## Stress-Strain Behavior

12.D2 This problem asks for us to determine which of the ceramic materials in Table 12.5, when fabricated into cylindrical specimens and stressed in three-point loading, will not fracture when a load of 445 N (100 $lb_f$) is applied, and also will not experience a center-point deflection of more than 0.021 mm ($8.5 \times 10^{-4}$ in.). The first of these criteria is met by those materials that have flexural strengths greater than the stress calculated using Equation 12.7b. According to this expression

$$\sigma_{fs} = \frac{FL}{\pi R^3}$$

$$= \frac{(445\ \text{N})(50.8 \times 10^{-3}\ \text{m})}{(\pi)(3.8 \times 10^{-3}\ \text{m})^3} = 131 \times 10^6\ \text{N/m}^2 = 131\ \text{MPa}\ (18{,}900\ \text{psi})$$

Of the materials in Table 12.5, the following have flexural strengths greater than this value: $Si_3N_4$, $ZrO_2$, SiC, $Al_2O_3$, glass-ceramic, mullite, and spinel.

For the second criterion we must solve for the magnitude of the modulus of elasticity, *E*, from the equation given in Problem 12.41 where the expression for the cross-sectional moment of inertia appears in Figure 12.32; that is, for a circular cross-section $I = \frac{\pi R^4}{4}$. Solving for *E* from these two expressions

$$E = \frac{FL^3}{12\pi R^4 \Delta y}$$

$$= \frac{(445\ \text{N})(50.8 \times 10^{-3}\ \text{m})^3}{(12)(\pi)(3.8 \times 10^{-3}\ \text{m})^4(0.021 \times 10^{-3}\ \text{m})}$$

$$= 353 \times 10^9\ \text{N/m}^2 = 353\ \text{GPa}\ (49.3 \times 10^6\ \text{psi})$$

Of those materials that satisfy the first criterion, only $Al_2O_3$ has a modulus of elasticity greater than this value (Table 12.5), and, therefore, is a possible candidate.