Errata – How to design concrete structures using Eurocode 2: Second Edition
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Chapter 12, page 108: Document states ‘for η_{fi} see page 2’. It should read ‘see page 102’.

η_{fi} = reduction factor (see ‘combinations of actions’ section on page 2)

Beams

Curtailment

Unless the additional tensile force in the longitudinal reinforcement due to shear has been calculated, the curtailment length of the longitudinal reinforcement should be extended beyond the point at which it is required for flexural strength (this is known as the 'shift rule') using the following expression (see also Figure 7):

$a_l = z \cot \theta /2$ for vertical shear reinforcement.

where

z = lever arm

θ = angle of compression strut

This can conservatively be taken as:

$a_l = 1.125d$

For beams designed using the co-efficients given in Table 3 of Chapter 4, the simplified rules shown in Figure 8 may be used. However, the simplifications are conservative and economies can be achieved by curtailing bars to suit the actual moments.

Figure 6
Transverse reinforcement for lapped splices

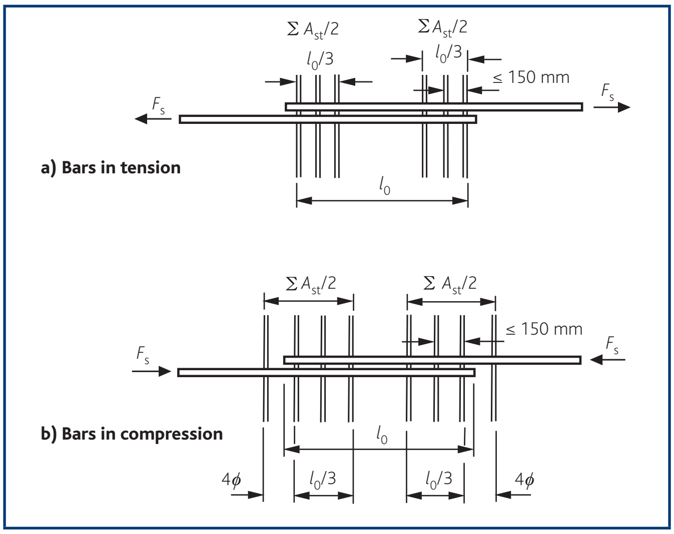


Table 3
Bar sizes for transverse reinforcement

Lap length (mm), for transverse bars at 150 mm centres[a]	Number of bars at end of each lap	Bar size (mm)			
		20	25	32	40
		$A_s = 314$	$A_s = 491$	$A_s = 804$	$A_s = 1260$
≤450	2	10	16	16	25
451 – 900	3	10	12	16	20
901 – 1350	4	8	10	12	16
1351 – 1800	5	8	8	12	16
1801 – 2250	6	8	8	10	12
2251 – 2700	7	N/A	8	10	12

Key

a For transverse bars at less than 150 mm centres use the following expression to calculate the required number of bars and hence the required transverse bar diameter: Number of bars required = 1 + $l_0/(3s)$ where s = spacing of the transverse bars.

Figure 7
Illustration of curtailment of longitudinal reinforcement

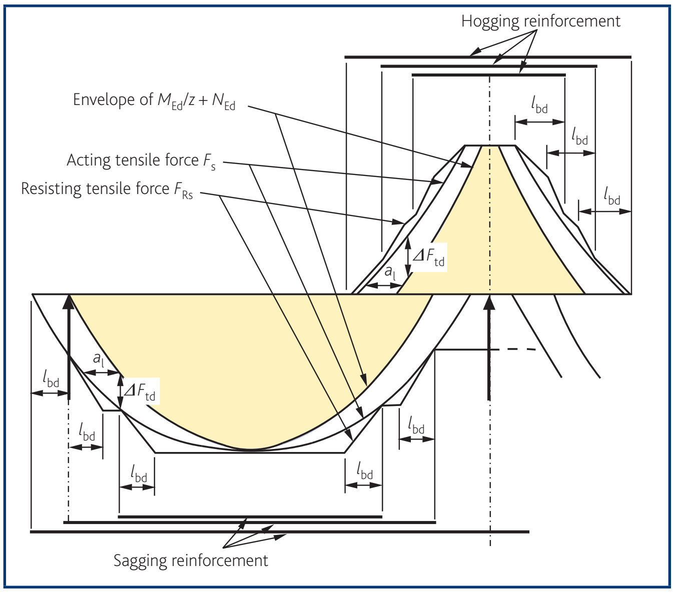
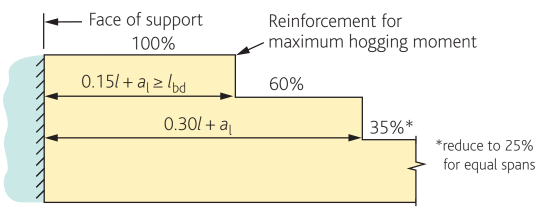
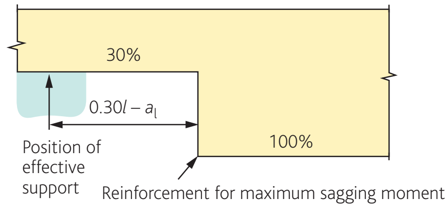


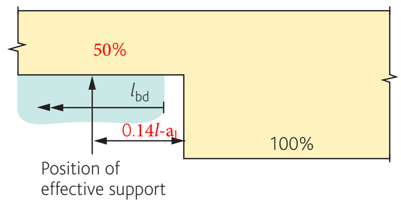
Figure 8
Simplified detailing rules for beams



a) Continuous member, top reinforcement



b) Continuous member, bottom reinforcement



c) Simple support, bottom reinforcement

Notes

1. l is the effective length.
2. a_l is the distance to allow for tensile force due to shear force.
3. l_{bd} is the design anchorage length.
4. $Q_k \leq G_k$.
5. Minimum of two spans required.
6. Applies to uniformly distributed loads only.
7. The shortest span must be greater than or equal to 0.85 times the longest span.
8. a) and b) applies where 15% redistribution has been used, c) applies where the beam is designed with both ends simply supported.

Reinforcement in end supports

In monolithic construction, even when simple supports have been assumed in design, the section at supports (top reinforcement) should be designed for a bending moment arising from partial fixity of at least 25% of the maximum bending moment in the span (i.e. provide 25% of mid-span bottom reinforcement).

The area of bottom reinforcement provided at supports with little or no end fixity assumed in design, should be at least 25% of the area of steel provided in the span. The bars should be anchored to resist a force , F_E.

$$F_E = (|V_{Ed}|\, a_l / z) + N_{Ed}$$

where

$|V_{Ed}|$ = absolute value of shear force

N_{Ed} = the axial force if present

The anchorage, l_{bd}, should be measured beyond the line of contact between the beam and support.

Provided σ_{sd} is taken as 435 MPa in the calculation of the anchorage length (which is assumed in Tables 2 and 13) then it should not be necessary to calculate F_E.

Flanged beams

At supports the tension reinforcement to resist hogging moments should be distributed across the full width of the effective flange as shown in Figure 9; part of it may be concentrated over the web.

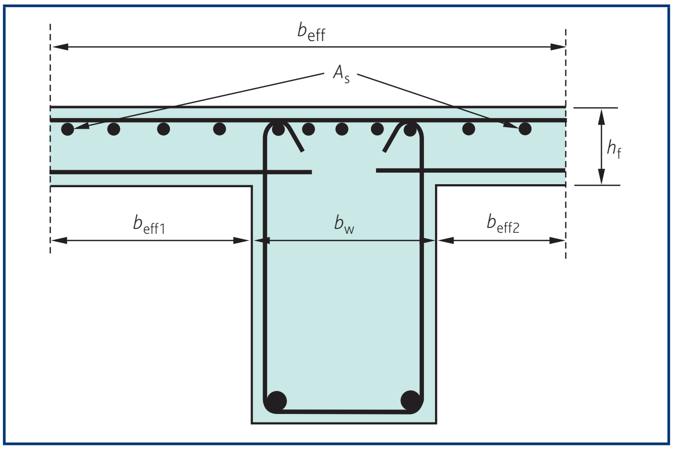
Minimum area of longitudinal reinforcement

The minimum area of reinforcement is $A_{s,min} = 0.26\, f_{ctm}\, b_t\, d/f_{yk}$ but not less than $0.0013 b_t d$, where b_t is the mean width of the tension zone (see Table 4). For a T-beam with the flange in compression, only the width of the web is taken into account in calculating the value of b_t.

Maximum area of longitudinal reinforcement

Outside lap locations, the maximum area of tension or compression reinforcement should not exceed $A_{s,max} = 0.04\, A_c$.

Figure 9
Placing of tension reinforcement in flanged cross section



Minimum spacing of reinforcement

The minimum clear distance between bars should be the greater of:

- Bar diameter
- Aggregate size plus 5 mm
- 20 mm

Shear reinforcement

The longitudinal spacing of vertical shear reinforcement should not exceed $0.75d$. Note the requirement for a maximum spacing of 150 mm where the shear reinforcement acts as a transverse reinforcement at laps in the longitudinal bars. The transverse spacing of the legs in a series of shear links should not exceed:

$$s_{t,max} = 0.75d \leq 600 \text{ mm}$$

The minimum area of shear reinforcement in beams, $A_{sw,min}$ should be calculated from:

$$\frac{A_{sw}}{s\, b_w} \geq \rho_{w,min}$$ where $\rho_{w,min}$ can be obtained from Table 4.

Slabs

Curtailment

The curtailment rules for beams should be followed, except that a value of $a_l = d$ may be used.

For slabs designed using the co-efficients given in Table 3 of Chapter 3, the simplified rules shown in Figure 10 may be used.

Reinforcement in end supports

In simply supported slabs, the area of reinforcement may be reduced to half the calculated span reinforcement from a distance of 0.14l-d to the support, ~~otherwise 100% of the reinforcement may be continued to the support. Beyond the face of the support 15% of the area of maximum reinforcement should be provided (see Figure 10c).~~ The bars should be anchored to resist a force, F_E, as given in the section on beams, beyond the position of support.

~~Table~~ beams 4
Minimum percentage of reinforcement required

f_{ck}	f_{ctm}	Minimum percentage ($0.26\, f_{ctm} / f_{yk}$[a])	~~$\rho_{w,min} \times 10^{-3}$~~
25	2.6	0.13%	0.80
28	2.8	0.14%	0.85
30	2.9	0.15%	0.88
32	3.0	0.16%	0.91
35	3.2	0.17%	0.95
40	3.5	0.18%	1.01
45	3.8	0.20%	1.07
50	4.1	0.21%	1.13

Key
a Assuming f_{yk} = 500 MPa

Similar to beams, even when simple supports have been assumed in design, end supports of slabs should have top reinforcement equal to at least 25% mid-span bottom reinforcement and this reinforcement should extend at least 20% of the span from the face of support.

Minimum spacing requirements

The minimum clear distance between bars (horizontal or vertical) should not be less than the bar size, *b*, (d_g + 5 mm), or 20 mm, where d_g is the maximum size of aggregate.

Maximum spacing of reinforcement

For slabs less than 200 mm thick the following maximum spacing rules apply (*h* is the depth of the slab):

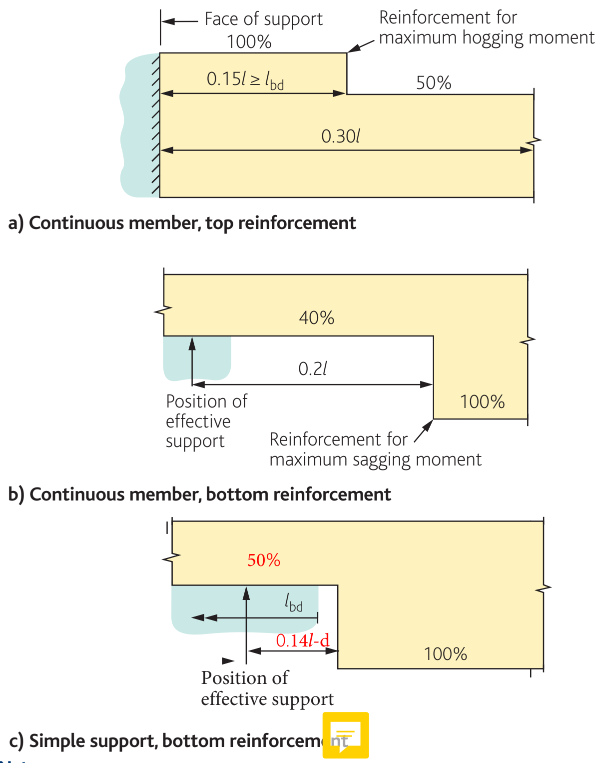
- For the principal reinforcement: 3*h* but not more than 400 mm.
- For the secondary reinforcement: 3.5*h* but not more than 450 mm.

The exception is in areas with concentrated loads or areas of maximum moment where the following applies:

- For the principal reinforcement: 2*h* but not more than 250 mm.
- For the secondary reinforcement: 3*h* but not more than 400 mm.

For slabs 200 mm thick or greater, the spacing requirements are given in Table 5. Where the designer has not specified the required spacing or provided the steel stress, σ_s, it can generally be assumed that σ_s will not exceed 320 MPa for a typical slab. Where the slab supports office or residential areas it is unlikely that σ_s will exceed 280 MPa. σ_s may be estimated using Figure 6 on page 15.

Figure 10
Simplified detailing rules for slabs



Notes

1 *l* is the effective length.
2 l_{bd} is the design anchorage length.
3 $Q_k \leq 1.25\ G_k$ and $q_k \leq 5\text{kN/m}^2$.
4 Minimum of two spans required.
5 Applies to uniformly distributed loads only.
6 The shortest span must be greater than or equal to 0.85 times the longest span.
7 a) and b) applies where 20% redistribution has been used, c) applies where the slab is is designed with both supports simply supported,

Minimum areas of reinforcement

The minimum area of reinforcement to be provided varies with the concrete strength (see Table 4).

Maximum area of longitudinal reinforcement

Outside lap locations, the maximum area of tension or compression reinforcement, should not exceed $A_{s,max} = 0.04A_c$. At lap locations $A_{s,max} = 0.08A_c$.

Edge reinforcement

Along a free (unsupported) edge, a slab should normally contain longitudinal and transverse reinforcement, generally arranged as shown in Figure 11.

Flat slabs

A flat slab should be divided into column and middle strips (see Figure 12); the division of the moments between the column and middle strips is given in Table 6.

Figure 11
Edge reinforcement for slab

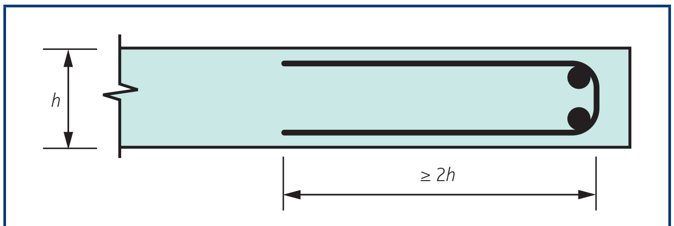


Table 5
Maximum bar size or spacing to limit crack width

Steel stress (σ_s) MPa	w_{max} = 0.4 mm			w_{max} = 0.3 mm		
	Maximum bar size (mm)		Maximum bar spacing (mm)	Maximum bar size (mm)		Maximum bar spacing (mm)
160	40		300	32		300
200	32	OR	300	25	OR	250
240	20		250	16		200
280	16		200	12		150
320	12		150	10		100
360	10		100	8		50

Table 6
Apportionment of bending moments in flat slabs – equivalent frame method

Location	Negative moments	Positive moments
Column strip	60% – 80%	50% – 70%
Middle strip	40% – 20%	50% – 30%

Notes
The total negative and positive moments to be resisted by the column and middle strips together should always add up to 100%