TIMBER MEMBER DESIGN

Design member **1**

Nodes: **1-2**

Code: **Eurocode**

EN 1995-1-1:2004 + A1:2008

Material: **C40**

Service class: **2**

Cross-section: **PCA_20x60**

Load case: **ST1**

Load-duration class: **Permanent**

1. Axial force

EN 1995-1-1: 6.1.2, 6.1.4

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$$\sigma_{t,0,d} = \frac{N_x}{A_x} = \frac{0}{1200.000} = 0 \text{ kN/cm}^2$$

$$k_{h,y} = 1$$

$$f_{t,0,d} = \frac{k_{mod} \cdot k_{h,y} \cdot f_{t,0,k}}{\gamma_M} = \frac{0.600 \cdot 1 \cdot 2.400}{1.3} = 1.108 \text{ kN/cm}^2$$

$$\eta_N = \frac{\sigma_{t,0,d}}{f_{t,0,d}} = \frac{0}{1.108} = 0\ \% \quad (6.1)$$ **passed**

2. Bending (y)

EN 1995-1-1: 6.1.6

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$$\sigma_{m,y,d} = \frac{|M_y|}{W_y} = \frac{|24500.000|}{12000.001} = 2.042 \text{ kN/cm}^2$$

$$k_{h,y} = 1 \quad (3.1)$$

$$f_{m,y,d} = \frac{k_{mod} \cdot k_{h,y} \cdot f_{m,k}}{\gamma_M} = \frac{0.600 \cdot 1 \cdot 4.000}{1.3} = 1.846 \text{ kN/cm}^2$$

$$\eta_{M_y} = \frac{\sigma_{m,y,d}}{f_{m,y,d}} = \frac{2.042}{1.846} = 110.6\ \%$$ **not passed**

3. Bending (z)

EN 1995-1-1: 6.1.6

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$$\sigma_{m,z,d} = \frac{|M_z|}{W_z} = \frac{|0|}{4000.000} = 0 \text{ kN/cm}^2$$

$$k_{h,z} = 1 \quad (3.1)$$

$$f_{m,z,d} = \frac{k_{mod} \cdot k_{h,z} \cdot f_{m,k}}{\gamma_M} = \frac{0.600 \cdot 1 \cdot 4.000}{1.3} = 1.846 \text{ kN/cm}^2$$

$$\eta_{M_z} = \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{0}{1.846} = 0\ \%$$ **passed**

4. Shear(y)

EN 1995-1-1: 6.1.7

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$k_{cr} = 0.670$ (6.13a)

$$\tau_{V_y,d} = \frac{1.5 \cdot |V_y|}{k_{cr} \cdot b \cdot h} = \frac{1.5 \cdot |0|}{0.670 \cdot 20.000 \cdot 60.000} = 0 \text{ kN/cm}^2$$

$$f_{v,y,d} = \frac{k_{mod} \cdot f_{v,y,k}}{\gamma_M} = \frac{0.600 \cdot 0.400}{1.3} = 0.185 \text{ kN/cm}^2$$

$$\eta_{V_y} = \frac{\tau_{V_y,d}}{f_{v,y,d}} = \frac{0}{0.185} = 0\ \% \quad (6.13)$$ **passed**

5. Shear(z)

EN 1995-1-1: 6.1.7

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$k_{cr} = 0.670$ (6.13a)

$$\tau_{V_z,d} = \frac{1.5 \cdot |V_z|}{k_{cr} \cdot b \cdot h} = \frac{1.5 \cdot |(-70.000)|}{0.670 \cdot 20.000 \cdot 60.000} = 0.131 \text{ kN/cm}^2$$

$$f_{v,z,d} = \frac{k_{mod} \cdot f_{v,z,k}}{\gamma_M} = \frac{0.600 \cdot 0.400}{1.3} = 0.185 \text{ kN/cm}^2$$

$$\eta_{V_z} = \frac{\tau_{V_z,d}}{f_{v,z,d}} = \frac{0.131}{0.185} = 70.7\ \% \quad (6.13)$$ **passed**

6. Torsion

EN 1995-1-1: 6.1.8

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$\tau_{tor,d} = 0$ kN/cm²

$$f_{v,d} = \frac{k_{mod} \cdot f_{v,k}}{\gamma_M} = \frac{0.600 \cdot 0.400}{1.3} = 0.185 \text{ kN/cm}^2$$

$$k_{shape} = \min\left(1 + 0.05 \cdot \frac{h}{b}\ ;\ 1.3\right) = \min\left(1 + 0.05 \cdot \frac{60.000}{20.000}\ ;\ 1.3\right) = 1.15 \quad (6.15)$$

$$\eta_{M_x} = \frac{\tau_{tor,d}}{k_{shape} \cdot f_{v,d}} = \frac{0}{1.15 \cdot 0.185} = 0\ \% \quad (6.14)$$ **passed**

INTERACTION CHECK

7. Axial Force-Bending

EN 1995-1-1: 6.3.2, 6.2.4

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$$\eta_1 = \frac{\sigma_{t,0,d}}{f_{t,0,d}} + \frac{|\sigma_{m,y,d}|}{f_{m,y,d}} + k_m \cdot \frac{|\sigma_{m,z,d}|}{f_{m,z,d}} = \frac{0}{1.108} + \frac{|2.042|}{1.846} + 0.7 \cdot \frac{|0|}{1.846} = 110.6\ \% \quad (6.17)$$

$$\eta_2 = \frac{\sigma_{t,0,d}}{f_{t,0,d}} + k_m \cdot \frac{|\sigma_{m,y,d}|}{f_{m,y,d}} + \frac{|\sigma_{m,z,d}|}{f_{m,z,d}} = \frac{0}{1.108} + 0.7 \cdot \frac{|2.042|}{1.846} + \frac{|0|}{1.846} = 77.4\ \% \quad (6.18)$$

$$\eta_{N,M} = \max(\eta_1 ; \eta_2) = \max(110.6 ; 77.4) = 110.6\ \%$$ **not passed**

8. Compression-Bending-Buckling

EN 1995-1-1: 6.3.2

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$$\eta_1 = \frac{|\sigma_{m,y,d}|}{f_{m,y,d}} + k_m \cdot \frac{|\sigma_{m,z,d}|}{f_{m,z,d}} = \frac{|2.042|}{1.846} + 0.7 \cdot \frac{|0|}{1.846} = 110.6\ \% \quad (6.23)$$

$$\eta_2 = k_m \cdot \frac{|\sigma_{m,y,d}|}{f_{m,y,d}} + \frac{|\sigma_{m,z,d}|}{f_{m,z,d}} = 0.7 \cdot \frac{|2.042|}{1.846} + \frac{|0|}{1.846} = 77.4\ \% \quad (6.24)$$

$\eta_{N,M,Buck} = \max(\eta_1 ; \eta_2) = \max(110.6 ; 77.4) = 110.6\ \%$ **not passed**

9. Axial force-Bending-Lateral torsional buckling

EN 1995-1-1: 6.3.3

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$dL = 2 \cdot h_{max} = 2 \cdot 60.000_{max} = 120.000$ cm

$$\sigma_{m,crit} = \frac{0.78 \cdot b^2}{h \cdot (K_{LT} \cdot L_{tot} + dL)} \cdot E_{0.05} = \frac{0.78 \cdot 20.000^2}{60.000 \cdot (2.000 \cdot 700.000 + 120.000)} \cdot 940.000 = 3.216 \text{ kN/cm}^2 \quad (6.32)$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,k}}{\sigma_{m,crit}}} = \sqrt{\frac{4.000}{3.216}} = 1.115 \quad (6.30)$$

$$k_{crit} = 1.56 - 0.75 \cdot \lambda_{rel,m} = 1.56 - 0.75 \cdot 1.115 = 0.724 \quad (6.34)$$

$$\eta_1 = \frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,d}} + \left(\frac{|\sigma_{m,y,d}|}{k_{crit} \cdot f_{m,y,d}}\right)^2 = \frac{0}{0.058 \cdot 1.200} + \left(\frac{|2.042|}{0.724 \cdot 1.846}\right)^2 = 233.6\ \% \quad (6.35)$$

$$\eta_2 = \frac{|\sigma_{m,y,d}|}{k_{crit} \cdot f_{m,y,d}} = \frac{|2.042|}{0.724 \cdot 1.846} = 152.8\ \% \quad (6.33)$$

$\eta_{N,M,LTB} = \min(\eta_1 ; \eta_2) = 152.8\ \%$ **not passed**

10. Shear-Torsion

DIN EN 1995-1-1/NA:2010-12 NCI NA.6.1.9 (no EN 1995-1-1 formula)

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

At Point A (middle pont of the b side); $\tau_{V_z,d} = 0$

$\tau_{tor,d,A} = 0$ kN/cm²

$$\tau_{V_y,d} = \frac{1.5 \cdot |V_y|}{k_{cr} \cdot h \cdot b} = \frac{1.5 \cdot |0|}{0.670 \cdot 60.000 \cdot 20.000} = 0 \text{ kN/cm}^2$$

$$\eta_A = \frac{|\tau_{tor,d,A}|}{k_{shape} \cdot f_{v,d}} + \left(\frac{\tau_{V_y,d}}{f_{v,d}}\right)^2 = \frac{|0|}{1.15 \cdot 0.185} + \left(\frac{0}{0.185}\right)^2 = 0\ \% \quad (NA.55)$$

At Point B (middle pont of the h side); $\tau_{V_y,d} = 0$

$\tau_{tor,d,B} = 0$ kN/cm²

$$\tau_{V_z,d} = \frac{1.5 \cdot |V_z|}{k_{cr} \cdot h \cdot b} = \frac{1.5 \cdot |(-7.000)|}{0.670 \cdot 60.000 \cdot 20.000} = 0.131 \text{ kN/cm}^2$$

$$\eta_B = \frac{|\tau_{tor,d,B}|}{k_{shape} \cdot f_{v,d}} + \left(\frac{\tau_{V_z,d}}{f_{v,d}}\right)^2 = \frac{|0|}{1.15 \cdot 0.185} + \left(\frac{0.131}{0.185}\right)^2 = 50.0\ \% \quad (NA.55)$$

At Point O (center of the cross-section); $\tau_{tor,d,O} = 0$

$$\eta_O = \left(\frac{\tau_{V_y,d}}{f_{v,d}}\right)^2 + \left(\frac{\tau_{V_z,d}}{f_{v,d}}\right)^2 = \left(\frac{0}{0.185}\right)^2 + \left(\frac{0.131}{0.185}\right)^2 = 50.0\ \% \quad \text{(NA.55)}$$

$$\eta_{V_y,V_z,M_x} = \max\left(\eta_A ; \eta_B ; \eta_O ; \eta_{V_y} ; \eta_{V_z}\right) = \max\,(0 ; 50.0 ; 50.0 ; 0 ; 70.7) = 70.7\ \%$$ **passed**

11. Apex zone tensile stress perpendicular to the axis

EN 1995-1-1: 6.4.3

Critical section: $x = 0.00 \cdot L = 0.00 \cdot 700.000 = 0$ cm

$\eta_{Apex} = 0\ \%$ (6.53) **passed**

12. SLS (Serviceability Limit State)

EN 1995-1-1: 2.2.3, 7.2

Critical section: $x = 0.40 \cdot L = 0.40 \cdot 700.000 = 280.000$ cm

$k_{def} = 0.8$

$$w_{net,fin,z} = \left| w_{fin,z} - u_{fin,j,z} \cdot \frac{x}{L} \right| = \left| (-2.607) - (-10.719) \cdot \frac{280.000}{700.000} \right| = 1.681\ \text{cm}$$

$$w_{limit,z} = \frac{L}{300.0} = \frac{700.000}{300.0} = 2.333\ \text{cm}$$

$$\eta_{SLS,z} = \frac{w_{net,fin,z}}{w_{limit,z}} = \frac{1.681}{2.333} = 72.0\ \%$$

$\eta_{SLS} = \eta_{SLS,z} = 72.0 = 72.0\ \%$ **passed**