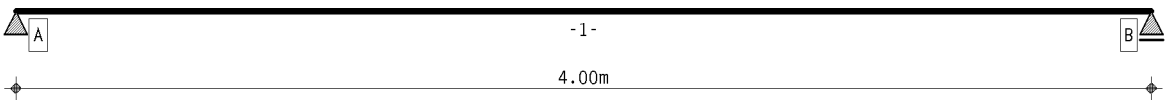
1. Options for Calculations

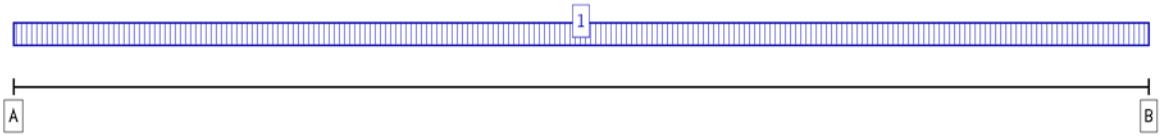
calculation DIN EN 1995:2010, Germany
service class 1
coefficient of thermal expansion for timber α_t = 0.500 *10^{-5}/°K
ψ_2 = 0.60 (factor acc. to DIN EN 1995-1-1 2.3.2.2 (2))

2. Structural system

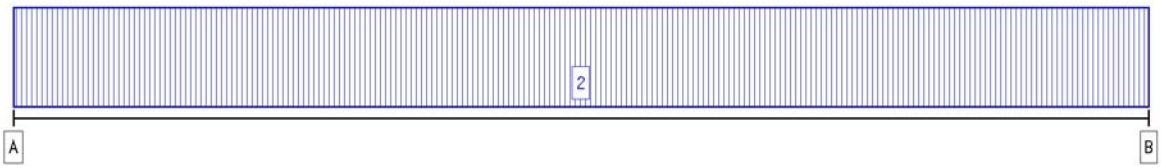


main beam

3. Loading



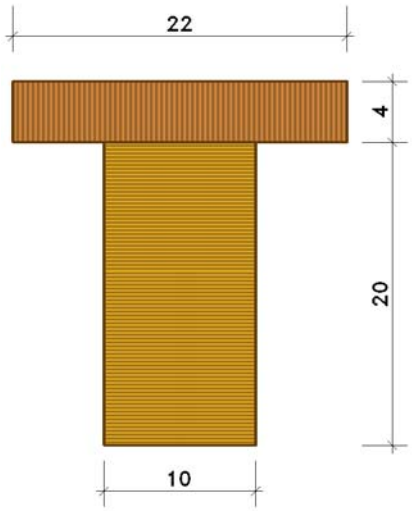
action effect 1: permanent loads (permanent, 1 load cases)



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

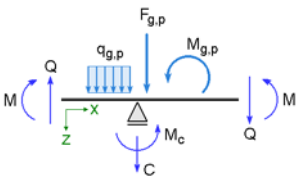
4. main beam

section scale 1: 5



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}	:	88.000 cm²
moment of inertia	I_{flange}	:	117.333 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}	:	200.000 cm²
moment of inertia	I_{flange}	:	6666.667 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	4.00	4.00	2.00	28.9000	1.2827	69.2042	1.1788	0.5592	4.00	-	36.0

stiffness values serviceability initial state

section	γ_2 -	a_2 mm	K_1 N/mm	γ_{1r} -	a_1 mm	$EI_{ef,inst}$ Nmm2	ø k_{def} -
1	1.0000	-22.0	2245	0.5109	-98.0	1.3277E12	0.4255

stiffness values load-carrying capacity initial state

section	γ_2 -	a_2 mm	K_1 N/mm	γ_{1r} -	a_1 mm	$EI_{ef,inst}$ Nmm2	$I_{ef,inst}$ mm2	$h_{q,inst}$ mm	$A_{q,inst}$ mm
1	1.0000	-18.4	1497	0.4105	-101.6	1.2309E12	111901344.0	11.84	159.76

stiffness values load-carrying capacity final state

section	γ_2 -	a_2 mm	K_1 N/mm	γ_1 -	a_1 mm	$EI_{ef,inf}$ Nmm2	$I_{ef,inf}$ mm2	$h_{q,inf}$ mm	$A_{q,inf}$ mm
1	1.0000	-16.2	870	0.3551	-103.8	8.6348E11	106757656.0	11.62	158.09

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
1	190.40	666.67	6666.67	83.20	58.67	117.33

6. Fasteners

section 1 from x_A = 0.00 m to x_E = 4.00
nail, 6.0 x 120.0 mm, d_k = 0.0 mm, predrilled
2-row with a_1 = **72.0 mm**
2 - row with a_2 = 22.0 mm, simplified verification acc. to NA.8.2.4
nail ends in timber member 2, penetration depth t = 80 mm > 4 d = 24 mm, 1 shear plane
f_{uk} = 600 N/mm², M_{yk} = 18987 Nmm
reduction of R_k with f = 0.941 for t_{vorh} < t_{req}
K_{ser} = 2245 N/mm, γ_M = 1.10, **R_k = 2332.1 N, all values per shear plane**

7. Supports

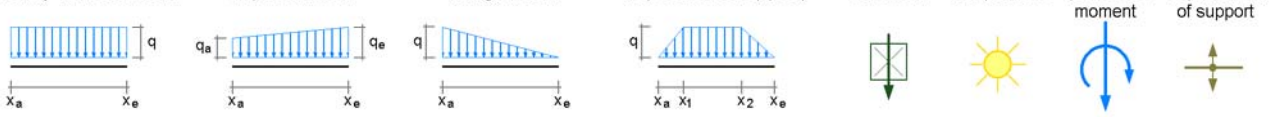
coordinates of supports

supp.name	x m	width mm	depth mm	c_F kN/m	c_M kNm/-	restraint (F)	restraint (M)
A	0.00	150	100	fix	----	X	-
B	4.00	150	100	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

uniformly distributed load | trapezoidal load | triangular load | trapezoidal load (spec.) | dead load | temperature | point load/ moment | displacement of support



Permanent action effect: permanent loads
1. additive load case: dead load (1)
⇒ unif.distr.load: q = 0.70 kN/m from x_a = 0.00 m to x_e = 4.00 m

2. Transient action effect: live loads (1)
2. additive load case: live loads (1/1)
⇒ unif.distr.load: q = 2.45 kN/m from x_a = 0.00 m to x_e = 4.00 m

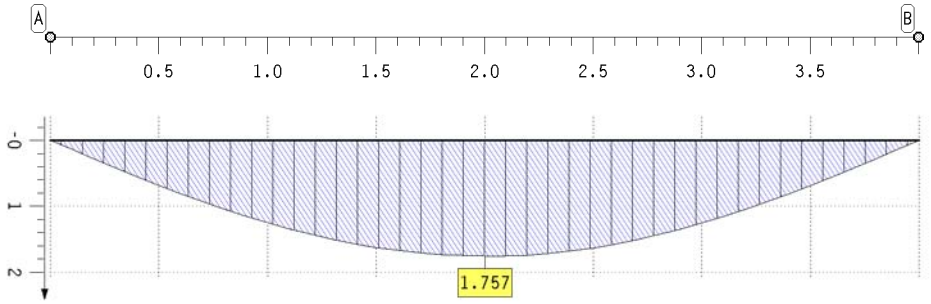
9. verifications

1: EC 5 load-carrying capacity
buckling analysis of compression flange acc. to DIN EN 1995, 6.3.2 will be executed
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)

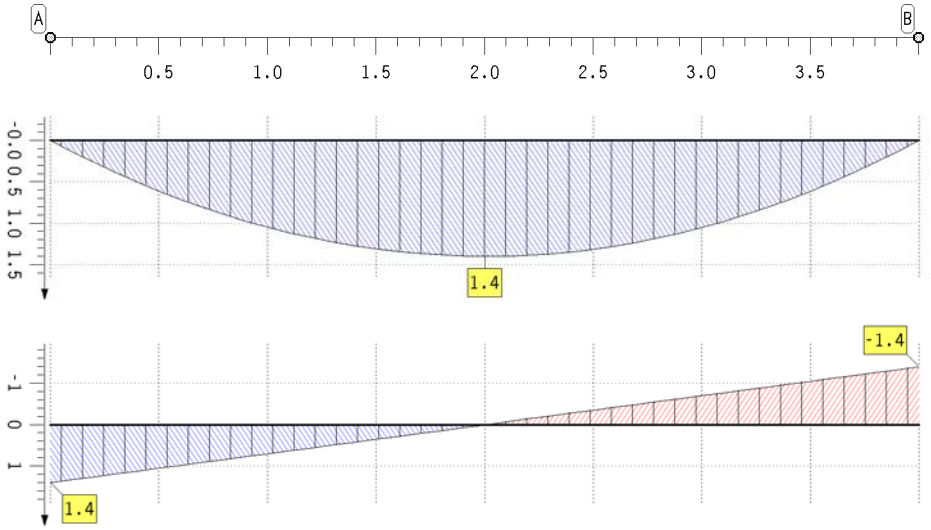


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 1.76

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	4.000	-0.00	-0.00
	1.100	1.34	1.34	**minimum**		**-0.00**	**-0.00**
	2.000	1.76	1.76	**maximum**		**1.76**	**1.76**
	2.900	1.34	1.34				

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 1.40

shear force
main beam
V in kN
Min: -1.40
Max: 1.40

extremal internal forces

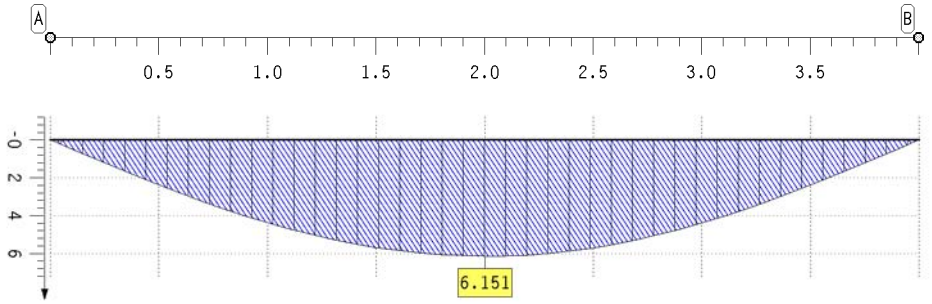
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	1.40	1.40	B	4.000	0.00	0.00	-1.40	-1.40
	1.000	1.05	1.05	0.70	0.70	**minimum**		**0.00**	**0.00**	**-1.40**	**-1.40**
	2.000	1.40	1.40	0.00	0.00	**maximum**		**1.40**	**1.40**	**1.40**	**1.40**
	3.000	1.05	1.05	-0.70	-0.70						

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-1.40	-1.40
B	4.000	-1.40	-1.40

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)



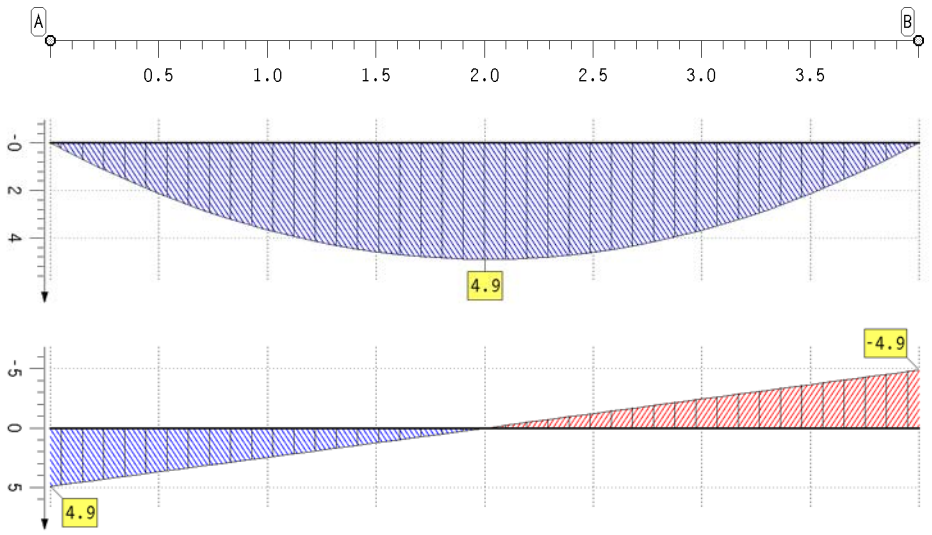
deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 6.15

extremal deflections of main beam (characteristic)

point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.100	0.00	4.71
	2.000	0.00	6.15
	2.900	0.00	4.71

point	x	min w	max w
-	m	mm	mm
B	4.000	-0.00	-0.00
minimum		**-0.00**	**0.00**
maximum		**0.00**	**6.15**

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 4.90

shear force
main beam
V in kN
Min: -4.90
Max: 4.90

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	4.90
	1.000	0.00	3.67	0.00	2.45
	2.000	0.00	4.90	0.00	0.00
	3.000	0.00	3.67	-2.45	-0.00

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	4.000	0.00	0.00	-4.90	-0.00
minimum		**0.00**	**0.00**	**-4.90**	**0.00**
maximum		**0.00**	**4.90**	**0.00**	**4.90**

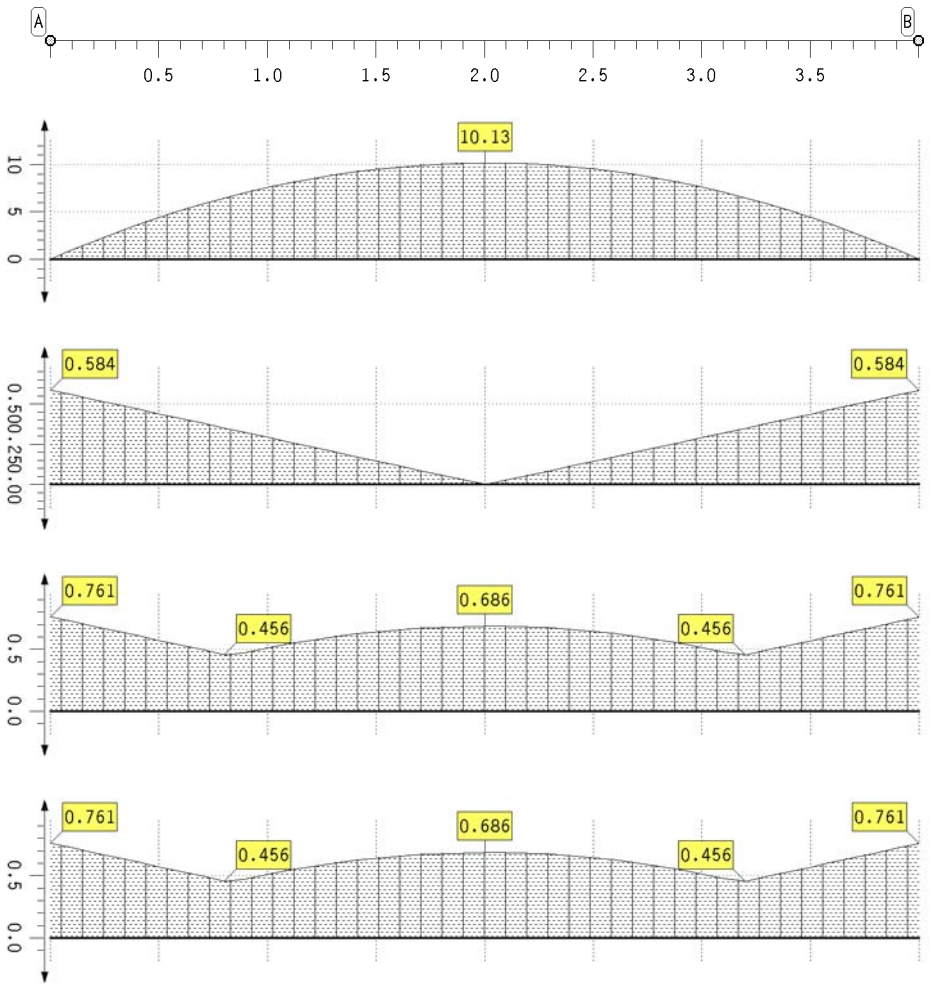
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-4.90	-0.00
B	4.000	-4.90	-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: 10.13

shear stress
main beam
τ_h in MN/m²
Max: 0.58

utilization
main beam
Max: 0.76

maximal
utilization
Max: 0.76

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	0.761		2.000	0.686	B	4.000	0.761
	0.800	0.456		2.600	0.624	**minimum**		**0.456**
	1.400	0.624		3.200	0.456	**maximum**		**0.761**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-9.24	-1.40
B	4.000	-9.24	-1.40

verification of bearing stress

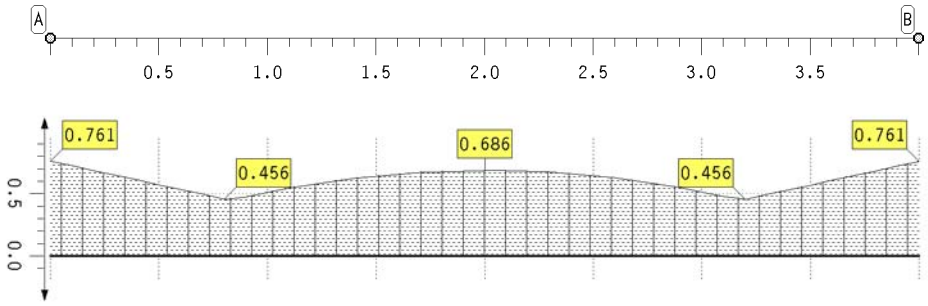
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm²	N		-	N/mm²	N/mm²	-
A	180	18000	9240	1.00	0.80	1.54	0.51	0.33
B	180	18000	9240	1.00	0.80	1.54	0.51	0.33

verification of bearing stresses für den main beam(u = 0.334) successful!

12. Summary

12.1. Summary of all verifications

maximal utilization



utilization
Max: 0.76

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	0.761		2.000	0.686	B	4.000	0.761
	0.800	0.456		2.600	0.624	**minimum**		**0.456**
	1.400	0.624		3.200	0.456	**maximum**		**0.761**

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	18000	9240	1.00	0.80	1.54	0.51	0.33
B	180	18000	9240	1.00	0.80	1.54	0.51	0.33

verification of bearing stresses für den main beam(u = 0.334) successful!

13. Utilizations of all verifications

all verifications successful!

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
	kNm	kN	Nmm	N	Nmm	N
start,min	0.00	1.40	0	-0	0	0
start,max	0.00	9.24	0	-0	0	0
end,min	0.00	1.40	0	-0	0	0
end,max	0.00	9.24	0	-0	0	0

stresses and utilization

state	$k_{mod,1}$	$\sigma_{m,1}$	$\sigma_{c,1}$	u_1	$k_{mod,2}$	$\sigma_{m,2}$	$\sigma_{c,2}$	$u_{\sigma,2}$	τ_2	u_τ	u_2
	-	N/mm^2	N/mm^2	-	-	N/mm^2	N/mm^2	-	N/mm^2	-	-
start	0.8	0.00	-0.00	**0.00**	0.8	0.00	0.00	**0.00**	0.58	0.23	0.23
end	0.8	0.00	-0.00	0.00	0.8	0.00	0.00	0.00	0.58	0.24	0.24

fastener

state	$F_{1,d}$	$u_{1,d}$
	N	-
start	-1091	**0.76**
end	-1011	0.70

resulting utilization at verification point u_{res} = 0.761