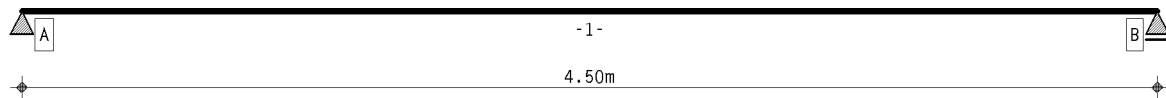


1. Options for Calculations

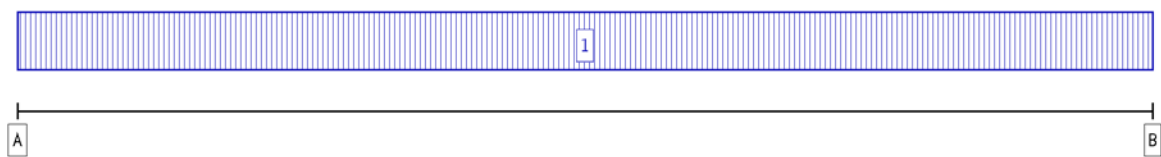
calculation acc. to DIN 1052:2008
service class 2

2. Structural system

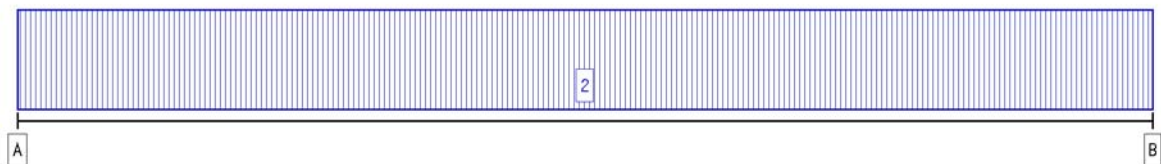


main beam

3. Loading



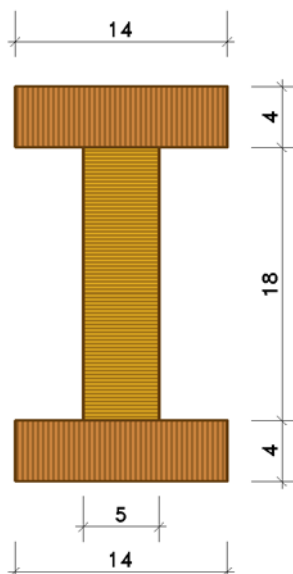
action effect 1: permanent loads (permanent, 1 load cases)



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

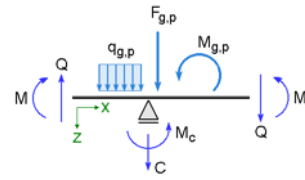
4. main beam

section scale 1: 5



timber grade top flange		solid coniferous timber, C24 (S10)
char. bend. strength $f_{m,k}$	: 24.0 N/mm ²	
char. shear strength $f_{v,k}$	: 2.0 N/mm ²	
char. ten. strength $f_{t,k}$	: 14.0 N/mm ²	
char. compr. strength $f_{c,0,k}$	: 21.0 N/mm ²	
char. compr. strength $f_{c,90,k}$	: 2.5 N/mm ²	
modulus of elasticity $E_{0,mean}$	: 11000 N/mm ²	
Dichte ρ_k/ρ_m	: 350 / 420 kg/m ³	
deformation factor k_{def}	: 0.60 -	
area A_{flange}	: 56.000 cm ²	
moment of inertia I_{flange}	: 74.667 cm ⁴	
timber grade web		solid coniferous timber, C24 (S10)
char. bend. strength $f_{m,k}$	: 24.0 N/mm ²	
char. shear strength $f_{v,k}$	: 2.0 N/mm ²	
char. ten. strength $f_{t,k}$	: 14.0 N/mm ²	
char. compr. strength $f_{c,0,k}$	: 21.0 N/mm ²	
char. compr. strength $f_{c,90,k}$	: 2.5 N/mm ²	
modulus of elasticity $E_{0,mean}$	: 11000 N/mm ²	
Dichte ρ_k/ρ_m	: 350 / 420 kg/m ³	
deformation factor k_{def}	: 0.60 -	
area A_{flange}	: 90.000 cm ²	
moment of inertia I_{flange}	: 2430.000 cm ⁴	
timber grade bottom flange		solid coniferous timber, C24 (S10)
char. bend. strength $f_{m,k}$	: 24.0 N/mm ²	
char. shear strength $f_{v,k}$	: 2.0 N/mm ²	
char. ten. strength $f_{t,k}$	: 14.0 N/mm ²	
char. compr. strength $f_{c,0,k}$	: 21.0 N/mm ²	
char. compr. strength $f_{c,90,k}$	: 2.5 N/mm ²	
modulus of elasticity $E_{0,mean}$	: 11000 N/mm ²	
Dichte ρ_k/ρ_m	: 350 / 420 kg/m ³	
deformation factor k_{def}	: 0.60 -	
area A_{flange}	: 56.000 cm ²	
moment of inertia I_{flange}	: 74.667 cm ⁴	

definition of internal forces and moments:



5. Beam sections

beam sections

section	x_A m	x_E m	l m	l_{ef} m	l_z mm	k -	λ -	$\lambda_{rel,c}$ -	k_c -	l_v m	cant.11.	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	$E I_{ef,inst}$ Nmm ²	ϕ k_{def} -
1	1.0000	-0.0	1	1.0000	-110.0	1	1.0000	110.0	1.7744E12	0.6000

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	$E I_{ef,inst}$ Nmm ²	$I_{ef,inst}$ mm ²	$h_{q,inst}$ 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	$E I_{ef,inf}$ Nmm ²	$I_{ef,inf}$ mm ²	$h_{q,inf}$ mm	$A_{q,inf}$ mm
1	1.0000	-0.0	1	1.0000	-110.0	1	1.0000	110.0	1.1090E12	161313328.0	9.00	86.67

net section properties

section	$A_{n,2}$ cm ²	$W_{n,2}$ cm ³	$I_{n,2}$ cm ⁴	$A_{n,1}$ cm ²	$W_{n,1}$ cm ³	$I_{n,1}$ cm ⁴	$A_{n,3}$ cm ²	$W_{n,3}$ cm ³	$I_{n,3}$ cm ⁴
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 $x_E = 4.50$ m, glued joint

7. Supports

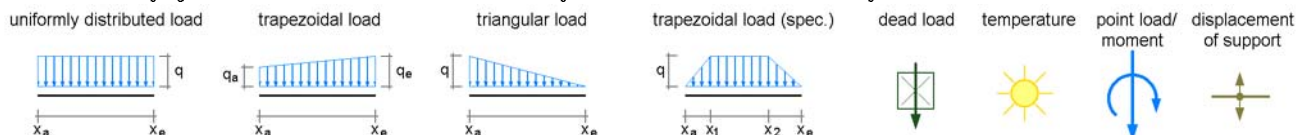
coordinates of supports

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

8. Action effects

Attention! Acc. to DIN 1052, 8.6.2 (2)

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: $q = 1.50$ 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: DIN 1052:2008 load-carrying capacity

buckling analysis of compression flange acc. to DIN 1052, 10.3.1 will be executed

verification of bearing stress DIN 1052, 10.2.4 will be executed

Extreme rule 1

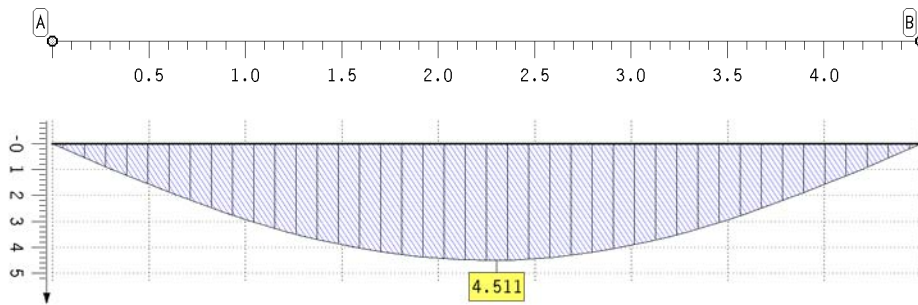
2: DIN 1052:2008 deformations (rarely)

3: DIN 1052:2008 deformations (quasicontinuous)

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

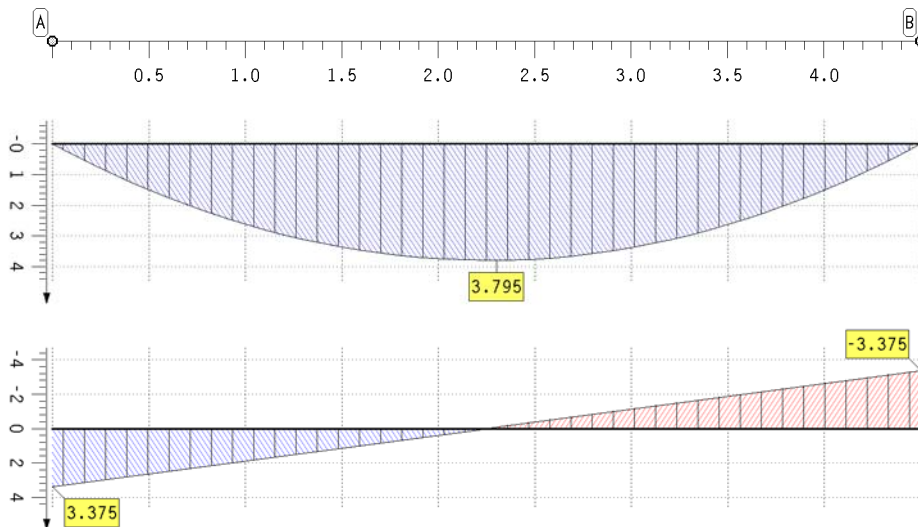


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 4.51

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

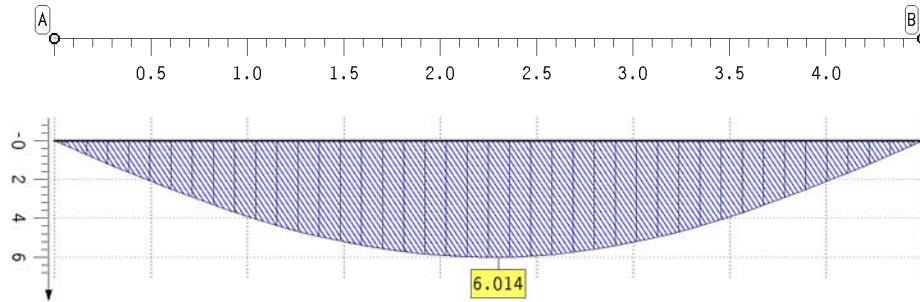
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	3.38	3.38	B	4.500	0.00	0.00	-3.38	-3.38
	1.100	2.81	2.81	1.73	1.73	minimum		0.00	0.00	-3.38	-3.38
	2.200	3.80	3.80	0.08	0.08	maximum		3.80	3.80	3.38	3.38
	3.400	2.81	2.81	-1.73	-1.73						

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)

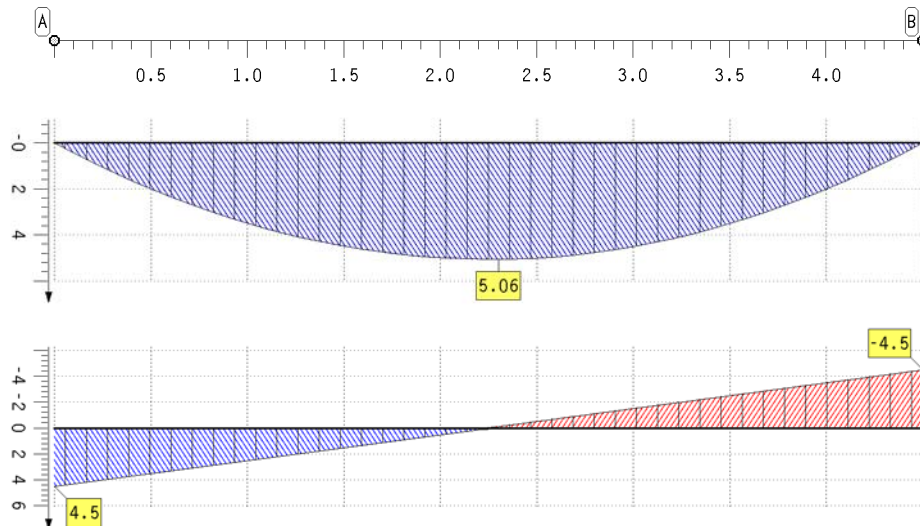


deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 6.01

extremal deflections of main beam (characteristic)

point	x	min w	max w	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	0.00	4.50	minimum		0.00	0.00
	2.200	0.00	6.01	maximum		0.00	6.01
	3.200	0.00	4.77				

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	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	0.00	4.50	B	4.500	0.00	0.00	-4.50	-0.00
	1.100	0.00	3.74	0.00	2.30	minimum		0.00	0.00	-4.50	-0.00
	2.200	0.00	5.06	0.00	0.10	maximum		0.00	5.06	0.00	4.50
	3.400	0.00	3.74	-2.30	-0.00						

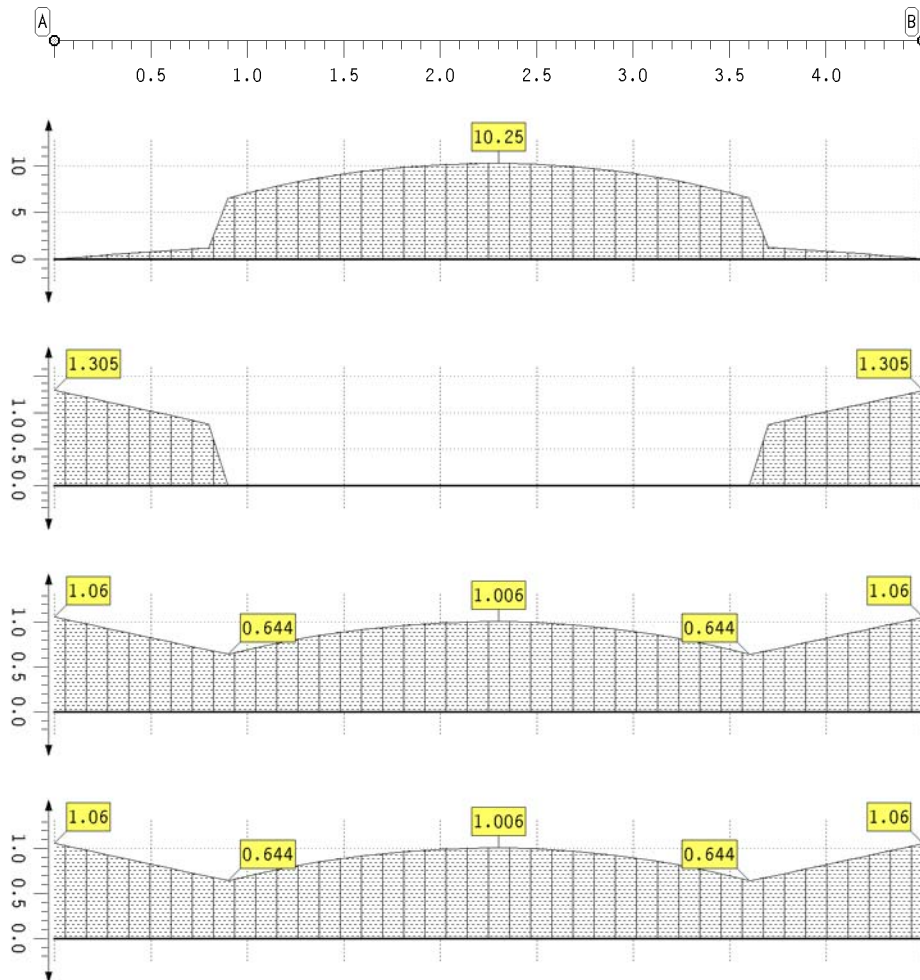
extremal support forces

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

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	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	1.060		2.300	1.006	B	4.500	1.060
	0.900	0.644		2.900	0.923	minimum		0.644
	1.600	0.923		3.600	0.644	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

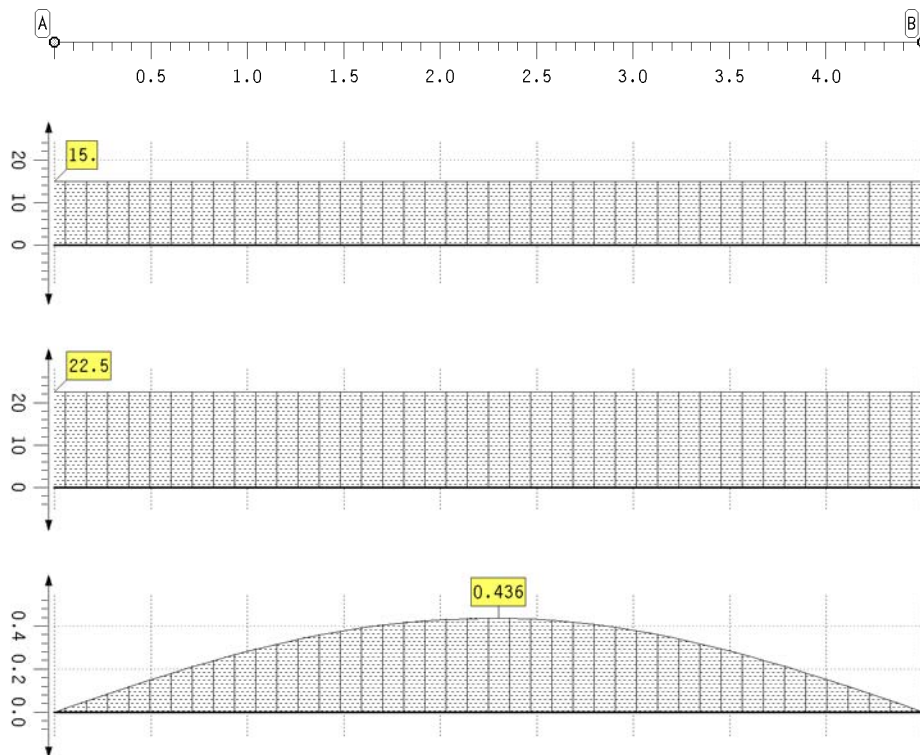
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm ²	N			N/mm ²	N/mm ²	-
A	180	25200	11306	1.25	0.80	1.54	0.45	0.23
B	180	25200	11306	1.25	0.80	1.54	0.45	0.23

verification of bearing stresses für den main beam(u = 0.233) successful!

12. Results of verification of deflections (rarely)

12.1. Verification of deflections (rarely)

results of verification of deflections (rarely)



decisive
deflection
WA,req in mm
Min: 15.00
Max: 15.00

decisive
deflection
WB,req in mm
Min: 22.50
Max: 22.50

maximal
utilization
Max: 0.44

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	0.000	B	4.500	0.000
	1.200	0.326	minimum		0.000
	2.200	0.436	maximum		0.436
	3.200	0.345			

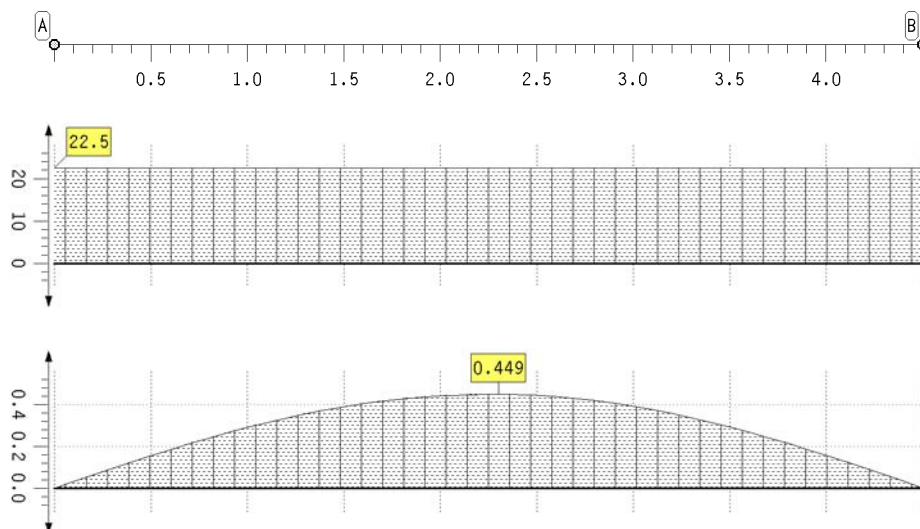
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-7.34	-0.00
B	4.500	-7.34	-0.00

13. Results of verification of deflections (quasicontinuous)

13.1. Verification of deflections (quasicontinuous)

results of verification of deflections (quasicontinuous)



decisive
deflection
Wreq in mm
Min: 22.50
Max: 22.50

maximal
utilization
Max: 0.45

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	0.000	B	4.500	0.000
	1.200	0.336	minimum		0.000
	2.200	0.449	maximum		0.449
	3.200	0.356			

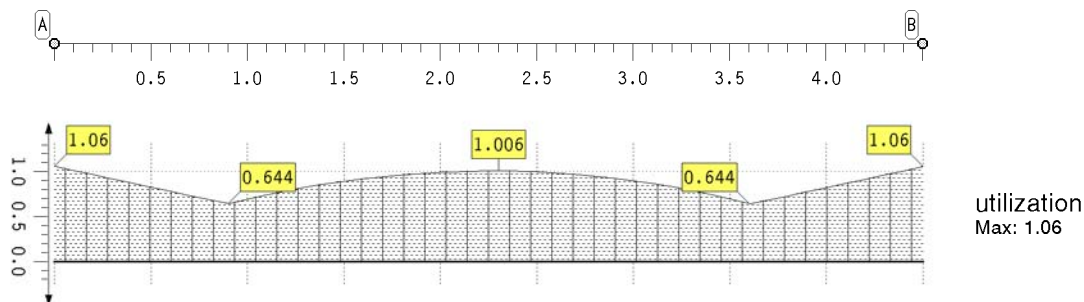
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-7.56	-5.40
B	4.500	-7.56	-5.40

14. Summary

14.1. Summary of all verifications

maximal utilization



maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	1.060		2.300	1.006	B	4.500	1.060
	0.900	0.644		2.900	0.923	minimum		0.644
	1.600	0.923		3.600	0.644	maximum		1.060

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	25200	11306	1.25	0.80	1.54	0.45	0.23
B	180	25200	11306	1.25	0.80	1.54	0.45	0.23

verification of bearing stresses für den main beam(u = 0.233) successful!

15. Utilizations of all verifications

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

16. Detailed verification piont

16.1. 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/mm ²	N/mm ²	-	N/mm ²	-	-
start	0.8	0.00	0.00	0.00	1.30	1.06	1.06
end	0.8	0.00	0.00	0.00	1.30	1.06	1.06

stresses and utilization flanges

state	$k_{mod,1}$ -	$\sigma_{m,1}$ N/mm ²	$\sigma_{c,1}$ N/mm ²	u_1 -	$k_{mod,3}$ -	$\sigma_{m,3}$ N/mm ²	$\sigma_{c,3}$ N/mm ²	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 $f_{v1,d} = 1.231 \text{ N/mm}^2$

state	$S_{1,d}$ cm ²	$\tau_{1,d}$ N/mm ²	$u_{1,d}$ -	$S_{2,d}$ cm ²	$\tau_{2,d}$ N/mm ²	$u_{2,d}$ -
start	616	0.8635	0.70	616	0.8635	0.70
end	616	0.8635	0.70	616	0.8635	0.70

resulting utilization at verification point $u_{res} = 1.060$