# CIVL471 DESIGN OF RC STRUCTURES

## LECTURE NOTE #10

# Load Transfer from Two-Way Slabs to Beams

- In edge-supported slabs, if supports are beams, slab loads are transmitted to the beams and then to the columns.

- It is assumed that the slab loads on the triangular and trapezoidal parts of the slabs are carried by supporting beams as if they are acting vertically on the beams.

$l_x$

$l_y$

45º   45º

45º   45º

$\overline{q}$

$l_x/2$

$l_x/2$

$\overline{q}$
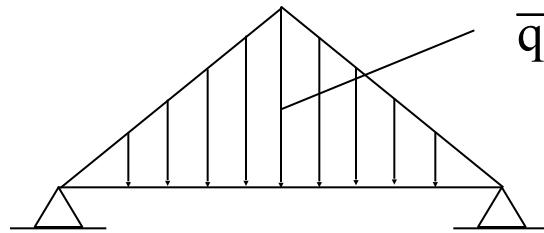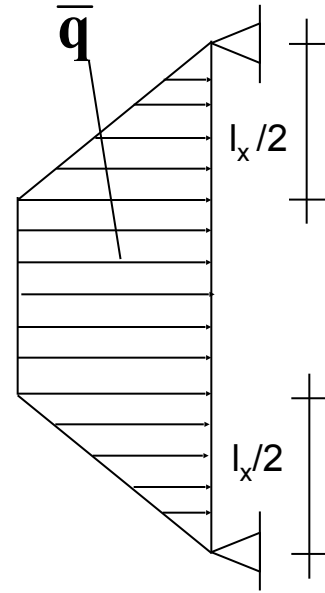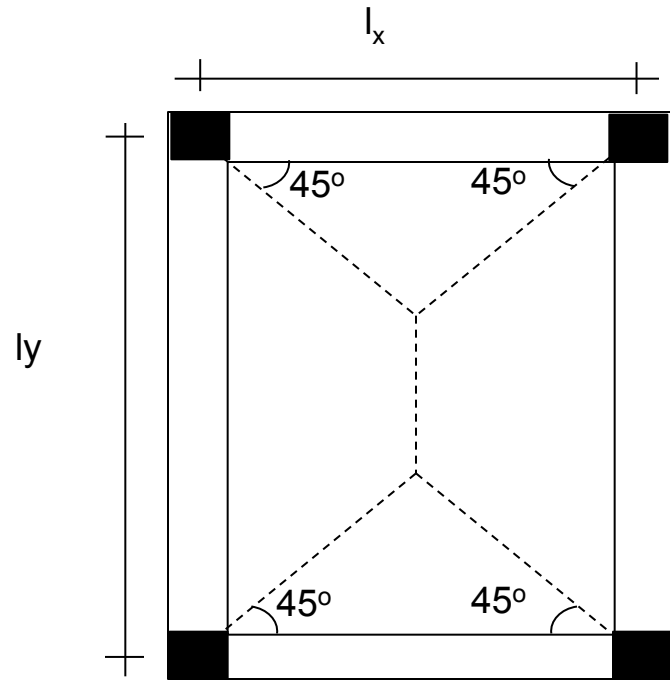
The same distribution of the loads may be assumed if the supports are walls. It can be observed that short beams are receiving triangular distributed loads whereas long beams are receiving trapezoidal distributed loads. If **W** is the uniformly distributed load per unit area, maximum value of the beam loads is:

$$\overline{q} = W \frac{l_x}{2} \qquad\qquad (1.7)$$

TS500 allows using equivalent uniformly distributed loads instead of triangular and trapezoidal loads. The following equations can be used for the calculation of equivalent loads:

Triangular load:
$$q = \frac{Wl_{xn}}{3} \qquad (1.8)$$

Trapezoidal load:
$$q = \frac{Wl_{xn}}{3}\left(1.5 - \frac{1}{2\varepsilon^2}\right) \qquad (1.9)$$

- Example 1.3:

  Determine the uniformly distributed equivalent beam loads which are transmitted from the slabs designed in Example 1.2
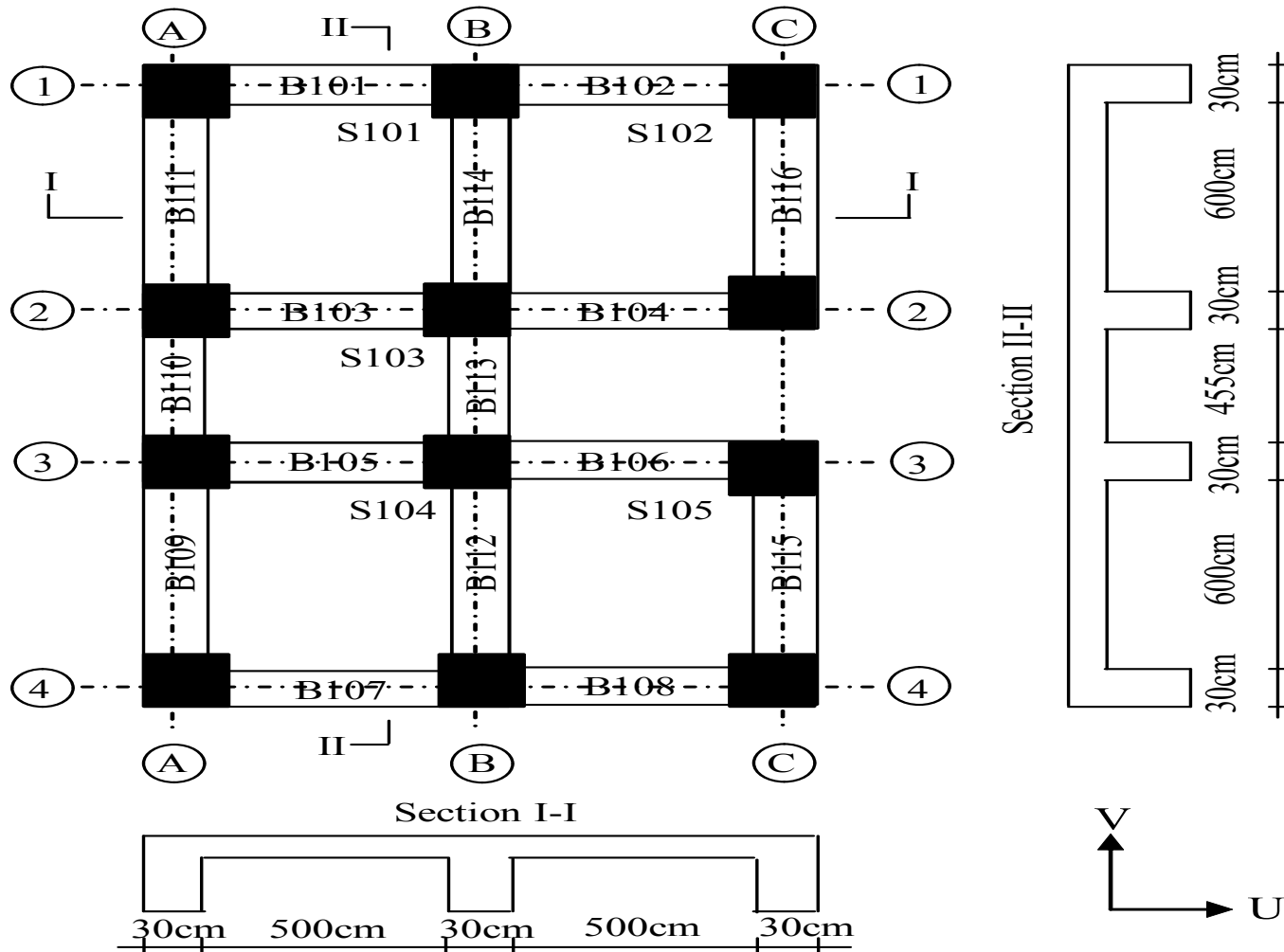
Example 1.2



Figure 1.16

Live load: 2.5 kN/m$^2$
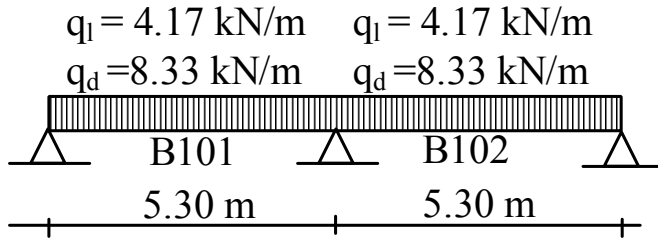Additional dead load (floor finish, plaster etc.): 1.25 kN/m$^2$
Materials: C16, S220

Design the slabs shown in Fig.1.16. Use half straight and half bent-up bars.

Solution:

Beams B101-B102:

$q_l = 4.17$ kN/m    $q_l = 4.17$ kN/m
$q_d = 8.33$ kN/m    $q_d = 8.33$ kN/m



B101    B102

5.30 m     5.30 m

B101 receives the loads from S101 and B102 receives the loads from S102. Both of the beams are short beams in S101 and S102. Therefore Eq. (1.8) will be used for load calculations.
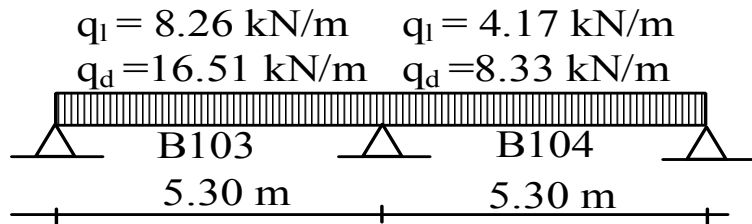
B101:

Dead load transferred from S101…….$q_d = \dfrac{5*5}{3} = 8.33$kN/m

Live load transferred from S101……..$q_1 = \dfrac{2.5*5}{3} = 4.17$ kN/m

Since the loads and spans are equal in S102 loads are same in B102.

Beams B103-B104:

$q_l = 8.26$ kN/m     $q_l = 4.17$ kN/m
$q_d = 16.51$ kN/m    $q_d = 8.33$ kN/m



B103      B104

5.30 m      5.30 m

B103 receives loads from S101 and from S103. It is a short beam in S101 but a long beam in S103. Therefore the loads transferred from S101are equal to the loads of B101. For the loads transferred from S103 Eq. (1.9) will be used where ε equals to 1.09.
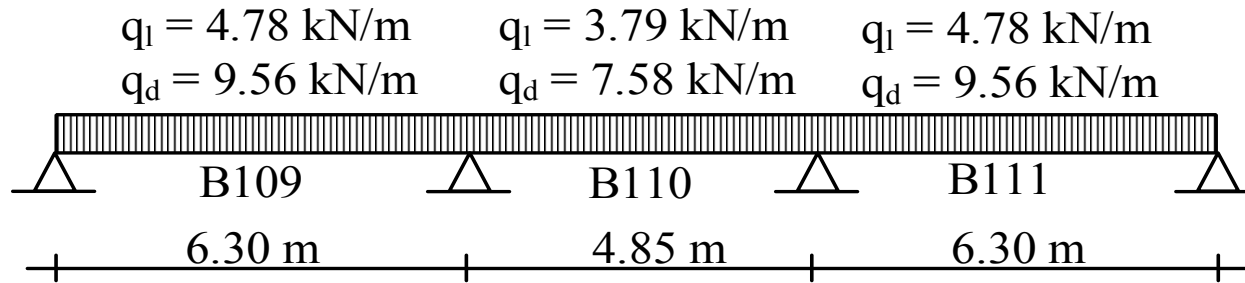
B103:

Dead load transferred from S101............................................8.33 kN/m

Dead load transferred from S103... $\dfrac{5*4.55}{3}(1.5 - \dfrac{1}{2*1.09^2})$ = 8.18 kN/m

$q_d = 16.51$ kN/m

Live load transferred from S101...........................................4.17 kN/m

Live load transferred from S103.. $\dfrac{2.5*4.55}{3}(1.5 - \dfrac{1}{2*1.09^2})$ = 4.09 kN/m

$q_l = 8.26$ kN/m

B104 receives the loads only from S102 where it is a short beam. Therefore the loads of B104 are equal to the loads of B102. The beams B105 and B106 are identical to the beams B103 and B104. Similarly the beams B107 and B108 are identical to the beams B101 and B102.

Beams B109-B110-B111:

$q_l$ = 4.78 kN/m      $q_l$ = 3.79 kN/m      $q_l$ = 4.78 kN/m
$q_d$ = 9.56 kN/m      $q_d$ = 7.58 kN/m      $q_d$ = 9.56 kN/m

| B109 | B110 | B111 |
|------|------|------|
| 6.30 m | 4.85 m | 6.30 m |

The only loads transferred to B109 are trapezoidal loads from S104 where $\varepsilon$ = 1.19. By using Eq. (1.9):

$$\text{Dead load transferred from S104.. } q_d = \frac{5*5}{3}(1.5 - \frac{1}{2*1.19^2})=9.56 \text{ kN/m}$$

$$\text{Live load transferred from S104.. } q_l = \frac{2.5*5}{3}(1.5 - \frac{1}{2*1.19^2}) = 4.78 \text{ kN/m}$$
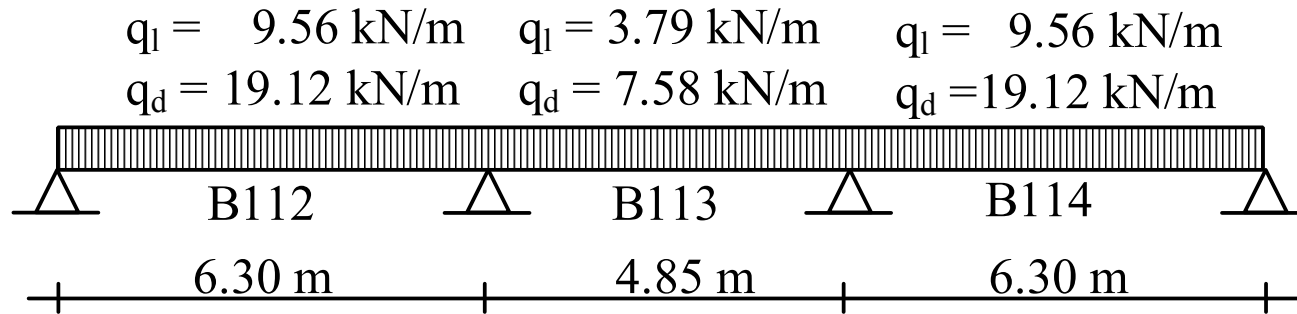
B110 receives only triangular loads from S103. Therefore,

$$\text{Dead load transferred from S103............. } q_d = \frac{5*4.55}{3} = 7.58 \text{kN/m}$$

$$\text{Live load transferred from S103............. } q_l = \frac{2.5*4.55}{3} = 3.79 \text{kN/m}$$

Because of symmetry the loads of B111 are equal to the loads of B109.

Beams B112-B113-B114:

$$q_l = \ 9.56 \ kN/m \qquad q_l = 3.79 \ kN/m \qquad q_l = \ 9.56 \ kN/m$$
$$q_d = 19.12 \ kN/m \qquad q_d = 7.58 \ kN/m \qquad q_d = 19.12 \ kN/m$$

| B112 | B113 | B114 |
|------|------|------|
| 6.30 m | 4.85 m | 6.30 m |

B112 receives the loads from S104 and S105 where the loads and the spans are equal. The loads transmitted from them are equal to the loads of B109. That is:

Dead load transferred from S104………..9.56 kN/m
Dead load transferred from S105………..9.56 kN/m
$$q_d = 19.12 \ kN/m$$

Live load transferred from S104…………4.78 kN/m
Live load transferred from S105………….4.78 kN/m
$$q_l = \ 9.56 \ kN/m$$

The loads of B113 are equal to the loads of B110 and because of symmetry the loads of B114 are equal to the loads of B112.

B115:

$$q_l = 4.78 \text{ kN/m}$$
$$q_d = 9.56 \text{ kN/m}$$

B115

6.30 m
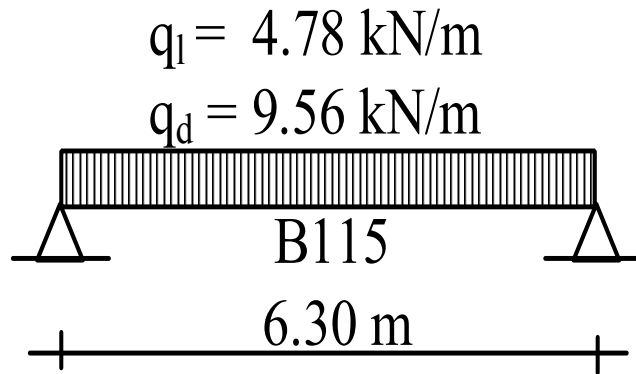
B115 is the long beam in the slab S105. Therefore as calculated earlier:

$$q_d = 9.56 \text{ kN/m} \qquad q_l = 4.78 \text{ kN/m}$$

B116 is identical to B115, that is, the loads are equal to the loads of B115.

# Openings in Edge Supported Slabs

For many reasons small or large openings may be necessary in slabs. For example relatively small openings may be needed for heating or ventilating ducts or piping etc. Such small openings may not be harmful in edge- supported slabs. For these openings it is sufficient to provide additional reinforcement at the sides of the opening. The area of these additional bars should be equal to the area of the interrupted reinforcement. They must be extended beyond the sides of the opening as long as the development length. There should also be diagonally located bars at the corners of the openings to control cracking at the corners.

Large openings need special treatment and possibly require additional beams provided at one or more sides of the opening.

# Two-Way Column Supported (Beamless) Slabs

Column supported slabs can be analyzed by "Equivalent Frame Method" or "Yield Lines Theory" or by some semi-empirical methods if high precision is not necessary. Two-way column supported slabs may be completely flat (flat plate slabs) or slabs may be thickened by drop panels above the columns or column tops may be formed as column capitals. Slabs of this kind are known as flat slabs or mushroom slabs because of the appearance.

≤ 0.4 $l_1$

$h \geq 14$ cm

$t_o \geq h / 2$

Drop panel

Column capital

≤ 0.4 $l_1$

$h \geq 14$ cm

≤ $l_1/10$

≤ $l_1/10$

$l_1$
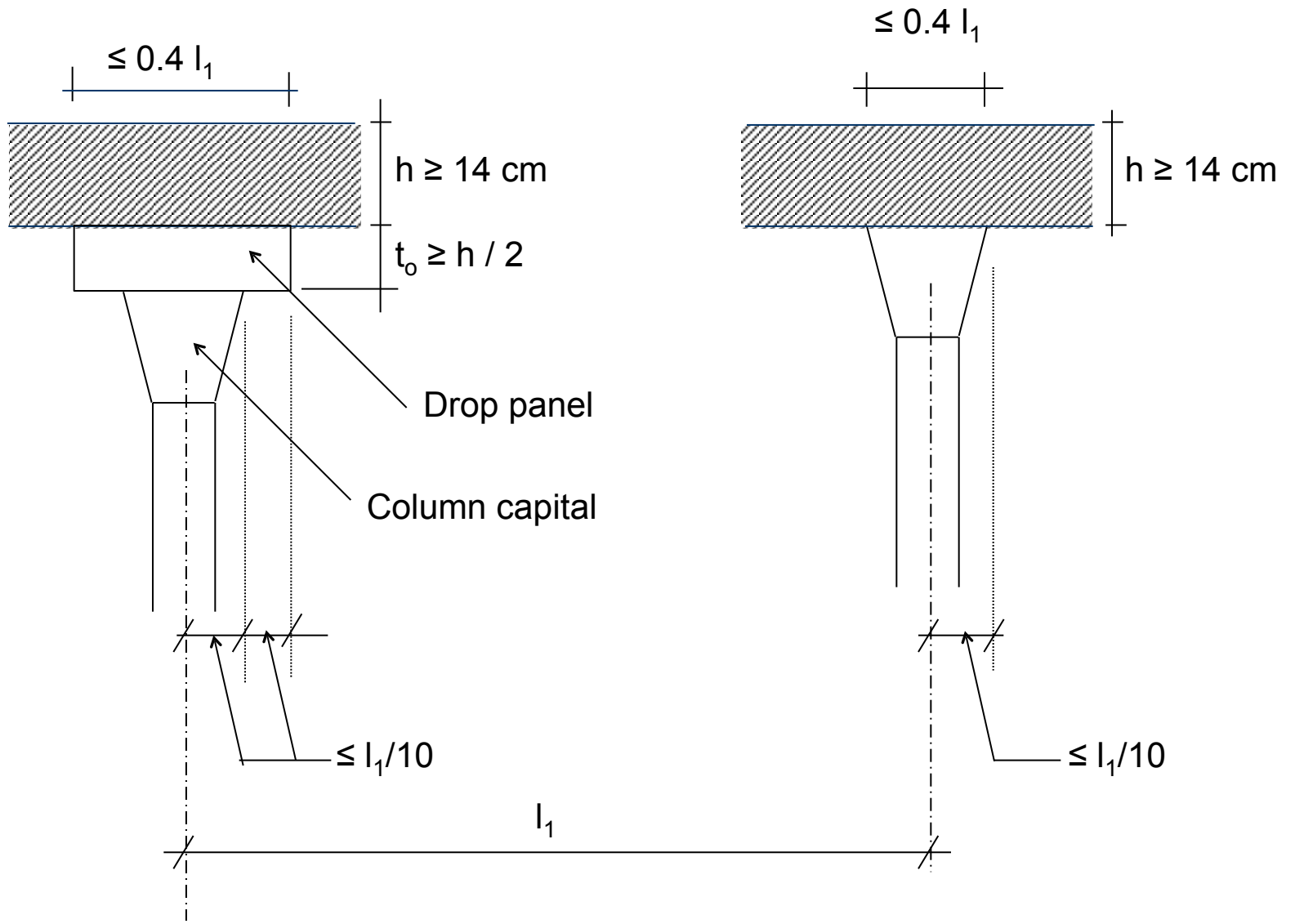
In TS500 minimum slab thickness is defined as follows:

Flat plate slabs: $\dfrac{l_n}{30}$ and 18 cm.

Flat slabs: $\dfrac{l_n}{35}$ and 14 cm.

in which $l_n$ is the free span.

However if approximate methods are used in design minimum thickness should be (long span / 30) or 20 cm, whichever is the larger. Column dimension in the direction of the analysis should not be less than 1/20 of the span in that direction and 30 cm.

Beamless slabs can be analyzed assuming that they are formed by the frames in two basic directions. Horizontal members of the frames are the slab parts between the center lines of two adjacent slabs. In the analyses of the frames total slab load is used in either direction. Variations of the moment of inertia values across the span lengths and across the column heights should be considered in the rigidity calculations of these members. Calculated support and span moments are distributed to the column and middle strips which are shown in Fig. 1.13.
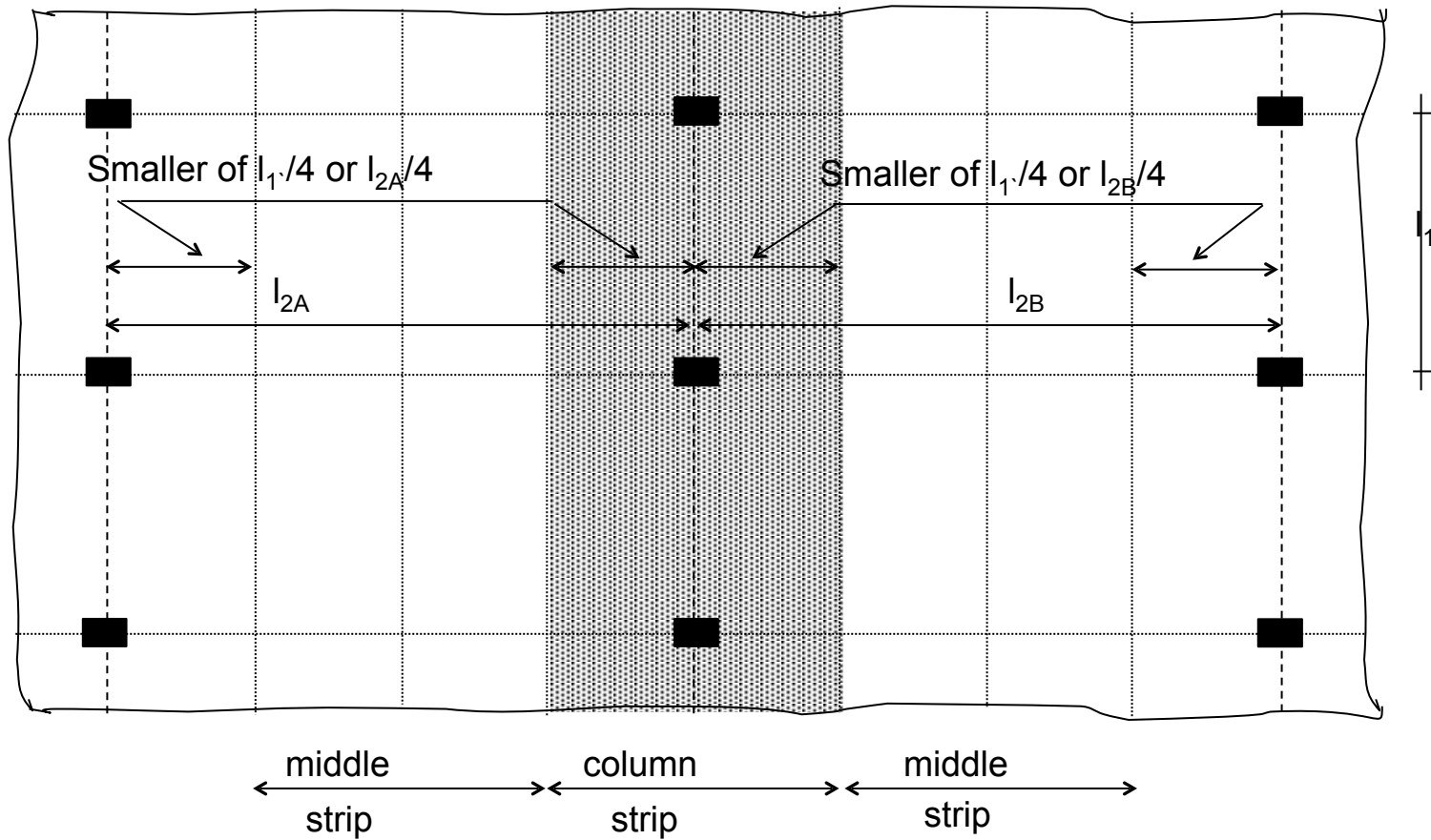
Fig.1.13

Punching forces can be very critical in beamless slabs. Most of the catastrophic accidents encountered in beamless slabs were due to punching failures. It is advisable to increase the slab thickness or to use drop panels instead of providing punching reinforcement.