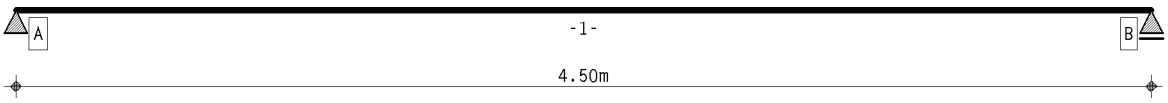
1. Options for Calculations

calculation acc. to DIN 1052:2008

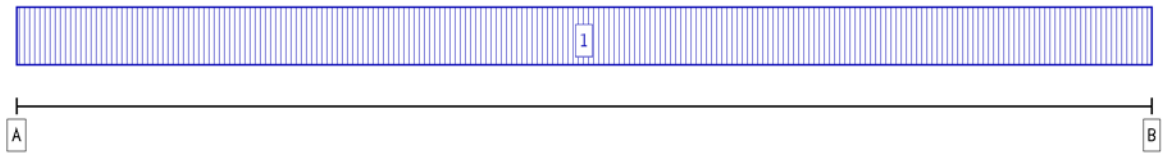
service class 2

2. Structural system

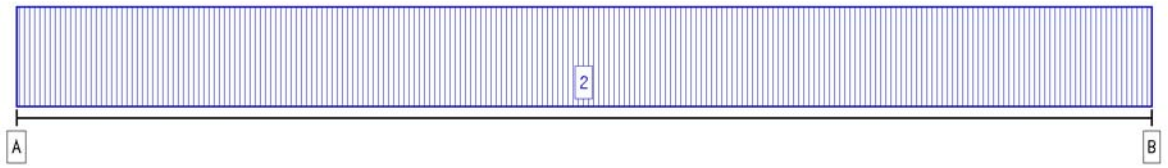


main beam

3. Loading



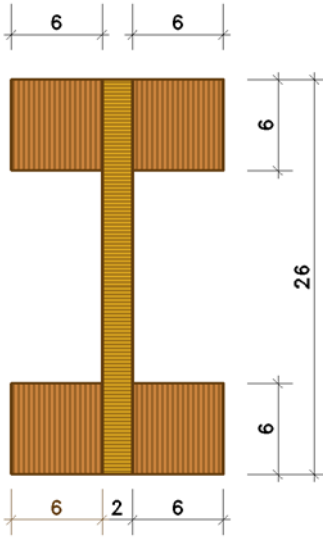
action effect 1: permanent loads (permanent, 1 load cases)



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

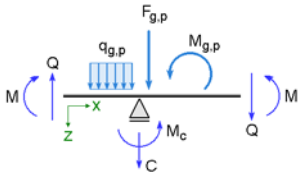
4. main beam

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}	:	72.000 cm²
moment of inertia	I_{flange}	:	216.000 cm⁴
timber grade web (fibre ll)			**plywood F40/30**
d = 20.0 mm (hochkant)			
char. bend. strength	$f_{m,k}$	:	29.0 N/mm²
char. shear strength	$f_{v,k}$	:	9.5 N/mm²
char. ten. strength	$f_{t,k}$	:	29.0 N/mm²
char. compr. strength	$f_{c,0,k}$	:	21.0 N/mm²
char. compr. strength	$f_{c,90,k}$	:	9.0 N/mm²
e-modulus	$E_{0,mean}$ (diaphragm)	:	4400 N/mm²
e-modulus	$E_{0,mean}$ (plate)	:	6000 N/mm²
Dichte	ρ_k / ρ_m	:	600 / 720 kg/m³
deformation factor	k_{def}	:	0.80 -
area	A_{flange}	:	52.000 cm²
moment of inertia	I_{flange}	:	2929.333 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}	:	72.000 cm²
moment of inertia	I_{flange}	:	216.000 cm⁴

definition of internal forces and moments:



5. Beam sections

beam sections

section	x_A m	x_E m	l m	l_v m	cantil.	s_{ef} mm
1	0.00	4.50	4.50	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	-100.0	1	1.0000	100.0	1.7604E12	0.6131

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	-100.0	1	1.0000	100.0	1.7604E12	160037328.0	13.00	34.67

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	-100.0	1	1.0000	100.0	1.0913E12	158735408.0	13.00	34.67

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	52.00	225.33	2929.33	72.00	72.00	216.00	72.00	72.00	216.00

6. Fasteners

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

7. Supports

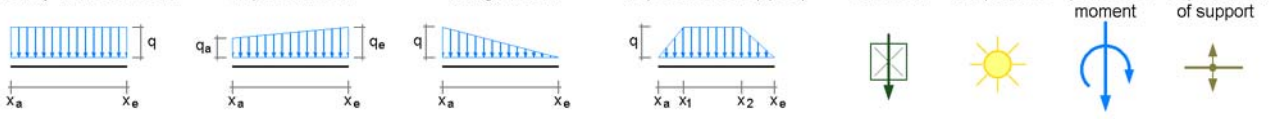
coordinates of supports

supp.name	x m	width mm	depth mm	c_F kN/m	c_M kNm/-	restraint (F)	restraint (M)
A	0.00	150	20	fix	----	X	-
B	4.50	150	20	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

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: DIN 1052:2008 load-carrying capacity
verification of buckling resistance acc. to DIN 1052, 10.5.1(3) will be executed
verification of bearing stress DIN 1052, 10.2.4 will be executed
Extreme rule 1

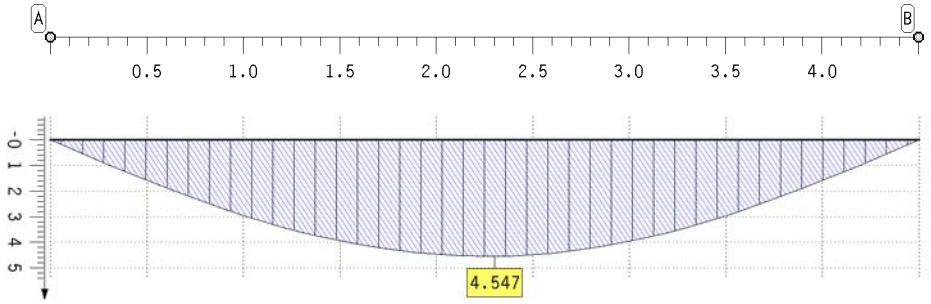
2: DIN 1052:2008 deformations (rarely)
Extreme rule 1

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)



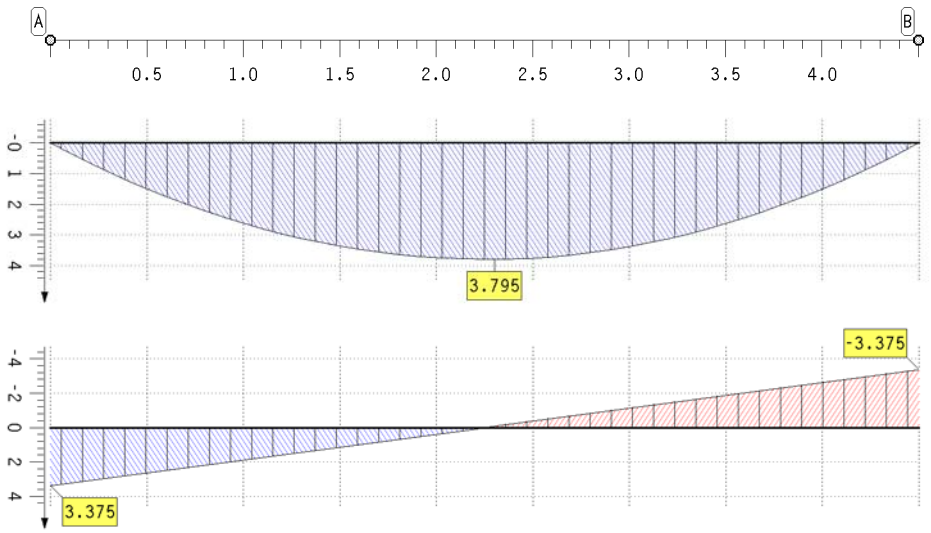
deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 4.55

extremal deflections of main beam (characteristic)

point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.200	3.40	3.40
	2.200	4.55	4.55
	3.200	3.61	3.61

point	x	min w	max w
-	m	mm	mm
B	4.500	0.00	0.00
minimum		**0.00**	**0.00**
maximum		**4.55**	**4.55**

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
-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	3.38	3.38
	1.100	2.81	2.81	1.73	1.73
	2.200	3.80	3.80	0.08	0.08
	3.400	2.81	2.81	-1.73	-1.73

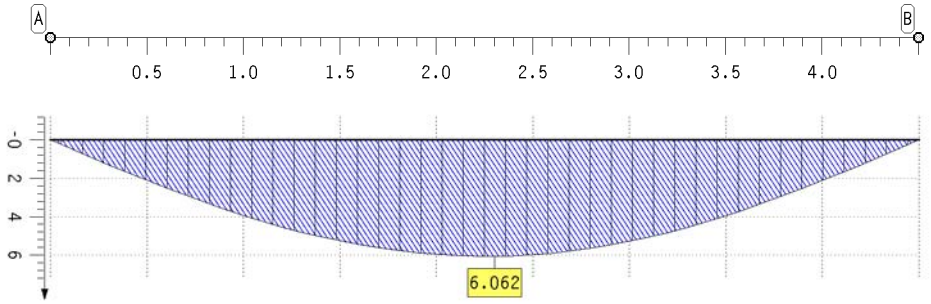
point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	4.500	0.00	0.00	-3.38	-3.38
minimum		**0.00**	**0.00**	**-3.38**	**-3.38**
maximum		**3.80**	**3.80**	**3.38**	**3.38**

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)



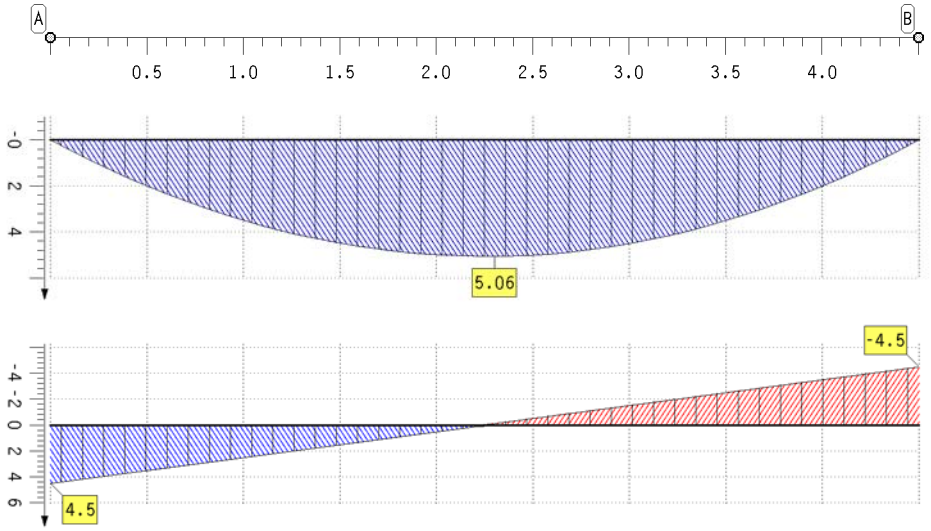
deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 6.06

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	4.54
	2.200	0.00	6.06
	3.200	0.00	4.81

point	x	min w	max w
-	m	mm	mm
B	4.500	0.00	0.00
minimum		**0.00**	**0.00**
maximum		**0.00**	**6.06**

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**

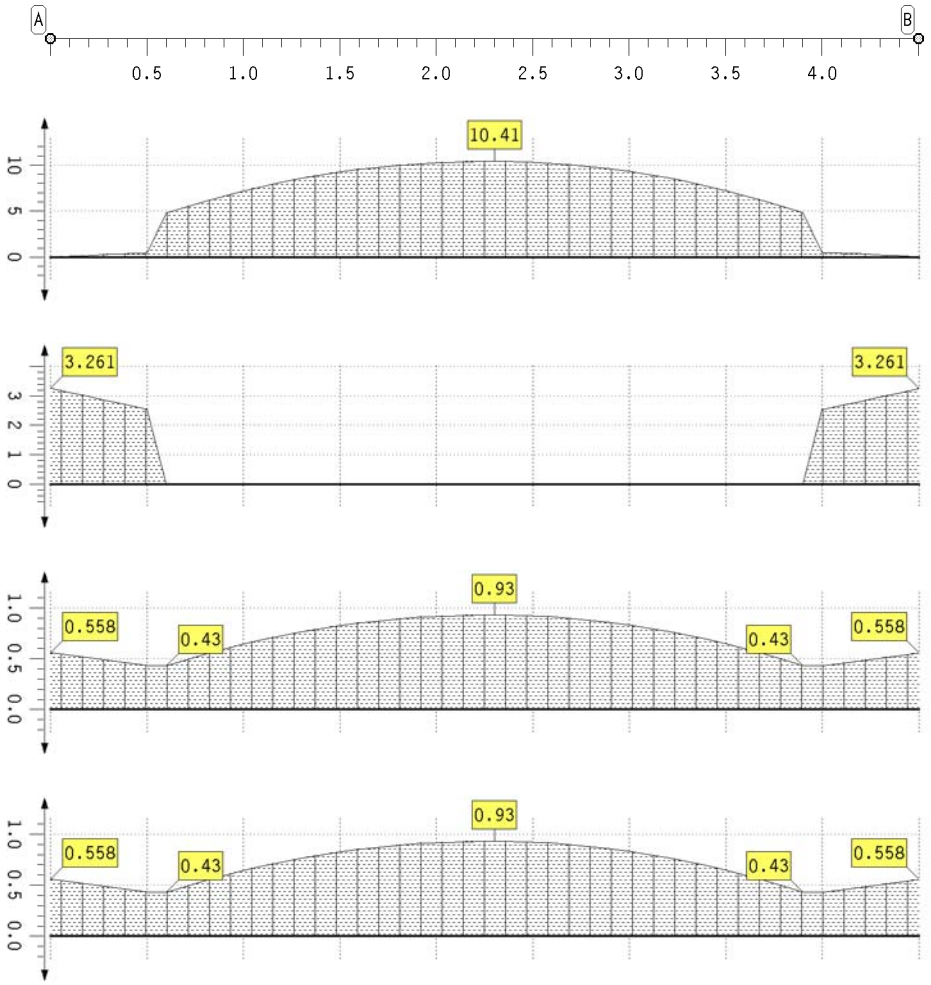
extremal support forces

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: 10.41

shear stress
main beam
τ_h in MN/m²
Max: 3.26

utilization
main beam
Max: 0.93

maximal
utilization
Max: 0.93

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	0.558		2.200	0.930	B	4.500	0.558
	0.600	0.430		3.000	0.827	**minimum**		**0.430**
	1.400	0.797		3.900	0.430	**maximum**		**0.930**

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

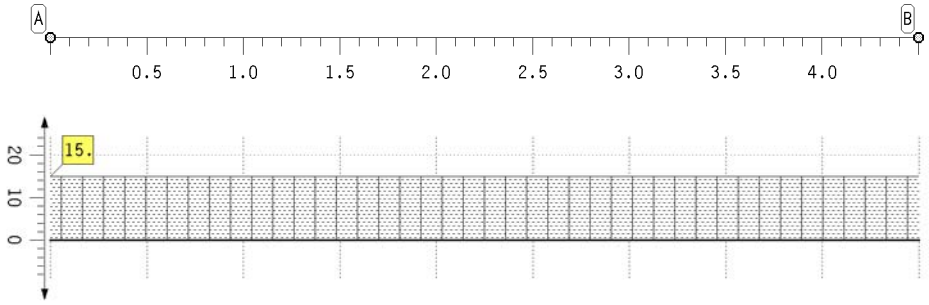
verification of bearing stress

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	3600	11306	1.00	0.80	5.54	3.14	0.57
B	180	3600	11306	1.00	0.80	5.54	3.14	0.57

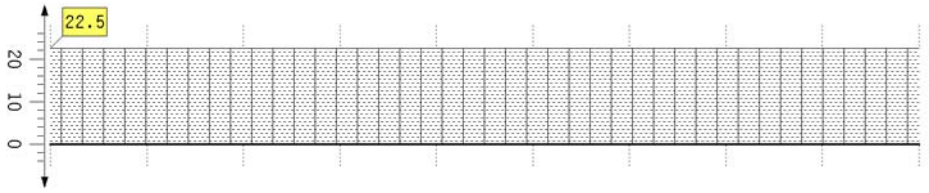
verification of bearing stresses für den main beam(u = 0.567) successful!

12. Results of verification of deflections (rarely)

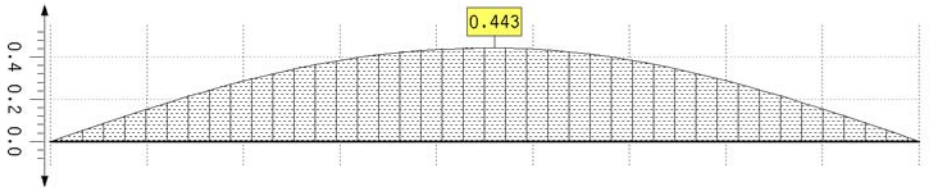
12.1. Verification of deflections (rarely)
results of verification of deflections (rarely)



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: 0.44

maximal utilization

point	x	U
-	m	-
A	0.000	0.000
	1.200	0.332
	2.200	0.443
	3.200	0.351

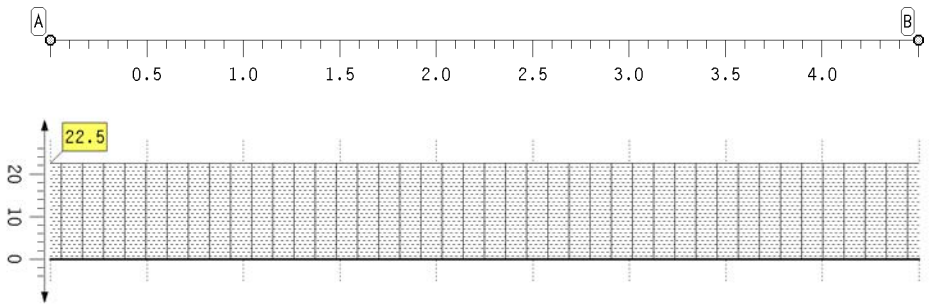
point	x	U
-	m	-
B	4.500	0.000
minimum		**0.000**
maximum		**0.443**

extremal support forces

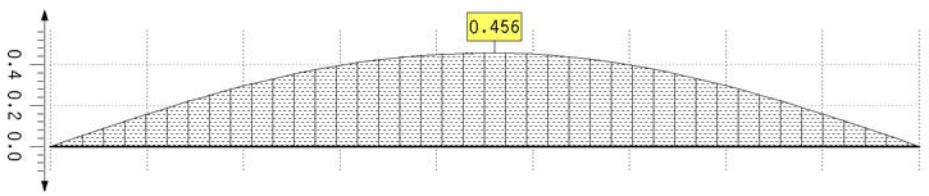
point	x	min AP	max AP
-	m	kN	kN
A	0.000	-7.40	-0.00
B	4.500	-7.40	-0.00

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: 0.46

maximal utilization

point	x	U
-	m	-
A	0.000	0.000
	1.200	0.342
	2.200	0.456
	3.200	0.362

point	x	U
-	m	-
B	4.500	0.000
minimum		**0.000**
maximum		**0.456**

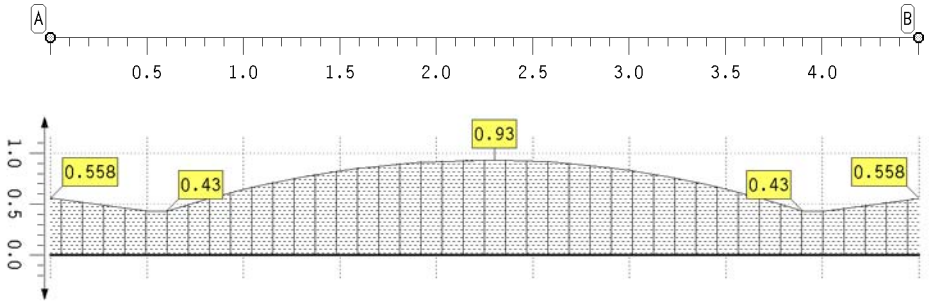
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-7.62	-5.44
B	4.500	-7.62	-5.44

14. Summary

14.1. Summary of all verifications

maximal utilization



utilization
Max: 0.93

maximal utilization

point	x	U
-	m	-
A	0.000	0.558
	0.600	0.430
	1.400	0.797

point	x	U
-	m	-
	2.200	0.930
	3.000	0.827
	3.900	0.430

point	x	U
-	m	-
B	4.500	0.558
minimum		**0.430**
maximum		**0.930**

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	3600	11306	1.00	0.80	5.54	3.14	0.57
B	180	3600	11306	1.00	0.80	5.54	3.14	0.57

verification of bearing stresses für den main beam(u = 0.567) successful!

15. Utilizations of all verifications

all verifications successful!

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/mm²	N/mm²	-	N/mm²	-	-
start	0.8	0.00	0.00	**0.00**	3.26	0.56	0.56
end	0.8	0.00	0.00	0.00	3.26	0.56	0.56

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 fv1,d = 1.231 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	720	0.4274	**0.35**	720	0.4274	**0.35**
end	720	0.4274	0.35	720	0.4274	0.35

16.1.1. Verification of web buckling acc. to DIN 1052, 10.5.1 with bw/hw = 20/140 mm

Eq. (101) $h_w = 14 \leq 70\ b_w = 140$

Eq. (102) $V_d = 11.31\ kN \leq 233.85\ kN$

resulting utilization at verification point $u_{res} = 0.558$