

Stair with landings

Flight and landings spanning together between end supports · EN 1992-1-1 §6.1, §6.2, §7.4, §9.3 · UK NA / PN-EN

Reference	NAE-RC-024 · 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) · stair loads to EN 1991-1-1 (imposed load from the user)
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 straight reinforced concrete flight with a landing at the foot, at the head or at both, spanning longitudinally as one member between supports at the ends of the landings: loads of the landings and of the flight, the reactions, the largest moment and where it occurs, the bars of the waist and of the landings, shear without links, deflection by the span to depth ratio and the detailing of the knees.

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

Simply supported 1 m wide strip on plan: lower landing a1, flight of n risers with (n – 1) goings, upper landing a2; the span adopted is $L = a1 + (n - 1)g + a2$ between the support centre lines (conservative where the effective span of 5.3.2.2 for the actual supports is shorter). Loads per m² on plan: landings $\gamma_c h$, flight $\gamma_c t / \cos \theta + \gamma_c r / 2$, finishes and the imposed load from the user (EN 1991-1-1 Table 6.2: stairs) over the whole length, changing at the first and the last riser; the concrete of the upper knee outside these zones (a triangle of height $r + w - h$ at the last riser) is added as a point load at its centroid, and the smaller volume at the lower knee is ignored (conservative). The soffit knees and the bar crossings must lie within the member: the lower ones between the lower support and the last riser, the upper ones between the first riser and the upper support. The largest moment is found where the shear is zero; the waist (d at right angles to the soffit) is designed for the largest moment within the flight and the landings for the largest moment within them, with the same main bars throughout. Shear: each support reaction against the section at that support, and the vertical shear at the first and last risers against the waist (conservative: $\geq$ the component normal to the waist). Upper knee: bars crossed, straight anchorage (8.4.3, 8.4.4, $\alpha = 1$; good bond within 250 mm of the soffit below the bar, $\eta_1 = 0.7$ beyond, Figure 8.2) for the bar stress from the largest moment within d of the crossing (9.2.1.3(2)), compared with the room before the far face or the end of the member, less cover; otherwise a warning to bend the bars and check by hand. Deflection by (7.16) with $K = 1.0$ on L, conservatively with the smaller effective depth and the steel it needs for the largest moment, the $(A_s, \text{prov} / A_s, \text{req})(500 / f_{yk})$ factor ($UK \leq 1.5$), 7/L for spans over 7 m with brittle partitions and the UK 40K cap; a span to depth check, so where the landings and the waist differ much in depth or deflection is critical, calculate it (7.4.3). Not checked here: partial fixity at the supports (top bars to 9.3.1.2(2) are listed), landings spanning across the stair or flights built into walls, the concentrated imposed load (EN 1991-1-1 6.2.1(3)) and free edges (9.3.1.4). $f_{yk} 400 - 500$ 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: Slabs.
 - The Concrete Centre, Standard method of detailing structural concrete (IStructE / Concrete Society): stairs and knee joints.
 - The Concrete Centre, RC Spreadsheets v4, TCC72 Stairs with landings (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

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Revision history

v1.0 29 Oct 2026 · First issue

Project
Element
Date

Job no.
Made by
Checked

Inputs · geometry and bars
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
5.3.2.2	Lower landing: support centre to the first riser (0: none)	a_1	1000	mm
	Number of risers in the flight (2 – 24)	n	12	
	Going	g	250	mm
	Rise	r	175	mm
5.3.2.2	Upper landing: last riser to the support centre (0: none)	a_2	1000	mm
	Waist thickness (at right angles to the soffit)	t	200	mm
	Landing thickness	h	200	mm
4.4.1	Nominal cover	c_{nom}	25	mm
	Main bars: diameter (waist and landings)	φ	12	mm
	Main bars: spacing	s	125	mm
	Distribution bars: diameter	φ_d	10	mm
	Distribution bars: spacing	s_d	300	mm

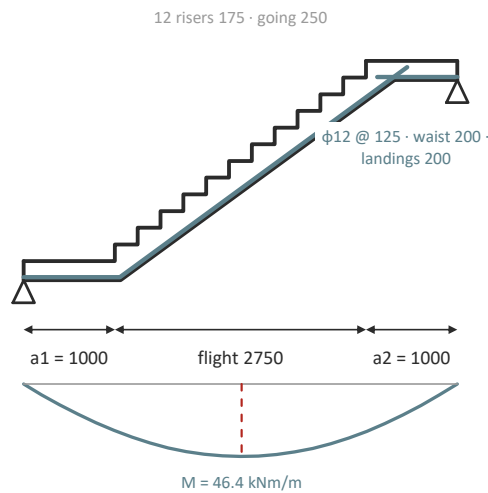
Inputs · loads
Characteristic, per m² on plan

	Finishes	g_k	1.00	kN/m ²
	Imposed load (EN 1991-1-1 Table 6.2, stairs)	q_k	3.00	kN/m ²
EN 1990 A1.2(B)	Partial factor, permanent	γ_G	1.35	
EN 1990 A1.2(B)	Partial factor, variable	γ_Q	1.50	
7.4.2(2)	Brittle partitions on a span over 7 m?		No	
	Inputs valid and consistent			OK

Results

Bending, flight $A_{s,req} / A_{s,prov}$ (waist)	0.73		OK
Bending, landings $A_{s,req} / A_{s,prov}$	0.48		OK
Shear without links $V_{Ed} / V_{Rd,c}$ (worse support)	0.35		OK
Deflection actual $l/d \div$ limiting l/d	0.72		OK
Detailing (distribution bars, spacing, $A_{s,max}$)	262	mm ² /m	OK
Upper knee: straight anchorage beyond the crossing length / room	0.75		OK
Comfort $2r + g$ (550 – 700 mm, usual range)	600	mm	OK

Your stair, to scale · landings, flight, waist, supports and main bars (crossed at the upper knee); bending moment below



Calculation · loads and actions (per m width)

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
6.2.2(1), 6.4.4(1)	Coefficient $0.18 / \gamma_c$	$C_{Rd,c}$	0.120	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_{yd}	434.8	MPa
	Pitch $\theta = \text{atan}(r / g)$	θ	35.0	°
	Upper knee: extra concrete $(r + w - h)^2 g / (2r)$	A_k	0.0343	m ² /m
	Its weight $\gamma G 25 A_k$, applied at its centroid	P_k	1.16	kN/m
	Centroid from the lower support (last riser $\pm (r + w - h) g / (3r)$)	x_k	3.854	m
	Lower landing a_1	a_1	1.000	m
	Flight on plan $(n - 1) g$	l_f	2.750	m
	Upper landing a_2	a_2	1.000	m
5.3.2.2	Effective span $L = a_1 + l_f + a_2$	L	4.750	m
EN 1990 (6.10)	Landings: design load $\gamma G (25 h + gk) + \gamma Q qk$	n_l	12.60	kN/m ²
EN 1990 (6.10)	Flight: design load $\gamma G (25 t / \cos \theta + 25 r / 2 + gk) + \gamma Q qk$	n_f	17.04	kN/m ²
	Total load $n_l (a_1 + a_2) + n_f l_f + P_k$	W	73.2	kN/m
	Reaction at the lower support (moments about the upper)	R_A	36.3	kN/m

Reaction at the upper support $W - R_A$	R_B	37.0	kN/m
Zero shear, largest moment, from the lower support	x_0	2.388	m
Largest moment $M(x_0)$	M_{Ed}	46.4	kNm/m
Largest moment within the flight (x_0 kept within it)	M_f	46.4	kNm/m
Largest moment within the landings (next to the flight)	M_l	30.6	kNm/m
Shear in the waist at the first riser $R_A - n_l a_1$	V_{f1}	23.7	kN/m
Shear in the waist at the last riser $R_B - n_l a_2$ ($-P_k$ on the lar	V_{f2}	23.2	kN/m

Calculation · sections

	Waist: effective depth $t - c - \phi/2$ (at right angles to the soffit)	d_w	169	mm	
	Landing: effective depth $h - c - \phi/2$	d_l	169	mm	
3.1.7(3)	Limit on K without compression bars ($\xi \leq 0.45$)	K'	0.167		
	As provided $1000 \pi \phi^2 / (4 s)$	$A_{s,prov}$	905	mm ² /m	
	Waist: $K = M / (b d^2 f_{ck})$	K	0.051		
	Waist: As required $M / (f_{yd} z)$, $z \leq 0.95 d$	$A_{s,req}$	664	mm ² /m	
(9.1N)	Waist: $A_{s,min} \max(0.26 f_{ctm}/f_{yk}; 0.0013) b d$	$A_{s,min}$	266	mm ² /m	
(6.2)	Waist: shear resistance without links	$V_{Rd,c}$	104.6	kN/m	
9.3.1.1(3)	Waist: $A_{s,prov} \geq \max(A_{s,req}; A_{s,min})$, $s \leq \min(2h; 250)$	A_s	905	mm ² /m	OK
	Landing: $K = M / (b d^2 f_{ck})$	K	0.033		
	Landing: As required $M / (f_{yd} z)$, $z \leq 0.95 d$	$A_{s,req}$	438	mm ² /m	
(9.1N)	Landing: $A_{s,min} \max(0.26 f_{ctm}/f_{yk}; 0.0013) b d$	$A_{s,min}$	266	mm ² /m	
(6.2)	Landing: shear resistance without links	$V_{Rd,c}$	104.6	kN/m	
9.3.1.1(3)	Landing: $A_{s,prov} \geq \max(A_{s,req}; A_{s,min})$, $s \leq \min(2h; 250)$	A_s	905	mm ² /m	OK
(6.2)	Lower support: $V_{Rd,c}$ of the section there (landing if $a_1 > 0$)	$V_{Rd,A}$	104.6	kN/m	
(6.2)	Upper support: $V_{Rd,c}$ of the section there (landing if $a_2 > 0$)	$V_{Rd,B}$	104.6	kN/m	
(6.2)	Shear $R_A \leq V_{Rd,A}$, $R_B \leq V_{Rd,B}$ and the waist at both risers $\leq V_{Ed}$	V_{Ed}	37.0	kN/m	OK

Calculation · deflection and detailing

7.4.2	Smaller effective depth $\min(d_w; d_l)$ (conservative)	d	169	mm	
	K for the largest moment on that depth	K	0.051		
	As required for it ($z \leq 0.95 d$)	$A_{s,req}$	664	mm ² /m	
7.4.2	$\rho = \max(A_{s,req}; A_{s,min}) / (b d)$	ρ	0.00393		N/A: bending fails
(7.16)	$\rho_0 = \sqrt{f_{ck}} \cdot 10^{-3}$	ρ_0	0.00566		
(7.16)	Basic span to depth ratio ($K = 1.0$)	l/d	28.5		
7.4.2(2)	Steel stress factor ($A_{s,prov} / A_{s,req}$)(500 / f_{yk}) ($UK \leq 1.5$)	F_3	1.362		
7.4.2(2)	Long span factor $7 / L$ ($L > 7$ m, brittle partitions)	F_2	1.000		
7.4.2	Limiting span to depth ratio ($UK NA: \leq 40$)	l/d_{lim}	38.8		
	Actual L / d	l/d	28.1		
7.4.2	Deflection $l/d \leq \text{limit}$ (with the bending checks passing)	l/d	28.1		OK
8.2(2)	Minimum clear gap $\max(\phi; d_g + 5; 20)$	a_{min}	25	mm	
	Distribution bars provided	$A_{s,d}$	262	mm ² /m	
9.3.1.1	Distribution $\geq 20\%$ main, spacings, clear gaps, $A_s \leq 0.04 A_c$		262	mm ² /m	OK
9.2.1.3(2)	Upper knee: largest moment within $a_l = d$ of the bar crossing	M_k	27.3	kNm/m	
	Lever arm with $A_{s,prov}$ at f_{yd} $d - 0.4 x$, $x = A_s f_{yd} / (0.8 f_{cd} b)$	z	158	mm	
8.4.3(2)	Bar stress at the knee $M_k / (A_{s,prov} z) \leq f_{yd}$	σ_{sd}	191	MPa	
3.1.6(2)	Design tensile strength $\alpha_{ct} 0.7 f_{ctm} / \gamma_c$	f_{ctd}	1.41	MPa	
(8.2)	Bond stress, good conditions $2.25 \eta_2 f_{ctd}$ ($\eta_1 = 1$)	f_{bd}	3.18	MPa	
(8.3), (8.4)	Anchorage $\max(\phi \alpha_{sd} / (4 f_{bd}); 0.3 l_{brqd}; 10\phi; 100)$ ($\alpha = 1$)	l_{bd}	180	mm	
	Room for the waist bars into the landing: top face or end face, l_1	l_1	241	mm	
	Room for the landing bars into the waist: steps or end face, less	l_2	241	mm	
8.4.2(2)	Waist bars: length within 250 mm of the soffit ($250 - o/\cos \theta$) /	l_{g1}	370	mm	
8.4.2(2)	Landing bars: length within 250 mm of the soffit ($250 - o/\cos \theta$)	l_{g2}	303	mm	
8.4.2(2)	Waist bars: length needed (beyond l_g at $l_{bd} / 0.7$, poor bond	l_1	180	mm	
8.4.2(2)	Landing bars: length needed (beyond l_g at $l_{bd} / 0.7$, poor bor	l_2	180	mm	
8.4.4	Upper knee: lengths needed $\leq$ room for straight bars (else benc	l	180	mm	OK

Knees: at the upper knee the soffit is re-entrant, so do not bend the bottom bars round it; run the waist bars straight into the upper landing and the landing bars straight into the waist, crossing, each anchored beyond the crossing by l_{bd} (drawn up to the room available; where it does not fit, bend the bars along the far face and check the bent anchorage by hand). At the lower knee the bars may follow the soffit, bent on the mandrel of 8.3. Anchor the bottom bars at the supports (9.3.1.2(1), 9.2.1.4), not checked here. Also detail top bars over both supports for 25 % of the span moment, extending $0.2 L$ (9.3.1.2(2)), and the local check of the concentrated imposed load (EN 1991-1-1 6.2.1(3)).

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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 $v_{Rd,c}$. 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