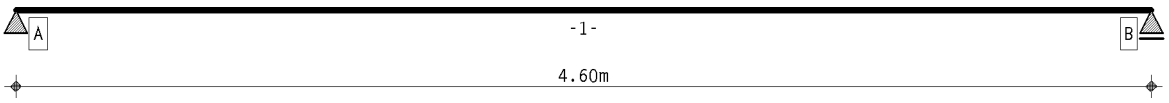
1. Options for Calculations

calculation DIN EN 1995:2010, Germany
service class 1

2. Structural system

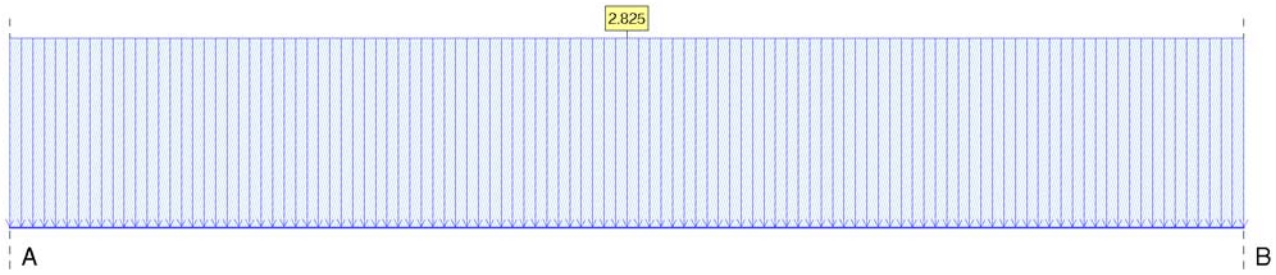


main beam

3. Loading

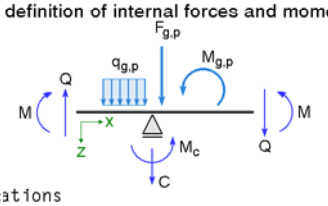
The load images are displayed separately according to the load application.

load case 1, beam: dead load (1)
action effect 1: permanent loads



4. material parameters

definition of internal forces and moments:



beam	Cross Laminated Timber
structure	**Derix X-Lam, X-150/5s**
	30.0-30.0-**30.0**-30.0-**30.0** solid coniferous timber C24
direction of fibre	x-axis (strong axis)
service class	1
beam width/-height	b/h = 1000 mm / 150 mm
coeff. thermal expan. timber	0.500 *10-5 /°K
shear coefficient κ	0.174823

Please check the layer structures and strengths with the current manufacturer's specifications

$f_{c,k}$ N/mm2	$f_{c90,k}$ N/mm2	$f_{t,k}$ N/mm2	$f_{m,k}$ N/mm2	$f_{v,k}$ N/mm2	$f_{vR,k}$ N/mm2
21.00	2.50	14.50	27.00	4.00	1.00

5. Beam sections

beam sections

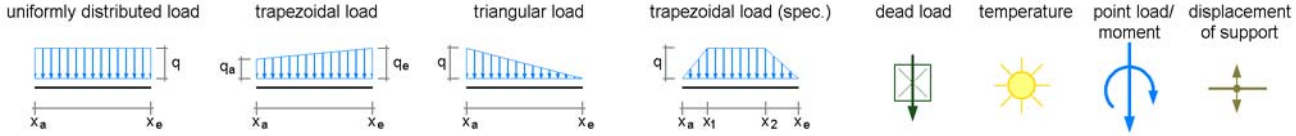
section	x_A m	x_E m	l m	l_v m	cantilever	EI_{eff} Nmm2	GA_{eff} N	EA_{eff} N
1	0.00	4.60	4.60	4.60	-	2450.250	11381004.00	990000000.0

6. 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	4	1000	fix	----	X	-
B	4.60	4	1000	fix	----	X	-

7. Action effects



Permanent action effect: permanent loads
1. additive load case: dead load (1)
⇒ equal area load (beam): q = 2.83 kN/m² from x_a = 0.00 m to x_e = 4.60 m

8. verifications

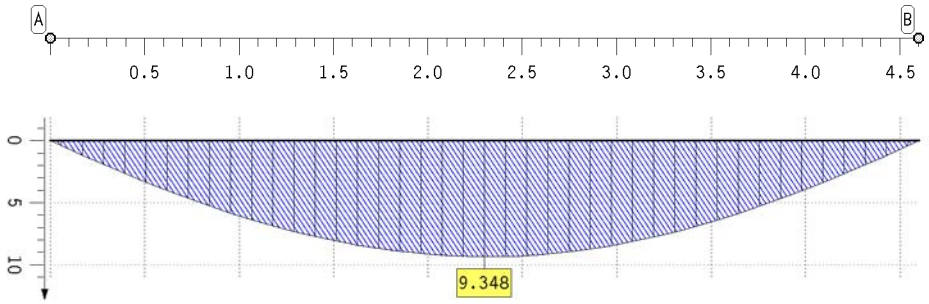
1: EC 5 load-carrying capacity
buckling analysis of compression flange acc. to DIN EN 1995, 6.3.2 will be executed
Extreme rule 1

2: 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 = 0.50 mm/kN ⇒ b = 150.00
modal damping ratio ξ = 0.01
numeric calculation with Fourier series
Attention! Joints are not taken into account
Springs are only taken into account in the interim storage facilities
Without consideration of shear deformation
Poisson's ratio ν = 0.00, torsionstiffness = 0.0 %
Quasi-permanent load component is taken into account
Screed is not taken into account

9. Results of load cases

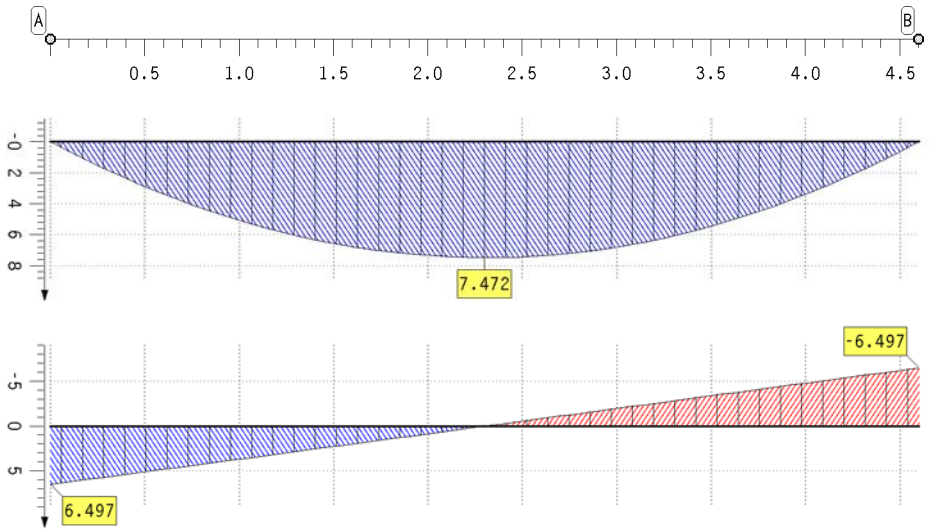
9.1. Action effect 1: load case 1: dead load (1)

deflections of main beam (characteristic)



deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 9.35

internal forces and moments



flexural moment
main beam
M in kNm
Min: -0.00
Max: 7.47

shear force
main beam
V in kN
Min: -6.50
Max: 6.50

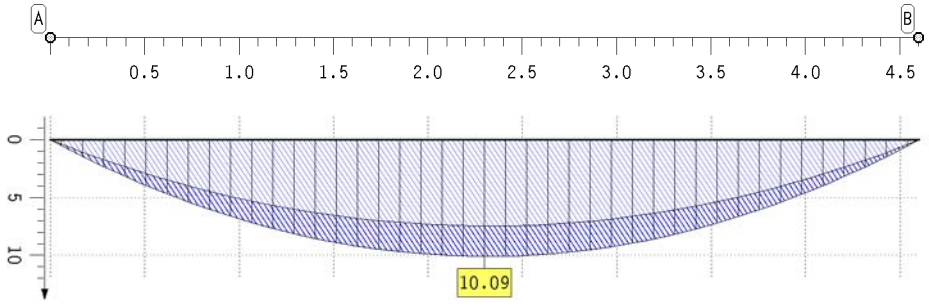
support forces

point	x	AP
-	m	kN
A	0.000	-6.50
B	4.600	-6.50

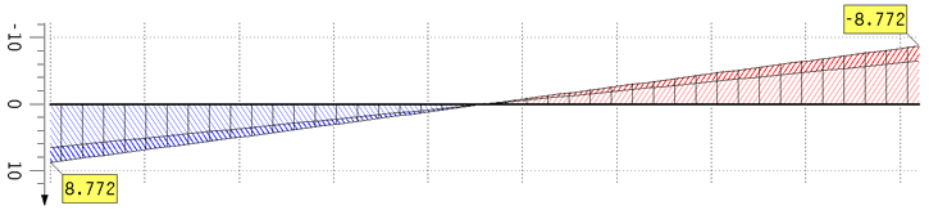
10. Results of verification of ultimate limit state

10.1. Verification of ultimate limit state

extremal internal forces

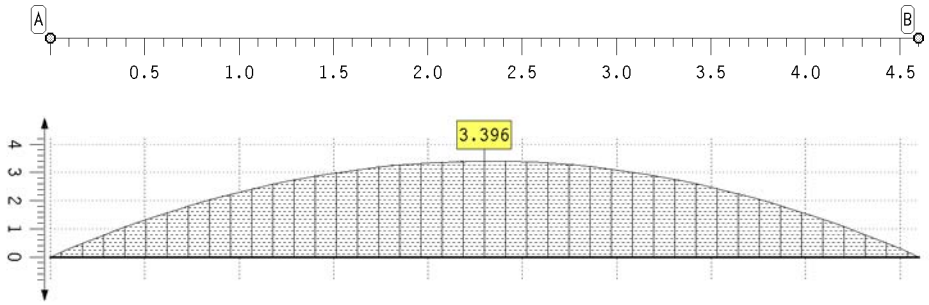


flexural moment
main beam
M in kNm
Min: -0.00
Max: 10.09

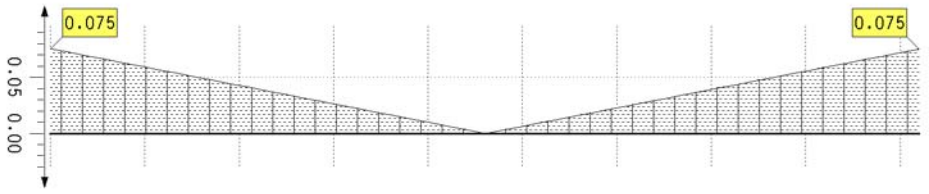


shear force
main beam
V in kN
Min: -8.77
Max: 8.77

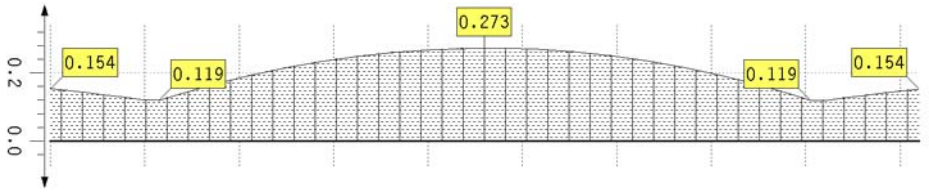
results of verification of ultimate limit state



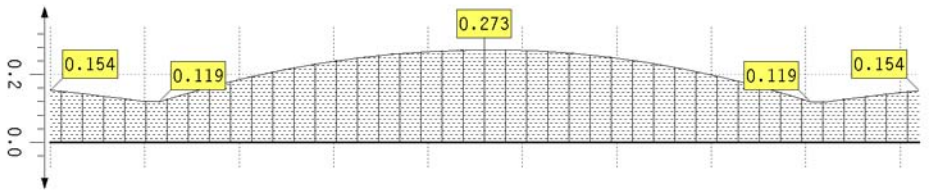
bending stress
main beam
σ_h in MN/m²
Max: 3.40



shear stress
main beam
τ_h in MN/m²
Max: 0.08



utilization
main beam
Max: 0.27



maximal
utilization
Max: 0.27

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	0.08	0.154
	0.575	0.000	1.49	0.06	0.119
	1.438	0.000	2.92	0.03	0.234
	2.300	0.000	3.40	0.00	0.273
	3.162	0.000	2.92	0.03	0.234
	4.025	0.000	1.49	0.06	0.119
B	4.600	0.000	0.00	0.08	0.154
minimum		**0.000**	**0.00**	**0.00**	**0.119**
maximum		**0.000**	**3.40**	**0.08**	**0.273**

maximal utilization

point	x	U	point	x	U	point	x	U
-	m	-	-	m	-	-	m	-
A	0.000	0.154		2.300	0.273	B	4.600	0.154
	0.575	0.119		3.162	0.234	**minimum**		**0.119**
	1.438	0.234		4.025	0.119	**maximum**		**0.273**

11. vibration verification results

11.1. natural frequency

$EI_{lengthwise}$ = 2.450250 MNm²/m, EI_{cross} = 0.643500 MNm²/m, m = 28250.0 kG/m²
f_e = 6.980 Hz < f_{min} = 8 Hz ⇒ special examination

11.2. stiffness criterion

$x_{max\ F}$ = 2.300 m, $x_{max\ w}$ = 2.300 m ⇒ w_{max} = 0.276 mm
w(1kN) = 0.28 mm ≤ w_{grenz} = 0.5 mm ⇒ **criterion met!**

11.3. unit pulse speed

n_{40} = 14.5195
v = 5.341 mm/s ≤ v_{grenz} = 9.458 mm/s ⇒ **criterion met!**

11.4. heel strike

v = 34.211 mm/s ≤ v_{grenz} = 56.749 mm/s ⇒ **criterion met!**

11.5. acceleration/resonance

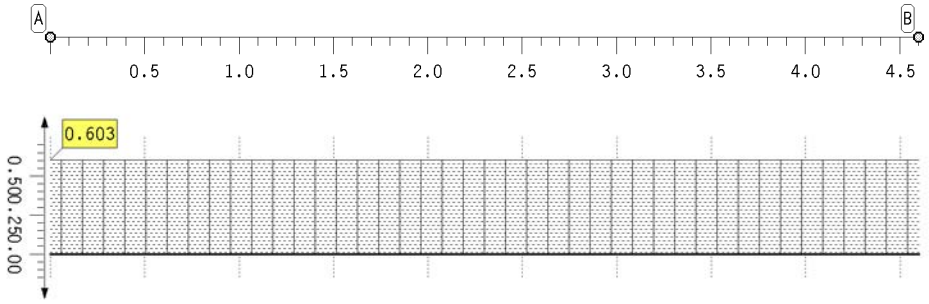
a = 0.927077 m/s² > 0.3 m/s² ⇒ noticeable, not disturbing

verification successful!

12. Summary

12.1. Summary of all verifications

maximal utilization



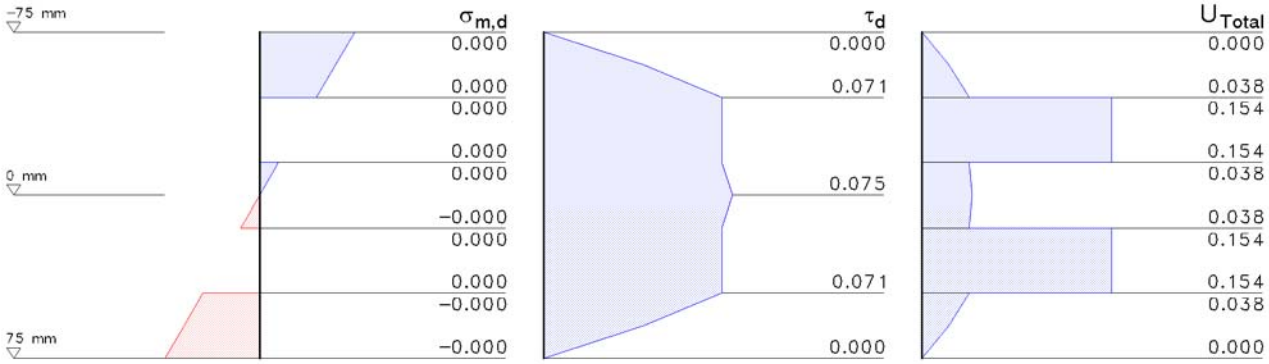
utilization
Max: 0.60

13. Utilizations of all verifications

all verifications successful!

14. Detailed verification piont

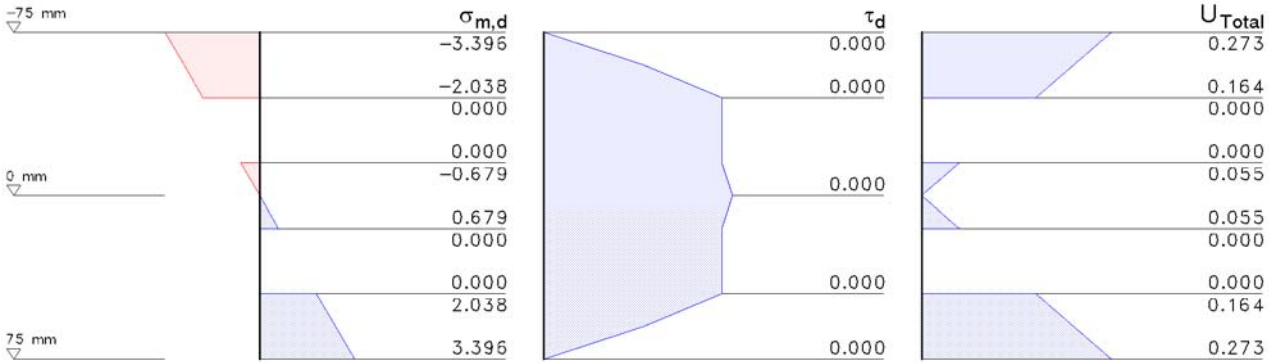
14.1. load-carrying capacity at x = 4.60 m, $minV_d$ = -8.77 kN, $maxV_d$ = -6.50 kN, $minM_d$ = -0.00 kNm, $maxM_d$ = -0.00 kNm



mechanical resistance and static terms: stiffness B_x = 2450.250 Nmm

z	ES$_x$	$\sigma_{m,d}$	$f_{m,d}$	$\tau_{v,d}$	$f_{v,d}$	z	ES$_x$	$\sigma_{m,d}$	$f_{m,d}$	$\tau_{v,d}$	$f_{v,d}$
mm	Nmm	N/mm²	N/mm²	N/mm²	N/mm²	mm	Nmm	N/mm²	N/mm²	N/mm²	N/mm²
75.0	0.000	-0.000	12.46	0.000	1.85	-15.0	-19.800	0.000	12.46	0.071	0.46
60.0	-11.137	-0.000	12.46	0.040	1.85	-30.0	-19.800	0.000	12.46	0.071	0.46
45.0	-19.800	0.000	12.46	0.071	0.46	-45.0	-19.800	0.000	12.46	0.071	1.85
30.0	-19.800	0.000	12.46	0.071	0.46	-60.0	-11.137	0.000	12.46	0.040	1.85
15.0	-19.800	-0.000	12.46	0.071	1.85	-75.0	-0.000	0.000	12.46	0.000	1.85
0.0	-21.038	-0.000	12.46	0.075	1.85						

14.2. load-carrying capacity at x = 2.30 m, minV_d = -0.00 kN, maxV_d = -0.00 kN, minM_d = 7.47 kNm, maxM_d = 10.09 kNm



mechanical resistance and static terms: stiffness B_x = 2450.250 Nmm

z	ES$_x$	$\sigma_{m,d}$	$f_{m,d}$	$\tau_{v,d}$	$f_{v,d}$	z	ES$_x$	$\sigma_{m,d}$	$f_{m,d}$	$\tau_{v,d}$	$f_{v,d}$
mm	Nmm	N/mm²	N/mm²	N/mm²	N/mm²	mm	Nmm	N/mm²	N/mm²	N/mm²	N/mm²
75.0	0.000	3.396	12.46	0.000	1.85	-15.0	-19.800	0.000	12.46	0.000	0.46
60.0	-11.137	2.717	12.46	0.000	1.85	-30.0	-19.800	0.000	12.46	0.000	0.46
45.0	-19.800	0.000	12.46	0.000	0.46	-45.0	-19.800	-2.038	12.46	0.000	1.85
30.0	-19.800	0.000	12.46	0.000	0.46	-60.0	-11.137	-2.717	12.46	0.000	1.85
15.0	-19.800	0.679	12.46	0.000	1.85	-75.0	-0.000	-3.396	12.46	0.000	1.85
0.0	-21.038	0.000	12.46	0.000	1.85						