

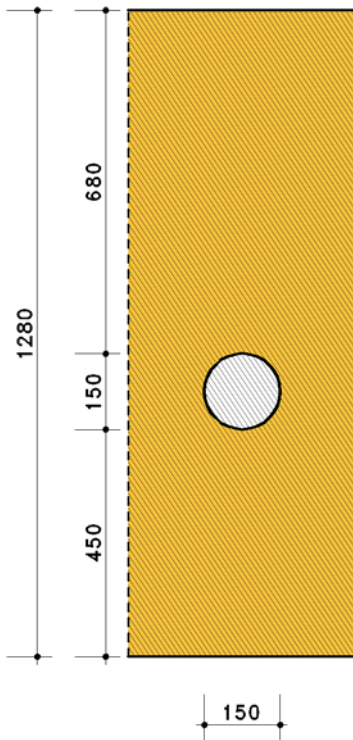
## 1. Input parameters

### 1.1. girder opening circular unreinforced acc. to DIN EN 1995-1-1/NA:2013-08, NCI NA.6.7

### 1.2. beam

beam of glue laminated timber EC, GL24h 200/1280 mm,  $\rho_k = 385 \text{ kg/m}^3$ , NKL 2  
 $h_{ro} = 680 \text{ mm}$ ,  $h_{ru} = 450 \text{ mm}$ ,  $a = 150 \text{ mm}$  (expressions acc. to NA:2013-08, NCI NA.6.7 figure NA.7)  
 $f_{m,k} = 24.00 \text{ N/mm}^2$ ,  $f_{t,k} = 19.20 \text{ N/mm}^2$ ,  $f_{c,k} = 24.00 \text{ N/mm}^2$ ,  $f_{v,k} = 3.50 \text{ N/mm}^2$ ,  $f_{t90,k} = 0.50 \text{ N/mm}^2$   
 $f_{m,k}$  increased with  $k_h = 1.000$

elevation scale 1:150, unit of length [mm]



### 1.3. internal forces and moments

Nr.	name	left edge			right edge			KLED	k <sub>mod</sub>	γ
		N <sub>d</sub> kN	V <sub>d</sub> kN	M <sub>d</sub> kNm	N <sub>d</sub> kN	V <sub>d</sub> kN	M <sub>d</sub> kNm			
1	g+t+s	0.00	128.75	195.23	0.00	136.25	175.36	sh.-term	0.900	1.30

## 2. results

### 2.1. tension stress perpendicular to grain in opening area

$h_r = 473 \text{ mm}$ ,  $l_{t,90} = 693 \text{ mm}$ ,  $f_{t,90k} = 0.500 \text{ N/mm}^2$

Nr	f <sub>t90,d</sub> N/mm <sup>2</sup>	z <sub>u1</sub>	F <sub>t90,d</sub> kN	left edge				right edge				u
				F <sub>tV,d</sub> kN	F <sub>tM,d</sub> kN	F <sub>t90,d</sub> kN	u <sub>1</sub>	F <sub>tV,d</sub> kN	F <sub>tM,d</sub> kN	F <sub>t90,d</sub> kN	u <sub>r</sub>	
1	0.346	14.222	14.222	7.90	3.31	11.21	0.788	8.36	2.97	11.33	0.797	0.797

$u_{max} = 0.797 \leq 1 \Rightarrow \text{ok.}$

### 2.2. bending at the opening area cross-section

$I_{nz} = 3444687 \text{ cm}^4$ ,  $z_s = 625 \text{ mm}$ ,  $W_{no} = 55138 \text{ cm}^3$ ,  $W_{nu} = 52569 \text{ cm}^3$ ,  $W_o = 15413 \text{ cm}^3$ ,  $W_u = 6750 \text{ cm}^3$

Nr	f <sub>m,d</sub> N/mm <sup>2</sup>	f <sub>t,d</sub> N/mm <sup>2</sup>	f <sub>c,d</sub> N/mm <sup>2</sup>	σ <sub>N,d</sub> N/mm <sup>2</sup>	σ <sub>M,o,d</sub> N/mm <sup>2</sup>	σ <sub>M,u,d</sub> N/mm <sup>2</sup>	σ <sub>u,d</sub> N/mm <sup>2</sup>	σ <sub>o,d</sub> N/mm <sup>2</sup>	u <sub>o,d</sub>	u <sub>u,d</sub>	u
1	16.62	13.29	16.62	0.000	-3.361	3.525	-3.361	3.525	0.202	0.212	0.212

$u_{max} = 0.212 \leq 1 \Rightarrow \text{ok.}$

### 2.3. shear at the reduced cross section in circlemitte

beam width = 200 mm, beam height = 1130 mm,  $k_{cr} = 0.714 \Rightarrow A_{ef} = 161429 \text{ mm}^2$ ,  $\kappa_{max} = 1.339$

Nr	$f_{v,d}$ N/mm <sup>2</sup>	$V_d$ kN	$\tau_{m,d}$ N/mm <sup>2</sup>	u
1	2.42	132.50	1.231	0.508

$u_{max} = 0.508 \leq 1 \Rightarrow \text{ok.}$

### 3. Summary

total utilization all verifications  $u_{max,Ges} = 0.797 \leq 1 \Rightarrow \text{ok.}$