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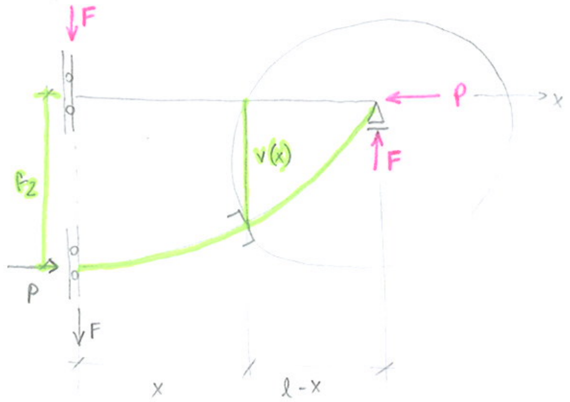
Exercício 2. $f_2 = ?$ $P_{CR} = ?$



$$M(x) = F(l-x) + P.v(x)$$

$$v''(x) = -\frac{M}{EJ} = -\frac{F(l-x)}{EJ} - \frac{Pv}{EJ}$$

$$v'' + K^2 v = -\frac{F(l-x)}{EJ}$$

$$v(x) = c_1 \, \text{sen} Kx + c_2 \cos Kx - \frac{F(l-x)}{EJK^2}$$

$$v'(x) = c_1 K \cos Kx - c_2 K \, \text{sen} Kx + \frac{F}{EJK^2}$$

$$\begin{cases} v'(0) = 0 \longrightarrow c_1 K + \frac{F}{EJK^2} = 0 \longrightarrow c_1 = -\frac{F}{EJK^3} \\ v(l) = 0 \longrightarrow -\frac{F}{EJK^3} . \text{sen} Kl + c_2 \cos Kl = 0 \longrightarrow c_2 = \frac{F}{EJK^3} . \text{tg} Kl \end{cases}$$

$$f_2 = v(0) = c_2 . 1 - \frac{F(l)}{EJK^2} = \frac{F \, \text{tg} Kl}{EJK^3} - \frac{FlK}{EJK^3} = \frac{F(\text{tg} Kl - Kl)}{EJK^3}$$

$$(Kl)_{CR} = \frac{\pi}{2}$$

$$\sqrt{\frac{P_{CR}}{EJ}} . l = \frac{\pi}{2}$$

$$P_{CR} = \frac{\pi^2 . EJ}{4l^2}$$

Exercício 3. Flambagem

determinar P_{CR} (P_1) e 1º modo

$$M(x) = -P(\delta - v(x))$$

$$v'' = -\frac{M}{EI} = \frac{P(\delta - v(x))}{EI}$$

$$v'' + K^2 v = K\delta$$

$$v(x) = c_1 \, \text{sen} Kx + c_2 \cos Kx + \delta$$

$$v'(x) = c_1 K \cos Kx - c_2 K \, \text{sen} Kx$$

$$\begin{cases} v(0) = 0 \rightarrow c_2 + \delta = 0 \rightarrow c_2 = -\delta \\ v(l) = \delta \rightarrow c_1 \, \text{sen} Kl - \delta \cos Kl + \cancel{\delta} = \cancel{\delta} \\ \qquad c_1 = \frac{\delta \cos Kl}{\text{sen} Kl} \\ v'(0) = 0 \rightarrow c_1 = 0 \end{cases}$$

Para $c_1 = 0$, $\delta = 0$ ou $\cos Kl = 0$

$Kl = \frac{n\pi}{2}$, onde $n = 1, 2, 3, \ldots$

Quando $n = 1$, $K = \frac{\pi}{2l}$, $P_{CR} = \frac{\pi^2 EI}{4l^2} \rightarrow v(x) = \delta - \underbrace{\delta}_{c_2} \cos \underbrace{\frac{\pi}{2l}}_{K} x$