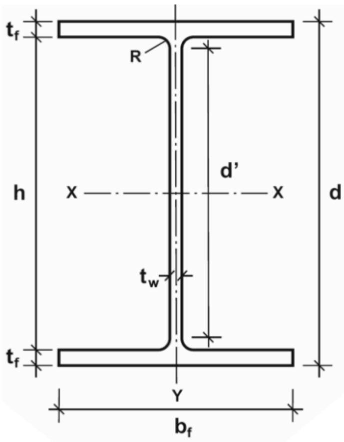
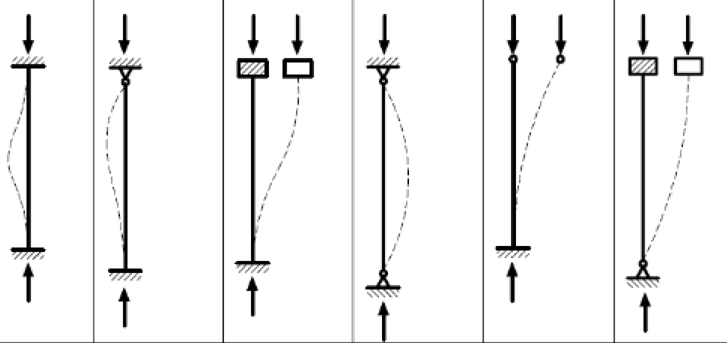
Questão – Encontre a maior força de compressão, $N_{c,Rd}$, em ELU que a coluna biarticulada (adote k_x=k_y=k_z=1,0) de comprimento L=520 cm poder suportar, sem enrijecedores transversais, escolhendo o perfil Gerdau laminado W310×38,7 kg/m. Adote aço com as seguintes propriedades mecânicas: f_y=25,0 kN/cm^2, E=20000 kN/cm^2 e G=7700 kN/cm^2. Caso o perfil escolhido não atenda a condição de segurança, qual seria o próximo perfil de menor massa linear para atender?

A_g= 49,70 cm^2
I_x= 8581,0 cm^4
r_x= 13,14 cm
I_y= 727 cm^4
r_y= 3,82 cm
I_t= 13,20 cm^4
C_w= 163728,0 cm^6
d'= 27,10 cm
t_w= 0,58 cm
b_f = 16,50 cm
t_f= 0,97 cm

L= 520 cm
E= 20000 kN/cm^2
G= 7700 kN/cm^2
k_x= k_y= k_z= 1,0
f_y= 25 kN/cm^2
γ_{a1}= 1,10



	(a)	(b)	©	(d)	(e)	(f)
A linha tracejada indica a linha elástica de flambagem						
Valores teóricos de K_x ou K_y	0,5	0,7	1,0	1,0	2,0	2,0
Valores recomendados	0,65	0,80	1,2	1,0	2,1	2,0

Cálculo de Q

→Alma AA (Grupo 2)

$$b/t = \frac{d'}{t_w} = \frac{27,10}{0,58} = 46,72$$

$$\left(b/t\right)_{lim} = 1,49\sqrt{\frac{E}{f_y}} = 1,49\sqrt{\frac{20000}{25}} = 42,14$$

$$Q_a = 1,0 \qquad se \qquad \frac{b}{t} \leq \left(b/t\right)_{lim}$$

$$Q_a = \frac{A_{ef}}{A_g} \qquad se \qquad \frac{b}{t} > \left(b/t\right)_{lim}$$

$\chi = 1,0$

$\sigma = \chi \, f_y$

$C_a = 0,34$

$$b_{ef} = 1,92t\sqrt{\frac{E}{\sigma}}\left[1 - \frac{C_a}{b/t}\sqrt{\frac{E}{\sigma}}\right] = 25,01$$

$$A_{ef} = A_g - \sum(b - b_{ef})t = 49,70 - (27,10 - 25,01) \times 0,58 = 48,49 \ \text{cm}^2$$

$$Q_a = \frac{A_{ef}}{A_g} = \frac{48,49}{49,70} = 0,975$$

→**Mesa AL (Grupo 4)**

$$\mathbf{b/t} = \frac{b_f/2}{t_f} = \frac{16,50}{2 \times 0,97} = 8,51$$

$$Q_s = 1,0 \qquad se \qquad \frac{\mathbf{b}}{\mathbf{t}} \leq (b/t)_{lim} = 0,56\sqrt{\frac{E}{f_y}} = 15,84$$

$$Q_s = 1,415 - 0,74\frac{b}{t}\sqrt{\frac{f_y}{E}} \qquad se \quad 0,56\sqrt{\frac{E}{f_y}} < \frac{\mathbf{b}}{\mathbf{t}} \leq 1,03\sqrt{\frac{E}{f_y}}$$

$$Q_s = \frac{0,69E}{f_y\left(\frac{b}{t}\right)^2} \qquad se \qquad \frac{\mathbf{b}}{\mathbf{t}} > 1,03\sqrt{\frac{E}{fy}}$$

$Q_s = 1,000$

$\therefore Q = Q_a \, Q_s = 0,975$

Cálculo de χ

$$r_0 = \sqrt{r_x^2 + r_y^2} = \sqrt{13{,}14^2 + 3{,}82^2} = 13{,}684 \text{ cm}$$

$$N_{ex} = \frac{\pi^2 \, E \, I_x}{(k_x \, L_x)^2} = \frac{\pi^2 \times 20000 \times 8581}{(1{,}0 \times 520)^2} = 6264{,}1 \text{ kN}$$

$$N_{ey} = \frac{\pi^2 \, E \, I_y}{\left(k_y \, L_y\right)^2} = \frac{\pi^2 \times 20000 \times 727}{(1{,}0 \times 520)^2} = 530{,}71 \text{ kN}$$

$$N_{ez} = \frac{1}{r_0^2}\left[\frac{\pi^2 \, E \, C_w}{(k_z \, L_z)^2} + G \, I_t\right] =$$

$$N_{ez} = \frac{1}{13{,}684^2}\left[\frac{\pi^2 \times 20000 \times 163728}{(1{,}0 \times 520)^2} + 7700 \times 13{,}20\right] = 1181{,}1 \text{ kN}$$

$$N_e = \text{mín}\left(N_{ex}; N_{ey}; N_{ez}\right) = 530{,}71 \text{ kN}$$

$$\lambda_0 = \sqrt{\frac{Q \, A_g \, f_y}{N_e}} = \sqrt{\frac{0{,}975 \times 49{,}7 \times 25}{530{,}71}} = 1{,}511$$

Se $\lambda_0 \leq 1{,}5$ então $\chi = 0{,}658^{\lambda_0^2}$

Se $\lambda_0 > 1{,}5$ então $\chi = \dfrac{0{,}877}{\lambda_0^2}$

$\therefore \chi = 0{,}384$

Assim:

$$N_{c,Rd} = \frac{\chi \, Q \, A_g \, f_y}{\gamma_{a1}} = \frac{0{,}384 \times 0{,}975 \times 49{,}7 \times 25{,}0}{1{,}10}$$

$$\therefore N_{c,Rd} = 422 \text{ kN}$$