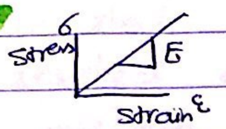
Chapter 6:

materials

linear

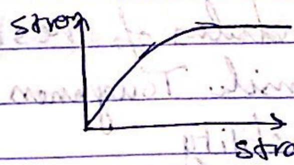
(Elastic)



Slope = E

Ex Metals

non linear



E is not constant = tangent

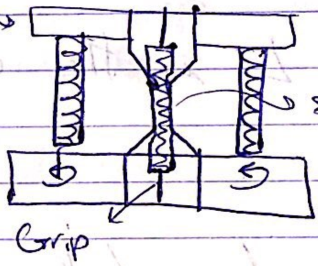
Ex: concrete, ruber

The Tensile test:- * Eng stress $\sigma_x = F/A_0$

* Eng strain $\varepsilon = \frac{\Delta L}{L_0} \times 100\%$

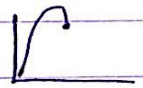
→ Force applied: unidirectional

- movable cross head movement can be proformed using screws or a hydraulic mechanism

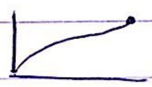


→ Curves for materials

Metal

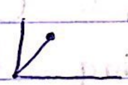


Elastomer



σ, ε > 0 Tension

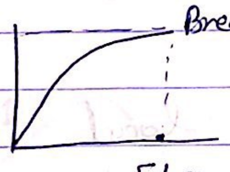
Creramics, glasses, Concrete



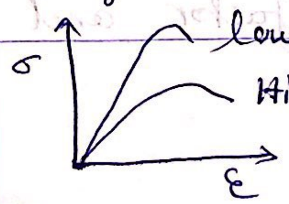
(brittle)

σ, ε < 0 Compression

Thermoplastic materials ($T > T_g$)



Temprehre effect

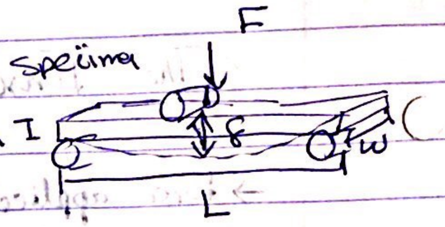


- MPa: Mega Pascal $= MN/m^2$
- 1 pound (Ib) = 4.448 Neuton (N)
- 1 Ksi = 1000 psi = 6.895 MPa
- PSi: Pounds per square inch
- 1psi = 0.006895 MPa

Properties Obtained from the Tensile test:-

1- Elastic limit.
2- Tensile strength / Necking.
3- Hook's law.
4- Poisson's Ratio.
5- Modulus of resilience (Er).
6- Tensile Toughness.
7- Ductility.

• Bend Test for Brittle Materials



stress 1- flexural strength $= \frac{3FL}{2wh^2}$

flexibility 2- flexural modulus $= FL^3 / 4wh^3\delta$ ↳ Deflection

L is the distance between supports not the light

• Hardness test

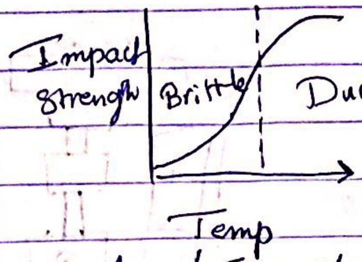
• Types: 1- Macro hardness :- Overall-bulk hardness of a materials measured using loads > 2N (Rockwell, Brinell, Veckers)
2- Micro " : loads less than 2N (Knoop 1412)
3- Nano " :- 1-10nm length using small forces (~100 μN)

• Impact test:-

Izod : vertically / notch facing load
Charpy : Horizontally / notch in opposite to notch

We make the nouch for safety factor and to make the test more realistic

DBTT :



- for stainless steel (Fcc structure)
  → high absorbed energies and No transition Temp
  → high toughness

- **Fracture Mechanics**

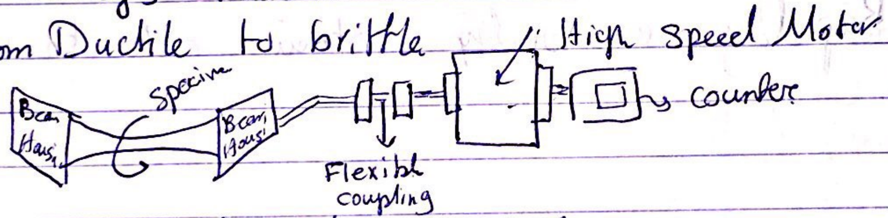
Steps 1- crack formation ;
2- " propagation

Fracture Modes :- ① Ductile ; (metals [not cold])
- Extensive plastic deformation
- Crack is stable

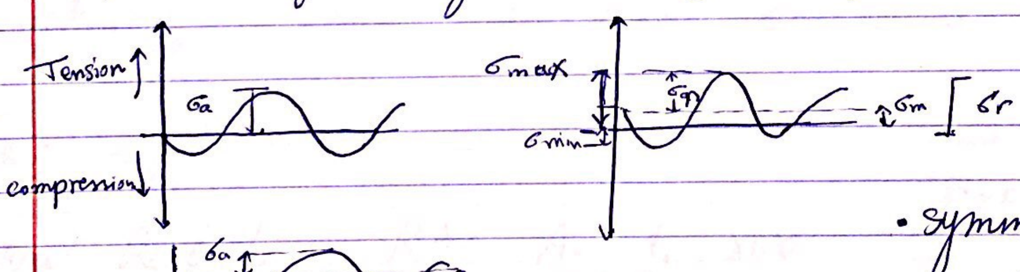
② Brittle ; (Concrete ?, glass, ceram—)
- Brittle plastic deformation
- Crack is unstable

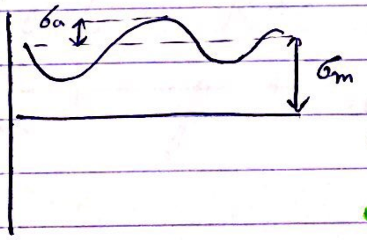
Fatigue :-

→ It changes material from Ductile to brittle



Application of Fatigue testing :- cyclic stress



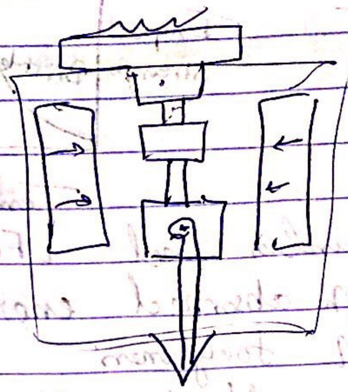


- symmetric and periodic about zero or An symmetric

- Mean stress = $\sigma_m = \dfrac{\sigma_{max} + \sigma_{min}}{2}$
- Range of stress $= \sigma_r = \sigma_{max} - \sigma_{min}$
- Amplitude $= \sigma_A = \dfrac{\sigma_r}{2}$

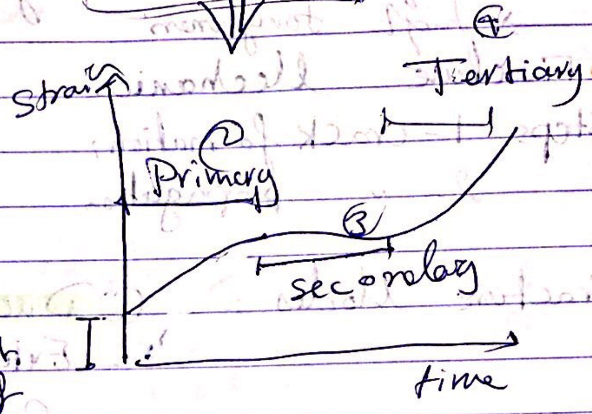
Stress ration = $R = \sigma_{min} / \sigma_{max}$

• Creep test :-



Temp ≥ 0.4 T_m

Stages of creep



① mainly elastic
② slope Strain/Time ↓ with time
③ steady stat :- Rate of straining is constant

T_r : time of Rupture

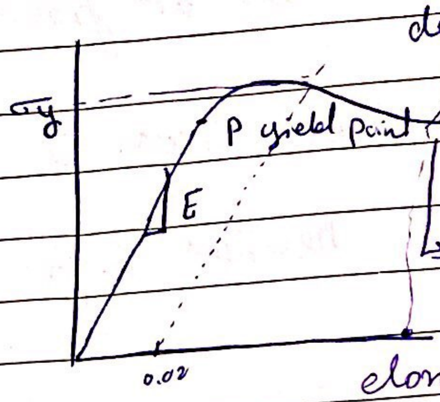
④ Rapidly accelerating strain rate to rupture

$A = \frac{\pi}{4} d^2$

Notes about Tensile Test :-

Shear Stress $\tau = F/A_0$

Shear Strain $\gamma = \tan\theta \times 100\%$



$\sigma = E\, \varepsilon$

$E \uparrow$, stiffness $\uparrow$

Non linear $\frac{\Delta\sigma}{\Delta\varepsilon}$ = secant between origin an σ

Plastic deformation

- stress - strain are NOT proportional
- irreversable
- occurs by: breaking and rearrangement of atomic bond by Motion of dislocation
- P consists of { upper point / lower point }

- Elastic deformation is time dependent (It takes time

Because of the finite rate of atomic / molecular deformation

This behavor is called Anelasticity

- small for metals

Significant for non-lin materials (visco-elastic beh)

$\nu = \frac{-\varepsilon_x}{\varepsilon_y} = \frac{-\varepsilon_y}{\varepsilon_z}$

Ductility (Area under curve stress-strain)

$\% E_l = \frac{l - l_0}{l_0} \times 100\%$

% Area Reduction = $RA\% = \frac{A_0 - A_1}{A_0} \times 100\%$

True stress = $\frac{F}{A}$

True strain = $\ln\left(\frac{l}{l_0}\right)$

- Toughness can be found using $T\sigma$

Necking occurs when σ is > σ_T ✓ tensile strength

- $\varepsilon = \frac{2 - d_{open}}{d_{open}} = \frac{l - l_0}{l_0}$

Fracture :-

Fracture Strength = $E/10$ (Theo)

$= \frac{E}{100} - \frac{E}{1000}$ (EXP) much lower due to stress concentration

Stress is amplified at :- 5 stress raisors

length of crack

$$\sigma_m = 2\sigma_0 \left(\frac{a}{P_t}\right)^{\frac{1}{2}}$$

σ_m ↗ max stress near the crack tip

σ_0 ↗ applied stress

$$K_t = \frac{\sigma_m}{\sigma_0} = 2\left(\frac{a}{P_t}\right)^{\frac{1}{2}}$$

↳ P_t Radius of crack

Fatigue :-

* 90% of failures is due to fatigue
* Fatigue failure is Brittle like (sudden & catastrophic)
* Stages :- 1- crack initiation
  2- Incremental crack propagation
  3- final catastrophic failure