POSITION 2: PAIR OF COLLAR BEAMS/NGL.

1. Input parameters

1.1. Fasteners

smooth nail, 4.2 x 120.0 mm, alternating, d_k = 8.4 mm, not predrilled
design resistance reduced acc. to DIN EN 1995-1-1, 8.3.1.1(8)
$F_{v,Rd}$ calculated with the simplified verification acc. to NA.8.2.4
connection rafter/collar beam: 20 x smooth nail

1.2. Internal forces combination collar beam

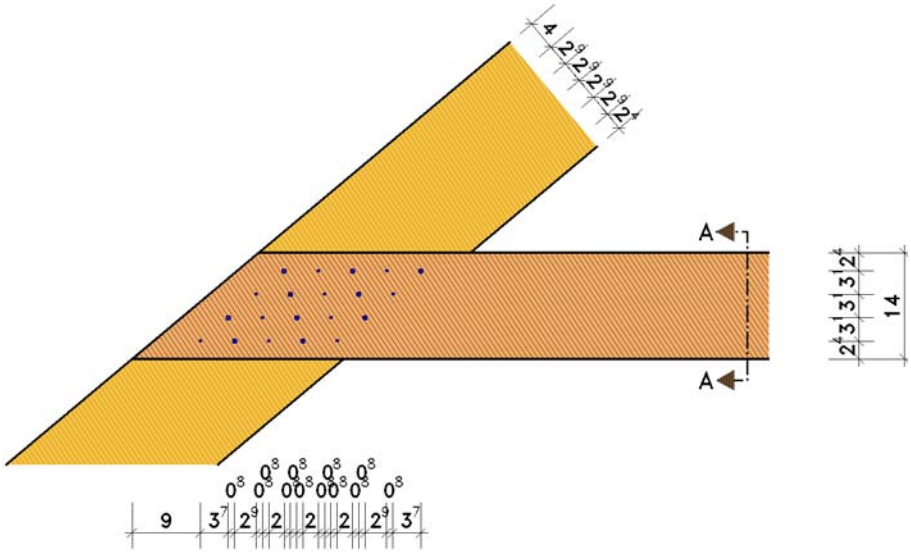
Nr	N_d kN	V_d kN	k_{mod} -	A
1	13.20	3.56	0.90	

* in column A in case of accidental combination

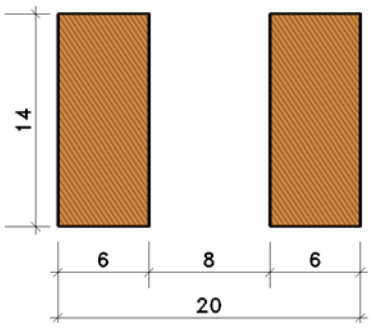
2. System visualisation

2.1. Static values and constructive boundary conditions

service class 2, connection angle α = 40.0°
timber members of solid coniferous timber, C24 (S10) with ρ_k = 350 kg/m³
pair of collar beams : t = 6.0 cm, h = 14.0 cm, A_n = 84.00 cm², W_n = 196.00 cm³, I_n = 1372.00 cm⁴
rafter: t = 8.0 cm, h = 18.0 cm, A_n = 137.60 cm², W_n = 394.45 cm³, I_n = 3392.30 cm⁴
connection collar beam/rafter
max α = 18.3 ° => minimum spacings at collar beam
a_1 = 4.1 cm, a_2 = 2.1 cm, $a_{1,t}$ = 6.2 cm, $a_{1,c}$ = 4.2 cm, $a_{2,t}$ = 2.4 cm, $a_{2,c}$ = 2.1 cm
max α = 21.7 ° => minimum spacings at rafter
a_1 = 4.1 cm, a_2 = 2.1 cm, $a_{1,t}$ = 6.2 cm, $a_{1,c}$ = 4.2 cm, $a_{2,t}$ = 2.4 cm, $a_{2,c}$ = 2.1 cm
$a_{1,exist}$ = 4.51 cm, $a_{2,exist}$ = 3.09 cm
centroid of fasteners from hinge point S at x_s = 1.22 cm, y_s = 0.00 cm
polar moment of inertia I_{pl} = 1393.37 cm⁴
elevation scale 1:10



section A-A collar beam scale 1: 5



3. Verification of fasteners acc. to DIN EN 1995, NA Germany

$\gamma_{M,outer\ timber\ member}$ = 1.30, $\gamma_{M,central\ timber\ member}$ = 1.30, γ_{steel} = 1.10, $\gamma_{accidental}$ = 1.00
min. thickness of timber members due to possibility of splitting $t_{min,1}$ = 5.88 cm

3.1. Decisive load combination collar beam

3.1.1. Fasteners rafter/collar beam

N_d = 13.20 kN, V_d = 3.56 kN, $M_{v,d}$ = |0.01 x 3.56| = 0.04 kNm, k_{mod} = 0.90
$F_{Hi,d}$ = 13.20 / (1 x 20) = 0.66 kN
$F_{Vi,d}$ = 3.56 / (1 x 20) = 0.18 kN
α_{min} = 21.67, a_1 = 45 mm, n = 5 => n_{ef} = 4.22
nail ends in rafter, 1-shear connection, nails alternating, penetration depth t = 60 mm
forces per shear plane (f_{red} = t_{exist} / t_{req})

Nr	F_{Mi} kN	F_{MHi} kN	F_{MVi} kN	F_{totHi} kN	F_{totVi} kN	F_{toti} kN	$\alpha_{toti,k}$ °	$\alpha_{toti,s}$ °	f_{red} -	$F_{v,Rk}$ kN	$F_{v,Rd}$ kN	U -
1	0.05	0.01	0.05	0.67	0.22	0.71	18.33	21.67	1.000	1.0851	0.7500	0.95

maximum utilization of fasteners U_{max} = 0.95 ≤ 1 => **verification successful**

4. Verification pair of collar beams

4.1. Decisive load combination collar beam

strengths and design resistances for k_{mod} = 0.90

$f_{1h,\alpha,k}$ = 18.66 N/mm², $f_{2h,\alpha,k}$ = 18.66 N/mm²
$f_{t,d}$ = 6.55 N/mm², $f_{m,d}$ = 16.85 N/mm², $f_{c,d}$ = 14.54 N/mm², $f_{v,d}$ = 1.38 N/mm²
$\sigma_{t,d}$ = 0.79 N/mm², τ_d = 0.64 N/mm² => U = 0.23
maximum utilization of pair of collar beams U_{max} = 0.23 ≤ 1 => **verification successful**

5. Verification rafter

b/h = 8.0/18.0 cm, $k_{c,bottom}$ = 0.600, $k_{c,top}$ = 0.900, A_n = 137.60 cm², W_n = 394.45 cm³, I_n = 3392.30 cm⁴
engraving considered c = 0.8 cm

5.1. Internal forces combination rafter bottom cutting

Nr	M_d kNm	N_d kN	V_d kN	ΔM_d kNm	k_{mod} -	A
1	0.00	3.00	6.00	0.01	0.60	

moment due to eccentricity of engraving $\Delta M_d = N_d$ c/2
* in column A in case of accidental combination

5.2. Strengths and design resistances

$f_{t,d}$ = 6.46 N/mm², $f_{m,d}$ = 11.08 N/mm², $f_{c,d}$ = 9.69 N/mm², $f_{v,d}$ = 0.92 N/mm²

5.2.1. Decisive load combination bottom cutting

$\sigma_{c,d}$ = 0.22 N/mm², $\sigma_{m,d}$ = 0.03 N/mm², τ_d = 0.68 N/mm² => U = 0.37 ≤ 1 => **verification successful**

5.3. Internal forces combination rafter upper cutting

Nr	M_d kNm	N_d kN	V_d kN	ΔM_d kNm	k_{mod} -	A
1	0.00	3.00	6.00	0.01	0.60	

* in column A in case of accidental combination
moment due to eccentricity of engraving $\Delta M_d = N_d \, c/2$

5.4. Strengths and design resistances

$f_{t,d}$ = 6.46 N/mm², $f_{m,d}$ = 11.08 N/mm², $f_{c,d}$ = 9.69 N/mm², $f_{v,d}$ = 0.92 N/mm²

5.4.1. Decisive load combination upper cutting

$\sigma_{c,d}$ = 0.22 N/mm², $\sigma_{m,d}$ = 0.03 N/mm², τ_d = 0.68 N/mm² => U = 0.37 ≤ 1 => **verification successful**

6. Summary

maximum utilization of all verifications U_{max} = 0.95 ≤ 1 => **all verifications successful**