Steel Structures

For

Civil Engineering

By

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Syllabus for Steel Structures

Analysis and Design of Tension and Compression Members, Beams and Beam- Columns, Column Bases. Connections- Simple and Eccentric, Beams Column Connections, Plate Girders and Trusses. Plastic Analysis of Beams and Frames.

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"Learn from yesterday, live for today
hope for tomorrow."

.... Albert Einstein

CHAPTER 1

Introduction to Steel Structures

Learning Objectives

After reading this chapter, you will know:

1. Steel Structures
2. Types of Steels
3. Bolted Connections
4. Terminology
5. Types of Bolted Connections

Introduction to Steel Structures

Structural steel is a material used for steel construction, which is formed with a specific shape following certain standards of chemical composition and strength. They can also be defined as hot rolled products, with a cross section of special form like angles, channels and beams/joints. There has been an increasing demand for structural steel for construction purposes in the United States and India.

Measures are been taken by the structural steel authority for ready availability of structural steel on time for the various projects. The people at every level are working hard to realize the purpose of producing steel on time, like, service centers, producers, fabricators and erectors along with the general contractors, engineers and architects are all working hand in hand. Steel has always been more preferred to concrete because steel offers better tension and compression thus resulting in lighter construction.

The structural steel all over the world pre-dominates the construction scenario. This material has been exhaustively used in various constructions all over the world because of its various specific characteristics that are very much ideally suited for construction. Structural steel is durable and can be well molded to give the desired shape to give an ultimate look to the structure that has been constructed.

Advantages and Disadvantages of Steel Structures

Advantages:

- High strength per unit mass
- High quality and durability
- Easily repairable and reusable

Disadvantages:

- Corrosion susceptible
- High maintenance cost
- Costly

Types of Steels

Though many varieties of steel can be produced by adding different percentages of admixture like carbon, manganese, chromium etc. However, structural steel is broadly divided in two categories viz., mild steel and high tensile steel.

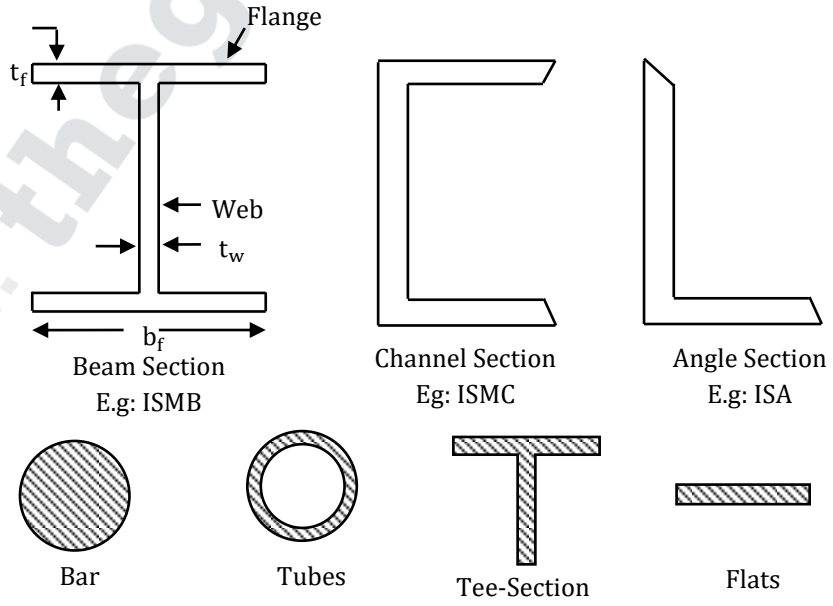
Properties of Structural Steel

1. **Physical Properties**
   - Density $\rho = 7850\ kg/m^3$
   - Modulus of elasticity $E = 2 \times 10^5\ N/mm^2$
   - Poisson's ratio, $\mu = 0.3$
   - Modulus of rigidity $G = 0.769 \times 10^5\ N/mm^2$
   - Co-efficient of thermal expansion $\alpha = 12 \times 10^{-6}\ /\ ℃$
2. **Mechanical Properties**
   - Yield stress
   - The tensile or Ultimate stress (f_u)
   - Maximum allowable strain
   - Toughness

Types of Sections Available in the Market are listed as below

Types of Standard Steel Sections

1. Rolled Steel I – section (Beam sections) (ISHB,ISMB, ISLB, ISWB)
2. Rolled steel channel sections (ISMC, ISLC etc.)
3. Rolled steel angle sections (ISA)
4. Rolled steel tee sections
5. Rolled steel bars
6. Rolled steel tubes
7. Flats
8. Sheets and strips



Design Philosophies

1. Working stress method (WSM)
2. Ultimate load design (ULD)
3. Limit state design (LSD)

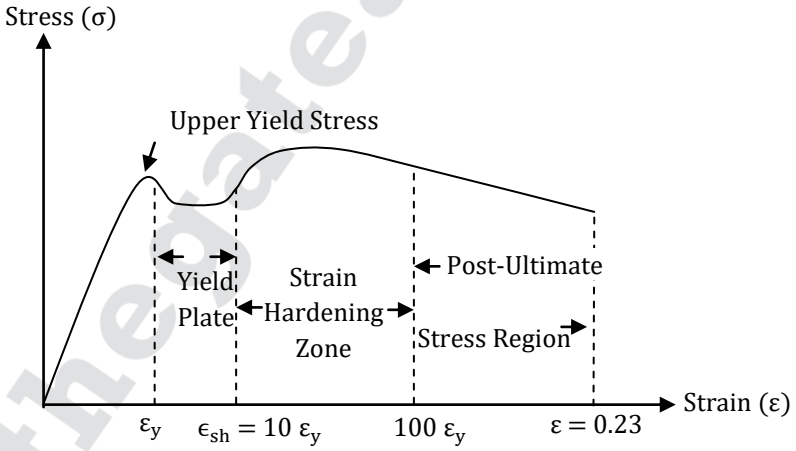
1. **Working Stress Method (IS 800:984):** In this method the stress strain relationship is considered linear till the yield stress. Though the method is simple and reliable, it has following limitations
   a. It gives highly conservative result by considering the failure at yield stress, which is not true because just the formation of plastic hinge can't be considered as failure and the structural member can resist even more stress.
   b. Uneconomical sections are suggested by WSM.

2. **Limit State Design (IS 800:2007):** This method takes care of both strength and severability requirements. IS:800-2007 recommends reduction in the strength of materials by a partial safety factor

$$\gamma_m = \frac{S_u}{S_d} \Rightarrow S_d = \frac{S_u}{\gamma_m}$$

Where, S_u = Ultimate strength
S_d = Design strength
$\gamma_m = 1.10$ for yielding and buckling criteria
$= 1.25$ for ultimate strength criteria

The Stress- Strain Curve of Steel



Normally $\varepsilon_y = 0.00125$ or 0.125%

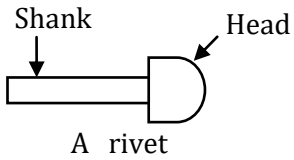
$\varepsilon_{sh} = 5\ \varepsilon_y$ to $15\varepsilon_y$ (Depending on the steel)

- Initial slope of the strain – Hardening part of the curve is called strain-hardening modulus E_{sh}
  Generally, $\frac{E_{sh}}{E} = \frac{1}{30}$ to $\frac{1}{100}$
- The value of $\frac{\text{Upper yield stress}}{\text{Lower yield stress}} = 1.05$ to 1.10

Bolted Connections

The following three types of connections used in steel structures

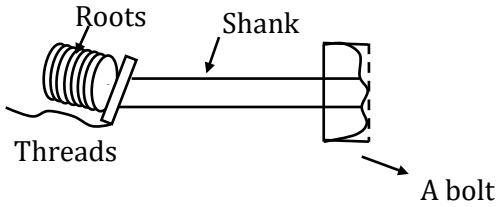
1. Riveted
2. Bolted
3. Welded



1. Riveted Connections

- Size of a rivet indicates the diameter of its shank
- For rivets up to size 25 mm, diameter of hole = Diameter of rivet + 1.5 mm.
  For rivet up to size more than 25 mm, Diameter of hole = Diameter of rivet + 2 mm.
- Installation causes noise and needs heating of rivet. Inspection requires for skilled work.
- Cold driven rivet of diameter more than 10 mm are not permitted.

2. Bolted Connections



- Preferred in almost all the cases where structure is subjected to vibration, expect the size of bolts represents the diameter of bolts in the part unthreaded (shank).

Types of Bolts

(a) **Unfinished (Black Bolts)**

- Commonly hexagonal or square headed
- Made of medium or low carbon steel
- M 16 means a standard bolt of diameter of 16mm specifications of which are given in IS 1364 part (1)

(b) **Finished (Turned Bolts)**

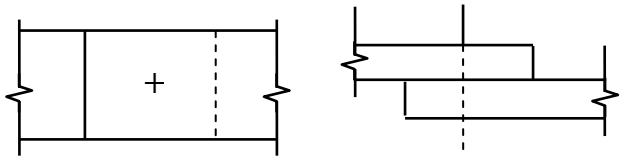
- Formed from hexagonal rods
- Also known as close tolerance bolts
  Sometimes to prevent slip, close tolerance bolts with a oversize of 0.15 to 0.2mm is provided in holes, which may cause difficulty in alignment and delay in the progress of work.

(c) **High Strength Friction Grip (HSFG) Bolts**

- Also called HYSD (High yield strength deformed bolts).
- Washers are used to introduce initial tension, this tension induced in the bolts causes initial friction between the two connected plates.
- No slip occurs in the joint made with these bolts.

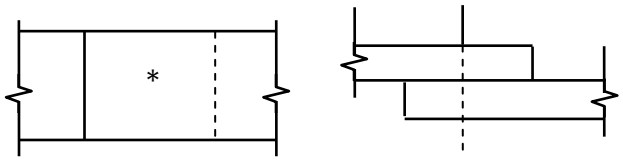
Some Convention Symbols

1. Rivet General

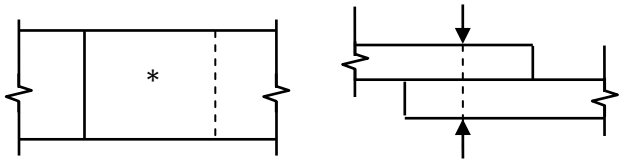


Plan Section

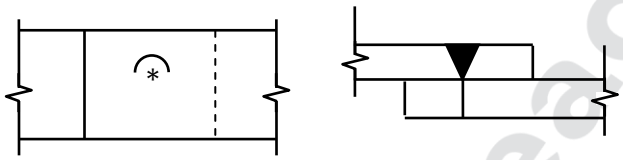
2. Bolt General



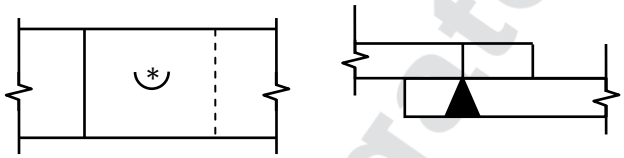
3. Bolt to Distinguish from Rivet



4. Bolt Head Counter Sunk on Front Side

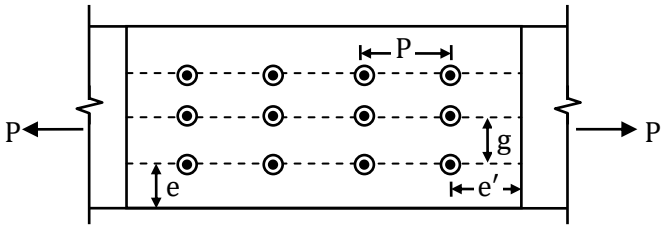


5. Bolt Head Counter Sunk on Back Side



Terminology

1. **Normal Diameter (d):** The diameter of the unthread portion of the shank of bolt or rivet.
2. **Effective Diameter or Gross Diameters**
   For rivet: Diameter of the hole it fills after riveting.
   For bolts: Equal to the nominal diameter.
3. **Net Area:** Area at the root of the thread of the bolt.
4. **Pitch (P):** Centre to centre spacing of the bolts in a row, measured along the direction of load.
5. **Gauge (g):** Centre to centre spacing of the bolts of adjacent rows, measured perpendicular to the direction of load.
6. **Edge Distance (e):** Distance of centre of bolt hole from the adjacent edge of the plate.
7. **End Distance (e′):** Distance of the plate bolt in the direction of load.



8. **Proof Load:** Initial tension in HSFG bolts.
9. **Slip Factor:** Coefficient of friction in case of connection with HSFG bolts

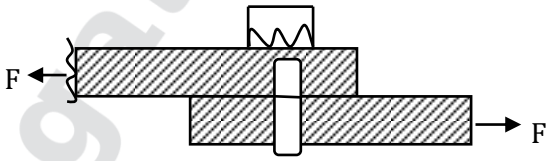
IS 800:2007 Specifications for Spacing and Edge Distances of Bolt Holes

1. Minimum pitch 'p_{min}' = 2.5d where d = Nominal diameter of bolt.
2. Maximum pitch (Minimum of following):
   - 16t or 200 mm → For tension members
   - 12 t or 200 mm → For compression members
   - In case of staggered bolts, 'p' may be increased by 50% of above cases
     Where, t = Thickness of the thinner plate of the two
3. Maximum gauge distance 'g' = 100 + 4t or 200 mm whichever is less
4. Minimum edge distance
   = 1.7 × d_0 (d_0 = Diameter of hole)→For sheared or hand flame cut edge
   = 1.5 d_0→ for rolled, machine flame cut

Types of Bolted Connections

1. Lap Joint

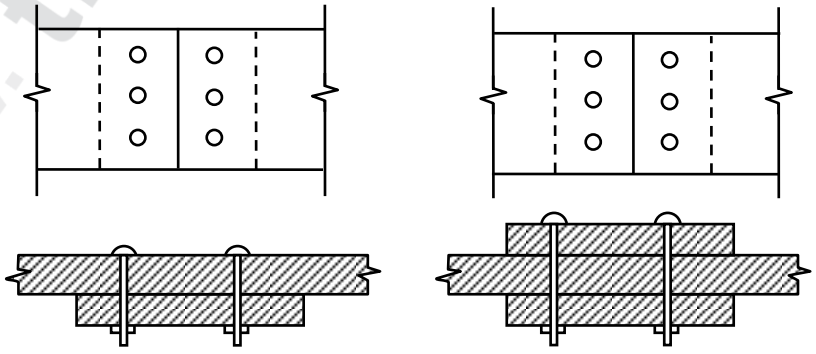
- In this type the plates to be connected overlap each other
- May be have a single row, staggered or chain riveting
- Simplest



A Lap Joint

2. Butt Joint

In this type, the two main plates to be connected against each other and the connections are made by providing a cover plate on one or both sides of joint.



(a) Single Cover Butt Joint **(b) Double Cover Butt**