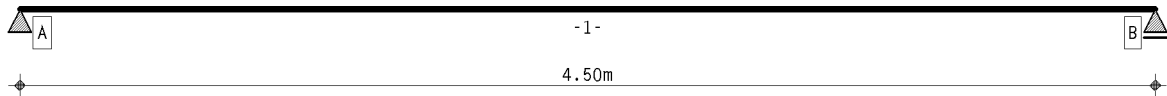


1. Options for Calculations

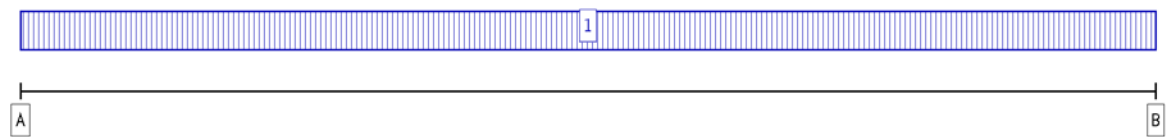
calculation acc. to DIN 1052:2008
service class 2

2. Structural system

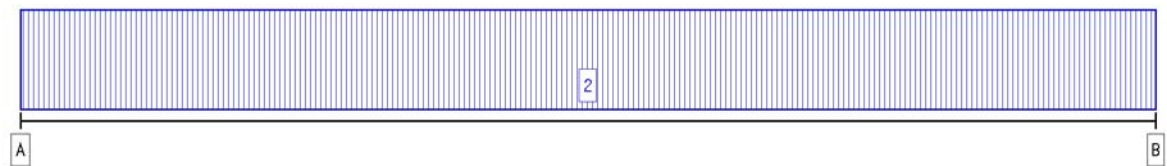


main beam

3. Loading



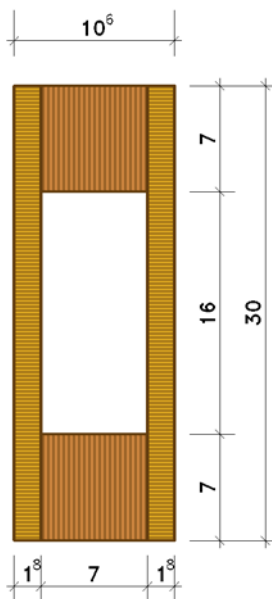
action effect 1: permanent loads (permanent, 1 load cases)



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

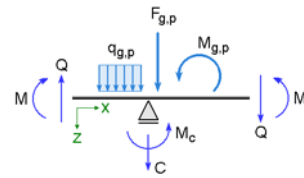
4. main beam

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}	: 49.000 cm ²
moment of inertia I_{flange}	: 200.083 cm ⁴
timber grade web (fibre II)	plywood F40/30
d = 18.0 mm (hochkant)	
char. bend. strength $f_{m,k}$	: 29.0 N/mm ²
char. shear strength $f_{v,k}$	: 9.5 N/mm ²
char. ten. strength $f_{t,k}$	: 29.0 N/mm ²
char. compr. strength $f_{c,0,k}$	: 21.0 N/mm ²
char. compr. strength $f_{c,90,k}$	: 9.0 N/mm ²
e-modulus $E_{0,mean}$ (diaphragm)	: 4400 N/mm ²
e-modulus $E_{0,mean}$ (plate)	: 6000 N/mm ²
Dichte ρ_k/ρ_m	: 600 / 720 kg/m ³
deformation factor k_{def}	: 0.80 -
area A_{flange}	: 108.000 cm ²
moment of inertia I_{flange}	: 8100.000 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}	: 49.000 cm ²
moment of inertia I_{flange}	: 200.083 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	4.50	-	33.0

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	$E I_{ef,inst}$ Nmm ²	ϕ kdef -
1	1.0000	-0.0	737	0.4596	-115.0	737	0.4596	115.0	1.0557E12	0.7109

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	492	0.3618	-115.0	492	0.3618	115.0	9.1628E11	83298416.00	15.00	81.96

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	$E I_{ef,int}$ Nmm ²	$I_{ef,int}$ mm ²	$h_{q,int}$ mm	$A_{q,int}$ mm
1	1.0000	0.0	289	0.3480	-115.0	289	0.3480	115.0	5.3556E11	77899696.00	15.00	82.46

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	108.00	540.00	8100.00	49.00	57.17	200.08	49.00	57.17	200.08

6. Fasteners

section 1 from $x_A = 0.00$ m to $x_E = 4.50$

nail, 2.2 x 45.0 mm, $d_k = 5.5$ mm, not predrilled

2-row with $a_1 = 33.0$ mm

2 - row with $a_2 = 30.0$ mm, simplified verification acc. to DIN 1052:2008, 12.2(2)

nail ends in timber member 2, penetration depth $t = 27$ mm $> 4 d = 9$ mm, 1 shear plane

$f_{uk} = 600$ N/mm², $M_{yk} = 1398$ Nmm

$K_{ser} = 737$ N/mm, $\gamma_M = 1.10$, $R_k = 452.9$ N, all values per shear plane

7. Supports

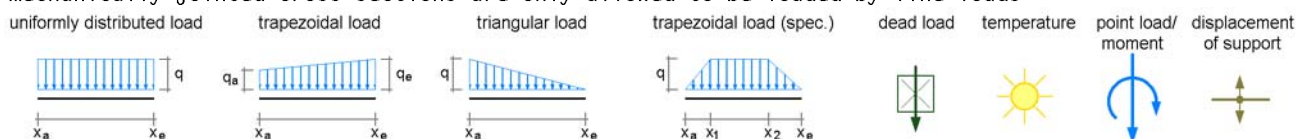
coordinates of supports

supp.name	x m	width mm	depth mm	CF kN/m	CM kNm/-	restraint (F) (M)
A	0.00	150	36	fix	----	X -
B	4.50	150	36	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: $q = 1.00$ 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

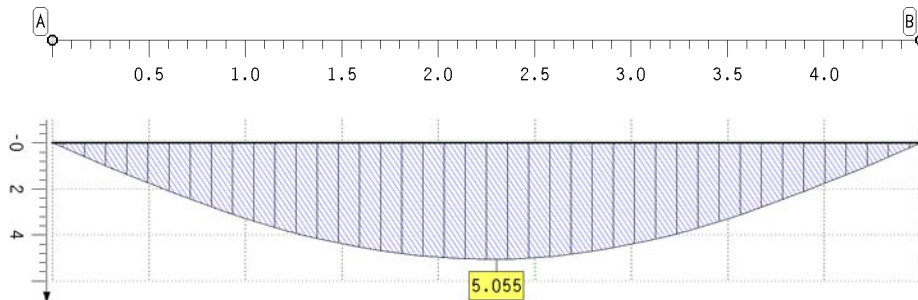
3: DIN 1052:2008 deformations (quasicontinuous)

Extreme rule 1

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

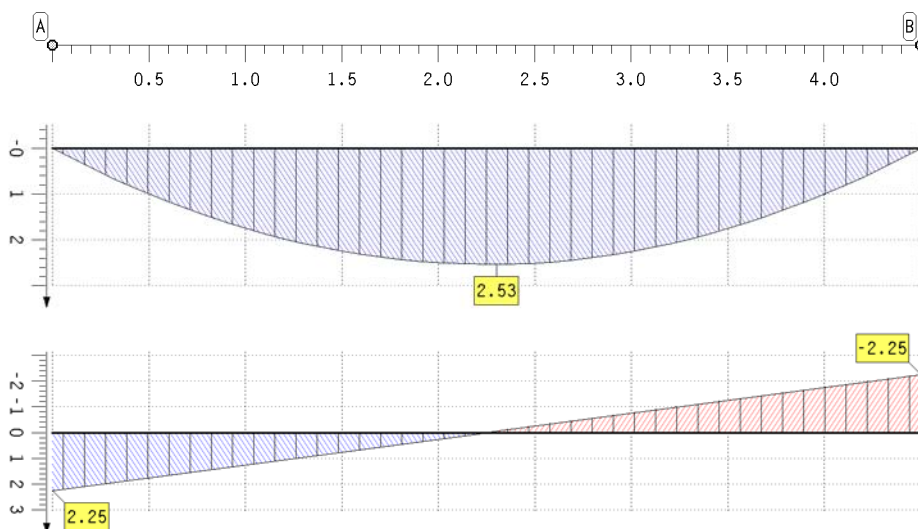


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 5.05

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	3.78	3.78	minimum		-0.00	-0.00
	2.200	5.05	5.05	maximum		5.05	5.05
	3.200	4.01	4.01				

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 2.53

shear force
main beam
V in kN
Min: -2.25
Max: 2.25

extremal internal forces

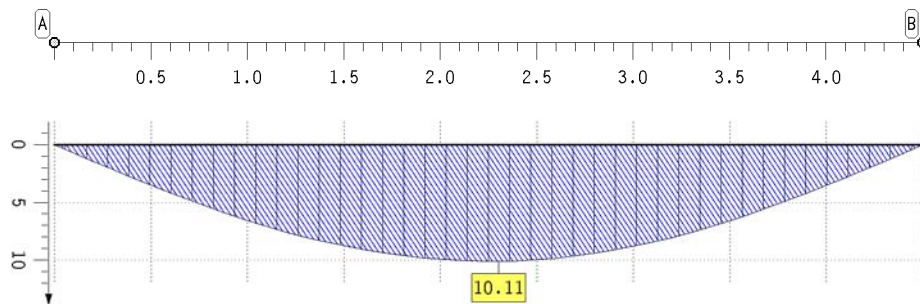
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	2.25	2.25	B	4.500	0.00	0.00	-2.25	-2.25
	1.100	1.87	1.87	1.15	1.15	minimum		0.00	0.00	-2.25	-2.25
	2.200	2.53	2.53	0.05	0.05	maximum		2.53	2.53	2.25	2.25
	3.400	1.87	1.87	-1.15	-1.15						

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-2.25	-2.25
B	4.500	-2.25	-2.25

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)

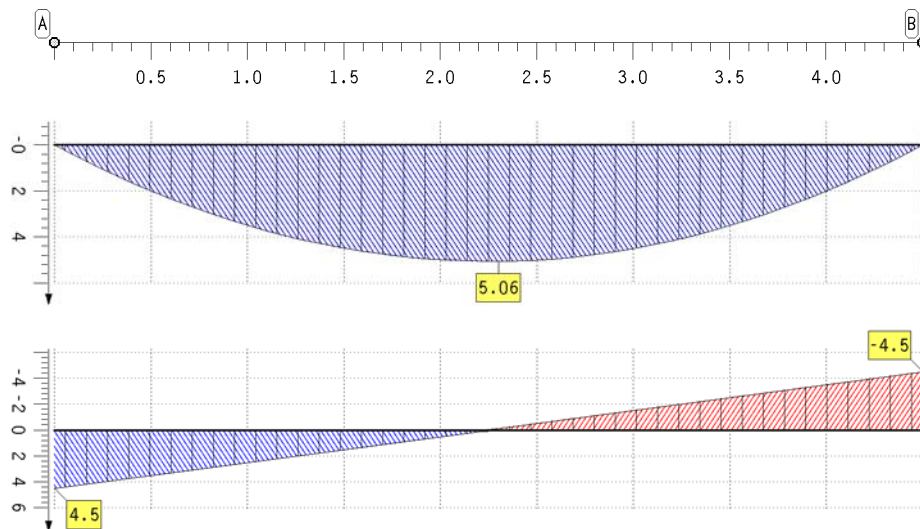


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 10.11

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	7.57	minimum		-0.00	0.00
	2.200	0.00	10.11	maximum		0.00	10.11
	3.200	0.00	8.02				

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						

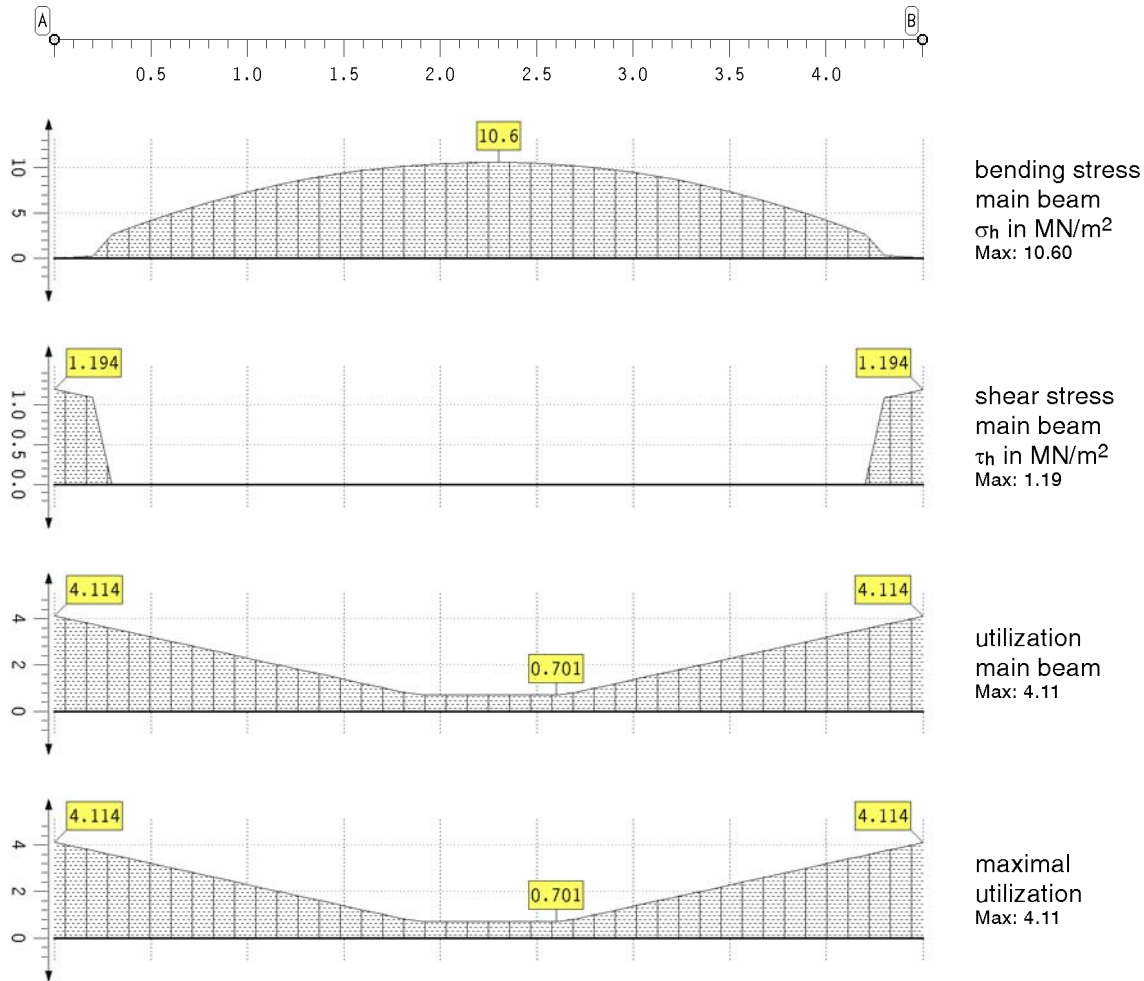
extremal support forces

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 m	U	point	x m	U
A	0.000	4.114	B	4.500	4.114
	1.900	0.701	minimum		0.701
	2.700	0.823	maximum		4.114

extremal support forces

point	x m	min AP kN	max AP kN
A	0.000	-9.79	-2.25
B	4.500	-9.79	-2.25

verification of bearing stress

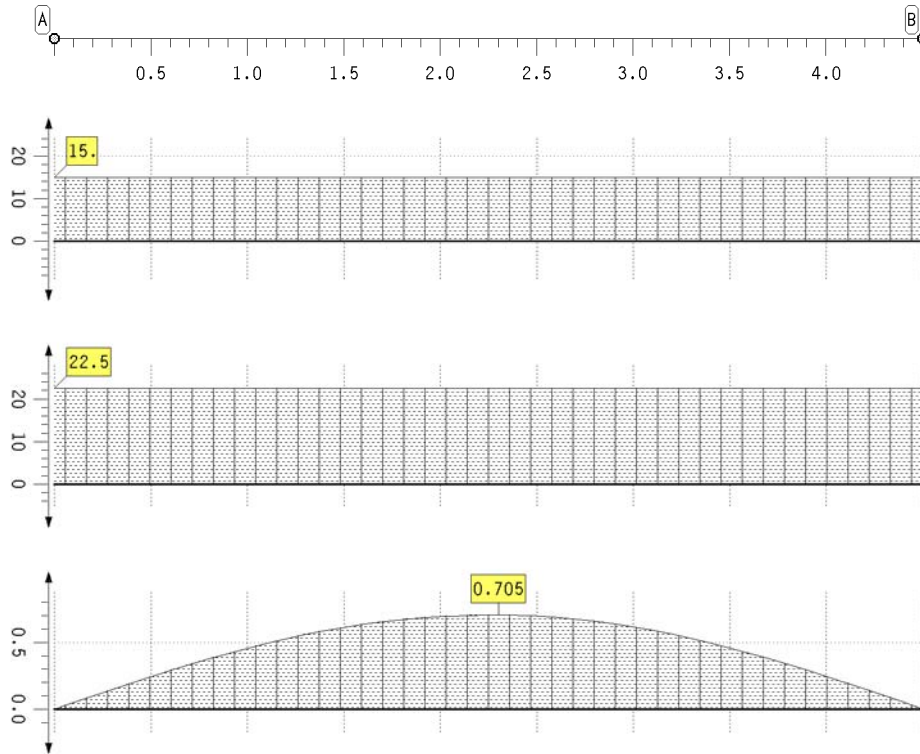
support	l_{ef} mm	A_{ef} mm^2	A_P N	k_{c90}	k_{mod}	f_{c90d} N/mm^2	σ_{c90d} N/mm^2	u
A	180	6480	9788	1.00	0.80	5.54	1.51	0.27
B	180	6480	9788	1.00	0.80	5.54	1.51	0.27

verification of bearing stresses für den main beam(u = 0.273) 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: 0.70

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	0.000	B	4.500	0.000
	1.200	0.528	minimum		0.000
	2.200	0.705	maximum		0.705
	3.200	0.559			

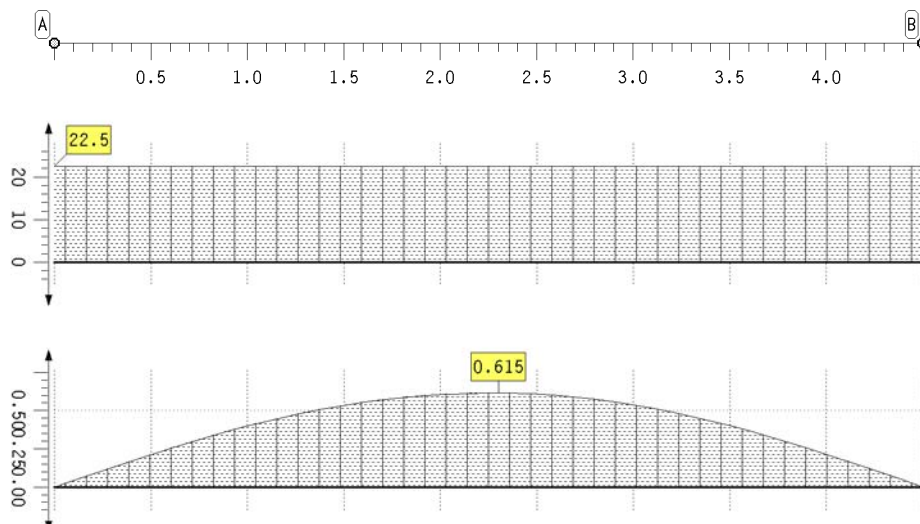
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-7.06	-0.00
B	4.500	-7.06	-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: 0.61

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	0.000	B	4.500	0.000
	1.200	0.460	minimum		0.000
	2.200	0.615	maximum		0.615
	3.200	0.488			

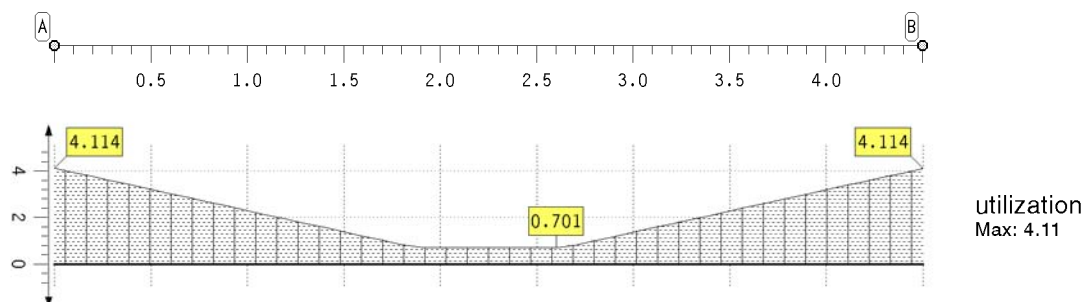
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-6.16	-3.85
B	4.500	-6.16	-3.85

14. Summary

14.1. Summary of all verifications

maximal utilization



maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	4.114	B	4.500	4.114
	1.900	0.701	minimum		0.701
	2.700	0.823	maximum		4.114

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	6480	9788	1.00	0.80	5.54	1.51	0.27
B	180	6480	9788	1.00	0.80	5.54	1.51	0.27

verification of bearing stresses für den main beam(u = 0.273) successful!

15. Utilizations of all verifications

verification of load-carrying capacity (u = 4.114) 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	2.25	0	-0	0	0	0	0
start,max	0.00	9.79	0	-0	0	0	0	0
end,min	0.00	2.25	0	-0	0	0	0	0
end,max	0.00	9.79	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	1.19	0.20	0.20
end	0.8	0.00	0.00	0.00	1.19	0.20	0.20

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

fastener

state	$F_{1,d}$ N	$u_{1,d}$ -	$F_{2,d}$ N	$u_{2,d}$ -
start	-791	2.84	791	2.84
end	-813	2.92	813	2.92

16.1.1. Verification of web buckling acc. to DIN 1052, 10.5.1 with $b_w/h_w = 18/160$ mm

Eq. (101) $h_w = 16 \leq 70$ $b_w = 126$

Eq. (102) $V_d = 9.79$ kN ≤ 484.06 kN

resulting utilization at verification point $u_{res} = 4.114$