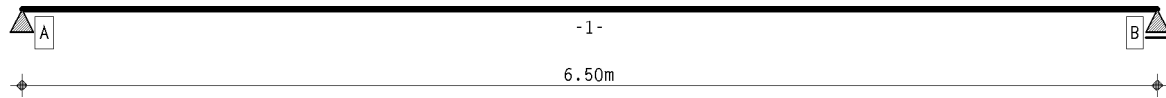


1. Options for Calculations

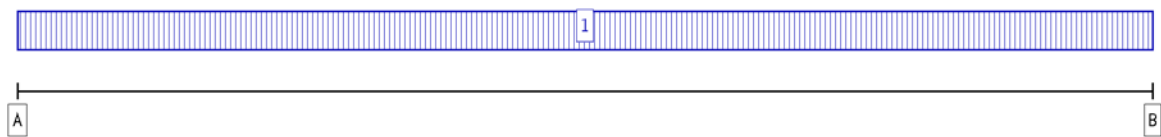
calculation acc. to DIN 1052:2008
service class 2

2. Structural system

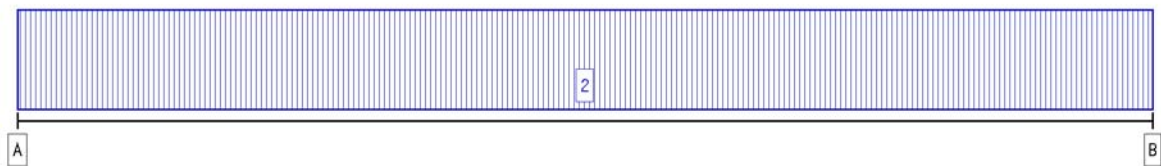


main beam

3. Loading



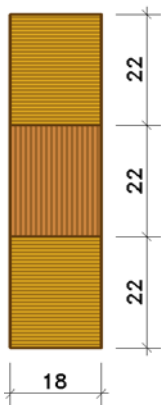
action effect 1: permanent loads (permanent, 1 load cases)



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

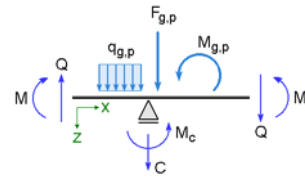
4. main beam

section scale 1:15



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}	: 396.000 cm ²
moment of inertia I_{flange}	: 15972.000 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}	: 0.60 -
area A_{flange}	: 396.000 cm ²
moment of inertia I_{flange}	: 15972.000 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}	: 396.000 cm ²
moment of inertia I_{flange}	: 15972.000 cm ⁴

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	6.50	6.50	6.50	-	100.0

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 K_{def} -
1	1.0000	-0.0	6548	0.3915	-220.0	6548	0.3915	220.0	2.1780E13	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	$E I_{ef,inst}$ Nmm ²	$I_{ef,inst}$ mm ²	$h_{q,inst}$ mm	$A_{q,inst}$ mm
1	1.0000	0.0	4365	0.3002	-220.0	4365	0.3002	220.0	1.7929E13	1629935104.	11.00	792.00

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	2728	0.3002	-220.0	2728	0.3002	220.0	1.1206E13	1629935104.	11.00	792.00

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	308.00	1452.00	15972.00	352.00	1452.00	15972.00	352.00	1452.00	15972.00

6. Fasteners

section 1 from $x_A = 0.00$ m to $x_E = 6.50$

bolt 20 mm, FK 4.6 as fitted bolt

2-row with $a_1 = 100.0$ mm

2 - row with $a_2 = 60.0$ mm, simplified verification acc. to DIN 1052:2008, 12.2(2)

$f_{uk} = 400$ N/mm², $M_{yk} = 289640$ Nmm

$K_{ser} = 6548$ N/mm, $\gamma_M = 1.10$, $R_k = 16309.7$ N, all values per shear plane

7. Supports

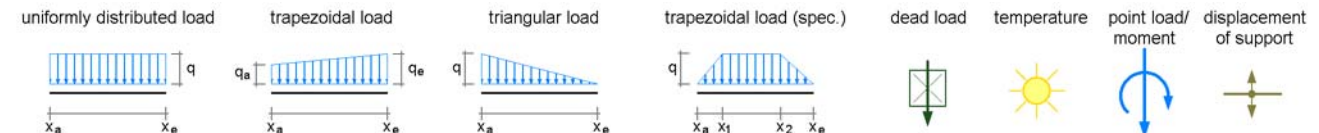
coordinates of supports

supp.name	x m	width mm	depth mm	cf kN/m	cm kNm/-	restraint (F) (M)
A	0.00	150	180	fix	----	X -
B	6.50	150	180	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: $q = 4.00$ kN/m from $x_A = 0.00$ m to $x_E = 6.50$ m

2. Transient action effect: live loads (1)

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

→ unif.distr.load: $q = 8.00$ kN/m from $x_A = 0.00$ m to $x_E = 6.50$ m

9. verifications

1: DIN 1052:2008 load-carrying capacity

verification of bearing stress DIN 1052, 10.2.4 will be executed
Extreme rule 1

2: DIN 1052:2008 deformations (rarely)

Extreme rule 1

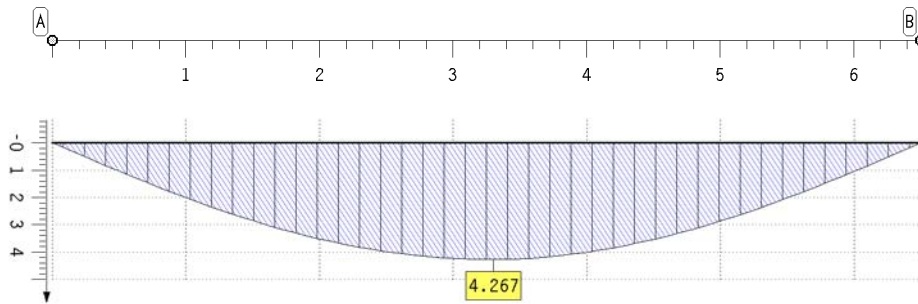
3: DIN 1052:2008 deformations (quasicontinuous)

Extreme rule 1

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

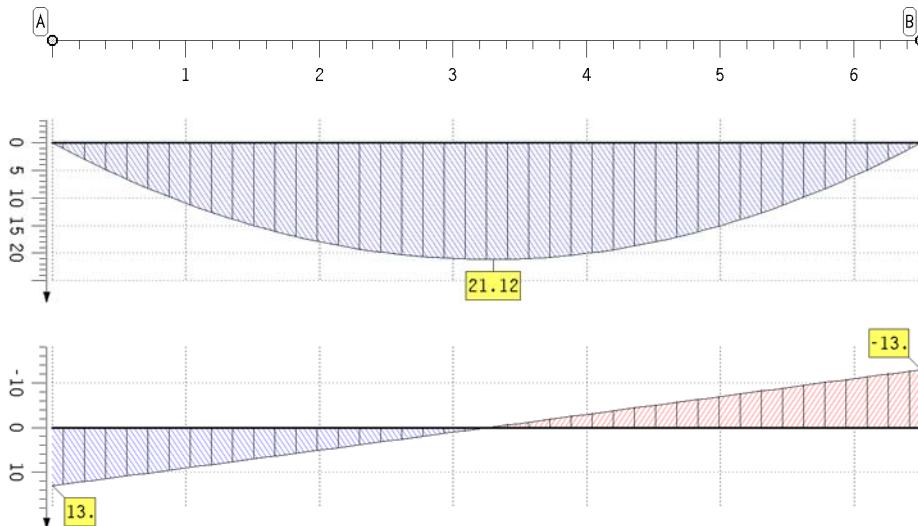


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 4.27

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	6.500	-0.00	-0.00
	1.800	3.28	3.28	minimum		-0.00	-0.00
	3.200	4.27	4.27	maximum		4.27	4.27
	4.700	3.28	3.28				

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 21.12

shear force
main beam
V in kN
Min: -13.00
Max: 13.00

extremal internal forces

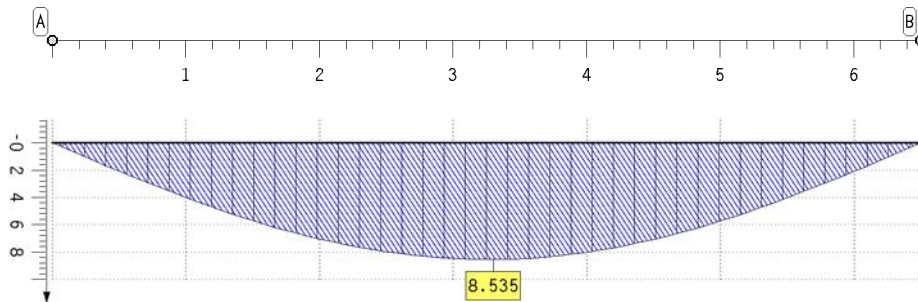
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	13.00	13.00	B	6.500	0.00	0.00	-13.00	-13.00
	1.600	15.68	15.68	6.60	6.60	minimum		0.00	0.00	-13.00	-13.00
	3.200	21.12	21.12	0.20	0.20	maximum		21.12	21.12	13.00	13.00
	4.900	15.68	15.68	-6.60	-6.60						

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-13.00	-13.00
B	6.500	-13.00	-13.00

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)

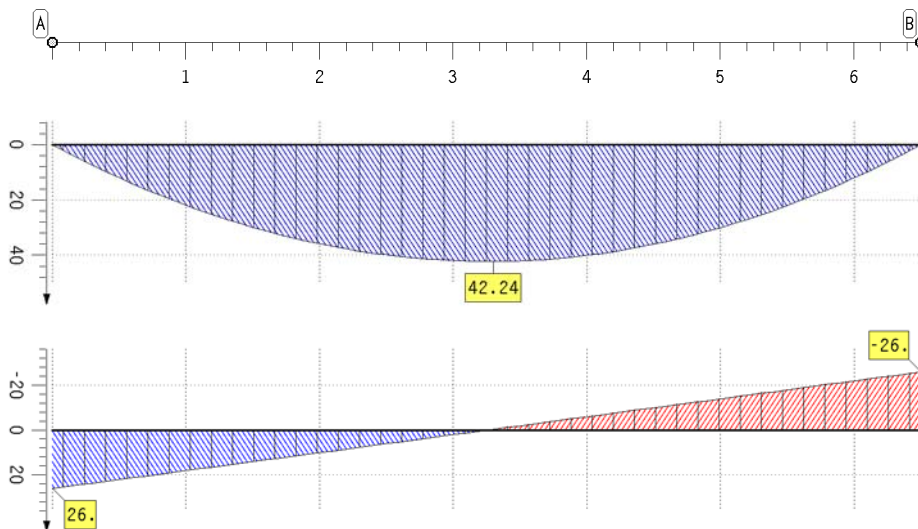


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 8.53

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	6.500	-0.00	-0.00
	1.800	0.00	6.57	minimum		-0.00	0.00
	3.200	0.00	8.53	maximum		0.00	8.53
	4.700	0.00	6.57				

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 42.24

shear force
main beam
V in kN
Min: -26.00
Max: 26.00

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	26.00	B	6.500	0.00	0.00	-26.00	-0.00
	1.600	0.00	31.36	0.00	13.20	minimum		0.00	0.00	-26.00	-0.00
	3.200	0.00	42.24	0.00	0.40	maximum		0.00	42.24	0.00	26.00
	4.900	0.00	31.36	-13.20	-0.00						

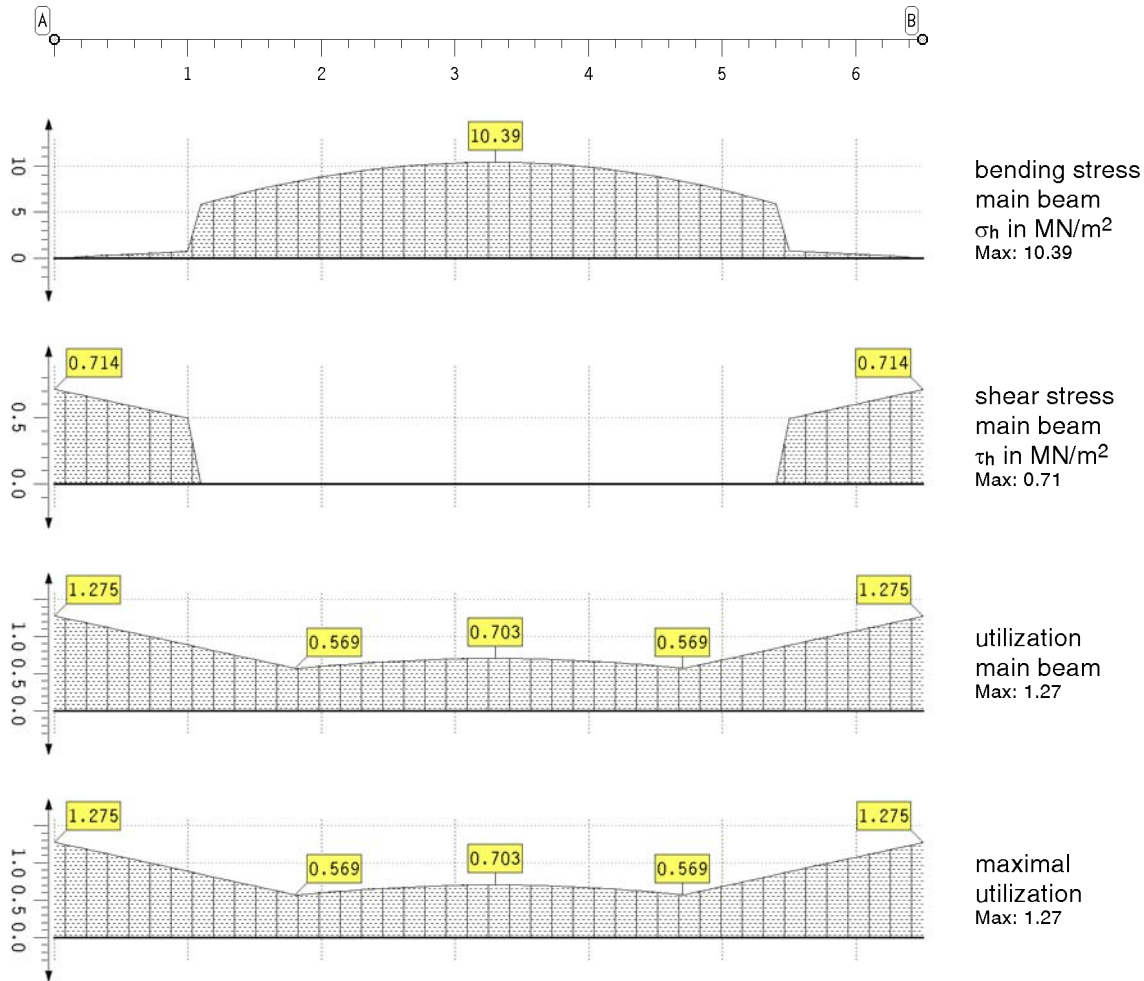
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-26.00	-0.00
B	6.500	-26.00	-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	1.275	B	6.500	1.275
	1.800	0.569	minimum		0.569
	3.300	0.703	maximum		1.275
	4.700	0.569			

extremal support forces

point	x m	min AP kN	max AP kN
A	0.000	-56.55	-13.00
B	6.500	-56.55	-13.00

verification of bearing stress

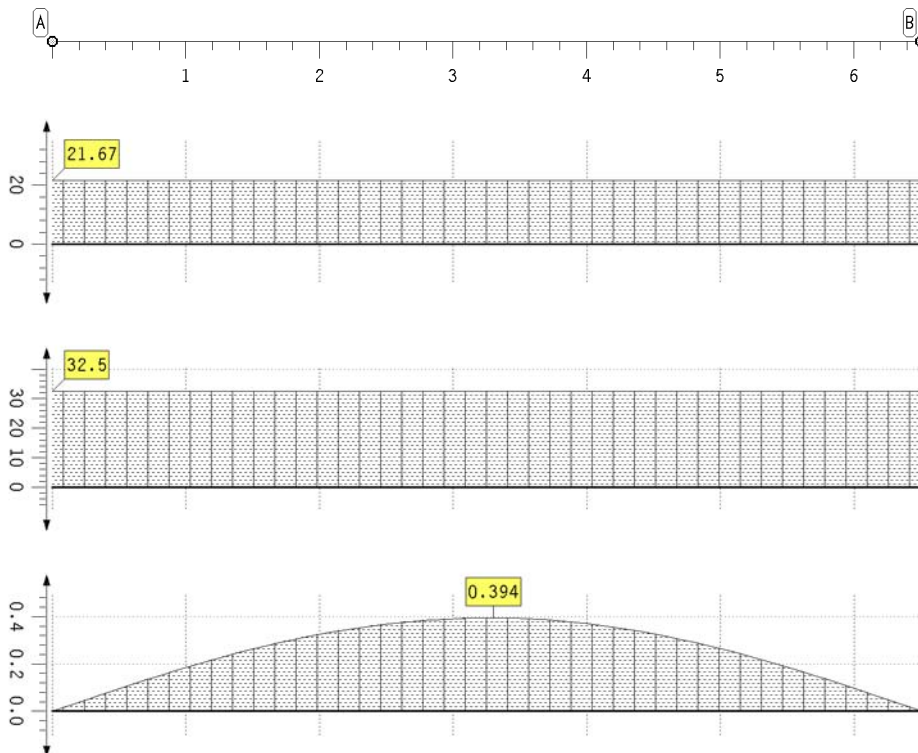
support	l_{ef} mm	A_{ef} mm^2	A_P N	k_{c90}	k_{mod}	f_{c90d} N/mm^2	σ_{c90d} N/mm^2	u
A	180	32400	56550	1.25	0.80	1.54	1.75	0.91
B	180	32400	56550	1.25	0.80	1.54	1.75	0.91

verification of bearing stresses für den main beam(u = 0.908) successful!

12. Results of verification of deflections (rarely)

12.1. Verification of deflections (rarely)

results of verification of deflections (rarely)



decisive
deflection
WA, req in mm
Min: 21.67
Max: 21.67

decisive
deflection
WB, req in mm
Min: 32.50
Max: 32.50

maximal
utilization
Max: 0.39

maximal utilization

point	x m	U	point	x m	U
A	0.000	0.000	B	6.500	0.000
	1.800	0.303	minimum		0.000
	3.200	0.394	maximum		0.394
	4.700	0.303			

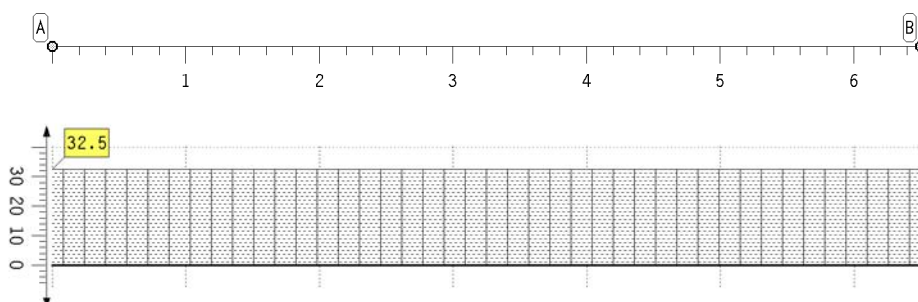
extremal support forces

point	x m	min AP kN	max AP kN
A	0.000	-38.48	-0.00
B	6.500	-38.48	-0.00

13. Results of verification of deflections (quasicontinuous)

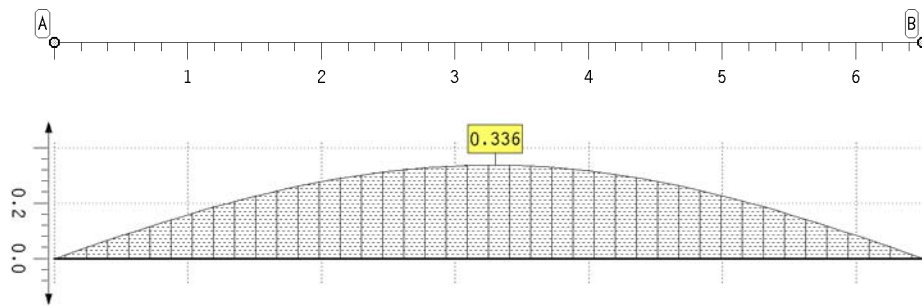
13.1. Verification of deflections (quasicontinuous)

results of verification of deflections (quasicontinuous)



decisive
deflection
Wreq in mm
Min: 32.50
Max: 32.50

results of verification of deflections (quasicontinuous)



maximal
utilization
Max: 0.34

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	0.000	B	6.500	0.000
	1.800	0.259	minimum		0.000
	3.200	0.336	maximum		0.336
	4.700	0.259			

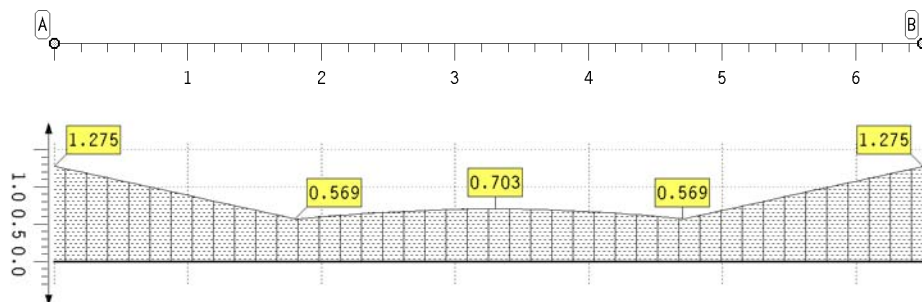
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-33.28	-20.80
B	6.500	-33.28	-20.80

14. Summary

14.1. Summary of all verifications

maximal utilization



utilization
Max: 1.27

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	1.275	B	6.500	1.275
	1.800	0.569	minimum		0.569
	3.300	0.703	maximum		1.275
	4.700	0.569			

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	32400	56550	1.25	0.80	1.54	1.75	0.91
B	180	32400	56550	1.25	0.80	1.54	1.75	0.91

verification of bearing stresses für den main beam(u = 0.908) successful!

15. Utilizations of all verifications

verification of load-carrying capacity ($u = 1.275$) does not meet the requirements!

16. Detailed verification point

16.1. Verification of load-carrying capacity at $x = 0.00$ m

internal forces and moments

state	M kNm	V kN	M ₁ Nmm	N ₁ N	M ₂ Nmm	N ₂ N	M ₃ Nmm	N ₃ N
start,min	0.00	13.00	0	-0	0	-0	0	0
start,max	0.00	56.55	0	-0	0	-0	0	0
end,min	0.00	13.00	0	-0	0	-0	0	0
end,max	0.00	56.55	0	-0	0	-0	0	0

stresses and utilization web

state	k _{mod,2} -	σ _{m,2} N/mm ²	σ _{c,2} N/mm ²	u _{σ,2} -	τ ₂ N/mm ²	u _τ -	u ₂ -
start	0.8	0.00	0.00	0.00	0.71	0.58	0.58
end	0.8	0.00	0.00	0.00	0.71	0.58	0.58

stresses and utilization flanges

state	k _{mod,1} -	σ _{m,1} N/mm ²	σ _{c,1} N/mm ²	u ₁ -	k _{mod,3} -	σ _{m,3} N/mm ²	σ _{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} -
start	-9074	0.90
end	-9074	0.90

resulting utilization at verification point $u_{res} = 1.275$