POISSON’S RATIO

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Whenever a body is subjected to a force in a particular direction,there is a change in the dimensions in the body in the other two perpendicular directions.

Here the strain produced in the transverse direction is called lateral strain and longitudinal strain is in the direction of stretching force.

Poisson's ratio is the ratio lateral strain to longitudinal strain

Let α be the longitudinal strain per unit stress and β is the lateral stain per unit stress.

Within elastic limit, $\beta \propto \alpha$ or $\beta = \sigma\alpha$

Poisson's ratio $\sigma = \beta/\alpha$

Consider a wire of length L and diameter D.It is fixed at one end and a force is applied at the other end .

The length of the wire increases and the diameter of the wire decreases.

Let dL be the increase in length and dD be the decrease in diameter

Then $\alpha = dL/L$ & $\beta = dD/D$

$$\sigma = \frac{\beta}{\alpha} = -\frac{dD/D}{dL/L} = -\frac{dD}{dL}\frac{L}{D}$$

Tensile deformation always considered as positive and compressive deformations as negative

Normal materials have a positive poisson's ratio and it is unitless & dimensionless

For most of the substances σ varies between 0.2 and 0.4

The maximum possible value of Poisson’s ratio is 0.5

Isotropic upper limit is 0.5 and isotropic lower limit is -1

Materials with negative poisson’s ratio expands laterally when stretched in contrast to ordinary materials.

Examples:

In White dwarfs and neutron stars negative poisson’s ratio might exist.

Carbon nanotube sheets can be turned from positive to negative poisson’s ratio.

Material	Poisson's ratio
Isotropic upper limit	0.5
Rubber	0.48-0.5
Lead	0.44
Copper	0.37
Aluminium	0.35
Polystyrene	0.34
Brass	0.33
Ice	0.33
Stainless steel	0.3
Wrought Iron	0.278
Cast iron	0.265
Concrete	0.2
Bronze	0.14
Cork	~0
Isotropic lower limt	-1

Application-Cork of wine bottle

The cork must be easily inserted and removed.But rubber (Poisson’s ratio 0.5)cannot be used for this purpose because it would expand laterally when compressed into the neck of the bottle and would jam.

Cork(Poisson’s ratio of nearly zero)is ideal in this application.It behave well as a bottle stopper.

Incompressible means there is no volume change(They have Poisson’s ratio close to 0.5)

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Proof: No change in volume means Volume is a constant.

$\pi r^2 L$=Constant

$$r^2 L = Const.$$

$$D^2 L = Const.$$

$$Differentiating\ 2D\ dD\ L + D^2\ dL = 0$$

$$2dD\ L + DdL = 0$$

$$2dD\ L = -DdL$$

$$-\frac{dD\ L}{D\ dL} = \frac{1}{2}$$

Means σ=0.5 for incompressible materials.

Relation between elastic constants

$$\frac{9}{Y} = \frac{3}{n} + \frac{1}{B} \qquad ------(1)$$

$$B = \frac{Y}{3(1-\sigma)} \qquad -------(2)$$

$$n = \frac{Y}{2(1+\sigma)} \qquad -------(3)$$

$$Show\ that\ Y = \frac{9nB}{3B+n}, \quad B = \frac{nY}{9n-3Y}, \quad n = \frac{3BY}{9B-Y}$$

PROBLEMS

1. $If\ \dfrac{Y}{n} = \dfrac{1}{2}, Find\ the\ value\ of\ \sigma.$

2. $If\ \dfrac{B}{n} = \dfrac{1}{2}, then\ Y\ and\ n\ are\ related\ by$

$$Y = \frac{2}{5}n, \quad Y = \frac{9}{5}n, \quad Y = \frac{3}{5}n$$

3.Calculate the Poisson's ratio for the material ,given$Y=12.25 \times 10^{10} N/m^2$ and $n=4.55 \times 10^{10} N/m^2$

4.Calculate the Poisson's ratio for Aluminium ,Given $Y=7 \times 10^{10} N/m^2$ and $n=2.5 \times 10^{10} N/m^2$

THANK YOU