

Corbel

Short corbels · strut-and-tie, EN 1992-1-1 §6.5, Annex J.3 · UK NA / PN-EN

Reference	NAE-RC-009 · 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 short concrete corbel projecting from a column face under a vertical load and a horizontal force on a bearing: strut-and-tie model, main tie reinforcement, node and bearing stresses, the shear limit and the horizontal or vertical links of Annex J.3.

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 corbel of constant width with a straight sloping soffit, one load on one bearing plate, $a_c < z_0$ (Annex J.3(1)). Lower node at the column face as a compressed block of depth y_0 at $k_1 v' f_{cd}$ (CCC node, 6.5.4(4)a), from moments about the tie: $b y_0 \sigma (d - y_0/2) = F_{Ed} a_c + H_{Ed} a_H$, $z_0 = d - y_0/2$; bearing and strut checked at the CCT node at $k_2 v' f_{cd}$ (6.5.4(4)b). The horizontal force H_{Ed} acts at the top surface, $a_H = h_c - d$ above the tie; enter at least 0.2 F_{Ed} for bearings without a controlled sliding surface (common practice). The resultant of F_{Ed} and H_{Ed} meets the tie at $a_{eq} = a_c + H_{Ed} a_H / F_{Ed}$: the strut runs from there, $\tan \theta = z / a_{eq}$ within 1 – 2.5, and the tie force is $F_{Ed} a_{eq} / z + H_{Ed}$. The strut is checked at 0.6 $v' f_{cd}$ (6.5.2(2), cracked zone) on its width at the loaded node; the lower node is taken as hydrostatic. Main tie within $A_{s,min}$ and $A_{s,max}$ of 9.2.1.1. Shear limit 0.5 $b d v' f_{cd}$ (6.2.2(6)). Horizontal links 0.5 $A_{s,min}$ (PL NA.8: $k_1 = 0.5$; UK: PD 6687, which the UK NA refers to for Annex J) and vertical links 0.5 F_{Ed} / f_{yd} (J.3(3), $k_2 = 0.5$). Where z_0 / a_c exceeds 2.5 the strut is kept at $\tan \theta = 2.5$: the lever arm becomes 2.5 a_c and the lower node deepens accordingly, so the model stays in equilibrium. The anchorage of the main bars at both ends (J.3(4)), the column itself and crack control (J.3(5)) are the user's to check. Concrete classes up to C50/60, $f_{yk} \leq 500$ MPa. The second-generation EN 1992-1-1:2023 is not yet implemented.

Further reading and independent cross-check

- EN 1992-1-1, 6.5 and Annex J.3.
- The Concrete Centre, Worked Examples to Eurocode 2: Volume 1 (corbels).
- IStructE, Manual for the design of concrete building structures to Eurocode 2.

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About NA Engineering

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Revision history

v1.0 29 Oct 2026 · First issue

Project
Element
Date

Job no.
Made by
Checked

Inputs · geometry

Shaded cells only

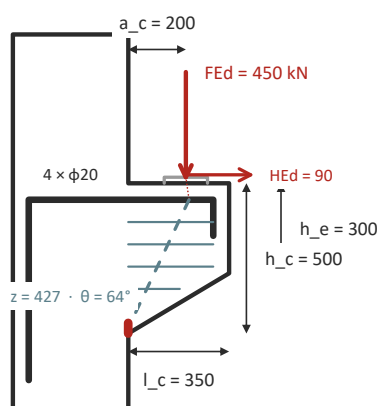
	National Annex		UK NA (BS EN)	
Table 3.1	Concrete strength class		C32/40	
3.2.2	Reinforcement characteristic yield strength (≤ 500 MPa)	f_{yk}	500	MPa
8.2(2)	Maximum aggregate size	d_g	20	mm
	Column depth (in the plane of the corbel)	w_c	400	mm
	Corbel width	b	400	mm
	Corbel depth at the column face	h_c	500	mm
	Corbel depth at the outer edge ($\leq h_c$)	h_e	300	mm
	Projection from the column face	l_c	350	mm
	Load position from the column face (bearing centre)	a_c	200	mm
	Bearing plate length (along the projection)	l_p	150	mm
	Bearing plate width	b_p	300	mm
4.4.1	Nominal cover to links	c_{nom}	35	mm
	Main tie bars: diameter	φ_m	20	mm
	Main tie bars: number	n_m	4	
	Links: diameter	φ_l	10	mm
J.3(2)	Horizontal link sets (2 legs each)	n_{lh}	4	
J.3(3)	Vertical link sets (2 legs each)	n_{lv}	0	

Inputs · actions

ULS design values

Vertical load on the bearing	F_{Ed}	450	kN
Horizontal force at the bearing ($\geq 0.2 F_{Ed}$ advised)	H_{Ed}	90	kN
Inputs valid and consistent			OK

Your corbel, to scale · elevation · strut (dashed) and tie of the truss model



Results

Main tie $A_{s,prov} / \max(A_{s,req}; A_{s,min})$ (bars in one layer)	A_s	1.75	OK
Bearing ($k_2 v' f_{cd}$) and strut ($0.6 v' f_{cd}$) largest σ / limit		0.96	OK

Shear limit $F_{Ed} / (0.5 b d v_{fcd})$		0.45	OK
Links to Annex J.3		horizontal	OK
Model valid ($a_c < z_0$; $1 \leq \tan \theta \leq 2.5$; nodes fit)	$z_0 / a_{c,c}$	2.14	OK

No real y_0 : the compression at the column face exceeds the node strength — increase b , h_c or the concrete class. $z_0 / a_c \leq 1$: the corbel is not short in the sense of J.3(1) — reduce a_c or deepen the corbel (a cantilever beam design is outside this sheet).

Calculation • materials and truss

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(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
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_{yd}	434.8	MPa
(6.57N)	$v' = 1 - f_{ck} / 250$	v'	0.872	
6.5.4(4)a	CCC node limit $k_1 v' f_{cd}$, $k_1 = 1.0$	$\sigma_{Rd,CCC}$	15.81	MPa
6.5.4(4)b	CCT node limit $k_2 v' f_{cd}$, $k_2 = 0.85$	$\sigma_{Rd,CCT}$	13.44	MPa
6.5.2(2)	Strut in a cracked zone $0.6 v' f_{cd}$	$\sigma_{Rd,max}$	9.49	MPa
	Effective depth $h_c - c - \phi_l - \phi_m / 2$	d	445	mm
	Lever of HEd above the tie $h_c - d$	a_H	55	mm
6.5	Moment about the tie $F_{Ed} a_c + H_{Ed} a_H$	M_t	94950	kNm
J.3(1)	Lower node depth $d - \sqrt{d^2 - 2 M_t / (b \sigma_{Rd,CCC})}$	y_0	35.1	mm
J.3(1)	Lever arm $z_0 = d - y_0 / 2$	z_0	427.4	mm
J.3(1)	z_0 / a_c (> 1.0 : short corbel)	$z_0 / a_{c,c}$	2.137	
6.5	Where the resultant of F_{Ed} and H_{Ed} meets the tie M_t / F_{Ed}	a_{eq}	211.0	mm
	End of the tie $l_c - c - \phi_l - \phi_m / 2$ ($\geq a_{eq}$)		295	mm
J.3(1)	Lever arm used $\min(z_0; 2.5 a_{eq})$ ($\tan \theta \leq 2.5$)	z	427.4	mm
J.3(1)	Lower node depth used $2(d - z)$	y	35.1	mm
J.3(1)	Strut inclination $\tan \theta = z / a_{eq}$ ($1 \leq \tan \theta \leq 2.5$)	$\tan \vartheta$	2.026	
6.5	Compression at the column face M_t / z ($= F_{Ed} / \tan \theta$)	C	222.1	kN
6.5.4(4)a	Stress on the lower node $C / (b y)$ ($\leq \sigma_{Rd,CCC}$)	σ_c	15.81	MPa
6.5	Tie force $C + H_{Ed}$	F_{td}	312.1	kN
6.5	Strut force $F_{Ed} / \sin \theta = \sqrt{F_{Ed}^2 + C^2}$	F_c	501.8	kN
6.5.4(4)b	Strut width at the loaded node $l_p \sin \theta + 2 a_H \cos \theta$	w	183.2	mm
6.5.2(2)	Strut stress at its narrowest $F_c / (b p w)$ ($\leq 0.6 v' f_{cd}$)	σ_{st}	9.13	MPa
6.5.4(4)a	Lower node, inclined face $F_c / (b y / \cos \theta)$ (hydrostatic: $= \sigma_c$)	$\sigma_{c,\vartheta}$	15.81	MPa
	Main reinforcement required F_{td} / f_{yd}	$A_{s,req}$	718	mm ²
	Main reinforcement provided $n \pi \phi^2 / 4$	$A_{s,prov}$	1257	mm ²
9.2.1.1(1)	Minimum $\max(0.26 f_{ctm} / f_{yk}; 0.0013) b d$	$A_{s,min}$	280	mm ²
9.2.1.1(3)	Maximum $0.04 b h_c$	$A_{s,max}$	8000	mm ²
6.5.4(4)b	Bearing stress $F_{Ed} / (l_p b p)$	σ_{Ed}	10.00	MPa
9.2.1.1	Main tie $\max(A_{s,req}; A_{s,min}) \leq A_{s,prov} \leq A_{s,max}$	A_s	1257	mm ²
6.5.4(4)b	Bearing node $\sigma_{Ed} \leq \sigma_{Rd,CCT}$	σ_{Ed}	10.00	MPa
6.5.2(2)	Strut $\sigma_{st} \leq 0.6 v' f_{cd}$	σ_{st}	9.13	MPa
8.2(2)	Minimum clear gap $\max(\phi; d_g + 5; 20)$	a_{min}	25	mm
	Clear gap of the main bars $(b - 2(c + \phi_l) - n \phi) / (n - 1)$	a	77	mm
8.2(2)	Main bars fit in one layer $a \geq a_{min}$	a	77	mm

Calculation • shear and links

3.1.6(1)	Design compressive strength for shear	$f_{cd,v}$	21.33	MPa
(6.6N)	$v = 0.6 (1 - f_{ck} / 250)$	v	0.523	
6.2.2(6)	Shear limit $0.5 b d v_{fcd}$	V_{max}	993.4	kN
6.2.2(1)	Size factor $1 + \sqrt{200/d} \leq 2$	k	1.670	

6.2.2(1)	$\rho_l = A_{s,prov} / (b d) \leq 0.02$	ρ_l	0.0071		
(6.2)	Shear resistance without links	$V_{Rd,c}$	100.9	kN	
6.2.2(6)	Shear $F_{Ed} \leq 0.5 b d v_{fcd}$	F_{Ed}	450	kN	OK
J.3(2)	Horizontal links needed ($a_c \leq 0.5 h_c$) $0.5 A_{s,main}$ (PL NA.8; UK	$A_{s,lnk,h}$	628	mm ²	
	Horizontal links provided $n_{lh} \cdot 2 \pi \phi_l^2 / 4$	$A_{s,lnk,h}$	628	mm ²	
J.3(3)	Vertical links needed ($a_c > 0.5 h_c$, $F_{Ed} > V_{Rd,c}$) $0.5 F_{Ed} / f_{yd}$	$A_{s,lnk,v}$	0	mm ²	
	Vertical links provided $n_{lv} \cdot 2 \pi \phi_l^2 / 4$	$A_{s,lnk,v}$	0	mm ²	
J.3(2)	Lowest horizontal link (d/3): reach along the corbel, cover to the	x_{link}	179	mm	
8.2(2)	Clear gap between links $\max(\phi_l; d_g + 5; 20)$	$a_{l,min}$	25	mm	
	Clear gap, horizontal links $(2d/3) / n_{lh} - \phi_l$	a_{lh}	64	mm	
	Clear gap, vertical links $x_{tie} / (n_{lv} + 1) - \phi_l$	a_{lv}	—	mm	
J.3(2), (3)	Links provided $\geq$ needed		628	mm ²	OK

Anchor the main bars at both ends (J.3(4)): in the column on its far face, with the anchorage length measured from the vertical bars at the near face, and in the corbel from the inner edge of the bearing plate (loops or welded cross bars). The horizontal links are spread over the top 2/3 of d in the drawing; the vertical links over the projection.

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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