Module III: Flooring System in Steel Structures

1. Concept of Floor System

A floor system in structural engineering typically consists of slabs (decking), secondary beams, main beams (girders), and columns. It efficiently transfers imposed floor loads to the columns and ultimately to the foundation.

Key Components

- **Slab or Decking:** The surface on which loads (people, furniture, equipment) are directly applied.
- **Secondary Beams:** Closely spaced beams that support the slab or decking, spanning between the main beams.
- **Main Beams (Girders):** Larger beams that support the secondary beams and transfer their loads to columns.
- **Columns:** Vertical structural members transferring loads from beams to the foundation.

Load Transfer Path

1. Loads act directly on the slab or decking.
2. Slab transfers loads to secondary beams.
3. Secondary beams transfer concentrated loads to main beams.
4. Main beams convey cumulative loads to columns.
5. Columns direct these loads down to the foundations.

Advantages of This System

- Allows for modular and flexible floor layouts.
- Efficient use of rolled steel sections.
- Facilitates the accommodation of services (ducts, pipes) between beams.
- Enables longer, unobstructed spans.

2. Types of Floor Systems with Steel Beams

Component	Typical Span (m)	Description
Secondary Beams	2–4	Spaced closely (1.5–3m) to support the slab
Main Beams (Girders)	6–12	Spaced wider, carry grouped loads from secondaries

Component	Typical Span (m)	Description
Columns	Variable	Located at main beam intersections

3. Design of Simply Supported Beams Using Rolled Steel Sections

Simply Supported Beams

A simply supported beam has supports at both ends and is free to rotate, with no moment restraint at those points. In floor systems, both secondary and main beams are commonly designed as simply supported.

Common Rolled Steel Sections

- **I-sections (ISMB, ISWB, UB, UC):** High flexural strength, used for primary and secondary beams.
- **Channel sections (ISMC):** Sometimes used for small span secondary beams.
- **T-sections, angles:** Used for light or infill framing.

Key Steps in Beam Design

1. Determination of Design Loads

- Calculate imposed (live) load, dead load (self-weight, slab), and any other loads (services, partitions) per code (e.g., IS 875).
- Calculate load per meter length on the beam.

2. Structural Analysis

- For a simply supported beam with uniformly distributed load $ w $ over span $ L $:
  - **Maximum Bending Moment:**
$$M_{max} = \frac{wL^2}{8}$$
  - **Maximum Shear Force:**
$$V_{max} = \frac{wL}{2}$$

3. Selection of Rolled Steel Section

- **Section Modulus ($ Z $):**
$$Z_{required} = \frac{M_{max}}{f_{b,design}}$$
  Where $ f_{b,design} $ is the design bending stress (depends on grade, code).
- Choose a standard rolled section with $ Z_{provided} \geq Z_{required} $ and check for depth, weight, and economy.
- Check for deflection ($ \Delta_{max} $) using:

$$\Delta_{max} = \frac{5wL^4}{384EI}$$

and ensure it is within permissible limits (usually span/325 or as per codes).

- Verify shear strength of the section is adequate.

4. Detailing and Connections

- End plates, cleat angles, or seat connections used at supports.
- Ensure adequate bearing length on supports.
- Provide lateral bracing if required (to prevent lateral-torsional buckling).

Example Table: Typical Design of a Simply Supported Secondary Beam

Parameter	Value / Description
Span (L)	4.0 m
Load (w)	5.0 kN/m (including self-weight)
Max Moment (M_{max})	10 kNm
Section Chosen	ISMB 200
Section Modulus (Z)	135 cm³
Permissible Bending Stress	165 MPa (for Fe410)
Max Deflection (Δ_{max})	6.5 mm (checks OK)

4. Summary Table: Floor System Elements

Element	Purpose	Typical Section
Secondary Beam	Supports slab/deck; spans between main beams	ISMB/ISMC/UB
Main Beam	Supports secondary beams; spans between columns	ISMB/ISWB/UC
Column	Transfers floor and beam loads to foundation	ISHB/UC/H-section

5. Detailing Considerations

- Ensure correct orientation of beams with respect to loading.
- Provide clear details for connections between secondary and main beams.
- Allow for service holes or web openings as needed, but check local web weakening.
- Maintain fire protection and corrosion protection as per specifications.

In conclusion, understanding the interaction between secondary beams, main beams, and columns, and the step-by-step design process for simply supported steel beams, is fundamental to the safe and economic design of modern floor systems in steel structures. Proper section selection, connection detailing, and load assessment ensure robust, serviceable, and durable floor construction.