

# Crane Runway Girder S9+

$\sim$				
C	or	٦ŤE	эn.	ts
<u> </u>	<u> </u>			•••

Application options	2
Basis of calculation	3
Input	4
Basic Parameters	4
Structural system	5
Stiffeners	6
Supports	6
Hinges	7
Impact buffers	7
Load	8
Cranes	8
Load cases	9
Crane crossings	10
Design	11
Output sections	11
Calculation and design	11
Interfaces to BTII+/PLII+ - further calculations	11
Transfer Support Reactions	12
Output	13
Reference literature	14

#### Basic Documentation – Overview

In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage <u>www.frilo.com</u> in the Campus-download-section.



# Application options

The S9+ application is suitable for the calculation of crane runways in accordance with EN 1993-1-1 and EN 1993-6.

#### Crane system

One or two

- top-mounted cranes (overhead travelling cranes CFF, IFF, CFM, IFM system)
- underslung cranes (below the runway beams)
- monorail hoist blocks

#### Available standards

- DIN EN 1993
- ÖNORM EN 1993
- BS EN 1993
- PN EN 1993
- EN 1993

#### Verifications

- Verification of the stability against lateral torsional buckling in a second-order analysis
- Stress analyses for the cross section and the weld seams
- Analysis of the local wheel load transfer at the top or bottom flange
- Verifications in the fatigue limit state for the cross section and the weld seams
- Verifications in the fatigue limit state for the local wheel load transfer on the upper and lower flange
- Verification of the stability against buckling in accordance with the method of effective cross sections
- Serviceability verifications

#### Definition of the structural system

After having selected the crane system, you must define discrete supporting conditions, pinned joints and buckling stiffeners along the craneway girder. The total length of the girder must be specified. Any type of support can be defined with consideration of horizontal stiffening bracings.

- Material: S235, S275, S355...
- Constant cross section: rolled-shaped sections: I, IPE, HE-A, -B, -M, user-defined I-sections with or without reinforcing top flange angles on both sides.
- Crane rail: A-type, F-type or block rail (w/h) with structural effect, if applicable
- Elastic base of top-mounted crane rails
- Bumpers can optionally be fitted outside of the crane runway.

#### Loading

You can define one or two cranes that are operated independently of each other and optionally assign

- one of the lifting classes H1 to H4 and
- one of the duty groups S0 to S9 as per EN 1991-3

to them.



S9+ allows the calculation of lateral horizontal loads as per EN 1991-3.

Automatic generation of loads for special cases:

The following actions on the crane runway are automatically derived from the specified crane parameters:

- Self-weight
- Vertical wheel loads
- Horizontal lateral loads

In special cases, you can edit these actions. By defining other variable loads, for instance, you can work around a limitation to particular crane systems.

The S9+ application is distinguished by an easy and simple definition of standard cases on the one hand and a maximum of flexibility in special cases on the other hand.

In addition, wind and earthquake loads can be taken into account.

S9+ determines and puts out the bumper forces.

The combinations of actions are generated automatically. You can also directly influence this process.

Imperfection is taken into account in accordance with the horizontal supporting conditions right from the beginning.

#### Output / interfaces

- Additional output sections showing particular calculation results
- Variable output profile optionally structured according to the system, the loads, the general structural safety verifications or special verifications of the crane runway
- 3-dimensional graphical representation of the results of each superposition for the structural safety, the serviceability and the service strength
- Graphical representation of the limit line of the internal forces Qz, My, Qy, Mz, Mt and Mw
- Graphical representation of axial, shear and comparison stresses in each relevant point of the cross section over the entire crane runway girder, selectable per mouse click
- Graphical representation of the fatigue strength verifications of the entire crane runway girder.
- If the PLII+ and/or BTII+ applications are installed, you can transfer the system and the loading for the web buckling and/or <u>stability analyses</u>. Loads can be <u>transfered</u> to STS+ Single-span Steel Column, B5+ Reinforced Concrete Column and HO1+ Timber Column.

#### Limitations

- Constant cross section
- No hollow boxes
- Forces produced by start-up and braking operations of the crane bridge are not considered in the present software version.

You might be required to adjust subsequently the imperfection produced by the decisive action.

# Basis of calculation

The theoretical fundamentals of the calculation of crane runway girders are described in detail in the <u>reference literature</u> mentioned in the software manuals.



# Input

Help texts and information on each individual input value are an integral part of the program interface. As soon as you click in an input field, a corresponding explanation of the input value is displayed in the information area (below). A general description of the program interface can be found in the document: <u>Basic Operating Instructions</u>.

*Tip:* Use the interactive input options directly in the graphic for changes - e.g. double-click on a graphic element or right-click for the context menu.

## **Basic Parameters**

#### Design Standards and Safety Concept

Definition of the design standard and its National Annex.

#### NDP EN

Displays the nationally defined parameters of EN 1991-3 or EN 1993-6.

Properties	<b>4</b>
Basic Parameters	۹ 🔿
⊕ System	
🗄 - Loads	
Design	
Output	

DIN EN 1993-6:2010

Design Standards and Safety Concept

Design Standard

		NDP EN 1991-3		Z
Ultimate Limit State		NDP EN 1993-6		2
Design concept	design principles to prevent fatigue	Ultimate Limit State		0
	failure.	Cross-section design	elastic	Ψ.
	<ul> <li>Concept of damage tolerance</li> <li>Concept without notice</li> <li>The selection of the design concept has an influence on the partial safety factor γMF.</li> <li>number (1-4) of required inspections during the service life of the crane runway</li> </ul>	System sustainability	Theory 2nd order	Ŧ
		Design concept	Concept of damage tolerance	•
		Inspection intervals	Concept of damage tolerance	1
		Support reactions for connections	Concept without notice	
		Support reactions for foundations		
Inspection intervals		Serviceability		0
		Design situation	characteristic	-
Current reactions for some	ations calculation of the cumpart	Ultimate deformation in y	[cm]	0.8
Support reactions for connections calculation of the supp		Ultimate deformation in z	[cm]	1.0
	with reduced dynamic coefficients.	Limit deformation		0
		Individual limit deformations		
	combinations of the support forces ar for calculation.	re to be passed on to a <u>col</u>	umn program	

Support reactions for foundations calculation of the support reactions for foundations with reduced dynamic coefficients.

#### Serviceability Limit State

Design situation	defines the design situation for the serviceability verifications: - characteristic - frequent - quasi-permanent
Ultimate deformation in y/z	The ultimate permissible limit deformations are calculated by the software but can also be entered if the option "Individual limit deformations" is checked.



д

00

# Structural system

#### Crane system

Number of cranes	1 or 2 canes
Crane system	<ul> <li>Top-mounted gantry crane</li> <li>Suspension crane</li> <li>Monorail underslung crane</li> <li>Note: The availability of menu items depends on the previous settings.</li> </ul>
Span of crane bridge	distance of system axes of the undeformed crane runways.

#### Steel

Selection of the steel type and grade; you can set the parameters also manually (user defined type).

#### Crane Runway Girder

total length of the crane runway. The length corresponds to the dimension in the x-direction.

Cross section

Length of girder

name of the selected cross section. Press it access a <u>dialog</u> for editing the cross section.

System     System     Support     Support     Minges     Impact Buffers     Coads     Design     Output		
Crane System		0
Number of cranes	1	-
Crane system	Top-mounted gantry crane	•
Span of crane bridge Steel	Top-mounted gantry crane Suspension crane Monorail underslung crane	
Туре	Structural steel	-
Grade	S235	+
Characteristic values		Z
Crane Runway Girder	t.	0
Length of girder	[m]	10.00
Cross-section	Template: KBTR	1
Remarks		0
about the system		1

Properties

---- Basic Parameters

### Detail category

In the <u>cross-section dialog</u> click with the right mouse button on one of the crosssection points shown as points. The functions "Detail category remove" and "Properties" are displayed. Click "Properties" to open the dialog for the Detail category and tick the desired options.

Detail category	
for SigmaX	8
Detail category 160	
Detail category 140	
Detail category 125	
for SigmaZ	0
Detail category 160	$\checkmark$
Detail category 71	
Detail category 36	
for TauXZ	8
Detail category 100	$\checkmark$
Detail category 80	
Detail category 36	



*Note:* when moving the mouse over the cross-section points, the properties and the point number are displayed.

#### Remarks

Allows you to enter comments about the defined system.



д

۹ 🕲

rigid 🔽

rigid 🗹

rigid 🔽

0.0

0.0

0.00

0 1

# Stiffeners

The definition of multiple buckling stiffeners is described in the chapter Data entry via tables (Basic operating instructions-PLUS)

Alternatively, you can edit stiffeners in a well structured table that is accessible via the "Stiffeners" tab (below the graphic screen).

х	distance of the stiffener (central axis) to the left girder edge.
Welding seam	thickness of the weld seam of the buckling stiffener.
t	thickness of the buckling stiffener.
Detail category	activate the Edit button to access the selection dialog "Detail category".

#### Support Hinges Impact Buffers +- Load Design Output Stiffeners 0 Buckling stiffener 🜒 1/3 🚺 👍 💥 🔠 🛃 0.00 [m] Welding seam 0.4 [cm] [cm] 1.0 Detail category KF\_80/KF\_80 0 Supports Supports 🕚 1/3 🜔 🛃 🗙 🔠 🗃 🌌 Position 0 Position 0.50 [m] Conditions 0

[kNm/rad]

[kNm/rad]

[kNm<sup>3</sup>]

Location in Cross-section

Properties

- System

х

t

Cy

Cz

Θx

Θy

Θz

Θху

... Show

Basic Parameters

# Supports

To define multiple supports, see the chapter Data-entry via tables (Basic **Operating Instructions)** 

Position distance of the discrete support conditions to the left girder edge

Conditions

definition of discrete support conditions for translation, rotation and warping.

Location at cross section displays the dialog for the definition of the support position in relation to the cross section (for Suspension crane / Monorail underslung crane).

Conditions		0	
Су	[kN/m]	rigid 🗹	ā
Cz		rigid 🗹	3
Θx		rigid 🔽	3
Location in Cross-se	ction	0	
Distance	[cm]	3.0	
equivalent spacing		1	



# Hinges

х	distance of the joint to the left girder edge
Cy/Cz	shear force joint in the y-/z-direction.
θ	moment joint around the axis (x, y, z, xy = warping joint).

Hinges		0
Hinge	0 1/1 0	👍 🗙 🙀 🗐 🌶
Position		0
x	[m]	1.00
Hinge values		0
Су		
Cz		
θx		$\checkmark$
θу		$\checkmark$
θz		$\checkmark$
θxy		$\checkmark$

# Impact buffers

Bumpers can be defined on the left and/or on the right or on both sides.

equal on both sides	the parameter setting of the left bumper is automatically transferred to the right bumper.
Distance left/right	distance of the buffer to the left/right girder edge. If the value is negative, the bumper is fitted outside the girder.
Height	distance between the bumper's line of action and the top edge of the rail.
Dynamic coefficient	dynamic factor for the impact on the bumper.
Impact load	characteristic value of the bumper end force without dynamic coefficient. Press the F5 key to access a <u>dialog</u> for the calculation of the bumper end force.

Buffer Arrangement		۵			
Buffer equal on both sides					
Buffer left available		$\checkmark$			
Buffer right available					
Left Impact Buffer		0			
Distance left		[m]	0.00		
Height		[cm]	20.0		
Dynamic coefficient		1.25			
Impact load	F5	[kN]	23.22		
Right Impact Buffer			0		

?

Coefficient of resilience

X

•

+

40

0.70 3900

80.0

6.30

0.467

424.667

634921

23.2

#### Dialog "Calculation of the buffer end forces" (F5-key)

Calculation method	two methods are available for the calculation	Calculation of buffer forces			
	of the bumper end forces:				
	(coefficient of resilience)	Calculation method	Coefficient of		
	Or	Buffer count	Double buffer		
	- via the line of action of the bumper (buffer	Crane Data			
	curve)	Nominal speed v0	[m/min]		
Buffer count	single and double bumpers are available for	Reduction factor fv0			
	selection.	Crane Mass mc	[kg]		
v0	rated crane speed.	Buffer curve values			
fv0	factor for the reduction of the rated crane	Buffer end force Fp	[kN]		
	speed for the bumping situation (normally	Spring motion	[cm]		
	70 %).	Calculation results			
mc	crane mass that acts immediately on the	Velocity v1	[m/s]		
	bumper.	Energy crane Ekin	[Nm]		
Fn	(select calculation method "buffer curve")	Coefficient of resilience c	[N/m]		
μ	energy capacity of the bumper, which is part of	НВ	[kN]		
	the bumper end force.				
Fp	bumper end force; it is the maximum force the buarea.	umper can bear in its e	lastic		
Spring motion	maximum spring deflection on the bumper, whicl	h is part of the bumper	end force.		

The calculation results are displayed in the lower section of the dialog.



### Load

### Seismic Loads

Earthquake proof

when you tick this option, earthquake loads are taken into account in the generation of the load cases and the superpositions. The dialog "Basic values for the determination of the ground acceleration response spectrum" is displayed. Additional information: see <u>Eartquake-chapter</u> in the Building-programm GEO.

#### Remarks

Allows you to enter <u>comments</u> on the actions.

### Create groups of loads and crane crossings

You can optionally select whether the generated load groups and crane crossings should be editable and how the dynamic factors shall be taken into account with <u>two cranes</u>. Horizontal crane effects indicates for which cranes these actions are applied. See also DIN EN 1991-3, Corrigendum 1: 2013-08.

## Cranes

The number of cranes (1 or 2) is defined in the <u>Structural system</u> section. The right/left arrows allow you to move the cursor to the next/previous dataentry field: Crane 2/2 2/2 2/2 2/2 2/2

### **Crane Parameters**

Determination of the crane loads:

		Sell-weig	
Calculation	the crane loads are calculated by the software on the		
	basis of the parameters listed below and in	Lifting ca	
	accordance with EN 1991-3.	Hoist cla	
Crane datasheet	you must enter the crane loads (as specified on the	Exposure	
	datasheet). The definition menu is adjusted	Nominal	
	accordingly.	Hoist spe	
Qcb	self-weight of the crane bridge or the trolley.	Drive S	
Qcrab	self-weight of the trolley without hoisting devices.	Number	
Ocrah	solf weight of the grane without hoisting devices	Drive sys	
QCIAD	self-weight of the chane without hoisting devices.	Guide sy	
emin	minimum distance between the centroid axes of the		
	wheels and the centre of gravity of the trolley at its	Crane L	
	outermost limit position.	Consider	
Qh	rated hoisting capacity of the crane.		
	The hoisting capacity includes the masses of imposed loads and the hoisting devices as well as a part of the mass of the ropes and chains of the hoisting		
Hoisting class	hoisting class of the crane as per EN 1991-3, Annex B.	,	
Exposure class	Exposure class as per EN 1991-3, Annex B.		
vO	rated crane speed.		
vh	hoisting speed of the crane.		



Seismic Loads		0
Earthquake check		
Remarks		۲
about the actions		Z
Create groups of loads and o	crane crossings	0
Load groups/ crane crossings	not editable	٠
Reduction of vibration coefficie	automatically	•
Horizontal crane effects	acting on the first crane only	•

Cranes			0
Crane	0 2	/2 0 🛃	× 🗃 🌶
Crane Parameters			0
Determination of crane	loads	Calculation	+
Description		Cran data she	et
Self-weight bridge	Qcb	[KN]	60.0
Self-weight trolley	Qcrab	[kN]	10.0
Self-weight crane	Qc	[kN]	70.0
Trolley position	e min	[m]	1.50
Lifting capacity	Qh	[kN]	100.0
Hoist class		HC2	
Exposure class		S4	+
Nominal speed	v0	[m/min]	40.00
Hoist speed	vh	[m/min]	5.00
Drive System			0
Number of crane axes		2	-
Drive system		IFF - mono wh	neel drive 🔹
Guide system		Wheel flange	s •
Distance cranes		[m]	1.00
Crane Loads			0
Consider vibration coef	ficients	reduced value	в т
Crane Loads		Detail	s (2)
Wind force		[kN]	0.0



#### Runway system

Number of crane axles	2 or 4					
Drive system	selection of the crane drive (central drive, individual wheel drives) and of the type of axles (fixed/fixed or fixed/free).					
Track guidance system	wheel flange, outer or inner guide rolls.					
Distance cranes	distance of the guiding devices to the front/rear axle.					
Crane Loads						
Vibration coefficients	when you set the option for the reduction of the dynamic coefficients to " <u>Manually</u> ", you can optionally decide whether the dynamic factors should be included with their full values or with reduced ones.					
Crane Loads	click on the "Details" button to display the dialog for the definition of the wheel loads. $\begin{array}{ c c c c c c c c c c c c c c c c c c c$					
Wind force	characteristic value of the total wind power as per EN 1991-1-4, para. 5.3. Press the F5 key to launch a wizard (definition dialog) for the calculation of the wind power.					

### Load cases

The load cases are generated automatically by default. Tables are only editable when the corresponding option ("Editable") is activated, see Loading / Definition of load groups and crane crossings.

To define multiple load cases with the help of the load case toolbar see the chapter <u>Data entry via tables</u> (basic operating instructions).

Alternatively, you can edit load cases in the well structured load case table that is accessible via the Load Cases tab (below the graphic screen).

Single load in a

Load Cases	0
Load case 🔇 2/7	💿 👍 🗙 油 🗃 🌛
Description	Crane 1 - dead load Qc, ma
Action	Kranlastgruppe - Qc 🛛 🔻
Dynamic concentrated loads	
Crane number	Crane 1 *
Loads	Edit (2)

Action	selectio EN 199	on of actions in acco 0.	ordance w	ith	Loads			Edit	2)
Dynamic concentrated load	s conside	when you tick this over the second seco	option, the s, otherwis	concer se as sta	ntrated atic load	loads of ds.	the load cas	se are	
Crane number	number	r of the crane whose	e wheel loa	ads are	include	d in the l	oad case.		
Loads	click or selecte click int	n the "Edit" button to d load case. Explica to a table cell.	o display th ations on t	ne dialog he diffe	g for the rent col	e definiti lumns ar	on of the loa e displayed	ads of when	the you
		Load type	Direction	Value left	Distance	Value right	Load extension	Impact	Description
					[m]		[m]		2

19.5

3.50

2
4
镭

2

2

Qc.2.2.max.n



# Crane crossings

The crane crossings are generated automatically by default. Tables are only editable when the corresponding option ("Editable") is activated, see <u>Loading</u> / Definition of load groups and crane crossings.

Properties		Cran		
Crane crossing	selection of the crane passage in view of the			
	verifications to be performed: - Structural safety			
	- Serviceability			
	- Support forces - Fatigue			
Superposition factors	activate the "Edit" button to display the dialog for			
	the definition of the superposition factors			
	(dynamic coefficient $\varphi$ i, partial safety factor $\varphi$ F, combination coefficient $\psi$ i - the superposition factor is the product of these three values).	Dou		

Crane Crossings	0
Crane crossing 🔘 1	/5 🜔 🛃 💥 🛗 🗃 🌛
Properties	0
Description	LG 1: Qc+Qh+HT - STR P/T
Crane crossing	Bearing safety 🔹
Superposition factors	Edit (7)
Crane crossing	0
Criterion for load position	maximal effective stress
Starting coordinate x min	[m] 0.00
End coordinate x max	[m] 16.00
Imperfection	0
Type of imperfection	parabolic 🔹
Imperfection	Edit (2)
Double amplitude	

Crane Crossing		minimal st
Criterion for load position xmin / xmax	selection of the target function for the decisive load position of a crane passage (minimum/maximum shear force maximum deformation). coordinates of the beginning and the end of the first	maximal s minimal s maximal s minimal m maximal n minimal m maximal n minimal to
	wheel of the first (front) crane in the x-direction	maximal minimal w maximal v

maximal shear force in y-direction minimal shear force in y-direction minimal shear force in y-direction maximal shear force in z-direction minimal moment about y-axis minimal moment about y-axis minimal moment about y-axis minimal moment about z-axis maximal moment about z-axis minimal torsional moment maximal torsional moment minimal warping moment maximal warping moment maximal momal stress of the beam maximal deformation

#### Imperfection

Type of imperfection

select whether the imperfection half waves shall be sineshaped or parabola-shaped.

Imperfection

click on the "Edit" button to display the dialog for the definition of the imperfections for the current crane passage.

		Direction		from x	to x	Amplitude in y	Amplitude in z	Amplitude at x	Auto
				[m]	[m]	[cm]	[cm]	[rad]	
	1	in y-direction	•	0.00	5.00	1.0	. 222	2023	1
٩	2	in y-direction	•	5.00	10.00	-1.0			
		about x-axis in y-direction in z-direction	6						

```
C
```

Invert amplitudes of the imperfection half waves. Note: A imperfection direction is assigned to the current crane passages. Alternatively, the opposite deflection direction must also be examined.

Double amplitude

according to DIN EN 1993, the amplitudes of the initial bow imperfections are to be doubled if 0.7 < lambdaLT < 1.3.



# Design

#### Output sections

To define multiple output sections with the help of the table toolbar:

🔘 1/2 🜔 👍 🗙 🛄 🎒

- see Data entry via tables (Basic Operating Instructions)

Output section indicates the x-coordinate of the user-defined output section. The output sections allow you to obtain calculation results at particular points of the girder.

#### Calculation and design

Calculation parameters accesses a dialog for the setting of the calculation parameters.

#### **Dialog Calculation parameters**

#### Minimum element length:

minimum length of a finite element in [cm]. A minimum length greater than one centimetre is recommended.

#### Number of elements:

number of finite elements to be produced in the system discretisation  $(1 \le n \le 5,000)$ .

#### Primary/secondary torsion:

When you check this option, the shear stresses due to primary torsion are taken into account in the calculation of the comparison stresses.

#### Verification of local bearing load introduction:

Specifies whether the verification of the local support load introduction should be performed (Suspension crane / Monorail underslung crane).

Properties		д
Basic Parameters ⊕ System ⊕ Loads — Design — Output		۹0
Sections for Output		0
Edit output sections	1/1 🔘 🛃	× 🏦 🏖
Output section	[m]	0.00
Design		0
Calculation parameters		
Further Calculations		0
Stability checks	BTII+	1
Web buckling	PLII+	
Remarks		0
about the results		
Transfer Support Reactio	ns	0
Support (	1/3 🜔 📑	× 🗃 🌶
Position	[m]	0.00
Start STS+	(0)	)
Start B5+	(0)	)
Start HO1+	Start HO1+ (0)	

Calculation parameters	?	×
Design		
Minimum element length	[cm]	1.00
Number of elements		50
Primary torsion		$\checkmark$
Secondary torsion		$\checkmark$
Detection of local bearing load introduction		
Specifies whether the check of the local su introduction should be performed.	upport loa	ad
	ОК	

#### Interfaces to BTII+/PLII+ - further calculations

Stability verificationsinterface to BTII+ (Lateral Torsional Buckling Analysis). Activating the option<br/>launches the software and transfers the entire structural system to BTII+.1)Web bucklinginterface to PLII+ (Plate Buckling). Activating the option launches the software<br/>and transfers a selected buckling field and its loading to PLII+.1)

<sup>1)</sup> If this software is installed on your computer and you hold a valid licence.



### Transfer Support Reactions

The combinations of support forces can be transferred to

- STS+ Single-span Steel Column,
- B5+ Reinforced Concrete Column
- H01+ Timber Column

To do this, the "Support reactions for connections" option must be selected under <u>Basic parameters</u>.

6	
	Delete
-	Properties
	Transfer of support reactions to STS+
-	Transfer of support forces to B5+
	Transfer of support forces to HO1+

Load transfer can also be called up via the context menu (right mouse button) on a support (Fig. above).

The desired combinations can be selected (marked) in a dialog, the load axes can optionally be rotated through 90°, and the combinations can be assigned to actiongroups.

In a further intermediate dialog, parameters such as column height, cross-section width/height, height of the load application point and eccentricity can be specified.



# Output

A general description of the output options is available in the document:

▶ Output and printing

#### View selection

The tabs "System graphics", "Crane graphics" and "Document" allow you to toggle between the GUI, the 3-d view of the structural system and the preview of text documents.

### Output options

The different options and the corresponding "Details" buttons allow you to determine and limit the output scope.

System graphics	Crane graphics	Document
Properties		ф.
Basic Para System Loads Design Output	meters	৫ 💿
General		0
Compact output	t	
Legends		
System		0
System graphic	× -	
Scale	[1:]	75
More settings	De	tails (10)
Actions		0
More settings	De	etails (5)
Results		0
Superpositions	De	etails (5)
Summary		$\checkmark$

#### Results

You can access the views of the different result graphs via this tab (select by clicking).





# Reference literature

- [1] EN 1990 2002-10: Eurocode: Bases of structural design
- [2] DIN EN 1991-3:12-2010: Eurocode 1: Actions on structures Part 3: Actions induced by cranes and machinery, German version of EN 1991-3:2006
- [3] DIN EN 1991-3/NA:2012-12: National Annex to Eurocode 1 Nationally Defined Parameters: Actions on structures Part 3: Actions induced by cranes and machinery.
- [4] ÖNORM B 1991-3 Eurocode 1:2007-06-01: Actions on structures Part 3: Actions induced by cranes and machinery.
- [5] NA to BS EN 1991-3:2006: UK National Annex to Eurocode 1: Actions on structures Part 3: Actions induced by cranes and machinery.
- [6] DIN EN 1993-6:2010-12: Eurocode 3: Design of steel structures Part 6: Crane supporting structures
- [7] DIN EN 1993-6/NA:2010-12: National Annex to Eurocode 3 Nationally Defined Parameters: Design of steel structures Part 6: Crane supporting structures
- [8] ÖNORM B 1993-6:2008-12-01: Eurocode 3: Design of steel structures Part 6: Crane supporting structures
- [9] NA to BS EN 1993-6:2007 UK National Annex to Eurocode 3: Design of steel structures Part 6: Crane supporting structures.
- [10] Kindmann, Rolf, Prof. Dr.-Ing.: Tragfähigkeit von doppeltsymmetrischen I-Querschnitten auf Basis der DIN EN 1993-1-1, Tagungsband Dresdner Stahlfachtagung 2012, TU Dresden: 2012.
- [11] Kuhlmann, Ulrike, Prof. Dr.-Ing., Zizza, Antonio, Dipl.-Ing., Braun, Benjamin, Dr.-Ing.: Stahlbaunormen DIN EN 1993-1-5: Bemessung und Konstruktion von Stahlbauten – Plattenförmige Bauteile, Stahlbaukalender 2012, Ernst & Sohn Verlag: 2012.
- [12] Stahlbaukalender 2006
- [13] Nussbaumer, Alian, Prof. Dr. Dipl.-Ing., Günther, Hans-Peter, Dr.-Ing.: Stahlbaunormen Kommentar zur DIN EN 1993-1-9: Ermüdung, Grundlagen und Erläuterungen, Stahlbaukalender 2012, Ernst & Sohn Verlag: 2012.
- [14] Osterrieder, Peter, Prof. Dr.-Ing.: Ermüdungsbeanspruchung nach EN 1993 (EC3), Tagungsband Brandenburgischer Bauingenieurtag BBIT2013, page 115 et seq., 2013.
- [15] Von Berg, Dietrich: Krane und Kranbahnen: Berechnung Konstruktion Ausführung: B. G. Teubner Stuttgart: 1988.
- [16] Seeßelberg, Christoph, Prof. Dr.-Ing.:Kranbahnen Bemessung und konstruktive Gestaltung, 3. Auflage, Bauwerk-Verlag: Berlin, 2009.
- [17] Wagner, Hoffmann: Plattenbeulen
- [18] Schweda, Erwin, Prof. Dipl.-Ing., Krings, Wolfgang, Prof. Dr.-Ing: Baustatik Festigkeitslehre, 3. Auflage, Bauwerk-Verlag: Düsseldorf 2000.