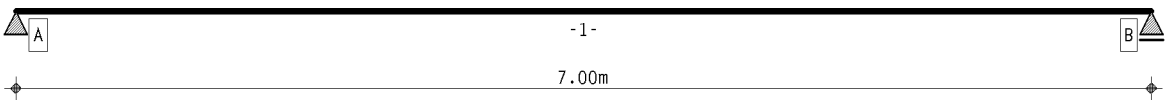
1. Options for Calculations

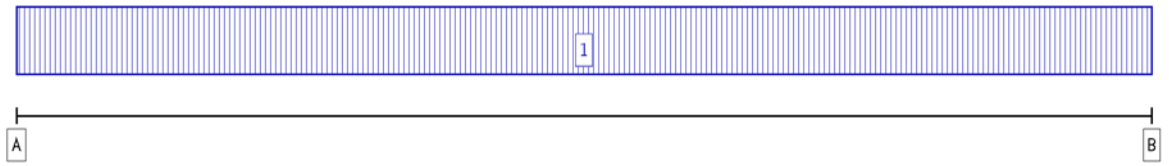
calculation DIN EN 1995:2010, Germany
service class 1
coefficient of thermal expansion for timber α_t = 0.500 *10^{-5}/°K
ψ_2 = 0.60 (factor acc. to DIN EN 1995-1-1 2.3.2.2 (2))

2. Structural system

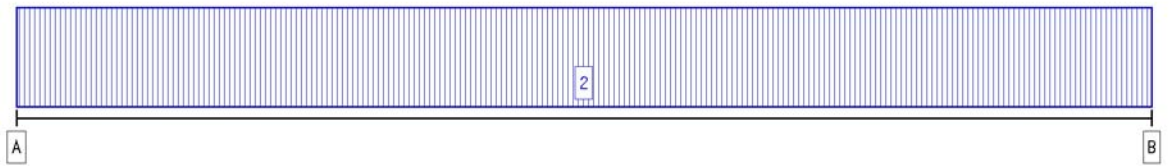


main beam

3. Loading



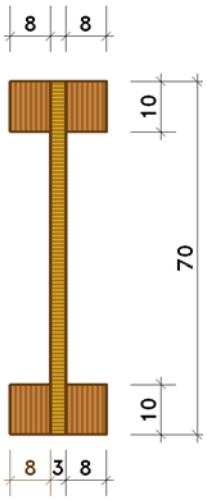
action effect 1: permanent loads (permanent, 1 load cases)



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

4. main beam

section scale 1:15



timber grade top flange — **solid coniferous timber, C30 (S13)**

char. bend. strength	$f_{m,k}$	: 30.0 N/mm²
char. shear strength	$f_{v,k}$	: 4.0 N/mm²
char. ten. strength	$f_{t,k}$	: 19.0 N/mm²
char. compr. strength	$f_{c,0,k}$	: 24.0 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}	: 160.000 cm²
moment of inertia	I_{flange}	: 1333.333 cm⁴

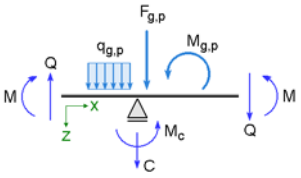
timber grade web (fibre ⊥) — **plywood F40/30**
d = 30.0 mm (hochkant)

char. bend. strength	$f_{m,k}$	: 29.0 N/mm²
char. shear strength	$f_{v,k}$	: 9.5 N/mm²
char. ten. strength	$f_{t,k}$	: 29.0 N/mm²
char. compr. strength	$f_{c,0,k}$	: 21.0 N/mm²
char. compr. strength	$f_{c,90,k}$	: 9.0 N/mm²
	k_{cr}	: 1.00 mm²/N
e-modulus	$E_{0,mean}$ (diaphragm)	: 4400 N/mm²
e-modulus	$E_{0,mean}$ (plate)	: 6000 N/mm²
Dichte	ρ_k / ρ_m	: 600 / 720 kg/m³
deformation factor	k_{def}	: 0.80 -
area	A_{flange}	: 210.000 cm²
moment of inertia	I_{flange}	:85750.000 cm⁴

timber grade bottom flange — **solid coniferous timber, C30 (S13)**

char. bend. strength	$f_{m,k}$	: 30.0 N/mm²
char. shear strength	$f_{v,k}$	: 4.0 N/mm²
char. ten. strength	$f_{t,k}$	: 19.0 N/mm²
char. compr. strength	$f_{c,0,k}$	: 24.0 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} : 160.000 cm²
moment of inertia I_{flange} : 1333.333 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	7.00	7.00	2.33	17.3400	6.3710	134.3714	3.3814	0.0850	7.00	-	50.0

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	0.0	3578	0.6492	-300.0	3578	0.6492	300.0	2.6528E13	0.5522

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	-0.0	2385	0.5523	-300.0	2385	0.5523	300.0	2.3180E13	1931694720.	35.00	174.30

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	0.0	1302	0.4781	-300.0	1302	0.4781	300.0	1.4934E13	1692531712.	35.00	174.25

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	195.60	2077.14	72699.96	128.80	234.62	1173.08	128.80	234.62	1173.08

6. Fasteners

section 1 from x_A = 0.00 m to x_E = 7.00
nail, 6.0 x 160.0 mm, d_k = 20.0 mm, predrilled
4-row with a_1 = **200.0 mm**
4 - row with a_2 = 20.0 mm, simplified verification acc. to NA.8.2.4
nail ends in timber member 2, 2 shear plane(s), penetration depth t = 50 mm > 4 d = 24 mm
f_{uk} = 600 N/mm², M_{yk} = 18987 Nmm
K_{ser} = 3578 N/mm, γ_M = 1.10, **R_k = 3007.8 N, all values per shear plane**

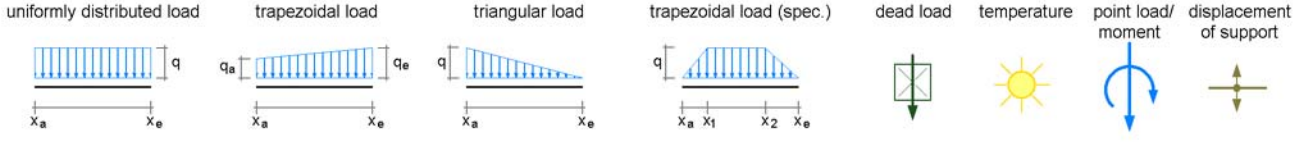
7. Supports

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	30	fix	----	X	-
B	7.00	150	30	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



Permanent action effect: permanent loads
1. additive load case: dead load (1)
⇒ unif.distr.load: q = 4.40 kN/m from x_a = 0.00 m to x_e = 7.00 m
2. Transient action effect: live loads (1)
2. additive load case: live loads (1/1)

⇒ unif.distr.load: q = 5.00 kN/m from x_a = 0.00 m to x_e = 7.00 m

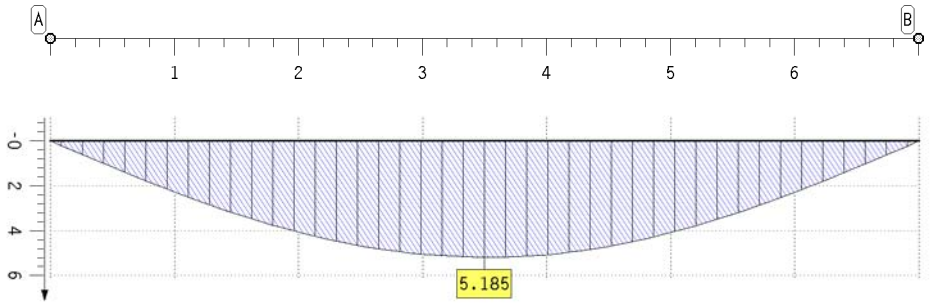
9. verifications

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)

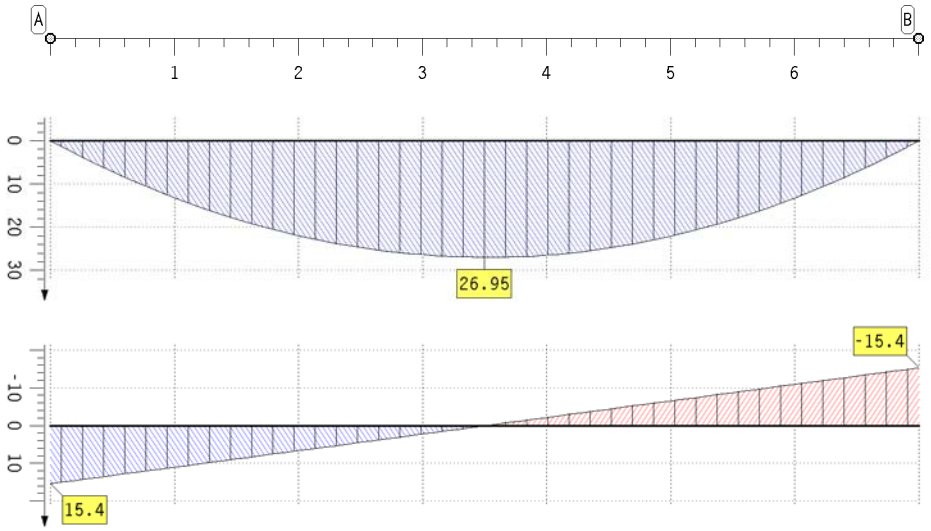


deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 5.19

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	7.000	-0.00	-0.00
	1.900	3.93	3.93	**minimum**		**-0.00**	**-0.00**
	3.500	5.19	5.19	**maximum**		**5.19**	**5.19**
	5.100	3.93	3.93				

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 26.95

shear force
main beam
V in kN
Min: -15.40
Max: 15.40

extremal internal forces

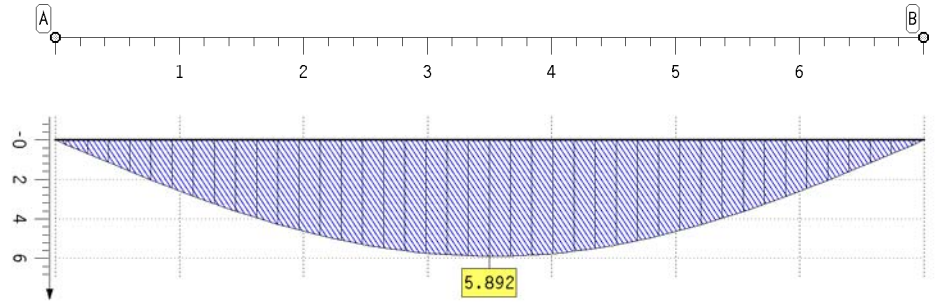
point	x	min M	max M	min V	max V	point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN	-	m	kNm	kNm	kN	kN
A	0.000	0.00	0.00	15.40	15.40	B	7.000	0.00	0.00	-15.40	-15.40
	1.700	19.82	19.82	7.92	7.92	**minimum**		**0.00**	**0.00**	**-15.40**	**-15.40**
	3.500	26.95	26.95	0.00	0.00	**maximum**		**26.95**	**26.95**	**15.40**	**15.40**
	5.300	19.82	19.82	-7.92	-7.92						

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-15.40	-15.40
B	7.000	-15.40	-15.40

10.2. Action effect 2: live loads (1)

extremal deflections of main beam (characteristic)



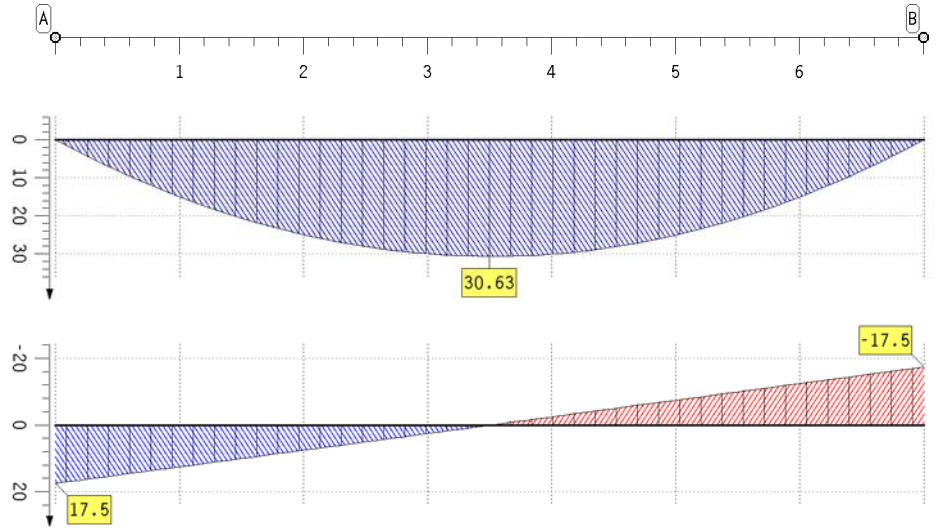
deflection
main beam
characteristic
w in mm
Min: -0.00
Max: 5.89

extremal deflections of main beam (characteristic)

point	x	min w	max w
-	m	mm	mm
A	0.000	0.00	0.00
	1.900	0.00	4.47
	3.500	0.00	5.89
	5.100	0.00	4.47

point	x	min w	max w
-	m	mm	mm
B	7.000	-0.00	-0.00
minimum		**-0.00**	**0.00**
maximum		**0.00**	**5.89**

extremal internal forces



flexural moment
main beam
M in kNm
Min: 0.00
Max: 30.62

shear force
main beam
V in kN
Min: -17.50
Max: 17.50

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	17.50
	1.800	0.00	23.40	0.00	8.50
	3.500	0.00	30.62	0.00	0.00
	5.300	0.00	22.52	-9.00	-0.00

point	x	min M	max M	min V	max V
-	m	kNm	kNm	kN	kN
B	7.000	0.00	0.00	-17.50	-0.00
minimum		**0.00**	**0.00**	**-17.50**	**0.00**
maximum		**0.00**	**30.62**	**0.00**	**17.50**

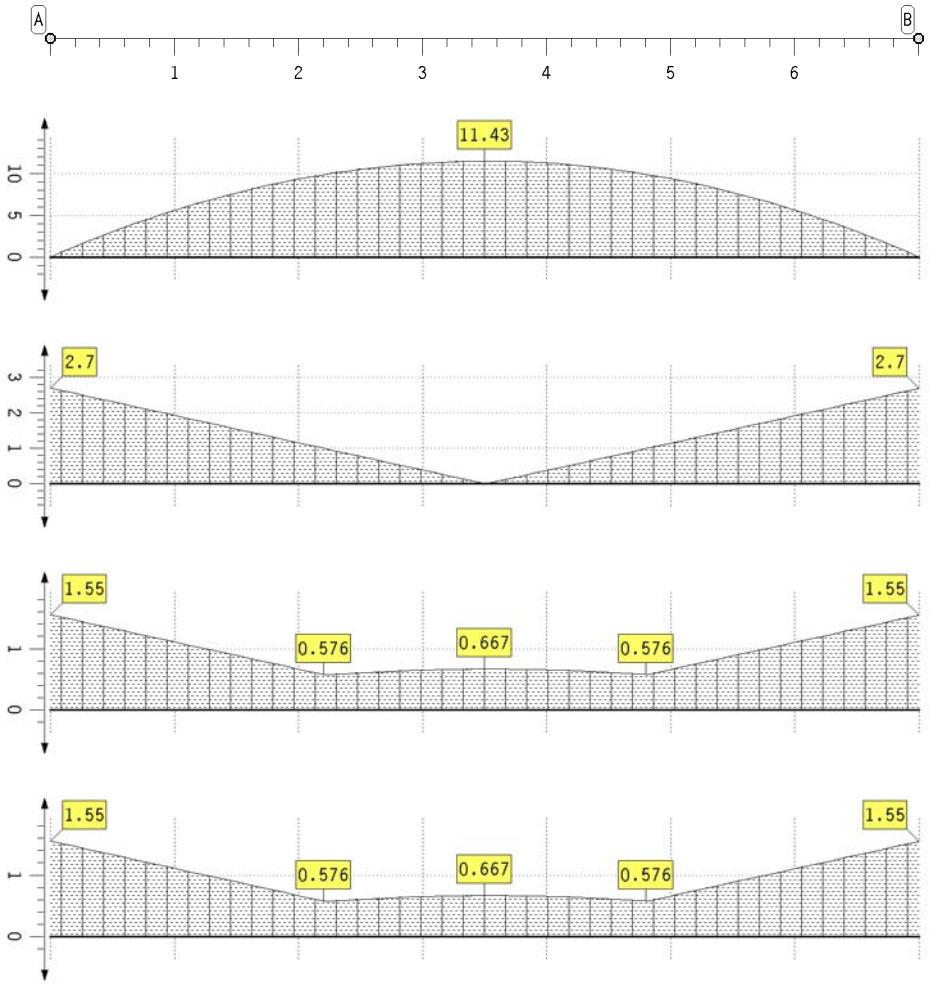
extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-17.50	-0.00
B	7.000	-17.50	-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: 11.43

shear stress
main beam
τ_h in MN/m²
Max: 2.70

utilization
main beam
Max: 1.55

maximal
utilization
Max: 1.55

maximal utilization

point	x	U	point	x	U
-	m	-	-	m	-
A	0.000	1.550	B	7.000	1.550
	2.200	0.576	**minimum**		**0.576**
	4.800	0.576	**maximum**		**1.550**

extremal support forces

point	x	min AP	max AP
-	m	kN	kN
A	0.000	-47.04	-15.40
B	7.000	-47.04	-15.40

verification of bearing stress

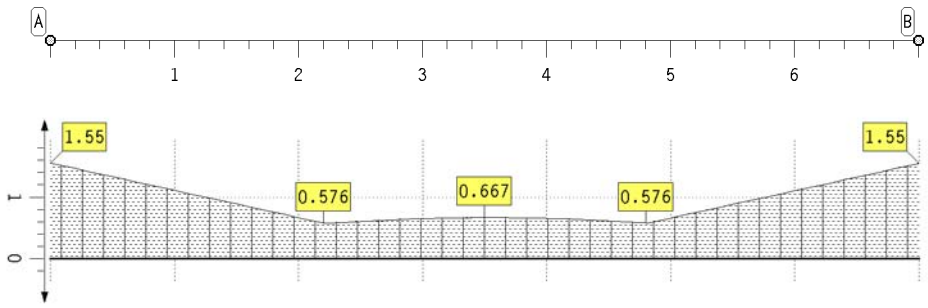
support	l_{ef}	A_{ef}	A_P	k_{c90}	k_{mod}	f_{c90d}	σ_{c90d}	u
	mm	mm²	N		-	N/mm²	N/mm²	-
A	180	5400	47040	1.00	0.90	6.23	8.71	1.40
B	180	5400	47040	1.00	0.90	6.23	8.71	1.40

verification of bearing stresses für den main beam(u = 1.398) does not meet the requirements!

12. Summary

12.1. Summary of all verifications

maximal utilization



utilization
Max: 1.55

maximal utilization

point	x	U
-	m	-
A	0.000	1.550
	2.200	0.576
	4.800	0.576

point	x	U
-	m	-
B	7.000	1.550
minimum		**0.576**
maximum		**1.550**

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	5400	47040	1.00	0.90	6.23	8.71	1.40
B	180	5400	47040	1.00	0.90	6.23	8.71	1.40

verification of bearing stresses für den main beam(u = 1.398) does not meet the requirements!

13. Utilizations of all verifications

verification of load-carrying capacity (u = 1.550) 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	15.40	0	-0	0	0	0	0
start,max	0.00	47.04	0	-0	0	0	0	0
end,min	0.00	15.40	0	-0	0	0	0	0
end,max	0.00	47.04	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	0.9	0.00	0.00	**0.00**	2.70	0.41	0.41
end	0.9	0.00	0.00	0.00	2.70	0.41	0.41

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	0.9	0.00	-0.00	**0.00**	0.9	0.00	0.00	**0.00**
end	0.9	0.00	-0.00	0.00	0.9	0.00	0.00	0.00

fastener

state	$F_{1,d}$	$u_{1,d}$	$F_{2,d}$	$u_{2,d}$
	N	-	N	-
start	-3228	**1.55**	3228	**1.55**
end	-3189	1.53	3189	1.53

resulting utilization at verification point u_{res} = 1.550