

SYSTEM DESCRIPTION

General information

The extension of the longitudinal axis of the beam is oriented to the global X-axis.
Dead loads act in direction of vector G mit $G_X = -1.00000$, $G_Y = 0.00000$ und $G_Z = 0.00000$.
Calculation is carried out taking into account warping torsion but not 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 verification 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

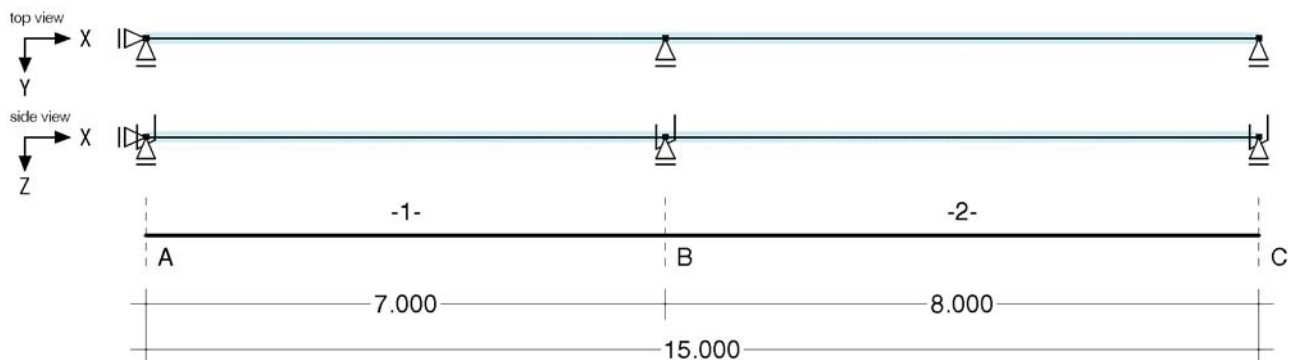
DIN EN 1993-1-1 verification parameters

NA Germany

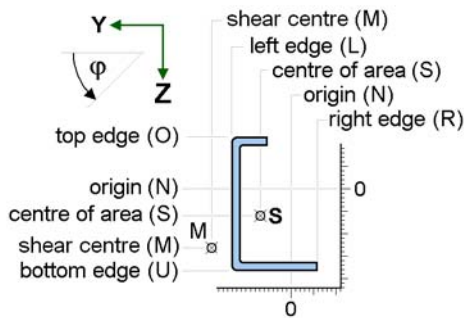
chapter	value	definition
6.1(1)	permanent/transient sit.	partial factors for structural steel
	$\gamma_{M0} = 1.00$	collapse of cross-sections
	$\gamma_{M1} = 1.10$	instability
	accidental situation	partial factors for structural steel
	$\gamma_{M0} = 1.00$	collapse of cross-sections
	$\gamma_{M1} =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

System sketch

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



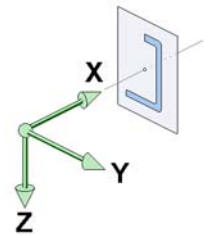
List of sections



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 m m		l m	Orientation at the beginning		Orientation at the end		φ °
				horizontal	vertical	horizontal	vertical	
1	0.00	7.00	7.00	(S) + 0.00 cm	(S) + 0.00 cm	(S) + 0.00 cm	(S) + 0.00 cm	0.00
2	7.00	15.00	8.00	(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	S235	1.00	HE160A
2	S235	1.00	HE160A

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 cm	eZ cm	α °	YSM cm	ZSM cm	A cm ²	I_{η} cm ⁴	I_{ζ} cm ⁴	I_T cm ⁴	I_{ω} cm ⁶	iM cm	r_{η} cm	r_{ζ} cm	r_{ω} -
1	0.00	0.00	0.00	0.00	0.00	38.80	1670	616	12.30	31410	7.68	-0.00	-0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	38.80	1670	616	12.30	31410	7.68	-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. CM ω is the warping restraint.

support at x -	m	CPX kN/m	CPY kN/m	CPZ kN/m	CMX kNm/-	CMY kNm/-	CMZ kNm/-	CM ω kNm/m ³	ΔY cm	ΔZ cm	φ °
A	0.00	fix	fix	fix	fix	----	----	----	0.00	0.00	0.00
B	7.00	----	fix	fix	fix	----	----	----	0.00	0.00	0.00
C	15.00	----	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

1: normal

2: loaden z

2: quer z

3: loaden y

3: quer y

imperfection cases

1: imperfection (1)

permanent loads

additive

other transient action effects

additive

other transient action effects

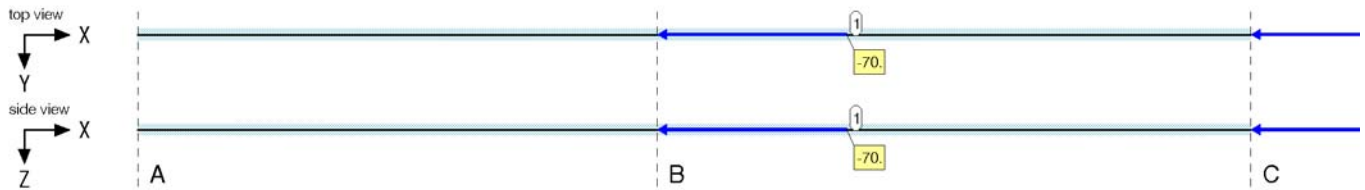
additive

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.

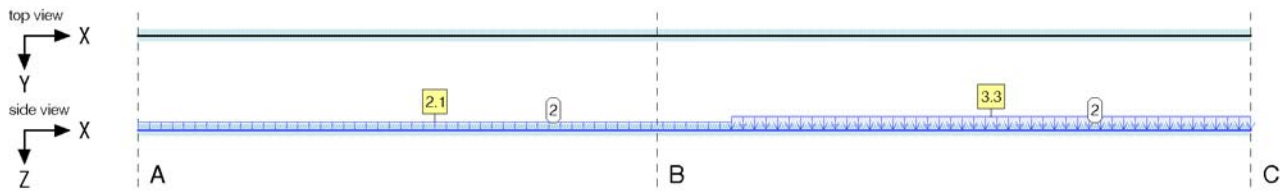
action effect 1: permanent loads

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



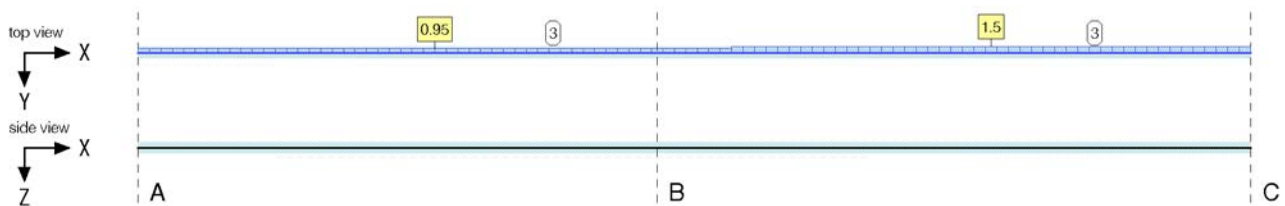
action effect 2: loaden z

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



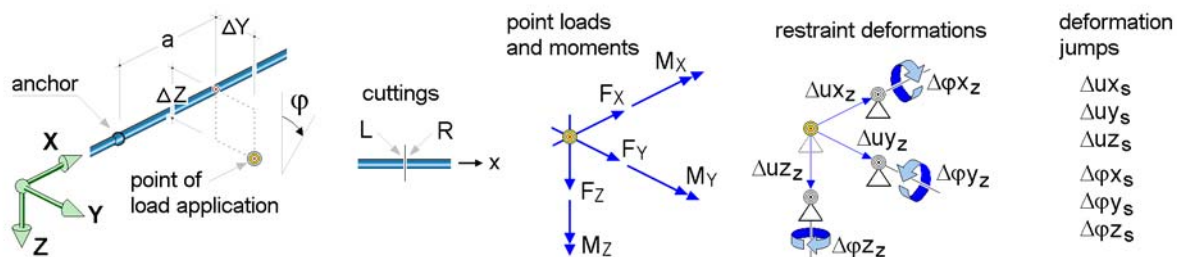
action effect 3: loaden y

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



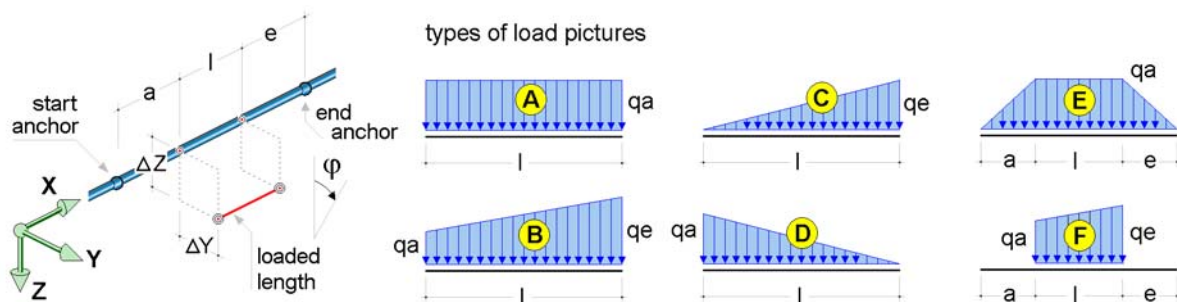
DESCRIPTION OF THE LOAD PICTURES

List of point loads



load case	anchor	a m	ΔY cm	ΔZ cm	bank	load type, ordinates				φ °
1	B	0.000	0.000	0.000	L	F _x =	-70.000 kN	M _x =	0.000 kNm	0.00
1	C	0.000	0.000	0.000	L	F _x =	-70.000 kN	M _x =	0.000 kNm	0.00

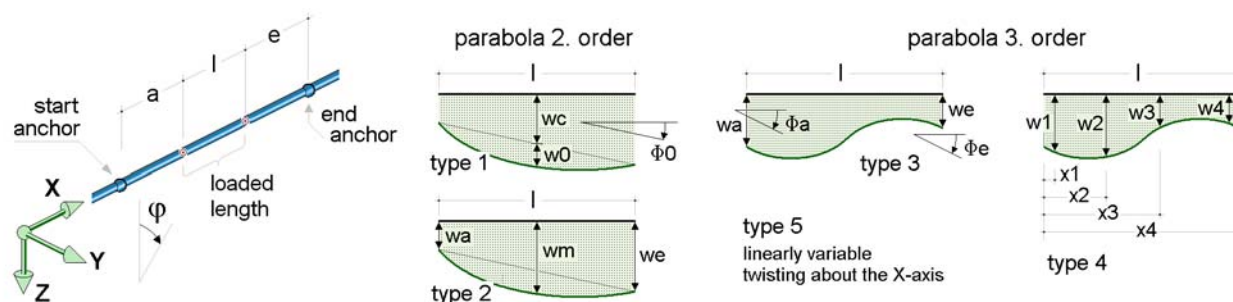
List of line loads



In the column "type" the load image type shown in the sketch and (separated by "/") the load direction of the line load is indicated. "X", "Y" and "Z" mark normal line loads in kNm. "D" describes a torsional moment about the longitudinal axis of the section of the line in kNm/m.

load case	start anchor	a	section l	e	end anchor	excentricities		type	qa	qe	φ
-	-	m	m	m	-	ΔY	ΔZ	-	kN, m	kN, m	°
2	A	0.000	8.000	-1.000	B	0.000	0.000	F/Z	2.100	2.100	0.00
2	B	1.000	7.000	0.000	C	0.000	0.000	F/Z	3.300	3.300	0.00
3	B	1.000	7.000	0.000	C	0.000	0.000	F/Y	1.500	1.500	0.00
3	A	0.000	8.000	-1.000	B	0.000	0.000	F/Y	0.950	0.950	0.00

Explanation of the types of description for imperfections



Imperfections: type of description 2

imperf. case	start anchor	a	line sections l	e	end anchor	direction	φ	wa	wm	we
-	-	m	m	m	-	-	°	mm	mm	mm
1	A	0.000	7.000	0.000	B	Y	0.00	0.000	1/-200	0.000
1	B	0.000	8.000	0.000	C	Y	0.00	0.000	1/200	0.000

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	2	3	-1
1	1.00	1.00	1.00	1.00
2	1.00	1.00	1.00	-1.00
3	1.00	1.00	1.00	-

verification 2: EC 3 design resistance (Th. I. Ord.)

EC 3 design resistance (Th. I. Ord.): design resistance acc. to DIN EN 1993

Verification options of verification 2:

☒ Safety as for stability

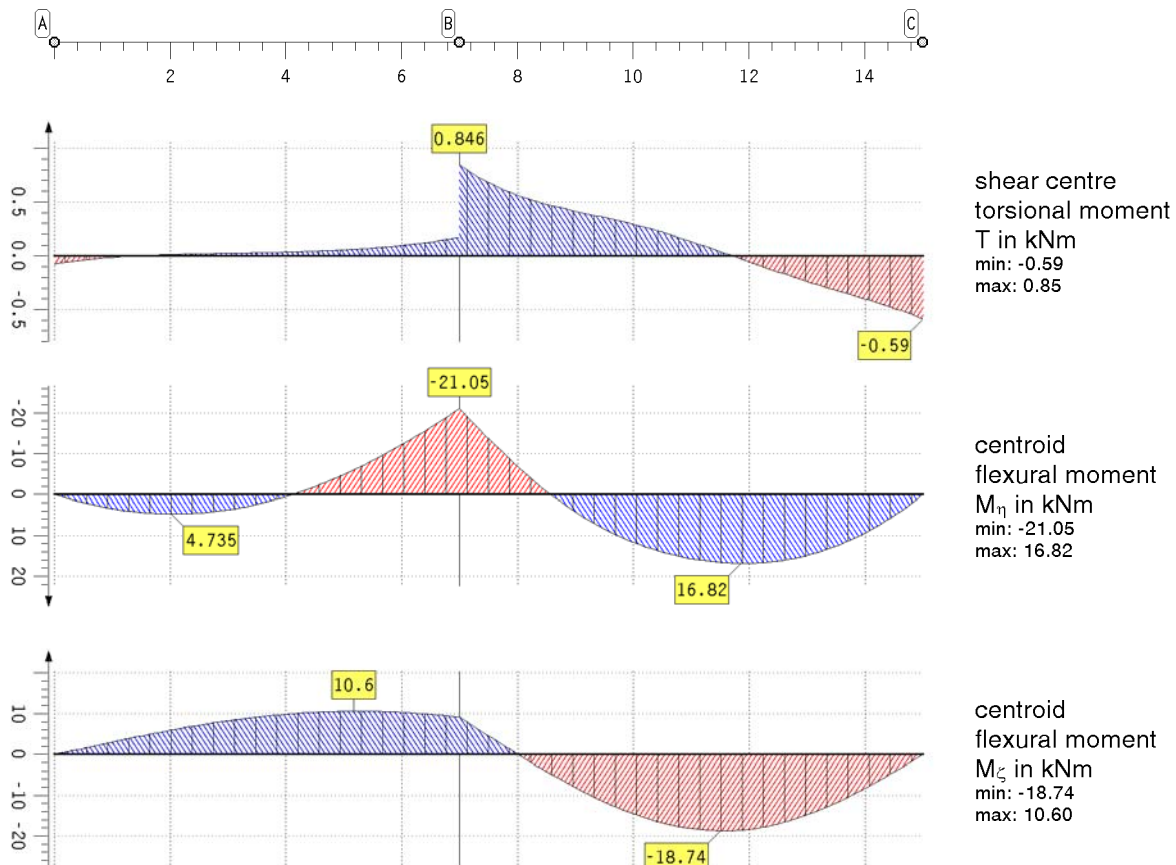
load spectra for verification 2

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

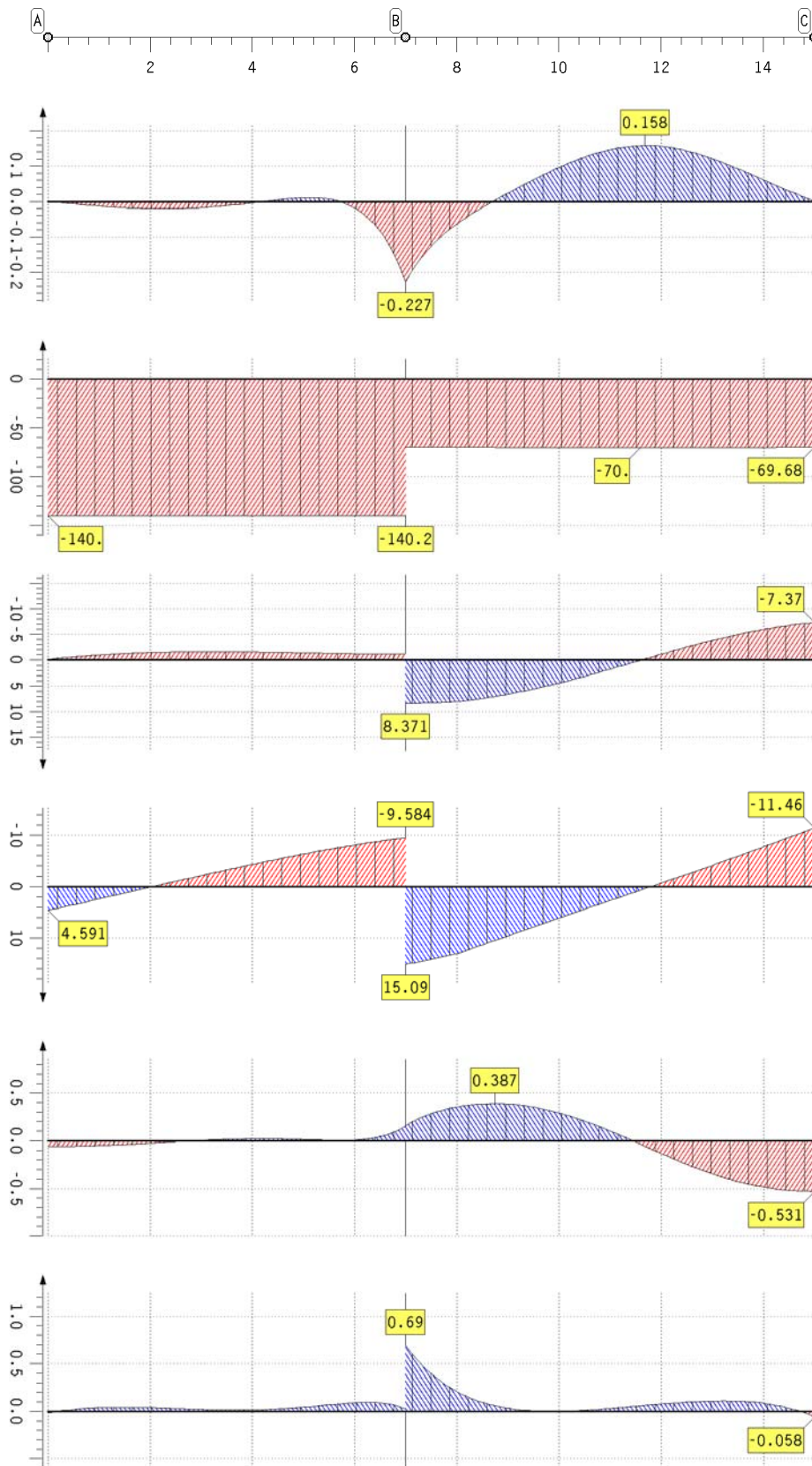
LS	1	2	3
1	1.00	1.00	1.00

VERIFICATION 1: LOAD SPECTRUM 1: CHARAKTERISTISCH +V0

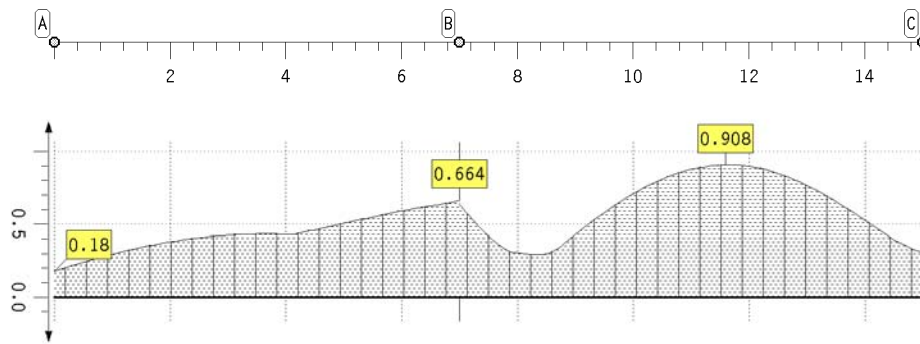
Internal forces and moments in system of principal axis



Internal forces and moments in system of principal axis



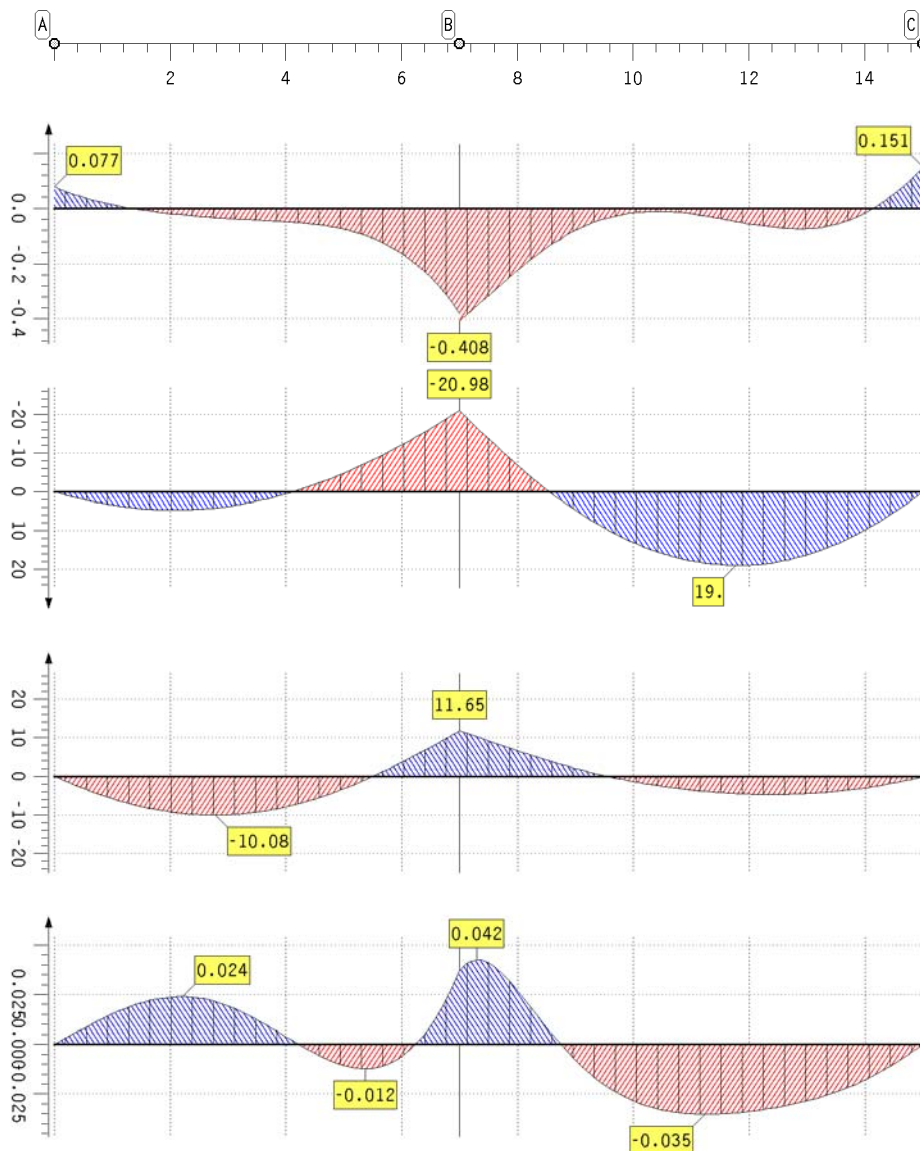
Results of steel design



plastic
utilization $U_{\sigma,pl}$
of cross-section
max: 0.91

VERIFICATION 1: LOAD SPECTRUM 2: CHARAKTERISTISCH -V0

Internal forces and moments in system of principal axis



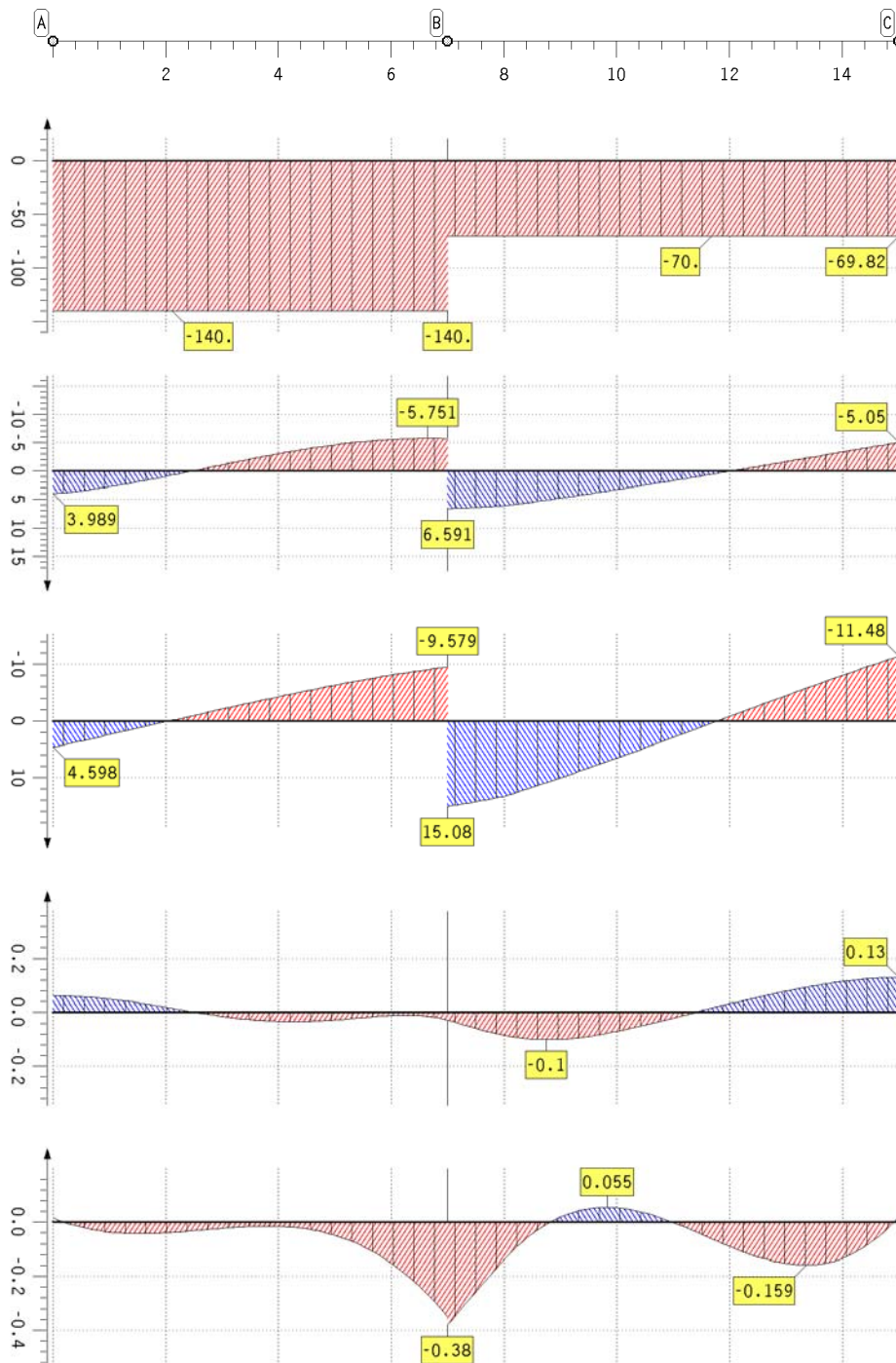
shear centre
torsional moment
 T in kNm
min: -0.41
max: 0.15

centroid
flexural moment
 M_η in kNm
min: -20.98
max: 19.00

centroid
flexural moment
 M_ξ in kNm
min: -10.08
max: 11.65

shear centre
warping bimoment
 B in kNm²
min: -0.04
max: 0.04

Internal forces and moments in system of principal axis



centroid
normal force
N in kN
min: -140.03
max: -69.82

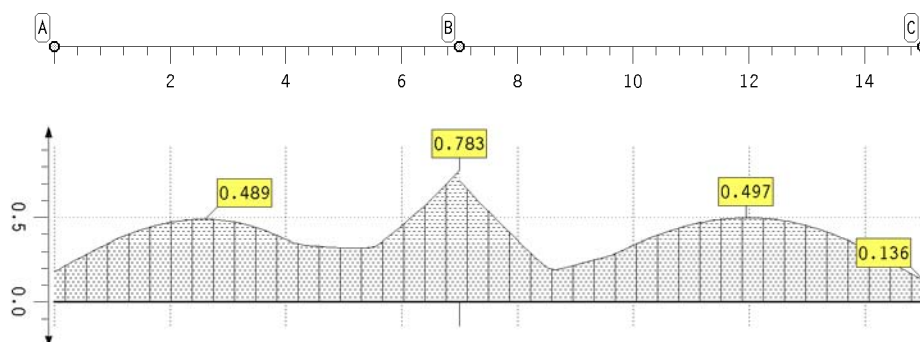
shear centre
shear force
 V_η in kN
min: -5.75
max: 6.59

shear centre
shear force
 V_ξ in kN
min: -11.48
max: 15.08

St. Venant
torsional moment
 T_t in kNm
min: -0.10
max: 0.13

torsional moment
from warping
 T_w in kNm
min: -0.38
max: 0.05

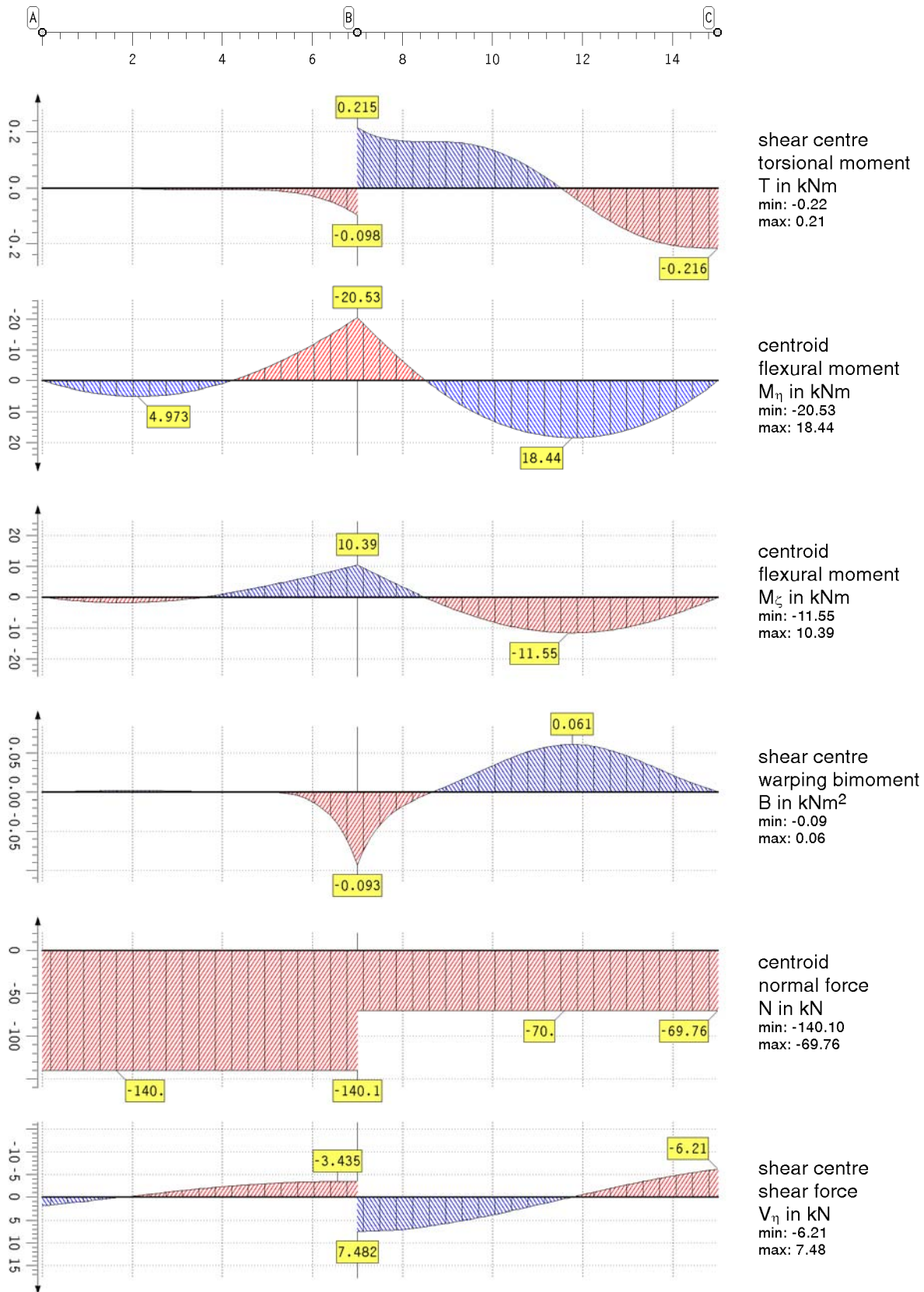
Results of steel design



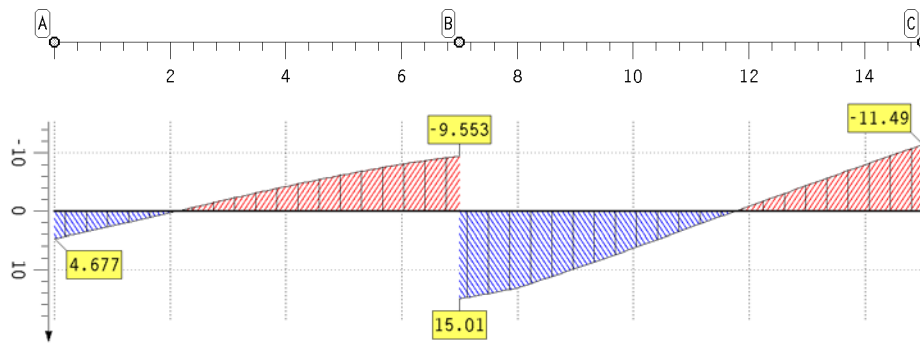
plastic
utilization $U_{\sigma,pl}$
of cross-section
max: 0.78

VERIFICATION 1: LOAD SPECTRUM 3: CHARAKTERISTISCH

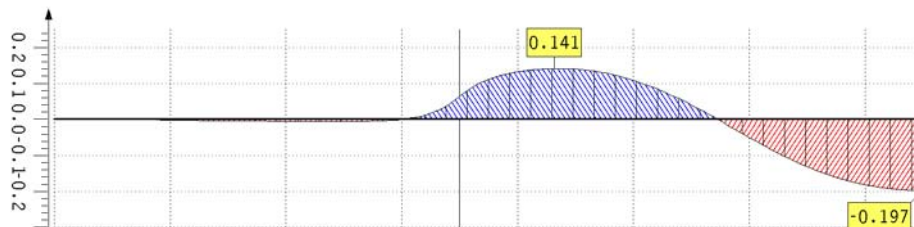
Internal forces and moments in system of principal axis



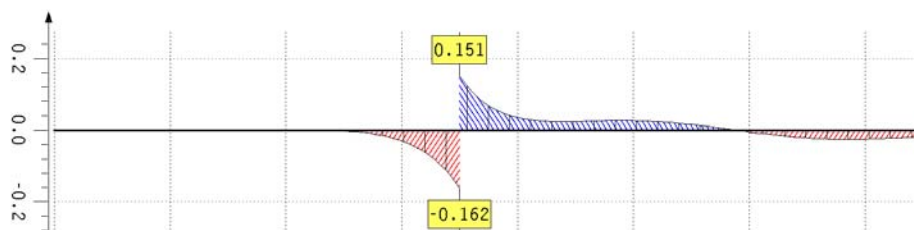
Internal forces and moments in system of principal axis



shear centre
shear force
V_z in kN
min: -11.49
max: 15.01

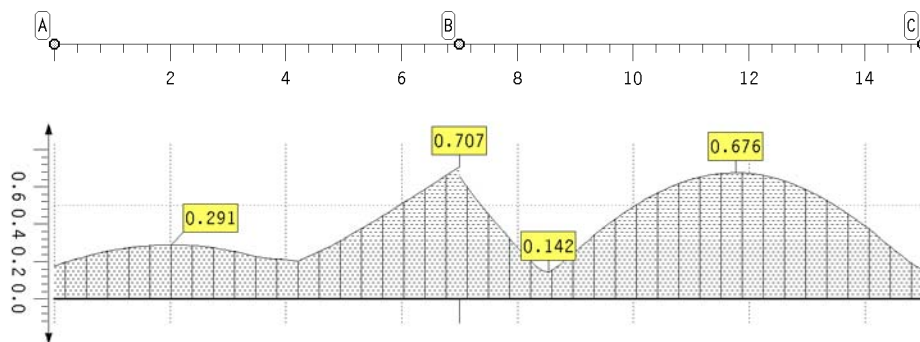


St. Venant
torsional moment
T_t in kNm
min: -0.20
max: 0.14



torsional moment
from warping
T_w in kNm
min: -0.16
max: 0.15

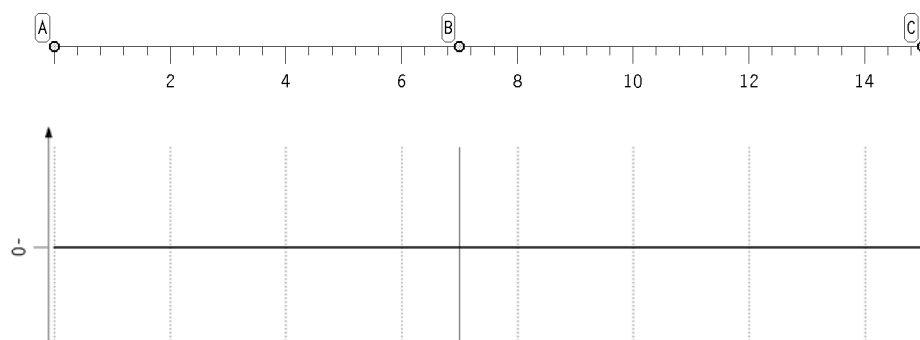
Results of steel design



plastic
utilization U_{σ,pl}
of cross-section
max: 0.71

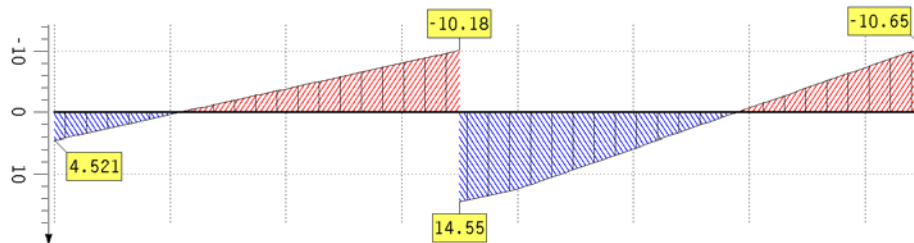
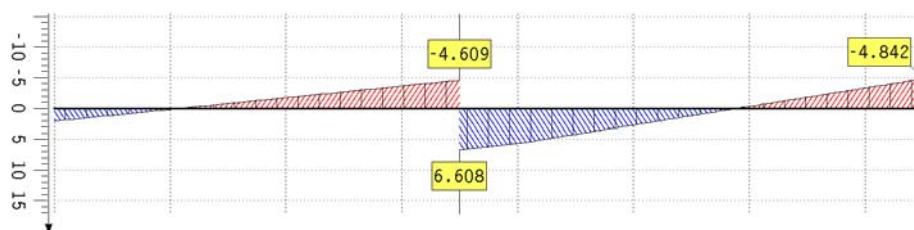
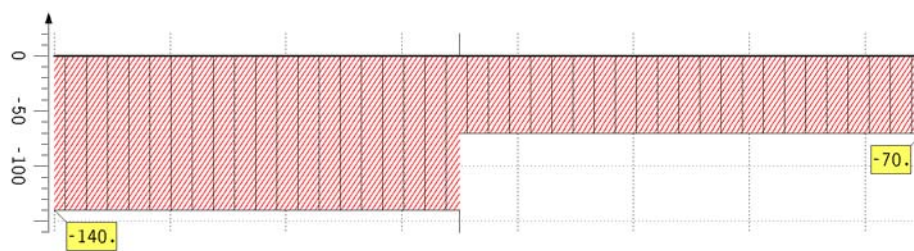
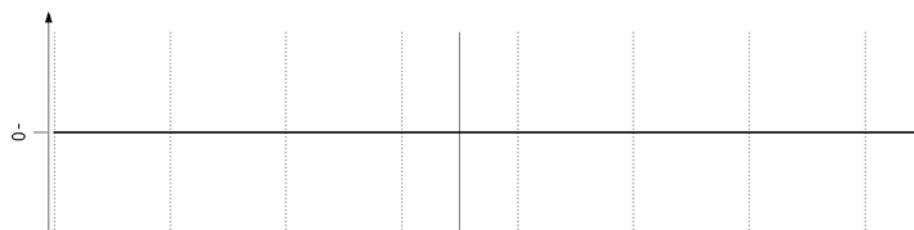
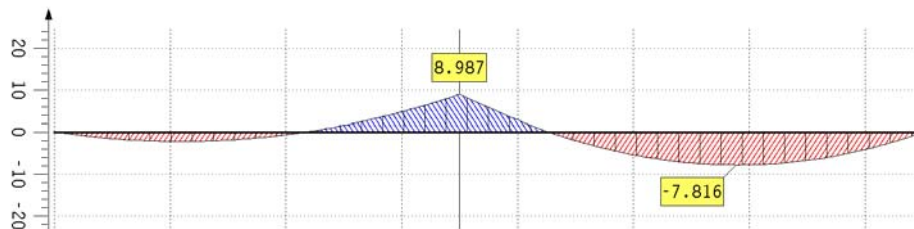
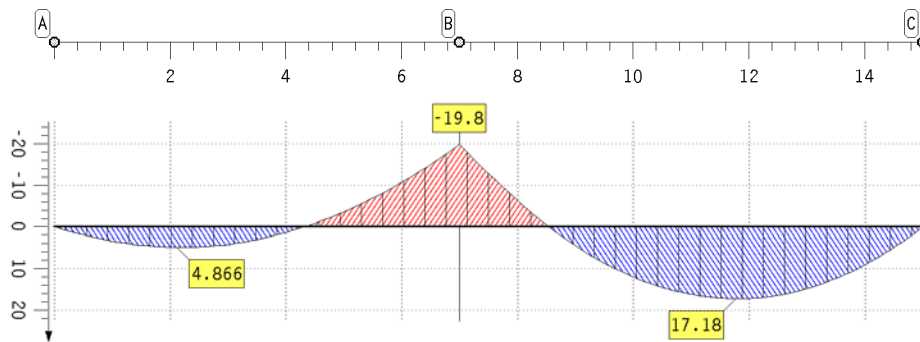
VERIFICATION 2: LOAD SPECTRUM 1: CHARAKTERISTISCH

Internal forces and moments in system of principal axis

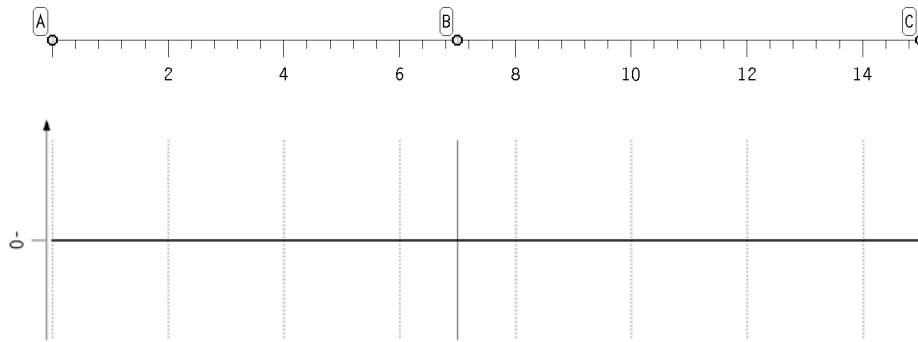


shear centre
torsional moment
T in kNm
min: -0.00
max: 0.00

Internal forces and moments in system of principal axis

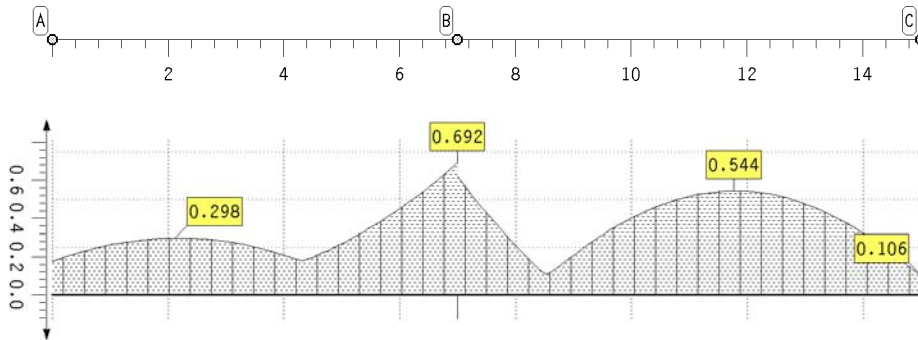


Internal forces and moments in system of principal axis



torsional moment
from warping
 T_w in kNm
min: -0.00
max: 0.00

Results of steel design



plastic
utilization $U_{\sigma,pl}$
of cross-section
max: 0.69