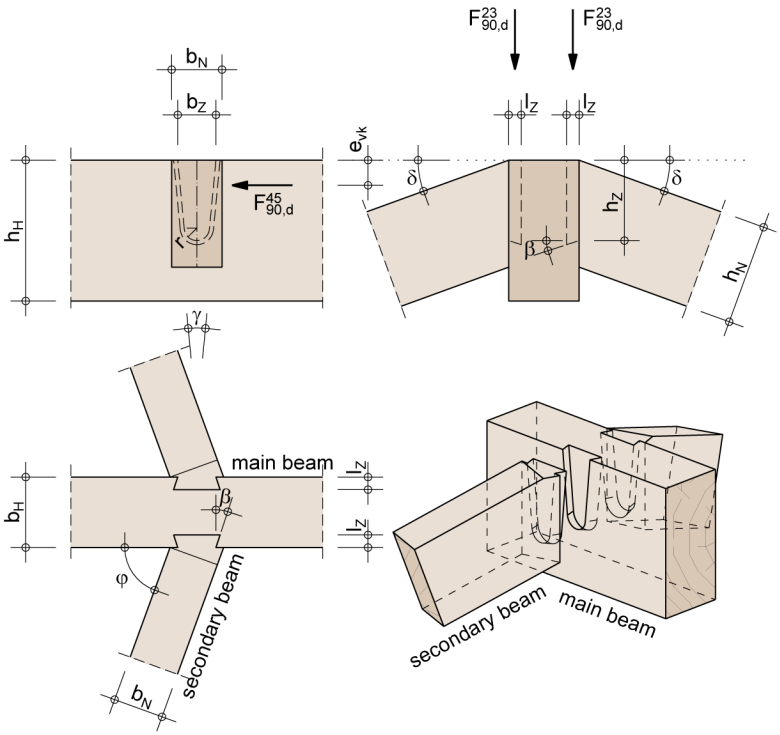
Verification Dovetail-Connection

according to building approval Z-9.1-649 (validity 18 June 2018 - 5 October 2022)

Connection & Geometry

double-sided connection

material:	laminated timber
solidity:	GL24c according to DIN EN 14080:2013-09
width secondary beam b_N:	120 mm
height secondary beam h_N:	280 mm
width main beam b_H:	180 mm
height main beam h_H:	480 mm
inclination δ:	20 °
connection angle φ:	60 °
milling angle β:	10 °
pin cone angle γ:	4 °
length pin l_Z:	28 mm
width pin b_Z:	96 mm
height pin h_Z:	264 mm
pin hole radius r:	39.5 mm
dimensional tolerances:	+/- 0.2 mm



Loads

Load $F_{23,90,d}$:	22.00 kN
Load $F_{45,90,d}$:	4.00 kN
e_{vk}:	0 mm
Service class:	NKL1 - heated interiors
KLED:	short
modification factor k_{mod}:	0.9

Verification:	$0.97 \leq 1.00$	**Verification fulfilled**

Construction tip

Building approval Z-9.1-649 must be observed.

Stress resistance in insertion direction

k_n: 6.50

$$\alpha = \cos(\delta) * \frac{h_Z - r}{h_N} = \cos(20) * \frac{264 - 39.5}{280} = 0.75$$

$$k_v = min \begin{Bmatrix} 1 \\ \frac{k_n}{\sqrt{h_N} * \left(\sqrt{\alpha * (1-\alpha)} + 0.4 * \frac{l_Z}{h_N} * \sqrt{\frac{1}{\alpha} - \alpha^2}\right)} \end{Bmatrix}$$

$$= min \begin{Bmatrix} 1 \\ \frac{6.50}{\sqrt{280} * \left(\sqrt{0.75 * (1-0.75)} + 0.4 * \frac{28}{280} * \sqrt{\frac{1}{0.75} - 0.75^2}\right)} \end{Bmatrix}$$

$$= min \begin{Bmatrix} 1 \\ 0.83 \end{Bmatrix}$$

k_{ab}: 0.90

$f_{t,90,d}$: 0.346 N/mm² (with $f_{t,90,k}$ = 0.5 N/mm² according to approval)

$f_{v,d}$: 1.731 N/mm² (with $f_{v,k}$ = 2.5 N/mm² according to approval)

$$F_{90,Rd}^{23} = min \begin{Bmatrix} k_{ab} * \frac{h_Z}{h_Z - r} * \left(6.5 + \frac{18 * (h_H - h_Z + r)^2}{h_H^2}\right) * (t_{ef} * h_H)^{0.8} * f_{t,90,d} \\ \frac{k_v * b_N * (h_Z - r)}{1.5} * f_{v,d} \end{Bmatrix}$$

$$= min \begin{Bmatrix} 0.90 * \frac{264}{264 - 39.5} * \left(6.5 + \frac{18 * (480 - 264 + 39.5)^2}{480^2}\right) * (100 * 480)^{0.8} * 0.346 \\ \frac{0.83 * 120 * (264 - 39.5)}{1.5} * 1.731 \end{Bmatrix}$$

$$= min \begin{Bmatrix} 23.62 \\ 25.79 \end{Bmatrix}$$

stress resistance $F_{90,Rd}^{23}$: 23.62 kN

Verification in insertion direction:	$\frac{F_{90,d}^{23}}{F_{90,Rd}^{23}} = \frac{22.00}{23.62} =$	$0.93 \leq 1.00$

Stress resistance perpendicular to insertion direction

$$b_{Z,ef} = b_Z - 2 * e_{vk} * \tan\left(\frac{\gamma}{2}\right) = 96 - 2 * 0 * \tan\left(\frac{4}{2}\right) = 96.0 \text{ mm}$$

$$\alpha = 0.5 * \frac{(b_N + b_{Z,ef})}{b_N} = 0.5 * \frac{(120 + 96.0)}{120} = 0.9$$

$$e = \left|\frac{h_Z}{2} - e_{vk}\right| = \left|\frac{264}{2} - 0\right| = 132.0 \text{ mm}$$

$$k_v = min \begin{cases} 1 \\ \dfrac{k_n}{\sqrt{b_N} * \left(\sqrt{\alpha * (1-\alpha)} + 0.4 * \dfrac{l_Z}{b_N} * \sqrt{\dfrac{1}{\alpha} - \alpha^2}\right)} \end{cases}$$

$$= min \begin{cases} 1 \\ \dfrac{6.50}{\sqrt{120} * \left(\sqrt{0.9 * (1-0.9)} + 0.4 * \dfrac{28}{120} * \sqrt{\dfrac{1}{0.9} - 0.9^2}\right)} \end{cases}$$

$$= min \begin{cases} 1 \\ 1.69 \end{cases}$$

$$F_{90,Rd}^{45} = \frac{k_v * f_{v,d} * h_Z * b_{Z,ef}}{1.5} * \left(\sqrt{\left(\frac{2 * e}{h_Z}\right)^2 + 1} - \frac{2 * e}{h_Z}\right)$$

$$= \frac{1.00 * 1.731 * 264 * 96.0}{1.5} * \left(\sqrt{\left(\frac{2 * 132.0}{264}\right)^2 + 1} - \frac{2 * 132.0}{264}\right)$$

$$= 12.11$$

stress resistance $F_{90,Rd}^{45}$: 12.11 kN

Ver. perpendicular to insertion direction:	$\frac{F_{90,d}^{45}}{F_{90,Rd}^{45}} = \frac{4.00}{12.11} =$	$0.33 \leq 1.00$

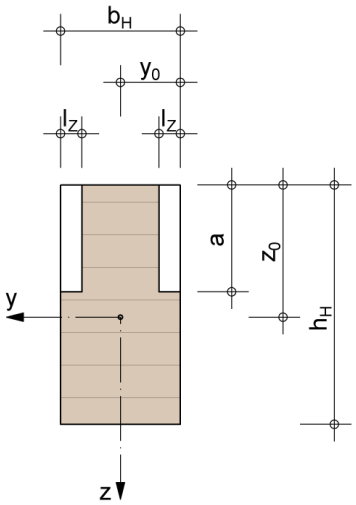
Compilation of results

Verification in insertion direction:	$\frac{F_{90,d}^{23}}{F_{90,Rd}^{23}} = \frac{22.00}{23.62} =$	$0.93 \leq 1.00$
Ver. perpendicular to insertion direction:	$\frac{F_{90,d}^{45}}{F_{90,Rd}^{45}} = \frac{4.00}{12.11} =$	$0.33 \leq 1.00$
combined strain:	$\left(\frac{F_{90,d}^{23}}{F_{90,Rd}^{23}}\right)^2 + \left(\frac{F_{90,d}^{45}}{F_{90,Rd}^{45}}\right)^2 =$	$0.97 \leq 1.00$

Verification:	$0.97 \leq 1.00$	**Verification fulfilled**

Cross-sectional weakening

width main beam b_H:	180 mm
height main beam h_H:	480 mm
height a:	268.9 mm
length pin l_Z:	28 mm
position of centre y_0:	90.0 mm
position of centre z_0:	262.3 mm
moment of interia I_y:	136497 cm^4



moment of inertia of the unattenuated main beam:

$$I_{y,H} = \frac{b_H * h_H^3}{12} = \frac{180 * 480^3}{12} * 10^{-4} = 165888 \text{ cm}^4$$

required cross-sectional height with the same moment of interia I_y related to the unattenuated cross-sectional of the main beam:

width beam b_H:	180 mm
height beam h_{erf}:	513 mm
height a:	268.9 mm
length pin l_Z:	28 mm
position of centre y_0:	90.0 mm
position of centre z_0:	280.3 mm
moment of interia I_y:	166633 cm^4