

Version March 2010

Add-on Module



Allowable Stress Design (ASD), Load and Resistance Factor Design (LRFD), Serviceability Limit State Design according to ANSI/AISC 360-05

# **Program Description**

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# Introduction

# 1.1 Additional Module STEEL AISC

The U.S. *Specification for Structural Steel Buildings* (ANSI/AISC 360-05) determines rules for the design, analysis and construction of steel buildings in the United States of America. With the add-on module STEEL AISC from the company DLUBAL ENGINEERING SOFTWARE 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 AISC. Different actions are taken into account during the load capacity design. The allocation of designed cross-sections into three types (compact, noncompact and slender) makes an important part of the design according to the Specification mentioned above. The purpose of this classification is to determine the range in which the local buckling in cross-section parts limits the load capacity so that the rotational capacity of cross-sections can be verified. Further, STEEL AISC automatically calculates the limiting width-to-thickness ratios of compressed parts and carries out the classification automatically.

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. All comparative slendernesses and critical stresses are automatically determined by STEEL AISC on the basis of the boundary conditions. For the design of lateral torsional buckling, the elastic critical moment that is necessary for the design can be either calculated automatically or entered manually. The location where the loads are applied, which influences the elastic critical moment, can also be defined in the detailed settings.

The serviceability limit state has become important for the static calculations of modern civil engineering as more and more slender cross-sections are being used. In STEEL AISC, load cases and groups and combinations of load cases can be arranged individually to cover the various design situations.

Like other modules, STEEL AISC is fully integrated into the RSTAB 7 program. However, it is not only an optical part of the program. The results of the module can be incorporated to the central printout report. Therefore, the entire design can be easily and especially uniformly organized and presented.

The program includes an automatic cross-section optimization and a possibility to export all modified profiles to RSTAB.

Individual design cases make it possible to flexibly analyze separate parts of extensive structures.

We wish you much success and delight when working with our module STEEL AISC.

Your DLUBAL ENGINEERING SOFTWARE company.



# 1.2 STEEL AISC Team

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

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## 1.3 Using the Manual

All general topics such as installation, user interface, results evaluation and printout report are described in detail in the manual for the main program RSTAB. Hence, we omit them in this manual and will focus on typical features of the add-on module STEEL AISC.

During the description of STEEL AISC, we use the sequence and structure of the different input and output tables. We feature the described **icons** (buttons) in square brackets, e.g. [Details]. The buttons are simultaneously displayed on the left margin. The **names** of dialog boxes, tables and particular menus are marked in *italics* in the text so that they can be easily found in the program.

The index at the end of this manual enables you to quickly look up specific terms.



# 1.4 Starting STEEL AISC

It is possible to initialize the add-on module STEEL AISC in several ways.

### Main Menu

You can call up STEEL AISC by the command from the main menu of the RSTAB program: Add-on Modules  $\rightarrow$  Design - Steel  $\rightarrow$  STEEL AISC.

Additional Modules Window	Help		
Current Module	X.XX	🔎 챋 🕅 🕅	🗟 🛤 🗄 🎬 🚑 🥵 🕸 🎜 🖄 💠 🥼
Shape Properties	► I I I	7 🖘   🎿 🗖	
Design - St <u>e</u> el	٦	<u>S</u> TEEL	General Stress Analysis
Design - Conc <u>r</u> ete	► I	STEEL EC3	Design according to Eurocode 3
Design - <u>T</u> imber	+ Aise	STEEL AISC	Design according to AISC (LRFD or ASD)
Design - Co <u>m</u> posite	۲ Is	STEEL IS	ん Design according to IS 800
<u>D</u> ynamic	+ Ist	STEEL SIA	Design according to SIA
Connections	۲ 🛉	<u>K</u> APPA	Buckling Check for Compression Members
<u>F</u> oundations	€ ا	LTB	Lateral Torsional Buckling Check
Stability	• ₽	EE-LTB	Lateral Torsional Buckling Analysis with Finite Elements
<u>O</u> thers	• 4	<u>E</u> L-PL	Elastic-plastic Design
		<u>с</u> -то-т	Limiting Width-Thickness Ratios Check
	2	PLATE-BUCKLING	FEM Plate Buckling Analysis

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

### Navigator

Further, it is possible to start STEEL AISC from the *Data* navigator by clicking on the item Add-on Modules  $\rightarrow$  STEEL AISC.

Project Navig	ator	×
🚊 - 🚞 A(	dditional Modules	~
1	SHAPE-THIN 7 - Section Properties of Thin-walled Sections	_
	SHAPE-MASSIVE - Section Properties of Thick-walled Sections	
1	STEEL - General Stress Analysis for Steel Members	
- I	STEEL EC3 - Steel Design according to Eurocode 3	
	KAPPA - Buckling Analysis for Compression Members	
	LTB - Lateral Torsional Buckling Analysis	
	FE-LTB - Lateral Torsional Buckling Check with Finite Members	
	EL-PL - Elastic-plastic Design	
	C-TO-T - Limiting Width-Thickness Ratio Check (c/t)	
	PLATE-BUCKLING - FEM Plate Buckling Analysis	
	VERBAND - Wind Bracings with Stabilisation Loads	
	ASD - Steel Design according to US-Norm AISC ASD	
A	CRANEWAY - Crane Girder Analysis	
	CONCRETE - Concrete Design of Members	
- 2	RSBUCK - Analysis of Stability	
····· 17	DEFORM - Deformation Analysis	
	RSMOVE Members - Generation of Moving Loads	
🏴	RSIMP - Generation of Imperfections or Pre-deformed Initial Str	UI
	RSCOMBI 2006 - Generating Load Groups or Load Combinations	5
	RSCOMBI - Generation of Load Groups and Load Combinations	
	STEEL AISC - Steel Design according to AISC (LRFD or ASD)	
	STEEL IS - Steel Design according to IS 800 が	~
<		>
4 Data 🔳	Display 4	Þ

Figure 1.2: Data Navigator: Additional Modules → STEEL AISC



### Panel

LC1 - Vz 🔽	$\triangleleft$
LC1 - Vz L C2 - Vii	
STEEL AISC CA1 - Steel Design	N
	λĉ



If results of STEEL AISC are already available in the RSTAB position, you can set the relevant design case of this module in the list of load cases in the menu bar. The design criterion on members is displayed graphically in the work window of RSTAB by using the [Results on/off] button.

The [STEEL AISC] button that enables you to start STEEL AISC is now available in the panel.

Panel	×	
Max Design Ratio [-]		
1.00 0.90 0.80 0.70 0.50 0.50 0.40 0.30 0.20 0.10 0.00		
Max : 0.50 Min : 0.00		
STEEL AISC		
	٩	
📑 🕾 🛛 🔟		
ure 1.3: [STEEL A	ISC]	Butto

STEEL AISC

Program STEEL AISC © 2010 by Dlubal Engineering Software



# 2. Input Data

The data of the design cases is entered in different tables of this module. Furthermore, the graphic input using the function [Pick] is available for members and sets of members.

After the initialization of the STEEL AISC module, a new window is displayed. In its left part, a navigator is shown that enables you to access all existing tables. The roll-out list of all possibly entered design cases is located above this navigator (see chapter 7.1, page 46).

If STEEL AISC is called up for the first time in a position of RSTAB, the following important data is loaded automatically:

- Members and sets of members
- Load cases, load groups and combinations
- Materials
- Cross-sections
- Internal forces (in the background if calculated)

You can switch among the tables either by clicking on the individual navigator items of STEEL AISC or by using the buttons visible on the left. The [F2] and [F3] function keys can also be used to browse the tables in both directions.

ОК	
Cancel	

Save entered data by the [OK] button and close the module STEEL AISC, while by the [Cancel] button you terminate the module without saving data.

# 2.1 General Data

In the table 1.1 *General Data*, members, sets of members and actions are selected for the design. You can specify load cases, load groups and combinations for the ultimate limit state and the serviceability limit state design separately in the corresponding tabs.

### 2.1.1 Ultimate Limit State

A1 - Steel Design according to 🗙	.1 General Data
nput Data General Data Materials Cross-sections Lateral Intermediate Supports Effective Lengths - Members Effective Lengths - Sets of Men Design Parameters Nodal Supports Set of Members No. 1 - Cor Member Releases Set of Members No. 1 - Cor	Design of       Design according to         Members:       1-811-18.21-28.31-46.551-64.66-69.71       Image: Algorithm of the set of th
	Comment

Figure 2.1: Table 1.1 General Data, Ultimate Limit State tab



### Design of

A

-

You can select both *Members* and *Sets of Members* for the design. If only specific objects are to be designed, it is necessary to clear the check box *All*. By doing so, both input boxes become accessible and you can enter the numbers of the relevant members or sets of members there. With the [Pick] button, you can also select members or sets of members graphically in the RSTAB work window. To rewrite the list of default member numbers, select it by double-clicking it, and then enter the relevant numbers.

If no sets of members have been defined in RSTAB yet, they can be created in STEEL AISC via the [New Set of Members...] button. The familiar RSTAB dialog box to create a new set of members opens in which you enter the relevant data.

Designing sets of members has the advantage that selected members can be analyzed to determine the total maxima of the design ratios. In this case, the results tables 2.3 *Design by Set of Members* and 4.2 *Parts List by Set of Members* are displayed additionally.

### Design according to

The list box controls whether the analysis is carried out according to the provisions of the Allowable Strength Design (ASD) or the Load and Resistance Factor Design (LRFD).

### **Existing Load Cases / Load Groups and Load Combinations**

All design-relevant load cases, load groups and load combinations that were created in RSTAB are listed in these two sections. The [▶] button moves the selected load cases, load groups or combinations to the list *Selected for Design* on the right. Specific items can also be selected by double-clicks. The [▶▶] button transfers all items to the list on the right.

If an asterisk (\*) is displayed at load cases or combinations, as you can see e.g. in Figure 2.1 at load cases 8 to 10, they are excluded from the design. It signifies that no loads were assigned to these load cases or that they contain only imperfections (as in our example).

Furthermore, it is only possible to select load combinations for which the minimum and maximum values can be determined unambiguously. This restriction is necessary because the calculation of the elastic critical moment at lateral buckling requires the unambiguous assignment of moment diagrams. If an invalid load combination is selected, the following warning appears:



Figure 2.2: Warning when Selecting Invalid LC, LG or CO

A multiple choice of load cases can be done by using the [Ctrl] key, as a routine procedure in Windows. Hence, you can select and transfer several load cases to the list on the right simultaneously.

### Selected for Design

The loads selected for the design are listed in the right column. By the [ $\blacktriangleleft$ ] button you can remove the selected load cases, load groups or load combinations from the list. As before, the selection can be executed by double-clicks. The [ $\blacktriangleleft \triangleleft$ ] button removes all items from the list.

Design according to	
LRFD	×
ASD	
LRFD	



5

Generally, the calculation of an enveloping *Or* load combination is faster than the analysis of all contained load cases or groups. On the other hand, you must keep in mind the abovementioned restriction: to determine the maximum or minimum values unambiguously, the *Or* load combination must only contain load cases, groups or combinations which enter the combination with the criterion *Constant*. Moreover, the design of an enveloping load combination makes it a bit difficult to retrace the influence of the contained actions.

### 2.1.2 Serviceability Limit State

🗤 - Steel Design according to 🔽	1.1 General Data	
put Data General Data Materials Cross-sections Lateral Intermediate Supports Effective Lengths - Members Effective Lengths - Sets of Men Design Parameters Nodal Supports Member Releases Set of Members No. 2 - Slei Set of Members No. 2 - Slei Set of Members No. 2 - Slei Set of Members No. 2 - Slei	Design of         Design according to           Members:         19.11-18.21-28.31-46.51-64.66.69.71         Image: Aspace of the state	Steel Design of Members act. to Design (RFD) Steel Design (RSD) Members act to Design (RFD)
	Comment	

Figure 2.3: Table 1.1 General Data, Serviceability Limit State tab

### **Existing Load Cases / Load Groups and Load Combinations**

All load cases, load groups and load combinations that were created in RSTAB are listed in these two sections.

#### Selected for Design

Adding load cases and their groups and combinations to the list for the design, resp. removing them from the list is done in the same way like in the previous register tab (see Chapter 2.1.1).



# 2.2 Materials

This table is divided into two parts. The materials for the design are listed in the upper part. In the lower part, the *Material Properties* of the current material are displayed, i.e. the material whose line is selected in the upper table.

The material properties that are necessary to calculate the internal forces in RSTAB are described in detail in the RSTAB manual, Chapter 5.2. The design-relevant material characteristics are stored in the global material library. Those are automatically set as default.

The units and decimal places of the material properties and stresses can be edited from the main menu **Options**  $\rightarrow$  **Units and Decimal Places...** (see Chapter 7.4, page 51).

nput Data General Data Material Cross-sections Lateral Intermediate Supports Effective Lengths - Members Design Parameters Material Properties <b>BSTAB Relevant</b> Material Properties <b>BSTAB Relevant</b> Material Safety Factor <b>Design Relevant</b> Material Safety Factor <b>Design Relevant</b> Mitinat Tensile Strength	al sion E G A A A A A A A A A A A A A A A A A A	B Commer 199338. 76899. 0. 77 1 2000	000 MPa 200 MPa 300 Juni/20	<i>4</i>		
General Data Materials Cross-sections Lateral Intermediate Supports Design Parameters Material Properties Material Properties Material Properties Material Properties Material Properties Material Properties Partial Safety Factor Design Relevant Yield Strength Utimate Tensile Strength	al sion E G A A A A A A A A A A A A A A A A A A	Commer 199938. 76899. 0. 76	000 MPa 200 MPa 300 Julia	<i>§</i>		
Lores sections     Lateral Intermediate Supports     Effective Lengths - Members     Design Parameters     Material Properties     BRTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Exp.     Partial Safety Factor     Design Relevant     Yield Strength     Utimate Tensile Strength	E G J Snsion a	199938. 76899. 0. 771 1.2000	000 MPa 200 MPa 300	<b></b>		
Lateral Intermediate Supports Effective Lengths - Members Design Parameters Material Properties BRTAB Relevant Modulus of Elasticity Shear Modulus Poisson's Ratio Unit Weight Coefficient of Thermal Exp. Partial Safety Factor Design Relevant Yield Strength	E G A y ansion a	199938. 76899. 0. 76	000 MPa 200 MPa 300 50 LM/a3	<ul> <li>*</li> </ul>		
Effective Lengths - Members Design Parameters  Material Properties  RSTAB Relevant Modulus of Elasticity Shear Modulus Poisson's Ratio Unit Weight Coefficient of Thermal Exp. Partial Safety Factor Design Relevant Yield Strength Ultimate Tensile Strength	E G A ansion a	199938. 76899. 0. 76	000 MPa 200 MPa 300 LN /a3	<b>N</b>		
Design Parameters  Material Properties  BR54B Relevant  Modulus of Elasticity Shear Modulus Poisson's Ratio Unit Weight Coefficient of Thermal Exp. Partial Safety Factor Design Relevant Yield Strength Ultimate Tensile Strength	E G μ γ ansion α	199938. 76899. 0. 76	000 MPa 200 MPa 300 LN/a3			
Material Properties B RSTAB Relevant Modulus of Elasticity Shear Modulus Poisson S Ratio Unit Weight Coefficient of Thermal Exp. Partial Safety Factor Design Relevant Yield Strength Ultimate Tensile Strength	E G μ γ ansion α	199938. 76899. 0. 76 1.2000	000 MPa 200 MPa 300			
Material Properties  BRTAB Relevant Modulus of Elasticity Shear Modulus Poisson's Ratio Unit Weight Coefficient of Thermal Exp. Partial Safety Factor BDesign Relevant Yield Strength Ultimate Tensile Strength	E G H ansion a	199938. 76899. 0. 78	000 MPa 200 MPa 300			
■ RSTAB Relevant Modulus of Elasticity Shear Modulus Poisson's Ratio Unit Weight Coefficient of Thermal Exp. Partial Safety Factor ■ Design Relevant Yield Strength Utimate Tensile Strength	E G μ γ ansion α	199938. 76899. 0. 78	000 MPa 200 MPa 300	^		
Modulus of Elasticity Shear Modulus Poisson's Ratio Unit Weight Coefficient of Thermal Exp. Partial Safety Factor Design Relevant Yield Strength Ultimate Tensile Strength	E G μ γ ansion α	199938. 76899. 0. 78 1.2000	000 MPa 200 MPa 300			
Shear Modulus Poisson's Ratio Unit Weight Coefficient of Thermal Exp. Partial Safety Factor <b>⊟ Design Relevant</b> Yield Strength Utimate Tensile Strength	G μ γ ansion α	76899. 0. 78 1 2000	200 MPa 300	_		
<ul> <li>Poisson's Ratio</li> <li>Unit Weight</li> <li>Coefficient of Thermal Exp.</li> <li>Partial Safety Factor</li> <li>E Design Relevant</li> <li>Yield Strength</li> <li>Ultimate Tensile Strength</li> </ul>	μ γ ansion α	0.	300			
Unit Weight Coefficient of Thermal Exp. Partial Safety Factor Design Relevant Yield Strength Ultimate Tensile Strength	γ ansion α	78 1.2000E	a do Liki Jav3 -			
Coefficient of Thermal Exp. Partial Safety Factor Design Relevant Yield Strength Ultimate Tensile Strength	ansion α	1.2000F	3.50 KN/M2			
Partial Safety Factor <b>□ Design Relevant</b> Yield Strength Ultimate Tensile Strength	22.4	1.20002	:-05 1/°C			
Design Relevant     Yield Strength     Ultimate Tensile Strength	7101	1	1.00			
Yield Strength Ultimate Tensile Strength						
<ul> <li>Ultimate Tensile Strength</li> </ul>	fy	248.	199 MPa		Material No	. 1 Used in
	fu	399.	.876 MPa		Cross-	
<ul> <li>Max. Structural Thickness</li> </ul>	(for Range 1) t <sub>1</sub>	20	3.32 cm		sections:	1-3,6,7,10,12,13,15
<ul> <li>Yield Strength (for Range 2</li> </ul>	2) fy,2	2 220.	.621 MPa			
<ul> <li>Modulus of Elasticity Parall</li> </ul>	el Eo	199938.	.000 MPa		Members:	1-8,11-18,21-28,31-46,51-
Modulus of Elasticity Perpe	endicular Egg	u 199938.	.000 MPa		Sets of	
Shear Modulus Parallel	Go	76899.	200 MPa		Members:	
Shear Modulus Perpendicu	ular Ggg	a 76899.	200 MPa		S Longth:	AFE AF Ind
<ul> <li>Stress Limit for Compression</li> </ul>	n Parallel 🛛 🖉 σ с. 🕻	o 248.	199 MPa		z Lengin.	400.40 [iii]
<ul> <li>Stress Limit for Tension Pa</li> </ul>	rallel ot.0	248.	199 MPa	~	Σ Weight:	16.525 [t]

Figure 2.4: Table 1.2 Materials

### **Material Description**

The materials that have been defined in RSTAB are set by default. You can also enter materials manually here. If the *Material Description* corresponds to an entry in the material library, STEEL AISC automatically imports the relevant material properties.

To select a material from the list, place the cursor in column A and click on the  $[\Psi]$  button or press the [F7] function key. A list is opened that you can see on the left. As soon as you have chosen the appropriate material, the material characteristics are updated in the table below.

The list of materials includes only materials from the category **Steel**. How to import materials from the library is described below.

#### Import Material from Library

A considerable amount of materials is stored in the library. Open the library via menu

 $\mathbf{Edit} \rightarrow \mathbf{Material} \ \mathbf{Library}...$ 

or by clicking on the button visible on the left.





litter Choice	Material to Select			0.05, 2005,02	
Material Category:	Steel 4441 G1 2		ANSI/AISC 3	60-05: 2005-03	
Steel	Steel A441 G3		ANSI/AISC 3	60-05: 2005-03	
	Steel A441 G4,5		ANSI/AISC 3	60-05: 2005-03	
Code Group:	Steel A441		ANSI/AISC 3	60-05: 2005-03	
ASTM	Steel A572 Grade 42		ANSI/AISC 3	60-05: 2005-03	
	Steel A572 Grade 50		ANSI/AISC 3	60-05: 2005-03 co.os. 2005.02	
Code:	Steel A572 Grade 55 Steel A572 Grade 60	ANSI/AISC 360-05: 2005 ANSI/AISC 360-05: 2005			
۵II 🗸	Steel A572 Grade 65		60-05: 2005-03		
	Steel A242 G1,2		ANSI/AISC 3	60-05: 2005-03	
	Steel A242 G3		ANSI/AISC 3	60-05: 2005-03	
Chaun	Steel A242 G4,5		ANSI/AISC 3	60-05: 2005-03	
Show:	Steel A588		ANSI/AISC 3	60-05: 2005-03	
Materials of 'Uld' Codes	Steel A852		ANSI/AISC 3	60-05: 2005-03	
📃 Favorites Only 🛛 🛛 🕌	1 🖻 🖻 🛃			×	
Natorial Constants			areer wae 1 willaw	NGC 300-03, 2003-	
RSTAB Relevant			100000.000	ND-	
RSTAB Relevant     Modulus of Elasticity		E	199938.000	MPa	
RSTAB Relevant     Modulus of Elasticity     Shear Modulus		E G	199938.000 76899.200	MPa MPa	
RSTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unable Kale		E G H	199938.000 76899.200 0.300	MPa MPa	
RSTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Themael Former		Ε G μ γ	199938.000 76899.200 0.300 78.50	MPa MPa kN/m <sup>3</sup>	
RSTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Expan:     Datie Seature	sion	Ε G μ γ α	199938.000 76899.200 0.300 78.50 1.2000E-05	MPa MPa kN/m <sup>3</sup> 1/°C	
RFTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Expan-     Partial Safety Factor     Partial Relevant	sion	Ε G μ γ α γΜ	199938.000 76899.200 0.300 78.50 1.2000E-05 1.00	MPa MPa kN/m <sup>3</sup> 1/°C	
■ RSTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Expan:     Partial Safety Factor     Design Relevant     Vield Creanth	sion	E G μ γ α γΜ	199938.000 76899.200 0.300 78.50 1.2000E-05 1.00	MPa MPa kN/m <sup>3</sup> 1/°C	
RFTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Expan-     Partial Safety Factor     Design Relevant     Yield Strength     Ultingta Tancile Strength	sion	E G μ γ α γ Μ	199938.000 76899.200 0.300 78.50 1.2000E-05 1.00 248.199 299.975	MPa MPa kN/m <sup>3</sup> 1/°C	
RSTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Expan     Partial Safety Factor     Design Relevant     Yield Strength     Ultimate Tensile Strength     May Structural Thickness (fin	sion	E G μ γ α γM	19938.000 76899.200 0.300 78.50 1.2000E-05 1.00 248.199 399.876 20.22	MPa MPa kN/m <sup>3</sup> 1/°C MPa MPa cm	
RSTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Expan     Partial Safety Factor     Design Relevant     Yield Strength     Ultimate Tensile Strength     Max. Structural Thickness (for Yield Strength     Strength     Yield Strength     Strength     Yield Strength	sion r Range 1)	E G μ γ α γ M fy fu t1	199938.000 76899.200 0.300 78.50 1.2000E-05 1.00 248.199 399.876 20.32 220.621	MPa MPa kN/m <sup>3</sup> 1/°C MPa MPa cm MPa	
<ul> <li>□ RSTAB Relevant</li> <li>Modulus of Elasticity</li> <li>Shear Modulus</li> <li>Poisson's Ratio</li> <li>Unit Weight</li> <li>Coefficient of Thermal Expansion</li> <li>Partial Safety Factor</li> <li>□ Design Relevant</li> <li>Yield Strength</li> <li>Ultimate Tensile Strength</li> <li>Max. Structural Thickness (for Yield Strength (for Range 2)</li> </ul>	sion r Range 1)	E G μ γ α γM fy fu t1 fy,2	19938.000 76899.200 0.300 78.50 1.2000E-05 1.00 248.199 399.876 20.32 220.621	MPa MPa kN/m <sup>3</sup> 1/°C MPa MPa cm MPa	
■ RSTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Expan:     Partial Safety Factor     Design Relevant     Yield Strength     Ultimate Tensile Strength     Max. Structural Thickness (for     Yield Strength (for Range 2)	sion r Range 1)	E G γ α γ fu fu t1 fy,2	199938.000 76899.200 0.300 78.50 1.2000E-05 1.00 248.199 399.876 20.32 220.621	MPa MPa kN/m <sup>3</sup> 1/ <sup>2</sup> C MPa mPa cm MPa	
RSTAB Relevant     Modulus of Elasticity     Shear Modulus     Poisson's Ratio     Unit Weight     Coefficient of Thermal Expan-     Partial Safety Factor     Design Relevant     Yield Strength     Ultimate Tensile Strength     Max. Structural Thickness (for     Yield Strength (for Range 2)	sion r Range 1)	E G γ α γ fu fu t1 fy,2	199938.000 76899.200 0.300 78.50 1.2000E-05 1.00 248.199 399.876 20.32 220.621	MPa MPa kN/m <sup>3</sup> 1/°C MPa MPa cm MPa	

Figure 2.5: Material Library Dialog Box

In the section *Filter Choice*, the material category **Steel** is set by default. In the list *Material* to *Select* which is located on the right, you can select a particular material, and in the lower part of the dialog box you can check its characteristic values. After clicking on [OK] or pressing the [ $\downarrow$ ] key, the material is taken over to the table 1.2 *Materials* of STEEL AISC.

Chapter 5.2 of the RSTAB manual explains in detail how materials can be filtered, added to the library or newly classified.

Basically, you can also select materials of the categories *Cast Iron* and *Stainless Steel* of the library. However, you have to bear in mind that those materials are not thoroughly covered by the ANSI/AISC 360-05 standard. For this reason, it is not possible to significantly modify the material properties in STEEL AISC.





#### 2.3 **Cross-Sections**

This table controls the cross-sections that are to be designed. The parameters of the optimization can be defined here as well.

#### **Coordinate System**

The sectional coordinate system yz of STEEL AISC corresponds to the one of RSTAB (see image in Figure 2.6). The y-axis is the major principal axis of the cross-section, the z-axis the minor axis. This coordinate system is used for both the input data and the results.

STEEL AISC - [Demo-5eng]									X
File Edit Settings Help									
CA1 - Steel Design according tc 🗸	1.3 Cro	oss-secti	ons						
Input Data	Section	A Material	B Cross-section	C Cross-section Type	D Max. Design	E Opti-	F	1 - W 18x	50 (AISC)
- Materials	No.	No.	Description [mm]	for Classification	Ratio	mize	Remark		
Cross-sections	1	1	W 18x60 (AISC)	I-shape rolled	1.07	×	2)		+ 191.9
- Lateral Intermediate Supports	2	1	W 16x45 (AISC)	I-shape rolled	0.48	<u>ط</u> ر		l +-	
- Effective Lengths - Members	3	1	W 16x40 (AISC)	I-shape rolled	0.48				
- Effective Lengths - Sets of Men	6	1	HP 10x10.1x42 (Al	I-shape rolled	0.11			8	
- Design Parameters	7	1	HP 8x8.2x36 (AISC	I-shape rolled	0.06				:
- Nodal Supports	9	2	W 18x40 (AISC)	I-shape rolled	0.66			8.8	
Set of Members No. 2 - Slev	10	1	HP 8x8.2x36 (AISC	I-shape rolled	0.07			- <del>8</del>	8 y
Member Releases	12	1	SHS 3x0.125 (AISC	Box Rolled	0.13				10.5
Set of Members No. 2 - Slev	13	1	Circle 24	Round Bar	0.04				
- Serviceability Data	15	1	HP 10x10.1x42 (AI	I-shape rolled	0.06				
Results	16	1	W 14x38 (AISC)	I-shape rolled	0.22				
- Design by Load Case	17	1	L 6x4x0.625 (AISC)	Angle			8)	_	z
- Design by Cross-section									
- Design by Set of Members									
- Design by Member									[mm]
<ul> <li>Design by x-Location</li> <li>Governing Internal Forces by M</li> </ul>								0	🎽 🛟 🕰
- Governing Internal Forces by M								Cross and	ion No. 1 Llood in
Member Slendernesses								C1055-560	
- Parts List by Member								Members:	1,2,11,12,21,22,31,32,39,40
- Parts List by Set of Members								Sets of Members:	2
								Σ Length:	48.00 [m]
	<						>	Σ Weight	4.278 [t]
<			2) The cross-si optimal section	ection will be optimized of the table is sought	l. Therefore th out.	e most	۱	Material:	1 - Steel S 355
	Calcula	ation	Details		Gra	aphic			OK Cancel
Cross-section No. 1 - W 18x60 (AISC)	in Membe	ers: 1,2,11	.12,21,22,31,32,39,40						

Figure 2.6: Table 1.3 Cross-Sections

#### **Cross-Section Description**

When you open this table, the sections that were defined in RSTAB are set by default, including the assigned material numbers.

The cross-sections can be changed any time for the design. The description of a modified cross-section is highlighted in blue color.

In order to edit a cross-section, enter the new description in the corresponding line or select the new section from the library. Open the library by clicking on the [Import Cross-Section from Library...] button. Alternatively, place the cursor in the corresponding line and click on the [...] button or press the [F7] key. The library opens which is already familiar from RSTAB, see Figure 2.7.

Chapter 5.3 of the RSTAB manual describes in detail how cross-sections can be selected from the library.

If the cross-sections are different in STEEL AISC and RSTAB, both cross-sections are shown in the graphic window next to the table. The internal forces from RSTAB are then used for the stress design of the cross-section that is set in STEEL AISC.



5



Cross-section Library		X
Rolled Cross-sections	Welded Cross-sections	Solid Cross-sections
ICT	ITT	TAT
LOO	TTL	I I O L
·- ~~ 1	LDC	
Combined Cross-sections	ΙΙΟ	
IIIT	$\nabla$ <b>I I</b>	LI I
	ΠΙΞ	User-defined Cross-sections
ŦII	ī + ·	6 1 2
1 I DI	- 1 l	Cross-section Programs
••	1	EJ
W, M, S, HP, UB, UC, I, IPE, IPEa,	.UC, HL, HE, HD, HP, IPN, PEo, IPEv, HE-B, HE-A, HE	IPE, WTM, UB, Cancel

Figure 2.7: Cross-Section Library

HSS cross-sections can only be designed if the thicknesses of web and flanges are the same. If they are different, footnote *1004*) *Non-permissible cross-section type of 'Rectangular HSS'* is shown.

#### **Tapered Member**

0

In case of a tapered member with different cross-sections at the member start and member end, both cross-section numbers are stated in two lines, following the definition in RSTAB. You can design tapered members in STEEL AISC if the following condition is fulfilled: an equal number of stress points is required at both member ends.

For example, the normal stresses are calculated from the moments of inertia and from the centroidal distances of the stress points. If the start and end cross-sections of the tapered member have different numbers of stress points, STEEL AISC cannot interpolate the intermediate values. An error message appears before the calculation:

RSTAB Error No. 1614
Member No. 7
Cross-section tapering mismatch!
Please check this in table 1.7, or possibly some other table.

Figure 2.8: Warning in Case of Incompatible Cross-Sections

To check on the stress points of the cross-section, you can display them including their numbers: Select the cross-section in the table 1.3 and click on the [Info about Cross-Section...] button.



### Info about Cross-Section

There are different display options for stress points and c/t cross-section parts in this dialog box.

Info about cross-section W 10x26	(AISC)				
Cross-section Value Description	Symbol	Value	Unit	^	W 10x26 (AISC)
Depth	d	262.4	mm		
Width	Ь	146.6	mm	_	
Web thickness	tw	6.6	mm		
Flange Thickness	tr	11.2	mm		
Fillet radius	r	10.4	mm		146.6
Depth of straight web	Т	219.2	mm		+ 140.0
Distance	k	21.6	mm		
Distance	k1	17.5	mm		
Cross-section area	A	4909.7	mm <sup>2</sup>		
Shear area	Ay	2736.6	mm <sup>2</sup>		
Shear area	Az	1587.5	mm <sup>2</sup>		
Shear area according to EC 3	Av,y	3388.3	mm <sup>2</sup>		
Shear area according to EC 3	Av,z	1940.4	mm <sup>2</sup>		
Plastic shear area	Apl,y	3275.9	mm <sup>2</sup>		+
Plastic shear area	Apl,z	1659.0	mm <sup>2</sup>		
Moment of inertia	ly	5.994E+07	mm4		v 3
Moment of inertia	lz	5868860.0	mm <sup>4</sup>		
Governing radius of gyration	fy	110.5	mm		66
Governing radius of gyration	ſz	34.5	mm		
Radius of gyration of flange plus 1/5 of we	fzg	38.3	mm		
Volume	V	4909670.0	mm <sup>3</sup> /m		
Weight	wt	38.5	kg/m		
Surface	ASurf	1.122	m²/m		
Section factor	Am/V	228.440	1/m		★
Torsional constant	J	166493.0	mm <sup>4</sup>		Z
Warping constant	Cw	9.264E+10	mm <sup>6</sup>		
Elastic section modulus	Sy	457199.0	mm <sup>3</sup>		
Elastic section modulus	Sz	80132.7	mm <sup>3</sup>		
Warping constant moment	Sw	1.004E+07	mm4		
Statical moment of area	Qy	255638.0	mm <sup>3</sup>		[mm]
Statical moment of area	Qz	99633.4	mm <sup>3</sup>		[1111]
Normalized warping constant	Wno	9225.8	mm <sup>2</sup>		🟋 📷 Stress Points 🛛 🔛 🕅
Warping statical moment	Qw	3766890.0	mm <sup>4</sup>		
Plastic section modulus	Ξy	512915.0	mm <sup>3</sup>		C/t-Parts
Plastic section modulus	∠z	122903.0	mm <sup>3</sup>	×	
(2)					Cancel

Figure 2.9: Info about Cross-Section Dialog Box

The currently selected cross-section is displayed in the right part of the dialog box. The various buttons below have the following functions:

Button	Function
I	The stress points are switched on and off.
	The cross-section parts (c/t) are switched on and off.
123	The numbering of stress points, resp. of cross-section parts (c/t) is switched on and off.
	The details of stress points, resp. of cross-section parts (c/t) are displayed.
X	The dimensioning of the cross-section is switched on and off.
<b>↓</b> →	The principal axes of the cross-section are switched on and off.

Table 2.1: Buttons for Cross-Section Graphics



### **Cross-Section Type for Classification**

In this column, the various cross-section types are listed which are applied for the design (e.g. I-shape rolled or welded, box, round bar etc.)

CA1 - Steel Design according to with the provided in the provid	STEEL AISC - [Demo-5eng] File Edit Settings Help								
Input Data       A       B       C       D       E       F       17 - L 6x4x0.625 (AISC)         Material Dross-sections - Lateal Intermediate Supports - Effective Lengths - Members - Effective Lengths - Sets of Mem Design Parameters - Set of Members No. 2 - Set Member Releases - Set of Members No. 2 - Set Serviceability Data       A       B       C       D       E       F       17 - L 6x4x0.625 (AISC)         Image: Set of Members No. 2 - Set Serviceability Data       1       W 18x60 (AISC)       I-shape rolled       I       Image: Set of Members No. 2 - Set 13       1       W 18x40 (AISC)       I-shape rolled       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 13       1       Image: Set of Members No. 2 - Set 14       1       Set of Members No. 2 - Set 16       1       Image: Set of Members No. 2 - Set 16       1       Image: Set of Members No. 17 Used Members Image: Set of Members No. 17 Used Members Image: Set of Membe	CA1 - Steel Design according to 🗸	1.3 Cro	oss-secti	ons					
(mm) Cross-section No. 17 Used Members: - Sets of Members: - Sets of Metrial: 1 - Steel S 355	Input Data General Data General Data Materials Cross-sections Lateral Intermediate Supports Effective Lengths - Members Effective Lengths - Sets of Men Design Parameters Nodal Supports Set of Members No. 2 - Set Member Releases Set of Members No. 2 - Set Serviceability Data	Section No. 1 2 3 6 7 9 9 9 10 12 13 15 16 17 18	A Material No. 1 1 1 1 2 1 1 1 1 1 1 1 1 1 2 2	B Cross-section Description (mm) W 18x60 (AISC) W 16x45 (AISC) W 16x40 (AISC) HP 10x10.1x42 ( HP 8x8.2x36 (AI W 18x40 (AISC) HP 8x8.2x36 (AI Gircle 24 HP 10x10.1x42 ( U 14x38 (AISC) L 6x4x40.625 (AIS TU 150/10/50/5	Cross-section Type for Classification 1-shape rolled 1-shape rolled 1-shape rolled 1-shape rolled 1-shape rolled 1-shape rolled 1-shape rolled Box Rolled Round Bar 1-shape rolled 1-shape rolled Angle General		Remark Remark	Comment Comment	17 - L 6x4x0.625 (AISC)
17 A Graphia Graphia Graphia	< >	Calcula	ling	8) Cross-section	n not assigned to any m	nember.	Grankia	•	(mm  Cross-section No. 17 Used  Members: - Sets of Members: 2 Length: 0.000 (m) 2 Mass: 0.000 (t) Material 1 - Steel S 355

Figure 2.10: Cross-section Types for Classification

#### Max. Design Ratio

Due to this column, you can decide whether to carry out an optimization. This column is only displayed after STEEL AISC has designed the cross-sections. It becomes visible from the data and the colored relation scales in this column which cross-sections have a low design ratio and therefore are oversized, resp. which are overstrained and therefore are too weak.

#### Optimize

Every cross-section can be optimized. During the optimization process, the cross-section within the same group of cross-sections is determined on the basis of the internal forces from RSTAB which fulfills best the maximum design ratio. Figure 2.6 shows how the optimization of a particular cross-section is set by ticking the corresponding box in column D.

The maximum allowable design ratio for the optimization is controlled in the *Details* dialog box, see chapter 3.1. Further information on the optimization of cross-sections can be found in chapter 7.2 on page 48.

#### Remark

...

In this column, the references to footnotes (below the list of cross-sections) are shown.

If the message *Non-permissible Cross-Section No. XX* appears before the design, then this is due to a cross-section which is not contained in the cross-section library. It may be a user-defined cross-section or a cross-section that was not calculated in the module SHAPE-THIN. Via the [...] button in column B *Cross-section Description*, you can set a cross-section that is suitable for the design (see Figure 2.7 with following remarks).



# 2.4 Lateral Intermediate Supports

In this table, lateral intermediate supports on members can be defined. The program always assumes these supports as perpendicular to the minor axis z (see Figure 2.6) of the cross-section. Hence, it is possible to change the effective lengths of the member that are important for the design of column buckling and lateral torsional buckling. It is also important to know that lateral intermediate supports are considered as forked supports for the design.

		Δ	B			F	F	G	н			К	
General Data	Member	Lateral	Length				Latera	al Intermedi	ate Suppi	orts [-]			
Materiale	No.	Supports	L [m]	Number	81	×2	X3	84	×5	×6	×7	×s	x9
Frage-sections	1	×	6,000	3	0.250	0.500	0.750						
Lateral Intermediate Supports	2		6.000										
Effective Lengths - Members	3	×	3.011	4	0.200	0.400	0.600	0.800					
Effective Lengths - Sets of Men	4		3.262										
Design Parameters	5		6.274	4	0.200	0.330	0.610	0.800					
Nodal Supports	6		6.274										
Set of Members No. 1 - Cor	7		3.262										
Member Releases													
Set of Members No. 1 - Cor					Helative	(U 1)							<u> </u>
Serviceability Data													
,	Settings	s for Mem	ber No. 5							D.	_		
	Cross-	section				2 - IPE 4	450						
	Latera	Supports E:	kisting				×						
	Membe	er Length			L		6.274	m			L ,		
	Numbe	er of Lateral I	ntermediate	Supports	n		4						/
	Positio	n of Lateral !	Support No.	1	×1		0.200				//	P	
	Positio	n of Lateral !	Support No. 3	2	X2		0.330				1	1	
	Positio	n of Lateral !	Support No. 3	3	X3		0.610			7	//	/	, f
	Positio	n of Lateral !	Support No.	4	84		0.800			- 7	1	77	
										/		</td <td></td>	
												/	
										•		•	

Figure 2.11: Table 1.4 Lateral Intermediate Supports

In the upper part of this table, up to nine lateral intermediate supports can be created per member. The lower part of the table displays the summary of the entered data for every single member.

Lateral intermediate supports can be defined either by directly entering the distances or by specifying the support locations *Relatively*. For the latter, it is necessary to tick the associated check box below the list. The relative distances of the supports are then calculated from the member lengths.

You have to be very careful if the model contains cantilever beams. Intermediate supports divide the member into several parts for the design. Therefore, intermediate supports are to be avoided for cantilever beams because they would imply statically underdetermined pieces with fork-type supports on only one side each.

Relatively (0 ... 1)





## 2.5 Effective Lengths - Members

The table 1.5 consists of two parts so that a good overview of the data is provided. In the upper table, the effective length factors  $K_y$  and  $K_z$ , the effective lengths  $K_yL$  and  $K_zL$ , the *Torsional Buckling* effective length factors  $K_x$  and the effective lengths  $K_xL$  for torsional buckling are summarized for every member. In the lower part of this table, detailed information on the member that is selected in the upper table is displayed. The lower table contains all information about the relevant lengths of this member.

A1 - Steel Design according tc 🔽	1.5 Effe	ective <u>Le</u>	ngths <u>- N</u>	dembers									
oput Data		A	в	C	D	E	F	G	Н		J	K	L
General Data	Member	Buckling	Bucklin	ng around Axis	y/u	Buckl	ing around A	xis z/v	Tors	sional Bucl	ding	L.T.B.	
Materials	No.	Possible	Possible	KyAu Ky	AL [m]	Possible	K <sub>z/v</sub>	Kz/vL [m]	Possible	Kx	K <sub>X</sub> L [m]	Possible	Comment
Cross-sections	1	X	×	1.000	6.000	×	1.000	3.000	×	1.000	3.000	×	
Lateral Intermediate Supports	2	×	×	1.000	6.000	×	1.000	3.000	×	1.000	3.000	×	
Effective Lengths Members	3	×	×	1.000	3.011	×	1.000	1.506	×	1.000	1.506	×	
Effective Lengths - Sets of Men	4	×	×	1.000	3.262	×	1.000	1.631	×	1.000	1.631	×	
Design Parameters	5	×	×	1.000	6.274	×	1.000	3.137	×	1.000	3.137	×	
Nodal Supports	6	×	×	1.000	6.274	×	1.000	3.137	×	1.000	3.137	×	
	7	×	×	1.000	3.262	×	1.000	1.631	×	1.000	1.631	×	
Member Releases												E	
Set of Members No. 2 - Slev													
- Serviceability Data	0	C 14								10/49-00	(1180)		
	Settings	s for Men	nber No.	1					VV 10X0U	(AISC)			
	Cross-s	section				1 -	W 18x60 (Al	SC)			+ 1	191.9	
	Length	1			L		6.000	m					
	Bucklin	ng Possible					×				.— T		+
	Bucklin	ng around f	Aajor Axis y	Possible	L.		×				꽃 두		
		ctive Lena	'h Factor		K		1 1 1 1 1 1				· · ·		
	Erre	Caro Long			INJ I		1.000					1	
	Effe	ctive Leng	h	5 11	KyL		6.000	l m		8			1
	Effe Bucklin	ctive Lengt ng around I	h Minor Axis z	z Possible	KyL		6.000	l m		463.3			398.7
	Effe Effe Bucklin Effe	ctive Lengt ng around f ctive Lengt	h Minor Axis z h Factor	z Possible	KyL Kz		6.000	l m		463.3		10.5	398.7
	Effe Effe Effe Effe	ctive Leng ng around f ctive Leng ctive Leng	h Minor Axis z h Factor	z Possible	KyL Kz KzL		6.000 6.000 1.000 3.000	l m l l m		463.3		10.5	2.985 
	Effe Effe Effe Effe Torsior	ctive Leng ng around f ctive Leng ctive Leng nal Bucklin	h Minor Axis z h Factor h g Possible	z Possible	Ky KyL Kz KzL		6.000 1.000 3.000 X	l m l l m		463.3		<u>10.5</u>	2882 <b>&gt;</b> y
	Effe Effe Effe Effe Effe Effe	ctive Leng ng around h ctive Leng ctive Leng nal Bucklin ctive Leng	h Minor Axis z h Factor g Possible h Factor (fo	z Possible or Torsional Bu	Ky KyL Kz KzL Kx		6.000 1.000 3.000 1.000	m 		463.3		<u>10.5</u>	<u>у</u>
	Effe Effe Effe Effe Effe Effe	ctive Leng ng around f ctive Leng ctive Leng nal Bucklin ctive Leng ctive Leng	h Minor Axis z h Factor h g Possible h Factor (fo h (for Torsi	z Possible or Torsional Bu ional Buckling)	Ky KyL Kz KzL Kx Kx KxL		6.000 1.000 3.000 1.000 3.000 3.000	I m I m I m I m I m		463.3	77	10.5	<u>к</u>
	Effe Effe Effe Effe Torsior Effe Effe Lateral	ctive Leng ng around I ctive Leng nal Bucklin ctive Leng ctive Leng ctive Leng litorsional B	h Minor Axis z h Factor h g Possible h Factor (fo h (for Torsi uckling Po	z Possible or Torsional Bu ional Buckling) issible	Ky KyL Kz KzL Kx Kx		1.000 6.000 1.000 3.000 ¥ 1.000 3.000	I M I M I M I M I M		463.3	77	10.5 	2888 
	Effe Effe Effe Effe Effe Effe Effe Lateral Comme	ctive Leng ng around I ctive Leng nal Bucklin ctive Leng ctive Leng ctive Leng I-torsional B ent	th Minor Axis z th Factor th g Possible th Factor (fo th (for Torsi uckling Po	z Possible or Torsional Bu ional Buckling) ssible	Ky KyL Kz KzL Kx Kx		1.000 6.000 1.000 3.000 ¥ 1.000 3.000	I m I		463.3		10.5 2	1 2 2 2 3 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3
	Effe Effe Effe Effe Effe Effe Lateral Comme	ctive Leng ng around I ctive Leng nal Bucklin ctive Leng ctive Leng ctive Leng I-torsional B ent puts for Me	Minor Axis z ch Factor ch g Possible h Factor (for h (for Torsi uckling Po mbers No.:	z Possible or Torsional Bu ional Buckling) issible	Ky KyL Kz KzL Kx KxL		1.000 6.000 3.000 3.000 3.000 3.000 3.000	i m i m i m i m i m		463.3	2	10.5 Z	



The effective lengths for the column buckling about the minor principal axis and the effective lengths for torsional buckling are automatically loaded from the previous table 1.4. If a member is divided into different lengths by lateral intermediate supports, then no values are displayed in the corresponding columns G and J of table 1.5. It is possible to change the buckling length coefficients both in the summary table in the upper part and in the detailed settings in the lower part. The data of the corresponding part of this table is then updated automatically. The buckling length of a member can also be defined graphically by using the function [Pick].

The tree structure in the lower part of the *Settings for Member* table contains the following parameters:

- Cross-section
- Length (actual length of the member)
- Buckling Possible (cf column A)
- Buckling around Axis y (buckling lengths, cf columns B D)
- Buckling around Axis z (buckling lengths, cf columns E G)
- Torsional buckling (buckling lengths, cf columns H J)
- Lateral-torsional Buckling Possible (cf column K)

It is also possible to modify the *Buckling Length Coefficients* in the relevant directions and decide whether the buckling design is to be executed. If a buckling length coefficient is changed, the respective effective member length is modified automatically.

...



The effective length factors of the members can also be defined in a special dialog box which is called by the button [Select Effective Length Factor...] below the upper table.

Select Effective Length Factor		
Type of K value O Theoretical O Recommended		
Buckling around Axis y	Buckling around Axis z	Torsional Buckling
O Ky = 0.8		
O K <sub>y</sub> = 1.2	O K <sub>2</sub> = 1.2	ОК <sub>х</sub> = 1.2
⊙ Ky = 1.0		
O Ky = 2.1	O K <sub>2</sub> = 2.1	O K <sub>x</sub> = 2.1
O Ky = 2.0	O K₂ = 2.0	O K <sub>x</sub> = 2.0
User-defined Ky =	User-defined Kz =	User-defined $K_{X} = \dots$
Import from Additional Module RSBUCK (Eigenvalue Analysis) RSBUCK-Case:	Import from Additional Module RSBUCK (Eigenvalue Analysis) RSBUCK-Case:	Rotation fixed and translation fixed     Rotation free and translation fixed     Rotation fixed and translation free     Rotation fixed and translation free
To Exported Effective Length Factor Ky : 1.000 \$	To Exported Effective Length Factor K2: 1.000	To Exported Torsional Buckling Length Factor K <sub>x</sub> : 1.000 🗇
0		OK Cancel

Figure 2.13: Dialog box: Select Effective Length Factor

The *Theoretical* or *Recommended* values of the K factor that are to be assigned to the selected member or group of members can be defined in this dialog box. The theoretical and the recommended values are described in [2] on page 240. Generally, it is possible to select predefined K factors or to enter *User-defined* values.

The effective lengths for buckling can also be imported from the add-on module RS-BUCK.

### **Buckling Possible**

For the stability design of the buckling and lateral buckling, it is necessary for the member to transfer compression forces. Members that cannot transfer compression forces due to their definition (e.g. tension members, elastic foundations, rigid couplings) are a priori excluded from the stability design in STEEL AISC. In such a case, a corresponding comment is displayed in the column *Comment* for this member.

The column *Buckling Possible* enables you to classify specific members as compression ones or, alternatively, to exclude them from the design according to Chapter E. Hence, the check boxes in column A and also in table *Settings for Member No.* control whether the input options for the buckling length parameters are accessible for a member.

#### Length

For your information, the actual length of the selected member is displayed in the lower table. It is not possible to modify this value.

#### Buckling around Axis y resp. Axis z

The columns *Buckling Possible* control members are prone to buckling around their axes y and/or axes z. The axis y represents the "major" principal member axis, the axis z the "minor"

<u>G</u>raphic



principal member axis. The buckling length factors  $K_y$  and  $K_z$  can be freely chosen for the buckling around the major and minor axes.

The orientation of the member axes can be checked in the cross-section graphics of this table. In the RSTAB work window which can be opened any time via the [Graphic] button, you can display the local member axes from the *Display* navigator.



Figure 2.14: Displaying the Local Member Axes in the Display Navigator of RSTAB

If buckling is possible around one or both member axes, the precise values can be entered in columns D and E respectively F and G or in table *Settings for Member No*. below.

If you define the buckling length coefficient K, the buckling length KL is determined by multiplying the member length L with this buckling length coefficient.

Via the [...] button at the end of the *KL* input fields, you can select two nodes in the RSTAB work window graphically. Their distance then defines the buckling length.

#### **Torsional Buckling**

Column H controls whether a torsional buckling design is to be performed. The effective length factors  $K_x$  and the torsional buckling lengths  $K_{xL}$  can be defined in columns I and J. The axis x represents the centre line of a member.



Figure 2.15: Member Axes





### Lateral-Torsional Buckling L.T.B.

Column K controls whether a lateral torsional buckling design is to be carried out. The lateral-torsional buckling lengths depend on the settings of table 1.4 *Lateral Intermediate Supports*. There is no possibility to insert a user-defined value here.

The modification factor  $C_b$  for lateral-torsional buckling can be defined in table 1.7 *Design Parameters* (see Chapter 2.7).

### Comment

In the last column the user can write down his own remarks at every member, e.g. to explain more closely the specific lengths of a member.

The check box *Set Inputs for Members No.* is located beneath the tree-structure lower table. If you tick this box, the data entered <u>consequently</u> will become valid for specific resp. *All* members. You can select the members graphically by using the function [Pick] or enter their numbers manually. This option is useful when you want to assign the same boundary conditions to several members. Please notice that this function must be activated prior to data entering. If you define the data and choose this option later, the data is not re-assigned.

# 2.6 Effective Lengths - Sets of Members

The input table 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 table 1.1 *General Data*.

A1 - Steel Design according tc 🚩	1.6 Eff	ective Le	ngths - :	Sets of Mem	bers								
iput Data		A	B	C	D	E	F	G	H		J	K	L
- General Data	Set	Buckling	Buck	ding around Ax	is y	Buck	kling around.	Axis z	Lors	ional Buc	kling	L.I.B.	
Materials	140.	Possible	Possible	Ky K	yL [M]	Possible	Kz	K <sub>z</sub> L [m]	Possible	K <sub>X</sub>	K <sub>X</sub> L [m]	Possible	Lomme
- Cross-sections	2	×	×	1.000	6.000	×	1.000	6.000	×	1.000	6.000	×	
<ul> <li>Lateral Intermediate Supports</li> </ul>													
Effective Lengths - Members													
<ul> <li>Effective Lengths - Sets of Men</li> </ul>													
<ul> <li>Design Parameters</li> </ul>													
Nodal Supports													
Set of Members No. 2 - Set													
Member Releases													
Set of Members No. 2 - Set													
Serviceability Data	Catting	a 6au 6at	of Marriel	have bla 2						W18v60	(AISC)		
	setting	s for Set	of Memi	Ders No. Z		<b></b>			** 10200	(AISC)			
	⊡ Set of	Members				Sel	t of Members	: 2			+ - ·	191.9	
	- Lro	ss-section				1 · W 18x60 (AISC)							
	Lengt	h 			L		6.000	) m			. — K	- Y	-+
	Buckl	ing Possible					×				1 12		
	Buckl	ing around I	Major Axis	y Possible			×				ol .		
	- Effe	ective Leng	th Factor		Ky		1.000	)		2			<u> </u>
	Effe	ective Lengl	th		KyL		6.000	) m	Ξ	<del>9</del> 9			8
	🗆 Buckl	ing around I	Minor Axis	z Possible			×	1				10.5	
	- Effe	ective Leng	th Factor		Kz		1.000	)				-	
	Effe	ective Leng	th		KzL		6.000	) m					<b>-</b>
	Torsia	inal Bucklin	g Possible				×	1		+	//		
	- Effe	ective Leng	th Factor (I	for Torsional Bu	/ Kx		1.000	)				÷.	
	Effe	ective Leng	th (for Tors	ional Buckling	I KxL		6.000	) m				2	
	Latera	al-torsional B	uckling Pa	ossible			×	1	~				
	Set Ir	nputs for to !	Sets No.:					a la	M AI	6			× 📬

Figure 2.16: Table 1.6 Effective Lengths - Set of Members

This table is very similar to the previous table 1.5. With regard to the effective lengths for buckling around the major and minor axes of the cross-sections, it is identical to table 1.5.

There are differences, however, as far as the parameters for torsional and lateral-torsional buckling are concerned. These are defined by means of specific boundary conditions in table 1.8 and 1.9 (see Chapters 2.8 and 2.9).



3



# 2.7 Design Parameters

In this table, several parameters can be defined that are necessary for design.

an otoorboolgindooolding to	1.7 Des	ign Paramete						
put Data		A	B	C	D	E	F	G
- General Data	Member	Modification	Distance	Gross Area	Net Area	Shear Lag	Effective Area	<b>.</b> .
Materials	NU.	Factor U <sub>b</sub> [·]	L <sub>v</sub> [m]	Ag [mm² ]	A <sub>n</sub> [mm²]	Factor U [·]	Ae [mm4]	Comments
- Cross-sections	1	1.000 👱	6.000	11354.8	11354.8	1.000	11354.8	
- Lateral Intermediate Supports	2	1.000	6.000	11354.8	11354.8	1.000	11354.8	
Effective Lengths - Members	3	1.000	3.011	7612.9	7612.9	1.000	7612.9	
<ul> <li>Effective Lengths - Sets of Men</li> </ul>	4	1.000	3.262	8580.6	8580.6	1.000	8580.6	
Design Parameters	5	1.000	6.274	8580.6	8580.6	1.000	8580.6	
Nodal Supports	6	1.000	6.274	8580.6	8580.6	1.000	8580.6	
- Set of Members No. 2 - Set	7	1.000	3.262	8580.6	8580.6	1.000	8580.6	
Member Releases								
Set of Members No. 2 - Set								Ľ
<ul> <li>Serviceability Data</li> </ul>	C	for Monthese	NI- 4				W 19ven (Also)	)
	Settings	s for Member	NO. 1				1 10x00 (AISC	, 
	Cross	section		_	1 · W 18x60 (AIS	(C)	-	191.9
	Modific	cation Factor		Сь	1.000	•		
	Distan	ce acc. to G6		Lv	6.000	m		
	Liross /	Area		Ag	11354.8	mm <sup>2</sup>		4
	Net An	ea		An	11354.8	mm²		
	Shear	Lag Factor		U	1.000			5
	Effecti	ve Area		Ae	11354.8	mm <sup>2</sup>		8
	Comme	ent						10.5
							· • · · · ·	
							-	÷.
								z
							-	
	 □ Set In	puts for Members	No:				A	

Figure 2.17: Table 1.7 Design Parameters

### **Modification Factor**

In column A, there is the possibility to choose among the three options of the lateral-torsional buckling modification factor  $C_b$ . The default value is set to 1.0. The  $C_b$  factor can also be entered manually or determined by the program according to Equation F1-1 [1].

### Distance L<sub>v</sub>

The distance  $L_v$  specifies the distance between the points of maximum and zero shear force according to the Section G6 [1]. This applies to round HSS members.

### Gross Area A<sub>g</sub> / Net Area A<sub>n</sub>

In the columns C and D, the gross and net areas of all members are listed. If required, the net area can be modified in order to consider holes.

### Shear Lag Factor U

For every member, the shear lag factor for tension design can be defined according to Table D3.1 [1].

### Effective Area A<sub>e</sub>

Column F lists the effective areas of the members which are determined according to Equation D3-1 [1] from the net areas and the shear lag factors.

	A
Member	Modification
No.	Factor C <sub>b</sub> [-]
1	1.000 🔥
2	1.0 \
3	acc. to F1-1
4	manually
5	1.000



# 2.8 Nodal Supports - Sets of Members

The stability design of sets of members is carried out according to Chapter C of the ANSI/ AISC Specification [1]. According to Chapter H of this standard, you can design doubly symmetrical, singly symmetrical and unsymmetrical cross-sections stressed by compression and/or bending in a plane. The value of the multiplier  $\alpha_{cr}$  has to be determined for the entire set of members in order to obtain the critical moment  $M_{cr}$  which is necessary for the design. The calculation of  $\alpha_{cr}$ , the bifurcation factor, also depends on the setting in the *Details* dialog box (see Chapter 3.1, page 27).

To determine  $\alpha_{crr}$  a planar member structure with four degrees of freedom per node is created. The specific support conditions are defined in table 1.8. This table is only available if you have selected one or more sets of member in table 1.1 *General Data*.

STEEL AISC - [Demo-Seng]												
File Edit Settings Help	-											
CA1 - Steel Design according to 💌	1.8 Noc	lal Supp	orts - Set of	Members	: No. 2	Set of N	<i>l</i> ember	s 2				
Input Data	_	A	B	C		D	E		F	G	Н	
- General Data	Support	Node	Support	Lat. Supp	oort	Rotationa	al Hestraint		Warping	Eccer	ntricity	
- Materials	NU.	No.	Hotation β [*]	uy.		φx	ψZ		Hestraint w	ex [mm]	ez [mm]	Comment
- Cross-sections		1	0.00	×		×	×			0.0	0.0	
- Lateral Intermediate Supports	2											
<ul> <li>Effective Lengths - Members</li> </ul>	3											
<ul> <li>Effective Lengths - Sets of Men</li> </ul>	4											
- Design Parameters	5											
Nodal Supports	5											
- Set of Members No. 2 - Set	(											
Member Releases												۵ 🖏
Set of Members No. 2 - Set												
Serviceability Data	Settings	for Nod	e Sunnort N	lo. 1								
	Cross-	ection				1. IPE	500				~ ~	
	Node	with Sunno	rt		No		1	1				
	Suppo	rt Botation			ß	L		*				
	Latera	Support in	Y'		uv'		200				1	
	Restra	int around)			0%							U
	Restra	int around i	Z'		ψZ							
	Warpir	ng Restrain	t		ω		<u> </u>					
	Eccen	tricity			ex		0.0	mm		Y*		
	Eccen	tricity			ez		0.0	mm		ž	KX .	
	Comme	ent									7, '	X"
											-	β
												X'
												Z''
											l	Z
	📃 Set In	puts for Su	pports No.:						🗹 All	0 🍸		🎽 🗂 🕰
are	Coluite		Datalla					-1.1	ר <sup>'</sup>	-	OK	
	Laiculai		Details				Lui	apnic		L	UK	Lancel

Figure 2.18: Table 1.8 Nodal Supports - Set of Members

To define the nodal supports, the orientation of the axes within a set of members is important. The program internally checks the location of the relevant nodes and then determines the axis system for the nodal supports that are to be defined in table 1.8 (see Figure 2.19 to Figure 2.22).



Figure 2.19: Auxiliary Coordinate System for Nodal Supports of Sets of Members

If all members within the set of members lie on a straight line, the local coordinate system of the first member within this set is applied for the entire set of members.





Figure 2.20: Auxiliary Coordinate System for Nodal Supports of Set of Members

Even if the members within a set do not lie on a straight line, they still must lie in a plane. We can see a vertical plane in Figure 2.20. In this case, the axis X' is horizontal and in the plane direction. The axis Y' is also horizontal, but perpendicular to the axis X'. The axis Z' points vertically downwards.



Figure 2.21: Auxiliary Coordinate System for Nodal Supports of Set of Members

If the members are located in a horizontal plane, the axis X' is parallel with the axis X of the global coordinate system. The axis Y' then points in the opposite direction of the global axis Z. The axis Z' is parallel with the axis Y of the global coordinate system.



Figure 2.22: Auxiliary Coordinate System for Nodal Supports of Set of Members

Figure 2.22 shows the most general case. The members within a set of members do not lie on a straight line but are located in one oblique plane. The orientation of the axis X' is then determined by the intersection between the oblique and the horizontal plane. The axis Y' is perpendicular to the axis X' and is also perpendicular to the oblique plane. The axis Z' is perpendicular to the axes X' and Y'.



# 2.9 Member Releases - Sets of Members

This table is only available if one or more sets of members have been selected in table 1.1 *General Data.* If any member in a given set is not able to transfer internal forces corresponding to the degrees of freedom restricted in table 1.8, then nodal releases can be inserted to a set of members in table 1.9. There is also the possibility to exactly define on which side the release is to act or to place a release at both sides.



Figure 2.23: Table 1.9 Member Releases - Set of Members



# 2.10 Serviceability Data

The final input table includes different possibilities for the serviceability design. It is only displayed if the serviceability limit state design has been selected in table 1.1 *General Data* (cf Figure 2.3, page 10).

Steel Design seconding to w	1 10 5	arvice a hility Da	ta						
<ul> <li>Steer besign according to v</li> </ul>	1.10 5		B		D	F	F	G	н
r Data Caracel Data			Member	Referen	ce Lenath	Direc-	Camber	u	
Materiala Materiala	Nr.	Reference to	No.	Manually	l [m]	tion	∆ <sub>camb</sub> (mm)	Beam Type	Commen
Processections	1	Member	81	×	6.546	V.Z	4.0	Beam	
ateral Intermediate Supports	2	Member	82		7.094	9, z	0.0	Beam	
Effective Lengths - Members	3	Member	83		6.546	y, z	0.0	Beam	
Effective Lengths - Sets of Men	4	Member	11		6.000	y, z	8.0	Cantilever Start Free	
Design Parameters	5	Member	21	×	6.000	y, z	0.0	Beam	
Nodal Supports	6	Member	123		7.810	y, z	0.0	Beam	
Set of Members No. 2 - Slev	7	Set of Members	2		6.000	y, z	0.0	Cantilever End Free	
Member Beleases	8								
Set of Members No. 2 - Sle	9								
Serviceability Data	10								
-	11								
	12								
	13								
	14								
	15								
	16								
	17								
	18								
	19								
	20								
	21								
	22								
	23								
	24					-			
	- 25								
									۲

Figure 2.24: Table 1.10 Serviceability Data

In column A, you can refer the deformation to individual members, list of members or sets of members. In column B, the relevant members or sets of members can be selected graphically by using the function [Pick]. The reference lengths *I* in column D are then filled automatically. The *Reference Length* is set as the length of the member or the entire length of the set of members resp. list of members. It can be changed Manually by using the corres-

ponding check box in column C and setting the value in column D.

In column E, you specify the governing *Direction* for the serviceability design. Column F controls whether *Camber*  $\Delta_{camb}$  is to be taken into account as well.

For a correct determination of the serviceability limit states, the *Beam Type* (beam or cantilever) is very important. It can be entered in column G.



# 3. Calculation

# 3.1 Details

<u>Calculation</u>

Details...

A particular design is carried out with the internal forces calculated in the RSTAB program. Before the [Calculation], you should check the detailed setting for the design. Open the appropriate dialog box from every input or output table by clicking on the [Details...] button.

Details		
Check of Maximum Effective Stenderness Ratio         Members with       KL /r         • Tension:       300 \$         • Compression / Flexure:       200 \$         Serviceability (Deflections)         Limiting Deflection:       L / 360 \$         Deformation Related to:       •         • Shifted Members Ends / Set of Members Ends       •         Undeformed System       •         Determination of Elastic Critical Moment for LTB         Point of Applied Load:       •         • On Cross-section Edge Directed to Shear Center (e.g. Top Flange, Destabilizing Effect)         • In Shear Center       • On Cross-section Edge Directed from Shear Center Shear Center	Limit Load for Special Cases Do not Take Small Moments into Account if: Bending $M_{r,y} / M_{0,y} \leq 0.010$ $M_{r,z} / M_{0,z} \leq 0.010$ Do not Take Small Axial Forces into Account if: Tension $P_{r,x} / P_{0,x} \leq 0.010$ Compression $P_{r,0} / P_{0,0} \leq 0.010$ Do not Take Small Shear Forces into Account if: Shear $V_{r,y} / V_{0,y} \leq 0.010$ $V_{r,z} / V_{0,z} \leq 0.010$ Limit Shear Stress for Cross-sections with: Torsion $\tau_r / \tau_0 \leq 0.010$ Cross-section Optimization Max Allowable Design Ratio: 1.00 $\diamondsuit$	Display Result Tables         Image:
		OK Cancel

Figure 3.1: Details Dialog box

### **Check of Maximum Effective Slenderness Ratio**

For members designed according to Chapter D [1], the slenderness ratio preferably should not exceed 300. This does not apply to the member types "Tension" and "Cable" because they are excluded from this check. For members designed according to Chapter E [1], the slenderness ratio preferably should not exceed 200. This value is applicable to all members with compression or flexure.

It is possible to set user-defined slenderness ratios for members with tension resp. compression or flexure. These maximum values are compared with the actual member slendernesses in table 3.3 which is available after the calculation (see Chapter 4.8).

### Serviceability (Deflections)

In this section, it is possible to change set the allowable deflection for the serviceability limit state design if the default value L/360 is not appropriate.

The two selection fields below control whether the *Deformation* is to be related to the undeformed model or to an imaginary connecting line between the shifted start and end nodes of the member resp. set of members within the deformed structure.



### **Determination of Elastic Critical Moment for LTB**

The elastic critical moment M<sub>cr</sub> for <u>set of members</u> is calculated automatically.

Usually, loads act on members. Then their application point has to be specified because this can have stabilizing or destabilizing effects, subject to the eccentricity. The *Point of Applied Load* can be set globally for all loads.

### Limit Load for Special Cases

It is possible to neglect small stresses due to bending, tension or compression, shear and torsion and, thus, allow a simplified design which eliminates negligible internal forces. In this section, the limits of these internal forces or stresses can be entered. Those are defined as the ratios between existing internal forces or stresses and the corresponding resistances of each cross-section.

### **Cross-section Optimization**

Cross-sections can be optimized if the Optimize option is chosen in table 1.3 *Cross-Sections*. (see Figure 2.6, page 13). The dialog box *Details* enables you to set the maximum allowable design ratio as a limit for the optimization process.

### **Display Results Tables**

In this section, the results tables can be specified which are to be displayed, inclusive of a parts list. The results tables are described individually in Chapter 4.

### **Design Wall Thickness of HSS**

The design wall thickness shall be taken equal to 0.93 times the nominal wall thickness for Hollow Structural Sections if the check is set here. This reduction is recommended for electric-resistance-welded HSS, not for submerged-arc-welded HSS.

## 3.2 Start Calculation

Calculation

In all input tables of STEEL AISC, you can start the design via the [Calculation] button.

At first, STEEL AISC searches for the results of the selected load cases, groups and combinations of load cases. If they are not found, the calculation of the governing internal forces in RSTAB is started. The calculation parameters of RSTAB are used for this analysis.

If cross-sections should be optimized (see Chapter 7.2, page 48), the required sections are calculated and relevant designs are carried out.

The STEEL AISC design can be also started from the RSTAB interface. All design cases of the add-on modules are displayed in the *To Calculate* dialog box, similarly to load cases or load groups. Open this dialog box in RSTAB via the main menu

 $\textbf{Calculate} \rightarrow \textbf{To Calculate}...$ 





To Calculate								X
Not Calculated					Selected for Calcula	tion		
Program / Mod	No.	Description	^		Program / Mod	No.	Description	^
RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB RSTAB	LC2 LC3 LC4 LC5 LC6 LC7 LC8 LC10 LG1 LG2 LG4 LG5 LG6 LG8 LG9 CO1 CA2	Snow Load Wind v +X Wind at peak v +Y Wind at peak v -Y Wind at peak v -Y Wind positive Live Load Imperfections v +X Imperfections v +Y 1.35*LC1 + 1.35*LC2 + 1.35*LC 1.35*LC1 + 1.5*LC2 + 1.25*LC LC1 + 1.5*LC4 + LC10 1.35*LC1 + 1.35*LC2 + 1.35*LC 1.35*LC1 + 1.35*LC2 + 1.35*LC Extreme design value Steel Design according to AISC		<b>×</b>	STEEL AISC	CA1	Steel Design according to AISC	
Show Additional	Modules							
0							Calculate Cance	

Figure 3.2: To Calculate Dialog box

If the design cases of STEEL AISC are missing in the list Not Calculated, it is necessary to tick the check box Show Additional Modules.

The [▶] button transfers selected design cases to the list on the right. You can then start the calculation by the [Calculate] button.

The calculation of a specific STEEL AISC design case can also be directly started from the toolbar. Set the required design case in the list and then click on the [Results on/off] button.

<u>A</u> dditional Modules	<u>W</u> indow	<u>H</u> elp				
STEEL AISC CA1 - S	teel Des 🔽	۹ ۵	3	1 xxx 👰 💥	જ જ	ने 🛤
🏗 🎜 🗇 🗗	🏂 - [	<b>b</b> i <i>1</i> 7	9		on/off IT	My

Figure 3.3: Direct Calculation of Design Case from STEEL AISC in RSTAB

A dialog box appears in which you can watch the progress of the design.

Calculation			×
VER	Running RSTAB - Calculation STEEL AISC Partial Steps	(*************	
RS-SOL	Calculation of Member Stresses         Initializating Data         Preparing Optimization         Loading Data for Optimization         Optimizing Cross-sections         Preparing Data for Calculation         Loading Internal Forces         Running Design         Creating Results Data         Member No. 13 (11/102)	Number of Members Number of LC Number of CG Number of CO	102 8 3 0
	Cancel	]	

Figure 3.4: Calculation in STEEL AISC



>

۲

Calculate

Program STEEL AISC © 2010 by Dlubal Engineering Software

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# 4. Results

# 4.1 Design by Load Case

Table 2.1 *Design by Load Case* is displayed immediately after the design. In the upper part of this table, a summary of all designs for every load case, load group and combination is displayed. The lower part includes all details of the material properties, design internal forces and design data of the load case which is selected in the upper part of the table.

The results tables 2.1 to 2.5 contain the detailed design summaries according to different selection criteria. Tables 3.1 and 3.2 include the governing internal forces. In table 3.3, the member slendernesses are compared with the maximum values as set in the *Details* dialog box (see Chapter 3.1). The parts lists are displayed in the last two tables 4.1 and 4.2.

The results tables are accessible from the navigator in STEEL AISC. You can also switch among the tables via the buttons as seen to the left or the functional keys [F2] and [F3].

Save the results by the [OK] button and close STEEL AISC.

In this chapter, we describe the particular tables in the given order. The following chapter 5 *Evaluation of Results* is devoted to the evaluation and checking of results.

A1 - Steel Design according to 🔽	2.1 Des	sign by Load Case										
iput Data		A	В	C	D	E				F		G
- General Data	Load		Member	Location	Desig	n	_					
Materials	Lase	Description	No.	x [m]	Ratio		D	esig	in acc	cording	to Formula	D
Cross-sections		Ultimate Limit State Design	_									
Lateral Intermediate Supports	LC1	Dead Load	1	1.000	0.94	≤1	350) Set of Me	embe	ers - S	itability	Analysis of Doubly an	d UL
Effective Lengths - Members	LC2	Snow Load	21	6.000	1.44	>1	204) Chapter H	H • C	Compre	essive l	Force with Single/Maj	or U
- Effective Lengths - Sets of Men	LC3	Wind v +X	11	5.400	0.21	≤1	113) Chapter F	÷L	ateral	-Torsion	nal Buckling - acc. to	F: U
- Design Parameters	LC4	Wind at peak v +Y	108	0.000	0.70	≤1	301) Chapter B	E - F	lexura	al Buckl	ling around y-Axis acc	.tU
Nodal Supports												
Set of Members No. 2 - Set		Serviceability Limit State De	esign									
Member Releases	LC1	Dead Load	1	3.000	0.10	≤1	401) Chapter L	- • D	esign	for Ser	rviceability - Deflection	i ir
Set of Members No. 2 - Set												
Serviceability Data				Marine [	1.44	11	a (@/	าเส				
esults				Max.	1.44		•		₽,			_
- Design by Load Case								_				
Design by Cross-section	Details	- Member 1 - x: 1.000	) m - LC1						1 - W	V 8×48	(AISC)	
- Design by Set of Members	⊞ Mater	ial Values - Steel S 355						^			206.0	+
- Design by Member	Cross	section Values + W 8x48 (A	ISC)									
Design by x-Location	⊞ Desig	n Internal Forces							†			I
- Governing Internal Forces by M	🕀 Cross	section Type								5	4	
- Governing Internal Forces by Si	🕀 Desig	n Ratio								~		~
Member Slendernesses	- Re	quired Compressive Strengl	Pr	63.148	kN				215.			-2
Parts List by Member	- Buo	ckling around Axis y									10.2	
Parts List by Set of Members	Effe	ective Length of Set	Leff,y	6.000	m							$\rightarrow$
-	- Sle	nderness Ratio	KyL/ry	65.391		≤ 4.71	√ł (E2)		∔		11111111111	1
	— Ela	stic Critical Buckling Stress	Fe,y	48.47	kN/cm <sup>2</sup>		(E3-4)				1	
	- Crit	ical Stress	Fer,y	26.13	kN/cm <sup>2</sup>		(E3-2 or E				z	
	— Saf	ety Factor for Compression	Ωc	1.670			(E1)					[H
	- No	minal Compressive Strengtł	Pn,y	2376.750	kN		(E3-1)			l		
	6 H -	ushla Comprossius Strong	Pau/0a	1423 210	kN			v	U		·   (→ )   ↓	

Figure 4.1: Table 2.1 Design by Load Case

#### Description

The load cases, load groups and combinations that are decisive for every relevant type of design are displayed in this column.

#### Member No.

The number of the member with the highest design ratio is stated for every designed load case, load group or load combination.



0K



### Location x

The location x on the member where the maximum stress ratio occurs is displayed in this column. The following locations x on the member are taken into account:

- Start and end nodes
- Internal nodes according to a potential user-defined member division
- Extreme values of internal forces

#### **Design Ratio**

Max: 0.92 🖾 🥹

For every design type and for every load case, load group or load combination, the design quotients according to the standard are displayed in this column.

### Design according to Formula

In this column, the equations that were followed in the design are displayed.

#### DS

The *Design Situation* which is relevant for the design is stated in this column: *ULS* (Ultimate Limit State) or *SLS* (Serviceability Limit State).

# 4.2 Design by Cross-Section

A I - Steel Design according to 🎽	2.2 Des	sign by	Cross-sect	tion									
nput Data		A	В	С	D	E				F			
- General Data	Section	Member	Location	Load	Desig	n							
- Materials	NO.	Nr.	x [m]	Case	Ratio				Design acci	ording	to Formula	a	
- Cross-sections	1	W 8x48	(AISC)										
- Lateral Intermediate Supports		83	4.676	LC1	0.01	≤1	100) No or \	/ery Sma	II Internal Forces	:			
- Effective Lengths - Members		21	6.000	LC2	0.98	≤1	111) Chapte	er F - Yiel	ding · Bending a	round	y-Axis acc	:. to F2 - F1	2
- Effective Lengths - Sets of Men		1	3.000	LC4	0.07	≤ 1	112) Chapte	er F - Yiel	ding · Bending a	round	z-Axis acc	:. to F2 - F1	2
- Design Parameters		21	6.000	LC2	1.17	>1	113) Chapte	er F - Late	eral-Torsional Bu	ckling	<ul> <li>acc. to</li> </ul>	F2 · F5	
- Nodal Supports		1	1.000	LC1	0.00	≤1	122) Chapte	r F - Flar	ige Local Bucklin	ng doe	es not App	ly - acc. to	F2 - F5
Set of Members No. 2 - Set		1	1.000	LC4	0.00	≤ 1	124) Chapte	er F - Flan	ige Local Bucklii	ng doe	es not App	ly - acc. to	F6
- Member Releases		32	0.000	LC2	0.25	≤1	160) Chapte	er G · Nor	minal Shear Strem	ngth in	z-Axis - a	cc. to G2 (	G4,G5) · Ur
Set of Members No. 2 - Set		21	6.000	LC2	1.44	>1	204) Chapte	er H - Cor	npressive Force	with Si	ingle/Majo	or Axis Ben	ding • acc. I
- Serviceability Data				Max:	1.44	$\geq 1$	3		9	۹.	ſ	5 😱	2
esults				in and i			·						
<ul> <li>Design by Load Case</li> </ul>	D 4 11		24	( 000	1.00					<b>a</b> 5	NO. 40 /		
- Design by Cross-section	Details	- Memt	er 21 - x:	6.000 r	n - LCZ					1-9	/V 0X40 (A	AISC)	
<ul> <li>Design by Set of Members</li> </ul>	Mater	ial Values	- Steel 5 355	)						_	+	206.	<u> </u>
- Design by Member	H Lross-	section V	alues · W 8	x48 (AISU)						-	<u> </u>		
<ul> <li>Design by x-Location</li> </ul>	Desigi	n Internal	Forces							_	∔_"	4	
<ul> <li>Governing Internal Forces by M</li> </ul>	E Cross	section I	ype							_	1.0	1	
<ul> <li>Governing Internal Forces by Syl</li> </ul>		n Hatio	101 1			107.001				- 3		-	
Member Slendernesses	- Hec	quirea Fie	kurai Strengtr	n Mr,y		167.291	KINM 2			- 2			
Parts List by Member	Tiel	id Stress		Fy 7		35.50	KN/CM4			_		<b>∔</b>	10.2
Parts List by Set of Members	- Pla:	stic Section	on Modulus	Zy	8	02966.0	mm <sup>2</sup>			-			
	- Pia:	stic Bena	ng moment	Mpl,	y	285.053	KINM		(50.1)	- 1		///////	
	- Nor	minal Flex	ural Strength	Mn.3	r –	285.053	KINM		(F2-1)	-		÷ 🐳	
	- Sar	ety Facto	r for Hexure	325	10.	1.670	L.M		(F1)	-		z	
	- Allo	wable Fie	xural Strengt	n Mn.)	,/ <u>₩</u> Б	170.690	KNM	11	(0.2.2)	_			
	- Des	sign Hatio		ηb		0.98		21	(B3-2)				

Figure 4.2: Table 2.2 Design by Cross-Section

In this table, the maximum design ratios are displayed for all designed members and for all designed load cases, load groups and combinations. The results are sorted according to cross-sections. For tapered members, both cross-section descriptions are shown in the line next to the cross-section number.



# 4.3 Design by Set of Members

CA1 - Steel Design according to 💙	2.3 Des	sign by	Set of Mer	nbers											
Input Data		A	В	С	D	E				F					^
General Data	Set	Member	Location	Load	Design										
Materials	No.	Nr.	x [m]	Case	Ratio				Design acc	ording	to Fo	rmula			
- Cross-sections		1	1.000	LC4	0.00	≤1	124) Chap	ter F - Flan	ge Local Buckli	ing doe	es not	: Apply - a	acc. to F6		
- Lateral Intermediate Supports		1	0.000	LC2	0.04	≤1	160) Chap	ter G - Nom	iinal Shear Stre	ngth in	ı z∙Ax	is - acc. I	to G2 (G4,G	i5) - Unstiff	•
Effective Lengths - Members		1	6.000	LC2	0.50	≤1	204) Chap	ter H - Com	pressive Force	with S	ingle,	/Major A	kis Bending	- acc. to H	1
Effective Lengths - Sets of Men		1	0.000	LC1	0.05	≤1	301) Chap	ter E - Flex	ural Buckling ar	ound y	Axis	acc. to E	E3		
Design Parameters		1	0.000	LC1	0.09	≤1	311) Chap	ter E - Flex	ural Buckling ar	ound z	Axis	acc. to E	53		
Nodal Supports		1	0.000	LC1	0.05	≤1	321) Chap	ter E - Tors	ional Buckling	acc, to	E4				
- Set of Members No. 2 - Set		1	1.000	LC2	1.17	>1	350) Set o	f Members	<ul> <li>Stability Analy</li> </ul>	isis of D	)oubļ	y and Sir	ngly Symme	tric Membe	
😑 Member Releases		1	0.000	LC1	0.00	≤1	400) Chap	ter L - Desi	gn for Servicea	ibility - I	No or	Very Sm	all Deflectio	ins	
- Set of Members No. 2 - Set		1	3.000	LC1	0.10	≤1	401) Chap	ter L - Desi	gn for Servicea	ibility - I	Defle	ction in z	-Direction (B	3eam)	~
Serviceability Data				Maar	1.44	>1	<u>A</u>		( <b>@</b>	۰.		E.			5
Results				Pigo.	1.44	· ·	•		4			E		ات	~
<ul> <li>Design by Load Case</li> </ul>															_
<ul> <li>Design by Cross-section</li> </ul>	Details	- Memb	er 1 - x: 1	.000 m	1 - LC4					1-1	/4 8ו	48 (AISC	5		
<ul> <li>Design by Set of Members</li> </ul>	Mater	ial Values	- Steel S 355	)						_		+	206.0	-+	
<ul> <li>Design by Member</li> </ul>	E Cross	section V	alues - W 8 -	x48 (AISC	J					_					
<ul> <li>Design by x-Location</li> </ul>	⊞ Desig	n Internal	Forces							_	Γļ	- 4	in pri	<u> </u>	
<ul> <li>Governing Internal Forces by M</li> </ul>	Cross	section I	ype							_	5	17.			
Governing Internal Forces by S	🗆 Desig	n Hatio									1.11		2	$\sim$	
Member Slendernesses	- b/t-	Limit for L	ompact Flan	ge λ <sub>Ρ.</sub>	f	9.242	2		Tab. 84.1	316			2	ŝ.	7
	- b/t-	Limit for N	IonCompact	Flan Ar, f		24.324	-		Tab. 84.1	_			10.2		
Parts List by Member		Batio		(b/I	Uf	5.920		Sλp,f	(200.0)	_				→	
Parts List by Member Parts List by Set of Members	- b/t-					~~~						-///			
Parts List by Member Parts List by Set of Members	De:	sign Ratio		ąь		0.00	,	21	(63-2)	_  ·	+				
Parts List by Member Parts List by Set of Members	De:	sign Ratio		ηь		0.00	1	21	(83-2)	-	•		÷		
Parts List by Member Parts List by Set of Members	De:	sign Ratio		ηь		0.00	,	21	(63-2)	_	•		z		
Parts List by Member Parts List by Set of Members	De:	sign Ratio		ηь 		0.00		21	(63-2)	_	+		Z	(m	im]
Parts List by Member Parts List by Set of Members	De:	sign Ratio		<i>п</i> ь		0.00		21		_	•		z	(n 	ım]

Figure 4.3: Table 2.3 Design by Set of Members

This table is displayed if at least one set of members was selected for design. The maximum design ratios are listed according to sets of members. The number of the member with the highest design ratio within each set of members is shown as well.

# 4.4 Design by Member

e Edit Settings Help														
<li>Steel Design according to V</li>	2.4 Des	sign by Me	mber											
nut Data		A	В		D				E					7
General Data	Member	Location	Load	Design	-									
Materials	No.	x [m]	Case	Ratio					Design according	g to Form	nula			
- Cross-sections		0.000	LC1	0.10	≤1	311) Char	oter E - Flex	ural Buc	kling around z-Ax	is acc. tr	o E3			
- Lateral Intermediate Supports		0.000	LC1	0.05	≤1	321) Char	oter E - Tor	sional Bu	ckling acc. to E4					_
Effective Lengths - Members														_
Effective Lengths - Sets of Men	13	Cross-sectio	n No. 3 - '	W 16x40 (AIS)	c1 :	2 - W 16x4	5 (AISC)							
Design Parameters		0.000	LC2	0.61	≤1	111) Char	pter F - Yiel	ding - Be	nding around y-A	xis acc.	to F2 - F12	2		
Modal Supports		0.000	LC2	0.72	≤1	113) Char	oter F - Late	eral-Torsi	onal Buckling - a	ec. to F2	2 - F5			
Set of Members No. 2 - Set		0.000	LC1	0.00	<u>≤</u> 1	122) Char	oter F - Flan	ige Loca	I Buckling does n	ot Apply	- acc. to F	2 - F5		_
Momber Balagges		0.000	LC2	0.08	<u>≤</u> 1	160) Char	oter G - Nor	minal She	aar Strength in z-/	Axis - acr	c. to G2 (G	- (4,G5) - Un	nstiffened V	Nε
Sat of Members No. 2 - Set		0.000	LC2	0.62	<u>s</u> 1	204) Char	oter H - Con	npressive	a Force with Sing!	le/Major	Axis Bend	ling - acc. M	to H1.3	
Corvice shilling Data					_	-					F		-	C
- Serviceability Data			Max:	1.44	>1	8				₽.	Ē	<u>_</u>	22	L
Bosian bull and Case														
Design by Load Case	Details	- Member	<u>13 - x:</u>	<u>0.00</u> 0 m -	LC2					3 - 2: 1	N 16×40 (	AISC) - W	16×45 (Al	s
Design by Cross-section Design by Set of Members	⊞ Materi	ial Values - St	eel S 355	i	-					-		177.7		
Design by Set or Members	E Cross-	section Value	s • W 16	6x40 (AISC)						-	T			
Design by Member	IFFI Desig	n Internal Ford	ies.							-	+ +	they man	+	
<ul> <li>Design by x-Location</li> <li>Coversing Internal Forces by M.</li> </ul>	FFI Cross	section Type								-	2 5		_	
<ul> <li>Governing internal Forces by m</li> </ul>	I Desig	n Ratio								-	~			
<ul> <li>Governing internal norces by 5- Mambar Clandarpassas</li> </ul>	Rer	ruired Flexura	Strength	Mr.v		154.308	kNm	1		- 20	į		\$ \$	
Parts List by Member	- Yie	ld Stress		Fv		35.50	kN/cm <sup>2</sup>		+	- 7		77	9 A	
Parts List by Member Parts List by Set of Members	- Pla	stic Section M	odulus	Zv	1	194620.0	mm <sup>3</sup>	-		-		<b>1</b>		
Parts List by Sec or members	- Pla	stic Bending M	Ioment	MoLy		424.089	kNm		+	-		-	-	
	- Nor	minal Flexural	Strength	Maar	-	424.089	kNm		(F2-1)	-	+	!		
	Saf	ety Factor for	Flexure	Ωh		1.670			(E1)	-		z		
	Alle	wable Flexura	I Strengt	n Μ <sub>π.ν</sub> /Ω	n -	253.946	kNm			-				ſn
	Der	sign Ratio		уь		0.61		≤1	(B3-2)	-		-	V (P)	0
				10	-					- 🙂		٩	À I	Ľ
·	1			5	<i>3</i>		1	-	_	_				-

Figure 4.4: Table 2.4 Design by Member



In this table, the maximum design ratios are arranged according to member numbers. The *Location* x at which the maximum value occurs is stated for every member.

The description of the individual columns can be found in chapter 4.1 on page 30.

# 4.5 Design by x-Location

CA1 - Steel Design according tc 🚩	2.5 Des	sign by x-L	ocation							
Input Data	Marchar	A	B	C	D			E		
- General Data	No	Location	Casa	Desi	gn				a ta Carro	_
- Materials	110.	x [iii]	Lase	nauu	- Z 1	211) Charles F	Elson and Develo	Jesign accordin	ig to Foliniai	1d To
- Cross-sections		3.000	LC4	0.2	2 2 1	221) Chapter E	Flexural Buck     Tessienal Buck	ung aroung z-A: Wing ang ta E-	KIS ACC. (O E	10
- Lateral Intermediate Supports		3.000	LC4	0.0		321) Unapter E	<ul> <li>Torsional Bud</li> <li>Casell Internal</li> </ul>	CKIING ACC. to E4	+	
Effective Lengths - Members		4.000	LL3	0.0		111) Chapter E	Violding Dor	ruices ding pround u A	wie zee te	E3 E13
Effective Lengths - Sets of Men		4.000	LCI	0.0	3 2 1	111) Chapter F	<ul> <li>neiding - ber</li> <li>l cool Buckling</li> </ul>	a of USS Sootie	wis acc. to	FZ-FIZ
Design Parameters		4.000	LCA	0.0	2 4 1	201) Chapter F	<ul> <li>Elocal Bucklin</li> <li>Elocural Buck</li> </ul>	lig of HSS Section	via aco, to l	TAPPIV- acc. to F7
Nodal Supports		4.000	LC4	0.2	2 2 1	211) Chapter E	- Flexural Buck	ting around y-A:	vis acc. to f	
Set of Members No. 2 - Set		4.000	LC4	0.2	5 4 1	321) Chapter E	Torsional Buck	aing around 244. Sklipg acc. to Ev	AIS OCC. (O E	_5
Member Heleases		4.000 5.000	1.01	0.0	1 < 1	100) No or Veri	<ul> <li>Torsionar.bdd</li> <li>Small Internal</li> </ul>	Forces	•	
Set of Members No. 2 - Set [		3.000	LUI	0.0	121		Sindi Internal		-	
Serviceability Data			Max:	1.4	4 >1	8			₽.	🎼 🔥 😂 🔍
Device had and Const										
Design by Load Lase	Details	- Member	99 - x:	4.000 m	- I C1				12 - SHS	3x0.125 (AISC)
Design by Cross-section	I∓I Materi	al Values - SI	eel S 355							76.2
Design by Sec of Members	FI Cross-	section Value	es - SHS	3x0.125 (A	ISCI					
Design by Member	— ⊞ Design	n Internal For	ces						-l +-	-
Governing Internal Forces by M	Eross-	section Type								3.2
- Governing Internal Forces by Su	🖯 Desigr	n Ratio								
- Member Slendernesses	— b/t-	Limit for Com	pact Flang	ge λ <sub>p,f</sub>		27.240		Tab. B4.1	26.2	•
- Parts List by Member	— b/t-	Limit for Nonl	Compact F	lan λ <sub>r,f</sub>		34.051		Tab. B4.1		
Parts List by Set of Members	— b/t-	Ratio		(b/t) <sub>f</sub>		18.000	≤ λp,f			
	- Des	sign Ratio		ųь		0.00	≤ 1	(B3-2)	-  ↓	And a state of the
				(						÷
										z
										[mr
									A	
<										

Figure 4.5: Table 2.5 Design by x-Location

This results table lists the maximum values of every member at the following locations x according to the division points of RSTAB:

- Start and end nodes
- Internal nodes according to a potential user-defined member division
- Division points according to the number of member divisions that were set in the RSTAB *Calculation Parameters* dialog box in the *Options* tab
- Extreme values of internal forces



# 4.6 Governing Internal Forces by Member

In this table, the governing internal forces are shown which lead to the maximum design ratios.

x1 - Steel Design according tc 🗙	3.1 Go	verning lr	nternal	Forces by	y Member					
put Data		A	B	C	D	E	F	G	H	I
- General Data	Member	Location	Load		Forces [kN]		Mo	oments [kNr	nj	
Materials	NO.	x [m]	Lase	N	Vy	V₂	MT	My	Mz	Design according to Formula
- Cross-sections	1	Cross-secti	on No. 1 ·	• W 8x48 (Al	ISC)	0.000	0.010	0.000	0.000	1000 N
Lateral Intermediate Supports		6.000	LC4	0,000	3.753	0.000	0.018	0.000	-0.020	100J No or Very Small Internal Forces
Effective Lengths - Members		6.000	LC2	-23,438	0.000	-13.941	0.000	83.646	0.000	111) Chapter F - Yielding - Bending a
Effective Lengths - Sets of Men		3.000	LU4	0,000	0.003	0.000	0.018	0.000	5,615	112 Chapter F - Yielding - Bending a
Design Parameters		6.000	LC2	-23,438	0.000	-13.941	0.000	-83.646	0.000	113 Chapter F - Lateral-Torsional Bu
Nodal Supports		1.000	LC1	-63,148	0.000	-10.808	0.001	-10.808	0.000	122J Chapter F - Flange Local Buckli
- Set of Members No. 2 - Set		1.000	LU4	0,000	-2.497	0.000	0.018	0.000	3.122	124 Chapter F - Flange Local Buckli
Member Releases		0.000	LC2	-23,438	0.000	-13.941	0.000	0.000	0.000	160) Chapter G - Nominal Shear Stre
- Set of Members No. 2 - Set		6.000	LC2	-23,438	0.000	-13.941	0.000	-83.646	0.000	204) Chapter H - Compressive Force
Serviceability Data		0.000	LC1	-72,140	0.000	-10.808	0.001	0.000	0.000	301 Chapter E - Flexural Buckling an
sults		0.000	LC1	-72,140	0.000	-10.808	0.001	0.000	0.000	311) Chapter E - Flexural Buckling an
Design by Load Case		0.000	LC1	-72,140	0.000	-10.808	0.001	0.000	0.000	321) Chapter E - Torsional Buckling
Design by Cross-section		1.000	LC2	-23,438	0.000	-13.941	0.000	-13.941	0.000	350) Set of Members - Stability Analy
-Design by Set of Members		0.000	LC1	-72,140	0.000	-10.808	0.001	0.000	0.000	400J Chapter L - Design for Servicea
- Design by Member		3.000	LC1	-45,166	Q.000	-10.808	0.001	-3 <b>2</b> .423	0.000	401) Chapter L - Design for Servicea
<ul> <li>Design by x-Location</li> </ul>										
- Governing Internal Forces by M	2	Cross-secti	on No. 1 ·	·₩ 8x48 (A	ISC)					
- Governing Internal Forces by Si		6.000	LC4	0.000	3.753	0.000	-0.018	0.000	-0.020	100) No or Very Small Internal Force:
<ul> <li>Member Slendernesses</li> </ul>		6.000	LC2	-2 <mark>3,</mark> 438	0.000	13.941	0.000	83.646	0.000	111) Chapter F · Yielding · Bending a
<ul> <li>Parts List by Member</li> </ul>		3.000	LC4	0,000	0.003	0.000	-0.018	0.000	5.615	112) Chapter F · Yielding · Bending a
- Parts List by Set of Members		6.000	LC2	-2 <b>3</b> ,438	0.000	13,941	0.000	83. <b>6</b> 46	0.000	113) Chapter F - Lateral-Torsional Bu
		1.000	LC1	-63,148	0.000	10.808	-0.001	10.808	0.000	122) Chapter F - Flange Local Buckli
		1.000	LC4	0,000	-2.497	0.000	-0.018	0.000	3.122	124) Chapter F - Flange Local Buckli
		0.000	LC2	-2 <mark>3,</mark> 438	0.000	13.941	0.000	0.000	0.000	160) Chapter G - Nominal Shear Stre
		6.000	LC2	-23,438	0.000	13.941	0.000	83. <b>6</b> 46	0.000	204) Chapter H - Compressive Force

Figure 4.6: Table 3.1 Governing Internal Forces by Member

#### Location x

For every member, the location x on the member with the maximum design ratio is shown.

#### Load Case

In this column, the numbers of the load cases, load groups or combination whose internal forces have the most unfavorable effects are displayed.

#### Forces / Moments

The decisive axial and shear forces as well as the torsional and bending moments are listed for every member.

#### **Design according to Formula**

The last column includes the relevant equations that were followed in the design.



# 4.7 Governing Internal Forces by Set of Members

STEEL AISC - [Demo-5eng]										
File Edit Settings Help										
CA1 - Steel Design according to 🗸	3.2 Go	verning li	nternal	Forces by	y Set of M	ember				
Input Data		A	В	С	D	E	F	G	Н	1
- General Data	Set	Location	Load		Forces [kN]		Me	oments [kNr	n]	
Materials	No.	x [m]	Case	N	Vy	Vz	Мт	My	Mz	Design according to Formula
- Cross-sections	2	Set of Men	nbers 2 (M	ember No.	1)					
- Lateral Intermediate Supports		6.000	LC4	0.000	3.753	0.000	0.018	0.000	-0.020	100) No or Very Small Internal Forces
Effective Lengths - Members		6.000	LC2	-23. <b>438</b>	0.000	-13.941	0.000	-83.646	0.000	111) Chapter F - Yielding - Bending around
- Effective Lengths - Sets of Men		3.000	LC4	0.000	0.003	0.000	0.018	0.000	5.615	112) Chapter F - Yielding - Bending around
Design Parameters		6.000	LC2	-23. <b>438</b>	0.000	-13.941	0.000	-83.646	0.000	113) Chapter F - Lateral-Torsional Buckling
Nodal Supports		1.000	LC1	-63.148	0.000	-10.808	0.001	-10.808	0.000	122) Chapter F - Flange Local Buckling do
Set of Members No. 2 - Set		1.000	LC4	0.000	-2.497	0.000	0.018	0.000	3.122	124) Chapter F - Flange Local Buckling do
Member Beleases		0.000	LC2	-23.438	0.000	-13.941	0.000	0.000	0.000	160) Chapter G · Nominal Shear Strength i
Set of Members No. 2 - Set		6.000	LC2	-23.438	0.000	-13.941	0.000	-83.646	0.000	204) Chapter H - Compressive Force with S
Serviceability Data		0.000	LC1	-72.140	0.000	-10.808	0.001	0.000	0.000	301) Chapter E - Flexural Buckling around
Besults		0.000	LC1	-72.140	0.000	-10.808	0.001	0.000	0.000	311) Chapter E - Flexural Buckling around
Design bull oad Case		0.000	LC1	-72.140	0.000	-10.808	0.001	0.000	0.000	321) Chapter E - Torsional Buckling acc. tr
Design by Cross-section		1.000	LC2	-23. <b>438</b>	0.000	-13.941	0.000	-13.941	0.000	350) Set of Members - Stability Analysis of
Design by Set of Members		0.000	LC1	-72.140	0.000	-10.808	0.001	0.000	0.000	400) Chapter L - Design for Serviceability -
Design by Seconnembers		3.000	LC1	-45,166	0.000	-10.808	0.001	-32,423	0.000	401) Chapter L - Design for Serviceability -
Design by Member										
- Governing Internal Forces bu M										
Governing Internal Forces by St										
Member Slendernesses										
- Parts List bu Member										
Parts List by Member										
Parts List by Set of Members										
										è 👻 🔍
	Calcula	ation	Details				Gra	aphic		OK Cancel

Figure 4.7: Table 3.2 Governing Internal Forces by Set of Members

In this results table, the governing internal forces that lead to the maximum design ratios of every set of members are shown.

# 4.8 Member Slendernesses

CA1 - Steel Design according to 🔽	3.3 Mer	nber Slendernesses							
nput Data		A	B	С	D	E	F	G	Н
- General Data	Member No	Under Charac	Length	V I	Major Axis y	<b>K</b> 1 1	V I	Minor Axis z	KII.
- Materials	110.	Under Stress	L [m]	Ny	ry [mm]	NyL / Iy	Nz	rz (mm)	N2L / 12
Cross-sections		Compression/Flexure	6.000	1.000	91.8	65.391	1.000	52.8	113.6
- Lateral Intermediate Supports	2	Compression/Flexure	6.000	1.000	91.8	65.391	1.000	52.8	113.6
Effective Lengths - Members	3	Compression/Flexure	3.011	1.000	168.3	17.894	1.000	39.4	/6.4
<ul> <li>Effective Lengths - Sets of Men</li> </ul>	4	Compression/Flexure	3.262	1.000	168.6	19.350	1.000	39.9	81.7
- Design Parameters	5	Compression/Flexure	6.274	1.000	168.6	37.212	1.000	39.9	157.2
Nodal Supports	5	Lompression/Flexure	6.274	1.000	168.6	37.212	1.000	39.9	157.2
Set of Members No. 2 - Set		Compression/Flexure	3.262	1.000	168.6	19.350	1.000	39.9	81.7
Member Releases	8	Compression/Flexure	3.011	1.000	168.3	17.894	1.000	39.4	/6.4
- Set of Members No. 2 - Set	10	Compression/Flexure	6.000	1.000	91.8	65.391	1.000	52.8	113.6
<ul> <li>Serviceability Data</li> </ul>	12	Compression/Flexure	6.000	1.000	91.8	65.391	1.000	52.8	113.6
Results	13	Compression/Flexure	3.011	1.000	168.3	17.894	1.000	39.4	/6.4
— Design by Load Case	14	Compression/Flexure	3.262	1.000	168.6	19.350	1.000	39.9	81.7
<ul> <li>Design by Cross-section</li> </ul>	10	Lompression/Flexure	6.274	1.000	168.6	37.212	1.000	39.9	157.2
<ul> <li>Design by Set of Members</li> </ul>	16	Compression/Flexure	6.274	1.000	168.6	37.212	1.000	39.9	157.2
<ul> <li>Design by Member</li> </ul>	17	Compression/Flexure	3.262	1.000	168.6	19.350	1.000	39.9	81.7
Design by x-Location	18	Compression/Flexure	3.011	1.000	168.3	17.894	1.000	39.4	76.4
<ul> <li>Governing Internal Forces by M</li> </ul>	21	Compression/Flexure	6.000	1.000	91.8	65.391	1.000	52.8	113.6
- Governing Internal Forces by S	22	Compression/Flexure	6.000	1.000	91.8	65.391	1.000	52.8	113.6
Member Slendernesses	23	Compression/Flexure	3.011	1.000	168.3	17.894	1.000	39.4	76.4
<ul> <li>Parts List by Member</li> </ul>	24	Compression/Flexure	3.262	1.000	168.6	19.350	1.000	39.9	81.7
Parts List by Set of Members	25	Compression/Flexure	6.274	1.000	168.6	37.212	1.000	39.9	157.2
	26	Compression/Flexure	6.274	1.000	168.6	37.212	1.000	39.9	157.2
		Members with Tension Onl	y:		Members wi	th Compression	h / Flexure:		
		Max KyL / ry: 168.975	5 ≤ 300 (	3	Max KyL / ry	<sub>/</sub> 168.975	i ≤ 200 (	9	
		Max K <sub>2</sub> L / r <sub>2</sub> : 193.406	6 ≤ 300	3	Max K <sub>z</sub> L /r <sub>z</sub>	193.406	≤ 200 🤇	•	<b>1</b>

Figure 4.8: Table 3.3 Member Slendernesses



In table 3.3, the effective slenderness ratios of all designed members are compared with the maximum values that were set in the *Details* dialog box (see Chapter 3.1). These ratios are listed with respect to the major and minor principal axes. This table provides information on the maximum effective slenderness ratios only, it does not give any design results.

Members of the types "Tension" or "Cable" are excluded from this table.

# 4.9 Parts List by Member

🖂 - Steel Design according to 🔽	4.1 Pa	rts List by Member								
nput Data		A	В	С	D	E	F	G	н	1
- General Data	Part		Number	Length	Tot Length	Surf. Area	Volume	Unit Weight	Weight	Tot Wei
Materials	NO.	Cross-section	Members	[m]	[m]	[m <sup>2</sup> ]	[m <sup>3</sup> ]	[kg/m]	[kg]	[t]
- Cross-sections	1	1 · W 8x48 (AISC)	6	6.00	36.00	45.52	0.33	71.41	428.46	2.5
- Lateral Intermediate Supports	2	2 · W 16x45 (AISC) 3 · W 16x	8	3.01	24.09	37.40	0.20	63.56	191.40	1.
- Effective Lengths - Members	3	2 - W 16x45 (AISC)	8	3.26	26.10	40.62	0.22	67.36	219.75	1.
Effective Lengths - Sets of Men	4	2 - W 16x45 (AISC)	8	6.27	50.19	78.12	0.43	67.36	422.60	3.3
- Design Parameters	5	1 · W 8x48 (AISC)	4	3.00	12.00	15.17	0.11	71.41	214.23	0.
Nodal Supports	6	10 - HP 8x8.2x36 (AISC)	3	3.00	9.00	10.72	0.06	53.68	161.05	0.
Set of Members No. 2 - Set	7	10 - HP 8x8.2x36 (AISC)	2	3.55	7.09	8.45	0.05	53.68	190.36	0.3
- Member Releases	8	10 - HP 8x8.2x36 (AISC)	1	4.09	4.09	4.88	0.03	53.68	219.78	0.
Set of Members No. 2 - Set	9	15 - HP 10x10.1x42 (AISC)	4	3.00	12.00	17.62	0.10	62.80	188.40	0.
Serviceability Data	10	6 - HP 10x10.1x42 (AISC)	3	3.00	9.00	13.22	0.07	62.80	188.40	0.
Results	11	6 - HP 10x10.1x42 (AISC)	2	3.55	7.09	10.41	0.06	62.80	222.69	0.
- Design by Load Case	12	6 - HP 10x10.1x42 (AISC)	1	4.09	4.09	6.01	0.03	62.80	257.10	0.3
- Design by Cross-section	13	7 - HP 8x8.2x36 (AISC)	4	6.27	25.10	29.90	0.17	53.68	336.80	1.
- Design by Set of Members	14	9 - W 18x40 (AISC)	8	6.25	50.00	77.18	0.38	59.76	373.51	2.
Design by Member	15	16 - W 14x38 (AISC)	1	6.55	6.55	9.29	0.05	56.72	371.31	0.
Design by x-Location	16	6 - HP 10x10.1x42 (AISC)	1	7.09	7.09	10.42	0.06	62.80	445.50	0.
- Governing Internal Forces by M	17	6 - HP 10x10.1x42 (AISC)	1	6.55	6.55	9.61	0.05	62.80	411.09	0.
Governing Internal Forces by Su	18	12 - SHS 3x0.125 (AISC)	25	5.00	125.00	36.74	0.11	7.09	35.45	0.
Member Slendernesses	19	13 - Circle 24	4	7.81	31.24	2.36	0.01	3.55	27.74	0.1
Parts List by Member	20	13 - Circle 24	8	8.02	64.18	4.84	0.03	3.55	28.49	0.
Parts List by Set of Members	Sum		102		516.46	468.47	2.55			19.
									F)	۹ (

Figure 4.9: Table 4.1 Parts List by Member

Finally, the parts list of all cross-sections that are considered in the given design case is displayed. This list contains only designed members by default. If all members of the structure are to be included, you can modify the setting in the *Details* dialog box (see Figure 3.1 on page 27) that can be opened via the [Details] button.

Part No.

Details...

The same part number is automatically assigned to identical members.

#### **Cross-section**

In this column, the cross-section description is displayed.

#### Number of Members

The number of identical members is given for each part.

#### Length

This column displays the unit lengths of every single member.

#### **Total Length**

This column represents the product of the values given in the two previous columns.



### Surface Area

The surface area which is related to the total length of the relevant part is calculated on the basis of the value  $A_{surf}$  of each cross-section. You can check on this value by clicking on the [Info about Current Cross-Section...] button in tables 1.3 or 2.1 to 2.5.

### Volume

8

The volume of every part is calculated from the surface area and the total length.

#### **Unit Weight**

The *Unit Weight* of the cross-section represents the weight per length of 1 m. In case of tapered cross-sections, the unit weight is calculated as the mean value of both cross-sections.

#### Weight

The value in this column is calculated as the product of values in the columns C and G.

### **Total Weight**

The total weight of each part is displayed in the last column.

#### Sum

The sums of the values in the individual columns are given in the final row of the list. The cell *Total Weight* shows the total required amount of steel.

## 4.10 Parts List by Set of Members

STEEL AISC - [Demo-5eng]										X
File Edit Settings Help										
CA1 - Steel Design according tc 🔽	4.2 Pa	ts List by Set of Members								
CA1 - Steel Design according tc ♥ Input Data General Data Materials Cross-sections Effective Lengths - Members Effective Lengths - Members Effective Lengths - Members Filterative Lengths - Sets of Mem Design Parameters Set of Members No. 2 - Set Set of Members No. 2 - Set Serviceability Data Results Design by Load Case Design by Case-section Design by Set of Members Design by Member Design by Wember Design by Wember Design by Member Design by Member Design by Member Governing Internal Forces by M Governing Internal Forces by Si Member Stendemesses Parts List by Member	Part No. Sum	A Description of Set of Members Set of Members 2	B Number Sets 1 1	C Length (m) 6.00	D Tot Length (m) 6.00 6.00	E Suf. Area [m <sup>2</sup> ] 7.59 7.59	F Volume [m <sup>3</sup> ] 2 0.05 0.05	G Unit Weight [kg/m] 71.41	H Weight [kg] 428.46	I Tot Weigh (1) 0.428 0.428
Parts List by Set of Members	Calcula	tion Details			Graphic			40		Cancel
						_				

Figure 4.10: Table 4.2 Parts List by Set of Members

The last table in STEEL AISC is presented when at least one set of members was selected for the design. The advantage of this table is that a parts list is given for the various groups of elements (e.g. for a beam).

The table columns are described in Chapter 4.9. If there are different cross-sections within the set of members, the mean values of surface area, volume and unit weight are listed.



# 5. Evaluation of Results

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

STEEL AISC - [Demo-5eng]															×
File Edit Settings Help															
CA1 - Steel Design according to 🗸	2.2 De	sign by	Cross-sec	tion											
Input Data		A	В	C	D	E				F					^
- General Data	Section	Member	Location	Load	Desigr	1									
- Materials	No.	Nr.	x [m]	Case	Ratio				Design a	cord	ing to	Formula			
Cross-sections	3	W 16x4	D (AISC)												
- Lateral Intermediate Supports		8	3.011	LC4	0.00	≤1	100) No oi	Very	Small Internal Ford	es					
- Effective Lengths - Members		23	0.000	LC2	0.66	≤1	111) Chap	ter F -	Yielding · Bending	arou	ind y-A	wis acc. to F	2 - F12		
- Effective Lengths - Sets of Men		23	0.000	LC2	0.78	≤1	113) Chap	ter F -	Lateral-Torsional I	Buckl	ing∙a	acc. to F2 - F	5		
<ul> <li>Design Parameters</li> </ul>		3	0.000	LC1	0.00	≤1	122) Chap	ter F -	Flange Local Buc	kling	does r	not Apply - ac	cc. to F2 -	F5	
- Nodal Supports		23	0.000	_LC2 [	0.10	≤1	160) Chap	ter G -	Nominal Shear SI	rengt	h in z-	Axis - acc. to	G2 (G4,G	5) - Unstif	ŕ
- Set of Members No. 2 - Set		23	0.000	LC2	0.67	≤1	204) Chap	ter H -	Compressive For	e wit:	h Sing	ile/Major Axis	s Bending	- acc. to H	1
Member Releases		41	0.000	LC2	0.05	≤1	303) Chap	ter E -	Flexural Buckling	arour	nd y-Ai	kis acc. to E7	7 - Slender	elements	
Set of Members No. 2 - Set		41	0.000	LC2	0.08	≤1	313) Chap	ter E -	Flexural Buckling	arour	nd z-Ai	kis acc, to E7	7 - Slender	elements	~
- Serviceability Data				May [	1.44	>1	<u>A</u>			۱ 💽		E	<b>V</b>		5
Results				Max.	1.44		•				-		21		10
- Design by Load Case										- 1					
<ul> <li>Design by Cross-section</li> </ul>	Details	- Memt	<u>er 23 - x:</u>	0.000 r	n - LC2						3 - 2: \	/V 16×40 (Als	SC) - W 16	6x45 (AIS)	C)
- Design by Set of Members	⊞ Mater	ial Values	- Steel S 35	5						^		+ 13	77.7 +		
- Design by Member	Cross	-section V	alues • W 1	6x40 (AISC	3										
<ul> <li>Design by x-Location</li> </ul>	⊕ Desig	n Internal	Forces										- T	t	
- Governing Internal Forces by M	Cross	-section T	уре									8 2			
- Governing Internal Forces by S	🖃 Desig	n Ratio									r-,		~		
- Member Slendernesses	- Re	quired Sh	ear Strength	Vr,z		44.282	2 kN				<u></u>		- <del>8</del>	· •	
<ul> <li>Parts List by Member</li> </ul>	— h/t	w Ratio		h/tw		44.689	)						7.7	-	
- Parts List by Set of Members	- Sh	ear Area		A <sub>w,z</sub>		3150.3	3 mm <sup>2</sup>		(G2)						
	- We	eb Shear (	Coefficient	Cv		1.00	)		(G2-2)				here -	+	
	— Mo	dulus of E	lasticity	E	21	000.00	) kN/cm <sup>2</sup>	_					÷		
	Yie	ld Stress		Fy		35.50	) kN/cm <sup>2</sup>						z		
	- No	minal She	ar Strength	Vn,z	6	671.024	kNm		(G2-1)					[n	nm]
	Sal	ety Facto	r for Shear	Ωv		1.500			(G1)		A		X		X
		wable Sh	ear Strength	Vn,z	/11.v 2	147.350	kNm			~	9		-		~
	Calcula	ation	Details	]				Gra	phic			OK		Cancel	

Figure 5.1: Buttons for Evaluation of Results

These buttons have the following functions:

Button	Name	Function
9	Design of Ultimate Limit State	Switch on/off the design results of the ultimate limit state
2	Design of Serviceability Limit State	Switch on/off the design results of the serviceabi- lity limit state
	Show Color Bars in Table	Switch on/off the color background in the results tables according to the reference scale
<b>%</b> 1	Show Rows with Ratio > 1	Show only rows with the stress ratios greater than 1 and, accordingly, the failed design
2	Show Result Diagrams of Current Member	Open the diagram <i>Result Diagram on Member</i> → Chapter 5.2, page 41
۲	Jump to Graphics to Change View	Go to the RSTAB work window in order to change the display settings
₹₹	Pick Member in Graphics and Go to This Member in Table	Click on a specific member in the RSTAB window whose result values are to be displayed in the table

Table 5.1: Buttons in Results Tables 2.1 to 2.5



## 5.1 Results on RSTAB Model

You can use the RSTAB work window to evaluate the design results. The RSTAB graphics in the background can be useful if you want to check the location of a specific member in the model: the member that is selected in the STEEL AISC results table is also highlighted in the selection color in the RSTAB background graphics. Additionally, an arrow marks the member location x which is stated as decisive in the selected line.



Figure 5.2: Selection of Member and Current Location x in RSTAB Model

If you do not get a favorable view even by moving the STEEL AISC window, you can apply the so-called *View Mode* by clicking on the [Change View] button: the STEEL AISC window is switched off and you can change the view on the RSTAB model. In this mode, the functions from the *View* menu are available, e.g. zoom, move or rotate the view.

The design ratios can be also displayed directly on the structural model. Close STEEL AISC via the [Graphic] button. The design ratios are then shown graphically in the RSTAB work window.

🔎 🏋

Similarly to the internal forces of RSTAB, you can activate or deactivate the design results by the [Results on/off] button. The [Show Result Values] button controls the display of the numerical values in the graphics.

Regarding the fact that the RSTAB tables are irrelevant to evaluate the STEEL AISC results, you can deactivate them by using the button visible on the left.









LC1 - Vz 🛛 🗸 🗸	$\triangleleft$
LC1 - Vz	
STEEL AISC CA1 - Steel Desig	n N
	72

A particular design case can be selected from the list of cases in the RSTAB toolbar.

The display of the results can be also controlled by the *Display* navigator, using the entry  $Results \rightarrow Members$ . The design ratio is displayed *Two Colored* by default.



Figure 5.3: Display Navigator: Results  $\rightarrow$  Members  $\rightarrow$  Two Colored

If you select the *Colored* results display, the panel colors becomes available with various options for the multicolor display. Those are described in Chapter 4.4.6 of the RSTAB manual.



Figure 5.4: Design ratios for Option Cross-sections in the Display Navigator



As for the member internal forces, you can set the scale factor for the graphics of the design results in the *Factors* tab. If you enter the factor *0* in the *Member Diagrams* input field, the design ratios will be shown with an increased line thickness.

This graphic view can be incorporated to the global printout report (see Chapter 6.2 on page 44).

You can return to STEEL AISC any time by clicking on the [STEEL AISC] button in the panel.

## 5.2 Result Diagrams

In order to view the detailed distribution of results of a specific member, the graph of results can be used. Select the relevant member or set of members in the results table of STEEL AISC and then activate the diagram by the button as seen to the left. This button is located below the upper tables of results.

The result diagrams are available in the RSTAB window via the main menu

#### Results $\rightarrow$ Member Results

or by using the corresponding button in the toolbar.

A new window is opened in which the result diagrams of the selected member or set of members are shown.



Figure 5.5: Result Diagram on Member Dialog Box

A particular design case can be selected from the list in the toolbar.

The *Result Diagram on Member* dialog box is described in detail in Chapter 9.8.4 of the RSTAB manual.



2

STEEL AISC

LC1 - Vz 
CC1 - Vz
LC2 - Vy
STEEL AISC CA1 - Steel Design



## 5.3 Filtering Results

The structure of the STEEL AISC tables makes it already possible to select the results according to certain criteria. Additionally, you can use the filter functions as described in the RSTAB manual to graphically evaluate the STEEL AISC results.

Firstly, you can use already defined partial views (cf RSTAB manual, Chapter 9.8.6) that group certain objects in a favorable way.

Secondly, you can set the stress ratios as criteria for filtering the results in the RSTAB work window. For this, the so-called control panel is to be displayed. If it is not visible, you can switch it on in the main menu

#### View $\rightarrow$ Control panel

or by clicking on the corresponding button in the Results toolbar.

This panel is described in Chapter 4.4.6 of the RSTAB manual. The settings to filter the results are defined in the *Color Spectrum* tab of the panel. As this register is not available in case of the two colored stress display, it can be switched on by selecting one of the display options *Colored* or *Cross-Sections* in the *Display* navigator.



Figure 5.6: *Display* Navigator: Results  $\rightarrow$  Members  $\rightarrow$  Colored

For a colored view of the results, you can set in the panel that e.g. only design ratios greater than 0.30 are to be displayed. Furthermore, you can adjust the color spectrum in a way that one single color range exactly covers the design ratio 0.05 (see Figure 5.7).

By the option *Display hidden result diagram* (*Display* navigator, entry Results  $\rightarrow$  Members), you can also display design results that do not satisfy the given conditions. Those design diagrams will then be drawn as dashed lines.







Figure 5.7: Filtering of Stress Ratios with Adjusted Color Spectrum

#### **Filtering Members**

1

In the *Filter* tab of the control panel, you can enter the numbers of the members whose design ratios are to be shown in the graphics. This function is described in Chapter 9.8.6 of the RSTAB manual.

Contrary to the partial view function, the entire structure is displayed here. The following figure shows the design ratios in the compressed flange of a footbridge. The other members of this structure are also shown in the model but they are without any design ratios.



Figure 5.8: Filtering Members: Design Ratios of Footbridge Flange



# 6. Printout

# 6.1 Printout Report

For the design results of STEEL AISC, a printout report can be created to which you can add graphics and comments. In this printout report, it is also possible to select the results tables of STEEL AISC that are to be printed.

The printout report is described in detail in the manual of the RSTAB program. In particular, Chapter 10.1.3.4 *Selecting Data of Add-on Modules* on page 227 is important. It deals with the selection of input and output data in all add-on modules.

You can create several printout reports for every design case. For very large structures, it is recommended to create several smaller reports instead of a single extensive one. If you create a specific report only for data of the STEEL AISC design case, the printout report will be processed fairly quickly.

# 6.2 Print STEEL AISC Graphics

It is possible to print the stress ratios displayed on the RSTAB model. All graphics can be incorporated to the printout report or sent directly to the printer. Chapter 10.2 of the RSTAB manual describes in detail how to print graphic displays.

#### **Results on RSTAB Model**

Every image of the RSTAB work window can be included in the printout report. The current STEEL AISC graphics is printed by using the main menu

 $\textbf{File} \rightarrow \textbf{Print}...$ 

or by clicking on the corresponding button in the toolbar.

ş	用 RSTAB 7.02 - [STEEL AISC]								
	4⊳	Eile	<u>E</u> dit	: <u>V</u>	jew	Inse	ert	⊆alcul	ate
		2	3	3	Ħ				5
	¢,	Ŷ₁	2	1	24	-	Ē	v Print	1

Figure 6.1: Print Button in Toolbar in Main Window

#### **Result Diagram**

You can also print the result diagrams of members by clicking on the [Print] button in the *Result Diagram on Member* window.

月 Result Diagram on Mem	ber
E 📷 STEEL AISC CA1 - S	iteel De 💌 \land 🔉 🔛 🔀
Navigator 🧷 🗴	
Design Ratio	
	Design Ratio [-]

Figure 6.2: Print Button in Toolbar of Result Diagram Window

The following dialog box opens.





Graphic Printout		D					
General Options Color Spectrum							
Graphic Picture	To Print Window	Graphic Size					
💿 Direct to Printer 💽	💿 Current Only	🔿 As Screen View					
🔿 In Printout Report: 🔃 🗸	🔿 All 📃	💿 Window Filling					
🔿 To Clipboard		🔿 To Scale 1: 100 🔽					
Graphic Picture Size	Options						
🔽 Use Whole Page Width	Show Printout Re	port on					
🔽 Use Whole Page Height							
Height: 100 \$ [% of Page]	Show Results for the Result Diagra	Selected x-Location in m					
Rotation: 0 🗢 [*]	Lock Graphic Pic	Lock Graphic Picture (without Update)					
Header of Graphic Picture							
STEEL AISC - Members Design R	atio, CA1						
D		OK Cancel					

Figure 6.3: Graphic Printout Dialog Box, General Tab

This dialog box is described in detail in chapter 10.2 on page 243 in the RSTAB manual. The remaining two tabs *Options* and *Color Spectrum* are also explained there.

In the printout report, any image of the STEEL AISC results can be moved to a different location by the Drag&Drop function. It is also possible to adjust inserted images subsequently: right mouse click on the relevant entry in the report navigator, then select *Properties* in the context menu. The *Graphic Printout* dialog box is displayed again in which the possible changes can be set.

Graphic Printout		X
General Options Color Sp	pectrum	
Script Proportional Constant Factor: 1	Symbols <ul> <li>Proportional</li> <li>Constant</li> </ul> Factor: 1 \$	Frame ○ None ④ Framed □ Title Box
Print Quality  Standard (max 1000 x 1)  Maximal (max 5000 x 50)	000 Pixels) 00 Pixels)	Color ◯ Lines and Text Black ⓒ All Colored
OUser Defined Max N of Pixe	umber els: 1000 😴	
D		OK Cancel

Figure 6.4: Graphic Printout Dialog Box, Options Tab

Remove from Printout Report Start with New Page

Selection...



# 7. General Functions

This chapter describes the commonly used functions of the main menu as well as the export options of the design results.

# 7.1 STEEL AISC Design Cases

There is an option to group members into separate design cases. In this way, it is possible to design separately certain structural parts with specific parameters, for example.

A member or set of members can be analyzed in different design cases without any problem.

All design cases created in STEEL AISC are contained in the list of load cases and load groups in the toolbar in the RSTAB work window.

### **Create New STEEL AISC Case**

A new design case can be created from the STEEL AISC main menu

File  $\rightarrow$  New Case...

The following dialog box opens:

New ST	EEL AISC-Case
No.	Description Steel Design according to AISC (LRFD or AS 🗸
D	OK Cancel

Figure 7.1: New STEEL AISC-Case Dialog Box

In this dialog box, you need to fill in the (not yet used) *Number* and *Description* of the new design case. After closing the dialog box with [OK], the STEEL AISC table 1.1 *General Data* is shown where you can define the new design data.

### **Rename STEEL AISC Case**

The description of a design case can be changed via the STEEL AISC main menu

File  $\rightarrow$  Rename Case...

The Rename STEEL AISC-Case dialog box is opened.

Rename	STEEL AISC-Case
No.	Description New Description
٦	OK Cancel

Figure 7.2: Rename STEEL AISC-Case Dialog Box





### **Copy STEEL AISC Case**

The input data of the current design case can be copied via the STEEL AISC main menu

File  $\rightarrow$  Copy Case...

The *Copy STEEL AISC-Case* dialog box opens. Enter the number and description of the new design case into which the selected case is to be copied.

Figure 7.3: Copy STEEL AISC-Case Dialog Box

### Delete STEEL AISC Case

Design cases can be deleted via the STEEL AISC main menu

 $\textbf{File} \rightarrow \textbf{Delete Cases}...$ 

In the *Delete Cases* dialog box, select a specific design case from the list of *Available Cases*. It will be deleted when clicking on [OK].

Delete	Delete Cases								
Availabl	e Cases								
No.	Description	^							
1 2	Steel Design Design of bottom flange								
3	Design of top flange								
		~							
Ø	ОК	Cancel							

Figure 7.4: Delete Cases Dialog Box



# 7.2 Cross-Section Optimization

The module STEEL AISC offers the possibility to optimize cross-sections. For this, select the cross-section that is to be optimized in column D resp. E of table 1.3 *Cross-sections* by ticking the appropriate box (see Figure 2.6 on page 13).

You can also start the optimization of a cross-section via the context menu in the results tables.

During the optimization, STEEL AISC examines which cross-section within the same crosssections series satisfies the design "optimally", i.e. is the closest to the maximum allowable design ratio which has been defined in the *Details* dialog box, section *Cross-section Optimization* (see Figure 3.1). The required cross-section properties are calculated on the basis of the internal forces from RSTAB. Finally, the cross-section is chosen which satisfies the design with the highest possible design ratio. For this reason, two cross-sections are shown graphically in table 1.3 on the right – the original cross-section from RSTAB and the optimized one (see Figure 7.6).

When ticking the optimization box for parameterized cross-sections from the library, the following dialog box appears for you to enter detailed data.



Figure 7.5: Welded Cross-Sections - I-Symmetric: Optimize Dialog Box

At first, select the parameter(s) that you want to modify in column *Optimize*. Hence, the columns *Minimal* and *Maximal* become accessible where the upper and lower limits of each optimization parameter can be defined. The column *Increment* controls in which intervals the parameter dimensions vary during the optimization process.

If you want to *Keep Current Side Proportions*, tick the corresponding box in the lower part of this dialog box. Additionally, it is necessary to tick all parameters for the optimization.

It is not possible to carry out the optimization for combined rolled cross-sections.



Please keep in mind that during the optimization the internal forces will not be recalculated automatically on the basis of the modified cross-sections. It depends on the user's decision when and which cross-sections are to be adapted in RSTAB for a new analysis. The internal forces based on the optimized cross-sections may differ considerably due to the changed rigidities within the structural model. Thus, we recommend recalculating the internal forces after one optimization run and then optimizing the cross-sections once more.





It is not necessary to transfer the modified cross-sections to RSTAB manually. Open table 1.3 *Cross-sections* and select in the main menu

 $\mathsf{Edit} \to \mathsf{Export} \ \mathsf{All} \ \mathsf{Cross}\text{-}\mathsf{Sections} \ \mathsf{to} \ \mathsf{RSTAB}$ 

The option to export the modified cross-sections to RSTAB is also contained in the context menu of table 1.3.

STEEL AISC - [Demo-5eng]								X		
File Edit Settings Help										
CA1 - Steel Design according to 🗸	1.3 Cro	oss-secti	ons							
Input Data	Castion	A	B	C.	D	E	F	16 - W 10x19 (AISC)		
- General Data Materials	No.	No.	Description [mm]	for Classification	mize	Remark	Comment			
- Cross-sections	1	1	IPE 500	I-shape rolled						
<ul> <li>Lateral Intermediate Supports</li> </ul>	2	1	IPE 450	I-shape rolled	<u> </u>			Υ .		
<ul> <li>Effective Lengths - Members</li> </ul>	3	1	IPE 450	I-shape rolled	<u> </u>					
<ul> <li>Effective Lengths - Sets of Men</li> </ul>		1	HE-A 160	I-shape rolled	<u> </u>					
<ul> <li>Design Parameters</li> </ul>		1	HE-A 140	I-shape rolled	<u> </u>			* *		
Nodal Supports	9	2	IPE 400	I-shape rolled	<u> </u>			-		
Set of Members No. 2 - Slev	10	1	HE-A 140	I-shape rolled	<u> </u>			16 - W 10x12 (AISC)		
Member Releases	12	1	QHU 80x4	Box Holled	<u> </u>			RSTAB		
Set of Members No. 2 - Slev	15	1	Lircle 24	Hound Bar	<u> </u>					
	10	1	HE-A 200	I-shape rolled	<u> </u>	43		······		
	17	1	W TUXT9 (AISU)	Info about Cross-	section			У		
	- 17	1	LISUXIUUXIZ							
				Cross-section Libra	ary			i i		
				.1 🔸	1					
				Optimize Cross-se	ction			🔁 🏹 🕰		
				Cross-section Opti	imization	Parameter:	5	o		
				Export Cross-secti	ion to RS	ТАВ		Members: 81		
				Export <u>A</u> ll Cross-se	ections to	RSTAB	И	Sets of		
				Import Cross-sect	ion from I	RSTAB		Members:		
				Import All Cross-se	ections fr	om RSTAB		Σ Length: 6.55 [m]		
			L					Σ Weight: 0.186 [t]		
			1) The cross-se STEEL AISC.	ection in RSTAB is differ	rent to tha	at in	۵ 🐧	Material: 1 - Steel S 355		
	Calcula	tion	Details			Graphic	]	OK Cancel		
Exports current cross-section to main	program a	nd deletes	results.							

Figure 7.6: Context Menu in Table 1.3 Cross-Sections

Before the cross-sections are transferred to RSTAB, a question appears because exporting also implies deleting the results. If you then start the [Calculation] in STEEL AISC, the internal forces of RSTAB and the design ratios of STEEL AISC are calculated in one calculation run.

STEEL AISC Question No. 252
Do you want to transfer the changed cross-sections to RSTAB
If so, the results of RSTAB and STEEL AISC will be deleted.

Figure 7.7: Question before Transferring Modified Cross-Sections to RSTAB

In a similar way, you can reload the original cross-sections from RSTAB to STEEL AISC by using the appropriate functions in the main menu or context menu. Please note that this option is only available in table 1.3 *Cross-Sections*.



If you want to optimize a tapered member, the cross-sections of the member start and of the member end are optimized. After this, the moments of inertia are linearly interpolated at the intermediate locations of the member. As those are considered by the fourth power, the stress design may be inaccurate if there are big differences in height of the start and end cross-sections. In such a case, we recommend dividing tapers into several members whose start and end cross-sections do not show such big differences.



# 7.3 Import / Export of Materials

If you change a material in table 1.2 of STEEL AISC, you can export it to RSTAB like crosssections or also reload the original material from RSTAB to the module. The materials that have been modified in the module are marked in blue color.

It is not necessary to transfer the modified materials to RSTAB manually. Instead, open table 1.2 *Materials* and choose in the main menu

Edit  $\rightarrow$  Export all Materials to RSTAB.

The option to export modified materials to RSTAB is also included in the context menu of table 1.2.

STEEL AISC - [Demo-5eng]									×
File Edit Settings Help									
CA1 - Steel Design according to 🗸	1.2 Ma	terials							
Input Data		Α			В				
- General Data Materials	Material No.	Material Description			Comment				
Cross-sections	1	Steel S 355							
<ul> <li>Lateral Intermediate Supports</li> <li>Effective Lengths - Members</li> </ul>	2	Steel A36	Material Library						
<ul> <li>Effective Lengths - Sets of Men</li> <li>Design Parameters</li> </ul>			E	xport Materia	l to RSTAB	<b>R</b>			
Nodal Supports Set of Members No. 2 - Slev	Materia	al Properties	E) 	xport <u>A</u> ll Mate	erials to RSTAB				
Member Releases	E RST/	AB Relevant dulus of Elasticity	Import All Materials from RSTAB						
	— She	ear Modulus		G	76899.200	MPa			
	— Poi	sson´s Ratio		μ	0.300				
	— Uni	t Weight		γ	78.50	kN/m <sup>3</sup>			
	— Coe	efficient of Thermal Expansion		α	1.2000E-05	1/°C			
	- Par	tial Safety Factor		γм	1.00				
	🗆 Desi	gn Relevant							
	— Yie	ld Strength		fy	248.199	MPa	Material No	o. 2 Used in	
	— Ulti	mate Tensile Strength		fu	399.876	MPa	Cross-		
	— Ma	x. Structural Thickness (for Range 1)		ti –	20.32	cm	sections:	9	
	- Yie	ld Strength (for Range 2)		fy,2	220.621	MPa		00 00 71 74	
							Members:	66-69,71-74	
							Sets of Members:		
							inclibers.		
							Σ Length:	50.00 [m]	
							Σ Weight:	3.317 [t]	
							-		
< >>									
	Calcula	tion Details			Graphic	)		ОК	Cancel
Exports material to main program.									

Figure 7.8: Context Menu in Table 1.2 Materials

<u>Calculation</u>

Before the materials are transferred to RSTAB, a question is shown because exporting also implies deleting the results. If you then start the [Calculation] in STEEL AISC, the internal forces of RSTAB and the design ratios of STEEL AISC are calculated in one calculation run.

STEEL AISC Question No. 366
Do you want to transfer the changed materials to RSTAB?
If so, the results of RSTAB and STEEL AISC will be deleted.

Figure 7.9: Question before Transferring Modified Materials to RSTAB



# 7.4 Units and Decimal Places

The units and decimal places are centrally managed for RSTAB and all its add-on modules. In STEEL AISC, open the dialog box to set the units via the main menu

Settings  $\rightarrow$  Units and Decimal Places...

The familiar RSTAB dialog box opens. The module STEEL AISC is already set by default.

Units and Decimal Places						×
Units and Decimal Places Program / Module RSTAB STEEL ASD RSBUCK STEEL AISC STEEL IS STEEL IS STEEL SIA	STEEL AISC Output Data Stresses: Design Ratios: Unitless:	Unit KN/cm <sup>*</sup> 2	Dec. Places	Parts List Lengths: Total Lengths: Surface Areas: Volumes: Single Weights: Weights: Total Weights:	Unit m v m^2 v m^3 v kg/m v t v	Dec. Places 2 2 2 2 2 2 2 2 2 2
					ОК	Cancel

Figure 7.10: Units and Decimal Places Dialog Box

The settings can be stored as a user profile. They can also be applied later in different cases. This function is described in Chapter 11.6.2 of the RSTAB manual.

## 7.5 Exporting Results

The design results can be transferred to other programs in different ways.

### Clipboard

Select the relevant cells in the results table of STEEL AISC and copy them to the clipboard via [Ctrl]+[C]. The contents can then be inserted via [Ctrl]+[V] to e.g. some text processing program. The headers of the table columns are not exported.

### **Printout Report**

The STEEL AISC data can be sent to the printout report (see Chapter 6.1, page 44) and then be exported via the main menu

File  $\rightarrow$  Export to RTF File or BauText...

This function is described in Chapter 10.1.11 of the RSTAB manual on page 239.



### Excel / OpenOffice

STEEL AISC enables you to directly export data to MS Excel or OpenOffice.org Calc. Call up this function via the main menu

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

The following dialog box opens:



Figure 7.11: Export - MS Excel Dialog Box

As soon as you have chosen the relevant options, you can start the export by [OK]. Excel or OpenOffice do not need to run in the background, they will be started automatically before the export.

	A	В	С	D	E	F	G
1	Section	Member	Location	Load	Desigr	n	
2	No.	Nr.	× [m]	Case	Ratio		Design according to Formula
3	1	IPE 500					
4		21	6,000	LC2	0,36	≤1	111) Chapter F - Yielding - Bending around y-Axis acc. to F2 - F12
5		21	6,000	LC2	0,66	≤1	113) Chapter F - Lateral-Torsional Buckling - acc. to F2 - F5
6		1	1,000	LC2	0,00	≤1	122) Chapter F - Flange Local Buckling does not Apply - acc. to F2 - F5
7		32	0,000	LC2	0,10	≤1	160) Chapter G - Nominal Shear Strength in z-Axis - acc. to G2 (G4,G5) - Uns
8		21	6,000	LC2	0,51	≤1	204) Chapter H - Compressive Force with Single/Major Axis Bending - acc. to
9		21	0,000	LC2	0,02	≤1	303) Chapter E - Flexural Buckling around y-Axis acc. to E7 - Slender element
10		21	0,000	LC2	0,07	≤1	313) Chapter E - Flexural Buckling around z-Axis acc. to E7 - Slender element
11		21	0,000	LC2	0,03	≤1	323) Chapter E - Torsional Buckling acc. to E4 and E7 - Slender elements
12		1	1,000	LC2	1,33	>1	350) Set of Members - Stability Analysis of Doubly and Singly Symmetric Mem
13							
14	2	IPE 450					
15		23	0,000	LC2	0,46	≤1	111) Chapter F - Yielding - Bending around y-Axis acc. to F2 - F12
16		25	5,647	LC2	0,56	≤1	113) Chapter F - Lateral-Torsional Buckling - acc. to F2 - F5
17		3	0,000	LC2	0,00	≤1	122) Chapter F - Flange Local Buckling does not Apply - acc. to F2 - F5
18		23	0,000	LC2	0,07	≤1	160) Chapter G - Nominal Shear Strength in z-Axis - acc. to G2 (G4,G5) - Uns
19		23	0,000	LC2	0,47	≤1	204) Chapter H - Compressive Force with Single/Major Axis Bending - acc. to
20		43	0,000	LC2	0,04	≤1	303) Chapter E - Flexural Buckling around y-Axis acc. to E7 - Slender element
21		43	0,000	LC2	0,16	≤1	313) Chapter E - Flexural Buckling around z-Axis acc. to E7 - Slender element
22		43	0,000	LC2	0,06	≤1	323) Chapter E - Torsional Buckling acc. to E4 and E7 - Slender elements
23							
24	3	IPE 450					
25		23	0,000	LC2	0,46	≤1	111) Chapter F - Yielding - Bending around y-Axis acc. to F2 - F12
26		23	0,000	LC2	0,53	≤1	113) Chapter F - Lateral-Torsional Buckling - acc. to F2 - F5

Figure 7.12: Results in Excel



### Example 8.

# Column with Biaxial Bending

In the following example, the decisive stability design of buckling and lateral buckling is carried out by analyzing the relevant interaction conditions. The calculation described below follows the Load and Resistance Factor Design provisions.

### **Design Values**



Design values of static loads:

W 8x24

ASTM A36

v Figure 8.1: Structure and Design Loads (γ-fold)

### Internal Forces according to Linear Static Analysis





#### Design Location (Decisive Location x)

The design proceeds according to locations x, i.e. on defined locations x of the equivalent member. The following internal forces act in the decisive location at x = 2.00 m:

 $P_r = -300.00 \text{ kN}$   $M_{ry} = 10.00 \text{ kNm}$   $M_{rz} = 7.50 \text{ kNm}$   $V_{ry} = 3.75 \text{ kN}$   $V_{rz} = 0.00 \text{ kN}$ 

#### Cross-Section Properties W 8x24, A36

Cross-Section Property	Symbol	Value	Units
Gross area of cross-section	A <sub>g</sub>	45.677	cm <sup>2</sup>
Moment of inertia	l <sub>y</sub>	3446.40	cm <sup>4</sup>
Moment of inertia	l <sub>z</sub>	761.70	cm <sup>4</sup>
Radius of inertia	r <sub>y</sub>	8.687	cm
Radius of inertia	r <sub>z</sub>	4.089	cm
Cross-section weight	G	35.9	kg/m
Moment of torsional rigidity	l	14.57	cm <sup>4</sup>
Warping moment of inertia	C <sub>w</sub>	69550.80	cm <sup>6</sup>
Elastic cross-section modulus	Sy	342.49	cm³
Elastic cross-section modulus	Sz	92.26	cm³
Plastic cross-section modulus	Zy	380.18	cm³
Plastic cross-section modulus	Zz	140.44	cm <sup>3</sup>

### Classification of cross-section – Table B4.1

#### Compression

Flange

Case 3 – Uniform compression in flanges of rolled I-shaped section:

b/t = 82.49/10.16 = 8.119

 $\lambda_p = N / A$ 

 $\lambda_r = 0.56 \sqrt{E/F_v} = 0.56 \sqrt{199938/248.2} = 15.894$ 

Flange is NonCompact in compression.

Web

Case 10 – Uniform compression in web of doubly symmetric rolled I-shaped section:

 $h/t_w = 155.7/6.22 = 25.02$ 

$$\lambda_{p} = N / A$$

 $\lambda_r = 1.49 \sqrt{E/F_v} = 1.49 \sqrt{199938/248.2} = 42.29$ 

Web is NonCompact in compression.

#### The section is NonCompact in compression.

#### Flexure

Case 1 – Flexure in flanges of rolled I-shaped section:

b / t = 82.49 / 10.16 = 8.119

 $\lambda_p = 0.38 \sqrt{E \,/\,F_y} = 0.38 \sqrt{199938 \,/\,248.2} = 10.785$ 

 $\lambda_r = 1.0 \sqrt{E\,/\,F_y} = 1.0 \sqrt{199938\,/\,248.2} = 28.382$ 

Flange is Compact in flexure.



Case 9 – Flexure in web of doubly symmetric rolled I-shaped section:

$$\begin{split} h \, / \, t_w &= 155.7 \, / \, 6.22 = 25.02 \\ \lambda_p &= 3.76 \sqrt{E \, / \, F_y} \, = 3.76 \sqrt{199938 \, / \, 248.2} = 106.717 \\ \lambda_r &= 5.7 \sqrt{E \, / \, F_y} \, = 5.7 \sqrt{199938 \, / \, 248.2} = 161.779 \end{split}$$

Web is Compact in flexure.

The section is Compact in flexure.

### **Chapter E**

#### Buckling about Minor Axis ( $\perp$ to z-z Axis)

Check slenderness ratio:

$$\frac{K_z L}{r_z} = \frac{1.0 \cdot 4000}{40.89} = 97.953$$

Check limit:

$$4.71\sqrt{\frac{E}{F_y}} = 4.71 \cdot \sqrt{\frac{199938.0}{248.2}} = 133.73$$

Calculate the elastic critical buckling stress F<sub>e</sub>:

$$Fe = \frac{\pi^2 E}{\left(\frac{K_z L}{r_z}\right)^2} = \frac{\pi^2 \cdot 199938}{\left(\frac{1.0 \cdot 4000}{40.89}\right)^2} = 205.665 \text{ MPa}$$

Calculate flexural buckling stress F<sub>cr,z</sub>:

Because 
$$\frac{K_z L}{r_z} \le 4.71 \sqrt{\frac{E}{F_y}}$$
  
 $F_{cr,z} = \left[ 0.658^{\frac{F_y}{F_e}} \right] \cdot F_y = \left[ 0.658^{\frac{248.2}{205.665}} \right] \cdot 248.2 = 149.773 \text{ MPa}$ 

Nominal compressive strength  $P_{n,z}$ :

$$P_{n,z} = F_{cr,z} \cdot Ag = 149.773 \cdot 4567.7 = 684120 \text{ N} = 684.12 \text{ kN}$$

Design compressive strength

 $\varphi_c \cdot P_{n,z} = 0.9 \cdot 684.12 = 615.71 \, kN$ 

Design ratio

$$\eta_z = \frac{P_r}{\phi_c \cdot P_{n,z}} = \frac{300}{0.9 \cdot 684.12} = 0.487 \qquad \qquad \text{- O.K, Decisive}$$



### **Chapter E**

Buckling about Major Axis (⊥ to y-y Axis)

Check slenderness ratio:

$$\frac{K_{y}L}{r_{y}} = \frac{1.0 \cdot 4000}{86.87} = 46.05$$

Check limit:

$$4.71\sqrt{\frac{E}{F_y}} = 4.71 \cdot \sqrt{\frac{199938.0}{248.2}} = 133.73$$

Calculate the elastic critical buckling stress F<sub>e</sub>:

$$Fe = \frac{\pi^2 E}{\left(\frac{K_y L}{r_y}\right)^2} = \frac{\pi^2 \cdot 199938}{\left(\frac{1.0 \cdot 4000}{86.87}\right)^2} = 930.55 \text{ MPa}$$

Calculate flexural buckling stress F<sub>cr,y</sub>:

Because 
$$\frac{K_yL}{r_y} \le 4.71 \sqrt{\frac{E}{F_y}}$$
  
 $F_{cr,y} = \left[0.658 \frac{F_y}{F_e}\right] \cdot F_y = \left[0.658 \frac{248.2}{930.55}\right] \cdot 248.2 = 221.981 \text{ MPa}$ 

Nominal compressive strength P<sub>n,y</sub>:

 $P_{n,y} = F_{cr,y} \cdot Ag = 221.981 \cdot 4567.7 = 1\,013\,950\,N = 1013.95\,kN$ 

Design compressive strength

 $\varphi_c \cdot P_{n,y} = 0.9 \cdot 1013.95 = 912.56 \ kN$ 

Design ratio

$$\eta_y = \frac{P_r}{\varphi_c \cdot P_{n,y}} = \frac{300}{0.9 \cdot 1013.95} = 0.328 - 0.K$$

#### Chapter F

#### I-Shaped Member Bent about Major Axis

<u>Note:</u> The nominal flexural strength M<sub>n,y</sub>, shall be the lower value obtained according to the *limit states* of *yielding* (*plastic moment*) and *lateral-torsional buckling*.

#### 1.Yielding

Calculate the nominal flexural strength M<sub>n,y</sub>:

$$M_{n,y} = M_{p,y} = F_y Z_y = 248.2 \cdot 380180 = 94360676$$
 Nmm = 94.36 kNm

Design flexural strength

$$\varphi_b\cdot M_{n,y}=0.9\cdot 94.36=84.92\ kNm$$

Design ratio

$$\eta_{b,y} = \frac{M_{r,y}}{\phi_b \cdot M_{n,y}} = \frac{10}{84.92} = 0.117 \qquad - \textbf{O.K}$$



### 2.Lateral-Torsional Buckling

<u>Note:</u> The calculation of lateral-torsional buckling modification factor  $C_b$  is based on formula F1-1.

Calculate C<sub>b</sub>:

$$\begin{split} C_b &= \frac{12.5 M_{max}}{2.5 M_{max} + 3 M_A + 4 M_B + 3 M_C} R_m \leq 3.0 \\ C_b &= \frac{12.5 \cdot 10}{2.5 \cdot 10 + 3 \cdot 7.5 + 4 \cdot 10 + 3 \cdot 7.5} \cdot 1.0 \leq 3.0 \end{split}$$

 $C_b=1.136\leq 3.0$ 

Limiting lengths  $L_{\rm p}$  and  $L_{\rm r}\!:$ 

$$\begin{split} L_p &= 1.76r_y \sqrt{\frac{E}{F_y}} = 1.76 \cdot 40.89 \cdot \sqrt{\frac{199938.0}{248.2}} = 2039.9 \text{ mm} \\ L_r &= 1.95r_{ts} \frac{E}{0.7F_y} \sqrt{\frac{Jc}{S_y h_0}} \sqrt{1.0 + \sqrt{1.0 + 6.76 \left(\frac{0.7F_y}{E} \frac{S_y h_0}{Jc}\right)^2}} = \\ &= 1.95 \sqrt{\frac{\sqrt{I_2.C_w}}{S_y}} \frac{E}{0.7F_y} \sqrt{\frac{J\cdot 1.0}{S_y h_0}} \sqrt{1.0 + \sqrt{1.0 + 6.76 \left(\frac{0.7F_y}{E} \frac{S_y h_0}{J\cdot 1.0}\right)^2}} = \\ &= 1.95 \sqrt{\frac{\sqrt{7617000 \cdot 69550.8 \cdot 10^6}}{342490}} \frac{199938}{0.7 \cdot 248.2} \sqrt{\frac{145700}{342490 \cdot 191.2}} \cdot \\ &\cdot \sqrt{1.0 + \sqrt{1.0 + 6.76 \cdot \left(\frac{0.7 \cdot 248.2}{199938} \frac{342490 \cdot 191.2}{145700}\right)^2}} = 7597.9 \text{ mm} \end{split}$$

Check limit:

$$L_p < L_b \le Lr$$
 - formula (F2-2)

Calculate the nominal flexural strength  $M_{n,y}$ :

$$\begin{split} M_{n,y} &= C_b \Biggl[ M_{p,y} - \Bigl( M_{p,y} - 0.7 F_y S_y \Bigl( \frac{L_b - L_p}{L_r - L_p} \Bigr) \Biggr] \le M_{p,y} \\ M_{n,y} &= 1.136 \cdot \Biggl[ 94.36 \cdot 10^6 - \Bigl( 94.36 \cdot 10^6 - 0.7 \cdot 248.2 \cdot 342490 \Bigl) \Bigl( \frac{4000 - 2039.9}{7597.9 - 2039.9} \Bigr) \Biggr] \le 94.36 \cdot 10^6 \text{ Nmm} \\ M_{n,y} &= 93.26 \cdot 10^6 \text{ Nmm} = 93.26 \text{ kNm} \end{split}$$

Design flexural strength

 $\varphi_b\cdot M_{n,y}=0.9\cdot 93.26=83.93\,kNm$ 

Design ratio

$$\eta_{b,y} = \frac{M_{r,y}}{\phi_b \cdot M_{n,y}} = \frac{10}{83.93} = 0.119 - 0.K, \text{ Decisive}$$



#### I-Shaped Member Bent about Minor Axis

<u>Note:</u> The nominal flexural strength M<sub>n,z</sub>, shall be the lower value obtained according to the *limit states* of *yielding (plastic moment)* and *flange local buckling*.

#### 1.Yielding

Calculate the nominal flexural strength M<sub>n,z</sub>:

 $M_{n,z} = M_{p,z} = F_y Z_z \le 1.6 \cdot F_y S_z$ 

 $F_v Z_z = 248.2 \cdot 140440 = 34857208$  Nmm = 34.86 kNm

 $1.6 \cdot F_v S_z = 1.6 \cdot 248.2 \cdot 92260 = 36.64 \text{ kNm}$ 

 $M_{p,z} = 34.86 \text{ kNm}$ 

Design flexural strength

 $\phi_b \cdot M_{n,z} = 0.9 \cdot 34.86 = 31.37 \text{ kNm}$ 

Design ratio

$$\eta_{b,z} = \frac{M_{r,z}}{\phi_b \cdot M_{n,z}} = \frac{7.5}{31.37} = 0.239$$
 - O.K

#### 2.Flange Local Buckling

For section with compact flanges, the limit state of yielding shall apply.

#### Chapter G

#### Shear in the Major axis

Calculate the nominal shear strength  $V_{n,y}$ :

$$\begin{split} &V_{n,y} = 0.6 \cdot F_y C_v A_{w,y} \\ &k_v = 1.2 \\ &\text{Check limit:} \\ &b / t_f \leq 1.10 \sqrt{k_v \cdot E / F_y} \\ &8.119 \leq 34.2 \\ &\text{if true } C_v = 1.0 \\ &\text{Shear area } A_{w,y} \\ &A_{w,y} = 2 \cdot b_f t_f = 2 \cdot 164.97 \cdot 10.16 = 3352.25 \text{ mm}^2 \\ &\text{after} \\ &V_{n,y} = 0.6 \cdot 248.2 \cdot 1.0 \cdot 3352.25 = 499\,220 \text{ N} = 499.22 \text{ kN} \\ &\text{Design shear strength} \\ &\varphi_v \cdot V_{n,y} = 1.0 \cdot 499.22 = 499.22 \text{ kN / m} \\ &\text{Design ratio} \\ &\eta_{v,y} = \frac{V_{r,y}}{\varphi_b \cdot V_{n,y}} = \frac{3.75}{499.22} = 0.007 \\ &- \text{O.K} \end{split}$$



### **Chapter H**

H1. Interaction of Flexure and Compression in Doubly Symmetric Members

Check limit:

$$\label{eq:relation} \begin{split} \frac{P_r}{P_c} &= \frac{P_r}{\varphi_c \cdot P_{n,y}} \geq 0.2 \\ 0.487 \geq 0.2 & \mbox{-true, then formula (H1-1a)} \end{split}$$

Interaction formula:

 $\frac{P_{r}}{P_{c}} + \frac{8}{9} \left( \frac{M_{r,y}}{M_{c,y}} + \frac{M_{r,z}}{M_{c,z}} \right) \le 1.0$   $\frac{P_{r}}{\phi_{c} \cdot P_{n,y}} + \frac{8}{9} \left( \frac{M_{r,y}}{\phi_{b} \cdot M_{n,y}} + \frac{M_{r,z}}{\phi_{b} \cdot M_{n,z}} \right) \le 1.0$   $\frac{300}{0.9 \cdot 684.12} + \frac{8}{9} \left( \frac{10}{0.9 \cdot 93.26} + \frac{7.5}{0.9 \cdot 34.86} \right) \le 1.0$   $0.487 + \frac{8}{9} (0.119 + 0.239) \le 1.0$   $0.805 \le 1.0 \qquad - O.K$ 



# **A** Literature

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- [2] Commentary on the Specification for Structural Steel Buildings, March 9, 2005
- [3] Rules for Member Stability in EN 1993-1-1, ECCS Technical Committee 8 Stability



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