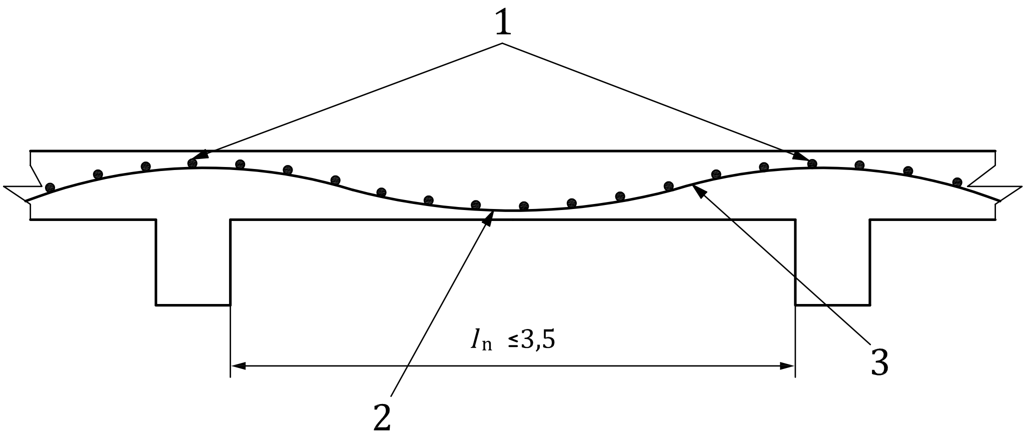


Key

1 placed close to top of slab over supports

2 placed close to bottom of slab near midspan

3 welded – wire reinforcement as positive and negative reinforcement

Figure 52 — Welded-wire reinforcement in short spans

11.3.6.4 Practical considerations for the value of d_c and d to employ in solid slabs

The determination of the distance from extreme tension fibre to centroid of tension reinforcement, [d_c], should include the appropriate concrete cover from 9.3.10, the bar diameters employed, and the existence of reinforcement in the perpendicular direction placed between the reinforcement under study and the concrete surface. It should be permitted to use the following values of d_c to compute d as $d = h - d_c$. 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.

11.4 Top thin solid slab that spans between joists

11.4.1 Dimensional guidelines

The thin solid slab that spans between joists should comply with the minimum thickness guidelines of 10.5.2.1. The top thin slab should not be permitted to cantilever out of the edge joist (see 10.1.4.1).

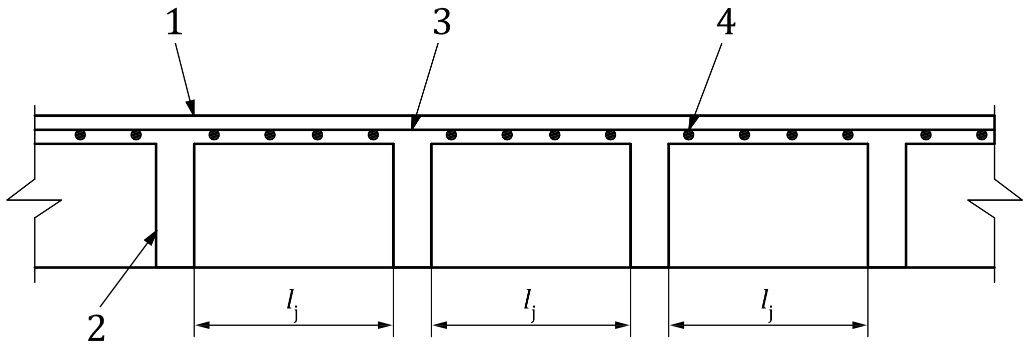
11.4.2 Factored bending moment

The factored bending moment, M_u, in N · m/m, for negative and positive bending moment in the thin slab that spans between joist in joist construction should be calculated using Formula (53), where l_j is the clear spacing between joists in m and q_u should be employed in N/m². See Figure 53.

$$M_u^+ = M_u^- = \frac{q_u \cdot l_j^2}{12} \tag{53}$$

11.4.3 Reinforcement

The flexural reinforcement ratio, ρ, perpendicular to the joist direction should be determined employing Formula (35) or Formula (36), with the value of M_u obtained from Formula (53), converted to N · mm (1 N · m/m = 10^3 · N · mm/m), using d in mm as one-half the thickness of the thin slab, and b = 1 000 mm. ρ should be made greater than or equal to the shrinkage and temperature ratio prescribed in 9.5.2.1. See Figure 53. The flexural reinforcing bar separations should meet the guides of 9.3.19. The reinforcement parallel to the joist direction should meet the guides of 11.3.2.



Key

1 top thin slab

2 joist

3 negative and positive flexural reinforcement

4 shrinkage and temperature reinforcement

Figure 53 — Reinforcement of the thin solid slab that span between joists

11.4.4 Shear strength verification

The factored shear V_u, in N/m, for the thin slab that span between joists in joist construction should be calculated using Formula (54), where l_j is the clear spacing between joists in m and q_u should be employed in N/m^2. See Figure 53.

$$V_u = \frac{q_u \cdot l_j}{2} \tag{54}$$

The design shear strength $\phi \cdot V_n$, in N/m, should be calculated using Formula (45), with d as one-half the thickness of the thin slab, in mm, and $b_w = b = 1\,000$ mm. Formula (43) should be complied with.

11.4.5 Calculation of the reactions on the joists

Factored uniformly distributed reaction on the supporting joists r_u, in N/m, should be the value obtained from Formula (55), where V_u is the factored shear from 11.4.4, in N/m, l is the centre-to-centre spacing of the joist, in m, and l_j is the clear spacing between joists, also in m.

$$r_u = \frac{2 \cdot V_u \cdot l}{l_j} \tag{55}$$

11.5 Cantilevers of slabs supported on girders, beams or walls

11.5.1 Dimensional guidelines

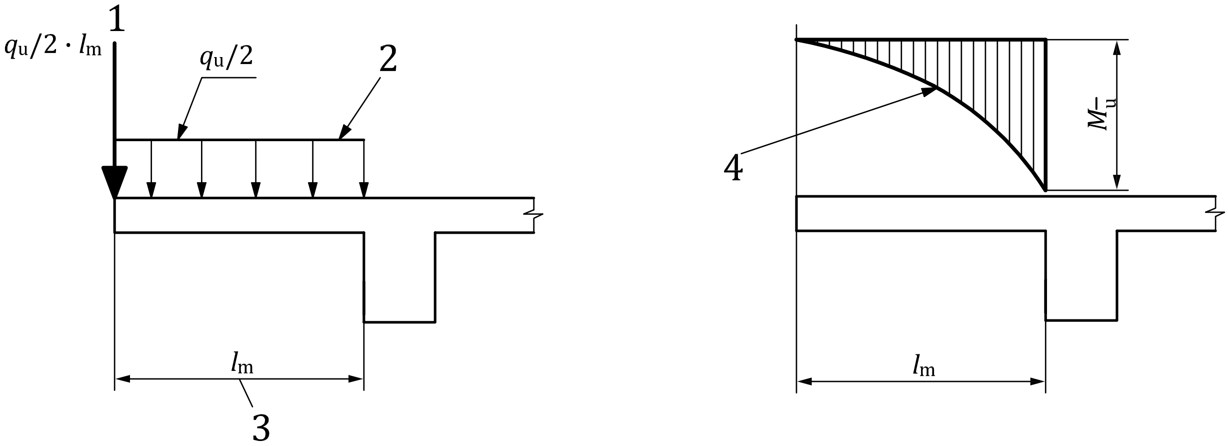
Solid slab cantilevers spanning out of the edge girder, beam or structural concrete wall, should comply with the minimum thickness guidelines of 10.5.2. The cantilever span should not exceed the limits of 6.1. No openings for ducts or shafts should be permitted in the internal one-half span of the cantilever. It should be permitted for the slab to cantilever in two directions at corners, with the same limitations for single cantilevers. The thin top slab that spans between joists should not cantilever out of the edge joist.

11.5.2 Factored negative bending moment

The factored negative bending moment, M_u, for slab cantilevers that span out of the edge supporting girders, beams or structural concrete walls, should be calculated supposing that one-half of the distributed factored load, q_u, acts as a concentrated load at the tip of the cantilever, and the other one-half acts as uniformly distributed load over the full span, using Formula (56), but it should not be less than the factored negative bending moment of the first interior span at the exterior supporting girder, beam or structural concrete wall, nor less than one-third of the positive bending moment, in the same direction, of the first interior span. See Figure 54.

$$M_u^- = \frac{3 \cdot q_u \cdot l_m^2}{4} \qquad (56)$$

where l_m should be the clear span of the cantilever in m, q_u should be employed in N/m^2, and M_u^- should be obtained in N · m/m.



Key

1 concentrated load

2 uniform load

3 cantilever clear span

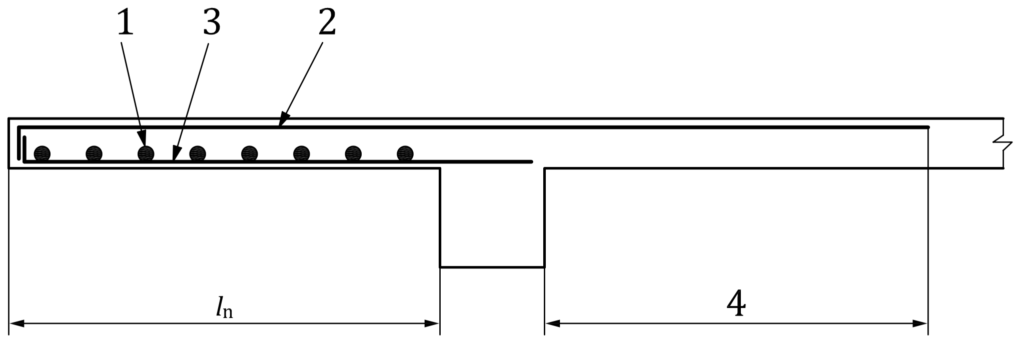
4 moment diagram

Figure 54 — Calculation of negative moment at slab cantilevers

11.5.3 Reinforcement

11.5.3.1 Negative flexural reinforcement

The negative flexural reinforcement ratio, ρ, in the direction of the cantilever should be determined employing Formula 35 or Formula 36, using the value of M_u obtained from Formula 56, converted to N · mm/m (1 N · m/m = 10^3 · N · mm/m), with the appropriate value of d in mm, and b = 1 000 mm. The negative flexural reinforcement should comply with 11.3.4. This reinforcement should be anchored in the first interior span not less than l_d for the reinforcing bar (see 9.4.1), nor the distance required for the negative reinforcement of the interior slab panel at the edge support. See Figure 55.



Key

1 shrinkage and temperature reinforcement

2 negative cantilever reinforcement

3 minimum positive reinforcement

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

Figure 55 — Reinforcement for slab cantilevers

11.5.3.2 Positive flexural reinforcement

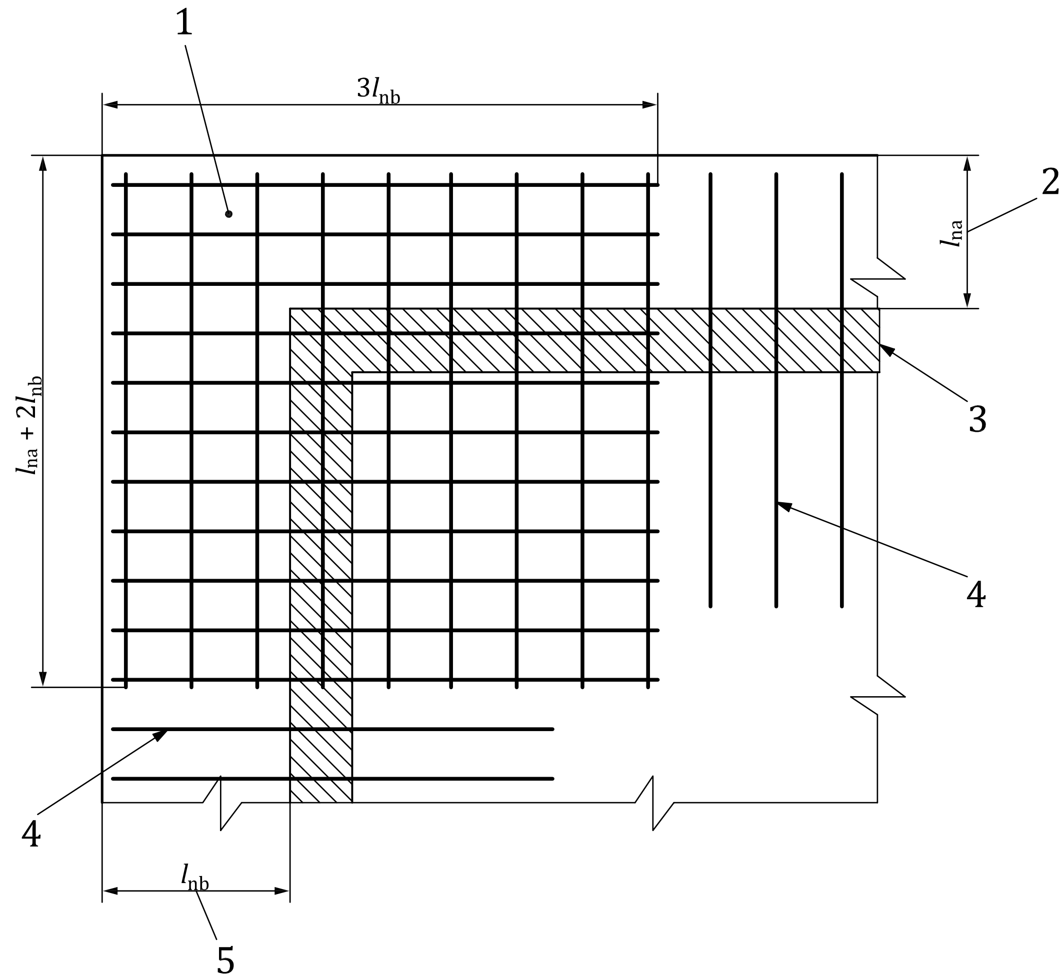
A minimum amount of positive flexural reinforcement with an area greater than or equal to the shrinkage and temperature reinforcement, complying with 11.3.2 should be provided in the direction of the cantilever. See Figure 55.

11.5.3.3 Shrinkage and temperature reinforcement

Reinforcement parallel to the edge of the cantilever complying with 11.3.1 should be provided. See Figure 55.

11.5.3.4 Reinforcement of two-way cantilevers

At corners where the slab cantilevers in two-directions, the negative flexural reinforcement should be calculated for the larger span cantilever, using 11.5.3.1. This reinforcement should be placed in both directions (see Figure 56), 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 as guided by 11.5.3.4 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 56 — Negative flexural reinforcement in two-way slab cantilevers

11.5.4 Shear verification

The factored shear V_u, in N/m, at the support of cantilever slabs should be calculated using Formula (57), where l_m should be the clear span of the cantilever in m, and q_u should be employed in N/m^2.

$$V_u = q_u \cdot l_m \tag{57}$$

For two-way cantilevers, the value of V_u should be taken as twice the value obtained from Formula (57) using the larger cantilever span.

The design shear strength $\phi \cdot V_n$, in N/m, should be calculated using Formula (45) with the appropriate value of d in mm, and b = 1 000 mm. Formula (43) should be complied with.

11.5.5 Calculation of reactions on the supports

Uniformly distributed factored reaction on the support of the cantilever r_u, in N/m, should be the value obtained from Formula (58):

$$r_u = \frac{V_u \cdot l}{l_m} \tag{58}$$

where

V_u is the factored shear from 11.5.4, in N/m;

l is the span of the canteliver measured from the centreline of the supporting element, in m;

l_m is the clear span of the canteliver, in m.

Where two-way cantilevers exists, it should be permitted in the calculation of the value of R_u to use Formula (58) employing the value of V_u obtained from Formula (57) for the larger cantilever span, without doubling it.

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

11.6.1 Dimensional guidelines

One-way one-span solid slabs should comply with the minimum thickness guidelines of 10.5.2. In addition to the appropriate guidelines of 11.6, these slabs should comply with the general dimensional guidelines set forth in 6.1, and the particular guidelines of 10.1.2 for slab-on-girder systems.

11.6.2 Factored bending moment

The factored positive and negative bending moment, M_u, in N · m/m, for one-span one-way slabs should be calculated using the formulae given in Table 13.

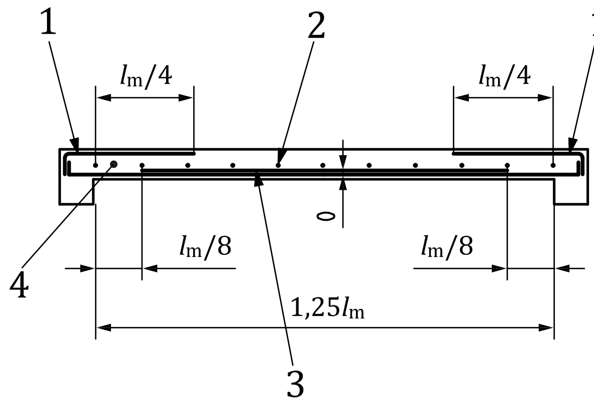
Table 13 — Factored flexural moment for one-way, one-span slabs

Positive moment: $M_u^+ = \frac{q_u \cdot l_m^2}{8}$	Formula (59)
Negative moment at supports: $M_u^- = \frac{q_u \cdot l_m^2}{24}$	Formula (60)

11.6.3 Longitudinal flexural reinforcement

11.6.3.1 Positive flexural reinforcement

The positive reinforcement ratio, ρ, in the direction of the span l_m, should be determined employing Formula (35) or Formula (36), with the value of M_u^+ obtained from Formula (59) converted to N · mm (1 N · m/m = 10^3 · N · mm/m), using d in mm, and b = 1 000 mm. This reinforcement should comply with the guides of 11.3.3. 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 $l_m/8$ measured from the internal face of the supports into the span. See Figure 57.



Key

1 negative flexural reinforcement

2 shrinkage and temperature reinforcement

3 positive flexural reinforcement

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

Figure 57 — Reinforcement for one-span one-way slabs

11.6.3.2 Negative flexural reinforcement

The negative flexural reinforcement ratio, ρ, in the direction of the span l_m, should be determined employing Formula (35) or Formula (36), with the value of M_u^- obtained from Formula (60) converted to N · mm (1 N · m/m = 10^3 · N · mm/m), using d in mm, and b = 1 000 mm. This reinforcement should comply with 11.3.4. At a distance equal to $l_m/4$ measured from the internal face of the supports into the span, all the negative flexural reinforcement should be permitted to be suspended. See Figure 57.

11.6.3.3 Shrinkage and temperature reinforcement

The reinforcement perpendicular to the span should meet the guides for shrinkage and temperature reinforcement of 11.3.2. See Figure 57.

11.6.4 Shear verification

The factored shear, V_u, in N/m, for the one-span one-way slab should be calculated at the face of the supports using Formula (61), where l_m is the clear span in m and q_u should be employed in N/m^2. See Figure 57.

$$V_u = \frac{q_u \cdot l_m}{2} \quad (61)$$

The design shear strength, $\phi \cdot V_n$, in N/m, should be calculated using Formula (45), with d in mm, and $b_w = b = 1\,000$ mm. Formula (43) should be complied with.

11.6.5 Calculation of the reactions on the supports

Uniformly distributed factored reaction on the supports of one-way one-span slabs, r_u, in N/m, should be the value obtained from Formula (62) plus the uniformly distributed reaction from any cantilever spanning from that support:

$$r_u = \frac{V_u \cdot l}{l_m} \tag{62}$$

where

V_u is the factored shear from 11.6.4, in N/m;

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

l_m is the clear span of the canteliver, in m.

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

11.7.1 Dimensional guidelines

One-way solid slabs with two or more spans should comply with the minimum thickness guidelines of 10.5.2. In addition to the appropriate guidelines of Clause 11, slabs should comply with the general dimensional guidelines in 6.1, and the particular guides of 10.1.2 for slab-on-girder systems.

The following restrictions should be in effect for slabs designed under 11.7:

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) loads are uniformly distributed;

d) unit live load, q_l, does not exceed three times unit dead load, q_d;

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

11.7.2 Factored bending moment

The factored positive and negative bending moment, M_u, in N · m/m, for one-way slabs should be calculated using the Formula (63) to Formula (68) for slabs with two or more spans.

Positive moment:

— at end spans:

$$M_u^+ = \frac{q_u \cdot l_n^2}{11} \tag{63}$$

— at interior spans:

$$M_u^+ = \frac{q_u \cdot l_n^2}{16} \tag{64}$$

Negative moment at supports:

— at interior face of external support:

$$M_u^- = \frac{q_u \cdot l_n^2}{24} \tag{65}$$

— at exterior face of first internal support, only two spans:

$$M_u^- = \frac{q_u \cdot l_n^2}{9} \tag{66}$$

— at faces of internal supports, more than two spans:

$$M_u^- = \frac{q_u \cdot l_n^2}{10} \tag{67}$$

— at faces of all supports for slabs with spans not exceeding 3 m:

$$M_u^- = \frac{q_u \cdot l_n^2}{12} \tag{68}$$

11.7.3 Longitudinal flexural reinforcement

11.7.3.1 Positive flexural reinforcement

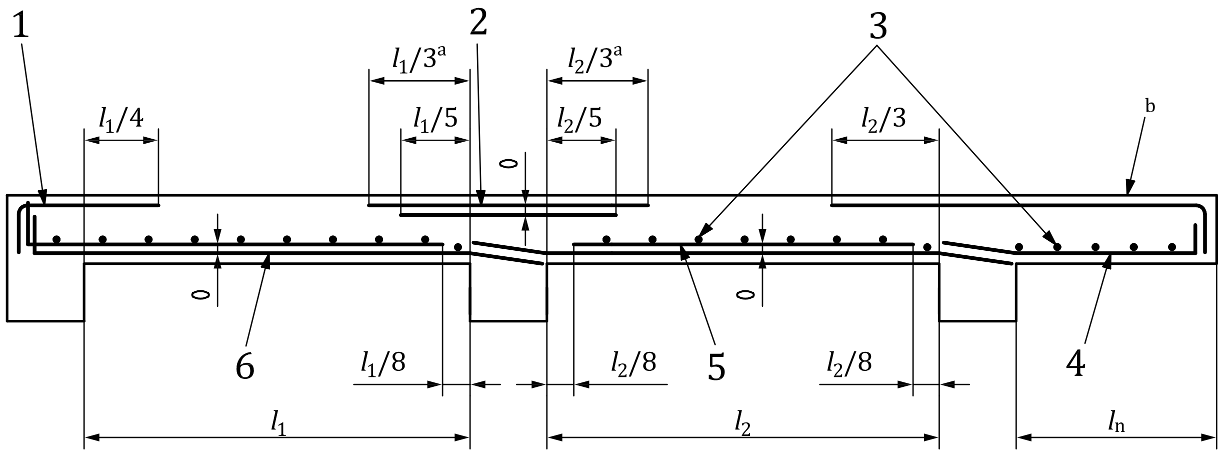
The positive reinforcement ratio, ρ, in the direction of the span l_m, should be determined employing Formula (35) or Formula (36), with the appropriate value of M_u^+ obtained from Formula (63) or Formula (64), converted to N · mm/m (1 N · m/m = 10^3 · N · mm/m), using d in mm, and b = 1 000 mm. This reinforcement should comply with 11.3.3. At internal supports, at a distance equal to $l_m/8$ 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 Figure 58.

11.7.3.2 Negative flexural reinforcement

The negative flexural reinforcement ratio, ρ, in the direction of the span, l_m, should be determined employing Formula (35) or Formula (36), with the appropriate value of M_u^- obtained, from Formula (65) to Formula (68), converted to N · mm/m (1 N · m/m = 10^3 ·N · mm/m), using d in mm, and b = 1 000 mm. This reinforcement should comply with 11.3.4. At internal supports, at a distance equal to $l_m/3$, where l_m 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 $l_m/4$ measured from the internal face of the support into the span, all the negative flexural reinforcement should be permitted to be suspended. See Figure 58 and Figure 59.

11.7.3.3 Shrinkage and temperature reinforcement

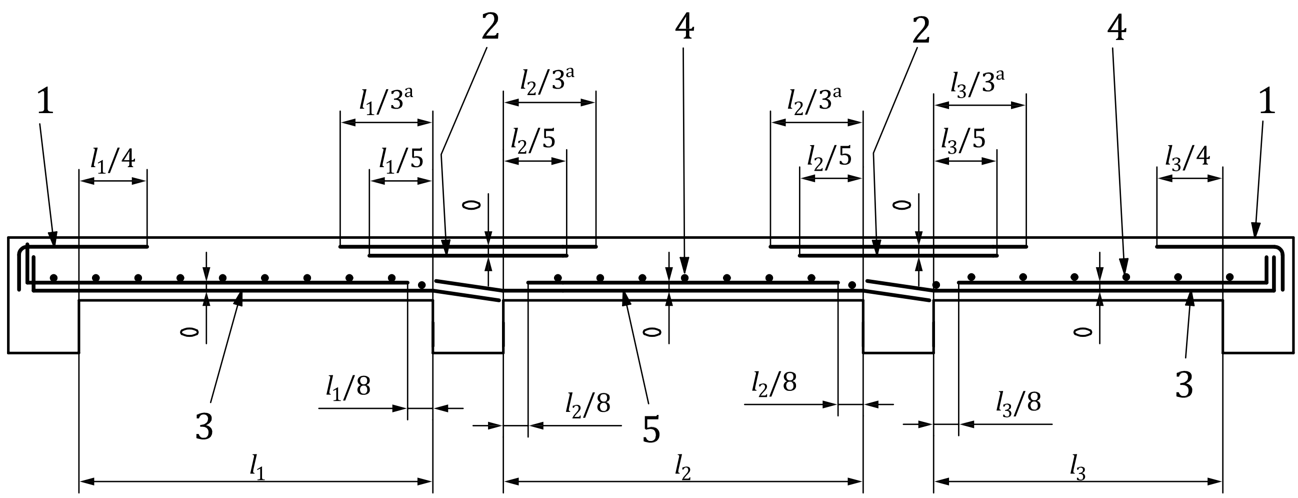
The reinforcement perpendicular to the span should meet the guides for shrinkage and temperature reinforcement of 11.3.2. See Figure 58 and Figure 59.



Key

1 negative reinforcement at interior face of external support
2 negative reinforcement 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 greater of the two neighbouring spans.
b Greater negative reinforcement from that required for the external support or for the cantilever.

Figure 58 — Reinforcement for two-span one-way slabs supported by girders, beams, or structural concrete walls



Key

1 negative reinforcement at interior face of external support
2 negative reinforcement at faces of internal support more than two spans
3 positive reinforcement end span
4 shrinkage and temperature reinforcement
5 positive reinforcement interior span
a Negative reinforcement cut-off points should be based upon greater of the two neighbouring spans.

Figure 59 — Reinforcement one-way slabs supported by girders, beams, or structural concrete walls, with three or more spans