PROJECT: Precision Underwater Positioner

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Title: Slope, Deflection, bending stress for Aluminum Wide Flange linkage

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Case 1a Concentrated intermediate load; left end free, right end fixed (cantilever)

Roark's Formulas for Stress and Strain 6th edition

UNITS: $kip \equiv 1000 \cdot lbf$ $ksi \equiv \frac{kip}{in^2}$ $psi \equiv \frac{lbf}{in^2}$ $k \equiv kip$ $ksf \equiv \frac{kip}{ft^2}$ $psf \equiv \frac{lbf}{ft^2}$ $pcf \equiv \frac{lbf}{ft^3}$ $plf \equiv \frac{lbf}{ft}$

PROPERTIES & ASSUMTIONS: Material = Aluminum 6061-T6

Modulus of elasticity: $E \equiv 30 \cdot 10^6 \cdot \frac{lbf}{in^2}$

Load: $W \equiv 45 \cdot lbf$

$W = 20.411\,kgf$

Total Length: $L := 14 \cdot in$

$L = 0.356\,m$

Length from end $a := 0 \cdot in$

WF 2 X 1.43 Wide Flange H-Beam

WF Area moment of inertia: $I \equiv 782 \cdot in^4$

WF weight per foot $WF := 1.43$

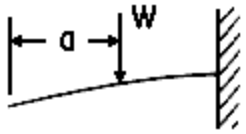
Added weight of beam: $W_B := WF \cdot 1.1667$

$W_B = 1.668 \frac{1}{lb}\,lb$

CALCULATION:

Slope:

$$\theta_A := \frac{W \cdot (L - a)^2}{2 \cdot E \cdot I} \qquad \theta_A = 1.077 \times 10^{-5}\,deg$$



Defelection:

$$y_A := \frac{-W}{6 \cdot E \cdot I} \cdot \left(2 \cdot L^3 - 3 \cdot L^2 \cdot a + a^3\right) \qquad y_A = -1.754 \times 10^{-6}\,in$$

$y_A = -4.456 \times 10^{-8}\,m$

At the right end of the beam (fixed to rotation joint):

Reaction:

$R_B := W$ $R_B = 45\,lbf$ $R_B = 20.411\,kgf$ $R_B = 200.165\,newton$

Moment:

$M_B := -W \cdot (L - a)$ $M_B = -630\,lbf \cdot in$ $M_B = -71.179\,newton \cdot m$

Deflection:

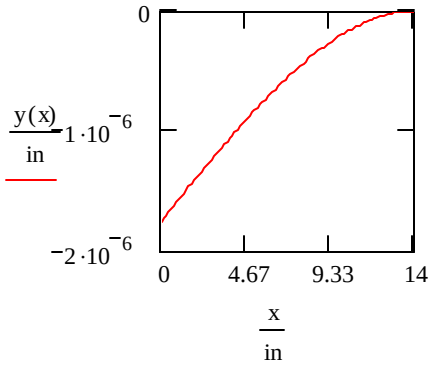
Reaction at end $R_A := 0 \cdot lbf$

Moment at end $M_A := 0 \cdot lbf$

x varies from 0 to end of beam. $x := 0 \cdot L, .01 \cdot L .. L$

A point along the beam length $x_1 := 6 \cdot in$

$$y(x) := y_A + \theta_A \cdot x + \frac{M_A \cdot x^2}{2 \cdot E \cdot I} + \frac{R_A \cdot x^3}{6 \cdot E \cdot I} - (x > a) \cdot \left[\frac{W}{6 \cdot E \cdot I} \cdot (x - a)^3 \right]$$



Stress due to Bending

section modulus $S := .481 \cdot in^3$

$$\sigma_B := \frac{M_B}{S}$$

$\sigma_B = -1.31 \times 10^3 \, psi$

$\sigma_B = -9.031 \times 10^6 \, Pa$