POSITION 4: INNENBLECHE BOLT

1. Input parameters

1.1. Fasteners

bolt 8 mm, FK 4.6
washer d = 28 mm
$F_{v,Rk}$ increased acc. to DIN EN 1995, 8.2.2(2) with washer d = 28 mm
$F_{v,Rd}$ calculated with the exact verification acc. to DIN EN 1995-1-1, 8.2.3
6 x bolt

1.2. design loads (splice in bending)

service class 2

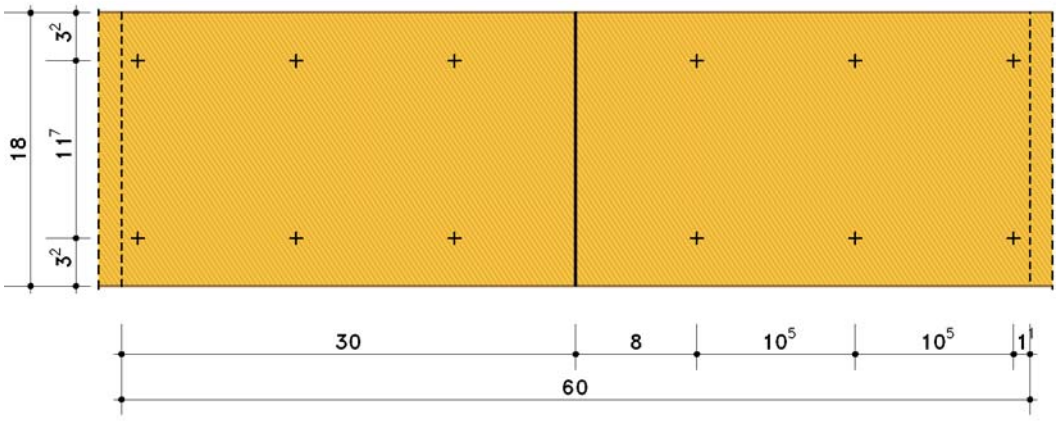
Nr	M_d kNm	N_d kN	V_d kN	k_{mod} -	A	comment
1	2.00	8.00	4.00	0.90		

2. System visualisation

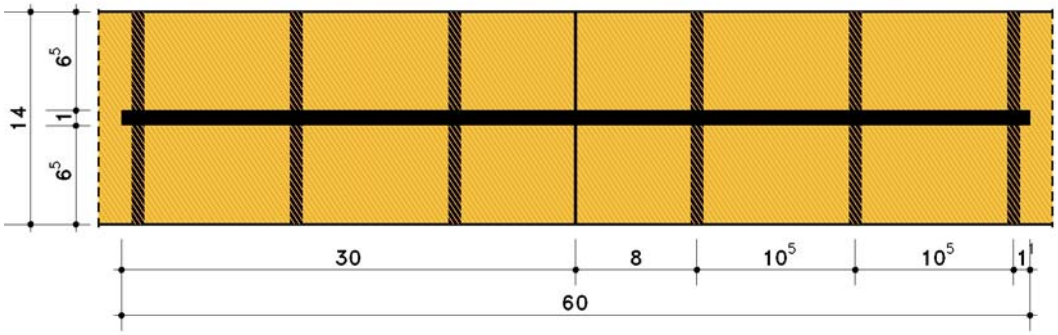
2.1. Static values and constructive boundary conditions

splice with 1 plate(s) => 2 shear connection with t_{red} = 6.50 cm
steel plate thickness t=10.0 mm in S235 (St37), A_n = 16.20 cm², W_n = 47.17 cm³, I_n = 424.52 cm⁴
timber: t = 14.0 cm, t_{red} = 6.50 cm, $A_{n,red}$ = 210.60 cm², $W_{n,red}$ = 613.19 cm³, $I_{n,red}$ = 5518.75 cm⁴
from solid coniferous timber C24 with ρ_k = 350 kg/m³
timber members from solid coniferous timber C24 with ρ_k = 350 kg/m³
min α = 9.9 ° => minimum spacings
a_1 = 4.0 cm, a_2 = 3.2 cm, $a_{3,t}$ = 8.0 cm, $a_{3,c}$ = 3.2 cm, $a_{4,t}$ = 2.4 cm, $a_{4,c}$ = 2.4 cm
$a_{1,exist}$ = 10.46 cm, $a_{2,exist}$ = 11.68 cm
polar moment of inertia I_p = 642.18 cm²
centroid of fasteners S at x_s = 18.46 cm, y_s = 0.00 cm

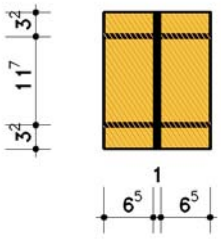
elevation scale 1: 5, unit of length [cm]



longitudinal section scale 1: 5, unit of length [cm]



cross section scale 1:10, unit of length [cm]



3. verifications acc. to DIN EN 1995, Germany

γ_M = 1.30, γ_s = 1.00
existing t_{red} = 6.50 cm

3.1. Load combination 1

3.1.1. Strengths and design resistances

k_{90} = 1.47, $f_{h,0,k}$ = 26.40 N/mm²
$f_{t,d}$ = 10.04 N/mm², $f_{m,d}$ = 16.62 N/mm², $f_{c,d}$ = 14.54 N/mm², $f_{v,d}$ = 2.77 N/mm²
$\sigma_{R,d}$ = 235.0 N/mm², $\tau_{R,d}$ = 135.7 N/mm²

3.1.2. Fasteners

N_d = 8.00 kN, V_d = 4.00 kN, $M_{v,d}$ = |2.00| + |0.18 x 4.00| = 2.74 KNm, k_{mod} = 0.90
$F_{Hi,d}$ = 8.00 / (2 x 6) = 0.67 kN
$F_{Vi,d}$ = 4.00 / (2 x 6) = 0.33 kN
α_{min} = 9.89, a_1 = 105 mm, n = 3 => n_{ef} = 2.73
forces per shear plane, mode = decisive failure mode acc. to DIN EN 1995-1-1, 8.2.3

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	2.55	1.24	2.23	1.91	2.56	3.20	53.29	0.00	Eq.(h)	5.9338	3.7323	0.86

maximum utilization of fasteners u_{max} = 0.86 ≤ 1 => **verification successful**

3.1.3. timber members

timber lamellas : $\sigma_{t,d}$ = 0.38 N/mm², $\sigma_{m,d}$ = 4.47 N/mm², τ_d = 1.56 N/mm² (mit V_d = 10.92 kN) ⇒ u = 0.56
maximum utilization of timber lamellas u_{max} = 0.56 ≤ 1 ⇒ **verification successful**

3.1.4. verification block shear failure acc. to DIN EN 1995-1-1, annex A

$L_{net,t}$ = 117 mm, t_1 = 65 mm ⇒ $A_{net,t}$ = 7590 mm², $M_{y,k}$ = 26743.3 Nmm
$L_{net,v}$ = 578 mm, t_{ef} = 65 mm ⇒ $A_{net,v}$ = 37596 mm² (failure mechanism c,f,j/l,k,m)
$F_{bs,Rk}$ = 165.08 kN, k_{mod} = 0.90 ⇒ $F_{bs,Rd}$ = 114.29 kN, N_d = 4.00 kN ⇒ u_{bs} = 0.035

3.1.5. steel plates acc. to DIN EN 1993-1-1

σ = 62.99 N/mm², σ_v = 65.38 N/mm², τ = 10.11 N/mm² (mit V_d = 10.92 kN)
maximum utilization of steel plates u_{max} = 0.28 ≤ 1 => **verification successful**

3.1.6. bearing forces acc. to DIN EN 1993-1-8

p_1 = 10.46 cm, e_1 = 1.08 cm, e_2 = 3.16 cm, p_2 = 11.68 cm, α_b = 1.00, k_1 = 2.50 => $F_{b,Rd}$ = 57.60 kN
e_{edge} = 0.00 cm, e_1 = 1.08 cm, e_2 = 3.16 cm, p_2 = 11.68 cm, α_b = 0.40, k_1 = 2.50 => $F_{b,Rd,edge}$ = 23.04 kN
forces per shear plane

Nr	F_{Mi} kN	F_{MHi} kN	F_{MVi} kN	F_{totHi} kN	F_{totVi} kN	F_{toti} kN	α_{toti} °	$F_{vll,Rd}$ kN	u -
1	5.11	2.49	4.46	3.82	5.13	6.40	53.29	23.04	0.28

maximum utilization of bearing force u_{max} = 0.28 ≤ 1 => **verification successful**

4. Summary

maximum utilization of all verifications u_{max} = 0.86 ≤ 1 => **all verifications successful**