TALAT Lecture 2301

Design of Members

Axial force and bending moment

Example 9.2 : Beam-column with rectangular hollow section

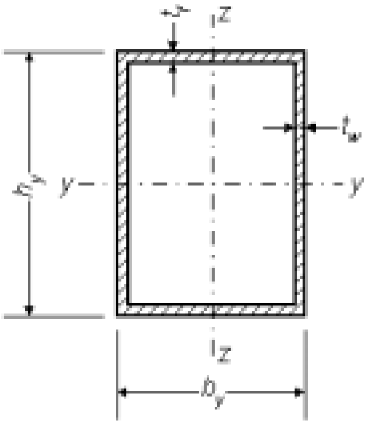
4 pages

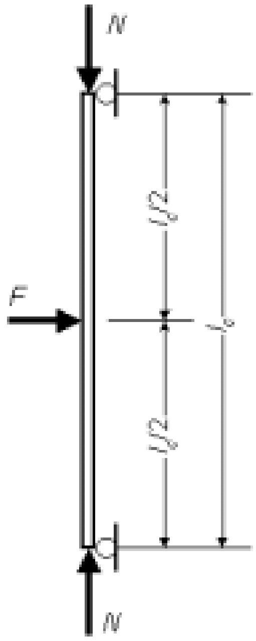
Advanced Level

prepared by Torsten Höglund, Royal Institute of Technology, Stockholm

Date of Issue: 1999
© EAA - European Aluminium Association

Example 9.2 Beam-column with rectangular hollow section





Dimensions and material properties

$MPa \equiv 10^6 \cdot Pa$

$kN \equiv 1000 \cdot newton$

Length $\quad l_c := 3800 \cdot mm$

Thickness $\quad t_w := 6 \cdot mm \quad t_f := 6 \cdot mm$

Width $\quad h_y := 180 \cdot mm \quad h_i := h_y - 2 \cdot t_f \quad h_i = 168 \circ mm$

$b_y := 120 \cdot mm \quad b_i := b_y - 2 \cdot t_w \quad b_i = 108 \circ mm$

[1] Table 3.2b $\quad$ Alloy: **EN AW-6060 T6** EP $t < 15$ mm $\quad f_{0.2} := 140 \cdot MPa \quad f_u := 170 \cdot MPa$

[1] (5.4), (5.5) $\quad f_o := f_{0.2} \quad f_a := f_u \quad E := 70000 \cdot MPa \quad \gamma_{M1} := 1.1 \quad \gamma_{M2} := 1.25$

Forces and moment

Axial force $\quad N_{Ed} := 110 \cdot kN$

Transverse force $\quad F_{Ed} := 8 \cdot kN$

Bending moment $\quad M_{y.Ed} := \dfrac{F_{Ed} \cdot l_c}{4} \quad M_{y.Ed} = 7.6 \circ kN \cdot m$

Classification of the cross section in axial compression

Web $\quad \beta_w := \dfrac{h_y - 2 \cdot t_f}{t_w} \quad \beta_w = 28 \quad \varepsilon := \sqrt{\dfrac{250 \cdot MPa}{f_o}} \quad \varepsilon = 1.336$

[1] Tab. 5.1 $\quad \beta_{1w} := 11 \cdot \varepsilon \quad \beta_{2w} := 16 \cdot \varepsilon \quad \beta_{3w} := 22 \cdot \varepsilon$

$class_c := if(\beta_w > \beta_{1w}, if(\beta_w > \beta_{2w}, if(\beta_w > \beta_{3w}, 4, 3), 2), 1) \quad class_c = 3$

[1] 5.8.4.1 $\quad A_e := A \quad \eta := 1.0$

Classification of the cross section in *y-y* axis bending

Web $\beta_w := 0.4 \cdot \frac{h_y - 2 \cdot t_f}{t_w}$ $\beta_w = 11.2$

[1] Tab. 5.1 $\beta_{1w} := 11 \cdot \varepsilon$ $\beta_{2w} := 16 \cdot \varepsilon$ $\beta_{3w} := 22 \cdot \varepsilon$

[1] 5.4.5 $class_w := if(\beta_w > \beta_{1w}, if(\beta_w > \beta_{2w}, if(\beta_w > \beta_{3w}, 4, 3), 2), 1)$ $class_w = 1$

Flange $\beta_f := \frac{b_y - 2 \cdot t_w}{t_f}$ $\beta_f = 18$

[1] Tab. 5.1 $\beta_{1f} := 11 \cdot \varepsilon$ $\beta_{2f} := 16 \cdot \varepsilon$ $\beta_{3f} := 22 \cdot \varepsilon$

[1] 5.4.5 $class_f := if(\beta_f > \beta_{1w}, if(\beta_f > \beta_{2f}, if(\beta_f > \beta_{3f}, 4, 3), 2), 1)$ $class_f = 2$

Classification of the total cross-section in *y-y* axis bending:

$class_y := if(class_f > class_w, class_f, class_w)$ $class_y = 2$

Classification of the cross section in *z-z* axis bending

Web $\beta_w := 0.4 \cdot \frac{b_y - 2 \cdot t_w}{t_f}$ $\beta_w = 7.2$

[1] Tab. 5.1 $\beta_{1w} := 11 \cdot \varepsilon$ $\beta_{2w} := 16 \cdot \varepsilon$ $\beta_{3w} := 22 \cdot \varepsilon$

[1] 5.4.5 $class_w := if(\beta_w > \beta_{1w}, if(\beta_w > \beta_{2w}, if(\beta_w > \beta_{3w}, 4, 3), 2), 1)$ $class_w = 1$

Flange $\beta_f := \frac{h_y - 2 \cdot t_f}{t_w}$ $\beta_f = 28$

[1] Tab. 5.1 $\beta_{1f} := 11 \cdot \varepsilon$ $\beta_{2f} := 16 \cdot \varepsilon$ $\beta_{3f} := 22 \cdot \varepsilon$

[1] 5.4.5 $class_f := if(\beta_f > \beta_{1w}, if(\beta_f > \beta_{2f}, if(\beta_f > \beta_{3f}, 4, 3), 2), 1)$ $class_f = 3$

Classification of the total cross-section in *z-z* axis bending:

$class_z := if(class_f > class_w, class_f, class_w)$ $class_z = 3$

Cross section constants

$A := b_y \cdot h_y - b_i \cdot h_i$ $A = 3.456 \cdot 10^3 \, mm^2$

$I_y := \frac{b_y \cdot h_y^3}{12} - \frac{b_i \cdot h_i^3}{12}$ $I_y = 1.565 \cdot 10^7 \, mm^4$ $I_z := \frac{h_y \cdot b_y^3}{12} - \frac{h_i \cdot b_i^3}{12}$ $I_z = 8.28 \cdot 10^6 \, mm^4$

$W_{el.y} := \frac{I_y \cdot 2}{h_y}$ $W_{el.y} = 1.738 \cdot 10^5 \, mm^3$ $W_{el.z} := \frac{I_z \cdot 2}{b_y}$ $W_{el.z} = 1.4 \cdot 10^5 \, mm^3$

$W_{pl.y} := \frac{b_y \cdot h_y^2}{4} - \frac{b_i \cdot h_i^2}{4}$ $W_{pl.y} = 2.1 \cdot 10^5 \, mm^3$

[1] 5.6.2.1 $class_y = 2$ $\alpha_y := \frac{W_{pl.y}}{W_{el.y}}$ $\alpha_y = 1.208$ $class_z = 3$ $\alpha_z := 1$

$i_y := \sqrt{\frac{I_y}{A}}$ $i_y = 67.3 \, mm$ $i_z := \sqrt{\frac{I_z}{A}}$ $i_z = 49 \, mm$

Flexural buckling

TALAT (5.6) $\bar{\lambda}_y := \frac{l_c}{\pi \cdot i_y} \cdot \sqrt{\frac{\eta \cdot f_o}{E}}$ $\bar{\lambda}_y = 0.804$ $\bar{\lambda}_z := \frac{l_c}{\pi \cdot i_z} \cdot \sqrt{\frac{\eta \cdot f_o}{E}}$ $\bar{\lambda}_z = 1.105$

[1] 5.8.4.1 $\phi_y := 0.5 \cdot \left[1 + \left[0.20 \cdot \left(\bar{\lambda}_y - 0.1\right) + \bar{\lambda}_y^{\,2}\right]\right]$ $\phi_z := 0.5 \cdot \left[1 + \left[0.20 \cdot \left(\bar{\lambda}_z - 0.1\right) + \bar{\lambda}_z^{\,2}\right]\right]$

$\chi_y := \frac{1}{\phi_y + \sqrt{\phi_y^{\,2} - \bar{\lambda}_y^{\,2}}}$ $\chi_y = 0.779$ $\chi_z := \frac{1}{\phi_z + \sqrt{\phi_z^{\,2} - \bar{\lambda}_z^{\,2}}}$ $\chi_z = 0.586$

[1] Table 5.5 $k_1 := 1$ $k_2 := 1$

$N_{Rd} := \frac{A \cdot f_o}{\gamma_{M1}}$ $N_{Rd} = 439.9 \cdot kN$

Exponents in interaction formula

[1] 5.9.4.2 (4) $\psi := \alpha_z \cdot \alpha_y$ $\psi := if(\psi > 2, 2, \psi)$ $\psi = 1.208$

$\psi_c := \chi_z \cdot \psi$ $\psi_c := if\left(\psi_c < 0.8, 0.8, \psi_c\right)$ $\psi_c = 0.8$

Cross weld in mid section

[1] Tab. 5.2 HAZ softening factor $\rho_{haz} := 0.65$

[1] 5.9.4.5 $\omega_o := \frac{\rho_{haz} \cdot f_u \cdot \gamma_{M1}}{f_o \cdot \gamma_{M2}}$ $\omega_o = 0.695$ $\omega_x := \omega_o$

$M_{y.Rd} := \alpha_y \cdot W_{el.y} \cdot \frac{f_o}{\gamma_{M1}}$ $M_{y.Rd} = 26.721 \cdot kN \cdot m$ $M_{y.Ed} = 7.6 \cdot kN \cdot m$

$M_{z.Rd} := \alpha_z \cdot W_{el.z} \cdot \frac{f_o}{\gamma_{M1}}$ $M_{z.Rd} = 17.572 \cdot kN \cdot m$ $M_{z.Ed} := 0 \cdot kN \cdot m$

$\chi_{min} := \chi_y$ $\chi_{min} = 0.779$

Flexural buckling check

[1] 5.9.4.2 (4) $\left(\frac{N_{Ed}}{\chi_{min} \cdot \omega_x \cdot N_{Rd}}\right)^{\psi_c} + \frac{1}{\omega_o} \cdot \left[\left(\frac{M_{y.Ed}}{M_{y.Rd}}\right)^{1.7} + \left(\frac{M_{z.Ed}}{M_{z.Rd}}\right)^{1.7}\right]^{0.6} = 0.939$ < 1,0 OK !