0.1 Problem description

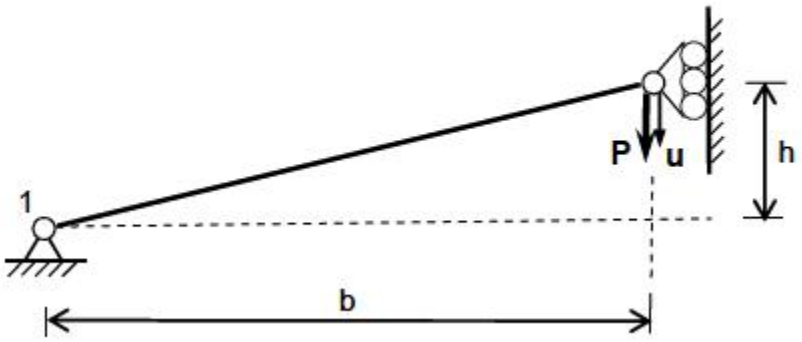

Figure 1: Problem

Given

b=5m, h=1m, p=1KN, A=4*10^{-2}m^2, E$_0$=200MPa

Non linear rule:$\sigma = E_0\left(\varepsilon - 260\varepsilon^2\right)$

Tangent stiffness=$E_T = \frac{d\sigma}{d\epsilon} = E_0\left(1 - 520\epsilon\right)$

Neglecting geometric non linearity and a one step load increment is applied.

- $K_T = K_M$
- $K_M = \begin{bmatrix} c^2 & sc & -c^2 & -sc \\ sc & s^2 & -sc & -s^2 \\ -c^2 & -sc & c^2 & sc \\ -sc & -s^2 & sc & s^2 \end{bmatrix}$
- To find the Θ
- $\Theta = \tan^{-1}\left(1/5\right) = 11.30$
- K*U=F
- $K_M = \frac{E_T A}{l}\begin{bmatrix} 0.9616 & 0.19214 & -0.9616 & -0.1921 \\ 0.1921 & 0.0383 & -0.1921 & -0.0383 \\ -0.9616 & -0.1921 & 0.9616 & 0.1921 \\ -0.1921 & -0.0383 & 0.1921 & 0.0383 \end{bmatrix} \times \begin{Bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{Bmatrix} = \begin{Bmatrix} F_{1x} \\ F_{1y} \\ F_{2x} \\ F_{2y} \end{Bmatrix}$
- $l = \sqrt{5^2 + 1^2} = 5.09$
- $F_{applied} = 1KN$

Steps:Iteration 1

1. assuming $\epsilon = 0$, $E_T = 2 * 10^8 * (1 - 520 * 0) = 2 * 10^8$
2. $K_M = \frac{2*10^8*0.04}{5.09} * [0.0383] \times \{v_2\} = \{1000\}$since $u_1 = v_1 = u_2 = 0$
3. $v_2 = \frac{1000}{60{,}196.4} = 0.0166$
4. $\triangle v = 0 + v_2 = 0.0166$

5. $\epsilon = \frac{v_2}{l} = \frac{0.0166}{5.09} = 0.0032$
6. stress update=$2 * 10^8 * (0.0032 - 260 * 0.0032^2) = 86,107.07$
7. $F_{internal} = A * \sigma_{updated} * \sin\theta = 0.04 * 86107.07 * 0.1959 = 674.89$
8. $Residual = F_{applied} - F_{internal} = 1000 - 674.89 = 325.10$

Iteration 2:

1. $\epsilon = 0.0032$, $E_T = 2 * 10^8 * (1 - 520 * 0.0032) = -1.3 * 10^8$

My problem is here, the tangent stiffness goes to negative. Is my procedure of solving the material non linearity correct?? I would like ur comments