POSITION 8: S-HLZ./NÄGEL

1. Input parameters

1.1. Fasteners

smooth nail, 2.8 x 65.0 mm, two-sided, d_k = 0.0 mm, not predrilled
design resistance reduced acc. to DIN EN 1995-1-1, 8.3.1.1(8)
$F_{v,Rd}$ calculated with the exact verification acc. to DIN EN 1995, 8.2.2
connection rafter/outer timber member: 50 x smooth nail
connection outer timber member/collar beam: 80 x smooth nail

1.2. Internal forces combination collar beam

Nr	N_d kN	V_d kN	k_{mod} -	A
1	5.00	2.00	0.60	

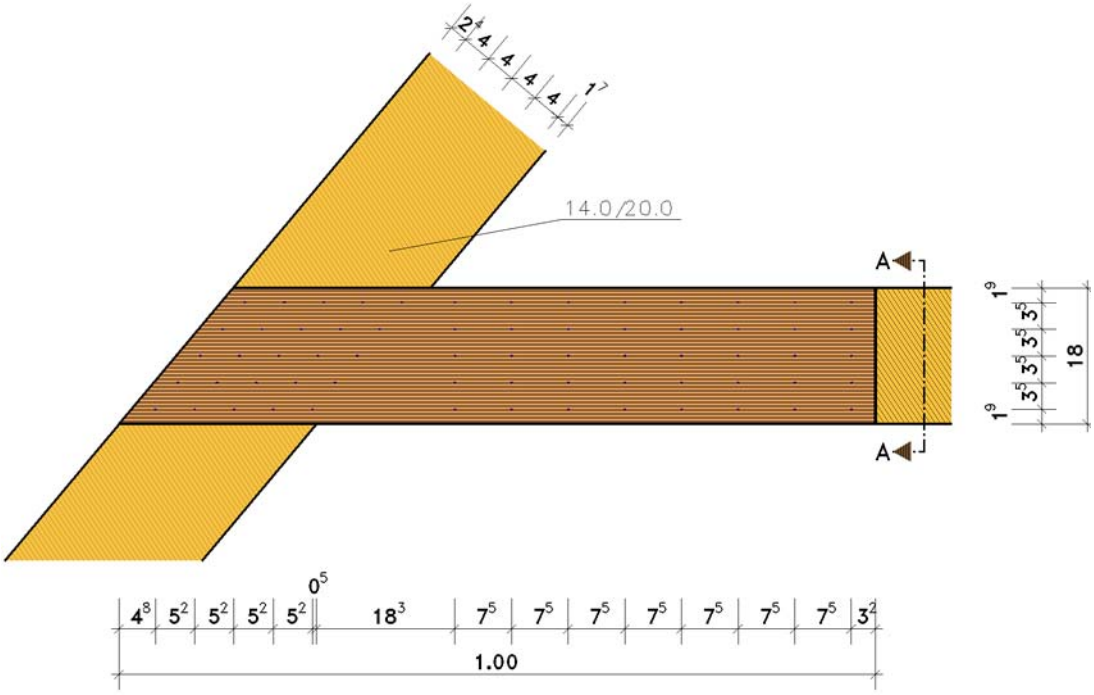
* in column A in case of accidental combination

2. System visualisation

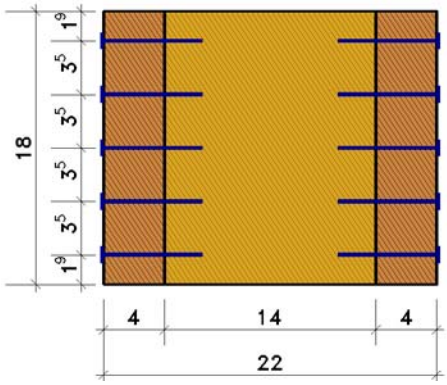
2.1. Static values and constructive boundary conditions

service class 2, connection angle α = 50.0°
connection with two-sided outer timber members
timber members of solid coniferous timber, C24 (S10) with ρ_k = 350 kg/m³, service class 2292624
outer timber member: t = 4.0 cm, h = 18.0 cm, A_n = 72.00 cm², W_n = 216.00 cm³, I_n = 1944.00 cm⁴
collar beam: t = 14.0 cm, h = 18.0 cm, A_n = 252.00 cm², W_n = 756.00 cm³, I_n = 6804.00 cm⁴
rafter: t = 14.0 cm, h = 20.0 cm, A_n = 224.00 cm², W_n = 597.33 cm³, I_n = 4778.67 cm⁴
connection outer timber member/rafter
max α = 74.7 ° => minimum spacings at outer timber member
a_1 = 1.8 cm, a_2 = 1.4 cm, $a_{1,t}$ = 3.2 cm, $a_{1,c}$ = 2.8 cm, $a_{2,t}$ = 1.9 cm, $a_{2,c}$ = 1.4 cm
max α = 26.8 ° => minimum spacings at rafter
a_1 = 2.6 cm, a_2 = 1.4 cm, $a_{1,t}$ = 4.0 cm, $a_{1,c}$ = 2.8 cm, $a_{2,t}$ = 1.7 cm, $a_{2,c}$ = 1.4 cm
$a_{1,exist}$ = 5.19 cm, $a_{2,exist}$ = 3.53 cm
centroid of fasteners from hinge point S at x_s = 0.51 cm, y_s = 0.00 cm
polar moment of inertia I_{p1} = 2409.01 cm⁴
connetion collar beam/outer timber member
max α = 74.7 ° => minimum spacings
a_1 = 1.8 cm, a_2 = 1.4 cm, $a_{1,t}$ = 3.2 cm, $a_{1,c}$ = 2.8 cm, $a_{2,t}$ = 1.9 cm, $a_{2,c}$ = 1.4 cm
$a_{1,exist}$ = 7.49 cm, $a_{2,exist}$ = 3.53 cm
centroid of fasteners from hinge point S at x_s = 50.00 cm, y_s = 0.00 cm
polar moment of inertia I_{p2} = 12777.15 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 outer timber members $t_{1,req}$ = 2.62 cm, min. thickness inner timber member $t_{2,req}$ = 2.62 cm
min. thickness of timber members due to possibility of splitting $t_{min,1}$ = 3.92 cm

3.1. Decisive load combination collar beam

3.1.1. Fasteners rafter/outer timber member

N_d = 5.00 kN, V_d = 2.00 kN, $M_{v,d}$ = |0.01 x 2.00| = 0.01 kNm, k_{mod} = 0.60
$F_{Hi,d}$ = 5.00 / (2 x 25) = 0.10 kN
$F_{Vi,d}$ = 2.00 / (2 x 25) = 0.04 kN
α_{min} = 26.83, a_1 = 52 mm, n = 5 => n_{ef} = 5.00
nail ends in rafter, nails two-sided, penetration depth t = 25 mm
forces per shear plane (mode = decisive failure mode acc. to DIN EN 1995, 8.2.2)

Nr	F_{Mi} kN	F_{MHi} kN	F_{MVi} kN	F_{totHi} kN	F_{totVi} kN	F_{toti} kN	$\alpha_{toti,k}$ °	$\alpha_{toti,s}$ °	$f_{h,\alpha,k}$ N/mm²	mode	$F_{v,Rk}$ kN	$F_{v,Rd}$ kN	U -
1	0.00	0.00	0.00	0.10	0.04	0.11	23.17	26.83	21.07	(e)	0.6209	0.2866	0.39

maximum utilization of fasteners U_{max} = 0.39 ≤ 1 => **verification successful**

3.1.2. Fasteners collar beam/outer timber member

N_d = 5.00 kN, V_d = 2.00 kN, $M_{v,d}$ = |0.50 x 2.00| = 1.00 kNm, k_{mod} = 0.60
$F_{Hi,d}$ = 5.00 / (2 x 40) = 0.06 kN
$F_{Vi,d}$ = 2.00 / (2 x 40) = -0.03 kN
nail ends in rafter, nails two-sided, penetration depth t = 25 mm
forces per shear plane (mode = decisive failure mode acc. to DIN EN 1995, 8.2.2)

Nr	F_{Mi} kN	F_{MHi} kN	F_{MVi} kN	F_{totHi} kN	F_{totVi} kN	F_{toti} kN	α_{toti} °	$f_{h,\alpha,k}$ N/mm²	mode	$F_{v,Rk}$ kN	$F_{v,Rd}$ kN	U -
1	0.11	0.03	-0.10	0.09	-0.13	0.16	54.76	21.07	(e)	0.6209	0.2866	0.55

maximum utilization of fasteners U_{max} = 0.55 ≤ 1 => **verification successful**

4. Verification timber members

4.1. Decisive load combination collar beam

strengths and design resistances for k_{mod} = 0.60

$f_{t,d}$ = 4.31 N/mm², $f_{m,d}$ = 11.08 N/mm², $f_{c,d}$ = 9.69 N/mm², $f_{v,d}$ = 0.92 N/mm²
collar beam : max $V_{90,d}$ = 0.13 N, $\sigma_{90,d}$ = 0.08 N/mm², $f_{t90,d}$ = 0.19 N/mm² ⇒ u = 0.41
outer timber members: max $V_{90,d}$ = 0.13 N, $\sigma_{90,d}$ = 0.05 N/mm², $f_{t90,d}$ = 0.24 N/mm² ⇒ u = 0.20
collar beam : $\sigma_{t,d}$ = 0.20 N/mm², $\sigma_{m,d}$ = 1.32 N/mm², τ_d = 0.16 N/mm² (mit V_d = 1.34 N) => u = 0.41
outer timber members: $\sigma_{t,d}$ = 0.35 N/mm², $\sigma_{m,d}$ = 2.31 N/mm², τ_d = 0.28 N/mm² (mit V_d = 1.34 N) => u = 0.29
max. util. of inner timber member resp. of outer t. members U_{max} = 0.41 ≤ 1 => **verification successful**

5. Verification rafter

b/h = 14.0/20.0 cm, $k_{c,bottom}$ = 0.600, $k_{c,top}$ = 0.900, A_n = 224.00 cm², W_n = 597.33 cm³, I_n = 4778.67 cm⁴
engraving considered c = 4.0 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	-3.66	-3.00	5.00	-0.06	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

$\sigma_{c,d}$ = -0.13 N/mm², $\sigma_{m,d}$ = 6.23 N/mm², τ_d = 0.42 N/mm² => U = 0.59 ≤ 1 => **verification successful**

6. Summary

maximum utilization of all verifications U_{max} = 0.59 ≤ 1 => **all verifications successful**