1. Options for Calculations

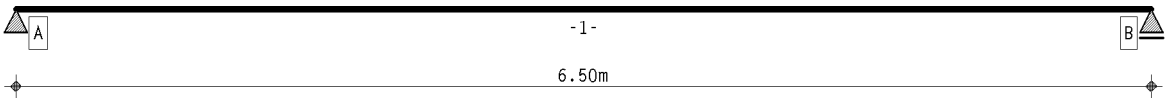
calculation DIN EN 1995:2010, Germany

service class 2

coefficient of thermal expansion for timber α_t = 0.500 *10^{-5}/°K

ψ_2 = 0.60 (factor acc. to DIN EN 1995-1-1 2.3.2.2 (2))

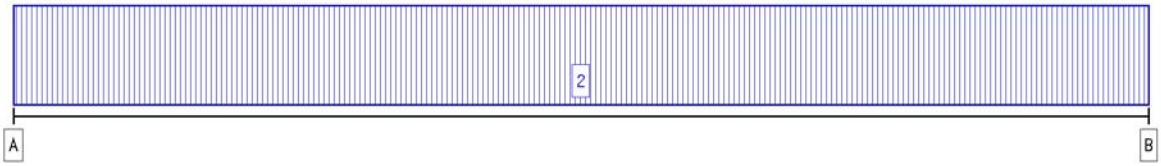
2. Structural system



main beam

3. Loading

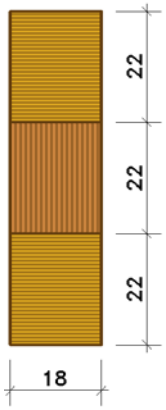
action effect 1: permanent loads (permanent, 1 load cases)



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

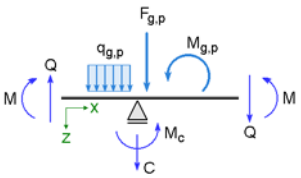
4. main beam

section scale 1:15



timber grade top flange			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	4.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.5 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}	:	396.000 cm²
moment of inertia	I_{flange}	:	15972.000 cm⁴
timber grade web			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	4.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.5 N/mm²
char. compr. strength	$f_{c,0,k}$	:	21.0 N/mm²
char. compr. strength	$f_{c,90,k}$	:	2.5 N/mm²
	k_{cr}	:	0.50 mm²/N
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}	:	396.000 cm²
moment of inertia	I_{flange}	:	15972.000 cm⁴
timber grade bottom flange			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	4.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.5 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} : 396.000 cm²
moment of inertia I_{flange} :15972.000 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	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	$EI_{ef,inst}$ Nmm2	ø k_{def} -
1	1.0000	-0.0	7485	0.4238	-220.0	7485	0.4238	220.0	2.3141E13	0.5269

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	4990	0.3290	-220.0	4990	0.3290	220.0	1.9144E13	1740407680.	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	$EI_{ef,inf}$ Nmm2	$I_{ef,inf}$ mm2	$h_{q,inf}$ mm	$A_{q,inf}$ mm
1	1.0000	0.0	2901	0.2794	-220.0	2901	0.2794	220.0	1.2538E13	1550182400.	11.00	792.00

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	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 NA.8.2.4
f_{uk} = 400 N/mm², M_{yk} = 289640 Nmm
K_{ser} = 7485 N/mm, γ_M = 1.10, **R_k = 16309.7 N, all values per shear plane**

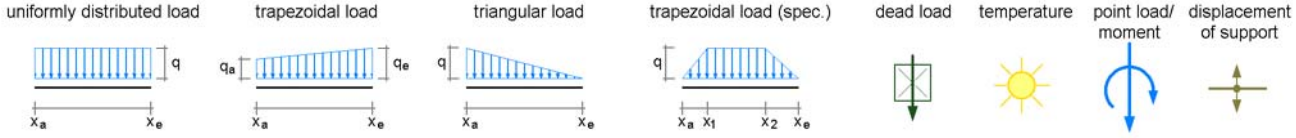
7. Supports

coordinates of supports

supp.name	x m	width mm	depth mm	c_F kN/m	c_M kNm/-	restraint (F)	restraint (M)
A	0.00	150	180	fix	----	X	-
B	6.50	150	180	fix	----	X	-

8. Action effects

Attention! Acc. to DIN EN 1995-1-1, annex B.1
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

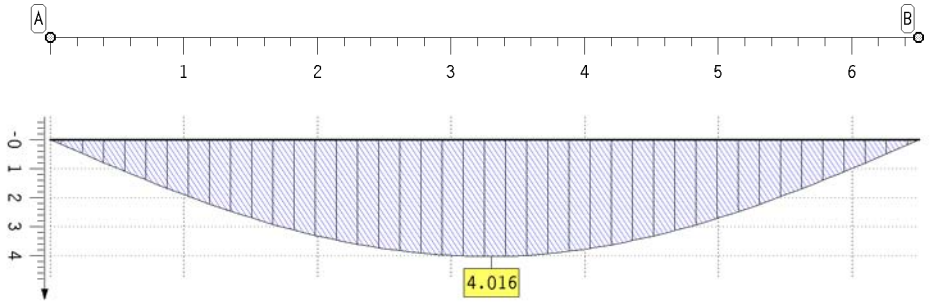
9. verifications

1: EC 5 load-carrying capacity
verification of bearing stress DIN EN 1995, 6.1.5 will be executed
Extreme rule 1

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

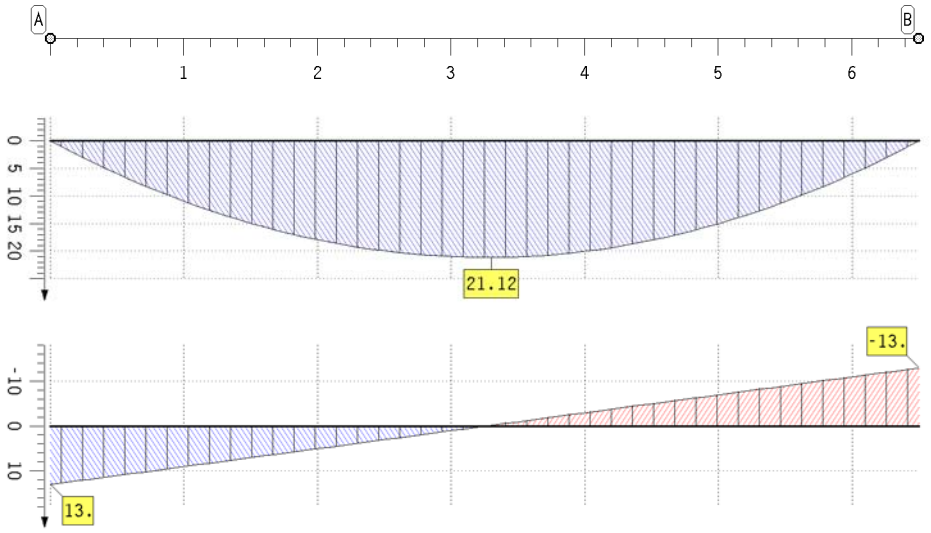


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 4.02

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	3.09	3.09	**minimum**		**-0.00**	**-0.00**
	3.200	4.02	4.02	**maximum**		**4.02**	**4.02**
	4.700	3.09	3.09				

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

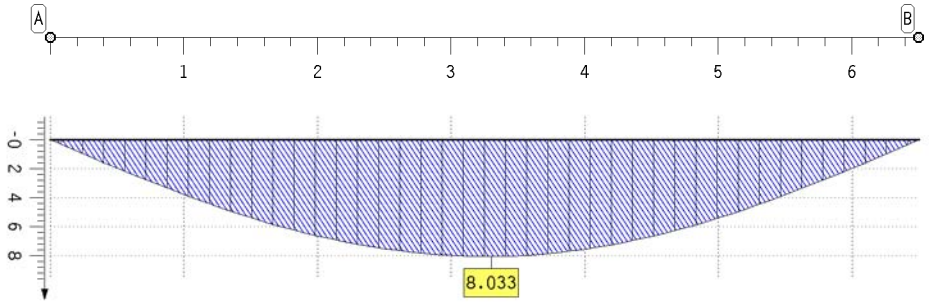
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	13.00	13.00	B	6.500	0.00	0.00	-13.00	-13.00
	1.600	15.68	15.68	6.60	6.60	**minimum**		**0.00**	**0.00**	**-13.00**	**-13.00**
	3.200	21.12	21.12	0.20	0.20	**maximum**		**21.12**	**21.12**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



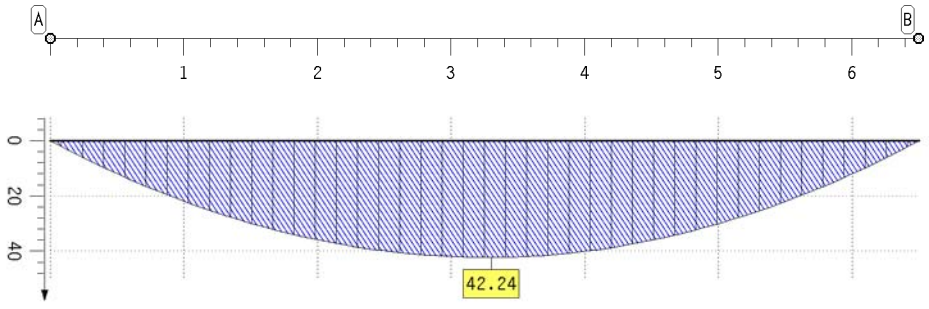
deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 8.03

extremal deflections of main beam (characteristic)

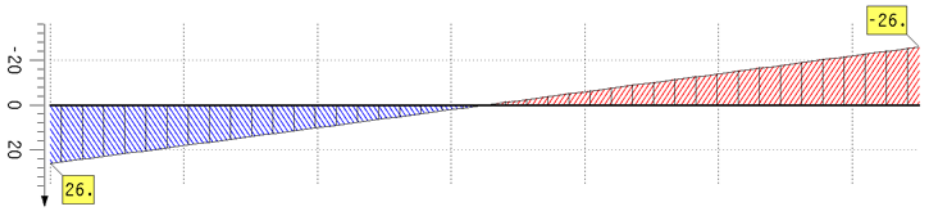
point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.800	0.00	6.18
	3.200	0.00	8.03
	4.700	0.00	6.18

point	x	min w	max w
-	m	mm	mm
B	6.500	-0.00	-0.00
minimum		**-0.00**	**0.00**
maximum		**0.00**	**8.03**

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
-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	0.00	26.00
	1.600	0.00	31.36	0.00	13.20
	3.200	0.00	42.24	0.00	0.40
	4.900	0.00	31.36	-13.20	-0.00

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	6.500	0.00	0.00	-26.00	-0.00
minimum		**0.00**	**0.00**	**-26.00**	**-0.00**
maximum		**0.00**	**42.24**	**0.00**	**26.00**

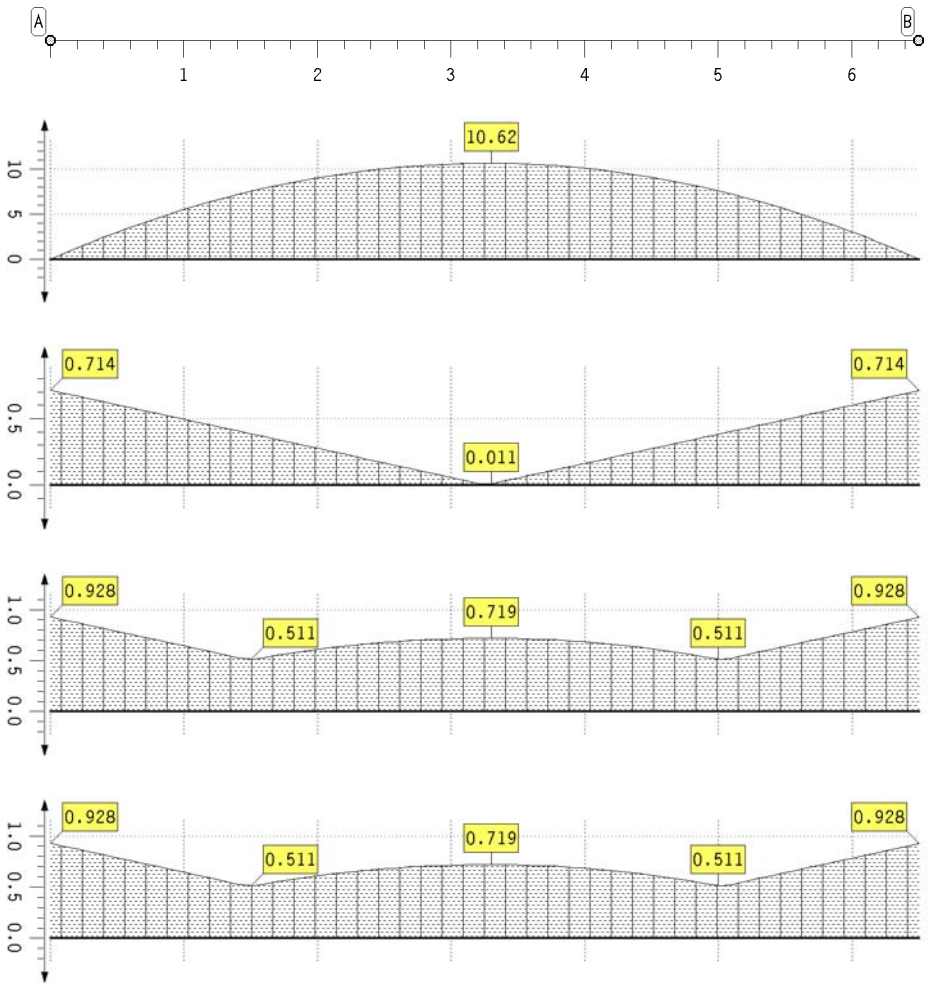
extremal support forces

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



bending stress
main beam
σ_h in MN/m²
Max: 10.62

shear stress
main beam
τ_h in MN/m²
Max: 0.71

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	0.928		3.200	0.719	B	6.500	0.928
	1.500	0.511		4.100	0.670	**minimum**		**0.511**
	2.400	0.670		5.000	0.511	**maximum**		**0.928**

extremal support forces

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

verification of bearing stress

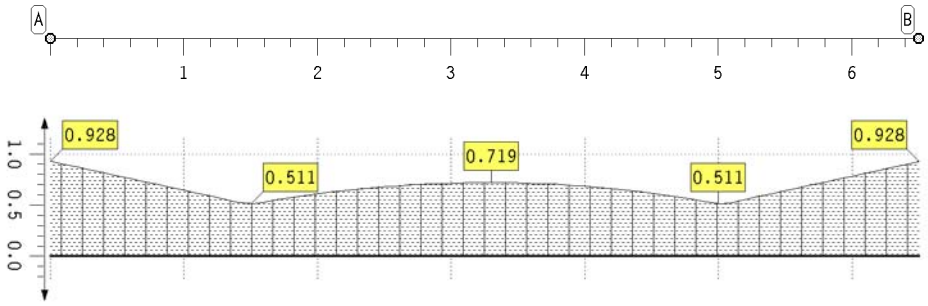
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm²	N		-	N/mm²	N/mm²	-
A	180	32400	56550	1.00	0.80	1.54	1.75	1.13
B	180	32400	56550	1.00	0.80	1.54	1.75	1.13

verification of bearing stresses für den main beam(u = 1.134) does not meet the requirements!

12. Summary

12.1. Summary of all verifications

maximal utilization



utilization
Max: 0.93

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	0.928		3.200	0.719	B	6.500	0.928
	1.500	0.511		4.100	0.670	**minimum**		**0.511**
	2.400	0.670		5.000	0.511	**maximum**		**0.928**

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	32400	56550	1.00	0.80	1.54	1.75	1.13
B	180	32400	56550	1.00	0.80	1.54	1.75	1.13

verification of bearing stresses für den main beam(u = 1.134) does not meet the requirements!

13. Utilizations of all verifications

verification of load-carrying capacity (u = 1.134) does not meet the requirements!

14. Detailed verification piont

14.1. 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	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	$k_{mod,2}$	$\sigma_{m,2}$	$\sigma_{c,2}$	$u_{\sigma,2}$	τ_2	u_τ	u_2
	-	N/mm²	N/mm²	-	N/mm²	-	-
start	0.8	0.00	0.00	0.00	0.71	0.29	0.29
end	0.8	0.00	0.00	**0.00**	0.71	0.29	0.29

stresses and utilization flanges

state	$k_{mod,1}$	$\sigma_{m,1}$	$\sigma_{c,1}$	u_1	$k_{mod,3}$	$\sigma_{m,3}$	$\sigma_{c,3}$	u_3
	-	N/mm²	N/mm²	-	-	N/mm²	N/mm²	-
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	$F_{1,d}$	$u_{1,d}$
	N	-
start	-9314	**0.93**
end	-8880	0.88

resulting utilization at verification point u_{res} = 0.928