

Beam torsion

Rectangular beam in torsion and shear · EN 1992-1-1 §6.3, §9.2.3 · UK NA / PN-EN

Reference	NAE-RC-026 · 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	29 October 2026

What it does

Design of a solid rectangular reinforced concrete beam for a torsional moment together with a shear force: the equivalent thin walled section, the strut inclination, crushing of the concrete under torsion and shear together, the closed links and the longitudinal bars for torsion added to those for shear, and the torsion detailing rules.

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

Solid rectangular section, equilibrium torsion (or compatibility torsion the designer chooses to design for), no axial force, no prestress ($\alpha_{cw} = 1$). Thin walled section to 6.3.2(1): $t_{ef} = A/u$, not less than twice the distance from the face to the centre of the longitudinal bars; A_k and u_k on the wall centre line. Strut angle: the largest $\cot \theta$, up to the National Annex limit, for which $T_{Ed}/T_{Rd,max} + V_{Ed}/V_{Rd,max} \leq 1$ (6.29), the same θ for torsion and shear (6.3.2(2)); $V_{Rd,max}$ on bw z with $z = 0.9 d$ and $v = 0.6(1 - f_{ck}/250)$. Where $T_{Ed}/T_{Rd,c} + V_{Ed}/V_{Rd,c} \leq 1$ (6.31), with $T_{Rd,c} = 2 f_{ctd} t_{ef} A_k$, only the minimum links (9.5N) are required (6.3.2(5)); otherwise links for torsion (one leg: the shear flow $T_{Ed} / 2A_k$ of (6.26) carried by a truss at θ , 6.3.2(3)) plus links for shear (6.8, two legs; legs $\leq \min(0.75 d; 600)$ apart, 9.2.2(8)), and longitudinal bars $\Sigma A_{sl} = T_{Ed} u_k \cot \theta / (2 A_k f_{yd})$ (6.28), each wall checked for its share by length with corner bars counted half to each wall, in addition to the bending steel (not reduced in the compression chord, conservative); the bending steel entered must meet $A_{s,min}$ (9.2.1.1), and the tension chord, A_{s1} plus the torsion bars of that wall ($n_b - 1$, corners half), must carry $M_{Ed} / (z f_{yd}) + 0.5 V_{Ed} \cot \theta / f_{yd}$ (6.2.3(7), not capped) + its torsion share. Detailing to 9.2.3: closed links anchored by laps or hooks, spacing $\leq u/8$, $0.75 d$ and b ; longitudinal bars at every corner, ≤ 350 mm apart. $V_{Rd,c}$ for (6.31) from the bending tension steel and its effective depth entered (the steel anchored beyond the section). Flanged and hollow sections, warping torsion and torsion with bending interaction in the compression chord are not covered. fyk 400 – 500 MPa.

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 (torsion).
- The Concrete Centre, Concise Eurocode 2, 7.5 (torsion).
- The Concrete Centre, RC Spreadsheets v4 (licensed product) can be used as an independent cross-check.

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About NA Engineering

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Revision history

v1.0	29 Oct 2026 · First issue
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Project
Element
Date

Job no.
Made by
Checked

Inputs · section and bars

Shaded cells only

	National Annex		UK NA (BS EN)	
Table 3.1	Concrete strength class		C32/40	
3.2.2	Longitudinal bars: characteristic yield strength (≤ 500 MPa)	f_{yk}	500	MPa
3.2.2	Links: characteristic yield strength (≤ 500 MPa)	f_{ywk}	500	MPa
	Width	b	300	mm
	Overall depth	h	600	mm
4.4.1	Nominal cover to the links	c_{nom}	30	mm
	Closed links: diameter (two legs)	ϕ_w	10	mm
9.2.3(3)	Closed links: spacing	s	150	mm
	Longitudinal bars for torsion: diameter	ϕ_l	16	mm
9.2.3(4)	Longitudinal bars along each b face, corners included (2 – 8)	n_b	3	
9.2.3(4)	Longitudinal bars along each h face, corners included (2 – 8)	n_h	4	
6.2.2(1)	Bending tension steel provided (besides the torsion bars of tha	A_{s1}	1473	mm ²
6.2.3(1)	Effective depth to the bending tension steel	d	545	mm

Inputs · design actions

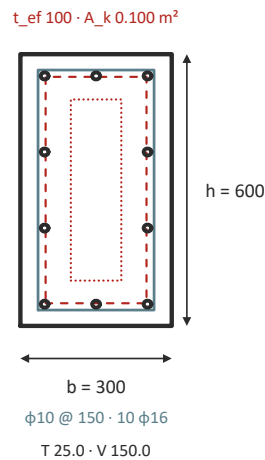
Ultimate limit state, at the same section

	Torsional moment	T_{Ed}	25.0	kNm
	Shear force	V_{Ed}	150.0	kN
	Bending moment (sagging or hogging, As1 in its tension face)	M_{Ed}	150.0	kNm
	Inputs valid and consistent			OK

Results

Concrete struts $T_{Ed}/T_{Rd,max} + V_{Ed}/V_{Rd,max}$ (6.29)	0.59	OK
Closed links, per leg need / provided	0.49	OK
Longitudinal bars (each wall; tension chord; $A_{s1} \geq A_{s,min}$)	0.66	OK
Detailing (link spacing along and across, bar spacing)	0.67	OK
Only minimum links $T_{Ed}/T_{Rd,c} + V_{Ed}/V_{Rd,c} \leq 1$ (6.31)	2.44	No: designed
Strut inclination used $\cot \vartheta$	2.50	

Your section, to scale · torsion reinforcement only: closed links, longitudinal bars, thin walled section (centre line dashed, inner face dotted)



Calculation · thin walled 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
3.1.6(2)	Coefficient on tensile strength	α_{ct}	1.00	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 $\cot \vartheta$	$\cot \vartheta_{max}$	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
3.1.6(1)	Design compressive strength for shear	f_{cd}	21.33	MPa
3.1.6(2)	Design tensile strength $\alpha_{ct} 0.7 f_{ctm} / \gamma_c$	f_{ctd}	1.41	MPa
3.2.7	Design yield strengths bars / links	f_{yd}	434.8	MPa
3.2.7		f_{ywd}	434.8	MPa
6.3.2(1)	Area and perimeter of the section $A = b h$, $u = 2(b + h)$	A	180000	mm ²
6.3.2(1)	Wall thickness $\max(A/u; \text{twice face to bar centre})$	t_{ef}	100.0	mm
6.3.2(1)	Area within the wall centre line $(b - t_{ef})(h - t_{ef})$	A_k	100000	mm ²
6.3.2(1)	Perimeter of A_k $2(b + h - 2 t_{ef})$	u_k	1400	mm
6.2.3(1)	Inner lever arm $0.9 d$	z	491	mm
(6.6N)	Strength reduction factor $v = 0.6 (1 - f_{ck}/250)$	v	0.523	

Calculation · resistances and reinforcement

(6.29)	(6.29) at 45°: $T_{Ed} / (v f_{cd} A_k t_{ef}) + 2 V_{Ed} / (b z v f_{cd})$	R	0.407	
6.2.3(2)	Strut inclination largest $\cot \vartheta \leq \cot \vartheta_{max}$ meeting (6.29)	$\cot \vartheta$	2.500	
(6.30)	$T_{Rd,max} = 2 v f_{cd} A_k t_{ef} \sin \theta \cos \theta$ ($\alpha_{cw} = 1$)	$T_{Rd,max}$	77.0	kNm

(6.9)	$VR_{d,max} = b z v_{fcd} / (\cot \theta + \tan \theta)$	$V_{Rd,max}$	566.4	kN	
(6.29)	$TEd/TR_{d,max} + VEd/VR_{d,max} \leq 1$		0.59		OK
6.3.2(5)	Cracking torsion $TR_{d,c} = 2 f_{ctd} t_{ef} A_k$	$T_{Rd,c}$	28.2	kNm	
(6.2)	Shear without links $VR_{d,c}$ (pl from As1, ≤ 0.02)	$V_{Rd,c}$	96.6	kN	
(6.26), 6.3.2(3)	Torsion links, one leg: shear flow $TEd / 2A_k$ over $f_{ywd} \cot \theta$	$A_{st/s}$	0.115	mm ² /mm	
(6.8)	Shear links, two legs $VEd / (z f_{ywd} \cot \theta)$	$A_{sw/s}$	0.281	mm ² /mm	
(9.5N)	Minimum links, two legs $0.08 \sqrt{f_{ck}} / f_{ywk} \cdot b$	$A_{sw,min/s}$	0.272	mm ² /mm	
	Needed per leg $\max(A_{sw}/2s + A_{st}/s; A_{sw,min}/2s)$	$A_{leg/s}$	0.256	mm ² /mm	
	Provided per leg $\pi \phi w^2 / 4 / s$	$A_{leg/s}$	0.524	mm ² /mm	
6.3.2(3)	Closed links: provided $\geq$ needed per leg		0.524	mm ² /mm	OK
(6.28)	Longitudinal bars for torsion $TEd_{uk} \cot \theta / (2 A_k f_{yd})$	ΣA_{sl}	1006	mm ²	
	Provided $n \pi \phi^2 / 4$ (2 nb + 2 nh – 4 bars)	$\Sigma A_{sl,prov}$	2011	mm ²	
6.3.2(3)	Each b wall: share $\Sigma A_{sl} (b - t_{ef}) / u_k$	$A_{sl,b}$	144	mm ²	
	Each b wall provides (nb – 1) bars (corner bars half)	$A_{sl,b,prov}$	402	mm ²	
6.3.2(3)	Each h wall: share $\Sigma A_{sl} (h - t_{ef}) / u_k$	$A_{sl,h}$	359	mm ²	
	Each h wall provides (nh – 1) bars (corner bars half)	$A_{sl,h,prov}$	603	mm ²	
(9.1N)	Bending steel minimum $\max(0.26 f_{ctm} / f_{yk}; 0.0013) b d$	$A_{s,min}$	257	mm ²	
3.1.7(3)	Tension chord: $K = MEd / (b d^2 f_{ck}) (\leq K'$ for $\xi \leq 0.45)$	K	0.053		
	Lever arm $d (1 - 0.5(1 - \sqrt{1 - 2K / (\alpha_{cc}/\gamma_c)})) \leq 0.95 d$	z_M	518	mm	N/A: compression bars needed, outside sc
6.2.3(7), 6.3.2(3)	Tension chord needs $MEd / (z_M f_{yd}) + 0.5 VEd \cot \theta / f_{yd} + A_{sl}$	$A_{s,ch}$	1241	mm ²	ΔF_{td} not capped (conservative)
	Tension chord has As1 + the torsion bars of that wall (nb – 1)	$A_{s,ch,prov}$	1875	mm ²	
6.3.2(3), 9.2.1.1	Longitudinal: each wall $\geq$ its share; tension chord; $As1 \geq A_{s,min}$		2011	mm ²	OK
9.2.3(3)	Maximum link spacing $\min(u/8; 0.75 d; b)$, $u = 2(b + h)$	s_{max}	225	mm	
9.2.2(8)	Transverse spacing of the two link legs $b - 2c - \phi_w$	s_t	230	mm	
9.2.2(8)	Its limit $\min(0.75 d; 600)$	$s_{t,max}$	409	mm	
9.2.3(4)	Largest spacing of the longitudinal bars round the section	s_l	168	mm	
9.2.2, 9.2.3	Links $\leq s_{max}$, legs $\leq s_{t,max}$ apart; bars ≤ 350 mm apart	s	150	mm	OK

Links for torsion must be closed and anchored by laps or hooks (9.2.3(1), Figure 9.6); the clear gaps between bars and the bending design are checked in RC-004. The tension chord check adds the force from shear $0.5 VEd \cot \theta$ (6.2.3(7)), uncapped, and the share of the torsion wall there to $MEd / (z f_{yd})$. The drawing shows the torsion reinforcement only.

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Nationally Determined Parameters

Values used by the Calculation sheet for the selected National Annex. Sources: UK NA to BS EN 1992-1-1:2004, Table NA.1; PN-EN 1992-1-1:2008, Załącznik krajowy NA. Edit only if your project specifies different values.

Parameter	Clause	UK NA	PL NA	Notes
Partial factor, concrete γ_c	2.4.2.4(1)	1.5	1.4	Persistent & transient. UK NA: recommended; PL: NA.2, Table NA.2
Partial factor, reinforcement γ_s	2.4.2.4(1)	1.15	1.15	UK NA: recommended; PL: NA.2, Table NA.2
α_{cc} (compression in flexure / axial)	3.1.6(1)	0.85	1	UK NA: 0.85; PL: recommended (NA.9)
α_{cc} (shear and punching)	3.1.6(1)	1	1	UK NA: 1.0 for other phenomena; PL: recommended (NA.9)
α_{ct} (design tensile strength)	3.1.6(2)	1	1	Recommended value in both annexes
CRd,c numerator (CRd,c = value / γ_c)	6.2.2(1), 6.4.4(1)	0.18	0.18	Recommended value in both annexes
k1 (axial stress term, punching)	6.4.4(1)	0.1	0.1	Recommended value in both annexes
$v_{Rd,max}$ factor ($v_{Rd,max} = \text{factor} \cdot v \cdot f_{cd}$)	6.4.5(3)	0.5	0.4	UK NA: 0.5 v fcd; PL: recommended value (NA.9), 0.4 v fcd since EN 1992-1-1 AC:2010 (PN-EN 1992-1-1:2008)
kmax ($v_{Ed} \leq k_{max} \cdot v_{Rd,c}$ at u1)	6.4.5	2	1.5	UK NA 6.4.5(3): 2 vRd,c. PL: no limit in PN-EN 1992-1-1:2008; 1.5 (A1:2014 recommendation) applied conse
ϕ_{large} (large bar threshold, mm)	8.8(1)	40	32	UK NA: 40 mm; PL: 32 mm recommended (NA.9)
cot θ upper limit (variable strut)	6.2.3(2)	2.5	2	UK NA: 2.5 (1.25 with axial tension); PL: NA.4, $1 \leq \cot \theta \leq 2.0$
k1 (x/d limit, $\delta \geq k_1 + k_2 x_u/d$)	5.5(4)	0.4	0.44	UK NA for $f_{yk} \leq 500$ MPa; PL: recommended (NA.9)
k2 (x/d limit, $\epsilon_{cu2} = 0.0035$)	5.5(4)	1	1.25	UK NA: $0.6 + 0.0014/\epsilon_{cu2}$; PL: $1.25(0.6 + 0.0014/\epsilon_{cu2})$
Upper limit on the (310/ σ_s) factor (0 = none)	7.4.2(2)	1.5	0	UK NA Table NA.5 Note 5: (310/ σ_s) or (500/ f_{yk})($A_{s,prov}/A_{s,req}$) ≤ 1.5 ; PL: none
L/d not to exceed 40 K (1 = applies)	7.4.2(2)	1	0	UK NA Table NA.5 Note 6; not in EN text
ϕ_{min} (longitudinal bars in columns, mm)	9.5.2(1)	12	6	UK NA: 12 mm; PL: NA.6, 6 mm
k3 (crack spacing)	7.3.4(3)	3.4	3.4	Recommended value in both annexes
k4 (crack spacing)	7.3.4(3)	0.425	0.425	Recommended value in both annexes