POSTAL BOOK PACKAGE 2025

MADE EASY PUBLICATIONS

CIVIL ENGINEERING

CONVENTIONAL Practice Sets

CONTENTS

STRENGTH OF MATERIALS

1 CHAPTER Properties of Metals

Q.1 A prismatic circular bar of diameter 20 mm and length 2.8 m is subjected to a tensile force of 10 kN. The measured extension of the bar is 1.2 mm. Calculate the tensile stress and strain in the bar.

Solution:

$$\text{Tensile stress } (\sigma) = \frac{P}{\text{Area}} = \frac{10 \times 10^3}{\frac{\pi}{4}(20)^2} = 31.83 \text{ N/mm}^2$$

$$\text{Tensile strain } (\in) = \frac{\Delta L}{L} = \frac{1.2}{2800} = 4.286 \times 10^{-4}$$

Q.2 In the above question find the actual stress (σ_a).

Solution:

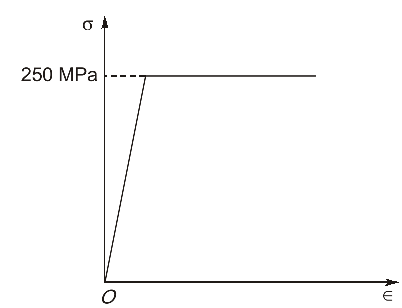
We know that for tension,

$$\boxed{\text{Actual stress } (\sigma_a) = \sigma(1+\in)}$$

$$= 31.83\,(1 + 4.285 \times 10^{-4})$$

$$= 31.84 \text{ N/mm}^2$$

Q.3 A bar of length 2 m is made of mild steel for which idealized stress-strain curve is shown. The yield stress of material of bar is 250 MPa and the slope of curve is 200 GPa. The bar is loaded axially until it elongates 6.5 mm. Find the final length of the bar after removal of the load.



Solution:

$$\text{Length } (L_0) = 2000 \text{ mm}$$

$$\text{Yield strain} = \text{elastic strain} = \frac{\sigma_y}{E} = \frac{250}{2 \times 10^5} = 1.25 \times 10^{-3}$$

$$\text{Total strain on loading} = \frac{6.5}{2000} = 3.25 \times 10^{-3}$$

Since total strain is greater than elastic strain, it means loading is applied beyond elastic limit. Therefore after unloading, certain permanent plastic strain will be left in the bar.

$$\text{Plastic strain } (\in_P) = 3.25 \times 10^{-3} - 1.25 \times 10^{-3} = 2 \times 10^{-3}$$

Permanent deformation after unloading

$$= \in_P \times L_0$$

$$= 2 \times 10^{-3} \times 2000 = 4 \text{ mm}$$

$$\text{Final length after unloading} = 2000 + 4 = 2004 \text{ mm}$$

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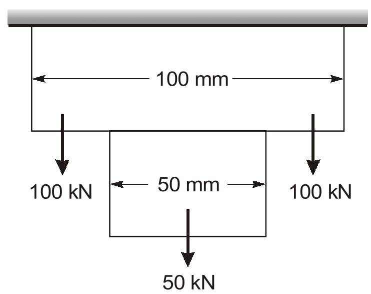
2 CHAPTER

Simple Stress Strain and Elastic Contants

Q.1 A bar of varying square cross-section is loaded symmetrically as shown in the figure. Loads shown are placed on one of the axes of symmetry of cross-section. Ignoring self-weight, calculate the maximum tensile stress anywhere in the section

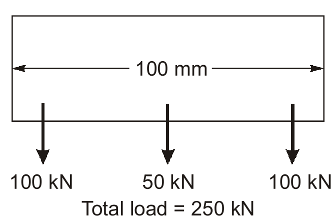


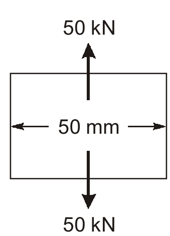
Solution:

$$\text{The stress in lower bar} = \frac{50 \times 1000}{50 \times 50} = 20 \text{ N/mm}^2$$

$$\text{The stress in upper bar} = \frac{250 \times 1000}{100 \times 100} = 25 \text{ N/mm}^2$$

Thus the maximum tensile stress anywhere in the bar is 25 N/mm^2.





Q.2 A metal bar of length 100 mm is inserted between two rigid supports and its temperature is increased by 10°C. If the coefficient of thermal expansion is 12×10^{-6} per °C and the Young's modulus is 2×10^5 MPa, then calcultae the stress in the bar

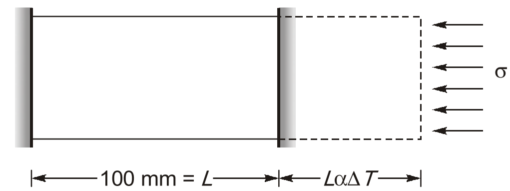
Solution:

Method-I

$$\boxed{\text{Temperature stress} = \alpha TE}$$

$$= 12 \times 10^{-6} \times 10 \times 2 \times 10^5 = 24 \text{ MPa}$$

Method-II



Due to temperature,

$$\Delta L = L\alpha\Delta T$$

But since support in fixed so, expansion is not allowed so stress is developed in the bar which is compressive in nature.

Now,

$$\text{Expansion due to temperature} = \text{Compression due to stress}$$

$$L\alpha\Delta T = \frac{\sigma}{E}\times L$$

$$\sigma = E\alpha\Delta T$$

$$= 1\times 10^5 \times 12\times 10^{-6}\times 10$$

$$= 24 \text{ MPa}$$

Q.3 A mild steel specimen is under uniaxial tensile stress. Young's modulus and yield stress for mild steel are 2×10^5 MPa and 250 MPa respectively. Calculate the maximum amount of strain energy per unit volume that can be stored in this specimen without permanent set

Solution:

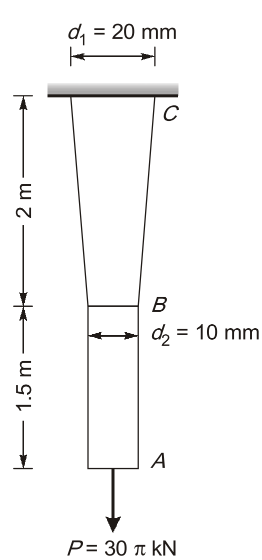
The strain energy per unit volume may be given as

$$u = \frac{1}{2}\times \text{Stresses} \times \text{Strain}$$

$$u = \frac{1}{2}\times\frac{\sigma_y^2}{E} = \frac{1}{2}\times\frac{(250)^2}{2\times 10^5}$$

$$= 0.156 \text{ N-mm/mm}^3$$

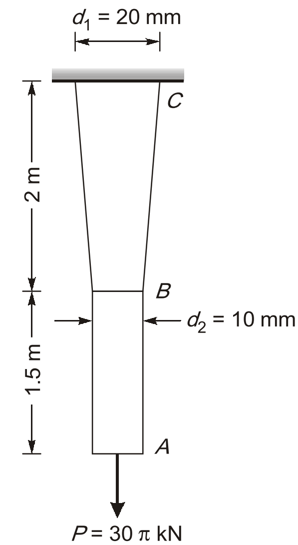
Q.4 A tapered circular rod of diameter varying from 20 mm to 10 mm is connected to another uniform circular rod of diameter 10 mm as shown in the following figure. Both bars are made of same material with the modulus of elasticity, $E = 2 \times 10^5$ MPa. If load subjected is 30π kN, then calculate deflection at point A (in mm)



Solution:

Total elongation,

AB is uniform



$$\text{So,}\Delta = \frac{PL}{AE}$$

BC is tapered

$$\boxed{\Delta = \frac{PL}{\frac{\pi}{4}d_1d_2E}}$$

$$\Delta = \Delta_{AB} + \Delta_{BC}$$

$$= \frac{PL}{AE} + \frac{4PL}{\pi d_1 d_2 E}$$

$$= \frac{30\pi \times 10^3 \times 1.5 \times 10^3}{\frac{\pi}{4}\times(10)^2 \times 2 \times 10^5} + + \frac{30\pi \times 10^3 \times 2 \times 10^3}{\frac{\pi}{4}\times 10 \times 20 \times 2 \times 10^5}$$

$$= (9 + 6) \text{ mm} = 15 \text{ mm}$$

Q.5 A steel specimen of 12 mm diameter extends by 6.31×10^{-2} mm over a gauge length of 150 mm when subjected to an axial load of 10 kN. The same specimen undergoes a twist of 0.5° an a length of 150 mm over a twisting moment of 10 N-m. Using the above data, determine the elastic constants E, μ, G and K.

Solution:

Tensile Test: $P = 10$ kN

Length of specimen, $L = 150$ mm

Cross-sectional area, $A = \frac{\pi}{4}\times 12^2 = 113.09 \text{ mm}^2$

Change in length of specimen, $\Delta = 6.31 \times 10^{-2}$ mm

Let E N/mm² is modulus of elasticity of material.

We know, axial deformation due to axial load is given by

$$\Delta = \frac{PL}{AE}$$

$$\therefore \quad E = \frac{PL}{A\Delta} = \frac{10\times1000\times150}{113.09\times6.31\times10^{-2}} = 2.10 \times 10^5 \text{ N/mm}^2$$

Torsion test:

We know, $$\frac{T}{I_P} = \frac{G\theta}{L} \quad \text{...(i)}$$

$\therefore$ Modulus of rigidity, $$G = \frac{TL}{I_P\theta}$$

$$I_P = \frac{\pi}{32}D^4 = \frac{\pi}{32}\times(12)^4 = 2035.75 \text{ mm}^4$$

Angle of twist, $$\theta = \frac{0.5\times\pi}{180} \text{ radian} = 8.73 \times 10^{-3} \text{ radian}$$

From eq. (i), we get

$$G = \frac{10\times10^3\times150}{2035.75\times8.73\times10^{-3}} = 8.44\times10^4 \text{ N/mm}^2$$

We know, $\boxed{E = 2G(1+\mu)}$

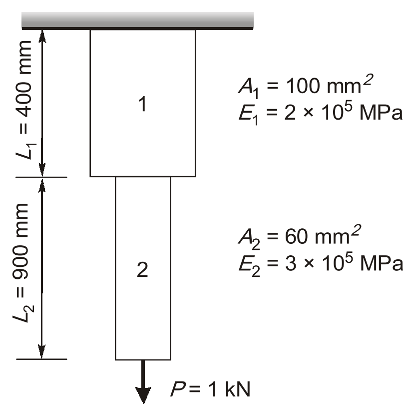
$$\frac{E}{2G} = 1+\mu$$

$$\therefore \quad \mu = \frac{E}{2G}-1 = \frac{2.10\times10^5}{2\times8.44\times10^4}-1 = 1.24-1 = 0.24$$

Also $E = 3k(1-2\mu)$

$$k = \frac{E}{3(1-2\mu)} = \frac{2.10\times10^5}{3(1-2\times0.24)} = 1.35\times10^5 \text{ N/mm}^2$$

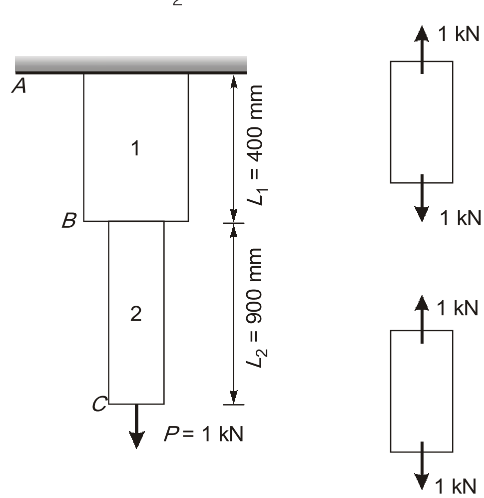
Q.6 Consider the stepped bar made with a linear elastic material and subjected to an axial load of 1 kN, as shown in the figure.



Segments 1 and 2 have cross-sectional area of 100 mm^2 and 60 mm^2. Young's modulus of 2 × 10^5 MPa and 3 × 10^5 MPa, and length of 400 mm and 900 mm, respectively. Calculate the strain energy stored in the bar (in N-mm) due to the axial load

Solution:

A_1 = 100 mm^2, EI = 2 × 10^5 MPa, A_2 = 60 mm^2, EI = 3 × 10^5 MPa



$$\Delta_{AC} = \Delta_{AB} + \Delta_{BC}$$