CLASS #5 - INTRODUCTION TO MATERIAL PROPERTIES

READ: CH 3.1 - 3.3 PHILPOT

OBJECTIVES:
1. DEFINE STRESS - STRAIN DIAGRAMS
2. IDENTIFY MATERIAL PROPERTIES FROM σ-ε DIAGRAMS
3. EXPLAIN TEST SET UP

LOAD → SOLID BODY → DEFORMATION

- STRESS
- MATERIAL
- GEOMETRY
- STRAIN

THERE IS AN INHERENT SCIENTIFIC RELATIONSHIP BETWEEN STRESS & STRAIN OF SOLID BODY. FUNCTION OF BODY MATERIAL & GEOMETRY

DISCOVER EXPERIMENTALLY

STRESS - STRAIN TESTING SETUP

LOAD FRAME

“COUPON” OF MATERIAL

ORIGINAL AREA, A₀

LOAD FRAME APPLIES TENSION OR COMPRESSION TEST ON COUPON

RECORD LOAD "P"

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2. Calculate Stress ($\sigma$)

Normal (or Engineering Stress):

$$\sigma_N = \frac{P}{A} \text{ measured by machine}$$

Assuming constant over cross section

3. Calculate Normal Strain ($\varepsilon$)

Measured in 2 ways:
- 1. Strain gage
- 2. Extensometer

1) Strain gage (metal foil)

Sensor whose resistance changes in proportion to strain

$$\Delta R \propto \varepsilon_N$$

- Low-cost (< $2)
- Good performance
- Conformable
- Dependent on temperature (wheatstone bridge)

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(c) Extensometer

- Output voltage \((V) \propto S\) (change in length)
  
  \[
  \epsilon = \frac{S}{L_0}
  \]

4) Stress - Strain Diagram:

By considering stress - strain, we are using two load & response parameters independent of geometry, only depend on material properties.

- Load coupon (e.g. steel) & measure load, \(P\), and extension, \(S\).

\[
\sigma = \frac{P}{A_0} \quad \epsilon = \frac{S}{L_0}
\]

- Plot \(\sigma\) vs. \(\epsilon\) (material property)

Ordinate \(\rightarrow\) Abscissa

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Consider steel in tension.

I - Elastic Region
- \( \sigma \) proportional to \( \varepsilon \) (straight line)
- Material is linearly elastic
- End of linearity is proportional limit, \( \sigma_{pl} \)
- After which slight non-linearity, \( \rightarrow \) yield limit (\( \sigma_y \) or \( \varepsilon_y \))
- Note: Not drawn to scale

II - Yielding Region
- Start of plastic deformation (permanent distortion)
- After yield, can elongate w/o increase in load for some time

III - Strain Hardening
- Add load (\( \sigma \)) get corresponding strain
- Up to ultimate load, \( \sigma_u \)
- Undergoing crystaline change
IV - NECKING

- AT A POINT IN CROSS SECTION, SPECIMEN "NECK"

DEVELOPMENT OF INTERNAL SLIP PLANES IN MATERIAL

- AS AREA DECREASES, IT CARRIES LESS STRESS, HENCE:

\[ \sigma_n = \frac{P}{A_0} \quad \text{GOING DOWN} \]

\[ \sigma_n = \frac{P}{A} \quad \text{FIXED} \]

- BUT, AREA IS DECREASING, SO TECHNICALLY

\[ \sigma_n = \frac{P}{A} \quad \text{ACTUAL AREA} \]

WOULD FIND \( \sigma_n \) IS INCREASING

TRUE STRESS - STRAIN DIAGRAM

"CONVENTIONAL" STRESS - STRAIN DIAGRAM

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