POSITION 6: BLOCK SHEAR FAILURE

1. Input parameters

1.1. Fasteners

bolt 10 mm, FK 5.6
washer d = 34 mm
$F_{v,Rk}$ increased acc. to DIN EN 1995, 8.2.2(2) with washer d = 34 mm
$F_{v,Rd}$ calculated with the exact verification acc. to DIN EN 1995-1-1, 8.2.3
8 x bolt

1.2. characteristic internal forces and moments

LF	type	M_k	N_k	V_k	remark
-		kN	kN	kN	
2	permanent loads	0.000	18.000	0.000	
3	live loads	0.000	20.000	0.000	

LF 3, live loads duration of load medium-term

1.3. design loads (splice in bending)

service class 2

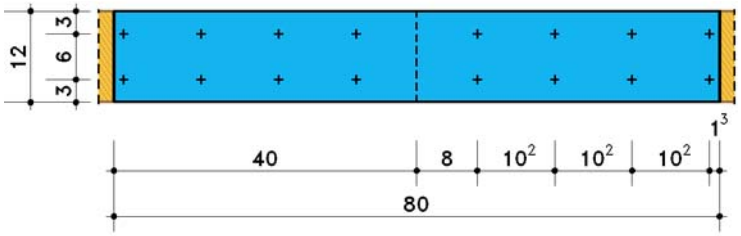
Nr	M_d	N_d	V_d	k_{mod}	A	comment
	kNm	kN	kN	-		
1	0.00	24.30	0.00	0.60		1.35*LF2 / permanent
2	0.00	18.00	0.00	0.60		1.00*LF2 / permanent
3	0.00	54.30	0.00	0.80		1.35*LF2 + 1.00*1.50*LF3 / medium-term
4	0.00	48.00	0.00	0.80		1.00*LF2 + 1.00*1.50*LF3 / medium-term

2. System visualisation

2.1. Static values and constructive boundary conditions

splice with external thin steel plates
timber members from solid coniferous timber C16 with ρ_k = 310 kg/m³
steel plates 5.0 x 120.0 mm in S235 (St37), A_n = 4.90 cm², W_n = 10.33 cm³, I_n = 61.99 cm⁴
timber: t = 12.0 cm, A_n = 117.60 cm², W_n = 247.96 cm³, I_n = 1487.74 cm⁴
timber members from solid coniferous timber C16 with ρ_k = 310 kg/m³
min α = 0.0 ° => minimum spacings
a_1 = 5.0 cm, a_2 = 4.0 cm, $a_{3,t}$ = 8.0 cm, $a_{3,c}$ = 4.0 cm, $a_{4,t}$ = 3.0 cm, $a_{4,c}$ = 3.0 cm
$a_{1,exist}$ = 10.23 cm, $a_{2,exist}$ = 6.00 cm
polar moment of inertia I_p = 1117.85 cm²
centroid of fasteners S at x_s = 23.34 cm, y_s = 0.00 cm

elevation scale 1:10, 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
$f_{t,d}$ = 3.92 N/mm², $f_{m,d}$ = 7.38 N/mm², $f_{c,d}$ = 7.85 N/mm², $f_{v,d}$ = 1.85 N/mm²
$\sigma_{R,d}$ = 235.0 N/mm², $\tau_{R,d}$ = 135.7 N/mm²

3.1.2. Fasteners

N_d = 24.30 kN, V_d = 0.00 kN, $M_{v,d}$ = |0.00| + |0.23 x 0.00| = 0.00 KNm, k_{mod} = 0.60
$F_{Hi,d}$ = 24.30 / (2 x 8) = 1.52 kN
α_{min} = 0.00, a_1 = 102 mm, n = 4 => n_{ef} = 3.28
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	0.00	-0.00	-0.00	1.52	0.00	1.52	0.00	22.62	Eq.(j)	7.4722	2.8275	0.54

maximum utilization of fasteners $u_{max} = 0.54 \leq 1$ => **verification successful**

3.1.3. timber members

inner timber member : $\sigma_{t,d} = 2.07$ N/mm², $\sigma_{m,d} = 0.00$ N/mm², $\tau_d = 0.00$ N/mm² (mit $V_d = 0.00$ kN) $\Rightarrow u = 0.53$
maximum utilization of timber lamellas $u_{max} = 0.53 \leq 1 \Rightarrow$ **verification successful**

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

$L_{net,t} = 60$ mm, $t_1 = 120$ mm $\Rightarrow A_{net,t} = 7200$ mm², $M_{y,k} = 59716.1$ Nmm
$L_{net,v} = 774$ mm, $t_{ef} = 28$ mm $\Rightarrow A_{net,v} = 44866$ mm² (failure mechanism b)
$F_{bs,Rk} = 100.50$ kN, $k_{mod} = 0.60 \Rightarrow F_{bs,Rd} = 46.38$ kN, $N_d = 24.30$ kN $\Rightarrow u_{bs} = 0.524$

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

$\sigma = 24.80$ N/mm², $\sigma_v = 24.80$ N/mm², $\tau = 0.00$ N/mm² (mit $V_d = 0.00$ kN)
maximum utilization of steel plates $u_{max} = 0.11 \leq 1$ => **verification successful**

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

$p_1 = 10.23$ cm, $e_1 = 1.32$ cm, $e_2 = 3.00$ cm, $p_2 = 6.00$ cm, $\alpha_b = 1.00$, $k_1 = 2.50$ => $F_{b,Rd} = 36.00$ kN
$e_{edge} = 0.00$ cm, $e_1 = 1.32$ cm, $e_2 = 3.00$ cm, $p_2 = 6.00$ cm, $\alpha_b = 0.40$, $k_1 = 2.50$ => $F_{b,Rd,edge} = 14.40$ 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} °	$F_{vII,Rd}$ kN	u -
1	0.00	-0.00	-0.00	1.52	0.00	1.52	0.00	14.40	0.11
2	0.00	0.00	-0.00	1.52	0.00	1.52	0.00	14.40	0.11
3	0.00	-0.00	-0.00	1.52	0.00	1.52	0.00	14.40	0.11
4	0.00	0.00	-0.00	1.52	0.00	1.52	0.00	14.40	0.11
5	0.00	-0.00	0.00	1.52	0.00	1.52	0.00	14.40	0.11
6	0.00	0.00	0.00	1.52	0.00	1.52	0.00	14.40	0.11
7	0.00	-0.00	0.00	1.52	0.00	1.52	0.00	14.40	0.11
8	0.00	0.00	0.00	1.52	0.00	1.52	0.00	14.40	0.11

maximum utilization of bearing force $u_{max} = 0.11 \leq 1$ => **verification successful**

3.2. Load combination 2

3.2.1. Fasteners

$N_d = 18.00$ kN, $V_d = 0.00$ kN, $M_{v,d} = |0.00| + |0.23 \times 0.00| = 0.00$ KNm, $k_{mod} = 0.60$
$F_{Hi,d} = 18.00 / (2 \times 8) = 1.13$ kN
$\alpha_{min} = 0.00$, $a_1 = 102$ mm, $n = 4$ => $n_{ef} = 3.28$
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	0.00	-0.00	-0.00	1.13	0.00	1.13	0.00	22.62	Eq.(j)	7.4722	2.8275	0.40

maximum utilization of fasteners $u_{max} = 0.40 \leq 1$ => **verification successful**

3.2.2. timber members

inner timber member : $\sigma_{t,d} = 1.53$ N/mm², $\sigma_{m,d} = 0.00$ N/mm², $\tau_d = 0.00$ N/mm² (mit $V_d = 0.00$ kN) $\Rightarrow u = 0.39$
maximum utilization of timber lamellas $u_{max} = 0.39 \leq 1 \Rightarrow$ **verification successful**

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

$L_{net,t} = 60$ mm, $t_1 = 120$ mm $\Rightarrow A_{net,t} = 7200$ mm², $M_{y,k} = 59716.1$ Nmm
$L_{net,v} = 774$ mm, $t_{ef} = 28$ mm $\Rightarrow A_{net,v} = 44866$ mm² (failure mechanism b)
$F_{bs,Rk} = 100.50$ kN, $k_{mod} = 0.60 \Rightarrow F_{bs,Rd} = 46.38$ kN, $N_d = 18.00$ kN $\Rightarrow u_{bs} = 0.388$

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

$\sigma = 18.37$ N/mm², $\sigma_v = 18.37$ N/mm², $\tau = 0.00$ N/mm² (mit $V_d = 0.00$ kN)
maximum utilization of steel plates $u_{max} = 0.08 \leq 1$ => **verification successful**

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

$p_1 = 10.23$ cm, $e_1 = 1.32$ cm, $e_2 = 3.00$ cm, $p_2 = 6.00$ cm, $\alpha_b = 1.00$, $k_1 = 2.50$ => $F_{b,Rd} = 36.00$ kN
$e_{edge} = 0.00$ cm, $e_1 = 1.32$ cm, $e_2 = 3.00$ cm, $p_2 = 6.00$ cm, $\alpha_b = 0.40$, $k_1 = 2.50$ => $F_{b,Rd,edge} = 14.40$ 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} °	$F_{vII,Rd}$ kN	u -
1	0.00	-0.00	-0.00	1.13	0.00	1.13	0.00	14.40	0.08
2	0.00	0.00	-0.00	1.13	0.00	1.13	0.00	14.40	0.08
3	0.00	-0.00	-0.00	1.13	0.00	1.13	0.00	14.40	0.08
4	0.00	0.00	-0.00	1.13	0.00	1.13	0.00	14.40	0.08
5	0.00	-0.00	0.00	1.13	0.00	1.13	0.00	14.40	0.08
6	0.00	0.00	0.00	1.13	0.00	1.13	0.00	14.40	0.08
7	0.00	-0.00	0.00	1.13	0.00	1.13	0.00	14.40	0.08
8	0.00	0.00	0.00	1.13	0.00	1.13	0.00	14.40	0.08

maximum utilization of bearing force u_{max} = 0.08 ≤ 1 => **verification successful**

3.3. Load combination 3

3.3.1. Strengths and design resistances

k_{90} = 0.00, $f_{h,0,k}$ = 0.00 N/mm²
$f_{t,d}$ = 5.23 N/mm², $f_{m,d}$ = 9.85 N/mm², $f_{c,d}$ = 10.46 N/mm², $f_{v,d}$ = 2.46 N/mm²
$\sigma_{R,d}$ = 235.0 N/mm², $\tau_{R,d}$ = 135.7 N/mm²

3.3.2. Fasteners

N_d = 54.30 kN, V_d = 0.00 kN, $M_{v,d}$ = |0.00| + |0.23 x 0.00| = 0.00 KNm, k_{mod} = 0.80
$F_{Hi,d}$ = 54.30 / (2 x 8) = 3.39 kN
α_{min} = 0.00, a_1 = 102 mm, n = 4 => n_{ef} = 3.28
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	0.00	-0.00	-0.00	3.39	0.00	3.39	0.00	22.62	Eq.(j)	7.4722	3.7700	0.90

maximum utilization of fasteners u_{max} = 0.90 ≤ 1 => **verification successful**

3.3.3. timber members

inner timber member : $\sigma_{t,d}$ = 4.62 N/mm², $\sigma_{m,d}$ = 0.00 N/mm², τ_d = 0.00 N/mm² (mit V_d = 0.00 kN) ⇒ u = 0.88
maximum utilization of timber lamellas u_{max} = 0.88 ≤ 1 ⇒ **verification successful**

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

$L_{net,t}$ = 60 mm, t_1 = 120 mm ⇒ $A_{net,t}$ = 7200 mm², $M_{y,k}$ = 59716.1 Nmm
$L_{net,v}$ = 774 mm, t_{ef} = 28 mm ⇒ $A_{net,v}$ = 44866 mm² (failure mechanism b)
$F_{bs,Rk}$ = 100.50 kN, k_{mod} = 0.80 ⇒ $F_{bs,Rd}$ = 61.85 kN, N_d = 54.30 kN ⇒ u_{bs} = 0.878

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

σ = 55.41 N/mm², σ_v = 55.41 N/mm², τ = 0.00 N/mm² (mit V_d = 0.00 kN)
maximum utilization of steel plates u_{max} = 0.24 ≤ 1 => **verification successful**

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

p_1 = 10.23 cm, e_1 = 1.32 cm, e_2 = 3.00 cm, p_2 = 6.00 cm, α_b = 1.00, k_1 = 2.50 => $F_{b,Rd}$ = 36.00 kN
e_{edge} = 0.00 cm, e_1 = 1.32 cm, e_2 = 3.00 cm, p_2 = 6.00 cm, α_b = 0.40, k_1 = 2.50 => $F_{b,Rd,edge}$ = 14.40 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	0.00	-0.00	-0.00	3.39	0.00	3.39	0.00	14.40	0.24
2	0.00	0.00	-0.00	3.39	0.00	3.39	0.00	14.40	0.24
3	0.00	-0.00	-0.00	3.39	0.00	3.39	0.00	14.40	0.24
4	0.00	0.00	-0.00	3.39	0.00	3.39	0.00	14.40	0.24
5	0.00	-0.00	0.00	3.39	0.00	3.39	0.00	14.40	0.24
6	0.00	0.00	0.00	3.39	0.00	3.39	0.00	14.40	0.24
7	0.00	-0.00	0.00	3.39	0.00	3.39	0.00	14.40	0.24
8	0.00	0.00	0.00	3.39	0.00	3.39	0.00	14.40	0.24

maximum utilization of bearing force u_{max} = 0.24 ≤ 1 => **verification successful**

3.4. Load combination 4

3.4.1. Fasteners

N_d = 48.00 kN, V_d = 0.00 kN, $M_{v,d}$ = |0.00| + |0.23 x 0.00| = 0.00 KNm, k_{mod} = 0.80
$F_{Hi,d}$ = 48.00 / (2 x 8) = 3.00 kN
α_{min} = 0.00, a_1 = 102 mm, n = 4 => n_{ef} = 3.28
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	0.00	-0.00	-0.00	3.00	0.00	3.00	0.00	22.62	Eq.(j)	7.4722	3.7700	0.80

maximum utilization of fasteners u_{max} = 0.80 ≤ 1 => **verification successful**

3.4.2. timber members

inner timber member : $\sigma_{t,d}$ = 4.08 N/mm², $\sigma_{m,d}$ = 0.00 N/mm², τ_d = 0.00 N/mm² (mit V_d = 0.00 kN) ⇒ u = 0.78
maximum utilization of timber lamellas u_{max} = 0.78 ≤ 1 ⇒ **verification successful**

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

$L_{net,t}$ = 60 mm, t_1 = 120 mm ⇒ $A_{net,t}$ = 7200 mm², $M_{y,k}$ = 59716.1 Nmm
$L_{net,v}$ = 774 mm, t_{ef} = 28 mm ⇒ $A_{net,v}$ = 44866 mm² (failure mechanism b)
$F_{bs,Rk}$ = 100.50 kN, k_{mod} = 0.80 ⇒ $F_{bs,Rd}$ = 61.85 kN, N_d = 48.00 kN ⇒ u_{bs} = 0.776

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

σ = 48.98 N/mm², σ_v = 48.98 N/mm², τ = 0.00 N/mm² (mit V_d = 0.00 kN)
maximum utilization of steel plates u_{max} = 0.21 ≤ 1 => **verification successful**

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

p_1 = 10.23 cm, e_1 = 1.32 cm, e_2 = 3.00 cm, p_2 = 6.00 cm, α_b = 1.00, k_1 = 2.50 => $F_{b,Rd}$ = 36.00 kN
e_{edge} = 0.00 cm, e_1 = 1.32 cm, e_2 = 3.00 cm, p_2 = 6.00 cm, α_b = 0.40, k_1 = 2.50 => $F_{b,Rd,edge}$ = 14.40 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	0.00	-0.00	-0.00	3.00	0.00	3.00	0.00	14.40	0.21
2	0.00	0.00	-0.00	3.00	0.00	3.00	0.00	14.40	0.21
3	0.00	-0.00	-0.00	3.00	0.00	3.00	0.00	14.40	0.21
4	0.00	0.00	-0.00	3.00	0.00	3.00	0.00	14.40	0.21
5	0.00	-0.00	0.00	3.00	0.00	3.00	0.00	14.40	0.21
6	0.00	0.00	0.00	3.00	0.00	3.00	0.00	14.40	0.21
7	0.00	-0.00	0.00	3.00	0.00	3.00	0.00	14.40	0.21
8	0.00	0.00	0.00	3.00	0.00	3.00	0.00	14.40	0.21

maximum utilization of bearing force u_{max} = 0.21 ≤ 1 => **verification successful**

4. Summary

maximum utilization of all verifications u_{max} = 0.90 ≤ 1 => **all verifications successful**