

## :- Introduction :-

Advantages of steel structures:

- (i) Small weight to strength ratio
- (ii) Speed of erection and dismantling
- (iii) Its scrap value

Disadvantages:-

- (i) The faster degradation of strength in the events of fire
- (ii) Requirement of skilled personals
- (iii) The accuracy desired in the fabrication.

Advantages of steel as a structural material:-

Steel has many advantages as a structural material.

- (i) Steel members have high strength per unit weight.  
Therefore a steel members of a small section which has little self weight is able to resist heavy loads.
- (ii) Steels being a ductile material does not fail suddenly but gives visible evidence of impending failure by large deflection.
- (iii) Structural steels are tough i.e. they have both strength and ductility. Thus steel members subjected to large deformation during fabrication and erection will not fracture. Also the steels may be bent & hammered, sheared or even the bolt holes may be punched without any visible damage.
- (iv) Being light, steel members can be conveniently handled, and transported. For this reason prefabricated members can be frequently provided.
- (v) Properly maintained steel structures have long life.
- (vi) Properties of steel mostly don't change with time.
- (vii) Additions and alterations can be made easily to steel structures.
- (viii) They can be erected at a faster rate.
- (ix) Steel has the highest scrap value amongst all building material
- (x) Steel is the ultimate recycle material.

## Disadvantages of steel as a structural material:-

- (i) Steel structures when placed in exposed conditions are subjected to corrosion. Therefore they require frequent painting and maintenance.
- (ii) Steel structures need fire proof treatment, which increases cost.
- (iii) Fatigue of steel is one of the major drawback. Fatigue involves a reduction in the strength when steel is subjected to large numbers of stress reversals.
- (iv) At the places of stress concentration in the steel section, under certain conditions, the steel may lose its ductility.

## Mechanical properties of structural steel:-

- Modulus of elasticity ( $E$ ) =  $2 \times 10^5 \text{ N/mm}^2$

- Shear modulus ( $G$ ) =  $0.769 \times 10^5 \text{ N/mm}^2$

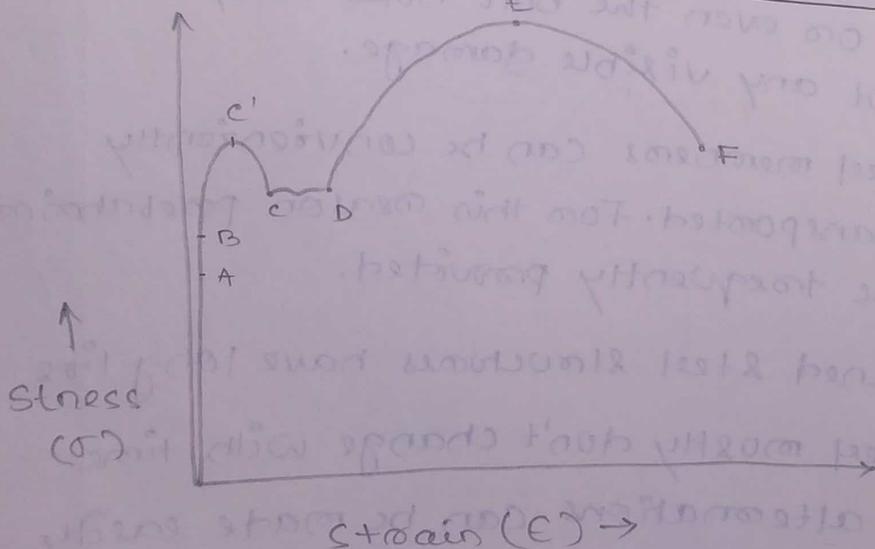
- Poisson's ratio ( $\mu$ )

(i) Elastic range 0.3

(ii) Plastic range 0.5

- Coef. of thermal expansion ( $\alpha$ ) =  $12 \times 10^{-6} / ^\circ\text{C}$

## Stress-strain curve for mild steel:-



A - Proportional limit

B - elastic limit

C' - upper yield point

C - lower yield point

CD - yield plateau / plastic yielding

DE - strain hardening zone

E - ultimate point

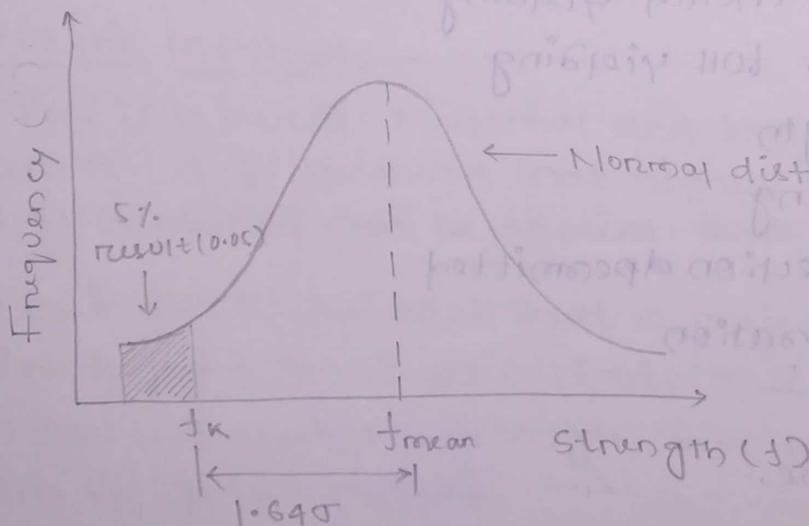
EF - strain softening zone

The strain that occurs before the yield point is called elastic strain and that which occurs after the yield point with no increase in stress is called plastic strain.

Ultimate strength : —

ultimate strength or tensile strength or minimum guaranteed ultimate tensile strength (UTS) is given by

$$UTS = \frac{\text{ultimate tensile load}}{\text{original area of cross section}}$$



The characteristic strength ( $t_k$ ) =  $t_{mean} - 1.64\sigma$ .

where  $\sigma$  = standard deviation

$$= \sqrt{\frac{\sum (t_{mean} - t)^2}{n-1}}$$

where  $n$  = no. of specimen.

## Ductility:-

Ductility is another property of steel and is defined as the capacity of the structure or of its members to undergo large elastic inelastic deformations without significant loss of strength or stiffness.

$$\% \text{ elongation} = \frac{\text{Elongated length} - \text{Gauge length}}{\text{Gauge length}} \times 100.$$

## Toughness:-

Toughness is defined as the capacity to absorb energy. It is a measure of the ability of steel to resist fracture under impact loading.

## \* Design philosophies:-

Design of structural steel elements is based on one or more of the following criteria.

- (i) Attainment of initial yielding
- (ii) Attainment of full yielding
- (iii) Tensile strength
- (iv) Critical buckling
- (v) Maximum deflection permitted
- (vi) Stress concentration
- (vii) Fatigue
- (viii) Brittle fracture.

A steel structure may be designed by any one of the three design philosophies

- Elastic or working stress method
- Plastic method
- Limit state method.

### Working stress method :-

- Working stress method is an elastic method of design. The worst combination of working (service) loads is ascertained and the members are proportioned on the basis of working stress. These stresses should never exceed the permissible stresses.
- The permissible stresses are some fraction of the yield stress of the material and may be defined as the ratio of the yield stress to factor of safety.

$$\text{Permissible stress} = \frac{\text{Yield stress}}{\text{FOS}}$$

- It may also be defined as the ratio of strength of the members to the expected load.
- When the yield point is well defined the factor of safety is defined as the ratio of the yield stress to the maximum expected stress.

### Plastic method :-

- Steel is a ductile material and from the stress-strain curve. It is observed that higher loads than in the elastic method can be applied over the structure.
- This is due to the fact that a major portion of the curve lies beyond the elastic limit. This extra strength is termed reserve strength, and forms the basis of plastic design method.
- In this method of design failure implies collapse or extremely large deformations, thus the structure fails at a much higher load called the collapse load, than the working load.
- In the plastic design method the working loads are multiplied by the load factors.

## Limit state method :-

- The acceptable limit to the safety and serviceability requirements before failure occurs is called Limit State.
- The objective of design is to achieve a structure that will not become unfit for use with an acceptable target reliability.

There are basically two categories of limit state.

- ① Limit state of strength
- ② Limit state of serviceability.

## Limit state of strength :-

Limit states of strength are those associated with failures, under the action of probable and most unfavourable combination of loads on the structure. Using the appropriate partial safety factors, which may endanger the safety of life and property.

Limit state of strength is also called ultimate limit state and includes

- Loss of equilibrium of the structure as a whole or any of its parts or component
- Loss of stability of structure (including the effect of sway where appropriate and overturning) or any of its parts including supports and foundation
- Failure by excessive deformation / formation of mechanism, general yielding, rupture of the structure or any of its parts or components or buckling.
- Fracture due to fatigue.
- Brittle fracture.

## Limit states of serviceability:-

Limit state of serviceability are limit beyond which specified service criteria are no longer met. These include

- Deformation and deflection
- vibration
- Repairable damage due to fatigue
- corrosion and durability
- ponding of structure.

## Limit states of strength:-

- For checking the strength and stability of a structure the loads are multiplied by the relevant load factor  $V_f$ . This is also called factored load.
- The load capacity ~~for~~ of each member and its connection as determined by the relevant provisions of the code should be such that the factored load would not cause failure. The design strength of the members and its connections is determined by dividing the ultimate strength with respective partial factor of safety ' $V_m$ '.
- When the ultimate limit states are exceeded the whole structure or part of it collapses. Failure may take a number of forms as discussed below.
  - ① Axial compression [where the material is shortened or whole section may buckle].
  - ② Bending. [By forming plastic hinges and large deformations of the members].
  - ③ Axial tension
  - ④ shear
  - ⑤ Local buckling.