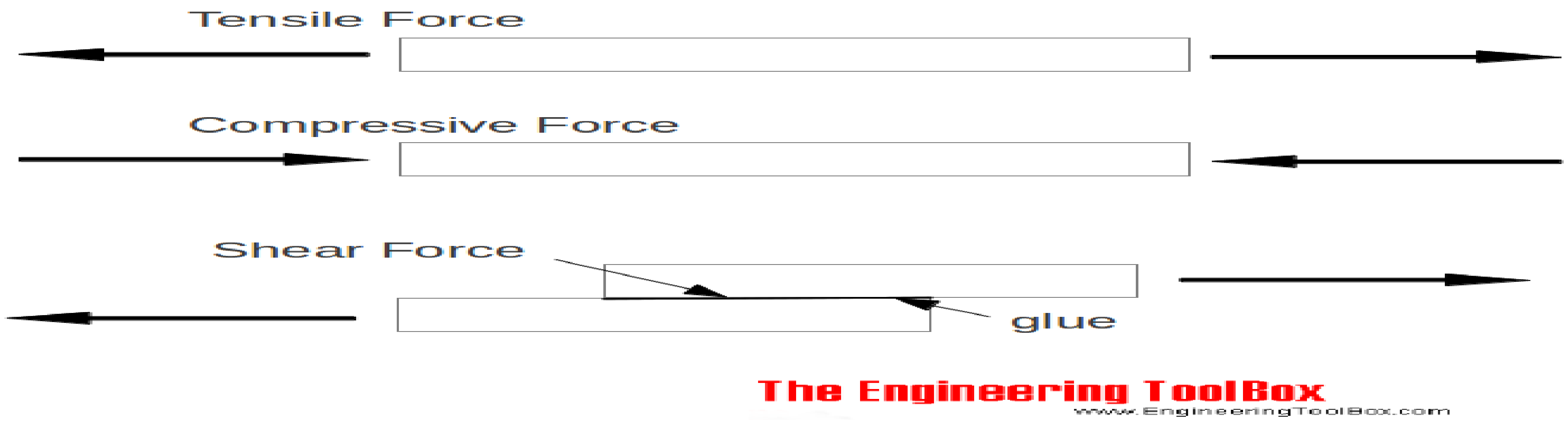
TOPICS TO BE COVERED

- Stresses
- Strain
- Types
- STRESS STRAIN DIAGRAM
- Hooks law
- Poisson ratio
- ELASTIC CONSTANTS AND THEIR RELATIONSHIPS

Stress

- Stress is "*force per unit area*" - the ratio of applied force *F* to cross section area - defined as "force per area".
- *tensile stress* - stress that tends to stretch or lengthen the material - acts normal to the stressed area
- *compressive stress* - stress that tends to compress or shorten the material - acts normal to the stressed area
- *shearing stress* - stress that tends to shear the material - acts in plane to the stressed area at right-angles to compressive or tensile stress



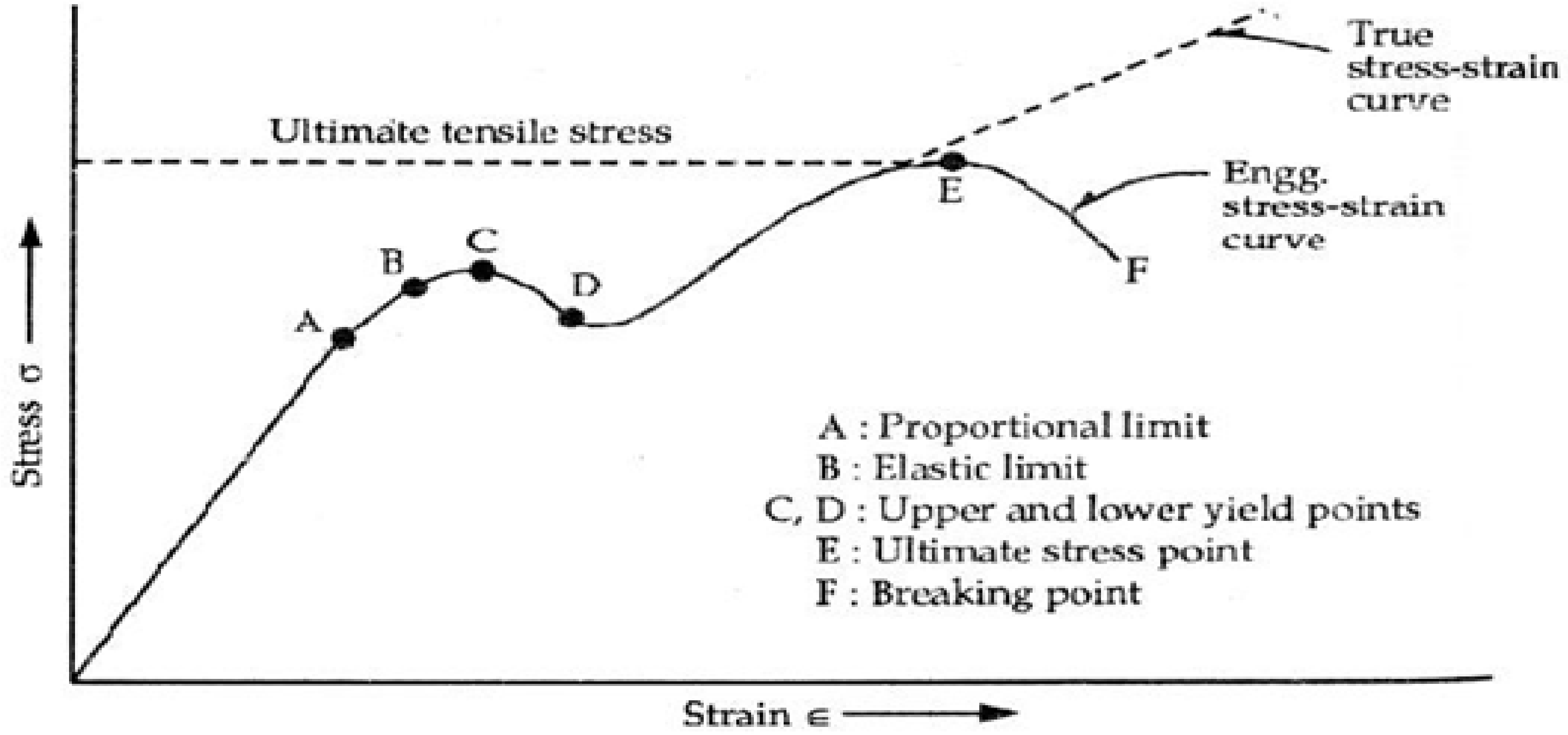
Strain

- When we apply a force on a body it will undergo deformation and its length will increase or decrease. Length increases when the force is tensile and decreases when the force applied is compressive.
- The ratio of Change in dimension to the original dimension is called strain.
- **Strain = ε = Change in dimension/original dimension**
- **There are two types of strains.**
- **1. Normal strain (Tensile, compressive and volumetric)**
- **2. Shear strain**

TYPES OF STRAIN

- **Normal strain:** It can be divided into three types.
- **a. Tensile strain:** When we apply a tensile force on a body its length increases. The ratio of increase in length to the original length.
- **Tensile strain = $\varepsilon_t = L – L_0 / L$**
- Where L = Original length
- L_0 = new length
- b. **Compressive strain:** When we apply a compressive force on a body its length decreases. The ratio of decrease in length to the original length is called compressive strain.
- **Compressive strain = $\varepsilon_c = L – L_0 / L$**
- Where L = Original length
- L_0 = new length
- c. **Volumetric strain:** When we apply a force on all sides of a body its volume will decrease. The ratio of change in volume to the original volume is called volumetric strain.
- **Volumetric strain = $\varepsilon_v = V – V_0 / V$**
- Where V = Original volume
- V_0 = new volume
- **Shear Strain**: When we apply a tangential force on a body there is an angular displacement (θ), which measures the shear strain.
- **Shear strain = tan θ**

STRESS-STRAIN DIAGRAM



The typical behavior of stress-strain curve for mild steel specimen and its salient features are:

1. Proportional Limit:

   Stress is a linear function of strain and the material obeys Hooke’s law. This proportionality extends up to point A and this point is called Proportional limit. O-A is a straight line and its slope represents the value of Modulus of Elasticity.

2. Elastic Limit :

   Beyond proportional limit, stress and strain depart from straight line relationship. The material however remains elastic upto state point B. The word elastic implies that the stress developed in the material is such that there is no residual or permanent deformation when the load is removed. Upto this point, the deformation is reversible or recoverable. Stress at B is called the elastic limit stress, this represents the maximum unit stress to which a material can be subjected to and is still able to return to its original form upon removal of load.

3. Yield Point :

   Beyond Elastic limit, the material shows considerable strain even though there is no increase in load or stress. This strain is not fully recoverable i.e. there is no tendency of the atoms to return to their original positions. The behavior of the material is inelastic and the onset of plastic deformation is called yielding of the material. Yielding pertains to the region C-D and there is drop in load at the point D. The point C is called the upper yield point & point D is lower yield point. The difference between the upper and lower yield point is small and the quoted yield stress is usually the lower value.

4. Ultimate Strength or Tensile Strength :

After yielding has taken place, the material becomes strain hardened and an increase in load is required to take the material to its maximum stress at point E.

Strain in this portion is about 100 times than that of the portion from 0 to D. Point E represents the maximum ordinate of the curve or tensile stress of the material.

5. Breaking Strength :

In the portion EF, there is falling off the load from the maximum until fracture takes place at F. The point F is referred to as the fracture or breaking point and the corresponding stress is called breaking stress.

The apparent fall in stress from E to F may be attributed to the fact that stress calculations are made on the basis of original cross-sectional area. In fact elongation of the specimen is accompanied by reduction in cross-sectional area and this reduction becomes significant near the ultimate stress. In case stress calculations are based on actual area, the curve would be seen to rise until fracture occurs. For mild steel, the test piece breaks making a cup and cone type fracture; the two pieces can be joined together to find out the diameter at the neck under the specimen breaks.

Hooke's law

- a law stating that the strain in a solid is proportional to the applied stress within the elastic limit of that solid.

Poisson's ratio

- Poisson's ratio, named after Siméon Poisson, also known as the coefficient of expansion on the transverse axial, is the negative ratio of transverse to axial strain. When a material is compressed in one direction, it usually tends to expand in the other two directions perpendicular to the direction of compression. This phenomenon is called the Poisson effect. Poisson's ratio is a measure of this effect. The Poisson ratio is the fraction (or percent) of expansion divided by the fraction (or percent) of compression, for small values of these changes.

Conversely, if the material is stretched rather than compressed, it usually tends to contract in the directions transverse to the direction of stretching. It is a common observation when a rubber band is stretched, it becomes noticeably thinner. Again, the Poisson ratio will be the ratio of relative contraction to relative expansion and will have the same value as above. In certain rare cases, a material will actually shrink in the transverse direction when compressed (or expand when stretched) which will yield a negative value of the Poisson ratio.

ELASTIC CONSTANTS

- **Young's Modulus or Modulus of Elasticity:** It is the ratio between compressive stress and compressive strain or tensile stress and tensile strain. It is denoted by 'E'. Its units are GN/m^2.
- E = stress/stain = $\sigma/\varepsilon = \sigma_t/\varepsilon_t = \sigma_c/\varepsilon_c$
- **Modulus of Rigidity or Shear Modulus of Elasticity:** It is the ratio of shear stress (τ) to shear strain (γ). It is represented by 'C', 'N' or 'G'. Its units are GN/m^2.
- C, N or G = τ/γ
- **Bulk Modulus or Volume Modulus of elasticity:** It is defined as the ratio of applied pressure (on each face of solid cube) to volumetric strain. It is represented by 'K'. Its units are GN/m^2.
- $K = p/\varepsilon_v$
- **Poisson's ratio:** The ratio of lateral strain to linear strain is called Poisson's ratio. It is denoted by 'μ' or 'ν' or '1/m'.
- μ = lateral strain/linear strain = 1/m
- The value of 'μ' varies from 1/3 to 1/4 depending upon the material.

RELATIONSHIPS BETWEEN ELASTIC CONSTANTS

- **Relation between E and C:** $E = 2C [1+ \mu]$
- **Relation between E and K:** $3K (1-2\mu)$
- **Relation between E, C and K:** $E=9KC/ (3K+C)$