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 $b = \underline{160}\,mm$ $h = \underline{840}\,mm$ $\gamma = \underline{5}\,\frac{kN}{m^3}$	
$A = 1344\,cm^2$	$g_{1,k} = 0.672\,kN/m$
$I_y = 790272\,cm^4$	$I_z = 28672\,cm^4$
$W_y = 18816\,cm^3$	$W_z = 3584\,cm^3$
$i_y = 24.25\,cm$	$i_z = 4.62\,cm$

$l = 8.79\,m$

$k_m = 0.7$ 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

$$\sigma_{c,0,d} = \frac{N_{Ed}}{A} = \frac{0\,kN}{1344\,cm^2} = 0\,MPa$$

$$\sigma_{m,y,d} = \frac{M_{Ed,y}}{W_y} = \frac{218.47\,kNm}{18816\,cm^3} = 11.61\,MPa$$

$$\sigma_{m,z,d} = \frac{M_{Ed,z}}{W_z} = \frac{0\,kNm}{3584\,cm^3} = 0\,MPa$$

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

$$\tau_{y,d} = \frac{1.5 \cdot V_{Ed,y}}{k_{cr} \cdot A} = \frac{1.5 \cdot 0\,kN}{0.714 \cdot 1344\,cm^2} = 0\,MPa$$

$$\tau_{z,d} = \frac{1.5 \cdot V_{Ed,z}}{k_{cr} \cdot A} = \frac{1.5 \cdot 73.27\,kN}{0.714 \cdot 1344\,cm^2} = 1.14\,MPa$$

Verifica flessione

$$\frac{\sigma_{m,y,d}}{f_{m,d}} + k_m \cdot \frac{\sigma_{m,z,d}}{f_{m,d}} = \frac{11.61\,MPa}{14.22\,MPa} + 0.7 \cdot \frac{0\,MPa}{14.22\,MPa} = 81.64\,\%\text{Ok}\ \checkmark$$

$$k_m \cdot \frac{\sigma_{m,y,d}}{f_{m,d}} + \frac{\sigma_{m,z,d}}{f_{m,d}} = 0.7 \cdot \frac{11.61\,\text{MPa}}{14.22\,\text{MPa}} + \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 57.15\,\%\text{Ok}\ \checkmark$$

Verifica flessione e compressione combinata

[EC5 §6.2.4]

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,d}} + k_m \cdot \frac{\sigma_{m,z,d}}{f_{m,d}} = \left(\frac{0\,\text{MPa}}{12.74\,\text{MPa}}\right)^2 + \frac{11.61\,\text{MPa}}{14.22\,\text{MPa}} + 0.7 \cdot \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 81.64\,\%\text{Ok}\ \checkmark$$

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + k_m \cdot \frac{\sigma_{m,y,d}}{f_{m,d}} + \frac{\sigma_{m,z,d}}{f_{m,d}} = \left(\frac{0\,\text{MPa}}{12.74\,\text{MPa}}\right)^2 + 0.7 \cdot \frac{11.61\,\text{MPa}}{14.22\,\text{MPa}} + \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 57.15\,\%\text{Ok}\ \checkmark$$

Verifica a taglio

$$\frac{\tau_{y,d}}{f_{v,d}} = \frac{0\,\text{MPa}}{2.07\,\text{MPa}} = 0\,\%\text{Ok}\ \checkmark$$

$$\frac{\tau_{z,d}}{f_{v,d}} = \frac{1.14\,\text{MPa}}{2.07\,\text{MPa}} = 55.2\,\%\text{Ok}\ \checkmark$$

Verifica instabilità di colonna

[EC5 §6.3.2]

$$\lambda_y = \frac{l_{0,y}}{i_y} = \frac{8.79\,\text{m}}{24.25\,\text{cm}} = 36.23$$

$$\lambda_{rel,y} = \frac{\lambda_y}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{36.23}{3.14} \cdot \sqrt{\frac{21.5\,\text{MPa}}{9100\,\text{MPa}}} = 0.561$$

$$k_y = 0.5 \cdot (1 + \beta_c \cdot (\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2) = 0.5 \cdot (1 + 0.1 \cdot (0.561 - 0.3) + 0.561^2) = 0.67$$

$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}^2}} = \frac{1}{0.67 + \sqrt{0.67^2 - 0.561^2}} = 0.964$$

$$\lambda_z = \frac{l_{0,z}}{i_z} = \frac{8.79\,\text{m}}{4.62\,\text{cm}} = 190.22$$

$$\lambda_{rel,z} = \frac{\lambda_z}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0,05}}} = \frac{190.22}{3.14} \cdot \sqrt{\frac{21.5\,\text{MPa}}{9100\,\text{MPa}}} = 2.94$$

$$k_z = 0.5 \cdot (1 + \beta_c \cdot (\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2) = 0.5 \cdot (1 + 0.1 \cdot (2.94 - 0.3) + 2.94^2) = 4.96$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} = \frac{1}{4.96 + \sqrt{4.96^2 - 2.94^2}} = 0.112$$

$$\frac{\sigma_{c,0,d}}{k_{c,y} \cdot f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,d}} + k_m \cdot \frac{\sigma_{m,z,d}}{f_{m,d}} = \frac{0\,\text{MPa}}{0.964 \cdot 12.74\,\text{MPa}} + \frac{11.61\,\text{MPa}}{14.22\,\text{MPa}} + 0.7 \cdot \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 81.64\,\%\text{Ok}\ \checkmark$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,d}} + k_m \cdot \frac{\sigma_{m,y,d}}{f_{m,d}} + \frac{\sigma_{m,z,d}}{f_{m,d}} = \frac{0\,\text{MPa}}{0.112 \cdot 12.74\,\text{MPa}} + 0.7 \cdot \frac{11.61\,\text{MPa}}{14.22\,\text{MPa}} + \frac{0\,\text{MPa}}{14.22\,\text{MPa}} = 57.15\,\%\text{Ok}\ \checkmark$$

Verifica instabilità di trave

[EC5 §6.3.3]

$$l_{ef} = \beta \cdot l = 1 \cdot 8.79\,\text{m} = 8.79\,\text{m}$$

$$\sigma_{m,crit} = \frac{0.78 \cdot b^2}{h \cdot l_{ef}} \cdot E_{0,05} = \frac{0.78 \cdot (160\,\text{mm})^2}{840\,\text{mm} \cdot 8.79\,\text{m}} \cdot 9100\,\text{MPa} = 24.62\,\text{MPa}$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,k}}{\sigma_{m,crit}}} = \sqrt{\frac{24\,\text{MPa}}{24.62\,\text{MPa}}} = 0.987$$

$$k_{crit} = \begin{cases} \text{if } \lambda_{rel,m} < 0.75\text{: } 1 \\ \text{if } \lambda_{rel,m} < 1.4\text{: } 1.56 - 0.75 \cdot \lambda_{rel,m} \\ \text{else: } \dfrac{1}{\lambda_{rel,m}^2} \end{cases} = \begin{cases} \text{if } 0.987 < 0.75\text{: } 1 \\ \text{if } 0.987 < 1.4\text{: } 1.56 - 0.75 \cdot 0.987 \\ \text{else: } \dfrac{1}{0.987^2} \end{cases} = 0.82$$

$$\frac{\sigma_{m,y,d}}{k_{crit} \cdot f_{m,d}} = \frac{11.61\,\text{MPa}}{0.82 \cdot 14.22\,\text{MPa}} = 99.62\,\%\text{Ok}\ \checkmark$$

$$\left(\frac{\sigma_{m,y,d}}{k_{crit}\cdot f_{m,d}}\right)^2+\frac{\sigma_{c,0,d}}{k_{c,z}\cdot f_{c,0,d}}=\left(\frac{11.61\,\text{MPa}}{0.82\cdot 14.22\,\text{MPa}}\right)^2+\frac{0\,\text{MPa}}{0.112\cdot 12.74\,\text{MPa}}=99.24\,\%\,\text{Ok}\ \checkmark$$

Freccia

$q_G=8.64\frac{\text{kN}}{\text{m}}$

$q_{Q1}=10.92\frac{\text{kN}}{\text{m}}$

$k_{def}=0.6$

$\psi_{21}=0.2$

$w_{lim,inst}=\frac{l}{300}=\frac{8.79\,\text{m}}{300}=29.29\,\text{mm}$

$w_{lim,fin}=\frac{l}{200}=\frac{8.79\,\text{m}}{200}=43.93\,\text{mm}$

$w(q)=\frac{5}{384}\cdot\frac{q\cdot l^4}{E_{0,mean}\cdot I_y}+1.2\cdot\frac{1}{8}\cdot\frac{q\cdot l^2}{G_{mean}\cdot A}$

$w\left(1\frac{\text{kN}}{\text{m}}\right)=1.03\,\text{mm}$

$w_{inst,G}=w(q_G)=w(8.64\,\text{kN/m})=8.86\,\text{mm}$

$w_{inst,Q1}=w(q_{Q1})=w(10.92\,\text{kN/m})=11.19\,\text{mm}$

$w_{inst,TOT}=w_{inst,G}+w_{inst,Q1}=8.86\,\text{mm}+11.19\,\text{mm}=20.05\,\text{mm}$

$w_{inst,TOT}=20.05\,\text{mm}\le w_{lim,inst}=29.29\,\text{mm}\,\text{Ok}\ \checkmark$

$w_{fin,G1}=w_{inst,G}\cdot(1+k_{def})=8.86\,\text{mm}\cdot(1+0.6)=14.17\,\text{mm}$

$w_{fin,Q1}=w_{inst,Q1}\cdot(1+\psi_{21}\cdot k_{def})=11.19\,\text{mm}\cdot(1+0.2\cdot 0.6)=12.54\,\text{mm}$

$w_{fin,TOT}=w_{fin,G1}+w_{fin,Q1}=14.17\,\text{mm}+12.54\,\text{mm}=26.71\,\text{mm}$

$w_{fin,TOT}=26.71\,\text{mm}\le w_{lim,fin}=43.93\,\text{mm}\,\text{Ok}\ \checkmark$