SYSTEM DESCRIPTION

General information

The extension of the longitudinal axis of the beam is oriented to the global X-axis.
Dead loads act in the direction of the Z-axis.
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 kNm²

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

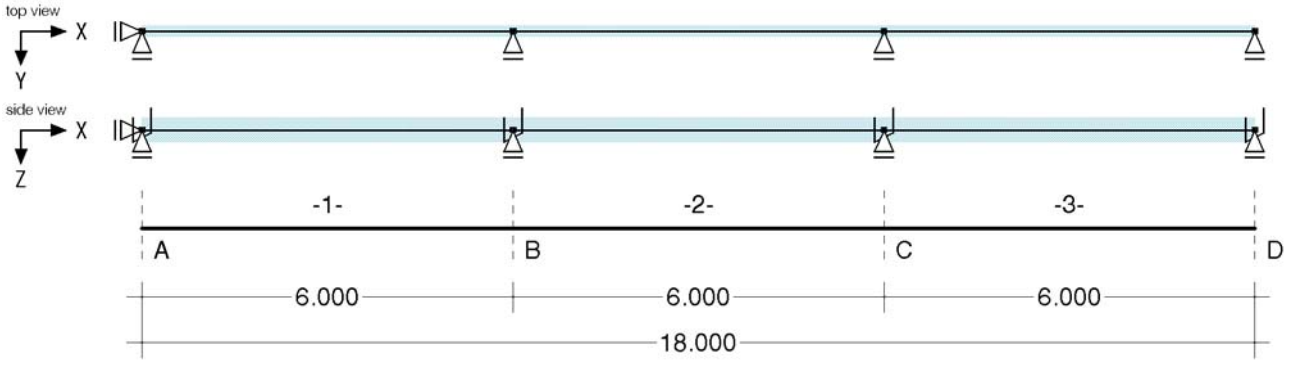
DIN EN 1993-1-1 verification parameters

NA Germany

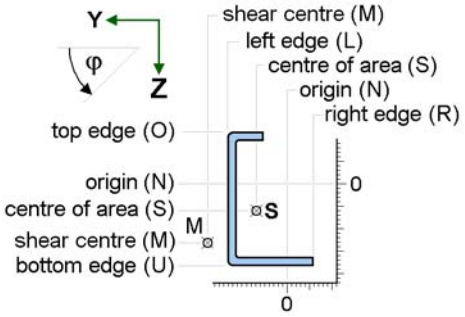
chapter	value	definition
6.1(1)	permanent/transient sit.	partial factors for structural steel
	γ_{M0} = 1.00	collapse of cross-sections
	γ_{M1} = 1.10	instability
	accidental situation	partial factors for structural steel
	γ_{M0} = 1.00	collapse of cross-sections
	γ_{M1} = 1.00	instability

System sketch

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



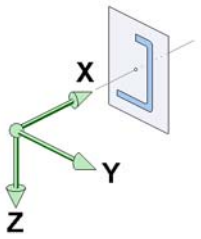
List of sections



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	6.00	6.00	(S) + 0.00 cm	(S) + 0.00 cm	(S) + 0.00 cm	(S) + 0.00 cm	0.00
2	6.00	12.00	6.00	(S) + 0.00 cm	(S) + 0.00 cm	(S) + 0.00 cm	(S) + 0.00 cm	0.00
3	12.00	18.00	6.00	(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	γM,E	st. section name
-	-	-	-
1	S235	1.00	IPE400
2	S235	1.00	IPE400
3	S235	1.00	IPE400

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	84.50	23130	1320	51.40	490000	17.01	-0.00	-0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	84.50	23130	1320	51.40	490000	17.01	-0.00	-0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	84.50	23130	1320	51.40	490000	17.01	-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	----	----	----	0.00	0.00	0.00
B	6.00	----	fix	fix	fix	----	----	----	0.00	0.00	0.00
C	12.00	----	fix	fix	fix	----	----	----	0.00	0.00	0.00
D	18.00	----	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 — **permanent loads**

1: dead load (1) — additive

imperfection cases

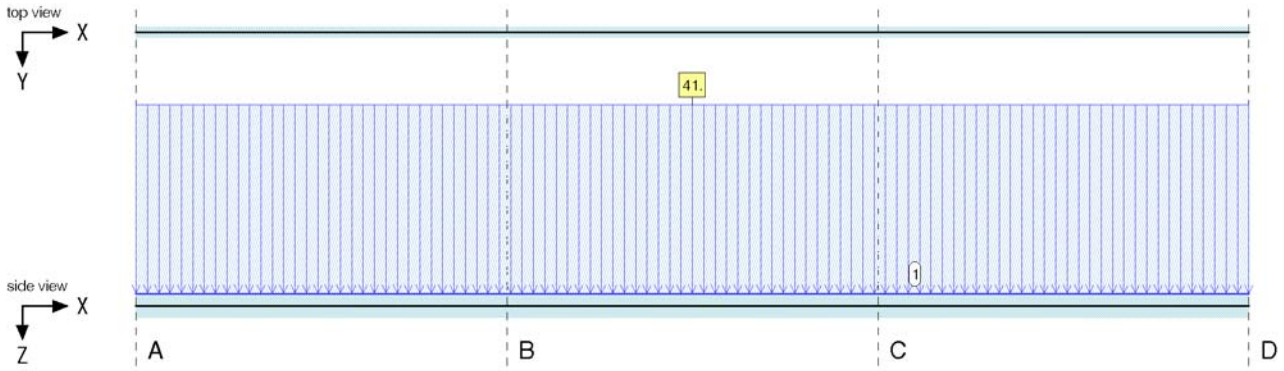
1: imperfection (1)

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 inages.

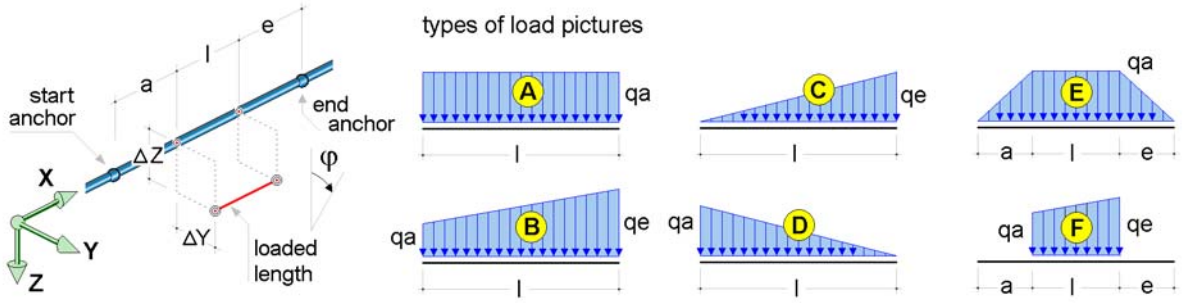
action effect 1: permanent loads

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



DESCRIPTION OF THE LOAD PICTURES

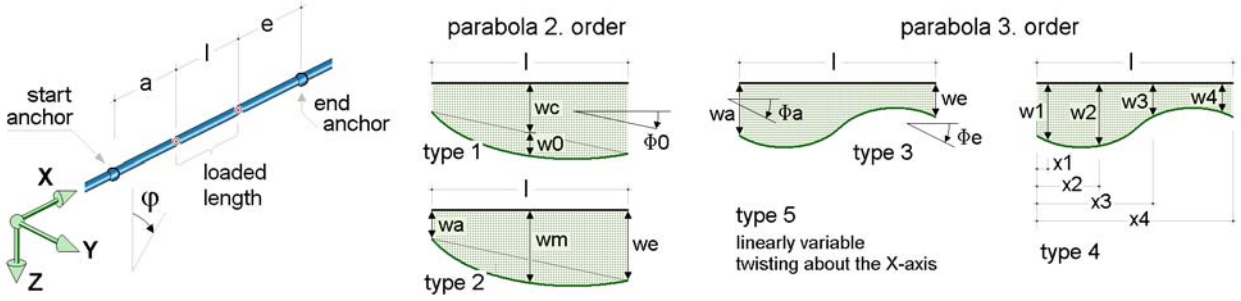
List of line loads



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	exzentricities ΔY	ΔZ	type	qa	qe	φ
-	-	m	m	m	-	cm	cm	-	kN,m	kN,m	°
1	A	0.000	18.000	0.000	D	0.000	-20.000	A/Z	41.000	---	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	direc-tion	φ	wa	wm	we
-	-	m	m	m	-	-	°	mm	mm	mm
1	A	0.000	6.000	0.000	B	Y	0.00	0.000	l/100	0.000
1	B	0.000	6.000	0.000	C	Y	0.00	0.000	l/-100	0.000
1	C	0.000	6.000	0.000	D	Y	0.00	0.000	l/100	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: Ideales Biegedrillknickmoment

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	-
2	1.61	-
3	1.62	-

verification 2: EC 3 design resistance (th. II. o.)

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

load spectra for verification 2

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

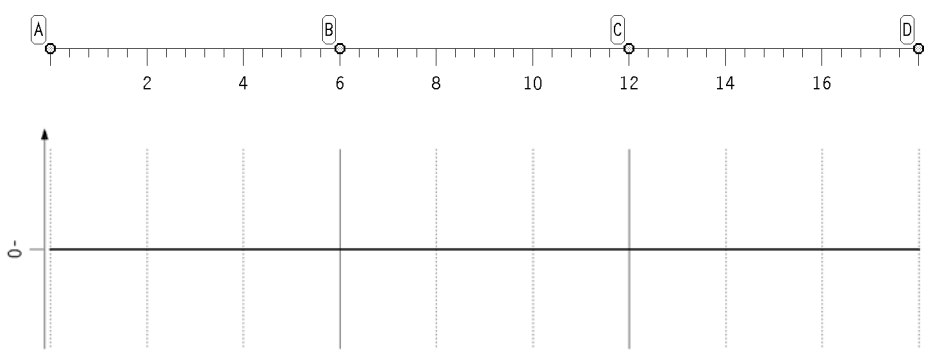
LS	1	-1
1	1.00	1.00

ERROR MESSAGES AND WARNINGS CONCERNING CALCULATION

load spectrum: Nw1:Lk3:1.62*Lc1
System of equations instable at x = 18.00 [ΓX]: diagonal element = -2.92E-001

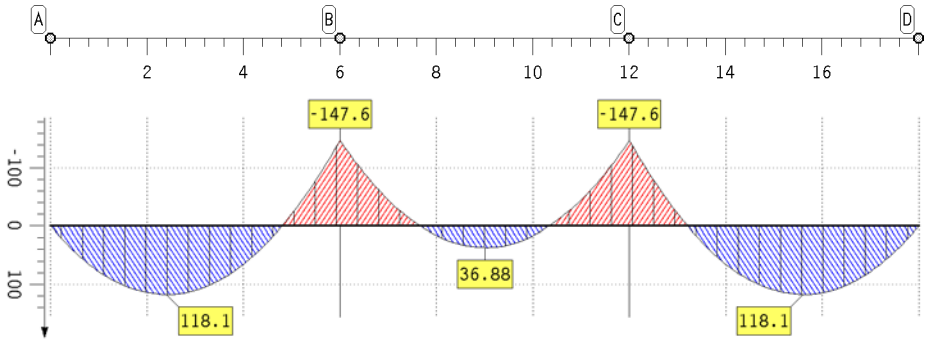
VERIFICATION 1: LOAD SPECTRUM 1: LOAD

Internal forces and moments in system of principal axis

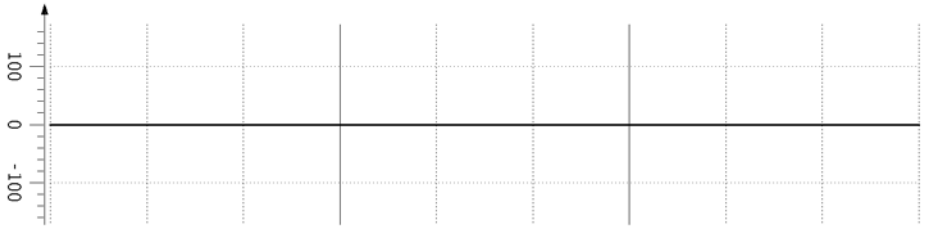


shear centre
torsional moment
T in kNm
min: 0.00
max: 0.00

Internal forces and moments in system of principal axis

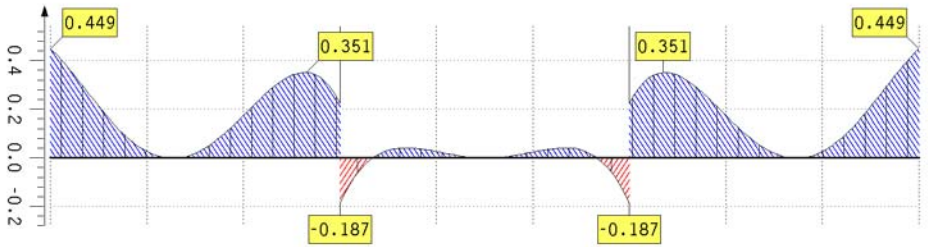


centroid
flexural moment
M_η in kNm
min: -147.62
max: 118.13



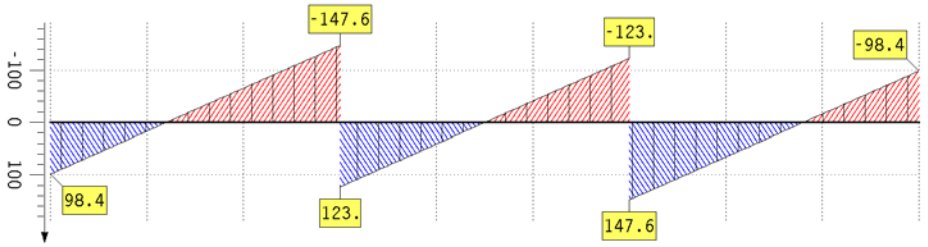
centroid
flexural moment
M_ζ in kNm
min: 0.00
max: 0.00

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



centroid
normal force
N in kN
min: -0.19
max: 0.45

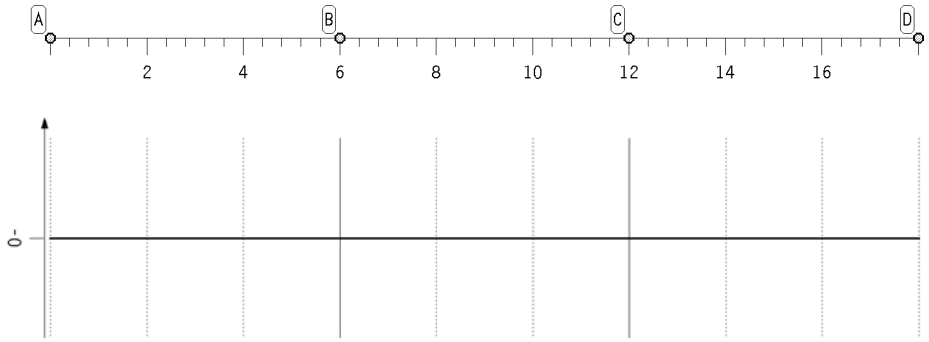
shear centre
shear force
V_η in kN
min: 0.00
max: 0.00



shear centre
shear force
V_ζ in kN
min: -147.60
max: 147.60

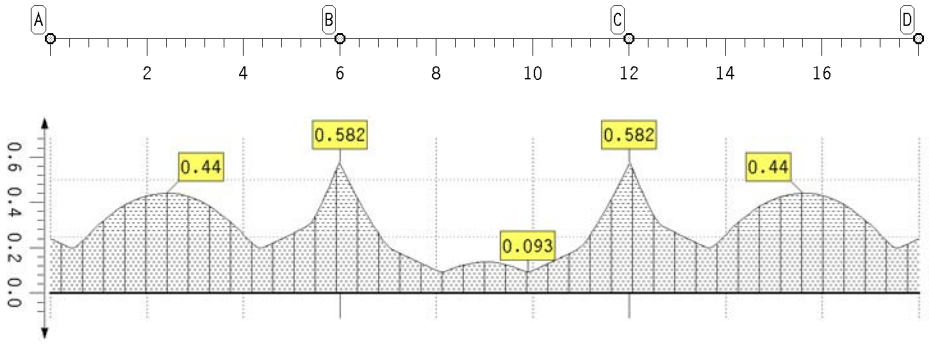
St. Venant
torsional moment
T_t in kNm
min: 0.00
max: 0.00

Internal forces and moments in system of principal axis



torsional moment
from warping
T_W in kNm
min: 0.00
max: 0.00

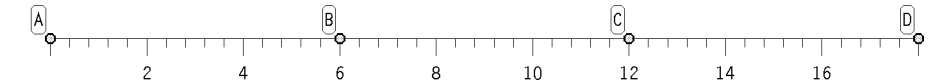
Results of steel design



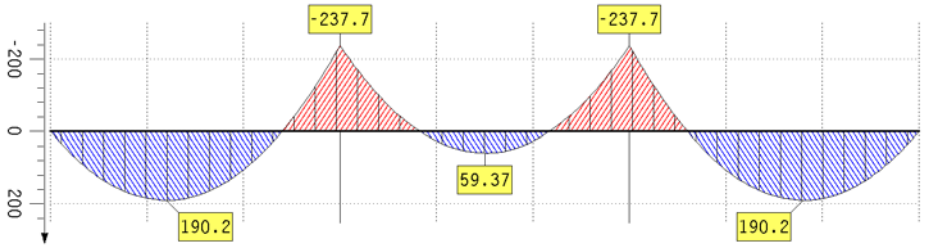
plastic
utilization $U_{\sigma,pl}$
of cross-section
max: 0.58

VERIFICATION 1: LOAD SPECTRUM 2: MCR: LOAD * 1.61

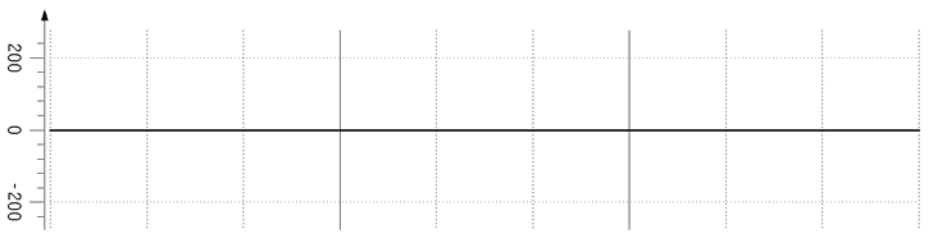
Internal forces and moments in system of principal axis



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

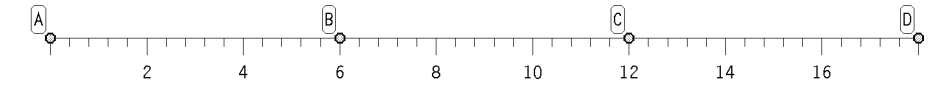


centroid
flexural moment
M_η in kNm
min: -237.69
max: 190.25

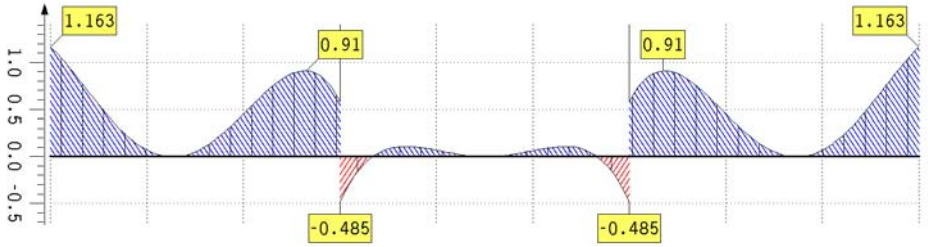


centroid
flexural moment
M_ζ in kNm
min: 0.00
max: 0.00

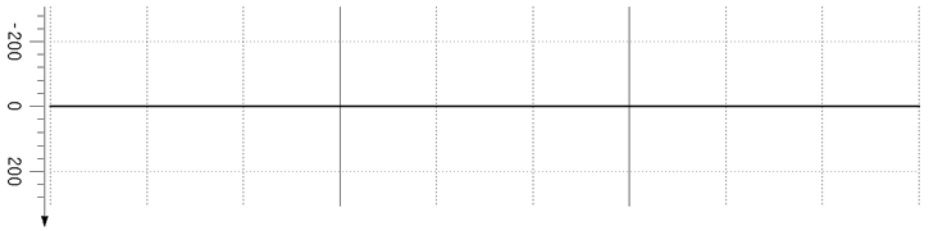
Internal forces and moments in system of principal axis



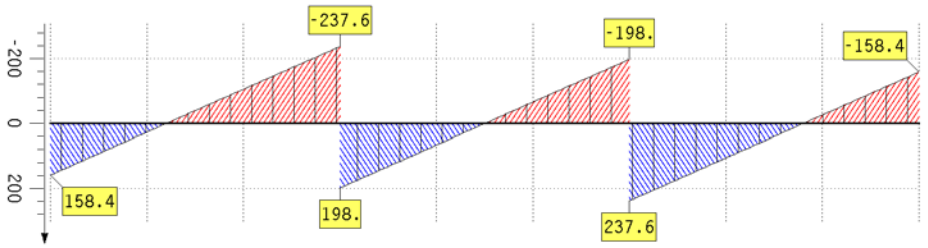
shear centre
warping bimoment
B in kNm²
min: 0.00
max: 0.00



centroid
normal force
N in kN
min: -0.49
max: 1.16



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

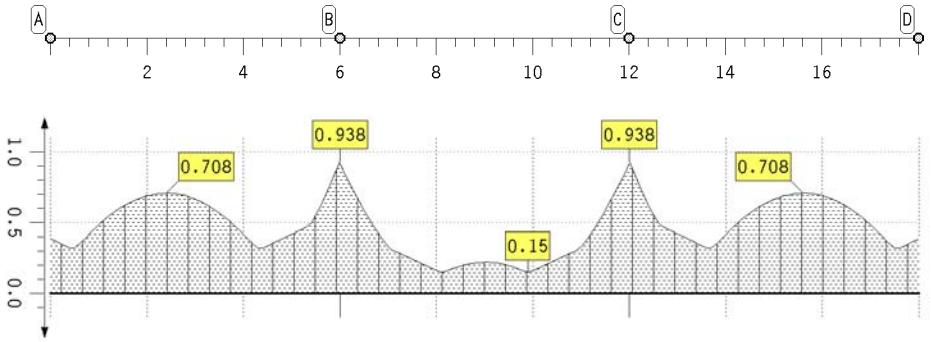


shear centre
shear force
V_ζ in kN
min: -237.65
max: 237.65

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

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

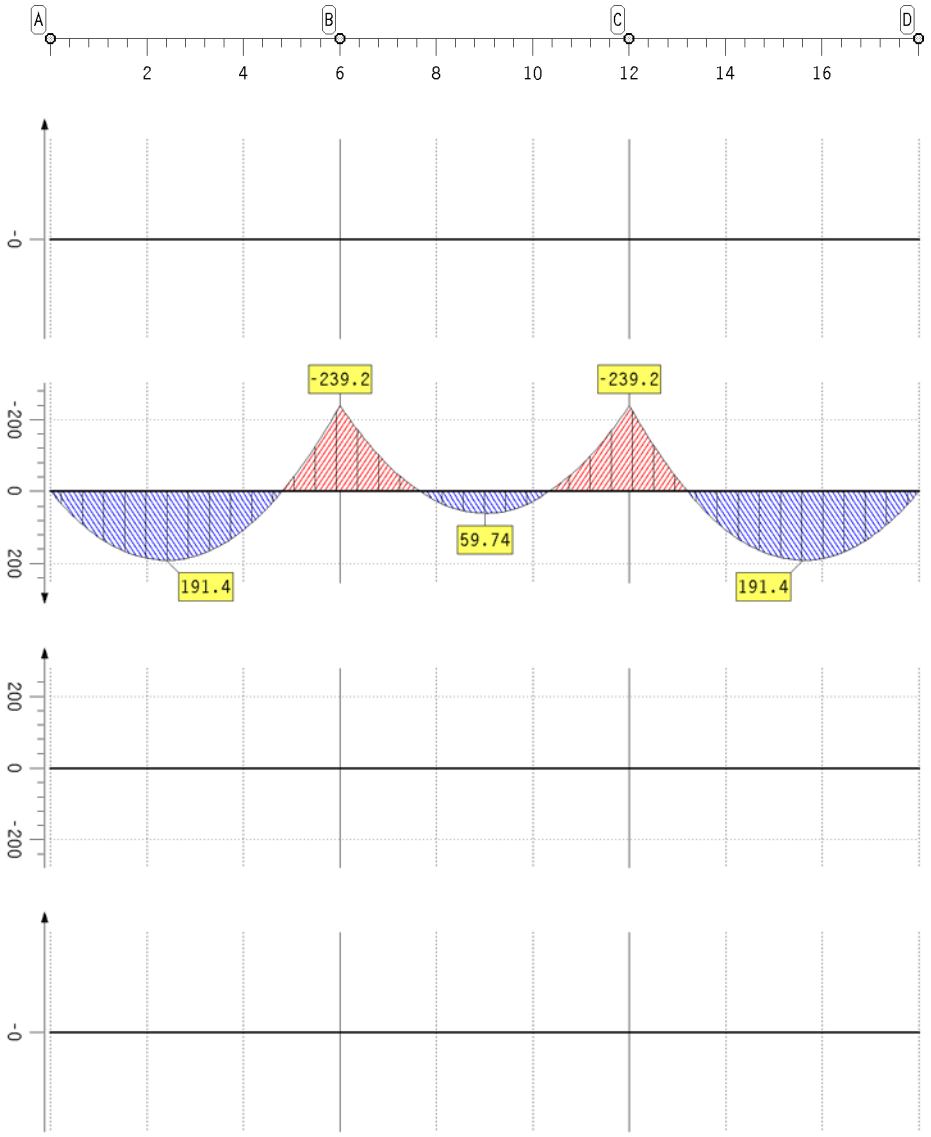
Results of steel design



plastic
utilization $U_{\sigma,pl}$
of cross-section
max: 0.94

VERIFICATION 1: LOAD SPECTRUM 3: INSTABIL: LOAD * 1.62

Internal forces and moments in system of principal axis



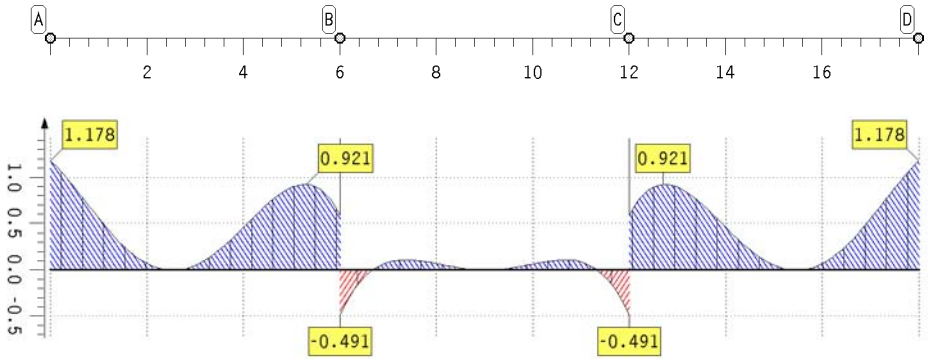
shear centre
torsional moment
T in kNm
min: 0.00
max: 0.00

centroid
flexural moment
M_η in kNm
min: -239.17
max: 191.43

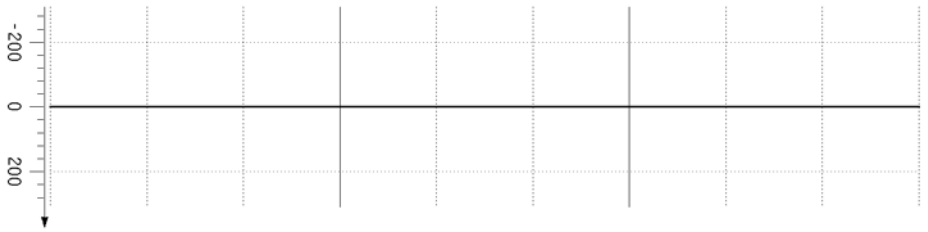
centroid
flexural moment
M_ζ in kNm
min: 0.00
max: 0.00

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

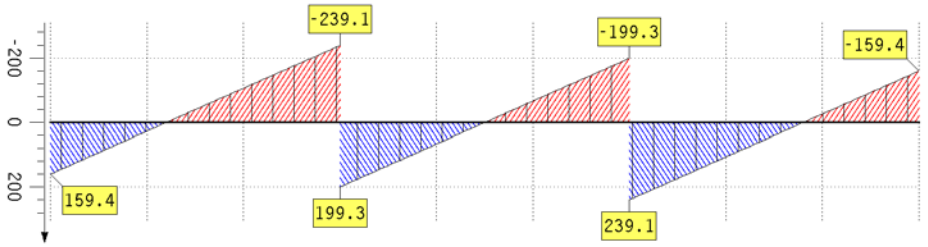
Internal forces and moments in system of principal axis



centroid
normal force
N in kN
min: -0.49
max: 1.18



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

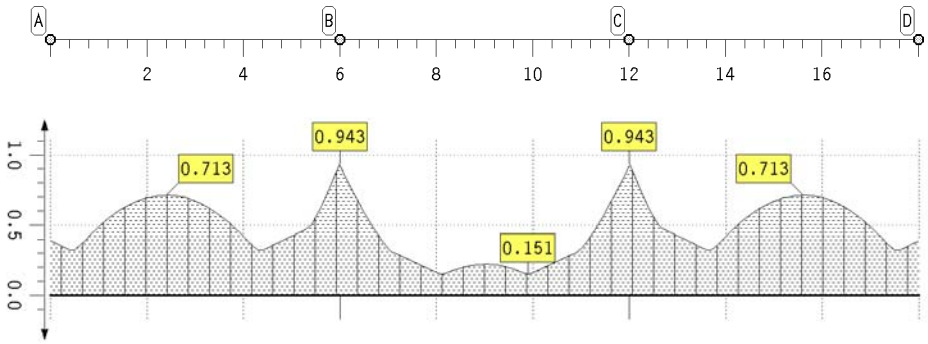


shear centre
shear force
V_ζ in kN
min: -239.12
max: 239.12

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

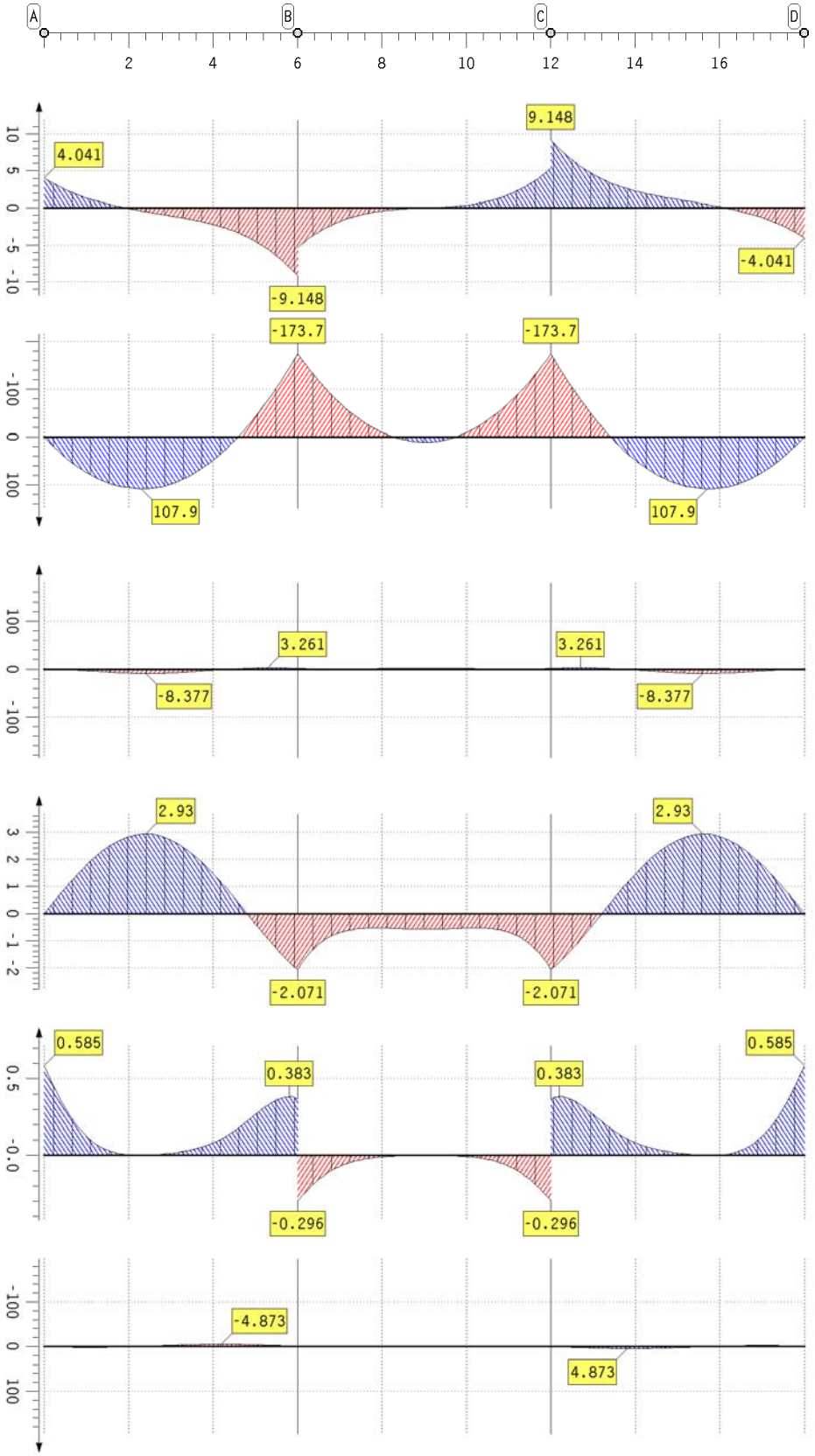
torsional moment
from warping
T_w in kNm
min: 0.00
max: 0.00

Results of steel design



plastic
utilization $U_{\sigma,pl}$
of cross-section
max: 0.94

Internal forces and moments in system of principal axis



shear centre
torsional moment
T in kNm
min: -9.15
max: 9.15

centroid
flexural moment
M_η in kNm
min: -173.66
max: 107.95

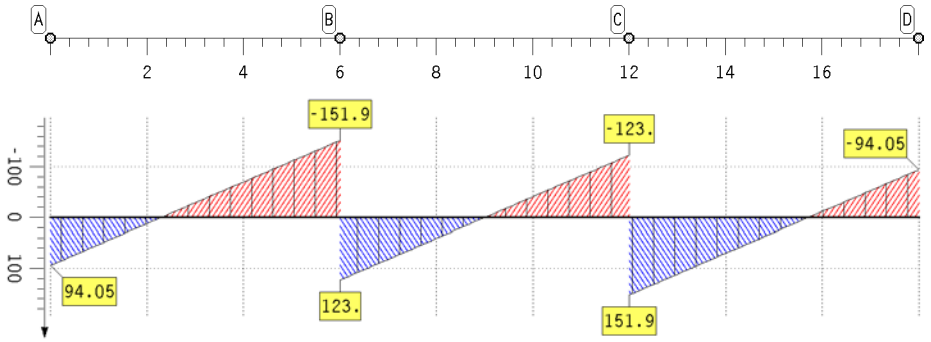
centroid
flexural moment
M_ζ in kNm
min: -8.38
max: 3.26

shear centre
warping bimoment
B in kNm^2
min: -2.07
max: 2.93

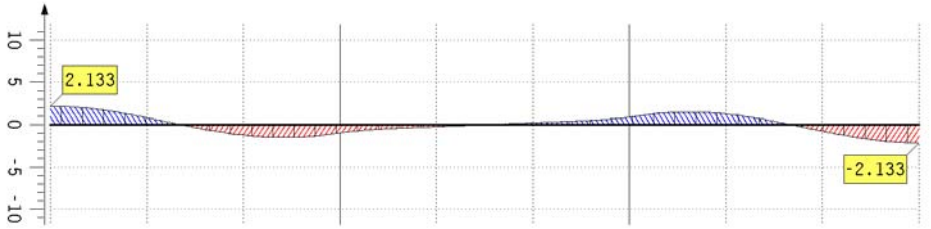
centroid
normal force
N in kN
min: -0.30
max: 0.59

shear centre
shear force
V_η in kN
min: -4.87
max: 4.87

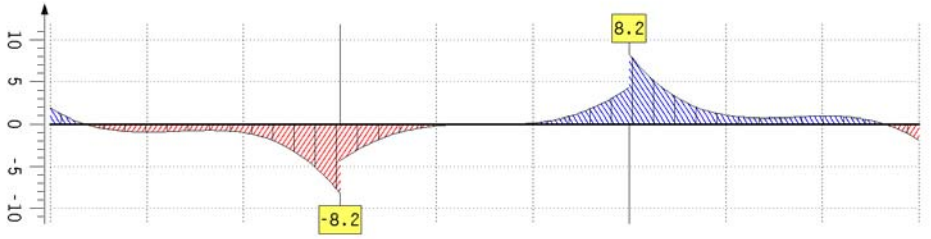
Internal forces and moments in system of principal axis



shear centre
shear force
V_ζ in kN
min: -151.95
max: 151.95

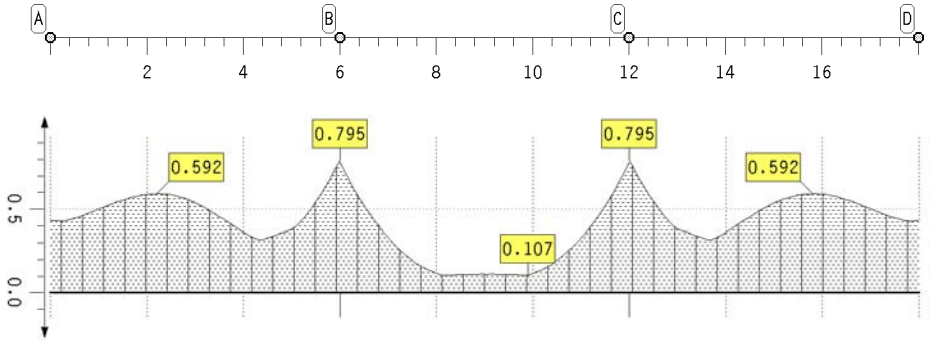


St. Venant
torsional moment
T_t in kNm
min: -2.13
max: 2.13



torsional moment
from warping
T_w in kNm
min: -8.20
max: 8.20

Results of steel design



plastic
utilization $U_{\sigma,pl}$
of cross-section
max: 0.80