# TIMBER BEAM N. 001

| Caratteristiche meccaniche legno GL24c<-<- $\gamma_M = \underline{1.35}$ $k_{mod} = \underline{0.8}$ | | |
|---|---|---|
| $f_{m,k} = 24\,MPa$ | $f_{m,d} = 14.22\,MPa$ | $E_{0,mean} = 11000\,MPa$ |
| $f_{t,0,k} = 17\,MPa$ | $f_{t,0,d} = 10.07\,MPa$ | $E_{0,05} = 9100\,MPa$ |
| $f_{t,90,k} = 0.5\,MPa$ | $f_{t,90,d} = 0.296\,MPa$ | $E_{90,mean} = 300\,MPa$ |
| $f_{c,0,k} = 21.5\,MPa$ | $f_{c,0,d} = 12.74\,MPa$ | $G_{mean} = 650\,MPa$ |
| $f_{c,90,k} = 2.5\,MPa$ | $f_{c,90,d} = 1.48\,MPa$ | $r_k = 365\,kg/m^3$ |
| $f_{v,k} = 3.5\,MPa$ | $f_{v,d} = 2.07\,MPa$ | $r_{mean} = 400\,kg/m^3$ |

| Caratteristiche sezione rettangolare $b = \underline{200}\,mm$ $h = \underline{400}\,mm$ $\gamma = \underline{5}\,\frac{kN}{m^3}$ | |
|---|---|
| $A = 800\,cm^2$ | $g_{1,k} = 0.4\,kN/m$ |
| $I_y = 106667\,cm^4$ | $I_z = 26666.7\,cm^4$ |
| $W_y = 5333.33\,cm^3$ | $W_z = 2666.67\,cm^3$ |
| $i_y = 11.55\,cm$ | $i_z = 5.77\,cm$ |

$l = 8.79\,m$

$k_m = 0.7$ legno massiccio, sezioni rettangolari

$\beta_c = 0.1$ legno lammellare

$l_{0,y} = 8.79\,m$

$l_{0,z} = 8.79\,m$

$\beta = 1$ coef. di vincolo

## Azioni agenti

$M_{Ed,y} = 218.47\,kNm$

$M_{Ed,z} = 0\,kNm$

$N_{Ed} = 0\,kN$

$V_{Ed,y} = 0\,kN$

$V_{Ed,z} = 73.27\,kN$

## Tensioni agenti

$$\sigma_{c,0,d} = \frac{N_{Ed}}{A} = \frac{0\,kN}{800\,cm^2} = 0\,MPa$$

$$\sigma_{m,y,d} = \frac{M_{Ed,y}}{W_y} = \frac{218.47\,kNm}{5333.33\,cm^3} = 40.96\,MPa$$

$$\sigma_{m,z,d} = \frac{M_{Ed,z}}{W_y} = \frac{0\,kNm}{5333.33\,cm^3} = 0\,MPa$$

$$k_{cr} = \frac{2.5\,MPa}{f_{v,k}} = \frac{2.5\,MPa}{3.5\,MPa} = 0.714$$

$$\tau_{y,d} = \frac{1.5 \cdot V_{Ed,y}}{k_{cr} \cdot A} = \frac{1.5 \cdot 0\,kN}{0.714 \cdot 800\,cm^2} = 0\,MPa$$

$$\tau_{z,d} = \frac{1.5 \cdot V_{Ed,z}}{k_{cr} \cdot A} = \frac{1.5 \cdot 73.27\,kN}{0.714 \cdot 800\,cm^2} = 1.92\,MPa$$

## Verifica flessione

$$\frac{\sigma_{m,y,d}}{f_{m,d}} + k_m \cdot \frac{\sigma_{m,z,d}}{f_{m,d}} = \frac{40.96\,\text{MPa}}{14.22\,\text{MPa}} + 0.7 \cdot \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 2.88 > 1 = 1 \text{ NO}$$

$$k_m \cdot \frac{\sigma_{m,y,d}}{f_{m,d}} + \frac{\sigma_{m,z,d}}{f_{m,d}} = 0.7 \cdot \frac{40.96\,\text{MPa}}{14.22\,\text{MPa}} + \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 2.02 > 1 = 1 \text{ NO}$$

## Verifica flessione e compressione combinata

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,d}} + k_m \cdot \frac{\sigma_{m,z,d}}{f_{m,d}} = \left(\frac{0\,\text{MPa}}{12.74\,\text{MPa}}\right)^2 + \frac{40.96\,\text{MPa}}{14.22\,\text{MPa}} + 0.7 \cdot \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 2.88 > 1 = 1 \text{ NO}$$ [EC5 §6.2.4]

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + k_m \cdot \frac{\sigma_{m,y,d}}{f_{m,d}} + \frac{\sigma_{m,z,d}}{f_{m,d}} = \left(\frac{0\,\text{MPa}}{12.74\,\text{MPa}}\right)^2 + 0.7 \cdot \frac{40.96\,\text{MPa}}{14.22\,\text{MPa}} + \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 2.02 > 1 = 1 \text{ NO}$$

## Verifica instabilità di colonna

$$\lambda_y = \frac{l_{0,y}}{i_y} = \frac{8.79\,\text{m}}{11.55\,\text{cm}} = 76.09$$ [EC5 §6.3.2]

$$\lambda_{rel,y} = \frac{\lambda_y}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{76.09}{3.14} \cdot \sqrt{\frac{21.5\,\text{MPa}}{9100\,\text{MPa}}} = 1.18$$

$$k_y = 0.5 \cdot (1 + \beta_c \cdot (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2) = 0.5 \cdot (1 + 0.1 \cdot (1.18 - 0.3) + 1.18^2) = 1.24$$

$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}^2}} = \frac{1}{1.24 + \sqrt{1.24^2 - 1.18^2}} = 0.619$$

$$\lambda_z = \frac{l_{0,z}}{i_z} = \frac{8.79\,\text{m}}{5.77\,\text{cm}} = 152.18$$

$$\lambda_{rel,z} = \frac{\lambda_z}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{152.18}{3.14} \cdot \sqrt{\frac{21.5\,\text{MPa}}{9100\,\text{MPa}}} = 2.35$$

$$k_z = 0.5 \cdot (1 + \beta_c \cdot (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2) = 0.5 \cdot (1 + 0.1 \cdot (2.35 - 0.3) + 2.35^2) = 3.37$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} = \frac{1}{3.37 + \sqrt{3.37^2 - 2.35^2}} = 0.173$$

$$\frac{\sigma_{c,0,d}}{k_{c,y} \cdot f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,d}} + k_m \cdot \frac{\sigma_{m,z,d}}{f_{m,d}} = \frac{0\,\text{MPa}}{0.619 \cdot 12.74\,\text{MPa}} + \frac{40.96\,\text{MPa}}{14.22\,\text{MPa}} + 0.7 \cdot \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 2.88 > 1 = 1 \text{ NO}$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,d}} + k_m \cdot \frac{\sigma_{m,y,d}}{f_{m,d}} + \frac{\sigma_{m,z,d}}{f_{m,d}} = \frac{0\,\text{MPa}}{0.173 \cdot 12.74\,\text{MPa}} + 0.7 \cdot \frac{40.96\,\text{MPa}}{14.22\,\text{MPa}} + \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 2.02 > 1 = 1 \text{ NO}$$

## Verifica instabilità di trave

$$l_{ef} = \beta \cdot l = 1 \cdot 8.79\,\text{m} = 8.79\,\text{m}$$ [EC5 §6.3.3]

$$\sigma_{m,crit} = \frac{0.78 \cdot b^2}{h \cdot l_{ef}} \cdot E_{0,05} = \frac{0.78 \cdot (200\,\text{mm})^2}{400\,\text{mm} \cdot 8.79\,\text{m}} \cdot 9100\,\text{MPa} = 80.79\,\text{MPa}$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,k}}{\sigma_{m,crit}}} = \sqrt{\frac{24\,\text{MPa}}{80.79\,\text{MPa}}} = 0.545$$

$$k_{crit} = \begin{cases} \text{if } \lambda_{rel,m} < 0.75\text{: } 1 \\ \text{if } \lambda_{rel,m} < 1.4\text{: } 1.56 - 0.75 \cdot \lambda_{rel,m} \\ \text{else: } \dfrac{1}{\lambda_{rel,m}^2} \end{cases} = \begin{cases} \text{if } 0.545 < 0.75\text{: } 1 \\ \text{if } 0.545 < 1.4\text{: } 1.56 - 0.75 \cdot 0.545 \\ \text{else: } \dfrac{1}{0.545^2} \end{cases} = 1$$

$$\frac{\sigma_{m,y,d}}{k_{crit} \cdot f_{m,d}} = \frac{40.96\,\text{MPa}}{1 \cdot 14.22\,\text{MPa}} = 2.88 > 1 = 1 \text{ NO}$$

$$\left(\frac{\sigma_{m,y,d}}{k_{crit} \cdot f_{m,d}}\right)^2 + \frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,d}} = \left(\frac{40.96\,\text{MPa}}{1 \cdot 14.22\,\text{MPa}}\right)^2 + \frac{0\,\text{MPa}}{0.173 \cdot 12.74\,\text{MPa}} = 8.3 > 1 = 1 \text{ NO}$$