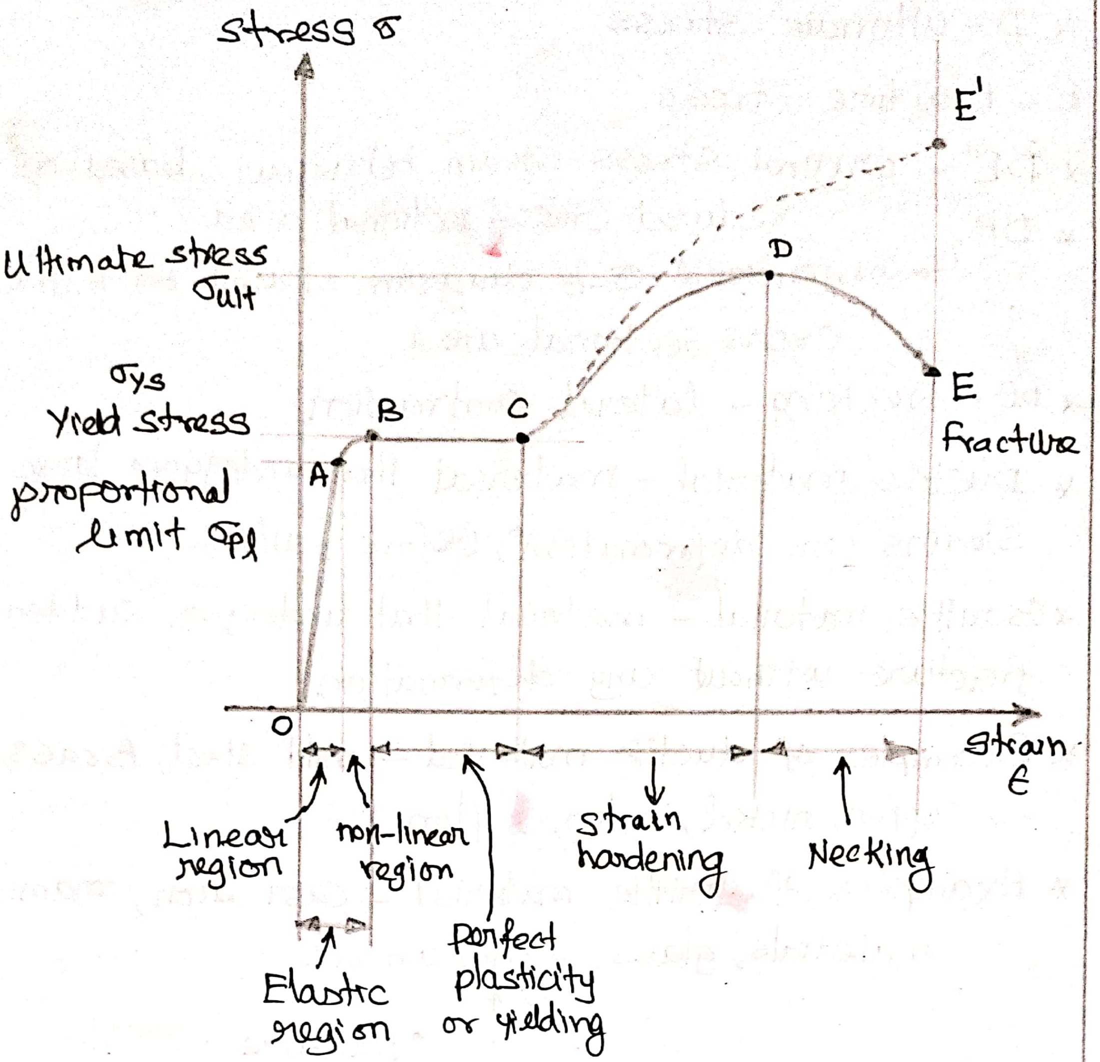


Stress-Strain diagram for a typical structural steel in Tension. — σ-ϵ diagram for a ductile material.

Stress-strain diagrams were originated by Jacob Bernoulli (1654-1705) and J.V. Poncelet (1788-1867).

σ-ϵ diagram is characteristic of the material and conveys important information about the mechanical properties and type of behaviour.

* Structural steel or mild steel or low carbon steel.
* OA - straight line - linear σ-ϵ behaviour. Elastic
* AB - curved line - non-linear σ-ϵ behaviour - Elastic
* B - Yield point, Yield stress σ_y
* BC → Yielding of the material - material is perfectly plastic.
* CD - Strain hardening.

1-8

* D - ultimate stress

E - fracture stress

* DE' - original stress-strain behaviour - based on reduced cross-sectional area

* DE - conventional σ-ϵ diagram - based on initial cross-sectional area

* DE - Necking - lateral contraction

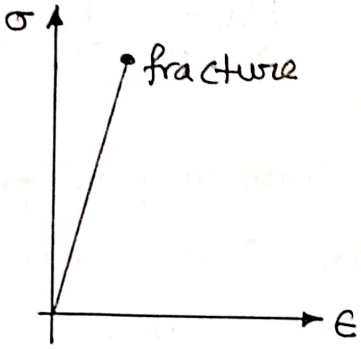
* Ductile material - material that undergoes large strains (or deformation) before failure.

* Brittle material - material that undergoes sudden fracture without any deformation

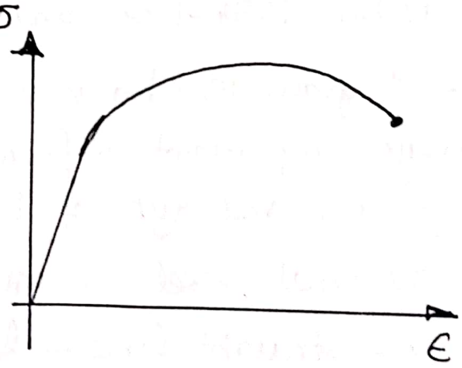
* Examples of ductile material - mild steel, Brass, copper, nickel, nylon, teflon.

* Examples of brittle material - cast iron, ceramic materials, glass, stone, concrete

Stress-strain diagram for a brittle material



Stress-strain diagram for a ductile material.



E_{st} - Young's modulus of steel = 210 GPa

$$= 210\,GPa = 210\times10^{9}\,Pa = 210\times10^{9}\,\frac{N}{m^2}$$

$$= 210\times10^{9}\,\frac{N}{m^2}\,\frac{(m)^2}{(1000mm)^2} = \frac{210\times10^{9}\,N}{10^{6}\,mm^2}$$

$$E_{st} = 210\times10^{3}\,\frac{N}{mm^2}$$

* Elastic material - material that undergoes deformation during loading and during unloading, it recovers its original shape.
* Plastic material - material that does not regain its original shape after unloading.
* Elastic material - Elastic strain - strain is completely recovered - Elastic recovery.
* Partially Elastic material - Partial Elastic recovery.
* Young's modulus - slope of the stress-strain curve in the elastic region.-(Thomas Young)
* Hooke's law in tension - Within the linear elastic limit, the normal stress is directly proportional to normal strain.
* Hooke's law in shear - Within the linear elastic limit, the shear stress is directly proportional to shear strain.

$\sigma \propto \epsilon$ $\qquad\qquad\qquad \tau \propto \gamma$

$\sigma = E\,\epsilon$ $\qquad\qquad\qquad \tau = G\gamma$

Poisson's ratio 'ν' (nu) $= -\dfrac{\text{lateral or transverse strain}}{\text{axial or longitudinal strain}}$.

Poisson's ratio 'ν' named after Simeon Denis Poisson (1781-1840).

Poisson's ratio for most metals = 0.25 to 0.35.

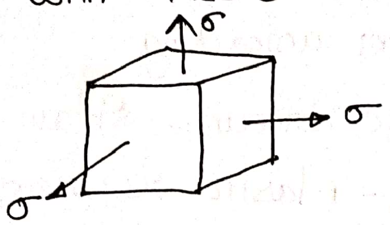
For Cork, $\nu \simeq 0$.

Theoretical upper limit for Poisson's ratio ν is 0.5.

* In elastic region, volume changes occur.
* In plastic region, no volume change.

* $E = 2G(1+\nu)$
* $E = 3K(1-2\nu)$
* K - Bulk modulus $= \dfrac{\text{spherical stress}}{\text{volumetric strain}}$

<u>spherical stress</u> - tri-axial state of stress, with stresses in all three directions equal.



If all three stresses are equal and compressive, then the stress state is known as <u>hydrostatic stress.</u> Example: an object submerged in a fluid, a rock deep within the earth.

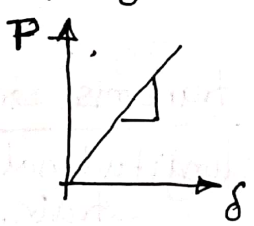
* factor of Safety $= \dfrac{\text{Yield stress}}{\text{allowable stress}}$

<u>* Elongation of a bar</u> :- <u>Deflection of Axially loaded members.</u>

$\sigma = \dfrac{P}{A}$, $\epsilon = \dfrac{\delta}{L}$, $\sigma = E\epsilon$, $\Rightarrow \dfrac{P}{A} = E\dfrac{\delta}{L}$.

$\boxed{\delta = \dfrac{PL}{AE}}$ AE - Axial rigidity.

Spring → $P = K\delta$, K → Stiffness of the spring



Slope of the force-deflection curve is called stiffness.

$K = \dfrac{P}{\delta} \rightarrow \dfrac{N}{mm}$

Stiffness K is defined as force required to produce unit deflection

for a spring

$P = K\delta$

for an axially loaded bar

$P = \dfrac{AE}{L}\delta$

$\dfrac{AE}{L}$ → stiffness of the bar.