Strain Energy

Energy is defined as the capacity to do work. Work done by force is equal to the product of Force and Displacement in the direction of force.

The energy absorbed by a body due to straining of the body is called strain energy. Strain energy is the ability of a body to do work because of its deformation and its tendency to return to its original shape.

8.1 **Elastic Strain Energy for Uni-Axial stress**

When either a Tensile or Compressive Load is applied to a bar, there will be a change in length δl for a material which obeys Hooke's law, is proportional to the load.

The Strain Energy (U) of the bar is defined as the work done by a gradually applied (Static) load P load during the change in length (i.e. Producing Strain).) is

Strain Energy **U = Work done = (Force x Displacement)**

$$U = \frac{1}{2} P . \delta$$

The Strain Energy can be expressed in terms of the Stress and deformations, For a bar of uniform cross section A and length L, will be

$U = \frac{1}{2} P . PL/AE = \frac{1}{2} (P/A) (P/AE) AL$

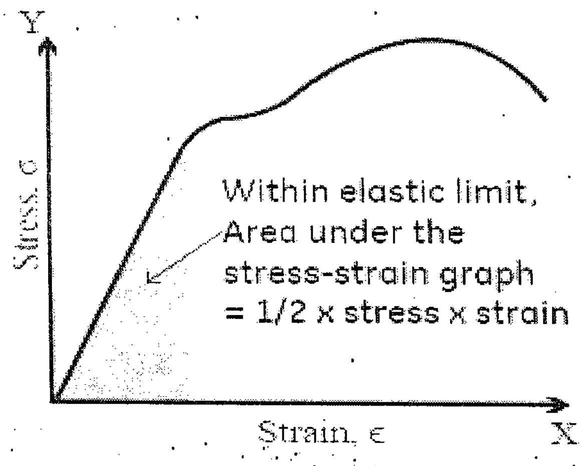
But A L is the volume of the bar V,

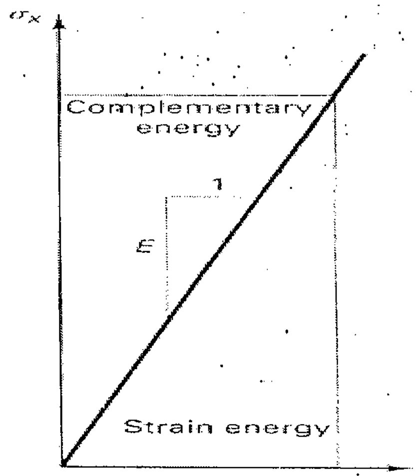
The Strain Energy can be also expressed

U = 1/2 (Stress)x(strain)x volume of the bar

$$U = \frac{1}{2} \sigma \varepsilon V = \sigma^2 / 2E \times V.$$

The Strain Energy stored in the body with in elastic limit is called **Resilience**, the maximum energy stored at elastic limit is known as **Proof Resilience**.





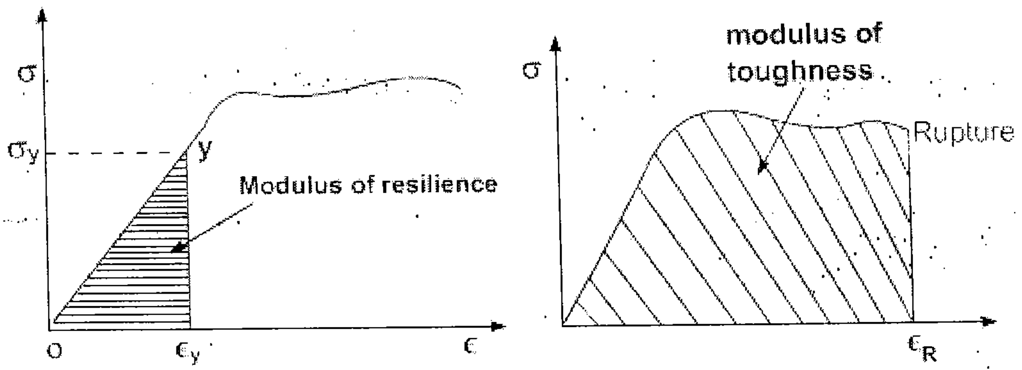
Complementary Strain Energy : ... The area enclosed by the inclined line and the vertical axis is called the complementary strain energy. For a linearly elastic materials the complementary strain energy and elastic strain energy are the same.

Proof Resilience for unit volume is called as **Modulus of Resilience (or) strain energy density**

The modulus of resilience is equal to the area under the straight line portion 'OY' of the stress – strain diagram as shown in Fig .

Toughness is the ability to absorb energy upto fracture. It is clear that the toughness of a material is related to its ductility as well as to its ultimate strength and that the capacity of a structure to withstand an impact Load depends upon the toughness of the material used.

From the stress – strain diagram, the area under the complete curve gives the measure of **modules of toughness**.



NOTE:

- ✓ In Proof Resilience, stress is the value at the elastic limit or for non-ferrous materials,the stress is the Proof Stress.
- ✓ Strain Energy is Always a positive quantity and is expressed in units of work.
- ✓ Instantaneous Stress developed in a bar subjected to suddenly applied load is equal to the twice of stress produced by the same load applied gradually.
- ✓ Instantaneous elongation developed in a bar subjected to suddenly applied load is equal to the twice of elongation, produced by the same load applied gradually.

S.M. - 1 UNIT - 1 ASSIGNMENT

1. Define Resilience and derive the equation of stresses for a body subjected to sudden and Impact loading

2. A 2m long bar of uniform section 50 mm2 extends 2mm under a limiting axial stress of 200N/mm2.What is the modulus of resilience for the bar..

3. Three round bars having the same length 'L' but different shapes are shown in fig below. The first bar has a diameter 'd' over its entire length, the second had this diameter over one – fourth of its length, and the third has this diameter over one eighth of its length. All three bars are subjected to the same load P. Compare the amounts of strain energy stored in the bars, assuming the linear elastic behavior.