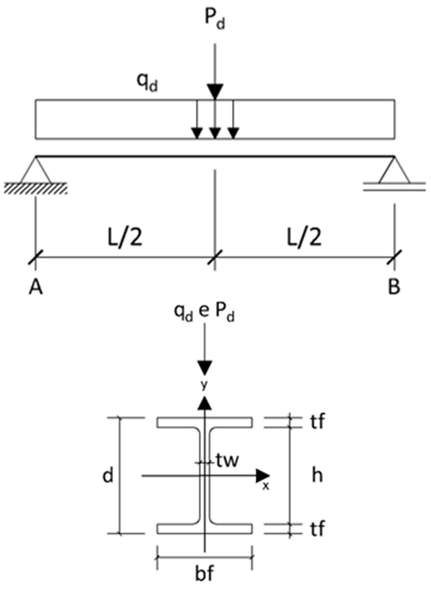
SE1_E08-05



A viga ao lado será construída em um perfil W (laminado) com as características abaixo:

$A := 83,6\ cm^2$ $Ix := 34971\ cm^4$

$d := 525\ mm$ $Iy := 857\ cm^4$

$tw := 8,9\ mm$ $Zx := 1558\ cm^3$

$h := 502\ mm$ $J := 28,09\ cm^4$

$tf := 11,4\ mm$ $bf := 165\ mm$

Considerando os seguintes dados:
- vão L = 5,0 m;
- carga distribuída em valor de cálculo qd = 20 kN/m;
- travamentos laterais somente nos apoios A e B;
- aço MR250 sendo que o perfil laminado indicado tem seção compacta para FLA e FLM;

Determine qual é o máximo valor da carga Pd (já em valor de cálculo) que pode ser aplicada de modo que a viga passe na verificação FLT.

$qd := 20\ \frac{kN}{m}$ $E := 200\ GPa$ $fy := 25\ \frac{kN}{cm^2}$

Propriedades Geométricas Restantes e Momentos Básicos:

$I_x = \frac{b_f(2*t_f+h_w)^3}{12} - \frac{(b_f-t_w)h_w^3}{12}$ $I_y = 2\frac{t_f b_f^3}{12} + \frac{h_w t_w^3}{12}$ $W_x = \frac{I_x}{0,5d}$ $W_y = \frac{I_y}{0,5b_f}$ $Z_x = 2\left(b_f t_f\left(\frac{h_w}{2}+\frac{t_f}{2}\right)+\frac{h_w^2}{8}t_w\right)$ $M_{pl} = Z_x f_y$

Nota 1 :

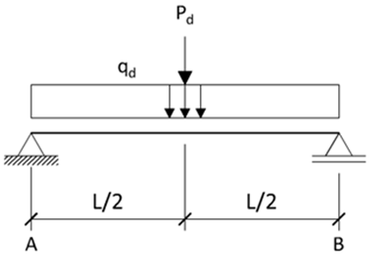
$\lambda_r = \frac{1,38\sqrt{I_y J}}{r_y J \beta_1}\sqrt{1+\sqrt{1+\frac{27C_w\beta_1^2}{I_y}}}$ $M_{cr} = \frac{C_b\pi^2 E I_y}{L_b^2}\sqrt{\frac{C_w}{I_y}\left(1+0,039\frac{JL_b^2}{C_w}\right)}$ $\beta_1 = \frac{(f_y-\sigma_r)W_x}{E\,J}$ $C_w = \frac{I_y(d-t_f)^2}{4}$ $J = \frac{1}{3}(2b_f t_f^3 + h_w t_w^3)$

$Wx := \frac{Ix}{0,5\cdot d} = 1332\ cm^3$ $ry := \sqrt{\frac{Iy}{A}} = 3,2017\ cm$ $Cw := \frac{Iy\cdot(d-tf)^2}{4} = 5,6516\cdot 10^5\ cm^6$

$\beta 1 := \frac{0,7\cdot fy\cdot Wx}{E\cdot J} = 0,0415\ \frac{1}{cm}$

$Mpl := Zx\cdot fy = 389,5\ kN\ m$ $Mr := Wx\cdot 0,7\cdot fy = 233,14\ kN\ m$

Momento Solicitante Máximo:

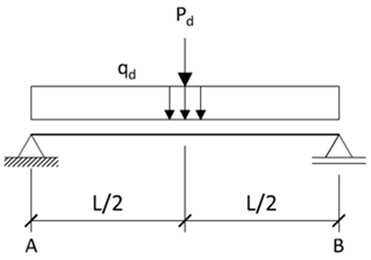


$qd = 20\ \frac{kN}{m}$ $L := 5\ m$

$Msd(Pd) := \frac{qd\cdot L^2}{8} + Pd\cdot\left(\frac{L}{2}\right)\cdot\left(\frac{L}{2}\right)\cdot\frac{1}{L} = \frac{5\ m\cdot\left(50000\ kg\ m + Pd\ s^2\right)}{4\ s^2}$

$\frac{qd\cdot L^2}{8} = 62,5\ kN\ m$

Fator Cb:



Equação de momento fletores:

$qd := 20\ \frac{kN}{m}$ $Pd := 144,7\ kN$

$M_{AP}(x) := qd \cdot \frac{L}{2} \cdot x - qd \cdot \frac{x^2}{2} + \frac{Pd}{2} \cdot x$

$Lb := L = 5\ m$

$Ma := \left| M_{AP}\left(\frac{1}{4} \cdot Lb\right) \right| = 137,3125\ kN\ m$

$Mb := \left| M_{AP}\left(\frac{2}{4} \cdot Lb\right) \right| = 243,375\ kN\ m$

$Mc := Ma = 137,3125\ kN\ m$

$Mmax := Mb = 243,375\ kN\ m$

* Devido a simetria Ma = Mc e Mb = Mmax

$Cb_ini := \min\left(\left[\ \frac{12,5 \cdot Mmax}{2,5 \cdot Mmax + 3 \cdot Ma + 4 \cdot Mb + 3 \cdot Mc}\ \ 3\ \right]\right) = 1,2645$ * O pior Cb possível ocorre quando Pd = 0

Verificação de Momentos Resistentes FLT:

FLT	$(f_y - \sigma_r)W$ Ver Nota 5	Ver Nota 1	$\frac{L_b}{r_y}$	$1,76\sqrt{\frac{E}{f_y}}$	Ver Nota 1

FLT		
Tipo de Viga	**Relação de Parâmetros**	**Expressão de Cálculo**
Curta	$\lambda \le \lambda_p$	$M_{Rd} = \frac{M_{pl}}{\gamma_{a1}}$
Intermediária	$\lambda_p < \lambda \le \lambda_r$	$M_{Rd} = \frac{C_b}{\gamma_{a1}}\left[M_{pl} - (M_{pl} - M_r)\frac{(\lambda - \lambda_p)}{(\lambda_r - \lambda_p)}\right] \le \frac{M_{pl}}{\gamma_{a1}}$
Longa	$\lambda_r < \lambda$	$M_{Rd} = \frac{M_{cr}}{\gamma_{a1}} \le \frac{M_{pl}}{\gamma_{a1}}$

$Lb := L = 5\ m$ $\gamma a1 := 1,1$

$\lambda_{VIGA} := \frac{Lb}{ry} = 156,16$

$\lambda_{pFLT} := 1,76 \cdot \sqrt{\frac{E}{fy}} = 49,7803$

$\lambda_{rFLT} := \frac{1,38 \cdot \sqrt{Iy \cdot J}}{ry \cdot J \cdot \beta 1} \cdot \sqrt{1 + \sqrt{1 + \frac{27 \cdot Cw \cdot \beta 1^2}{Iy}}} = 147,68$

$\frac{Mpl}{\gamma a1} = 354,0909\ kN\ m$

$Tipo_de_Viga :=$ if $\lambda_{VIGA} \le \lambda_{pFLT}$ = "Longa"
"Curta"
else
if $\lambda_{VIGA} \le \lambda_{rFLT}$
"Intermediária"
else
"Longa"

$Mrd_FLT :=$ if $\lambda_{VIGA} \le \lambda_{pFLT}$ $= 243,39\ kN\ m$
$\frac{Mpl}{\gamma a1}$
else
if $\lambda_{VIGA} \le \lambda_{rFLT}$
$\min\left(\left[\ \frac{Cb_ini}{\gamma a1} \cdot \left(Mpl - (Mpl - Mr) \cdot \frac{(\lambda_{VIGA} - \lambda_{pFLT})}{(\lambda_{rFLT} - \lambda_{pFLT})}\right)\ \frac{Mpl}{\gamma a1}\ \right]\right)$
else
$\min\left(\left[\ \frac{1}{\gamma a1} \cdot \frac{Cb_ini \cdot \pi^2 \cdot E \cdot Iy}{Lb^2} \cdot \sqrt{\frac{Cw}{Iy} \cdot \left(1 + \frac{0,039 \cdot J \cdot Lb^2}{Cw}\right)}\ \frac{Mpl}{\gamma a1}\ \right]\right)$

Cálculo da Carga Pd:

$$Msd = Mrd_FLT$$

$$\frac{qd \cdot L^2}{8} + Pd \cdot \left(\frac{L}{4}\right) = Mrd_FLT$$

$$Pd := \frac{4}{L} \cdot \left(Mrd_FLT - \frac{qd \cdot L^2}{8}\right) = 144,7117\ kN$$ * Processo iterativo