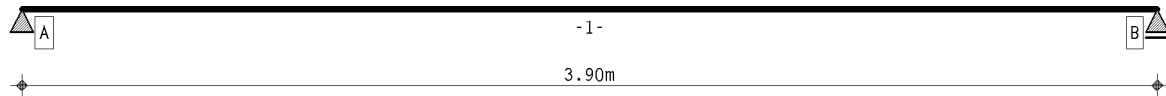


1. Options for Calculations

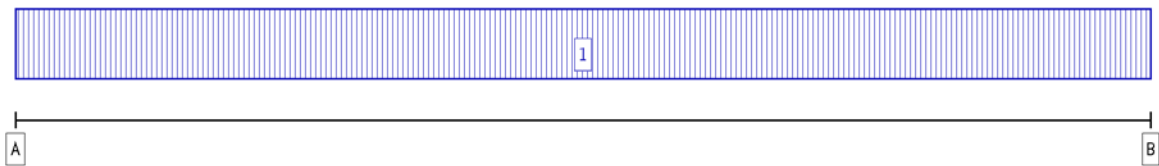
calculation acc. to DIN 1052:2008
service class 2

2. Structural system

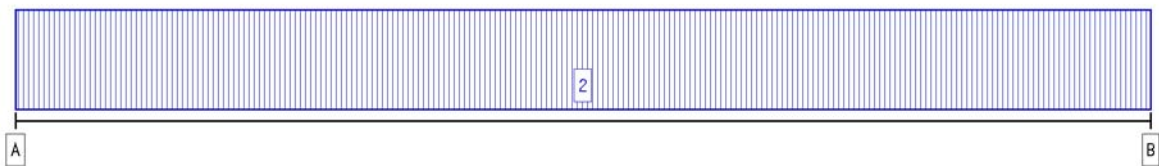


main beam

3. Loading



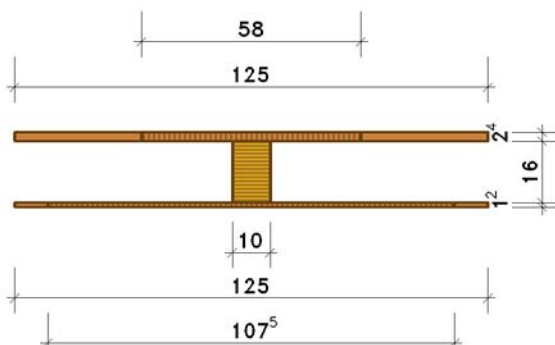
action effect 1: permanent loads (permanent, 1 load cases)



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

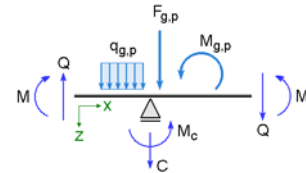
4. main beam

section scale 1:20



timber gr. top fl. (fibre II)	plywood F25/10
d = 24.0 mm (lying)	
char. bend. strength $f_{m,k}$	: 25.0 N/mm ²
char. shear strength $f_{v,k}$	: 1.1 N/mm ²
char. ten. strength $f_{t,k}$	: 18.0 N/mm ²
char. compr. strength $f_{c,0,k}$	: 18.0 N/mm ²
char. compr. strength $f_{c,90,k}$	: 6.5 N/mm ²
e-modulus $E_{0,mean}$ (diaphragm)	: 4500 N/mm ²
e-modulus $E_{0,mean}$ (plate)	: 5500 N/mm ²
Dichte ρ_k/ρ_m	: 400 / 480 kg/m ³
deformation factor k_{def}	: 1.00 -
area A_{flange}	: 300.000 cm ²
moment of inertia I_{flange}	: 144.000 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}	: 0.80 -
area A_{flange}	: 160.000 cm ²
moment of inertia I_{flange}	: 3413.333 cm ⁴
timber grade bottom flange (fibre II)	OSB 2
d = 12.0 mm (lying)	
char. bend. strength $f_{m,k}$	: 16.4 N/mm ²
char. shear strength $f_{v,k}$	: 1.0 N/mm ²
char. ten. strength $f_{t,k}$	: 9.4 N/mm ²
char. compr. strength $f_{c,0,k}$	: 15.4 N/mm ²
char. compr. strength $f_{c,90,k}$	: 10.0 N/mm ²
e-modulus $E_{0,mean}$ (diaphragm)	: 3800 N/mm ²
e-modulus $E_{0,mean}$ (plate)	: 4930 N/mm ²
Dichte ρ_k/ρ_m	: 550 / 660 kg/m ³
deformation factor k_{def}	: 2.25 -

area A_{flange} : 150.000 cm²
moment of inertia I_{flange} : 18.000 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	3.90	3.90	2.00	28.9000	1.2827	69.2042	1.1788	0.5592	3.90	-	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	-5.4	1	1.0000	-86.6	1	1.0000	91.4	1.2670E12	0.9078

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	-5.4	1	1.0000	-86.6	1	1.0000	91.4	1.2670E12	115186024.0	8.54	106.67

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	-9.2	1	1.0000	-82.8	1	1.0000	95.2	6.6414E11	96602464.00	8.92	106.67

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	160.00	426.67	3413.33	139.20	120.00	144.00	129.00	30.00	18.00

6. Fasteners

section 1 from $x_A = 0.00$ m to $x_E = 3.90$, glued joint

7. Supports

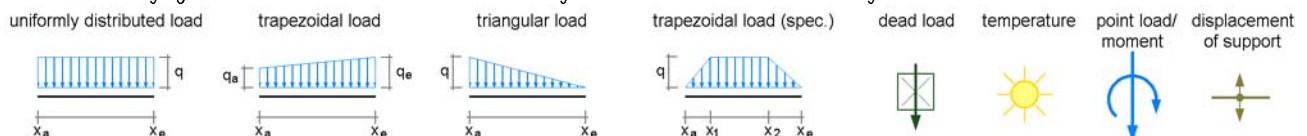
coordinates of supports

supp.name	x m	width mm	depth mm	c_F kN/m	c_M kNm/-	restraint (F) (M)
A	0.00	150	1250	fix	----	X -
B	3.90	150	1250	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: $q = 2.00$ kN/m from $x_a = 0.00$ m to $x_e = 3.90$ m

2. Transient action effect: live loads (1)

2. additive load case: live loads (1/1)

→ unif.distr.load: $q = 2.20$ kN/m from $x_a = 0.00$ m to $x_e = 3.90$ m

9. verifications

1: DIN 1052:2008 load-carrying capacity

safety against overturning will be executed

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

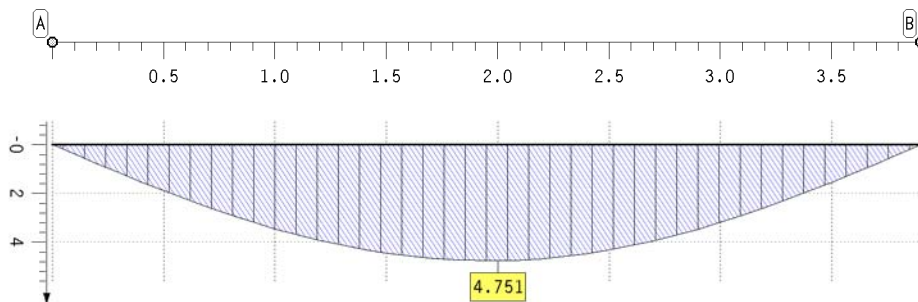
3: DIN 1052:2008 deformations (quasicontinuous)

Extreme rule 1

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

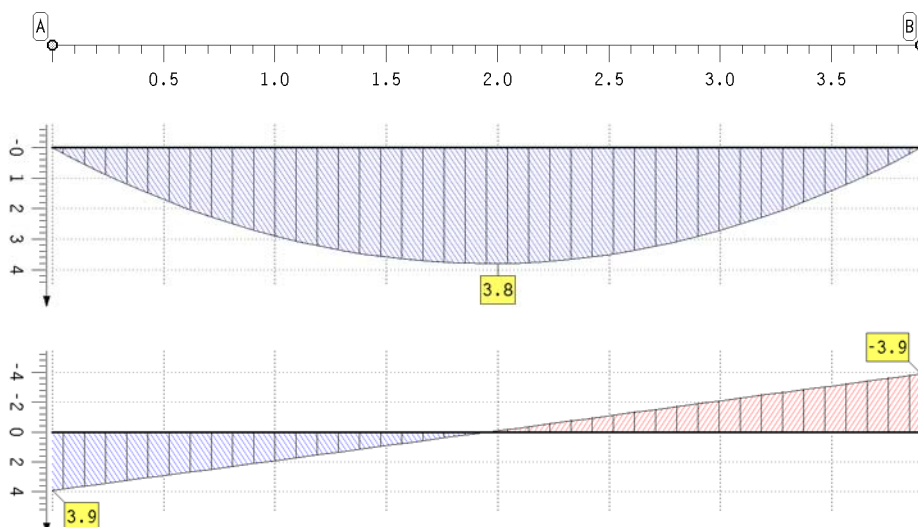


deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 4.75

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	3.900	0.00	0.00
	1.100	3.71	3.71	minimum		0.00	0.00
	1.900	4.75	4.75	maximum		4.75	4.75
	2.800	3.71	3.71				

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 3.80

shear force
main beam
V in kN
Min: -3.90
Max: 3.90

extremal internal forces

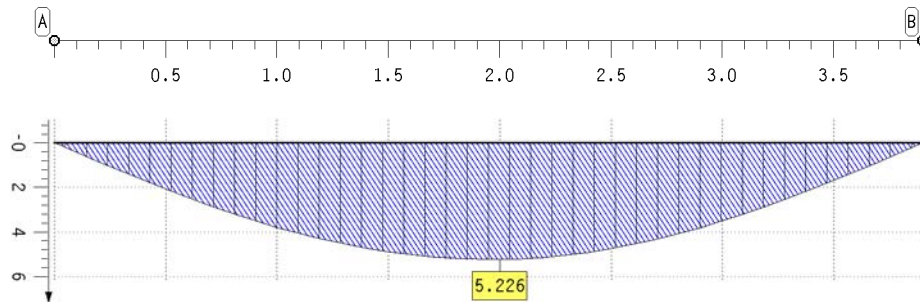
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	3.90	3.90	B	3.900	-0.00	-0.00	-3.90	-3.90
	1.000	2.90	2.90	1.90	1.90	minimum		-0.00	-0.00	-3.90	-3.90
	1.900	3.80	3.80	0.10	0.10	maximum		3.80	3.80	3.90	3.90
	2.900	2.90	2.90	-1.90	-1.90						

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-3.90	-3.90
B	3.900	-3.90	-3.90

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)

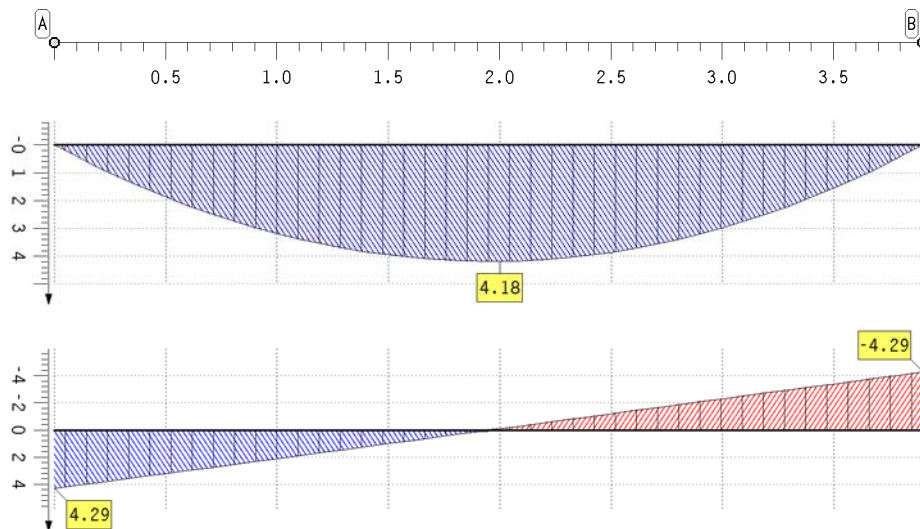


deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 5.23

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	3.900	0.00	0.00
	1.100	0.00	4.08	minimum		0.00	0.00
	1.900	0.00	5.23	maximum		0.00	5.23
	2.800	0.00	4.08				

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 4.18

shear force
main beam
V in kN
Min: -4.29
Max: 4.29

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	4.29	B	3.900	-0.00	-0.00	-4.29	-0.00
	1.000	0.00	3.19	0.00	2.09	minimum		-0.00	0.00	-4.29	-0.00
	1.900	0.00	4.18	0.00	0.11	maximum		0.00	4.18	0.00	4.29
	2.900	0.00	3.19	-2.09	-0.00						

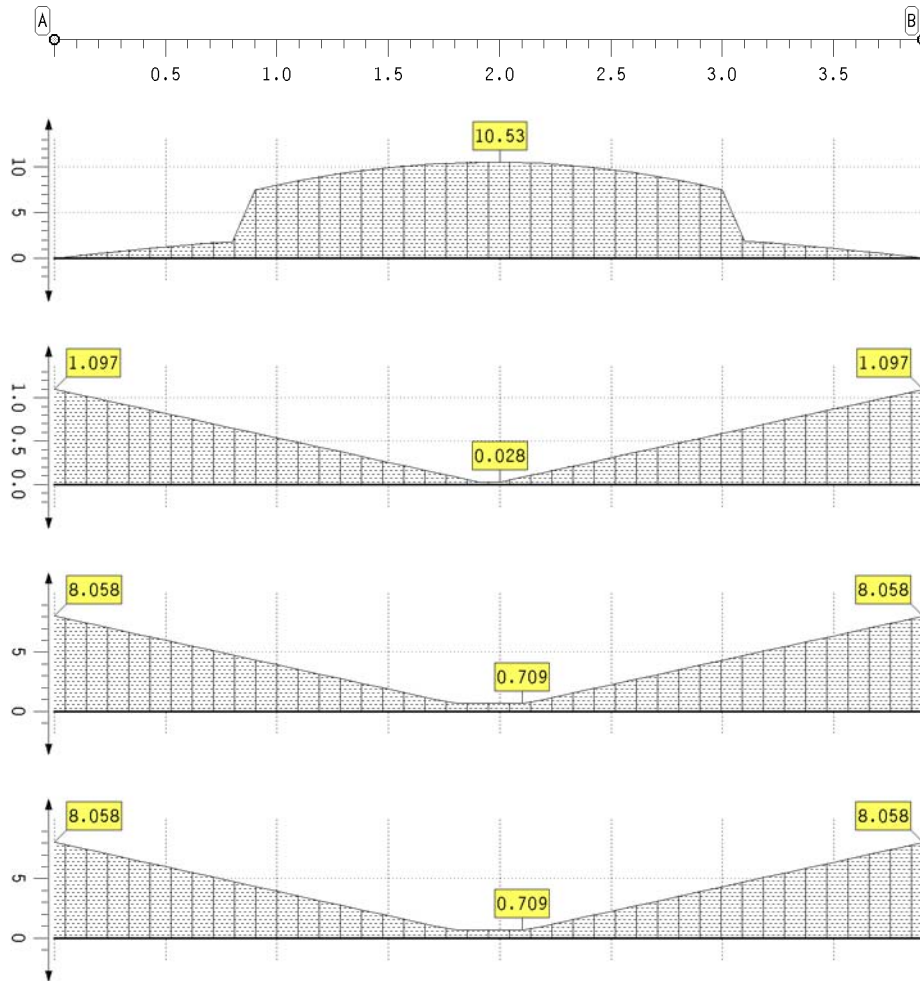
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-4.29	-0.00
B	3.900	-4.29	-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/m^2
Max: 10.53

shear stress
main beam
 τ_h in MN/m^2
Max: 1.10

utilization
main beam
Max: 8.06

maximal
utilization
Max: 8.06

maximal utilization

point	x m	U	point	x m	U
A	0.000	8.058	B	3.900	8.058
	1.800	0.709	minimum		0.709
	2.200	1.033	maximum		8.058

extremal support forces

point	x m	min AP kN	max AP kN
A	0.000	-11.70	-3.90
B	3.900	-11.70	-3.90

verification of bearing stress

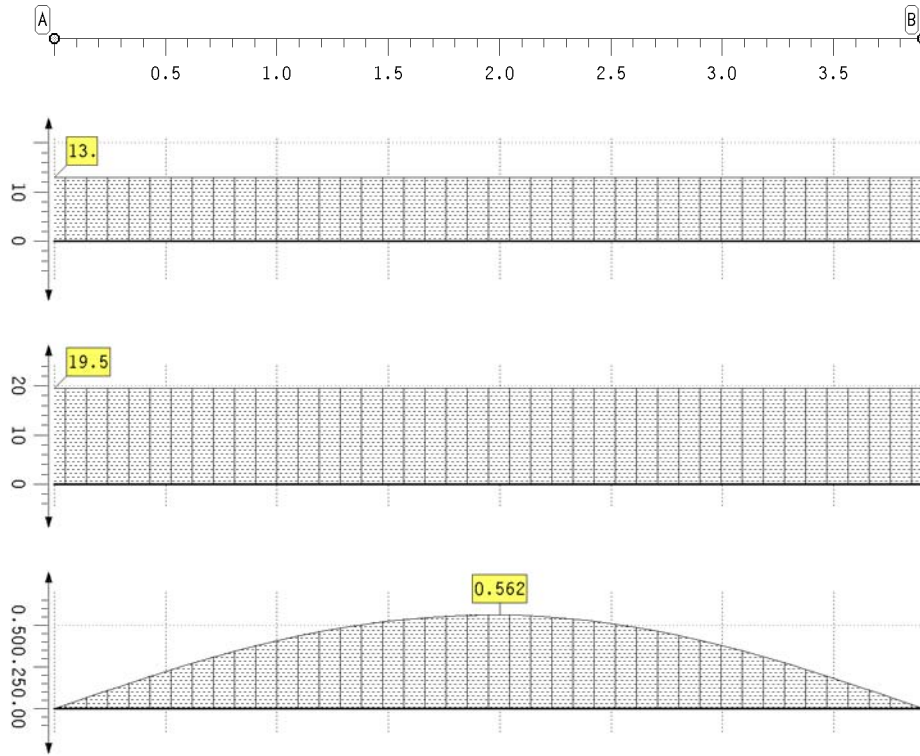
support	l_{ef} mm	A_{ef} mm^2	A_P N	k_{c90}	k_{mod}	f_{c90d} N/ mm^2	σ_{c90d} N/ mm^2	u
A	180	225000	11700	1.00	1.00	7.69	0.05	0.01
B	180	225000	11700	1.00	1.00	7.69	0.05	0.01

verification of bearing stresses für den main beam(u = 0.007) 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: 13.00
Max: 13.00

decisive
deflection
 $W_{B,req}$ in mm
Min: 19.50
Max: 19.50

maximal
utilization
Max: 0.56

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	0.000	B	3.900	0.000
	1.100	0.438	minimum		0.000
	1.900	0.562	maximum		0.562
	2.800	0.438			

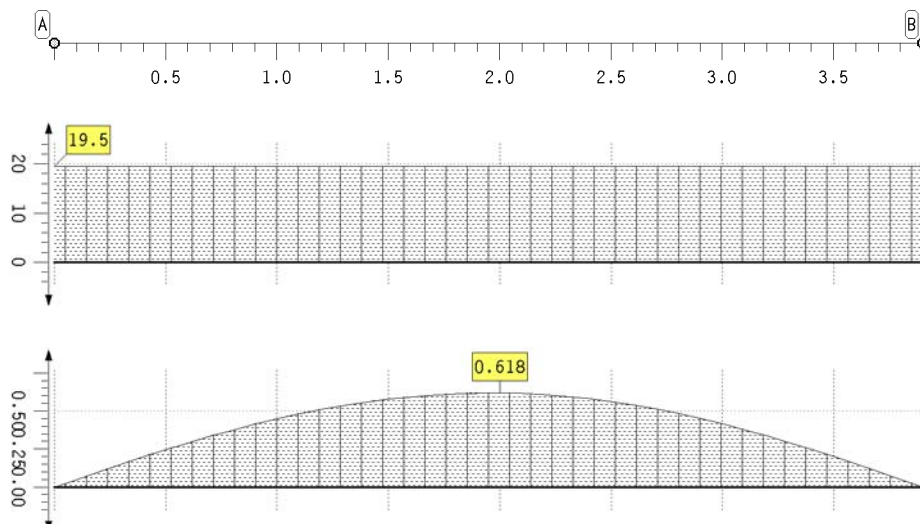
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-9.00	-0.00
B	3.900	-9.00	-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: 19.50
Max: 19.50

maximal
utilization
Max: 0.62

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	0.000	B	3.900	0.000
	1.100	0.482	minimum		0.000
	1.900	0.618	maximum		0.618
	2.800	0.482			

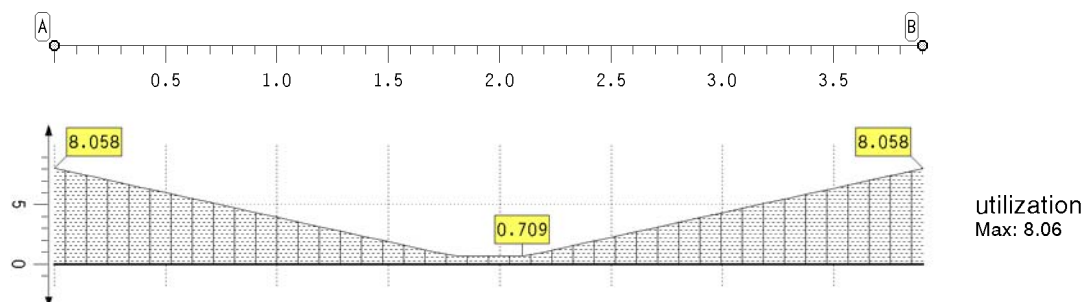
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-9.90	-7.44
B	3.900	-9.90	-7.44

14. Summary

14.1. Summary of all verifications

maximal utilization



maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	8.058	B	3.900	8.058
	1.800	0.709	minimum		0.709
	2.200	1.033	maximum		8.058

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	225000	11700	1.00	1.00	7.69	0.05	0.01
B	180	225000	11700	1.00	1.00	7.69	0.05	0.01

verification of bearing stresses für den main beam(u = 0.007) successful!

15. Utilizations of all verifications

verification of load-carrying capacity (u = 8.058) does not meet the requirements!

16. Detailed verification piont

16.1. Verification of load-carrying capacity at x = 1.90 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	3.80	0.10	19434	-16273	1126063	2839	2051	13434
start,max	11.40	0.30	58303	-48819	3378188	8517	6154	40302
end,min	3.80	0.10	20598	-16483	1342685	5801	1565	10682
end,max	11.40	0.30	61794	-49450	4028055	17403	4696	32047

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	7.92	0.53	0.57	0.03	0.02	0.57
end	0.8	9.44	1.09	0.71	0.03	0.02	0.71

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	0.49	-3.51	0.32	1.0	0.21	3.12	0.43
end	0.8	0.51	-3.55	0.32	1.0	0.16	2.48	0.34

adhering joint with $f_{v1,d} = 0.400$ 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	1206	0.0358	0.09	1179	0.0381	0.05
end	1152	0.0358	0.09	1228	0.0381	0.05

resulting utilization at verification point $u_{res} = 0.713$