

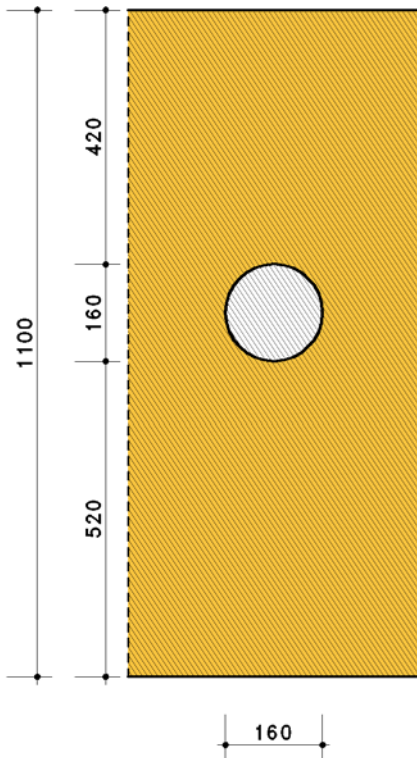
1. Input parameters

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, GL28h 220/1100 mm, $\rho_k = 425 \text{ kg/m}^3$, NKL 1
 $h_{ro} = 420 \text{ mm}$, $h_{ru} = 520 \text{ mm}$, $a = 160 \text{ mm}$ (expressions acc. to NA:2013-08, NCI NA.6.7 figure NA.7)
 $f_{m,k} = 28.00 \text{ N/mm}^2$, $f_{t,k} = 22.30 \text{ N/mm}^2$, $f_{c,k} = 28.00 \text{ N/mm}^2$, $f_{v,k} = 3.50 \text{ N/mm}^2$, $f_{t90,k} = 0.50 \text{ N/mm}^2$
 $f_{m,k}$ increased with $k_h = 1.000$

elevation scale 1:125, unit of length [mm]



1.3. internal forces and moments

Nr.	name	left edge			right edge			KLED	k _{mod}	γ
		N _d kN	V _d kN	M _d kNm	N _d kN	V _d kN	M _d kNm			
1	g+t+s	0.00	-84.00	392.83	0.00	93.60	378.62	sh.-term	0.900	1.30

2. results

2.1. tension stress perpendicular to grain in opening area

$h_r = 444 \text{ mm}$, $l_{t,90} = 606 \text{ mm}$, $f_{t,90k} = 0.500 \text{ N/mm}^2$

Nr	f _{t90,d} N/mm ²	zul	F _{t90,d} kN	left edge				right edge				u
				F _{tv,d} kN	F _{tM,d} kN	F _{t90,d} kN	u _l	F _{tv,d} kN	F _{tM,d} kN	F _{t90,d} kN	u _r	
1	0.346		14.770	6.39	7.08	13.47	0.912	7.12	6.82	13.94	0.944	0.944

$u_{max} = 0.944 \leq 1 \Rightarrow \text{ok.}$

2.2. bending at the opening area cross-section

$I_{nz} = 2422359 \text{ cm}^4$, $z_s = 559 \text{ mm}$, $W_{no} = 43372 \text{ cm}^3$, $W_{nu} = 44735 \text{ cm}^3$, $W_o = 6468 \text{ cm}^3$, $W_u = 9915 \text{ cm}^3$

Nr	f _{m,d} N/mm ²	f _{t,d} N/mm ²	f _{c,d} N/mm ²	$\sigma_{N,d}$ N/mm ²	$\sigma_{M,o,d}$ N/mm ²	$\sigma_{M,u,d}$ N/mm ²	$\sigma_{u,d}$ N/mm ²	$\sigma_{o,d}$ N/mm ²	u _{o,d}	u _{u,d}	u
1	19.38	15.44	19.38	0.000	-8.893	8.622	-8.893	8.622	0.459	0.445	0.459

$u_{max} = 0.459 \leq 1 \Rightarrow \text{ok.}$

2.3. shear at the reduced cross section in circle center

beam width = 220 mm, beam height = 940 mm, $k_{cr} = 0.714 \Rightarrow A_{ef} = 147714 \text{ mm}^2$, $\kappa_{max} = 1.433$

Nr	$f_{v,d}$ N/mm ²	V_d kN	$\tau_{m,d}$ N/mm ²	u -
1	2.42	4.80	0.049	0.020

$u_{max} = 0.020 \leq 1 \Rightarrow \text{ok.}$

3. Summary

total utilization all verifications $u_{max,Ges} = 0.944 \leq 1 \Rightarrow \text{ok.}$