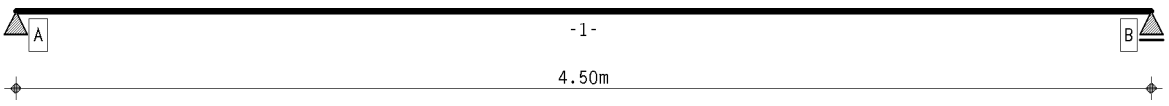
1. Options for Calculations

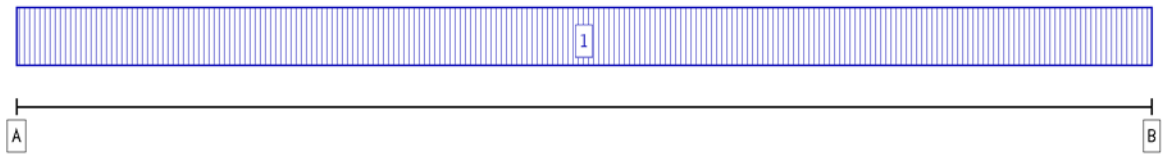
calculation DIN EN 1995:2010, Germany
service class 2
coefficient of thermal expansion for timber α_t = 0.500 *10^{-5}/°K
ψ_2 = 0.60 (factor acc. to DIN EN 1995-1-1 2.3.2.2 (2))

2. Structural system

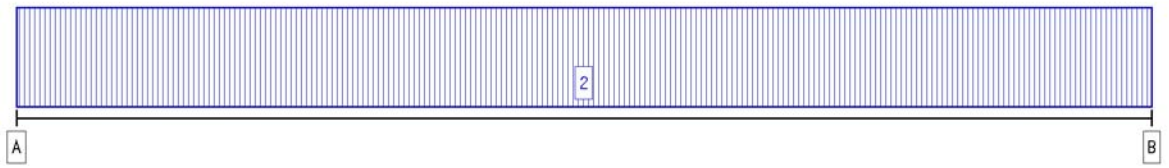


main beam

3. Loading



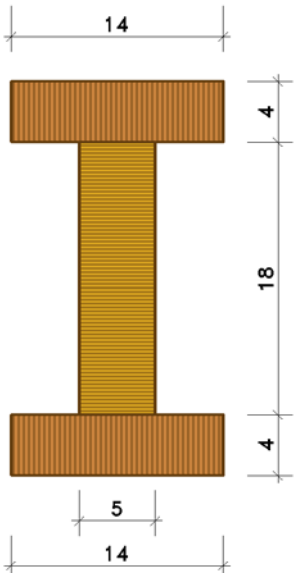
action effect 1: permanent loads (permanent, 1 load cases)



action effect 2: live loads (1) (transient, 1 load cases)

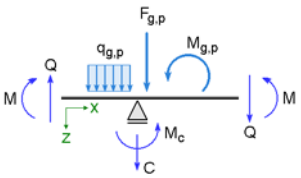
4. main beam

section scale 1: 5



timber grade top flange			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	4.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.5 N/mm²
char. compr. strength	$f_{c,0,k}$	:	21.0 N/mm²
char. compr. strength	$f_{c,90,k}$	:	2.5 N/mm²
modulus of elasticity	$E_{0,mean}$	:	11000 N/mm²
Dichte	ρ_k / ρ_m	:	350 / 420 kg/m³
deformation factor	k_{def}	:	0.60 -
area	A_{flange}	:	56.000 cm²
moment of inertia	I_{flange}	:	74.667 cm⁴
timber grade web			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	4.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.5 N/mm²
char. compr. strength	$f_{c,0,k}$	:	21.0 N/mm²
char. compr. strength	$f_{c,90,k}$	:	2.5 N/mm²
	k_{cr}	:	0.50 mm²/N
modulus of elasticity	$E_{0,mean}$	:	11000 N/mm²
Dichte	ρ_k / ρ_m	:	350 / 420 kg/m³
deformation factor	k_{def}	:	0.60 -
area	A_{flange}	:	90.000 cm²
moment of inertia	I_{flange}	:	2430.000 cm⁴
timber grade bottom flange			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	4.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.5 N/mm²
char. compr. strength	$f_{c,0,k}$	:	21.0 N/mm²
char. compr. strength	$f_{c,90,k}$	:	2.5 N/mm²
modulus of elasticity	$E_{0,mean}$	:	11000 N/mm²
Dichte	ρ_k / ρ_m	:	350 / 420 kg/m³
deformation factor	k_{def}	:	0.60 -

area A_{flange} : 56.000 cm²
moment of inertia I_{flange} : 74.667 cm⁴
definition of internal forces and moments:



5. Beam sections

beam sections

section	x_A m	x_E m	l m	l_{ef} m	i_z mm	k -	λ -	$\lambda_{rel,c}$ -	k_c -	l_v m	cantil.	s_{ef} mm
1	0.00	4.50	4.50	1.12	40.4600	0.6283	27.6817	0.4715	0.9582	4.50	-	n.e.

stiffness values serviceability initial state

section	γ_2 -	a_2 mm	K_1 N/mm	γ_{1r} -	a_1 mm	K_3 N/mm	γ_{3r} -	a_3 mm	$EI_{ef,inst}$ Nmm²	ø k_{def} -
1	1.0000	-0.0	1	1.0000	-110.0	1	1.0000	110.0	1.7744E12	0.3600

stiffness values load-carrying capacity initial state

section	γ_2 -	a_2 mm	K_1 N/mm	γ_1 -	a_1 mm	K_3 N/mm	γ_3 -	a_3 mm	$EI_{ef,inst}$ Nmm²	$I_{ef,inst}$ mm²	$h_{q,inst}$ mm	$A_{q,inst}$ mm
1	1.0000	-0.0	1	1.0000	-110.0	1	1.0000	110.0	1.7744E12	161313328.0	9.00	86.67

stiffness values load-carrying capacity final state

section	γ_2 -	a_2 mm	K_1 N/mm	γ_1 -	a_1 mm	K_3 N/mm	γ_3 -	a_3 mm	$EI_{ef,inf}$ Nmm²	$I_{ef,inf}$ mm²	$h_{q,inf}$ mm	$A_{q,inf}$ mm
1	1.0000	0.0	1	1.0000	-110.0	1	1.0000	110.0	1.3047E12	161313328.0	9.00	86.67

net section properties

section	$A_{n,2}$ cm²	$W_{n,2}$ cm³	$I_{n,2}$ cm⁴	$A_{n,1}$ cm²	$W_{n,1}$ cm³	$I_{n,1}$ cm⁴	$A_{n,3}$ cm²	$W_{n,3}$ cm³	$I_{n,3}$ cm⁴
1	90.00	270.00	2430.00	56.00	37.33	74.67	56.00	37.33	74.67

6. Fasteners

section 1 from x_A = 0.00 m to x_E = 4.50, glued joint

7. Supports

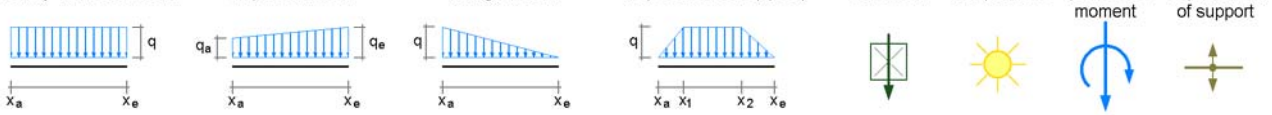
coordinates of supports

supp.name	x m	width mm	depth mm	c_F kN/m	c_M kNm/-	restraint (F)	restraint (M)
A	0.00	150	140	fix	----	X	-
B	4.50	150	140	fix	----	X	-

8. Action effects

Attention! Acc. to DIN EN 1995-1-1, annex B.1
mechanically jointed cross-sections are only allowed to be loaded by line loads

uniformly distributed load | trapezoidal load | triangular load | trapezoidal load (spec.) | dead load | temperature | point load/ moment | displacement of support



Permanent action effect: permanent loads
1. additive load case: dead load (1)
⇒ unif.distr.load: q = 1.50 kN/m from x_a = 0.00 m to x_e = 4.50 m

2. Transient action effect: live loads (1)
2. additive load case: live loads (1/1)
⇒ unif.distr.load: q = 2.00 kN/m from x_a = 0.00 m to x_e = 4.50 m

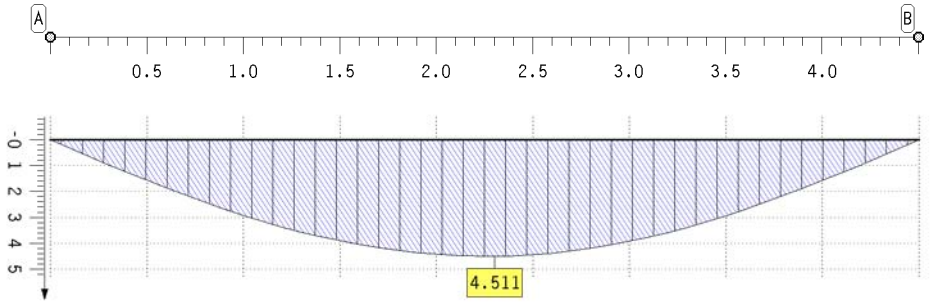
9. verifications

1: EC 5 load-carrying capacity
buckling analysis of compression flange acc. to DIN EN 1995, 6.3.2 will be executed
verification of bearing stress DIN EN 1995, 6.1.5 will be executed
Extreme rule 1

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

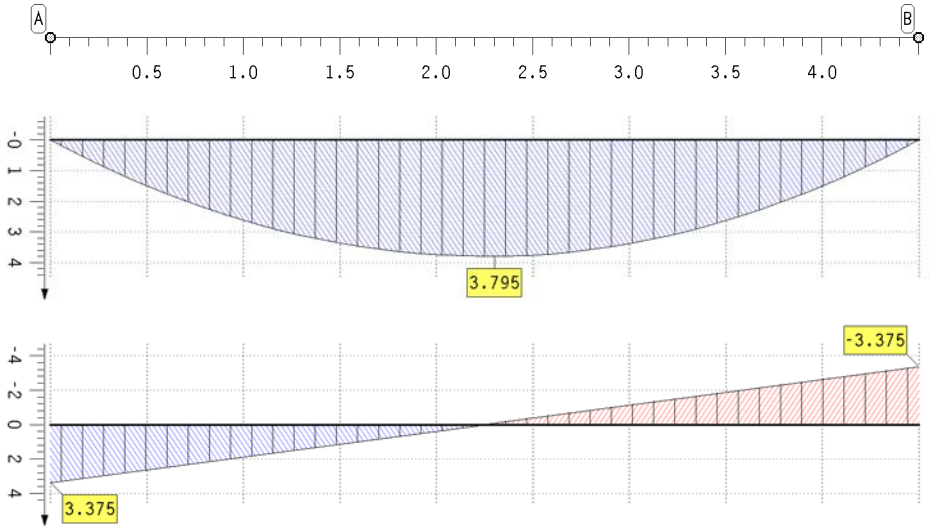


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 4.51

extremal deflections of main beam (characteristic)

point	x	min w	max w	point	x	min w	max w
-	m	mm	mm	-	m	mm	mm
A	0.000	0.00	0.00	B	4.500	-0.00	-0.00
	1.200	3.38	3.38	**minimum**		**-0.00**	**-0.00**
	2.200	4.51	4.51	**maximum**		**4.51**	**4.51**
	3.200	3.58	3.58				

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 3.80

shear force
main beam
V in kN
Min: -3.38
Max: 3.38

extremal internal forces

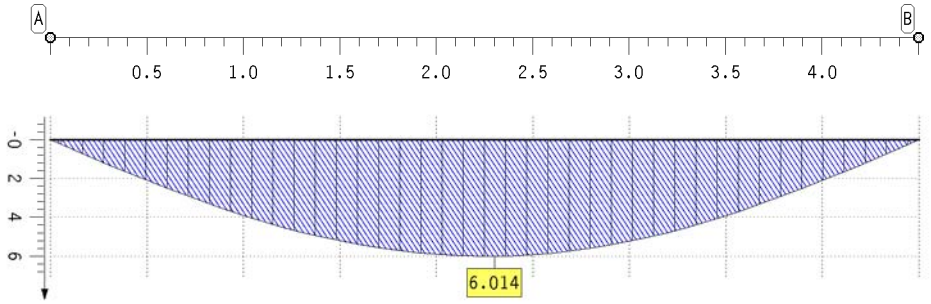
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	3.38	3.38	B	4.500	0.00	0.00	-3.38	-3.38
	1.100	2.81	2.81	1.73	1.73	**minimum**		**0.00**	**0.00**	**-3.38**	**-3.38**
	2.200	3.80	3.80	0.08	0.08	**maximum**		**3.80**	**3.80**	**3.38**	**3.38**
	3.400	2.81	2.81	-1.73	-1.73						

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-3.38	-3.38
B	4.500	-3.38	-3.38

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)



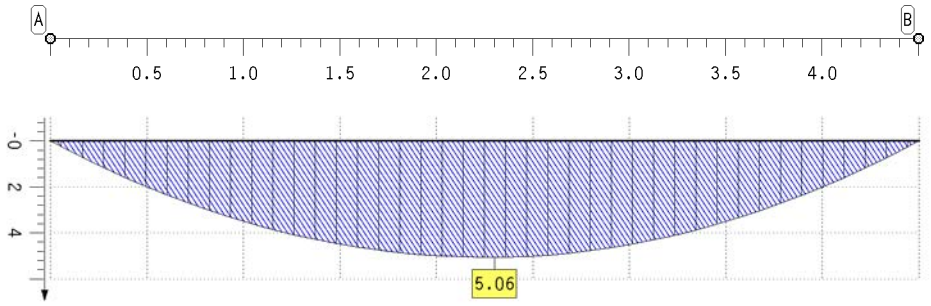
deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 6.01

extremal deflections of main beam (characteristic)

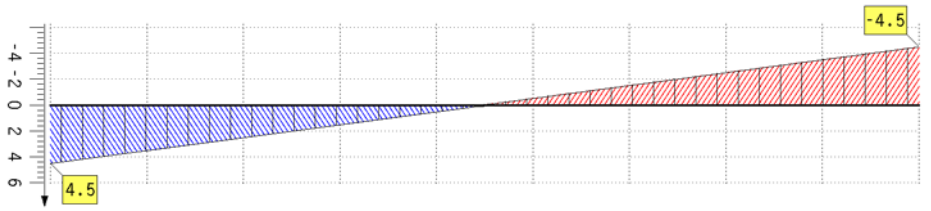
point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.200	0.00	4.50
	2.200	0.00	6.01
	3.200	0.00	4.77

point	x	min w	max w
-	m	mm	mm
B	4.500	0.00	0.00
minimum		**0.00**	**0.00**
maximum		**0.00**	**6.01**

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 5.06



shear force
main beam
V in kN
Min: -4.50
Max: 4.50

extremal internal forces

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	0.00	4.50
	1.100	0.00	3.74	0.00	2.30
	2.200	0.00	5.06	0.00	0.10
	3.400	0.00	3.74	-2.30	-0.00

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	4.500	0.00	0.00	-4.50	-0.00
minimum		**0.00**	**0.00**	**-4.50**	**-0.00**
maximum		**0.00**	**5.06**	**0.00**	**4.50**

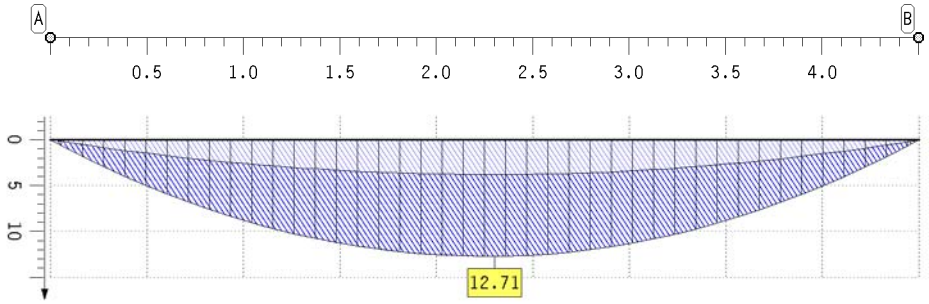
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-4.50	-0.00
B	4.500	-4.50	-0.00

11. Results of verification of ultimate limit state

11.1. Verification of ultimate limit state

extremal internal forces



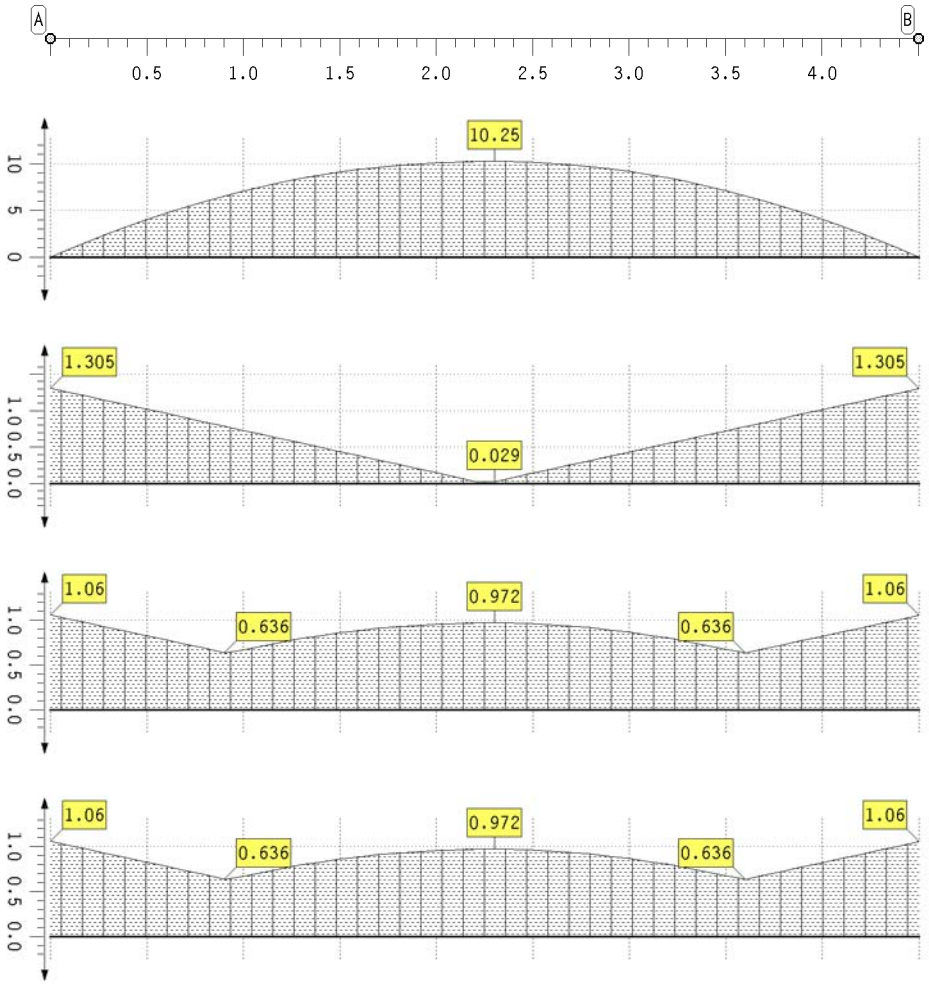
flexural moment
main beam
M in kNm
Min: 0.00
Max: 12.71

extremal internal forces

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	3.38	11.31
	1.100	2.81	9.40	1.73	5.78
	2.200	3.80	12.71	0.08	0.25
	3.400	2.81	9.40	-5.78	-1.73

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	4.500	0.00	0.00	-11.31	-3.38
minimum		**0.00**	**0.00**	**-11.31**	**-3.38**
maximum		**3.80**	**12.71**	**3.38**	**11.31**

results of verification of ultimate limit state



bending stress
main beam
σ_h in MN/m²
Max: 10.25

shear stress
main beam
τ_h in MN/m²
Max: 1.30

utilization
main beam
Max: 1.06

maximal
utilization
Max: 1.06

maximal utilization

point	x	U
-	m	-
A	0.000	1.060
	0.900	0.636
	1.600	0.891

point	x	U
-	m	-
	2.200	0.972
	2.900	0.891
	3.600	0.636

point	x	U
-	m	-
B	4.500	1.060
minimum		**0.636**
maximum		**1.060**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-11.31	-3.38
B	4.500	-11.31	-3.38

verification of bearing stress

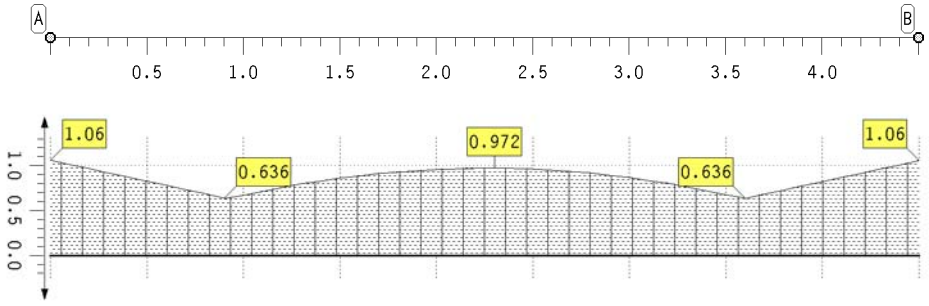
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm²	N		-	N/mm²	N/mm²	-
A	180	25200	11306	1.00	0.80	1.54	0.45	0.29
B	180	25200	11306	1.00	0.80	1.54	0.45	0.29

verification of bearing stresses für den main beam(u = 0.292) successful!

12. Summary

12.1. Summary of all verifications

maximal utilization



utilization
Max: 1.06

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	1.060		2.200	0.972	B	4.500	1.060
	0.900	0.636		2.900	0.891	**minimum**		**0.636**
	1.600	0.891		3.600	0.636	**maximum**		**1.060**

verification of bearing stress

support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm²	N		-	N/mm²	N/mm²	-
A	180	25200	11306	1.00	0.80	1.54	0.45	0.29
B	180	25200	11306	1.00	0.80	1.54	0.45	0.29

verification of bearing stresses für den main beam(u = 0.292) successful!

13. Utilizations of all verifications

verification of load-carrying capacity (u = 1.060) does not meet the requirements!

14. Detailed verification piont

14.1. Verification of load-carrying capacity at x = 0.00 m

internal forces and moments

state	M	V	M_1	N_1	M_2	N_2	M_3	N_3
	kNm	kN	Nmm	N	Nmm	N	Nmm	N
start,min	0.00	3.38	0	-0	0	0	0	0
start,max	0.00	11.31	0	-0	0	0	0	0
end,min	0.00	3.38	0	-0	0	0	0	0
end,max	0.00	11.31	0	-0	0	0	0	0

stresses and utilization web

state	$k_{mod,2}$	$\sigma_{m,2}$	$\sigma_{c,2}$	$u_{\sigma,2}$	τ_2	u_τ	u_2
	-	N/mm²	N/mm²	-	N/mm²	-	-
start	0.8	0.00	0.00	**0.00**	1.30	0.53	0.53
end	0.8	0.00	0.00	0.00	1.30	0.53	0.53

stresses and utilization flanges

state	$k_{mod,1}$ -	$\sigma_{m,1}$ N/mm²	$\sigma_{c,1}$ N/mm²	u_1 -	$k_{mod,3}$ -	$\sigma_{m,3}$ N/mm²	$\sigma_{c,3}$ N/mm²	u_3 -
start	0.8	0.00	-0.00	**0.00**	0.8	0.00	0.00	**0.00**
end	0.8	0.00	-0.00	0.00	0.8	0.00	0.00	0.00

adhering joint with $f_{v1,d}$ = 2.462 N/mm²

state	$S_{1,d}$ cm²	$\tau_{1,d}$ N/mm²	$u_{1,d}$ -	$S_{2,d}$ cm²	$\tau_{2,d}$ N/mm²	$u_{2,d}$ -
start	616	0.8635	**0.35**	616	0.8635	**0.35**
end	616	0.8635	0.35	616	0.8635	0.35

resulting utilization at verification point u_{res} = 1.060