A friction force \( f \) acts on the surface of the cylinder as shown in Figure 2. It varies with distance from position \( O \) and is given per unit length as \( f = 10x^2 \) lb/ft with \( x \) in feet. If \( E = 10 \times 10^6 \) psi, what is the movement of \( O \) from the loading.

\[ R(x) = \int f(x) \, dx = \int 10x^2 \, dx = \frac{10}{3} x^3 \]

Normal stress and strain

\[ \sigma_n(x) = \frac{R(x)}{A} \quad \text{and} \quad \varepsilon(x) = \frac{\sigma_n(x)}{E} \]

Deformation

\[ \Delta \varepsilon = \varepsilon(x) \, dx = \int_0^x \frac{R(x)}{AE} \, dx = \frac{1}{AE} \int_0^x \frac{10}{3} x^3 \, dx = \frac{10}{12} \frac{x^4}{AE} \]

\[ A = \frac{\pi}{4} \left( \frac{3}{12} \right)^2 = 0.049087 \text{ ft}^2 \]

\[ E = 10 \times 10^6 \text{ psi} = \frac{10 \times 10^6}{(\frac{1}{12})^2} \]

\[ E = 1440 \times 10^6 \text{ lb/ft}^2 \]

\[ \Delta \varepsilon(x) = \frac{10}{12} \frac{x^4}{AE} = \frac{10}{12} \frac{1}{0.049087 \times 1440 \times 10^6} x^4 \]

\[ \Delta \varepsilon(x) = 1.178935 \times 10^{-8} x^4 \]

for \( x = 5 \text{ ft} \)

\[ \Delta \varepsilon = 1.178935 \times 10^{-8} \times 5^4 \]

\[ \Delta \varepsilon = 7.3683 \times 10^{-6} \text{ ft} \]