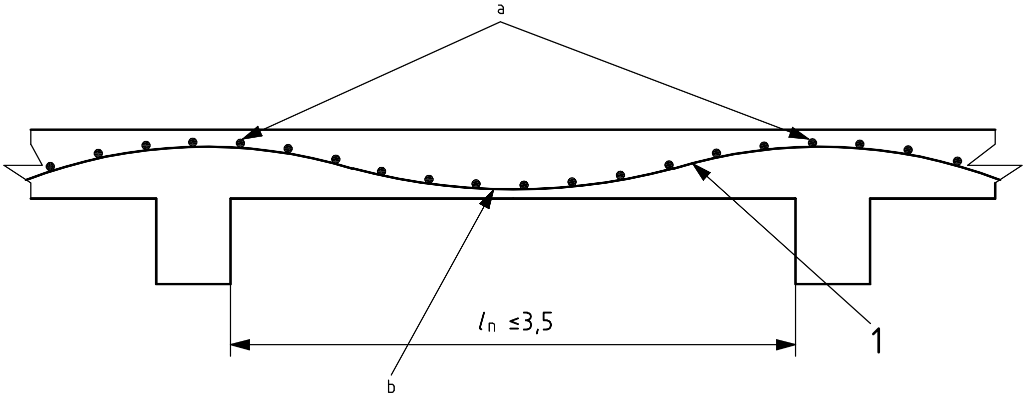
Dimension in metres



Key

1 welded-wire fabric as positive and negative reinforcement

a Placed close to the top of the slab over supports.

b Placed close to the bottom of the slab near mid-span.

Figure 53 — Welded-wire fabric in short spans

7.5.3.8 Practical considerations for the value of d_c and d as applied in solid slabs

A determination of the distance, [d_c], from the extreme tension fibre to the centroid of tension reinforcement should include the appropriate concrete cover as specified in 7.3.4, the bar diameters employed and the existence of reinforcement in a perpendicular direction placed between the reinforcement under study and the concrete surface. It should be permitted to use the values of d_c specified in this subclause to compute d in accordance with the relationship $d = h - d_c$. For one-way slabs and for the reinforcement in the short direction in two way slabs, $d_c = 40$ mm for internal exposure and $d_c = 60$ mm for external exposure. For reinforcement in the long direction of two-way slabs, $d_c = 55$ mm for internal exposure and $d_c = 75$ mm for external exposure.

7.5.4 Top thin solid slab that spans between joists

7.5.4.1 Dimensions

A thin solid slab that spans between joists should comply with the minimum thickness as specified in 7.4.5.2.1. The top thin slab should not be permitted to be cantilevered beyond the edge joist; see 7.4.1.3.1.

7.5.4.2 Factored flexural moment

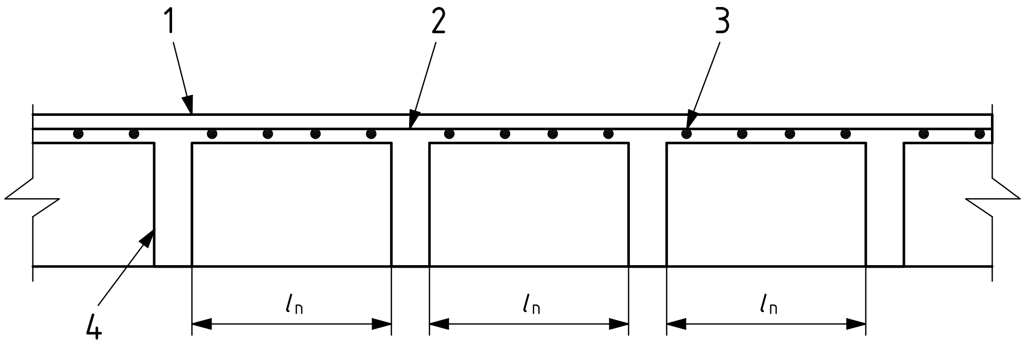
The factored flexural moment, M_u, expressed in newton·metres per metre, for negative and positive flexural moment in a thin slab that spans between joists in joist construction, should be calculated in accordance with Equation (67)

$$M_u^+ = M_u^- = \frac{q_u \cdot l_n^2}{12} \tag{67}$$

where l_n is the clear spacing, expressed in metres, between joists and q_u is expressed in newtons per square metre; see Figure 54.

7.5.4.3 Reinforcement

The flexural reinforcement ratio, ρ, perpendicular to the joist direction, should be calculated in accordance with Equation (27) or (29), with the value of M_u derived from Equation (67), converted to newton·millimetres (1 · m/m = 10^3 N · mm/m), defining d, expressed in millimetres, as one-half of the thickness of the thin slab, and $b = 1\,000$ mm. The value of ρ should be defined as equal to or greater than the shrinkage and temperature ratio specified in 7.3.9.2.1; see Figure 54. The flexural reinforcing bar separations should meet the provisions of 7.3.7.6. The reinforcement parallel to the joist direction should meet the provisions of 7.5.3.2.



Key

1 top thin slab

2 negative and positive flexural reinforcement

3 shrinkage and temperature reinforcement

4 joist

Figure 54 — Reinforcement of the thin solid slab that spans between joists

7.5.4.4 Shear strength verification

The factored shear, V_u, expressed in newtons per metre, for the thin slab that spans between joists in joist construction should be calculated in accordance with Equation (68):

$$V_u = \frac{q_u \cdot l_n}{2} \tag{68}$$

where l_n is the clear spacing, expressed in metres, between joists and q_u is expressed in newtons per square metre; see Figure 54. The design shear strength, $\phi \cdot V_n$, expressed in newtons per metre, should be calculated in accordance with Equation (52), defining d, expressed in millimetres, as one-half the thickness of the thin slab and $b_w = b = 1\,000$ mm. This should be in accordance with Equation (50).

7.5.4.5 Calculation of the reactions on the joists

The factored uniformly distributed reaction, r_u, expressed in newtons per metre, on the supporting joists should be calculated in accordance with Equation (69):

$$r_u = \frac{2 \cdot V_u \cdot l}{l_n} \tag{69}$$

where

V_u is the factored shear, expressed in newtons per metre, in accordance with 7.5.4.4,

l is the centre-to-centre spacing, expressed in metres, of the joist;

l_n is the clear spacing, expressed in metres, between joists.

7.5.5 Cantilevers of slabs supported on girders, beams or walls

7.5.5.1 Dimensions

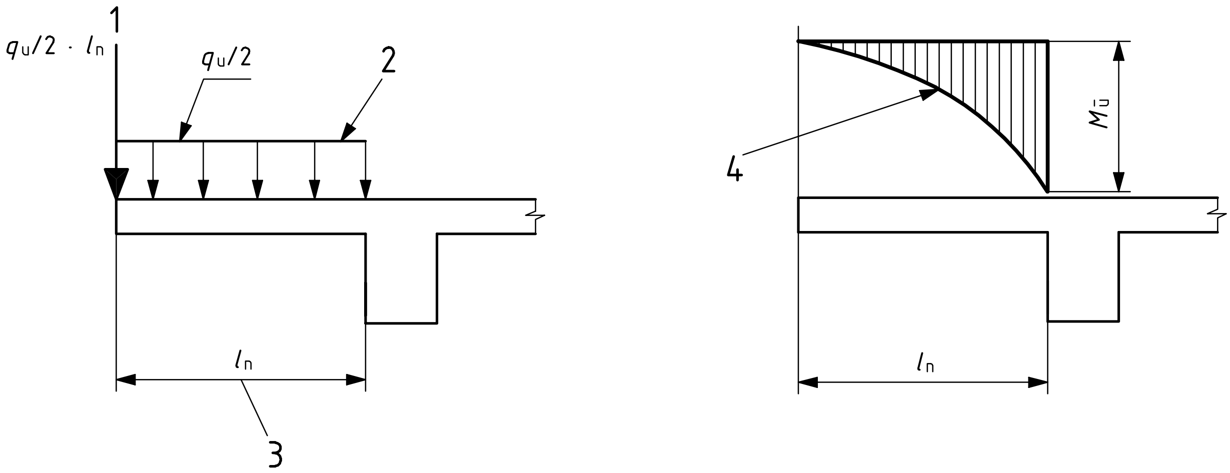
Solid slab cantilevers, spanning beyond the edge girder, beam or structural concrete wall, should be in accordance with the minimum thickness provisions specified in 7.4.5.2. The cantilever span should not exceed the limits specified in 6.1. No openings for ducts or shafts should be permitted in the internal one-half span of the cantilever. It should be permitted for the slab to be cantilevered in two directions at corners, with the same limitations for single cantilevers. The thin top slab that spans between joists should not be cantilevered beyond the edge joist.

7.5.5.2 Factored negative flexural moment

The factored negative flexural moment, M_u, for slab cantilevers that span beyond the edge-supporting girders, beams or structural concrete walls should be calculated in accordance with Equation (70) on the assumption that half of the distributed factored load, q_u, acts as a concentrated load at the tip of the cantilever and the other half acts as a uniformly distributed load over the full span. However, it should not be less than the factored negative flexural moment of the first interior span at the exterior supporting girder, beam or structural concrete wall, nor less than one-third of the positive flexural moment, in the same direction, of the first interior span; see Figure 55.

$$M_u^- = \frac{3 \cdot q_u \cdot l_n^2}{4} \tag{70}$$

where l_n is the clear span, expressed in metres, of the cantilever, q_u is expressed in newtons per square metre, and M_u^- is expressed in newton·metres per metre.



a) b)

Key

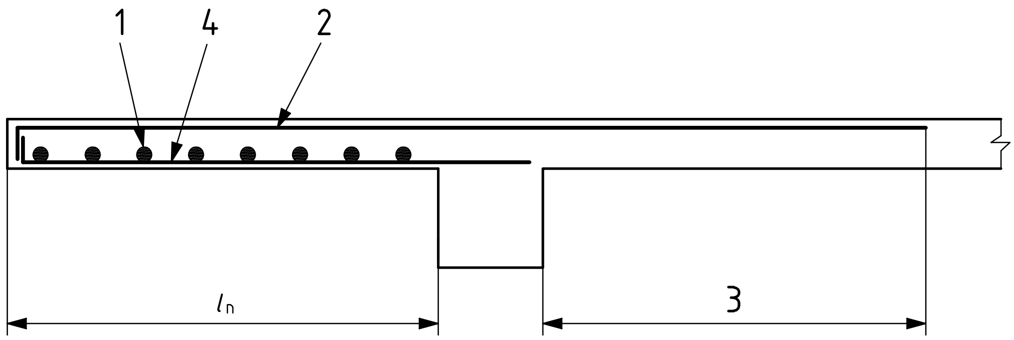
1 concentrated load
2 uniform load
3 cantilever clear span
4 moment diagram

Figure 55 — Calculation of the negative moment for slab cantilevers

7.5.5.3 Reinforcement

7.5.5.3.1 Negative flexural reinforcement

The negative flexural reinforcement ratio, ρ, in the direction of the cantilever should be calculated in accordance with Equation (27) or (29), using the value of M_u derived from Equation (70), converted to newton millimetres per metre (1 · m/m = 10^3 N · mm/m), with the appropriate value of d, expressed in millimetres, and $b = 1\,000$ mm. The negative flexural reinforcement should be in accordance with 7.5.3.4. This reinforcement should be anchored in the first interior span not less than l_d for the reinforcing bar (see 7.3.8.1), nor the distance required for the negative reinforcement of the interior slab panel at the edge support; see Figure 56.



Key

1 shrinkage and temperature reinforcement

2 negative cantilever reinforcement

3 distance required for the negative reinforcement of the first interior span, but not less than l_n for the bar

4 minimum positive reinforcement

Figure 56 — Reinforcement for slab cantilevers

7.5.5.3.2 Positive flexural reinforcement

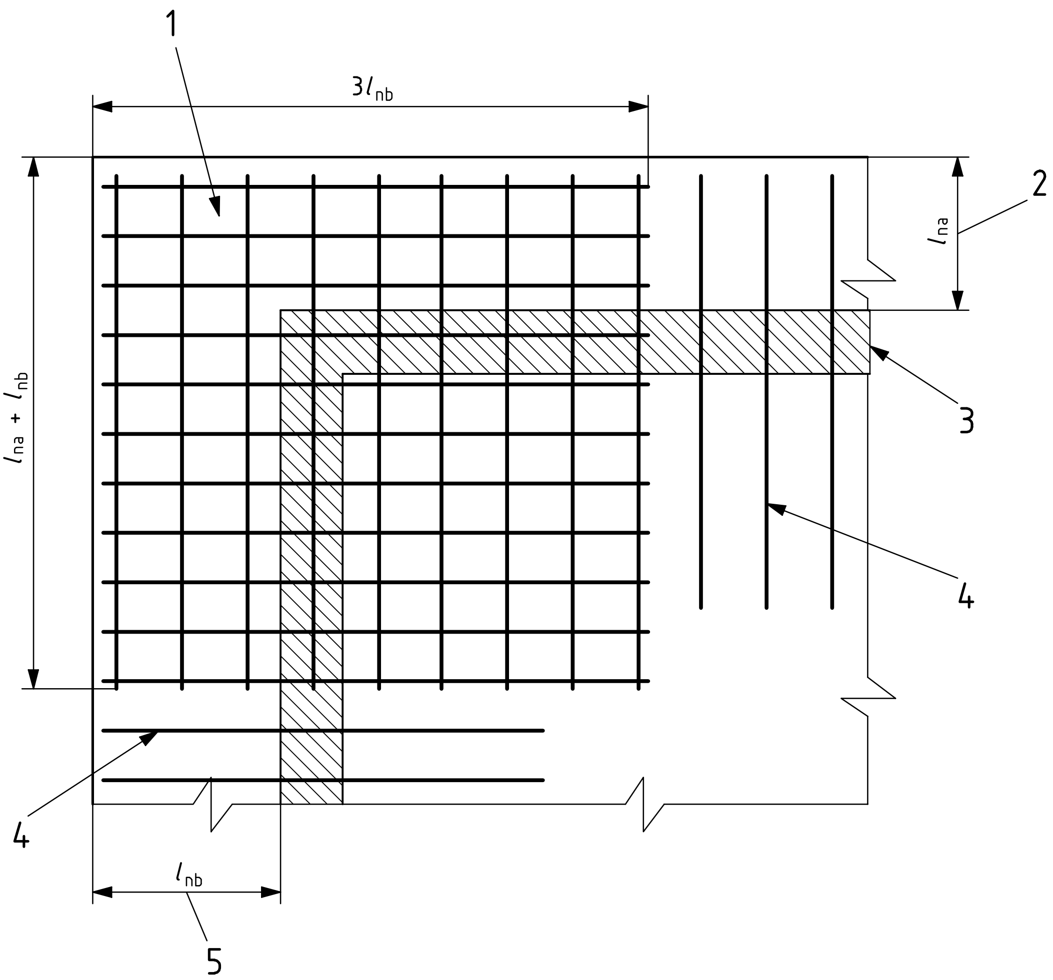
A minimum amount of positive flexural reinforcement with an area greater or equal to the shrinkage and temperature reinforcement, in accordance with the provisions of 7.5.3.2, should be provided in the direction of the cantilever; see Figure 56.

7.5.5.3.3 Shrinkage and temperature reinforcement

Reinforcement parallel to the edge of the cantilever, in accordance with the provisions of 7.5.3.1, should be provided; see Figure 56.

7.5.5.3.4 Reinforcement of two-way cantilevers

At corners where the slab is cantilevered in two directions, the negative flexural reinforcement should be calculated for the larger span cantilever, in accordance with the provisions of 7.5.5.3.1. This reinforcement should be placed in both directions (see Figure 57) for a distance, measured from the corner, equal to the cantilever clear span plus two times the larger cantilever span, but not less than the distance required for the negative flexural reinforcement of the first interior span plus the cantilever span. Reinforcement in accordance with the provisions of 7.5.5.3.2 should be placed in both directions.



Key

1 two-way cantilever negative reinforcement
2 smaller cantilever span
3 girder, beam or wall
4 one-way negative cantilever reinforcement
5 larger cantilever span

Figure 57 — Negative flexural reinforcement in two-way slab cantilevers

7.5.5.4 Shear verification

The factored shear, V_u, expressed in newtons per metre, for the support of cantilever slabs should be calculated in accordance with Equation (71):

$$V_u = q_u \cdot l_n \quad (71)$$

where l_n should be the clear span, expressed in metres, of the cantilever and q_u should be expressed in newtons per square metre.

For two-way cantilevers, the value of V_u should be taken as twice the value derived from Equation (71) using the larger cantilever span.

The design shear strength $\phi \cdot V_n$, expressed in newtons per metre, should be calculated in accordance with Equation (52) with the appropriate value of d, expressed in millimetres and $b = 1\,000$ mm. This should be in accordance with Equation (50).

7.5.5.5 Calculation of the reactions on the supports

The uniformly distributed factored reaction, r_u, on the support of the cantilever, expressed in newtons per metre, should be the value derived from Equation (72):

$$r_u = \frac{V_u \cdot l}{l_n} \tag{72}$$

where

- V_u is the factored shear, expressed in newtons per metre, as specified in 7.5.5.4;
- l is the span, expressed in metres, of the cantilever measured from the centreline of the supporting element;
- l_n is the clear span, expressed in metres, of the cantilever.

Where two-way cantilevers exist, it should be permitted to calculate of the value of R_u in accordance with Equation (72), employing the value of V_u for the larger cantilever span derived from Equation (71) without doubling it.

7.5.6 One-way one-span solid slabs spanning between girders, beams or structural concrete walls

7.5.6.1 Dimensions

One-way one-span solid slabs should comply with the minimum thickness provisions as specified in 7.4.5.2. In addition to the appropriate provisions specified in 7.5.6, these slabs should comply with the general dimensional provisions as specified in 6.1 and the particular provisions specified in 7.4.1.2 for slab-on-girder systems.

7.5.6.2 Factored flexural moment

The factored positive and negative flexural moment, M_u, expressed in newton·metres per metre, for one-span one-way slabs should be calculated in accordance with Equations (73) and (74) as specified in Table 12.

Table 12 — Factored flexural moment for one-way, one-span slabs

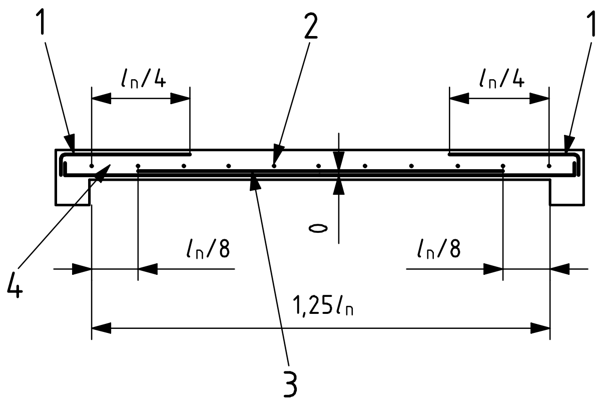
Positive moment: $M_u^+ = \dfrac{q_u \cdot l_n^2}{8}$	(73)
Negative moment at supports: $M_u^- = \dfrac{q_u \cdot l_n^2}{24}$	(74)

7.5.6.3 Longitudinal flexural reinforcement

7.5.6.3.1 Positive flexural reinforcement

The positive reinforcement ratio, ρ, in the direction of the span, l_n, should be determined in accordance with Equation (27) or (29), with the value of M_u^+ derived from Equation (73) converted to newton·millilmetres (1 N·m/m = 10^3 N · mm/m), using d expressed in millimetres, and b = 1 000 mm. This reinforcement should be in accordance with the provisions specified in 7.5.3.3. In those cases in which the slab is cast monolithically with a supporting girder, beam or structural concrete wall and the supporting element has a depth at least three times greater than the depth of the slab, it should be permitted to suspend up to one-half of the positive flexural reinforcement at a distance equal to $l_n/8$, measured from the internal face of the supports into the span; see Figure 58.

Dimension in millimetres



Key

1 negative flexural reinforcement

2 shrinkage and temperature reinforcement

3 positive flexural reinforcement

4 positive flexural reinforcement suspension, only if the slab is built monolithically with the support at least three times deeper than the slab

Figure 58 — Reinforcement for one-span one-way slabs

7.5.6.3.2 Negative flexural reinforcement

The negative flexural reinforcement ratio, ρ, in the direction of the span, l_n, should be determined in accordance with Equation (27) or (29), with the value of M_u^- derived from Equation (74) converted to newton·millimetres (1 N·m/m = 10^3 N · mm/m), using d expressed in millimetres, and b = 1 000 mm. This reinforcement should be in accordance with the provisions specified in 7.5.3.4. At a distance equal to $l_n/4$, measured from the internal face of the supports into the span, all the negative flexural reinforcement should be permitted to be suspended; see Figure 58.

7.5.6.3.3 Shrinkage and temperature reinforcement

The reinforcement perpendicular to the span should meet the provisions for shrinkage and temperature reinforcement specified in 7.5.3.2; see Figure 58.

7.5.6.4 Shear verification

The factored shear, V_u, expressed in newtons per metre, for the one-span one-way slab should be calculated at the face of the supports in accordance with Equation (75):

$$V_u = \frac{q_u \cdot l_n}{2} \tag{75}$$

where l_n is the clear span, expressed in metres and q_u is expressed in newtons per square metre; see Figure 58.

The design shear strength, $\phi \cdot V_n$, in N/m, should be calculated in accordance with Equation (52), with d expressed in millimetres and $b_w = b = 1\ 000$ mm. This should be in accordance with Equation (50).

7.5.6.5 Calculation of the reactions on the supports

Uniformly distributed factored reaction, r_u, on the supports of one-way one-span slabs expressed in newtons per metre, should be the value derived from Equation (76) plus the uniformly distributed reaction from any cantilever spanning from that support:

$$r_u = \frac{V_u \cdot l}{l_n} \tag{76}$$

where

V_u is the factored shear, expressed in newtons per metre, as specified in 7.5.6.4;

l is the centre-to-centre span, expressed in metres, of the slab;

l_n is the clear span, expressed in metres, of the slab.

7.5.7 One-way solid slabs supported on girders, beams or walls with two or more spans

7.5.7.1 Dimensions

One-way solid slabs with two or more spans should comply with the minimum thickness provisions as specified in 7.4.5.2. In addition to the appropriate provisions specified in 7.5, slabs should comply with the general dimensions as specified in 6.1 and the particular provisions specified in 7.4.1.2 for slab-on-girder systems.

The following restrictions should be in effect for slabs designed in accordance with 7.5.7.

a) There are two or more spans.

b) The spans are approximately equal, with the larger of two adjacent spans not greater than the shorter by more than 20 %; see 6.1.

c) The loads are uniformly distributed.

d) The unit live load, q_l, does not exceed three times the unit dead load, q_d.

e) For negative moment evaluation at internal supports, l_n should correspond to the largest of the neighbouring spans.

7.5.7.2 Factored flexural moment

The factored positive and negative flexural moment, M_u, in N·m/m, for one-way slabs should be calculated using Equations (77) to (82) and those given in Table 13 for slabs with two or more spans.

For positive moment, use Equations (77) and (78):

a) at end spans, in accordance with Equation (77):

$$M_u^+ = \frac{q_u \cdot l_n^2}{11} \quad (77)$$

b) at interior spans, in accordance with Equation (78):

$$M_u^+ = \frac{q_u \cdot l_n^2}{16} \quad (78)$$

For negative moment at supports, use Equations (79) to (82).

a) at the interior face of an external support, in accordance with Equation (79):

$$M_u^- = \frac{q_u \cdot l_n^2}{24} \quad (79)$$

b) at the exterior face of the first internal support for only two spans, in accordance with Equation (80):

$$M_u^- = \frac{q_u \cdot l_n^2}{9} \quad (80)$$

c) at the faces of internal supports for more than two spans, in accordance with Equation (81):

$$M_u^- = \frac{q_u \cdot l_n^2}{10} \quad (81)$$

d) at the faces of all supports for slabs with spans not exceeding 3 m, in accordance with Equation (82):

$$M_u^- = \frac{q_u \cdot l_n^2}{12} \quad (82)$$

7.5.7.3 Longitudinal flexural reinforcement

7.5.7.3.1 Positive flexural reinforcement

The positive reinforcement ratio, ρ, in the direction of the span, l_n, should be determined in accordance with Equation (27) or (29), with the appropriate value of M_u^+ derived from Equations (77) or (78), converted to newton·millimetres per metre (1 N·m/m = 10^3 N·mm/m), using d, expressed in millimetres, and b = 1 000 mm. This reinforcement should be in accordance with the provisions specified in 7.5.3.3. At internal supports, at a distance equal to $l_n/8$ measured from the face of the supports into the span, up to one-half of the positive flexural reinforcement should be permitted to be suspended; see Figures 59 and 60.

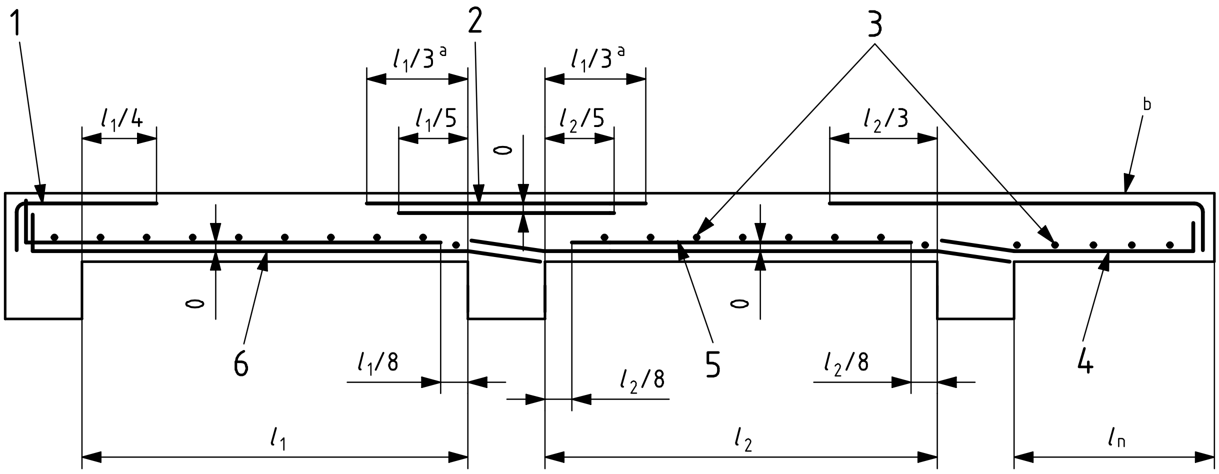
7.5.7.3.2 Negative flexural reinforcement

The negative flexural reinforcement ratio, ρ, in the direction of the span, l_n, should be determined in accordance with Equation (27) or (29), with the appropriate value of M_u^- derived from Equations (79) to (82), converted to newton·millimetres per metre (1 N·m/m = 10^3 N·mm/m), using d, expressed in millimetres, and b = 1 000 mm. This reinforcement should be in accordance with the provisions specified in 7.5.3.4. At internal supports, at a distance equal to $l_n/3$ where l_n should correspond to the largest of the neighbouring spans, measured from the face of the support into the span, all the negative flexural reinforcement should be permitted to be suspended. At external supports, at a distance equal to $l_n/4$ measured from the internal face of the support into the span, all the negative flexural reinforcement should be permitted to be suspended; see Figures 59 and 60.

7.5.7.3.3 Shrinkage and temperature reinforcement

The reinforcement perpendicular to the span should meet the provisions for shrinkage and temperature reinforcement specified in 7.5.3.2; see Figures 59 and 60.

Dimensions in millimetres



Key

1 negative reinforcement at the interior face of an external support
2 negative reinforcement at the interior support for two spans
3 shrinkage and temperature reinforcement
4 minimum cantilever positive reinforcement
5 positive reinforcement interior span
6 positive reinforcement end span

a Negative reinforcement cut-off points should be based upon the greater of the two neighbouring spans.

b Greater negative reinforcement from that required for the external support or for the cantilever.

Figure 59 — Reinforcement for two-span one-way slabs supported by girders, beams or structural concrete walls