Reinforced concrete Design II

Syllabus

1-Deflection Control of Two way slabs.

2-Analysis and Design of Two-Way Slab Systems by Direct Design Method (D.D.M).

3-Shear in Two Way Slab Systems.

4- Analysis and Design of Two Way Slabs Equivalent Frame Method (EFM).

5-Analysis and Design of Two Way Slabs by Yield Line Method.

References:-

Textbooks:

1-Design of Concrete Structures, A.H. Nilson et. al., 13th Ed., McGraw Hill, 2004.

2-ACI Committee 318M,2008, Building Code Requirements for Structural Concrete Institute, USA.

Suggested references:

1-Jack C. McCormac "Design of Reinforced Concrete", 9th ED. 2014

2-Nawy, E., "Reinforced Concrete ", 6th Edition, (2009).

3-Reinforced Concrete a Fundamental Approach, 4th ED., 2000, by Edward G. Nawy, Prentice- Hall. Inc. USA.

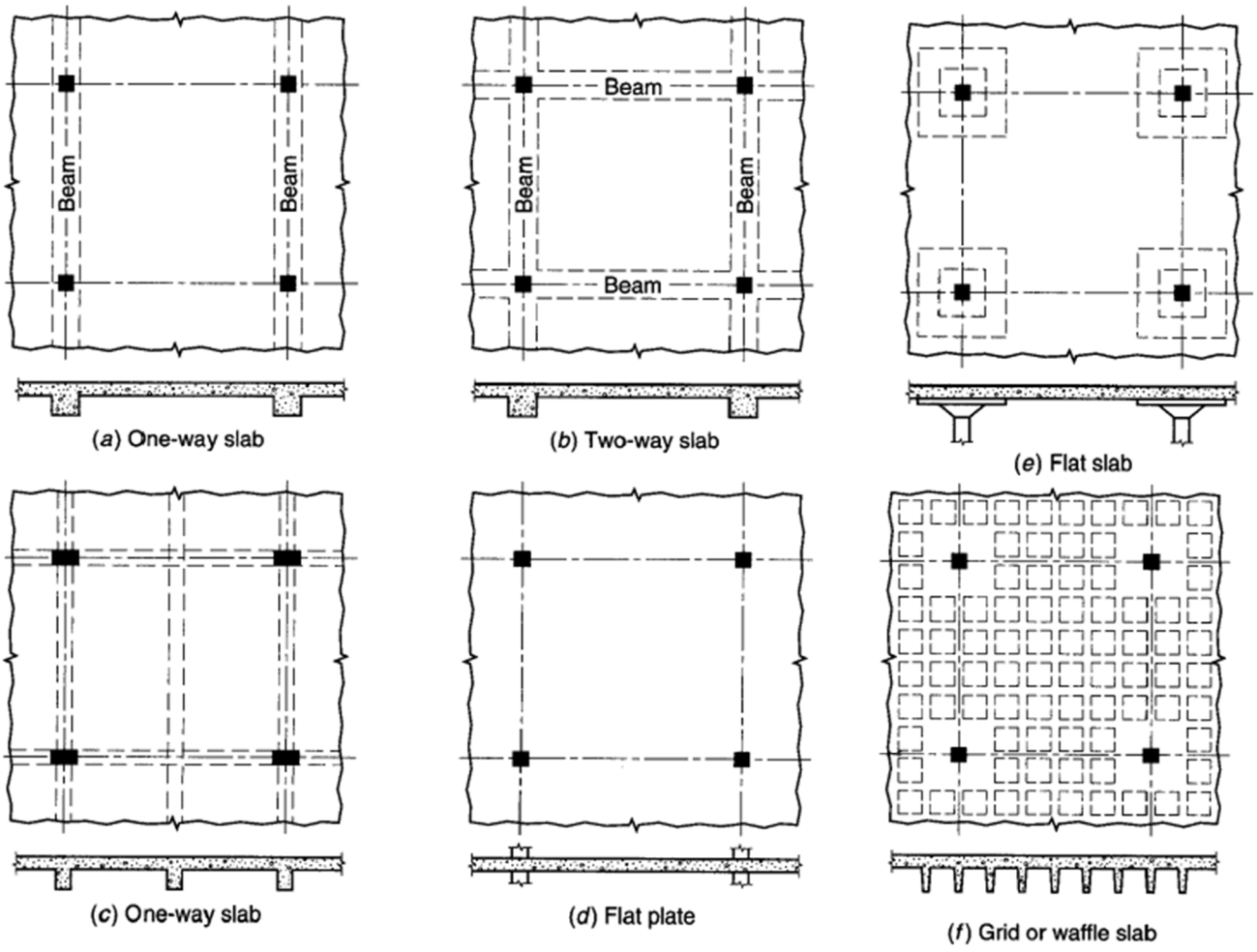
4-Fundamental of Reinforced Concrete, 5th Ed., 2012, by N.C. Sinha and S.K. Roy, INDIA.

5-Fundamental of Prestressed Concrete, 3th Ed., 2011, by N.C. Sinha and S.K. Roy, INDIA.

Reinforced Concrete Slab

1 TYPES OF SLABS

Structural concrete slabs are constructed to provide flat surfaces, usually horizontal, in building floors, roofs, bridges, and other types of structures. The slab may be supported by walls, by reinforced concrete beams usually cast monolithically with the slab, by structural steel beams, by columns, or by the ground. The depth of a slab is usually very small compared to its span.

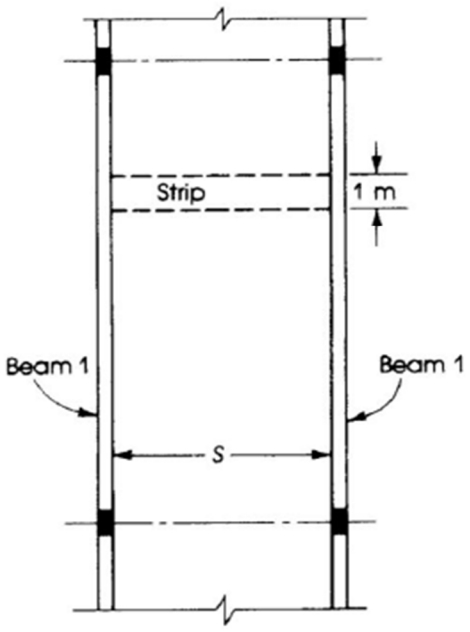


Types of structural slabs.

Structural concrete slabs in buildings may be classified as follows:

1. <u>One-Way Slabs</u>: If a slab is supported on two opposite sides only, it will bend or deflect in a direction perpendicular to the supported edges. The structural action is one way, and the loads are carried by the slab in the deflected short direction. This type of slab is called a one-way slab.

If the slab is supported on four sides and the ratio of the long side to the short side is equal to or greater ***than 2 (L_long / L_short ≥ 2***), most of the load (about or more) is carried in the short direction, and one-way action is considered for all practical purposes. If the slab is made of reinforced concrete with no voids, then it is called a one-way solid slab.



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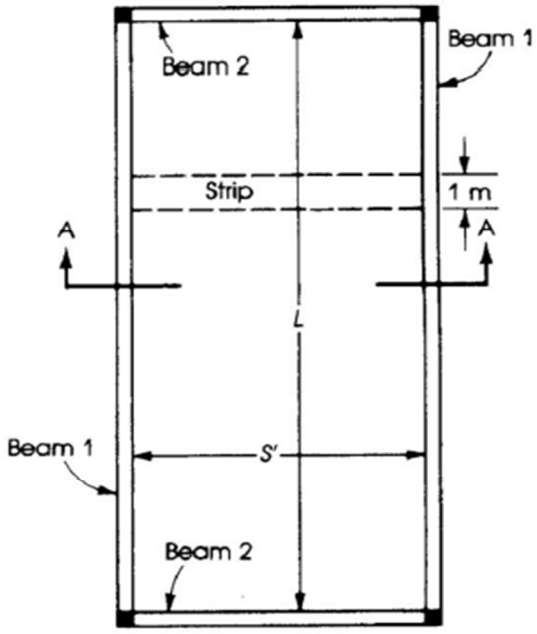

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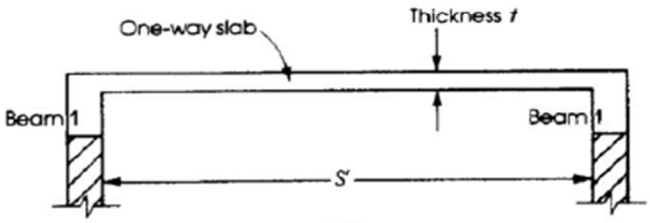

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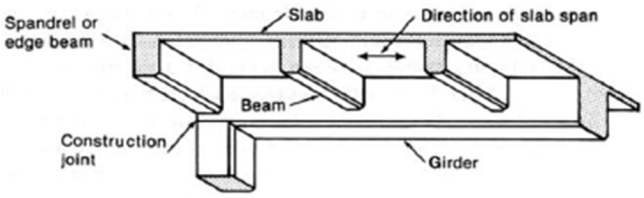
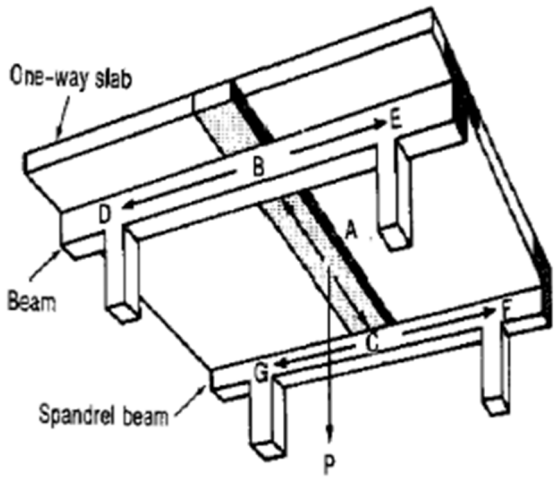
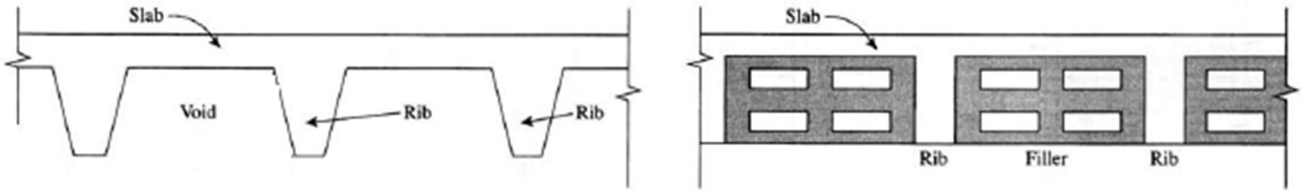


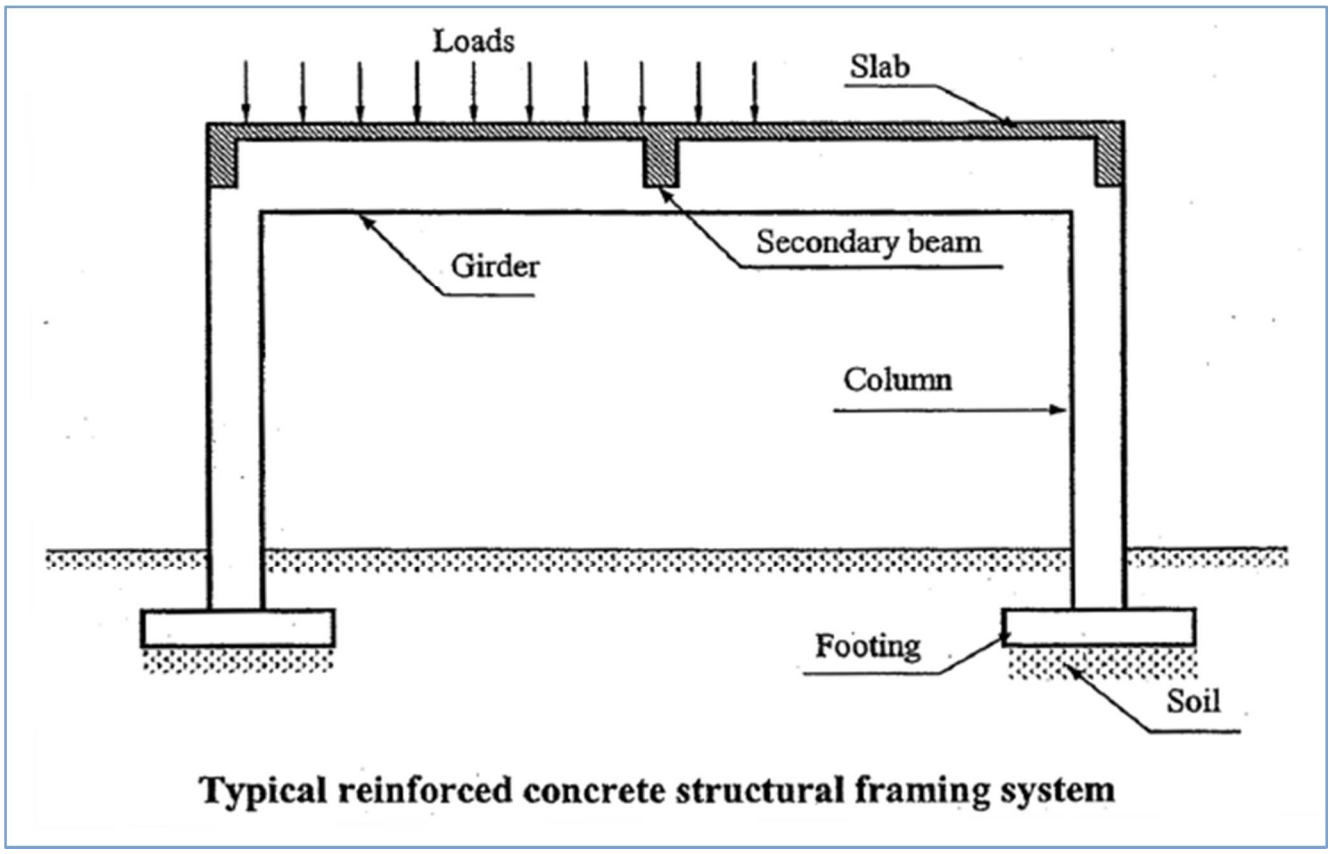


2. <u>One-way joist floor system</u>:

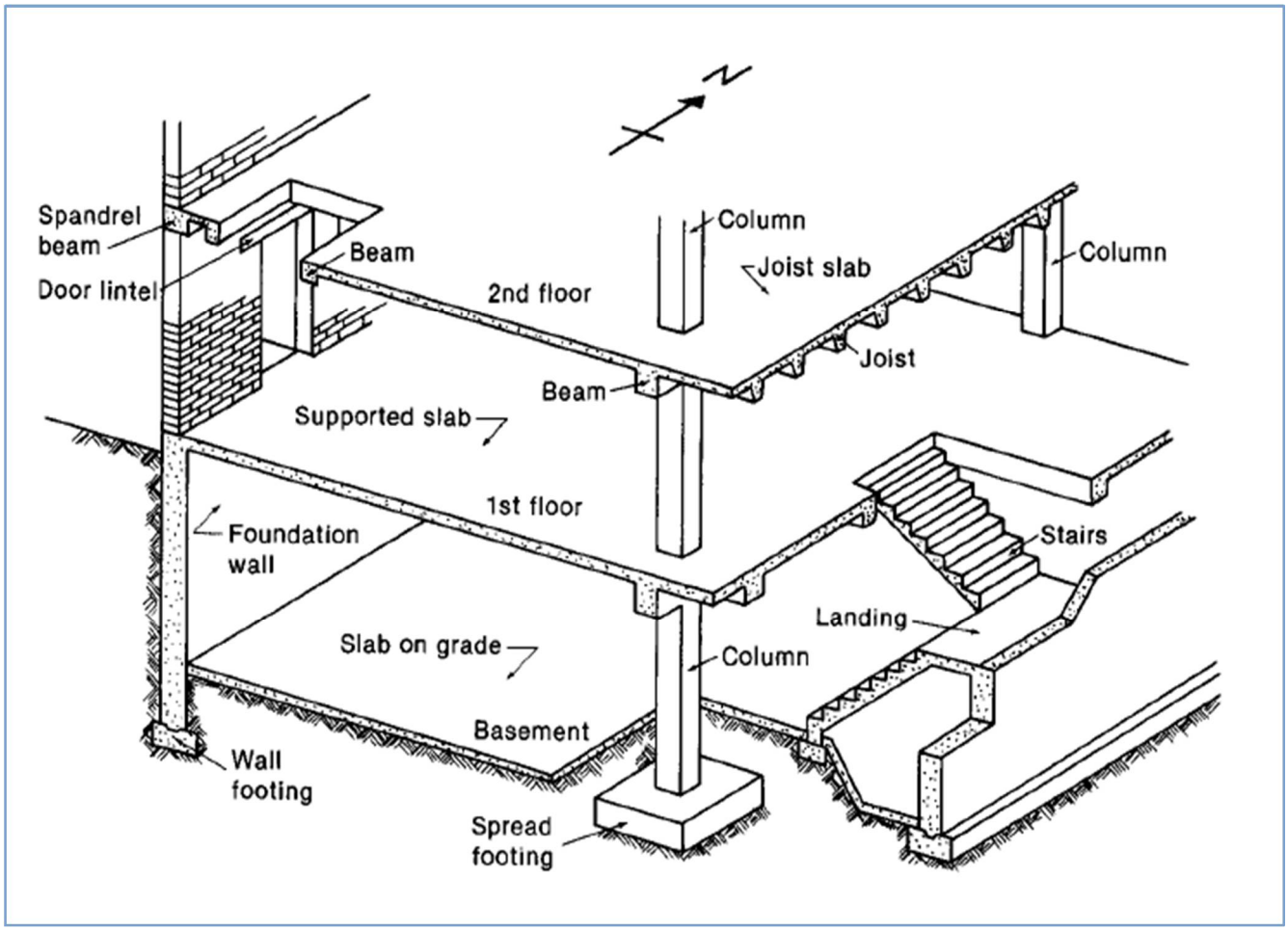
This type of slab is also called a ribbed slab. It consists of a floor slab, usually ***(50 to 100 mm thick)***, supported by reinforced concrete ribs (or joists). The ribs are usually tapered and are uniformly spaced at distances that do not exceed ***(750 mm)***. The ribs are supported on girders that rest on columns. The spaces between the ribs may be formed using removable steel or fiberglass form fillers (pans), which may be used many times. In some ribbed slabs, the spaces between ribs may be filled with permanent fillers to provide a horizontal slab.

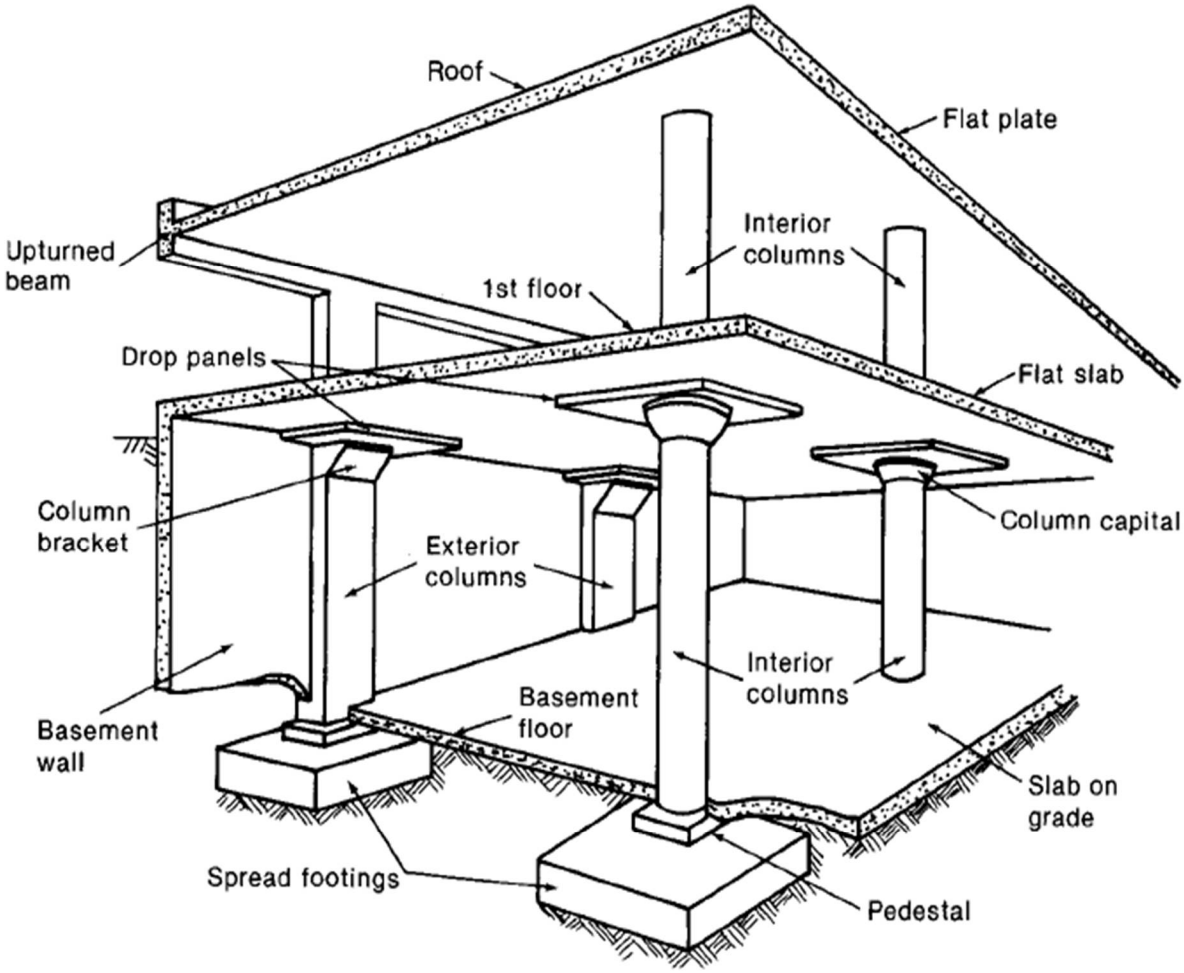
The long side to the short side is less than ***2 (L_long / L_short < 2***), the slab will deflect in double curvature in both directions. The floor load is carried in two directions to the four beams surrounding the slab. Other types of two-way floor systems are flat plate floors, flat slabs, and waffle slabs. This chapter deals only with one-way floor systems





Typical reinforced concrete structural framing system



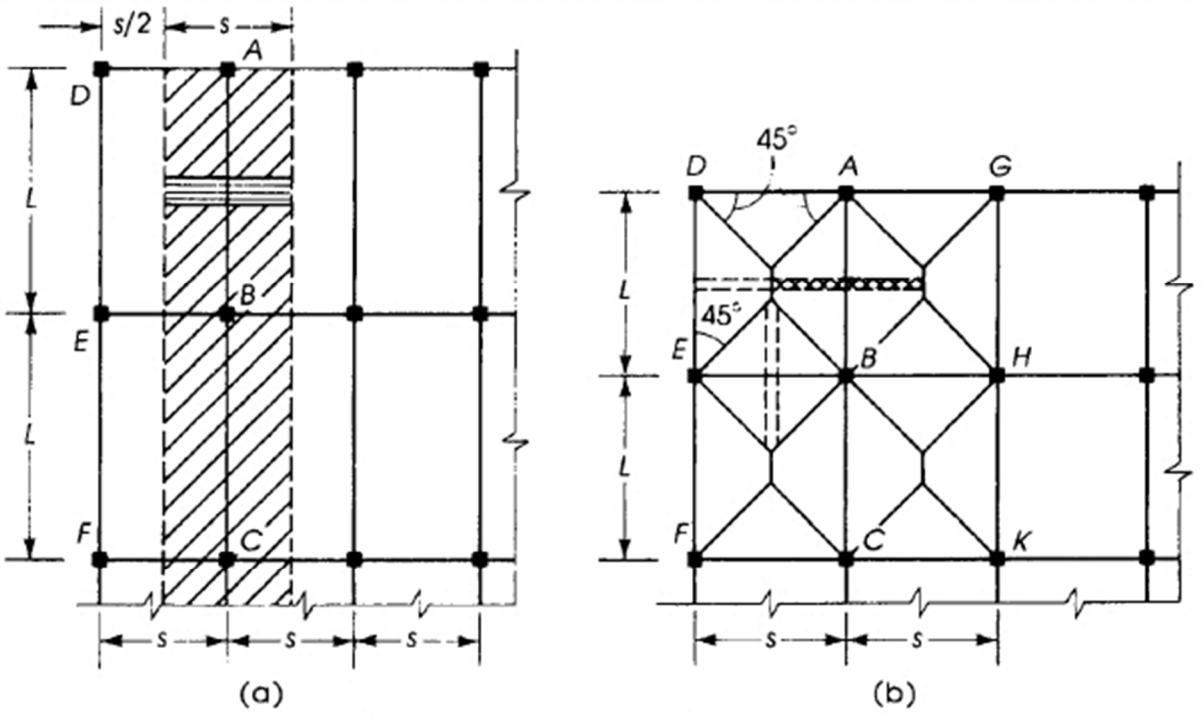


Reinforced concrete building elements

2. Two-Way Slabs

2.1 Introduction

When the slab is supported on all four sides and the length L , is less than twice the width, , the slab will deflect in two directions, and the loads on the slab are transferred to all four supports. This slab is referred to as a two-way slab. The bending moments and deflections in such slabs are less than those in one-way slabs; thus, the same slab can carry more load when supported on four sides. The load in this case is carried in two directions, and the bending moment in each direction is much less than the bending moment in the slab if the load were carried in one direction only.



Slab loads on supporting beams:

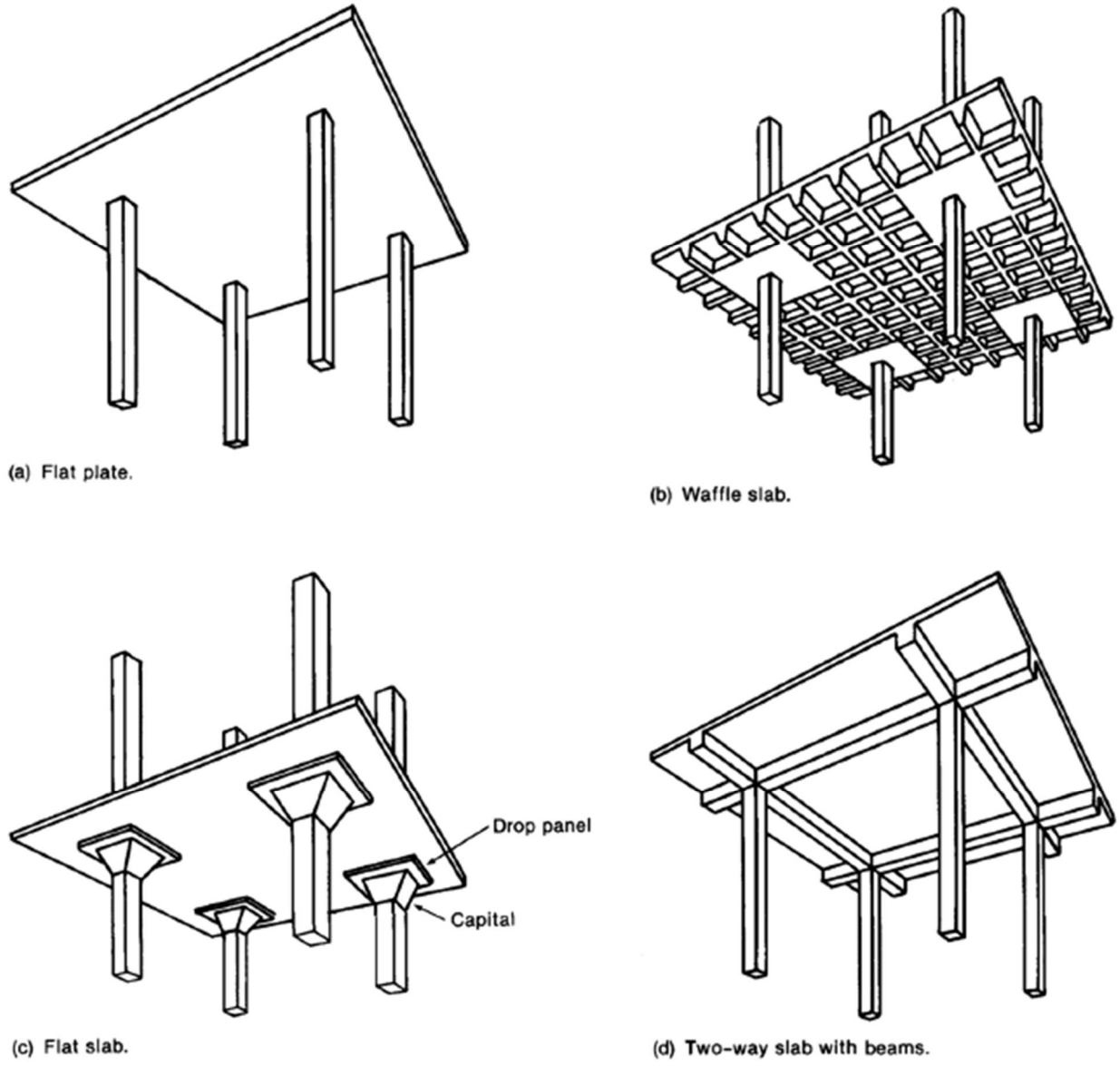
(a) one-way direction, $L/s > 2$; (b) two-way direction, $L/s \leq 2$.

2.2 TYPES OF TWO-WAY SLABS

Structural two-way concrete slabs may be classified as follows:

1. **Two-Way Slabs on Beams:** This case occurs when the two-way slab is supported by beams on all four sides. The loads from the slab are transferred to all four supporting beams, which, in turn, transfer the loads to the columns.

2. **Flat Slabs**: A flat slab is a two-way slab reinforced in two directions that usually does not have beams or girders, and the loads are transferred directly to the supporting columns. The column lends to punch through the slab, which can be treated by three methods:



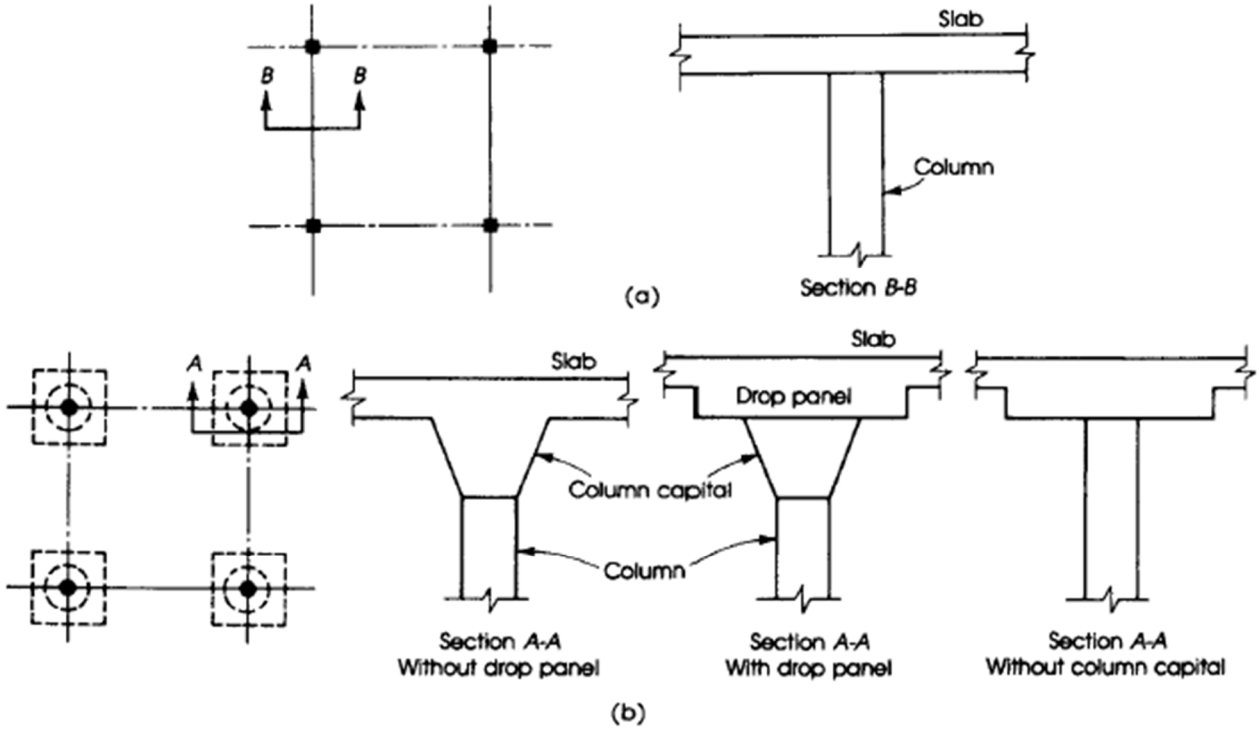
(a) Flat plate.
(b) Waffle slab.
(c) Flat slab.
(d) Two-way slab with beams.

a. Using a drop panel and a column capital.

b. Using a drop panel without a column capital. The concrete panel around the column capital should be thick enough to withstand the diagonal tensile stresses arising from the punching shear.

c. Using a column capital without drop panel, which is not common.

3. **Flat-Plate Floors:** A flat-plate floor is a two-way slab system consisting of a uniform slab that rests directly on columns and does not have beams or column capitals (Fig. a). In this case the column tends to punch through the slab, producing diagonal tensile stresses. Therefore, a general increase in the slab thickness is required or special reinforcement is used.



Two-way slabs without beams:

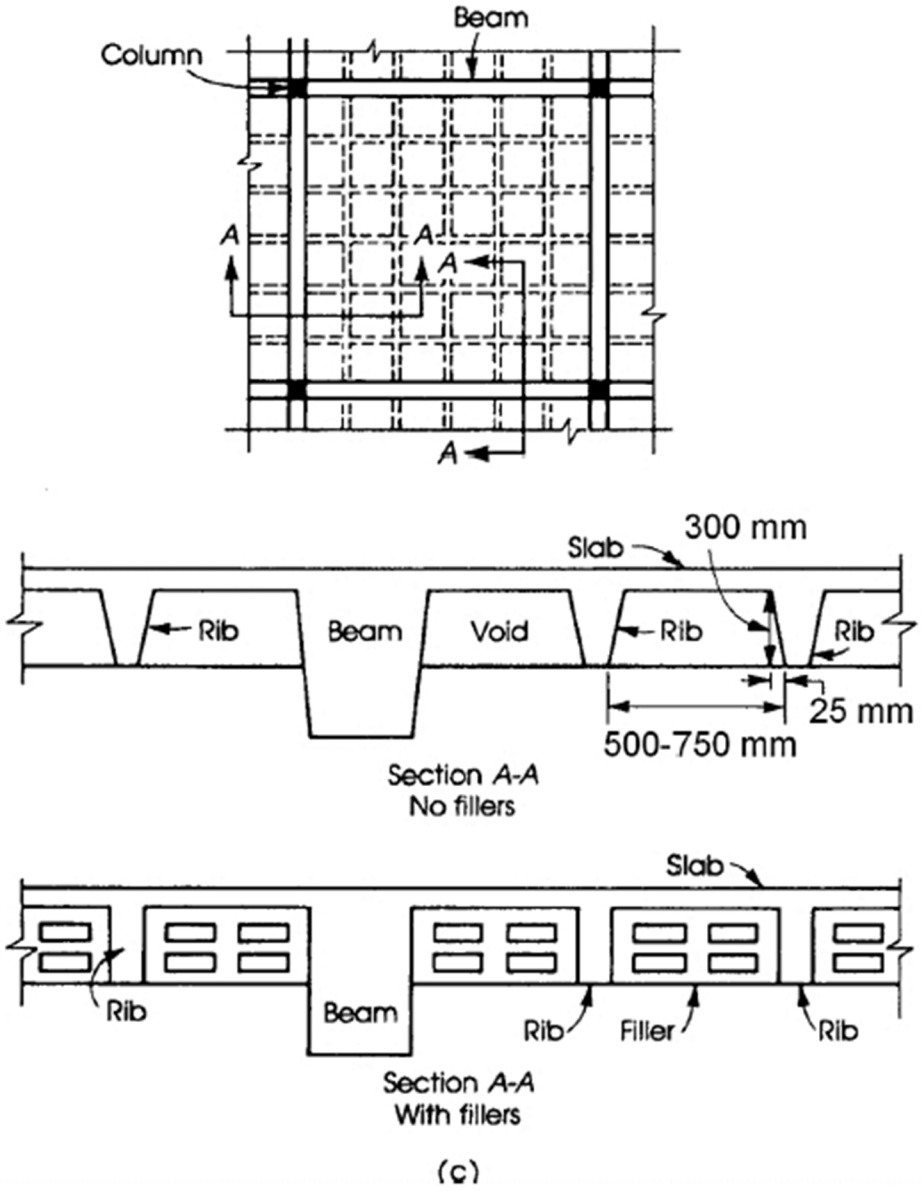
(*a*) flat plate floor and section; (*b*) flat slab floor and sections; (*c*) ribbed slab and sections.

4. **Two-Way Ribbed Slabs and the Waffle Slab System**: This type of slab consists of a floor slab with a length-to-width ratio less than 2. The thickness of the slab is usually 5 to 10 cm and is supported by ribs (or joists) in two directions. The ribs are arranged in each direction at spacing of about **50 cm** to **75 cm**, producing square or rectangular shapes. The ribs can also be arranged at **45° or 60°** from the centerline of slabs, producing architectural shapes at the soffit of the slab. In two-way ribbed slabs, different systems can be adopted:

a. **A two-way rib system with voids between the ribs**, obtained by using special removable and usable forms (pans) that are normally square in shape. The ribs are supported on four sides by girders that rest on columns. This type is called a two-way ribbed (joist) slab system.

b. **A two-way rib system with permanent fillers between ribs** that produce horizontal slab soffits. The fillers may be of hollow, lightweight or normal-weight concrete or any other lightweight material. The ribs are supported by girders on four sides, which in turn are supported by columns. This type is also called a two-way ribbed (joist) slab system or a hollow-block two-way ribbed system.

c. A two-way rib system with voids between the ribs with the ribs continuing in both directions without supporting beams and resting directly on columns through solid panels above the columns. This type is called a waffle slab system.



3. Economical Choice of Concrete Floor Systems

Various types of floor systems can be used for general buildings, such as residential, office, and institutional buildings. The choice of an adequate and economic floor system depends on the type of building, architectural layout, aesthetic features, and the span length between columns. In general, the superimposed live load on buildings varies between **4 and 7 kN/m^2**. A general guide for the economical use of floor systems can be summarized as follows:

1. **Flat Plates:** Flat plates are most suitable for spans of **6 to 8 m** and live loads between **3 and 5 kN/m^2**. The advantages of adopting flat plates include low-cost formwork, exposed flat ceilings, and fast construction. Flat plates have low shear capacity and relatively low stiffness, which may cause noticeable deflection. Flat plates are widely used in buildings either as reinforced or prestressed concrete slabs.