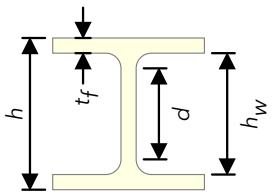
# EC3 Design : Class 1 - H

*References are to EN1993-1-1:2005 unless otherwise stated.*

## Section properties (shape)

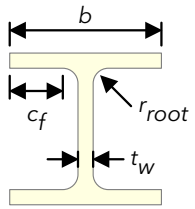
| Designation | Shape | Manufacture | |
|---|---|---|---|
| 125 x 100 H | Doubly Symmetrical I | Rolled | Hot-Finished |

| Depth h mm | Width b mm | Thicknesses | | Root radius $r_{root}$ mm |
|---|---|---|---|---|
| | | Web $t_w$ mm | Flange $t_f$ mm | |
| 125 | 100 | 6.1 | 5 | 8 |

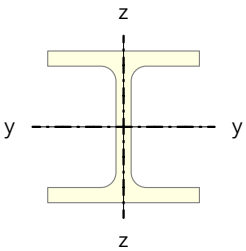



## Section properties (derived)

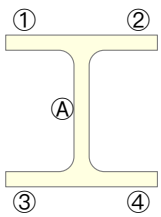
| Gross area A cm² | Second moments of area | | Product moment of area $I_{yz}$ cm⁴ | Torsional constant $I_T$ cm⁴ |
|---|---|---|---|---|
| | Major $I_y$ cm⁴ | Minor $I_z$ cm⁴ | | |
| 17.573 | 454.83 | 83.695 | 0 | 2.3611 |




| Elastic section moduli (minima) | | Plastic section moduli | | Torsional section modulus |
|---|---|---|---|---|
| Major $W_{el,y,min}$ cm³ | Minor $W_{el,z,min}$ cm³ | Major $W_{pl,y}$ cm³ | Minor $W_{pl,z}$ cm³ | $W_t$ cm³ |
| 72.773 | 16.739 | 83.274 | 26.34 | 4.7221 |




| Shear centre | | Warping constant $I_w$ dm⁶ |
|---|---|---|
| Horizontal $y_o$ mm | Vertical $z_o$ mm | |
| 0 | 0 | 0.003 |




## Material properties

| Steel grade | Modulus of elasticity E kN/mm² | Modulus of rigidity G kN/mm² | Yield stress $f_y$ N/mm² | Ultimate stress $f_u$ N/mm² |
|---|---|---|---|---|
| S275 | 210 | 81 | 275 | 430 |

## Member geometry properties

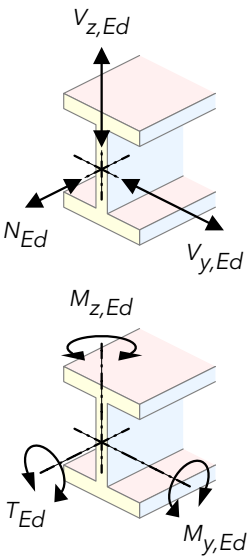
| Restrained lengths | | |
|---|---|---|
| Geometrical axes | | |
| Major<br>$L_y$ m | Minor<br>$L_z$ m | Torsional<br>$L_T$ m |
| 7 | 3 | 5 |

| Buckling length ratios | | |
|---|---|---|
| $k_{cr,y}$ | $k_{cr,z}$ | $k_{cr,T}$ |
| 1.000 | 0.900 | 0.800 |

| Buckling lengths, $L_{cr}$ = $k_{cr}$ L | | |
|---|---|---|
| $L_{cr,y}$ m | $L_{cr,z}$ m | $\ell_T$ m |
| 7 | 2.7 | 4 |

## Design forces ($F_d$ )

| | In plane of web | | | In plane of flange | |
|---|---|---|---|---|---|
| Axial<br>$N_{Ed}$ kN | Shear<br>$V_{z,Ed}$ kN | B.M.<br>$M_{y,Ed}$ kN.m | Torsion<br>$T_{Ed}$ kN.m | Shear<br>$V_{y,Ed}$ kN | B.M.<br>$M_{z,Ed}$ kN.m |
| 17 (C) | 11 | 0.13 | 0.3 | 5 | 0.7 |




## National Annex (Generic)

| Global partial factors of resistance | | | |
|---|---|---|---|
| Of cross-section<br>$\gamma_{M0}$ | To instability<br>$\gamma_{M1}$ | To tensile fracture<br>$\gamma_{M2}$ | Factor for shear area<br>$\eta$ |
| 1.00 | 1.00 | 1.25 | 1.00 |

## Design Summary : Class 1 - H

| Class | Local | | | | | Buckling | | | Overall |
|---|---|---|---|---|---|---|---|---|---|
| | Axial | Torsion | Bending | Shear | Utilisation | Flexural | L-T | Stability | |
| Class 1 | 0.04 | 0.40 | 0.36 | 0.10 | 0.40 | 0.11 | 0.01 | 0.21 | **ACCEPT** |
| | **PASS** | **PASS** | **PASS** | **PASS** | **PASS** | **PASS** | **PASS** | **PASS** | |

## Supplementary data

*Computed from input*

| Net area $A_{net}$ cm² | Depth of web | | Width of single flange | |
|---|---|---|---|---|
| | Full $h_w$ mm | Straight d mm | Full $b_f$ mm | Straight $c_f$ mm |
| 17.573 | 115 | 99 | 46.95 | 38.95 |

| Radii of gyration | | Elastic section moduli (maxima) | |
|---|---|---|---|
| Major $i_y$ mm | Minor $i_z$ mm | Major $W_{el,y,max}$ cm³ | Minor $W_{el,z,max}$ cm³ |
| 50.875 | 21.824 | 72.773 | 16.739 |

## Loadcases of characteristic actions & factors

*EN1990:2002+A1:2005, 6.3.1*

**$F_{k,i}$** *are the characteristic actions, i.e. the unfactored forces.*

**$\gamma_{F,i}$** *is the partial factor ("load factor") for the loadcase.*

**$\psi_i$** *is the combination factor for variable actions (or 1.0 for permanent actions).*

$$F_d = \left| \sum \gamma_{F,i} \, \psi_i \, F_{k,i} \right|$$

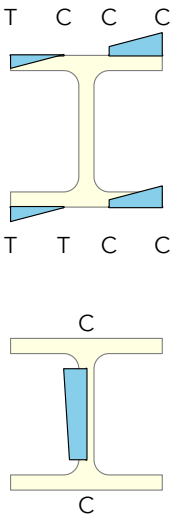
| Axial $N_{k,i}$ kN | In plane of web | | Torsion $T_{k\_i}$ kN.m | In plane of flange | | Partial factors | |
|---|---|---|---|---|---|---|---|
| | Shear $V_{z,k,i}$ kN | B.M. $M_{y,k,i}$ kN.m | | Shear $V_{y,k,i}$ kN | B.M. $M_{z,k\_i}$ kN.m | $\gamma_{F,i}$ | $\psi_i$ |
| 17 | 11 | 0.13 | 0.3 | 5 | 0.7 | 1.00 | 1.00 |

# Calculation Sheet : Class 1 - H

*References are to EN1993-1-1:2005 unless otherwise stated.*

## Stresses

| Stress components relative to centroid (N/mm²) | |
|---|---|
| Lesser | Greater |
| $\sigma_{axial} = \frac{N_{Ed}}{A} = 9.6739$ (C) | |
| $\sigma_{y,<} = \frac{M_{y,Ed}}{W_{el,y,max}} = \pm 1.7864$ | $\sigma_{y,>} = \frac{M_{y,Ed}}{W_{el,y,min}} = \pm 1.7864$ |
| $\sigma_{z,<} = \frac{M_{z,Ed}}{W_{el,z,max}} = \pm 41.819$ | $\sigma_{z,>} = \frac{M_{z,Ed}}{W_{el,z,min}} = \pm 41.819$ |




$\sigma_{x,Ed} = |\sigma_{axial}| + \sigma_{y,>} + \sigma_{z,>} = 53.279$ N/mm²

$\sigma_{y,Ed} = \max\left(|\sigma_{y,<}|, |\sigma_{y,>}|\right) = 1.7864$ N/mm²

$\sigma_{z,Ed} = \max\left(|\sigma_{z,<}|, |\sigma_{z,>}|\right) = 41.819$ N/mm²

## Classification

*5.5, Table 5.2*

$\varepsilon = \sqrt{\frac{235}{f_y}} = 0.924$

*Table 5.2*

### Classify web Ⓐ

*Table 5.2*
*internal compression parts*

Fibre extremities: $\left\{ \begin{array}{l} \sigma_{fibre,<} = \sigma_{axial} - \sigma_{y,<} = 7.8876 \text{ (C)} \\ \sigma_{fibre,>} = \sigma_{axial} + \sigma_{y,>} = 11.46 \text{ (C)} \end{array} \right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

Part/fibre extents: $p_< = \frac{h - d}{2\,h} = 0.10$ , $p_> = 1 - p_< = 0.90$

*Measured from bottom*

Stresses: $\left\{ \begin{array}{l} \sigma_< = \sigma_{fibre,>}\, p_< + \sigma_{fibre,<} \left(1 - p_<\right) = 8.2591 \text{ (C)} \\ \sigma_> = \sigma_{fibre,>}\, p_> + \sigma_{fibre,<} \left(1 - p_>\right) = 11.089 \text{ (C)} \end{array} \right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

$\frac{c}{t} = \frac{d}{t_w} = 16.23$ and subject to compression only.

$\frac{c}{t} \le 33\,\varepsilon$ i.e. $16.23 \le 30.51$ ⇒ Class 1

*Table 5.2*

## Classify flange ①

*Table 5.2*
*outstand flanges*

Fibre extremities: $\left\{\begin{array}{l} \sigma_{fibre,<} = \sigma_{axial} + \sigma_{y,>} - \sigma_{z,<} = -30.358 \ (T) \\ \sigma_{fibre,>} = \sigma_{axial} + \sigma_{y,>} + \sigma_{z,>} = 53.279 \ (C) \end{array}\right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

Part/fibre extents: $p_{<} = 0.00 \ , \ p_{>} = \frac{c_f}{b} = 0.39$

*Measured from left*

Stresses: $\left\{\begin{array}{l} \sigma_{root} = \sigma_{fibre,>} \ p_{>} + \sigma_{fibre,<} \ \left(1 - p_{>}\right) = 2.2184 \ (C) \\ \sigma_{tip} = \sigma_{fibre,>} \ p_{<} + \sigma_{fibre,<} \ \left(1 - p_{<}\right) = -30.358 \ (T) \end{array}\right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

$\frac{\mathbf{c}}{\mathbf{t}} = \frac{c_f}{t_f} = 7.79$ and subject to bending and compression with tip in tension.

$\boldsymbol{\alpha} = \frac{\sigma_{root}}{\sigma_{root} - \sigma_{tip}} = 0.07$ $\quad$ $\boldsymbol{\psi} = \frac{\sigma_{tip}}{\sigma_{root}} = -13.68$

*Depicted in table 5.2*

$\psi \leq -1$ therefore $\mathbf{k_\sigma} = 23.80$

*EN1993-1-5:2006, Table 4.2*
*No guidance in EN1993-1-5:2005*

$\frac{c}{t} \leq \frac{9\varepsilon}{\alpha\sqrt{\alpha}}$ i.e. $7.79 \leq 468.17 \Rightarrow$ Class 1

*Table 5.2*

## Classify flange ②

*Table 5.2*
*outstand flanges*

Fibre extremities: $\left\{\begin{array}{l} \sigma_{fibre,<} = \sigma_{axial} + \sigma_{y,>} - \sigma_{z,<} = -30.358 \ (T) \\ \sigma_{fibre,>} = \sigma_{axial} + \sigma_{y,>} + \sigma_{z,>} = 53.279 \ (C) \end{array}\right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

Part/fibre extents: $p_{<} = b - \frac{c_f}{b} = 0.61 \ , \ p_{>} = 1.00$

*Measured from left*

Stresses: $\left\{\begin{array}{l} \sigma_{root} = \sigma_{fibre,>} \ p_{<} + \sigma_{fibre,<} \ \left(1 - p_{<}\right) = 20.702 \ (C) \\ \sigma_{tip} = \sigma_{fibre,>} \ p_{>} + \sigma_{fibre,<} \ \left(1 - p_{>}\right) = 53.279 \ (C) \end{array}\right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

$\frac{\mathbf{c}}{\mathbf{t}} = \frac{c_f}{t_f} = 7.79$ and subject to compression only.

$\frac{c}{t} \leq 9\varepsilon$ i.e. $7.79 \leq 8.32 \Rightarrow$ Class 1

*Table 5.2*

## Classify flange ③

*Table 5.2*
*outstand flanges*

Fibre extremities: $\left\{\begin{array}{l} \sigma_{fibre,<} = \sigma_{axial} - \sigma_{y,<} - \sigma_{z,<} = -33.931 \ (T) \\ \sigma_{fibre,>} = \sigma_{axial} - \sigma_{y,<} + \sigma_{z,>} = 49.706 \ (C) \end{array}\right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

Part/fibre extents: $p_{<} = 0.00$ , $p_{>} = \frac{c_f}{b} = 0.39$

*Measured from left*

Stresses: $\left\{ \begin{array}{l} \sigma_{root} = \sigma_{fibre,>}\ p_{>} + \sigma_{fibre,<}\ \left(1 - p_{>}\right) = \text{-1.3543 (T)} \\ \sigma_{tip} = \sigma_{fibre,>}\ p_{<} + \sigma_{fibre,<}\ \left(1 - p_{<}\right) = \text{-33.931 (T)} \end{array} \right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

$\frac{\mathbf{c}}{\mathbf{t}} = \frac{c_f}{t_f} = 7.79$ and subject to tension only.

Part is entirely in tension ⇒ Class 1

*Table 5.2*
*No guidance in EN1993-1-1:2005*

## Classify flange ④

*Table 5.2*
*outstand flanges*

Fibre extremities: $\left\{ \begin{array}{l} \sigma_{fibre,<} = \sigma_{axial} - \sigma_{y,<} - \sigma_{z,<} = \text{-33.931 (T)} \\ \sigma_{fibre,>} = \sigma_{axial} - \sigma_{y,<} + \sigma_{z,>} = 49.706 \text{ (C)} \end{array} \right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

Part/fibre extents: $p_{<} = b - \frac{c_f}{b} = 0.61$ , $p_{>} = 1.00$

*Measured from left*

Stresses: $\left\{ \begin{array}{l} \sigma_{root} = \sigma_{fibre,>}\ p_{<} + \sigma_{fibre,<}\ \left(1 - p_{<}\right) = 17.129 \text{ (C)} \\ \sigma_{tip} = \sigma_{fibre,>}\ p_{>} + \sigma_{fibre,<}\ \left(1 - p_{>}\right) = 49.706 \text{ (C)} \end{array} \right\}$ N/mm²

*(C) = Compressive, +ve*
*(N) = Neutral, zero*
*(T) = Tensile, -ve*

$\frac{\mathbf{c}}{\mathbf{t}} = \frac{c_f}{t_f} = 7.79$ and subject to compression only.

$\frac{c}{t} \le 9\varepsilon$ i.e. $7.79 \le 8.32$ ⇒ Class 1

*Table 5.2*

Section is **CLASS 1.**

## Class 1 Additional Parameters

$\begin{bmatrix} \mathbf{\Delta M_{y,Ed}} \\ \mathbf{\Delta M_{z,Ed}} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$ kN.m

*6.2.2.5(4), no shift of centroid in class 1, 2, or 3*

## Axial – Compression

$\mathbf{N_{pl,Rd}} = \frac{A\ f_y}{\gamma_{M0}} = 483.26$ kN

*6.2.3(2a), eq. 6.6*

## Compression check

*6.2.4*

$\mathbf{N_{c,Rd}} = \frac{A\ f_y}{\gamma_{M0}} = 483.26$ kN

*6.2.4(2), eq. 6.10*

Check: $\frac{N_{Ed}}{N_{c,Rd}} = \frac{17}{483.26} = 0.035 \leq 1$

*6.2.4(1), eq. 6.9*

Compression check: **PASS**

*6.2.4*

## Longitudinal – Torsion

Assumption: St. Venant torsion is taken as the whole design torsion.

$\boldsymbol{\tau_{t,Ed}} = \frac{T_{Ed}}{W_t} = 63.531$ N/mm²

*St.Venant shear stress.*
*SCI P385, 2.1*

Assumption: Warping torsion is taken as the whole design torsion, and applied as an additional bending moment to the flanges (local check only).

$\mathbf{B_{w,Ed}} = \frac{T_{Ed}\ L_z}{4\,(h - t_f)} = 1.875$ kN.m

*Warping bimoment.*
*SCI P385, 2.2*

$\mathbf{T_{Rd}} = \frac{W_t\ f_y}{\gamma_{M0}\ \sqrt{3}} = 0.74973$ kN.m

*6.2.6(4), eq. 6.19 rearranged.*
*No guidance in EN1993-1-1:2005*

## Torsion check

*6.2.7*

Check: $\frac{T_{Ed}}{T_{Rd}} = \frac{0.3}{0.74973} = 0.400 \leq 1$

*6.2.7(1), eq. 6.23*

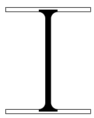
Torsion check: **PASS**

*6.2.7*

## Major-Axis – Shear

*In plane of web*

### Shear area (major axis)



*6.2.6(3), in plane of web*

Factor for shear area, $\boldsymbol{\eta} = 1.00$

*Absent NA to EN1993-1-5:2006 [5.1(2)]*

$\mathbf{A_{v,z}} = \max\left(\begin{matrix} A - 2\,b\,t_f + (t_w + 2\,r_{root})\,t_f \\ \eta\ h_w\ t_w \end{matrix}\right) = \max\begin{pmatrix} 8.678 \\ 7.015 \end{pmatrix} = 8.678$ cm²

*Shear area, 6.2.6(3)*

Plastic section modulus for shear area, $\mathbf{W_{v,pl,y}} = 29.766$ cm³

*About y-y geometrical axis; plane of web*

### Plastic shear check (major axis)

*6.2.6, in plane of web.*

$\mathbf{V_{pl,z,Rd}} = \frac{A_{v,z}\ f_y}{\gamma_{M0}\ \sqrt{3}} = 137.78$ kN

*6.2.6(2), eq. 6.18*
*Assumes in absence of torsion.*

$\mathbf{V_{pl,T,z,Rd}} = \sqrt{1 - \frac{\tau_{t,Ed}\ \sqrt{3}\ \gamma_{M0}}{1.25\ f_y}}\ V_{pl,z,Rd} = 113.61$ kN — *6.2.7(9), eq. 6.26.*

$\mathbf{V_{c,z,Rd}} = V_{pl,T,z,Rd}$ — *6.2.6(1), plastic design.*

Check: $\frac{V_{z,Ed}}{V_{c,z,Rd}} = \frac{11}{113.61} = 0.097 \le 1$ — *6.2.6(1), eq. 6.17*
*Low shear, 6.2.8(2)/.10(2)*

Plastic shear (major) check: **PASS** — *6.2.6, in plane of web*

## Major-Axis – Bending

*In plane of web*

### Moment resistance reduction factors (major axis)

$V_{z,Ed} \le \frac{V_{pl,T,z,Rd}}{2}$ therefore no reduction required due to shear force. — *6.2.8(2)*
*6.2.10(2)*

$\frac{h_w}{t_w} \le \frac{72\ \varepsilon}{\eta}$ therefore not susceptible to shear buckling. — *6.2.6(6) eq.6.22*
*EN1993-1-5:2006 5.1(2)*

Reduction factor due to shear, $\boldsymbol{\rho} = 0$

$N_{Ed} \le 0.25\ N_{pl,Rd}$ and — *6.2.9.1(4) eq. 6.33*

$N_{Ed} \le \frac{0.5\ h_w\ t_w\ f_y}{\gamma_{M0}}$ therefore no reduction required due to axial force. — *6.2.9.1(4) eq. 6.34*

### Bending moment check (major axis)

*6.2.5, bending in plane of web*

$\mathbf{M_{pl,y,Rd}} = \frac{W_{pl,y}\ f_y - W_{v,pl,y}\ \rho\ f_y}{\gamma_{M0}}$ (but ≥ 0) $= 22.9$ kN.m — *6.2.5(2), eq. 6.13*

$\mathbf{M_{c,y,Rd}} = M_{pl,y,Rd}$ — *Design resistance for bending*

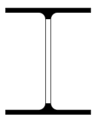
Check: $\frac{M_{y,Ed}}{M_{c,y,Rd}} = \frac{0.13}{22.9} = 0.006 \le 1$ — *6.2.5(1), eq. 6.12*

Bending moment (major) check: **PASS** — *6.2.5, in plane of web*

## Minor-Axis – Shear

*In plane of flange*

### Shear area (minor axis)



*6.2.6(3), in plane of flange*

$\mathbf{A_{v,y}} = A - d\ t_w = 11.534$ cm² — *Shear area*
*No guidance in EN1993-1-1:2005*

Plastic section modulus for shear area, $\mathbf{W_{v,pl,z}} = 25.419$ cm³ — *About z-z geometrical axis; plane of flange.*

## Plastic Shear check (minor axis)

*6.2.6, in plane of flange.*

$\mathbf{V_{pl,y,Rd}} = \frac{A_{v,y}\ f_y}{\gamma_{M0}\ \sqrt{3}} = 183.13$ kN

*6.2.6(2), eq. 6.18*
*Assumes in absence of torsion.*

$\mathbf{V_{pl,T,y,Rd}} = \sqrt{1 - \frac{\tau_{t,Ed}\ \sqrt{3}\ \gamma_{M0}}{1.25\ f_y}}\ V_{pl,y,Rd} = 151$ kN

*6.2.7(9), eq. 6.26.*

$\mathbf{V_{c,y,Rd}} = V_{pl,T,y,Rd}$

*6.2.6(1), plastic design.*

Check: $\frac{V_{y,Ed}}{V_{c,y,Rd}} = \frac{5}{151} = 0.033 \le 1$

*6.2.6(1), eq. 6.17*
*Low shear, 6.2.8(2)/.10(2)*

Plastic shear (minor) check: **PASS**

*6.2.6, in plane of flange*

# Minor-Axis – Bending

*In plane of flange*

## Moment resistance reduction factors (minor axis)

$V_{y,Ed} \le \frac{V_{pl,T,y,Rd}}{2}$ therefore no reduction required due to shear force.

*6.2.8(2)*
*6.2.10(2)*

$\frac{b_f}{t_f} \le \frac{72\ \varepsilon}{\eta}$ therefore not susceptible to shear buckling.

*Based on 6.2.6(6) eq.6.22*
*No guidance in EN1993-1-5:2005*

Reduction factor due to shear, $\boldsymbol{\rho} = 0$

$N_{Ed} \le \frac{h_w\ t_w\ f_y}{\gamma_{M0}}$ therefore no reduction required due to axial force.

*6.2.9.1(4) eq. 6.35*

## Bending moment check (minor axis)

*6.2.5, bending in plane of flange*

$\mathbf{M_{pl,z,Rd}} = \frac{W_{pl,z}\ f_y\ - W_{v,pl,z}\ \rho\ f_y}{\gamma_{M0}}$ (but $\ge 0$) $= 7.2435$ kN.m

*6.2.5(2), eq. 6.13*

$\mathbf{M_{c,z,Rd}} = M_{pl,z,Rd}$

*Design resistance for bending*

Check: $\frac{M_{z,Ed}\ + B_{w,Ed}}{M_{c,z,Rd}} = \frac{2.575}{7.2435} = 0.355 \le 1$

*6.2.5(1), eq. 6.12*

Bending moment (minor) check: **PASS**

*6.2.5, in plane of flange*

# Combined Checks

*All axes*

## Bending moment + axial check

*6.2.9.1(6)*

$\mathbf{n} = \frac{N_{Ed}}{N_{pl,Rd}}$ (but $\le 1$) $= 0.035178$

*6.2.9.1(5)*

$\boldsymbol{\alpha} = 2$

*6.2.9.1(6)*

$\beta = \max\begin{pmatrix} 5\,n \\ 1 \end{pmatrix} = 1$ — *6.2.9.1(6)*

Check: $\left(\frac{M_{y,Ed}}{M_{c,y,Rd}}\right)^{\alpha} + \left(\frac{M_{z,Ed} + B_{w,Ed}}{M_{c,z,Rd}}\right)^{\beta} = 0.356 \le 1$ — *6.2.9.1, eq. 6.41*

Bending plus axial check: **PASS** — *6.2.9*

## Conservative utilisation check

*6.2.1(7)*

Check: $\frac{N_{Ed}}{N_{Rd}} + \frac{M_{y,Ed}}{M_{y,Rd}} + \frac{M_{z,Ed} + B_{w,Ed}}{M_{z,Rd}} = \frac{17}{483.26} + \frac{0.13}{22.9} + \frac{2.575}{7.2435} = 0.396 \le 1$ — *6.2.1(7), eq. 6.2*

Conservative utilisation check: **PASS** — *6.2.1(7)*

# Buckling – Flexural

## Flexural buckling check (major axis)

*6.3.1, in plane of web*

Flexural buckling curve = a — *6.3.1.2(2), Table 6.2*

Imperfection factor, $\alpha = 0.210$ — *6.3.1.2(2), Table 6.1*

$N_{cr,y} = \frac{\pi^2 E I_y}{L_{cr,y}^2} = 192.39$ kN — *6.3.1.3(1), eq.6.50 (rearranged). Euler Load; SCI P362, 6.3.1.2(2)*

$\overline{\lambda}_y = \sqrt{\frac{A f_y}{N_{cr,y}}} = 1.5849$ — *6.3.1.3(1), eq.6.50*

$\Phi = 0.5\left(1 + \alpha\left(\overline{\lambda}_y - 0.2\right) + \overline{\lambda}_y^{\,2}\right) = 1.901$

$\chi_y = \frac{1}{\Phi + \sqrt{\Phi^2 - \overline{\lambda}_y^{\,2}}}$ (but $\le 1$) $= \min\begin{pmatrix} 0.339 \\ 1 \end{pmatrix} = 0.339$ — *Reduction factor 6.3.1.2(1), eq. 6.49*

$N_{b,Rd} = \frac{\chi_y A f_y}{\gamma_{M1}} = 163.72$ kN — *6.3.1.1(3), eq. 6.47*

Check: $\frac{N_{Ed}}{N_{b,Rd}} = \frac{17}{163.72} = 0.104 \le 1$ — *6.3.1.1(1), eq. 6.46*

Flexural buckling (major) check: **PASS** — *6.3.1, in plane of web*

## Flexural buckling check (minor axis)

*6.3.1, in plane of flange*

Flexural buckling curve = b — *6.3.1.2(2), Table 6.2*

Imperfection factor, $\alpha = 0.340$ — *6.3.1.2(2), Table 6.1*

$$\mathbf{N_{cr,z}} = \frac{\pi^2 \, E \, I_z}{L_{cr,z}^{\,2}} = 237.95 \text{ kN}$$

*6.3.1.3(1), eq.6.50 (rearranged). Euler Load; SCI P362, 6.3.1.2(2)*

$$\overline{\lambda}_z = \sqrt{\frac{A \, f_y}{N_{cr,z}}} = 1.4251$$

*6.3.1.3(1), eq.6.50*

$$\Phi = 0.5 \left( 1 + \alpha \left( \overline{\lambda}_z - 0.2 \right) + \overline{\lambda}_z^{\,2} \right) = 1.724$$

$$\chi_z = \frac{1}{\Phi + \sqrt{\Phi^2 - \overline{\lambda}_z^{\,2}}} \text{ (but} \le 1) = \min \begin{pmatrix} 0.371 \\ 1 \end{pmatrix} = 0.371$$

*Reduction factor 6.3.1.2(1), eq. 6.49*

$$\mathbf{N_{b,Rd}} = \frac{\chi_z \, A \, f_y}{\gamma_{M1}} = 179.42 \text{ kN}$$

*6.3.1.1(3), eq. 6.47*

Check: $\frac{N_{Ed}}{N_{b,Rd}} = \frac{17}{179.42} = 0.095 \le 1$

*6.3.1.1(1), eq. 6.46*

Flexural buckling (minor) check: **PASS**

*6.3.1, in plane of flange*

## Buckling – Torsional and Torsional-Flexural

*6.3.1.4*

### Torsional buckling force

*EN1993-1-3:2006*

$$\mathbf{i_o} = \sqrt{i_y^{\,2} + i_z^{\,2} + y_o^{\,2} + z_o^{\,2}} = \sqrt{50.875^2 + 21.824^2 + 0^2 + 0^2} = 55.358 \text{ mm}$$

*EN1993-1-3:2006, 6.2.3(5), eq. 6.33b*

$$\mathbf{N_{cr,T}} = \frac{1}{i_o^{\,2}} \left( G I_T + \frac{\pi^2 \, E \, I_w}{\ell_T^{\,2}} \right) = 750.89 \text{ kN}$$

*EN1993-1-3:2006, 6.2.3(5), eq. 6.33a*

### Torsional-flexural buckling force

*EN1993-1-3:2006*

Torsional-flexural buckling might not be valid because torsional buckling length differs from flexural buckling length.

*EN1993-1-3:2006, 6.2.3(7)*
*No guidance in EN1993-1-3:2006*

$$\beta = 1 - \left( \frac{y_o}{i_o} \right)^2 = 1$$

$$\mathbf{N_{cr,TF}} = \frac{N_{cr,y}}{2\beta} \left[ 1 + \frac{N_{cr,T}}{N_{cr,y}} - \sqrt{\left( 1 - \frac{N_{cr,T}}{N_{cr,y}} \right)^2 + 4 \left( \frac{y_o}{i_o} \right)^2 \frac{N_{cr,T}}{N_{cr,y}}} \right] = 192.39 \text{ kN}$$

*EN1993-1-3:2006, 6.2.3(7), eq. 6.35*

## Torsional and torsional-flexural buckling check

*6.3.1*

$$\mathbf{N_{cr,i}} = \min \begin{pmatrix} N_{cr,T} \\ N_{cr,TF} \end{pmatrix} = \min \begin{pmatrix} 750.89 \\ 192.39 \end{pmatrix} = 192.39 \text{ kN}$$

*6.3.1.4(2)*

Buckling curve = b

*6.3.1.4(3), as per minor axis*

Imperfection factor, $\boldsymbol{\alpha} = 0.340$

*6.3.1.2(2), Table 6.1*

$$\overline{\lambda}_T = \sqrt{\frac{A\ f_y}{N_{cr,i}}} = 1.5849$$

*6.3.1.3(1), eq.6.50*

$$\Phi = 0.5 \left( 1 + \alpha \left( \overline{\lambda}_T - 0.2 \right) + \overline{\lambda}_T^{\,2} \right) = 1.991$$

$$\chi_T = \frac{1}{\Phi + \sqrt{\Phi^2 - \overline{\lambda}_T^{\,2}}} \text{ (but} \le 1) = \min \begin{pmatrix} 0.313 \\ 1 \end{pmatrix} = 0.313$$

*Reduction factor*
*6.3.1.2(1), eq. 6.49*

$$\mathbf{N_{b,Rd}} = \frac{\chi_T\ A\ f_y}{\gamma_{M1}} = 151.15 \text{ kN}$$

*6.3.1.1(3), eq. 6.47*

Check: $\frac{N_{Ed}}{N_{b,Rd}} = \frac{17}{151.15} = 0.112 \le 1$

*6.3.1.1(1), eq. 6.46*

Torsional/Torsional-flexural buckling check: **PASS**

*6.3.1*

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# Buckling – Lateral-Torsional

*6.3.2*

## Parameters

Lateral-torsional buckling curve = a

*6.3.2.2(2), Table 6.4*

Imperfection factor, $\boldsymbol{\alpha_{LT}} = 0.210$

*6.3.2.2(2), Table 6.3*

$\mathbf{W_y} = W_{pl,y} = 83.274 \text{ cm}^3$

*6.3.2.1(3), classes 1 & 2*

## Buckling resistance moment & Slenderness

*No guidance in EN1993-1-1:2005*

Assumptions: $\mathbf{k} = 1$ , $\mathbf{k_w} = 1$ , $\mathbf{z_g} = 0$ , $\mathbf{C_2}$ is not applicable.

$$\mathbf{M_{cr,0}} = \frac{\pi^2\ E\ I_z}{(k\ L_z)^2} \left[ \sqrt{\left(\frac{k}{k_w}\right)^2 \frac{I_w}{I_z} + \frac{(k\ L_z)^2\ G\ I_T}{\pi^2\ E\ I_z} + (C_2\ z_g)^2} - C_2\ z_g \right] = 22.4 \text{ kN.m}$$

*SN003a-EN-EU, eq.1*
*Uniform moment distribution*

$$\overline{\lambda}_0 = \sqrt{\frac{W_y\ f_y}{M_{cr,0}}} = 1.0111$$

*6.3.2.2(1)*
*Annex A, table A.1*

Assumptions: $\mathbf{C_1} = 1$

*Uniform moment distribution*

$\mathbf{M_{cr}} = C_1\ M_{cr,0} = 22.4 \text{ kN.m}$

*SN003a-EN-EU, eq.1*

$\overline{\lambda}_{LT} = \sqrt{\frac{W_y f_y}{M_{cr}}} = 1.0111$ — *6.3.2.2(1)*, *Annex A, table A.1*

## Lateral-torsional buckling check

*General case*

$\Phi_{LT} = 0.5 \left(1 + \alpha_{LT} \left(\overline{\lambda}_{LT} - 0.2\right) + \overline{\lambda}_{LT}^{2}\right) = 1.096$

$\chi_{LT} = \frac{1}{\Phi_{LT} + \sqrt{\Phi_{LT}^{2} - \overline{\lambda}_{LT}^{2}}}$ (but ≤ 1) $= \min \begin{pmatrix} 0.658 \\ 1 \end{pmatrix} = 0.658$ — *Reduction factor*, *6.3.2.2(1), eq. 6.56*

$M_{b,Rd} = \frac{\chi_{LT} W_y f_y}{\gamma_{M1}} = 15.065$ kN.m — *6.3.2.1(3), eq. 6.55*

Check: $\frac{M_{y,Ed}}{M_{b,Rd}} = \frac{0.13}{15.065} = 0.009 \le 1$ — *6.3.2.1(1), eq. 6.54*

Lateral-torsional buckling check: **PASS** — *6.3.2*

# Stability – Combined Bending & Axial

*6.3.3*

## Resistances

*Table 6.7*

$N_{Rk} = f_y A = 483.26$ kN — *6.3.3(4), table 6.7*

$\begin{bmatrix} M_{y,Rk} \\ M_{z,Rk} \end{bmatrix} = \begin{bmatrix} f_y W_{pl,y} \\ f_y W_{pl,z} \end{bmatrix} = \begin{bmatrix} 22.9 \\ 7.2435 \end{bmatrix}$ kN.m — *6.3.3(4), table 6.7, classes 1 & 2*

## Bending moment shapes & limiting slenderness

*Table 6.6*

$\psi_y = 1.00$ (conservative uniform distribution) — *Table 6.6*

$\psi_z = 1.00$ (conservative uniform distribution) — *Table 6.6*

$k_{c,y} = 1.00$ — *Table 6.6*

$C_1 = \frac{1}{k_{c,y}^{2}} = 1.000$ — *Annex A, table A.1*

$\overline{\lambda}_{0,lim} = 0.2\sqrt{C_1}\sqrt[4]{\left(1 - \frac{N_{Ed}}{N_{cr,z}}\right)\left(1 - \frac{N_{Ed}}{N_{cr,TF}}\right)} = 0.19184$ — *Annex A, table A.1*, *Note fourth root.*

## Annex A: Interaction factors

*Annex A, Table A.1*

$\varepsilon_y = \frac{M_{y,Ed}}{N_{Ed}} \frac{A}{W_{el,y}} = 0.185$ — *Annex A, table A.1*

$$\mathbf{a_{LT}} = 1 - \frac{I_T}{I_y} \text{ (but} \geq 0) = \max\left(\begin{matrix}0.995\\0.0\end{matrix}\right) = 0.995$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{C_{my,0}} = 0.79 + 0.21\,\psi_y + 0.36\left(\psi_y - 0.33\right)\frac{N_{Ed}}{N_{cr,y}} = 1.021$$

*Annex A, table A.2*

$$\mathbf{C_{mz,0}} = 0.79 + 0.21\,\psi_z + 0.36\left(\psi_z - 0.33\right)\frac{N_{Ed}}{N_{cr,z}} = 1.017$$

*Annex A, table A.2*

$$\overline{\lambda}_0 > \overline{\lambda}_{0,lim} \Rightarrow \begin{cases} \mathbf{C_{my}} = C_{my,0} + (1 - C_{my,0})\dfrac{\sqrt{\varepsilon_y}\,a_{LT}}{1 + \sqrt{\varepsilon_y}\,a_{LT}} = 1.015 \\ \mathbf{C_{mz}} = C_{mz,0} = 1.017 \\ \mathbf{C_{mLT}} = C_{my}^{\,2}\dfrac{a_{LT}}{\sqrt{\left(1 - \dfrac{N_{Ed}}{N_{cr,z}}\right)\left(1 - \dfrac{N_{Ed}}{N_{cr,T}}\right)}} \text{ (but} \geq 1) \\ \quad = \max\left(\begin{matrix}1.076\\1\end{matrix}\right) = 1.076 \end{cases}$$

*Annex A, table A.1*

$$\mathbf{\mu_y} = \frac{1 - \dfrac{N_{Ed}}{N_{cr,y}}}{1 - \chi_y \dfrac{N_{Ed}}{N_{cr,y}}} = 0.940$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{\mu_z} = \frac{1 - \dfrac{N_{Ed}}{N_{cr,z}}}{1 - \chi_z \dfrac{N_{Ed}}{N_{cr,z}}} = 0.954$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{\overline{\lambda}_{max}} = \max\left(\begin{matrix}\overline{\lambda}_y\\\overline{\lambda}_z\end{matrix}\right) = \max\left(\begin{matrix}1.5849\\1.4251\end{matrix}\right) = 1.5849$$

*Annex A, table A.1*

$$\mathbf{n_{pl}} = \frac{N_{Ed}}{\left(\dfrac{N_{Rk}}{\gamma_{M0}}\right)} = 0.035$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{w_y} = \frac{W_{pl,y}}{W_{el,y}} \text{ (but} \leq 1.5) = \min\left(\begin{matrix}1.144\\1.5\end{matrix}\right) = 1.144$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{b_{LT}} = 0.5\,a_{LT}\,\overline{\lambda}_0^{\,2}\,\frac{M_{y,Ed}}{\chi_{LT}\,M_{pl,y,Rd}}\frac{M_{z,Ed}}{M_{pl,z,Rd}} = 0.000$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{C_{yy}} = 1 + (w_y - 1)\left[\left(2 - \frac{1.6}{w_y} C_{my}^{\ 2}\ \overline{\lambda}_{max} - \frac{1.6}{w_y} C_{my}^{\ 2}\ \overline{\lambda}_{max}^{\ 2}\right) n_{pl} - b_{LT}\right]$$

*Auxiliary term*
*Annex A, table A.1*

$$\text{but} \geq \frac{W_{el,y}}{W_{pl,y}} \quad \Rightarrow \quad \max\begin{pmatrix} 0.980 \\ 0.874 \end{pmatrix} = 0.980$$

$$\mathbf{k_{yy}} = C_{my}\ C_{mLT}\ \frac{\mu_y}{1 - \frac{N_{Ed}}{N_{cr,y}}}\ \frac{1}{C_{yy}} = 1.148$$

$$\mathbf{w_z} = \frac{W_{pl,z}}{W_{el,z}}\ (\text{but} \leq 1.5) = \min\begin{pmatrix} 1.574 \\ 1.5 \end{pmatrix} = 1.500$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{c_{LT}} = 10\, a_{LT}\ \frac{\overline{\lambda}_0^{\ 2}}{5 + \overline{\lambda}_z^{\ 4}}\ \frac{M_{y,Ed}}{C_{my}\ \chi_{LT}\ M_{pl,y,Rd}} = 0.009$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{C_{yz}} = 1 + (w_z - 1)\left[\left(2 - 14\frac{C_{mz}^{\ 2}\ \overline{\lambda}_{max}^{\ 2}}{w_z^{\ 5}}\right) n_{pl} - c_{LT}\right]$$

*Auxiliary term*
*Annex A, table A.1*

$$\text{but} \geq 0.6\sqrt{\frac{w_z}{w_y}}\frac{W_{el,z}}{W_{pl,z}} \quad \Rightarrow \quad \max\begin{pmatrix} 0.946 \\ 0.437 \end{pmatrix} = 0.946$$

$$\mathbf{k_{yz}} = C_{mz}\ \frac{\mu_y}{1 - \frac{N_{Ed}}{N_{cr,z}}}\ \frac{1}{C_{yz}}\ 0.6\sqrt{\frac{w_z}{w_y}} = 0.747$$

$$\mathbf{d_{LT}} = 2\, a_{LT}\ \frac{\overline{\lambda}_0}{0.1 + \overline{\lambda}_z^{\ 4}}\ \frac{M_{y,Ed}}{C_{my}\ \chi_{LT}\ M_{pl,y,Rd}}\ \frac{M_{z,Ed}}{C_{mz}\ M_{pl,z,Rd}} = 0.000$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{C_{zy}} = 1 + (w_y - 1)\left[\left(2 - 14\frac{C_{my}^{\ 2}\ \overline{\lambda}_{max}^{\ 2}}{w_y^{\ 5}}\right) n_{pl} - d_{LT}\right]$$

*Auxiliary term*
*Annex A, table A.1*

$$\text{but} \geq 0.6\sqrt{\frac{w_y}{w_z}}\frac{W_{el,y}}{W_{pl,y}} \quad \Rightarrow \quad \max\begin{pmatrix} 0.916 \\ 0.458 \end{pmatrix} = 0.916$$

$$\mathbf{k_{zy}} = C_{my}\ C_{mLT}\ \frac{\mu_z}{1 - \frac{N_{Ed}}{N_{cr,y}}}\ \frac{1}{C_{zy}}\ 0.6\sqrt{\frac{w_y}{w_z}} = 0.653$$

$$\mathbf{e_{LT}} = 1.7\, a_{LT} \frac{\overline{\lambda}_0}{0.1 + \overline{\lambda}_z^{\,4}} \frac{M_{y,Ed}}{C_{my}\, \chi_{LT}\, M_{pl,y,Rd}} = 0.003$$

*Auxiliary term*
*Annex A, table A.1*

$$\mathbf{C_{zz}} = 1 + (w_z - 1)\left[2 - \frac{1.6}{w_z} C_{mz}^{\,2}\, \overline{\lambda}_{max} - \frac{1.6}{w_z} C_{mz}^{\,2}\, \overline{\lambda}_{max}^{\,2} - e_{LT}\, n_{pl}\right]$$

*Auxiliary term*
*Annex A, table A.1*

$$\text{but} \geq \frac{W_{el,z}}{W_{pl,z}} \quad \Rightarrow \quad \max\begin{pmatrix} 0.956 \\ 0.635 \end{pmatrix} = 0.956$$

$$\mathbf{k_{zz}} = C_{mz} \frac{\mu_z}{1 - \frac{N_{Ed}}{N_{cr,z}}} \frac{1}{C_{zz}} = 1.094$$

## Combined bending & axial stability check (Annex A)

*6.3.3(4)*

Check:
$$\left\{ \frac{N_{Ed}}{\chi_y \left(\frac{N_{Rk}}{\gamma_{M1}}\right)} + k_{yy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{LT} \left(\frac{M_{y,Rk}}{\gamma_{M1}}\right)} + k_{yz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\left(\frac{M_{z,Rk}}{\gamma_{M1}}\right)} \right\} = 0.186 \leq 1$$

$$\frac{17}{163.72} + 1.148 \frac{0.13}{15.065} + 0.747 \frac{0.7}{7.2435}$$

*6.3.3(4), eq. 6.61*

Check:
$$\left\{ \frac{N_{Ed}}{\chi_z \left(\frac{N_{Rk}}{\gamma_{M1}}\right)} + k_{zy} \frac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{LT} \left(\frac{M_{y,Rk}}{\gamma_{M1}}\right)} + k_{zz} \frac{M_{z,Ed} + \Delta M_{z,Ed}}{\left(\frac{M_{z,Rk}}{\gamma_{M1}}\right)} \right\} = 0.206 \leq 1$$

$$\frac{17}{179.42} + 0.653 \frac{0.13}{15.065} + 1.094 \frac{0.7}{7.2435}$$

*6.3.3(4), eq. 6.62*

Combined bending & axial stability check (Annex A): **PASS**

*6.3.3*

## Annex B: Interaction factors

*Annex B, Table B.1/B.2*

$\overline{\lambda}_0 > \overline{\lambda}_{0,lim}$ therefore susceptible to torsional deformation (use Table B.2)

*No guidance in EN1993-1-1:2005*

$$\mathbf{C_{my}} = 0.6 + 0.4\,\psi_y \quad \text{but} \geq 0.4 \quad = \max\begin{pmatrix} 1.000 \\ 0.4 \end{pmatrix} = 1.000$$

*Annex B, table B.3*

$$\mathbf{C_{mz}} = 0.6 + 0.4\,\psi_z \quad \text{but} \geq 0.4 \quad = \max\begin{pmatrix} 1.000 \\ 0.4 \end{pmatrix} = 1.000$$

*Annex B, table B.3*

$$\mathbf{k_{yy}} = C_{my} + \left(\overline{\lambda}_y - 0.2\right)\frac{N_{Ed}}{\chi_y \frac{N_{Rk}}{\gamma_{M1}}} \text{ but} \leq C_{my} + 0.8\frac{N_{Ed}}{\chi_y \frac{N_{Rk}}{\gamma_{M1}}} = \min\begin{pmatrix}1.144\\1.083\end{pmatrix} = 1.083$$ *Annex B, Table B.1*

$$\mathbf{C_{mLT}} = 0.6 + 0.4\,\psi_y \text{ but} \geq 0.4 = \max\begin{pmatrix}1.000\\0.4\end{pmatrix} = 1.000$$ *Annex B, table B.3*

$$\mathbf{k_{zy}} = 1 - \frac{0.1\,\overline{\lambda}_z}{C_{mLT} - 0.25}\frac{N_{Ed}}{\chi_z \frac{N_{Rk}}{\gamma_{M1}}} \text{ but} \geq 1 - \frac{0.1}{C_{mLT} - 0.25}\frac{N_{Ed}}{\chi_z \frac{N_{Rk}}{\gamma_{M1}}} = \max\begin{pmatrix}0.982\\0.013\end{pmatrix} = 0.982$$ *Annex B, Table B.2*

$$\mathbf{k_{zz}} = C_{mz} + \left(2\,\overline{\lambda}_z - 0.6\right)\frac{N_{Ed}}{\chi_z \frac{N_{Rk}}{\gamma_{M1}}} \text{ but} \leq C_{mz} + 1.4\frac{N_{Ed}}{\chi_z \frac{N_{Rk}}{\gamma_{M1}}} = \min\begin{pmatrix}1.213\\1.133\end{pmatrix} = 1.133$$ *Annex B, Table B.1*

$$\mathbf{k_{yz}} = 0.6\,k_{zz} = 0.680$$ *Annex B, Table B.1*

## Combined bending & axial stability check (Annex B)

*6.3.3(4)*

Check:
$$\left\{\begin{array}{l}\dfrac{N_{Ed}}{\chi_y\left(\frac{N_{Rk}}{\gamma_{M1}}\right)} + k_{yy}\dfrac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{LT}\left(\frac{M_{y,Rk}}{\gamma_{M1}}\right)} + k_{yz}\dfrac{M_{z,Ed} + \Delta M_{z,Ed}}{\left(\frac{M_{z,Rk}}{\gamma_{M1}}\right)}\\ \dfrac{17}{163.72} + 1.083\dfrac{0.13}{15.065} + 0.680\dfrac{0.7}{7.2435}\end{array}\right\} = 0.179 \leq 1$$ *6.3.3(4), eq. 6.61*

Check:
$$\left\{\begin{array}{l}\dfrac{N_{Ed}}{\chi_z\left(\frac{N_{Rk}}{\gamma_{M1}}\right)} + k_{zy}\dfrac{M_{y,Ed} + \Delta M_{y,Ed}}{\chi_{LT}\left(\frac{M_{y,Rk}}{\gamma_{M1}}\right)} + k_{zz}\dfrac{M_{z,Ed} + \Delta M_{z,Ed}}{\left(\frac{M_{z,Rk}}{\gamma_{M1}}\right)}\\ \dfrac{17}{179.42} + 0.982\dfrac{0.13}{15.065} + 1.133\dfrac{0.7}{7.2435}\end{array}\right\} = 0.213 \leq 1$$ *6.3.3(4), eq. 6.62*

Combined bending & axial stability check (Annex B): **PASS** *6.3.3*