CHAPTER-1
STRUCTURAL STEEL AND SECTION

❖ STEEL AS A CONSTRUCTION MATERIAL:-

- The material steel, is an alloy of iron and carbon (small percentage) and other elements e.g. silicon, phosphorus and sulphur in varying percentages.
- Steel is generally manufactured by Open hearth process, Electric process, Bessemer process. Concentration process, Basic oxygen process or combination of above processes.
- Pure iron is very soft, therefore when carbon is added to iron (chemically combined with iron), it forms iron carbide known as Cementite.
- Maximum limit of carbon in steel is limited to 1.5%.

➢ Various tests are conducted in the laboratory to determine the following properties of steel and its behaviour:-

1. Physical properties
2. Chemical properties
3. Mechanical properties.

➢ Factors affecting the physical properties of steel:-

1. Percentage of carbon:- More percentage of carbon increases the hardness and strength of steel but decreases its ductility at the same time. For structural steel (mild steel) having carbon content 0.1 to 0.25% is normally used with maximum limit of 1.5%.

2. Presence of impurities:- the main impurities in steel are silicon, sulphur, phosphorus and manganese

- percentage of silicon from 0.3 to 0.4% in the steel, it increases elasticity and strength of steel without much reduction in its ductility.
- Presence of sulphur than 0.02 to 0.10% has negligible effect on the ductility and strength of steel. If the percentage of sulphur increases beyond permissible limit, then it decreases the strength and ductility of steel.
- Phosphorus is not helpful in improving the strength of steel. Infact, it is harmful because it reduces the toughness, strength and ductility of steel. Therefore, the percentage of phosphorus should be limited to 0.12%.
- Manganese, if present in steel, increases its strength. The percentage of maganese range from 0.3% to 1.0% is desirable. But if the quantity is more than 1.5%, then steel looses its strength and becomes brittle.

3. Type of heat treatment:- The heat treatment hardens the outer shell whereas the inner core remains soft. This type of treatment gives dual advantage of strength and ductility.

➢ Mechanical properties of steel:-

1. Elasticity:- Elasticity is the property of the material by virtue of which it regains its original shape and size on the removal of loads. Structural steel must have elasticity.

2. Plasticity:- Plasticity is the property of steel by virtue of which, it retains the deformed shape even after the removal of the applied loads.

3. Ductility:- Ductility is an essential property of steel as it helps in uniform distribution of stresses, thereby reducing the stress concentrations. ductility may be defined as the property of steel by virtue of which it can be drawn into thin wires. Permanently, without breaking (or rupture) on the application of tensile load.

4. Brittleness:- The property of steel by virtue of which it can be ruptured with little or no plastic deformation is called brittleness. As the percentage of carbon in steel increases, brittleness increases but its ductility decreases.

5. Malleability:- It is the property of a material by virtue of which it can be rolled into thin sheets without rupture.

6. Hardness:- It is the property of a material by virtue of which it can resist abrasion (wear), machining. scratching and indentations (penetration by harder materials) etc.

7. Toughness:- Toughness is the property in steel by virtue of which it can be bent, twisted or stretched under a high stress before failure. Toughness indicates the amount of energy stored by the material before it ruptures.

8. Elastic toughness:- Elastic toughness is the amount of energy stored per unit volume of the stressed material when it is stressed upto the elastic limit, It can be obtained from the area under the stress strain graph within the elastic limit (It is also known as modulus of resilience.

9. Fatigue:- It is the property of steel in which failure of material, due to repeated application of stress, is less than the ultimate stress. The maximum stress that a material can withstand without failure for a specific large number of cycles is called its fatigue or endurance limit. This type of failure generally occurs in rigid members of a steel structure subjected to vibrations.

10. Creep:- The continuous deformations of a material under a constant load at high temperature is known as creep.

❖ **STRUCTURAL STEEL:-** Depending upon the chemical composition, the different types of steel are classified as mild steel, medium carbon steel, high carbon steel, low alloy steel and high alloy steel. The mild steel, medium carbon steel and low alloy steel are generally used for steel structures.

Structural steel to be used for structural members for building purposes, has been standardised by Indian Standard Institution (I.S.I.).

- **Specification of various qualities are contained in the following standards (as per IS: 800- 1984, Clause 2.1):-**

I. IS 2261975 Structural steel (Standard quality)
II. IS 1977-1975 Structural steel (Ordinary quality)
III. IS: 20621984 Weldable structural steel (Fusion welding)
IV. IS: 961-1975 Structural steel (High tensile)
V. IS: 960-1977 Weldable structural steel (Medium and high strength qualities).

Standard quality steel (mild steel) is the most commonly used steel for general construction purposes of buildings, railway bridges, transmission line towers, industrial structures etc. Mild steel is used for the manufacture of rolled steel structural sections, rivets and bolts because following operations can be done easily.

I. Cutting , II. Machining , III. Drilling
IV. Welding , V. Punching , VI. Forging when heated.

➢ Advantages and disadvantages of steel as structural material:-

- The steel members have high strength and for this reason, they can resist heavy loads with comparatively light weight and small size of members.
- The steel members are gas and water tight because of high density of steel.
- The steel members can be conveniently handled and transported because of small sizes and light weights.
- The steel members have long service life because of high density and homogeneous strength.
- The steel members can be inspected conveniently and quickly.
- If maintained properly, steel structures have a long life.
- The existing steel structures and structural components may be strengthened by connecting additional sections or plates.
- The steel members can be easily replaced, assembled and disassembled.
- Additions and alternations can be made easily to steel structures.
- As the properties of steel do not change much with time, it makes steel as the most stable and suitable material for steel structures.
- Steel structures can be erected at a faster rate.
- It provides better strength to weight ratio.
- Steel being a ductile material does not have sudden failure, rather it gives clear indication by deflection before failure.

➢ Disadvantages of steel as a structural material:-

- The initial cost of steel structures is high.
- The steel members are prone to corrosion, therefore they require some frequent treatment like painting and other methods for their protection.

➢ Physical properties:-

I. Unit weight of steel = 78430 to 79000 N/m^3
II. Co-efficient of thermal contraction or expansion (a) = 12 X 10^{-6}/°C
III. Youngs modulus of elasticity, (E) = 2.04 to 2.18 X 10^5 N/mm^2
IV. Modulus of rigidity = 0.84 to 0.98 X 10^5 N/mm^2

❖ STRUCTURAL STEEL SECTIONS:-

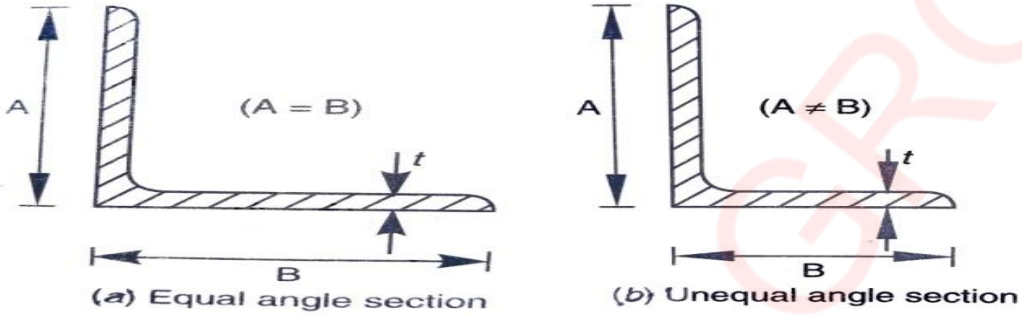
Some common rolled steel sections, which have been standardized by Bureau of Indian Standards (BIS), have been listed below:-

1. Angle section , 2. I-section or Beams , 3. Channel sections
4. Tee sections , 5. Rolled steel bars , 6. Rolled steel flats
7. Rolled steel plates , 8. Rolled steel sheets and strips , 9. Rolled steel tubes, etc.

1. Rolled steel angle sections:-

The rolled steel angle sections are classified into the following three series.

I. Indian Standard Equal Angles.
II. Indian Standard Unequal Angles
III. Indian Standard Bulb Angles.



(a) Equal angle section (b) Unequal angle section

For example:-

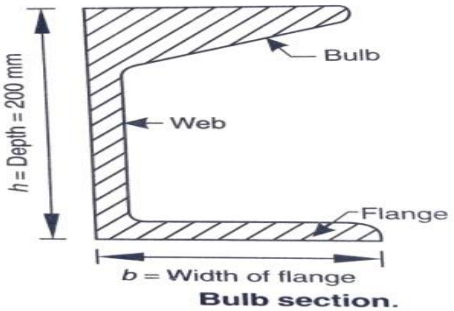
I. ISA 100 X 100 X 6 mm is an equal angle with both legs 100 mm long and thickness of 6 mm throughout.
II. ISA 100 X 75 X 6 mm is an unequal angle with longer leg 100 mm and shorter leg of 75 mm with thickness of 6 mm throughout.

Uses:-

- These angle sections are used as compression and tension members in trusses.
- Angles combined with plates form heavy girders
- Two angles along with tracking rivets can be used to carry heavy loads.
- Stanchions (columns) can be made by four angles connected by lacing, to form box.
- Angle sections are used as connecting elements to join beams to columns.

III. Bulb angle section:-

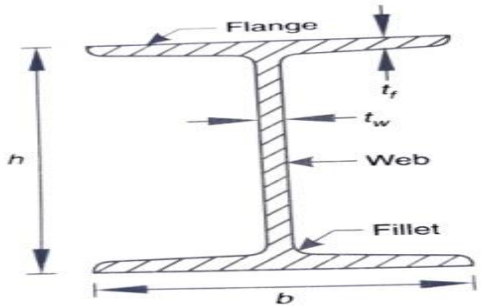
- The bulb angle section shown in Fig. 1.3 consists of web, flange and on one end of web a bulb project on.
- They are used in special cases like ship building and to stiffen the outstanding leg under compression.
- This type of member with a bulb is designated with prefix ISBA along with the depth of the section and weight per metre length (N/m) of the section.



Bulb section.

For example:- ISBA 200 @ 282 N/m means overall depth of angle section = 200 mm whereas it has weight of 282 N for 1 metre length.

2. Rolled steel I-sections or beams:-



Beam section.

- Sections are also known as rolled steel joists.
- The shape of I-section is best suitable for resisting shear force and bending moments.
- The beam section consists of a web and two flanges.
- The junction between the flange and the web is known as fillet,

where, h = height or depth of I-section , b = width of flange
t_W = thickness of web , t_F = thickness of flange.

In an I-section about, 80% of the bending moment is resisted by flanges.
about 95% of the shear force is resisted by the web of I-section.

The rolled steel beams are classified into following four series as per BIS: (IS: 808 - 1989):-

I. Indian Standard Junior Beams (ISJB)
II. Indian Standard Light Beams (ISLB)
III. Indian Standard Medium Beams (ISMB)
IV. Indian Standard Wide flange Beams (ISWB).

- **The rolled steel columns or heavy weight beams are classified into two series as per (IS: 808 - 1989):-**

I. Indian Standard Column Section (ISSC) , II. Indian Standard Heavy Weight Beams (ISHB).

For example:- ISMB 250 @ 365.9 N/m
Prefix ISMB stands for Indian Standard Medium Beam, with an overall depth of 250 mm and its weight per metre length 365.9 N

Uses: Following are the main uses of I-sections.
I. They are used as beams and columns.
II. Rolled steel beams are mainly used to resist bending.
III. The rolled steel beams are used independently to resist axial forces (i.e. compressive and tensile).
IV. These are also used in the construction of built up sections to form heavy beam and column sections.

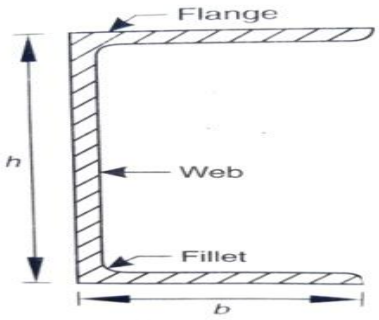
3. Rolled steel channel sections:-

The channel section consists of a web and two flanges. The juction between the flange and the web is known as fillet.

Where, b = Width of the channel , h = Height/Depth of the channel.

- **The rolled steel channel sections are classified in the following three categories as per ISI:-**

1. Indian Standard Junior Channels (ISJC)
2. Indian Standard Light Channels (ISLC)
3. Indian Standard Medium Channels (ISMC).



Channel section.

For example: ISJC 200 @ 136.4 N/m , ISJC stands for Indian Standard Junior Channel Section with overall depth of 200 mm and weight for one metre length is 136.4 N.

Uses:- Following are the main uses of channel sections.

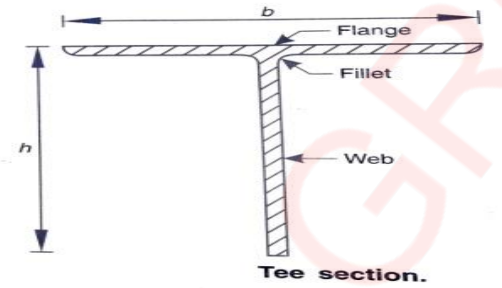
- The channel sections are used as elements to resist bending in case of purlins in the trusses of industrial building.
- Channel sections are commonly used as members subjected to axial compression (i.e. columns) in the form of built up sections of two channels connected by batten plates or perforated cover plates.
- Double channel members are often used for bridge truss members.

4. Rolled steel tee sections:-

1. Indian Standard Normal Tee bars/section (ISNT)
2. Indian Standard Wide Flange Tee bars (ISHT)
3. Indian Standard long legged Tee bars (ISST)
4. Indian Standard Light Tee bars (ISLT)
5. Indian Standard Junior Tee bars (ISJT)

Tee section consists of a web and a flange. The function between the flange and the web is known as fillet,

For example:- ISHT 150 @ 288.4 N/m. , ISHT means an Indian Standard Wide flange Tee bar with overall depth of 150 mm and weight 288.4 N per metre length.



Tee section.

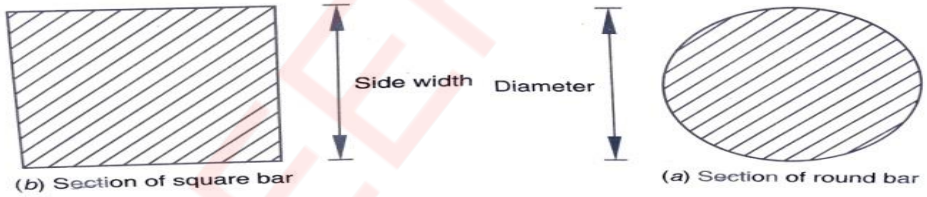
Uses:- Following are the main uses of T-sections.

- T-sections are used as compression or tension members.
- T-sections are used in the frames of doors and windows etc.
- T-sections are used to transmit bracket loads to the columns.
- These are used with flat strips to connect plates in the steel rectangular tanks.

5. Rolled steel bars:-

These types of rolled steel bars are classified into following two series.

1. Indian Standard Square bars (ISSQ) , 2. Indian Standard Round bars (ISRO).



For example: ISRO 10 , ISRO 10 stands for Indian Standard Round bar of 10 mm diameter. (ii) Square bars are designated by their class followed by side (in mm)

For example: ISSQ 10 , ISSQ stands for Indian Standard Square bars with side of 10 mm.

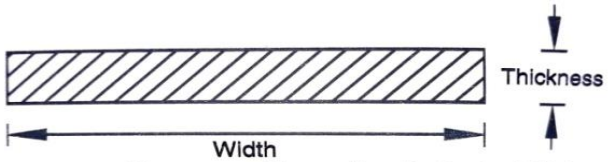
Uses :-

- Rolled steel round bars are generally used as reinforcement in RCC works.
- Rolled steel bars are used as ties and lateral bracing of two members.
- Bars threaded at the ends or hooked at the ends are used as tension membersSS-12
- Square bars are also used for making grills of windows.
- Rolled steel bars are also used to make furniture.

6. Rolled steel Indian Standard Flats (ISF):-

The thickness of flats is greater than or equal to 5 mm but their width can vary upto 250 mm.

For example:- 50 ISF 8 means a flat of width 50 mm and thickness 8 mm



Cross-section of rolled steel flat.

Uses:-

- Flats are never used alone as load bearing structural member except where loads are very light in nature.
- Rolled steel flats are also used as tension members.
- Rolled steel flats are used as lattice bars for lacing the built up columns. (
- These are used as parts of compound section in flexural members and both for compression and tension members.

7. Rolled steel plates:- The rolled steel sheets and plates are widely used in construction of steel structures. Any section of the required dimensions, thickness and configuration can be made by welding or riveting the separate plates depending upon the load coming over the member. The thickness of plates is greater than 5 mm.

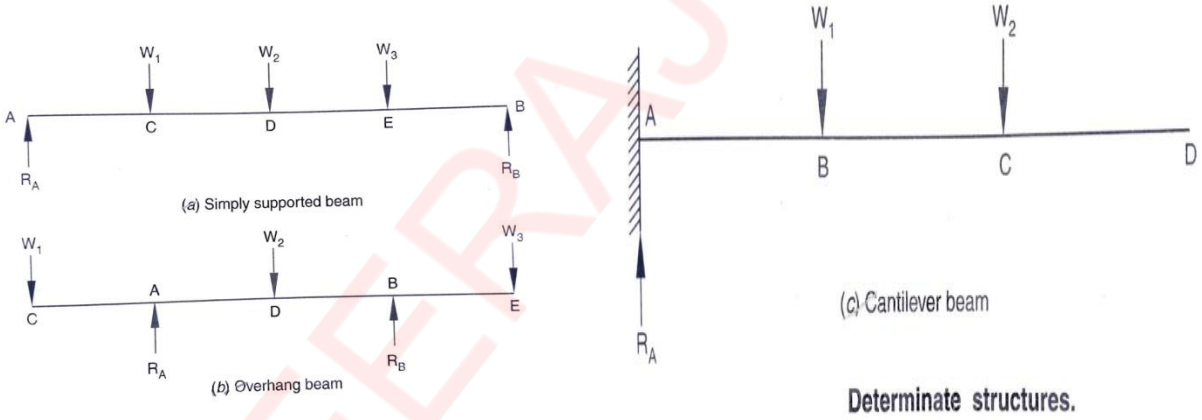
For example:- ISPL 2000 mm x 1000 mm x 6 mm indicates that the plate is 2000 mm long, 1000 mm wide and 6 mm thick.

Uses:-

- The rolled steel plates are used in the web and the flanges of plate girders.
- Steel plates are used in special steel structures like shells, steel tanks and chimneys.

❖ **Determinate structures:-** The structures which can be analyzed by using the three equations of equilibrium are known as statically determinate structures.

For example:- Simply supported beam, overhang beam and cantilever beam are examples of statically determinate structures (as shown in Fig 1.10 (a), (b) and (c)).



Determinate structures.

❖ **Indeterminate structures:-** The structures which can not be analyzed by using the three equations of equilibrium are known as indeterminate structures.

For example:- Continuous beams and fixed beams as shown in Fig.