Steel Beam Flexural Capacity.xlsx

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Calculations reviewed by .... on ....

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1 Bending Capacity Calculations

1.0.1 Inputs

Single inputs	Value	Units	Comments	Cell Ref.
E	200	GPa	Young's Modulus of section.	C10
G	80	GPa	Shear modulus of section.	C12
I_w	9.29×10^{10}	mm^6	Warping constabt.	C14
I_y	4.42	mm^4	Moment of inertia (y-y).	C11
J	86500	mm^4	Torsional constant.	C13
L	3	m	Section length.	C3
S_x	475000	mm^3	Plastic section modulus.	C8
Z_x	424000	mm^3	Elastic section modulus.	C9
b_f	149	mm	Width of flange.	C4
d	298	mm	Depth of section.	C6
f_{yf}	320	MPa	Yield Stress (flange).	C15
t_f	8	mm	Thickness of flange.	C5
t_w	5.5	mm	Thickness of web.	C7
Ø	0.9	-	Strength reduction factor.	C16

1.0.2 Fully restrained section calculations

Single inputs	Value	Units	Comments	Cell Ref.	
λ_{efp}	9	-	Flange plastic slenderness.	C22	*Table 5.2*
λ_{efy}	16	-	Flange yield slenderness.	C21	*Table 5.2*
λ_{ewp}	82	-	Web plastic slenderness.	C24	*Table 5.2*
λ_{ewy}	130	-	Web yield slenderness.	C23	*Table 5.2*

Flange slenderness.

$$\lambda_{ef\,[C19]} = \frac{b_f - t_w}{2 \cdot t_f} \cdot \sqrt{\frac{f_{yf}}{250}}$$

Sec. 5.2.2

$= \frac{149-5.5}{2 \cdot 8} \cdot \sqrt{\frac{320}{250}}$ $= 10.1$

Web slenderness.

$\lambda_{ew[C20]} = \frac{d-2 \cdot t_f}{t_w} \cdot \sqrt{\frac{f_{yf}}{250}}$ *Sec. 5.2.2*

$= \frac{298-2 \cdot 8}{5.5} \cdot \sqrt{\frac{320}{250}}$ $= 58.0$

(flange is more critical). check governing slenderness.

$\lambda_{ef}/\lambda_{efy[C26]} = \frac{\lambda_{ef}}{\lambda_{efy}}$

$= \frac{10.1}{16}$ $= 0.634$

$\lambda_{ew}/\lambda_{ewy[C27]} = \frac{\lambda_{ew}}{\lambda_{ewy}}$

$= \frac{58.0}{130}$ $= 0.446$

Section slenderness limits.

$\lambda_{sy[C29]} = \mathrm{IF}(\lambda_{ef}/\lambda_{efy} > \lambda_{ew}/\lambda_{ewy}, \quad \lambda_{efy}, \quad \lambda_{ewy})$

$= \mathrm{IF}(0.634 > 0.446, \quad 16, \quad 130)$ $= 16$

$\lambda_{s[C30]} = \mathrm{IF}(\lambda_{ef}/\lambda_{efy} > \lambda_{ew}/\lambda_{ewy}, \quad \lambda_{ef}, \quad \lambda_{ewp})$

$= \mathrm{IF}(0.634 > 0.446, \quad 10.1, \quad 82)$ $= 10.1$

$\lambda_{sp[C31]} = \mathrm{IF}(\lambda_{ef}/\lambda_{efy} > \lambda_{ew}/\lambda_{ewy}, \quad \lambda_{efp}, \quad \lambda_{ewp})$

$= \mathrm{IF}(0.634 > 0.446, \quad 9, \quad 82)$ $= 9$

Compact section plastic modulus.

$Z_{c[C33]} = \mathrm{MIN}(1.5 \cdot Z_x, \quad S_x)$

$= \mathrm{MIN}(1.5 \cdot 424000, \quad 475000)$ $= 475000$

(since λs=10.15>λsp=9). Effective section plastic modulus.

$Z_{e[C34]} = Z_x + \frac{(\lambda_{sy}-\lambda_s) \cdot (Z_c - Z_x)}{\lambda_{sy}-\lambda_{sp}}$

$= 424000 + \frac{(16-10.1) \cdot (475000-424000)}{16-9}$ $= 467000.0\ \mathrm{mm}^3$

Sectional flexural strength.

$M_{s[C35]} = \frac{Z_e \cdot f_{yf}}{1000000}$

$= \frac{467000.0 \cdot 320}{1000000}$ $= 149.0$ kNm

(As the beam is fully restrained, Mb=Ms) . Beam flexural strength.

$\O M_{s[C36]} = \O \cdot M_s$

$= 0.9 \cdot 149.0$ $= 134.0$ kNm

1.0.3 Fully braced at ends calculations

Single inputs	Value	Units	Comments	Cell Ref.	
k_l	1	-		C41	*Table 5.6.3*
k_r	1	-		C42	*Table 5.6.3*
k_t	1	-	Effective length factors.	C40	*Table 5.6.3*

Moment modification factor.

$\alpha_{m[C39]} = \frac{1.7}{\sqrt{1^2+1^2+1^2}}$ *Eq. 5.6.1.1(2)*

$= \frac{1.7}{\sqrt{1^2+1^2+1^2}}$ $= 0.981$

Effective section length.

$L_{e[C43]} = k_t \cdot k_l \cdot k_r \cdot L$

$= 1 \cdot 1 \cdot 1 \cdot 3$ $= 3$ m

Reference buckling moment.

$M_{o[C44]} = \frac{\sqrt{\frac{\pi^2 \cdot E \cdot 10^3 \cdot I_y}{L_e^2} \cdot (\frac{G \cdot J}{1000} + \frac{\frac{\pi^2 \cdot E \cdot I_w}{1000000000}}{L_e^2})}}{1000}$ *Eq. 5.6.1.1(4)*

$= \frac{\sqrt{\frac{\pi^2 \cdot 200 \cdot 10^3 \cdot 4.42}{3^2} \cdot (\frac{80 \cdot 86500}{1000} + \frac{\frac{\pi^2 \cdot 200 \cdot 9.29 \times 10^{10}}{1000000000}}{3^2})}}{1000}$ $= 163.0$ kNm

Slenderness reduction factor.

$\alpha_{s[C45]} = 0.6 \cdot (\sqrt{(\frac{M_s}{M_o})^2 + 3} - \frac{M_s}{M_o})$ *Eq. 5.6.1.1(3)*

$= 0.6 \cdot (\sqrt{(\frac{149.0}{163.0})^2 + 3} - \frac{149.0}{163.0})$ $= 0.625$

Member flexural capacity.

$M_{b[C46]}$ $= \text{MIN}(\alpha_s \cdot \alpha_m \cdot M_s, \quad M_s)$

$= \text{MIN}(0.625 \cdot 0.981 \cdot 149.0, \quad 149.0)$ $= 91.7$ kNm

Reduced member flex. capacity.

$\O M_{b[C47]}$ $= 0.9 \cdot M_b$

$= 0.9 \cdot 91.7$ $= 82.5$ kNm