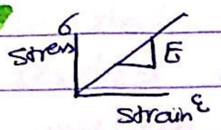
Chapter 6:

materials

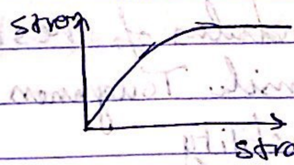
linear (Elastic)



slope = E

Ex Metals

non linear



E is not constant = tangent

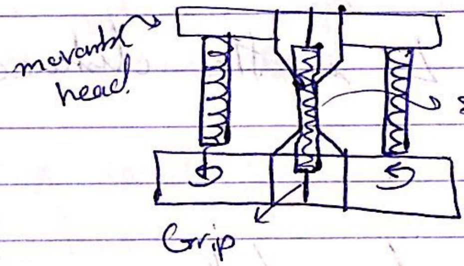
Ex: concrete, rubber

The Tensile test:-

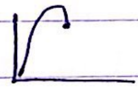
* Eng stress $\sigma_s = F/A_o$
* Eng strain $\varepsilon = \frac{\Delta L}{L_o} \times 100\%$

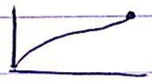
→ force applied : unidirectional

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

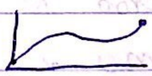


→ Curves for materials

Metal 

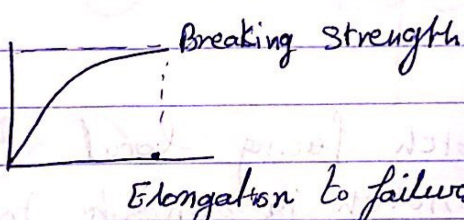
Elastomer 

Creramics, glasses, Concrete  (brittle)

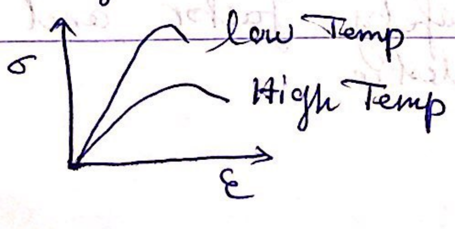
Thermoplastic materials ($T > T_g$) 

$\sigma, \varepsilon > 0$ Tension

$\sigma, \varepsilon < 0$ Compression



Temprature effect

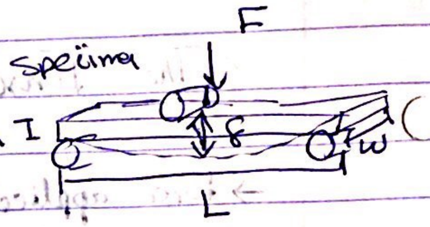


- MPa: Mega Pascal $= MN/m^2$
- 1 pound (Ib) = 4.448 Neuton (N)
- 1 Ksi = 1000 psi = 6.895 MPa
- PSi: Pounds per square inch
- 1 psi = 0.006895 MPa

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 (E_r).
6- Tensile Toughness.
7- Ductility.

• Bend Test for Brittle Materials



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

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

L is the distance between supports not the light

• Hardness test

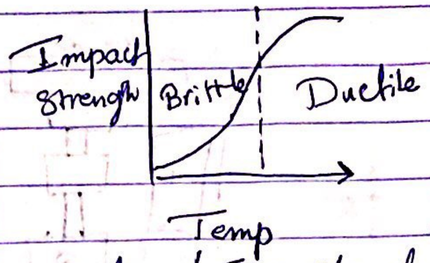
• Types: 1- Macro hardness :- Overall-bulk hardness of a materials measured using loads >2N
2- Micro " : loads less than 2N (Knoop HK) (Rockwell, Brinell, Veckers)
3- Nano " :- 1-10nm length using small forces (~100 μN)

• 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 realestic

DBTT :



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

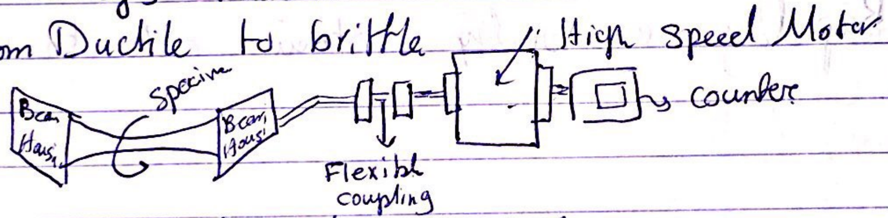
Steps 1 – Crack formation;
2 – " propagation

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

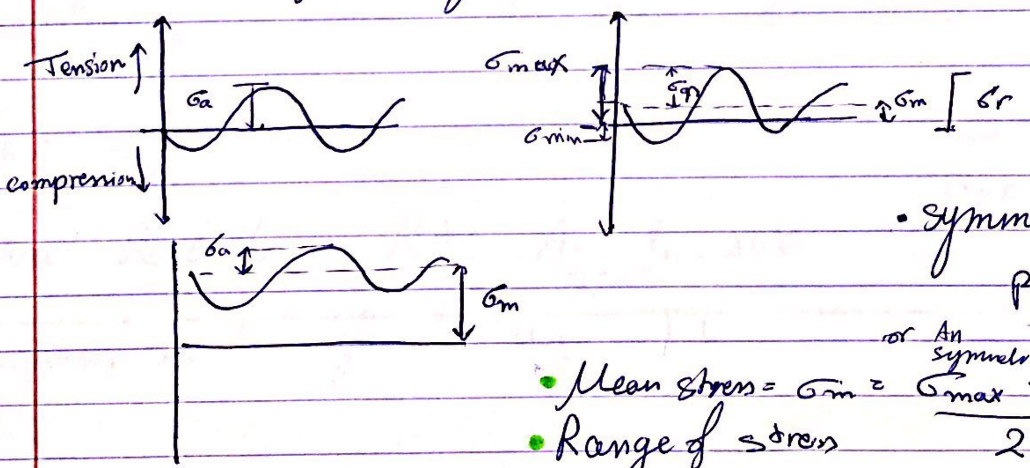
② Brittle; (Concrete, glass, ceram—)
- Brittle plastic deformation
- Crack is unstable

Fatigue :–

→ It changes material from Ductile to brittle



Application of Fatigue testing :– cyclic stress

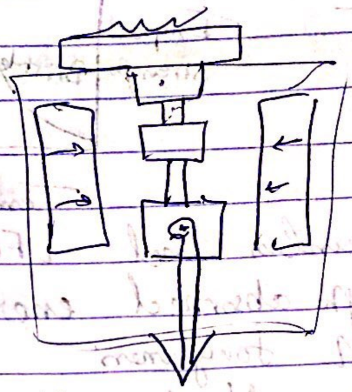


- symmetric and periodic about zero
  or An symmetric

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

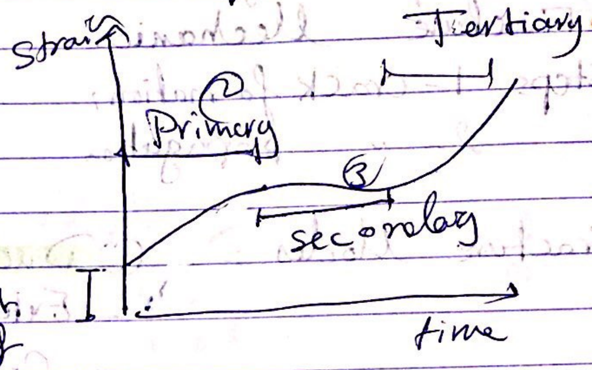
Stress ration = $R = \sigma_{min} / \sigma_{max}$

- Creep test :-



Temp $\geq 0.4 T_m$

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

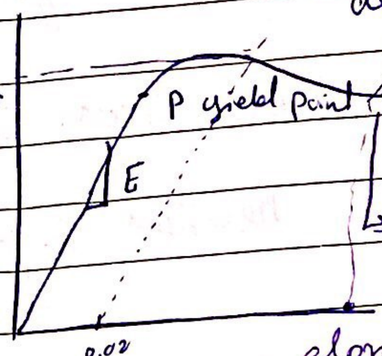
④ Rapidly accelerating strain rate to rupture

Notes about Tensile Test :-

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

Shear Stress $\tau = F/A_0$

Shear Strain γ = ~~tan θ x100%~~



at it, strain deviates from being proportional to stress

↳ Breaking strength

elongation to failure

$\sigma = E \, \varepsilon$

$E \uparrow$, stiffness $\uparrow$

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

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

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 }

Ductility (Area under Curve stress-strain)

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

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

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

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

- Toughness can be found using TO

Necking occurs when σ is $> \sigma_T$ ✓ 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

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

σ_m: max stress near the crack tip; σ_0: applied stress; a: length of crack

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

ρ_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