Mechanics of Solids

Home Work No.3

Problem 2.4-4 A bar ACB having two different cross-sectional areas \( A_1 \) and \( A_2 \) is held between rigid supports at A and B (see figure). A load \( P \) acts at point C, which is distance \( b_1 \) from end A and distance \( b_2 \) from end B.

(a) Obtain formulas for the reactions \( R_A \) and \( R_B \) at supports A and B, respectively, due to the load \( P \).
(b) Obtain a formula for the displacement \( \delta_C \) of point C.
(c) What is the ratio of the stress \( \sigma_1 \) in region AC to the stress \( \sigma_2 \) in region CB?

Problem 2.5-5 A bar AB of length \( L \) is held between rigid supports and heated nonuniformly in such a manner that the temperature increase \( \Delta T \) at distance \( x \) from end A is given by the expression \( \Delta T = \Delta T_B x^2 / L^3 \), where \( \Delta T_B \) is the increase in temperature at end B of the bar (see figure).

Derive a formula for the compressive stress \( \sigma_x \) in the bar. (Assume that the material has modulus of elasticity \( E \) and coefficient of thermal expansion \( \alpha \)).

Problem 2.5-9 Rectangular bars of copper and aluminum are held by pins at their ends, as shown in the figure. Thin spacers provide a separation between the bars. The copper bars have cross-sectional dimensions 0.5 in. \( \times \) 2.0 in., and the aluminum bar has dimensions 1.0 in. \( \times \) 2.0 in.

Determine the shear stress in the 7/16 in. diameter pins if the temperature is raised by 100°F. (For copper, \( E_c = 18,000 \) ksi and \( \alpha_c = 9.5 \times 10^{-6}/\text{°F} \); for aluminum, \( E_a = 10,000 \) ksi and \( \alpha_a = 13 \times 10^{-6}/\text{°F} \).) Suggestion: Use the results of Example 2-8.

Problem 2.6-6 A steel bar with diameter \( d = 12 \) mm is subjected to a tensile load \( P = 9.5 \) kN (see figure).

(a) What is the maximum normal stress \( \sigma_{\text{max}} \) in the bar?
(b) What is the maximum shear stress \( \tau_{\text{max}} \)?
(c) Draw a stress element oriented at 45° to the axis of the bar and show all stresses acting on the faces of this element.

Problem 2.6-15 Acting on the sides of a stress element cut from a bar in uniaxial stress are tensile stresses of 10,000 psi and 5,000 psi, as shown in the figure.

(a) Determine the angle \( \theta \) and the shear stress \( \tau_\theta \) and show all stresses on a sketch of the element.
(b) Determine the maximum normal stress \( \sigma_{\text{max}} \) and the maximum shear stress \( \tau_{\text{max}} \) in the material.

Problem 2.6-9 A compression member in a bridge truss is fabricated from a wide-flange steel section (see figure). The cross-sectional area \( A = 7.5 \) in.\(^2 \) and the axial load \( P = 90 \) k.

Determine the normal and shear stresses acting on all faces of stress elements located in the web of the beam and oriented at (a) an angle \( \theta = 0° \), (b) an angle \( \theta = 30° \), and (c) an angle \( \theta = 45° \). In each case, show the stresses on a sketch of a properly oriented element.