

Punching shear

Flat slabs · EN 1992-1-1 §6.4 · UK NA / PN-EN

Reference	NAE-RC-002 · 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

Punching shear check of a flat slab at a rectangular column: maximum shear at the column face, resistance without shear reinforcement at the basic control perimeter u_1 ($2d$), required punching reinforcement per perimeter and the extent of the reinforced zone ($u_{out,ef}$).

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 internal, edge and corner columns away from openings. β from the simplified values of 6.4.3(6) (braced structures, adjacent spans within 25 %), calculated from the unbalanced moments (6.39, 6.43, 6.44, 6.46; edge and corner eccentricity towards the slab interior) or entered by the user. The load inside u_1 may be deducted (6.4.1(5), 6.48); EC2 gives this for footings and special cases, so for suspended slabs it is the designer's decision (default: no). Only the basic control perimeter at $2d$ is checked, so this is not a complete check of column bases or footings, which need perimeters within $2d$ (6.4.4(2)). Control perimeters assume the slab edge is flush with the column face. Vertical links or studs ($\alpha = 90^\circ$). Column heads, drops, openings and prestress beyond α_{cp} are outside the scope. Concrete classes up to C50/60.

Shear links: A_{sw} per perimeter from (6.52); the sheet lays out perimeters at s_0 and then every s_r out to $r_{out} - 1.5d$ (at least two; UK NA: within $0.3d - 1.5d$ where $r_{out} < 3d$) and on each the number of legs of the chosen size that gives A_{sw} and keeps the tangential spacing within $1.5d$ inside $2d$ and $2d$ outside (9.4.3(1)); the minimum leg area (9.11) uses the largest tangential spacing. The legs are drawn for internal columns; at edges and corners only the perimeters are drawn. The tension reinforcement must be averaged over the column width plus $3d$ each side (6.4.4(1)); at edge and corner columns the averaging width stops at the slab edge.

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: Flat slabs.
- The Concrete Centre, Worked Examples to Eurocode 2: Volume 1.
- The Concrete Centre, RC Spreadsheets v4, TCC13 Slab Punching (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

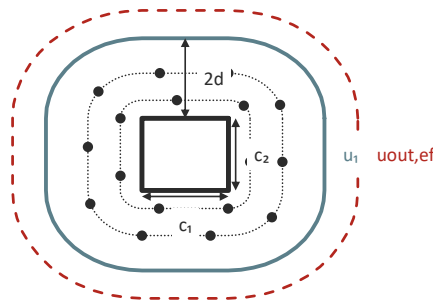
Job no.
Made by
Checked

Inputs · geometry

Shaded cells only

	National Annex		UK NA (BS EN)		
Table 3.1	Concrete strength class		C32/40		
	Column position		Internal		
	Column shape		Rectangular	Edge, corner: as square $\pi D/4$	
	Column dimension c1 (y), or diameter D if circular	c_1	400	mm	Perpendicular to slab edge
	Column dimension c2 (z), parallel to slab edge	c_2	400	mm	Not used if circular
Fig. 6.15	Column face to slab edge, y direction (edge, corner)	a_1	0	mm	0 = flush with the edge
Fig. 6.15	Column face to slab edge, z direction (corner)	a_2	0	mm	0 = flush with the edge
	Effective depth, y-direction bars	d_y	230	mm	
	Effective depth, z-direction bars	d_z	214	mm	
6.4.4(1)	Bonded tension reinforcement, y direction	$A_{s,y}$	1340	mm ² /m	Average over c + 3d each side
6.4.4(1)	Bonded tension reinforcement, z direction	$A_{s,z}$	1340	mm ² /m	Average over c + 3d each side
6.4.4(1)	Mean normal stress in slab (compression +)	σ_{cp}	0.00	MPa	

Your column, to scale · u1 at 2d (blue) · uout,ef (red, dashed) · link perimeters and legs (dotted, dots) · slab edge (grey)

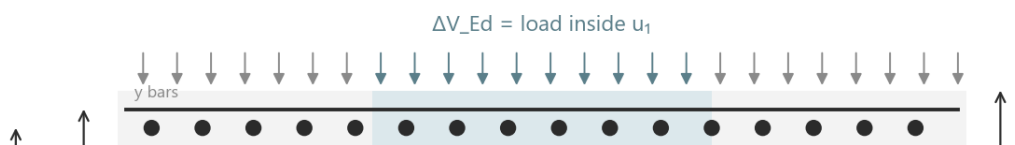


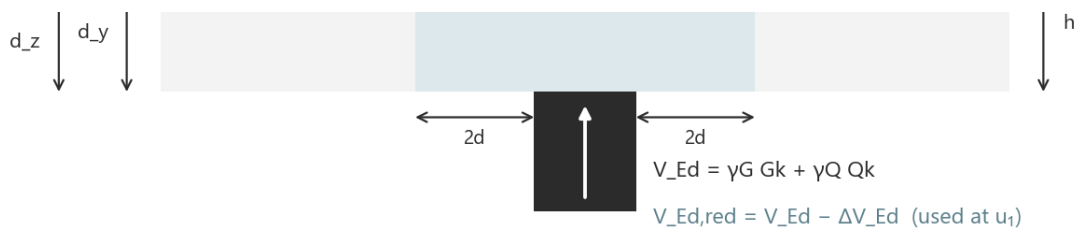
Inputs · loads

Characteristic column reactions

	Column reaction, permanent	G_k	320 kN
	Column reaction, variable	Q_k	145 kN
EN 1990 A1.2(B)	Partial factor, permanent	γ_G	1.35
EN 1990 A1.2(B)	Partial factor, variable	γ_Q	1.50
6.4.1(5)	Deduct the load applied inside u1?		No
	Permanent load inside u1	ΔG_k	0.0 kN
	Variable load inside u1	ΔQ_k	0.0 kN

Section through the column · $d = (d_y + d_z) / 2$





Inputs · eccentricity β

6.4.3

Method for β		Simplified		Simplified: Fig. 6.21N
Unbalanced moment, eccentricity along c1 (y)	$M_{Ed,1}$	0.0	kNm	Calculated method only
Unbalanced moment, eccentricity along c2 (z)	$M_{Ed,2}$	0.0	kNm	Edge: parallel to the edge
β , user value (≥ 1.0)	β	1.15		User value method only

Inputs · shear reinforcement

Used if required

	Shear reinforcement yield strength	f_{ywk}	500	MPa
	Link (or stud) diameter	φ_{sw}	10	mm
9.4.3(1)	First perimeter from the column face ($0.3d - 0.5d$)	s_0	100	mm
9.4.3(1)	Radial spacing of reinforcement perimeters ($\leq 0.75d$)	s_r	150	mm
Inputs valid and consistent				OK

Results

	Design punching force at u1	$V_{Ed,red}$	650	kN
	Load enhancement factor	β	1.15	Simplified
	Utilisation at column face $v_{Ed,0} / v_{Rd,max}$		0.38	OK
	Utilisation at u1 without reinforcement $v_{Ed} / v_{Rd,c}$		1.22	! Reinf. required
	Utilisation at u1 with reinforcement $v_{Ed} / (k_{max} v_{Rd,c})$		0.61	OK
	Area per perimeter from (6.52)	A_{sw}	425	mm ²
	Reinforced zone, distance from column face		67 – 333	mm
	Shear links (perimeters × legs, see the table)		× 7–10 legs $\phi 10 @ 150$ (17 l)	OK

The link layout follows from the chosen diameter, first perimeter s_0 and radial spacing s_r : change them to see the number of perimeters and legs update in the table and the drawing. Check the slab outside the reinforced zone at $u_{out,ef}$.

Calculation

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 / γ_c	$C_{Rd,c}$	0.120	NDP sheet
6.4.4(1)	Coefficient on axial stress	k_1	0.10	NDP sheet
6.4.5(3)	Factor on v_{fcd} for $v_{Rd,max}$		0.50	NDP sheet
6.4.5	Limit on resistance with shear reinforcement	k_{max}	2.00	NDP sheet
Table 3.1	Characteristic cylinder strength	f_{ck}	32	MPa
Table 3.1	Mean tensile strength	f_{ctm}	3.02	MPa
6.4.2(1)	Mean effective depth	d_{eff}	222	mm
	Column size used, c1 (circular edge/corner: $\pi D/4$)	$c_{1,e}$	400	mm
	Column size used, c2	$c_{2,e}$	400	mm
	Distance to slab edge used, a1 (same column centre)	$a_{1,e}$	0	mm
	Distance to slab edge used, a2	$a_{2,e}$	0	mm

Circular columns at an edge or corner are checked as the square of equal perimeter (side $\pi D/4$) with the same centre: for an internal column it gives the same u_0 and u_1 as the circle. EC2 gives no edge perimeters for circular columns (assumption).

Position index (1 internal, 2 edge, 3 corner) 1

6.4.5(3)	Column face perimeter	u_0	1600	mm	
6.4.2(1)	Control perimeter at 2d all round	$u_{1,int}$	4390	mm	
6.4.2(4)	Control perimeter running to the free edge(s) (Fig. 6.15)	$u_{1,edge}$	4390	mm	Corner: also one edge only, where u_1 stay
6.4.2(4)	Governing perimeter shape (1 all round, 2 to edge a1, 3 corner, 4 to edge a2)		1		
6.4.2(4)	Edge or corner column far enough from the edge to act as internal				n/a
6.4.2	Basic control perimeter at 2d (the smaller)	u_1	4390	mm	
	Plan area inside u_1 (for ΔG , ΔQ from area loads)	A_{u1}	1.490	m ²	$\Delta G = g_k \cdot A$; $\Delta Q = q_k \cdot A$
EN 1990 (6.10)	Design column reaction $\gamma G G_k + \gamma Q Q_k$	V_{Ed}	649.5	kN	
6.4.1(5)	Design load deducted inside u_1	ΔV_{Ed}	0.0	kN	
(6.48)	Net punching force at u_1 $V_{Ed} - \Delta V_{Ed}$	$V_{Ed,red}$	649.5	kN	
6.4.3(3)	Eccentricity along c1 (y) $M_{Ed,1} / V_{Ed,red}$	e_1	0	mm	
6.4.3(3)	Eccentricity along c2 (z) $M_{Ed,2} / V_{Ed,red}$	e_2	0	mm	
Table 6.1	k for eccentricity along c1 (ratio c1/c2)	k_1	0.600		Internal
Table 6.1	k for eccentricity along c2 (ratio c2/c1)	k_2	0.600		Internal
(6.41)	W1 for eccentricity along c1	$W_{1,1}$	1941691	mm ²	Internal
(6.41)	W1 for eccentricity along c2	$W_{1,2}$	1941691	mm ²	Internal
Fig. 6.13	Control perimeter dimension in y $c_1 + 4d$	b_y	1288	mm	Internal, (6.43)
Fig. 6.13	Control perimeter dimension in z $c_2 + 4d$	b_z	1288	mm	Internal, (6.43)
Fig. 6.20	Reduced basic control perimeter	u_{1*}	4390	mm	Edge and corner
Table 6.1	k for edge column (ratio c1 / 2c2)	k	0.450		Edge
(6.45)	W1 for edge column	W_1	1228445	mm ²	Edge
(6.39) (6.42) (6.43)	β calculated	β_{calc}	1.000		

Circular (internal): (6.42) with $e = \sqrt{e_1^2 + e_2^2}$. Internal: one moment $\rightarrow$ (6.39) with W_1 (6.41); both moments $\rightarrow$ (6.43), printed in EN 1992-1-1:2004 as e_y/b_z , e_z/b_y (Fig. 6.13); published copies differ, so the larger of the two axis pairings is used (conservative). Edge and corner: eccentricity perpendicular to the edge is taken towards the slab interior (6.4.3(4), (5)); $M_{Ed,2}$ gives e_{par} for (6.44). If it acts towards the exterior, (6.39) applies and this sheet should not be used. With a set-back a_1 , a_2 the reduced perimeter u_{1*} is kept as for a flush column, so $\beta = u_1/u_{1*}$ grows with the set-back (conservative).

6.4.3	Load enhancement factor used	β	1.150		
6.4.3	β at the column face (calculated β with the full V_{Ed})	β_0	1.150		Eccentricity M / V_{Ed}
6.4.4(1)	Size factor $1 + \sqrt{200/d} \leq 2$	k	1.949		
6.4.4(1)	Reinforcement ratio, y	ρ_{ly}	0.0058		
6.4.4(1)	Reinforcement ratio, z	ρ_{lz}	0.0063		
6.4.4(1)	Mean ratio $\sqrt{\rho_{ly} \cdot \rho_{lz}} \leq 0.02$	ρ_l	0.0060		
(6.3N)	Minimum shear resistance	v_{min}	0.539	MPa	
(6.47)	Punching resistance without shear reinforcement	$v_{Rd,c}$	0.628	MPa	
(6.6N)	Strength reduction factor $0.6(1 - f_{ck}/250)$	v	0.523		
3.1.6(1)	Design compressive strength	f_{cd}	21.33	MPa	
6.4.5(3)	Maximum punching shear stress	$v_{Rd,max}$	5.581	MPa	
(6.53)	Shear stress at column face (full V_{Ed})	$v_{Ed,0}$	2.103	MPa	OK
(6.38)	Shear stress at basic control perimeter	v_{Ed}	0.766	MPa	! Reinf. required
6.4.5	Maximum with shear reinforcement $k_{max} \cdot v_{Rd,c}$	$v_{Rd,max,cs}$	1.255	MPa	OK
3.2.7	Design yield strength of shear reinforcement	f_{ywd}	434.8	MPa	
6.4.5(1)	Effective design strength $250 + 0.25d \leq f_{ywd}$	$f_{ywd,ef}$	305.5	MPa	
(6.52)	Required area per perimeter (sin $\alpha = 1$)	A_{sw}	425	mm ²	
(6.54)	Outer perimeter where no reinforcement is required	$u_{out,ef}$	5360	mm	
6.4.5(4)	Distance of $u_{out,ef}$ from column face (shortest perimeter gove	r_{out}	598	mm	
6.4.2(4)	Shape of $u_{out,ef}$ (1 all round, 2 to edge a1, 3 corner, 4 to edge a2)		1		
6.4.5(4)	Outermost perimeter at least $r_{out} - 1.5d$ from the face		265	mm	
UK NA 6.4.5(4)	UK NA: if $r_{out} < 3d$, place the reinforcement within $0.3d - 1.5d$				! Zone 0.3d–1.5d
	Area of one leg $\pi \phi_{sw}^2 / 4$	A_{leg}	78.5	mm ²	
	Legs needed for A_{sw} on every perimeter A_{sw} / A_{leg}	n_A	6		
6.4.5(4)	Number of perimeters (outermost $\geq r_{out} - 1.5d$; at least 2)	n_{per}	2		Table: up to 12
perimeter	r (mm)	u (mm)	legs	s_t (mm)	$A_{sw,prov}$ (mm ²)
1	100	2228	7	318	550
2	250	3171	10	317	785
3	—	—	—	—	—
4	—	—	—	—	—
5	—	—	—	—	—

6	—	—	—	—	—
7	—	—	—	—	—
8	—	—	—	—	—
9	—	—	—	—	—
10	—	—	—	—	—
11	—	—	—	—	—
12	—	—	—	—	—
Total number of legs		Σn	17		
(9.11)	Minimum area of one leg $0.08 \sqrt{f_{ck}} / f_{yk} \cdot s_r \cdot s_t / 1.5$ (largest side)	$A_{sw,min}$	28.8	mm ²	
(9.11)	Leg area $A_{leg} \geq A_{sw,min}$ (slab within $vR_{d,max}$ and $k_{max} vR_{d,c}$)	A_{leg}	78.5	mm ²	OK
9.4.3(1)	First perimeter $0.3d \leq s_0 \leq 0.5d$	s_0	100	mm	OK
9.4.3(1)	Radial spacing $s_r \leq 0.75d$	s_r	150	mm	OK
Perimeters within the table (≤ 12)		n	2		

Spacing checks apply only where shear reinforcement is required. Legs per perimeter: the larger of A_{sw} / A_{leg} and the number that keeps the tangential spacing within $1.5d$ inside $2d$ and $2d$ outside (9.4.3(1)); perimeters running to a free edge get one leg more. More perimeters than the table holds: increase s_r or s_0 within their limits.

Prepared with NA Engineering calculation tools · naengineering.uk · adrian@naengineering.uk. Free for use by competent engineers; see the About sheet for scope and disclaimer.

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