Compressive load in tapered circular bar, with temperature change

Geometrical constraint: no overall deformation:

\[ eq1 := \delta = 0 \]

Deformation is sum of incremental deformations; strain is not constant:

\[ \delta := \int_{0}^{L} \varepsilon(x) \, dx \]

Strain is sum of mechanical and thermal components:

\[ \varepsilon(x) := \frac{\sigma(x)}{E} + \alpha \Delta T \]

Stress is load (constant over \( x \)) divided by \( A \) (not constant):

\[ \sigma(x) := \frac{P}{A(x)} \]

Variation of \( A(x) \) with diameter:

\[ A(x) := \frac{\pi d(x)^2}{4} \]

Linear variation of diameter with distance \( x \):

\[ d(x) := d[1] - (d[1] - d[2]) \times \left( \frac{x}{L} \right) \]

Everthing now known; solve \( eq1 \) for \( P \):

\[ P = -\frac{1}{4} \alpha \Delta T E d_2 d_1 \]
3.11 Mechanics of Materials
Fall 1999

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