CIV102 - STRUCTURES and MATERIALS

Topic: Stress, Strain, and Young's Modulus

1) Design Main Cable

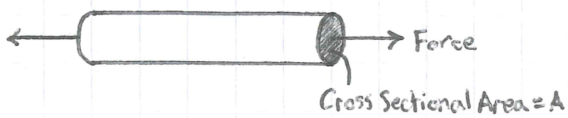
(a) Select a material

(b) Select the size of material needed

Key Considerations:

- Strength → related to forces (kN)
- Deformability → displacement (mm)

2) Consider Only the Material Part



Stress $= \sigma = \frac{\text{Force}}{\text{Area}}$

- Units: $[\frac{N}{m^2}]$ or [Pa] (Pascal)

CIV102 will use [MPa] (Mega pascal = 1,000,000 Pa)

- $[MPa] = [\frac{MN}{m^2}]$

Consistent Set of Units:

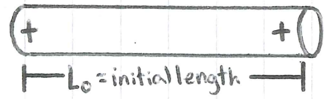
- [N], [mm], [MPa]

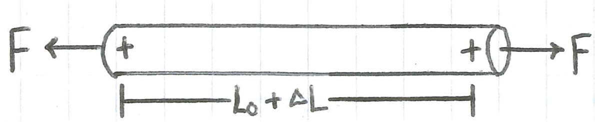
$$1[MPa] = \frac{1[MN]}{[m^2]}\left(\frac{1\times10^6[N]}{1[MN]}\right)\left(\frac{1[m]}{1000[mm]}\right)^2$$

$$\Rightarrow 1[MPa] = \frac{1[MN]}{[m^2]} = \frac{1[N]}{[mm^2]}$$

(Other Possible Units: • [lb], [inch], [psi])

3) Strain





Strain $= \varepsilon = \frac{\Delta L}{L_0}$ (Unitless)

Often Strains are small, ∴ Call $1\times10^{-3} = \frac{[mm]}{[m]}$

$3\times10^{-3} = 3\frac{[mm]}{[m]}$

Engineering Stress and Strain

- L_0, A = Constants

True Stress and Strain: $L_0, A \neq$ Constants

Robert Hooke (1678)

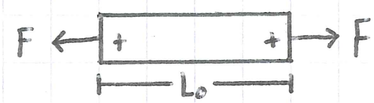
"ceiiinosssttuv"

↳ "ut tensio sic vis"

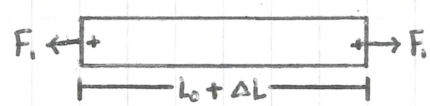
Means: As the extension, so the force.

Hooke's Law

- There is a linear relationship between how hard you pull on something, and how much it gets longer



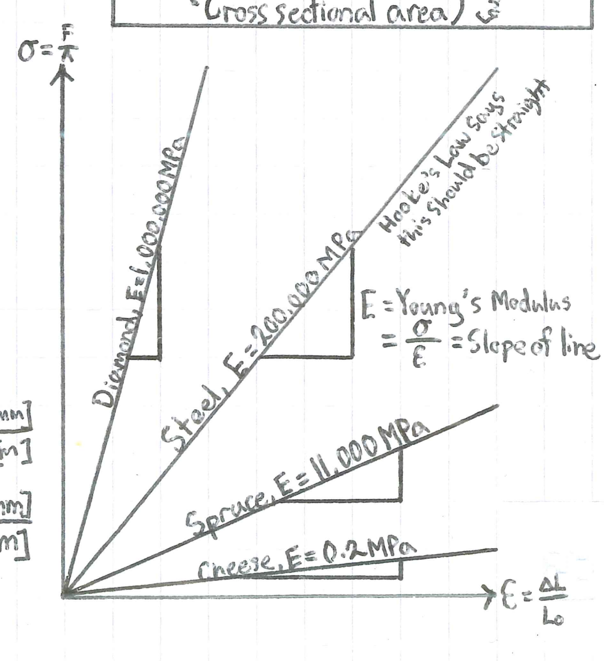
$F = 0$ (Undeformed Shape)



$F_1 \neq 0$ (Deformed Shape)

Hooke's Law: $F = k(\Delta L)$

- k is the spring constant
  - Depends on:
    - material
    - length, L_0 } Geometry
    - Cross sectional area } Geometry



4) Compare Hooke's Law to Hooke's Law!

$F = k(\Delta L)$ Structural Component

$\sigma = E \cdot \varepsilon$ Material Level

$\sigma = \frac{F}{A} \quad \varepsilon = \frac{\Delta L}{L_0}$

$\frac{F}{A} = E \cdot \frac{\Delta L}{L_0}$

$F = \left(\frac{EA}{L_0}\right) \Delta L$

$\therefore \boxed{k = \frac{EA}{L_0}}$