Module I: Bolted and Welded Connections

1. Introduction to Riveted, Bolted, and Welded Connections

Riveted Connections

- Traditionally used before the widespread adoption of bolting and welding.
- **Rivets** are cylindrical steel pins driven while hot through pre-drilled holes in the connected members, expanding to fill the hole as they cool.
- Not common in modern structural steelwork due to labor intensity and better alternatives.

Bolted Connections

- **Bolted joints** use high-strength bolts (HSFG – High Strength Friction Grip; black bolts for low-strength) to connect structural steel members.
- Preferred for ease, speed, and clean installation.
- Types:
  - *Bearing-type*: Shear transferred by bolt bearing on holes.
  - *Friction-type*: Shear resisted by friction between connected plates, achieved by pre-tensioned bolts.
- **Common Applications:** Beam-to-beam, beam-to-column, bracket plates.

Welded Connections

- **Welds** create joints by fusing steel parts using heat with/without filler.
- Strong, rigid, and suited for prefabrication.
- Types:
  - *Fillet welds*: Triangular cross-section, common for lap, tee, and corner joints.
  - *Butt welds*: Joining ends of plates typically in the same plane.

2. Design of Bolted and Welded Connections

Bolted Connection Design

- **Design Strength in Shear & Bearing:**
  - Calculated using code provisions (e.g., IS 800, AISC, Eurocode).
- **Bolt Arrangement:** Symmetrical for load balance.

- **Edge and Pitch Distances:** Sufficient distances to prevent tear-out, failure.
- **Gusset Plates/Bracket Plates:** Distribute forces, increase connection strength.

Steps:

1. Determine type and number of bolts required based on the design load.
2. Check bolts for shear, bearing, and tension as relevant.
3. Check connection plates for block shear and bearing.
4. Ensure minimum edge, end, and pitch distances per standards.

Welded Connection Design

- **Fillet Weld:** Strength calculated from effective throat and length.
- **Butt Weld:** Assumes full-section strength when properly executed.
- **Throat Thickness:** Minimum = 0.7 × weld size (for fillet weld).
- **Weld Length:** Sufficient to transfer designed force.
- **Weld Types:**
  - Intermittent, continuous (based on requirement).

Steps:

1. Calculate total length/throat required based on design force and allowable weld stress.
2. Layout welds to ensure balanced force transfer.
3. Detail weld types and sizes clearly in fabrication drawings.

3. Axially and Eccentrically Loaded Joints

Axially Loaded Joints

- Load acts through the centroid of the connection.
- Simpler analysis; bolts/welds resist direct shear (and/or tension, where relevant).

Eccentrically Loaded Joints

- Load does not pass through centroid; causes additional moment.
- Bolts/welds subject to combined shear and tension.
- **Design Approach:**
  - Calculate force in each bolt/weld considering direct load and secondary moments.
  - Use vector addition for resultant force.
  - Check each bolt/weld for combined effects.

4. Simple Connection of Bracket Plates to Columns

- **Bracket Plate:** Projects from a column to support beams, machinery, or platforms.
- **Design Steps:**
  - Analyze applied loads (shear, moment).
  - Design bolts/welds/plates to safely transmit loads into the column.
  - Check for prying action and local column web/flange strengths.
- **Details:** Use stiffeners if plate thickness is inadequate; check for plate bending.

5. Beam to Beam and Beam to Column Connections

Beam to Beam (Secondary to Primary)

- Types: Simple end-plate, cleat angle, seated connections.
- Bolted or welded, designed to transfer shear (and sometimes end reaction moments).

Beam to Column

- **Shear Connections (Simple):** Transfer shear only (common in simple construction).
- **Moment Connections (Rigid):** Transfer shear and moment (for rigid frames).
- End-plate or angle cleat connections are common.
- **Stiffeners** may be required for columns supporting heavy loads/moments.

6. Framed, Unstiffened, and Stiffened Seat Connections

Framed Connection

- Beam connected to column/flange using angle or end-plate; designed for shear transfer.

Seat Connections

Unstiffened Seat

- **Unstiffened Seat**: A single angle or plate supports beam end; simple to fabricate and install.
- Limited to light or moderate loads.

Stiffened Seat

- **Stiffened Seat**: Incorporates an additional vertical stiffener plate to resist higher loads.
- Increases capacity and reduces seat deformation.

Connection Type	Key Features	Typical Use
Framed	Angle/end-plate, shear	Most steel structures

Connection Type	Key Features	Typical Use
Unstiffened Seat	Simple angle/plate support	Light beam connections
Stiffened Seat	With vertical stiffener	Heavy loaded beam ends

7. Summary Table: Connection Types

Connection Type	Transfer Force Types	Typical Details
Bolted	Shear/tension/bearing	Bolts, spacing, edge distances
Welded	Shear/tension	Fillet/butt welds, length
Axial/Eccentric	Shear and/or moment	Bolt/weld layout for moments
Bracket to Column	Shear/bending/moment	Plate size, bolts, stiffeners
Beam to Beam/Column	Shear ± moment	End-plates, cleats, seat
Seat (Unstif./Stif.)	Vertical reaction/shear	Angles, stiffener plates

Conclusion:
A fundamental understanding of bolted and welded connections in steel structures is critical. Proper design ensures reliable, safe, and cost-effective connections for direct (axial) and complex (eccentric, moment) loads in building and infrastructure systems.