POSITION 3: EXTERNAL PLATEE 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

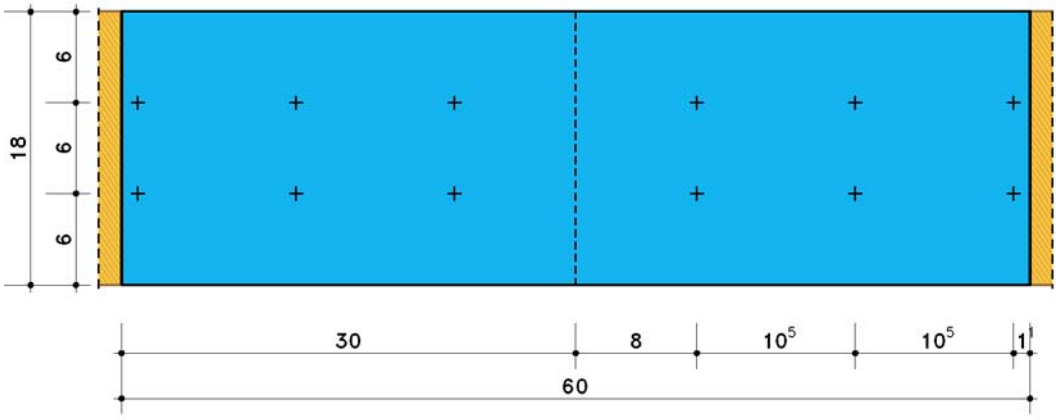
Nr	M_d kNm	N_d kN	V_d kN	k_{mod} -	A	comment
1	2.00	10.00	2.00	0.80		

2. System visualisation

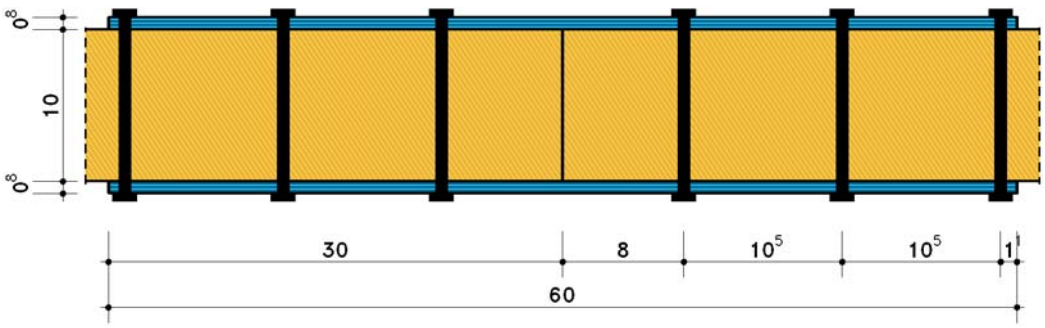
2.1. Static values and constructive boundary conditions

splice with external steel plates
timber members from solid coniferous timber C24 with ρ_k = 350 kg/m³
steel plates 8.0 x 180.0 mm in S235 (St37), A_n = 12.96 cm², W_n = 41.75 cm³, I_n = 375.74 cm⁴
timber: t = 10.0 cm, A_n = 162.00 cm², W_n = 521.87 cm³, I_n = 4696.78 cm⁴
timber members from solid coniferous timber C24 with ρ_k = 350 kg/m³
min α = 6.1 ° => 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, $a_{2,exist}$ = 6.00 cm
polar moment of inertia I_p = 491.65 cm²
centroid of fasteners S at x_s = 18.46 cm, y_s = 0.00 cm

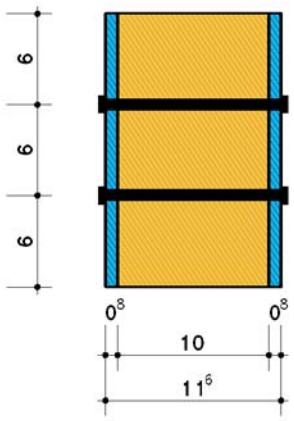
elevation scale 1: 5, unit of length [cm]



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



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



3. verifications acc. to DIN EN 1995, Germany

γ_M = 1.30, γ_s = 1.00

3.1. Load combination 1

3.1.1. Strengths and design resistances

k_{90} = 0.00, $f_{h,0,k}$ = 0.00 N/mm²
$f_{t,d}$ = 8.92 N/mm², $f_{m,d}$ = 14.77 N/mm², $f_{c,d}$ = 12.92 N/mm², $f_{v,d}$ = 2.46 N/mm²
$\sigma_{R,d}$ = 235.0 N/mm², $\tau_{R,d}$ = 135.7 N/mm²

3.1.2. Fasteners

N_d = 10.00 kN, V_d = 2.00 kN, $M_{v,d}$ = |2.00| + |0.18 x 2.00| = 2.37 KNm, k_{mod} = 0.80
$F_{Hi,d}$ = 10.00 / (2 x 6) = 0.83 kN
$F_{Vi,d}$ = 2.00 / (2 x 6) = 0.17 kN
α_{min} = 6.11, a_1 = 105 mm, n = 3 => n_{ef} = 2.71
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	2.62	-0.72	-2.52	0.11	-2.35	2.36	87.31	26.12	Eq.(j)	6.7960	3.7816	0.62
2	2.62	0.72	-2.52	1.56	-2.35	2.82	56.53	26.12	Eq.(j)	6.7960	3.7816	0.75
3	0.72	-0.72	0.00	0.11	0.17	0.20	56.46	26.12	Eq.(j)	6.7960	3.7816	0.05
4	0.72	0.72	0.00	1.56	0.17	1.57	6.11	26.12	Eq.(j)	6.7960	3.7816	0.41
5	2.62	-0.72	2.52	0.11	2.69	2.69	87.65	26.12	Eq.(j)	6.7960	3.7816	0.71
6	2.62	0.72	2.52	1.56	2.69	3.11	59.92	26.12	Eq.(j)	6.7960	3.7816	0.82

maximum utilization of fasteners u_{max} = 0.82 ≤ 1 => **verification successful**

3.1.3. timber members

inner timber member : $\sigma_{t,d}$ = 0.62 N/mm², $\sigma_{m,d}$ = 4.54 N/mm², τ_d = 2.05 N/mm² (mit V_d = 11.08 kN) ⇒ u = 0.83
maximum utilization of timber lamellas u_{max} = 0.83 ≤ 1 ⇒ **verification successful**

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

$L_{net,t}$ = 60 mm, t_1 = 100 mm ⇒ $A_{net,t}$ = 6000 mm², $M_{y,k}$ = 26743.3 Nmm
$L_{net,v}$ = 578 mm, t_{ef} = 28 mm ⇒ $A_{net,v}$ = 40488 mm² (failure mechanism e)
$F_{bs,Rk}$ = 130.50 kN, k_{mod} = 0.80 ⇒ $F_{bs,Rd}$ = 80.31 kN, N_d = 10.00 kN ⇒ u_{bs} = 0.125

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

σ = 32.23 N/mm², σ_v = 34.09 N/mm², τ = 6.41 N/mm² (mit V_d = 11.08 kN)
maximum utilization of steel plates u_{max} = 0.15 ≤ 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 = 6.00 cm, p_2 = 6.00 cm, α_b = 1.00, k_1 = 2.50 => $F_{b,Rd}$ = 46.08 kN
e_{edge} = 0.00 cm, e_1 = 1.08 cm, e_2 = 6.00 cm, p_2 = 6.00 cm, α_b = 0.40, k_1 = 2.50 => $F_{b,Rd,edge}$ = 18.43 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	2.62	-0.72	-2.52	0.11	-2.35	2.36	87.31	18.43	0.13
2	2.62	0.72	-2.52	1.56	-2.35	2.82	56.53	18.43	0.15
3	0.72	-0.72	0.00	0.11	0.17	0.20	56.46	18.43	0.01
4	0.72	0.72	0.00	1.56	0.17	1.57	6.11	18.43	0.08
5	2.62	-0.72	2.52	0.11	2.69	2.69	87.65	18.43	0.15
6	2.62	0.72	2.52	1.56	2.69	3.11	59.92	18.43	0.17

maximum utilization of bearing force u_{max} = 0.17 ≤ 1 => **verification successful**

4. Summary

maximum utilization of all verifications $u_{max} = 0.83 \leq 1$ => **all verifications successful**