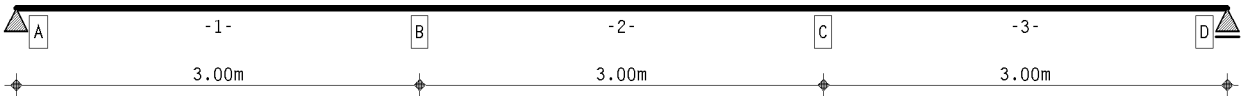
1. Options for Calculations

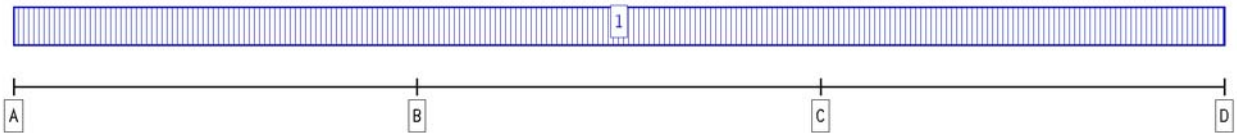
calculation acc. to DIN 1052:2008
service class 1

2. Structural system

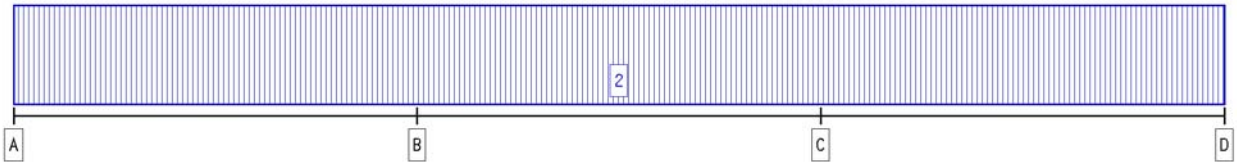


main beam

3. Loading



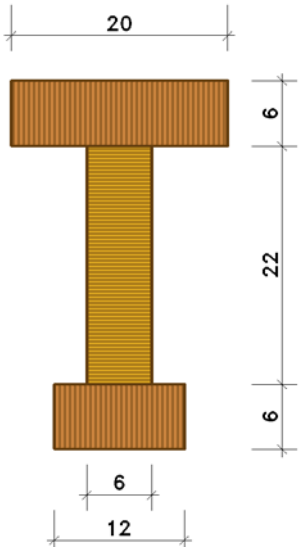
action effect 1: permanent loads (permanent, 1 load cases)



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

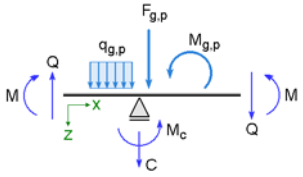
4. main beam

section scale 1: 7



timber grade top flange		**solid coniferous timber, C30 (S13)**
char. bend. strength	$f_{m,k}$	: 30.0 N/mm²
char. shear strength	$f_{v,k}$	: 2.0 N/mm²
char. ten. strength	$f_{t,k}$	: 18.0 N/mm²
char. compr. strength	$f_{c,0,k}$	: 23.0 N/mm²
char. compr. strength	$f_{c,90,k}$	: 2.7 N/mm²
modulus of elasticity	$E_{0,mean}$	:12000 N/mm²
Dichte	ρ_k / ρ_m	: 380 / 456 kg/m³
deformation factor	k_{def}	: 0.60 -
area	A_{flange}	: 120.000 cm²
moment of inertia	I_{flange}	: 360.000 cm⁴
timber grade web		**solid coniferous timber, C30 (S13)**
char. bend. strength	$f_{m,k}$	: 30.0 N/mm²
char. shear strength	$f_{v,k}$	: 2.0 N/mm²
char. ten. strength	$f_{t,k}$	: 18.0 N/mm²
char. compr. strength	$f_{c,0,k}$	: 23.0 N/mm²
char. compr. strength	$f_{c,90,k}$	: 2.7 N/mm²
modulus of elasticity	$E_{0,mean}$	:12000 N/mm²
Dichte	ρ_k / ρ_m	: 380 / 456 kg/m³
deformation factor	k_{def}	: 0.60 -
area	A_{flange}	: 132.000 cm²
moment of inertia	I_{flange}	: 5324.000 cm⁴
timber grade bottom flange		**solid coniferous timber, C30 (S13)**
char. bend. strength	$f_{m,k}$	: 30.0 N/mm²
char. shear strength	$f_{v,k}$	: 2.0 N/mm²
char. ten. strength	$f_{t,k}$	: 18.0 N/mm²
char. compr. strength	$f_{c,0,k}$	: 23.0 N/mm²
char. compr. strength	$f_{c,90,k}$	: 2.7 N/mm²
modulus of elasticity	$E_{0,mean}$	:12000 N/mm²
Dichte	ρ_k / ρ_m	: 380 / 456 kg/m³
deformation factor	k_{def}	: 0.60 -
area	A_{flange}	: 72.000 cm²
moment of inertia	I_{flange}	: 216.000 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	3.00	3.00	4.50	57.8000	1.4857	77.8547	1.3288	0.4651	9.00	-	45.0
2	3.00	6.00	3.00	4.50	57.8000	1.4857	77.8547	1.3288	0.4651	9.00	-	74.0
3	6.00	9.00	3.00	4.50	57.8000	1.4857	77.8547	1.3288	0.4651	9.00	-	45.0

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	-9.9	934	0.5419	-130.1	934	0.6635	149.9	3.3324E12	0.6000
2	1.0000	-6.9	934	0.4184	-133.1	934	0.5452	146.9	2.7994E12	0.6000
3	1.0000	-9.9	934	0.5419	-130.1	934	0.6635	149.9	3.3324E12	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	$EI_{ef,inst}$ Nmm2	$I_{ef,inst}$ mm2	$h_{q,inst}$ mm	$A_{q,inst}$ mm
1	1.0000	-7.5	623	0.4409	-132.5	623	0.5679	147.5	2.8991E12	241589456.0	11.75	142.56
2	1.0000	-4.8	623	0.3241	-135.2	623	0.4442	144.8	2.3695E12	197458784.0	11.48	138.05
3	1.0000	-7.5	623	0.4409	-132.5	623	0.5679	147.5	2.8991E12	241589456.0	11.75	142.56

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	-7.5	389	0.4409	-132.5	389	0.5679	147.5	1.8119E12	241589456.0	11.75	142.56
2	1.0000	-4.8	389	0.3241	-135.2	389	0.4442	144.8	1.4809E12	197458784.0	11.48	138.05
3	1.0000	-7.5	389	0.4409	-132.5	389	0.5679	147.5	1.8119E12	241589456.0	11.75	142.56

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	132.00	484.00	5324.00	120.00	120.00	360.00	72.00	72.00	216.00
2	132.00	484.00	5324.00	120.00	120.00	360.00	72.00	72.00	216.00
3	132.00	484.00	5324.00	120.00	120.00	360.00	72.00	72.00	216.00

6. Fasteners

section 1 from x_A = 0.00 m to x_E = 3.00
nail, 4.2 x 100.0 mm, d_k = 20.0 mm, not predrilled
1-row with a_1 = **45.0 mm**
1 - row, simplified verification acc. to DIN 1052:2008, 12.2(2)
nail ends in timber member 2, penetration depth t = 40 mm > 4 d = 17 mm, 1 shear plane
f_{uk} = 600 N/mm², M_{yk} = 7511 Nmm
K_{ser} = 934 N/mm, γ_M = 1.10, **R_k = 1130.6 N, all values per shear plane**

section 2 from x_A = 3.00 m to x_E = 6.00
nail, 4.2 x 100.0 mm, d_k = 0.0 mm, not predrilled
1-row with a_1 = **74.0 mm**
1 - row, simplified verification acc. to DIN 1052:2008, 12.2(2)
nail ends in timber member 2, penetration depth t = 40 mm > 4 d = 17 mm, 1 shear plane
f_{uk} = 600 N/mm², M_{yk} = 7511 Nmm
K_{ser} = 934 N/mm, γ_M = 1.10, **R_k = 1130.6 N, all values per shear plane**

section 3 from x_A = 6.00 m to x_E = 9.00
nail, 4.2 x 100.0 mm, d_k = 0.0 mm, not predrilled
1-row with a_1 = **45.0 mm**
1 - row, simplified verification acc. to DIN 1052:2008, 12.2(2)
nail ends in timber member 2, penetration depth t = 40 mm > 4 d = 17 mm, 1 shear plane
f_{uk} = 600 N/mm², M_{yk} = 7511 Nmm
K_{ser} = 934 N/mm, γ_M = 1.10, **R_k = 1130.6 N, all values per shear plane**

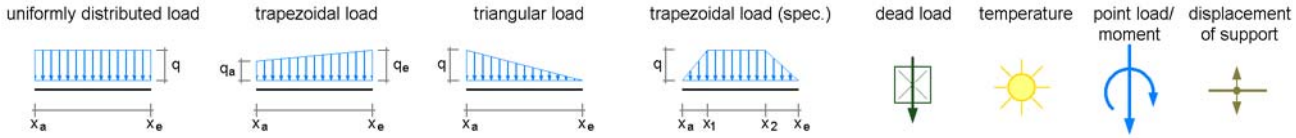
7. Supports

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	120	fix	----	X	-
B	3.00	0	120	----	----	-	-
C	6.00	0	120	----	----	-	-
D	9.00	150	120	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 = 0.35 kN/m from x_a = 0.00 m to x_e = 9.00 m

2. Transient action effect: live loads (1)
2. additive load case: live loads (1/1)
⇒ unif.distr.load: q = 0.70 kN/m from x_a = 0.00 m to x_e = 9.00 m

9. verifications

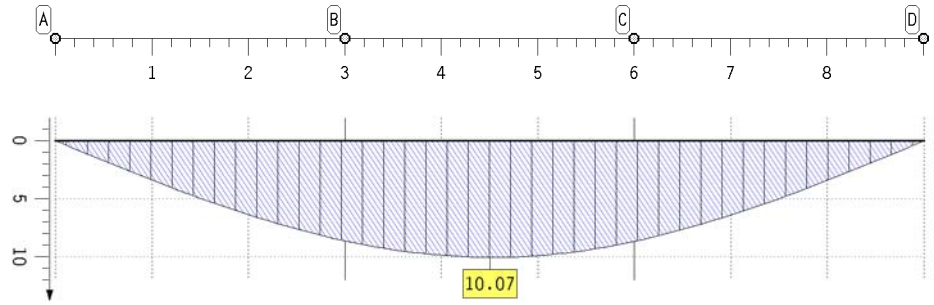
1: DIN 1052:2008 load-carrying capacity
verification of buckling resistance acc. to DIN 1052, 10.5.1(3) will be executed
buckling analysis of compression flange acc. to DIN 1052, 10.3.1 will be executed
verification of bearing stress DIN 1052, 10.2.4 will be executed
Extreme rule 1

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

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

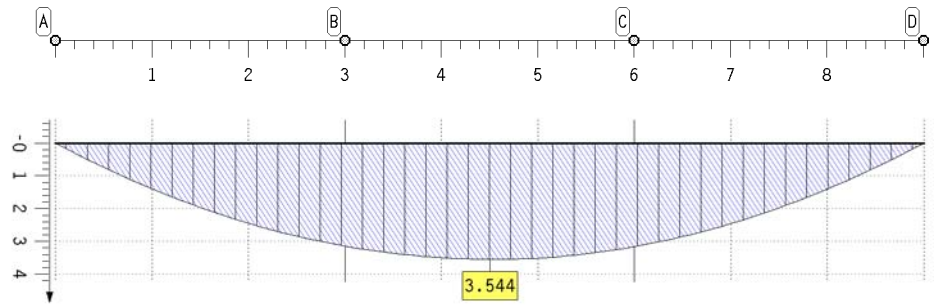


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 10.07

extremal deflections of main beam (characteristic)

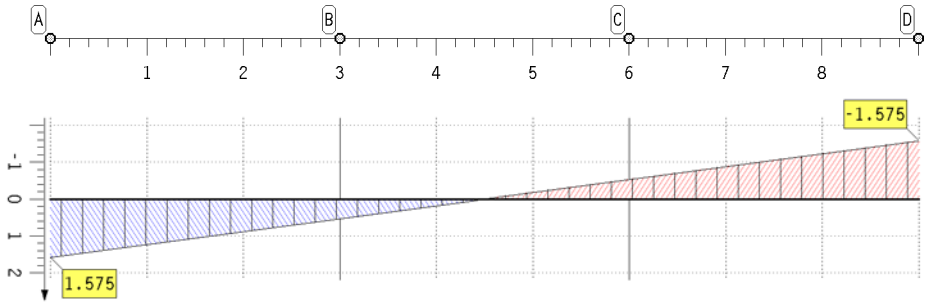
point	x	min w	max w	point	x	min w	max w	point	x	min w	max w
-	m	mm	mm	-	m	mm	mm	-	m	mm	mm
A	0.000	0.00	0.00		4.500	10.07	10.07	D	9.000	-0.00	-0.00
B	3.000	8.68	8.68		5.200	9.76	9.76	**minimum**		**-0.00**	**-0.00**
B	3.000	8.68	8.68	C	6.000	8.68	8.68	**maximum**		**10.07**	**10.07**
	3.800	9.76	9.76	C	6.000	8.68	8.68				

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 3.54

extremal internal forces



shear force
main beam
V in kN
Min: -1.58
Max: 1.58

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	1.58	1.58
	1.500	1.97	1.97	1.05	1.05
B	3.000	3.15	3.15	0.52	0.52
B	3.000	3.15	3.15	0.52	0.52
	3.700	3.43	3.43	0.28	0.28
	4.500	3.54	3.54	-0.00	-0.00
	5.300	3.43	3.43	-0.28	-0.28

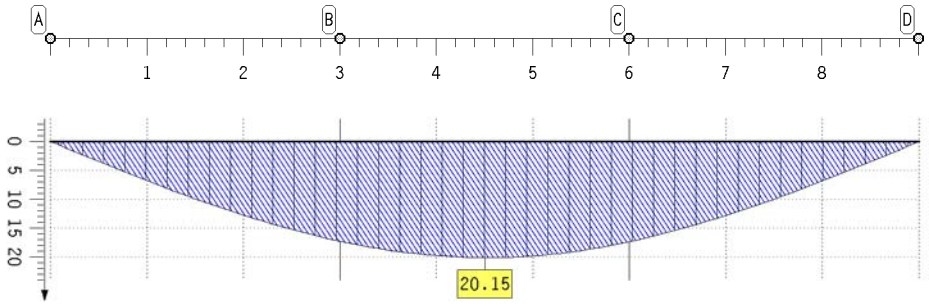
point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
C	6.000	3.15	3.15	-0.52	-0.52
C	6.000	3.15	3.15	-0.52	-0.52
	7.500	1.97	1.97	-1.05	-1.05
D	9.000	0.00	0.00	-1.58	-1.58
minimum		**-0.00**	**-0.00**	**-1.58**	**-1.58**
maximum		**3.54**	**3.54**	**1.58**	**1.58**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-1.58	-1.58
D	9.000	-1.58	-1.58

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)



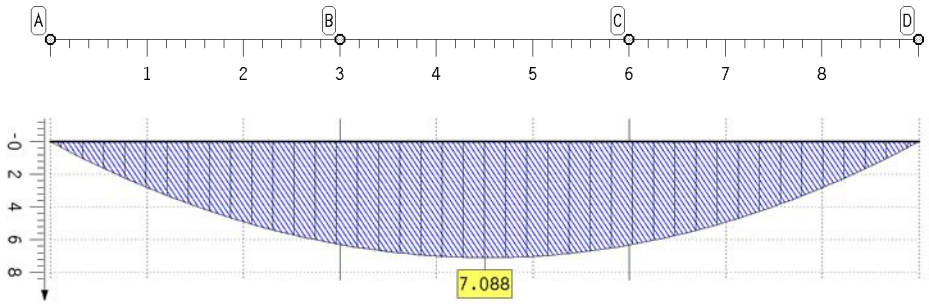
deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 20.15

extremal deflections of main beam (characteristic)

point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
B	3.000	0.00	17.35
B	3.000	0.00	17.35
	3.800	0.00	19.53
	4.500	0.00	20.15
	5.200	0.00	19.53
C	6.000	0.00	17.35
C	6.000	0.00	17.35

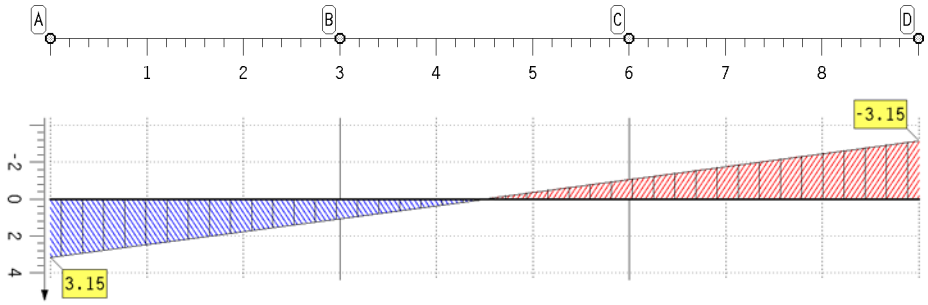
point	x	min w	max w
-	m	mm	mm
D	9.000	-0.00	-0.00
minimum		**-0.00**	**0.00**
maximum		**0.00**	**20.15**

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 7.09

extremal internal forces



shear force
main beam
V in kN
Min: -3.15
Max: 3.15

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	3.15
	1.500	0.00	3.94	0.00	2.10
B	3.000	0.00	6.30	0.00	1.05
B	3.000	0.00	6.30	0.00	1.05
	3.700	0.00	6.86	0.00	0.56
	4.500	0.00	7.09	-0.00	-0.00
	5.300	0.00	6.86	-0.56	-0.00
C	6.000	0.00	6.30	-1.05	-0.00
C	6.000	0.00	6.30	-1.05	-0.00
	7.500	0.00	3.94	-2.10	-0.00
D	9.000	0.00	0.00	-3.15	-0.00
minimum		**-0.00**	**-0.00**	**-3.15**	**-0.00**
maximum		**0.00**	**7.09**	**0.00**	**3.15**

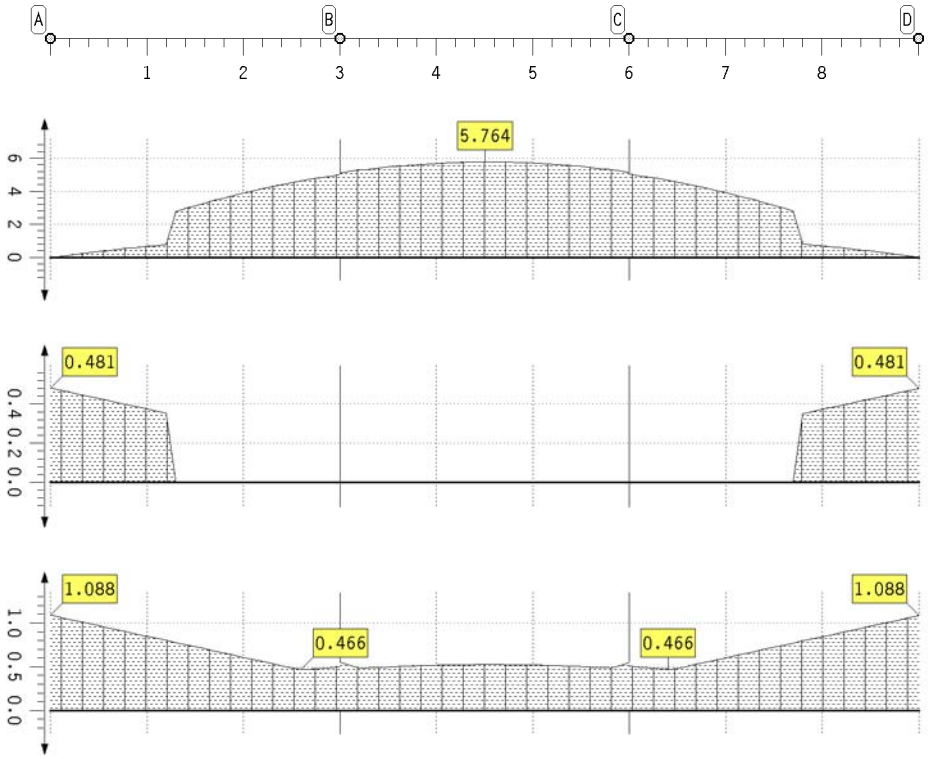
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-3.15	-0.00
D	9.000	-3.15	-0.00

11. Results of verification of ultimate limit state

11.1. Verification of ultimate limit state

results of verification of ultimate limit state

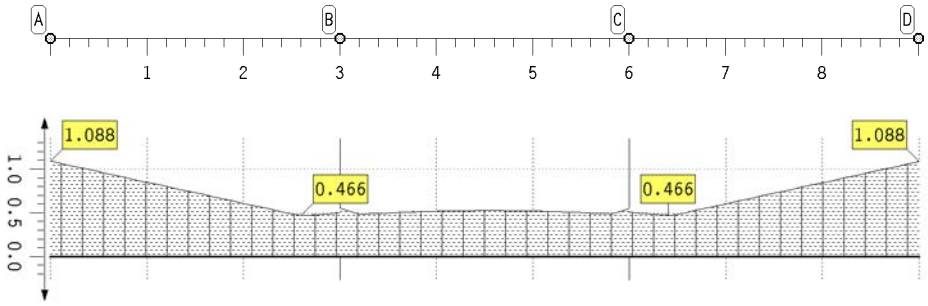


bending stress
main beam
σ_h in MN/m²
Max: 5.76

shear stress
main beam
τ_h in MN/m²
Max: 0.48

utilization
main beam
Max: 1.09

results of verification of ultimate limit state



maximal utilization
Max: 1.09

maximal utilization

point	x	U	point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-	-	m	-
A	0.000	1.088		3.200	0.482		5.800	0.482	D	9.000	1.088
	2.600	0.466		3.800	0.513	C	6.000	0.547	**minimum**		**0.466**
B	3.000	0.504		4.500	0.525	C	6.000	0.504	**maximum**		**1.088**
B	3.000	0.547		5.200	0.513		6.400	0.466			

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-6.85	-1.58
D	9.000	-6.85	-1.58

verification of bearing stress

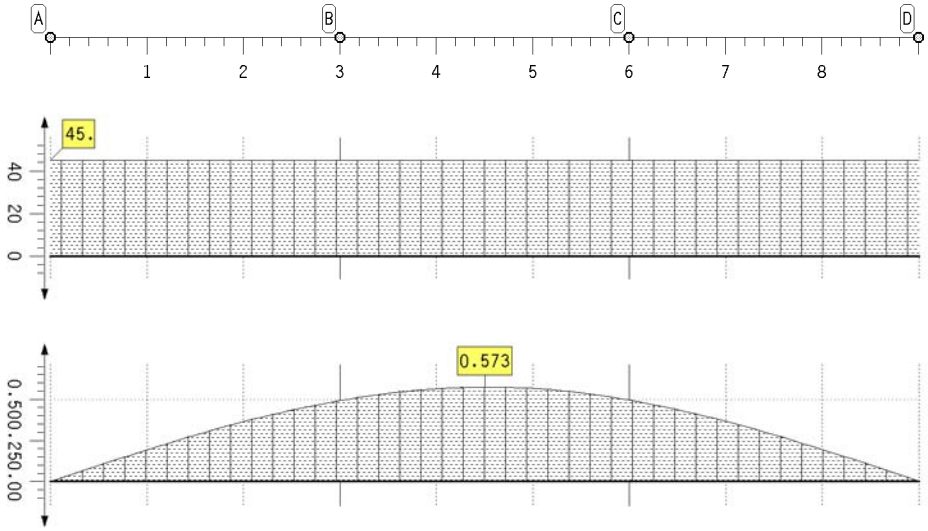
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm^2	N		-	N/mm^2	N/mm^2	-
A	180	21600	6851	1.25	0.80	1.66	0.32	0.15
D	180	21600	6851	1.25	0.80	1.66	0.32	0.15

verification of bearing stresses für den main beam(u = 0.153) successful!

12. Results of verification of deflections (quasicontinuous)

12.1. Verification of deflections (quasicontinuous)

results of verification of deflections (quasicontinuous)



decisive deflection w_{req} in mm
Min: 45.00
Max: 45.00

maximal utilization
Max: 0.57

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	0.000		4.500	0.573	D	9.000	0.000
B	3.000	0.494		5.200	0.556	**minimum**		**0.000**
B	3.000	0.494	C	6.000	0.494	**maximum**		**0.573**
	3.800	0.556	C	6.000	0.494			

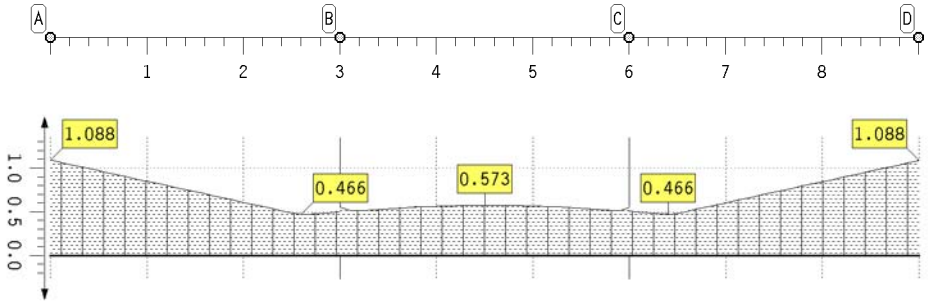
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-4.03	-2.52
D	9.000	-4.03	-2.52

13. Summary

13.1. Summary of all verifications

maximal utilization



utilization
Max: 1.09

maximal utilization

point	x	U	point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-	-	m	-
A	0.000	1.088		3.100	0.511		5.900	0.511	D	9.000	1.088
	2.600	0.466		3.900	0.560	C	6.000	0.547	**minimum**		**0.466**
B	3.000	0.504		4.500	0.573	C	6.000	0.504	**maximum**		**1.088**
B	3.000	0.547		5.100	0.560		6.400	0.466			

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	21600	6851	1.25	0.80	1.66	0.32	0.15
D	180	21600	6851	1.25	0.80	1.66	0.32	0.15

verification of bearing stresses für den main beam(u = 0.153) successful!

14. Utilizations of all verifications

verification of load-carrying capacity (u = 1.088) does not meet the requirements!

15. Detailed verification piont

15.1. 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	1.58	-0	0	-0	-0	-0	-0
start,max	-0.00	2.13	-0	0	-0	-0	-0	-0
end,min	-0.00	1.58	-0	0	-0	-0	-0	-0
end,max	-0.00	2.13	-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	0.6	0.00	0.00	0.00	0.15	0.16	0.16
end	0.6	0.00	0.00	**0.00**	0.15	0.16	0.16

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	0.6	0.00	0.00	0.00	0.6	0.00	-0.00	**0.00**
end	0.6	0.00	0.00	**0.00**	0.6	0.00	-0.00	0.00

fastener

state	$F_{1,d}$ N	$u_{1,d}$ -	$F_{2,d}$ N	$u_{2,d}$ -
start	-278	0.53	239	**0.46**
end	-278	**0.53**	239	0.46

15.1.1. Verification of web buckling acc. to DIN 1052, 10.5.1 with bw/hw = 60/220 mm

Eq. (101) h_w = 22 ≤ 70 b_w = 420
Eq. (102) V_d = 2.13 kN ≤ 206.77 kN
resulting utilization at verification point u_{res} = 0.067

15.2. Verification of load-carrying capacity at x = 4.50 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	3.54	-0.00	64608	-9439	955487	1130	38765	8310
start,max	15.42	-0.00	281047	-41062	4156367	4915	168628	36147
end,min	3.54	-0.00	64608	-9439	955487	1130	38765	8310
end,max	15.42	-0.00	281047	-41062	4156367	4915	168628	36147

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	0.8	8.59	0.37	**0.49**	0.00	0.00	0.49
end	0.8	8.59	0.37	0.49	0.00	0.00	0.49

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	2.34	-3.42	**0.53**	0.8	2.34	5.02	**0.45**
end	0.8	2.34	-3.42	0.53	0.8	2.34	5.02	0.45

15.2.1. Verification of web buckling acc. to DIN 1052, 10.5.1 with bw/hw = 60/220 mm

Eq. (101) h_w = 22 ≤ 70 b_w = 420
Eq. (102) V_d = 0.00 kN ≤ 206.77 kN
resulting utilization at verification point u_{res} = 0.525

15.3. Verification of load-carrying capacity at x = 9.00 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	-6.85	0	-0	0	0	0	0
start,max	0.00	-1.58	0	-0	0	0	0	0
end,min	0.00	-6.85	0	-0	0	0	0	0
end,max	0.00	-1.58	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	0.8	0.00	0.00	**0.00**	0.48	0.39	0.39
end	0.8	0.00	0.00	0.00	0.48	0.39	0.39

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	-895	1.29	769	**1.11**
end	-895	**1.29**	769	1.11

15.3.1. Verification of web buckling acc. to DIN 1052, 10.5.1 with bw/hw = 60/220 mm

Eq. (101) $h_w = 22 \leq 70$ $b_w = 420$

Eq. (102) $V_d = 6.85$ kN ≤ 206.77 kN

resulting utilization at verification point $u_{res} = 1.088$