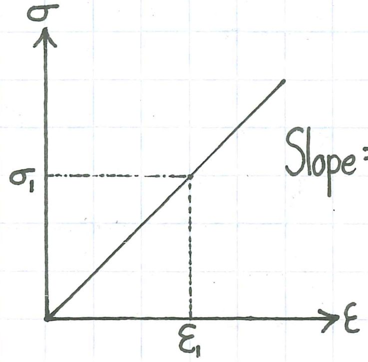
CIV102 - STRUCTURES and MATERIALS

Topic: Mild Steel, Strain Energy, and Material Properties Table

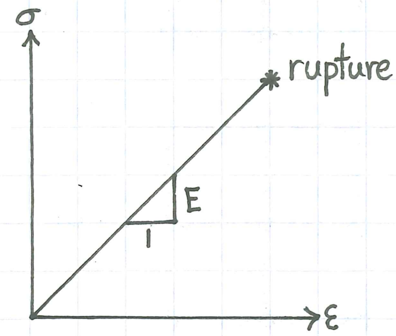
1) $\sigma = \frac{F}{A}$ and $\varepsilon = \frac{\Delta L}{L_o}$

Hooke's Law

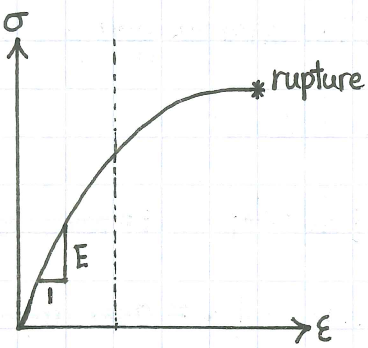


$$\text{Slope} = E = \frac{\sigma_1}{\varepsilon_1}$$

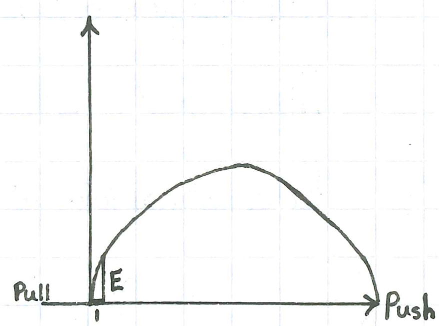
Glass



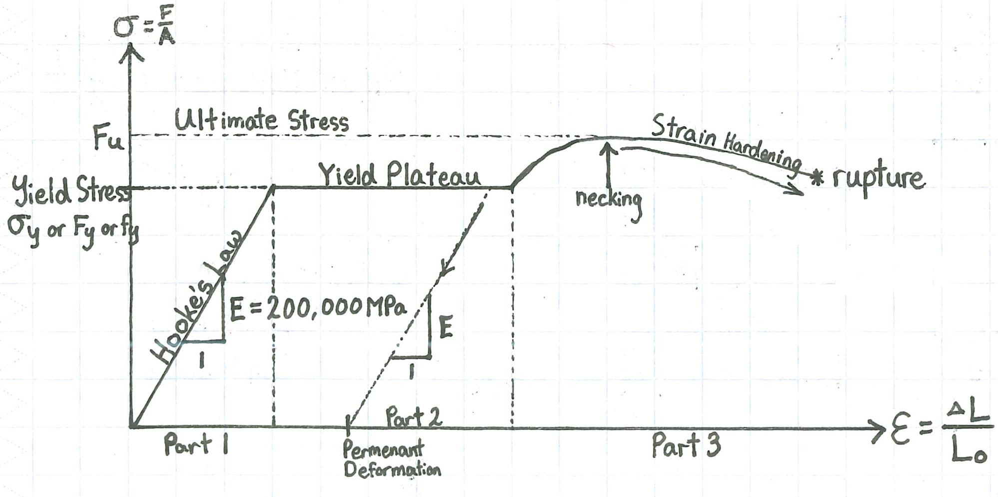
Brass

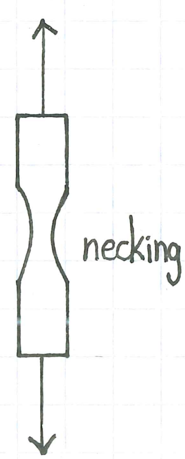


Concrete



2) Stress - Strain of Mild Steel



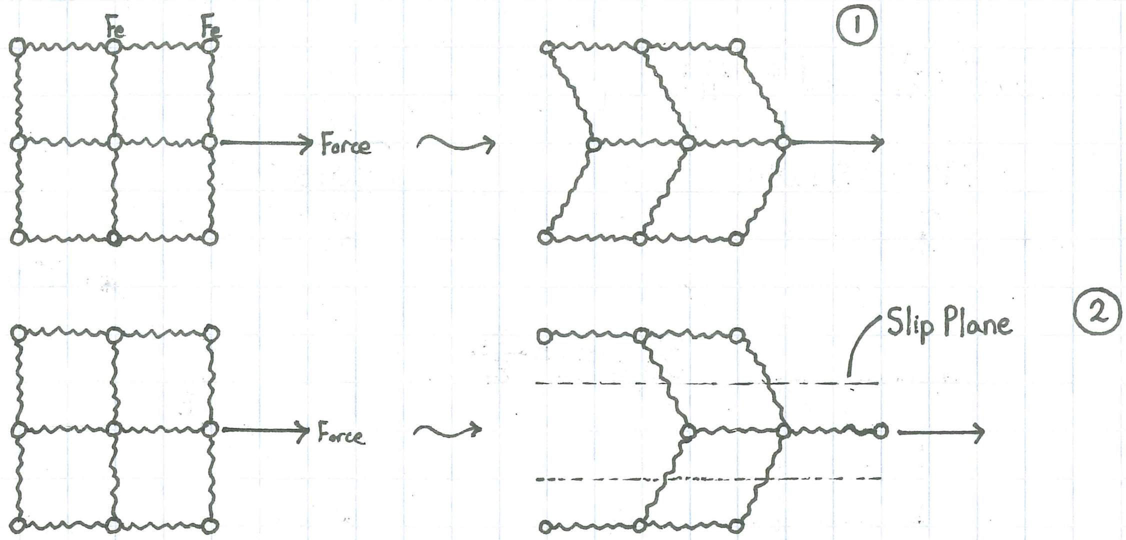


① Hooke's Law applies ⟶ linearly elastic
- no permanent damage or deformation
- $\sigma \leq F_y$
- design for this region

② Yield Plateau
- Material is being damaged
  ⟶ Permanent
- $\sigma = F_y$

③ Strain Hardening
- $F_y < \sigma < F_u$

3) Why?



4) Strain Energy

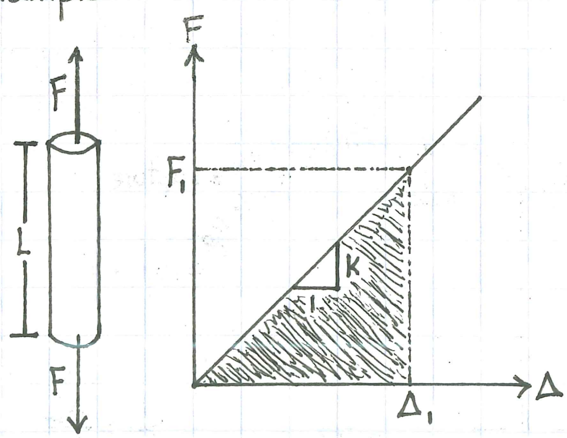
Strain energy is a form of potential energy you get if you deform a solid.

High School: work = Force · distance

for a material test: $work = \sum_i Force_i \cdot \Delta_i$ i = small steps

or $Work = Energy = \int F \, d\Delta$ = area under a load-displacement curve

Example



$$\text{Strain Energy} = \frac{\Delta_1 F_1}{2} \quad (F_1 = K \cdot \Delta_1)$$

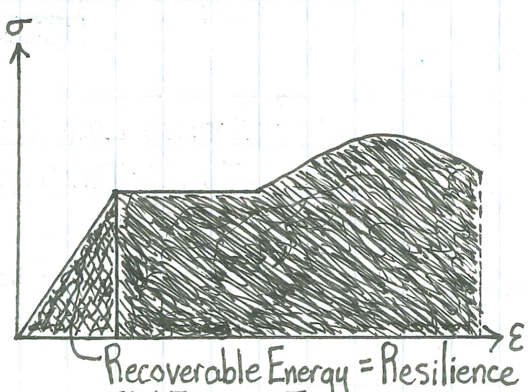
$$\text{Energy} = \frac{\Delta_1 \cdot K \cdot \Delta_1}{2} = \frac{K(\Delta_1)^2}{2}$$

Units = kN · mm
= 10^3 N · 10^{-3} m
= Nm = Joule

Normalize by Volume
= Energy Density = Specific Energy

$$\frac{J}{m^3} \rightsquigarrow \frac{MJ}{m^3}$$

= Area Under σ-ε Curve



Recoverable Energy = Resilience
Total Energy = Toughness = Total Area