Problems of Practices
Of
Mechanics of Solids
1- Introduction and Review

Prepared By


Brij Bhooshan
Asst. Professor
B. S. A. College of Engg. And Technology
Mathura, Uttar Pradesh, (India)

Supported By:

Purvi Bhooshan

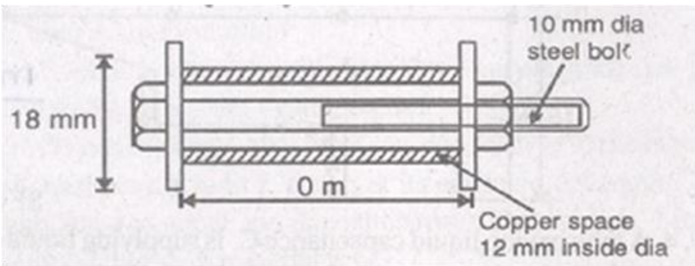
Please welcome for any correction or misprint in the entire manuscript and your valuable suggestions kindly mail us brijrbedu@gmail.com.

1. A tyre is shrunk on a wheel of 12 meters diameter. Assuming the wheel to be rigid, calculate the internal diameter of the tyre, if after shrinking, the hoop stress in the tyre is 1,200 kgf/cm². α for the tyre is 11.7×10^{-8} per °C and $E = 2 \times 10^{6}$ kgf/cm². Find the least temperature to which the tyre must be heated above that of the wheel before it could be fitted.

2. Prove that Poisson's ratio cannot be greater than 0.5.

3. A 100 mm long steel bush, having 80 mm inside diameter and 40 mm wall thickness, is shrunk fit on a steel shaft with diametral interference 0.04 mm. Young's modulus of elasticity and Poisson's ratio of the steel are 200 GPa and 0.3 respectively. Coefficient of friction between the bush and the shaft is 0.25. Determine the axial force that is to be applied to remove the bush from the shaft.

4. The steel belt shown in figure given below has a thread pitch of 1.6 mm. If the nut is initially tightened up by hand so as to cause no stress in the copper spacing tube calculate the stress inducted in the tube and in the bolt if a spanner is then used to turn the nut through 90°. Take E_C and E_S as 100 GPa and 209 GPa respectively.



5. The elastic and shear modulii of an elastic malarial are respectively 2×10^{11} Pa and 8×10^{10} Pa respectively. Determine Poisson's ratio of the material.

6. If the Poisson ratio of an elastic material is 0.3, determine the ratio of its elastic modulus to its shear modulus. Write the formula you use.

7. A solid right cone of axial length h is made of a material having density ρ and elasticity modulus E. It is suspended from its circular base. Determine its elongation under its own weight.

8. A copper tube 22 mm internal diameter, 30 mm outer diameter and 150 mm long is compressed by a nut lightening over a steel bolt. 20 mm diameter with 1 mm pitch.

(i) If the nut is tightened by a quarter of a turn beyond the just touching position, determine the stress in the bolt.

(ii) What would be the final stress in the bolt if the temperature of the assembly in (i) is to increase by 10°C?

Assume: $E_{steel} = 2 \times 10^6$ kg/cm²; $E_{Cu} = 6 \times 10^5$ kg/cm²;

$\alpha_{steel} = 12 \times 10^{-6}$ /°C; $\alpha_{Cu} = 18 \times 10^{-6}$ /°C.

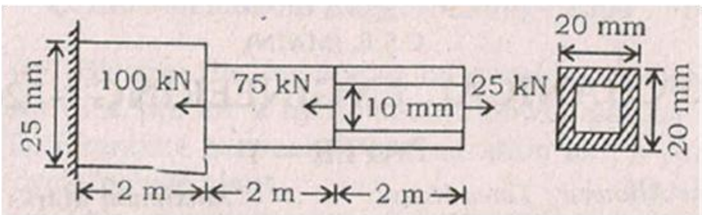
9. A steel bolt of diameter 10 mm passes through a brass tube of internal diameter 15 mm and external diameter 25 mm. The bolt is tightened by a nut so that the length of tube is reduced by 1.5 mm. If the temperature of the assembly is raised by 40°C, estimate the axial stresses in the bolt and the tube before and after heating. Material properties for steel and brass are: $E_S = 2 \times 10^5$ N/mm², $\alpha_S = 1.2 \times 10^{-5}$ /°C and $E_b = 1 \times 10^5$ N/mm², $\alpha_b = 1.9 \times 10^{-5}$ /°C.

10. A steel bar of diameter 60 mm and length 300 mm is subjected to an axial compressive load of 50 kN. To what diameter the middle one-third length of the bar be reduced in order to increase the stored energy by 50%?

11. A compound tube is made by shrinking a thin steel tube on a thin brass tube. The areas of cross-section of these tubes are A_s and A_b, while the Young's moduli are E_s and E_b respectively. Show that for any tensile load, the extension of the compound tube is equal to that of a single tube of the same length and total cross-sectional area, but having a Young's modulus of

$$\frac{E_s A_s + E_b A_b}{A_s + A_b}$$

12. A steel rod of square cross-section is loaded as shown in the figure.



Find the section which is subjected to maximum stress, its magnitude and nature. What will be total change in its length? Take E = 200 GPa.

13. Calculate the change in volume of a cube of steel with sides measuring 15 cm when it is immersed to a depth of 800 m in sea water which weighs 10 kN/m^3. Take E = 200 GPa and Poisson's ratio $\nu = 0.28$.

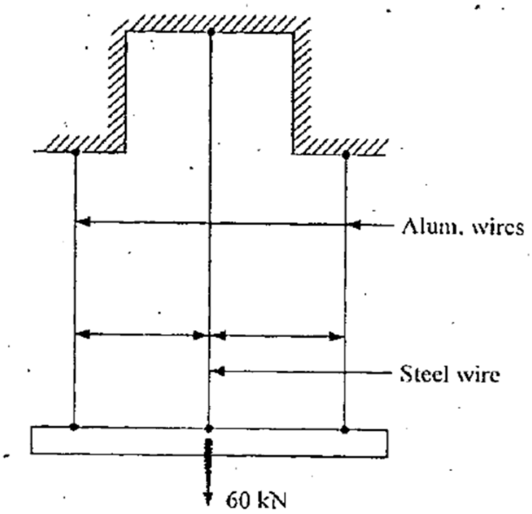
14. How much change in volume would a 100 mm side cube of steel will have when it is kept at a depth of 2 km in sea water? Assume specific gravity of sea water equal to 1.02, modulus of elasticity equal to 2.08 GPa and Poisson's ratio equal to 0.29.

15. A steel bolt of diameter 1.8 cm passes coaxially through a copper tube of inner diameter 2 cm and outer diameter 3 cm. The length of the tube is 50 cm. Washers are placed at both ends of the tube. The bolt has threads at one end having pitch equal to 0.24 cm. The nut is turned on the bolt through 45° against the washer to tighten the assembly. Determine the stress developed in the bolt and the tube. Assume the modulus of elasticity of steel to be 1×10^5 N/mm^2 and modulus of elasticity of copper is half that of steel.

16. An axial tensile load of 100 kN is applied to a steel rod of 38 mm diameter and 500 mm long. Calculate the change in volume of the rod, if E = 200 GPa and $\nu = 0.26$.

17. If a load of 60 kN is applied to a rigid bar suspended by 3 wires as shown in the above figure what force will be resisted by each wire?

The outside wires are of Al, cross-sectional area 300 mm^2 and length 6 m. The central wire is steel with area 200 mm^2 and length 8 m. Initially there is no slack in the wires $E = 2 \times 10^5$ N/mm^2 for Steel = 0.0667×10^5 N/mm^2 for Aluminium.



18. A tapered bar 200 mm long, tapers uniformly from a diameter of 40 mm to a diameter of 20 mm over its axial length. If an axial compressive force of 10 kN is applied on the bar, what is the strain energy absorbed in the bar? E = 100 kN/mm^2.

19. A steel tube, 24 mm external diameter and 18 mm internal diameter, encloses a copper rod 15 mm diameter to which it is rigidly joined at each end. If at a temperature of 30°C there is no longitudinal stress, calculate the stresses in the rod and tube, when the temperature is raised to 200°C. Given—

For steel: E_s = 210 GPa; α_s = coefficient of thermal expansion = 11×10^{-6} /°C

For copper: E_c = 100 GPa; α_c = coefficient of thermal expansion = 18×10^{-6} /°C.

20. A steel tube 2.5 cm external diameter and 1.8 cm internal diameter encloses a copper rod 1.6 cm diameter to which it is rigidly joined at each end. If, at a temperature of 20°C there is no longitudinal stress, calculate the stresses in the rod and tube when the temperature is raised to 210°C.

Given: E_S = 210 Pa and $\alpha_S = 12 \times 10^{-6}$ /°C

and E_C = 100 GPa and $\alpha_C = 20 \times 10^{-6}$ /°C

21. A circular steel rod tapers uniformly from 40 mm diameter to 150 mm diameter in a length of 400 mm. How much the bar will elongate under an axial pull of 40 kN? Take E = 200 GPa.

22. Derive equation for compressive and tensile thermal stresses.

23. A bar of length L, material density S and modulus of elasticity E is rotating about one end with an angular speed of ω radians per second. Find the maximum stress set up in the bar and its extension due to rotation.

24. A tapering bar having d_1, and d_2 as diameters of end sections and another bar of uniform cross-section d are of same length l. Both are subjected to the same axial pull P. What should be the value of d in terms of d_1, and d_2 so that both the bars of same material will have same extension? Evaluate maximum stresses in both the bars.

25. A steel rod of 10 cm diameter is forced into a steel ring of 15 cm external diameter and 6 cm wide. Measured strain in the circumferential direction on the external surface of the ring is found to be 1.55×10^{-4}. Assuming coefficient of friction for the mating surfaces to be 0.25, estimate the force required to push the rod out of the ring. Use E = 200 GPa.

26. A rod of 1 m length is kept at a temperature of 30°C. Find the expansion of the rod when the temperature is raised to 80°C. If this expansion is prevented, find the stress induced in the material of the rod. Take E = 100 GPa and α = 0.000012/°C.

27. If the ratio of Young's modulus to the modulus of rigidity is 2.5 for a certain material, find its Poisson's ratio and the ratio of Young's modulus to bulk modulus.

28. A bar of 2 m length is rigidly fixed to a support at top section where diameter is 50 mm and remains constant up to a length of 1 m. For the remaining portion, the diameter is 25 mm. If a weight of 1000 N falls freely through 100 mm and lands uniformly on a rigid collar at the lowermost cross-section, calculate the stress and extension in the bar. Take $E = 2.1 \times 10^5$ N/mm².

29. In a tensile test on a steel tube, outside diameter of 18 mm and inside diameter of 12 mm, an axial load of 12 kN produces a stretch of 3.5375×10^{-3} mm, on a length of 50 mm and a lateral contraction of outer diameter of 3.18375×10^{-4} mm. Calculate all the four elastic constants.

30. A compound bar is constructed from three bars 50 mm wide by 12 mm thick fastened together to form a bar 50 mm wide by 36 mm thick. The middle bar is of aluminium alloy for which $E = 70 \times 10^9$ N/m² and the outside bars are of brass with $E = 100 \times 10^9$ N/m². If the bars are initially fastened at 18°C and the temperature of the whole assembly is then raised to 50°C, determine the stresses set up in the brass and the aluminium alloy. Take the coefficient of expansion of the brass (α_B) and the aluminium alloy (α_A) as follows :

$$\alpha_B = 18 \times 10^{-6} \text{ per °C and } \alpha_A = 22 \times 10^{-6} \text{ per °C}$$

31. A steel tube of 100 mm internal diameter and 10 mm wall thickness in a plant is lined internally with well-fitted copper sleeve of 2 mm wall thickness. If the composite tube is initially unstressed, calculate the hoop stress set up assumed to be uniform throughout the wall thickness, in a unit length of each part of the tube due to an increase in temperature of 100°C.

For steel, $E = 208$ GPa, $\alpha = 11 \times 10^{-6}$ /°C

For copper, $E = 104$ GPa, $\alpha = 18 \times 10^{-6}$ /°C