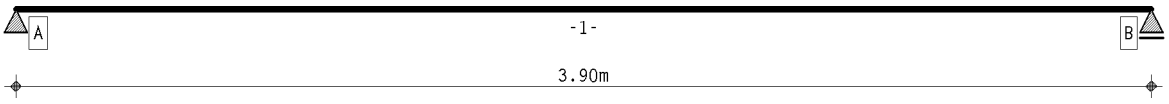
1. Options for Calculations

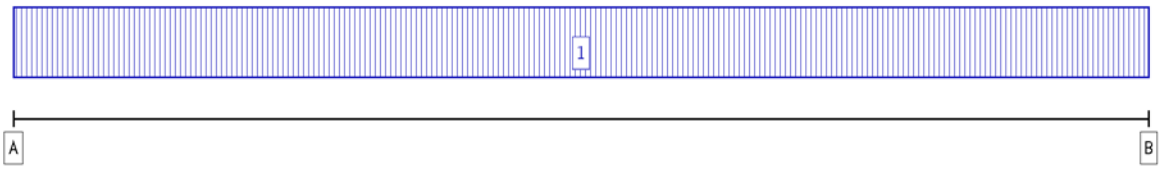
calculation DIN EN 1995:2010, Germany
service class 2
coefficient of thermal expansion for timber α_t = 0.500 *10^{-5}/°K
ψ_2 = 0.60 (factor acc. to DIN EN 1995-1-1 2.3.2.2 (2))

2. Structural system

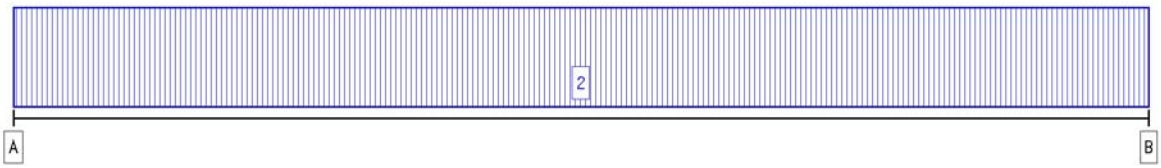


main beam

3. Loading



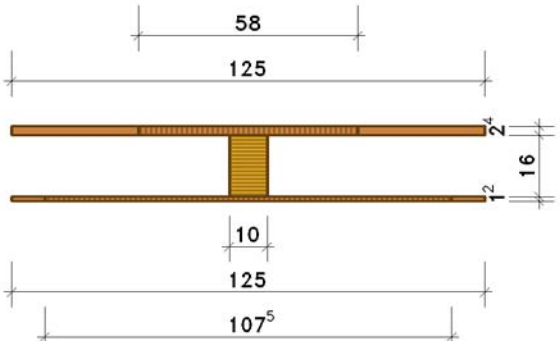
action effect 1: permanent loads (permanent, 1 load cases)



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

4. main beam

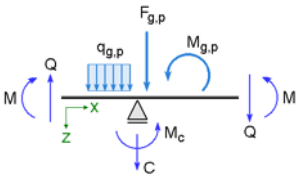
section scale 1:20



timber gr. top fl. (fibre ||) plywood F25/10
d = 24.0 mm (lying)
char. bend. strength $f_{m,k}$: 25.0 N/mm²
char. shear strength $f_{v,k}$: 1.1 N/mm²
char. ten. strength $f_{t,k}$: 18.0 N/mm²
char. compr. strength $f_{c,0,k}$: 18.0 N/mm²
char. compr. strength $f_{c,90,k}$: 6.5 N/mm²
e-modulus $E_{0,mean}$ (diaphragm): 4500 N/mm²
e-modulus $E_{0,mean}$ (plate) : 5500 N/mm²
Dichte ρ_k/ρ_m : 400 / 480 kg/m³
deformation factor k_{def} : 1.00 -
area A_{flange} : 300.000 cm²
moment of inertia I_{flange} : 144.000 cm⁴
timber grade web solid coniferous timber, C24 (S10)
char. bend. strength $f_{m,k}$: 24.0 N/mm²
char. shear strength $f_{v,k}$: 4.0 N/mm²
char. ten. strength $f_{t,k}$: 14.5 N/mm²
char. compr. strength $f_{c,0,k}$: 21.0 N/mm²
char. compr. strength $f_{c,90,k}$: 2.5 N/mm²
k_{cr} : 0.50 mm²/N
modulus of elasticity $E_{0,mean}$:11000 N/mm²
Dichte ρ_k/ρ_m : 350 / 420 kg/m³
deformation factor k_{def} : 0.80 -
area A_{flange} : 160.000 cm²
moment of inertia I_{flange} : 3413.333 cm⁴
timber grade bottom flange (fibre ||) OSB 2
d = 12.0 mm (lying)
char. bend. strength $f_{m,k}$: 16.4 N/mm²
char. shear strength $f_{v,k}$: 1.0 N/mm²
char. ten. strength $f_{t,k}$: 9.4 N/mm²
char. compr. strength $f_{c,0,k}$: 15.4 N/mm²
char. compr. strength $f_{c,90,k}$: 10.0 N/mm²

e-modulus $E_{0,mean}$ (diaphragm): 3800 N/mm²
e-modulus $E_{0,mean}$ (plate) : 4930 N/mm²
Dichte ρ_k / ρ_m : 550 / 660 kg/m³
deformation factor k_{def} : 2.25 -
area A_{flange} : 150.000 cm²
moment of inertia I_{flange} : 18.000 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	3.90	3.90	2.00	28.9000	1.2827	69.2042	1.1788	0.5592	3.90	-	n.e.

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	-5.4	1	1.0000	-86.6	1	1.0000	91.4	1.2670E12	0.7467

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	-5.4	1	1.0000	-86.6	1	1.0000	91.4	1.2670E12	115186024.0	8.54	106.67

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	-10.1	1	1.0000	-81.9	1	1.0000	96.1	7.2541E11	97600776.00	9.01	106.67

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	160.00	426.67	3413.33	139.20	120.00	144.00	129.00	30.00	18.00

6. Fasteners

section 1 from x_A = 0.00 m to x_E = 3.90, glued joint

7. Supports

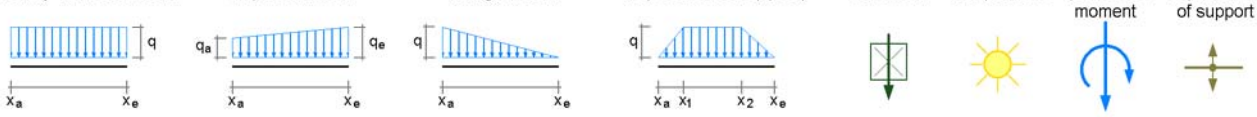
coordinates of supports

supp.name	x m	width mm	depth mm	c_F kN/m	c_M kNm/-	restraint (F)	restraint (M)
A	0.00	150	1250	fix	----	X	-
B	3.90	150	1250	fix	----	X	-

8. Action effects

Attention! Acc. to DIN EN 1995-1-1, annex B.1
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 = 2.00 kN/m from x_a = 0.00 m to x_e = 3.90 m

2. Transient action effect: live loads (1)
2. additive load case: live loads (1/1)
⇒ unif.distr.load: q = 2.20 kN/m from x_a = 0.00 m to x_e = 3.90 m

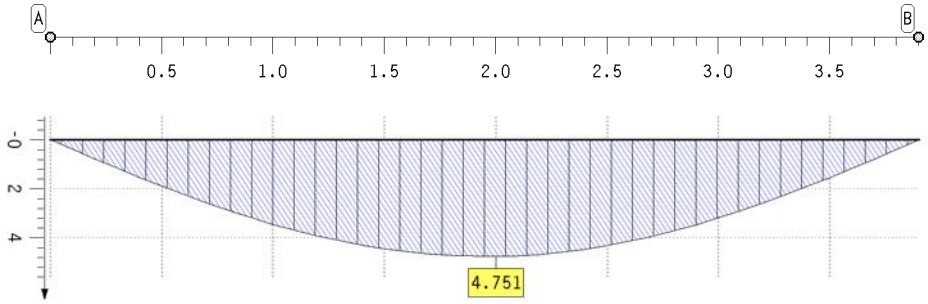
9. verifications

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

10. Results of action effects

10.1. Action effect 1: permanent loads

extremal deflections of main beam (characteristic)

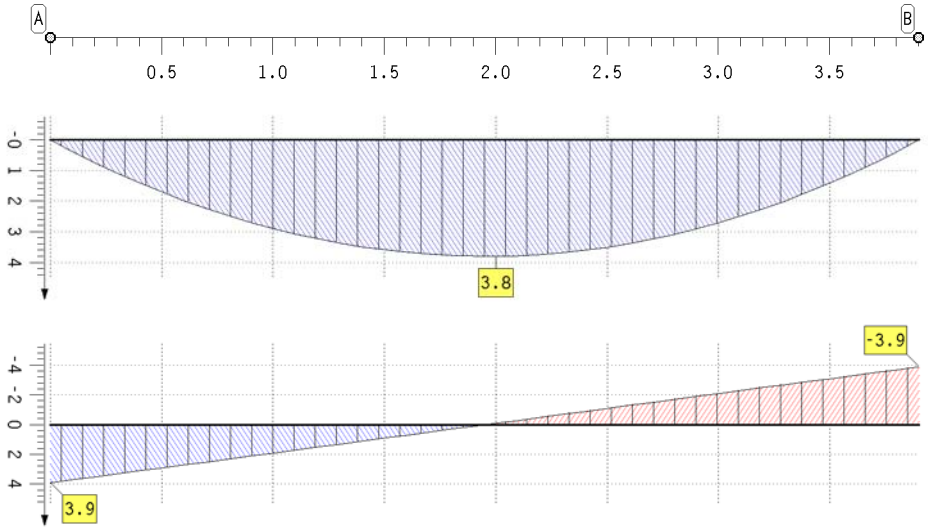


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 4.75

extremal deflections of main beam (characteristic)

point	x	min w	max w	point	x	min w	max w
-	m	mm	mm	-	m	mm	mm
A	0.000	0.00	0.00	B	3.900	-0.00	-0.00
	1.100	3.71	3.71	**minimum**		**-0.00**	**-0.00**
	1.900	4.75	4.75	**maximum**		**4.75**	**4.75**
	2.800	3.71	3.71				

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 3.80

shear force
main beam
V in kN
Min: -3.90
Max: 3.90

extremal internal forces

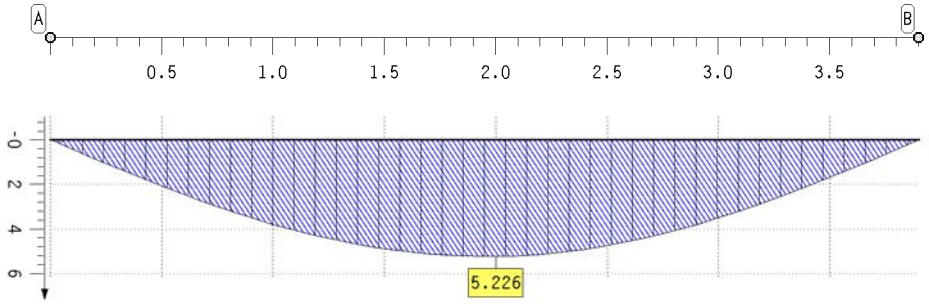
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	3.90	3.90	B	3.900	-0.00	-0.00	-3.90	-3.90
	1.000	2.90	2.90	1.90	1.90	**minimum**		**-0.00**	**-0.00**	**-3.90**	**-3.90**
	1.900	3.80	3.80	0.10	0.10	**maximum**		**3.80**	**3.80**	**3.90**	**3.90**
	2.900	2.90	2.90	-1.90	-1.90						

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-3.90	-3.90
B	3.900	-3.90	-3.90

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)



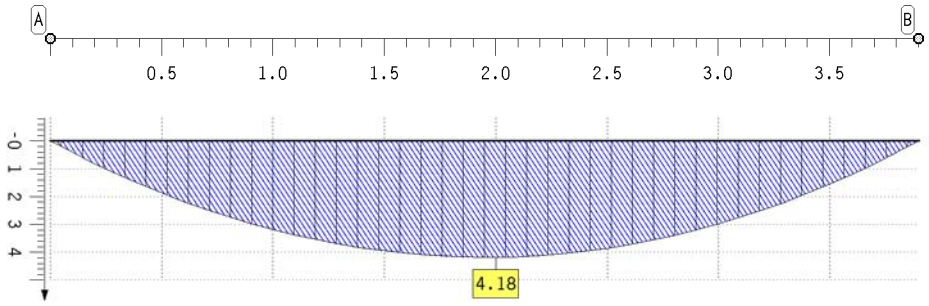
deflection
main beam
characteristic
w in mm
Min: 0.00
Max: 5.23

extremal deflections of main beam (characteristic)

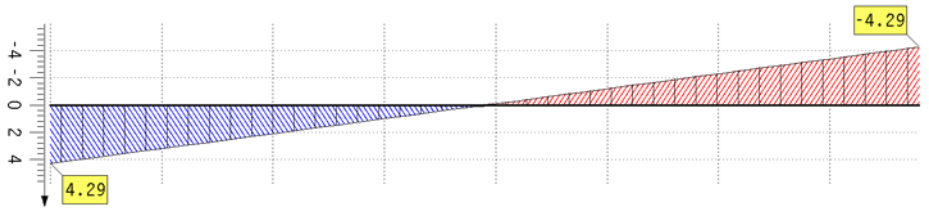
point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.100	0.00	4.08
	1.900	0.00	5.23
	2.800	0.00	4.08

point	x	min w	max w
-	m	mm	mm
B	3.900	0.00	0.00
minimum		**0.00**	**0.00**
maximum		**0.00**	**5.23**

extremal internal forces



flexural moment
main beam
M in kNm
Min: -0.00
Max: 4.18



shear force
main beam
V in kN
Min: -4.29
Max: 4.29

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	4.29
	1.000	0.00	3.19	0.00	2.09
	1.900	0.00	4.18	0.00	0.11
	2.900	0.00	3.19	-2.09	-0.00

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	3.900	-0.00	-0.00	-4.29	-0.00
minimum		**-0.00**	**0.00**	**-4.29**	**-0.00**
maximum		**0.00**	**4.18**	**0.00**	**4.29**

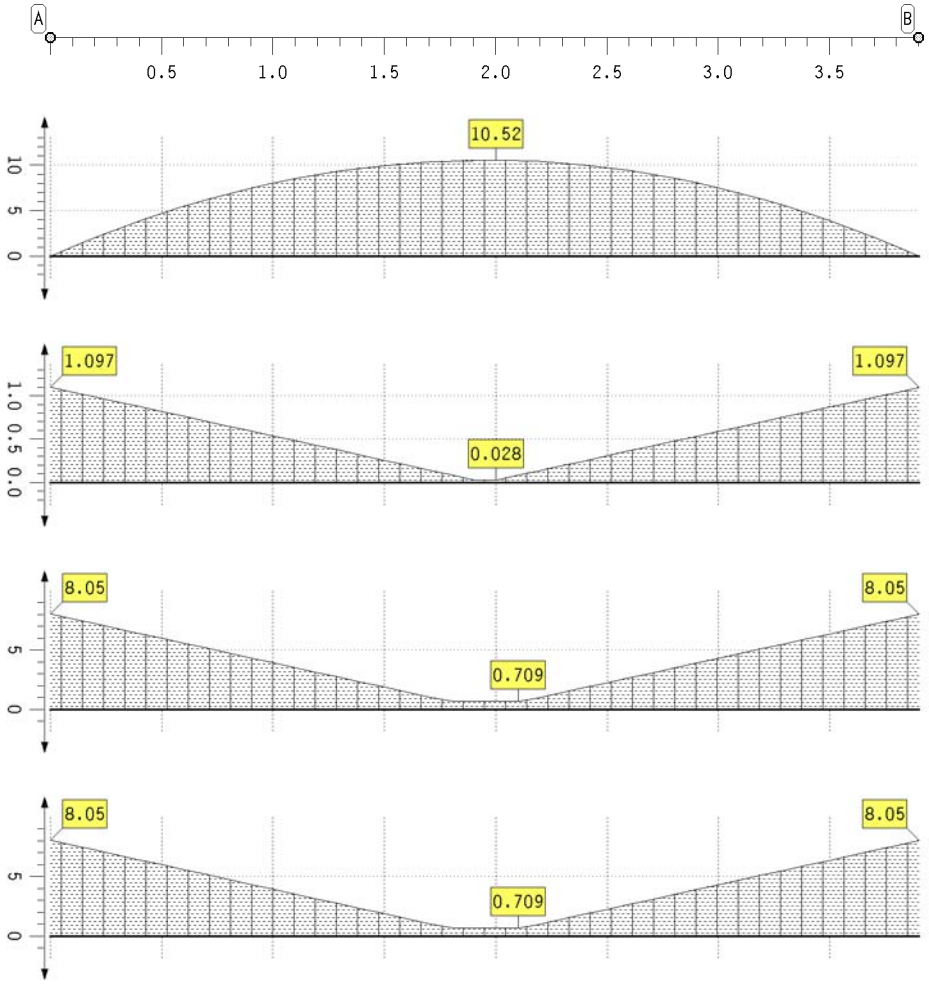
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-4.29	-0.00
B	3.900	-4.29	-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: 10.52

shear stress
main beam
τ_h in MN/m²
Max: 1.10

utilization
main beam
Max: 8.05

maximal
utilization
Max: 8.05

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	8.050	B	3.900	8.050
	1.800	0.709	**minimum**		**0.709**
	2.200	1.032	**maximum**		**8.050**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-11.70	-3.90
B	3.900	-11.70	-3.90

verification of bearing stress

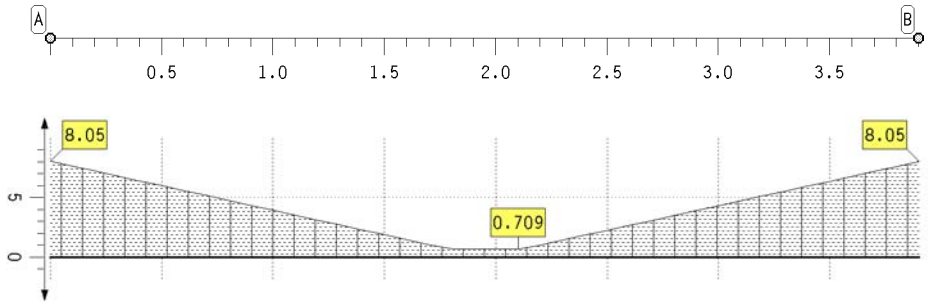
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm²	N		-	N/mm²	N/mm²	-
A	180	225000	11700	1.00	1.00	7.69	0.05	0.01
B	180	225000	11700	1.00	1.00	7.69	0.05	0.01

verification of bearing stresses für den main beam(u = 0.007) successful!

12. Summary

12.1. Summary of all verifications

maximal utilization



utilization
Max: 8.05

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	8.050	B	3.900	8.050
	1.800	0.709	**minimum**		**0.709**
	2.200	1.032	**maximum**		**8.050**

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	225000	11700	1.00	1.00	7.69	0.05	0.01
B	180	225000	11700	1.00	1.00	7.69	0.05	0.01

verification of bearing stresses für den main beam(u = 0.007) successful!

13. Utilizations of all verifications

verification of load-carrying capacity (u = 8.050) does not meet the requirements!

14. Detailed verification piont

14.1. 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	3.90	0	-0	0	0	0	0
start,max	0.00	11.70	0	-0	0	0	0	0
end,min	0.00	3.90	0	-0	0	0	0	0
end,max	0.00	11.70	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	0.8	0.00	0.00	**0.00**	1.10	0.45	0.45
end	0.8	0.00	0.00	0.00	1.10	0.45	0.45

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	0.8	0.00	-0.00	**0.00**	1.0	0.00	0.00	**0.00**
end	0.8	0.00	-0.00	0.00	1.0	0.00	0.00	0.00

adhering joint with $f_{v1,d}$ = 0.400 N/mm²

state	$S_{1,d}$	$\tau_{1,d}$	$u_{1,d}$	$S_{2,d}$	$\tau_{2,d}$	$u_{2,d}$
	cm²	N/mm²	-	cm²	N/mm²	-
start	1206	1.3666	**3.42**	1179	1.4862	**1.93**
end	1140	1.3666	3.42	1240	1.4862	1.93

resulting utilization at verification point u_{res} = 8.050