10.4.5.3.2 Positive flexural reinforcement

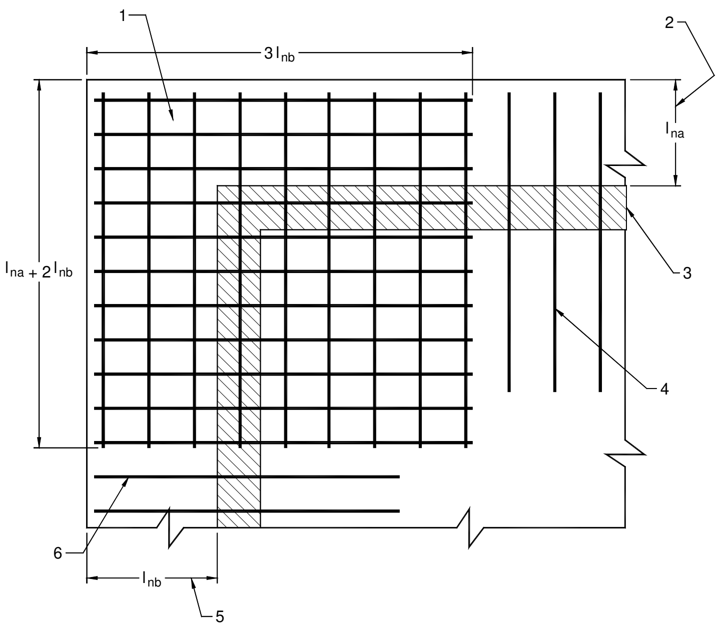
A minimum amount of positive flexural reinforcement with an area greater or equal to the shrinkage and temperature reinforcement, complying with the guides of 10.4.3.2 should be provided in the direction of the cantilever. See Figure 58.

10.4.5.3.3 Shrinkage and temperature reinforcement

Reinforcement parallel to the edge of the cantilever complying with 10.4.3.1 should be provided. See Figure 58.

10.4.5.3.4 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 the guides of 10.4.5.3.1. This reinforcement should be placed in both directions (see Figure 59), 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 guide by 10.4.5.3.2 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

6 one-way negative cantilever reinforcement

Figure 59 — Negative flexural reinforcement in two-way slab cantilevers

10.4.5.4 Shear verification

The factored shear V_u, in N/m, at the support of cantilever slabs should be calculated using Equation 45, where l_m should be the clear span of the cantilever in m, and q_u should be employed in N/m^2.

$$V_u = q_u \cdot l_m \qquad \text{Equation (45)}$$

For two-way cantilevers the value of V_u should be taken as twice the value obtained from Equation 45 using the larger cantilever span.

The design shear strength $\phi \cdot V_n$, in N/m, should be calculated using Equation 33 with the appropriate value of d in mm, and b = 1 000 mm. Equation 31 should be complied with.

10.4.5.5 Calculation of the 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 Equation 46, where V_u is the factored shear from 10.4.5.4, in N/m, l is the span of the cantilever measured from the centerline of the supporting element, in m, and l_m is the clear span of the cantilever, also in m.

$$r_u = \frac{V_u \cdot l}{l_m} \qquad \text{Equation (46)}$$

Where two-way cantilevers exists it should be permitted in the calculation of the value of R_u to use Equation 26 employing the value of V_u obtained from Equation 45 for the larger cantilever span, without doubling it.

10.4.6 One-way one-span solid slabs spanning between girders or beams

10.4.6.1 Dimensional specifications

One-way one-span solid slabs should comply with the minimum thickness guides of 10.3.5.2. In addition to the appropriate guides of 10.4.6 these slabs should comply with the general dimensional guides set forth in 6.1, and the particular guides of 10.3.1.2 for slab-on-girder systems.

10.4.6.2 Factored flexural moment

The factored positive and negative flexural moment, M_u, in N · m/m, for one-span one-way slabs should be calculated using the Equations. given in Table 26.

Table 26 — Factored flexural moment for one-way, one-span slabs

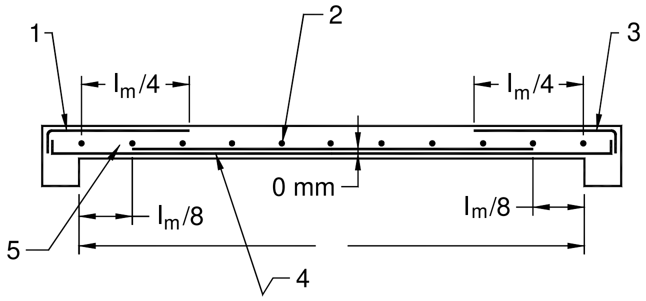
Positive moment: $M_u^+ = \frac{q_u \cdot l_m^2}{8}$	Equation (47)
Negative moment at supports: $M_u^- = \frac{q_u \cdot l_m^2}{24}$	Equation (48)

10.4.6.3 Longitudinal flexural reinforcement

10.4.6.3.1 Positive flexural reinforcement

The positive reinforcement ratio, ρ, in the direction of the span l_m, should be determined employing Equation 23 or Equation 24, with the value of M_u^+ obtained from Equation 47 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 10.4.3.3. In those cases in which the slab is cast monolithically with a supporting girder or beam, 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 60.



Key

1 negative flexural reinforcement

2 shrinkage and temperature reinforcement

3 negative flexural reinforcement

4 positive flexural reinforcement

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

Figure 60 — Reinforcement for one-span one-way slabs

10.4.6.3.2 Negative flexural reinforcement

The negative flexural reinforcement ratio, ρ, in the direction of the span l_m, should be determined employing Equation 23 or Equation 24, with the value of M_u^- obtained from Equation 48 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 10.4.3.4. At a distance equal to lm/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 60.

10.4.6.3.3 Shrinkage and temperature reinforcement

The reinforcement perpendicular to the span should meet the guides for shrinkage and temperature reinforcement of 10.4.3.2. See Figure 60.

10.4.6.4 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 Equation 49, where lm is the clear span in m and q_u should be employed in N/m^2. See Figure 60.

$$V_u = \frac{q_u \cdot l_m}{2}$$ Equation (49)

The design shear strength, $\phi \cdot V_n$, in N/m, should be calculated using Equation 33, with d in mm, and b_w = b = 1 000 mm. Equation 31 should be complied with.

10.4.6.5 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 Equation 49 plus the uniformly distributed reaction from any cantilever spanning from that support. In Equation 50 V_u is the factored shear from 10.4.6.4, in N/m, l is the center-to-center span of the slab, in m, and l_m is the clear span of the slab, also in m.

$$r_u = \frac{V_u \cdot l}{l_m}$$ Equation (50)

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

10.4.7.1 Dimensional specifications

One-way solid slabs with two or more spans should comply with the minimum thickness guides of 10.3.5.2. In addition to the appropriate guides of 10.4, slabs should comply with the general Dimensional specifications set forth in 6.1, and the particular guides of 10.3.1.2 for slab-on-girder systems.

The following restrictions should be in effect for slabs designed under 10.4.7:

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 per cent (see 6.1),

c) loads are uniformly distributed,

d) unit live load, ql, does not exceeds three times unit dead load, q_d, and

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

10.4.7.2 Factored flexural moment

The factored positive and negative flexural moment, M_u, in N ·m/m, for one-way slabs should be calculated using the Equation 51, Equation 52, Equation 53, Equation 54, Equation 55, and Equation 56 for slabs with two or more spans.

Positive moment

at end spans

$$M_u^+ = \frac{q_u \cdot l_n^2}{11}$$ Equation (51)

at interior spans:

$$M_u^+ = \frac{q_u \cdot l_n^2}{16}$$ Equation (52)

Negative moment at supports at interior face of external support

$$M_u^- = \frac{q_u \cdot l_n^2}{24}$$ Equation (53)

at exterior face of first internal support, only two spans

$$M_u^- = \frac{q_u \cdot l_n^2}{9}$$ Equation (54)

at faces of internal supports, more than two spans

$$M_u^- = \frac{q_u \cdot l_n^2}{10}$$ Equation (55)

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

$$M_u^- = \frac{q_u \cdot l_n^2}{12}$$ Equation (56)

10.4.7.3 Longitudinal flexural reinforcement

10.4.7.3.1 Positive flexural reinforcement

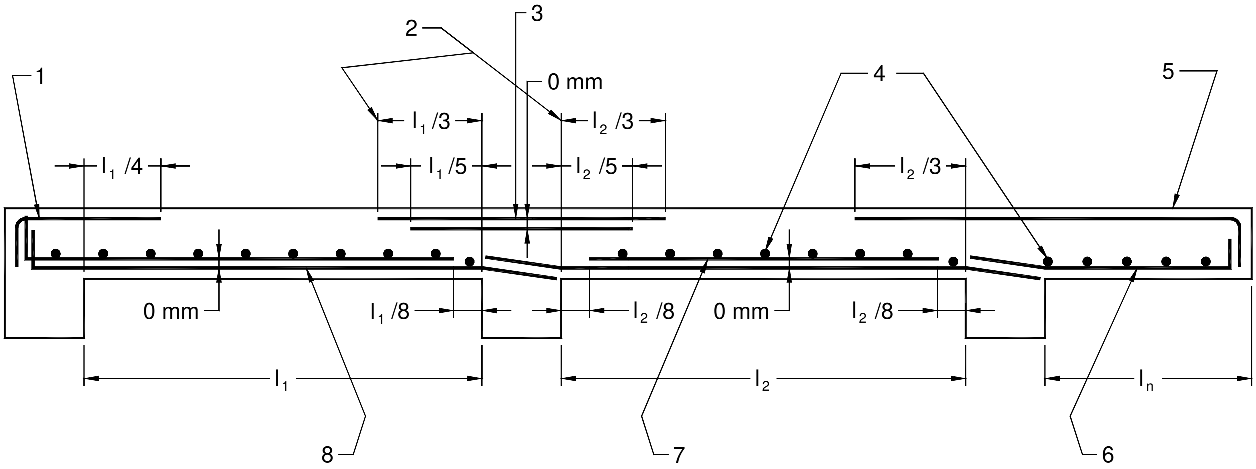
The positive reinforcement ratio, ρ, in the direction of the span l_m, should be determined employing Equation 23 or Equation 24, with the appropriate value of M_u^+ obtained from Equation 51 or Equation 52, converted to N · mm/m (1 N ·m/m = 10^3 ·N ·mm/m), using d in mm, and b = 1 000 mm. This reinforcement should comply with the guides of 10.4.3.3. 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 61.

10.4.7.3.2 Negative flexural reinforcement

The negative flexural reinforcement ratio, ρ, in the direction of the span, lm, should be determined employing Equation 23 or Equation 24, with the appropriate value of M_u^- obtained, from Equation 53, to Equation 56, 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 the guides of 10.4.3.4. At internal supports, at a distance equal to $l_m/3$, where l_m should correspond to the largest of the neighboring 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 61 and Figure 62.

10.4.7.3.3 Shrinkage and temperature reinforcement

The reinforcement perpendicular to the span should meet the guides for shrinkage and temperature reinforcement of 10.4.3.2. See Figure 61 and Figure 62.



Key

1 negative reinforcement at interior face of external support

2 negative reinforcement cut-off points should be based upon greater of the two neighboring spans

3 negative reinforcement interior support for two spans

4 shrinkage and temperature reinforcement

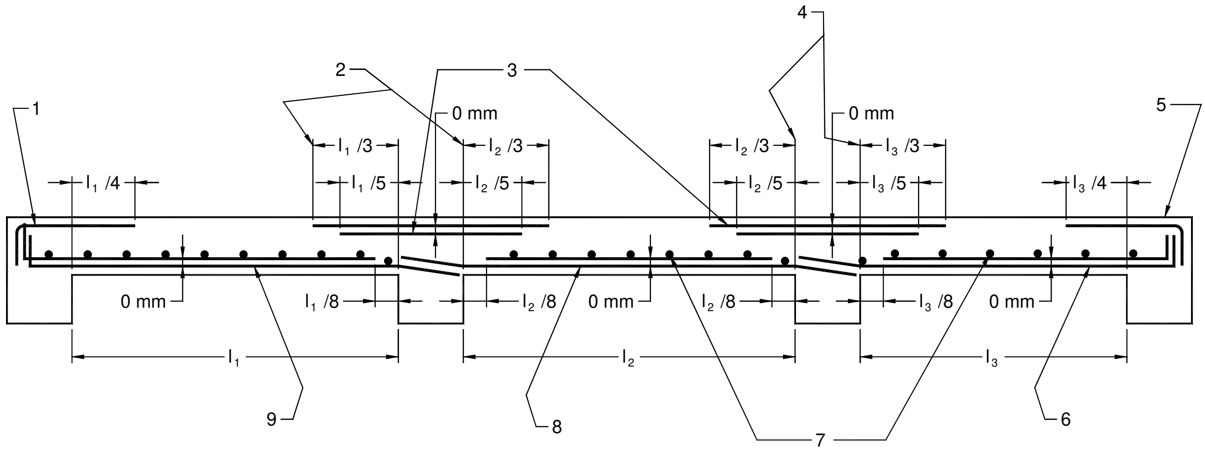
5 greater negative reinforcement from that required for the external support or for the cantilever

6 minimum cantilever positive reinforcement

7 positive reinforcement interior span

8 positive reinforcement end span

Figure 61 — Reinforcement for two-span one-way slabs supported by girders or beams



Key

1 negative reinforcement at interior face of external support

2 negative reinforcement cut-off points should be based upon greater of the two neighboring spans

3 negative reinforcement at faces of internal support more than two spans

4 negative reinforcement cut-off points should be based upon greater of the two neighboring spans

5 negative reinforcement at interior face of external support

6 positive reinforcement end span

7 shrinkage and temperature reinforcement

8 positive reinforcement interior span

9 positive reinforcement end span

Figure 62 — Reinforcement one-way slabs supported by girders or beams, or structural concrete walls, with three or more spans

10.4.7.4 Shear verification

The factored shear, V_u, in N/m, for the slab should be calculated at the faces of all supports using the Equation 57 and Equation 58, where l_m is the clear span in m and q_u should be employed in N/m^2. Figure 61 and Figure 62.

at exterior face of first interior support

$$V_u = 1{,}15 \cdot \frac{q_u \cdot l_m}{2} \qquad \text{Equation (57)}$$

at faces of all other supports

$$V_u = \frac{q_u \cdot l_m}{2} \qquad \text{Equation (58)}$$

The design shear strength, $\phi \cdot V_n$, in N/m, should be calculated using Equation 33, with d in mm, and b_w = b = 1 000 mm. Equation 31 should be complied with at all faces of supports.

10.4.7.5 Calculation of the reactions on the supports

Uniformly distributed factored reaction on the support contributed by any span of one-way slabs, r_u, in N/m, should be the value obtained from Equation 59, where V_u is the factored shear from 10.4.7.4, in N/m, l is the center-to-center span, in m, and l_m is the clear span, also in m.

$$r_u = \frac{V_u \cdot l}{l_m} \qquad \text{Equation (59)}$$

Total factored uniformly distributed reaction on the external supports should be equal to the value of the factored uniformly distributed reaction from the span, r_u, obtained from Equation 59 at the support, plus the uniformly distributed reaction of any cantilever spanning from that support. Total factored uniformly distributed reactions on internal supports should be the sum of the factored uniformly distributed reactions, r_u, obtained using Equation 59 for both neighbouring spans at that support.

10.4.8 Two-way solid slabs spanning between girders, or beams

10.4.8.1 Dimensional specifications

Two-way solid slabs having girders, beams in all edges should comply with the minimum thickness guides of 10.3.5.4. In addition to the appropriate guides of 10.4, two-way slabs should comply with the general Dimensional specifications set forth in 6.1, and the particular guides of 10.3.1.2 for slab-on-girder systems.

The following restrictions should be in effect for the use of the procedure of 10.4.8.1:

a) there are two or more spans,

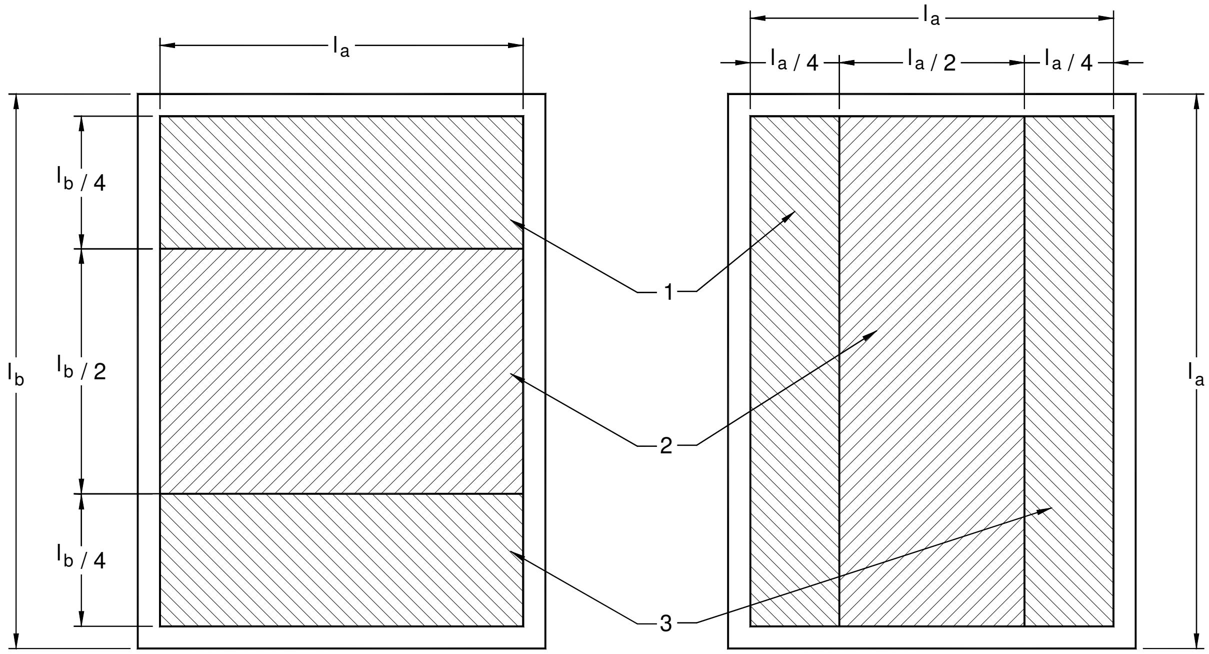
b) the spans are approximately equal, with the larger of two adjacent spans not greater than the shorter by more than 20 per cent of the larger (see 6.1),

c) the supporting girders or beams should be cast monolithically with the slab and should have a total depth not less than 3 times the slab thickness,

d) loads are uniformly distributed, and

e) unit live load, q_l, does not exceeds three times unit dead load, q_d.

The slab panel should be divided, in both directions, into central and border regions. The central region should be the central half of the panel, and the border regions should be two one-quarter regions adjacent on both sides of the central region. See Figure 63.



Key

1 border region

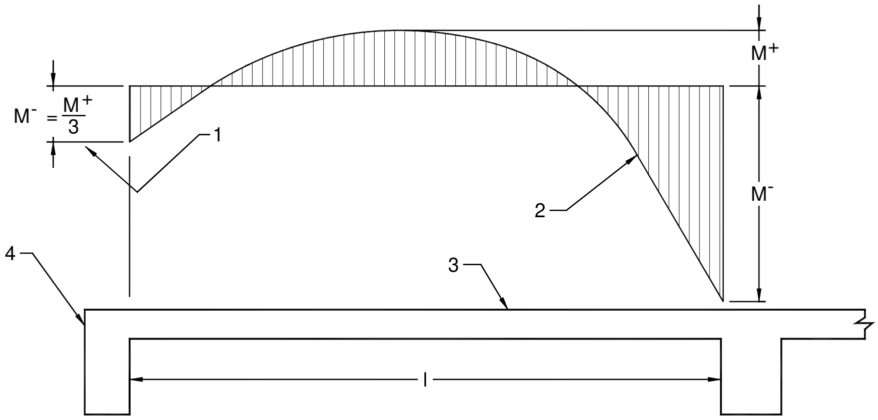
2 central region

3 border region

Figure 63 — Central and border regions for two-way slabs supported on girders or beams Factored flexural moment

The factored positive and negative moment, M_u, for two-way solid slabs should be calculated using the procedure set forth in 10.4.8.2. The negative and positive factored flexural moment for the central region of the panel, in each direction, should be calculated using the Eqs. given in Table 26 for central panels, in Table 27 for edge panels with the short span at the edge, in Table 27 for edge panels with the long span at the edge, and in Table 28 for corner panels. In each table the values of the factored flexural moments should be obtained for the appropriate ratio, β, of long clear span, l_b, to short clear span, l_a, and the corresponding edge continuity conditions.

The negative moment at discontinuous edges should be one-third of the positive moment in the same direction. See Figure 64.



Key

1 value of negative moment at discontinuous edge

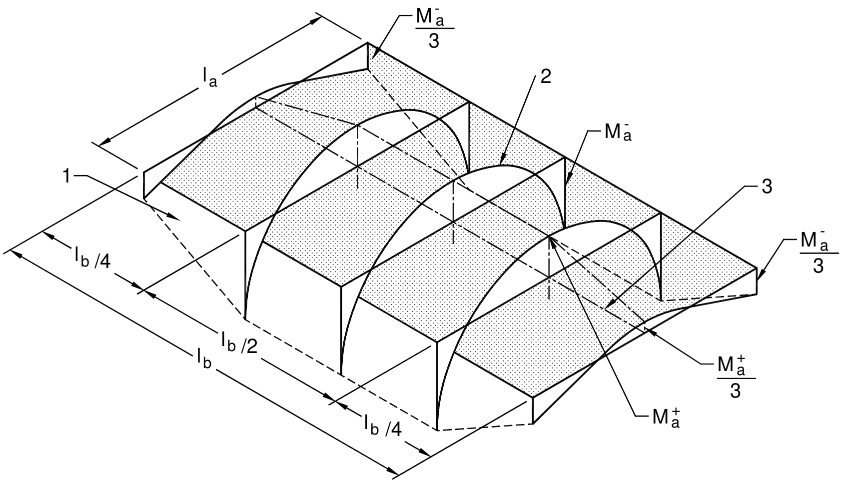
2 moment diagram

3 end slab span

4 discontinuous edge

Figure 64 — Negative moment at discontinuous edges of two-way solid slabs-on-girders

It should be permitted to decrease the moment strength values at the edge of the central regions, to one-third of this value at the edge of the panel, as shown in Figure 65 for moments in the short directions, and in Figure 66 for moments in the long direction.



Key

1 variation of M'a along lb

2 variation of M'a along la

3 variation of M_a^+ along lb

Figure 65 — Variation of moment M_a across the width of critical sections for design, for two-way slabs supported on girders, beams