

Version June 2013

Program

CRANEWAY

Design of Crane Supporting Structures According to EN 1993-6 or DIN 4132 (02.81) Including Adaptations to Technical Progress

Program Description

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I. Introduction

1.1 About CRANEWAY

Dear user of CRANEWAY,

this program expands DLUBAL'S product range by the crane runway girder design. Thanks to the well-known user-friendliness of Dlubal programs, you can carry out even complicated analyses according to EN 1993-6, DIN 4132, and DIN 18800 in an easy and comprehensible way.

The crane runway girder is specified in the CRANEWAY module. Based on the defined loadings, the program creates load cases that are combined in load positions. Each load position results in three load combinations. Each load combination is calculated with three loading levels in order to determine the internal forces for the general stress design, the deformation analysis, or the fatigue design. The internal forces are determined according to the second-order analysis for warping torsion. With these calculated internal forces, CRANEWAY provides the appropriate analyses according to EN 1993-6, DIN 4132, or DIN 18800.

CRANEWAY includes the following features:

• Input

Clearly structured input options

Graphic representation and 3D visualization of nearly all input data Import of cross-sections from the extensive RSTAB/RFEM cross-section library Import of cranes from the crane library or a user-defined crane database Calculation of eigenvalues considering loading with automatic assignment of the eigenvalues as imperfections Automatic determination of stress points and assignment of detail categories Numerous parameters for control of calculation **Results**

• Results

Clear summary of all results

Clear structure of separate results windows for each analysis

Representation in result tables: overall, by x-location, by stress points

Easy verification of the results by means of the detailed intermediate values

Results evaluation in tables as well as in the corresponding graphic

Printout report with individual layout options

Export of graphics to the printout report

We hope that this program will make your work easier. Please do not hesitate to share your ideas, remarks, or suggestions on how to improve CRANEWAY.

We hope you will enjoy working with CRANEWAY.

Your DLUBAL Team



1.2 CRANEWAY Team

The following people were involved in the development of CRANEWAY:

Program coordination

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Ing. Marek Posch

Ing. Martin Deyl

Ing. Marek Posch

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1.3 Using the Manual

Topics such as installation, graphical user interface, results evaluation, and printout reports are described in detail in the manuals for RSTAB/RFEM and will not be introduced here. Instead, this manual focuses on the particular features of CRANEWAY.

The description follows the order and structure of the input and output windows. The text of the manual shows the described **buttons** in square brackets, for example [View mode]. At the same time, they are depicted at the left margin. The **Expressions** used in program dialog boxes, tables, or menus are emphasized by *italics* so that the explanation is easy to follow.

At the end of the manual, you can find an index. If you still cannot find what you are looking for, please check our website www.dlubal.com where you can go through the *FAQ* pages and find a solution for the problem by using various criteria.





1.4 Installation Process

The program **CRANEWAY** is delivered on the DVD *Stand-Alone Applications*. This DVD contains the stand-alone programs RX-TIMBER, CRANEWAY, COMPOSITE-BEAM, and PLATE-BUCKLING.

Before you install CRANEWAY, close the applications running in the background.



Please make sure that you are logged on as administrator or have administrator rights for installing the program. When working with CRANEWAY, user rights will be sufficient. For detailed instructions, see the Assignment of user rights video on our website.

On the back side of the DVD case, you can find installation instructions.

- Insert the DVD into your DVD-ROM drive.
- The installation process starts automatically. If this does not happen, the *autorun* function is probably deactivated. In this case, start the file *setup.exe* on the DVD by using the explorer or by entering the command ,D':\setup.exe in the input field of the start menu (,D' stands for the drive letter of your DVD drive).
- In the start dialog box, select the language.



Figure 1.1: Language settings

- In the next dialog box, select the CRANEWAY program version (64-bit or 32-bit).
- Follow the instructions of the Installation Wizard.

Connect the dongle to a USB port of your computer only after the installation is complete. The dongle driver will be installed automatically.

The DVD also contains installation instructions and the CRANEWAY manual as PDF file. To view it, you need the Acrobat Reader, which you can install from the DVD.



Program selection



CRANEWAY as full or trail version

If you start the program after the successful installation for the first time, you have to specify if you want to use CRANEWAY as full version or as trail version (30 days).

To use this program as full version, you need a dongle (hardlock) and an authorization file *Author.ini*. The dongle is a plug-in device that you have to connect to a USB port of the computer; the authorization file contains coded information for your license(s). Usually, we send you the *Author.ini* file via e-mail. You can also use the Extranet on www.dlubal.com to access the authorization file. Save this *Author.ini* file on your computer, an USB flash drive, or in the network.

The authorization file is needed for <u>every</u> work place. You can copy the file as often as you like. If, however, the content of this file is changed, the authorization becomes invalid.

The full version of CRANEWAY can also be run as a *softlock* license without a dongle.



Direct start of CRANEWAY

To start the program, use the Windows start menu or the Dlubal icon on the desktop.

RSTAB or RFEM navigator

You can also start CRANEWAY in RSTAB or RFEM in the project navigator: In the *Data* navigator, select

Stand-Alone Programs \rightarrow CRANEWAY 8 - Design of crane runway girders.



Figure 1.2: Data navigator of RSTAB: Add-on Modules \rightarrow CRANEWAY 8 - Design of crane runway girders





2. Input Data

When you have started the program, the CRANEWAY window appears. A navigator on the left manages the available input and output windows. All settings required for the design are entered in the six input windows of the program.



Details...

3D-Rendering

Cancel

Graphics

OK

To go to a particular CRANEWAY window, click the corresponding entry in the navigator. In addition to that, you can use the button shown on the left to set the previous or next window. Alternatively, you can also use the function keys [F2] (next) or [F3] (previous) to browse through the windows.

By clicking [Details], you open the *Details* dialog box for specific calculation settings (see chapter 3.1).

With the [3D-Rendering] button, you can visualize the input data as 3D graphic (see chapter 6.3).

To save the input and results data before you exit CRANEWAY, click [OK]. To exit the program without saving the data, click [Cancel].

In the results windows, you can use the [Graphics] button to check the internal forces, deformations, stresses, etc. in the work window of RSTAB or RFEM (see chapter 6.3.2).

2.1 General Data

The 1.1 *General Data* window manages the general specifications for the material, design standard, and crane type.

le Settings Help				
put Data General Data Geometru	1.1 General Data Material	Standard / National Annex (NA)		
- Cross-Section	Description:	EN 1993-6		
Loading Load Combinations Imperfections	Steel S 235 (EN 10025-2.2004-11)			
	Crane Type			
	Bridge crane Suspension crane		X	
			CRANEWA	
			Design of crane runway girders: - DIN 4132 - EN 1993-6	
	Comment		7	
		*		

Figure 2.1: Window 1.1 General Data

Material

Ŧ

Steel S 235 (EN 10025-2:2004-11)

In the *Description* drop-down list, you can select one of the materials stored in the program. It contains the steel grades, which are dependent on the selected standard.



The parameters of the steel grade are stored in a [Library], which you can access by clicking the corresponding button.

ilter	Material to Select			
faterial category group:	Material Description	Standa	d	
Metal	▼ Steel S 235	🔯 EN	10025-2:2004-11	
	Steel S 275	💿 EN	10025-2:2004-11	
faterial category:	Steel S 355	💿 EN	10025-2:2004-11	
Steel	Steel S 450	I FN	10025-2:2004-11	
	Steel S 185	EN EN	10025-2:2004-11	
itandard group:	Steel S 225 IP		10025-2:2004-11	
💿 EN			10025-2.2004-11	
		EN EN	10025-2:2004-11	
itandard:	Steel 5 235 J2	EN EN	10025-2:2004-11	
💿 EN 10025-2:2004-11	Steel S 275 JR	🔟 EN	10025-2:2004-11	
	Steel S 275 J0	EN EN	10025-2:2004-11	
	Steel S 275 J2	🔯 EN	10025-2:2004-11	
	Steel S 355 JR	🔟 EN	10025-2:2004-11	
	Steel S 355 J0	🔯 EN	10025-2:2004-11	
7 Include invalid	🐷 📘 Steel S 355 J2	🔯 EN	10025-2:2004-11	
		1		ſ
ravoikes only				l
laterial Properties		:	Steel S 235 EN 10	0025-2:200
Main Properties				
Modulus of Elasticity		-		
		E	21000.00	kN/cm ²
Shear Modulus		G	21000.00 8076.92	kN/cm ² kN/cm ²
Shear Modulus Poisson´s Ratio		G V	21000.00 8076.92 0.300	kN/cm ² kN/cm ²
Shear Modulus Poisson's Ratio Specific Weight		E G ν γ	21000.00 8076.92 0.300 78.50	kN/cm ² kN/cm ² kN/m ³
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa	nsion	E G ν γ α	21000.00 8076.92 0.300 78.50 1.2000E-05	kN/cm ² kN/cm ² kN/m ³ 1/℃
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties	insion	E G ν γ α	21000.00 8076.92 0.300 78.50 1.2000E-05	kN/cm ² kN/cm ² kN/m ³ 1/°C
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties Coefficient for Limiting Stres	insion ses of Welds	E G ν γ α	21000.00 8076.92 0.300 78.50 1.2000E-05	kN/cm ² kN/cm ² kN/m ³ 1/°C
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties Coefficient for Limiting Stres Correlation Factor for Fillet V ThisInces Descent / Clark	insion ises of Welds Velds	Ε G ν γ α α βw βw	21000.00 8076.92 0.300 78.50 1.2000E-05 0.950 0.800	kN/cm ² kN/cm ² kN/m ³ 1/°C
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties Coefficient for Limiting Stres Correlation Factor for Fillet 1 E Thickness Range t \$ 16.0 r Vield Preport	insion ises of Welds Velds nm	E G V γ α α βw	21000.00 8076.92 0.300 78.50 1.2000E-05 0.950 0.800	kN/cm ² kN/cm ² kN/m ³ 1/°C
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties Coefficient for Limiting Stress Correlation Factor for Fillet \ □ Thickness Range t ≤ 16.0 r Yield Strength Lillingte Strength	insion ises of Welds Velds nm	E G V γ α α βw	21000.00 8076.92 0.300 78.50 1.2000E-05 0.950 0.800 23.50 36.00	kN/cm ² kN/cm ² kN/m ³ 1/°C kN/cm ² kN/cm ²
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties Coefficient for Limiting Stres Correlation Factor for Fillet V ⊡ Thickness Range t ≤ 16.0 r Yield Strength ⊟ Thickness Ranget 1 ≤ 16.0 r	nsion ises of Welds Nelds nm nm and t ≤ 40 0 mm	E G V γ α δw βw	21000.00 8076.92 0.300 78.50 1.2000E-05 0.950 0.800 23.50 36.00	kN/cm ² kN/cm ² kN/m ³ 1/°C kN/cm ² kN/cm ²
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties Coefficient for Limiting Stres Correlation Factor for Fillet \ □ Thickness Range t ≤ 16.0 r Yield Strength Ultimate Strength □ Thickness Range t > 16.0 r Yield Strength	insion ises of Welds Nelds nm nm and t ≤ 40.0 mm	E G V γ α Δ βw Fy fu fu	21000.00 8076.92 0.300 78.50 1.2000E-05 0.950 0.800 23.50 36.00	kN/cm ² kN/cm ² kN/m ³ 1/°C kN/cm ² kN/cm ² kN/cm ²
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties Coefficient for Limiting Stres Correlation Factor for Fillet V □ Thickness Range t ≤ 16.0 r Yield Strength Ultimate Strength Ultimate Strength Ultimate Strength Ultimate Strength	insion ises of Welds Nelds nm nm and t ≤ 40.0 mm	E G V γ α α βw F y fu fu	21000.00 8076.92 0.300 78.50 1.2000E-05 0.950 0.800 23.50 36.00 22.50 36.00	kN/cm ² kN/cm ² kN/m ³ 1/°C kN/cm ² kN/cm ² kN/cm ²
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Goditional Properties Corelation Factor for Fillet Y □ Thickness Ranget ≤ 16.0 r Yield Strength Ultimate Strength Ultimate Strength Ultimate Strength □ Thickness Ranget > 16.0 r Yield Strength Ultimate Strength □ Thickness Ranget > 40.0 r New Strength	Insion Ises of Welds Welds nm nm and t ≤ 40.0 mm nm and t ≤ 100.0 mm	E G V γ α α βw βw fu fy fu	21000.00 8076.92 0.300 78.50 1.2000E-05 0.950 0.800 23.50 36.00 22.50 36.00	kN/cm ² kN/cm ² kN/m ³ 1/°C kN/cm ² kN/cm ² kN/cm ² kN/cm ²
Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expa Additional Properties Coefficient for Limiting Stres Correlation Factor for Fillet 1 Thickness Range t ≤ 16.0 r Yield Strength Ultimate Strength	nsion ises of Welds Welds nm nm and t ≤ 40.0 mm nm and t ≤ 100.0 mm	E G V V 7 α α βw βw Fy fu fu fy fu	21000.00 8076.92 0.300 78.50 1.2000E-05 0.950 0.800 23.50 36.00 22.50 36.00 22.50	kN/cm ² kN/m ³ 1/°C kN/cm ² kN/cm ² kN/cm ² kN/cm ² kN/cm ²

Figure 2.2: Material Library

The material properties are also included in the library. There, you can select a material, and then import it to window 1.1 by clicking [OK].

If you calculate according to DIN 4132, it is not possible to define a new steel grade in the library: According to this standard, only materials with defined allowable stresses for the fatigue analysis may be selected. In contrast to that, you can define your own materials in a calculation according to EN 1993-6. Notice that all parameters necessary for the design are preset or else are to be defined.

Standard / National Annex

In the drop-down list of this section, you select a standard for design and, if necessary, the according National Annex (NA). You can select either the standard EN 1993-6 or DIN 4132.

If you design according to EN 1993-6, you can also select a National Annex whose parameters will be used for the design. The list of the design standards will be extended as we continue to develop CRANEWAY.



2 Input Data



To check and, if necessary, adjust the current default parameters of the Standard or National Annex, click [Edit]. This is particularly useful if you want to modify the partial safety factors and combination coefficients for the combination rules.

To create a user-defined national annex, click [New].

Crane Type

20

8

5

With CRANEWAY, you can design bridge cranes as well as suspension cranes. To select the desired crane type, use the respective option buttons. The graphic will be automatically adjusted according to the crane type.

For the design according to DIN 4132, only bridge cranes are available.

Type of the Crane
Ø Bridge crane
Suspension crane

Figure 2.3: Crane type Bridge crane

D Bridge cran	e	
Suspension	crane	
	-	T
ſ	1 6 6	6
L		

Figure 2.4: Crane type Suspension crane

Comment

In this input field, you can write your comments.

×

Figure 2.5: Comment



Time of the Course



2.2 Geometry



Figure 2.6: Window 1.2 Geometry

Total girder length

First, you must define the *Total girder length* for the one-span or continuous girder. If there are already entries in the *Supports* tab for the location *x* of the supports, the total length may not be less than the maximum distance of the x-location from the beginning of the girder. Otherwise, the maximum distance x will be automatically reduced to the total length.

Supports

In this tab, you define the support locations and degrees of freedom of the supports. By placing the cursor inside a row, you can define the *Location x* of the support manually.

Supports Spring Constants Releases Stiffeners

			-										
	A	В	С	D	E	F	G	H		J	K	L	
Support	Location		Di	isplacement	in		Rotation about				Sup	port	
No.	x [m]	Type of Support	X	Y	Z	X	Y	Z	Warping	Release	Stiffener	Width a [mm]	
1	0.000	Hinged	1	I	~	1					Rigid		
2	2.000	Free									Non-rigid		
3	4.000	Lateral on upper flange		2							None	200.0	
4	6.000	Lateral on bottom flange		1							Non-rigid		
5	8.000	User-defined		Spring	√						None	200.0	
6	10.000	Hinged movable		I	1	1					Rigid		
7													Ŧ

Figure 2.7 Window 1.2 Geometry, tab Supports



Hinged Hinged movable Rigid Free Lateral on upper flange Lateral on bottom flange User-defined In column B, you assign the *Type of Support* to the respective support by using the drop-down list. You can select from the following types:

- Hinged
- Hinged movable
- Rigid
- Free
- Lateral on upper flange
- Lateral on bottom flange
- User-defined

The types of support *Hinged* and *Hinged movable* do not allow any changes in the displacement or rotation definition (columns C through H).

A lateral spring support on the upper or bottom flange of the girder cross-section can only be assigned if you select the options *Lateral on upper flange* or *Lateral on bottom flange*. The corresponding spring constant is to be specified in the following tab.

For the *User-defined* type of support, you can specify the displacement, rotation, or warping restraint manually. To define the possibility of displacement or rotation as well as spring behavior, you can use the lists or check boxes in columns C through I. This is possible for an elastic support, elastic restraints, and warping.

Furthermore, it is possible to apply *Releases* at the supports. To assign a release, select the check box in column J of this tab. The release properties are then to be defined in the *Releases* tab. In this way, you can, for example, create a chain of one-span girders.



For each support, you can specify manually if there is a stiffener (end post). You can select from the options *None, Rigid*, and *Non-rigid*. The type of stiffener has an influence on the plate-buck-ling analysis of the girder, as it influences the shear buckling resistance of the web.

If no stiffener is defined, you must specify the *Width a* of the support in order to perform the stress, fatigue, and plate-buckling analyses.

Spring Constants

The second tab becomes available if you select a spring in the Supports tab.

Supports	Spring Constants	Releases	Stiffeners

		-								
	A	В	C	D	E	F	G	H		J
Support	Location	Trans	slational Spring [k	:N/m]	Rotat	ional Spring [kNn	n/rad]	Warping Spring	Lateral Flange	Spring [kN/m]
No.	x [m]	C _{u,X}	C _{u,Y}	C _{u,Z}	C _{φ.X}	C _{φ.Y}	C _{φ.Z}	C _∞ [kNm ³]	C _{u,Y} upper	C _{u,Y} bottom
3	4.000								50.000	
4	6.000							9.720		25.000
5	8.000		7.500						15.000	15.000

Figure 2.8: Window 1.2 Geometry, tab Spring Constants

By placing the cursor in the relevant row, you can define the constants for the translational, rotational, or warping spring.

....

The stiffness of the *warping spring* is dependent on the type of warping restraint. This calculation can be done automatically in CRANEWAY. If you click in a cell of column H, the [...] button appears. By clicking this button, you open a new dialog box. After you specify the relevant parameters, the resulting stiffness is shown (see the following figure).



Calculate Warping Spring	X
Calculate Warping Spring Due to Calculate Warping Spring Due to Channel section Channel section Cantilevered portion Angle Material Steel S 235 End Plate Dimensions Width b: 150.00 [mm] Depth h: 300.00 [mm] Thick. d: 20.00 [mm]	d d
	Warping spring C-Om: 9.720 [kNm ³]
	OK Cancel

Figure 2.9: Dialog box Calculate Warping Spring

The input options in this dialog box differ depending on the type of warping spring. You define the spring type in section *Calculate Warping Spring Due to*. Then, you can define the geometry.

Releases

The third tab becomes available if you select a release in the Support tab.

Supports Spring Constants Releases Stiffeners

	Δ Ι	D	C	D	E	C	G	L	
Support	Location	0	N-/V-Release	0	L	T-/M-Release	u	Warping	
No.	x [m]	N	Vy	Vz	Мт	My	Mz	Mω	
3	4.000					V			
5	8.000								

Figure 2.10: Window 1.2 Geometry, tab Releases

In this tab, you define the degrees of freedom or release properties at the relevant x-locations. You can define a release by selecting the relevant check boxes.



Stiffeners

In the last tab, you can specify the number and arrangement of the stiffeners in the panels.

Supports	Spring Cons	stants Release	s Stiffeners	
	A	B	С	Option
Span	Length	Number of	Type of	The leasting of internal difference is related to the support limiting the
No.	L [m]	Int. Panels	Location	degree of freedom in the Z-direction
1	2.000	3	Regularly	
2	2.000	4	User-defined 🚬	
3	2.000	1	User-defined	
4	2.000	3	Regularly	
5	2.000	3	User-defined	

Figure 2.11: Window 1.2 Geometry, tab Stiffeners

The defined supports divide the girder in internal panels. Now, you can further modify the arrangement of the stiffeners in these panels. Column C provides two options of how to arrange the stiffeners.

By using the *Regularly* option, you generate a uniform distribution in respect to the number of internal panels. If the number of internal panels is one (minimum number for division), the stiffeners are always arranged at the support. If the number of internal panels is 2, one more stiffener is considered in the middle of the span. If the numbers is 3, the stiffeners will be placed in the third-points of the span. The stiffeners influence the plate buckling analysis.

To specify different distances of the stiffeners in the span, you can select the option *User-defined*. If you click in a cell of column C, the [...] button appears. By clicking it, you open the following dialog box where you can specify the stiffener locations for the selected span.

	A			
Stiffener	Location			
No.	x [m]			
1	0.000 🚍			
2	0.500			
3	0.750			
4	1.750			
5	2.000			
6				
				×

Figure 2.12: Window 1.2 Geometry, tab Stiffeners, dialog box Location of Stiffeners

The *Option* dialog box section provides you the possibility to position the stiffeners: By selecting this check box, the stiffeners will be arranged only between those supports that restrain the degrees of freedom in the Z-direction. The division is carried out based on the selected number of internal panels. The following figure illustrates this option:



Figure 2.13: Regular positioning of the stiffeners only between the supports acting in the Z-direction



2.3 Cross-Section

In this window, you select the cross-section parameters, define rails, and specify requirements for the fatigue and weld designs.

1.3 Cross-Section		
Girder	Additional Designs	KB(L) HE B 300-50/30 DIN 1025-2:1995
Rolled section:	Perform fatigue design	
HE-B 300	Detail Categories	
© Welded section: IU 400/180/13.5/8.6/180/13.5	Perform weld seam design	
Rail Section	- Rail and flange	
🔿 Rail:	a : 5.0 📩 [mm]	164.0
SA 45 (worn-out)	· Upper flange and web	
Splice	a _o : 6.0 [mm]	330.0
a: 50.0 🔶 [mm]	Lower flange and web	11.0
b: 40.0 🚖 [mm]	au: 6.0 [mm]	9
Additional Section	Intermittent weld seam between rail and flange:	
Activate	- Weld seam length	
(a) ångler:	Lw: 100.0 [mm]	[mm]
L 50x5	Interruption length	i 🖾 🖾 🖾 🕅
	Li: 250.0 [mm]	Options
O Rolled channel:		25% reduction of the splice section due to wear
UPE 400		
Welded channel:		Consider rail section for the cross-section properties
UU 100/100/10/10/10/400 💿 🕼		
Cross-Sections Description		
HE B 300 DIN 1025-2:1995 + 50/30		

Figure 2.14: Window 1.3 Cross-Section

Girder

In this section, you define the cross-section of the crane runway beam.

Girder	
O Rolled section:	
HE-B 300	1
Welded section:	
IU 400/180/13.5/8.6/180/13.5	💽 💽

Figure 2.15: Section Girder

You can select the following cross-section types:

- Rolled section
- Welded section



For a rolled section, you can open an extensive [Library] of I-sections by clicking the according button. In the new dialog box, you can find the following I-section series (tables): I, IPE, IPEa, IPEo, IPEv, HE-B, HE-A, HE-M, HE-AA, etc. Having chosen an I-section series, you can then select the desired cross-section from the series. By clicking [Info], you can see the detailed information about the cross-section.



	To Select		To Select	HEB 300
	Table	Manufacturer/Standard	Cross-Section	
	I HE	•	HEB 100	
	I HEAA	•	HEB 120	
	I HEA	•	HEB 140	300.0
	II HEB	🔲 e 👘 👘	HEB 160	+ +
	Т НЕМ	•	HEB 180	
	I HSL	•	HEB 200	[⊕] 27.0
	I HP	•	E HEB 220	
	I UB	🚟 BS 4-1	HEB 240	
	IUC	🚟 BS 4-1	HEB 260	0.0
Filter	I IPN	🔼 Arbed	HEB 280	300
Hans for the set of the stand area as	I IPE	🔼 Arbed	HEB 300	
Manuracturer/standard group:	THE	📉 Arbed	HEB 320	11.0
All 🔻	THD	📉 Arbed	HEB 340	
Manufacturer/Standard:	IHL	🔼 Arbed	HEB 360	
	THP	🔼 Arbed	HEB 400	
AI	IW	Arbed	HEB 450	
Cross-section shape:	I WTM	Arbed	HEB 500	2
All 🗸	Inc	Arbed	HEB 550	
	IIPN	DIN 1025-1:1995	HEB 600	
Cross-section note:	I IPE	DIN 1025-5:1994	HEB 650	
All 👻	T HE B	DIN 1025-2:1995	HEB 700	
	THEA	DIN 1025-3:1994	HEB 800	
	THEM	DIN 1025-4:1994	HEB 900	
	T HE	British Steel	HEB 1000	
	1 IPE	British Steel		
🛿 Include invalid 🛛 🔤	I IPER	British Steel		
Favorites group:	T UD	British Steel		
- 🍋 🐺	TUB	Bita British Steel	-	HEB 300
	T OBP	I 🛲 British Steel		

Figure 2.16: Cross-section library for Rolled sections

If you select a *Welded section*, you can define a uniaxially symmetric I-section by using the [Edit] button.



Figure 2.17: Parametric input for Welded sections



The dimensions must be defined manually, but you can also import them by using the [^k] button from the rolled I-sections. You can save the defined cross-section in the user-defined library by clicking [Save]. The saved sections can be loaded from the library by clicking [Load].





Rail Section

For a bridge crane, you can specify the crane rail in this dialog box section.

Bail:		
SA 45		
🔘 Splice		
Splice	50.0 🔺 [mm]	

Figure 2.18: Dialog box section Rail section

Rolled rails can also be selected from the [Library].

Rolled Cross-Sections - Crane Rail	5			×
	To Select		To Select	SA 45 DIN 536-1 (b: 0.00 %)
	Table	Manufacturer/Standard	Cross-Section	
	≛ SA	💻 DIN 536-1	SA 45	
	🗷 SF	💻 DIN 536-2	SA 55	
	🚨 SA	Manual CAN/CSA-S16-01	SA 65	
	≛ CR	IS 3443:1980	SA 75	45.0
	≭ CR	IS 3443:1980, A	SA 100	
	± UR	🔤 15-3443:1980, B	SA 120 SA 150	201
			5A 150	
				+
Filter				
Manufacturer/Standard group:				
				125.0
Manufacturer/Standard:				
All 🗸				z
Cross-section shape:				
All				
Cross-section note:				
Al				
V Include invalid				
Eavorites group:				
			b: 50.00 A [%]	SA 45 LDIN 536.1 (b: 0.00 %)
		1		
2 📰 🎒 🗐				

Figure 2.19: Cross-section library for Rolled Cross-Sections - Crane Rails

For Splices, you must define the dimensions manually.

Any girder cross-section with a rolled or welded section can be combined with any rail or splice.

If the selected rail section is too large for the girder or the girder section too small for the rail, the input cannot continue until a plausible runway girder section is selected.



Additional Section

For a bridge crane, you can arrange additional cross-sections on the runway girder.

🔿 Angles:	
L 50x5	
L 50x5	
	(about
Solled channel:	
Rolled channel:	
Rolled channel: UPE 400	
Rolled channel: UPE 400 Welded channel:	

Figure 2.20: Dialog box section Additional Section

The following options can be selected:

- Angles
- Rolled channel
- Welded channel



The additional sections can be selected from the [Library] in the same way as for girders.

Rolled Cross-Sections - Channel Se	ections			
	To Select		To Select	UPE 400 DIN 1026-2:2002
	Table	Manufacturer/Standard 🔺	Cross-Section	
	EU	E DIN 1026-1:1963	UPE 80	
	C UPE	💻 DIN 1026-2:2002	UPE 100	115.0
	E UPE	🔼 Arbed	UPE 120	
	E UAP	INF A 45-255:1983	UPE 140	
	E UPN	🔼 Arbed	UPE 160	
	EU	🔡 British Steel	UPE 180	
	EU	🚃 GOST 8240-72	UPE 200	13.5
	EU	드 GOST 19425-74	UPE 220	
	E UP	📕 GOST 8240-72	UPE 240	0.00
Filter	E U	GB/T 707-88	UPE 270	4 y
Manufacturer (Chandard group)	EU	PN-86/H-93403	UPE 300	
Manuracturer/Standard group:	EU	📟 Malaysia 📰	UPE 330	29.8
All	EU	 JIS G 3192 	UPE 360	
Manufacturer/Standard:	EU	📧 KS D 3503, 3515/3!	UPE 400	
	EC	CAN/CSA-S16-01		
All	EMC	CAN/CSA-S16-01		
Cross-section shape:	EU	DIN 1026-1:1963 (R		z
All		GOST 8240-97		
	LUP	GUST 8240-97		
Cross-section note:		GUST 8240-97		[mm
All 👻	LUB	GUST 5267.1-90		
		15 000 1909		
💷 lu el ale tonella 🛛 📰		ArcelorMittal		
Minclude invalid	Гмс			
Favorites group:	C UE			
- 🗎 🔤		SZS -		UPE 400 DIN 1026-2:2002
(2)				OK Cancel

Figure 2.21: Cross-section library for Rolled Cross-Sections - Channel Sections

The selection and input in this dialog boxes is done in the same as for the girder cross-sections.

2 Input Data



0

At the end of the input fields for the individual section as well as the total cross-section, you find the [Info] button. The button opens the dialog box *Info About Cross-Section* with the properties of the selected cross-section.

Cross-sectional area A Shear area A Shear area A Distance to center of gravity e Moment of inertia Ij Yolar moment of inertia Ia Polar moment of inertia Ij Soverning radius of gyration rs Polar radius of gyration rs	A Ay Az ez Iy Iz Ip Iy Iz Ig Ig Ig	164.00 95.67 30.10 164.9 28891.50 8591.25 37482.70 132.7 72.4 151.2	cm ² cm ² cm ² cm ⁴ cm ⁴ cm ⁴ cm ⁴ mm	III		30.0	300.0		
Shear area A Shear area A Distance to center of gravity e Moment of inertia I Polar moment of inertia I Solar moment of inertia I Soverning radius of gyration I Polar radius of gyration I	Ay Az ez ly lz lp fy fz fo	95.67 30.10 164.9 28891.50 8591.25 37482.70 132.7 72.4 151.2	cm ² cm ² cm ⁴ cm ⁴ cm ⁴ cm ⁴ mm	Ш		30.0	300.0		
Shear area A Distance to center of gravity e Moment of inertia Ia Polar moment of inertia Ia Soverning radius of gyration ra Soverning radius of gyration ra Polar radius of gyration ra	Az ez ly lz lp fy fz fo	30.10 164.9 28891.50 8591.25 37482.70 132.7 72.4 151.2	cm ² mm cm ⁴ cm ⁴ cm ⁴ mm mm	m	-	30.0	300.0		
Distance to center of gravity e Moment of inertia la Polar moment of inertia la Soverning radius of gyration ra Soverning radius of gyration ra Polar radius of gyration ra	ez ly lz lp fy fz fo	164.9 28891.50 8591.25 37482.70 132.7 72.4 151.2	mm cm ⁴ cm ⁴ cm ⁴ mm mm	Ш	-	30.0	300.0		
Moment of inertia Ib Moment of inertia Ib Polar moment of inertia Ib Soverning radius of gyration rb Soverning radius of gyration rb Polar radius of gyration rb	ly lz lp ſy ſz	28891.50 8591.25 37482.70 132.7 72.4 151.2	cm ⁴ cm ⁴ cm ⁴ mm mm	ш	-	30.0	50.0		
Moment of inertia Ia Polar moment of inertia Ig Soverning radius of gyration rg Soverning radius of gyration ra Polar radius of gyration rg	lz lp ſy ſz	8591.25 37482.70 132.7 72.4 151.2	cm ⁴ cm ⁴ mm mm	Ш		30.0			
Polar moment of inertia I Soverning radius of gyration r Soverning radius of gyration r Polar radius of gyration re	lp ry rz ro	37482.70 132.7 72.4 151.2	cm ⁴ mm mm	ш		+			
Governing radius of gyration rg Governing radius of gyration ra ³ olar radius of gyration rd	ry rz ro	132.7 72.4 151.2	mm mm	=			<u> </u>	。	
Governing radius of gyration ra Polar radius of gyration ra	rz fo	72.4 151.2	mm	=				0	
Polar radius of gyration for	ſo	151.2	000				Ň	64.	
								-	
Weight w	WC	128.7	kg/m		0.0				
Surface A	Asurf	1.790	m²/m		330	00.00	M	+	۰. v
Forsional constant J	J	231.00	cm ⁴			с С			
Distance from the shear center to the central z	zM	14.5	mm				11.0		
Warping constant referring to M	Cw	1.696E+06	cm ⁶					0.0	
Fade factor A	λ	0.000724	1/mm					15	
Elastic section modulus S	Sy,max	1750.03	cm ³		1			•	
Elastic section modulus S	Sy,min	-1751.97	cm ³				+		
Elastic section modulus S	Sz	572.75	cm ³				-		
Warping section modulus S	Sw	8013.24	cm ⁴						
Statical moment of area	Q _{y,max}	1046.07	cm ³						
Statical moment of area	Q _{z,max}	214.70	cm ³						[mm]
Normalized warping constant V	Wno	211.68	cm ²				Change mainte		
Warping statical moment Q	Qw	3016.48	cm ⁴			123		🚔 🏹	
Stability parameter according to Kindem 👘 👔	y,Kindem	25.6	mm	-		123	C/t-Parts		
>=====================================	··· I	2.4							

Figure 2.22: Dialog box Info About Cross-Section

This dialog box provides also information about the Stress points and c/t-Parts.

The buttons below the graphic have the following functions:

Button	Function
Ŧ	Displays or hides the stress points
H	Displays or hides the c/t-parts
123	Displays or hides the numbers of stress points or c/t-parts
Ø	Shows details of the stress points or c/t-parts
X	Displays or hides the dimensions of the cross-section
\$⇒	Displays or hides the principal axes of the cross-section
X	Shows entire graphic of the cross-section

Table 2.1: Buttons in the dialog box Info About the Cross-Section

2 Input Data



If you activate the buttons [Stress Points on/off] and [Numbering], all automatically created stress points are displayed in the cross-section graphic.

If you click [Details of Stress Points], a dialog box opens showing the coordinates, statical moments of area, thicknesses, and warping ordinates of the stress points.

	A	B	C	D	E	F	G	KB(L) HE B 300-50/30 DIN 1025-2:19
ressP	Coordin	nates	Statical Mom	ents of Area	Thickness	Warp	ing	
No.	y [mm]	z [mm]	Qy [cm ³]	Q _z [cm ³]	t [mm]	W _{no} [cm ²]	Qω [cm ⁴]	
1	-25.0	-164.9	0.00	0.00	30.0	41.09	0.00	
2	0.0	-164.9	-112.42	-9.38	30.0	0.00	-154.10	
3	25.0	-164.9	0.00	0.00	30.0	-41.09	0.00	
4	-150.0	-134.9	0.00	0.00	19.0	209.82	0.00	
5	-32.5	-134.9	-279.62	-203.66	19.0	45.46	-2849.53	4 123
6	-32.5	-134.9	-279.62	-203.66	19.0	45.46	-2849.53	in the second se
7	0.0	-134.9	-361.28	-214.70	19.0	0.00	-2989.89	l Y
8	32.5	-134.9	-279.62	203.66	19.0	-45.46	2849.53	
9	32.5	-134.9	-279.62	203.66	19.0	-45.46	2849.53	13 y
10	150.0	-134.9	0.00	0.00	19.0	-209.82	0.00	
11	0.0	-88.9	-998.62	0.00	11.0	0.00	0.00	
12	0.0	119.1	-946.44	0.00	11.0	0.00	0.00	
13	0.0	0.0	-1045.98	0.00	11.0	0.00	0.00	14 15 101/ 18
14	-150.0	165.1	0.00	0.00	19.0	-211.68	0.00	z
15	-32.5	165.1	-347.41	203.66	19.0	-45.86	-2874.88	
16	0.0	165.1	-448.52	214.70	19.0	0.00	-3016.48	
17	32.5	165.1	-347.41	-203.66	19.0	45.86	2874.88	
18	150.0	165.1	0.00	0.00	19.0	211.68	0.00	
								A 🚺

Figure 2.23: Dialog box Stress Points

After you activate the buttons [c/t-Parts] and [Numbering], the c/t-parts of the cross-section are displayed in the cross-section graphic.

You can display the width c to thickness t ratio of all c/t-parts in a table by clicking the [Details] button. These values can be compared for example with [1] Part 1, Table 12.

	A	B	C	D	E	F	G	H		J	KB(L) HE B 300-50/30 DIN 1025-2:199
t-Part	Restrained	с	t	c/t	Coordinat	es Start	Coordinat	es End	Average Static	al Moments	
No.	Shape	[mm]	[mm]	[-]	y [mm]	z [mm]	y [mm]	z [mm]	Qy [cm ³]	Q _z [cm ³]	
1	One Side	117.5	19.0	6.18	-32.5	-134.9	-150.0	-134.9	139.81	123.71	
2	One Side	117.5	19.0	6.18	32.5	-134.9	150.0	-134.9	139.81	123.71	
3	One Side	117.5	19.0	6.18	-32.5	165.1	-150.0	165.1	173.70	123.71	
4	One Side	117.5	19.0	6.18	32.5	165.1	150.0	165.1	173.70	123.71	
5	Both Sides	208.0	11.0	18.91	0.0	-88.9	0.0	119.1	1020.72	0.00	1 2

Figure 2.24: Dialog box c/t-Parts



Q



Additional Designs

Perform fatigue design

In addition, you can perform a fatigue design.

Additional Designs	
📝 Perform fatigue design	
Detail Categories	
📝 Perform weld seam design	
Thickness of welds between	
- Rail and flange	
a: 6.0 🔿 [mm]	
- Upper flange and web	
ao: 6.0 🜩 [mm]	
Lower flange and web	
au: 6.0 fmm]	
🔲 Intermittent weld seam between rail and flange	:
- Weld seam length	
Lw: 100.0 [mm]	
Figure 2.25: Section <i>Fatigue design</i> (fo Additional Designs I Perform fatigue design	or EN 1993
Figure 2.25: Section <i>Fatigue design</i> (fo Additional Designs	or EN 1993
Figure 2.25: Section <i>Fatigue design</i> (fo Additional Designs Perform fatigue design Detail Categories Perform weld seam design	or EN 1993
Figure 2.25: Section <i>Fatigue design</i> (fo Additional Designs Perform fatigue design Detail Categories Perform weld seam design Thickness of welds between	or EN 1993
Figure 2.25: Section <i>Fatigue design</i> (fo Additional Designs	or EN 1993
Figure 2.25: Section Fatigue design (fo Additional Designs Perform fatigue design Detail Categories Perform weld seam design Thickness of welds between - Rail and flange ar: 6.0 [] [mm]	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs Perform fatigue design Detail Categories Perform weld seam design Thickness of welds between - Rail and flange ar:6.0 (mm) - Elange and web	or EN 1993
Figure 2.25: Section Fatigue design (fo Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between • Rail and flange ar: 6.0 ♣ [mm] • Flange and web au: 6.0 ♣ [mm]	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs Perform fatigue design Detail Categories Perform weld seam design Thickness of welds between - Rail and flange ar: 6.0 mm - Flange and web aw: 6.0 mm (mm)	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between - Rail and flange ar:6.0	or EN 1993
Figure 2.25: Section Fatigue design (fe Additional Designs Perform fatigue design Detail Categories Perform weld seam design Thickness of welds between - Rail and flange ar: 6.0 ← [mm] - Flange and web aw: 6.0 ← [mm]	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs Perform fatigue design Detail Categories Perform weld seam design Thickness of welds between - Rail and flange ar:6.0 [mm] - Flange and web aw :6.0 [mm]	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between - Rail and flange ar:6.0 [mm] - Flange and web aw:6.0 [mm]	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between - Rail and flange ar:6.0 (mm) - Flange and web aw:6.0 (mm)	or EN 1993
Figure 2.25: Section Fatigue design (fe Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between • Rail and flange ar:6.0 ↓ [mm] • Flange and web aw:6.0 ↓ [mm]	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs Perform fatigue design Detail Categories Perform weld seam design Thickness of welds between - Rail and flange ar:6.0 (mm) - Flange and web aw:6.0 (mm)	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between - Rail and flange ar:6.0	or EN 1993
Figure 2.25: Section Fatigue design (for Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between - Rail and flange ar:60	or EN 1993
Figure 2.25: Section Fatigue design (fe Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between • Rail and flange ar:	or EN 1993
Figure 2.25: Section Fatigue design (fe Additional Designs Perform fatigue design Detail Categories Perform weld seam design Thickness of welds between - Rail and flange ar:6.0 mm] - Flange and web aw:6.0 mm]	or EN 1993
Figure 2.25: Section Fatigue design (fe Additional Designs ♥ Perform fatigue design Detail Categories ♥ Perform weld seam design Thickness of welds between - Rail and flange ar: 6.0 € [mm] - Flange and web aw: 6.0 € [mm]	or EN 1993

2 Input Data



Detail Categories...

If you select this check box, the [Detail Categories] button becomes available. By clicking it, you open the *Edit Detail Categories* dialog box, where you can specify settings for the relevant stress points.

etail Cate	egories on En	tire Girder	Length					HE B 300
	A	В	C	D	E	F	G	
Stress	Coordinate	es [cm]	Thickness		Detail	Category		
pint No.	У	z	t [cm]	Existing	for σ_X	for σ _z	for τ _{xz}	1 2 3 4
1	-15.00	-15.00	1.90	✓	160		100	
2	-3.25	-15.00	1.90	✓	125		80	
3	0.00	-15.00	1.90		160		100	
4	3.25	-15.00	1.90	√	125		80	
5	15.00	-15.00	1.90	\checkmark	160		100	
6	-15.00	15.00	1.90	✓	160		100	13
7	-3.25	15.00	1.90		160		100	
8	0.00	15.00	1.90		160		100	
9	3.25	15.00	1.90		160		100	
10	15.00	15.00	1.90	V	160		100	
11	0.00	-10.40	1.10	V	160	160	100	, 18 9
12	0.00	10.40	1.10	V	160	160	100	z
13	0.00	0.00	1.10	Image: A state of the state	160		100	
etail Cat	ecories at Stif	ffeners						
	A	В	C	D	F	-	F	
Stress	Coordinate	es [cm]	Thickness	Detail Ca	ategory Alloca	ation	Distance	
oint No.	у	z	t [cm]	Existing	for	σχ	e [cm]	Stiffener -
14	-15.00	-13.10	1.90	2	8	0	0.00	
15	15.00	-13.10	1.90	2	8	0	0.00	
16	-15.00	13.10	1.90	2	8	0	0.00	S
17	15.00	13.10	1.90		8	0	0.00	+ ^e / _→ ← [−]
Symm	etrical layout o	of detail cat	egories	Dista e :	nce 0.00	🔶 [cm]		z
ietaii cat 30	The second secon							

Figure 2.27: Dialog box Edit Detail Categories

The upper table lists the automatically generated stress points including the automatic assignment of the detail categories for the fatigue design. If you select a stress point in column D *Existing*, the appropriate detail category can be assigned.

Due to the great additional normal stresses σ_{z_r} it is necessary (unlike for the upper flange) to specify a detail category for stress in z-direction.

....

If you click in a cell in column E or F to specify the detail category, the buttons [$\mathbf{\nabla}$] and [...] appear in the cell. [$\mathbf{\nabla}$] opens a drop-down list in which you can select the desired detail category; [...] opens a dialog box with an abstract from [2] or [8]. This dialog box also allows you to select the appropriate detail category.



Category	Structural Detail	Description
ම 160		Rolled and formed products: 1) Plate and wide flats. 2) Rolled cross-sections. 3) Seamless hollow rectangular or round cross-sections. Details 1) to 3): Sharp edges and surface and rolling defects are corrected by grinding until a smooth transition is reached.
© 140		Scissored surfaces or surfaces cut by oxygen: 4) All visible edge asperities will be removed. Cut surfaces will be machined and grinded and all slivers removed. All scratches can be only in loading direction.
O 125	S	Edges machine-cut by oxygen: 5) Material cut manually by oxygen with subsequer processing of all irregularities at burned edges.

Figure 2.28: Dialog box Allocate Detail Category according to EN 1993-1-9

Alloca	te Detail Ca	ategory for Sigma-x According to DIN 4132		X
Notch Category	Indenture Number	Description	Picture	Symbol
© wo	W01	Components with ordinary surface integrity and with lateral surfaces as rolled edges or saw notches, if superposed geometric notch effects do not exist or have been taken into account for the stress analysis, e.g. first cuts. Thermal cut surfaces must at least be of quality as required in DIN 2310 Part 3, edition February 1975, subclause 2.		
O WI	WII	Components with scissor or thermal cut surfaces with at least quality 23 according to DIN 2310 Part 3, edition February 1975, subclause 2, if superposed geometric notch effects do not exist or have been taken into account for the stress analysis, e.g. cut-outs.		
Юко	021	Components connected by ordinary-quality butt-weld, bevel seam with fillet or double bevel seam with double fillet along the force direction.		жлхк
Окі	123	Components connected by double level web seam with double fillet, single bevel groove plus root face with fillet, double level groove along the force direction.		مححه ط> € م
				ancel

Figure 2.29: Dialog box Allocate Detail Category according to DIN 4132

....

In the lower table of the *Edit Detail Categories* dialog box (see Figure 2.27), you can define the stress points at stiffeners with the corresponding detail categories for fatigue design. Only the stress points at the x-locations of stiffeners are considered. The relevant detail category must also be assigned to these stress points. By clicking [...], you access the abstract from [2] or [8], which can help you with the selection of the detail category.

Q



The stress points and detail categories are preset for the stiffeners; you can, however, edit their coordinates and numbers. If you select the option *Symmetrical layout of detail categories*, the data for the distance *e* and the detail categories for all stress points of the stiffeners is changed. Then, you can use the input field *Distance e* and the *Detail category* drop-down list located below the table with new stress points.

	A	B	C	D	E	F	
Stress	Coordina	tes [cm]	Thickness	Detail Categ	ory Allocation	Distance	76
oint No.	У	z	t [cm]	Existing	for σ _x	e [cm]	
14	-15.00	-13.10	1.90		80	0.00	1
15	15.00	-13.10	1.90		80	0.00	7
16	-15.00	13.10	1.90	✓	80	0.00	
17	15.00	13.10	1.90		80	0.00	7
🗸 Symme	trical layout	of detail cat	egories	Distance			
				e:	0.00 🚖 (cm		
Detail cate	egory:						

Figure 2.30: Section Notch Categories at Stiffeners for Symmetrical layout of notch categories

If you clear the selection of the check box *Symmetrical layout of detail categories*, the columns E and F for each stress point of the stiffeners become available. They allow you to define a detail category and a distance *e* for each stress point.

By clicking [Details] in this section, you open a dialog box with the coordinates and static properties of these stress points arranged in a table.

Juessilo		P (C	D	E	F	G
Stress	Coordinate [cm]		Statical Moments [cm ³]		Thickness	Warping Coordinate	Warping Area
Point No.	у	z	Qy	Qz	t [cm]	ω [cm ²]	A _w [cm ⁴]
18	-15.00	-10.37	0.00	0.00	1.90	205.87	0.00
19	15.00	-10.37	0.00	0.00	1.90	-205.87	0.00
20	-15.00	15.83	0.00	0.00	1.90	-215.63	0.00
21	15.00	15.83	0.00	0.00	1.90	215.63	0.0
							e





24



Perform weld seam design

If you select the check box Perform weld seam design, you can define the thickness of the weld seam between rail and flange. For a welded cross-section, you can also specify the weld thicknesses between rail and flange.

Additional Designs	
📝 Perform fatigue design	
Detail Categories]
	, ,
📝 Perform weld seam design	
Thickness of welds between	
- Rail and flange	
a: 6.0 🚔 [mm]	
- Upper flange and web	
ao: 6.0 + [mm]	
- Lower flange and web	
au: 6.0 📩 [mm]	
📝 Intermittent weld seam betweer	rail and flange:
- Weld seam length	
Lw: 100.0 🚔 [mm]	
- Interruption length	
Li: 250.0 [mm]	

Figure 2.32: Section Additional Designs

The Intermittent weld seam is appropriate for cases in which the weld seam between the crane rail and flange is not continuous. A parallel opposing arrangement is assumed. After you select the check box, you can specify the length of the weld seam and the interruption. These specifications are considered in the design.

Options

This section provides two check boxes relevant for rail sections.

Options
25% reduction of the rail section due to wear
Consider rail section for the cross-section properties
Figure 2.33: Section Option
If you select the check box 25% reduc

ction of the rail section due to wear, a reduced cross-section will be considered for the rail or splice. In this way, the cross-section SA 45 (worn-out) for rail SA 45 or the splice 50/30 for splice 50/40, for example.

If you select the check box Consider rail section for the cross-section properties, not only the increased cross-section properties will be considered, but also the crane loads will be related to the upper rail edge.



2.4 Loading

In Window 1.4, you define the loadings applied to the crane runway girders.



Figure 2.34: Window 1.4 Loading

By using the *Number of cranes* drop-down list, you can define how many cranes can travel together on the same crane runway girder (the maximum is three cranes). If there are *Girder buffers* keeping the crane from driving outside the girder on the left or right end, the number of the load combinations is reduced.

In addition to the loading due to crane operation, two *Additional loads* can be defined: permanent load *g* and lateral load *w* (wind). The self-weight need not be defined as permanent load, because it is considered automatically. The lateral load is applied as variable line load in the center of gravity.

The two options in the right upper corner help to differentiate between the loads applied on the crane runway girder: If the design of the crane runway girder with the maximum wheel loads is sufficient, you can select the *Only girder with* W_{max} option. However, if it is not clear, which loads are governing on which girder, the conservative option *Crane loads at both girders* (W_{max} and W_{min}) should be selected. Thus, the number of load combinations also increases.

The middle part of this window includes two sections, where you can define the *Crane Parameters* and *Crane Loads*.

By clicking [Copy], you can copy the input parameters of the crane No. 1 to the second or the third crane. You can always switch between the cranes by clicking the respective tab.

You can select a crane by using the [Library] button that opens the according dialog box. For DIN 4132, a *Database* with cranes from the producers DEMAG and KÜHNEZUG is available. The parameters can also be *user-defined* and [Saved] for later usage.



Crane Parameters

The input fields of this section are dependent on the selected standard.

DIN 4231

Crane Para	meters		
Crane desc	ription:		
📃 Hoisting	class:		Stress group
H1 🔻			B2 🔻
Dynamic co	efficient		Number of crane axles:
Girder	φG:	1.10 🚔 [·]	2 🗸 🚔
Support	φs:	1.00 🚔 [•]	
			Center distances
Crane buffe	r		a1: 3.600 🚔 [m]
Left	aL:	0.050 🚔 [m]	a2: 1.000 📩 [m]
Right	aR:	0.050 🚖 [m]	a3: 1.000 🛬 [m]

Figure 2.35: Section Crane Parameters

The *Hoisting class* (H1 through H4) determines the value of the *Dynamic coefficient*. The selection of the hoisting class becomes available after you select the check box. Otherwise, you enter the *Dynamic coefficient* for the girder and the support manually.

The *Stress group* (B1 through B6) influences the value of the allowable stresses for the fatigue design. If the stress group is B4 to B6, the program considers the eccentric load application at ¼ of the rail head width according to [2].

For one crane, the *Number of crane axles* cannot be higher than four. Furthermore, you can enter the *Axle distances* and the distance of *Crane buffers*.

EN 1993-6

Crane Para	imeters		
Crane desc	cription:		
S-Class:			Number of crane axles:
S2,S3	•		2 🔹 🚔
Dynamic c	pefficients q .		Axle distances:
Crane buff	-re		i a; [m] 🔺
Loft		0.050 🛋 [m]	1 3.600 ≡
Len	aL:	0.000 📼 [m]	2
Right	ar:	0.050 🚖 [m]	3
			5
Wheel dist	ance		6
n:	20.0 🌲 [r	nm]	7

Figure 2.36: Section Crane Parameters

In the *S-Class* list, you can select the relevant stress group (damage group). For the stress groups S4 (S3 according to DIN) through S9, CRANEWAY considers the eccentric load application of ¼ of the rail head width according to [5] and [8].

You can specify up to 20 *Crane axles* for each crane. In the table or the input fields below, you can enter the according *Axle distances* and the distances of the *Crane buffers*.

By clicking [Grouping Wheels], you open a dialog box where you can define wheel groups. The dialog box is shown in the following figure.



Groups	Parameters of Craneway
Number of groups:	Crane buffers aL: 0.050 (m) aB: 0.055 (m)
Distance between groups s : 2.000 🚔 [m]	Total length of the craneway
Wheels in Group	L: 7.100 [m]
Number of wheels:	
Distance between wheels	
a: 1.250 🚔 [m]	

Figure 2.37: Dialog box Grouping Wheels

In the *Groups* section, you specify the number and distance between the groups. In the *Wheels in Group* section, you can specify the number of wheels and the distance between them (axle distance). The *Parameters of Craneway* section shows the resulting crane length with the crane buffers used.



By clicking [Edit Dynamic Coefficients] in the *Crane Parameters* section (Figure 2.36), you open a dialog box where you can specify the dynamic coefficients φ of the crane runway beam according to [5].

Dynamic Coefficients		×
Crane No. 1		
Dynamic Coefficient for		
-Weight of crane	φ1:	1.100 🚔
- Load lifting	φ2:	1.130 🚔
- Sudden pull-off weight	Q 3:	1.000 🛬
- Crane travel	φ 4:	1.000 🛬
- Driving force	φ5:	1.500 🛬
Option		
Apply values to all cranes		
	 C	IK Cancel

Figure 2.38: Dialog box Dynamic Coefficients

Crane Loads

The input of the Crane Loads differs depending on the selected standard:

Axle	Vertical Wheel Load	Horizontal V	Vheel Loads	
j j	W _{max} [kN]	H _M [kN]	Hs[kN]	
1	75.0	0.00	0.00	
2	75.0	0.00	20.00	
3				
4				
		,	D'1 (

Figure 2.39: Section Crane Loads according to DIN 4132



Axle	Vertical Wh	eel Loads	Horizontal Wheel Loads					
j –	Qc,i,j [kN]	Qн,i,j [kN]	H _{T,i,j} [kN]	Hs,i,j [kN]	Нтз,і,ј [kN]			
1	18.00	57.00	-8.60	0.00	0.00			
2	18.00	57.00	8.60	20.00	0.00			
3								
4								
5								
6								
7								
8								
9								

Figure 2.40: Section Crane Loads according to EN 1993-6

For each wheel, all applied loads must be specified. For the calculation according to **DIN 4132**, these are the maximum *Vertical Wheel Loads W* and the *Horizontal Wheel Loads* from the inertial forces caused by operation H_M and the *Skew force* H_S and *S*.

For **EN 1993-6**, you must define the maximum *Vertical Wheel Loads* Q_c (due to self-weight of the crane) and Q_H (due to hoist load), the Horizontal Wheel Loads H_T (due to acceleration and braking of the crane bridge), H_{T3} (due to acceleration and braking of the crane trolley or the hoist), and the Skew forces H_S and S.

All loads act on the top of the rail: The skew force can be applied independently of other loads (for example for guide rollers) with a different distance from the axle. In such a case, you define the *Distance e* of the load application point of S to the selected *Axle*.

If you activate the option **Additional loads at both girders (W**_{max} **and W**_{min}), a second tab becomes available. There, you can specify the minimum *Vertical* and the according *Horizontal Wheel Loads*.

Axle	Vertical Wh	neel Loads	Horizontal Wheel Loads						
j	Qc,i,j [kN]	Q _{H,i,j} [kN]	HT,i,j [kN]	Hs,i,j [kN]	Нтз,і,ј [kN]				
1	0.00 🗄	0.00	0.00	0.00	0.00				
2	0.00	0.00	0.00	0.00	0.00				
3									
4									
5									
6									
7									
7									

Figure 2.41: Section Crane Loads if option Additional loads at both girders is selected

Load Increment

This section controls the increment of the crane load positions.

Increment of crane positions:	0.500 🚔 [m]
Number of generated	
Crane positions:	756
- Load combinations:	3781

Figure 2.42: Section Load Increment

The default distance is 50 cm. When defining the load increment, remember that all generated load combinations must be calculated. The *Number of generated crane positions* and *Load combinations* is dependent on the geometry of the runway beam, the loads to be considered, and the load increment.

Additional loads at:

Both girders (W-max and W-min)
 Only girder with W-max



2.5 Load Cases

The dynamic 1.5 *Load Cases* window provides an overview of the action situations with all loads and load combinations.

1.5 Load	Combinatio	ons										
Load Cor	mbinations								Load Cases	3		
A	В	C	D	E			F		A	В		
CO		Location of	1st Wheel of	Crane [m]			Load		LC			
No.	Girder	Crane 1	Crane 2	Crane 3			Description		No.	Description		
CO58	Max	5.100			γg (LC	1+	LC91) + γο LC96 + γοο LC2		LC1	Self-Weight + Permanent Load		
CO59	Max	5.100			γG (LC1 + LC93) + γQ (LC95 + LC96) + γQo LC2				LC2	Additional loads lateral		
CO60	Max	5.100			γG (LC1 + LC93) + γQ (LC95 + LC97) + γQo LC2				LC107	Qc		
CO61	Max	5.100			γg (LC	1+	LC93) + γο (LC95 + LC98)		LC108	Qc @1		
CO62	Max	5.600			γg (LC	1+	LC100) + γ _Q (LC102 + LC104) + γ _{Qo} LC2		LC109	Qc @4		
CO63	Max	5.600			γg (LC	1+	LC99) + γο LC104 + γοο LC2		LC110	Q h max(φ2, φ3)		
CO64	Max	5.600			γg (LC	1+	LC101) + γ _Q (LC103 + LC104) + γ _{Qo} LC2		LC111	Qh φ4		
CO65	Max	5.600			γg (LC	1+	LC101) + γ _Ω (LC103 + LC105) + γ _{Ωo} LC2		LC112	Ητ φ5		
CO66	Max	5.600			γg (LC	γG (LC1 + LC101) + γQ (LC103 + LC106)			LC113	(H _s + S)		
CO67	Max	6.100			γg (LC	γG (LC1 + LC108) + γQ (LC110 + LC112) + γQo LC2				H _{T3}		
CO68	Max	6.100			γg (LC	G (LC1 + LC107) + γο LC112 + γοο LC2 -						
For:	Resistance		•	·								
Details Partial	Safety Fact	ors			со	67	C067 : 1.35*LC1+1.35*LC108+1.35*LC110+1.35	*LC1	12			
Pen	manent Actio	ons	γG	1.350								
- Vari	iable Actions	s - Crane	γQ	1.350			. 86 954					
- Vari	iable Actions	- Other	γQo	1.500								
Con	nbination Fa	ctor	Ψ	1.000			26.730					
Additio	onal loads pe	ermanent	g	0.00	kN/m		T T		00.004			
Additio	onal loads lat	teral	w	0.00	kN/m				26.730			
Crane	No. 1						1.738		†			
- Dyn	namic Coeffic	cient	Φ1	1.100			17.415		ŧ			
- Dyn	namic Coeffic	cient	φ2	1.130		=						
- Dyn	namic Coeffic	cient	φ3	1.000			17.415	-		1.738		
- Dyn	namic Coeffic	cient	φ5	1.500			-	1				
🗆 Wh	eel No.1							1				
- P	osition		X1	6.100	m							
- G	λc φ1		LC108	19.80	kN							
G	h [*] Ø2		LC110	64.41	kN							
- H	Τ Φ5		LC112	-12.90	kN							
🗆 Wh	eel No.2											
- P	osition		×2	2.500	m				0			
G	c @1		LC108	19.80	kN	Ŧ			203			

Figure 2.43: Window 1.5 Load Cases

Load Combinations

The row selected in this section determines the content of all other sections. The corresponding load cases, details, and load graphic are dynamically displayed for the selected load combination.

Load combination for calculation

From the drop-down list located below the *Load Combinations* table, you can select the design situation whose load combinations you want to be displayed: *Resistance, Fatigue* (EN 1993-6), *Deformation*, and *Support Forces*.

Load Cases

This section lists all load cases which are used in the current load combination (that is, the CO selected in the table to the left).

Details

This section lists the partial safety factors and dynamic coefficients as well as the loads of the current load combination. When you select another load combination or design situation, the graphic is updated.





Preview

The graphic shows the current design situation in 3D-rendering.



The load action and load values can be displayed or hidden by using the [Loads] and [Show Value] buttons.

Use the **mouse wheel** to zoom, move, or rotate the view. The position of the pointer is always assumed as center of the zoom area.

Press the wheel button to move the model directly within the workspace, that is, without previously activating the toolbar button [Move, Zoom]. If you additionally press the [Ctrl] key, you can rotate the model. Rotating the model is also possible by moving the mouse while pressing the wheel button the right mouse button at the same time. The mouse pointer symbols are indicating the selected function.





2.6 Imperfections

In this window, you can define the initial imperfections of the girder according to EN 1993-1-1 [7] or DIN 18800 Part 2 [1]. They are needed for the second-order flexural-torsional buckling analysis. The imperfections will be created from the camber rise of the local bow imperfection.

of Defi	nition									
Calculate nethod	e automatically	with the eigenvalu	e Bucklii	stress curve						
efine m	anually		BSC ₂ :	b 🔻 🚺						
							w	w		
erfection	Parameters	-			1		Т	н нѕ		
00	A	B Defectionath	Comber Bies	A			<u>. V</u>	11/		
No.	No	Lengui	wa fom]	=		VT	N	^{'0}	—	—
0.1*	0.	L [m]	w 0 [cm]]		ŶĨ				
C02*		6.000	0.00			+		- +	+	+
C02	1	6.000	0.800							
CO4*	1	6.000	0.000			L	.oca	l bow imperfect	ion	
CO5*	1	6 000	0.000					Buckling	Camb	er
CO6*	1	6.000	0.800			-	_	Stress Curv	ve Wo	
C07*	1	6 000	0.800				1	ao	L/350	
CO8*	1	6.000	0.800				2	я	L/300	,
CO9*	1	6.000	0.800			-	-			_
CO10*	1	6.000	0.800				3	b	L/250	
011*	1	6.000	0.800				4	с	L/200	•
012*	1	6.000	0.800			ŀ	-			-
CO13*	1	6.000	0.800			L	5	a	L/150	•
014*	1	6.000	0.800			а	ccor	ding to EN 1993-	1-1, Table 5.1	
015*	1	6.000	0.800			Selecting la	itera	l torsional buck	ling curve	
CO16*	1	6.000	0.800			Cross-			Buckling Stress	Camber(k en)
CO17*	1	6.000	-1.200			Section		Limits	Curve	wo
018*	1	6.000	0.800					h/b <= 2	b	1/500
CO19*	1	6.000	0.800			Rolled	e .		-	
2020	1	6.000	0.800			1 500001		h/b > 2	c	1 / 400
2021	1	6.000	0.800			Welded		h/b <= 2	c	1 / 400
2022*		6.000	0.800			I-sections	5	LL. 2		4 / 200
2023		6.000	0.800					n/o > 2	0	17300
2024		6.000	0.800			according to	EN	1993-1-1, Table 6	3.5	
2025		6.000	0.800			9				
020		6.000	0.800							
JU21		6.000	0.800	-						

Figure 2.44: Window 1.6 Imperfections

Type of Definition

If you select the option *Calculate automatically with the eigenvalue method*, CRANEWAY determines the appropriate imperfection (shape, camber rise, and direction) for each load combination. They are considered in the second-order analysis, always applying the first eigenmode.

If you select the *Define manually* option, you first decide whether the imperfections should be determined automatically first.

CF	BANEWAY		
Question: Should the at first and t	imperfections b hen set as defe	e calculated ault?	automatically
	Yes	<u>N</u> o	

Figure 2.45: Question for option Define manually

0

Then you can manually define or edit the imperfection parameters.

The *Buckling stress curve* Bsc_z is always automatically preset. It is dependent on the selected cross-section with consideration of the rail section. The [Info] button opens the *Info About Cross-Section* dialog box, where the buckling stress curve of the cross-section is also listed (see Figure 2.22, page 19).



Imperfection Parameters

In this section, you can edit the imperfections for all load combinations. For the type of definition *Calculate automatically with the eigenvalue method*, the table is disabled and filled with question marks before the calculation.

After the calculation or by clicking [Calculation], the question marks will be replaced by the determined imperfection parameters.

For the type of definition *Define manually*, the imperfection parameters are available so that the higher eigenmodes can be used. For the selection of the eigenmode, you can use a list, which you open by clicking [\checkmark].

	A	B	C	
CO	Eigenmode	Refer. Length	Camber Rise	
No.	No.	L [m]	wo [cm]	
CO1*	1	6.000	1.500	
CO2*	1 😼	6.000	0.800	
CO3*	2	6.000	0.800	
CO4*	3	6.000	0.800	
CO5*	4	6.000	0.800	
CO6*	5	6.000	0.800	
C07*	6	6.000	0.800	
CO8*	7	6.000	0.800	
CO3*	8	6.000	0.800	
CO10*	9	6.000	0.800	
CO11*	10	6.000	0.800	
CO12*	1	6.000	0.800	
CO13*	1	6.000	0.800	
CO14*	1	6.000	0.800	
CO15*	1	6.000	0.800	
CO16*	1	6.000	0.800	
CO17*	1	6.000	-1.200	
CO18*	1	6.000	0.800	
CO19*	1	6.000	0.800	
CO20*	1	6.000	0.800	
CO21*	1	6.000	0.800	
CO22*	1	6.000	0.800	
CO23*	1	6.000	0.800	
CO24*	1	6.000	0.800	
CO25*	1	6.000	0.800	
CO26*	1	6.000	0.800	
CO27*	1	6.000	0.800	

Figure 2.46: Selection of Eigenmode

....

1

Using the manual definition, you also can determine the camber rise according to [7] or [1]: By clicking the [...] button in a cell of the camber rise or the [Edit] button at the end of the table, you open the following dialog box.

nperfection Parameters								
.ocal bow imperfections:								
Define	WD:	0.800 🚖 [cm]						
Calculate according to EN 1993-1-1								
Reference or span length	L:	6.000 🚖 [m]						
Buckling stress curve of the cross-section	Bscz:	b 🔹 🕄						
Local bow imperfection acco to EN 1993-1-1 Table 6.5:	rding	L/250						
Resulting local bow imperfection	WD:	0.800 [cm]						

Figure 2.47: Dialog box Determine Camber Rise of the Imperfection

If you open the dialog box from a *Camber Rise* cell, the determined value will be assigned only to the current load combination. If you open this dialog box clicking [Edit] at the end of the table, the value will be assigned to all load combinations.

Calculation



3. Calculation

3.1 Detail Settings

Before you start the [Calculation], check the design details first. To this end, open the according dialog box by clicking [Details]. This button is available in all windows.

The content of this dialog box depends on the Standard selected for design.

3.1.1 EN 1993-6

Calculation of Internal Fo	rces		Rail-Flange Connection The rail is immovably connected with flange The rail is movably connected with flange The rail is lying on the elastomeric bearing pad				Reduction of Imperfections				
 Fast Calculation Calculation of the gov FE-LTB Detailed Calculation Calculation of all load 	verning load po positions in FE	sitions in -LTB					 ☑ 0.5 reduction for lateral-torsional buckling according to EN 1993-1-1, 5.3.4 Modify imperfection values for 0.7 ≤ λ_{LT} ≤ 1.3 according to DIN EN 1993-1-1, 5.3.4 				
Allowable Deformation											
Vertical: L / 600 Horizontal: L / 800 Horizontal: L / 800 Ho							ation of <u>h</u> oriz ing the colum I-6, Tab. 7.1 I	on of <u>h</u> orizontal deformations the column height according to Tab. 7.1 b			
		Metho Deforn (only fo	d <u>2</u> nation relativ or elastic sup	e to the defor ports with sim	med system ilar stiffness)		Column H he : Hoisting clas	3.000 🚖	[m] HC1 -	·	
Method 3 Deformation relative to the line connecting inflection points of deformed member axis											
)amage Equivalent Coef	ficients Lambd	a-i									
Category S	So	S1	S2	S3	S4	S5	Se	S7	S8	Se	
Normal Stress Shear Stress	0.198	0.250	0.315	0.397 0.575	0.500	0.630 0.758	0.794	1.000	1.260 1.149	1.58	
								OP			

Figure 3.1: Dialog box Details, tab CRANEWAY for EN 1993-6

Calculation of Internal Forces

You can choose between two calculation methods. The *Detailed Calculation* analyzes all load combinations according to the second-order analysis for warping torsion, while the *Fast Calculation* only according to the linear-static analysis. From these results, the governing load combinations are selected, which are then used for the second-order analysis for warping torsion.

Rail-Flange Connection:

The settings in this section control the effective width of the wheel load distribution on the upper flange according to [6] clause 5.7. The equations implemented for these three options are according to [6] Table 5.1.

Reduction of Imperfections

According to [7] clause 5.3.4, the camber rise of the bow imperfection about the minor axis of the structural component can be reduced by coefficient *k* for lateral-torsional buckling. The recommended value is 0.5.

Calculation

Details...



Allowable Deformation

For the determination of the limit deformations, you can select one of three methods:

Method 1: allowable deformations are relative to the undeformed system and its member axes. This approach is suitable for rigid supports, because the displacements at the support nodes in Z-direction are zero.

Method 2: limit deformations are determined relative to the deformed system. You can select this check box only if you defined spring constants for the supports.

Method 3: inflection points of the deflection curve are calculated and the allowable deformations are relative to the according lengths.

In addition, the allowable deformations can be determined *considering the column height*. Optionally, it is also possible to perform an *Assessment of outdoor craneway* according to [6] Table 7.1 d.

Damage Equivalent Coefficients λ_i

These coefficients are required for the calculation of the damage equivalent stress range in fatigue design and are taken from [5], Table 2.12. The default coefficients can be edited, if necessary.

3.1.2 DIN 4231

Details - DIN 4132	×
CRANEWAY FE-LTB	
Calculation of Internal Forces	Localized Plasitification
 Fast Calculation Calculation of only the governing load positions in FE-LTB (torsional buckling second order theory) 	Exceed equivalent stresses or R,d by 10 % according to DIN 18800 Part 2, Element (749)
 Detailed Calculation Calculation of all load positions in FE-LTB 	Assumption of Loads
	Handle lateral loads as principal loads according to DIN 4132,
Allowable Deformations	Subclause 3.1 for the stress analysis
 According to Bases of Calculation for Craneways, Swiss Central Office of Steel Construction, 1979 	Handle lateral loads as principal loads according to DIN 4132, Subclause 3.1 for the serviceability limit state design
O User-defined Vertical: L / Horizontal: L /	□ Increase lateral loads \underline{H}_{s} and S by 10 % according to DIN 4132, Subclause 3.2.1.1 and ignore lateral loads H _M . Note: Load combinations with H _M are not ignored if using the Fast Caluculation method.
	Reduction of Imperfections
	☑ 2/3 reduction according to DIN18800 Part 2, Element (201) for elastic-elastic design
	☑ 0.5 reduction according to DIN 18800 Part 2, Element (202) for lateral torsional buckling
	OK Cancel

Figure 3.2: Dialog box Details, tab CRANEWAY for DIN 4132

Calculation of Internal Forces

This section is described in chapter 3.1.1.

Allowable Deformation

The values of limit deformations can be defined *According to Bases of Calculation for Craneways, Swiss Central Office of Steel Construction* [15] or *User-defined* for the vertical and horizontal directions.



Localized Plastification

If you select this check box, the *equivalent stresses* $\sigma_{R,d}$ can be exceeded by 10 %. In the stress analysis, the stresses σ_x and σ_{eqv} are then compared with the increased limit stresses. The stresses σ_z , on the other hand, are compared to the usual (not increased) limit stresses.

Assumption of Loads

The *Calculation of Internal Forces* (see dialog section to the left) controls which check boxes can be accessed here.

The option *Handle lateral loads as principal loads for the stress analysis* specifies that the horizontal inertial forces caused by operation and the wheel loads will be regarded as one load. If they occur simultaneously, these actions will therefore not be multiplied by the combination coefficient ψ in the determination of the internal forces.

The option *Handle lateral loads as principal loads for the serviceability limit state design* specifies that the horizontal inertial forces due to operation will be considered in the fatigue design. Thus, not only the load combination with vertical wheel loads (fundamental combination 1), but also the load combinations with the horizontal inertial forces due to operation (fundamental combination 2) will be analyzed in the fatigue design.

While the first two check boxes need to be selected only rarely, it is always recommended to select the option *Increase lateral loads* H_s and S by 10% and ignore lateral loads H_M . However, this check box is accessible only for the *Detailed Calculation* option (see dialog section to the left).

According to [2], the possible superposition of the lateral forces from operation and from skew forces may be considered in this way. Only the increase of skew forces by 10% is carried out in CRANEWAY. The Fundamental combinations 1 and 2 remain unchanged. Therefore, only the internal forces for fundamental combination 3 will change.

Reduction of Imperfections

The settings in this section have an effect only on the automatic determination of the imperfections. Smaller camber rises of the bow imperfections can be achieved by both options 2/3 reduction for elastic-elastic design and 0.5 reduction for lateral torsional buckling.


3.1.3 FE-LTB

The second tab of the *Details* dialog box is independent of the selected design standard. It controls the calculation parameters of the integrated module FE-LTB.

etails - DIN 4132	×
CRANEWAY FE-LTB	
Calculation Parameters	Settings for Iterations
Calculate critical load factors of all load combinations	Maximum number of equilibrium iterations: 50
Consider secondary shear stresses	Maximum factor nu: 10.000 🚖
Target length of	Increment: 2.000 🜩
Finite elements: 0.500 😓 [m]	Break-off limit: 0.00100 🛬
Number of buckling modes to be calculated for the effective imperfections:	
	OK Cancel

Figure 3.3: Dialog box Details, tab FE-LTB

FE-LTB is an analysis core that determines the internal forces according to the second-order analysis for warping torsion and therefore is suited for the lateral-torsional analysis of crane runway beams.

Calculation Parameters

You have to select whether or not CRANEWAY should *Calculate critical load factors of all load combinations*. If you select this check box, the program checks whether or not a stability failure occurs under the defined external action: If the critical load factor is less than 1, a warning appears and the calculation is stopped.

The check box *Consider secondary shear stresses* applies for the shear stresses due to the secondary torsional moment $M_{T,s}$. If the check box is not selected, only the shear stresses due to the shear forces and the first torsional moment $M_{T,p}$ are determined.

The *Target Length of Finite Elements* check box controls the length of the finite elements of the crane runway girder. The length of the element should not be greater than 1/8 of the span: Usually, 8 elements for each girder span are enough to calculate the deformations with a deviation of less than 5% relative to the precise solution.

The Number of buckling modes to be calculated for the effective imperfections defines how many eigenmodes for the imperfections of the load combinations will be calculated (see Figure 2.46, page 33).



Settings for Iterations

This section controls the calculation of FE-LTB. The iterative determination of the deformations stops when the ratio of the displacement difference to the determined displacement in an iteration is smaller than the *Break-off limit*. At the latest, the calculation stops when the *Maximum number of equilibrium iterations* is reached and shows the result. The recommended values are **50** for the number of iterations and **0.001** for the break-off limit.

The values in the fields *Maximum factor nu* and *Increment* represent additional break-off criteria for the determination of the critical load factors and the increments of the load increase. CRANEWAY proceeds in the following way: First, it performs a calculation with the given loading. Then, in the determination of the critical load factor, the load is incrementally increased until the maximum factor nu is reached. As soon as the stability failure occurs, the program tries to distinguish more accurately between the two last increments of loading to determine the critical load factor as precisely as possible.

The recommended values are **10** for the maximum factor nu and **2** for the Increment.

3.2 Start Calculation

To start the calculation, click the [Calculation] button, which is available in all input windows of CRANEWAY.

The process of the calculation is then displayed in a dialog box.

	RSTAB - Calculation			
	Calculation of Load Combinations	CO139		
	Partial Steps			
	Calculation Stages	46 / 46	Number of supports:	
-	- Initializing		Number of members:	
0	- Determining imperfections		Number of cranes:	
	- Internal forces - second order the	ory	Number of stress points:	1
5	- Stress analyses	-	Number of load combinations:	13
10	- Internal forces - second order the	ory		
0	- Serviceability limit state design			
C	- Deformations - second order theor	у		
	-	C055		
	FE-LTB Calculation	C014		

Figure 3.4: Dialog box Calculation

Calculation



4. Results

After the calculation, the 2.1 Design Summary window appears.

ita	2.1 Design Summary							
eral Data		P	1 C	(n	(E)	F	HE 8 200	
metry	<u>^</u>	Member	Location	Design	Criterion	Governing	HE 8 300	
s-Section	Type of Design	No.	x [m]	existing	limiting	CO		
ang	2.4 Stress Analysis	2	3 400	0.898	<1.00	CO140		
d Combinations	2.5 Deformation Analysis - Horizontal	2	3,400	769 180	> 600.000	CO140		
rrections	2.5 Deformation Analysis - Vertical	2	3 400	1164 822	> 800 000	C0112	1 2 3 4	
an Cumman	2.6 Fatique Design	1	0.500	0.253	< 1.00			1111
an Sammary nal Forces - Casacity	2.7 Plate Buckling Analysis	1	0.500	0.594	< 1.00		N N N	
nal Forces - Estimue	2.8 Welds - Stress Analysis	1	6.000	0.870	< 1.00	CO62		
nati forces i aligue	2.9 Welds - Fatigue Design	1	5.600	7.590	> 1.00			
is Analusis	2.10 Critical Load Factors	1		7.531	> 1.00	CO62		
mation Analysis								
ue Design	2.4 Stress Analysis						3	
Buckling Analysis	Normal Stresses σ _x							
ls - Stress Analysis	Governing Member	Member No.	2 400					
ds - Fatigue Design	Governing Location in Member	X Draw Dr. N	3.400	m				
al Load Factors	Governing Stress Point	Stress Pt. IV	1 251 5223	1.1.25*1.5226	-		2	
	Howening Internal Porces CO 140 : 1.	55 LF I+1.55 LF22 I-	10.10 10	+1.55 LF22:)			1111
	Limiting Normal Stress	0 x,exist	-13.10	kN/cm²			6 7 8 9	1
	Design Criterion	D	0 000	<10			z	
	Design Citerion	D _{G.X}	0.030	< 1.0				
	Governing Member	Member No.	2					
	Governing Member	Stress Pt Ni	12					
	Maximum Normal Strage	Ge eviet	.767	kN/cm2		=		
	Limiting Normal Stress	Galim	21.36	kN/cm2				
	Design Criterion	D_ 7	0.359	<10				123
	E Shear Stresses T	06.2	0.000	\$ 1.0				
	Governing Member	Member No.	1					
	Governing Location in Member	x	5 600	m				
	Governing Stress Point	Stress Pt. N	13					
	FI Governing Internal Forces CO62 : 1.3	5*LF1+1.35*LF100+	1.35*LF102+	1.35*LF104				
	Maximum Shear Stress	τ	5.57	kN/cm ²				
	Limiting Shear Stress	τlim	12.33	kN/cm ²				
	Design Criterion	DT	0.452	< 1.0				
	Equivalent Stresses σegv							
	Governing Member	Member No.	2					
	Governing Location in Member	x	3.400	m				
	 Governing Stress Point 	Stress Pt. N	1			-		

Figure 4.1: Results window with designs and results details

The results of the analysis are sorted by various criteria in the results windows 2.1 through 2.10.



You can select every window by clicking the corresponding entry in the navigator. In addition to that, you can use the buttons shown on the left to set the previous or next window. Alternatively, you can press the function keys [F2] and [F3].

Chapter 4 *Results* presents the results windows in their order. This chapter describes the results obtained according to **EN 1993-6**.

To save the results and exit CRANEWAY, click [OK].





4.1 Design Summary

The upper part of the window shows a summary of designs sorted by the governing design criteria. It provides an overview of all designs: Thus, you can see immediately which checks are satisfactory and which failed.

The lower part contains more detailed data about stresses, deformations, weld seams, etc. for the design selected in the upper part.

A	B	C	D	E	F
	Memb	er Location	Design	Criterion	Governing
Type of Design	No	x [m]	existing	limiting	CO
2.4 Stress Analysis	2	3.400	0.898	< 1.00	CO140
2.5 Deformation Analysis - Horizontal	2	3.400	769.180	> 600.000	CO140
2.5 Deformation Analysis - Vertical	2	3.400	1164.822	> 800.000	CO112
2.6 Fatigue Design	1	0.500	0.253	< 1.00	
2.7 Plate Buckling Analysis	1	0.500	0.594	< 1.00	
2.8 Welds - Stress Analysis	1	6.000	0.870	< 1.00	CO62
2.9 Welds - Fatigue Design	1	5.600	7.590	> 1.00	
2.10 Critical Load Factors	1		7.531	> 1.00	CO62
2.4 Stress Analysis					
- Normal Stresses σ _x					
Governing Member	Member No	2			
 Governing Location in Member 	×	3.400	m		
Governing Stress Point	Stress Pt. N	1			
Governing Internal Forces CO140 : 1.3	35*LF1+1.35*LF2	21+1.35*LF22	3+1.35*LF225		
Maximum Normal Stress	σ _{x,exist}	-19.18	kN/cm ²		
Limiting Normal Stress	σx,lim	21.36	kN/cm ²		
Design Criterion	D _{σ.x}	0.898	< 1.0		
Normal Stresses σ _z					
Governing Member	Member No	2			
Governing Stress Point	Stress Pt. N	12			
Maximum Normal Stress	σ _{z,exist}	-7.67	kN/cm ²		
Limiting Normal Stress	σz,lim	21.36	kN/cm ²		
Design Criterion	D _{g,z}	0.359	< 1.0		
Shear Stresses τ	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				
Governing Member	Member No	1			
Governing Location in Member	×	5.600	m		
Governing Stress Point	Stress Pt. N	13			
Governing Internal Forces CO62 : 1.35	5*LF1+1.35*LF10	+1.35*LF102	+1.35*LF104		
Maximum Shear Stress	τ	5.57	kN/cm ²		
Limiting Shear Stress	τlim	12.33	kN/cm ²		
Design Criterion	D _T	0.452	< 1.0		
T Equivalent Stresses Georg					
Governing Member	Member No	2			
Governing Location in Member	x	3 400	m		
Governing Strees Point	Strace Pt N	3.400			
dovening bliess rollit	Juess Pt. N		1		

Figure 4.2: Window 2.1 Design Summary

Type of Design

The column shows the performed designs.

Member No.

This column displays the number of the member with the highest design criterion.

Location x

At this location of the member (relative to the member start), the maximum value was found.

Design Criterion

In columns D and E, the conditions of the design check are given according to the selected Standard. If the design criterion is not satisfied, the values will be displayed in **bold black** font.

Governing CO

The last column provides information about the load combinations whose internal forces are relevant for the respective designs.

2.2.1 Internal Forces - Capacity



4.2 Internal Forces

The internal forces are shown in two windows for the ultimate limit state (capacity) and fatigue design (if selected in module window 1.3 *Cross-Sections*).

4.2.1 Internal Forces - Capacity

In this window, you specify the internal forces of the calculated load combinations (load positions) that were determined for the ultimate limit state designs. You can show either *All* internal forces or *Only max/min*- values.

A	B	C	U	E		G	H		J	K	
ember	Location	Govern.	Forces	kNJ	M	oments [kNm]		Mome	ents[kNm², k	Nmj	
No.	x [m]	00	Vy	Vz	MT	My	Mz	Mω	MT,pri	MT,sek	
1	0.000	CO1	0.00	4.03	-0.03	0.00	0.00	0.00	-0.02	-0.01	
		CO47	11.71	131.50	2.68	0.01	0.00	0.00	0.26	2.42	
		CO57	10.45	92.98	1.70	0.01	0.00	0.00	0.67	1.03	
		CO62	9.63	75.56	1.68	0.01	0.00	0.00	0.93	0.75	
		CO70	13.32	53.58	2.70	0.01	0.01	0.00	1.76	0.94	
		CO75	10.88	40.87	2.24	0.01	0.01	0.00	1.59	0.65	
		CO82	5.65	21.80	1.06	0.00	0.00	0.00	0.86	0.21	
		CO85	6.47	19.85	1.34	0.00	0.00	0.00	1.06	0.28	
		CO107	0.67	-8.22	0.05	0.00	0.00	0.00	0.04	0.01	
		CO112	-0.13	-9.48	-0.06	0.00	0.00	0.00	-0.05	-0.01	
		CO122	-1.40	-8.38	-0.21	0.00	0.00	0.00	-0.18	-0.03	
		CO140	-2.51	-4.85	-0.33	0.00	0.00	0.00	-0.27	-0.05	
	0.5001	CO1	0.00	3.13	-0.03	1.79	0.00	-0.01	-0.02	-0.01	
		CO47	11.80	130.60	2.67	65.55	-5.90	1.23	0.13	2.54	
		CO57	10.64	92.06	1.70	46.26	-5.32	0.53	0.61	1.09	
		CO62	9.86	74.64	1.68	37.55	-4.93	0.38	0.89	0.79	
		CO70	13.62	52.61	2.70	26.54	-6.81	0.48	1.71	0.99	
		CO75	11.09	39.91	2.24	20.19	-5.54	0.33	1.56	0.68	
		CO82	5.71	20.89	1.06	10.67	-2.86	0.11	0.85	0.22	
		CO85	6.53	18.93	1.34	9.69	-3.26	0.14	1.04	0.30	
		CO107	0.67	-9.12	0.05	-4.34	-0.33	0.00	0.04	0.01	
		CO112	-0.12	-10.37	-0.06	-4.96	0.06	0.00	-0.05	-0.01	
		CO122	-1.39	-9.27	-0.21	-4.41	0.70	-0.02	-0.18	-0.03	
		CO140	-2.50	-5.74	-0.33	-2.65	1.25	-0.03	-0.27	-0.05	
	0.500 r	CO1	0.00	3.13	-0.03	1.79	0.00	-0.01	-0.02	-0.01	
		CO47	-5.70	16.97	-0.65	65.54	-5.90	1.23	0.13	-0.78	
		CO57	10.64	92.06	1.70	46.26	-5.32	0.53	0.61	1.09	
		CO62	9.86	74.64	1.68	37.55	-4.93	0.38	0.89	0.79	
		CO70	13.62	52.61	2.70	26.54	-6.81	0.48	1.71	0.99	
		CO75	11.09	39.91	2.24	20.19	-5.54	0.33	1.56	0.68	
		CO82	5.71	20.89	1.06	10.67	-2.86	0.11	0.85	0.22	
		CO85	6.53	18.93	1.34	9.69	-3.26	0.14	1.04	0.30	
		CO107	0.67	-9.12	0.05	-4.34	-0.33	0.00	0.04	0.01	
		CO112	-0.12	-10.37	-0.06	-4.96	0.06	0.00	-0.05	-0.01	

Figure 4.3: Window 2.2.1 Internal Forces - Capacity with option All Internal Forces

The internal forces are design values, that is, when determining these internal forces, all relevant partial safety factors, dynamic coefficients, and combination factors were taken into account. These internal forces are used for the stress analysis, the plate-buckling analysis, and the calculation of the critical load factor.

If you select the option *All*, CRANEWAY displays all determined internal forces at all x-locations for the considered load combinations (dependent on the calculation method *Fast Calculation* or *Detailed Calculation*).

If you select the option *Max/min only*, only the internal forces of the x-locations with the extreme values are displayed for each member.



A	В	C	D	E	F	G	H		J	K	L	
lember	max	Govern.	Location	Forces	[kN]	M	loments [kNm]		Mome	nts [kNm², k	Nm]	
No.	min	CO	x [m]	Vy	Vz	MT	My	Mz	Mω	MT.pri	MT,sek	
1	max Vy	CO70	2.5001	14.36	48.81	2.91	127.60	-36.01	3.64	0.19	2.72	
	min Vy	CO85	4.000 r	-21.94	-88.22	-3.89	64.66	-26.89	3.15	-0.65	-3.24	
	max V _z	CO47	0.000	11.71	131.50	2.68	0.01	0.00	0.00	0.26	2.42	
	min Vz	CO62	6.000	9.63	-162.60	2.17	-79.08	4.90	-0.20	-0.10	2.27	
	max MT	CO70	2.5001	14.36	48.81	2.91	127.60	-36.01	3.64	0.19	2.72	
	min MT	CO85	4.000 r	-21.94	-88.22	-3.89	64.66	-26.89	3.15	-0.65	-3.24	
	max My	CO62	2.0001	10.30	71.89	1.89	147.40	-20.62	2.05	0.18	1.71	
	min My	CO82	6.000	-11.76	-102.60	-2.19	-128.80	0.92	-0.02	-1.31	-0.88	
	max M _z	CO75	6.000	-16.12	-71.13	-2.86	-90.79	15.75	-1.90	-0.94	-1.92	
	min Mz	CO70	2.5001	14.36	48.81	2.91	127.60	-36.01	3.64	0.19	2.72	
	max M _ω	CO70	2.5001	14.36	48.81	2.91	127.60	-36.01	3.64	0.19	2.72	
	min M _w	CO85	6.000	-20.53	-92.14	-3.82	-115.60	15.22	-2.15	-1.02	-2.80	
	max MT,pri	CO70	0.000	13.32	53.58	2.70	0.01	0.01	0.00	1.76	0.94	
	min MT,pri	CO85	5.100 I	-21.22	-90.37	-3.86	-33.45	-3.01	0.15	-1.39	-2.47	
	max M _{T,sek}	CO70	2.5001	14.36	48.81	2.91	127.60	-36.01	3.64	0.19	2.72	
	min MT,sek	CO85	4.000 r	-21.94	-88.22	-3.89	64.66	-26.89	3.15	-0.65	-3.24	
2	max Vy	CO140	3.4001	15.52	53.01	2.75	129.70	-36.45	4.06	-0.14	2.89	
	min Vy	CO140	3.400 r	-13.97	-47.54	-2.86	129.70	-36.45	4.06	-0.14	-2.72	
	max Vz	CO107	0.000	9.78	159.20	1.76	-81.57	-4.01	0.33	-0.15	1.92	
	min Vz	CO122	6.000	11.85	-135.60	2.07	-0.01	0.00	0.00	-0.25	2.32	
	max M _T	CO140	0.000	14.21	59.47	2.92	-61.30	15.06	-2.01	0.96	1.95	
	min MT	CO140	6.000	-12.79	-52.53	-3.03	0.01	0.01	0.00	-1.99	-1.04	
	max My	CO107	4.1001	-8.07	38.06	-1.41	146.50	20.27	-2.45	0.31	-1.72	
	min My	CO82	0.000	-12.62	110.20	-2.49	-128.80	0.92	-0.02	-1.31	-1.18	
	max M _z	CO82	1.6001	-13.84	107.20	-2.54	44.98	21.63	-2.33	-0.58	-1.96	
	min Mz	CO140	3.4001	15.52	53.01	2.75	129.70	-36.45	4.06	-0.14	2.89	
	max M _ω	CO140	3.4001	15.52	53.01	2.75	129.70	-36.45	4.06	-0.14	2.89	
	min M _w	CO107	4.1001	-8.07	38.06	-1.41	146.50	20.27	-2.45	0.31	-1.72	
	max MT.pri	CO140	1.3001	14.85	56.97	2.90	14.45	-3.58	0.06	1.47	1.43	
	min MT,pri	CO140	6.000	-12.79	-52.53	-3.03	0.01	0.01	0.00	-1.99	-1.04	
	max MT,sek	CO140	3.4001	15.52	53.01	2.75	129.70	-36.45	4.06	-0.14	2.89	
	min MT,sek	CO140	3.400 r	-13.97	-47.54	-2.86	129.70	-36.45	4.06	-0.14	-2.72	

Figure 4.4: Window 2.2.1 Internal Forces - Capacity with the option Max/min only

4.2.2 Internal Forces - Fatigue

The display of the internal forces and the sorting options are identical to the previously described window 2.2.1 *Internal Forces -Capacity*.

The internal forces in this window are also design values: In the calculation of the internal forces, all relevant partial safety factors, dynamic coefficients, and combination factors are taken into account.

These internal forces are used for the fatigue design of the girder as well as the weld designs.



4.3 Support Forces

This results window offers three sorting options for the display.

	B	C	D	E	F	G	H
lode	Govern.		Supp	ort Forces [k]	1]	Support Mome	ents [kNn
No.	LC/CO	LC/CO Description	Px	Py	Pz	MY	Mz
	LC2	Wind Load					
1	C01	Self-Weight + Permanent Load	0.00	0.00	2.99	0.00	0
	CO2	Total, γ _G (LC1 + LC4) + γ _Q (LC6 + LC8) + γ _{Qo} LC2	0.00	0.00	2.99	0.00	0
	C07	Total, γg (LC1 + LC12) + γg (LC14 + LC16) + γgo LC2	0.00	-10.78	73.33	0.00	0
	CO8	Total, γ _G (LC1 + LC11) + γ _Q LC16 + γ _{Qo} LC2	0.00	-10.79	19.11	0.00	C
	CO42	Total, γ _G (LC1 + LC68) + γ _Q (LC70 + LC72) + γ _{Qo} LC2	0.00	-3.62	26.86	0.00	0
	CO47	Total, γ _G (LC1 + LC76) + γ _Q (LC78 + LC80) + γ _{Qo} LC2	0.00	8.10	91.04	0.00	0
	CO50	Total, γ _G (LC1 + LC77) + γ _Q (LC79 + LC81) + γ _{Qo} LC2	0.00	17.90	87.10	0.00	0
	CO52	Total, γ _G (LC1 + LC84) + γ _Q (LC86 + LC88) + γ _{Qo} LC2	0.00	7.70	77.35	0.00	0
	CO82	Total, γ _G (LC1 + LC132) + γ _Q (LC134 + LC136) + γ _{Qo} LC2	0.00	3.91	15.25	0.00	C
	CO110	Total, γg (LC1 + LC173) + γg (LC175 + LC177) + γgo LC2	0.00	-0.75	-5.10	0.00	C
	CO112	Total, γ _G (LC1 + LC180) + γ _Q (LC182 + LC184) + γ _{Qo} LC2	0.00	-0.09	-6.34	0.00	C
	CO122	Total, γg (LC1 + LC196) + γg (LC198 + LC200) + γgo LC2	0.00	-0.95	-5.58	0.00	(
	CO165	Total, γ _G (LC1 + LC261) + γ _Q (LC263 + LC265) + γ _{Qo} LC2	0.00	-0.08	2.67	0.00	(
	max		0.00	17.90	91.04	0.00	(
	min		0.00	-10.79	-6.34	0.00	(
	LC2	Wind Load					
2	C01	Self-Weight + Permanent Load	0.00	0.00	9.95	0.00	(
	CO2	Total, γg (LC1 + LC4) + γg (LC6 + LC8) + γgo LC2	0.00	0.00	9.95	0.00	(
	C07	Total, γ _G (LC1 + LC12) + γ _Q (LC14 + LC16) + γ _{Qo} LC2	0.00	-1.51	19.74	0.00	(
	CO8	Total, γg (LC1 + LC11) + γg LC16 + γgo LC2	0.00	-1.50	12.19	0.00	(
	CO42	Total, γg (LC1 + LC68) + γg (LC70 + LC72) + γgo LC2	0.00	-9.62	72.12	0.00	(
	CO47	Total, γg (LC1 + LC76) + γg (LC78 + LC80) + γgo LC2	0.00	-8.98	87.68	0.00	(
	CO50	Total, γg (LC1 + LC77) + γg (LC79 + LC81) + γgo LC2	0.00	2.53	84.21	0.00	(
	CO52	Total, γg (LC1 + LC84) + γg (LC86 + LC88) + γgo LC2	0.00	-8.17	102.00	0.00	(
	CO82	Total, γG (LC1 + LC132) + γQ (LC134 + LC136) + γQo LC2	0.00	-0.60	147.70	0.00	0
	CO110	Total, γg (LC1 + LC173) + γg (LC175 + LC177) + γgo LC2	0.00	19.83	118.60	0.00	(
	CO112	Total, γg (LC1 + LC180) + γg (LC182 + LC184) + γgo LC2	0.00	7.41	112.30	0.00	(
	CO122	Total, γG (LC1 + LC196) + γQ (LC198 + LC200) + γQo LC2	0.00	9.12	84.66	0.00	(
	CO165	Total, γg (LC1 + LC261) + γg (LC263 + LC265) + γgo LC2	0.00	0.50	11.82	0.00	(
	max		0.00	19.83	147.70	0.00	(
	min		0.00	-9.62	9.95	0.00	(
	LC2	Wind Load					
3	C01	Self-Weight + Permanent Load	0.00	0.00	2,99	0.00	(

Figure 4.5: Window 2.3 Support Forces with option All support forces

If you select the first option, the window shows *All* determined support forces of the load combinations. Additionally, the load case 2 *Wind Load* is displayed, so the support forces of the individual components (crane, permanent load, and wind) can be calculated backwards.

	B	C	D	E	F	G	H	
Node	max	Govern.	Horizontal	Support Force	s P y [k N]	Vertical S	Support Forces	Pz[kN]
No.	min	CO	Total	Due to Crane	Due to Wind	Total	Due to Crane	Permanent
1	max Py	CO50	17.90	17.90	0.00	87.10	84.11	2.98
	min Py	CO8	-10.79	-10.79	0.00	19.11	16.13	2.98
	max Pz	CO47	8.10	8.10	0.00	91.04	88.06	2.98
	min Pz	CO112	-0.09	-0.09	0.00	-6.34	-9.33	2.98
2	max P _Y	CO110	19.83	19.83	0.00	118.60	108.65	9.95
	min PY	CO42	-9.62	-9.62	0.00	72.12	62.17	9.95
	max Pz	CO82	-0.60	-0.60	0.00	147.70	137.75	9.95
	min Pz	C01	0.00	0.00	0.00	9.95	0.00	9.95
3	max P _Y	CO165	19.58	19.58	0.00	76.42	73.43	2.98
	min PY	CO122	-8.17	-8.17	0.00	93.86	90.88	2.98
	max Pz	CO122	-8.17	-8.17	0.00	93.86	90.88	2.98
	min Pz	CO52	0.47	0.47	0.00	-6.40	-9 38	2.98

Figure 4.6: Window 2.3 Support Forces with option Max/min only



If you select the option *Max/min only*, only the extreme values of the support forces are displayed for the respective directions, that is, the characteristic support forces multiplied by the corresponding dynamic coefficient for supports.

A	B	C	D	E	F	G	H	
Node	Govern.	Horizontal S	Support Forces	Py [kN]	Vertical Su	pport Forces	Pz[kN]	
No.	CO	Total D	Due to Crane	Due to Wind	Total [Oue to Crane	Permanent	Comment
Extreme in	Node No.1 - r	nax P _Y						
1	CO50	17.90	17.90	0.00	87.10	84.11	2.98	
2	CO50	2.53	2.53	0.00	84.21	74.26	9.95	
3	CO50	-0.43	-0.43	0.00	-5.39	-8.38	2.98	
Extreme in	Node No.1 - r	nin PY						
1	CO8	-10.79	-10.79	0.00	19.11	16.13	2.98	
2	CO8	-1.50	-1.50	0.00	12.19	2.24	9.95	
3	CO8	0.25	0.25	0.00	2.61	-0.37	2.98	
Extreme in	Node No.1 - r	nax Pz						
1	CO47	8.10	8.10	0.00	91.04	88.06	2.98	
2	CO47	-8.98	-8.98	0.00	87.68	77.73	9.95	
3	CO47	0.88	0.88	0.00	-5.79	-8.77	2.98	
Extreme in	Node No.1 - r	nin Pz						
1	CO112	-0.09	-0.09	0.00	-6.34	-9.33	2.98	
2	CO112	7.41	7.41	0.00	112.30	102.35	9.95	
3	CO112	-7.32	-7.32	0.00	66.93	63.94	2.98	
Extreme in	Node No.2 - r	nax Py						
1	CO110	-0.75	-0.75	0.00	-5.10	-8.09	2.98	
2	CO110	19.83	19.83	0.00	118.60	108.65	9.95	
3	CO110	0.92	0.92	0.00	52.40	49.42	2.98	
Extreme in	Node No.2 - r	nin Py	· · ·					
1	CO42	-3.62	-3.62	0.00	26.86	23.88	2.98	
2	CO42	-9.62	-9.62	0.00	72.12	62.17	9.95	
3	CO42	1.20	1.20	0.00	-4.55	-7.53	2.98	
Extreme in	Node No.2 - r	nax Pz						
1	CO82	3.91	3.91	0.00	15.25	12.27	2.98	
2	CO82	-0.60	-0.60	0.00	147.70	137.75	9.95	
3	CO82	-3.32	-3.32	0.00	10.02	7.03	2.98	
Extreme in	Node No.2 - r	nin Pz						
1	C01	0.00	0.00	0.00	2.98	0.00	2.98	
2	C01	0.00	0.00	0.00	9.95	0.00	9.95	
3	C01	0.00	0.00	0.00	2.98	0.00	2.98	
Extreme in	Node No.3 - r	nax Py						
1	CO165	-0.08	-0.08	0.00	2.67	-0.31	2.98	

Figure 4.7: Window 2.3 Support Forces with option Only max/min advanced

If you select the display option *Max/min only advanced*, the table shows the extreme values of the horizontal support forces (with components from crane and wind load) and vertical (with components from crane and permanent load).

The support forces will be combined in the same way as the internal forces from the load cases taking into account the dynamic coefficients. Thus, the support forces (except for LC1 and LC2) are multiplied by the ratio of the dynamic coefficient of the girder to the dynamic coefficient of support and added using the LC criterion, since the wheel loads, starting from LC3, already include the dynamic coefficient of the girder.

The support forces are from the calculation according to the second-order analysis for warping torsion. Hence, not all load combinations are available in the *Fast Calculation* method but only those according to second-order analysis for warping torsion.



4.4 Stress Analysis

This window offers three display options controlled in the Method of Output section.

ABCOD			H H	HE B 300
Member Location Stress Gover	ning Stress	Stree	1	Member No. 2, x: 3,400 r [m]
No. x [m] Point No. CC	Type [kN/c	m ² 1 Rati	0	internet internet and internet and
2 3.400 r 1 CO1	40 Geov	19.18 0	898	19.18
				10.34 0.15 11.49
lember No. 2				
Normal Stresses σ _x				1 2 3 4 5
Governing Member	Member No.	2		
Governing Location in Member	x	3.400	m	
Governing Stress Point	Stress Pt. N	1		
⊕ Governing Internal Forces CO140 : 1	.35*LF1+1.35*LF22	1+1.35*LF223	+1.35*LF225	
Maximum Normal Stress	σ _{x,exist}	-19.18	kN/cm ²	9.24
Limiting Normal Stress	σ _{x,lim}	21.36	kN/cm ²	
Design Criterion	D _{σ,x}	0.898	< 1.0	y 3 y
- Normal Stresses σ _z				
 Governing Member 	Member No.	2		7.65
Governing Stress Point	Stress Pt. N	12		8
Maximum Normal Stress	σ _{z,exist}	-7.67	kN/cm ²	7.89 7.507.81 8.05 5.00
Limiting Normal Stress	σ _{z,lim}	21.36	kN/cm ²	
Design Criterion	D _{σ,z}	0.359	< 1.0	6 7 8 9 10
Shear Stresses τ				
Governing Member	Member No.	1		
 Governing Location in Member 	x	5.600	m	
Governing Stress Point	Stress Pt. N	13		Min: 3.24 kN/cm^2 (13)
Governing Internal Forces CO62 : 1.3	35*LF1+1.35*LF100+	+1.35*LF102+	1.35*LF104	Max: 19.18 kN/cm^2 (1)
Maximum Shear Stress	τ	5.57	kN/cm ²	
Limiting Shear Stress	τlim	12.33	kN/cm ²	
Design Criterion	Dτ	0.452	< 1.0	Made of Output
Ξ Equivalent Stresses σ _{eqv}				
Governing Member	Member No.	2		 Overall
Governing Location in Member	x	3.400	m	O By x-location
Governing Stress Point	Stress Pt. No	1		Bu stress point
⊕ Governing Internal Forces CO140 : 1	.35*LF1+1.35*LF22	1+1.35*LF223	+1.35*LF225	by outpoint
Maximum Equivalent Stress	Geqv	19.18	kN/cm ²	
Limiting Equivalent Stress	Gegv,lim	21.36	kN/cm ²	
Design Criterion	D _{g.eqv}	0.898	< 1.0	

Figure 4.8: Window 2.4 Stress Analysis Overall

If you select the *Overall* method of output, the upper table shows only the x-location with the governing ratio. To this end, all x-locations, stress components, stress points, and load combinations are analyzed. Thus, this table displays also the governing stress points, governing load combinations, and the type of stress, which lead to the maximum *Stress Ratio* (represents the ratio of calculated stress to limit stress). The stress analysis is satisfied if the ratio is smaller than one.

For the stress analysis, the internal forces according to the second-order analysis for warping torsion are used, that is, the partial factors γ_F , combination factor ψ , and dynamic coefficient ϕ are considered.

Details - Stresses

Below the table, the detailed intermediate results leading to this ratio are shown. They include the normal stresses σ_x and σ_z , shear stress τ , and the equivalent stresses σ_{eqv} . For each stress component, you can see the maximum stress at this x-location and the underlying governing internal forces.

If you click [+] at the beginning of a row with the load combination, you can see the internal forces of this CO. The exception is the normal stress σ_z , which is determined according to the standard directly from the wheel pressure. The last row of each stress component shows the design, which is compared with the value 1.

Stress graphic

On the right, you can find a graphic with the stress diagram for the cross-section. The graphic depends on the selected design in the table. Thus, you can visualize the governing normal, shear, and equivalent stresses at the current x-location.



	D	C	D	E	F	G		H	A	HE B 300
Member	Location	Stress	Governing	9	Stress	Stre	55			Member No. 1, x: 0.000 r [m]
No.	x [m]	Point No.	CO	Туре	kN/cr	n²] Rat	io		=	
1	0.000 r	11	CO47	σeqv	1().69 C	.500			4.15 10.59
	0.5001	11	CO47	Geqv		9.91 C	.464			4.15 10.05 3.11
	1.000 r	1	CO57	σeqv	1	3.80 C	.412			1 2/3/4 5
	1.5001	1	CO57	σeqv	13	3.35 0	.625			
	2.0001	1	CO62	Geqv	14	4.95 C	.700			
	2.5001	1	CO70	σeqv	18	3.46 C	.864			7.04
	3.000 r	1	CO75	σeqv	1	7.44 0	.816			
	3.500 r	1	CO75	σeqv	12	2.41 0	.581			
	4.0001	1	CO85	σeqv	12	2.55 0	.588			
	4.1001	5	CO47	σeqv	1	1.65 0	.545		-	³ 10.17 ¥
Jember No.	. 1 - Locat	ion x: 0.00	00							
- Normal	Stresses (σx							^	
Gover	ning Membe	r		Membe	er No.	1				3.57.3:74 3.86 3.11
Gover	ning Locatio	n in Memb	er	x		0.000	m			
Gover	ning Stress I	Point		Stress	Pt. Ne	5				6 7 8 9 10
+ Gover	ning Internal	Forces CC	070:1.35°LC	1+1.351	LC109+	1.35°LC1114	-1.35°LC113			
Maxim	um Normal S	Stress		σ _{x,exis}	t	0.00	kN/cm2			2
- Limitin	g Normal Str	ess		σx,lim		21.36	kN/cm ²			
Design	n Criterion			D _{σ.x}		0.000	< 1.0			
3 Normal	Stresses of	5 _Z							=	Min: 3.11 kN/cm ² (6)
Gover	ning Membe	r		Membe	er No.	1				Max: 10.69 KN/cm ² (11)
Gover	ning Stress I	Point		Stress	Pt. N	11				🔁 🗳 💯 🥁 🗟 🚺 🎞 🖾 🎁
Maxim	um Normal S	Stress		σ _{z,exis}	t	-/.6/	kN/cm2			
- Limitin	g Normal Str	ess		σz,lim		21.36	kN/cm ²			Mode of Output
- Desigr	n Criterion			D _{G,Z}		0.359	< 1.0			O Overall
Shear S	Stresses T									
Gover	ning Membe	r		Membe	er No.	1				By x-location
Gover	ning Locatio	n in Memb	er	×		0.000	m			By stress point
Gover	ning Stress I	Point		Stress	Pt. N	13				
Gover	ning Internal	Forces CC)4/:1.35*LC	1+1.35*	LC76+1.	35*LC78+1.	35"LC80			
Maxim	um Shear St	tress		τ		4.58	kN/cm ²			
Limitin	g Shear Stre	SS		τlim		12.33	kN/cm ²			
Design	n Criterion			Dτ		0.371	< 1.0			
C Equipued	lent Stress	CS Genv								

Figure 4.9: Window 2.4 Stress Analysis by x-Location

If you select the By x-location mode of output, the maximum ratios are shown at each x-location.



Figure 4.10: Window 2.4 Stress Analysis by Stress Point

If the output is set as *By stress point*, then the results in the upper table are listed for each stress point and for each x-location.



4.4.1 Theoretical Background on Stress Calculation

CRANEWAY calculates the normal stresses σ_x , shear stresses τ , and the equivalent stresses σ_{eqv} at all cross-section points. At the top edge of the web plate, the normal stresses σ_z from the applied wheel load are also taken into account.

The calculation is carried out along the crane runway girder in so-called x-locations. These xlocations can be found at the nodes of the finite elements into which the girder was subdivided and also at the load application locations of the crane in the individual load combinations.

In the following, the stress points are indicated by the coordinates (y_i, z_i). The normal stresses σ_x and the shear stresses τ are calculated from the internal forces which were computed according to the second-order analysis subjected to γ_F times the loading.

Normal Stresses

Because the warping torsion is taken into account, not only parts from axial force and bending, but also from the warping torsional moment occur for the normal stresses σ_x . In all, we obtain for the normal stress σ_x in a point i of the cross-section:

$$\sigma_{\mathbf{x},i} = \frac{N}{A} + \frac{M_{y}}{S_{y}(y_{i}, z_{i})} - \frac{M_{z}}{S_{z}(y_{i}, z_{i})} - \frac{M_{\omega}}{C_{w}} \omega_{M}(y_{i}, z_{i})$$

The symbols mean:

- N Axial force
- My Bending moment about y-axis
- M_z Bending moment about z-axis
- M_ω Warping torsional moment
- A Cross-section surface
- $S_y(y_i,z_i)$ Section modulus about y-axis for point (y_i,z_i)
- S_z(y_i,z_i) Section modulus about z-axis for point (y_i,z_i)
- C_w Warping constant relative to the shear center M
- ω_M Principal warping at point (y_i,z_i)

Shear stresses

The shear stresses consist of shear force components and torsional components. The relation to the determination of the primary shear stresses is:

$$\tau_{p,i} = \frac{V_y \cdot Q_z(y_i, z_i)}{I_z \cdot t(y_i, z_i)} + \frac{V_z \cdot Q_y(y_i, z_i)}{I_y \cdot s(y_i, z_i)} + \left| \frac{M_{T,p}}{S_T(y_i, z_i)} \right|$$

The descriptions mean:

- V_y Shear force in y-axis direction
- V_z Shear force in z-axis direction
- M_{T,p} Primary torsional moment
- I_y Second moment of area relative to y-axis
- Iz Second moment of area relative to z-axis
- $Q_y(y_i,z_i)$ First moment of area relative to y-axis for point (y_i,z_i)
- $Q_z(y_i,z_i)$ First moment of area relative to z-axis for point (y_i,z_i)
- t(y_i,z_i) Thickness of cross-section part in point (y_i,z_i)
- s(y_i,z_i) Thickness of cross-section part in point(y_i,z_i)
- S_T(y_i,z_i) Torsional section modulus for point (y_i,z_i)



Secondary shear stresses

Furthermore, the secondary shear stress due to the secondary torsional moment $M_{\ensuremath{\tau},s}$ is computed.

$$\mathbf{r}_{s,i} = \frac{\mathbf{M}_{\mathsf{T},s} \cdot \mathbf{Q}_{\omega}(\mathbf{y}_{i}, \mathbf{z}_{i})}{\mathbf{C}_{\mathsf{w}} \cdot \mathbf{t}(\mathbf{y}_{i}, \mathbf{z}_{i})}$$

The descriptions mean:

M_{T,s} Secondary torsional moment

 $Q_{\omega}(y_{i,}z_{i})$ Warping surface in point $(y_{i,}z_{i})$

C_w Warping constant

t(y_i,z_i) Cross-section thickness in point (y_i,z_i)

In CRANEWAY, you can choose whether to take into account the secondary shear stresses in the stress calculation (see Figure 3.3, page 37). If they are considered in the stress calculation, they are directly added to the primary shear stresses.

Normal stresses from applied wheel loads

The normal stresses σ_z are, in contrast to the normal stresses σ_x and shear stresses τ , not calculated according to the second-order analysis but according to the following equations:

$$\sigma_{z,i} = \frac{W}{c(y_i, z_i) \cdot t(y_i, z_i)}$$

The descriptions mean:

W	Wheel load multiplied b	y the partial safety	/ factor γ _F , and d	ynamic coefficient ϕ
---	-------------------------	----------------------	---------------------------------	---------------------------

- c(y_i,z_i) Load application length of the wheel load
- t(y_i,z_i) Thickness of the governing cross-section parts in point (y_i,z_i)

The length $c(y_i, z_i)$ is calculated according to [2] section 4.1.2. The following figure illustrates the principle of the determination of the load application length c.



Figure 4.11: Length of the uniformly distributed wheel load



• EN 1993-6

$$\sigma_{z,i} = \frac{F_{z,Ed}}{I_{eff} \cdot t_w} \quad \text{or for rolled cross-sections} \ \sigma_{z,i} = \frac{F_{z,Ed}}{(I_{eff} + 2 \cdot r) \cdot t_w}$$

The descriptions mean:

- F_{z,Ed} Design value of the wheel load
- I_{eff} Effective loaded length of wheel load acc. to [6], Table 5.1
- t_w Thickness of the web plate



Figure 4.12: Effective loaded length

Table 5.1. Ellective loaded length set
--

Cas	e De	scription	Effective loaded length ℓ_{eff}							
(a)	Cra	ane rail rigidly fixed to the flange	$\ell_{\rm eff} = 3.25 [I_{\rm rf} / t_{\rm w}]^{\frac{1}{3}}$							
(b)	Cra	ane rail not rigidly fixed to flange	$\ell_{\rm eff} = 3.25 [(I_{\rm r} + I_{\rm f, eff})/t_{\rm w}]^{\frac{1}{3}}$							
(c)	Cra ela	ane rail mounted on a suitable resilient stomeric bearing pad at least 6mm thick.	$\ell_{\rm eff} = 4.25 \left[(I_{\rm r} + I_{\rm f, eff}) / t_{\rm w} \right]^{\frac{1}{3}}$							
	$I_{\rm f,eff}$ is the second moment of area, about its horizontal centroidal axis, of a flange with an effective width of $b_{\rm eff}$									
	Ir is the second moment of area, about its horizontal centroidal axis, of the rail									
	I _{rf}	is the second moment of area, about its horizonta section comprising the rail and a flange with an	al centroidal axis, of the combined cross- effective width of $b_{\rm eff}$							
	$t_{\rm W}$	is the web thickness.								
	b _{eff} :	$= b_{\rm fr} + h_{\rm r} + t_{\rm f}$ but $b_{\rm eff} \le b$								
v	where:	b is the overall width of the top flange;								
	$b_{\rm fr}$ is the width of the foot of the rail, see figure 5.2;									
	h_r is the height of the rail, see figure 5.1;									
		$t_{\rm f}$ is the flange thickness.								
N	lote: Al	low for crane rail wear, see 5.6.2(2) and 5.6.2(3) in dete	ermining Ir, Iri and hi.							

Figure 4.13: Effective loaded length



Designs

In the elastic-elastic design method, you have to verify that under the design actions (γ_F times the loads) the following applies:

$$\begin{split} \max \sigma_{x} &\leq f_{y,d} \\ \max \sigma_{z} &\leq f_{y,d} \\ \max \tau &\leq \frac{1}{\sqrt{3}} \cdot f_{y,d} \\ \max \sigma_{eqv} &\leq f_{y,d} = \frac{f_{y,k}}{\gamma_{M}} \end{split}$$

The equivalent stress σ_{eqv} according to VON MISES is determined from the normal and shear stresses as follows:

$$\sigma_{eqv} = \sqrt{\sigma_x^2 + \sigma_z^2 - \sigma_x \cdot \sigma_z + 3\tau^2}$$

In this formula, the sign must be considered in the calculation of the stresses. Due to the distribution of the compression stress, the stress σ_z under the wheel is always negative.

Since the stress σ_z exists only at the top edge of the web plate or does not have any influence further down in the beam, the following simplified formula is used for the other stress points.

$$\sigma_{eqv} = \sqrt{\sigma_x^2 + 3\tau^2}$$

The stress analysis is carried out in every stress point at all x-locations of the crane runway girder with the according design internal forces according to the second-order analysis for warping torsion.

In the stress analysis, the normal stresses σ_x have the greatest influence. The greatest normal stress σ_x occurs on the edge of the flange, where the normal stress components from the bending moments about both principal axes and from the warping torsional moment super-impose each other. The superposition is shown in the following figure.



Figure 4.14: Normal stress components for biaxial bending with warping torsion



4.5 Deformation Analysis

This window contains two display options that you can control by selecting the Mode of Output.

А	В	C	D	E	F	G	Н	HE B 300	
	Member	Location	Govern.	[Displacement				
Direction	No.	x [m]	CO	u [mm]	L/u	limit L/u			
Horizontal	2	3.400	CO140	7.8	769.180	> 600.000			
Vertical	2	3.400	CO112	5.2	1164.822	> 800.000			
Details - Defo	rmations								ullinnuun nuu seesesteesesteesesteesesteesesteesesteesesteesesteesesteesesteesesteesesteesesteesesteesesteesest
Governing	Member Ler	ath		L	6.000	m			Y
Horizontal	Displacemen	t in Shear Ce	nter	UY.M	3.8	mm		_	
Horizontal	Displacemen	t Due to Tors	ion	UY.e	4.0	mm		_	8
Horizontal	Displacemen	t in Rail Top		UY	7.8	mm			8
Vertical Dis	placement			uz	4.7	mm			
Rotation A	out X-Axis			φx	17.570	mrad			y y
Rotation A	bout Y-Axis			φγ	0.226	mrad			
Rotation About Z-Axis				φz	-0.184	mrad			8
Warping				ω	-0.001	1/m			8
Deformatio	n Analysis - I	DIN EN 1993-	-6/NA:2010-	12					
Govern	ing check	of the hori:	zontal defo	mation acc	. to Tab. 7	.1 a)			
Caladat									
Calculati	on Method			Metry	1				
- Govern	on Method ing check	of the vert	ical deform	Mety nation acc. t	1 o Tab. 7.2	a)			¥ z
Govern Calculati	on Method iing check on Method	of the vert	ical deform	Mety nation acc.t Metz	1 o Tab. 7.2 1	a)			z
Govern Calculati	on Method ing check on Method	of the vert	ical deform	Mety Metz Metz	1 o Tab. 7.2 1	a)			z
Govern Calculati	on Method ing check on Method	of the vert	ical deform	Mety Metz Metz	1 o Tab. 7.2 1	a)			z
Calculati Govern Calculati	on Method ing check on Method	of the vert	ical defom	Mety nation acc.t Metz	1 o Tab. 7.2 1	a)			¥ z
Govern Calculati	on Method ing check on Method	of the vert	ical deform	Mety nation acc.t Metz	1 o Tab. 7.2 1				¥ Z
Calculati	on Method ing check on Method	of the vert	ical deform	Mety nation acc.t Metz	1 o Tab. 7.2 1	a)		•	
Govern Calculati	on Method ing check on Method	of the verti	ical defom	Mety nation acc. t Metz	1 o Tab. 7.2 1	a)		ð 😂	
Govern Calculati	on Method ing check on Method	of the vert	ical deform	Met Y aation acc. t Met z	1 o Tab. 7.2 1	a)		Mode of Output	
Calculati Govern Calculati	on Method ing check on Method	of the vert	ical deform	Met Y ation acc. t Metz	1 o Tab. 7.2 1	a) 		Mode of Output © Overall	
Calculati Govern Calculati	on Method ing check on Method	of the vert	ical deform	Met Y ation acc. t Metz	1 o Tab. 7.2 1			Mode of Output © Overall © By x-location	
Calculati	on Method ing check on Method	of the vert	ical deform	Met Y ation acc. t Met z	1 o Tab. 7.2 1			Mode of Output © Overall © By x-location	
Govern Calculati	on Method ing check on Method	of the vert	ical deform	Met Y ation acc. t Met z	1 o Tab. 7.2 1			Mode of Output Overall By x-location	
Govern Calculati	on Method ing check on Method	of the vert	ical defom	Met y Met z Met z	1 o Tab. 7.2 1	a)		Mode of Output Overall By x-location	
Govern Calculat	on Method	of the vert	ical deform	Met y Netz Metz Metz	1 o Tab. 7.2 1	a) 		Mode of Output © Overall © By x-location	
Calculat Govern Calculat	on Method	of the vert	ical deform	Met y Nation acc. t Metz	1 o Tab. 7.2 1			Mode of Output Overall By x-location	
Calculat Govern Calculat	on Method	of the vert	ical defom	Met y ation acc. t Metz	1 o Tab. 7.2 1			Mode of Output Overall By x-location	

Figure 4.15: Window 2.5 Deformation Analysis Overall

The deformations of the relevant load combinations are analyzed for each x-location. If you select the *Overall* option, the table shows only the x-locations with the CO numbers at which the governing displacement occurs in the horizontal and vertical direction.

In the analysis, the ratio of field length to greatest displacement in the field is compared with the allowable ratio L/u. The design is satisfied if the existing ratio L/u is greater than the allowable quotient.

The deformations are calculated according to the second-order analysis for warping torsion with the characteristic values, that is, the partial safety factor $\gamma_F = 1.0$, combination factor $\psi = 1.0$, and dynamic coefficient $\phi = 1.0$.

Details - Deformations

The intermediate results of the governing displacements u_y and u_z are listed below the table. There, you can also see the parts of the rotations ϕ_x , ϕ_y , and ϕ_z and the warping ω . All deformation components are relative to the shear center M. The only exception is the displacement u_y : this component is related to the upper edge of the rail.

In the mode of output *By x-location* (see Figure 4.16), all performed deformation analyses are listed at each x-location and for each load combination. If you click in a row of the upper table, the corresponding *Details* of the current displacement are set in the table below. This mode of output also includes the calculation method for the horizontal and vertical deformations (see chapter 3.1.1, page 34).





4	В	C	D	E	F	G	H		-
nber	Location	Govern.	Horizonta	l Displacemen	t [mm]	Vertica	I Displaceme	ent [mm]	
No.	x [m]	CO	UΥ	L/uy	limit L/uy	υz	L/uz	limit L/uz	
1	0.000	CO1	0.0		-	0.0	-	÷	
		CO47	0.0	-	-	0.0	-	-	
		CO57	0.0	-	-	0.0	-	-	
		CO62	0.0		-	0.0	-	-	
		CO70	0.0	-	-	0.0	-	÷	
		CO75	0.0	-	-	0.0	-	-	
		CO82	0.0	-	-	0.0	-	-	
		CO85	0.0	-	-	0.0	-	-	
		CO107	0.0		-	0.0	-	-	
		CO112	0.0	-	-	0.0	-	-	
		CO122	0.0	-	-	0.0	-	-	
		CO140	0.0		-	0.0	-	•	
	0.500	CO1	0.0	-	-	0.1	108381.5	> 800.000	
		CO47	0.0	211759.656	> 600.00	1.4	4338.395	> 800.000	_
		CO57	0.5	13086.834	> 600.00	1.6	3863.490	> 800.000	
		CO62	0.7	8999.684	> 600.00	1.5	4132.231	> 800.000	
		CO70	2.0	3047.595	> 600.00	1.3	4705.882	> 800.000	-
otaila D	oformation								
etans - D	elormation	S al an atla		1		C 000			
Govern	ing Membe	r Length	and Contar	L		0.000 m			
Horizon	tal Displace	emeni in Sn	ear center	UY,M		0.0 mm			
Horizon	tal Displaci	ement Due t	U Torsion	UΥ,φ		0.0 mm			
Vertical	Displace	emeni in Ka	пор	UY UT		0.0 mm			
Potntical	Displacem	erii. Avia		UZ		0.00 mm			
Rotation	About X-	-vus Avie		ΨX		0.000 mrad			
Rotatio	About 1-/	400S		φγ		0.113 mrad			
Mania	- ADOUL Z-/	was		φΖ		0.000 1/m			
vvarpin	9			ω		U.UUU 1/m			

Figure 4.16: Window 2.5 Deformation Analysis by x-Location

4.5.1 Theoretical Background on Deformation Analysis

In addition to the internal forces and stresses, CRANEWAY determines the according deformations. These are the displacements u_y , $u_{y,M}$, u_z , the rotations ϕ_x , ϕ_y , ϕ_z , and the warping ω .

The deformation analysis is performed for the displacements in horizontal direction u_y and for the displacements in vertical direction u_z . CRANEWAY allows you to compare them with guide values, which can be defined manually.

- Vertical deflection of the crane runway beam
- Horizontal deformation of the crane runway beam

In the calculation of the deformation, the partial safety factor $\gamma_F = 1.0$ and the combination coefficient $\psi = 1.0$ is used.

The deformation analysis of the lateral displacement is of great importance: The analysis of the horizontal deformation is often the governing design and therefore determines the dimensions of the runway beam.





4.6 Fatigue Design

This window provides two display options that are controlled by means of the *Mode of Output*.

A	B	C	D			E					HE B 300
lember	Location	Stress	Stress								
No.	x [m]	Point No.	Ratio			Governing De	sign				
2	2.900	1	0.212	Design ∆ (x						
2	2.900	2	0.217	Design ∆ (7E2(x)						
2	2.900	4	0.217	Design Δ (7E2(x)					E	1 2 3 4 5
2	2.900	5	0.212	Design ∆ (x						www.com////www.com
2	2.900	6	0.212	Design Δ (7x						N N
2	2.900	10	0.212	Design ∆ (x						8
1	0.500	11	0.253	Design ∆ (7E2(z)					-	
1	5.600	13	0.243	Design ∆1	E2(xz)						
1	6.000	14	0.200	Design ∆ (5E2(x)					Ŧ	N ¹³
lember No	2 - Locat	ion v: 2.90	0 - Stress	Pt No. 1							
Genera	d Characte	rietice	- 30635	11.110.1							
Nomi	nal value of s	tool viold et	renath:		Fran	23.50	kN/cm2		1		
Partia	Eactor for F	atique Loai	dengun.		тук	1 000	KN/GII-		[1] 9 2 (1)	2
Partia	Eactor of Fa	aligue Loai	u vath		700	1 150			[1], J.2 (2	
- Dyna	mic Coefficie	nt of Fouriv	alent Impact	Damage	(Mint 1	1.150			[5] Fa. (2	21	6 7 <u>8</u> 9 10
Dyna	mic Coefficie	nt of Equiv	alent Impact	Damage	Wfat, 1	1.055			[6] Eq. (2	21	z
Stress	Gy	a or aquiri	and a support	2 aago	yrat, 2	1.000			fol ed. (s		
Cated	orv of Struct	ural Detail o	īv.		CDex	160			[5] Tab.	8.	
Stres	s Range		~		Δσχ	7.47	kN/cm ²		1-1 1001		
Crane	Load Cateo	orv for σ _×			Siax	S2			[6] Tab.	B.	
Coeff	icient of Equi	valent Dan	age for σ_x		λί.σχ	0.315			[6] Tab.	2.	
Equiv	alent Consta	nt Amplitud	e Stress Rar	nge	ΔσxE.2	2.35	kN/cm ²			_	
Stress	τχ			-							Hode of Output
Cated	ory of Struct	ural Detail 1	L _{XZ}		CD _{TXZ}	100			[5] Tab.	8.1	mode of output
Stress	s Range τ _{xz}				Δτ _{xz}	0.00	kN/cm ²				Overall
Crane	Load Categ	ory for τ_{xz}			Si	S3					By x-location
Coeff	icient of Equi	valent Dan	hage for τ_{xz}		λi.τxz	0.575			[6] Tab.	2.	,
Equiv	alent Consta	nt Amplitud	e Stress Rar	Δ τ _{xz} E.:	0.00	kN/cm ²					
Design	1			-		1					
Desig	n Δσ _x				ηΔσχ	0.212		≤1	[5], 8 (1)		
Desig	nΔτ _{xz}				ηΔτχ	0.000		≤1	[5], 8 (1)		
Desig	n ΔσE2(x)				η _{Δσ} E2(x	0.169		≤1	[5], 8 (2)		
Desig	n ΔτE2(xz)				η _{Δτ} Ε2(x	0.000		≤1	[5], 8 (2)		
Deere					0	0.005			151 0 (0)	_	

Figure 4.17: Window 2.6 Fatigue Design Overall

If you select the *Overall* mode of output, the upper table shows for the stress points, to which detail categories were assigned (see chapter 2.3, page 22), the respective x-locations with the greatest stress ratio. Column E shows the governing types of stress.

A	B	C	D			E					HE B 300
Member	Location	Stress	Stress								
No.	x [m]	Point No.	Ratio			Governing De	sign				
1	0.000	1	0.000	Design Δσ	esign $\Delta \sigma_x$						
		2	0.050	Design $\Delta \tau$	Design Δ τE2(xz)						
		4	0.050	Design $\Delta \tau$	E2(xz)					1 2 3 4 5	
		5	0.000	Design Δσ	x						www.com///www.com/
		6	0.000	Design $\Delta \sigma$	x						∑ ¹
		10	0.000	Design Δσ	x						
		11	0.191	Design $\Delta \tau$	E2(xz)						
		13	0.204	Design $\Delta \tau$	E2(xz)						
		14	0.000	Design Δσ	x						
		15	0.000	Design Δσ	x					Ŧ	¥13 y
Nomir	nal value of s	teel yield s	trength:		fyk	23.50	kN/cm ²				2
Nomir	nal value of s	teel vield s	trenath:		Evele	23 50	kN/cm ²			l	
Partia	I Factor for F	atigue Loa	d		YEf	1.000			[1], 9.2 (1	1)	
Partia	I Factor of Fa	atigue Strer	ngth		γMf	1.150			[5] Tab. 3	3.1	6 7 8 9 10
- Dynai	mic Coefficie	nt of Equiv	alent Impact	Damage	φfat, 1	1.050			[6] Eq. (2	.1	
 Dynai 	mic Coefficie	nt of Equiv	alent Impact	Damage	φfat, 2	1.065			[6] Eq. (2	.1	z
Stress	σx										
Categ	ory of Struct	ural Detail	σx		CD _{σx}	160			[5] Tab. 8	8.1	
Stress	s Range				$\Delta \sigma_X$	0.00	kN/cm ²				
Crane	e Load Categ	ory for σ_X			Si, σx	S2			[6] Tab. I	B.	
Coeffi	icient of Equi	valent Dan	nage for σ_X		$\lambda_{i,\sigma X}$	0.315			[6] Tab. 2	2.1	A 😫 🛛 🔳 🖽
Equiv	alent Consta	nt Amplitud	le Stress Ra	nge	$\Delta \sigma_{X E,2}$	0.00	kN/cm ²				
Stress	τχΖ										Mode of Output
Categ	ory of Struct	ural Detail	τ _{xz}		CD _{TXZ}	100			[5] Tab. 8	8.1	O Oursel
Stress	s Range τ_{xz}				$\Delta \tau_{xz}$	0.00	kN/cm ²				Uverall
Crane	e Load Categ	ory for τ_{xz}			Si	S3					O By x-location
Coeffi	icient of Equi	valent Dan	nage for τ_{xz}		λi, τxz	0.575			[6] Tab. 2	2.1	
- Equiv	alent Consta	nt Amplitud	le Stress Ra	nge	$\Delta\tau_{\text{XZ}}\text{E}_{*}\text{I}$	0.00	kN/cm ²				
Design	I										
 Desig 	n Δσ _x				ηΔσχ	0.000		≤1	[5], 8 (1)		
Desig	n Δτ _{xz}				$\eta_{\Delta\tau xz}$	0.000		≤1	[5], 8 (1)		
Desig	n Δσε2(x)				$\eta_{\Delta\sigma}$ E2(x	0.000		≤1	[5], 8 (2)		
Desig	n ΔτE2(xz)				$\eta_{\Delta \tau} E2(x)$	0.000		≤1	[5], 8 (2)		
Dama	age				D	0.000		<1	[5] 8 (3)		

2.6 Fatigue Design by x Location

Figure 4.18: Window 2.6 Fatigue Design by x-Location



For the mode of output *By x-Location*, the designs are listed for each member location x and each stress point, to which a detail category was assigned.

Design Details

The lower part of the window lists all intermediate results that apply for the ratio at the stress point selected above. In addition to the general parameters, you can also check the components of the normal and shear stresses as well as the equivalent constant amplitude stress ranges.

4.6.1 Theoretical Background on Fatigue Designs

DIN 4132

In contrast to the stress analysis, the fatigue design uses the partial safety factors $\gamma_F = 1$. Therefore, the provided stresses in the fatigue design <u>cannot</u> be set in relation to the design values of the general stress analysis but must be compared with the according allowable stresses for the fatigue design. They depend on the used steel grade, the detail category, the stress relation of minimum stress to maximum stress ($\chi = \sigma_{min}/\sigma_{max}$) and the number of crane travels defined in the stress group of the crane.

Fatigue damage accumulation is characteristic for the material steel. Each single stress amplitude can be of great importance. Therefore, the following condition is to be satisfied.

$$\sum \left(\frac{\max_{\tau_{i}}^{\sigma}}{\text{allow}_{\tau}^{\sigma}S_{i}}\right)^{k} + \left(\frac{\max_{\tau}^{\sigma}}{\text{allow}_{\tau}^{\sigma}S}\right)^{k} \le 1$$

The following values are to be included in the combination formula:

\max_{τ}^{o}	Maximum stress due to single crane i
$allow_\tau^\sigma S$	Allowable stress for the corresponding stress group
$\max_{ au}^{\sigma}$	Maximum stress from several cranes together
$allow_{\tau}^{\sigma}S$	Allowable stress for the according stress group of several cranes

Exponent k:

k = 6.635 for detail categories W0 through W2 for S	St 37
---	-------

k = 5.336 for detail categories W0 through W2 for St 52

k = 3.323 for detail categories K0 through K4

In determining the allowable stresses for two cranes, the program uses a stress group lower by two levels than the stress group of the crane with the lowest stress group. If there are three cranes, the program uses a stress group lower by three levels than the stress group of the crane with the lowest stress group of the crane with the lowest stress group.

If during the traveling of a crane the maximum stress values σ or τ are already induced by individual crane wheels or wheel groups, they have to be considered for themselves as actions with the allowable stress in the design by using the previous formula.

For complicated stress distributions, the assessment of the amplitudes and the values σ_o and σ_u is difficult. This problem can be solved by using the rainflow method: In this method, the amplitudes and the corresponding top σ_t and bottom σ_b stresses are determined from the stress diagrams. Furthermore, this method can consider all forms of stress diagrams. The determined stresses σ_t and σ_b are then used as input parameters for the actual fatigue design.



The rainflow method gives the resulting stress couples σ_t and σ_b for each period (amplitude). Next, the fatigue design is carried out for these stress couples. Furthermore, it is important to consider if these are full or half periods. In the following combination formulas, the influence of the periods (amplitudes) was added.

$$\sum s_i \left(\frac{\max_{\tau_i}^{\sigma}}{\text{allow}_{\tau}^{\sigma} R_i} \right)^k + \left(\frac{\max_{\tau}^{\sigma}}{\text{allow}_{\tau}^{\sigma} R} \right)^k \leq 1$$

s_i means:

 $s_i = 1.0$ for full period

 $s_i = 0.5$ for half period

For the normal stress σ_z , in contrast to the stresses σ_x and τ , the top stress σ_t and the bottom stress σ_b are not determined by means of the rainflow methods from the stress diagrams. It is assumed that each vertical wheel load travels over the location to be examined and induces the corresponding top stresses σ_t :

$$\sigma_{o,i} = \frac{\phi \cdot W_i}{c \cdot t}$$

where

- φ Dynamic coefficient
- W_i Wheel load
- c Load application length of wheel load
- t Thickness of web plate

CRANEWAY also takes into account eccentrically acting wheel loads that induce a torsional moment. For the stress group B4 - B6, an eccentric load application of $\pm 1/4$ of the rail head width is taken into account. This is done by adding stresses of the according torsional moment $M_{T,i}$ to the centric wheel load application, see Figure 4.19a).





Figure 4.19: Stress at the upper edge of the web due to eccentric wheel load

4 Results



If the horizontal inertial forces H_M are considered in the fatigue design, we obtain the torsional moment $M_{T,i}$ according to Figure 4.19 b).

The composed normal stress $\sigma_{\text{z,i,}}$ is thus:

$$\sigma_{z,i} = \sigma_{z,i,V} + \sigma_{z,i,M}$$

where

$$\sigma_{z,i,V} = \sigma_{o,i}$$

$$\sigma_{z,i,M} = \frac{6}{t^2} \cdot M_{T,i} \cdot \frac{\lambda}{2} \cdot \tanh\left(\frac{\lambda \cdot a}{2}\right)$$

where

$$\lambda = \sqrt{\frac{m_d}{G \cdot I_T}}$$
$$m_d = 1.15 \cdot \frac{E \cdot t^3}{a} \cdot \frac{\left(\sinh\left(\frac{\pi \cdot b}{a}\right)\right)^2}{\sinh\left(\frac{2 \cdot \pi \cdot b}{s}\right) - 2 \cdot \frac{\pi \cdot b}{a}}$$

The descriptions mean:

- t Thickness of the web plate
- G Shear module (steel G = 8100 kN/cm²)
- E Modulus of elasticity (steel G = 21000 kN/cm²)
- I_T Torsion constant
- a Spacing of the transverse web stiffeners
- b Depth of the transverse web stiffener (is usually equal to the depth of the web plate)

In the fatigue design, the stress σ_z from the wheel load has an influence, according to [2] clause 4.1.2 τ , on the shear stresses at the loaded upper edge of the web plate. The stress σ_z from the wheel load induces the sheer stress τ_{xz} in the web plate. In CRANEWAY, this is taken into account by the following formula:

 $\tau_{xz}=0.2\cdot\sigma_z$



EN 1993-6 (EN 1993-1-9)

The fatigue design according to EN 1993-1-9 is based on the nominal stress concept. The internal forces are determined according to the structural analysis for members; the stresses are calculated at the location of the expected crack formation according to the mechanics of materials. In the fatigue design, the nominal stress ranges $\Delta\sigma$ and $\Delta\tau$ due to actions are compared to the design values of the fatigue strength $\Delta\sigma_R$ and $\Delta\tau_R$. Furthermore, the concept of the partial safety values applies in EN 1993-1-9.

The standard procedure according to EN 1993-1-9 is the design by means of the damage equivalent factors: Here, the equivalent constant amplitude stress ranges $\Delta\sigma_{E,2}$ and $\Delta\tau_{E,2}$ relative to $n = 2*10^6$ stress cycles under consideration of the partial safety factors are to be set in relation to the limit values of the fatigue strength $\Delta\sigma_c$ or $\Delta\tau_c$ for $n = 2*10^6$ stress cycles of the detail category. This leads to the following design requirements:

$$\frac{\gamma_{\text{Ff}} \cdot \Delta \sigma_{\text{E,2}}}{\Delta \sigma_{\text{C}} \,/ \, \gamma_{\text{Mf}}} \! \leq \! 1.0 \qquad \text{ and } \qquad$$

$$\frac{\gamma_{\rm Ff} \cdot \Delta \tau_{\rm E,2}}{\Delta \tau_{\rm C} \, / \, \gamma_{\rm Mf}} \leq 1.0$$

where

 $\gamma_{\rm Ff} \cdot \Delta \sigma_{\rm E,2} = \lambda \cdot \Delta \sigma$

EN 1993-1-9, chapter 8, Eq. 8.2

For simultaneous occurrence of direct and shear stress ranges, the following is valid:

$$\left(\frac{\gamma_{\text{Ff}} \cdot \Delta \sigma_{\text{E,2}}}{\Delta \sigma_{\text{C}} / \gamma_{\text{Mf}}}\right)^3 + \left(\frac{\gamma_{\text{Ff}} \cdot \Delta \tau_{\text{E,2}}}{\Delta \tau_{\text{C}} / \gamma_{\text{Mf}}}\right)^5 \le 1.0$$

EN 1993-1-9, chapter 8, Eq. 8.3

To determine the equivalent constant amplitude stress range, EN 1991-3 gives the damage equivalent factors λ_i for the respective damage classes. The following table is implemented in CRANEWAY.

Classes S	S ₀	S_1	S ₂	S ₃	S_4	S ₅	S ₆	S ₇	S ₈	S9
normal stresses	0,198	0,250	0,315	0,397	0,500	0,630	0,794	1,00	1,260	1,587
shear stresses	0,379	0,436	0,500	0,575	0,660	0,758	0,871	1,00	1,149	1,320

Table 2.12 —	λ_i -value	s according	to the	classification	of	cranes
--------------	--------------------	-------------	--------	----------------	----	--------

NOTE 1: In determining the λ -values standardized spectra with a gaussian distribution of the load effects, the Miner rule and fatigue strength S-N lines with a slope m = 3 for normal stresses and m = 5 for shear stress have been used.

NOTE 2: In case the crane classification is not included in the specification documents of the crane indications are given in Annex B.

Figure 4.20: Damage equivalent factors according to EN 1991-3, Table 2.12



4.7 Plate Buckling Analysis

For the *Overall* mode of output, the upper table shows the member with the x-location where the maximum ratio occurs for each panel of the crane runway beam. In the table below, you can see detailed characteristics of the buckling panel, local stresses, coefficients, etc. for the row selected in the table above.

A B C D		E					HE B 300
Nember Buckling Location Stress							Member No. 1, x: 0.500 I [m]
No. Panel No. X [m] Hatio							
1 1 0.500 0.594							
2 1 0.100 0.594							1 2 3 4 5
Member No. 1 - Location x: 0.500 - Buckling Panel N	lo. 1						
Crane girder cross-section							-1.34
Stiffener Spacing	a	6.000	m				-4.46-3.91 3.30
Buckling Panel Depth	b	262.0	mm				-6.48 -2.71
Buckling Panel Thickness	t	11.0	mm				
∃ Local Stress							
 Design Value of Wheel Load 	Fz,Ed 1	13.68	kN		[1], 5.7.1 E		13 y
 Effective Transmission Length of Flange 	leff (0.081	m		[1], 5.7.1 E		
Transmission Length = leff-2t f up	Ss	0.043	m		[3] 6.3		2.71
Local Vertical Stress	σoz.Ed	7.67	kN/cm ²		[1], 5.7.1 E		4.41 4.02 3.91 3.80 3.40
 Local Shear Stress 	Toxz,Ed	1.53	kN/cm ²		[1], 5.7.2 (1	Ξ	
 Global Shear Stress 	τd,glob	1.38	kN/cm ²				
 Resulting Shear Stress 	τd	2.91	kN/cm ²				6 7 8 9 10
 Local Bending Stress Due to Wheel Eccentricity 	OT,Ed	12.68	kN/cm ²		[1], 5.7.3 E		2
— Design Ratio σ _{oz,Ed}	η _σ oz,Ed	0.359		≤1			
— Design Ratioτ _{oxz,Ed}	η _τ oxz,Ed	0.236		≤1	[1], 5.7.2 (1		
Design Ratio ot,Ed	ησT,Ed	0.594		≤1			
Coefficients							Min: -6.48 kN/cm^2 (1)
 Factor of Buckling Resistance 	η	1.200					Max: 4.41 kN/cm^2 (6)
 Coefficient of Critical Shear Stress 	k _τ !	5.340			[3], A.3 (1)		🖪 😂 💷 🔜 🔚 Ҭ 🖽 🛤 😭 🧭
 Coefficient of Buckling Due to Flange Bending 	k (0.550			[3], 8 (1)		
 Coefficient of Shear Resistance 	ηshear	1.200			[3], 5.1		Mode of Output
 Coefficient of Web Contribution to Shear Buckling 	χw	1.200			[3] Tab. 5.1		
 Slenderness Coef. of Local Shear Buckling 	λw	0.276			[3], 5.3 Eq.		Uverall
Buckling Coefficient	kr (6.004			[3] Fig. 6.1		O By x-location
 Coefficient of Local Buckling 	χF	1.000			[3], 6.4 (1)		
 Slendemess Coef. of Local Buckling 	λF	0.354			[3], 6.4 (1)		
 Coeff. of Effective Loaded Length 	m1 2	7.273			[3], 6.5 (1)		
Coeff. of Effective Loaded Length	m2	0.000			[3], 6.5 (1)		
Buckling stress							
σε	σE	33.46	kN/cm ²		[3], A.1 (2)		
 Critical Stress Under Shear Buckling 	Ter 1	78 66	kN/cm ²		[3] 5 3 Eq.		

Figure 4.21: Window 2.7 Plate Buckling Analysis - Overall

You can display the governing designs also By x-location.

2.7 Plate Buckling Analysis by x Location

A	В	С	D		E					HE B 300
Member	Buckling	Location	Stress						h	Member No. 1, x: 0.500 I [m]
No.	Panel No.	x [m]	Ratio							
1	1	0.500	0.594							
		1.000	0.594							
		1.500	0.594							
		2.000	0.594							-1.34
		2.500	0.594							2 01 3 35
		3.000	0.594							4.46 3.37
		3.500	0.594							-6.48 -2.71
		4.000	0.594							
		4.100	0.594							13
_		4.600	0.594						Ŧ	· · · · · · · · · · · · · · · · · · ·
Member N	- 1 Loc	ation v: 0.5	00 Buckling Danel M	lo 1						2,71
	airder ca	autori X. 0.5		10. 1					1.	4.41 4.02 3.91 3.80 3.40
Stiffe	ner Snacin			a	6 000	m			6	2
Buck	ling Panel	9 Denth		h	262.0	mm	-			
Buck	ling Panel	Thickness		E E	11.0	mm				6 7 8 9 10
	Stress									•
Desic	n Value of	Wheel Load		Fz.Ed	113.68	kN		[1], 5.7.1 E		
Effec	, tive Transr	nission Lenat	th of Flance	leff	0.081	m		[1], 5.7.1 E		
Trans	mission Le	ngth = leff-2	tfuo	Ss	0.043	m		[3] 6.3		
Loca	Vertical St	ress		σoz.Ed	7.67	kN/cm ²		[1], 5.7.1 E		Min: -6.48 kN/cm^2 (1)
Loca	Shear Stre	ss		Toxz,Ed	1.53	kN/cm ²		[1], 5.7.2 (1		Max: 4.41 kN/cm^2 (6)
Globa	al Shear Str	ress		τd,glob	1.38	kN/cm ²				
Resu	Iting Shear	Stress		τd	2.91	kN/cm ²				
- Loca	Bending S	Stress Due to	Wheel Eccentricity	GT,Ed	12.68	kN/cm ²		[1], 5.7.3 E		Mode of Output
Desig	n Ratio σ _o	z,Ed		η _σ οz,Ed	0.359		≤1			
- Desig	n Ratioτ _o	z,Ed		η _τ oxz,Ed	0.236		≤1	[1], 5.7.2 (1		O verall
- Desig	n Ratio στ	,Ed		η _σ τ.Ed	0.594		≤1			By x-location
⊡ Coeffic	cients									
- Facto	or of Bucklin	ng Resistanc	æ	η	1.200					
- Coeff	 Coefficient of Critical Shear Stress 				5.340			[3], A.3 (1)		
Coeff	icient of Bu	uckling Due t	o Flange Bending	k	0.550			[3], 8 (1)		
Coeff	 Coefficient of Shear Resistance 				1.200			[3], 5.1		
- Coeff	icient of W	eb Contributi	ion to Shear Buckling	χw	1.200			[3] Tab. 5.1		
Slend	lemess Co	ef. of Local S	Shear Buckling	λw	0.276			[3], 5.3 Eq.		
Buck	ling Coeffic	ient		kf	6.004			[3] Fig. 6.1	Ŧ	

Figure 4.22: Window 2.7 Plate Buckling Analysis by x-Location



4.8 Welds - Stress Analysis

This window is displayed only if you selected the weld seam design in the 1.3 *Cross-Section* window (see chapter 2.3, page 15). The stresses of the weld seams can also be displayed *Overall* or *By x-location*.

A	B	С	D			F		0	i	HE B 300	
Member	Location		Govern.	Str	ess	Stress	•				
No.	x [m]	Weld Position	CO	[kN/	cm2]	Ratio					
1	6.000	Rail - Flange	CO62		0.81	0.8	70				
ember No). 1 - Locati	on x: 6.000 - Weld:Ra	il - Flange							1 2 3 4 5	
Genera	al Weld Cha	racteristics								yuuuuu (Muuuuuuu)	
Nomin	nal Value of S	teel Ultimate Strength:	fi			36.00	kN/cm ²			N N N N N N N N N N N N N N N N N N N	
Partia	l Factor		Y	Mw		1.250			[4] Tab. 2.1		
Correl	ation Factor		β	w		0.800			[4] Tab. 4.1		
Crane	Governing fo	or Wheel Load	N	lo.		1					
Desig	n Value of Ve	ertical Wheel Load	F	Z,d		113.68	kN				
Desig	n Value of Ho	prizontal Wheel Load	H	d		0.00	kN			3	• y
Effect	tive Weld Dep	oth	а	w		9.0	mm			S S	
Welds	- Stresses	σ, τ									
⊞ Intem	al forces CO	62 : 1.35*LF1+1.35*LF10	0+1.35*LF10	2+1.35*	LF104						
Effect	tive Load Tra	nsmission Length	L	eff		0.043	m				
Result	ting Vertical S	Stress	σ	w,z		22.13	kN/cm ²				
Result	ting Horizonta	al Stress	σ	w.y		0.00	kN/cm ²			6 7 8 9 10	
Axial \$	Stress Perper	dicular to Weld Plane	σ	L		15.65	kN/cm ²		[4], 4.5.3.2	L +	
Shear	r Stress Perpe	endicular to Weld Plane	τ	L		15.65	kN/cm ²		[4], 4.5.3.2	Z	
Shear	r Stress Parall	el with Weld Plane	τ			0.81	kN/cm ²		[4], 4.5.3.2		
Desig	n Ratio		η	weld		0.870		≤1	[4] Eq. 4(1)		
											-
										Mode of Output	
										 Overall 	
										Bu v-location	
										U by Mocatori	

Figure 4.23: Window 2.8 Welds - Stresses Overall

For the *Overall* mode of output, the upper table shows only those x-locations of each weld seam (rail-flange and flange-web) that result in a maximum ratio. It also shows for which load combination this design criterion is relevant.

The design criterion is met if the ratio is smaller than 1. The stress ratio is the ratio of determined equivalent stress to the limit equivalent stress of the weld seam.

Details of weld seams

The lower table of this window lists the intermediate results for the design criterion of the location selected in the table above. In addition to the general weld characteristics, the table shows the internal forces, normal stresses σ , and shear stresses τ of the weld seam.



If you select the mode of output *By x-location*, the table shows the governing stress analyses for the weld seams at every x-location.

A	B	С	D	E	F		G		HE B 300
ember	Location		Govern.	Stress	Stress			h	
No.	x [m]	Weld Position	CO	[kN/cm ²]	Ratio			-	
1	0.000	Rail - Flange	CO47	0.65	0.870				
	0.500	Rail - Flange	CO47	0.65	0.870				
	1.000	Rail - Flange	CO57	0.45	0.870				1 2 3 4 5
	1.500	Rail - Flange	CO57	0.45	0.870				annan Mhananan a
	2.000	Rail - Flange	CO62	0.36	0.870				
	2.500	Rail - Flange	CO70	0.26	0.869				
	3.000	Rail - Flange	CO75	0.32	0.870				
	3.500	Rail - Flange	CO75	0.33	0.870				
	4.000	Rail - Flange	CO82	0.49	0.870				
	4.100	Rail - Flange	CO47	0.51	0.870			-	3 y
Genera Nomin	al Weld Char nal Value of Ste	acteristics eel Ultimate Strength:	fu	36	00 kN/cm ²	T		-	
Partial	I Factor		7Mw	1.2	50		[4] Tab. 2.		
Correl	ation Factor		Bw	3.0	00		[4] Tab. 4.		
Crane	Governing for	Wheel Load	No.		1				
Desig	n Value of Vert	ical Wheel Load	Fz,d	113	68 kN				z
Design Value of Horizontal Wheel Load			Ha	0	00 kN				
Effect	tive Weld Dept	h	aw		9.0 mm				
Welds ·	- Stresses σ	τ						-	
International	al forces CO47	: 1.35*LC1+1.35*LC76	+1.35*LC78+	1.35*LC80				-	
Effect	ive Load Trans	mission Length	Leff	0.0	143 m				🖌 😂 🛛 🔭 🖽 😭
Result	ting Vertical Str	ress	σ _{w,z}	22	13 kN/cm ²				
Result	ting Horizontal	Stress	σ _{w,y}	0	.00 kN/cm ²				Mode of Output
Axial S	Stress Perpend	icular to Weld Plane	σL	15	.65 kN/cm ²		[4], 4.5.3.2		C Russell
Shear	r Stress Perpen	dicular to Weld Plane	τL	15	.65 kN/cm ²		[4], 4.5.3.2		Uverali
Shear	Stress Parallel	with Weld Plane	τ	0	.65 kN/cm ²		[4], 4.5.3.2		By x-location
Desig	n Ratio		ηweb	8.0	70	≤1	[4] Eq. 4(1)		

Figure 4.24: Window 2.8 Welds - Stresses by x-Location

4.9 Welds - Fatigue Design

This window shows the weld seam ratios for the fatigue design. As in the other output windows, you can select between the modes of output *Overall* and *By x-Location*.

A B C D			E			HE B 300
ember Location Stress		(Governing			
No. x [m] Weld Position Ratio		Ту	pe of Stress	;		
1 5.600 Rail - Flange 7.55)) Damag	e				
shar No. 1 Loostian v: 5 600 Wold: Dail Elange						
hiber No. 1 - Location X. 5.600 - Weld. Rail - Plange						
Design Value of Vertical Wheel Load	E.	70.61	LaNI	1		
Cropp Geverning for Wheel Load	FZ,d	/3.01	KIN			
Effective Wold Depth	110.	90				
Nominal value of steel yield strength:	E.a.	22 50	kN/cm ²			
Nominal Value of Steel Ultimate Strendth:	F.,	23.00	kN/cm ²			
Partial Eactor for Estique Load	10	1 000	Kin/Gill*	-	[1] 9 2 (1)	
Partial Factor of Fatigue Strength	711	1 150			[1], J.Z (1)	
Dynamic Coefficient of Equivalent Impact Damage	TMT Ofert 4	1.100			[0] 1a0. 3.	
Dynamic Coefficient of Equivalent Impact Damage	wfat, 1	1.000			[6] Eq. (2.1	
Category of Structural Detail ov	CD_w	1.000			[5] Eq. (2.1	
Category of Structural Detail or	CD-7	36			[5] Tab. 8	
Category of Structural Detail 1/2	CD_vr	36			[5] Tab. 8	
conficients	00112	50	1		[0] (d). 0.	6
Crane Load Category for gy	Sigr	\$2			[6] Tab. B	
Crane Load Category for Gr. Type welds	Sieve	52	l		[6] Tab. B.	
Coefficient of Equivalent Damage for gx	higy	0.315			[6] Tab. 2	
Coefficient of Equivalent Damage for typ	λί της	0.575			[6] Tab. 2.	
Coefficient of Equivalent Damage for σ_2	λi σ7	0.397			[6] Tab. 2.	
Velds - Stresses g. t		0.007	1		and the second	
Resulting Vertical Stress	σw.z	15.50	kN/cm ²			
Shear Stress Perpendicular to Weld Plane	τι	0.54	kN/cm ²		[5], 5 (6)	Made of Output
Shear Stress Parallel with Weld Plane	τ	0.54	kN/cm ²		[5], 5 (6)	mode of output
Axial Stress Perpendicular to Weld Axis	σwf	15.50	kN/cm ²		[5], 5 (6)	 Overall
Design Ratio	ηweld	0.440		≤1	[5] 5(6)	By x-location
Design Δ τ _{xz}	ηΔτχ	0.027		≤1	[5], 8 (1)	
Design $\Delta \sigma E2(x)$	η _{Δσ} E2(x	0.000		≤1	[5], 8 (2)	
Design $\Delta \sigma E_2(z)$	η _{Δσ} E2(z	1.965		>1	[5], 8 (2)	
Design $\Delta \tau E2(xz)$	η _{Δτ} Ε2(×	0.100		≤1	[5], 8 (2)	
Damage	D	7.590		>1	[5], 8 (3)	

Figure 4.25: Window 2.9 Welds - Fatigue Design Overall



4.10 Critical Load Factors

The last results window appears if you select the check box *Calculate critical load factors of all load combinations* in the *FE-LTB* tab of the *Details* dialog box (see Figure 3.3, page 37). It provides an overview of the critical load factors determined for the relevant load combinations (load positions).

А	В	C	
	Critical		
CO	Load Factor	Reason for Ending Calculation	
CO1	9.000	9) Maximum nu factor has been reached -> no stability problem	
:047	8.969	Diagonal coefficient in matrix is less than zero	
:057	8.453	3) Maximum number of 50 equilibrium iterations has been reached	
:062	7.531	3) Maximum number of 50 equilibrium iterations has been reached	
:070	7.781	3) Maximum number of 50 equilibrium iterations has been reached	
075	7.969	2) Diagonal coefficient in matrix is less than zero	
082	8.531	2) Diagonal coefficient in matrix is less than zero	
:085	9.564	2) Diagonal coefficient in matrix is less than zero	
0107	7.656	3) Maximum number of 50 equilibrium iterations has been reached	
0112	8.656	3) Maximum number of 50 equilibrium iterations has been reached	
0122	8.719	3) Maximum number of 50 equilibrium iterations has been reached	
0140	7.656	3) Maximum number of 50 equilibrium iterations has been reached	

Figure 4.26: Window 2.10 Critical Load Factors

Critical Load Factor

The value is an indicator for the stability of the structural system. A critical load factor of, for example, 7.969 for the load combination CO75 (see figure above) means that the loading of this load combination can be increased only by the factor 7.969 until the system becomes unstable (comment *Diagonal coefficient in matrix is less than zero*). An elastic material behavior is assumed.

Reason for Ending Calculation

In most cases, column C shows the comments *Diagonal coefficient in matrix is less than zero* or *Maximum number of x equilibrium iterations has been reached*. The first comment indicates that the loss of stability could be confirmed mathematically. The second comment means that it was not possible to reach the break-off limit in the allowed number of iterations. The *Maximum number of equilibrium iterations* and the *Break-off limit* are set in the *FE-LTB* tab of the *Details* dialog box (see Figure 3.3, page 37).



If the critical load factor is smaller than 1, the model becomes unstable already before reaching the design load.

If the critical load factor is 0, the calculation could not be carried out. The model is probably kinematic so that you have to check the support conditions.



5. Printout Report

The CRANEWAY input and output data is not automatically sent to a printer. Instead, the printout report is first generated from the data. You can add graphics, descriptions or comments, scans, etc. to the printout report (see Figure 5.5, page 66).

5.1 Create Printout Report

Since the printout report has not been created in RSTAB or RFEM yet, you must first exit CRANEWAY by clicking [OK] or [Graphics]. The printout report can then be started in RSTAB or RFEM by selecting from the menu

File \rightarrow Open Printout Report

or clicking the corresponding button.

If a printout report does not exist yet, the New Printout Report dialog box appears.

1
<u>}</u>
2

The *number* of the report is set by default but can also be changed. You can add a *Description* for the report, which makes it easier to select it from the list of other reports later. The description does not appear in the printout.

Furthermore, you can select a particular report template from the list in the dialog section *Printout Report Template*.

The buttons in the dialog box have the following functions:

~	A new report template can be created.
	The selection of the report can be edited (\rightarrow chapter 5.2, page 63).

Table 5.1: Buttons in dialog box New Printout Report

OK

Graphics

Figure 5.1: Dialog box New Printout Report



5.2 Selection in Printout Report

You can select the chapters to be displayed in the printout report in a dialog box. To open this dialog box, select in the printout report menu

Edit ightarrow Selection

Ť

or click [Select Topics for Printout Report].

The Printout Report Selection dialog box appears.

ogram / Modules	Global Selection Input Data Results	
ISTAB	Display	
RANEWAY	V Data of Module	
	I locat Data	
	Cases to Display	
	V Display all cases	
	Existing cases: Cases to display:	
	CRANEWAY Crane runway girder	
	•	
splay		
Cover sheet		
Contents		
Info pictures		

Figure 5.2: Dialog box Printout Report Selection, tab Global Selection

The list in the *Program / Modules* section contains the modules, for which input data is available. After you select the program in this list, you can continue with the tabs to the right to select the chapters that you want to print.

Global Selection

The first tab manages the main chapters of the report. If you clear the selection of a check box, the corresponding detail tab disappears as well. To display only the input data and results from CRANEWAY, you can clear the selection of the *RSTAB Data* or *RFEM Data* in the global selection of these programs.

Use the three check boxes in the lower-left section *Display* to decide if you want to display the *Cover sheet*, *Contents*, or small *Info pictures* in the report margin.

Input Data

The second tab controls which input data should appear in the report.

5 Printout Report



rogram / Modules	Global Selection Input Data Results			
RSTAB	Display			
CRANEWAY	V Details			
	Data for National Annex			
	V List of Standards Lised			
	Material Data			
	V Load Case Description			
	Load Case Description			
	Load Case Description for Paligue			
		Continution	No. Selection (e.g. '1-5,20')	
	Load Combination Description	Combinations:	All	
	Load Combination Description for Fatigue	Combinations:	All	
	Imperfections			
lisplay				
Cover sheet				
Contents				
Info pictures				

Figure 5.3: Dialog box Printout Report Selection, tab Input Data

For many of the listed categories, you can specifically define the scope of the data to be printed by clicking [Details].





Results

In this tab, you can also define which results should be included in the printout report and how detailed the output should be by using the check boxes and option buttons.

rogram / Modules	Global Selection Input Data Results		
RSTAB	Disolay		
CRANEWAY	Design Summary		
	Internal Forces Capacity - All	Support Forces - All	
	Internal Forces Fatigue - All	📝 Support Forces - Max/m	in only
	Internal Forces Capacity - Max/min only	Support Forces - Only m	ax/min advanced
	📝 Internal Forces Fatigue - Max/min only		
			Members No. Selection (e.g. '1-5,20')
	Stress Analysis	Overall	All 👻
		By x-location	
		By stress point	
	Deformation Analysis	Overall	All 👻
		By x-location	
	✓ Fatigue Design	Overall	All 👻
		By x-location	
	V Plate Buckling Analysis	Overall	All 👻
		By x-location	
	Welds - Stress Analysis	Overall	All 🗸
		By x-location	
	Welds - Fatigue Design	Overall	A
		By x-location	
	Critical Load Factors		
isplay			
Cover sheet			
Contents			
Info pictures			

Like the CRANEWAY results windows, the printable results are sorted by designs. To specify the

Figure 5.4: Dialog box Printout Report Selection, tab Results

scope of the printed results, click [Details].



5.3 Printout Report Navigator

The generated printout report shows a Navigator on the left and a preview of the printout report in the main window on the right.

The individual chapters of the report can be moved anywhere in the Navigator by using the drag-and-drop function.

The context menu in the Navigator provides further options for adjusting the printout report. To open the context menu, right-click the relevant chapter. As common for Windows applications, you can use multiple selections by pressing [Ctrl] or $[\hat{T}]$.



Figure 5.5: Context menu in navigator and preview

Remove from Printout Report

The selected chapter will be deleted. If you want to reinsert it, select menu $Edit \rightarrow Selection$.



The selected chapter starts on a new page and is marked by a red pin in the navigator.

Selection

You have access to the global selection that is described on the following pages. The selected chapter is preset.

Properties

Some general properties of a chapter can be modified; for example, you can change the title or enter an additional description.





6. General Functions

This chapter describes useful menu functions and graphical options for input and evaluation.

6.1 Menu File

With these menu functions, you can change the description of the CRANEWAY case and export the windows as tables.

Rename

This function allows you to enter a new Description for the CRANEWAY case.

Rename C	RANEWAY Case	×
No.	Description Crane runway girder	-
٦		OK Cancel

Figure 6.1: Dialog box Rename CRANEWAY Case

Export Tables

CRANEWAY allows you to directly export data to *MS Excel*, *OpenOffice.org Calc*, or the *CSV* file format. The following export dialog box appears.

xport - MS Excel	×
Table Parameters	Application
📝 With table header	Microsoft Excel
Only marked rows	OpenOffice.org Calc
	CSV file format
Transfer Parameters	
Export table to active workbook	
Export table to active workshee	t
Rewrite existing worksheet	
Selected Tables	
 Active table 	Export tables with details
All tables	
📝 Input tables	
Result tables	
2	OK Cancel

Figure 6.2: Dialog box Export - MS Excel

When your selection is complete, you can start the export by clicking [OK]. Excel or OpenOffice will be started automatically, that is, the programs do not have to be opened first.

File	Settings Help	
	Rename	
	Save	CTRL+S
	Save As	
	Export Tables	



Fi	le H	ome Insert Pag	e Layout	Formulas	s D	ata Revi	iew Vie	w Add-Ins			\$	0 -	, ¢
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Pas	te 🛷	🔆 - 🖄 - <u>A</u> -	-	نو ک	◆ .0	.00	📑 Cell St	yles *	📰 For	rmat -	2-	Sort & Filter ▼	Sele
lipt	board 🕞	Font	G AI	ignment	G N	umber 🛛 🛱		Styles	Cel	lls		Editing	9
	A1	- (0	f _x										
4	А	В	С	D	E	F	G	Н		1		J	
1 Member		Location	Stress	Governing	Stress		Stress						
2	No.	x [m]	Point No.	со	Туре	[kN/cm ²]	Ratio						
3	1	0.000 r	11	CO47	σαν	10,69	0,500						
4		0.5001	11	CO47	σααν	9,91	0,464						
5		1.000 r	1	C057	σαν	8,80	0,412						
5		1.500	1	C057	σααν	13,35	0,625						
7		2.0001	1	C062	σαν	14,95	0,700						
3		2.5001	1	C070	σααν	18,46	0,864						
•		3.000 r	1	C075	σαν	17,44	0,816						
.0		3.500 r	1	C075	σααν	12,41	0,581						
1		4.000	1	C085	σαν	12,55	0,588						
2		4.100	5	CO47	σααν	11,65	0,545						
.3		4.600 r	11	CO47	σαν	9,30	0,435						
4		5.100 r	11	C057	σααν	12,37	0,579						
5		5.600 r	11	CO62	σαν	13,48	0,631						
6		6.000 I	11	CO62	σααν	14,44	0,676						
7	2	0.000 r	11	CO107	σααν	14,36	0,672						
8		0.100 r	11	CO107	σααν	14,08	0,659						
9		0.500 I	11	CO107	σααν	13,22	0,619						
0		0.600 r	11	CO112	σααν	12,41	0,581						
1		1.000	11	CO112	σααν	12,16	0,569						
2		1.300 r	11	CO122	σααν	11,46	0,537						
3		1.6001	5	C082	σαυ	9,44	0,442						
4		2.000	1	C0122	σααν	12,59	0,589						
5		2.500 r	1	CO140	σααν	11,32	0,530						
26		3.000 r	1	CO140	σααν	15,52	0,727						
7		3.400 r	1	CO140	σα	19,18	0,898						

Figure 6.3: Result in Excel



6.2 Menu Settings

This menu contains functions for controlling the calculation and units.

Details

This function opens the *Details* dialog box. The tabs of this dialog box are described in chapter 3.1, page 34.

Units and Decimal Places

This function allows you to adjust the units and decimal places of the input and output data. A dialog box appears containing the two tabs *Input Data* and *Results*.

Units and Decimal Places							×	
Program / Module		Input Data Results						
RSTAB								
STEEL		Deformations			Internal Forces			
STEEL EC3			Unit	Dec. Places		Unit	Dec. Places	
STEEL AISC		Displacements:	mm	1	Forces:	LN -	2 4	
STEEL IS		Displacements.			101003.			
STEEL SIA		Rotations:	mrad 🔻	3 🌲	Lengths for moments:	m 🔻	2 🌲 🖣	
STEEL BS		Waming	1/m -	3				
STEEL GB		Waiping.	1/111 •					
STEEL CS	=	Design criteria:	% 🔻	3 ≑				
STEEL AS	-							
STEEL SP		Stresses			Support Forces			
- STEEL NTC-DF					-			
STEEL Plastic		Stresses:	kN/cm [™] 2 ▼	2 🖃	Forces:	kN 🔻	2 🛫	
- ALUMINIUM		Stress ratios:	% 👻	3 🌩 🖣	Lengths for moments:	m 🔻	2 🌩	
KAPPA								
LTB		Factors:	% 🔻	3 🖶 🏼				
FE-LTB								
EL-PL								
- С-ТО-Т								
PLATE-BUCKLING								
CRANEWAY								
CONCRETE								
CONCRETE Columns								
TIMBER Pro								
TIMBER AWC								
DVNAM								
	-							
JUNIS		L						
	U					ОК	Cancel	

Figure 6.4: Dialog box Units and Decimal Places



The settings can be saved as a user profile by clicking [Save as Profile] and reused in other models by clicking [Load Saved Profile]. By clicking [Default], you can restore the default settings.





6.3 Graphic

6.3.1 Input Data

To check the input data graphically, click [3D-Rendering]. A new window appears showing a visualization of the crane runway girder.



Figure 6.5: Graphic of the crane runway girder

The graphic shows the model of the runway girder and the load positions with the crane position and the acting forces.

Ð

Ø De Las Tap

The toolbar provides information on the current *Crane Position* and the total number of positions. Here, you can set another crane position. The movement of the crane on the girder can also be visualized by an animation.

Furthermore, you can also display all loads acting in individual crane positions. For all load combinations, you can also display the according imperfections.

In the list *Load cases to calculate*, you can select between the various design situations (resistance, fatigue, deformation, or support forces).



3D-Rendering



6.3.2 Results

The results can be displayed graphically in the RSTAB or RFEM work window. There, you can use all functions of the *Display* navigator to change the view.

To go to the work window, click [Graphics].



Figure 6.6: Graphic of results

If the results of the CRANEWAY case are not shown, you can display them by clicking the button [Show Results].

Panel

٩

The control panel contains the tabs *Color Spectrum, Factors*, and *Filter*. They allow you to check the values by colors and modify the color scales, define the display factors or select the members for the results display.

Navigator

The *Results* navigator controls which result diagrams are to be displayed on the model:

- Stresses σ_{x+}, σ_{x-}, τ, and σ_{eqv}
- Ratio for σ_x , τ , and σ_{eqv}
- Deformations
- Internal Forces



6 General Functions





Figure 6.7: Results navigator for CRANEWAY

For the display of the *Deformations*, you can visualize the total displacement *u* as well as the displacements and rotations related to the global coordinate axes X,Y, and Z. The displacements in Y-direction always refer to the upper rail edge and also contain components from the rotation of the cross-section.

The Internal Forces N, V_y, V_z, M_T, M_y, M_z, M_{Tprim}, M_{Tsek}, and M_{ω} can be checked graphically.

CRANEWAY

To return to CRANEWAY, click [CRANEWAY].


7. Example

7.1 Two-Span Crane Runway acc. to DIN EN 1993-6

The following example from literature is calculated with CRANEWAY. In this way, it is possible to understand the calculations and to see the various possibilities of the program in action. The example is from [19].

System

- Two-span crane runway, cross-section HEB 300, flat steel crane rail 5 cm x 3 cm (worn-out), connected with double fillet weld $a_w = 5$ mm, S 235
- Self-weight of crane runway girder with rail g = 1.35 kN/m
- Transverse stiffeners only at the supports, welded at web and flanges, respectively
- Support on consoles at the hall columns, fork support
- Travel by means of a single crane bridge, crane system IFF
- Hoisting class HC2
- Stress group S₂
- Wheel distance c = 3.6 m

Loads

• Vertical wheel loads:

Q_c=18.00 kN Q_h=57.00 kN, due to self-weight due to hoist load

• Horizontal wheel loads:

 $H_s = 20.00 \text{ kN}$ $H_{T1}(H_1) = -H_{T2}(H_2) = 8.60 \text{ kN}$ Guide forces = S-Hs Loads from acceleration and braking



Figure 7.1: Sketch of system



Figure 7.2: Cross-section



7.2 Internal Forces - Capacity

		1	Acc. to [19]]		(CRANEW	AY	
Maximum field moment				x- location				x- location	
RC1	$M_{\text{y,d}}$	147.90	[kNm]	2.10	[m]	147.20	[kNm]	2.10	[m]
	$M_{z,d}$	23.70	[kNm]	3.36	[m]	23.52	[kNm]	2.60	[m]
RC2	$M_{\text{y,d}}$	132.20	[kNm]	2.10	[m]	132.00	[kNm]	2.10	[m]
	$M_{z,d}$	33.60	[kNm]	2.58	[m]	37.17	[kNm]	2.50	[m]
Maximum supporting moment									
RC1	$M_{\text{y,d}}$	-129.87	[kNm]	6.00	[m]	-129.30	[kNm]	6.00	[m]
RC2	$M_{\text{y,d}}$	-116.37	[kNm]	6.00	[m]	-116.34	[kNm]	6.00	[m]
Maximum shear force									
RC1	$V_{z,d} \\$	-175.50	[kN]	0.00	[m]	-172.10	[kN]	0.00	[m]
	$V_{\text{y,d}}$	-17.40	[kN]	0.00	[m]	-17.41	[kN]	0.00	[m]
RC2	$V_{z,d} \\$	-157.00	[kN]	6.00	[m]	-154.00	[kN]	6.00	[m]
	$V_{\text{y,d}}$	-27.00	[kN]	6.00	[m]	-26.83	[kN]	6.00	[m]

7.3 LTB Analysis as Stress Analysis

Equivalent imperfections

Acc. to [19]

The camber rise in y-direction is $v_y = 1.5$ cm.

CRANEWAY

The equivalent imperfections can be determined either automatically according to the eigenvalue method or defined manually. For this example, we select the manual definition.

Stress calculation

Acc. to [19]	CRANEWAY
The maximum equivalent stress according to second-order analysis is obtained for $x = 2.28$ m (left span) at the upper surface of the ten flange	x = 2.20 m (loft coop)
(left span) at the upper surface of the top hange	x – 2.50 m (left span)
$\sigma_{eqv} = 19.10 \text{ kN/cm}^2$	$\sigma_{eqv} = 19.06 \text{ kN/cm}^2$

Elastic-elastic stress analysis

The stress analysis is carried out with the partial safety factor γ_{M1} .

Acc. to [19]	CRANEWAY
19.10/21.36 = 0.894 < 1	19.06/21.36 = 0.892 < 1
LTB design satisfied	Design satisfied



7.4 Load Application Stresses

Loaded length at transition between fillet radius and web

Rail is welded, that is, rigidly fixed to the top flange.

Acc. to [19]	CRANEWAY
l _{eff} = 12.8 cm	$I_{eff} = 12.8 \text{ cm}$
Web compression at transition betweer Acc. to [19]	n fillet radius and web CRANEWAY
Web compression: $\sigma_{oz,Ed} = -5.70 \text{ kN/cm}^2$	$\sigma_{\text{oz,Ed}}$ = -5.68 kN/cm ²
Corresponding local shear stress:	

 $\tau_{\text{oxz,Ed}} = 1.10 \text{ kN/cm}^2$

 $\tau_{\text{oxz,Ed}}\!=1.14~kN/cm^2$

7.5 Plate Buckling Analyses of Web Plate Under Wheel Load

Length of stiff bearing	
Acc. to [19]	CRANEWAY
s _s = 9.0 cm	s _s = 9.0 cm
Plate buckling coefficient a Acc. to [19]	and critical plate buckling load CRANEWAY
k _F =6.00	k _F =6.004
F _{cr} = 5761 kN	F _{cr} = 5764.55 kN
Auxiliary values Acc. to [19]	CRANEWAY
m ₁ = 27.3	m ₁ = 27.27
$m_2 = 0.00$	$m_2 = 0.00$
l _y = 32.7 cm	$l_y = 32.6 \text{ cm}$
$F_y = 845.3$ $\lambda_{trans} = 0.38$ $\chi_F = 1.0$	$\lambda_{trans} = 0.383$ $\chi_F = 1.0$
Interaction design	
Acc. to [19]	CRANEWAY
$\eta_1 = 0.41 < 1.0$	$\eta_{1}=0.409<1.0$
Web plate buckling	
Acc. to [19]	CRANEWAY
$\eta = 0.068 < 1.0$	$\eta = 0.068 < 1.0$



7.6 Fatigue Designs

Dynamic coefficients and design location	ons
Acc. to [19]	CRANEWAY
$\phi_{fat,1} = 1.05$ $\phi_{fat,2} = 1.065$	$\label{eq:pfat,1} \begin{split} \phi_{\text{fat,1}} &= 1.05 \\ \phi_{\text{fat,1}} &= 1.065 \end{split}$
a: 112 (σ_x) 36 (σ_w) c: 160 (σ_x, σ_2) 100 (τ_{xz}) in span at intermediate support	80 (σ_x) 100 (τ_{xx})
Figure 7.3: Design locations and detail categories	
Normal stresses at the top of flange in s	pan
Acc. to [19]	CRANEWAY
In span at x = 2.1 m max M _y = 100.3 kNm min M _y = -20.1 kNm $\Delta \sigma_x = 7.22$ kN/cm ² $\Delta \sigma_{E,2} = 2.3$ kN/cm ² $\eta = 0.24 < 1.0$	$\Delta \sigma_x$ = 7.33 kN/cm ² $\Delta \sigma_{\text{E,2}}$ =2.31 kN/cm ² η = 0.237 < 1.0
Normal stresses at web base in span	
Acc. to [19]	CRANEWAY
In span at x = 2.1 m max M_y = 100.3 kNm min M_y = -20.1 kNm $\Delta \sigma_x$ = 5.0 kN/cm ² $\Delta \sigma_{E,2}$ = 1.6 kN/cm ² η = 0.12 < 1.0	$\label{eq:stars} \begin{split} \Delta\sigma_{x} = & 4.92 \ \text{kN/cm}^2 \\ \Delta\sigma_{\text{E},2} = & 1.55 \ \text{kN/cm}^2 \\ \eta = & 0.14 < 1.0 \end{split}$
Normal stresses at top flange at interm	ediate column
Acc. to [19]	CRANEWAY
$\label{eq:stars} \begin{split} & \mbox{max } M_{y} = -85.2 \ \mbox{kNm} \\ & \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	$\begin{split} \Delta \sigma_x = \textbf{4.37 kN/cm}^2 \\ \Delta \sigma_{\text{E,2}} = \textbf{1.38 kN/cm}^2 \\ \eta = \textbf{0.198} < \textbf{1,0} \end{split}$



7.7 Deflections

Deflections

Acc. to [19]

Vertical deflection

$$\begin{split} \delta_z &= \gamma \cdot R \cdot l^3 / (100 \cdot El_y) + \beta \cdot g \cdot l^4 / (El_y) \\ \text{where } \beta &= 0.0054 \text{ and } \gamma = 1.62 \\ \delta_z &= 0.50 + 0.02 = 0.52 \text{ cm} \end{split}$$

Horizontal deflection

$$\begin{split} \delta_y &= \gamma \cdot H_1 \cdot l^3 / (100 \cdot El_{z,Og}) \\ where &\gamma = 3.01 \\ \delta_y &= 0.72 \ cmu_y = 0.72 \ cm \end{split}$$

CRANEWAY

 $u_z = 0.52 \text{ cm}$



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