

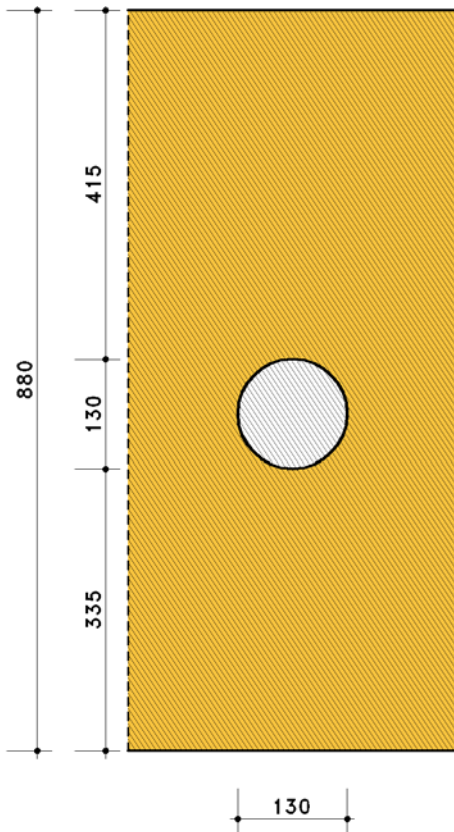
1. Input parameters

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 220/880 mm, $\rho_k = 425 \text{ kg/m}^3$, NKL 1
 $h_{ro} = 415 \text{ mm}$, $h_{ru} = 335 \text{ mm}$, $a = 130 \text{ mm}$ (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 1:90, 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 | 108.78 | 211.31 | 0.00 | 105.14 | 197.40 | sh.-term | 0.900 | 1.30 |

2. results

2.1. tension stress perpendicular to grain in opening area

$h_r = 355 \text{ mm}$, $l_{t,90} = 486 \text{ mm}$, $f_{t,90k} = 0.500 \text{ N/mm}^2$

| Nr | f _{t90,d} N/mm ² | zul | left edge | | | | u _l | right edge | | | | u |
|----|---|--------|--------------------------|-------------------------|-------------------------|--------------------------|----------------|-------------------------|-------------------------|--------------------------|----------------|---|
| | | | F _{t90,d} kN | F _{tV,d} kN | F _{tM,d} kN | F _{t90,d} kN | | F _{tV,d} kN | F _{tM,d} kN | F _{t90,d} kN | u _r | |
| 1 | 0.346 | 13.230 | 8.41 | 4.77 | 13.18 | 0.996 | 8.13 | 4.45 | 12.58 | 0.951 | 0.996 | |

$u_{max} = 0.996 \leq 1 \Rightarrow \text{ok.}$

2.2. bending at the opening area cross-section

$I_{nz} = 1239968 \text{ cm}^4$, $z_s = 433 \text{ mm}$, $W_{no} = 28632 \text{ cm}^3$, $W_{nu} = 27744 \text{ cm}^3$, $W_o = 6315 \text{ cm}^3$, $W_u = 4115 \text{ cm}^3$

| 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 | -7.137 | 7.366 | -7.137 | 7.366 | 0.368 | 0.380 | 0.380 |

$u_{max} = 0.380 \leq 1 \Rightarrow \text{ok.}$

2.3. shear at the reduced cross section in circlemitte

beam width = 220 mm, beam height = 750 mm, $k_{cr} = 0.714 \Rightarrow A_{ef} = 117857 \text{ mm}^2$, $\kappa_{max} = 1.441$

| Nr | $f_{v,d}$ N/mm ² | V_d kN | $\tau_{m,d}$ N/mm ² | u - |
|----|--------------------------------|-------------|-----------------------------------|----------|
| 1 | 2.42 | 106.96 | 1.361 | 0.562 |

$u_{max} = 0.562 \leq 1 \Rightarrow \text{ok.}$

3. Summary

total utilization all verifications $u_{max,Ges} = 0.996 \leq 1 \Rightarrow \text{ok.}$