



STRESS AND STRAIN

STRESS: when a material is being subjected to external forces, resistance forces are set up within the body of the material. The resistance force per unit area is called stress.

Stress = force / unit area

Direct stress

Tensile stress:

Compressive stress

Shear stress: A tangential stress produced either by transverse stress or by torsion

Strain: when an external force is applied on a body, the body tends to move in that direction till it is balanced by an opposite force. **This external force produces a deformation which is called strain.** The deformation /unit length is called unit strain.

Longitudinal strain

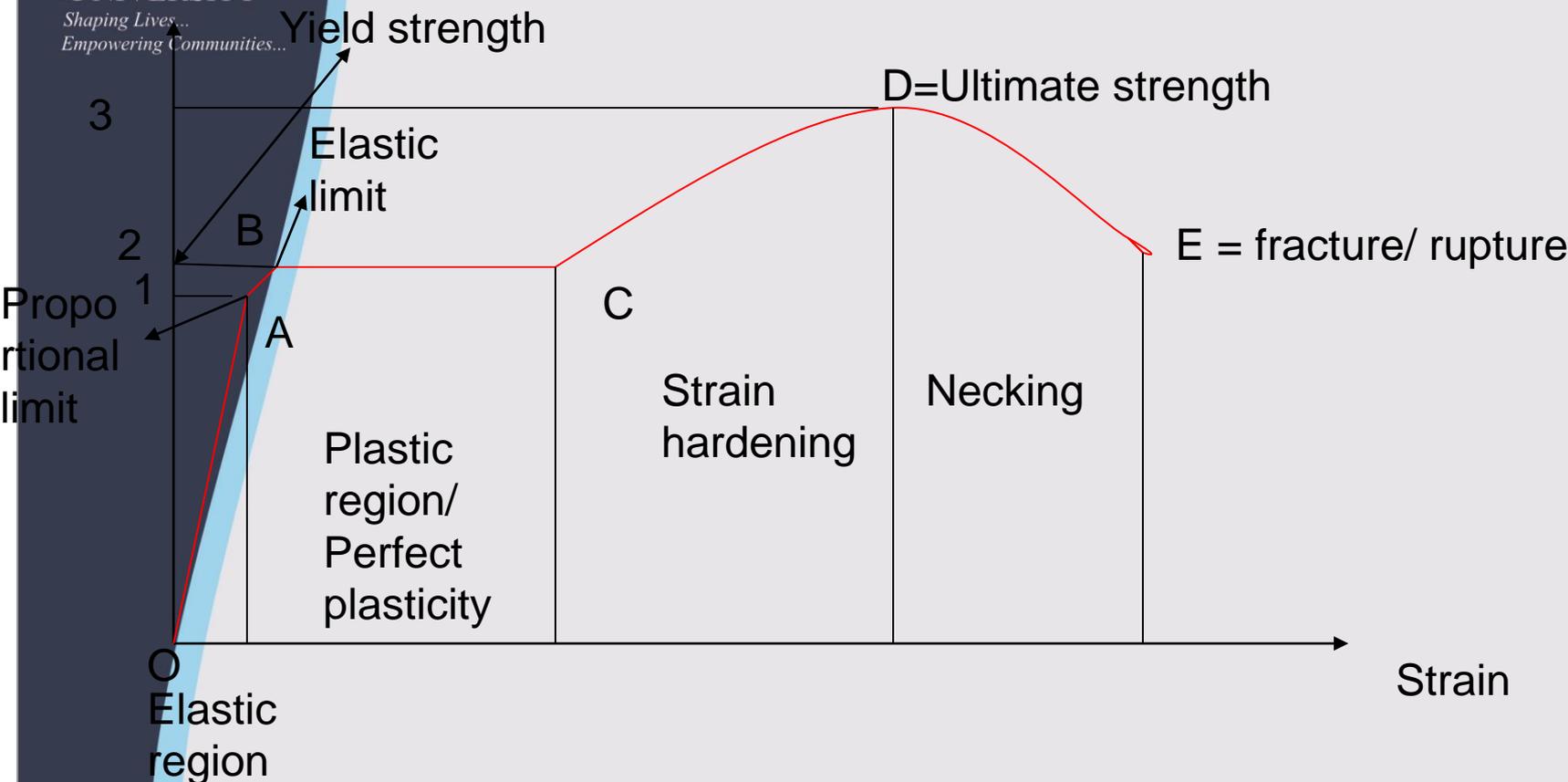
Shear strain



Stress – strain curve

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Yield strength is stress at which appreciable elongation occurs without increase in stress

Ultimate strength: The maximum stress required to break a specimen is called its ultimate strength.



STRAIN HARDENING

After the yield point, the metal will undergo a period of strain hardening, in which the stress increases again with increasing strain up to the *ultimate strength*.

In many application, static load is applied more than once. The loading and unloading within elastic region results in cyclic load up and down the linear portion.

If loading and unloading takes place in the plastic region then the path of the stress strain curve will be different and a hysteresis loop is formed.

The consumed energy by the loop is transformed to heat energy and the material is heated causing work hardening of the material which raises the ultimate strength

DEFINITION OF SOME MATERIAL PROPERTIES

**Elasticity: Property which enables the material to return to its original shape after an external stress is withdrawn.
Steel is more elastic than rubber**

**Plasticity: The property of the materials by which it may be permanently deformed when subjected to an external force great enough to exceed the elastic limit.
Ductile materials are more plastic than brittle materials**

Strength: It is the ability of a material to resist the externally applied forces without breaking or yielding.



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Toughness: Property that enables the materials to withstand a sudden impact or a high stress without rupture.

Strength and toughness are quite related. A material may be strong and tough if it **ruptures/breaks** at **high strain and stress**. But a brittle material is strong but breaks with little strain. **So it is strong but not tough.**



Ductility: The property of a material enabling it to be drawn into wires under tensile force without fracturing the materials. Ductility is a mechanical property used to describe the extent to which materials can be deformed plastically without fracture.



Malleability: The ability of a metal to be deformed by *hammering or rolling* is malleability.

Wear resistance: Wear is the **unintentional deterioration** of a material due to use. The ability of a material to resist *wear and abrasion* is called wear resistance.



FATIGUE

When a material is subjected to repeated stresses, it is believed to produce minute amount of **plastic strain** which is called fatigue.

The failure is caused by means of a progressive crack formation which are usually fine and of microscopic size

The material fails at stresses below the yield point stresses. Such type of failure of a material is known as *fatigue failure*.

This property is considered in designing crank shafts, connecting rods, springs, gears, etc.



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Resilience: The capacity of a material to **absorb energy** when it is **elastically** deformed and then upon unloading to have this energy recovered is called **resilience**.

Creep: When a part is subjected to constant stress at high temperature for a long period of time, it will undergo a **slow and permanent deformation** called **creep**. This property is considered in designing internal combustion engines, boilers and turbines. Creep is measured in term of **plastic deformation** during a certain time. The **limiting creep stress** is the **maximum stress at which the material will not fail at a certain temperature** for a prescribed length of time.



Brittleness: The property of a material causing it to break with little distortion.

Stiffness: The ability of the material to resist bending, stretching, shortening and twisting is called stiffness.



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Machinability

It is the property of a material which refers to a relative ease with which a material can be cut.

The machinability of a material can be measured in a number of ways such as *comparing the tool life for cutting different materials or thrust required to remove the material at some given rate or the energy required to remove a unit volume of the material.*

It may be noted that brass can be easily machined than steel.