School of Engineering & Built Environment

MEng/BEng(Hons) in:

Mechanical-Electronic Systems Engineering
Mechanical & Power Plant Systems
Electrical Power Engineering
Computer-Aided Mechanical Engineering

Module: Engineering Design & Analysis 2

(Module No. M2H721926)

Revision Notes:
Bending and Direct Stress: A Summary

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ENGINEERING DESIGN & ANALYSIS 2 (M2H721926) – Direct and Bending Stresses - Revision

Loads

Types of loading imposed on components/structures:

a) **STATIC or DEAD LOADS –** non-fluctuating, non-moving (static), gravity (weight), thermal.

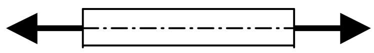
b) **LIVE LOADS –** short time span, moving (dynamic).

c) **IMPACT or SHOCK LOADS –** very short time span, large magnitudes.

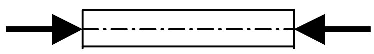
d) **ALTERNATING or FATIGUE LOADS –** magnitude and sign (+ve / –ve) changes with time.

Effects of loading on components/structures:

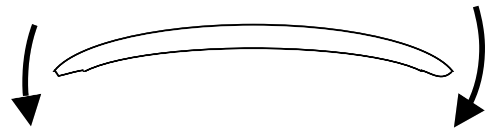
TENSILE pulling/stretching



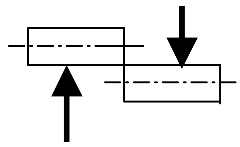
COMPRESSIVE pushing/squeezing



BENDING flexure

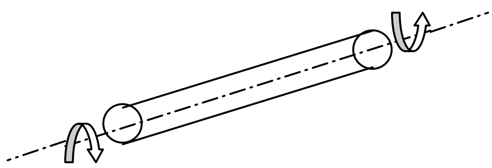


SHEAR sliding



THERMAL expansion/contraction with change in temperature

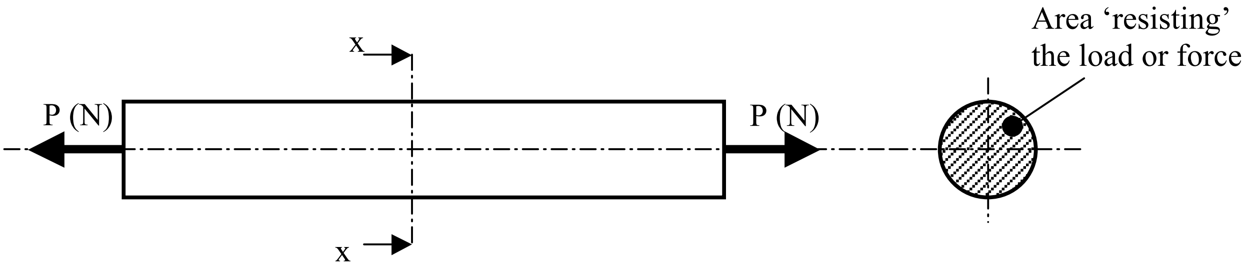
TORSION twisting



DIRECT STRESS

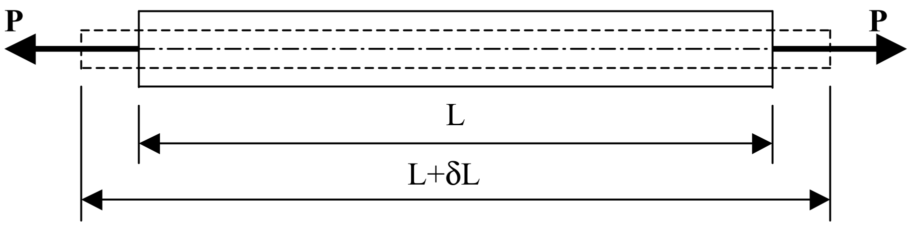
Direct Stress, $\sigma = \frac{P}{A} (N / m^2)$ [Note: +ve for tensile load, -ve for compression load]

Note: Units: 1 N/m^2 = 1 Pascal (Pa)
1 MN/m^2 = 1 x 10^6 N/m^2 = 1 N/mm^2



DIRECT STRAIN

Longitudinal Strain, $\varepsilon_L = \frac{\delta L}{L}$ [Note: ε_L has *no* units!]



ELASTIC MATERIAL

Young's Modulus of Elasticity, $E = \frac{\sigma}{\varepsilon_L}$ (N/m^2)

A value for E for a material can be obtained from a *tensile test* where a test specimen of the material of specified shape and dimensions is stretched until it breaks. E is calculated as the gradient of the straight line within the elastic behaviour region of the stress-strain graph obtained from the test. The graph below shows typical tensile test curves for various materials with significant points highlighted.

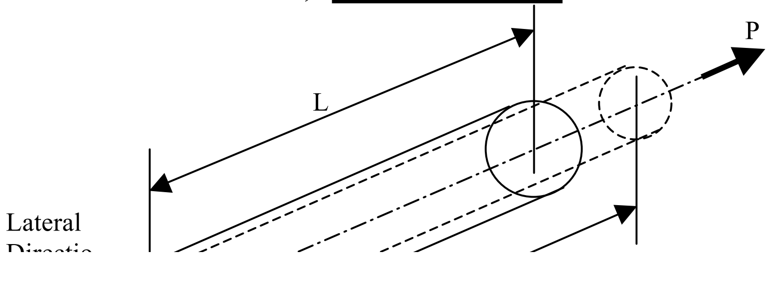
Note: For Low Carbon Steel, E = 200 GN/m^2; Aluminium, E = 70 GN/m^2

POISSON'S RATIO

Lateral strain, $\varepsilon_{Lat} = \frac{\delta R}{R}$ or $\varepsilon_{Lat} = \frac{\delta d}{d}$ or $\varepsilon_{Lat} = \frac{\delta W}{W}$

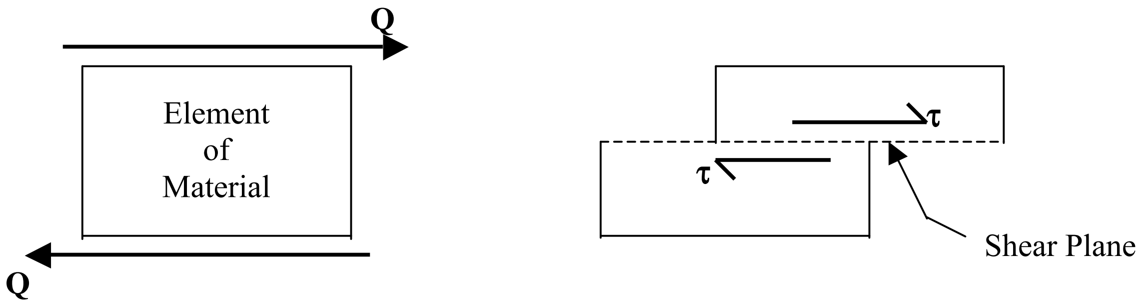
Poisson's ratio, $\nu = \frac{\varepsilon_{Lat}}{\varepsilon_L}$ [Note: ν has *no* units!]

Note: For most metallic materials, <u>0.25 < ν < 0.33.</u>

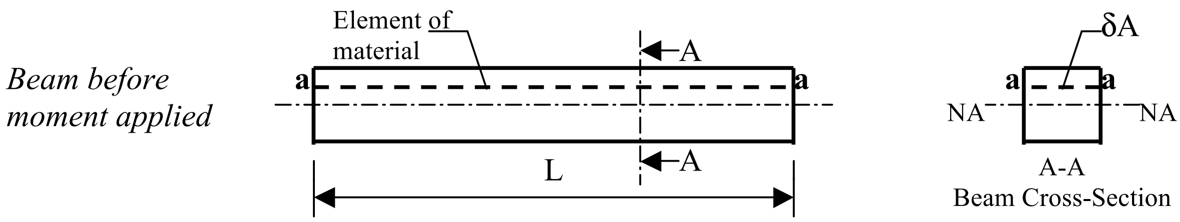


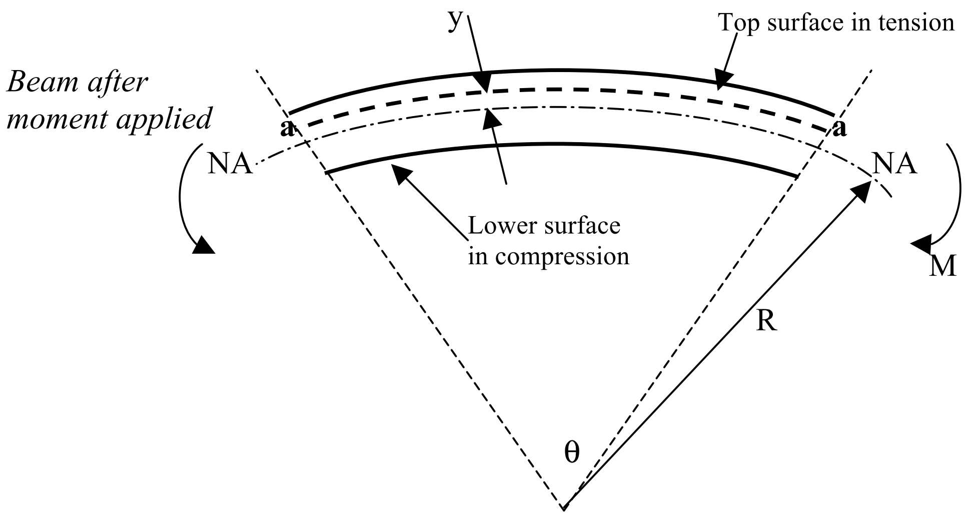
INDIRECT STRESS: SHEAR STRESS

Shear stress, $\tau = \dfrac{Q}{A_s}$ (N/m^2)



BENDING STRESS



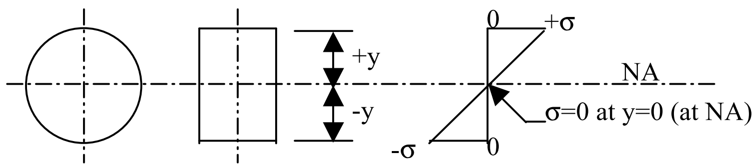


The theory of elastic bending equation is gven by: $\dfrac{M}{I} = \dfrac{\sigma_b}{y} = \dfrac{E}{R}$

The bending stress can be calculated from: $\sigma_b = \frac{My}{I}$ (N/m^2)

Bending stress is distributed down through a cross-section as follows:

Symmetrical Cross-Sections:



Unsymmetrical Cross-Sections: