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IPE300-H=363 Properties :

$b = 0.15\ m$ $t_f = 0.0107\ m$

$h = 0.3625\ m$ $t_w = 0.0071\ m$

$A = 0.00572687\ m^2$

$I_x = 0.000125521\ m^4$

$I_y = 6.03268E\text{-}06\ m^4$

$S_x = 0.000692529\ m^3$

$S_y = 8.04357E\text{-}05\ m^3$

$Z_x = 0.000787131\ m^3$

$Z_y = 0.000125236\ m^3$

$i_x = 0.148047\ m$

$i_y = 0.0324561\ m$

$C_w = 1.86656E\text{-}07\ m^6$

$J_c = 2.08641E\text{-}07\ m^4$

Material Properties: S275

F_y :Yield stress = 275000 kN/m²

F_u :Ultimate stres = 430000 kN/m²

E :Elasticity modulus = 2.000E+8 kN/m²

G : Shear modulus = 7.692E+7 kN/m²

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Classification

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Flange Slenderness

Slender Limit $\lambda_r = 0.56\sqrt{\frac{E}{F_y}} = 0.56\sqrt{\frac{2.000E+8}{275000}} = 15.1$

$b/f = 0.075/0.0107 = 7.01 \Longrightarrow 7.01 < 15.1$ *NonSlender*

Web Slenderness

Slender Limit $\lambda_r = 1.49\sqrt{\frac{E}{F_y}} = 1.49\sqrt{\frac{2.000E+8}{275000}} = 40.2$

$h/tw = 0.311/0.0071 = 43.8 \Longrightarrow 43.8 \geq 40.2$ *Slender*

Flange Slenderness

Compact Limit $\lambda_p = 0.38\sqrt{\frac{E}{F_y}} = 0.38\sqrt{\frac{2.000E+8}{275000}} = 10.2$

Non compact Limit $\lambda_r = 1\sqrt{\frac{E}{F_y}} = 1\sqrt{\frac{2.000E+8}{275000}} = 27$

$b/f = 0.075/0.0107 = 7.01 \Longrightarrow$ *Compact*

Web Slenderness

Compact Limit $\lambda_p = 3.76\sqrt{\frac{E}{F_y}} = 3.76\sqrt{\frac{2.000E+8}{275000}} = 101.4$

Non compact Limit $\lambda_r = 5.7\sqrt{\frac{E}{F_y}} = 5.7\sqrt{\frac{2.000E+8}{275000}} = 153.72$

$h/tw = 0.311/0.0071 = 43.8 \Longrightarrow$ *Compact*

Check against flexure and axial force

Load Combinations

ComboType = ULS

Combo Name = 1.2xD+1.2xSELF+1.2xPUR+1.2xSHE+1.6xSNOW1+0.5xWB(Cpi+)

Station

Loc	:	0.215	m
N	:	-98	kN
M33	:	-151.29	kN.m
V22	:	0.0	kN
M22	:	0.0	kN.m
V33	:	69.7	kN
T	:	0.0	kN

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Calculation of nominal compressive strength against flexural buckling of members without slender elements, as per E3

$$\left(\frac{L_c}{r}\right)_{major} = \frac{k_x \cdot L_{major}}{i_x} = \frac{k_x \cdot L_{major}}{\sqrt{\frac{I_{xx}}{A_g}}} = \frac{1 \cdot 1.72}{\sqrt{\frac{0.000126}{0.00573}}} = 11.6$$

$$\left(\frac{L_c}{r}\right)_{minor} = \frac{k_y \cdot L_{minor}}{i_y} = \frac{k_y \cdot L_{minor}}{\sqrt{\frac{I_{yy}}{A_g}}} = \frac{1 \cdot 1.72}{\sqrt{\frac{6.03E\text{-}06}{0.00573}}} = 52.9$$

$$\frac{L_c}{r} = \max\left\{\left(\frac{L_c}{r}\right)_{major}, \left(\frac{L_c}{r}\right)_{minor}\right\} = 52.9$$

Elastic buckling stress, as per eq. E3 − 4

$$F_e = \frac{\pi^2 E}{\left(\frac{L_c}{r}\right)^2} = \frac{\pi^2 \cdot 200E{+}6}{(52.9)^2} = 704523.89 \ kN/m^2 \qquad (E3-4)$$

Calculation of critical stress F_{cr}, as per E3 − 2

$$When\ \frac{L_c}{r} \le 4.71\sqrt{\frac{E}{F_y}} \qquad 52.9 \le 4.71\sqrt{\frac{200E{+}6}{275000}} \qquad 52.9 \le 127.02$$

$$F_{cr} = \left[0.658^{\frac{F_y}{F_e}}\right] \cdot F_y = \left[0.658^{\frac{275000}{704523.89}}\right] \cdot 275000 = 233550.06 \ kN \qquad (E3-2)$$

$$P_n = F_{cr} \cdot A_g = 233550.06 \cdot 0.00573 = 1337.51 \ kN \qquad (E3-1)$$

$$\left(\frac{KL}{r}\right)_{major} = \frac{k_x L_x}{i_x} = \frac{k_x L_x}{\sqrt{\frac{I_{xx}}{A_g}}} = \frac{1 \cdot 1.72}{\sqrt{\frac{0.000126}{0.00573}}} = 11.6$$

$$\left(\frac{KL}{r}\right)_{minor} = \frac{k_y L_y}{i_y} = \frac{k_y L_y}{\sqrt{\frac{I_{yy}}{A_g}}} = \frac{1 \cdot 1.72}{\sqrt{\frac{6.03E\text{-}06}{0.00573}}} = 52.9$$

$$F_{e\_x} = \frac{\pi^2 E}{\left(\frac{L_c}{r}\right)^2_{major}} = \frac{\pi^2 \cdot 200E{+}6}{(11.6)^2} = 14658908.9 \ kN \qquad (E3-4-axis)$$

$$F_{e\_y} = \frac{\pi^2 E}{\left(\frac{L_c}{r}\right)^2_{minor}} = \frac{\pi^2 \cdot 200E{+}6}{(52.9)^2} = 704523.89 \ kN \qquad (E3-4-axis)$$

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$$F_{eaxis}=\left(\frac{\pi^2\cdot E\cdot C_w}{(K_z\cdot L)^2}+G\cdot I_t\right)\frac{1}{(I_{xx}+I_{yy})} \qquad (E4-2)$$

$$F_e=\left(\frac{\pi^2\cdot 200E+6\cdot 1.87E\text{-}07}{(1\cdot 0.429)^2}+7.692E+7\cdot 2.09E\text{-}07\right)\frac{1}{(6.03E\text{-}06+0.000126)}=15305167.44 \quad kN$$

Calculation of critical stress F_{cr}, as per E3−2

$$When\ \frac{L_c}{r}\le 4.71\sqrt{\frac{E}{F_y}} \qquad 52.9\le 4.71\sqrt{\frac{200E+6}{275000}} \qquad 52.9\le 127.02$$

$$F_{cr}=\left[0.658^{\frac{F_y}{F_e}}\right]\cdot F_y=\left[0.658^{\frac{275000}{15305167.44}}\right]\cdot 275000=272939.64 \quad kN \qquad (E3-2)$$

$$P_n=F_{cr}\cdot A_g=272939.64\cdot 0.00573=1563.09 \quad kN \qquad (E3-1)$$

E7. The effective width, b_e for Web

$$When\ \lambda>\lambda_r\sqrt{\frac{F_y}{F_{cr}}} \qquad 43.8>40.2\cdot\sqrt{\frac{275000}{233550.06}}$$

$$c_2=\left(1-\sqrt{1-4c_1}\right)/(2c_1) \qquad 1.31=\left(1-\sqrt{1-4\cdot 0.18}\right)/(2\cdot 0.18) \qquad (E7-4)$$

$$F_{el}=\left(c_2\frac{\lambda_r}{\lambda}\right)^2F_y \qquad 396882.36=(1.31\cdot 40.2/43.8)^2 \qquad (E7-5)$$

$$b_e=b\left(1-c_1\sqrt{\frac{F_{el}}{F_{cr}}}\right)\sqrt{\frac{F_{el}}{F_{cr}}} \qquad (E7-3)$$

$$b_e=0.31\cdot\left(1-0.18\cdot\sqrt{\frac{396882.36}{233550.06}}\right)\cdot\sqrt{\frac{396882.36}{233550.06}}=0.31 \quad m$$

E7.1The effective width, b_e for Flanges

$$When\ \lambda\le\lambda_r\sqrt{\frac{F_y}{F_{cr}}} \qquad 7.01\le 15.1\cdot\sqrt{\frac{275000}{233550.06}}$$

$$b_e=b \qquad (E7-2)$$

$$b_e=0.08 \quad m$$

E7.2 The effective area, A_e

$$A_e=0.00572 \quad m^2$$

E7. The nominal compresive strenght, 1336.33

$$P_n=F_{cr}\cdot A_e \qquad (E7-1)$$

$$P_n=233550.06\cdot Ae=1336.33 \quad kN$$

Selection of Compressive Design Strength

$$P_n=\min\{P_1,P_2,P_3,P_4\}$$
$$P_n=\min\{1337.51,1563.09,1336.33,0.0\}=1336.33$$
$$P=\Phi_c\cdot P_n=0.9\cdot 1336.33=1202.7$$

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C_b *lateral torsional buckling modification factor, as per F1 − 1*

$$C_b = \frac{12.5 M_{max}}{2.5 M_{max} + 3 M_A + 4 M_B + 3 M_C}$$

$$C_b = \frac{12.5 \cdot 267.43}{2.5 \cdot 267.43 + 3 \cdot 231.9 + 4 \cdot 198.25 + 3 \cdot 166.48} = 1.26$$

Double symmetric compact I-Shaped members and channels bent about their major axis - Yielding strength, as per F2.1

F2. DOUBLE SYMETRIC COMPACT I SHAPED MEMBERS
AND CHANNELS BENT ABOUT THEIR MAJOR AXIS

$$M_n = M_p = F_y Z_x \qquad (F2-1)$$

$$M_n = Mp = 275000 \cdot 0.000787 = 216.46 \quad kNm$$

Lateral torsional buckling resistance of doubly symmetric compact I-Shaped members and channels bent about their major axis, as per F2.2

$$r_{ts}^2 = \frac{\sqrt{I_y C_w}}{S_x} \qquad (F2-7)$$

$$r_{ts}^2 = \frac{\sqrt{6.03E\text{-}06x1.866559E\text{-}007}}{0.000693} = 0.00153 \Longrightarrow r_{ts} = 0.0391$$

$$L_p = 1.76 r_y \sqrt{\frac{E}{F_y}} \qquad (F2-5)$$

$$L_p = 1.76 \cdot 0.0325 \cdot \sqrt{\frac{200E+6}{275000}} = 1.54 \quad m$$

$$L_r = 1.95 r_{ts} \frac{E}{0.7F_y} \sqrt{\frac{Jc}{S_x h_o} + \sqrt{\left(\frac{Jc}{S_x h_o}\right)^2 + 6.76\left(\frac{0.7F_y}{E}\right)^2}} \qquad (F2-6)$$

$$L_r = 1.95 \cdot 0.0391 \frac{200E+6}{0.7 \cdot 275000} \sqrt{\frac{2.09E\text{-}07}{0.000693 \cdot 0.352} + \sqrt{\left(\frac{2.09E\text{-}07}{0.000693 \cdot 0.352}\right)^2 + 6.76\left(\frac{0.7 \cdot 275000}{200E+6}\right)^2}}$$

$$L_r = 4.69 \quad m$$

Lb=0.00 Lp=1.54 Lb <= Lp =>

Check does Not apply

$$M_{n\text{-}major} = \min\{M_{F2\text{-}1}, M_{F2\text{-}1}\}$$

$$M_{n\text{-}major} = \min\{216.46, 216.46\}$$

$$M_{n\text{-}major} = 216.46 \quad kN\text{-}m$$

Bending resistance of I-Shaped members and channels bent about their minor axis, as per F6

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Yielding

$$M_n = M_p = F_y Z_y \leq 1.6 F_y S_y \qquad (F6-1)$$

$$M_n = M_p = 275000 \cdot 0.000125 \leq 1.6 \cdot 275000 \cdot 8.04E\text{-}05 = Mp = 34.4 \ \ kN\text{-}m$$

Nominal flexural strength

$$M_{desing,cx+} = \Phi_b \cdot M_{n,x+} = 0.9 \cdot 216.46 = 194.81 \quad kN\text{-}m$$

$$M_{desing,cy+} = \Phi_b \cdot M_{n,y+} = 0.9 \cdot 34.4 = 31 \quad kN\text{-}m$$

Doubly and Singly Symmetric Members Subject to Flexure and Axial Force H1.1(b)

$$When \ \frac{P_r}{P_c} < 0.2 \Rightarrow \frac{98}{1202.7} < 0.2$$

$$\frac{P_r}{2P_c} + \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}}\right) \leq 1.0 \qquad (\mathrm{H1-1b})$$

$$\frac{98}{2 \cdot 1202.7} + \left(\frac{-151.29}{194.81} + \frac{0.0}{31}\right) \leq 1.0$$

$0.817 \ \leq \ 1.0$ *Satisfactory* ✔ *o.k.*

Check against shear

Load Combinations

ComboType = *ULS*

Combo Name = 1.2xD+1.2xSELF+1.2xPUR+1.2xSHE+1.6xSNOW1+0.5xWB(Cpi+)

Station

Loc	:	0.215	*m*
N	:	-98	*kN*
M33	:	-151.29	*kN.m*
V22	:	0.0	*kN*
M22	:	0.0	*kN.m*
V33	:	69.7	*kN*
T	:	0.0	*kN*

G − SHEAR STRENGHT in y direction

$E = 200E{+}6 \ \ kN/m^2$

$F_y = 275000 \ \ kN/m^2$

$A_v = 0.00291 \ \ m^2$

Section Type = *HSection*

$h = h\_2c = 0.311 \ \ m$

$t_w = 0.0071 \ \ m$

Calculates the C_v *factors*

$$h/t_w \leq 2.24 \cdot \sqrt{E/F_y} \Longrightarrow$$

$$43.8 \leq 2.24 \cdot \sqrt{200E{+}6/275000} \Longrightarrow C_w = 1 \qquad (G2-2)$$

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$V_n = 0.6 \cdot F_y \cdot A_w \cdot C_{vPB} \quad (G2-1)$

$V_n = 0.6 \cdot 275000 \cdot 0.00291 \cdot 1 = 480.78\ kN$

$ratio_{shear\ y} = V_y \Big/ \Phi_n V_{n-y}$

$ratio_{shear\ y} = 69.7 / (1 \cdot 480.78) = 0.145 < 1.0$ ✔ o.k.