16. Poisson's ratio $\frac{1}{m}$ or $\mu = \frac{\text{lateral strain}}{\text{linear strain}}$

or lateral strain $= \varepsilon \times \frac{1}{m}$

17. Volumetric strain ε_V = Algebraic sum of strains along the three principal axes.

$$= \frac{1}{E}(\sigma_1 + \sigma_2 + \sigma_3)\left(1 - \frac{2}{m}\right) \text{ of both } \sigma_2 \text{ and } \sigma_3 \text{ are zero then:}$$

$$\varepsilon_V = \frac{\sigma_1}{E}\left(1 - \frac{2}{m}\right) \text{ of all the three stress are equal then:}$$

$$\sigma_V = \frac{3\sigma}{E}\left(1 - \frac{2}{m}\right)$$

18. $E = 3K\left(1 - \frac{2}{m}\right) = 2C\left(1 + \frac{1}{m}\right) = \frac{9KC}{3K + C}$

Exercises

Multiple Choice Questions

1. Load treated to be acting at a point is called:
   (a) Uniformly distributed load (b) Point load
   (c) Varying load (d) None of these
2. Internal resistance of a body to external forces/loads that the body is subjected to is called:
   (a) Strain (b) Stress (c) Pressure (d) Load
3. On application of a load if length l of a body undergoes a deformation δl then the strain is:
   (a) $\frac{\delta l}{l}$ (b) $l \times \delta l$ (c) $\frac{l}{\delta l}$ (d) None of these
4. Change in length l of a body of cross-sectional area A on application of axial load P is:
   (a) $\frac{PE}{Al}$ (b) $\frac{PA}{lE}$ (c) $\frac{Pl}{AE}$ (d) $\frac{AE}{Pl}$
   Where E is the modulus of elasticity of the material that the body is made of.
5. The ratio between longitudinal stress and strain is termed as:
   (a) Modulus of rigidity (b) Modulus of plasticity
   (c) Modulus of elasticity (d) None of these
6. Elongation produced due to self weight in a bar of uniform cross-sectional area A, length l and weight W having modulus of elasticity E, hung vertically at top end is:
   (a) $\frac{2Wl}{AE}$ (b) $\frac{2WA}{El}$ (c) $\frac{Wl}{2AE}$ (d) $\frac{Wl}{4AE}$
7. Elongation of a circular rod tapering from diameter D to d, of length l and having modulus of elasticity E under an axial pull P, hung vertically from the larger end is:
   (a) $\frac{4Pl}{\pi EDd}$ (b) $\frac{2Pl}{\pi EDd}$ (c) $\frac{Pl}{2\pi EDd}$ (d) $\frac{PDd}{\pi lE}$
8. Elongation of a rod of square cross-section length l tapering from square section of side D at one end to side d at the lower end when subjected to axial pull P is:

(a) $\frac{2Pl}{EDd}$ (b) $\frac{Pl}{2EDd}$ (c) $\frac{Pl}{EDd}$ (d) $\frac{4Pl}{EDd}$

9. Strain in a metallic bar rigidly held at ends on change of temperature of t is:

   (a) αt (b) $\frac{t}{\alpha}$ (c) $\frac{\alpha}{t}$ (d) None of these

   Where α is the co-efficient of expansion for the material of rod.

10. A steel tyre of inside diameter D_i is heated and slipped on to a wooden wheel of outside diameter D_o. If $D_i < D_o$ then on cooling the hoop stress in the tyre is:

    (a) $\left(\frac{D_o - D_i}{D_o}\right) \times E$ (b) $\frac{D_o \times E}{D_o - D_i}$ (c) $\frac{D_o - D_i}{D_o E}$ (d) None of these

11. Poisson's ratio is:

    (a) $\frac{\text{Stress}}{\text{Lateral Strain}}$ (b) $\frac{\text{Linear Strain}}{\text{Lateral Strain}}$ (c) $\frac{\text{Lateral Strain}}{\text{Linear Strain}}$ (d) None of these

12. Value of Poisson's ratio ranges from:

    (a) 1 to 2 (b) 1 to 5 (c) 0 to 0.5 (d) 0.5 to 1.5

13. Ratio between normal stress, (in case of a cube) subjected to three equal and mutually perpendicular pairs of stresses acting on the six faces, to volumetric strain is called:

    (a) Poisson's ratio (b) Bulk modulus
    (c) Modulus of elasticity (d) None of these

14. Relation between E and C is:

    (a) $E = 2C\left(1 + \frac{1}{m}\right)$ (b) $E = C\left(1 + \frac{1}{m}\right)$ (c) $E = C\left(1 - \frac{1}{m}\right)$ (d) $E = 2C\left(1 - \frac{1}{m}\right)$

15. Relation between E, C and K is:

    (a) $E = \frac{KC}{K + C}$ (b) $E = \frac{3KC}{3K + C}$ (c) $E = \frac{9KC}{3K + C}$ (d) $E = \frac{K + C}{KC}$

16. A metallic bar firmly restrained at ends, on rise in temperature developes:

    (a) Shear stress (b) Compressive stress
    (c) Tensile stress (d) Temperature stress

Answers

1. (b)	2. (b)	3. (a)	4. (c)	5. (b)	6. (c)	7. (a)	8. (c)
9. (a)	10. (a)	11. (c)	12. (c)	13. (b)	14. (a)	15. (c)	16. (b)

Short Answer Questions

1. A 5 metre long steel bar that is 2.5 cm in diameter is stretched 2.0 mm by a load of 80 kN in pulling it axially. Calculate the stress, strain and the modulus of elasticity of the bar.

   (163 MN/m²; 0.0004; 407.5 GN/m²)

2. A steel bar, 100 mm × 12 mm in cross-section, and 3 m long is subjected to an axial pull of 30 kN. How much will it increase in length if the modulus of elasticity of the steel is 210 GN/m²

   (1.5 mm)

3. An aluminium rod of 20 mm diameter is elongated by 3.5 mm along its longitudinal direction by a load of 25 kN. If the modules of elasticity of aluminium is E = 70 GPa, determine the original length of the bar.

   (3.08 m)

4. A hollow right circular 600 mm long cast-iron cylinder is of 75 mm outside diameter and 60 mm inside diameter. It carries a 50 kN axial load. Determine the decrease in length of cylinder. Take E = 100 GN/m².

   (0.188 mm)

5. A hollow steel tube with an inside diameter of 100 mm is to carry a tensile load of 400 kN. Determine the outside diameter of the tube if the stress is limited to 120 MN/m^2. (119 mm)
6. Two plates, each 110 mm width, are joined by a rivet of 20 mm diameter as shown in Fig. 1.63

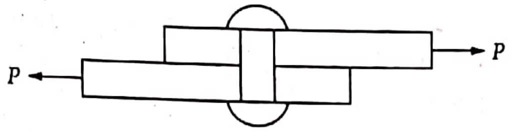

Fig 1.63

Allowable stresses are 120 MPa for bearing in the plate material and 60 MPa for shearing of rivet. Determine (a) the minimum thickness of each plate, and (b) the largest average tensile stress in the plates. **(7.85 mm; 26.7 MPa)**

7. Calculate the force required to punch a circular hole, 20 mm in diameter, in a 20 mm thick plate. Take ultimate shear stress of the plate = 300 MN/m^2. **(377 kN)**
8. Find the change in length of a steel bar subjected to the forces as shown in Fig. 1.64. Take E = 200 GN/m^2 and area of cross-section of bar = 10 cm^2 **(1.6 mm)**

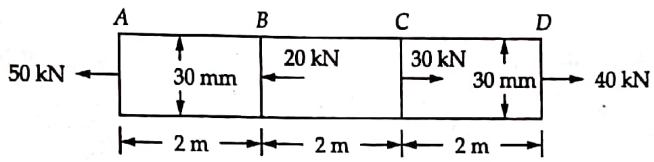

Fig 1.64

9. A 140 cm long steel bar is acted upon by forces as shown in Fig. 1.65 Determine the total elongation of the bar. Take E = 200 GPa. **(0.6 mm)**

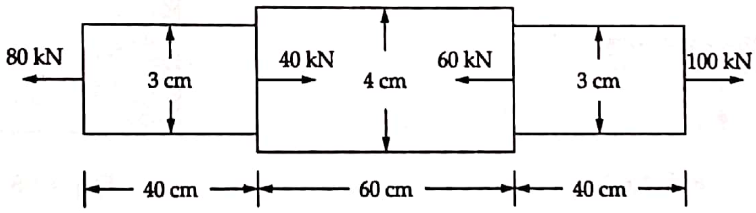

Fig 1.65

10. A steel hoisting wire of 5 mm diameter and 100 m length is used vertically to lift a weight of 2.0 kN at its lowest end. Determine the total elongation of the wire. Take specific weight of steel = 78.5 kN/m^3 and E = 205 GPa. **(5.17 cm)**
11. A circular steel rod tapers uniformly from a 4 cm diameter to a 1.5 cm diameter in a length of 40 cm. How much will the bar elongate under an axial pull of 40 kN? Take E = 200 GPa. **(0.17 mm)**
12. A flat steel plate of trapezoidal form is 10 mm thick and tapers uniformly from a width of 50 mm to 100 mm as shown in Fig. 1.66. It is 500 mm long and is subjected to an axial pull of 50 kN at its ends. Determine elongation of the plate. Take E = 200 GPa. **(0.06 cm)**

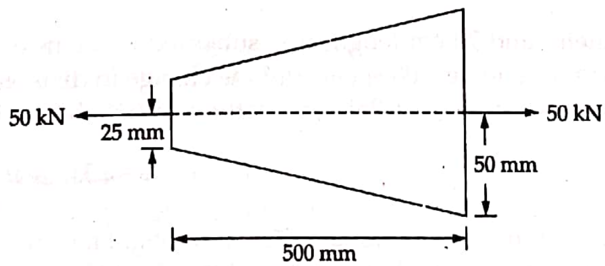

Fig 1.66

13. A tube of aluminium of 4 cm external diameter and 2 cm internal diameter is snugly fitted on a solid steel rod of 2 cm diameter. The composite section is loaded in compression by an axial load P. Find the stress in aluminium when the load is such that the stress in steel is 70 MN/m^2. What is the value of P? E for steel is 200 GPa; E for aluminium is 70 GPa. **(24.5 kN/m^2; 45.1 kN)**

14. A 75 mm diameter compound bar is constructed by shrinking a circular brass bush onto the outside of a 50 mm diameter solid steel rod. If the compound bar is then subjected to an axial compressive load of 160 kN, determine the load carried by the steel rod and the brass bush as also the compressive stress set up in each material.
For steel, take E = 210 GPa and for brass, E = 100 GPa. **(100.3 kN, 59.7 kN; 51 MPa, 24.3 MPa)**

15. Two vertical wires are suspended at a distance of 500 mm apart as shown in Fig. 1.67. Their upper ends are firmly secured and their lower ends support a rigid horizontal bar which carries a load W. The left hand wire has a diameter of 1.6 mm and is made of copper. The wire on the right side has a diameter of 0.9 mm and is made of steel. Both wires are initially 4.5 m long.
Neglect weight of the bar.
Take values of E for Copper = 130 GPa; Steel 210 GPa
Determine the position of the line of action of W if, due to W, both wires elongate by the same amount. **(16.9 cm from copper wire)**

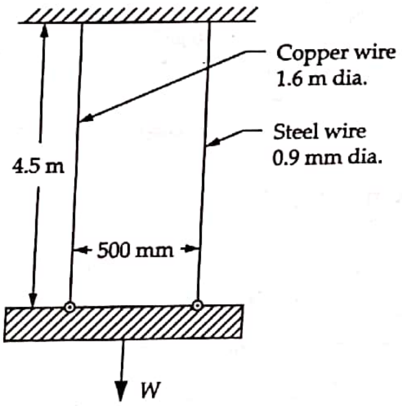

Fig 1.67

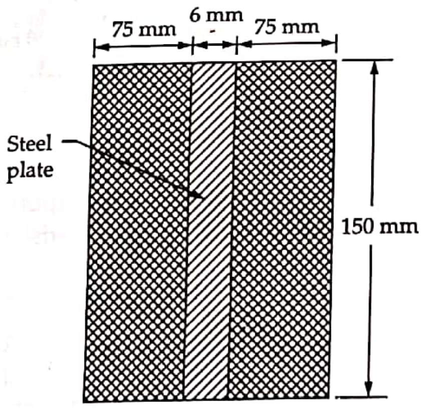

Fig 1.68

16. Two 150 mm × 75 mm × 4 m long timber members are reinforced with a steel plate 150 mm 6 mm × 4 m long (Fig. 1.68). The three members are adequately bolted together. The permissible stresses for the timber and the steel members are 6 N/mm^2 and 130 N/mm^2 respectively. E for timber is 8.4 GN/m^2 and for steel is 210 GN/m^2. Calculate the permissible tensile load for the composite member and the amount of elongation due to this load. **(234 kN; 2.5 mm)**

17. A coper rod of 36 mm diameter passes centrally through a steel tube of 40 mm internal diameter and 50 mm external diameter. The composite section is rigidly fixed together with nuts and washers of negligible thickness. The bar is then heated through 30°C. Find the stresses in rod and the tube.
Take E_s = 200 GPa α_s = 0.000012/°C
E_c = 110 GPa α_c = 0.000016/°C **(7.36 MPa)**

18. Define Poisson's ratio
A steel bar of 2 cm diameter and 20 cm length was subjected to a tension test. On applying a load of 20 kN, the extension was found to be 0.0054 cm, and the change in diameter was 0.00022 cm. Calculate the values of (*i*) modulus of elasticity, (*ii*) Poisson's ratio, and (*iii*) change in volume.

$$\left(\mathbf{E = 2.33\,GPa;\ \frac{1}{m} = 0.4;\ dV = 0.000339\,cm^2}\right)$$

19. A cylindrical brass bar is 50 mm in diameter and 250 mm long. Find the change in volume of the bar when an axial compressive load of 150 kN is applied. Take E = 100 GPa and Poisson's ratio = 0.27. **(172.5 mm^3)**