STEEL STRUCTURES

By Vijyat Pahwa Sir

MADE BY SUMIT GUPTA
YEAR : 2024 PRIME BATCH
BATCH : L6
GATE + ESE

Topics

1. General Design Consideration (Basic)
2. Design of Simple Bolted Connection
3. Design of simple Welded Connection
4. Design of eccentric connection

} Part-I

5. Design of Tension member
6. Design of Compression member
7. Plastic analysis of beam & frame.
8. Design of Flexural member

} Part-II

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9. Design of Girder (Plate Girder, Gantry Girder)
10. Industrial Roof system (Purlin, Bracing)

} Part-III ESE

Material :- 1.) Class notes

2.) Book → SK Duggal (LSM) - IV

3.) IS 800 : 2007

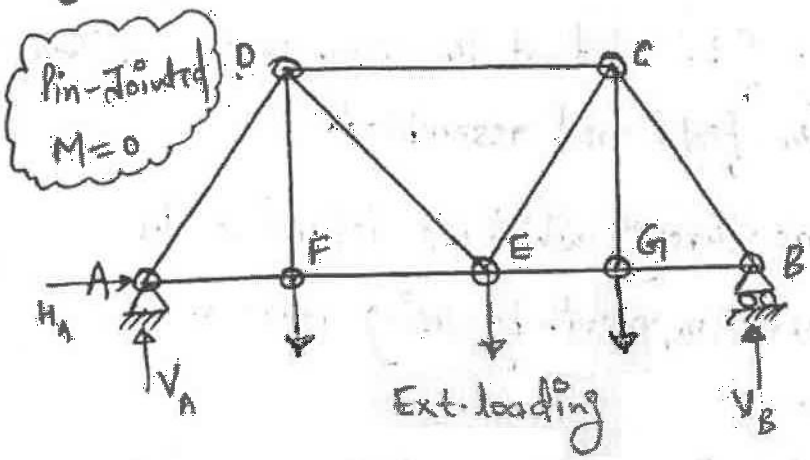
4.) IS 808 → Structural Steel Geometric Data

CHAPTER-1, GENERAL DESIGN CONSIDERATION

1.1, Introduction

- Steel Structure :- It can be defined as the assemblage of various structural members which are interconnected with each other in an organised pattern. So that the structural components can sustain and transfer the upcoming load effects.

e.g- (a) Steel truss



A, B, C, D, E, F, G → Nodal point or Joint.

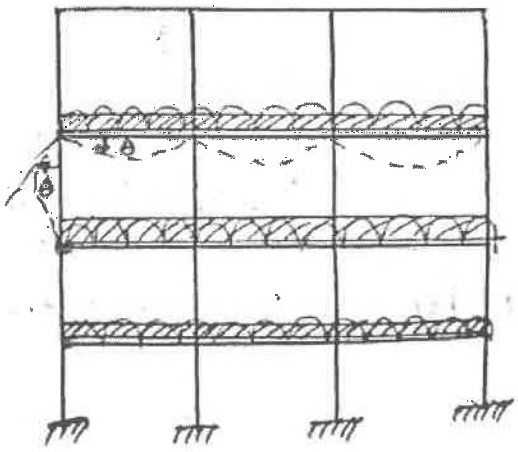
AD, DC, BC, AE, EB, DE, CG → Structural member.

→ Trusses are the pin jointed structures in which the load effects are :-
- in Connection → Direct Force
- in Members → Axial Tension, Axial Compression.

Note :- In trusses, the external load is transferred through the nodal points only.

(b) Rigid Jointed Steel frame.

→ In steel frames, vertical members are called as Columns and horizontal members are called as Beams & they are rigidly connected with each other.



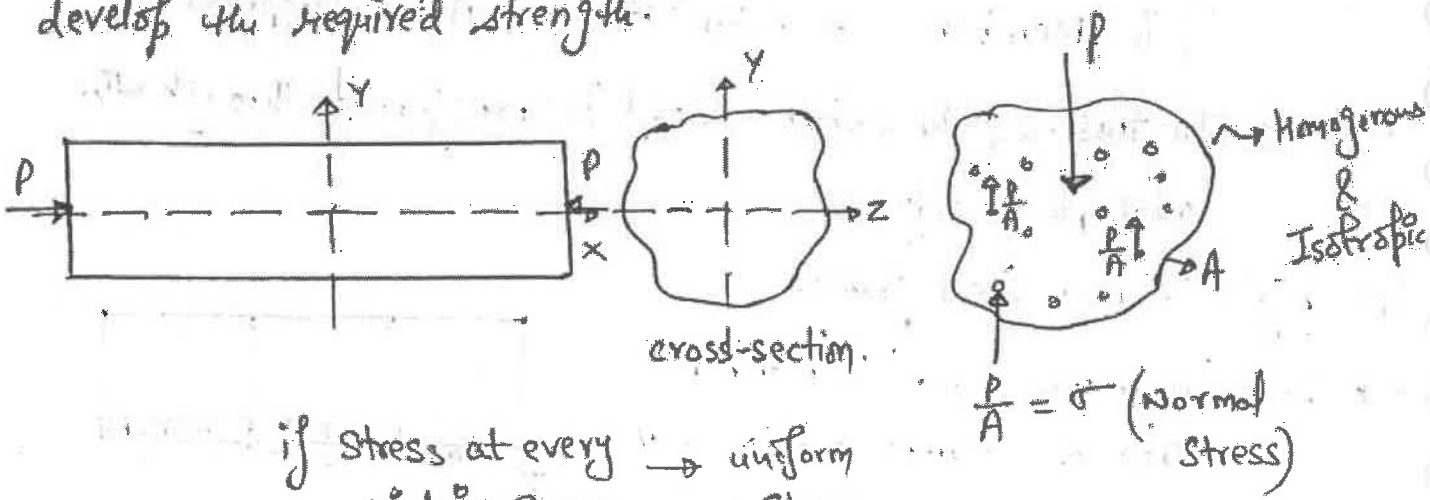
→ The load effects are :-

- Beam → Shear force & Bending moment
- Column → Axial compression & Bending moment.
- Connection → Direct force + Moment.

Note :- Connections are considered more important structural component than the members. Hence, in the design larger value of safety factors will be taken for the connections.

Note :- Connections are generally fabricated at the workshop. and then they are transported to the field and assembled.

- Analysis :- It is the procedure through which we determine the load effects in any structural component. by using force and moment equilibrium equations.
- Design :- Design is a procedure in which we select appropriate cross-section size, shape and material so that the c/s is able to develop the required strength.



if Stress at every point is Same → uniform Stress.

→ For safety, Load effect ≤ Strength of c/s.

* Design objectives -

(i) Safety → Safety can be attained by either overestimating the upcoming loads or by underestimating the material strength.

(ii) Serviceibility → It is defined as the ability of the structure to provide comfort to the user during its service life.

Serviceibility includes following parameters :-

- Deflection
- Vibration
- Corrosion, and
- Fire resistance.

(iii) Economy → The structure designed should be within the budget of client.

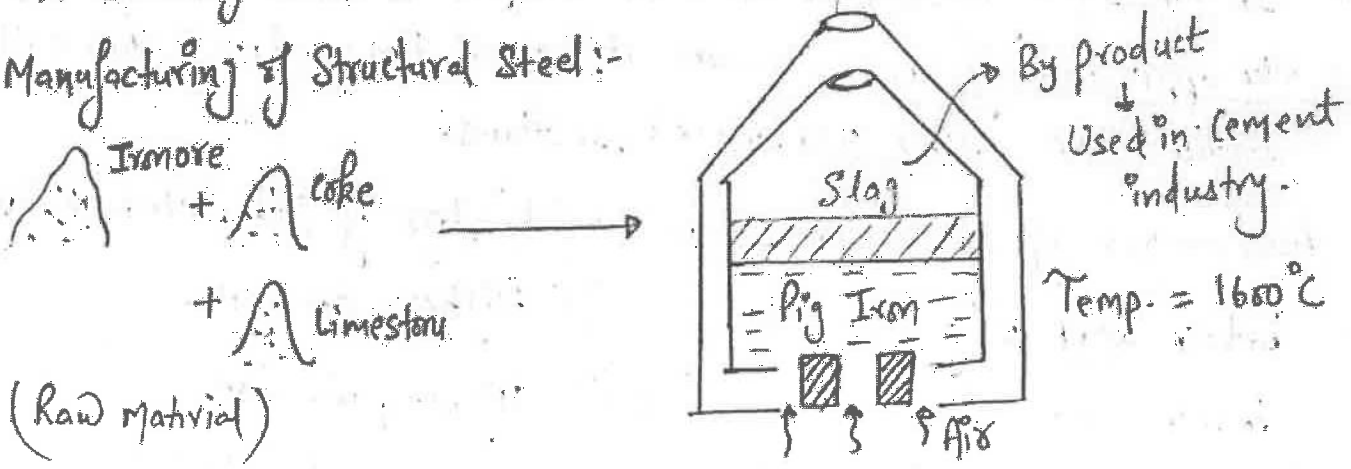
(iv) Aesthetics → Welded connections are preferred over the bolted conn.

(v) Durability

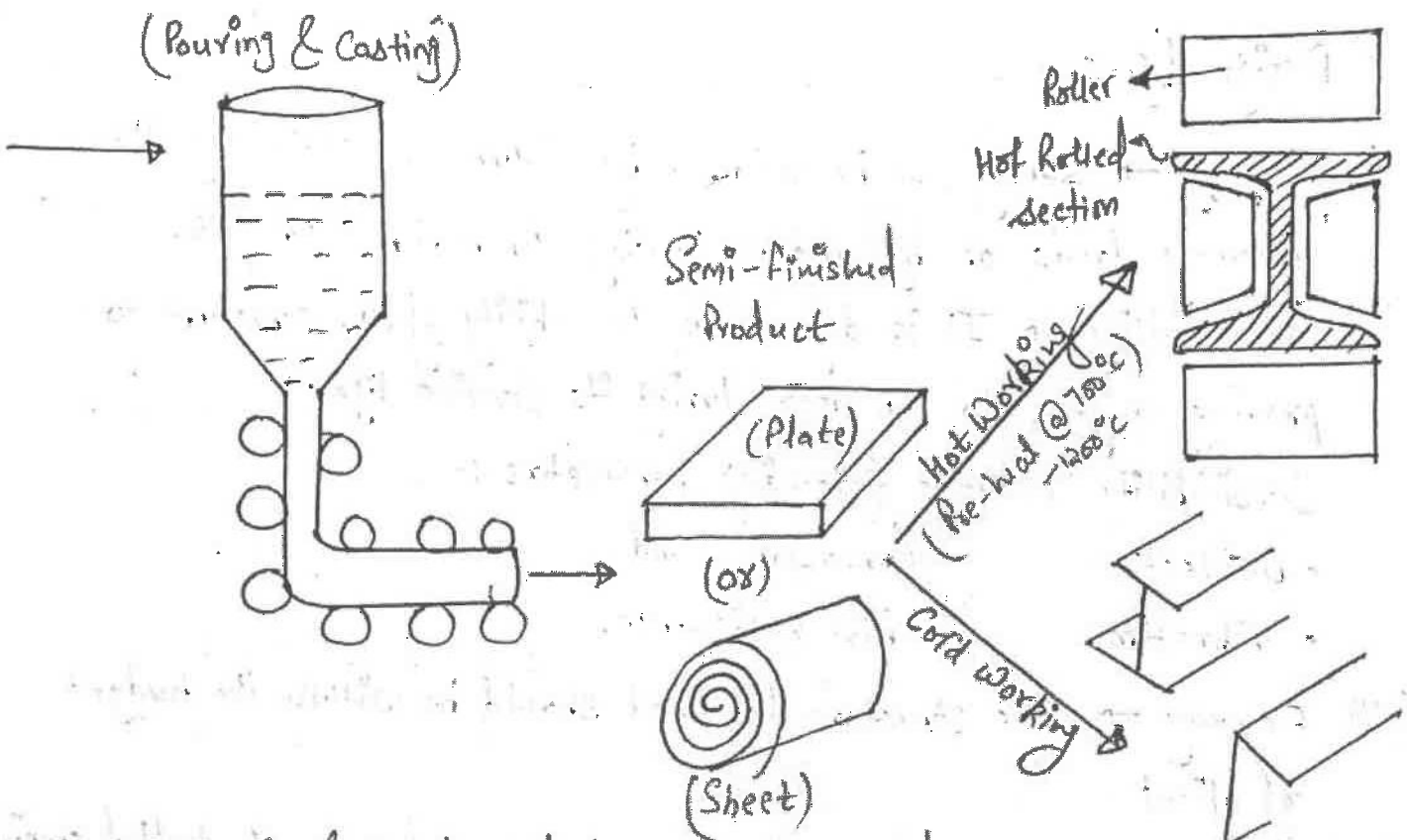
1.2 Structural Steel

→ It is that category of steel which is used in load bearing frames in building and as members in trusses and bridges.

* Manufacturing of Structural Steel :-



- Fe (Iron) = 98%
- Carbon (C) = 0.1% - 1.1%
- Phosphorus = 0.025% - 0.05%
- Sulphur = 0.025% - 0.05%
- Manganese = 0.04% - 0.12%



→ The semi-finished products are again heated at a temp. of about 700°C to 1200°C to make metal malleable and then rolled into finished product. Such c/s shapes formed are called as Hot Rolled sections.

→ If the semi-finished products are shaped without heating through the application of high pressure at normal temperature, then such sections are called cold-rolled sections.

- Advantages of Hot rolled section
  - (i) better workability
  - (ii) lower cost
  - (iii) Ductility is maintained.

- Advantages of Cold Rolled section.
  - (i) Higher strength.
  - (ii) Higher precision.
  - (iii) Better surface finish

→ Physical properties of steel such as ductility, elasticity, strength, Hardness & toughness are influenced by

• Carbon content • Heat Treatment process • Alloying element.

• Carbon content :- When we increase the carbon content, the strength and hardness of the steel increases but its ductility and toughness is reduced.

(i) Low Carbon Steel (0.1 % – 0.25 %) → eg- Mild steel, Standard structural Steel.

(ii) Medium Carbon Steel (0.26 %–0.6 %) → eg- Rails & tyre.

(iii) High carbon steel (0.7 %. – 1.1 %) → eg- Drill & punches.

• Alloys – Elements like copper, Vanadium, Manganese, Nickle, Chromium, Molybedneum can be added to the steel for its better working.

for eg- when 10.5 % chromium and 0.5 % Nickel is added to the Steel, then its resistance towards the corrosion becomes very high and the steel formed is called as Stainless steel.

• Carbon equivalent (C_{eq}) → It is a number which designates weldability of the steel. Higher the value of C_{eq}, lesser will be the weldability of the steel.

$$C_{eq} = \frac{C + Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

→ $C_{eq} \leq 0.43$ – for Welding.

→ each symbol refers to the proportion of weight of that particular element in percentage.

Type of Structural Steel

1.) IS 2062 (Standard Quality Structural Steel)

→ Grade E 250 Fe 410 W(A)

where, Yield tensile strength → $f_y = 250 N/mm^2$, W → Weldable

Ultimate tensile strength → $f_u = 410 N/mm^2$, A → normal loading & temperature.

→ f_y → $230 N/mm^2$ — $250 N/mm^2$ — Size effect

($d > 40mm$) ($d < 20mm$)

Percentage elongation = 23 % → Ductility.

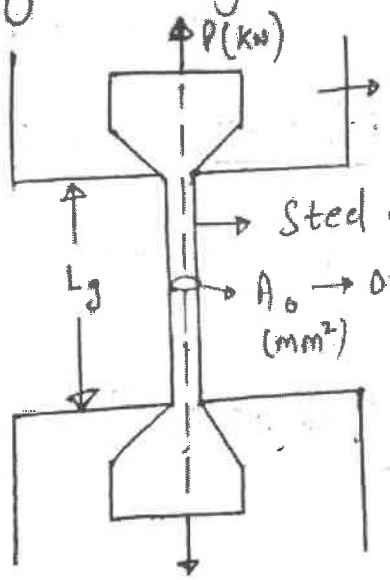
2.) Medium / High Strength Alloyed Steel (IS 8500)

→ $f_y = 300 N/mm^2$ — $450 N/mm^2$.

$f_u = 440 N/mm^2$ — $590 N/mm^2$.

1.3 Mechanical Properties of Steel

→ Important properties of steel such as yield strength and Ultimate Strength, Ductility, toughness and hardness can be determined by conducting a tension test on steel specimen.



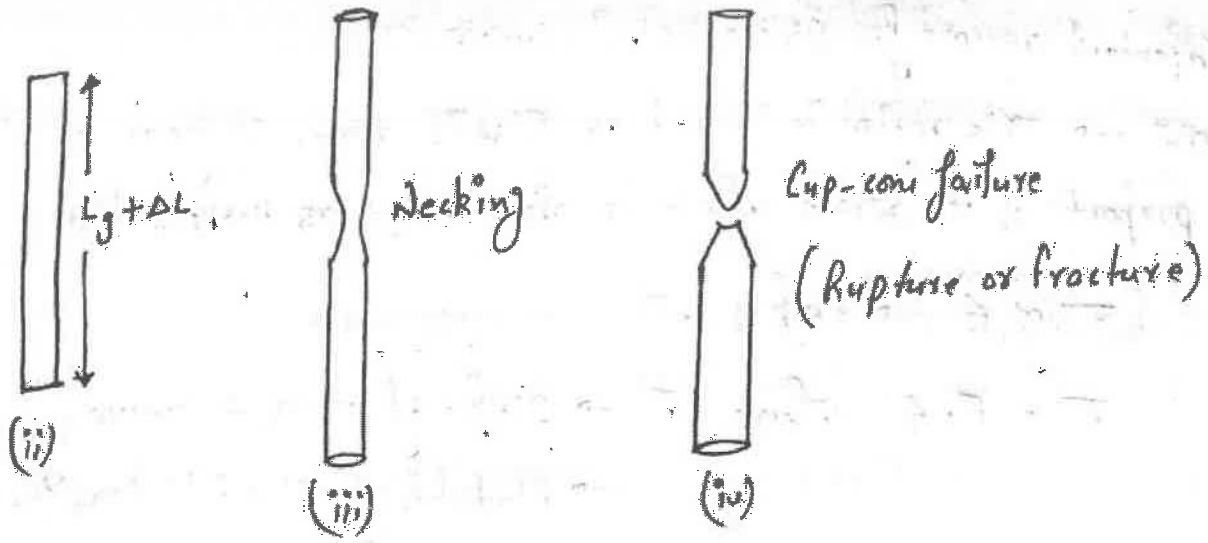
L_g → Initial Gauge length.

$L_g = 5.65\sqrt{A_o}$ (Rectangle)

$= 5 \times d$ (circular)

P → Axial tensile load.

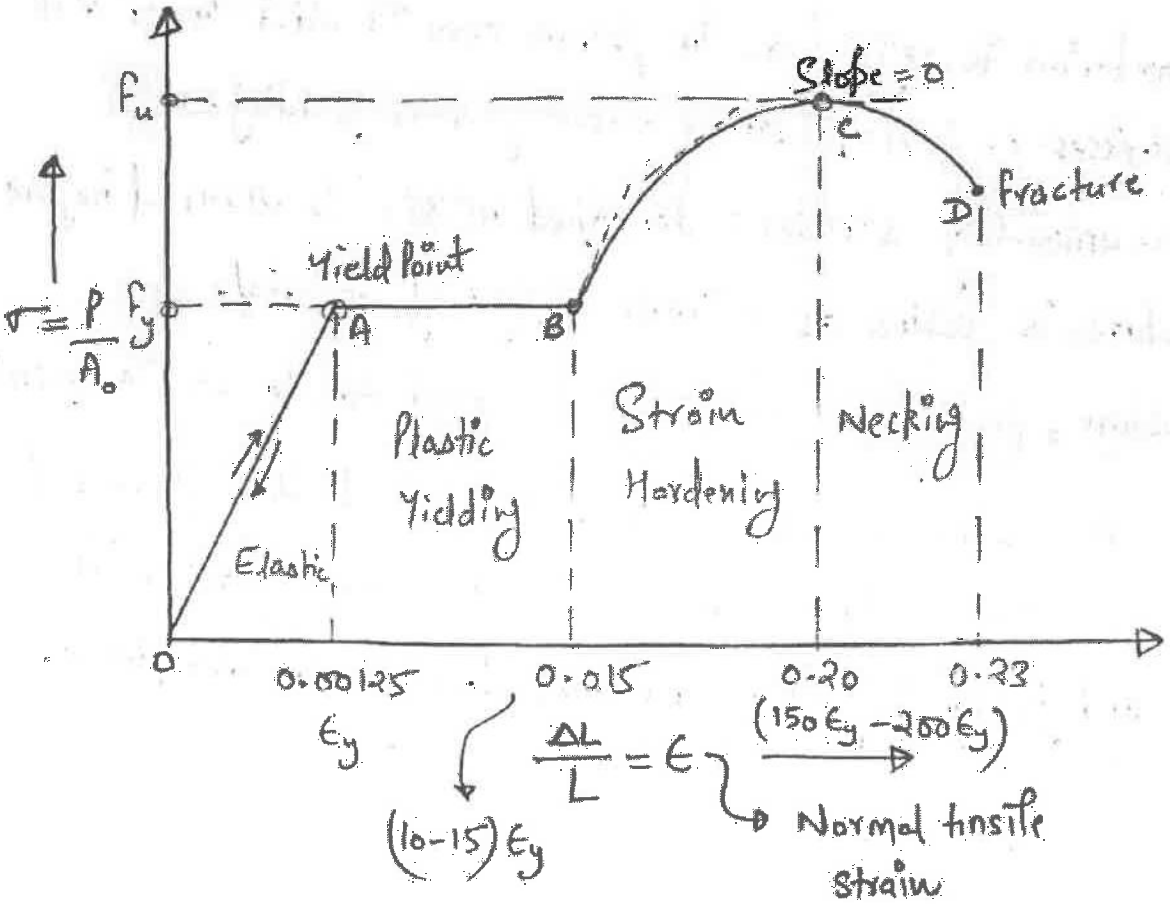
ΔL → Extension or Elongation



Lecture - 2

→ The readings recorded during the tension test are axial load applied (P) and the extension of the specimen. However we plot Normal tensile stress (σ) vs Normal tensile strain (ϵ) curve because this curve will be independent of the size of specimen and it will show characteristic properties of the material.

- Low Carbon Steel



- Important regions for Stress - Strain Curve

(i) OA → This region is called as Elastic zone. Stresses are directly proportional to strain which is also termed as Hooke's law.

$\sigma \propto \epsilon$ → Hook's law

$\sigma = E \cdot \epsilon$ where E → slope of σ vs ϵ curve.

→ Modulus of Elasticity (or) Young's mod.

- Elasticity is the ability of the material through which it can regain its shape, size and geometry.

(ii) AB → This is called as the zone of plasticity. in which the material extends without developing any stresses.
The amount of stress required to develop plastic yielding is called as yield strength of the material.

(iii) BC → This is the zone for strain hardening.

- Strain hardening is defined as the phenomenon in which the material resist the loads or develop stress even after its yielding.
- The max. amount of stresses developed within the material before its fracture is called as Ultimate Strength of material.
- At this stage, percentage elongation or normal tensile strain = 20%

(iv) CD → This zone is called as Necking in which the c/s area of the specimen starts reducing due to which the material looses its strength and finally it fails by breaking down into two pieces.