SYSTEM DESCRIPTION

General information

The extension of the longitudinal axis of the beam is oriented to the global X-axis.
Dead loads act in global X-direction.
Calculation is carried out taking into account warping torsion and the Wagner effect.
The deformations of the load spectra don't include the imperfections.

At non linear calculation iteration runs through maximal 50 steps per load spectrum.
Convergence criterion: The iteration is stopped if the result differences of two following steps do not exceed at no point the tolerances listed below.

criterion	tolerance	criterion	tolerance
displacements	0.00010 mm	int. forces	0.00010 kN
rotations	0.00010 ‰	int. moments	0.00010 kNm
twists	0.00010 ‰/m	warping bimom.	0.00010 kNm^2

verification options

Results acc. to DIN EN 1993:2010, NA Germany
Limiting values of (c/t) acc. to DIN EN 1993-1-1 table 5.2 are not being checked.
Plastic cross-section verfication acc. to DIN EN 1993-1-1 paragraph 6.2.1(6).
The ultimate limit state is determined according to the extended partial section method.
For triple-sheet cross-sections, the partial section sizing method with rearrangement (KINDMANN) is used.
There is no limitation of limiting bending moments.

Regulations

DIN EN 1993-1-1, Eurocode 3: Bemessung und Konstruktion von Stahlbauten -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln für den Hochbau;
Deutsche Fassung EN 1993-1-1:2005 + AC:2009, Ausgabe Dezember 2010
DIN EN 1993-1-1/A1, Ergänzungen zur DIN EN 1993-1-1, Ausgabe Juli 2014
DIN EN 1993-1-1/NA, Nationaler Anhang zur DIN EN 1993-1-1, Ausgabe Dezember 2018

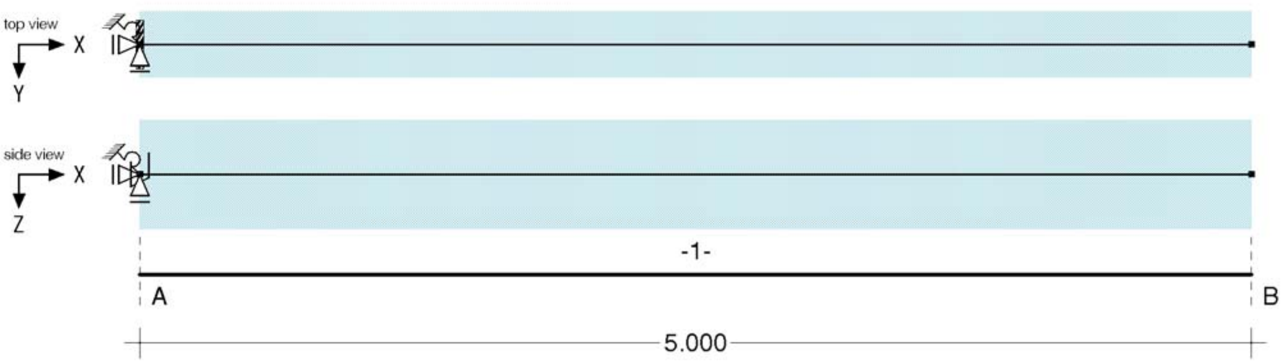
DIN EN 1993-1-1 verification parameters

NA Germany

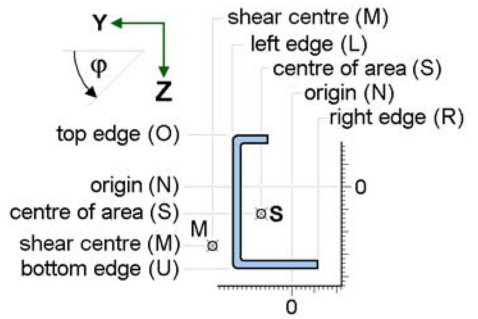
chapter	value	definition
6.1(1)	permanent/transient sit.	partial factors for structural steel
	γ_{M0} = 1.00	collapse of cross-sections
	γ_{M1} = 1.10	instability
	accidental situation	partial factors for structural steel
	γ_{M0} = 1.00	collapse of cross-sections
	γ_{M1} = 1.00	instability

System sketch

with point bearings of the section ends and position of the point/lines/hinged springs within the sections



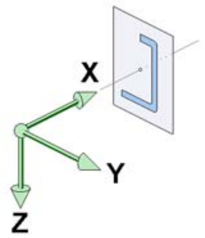
List of sections



The penetration point of the global X-axis through the plane of the cross-section is defined using the alongside shown horizontal and vertical alignment points.

The alignment points are also used to describe the points of action of flexible point or line supports.

Following the alignment the cross-section is rotated through φ about the global X-axis.



sec.	from xa	to xe	l	Orientation at the beginning		Orientation at the end		φ
-	m	m	m	horizontal	vertical	horizontal	vertical	°
1	0.00	5.00	5.00	(S) + 0.00 cm	(S) + 0.00 cm	(S) + 0.00 cm	(S) + 0.00 cm	0.00

Bars with normed steel sections

section	material	$\gamma_{M,E}$	st. section name
-	-	-	-
1	S355	1.10	HE500A

section properties of bar sections

The position of the centre of gravity eY, eZ and the angle of rotation α of the principal axes η, ζ or the distance YSM, ZSM of the shear centre from the centroid of gravity is described with respect to the global XYZ system. All other cross-section values are given in the principal axis system

sec.	eY	eZ	α	YSM	ZSM	A	Iη	Iζ	IT	Iω	iM	rη	rζ	rω
-	cm	cm	°	cm	cm	cm2	cm4	cm4	cm4	cm6	cm	cm	cm	-
1	0.00	0.00	0.00	-0.00	0.00	198.00	86970	10370	310.00	5643000	22.17	-0.00	0.00	-0.00

Point supports at the ends of sections

The support is relocated from the X-axis with ΔY and ΔZ and distorted with the angle φ. Numeric values indicate spring constants. CPX, CPY and CPZ describe the bearings for the forces in the indexed direction. CMX, CMY and CMZ describe the moment restraint around the indexed axes. CMΩ is the warping restraint.

support	at x	CPX	CPY	CPZ	CMX	CMY	CMZ	CMω	ΔY	ΔZ	φ
-	m	kN/m	kN/m	kN/m	kNm/-	kNm/-	kNm/-	kN/m3	cm	cm	°
A	0.00	fix	fix	fix	fix	fix	fix	fix	0.00	0.00	0.00

Description of loading structure

On the left-hand side, the relationship between the actions effects, load case file and load cases are shown in a tree structure. The right-hand side shows the characteristics of the superposition to the associated objects on the left-hand. In terms of the superposition, a load case file is equivalent to an extreme rule of the defined objects therein and can be additive or alternatively superpositioned.

applied symbols: action effect load case file load case imperfection cases

1: permanent loads — **permanent loads**
- 1: dead load (1) — additive

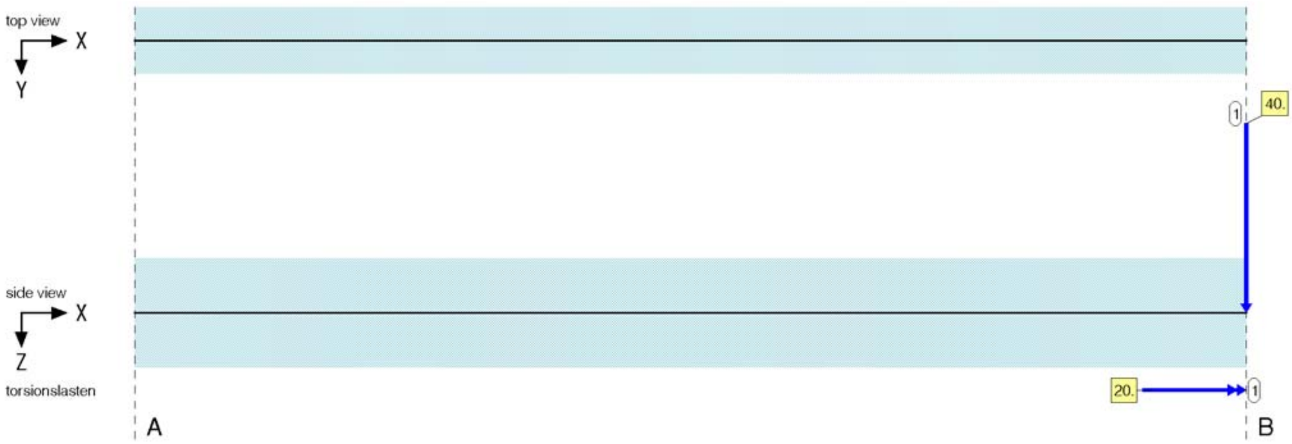
imperfection cases
- 1: imperfection (1)

GRAPHIC OF LOADS OF ACTION EFFECTS

The load images are displayed as projections with regard to the top view (X-Y plane) and the side view (X-Z plane).
Dead loads and torsion loads are drawn separately from the views in a separate line.
The load case numbers are indicated on the individual load images.

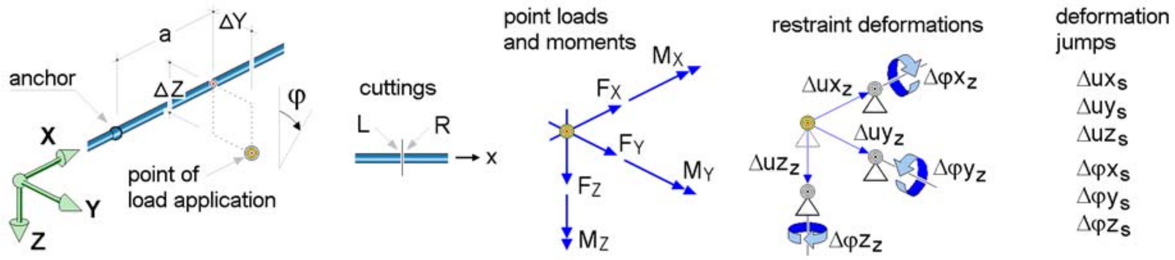
action effect 1: permanent loads

permanent, 1 load case (see numbers of load cases)



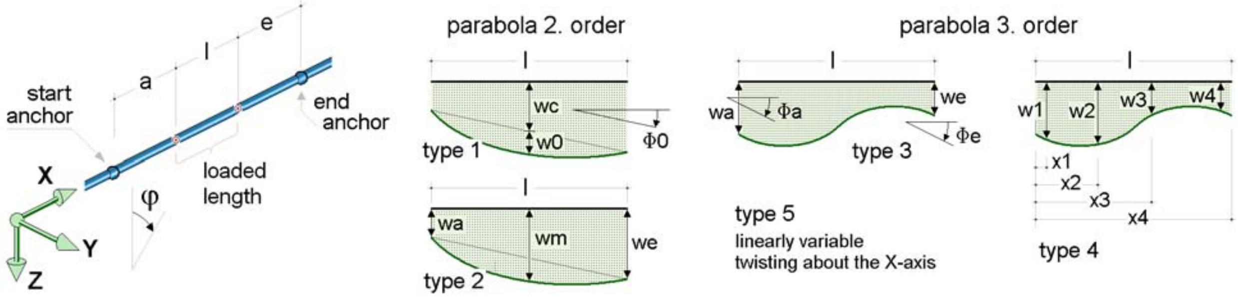
DESCRIPTION OF THE LOAD PICTURES

List of point loads



load case	anchor	a	ΔY	ΔZ	bank	load type, ordinates						φ
-	-	m	cm	cm	-							°
1	B	0.000	0.000	0.000	L	F_Z	=	40.000 kN	M_Y	=	0.000 kNm	0.00
1	B	0.000	0.000	0.000	L	F_X	=	0.000 kN	M_X	=	20.000 kNm	0.00

Explanation of the types of description for imperfections



Imperfections: type of description 2

imperf. case	start anchor	line sections a	l	e	end anchor	direc-tion	φ	wa	wm	we
-	-	m	m	m	-	-	°	mm	mm	mm
1	A	0.000	5.000	0.000	B	Y	0.00	0.000	1/-500	0.000
1	A	0.000	5.000	0.000	B	Y	0.00	0.000	1/400	1/200

Meanings in the case of application of rules of superposition acc. to Eurocode:

Ψ_{dom}	combination coefficient of a	leading	traffic load action	(dominant action)
Ψ_{sub}	combination coefficient of a	non-leading	traffic load action	(accompanying action)
γ_{sup}	Partial safety factor for	unfavourable	load positions	
γ_{inf}	Partial safety factor for	favourable	load positions	

rules of superposition bridge construction and DIN 1055-100 behave like Eurocode.
In non-linear analysis, rules of extremization will not be considered

If verifications according to Eurocode are listed below, the following applies:
The national annex "Germany" is taken into account.

verification 1: EC3 design resistance (th. II. o.)

EC 3 design resistance (th. II. o.): design resistance acc. to DIN EN 1993

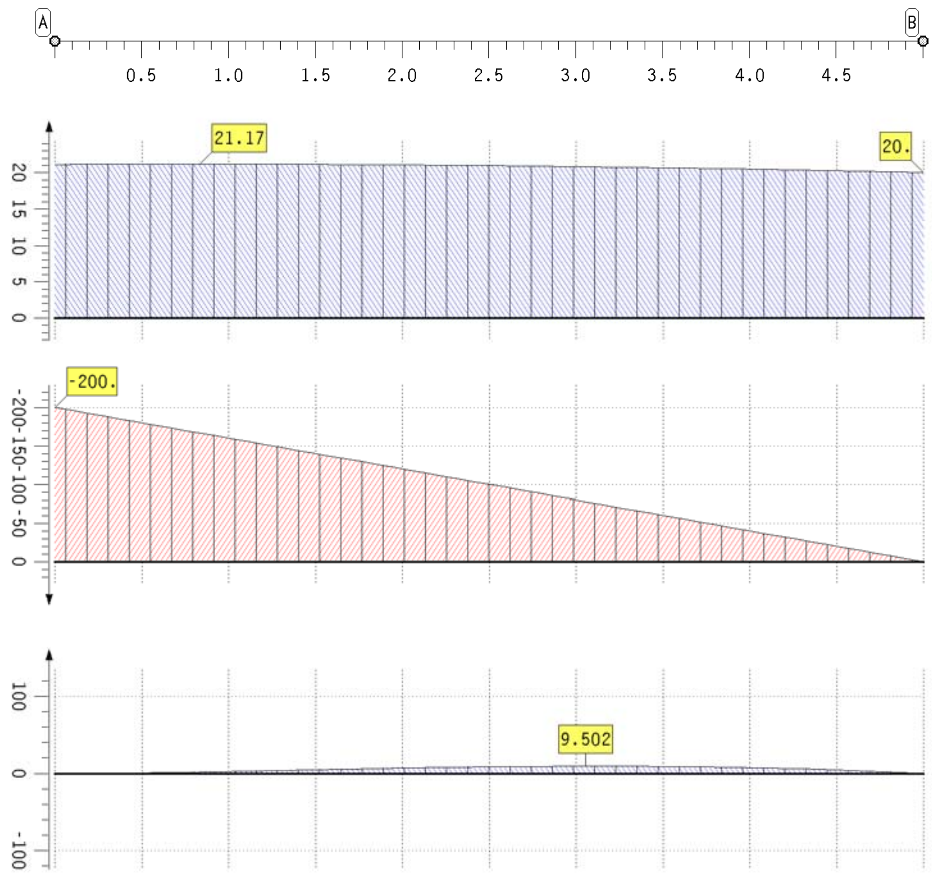
load spectra for verification 1

Factorization of load cases. Negative numbers of load cases refer to imperfections

LS	1	-1
1	1.00	1.00

SUMMARY VERIFICATION 1: EC3 DESIGN RESISTANCE (TH. II. O.)

extremal internal forces and moments in system of principal axis

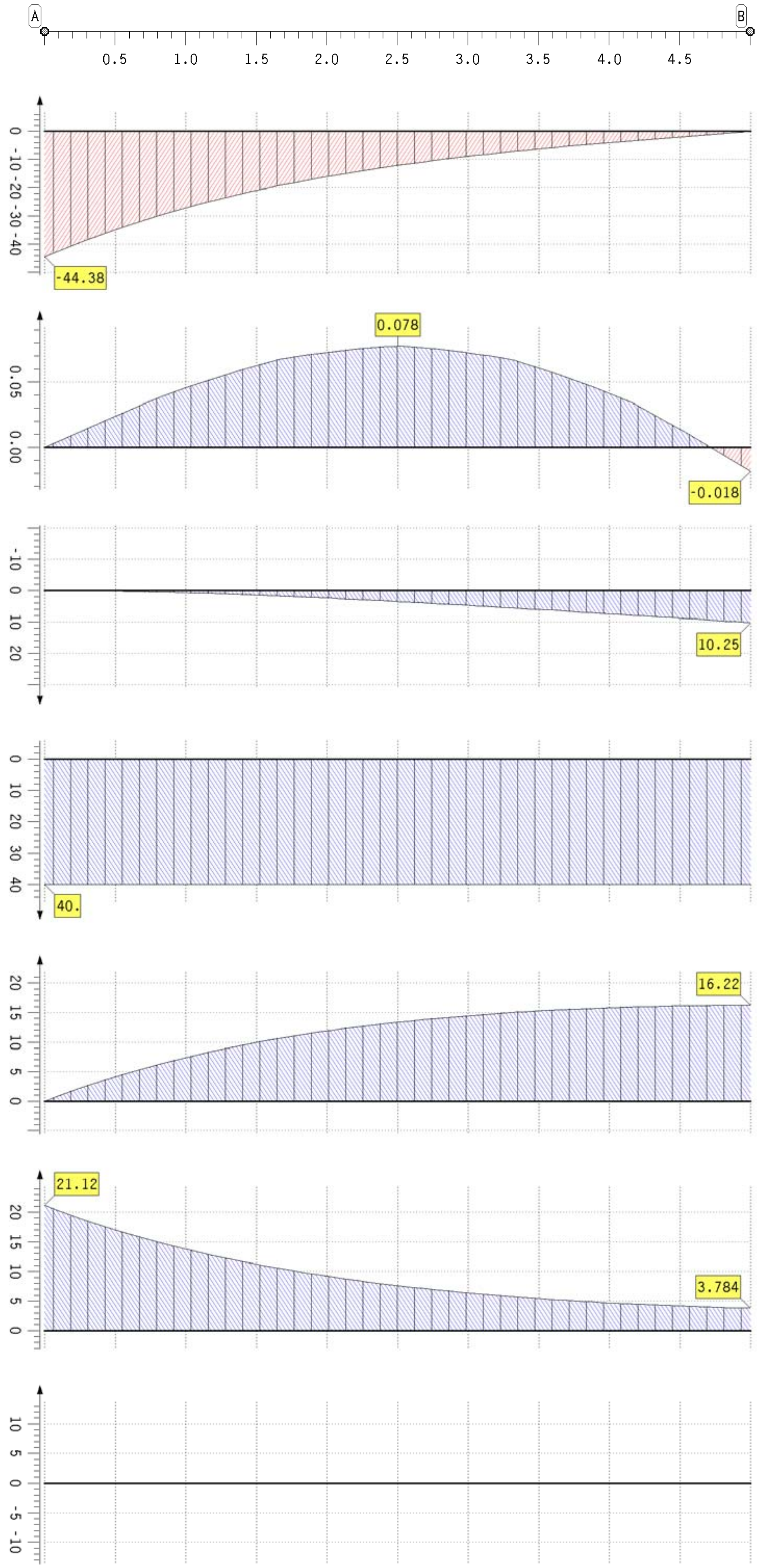


shear centre
torsional moment
T in kNm
min: 20.00
max: 21.17

centroid
flexural moment
M_η in kNm
min: -199.99
max: -0.03

centroid
flexural moment
M_ζ in kNm
min: 0.00
max: 9.50

extremal internal forces and moments in system of principal axis



shear centre
warping bimoment
B in kNm^2
min: -44.38
max: -0.00

centroid
normal force
N in kN
min: -0.02
max: 0.08

shear centre
shear force
V_η in kN
min: 0.00
max: 10.25

shear centre
shear force
V_ζ in kN
min: 40.00
max: 40.00

St. Venant
torsional moment
T_t in kNm
min: 0.00
max: 16.22

torsional moment
from warping
T_w in kNm
min: 3.78
max: 21.12

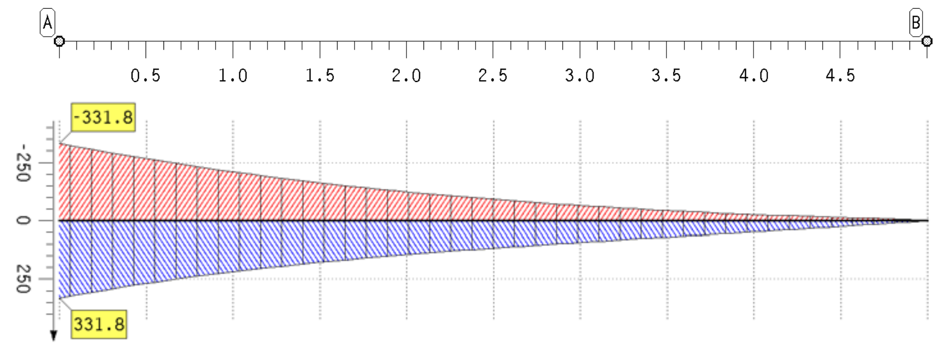
Wagner effect
torsional moment
T_σ in kNm
min: -0.00
max: 0.00

extremal internal forces and moments in system of principal axis

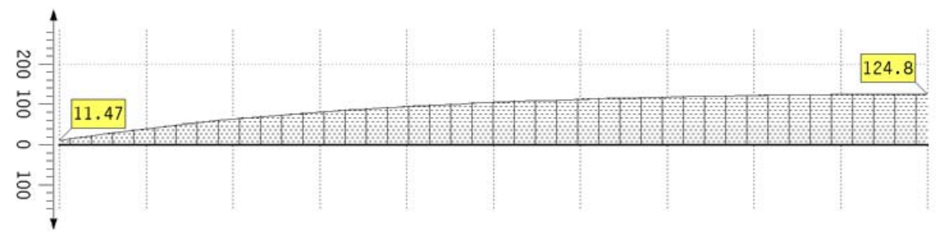
Shear forces V_η, V_ζ, torsional moments T, T_t, T_w, T_σ and warping bimoment B act in the shear centre.
Normal force N and flexural moments M_η, M_ζ refer to the centroid.

point	x	type	N	V_η	V_ζ	T	M_η	M_ζ	T_t	T_w	T_σ	K_σ	B
-	m		kN	kN	kN	kNm	kNm	kNm	kNm	kNm	kNm	kNm2	kNm2
A	0.000	min	0.0	0.00	40.00	21.12	-200.0	0.0	0.00	21.12	0.00	0.00	-44.377
		max	0.0	0.00	40.00	21.12	-200.0	0.0	0.00	21.12	0.00	0.00	-44.377
	0.741	min	0.0	0.40	40.00	21.17	-170.4	1.7	5.85	15.32	0.00	0.00	-30.799
		max	0.0	0.40	40.00	21.17	-170.4	1.7	5.85	15.32	0.00	0.00	-30.799
	1.667	min	0.1	1.77	40.00	21.11	-133.3	5.9	10.66	10.45	0.00	0.00	-19.115
		max	0.1	1.77	40.00	21.11	-133.3	5.9	10.66	10.45	0.00	0.00	-19.115
	2.500	min	0.1	3.54	40.00	20.95	-100.0	8.8	13.38	7.58	-0.00	-0.00	-12.045
		max	0.1	3.54	40.00	20.95	-100.0	8.8	13.38	7.58	-0.00	-0.00	-12.045
	3.056	min	0.1	4.91	40.00	20.80	-77.8	9.5	14.59	6.22	-0.00	-0.00	-8.567
		max	0.1	4.91	40.00	20.80	-77.8	9.5	14.59	6.22	-0.00	-0.00	-8.567
	3.241	min	0.1	5.38	40.00	20.74	-70.4	9.4	14.90	5.84	-0.00	-0.00	-7.528
		max	0.1	5.38	40.00	20.74	-70.4	9.4	14.90	5.84	-0.00	-0.00	-7.528
	4.167	min	0.0	7.90	40.00	20.39	-33.4	6.6	15.93	4.46	0.00	0.00	-3.231
		max	0.0	7.90	40.00	20.39	-33.4	6.6	15.93	4.46	0.00	0.00	-3.231
B	5.000	min	-0.0	10.25	40.00	20.00	-0.0	0.0	16.22	3.78	0.00	0.00	-0.000
		max	-0.0	10.25	40.00	20.00	-0.0	0.0	16.22	3.78	0.00	0.00	-0.000
minimum			**-0.0**	**0.00**	**40.00**	**20.00**	**-200.0**	**0.0**	**0.00**	**3.78**	**-0.00**	**-0.00**	**-44.377**
maximum			**0.1**	**10.25**	**40.00**	**21.17**	**-0.0**	**9.5**	**16.22**	**21.12**	**0.00**	**0.00**	**-0.000**

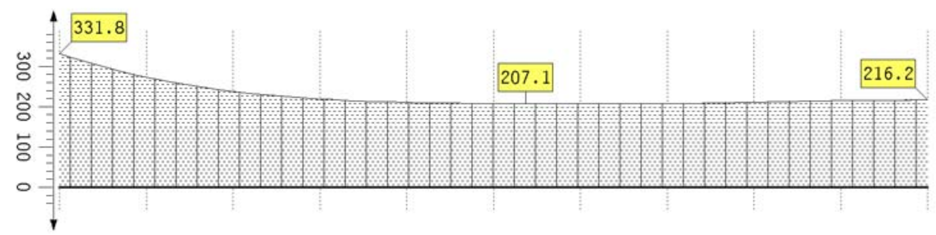
Results of steel design



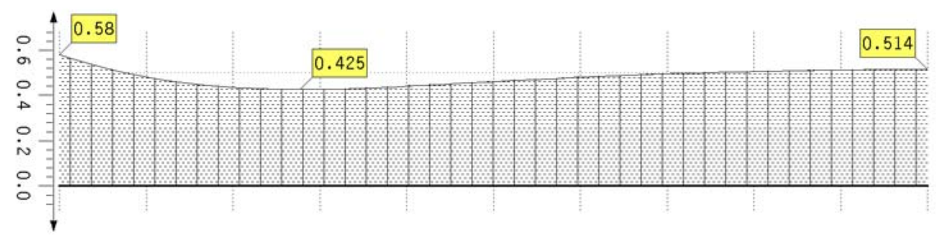
elastic
edge stresses
σ_x in MN/m²
min: -331.78
max: 331.78



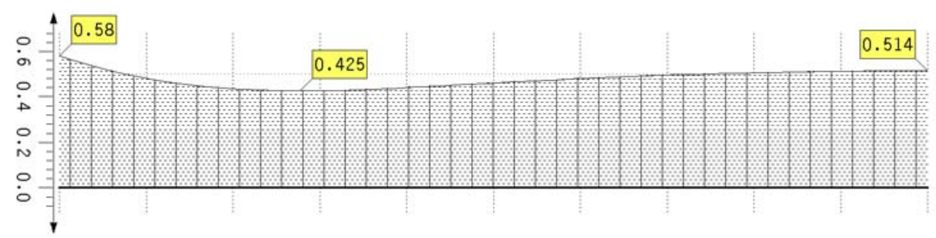
elastic
shear stress
τ in MN/m²
max: 124.83



elastic
equivalent tensile stress
σ_v in MN/m²
max: 331.78



plastic
utilization $U_{\sigma,pl}$
of cross-section
max: 0.58



utilization
max: 0.58

Results of steel design

stresses are calculated elastically.

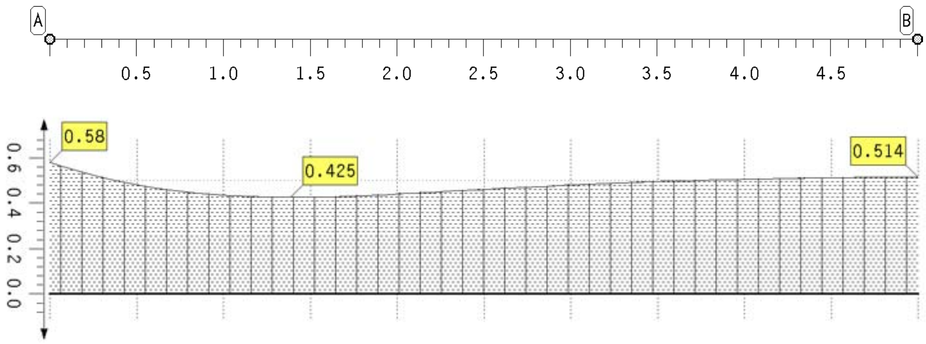
point	x	min σ_x	max σ_x	τ	σ_v	σ_{el}	$U_{\sigma,el}$	$U_{\sigma,pl}$	0-0	--0	U
-	m	MN/m²	MN/m²	MN/m²	MN/m²	MN/m²	-	-	-	-	-
A	0.000	-331.78	331.78	11.47	331.78	----	----	0.580	----	----	0.580
	0.648	-247.49	251.38	47.89	260.21	----	----	0.460	----	----	0.460
	1.389	-171.72	185.02	77.33	221.31	----	----	0.425	----	----	0.425
	2.593	-84.99	111.07	106.41	207.15	----	----	0.465	----	----	0.465
B	5.000	-0.02	0.02	124.83	216.21	----	----	0.514	----	----	0.514
minimum		**-331.78**	**0.02**	**11.47**	**207.15**	**0.00**	**0.000**	**0.425**	**0.000**	**0.000**	**0.425**
maximum		**-0.02**	**331.78**	**124.83**	**331.78**	**0.00**	**0.000**	**0.580**	**0.000**	**0.000**	**0.580**

Reactions in support points bzgl. der beam axis (γ_F-fach)

point	X	type	AP_X	AP_Y	AP_Z	AM_X	AM_Y	AM_Z	AB_X
-	m		kN	kN	kN	kNm	kNm	kNm	kNm²
A	0.000	min	0.00	-0.00	-40.00	-21.12	199.99	-0.00	44.38
		max	0.00	-0.00	-40.00	-21.12	199.99	-0.00	44.38
B	5.000	min	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00
		max	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00

SUMMARY

Utilizations



utilization
max: 0.58