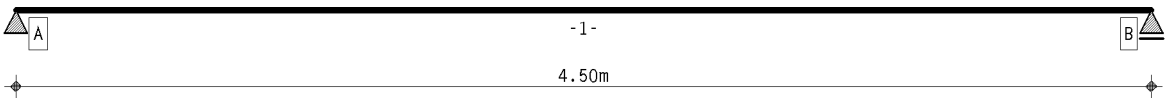
1. Options for Calculations

calculation acc. to DIN 1052:2008

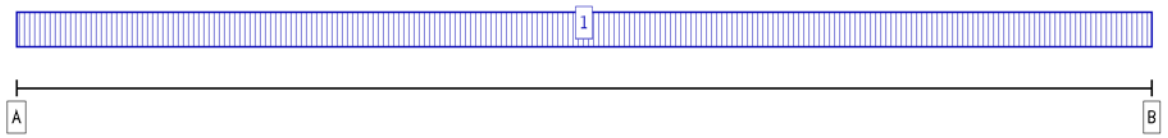
service class 2

2. Structural system

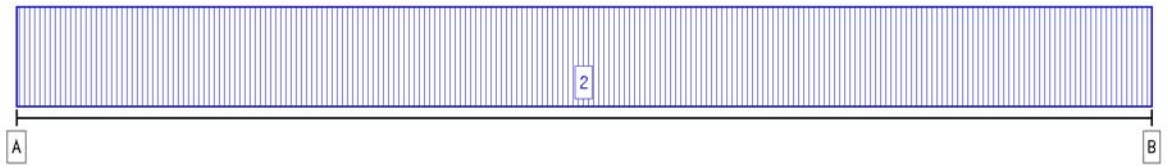


main beam

3. Loading



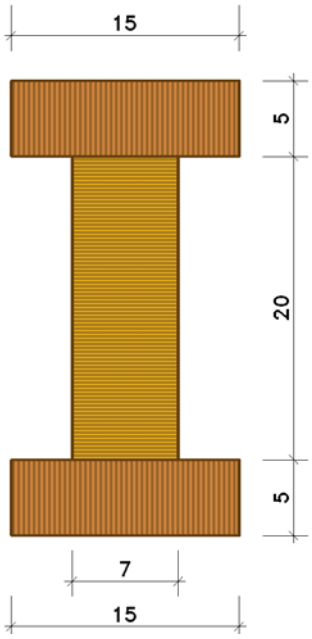
action effect 1: permanent loads (permanent, 1 load cases)



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

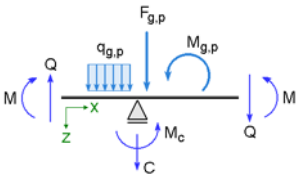
4. main beam

section scale 1: 5



timber grade top flange			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	2.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.0 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}	:	75.000 cm²
moment of inertia	I_{flange}	:	156.250 cm⁴
timber grade web			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	2.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.0 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}	:	140.000 cm²
moment of inertia	I_{flange}	:	4666.667 cm⁴
timber grade bottom flange			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	2.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.0 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}	:	75.000 cm²
moment of inertia	I_{flange}	:	156.250 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	1.13	43.3500	0.6130	26.0669	0.4440	0.9656	4.50	-	42.0

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	1375	0.4488	-125.0	1375	0.4488	125.0	1.7048E12	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	$EI_{ef,inst}$ Nmm2	$I_{ef,inst}$ mm2	$h_{q,inst}$ mm	$A_{q,inst}$ mm
1	1.0000	0.0	917	0.3518	-125.0	917	0.3518	125.0	1.4548E12	132252832.0	10.00	136.17

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	573	0.3518	-125.0	573	0.3518	125.0	9.0924E11	132252832.0	10.00	136.17

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	135.46	466.67	4666.67	73.11	62.50	156.25	73.11	62.50	156.25

6. Fasteners

section 1 from x_A = 0.00 m to x_E = 4.50
nail, 4.2 x 110.0 mm, d_k = 8.4 mm, predrilled
1-row with a_1 = **42.0 mm**
1 - row, simplified verification acc. to DIN 1052:2008, 12.2(2)
nail ends in timber member 2, penetration depth t = 60 mm > 4 d = 17 mm, 1 shear plane
f_{uk} = 600 N/mm², M_{yk} = 7511 Nmm
K_{ser} = 1375 N/mm, γ_M = 1.10, **R_k = 1317.1 N, all values per shear plane**

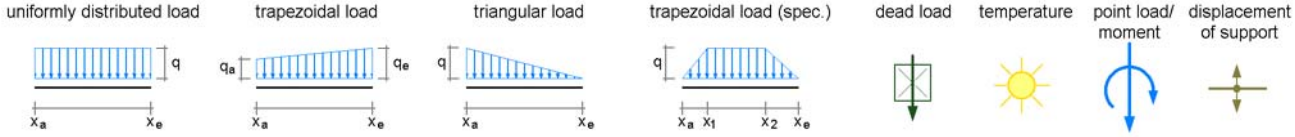
7. Supports

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	150	fix	----	X	-
B	4.50	150	150	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 = 0.90 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

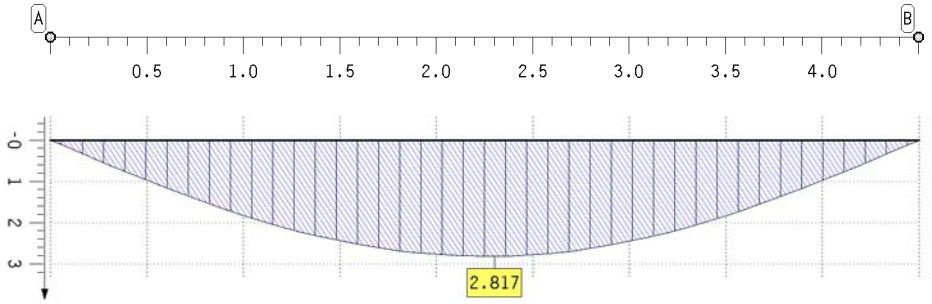
2: DIN 1052:2008 deformations (rarely)
Extreme rule 1

3: DIN 1052:2008 deformations (quasicontinuous)
Extreme rule 1

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

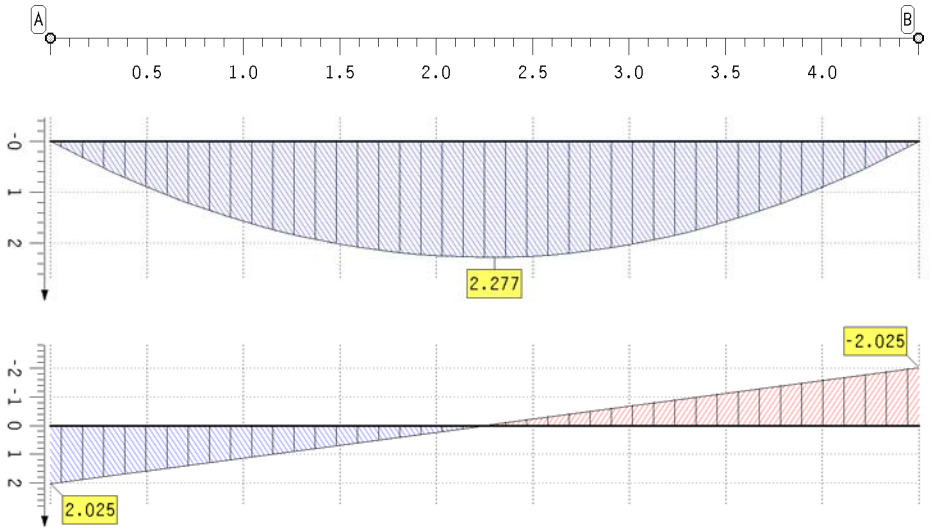


deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 2.82

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	2.11	2.11	**minimum**		**0.00**	**0.00**
	2.200	2.82	2.82	**maximum**		**2.82**	**2.82**
	3.200	2.23	2.23				

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 2.28

shear force
main beam
V in kN
Min: -2.03
Max: 2.03

extremal internal forces

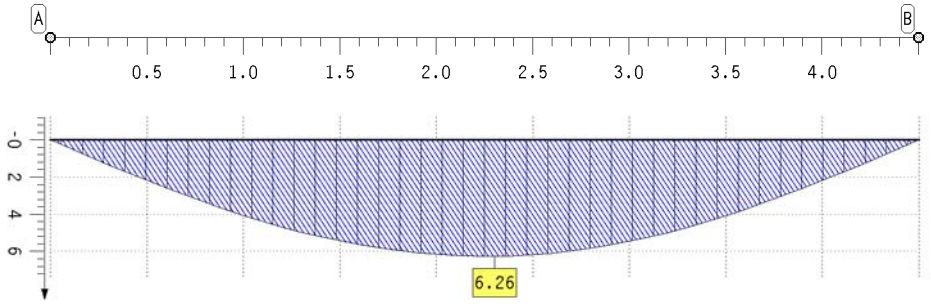
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	2.03	2.03	B	4.500	-0.00	-0.00	-2.03	-2.03
	1.100	1.68	1.68	1.03	1.03	**minimum**		**-0.00**	**-0.00**	**-2.03**	**-2.03**
	2.200	2.28	2.28	0.05	0.05	**maximum**		**2.28**	**2.28**	**2.03**	**2.03**
	3.400	1.68	1.68	-1.03	-1.03						

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-2.03	-2.03
B	4.500	-2.03	-2.03

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)



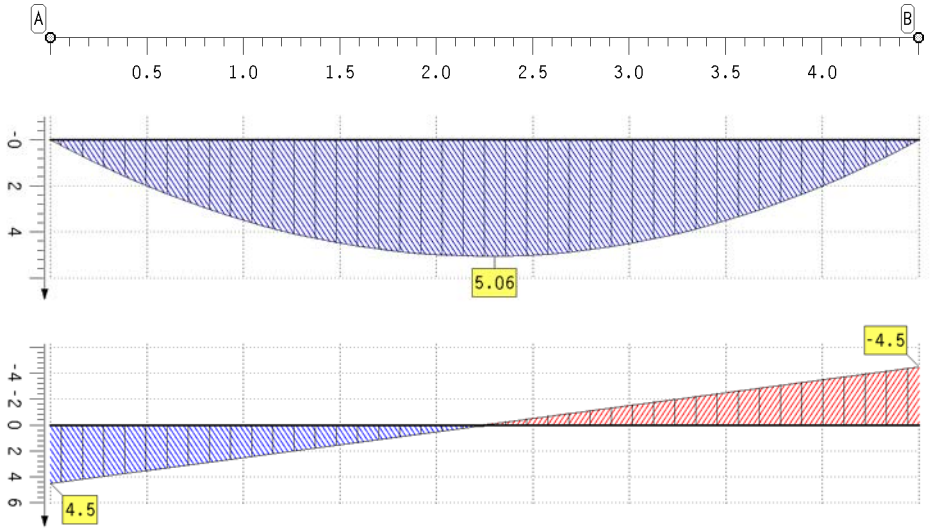
deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 6.26

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	4.69
	2.200	0.00	6.26
	3.200	0.00	4.96

point	x	min w	max w
-	m	mm	mm
B	4.500	0.00	0.00
minimum		**0.00**	**0.00**
maximum		**0.00**	**6.26**

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**

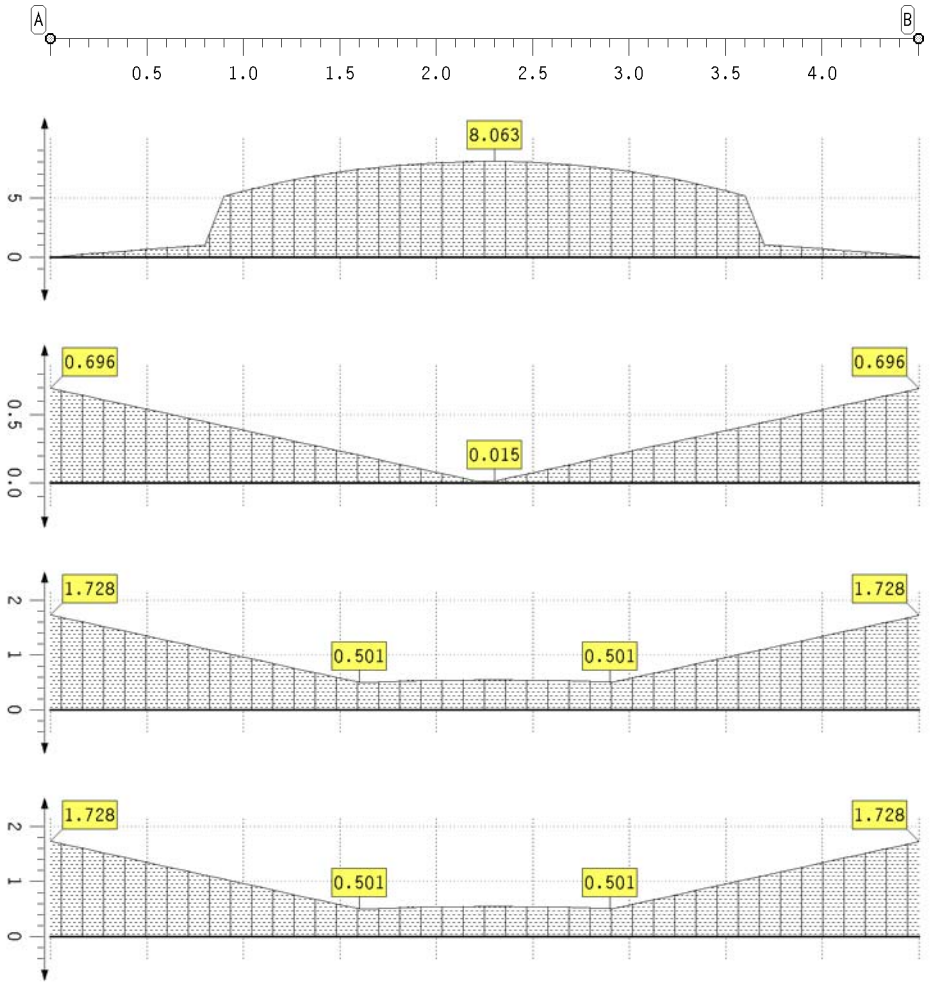
extremal support forces

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

results of verification of ultimate limit state



bending stress
main beam
σ_h in MN/m²
Max: 8.06

shear stress
main beam
τ_h in MN/m²
Max: 0.70

utilization
main beam
Max: 1.73

maximal
utilization
Max: 1.73

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	1.728	B	4.500	1.728
	1.600	0.501	**minimum**		**0.501**
	2.900	0.501	**maximum**		**1.728**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-9.48	-2.03
B	4.500	-9.48	-2.03

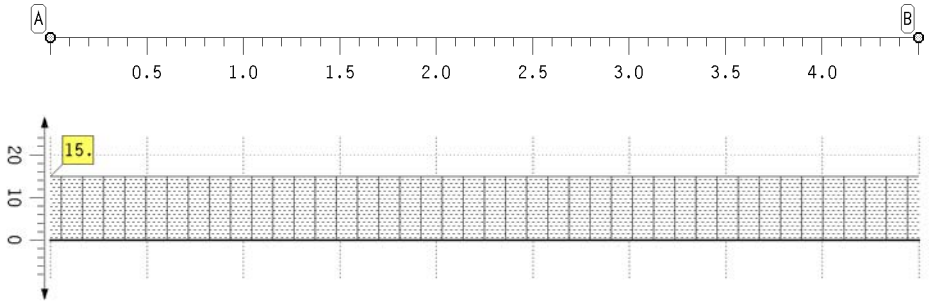
verification of bearing stress

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	27000	9484	1.25	0.80	1.54	0.35	0.18
B	180	27000	9484	1.25	0.80	1.54	0.35	0.18

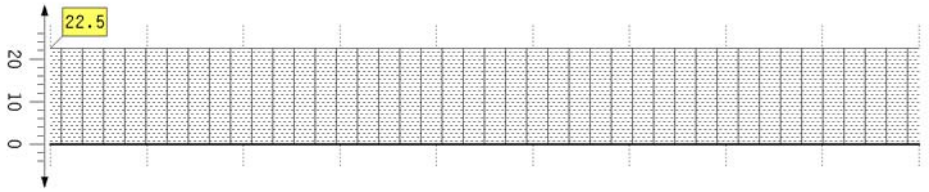
verification of bearing stresses für den main beam(u = 0.183) successful!

12. Results of verification of deflections (rarely)

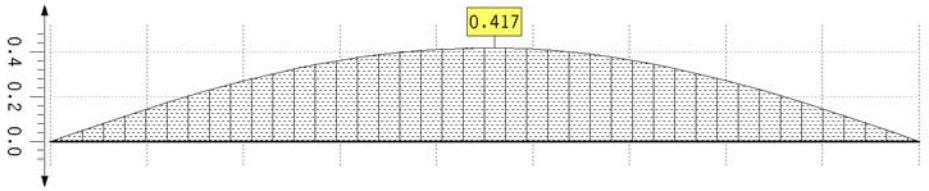
12.1. Verification of deflections (rarely)
results of verification of deflections (rarely)



decisive deflection $w_{A,req}$ in mm
Min: 15.00
Max: 15.00



decisive deflection $w_{B,req}$ in mm
Min: 22.50
Max: 22.50



maximal utilization
Max: 0.42

maximal utilization

point	x	U
-	m	-
A	0.000	0.000
	1.200	0.312
	2.200	0.417
	3.200	0.331

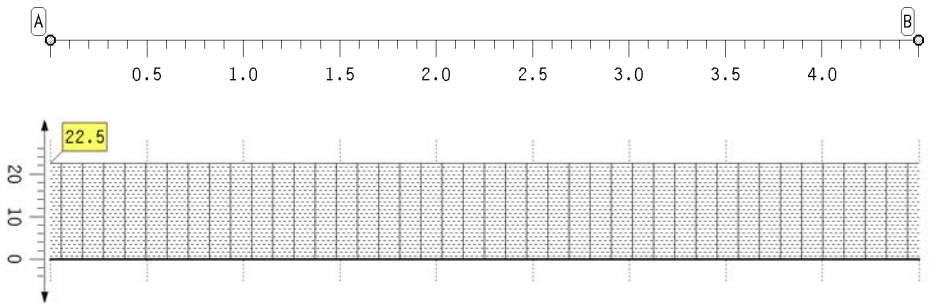
point	x	U
-	m	-
B	4.500	0.000
minimum		**0.000**
maximum		**0.417**

extremal support forces

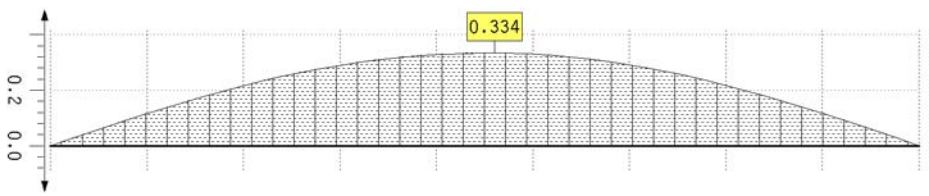
point	x	min AP	max AP
-	m	kN	kN
A	0.000	-6.53	-0.00
B	4.500	-6.53	-0.00

13. Results of verification of deflections (quasicontinuous)

13.1. Verification of deflections (quasicontinuous)
results of verification of deflections (quasicontinuous)



decisive deflection w_{req} in mm
Min: 22.50
Max: 22.50



maximal utilization
Max: 0.33

maximal utilization

point	x	U
-	m	-
A	0.000	0.000
	1.200	0.250
	2.200	0.334
	3.200	0.265

point	x	U
-	m	-
B	4.500	0.000
minimum		**0.000**
maximum		**0.334**

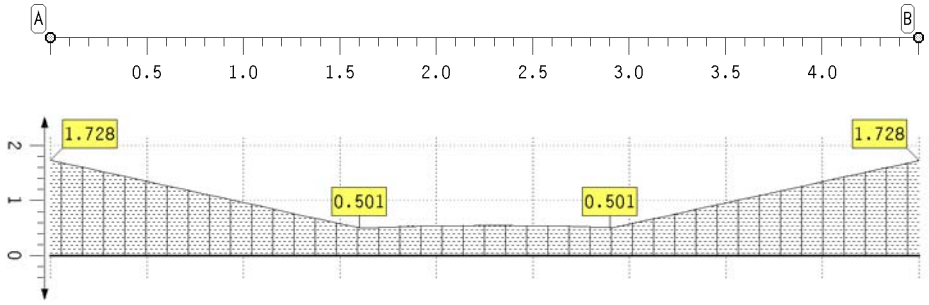
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-5.40	-3.24
B	4.500	-5.40	-3.24

14. Summary

14.1. Summary of all verifications

maximal utilization



utilization
Max: 1.73

maximal utilization

point	x	U
-	m	-
A	0.000	1.728
	1.600	0.501
	2.900	0.501

point	x	U
-	m	-
B	4.500	1.728
minimum		**0.501**
maximum		**1.728**

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	27000	9484	1.25	0.80	1.54	0.35	0.18
B	180	27000	9484	1.25	0.80	1.54	0.35	0.18

verification of bearing stresses für den main beam(u = 0.183) successful!

15. Utilizations of all verifications

verification of load-carrying capacity (u = 1.728) 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	2.03	0	-0	0	-0	0	0
start,max	0.00	9.48	0	-0	0	-0	0	0
end,min	0.00	2.03	0	-0	0	-0	0	0
end,max	0.00	9.48	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**	0.70	0.57	0.57
end	0.8	0.00	0.00	0.00	0.70	0.57	0.57

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	-993	**1.23**	993	**1.23**
end	-993	1.23	993	1.23

resulting utilization at verification point u_{res} = 1.728