Plain & Reinforced Concrete-1

Sixth Term
Civil Engineering

CE-314

Lecture # 26

RB Slabs and Structural Scheme

REINFORCED BRICK (RB) SLABS

- Traditionally the term "reinforced brick work" was used for cement mortar brickwork reinforced by steel rods embedded in the mortar layers.
- This type of construction was not found to be satisfactory in the localities having lot of moisture causing very early rusting of steel and deterioration of concrete.
- The life of the structures was significantly reduced (up to 10 to 15 years) in such cases.
- Recently, RB slab is a term commonly used for slab having single or pair of bricks joined together by concrete ribs having the steel reinforcement with proper cover from the porous bricks and a protective concrete layer at the top.
- Thus the bricks are either placed individually or are joined together in pairs using C/S mortar before placing them for the final casting.

- A top 30 to 40 mm continuous layer of concrete is provided to make the slab impervious and to provide sufficient compressive strength.
- Used in this way, RB slab more behaves like a special type of waffle slab, with the voids filled by the bricks, rather than the traditional RB construction.
- The strength of the bricks may be ignored and hence lesser quality bricks not having more percentages of salts and porosity may be used to reduce the cost.

- The provision of voids or lesser strength bricks is justified due to the following two factors:
  1. For positive moment, the ultimate compression block lies in the top concrete layer and the concrete below the neutral axis is to be neglected. Hence, if this concrete is replaced with voids or bricks, the flexural strength is not affected.
  2. For negative moments over continuous supports, the ribs of concrete along with the bottom steel (acting as compression reinforcement) resist most of the compression. However, the bricks may also contribute somewhat in providing the compressive strength.

- As a common practice, the design of RB slabs is based on the recommendations of the Khanna’s handbook giving very conservative estimate of the steel.
- Further, the design is originally derived for the traditional brickwork with steel embedded in the mortar, whereas concrete is not used as a binding material.

Defects In Ordinary Reinforced Brick Slabs / Better Construction Practices

1. The design of such slabs is not based on actual calculations considering the expected loads, geometric dimensions and a verified design procedure.

   In majority of the cases, the design is either based on recommendations of the Khanna's Handbook or is purely based on the judgment of the designer.

   Using lesser steel than the amount actually required is obviously an undesirable condition.

   If extra steel is used, it not only makes the construction uneconomical but also can be unsafe in certain situations because of over-reinforced sudden mode of failure without any warning.

2. Qualified engineers or sub-engineers are not generally employed to supervise reinforced brick construction.
3. The steel is not placed correctly along the depth of the slab, which modifies the effective depth.

   Occasionally people provide steel very close to neutral axis and thus make the steel nearly ineffective in resisting the moments.

   In some cases, negative steel in cantilevers is replaced by bottom steel, which is similar to having no steel at all.

4. The bricks are not properly soaked in water before pouring of the concrete.

   The correct method is to soak all bricks in water up to such a level that these should not be able to absorb more moisture from the poured concrete.

   If moisture is sucked from the fresh concrete, the workability of the concrete will be adversely affected.

   The result will be that the joints between the bricks will not be completely filled with the concrete and there will be lots of honeycombing.

5. Manual rodding of the fresh concrete is the only method available for compaction as compared with mechanical vibration used in case of reinforced concrete.

   Further, concrete in RB work is poured through the gaps in the bricks and the steel, whereas, it is only poured through the reinforcement in case of reinforced concrete.

   Hence, a little lack of attention during construction can severely affect the concrete both in terms of strength and porosity.

   More workable mixes with smaller size aggregates are generally preferred.

6. The width of ribs between the bricks should be sufficient to accommodate the steel with required minimum covers up to the bricks to avoid rusting of steel and for easy pouring of the concrete.

   Maximum aggregate size must be selected such that the concrete may pass through such smaller dimensions.

   If these conditions are not fulfilled, the quality of RB construction will decrease.

7. The pattern of placement of bricks is also very important.

   Traditionally, the bricks were first joined together by cement mortar to form pairs, which were then placed on the shuttering to get a stable, regular and organized pattern of bricks.

   With the new concept of RB slabs with the bricks only used as a filling material, contractors have started to spread the single bricks in an irregular pattern, after placing the steel.

- This pattern is unstable, especially when bricks on edge are used, and the position of bricks changes during pouring of concrete due to working of labor and due to lateral pressure of the fresh concrete.
- If the bricks are displaced and come closer to the reinforcement, corrosion of steel occurs and the life of such slabs is greatly reduced.
- There is a need to go back to the traditional methods and the bricks should be joined in groups by using cement sand mortar at least three days before their placing on the shuttering.

8. If temperature steel is not sufficiently provided on exposed roofs and sunshades without insulation, cracking of the slab may take place.

   This will lead to a complete failure of the structure.

9. In some cases, negative steel is not provided at the continuous edges of the slab.

   This reduces the flexural strength, increases the deflections and causes the formation of cracks at undefined locations on the top surface.

   This facilitates percolation of water in to the slab and produces deterioration and rusting of the materials.

10. Cover to steel on the exposed surfaces should also be well maintained.
11. A top concrete layer of 30 to 40 mm should always be provided on the top of the bricks to protect them from moisture.

    If this layer is not provided, the water may seep into the slab through bricks during rain on top surface or during washing of the intermediate floors.
12. The bricks must not have excessive salts and absorption.
13. The shuttering in case of RB slabs comprises of mud plaster on wooden planks.

    If this shuttering is not properly constructed, the cement slurry flows out of this shuttering during pouring and causes voids in the concrete.

14. Occasionally, the beams supporting the slab panels are not properly designed and only concealed beams with minimum reinforcement are provided everywhere.

- Concealed beams are very useful for small spans and less loads to improve the architectural appearance.
- However, for bigger spans and heavy loads, these beams become very expensive and may produce excessively large deflections.
- These large beam deflections change the behavior of the supported slab and may produce excessive bending and cracking.

15. Complete damp proofing is to be carried out on the roof surfaces.
16. The supporting walls should have properly foundations.

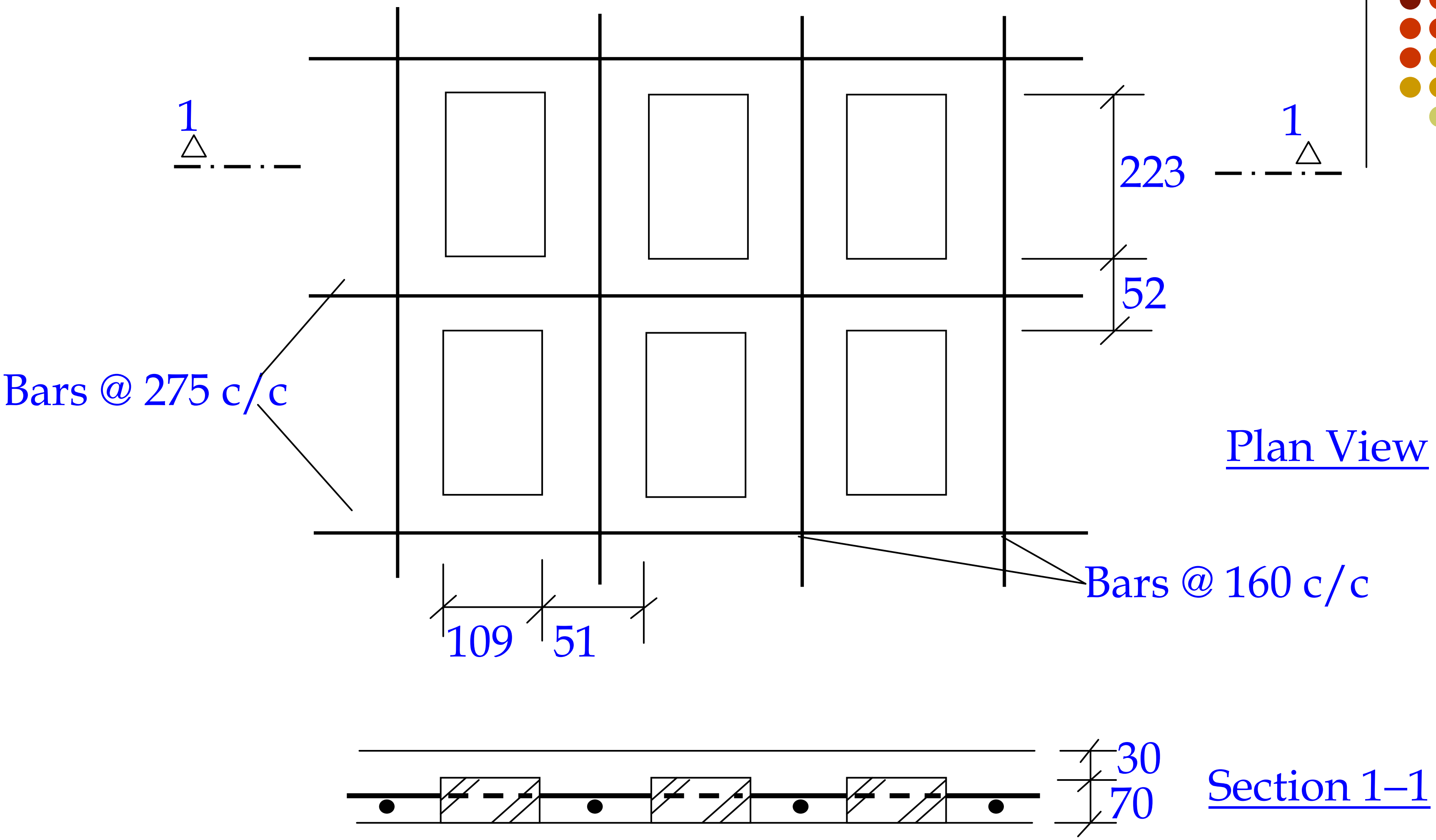
17. The pipes for electrification and plumbing are to be placed at proper locations and must be handled with care during the construction.
18. The depth of the slab is to be sufficient to avoid the excessive deflections and cracking.
19. Proper distribution and temperature steel must be provided in case of one-way slabs.
20. Water cement ratio and workability are to be properly maintained during the construction.
21. Curing must properly be carried out for the specified minimum time.

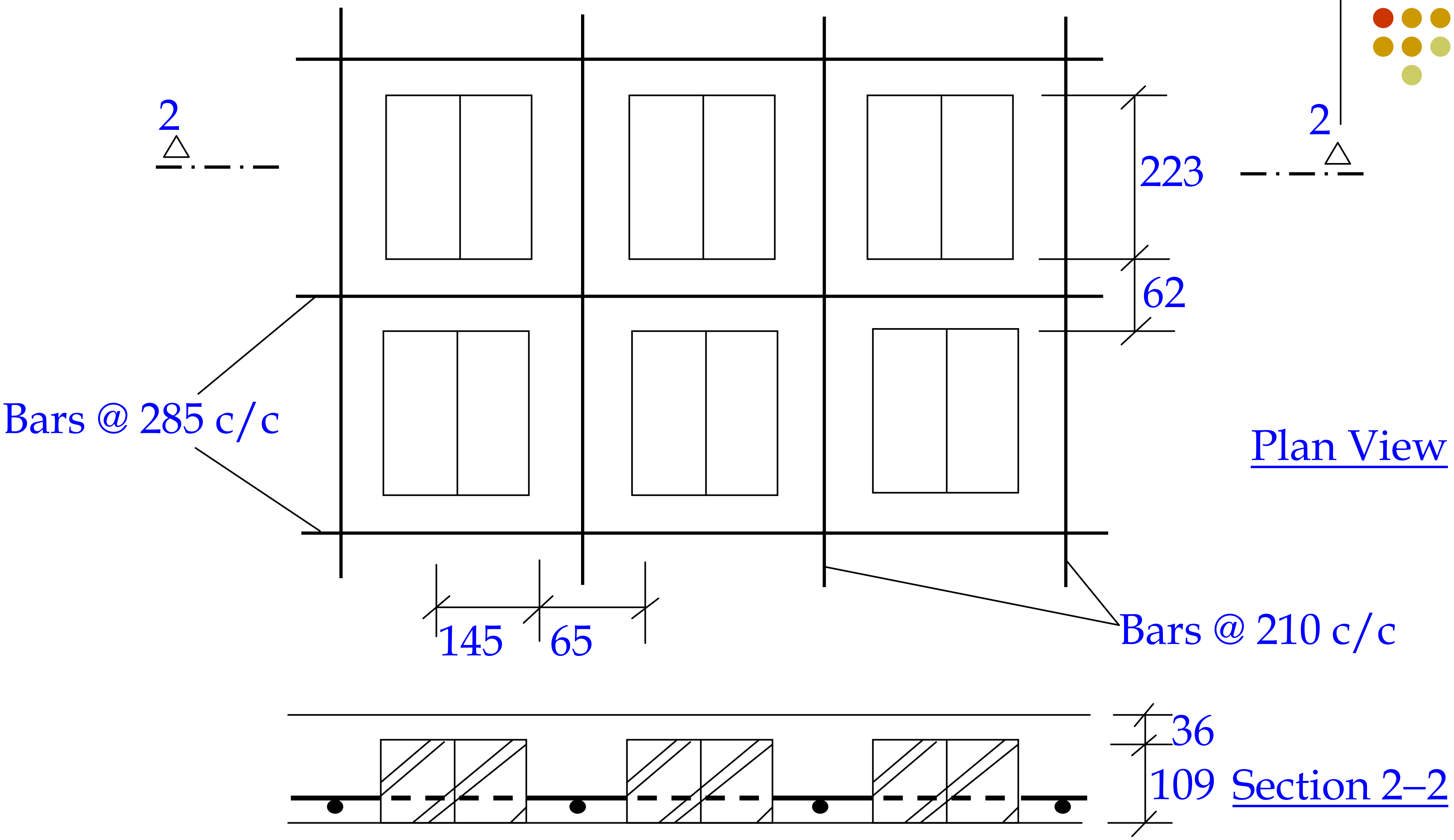
Similarities And Differences In RC And RB Slab Designs

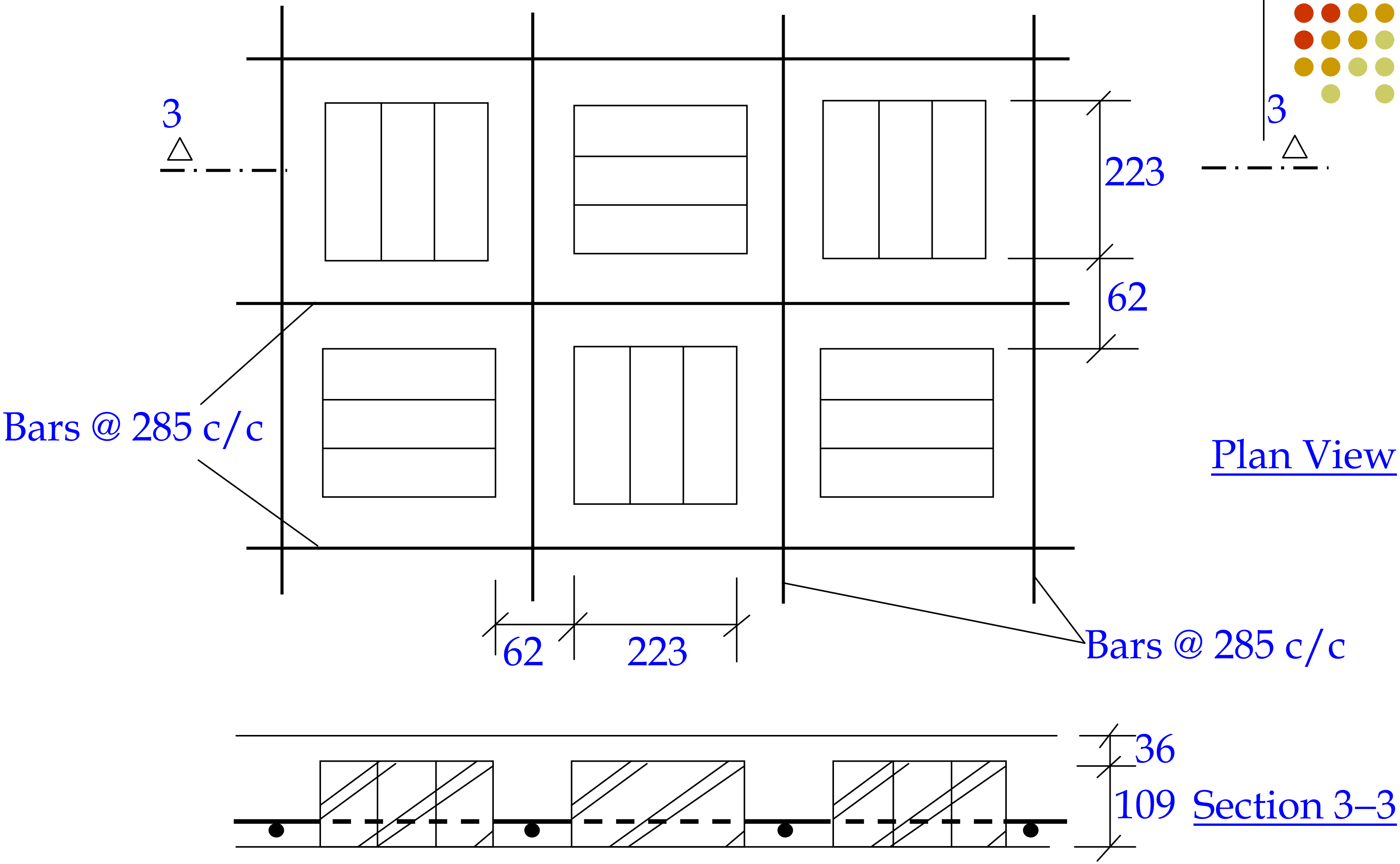
- RB slabs may be designed just like ordinary reinforced concrete one-way and two-way slabs with only some minor modifications.
- The spacing of bars is fixed for a particular selected pattern of RB slab and only the required diameter of the bar is to be found out in design. This gives less choices of providing the reinforcement, requiring more steel for safe designs.
- The thickness of slab has only few options depending upon the arrangement of bricks.
- The top steel may be provided at any spacing within the top concrete layer.

Typical Brick Arrangements In RB Slabs

- The first brick arrangement is obtained by placing flat bricks individually to get a total thickness of 100mm. This pattern is used for smaller slabs and shades.
- The size of brick without mortar may be considered equal to approximately 223 × 109 × 70 mm.
- In the second brick arrangement, the bricks are placed in the form of pairs already joined together by cement-sand mortar to obtain the plan size of 145 × 223 mm.
- This arrangement is suitable for rectangular panels where the steel in one of the directions is to be placed at a lesser spacing.
- Brick triplets of size 123 × 123 mm in plan dimensions placed side-by-side give the third arrangement.


1
1
223
52
Bars @ 275 c/c
Plan View
109
51
Bars @ 160 c/c
30
70
Section 1–1


2
2
223
62
Bars @ 285 c/c
Plan View
145
65
Bars @ 210 c/c
36
109
Section 2–2


3
3
223
62
Bars @ 285 c/c
Plan View
62
223
Bars @ 285 c/c
36
109
Section 3–3

Economy In RB Slab Of 145 mm Depth Consisting Of Brick Triplets

- To get an idea about the possible percentage economy of RB slabs with respect to RC slabs, the case of 145 mm depth slab made by using brick triplets is considered. The calculations may be performed as under:
- Volume of RB for one segment within the steel bars

  $= 0.285 \times 0.285 \times 0.145 = 0.01178 \text{ m}^3$
- Volume of bricks in above volume of RB = 0.00535 m^3
- Volume of concrete in above volume of RB = 0.00643 m^3

- The cost of concrete including formwork, labor and contractor's profit is taken equal to Rs. 4400 per m^3 and the cost of a single brick including all the expenses to put it in the RB work is taken equal to 4.5 per unit.
- The weight of steel in RC slab is taken equal to 70 kg/m^3.
- The weight of steel in RB slab will be relatively more due to limited choices for the spacing, which may be taken equal to 80 kg/m^3.
- The cost of steel including cutting, bending, placing and contractor's profit is taken equal to Rs. 45 per kg.

- Volume of RB for one part

  = $0.285 \times 0.285 \times 0.145 = 0.01178 \text{ m}^3$
- Volume of bricks for the selected part = 0.00643 m^3
- Volume of concrete for the selected part = 0.00535 m^3
- Weight of steel in reinforced concrete = 70 kg per m^3

  = $70 \times 0.01178 = 0.8246$ kg
- Weight of steel in RB slab = 80 kg per m^3

  = $80 \times 0.01178 = 0.9424$ kg
- Cost of RC slab of equivalent thickness

  = $0.01178 \times 4400 + 45 \times 0.01178 =$ Rs. 88.94

- Cost of RB slab of the selected thickness

  = 0.00643 × 4400 + 45 × 0.0.9424 + 4.5 × 3

  = Rs. 84.20

- Percentage saving w.r.t. concrete slab

  = (88.94 − 84.20) / 88.94 ≅ 5 %

Behavior Of Reinforced Brick Slabs And Possible Design Approaches

- Concrete suddenly crushes at a strain equal to or slightly above a value of 0.003, whereas, bricks starts crushing very early but continue to resist more load and the complete failure is defined at a large strain.
- This is probably due to the size and orientation of the specimens tested in the machine. These two materials interact with each other in the compression zone producing a highly complicated mechanism.
- The fundamental assumption can be ignoring of the compressive strength provided by the bricks. This is supported by the fact the brick strength is much lesser than concrete at a strain lesser or equal to 0.003 and further this is less reliable than concrete.

Solid Reinforced Concrete Analogy: When RB slabs are subjected to sagging moments and a concrete layer of 30 to 40 mm is provided on the top, the neutral axis usually lies within this top concrete layer.

This means that the concrete in the ribs and bricks are all in tension and their strengths must be neglected. In such cases, the RB slab exactly behaves like a solid reinforced concrete slab.

The formulas to estimate the flexural strength of RC members are applicable here without any modification.

Nevertheless, it is important to note the concrete cylinder strength in case of RB slabs will be much less due to manual compaction, more congestion and lesser control of workability and water-cement ratio.

Reinforced Concrete Ribs Analogy: In cases where the RB slabs with top concrete layer are subjected to hogging moments, the strength of this top layer of concrete is wasted due to the presence of tension on this face.

The ribs of concrete between the bricks and the bricks will now be in compression.

Neglecting the compressive strength of bricks and the strength of the top concrete layer as mentioned above, only concrete ribs are left to resist compression.

The width of ribs alone may be used in calculations in place of the total width of the slab.

The torsional stiffness between the perpendicular ribs is neglected for the simplicity of the calculations.

STRUCTURAL SCHEME

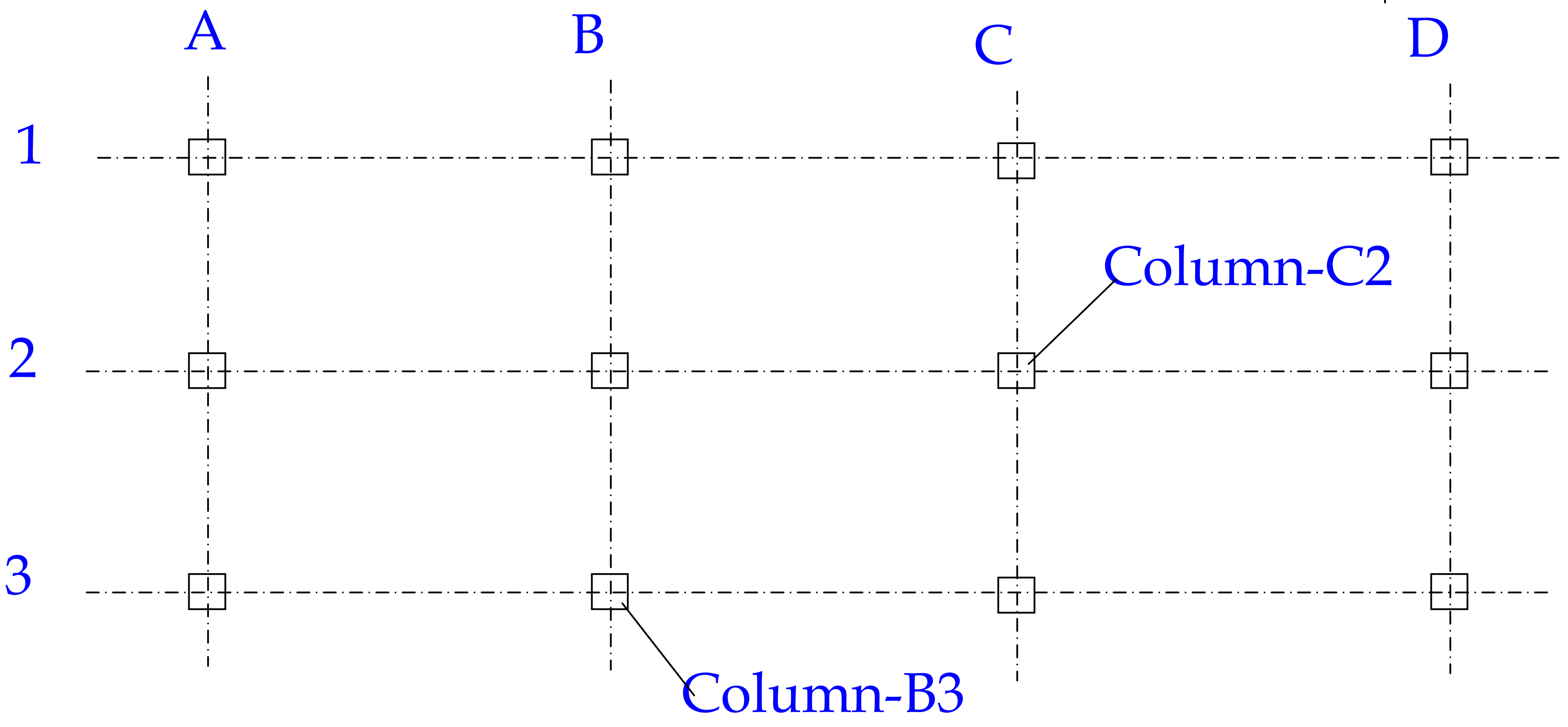
- Structural scheme means the decision about placement and spacing of columns, position of main beams, location of secondary beams and position of expansion and contraction joints giving the maximum economy and structural efficiency.
- This scheme is to be decided based on the architectural scheme and operational use of the building.
- Following points must be kept in mind while finalizing the structural scheme:

1. The column spacing should not be too less to give a congested plan.

- It is to be remembered that larger number of columns may even the structural cost.
- The minimum spacing of columns is generally taken as 3.0 m, unless the columns are hidden within the walls.
- The maximum spacing is approximately 10 m, leaving exceptionally larger unobstructed halls.

2. The columns are placed as symmetrically as possible where these are lying along two mutually perpendicular axes at almost a regular spacing.

- The reference lines in one direction are marked by alphabets while the reference lines in the other direction are designated by numerals, as shown in Fig. 20.4.
- In this way, every column may uniquely be designated by its alphabetic reference combined with the numeral reference.



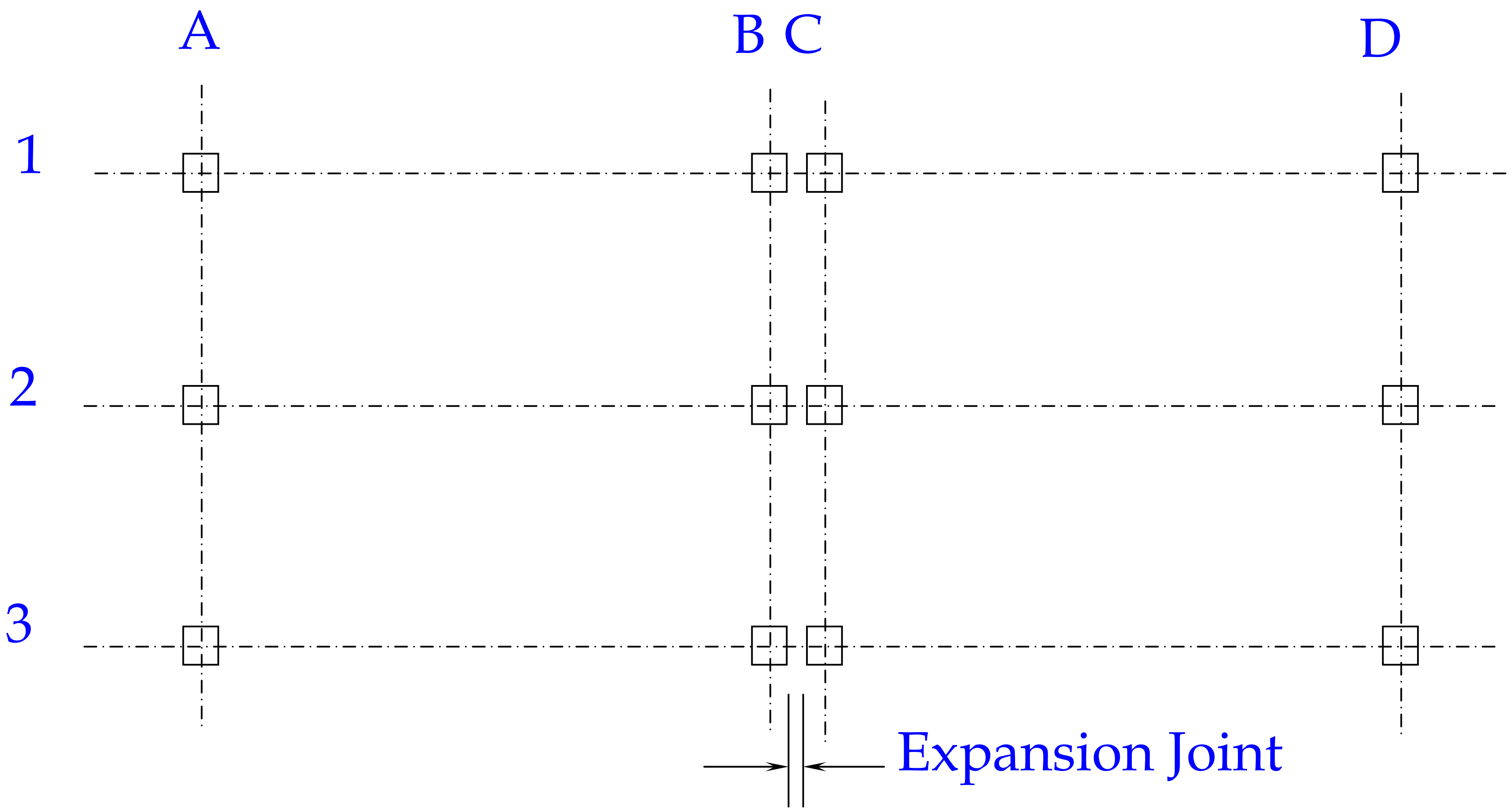
A Typical Structural Scheme with Reference Axes.

3. Primary beams usually run on all columns along the two perpendicular directions.
4. Secondary beams are sometimes provided such that the slab panels become sufficiently smaller to get a preferable depth of solid slab not exceeding about 150 mm.

   However, in some cases, we may go up to a depth of 175 to 200 mm.
5. Expansion joints must be provided at a spacing of 30 to 50 m and preferably at all changes in the geometry of the structure.

- For example, in case of L, I or T – shaped building, these are to be provided at every junction of various arms of the building.
- These joints must be accommodated at reasonable locations within the plan, such as end of various portions or blocks of the building.

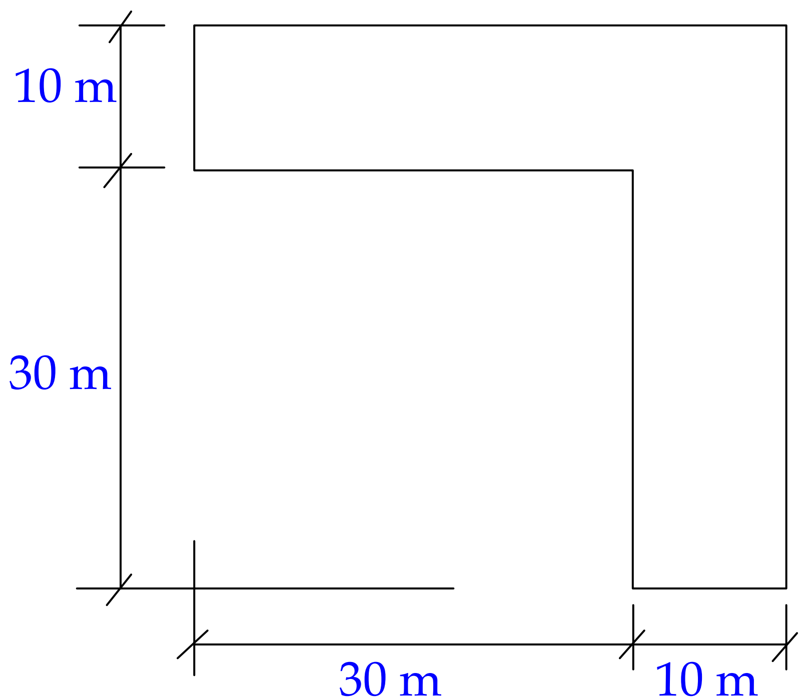
- At an expansion joint, the two sides of the building must be fully divided into separate parts with no connection inbetween; the only exception to this may be the foundation.
- Due to temperature changes, the structure may expand or contract at these joints. The building must have separate columns and beams at each side of joint, as shown in Fig. 20.5.


A
B
C
D
1
2
3
Expansion Joint

- The coefficient of linear thermal expansion for reinforced concrete (α) is approximately 9.9×10^{-6} per °C.
- The maximum change of temperature throughout the year may be taken as 40° C, although the protected concrete may have lesser temperature variation.
- For 30m and 50m lengths of the building, the corresponding change in lengths become 12mm and 20mm, respectively.
- Hence, the gap for the expansion joint should be 10 to 25 mm with more value adopted for construction in summer and less value for construction in winter.

- The gap for the expansion joint within the slab must be properly sealed against the water penetration, yet it should allow free movement of the structure.
- The materials used for filling this joint are usually bitumen and cork or asphaltic mixes with other compressible materials.
- The visible surfaces of these joints at floor levels or at ceiling levels must be covered by flexible cover strips to improve the appearance, to make the surface smooth and to prevent the infiltration of water.

Example 20.1: Make structural scheme for the building whose outline is shown in Fig. 20.6. The dimensions in this figure are all inside values. Outer wall and columns are 456 mm thick and no inside columns are to be provided.



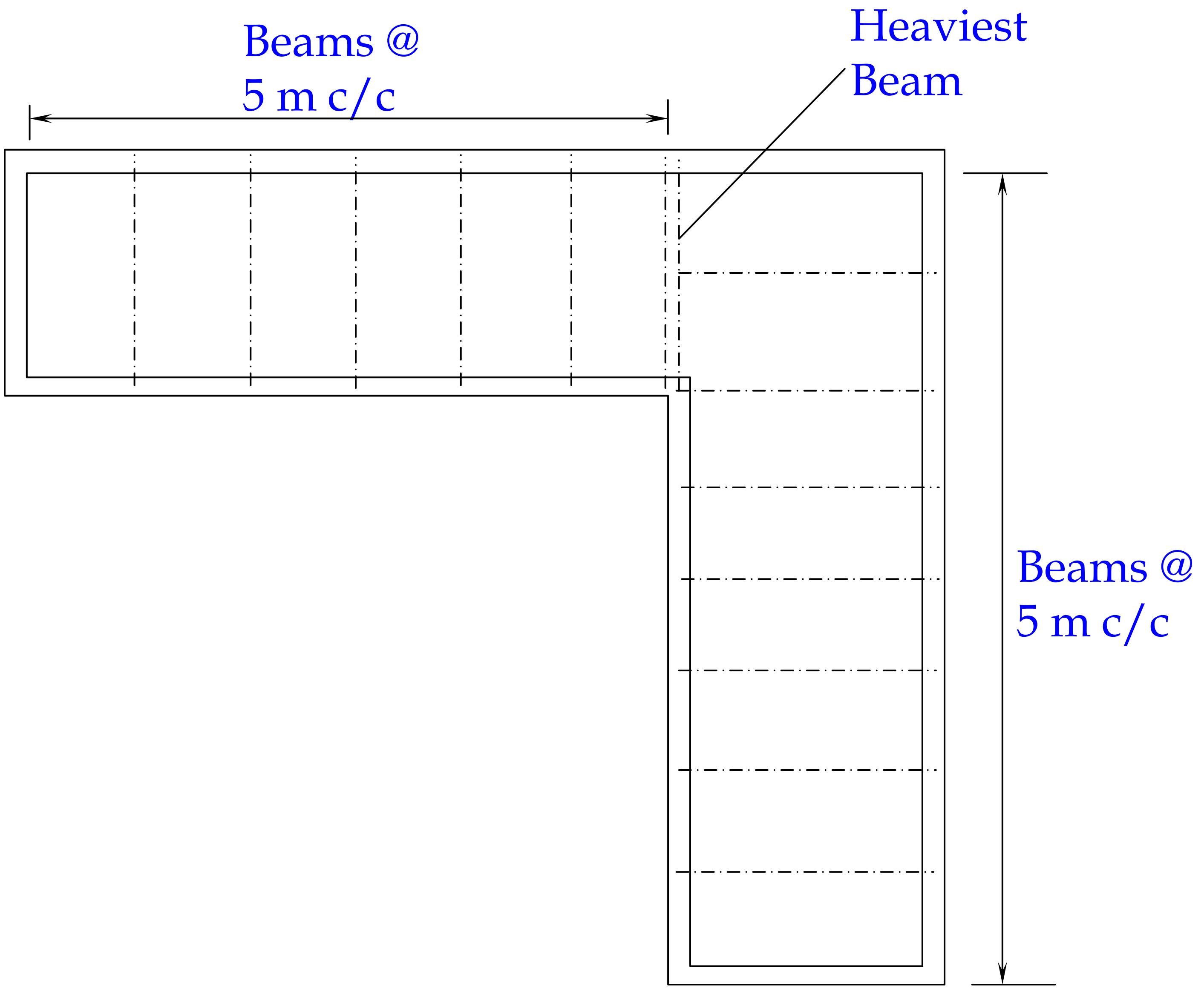
Solution:

- The maximum spacing between the beams for 150 to 175 mm thick one-way slab having one end continuous may be determined as follows:

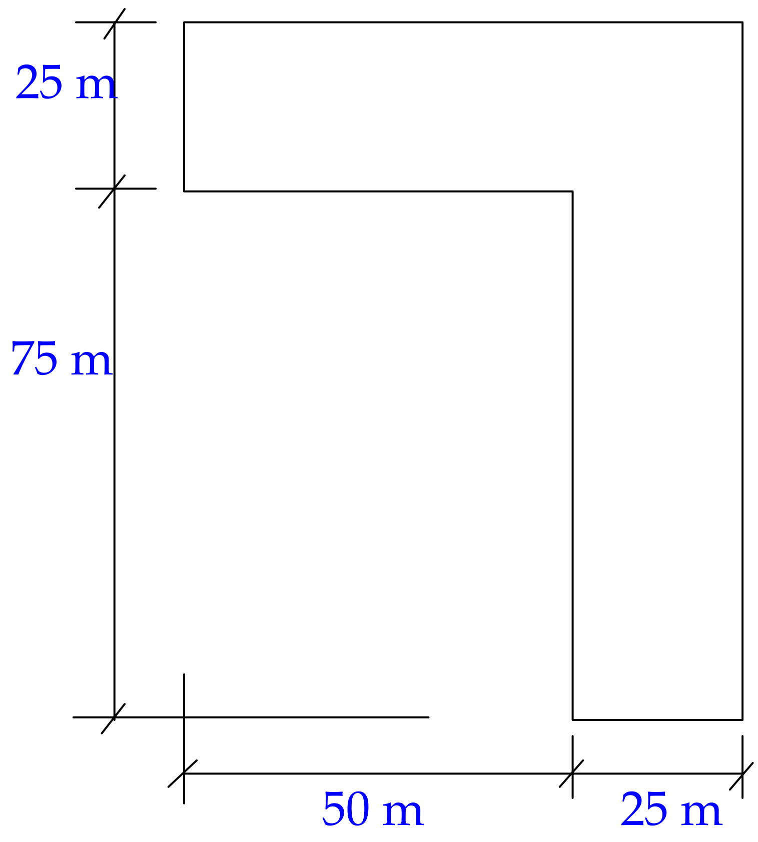
$$S / 30 = 150 \quad \Rightarrow S_{max} = 30 \times 150 / 1000 = 4.5 \text{ m}$$

$$S / 30 = 175 \quad \Rightarrow S_{max} = 30 \times 175 / 1000 = 5.25 \text{ m}$$

- One possible structural scheme is shown in Fig. 20.7.


Beams @
5 m c/c
Heaviest
Beam
Beams @
5 m c/c

Example 20.2: Make structural scheme for the building of Fig. 20.8 where internal dimensions are shown. Column spacing is not to be less than 11m along the width of the building arm and 6m along the length. Secondary beams are to be used for the building.

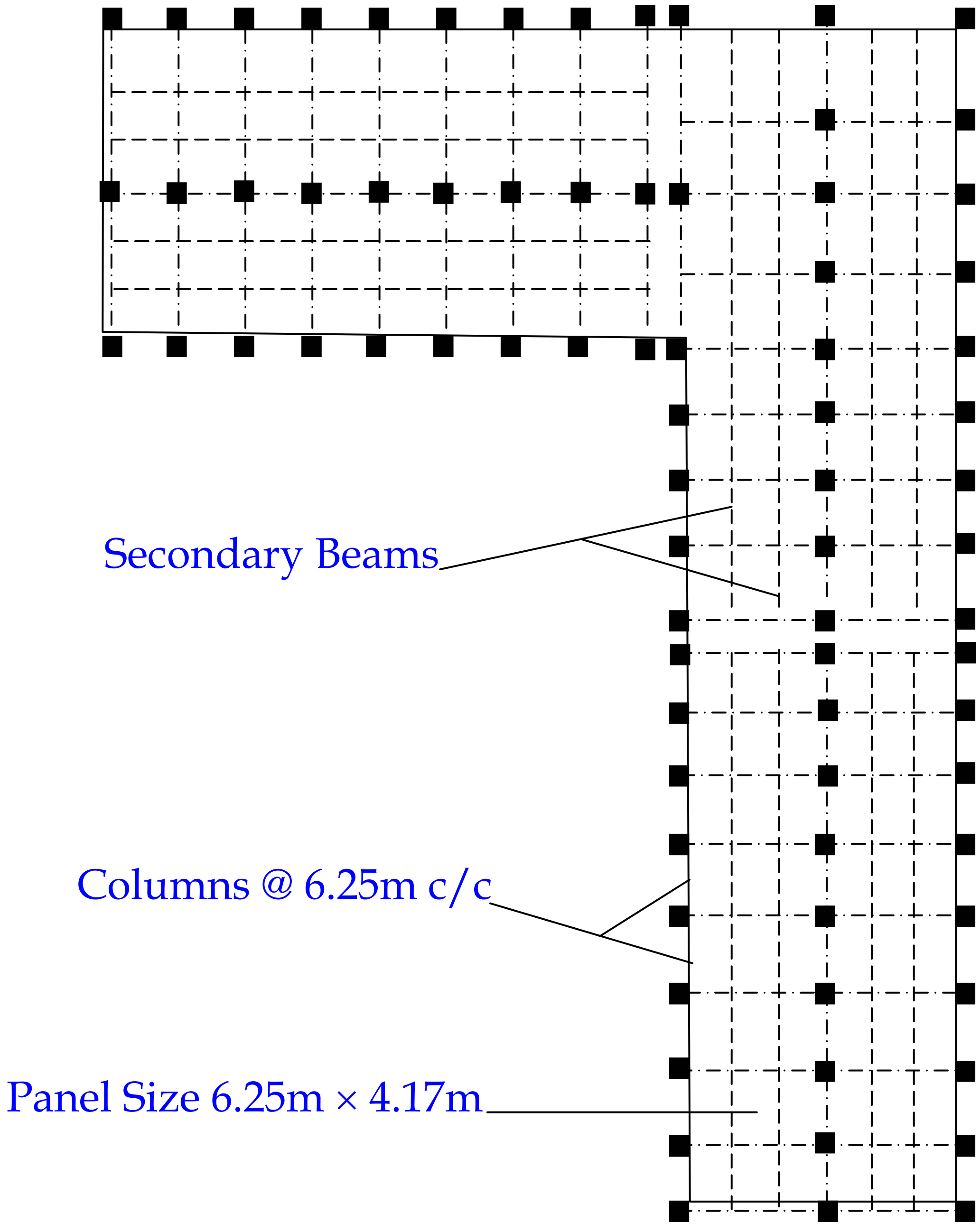


Solution:

- If length of a slab panel is 6m, the other dimension, *x*, may be calculated for a 125 mm thick two-way slab, as follows:

  $(6000 + x) \times 2 / 180 = 125 \Rightarrow \quad x = 5250$ mm

- One possible structural scheme is shown in Fig. 20.9, assuming an expansion joint spacing of 50 m (which is on higher side).


Secondary Beams
Columns @ 6.25m c/c
Panel Size 6.25m × 4.17m

End of Topic