B office	
	ψ_2 (category Other only)	ψ_2	0.30	
7.4.2(2)	Brittle partitions supported?		No	
7.3.1(5)	Limiting crack width	w_{max}	0.3	mm
	Inputs valid and consistent			OK

Results

Bending $\max(A_{s,req}; A_{s,min}) / A_{s,prov}$ (no compression reinforcement)	A_s	0.59		OK
Deflection actual $l/d \div$ limiting l/d		0.44		OK
Cracking (Table 7.2N bar size or Table 7.3N spacing) $\cdot h \leq$	σ_s	134	MPa	OK
Detailing (spacing, clear gap)		150	mm	OK
Tension reinforcement required / provided		442 / 754	mm ² /m	

Your section, to scale · tension face at the bottom in a span, at the top at a support or cantilever · neutral axis (dashed)



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
5.5(4)	Coefficient for x/d limit	k_1	0.40	NDP sheet
5.5(4)	Coefficient for x/d limit	k_2	1.00	NDP sheet
7.4.2(2)	Upper limit on the stress / area factor		1.50	NDP sheet
7.4.2(2)	$L/d \leq 40K$ applies (1 = yes)		1.00	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_{yk} / γ_s	f_{yd}	434.8	MPa
	Effective depth $h - c - \phi/2$	d	219	mm
	Width of the strip	b	1000	mm

Calculation · bending (rectangular block $\lambda = 0.8$, $\eta = 1$)

3.2.7	Neutral axis depth at first yield $\epsilon_{cu2} / (\epsilon_{cu2} + f_{yd}/E_s)$	ξ_y	0.617	
5.5(4)	Limiting neutral axis depth $\min((\delta - k_1) / k_2; \xi_y)$	$x_{u/d}$	0.600	
3.1.7(3)	Limiting K (α_{cc}/γ_c) $0.8 \xi (1 - 0.4 \xi)$	K'	0.207	
	Limiting neutral axis depth	x_{lim}	131	mm
	Concrete force at x_{lim} $f_{cd} b 0.8 x_{lim}$	C_{lim}	1906.2	kN/m
3.1.7(3)	Moment of the concrete at x_{lim} $K' f_{ck} b d^2$	M_{lim}	317.3	kNm/m
3.1.7(3)	$K = MEd / (b d^2 f_{ck})$	K	0.026	
3.1.7(3)	Neutral axis $x/d = (1 - \sqrt{1 - 2K/(\alpha_{cc}/\gamma_c)})/0.8$; x_{lim} if $MEd > M$	x/d	0.059	
	Neutral axis depth	x	13	mm
	Lever arm $d (1 - 0.4 x/d) \leq 0.95 d$	z	208	mm 0.95 d: common practice
	Tension reinforcement $MEd / (f_{yd} z)$ (N/A: $K > K'$, a slab has no compression reinforcement)	$A_{s,req}$	442	mm ² /m
	Gross area $b h$	A_c	250000	mm ² /m
(9.1N)	Minimum tension reinforcement $\max(0.26 f_{ctm}/f_{yk}; 0.0013) b t$	$A_{s,min}$	344	mm ² /m
9.2.1.1(3)	Maximum reinforcement $0.04 A_c$	$A_{s,max}$	10000	mm ² /m Outside lap locations
	Provided $1000 \pi \phi^2 / (4 s)$	$A_{s,prov}$	754	mm ² /m

5.5(4)	Bars provided, tension force $A_{s,prov} f_{yd}$	T	327.8	kN/m	
5.5(4)	Compression at x_{lim} C_{lim} ($T \leq$ this: $x \leq x_{lim}$)	C	1906.2	kN/m	Checked when $\delta < 1$
6.1, 9.2.1.1	$A_{s,prov} \geq \max(A_{s,req}; A_{s,min}), \leq A_{s,max}; \delta < 1: x \leq x_{lim}$		754	mm ² /m	OK

Calculation · detailing

9.3.1.1(3)	Maximum spacing of main bars at the maximum moment $\min(z)$	s_{max}	250	mm	
8.2(2)	Minimum clear gap $\max(\phi; dg + 5; 20)$	a_{min}	25	mm	
9.3.1.1(3), 8.2(2)	Spacing $s \leq s_{max}$ and clear gap $s - \phi \geq a_{min}$	s	150	mm	OK

Calculation · serviceability stress and deflection (7.4.2)

EN 1990 A1.1	ψ_2 for the category of use	ψ_2	0.30		
7.4.2(2)	Quasi-permanent / ULS load $(g_k + \psi_2 q_k) / (\gamma_G g_k + \gamma_Q q_k)$		0.524		
	Tension steel for the ratios $\max(A_{s,req}; A_{s,min})$	$A_{s,req}$	442	mm ² /m	
7.4.2(2), 7.3.3	Steel stress, quasi-permanent $f_{yd} \times \text{ratio} \times A_{s,req} / A_{s,prov} / \delta$	σ_s	133.7	MPa	
Table 7.4N	K for the section location	K	1.3		
(7.16)	Reference ratio $\rho_0 = \sqrt{f_{ck}} \cdot 10^{-3}$	ρ_0	0.00566		
(7.16)	Tension reinforcement ratio $A_{s,req} / (b d)$	ρ	0.00202		
(7.16b)	Compression reinforcement ratio $A_{s2,req} / (b d)$	ρ'	0.00000		
(7.16a), (7.16b)	Basic span / effective depth ratio	l/d	102.1		
7.4.2(2)	Brittle partitions: $7 / l$ over 7 m (flat slab: $8.5 / l$ over 8.5 m)	F_2	1.000		
(7.17)	Steel stress factor $310 / \sigma_s$ ($\sigma_s \geq 1$ MPa; UK NA: ≤ 1.5)	F_3	1.500		
7.4.2	Limiting span / effective depth (UK NA: $\leq 40 K$)	l/d_{lim}	52.0		
	Actual span / effective depth	l/d	22.8		
7.4.2	Deflection $l/d \leq$ limiting l/d (support: not checked)	l/d	22.8		OK

Calculation · cracking without direct calculation (7.3.3)

7.3.2(2)	Tensile strength when the cracks form $f_{ct,eff} = f_{ctm}$	$f_{ct,eff}$	3.02	MPa	
(7.6N)	Tension zone before cracking $h/2$	h_{cr}	125	mm	
(7.6N)	Bar size factor $(f_{ct,eff} / 2.9) k_c h_{cr} / (2 (h - d))$, $k_c = 0.4$		0.841		
Table 7.2N	Maximum bar size from the table at $\sigma_s \phi_s^*$	ϕ_{s^*}	32.0	mm	0: no value in the table
(7.6N)	Adjusted maximum bar size $\phi_s^* \times \text{factor}$	ϕ_s	26.9	mm	
Table 7.3N	Maximum bar spacing at σ_s	s_{max}	300	mm	0: no value in the table
	Bar spacing	s	150	mm	
Table 7.2N	Bar size $\phi \leq \phi_s$	ϕ	12	mm	OK
Table 7.3N	Bar spacing $s \leq s_{max}$	s	150	mm	OK

Either table is enough for cracking caused mainly by loading (7.3.3(2)). Slabs in buildings in bending with $h \leq 200$ mm need no specific measures when 9.3 is applied (7.3.3(1)): taken here when the spacing and gap checks pass; the secondary bars (9.3.1.1(2)) and the curtailment rules are for the designer. The minimum reinforcement for crack control (7.3.2) and restraint cracking (RC-022) are separate checks. as uses $A_{s,req} / A_{s,prov}$ and $1/\delta$ (TCC How to); the same stress gives $310/\sigma_s$ for the deflection check.

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Inputs · section

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	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
Annex C	Reinforcement ductility class		B	$\delta \geq 0.7$ (B, C) / 0.8 (A)
8.2(2)	Maximum aggregate size	d_g	20	mm
Table 7.4N	Section location		End span	Support: hogging, no l/d
	Section width	b	300	mm
	Overall depth	h	500	mm
4.4.1	Nominal cover to links	c_{nom}	35	mm
	Link diameter	φ_w	10	mm
	Tension bars: number (one layer, ≤ 12)	n	4	
	Tension bars: diameter	φ	20	mm
	Compression bars: number (0 = none, ≤ 12)	n_2	2	
	Compression bars: diameter	φ_2	16	mm

Inputs · actions and serviceability

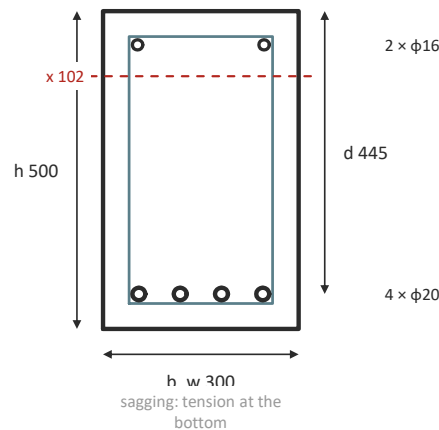
ULS moment; characteristic loads for σ_s

	Design moment at the section (support, cantilever: hogging)	M_{Ed}	180.0	kNm
5.5(4)	Moment redistribution ratio (1.0 = none)	δ	1.00	
7.4.2	Span for l/d (cantilever: its length; flat slab: the longer span)	l	7.00	m
	Characteristic permanent load (any unit: only the ratio is used)	g_k	25.00	
	Characteristic variable load	q_k	15.00	
EN 1990 A1.2(B)	Partial factor, permanent	γ_G	1.35	
EN 1990 A1.2(B)	Partial factor, variable	γ_Q	1.50	
EN 1990 A1.1	Category of use (gives ψ_2)		B office	
	ψ_2 (category Other only)	ψ_2	0.30	
7.4.2(2)	Brittle partitions supported?		No	
7.3.1(5)	Limiting crack width	w_{max}	0.3	mm
	Inputs valid and consistent			OK

Results

Bending $\max(A_{s,req}; A_{s,min}) / A_{s,prov}$	A_s	0.82		OK
Compression reinforcement required / provided	A_{s2}	0 / 402	mm ²	Not needed
Deflection actual $l/d \div$ limiting l/d		0.47		OK
Cracking (Table 7.2N bar size or Table 7.3N spacing)	σ_s	186	MPa	OK
Detailing (clear gaps, layers)		43	mm	OK
Tension reinforcement required / provided		1025 / 1257	mm ²	

Your section, to scale · tension face at the bottom in a span, at the top at a support or cantilever · neutral axis (dashed)



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
5.5(4)	Coefficient for x/d limit	k_1	0.40	NDP sheet
5.5(4)	Coefficient for x/d limit	k_2	1.00	NDP sheet
7.4.2(2)	Upper limit on the stress / area factor		1.50	NDP sheet
7.4.2(2)	$L/d \leq 40K$ applies (1 = yes)		1.00	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_{yk} / γ_s	f_{yd}	434.8	MPa
	Effective depth $h - c - \phi_w - \phi/2$	d	445	mm
	Depth to the compression bars $c + \phi_w + \phi/2$	d_2	53	mm

Calculation · bending (rectangular block $\lambda = 0.8$, $\eta = 1$)

3.2.7	Neutral axis depth at first yield $\epsilon_{cu2} / (\epsilon_{cu2} + f_{yd}/E_s)$	ξ_y	0.617	
5.5(4)	Limiting neutral axis depth $\min((\delta - k_1) / k_2; \xi_y)$	$x_{u/d}$	0.600	
3.1.7(3)	Limiting K $(\alpha_{cc}/\gamma_c) 0.8 \xi (1 - 0.4 \xi)$	K'	0.207	
	Limiting neutral axis depth	x_{lim}	267	mm
	Concrete force at x_{lim} $f_{cd} b 0.8 x_{lim}$	C_{lim}	1162.0	kN
3.1.7(3)	Moment of the concrete at x_{lim} $K' f_{cd} b d^2$	M_{lim}	393.0	kNm
3.1.7(3)	$K = MEd / (b d^2 f_{cd})$	K	0.095	
3.1.7(3)	Neutral axis $x/d = (1 - \sqrt{1 - 2K/(\alpha_{cc}/\gamma_c)})/0.8$; x_{lim} if $MEd > M$	x/d	0.230	
	Neutral axis depth	x	102	mm
	Lever arm $d (1 - 0.4 x/d) \leq 0.95 d$	z	404	mm
				0.95 d: common practice

3.2.7	Compression bar stress at x_{lim} $E_s \epsilon_{cu2} (x - d_2)/x$, $ \sigma \leq f_{yd}$	f_{sc}	434.8	MPa	
	Net of the concrete displaced (bars inside the block: $-f_{cd}$)	$f_{sc,net}$	416.6	MPa	
	Compression reinforcement (MEd – Mlim) / (fsc,net (d – d2))	$A_{s2,req}$	0	mm ²	
	Tension reinforcement $F_{out}/f_{yd} + M_r/(f_{yd} z)$; doubly: (C_lim +	$A_{s1,req}$	1025	mm ²	
	Gross area $b h$	A_c	150000	mm ²	
(9.1N)	Minimum tension reinforcement $\max(0.26 f_{ctm}/f_{yk}; 0.0013) b t$	$A_{s,min}$	210	mm ²	
9.2.1.1(3)	Maximum reinforcement $0.04 A_c$	$A_{s,max}$	6000	mm ²	Outside lap locations
	Tension bars provided $n \pi \phi^2 / 4$	$A_{s1,prov}$	1257	mm ²	
	Compression bars provided $n_2 \pi \phi_2^2 / 4$	$A_{s2,prov}$	402	mm ²	
5.5(4)	Bars provided, tension force $A_{s,prov} f_{yd}$	T	546.4	kN	
5.5(4)	Compression at x_{lim} $C_{lim} + A_{s2,prov} f_{sc,net}$ ($T \leq$ this: $x \leq x_{li}$	C	1329.5	kN	Checked when $\delta < 1$
6.1, 9.2.1.1	$A_{s,prov} \geq \max(A_{s,req}; A_{s,min}), \leq A_{s,max}, A_{s2} \geq A_{s2,req}; \delta < 1: x \leq x_{lim}$		1257	mm ²	OK

Calculation · detailing

8.2(2)	Minimum clear gap, tension bars $\max(\phi; d_g + 5; 20)$	$a_{min,1}$	25	mm	
8.2(2)	Minimum clear gap, compression bars $\max(\phi_2; d_g + 5; 20)$	$a_{min,2}$	25	mm	
	Clear gap, tension bars $(b_w - 2c - 2\phi_w - n\phi)/(n - 1)$	a_1	43	mm	
	Clear gap, compression bars	a_2	178	mm	
8.2(2)	Vertical clear distance between layers $h - 2c - 2\phi_w - \phi - \phi_2$	a_v	374	mm	
8.2(2)	Minimum vertical clear distance $\max(\phi; \phi_2; d_g + 5; 20)$	$a_{min,v}$	25	mm	
8.2(2)	Bars fit in one layer each, layers apart	a_1	43	mm	OK

Calculation · serviceability stress and deflection (7.4.2)

EN 1990 A1.1	ψ_2 for the category of use	ψ_2	0.30		
7.4.2(2)	Quasi-permanent / ULS load $(g_k + \psi_2 q_k)/(\gamma_G g_k + \gamma_Q q_k)$		0.524		
	Tension steel for the ratios $\max(A_{s,req}; A_{s,min})$	$A_{s,req}$	1025	mm ²	
7.4.2(2), 7.3.3	Steel stress, quasi-permanent $f_{yd} \times \text{ratio} \times A_{s,req} / A_{s,prov} / \delta$	σ_s	185.9	MPa	
Table 7.4N	K for the section location	K	1.3		
(7.16)	Reference ratio $\rho_0 = \sqrt{f_{ck}} \cdot 10^{-3}$	ρ_0	0.00566		
(7.16)	Tension reinforcement ratio $A_{s,req} / (b d)$	ρ	0.00768		
(7.16b)	Compression reinforcement ratio $A_{s2,req} / (b d)$	ρ'	0.00000		
(7.16a), (7.16b)	Basic span / effective depth ratio	l/d	22.4		
7.4.2(2)	Brittle partitions: $7 / l$ over 7 m (flat slab: $8.5 / l$ over 8.5 m)	F_2	1.000		
(7.17)	Steel stress factor $310 / \sigma_s$ ($\sigma_s \geq 1$ MPa; UK NA: ≤ 1.5)	F_3	1.500		
7.4.2	Limiting span / effective depth (UK NA: $\leq 40 K$)	l/d_{lim}	33.6		
	Actual span / effective depth	l/d	15.7		
7.4.2	Deflection $l/d \leq$ limiting l/d (support: not checked)	l/d	15.7		OK

Calculation · cracking without direct calculation (7.3.3)

7.3.2(2)	Tensile strength when the cracks form $f_{ct,eff} = f_{ctm}$	$f_{ct,eff}$	3.02	MPa	
(7.6N)	Tension zone before cracking $h/2$	h_{cr}	250	mm	
(7.6N)	Bar size factor $(f_{ct,eff} / 2.9) k_c h_{cr} / (2 (h - d))$, $k_c = 0.4$		0.948		
Table 7.2N	Maximum bar size from the table at $\sigma_s \phi_s^*$	ϕ_{s^*}	27.5	mm	0: no value in the table
(7.6N)	Adjusted maximum bar size $\phi_s^* \times \text{factor}$	ϕ_s	26.0	mm	
Table 7.3N	Maximum bar spacing at σ_s	s_{max}	268	mm	0: no value in the table
	Bar spacing (centres, one layer)	s	63	mm	
Table 7.2N	Bar size $\phi \leq \phi_s$	ϕ	20	mm	OK
Table 7.3N	Bar spacing $s \leq s_{max}$	s	63	mm	OK
7.3.3(3)	Beams deeper than 1 m: skin reinforcement (Annex J)				n/a

Either table is enough for cracking caused mainly by loading (7.3.3(2)). Beams deeper than 1 m need skin reinforcement (7.3.3(3), Annex J). The minimum reinforcement for crack control (7.3.2) and restraint cracking (RC-022) are separate checks. as uses $A_{s,req} / A_{s,prov}$ and $1/\delta$ (TCC How to); the same stress gives $310/\sigma_s$ for the deflection check.

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Inputs · section

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	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
Annex C	Reinforcement ductility class		B	$\delta \geq 0.7$ (B, C) / 0.8 (A)
8.2(2)	Maximum aggregate size	d_g	20	mm
Table 7.4N	Section location		End span	Support: hogging, no l/d
	Section		T-beam (flange both sides)	
	Web width	b_w	300	mm
	Overall depth	h	600	mm
	Flange thickness	h_f	150	mm
Figure 5.3	Half the clear distance to the next web, side 1	b_1	1350	mm
Figure 5.3	Side 2 (T-beam only)	b_2	1350	mm
Figure 5.2	Distance between points of zero moment	l_0	6000	mm Support: 0.15 ($l_1 + l_2$)
4.4.1	Nominal cover to links	c_{nom}	35	mm
	Link diameter	ϕ_w	10	mm
	Tension bars: number (one layer, ≤ 12)	n	4	
	Tension bars: diameter	ϕ	25	mm
	Compression bars: number (0 = none, ≤ 12)	n_2	2	
	Compression bars: diameter	ϕ_2	16	mm

Inputs · actions and serviceability

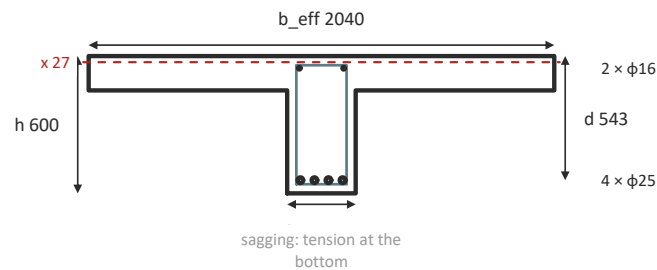
ULS moment; characteristic loads for as

	Design moment at the section (support, cantilever: hogging)	M_{Ed}	420.0	kNm
5.5(4)	Moment redistribution ratio (1.0 = none)	δ	1.00	
7.4.2	Span for l/d (cantilever: its length; flat slab: the longer span)	l	7.00	m
	Characteristic permanent load (any unit: only the ratio is used)	g_k	25.00	
	Characteristic variable load	q_k	15.00	
EN 1990 A1.2(B)	Partial factor, permanent	γ_G	1.35	
EN 1990 A1.2(B)	Partial factor, variable	γ_Q	1.50	
EN 1990 A1.1	Category of use (gives ψ_2)		B office	
	ψ_2 (category Other only)	ψ_2	0.30	
7.4.2(2)	Brittle partitions supported?		No	
7.3.1(5)	Limiting crack width	w_{max}	0.3	mm UK NA Table NA.4; Table 7.1N
	Inputs valid and consistent			OK

Results

Bending $\max(A_{s,req}; A_{s,min}) / A_{s,prov}$	A_s	0.95		OK
Compression reinforcement required / provided	A_{s2}	0 / 402	mm ²	Not needed
Effective flange width	b_{eff}	2040	mm	
Neutral axis (stress block in the flange or reaching the web)	x	27	mm	block in flange
Deflection actual $l/d \div$ limiting l/d		0.36		OK
Cracking (Table 7.2N bar size or Table 7.3N spacing)	σ_s	218	MPa	OK
Detailing (clear gaps, layers)		37	mm	OK
Tension reinforcement required / provided		1874 / 1963	mm ²	

Your section, to scale · tension face at the bottom in a span, at the top at a support or cantilever · neutral axis (dashed)



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
5.5(4)	Coefficient for x/d limit	k_1	0.40	NDP sheet
5.5(4)	Coefficient for x/d limit	k_2	1.00	NDP sheet
7.4.2(2)	Upper limit on the stress / area factor		1.50	NDP sheet
7.4.2(2)	$L/d \leq 40K$ applies (1 = yes)		1.00	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_{yk} / γ_s	f_{yd}	434.8	MPa
	Effective depth $h - c - \phi_w - \phi/2$	d	543	mm
	Depth to the compression bars $c + \phi_w + \phi/2$	d_2	53	mm
(5.7a), (5.7b)	Side 1 $\min(0.2 b_1 + 0.1 l_0; 0.2 l_0; b_1)$	$b_{eff,1}$	870	mm
(5.7a), (5.7b)	Side 2 $\min(0.2 b_2 + 0.1 l_0; 0.2 l_0; b_2)$ (0 for an L-beam)	$b_{eff,2}$	870	mm
(5.7)	Effective flange width $b_w + \sum b_{eff,i}$	b_{eff}	2040	mm
	Compression face width (support, cantilever: the web)	b_c	2040	mm
	Compression flange depth (support, cantilever: whole depth)	$h_{f,c}$	150	mm

Calculation · bending (rectangular block $\lambda = 0.8, \eta = 1$)

3.2.7	Neutral axis depth at first yield $\epsilon_{cu2} / (\epsilon_{cu2} + f_{yd}/E_s)$	ξ_y	0.617	
5.5(4)	Limiting neutral axis depth $\min((\delta - k_1) / k_2; \xi_y)$	$x_{u/d}$	0.600	

3.1.7(3)	Limiting K (α_{cc}/γ_c) $0.8 \xi (1 - 0.4 \xi)$	K'	0.207	
	Limiting neutral axis depth	x_{lim}	326	mm
3.1.7(3)	Flange alone $f_{cd} b c h_{f,c} (d - h_{f,c} / 2)$	M_f	2594.1	kNm
	Outstands when the block reaches the web $f_{cd} (b c - b w) h_{f,c}$	F_{out}	0.0	kN
	Concrete force at x_{lim} (block $0.8 x_{lim}$ in the flange, or outsta	C_{lim}	6149.4	kN
3.1.7(3)	Moment of the concrete at x_{lim} ($K' f_{ck} b d^2$, outstands added)	M_{lim}	2796.6	kNm
	Moment for the rectangle $M_{Ed} - F_{out} (d - h_{f,c}/2)$	M_r	420.0	kNm
	Width of the rectangle (bc in the flange, else bw)	b_r	2040	mm
3.1.7(3)	$K = M_r / (b_r d^2 f_{ck})$	K	0.022	
3.1.7(3)	Neutral axis $x/d = (1 - \sqrt{1 - 2K/(\alpha_{cc}/\gamma_c)})/0.8$; x_{lim} if $M_{Ed} > M$	x/d	0.049	
	Neutral axis depth	x	27	mm
	Lever arm $d (1 - 0.4 x/d) \leq 0.95 d$	z	515	mm 0.95 d: common practice
3.2.7	Compression bar stress at x_{lim} $E_s \epsilon_{cu2} (x - d_2)/x$, $ \sigma \leq f_{yd}$	f_{sc}	434.8	MPa
	Net of the concrete displaced (bars inside the block: - fcd)	$f_{sc,net}$	416.6	MPa
	Compression reinforcement ($M_{Ed} - M_{lim}) / (f_{sc,net} (d - d_2))$	$A_{s2,req}$	0	mm ²
	Tension reinforcement $F_{out}/f_{yd} + M_r/(f_{yd} z)$; doubly: ($C_{lim} +$	$A_{s1,req}$	1874	mm ²
	Gross area $b w (h - h_{f,c}) + b_{eff} h_{f,c}$	A_c	441000	mm ²
	Centroid of the gross section from the top	y_g	166.8	mm
9.2.1.1(1)	Mean width of the tension zone (flange in compression: bw; in	b_t	300	mm
(9.1N)	Minimum tension reinforcement $\max(0.26 f_{ctm}/f_{yk}; 0.0013) b t$	$A_{s,min}$	256	mm ²
9.2.1.1(3)	Maximum reinforcement $0.04 A_c$	$A_{s,max}$	17640	mm ² Outside lap locations
	Tension bars provided $n \pi \phi^2 / 4$	$A_{s1,prov}$	1963	mm ²
	Compression bars provided $n_2 \pi \phi^2 / 4$	$A_{s2,prov}$	402	mm ²
5.5(4)	Bars provided, tension force $A_{s,prov} f_{yd}$	T	853.7	kN
5.5(4)	Compression at x_{lim} $C_{lim} + A_{s2,prov} f_{sc,net}$ ($T \leq$ this: $x \leq x_{li}$	C	6316.9	kN Checked when $\delta < 1$
6.1, 9.2.1.1	$A_{s,prov} \geq \max(A_{s,req}; A_{s,min}), \leq A_{s,max}$, $A_{s2} \geq A_{s2,req}$; $\delta < 1$: $x \leq x_{lim}$		1963	mm ² OK

Calculation · detailing

8.2(2)	Minimum clear gap, tension bars $\max(\phi; d_g + 5; 20)$	$a_{min,1}$	25	mm
8.2(2)	Minimum clear gap, compression bars $\max(\phi_2; d_g + 5; 20)$	$a_{min,2}$	25	mm
	Clear gap, tension bars $(b w - 2 c - 2 \phi w - n \phi)/(n - 1)$	a_1	37	mm
	Clear gap, compression bars	a_2	178	mm
8.2(2)	Vertical clear distance between layers $h - 2 c - 2 \phi w - \phi - \phi_2$	a_v	469	mm
8.2(2)	Minimum vertical clear distance $\max(\phi; \phi_2; d_g + 5; 20)$	$a_{min,v}$	25	mm
8.2(2)	Bars fit in one layer each, layers apart	a_1	37	mm OK

Calculation · serviceability stress and deflection (7.4.2)

EN 1990 A1.1	ψ_2 for the category of use	ψ_2	0.30	
7.4.2(2)	Quasi-permanent / ULS load $(g_k + \psi_2 q_k)/(\gamma_G g_k + \gamma_Q q_k)$		0.524	
	Tension steel for the ratios $\max(A_{s,req}; A_{s,min})$	$A_{s,req}$	1874	mm ²
7.4.2(2), 7.3.3	Steel stress, quasi-permanent $f_{yd} \times \text{ratio} \times A_{s,req} / A_{s,prov} / \delta$	σ_s	217.7	MPa
Table 7.4N	K for the section location	K	1.3	
(7.16)	Reference ratio $\rho_0 = \sqrt{f_{ck}} \cdot 10^{-3}$	ρ_0	0.00566	
Concise EC2 10.5.2	Concrete above the tension steel (hogging: bw d)	A_p	423750	mm ²
(7.16)	Tension reinforcement ratio $A_{s,req} / A_p$	ρ	0.00442	
(7.16b)	Compression reinforcement ratio $A_{s2,req} / A_p$	ρ'	0.00000	
(7.16a), (7.16b)	Basic span / effective depth ratio	l/d	31.9	
7.4.2(2)	Flanged section $b_{eff} / b w > 3$: 0.8 (sagging)	F_1	0.80	
7.4.2(2)	Brittle partitions: $7 / l$ over 7 m (flat slab: 8.5 / l over 8.5 m)	F_2	1.000	
(7.17)	Steel stress factor $310 / \sigma_s$ ($\sigma_s \geq 1$ MPa; UK NA: ≤ 1.5)	F_3	1.424	
7.4.2	Limiting span / effective depth (UK NA: ≤ 40 K)	l/d_{lim}	36.3	
	Actual span / effective depth	l/d	12.9	
7.4.2	Deflection $l/d \leq$ limiting l/d (support: not checked)	l/d	12.9	OK

Calculation · cracking without direct calculation (7.3.3)

7.3.2(2)	Tensile strength when the cracks form $f_{ct,eff} = f_{ctm}$	$f_{ct,eff}$	3.02	MPa
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(7.6N)	Tension zone before cracking (gross section: $h - y_g$; hogging y_c)	h_{cr}	433	mm	
(7.6N)	Bar size factor ($f_{ct,eff} / 2.9$) $k_c h_{cr} / (2(h - d))$, $k_c = 0.4$		1.571		
Table 7.2N	Maximum bar size from the table at σ_s ϕ_s^*	ϕ_{s^*}	21.0	mm	0: no value in the table
(7.6N)	Adjusted maximum bar size $\phi_s^* \times \text{factor}$	ϕ_s	33.0	mm	
Table 7.3N	Maximum bar spacing at σ_s	s_{max}	228	mm	0: no value in the table
	Bar spacing (centres, one layer)	s	62	mm	
Table 7.2N	Bar size $\phi \leq \phi_s$	ϕ	25	mm	OK
Table 7.3N	Bar spacing $s \leq s_{max}$	s	62	mm	OK
7.3.3(3)	Beams deeper than 1 m: skin reinforcement (Annex J)				n/a

Either table is enough for cracking caused mainly by loading (7.3.3(2)). Beams deeper than 1 m need skin reinforcement (7.3.3(3), Annex J). The minimum reinforcement for crack control (7.3.2) and restraint cracking (RC-022) are separate checks. σ_s uses $A_{s,req} / A_{s,prov}$ and $1/\delta$ (TCC How to); the same stress gives $310/\sigma_s$ for the deflection check.

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	National Annex		UK NA (BS EN)	
Table 3.1	Concrete strength class		C32/40	
6.2.2, 6.2.3	Member		Beam (with links)	
	Width (web; slab: 1000 per metre)	b_w	300	mm
	Overall depth	h	600	mm
	Effective depth	d	545	mm
6.2.2(1)	Tension bars anchored beyond the section ($\geq l_{bd} + d$)	A_{sl}	1473	mm ²

Inputs · actions and links

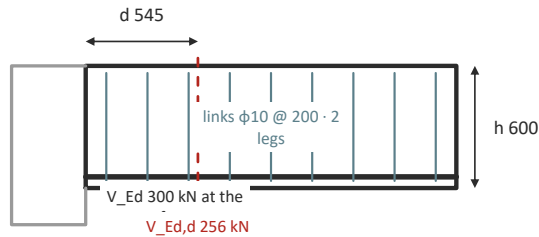
ULS design values

	Design shear force at the face of the support	V_{Ed}	300.0	kN
6.2.1(8)	Loading		Uniformly distributed	
	Design uniformly distributed load (uniform loading only)	w_{Ed}	80.0	kN/m
	Link characteristic yield strength (≤ 500 MPa)	f_{ywk}	500	MPa
	Link diameter	φ_w	10	mm
	Number of legs	n_w	2	
	Link spacing	s	200	mm
4.4.1	Nominal cover to links	c_{nom}	35	mm
	Inputs valid and consistent			OK

Results

Crushing at the face of the support $V_{Ed} / V_{Rd,max}$		0.53		OK
Shear at the critical section (beam: links prov / need; slab: $V_{Ed,d} / V_{Rd,c}$)		1.63		OK
Link spacing (longitudinal and across the web)		0.54		OK
Design shear at the critical section	$V_{Ed,d}$	256.4	kN	
Strut inclination used (beam)	$\cot \theta$	2.50		

Your member near the support, to scale · the section at d from the face (red, uniform load) · links at the spacing entered



Calculation · shear resistance

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
6.2.3(2)	Upper limit of $\cot \theta$	$\cot \theta_{max}$	2.50	NDP sheet
Table 3.1	Characteristic cylinder strength	f_{ck}	32	MPa
Table 3.1	Mean tensile strength	f_{ctm}	3.02	MPa
6.2.1(8)	Shear at d from the face (uniform load: $V_{Ed} - w d$; else V_{Ed})	$V_{Ed,d}$	256.4	kN
6.2.2(1)	Size factor $1 + v(200/d) \leq 2$	k	1.606	
6.2.2(1)	$\rho_l = A_{sl} / (b_w d) \leq 0.02$	ρ_l	0.0090	
(6.3N)	Minimum $0.035 k^{1.5} v_{fck}$	v_{min}	0.403	MPa
(6.2)	Resistance without links $\max(CR_{d,c} k (100 \rho_l f_{ck})^{1/3}; v_{min}) b_w d$	$V_{Rd,c}$	96.6	kN
(6.6N)	Strength reduction $v = 0.6 (1 - f_{ck}/250)$	v	0.523	
3.1.6(1)	f_{cd} for shear $\alpha_{cc} f_{ck} / \gamma_c$	f_{cd}	21.33	MPa
6.2.3(1)	Lever arm $z = 0.9 d$	z	491	mm
(6.9)	$V_{Ed} / V_{Rd,max}$ at 45° $2 V_{Ed} / (b_w z v f_{cd})$ (beam)		0.365	
6.2.3(2)	Strut inclination for V_{Ed} at the face $1 \leq \cot \theta \leq \cot \theta_{max}$	$\cot \theta$	2.500	
(6.9), (6.5)	Crushing beam: $b_w z v f_{cd} / (\cot \theta + \tan \theta)$; slab: $0.5 b_w d v f_{cd}$	$V_{Rd,max}$	566.4	kN
(6.9), 6.2.2(6)	V_{Ed} at the face $\leq V_{Rd,max}$	V_{Ed}	300.0	kN

Calculation · links (beam) · slab: $V_{Ed,d} \leq V_{Rd,c}$

3.2.7	Link design strength f_{yk} / γ_s	f_{ywd}	434.8	MPa
(6.8)	Links for $V_{Ed,d}$ (0 if $V_{Ed,d} \leq V_{Rd,c}$) $V_{Ed,d} / (z f_{ywd} \cot \theta)$	$A_{sw/s}$	0.481	mm ² /mm
(9.4), (9.5N)	Minimum links $0.08 v_{fck} / f_{yk} \cdot b_w$	$A_{sw/s,min}$	0.272	mm ² /mm
	Links needed $\max(\text{required}; \text{minimum})$		0.481	mm ² /mm
	Links provided $n_w \pi \phi_w^2 / 4 / s$	$A_{sw/s,prov}$	0.785	mm ² /mm
(6.8)	Resistance of the links provided	$V_{Rd,s}$	418.7	kN
(6.8), (6.2)	Beam: links provided $\geq$ needed; slab: $V_{Ed,d} \leq V_{Rd,c}$		256.4	kN
(9.6N)	Maximum longitudinal spacing $0.75 d$	$s_{l,max}$	409	mm

(9.8N)	Maximum spacing of legs across the web $\min(0.75 d; 600)$	$s_{t,max}$	409	mm	
	Spacing of legs across the web $(bw - 2c - \phi w)/(nw - 1)$	s_t	220	mm	
8.2(2)	Minimum clear gap between links and between legs $\max(\phi w; 2)$	a_{min}	20	mm	+ dg + 5 by the user
(9.6N), (9.8N), 8.2(2)	Spacing $s \leq s_{l,max}$, $s_t \leq s_{t,max}$, clear gaps $\geq a_{min}$	s	200	mm	OK
(6.18)	Additional tensile force $\Delta F_{td} = 0.5 V_{Ed} d \cot \theta$ (shift $a_l = z \cot \theta$)	ΔF_{td}	320.5	kN	

V_{Ed} at d applies to predominantly uniform loading; the links needed there continue to the support and V_{Ed} at the face is checked against $V_{Rd,max}$ (6.2.1(8)). The strut angle is set by V_{Ed} at the face. No axial force ($\sigma_{cp} = 0$, $\alpha_{cw} = 1$), vertical links. Loads near the support ($a_v < 2d$, 6.2.2(6), 6.2.3(8)) are not reduced. Slabs with links: 9.3.2 ($h \geq 200$ mm) applies — use the beam option.

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	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	300	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
9.5.2(1)	Bar diameter	φ	20	mm
	Bars on each of the two faces parallel to b	n	3	

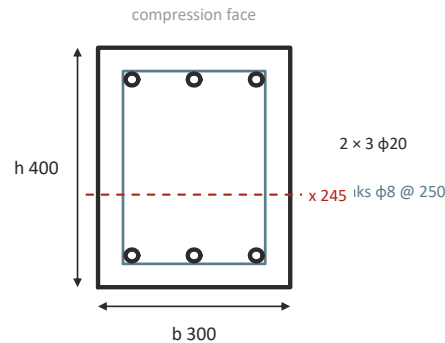
Inputs · actions
ULS design values

	Design axial force (compression)	N_{Ed}	1200	kN	
	Design moment about the axis parallel to b (second order inclu	M_{Ed}	150.0	kNm	RC-008, RC-037
	Inputs valid and consistent				OK

Results

Steel area required / provided (symmetric, two faces)	A_s	908 / 1885 mm ²	OK
Bending with the bars provided M_{Ed} / M_{Rd} at N_{Ed}		0.74	OK
Axial force N_{Ed} / $N_{Rd,max}$ (bars provided)		0.41	OK
Detailing (areas, bar size, gaps, links)		1885 mm ²	OK
Design moment $\max(M_{Ed}; N_{Ed} e_0)$	M_{Ed}	150.0 kNm	

Your section, to scale · compression face on top · neutral axis at M_{Rd} of the bars provided (dashed)



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 $\alpha_{cc} f_{ck} / \gamma_c$	f_{cd}	18.13 MPa	
3.2.7	Design yield strength ($E_s = 200$ GPa)	f_{yd}	434.8 MPa	
	Gross area $b h$	A_c	120000 mm ²	
	Centre of the bars from each face $c + \phi_w + \phi/2$	d_z	53 mm	
6.1(4)	Minimum eccentricity $\max(h/30; 20 \text{ mm})$	e_0	20.0 mm	
6.1(4)	Design moment $\max(M_{Ed}; N_{Ed} e_0)$	M_{Ed}	150.0 kNm	

Calculation · steel area by strain compatibility (see Iter Column)

	Upper bound of the search $0.1 A_c$		12000 mm ²	
6.1	M_{Rd} at N_{Ed} with the upper bound ($-1E9: N_{Ed}$ above $N_{Rd,max}$)		809.4 kNm	
6.1	Steel area required (bisection: $M_{Rd}(A_s)$ at $N_{Ed} = M_{Ed}$)	$A_{s,req}$	908 mm ²	N/A: more than $0.1 A_c$
	Steel area provided $2 n \pi \phi^2 / 4$	$A_{s,prov}$	1885 mm ²	
6.1	Moment resistance at N_{Ed} with the bars provided	M_{Rd}	203.7 kNm	
6.1(5)	Axial resistance, uniform strain $\epsilon_{c2} = 0.002$ $f_{cd} A_c + A_s (\sigma_s - f_{cd})$	$N_{Rd,max}$	2896 kN	
6.1	$A_{s,prov} \geq A_{s,req}$ and $M_{Ed} \leq M_{Rd}$	A_s	1885 mm ²	OK
6.1(5)	$N_{Ed} \leq N_{Rd,max}$	N_{Ed}	1200 kN	OK

Calculation · detailing (9.5)

(9.12N)	Minimum $\max(0.10 N_{Ed} / f_{yd}; 0.002 A_c)$	$A_{s,min}$	276 mm ²	
9.5.2(3)	Maximum $0.04 A_c$ (outside laps)	$A_{s,max}$	4800 mm ²	
8.2(2)	Minimum clear gap $\max(\phi; d_g + 5; 20)$	a_{min}	25 mm	
	Clear gap along b $(b - 2 d_z) / (n - 1) - \phi$	a	77 mm	

8.2(2)	Clear gap between the two layers $h - 2 d_2 - \phi$	a_h	274	mm	
9.5.3(1)	Minimum link diameter $\max(6; \phi/4)$	$\phi_{w,min}$	6.0	mm	
9.5.3(3)	Maximum link spacing $\min(20 \phi; b; h; 400)$	$s_{cl,tmax}$	300	mm	
9.5	$A_{s,min} \leq A_s \leq A_{s,max}, \phi \geq \phi_{min}, \text{ gaps, links}$	A_s	1885	mm ²	OK

Two layers of bars, n_b on each face parallel to b , symmetric; bars along the sides are not counted. Concrete: parabola-rectangle diagram of 3.1.7(1), $\sigma_c = f_{cd} [1 - (1 - \epsilon_c / \epsilon_{c2})^2]$ up to $\epsilon_{c2} = 0.002$ and f_{cd} up to $\epsilon_{cu2} = 0.0035$, integrated over the section in closed form, for every neutral axis depth. Strain limits of 6.1(5) and Fig 6.1: ϵ_{cu2} at the compressed face while $x \leq h$; with the whole section compressed the strain diagram turns about ϵ_{c2} at $3h/7$ from the compressed face, ending at ϵ_{c2} everywhere (NRd,max). Bars elastic-plastic, $E_s = 200$ GPa, horizontal top branch; the concrete they displace is deducted as $A_s a_c$ at the bar centre. $N(x)$ rises with x for two equal layers, so one root. MEd is the design moment about the axis parallel to b with imperfections and second order effects included (RC-008, RC-037); biaxial bending is not covered. Cross-ties of the bars within 150 mm (9.5.3(6)) and the 0.6 link spacing near beams and laps (9.5.3(4)) are for the designer.

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Project
Element
Date

Job no.
Made by
Checked

Inputs · beams

Shaded cells only

	National Annex		UK NA (BS EN)	
3.2.2	Reinforcement characteristic yield strength (≤ 500 MPa)	f_{yk}	500	MPa
9.2.5(1)	Reaction of the supported beam	V_{Ed}	250.0	kN
	Supporting beam A: web width	b_1	350	mm
Figure 9.7	Supporting beam A: overall depth	h_1	700	mm
	Supported beam B: web width	b_2	300	mm
Figure 9.7	Supported beam B: overall depth ($\leq h_1$)	h_2	550	mm
4.4.1	Cover to the links	c	35	mm

Inputs · hanger links

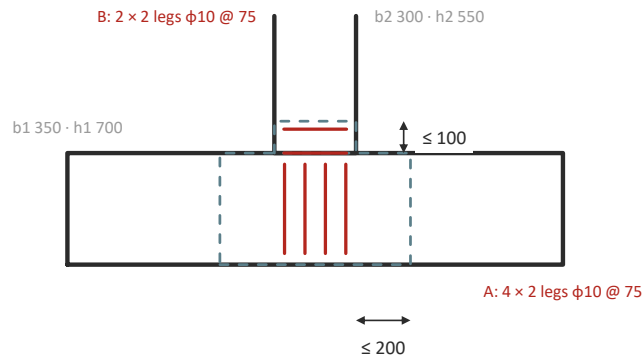
In addition to the links for shear

	In A (around its bottom bars): link diameter	φ_A	10	mm
	legs per set	n_A	2	
	sets (spread over the zone in A)	m_A	4	
	spacing	s_A	75	mm
	In B (next to A): link diameter	φ_B	10	mm
	legs per set	n_B	2	
	sets (0 = none)	m_B	2	
	spacing	s_B	75	mm
	Inputs valid and consistent			OK

Results

Hanger reinforcement required / provided	0.61	OK
Link sets within the zones of Figure 9.7, clear gaps $\geq \max(\phi; 20)$	225 $\leq$ 700 mm	OK
Extra legs needed at the size used in A (all in A)	8	

Plan of the intersection · supporting beam (horizontal), supported beam (vertical) · zones of Figure 9.7 (dashed) and the hanger links



Calculation · 9.2.5

2.4.2.4(1)	Partial factor, reinforcement	γ_s	1.15	NDP sheet
3.2.7	Design yield strength f_{yk} / γ_s	f_{yd}	434.8	MPa
9.2.5(1)	Hanger reinforcement for the whole reaction V_{Ed} / f_{yd}	$A_{s,req}$	575	mm ²
Figure 9.7	Zone in A beyond each face of B $\min(h1/3; h1/2 - b2/2)$	L_A	200	mm
Figure 9.7	Zone in B from the face of A $\min(h2/3; h2/2 - b1/2)$	L_B	100	mm
	Provided in A $m_A n_A \pi \phi A^2 / 4$	$A_{s,A}$	628	mm ²
	Provided in B $m_B n_B \pi \phi B^2 / 4$	$A_{s,B}$	314	mm ²
	Total provided	$A_{s,prov}$	942	mm ²
9.2.5	Provided $\geq$ required	A_s	942	mm ² OK
Figure 9.7, 8.2(2)	Sets within the zones $(m_A - 1) s_A \leq b2 + 2 L_A$; $(m_B - 1) s_B \leq L_B$; clear gaps		225	mm OK

The links hang the whole reaction (common practice; EN 1992-1-1 gives no reduction). They surround the bottom bars of the supporting beam and are in addition to the links needed for shear in either beam (9.2.5(1)). The sets in A are centred on the supported beam; the first set in B sits at the face of A. Figure 9.7 applies with $h1 \geq h2$; a slab not supported at the top of a beam is treated in the same way.

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Nationally Determined Parameters

Values used by every calculation tab for the National Annex selected on that tab. 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

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)
$\alpha_{cc,pl}$ (plain concrete, compression)	12.3.1(1)	0.6	0.8	UK NA Table NA.1: 0.6; 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
vRd,max factor (vRd,max = factor · v · fcd)	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 (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
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, $\delta \geq k1 + k2 x_u/d$)	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
k1 (concrete stress, characteristic; XD, XF, XS)	7.2(2)	0.6	1	UK NA: recommended; PL: NA.5, $k_1 = 1.0$
k2 (concrete stress, quasi-permanent; linear cr)	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)