UNIT 8 RC FLAT FLOORS AND SHELL ROOF

Structure

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8.1 INTRODUCTION

From functional point of view, floors are always flat except the uppermost floor (roof) which may also be sloping or curved. In tropical climate, flat roofs are preferred; whereas sloping or curved roofs are provided in regions of heavy rain or snowfall. Sometimes curved roofs are provided for economy or elegance.

From structural point of view, reinforced concrete (RC) is a composite material. Due to loads, compressive and tensile internal stresses develop within an element. Concrete is provided to resist compressive force; whereas reinforcing steel bars resist tensile force. The composite action is possible due to bond between these two materials. The location and quantity of reinforcement at any cross-section of an element depend on the location and intensity of tensile force, respectively at that cross section. Nominal reinforcement is sometimes provided to limit cracks. Hence, detailing of reinforcement for reinforced concrete element is very important.

Objectives

After studying this unit, you should be able to

- describe simple slab floors, beam-slab floors, flat slab floors and ribbed slab floors, and
- describe cylindrical shell roofs and spherical shell roofs.

8.2 RC FLAT FLOORS AND ROOFS

Size of enclosed space, view of ceiling, etc. determine the type of flat floors. Here only four types of flat floors have been described.

8.2.1 Simple Slab Floors

As the name suggests, it is simply supported slab on an isolated room. It may be one-way or two-way slab depending upon whether longer to shorter span ratio is more than or less than 2, respectively. In one-way slab, only nominal reinforcement is provided along longer span. Nominal reinforcement is also provided at supports as the bending moment is zero. The reinforcement detailing has been shown in Figures 8.1 and 8.2.

Figure 8.1 : Sectional View of Simple One-way Slab Flooring

Figure 8.2 : Typical Details of Simple Two-way Slab Flooring

8.2.2 Beam Slab Floors

In large enclosed space like halls, auditorium, class rooms, etc. without intermediate supporting walls or columns, a floor slab is supported on beams in one or both perpendicular directions. Such floors are named as Beam-slab floors. A typical floor plan and sections have been shown in Figures 8.3 to 8.5.

8.2.3 Flat Slab Floors

* Very rarely flat slab is supported on

A flat slab floor is a slab floor with or without rectangular drops and supported on columns with or without flared heads* (Figure 8.6). It may consist of solid slab or may have recesses formed on the soffit.

The length of a drop in each direction shall not be less than one-third of the span in that direction for interior panels. For exterior ones, lengths for drop shall be measured from centre line of the columns and shall be one-half the length of drop for interior panels.

Figure 8.3 : Slabs Spanning in Two Directions

Figure 8.4 : Curtailment Rules for Two-way Slab

The minimum thickness of the slab shall not be less than that provided for solid slab based on deflection criteria; but in no case it shall be less than 125 mm. For design purposes, following additional dimensional parameters shall be considered :

(a) The portion of a column head which lies within the largest right circular cone or pyramid that has the vertex angle of 90° and can be included entirely within the outlines of the column and the column head.

Figure 8.5 : Torsional Reinforcement in Slab

Figure 8.6: Flat Slab Floors

(b) A strip along a column centre line of 0.5 l_2 width which shall not be less than 0.5 l_1 is named as a *Column strip*.

Here,

l_1 = span length measured along the centre line length in the direction moments are being determined, and

l_2 = span transverse to l_1 (Figure 8.7).

(c) A strip of slab lying between two opposite column strips is called a middle strip.

Figure 8.7 : Plan of a Flat Slab

(d) The part of the slab bounded on all sides by the centre line joining columns is called a *panel*.

A flat slab may be designed either by 'Direct Design Method' or by 'Equivalent Frame Method'; but the former method being simple with certain limitations has been described here.

Total design Moment for a span,

$$M_0 = \frac{W\, l_n}{8}$$

where, W = design load on an area $l_2\, l_n$, and

l_n = clear span extending from face to face of columns, capitals, etc.

M_0 is distributed into negative and positive design moments in proportions prescribed by the Code. The shear force at critical section is resisted by the slab. A typical cross section of a flat slab is shown in Figure 8.8.

Figure 8.8 : Typical Arrangement of Bars in a Flat Slab with Drop Panels

8.2.4 Ribbed Slab Floors

A ribbed slab is analysed and designed as a continuous solid slab and hence reinforcement detailing shall also be done accordingly except that they will be continued in the ribs the same way as that in solid slabs. A ribbed slab shall satisfy the following dimensional conditions :

(a) Ribs shall not be less than 65 mm width.

(b) They shall not be more than 1.5 m apart.

(c) Their depth excluding topping shall not be more than 4 times their width.

(d) Ribs shall be formed along each edge parallel to the span of one-way slabs.

(e) When the edge is built into a wall or rests on a beam, a rib at least as wide as the bearing shall be formed along the edge.

A typical ribbed slab has been described in Figures 8.9 and 8.10.

Figure 8.9 : A Typical Ribbed Slab Detailing of Reinforcement

Figure 8.10: Section *X-X* and *Y-Y* Shown on Figure 8.9

SAQ 1

(a) Why sometimes curved roofs are preferred over flat roofs?

(b) Sketch a simple slab floor.

(c) Sketch an isometric view of a flat slab.

(d) Show column strip, middle strip and panel in a flat slab.

8.3 SHELL ROOFS

Shell roof is a curved shaped structure. Singly curved (cylindrical or barrel) shells and spherical shells (domes) are more prevalent kinds of shell roofs. Because of their small flexural rigidity due to small thickness and their geometry, the load is being carried primarily by direct stresses acting along their planes. Shells are also called *stressed skin structure* for the reasons mentioned above. Ideally, main reinforcement is provided in the form of diagonal grid at the middle surface of the shell in the directions of principal stresses. However, generally, rectangular grid reinforcement is provided in place of diagonal one. In addition, square mesh reinforcement at corners for shear and top reinforcement according to end conditions at edge of diaphragms are also provided (Figures 8.11 and 8.12).

Figure 8.11 : Isometric View of a Cylindrical Shell Showing Reinforcement

Figure 8.12 : Reinforcement at Edge Member

Domes also carry loads by generating direct stresses – meridional as well as hoop stresses. Both of these stresses are compression only upto 51.48º semi-central angle – which concrete alone is capable to carry. Therefore, only nominal reinforcement in the direction of stresses are provided (Figure 8.13).

Figure 8.13 : Reinforcement in Dome

SAQ 2

(a) Explain as to why thin shells and domes are called Stressed Skin Structures?

(b) Why diagonal grid reinforcement should be ideally provided in barrel shell?

8.4 SUMMARY

A floor is always an internal horizontal surface to be used for living, office, workshop, storage, etc. whereas roof may be horizontal, inclined or curved surfaces depending upon climatic conditions, economy, aesthetic considerations, etc.

Here, in this unit, four types of horizontal RC floors such as simple slab floors, beam-slab floors, flat slab floors, and ribbed slab floors have been described. Besides, two types of curved shaped roofs, i.e. cylindrical shell and dome have also been described.

8.5 ANSWERS TO SAQs

SAQ 1

(a) Refer Section 8.1.

(b) Refer Section 8.2.

(c) Refer Section 8.2.

SAQ 2

(a) Refer Section 8.3.

(b) Refer Section 8.3.

FURTHER READING

Arora and Gupta (2004), *Building Construction*, Satya Prakashan, New Delhi.

Mantri, Sandeep (1994), *The A to Z of Practical Building Construction and Its Management*, Mantri Institute of Development and Research, Pune.

Punmia, B. C., Jain, Ashok Kumar, Jain, Arun Kumar (1993), *Building Construction*, Laxmi Publications (P) Ltd., New Delhi.

CONSTRUCTION DRAWING

Construction Drawing, aptly considered as the language of civil engineers, is the graphic medium of communication through which civil engineers communicate their ideas and views to others. These drawings are required for execution of works, sanctioning of jobs, preparing estimates of buildings and other civil engineering structures. And for the better expression and proper interpretation of ideas, you should, therefore, have thorough knowledge and perception of drawing. The objectives of this course are to provide in depth knowledge and to train you for the preparation, reading and interpretation of construction drawings.

The course has been divided into eight units.

In Unit 1, you are introduced to the basics of drawing, e.g. definition, types and requirements of drawing. Since the drawing are prepared in accordance with the rules and specifications laid down by ISO as well as BIS, this unit also enables you to get acquainted with the drawing sheet requirements, lettering, scales, dimensioning, symbols, abbreviations, etc.

Proper designing and layout of foundation requires proper assessment of site conditions, types of soil, bearing capacity of soil and load transmitted through foundation. These prerequisites of proper design and layout of foundation have been discussed in Unit 2.

Foundations form the lowermost portion of a building responsible for the transfer of the load of the building to the soil. In Unit 3, shallow as well as deep foundations have been described.

A curved structural component called arch, which bridges an opening and transfers superimposed loads to the foundation, needs proper designing. Unit 4 deals with the design and detailing of different masonry, stone, concrete and RCC arches.

Unit 5 explains different types and methods of joining frame or structure such as doors, windows, staircases, trusses, walls, floors, etc. made of wood or steel. Different types of door and window have also been discussed in this unit.

In Unit 6, architectural aspects and types of RCC stair and different types of false ceiling are described.

Unit 7 discusses different types and methods of preparation of detailed drawings of different wooden and steel trusses and their components.

Finally, Unit 8, the last unit of this course, deals with the different types of flat floors and shell roofs.

The Self Assessment Questions (SAQs) given in each unit are intended to help you check your own progress. You are advised to go through the text attentively and attempt the SAQs independently and verify your answers with those given at the end of each unit. This will definitely develop your confidence.

At the end, we wish you all the best for your all future educational endeavours.