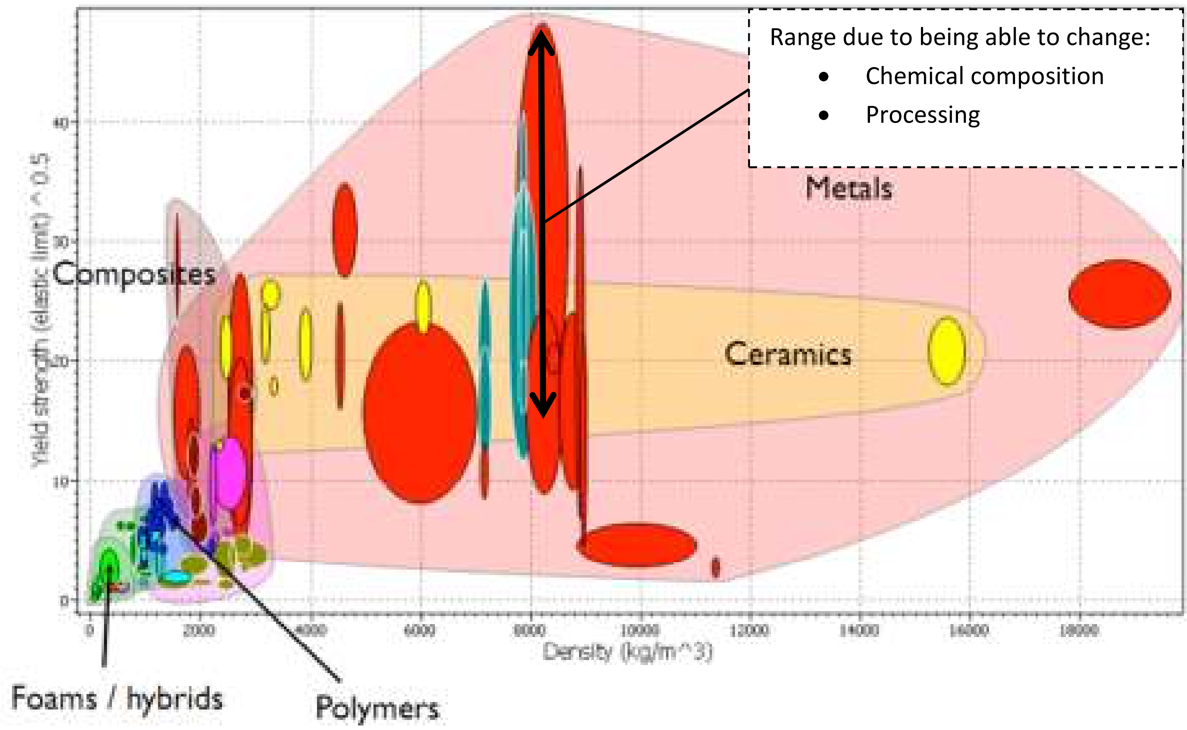
ENG1050 – Engineering Materials Notes

Contents

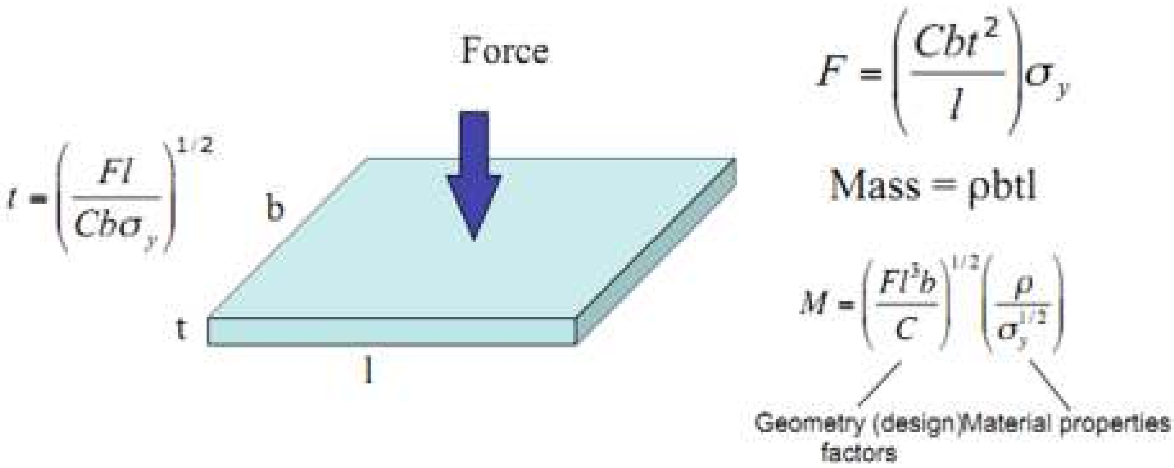
Selecting appropriate Materials

Engineers choose materials for construction based on factors such as physical properties:



Other factors to consider include:

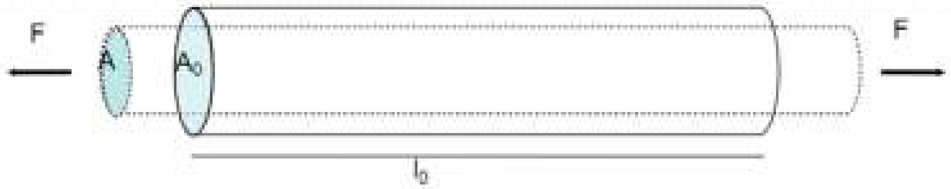
- Ease of manufacture
- Price
- Safety (toxicity)
- Availability



- For something like a car panel, $\left(\frac{\rho}{\sigma_y^{1/2}}\right)$ should be minimized (low density, high yield stress)

Ultimate Tensile Strength - The maximum stress measured on the **nominal** stress-strain curve. Necking occurs at this point. If maintained, fracture will occur.

Stress	Strain
The load/**force** applied to the material. Measured as force/area or **pressure** so independent of material cross section size. $\sigma = \frac{F}{A_0}\ (nominal)\ \ or\ \ \sigma = \frac{F}{A}\ (true)$	The resulting effect of the stress on the material - the percentage increase in length. $\varepsilon = \frac{\Delta l}{l_0}$



Neck formation – Struggle between Micro and Macro

Micro	Macro
Strain increases → **work hardening** occurs Work hardening → able to support higher stress	Specimen has constant volume Length increases → Cross sectional area decreases Area decreases → True stress increases Stress increases → extends more readily

There is a **feedback loop** between the **micro** and **macro**.

- Eventually the cross-sectional area decreases so much and the stress increases enough to overcome the strengthening effects of work hardening.

Maths:

$$dP = 0$$

Constant force

$$P = \sigma A$$

$$dP = \sigma dA + A d\sigma = 0 \quad (1)$$

$$\frac{dL}{L} = -\frac{dA}{A} = d\varepsilon$$

Length increases, cross sectional area decreases

$$-\frac{dA}{A} = \frac{d\sigma}{\sigma}$$

From (1)

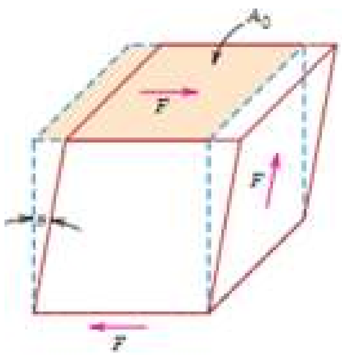
$$\frac{d\sigma}{d\varepsilon} = \sigma$$

In the **plastic** region:

$$\sigma = A\varepsilon^n$$

$n\ =\ work\ hardening\ exponent$

Shear Stress and Strain



Shear Stress:

$$\tau = \frac{F}{A_0}$$

Shear Strain:

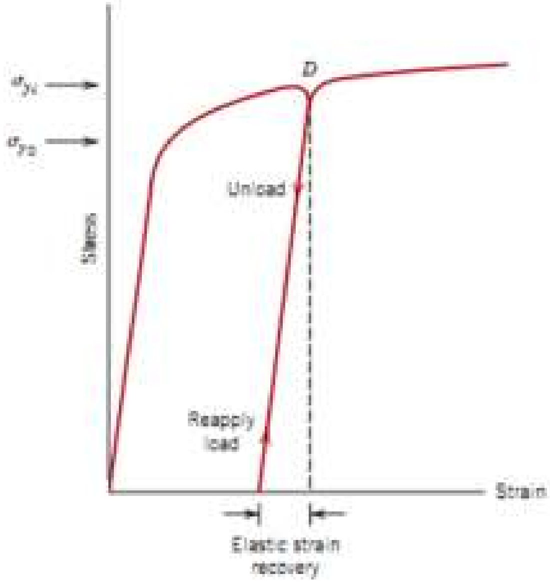
$$\gamma = tan\theta$$

Relationship:

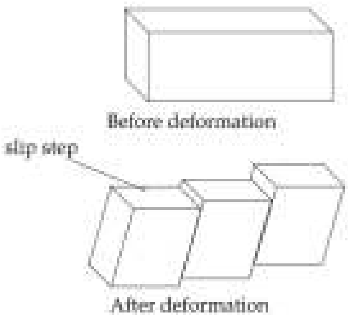
$$\tau = G\gamma$$

G = Shear modulus

When stress is released (at point D):



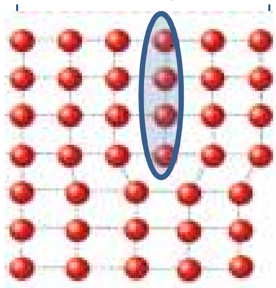
Plastic Deformation

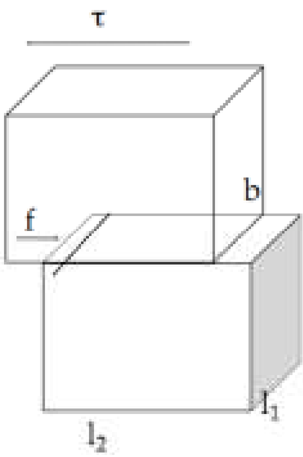


Permanent deformation is the result of **slip** of planes of atoms.

- Stress required to break bonds and slip planes is very high
- There are line defects in real-world materials called **dislocations**
- Requires much less energy to move the dislocations than the entire atom plane

Dislocation (extra half-plane)





In order to slip,

$$Force\ from\ shear\ stress > \ resistance\ to\ motion$$

Work to move upper block is:

$$\tau l_1 l_2 b$$

Work of dislocation motion:

$$f l_1 l_2$$

$$\boldsymbol{\therefore \tau b = f \qquad b = Burger's\ Vector \quad \tau = shear\ yeild\ stress}$$

$$The\ amount\ of\ slip\ produced\ by\ the\ motion\ of\ one\ dislocation$$

Dislocation - A line defect or imperfection in the crystal lattice comprising an extra half plane of atoms

Dislocation density - The length of dislocation line per unit volume (m/m^3)

Slip - Process by which plastic deformation is produced by dislocation motion