

1. Input parameters

1.1. girder opening circular with glued on reinforcements acc. to DIN EN 1995-1-1/NA:2013-08, NCI NA.6.8.4

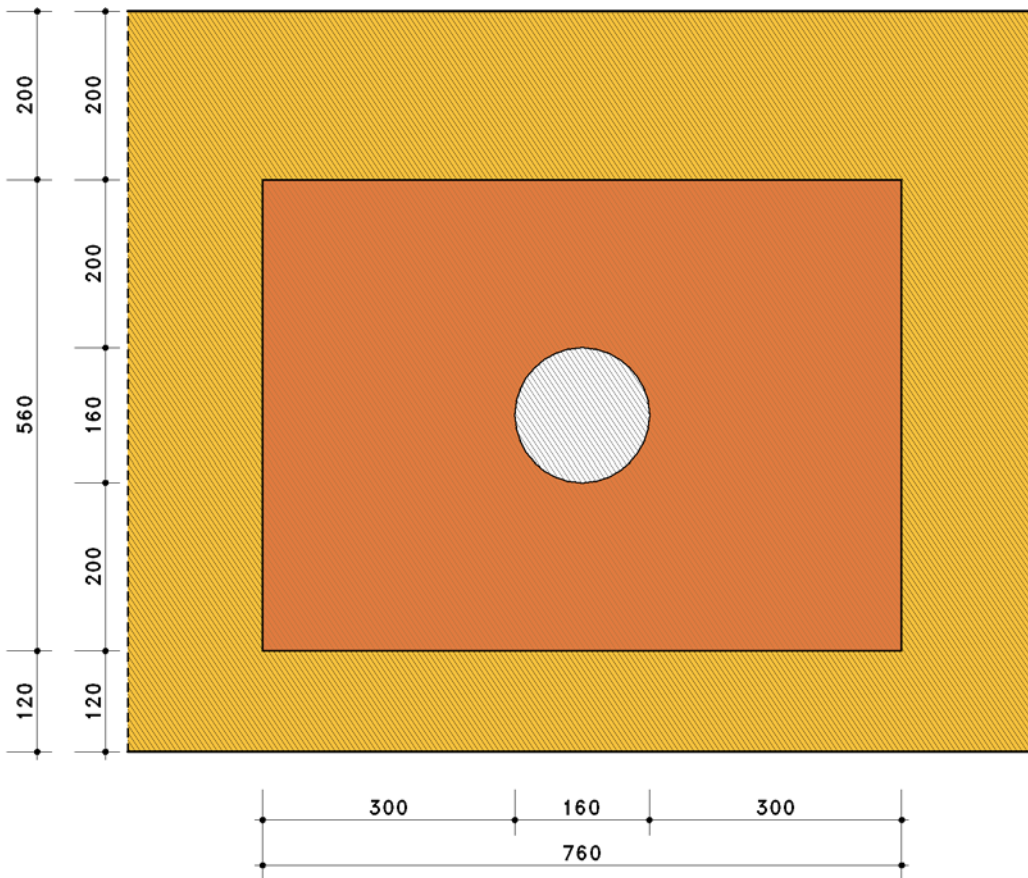
1.2. beam

beam of glue laminated timber EC, GL28h 220/880 mm, $\rho_k = 425 \text{ kg/m}^3$, NKL 1
 $h_{ro} = 400 \text{ mm}$, $h_{ru} = 320 \text{ mm}$, $a = 160 \text{ mm}$ (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 $k_h = 1.000$

1.3. reinforcement by glued lugs

plywood F40/30 $a_r = 300 \text{ mm}$, $h_1 = 200 \text{ mm}$, $t_r = 10 \text{ mm}$, $f_{t,k} = 29.00 \text{ N/mm}^2$
 parallel to the grain direction of the face grain

elevation scale 1:90, unit of length [mm]



1.4. internal forces and moments

Nr.	name	left edge			right edge			KLED	Kmod	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	409.50	798.53	0.00	392.70	734.35	sh.-term	0.900	1.30

2. results

2.1. tension stress perpendicular to grain in opening area

$f_{k2,k} = 0.75 \text{ N/mm}^2$ (table NA.12)

Nr	f _{t90,d} N/mm ²	f _{k2,d} N/mm ²	f _{t,d} N/mm ²	left edge							
				F _{tV,d} kN	F _{tM,d} kN	F _{t90,d} kN	$\tau_{ef,d}$ N/mm ²	$\sigma_{t,d}$ N/mm ²	u _{ref,d} -	u _{σ,d} -	u ₁ -
1	0.346	0.519	20.08	38.88	18.57	57.45	0.479	9.57	0.922	0.954	0.954

Nr	f _{t90,d} N/mm ²	f _{k2,d} N/mm ²	f _{t,d} N/mm ²	right edge								
				F _{tV,d} kN	F _{tM,d} kN	F _{t90,d} kN	$\tau_{ef,d}$ N/mm ²	$\sigma_{t,d}$ N/mm ²	u _{ref,d} -	u _{σ,d} -	u _r kN	u -
1	0.346	0.519	20.08	37.28	17.08	54.36	0.453	9.06	0.872	0.903	0.903	0.954

$U_{max} = 0.954 \leq 1 \Rightarrow$ **ok.**

2.2. bending at the opening area cross-section

$I_{nz} = 1234972 \text{ cm}^4$, $z_s = 431 \text{ mm}$, $W_{no} = 28646 \text{ cm}^3$, $W_{nu} = 27512 \text{ cm}^3$, $W_o = 5867 \text{ cm}^3$, $W_u = 3755 \text{ cm}^3$

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	-26.755	27.859	-26.76	27.859	1.380	1.437	1.437

$U_{max} = 1.437 > 1 \Rightarrow$ **not ok. !!**

2.3. shear at the reduced cross section in circlemitte

beam width = 220 mm, beam height = 720 mm, $k_{cr} = 0.714 \Rightarrow A_{ef} = 113143 \text{ mm}^2$, $\kappa_{max} = 1.546$

Nr	$f_{v,d}$ N/mm ²	V_d kN	$\tau_{m,d}$ N/mm ²	u -
1	2.42	401.10	5.318	2.195

$U_{max} = 2.195 > 1 \Rightarrow$ **not ok. !!**

3. Summary

total utilization all verifications $U_{max,Ges} = 2.195 > 1 \Rightarrow$ **not ok. !!**