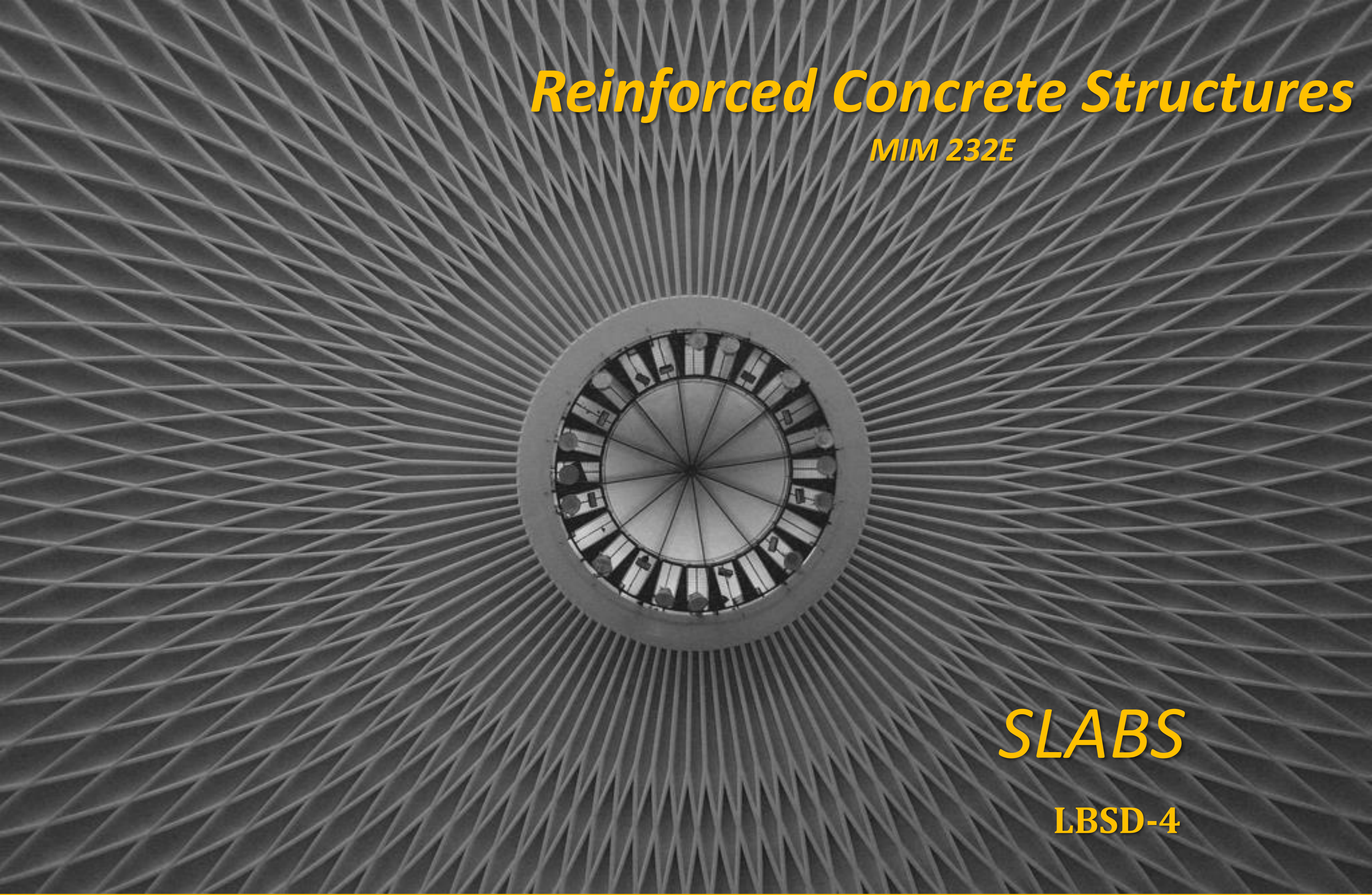


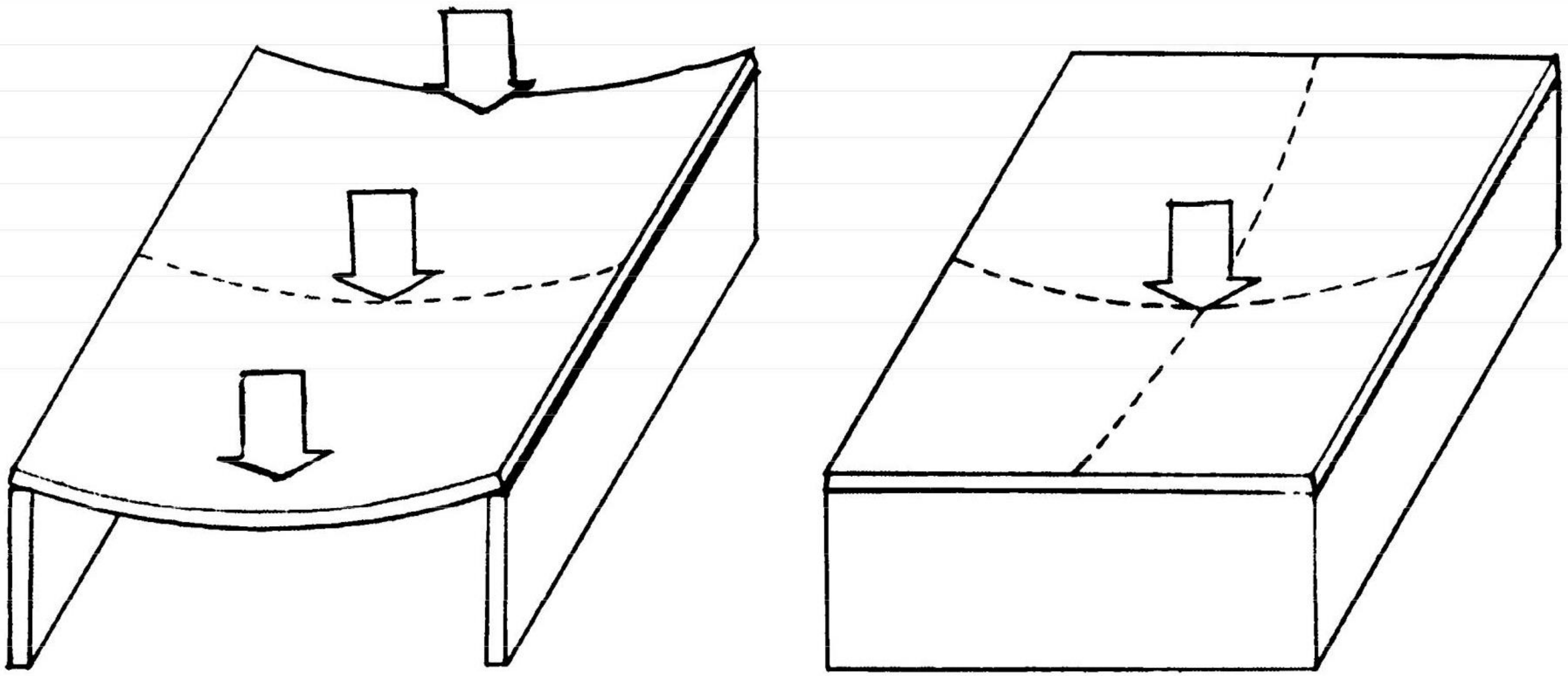
Reinforced Concrete Structures

MIM 232E

SLABS

LBSD-4

Dr. Haluk Sesigür
I.T.U. Faculty of Architecture
Structural and Earthquake Engineering WG



Plate, grid, and space-frame structures. The general curvatures and external moments induced in plate, grid, and space-frame structures are similar if their loads and general dimensions are similar. The exact way each structure provides internal resisting moments and the specifics of behavior, however, is different..

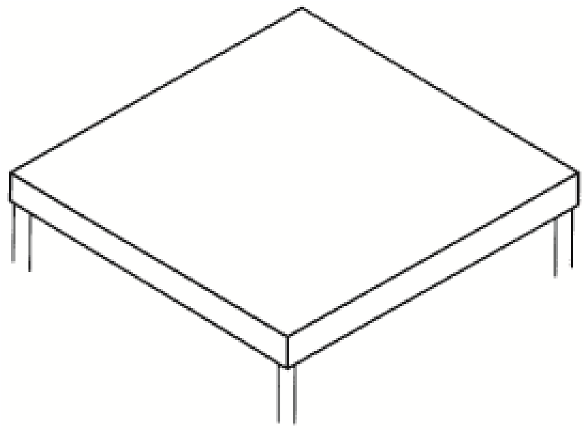
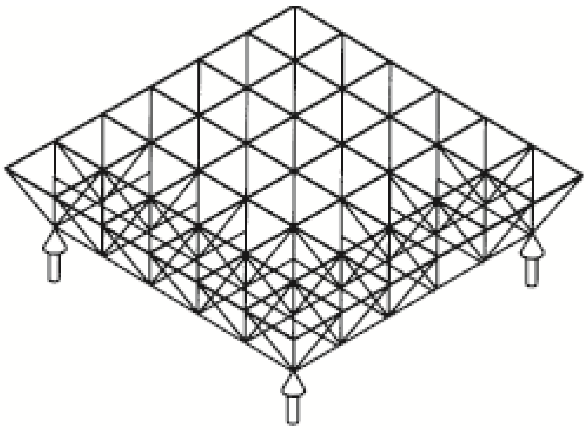
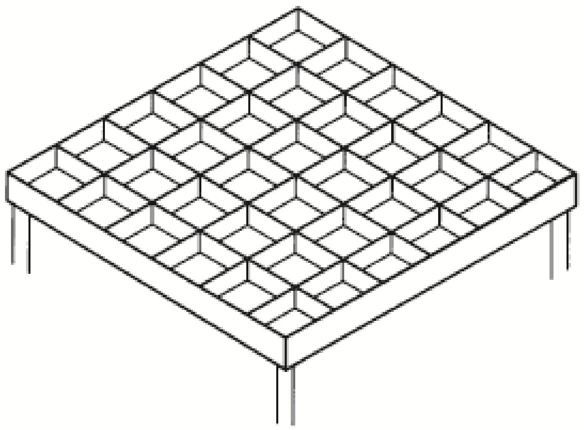


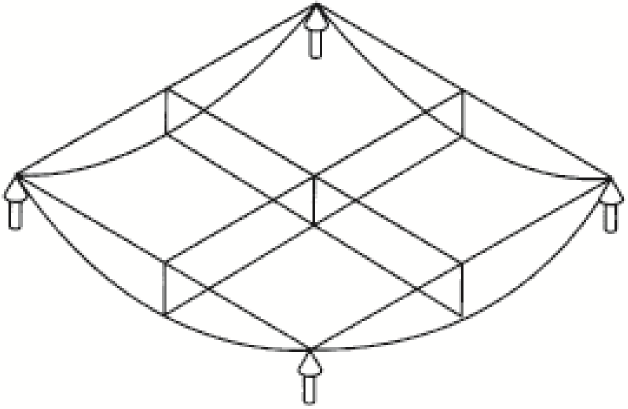
Plate structure



Space frame



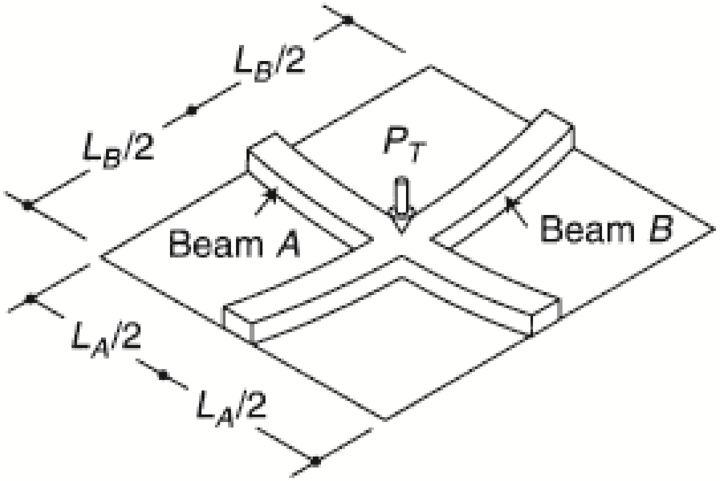
Grid structure

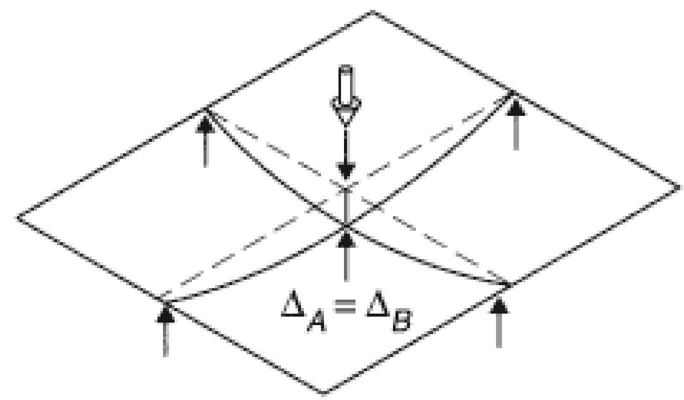


Deflected shape

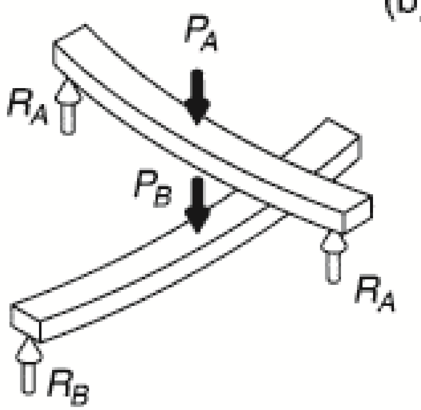
Reference: Structures, Daniel Schodek, Martin Bechthold.

Simple two-way grid structure.





(a) Basic structure

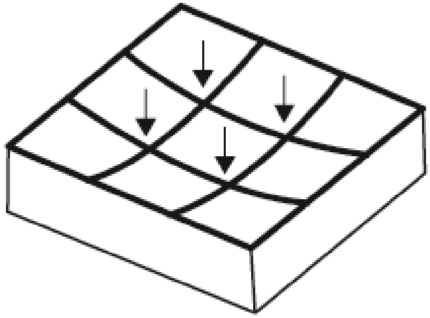


(b) Each beam carries a portion of the total load. $P_T = P_A + P_B$.

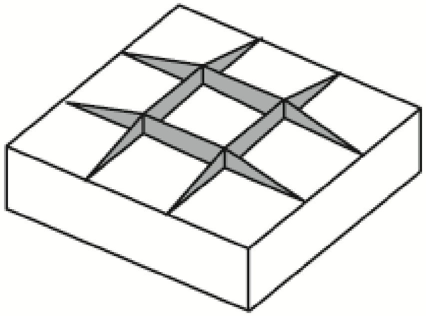
(c) P_A and P_B can be found by equating deflection expressions because $\Delta_A = \Delta_B$.

Reference: Structures, Daniel Schodek, Martin Bechthold.

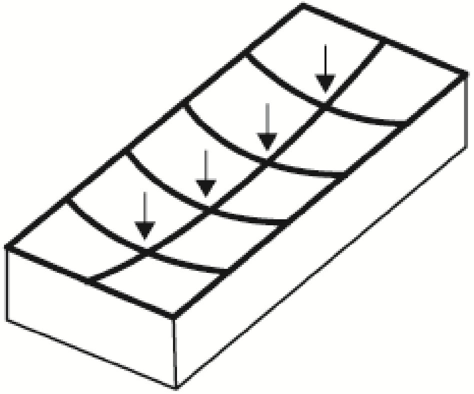
Effects of bay proportions on behavior of two-way grids. Two-way grids operate most effectively when bays are square. When used on rectangular bays, the stiffer short-span members pick up the greatest portion of the applied loads and do the most work. Longer members are less stiff and do not contribute much to carrying the applied loads.



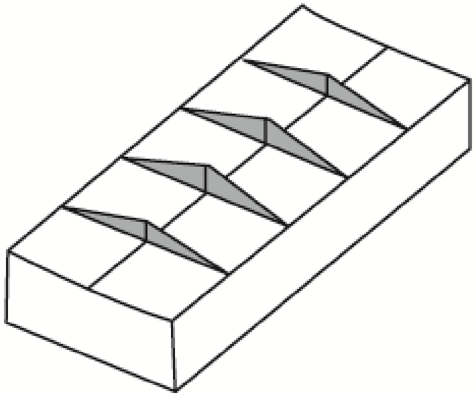
(a-1) Deflected shape (exaggerated) of a two-way grid on square bay, simply supported. The cross-beams have similar stiffnesses and hence similar deflected shapes.



(a-2) Bending moment diagrams. All four cross-beams share equally in carrying the loads and hence carry equal bending moments.



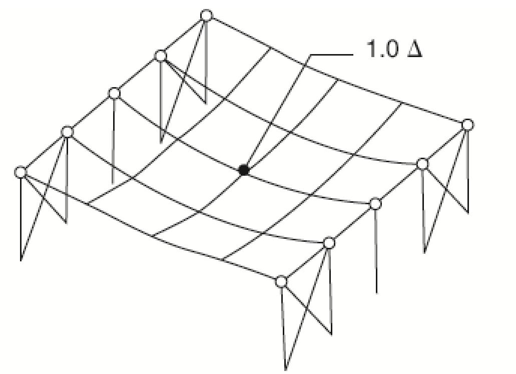
(b-1) Deflected shape (exaggerated) of a two-way grid on rectangular bay, simply supported. The stiffer short-span beams experience sharper curvatures (hence bending moments) than the more flexible long-span beam.



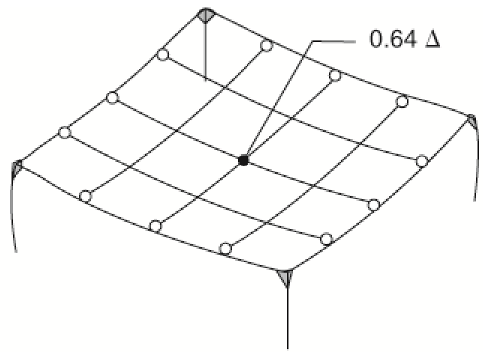
(b-2) The stiffer short-span beams carry a greater percentage of the loading—and hence have higher bending moments—than the long span member, which does very little.

Reference: Structures, Daniel Schodek, Martin Bechthold.

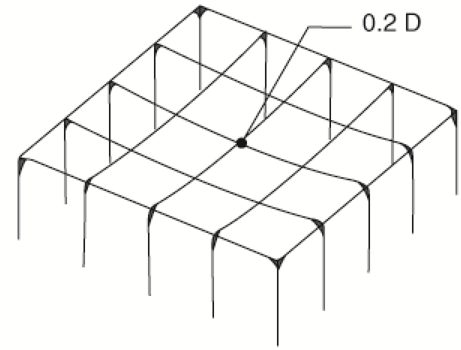
This diagram compares one-way and several two-way systems, and shows that two-way systems have reduced bending moments and increased stiffness and reduced deflections. For comparison, each of the structures shown has the same spans, carries the same loading conditions, and horizontal members are all made out of identical members. Member sizes could be uniquely designed for each case so that the same stress and deflection criteria could be safely met. The approach shown in Figure 10.4(c) would then result in having the smallest members.



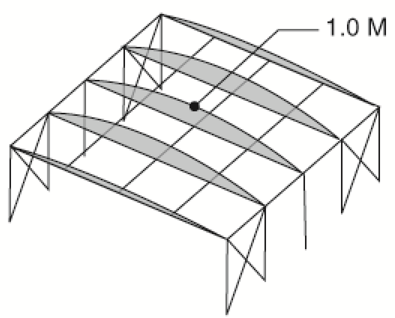
(a-1) Reference case—simple one-way beams with pinned ends. The maximum deflection present (at midspan) is defined as 1.0 Δ.



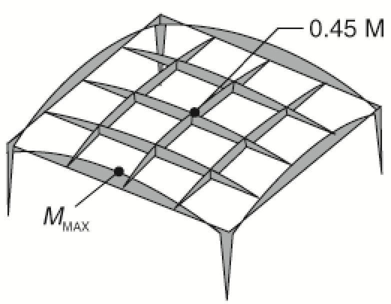
(b-1) Two-way grid system supported with pinned connections by surrounding rigid frames. The deflection shown is relative to the one-way system in (a).



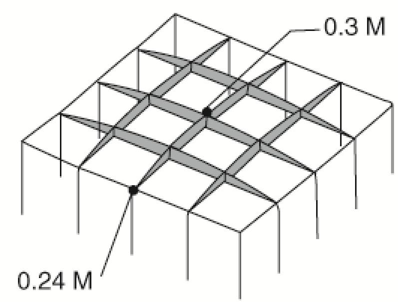
(c-1) Two-way framed interconnected grid system. Columns and beams are rigidly connected with moment resisting joints. Deflections are reduced relative to (a).



(a-2) Moment diagrams. The maximum bending moment at midspan is defined as 1.0 M.



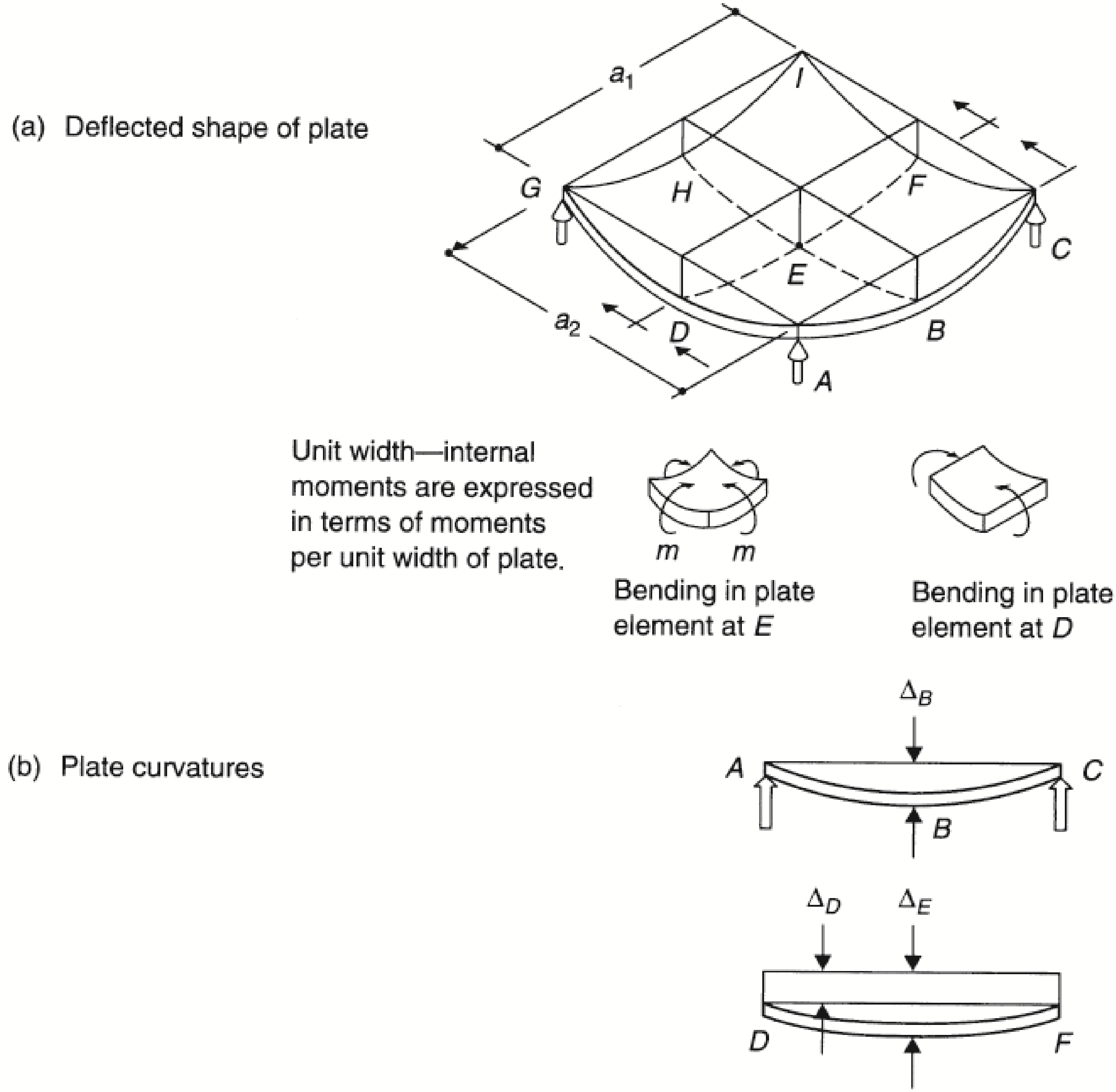
(b-2) Moments relative to (a). Moments in spanning members are decreased. The maximum moment is in a surrounding edge beam.



(c-2) Movement diagrams. The rigid connections help reduce bending moments throughout the structure.

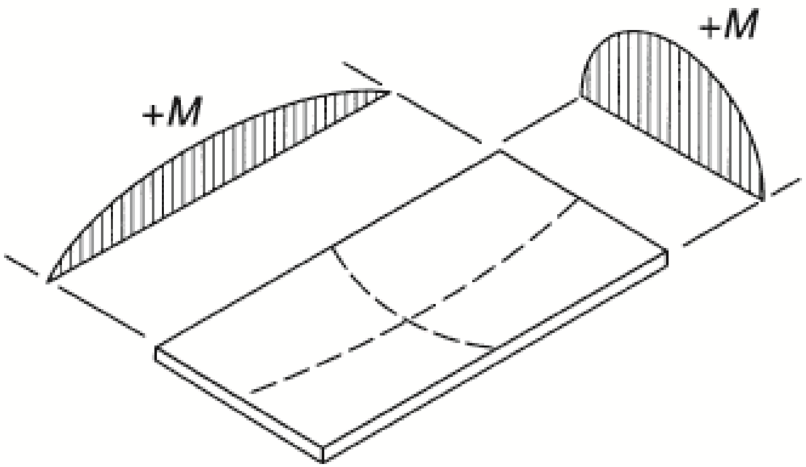
Reference: Structures, Daniel Schodek, Martin Bechthold.

Square plate simply supported on four columns (uniformly distributed load w).



Reference: Structures, Daniel Schodek, Martin Bechthold.

Effects of different boundary conditions and bay proportions.



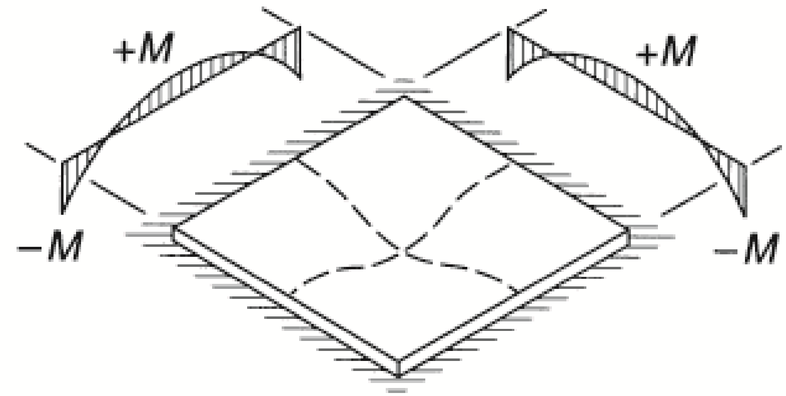
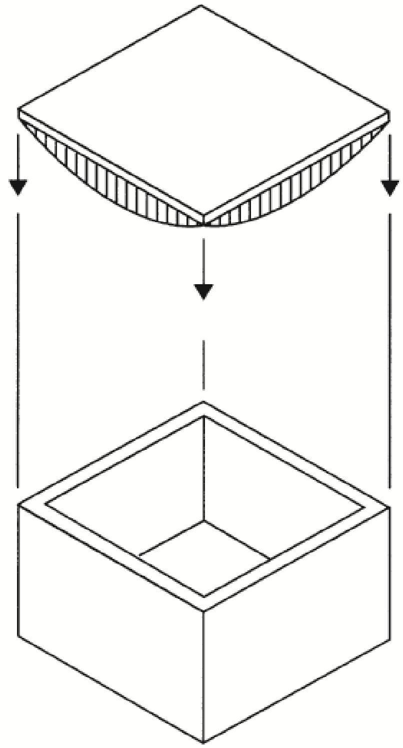


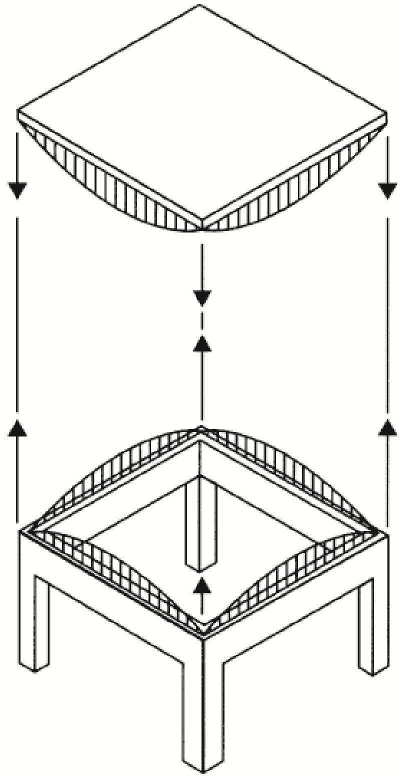
Plate with fully fixed edges

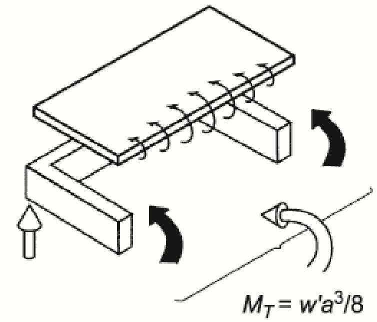
Simply supported: Plate curvatures are the great-est in the short rather than the long direction. Moments are consequently greater in the short span direction than in the long span direction.

Reference: Structures, Daniel Schodek, Martin Bechthold.

Two-way beam-and-slab system.


(a) Plate on walls. This is a favorable support condition for plates.

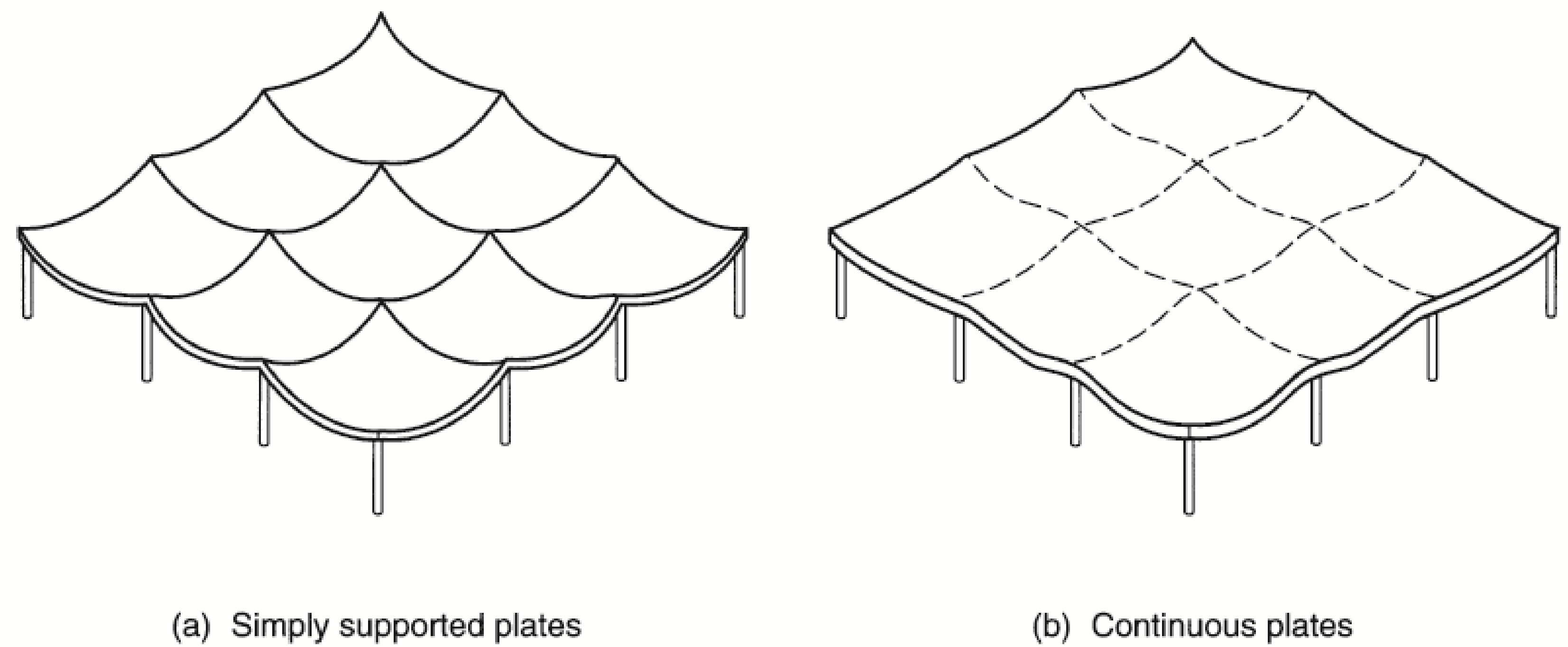

(b) Two-way beam and slab system. Plate on beams. If the beams are very stiff, the plate behaves as if it were supported on walls. If the beams are highly flexible, then the plate behaves as if it were supported on four columns.



(c) The total internal resisting moment provided by the beam and slab system must equal the total applied external moment.

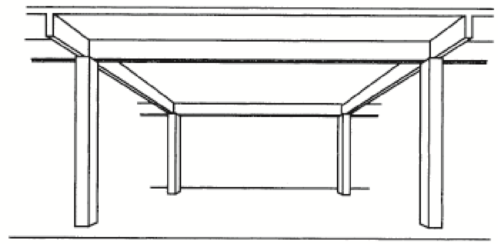
Reference: Structures, Daniel Schodek, Martin Bechthold.

Plates on a column grid. A continuous plate surface is preferable to a series of simply supported plates because design moments are reduced and rigidity is increased by the continuity.

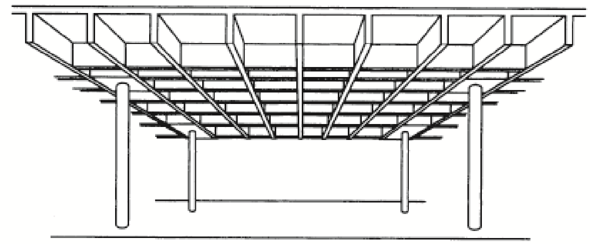


Reference: Structures, Daniel Schodek, Martin Bechthold.

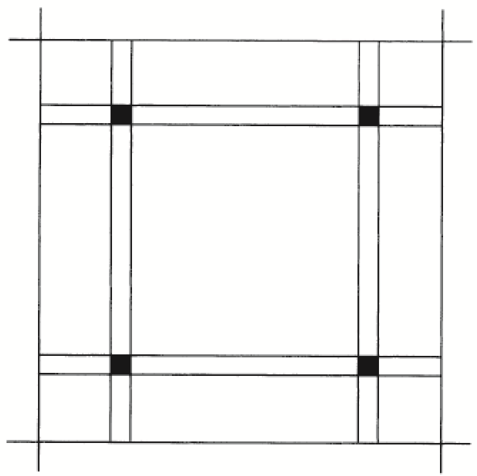
Two-way beam-and-slab systems and waffle systems.



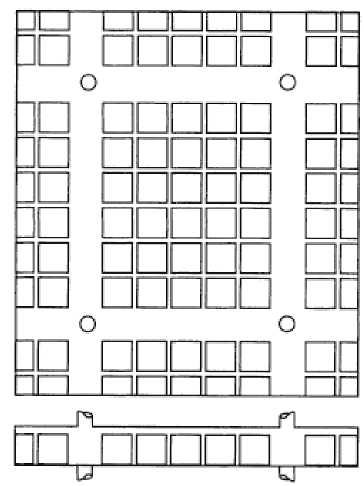
(a) Two-way beam and slab



(d) Waffle slab



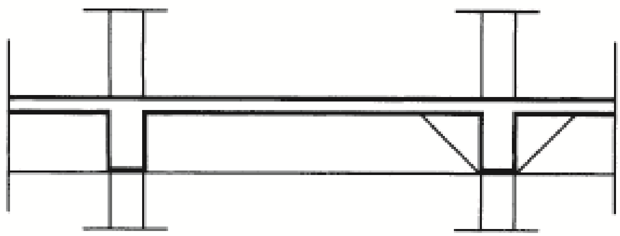
(b) Plan view. The continuous edge support provided to the slab by the beams gives the slab a favorable support condition whereby plate moments are reduced.



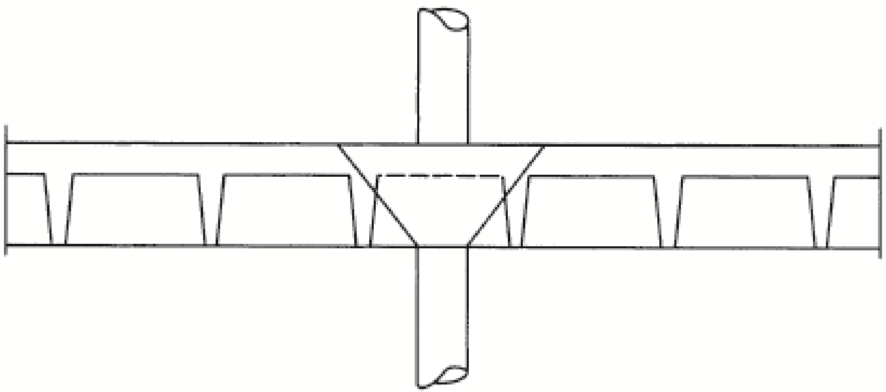
(e) The overall spanning capacity of a waffle slab can be increased by not hollowing out lines between columns. Two-way beam-and-slab action is thus obtained.

Reference: Structures, Daniel Schodek, Martin Bechthold.

Two-way beam-and-slab systems and waffle systems.



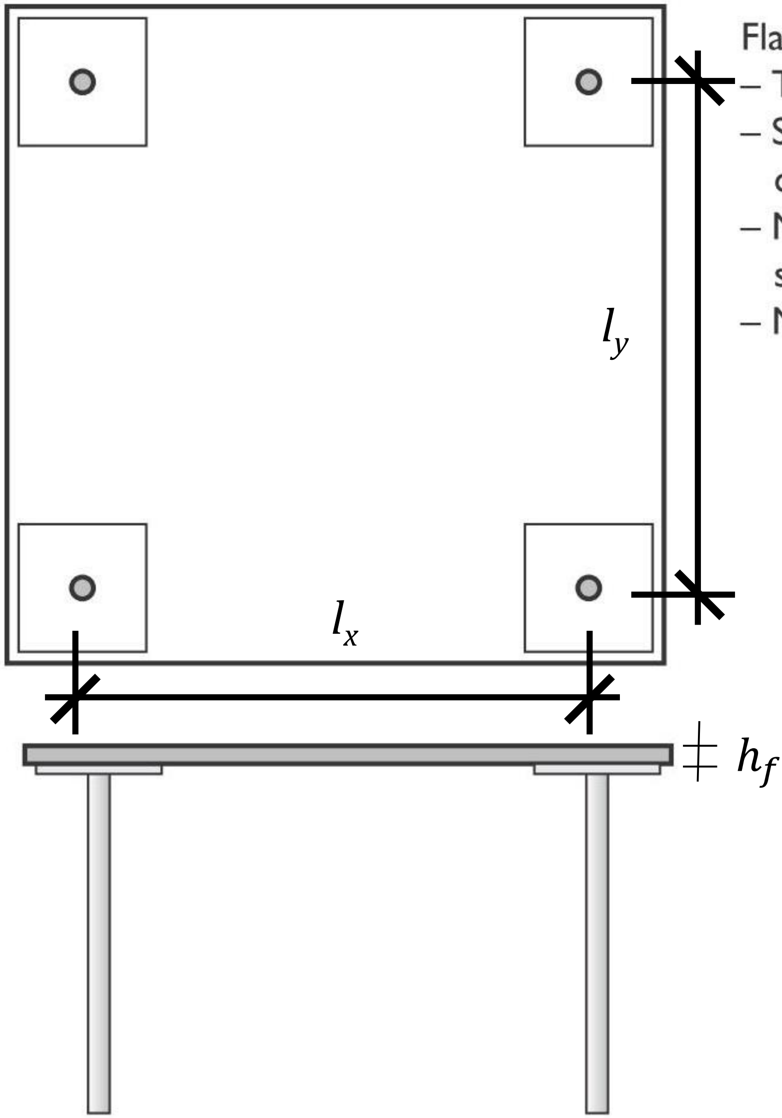
(c) Shear is not a major problem in this type of system because of the presence of the beams, which have a large shear capacity.



(f) To increase the shear capacity of the structure, the plate is not hollowed adjacent to the column heads.

Reference: Structures, Daniel Schodek, Martin Bechthold.

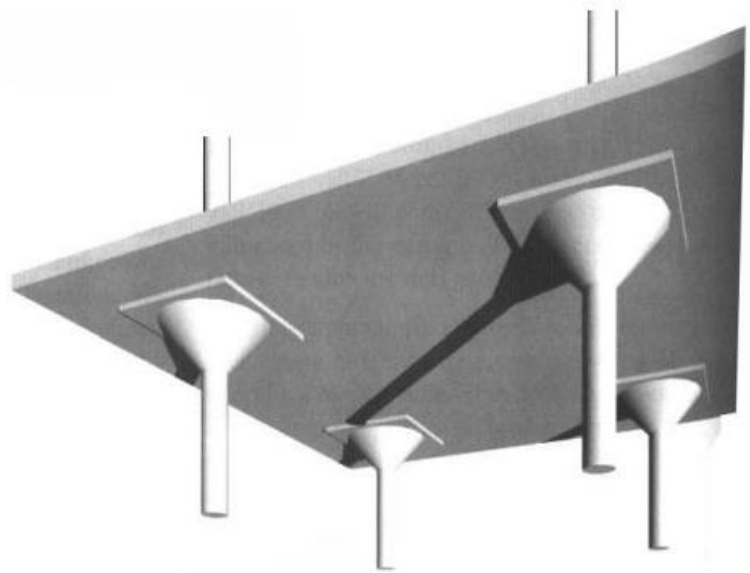
FLAT PLATE



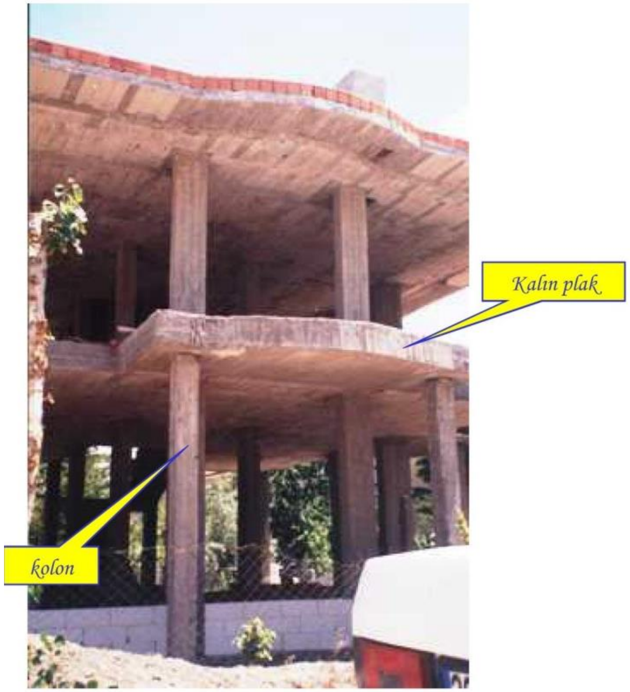
Flat Plate

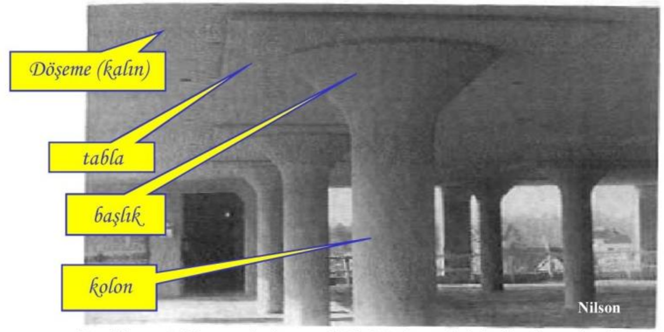
- Two-way structural action
- Shear between plate and columns may require column plates as shown
- Made with flat formwork, therefore relatively simple to construct
- Minimum structural depth, but heavy

$$h_f \cong \left(\frac{1}{30}\right) * (l_x \, , l_y)_{max}$$

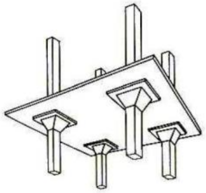


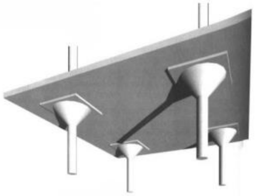
Kirişsiz (mantar) döşemeler





Başlık ve tabla zımbalama riskini önlemek içindir. Ters kesik pramid başlığın kalıp işçiliği daha basittir.






YUVAM MOBİLYA BU BİNADA HİZMET VERECEKTİR
09.09.2006 20:46
Foto: Gökhan KOCABAŞ
Kirişsiz döşeme çok ince

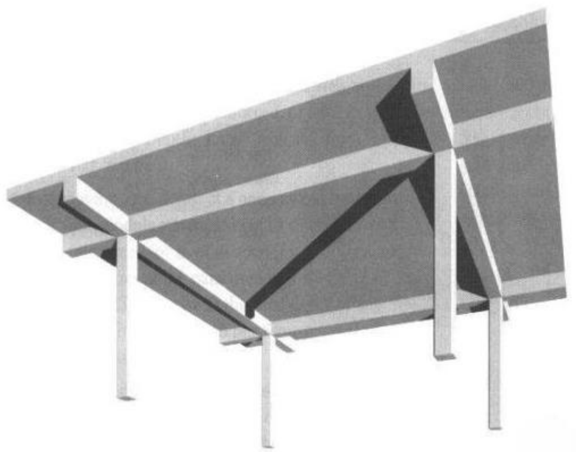

09.09.2006 20:45
Zayıf bağlantı


Kirişsiz döşeme çok ince
Foto: Mahmut YALÇIN, Manhattan, New York, 2011

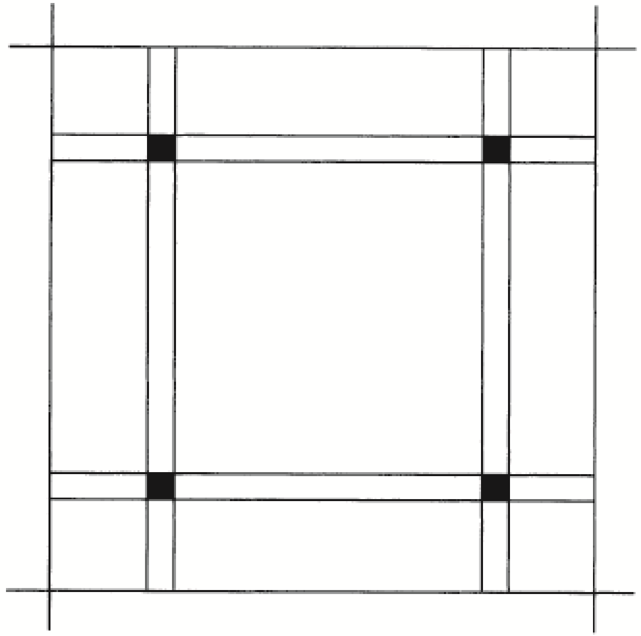

Zayıf bağlantı
Foto: Mahmut YALCIN, New York, 2011

Plate and Beam

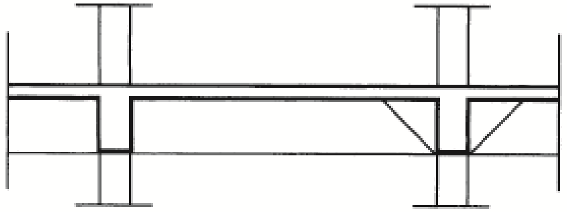
- One- or two-way structural action depending on beam layout
- Shear between plate and columns taken up by beams
- Beams require drop-down formwork
- Similar structural depth as Flat Plate, but with added depth of beams



Optimum span : 6~8m



(b) Plan view. The continuous edge support provided to the slab by the beams gives the slab a favorable support condition whereby plate moments are reduced.

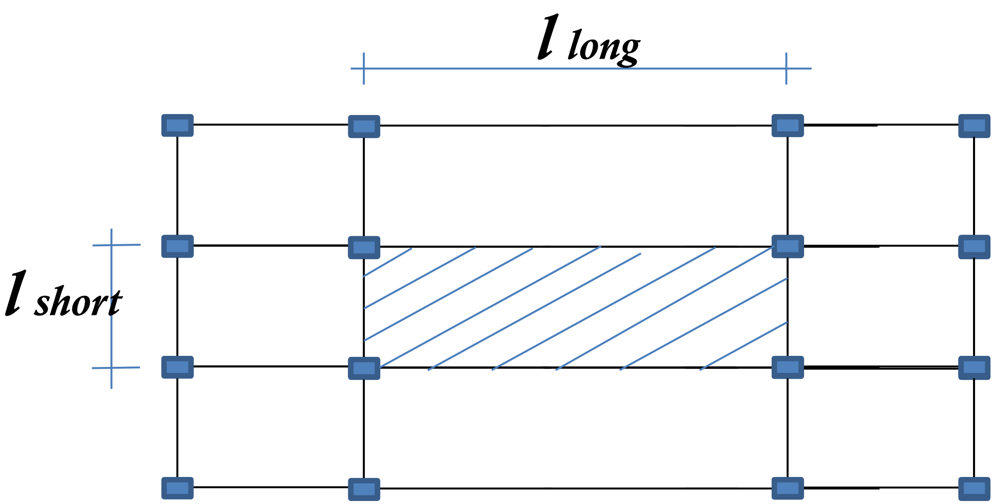


(c) Shear is not a major problem in this type of system because of the presence of the beams, which have a large shear capacity.

Flat slab with beams

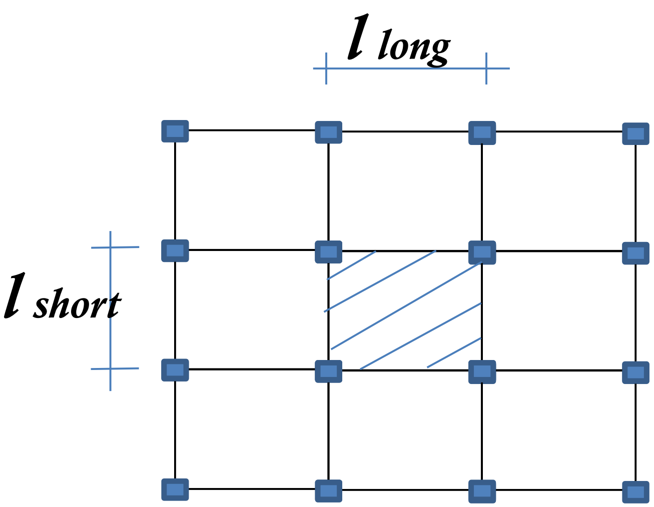
One-way Flat slab with beams

$$l_{long}/l_{short} > 2$$



Two-way Flat slab with beams

$$l_{long}/l_{short} \leq 2$$



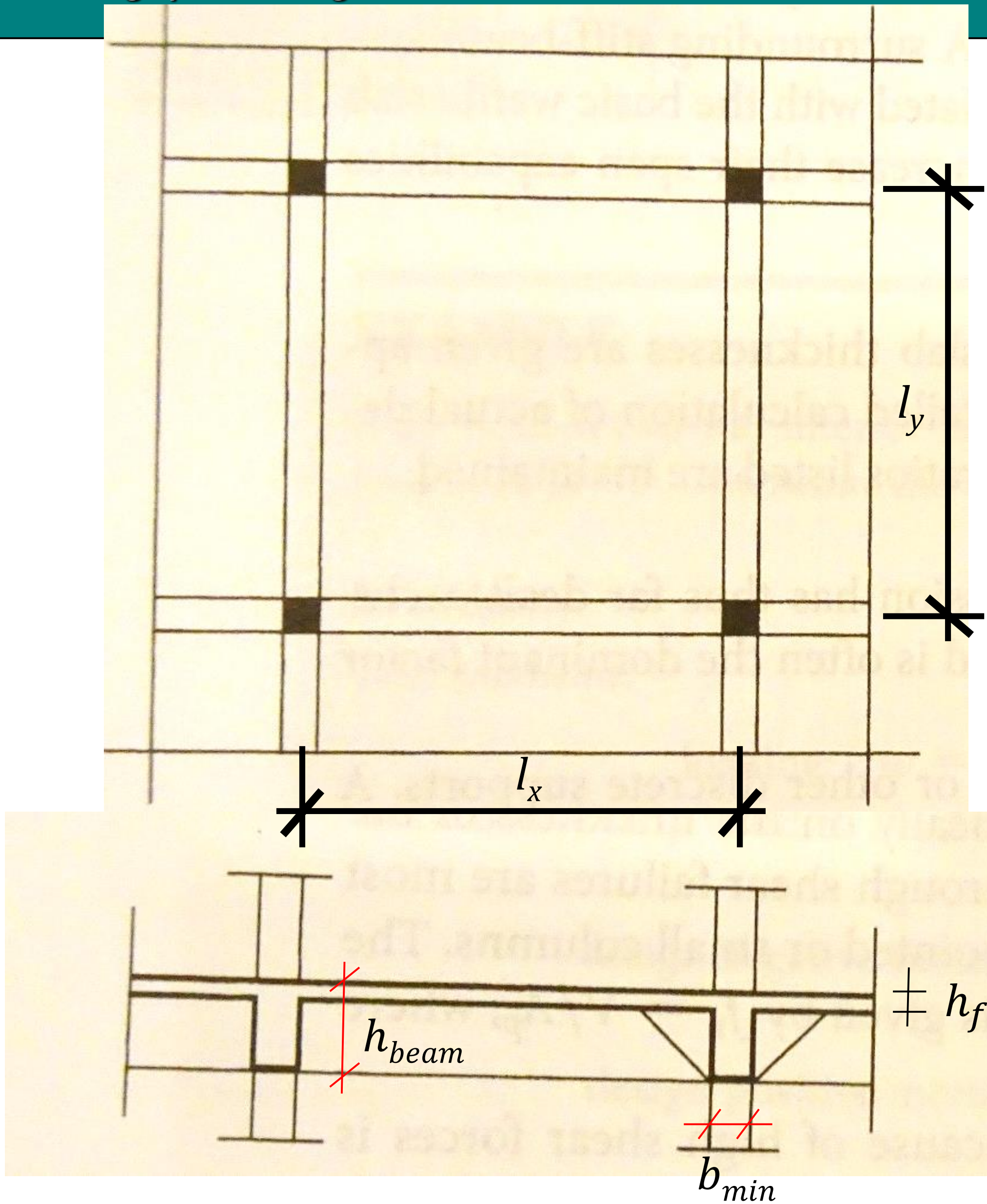


PLATE WITH BEAM
TWO WAY SLAB

$$h_f \cong \left(\frac{1}{40}\right) * (l_x, l_y)_{max}$$

$$h_{beam} \cong (1/10) * (l_x, l_y)$$

$$h_{beam} \geq 3 * h_f$$

$$b_{min} \cong 25cm$$

Reference: Structures, Daniel Schodek, Martin Bechthold.

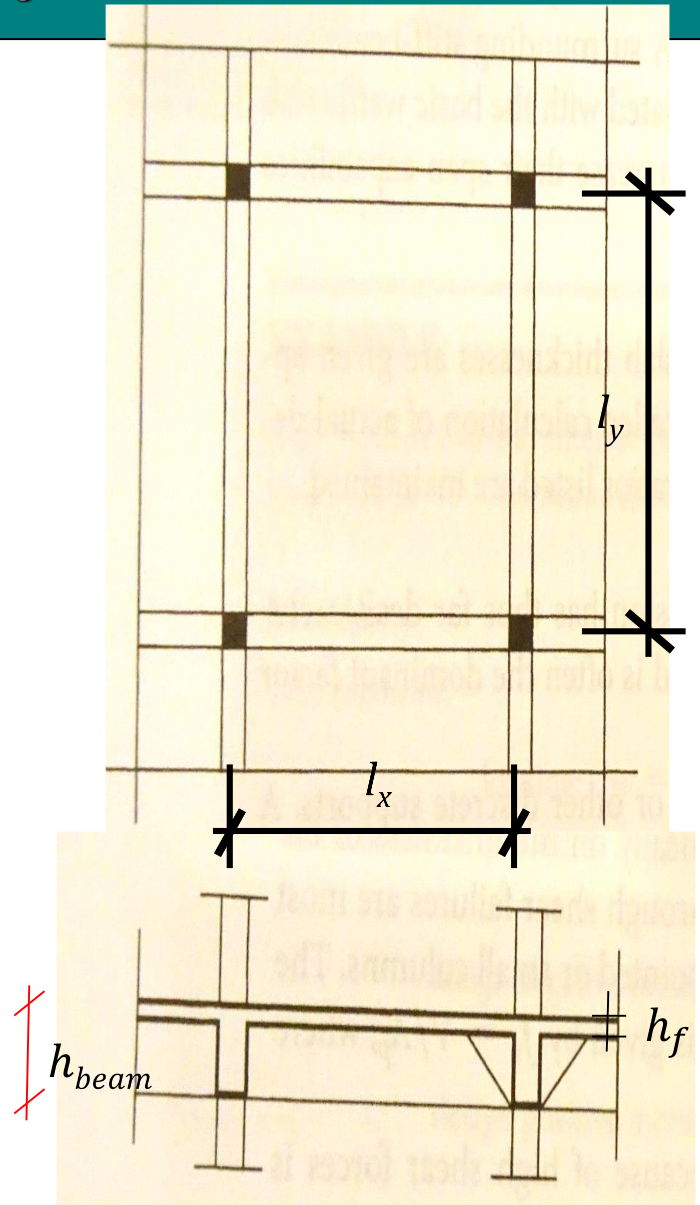


PLATE WITH BEAM
ONE WAY SLAB

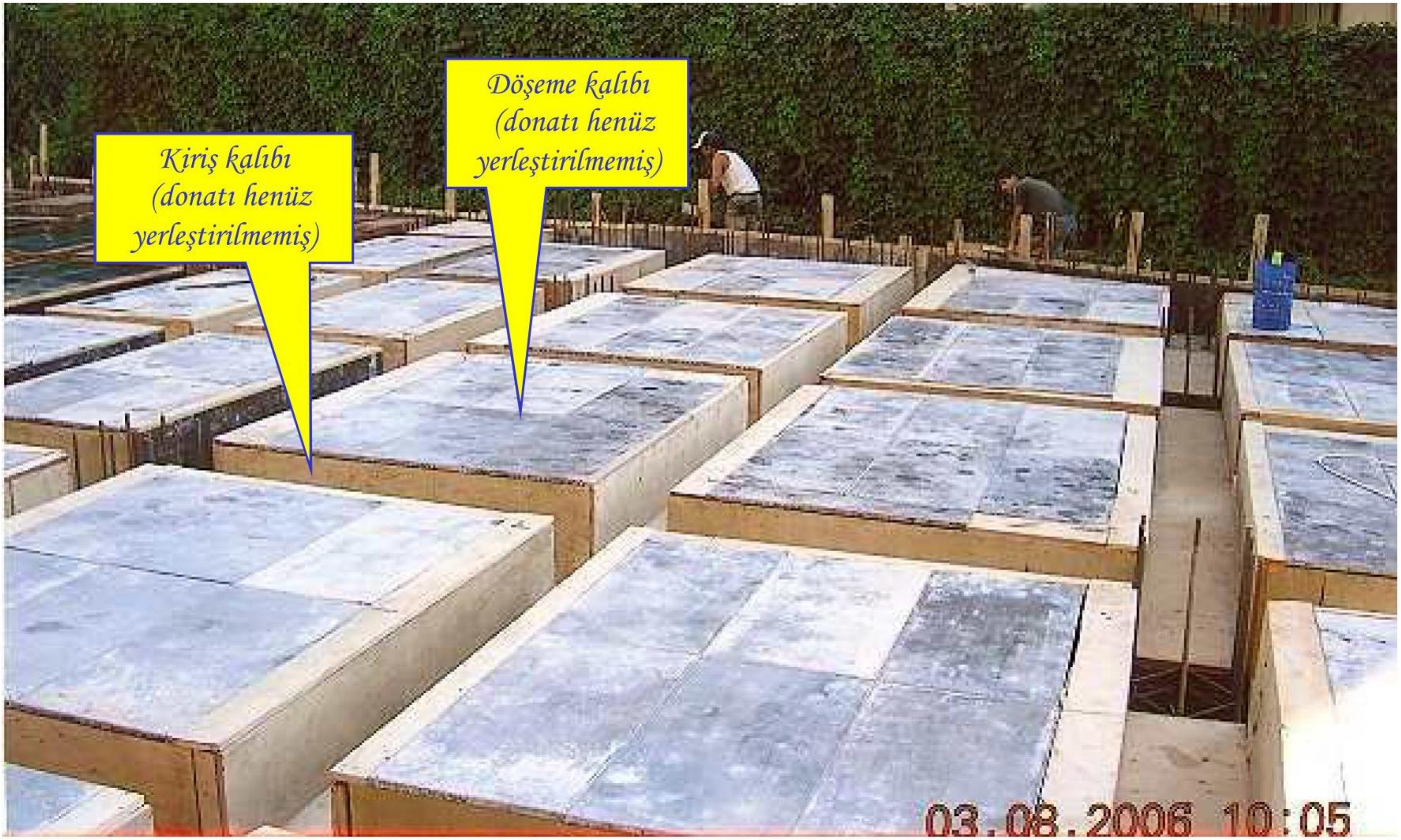
$$h_f \cong \left(\frac{1}{30}\right) * l_x$$

$$h_{beam} \cong (1/10) * l_y$$

$$h_{beam} \geq 3 * h_f$$

$$b_{min} \cong 25cm$$

Reference: Structures, Daniel Schodek, Martin Bechthold.

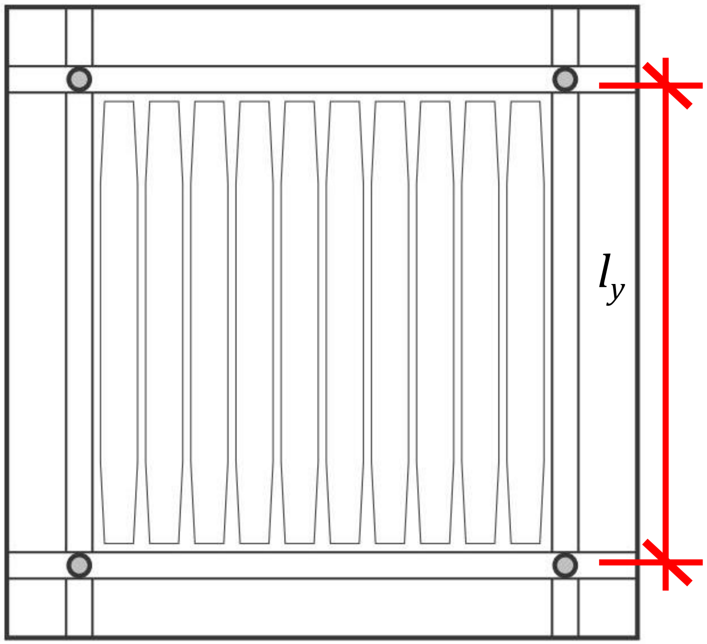


Kiriş-döşeme kalıbı hazırlanıyor

Kiriş donatıları yerleştirilmiş, döşeme donatıları yerleştiriliyor

Kalıp söküldükten sonra alttan görünüş

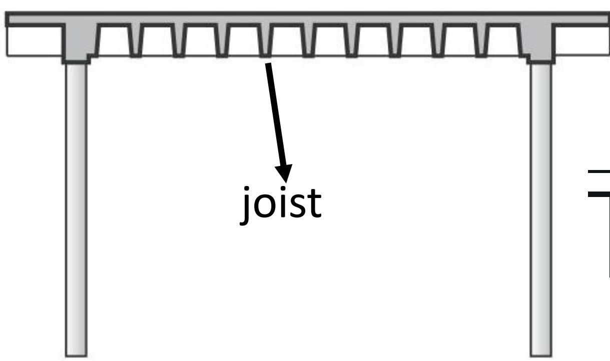
RIBBED SLAB

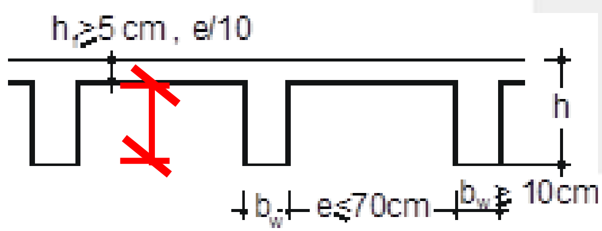


One way pan joists

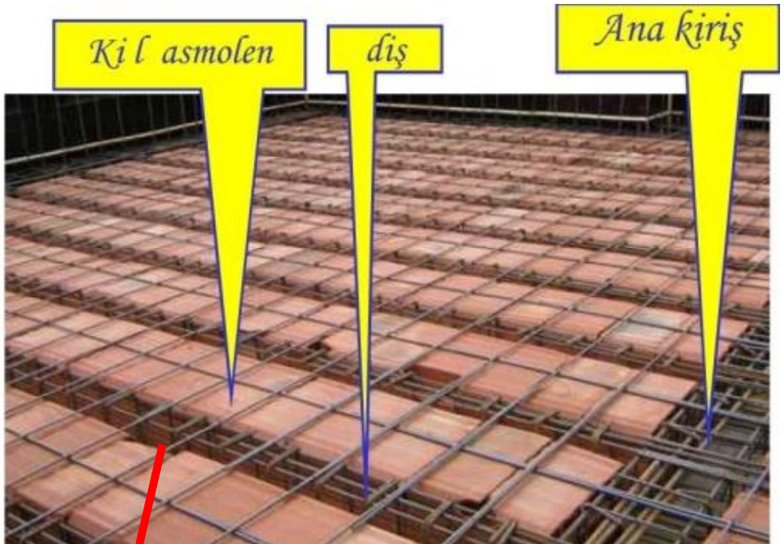
- One-way structural action
- Shear between joists and columns taken up by beams
- Made with metal pans on flat formwork, drop-down details at beams
- Greater structural depth, but slab itself can be much thinner than Flat Plate

$$h \cong \left(\frac{1}{20}\right) * l_y$$



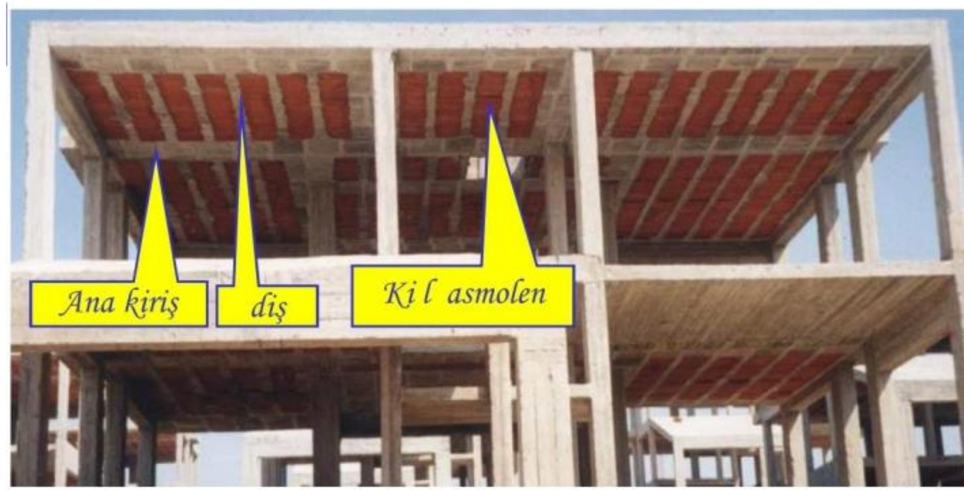


Asmolen döşeme: Dişler arası asmolen olarak adlandırılan hafif bir malzeme ile doldurulmuş bir veya iki yönde dişli döşemedir. Tavan düz görünür. Asmolen döşemelerin depremde davranışı iyi değildir. Mutlaka deprem perdeleri düzenlenmelidir.

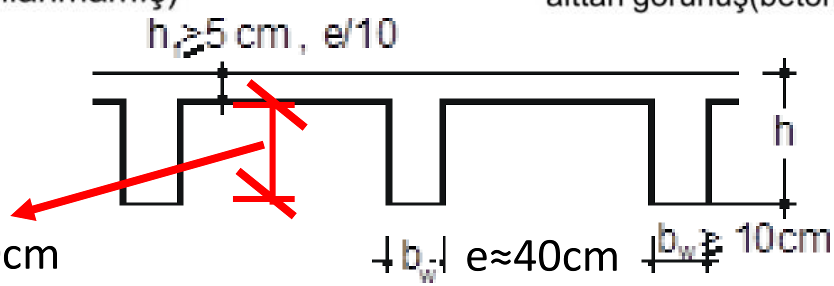


üstten görünüş(betonlanmamış)

joist

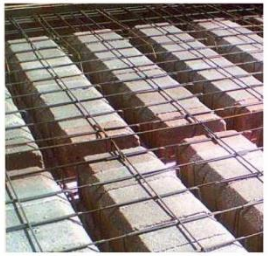


alttan görünüş(betonlanmış)



$h_e \approx 30$cm

Kil asmolen döşeme



Hafif beton asmolen döşeme

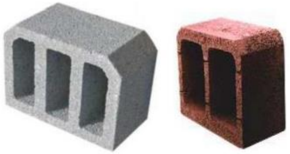
Gazbeton asmolen döşeme

Strafor asmolen döşeme

Prefabrik dişli kil asmolen döşeme

Asmolen türleri: Çok farklı malzeme, geometri ve boyutlarda üretilmektedir.

Clay brick



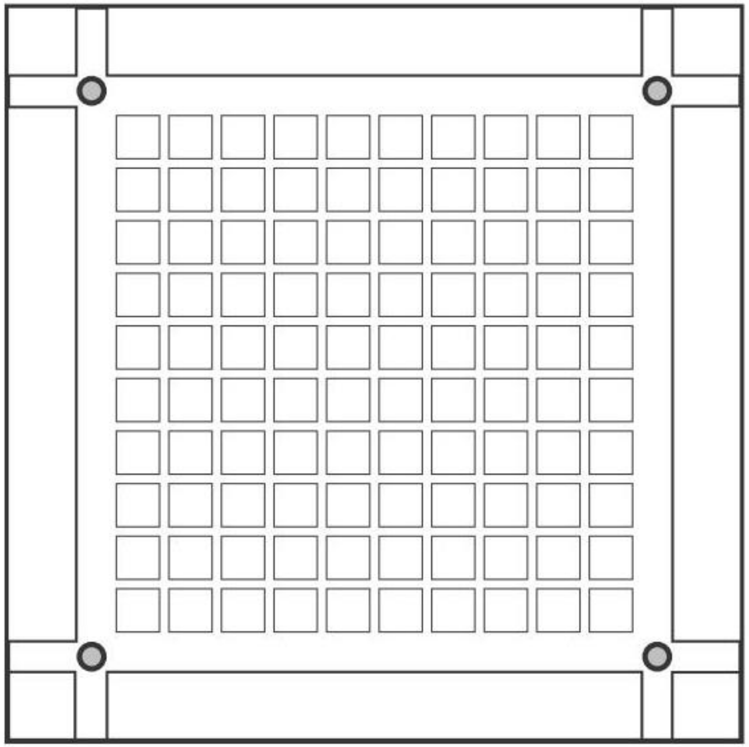
Lightweight concrete

Aerated concrete

Foam

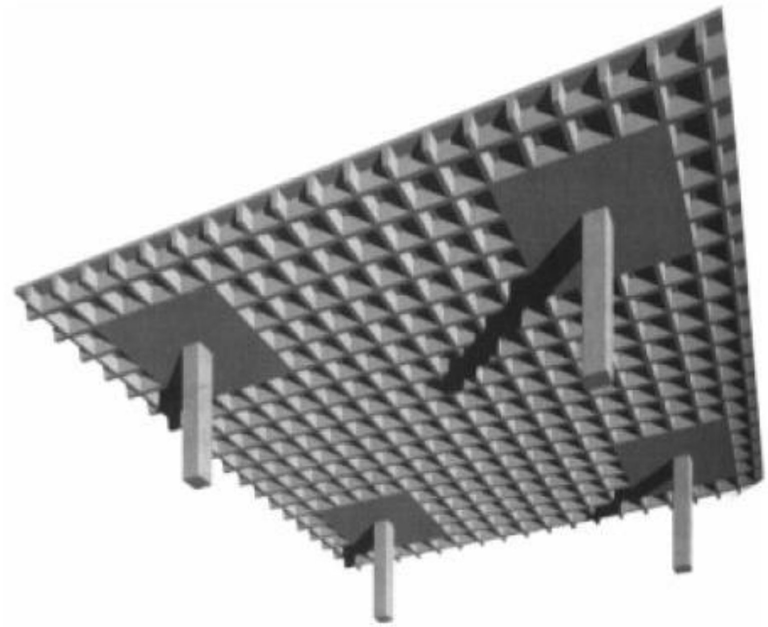
En hafif: Strafor
En ağır: Kil
En sorunlu: Strafor (sıva tutturmak zordur, sıva filesi kullanılmalıdır. yangına dayanıklı değildir, en az 2 cm yangına dayanıklı sıva zorunludur.)
Nakliyesi, işçiliği, firesi en az: Strafor ve gaz beton
En çok kullanılan: Gazbeton ve hafif beton

WAFFLE SLAB

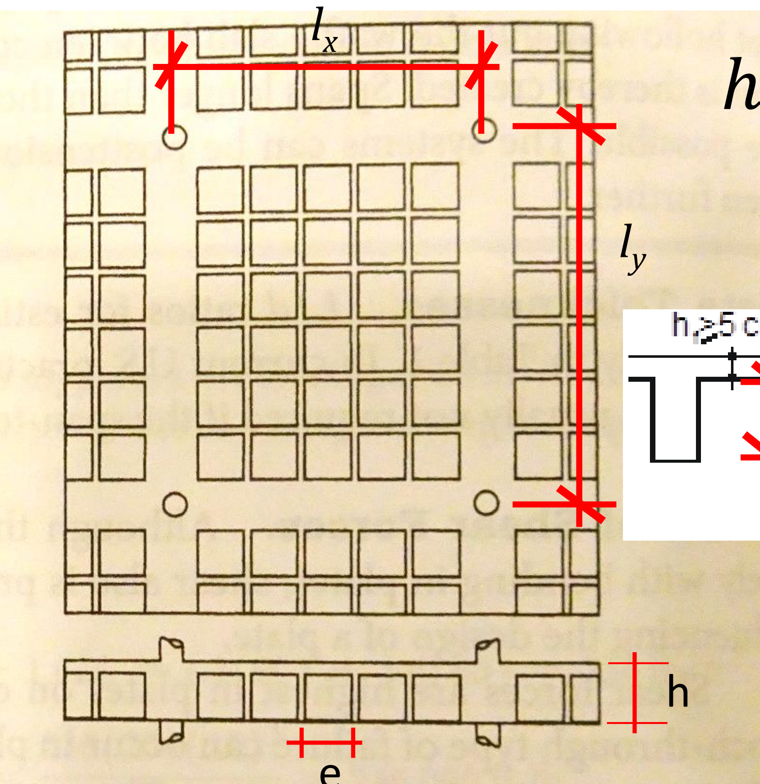


Waffle slab

- Two-way structural action
- Shear between plate and columns taken up by nominal 'beams'
- Made with metal domes on flat formwork, may be drop downs at beams (not shown)
- Shallower total depth than One Way Joist system,

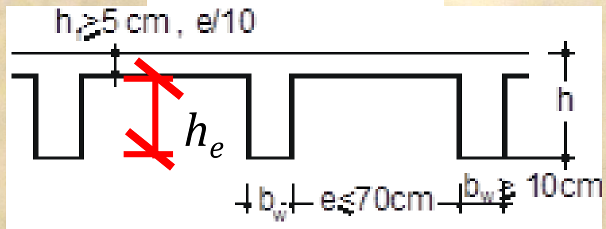


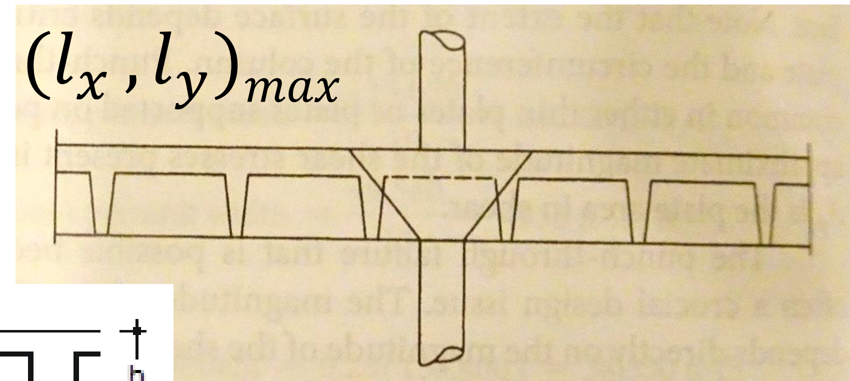
WAFFLE SLAB



(e) The overall spanning capacity of a waffle slab can be increased by not hollowing out lines between columns. Two-way beam-and-slab action is thus obtained.

$$h \cong \left(\frac{1}{30}\right) * (l_x, l_y)_{max}$$





(f) To increase the shear capacity of the structure, the plate is not hollowed adjacent to the column heads.

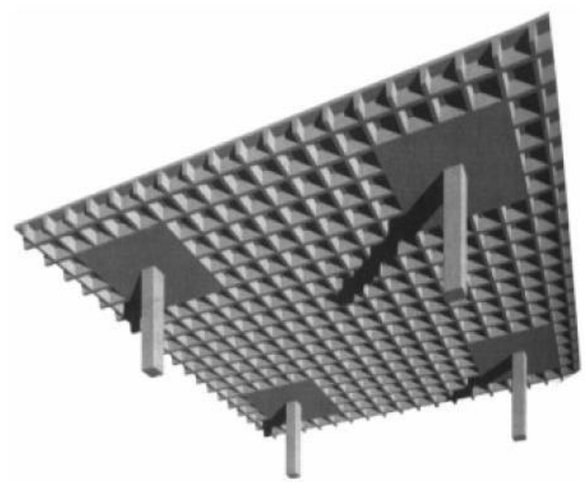
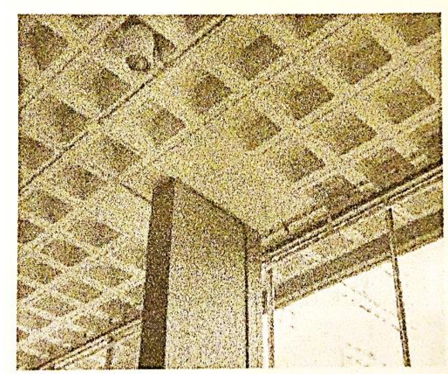
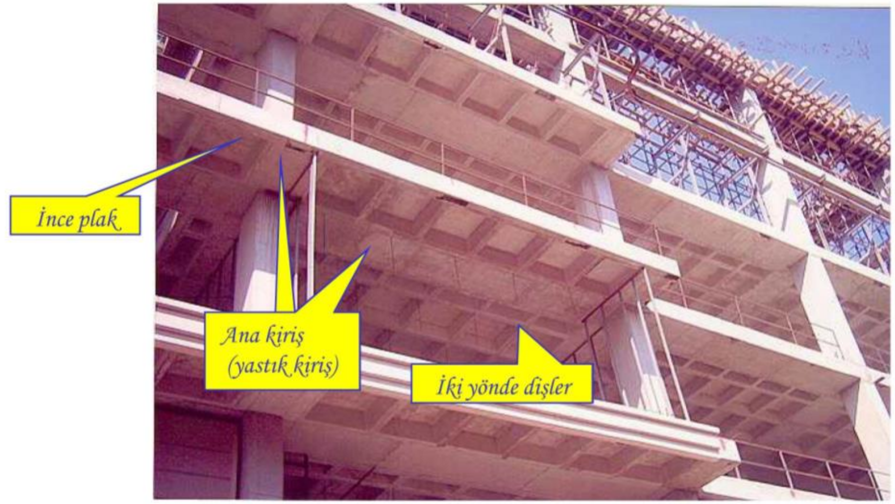


FIGURE 18 A typical waffle slab with infills around columns to increase shear capacity.



Reference: Structures, Daniel Schodek, Martin Bechthold.

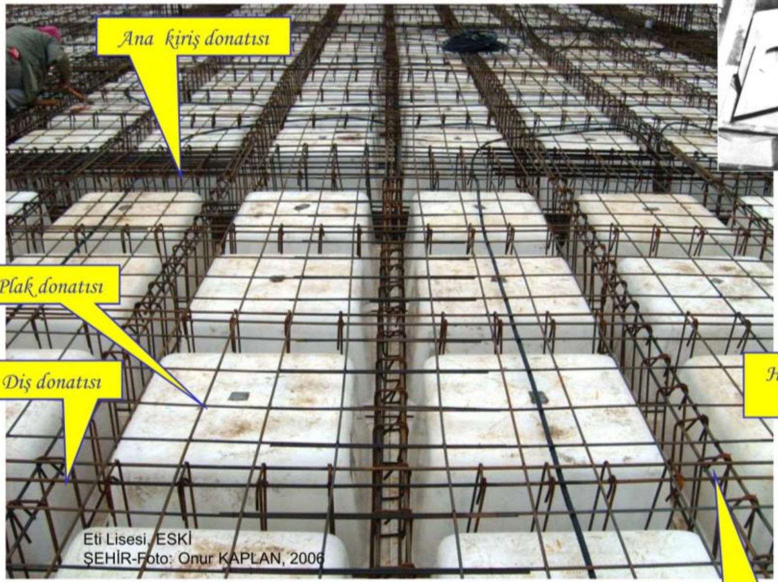


Eti Lisesi, ESKİŞEHİR-Foto: Onur KAPLAN, 2006

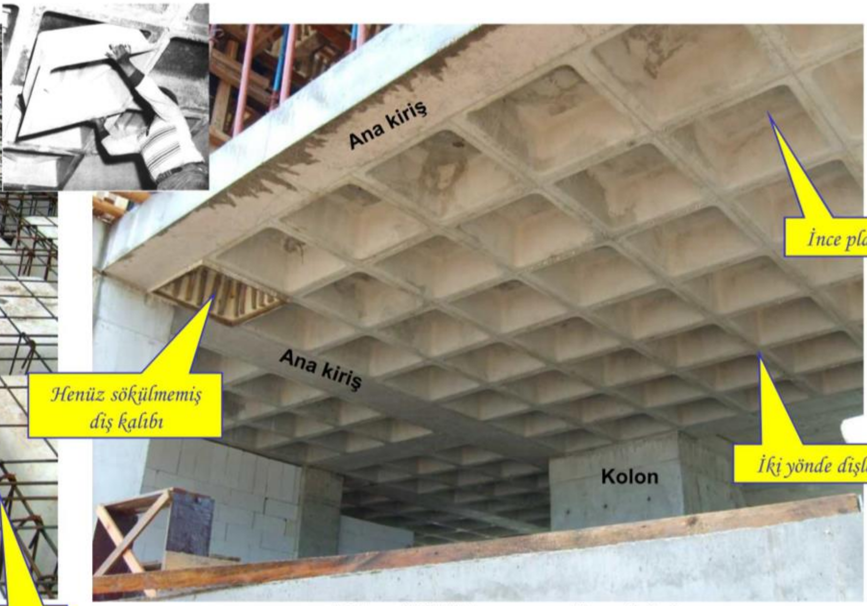
İki yönde dişli döşeme

Diş kalıpları dizilmiş, ana kiriş donatıları yerleştiriliyor

Diş donatıları yerleştirilmiş, plak donatısı henüz yok.

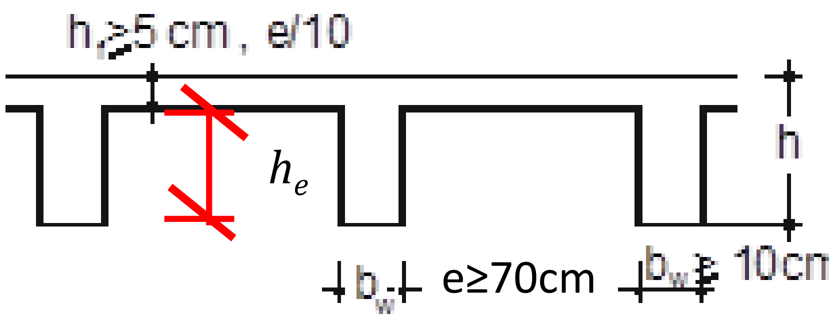


Plak donatıları yerleştiriliyor



Kalıp söküldükten sonra alttan görünüş

GRID SLAB



$$h \approxeq \left(\frac{1}{30}\right) * (l_x , l_y)_{max}$$

Kaset kiriş döşeme

Kaset kiriş döşeme

ITU Faculty of Architecture
Structural and EQ Engineering WG

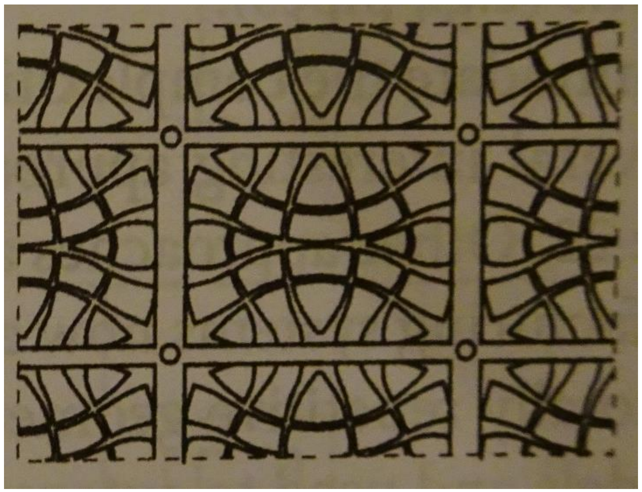
▲ 7.64 Villa Savoye, Paris, France, Le Corbusier, 1929. The front and a side elevation.

▲ 7.65 Plain exterior column and beam detailing.

▲ 7.3 Coffered slab soffit.

▲ 7.66 Schlumberger Extension building, Cambridge, England, Michael Hopkins and Partners, 1992. Exposed ribbed soffits around the perimeter.

RIBBED SLAB



(g) Continuous plate structure with ribs reflecting isostatic lines

Figure 4.6.7. *An experimental concrete floor system designed by Pier Luigi Nervi for the Gatti Wool Factory in Rome (1953). By using custom-shaped pans (of light cement and wire), Nervi was able to re-configure a standard waffle slab so that its ribs followed the lines of static 'flow' from slab to column.*

WAFFLE SLAB

Figure 4.6.8. *Another expressive floor slab by Nervi. This one, for a tobacco factory in Bologna (1952) thickens the ribs of a waffle slab where they meet supporting beams – and where they experience the greatest shear stress.*

SLAB WITH OPENINGS

▲ **8.9** Railway Station at Satolas Airport, Lyons, France, Santiago Calatrava, 1994. Glazing centred over the main concourse.

▲ **8.10** A view across the concourse. Glazed areas are integrated with the pattern of ribs.