SNS COLLEGE OF TECHNOLOGY

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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

16CET204 – MECHANICS OF MATERIALS

II YEAR / IV SEMESTER

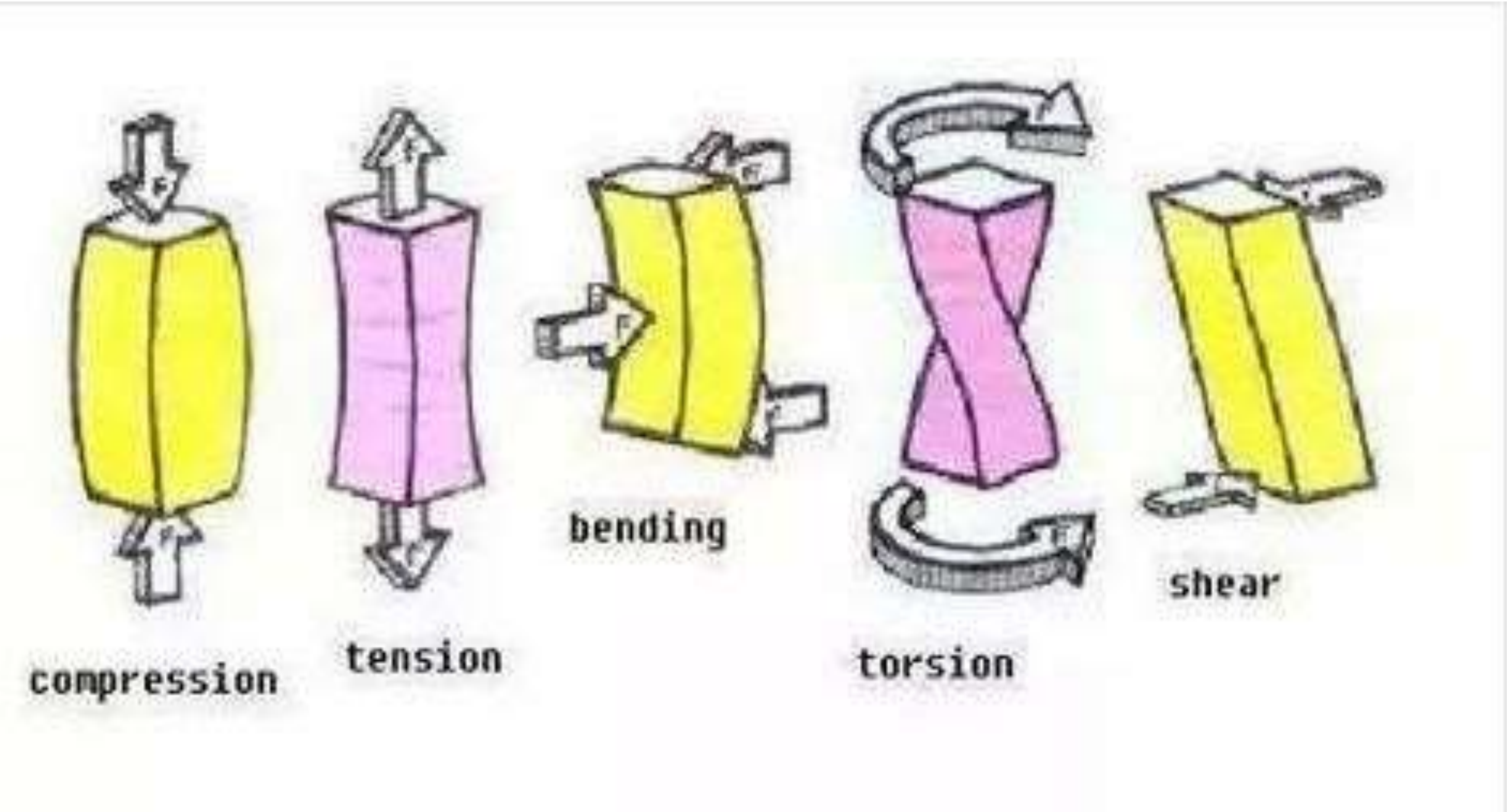
Unit 1 : ENERGY PRINCIPLES

Topic 2 : Strain Energy Due To Loading

ENERGY PRINCIPLES

STRAIN ENERGY DUE TO LOADING

- Strain energy due to gradual loadings
- Strain energy due to sudden loadings
- Strain energy due to impact loadings
- Strain energy due to shear
- Strain energy due to flexure
- Strain energy due to torsion


compression
tension
bending
torsion
shear

STRESS DUE TO LOADINGS

Stresses due to different types of loads

- Gradually applied load
- Suddenly applied load
- Impact loads or falling loads

Gradually applied loads

1. Load increases zero to final value step by step

$$\sigma = P/A$$

STRESS DUE TO LOADINGS

Suddenly applied loads

1. Load applied all of a sudden and not stepwise is called suddenly applied loads.

$$\sigma = 2P/A$$

Impact loads

1. Load which falls from a height or strike the body with certain moment is called impact load.

$$\sigma_{max} = \frac{P}{A} + \sqrt{\left(\frac{P}{A}\right)^2 + \frac{2EPh}{AL}}$$

P → Load falling from a height (mm)
A → Area of Rod (mm^2)
E → Young's Modulus (N/mm^2)
h → Height of fall (mm)
L → Length of Rod.

STRAIN ENERGY EXPRESSION

STRAIN ENERGY CONDITION	EXPRESSION
Axial load	U= $\frac{\sigma^2 \ V}{2E}$
Shear	U= $\frac{\tau^2 \ V}{2C}$
Flexure	U = $\frac{M^2 L}{2EI}$
Torsion	U= $\frac{\tau^2 \ V}{4C}$

DERIVATIONS AND PROBLEMS

GRADUALLY APPLIED LOAD

1. A steel bar 4x4 cm in section, 3m long is subjected to an axial load of 128kN. Taking E=200GN/m². Calculate the alternation in the length of the bar. Calculate also the amount of energy stored in the bar during extension.

SUDDENLY APPLIED LOADS

1.A tensile load of 60kN is gradually applied to a circular bar of 4cm diameter and 5m long. If the value of E= $2.0x10^5$ N/mm². determine

- Stretch In Rod
- Stress In The Rod
- Strain Energy Absorbed by Rod
- Maximum Instantaneous Stress Induced
- Instaneous Elongation In Rod

2. A bar of uniform cross-section 'A' and length 'L' hangs vertically, subjected to its own weight. Prove that the strain energy within the bar is given by

$$U=\frac{AXp^2XL^3}{6E}$$

where E=modulus of elasticity, p= weight per unit volume of bar.

SUDDENLY APPLIED LOADS

3) The maximum stress produced by the pull in a bar length 1m is 150N/mm². the area of cross-section and length are shown in figure. Calculate the strain energy stored in the bar if E=2x10^5 N/mm^2.

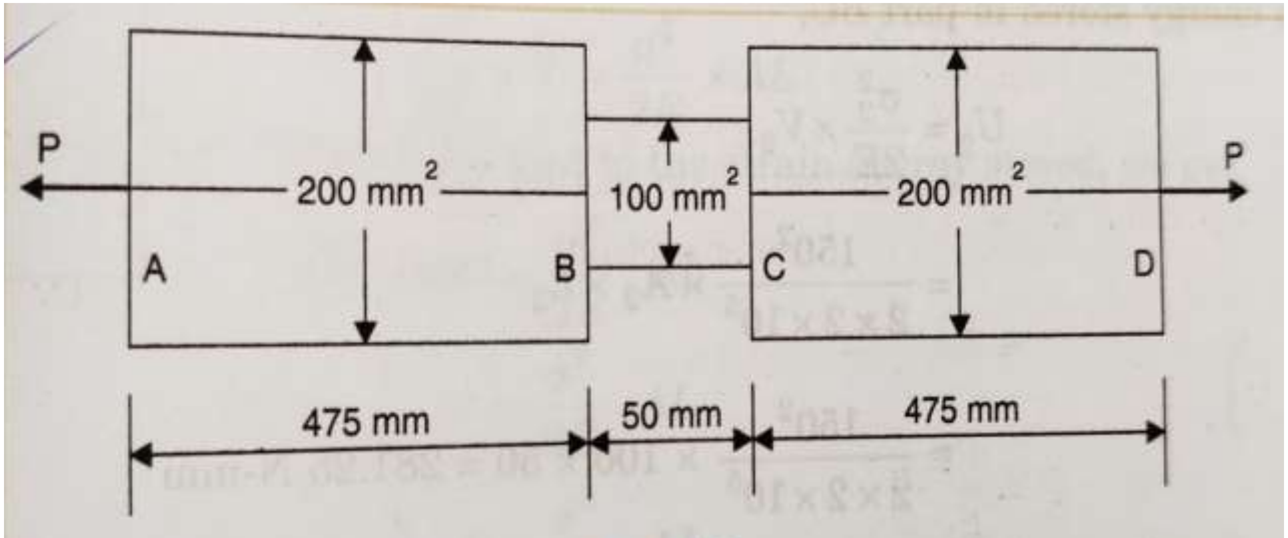


Fig. 4.3

STRAIN ENERGY DUE TO IMPACT

1) A vertical compound tie member fixed rigidly at its upper end, consists of a steel rod 2.5m long and 200mm in diameter, placed within an equally long brass tube 21mm in internal diameter and 30mm external diameter. The rod and the tube are fixed together at the ends. The compound member is then suddenly loaded in tension by a weight of 10kN falling through the height of 3mm on to a flange fixed to its lower end. Calculate the maximum stresses in steel and brass. $E_S = 2\text{x}10^5 \text{N/mm}^2$ and $E_b = 1.0\text{x}10^5 \text{N/mm}^2$

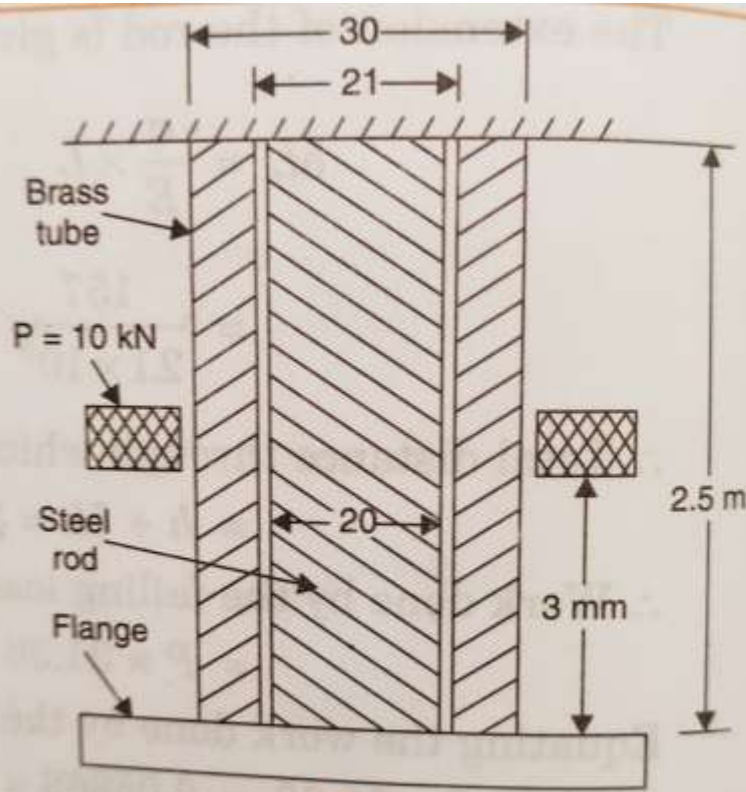


Fig. 4.5

STRAIN ENERGY DUE TO SHEAR

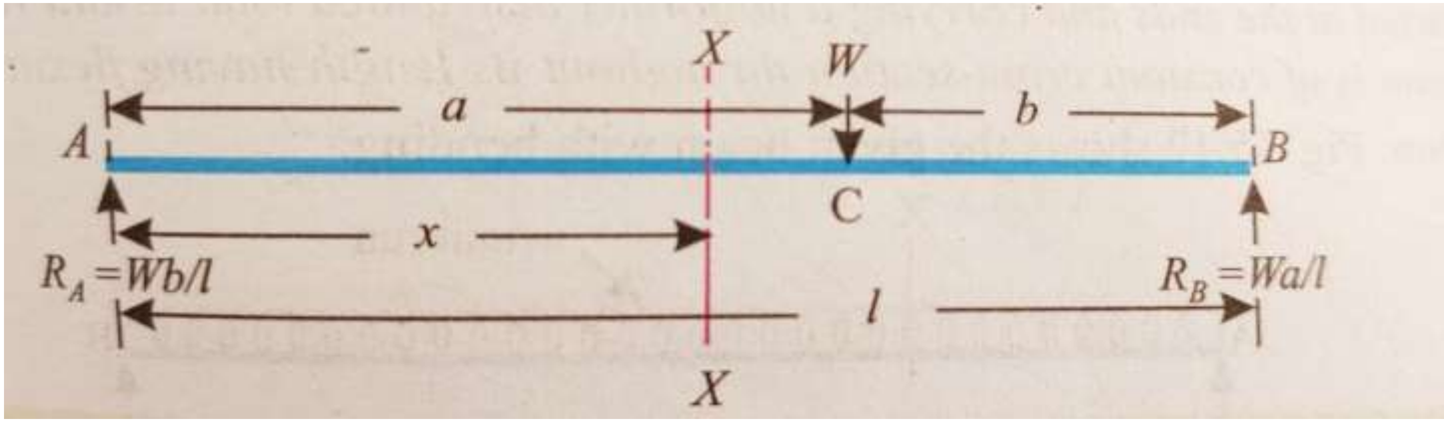
1) The shear stress in a material at a point is given as $50 N/mm^2$. determine the local strain energy per unit volume stored in a material due to shear stress. Take C= $8x10^4 N/mm^2$

STRAIN ENERGY DUE TO TORSION

1) The external diameter of the hollow shaft is twice the internal diameter. It is subjected to pure torque and it attains the maximum shear stress τ. Show that the strain energy stored per unit volume of the shaft is $\frac{5\tau^2}{16C}$. such a shaft is required to transmit 5400kW at 110r.p.m with uniform torque, the maximum stress not exceeding 84MN/mm^2. determine the shaft diameters and energy stored per m^3.

STRAIN ENERGY DUE TO BENDING

1) A beam of length l simply supported at ends is loaded with a point load W at a distance a from one end. Assuming that the beam has constant cross-section with moment of inertia as I and young's modulus of the beam as E, find the strain energy of the beam and hence find the deflection under load. Strain energy due to shear can be neglected.



Reference

1)R.K.BANSAL STRENGTH OF MATERIALS

2)Er.R.K.RAJPUT STRENGTH OF MATERIALS

THANK YOU