Example: Creep of a Plastic Hook

A utility hook is fabricated from an 8 mm OD, 4 mm ID polycarbonate tube. A 30 N load is applied 40 mm from the base of the hook.

1. Estimate the instantaneous deflection of the hook.
2. Estimate the deflection if the load is left hanging for 1 week.

Solution:

\[ I = \frac{\pi}{64} (d_o^4 - d_i^4) = \frac{\pi}{64} \left[ (0.008 \text{ m}^4) - (0.004 \text{ m}^4) \right] = 1.885 \times 10^{-10} \text{ m}^4 \]

\[ \sigma = \frac{Mc}{I} = \frac{(0.040 \text{ m})(30 \text{ N})(0.004 \text{ m})}{1.885 \times 10^{-10} \text{ m}^4} = 25.5 \text{ MPa} \]

1. From the isochronous graph for \( t = 0.1 \text{ hr} \) (see p. 2):

When \( \sigma = 25.5 \text{ MPa} \), \( \epsilon_{(0.1 \text{ hr})} = 1.21\% \)

\[ E_{(0.1 \text{ hr})} \approx \frac{25.5 \text{ MPa}}{0.0121} = 2.11 \text{ GPa} \]

Note: “Handbook” value for \( E_{\text{polycarbonate}} = 2.4 \text{ GPa} \)

\[ \delta = \frac{PL^3}{3EI} \quad \text{(J&M Appendix D – 1)} \]

\[ \therefore \delta_{(0.1 \text{ hr})} = \frac{(30 \text{ N})(0.040 \text{ m})^3}{3 \left( 2.11 \times 10^9 \frac{\text{N}}{\text{m}^2} \right) \left( 1.885 \times 10^{-10} \text{ m}^4 \right)} = 1.61 \text{ mm} \]

2. From the isochronous graph for \( t = 168 \text{ hr} \) (1 week):

When \( \sigma = 25.5 \text{ MPa} \), \( \epsilon_{(168 \text{ hrs})} = 1.51\% \)

\[ E_{(168 \text{ hrs})} \approx \frac{25.5 \text{ MPa}}{0.0151} = 1.689 \text{ GPa} \]

\[ \therefore \delta_{(168 \text{ hrs})} = \frac{(30 \text{ N})(0.040 \text{ m})^3}{3 \left( 1.689 \times 10^9 \frac{\text{N}}{\text{m}^2} \right) \left( 1.885 \times 10^{-10} \text{ m}^4 \right)} = 2.01 \text{ mm} \]
Note 1: Polycarbonate is “good stuff” - - did not creep very much!

Note 2: These numbers are only approximations, since only the worst stressed point actually sees the stress of 25.5 MPa. (However, they should provide a conservative estimate.)

Note 3: Strains are way higher than steel! (Because E is 100 X lower.)