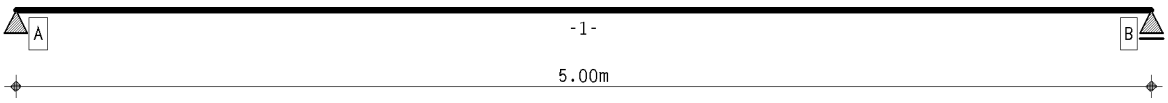
1. Options for Calculations

calculation acc. to DIN 1052:2008

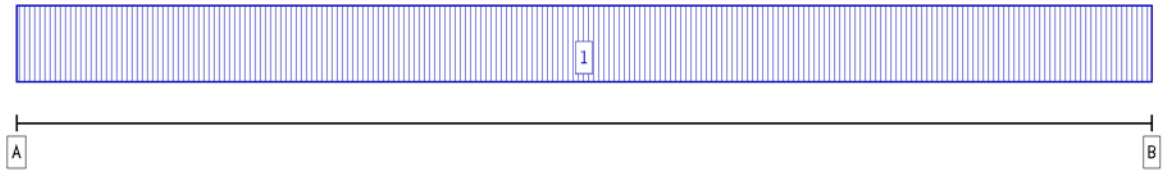
service class 2

2. Structural system

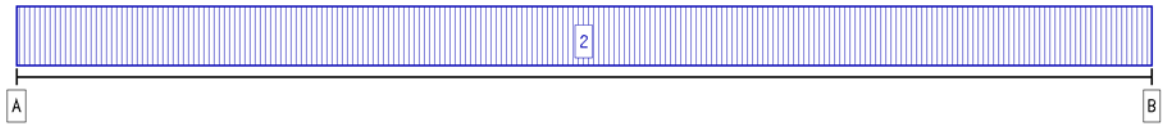


main beam

3. Loading



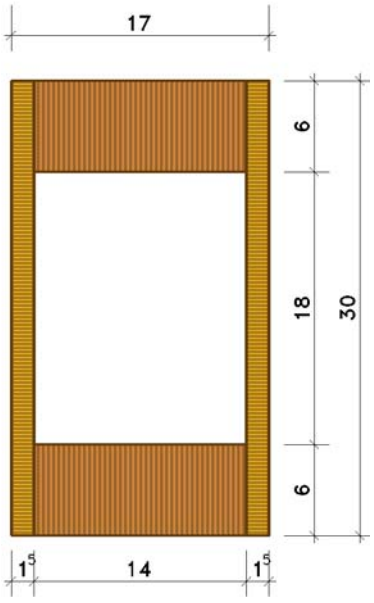
action effect 1: permanent loads (permanent, 1 load cases)



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

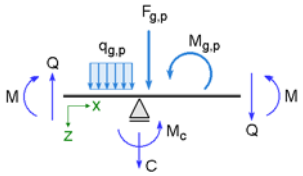
4. main beam (not acc. to DIN)

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	$f_{v,k}$	:	2.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.0 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}	:	84.000 cm²
moment of inertia	I_{flange}	:	252.000 cm⁴
timber grade web (fibre ⊥)			**OSB 3**
d = 15.0 mm (hochkant)			
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	9.0 N/mm²
char. ten. strength	$f_{t,k}$	:	21.0 N/mm²
char. compr. strength	$f_{c,0,k}$	:	14.0 N/mm²
char. compr. strength	$f_{c,90,k}$	:	2.5 N/mm²
e-modulus	$E_{0,mean}$ (diaphragm)	:	2500 N/mm²
e-modulus	$E_{0,mean}$ (plate)	:	11000 N/mm²
Dichte	ρ_k / ρ_m	:	550 / 660 kg/m³
deformation factor	k_{def}	:	1.50 -
area	A_{flange}	:	90.000 cm²
moment of inertia	I_{flange}	:	6750.000 cm⁴
timber grade bottom flange			**solid coniferous timber, C24 (S10)**
char. bend. strength	$f_{m,k}$	:	24.0 N/mm²
char. shear strength	$f_{v,k}$	:	2.0 N/mm²
char. ten. strength	$f_{t,k}$	:	14.0 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}	:	84.000 cm²
moment of inertia	I_{flange}	:	252.000 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	5.00	5.00	5.00	40.4600	2.8960	123.5788	2.1050	0.2047	3.00	-	23.3

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	909	0.5173	-120.0	909	0.5173	120.0	1.6007E12	0.9111

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	606	0.4167	-120.0	606	0.4167	120.0	1.3331E12	121188288.0	15.00	73.19

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	296	0.3580	-120.0	296	0.3580	120.0	6.9753E11	101458448.0	15.00	74.25

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	90.00	450.00	6750.00	84.00	84.00	252.00	84.00	84.00	252.00

6. Fasteners

section 1 from x_A = 0.00 m to x_E = 5.00
nail, 3.1 x 70.0 mm, d_k = 20.0 mm, not predrilled
2-row with a_1 = **46.5 mm**
2 - row with a_2 = 22.0 mm, simplified verification acc. to DIN 1052:2008, 12.2(2)
nail ends in timber member 2, penetration depth t = 55 mm > 4 d = 12 mm, 1 shear plane
f_{uk} = 600 N/mm², M_{yk} = 3410 Nmm
reduction of R_k with f = 0.691 for t_{vorh} < t_{req}
K_{ser} = 909 N/mm, γ_M = 1.10, **R_k = 499.6 N, all values per shear plane**

7. Supports

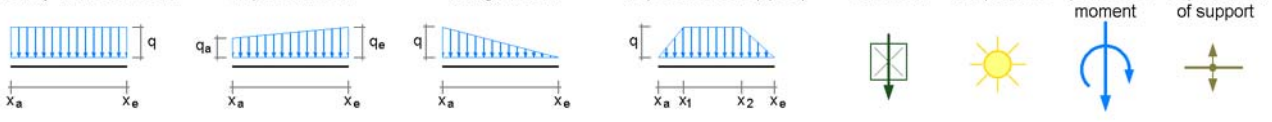
coordinates of supports

supp.name	x m	width mm	depth mm	c_F kN/m	c_M kNm/-	restraint (F)	restraint (M)
A	0.00	150	30	fix	----	X	-
B	5.00	150	30	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

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 = 0.80 kN/m from x_a = 0.00 m to x_e = 5.00 m
2. Transient action effect: live loads (1)
2. additive load case: live loads (1/1)
⇒ unif.distr.load: q = 0.47 kN/m from x_a = 0.00 m to x_e = 5.00 m

9. verifications

1: DIN 1052:2008 load-carrying capacity
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

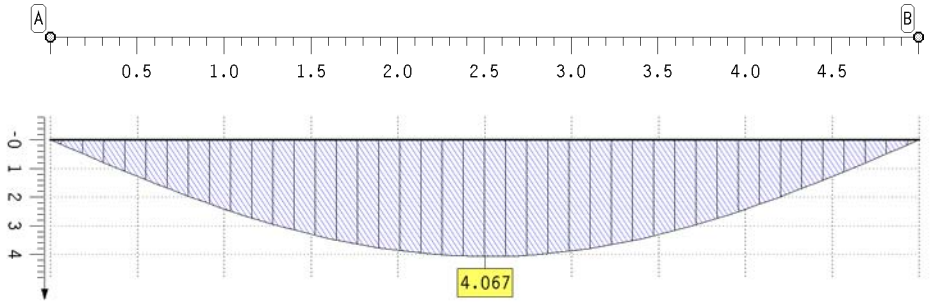
2: DIN 1052:2008 deformations (rarely)
Extreme rule 1

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)



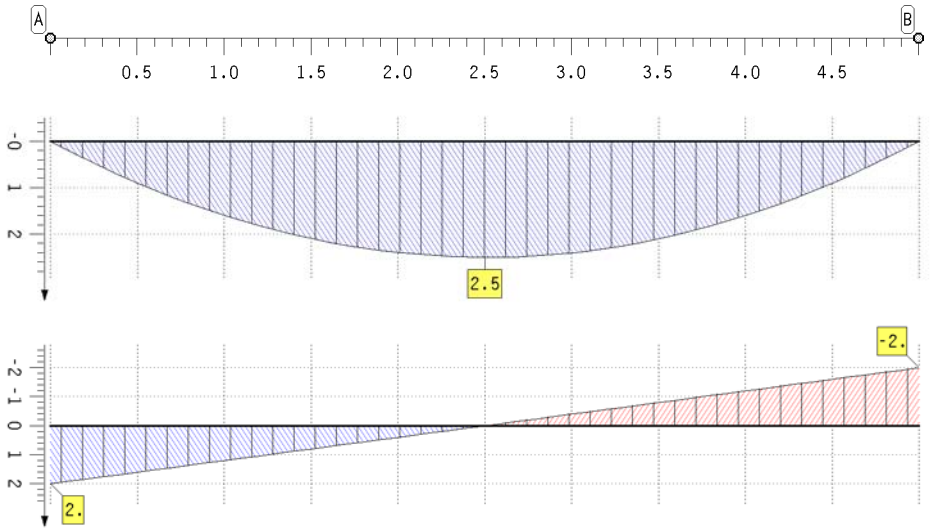
deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 4.07

extremal deflections of main beam (characteristic)

point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.400	3.15	3.15
	2.500	4.07	4.07
	3.600	3.15	3.15

point	x	min w	max w
-	m	mm	mm
B	5.000	0.00	0.00
minimum		**0.00**	**0.00**
maximum		**4.07**	**4.07**

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 2.50

shear force
main beam
V in kN
Min: -2.00
Max: 2.00

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	2.00	2.00
	1.300	1.92	1.92	0.96	0.96
	2.500	2.50	2.50	0.00	0.00
	3.700	1.92	1.92	-0.96	-0.96

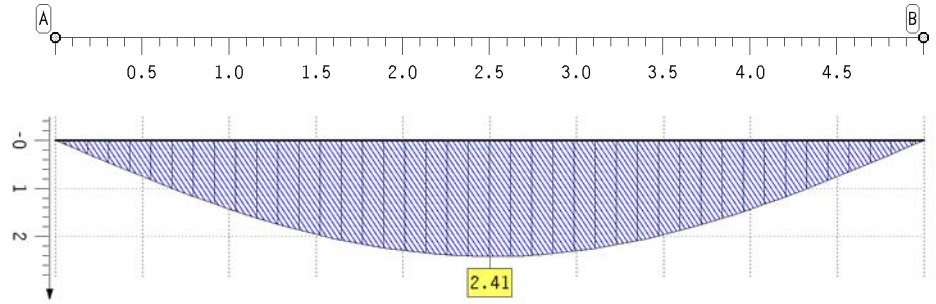
point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	5.000	-0.00	-0.00	-2.00	-2.00
minimum		**-0.00**	**-0.00**	**-2.00**	**-2.00**
maximum		**2.50**	**2.50**	**2.00**	**2.00**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-2.00	-2.00
B	5.000	-2.00	-2.00

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)



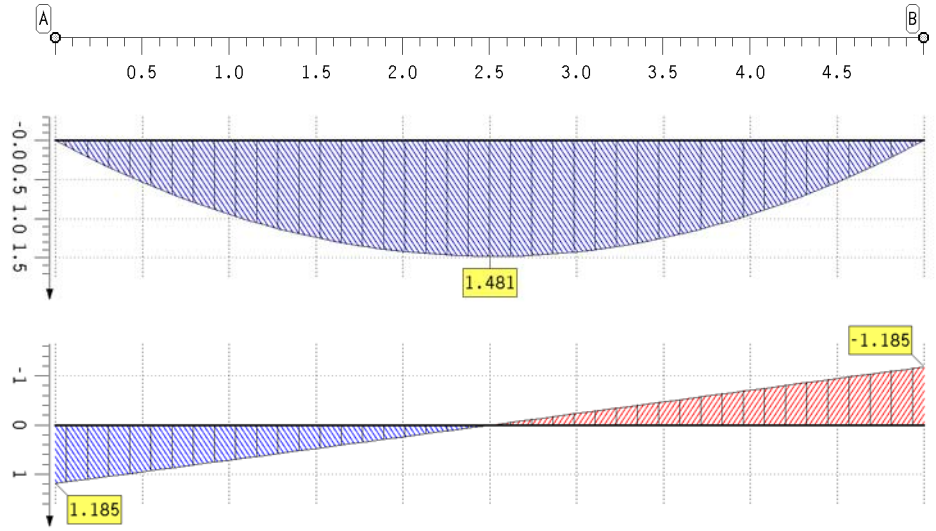
deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 2.41

extremal deflections of main beam (characteristic)

point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.400	0.00	1.87
	2.500	0.00	2.41
	3.600	0.00	1.87

point	x	min w	max w
-	m	mm	mm
B	5.000	0.00	0.00
minimum		**0.00**	**0.00**
maximum		**0.00**	**2.41**

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 1.48

shear force
main beam
V in kN
Min: -1.18
Max: 1.18

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	1.18
	1.300	0.00	1.14	0.00	0.57
	2.500	0.00	1.48	0.00	0.00
	3.700	0.00	1.14	-0.57	-0.00

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	5.000	-0.00	-0.00	-1.18	-0.00
minimum		**-0.00**	**-0.00**	**-1.18**	**-0.00**
maximum		**0.00**	**1.48**	**0.00**	**1.18**

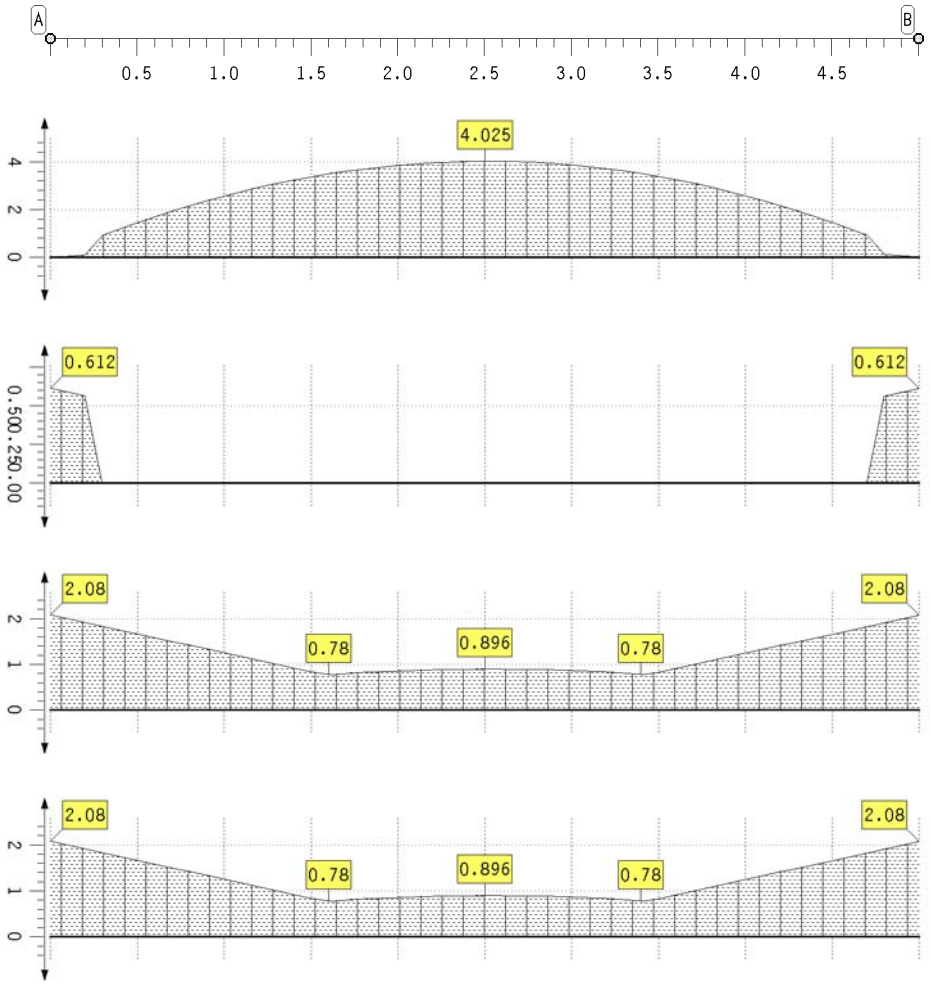
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-1.18	-0.00
B	5.000	-1.18	-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: 4.02

shear stress
main beam
τ_h in MN/m²
Max: 0.61

utilization
main beam
Max: 2.08

maximal
utilization
Max: 2.08

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	2.080	B	5.000	2.080
	1.600	0.780	**minimum**		**0.780**
	3.400	0.780	**maximum**		**2.080**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-4.48	-2.00
B	5.000	-4.48	-2.00

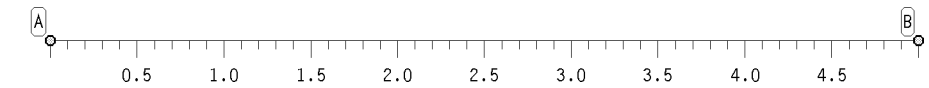
verification of bearing stress

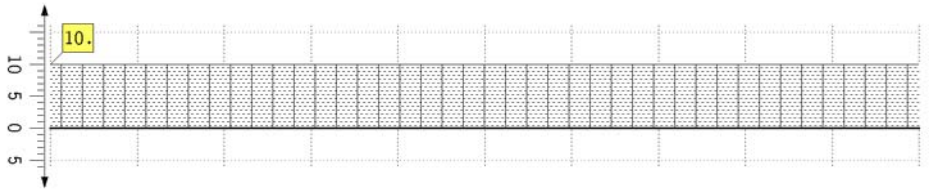
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm²	N		-	N/mm²	N/mm²	-
A	180	5400	2700	1.00	0.30	0.58	0.50	0.87
B	180	5400	2700	1.00	0.30	0.58	0.50	0.87

verification of bearing stresses für den main beam(u = 0.867) successful!

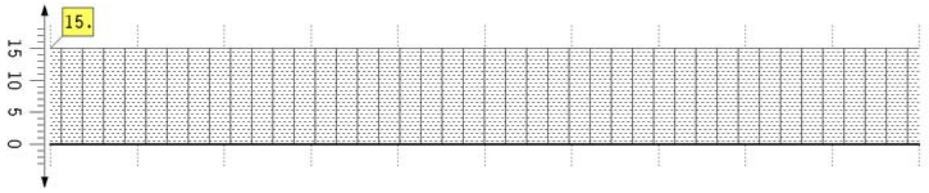
12. Results of verification of deflections (rarely)

12.1. Verification of deflections (rarely)
results of verification of deflections (rarely)

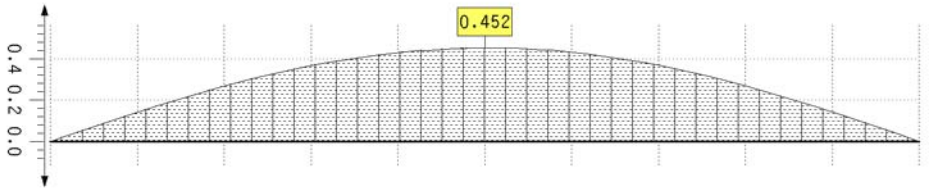




decisive deflection $w_{A,req}$ in mm
Min: 10.00
Max: 10.00



decisive deflection $w_{B,req}$ in mm
Min: 15.00
Max: 15.00



maximal utilization
Max: 0.45

maximal utilization

point	x	U
-	m	-
A	0.000	0.000
	1.400	0.350
	2.500	0.452
	3.600	0.350

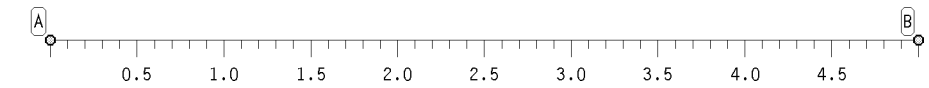
point	x	U
-	m	-
B	5.000	0.000
minimum		**0.000**
maximum		**0.452**

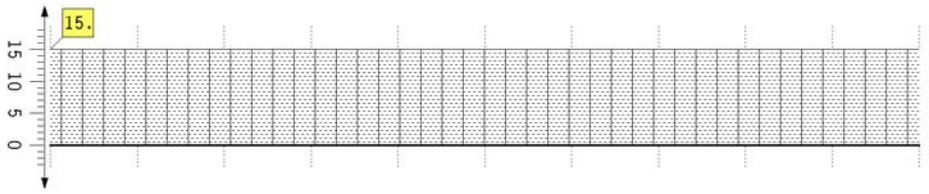
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-3.33	-0.00
B	5.000	-3.33	-0.00

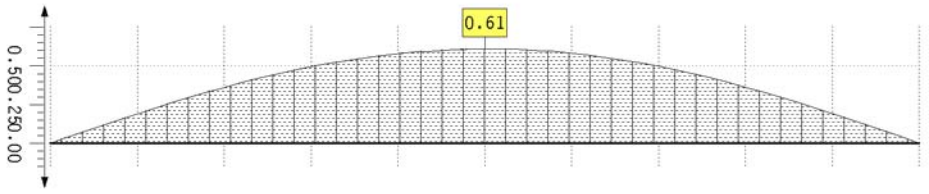
13. Results of verification of deflections (quasicontinuous)

13.1. Verification of deflections (quasicontinuous)
results of verification of deflections (quasicontinuous)





decisive deflection w_{req} in mm
Min: 15.00
Max: 15.00



maximal utilization
Max: 0.61

maximal utilization

point	x	U
-	m	-
A	0.000	0.000
	1.400	0.473
	2.500	0.610
	3.600	0.473

point	x	U
-	m	-
B	5.000	0.000
minimum		**0.000**
maximum		**0.610**

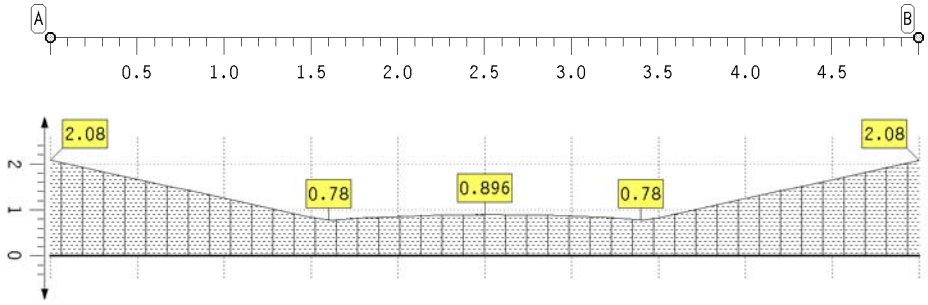
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-4.50	-3.82
B	5.000	-4.50	-3.82

14. Summary

14.1. Summary of all verifications

maximal utilization



utilization
Max: 2.08

maximal utilization

point	x	U
-	m	-
A	0.000	2.080
	1.600	0.780
	3.400	0.780

point	x	U
-	m	-
B	5.000	2.080
minimum		**0.780**
maximum		**2.080**

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	5400	2700	1.00	0.30	0.58	0.50	0.87
B	180	5400	2700	1.00	0.30	0.58	0.50	0.87

verification of bearing stresses für den main beam(u = 0.867) successful!

15. Utilizations of all verifications

verification of load-carrying capacity (u = 2.080) does not meet the requirements!

16. Detailed verification piont

16.1. Verification of load-carrying capacity at x = 1.50 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	2.10	0.80	43668	-7278	265834	0	43668	7278
start,max	4.70	1.79	97761	-16295	595135	0	97761	16295
end,min	2.10	0.80	52159	-7469	203218	0	52159	7469
end,max	4.70	1.79	116772	-16720	454954	0	116772	16720

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	0.6	1.32	0.00	**0.13**	0.24	0.06	0.13
end	0.6	1.01	0.00	0.10	0.24	0.06	0.10

stresses and utilization flanges

state	$k_{mod,1}$ -	$\sigma_{m,1}$ N/mm²	$\sigma_{c,1}$ N/mm²	u_1 -	$k_{mod,3}$ -	$\sigma_{m,3}$ N/mm²	$\sigma_{c,3}$ N/mm²	u_3 -
start	0.8	1.16	-1.94	0.73	0.8	1.16	1.94	0.23
end	0.8	1.39	-1.99	**0.75**	0.8	1.39	1.99	**0.23**

fastener

state	$F_{1,d}$ N	$u_{1,d}$ -	$F_{2,d}$ N	$u_{2,d}$ -
start	-144	0.47	144	0.47
end	-148	**0.48**	148	**0.48**

resulting utilization at verification point u_{res} = 0.832

16.2. Verification of load-carrying capacity at x = 2.50 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	2.50	0.00	51985	-8665	316468	0	51985	8665
start,max	5.60	0.00	116382	-19398	708494	0	116382	19398
end,min	2.50	0.00	62094	-8891	241926	0	62094	8891
end,max	5.60	0.00	139014	-19905	541612	0	139014	19905

stresses and utilization web

state	$k_{mod,2}$ -	$\sigma_{m,2}$ N/mm²	$\sigma_{c,2}$ N/mm²	$u_{\sigma,2}$ -	τ_2 N/mm²	u_τ -	u_2 -
start	0.6	1.57	0.00	**0.16**	0.00	0.00	0.16
end	0.6	1.20	0.00	0.12	0.00	0.00	0.12

stresses and utilization flanges

state	$k_{mod,1}$ -	$\sigma_{m,1}$ N/mm²	$\sigma_{c,1}$ N/mm²	u_1 -	$k_{mod,3}$ -	$\sigma_{m,3}$ N/mm²	$\sigma_{c,3}$ N/mm²	u_3 -
start	0.8	1.39	-2.31	0.87	0.8	1.39	2.31	0.27
end	0.8	1.65	-2.37	**0.90**	0.8	1.65	2.37	**0.28**

resulting utilization at verification point u_{res} = 0.896

16.3. Verification of load-carrying capacity at x = 5.00 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	-4.48	-0	0	-0	-0	-0	-0
start,max	-0.00	-2.00	-0	0	-0	-0	-0	-0
end,min	-0.00	-4.48	-0	0	-0	-0	-0	-0
end,max	-0.00	-2.00	-0	0	-0	-0	-0	-0

stresses and utilization web

state	$k_{mod,2}$ -	$\sigma_{m,2}$ N/mm²	$\sigma_{c,2}$ N/mm²	$u_{\sigma,2}$ -	τ_2 N/mm²	u_τ -	u_2 -
start	0.6	0.00	0.00	**0.00**	0.61	0.16	0.16
end	0.6	0.00	0.00	0.00	0.60	0.16	0.16

stresses and utilization flanges

state	$k_{mod,1}$ -	$\sigma_{m,1}$ N/mm²	$\sigma_{c,1}$ N/mm²	u_1 -	$k_{mod,3}$ -	$\sigma_{m,3}$ N/mm²	$\sigma_{c,3}$ N/mm²	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	-361	1.17	361	1.17
end	-370	**1.20**	370	**1.20**

resulting utilization at verification point u_{res} = 2.080