

Physics

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(Chapter 9) (Mechanical Properties of Solids) (Exercises)

(Class 11)

Question 9.6:

The edge of an aluminium cube is 10 cm long. One face of the cube is firmly fixed to a vertical wall. A mass of 100 kg is then attached to the opposite face of the cube. The shear modulus of aluminium is 25 GPa. What is the vertical deflection of this face?

Answer 9.6:

Edge of the aluminium cube, $L = 10 \text{ cm} = 0.1 \text{ m}$

The mass attached to the cube, $m = 100 \text{ kg}$

Shear modulus (η) of aluminium = 25 GPa = $25 \times 10^9 \text{ Pa}$

$$\text{Shear modulus, } \eta = \frac{\text{Shear stress}}{\text{Shear strain}} = \frac{\frac{F}{A}}{\frac{\Delta L}{L}}$$

Where, $F = \text{Applied force} = mg = 100 \times 9.8 = 980 \text{ N}$

$A = \text{Area of one of the faces of the cube} = 0.1 \times 0.1 = 0.01 \text{ m}^2$

$\Delta L = \text{Vertical deflection of the cube}$

$$\begin{aligned} \therefore \Delta L &= \frac{FL}{A\eta} \\ &= \frac{980 \times 0.1}{10^{-2} \times (25 \times 10^9)} \end{aligned}$$

$$= 3.92 \times 10^{-7} \text{ m}$$

The vertical deflection of this face of the cube is $3.92 \times 10^{-7} \text{ m}$.

Question 9.7:

Four identical hollow cylindrical columns of mild steel support a big structure of mass 50,000 kg. The inner and outer radii of each column are 30 and 60 cm respectively. Assuming the load distribution to be uniform, calculate the compressional strain of each column.

Answer 9.7:

Mass of the big structure, $M = 50,000 \text{ kg}$

Inner radius of the column, $r = 30 \text{ cm} = 0.3 \text{ m}$, Outer radius of the column, $R = 60 \text{ cm} = 0.6 \text{ m}$

Young's modulus of steel, $Y = 2 \times 10^{11} \text{ Pa}$

Total force exerted, $F = Mg = 50000 \times 9.8 \text{ N}$

$$\text{Stress} = \text{Force exerted on a single column} = \frac{50000 \times 9.8}{4} = 122500 \text{ N}$$

$$\text{Young's modulus, } Y = \frac{\text{Stress}}{\text{Strain}}$$

$$\text{Strain} = \frac{F}{Y}$$

Where,

$$\text{Area, } A = \pi (R^2 - r^2) = \pi ((0.6)^2 - (0.3)^2)$$

$$\text{Strain} = \frac{122500}{\pi [(0.6)^2 - (0.3)^2] \times 2 \times 10^{11}} = 7.22 \times 10^{-7}$$

Hence, the compressional strain of each column is 7.22×10^{-7} .

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