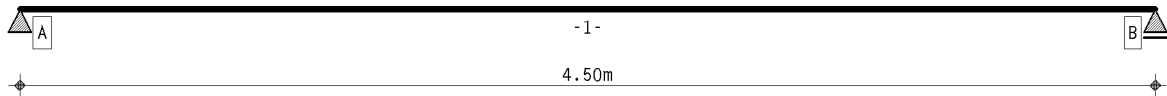


1. Options for Calculations

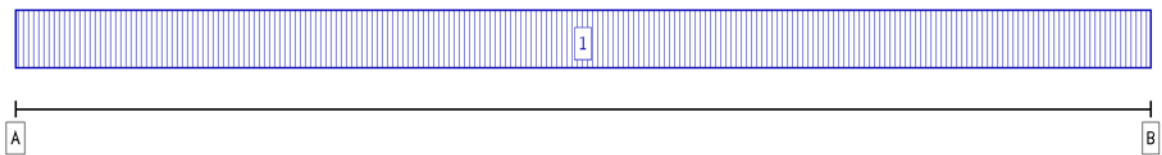
calculation acc. to DIN 1052:2008
service class 1

2. Structural system

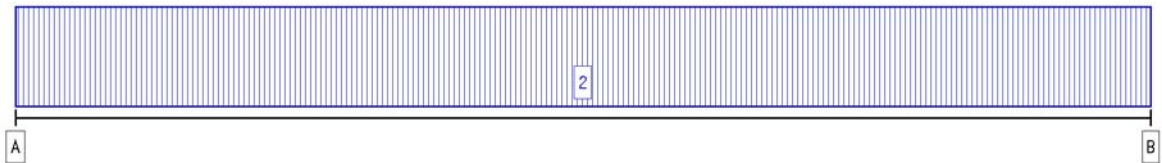


main beam

3. Loading



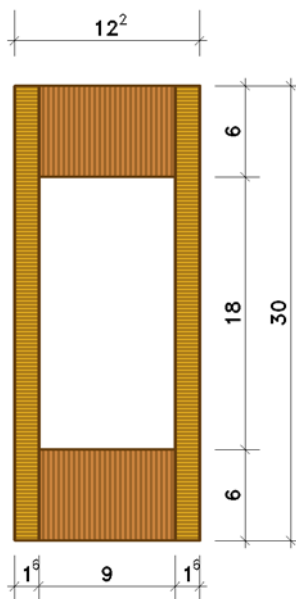
action effect 1: permanent loads (permanent, 1 load cases)



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

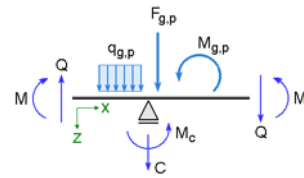
4. main beam

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}	: 54.000 cm ²
moment of inertia I_{flange}	: 162.000 cm ⁴
timber grade web	particleboard type P6
d = 16.0 mm (hochkant)	
char. bend. strength $f_{m,k}$	: 9.5 N/mm ²
char. shear strength $f_{v,k}$	: 7.3 N/mm ²
char. ten. strength $f_{t,k}$	: 9.5 N/mm ²
char. compr. strength $f_{c,0,k}$	: 13.3 N/mm ²
char. compr. strength $f_{c,90,k}$	: 13.3 N/mm ²
e-modulus $E_{0,mean}$ (diaphragm)	: 2400 N/mm ²
e-modulus $E_{0,mean}$ (plate)	: 4100 N/mm ²
Dichte ρ_k/ρ_m	: 550 / 660 kg/m ³
deformation factor k_{def}	: 2.25 -
area A_{flange}	: 96.000 cm ²
moment of inertia I_{flange}	: 7200.000 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}	: 54.000 cm ²
moment of inertia I_{flange}	: 162.000 cm ⁴





5. Beam sections

beam sections

section	x_A m	x_E m	l m	l_v m	cant11.	s_{ef} mm
1	0.00	4.50	4.50	0.00	-	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_3 -	a_3 mm	$E I_{ef,inst}$ Nmm ²	ϕ k_{def} -
1	1.0000	-0.0	1	1.0000	-120.0	1	1.0000	120.0	1.9192E12	0.6766

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	-120.0	1	1.0000	120.0	1.9192E12	174469088.0	15.00	64.00

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	-120.0	1	1.0000	120.0	1.1446E12	166493712.0	15.00	64.00

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	96.00	480.00	7200.00	54.00	54.00	162.00	54.00	54.00	162.00

6. Fasteners

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

7. Supports

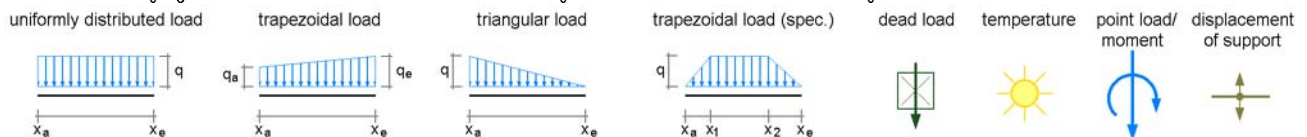
coordinates of supports

supp.name	x m	width mm	depth mm	cF kN/m	cm kNm/-	restraint (F) (M)
A	0.00	150	90	fix	----	X -
B	4.50	150	32	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

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

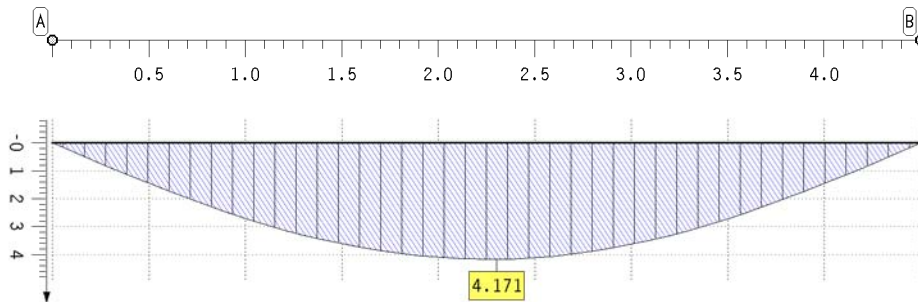
3: DIN 1052:2008 deformations (quasicontinuous)

Extreme rule 1

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

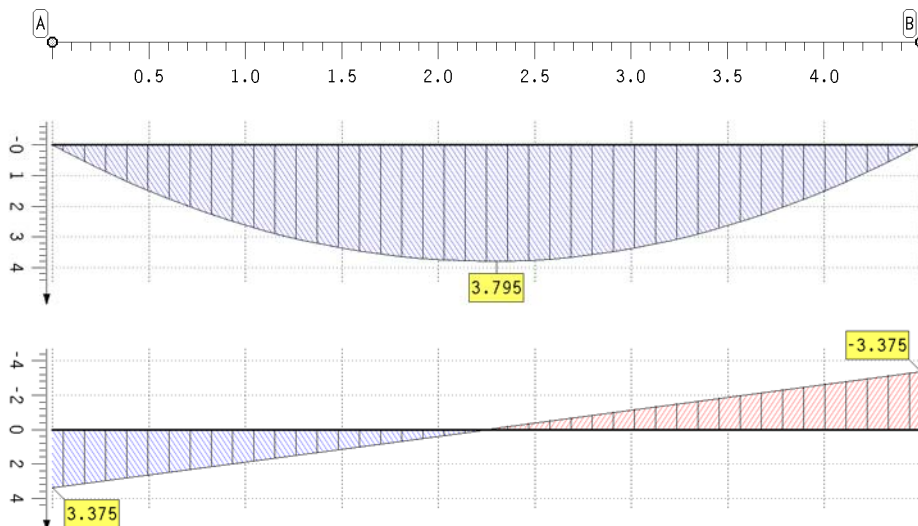


deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 4.17

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	3.12	3.12	minimum		0.00	0.00
	2.200	4.17	4.17	maximum		4.17	4.17
	3.200	3.31	3.31				

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

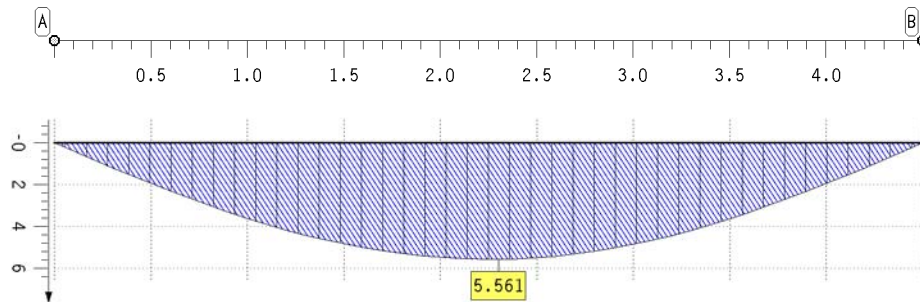
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	3.38	3.38	B	4.500	0.00	0.00	-3.38	-3.38
	1.100	2.81	2.81	1.73	1.73	minimum		0.00	0.00	-3.38	-3.38
	2.200	3.80	3.80	0.08	0.08	maximum		3.80	3.80	3.38	3.38
	3.400	2.81	2.81	-1.73	-1.73						

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)

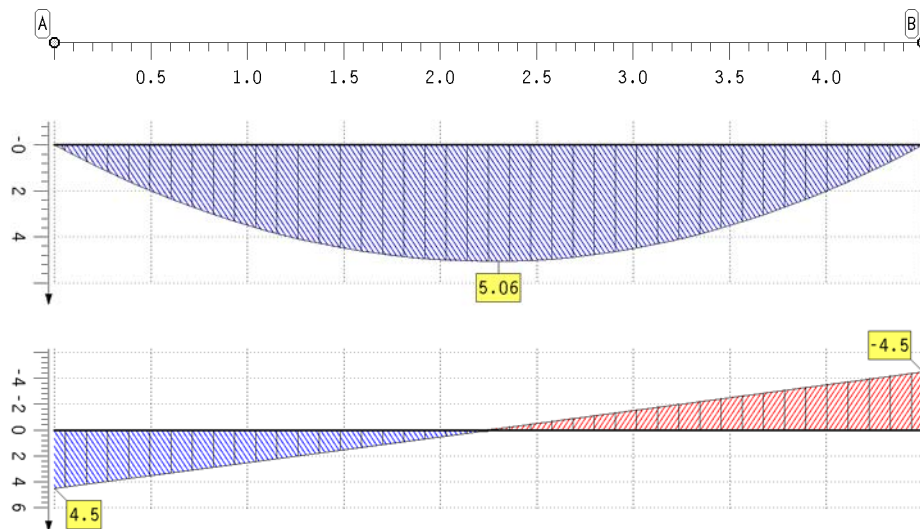


deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 5.56

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	4.16	minimum		0.00	0.00
	2.200	0.00	5.56	maximum		0.00	5.56
	3.200	0.00	4.41				

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						

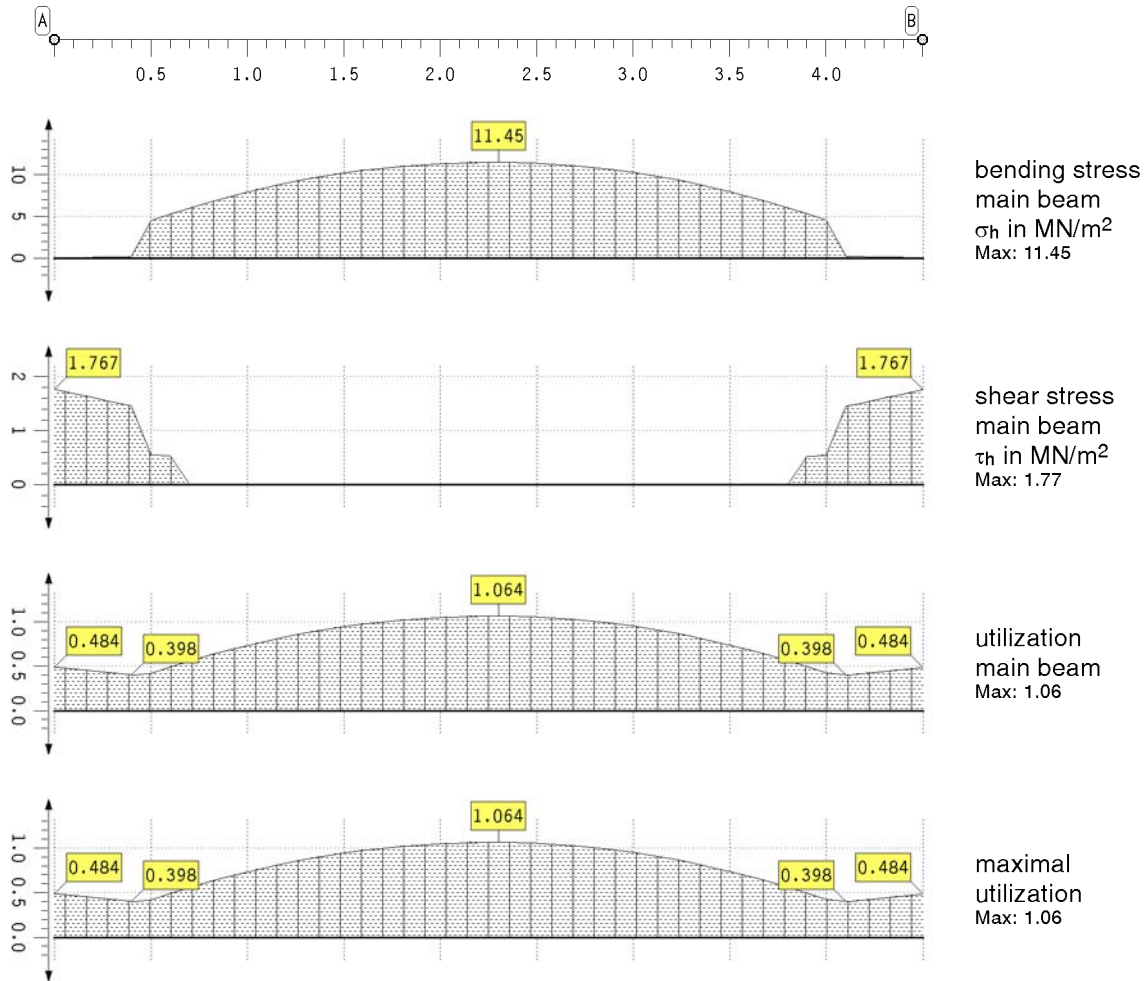
extremal support forces

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



maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	0.484		2.200	1.064	B	4.500	0.484
	0.400	0.398		3.100	0.912	minimum		0.398
	1.400	0.912		4.000	0.420	maximum		1.064

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

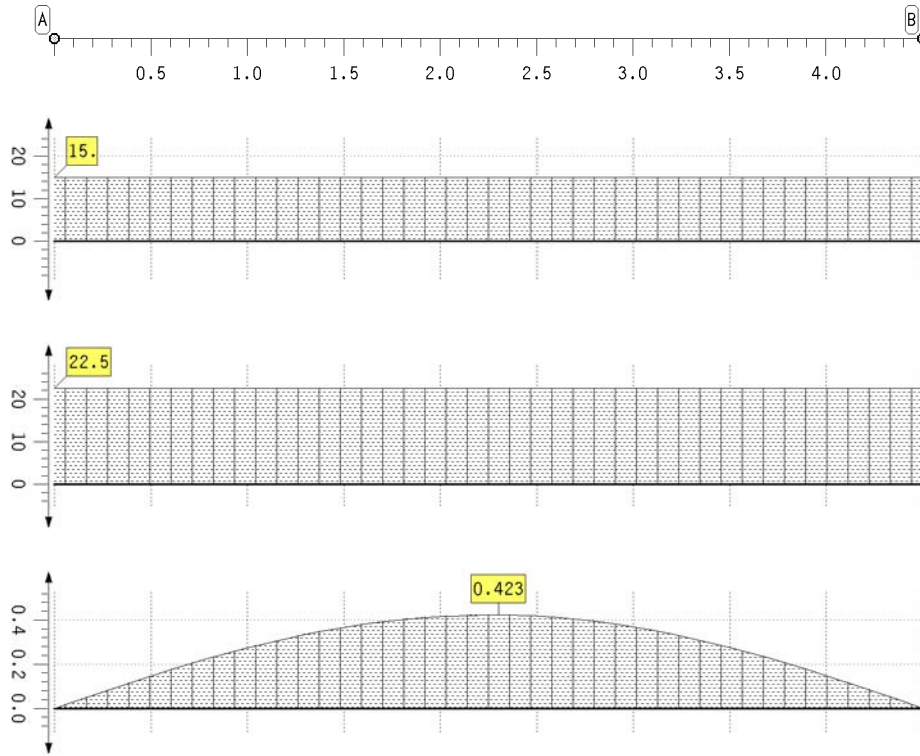
support	l_{ef}	A_{ef}	A_p	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm^2	N		-	N/mm^2	N/mm^2	-
A	180	16200	11306	1.25	0.80	1.54	0.70	0.36
B	180	5760	11306	1.00	0.65	6.65	1.96	0.30

verification of bearing stresses für den main beam(u = 0.363) 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	point	x	U
-	m	-	-	m	-
A	0.000	0.000	B	4.500	0.000
	1.200	0.316	minimum		0.000
	2.200	0.423	maximum		0.423
	3.200	0.335			

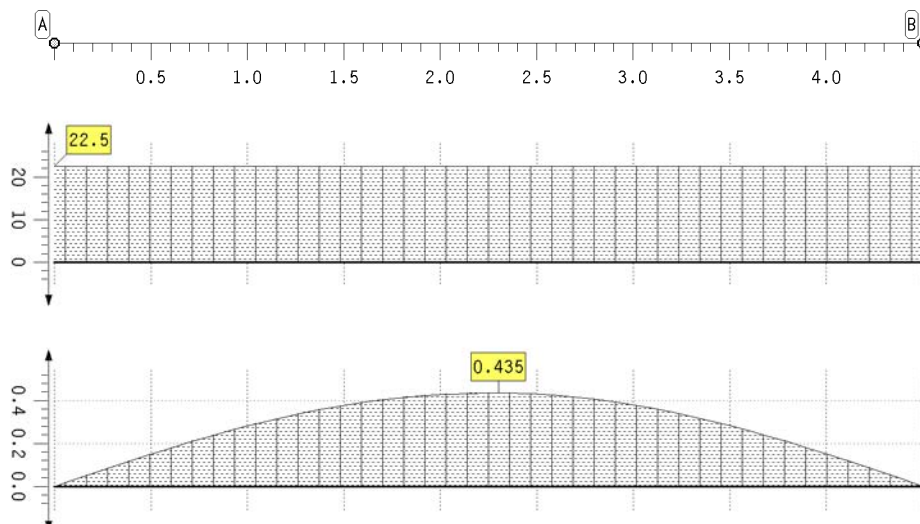
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-7.70	-0.00
B	4.500	-7.70	-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: 0.44

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	0.435	maximum		0.435
	3.200	0.345			

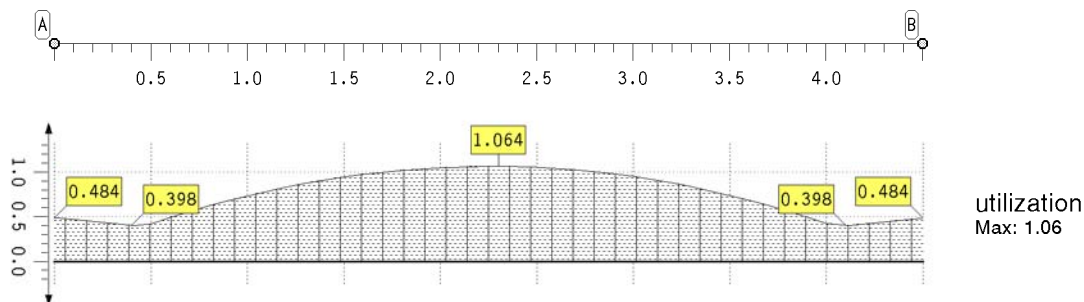
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-7.92	-5.66
B	4.500	-7.92	-5.66

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	0.484				B	4.500	0.484
	0.400	0.398	2.200	1.064		minimum		0.398
	1.400	0.912	3.100	0.912		maximum		1.064
			4.000	0.420				

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	16200	11306	1.25	0.80	1.54	0.70	0.36
B	180	5760	11306	1.00	0.65	6.65	1.96	0.30

verification of bearing stresses für den main beam(u = 0.363) successful!

15. Utilizations of all verifications

verification of load-carrying capacity (u = 1.064) 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	0.6	0.00	0.00	0.00	1.77	0.48	0.48
end	0.6	0.00	0.00	0.00	1.77	0.48	0.48

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 $f_{v1,d} = 0.850$ N/mm²

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	648	0.3667	0.43	648	0.3667	0.43
end	648	0.3667	0.43	648	0.3667	0.43

16.1.1. Verification of web buckling acc. to DIN 1052, 10.5.1 with $b_w/h_w = 16/180$ mm

Eq. (101) $h_w = 18 \leq 70$ $b_w = 112$

Eq. (102) $V_d = 11.31$ kN ≤ 280.32 kN

resulting utilization at verification point $u_{res} = 0.484$