Module-IV: Columns and Bases

1. Design of Steel Columns Under Axial Loads

Steel columns are critical vertical load-bearing members designed to support compression forces from slabs, beams, or trusses. Proper design ensures structural safety against buckling and compressive failure.

Single Rolled Steel Sections

- **Typical Sections:** ISHB, ISMB, ISJC, UC, or H-section, chosen for their high buckling resistance.
- **Design Steps:**
  1. **Calculate Factored Axial Load (Pu):** Pu = applied load × partial safety factor (as per code).
  2. **Select Section:** Using tables, check that the design compressive strength (Pd) of the section (based on buckling class and slenderness ratio) exceeds Pu.
  3. **Check Slenderness Ratio (λ):** λ = (effective length) / (least radius of gyration, r).
  4. **Verify Local Buckling:** Ensure section is adequate for local buckling by code (e.g., IS 800:2007).
  5. **Check Serviceability:** Deflection and lateral stability as required.

Multiple Rolled Steel Sections (Built-up Columns)

- Used when higher load capacity or longer column length is required.
- **Configuration:** Two or more sections (e.g., channels, angles, or beams) spaced apart and connected by lacing or batten plates.
- **Design Process:**
  - **Select Section Arrangement:** Symmetrical, to avoid torsion/buckling.
  - **Combine Section Properties:** Calculate total area, moment of inertia, and radius of gyration about principal axes.
  - **Design for Overall Stability:** As for single columns, but use combined properties.
  - **Spacing:** Adequate spacing provided to prevent local buckling.

2. Design of Lacing and Battens

Lacing

- Provides lateral stability by connecting the individual column elements in built-up columns.
- **Types:** Single or double lacing, arranged diagonally.
- **Design Guidelines:**
  - Angle of lacing typically 40–70° with axis.
  - Designed for transverse shear (usually 2.5% of axial load distributed among laces).
  - Lacing members are designed as slender compression/tension members with appropriate slenderness limits.

Battens

- Flat plates placed perpendicular to the axis to connect built-up sections.
- **Design Guidelines:**
  - Minimum of three battens in the column length.
  - Thickness and connections designed to carry transverse shear (typically 2.5% of axial load).
  - Battens spaced to limit slenderness of individual component sections.

Parameter	Lacing	Batten
Orientation	Diagonal	Perpendicular
Function	Prevent buckling, transfer shear	Prevent buckling, transfer shear
Common Use	Tall/lighter build-ups	Shorter/stockier build-ups

3. Columns Subjected to Axial Load and Bending (Beam-Columns)

Columns may also resist significant bending moments along with axial compression (due to eccentric loading, wind, seismic forces, or frame action).

Design Procedure

- **Combined Axial and Bending Check:**
  - Ensure both axial load and moment capacities are checked using appropriate interaction equations given by codes (e.g., IS 800:2007, Clause 9.3.2):
    $$\frac{P}{P_d} + \frac{M}{M_d} \leq 1.0$$
    Where $ P $ = applied load, $ P_d $ = axial strength, $ M $ = applied moment, $ M_d $ = moment strength.
  - Advanced codes provide more refined interaction checks involving shape, slenderness, and load eccentricity factors.

- **Design for Major and Minor Axis Moments:** Check capacities about both axes.
- **Serviceability:** Check deflections and second-order (P-Δ) effects if significant.

4. Design of Slab Base and Gusseted Base

Steel columns transfer loads to foundations via base plates.

Slab (Flat) Base

- Used for columns under moderate axial loads.
- **Consists of:** Thick steel base plate on a concrete pedestal, with or without holding-down bolts.
- **Design Steps:**
  1. **Base Plate Area:** $A_{base} \geq \frac{P_u}{0.45 f_{ck}}$, where f_{ck} is concrete strength.
  2. **Plate Thickness:** Designed to resist maximum bending due to load dispersion (projecting portion treated as cantilever).
  3. **Attachment:** Designed for transfer of load (welded or bolted).

Gusseted Base

- Used for columns under heavy/large loads.
- **Consists of:** Base plate supported by gusset plates and/or angles providing extra stiffness and load transfer.
- **Design Steps:**
  1. **Gusset Plate & Angle Design:** Designed to transfer both vertical loads and moments to the base plate and foundation.
  2. **Base Plate Sizing:** As per above, but allows for greater load spread and reduced plate thickness.
  3. **Anchor Bolts:** Designed for uplift, shear, and moment if present.

Base Type	Preferred When	Features
Slab (Flat)	Axial, moderate load	Simple, thick plate, economical
Gusseted	Large loads/moments	Gusset plates/angles, greater stiffness

5. Summary Table: Column and Base Design

Item	Key Points
Single Steel Column	ISHB, ISMB; check axial capacity and buckling
Built-up Column (Multi-section)	Use lacing/battens, check spacing/slenderness
Lacing/Battens	Ensure stability, transfer shear

Item	Key Points
Beam-Column (Axial + Moment)	Use interaction equations for combined loading
Slab Base	Flat plate, check area and thickness
Gusseted Base	Gusset plates/angles, for large or complex loads

In summary:
Module-IV covers the selection and design of steel columns and bases, including construction with single or built-up sections, design of lacing and battens for composite columns, column interaction with bending, and robust detailing of foundation bases for safe load transfer, all following modern structural codes and standards.