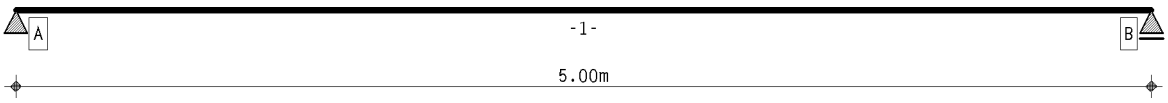
1. Options for Calculations

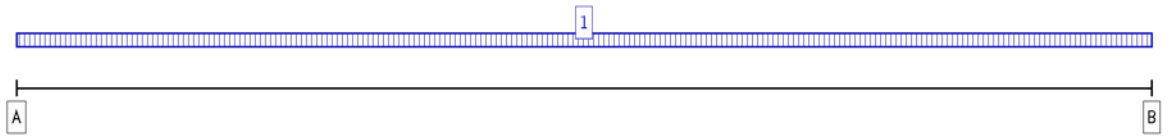
calculation DIN EN 1995:2010, Germany
service class 1

2. Structural system

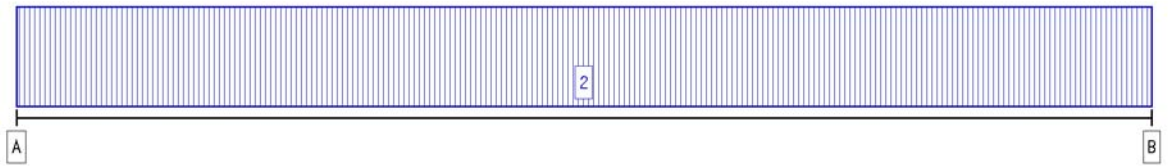


main beam

3. Loading



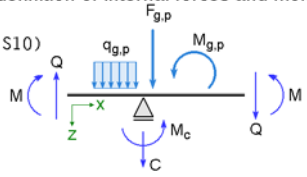
action effect 1: permanent loads (permanent, 1 load cases)



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

4. material parameters

definition of internal forces and moments:



beam Cross Laminated Timber	**userdefined, BSP Brand**
structure	**34.0**-22.0-**34.0**-22.0-**34.0** solid coniferous timber, C24 (S10)
direction of fibre	x-axis (strong axis)
service class	1
beam width/-höhe	b/h = 1000 mm / 146 mm
coeff. thermal expan. timber	0.500 *10-5 /°K
shear coefficient κ	0.243560

5. Beam sections

beam sections

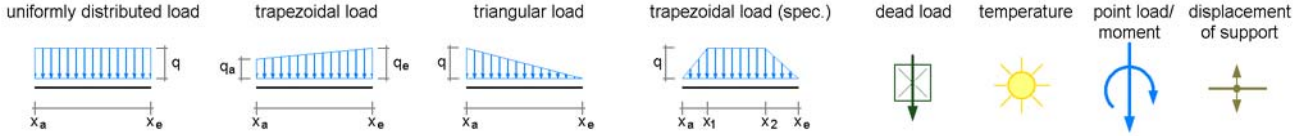
section	x_A m	x_E m	l m	l_v m	cantil.	EI_{eff} Nmm2	GA_{eff} N	EA_{eff} N	$EI_{eff,fire}$ Nmm2	$GA_{eff,fire}$ N	$EA_{eff,fire}$ N	$z_{s,fire}$ mm	
1	5.00	5.00	5.00	5.00	-	2453.814	17881190.00	1122000000.	1709.327	15799731.00	968000000.0	66.0	

6. Supports

coordinates of supports

supp.name	x m	width mm	depth mm	c_F kN/m	c_M kNm/-	restraint (F)	(M)
A	0.00	100	1000	fix	----	X	-
B	5.00	80	1000	fix	----	X	-

7. Action effects



Permanent action effect: permanent loads
1. additive load case: dead load (1)
⇒ unif.distr.load: q = 0.66 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 = 4.00 kN/m from x_a = 0.00 m to x_e = 5.00 m

8. 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

2: EC 5 deformations
Grenzwerte für deformations acc. to DIN EN 1995-1-1, Tab. 7.2!
Extreme rule 1

3: EC 5 fire protection
fire resistance duration t_f = 60 min

side	protected	t_{ch}	t_f=t_{ch}	t_f	k_2	d_{ef}
bottom	-	-	-	-	-	7.00
top	-	-	-	-	-	7.00

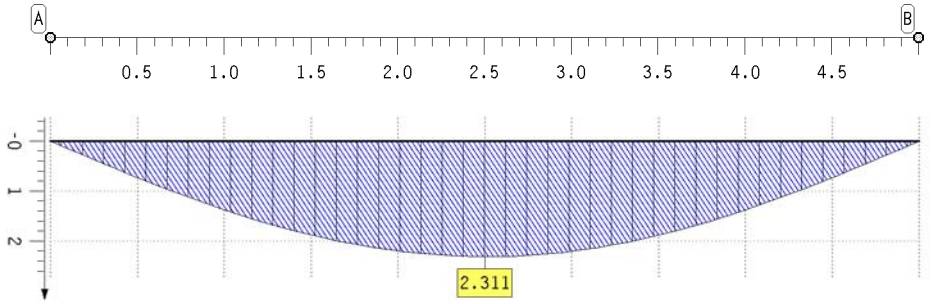
Extreme rule 1

4: EC 5 Verification of vibration
verification of vibration acc. to DIN EN 1995-1-1, 7.3
value acc. to DIN EN 1995-1-1, 7.3.3, figure 7.2: a = 1.00 mm/kN ⇒ b = 120.00
modal damping ratio ξ = 0.00
numeric calculation with Fourier series
Attention! Gelenke bleiben unberücksichtigt
Federn werden nur in den Zwischenlagern berücksichtigt
in consideration of shear deformation
Poisson's ratio ν = 0.00, torsionstiffness = 0.0 %
60 mm, E = 25000 N/mm², g = 0.220 kN/mm², I_{screed} = 18 mm⁴
in consideration of 2-dimensional effects

9. Results of load cases

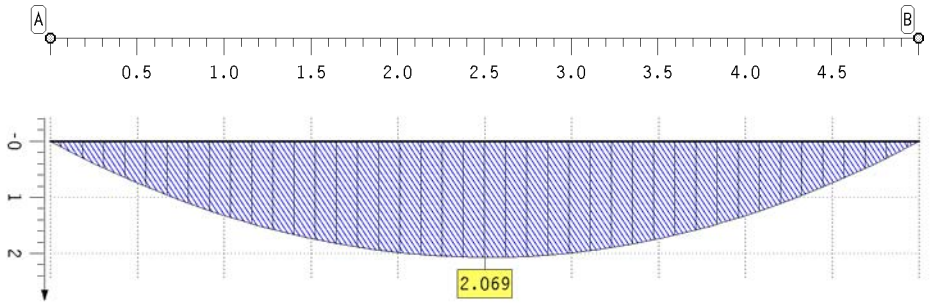
9.1. Action effect 1: load case 1: dead load (1)

deflections of main beam (characteristic)

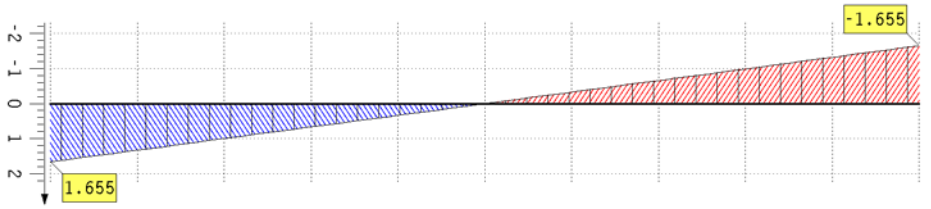


deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 2.31

internal forces and moments



flexural moment
main beam
M in kNm
Min: -0.00
Max: 2.07



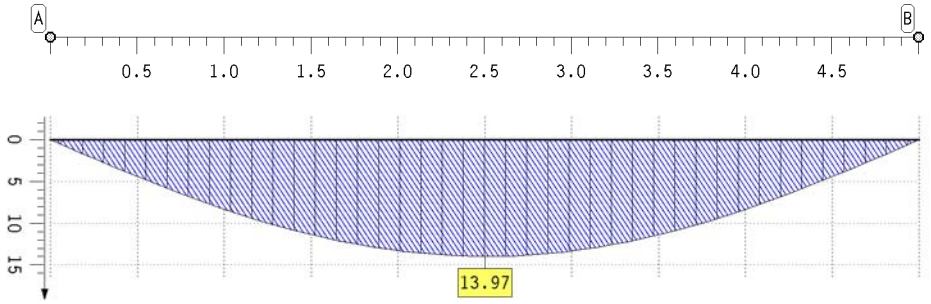
shear force
main beam
V in kN
Min: -1.65
Max: 1.65

support forces

point	x	AP
-	m	kN
A	0.000	-1.65
B	5.000	-1.65

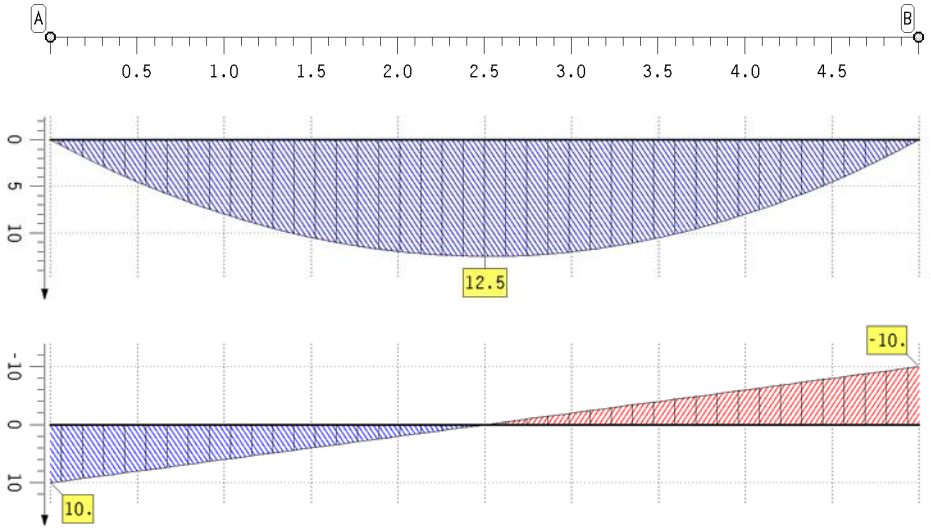
9.2. Action effect 2: load case 2: live loads (1/1)

deflections of main beam (characteristic)



deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 13.96

internal forces and moments



flexural moment
main beam
M in kNm
Min: 0.00
Max: 12.50

shear force
main beam
V in kN
Min: -10.00
Max: 10.00

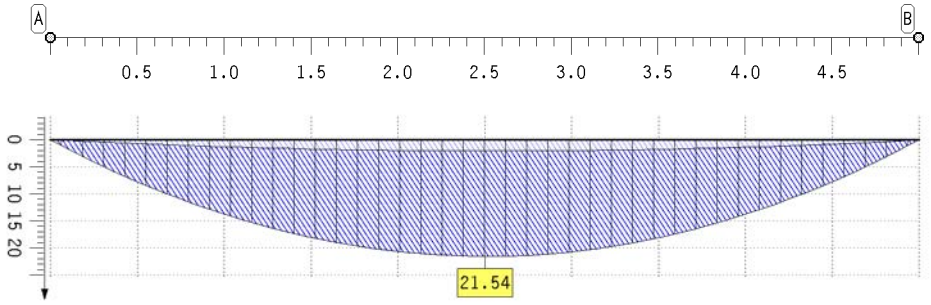
support forces

point	x	AP
-	m	kN
A	0.000	-10.00
B	5.000	-10.00

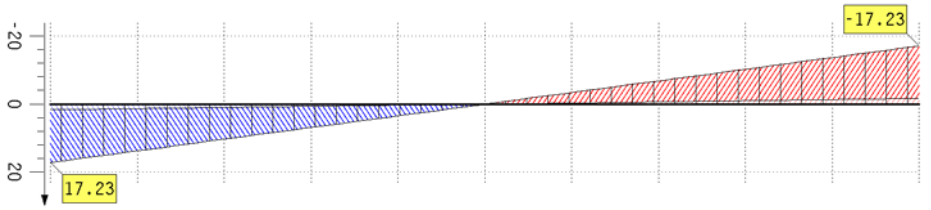
10. Results of verification of ultimate limit state

10.1. Verification of ultimate limit state

extremal internal forces

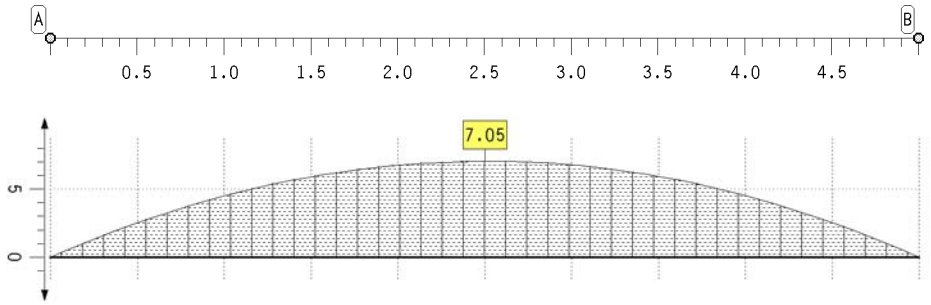


flexural moment
main beam
M in kNm
Min: -0.00
Max: 21.54

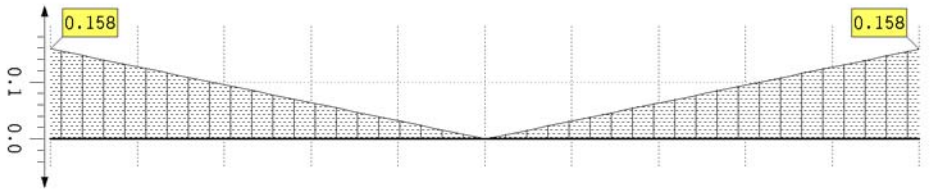


shear force
main beam
V in kN
Min: -17.23
Max: 17.23

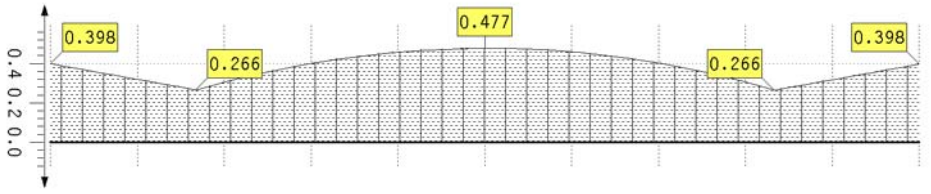
results of verification of ultimate limit state



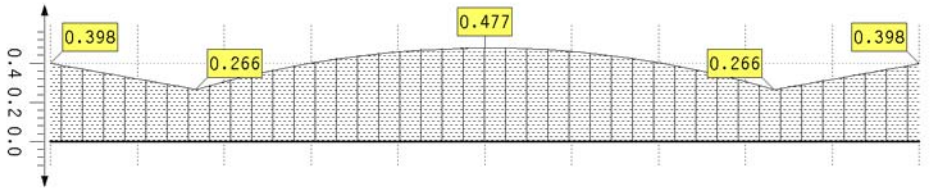
bending stress
main beam
σ_h in MN/m²
Max: 7.05



shear stress
main beam
τ_h in MN/m²
Max: 0.16



utilization
main beam
Max: 0.48



maximal
utilization
Max: 0.48

verification of ultimate limit state of main beam

point	x	$k_{mod,h}$	σ_h	τ_h	U_h
-	m	-	MN/m²	MN/m²	-
A	0.000	0.000	0.00	0.16	0.398
	0.833	0.000	3.92	0.11	0.266
	1.667	0.000	6.27	0.05	0.424
	2.500	0.000	7.05	0.00	0.477
	3.333	0.000	6.27	0.05	0.424
	4.167	0.000	3.92	0.11	0.266
B	5.000	0.000	0.00	0.16	0.398
minimum		**0.000**	**0.00**	**0.00**	**0.266**
maximum		**0.000**	**7.05**	**0.16**	**0.477**

maximal utilization

point	x	U
-	m	-
A	0.000	0.398
	0.833	0.266
	1.667	0.424
	2.500	0.477
	3.333	0.424
	4.167	0.266
B	5.000	0.398
minimum		**0.266**
maximum		**0.477**

verification of bearing stress

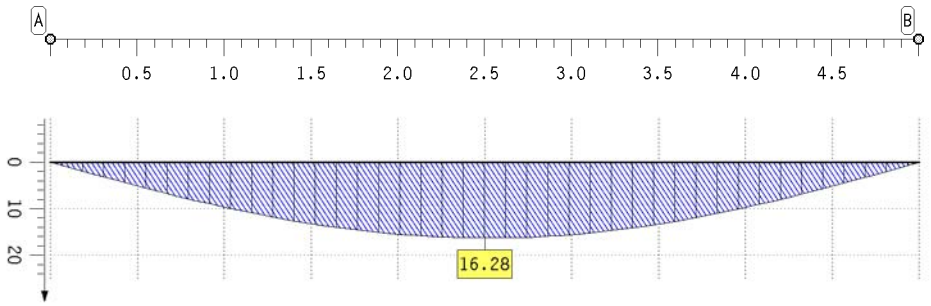
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm²	N		-	N/mm²	N/mm²	-
A	130	130000	17234	1.00	0.80	1.54	0.13	0.09
B	110	110000	17234	1.00	0.80	1.54	0.16	0.10

verification of bearing stresses für den main beam(u = 0.102) successful!

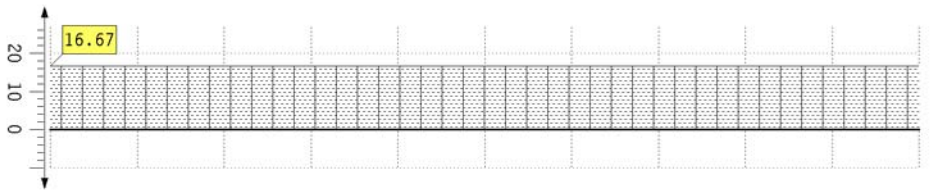
11. Results of verification of deflections

11.1. Verification of deflections

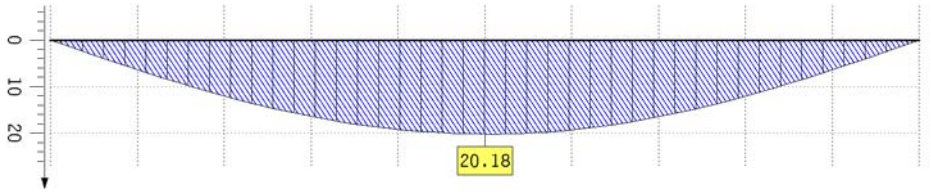
results of verification of deflections



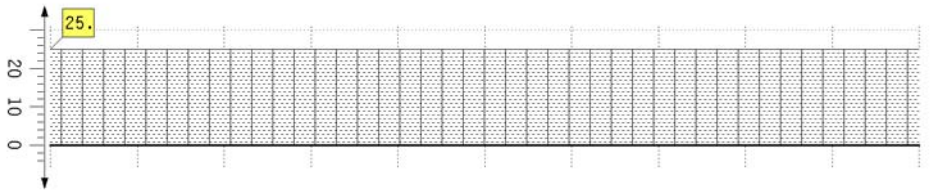
extremal deflections
Winst
in mm
Min: 0.00
Max: 16.28



decisive deflection
Winst,req
in mm
Min: 16.67
Max: 16.67

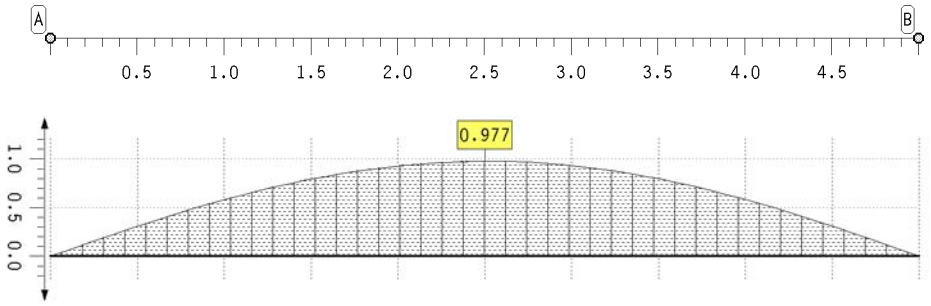


extremal deflections
Wfin
in mm
Min: 0.00
Max: 20.18



decisive deflection
Wfin,req
in mm
Min: 25.00
Max: 25.00

results of verification of deflections



maximal utilization
Max: 0.98

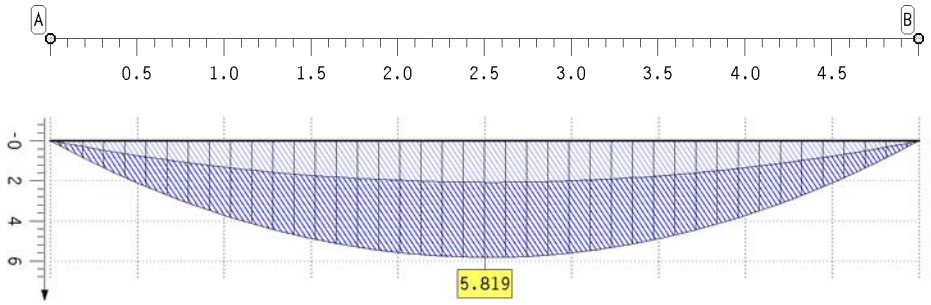
verification of deflections

point	x	min/max/req w_{inst}			min/max/req w_{fin}			min/max/req $w_{net,fin}$			U
-	m	mm	mm	mm	mm	mm	mm	mm	mm	mm	-
A	0.000	0.00	0.00	16.67	0.00	0.00	25.00	----	----	----	0.000
	1.389	0.00	12.57	16.67	0.00	15.58	25.00	----	----	----	0.754
	2.500	0.00	16.28	16.67	0.00	20.18	25.00	----	----	----	0.977
	3.611	0.00	12.57	16.67	0.00	15.58	25.00	----	----	----	0.754
B	5.000	0.00	0.00	16.67	0.00	0.00	25.00	----	----	----	0.000
minimum		**0.00**	**0.00**	**16.67**	**0.00**	**0.00**	**25.00**	**0.00**	**0.00**	**0.00**	**0.000**
maximum		**0.00**	**16.28**	**16.67**	**0.00**	**20.18**	**25.00**	**0.00**	**0.00**	**0.00**	**0.977**

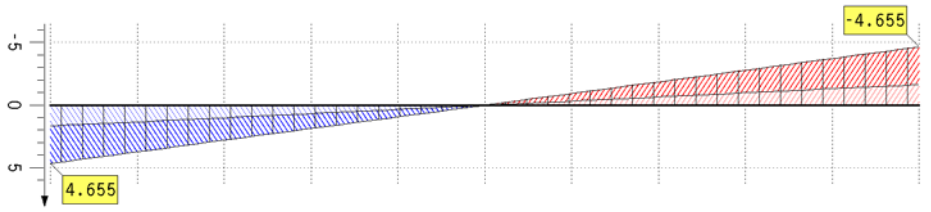
12. Results of verification of fire protection

12.1. Verification of fire protection

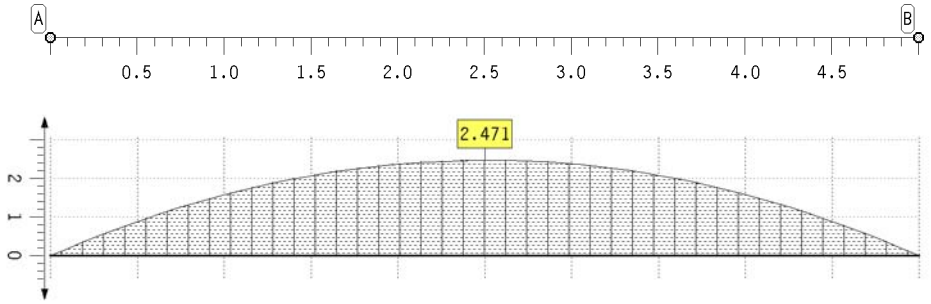
extremal internal forces



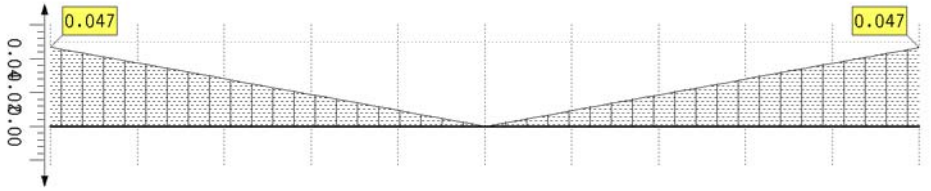
flexural moment
main beam
M in kNm
Min: -0.00
Max: 5.82



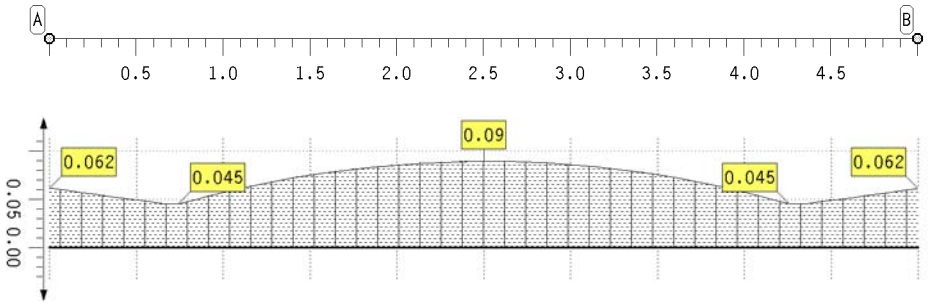
shear force
main beam
V in kN
Min: -4.66
Max: 4.66



bending stress
main beam
σ_h in MN/m²
Max: 2.47



shear stress
main beam
τ_h in MN/m²
Max: 0.05



utilization
main beam
Max: 0.09

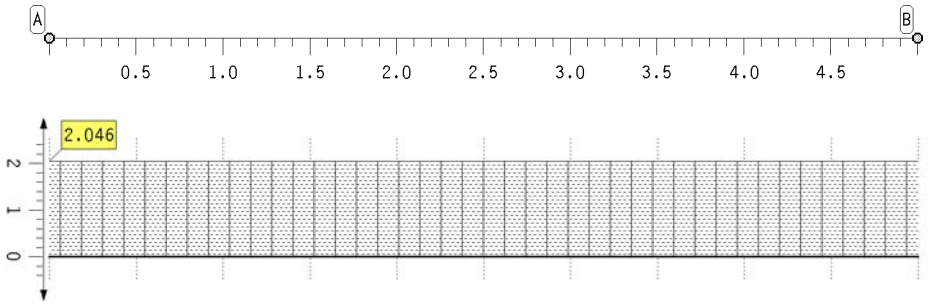
verification of ultimate limit state of main beam

point	x	$k_{mod,h}$	σ_h	τ_h	U_h
-	m	-	MN/m²	MN/m²	-
A	0.000	0.000	0.00	0.05	0.062
	0.741	0.000	1.25	0.03	0.045
	1.574	0.000	2.13	0.02	0.077
	2.500	0.000	2.47	0.00	0.090
	3.426	0.000	2.13	0.02	0.077
	4.259	0.000	1.25	0.03	0.045
B	5.000	0.000	0.00	0.05	0.062
minimum		**0.000**	**0.00**	**0.00**	**0.045**
maximum		**0.000**	**2.47**	**0.05**	**0.090**

13. Summary

13.1. Summary of all verifications

maximal utilization



utilization
Max: 2.05

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	130	130000	17234	1.00	0.80	1.54	0.13	0.09
B	110	110000	17234	1.00	0.80	1.54	0.16	0.10

verification of bearing stresses für den main beam(u = 0.102) successful!

13.2. Eigenfrequenz

$EI_{längs}$ = 2.903814 MNm²/m, EI_{quer} = 0.848977 MNm²/m
f_e = 13.286 Hz ≥ f_e = 8 Hz ⇒ **Kriterium successful!**

13.3. Steifigkeitskriterium

Raumbreite b = 1.000 m, b_{ef} = 1.000 m, $x_{max\ F}$ = 2.500 m, $x_{max\ w}$ = 2.500 m ⇒ w_{max} = 0.897 mm
w(1kN) = 0.90 mm ≤ w_{grenz} = 1.0 mm ⇒ **Kriterium successful!**

13.4. Einheitsimpulsgeschwindigkeit

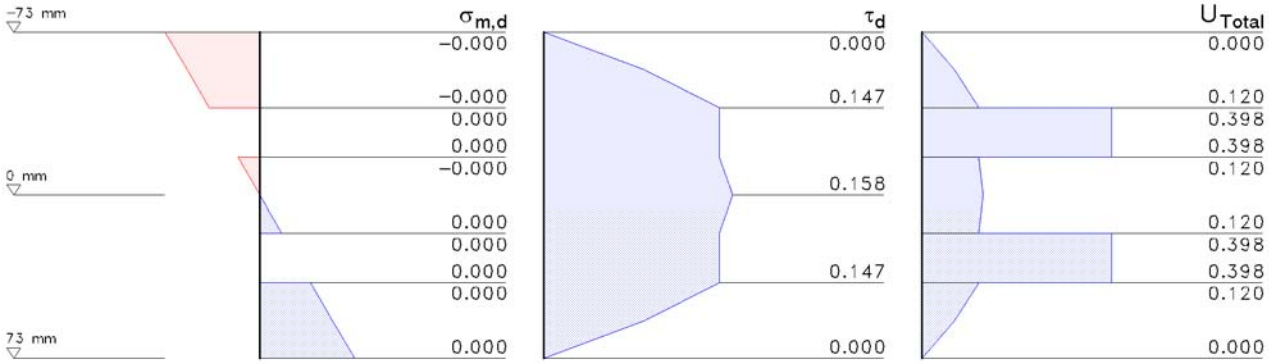
n_{40} = 1
v = 17.2 mm/(Ns²) > v_{grenz} = 8.4 mm/(Ns²) ⇒ **Kriterium does not meet the requirements!!!**

14. Utilizations of all verifications

Verification of vibration (u = 2.046) does not meet the requirements!

15. Detailed verification piont

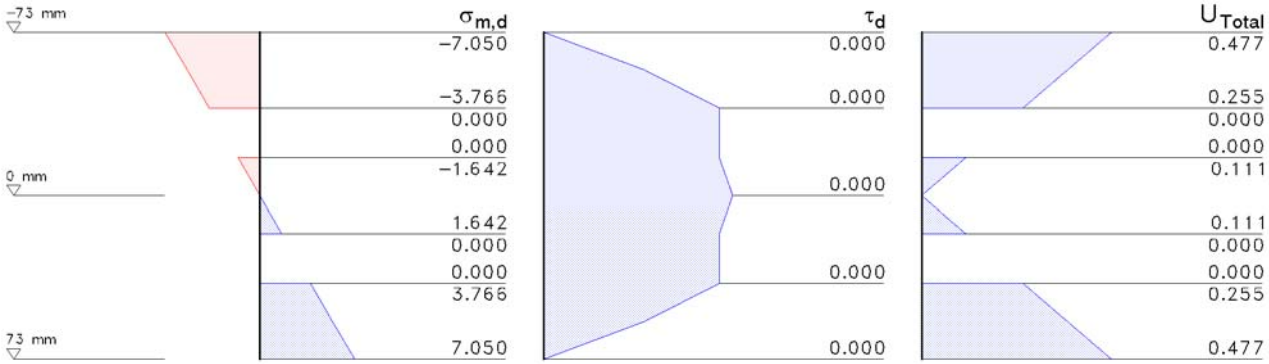
15.1. Verification of load-carrying capacity at x = 5.00 m, maxV_d = -1.65 kN, minM_d = 0.00 kNm, maxM_d = 0.00 kNm



mechanical resistance and static terms: stiffness B_x = 2453.814 Nmm

z mm	ES$_x$ Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²	z mm	ES$_x$ Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²
73.0	0.000	0.000	14.77	0.000	1.23	-17.0	-20.944	0.000	14.77	0.147	0.37
56.0	-12.061	0.000	14.77	0.085	1.23	-28.0	-20.944	0.000	14.77	0.147	0.37
39.0	-20.944	0.000	14.77	0.147	0.37	-39.0	-20.944	-0.000	14.77	0.147	1.23
28.0	-20.944	0.000	14.77	0.147	0.37	-56.0	-12.061	-0.000	14.77	0.085	1.23
17.0	-20.944	0.000	14.77	0.147	1.23	-73.0	0.000	-0.000	14.77	0.000	1.23
0.0	-22.534	0.000	14.77	0.158	1.23						

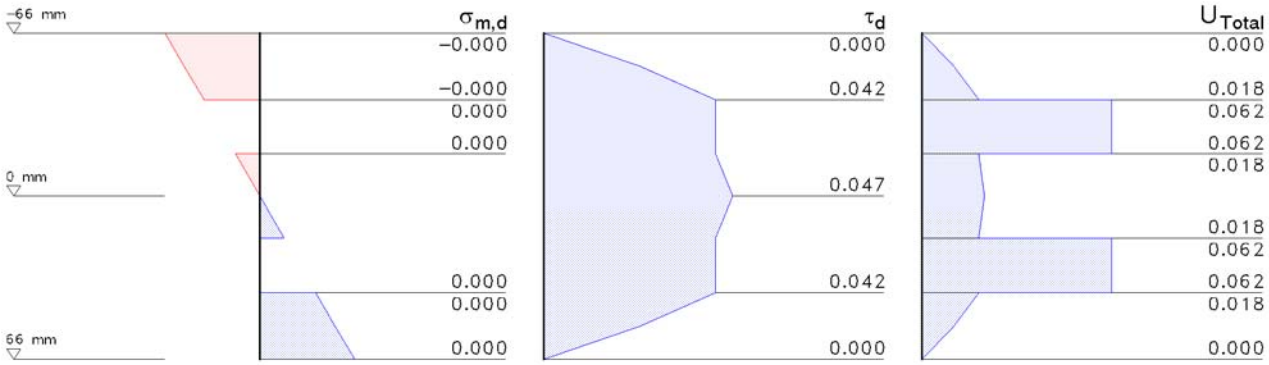
15.2. Verification of load-carrying capacity at x = 2.50 m, maxV_d = 0.00 kN, minM_d = 2.07 kNm, maxM_d = 21.54 kNm



mechanical resistance and static terms: stiffness B_x = 2453.814 Nmm

z mm	ES$_x$ Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²	z mm	ES$_x$ Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²
73.0	0.000	7.050	14.77	0.000	1.23	-17.0	-20.944	0.000	14.77	0.000	0.37
56.0	-12.061	5.408	14.77	0.000	1.23	-28.0	-20.944	0.000	14.77	0.000	0.37
39.0	-20.944	0.000	14.77	0.000	0.37	-39.0	-20.944	-3.766	14.77	0.000	1.23
28.0	-20.944	0.000	14.77	0.000	0.37	-56.0	-12.061	-5.408	14.77	0.000	1.23
17.0	-20.944	1.642	14.77	0.000	1.23	-73.0	0.000	-7.050	14.77	0.000	1.23
0.0	-22.534	0.000	14.77	0.000	1.23						

15.3. Resistance to fire at x = 5.00 m, maxV_d = -1.65 kN, minM_d = 0.00 kNm, maxM_d = 0.00 kNm



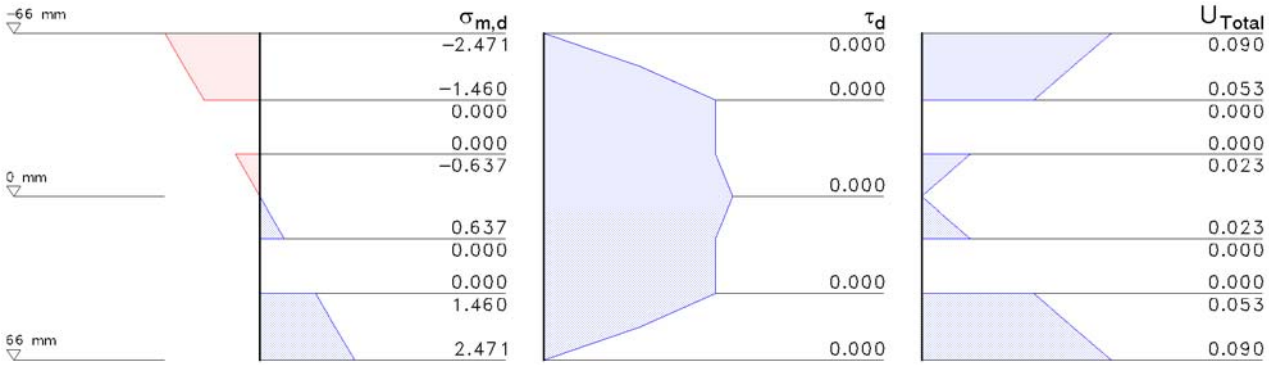
mechanical resistance and static terms: stiffness B_x = 1709.327 Nmm

z mm	ES$_x$ Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²	z mm	ES$_x$ Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²
66.0	0.000	0.000	27.60	0.000	2.30	17.0	-15.592	0.000	27.60	0.042	2.30
52.5	-8.799	0.000	27.60	0.024	2.30	0.0	-17.182	0.000	27.60	0.047	2.30
39.0	-15.592	0.000	27.60	0.042	0.69	-17.0	-15.592	0.000	27.60	0.042	0.69
28.0	-15.592	0.000	27.60	0.042	0.69	-28.0	-15.592	0.000	27.60	0.042	0.69

mechanical resistance and static terms: stiffness B_x = 1709.327 Nmm

z mm	ES_x Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²
-39.0	-15.592	-0.000	27.60	0.042	2.30
-52.5	-8.799	-0.000	27.60	0.024	2.30
-66.0	0.000	-0.000	27.60	0.000	2.30

15.4. Resistance to fire at x = 2.50 m, maxV_d = 0.00 kN, minM_d = 2.07 kNm, maxM_d = 5.82 kNm



mechanical resistance and static terms: stiffness B_x = 1709.327 Nmm

z mm	ES_x Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²
66.0	0.000	2.471	27.60	0.000	2.30
52.5	-8.799	1.966	27.60	0.000	2.30
39.0	-15.592	0.000	27.60	0.000	0.69
28.0	-15.592	0.000	27.60	0.000	0.69
17.0	-15.592	0.637	27.60	0.000	2.30
0.0	-17.182	0.000	27.60	0.000	2.30

z mm	ES_x Nmm	$\sigma_{m,d}$ N/mm²	$f_{m,d}$ N/mm²	$\tau_{v,d}$ N/mm²	$f_{v,d}$ N/mm²
-17.0	-15.592	0.000	27.60	0.000	0.69
-28.0	-15.592	0.000	27.60	0.000	0.69
-39.0	-15.592	-1.460	27.60	0.000	2.30
-52.5	-8.799	-1.966	27.60	0.000	2.30
-66.0	0.000	-2.471	27.60	0.000	2.30