1 Breadth Problems

MECHANICAL SYSTEMS AND MATERIALS

PROBLEM 1

A 0.25 in diameter steel support wire with modulus of elasticity 30×10^6 psi is normally strung between two utility poles 125 ft apart under 2500 lbf of tension. A winch maintains the tension by stretching the wire. A new procedure requires 6250 lbf of tension. The length of additional wire the winch must decrease to reach the new tension is most nearly

(A) 2.6 in

(B) 3.8 in

(C) 6.4 in

(D) 8.9 in

Hint: Find the wire length for each tension.

PROBLEM 2

A bridge's steel midspan is to be installed at 35°F during the winter. Rivet holes at each end of the midspan must measure 48.5 ft from the center. The I-beams for the midspan are prepared in a fabrication shop with a controlled temperature of 72°F. The change to the center distance that should be made when the rivet holes are drilled in the shop is most nearly

(A) −0.14 in

(B) −0.012 in

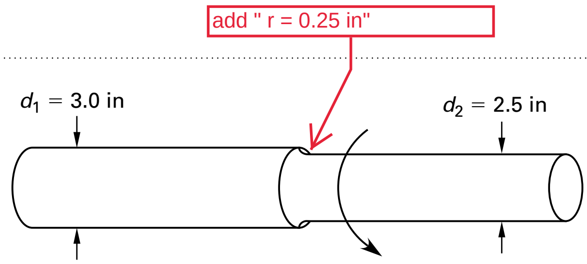
(C) 0.012 in

(D) 0.14 in

Hint: Use the coefficient of linear thermal expansion of steel.

PROBLEM 3

A 250 hp motor turns a shaft at 2400 rpm. The shaft steps down in diameter from 3.0 in to 2.5 in.



The maximum torsional shear stress is most nearly

(A) 1700 psi

(B) 2100 psi

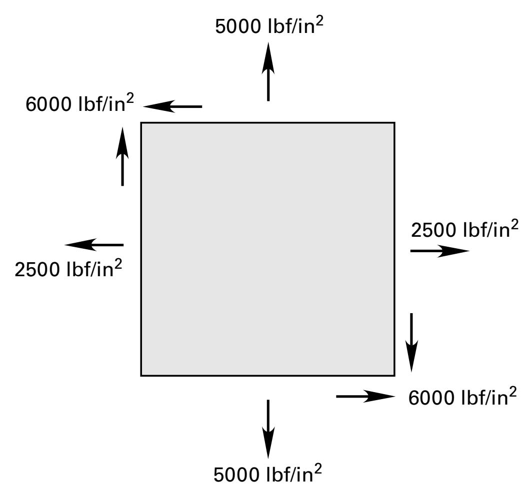
(C) 2800 psi

(D) 3700 psi

Hint: Find the stress concentration factor for a filleted shaft in torsion.

PROBLEM 4

The principal stresses on the object shown are most nearly



(A) 2400 psi, −9900 psi

(B) 2500 psi, 5000 psi

(C) 9900 psi, −2400 psi

(D) 3800 psi, 6100 psi

Hint: Determine the applied stresses, σ_x, σ_y, and τ. Remember that tensile stresses are positive.

SOLUTION 1

The cross-sectional area of the wire is

$$A = \pi r^2 = \pi\left(\frac{0.25 \text{ in}}{2}\right)^2 = 0.049 \text{ in}^2$$

The modulus of elasticity for steel is

$$E = 30 \times 10^6 \text{ psi}$$

The change in wire length for the old tension is

$$\delta_1 = \frac{L_o F_1}{EA} = \frac{(125 \text{ ft})\left(12 \frac{\text{in}}{\text{ft}}\right)(2500 \text{ lbf})}{\left(30 \times 10^6 \frac{\text{lbf}}{\text{in}^2}\right)(0.049 \text{ in}^2)} = 2.55 \text{ in}$$

The change in wire length for the new tension is

$$\delta_2 = \frac{L_o F_2}{EA} = \frac{(125 \text{ ft})\left(12 \frac{\text{in}}{\text{ft}}\right)(6250 \text{ lbf})}{\left(30 \times 10^6 \frac{\text{lbf}}{\text{in}^2}\right)(0.049 \text{ in}^2)} = 6.38 \text{ in}$$

The additional change in length from the old tension to the new tension is

$$\delta = \delta_2 - \delta_1 = 6.38 \text{ in} - 2.55 \text{ in} = 3.83 \text{ in} \quad (3.8 \text{ in})$$

The winch would have to pull 3.8 in of additional wire to achieve the new tension.

The answer is (B).

Why Other Options Are Wrong

(A) This incorrect solution is the change in length for the old tension.

(C) This incorrect solution is the change in length for the new tension.

(D) This incorrect solution results when the changes in wire length for the old and new tensions are added together instead of subtracted.

SOLUTION 2

From a table of steel properties, the coefficient of linear thermal expansion of steel is

$$\alpha = 6.5 \times 10^{-6} \text{ 1/°F}$$

The change in the length of the beam from the cold temperature to the hot temperature is

$$\Delta L = \alpha L_0 (T_2 - T_1) = \left(6.5 \times 10^{-6} \frac{1}{\text{°F}}\right)(48.5 \text{ ft})\left(12 \frac{\text{in}}{\text{ft}}\right)(72\text{° F} - 35\text{°F}) = 0.140 \text{ in}$$

The answer is (D).

Why Other Options Are Wrong

(A) This incorrect solution results when the temperature change is reversed.

(B) This incorrect solution results when the change in length is not converted to inches and the temperature change is reversed.

(C) This incorrect solution results when the change in length is not converted to inches.

SOLUTION 3

~~The shoulder has a radius of~~

$$r = \frac{d_1}{2} - \frac{d_2}{2} = \frac{3.0 \text{ in}}{2} - \frac{2.5 \text{ in}}{2} = 0.25 \text{ in}$$

Find the stress concentration factor for the fillet.

$$\frac{r}{d_2} = \frac{0.25 \text{ in}}{2.5 \text{ in}} = 0.1$$

$$\frac{d_1}{d_2} = \frac{3 \text{ in}}{2.5 \text{ in}} = 1.2$$

Find (0.1, 1.2) on a graph of stress concentration factors for a filleted shaft in torsion.

$$k = 1.3$$