SCIENCE AND ENGINEERING MATERIALS

Mechanical Properties of Materials

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Chapter Description

- Learning Objectives
  - Understand the elastic and plastic deformation
  - Describe the stress and strain behavior
  - Identify the measurement of various mechanical properties of materials
  - Apply the mechanics of materials in design and selection of materials

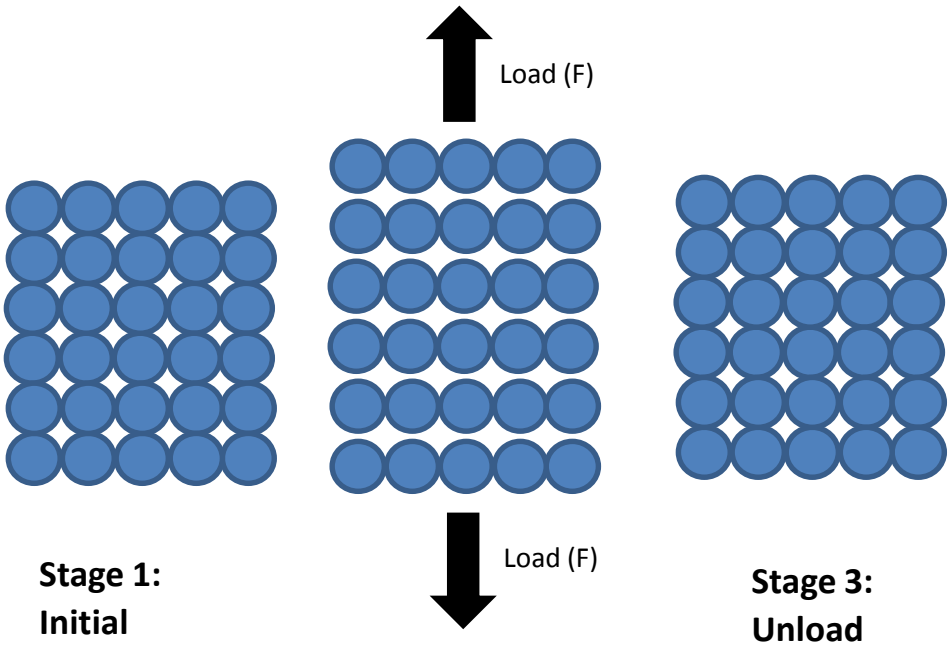
Material Deformation

In materials science, deformation is a change in shape or size of a material casued by:

- Applied load (e.g.: tensile load, compressive load, shear, bending or torion)
- Temperature change

Material Deformation

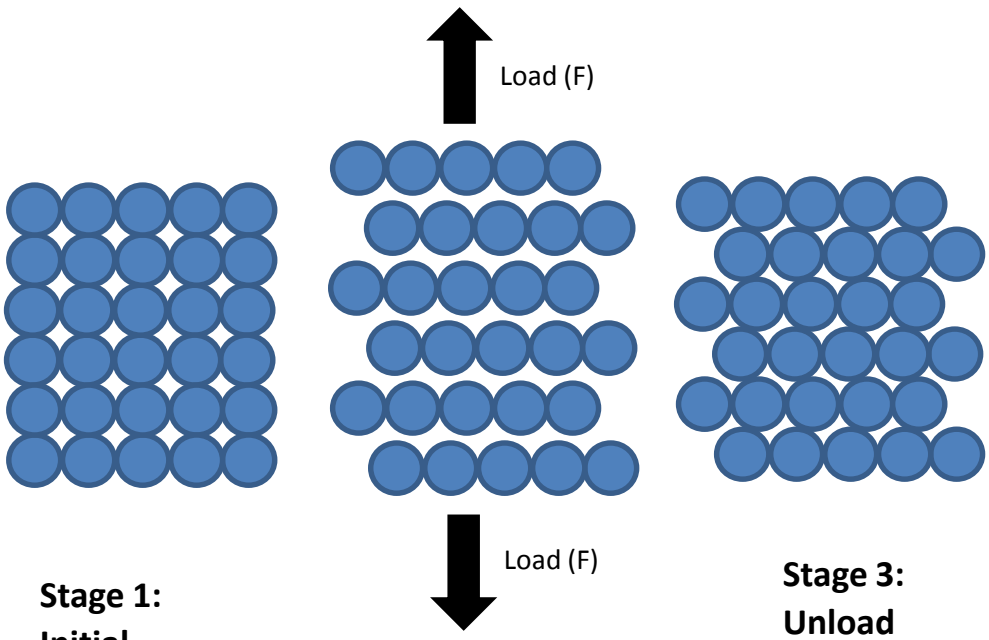
Elastic deformation = Reversible deformation



- Stage 1: Close-packed atoms
- Stage 2: Bonds stretch
- Stage 3: Return to original arrangement

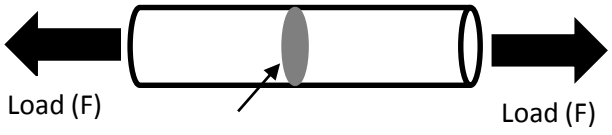
Plastic Deformation

Plastic deformation = Irreversible deformation



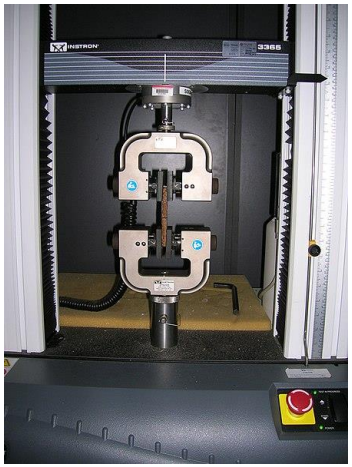
- Stage 1: Close-packed atoms
- Stage 2: Bonds stretch and planes shear
- Stage 3: Planes remain sheared

Common State of Stress

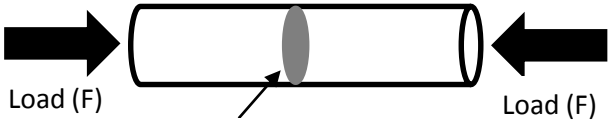


A_o = Unload cross sectional area

Simple tension stress

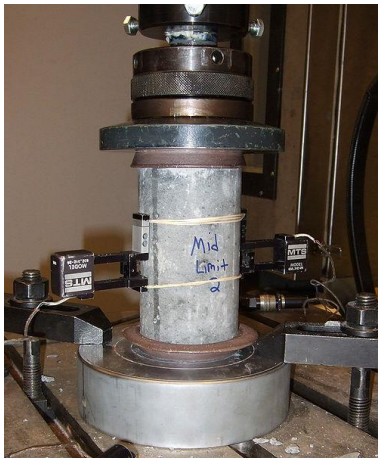


Source: Kerina yin; Wikimedia



A_o = Unload cross sectional area

Simple compressive stress



Source: Xb-70; Wikimedia

Stress and Strain

- Stress, σ= Force/Area

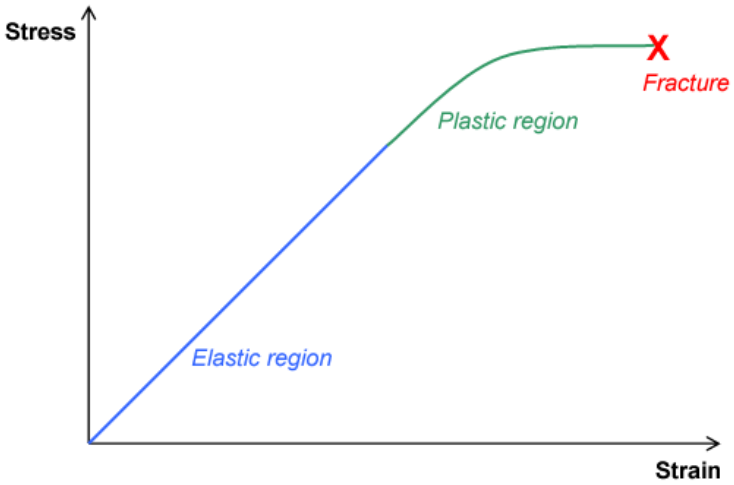
Force (also called load) is measured in Newton

Therefore, $\sigma = N/m^2 = Pa$

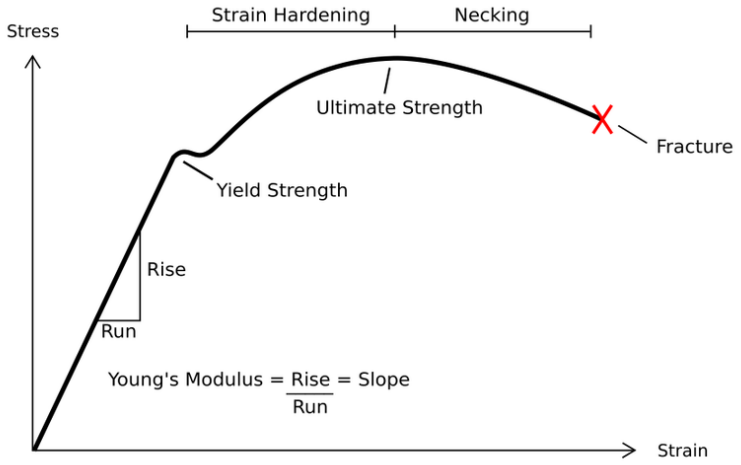
- Strain, Є = extension/ original length

$Є = l_2 - l_1 / l_1$ =mm/mm (dimensionless)

Stress-Strain Curve



Source: Moondoggy; Wikimedia



Source: Breakdown; Wikimedia

- Stress-strain curve shows relationship between stress and strain of material under load.
- Reveal many important mechanical properties of materials

Stress-Strain Curve

- **Ultimate tensile strength (TS): T**he highest engineering stress developed in material before rupture.
- **Yield strength (YS):** The stress at the beginning of plastic
- **Modulus of elasticity:** Measure of the stiffness during elastic region of the material
  - Modulus of elasticity = slope at the linear region
- **Hooke's law :** Stress is proportional to strain
- **Ductility:** Measure amount of plastic deformation before fracture
  - % Elongation $= \frac{Final\ length - Initial\ length}{Initial\ length} \times 100$
- **Toughness:** The amount of energy per volume a material can absorb before rupture.
  - Measurement of area under the curve

Conclusion of The Chapter

- The occurrence of deformation in material during loading can be classified into elastic or plastic behaviour.
- Important mechanical characteristics of materials can be examine by simple stress-strain tests.
- Information gathered from basic stress-strain curve is useful in material design and selection for engineering application purposes.

References

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