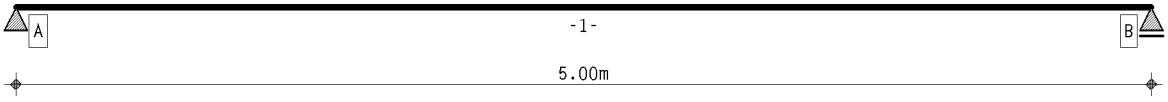
1. Options for Calculations

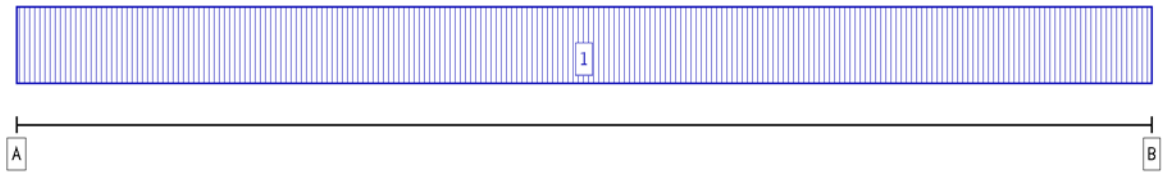
calculation DIN EN 1995:2010, Germany
service class 2
coefficient of thermal expansion for timber α_t = 0.500 *10^{-5}/°K
ψ_2 = 0.60 (factor acc. to DIN EN 1995-1-1 2.3.2.2 (2))

2. Structural system

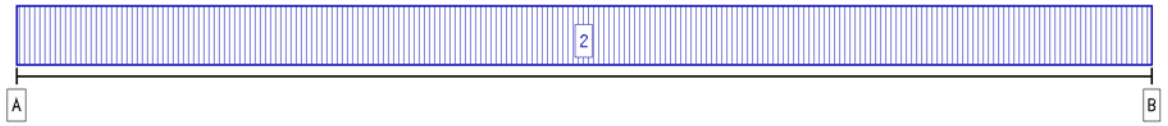


main beam

3. Loading



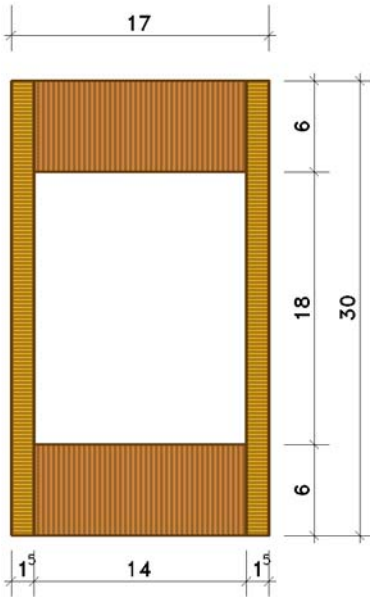
action effect 1: permanent loads (permanent, 1 load cases)



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

4. main beam (not acc. to DIN)

section scale 1: 5

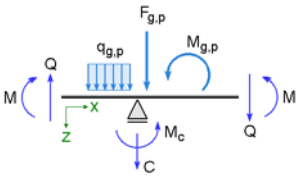


timber grade top flange **solid coniferous timber, C24 (S10)**
char. bend. strength $f_{m,k}$: 24.0 N/mm²
char. shear strength $f_{v,k}$: 4.0 N/mm²
char. ten. strength $f_{t,k}$: 14.5 N/mm²
char. compr. strength $f_{c,0,k}$: 21.0 N/mm²
char. compr. strength $f_{c,90,k}$: 2.5 N/mm²
modulus of elasticity $E_{0,mean}$:11000 N/mm²
Dichte ρ_k / ρ_m : 350 / 420 kg/m³
deformation factor k_{def} : 0.60 -
area A_{flange} : 84.000 cm²
moment of inertia I_{flange} : 252.000 cm⁴

timber grade web (fibre ⊥) **OSB 3**
d = 15.0 mm (hochkant)
char. bend. strength $f_{m,k}$: 24.0 N/mm²
char. shear strength $f_{v,k}$: 9.0 N/mm²
char. ten. strength $f_{t,k}$: 21.0 N/mm²
char. compr. strength $f_{c,0,k}$: 14.0 N/mm²
char. compr. strength $f_{c,90,k}$: 2.5 N/mm²
k_{cr} : 1.00 mm²/N
e-modulus $E_{0,mean}$ (diaphragm): 2500 N/mm²
e-modulus $E_{0,mean}$ (plate) :11000 N/mm²
Dichte ρ_k / ρ_m : 550 / 660 kg/m³
deformation factor k_{def} : 1.50 -
area A_{flange} : 90.000 cm²
moment of inertia I_{flange} : 6750.000 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} : 84.000 cm²
moment of inertia I_{flange} : 252.000 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	5.00	5.00	5.00	40.4600	2.8960	123.5788	2.1050	0.2047	3.00	-	20.0

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	996	0.5771	-120.0	996	0.5771	120.0	1.7599E12	0.7619

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	664	0.4764	-120.0	664	0.4764	120.0	1.4919E12	135622976.0	15.00	73.06

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	310	0.3665	-120.0	310	0.3665	120.0	8.4674E11	104688240.0	15.00	74.01

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	450.00	6750.00	84.00	84.00	252.00	84.00	84.00	252.00

6. Fasteners

section 1 from x_A = 0.00 m to x_E = 5.00
nail, 3.1 x 70.0 mm, d_k = 20.0 mm, not predrilled
2-row with a_1 = **40.0 mm**
2 - row with a_2 = 22.0 mm, simplified verification acc. to NA.8.2.4
nail ends in timber member 2, penetration depth t = 55 mm > 4 d = 12 mm, 1 shear plane
f_{uk} = 600 N/mm², M_{yk} = 3410 Nmm
reduction of R_k with f = 0.691 for t_{vorh} < t_{req}
K_{ser} = 996 N/mm, γ_M = 1.10, **R_k = 499.6 N, all values per shear plane**

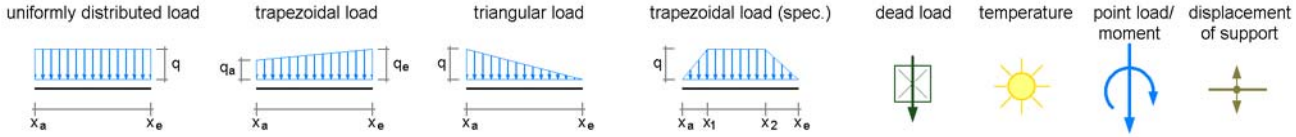
7. Supports

coordinates of supports

supp.name	x	width	depth	c_F	c_M	restraint	
	m	mm	mm	kN/m	kNm/-	(F)	(M)
A	0.00	150	30	fix	----	X	-
B	5.00	150	30	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



Permanent action effect: permanent loads
1. additive load case: dead load (1)
⇒ unif.distr.load: q = 0.80 kN/m from x_a = 0.00 m to x_e = 5.00 m

2. Transient action effect: live loads (1)
2. additive load case: live loads (1/1)
⇒ unif.distr.load: q = 0.47 kN/m from x_a = 0.00 m to x_e = 5.00 m

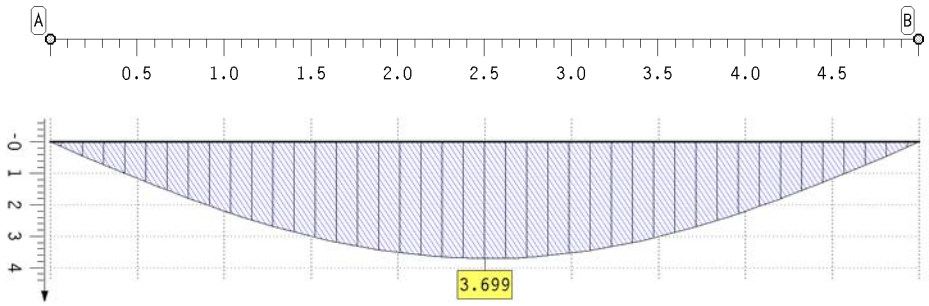
9. verifications

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)

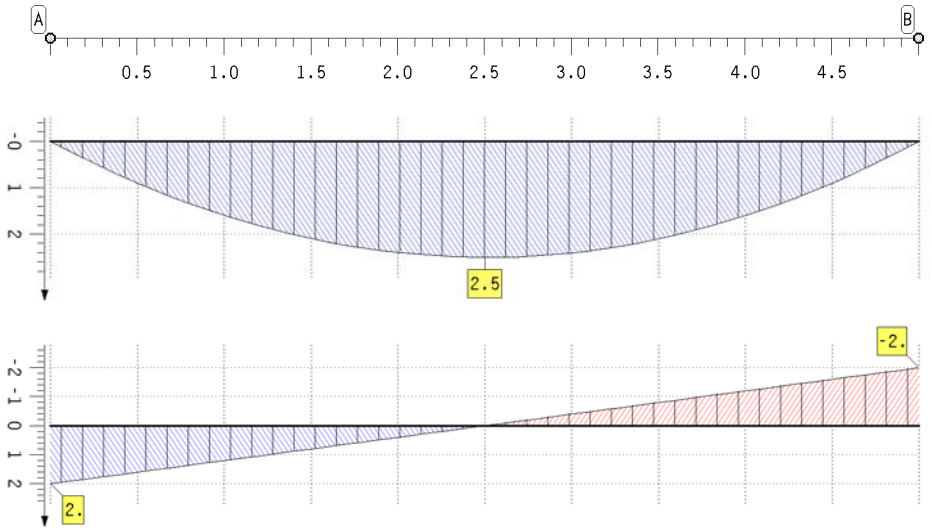


deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 3.70

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	5.000	0.00	0.00
	1.400	2.87	2.87	**minimum**		**0.00**	**0.00**
	2.500	3.70	3.70	**maximum**		**3.70**	**3.70**
	3.600	2.87	2.87				

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 2.50

shear force
main beam
V in kN
Min: -2.00
Max: 2.00

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	2.00	2.00
	1.300	1.92	1.92	0.96	0.96
	2.500	2.50	2.50	-0.00	-0.00
	3.700	1.92	1.92	-0.96	-0.96

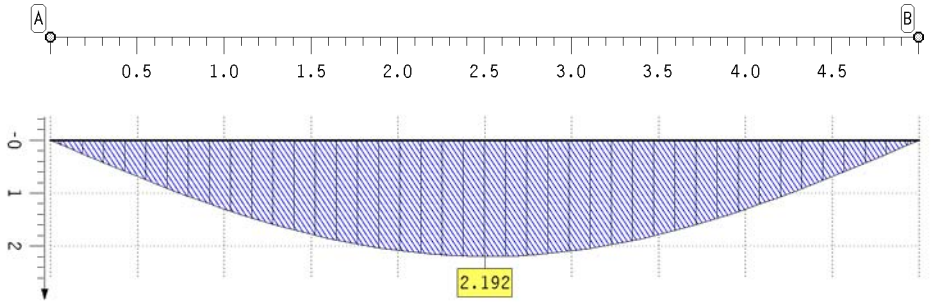
point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	5.000	0.00	0.00	-2.00	-2.00
minimum		**-0.00**	**-0.00**	**-2.00**	**-2.00**
maximum		**2.50**	**2.50**	**2.00**	**2.00**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-2.00	-2.00
B	5.000	-2.00	-2.00

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)



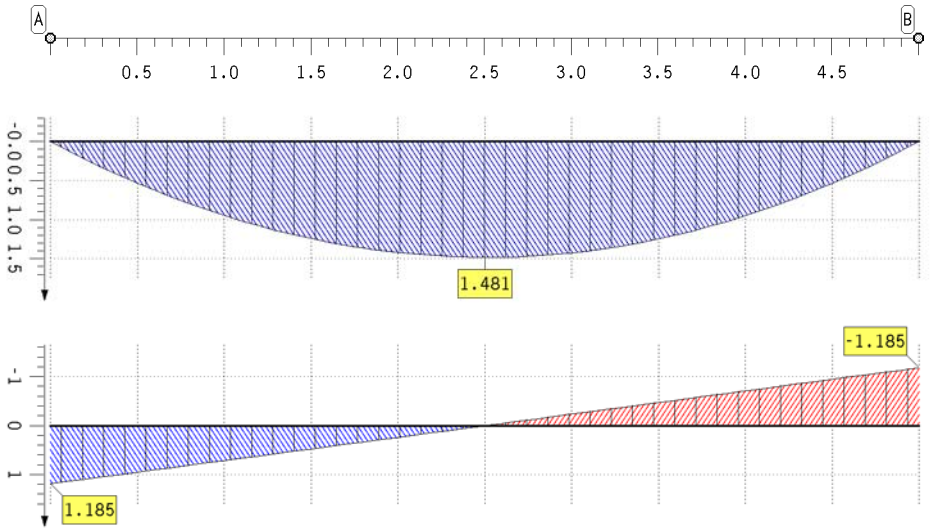
deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 2.19

extremal deflections of main beam (characteristic)

point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.400	0.00	1.70
	2.500	0.00	2.19
	3.600	0.00	1.70

point	x	min w	max w
-	m	mm	mm
B	5.000	0.00	0.00
minimum		**0.00**	**0.00**
maximum		**0.00**	**2.19**

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 1.48

shear force
main beam
V in kN
Min: -1.18
Max: 1.18

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	1.18
	1.300	0.00	1.14	0.00	0.57
	2.500	0.00	1.48	-0.00	-0.00
	3.700	0.00	1.14	-0.57	-0.00
B	5.000	-0.00	-0.00	-1.18	-0.00
minimum		**-0.00**	**-0.00**	**-1.18**	**-0.00**
maximum		**0.00**	**1.48**	**0.00**	**1.18**

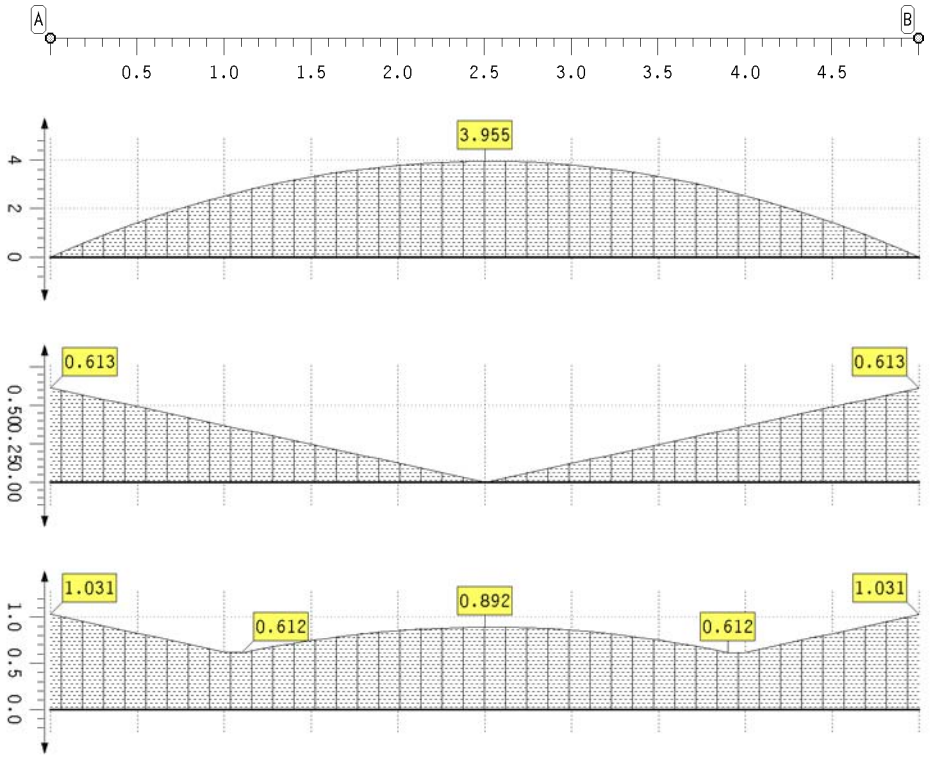
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-1.18	-0.00
B	5.000	-1.18	-0.00

11. Results of verification of ultimate limit state

11.1. Verification of ultimate limit state

results of verification of ultimate limit state

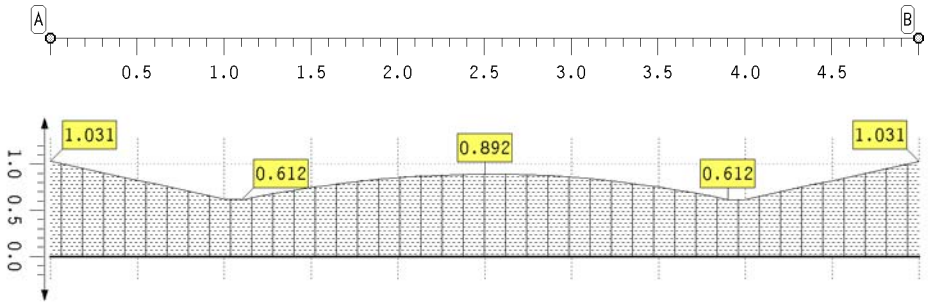


bending stress
main beam
σ_h in MN/m²
Max: 3.96

shear stress
main beam
τ_h in MN/m²
Max: 0.61

utilization
main beam
Max: 1.03

results of verification of ultimate limit state



maximal utilization
Max: 1.03

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	1.031		2.500	0.892	B	5.000	1.031
	1.100	0.612		3.100	0.840	**minimum**		**0.612**
	1.800	0.822		4.000	0.619	**maximum**		**1.031**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-4.48	-2.00
B	5.000	-4.48	-2.00

verification of bearing stress

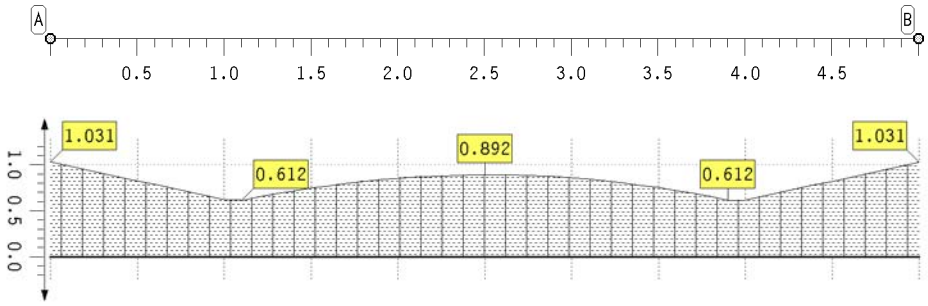
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm^2	N		-	N/mm^2	N/mm^2	-
A	180	5400	2700	1.00	0.30	0.58	0.50	0.87
B	180	5400	2700	1.00	0.30	0.58	0.50	0.87

verification of bearing stresses für den main beam(u = 0.867) successful!

12. Summary

12.1. Summary of all verifications

maximal utilization



utilization
Max: 1.03

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	1.031		2.500	0.892	B	5.000	1.031
	1.100	0.612		3.100	0.840	**minimum**		**0.612**
	1.800	0.822		4.000	0.619	**maximum**		**1.031**

verification of bearing stress

support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm^2	N		-	N/mm^2	N/mm^2	-
A	180	5400	2700	1.00	0.30	0.58	0.50	0.87
B	180	5400	2700	1.00	0.30	0.58	0.50	0.87

verification of bearing stresses für den main beam(u = 0.867) successful!

13. Utilizations of all verifications

verification of load-carrying capacity (u = 1.031) 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 kNm	V kN	M_1 Nmm	N_1 N	M_2 Nmm	N_2 N	M_3 Nmm	N_3 N
start,min	-0.00	2.00	-0	0	-0	0	-0	-0
start,max	-0.00	2.70	-0	0	-0	0	-0	-0
end,min	-0.00	2.00	-0	0	-0	0	-0	-0
end,max	-0.00	2.70	-0	0	-0	0	-0	-0

stresses and utilization web

state	$k_{mod,2}$ -	$\sigma_{m,2}$ N/mm²	$\sigma_{c,2}$ N/mm²	$u_{\sigma,2}$ -	τ_2 N/mm²	u_τ -	u_2 -
start	0.3	0.00	0.00	**0.00**	0.37	0.18	0.18
end	0.3	0.00	0.00	0.00	0.36	0.18	0.18

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	0.6	0.00	0.00	**0.00**	0.6	0.00	-0.00	0.00
end	0.6	0.00	0.00	0.00	0.6	0.00	-0.00	**0.00**

fastener

state	$F_{1,d}$ N	$u_{1,d}$ -	$F_{2,d}$ N	$u_{2,d}$ -
start	-191	**0.83**	191	**0.83**
end	-191	0.83	191	0.83

resulting utilization at verification point u_{res} = 0.178

14.2. Verification of load-carrying capacity at x = 1.50 m

internal forces and moments

state	M kNm	V kN	M_1 Nmm	N_1 N	M_2 Nmm	N_2 N	M_3 Nmm	N_3 N
start,min	2.10	0.80	39020	-7435	237540	-0	39020	7435
start,max	4.70	1.79	87356	-16645	531793	-0	87356	16645
end,min	2.10	0.80	50550	-7411	220271	-0	50550	7411
end,max	4.70	1.79	113169	-16591	493132	-0	113169	16591

stresses and utilization web

state	$k_{mod,2}$ -	$\sigma_{m,2}$ N/mm²	$\sigma_{c,2}$ N/mm²	$u_{\sigma,2}$ -	τ_2 N/mm²	u_τ -	u_2 -
start	0.6	1.18	0.00	**0.12**	0.25	0.06	0.12
end	0.6	1.10	0.00	0.11	0.24	0.06	0.11

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	1.04	-1.98	**0.75**	0.8	1.04	1.98	**0.22**
end	0.8	1.35	-1.98	0.75	0.8	1.35	1.98	0.22

fastener

state	$F_{1,d}$ N	$u_{1,d}$ -	$F_{2,d}$ N	$u_{2,d}$ -
start	-127	**0.41**	127	**0.41**
end	-126	0.41	126	0.41

resulting utilization at verification point u_{res} = 0.749

14.3. Verification of load-carrying capacity at x = 2.50 m

internal forces and moments

state	M kNm	V kN	M_1 Nmm	N_1 N	M_2 Nmm	N_2 N	M_3 Nmm	N_3 N
start,min	2.50	-0.00	46452	-8851	282786	-0	46452	8851
start,max	5.60	-0.00	103995	-19816	633087	-0	103995	19816
end,min	2.50	-0.00	60179	-8823	262228	-0	60179	8823
end,max	5.60	-0.00	134725	-19752	587062	-0	134725	19752

stresses and utilization web

state	$k_{mod,2}$ -	$\sigma_{m,2}$ N/mm²	$\sigma_{c,2}$ N/mm²	$u_{\sigma,2}$ -	τ_2 N/mm²	u_τ -	u_2 -
start	0.6	1.41	0.00	**0.14**	0.00	0.00	0.14
end	0.6	1.30	0.00	0.13	0.00	0.00	0.13

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	1.24	-2.36	**0.89**	0.8	1.24	2.36	**0.26**
end	0.8	1.60	-2.35	0.89	0.8	1.60	2.35	0.26

resulting utilization at verification point u_{res} = 0.892

14.4. Verification of load-carrying capacity at x = 5.00 m

internal forces and moments

state	M kNm	V kN	M_1 Nmm	N_1 N	M_2 Nmm	N_2 N	M_3 Nmm	N_3 N
start,min	0.00	-4.48	0	-0	0	-0	0	0
start,max	0.00	-2.00	0	-0	0	-0	0	0
end,min	0.00	-4.48	0	-0	0	-0	0	0
end,max	0.00	-2.00	0	-0	0	-0	0	0

stresses and utilization web

state	$k_{mod,2}$ -	$\sigma_{m,2}$ N/mm²	$\sigma_{c,2}$ N/mm²	$u_{\sigma,2}$ -	τ_2 N/mm²	u_τ -	u_2 -
start	0.6	0.00	0.00	**0.00**	0.61	0.16	0.16
end	0.6	0.00	0.00	0.00	0.60	0.16	0.16

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

fastener

state	$F_{1,d}$ N	$u_{1,d}$ -	$F_{2,d}$ N	$u_{2,d}$ -
start	-317	**1.03**	317	**1.03**
end	-316	1.03	316	1.03

resulting utilization at verification point u_{res} = 1.031