

Stress limitation

Serviceability stresses · EN 1992-1-1 §7.2 · UK NA / PN-EN

Reference	NAE-RC-047 · 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
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What it does

Service stresses of a reinforced concrete section in bending, with or without axial compression, checked against the stress limits of 7.2: concrete under the characteristic combination ($k_1 f_{ck}$, exposure XD, XF and XS), concrete under the quasi-permanent combination ($k_2 f_{ck}$, linear creep) and reinforcement under the characteristic combination ($k_3 f_{yk}$, or $k_4 f_{yk}$ for imposed deformation).

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 or flanged section (flange at the top face) with one layer of bars at the top and one at the bottom. One moment sense, chosen as sagging (top face compressed) or hogging (bottom face compressed); moments entered as magnitudes, axial force compression or zero (tension members are not covered). Moments are about the centroid of the gross concrete section, where the axial force acts. Linear elastic analysis, $E_s = 200$ GPa: the section is analysed uncracked (transformed with α_e) and, when cracked, with the concrete in tension ignored (bars in the compressed concrete counted with $\alpha_e = 1$). It is taken as cracked when the flexural tension of the uncracked section under either combination exceeds $f_{ct,eff} = f_{ctm}$ or $f_{ctm,fl}$ (7.1(2)), or when declared cracked. Each combination is analysed with the short-term modular ratio E_s / E_{cm} and the long-term $E_s / E_{c,eff}$, $E_{c,eff} = E_{cm} / (1 + \phi)$ (7.4.3(5)); the characteristic combination also staged: uncracked, the quasi-permanent actions long term plus the increment ($N_k - N_{qp}$, $M_k - M_{qp}$) short term, superposed exactly; cracked, one analysis of the characteristic actions with the creep coefficient scaled by M_{qp} / M_k (as ϕ_{ef} in 5.8.4(2); N_{qp} / N_k when $M_k = 0$), an approximation that we found conservative in pure bending and when the axial force is sustained in the same share as the moment, but not otherwise: a cracked section whose axial force is largely transient shows "!" approximate" instead of OK and needs a separate staged analysis. The largest stress is checked. E_{cm} from Table 3.1 with the aggregate factor of 3.1.3(2). The elastic model needs every bar stress, tension or compression, below f_{yk} (checked, 7.2(4)P). $f_{ctm,fl}$ may be used only if the minimum reinforcement (7.3.2) is based on it too; the steel stress for crack control is always from the cracked section. The flange counts with the full width entered: use the effective width b_{eff} of 5.3.2.1. The k_1 limit applies where the exposure is XD, XF or XS unless other measures (more cover, confinement by links) are taken; above $k_2 f_{ck}$ non-linear creep must be considered (3.1.4(4)). Concrete classes up to C50/60. Clear gaps between bars and between the layers against $\max(\phi; 20 \text{ mm})$ of 8.2(2) as a warning (the aggregate size $d_g + 5 \text{ mm}$ is not checked). Prestressing (k_5), shear, crack widths and deflections are not covered here (RC-003, RC-016, RC-033).

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: Serviceability.
- The Concrete Centre, Concise Eurocode 2, section 10 (serviceability).
- 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 30 Oct 2026 · First issue

Project
Element
Date

Job no.
Made by
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	f_{yk}	500	MPa
	Section shape		Rectangular	
	Web width (rectangle: the width)	b_w	300	mm
	Overall depth	h	500	mm
	Flanged: flange width (effective, 5.3.2.1)	b_f	1000	mm
	Flanged: flange thickness	h_f	150	mm
4.4.1	Nominal cover to links	c_{nom}	30	mm
	Link diameter (0: no links, cover to the bars)	φ_w	8	mm
	Top bars (number)	n_t	2	
	Top bar diameter	φ_t	16	mm
	Bottom bars (number)	n_b	3	
	Bottom bar diameter	φ_b	20	mm

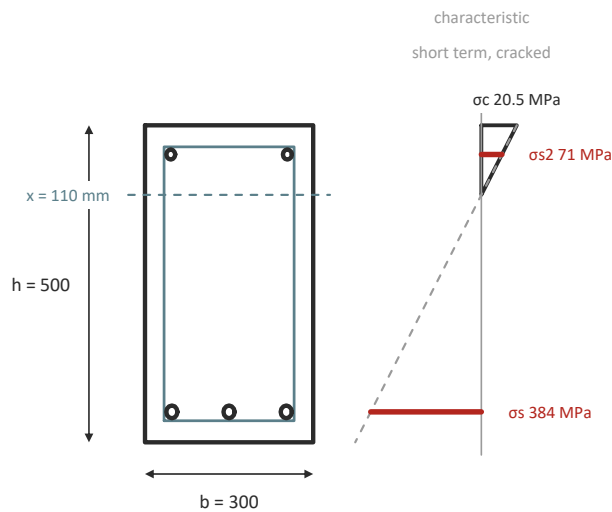
Inputs · service actions and conditions
EN 1990 (6.14b), (6.16b)

	Moment sense		Sagging (top face compressed)	
7.2(2), (5)	Characteristic combination: moment ($\geq M_{qp}$)	M_k	150.0	kNm
	Characteristic combination: axial compression ($\geq N_{qp}$)	N_k	0	kN
7.2(3)	Quasi-permanent combination: moment	M_{qp}	100.0	kNm
	Quasi-permanent combination: axial compression	N_{qp}	0	kN
3.1.4, Annex B	Creep coefficient $\phi(\infty, t_0)$	ϕ	2.00	
3.1.3(2)	Aggregate (factor on E_{cm})		Quartzite (1.0)	
Table 4.1	Exposure class		XC1	
7.2(5)	Steel stress caused by		Loads (k3 f_{yk})	
7.1(2)	Tensile strength for the uncracked check $f_{ct,eff}$		f_{ctm}	$f_{ctm,fl}$: As,min on it too
7.1(2)	Cracking		From the stresses (7.1(2))	
	Stress diagram shows		Characteristic short term	
	Inputs valid and consistent			OK

Results

Section state (largest flexural tension, uncracked: $\sigma_{ct} / f_{ct,eff}$)		3.60		cracked
Concrete, characteristic $\sigma_c \leq k_1 f_{ck}$ (XD, XF, XS)	$\sigma_{c,k}$	20.5	MPa	not required
Concrete, quasi-permanent $\sigma_c \leq k_2 f_{ck}$ (linear creep)	$\sigma_{c,qp}$	13.7	MPa	OK
Reinforcement, characteristic $\sigma_s \leq k_3 f_{yk}$ (k4 fyk)	$\sigma_{s,k}$	399	MPa	OK
Reinforcement, quasi-permanent, cracked (crack control)	$\sigma_{s,qp}$	266	MPa	
Largest bar stress $\leq f_{yk}$ (elastic analysis valid)	$ \sigma_{s,l} $	399	MPa	OK
Smallest clear gap between bars $\geq \max(\phi; 20 \text{ mm})$		82	mm	OK

Your section, to scale · stresses of the case chosen above (concrete solid, the strain line dashed, bars at σ_s / a_e)



Calculation · materials

7.2(2)	Concrete stress factor, characteristic	k_1	0.60	NDP sheet
7.2(3)	Concrete stress factor, linear creep	k_2	0.45	NDP sheet
7.2(5)	Steel stress factor, characteristic	k_3	0.80	NDP sheet
7.2(5)	Steel stress factor, imposed deformation	k_4	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
3.1.3(2)	Aggregate factor (quartzite 1.0, limestone 0.9, sandstone 0.7, basalt 1.2)		1.0	
Table 3.1	Mean modulus $22 (f_{cm} / 10)^{0.3} \times \text{factor}$	E_{cm}	33346	MPa
(3.23)	Flexural tensile strength $\max((1.6 - h/1000) f_{ctm}; f_{ctm})$	$f_{ctm,fl}$	3.33	MPa
7.1(2)	Tensile strength for the uncracked check	$f_{ct,eff}$	3.02	MPa
3.2.7(4)	Modulus of the reinforcement	E_s	200000	MPa
(7.20)	Effective modulus $E_{cm} / (1 + \phi)$	$E_{c,eff}$	11115	MPa
	Modular ratio, short term E_s / E_{cm}	$\alpha_{e,S}$	6.00	
7.4.3(5)	Modular ratio, long term $E_s / E_{c,eff}$	$\alpha_{e,L}$	17.99	
5.8.4(2)	Mixed, creep $\phi M_{qp} / M_k$ (N_{qp} / N_k when $M_k = 0$)	$\alpha_{e,M}$	13.99	

Calculation · section (depths y from the compressed face)

Gross concrete area $b w h + (b_f - b w) h_f$	A_c	150000	mm ²
Its centroid below the top face	y_g	250.0	mm
Its second moment of area	I_c	3.125E+09	mm ⁴
Top bars $n t \pi \phi t^2 / 4$	$A_{s,t}$	402	mm ²

Bottom bars $n_b \pi \phi b^2 / 4$	$A_{s,b}$	942	mm ²
Centroid of the gross section from the compressed face	y_c	250.0	mm
Bars at the compressed face (area)	A_{s2}	402	mm ²
Their depth $c + \phi w + \phi / 2$	d_2	46.0	mm
Bars at the tension face (area)	A_s	942	mm ²
Effective depth $h - c - \phi w - \phi / 2$	d	452.0	mm

Calculation · uncracked section (transformed; + compression, – tension)

Transformed area, short term $A_c + (\alpha_e - 1)(A_s + A_{s2})$	$A_{I,S}$	156720	mm ²
Its centroid from the compressed face	$y_{I,S}$	253.5	mm
Its second moment of area	$I_{I,S}$	3.399E+09	mm ⁴
Transformed area, long term $A_c + (\alpha_e - 1)(A_s + A_{s2})$	$A_{I,L}$	172849	mm ²
Its centroid from the compressed face	$y_{I,L}$	260.7	mm
Its second moment of area	$I_{I,L}$	4.043E+09	mm ⁴
Transformed area, mixed $A_c + (\alpha_e - 1)(A_s + A_{s2})$	$A_{I,M}$	167473	mm ²
Its centroid from the compressed face	$y_{I,M}$	258.4	mm
Its second moment of area	$I_{I,M}$	3.830E+09	mm ⁴
Characteristic, short term: compressed face	σ_{top}	11.19	MPa
Characteristic, short term: tension face	σ_{bot}	-10.88	MPa
Characteristic, long term: compressed face	σ_{top}	9.67	MPa
Characteristic, long term: tension face	σ_{bot}	-8.88	MPa
Quasi-permanent, short term: compressed face	σ_{top}	7.46	MPa
Quasi-permanent, short term: tension face	σ_{bot}	-7.25	MPa
Quasi-permanent, long term: compressed face	σ_{top}	6.45	MPa
Quasi-permanent, long term: tension face	σ_{bot}	-5.92	MPa
Increment $k - qp$, short term: compressed face	σ_{top}	3.73	MPa
Increment $k - qp$, short term: tension face	σ_{bot}	-3.63	MPa
Characteristic, creep $\phi m_{qp} / m_k$: compressed face	σ_{top}	10.12	MPa
Characteristic, creep $\phi m_{qp} / m_k$: tension face	σ_{bot}	-9.46	MPa
Characteristic, staged (qp long term + increment short term): c	σ_{top}	10.17	MPa
Characteristic, staged: tension face	σ_{bot}	-9.55	MPa
7.1(2) Largest flexural tension, uncracked (any analysis)	σ_{ct}	10.88	MPa
7.1(2) Section cracked ($\sigma_{ct} > f_{ct,eff}$, or declared)			cracked
Compressed face as entered (FAIL: the other face is; change the sense)			OK

Calculation · cracked section (concrete in tension ignored; see Solver)

Neutral axis in pure bending, short term ($Q = 0$)	$x_{0,S}$	109.7	mm
Neutral axis in pure bending, long term	$x_{0,L}$	164.6	mm
Neutral axis in pure bending, mixed	$x_{0,M}$	151.0	mm
Neutral axis, characteristic, short term ($N J = M Q$)	x	109.7	mm
Concrete stress at the compressed face	σ_c	20.51	MPa
Bars at the compressed face (+ compression)	σ_{s2}	71.5	MPa
Bars at the tension face (– tension)	σ_s	-383.7	MPa
Neutral axis, characteristic, long term ($N J = M Q$)	x	164.6	mm
Concrete stress at the compressed face	σ_c	12.71	MPa
Bars at the compressed face (+ compression)	σ_{s2}	164.8	MPa
Bars at the tension face (– tension)	σ_s	-399.3	MPa
Neutral axis, quasi-permanent, short term ($N J = M Q$)	x	109.7	mm
Concrete stress at the compressed face	σ_c	13.68	MPa
Bars at the compressed face (+ compression)	σ_{s2}	47.6	MPa
Bars at the tension face (– tension)	σ_s	-255.8	MPa
Neutral axis, quasi-permanent, long term ($N J = M Q$)	x	164.6	mm
Concrete stress at the compressed face	σ_c	8.47	MPa
Bars at the compressed face (+ compression)	σ_{s2}	109.8	MPa
Bars at the tension face (– tension)	σ_s	-266.2	MPa
Neutral axis, increment $k - qp$, short term ($N J = M Q$)	x	109.7	mm

Concrete stress at the compressed face	σ_c	6.84	MPa
Bars at the compressed face (+ compression)	σ_{s2}	23.8	MPa
Bars at the tension face (– tension)	σ_s	-127.9	MPa
Neutral axis, characteristic, creep ϕ Mqp / Mk (N J = M Q)	x	151.0	mm
Concrete stress at the compressed face	σ_c	14.19	MPa
Bars at the compressed face (+ compression)	σ_{s2}	138.1	MPa
Bars at the tension face (– tension)	σ_s	-395.7	MPa
Characteristic, staged (uncracked: qp long term + increment sh	σ_c	14.19	MPa
Bars at the compressed face	σ_{s2}	138.1	MPa
Bars at the tension face	σ_s	-395.7	MPa

Calculation · stress limits (largest of the analyses)

7.2(2)	Concrete, characteristic (short, long term, staged)	$\sigma_{c,k}$	20.51	MPa	
7.2(2)	Limit k1 fck		19.2	MPa	
7.2(2)	$\sigma_{c,k} \leq k1 fck$ (required for exposure XD, XF, XS)				not required
7.2(3)	Concrete, quasi-permanent	$\sigma_{c,qp}$	13.68	MPa	
7.2(3)	Limit for linear creep k2 fck		14.4	MPa	
7.2(3)	$\sigma_{c,qp} \leq k2 fck$ (else non-linear creep, 3.1.4(4))				OK
7.2(5)	Reinforcement tension, characteristic (short, long term, staged	$\sigma_{s,k}$	399.3	MPa	
7.2(5)	Limit k3 fyk (loads) or k4 fyk (imposed deformation)		400	MPa	
7.2(5)	$\sigma_{s,k} \leq \text{limit}$				OK
7.3.3	Reinforcement tension, quasi-permanent, cracked section (RC- $\perp$	$\sigma_{s,qp}$	266.2	MPa	
	Staged estimate (cracked: Nqp / Nk = Mqp / Mk within 0.01, else approximate)				OK
7.2(4)P	Largest bar stress (any analysis, incl. the cracked one of 7.3.3)	$ \sigma_{s,l} $	399.3	MPa	
7.2(4)P	Bars $\leq fyk$ (else the elastic analysis does not apply)				OK
8.2(2)	Clear gap, top bars (bw – 2(c + ϕw) – n ϕ) / (n – 1)		192	mm	
8.2(2)	Clear gap, bottom bars		82	mm	
8.2(2)	Clear gap between the layers h – 2(c + ϕw) – ϕt – ϕb		388	mm	
8.2(2)	Gaps $\geq \max(\phi; 20 \text{ mm})$ (dg + 5 mm not checked)				OK

Stresses from a linear elastic analysis with $E_s = 200 \text{ GPa}$; the short-term modular ratio gives the stresses when the load is applied, the long-term one after creep; for the characteristic combination a staged value is added (uncracked: sustained part long term plus the rest short term, exact; cracked: creep scaled by Mqp / Mk) and the largest of the three is checked. A section once cracked stays cracked: the cracked analysis is used for both combinations. Where the whole section is compressed it is analysed uncracked. Tension in the bars at the compressed face counts in σ_s . The face entered as compressed must carry no tension (cracked) or no more than $f_{ct,eff}$ (uncracked); otherwise the other face is the compressed one and every check reports FAIL. The k1 limit may be relaxed where other measures, such as more cover or confinement by transverse reinforcement, are taken (7.2(2)).

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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)
$\alpha_{cc,pl}$ (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)