DME3051 Mechanical Design
Summary 2
Date: Sep. 13, 2018
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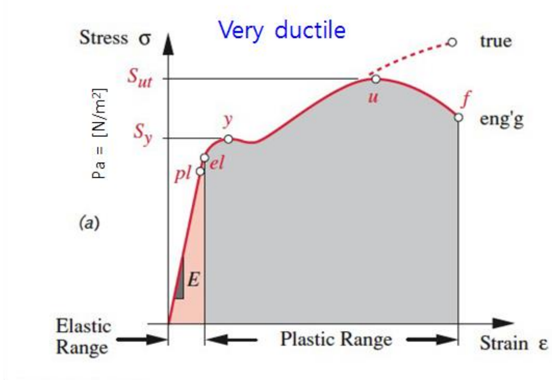
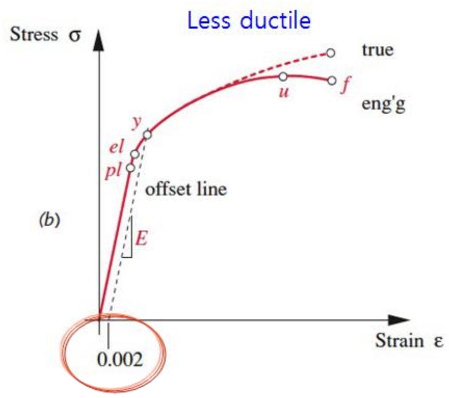
Factor of Safety N = (Material Strength)/(Design Load)

Chap. 3 Materials
SEE: Appendix C-1

Young's Modulus (E)

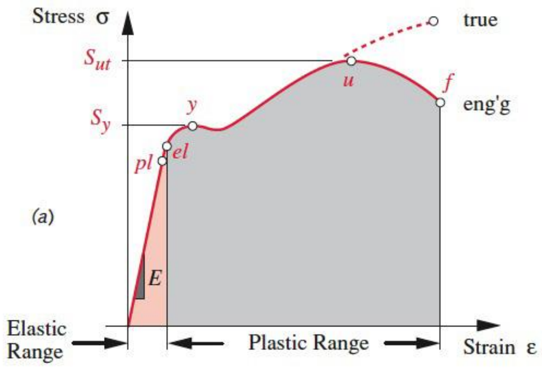


Low-carbon steel



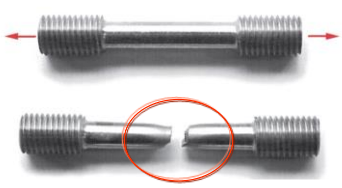
Annealed High-carbon steel

pl: proportional limit
el: elastic limit → permanent set or plastic deformation; *el* and *pl* are often the same
y: Yeild point → S_y: yield strength
S_{ut}:ultimate tensile strength → Largest tensile stress the material can sustain before braking



Stress drops to fall off to a smaller value at the facture point

→ Cause by the "necking-down" or reduction in area of the ductile material.



Non-uniform cross-sectional area

True stress-strain curve: the change in area considered
Engineering stress-strain curve: Used in practice

Ductility:

1. Percent elongation to fracture or percent reduction in area at fracture

➔ Materials with more than 5% elongation at fracture are considered ductile

→ Most ductile metals have elongations to fracture more than 10%.

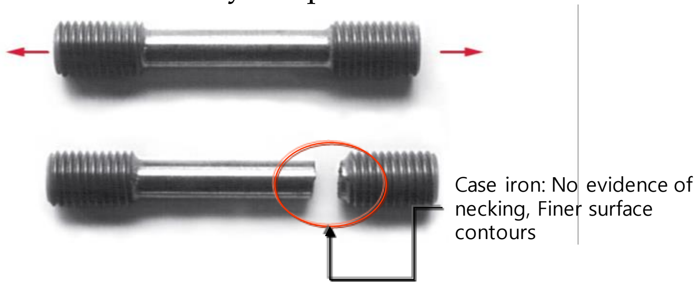
2. Tendency for a material to deform significantly before fracturing

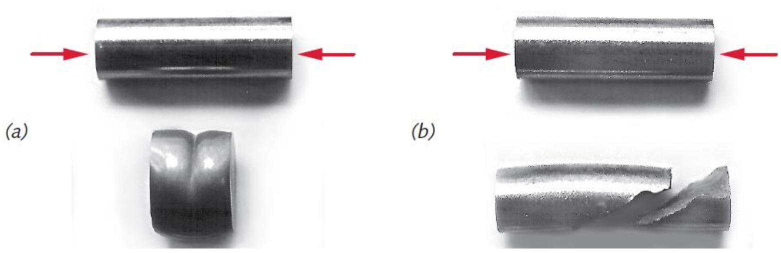
Brittleness: Absence of significant deformation before fracture

Brittle?

➔ Lack of a clearly defined yield point and the absence of any plastic range before fracture

: Brittle materials do not exhibit a clear yield point.





- Brittle materials proceed to fracture without significant shape change.
- If cracks are present in a ductile material, it can suddenly fracture at nominal stress levels well below the yield strength, even under static loads

Shear Modulus (G)

Stress-Strain relation for pure torsion

$$\tau = \frac{Gr\theta}{l_0}$$

Radius of specimen

Angular twist in radian

Shear stress

Original gauge length

G: Shear Modulus or Modulus of rigidity

G can be defined in terms of E and ν

$$G = \frac{E}{2(1+\nu)}$$

Poisson's ratio: Ratio between lateral and longitudinal strain. ~0.3 (Most metal)

Poisson's ratio: Ratio of the proportional decrease in a lateral measurement to the proportional increase in length in a sample of material that is elastically stretched.

➔ The transverse contraction during a tensile test is related to the longitudinal elongation.

$$\varepsilon_y = \varepsilon_z = -\frac{\nu\sigma_x}{E}$$

$$\nu = \left|\frac{\varepsilon_y}{\varepsilon_x}\right| = \left|\frac{\varepsilon_z}{\varepsilon_x}\right|$$

$$\varepsilon_x = \frac{\sigma_x}{E}$$

• **Toughness:** Ability of a material to absorb energy per unit volume without fracture [in-lbf/in^3 or J/m^3] → Charpy IMPACT TEST.

• **Fracture toughness *Kc*:** A material property that defines its ability to resist stress at the tip of a crack. Measured by subjecting a standardized, pre-cracked test specimen to cyclical tensile loads until it breaks.

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