Properties of Materials
BTM 2413

CHAPTER 4:
THE ROLE OF MECHANICAL PROPERTIES IN ENGINEERING MATERIALS

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Introduction

- Aims
  - To introduce the mechanical properties

- Expected Outcomes
  - Identify the mechanical properties of materials
  - Explain the testing methods of mechanical properties….

- Other related Information
  - ….
- References

- Kenneth G Budinsky & Michael G Biddinsky, Engineering Materials: Properties and Selection, Ed 9, Prentice Hall

Mechanical Properties: Introduction

- Mechanical properties are the characteristics of a material that are displayed when a force is applied to the material.
- Usually measured by performing a destructive test on a specimen under study
- Key word in discussing mechanical properties are

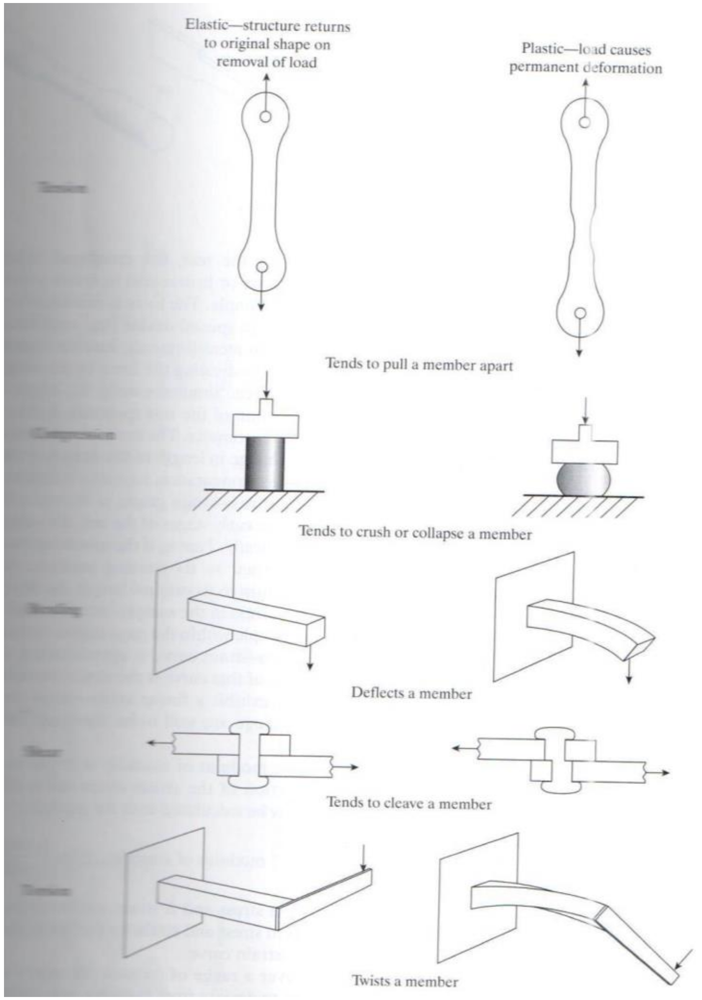
i) Stress

- force distributed over an area
- tensile, compression, bending, shear, and torsion

ii) Strength

- material's ability to accommodate stress
- limiting stress that can be tolerated
- tensile strength, torsional strength, shear strength, compressive strength, creep strength

Example of five basic types of stress

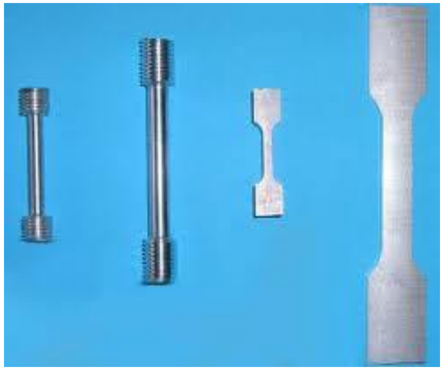


Tensile Testing

- Strength can be determined by testing
- By pulled, bent, twisted, compressed, sheared until break
- Stress measured at fracture becomes the designated strength of the material
- Usually strength value will have a range
- ex : tensile strength of 1133 steel is 55 to 57MPa
- Tensile test is a laboratory technique for determining material properties ; tensile strength, yield strength, modulus of elasticity, % of elongation
- With different techniques the same machine can be used for compressive strength, shear strength and flexural strength

Tensile Testing

- Typical tensile tester, also called *universal test machine*
- the same machine can be used for determining compressive strength, shear strength and flexural strength.
- Tensile sample typically Cylindrical rods with a reduced diameter in the Center.



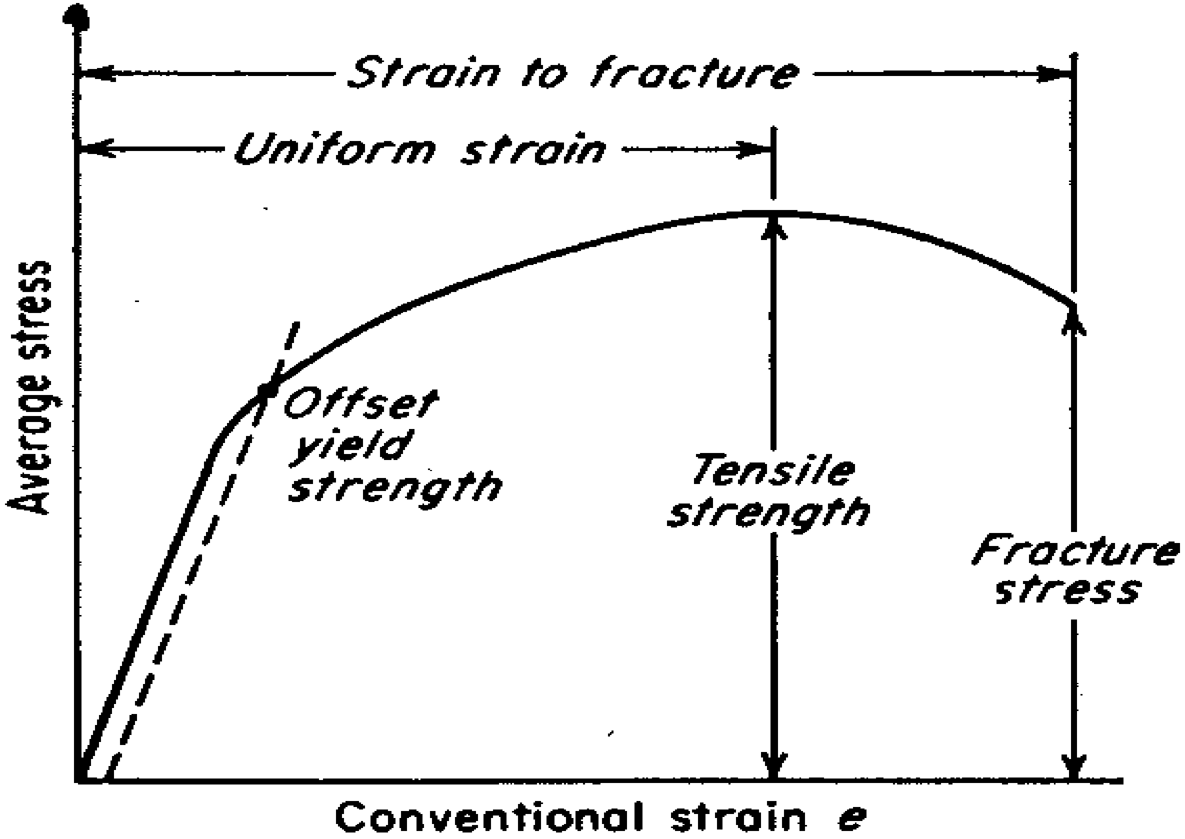
Tensile Testing

During the test,

- Force is measured using a force transducer
- Tensile stress is calculated by dividing force by the original cross-sectional area
- Strain is calculated by dividing the change in the length of the sample by the original length
- Stress –strain curve can be computed

Tensile Testing

- Stress-Strain Curve



1) TENSILE TESTING

During the early stages of the test ;

- sample will behave elastically – the sample would return to original length
- Stress-strain curve approximately linear
- Slope of the curve is elastic modulus, E

$$E = \frac{\Delta\, stress}{\Delta\, strain}$$

As the stress continues ;

- The sample continues to elongate until reaches a point where permanent plastic deformation occurs.
- Point of transition from elastic deformation to plastic deformation
- Also known as *elastic limit* or *yield point*.
- Offset strain of 0.2% (engineers consideration)

As the tensile tester continues to elongate the sample;

- The stress continues to increase in a non linear manner
- Cross-sectional area at the center begin to decrease as the sample length increases.
- Reduction occurs uniformly

As the tester continues to pull the sample;

- Material continues to harden and get stronger
- Cross sectional area begins to rapidly decrease
- Stress reaches a peak and begins to drop off
- Stress calculated at the peak is *ultimate tensile strength* and the force is also known as *peak load*
- The reduction area is known as *necking*.

Once the sample fracture; Two measurements are made :

i. Final length ii) Final diameter

Ductility – ability to be stretched Also known as *percent elongation* or *percent reduction in area*

$$\text{percent elongation} = \frac{\text{final length} - \text{initial length}}{\text{initial length}}$$

The higher the percent elongation, the more ductile material is *percent reduction in area*

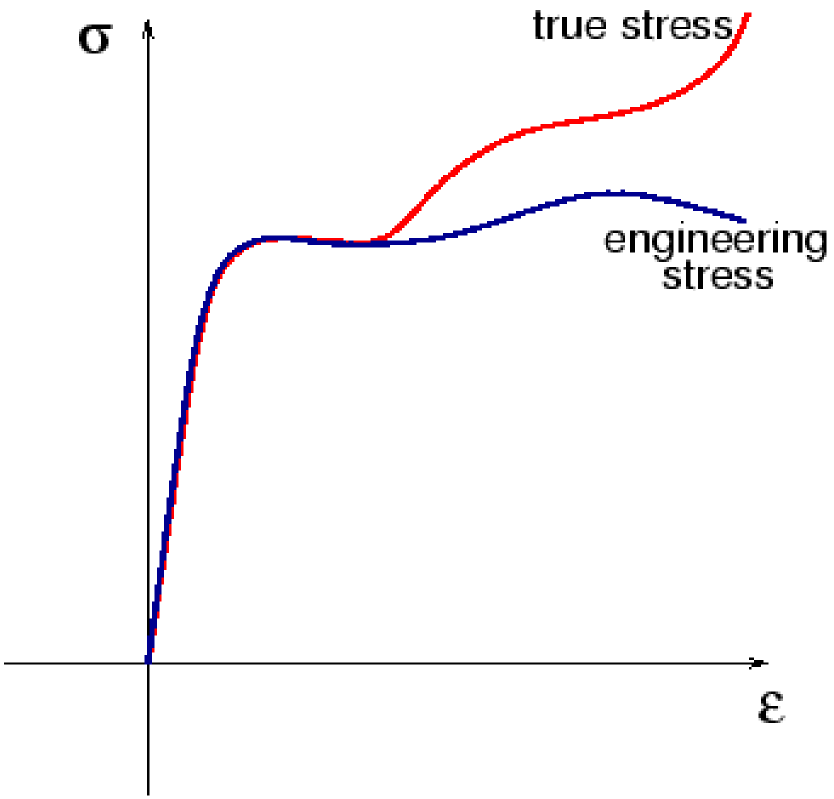
$$\text{percent reduction in area} = \frac{\text{initial area} - \text{final area}}{\text{initial area}}$$

Two types of stress-strain curve;

1) Engineering stress-strain curves
2) True stress-strain curves

What the difference between these two curves???

Engineering and True Stress Strain Curves



Engineering and True Stress Strain Curves

- Stress values in engineering stress strain curve are calculated by dividing the force measured during the tensile test by the original cross section area of the specimen.
- In reality the cross section area actually reduces as the sample is tested in the tensile tester. In true stress strain curve the stress is calculated by dividing the force measured during the test by actual or instantaneous cross sectional area