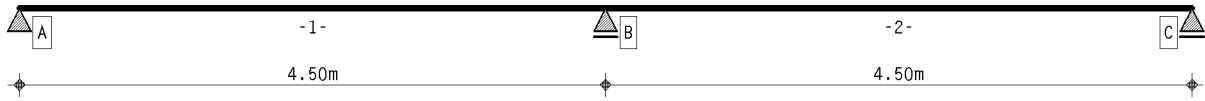


# 1. Options for Calculations

calculation DIN EN 1995:2010, Germany  
 service class 1

## 2. Structural system

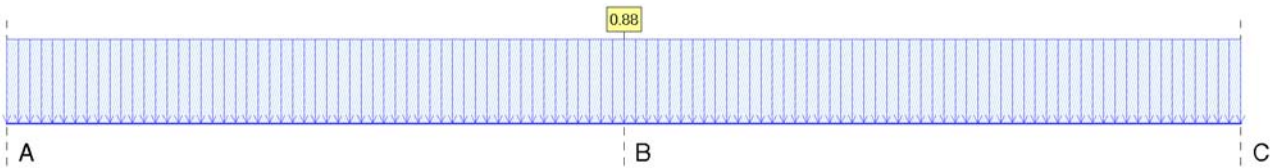


main beam

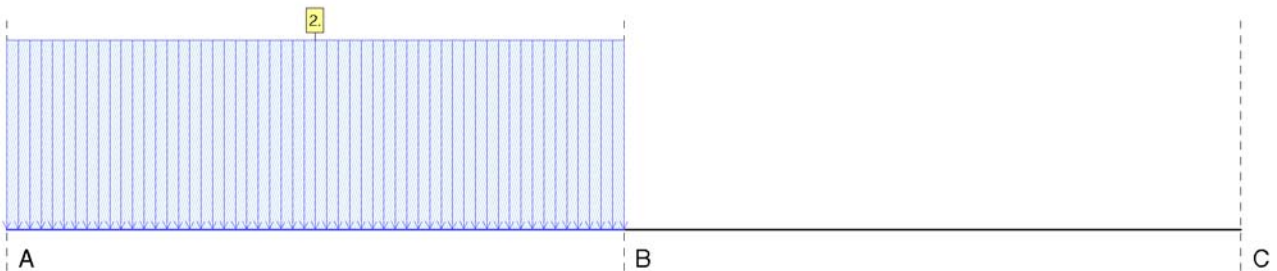
## 3. Loading

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

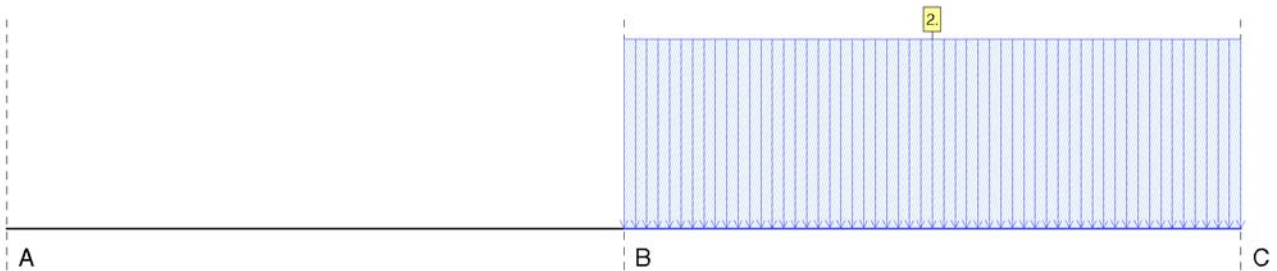
load case 1, beam: dead load (1)  
 action effect 1: permanent loads



load case 2, beam: live loads (1/1)  
 action effect 2: live loads (1)



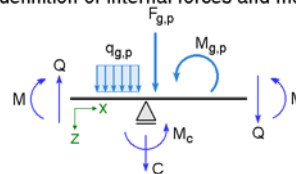
load case 3, beam: live loads (1/2)  
 action effect 2: live loads (1)



## 4. material parameters

beam der timber grade	Steico Joist SJ LVL,HB 45/240
service class	1
beamwidth/-height	45 / 240 mm
bar spacing	a = 600 mm
coeff. therm.expan. timber:	0.500 *10 <sup>-5</sup> /°K
coeff. thermal expan. steel:	1.200 *10 <sup>-5</sup> /°K
char. bend. strength $f_{m,k}$ :	9.78 N/mm <sup>2</sup>
char. shear strength $f_{v,k}$ :	15.26 N/mm <sup>2</sup>
modulus of elast. $E_{0,mean}$ :	13827 N/mm <sup>2</sup>
$k_{cr}$	1.00 mm <sup>2</sup> /N
Panelling with	: solid coniferous timber C16, thickness = 30 mm, $\rho = 310 \text{ kg/m}^3$

definition of internal forces and moments:

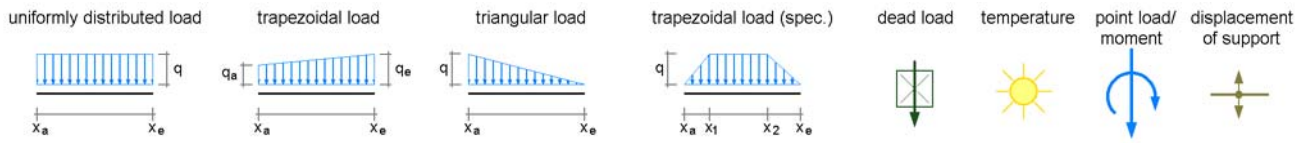


## 5. Supports

coordinates of supports

supp. name	x m	width mm	depth mm	cF kN/m	cm kNm/-	restraint (F) (M)	web reinforcem. -
A	0.00	100	45	fix	----	X -	no
B	4.50	110	45	fix	----	X -	no
C	9.00	102	45	fix	----	X -	no

## 6. Action effects



### Permanent action effect: permanent loads

1. additive load case: dead load (1)  
 $\Rightarrow$  equal area load (beam):  $q = 0.88 \text{ kN/m}^2$  from  $x_a = 0.00 \text{ m}$  to  $x_e = 9.00 \text{ m}$
2. Transient action effect: live loads (1)  
  2. additive load case: live loads (1/1)  
 $\Rightarrow$  equal area load (beam):  $q = 2.00 \text{ kN/m}^2$  from  $x_a = 0.00 \text{ m}$  to  $x_e = 4.50 \text{ m}$
  3. additive load case: live loads (1/2)  
 $\Rightarrow$  equal area load (beam):  $q = 2.00 \text{ kN/m}^2$  from  $x_a = 4.50 \text{ m}$  to  $x_e = 9.00 \text{ m}$

## 7. 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

limit values for deformations acc. to DIN EN 1995-1-1, Tab. 7.2!  
 Extreme rule 1

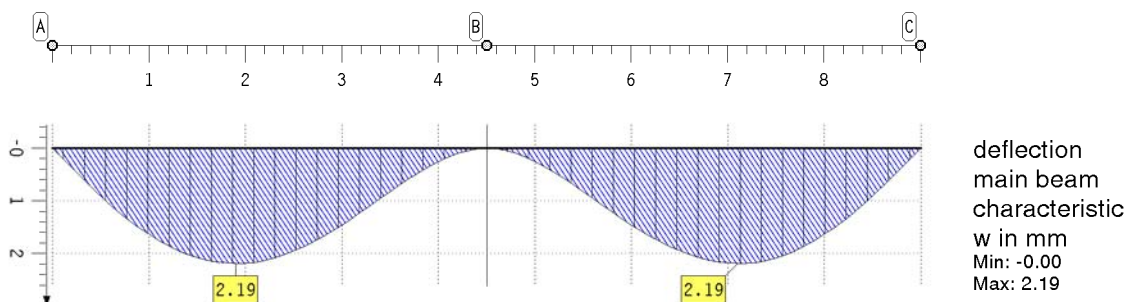
### 3: EC 5 Verification of vibration

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:  $a = 1.50 \text{ mm/kN} \Rightarrow b = 100.00$   
 modal damping ratio  $\xi = 0.01$   
 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  $\nu = 0.00$ , torsionstiffness = 0.0 %  
 $60 \text{ mm}$ ,  $E = 25000 \text{ N/mm}^2$ ,  $g = 0.220 \text{ kN/m}^2$ ,  $I_{screed} = 18000000 \text{ mm}^4/\text{m}$   
 in consideration of 2-dimensional effects  
 Contributing width for deflection criterion 600 mm

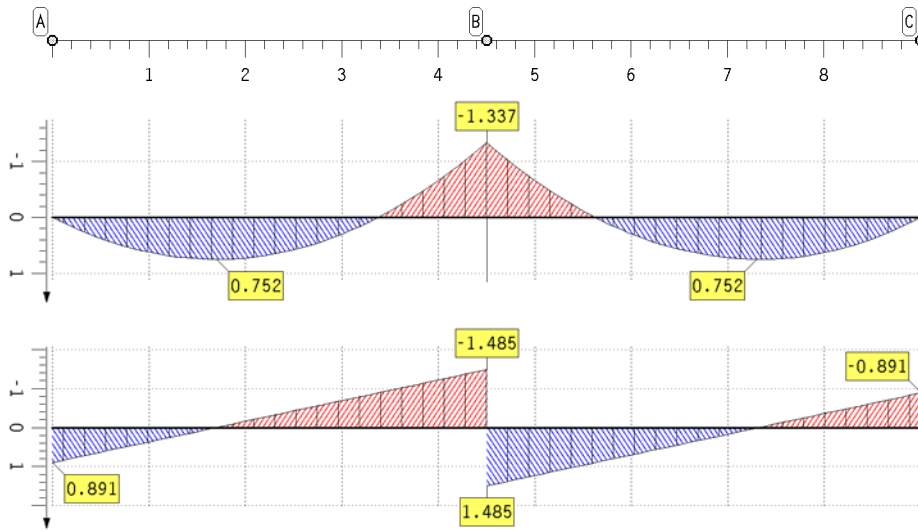
## 8. Results of load cases

### 8.1. Action effect 1: load case 1: dead load (1)

deflections of main beam (characteristic)



internal forces and moments



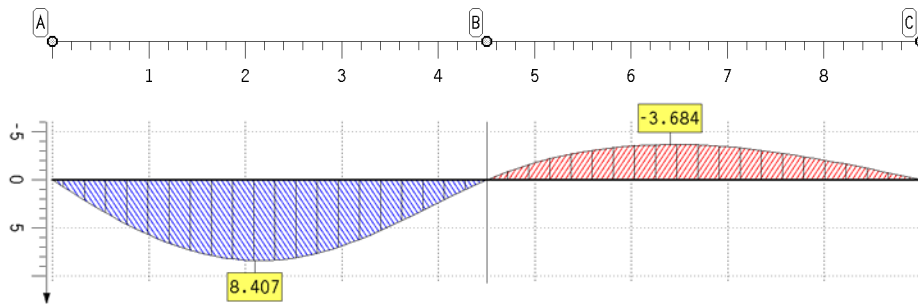
flexural moment  
main beam  
M in kNm  
Min: -1.34  
Max: 0.75

shear force  
main beam  
V in kN  
Min: -1.49  
Max: 1.49

support forces

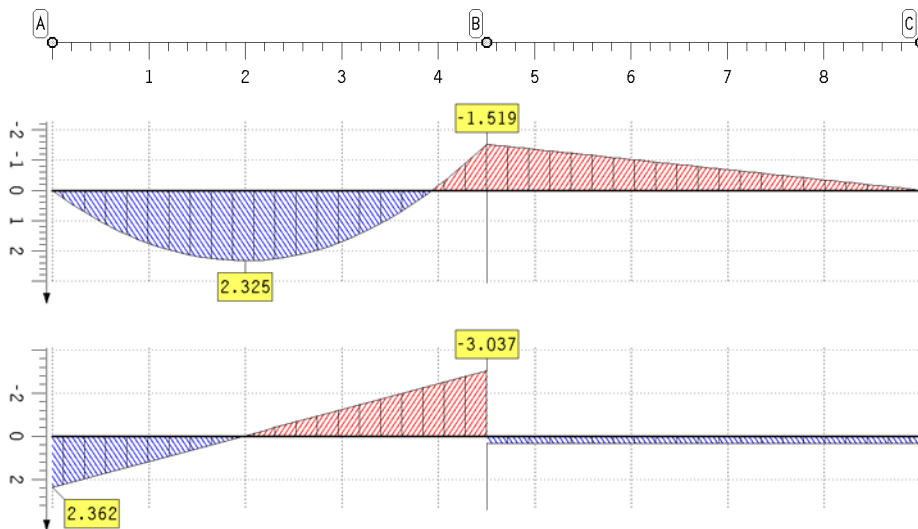
point	x m	AP kN
A	0.000	-0.89
B	4.500	-2.97
C	9.000	-0.89

8.2. Action effect 2: load case 2: live loads (1/1)  
deflections of main beam (characteristic)



deflection  
main beam  
characteristic  
w in mm  
Min: -3.68  
Max: 8.41

internal forces and moments



flexural moment  
main beam  
M in kNm  
Min: -1.52  
Max: 2.33

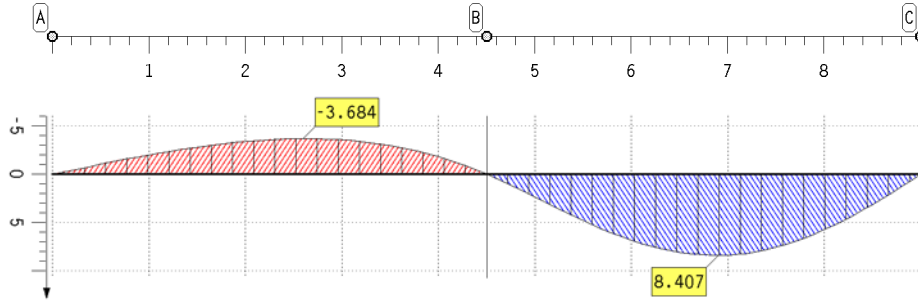
shear force  
main beam  
V in kN  
Min: -3.04  
Max: 2.36

support forces

point	x m	AP kN
A	0.000	-2.36
B	4.500	-3.38
C	9.000	0.34

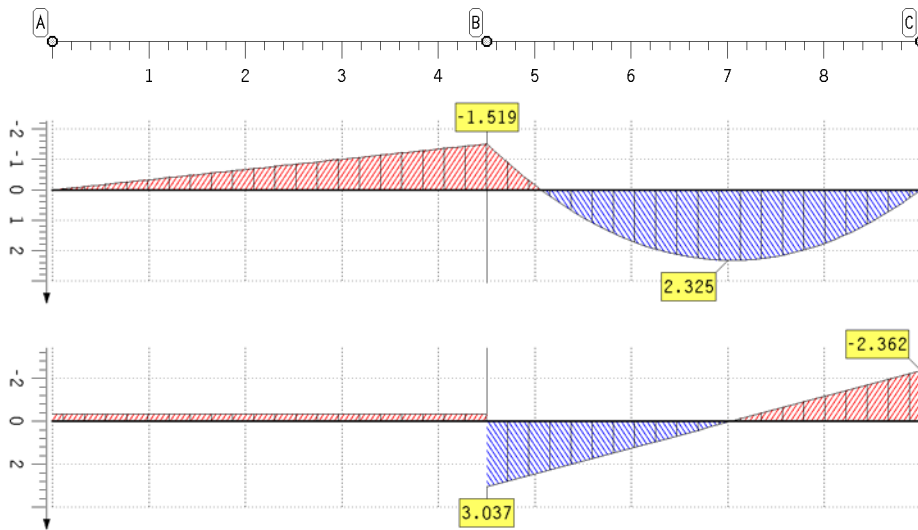
### 8.3. Action effect 2: load case 3: live loads (1/2)

deflections of main beam (characteristic)



deflection  
main beam  
characteristic  
w in mm  
Min: -3.68  
Max: 8.41

internal forces and moments



flexural moment  
main beam  
M in kNm  
Min: -1.52  
Max: 2.33

shear force  
main beam  
V in kN  
Min: -2.36  
Max: 3.04

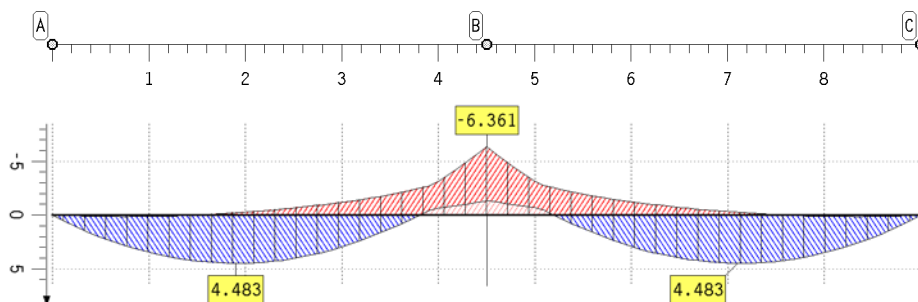
support forces

point	x m	AP kN
A	0.000	0.34
B	4.500	-3.38
C	9.000	-2.36

## 9. Results of verification of ultimate limit state

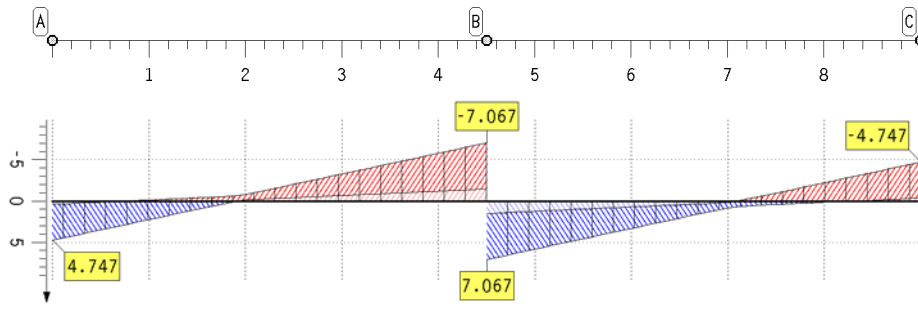
### 9.1. Verification of ultimate limit state

extremal internal forces



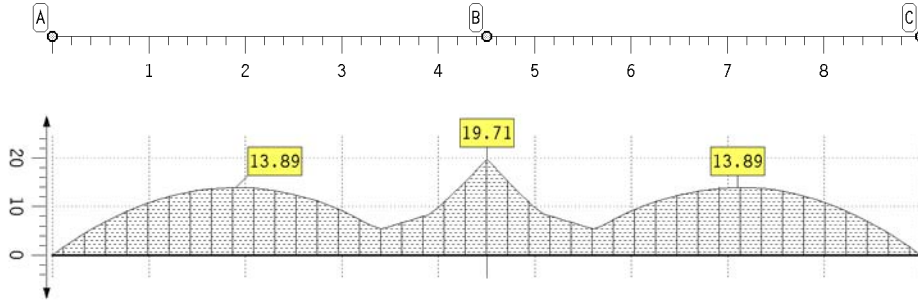
flexural moment  
main beam  
M in kNm  
Min: -6.36  
Max: 4.48

extremal internal forces

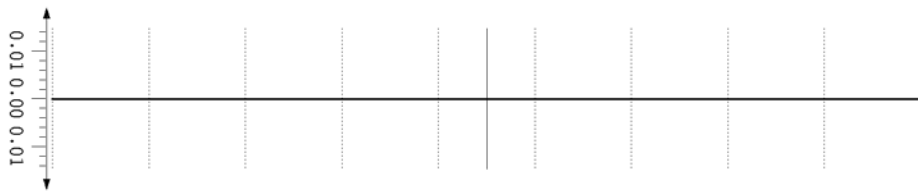


shear force  
main beam  
V in kN  
Min: -7.07  
Max: 7.07

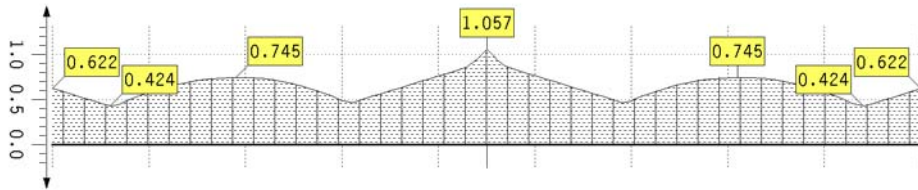
results of verification of ultimate limit state



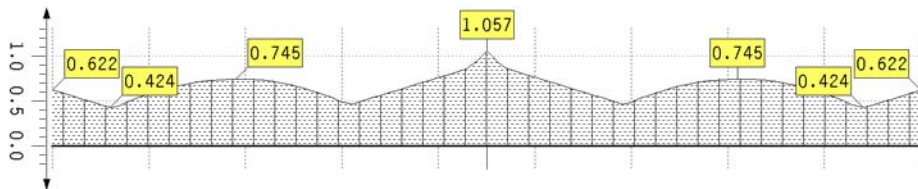
bending stress  
main beam  
 $\sigma_h$  in MN/m<sup>2</sup>  
Max: 19.71



shear stress  
main beam  
 $\tau_h$  in MN/m<sup>2</sup>  
Max: 0.00



utilization  
main beam  
Max: 1.06



maximal  
utilization  
Max: 1.06

verification of ultimate limit state of main beam

point	x	$k_{mod,h}$	$\sigma_h$	$\tau_h$	$U_h$	point	x	$k_{mod,h}$	$\sigma_h$	$\tau_h$	$U_h$
-	m	-	MN/m <sup>2</sup>	MN/m <sup>2</sup>	-	-	m	-	MN/m <sup>2</sup>	MN/m <sup>2</sup>	-
A	0.000	0.650	0.00	0.00	0.622						
	0.600	0.650	7.42	0.00	0.424		4.700	0.650	15.48	0.00	0.860
	1.800	0.650	13.86	0.00	0.743		5.100	0.650	8.38	0.00	0.729
	2.400	0.650	12.87	0.00	0.690		5.600	0.650	5.43	0.00	0.564
	3.100	0.650	8.18	0.00	0.465		5.900	0.650	8.18	0.00	0.465
	3.400	0.650	5.43	0.00	0.564		6.600	0.650	12.87	0.00	0.690
	3.900	0.650	8.38	0.00	0.729		7.200	0.650	13.86	0.00	0.743
	4.300	0.650	15.48	0.00	0.860		8.400	0.650	7.42	0.00	0.424
B	4.500	0.650	19.71	0.00	1.057	C	9.000	0.650	0.00	0.00	0.622
B	4.500	0.650	19.71	0.00	1.057	minimum		0.650	0.00	0.00	0.424
						maximum		0.650	19.71	0.00	1.057

maximal utilization

point	x m	U	point	x m	U	point	x m	U	point	x m	U
A	0.000	0.622		3.100	0.465		4.700	0.860		8.400	0.424
	0.600	0.424		4.300	0.860		5.900	0.465	C	9.000	0.622
	1.800	0.743	B	4.500	1.057		6.600	0.690	minimum		0.424
	2.400	0.690	B	4.500	1.057		7.200	0.743	maximum		1.057

verification of bearing stress

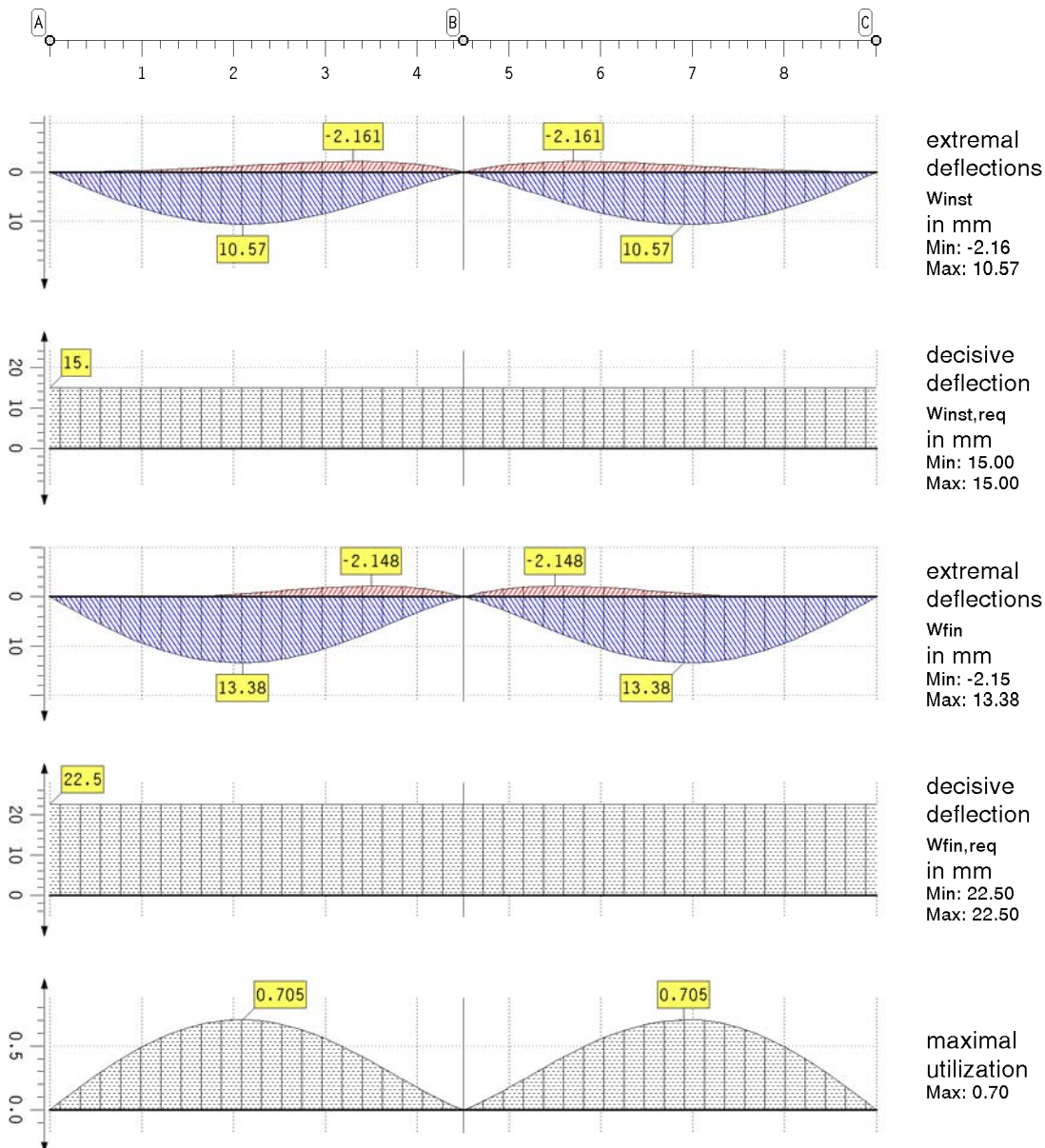
supp.	l <sub>ef</sub> mm	exist A <sub>p</sub> N	k <sub>mod</sub>	zul A <sub>p</sub> N	u
A	100	4747	0.80	5215	0.68
B	110	14135	0.80	9785	1.08
C	102	4747	0.80	5215	0.68

verification of bearing stresses für den main beam(u = 1.083) does not meet the requirements!

## 10. Results of verification of deflections

### 10.1. Verification of deflections

results of verification of deflections



verification of deflections

point	x m	min/max/req $w_{inst}$			min/max/req $w_{fin}$			min/max/req $w_{net,fin}$			U
		mm	mm	mm	mm	mm	mm	mm	mm	mm	
A	0.000	0.00	0.00	15.00	0.00	0.00	22.50	0.00	0.00	15.00	0.000
	1.100	-0.45	7.93	15.00	0.00	10.09	22.50	0.00	5.77	15.00	0.528
	1.500	-0.76	9.64	15.00	-0.02	12.25	22.50	0.00	6.96	15.00	0.643
	2.000	-1.23	10.56	15.00	-0.54	13.37	22.50	0.00	7.51	15.00	0.704
	2.100	-1.33	10.57	15.00	-0.66	13.38	22.50	0.00	7.49	15.00	0.705
	2.700	-1.90	9.50	15.00	-1.49	11.95	22.50	0.00	6.55	15.00	0.633
	3.300	-2.16	6.79	15.00	-2.09	8.47	22.50	-0.47	4.47	15.00	0.453
	3.500	-2.11	5.65	15.00	-2.15	7.01	22.50	-0.58	3.64	15.00	0.376
	3.800	-1.86	3.83	15.00	-2.00	4.72	22.50	-0.65	2.36	15.00	0.256
	4.200	-1.05	1.48	15.00	-1.20	1.79	22.50	-0.45	0.82	15.00	0.099
B	4.500	-0.00	0.00	15.00	-0.00	0.00	22.50	0.00	0.00	15.00	0.000
B	4.500	0.00	0.00	15.00	0.00	0.00	22.50	0.00	0.00	15.00	0.000
	4.800	-1.05	1.48	15.00	-1.20	1.79	22.50	-0.45	0.82	15.00	0.099
	5.200	-1.86	3.83	15.00	-2.00	4.72	22.50	-0.65	2.36	15.00	0.256
	5.500	-2.11	5.65	15.00	-2.15	7.01	22.50	-0.58	3.64	15.00	0.376
	5.700	-2.16	6.79	15.00	-2.09	8.47	22.50	-0.47	4.47	15.00	0.453
	6.300	-1.90	9.50	15.00	-1.49	11.95	22.50	0.00	6.55	15.00	0.633
	6.900	-1.33	10.57	15.00	-0.66	13.38	22.50	0.00	7.49	15.00	0.705
	7.000	-1.23	10.56	15.00	-0.54	13.37	22.50	0.00	7.51	15.00	0.704
	7.500	-0.76	9.64	15.00	-0.02	12.25	22.50	0.00	6.96	15.00	0.643
	7.900	-0.45	7.93	15.00	0.00	10.09	22.50	0.00	5.77	15.00	0.528
C	9.000	-0.00	0.00	15.00	-0.00	0.00	22.50	-0.00	0.00	15.00	0.000
minimum		-2.16	0.00	15.00	-2.15	0.00	22.50	-0.65	0.00	15.00	0.000
maximum		0.00	10.57	15.00	0.00	13.38	22.50	0.00	7.51	15.00	0.705

## 11. vibration verification results

### 11.1. natural frequency

$EI_{lengthwise} = 0.536000 \text{ MNm}^2/\text{m}$ ,  $EI_{cross} = 0.450000 \text{ MNm}^2/\text{m}$ ,  $m = 14800.0 \text{ kg/m}^2$   
 $f_e = 8.369 \text{ Hz} \geq f_e = 8 \text{ Hz} \Rightarrow$  **critereon met!**

### 11.2. unit pulse speed

$n_{40} = 3.1574$   
 $v = 2.553 \text{ mm/s} \leq v_{grenz} = 14.702 \text{ mm/s} \Rightarrow$  **critereon met!**

### 11.3. heel strike

$v = 24.419 \text{ mm/s} \leq v_{grenz} = 88.214 \text{ mm/s} \Rightarrow$  **critereon met!**

### 11.4. acceleration/resonance

$a = 1.374775 \text{ m/s}^2 > 0.3 \text{ m/s}^2 \Rightarrow$  noticeable, not disturbing

### 11.5. acceleration/resonance

$a = 1.3748 \text{ m/s}^2 \leq a > 0.7000 \text{ m/s}^2 \Rightarrow$  **critereon not met!!!**

### 11.6. stiffness criterion

$X_{max F} = 2.250 \text{ m}$ ,  $X_{max w} = 2.250 \text{ m} \Rightarrow w_{max} = 0.513 \text{ mm}$   
 $w(1\text{kN}) = 0.51 \text{ mm} \leq w_{grenz} = 1.5 \text{ mm} \Rightarrow$  **critereon met!**

### 11.7. unit pulse speed

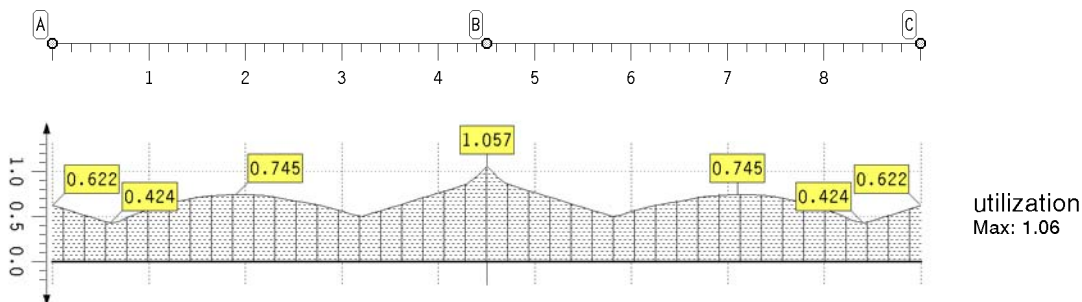
$n_{40} = 3.1574$   
 $v = 2.553 \text{ mm/s} \leq v_{grenz} = 14.702 \text{ mm/s} \Rightarrow$  **critereon met!**

**verification successful!**

## 12. Summary

### 12.1. Summary of all verifications

maximal utilization



## verification of bearing stress

supp.	$t_{ef}$ mm	exist $A_p$ N	$k_{mod}$ -	zul $A_p$ N	u -
A	100	4747	0.80	5215	0.68
B	110	14135	0.80	9785	1.08
C	102	4747	0.80	5215	0.68

verification of bearing stresses für den main beam( $u = 1.083$ ) does not meet the requirements!

## 13. Utilizations of all verifications

verification of load-carrying capacity ( $u = 1.083$ ) does not meet the requirements!