4 Diubal

Version March 2014

Add-on Module

STEEL SANS

Ultimate Limit State and Serviceability Limit State Design According to SANS 10162-1:2011

Program **Description**

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I. Introduction

1.1 Additional Module STEEL SANS

The South African National Standard *SANS 10162-1* determines rules for the design, analysis and construction of steel buildings in South Africa. With the add-on module STEEL SANS from the DLUBAL SOFTWARE GMBH company all users obtain a highly efficient and universal tool to design steel structures according to this standard.

All typical designs of load capacity, stability and deformation are carried out in the module STEEL SANS. Different actions are taken into account during the load capacity design. It is also possible to choose among the interaction formulae mentioned in the code. The slenderness types of the cross-sections are taken into account automatically. Thus, it is possible to check the limitation of the design capacity and of the rotational capacity due to local buckling for cross-section parts. STEEL SANS automatically calculates the limiting width-to-thickness ratios of compressed parts and classifies the cross-section.

The sectional coordinate system in STEEL SANS is different from the indices used in the South African standard. It corresponds to the one used in RSTAB: The indices "y" and "z" refer to the axes in the cross-section plane as seen in the image to the left.

For the stability design, you can determine for every single member or set of members whether buckling is possible in the direction of y-axis and/or z-axis. Lateral supports can be added for a realistic representation of the structural model. The specific ratios of slendernesses and critical stresses are automatically determined by STEEL SANS on the basis of the boundary conditions. The location where the loads are applied, which influences the lateral torsional design, can be defined in the detailed settings.

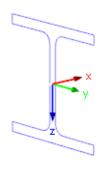
The serviceability limit state has become important for the static calculation of modern civil engineering as more and more slender cross-sections are being used. In STEEL SANS, load cases, load combinations and result combinations can be arranged individually to cover the various design situations. It is also possible to specify reference lengths and precambers for the design.

If required, you can optimize the cross-sections and export the modified cross-sections to RSTAB. Using the design cases, you can design separate structural components in complex structures or analyze variants.

STEEL SANS is an add-on module integrated in RSTAB. For this reason, the design relevant input data is already preset when you have started the module. Subsequent to the design, you can use the graphical RSTAB user interface to evaluate the results. Finally, the design process can be documented in the global printout report, from the calculation of the internal forces to all design details.

We hope you will enjoy working with STEEL SANS.

Your DLUBAL Team



Axis system



1.2 STEEL SANS Team

The following people participated in the development of the STEEL SANS module:

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1.3 Using the Manual

Topics like installation, graphical user interface, results evaluation, and printout are described in detail in the manual of the main program RSTAB. The present manual focuses on typical features of the add-on module STEEL SANS.

The descriptions in this manual follow the sequence and structure of the module's input and results windows. The text of the manual shows the described **buttons** in square brackets, for example [View mode]. At the same time, they are pictured on the left. **Expressions** appearing in dialog boxes, windows, and menus are set in *italics* to clarify the explanations.

At the end of the manual, you find the index. However, if you don't find what you are looking for, please check our website **www.dlubal.com** where you can go through our comprehensive *FAQ* pages by selecting particular criteria.





1.4 Starting STEEL SANS

RSTAB provides the following options to start the add-on module STEEL SANS.

Menu

To start the program in the RSTAB menu bar, click

```
\textbf{Add-on Modules} \rightarrow \textbf{Design-Steel} \rightarrow \textbf{STEEL SANS}.
```

Current Module	>	🖻 🔭 🍃 🐄 🕅	瞬
Design - Steel	1	STEEL	General stress analysis of steel members
Design - Concrete) Iec	STEEL EC3	Design of steel members according to Eurocode 3
Design - Timber	Aisc	STEEL AISC	Design of steel members according to AISC (LRFD or ASD)
Design - Aluminium	LIS	STEEL IS	Design of steel members according to IS
Dynamic	SIA	STEEL SIA	Design of steel members according to SIA
Connections		STEEL BS	Design of steel members according to BS
Foundations	168	STEEL GB	Design of steel members according to GB
Stability	15	STEEL CS	Design of steel members according to CS
Towers	1 IAS	STEEL AS	Design of steel members according to AS
Others	► NIC	STEEL NTC-DF	Design of steel members according to NTC-DF
Stand-Alone Programs	► ISP	STEEL SP	Design of steel members according to SP
	PIPM	STEEL Plastic	Design of steel members according to PIFM
	SANS	STEEL SANS	Design of steel members according to SANS
	1FD	STEEL Fatigue Member	rs Fatigue design of steel members
	1	КАРРА	Flexural buckling analysis
	13	LTB	Lateral-torsional and torsional-flexural buckling analysis
	4	FE-LTB Lateral	-torsional and torsional-flexural buckling analysis by FEM
	12	EL-PL	Elastic-plastic design
		C-TO-T	Analysis of limit slenderness ratios (c/t)
		PLATE-BUCKLING	Plate buckling analysis
	×₿		

Figure 1.1: Main Menu: Additional Modules \rightarrow Design - Steel \rightarrow STEEL SANS



Navigator

You can also start the add-on module in the Data navigator by clicking

```
Add-on Modules \rightarrow STEEL SANS.
```

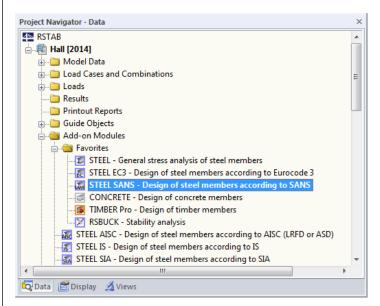
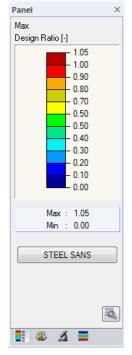


Figure 1.2: Data Navigator: Add-on Modules → STEEL SANS

If results from STEEL SANS are already available in the RSTAB model, you can also open the design module in the panel:

Set the relevant STEEL SANS design case in the load case list of the RSTAB toolbar. Then click the button [Show Results] to display the design criterion on the members graphically.

When the results display is activated, the panel is available, too. Now you can click the button [STEEL SANS] in the panel to open the module.



STEEL SANS

STEEL SANS CA1 - Beams LC1 - Self-weight LC2 - Imposed load CO1 - 1.35*LC1 + 1.5*LC2

STEEL SANS CA2 - Columns

X_XX



```
Panel
```



2. Input Data

When you have started the add-on module, a new window opens. In this window, a Navigator is displayed on the left, managing the windows that can be currently selected. The drop-down list above the navigator contains the design cases (see chapter 7.1, page 52).

The design relevant data is defined in several input windows. When you open STEEL SANS for the first time, the following parameters are imported automatically:

- Members and sets of members
- Load cases, load combinations, result combinations and super combinations
- Materials
- Cross-sections
- Effective lengths
- Internal forces (in background, if calculated)

To select a window, click the corresponding entry in the navigator. To set the previous or next input window, use the buttons shown on the left. You can also use the function keys to select the next [F2] or previous [F3] window.

Click [OK] to save the results. Thus you exit STEEL SANS and return to the main program. If you click [Cancel], you exit the module but without saving the data.

2.1 General Data

In window 1.1 *General Data*, you select the members, sets of members and actions that you want to design. The tabs are managing the load cases, load combinations, result combinations and super combinations for the different designs.

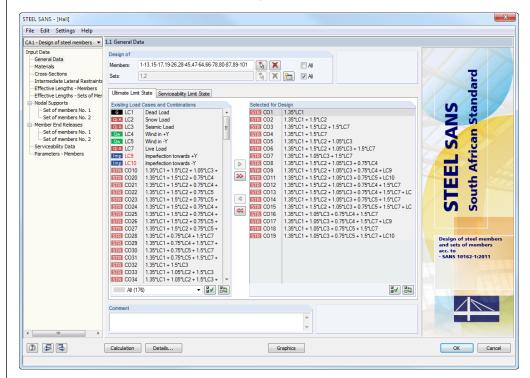


Figure 2.1: Window 1.1 General Data

Cancel

OK

-3



Design of

Design of			
Members:	1-8,11-18,21-28,31-46,51-64,66-69	X	🔲 All
Sets:	1,3,5-8	🗞 🗙 🎦	🗸 All

Figure 2.2: Design of members and sets of members



2

The design can be carried out for *Members* as well as for *Sets of Members*. If you want to design only selected objects, clear the *All* check box: Then you can access the text boxes to enter the numbers of the relevant members or sets of members. The list of the numbers preset in the field can be cleared by clicking the [Delete] button. Alternatively, you can select the objects graphically in the RSTAB work window after clicking [⁵].

When you design a set of members, the program determines the extreme values of the designs of all members contained in the set of members and takes into account the boundary conditions of connected members for the stability analysis. The results are shown in the result windows 2.3 *Design by Set of Members*, 3.2 *Governing Internal Forces by Set of Members*, and 4.2 *Parts List by Set of Members*.

Click [New] to create a new set of members. The dialog box that you already know from RSTAB appears where you can specify the parameters for a set of members.

2.1.1 Ultimate Limit State

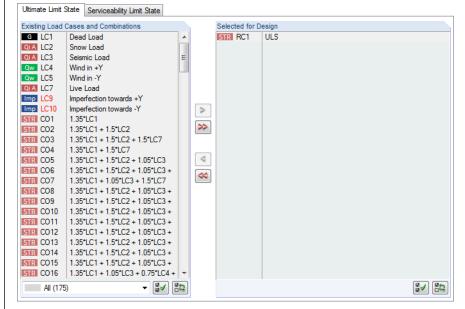


Figure 2.3: Window 1.1 General Data, Ultimate Limit State tab

Existing Load Cases and Combinations

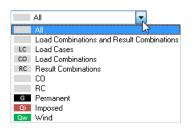
This column lists all load cases, load combinations, result combinations and super combinations created in RSTAB.



Click [▶] to transfer selected entries to the list *Selected for Design* on the right side. You can also double-click the items. To transfer the complete list to the right, click [▶▶].

To transfer multiple entries at once, select them while pressing the [Ctrl] key, as common for Windows applications.

Load cases written in red like load cases 9 and 10 in Figure 2.3 cannot be designed: Those load cases are defined without any load data, or they contain only imperfections. When you transfer such a load case, a warning appears.



At the end of the list, several filter options are available. They will help you assign the entries
sorted by load case, load combination, or action category. The buttons have the following
functions:

Select all cases in the list.
Invert selection of load cases.

Table 2.1: Buttons in tab Ultimate Limit State

Selected for Design

The column on the right lists the load cases, load and result combinations selected for design. To remove selected items from the list, click [4] or double-click the entries. To transfer the entire list to the left, click [◀◀].

The design of an enveloping max/min result combination is performed faster than the design of all contained load cases and load combinations. However, the analysis of a result combination has also disadvantages: First, the influence of the contained loads is difficult to discern.

Second, for the determination of the critical elastic moment for lateral-torsional buckling, the envelope of the moment distributions is analyzed, from which the most unfavorable distribution (max or min) is taken. However, this distribution only rarely reflects the moment distribution in the individual load combinations. Thus, in the case of a RC design, more unfavorable values for the critical elastic moment are to be expected, leading to higher ratios.

Result combinations should be selected for design only for dynamic combinations. For "usual" combinations, load combinations are recommended.



combination



2.1.2 Serviceability Limit State

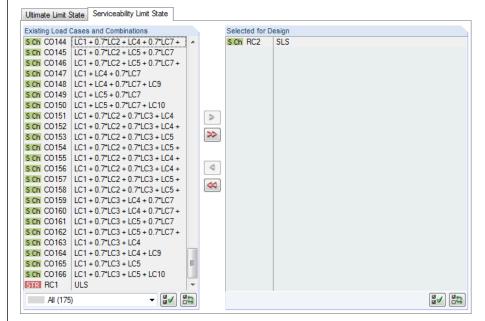


Figure 2.4: Window 1.1 General Data, Serviceability Limit State tab

Existing Load Cases and Combinations

This section lists all load cases, load combinations, result combinations and super combinations created in RSTAB.

Selected for Design

Load cases, load combinations and result combinations can be added or removed as described in chapter 2.1.1.

The limit values of the deformations are controlled by the settings in the *Details* dialog box (see Figure 3.3, page 31) which you can call up by clicking the [Details] button.

In the window 1.9 *Serviceability Data*, the reference lengths decisive for the deformation check are managed (see chapter 2.9, page 26).



>>



2.2 Materials

The window consists of two parts. In the upper part, all materials created in RSTAB are listed. In the *Material Properties* section, the properties of the current material, that is, the table row currently selected in the upper section, are displayed.

	A		В		
Material	Material				
No.	Description		Comm	ent	
1 Stee	S 235 JR SANS 50025-2	1			
2 Stee	el S 355 JR SANS 50025-2				
				i	
laterial Propertie					
Main Propertie			000000 000	MD-	
Modulus of Shear Modu		E	200000.000		
Poisson's R			77000.000	МРа	
		v	0.300	1.11.4.2	
- Specific We		γ		kN/m ³	
	of Thermal Expansion	α	1.1700E-05	1/K	
Partial Safet		7M	1.00		Material No. 1 used in
Additional Prop					
- Thermal Cor		λ		W/m/K	Cross-sections No.:
Specific He		Cp	480.0	J/kg/K	1,2,6,7,10,12,13,15,16
	Ranget ≤ 1.60 cm				
 Yield Street 		fy	235.000		Members No.:
Ultimate		fu	360.000	мга	1-19,22-38,40,42-57,59,61-80,83-102
	Range t > 1.60 cm and t ≤ 4.00 cm		005 000	110	1-13,22-30,40,42-37,33,01-60,63-102
 Yield Street 		fy	225.000		
Ultimate S		fu	360.000	мга	Sets of members No.:
	Range t > 4.00 cm and t ≤ 10.00 cm				1,2
 Yield Street 		fy	215.000		
Ultimate	Strength	fu	360.000	MPa	Σ Lengths: Σ Masses:
					466.46 [m] 21.802 [t]

Figure 2.5: Window 1.2 Materials

Materials that will not be used in the design are dimmed. Materials that are not allowed are highlighted in red. Modified materials are displayed in blue.

The material properties required for the determination of internal forces are described in chapter 4.2 of the RSTAB manual (*Main Properties*). The material properties required for design are stored in the global material library. The values are preset (*Additional Properties*).

To adjust the units and decimal places of material properties and stresses, select in the module's menu **Settings** → **Units and Decimal Places** (see chapter 7.3, page 56).

Material Description

The materials defined in RSTAB are already preset, but it is always possible to modify them. To do this, click the material in column A. Then click [♥] or press function key [F7] to open the material list.

Material	
Description	
Steel S 235 JR SANS 50025-2	-
Steel S 185	SANS 50025 / EN 10025-2:2004 🔺
Steel S 235 JR	SANS 50025 / EN 10025-2:2004
Steel S 235 J0	SANS 50025 / EN 10025-2:2004
Steel S 235 J2	SANS 50025 / EN 10025-2:2004
Steel S 275 JR	SANS 50025 / EN 10025-2:2004
Steel S 275 J0	SANS 50025 / EN 10025-2:2004
Steel S 275 J2	SANS 50025 / EN 10025-2:2004
Steel S 355 JR	SANS 50025 / EN 10025-2:2004
Steel S 355 J0	SANS 50025 / EN 10025-2:2004
Steel S 355 J2	SANS 50025 / EN 10025-2:2004 -

Figure 2.6: List of materials



According to the design concept of SANS 10162-1 [1], you can select only materials of the "Steel" category.

When you have imported a material, the design relevant Material Properties are updated.

If you change the material description manually and the entry is stored in the material library, STEEL SANS will import the material properties, too.

Principally, it is not possible to edit the material properties in the add-on module STEEL SANS.

Material Library

Numerous materials are already available in the library. To open the corresponding dialog box, click

Edit \rightarrow Material Library

or use the button shown on the left.

Filter	Material to Select			
Material category group:	Material Description	Standard		
Metal	✓ Steel S 235 JR	🔀 SANS	50025-2	
	Steel S 235 J0	🚝 SANS	50025-2	
Material category:	Steel S 235 J2	SANS	50025-2	
Steel Steel S 275 JR				
	Steel S 275 J0	SANS 50025-2		
Standard group:	Steel S 275 J2	SANS		
SANS	 Steel S 275 J2 Steel S 355 JB 	SANS		
		SANS		
Standard:	Steel S 355 J0	SANS		
Include invalid				
Favorites only				7
Material Properties		S	Steel S 235 JR SA	6
Material Properties				
Material Properties Main Properties Modulus of Elasticity		E	200000.000	NS 50025
Material Properties Main Properties Modulus of Elasticity Shear Modulus		E G	200000.000	NS 50025
Material Properties Main Properties Modulus of Elasticity Shear Modulus Poisson's Ratio		E G v	200000.000 77000.000 0.300	MPa MPa
Material Properties Main Properties Modulus of Elasticity Shear Modulus Poisson's Ratio Specific Weight		Ε G V γ	200000.000 77000.000 0.300 78.50	MPa MPa kN/m ³
Material Properties Main Properties Modulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expe		E G v	200000.000 77000.000 0.300	MPa MPa kN/m ³
Material Properties Main Properties Modulus of Elasticity Shear Modulus Poisson's Ratio Specific Weight		Ε G V γ	200000.000 77000.000 0.300 78.50 1.1700E-05	MPa MPa kN/m ³ 1/K
Material Properties Main Properties Modulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Exp: Additional Properties		Ε G V 7 α	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000	MPa MPa kN/m ³
Material Properties ☐ Main Properties Modulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expe ☐ Additional Properties Thermal Conductivity	ansion	E G ν γ α	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000	MPa MPa kN/m ³ 1/K W/m/K
Material Properties ☐ Main Properties Modulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expe ☐ Additional Properties Thermal Conductivity Specific Heat Capacity ☐ Thickness Ranget t ≤ 1.60 ☐ Yield Strength	ansion	E G V γ α λ Cp	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000 480.0	MPa MPa MPa kN/m ³ 1/K W/m/K J/kg/K MPa
Material Properties ☐ Main Properties Modulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expander ☐ Additional Properties Thermal Conductivity Specific Heat Capacity ☐ Thickness Range t ≤ 1.60 Yield Strength Utimate Strength	ansion	E G V γ α λ Cp	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000 480.0	MPa MPa MPa kN/m ³ 1/K W/m/K J/kg/K MPa
Material Properties ☐ Main Properties Modulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expe ☐ Additional Properties Thermal Conductivity Specific Heat Capacity ☐ Thickness Ranget ≤ 1.60 Yield Strength Utimate Strength ☐ Thickness Ranget > 1.60	ansion	E G V γ α λ cp fy fu	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000 480.0 235.000 360.000	MPa MPa kN/m ³ 1/K W/m/K J/kg/K MPa MPa
Material Properties ☐ Main Properties Modulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expe ☐ Additional Properties Thermal Conductivity Specific Heat Capacity ☐ Thickness Range t ≤ 1.60 Yield Strength ☐ Thickness Range t > 1.60. Yield Strength	ansion	E G V γ α λ cp fy fu fy	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000 480.0 235.000 360.000 225.000	MPa MPa kN/m ³ 1/K W/m/K J/kg/K MPa MPa MPa
Material Properties Main Properties Main Properties Madulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expe Additional Properties Thermal Conductivity Specific Heat Capacity Thickness Range t ≤ 1.60 Yield Strength Utimate Strength Utimate Strength	ansion cm cm and $t \le 4.00$ cm	E G V γ α λ cp fy fu	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000 480.0 235.000 360.000	MPa MPa kN/m ³ 1/K W/m/K J/kg/K MPa MPa MPa
Material Properties Main Properties Main Properties Modulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expr Additional Properties Thermal Conductivity Specific Heat Capacity Thickness Range t ≤ 1.60 Yield Strength Ultimate Strength Ultima	ansion cm cm and $t \le 4.00$ cm	E G V γ α Δ Cp fy fu fu fu	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000 480.0 235.000 360.000 225.000 360.000	MPa MPa kN/m ³ 1/K W/m/K J/kg/K MPa MPa MPa
Material Properties Main Properties Main Properties Madulus of Basticity Shear Modulus Poisson's Ratio Specific Weight Coefficient of Thermal Expe Additional Properties Thermal Conductivity Specific Heat Capacity Thickness Range t ≤ 1.60 Yield Strength Utimate Strength Utimate Strength	ansion cm cm and $t \le 4.00$ cm	E G V γ α λ cp fy fu fy	200000.000 77000.000 0.300 78.50 1.1700E-05 50.000 480.0 235.000 360.000 225.000	MPa MPa KN/m ³ 1/K W/m/K J/kg/K MPa MPa MPa MPa MPa

Figure 2.7: Dialog box Material Library

In the *Filter* section, *Steel* is preset as the material category. Select the steel grade that you want to use for the design in the list *Material to Select*. The corresponding properties can be checked in the dialog section below.

Click [OK] or [] to transfer the selected material to window 1.2 of the module STEEL SANS.

Chapter 4.2 in the RSTAB manual describes in detail how materials can be filtered, added or rearranged.

You can also select material categories like *Cast Iron* or *Stainless Steel*. Please check, however, whether these materials are covered by the design concept of the Code [1].



2.3 Cross-Sections

This window manages the cross-sections used for design. In addition, the window allows you to specify optimization parameters.

Coordinate System

The sectional coordinate system in STEEL SANS is different from the indices used in the South African standard. It corresponds to the one used in RSTAB (see image in Figure 2.8): The **y**-axis is the <u>major</u> principal axis of the cross-section, the **z**-axis the <u>minor</u> axis. This coordinate system is used for both the input data and the results.

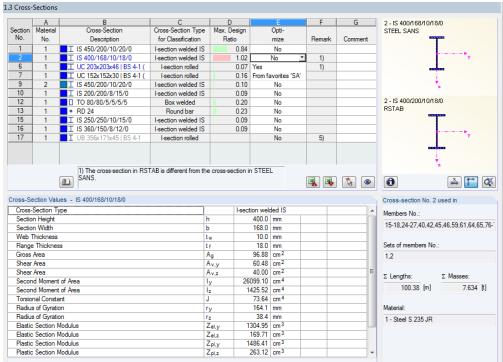


Figure 2.8: Window 1.3 Cross-Sections

Cross-Section Description

The cross-sections defined in RSTAB are preset together with the assigned material numbers.



3

To modify a cross-section, click the entry in column B selecting this box. Click [Cross-section Library] or [...] in the box or press function key [F7] to open the cross-section table of the current cross-section box (see the following figure).

In this dialog box, you can select a different cross-section or a different cross-section table. To select a different cross-section category, click [Back to cross-section library] to access the general cross-section library.

Chapter 4.3 of the RSTAB manual describes how cross-sections can be selected from the library.



5

/ __ Dlubal

Thin-Walled Cross-Sections - Sym	metric I-Section		×
Cross-Section Type $\begin{bmatrix} I & I & I & T \\ T & L & L \\ \hline T & L & L \\ \hline C & T & T \\ \hline T & $	Parameters h: 450.0 ⊕/k [mm] b: 200.0 ⊕/k [mm] s: 10.0 ⊕/k [mm] t: 20.0 ⊕/k [mm] a: 0.0 ⊕/k [mm]		
-		IS 450/200/10/20/0	۱
		ок	Cancel

Figure 2.9: IS cross-sections in the cross-section library

The new cross-section description can be entered in the cross-section box directly. If the data base contains an entry, STEEL SANS imports these cross-section parameters, too.

A modified cross-section will be highlighted in blue.

If cross-sections set in STEEL SANS are different from the ones used in RSTAB, both crosssections are displayed in the graphic in the right part of the window. The designs will be performed with the internal forces from RSTAB for the cross-section selected in STEEL SANS.

Cross-Section Type for Classification

The cross-section type used for the classification is displayed, e.g. I-shape rolled, welded, box, round bar, etc. The cross-sections listed in [1] tables 3 and 4 can be designed plastically or elastically depending on the class. Cross-sections that are not covered by the standard are classified as *General*.

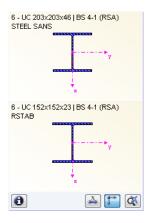
Max. Design Ratio

This table column is displayed only after the calculation. It is a decision support for the optimization. By means of the displayed design ratio and colored relation scales, you can see which cross-sections are little utilized and thus oversized, or overloaded and thus undersized.

Optimize

You can optimize every cross-section from the library: For the RSTAB internal forces, the program searches the cross-section in the same table that comes as close as possible to a userdefined maximum ratio. The maximum ratio can be defined in the *Details* dialog box (see Figure 3.4, page 32).

If you want to optimize a cross-section, open the drop-down list in column D or E and select the desired entry: *From Current Row* or, if available, *From favorites 'Description'*. Recommendations for the cross-section optimization can be found in chapter 7.2 on page 54.





Remark

0

0

This column shows remarks in the form of footers that are described in detail below the crosssection list.

A warning might appear before the calculation: *Incorrect type of cross-section!* This means that there is a cross-section that is not registered in the data base. This may be a user-defined cross-section, or a SHAPE-THIN cross-section that has not been calculated yet. To select an appropriate cross-section for design, click [Library] (see description after Figure 2.8).

Member with tapered cross-section

For tapered members with different cross-sections at the member start and member end, the module displays both cross-section numbers in two rows, in accordance with the definition in RSTAB.

STEEL SANS also designs tapered members, provided that the cross-section at the start of the member has the same number of stress points as the cross-section at the end of the member. For example, the normal stresses are determined from the moments of inertia and the centroidal distances of the stress points. If the start and the end cross-section of a tapered member have a different number of stress points, the intermediate values cannot be interpolated. The calculation is possible neither in RSTAB nor in STEEL SANS.

The cross-section's stress points including numbering can also be checked graphically: Select the cross-section in window 1.3 and click [Info]. The dialog box shown in Figure 2.10 appears.

Info About Cross-Section

In the dialog box *Info About Cross-Section*, you can view the cross-section properties, stress points and c/t-parts.

Cross-Section Property	Symbol	Value	Unit	-	UC 203×203×46 BS 4-1 (RSA)
Depth	d	203.2	mm		
Vidth	b	203.6	mm		
Web thickness	tw	7.2	mm		
lange thickness	tf	11.0	mm		203.6
Root fillet radius	r	10.2	mm		
Depth between flanges	d-2t _f	181.2	mm		
Cross-sectional area	Α	5873.0	mm ²	Ξ	F 10.2
Shear area	Ay	3735.3	mm ²		
ihear area	Az	1264.7	mm ²		
hear area according to EC 3	Av,y	4604.5	mm ²		8
hear area according to EC 3	A _{v,z}	1697.4	mm ²		503:3
Neb area	Aweb	1304.6	mm ²		N Y
Moment of inertia	ly	4.568E+07			7.2
Moment of inertia	Iz	1.548E+07	mm ⁴		
Governing radius of gyration	٢y	88.2	mm		
Governing radius of gyration	٢z	51.3	mm		
olar radius of gyration	٢o	102.0	mm		
Radius of gyration of flange plus 1/5 of wel	rzg	55.1	mm		z
/olume	V	5873000.0	mm³/m		
Veight	wt	46.1	kg/m		
Surface	Asurf		m²/m		
Section factor	A _m /V	202.452	1/m		[mr
Forsional constant	J	223400.0	mm ⁴		
Varping constant	Cw	1.429E+11	mm ⁶		T I I I I I I I I I I I I I I I I I I I
Bastic section modulus	Sy	449600.0		-	C/t-Parts
7	c	150100.0	3		

Figure 2.10: Dialog box Info about Cross-Section

In the right part of the dialog box, the currently selected cross-section is displayed.



The buttons below the graphic have the following functions:

Button	Function
I	Displays or hides the stress points
	Displays or hides the c/t-parts
123	Displays or hides the numbering of stress points or c/t-parts
	Displays or hides the details of the stress points or c/t-parts (see Figure 2.11)
X	Displays or hides the dimensions of the cross-section
1	Displays or hides the principal axes of the cross-section
ă l	Resets the full view of the cross-section graphic

Table 2.2: Buttons of cross-section graphic

Click [Details] to call up detailed information on stress points (distance to center of gravity, statical moments of area, normalized warping constants etc.) and c/t-parts.

	A	B	C	D	E	F	G	UC 203x203x46
StressP	Coordin	nates	Statical Mom	ents of Area	Thickness	Warp	ing	
No.	y [mm]	z [mm]	Q _y [mm ³]	Q _z [mm ³]	t [mm]	W _{no} [mm ²]	Sw [mm 4]	
1	-101.8	-101.6	0.0	0.0	11.0	9783.0	0.0	
2	-13.8	-101.6	-93149.5	-55956.4	11.0	1326.2	-5376830.0	
3	0.0	-101.6	-107291.0	-57034.8	11.0	0.0	-5477490.0	
4	13.8	-101.6	-93149.5	55956.4	11.0	-1326.2	5376830.0	1 2 3 4 5
5	101.8	-101.6	0.0	0.0	11.0	-9783.0	0.0	
6	-101.8	101.6	0.0	0.0	11.0	-9783.0	0.0	
7	-13.8	101.6	-93078.1	55956.6	11.0	-1326.2	-5376830.0	
8	0.0	101.6	-107291.0	57034.8	11.0	0.0	-5477490.0	
9	13.8	101.6	-93078.1	-55956.6	11.0	1326.2	5376830.0	13 y
10	101.8	101.6	0.0	0.0	11.0	9783.0	0.0	
11	0.0	-80.4	-225110.0	0.0	7.2	0.0	0.0	
12	0.0	80.4	-224993.0	0.0	7.2	0.0	0.0	
13	0.0	0.0	-248524.0	0.0	7.2	0.0	0.0	6 7 18 9 10
								Z

Figure 2.11: Dialog box Stress Points of UC 203x203x46



Intermediate Lateral Restraints 2.4

In window 1.4, you can define intermediate lateral restraints for members. STEEL SANS always assumes this kind of support to be perpendicular to the cross-section's minor axis z (see Figure 2.8). Thus, it is possible to influence the members' effective lengths which are important for the



design of column buckling and lateral torsional buckling. For the calculation, all intermediate lateral restraints are considered as torsional supports. 1.4 Intermediate Lateral Restraints G Latera No Restraint L [m] Number х3 X4 X5 X6 X7 X1 X2 x8 X9 0.500 1 2 0.333 Ø 0.667 0.200 0.400 0.600 0.800 ī ö Relatively (0 ... 1) 🛐 😼 💊 Settings - Member No. 5 Cross-Section Lateral Restraints Ø Member Length Number of Intermediate Lateral Restraints Location of Lateral Restraint No. 1 **X1** 0.200 Location of Lateral Restraint No. 2 0.400 Location of Lateral Restraint No. 0.600 **X**3 Location of Lateral Restraint No. 4 **X**4 0.800 Set input for members No. **A** V AI 0 Figure 2.12: Window 1.4 Intermediate Lateral Restraints

In the upper part of the window, you can assign up to nine lateral supports for each member. The Settings section arranges the input in a column for an overview of the member selected above.

To define the intermediate restraints of a member, select the Lateral Restraint check box in column A. To graphically select the member and to activate its row, click [5]. By selecting the check box, the other columns become available for you to enter the parameters.

In column C, you specify the number of the intermediate restraints. Depending on the specification, one or more of the following Intermediate Lateral Restraints columns for the definition of the x-locations are available.

If the check box *Relatively* (0 ... 1) is selected, the support points can be defined by relative-

input. The positions of the intermediate supports are determined from the member length and the relative distances from the member start. When the check box Relatively (0 ... 1) is

🔽 Relatively (0 ... 1)

5

cleared, you can define the distances manually in the upper table. In case of cantilevers, avoid intermediate restraints because such supports divide the member into segments. For cantilevered beams, this would results in segments with torsional restraints



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on one end each that are statically underdetermined.



2.5 Effective Lengths - Members

Window 1.5 consists of two parts. The table in the upper part provides summarized information on the effective length factors K_y and K_z , the effective lengths K_yL and K_zL , the lengths L_w and L_T for torsional or torsional-flexural buckling and the member types of the beams to be designed. The effective lengths defined in RSTAB are preset. In the *Settings* section, further information is shown about the member whose row is selected in the upper section.



....

Click the button [[^]] to select a member graphically and to show its row.

Changes can be made in the table as well as in the Settings tree.

	A	B	С	D	E	F	G	H		J	K	L	М	N
	Buckling	Bucklir	ng About	Axis y	Bucklin	ng About	Axis z	Late	ral-Torsio	nal and To	sional-Flex	ural Buckling		
No.	Possible	Possible	Ky	KyL [m]	Possible	Kz	KzL [m]	Possible	K	L _w [m]	LT [m]	M _{cr} [kNm]	Member Type	Comment
1	V	V	1.000	3.000	V	1.000	3.000	V	1.00	3.000	3.000	acc. to 13.6	Beam	
2	☑		1.000	3.000	V	1.000	3.000	V	1.00	3.000	3.000	acc. to 13.6	Beam	
3	v	V	1.000	5.000	V	1.000	5.000		1.00	5.000	5.000	Eigenvalue		
4	I	v	1.000	5.000		1.000	5.000		1.00	5.000	5.000	Eigenvalue		
5	I	v	1.000	3.000		1.000	3.000		1.00	3.000	3.000	Eigenvalue		
6	v	v	1.000	3.000	V	1.000	3.000		1.00	3.000	3.000	Eigenvalue		
7	☑	v	1.000	5.000	V	1.000	5.000		1.00	5.000	5.000	Eigenvalue		
8	Image: Second	V	1.000	6.000	V	1.000	6.000		1.00	6.000	6.000	Eigenvalue		
9	Image: Second	V	1.000	5.000	V	1.000	5.000		1.00	5.000	5.000	Eigenvalue		
10			1.000	7.810		1.000	7.810		1.00	7.810	7.810	Eigenvalue		This type of memb
Cross	- Member Section	No. 1					1	5 - IS 250/	250/10/1	5/0			IS 250/250/10/15/	D
Lengt						L			250/10/1 000 m	5/0			-	
	ing Possibl	e				-		3.	V				-	
	ing About I		v Possibl	e					V				-	
	ective Lend			-		Ky		1	000				. 2	250.0
	ective Leng					KyL) [m					
🗆 Buckli	ing About I	Minor Axis	z Possibl	e					2					
	ective Leng					Kz		1.	000					0.0
	ective Leng					KzL		3.	000 m					
	al-Torsional	Buckling	Possible						2				250.0	··-·-
— K									.00				10.	.0
	3 Length					Lw			000 m					
	sional Leng	gth				LT			000 m				_	l l
— Mo								acc. to 1	3.6					
	er Type									Beam			_	ž
Comm	ent												_	-
						_							_	
						_			_				_	
													_	
Set in	put for me	mbers No.												(r

Figure 2.13: Window 1.5 Effective Lengths - Members

The effective lengths for the column buckling about the minor axis z and the effective lengths for lateral-torsional buckling are aligned automatically with the entries of window 1.4 *Interme*-*diate Lateral Restraints*. If intermediate restraints divide the member into member segments of different lengths, the program displays no values in the table columns G and J of window 1.5.

The effective lengths can be entered manually in the table and in the *Settings* tree, or defined graphically in the work window after clicking [...]. This button is enabled when you click in the effective length box.

The Settings tree manages the following parameters:

- Cross-section
- Length (actual length of the member)
- Buckling Possible (cf column A)
- Buckling About Major Axis y Possible (buckling lengths, cf columns B D)
- Buckling About Minor Axis z Possible (buckling lengths, cf columns E G)
- Lateral-Torsional Buckling Possible (LTB and torsional lengths, cf columns H L)
- Member Type (cf column M)



In this table, you can specify for the currently selected member whether to carry out a buckling or a lateral-torsional buckling analysis. In addition to this, you can adjust the *Effective Length Factor* for the respective lengths. When a coefficient is modified, the equivalent member length is adjusted automatically, and vice versa.

You can also define the buckling length of a member in a dialog box. To open it, click the button shown on the left. It is located on the right below the upper table of the window.

Type of K Value	
Theoretical	
Recommended	
Buckling About Axis y	Buckling About Axis z
© Ky = 0.65	© Kz = 0.65
© Ky = 0.8	© Kz = 0.8
© Ky = 1.2	© Kz = 1.2
© K _y = 1.0	(i) K _z = 1.0 (i) K
© K _Y = 2.0	© K _z = 2.0
© Ky = 2.0	С К _z = 2.0
© User-defined Ky =	© User-defined Kz = y
 Import from add-on module RSBUCK (Eigenvalue Analysis) 	 Import from add-on module RSBUCK (Eigenvalue Analysis)
RSBUCK-Case:	RSBUCK-Case:
CA1 - Stability analysis 🔹	CA1 - Stability analysis 👻
Buckling mode No.: 1 🔄 🔀	Buckling mode No.: 1 💭 🐧
Export effective length factor Ky : 1.000	Export effective length factor Kz : 1.000
	OK Cancel

Figure 2.14: Dialog box Select Effective Length Coefficient

In this dialog box, the values of the coefficient *K* can be defined that are to be assigned to the selected member(s). The *Theoretical* and *Recommended* values are described in [1], Annex E. Generally, it is possible to select predefined coefficients or to enter *User-defined* values.

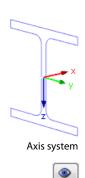
If a RSBUCK case calculated according to the eigenvalue analysis is already available, you can also select a *Buckling mode* to determine the factor.

Buckling Possible

A stability analysis for buckling and lateral buckling requires the ability of members to absorb compressive forces. Therefore, members for which such absorption is not possible because of the member type (for example tension members, elastic foundations, rigid connections) are excluded from design in the first place. The corresponding rows appear dimmed and a note is indicated in the *Comment* column.

The *Buckling Possible* check boxes in table row A and in the *Settings* tree enable you to classify specific members as compression members or, alternatively, to exclude them from the design according to [1].

2 Input Data



Buckling About Axis y or Axis z

With the check boxes in the *Possible* table columns, you decide whether a member is susceptible to buckling about the y-axis and/or z-axis. These axes represent the local member axes, with axis y being the "major" and axis z the "minor" member axis. The effective length coefficients K_y and K_z for buckling about the major or the minor axes can be selected freely.

You can check the position of the member axes in the cross-section graphic in window 1.3 *Cross-Sections* (see Figure 2.8, page 14). To access the RSTAB work window, click [View mode]. In the work window, you can display the local member axes by using the member's context menu or the *Display* navigator.

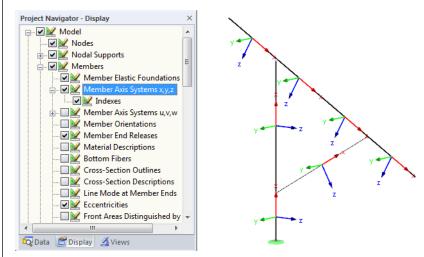


Figure 2.15: Displaying the member axes in the Display navigator of RSTAB

If buckling is possible about one or even both member axes, you can enter the buckling length coefficients as well as the buckling lengths in the columns C and D respectively F and G. The same is possible in the *Settings* tree.

....

To specify the buckling lengths in the work window graphically, click [...]. This button becomes available when you click in a *KL* text box.

When you define the effective length coefficient *K*, the program determines the effective length *KL* by multiplying the member length *L* by this buckling length coefficient.

Lateral-Torsional and Torsional-Flexural Buckling

Table column H controls whether a lateral-torsional and torsional-flexural buckling design is to be carried out.

The effective lengths L_W and L_T depend on the settings of window 1.4 Intermediate Lateral Restraints. It is also possible to enter user-defined values into the columns J and K. The factor K (column I) is calculated from the lateral-torsional buckling length L_W of each member or member segment.

The effective length factors are to be determined according to [1], Table 1 or Table 2.

In column L, three options are available for the calculation of the critical elastic moment M_{cr} .

M_{cr} can be calculated according to the equation as specified in [1], clause 13.6 a) ii):

$$M_{cr} = \frac{\omega_2 \pi}{KL} \sqrt{E \cdot I_z \cdot G \cdot J + \left(\frac{\pi \cdot E}{KL}\right)^2 \cdot I_z \cdot C_w}$$

For that, it is necessary to define the *Member Type* in column M.

By default, M_{cr} is determined by the *Eigenvalue* solver which takes into account the specific boundary conditions by using a finite model. The value of M_{cr} can also be entered *Manually*.





Member Type

Column M provides two options to allocate the Member Type according to [1], clause 13.6.

Comment

In the last table column, you can enter your own comments for each member to describe, for example, the effective member lengths.

Below the *Settings* table, you find the *Set input for members No.* check box. If selected, the settings entered <u>afterwards</u> will be applied to the selected or to *All* members. Members can be selected by typing the member number or by selecting them graphically using the [\S] button. This option is useful when you want to assign the same boundary conditions to several members. Please note that already defined settings cannot be changed subsequently with this function.

2.6 Effective Lengths - Sets of Members

Input window 1.6 controls the effective lengths for sets of members. It is only available if one or more sets of members have been selected in window 1.1 *General Data*.

	A	B	C	D	E	F	G	H		J	K	L	M	N
Set	Buckling	Bucklin	ng About	Axis y	Bucklin	ng About			al-Torsio	nal and To	sional-Flex	ural Buckling		
No.	Possible	Possible	Ky	KyL [m]	Possible	Kz	KzL [m]	Possible	K	L _w [m]	Lτ [m]	M _{or} [kNm]	Member Type	Comment
1	☑	•	1.000	37.096	•	1.000		V				Eigenvalue		
2		- -	1.000	37.096	v	1.000						Eigenvalue		
													E	🛃 🚳 🐧
													ن لکت	
ettings	- Set of Me	embers No	. 1										IS 450/200/10/20/	0
Set of	f Members						S	et of Membe	ers 1					
Me	mber 14 - 0	cross-Secti	on				1	- IS 450/20	0/10/20)/()				
Me	mber 18 - 0	Cross-Secti	on				2	- IS 400/20	0/10/18	3/0	-			
Me	mber 27 - 0	Cross-Secti	on				2	- IS 400/20	0/10/18	3/0			-	
Me	mber 46 - 0	Cross-Secti	ion				2	- IS 400/20	0/10/18	3/0			_ + <u>+</u>	50
Me	mber 65 - 0	Cross-Secti	ion				2	- IS 400/20	0/10/18	3/0			+	5
Me	mber 79 - 0	Cross-Secti	on				2	- IS 400/20	0/10/18	3/0				0.0
	mber 88 - 0						2	- IS 400/20	0/10/18	3/0				_
Me	mber 102 -	Cross-Sec	tion				1	- IS 450/20	0/10/20)/0				
Lengt						L			96 m				150.0	
	ling Possible						C		2				1	
	ling About I		y Possibl	e					v				10	0.0
	ective Leng					Ky		1.0	00					
	ective Leng					KyL			96 m					
	ling About I		z Possibl	e					v					
	ective Leng					Kz		1.0						z
	al-Torsional	Buckling	Possible						J					
Mo	-							Eigenval	ue					
Comm	nent													
Set in	nput for set	No :												[r
Jocili	iparior set	3 140						N					0	

Figure 2.16: Window 1.6 Effective Lengths - Set of Members

The concept of this window is similar to the one in the previous 1.5 *Effective Lengths - Members* window. In this window, you can enter the effective lengths of the set of members for buckling and lateral-torsional buckling as described in chapter 2.5.





2.7 Nodal Supports - Sets of Members

This window is displayed only if you have selected at least one set of members for the design in the 1.1 *General Data* window.

In STEEL SANS, the stability analysis for sets of members is performed with specific parameters. If, however, the *Member-Like Input* is set in the *Details* dialog box (see Figure 3.2, page 29), window 1.7 will not be displayed. In that case, the intermediate lateral restraints can be defined in window 1.4 by division points.

	Α	B	С	D	E	F	G	H	
Support	Node	Support	Lat. Support	Rotationa	l Restraint	Warping	Eccen	tricity	
No.	No.	Rotation ß [°]	uy.	φ _X [kNm/rad]	φz [kNm/rad] Restraint ω	ex [mm]	e <u>z</u> [mm]	Comment
1	12	0.00	J	V			0.0	0.0	
2	11	0.00	2				0.0	0.0	
3	35	0.00	2	12.800 💌	1.200		0.0	-200.0	
4	61	0.00	J				0.0	0.0	
5	62	0.00	2	V			0.0	0.0	
6									
7									
8									
9									
10									
)			🛐 😼 🔇
Settings - I I Set of N	Node Support No. 3	5		Set	of Members 1				
	ber 14 - Cross-Section	20			6 450/200/10/	20/0			
	ber 18 - Cross-Section				5 400/200/10/				
	ber 27 - Cross-Section				5 400/200/10/				
	ber 46 - Cross-Section				5 400/200/10/				
	ber 65 - Cross-Section				5 400/200/10/				
	ber 79 - Cross-Section				5 400/200/10/				
	ber 88 - Cross-Section				5 400/200/10/				
	ber 102 - Cross-Sec				5 450/200/10/				
	ith Support			No.	35	20/0			
	Rotation			B	0.00 °				
	Support in Y			JY.	2			T	X
	ned about X'			DX.	12.800 k	Nm/rad			2 Y'
	ned about Z'			Φ <u>Ζ'</u>	1.200 k				Ż' Ž'
	Restraint			φ <u>2</u>	1.200 1.				
Eccentri				ex:	0.0 m	m			× *
Eccentri				∋Z'	-200.0 m				* Z"
Commer				-	200.0				
C Set inpu	ut for supports No.:								
					V AI				8

Figure 2.17: Window 1.7 Nodal Supports - Set of Members

5

To determine the critical factor of lateral-torsional buckling, a planar framework is created with four degrees of freedom for each node. The parameters are to be defined in window 1.7. The settings in the table refer to the <u>current</u> set of members which is selected in the add-on mod-ule's navigator on the left.

The orientation of the axes in the set of members is important for the definition of nodal supports. The program checks the position of the nodes and internally defines, according to Figure 2.18 through Figure 2.21, the axes of the nodal supports for window 1.7.



Figure 2.18: Auxiliary coordinate system for nodal supports - straight set of members

If all members of a set of members lie in a straight line as shown in Figure 2.18, the local coordinate system of the first member in the set of members corresponds to the equivalent coordinate system of the entire set of members.





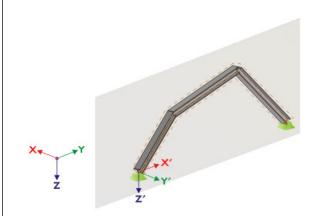


Figure 2.19: Auxiliary coordinate system for nodal supports - set of members in vertical plane

If members of a set of members are not lying in a straight line, they must at least lie in the same plane. In Figure 2.19, they are lying in a vertical plane. In this case, the X'-axis is horizontal and oriented in direction of the plane. The Y'-axis is horizontal as well and defined perpendicular to the X'-axis. The Z'-axis is oriented perpendicularly downwards.

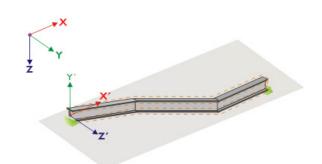


Figure 2.20: Auxiliary coordinate system for nodal supports - set of members in horizontal plane

If the members of a buckled set of members are lying in a horizontal plane, the X'-axis is defined parallel to the X-axis of the global coordinate system. Thus, the Y'-axis is oriented in the opposite direction to the global Z-axis and the Z'-axis is directed parallel to the global Y-axis.

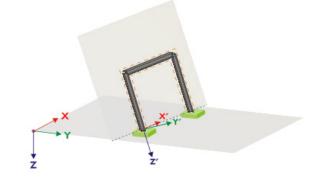


Figure 2.21: Auxiliary coordinate system for nodal supports - set of members in inclined plane

Figure 2.21 shows the general case of a buckled set of members: The members are not lying in one straight line but in an inclined plane. The definition of the X'-axis arises out of the intersection line of the inclined plane with the horizontal plane. Thus, the Y'-axis is defined perpendicular to the X'-axis and directed perpendicular to the inclined plane. The Z'-axis is defined perpendicular to the X'- and Y'-axes.



2.8 Member End Releases - Sets of Members

This window is displayed only if you have selected at least one set of members for the design in the 1.1 *General Data* window. Here, you can define releases for members and sets of members that, due to structural reasons, do not transfer the locked degrees of freedom specified in window 1.7 as internal forces. This window refers to the <u>current</u> set of members (selected in the add-on module's navigator on the left).

Details...

Window 1.8 is not displayed when the *Member-Like Input* is set in the dialog box *Details* (see Figure 3.2, page 29) for sets of members.

1.8 Member End Releases - Set of Members No. 1

	A	В	C	D	E	F		G
	Member	Member	Shear Release	Moment	Release	Warp Re	ease	
No.	No.	Side	Vy	Мт	M _z [kNm/rad]	Mo		Comment
1	46	End		✓				
2	88	Start			15.000			
3								
4								
5								
6								
7								
8								
9								
10								
						-		
								I I I I I I I I I I I I I I I I I I I
Settings - N	Aember No.	88						
Set of M	lembers				Set of M	lembers 1		
Memb	er 14 - Cros	s-Section			1 - IS 45	50/200/10	/20/0	
- Memb	er 18 - Cros	s-Section			2 - IS 40	0/200/10	/18/0	
Memb	er 27 - Cros	s-Section			2 - IS 40	0/200/10	/18/0	
Memb	er 46 - Cros	s-Section			2 - IS 40	0/200/10	/18/0	
Memb	er 65 - Cros	s-Section			2 - IS 40	0/200/10	/18/0	
Memb	er 79 - Cros	s-Section			2 - IS 40	0/200/10	/18/0	
Memb	er 88 - Cros	s-Section				0/200/10		
Memb	er 102 - Cro	ss-Section				50/200/10		×
Member	with Releas	e at the End		No.		881		+++
Member	Side			Side	5	Start		M _T M ₀ Y Vy
Shear R	elease in y-	Direction		Vy				z
	l Release			Мт		- H		Mz
	Release ab	out z-Axis		Mz		15.000	cNm/rad	••••••
	Release			Mo		13.000		
Commen				····@				
Commen								
_								
📃 Set inpu	It for release	e No.:						
						VA		0

Figure 2.22: Window 1.8 Member End Releases - Set of Members

Member	
Side	
Start	•
Start	
End	
Both	

In table column B, you define the *Member Side* to which the release should be assigned. You can also connect the releases to both member sides.

In the columns C through F, you can define releases or spring constants to align the set of members model with the support conditions in window 1.7.



2.9 Serviceability Data

This input window controls several settings for the serviceability limit state design. It is only available if you have set the according entries in the *Serviceability Limit State* tab of window 1.1 *General Data* (see Figure 2.4, page 11).

	A	В	C	D	E	F	G	Н
		Member	Referen	ice Length	Direc-	Precamber		
).	Reference to	No.	Manually	L [m]	tion	w _c [mm]	Beam Type	Comment
1	Member	59		6.274	z	0.0	Beam	
2	Member	68		5.000	z	0.0	Beam	
3	Member	41		6.250	z	0.0	Beam	
4	Member	39		6.250	z	0.0	Beam	
5	Member	20	J	4.250	y. z	0.0	Cantilever End Free	
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30 31								
32								
								3



...





Details...

Figure 2.23: Window 1.9 Serviceability Data

In column A, you decide whether you want to apply the deformation to single members, lists of members, or sets of members.

In table column B, you enter the numbers of the members or sets of members that you want to design. You can also click [...] to select them graphically in the RSTAB work window. Then, the *Reference Length* appears in column D automatically. This column presets the lengths of the members, sets of members, or member lists. If required, you can adjust these values after selecting the *Manually* check box in column C.

Table column E defines the governing *Direction* for the deformation analysis. You can select the directions of the local member axes y and z (or u and v for unsymmetrical cross-sections).

A precamber w_c can be taken into account by using entries specified in column F.

The *Beam Type* is of vital importance for the correct application of limit deformations. In table column G, you can select the girder to be a beam or a cantilever and decide which end should have no support.

The settings of the *Details* dialog box determine whether the deformations are related to the undeformed initial model or to the shifted ends of members or sets of members (see Figure 3.3, page 31).

2.10 Parameters - Members

The last input window controls additional design parameters for members.

A			В	
ember Cross-Sectional				
No. Area			Comment	
2				
3				
4 🗸				
5				
6				
7 🗸				
8				
9				
10 🔽				
				A A A
ettings - Member No. 1				
Cross-Section		15 - IS 250/250/	/10/15/0	
Cross-sectional area for tension design		I I I I Z J U/ Z J U/	10/13/0	
Start (x=0 m)		15 - IS 250/250/	/10/15/0	
Cross-Sectional Area	Ag	9700.0	mm2	
Effective Net Cross-Sectional Area	Ane	8500.0		
Effective Net Cross-Sectional Area - Shear Lag	A'ne	7650.0		
Shear Lag Factor U	U	0.900		
End (x=l)	-	15 - IS 250/250/		
Cross-Sectional Area	Ag	9700.0	mm2	
Effective Net Cross-Sectional Area	Ane	8600.0		
Effective Net Cross-Sectional Area - Shear Lag	A'ne	7740.0		
Shear Lag Factor U	U	0.900		
Comment	-	0.500		i
Connon				
				-Anet

Figure 2.24: Window 1.10 Parameters - Members

Cross-Sectional Area

This column provides an option to reduce the cross-sectional area of specific members due to connections. In the *Settings* section below, the effective net area according to [1], clause 12.3.1 and the shear lag factor according to [1], clause 12.3.3 can be defined. Those parameters can be set for the start and end nodes of each member.

The effective cross-sectional areas are taken into account for the cross-section design of members in tension.



3. Calculation

3.1 Details

Calculation

Details...

Before you start the [Calculation], it is recommended to check the design details. You can open the corresponding dialog box in all windows of the add-on module by clicking [Details].

The Details dialog box contains the following tabs:

- Ultimate Limit State
- Stability
- Serviceability
- General

3.1.1 Ultimate Limit State

Ultimate Limit State Stability Serviceability General	
Options	
Plastic design acc. to 8.6 (only I-sections)	
Elastic design (also for Class 1 and Class 2 cross-sections)	
Elastic design (based on Von Mises stress)	
Shear design of solid cross-sections	
Shear buckling design of webs	
General elastic design of simple shear based on shear stress	
Limit Internal Forces for Interaction	
Allow design without influence of torsion if:	
$\tau_t / \varphi 0.66 f_y \leq 0.500$	
	OK Cance

Figure 3.1: Dialog box Details, tab Ultimate Limit State

Options

The *Plastic design acc. to 8.6* of hot-formed doubly symmetric I-sections (class 1) is possible, provided that the requirement given in [1], clause 8.6 a) is satisfied.

Cross-sections that are assigned to class 1 or 2 are designed plastically in STEEL SANS. If you do not want to perform a plastic design, you can activate the *Elastic Design* for these cross-section classes, too.



The conservative general *Elastic design* is based on the analysis of stresses in stress points inclusive of VON MISES stresses. This method can be useful for cross-sections of complicated shapes or members with torsion.

If the *Shear design of solid cross-sections* (flat or round bars) or the *Shear buckling design of webs* is not required, it can be disabled.

The conservative *General elastic design based on simple shear stress* in the stress points can be activated to determine the stresses of x-locations where shear without bending occurs.

Limit Internal Forces for Interaction

The South African standard provides no exact recommendation how to design cross-sections with torsional moments. Therefore, it possible to ignore shear stress due to torsion if a user-defined ratio of torsional shear stress τ_t and shear strength (product of resistance factor ϕ and ultimate shear stress) is not exceeded.

3.1.2 Stability

tails	
Ultimate Limit State Stability Serviceability General	
Stability Analysis	Cross-Sections Fabrication Acc. to 13.3.1
V Use	Used for general cross-sections without defined fabrication
Second Order Effects Acc. to 13.8	Stress relieved
Bending about major y-axis	Hot-rolled
Include effects from second order theory by	Hot-finished
increasing bending moment - U _{1y}	Cold-formed
Bending about minor z-axis	Welded
Include effects from second order theory by increasing bending moment - U 12	☑ Consider oxy-flame-cut flange edges for doubly symmetric welded I-sections
Model Type	Limit Values for Special Cases
Unbraced frame in y-direction (U _{1y} = 1)	Cross-sections with compression and bending
Unbraced frame in z-direction (U 1z = 1)	Do not consider small moments and allow stability design acc. to 13.3 (Intended axial compression) if:
Lateral-Torsional Buckling	Bending $M_{u,v} / M_{r,s,pl,v} \leq 0.010$
Load application of positive transverse loads:	
 On cross-section edge directed to shear center (e.g. top flange, destabilizing effect) 	M _{u,z} / M _{r,s,pl,z} ≤ 0.010
 In shear center 	acc. to 13.5 and 13.6 (bending without compression) if:
On cross-section edge directed from shear center (e.g. bottom flange, stabilizing effect)	Compression $C_u / C_{r,s,pl} \leq 0.010$
Sets of Members - Member-Like Input	Cross-sections with torsion
	Limit shear stress for stability designs:
Do not use member-like input	$\tau_t / \varphi 0.66 f_y \leq 0.010$
O Use for all sets of members	
Use only for straight sets of members	
 Use only for straight sets of members without intermediate restraints (simple beams or cantilevers) 	
2 🐻 🕥 🕼	OK Cancel

Figure 3.2: Dialog box Details, tab Stability

Stability Analysis

The *Use* check box controls whether to run, in addition to the cross-section checks, a stability analysis. If you clear the check box, the input windows 1.4, 1.5 and 1.6 will not be displayed.

Second Order Effects Acc. to 13.8

It is possible to *Include effects from second order theory* according to [1], clause 13.8 by increasing the bending moments about the major and/or minor axes. Thus when you design, for ex-



ample, a frame whose governing buckling mode is represented by lateral displacement, you can determine the internal forces according to linear static analysis and increase them with the factors according to [1], clause 13.8.2 and 13.8.4. If you increase the bending moment, it does not affect the flexural-buckling analysis which is performed by using the axial forces.

Model Type

According to [1], clause 13.8.2, the design of axial compression and bending depends on the fact whether the members are part of unbraced or braced frames. Please note that the settings of this check box are applied to <u>all</u> members of the design case.

Lateral-Torsional Buckling

If transverse loads are present, it is important to define where those forces are acting on the cross-section: Depending on the *Load application* point, transverse loads can be stabilizing or destabilizing, and, thus, can influence the critical elastic moment decisively.

Sets of Members - Member-Like Input

By default, the boundary conditions of every set of members are to be defined in windows 1.6, 1.7 and 1.8. Alternatively, the "member-like input" can be applied: all sets of members are managed in the same manner as beams. Then, the input data of window 1.6 is internally transformed to the boundary conditions required for the stability design. Windows 1.7 and 1.8 are not existent for the member-like input. As a rule, the member-like input is recommended for straight sets of members only.

If the default *Do not use member-like input* is set, a general analysis is carried out. The support conditions have to be defined for each set of members in table 1.7.

The option *Use for all sets of members* makes it possible to design sets of members in the same way as single members. This approach is applicable when every set of members corresponds to a single member model. Then the default values for simple girders are used to determine the support conditions β , u_y , ϕ_z and ω .

It is possible to apply the member-like input *only for straight sets of members* which have the same cross-section (e.g. continuous beams).

The last option to use the member-like input *only for straight sets of members without intermediate restraints*, according to the definition in RSTAB: Only sets of members which have RSTAB supports or restraints at their ends will be considered. This option can be used to design e.g. simple beams or cantilevers. Tables 1.7 and 1.8 are not displayed. Transverse beams that are connected at the intermediate nodes cannot be accounted for.

Cross-Sections Fabrication Acc. to 13.3.1

The factor *n* is relevant for the flexural buckling design according to [1], clause 13.3.1. This factor depends on the fabrication of the sections (state of residual stresses). Rolled or oxy-flamecut plates can be used to fabricate welded I and H sections.

Please note that the type of fabrication which is set in this dialog section is applied to <u>all</u> crosssections of the design case.

Limit Values for Special Cases

To design non-symmetrical cross-sections for intended axial compression according to [1], clause 13.3, you can neglect *small moments* about the major and the minor axes using the settings defined in this dialog section.

In the same way, you can switch off *small compression forces* for the pure design of bending by defining a limit ratio for C_u to $C_{r,s,pl}$.





Intended *torsion* is not clearly specified in SANS 10162-1. If the torsional stresses do not exceed the shear stress ratio of 1 % (default), they are not considered in the stability design. The design is then carried for flexural buckling and lateral-torsional buckling.

If one of the limits in this dialog section is exceeded, a note appears in the results window. No stability analysis is carried out. However, the cross-section checks are run independently. These limit settings are <u>not</u> part of the code [1]. Changing the limits is in the responsibility of the user.

3.1.3 Serviceability

etails		
Ultimate Limit State Stability Serviceability General		
Deformation Related to		
Shifted members ends / set of members ends		
Undeformed system		
Serviceability Limits (Deflections) Annex D		
Cantilevers L / 300 T L _o / 150 T		
	l	OK Cancel

Figure 3.3: Dialog box Details, tab Serviceability

Deformation Related to

The option fields control whether the maximum deformations are related to the shifted ends of members or sets of members (connection line between start and end nodes of the deformed system) or to the undeformed initial system. As a rule, the deformations are to be checked relative to the displacements in the entire structural system.

Serviceability Limits (Deflections) Annex D

In this dialog section, you can check and, if necessary, adjust the limit deformations of simple beams and cantilevers. The recommended maximum values for deflections at serviceability are contained in [1], Table D.1.



3.1.4 General

Ultimate Limit State Stability Serviceability General	
Cross-Section Optimization	Display Result Tables
Cross-Section Optimization Max allowable design ratio: 1.000 ⊕ Check of Member Slendernesses Members with λ_{limit} - Tension only: 300 ⊕ - Compression / flexure: 200 ⊕	Display Result Tables Image: Section Image: Section <td< td=""></td<>
	OK Cancel

Figure 3.4: Dialog box Details, tab General

Cross-Section Optimization

The optimization is targeted on the maximum design ratio of 100 %. If necessary, you can specify a different limit value in this input field.

Check of Member Slendernesses

In the two text boxes, you can specify the limit values λ_{limit} in order to define member slendernesses. You can enter specifications separately for members with pure tension forces and members with bending and compression.

The limit values are compared to the real member slendernesses in window 3.3. This window is available after the calculation (see chapter 4.8, page 41) if the corresponding check box is selected in the *Display Result Tables* dialog box section.

Display Result Tables

In this dialog section, you can select the results windows including parts list that you want to display. Those windows are described in chapter 4 *Results*.

The 3.3 Member Slendernesses window is inactive by default.



3.2 Start Calculation

Calculation

To start the calculation, click the [Calculation] button that is available in all input windows of the STEEL SANS add-on module.

STEEL SANS searches for the results of the load cases, load and result combinations that are to be designed. If they cannot be found, the program starts the RSTAB calculation to determine the design relevant internal forces.

You can also start the calculation in the RSTAB user interface: In the dialog box *To Calculate* (menu *Calculate* \rightarrow *To Calculate*), design cases of the add-on modules like load cases and load combinations are listed.

Calculate					-
Load Cases / C	Combinations / Module Cases Result Tables				
Not Calculated	1			Selected for	Calculation
No.	Description	^		No.	Description
S Ch CO147	LC1 + LC4 + 0.7*LC7			CA1	STEEL SANS - Design of steel members according to SANS
S Ch CO148	LC1 + LC4 + 0.7*LC7 + LC9				
S Ch CO149	LC1 + LC5 + 0.7*LC7				
S Ch CO150	LC1 + LC5 + 0.7*LC7 + LC10				
S Ch CO151	LC1 + 0.7*LC2 + 0.7*LC3 + LC4				
S Ch CO152	LC1 + 0.7*LC2 + 0.7*LC3 + LC4 + LC9				
s Ch CO153	LC1 + 0.7*LC2 + 0.7*LC3 + LC5		_		
s ch CO154	LC1 + 0.7*LC2 + 0.7*LC3 + LC5 + LC10		>		
s ch CO155	LC1 + 0.7*LC2 + 0.7*LC3 + LC4 + 0.7*LC7		>>		
Ch CO156	LC1 + 0.7*LC2 + 0.7*LC3 + LC4 + 0.7*LC7 + LC9				
s ch CO157	LC1 + 0.7*LC2 + 0.7*LC3 + LC5 + 0.7*LC7				
s ch CO158	LC1 + 0.7*LC2 + 0.7*LC3 + LC5 + 0.7*LC7 + LC10		4		
S Ch CO159	LC1 + 0.7*LC3 + LC4 + 0.7*LC7		4		
s ch CO160	LC1 + 0.7*LC3 + LC4 + 0.7*LC7 + LC9				
s ch CO161	LC1 + 0.7*LC3 + LC5 + 0.7*LC7				
Ch CO162	LC1 + 0.7*LC3 + LC5 + 0.7*LC7 + LC10				
s ch CO163	LC1 + 0.7*LC3 + LC4				
s ch CO164	LC1 + 0.7*LC3 + LC4 + LC9				
S Ch CO165	LC1 + 0.7*LC3 + LC5				
s ch CO166	LC1 + 0.7*LC3 + LC5 + LC10	_			
STR RC1	ULS				
S Ch RC2	SLS	=			
CA1	RSBUCK - Stability analysis				-
					1
Al	•	Q			
) (OK Cancel

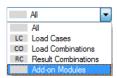


Figure 3.5: To Calculate dialog box

If the STEEL SANS design cases are missing in the *Not Calculated* list, select *All* or *Add-on Mod-ules* in the drop-down list at the end of the list.

To transfer the selected STEEL SANS cases to the list on the right, use the button [▶]. Click [OK] to start the calculation.

To calculate a design case directly, use the list in the toolbar. Select the STEEL SANS design case in the toolbar list, and then click [Show Results].

Ta <u>b</u> le <u>O</u> ptions <u>A</u> dd-on Modules <u>W</u> indow	Help
宁 🔲 📰 💁 STEEL SANS CA1 - Design c ≚	🔺 👂 🖉 🎬 🏭 🖌 🖌 📾 🖬 🕼 🖉 🏦 🎜
1 🗊 - 1 💥 🔍 🍳 🗊 🗗 1 🛱 🏹 2	

Figure 3.6: Direct calculation of a STEEL SANS design case in RSTAB

Subsequently, you can observe the design process in a separate dialog box.



Results 4.

Window 2.1 Design by Load Case is displayed immediately after the calculation.

<u>Eile E</u> dit <u>S</u> ettings <u>H</u> elp														
CA1 - Design of steel members 💌	2.1 Desigr	n by Load Case												
Input Data		A	B	C	D	E			F					G
General Data	Load-		Member	Location	Design									
Materials	ing	Description	No.	x [m]	Ratio				Design Accordi	ng to Fi	mula			0
Cross-Sections		Ultimate Limit State Design												
Intermediate Lateral Restraints	CO8	1.35*LC1 + 1.5*LC2 + 1.05*L	87	3.011	0.79	≤ 1 331	1) Stability	y analysis - Ber	ding about y-axis a	nd com	pression ac	c. to 13.8.2		U
Effective Lengths - Members	CO10	1.35*LC1 + 1.5*LC2 + 1.05*L	87	3.011	0.80	≤ 1 331	1) Stability	y analysis - Ber	ding about y-axis a	nd com	pression ac	c. to 13.8.2		ι
Effective Lengths - Sets of Mer	C017	1.35*LC1 + 1.05*LC3 + 0.75*	64	6.274	0.34	≤ 1 331	1) Stability	y analysis - Ber	ding about y-axis a	nd com	pression ac	c. to 13.8.2		l
Nodal Supports	CO26	1.35*LC1 + 1.5*LC2 + 0.75*L	87	3.011	0.74	≤ 1 331	1) Stability	y analysis - Ber	ding about y-axis a	nd com	pression ac	c. to 13.8.2		ι
- Set of members No. 1	CO61	1.35*LC1 + 1.05*LC2 + 1.5*L	64	6.274	0.61	≤ 1 341	1) Stability	y analysis - Bia	al bending and co	npressi	on acc. to	13.8.2		L
Set of members No. 2	C071	1.35*LC1 + 1.05*LC2 + 1.05*	87	3.011	0.67	≤ 1 331	1) Stability	v analysis - Ber	ding about y-axis a	nd com	pression ac	c. to 13.8.2		ι
Member End Releases														
Set of members No. 1		Serviceability Limit State Desig	n											
Set of members No. 2	RC2		68	3.000	0.20	≤ 1 401	1) Service	eability - Deflec	tion in z-direction - I	Beam				S
Serviceability Data						_								_
Parameters - Members				Max:	0.80	≤1 🕲		🎱 😫	3	<u> </u> 2	1.0	• 🕐 🔮		\$
esults														
- Design by Load Case		Member 87 - x: 3.011 m - CO8									2 - IS 40	0/200/10/18/0)	
- Design by Cross-Section		ial Values - Steel S 235 JR SAM		2						•				
Design by Set of Members		-Section Values - IS 400/200/1	0/18/0											
Design by Member		n Internal Forces												
Design by x-Location		Section Class										. 200.0		
Governing Internal Forces by N	E Design											1 200.0	- :	18.0
Governing Internal Forces by S		npression Axial Force			Cu		41.156				1			-
Member Slendernesses		nding Moment			M _{u.y}		211.112						0.0	
Parts List by Member		ximum Bending Moment			Mu,y,segm		211.112			=			_	
Parts List by Set of Members		ear Force			Vu,z		53.883	kN						
		tored Shear Resistance			V _{r,z}		508.108	kN	13.4		100.0			
	- Yiel	ld Strength			fy		225.000	MPa	5.1		4			
	Pla	stic Moment Resistance of Secti	on		Mpy		387.261	kNm				10.0	0.0	
	- Fac	tored Moment Resistance of Se	ction		Mr.s.y		348.535	kNm	13.5				<u></u>	
	Mo	dulus of Elasticity			E	200	000.000	MPa		_		annta	1111	
	- She	ear Modulus			G	77	7000.000	MPa				1		
	Sec	cond Moment of Area			Iz	240	030300.0	mm ⁴						
	Tor	sional Constant			J	8	360847.0	mm ⁴						
	Wa	ming Constant			Cw	8.755	544E+11	mm ⁶						
	Sec	ment Length			1		12 548	m						
		bility Factor			0.or		1.709			- 11				
		ical Elastic Moment			Mor		360.825	kNm		-				0
		tored Moment Resistance of Me	mher		Mr.m.y		280.365		13.6		0		A I	t +) [
	100	tored moment nesistance of me	and ca		in the second		200.000	N. MIL	10.0					
4														

Figure 4.1: Results window with designs and intermediate values

The designs are shown in the results windows 2.1 to 2.5, sorted by different criteria.

Windows 3.1 and 3.2 list the governing internal forces. Window 3.3 informs you about the member slendernesses. The last two results windows 4.1 and 4.2 show the parts lists sorted by member and set of members.



Every window can be selected by clicking the corresponding entry in the navigator. To set the previous or next input window, use the buttons shown on the left. You can also use the function keys to select the next [F2] or previous [F3] window.

Click [OK] to save the results. Thus you exit STEEL SANS and return to the main program.

Chapter 4 Results describes the different results windows one by one. Evaluating and checking results is described in chapter 5 Evaluation of Results, page 44.



OK

🎱 🚑



4.1 Design by Load Case

The upper part of this window provides a summery, sorted by load cases, load combinations and result combinations of the governing designs. Furthermore, the list is divided in *Ultimate Limit State Design* and *Serviceability Limit State Design* results.

The lower part gives detailed information on the cross-section properties, analyzed internal forces, and design parameters for the load case selected above.

	A	B	C	D		E				F					
Load-		Member	Location	D	esign										
ing	Description	No.	x [m]	Rat	io				D	esign Accordi)	ng to Fo	omula			
	Ultimate Limit State Design														
CO8	1.35*LC1 + 1.5*LC2 + 1.05*L	87	3.011		1.02					about y-axis ar] (
010	1.35*LC1 + 1.5*LC2 + 1.05*L	87	3.011							about y-axis ar					l
2017	1.35*LC1 + 1.05*LC3 + 0.75*	64	6.274							about y-axis ar					I
026	1.35*LC1 + 1.5*LC2 + 0.75*L	87	3.011							about y-axis ar					l
061	1.35*LC1 + 1.05*LC2 + 1.5*L	64	6.274							ending and cor					l
071	1.35*LC1 + 1.05*LC2 + 1.05*	87	3.011		0.86	≤1	331) Stability	r analysis -	Bending	about y-axis ar	nd comp	pression ac	c. to 13.8.2		l
	Serviceability Limit State Desig	n													
RC2	SLS	68	3.000		0.20	≤1	401) Service	ability - De	eflection ir	z-direction - E	Beam				5
			Max:		1.03	>1	0	Y 🖲			5	1.0	• 💎 😂	1	i
	Member 87 - x: 3.011 m - CO8 idulus of Elasticity			ſĔ			200000.000	MPa				2 - 15 40	0/180/10/16/0		
Mo	dulus of Elasticity			E							~				
	ear Modulus			G			77000.000								
	cond Moment of Area			l _z			15582700.0				_				
	rsional Constant			J			591997.0						. 180.0		
	arping Constant			С			5.73309E+1							16.0	
	gment Length			L			12.548	m				· ·			
	ability Factor				cr		1.285							0.0	
	tical Elastic Moment				cr		271.248								
	ctored Moment Resistance of Me	ember			r,m,y		228.224			13.6					
	istic Flexural Buckling Load				e.y		364.336	kN		13.3.1	_	400.0			
	efficient				1.y		1.000			13.8.5			10.0		
	ctor of Second Order Effect				1.y		1.000			13.8.4	_		-0.0	0.0	
	sign Component for My				My		0.79		≤1	13.8.2	_			_	
	oss Area			A			9440.0				_			NN2	
	ctored Compression Resistance (of Section			r,s		1996.560			13.3	Ξ				
	ctored Member Resistance			C	r,m		175.486	kN		13.3			z		
Fac				η	N		0.23		≤1	13.8.2					
Fac De	sign Component for N						0.900			13.1					
Fac De Re	sistance Factor			9											
Fac De Re De	sistance Factor sign Ratio			φ η			0.69		≤1	13.8.2					
Fac De Re De De	sistance Factor				1				≤1 ≤1	13.8.2 13.8.2 13.8.2					D

Figure 4.2: Window 2.1 Design by Load Case

Description

This column shows the descriptions of the load cases, load and result combinations used for the design.

Member No.

This column shows the number of the member that bears the maximum stress ratio of the designed loading.

Location x

This column shows the respective x-location where the member's maximum stress ratio occurs. For the table output, the program uses the following member locations *x*:

- Start and end node
- Division points according to possibly defined member division (see RSTAB table 1.6)
- Member division according to specification for member results (RSTAB dialog box *Calculation Parameters*, tab *Global Calculation Parameters*)
- Extreme values of internal forces

Design Ratio

Columns D and E display the design conditions according to SANS 10165-1 [1].

The lengths of the colored bars represent the respective utilizations.



Design according to Formula

This column lists the equations of the standard by which the designs have been performed.

DS

The final column provides information on the respective design-relevant design situation (DS): ULS (Ultimate Limit State) or SLS (Serviceability Limit State).

4.2 Design by Cross-Section

2.2 Design by Cross-Section

	A	B	С		D	E					F						
	Member	Location	Load		Design												
No.	No.	x [m]	Case		Ratio					Design Ad	cording to Form	ula					
1	IS 450/20	00/10/20/0															
	94	0.000	RC1				102) Cross-section										
	93	1.000	RC1	1			115) Cross-section										
	5	0.000	RC1				126) Cross-section					rce in	z-axis				
	93	0.000	RC1				132) Cross-section										
	96	6.000	RC1				172) Cross-section									8	
	102	5.400	RC1				192) Cross-section					nd sh	ear for	ce acc. t	o 13.8		
	100	0.000	RC1	1			302) Stability anal										
	100	0.000	RC1				306) Stability anal										
	100	0.000	RC1		0.06	≤1	311) Stability anal	ysis - Torsional	buckling	acc. to 13.	3.2(a) - Doubly s	ymme	trical c	ross-sec	tions		
			Max:		0.92	≤1	9		Y 2	-	🕃 🔁	>	1,0	-	7 😂	3	3
E Design	n Internal F	orces	0/200/10/	20/0													
	n Internal F Section Cl	Forces ass nge Start	0/200/10/	20/0			σf,A σf B	-8.038		< 0	Compression Compression			+	200.0		
Design Cross Flar St St	n Internal F Section Cla nge ress at Flar	orces ass nge Start nge End	0/200/10/	20/0			σf,B		MPa			III		t		1 8 0.0	+
Design Cross- Flar - St - St - St - St	n Internal F Section Cla nge ress at Flar ress at Flar	orces ass nge Start nge End	0/200/10/	20/0				-8.038	MPa MPa		Compression	III		t-			+
E Design Cross- Flar - St - St - St - St - Cle	n Internal F Section Clange ress at Flar ress at Flar ress at Flar ald Strengt	orces ass nge Start nge End	0/200/10/	20/0			σf,B fy,f	-8.038 225.000	MPa MPa mm		Compression	III		50.0			***
Design Cross- Flar - Sto - Sto - Yie - Cle - Th	n Internal F Section Cla nge ress at Flar ress at Flar eld Strengt ear Width	orces ass nge Start nge End h	0/200/10/	20/0			σf,B fy,f bo	-8.038 225.000 100.0	MPa MPa mm		Compression			450.0			• •
Desig Cross- Flar - St - St - Yi - Cl - Th - Sl	n Internal F Section Clange ress at Flar ress at Flar eld Strengt ear Width nickness enderness	orces ass nge Start nge End h					σf,B fy,f bo tf	-8.038 225.000 100.0 20.0	MPa MPa mm		Compression			450.0	10.0	<u>0.0</u>	*
Design Cross Flar - St - St - St - Ch - Ch - Ch - Sh - Sh - Ch	n Internal F Section Cli nge ress at Flar ress at Flar eld Strengt ear Width nickness endemess oss-sectior	arces ass nge Start nge End h Ratio	ressive force				σf,B fy,f bo tf	-8.038 225.000 100.0 20.0	MPa MPa mm		Compression			450.0	10.0		
Design Design Cross Flar - Stt - Stt - Ch	n Internal F Section Cli nge ress at Flar ress at Flar eld Strengt ear Width nickness endemess oss-sectior niform com	ass nge Start nge End h Ratio	ressive force				σf,B fy,f bo tf	-8.038 225.000 100.0 20.0	MPa MPa mm		Compression			450.0	10.0	<u>0.0</u>	
Design Cross Cross Flar St St St Cro St Cro St Cr Cr Cr Cr Cr Cr Sl Cr Sl Cr Sl Sl	n Internal F Section Cli nge ress at Flar ress at Flar eld Strengt ear Width nickness endemess oss-sectior niform com	orces ass nge Start nge End h Ratio n under compi pression in fla Ratio Limit	ressive force				of,B fy,f bo tf Wf	-8.038 225.000 100.0 20.0 5.000	MPa MPa mm		Compression 5.1			450.0	10.0	<u>0.0</u>	•
Design Cross- Flar - Sti - Sti - Ch - Ch - Ch - Ch - Ch - Ch - Sh - Ch - Sh - Sh - Sh - Sh - Sh - Sh - Sh - S	n Internal F Section Cl. nge ress at Flar eld Strengt ar Width nickness enderness oss-sectior niform comp enderness	ass ass nge Start nge End h Ratio n under compu pression in fla Ratio Limit Ratio	ressive force				6 f,B fy,f b 0 t f W f W f,3,Nc	-8.038 225.000 100.0 20.0 5.000 13.333	MPa MPa mm	< 0	Compression 5.1			450.0	10.0	<u>0.0</u>	
Design Cross Flar St St St Cross St St St Cross St St St Cro St St Cro St St St Cro St St St St Cro St St	n Internal F Section Cl. rge ress at Flar ress at Flar ress at Flar ar Width nickness endemess oss-section niform com endemess ass of Flan b	Forces ass nge Start nge End h Ratio n under compr pression in fla Ratio Limit Ratio ge	ressive force				of,B fy,f b0 tf Wf Wf	8.038 225.000 100.0 20.0 5.000 13.333 5.000 1	MPa MPa mm mm	< 0	Compression 5.1 Tab. 3			450.0	10.0	<u>0.0</u>	
Design Cross Flar St St St Cross St St St Cross St St St Cro St St Cro St St St Cro St St St St Cro St St	n Internal F Section Cla ress at Flar ress at Flar ress at Flar eld Strengt aar Width nickness enderness oss-section riform com enderness anderness ass of Flan	Forces ass nge Start nge End h Ratio n under compr pression in fla Ratio Limit Ratio ge	ressive force				of,B fy,f b0 tf Wf Wf	-8.038 225.000 100.0 20.0 5.000 13.333 5.000	MPa MPa mm mm	< 0	Compression 5.1 Tab. 3			450.0	10.0	<u>0.0</u>	
Design Cross Flar Sti Sti Sti Sti Cross Sti Sti Sti Cro Sti Cro Sli Cr Sli Cr Sli Cr Sli Cli Sli Cli Sli Sli Cli Sli Sli	n Internal F Section Cl. rge ress at Flar ress at Flar ress at Flar ar Width nickness endemess oss-section niform com endemess ass of Flan b	Forces ass nge Start nge End h Ratio under compr pression in fla Ratio ge b Start	ressive force				of,B fy,f bo lf Wf Wf Olassf,No	8.038 225.000 100.0 20.0 5.000 13.333 5.000 1	MPa MPa mm mm MPa	<0 ≤λ,f,3	Compression 5.1 Tab. 3 Tab. 3			450.0	10.0	<u>0.0</u>	
Design Cross Flar Sth Sth Sth Sth Cross Sth Sth Sth Cr Sth Cr Sth Cr Sth Cr Sth Cr Sth Sth	n Internal F Section Cl. nge ress at Flar ress at Flar ear Width nickness enderness oss-sectior niform com enderness ass of Flan b ress at We ress at We ress at We ress at We	Forces ass nge Start nge End h Ratio under compr pression in fila Ratio Limit Ratio ge b Start b End	ressive force				σf,B fy,f b0 tf Wff Wf,3,Nc Wf Gassf,Nc σw,A		MPa MPa mm mm MPa MPa	< 0 ≤ λ _{f,3}	Compression 5.1 Tab. 3 Tab. 3 Compression			450.0	10.0	<u>0.0</u>	‡
Design Cross Flar Sti Sti Sti Cross Sti Sti Cross Sti Sti Cro Sti Cro Sti Cro Sti Sti Cro Sti Sti	n Internal F Section Cl. nge ress at Flar ress at Flar ear Width lickness andemess andemess andemess andemess ass of Flan b b ress at We	Forces ass nge Start nge End h Ratio under compr pression in fila Ratio Limit Ratio ge b Start b End	ressive force				σf,B fy,f b0 lf Wf Wf Classf,Nc σw,A σw,B	-8.038 225.000 100.0 20.0 5.000 113.333 5.000 1 1 -8.038 -8.038	MPa MPa mm mm MPa MPa MPa	< 0 ≤ λ _{f,3}	Compression 5.1 Tab. 3 Tab. 3 Compression Compression		ð		10.0	<u>0.0</u>	[n]

Figure 4.3: Window 2.2 Design by Cross-Section

This window lists the maximum ratios of all members and actions selected for design, sorted by cross-section. The results are sorted by cross-section design and serviceability limit state design.

If there is a tapered member, the results of both cross-section numbers are listed.



4.3 Design by Set of Members

	A	B	C	D	E					F				
Set	Member	Location	Load	Design										
No.	No.	x [m]	Case	Ratio					Design A	ccording to For	mula			
1	(Member	No. 14,18,2	7,46,65,79,8	8,102)										
	102	0.000	RC1			102) Cross-section								
	102	0.000	RC1			115) Cross-section								
	14	0.000	RC1	0.00	≤1	126) Cross-section	on check - Shea	r bucklin	g acc. to 1	3.4.1.1 - Shear	force in	n z-axis		
	65	1.046	RC1			131) Cross-section								
	18	0.000	RC1			132) Cross-section								
	88	3.011	RC1			(172) Cross-section							acc. to 13.8	
	27	1.305	RC1			184) Cross-section								
	79	1.631	RC1			188) Cross-section								
	102	5.400	RC1	0.22	≤1	192) Cross-section	on check - Comp	pressive a	axial force,	biaxial bending	and sh	ear force acc. t	to 13.8	
			Max:	0.92	21	A		9				1.0 -	7 😂 🛐	
		3 - x: 3.011 m	I-RUI									2 - IS 400/18	0/10/18/0	
	n Internal F										~			
	Section Cl	ass												
	n Ratio													
	mpression /					Cu	-20.886				- 11		180.0	
	nding Mom	ent				Mu,y	117.207				- 11		<u>+ +</u>	18.0
	ear Force					Vu,z	30.495				- 11	 		-
	b Depth					hw	364.0			13.4.1.1	- 11		0.0	
	b Thickne	55				tw	10.0				- 11			
	ear Area					A _{v,z}	3640.0				- 11		1	
	mate Shea					f _{s,z}	155.100			13.4	Ε	400.0		•
		ar Resistance				Vr,z	508.108			13.4	- 11		10.0	
	ear Force					V _{u,y}	0.026				- 11		0.0	
	ear Area	_				Av.y	6480.0				_			
	mate Shea					fs,y	148.500			13.4	-11	+ -	unitim	
		ar Resistance				V _{r,y}	866.052			13.4	-11		÷	
	ld Strength					fy,f	225.000			5.1	- 11		z	
	ld Strength					f _{y,w}	235.000			5.1				
		n Modulus				Z _{pl,y}	1568920.0							
Pla							320.687	k Nm		13.5				
Pla Fac	tored Mom	ient Resistan	ce of Sectio	n		Mr.s.y		KINIII			_			
Pla Fac De	tored Mom	ent Resistan ment for M _y	ce of Sectio	n		Mr.s.y ηMy Ag	0.31		≤1	13.8				D

Figure 4.4: Window 2.3 Design by Set of Members

This results window is displayed if you have selected at least one set of members for design. The window lists the maximum ratios sorted by set of members.

The *Member No*. column shows the number of the one member within the set of members that bears the maximum ratio for the individual design criteria.

The output by set of members clearly presents the design for an entire structural group (for example a frame).



4.4 Design by Member

	A	В	C	D						E						
Member	Location	Load	Design													
No.	x [m]	Case	Ratio	1				Desi	gn Accor	ding to Formula						
97	Cross-section	n No. 12 -	TO 80/80/5/5/5	/5												
	0.000	RC1	0.04	≤1	102) Cross-	ection check - C	ompression ad	c. to 13.3	;							
	2.500	RC1	0.06	≤1	105) Cross-s	ection check - B	ending about	y-axis acc	to 13.5							
	0.000	RC1	0.00	≤1	115) Cross-s	ection check - S	hear force in z	-axis acc.	to 13.4							
	0.000	RC1	0.00	≤1	126) Cross-	ection check - S	hear buckling	acc. to 13	3.4.1.1 - S	hear force in z-a	xis					
	1.250	RC1				ection check - B										
	2.500	RC1				ection check - C					hearf	orce a	cc. to 13	.8		
	0.000	RC1				y analysis - Flexur										
	0.000	RC1				y analysis - Flexur										
	2.500	RC1	0.19	≤1	[333) Stabilit	y analysis - Bendi	ng about y-axi	s and com	pression	acc. to 13.8.3						
		Max:	0.92	1	0			9		🗊 🖺		1.0	•	7		
	mpression Axia	L Eoroo														
	nding Moment					Cu Mu,y	12.295 0.560	kNm								
Ma	ximum Bendin					M _{u,y} M _{u,y,segm}	0.560	kNm kNm		51				80	.0	
Mar Yie	ximum Bending Id Strength	g Moment	of Section			Mu,y Mu,y.segm fy	0.560 0.560 235.000	kNm kNm MPa		5.1			5.0	80	.0	5.0
Ma Yie Pla	ximum Bendin	g Moment Resistance	01 000001			M _{u,y} M _{u,y,segm} f _y M _{p,y}	0.560 0.560 235.000 9.929	kNm kNm MPa kNm					5.0	80	.0	<u>+5.0</u>
Ma Yie Pla Fac	ximum Bendin Id Strength stic Moment F ctored Moment	g Moment Resistance t Resistanc	ce of Section			Mu,y Mu,y,segm fy Mp,y Mr,s,y	0.560 0.560 235.000 9.929 8.936	kNm kNm MPa kNm kNm		5.1 13.5 13.5		+		80	.0	
Ma Yiel Pla Fac	ximum Bending Id Strength stic Moment F	g Moment Resistance t Resistanc t Resistance	ce of Section			Mu,y Mu,y,segm fy Mp,y Mr,s,y	0.560 0.560 235.000 9.929	kNm kNm MPa kNm kNm kNm		13.5		+	5.0	80	.0	
Ma Yie Pla Fac Fac	ximum Bending Id Strength stic Moment F ctored Moment ctored Moment	g Moment Resistance t Resistanc t Resistance	ce of Section			Mu,y Mu,y.segm fy Mp,y Mr,s,y Mr,s,y Ce,y	0.560 0.560 235.000 9.929 8.936 8.936	kNm kNm MPa kNm kNm kNm		13.5		•		80	.0	
Ma Yiel Pla Fac Ela Coe	ximum Bendin Id Strength stic Moment F stored Moment stored Moment stic Flexural B	g Moment Resistance t Resistand t Resistand uckling Lo	ce of Section ce of Section ad			Mu,y Mu,y.segm Fy Mp,y Mr,s,y Mr,s,y Ce,y ©1,y	0.560 0.560 235.000 9.929 8.936 8.936 111.527	kNm kNm MPa kNm kNm kNm		13.5 13.5 13.3.1		80.0		80	.0	
Ma Yiel Pla Fac Ela Coe Fac	ximum Bendin Id Strength stic Moment F stored Moment stored Moment stic Flexural B efficient	g Moment Resistance t Resistani t Resistani uckling Lo I Order Effe	ce of Section ce of Section ad			Mu,y Mu,y.segm fy Mp,y Mr,s,y Mr,s,y Ce,y	0.560 0.560 235.000 9.929 8.936 8.936 111.527 1.000 1.000 0.06	kNm kNm MPa kNm kNm kNm kN	≤1	13.5 13.5 13.3.1 13.8.5		80.0		80	.0	
Ma Yie Pla Fac Ela Coe Fac De: Gro	ximum Bendin, Id Strength stic Moment F ctored Moment stic Flexural Bi efficient ctor of Second sign Compone oss Area	g Moment Resistance t Resistan t Resistan uckling Lo I Order Effe nt for My	e of Section ce of Section ad			Mu,y Mu,y,segm Fy Mp,y Mr,s,y Mr,s,y Ce,y Ø1,y U1,y	0.560 0.560 235.000 9.929 8.936 8.936 111.527 1.000 1.000 0.06 1500.0	kNm kNm MPa kNm kNm kNm kN mm ²	≤1	13.5 13.5 13.3.1 13.8.5 13.8.4		80.0		80	.0	
Max Yiel Pla Fac Ela Coe Fac De: Gro Fac	ximum Bendin; Id Strength stic Moment F stored Moment stic Flexural B efficient stor of Second sign Compone siss Area stored Compre	g Moment Resistance t Resistanc t Resistan uckling Lo uckling Lo I Order Effe nt for My ssion Resi	e of Section ce of Section ad ect stance of Section			Mu,y Mu,y,segm Fy Mp,y Mr,s,y Ce,y 01,y U1,y U1,y My Ag Cr,s	0.560 0.560 235.000 9.929 8.936 8.936 111.527 1.000 1.000 0.06 1500.0 317.250	kNm kNm MPa kNm kNm kN kN mm ² kN	<u>≤</u> 1	13.5 13.5 13.3.1 13.8.5 13.8.4 13.8.3 13.3		€80.0 •		80	.0	
Max Yiel Pla Fac Ela Coe Fac Gro Fac Fac Fac	ximum Bendin, Id Strength stic Moment F stored Moment stic Flexural Bi efficient stor of Second sign Compone uss Area stored Compre stored Member	g Moment Resistance t Resistanc t Resistanc uckling Lo I Order Eff nt for My ssion Resi r Resistanc	e of Section ce of Section ad ect stance of Section ce			Mu,y Mu,y.segm fy Mp,y Mr,s,y Ce,y Ø1,y U1,y U1,y U1,y U1,y Cr,s Cr,m,y	0.560 0.560 235.000 9.929 8.936 8.936 111.527 1.000 1.000 0.06 1500.0 317.250 97.147	kNm kNm MPa kNm kNm kNm kN kN kN	≤1	13.5 13.5 13.3.1 13.8.5 13.8.4 13.8.3 13.3 13.3 13.3.1		80.0			.0	004 5.0
Ma Yie Pla Fac Ela Coe Fac Des Gro Fac Gro Fac Fac Fac Fac	ximum Bendin, Id Strength stic Moment F stored Moment stored Moment stored Moment stored Second sign Compone sss Area stored Compre stored Member stored Member	g Moment Resistance t Resistanc t Resistanc uckling Lo I Order Eff nt for My ssion Resi r Resistanc r Resistanc	ect of Section ad ect stance of Section ce			Mu,y Mu,y.segm fy Mp,y Mr,s,y Ce,y Ø1,y U1,y U1,y U1,y U1,y U1,y TMy Ag Cr,s Cr,m,y Cr,m,z	0.560 0.560 235.000 9.929 8.936 111.527 1.000 1.000 0.06 1500.0 317.250 97.147	kNm kNm MPa kNm kNm kNm kN kN kN kN	≤1	13.5 13.5 13.3.1 13.8.5 13.8.4 13.8.3 13.3 13.3.1 13.3.1		80.0		80	.0 2	
Ma Yie Pla Fac Ela Coe Fac De Gro Fac Fac Fac Fac Fac Fac Fac Fac	ximum Bendin, ld Strength stic Moment F tored Moment tored Moment stic Flexural Bi efficient tor of Second sign Compone tored Compre tored Member tored Member	g Moment Resistance t Resistanc t Resistanc uckling Lo I Order Eff nt for My ssion Resi r Resistanc r Resistanc r Resistanc	ect of Section ad ect stance of Section ce			Mu,y Mu,y,segm fy Mp,y Mr,s,y Mr,s,y Mr,s,y 0,y 0,y 0,y 0,y 0,y 0,y 0,y 0,y 0,y 0	0.560 0.560 235.000 9.929 8.936 8.936 111.527 1.000 0.06 1500.0 317.250 97.147 97.147	kNm kNm MPa kNm kNm kNm kN kN kN kN		13.5 13.5 13.3.1 13.8.5 13.8.4 13.8.3 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1		80.0			2	
Ma Yie Pla Fac Ela Coe Fac De Gro Fac Fac Fac Fac Fac Fac Fac Fac Fac Fac	ximum Bendin, Id Strength stored Moment F stored Moment stored Moment stored Fexural Bi efficient stor of Second sign Compone sso Area stored Compre- stored Member stored Member stored Member stored Member stored Member sign Compone	g Moment Resistance t Resistanc uckling Lo I Order Effe nt for My ssion Resistance r R R R R R R R R R R R R R R R R R R R	ect of Section ad ect stance of Section ce			Mu,y Mu,y,segm fy Mp,y Mr,s,y Mr,s,y Ce,y U1,y U1,y 1My Ag Cr,s Cr,m,y Cr,m,z Cr,m,z Cr,m,n N	0.560 0.560 235.000 9.929 8.936 8.936 111.527 1.000 1.000 1.000 0.06 1500.0 317.250 97.147 97.147 97.147 0.13	kNm kNm MPa kNm kNm kNm kN kN kN kN	≤1	13.5 13.5 13.3.1 13.8.5 13.8.4 13.8.3 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3 13.8.3		80.0			2	
Ma Yiel Pla Fac Ela Coe Fac Gro Fac Fac Fac Fac Fac Fac Fac Fac Fac Fac	ximum Bendin; Id Strength stic Moment Fi stored Moment stored Moment stored Moment stored Momber stored Second sign Compone siss Area stored Compre- stored Member stored Member stored Member stored Member stored Member stored Member stored Rember stored Rember stored Rember stored Rember stored Rember stored Rember stored Rember store Factor	g Moment Resistance t Resistanc uckling Lo I Order Effe nt for My ssion Resistance r R R R R R R R R R R R R R R R R R R R	ect of Section ad ect stance of Section ce			Mu,y Mu,y,segm fy Mp,y Mr,s,y Ce,y Ø1,y U1,y My, Ag Cr,s Cr,m,y Cr,m,z Cr,m NN Φ	0.560 0.560 235.000 9.929 8.936 8.936 111.527 1.000 0.06 1500.0 317.250 97.147 97.147 97.147 0.133 0.900	kNm kNm MPa kNm kNm kNm kN kN kN kN	≤1	13.5 13.5 13.3.1 13.8.5 13.8.4 13.8.3 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1		80.0			.0 z	
Ma Yiel Pla Fac Fac Fac Gro Fac Fac Fac Fac Fac Eac Fac Des Des Des Des Des Des Des Con Fac Fac Fac Fac Fac Fac Fac Fac Fac Fac	ximum Bendin, Id Strength stored Moment F stored Moment stored Moment stored Fexural Bi efficient stor of Second sign Compone sso Area stored Compre- stored Member stored Member stored Member stored Member stored Member sign Compone	g Moment Resistance t Resistanc uckling Lo I Order Effe nt for My ssion Resistance r R R R R R R R R R R R R R R R R R R R	ect of Section ad ect stance of Section ce			Mu,y Mu,y,segm fy Mp,y Mr,s,y Mr,s,y Ce,y U1,y U1,y 1My Ag Cr,s Cr,m,y Cr,m,z Cr,m,z Cr,m,n N	0.560 0.560 235.000 9.929 8.936 8.936 111.527 1.000 1.000 1.000 0.06 1500.0 317.250 97.147 97.147 97.147 0.13	kNm kNm MPa kNm kNm kNm kN kN kN kN		13.5 13.5 13.3.1 13.8.5 13.8.4 13.8.3 13.3.1 13.3.1 13.3.1 13.3.1 13.3.1 13.3 13.8.3		80.0			2	

Figure 4.5: Window 2.4 Design by Member

This results window presents the maximum ratios for the individual designs sorted by member number. The columns are described in detail in chapter 4.1 on page 35.

4.5 Design by x-Location

	A	В	C	D					[
Member	Location	Load	Design													
No.	x [m]	Case	Ratio					Desi	ign Accord	ling to Formula						
19	Cross-sectio	n No. 7 - U	JC 152x152x30 E													
	0.000	RC1					c - Shear force in a									
	0.000	RC1					 Shear buckling 									
	0.627	RC1					 Shear buckling 									
	0.627	RC1					 Rending about 			ce acc. to 13.4 a	nd 13	.5				
	0.627	RC1					ateral-torsional bu									
	0.896	RC1					 Shear buckling 									
	0.896	RC1					 Rending about 			ce acc. to 13.4 a	nd 13	.5				
	0.896	RC1					ateral-torsional bu									
	1.046	RC1	0.00	≤1	126) Cross-s	section check	 Shear buckling 	acc. to 13	3.4.1.1 - S	near force in z-ax	is					
		Max:	0.92	≤1	•			9	-	환 🖺) >	1,0	-	1 😂	🛐 🐧	
🛛 Desigi																
	Section Class															
- Ber	nding Moment	t				M _{u,y}	2.092							152.0		
Ber She	nding Moment ear Force					V _{u,z}	2.844	kN					+	152.9		
Ber She Fac	nding Moment ear Force stored Shear F					V _{u,z} V _{r,z}	2.844 142.996	kN kN		13.4		+		152.9		
Ber She Fac	nding Moment ear Force stored Shear F Id Strength	Resistance				Vu,z Vr,z V	2.844 142.996 235.000	kN kN MPa		13.4 5.1		t	8.4	152.9	7.5	
Ber She Fac Yiel Plas	nding Moment ear Force stored Shear F Id Strength stic Moment F	Resistance Resistance (Vu,z Vr,z V Mp,y	2.844 142.996 235.000 58.210	kN kN MPa kNm		5.1		t	9.4	152.9	7.6	
Ber She Fac Yiel Plas Fac	nding Moment ear Force stored Shear F Id Strength stic Moment F stored Moment	Resistance Resistance (it Resistanc				Vu,z Vr,z y Mp,y Mr,s,y	2.844 142.996 235.000 58.210 52.389	kN kN MPa kNm kNm				9	9.4	152.9	7.6	
Ber She Fac Yiel Plas Fac Mor	nding Moment ear Force stored Shear F Id Strength stic Moment F stored Momen dulus of Elasti	Resistance Resistance (it Resistanc				Vu,z Vr,z y Mp,y Mr,s,y E	2.844 142.996 235.000 58.210 52.389 200000.000	kN kN MPa kNm kNm MPa		5.1		157.6	9.4	152.9	7.6	
Ber She Fac Yiel Plas Fac Mor She	nding Moment ear Force stored Shear F Id Strength stic Moment F stored Momen dulus of Elasti ear Modulus	Resistance Resistance It Resistanc icity				Vu,z Vr,z y Mp,y Mr,s,y E G	2.844 142.996 235.000 58.210 52.389 200000.000 77000.000	kN kN MPa kNm kNm MPa MPa		5.1		157.6	9.4	152.9	7.6	
Ber She Fac Yiel Plas Fac Mor She She	nding Moment aar Force stored Shear F Id Strength stic Moment F stored Momen dulus of Elasti aar Modulus cond Moment	Resistance Resistance It Resistanc icity of Area				Vu,z Vr,z y Mp,y Mr,s,y E G	2.844 142.996 235.000 58.210 52.389 200000.000 77000.000 5605000.0	kN kN MPa kNm kNm MPa MPa mm ⁴		5.1		157.6	9.4		7.6	
Ber She Fac Yiel Pla: Fac Moi She Sec Tor	ding Moment aar Force stored Shear F Id Strength stic Moment F stored Moment dulus of Elasti aar Modulus cond Moment sional Consta	Resistance Resistance at Resistanc icity of Area int				Vu,z Vr,z Vy Mp,y Mr,s,y E G J J	2.844 142.996 235.000 58.210 52.389 200000.000 77000.000 5605000.0 106700.0	kN kN MPa kNm kNm MPa MPa mm ⁴ mm ⁴		5.1		157.6	9.14 19.14		7.6	
Ber She Fac Plas Fac Bac Sec Tor Wa	ding Moment aar Force stored Shear F Id Strength stic Moment F stored Moment dulus of Elasti aar Modulus cond Moment sional Consta riping Constar	Resistance Resistance it Resistanc icity of Area int				Vu,z Vr,z y Mp,y Mr,s,y E G G J Z W	2.844 142.996 235.000 58.210 52.389 200000.000 77000.000 5605000.0 106700.0 3.07500E+10	kN kN MPa kNm kNm MPa MPa mm ⁴ mm ⁴ mm ⁶		5.1		167.6	974 1977		<u>7.6</u>	- •
Ber She Fac Yiel Plas Fac Mo She Sec Tor Wa Seg	nding Moment ear Force stored Shear F Id Strength stic Moment F stored Moment dulus of Elasti ear Modulus cond Moment sional Consta riping Constar gment Length	Resistance Resistance It Resistanc icity of Area Int It				Vu,z Vr,z y Mp,y Mr,s,y E G J z U z L	2.844 142.996 235.000 58.210 52.389 200000.000 77000.000 5605000.0 106700.0 3.07500E+10 6.274	kN kN MPa kNm kNm MPa MPa mm ⁴ mm ⁴ mm ⁶		5.1		157.6	8.44		<u>7.6</u>	-•
Ber She Fac Yiel Plas Fac Moi She Sec Tor Wa Sec	nding Moment aar Force stored Shear F Id Strength stic Moment F stored Moment dulus of Elasti aar Modulus cond Moment sional Consta imping Constar imment Length ective Length	Resistance Resistance at Resistanc icity of Area int nt Factor				Vu,z Vr,z y Mp.y Mr,s,y E G G Iz J C w L K	2 844 142 996 235 000 58 210 52 389 20000 000 77000 000 5605000 0 106700 0 3.07500E+10 6.274 1.000	kN kN MPa kNm MPa MPa MPa mm ⁴ mm ⁶ m		5.1 13.5 Tab. 1 or 2	Number of the second se	197.6	9.4		<u>7.6</u>	-
Ber She Fac Yiel Plas Fac Moi She Sec Tor Wa Seg Effe Effe	nding Moment ear Force stored Shear F Id Strength stic Moment F stored Moment dulus of Elasti ear Modulus cond Moment sional Consta rping Constar gment Length active Length ective Length	Resistance Resistance at Resistanc icity of Area int nt Factor				Vu,z Vr,z y Mp.y Mr,s.y E G G J Z C w L K L e	2 844 142 996 235 000 58 210 52 389 20000 000 77000 000 5605000 0 106700 0 3.07500E+10 6.274 1.000 6.274	kN kN MPa kNm MPa MPa mm ⁴ mm ⁶ m		5.1 13.5 Tab. 1 or 2 10.2		197.6	9.4		<u>7.6</u>	-•
Ber Ber She Fac Yiel Plas Fac Moi She Sec Tor Wa Sec Effe Effe Effe Coe	nding Moment aar Force tored Shear F Id Strength stic Moment F stored Moment dulus of Elasti aar Modulus cond Moment sional Consta mping Constar ment Length sctive Length efficient	Resistance (tr Resistance) icity of Area nt nt Factor				Vu,z Vr,z y Mp,y Mr,s,y E G J C w L K L ε C w L L ε C w L ε C w L ε C w L ε ε C w L ε ε C w ε ε ε ε ε ε ε ε ε ε ε ε ε ε ε ε	2 844 142 996 235 000 58 210 52 389 200000 000 5605000.0 106700.0 3.07500E+10 3.07500E+10 6.274 1.000 6.274 1.256	kN kN MPa kNm MPa MPa mm ⁴ mm ⁶ m		5.1 13.5 Tab. 1 or 2	III	197.6			<u>7.6</u>	-
Ber Ber She Fac Yiel Pla: Fac Mo She Sec Tor Wa Sec Effe Effe Coe Coe	ading Moment aar Force toted Shear F Id Strength stored Moment F stored Moment aar Modulus sond Adulus sonal Consta priping Constar gment Length sctive Length sctive Length ficient ical Elastic Mo	Resistance Resistance it Resistanc icity of Area nt t Factor Factor	e of Section			Vu,z Vr,z Y Mp,y Mr,s,y E G G Iz C _W L C _W L C _W L C _W Δ 2 C _W Mor	2 844 142 996 235 000 58 210 52 389 20000 000 5605000.0 106700.0 3.07500E+10 6.274 1.000 6.274 1.256 70.422	kN kN MPa kNm MPa MPa MPa mm ⁴ mm ⁶ m m kNm		Tab. 1 or 2 13.6	III A	197.6	914		<u>7.6</u>	- •
Ber Ber She Fac Yiel Pla: Fac Moi She Sec Tor Wa Sec Effe Effe Coe Cotti Fac	nding Moment aar Force tored Shear F Id Strength stic Moment F stored Moment dulus of Elasti aar Modulus cond Moment sional Consta mping Constar ment Length sctive Length efficient	Resistance Resistance icity of Area nt Factor Factor	e of Section			Vu,z Vr,z y Mp,y Mr,s,y E G J C w L K L ε C w L L ε C w L ε C w L ε C w L ε ε C w L ε ε C w ε ε ε ε ε ε ε ε ε ε ε ε ε ε ε ε	2 844 142 996 235 000 58 210 52 389 200000 000 5605000.0 106700.0 3.07500E+10 3.07500E+10 6.274 1.000 6.274 1.256	kN kN MPa kNm kNm MPa mm ⁴ mm ⁶ m kNm kNm		5.1 13.5 Tab. 1 or 2 10.2		9.767	9.4		<u>7.6</u>	- •

Figure 4.6: Window 2.5 Design by x-Location



This results window lists the maxima for each member at the locations **x** resulting from the division points defined in RSTAB:

- Start and end node
- Division points according to possibly defined member division (see RSTAB table 1.6)
- Member division according to specification for member results (RSTAB dialog box *Calculation Parameters*, tab *Global Calculation Parameters*)
- Extreme values of internal forces

4.6 Governing Internal Forces by Member

3.1 Governing Internal Forces by Memb

	A	В	С	D	E	F	G	Н	
lember	Location	Load-		Forces [kN]		M	oments [kNm]		
No.	x [m]	ing	N	Vy	Vz	MT	My	Mz	Design According to Formula
1	Cross-section	No. 15 - IS	250/250/10/	15/0					
	2.500	RC1	-3.953	0.214	0.168	0.000	0.011	0.126	100) Negligible internal forces
	0.000	RC1	-13.642	-0.401	0.051	0.000	0.152	0.158	
	2.500	RC1	-3.987	-0.821	+0.049	0.000	0.025	-0.486	106) Cross-section check - Bending about z-axis acc. to 13.5
	0.000	RC1	13.608	-0.196	1.675	0.001	2.313	0.090	
	0.000	RC1	-13.608	-0.164	1.675	0.001	-2.313	0.189	
	1.000	RC1	-9.781	0.082	-0.049	0.000	0.099	-1.041	184) Cross-section check - Axial force, bending about z-axis a
	0.000	RC1	-13.621	0.687	1.150	-0.002	+1.551	-0.657	192) Cross-section check - Compressive axial force, biaxial be
	0.000	RC1	15.836	-0.140	+0.115	0.000	0.344	0.262	302) Stability analysis - Flexural buckling about y-axis acc. to 1
	0.000	RC1	15.836	-0.140	+0.115	0.000	0.344	0.262	
	0.000	RC1	-15.836	-0.140	+0.115	0,000	0.344		311) Stability analysis - Torsional buckling acc. to 13.3.2(a) - E
	0.000	RC1	-13.608	-0.164	1.675	0.001	-2.313		
	0.000	RC1	13.643	0.686	+0.049	0.000	0.148		336) Stability analysis - Bending about z-axis and compression
	0.000	RC1	13.621	0.687	1.150	-0.002	+1.551	-0.657	341) Stability analysis - Biaxial bending and compression acc.
	2.500	RC1	-35.542	0.507					
	0.000 0.000 1.000 1.000 1.000 2.500 0.000	RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1	-33.342 -45.233 -45.201 -46.248 -46.248 -46.248 -35.542 -45.233	-0.587 2.786 -0.951 -0.036 -0.036 -0.036 -0.587 2.786	2.327 0.060 3.800 0.058 0.058 0.058 2.327 0.060	0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.000	+3.287 0.080 -10.956 0.226 0.226 0.226 -3.287 0.080	5.077 -1.964 -0.058 -0.058 -0.058	194) Cross-section check - Axial force, bending about zaxis at 192) Cross-section check - Compressive axial force, biaxial ber 302) Stability analysis - Rexural buckling about y-axis acc. to 1 306) Stability analysis - Rexural buckling about z-axis acc. to 1 311) Stability analysis - Torsional buckling acc to 13.3.2(a) - C 331) Stability analysis - Bending about y-axis and compression
	0.000 1.000 1.000 2.500 0.000 0.500	RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1	-45.233 -45.201 -46.248 -46.248 -46.248 -35.542 -45.233 -43.278	2.786 -0.951 -0.036 -0.036 -0.036 -0.587 2.786 2.494	0.060 3.800 0.058 0.058 0.058 2.327	0.000 0.000 0.000 0.000 0.000 0.000 0.001	0.080 -10.956 0.226 0.226 0.226 -3.287	5.077 -1.964 -0.058 -0.058 -0.058 -0.035 5.077	184) Cross-section check - Axial force, bending about z-axia a 192) Cross-section check - Compressive axial force, biaxial be 302) Stability analysis - Rexural buckling about y-axis acc. to 306) Stability analysis - Rexural buckling about y-axis acc. to 311) Stability analysis - Torsional buckling acc. to 13.3.2(a) - C 331) Stability analysis - Bending about y-axis and compression 336) Stability analysis - Bending about y-axis and compression 336) Stability analysis - Bending about y-axis and compression
3	0.000 1.000 1.000 2.500 0.000 0.500 Cross-section	RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 No. 12 - T	45.233 45.201 46.248 46.248 46.248 35.542 45.233 43.278 0 80/80/5/5/	2.786 -0.951 -0.036 -0.036 -0.036 -0.036 -0.587 2.786 2.494 5/5	0.060 3.800 0.058 0.058 0.058 2.327 0.060 2.463	0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.000 -0.001	0.080 -10.956 0.226 0.226 0.226 -3.287 0.080 -6.323	5.077 -1.964 -0.058 -0.058 -0.058 -0.058 -0.035 5.077 3.747	184) Cross-section check - Axial force, bending about z-axis a 192) Cross-section check - Compressive axial force, biaxial be 302) Stability analysis - Rexural buckling about y-axis acc. to 306) Stability analysis - Rexural buckling about y-axis acc. to 311) Stability analysis - Bending about y-axis and compression 333) Stability analysis - Bending about y-axis and compression 341) Stability analysis - Biaxial bending and compression 341) Stability analysis - Biaxial bending and compression acc.
3	0.000 1.000 1.000 2.500 0.000 0.500 Cross-section 0.000	RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1	45.233 45.201 46.248 46.248 46.248 35.542 45.233 43.278 0 80/80/5/5/ 1-1.178	2.786 -0.951 -0.036 -0.036 -0.036 -0.587 2.786 2.494 	0.060 3.800 0.058 0.058 2.327 0.060 2.463	0.000 0.000 0.000 0.000 0.000 0.001 0.000 -0.001	0.080 -10.956 0.226 0.226 -0.226 -3.287 0.080 -6.323	5.077 -1.964 -0.058 -0.058 -0.058 -0.058 -0.035 5.077 3.747	184) Cross-section check - Axial force, bending about z-axis a 192) Cross-section check - Compressive axial force, biaxial be 302) Stability analysis - Rexural buckling about y-axis acc. to 1 305) Stability analysis - Rexural buckling about z-axis acc. to 1 311) Stability analysis - Bending about y-axis and compression 330) Stability analysis - Bending about y-axis and compression 341) Stability analysis - Bending about y-axis and compression 341) Stability analysis - Bending about z-axis and compression 341) Stability analysis - Biaxial bending and compression acc. I 102) Cross-section check - Compression acc. to 13.3
3	0.000 1.000 1.000 2.500 0.000 0.500 Cross-section 0.000 2.500	RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1	45.233 45.201 46.248 46.248 46.248 35.542 45.233 43.278 0 80/80/5/5/ 1-1.178 -0.616	2.786 -0.951 -0.036 -0.036 -0.036 -0.587 2.786 2.494 5/5 0.000 0.000	0.060 3.800 0.058 0.058 2.327 0.060 2.463 0.401 0.000	0.000 0.000 0.000 0.000 0.000 0.001 0.000 -0.001 0.000 0.000	0.080 -10.956 0.226 0.226 -3.287 0.080 -6.323 	5.077 -1.964 -0.058 -0.058 -0.035 5.077 3.747 	194) Cross-section check - Axial force, bending about z-axis a 192) Cross-section check - Compressive axial force, biaxial be 302) Stability analysis - Rexural buckling about y-axis acc. to 310) Stability analysis - Terxinal buckling about y-axis acc. to 311) Stability analysis - Torsional buckling about z-axis and compression 330) Stability analysis - Bending about y-axis and compression 340) Stability analysis - Bending about z-axis and compression 341) Stability analysis - Bending about z-axis and compression 341) Stability analysis - Biaxial bending and compression acc. 102) Cross-section check - Compression acc. to 13.3 105) Cross-section check - Bending about y-axis acc. to 13.5
3	0.000 1.000 1.000 2.500 0.000 0.500 Cross-section 0.000 2.500 0.000	RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1	45.233 45.201 46.248 46.248 46.248 35.542 45.233 43.278 0 80/80/5/5/9 1.178 -0.616 -1.178	2.786 -0.951 -0.036 -0.036 -0.036 -0.036 2.786 2.786 2.494 5/5 0.000 0.000 0.000	0.060 3.800 0.058 0.058 0.058 2.327 0.060 2.463 0.401 0.000 0.401	0.000 0.000 0.000 0.000 0.000 0.000 -0.001 -0.001 0.000 0.000 0.000 0.000	0.080 -10.956 0.226 0.226 0.226 -3.287 0.080 +6.323 	5.077 -1.964 -0.058 -0.058 -0.058 -0.035 5.077 3.747 0.000 0.000 0.000	184) Cross-section check - Axial force, bending about z-axis a 192) Cross-section check - Compressive axial force, biaxial be 302) Stability analysis - Rexural buckling about y-axis acc. to 306) Stability analysis - Rexural buckling about y-axis acc. to 311) Stability analysis - Bending about y-axis and compression 335) Stability analysis - Bending about y-axis and compression 341) Stability analysis - Bending about y-axis and compression 341) Stability analysis - Biaxial bending and compression acc. 102) Cross-section check - Compression acc. to 13.3 105) Cross-section check - Shear force in z-axis acc. to 13.5
3	0.000 1.000 1.000 2.500 0.000 0.500 Cross-section 0.000 2.500	RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1 RC1	45.233 45.201 46.248 46.248 46.248 35.542 45.233 43.278 0 80/80/5/5/ 1-1.178 -0.616	2.786 -0.951 -0.036 -0.036 -0.036 -0.587 2.786 2.494 5/5 0.000 0.000	0.060 3.800 0.058 0.058 2.327 0.060 2.463 0.401 0.000	0.000 0.000 0.000 0.000 0.000 0.001 0.000 -0.001 0.000 0.000	0.080 -10.956 0.226 0.226 -3.287 0.080 -6.323 	5.077 -1.964 -0.058 -0.058 -0.058 -0.035 5.077 3.747 0.000 0.000 0.000 0.000 0.000	194) Cross-section check - Axial force, bending about z-axis a 192) Cross-section check - Compressive axial force, biaxial be 302) Stability analysis - Rexural buckling about y-axis acc. to 310) Stability analysis - Terxinal buckling about y-axis acc. to 311) Stability analysis - Torsional buckling about z-axis and compression 330) Stability analysis - Bending about y-axis and compression 340) Stability analysis - Bending about z-axis and compression 341) Stability analysis - Bending about z-axis and compression 341) Stability analysis - Biaxial bending and compression acc. 102) Cross-section check - Compression acc. to 13.3 105) Cross-section check - Bending about y-axis acc. to 13.5

Figure 4.7: Window 3.1 Governing Internal Forces by Member

For each member, this window displays the governing internal forces, i.e. those internal forces that result in the maximum utilization of each design.

Location x

At this x location of the member, the respective maximum design ratio occurs.

Load Case

This column displays the number of the load case, the load combination or result combination whose internal forces result in the maximum design ratios.

Forces / Moments

For each member, this column displays the axial and shear forces as well as the torsional and bending moments producing maximum design ratios in the respective ultimate limit state and serviceability limit state designs.

Design According to Formula

The final column provides information on the types of design and the equations by which the designs according to [1] have been performed.



4.7 Governing Internal Forces by Set of Members

	A	B	C	D	E	F	G	Н	
Set	Location	Load-		Forces [kN]			Moments [kNm]		
No.	x [m]	ing	N	Vy	Vz	Мт	My	Mz	Design According to Formula
1	(Member No	14,18,27,4	6,65,79,88,10	(2)					
	0.000	RC1	-57.207	0.468	20.895	0.004	0.000	0.000	102) Cross-section check - Compression acc. to 13.3
	0.000	RC1	-57.207	0.468	20.895	0.004	0.000	0.000	115) Cross-section check - Shear force in z-axis acc. to 13.4
	0.000	RC1	-42.500	0.463	-6.671	-0.004	0.000	0.000	
	1.046	RC1	-16.050	-0.005	-0.951	0.023	55.086	0.232	131) Cross-section check - Torsion
	0.000	RC1	-20.634	-0.080	29.806	0.053	-108.370	-0.004	
	3.011	RC1	-20.886	-0.026	-30.495	0.027	-117.207	0.006	172) Cross-section check - Compressive axial force, bending a
	1.305	RC1	-19.653	-0.082	17.401	0.001	-0.319	0.351	
	1.631	RC1	-17.237	0.032	-15.394	0.012	-0.325	0.129	
	5.400	RC1	-35.045	-0.368	18.441	0.010	106.174	-0.253	
	0.000	RC1	-57.207	0.468	20.895	0.004	0.000		302) Stability analysis - Flexural buckling about y-axis acc. to 1
	0.000	RC1	-57.207	0.468	20.895	0.004	0.000		306) Stability analysis - Flexural buckling about z-axis acc. to 1
	0.000	RC1	-57.207	0.468	20.895	0.004	0.000		311) Stability analysis - Torsional buckling acc. to 13.3.2(a) - [
	3.011	RC1	-20.886	-0.026	-30.495	0.027	-117.207		331) Stability analysis - Bending about y-axis and compression
	1.087	RC1	-19.645	-0.027	-16.810	-0.002	3.612	-0.128	341) Stability analysis - Biaxial bending and compression acc.
2	0.000	RC1	5,64,78,87,10 -84.639	0.002	39.046	0.003	0.000		102) Cross-section check - Compression acc. to 13.3
	6.274	RC1	-0.457	-0.025	0.952	0.019	51.371	-0.221	
	0.000	RC1	-84.639	0.002	39.046	0.003	0.000	0.000	
	0.000	RC1	-34.015	-0.001	-2.730	0.003	0.000	0.000	
	1.046	RC1	-37.613	-0.017	-0.160	0.026	89.796	0.270	
	3.011	RC1	-38.348	-0.042	-55.005	0.053	-217.686	0.064	
	0.000	RC1	-0.891	0.021	-2.304	-0.019	51.151	-0.220	
	3.011	RC1	-38.348	-0.042	-55.005	0.053	-217.686	0.064	
	1.631	RC1	-29.938	-0.070	-27.843	-0.005	0.527	-0.209	
	5.019	RC1	-32.749	0.081	3.206	0.015	115.918	0.138	
	0.000	RC1	-84.639	0.002	39.046	0.003	0.000	0.000	
	0.000	RC1	-84.639	0.002	39.046	0.003	0.000		306) Stability analysis - Flexural buckling about z-axis acc. to 1
	0.000	RC1	-84.639	0.002	39.046	0.003	0.000		311) Stability analysis - Torsional buckling acc. to 13.3.2(a) - [
	6.274	RC1	-0.457	-0.025	0.952	0.019	51.371	-0.221	
	3.011	RC1	-41.798	0.029	-53.808	-0.060	-210.692	-0.051	
	6.274	RC1	-40.650	0.019	-25.340	0.016	41.848	0.132	341) Stability analysis - Biaxial bending and compression acc.
									🖺 😂 🖪 🖏

3.2 Governing Internal Forces by Set of Members

Figure 4.8: Window 3.2 Governing Internal Forces by Set of Members

This window shows the internal forces that result in the maximum ratios of the design for each set of members.



4.8 Member Slendernesses

Member No.		B	C	D	E	F	G	H	
No.		Length		Major Axis y			Minor Axis z		
	Under Stress	L [m]	ky[·]	iy [mm]	λy[-]	k _z [-]	iz [mm]	λz [-]	
1	Compression / Flexure	3.000	1.000	107.7	27.849	1.000	63.5	47.263	
2	Compression / Flexure	3.000	1.000	107.7	27.849	1.000	63.5	47.263	
3	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
4	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
5	Compression / Flexure	3.000	1.000	188.0	15.960	1.000	47.0	63.863	
6	Compression / Flexure	3.000	1.000	188.0	15.960	1.000	47.0	63.863	
7	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
8	Compression / Flexure	6.000	1.000	188.0	31.921	1.000	47.0	127.727	
9	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
12	Compression / Flexure	6.000	1.000	188.0	31.921	1.000	47.0	127.727	
13	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
15	Compression / Flexure	3.011	1.000	165.4	18.209	1.000	41.6	72.361	
16	Compression / Flexure	3.011	1.000	165.4	18.209	1.000	41.6	72.361	
17	Compression / Flexure	3.011	1.000	165.4	18.209	1.000	41.6	72.361	
19	Compression / Flexure	6.274	1.000	67.6	92.818	1.000	38.3	163.914	
20	Compression / Flexure	6.250	1.000	188.0	33.251	1.000	47.0	133.049	
21	Compression / Flexure	6.250	1.000	188.0	33.251	1.000	47.0	133.049	
24	Compression / Flexure	3.262	1.000	165.4	19.728	1.000	41.6	78.396	
25	Compression / Flexure	3.262	1.000	165.4	19.728	1.000	41.6	78.396	
26	Compression / Flexure	3.262	1.000	165.4	19.728	1.000	41.6	78.396	
28	Compression / Flexure	3.546	1.000	88.2	40.207	1.000	51.3	69.069	
29	Compression / Flexure	3.000	1.000	88.2	34.016	1.000	51.3	58.434	
30	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
31	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
32	Compression / Flexure	3.546	1.000	86.2	41.123	1.000	52.1	68.012	
33	Compression / Flexure	3.000	1.000	86.2	34.791	1.000	52.1	57.540	
34	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
35	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
	Compression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
35 36 37	Compression / Flexure	6.546	1.000	146.2	44,787	1.000	32.8	199.581	

3.3 Member Slendernesses

Figure 4.9: Window 3.3 Member Slendernesses

Details...

Details...

This results window is shown only when you have selected the respective check box in the *Details* dialog box (see Figure 3.4, page 32).

The table lists the effective slendernesses of the designed members for both directions of the principal axes. They were determined depending on the type of load. At the end of the list, you find a comparison with the limit values that have been defined in the *Details* dialog box (see Figure 3.4, page 32).

Members of the member type "Tension" or "Cable" are not included in this table.

This window is displayed only for information. No design of the slendernesses is carried out.



4.9 Parts List by Member

Finally, STEEL SANS provides a summary of all cross-sections that are included in the design case.

	A	B	С	D	E	F	G	H	
Part	Cross-Section	Number of	Length	Total Length	Surface Area	Volume	Unit Weight	Weight	Total Weight
No.	Description	Members	[m]	[m]	[m ²]	[m ³]	[kg/m]	[kg]	[t]
1	15 - IS 250/250/10/15/0	4	3.00	12.00	17.76	0.12	76.15	228.44	0.914
2	12 - TO 80/80/5/5/5/5	25	5.00	125.00	40.00	0.19	11.78	58.88	1.47
3	1 - IS 450/200/10/20/0	4	3.00	12.00	20.16	0.15	94.99	284.96	1.14
4	1 - IS 450/200/10/20/0	4	6.00	24.00	40.32	0.29	94.99	569.91	2.28
5	13 - RD 24	4	7.81	31.24	2.36	0.01	3.55	27.71	0.11
6	2 - IS 400/180/10/18/0	6	3.01	18.07	27.10	0.18	79.44	239.23	1.43
7	7 - UC 152x152x30 BS 4-1 (RSA)	4	6.27	25.10	22.61	0.10	30.03	188.43	0.75
8	9 - IS 450/200/10/20/0	8	6.25	50.00	84.00	0.61	94.99	593.66	4.74
9	13 - RD 24	8	8.02	64.18	4.84	0.03	3.55	28.47	0.228
10	2 - IS 400/180/10/18/0	6	3.26	19.57	29.36	0.20	79.44	259.18	1.55
11	6 - UC 203x203x46 BS 4-1 (RSA)	2	3.55	7.09	8.43	0.04	46.10	163.48	0.32
12	6 - UC 203x203x46 BS 4-1 (RSA)	3	3.00	9.00	10.70	0.05	46.10	138.31	0.41
13	10 - IS 200/200/8/15/0	2	3.55	7.09	8.40	0.05	57.78	204.87	
14	10 - IS 200/200/8/15/0	3	3.00	9.00	10.66	0.07	57.78	173.33	0.52
15	16 - IS 360/150/8/12/0	1	6.55	6.55	8.54	0.04	49.36	323.12	
16	2 - IS 400/180/10/18/0	6	6.27	37.64	56.47	0.38	79.44	498.42	2.99
17	6 - UC 203x203x46 BS 4-1 (RSA)	1	4.09	4.09	4.87	0.02	46.10	188.75	0.189
18	10 - IS 200/200/8/15/0	1	4.09	4.09	4.85	0.03	57.78	236.53	0.23
19	6 - UC 203x203x46 BS 4-1 (RSA)	1	7.09	7.09	8.43	0.04	46.10	327.05	0.327
20	6 - UC 203x203x46 BS 4-1 (RSA)	1	6.55	6.55	7.78	0.04	46.10	301.79	0.30
Sum		94		479.36	417.63	2.63			20.67

Figure 4.10: Window 4.1 Parts List by Member

Details...

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By default, this list contains only the designed members. If you need a parts list for all members of the model, select the corresponding option in the *Details* dialog box (see Figure 3.4, page 32).

Part No.

The program automatically assigns item numbers to similar members.

Cross-Section Description

This column lists the cross-section numbers and descriptions.

Number of Members

This column shows how many similar members are used for each part.

Length

This column displays the respective length of an individual member.

Total Length

This column shows the product determined from the two previous columns.

Surface Area

For each part, the program indicates the surface area related to the total length. The surface area is determined from the *Surface Area* of the cross-sections that can be seen in windows 1.3 and 2.1 to 2.5 in the cross-section information (see Figure 2.10, page 16).



Volume

The volume of a part is determined from the cross-sectional area and the total length.

Unit Weight

The *Unit Weight* of the cross-section is relative to the length of one meter. For tapered cross-sections, the program averages both cross-section masses.

Weight

The values of this column are determined from the respective product of the entries in column C and G.

Total Weight

The final column indicates the total mass of each part.

Sum

At the bottom of the list, you find a sum of the values in the columns B, D, E, F, and I. The last cell of the column *Total Weight* gives information about the total amount of steel required.

4.10 Parts List by Set of Members

	А	B	С	D	E	F	G	H	
Part	Set of Members	Number	Length	Total Length	Surface Area	Volume	Unit Weight	Weight	Total Weight
No.	Description	of Sets	[m]	[m]	[m ²]	[m ³]	[kg/m]	[kg]	[t]
1		2	37.10	74.19	115.61	0.80	84.47	3133.46	6.26
ium		2		74.19	115.61	0.80			6.26

Figure 4.11: Window 4.2 Parts List by Set of Members

The last results window is displayed if you have selected at least one set of members for design. The table summarizes an entire structural group (for example a horizontal beam) in a parts list.

Details on the various columns can be found in the previous chapter. If different cross-sections are used in the set of members, the program averages the surface area, the volume, and the cross-section weight.



5. Evaluation of Results

The design results can be evaluated in different ways. For this, the buttons in the results windows are very useful which are located below the upper tables.

	A	B	С	D	E						F			
	Member	Location	Load	Design										
No.	No.	x [m]	Case	Ratio					De	sign Acco	rding to Formula			
1	IS 450/20	0/10/20/0												
	94	0.000	CO6					neck - Compres						
	93	1.000	CO61					neck - Shear for						
	5	0.000	CO6	0.00	≤1	126) C	ross-section ch	neck - Shear bu	ckling aco	c. to 13.4.	1.1 - Shear force in	n z-axis		
	93	0.000	CO11					neck - Torsion a						1.
	96	6.000	CO6	0.45	≤1	172) C	ross-section ch	neck - Compres	sive axial f	force, ben	ding about y-axis a	and shear f	orce acc. to 13.8	
	102	5.400	CO11	0.22	≤1	192) C	ross-section ch	neck - Compres	sive axial f	force, biax	ial bending and sh	ear force a	acc. to 13.8	
	100	0.000	CO11					- Flexural buck						
	100	0.000	CO11	0.28	≤1	306) S	tability analysis	- Flexural buck	ling about	z-axis acc	c. to 13.3.1			4
	100	0.000	CO11	0.06	≤1	311) S	tability analysis	- Torsional bud	kling acc	to 13.3.2	(a) - Doubly symme	etrical cross	s-sections	1
			Max:	1.02	>1	8		9	1		🕃 📮 >	1.0	- 7 🖭 🖪	
She Thic Y U Thic Y	îeld Streng Iltimate Ter ckness ran îeld Streng Iltimate Ter	s ge t ≤ 16 mm th nsile Strength ge t > 16 mm	and t ≤ 40				E G fu fu fu	200000.000 77000.000 235.000 360.000 225.000 360.000	MPa MPa MPa MPa			450.0	200.0	20.0
			and $t \le 10$	U mm				015 000				450		•,
	ield Streng						fy	215.000					10.0	
		nsile Strength lues - IS 45		20.40			fu	360.000	мга				0.0	
			0/200/10/	20/0										
	n Internal F													
	Section Cla	ISS											+	
Design								07.077					z	
	pression A	xial Force					Cu	97.257						
	ss Area						Ag	12100.0						
	d Strength						fy	225.000			5.1			
 Fact 		pression Resi	stance of S	Section			Cr.s	2487.150	kN		13.3			ſm
							0	0.900			13.1			
	iistance Fa iign Ratio	ctor					Ψ	0.04			13.3	0		

Figure 5.1: Buttons for evaluation of results

These buttons have the following functions:

Button	Description	Function
	Ultimate Limit State Designs	Turns on and off the results of the ultimate limit state design
2	Serviceability Limit State Designs	Turns on and off the results of the serviceability limit state design
	New Result Combination	Creates a result combination from the governing load cases and load combinations
	Show Color Bars	Turns on and off the colored reference scales in the results windows
> 1,0 ▼ > 1,0 Max Define	Filter Parameters	Describes the filter criterion for the output in the tables: Design ratios greater than 1, maximum value or user-defined limit
7 ,1	Apply Filter	Displays only rows where the filter parameters are valid (ratio > 1, maximum, user-defined value)
2	Result Diagrams	Opens the window <i>Result Diagram on Member</i> → chapter 5.2, page 47
	Excel Export	Exports the table to MS Excel / OpenOffice → chapter 7.4.3, page 57



₹₹	Member Selection	Allows you to graphically select a member to display its results in the table
۲	View Mode	Jumps to the RSTAB work window to change the view

Table 5.1: Buttons in results windows 2.1 through 2.5

5.1 Results in the RSTAB Model

To evaluate the design results, you can also use the RSTAB work window.

RSTAB background graphic and view mode

The RSTAB work window in the background is useful when you want to find the position of a particular member in the model: The member selected in the STEEL SANS results window is highlighted in the selection color in the background graphic. Furthermore, an arrow indicates the member's x-location that is displayed in the selected table row.

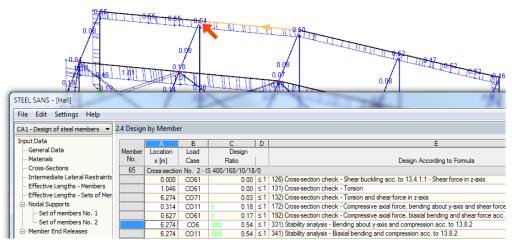


Figure 5.2: Indication of the member and the current Location x in the RSTAB model

If you cannot improve the display by moving the STEEL SANS module window, click [Jump to Graphic] to activate the *View Mode*: The program hides the module window so that you can modify the display in the RSTAB user interface. The view mode provides the functions of the *View* menu, for example zooming, moving, or rotating the display. The pointer remains visible.

Click [Back] to return to the add-on module STEEL SANS.

RSTAB work window

You can also graphically check the design ratios in the RSTAB model. Click [Graphics] to exit the design module. In the RSTAB work window, the design ratios are now displayed like the internal forces of a load case.

In the *Results* navigator, you can specify which design ratios of the service or ultimate limit state design you want to display graphically.

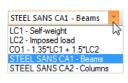
To turn the display of design results on or off, use the [Show Results] button known from the display of internal forces in RSTAB. To display the result values, use the toolbar button [Show Values] to the right.

As the RSTAB tables are of no relevance for the evaluation of design results, you can hide them.

The design cases can be set by means of the list in the RSTAB menu bar.









To adjust the graphical representation of the results, you can select $Results \rightarrow Members$ in the *Display* navigator. The display of the design ratios is *Two-Colored* by default.

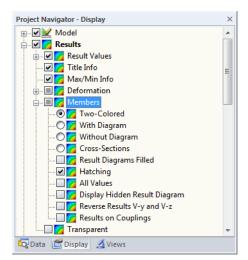


Figure 5.3: *Display* navigator: Results \rightarrow Members

When you select a multicolor representation (options *With/Without Diagram* or *Cross-Sections*), the color panel becomes available. It provides the common control functions described in detail in the RSTAB manual, chapter 3.4.6.

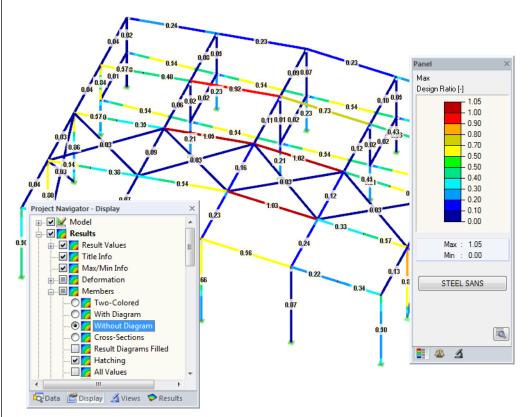


Figure 5.4: Design ratios with display option *Without Diagram*

This graphics of the design results can be transferred to the printout report (see chapter 6.2, page 50).

To return to the STEEL SANS module, click [STEEL SANS] in the panel.

STEEL SANS



5.2 Result Diagrams

You can also graphically evaluate a member's result distributions in the result diagram.

To do this, select the member (or set of members) in the STEEL SANS results window by clicking in the table row of the member. Then open the *Result Diagram on Member* dialog box by clicking the button shown on the left. The button is located below the upper results table (see Figure 5.1, page 44).

The result diagrams are also available in the RSTAB graphic. To display the diagrams, click

$\textbf{Results} \rightarrow \textbf{Result Diagrams for Selected Members}$

or use the button in the RSTAB toolbar shown on the left.

A window opens, graphically showing the distribution of the maximum design values on the member or set of members.

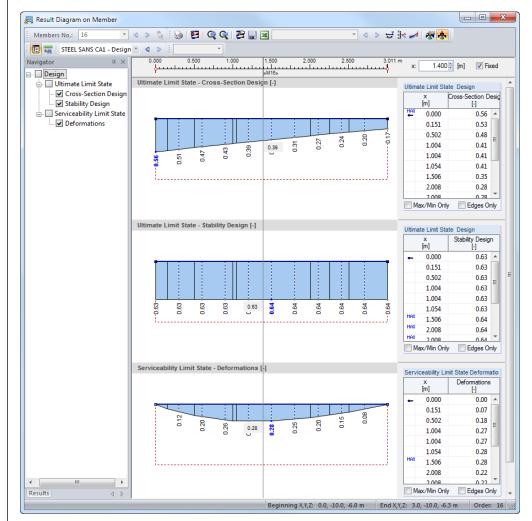
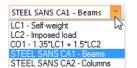


Figure 5.5: Dialog box Result Diagram on Member

Use the list in the toolbar above to choose the relevant STEEL SANS design case.

The Result Diagram on Member dialog box is described in the RSTAB manual, chapter 9.5.





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5.3 Filter for Results

The STEEL SANS results windows allow you to sort the results by various criteria. In addition, you can use the filter options described in chapter 9.7 of the RSTAB manual to evaluate the design results graphically.

You can use the *Visibility* options also for STEEL SANS (see RSTAB manual, chapter 9.7.1) to filter the members in order to evaluate them.

Filtering designs

The design ratios can easily be used as filter criteria in the RSTAB work window which you can access by clicking [Graphics]. To apply this filter function, the panel must be displayed. If it is not shown, click

View \rightarrow Control Panel (Color Scale, Factors, Filter)

or use the toolbar button shown on the left.

The panel is described in the RSTAB manual, chapter 3.4.6. The filter settings for the results must be defined in the first panel tab (Color spectrum). As this register is not available for the two-colored results display, you have to use the *Display* navigator and set the display options *Colored With/Without Diagram* or *Cross-Sections* first.

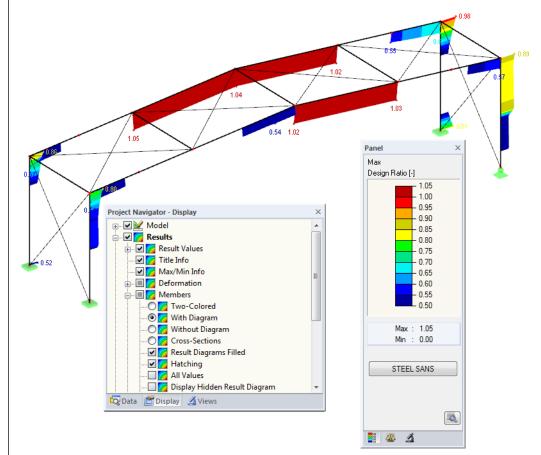


Figure 5.6: Filtering design ratios with adjusted color spectrum

As the figure above shows, the color spectrum can be set in such a way that only ratios higher than 0.50 are shown in a color range between blue and red.

If you select the Display Hidden Result Diagram option in the Display navigator (Results \rightarrow Members), you can display all stress ratio diagrams that are not covered by the color spectrum. Those diagrams are represented by dotted lines.





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Filtering members

In the *Filter* tab of the control panel, you can specify the numbers of particular members to display their results exclusively, that is, filtered. This function is described in detail in the RSTAB manual, chapter 9.7.3.

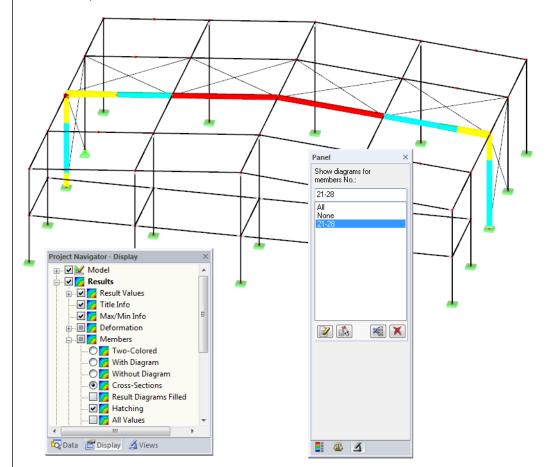


Figure 5.7: Member filter for the stress ratios of a hall frame

Unlike the partial view function (*Visibilities*), the graphic displays the entire model. The figure above shows the design ratios of a hall frame. The remaining members are displayed in the model but are shown without design ratios.





6. Printout

6.1 Printout Report

Similar to RSTAB, the program generates a printout report for the STEEL SANS results, to which graphics and descriptions can be added. The selection in the printout report determines what data from the design module will be included in the printout.



The printout report is described in the RSTAB manual. In particular, chapter 10.1.3.5 *Selecting Data of Add-on Modules* describes how to select input and output data of add-on modules for the printout.

For complex structural systems with many design cases, it is recommended to split the data into several printout reports, thus allowing for a clearly-arranged printout.

6.2 STEEL SANS Graphic Printout

In RSTAB, you can add every picture that is displayed in the work window to the printout report or send it directly to a printer. In this way, you can prepare the design ratios displayed on the RSTAB model for the printout, too.



The printing of graphics is described in the RSTAB manual, chapter 10.2.

Designs in the RSTAB model

To print the currently displayed graphic of the design ratios, click

File \rightarrow Print Graphic

or use the toolbar button shown on the left.

🧐 R	STAB	8.02.00	36 (64b	it) - [Hal	*]		
: 45	<u>F</u> ile	<u>E</u> dit	<u>V</u> iew	Insert	<u>C</u> alculate	<u>R</u> esults	<u>T</u> ools
:	2	33) 🛃 🖻	50	🖉 🍕	Q 🔁
1	- 2	22.5	V. 🐒	Print (Graphic 1	8 🎮 -	<u>2×x</u> 1

Figure 6.1: Button Print Graphic in RSTAB toolbar

Result Diagrams



You can also transfer the *Result Diagram on Member* to the report by using the [Print] button. It is also possible to print it directly.

肩 Result Diagram on Me	nber	
Members No.: 181	- < > 🏷 !	
Navigator 4	× 0.000	0.500 Print
🖃 🖌 Design	Ť	
Ultimate Limit	Sta Design [-]	

Figure 6.2: Button Print Graphic in the dialog box Result Diagram on Member

The dialog box Graphic Printout opens (see figure on next page).





Graphic Picture	Window To Print	Graphic Size		
Directly to a printer	 Current only 	As screen view		
To a printout report: PR1	O More	Window filling		
🗇 To the Clipboard	🔘 Mass print	○ To scale 1: 20 ▼		
D To 3D PDF				
Graphic Picture Size and Rotation	Options			
Use whole page width	Show results for selected x-location in result diagram			
🗇 Use whole page height	Lock graphic picture (without update)			
● Height: 49 🚔 [% of page]		,		
	Show printout report on [[OK]		
Rotation: 0 🐳 [°]				
landar of Orachia Distance				
leader of Graphic Picture				

Figure 6.3: Dialog box Graphic Printout, tab General

This dialog box is described in the RSTAB manual, chapter 10.2. The RSTAB manual also describes the *Options* and *Color Spectrum* tab.

You can move a graphic anywhere within the printout report by using the drag-and-drop function.

To adjust a graphic subsequently in the printout report, right-click the relevant entry in the navigator of the printout report. The option *Properties* in the context menu opens the dialog box *Graphic Printout*, offering various options for adjustment.

raphic Printout				— X
Properties Options Color Scale Fa	actors Border and Streto	ch Factors		
Script	Symbols		Frame	
Proportional	Proportional		None	
Onstant	Constant		Framed	
Factor: 1	Factor: 1		Title box	
Print Quality		Color		
Standard (max 1000 x 1000 Pixels))	🔘 Grayscale		
Maximum (max 5000 x 5000 Pixels))	Texts and lines in black		
O User-defined		All colore	d	
Max number of pixels:	1000 📩			
D			ОК	Cancel

Figure 6.4: Dialog box Graphic Printout, tab Options

Remove from Printout Report Start with New Page Selection... Properties...



7. General Functions

This chapter describes useful menu functions as well as export options for the designs.

7.1 Design Cases

Design cases allow you to group members for the design: In this way, you can combine groups of structural components or analyze members with particular design specifications (for example changed materials, partial safety factors, optimization).

It is no problem to analyze the same member or set of members in different design cases.

To calculate a STEEL SANS design case, you can also use the load case list in the RSTAB toolbar.

Create New Design Case

To create a new design case, use the STEEL SANS menu and click

File ightarrow New Case.

The following dialog box appears:

Vew STEE	L SANS Case
No.	Description
2	Design of steel members according to SANS -

Figure 7.1: Dialog box New STEEL SANS Case

In this dialog box, enter a *No*. (one that is still available) for the new design case. The corresponding *Description* will make the selection in the load case list easier.

Click [OK] to open the STEEL SANS window 1.1 *General Data* where you can enter the design data.

Rename a Design Case

To change the description of a design case, use the STEEL SANS menu and click

$\textbf{File} \rightarrow \textbf{Rename Case}.$

The following dialog box appears:

Rename S	TEEL SANS Case	X
No. 2	Description New description	-
Ø		OK Cancel

Figure 7.2: Dialog box Rename STEEL SANS Case

In this dialog box, you can define a different *Description* as well as a different *No*. for the design case.

STEEL SANS CA1 - Beams LC1 - Self-weight LC2 - Imposed load CO1 - 1.35*LC1 + 1.5*LC2 STEEL SANS CA1 - Beams STEEL SANS CA2 - Columns



Copy a Design Case

To copy the input data of the current design case, use the STEEL SANS menu and click

```
File 
ightarrow Copy Case.
```

The following dialog box appears:

CA1 - D	esign of steel members according to SANS
New Ca	se
No.:	Description:
3	Member-like input

Figure 7.3: Dialog box Copy STEEL SANS Case

Define the No. and, if necessary, a Description for the new case.

Delete a Design Case

To delete design cases, use the STEEL SANS menu and click

File \rightarrow Delete Case.

The following dialog box appears:

	le Cases
No.	Description
1	Design of steel members according to SAN:
2	New description
	Member-like input

Figure 7.4: Dialog box Delete Cases

The design case can be selected in the list *Available Cases*. To delete the selected case, click [OK].





7.2 Cross-Section Optimization

The design module offers you the option to optimize overloaded or little utilized cross-sections. To do this, select in column D or E of the relevant cross-sections in the 1.3 *Cross-Sections* window whether to determine the cross-section *From the current row* or the user-defined *Favorites* (see Figure 2.8, page 14). You can also start the cross-section optimization in the results windows by using the context menu

	A	B	С	D	E		F	
Section	Member	Location	Load	Design				
No.	No.	x [m]	Case	Ratio			Design According to Formula	
2	2 IS 400/168/10/18/0							
	76	0.652	CO37	0.04	≤1	102) C	Cross-section check - Compression acc. to 13.3	
	77 Go to Cross-Section Doubleclick oss-section check - Shear force in z-axis acc. to 13.4							
	15	Go to cross-section Doubleclick				LIICK	ross-section check - Shear buckling acc. to 13.4.1.1 - Shear force in z-axis	
	40	10 Info About Cross-Section					ross-section check - Torsion	
	16	16 Optimize Cross-Section					oss-section check - Torsion and shear force in z-axis	
	86		_,			oss-section check - Compressive axial force, bending about y-axis and shear force ac		
	25	Cross-Section Optimization Parameters			neter	S	oss-section check - Axial force, bending about z-axis and shear force	
	24	1.957	CO61	0.07	≤1	188) C	ross-section check - Axial force, bending about z-axis, shear force and torsion	
	15	0.753	CO6	0.43	≤1	192) C	Cross-section check - Compressive axial force, biaxial bending and shear force acc. to 1	

Figure 7.5: Context menu for cross-section optimization

During the optimization process, the module determines the cross-section that fulfills the analysis requirements in the most optimal way, that is, comes as close as possible to the maximum allowable design ratio specified in the *Details* dialog box (see Figure 3.4, page 32). The required cross-section properties are determined with the internal forces from RSTAB. If another crosssection proves to be more favorable, this cross-section is used for the design. Then, the graphic in window 1.3 shows two cross-sections: the original cross-section from RSTAB and the optimized one (see Figure 7.7).

For a parameterized cross-section, the following dialog box appears when you select 'Yes' from the drop-down list.

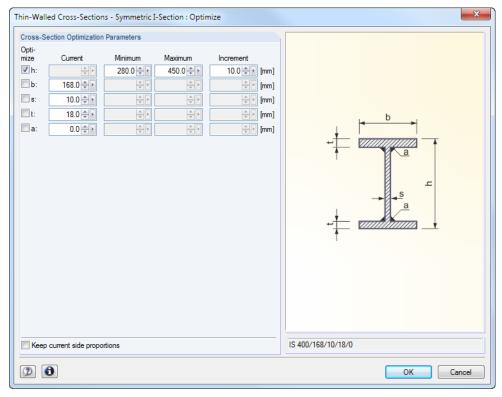


Figure 7.6: Dialog box Welded Cross-Sections - I symmetric : Optimize

7 General Functions



By selecting the check boxes in the *Optimize* column, you decide which parameter(s) you want to modify. This enables the *Minimum* and *Maximum* columns, where you can specify the upper and lower limits of the parameter. The *Increment* column determines the interval in which the size of the parameter varies during the optimization process.

If you want to *Keep current side proportions*, select the corresponding check box. In addition, you have to select at least two parameters for optimization.

Cross-sections based on combined rolled cross-sections cannot be optimized.



Please note that the internal forces are not automatically recalculated with the changed crosssections during the optimization: It is up to you to decide which cross-sections should be transferred to RSTAB for recalculation. As a result of optimized cross-sections, internal forces may vary significantly because of the changed stiffnesses in the structural system. Therefore, it is recommended to recalculate the internal forces of the modified cross-section data after the first optimization, and then to optimize the cross-sections once again.

You can export the modified cross-sections to RSTAB: Go to the 1.3 *Cross-Sections* window, and then click

$\textbf{Edit} \rightarrow \textbf{Export All Cross-Sections to RSTAB}.$

Alternatively, you can use the context menu in window 1.3 to export optimized cross-sections to RSTAB.

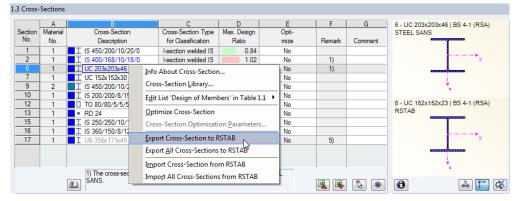


Figure 7.7: Context menu in window 1.3 Cross-Sections

Before the modified cross-sections are transferred to RSTAB, a security query appears as to whether the results of RSTAB should be deleted.

	STEEL SANS Information No. 53850
Do you	want to transfer the changed cross-sections to RSTAB?
If so, th	e results of RSTAB and STEEL SANS will be deleted.
	Yes No

Figure 7.8: Query before transfer of modified cross-sections to RSTAB

Calculation

By confirming the query and then starting the [Calculation] in the STEEL SANS module, the RSTAB internal forces as well as the designs will be determined in one single calculation run.

If the modified cross-sections have not been exported to RSTAB yet, you can import the original cross-sections in the design module by using the options shown in Figure 7.7. Please note that this option is only available in window 1.3 *Cross-sections*.



If you optimize a tapered member, the program modifies the member start and end. Then it linearly interpolates the second moments of area for the intermediate locations. As these moments are considered with the fourth power, the designs may be inaccurate if the depths of the start and end cross-section differ considerably. In such a case, it is recommended to divide the taper into several members, thus manually modeling the taper layout.

7.3 Units and Decimal Places

Units and decimal places for RSTAB and the add-on modules are managed in one dialog box. In STEEL SANS, you can use the menu to define the units. To open the corresponding dialog box, click

Settings \rightarrow Units and Decimal Places.

The program opens the following dialog box that you already know from RSTAB. STEEL SANS will be preset in the list *Program/Module*.

Units and Decimal Places						×
Program / Module		STEEL SANS				
RSTAB	*	Output Data		Parts List		
STEEL		Output Data		Fulta Liat	11.0	
STEEL EC3			Unit Dec. places		Unit	Dec. places
STEEL AISC		Stresses:	MPa 🔹 3 🜩	Lengths:	m 🔻	2 🌲
STEEL IS		Design ratios:	2	Total lengths:	m 🔻	2 🌩
STEEL SIA		Design ratios.		rotariengtris.		
STEEL BS		Dimensionless:	- 👻 3 荣	Surface areas:	m^2 ▼	2 🌲
- STEEL GB				Volumes:		2 🚔
STEEL CS	Ξ					
STEEL AS				Weight per length:	kg/m ▼	2 🌩
STEEL NIC-DF				Weight:	kg 🔻	2 🌲
STEEL SP				-		
STEEL SANS				Total weight:	t 🔻	3 🌩
STEEL SANS						
ALUMINIUM						
KAPPA						
LTB						
FE-LTB						
EL-PL						
C-TO-T						
PLATE-BUCKLING						
CONCRETE						
CONCRETE Columns						
TIMBER Pro						
TIMBER AWC						
- TIMBER						
DYNAM						
JOINTS	Ŧ					
2	Ē				ОК	Cancel

Figure 7.9: Dialog box Units and Decimal Places

You can save the settings as a user profile to reuse them in other models. These functions are described in the RSTAB manual, chapter 11.1.3.





7.4 Data Transfer

7.4.1 Export Material to RSTAB

If you have adjusted the materials in STEEL SANS for design, you can export the modified materials to RSTAB in a similar manner as you export members and cross-sections: Open window 1.2 *Materials*, and then click

Edit \rightarrow Export All Materials to RSTAB.

You can also export the modified materials to RSTAB by using the context menu of window 1.2.

Material Library
Export Material to RSTAB
Export <u>A</u> ll Materials to RSTAB
Import Material from RSTAB
Import All Materials from RSTAB

Figure 7.10: Context menu of window 1.2 Materials

Calculation

Before the modified materials are transferred to RSTAB, a security query appears as to whether the results of RSTAB should be deleted. When you have confirmed the query and then start the [Calculation] in STEEL SANS, the RSTAB internal forces and designs are determined in one single calculation run.

If the modified materials have not been exported to RSTAB yet, you can transfer the original materials to the design module, using the options shown in Figure 7.10. Please note, however, that this option is only available in window 1.2 *Materials*.

7.4.2 Export Effective Lengths to RSTAB

If you have adjusted the materials in STEEL SANS for design, you can export the modified materials to RSTAB in a similar manner as you export cross-sections: Open window 1.5 *Effective Lengths - Members*, and then click

```
Edit \rightarrow Export All Effective Lengths to RSTAB.
```

or use the corresponding option on the context menu of window 1.5.

Export Effective Length to RSTAB
Export All Effective Lengths to RSTAB
Import Effective Length from RSTAB
Import <u>A</u> ll Effective Lengths from RSTAB

Figure 7.11: Context menu of window 1.5 Effective Lengths - Members

Before the modified materials are transferred to RSTAB, a security query appears as to whether the results of RSTAB should be deleted.

If the modified effective lengths have not been exported to RSTAB yet, you can retransfer the original effective lengths to the design module, using the options shown in Figure 7.11. Please note, however, that this option is only available in window 1.5 *Effective Lengths - Members* and 1.6 *Effective Lengths - Sets of Members*.

7.4.3 Export Results

The STEEL SANS results can also be used by other programs.

Clipboard

To copy cells selected in the results windows to the Clipboard, press the keys [Ctrl]+[C]. To insert the cells, for example in a word-processing program, press [Ctrl]+[V]. The headers of the table columns will not be transferred.



Printout report

You can print the data of the STEEL SANS add-on module into the global printout report (see chapter 6.1, page 50) for export. Then, in the printout report, click

File \rightarrow Export to RTF.

The function is described in the RSTAB manual, 10.1.11.

Excel / OpenOffice

STEEL SANS provides a function for the direct data export to MS Excel, OpenOffice.org Calc or the file format CSV. To open the corresponding dialog box, click

```
\textbf{File} \rightarrow \textbf{Export Tables}.
```

The following export dialog box appears

Microsoft Excel OpenOffice.org Calc CSV file format
© CSV file format
Export tables with details
OK Cancel

Figure 7.12: Dialog box Export - MS Excel

When you have selected the relevant parameters, you can start the export by clicking [OK]. Excel or OpenOffice will be started automatically, i.e. they do not have to be opened first.

X	9 9	. 6 1	Ŧ			Ta	ble1.xlsx - Microsoft Excel	x
Fi	ile	Home	Insert	Page Lay	yout F	ormu	ilas Data Review View Add-Ins 🛆 🕜 🗆 🗟	23
Pas Clipt	te 🛷	Calibr B	<u>υ</u> -	10 * A* A*	≡ ≡	■ [≫⁄~	Text ▼ Image: Styles Styles Image: Styles Styles <t< th=""><th></th></t<>	
	В	3	(0	j	fx IS 450	0/20	0/10/20/0	~
	А	В	С	D	E	F	G	
1	Section	Member	Location	Load	Desig	n		
2	No.	No.	x [m]	Case	Ratio		Design According to Formula	
3	1	IS 450/2	00/10/20/	0				
4		94	0,000	CO6	0,04	≤1	102) Cross-section check - Compression acc. to 13.3	-
5		93	1,000	CO61	0,13	≤1	115) Cross-section check - Shear force in z-axis acc. to 13.4	_
6		5	0,000	CO6	0,00	≤1	126) Cross-section check - Shear buckling acc. to 13.4.1.1 - Shear force in z-	·a
7		93	0,000	CO11	0,17	≤1	132) Cross-section check - Torsion and shear force in z-axis	
8		96	6,000	CO6	0,45	≤1	172) Cross-section check - Compressive axial force, bending about y-axis a	n
9		102	5,400	CO11	0,22	≤1	192) Cross-section check - Compressive axial force, biaxial bending and sh	ei
10		100	0,000	CO11	0,15	≤1	302) Stability analysis - Flexural buckling about y-axis acc. to 13.3.1	
11		100	0,000	CO11	0,28	≤1	306) Stability analysis - Flexural buckling about z-axis acc. to 13.3.1	_
12		100	0,000	CO11	0,06	≤1	311) Stability analysis - Torsional buckling acc. to 13.3.2(a) - Doubly symm	e.
13		12	0,300	CO11	0,84	≤1	331) Stability analysis - Bending about y-axis and compression acc. to 13.8	3.2
14		102	1,000	CO11	0,46	≤1	341) Stability analysis - Biaxial bending and compression acc. to 13.8.2	
15 I≪ ∢ Rea	► ►I	2.1 Des	sign by Loa	d Case 🔍	2.2 Des	ign	by Cross-Section 1 4	

Figure 7.13: Results in Excel



8. Example

Column with Biaxial Bending

In this example, the stability design of flexural buckling and lateral-torsional buckling is carried out by analyzing the relevant interaction conditions according to [1].

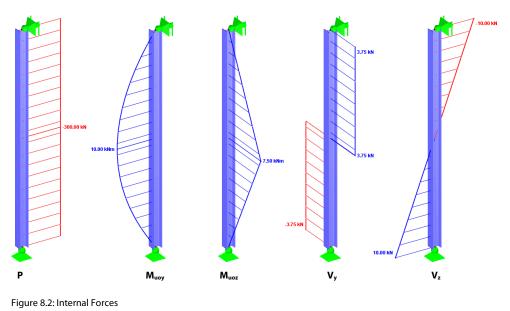
Design values

System and loads q_z q_z

Figure 8.1: System and design loads (y-fold)

Internal forces according to linear static analysis

₽z





Design location (decisive location x)

The design is performed for all locations x (see chapter 4.5) of the member. The following internal forces act in the decisive location at x = 2.00 m:

 $P = -300.00 \ kN \qquad M_{uoy} = 10.00 \ kNm \qquad M_{uoz} = 7.50 \ kNm \qquad V_y = 3.75 \ kN \qquad V_z = 0.00 \ kN$

Cross-section properties UC 152x152x37, Steel S 235

Property	Symbol	Value	Unit
Area of cross-section	Ag	47.11	cm ²
Moment of inertia	ly	2210.00	cm⁴
Moment of inertia	lz	7060.00	cm⁴
Radius of inertia	r _y	6.85	cm
Radius of inertia	rz	3.87	cm
Polar radius of gyration	r₀	7.86	cm
Polar radius of gyration	r _{o,M}	41.90	cm
Cross-section weight	G	37.00	kg/m
Torsional constant	J	19.70	cm⁴
Warping constant	Ca	399000.00	cm⁵
Elastic section modulus	Sy	274.00	cm³
Elastic section modulus	Sz	91.50	cm³
Plastic section modulus	Zy	309.00	cm³
Plastic section modulus	Zz	140.00	cm³

Flexural buckling about the minor axis (\perp to z-z axis)

Elastic flexural buckling stress

$$f_{ez} = \frac{\pi^2 \cdot E}{(K_z \cdot L/r_z)^2} = \frac{\pi^2 \cdot 200000}{(1 \cdot 4000/38.71)^2} = 184.866 \text{ MPa}$$

Elastic flexural buckling load

$$C_{e,z} = A_g \frac{\pi^2 \cdot E}{(K_z \cdot L/r_z)^2} = 4711 \frac{\pi^2 \cdot 200000}{(1 \cdot 4000/38.71)^2} = 870.90 \text{ kN}$$

Cross-section type acc. to Table 3 is "compact":

 $A_e = A_g$

Slenderness ratio

$$\lambda_{z} = \frac{K_{z} \cdot L}{r_{z}} \sqrt{\left(\frac{f_{y}}{\pi^{2} \cdot E}\right)} = \frac{1 \cdot 4000}{38.71} \sqrt{\left(\frac{235}{\pi^{2} \cdot 200000}\right)} = 1.127$$

The appropriate constant *n* is given in [1], clause 13.3.1.

n = 1.34 for hot-rolled I-section

Factored member resistance in compression

$$C_{r,z} = \phi A \cdot f_y \left(1 + \lambda_z^{2n} \right)^{-1/n} = 0.9 \cdot 4711 \cdot 235 \left(1 + 1.127^{2\cdot 1.34} \right)^{-1/1.34} = 522.04 \text{ kN}$$

Design ratio

$$\frac{C_{u}}{C_{r,z}} = \frac{300}{522.04} = \underbrace{0.575 \le 1}_{t}$$



		1		r	
Compression Axial Force	Cu	300.00	kN		
Factored Compression Resistance of Section	C _{r,s}	996.38	kN		13.3
Yield Strength	f_y	235	MPa		5.1
Modulus of Elasticity	E	200000	MPa		
Gross Area	Ag	4711	mm²		
Second Moment of Area	lz	7060000	mm⁴		
Radius of Gyration	r _z	38.712	mm		
Effective Length	L _{e,z}	4000	mm		
Geometrical Slenderness Ratio	$\lambda_{\text{g,z}}$	103.327			
Elastic Flexural Buckling Load	C _{e,z}	870.99	kN		13.3.1
Elastic Flexural Buckling Stress	f _{e,z}	184.885	MPa		13.3.1
Slenderness Ratio	λz	1.127			13.3.1
Cross-Section Fabrication Factor	n	1.340			13.3.1
Resistance Factor	Φ	0.900			13.1
Factored Member Resistance	C _{r,m,z}	521.82	kN		13.3.1
Design Ratio	η	0.575		≤ 1	13.3.1

Result values from STEEL SANS calculation

Flexural buckling about the major axis (\perp to y-y axis)

Elastic flexural buckling stress

$$f_{e,y} = \frac{\pi^2 \cdot E}{(K_y \cdot L/r_y)^2} = \frac{\pi^2 \cdot 200000}{(1 \cdot 4000 / 68.49)^2} = 578.714 \text{ MPa}$$

Elastic flexural buckling load

$$C_{e,y} = A_g \frac{\pi^2 \cdot E}{\left(K_y \cdot L/r_y\right)^2} = 4711 \frac{\pi^2 \cdot 200000}{\left(1 \cdot 4000 / 68.49\right)^2} = 2726.32 \text{ kN}$$

Cross-section type acc. to Table 3 is "compact": $A_e = A_g$

Slenderness ratio

$$\lambda_{y} = \frac{K_{y} \cdot L}{r_{y}} \sqrt{\left(\frac{f_{y}}{\pi^{2} \cdot E}\right)} = \frac{1 \cdot 4000}{68.49} \sqrt{\left(\frac{235}{\pi^{2} \cdot 200000}\right)} = 0.637$$

The appropriate constant *n* is given in [1], clause 13.3.1.

n = 1.34 for hot-rolled I-section

Factored member resistance in compression

$$C_{r,y} = \phi A \cdot f_y \left(1 + \lambda_y^{2n} \right)^{-1/n} = 0.9 \cdot 4711 \cdot 235 \left(1 + 0.637^{2 \cdot 1.34} \right)^{-1/1.34} = 819.86 \text{kN}$$

Design ratio

$$\frac{C_{u}}{C_{r,y}} = \frac{300}{819.86} = \underbrace{0.366 \le 1}_{t}$$



	-				
Compression Axial Force	Cu	300.00	kN		
Factored Compression Resistance of Section	C _{r,s}	996.38	kN		13.3
Yield Strength	f_y	235	MPa		5.1
Modulus of Elasticity	E	200000	MPa		
Gross Area	Ag	4711	mm²		
Second Moment of Area	ly	22100000	mm⁴		
Radius of Gyration	r _y	68.492	mm		
Effective Length	L _{e,y}	4000	mm		
Geometrical Slenderness Ratio	$\lambda_{g,y}$	58.401			
Elastic Flexural Buckling Load	C _{e,y}	2726.48	kN		13.3.1
Elastic Flexural Buckling Stress	f _{e,y}	578.747	MPa		13.3.1
Slenderness Ratio	λ _y	0.637			13.3.1
Cross-Section Fabrication Factor	N	1.340			13.3.1
Resistance Factor	Φ	0.900			13.1
Factored Member Resistance	C _{r,m,y}	819.73	kN		13.3.1
Design Ratio	η	0.366		≤ 1	13.3.1

Result values from STEEL SANS calculation

Lateral-torsional buckling

Critical elastic moment acc. to [1], clause 13.6

The critical elastic moment of the unbraced member is given by the formula in clause 13.6 a) ii). The cross-section shape is doubly symmetric – class 1. The member is considered as a simply supported beam.

$$M_{cr} = \frac{\omega_2 \cdot \pi}{KL} \sqrt{E \cdot I_z \cdot G \cdot J + \left(\frac{\pi \cdot E}{KL}\right)^2 \cdot I_z \cdot C_w}$$

$$M_{cr} = \frac{1.00 \cdot \pi}{1.4000} \sqrt{2.0e5 \cdot 7.06e6 \cdot 77000 \cdot 197000} + \left(\frac{\pi \cdot 2.0e5}{1.4000}\right)^2 \cdot 7.06e6 \cdot 3.99e10 = 132.285 \text{ kNm}$$

where κ = 0.00 and ω_2 = 1.00.

Factored moment resistance acc. to [1], clause 13.5

Nominal moment plastic resistances acc. to [1], clause 13.5 a)

UC 152x152x37, cross-section class acc. to Table 4 is "1":

 $M_{p,y} = Z_{pl,y} \cdot f_y = 309000 \cdot 235 = 72.62 \text{ kNm}$

 $M_{p,z} = Z_{pl,z} \cdot f_y = 140000 \cdot 235 = 32.9 \text{ kNm}$

. Dlubal

Factored moment resistance of member

lf

$$M_{cr} > 0.67 \cdot M_{py} \qquad \qquad M_{ry} = 1.15 \phi M_{py} \left(1 - \frac{0.28M_{py}}{M_{cr}} \right) \le \phi M_{py}$$

 $132.285 > 0.67 \cdot 72.62 = 48.65 \qquad M_{ry} = min \left\{ 1.15 \cdot 0.9 \cdot 72.62 \left(1 - \frac{0.28 \cdot 72.62}{132.285} \right), 0.9 \cdot 72.62 \right\}$

 $M_{rv} = 63.61 \text{kNm}$

Interaction of biaxial bending and compression

The determination of the design ratio is given in [1], clause 13.8.2. To calculate the final design ratio, we need to determinate the values of the interaction factors U_{1y} , U_{1z} and β . These values are calculated according to [1], clause 13.8.4 and 13.8.5. We consider the member as "braced frame".

 $\beta = \min\{0.6 + 0.4 \cdot \lambda_7; 0.85\} = \min\{0.6 + 0.4 \cdot 1.127; 0.85\} = 0.85$

The member is subjected to a distributed load in z-axis ($\omega_{1y} = 1.00$) and a concentrated load in y-axis ($\omega_{1z} = 0.85$), see [1] clause 13.8.5 b) and c).

$$U_{1y} = \frac{\omega_{1y}}{1 - C_u / C_{e,y}} = \frac{1.00}{1 - 300 / 2726.32} = 1.124$$
$$U_{1z} = \frac{\omega_{1z}}{1 - C_u / C_{e,z}} = \frac{0.85}{1 - 300 / 870.90} = 1.297$$

Interaction design ratio acc. to 13.8.2 (a) - cross-sectional strength

$$C_{r,s} = \phi \cdot A_g \cdot f_y = 0.9 \cdot 4711 \cdot 235 = 996.38 \text{ kN}$$

$$\frac{C_{u}}{C_{r,s}} \! + \! \frac{0.85 \! \cdot \! U_{1y} \cdot \! M_{uy}}{M_{ry}} \! + \! \frac{\beta \! \cdot \! U_{1z} \cdot \! M_{uz}}{M_{rz}} \! \le \! 1$$

Interaction design ratio acc. to 13.8.2 (b) - overall member strength

$$\frac{\mathsf{C}_{\mathsf{u}}}{\mathsf{C}_{\mathsf{r}}} + \frac{0.85 \cdot \mathsf{U}_{1\mathsf{y}} \cdot \mathsf{M}_{\mathsf{u}\mathsf{y}}}{\mathsf{M}_{\mathsf{r}\mathsf{y}}} + \frac{\beta \cdot \mathsf{U}_{1\mathsf{z}} \cdot \mathsf{M}_{\mathsf{u}\mathsf{z}}}{\mathsf{M}_{\mathsf{r}\mathsf{z}}} \le 1$$

 $\frac{300.00}{522.04} + \frac{0.85 \cdot 1.124 \cdot 10.00}{0.9 \cdot 72.62} + \frac{0.85 \cdot 1.297 \cdot 7.50}{0.9 \cdot 32.9} = 0.575 + 0.146 + 0.279 = \underbrace{1.000 \le 1}_{1.000 \le 1}$

Interaction design ratio acc. to 13.8.2 (c) - lateral-torsional buckling strength

$$\frac{C_u}{C_r} + \frac{0.85 \cdot U_{1y} \cdot M_{uy}}{M_{ry}} + \frac{\beta \cdot U_{1z} \cdot M_{uz}}{M_{rz}} \le 1$$

 $\frac{300.00}{522.04} + \frac{0.85 \cdot 1.124 \cdot 10.00}{63.61} + \frac{0.85 \cdot 1.297 \cdot 7.50}{0.9 \cdot 32.9} = 0.575 + 0.150 + 0.279 = \underbrace{1.004 \ge 1}_{1.004 \ge 1}$



Result values from STEEL SANS calculation

Compression Axial Force	Cu	300.00	kN		
Bending Moment	M _{u,y}	10.00	kNm		
Maximum Bending Moment	M _{u,y,segm}	10.00	kNm		
Bending Moment	M _{u,z}	7.50	kNm		
Maximum Bending Moment	$M_{u,z,segm}$	7.50	kNm		
Yield Strength	fy	235	MPa		5.1
Plastic Moment Resistance of Section	M _{p,y}	72.62	kNm		
Factored Moment Resistance of Section	M _{r,s,y}	65.35	kNm		13.5
Plastic Moment Resistance of Section	$M_{p,z}$	32.90	kNm		
Factored Moment Resistance of Section	M _{r,s,z}	29.61	kNm		13.5
Modulus of Elasticity	E	200000	MPa		
Shear Modulus	G	77000	MPa		
Second Moment of Area	l _z	7060000	mm ⁴		
Torsional Constant	J	197000	mm ⁴		
Warping Constant	C _w	3.99E+10	mm⁵		
Segment Length	L	4000	mm		
Effective Length Factor	K	1.000			Tab. 1 or 2
Effective Length	Le	4000	mm		10.2
Coefficient	ω ₂	1.000			13.6
Critical Elastic Moment	Mcr	132.29	kNm		
Factored Moment Resistance of Member	M _{r,m,y}	63.61	kNm		13.6
Elastic Flexural Buckling Load	C _{e,y}	2726.48	kN		13.3.1
Coefficient	ω _{1,y}	1.000			13.8.5
Factor of Second Order Effect	U _{1,y}	1.124			13.8.4
Design Component for M _y	η_{My}	0.150		≤ 1	13.8.2
Factor	β	0.850			13.8.2
Elastic Flexural Buckling Load	C _{e,z}	870.99	kN		13.3.1
Coefficient	ω _{1,z}	0.850			13.8.5
Factor of Second Order Effect	U _{1,z}	1.297			13.8.4
Design Component for Mz	η_{Mz}	0.279		≤ 1	
Gross Area	A_{g}	4711	mm ²		
Factored Compression Resistance of Section	C _{r,s}	996.38	kN		13.3
Factored Member Resistance	C _{r,m,y}	819.73	kN		13.3.1
Factored Member Resistance	C _{r,m,z}	521.82	kN		13.3.1
Factored Member Resistance	C _{r,m,T}	850.35	kN		13.3.2
Factored Member Resistance	C _{r,m}	521.82	kN		13.3
Design Component for N	η_{N}	0.575		≤ 1	13.8.2
Resistance Factor	Φ	0.900			13.1
Design Ratio	η_1	0.644		≤ 1	13.8.2
Design Ratio	η_2	1.000		≤ 1	13.8.2
Design Ratio	η₃	1.004		≥ 1	13.8.2
Design Ratio	η	1.004		≥ 1	

A Literature

- [1] SABS Standards Division: South African National Standard SANS 10162-1:2011 The structural use of steel, Part 1: Limit-states design of hot-rolled steelwork, Pretoria 2011
- [2] Southern African Institute of steel construction: Southern African Steel Construction Handbook, 8th edition, 2013
- [3] PARROTT, G.: Structural steel design according to SANS 10162:1-2005, 2nd edition, Durban 2005



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