

Version May 2013

Add-on Module



Ultimate Limit State, Serviceability and Stability Design According to AS 4100

Program Description

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I. Introduction

1.1 Add-on Module STEEL AS

The Australian Standard AS 4100 for Steel Structures describes the design, analysis, and construction of steel structures. With the RSTAB add-on module STEEL AS the DLUBAL company provides a powerful tool to design steel structures according to the Australian code.

STEEL AS performs all typical ultimate limit state designs as well as stability and deformation analyses. The program is able to take into account various actions for the ultimate limit state design. Furthermore, you can choose between the interaction formulae mentioned in the code. In accordance with the Australian code, STEEL AS divides the cross-sections to be designed into the cross-section slenderness types. In this way, you can check the limitation of the design capacity and of the rotational capacity due to local buckling for cross-section parts. Moreover, STEEL AS determines the c/t-ratios of the cross-section elements subjected to compression and classifies the cross-sections completely automatically.

In STEEL AS, the indices of the member axes are different from those used in the code: The longitudinal axis is denoted by the index is **x** instead of *z*. For the axes in the cross-section plane, the axes **y** and **z** are used (see figure to the left).

For the stability analysis, you can specify for each member or set of members whether flexural buckling occurs in y- and/or z-direction. Furthermore, you can define additional lateral supports in order to represent the model close to reality. STEEL AS determines the slendernesses and elastic critical buckling loads from the boundary conditions. The ideal critical moment for lateral torsional buckling required for the lateral torsional buckling design is determined automatically. In addition to that, it is possible to take into account the load application point of transverse loads, which is affecting the torsional resistance considerably.

For structures employing extremely slender cross-sections, the serviceability limit state represents an important design. The load cases, load and result combinations can be assigned to different design situations. The limit deformations are preset by default settings and can be adjusted, if necessary. In addition, it is possible to specify reference lengths and precambers that are considered accordingly in the design.

If required, you can use the add-on module to optimise cross-sections and export the modified cross-sections to RSTAB. Design cases enable you to separately design structural components of complex models or to analyse variants.

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

We hope you will enjoy working with STEEL AS.

Your DLUBAL Team





1.2 STEEL AS - Team

The following people were involved in the development of STEEL AS:

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1.3 Using the Manual

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

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

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

1.4 Open the Add-on Module STEEL AS

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

Menu

۲

To start the program in the RSTAB menu bar, click

Add-on Modules \rightarrow Design - Steel \rightarrow STEEL AS.

Ad	d-on Modules Window	<u>H</u> elp		
-	Current Module	>	🞅 🕺 🔗 🚧 🕼	📾 📾 🗄 🚟 📽 🕸 🕼 😕 🛸 🖄 🗙 🗙
	Design - Steel	1	STEEL	General stress analysis of steel members
	Design - Concrete	1 JEC	STEEL EC3	Design of steel members according to Eurocode 3
	Design - Timber	Also	STEEL AISC	Design of steel members according to AISC (LRFD or ASD)
	Design - Aluminium	LIS	STEEL IS	Design of steel members according to IS
	Dynamic	BIA	STEEL SIA	Design of steel members according to SIA
	Connections	IBS	STEEL BS	Design of steel members according to BS
	Foundations		STEEL GB	Design of steel members according to GB
			STEEL CS	Design of steel members according to CS
			STEEL AS	Design of steel members according to AS
	Others P		KAPPA	Flexural buckling analysis
	Stand-Alone Programs	1 🕫	LTB	Lateral-torsional and torsional-flexural buckling analysis
			FE-LTB Lateral	-torsional and torsional-flexural buckling analysis by FEM
			EL-PL	Elastic-plastic design
			C-TO-T	Analysis of limit slenderness ratios (c/t)
		1	PLATE-BUCKLING	Plate buckling analysis
		₽ ₽	VERBAND (not installe	d) Design of wind bracings for roofs

Figure 1.1: Menu: Add-on Modules \rightarrow Design - Steel \rightarrow STEEL AS



Navigator

As an alternative, you can start the add-on module in the Data navigator by clicking

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

Project Navigator - Data	×
Hall* [Examples]	*
🗄 💼 Model Data 🛛 👘	
🗄 💼 Load Cases and Combinations	
🗄 📲 Loads	_
🕀 💼 Results	=
n Printout Reports	
🗄 💼 Guide Objects	-
🚊 📹 Add-on Modules	
SHAPE-THIN 7 - Design of thin-walled cross-sections	
- 🖅 STEEL EC3 - Design of steel members according to Eurocode 3	
- 🐷 STEEL AISC - Design of steel members according to AISC (LRFD or	
🔚 STEEL GB - Design of steel members according to GB	Ŧ
4 III > 1	
🛱 Data 📓 Display 🔏 Views	

Figure 1.2: Data navigator: Add-on Modules \rightarrow STEEL AS

Panel

In case results from STEEL AS are already available in the RSTAB model, you can also open the design module in the panel:

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

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

Panel	×
Max Design Ratio [·]	
1.01 1.00 0.90 0.80 0.70 0.50 0.50 0.40 0.30 0.20 0.10 0.00	
Max : 1.01 Min : 0.00	
STEEL AS	
🚦 🕾 🖄	

STEEL AS

Figure 1.3: Panel button [STEEL AS]





2. Input Data

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

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

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

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

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

2.1 General Data

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

A1 - Design of steel members a 🔻	1.1 General Data	
pu Data General Data Materials - Cross-Sections - Lateral Intermediate Supports - Effective Lengths - Members	Design of Members: 1-8,11-18,21-28,31-46,51-64,66-69,71-74,81-83,91-1 Sets: Ultimate Land State Existing Land Cases and Combinations Sets:	Standard Standard
	Comment	
	· · · · · · · · · · · · · · · · · · ·	



Cancel

OK



Design of

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

Figure 2.2: Design of members and sets of members



8

The design can be carried out for *Members* as well as for *Sets of Members*. If you want to design only selected objects, clear the *All* check box: Then you can access the input fields to enter the numbers of the relevant members or sets of members. The list of the numbers preset in the field can be selected by double-clicking and overwritten by entering the data manually. Click [$\$] to select the objects graphically in the RSTAB work window.

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

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





2.1.1 Ultimate Limit State





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

Existing Load Cases and Combinations

In this column, all load cases, load combinations, result combinations, and super combinations created in RSTAB are listed.

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

To transfer multiple entries of load cases, click the entries while pressing the [Ctrl] key, as common for Windows applications. Thus, you can transfer several load cases at the same time.

Load cases marked by an asterisk (*), like load case 9 in Figure 2.3, cannot be designed: This happens when the load cases are defined without any load data or the load cases contain only imperfections. When you try to transfer those load cases, a corresponding warning appears.

At the end of the list, several filter options are available. They will help you assign the entries sorted according to load cases, load combinations, or action categories. The buttons have the following functions:

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

Table 2.1: Buttons in the tab Ultimate Limit State

Selected for Design

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

The design of an enveloping max/min result combination is performed faster than the design of all contained load cases and load combinations. However, the analysis of a result combination has also disadvantages: First, the influence of the contained loads is difficult to discern. Second, for the determination of the factor β_m according to clause 4.4.2.2 (b), the envelope of the moment distributions is analyzed, from which the most unfavorable distribution (max or min) is taken. However, this distribution only rarely reflects the moment distribution in the







Result combination



individual load combinations. Thus, in the case of a RC design, more unfavorable values for β_m are likely that lead to higher ratios.

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

2.1.2 Serviceability

xisting Load	Cases and Combinations		1	Sele	cted for <u>D</u>	esign	
G LC1	Self-weight	*			CO11	Swt+s+wx+p+lmp (char. valu	Short term effects
Qi LC2	Snow				CO12	Swt+s+Imp (char. values)	Short term effects
Qw LC3	Side wind in X				CO13	Swt+wx+lmp (char. values)	Short term effects
w LC4	Wind on gable in Y				CO14	Swt+p+lmp (char. values)	Short term effects
LC5	Wind on gable in -Y						Short term effects
LC6	Wind lifting						Long term effects
Qi LC7	Roof live load						
Qi LC8	Imperfections in X						
Qi LC9	Imperfections in -Y						
Qi *LC10	Imperfections in Y	-	>>				
C01	Swt+s+wx+p+lmp	=					
CO2	Swt+s+Imp		_				
CO3	Swt+wx+Imp						
CO4	Swt+p+lmp						
CO5	Swt+Wind lifting+Imp		~				
CO6	Swt+wy+Imp						
C07	Swt+w(-y)+Imp						
CO8	Swt+s+wy+p+lmp						
CO9	Swt+s+w(-y)+p+lmp						
CO15	Swt+Wind lifting+Imp (char. values						
CO16	Swt+wy+Imp (char. values)						
CO17	Swt+w(-y)+Imp (char. values)						
CO18	Swt+s+wy+p+lmp (char. values)						
CO19	Swt+s+w(-y)+p+lmp (char. values)	Ŧ					

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

Existing Load Cases and Combinations

In this column, all load cases, load and result combinations created in RSTAB are listed.

Selected for Design

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

You can assign different limit values for deflection to the individual load cases, load combinations, and result combinations. The following design situations can be selected:

- Short term effects
- Long term effects

To modify the design situation, use the list which can be accessed at the end of the input field by clicking $[\mathbf{v}]$ (see Figure 2.4).

Details...

>

The limit values of the deformations are defined in the design details. To adjust these values according to the design situation, click [Details] to open the dialog box *Details*, tab *Serviceability* (see Figure 3.3, page 31).

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



2.2 Materials

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

	Α		В		
Material	Material				
INO.	Description		Comn	nent	
1 Steel	400 (Flats and Sections) AS/NZS 3679.1				
				🛃 😽 🐧	
Material Properties	3				
Main Properties					
 Modulus of E 	lasticity	E	200000.0	N/mm ²	
Shear Module	US	G	80000.0	N/mm ²	
- Poisson's Ra	tio	v	0.250		
 Specific Wei 	ght	γ	78.50	kN/m ³	
 Coefficient of 	Thermal Expansion	α	1.7000E-05	1/K	
Partial Safety	Factor	7M	1.00		
🕀 Additional Prope	erties				
- Thickness R	anget≤1.70 cm				
Ultimate St	trength	fu	520.0	N/mm ²	
Yield Stren	ngth	fy	400.0	N/mm ²	
Thickness R	ange t > 1.70 cm				
 Ultimate St 	trength	fu	520.0	N/mm ²	Makadal Na 14 yanad in
Yield Stren	ngth	fy	380.0	N/mm ²	Material No. 1 used in
					Cross-sections No.:
					1-3.6.7.9.10.15.16
					Members No.:
					1-8 11-18 21-28 31-46 51-64 66-69
					10,1110,2120,0140,0104,0000
					Sets of members No.:
					1,3
					Σ Lengths: Σ Masses:
					250.85 [m] 10.952 [t]

Figure 2.5: Table 1.2 Materials

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

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

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

Material Description

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

Steel 400 (Flats and Sections) AS/NZS 3679.	1_	•
Steel C450	AS 1163	*
Steel C450L0	AS 1163	Ξ
Steel C350	AS 1163	٣
Steel C350L0	AS 1163	
Steel C250	AS 1163	
Steel C250L0	AS 1163	
Steel HA400	AS/NZS 1594	
Steel HW350	AS/NZS 1594	
Steel HA350	AS/NZS 1594	
Steel HA300/1	AS/NZS 1594	_

Figure 2.6: List of materials



According to the design concept of the Australian Standard [1], you can select only materials of the "Steel" category.

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

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

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

Material Library

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

Edit ightarrow Material Library

or use the button shown on the left.

Material Library				_
Filter	Material to Select			
Material category group:	Material Description		Standard	
Metal		Sections)	Transis 2011	
	Steel 400L0 (Flats ar	nd Sections)	T AS/NZS 3679.1	
Material category:	Steel 400L15 (Flats a	and Sections)	AS/NZS 3679.1	
Steel	 Steel 350 (Flats and 	Sections)	AS/NZS 3679.1	
	Steel 350L0 (Flats ar	nd Sections)	AS/NZS 3679.1	
Standard group:	Steel 350L15 (Elats a	and Sections)	AS/NZS 36791	
🚰 AS	 Steel 300 (Flats and 	Sections)	AS/NZS 36791	
Chandrach	Steel 2001 0 (Elste av	nd Sections)		
standard:	Steel 200L0 (Flats a	and Sections)		
AS/NZS 3679.1	Steel 300L15 (Flats and	Caetiene)	AS/NZS 3073.1	
	Steel 250 (Flats and	Sections)	AS/NZS 3673.1	
	Steel 250L0 (Flats ar	nd Sections)	AS/NZS 36/9.1	
	Steel 250L15 (Flats a	and Sections)	E AS/NZS 36/9.1	
	Steel 400 (Hexagons	s, Rounds and Squares)	E AS/NZS 3679.1	
📃 Include invalid	Steel 400L0 (Hexago	ons, Rounds and Squares)	🏧 AS/NZS 3679.1	
Eavorites only	🔁 🞦			7
Material Properties			Steel 400 (Flats and Sectio	uns) AS/NZS 367
■ Main Properties				
 Modulus of Elasticity 		E	200000.0 N/mm ²	
- Shear Modulus		G	80000.0 N/mm ²	
Poisson's Ratio		ν	0.250	
- Specific Weight		γ	78.50 kN/m ³	
Coefficient of Thermal Exp	pansion	α	1.7000E-05 1/K	
Additional Properties Diskness Range t < 1.7(lom			
Ultimate Strength	7 cm	f.,	520.0 N/mm ²	
Yield Strength		fv	400.0 N/mm ²	
Thickness Range t > 1.70) cm		100.0	
Ultimate Strength		fu	520.0 N/mm ²	
Yield Strength		fy	380.0 N/mm ²	
Yield Strength		ty	380.0 N/mm²	
				Canad

Figure 2.7: Dialog box Material Library

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

Click [OK] or [\downarrow] to transfer the selected material to table 1.2 of the add-on module STEEL AS. Please check, however, whether these materials are allowed by the design concept of the Australian Standard [1].

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



2.3 Cross-sections

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

	A	B	C	D	E	F	1 - IPE 300 I DIN 1025-5:1994
Section	Material	Cross-Section	Cross-Section Type	Opti-			- ·
No.	No.	Description	for Classification	mize	Remark	Comment	450.0
1	1	I IPE 300 DIN 1025-5:1994	I-shape rolled	From Current Row -	2)		150.0
2	1	I IPE 300 DIN 1025-5:1994	I-shape rolled	No			+ +
3	1	I IPE 400 DIN 1025-5:1994	I-shape rolled	No			5 150
6	1	HE A 160 DIN 1025-3:1994	I-shape rolled	No			
7	1	HE A 120 DIN 1025-3:1994	I-shape rolled	No			
9	1	I IPE 360 DIN 1025-5:1994	I-shape rolled	No			
10	1	HE A 140 DIN 1025-3:1994	I-shape rolled	No			m
12	1	QRO 80x4 DIN 59410:1974	Box rolled	No	5)		7.1
13	1	RD 24 DIN 1013-1	Round bar	No	5)		
15	1	HE A 200 DIN 1025-3:1994	I-shape rolled	No			
16	1	Rectangle 200/200	General	No			
							Members No.: 1,2,11,12,21,22,31,32,39,40 Sets of members No.:
							Σ Lengths: Σ Masses:
							48.00 [m] 2.027 [
							Material:
							1 - Steel 400 (Flats and Sections)
		2) The cross-section will be opti	mized utilizing the best s	ection from the table			

Figure 2.8: Table 1.3 Cross-sections

Cross-Section Description

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



If you want to modify a cross-section, click the entry in column B to select this field. Click [Cross-section Library] or [...] in the field or press function key [F7] to open the cross-section table of the current input field (see the following figure).

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

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



Welded Cross-Sections - I symmet	tric		— ———————————————————————————————————
Cross-Section Type $I I I T T$ $T L U$ $C I T Y$ $O \nabla I U$ $\overline{I} \overline{I}$ $T T$ $I + \bullet$ $I L J$ $I \Sigma$	360.0 ** [mm] b: 170.0 ** [mm] s: 8.0 ** [mm] t: 14.0 ** [mm] a: 0.0 ** [mm]		
٦	à 🖻	IS 360/170/8/14/0	
		[OK Cancel

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

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

A modified cross-section will be highlighted in blue.

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

Cross-Section Type for Classification

The cross-section type used for the classification is displayed. The cross-sections listed in [1] table 5.2 can be designed plastically or elastically depending on the Class. Cross-sections that are not covered by this table are classified as *General*.

Max. Design Ratio

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

Optimise

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

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

Remark

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





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

Member with tapered cross-section

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

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

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

Info About Cross-Section

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

Cross-Section Value Description	Symbol	Value	Unit	-	HE B 360 DIN 1025-2:1995
Depth	h	36.00	cm		
√idth	Ь	30.00	cm		
Web thickness	tw	1.25	cm		
Flange Thickness	t r	2.25	cm		± 30.00
Root fillet radius	r	2.70	cm	=	
Cross-sectional area	A	181.00	cm ²	-	
Shear area	Ay	112.63	cm ²		2.70
Shear area	Az	39.80	cm ²		
Shear area according to EC 3	Av,y	139.94	cm ²		
Shear area according to EC 3	A _{v,z}	60.96	cm ²		
Web area	Aweb	39.40	cm ²		8
Plastic shear area	A _{pl,y}	135.00	cm ²		8
Plastic shear area	A _{pl,z}	42.19	cm ²		
Moment of inertia	ly	43190.00	cm ⁴		1.25
Moment of inertia	Iz	10140.00	cm ⁴		
Governing radius of gyration	ſy	15.50	cm		
Governing radius of gyration	٢z	7.49	cm		
Polar radius of gyration	ro	17.21	cm		↓ · · · · · · · · · · · · · · · · · · ·
Radius of gyration of flange plus 1/5 of we	fzg	8.03	cm		z
/olume	V	18100.00	cm ³ /m		
√eight	wt	142.1	kg/m		
Gurface	Asurf	1.850	m²/m		
Section factor	A _m /V	102.210	1/m		
Forsional constant	J	293.00	cm ⁴		🛄 🔯 Stress points 🔛 🚰
Warping constant	Cw	2.883E+06	cm ⁶		C/t-Parts
Elastic section modulus	S.,	2400.00	cm ³	-	

Figure 2.10: Dialog box Info About Cross-Section

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

In STEEL AS, the indices of the member axes are different from those used in the code: The longitudinal axis is denoted by the index is **x** instead of *z*. For the axes in the cross-section plane, the axes **y** and **z** are used (see Figure 2.10).





-5



The buttons below the graphic are reserved for the following functions:

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

Table 2.2: Buttons of cross-section graphic

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

Coordin	anton						112 0 200
	Idico	Statical Moments of Area		Thickness	Wan	bing	
y [cm]	z [cm]	Q _y [cm ³]	Q _z [cm ³]	t [cm]	W _{no} [cm ²]	Sco [cm ⁴]	
-13.00	-13.00	0.00	0.00	1.75	157.63	0.00	
-2.90	-13.00	-213.95	-140.47	1.75	35.16	-1703.76	
0.00	-13.00	-280.04	-148.63	1.75	0.00	-1792.98	
2.90	-13.00	-213.95	140.47	1.75	-35.16	1703.76	
13.00	-13.00	0.00	0.00	1.75	-157.63	0.00	
-13.00	13.00	0.00	0.00	1.75	-157.63	0.00	
-2.90	13.00	-214.31	140.52	1.75	-35.16	-1703.76	
0.00	13.00	-280.04	148.63	1.75	0.00	-1792.98	
2.90	13.00	-214.31	-140.52	1.75	35.16	1703.76	13 y
13.00	13.00	0.00	0.00	1.75	157.63	0.00	
0.00	-8.85	-599.75	0.00	1.00	0.00	0.00	
0.00	8.85	-600.56	0.00	1.00	0.00	0.00	
0.00	0.00	-638.91	0.00	1.00	0.00	0.00	6 7 8 9 10
							z
							A 🚺
	-13.00 -2.90 0.00 2.90 13.00 -3.90 0.00 2.90 13.00 0.00 0.00 0.00	-13.00 -13.00 -2.90 -13.00 0.00 -13.00 2.90 -13.00 13.00 -13.00 13.00 -13.00 13.00 -13.00 13.00 -13.00 0.00 13.00 2.90 13.00 0.00 13.00 0.00 13.00 0.00 8.85 0.00 8.85 0.00 0.00	-13.00 -13.00 0.00 2.90 -13.00 -213.95 0.00 -13.00 -280.04 2.90 -13.00 -280.04 2.90 -13.00 -213.95 13.00 -13.00 0.00 -13.00 13.00 -0.00 -13.00 13.00 -214.31 0.00 13.00 -280.04 2.90 13.00 -214.31 13.00 13.00 -280.04 2.90 13.00 -214.31 13.00 13.00 0.00 0.00 -8.85 -599.75 0.00 8.85 -600.56 0.00 0.00 -638.91	-13.00 -13.00 0.00 0.00 2.90 -13.00 -213.95 -140.47 0.00 -13.00 -280.04 -148.63 2.90 -13.00 -213.95 140.47 13.00 -213.95 140.47 13.00 -13.00 0.00 0.00 -13.00 13.00 0.00 0.00 -13.00 13.00 -214.31 140.52 0.00 13.00 -280.04 148.63 2.90 13.00 -280.04 148.63 2.90 13.00 -280.04 148.63 2.90 13.00 -0.00 0.00 0.00 8.85 -590.75 0.00 0.00 8.85 -500.56 0.00 0.00 0.00 -638.91 0.00	-13.00 -13.00 0.00 0.00 1.75 2.90 -13.00 -213.95 -140.47 1.75 0.00 -13.00 -280.04 -148.63 1.75 2.90 -13.00 -213.95 140.47 1.75 13.00 -213.95 140.47 1.75 13.00 -13.00 0.00 0.00 1.75 13.00 -13.00 0.00 0.00 1.75 13.00 13.00 -0.00 0.00 1.75 -2.90 13.00 -243.11 140.52 1.75 0.00 13.00 -280.04 148.63 1.75 13.00 13.00 -280.70 0.00 1.75 13.00 13.00 -280.75 0.00 1.00 0.00 8.85 -590.75 0.00 1.00 0.00 8.85 -600.56 0.00 1.00 0.00 0.00 -638.91 0.00 1.00	-13.00 -13.00 0.00 0.00 1.75 157.63 2.90 -13.00 -213.95 -140.47 1.75 35.16 0.00 -13.00 -280.04 -148.63 1.75 0.00 2.90 -13.00 -213.95 140.47 1.75 -35.16 13.00 -13.00 0.00 0.00 1.75 -157.63 13.00 -13.00 0.00 0.00 1.75 -157.63 -13.00 13.00 -214.31 140.52 1.75 -35.16 0.00 13.00 -240.04 148.63 1.75 0.00 2.90 13.00 -214.31 -140.52 1.75 35.16 13.00 13.00 -20.04 148.63 1.75 0.00 2.90 13.00 -214.31 -140.52 1.75 35.16 13.00 13.00 0.00 1.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00	-13.00 -13.00 0.00 0.00 1.75 157.63 0.00 2.90 -13.00 -213.95 -140.47 1.75 35.16 -1703.76 0.00 -13.00 -213.95 -140.47 1.75 35.16 -1703.76 0.00 -13.00 -213.95 140.47 1.75 -35.16 1703.76 1.300 -213.95 140.47 1.75 -35.16 1703.76 1.300 -13.00 0.00 0.00 1.75 -157.63 0.00 -13.00 13.00 0.00 0.00 1.75 -157.63 0.00 -290 13.00 -214.31 140.52 1.75 -35.16 1703.76 0.00 13.00 -220.04 148.63 1.75 0.00 1.73.76 0.00 13.00 -214.31 -140.52 1.75 35.16 1703.76 13.00 13.00 0.00 0.00 1.00 0.00 0.00 0.00 8.85 <t< td=""></t<>

Figure 2.11: Dialog box Stress Points of HE B 260





2.4 Lateral Intermediate Supports

In table 1.4, you can define lateral intermediate supports for members. STEEL AS always assumes this kind of support to be perpendicular to the cross-section's minor axis z (see Figure 2.10). Thus, it is possible to influence the members' effective lengths which are important for the stability analyses concerning flexural buckling and lateral-torsional buckling.



For the calculation, all lateral intermediate supports are considered as forked supports. 1.4 Lateral Intermediate Supports В Lateral Length L [m] No Supports Number **X**6 X3 X4 X5 x8 15 16 17 18 0.500 22 0.500 25 Relatively (0 ... 1) 🛐 😼 🐧 💌 ettings - Member No. 21 Cross-Section Lateral Supports Existing Cro Member Length Number of Lateral Intermediate Supports Position of Lateral Support No. X1 0.500 Set inputs for members No. V Al 🔁 🖭 🎽 🚰 🚳

Figure 2.12: Table 1.4 Lateral Intermediate Supports

In the upper part of the table, you can assign up to nine lateral supports for each member. The lower table part shows you a summary of the data entered for the member selected above.

📝 Relatively (0 ... 1)



If the check box *Relatively* $(0 \dots 1)$ is selected, the support points can be defined by relativeinput. The positions of the intermediate supports are determined from the member length and the relative distances from the member start. When the check box *Relatively* $(0 \dots 1)$ is cleared, you can define the distances manually in the upper table.

In case of cantilevers, avoid intermediate supports, as such supports divide the member in segments. Thus for cantilevered beams, this would results in segments that are forked supported on one side and thus statically underdetermined (forked support respectively on one end only).



2.5 Effective Lengths - Members

The table is subdivided into two parts. The table in the upper part contains summarised information about the factors for the lengths of buckling and lateral-torsional buckling as well as the equivalent member lengths of the members to be designed. The effective lengths defined in RSTAB are already preset. In the section *Settings*, further information is shown about the member whose row is selected in the upper section.



....

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

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

	A	B	Ċ	D	E	F	G	H		J	K	L	M	N	0
1ember	Buckling	Bucklin	ng About	Axis y	Bucklin	ng About	Axis z	Later	al-Torsion	al and To	sional-Flexural Buck	ding	Memb	er Type	
No.	Possible	Possible	Ky	KyL [m]	Possible	Kz	K _z L [m]	Possible	L _w [m]	LT [m]	αm	Kr	Type y-y	Type z-z	Comment
	2	✓	1.000	6.000		1.000	6.000	V	6.000	6.000	Eigenvalue 5.6.4	1.00	Beam	Beam	
2		<	1.000	6.000	V	1.000	6.000	V	6.000	6.000	Eigenvalue 5.6.4	1.00	Beam	Beam	
3		✓	1.000	3.011	V	1.000	3.011	V	3.011	3.011	Eigenvalue 5.6.4	1.00	Beam	Beam	
4	V	<	1.000	3.262	V	1.000	3.262	V	3.262	3.262	Eigenvalue 5.6.4	1.00	Beam	Beam	
5	V	✓	1.000	6.274		1.000	6.274	V	6.274	6.274	Eigenvalue 5.6.4	1.00	Beam	Beam	
6		<	1.000	6.274	V	1.000	6.274	V	6.274	6.274	Eigenvalue 5.6.4	1.00	Beam	Beam	
7		✓	1.000	3.262	V	1.000	3.262	V	3.262	3.262	Eigenvalue 5.6.4	1.00	Beam	Beam	
8	 ✓ 	✓	1.000	3.011	V	1.000	3.011	V	3.011	3.011	Eigenvalue 5.6.4	1.00	Beam	Beam	
11		✓	1.000	6.000		1.000	6.000	V	6.000	6.000	Eigenvalue 5.6.4	1.00	Beam	Beam	
12	V	✓	1.000	6.000		1.000	6.000	V	6.000	6.000	Eigenvalue 5.6.4	1.00	Beam	Beam	
attinge	Mambar	No. 1											IDE 20		6:4004
Cross-	Section	INU. I					1	- IPE 300	DIN 1025	-5:1994				U DIN 1025-	-5:1994
Length	٦					L		6.0	00 m						
Buckli	ng Possibl	e							V						
Buckli	ng About I	Major Axis y	y Possibl	е					V					15	50.0
- Effe	ctive Leng	gth Factor				Ky		1.0	00						†
Effe	ctive Leng	gth				KyL		6.0	00 m					+	
Buckli	ng About I	Minor Axis :	z Possibl	e					J					10.7	15.0
Effe	ctive Leng	gth Factor				Kz		1.0	00					· ·	
- Effe	ctive Leng	gth				KzL		6.0	00 m						
Latera	I-Torsional	Buckling I	Possible						J					300	
- LTE	3 Length					Lw		6.0	00 m						
- Ton	sional Len	gth				LT		6.0	00 m						1/-1
αm						_	E	igenvalue §	5.6						
— Kr	-							1.	00					+	
∃ Memb	er Type												_		÷
Тур	e y-y					_		Bea	m				_		z
Тур	e z-z					_		Bea	am						
Comm	ent		_			_									
													-		
📃 Setin	iputs for m	empers ivo	u:												

Figure 2.13: Table 1.5 Effective Lengths - Members

The effective lengths for local buckling about the minor axis are aligned automatically with the entries of table 1.4 *Lateral Intermediate Supports*. If lateral intermediate supports are dividing the member into member segments of different lengths, the program displays no value in the table columns G, I, and J of table 1.5.

The effective lengths can be entered manually in the table and in the *Settings* tree, or defined graphically by clicking the button [...] in the work window. This button is enabled when you click in the input field (see figure above).

The Settings tree manages the following parameters:

- Cross-Section
- Member Length
- Buckling Possible for member (cf columns B and E)
- Buckling about Axis y Possible (cf columns C and D)
- *Buckling about Axis z Possible* (cf columns F and G)
- Lateral-Torsional Buckling Possible (cf columns I L)
- Member Type y-y
- Member Type z-z



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

The buckling length of a member can also be defined in a dialog box that can be accessed by clicking the button shown on the left. The button is located below the table.

Select Effective Length Factor	
Buckling About Axis y	Buckling About Axis z
© ky = 0.7	© kz =0.7
© ky = 0.85	© k ₂ = 0.85
© ky = 1.2	© kz = 1.2
© ky = 2.2	© kz = 2.2
© ky = 2.2	© kz = 2.2
$ \begin{array}{c} & & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ $	© U <u>s</u> er-defined k _z =
 Import from Add-on Module RSBUCK (Eigenvalue Analysis) 	 Import from Add-on Module RSBUCK (Eigenvalue Analysis)
RSBUCK-Case:	RSBUCK-Cas <u>e</u> :
Buckling Shape	Buckling Shape
Export effective length factor ky : 1.000 -	Export effective length factor k2: 1.000
	OK Cancel

Figure 2.14: Dialog box Select Buckling Length Coefficient

For every direction, the buckling length can be defined according to one of the four Euler buckling modes or *User-defined*. If a RSBUCK case calculated according to the eigenvalue analysis is already available, you can also define a *Buckling Shape* to determine the factor.

Buckling Possible

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

The check boxes *Buckling Possible* in table row A and in the *Settings* tree offer you a control option for the stability analyses: They determine whether the analysis should or should not be performed for a member.

Buckling about Axis y or Axis z

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

The position of the member axes can be checked in the cross-section graphic in table 1.3 *Cross-Sections* (see Figure 2.8, page 14).

2 Input Data



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The indices of the member axes are different from those used in the Australian Standard: The longitudinal axis is denoted by the index is **x** instead of *z*. For the axes in the cross-section plane, the axes **y** and **z** are used.

To access the RSTAB work window, click [View mode]. To show the local member axes in the RSTAB work window, you can use the member's context menu or the *Display* navigator.



Figure 2.15: Selecting the member axis systems in the Display navigator of RSTAB

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

To specify the buckling lengths in the work window graphically, click [...]. This button becomes available when you click in a *KL* input field (see Figure 2.13).

If you specify the buckling length coefficient *K*, the program determines the effective length *KL* by multiplying the member length *L* by the buckling length coefficient *K*. The input fields *K* and *KL* are interactive.

Lateral-torsional Buckling Possible

Table column H shows you for which members the program performs an analysis of lateraltorsional buckling.

With the check box in the *Possible* table columns, you decide whether a member has a risk of torsional-flexural and lateral-torsional buckling. When you have set the check, you can edit the buckling lengths L_w and L_T in columns I and J.

Moment Modification Factor a_m

The moment modification factor α_m can be calculated according to the options given in clause 5.6.1.1 of the standard. It is also possible to define this factor *Manually*.

Lateral Rotation Restraint Factor K_r

The lateral rotation restraint factor depending on the arrangement of the restraint is given in Table 5.6.3 (3) of the standard.

Member Type

Columns M and N define the restraint type of member segment according to clauses 5.6.1 and 5.6.2 of the standard: *Beam* or *Cantilever*. The member type is equal for all member segments.

Comment

In the last table column, you can enter user-defined comments for each member to describe, for example, the selected equivalent member lengths.

Eigenvalue 5.6.4
1.0 (5.6.1 (a) (i))
Tab. 5.6.1 (a) (ii)
Eq. 5.6.1 (a) (iii)
Eigenvalue 5.6.4
Manually



....



Ē.



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

2.6 Effective Lengths - Sets of Members

This table appears only if at least one Set of Members has been selected for design in the table 1.1 *General Data*.

	A	В	С	D	E	F	G	(H (J	K	L	M	N	0
Set	Buckling	Buckli	ng About	Axis y	Bucklin	ng About	Axis z	Latera	I-Torsion	al and To	rsional-Flexural Buck	ding	Membe	er Type	
No.	Possible	Possible	Ky	KyL [m]	Possible	Kz	K _z L [m]	Possible	L _w [m]	LT [m]	αm	Kr	Туре у-у	Type z-z	Comment
1	V	V	1.000	6.000	√	1.000	6.000	V	6.000	6.000	Eigenvalue 5.6.4	1.00	Beam	Beam	
2		✓	1.000	12.548		1.000	12.548	Image: A start and a start	12.548	12.548	Eigenvalue 5.6.4	1.00	Beam	Beam	
3		√	1.000	12.548		1.000	12.548	V	12.548	12.548	Eigenvalue 5.6.4	1.00	Beam	Beam	
4		√	1.000	6.546		1.000	6.546	V	6.546	6.546	Eigenvalue 5.6.4	1.00	Beam	Beam	
5	V	V	1.000	7.094		1.000	7.094	V	7.094	7.094	Eigenvalue 5.6.4	1.00	Beam	Beam	
ttinas	- Set of M	embers No	1										HE A 2	00 LDIN 1024	5-3-1994
Set o	f Members						9	tabzug 1						.00 Dil4 102.	5-5.1554
Cr	oss-Section					_	1	5 - HF A 200	DIN 10	25-3-199	4		_		
Lend	th					L		6.0	00 m						
Buck	lina Possibl	e						F	2				_		
Buck	lina About I	Maior Axis	v Possibl	e		_			5				_	2	00.0
- Eff	ective Lend	th Factor				Kv		1.0	00				_		T
Eff	ective Lend	, ith				KvL		6.0	00 m				- +		
Buck	ling About I	, Minor Axis	z Possibl	e				[2)					10.	18.0
Eff	ective Lend	th Factor				Kz		1.0	00						
Eff	ective Lend	ith				KzL		6.0	00 m				0.08		
Later	al-Torsional	Buckling	Possible					[য				-		0.5
LT	B Length					Lw		6.0	00 m						0.5
То	rsional Leng	gth				LT		6.0	00 m						
α	n						E	genvalue 5.	6.				- +		
V								1.	00						÷
- Nr	ber Type														z
Memi	ne var							Bea	m						
Memi] Memi Ty	00,9.9							Bea	m						
] Memi] Memi Ty Ty	pe z-z														
Mem Mem Ty Ty Comr	pe z-z nent												_		

Figure 2.16: Table 1.6 Effective Lengths - Sets of Members

This table's concept is similar to the one in the previous table 1.5 *Effective Lengths - Members*. In this table, you can enter the effective lengths for the buckling about the two principal axes of the set of members as described in chapter 2.5.



2.7 Nodal Supports - Sets of Members

Details...

This table is displayed when you have chosen at least one set of members for the design in table 1.1 *General Data*. Table 1.7 is not available if in the dialog box *Details*, tab *Stability* (see Figure 3.2, page 29) the *Member-like input* has been selected for sets of members. In this case, you can define the lateral intermediate supports by division points in table 1.4.

	Α	B	С	D	E	F	G	H	
upport	Node	Support	Lat. Support	Rotational	Restraint	Warping	Eccen	tricity	
No.	No.	Rotation ß [°]	uy.	φ _X [kNm/rad]	φz.	Restraint ω	ex [mm]	e <u>z</u> [mm]	Comment
1	13	0.00	V	V			0.0	0.0	
2	16	0.00	V	12.800 💌			0.0	-150.0	
3									
4									
5									
6									
7									
8									
9									
10									
									🛐 🗣 🔇
tings -	Node Sup	oport No. 16							
Set of	Members								
Men	nber 13								
— S	tart				3 - IPE 40	0 DIN 1025-5:19	94		
— E	nd				2 - IPE 40	0 DIN 1025-5:19	94		
Men	nber 14 - C	ross-Section			2 - IPE 40	0 DIN 1025-5:19	94		
Men	nber 15 - C	ross-Section			2 - IPE 40	0 DIN 1025-5:19	94		



Figure 2.17: Table 1.7 Nodal Supports - Set of Members

5

To determine the critical factor for lateral-torsional buckling, a planar framework is created with four degrees of freedom for each node which you have to define in table 1.7. This table refers to the <u>current</u> set of members (selected in the add-on module's navigator on the left).

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



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

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





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

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



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

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



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

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



2.8 Member End Releases - Sets of Members

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

Table 1.8 is not available if in the dialog box Details, tab Stability (see Figure 3.2, page 29) the

Member-like input has been selected for the sets of members.

Details...

		B	C	D	E	F	G
Release	Member	Member	Shear Release	Moment	Release	Warp Release	
No.	No.	Side	Vv	Мт	Mz [kNm/rad]	Ma	Comment
1	15	Start	ń			n	
2	13	End		- H	15 000		
3							
4							
5							
6							
7							
8							
9							
10							
		10					
ettings -	Member N	0. 13					
JSet of	Members	en Cantina			D	10015	50 00
Men	nber I - Cro	ss-section			I - HE A	A TOU Euronom	n 53-62
	IDel 3				2 105		E 1004
- 3	ldil ad				3 - IPE 4	400 DIN 1025-	5:1994
Mon	nu shar (Cra	an Continn			Z-IPE	360 DIN 1025-	5.1994
Men	abor 5 Cro	ss-Section			2 - IFE -	200 DIN 1025-	5.1934
Mon	aber 6 - Cro	ss-Section			2-1FE	200 DIN 1025-	5.1004
Men	nber 7 - Cro	ss-Section			2 - IFE	20010101023-	5.1004
Men Men	nber 7 - Ciu nher 8	55-566001			ZHEL	500 [D1N 1023-	5.1354 E
S	tart				2 - IPE 1	360 I DIN 1025-	5-1994 Mu Vy
F	nd				2 IFE	150 I DIN 1025	5-1994 z V
Men	nher 2 - Cm	ss-Section			1-HE /	100 L Europom	53.62 Mz
Membe	er with Rele	ase at the End		No		13	
Memb	er Side			Side		End	
Shear	Release in	v-Direction		Vv			
Torsion	nal Release			Мт		- H	
Momen	nt Release	about z-Axis		M ₂		15.000 kNm/	rad
Warpir	na Release			Ma			····

Table 2.22: Table 1.8 Member Releases - Set of Members

Member Side Start Start End Both

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

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



2.9 Serviceability Data

This input table controls several settings for the serviceability limit state design. It is only available if you have set relevant entries in the *Serviceability Limit State* tab of table 1.1 (see chapter 2.1.2, page 11).

	A	B	C	D	E	F	G	H
		Set of Members	Referer	nce Length	Direc-	Precamber		
÷	Reference to	No.	Manually	L [m]	tion	w _c [mm]	Beam Type	Comment
	Set of Members	2		37.096	y, z	0.0	Beam	
	Set of Members	5		25.000	y, z	0.0	Beam	
	Member	81		6.546	y, z	0.0	Beam	
	Member	82	✓	7.094	y, z	0.0	Cantilever End Free	
	Member	83	I	6.546	y, z	0.0	Cantilever End Free	
	Member	15		6.274	y, z	0.0	Beam	
	Member	16		6.274	y, z	0.0	Beam	
	Member	25		6.274	y, z	0.0	Beam	
	Member	26		6.274	y, z	0.0	Beam	
)								
2								
•								
;;								
'								
)								
)								
2								
3								
5								
; ;								
7								
3								



...





Details...

Table 2.23: Table 1.9 Serviceability Data

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

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

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

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

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

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



3. Calculation

3.1 Detail Settings

Calculation

Details...

Before you start the calculation by clicking [Calculation], it is recommended to check the design details. The corresponding dialog box can be accessed in all tables of the add-on module by clicking [Details].

The dialog box *Details* contains the following tabs:

- Ultimate Limit State
- Stability
- Serviceability
- Other

3.1.1 Ultimate Limit State

etails	
Ultimate Limit State Stability Serviceability Other	
Options	Cross-Section Manufacture
 Plastic design acc. to 4.5 and 8.4.3 (only I-sections) Elastic design (also compact cross-sections) Elastic design (based on Von Mises stress) Shear design of solid cross-sections Shear buckling design of webs Use proportioning method acc. to 5.12.2 for cross-sections with slender webs Use alternative calculation acc. to 8.3 and 8.4 General elastic design of simple shear based on shear stress 	To calculate slendemess limits acc. to Tab. 5.2 or Tab. 6.2.4 of general cross-section or cross-section without defined manufacture plate elements use: Stress relieved Hot-rolled Gold-formed Lightly welded longitudinally Heavy welded longitudinally
Limit Internal Forces for Interaction Allow design without influence of torsion if: τt10.6fy ≤ 0.500 ★	
	OK Cancel

Figure 3.1: Dialog box Details, tab Ultimate Limit State

Options

The *Plastic design* according to clause 4.5 can be used I-shape sections. When the conditions described in clause 4.5 are satisfied, hot-formed doubly symmetric I-sections can also be designed according to clause 8.4.3.



Generally, cross-sections of the type "compact" are designed plastically. If you do not want to perform a plastic design, you can activate the *Elastic design* for compact cross-sections.

The conservative general *Elastic design* is based on a stress analysis in stress points and the VON MISES equivalent stresses. It can be useful for cross-section that have complicated shapes, for members with torsional moments etc.

The *Shear design* of solid flat or round bars or *Shear buckling design* of webs is not required in special cases. Those design options can be deactivated, if appropriate.

By default, the shear and bending interaction method is set according to clause 5.12.3. It is possible to set the proportioning method according to clause 5.12.2 for cross-sections where bending is assumed to be resisted only by the flanges.

The Australian standard offers alternative formulae for the compression and bending interaction design of doubly symmetric I-sections and rectangular hollow sections. They can be used to determine the cross-section capacity (clause 8.3) and member capacity (clause 8.4).

The conservative general elastic design based on shear stress analysis in stress points can be activated, if appropriate.

Limit Internal Forces for Interaction

The Australian standard gives no exact procedure how the design of torsional moments is to be handled. Therefore, STEEL AS includes an option to ignore shear stresses due to torsion, which makes it possible to design those cross-sections. The ratio of stress and shear strength can be defined manually.

Cross-section Manufacture

According to the Commentary on the Australian standard [2], residual stresses should be taken into account for the determination of element slenderness limits and cross-section types. In this dialog section, the type of manufacture can be specified that is to be applied for general and SHAPE-THIN cross-sections.



3.1.2 Stability



Figure 3.2: Dialog box Details, tab Stability

Stability Analysis

The check box *Use* controls whether to perform, in addition to the cross-section designs, a stability analysis. If you clear the check box, the input tables 1.4 to 1.8 will not be displayed.

Second Order Effects

You can *Include the effects from second order theory* according to clauses 4.4 and 4.5. When you design, for example, a frame whose governing buckling mode is represented by lateral displacement, you can determine the internal forces according to linear static analysis and increase them with the appropriate factors. If you increase the bending moment, this does not affect the flexural-buckling analysis according to [1], which is performed by using the axial forces.



The *Determination of factor* β_m can be conservative according to clause 4.4.2.2 a) or approximate according to clause 4.4.2.2 b) by matching the distribution of the bending moment along the member according to figure 4.4.2.2 in the Australian standard. The moment distributions can be displayed via the [Info] button.

Structure Type

According to clause 4.4.2, the type of member is required for determination of moment amplification factor. The check boxes of this dialog section define whether there are *Sway* or braced members in the model.

Additionally, the *Elastic buckling factor* λ_c of whole frame (model) according to clause 4.7.2 can be specified.



Lateral-torsional Buckling

If transverse loads exist, it is important to define where those forces are acting on the crosssection: Depending on the *Load Application* point, transverse loads can be stabilizing or destabilizing, and in this way they can critically influence the ideal critical moment. These settings have an effect on the determination of the load height factor K₁ (see [1] table 5.6.3(2)).

Set of Members - Member-Like Input

The input of stability data of sets of members can be realised as member-like (table 1.6) or as general (tables 1.7 and 1.8). It is recommended to apply the STEEL AS design only for straight sets of members. If the default *Do not use member-like input* is set, the support conditions have to be defined in table 1.7 for all sets of members. The factors K_r of table 1.6 will not be used.

The option *Use for all sets of members* makes it possible to define all stability data for sets of members in table 1.6 – analogically to table 1.5 for single members. In this case, tables 1.7 and 1.8 are not displayed. The factors K_r and member types y-y and z-z as defined in table 1.6 are used to determine the support conditions β , u_y, φ_x , φ_z , and ω .

It is possible to *Use only for Straight Sets of Members* the member-like input. Additionally, equal cross-section parameters must apply. The factors K_r as defined in table 1.6 are applied; tables 1.7 and 1.8 are not be displayed for straight sets. This option can be used e.g. for continuous beams. Please note that the factor K_r is identical for every segment or partial member of the set.

The last option *Use only to straight sets of members without intermediate restraints* applies the member-like input only to sets of members which have supports or restraints at their ends that have been defined in RSTAB. Thus, it is possible to design e.g. simple beams or cantilevers. The connection of transverse beams to the intermediate nodes of the set is not accounted for, however. Tables 1.7 and 1.8 are not displayed for straight sets that have no intermediate supports.

Welded I and H Sections Fabrications Acc. to 6.3.3

For the fabrication of welded I and H sections, rolled or flame-cut plates can be used. The member section constant α_b depends on the fabrication of the plates. It is given in table 6.3.3 of the Australian standard. The type of fabrication which is set in this dialog box applies to <u>all</u> cross-sections of the design case.

Limit Load for Special Cases

To design unsymmetrical cross-sections for intended axial compression according to [1] 6.3, it is possible to neglect *small moments* about the major and the minor axis by settings defined in this dialog section.

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

Intended *torsion* is not clearly specified in AS 4100. If a torsional stress is available that is not exceeding the shear stress ratio of 5 % preset by default, it is not considered in the stability design. In this case, the output shows results for flexural buckling and lateral-torsional buckling.



If one of the limits in this dialog section is exceeded, a note appears in the results table. No stability analysis is carried out. Nevertheless, the cross-section designs are performed. These limit settings are <u>not</u> part of the Australian standard. Changing the limits is in the responsibility of the program user.





3.1.3 Serviceability

ails					
Jltimate Limit State Sta	ability Serviceability C	ther			
Deformation Related to			1		
Shifted members end	ds / set of members ends				
Indeformed austern					
O onderoimed system					
Serviceability Limits (De	eflections) Annex B				
Combination of actions	acc. to AS 1170.0, cl. 4				
		Cantilevers			
Short term effects	L / 360 🚔	Lc/ 180 🚖			
Long term effects	L / 200 🚔	Lc/100 🕀			
					IK Cano

Figure 3.3: Dialog box Details, tab Serviceability

Deformation Related to

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

Serviceability Limits (Deflections) Annex B

In this dialog section, the limit deformations can be checked and, if necessary, adjusted.



3.1.4 Other

Itimate Limit State Stability Serviceability Other	
Cross-Section Optimization	Display Result Tables
Max allowable design	✓ 2.1 Design by Load Case
atio:	Image: 2.2 Design by Cross-Section
Check of Member Slendernesses	Image: Image
Members with Alimit	☑ 2.4 Design by Member
Tension only: 300	☑ 2.5 Design by x-Location
Compression / flexure: 200	✓ 3.1 Governing Internal Forces by Member
	✓ 3.2 Governing Internal Forces by Set of Members
	3.3 Member Slendemesses
	V 4 1 Parts List by Member
	✓ 4 2 Parts List by Set of Members
	Only for members / sets to be designed
	○ Of all members / sets of members
	OK Cance

Figure 3.4: Dialog box Details, tab Other

Cross-Section Optimisation

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

Check of Member Slendernesses

The two fields allow for the input of limit values λ_{limit} in order to define member slendernesses. It is possible to enter specifications separately for members with pure tension forces and members with bending and compression.

In table 3.3, the limit values are compared to the real member slendernesses. This table is available only after the calculation (see chapter 4.8, page 40) and if the corresponding check box is selected in the dialog section *Display Result Tables*.

Display Result Tables

In this dialog section, you can select the results tables including parts list that you want to be displayed. The tables are described in chapter 4 *Results*.

The table 3.3 Member Slendernesses is inactive by default.



3.2 Start Calculation

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

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

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

Calculate	Combinations / Module Cases Result Tables				
Not Calculated	i			Selected for C	Calculation
No.	Description	*		No.	Description
Qi LC2 Qiv LC3 Qiv LC4 Qiv LC6 Qi LC8 Qi LC9 Qi LC10 C010 C015 C016 C017 C018 C019 RC2 RC2	Snow Side wind in X Wind on gable in Y Wind on gable in -Y Wind lifting Imperfections in X Imperfections in Y 1.35°LC1 + 1.5°LC2 + 1.5°LC3 Swt+Wind lifting+Imp (char. values) Swt+wi-yinp (char. values) Swt+s+wiy-p+Imp (char. values) Swt+s+wiy-p+Imp (char. values) Swt+s+wiy-p+Imp (char. values) Swt+s+wiy-p+Imp (char. values) Extreme characteristic values		× ×	CA1	STEEL AS - Design of steel members according to AS
All	▼	Q)			
					OK Cancel

Figure 3.5: Dialog box To Calculate

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

To transfer the selected STEEL AS cases to the list on the right, use the button $[\blacktriangleright]$. Click [OK] to start the calculation.

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

<u>O</u> ptions	Add-on Modules Window	Help
🔲 💁	STEEL AS CA1 - Design of	A > 2 1 4 🙀 🖓 2 4 4 🖓 2 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
ें। 👷 🖉	🦉 🕼 🗗 🕅 📅 🦷	就 - 🛂 - 🛛 🗐 - Show Results] 🔻 🗸 🗸 🗤 🗤 🗤 🦷

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

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



>

Calculation





Results 4.

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

STEEL AS - [Demo-Seng]															×
<u>File Edit Settings H</u> elp															
CA1 - Design of steel members a 💌	2.1 Desig	n by Load Case													
Input Data		A	B	C	D	E				F				G	
General Data	Load-		Member	Location	Design										
Materials	ing	Description	No.	x [m]	Ratio				Design	according to Form	ula			DS	i
- Cross-Sections		Ultimate Limit State Design													18
Lateral Intermediate Supports	LC1	Dead Load	87	3.011	0.13	≤1	333) Stability analys	iis - Bendin	g about y	/u-axis and comp	ression act	: to 8.4.2.2			
Effective Lengths - Members	LC2	Snow Load	16	0.000	0.22	≤1	333) Stability analys	iis - Bendin	g about y	/u-axis and comp	ression act	:. to 8.4.2.2			
Effective Lengths - Sets of Men	LC3	Wind v +X	86	3.011	0.04	≤1	105) Cross-section	check - Be	nding abi	out y-axis acc. to	5.1				
Nodal Supports	LC4	Wind at peak v +Y	11	0.000	0.06	≤1	101) Cross-section	check · Te	nsion acc	c. to 7					
Set of members No. 1	LC5	Wind at peak v -Y	10	0.000	0.08	≤1	101) Cross-section	check - Te	nsion acc	c. to 7					
Set of members No. 2	LC6	Wind positive	16	0.000	0.05	≤1	141) Cross-section	check - Be	nding abi	out y-axis and she	ar force ac	c.to 5			
Member End Heleases	LC7	Live Load	20	3.125	0.02	≤1	105) Cross-section	check - Be	nding abi	out y-axis acc. to	5.1				
- Set of members No. 1	CO1		87	3.011	0.59	≤1	333) Stability analys	iis - Bendin	g about y	/u-axis and comp	ression act	:. to 8.4.2.2			
Set of members No. 2	CO2		87	3.011	0.56	≤1	333) Stability analys	sis - Bendin	g about y	/u-axis and comp	ression act	c. to 8.4.2.2			-
Hesults				Mary F	0.50		A			I	E				
Design by Load Lase				Mdx.	0.08	151	•					'>1 😂		3	<u> </u>
Design by Cross-Section	Details	March 4 07 0 044 m									0.10.1				_
Design by Set of Members	Details -	Member 67 - X: 3.011 m - LC1	Castiana)								2 - 15 4	00/200/10/1	5/0		
Design by Member		Section Values - Steel 400 (Flats and	10/1E/0												
Design by x-Location	E Cross	-Section values - 13 400/200/	10/15/0												
Governing Internal Forces by M	E Desig	Castian Trans													
Governing Internal Forces by S	E Cross	-Section Type										20	0.0		
Parts List by Member		a Patie												15.1	
Parts List by Set or Members	Desig	m Tuno				DT	Poom	1	-					=	
	Cor	monagion Avial Earca				N [*]	y Dealin	L-N					0.0		
	Ber	npression Additionce				M	5.040	IcNee							
	Vie	Iding Moment				F	y 50.141	kNI/om2		21	0.0				
	No	minal Member Canacity				N.	40.00	EN		6.2	40				YEH
	E a	rivalant Memort Easter				0	434.237	NIX		0.3		10.0			
	No	minal Section Canacity				M	452.205	lcNm		5.2			0.0		
	No	minal Section Capacity				M	452.555	k Nm		0.2					
	Ne	minal Section Capacity				M	40 007	IcNee		0.5			1		
	C~	ninai Inpiane Capacity				M IN	0 900	KINII		0.4 Tob 2.4			•		
	De	sign Patio				Ψ 	0.500		21	0.4.2			2 Eff		
	De	signi nauo				-	0.13		21	0.4.2					
						-									
						-									
						-								[mm]
						-					A		X		X
< III ►	-					-			1	-			-		~~
	Calculati	on Details			Graph	nics						0		Canc	el
			_								_				

Figure 4.1: Results table with designs and intermediate values

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

The tables 3.1 and 3.2 list the governing internal forces. Table 3.3 informs you about the member slendernesses. In the last two results tables, 4.1 and 4.2, parts lists are displayed by member and set of members.

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

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

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



OK

🌱 🚑



4.1 Design by Load Case

The upper part of this table offers a summery, sorted by load cases, load and result combinations of the governing designs. Furthermore, the list contains ultimate limit state, serviceability and stability design.

The lower part contains detailed information about the cross-section characteristics, analysed internal forces, and design parameters for the load case selected above.

	А	B	С	D	E				F			G	1.
Load-		Member	Location	Design	-								1-
ing	Description	No.	x [m]	Ratio				Design	according to Form	ula		DS	Ш
	Ultimate Limit State Design								-				18
LC1	Dead Load	87	3.011	0.13	≤1	333) Stability analys	is - Bending	about y	/u-axis and compr	ession acc.	to 8.4.2.2	T	1
LC2	Snow Load	16	0.000	0.22	≤1	333) Stability analys	is - Bending	about y	/u-axis and compr	ession acc.	to 8.4.2.2		14
LC3	Wind v +X	86	3.011	0.04	≤1	105) Cross-section of	heck - Ber	nding abo	out y-axis acc. to 5	i.1			1
LC4	Wind at peak v +Y	11	0.000	0.06	≤1	101) Cross-section of	check - Ter	nsion acc	:. to 7				1
LC5	Wind at peak v -Y	10	0.000	0.08	≤1	101) Cross-section of	check - Ter	nsion acc	:. to 7				1
LC6	Wind positive	16	0.000	0.05	≤1	141) Cross-section of	check - Ber	nding abo	out y-axis and shea	ar force acc	. to 5		1
LC7	Live Load	20	3.125	0.02	≤1	105) Cross-section of	check - Ber	nding abo	out y-axis acc. to 5	i.1			
CO1		87	3.011	0.59	≤1	333) Stability analys	is - Bending	g about y	/u-axis and compr	ession acc.	to 8.4.2.2]	
CO2		87	3.011	0.56	≤1	333) Stability analys	is - Bending	g about y	/u-axis and compr	ession acc.	to 8.4.2.2		•
			Мах:	0.59	≤1	۹			🎱 🍳		🏹 😂 🛐 🏾	3	۲
	n Internal Forces Section Type ive Cross-Section Properties n Ratio										200.0	15.0	
Bea	am Type				BT	v Beam					0.0	-+	
Cor	npression Axial Force				N*	34.981	kN				<u></u>		
Ber	nding Moment				M*	y 217.835	kNm						
— Yie	d Strength				fy	40.00	kN/cm ²		2.1	00.0			
- Nor	minal Member Capacity				No	434.297	kN		6.3	4		3	72:
- Equ	uivalent Moment Factor				βm	y -1.000			8.4.2.2		10.0		
- Nor	minal Section Capacity				Ms	y 452.395	kNm		5.2				
- Nor	minal Section Capacity				Mny	447.597	kNm		8.3	↓			
- Nor	minal In-plane Capacity				Miy	411.908	kNm		8.4				
— Cap	pacity Factor				Ф	0.900			Tab. 3.4		ZEff		
- De:	sign Ratio				η	0.59		≤1	8.4.2				
					L								
												[m	ım
					-						X	-	31

Figure 4.2: Table 2.1 Design by Load Case

Description

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

Member No.

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

Location x

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

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

Design

Columns D and E display the design conditions according to AS 4100-1998.

The length of the coloured scale represents the respective stress ratio.



0.98 ≤1 🥹

Max:



Design according to Formula

This column lists the code's equations by which the designs have been performed.

DS

The final column contains information about the respective design-relevant design situation (*DS*): *ULS* (ultimate limit state) or one of the two design situations for serviceability (*Short Term Effects, Long Term Effects*) according to the specification in table 1.1 *General Data* (see Figure 2.4, page 11).

4.2 Design by Cross-Section

	A	B	C	D	E						F					
Section	Member	Location	Load	Design	-											- -
No.	No.	x [m]	Case	Ratio					De	esign Acc	cording to Form	ula				-
	86	3.011	CO1	0.52	≤1	171) Cross-sectio	n check - A	cial forc	e, bending	about y-i	axis and shear	force a	cc. to 5			٦·
			Max:	0.59	≤1	9					9			%₁ 💕	5	
etails -	Member 8	6 - x: 3.011 m	1 - CO1										2 - IS 400	/200/10/15/0		_
Effect	ive Cross-S	Section Prope	erties													
🛛 Desigi	n Ratio															
- Axia	al Force					N°		36.234	kNm							
Ber	nding Mom	ent				M*v	21	10.667	kNm							
She	ar Force					V*z		50.595	kN			_				
We	b Depth					d		370.0	mm		5.1.1.2					
- We	b Thickne	SS				tw		10.0	mm							
- She	ar Area					Az	3	3700.0	mm ²							
- She	ar Reduct	ion Factor				ρz		1.000			5.12.3			200.0	-	
- Nor	ninal Shea	r Yield Capac	city			V _{w,z}	88	38.000	kN		5.11.4			T	15.0	
- She	ar Force					V* _V		0.001	kN				1 t		=	
She	ar Area					Av	(6000.0	mm ²					0.0		
- Nor	ninal Shea	r Yield Capac	city			V _{w.v}	144	40.000	kN		5.11.4					
- Yiel	d Strength		-					40.00	kN/cm ²		2.1		9			
- Ela:	stic Section	n Modulus				Zy	1323	3300.0	mm ³				400			► vz
- Pla:	stic Section	n Modulus				Sv	1497	7250.0	mm ³					10.0		-
- Yiel	d Slenderr	ness Limit				λs.v.	My 4	40.000								
- Pla	sticity Slen	demess Limit				λs.p.	My 3	30.000				=				
Sler	ndemess F	Ratio				λs,M	v 4	46.802					+			
Effe	ective Sect	ion Modulus				Zey	1130	0990.0	mm ³					÷		
- Nor	ninal Secti	on Capacity				Msy	45	52.395	kNm		5.2			ZEff		
- Gro	ss Area					Ag	9	9700.0	mm ²			-1				
For	n Factor					kr		0.945			6.2.2					
Effe	ctive Area	1				Ae	9	9162.3	mm ²							
- Nor	ninal Secti	on Capacity				Ns	366	64.910	kN							
- Nor	ninal Secti	on Capacity				Mry	44	47.425	kNm		8.3					
— Cap	acity Fact	or				Φ		0.900			Tab. 3.4					
Des	sign Ratio					η1		0.52		≤1	8.3					
- Des	sign Ratio					η2		0.06		≤1						[mm
- Des	sign Ratio					ηз		0.00		≤1	5.11			_	_	touu
- Des	sian Ratio					n		0.52		<1		-	8	X	1 ×	à

Figure 4.3: Table 2.2 Design by Cross-Section

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

If you have a tapered member, both cross-section descriptions are displayed in the table row next to the section number.



4.3 Design by Set of Members

	A	B	C	D	E				F					
Set	Member	Location	Load	Design										
No.	No.	x [m]	Case	Ratio				Design	According to For	nula				
1	(Member	No. 14,18,27	7,46,65,79,	38,102)										
	14	1.000	LC6	0.00	≤1	100) Negligible interna	al forces							
	102	0.000	CO2	0.01	≤1	102) Cross-section ch	eck - Compres	sion acc. to 6						
	46	5.647	CO15	0.04	≤1	105) Cross-section ch	eck - Bending	about y-axis acc	. to 5.1					
	14	3.000	LC4	0.01	≤1	106) Cross-section ch	eck - Bending	about z-axis acc	. to 5.1					
	79	1.468	CO2	0.02	≤1	115) Cross-section ch	eck - Shear for	ce in z-axis acc.	to 5.11.4					
	14	0.000	LC1	0.00	≤1	126) Cross-section ch	eck - Shear bu	ckling acc. to 5.	11.5 - Shear force	e in z-axi	s			
	18	0.000	CO15	0.09	≤1	141) Cross-section ch	eck - Bending	about y-axis and	shear force acc.	to 5				
	88	3.011	CO1	0.28	≤1	171) Cross-section ch	eck - Axial forc	e, bending abou	it y-axis and shea	r force a	cc. to 5			-
	27	1.631	CO2	0.02	≤1	181) Cross-section ch	eck - Axial forc	e, bending abou	it z-axis and shea	r force a	cc. to 5			
			I	0.50		•				0	Ē			
			man.	0.00	21	•			4					Ĺ.
] Effecti 1 Design	ive Cross-S	pe Section Prope	rties									200.0	15.0	
Axia	al Force					N*	-19 505	kNm		_				÷
Ben	nding Mom	ent				M [*] v	113 507	kNm		=			0.0	
- She	ar Force					V*7	28.145	kN		_				
We	b Depth					d	370.0	mm	5.1.1.2		0.0			
We	b Thickne	55				tw	10.0	mm			40			
She	ar Area					Az	3700.0	mm ²				10.0	0.0	
She	ar Reduct	ion Factor				ρz	1.000		5.12.3				0.0	
Non	ninal Shea	r Yield Capac	ity			V _{w,z}	888.000	kN	5.11.4	_		_ mmmm	NN	
She	ear Force					V [•] y	0.000	kN				1		
She	ear Area					Ay	6000.0	mm ²				ZEff		
Non	ninal Shea	r Yield Capac	ity			V _{w,y}	1440.000	kN	5.11.4					
Yiel	d Strength					fy	40.00	kN/cm ²	2.1					
	tic Section	n Modulus				Zy	1323300.0	mm ³						
Elas	SUC DECUOI													
Elas Plas	stic Section	n Modulus				Sγ	1497250.0	mm ³						

Figure 4.4: Table 2.3 Design by Set of Members

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

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

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



4.4 Design by Member

	A	B	С	D				E					
Member	Location	Load	Design										
No.	x [m]	Case	Ratio				Design Acco	rding to Formula					
8	Cross-section	n No. 1 - IS	450/200/12	/20/)								
	2.400	LC4	0.00	≤1	100) Negligible internal forces								
	0.000	CO8	0.02	≤1	102) Cross-section check - Con	npression acc. t	o 6						
	5.700	LC3	0.02	≤1	105) Cross-section check - Ben	iding about y-ax	is acc. to 5.1						
	0.000	CO2	0.03	≤1	115) Cross-section check - She	ar force in z-axi	s acc. to 5.11.4						
	0.000	LC1	0.00	≤1	126) Cross-section check - She	ar buckling acc	: to 5.11.5 - She	ar force in z-axis					
	6.000	CO15	0.04	≤1	141) Cross-section check - Ben	iding about y-ax	is and shear forc	e acc. to 5					
	6.000	CO2	0.34	≤1	171) Cross-section check - Axia	al force, bending	g about y-axis and	d shear force acc	. to 5				
	0.000	CO8	0.02	≤1	302) Stability analysis - Flexural	buckling about	y-axis acc. to 6.3	3					
	0.000	CO8	0.07	≤1	306) Stability analysis - Flexural	buckling about	z-axis acc. to 6.3	3					
		Max:	0.59	≤1	9			9	e -	F	🏹 😂 🛙	A	
Effecti Design	ive Cross-Sec n Ratio	tion Propert	ies						_		200.0	† al	
_ boolgi												5	
Axia	al Force				N*	-57.267	kNm		_			0.0	
Axia Ben	al Force Iding Moment				N* M*y	-57.267 205.174	kNm kNm		=			0.0	
Axia Ben She	al Force Iding Moment ar Force				N* M*y V*z	-57.267 205.174 33.914	kNm kNm kN	5112	=	q			
Axia Ben She Wel	al Force ading Moment ar Force b Depth				N* M*y V*z d	-57.267 205.174 33.914 410.0	kNm kNm kN mm	5.1.1.2	=	450.0		0.0	
Axia Ben She Wel Wel	al Force ading Moment ear Force b Depth b Thickness				N* M*y V*z d tw	-57.267 205.174 33.914 410.0 12.0	kNm kNm kN mm mm	5.1.1.2	E	450.0	12.0	0.0	-
Axia Ben She Wel Wel	al Force ading Moment ear Force b Depth b Thickness ear Area				N* M*y V*z d tw Az	-57.267 205.174 33.914 410.0 12.0 4920.0	kNm kNm kN mm mm mm ²	5.1.1.2		450.0	12.0	0.0	
Axia Ben She Wel She She	al Force ading Moment ear Force b Depth b Thickness ear Area ear Reduction	Factor			N* M*y V'z d tw Az Pz	-57.267 205.174 33.914 410.0 12.0 4920.0 11.000	kNm kNm kN mm mm mm ²	5.1.1.2	E	460.0	12.0	0.0	
Axia Ben She Wel She She She	al Force ading Moment ear Force b Depth b Thickness ear Area ear Reduction ninal Shear Yi	Factor eld Capacit	y		Ν [*] Μ [*] y d t _w A _z ν _{wz} ν _{wz}	-57.267 205.174 33.914 410.0 12.0 4920.0 1.000 1180.800	kNm kNm kN mm mm mm ² kN	5.1.1.2 5.12.3 5.11.4		450.0	12.0	0.0 0.0	
Axia Ben She Wel She She She She	al Force ading Moment ear Force b Depth b Thickness ear Area ear Reduction minal Shear Yi ear Force	Factor eld Capacit	y		N* M*y d Lw Az ρz Vw.z V*y	-57.267 205.174 33.914 410.0 12.0 4920.0 1.000 1180.800 0.015	kNm kNm kN mm mm mm ² kN kN kN	5.1.1.2 5.12.3 5.11.4		450.0	12.0	0.0 0.0	
Axia Ben She Wel She She She She	al Force ding Moment ar Force b Depth b Thickness ar Area ar Reduction ninal Shear Yi ar Force ar Area	Factor eld Capacit	y		N* M*y V*z d Lw Az Pz Vw.z V*y Ay	-57.267 205.174 33.914 410.0 12.0 4920.0 1.000 1180.800 0.015 8000.0	kNm kNm kN mm mm mm ² kN kN kN kN	5.1.1.2 5.12.3 5.11.4	E	450.0	12.0 12.0 2.254	0.0 0.0	
Axia Ben She Wel She She She She She	al Force ding Moment ar Force b Depth b Thickness ar Area ar Reduction ninal Shear Yi ar Force ar Area ninal Shear Yi	Factor eld Capacit	y y		N* M*y V*z d Iw Az Vwz V*y Ay Vwy Vwy	-57.267 205.174 33.914 410.0 4920.0 1.000 1180.800 0.015 8000.0 1824.000	kNm kNm kN mm mm² kN kN kN kN	5.1.1.2 5.12.3 5.11.4 5.11.4	E	450.0	12.0 2 2 5 4	0.0 0.0 0.0	-
Axia Ben She Wel She She She She She Non She	al Force Iding Moment ar Force b Depth b Thickness ar Area ar Reduction minal Shear Yi ar Force ar Area minal Shear Yi d Strength	Factor eld Capacit eld Capacit	у		N* M*y V*z d Lw Az Pz Vwy Ay Vy ywy fy,f	-57.267 205.174 33.914 410.0 12.0 4920.0 1180.800 0.015 8000.0 1824.000 38.00 0	kNm kNm kN mm mm mm² kN kN kN kN kN kN kN kN	5.1.1.2 5.12.3 5.11.4 5.11.4 5.11.4		450.0	<u>12.0</u>	0.0 0.0 0.0	
Axia Ben She Wel She She She She She She She	al Force dding Moment aar Force b Depth b Thickness aar Area aar Reduction ninal Shear Yi aar Area ninal Shear Yi d Strength d Strength	Factor eld Capacit eld Capacit	y y		N* M*y V*z d Lw Az Oz Vwz V*y Ay Vwy fy.f fy.w	-57.267 205.174 33.914 410.0 12.0 4920.0 1.000 1180.800 0.015 8000.0 1824.000 38.00 40.00	kNm kNm kN mm mm mm² kN kN kN kN kN kN kN kN	5.12.3 5.12.3 5.11.4 5.11.4 5.11.4 2.1 2.1		450.0	12.0 255	0.0 6	
Axia Ben She Wel She She She She She She She She She She	al Force dding Moment ear Force b Depth b Thickness ear Area ear Reduction ninal Shear Yi ar Force ear Area ninal Shear Yi d Strength d Strength stic Section M	Factor eld Capacit eld Capacit	y y		N* M*y V*z d 1w Az V*z V*z V*z V*y Ay Vw.z V*y Ay Vw.y f.y,t f.y,t f.y,t Zy	-57.267 205.174 33.914 410.0 12.0 4920.0 1.000 1180.800 0.015 8000.0 1824.000 38.00 38.00 0.015	kNm kNm kN mm mm mm2 kN kN kN kN kN/cm2 kN/cm2 mm3 mm3	5.1.1.2 5.12.3 5.11.4 5.11.4 2.1 2.1		450.0	12.0 225	0.0 0.0	[n
Axia Ben She Wel She She She She She She She She She She	al Force ding Moment ar Force b Depth b Thickness ar Area ar Reduction ninal Shear Yi ar Force ar Area ninal Shear Yi d Strength stic Section M stic Section M	Factor eld Capacit eld Capacit odulus odulus	y y y		N* M*y V*z d Az Øz Vwz Ay V*y Ay Vy,f fy,f fy,w Zy Sy	-57.267 205.174 33.914 410.0 12.0 4920.0 1180.800 0.015 8000.0 1824.000 38.00 40.00 1951060.0 2224300.0	kNm kNm kN mm mm mm2 kN kN kN kN kN mm2 mm2 mm4 mm3 mm3	5.1.1.2 5.12.3 5.11.4 5.11.4 2.1 2.1		450.0	12.0 2.55		[r

Figure 4.5: Table 2.4 Design by Member

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

4.5 Design by x-Location

	A	B	C	D									
Member	Location	Load	Design										
No.	x [m]	Case	Ratio					Design Acc	cording to Formula				
	1.568	CO8	0.15	≤1	171) Cross-section of	heck - Axia	l force, bending) about y-axis a	nd shear force acc. to	5			
	1.568	CO1	0.18	≤1	191) Cross-section of	heck - Axia	l force, biaxial b	ending and sh	ear force acc. to 5				
	1.568	CO8	0.16	≤1	333) Stability analysi	s - Bending	about y/u-axis	and compressi	on acc. to 8.4.2.2				
	1.568	CO1	0.09	≤1	344) Stability analysi	s - Biaxial b	ending and cor	npression acc.	to 8.4.5.1				
	1.793	LC7	0.00	≤1	100) Negligible inten	nal forces							
	1.793	CO5	0.01	≤1	105) Cross-section of	heck - Ben	ding about y-ax	is acc. to 5.1					
	1.793	LC1	0.00	≤1	126) Cross-section of	heck - She	ar buckling acc	: to 5.11.5 - Sh	near force in z-axis				
	1.793	CO6	0.06	≤1	141) Cross-section of	heck - Ben	ding about y-ax	is and shear fo	rce acc. to 5				
	1.793	CO8	0.16	≤1	171) Cross-section of	heck - Axia	l force, bending	about y-axis a	nd shear force acc. to	5			
	1.793	CO1	0.19	≤1	191) Cross-section of	heck - Axia	l force, biaxial b	ending and sh	ear force acc. to 5				
		Max	0.59	≤1	•				?			54 💕 萬	5
	ive Cross-Sec n Ratio	tion Propert	lies								+	200.0	15.0
Axia	al Force					N*	-33.803	kNm				0.0	-
- Ben	nding Moment					M [*] y	83.362	kNm					
Ben	nding Moment					M°z	0.249	kNm					
- She	ear Force					V*z	14.184	kN			00.0		
- We	b Depth					d	370.0	mm	5.1.1.2		4		
	b Thickness					tw	10.0	mm				0.0	
We								<u> </u>					
- Wel	ear Area					Az	3700.0	mm ²					
- Wel She She	ear Area ear Reduction	Factor				Az ρz	3700.0	mm²	5.12.3		↓		
Wel She She Nor	ear Area ear Reduction minal Shear Yi	Factor eld Capacit	у			Az Pz V _{w,z}	3700.0 1.000 888.000	mm² kN	5.12.3 5.11.4		↓		
Wel She She Nor She	ear Area ear Reduction minal Shear Yi ear Force	Factor eld Capacit	у			Az ρz V _{w,z} V [*] y	3700.0 1.000 888.000 0.047	kN kN	5.12.3 5.11.4	•	↓	ZEff	
Wel She Non She Ran	ear Area ear Reduction minal Shear Yi ear Force nge Width	Factor eld Capacit	у			Az ρz V _{w,z} V [*] y b	3700.0 1.000 888.000 0.047 95.0	mm ² kN kN mm	5.12.3 5.11.4 5.1.1.2	•	Ļ	ZEH	
Wel She Non She Flar	ear Area ear Reduction minal Shear Yi ear Force nge Width nge Thickness	Factor eld Capacit	у			Az Pz V _{w,z} V [*] y b tf	3700.0 1.000 888.000 0.047 95.0 15.0	mm ² kN kN mm mm	5.12.3 5.11.4 5.1.1.2	-	Ļ	ZEff	
Wel She She Non She Flar Flar She	ear Area ear Reduction minal Shear Yi ear Force nge Width nge Thickness ear Area	Factor eld Capacit	У			Az Pz Vw.z V [*] y b tf Ay	3700.0 1.000 888.000 0.047 95.0 15.0 6000.0	mm ² kN kN mm mm mm mm ²	5.12.3 5.11.4 5.1.1.2		+	ZEff	
Wel She Non She Rar Flar She She	ear Area ear Reduction minal Shear Yi ear Force nge Width nge Thickness ear Area ear Reduction	Factor eld Capacit	у			Az ρz V _{w,z} V [*] y b tf Ay ρy	3700.0 1.000 888.000 0.047 95.0 15.0 6000.0 1.000	mm ² kN kN mm mm mm mm ²	5.12.3 5.11.4 5.1.1.2 5.12.3		Ļ	ZEff	ſ
Wel She She Non She Flar Flar She She Non	ear Area ear Reduction minal Shear Yi ear Force nge Width nge Thickness ear Area ear Reduction minal Shear Yi	Factor eld Capacit s Factor eld Capacit	у			Az ρz V _{w,z} V [*] y b tf Ay ρy V _{w,y}	3700.0 1.000 888.000 0.047 95.0 15.0 6000.0 1.000 1440.000	mm ² kN kN mm mm mm ² kN	5.12.3 5.11.4 5.11.2 5.12.3 5.11.4		Ļ	ZEff	

Figure 4.6: Table 2.5 Design by x-Location



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

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

4.6 Governing Internal Forces by Member

3.1 Governing Internal Forces by Member

	A	B	C	D	E	F	G	H	
Nember	Location	Load-		Forces [kN]		N	Noments [kNm]	
No.	x [m]	ing	N	Vy	Vz	MT	My	Mz	Design According to Formula
1	Cross-section	No. 15 - IS	5 250/250/10/	/15/0					
	1.500	CO13	-6.973	0.000	0.467	0.000	-0.250	0.000	100) Negligible internal forces
	0.000	CO2	-17.393	-0.003	0.130	0.000	0.389	-0.009	102) Cross-section check - Compression acc. to 6
	0.150	LC3	-0.018	0.000	0.932	0.000	+1.033	0.000	105) Cross-section check - Bending about y-axis acc. to 5.1
	1.200	LC5	0.000	0.019	0.000	0.001	0.000	-0.607	106) Cross-section check - Bending about z-axis acc. to 5.1
	0.000	LC3	-0.018	0.000	0.992	0.000	+1.177	0.000	126) Cross-section check - Shear buckling acc. to 5.11.5 - S
	0.000	LC3	-0.018	0.000	0.992	0.000	1.177	0.000	141) Cross-section check - Bending about y-axis and shear f
	0.000	CO3	15.210	0.000	1.599	0.000	-2.083	0.001	171) Cross-section check - Axial force, bending about y-axis
	1.350	C07	-9.972	-0.038	-0.002	0.001	0.003	-0.873	181) Cross-section check - Axial force, bending about z-axis
	0.000	CO2	17.393	-0.003	0.130	0.000	-0.389	-0.009	302) Stability analysis - Flexural buckling about y-axis acc. to
	0.000	CO2	-17.393	-0.003	0.130	0.000	0.389	-0.009	306) Stability analysis - Flexural buckling about z-axis acc. to
2	Cross-section	No. 15 - IS	5 250/250/10/	(15/0					
	3.000	LC5	0.000	0.491	0.000	0.001	0.000	-0.292	100) Negligible internal forces
	2.250	CO9	-41.357	0.813	0.007	0.000	0.009	0.189	102) Cross-section check - Compression acc. to 6
	0.000	LC5	0.000	1.691	0.000	0.001	0.000	2.980	106) Cross-section check - Bending about z-axis acc. to 5.1
	0.000	LC3	-0.018	0.000	2.652	0.000	7.334	0.000	126) Cross-section check - Shear buckling acc. to 5.11.5 - S
	0.000	LC3	-0.018	0.000	2.652	0.000	7.334	0.000	141) Cross-section check - Bending about y-axis and shear f
	0.000	CO1	-50.067	-0.007	4.520	0.000	-13.199	-0.034	171) Cross-section check - Axial force, bending about y-axis
	0.000	C07	-35.399	2.363	0.003	0.001	+0.003	4.052	181) Cross-section check - Axial force, bending about z-axis
	0.000	CO4	-49.461	0.001	0.832	0.000	2.755	0.004	302) Stability analysis - Flexural buckling about y-axis acc. to
	0.000	CO4	-49.461	0.001	0.832	0.000	-2.755	0.004	306) Stability analysis - Flexural buckling about z-axis acc. to
	0.000	CO1	-50.067	-0.007	4.520	0.000	-13.199	-0.034	333) Stability analysis - Bending about y/u-axis and compres
	0.000	C07	-35.399	2.363	0.003	0.001	-0.003	4.052	337) Stability analysis - Bending about z-axis and compressio
3	Cross-section	No. 12 - T	O 80/80/5/5/	5/5					
	0.000	LC5	-0.748	0.000	0.000	0.000	0.000	0.000	100) Negligible internal forces
	2.500	C07	-1.055	0.000	0.000	0.000	0.502	0.000	105) Cross-section check - Bending about y-axis acc. to 5.1
	0.000	C07	-1.055	0.000	0.401	0.000	0.000	0.000	115) Cross-section check - Shear force in z-axis acc. to 5.11
	0.000	LC1	0.004	0.000	0.294	0.000	0.000	0.000	126) Cross-section check - Shear buckling acc. to 5.11.5 - S
4	Cross-section	No. 12 - T	0 80/80/5/5/	5/5					
4	Cross-section	No. 12 - T	O 80/80/5/5/	5/5	0.000	0.000	0.000	0.000	100) Negligible internal forces

Figure 4.7: Table 3.1 Governing Internal Forces by Member

This table displays for each member the governing internal forces that result in maximum stress ratios in each design.

Location x

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

Load Case

This column displays the number of the load case, the load or result combination whose internal forces produce maximum stresses.

Forces / Moments

For each member, this column displays the axial and shear forces as well as the torsional and bending moments producing maximum stresses in the respective cross-section designs, stability analyses and serviceability limit state designs.

Design According to Formula

The final column informs you about the design types and the equations by which the designs according to [1] have been performed.



4.7 Governing Internal Forces by Set of Members

Location x [m]	Load-			_		u u u		
x [m]			Forces [kN]		Ν	foments [kNm]		
	ing	N	Vy	Vz	Mτ	My	Mz	Design According to Formula
(Member No.	14,18,27,4	6,65,79,88,10	2)					
1.000	LC6	2.500	0.000	1.493	0.000	1.493	0.000	100) Negligible internal forces
0.000	CO2	-55.735	0.000	17.829	-0.003	0.000	0.000	102) Cross-section check - Compression acc. to 6
5.647	CO15	-5.856	0.002	0.014	0.000	20.694	0.001	105) Cross-section check - Bending about y-axis acc. to 5.1
3.000	LC4	0.000	0.001	0.000	0.005	0.000	1.797	106) Cross-section check - Bending about z-axis acc. to 5.1
1.468	CO2	-18.978	0.002	-16.282	0.001	-0.382	-0.003	115) Cross-section check - Shear force in z-axis acc. to 5.11.4
0.000	LC1	-31.485	0.000	-7.565	0.000	0.000	0.000	126) Cross-section check - Shear buckling acc. to 5.11.5 - She
0.000	CO15	-6.813	-0.002	9.353	0.000	-35.294	0.000	141) Cross-section check - Bending about y-axis and shear forc
3.011	C01	-19.505	0.000	-28.145	0.001	-113.507	-0.003	171) Cross-section check - Axial force, bending about y-axis and
1.631	CO2	-18.708	-0.060	16.302	-0.002	-0.296	0.272	181) Cross-section check - Axial force, bending about z-axis and
5.700	CO8	-30.271	1.483	-16.594	0.008	-94.986	0.464	191) Cross-section check - Axial force, biaxial bending and she
0.000	CO2	-55.735	0.000	17.829	-0.003	0.000	0.000	302) Stability analysis - Flexural buckling about y-axis acc. to 6.
0.000	CO2	-55.735	0.000	17.829	-0.003	0.000	0.000	306) Stability analysis - Flexural buckling about z-axis acc. to 6.
3.011	CO1	-19.505	0.000	-28.145	0.001	-113.507	-0.003	333) Stability analysis - Bending about y/u-axis and compressio
5.700	CO8	-30.271	1.483	-16.594	0.008	-94.986	0.464	344) Stability analysis - Biaxial bending and compression acc. to
(Member No.	12,17,26,4	15.64.78.87.10	0)					
5.333	LC3	-0.167	0.000	-1.316	0.000	1.040	0.000	100) Negligible internal forces
0.000	LC5	7.095	-0.013	0.885	0.005	0.291	-0.142	101) Cross-section check - Tension acc. to 7
0.000	CO9	-80.491	0.002	31.414	0.007	0.000	0.000	102) Cross-section check - Compression acc. to 6
6.274	C07	-0.780	-0.018	0.914	0.007	46.520	-0.079	105) Cross-section check - Bending about y-axis acc. to 5.1
1.631	CO2	-35.111	0.003	-32.055	0.001	-0.340	-0.004	115) Cross-section check - Shear force in z-axis acc. to 5.11.4
0.000	LC1	-26.749	0.000	-8.219	0.000	0.000	0.000	126) Cross-section check - Shear buckling acc. to 5.11.5 - She
5.647	C07	-0.851	-0.017	1.725	0.007	45.692	-0.091	141) Cross-section check - Bending about y-axis and shear force
3.011	CO1	-34.981	-0.001	-49.897	0.001	-204.707	-0.003	171) Cross-section check - Axial force, bending about y-axis an
2.121	CO2	-33.550	-0.059	29.755	-0.001	-0.197	0.299	181) Cross-section check - Axial force, bending about z-axis an
2.510	CO2	-33.016	0.051	15.258	-0.001	84.221	0.230	191) Cross-section check - Axial force, biaxial bending and she
0.000	CO9	-80.491	0.002	31.414	0.007	0.000	0.000	302) Stability analysis - Flexural buckling about y-axis acc. to 6.
0.000	CO9	-80.491	0.002	31.414	0.007	0.000	0.000	306) Stability analysis - Flexural buckling about z-axis acc. to 6.
3.011	CO1	-34.981	-0.001	-49.897	0.001	-204.707	-0.003	333) Stability analysis - Bending about y/u-axis and compression
2.510	CO2	-33.016	0.051	15.258	-0.001	84.221	0.230	344) Stability analysis - Biaxial bending and compression acc. to
	5.647 3.000 1.468 0.000 0.000 3.011 5.700 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 5.647 3.011 2.510	5 647 C015 3 000 LC4 1 468 CO2 0.000 LC1 0.000 CO15 3.011 CO1 1.631 CO2 0.000 CO3 0.000 LC3 0.000 LC5 0.000 CO9 6.274 CO7 0.000 LC1 5.647 CO1 3.011 CO1 2.510 CO2 0.000 CO9 0.000	5 647 C015 5.8547 3.000 LC4 0.000 1.468 CO2 -18.978 0.000 LC1 -31.485 0.000 C015 -6.813 3.011 CO1 -19.506 1.631 CO2 -18.778 0.000 CO2 -55.735 0.000 CO3 -30.271 (Member No. 12.17.26.45.64.78.87.10 CO3 -30.271 0.000 CO9 -80.491 -6.27 0.000 CO9 -80.491 -0.167 0.000 CO9 -80.491 -35.111 0.000 LC1 -26.749 -33.5111 0.000 LC1 -26.749 -33.111 0.000 CO2 -33.3016 -30.491 <t< td=""><td>5.647 CO15 -5.856 0.002 3.000 LC4 0.000 0.001 1.468 CO2 -18.978 0.002 0.000 LC1 -31.485 0.000 0.000 CO15 -6.813 -0.002 3.011 CO1 -118.978 0.002 3.011 CO1 -118.905 0.000 5.700 CO8 -30.271 1.483 0.000 CO2 -55.735 0.000 3.011 CO1 -15.505 0.000 3.011 CO1 -15.505 0.000 5.700 CO8 -30.271 1.483 Member No. 12.17.26.45.64.78.87.100) 5.333 LC3 -0.167 5.700 CO9 -80.491 0.002 6.274 0.013 0.000 CO9 -80.491 0.002 6.274 0.013 0.000 CO7 -85111 0.003 0.000 C47 -0.780 -0.013 0.000</td><td>5.647 CO15 5.856 0.002 0.014 3.000 LC4 0.000 0.001 0.000 1.468 CO2 1.8778 0.002 16.282 0.000 LC1 -31.485 0.000 -7.565 0.000 LC1 -31.485 0.000 -28.145 1.631 CO2 -18.708 -0.060 -28.145 1.631 CO2 -18.708 -0.060 -28.145 5.700 CO8 -30.271 1.483 -16.594 0.000 CO2 -56.735 0.000 17.829 0.000 CO2 -56.735 0.000 28.145 5.700 CO8 -30.271 1.483 -16.594 (Member No. 12,17.26.45.64,78.87,100) -3.316 0.000 -1.316 5.700 CO3 -30.271 1.483 -16.594 (Member No. 12,17.26,45.64,78.87,100) -3.316 0.000 23.141 6.747 CO7 -0.795 -0.013 0.321.141</td><td>5 647 CO15 -5.856 0.002 0.014 0.000 3.000 LC4 0.000 0.001 0.000 0.005 1.468 CO2 -18.978 0.002 -16.282 0.001 0.000 LC1 -31.485 0.000 -7.565 0.000 0.000 CO15 -6.813 -0.002 9.353 0.000 3.011 CO1 -118.708 -0.002 -9.354 0.000 5.700 CO8 -30.271 1.483 -16.544 0.000 5.700 CO8 -30.271 1.483 -16.544 0.000 0.000 CO2 -55.735 0.000 17.829 -0.003 3.011 CO1 -13.505 0.000 -13.16 0.000 5.700 CO8 -30.271 1.483 -16.594 0.008 0.000 CO2 -55.735 0.000 -1.316 0.000 5.700 CO8 -30.271 1.483 -0.613 0.885</td></t<> <td>5.647 CO15 -5.856 0.002 0.014 0.000 20.694 3.000 LC4 0.000 0.001 0.000 0.005 0.000 1.468 CO2 -18.978 0.002 -16.282 0.001 -0.382 0.000 LC1 -31.485 0.002 -9.555 0.000 -35.234 3.011 CO1 -18.505 0.000 -28.145 0.001 -113.505 5.700 CO8 -30.271 1.483 -16.594 0.003 9.4386 0.000 CO2 -55.735 0.000 17.829 -0.003 0.000 0.000 CO2 -55.735 0.000 17.829 -0.003 0.000 0.000 CO2 -55.735 0.000 1.78.29 -0.003 0.000 3.011 CO1 +35.05 0.000 1.78.29 -0.003 0.000 3.011 CO1 +35.05 0.000 1.13.60 -11.316 -11.316 0.000</td> <td>5 647 CO15 -5.856 0.002 0.014 0.000 20.694 0.001 3.000 LC4 0.000 0.011 0.000 0.005 0.000 1.797 1.468 CO2 18.378 0.002 15.282 0.001 0.302 0.003 0.000 LC1 31.485 0.002 9.353 0.000 0.000 0.000 0.000 C015 -6.813 -0.002 9.353 0.000 -35.294 0.003 3.11 CO1 -19.505 0.000 -28.145 0.000 -113.507 -0.003 5.700 CO8 -30.271 1.483 1-6.594 0.000 -9.286 0.272 5.700 CO8 -30.271 1.483 1-6.594 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.014 0.000 0.000</td>	5.647 CO15 -5.856 0.002 3.000 LC4 0.000 0.001 1.468 CO2 -18.978 0.002 0.000 LC1 -31.485 0.000 0.000 CO15 -6.813 -0.002 3.011 CO1 -118.978 0.002 3.011 CO1 -118.905 0.000 5.700 CO8 -30.271 1.483 0.000 CO2 -55.735 0.000 3.011 CO1 -15.505 0.000 3.011 CO1 -15.505 0.000 5.700 CO8 -30.271 1.483 Member No. 12.17.26.45.64.78.87.100) 5.333 LC3 -0.167 5.700 CO9 -80.491 0.002 6.274 0.013 0.000 CO9 -80.491 0.002 6.274 0.013 0.000 CO7 -85111 0.003 0.000 C47 -0.780 -0.013 0.000	5.647 CO15 5.856 0.002 0.014 3.000 LC4 0.000 0.001 0.000 1.468 CO2 1.8778 0.002 16.282 0.000 LC1 -31.485 0.000 -7.565 0.000 LC1 -31.485 0.000 -28.145 1.631 CO2 -18.708 -0.060 -28.145 1.631 CO2 -18.708 -0.060 -28.145 5.700 CO8 -30.271 1.483 -16.594 0.000 CO2 -56.735 0.000 17.829 0.000 CO2 -56.735 0.000 28.145 5.700 CO8 -30.271 1.483 -16.594 (Member No. 12,17.26.45.64,78.87,100) -3.316 0.000 -1.316 5.700 CO3 -30.271 1.483 -16.594 (Member No. 12,17.26,45.64,78.87,100) -3.316 0.000 23.141 6.747 CO7 -0.795 -0.013 0.321.141	5 647 CO15 -5.856 0.002 0.014 0.000 3.000 LC4 0.000 0.001 0.000 0.005 1.468 CO2 -18.978 0.002 -16.282 0.001 0.000 LC1 -31.485 0.000 -7.565 0.000 0.000 CO15 -6.813 -0.002 9.353 0.000 3.011 CO1 -118.708 -0.002 -9.354 0.000 5.700 CO8 -30.271 1.483 -16.544 0.000 5.700 CO8 -30.271 1.483 -16.544 0.000 0.000 CO2 -55.735 0.000 17.829 -0.003 3.011 CO1 -13.505 0.000 -13.16 0.000 5.700 CO8 -30.271 1.483 -16.594 0.008 0.000 CO2 -55.735 0.000 -1.316 0.000 5.700 CO8 -30.271 1.483 -0.613 0.885	5.647 CO15 -5.856 0.002 0.014 0.000 20.694 3.000 LC4 0.000 0.001 0.000 0.005 0.000 1.468 CO2 -18.978 0.002 -16.282 0.001 -0.382 0.000 LC1 -31.485 0.002 -9.555 0.000 -35.234 3.011 CO1 -18.505 0.000 -28.145 0.001 -113.505 5.700 CO8 -30.271 1.483 -16.594 0.003 9.4386 0.000 CO2 -55.735 0.000 17.829 -0.003 0.000 0.000 CO2 -55.735 0.000 17.829 -0.003 0.000 0.000 CO2 -55.735 0.000 1.78.29 -0.003 0.000 3.011 CO1 +35.05 0.000 1.78.29 -0.003 0.000 3.011 CO1 +35.05 0.000 1.13.60 -11.316 -11.316 0.000	5 647 CO15 -5.856 0.002 0.014 0.000 20.694 0.001 3.000 LC4 0.000 0.011 0.000 0.005 0.000 1.797 1.468 CO2 18.378 0.002 15.282 0.001 0.302 0.003 0.000 LC1 31.485 0.002 9.353 0.000 0.000 0.000 0.000 C015 -6.813 -0.002 9.353 0.000 -35.294 0.003 3.11 CO1 -19.505 0.000 -28.145 0.000 -113.507 -0.003 5.700 CO8 -30.271 1.483 1-6.594 0.000 -9.286 0.272 5.700 CO8 -30.271 1.483 1-6.594 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.014 0.000 0.000

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

This table contains the internal forces that result in the maximum ratios within the design of each set of members.

4.8 Member Slendernesses

Under Stress mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure	Length L [m] 3.000 3.000 5.000 5.000 3.000 3.000	ky [-] 1.000 1.000 1.000 1.000 1.000 1.000	Major Axis y iy [mm] 107.7 107.7 30.7 30.7	λ _y [-] 27.849 27.849 162.938	kz[-] 1.000 1.000 1.000	Minor Axis z iz [mm] 63.5 63.5 30.7	λ _z [-] 47.263 47.263	
Under Stress mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure	L [m] 3.000 3.000 5.000 5.000 3.000 3.000	k _y [-] 1.000 1.000 1.000 1.000 1.000	iy [mm] 107.7 107.7 30.7 30.7	λ _y [-] 27.849 27.849 162.938	k _z [-] 1.000 1.000 1.000	iz [mm] 63.5 63.5 30.7	λ _z [-] 47.263 47.263	
mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure	3.000 3.000 5.000 3.000 3.000 3.000	1.000 1.000 1.000 1.000 1.000	107.7 107.7 30.7 30.7	27.849 27.849 162.938	1.000 1.000 1.000	63.5 63.5 30.7	47.263 47.263	
mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure	3.000 5.000 5.000 3.000 3.000	1.000 1.000 1.000 1.000	107.7 30.7 30.7	27.849 162.938	1.000	63.5 30.7	47.263	
mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure	5.000 5.000 3.000 3.000	1.000 1.000 1.000	30.7 30.7	162.938	1.000	30.7	162 020	
mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure mpression / Rexure	5.000 3.000 3.000	1.000	30.7			00.7	102.330	
mpression / Flexure mpression / Flexure mpression / Flexure mpression / Flexure	3.000 3.000	1.000		162.938	1.000	30.7	162.938	
mpression / Flexure mpression / Flexure mpression / Flexure	3.000		184.3	16.275	1.000	45.5	65.961	
mpression / Flexure mpression / Flexure		1.000	184.3	16.275	1.000	45.5	65.961	
mpression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
	6.000	1.000	184.3	32.550	1.000	45.5	131.922	
mpression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
mpression / Flexure	6.000	1.000	184.3	32.550	1.000	45.5	131.922	
mpression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
mpression / Flexure	6.000	1.000	184.3	32.550	1.000	45.5	131.922	
mpression / Flexure	3.011	1.000	165.2	18.231	1.000	45.4	66.267	
mpression / Flexure	3.011	1.000	165.2	18.231	1.000	45.4	66.267	
mpression / Flexure	3.011	1.000	165.2	18.231	1.000	45.4	66.267	
mpression / Flexure	3.011	1.000	165.2	18.231	1.000	45.4	66.267	
mpression / Flexure	6.274	1.000	107.7	58.240	1.000	63.5	98.841	
mpression / Flexure	6.250	1.000	188.0	33.251	1.000	47.0	133.049	
mpression / Flexure	6.250	1.000	188.0	33.251	1.000	47.0	133.049	
mpression / Flexure	3.262	1.000	165.2	19.751	1.000	45.4	71.793	
mpression / Flexure	3.262	1.000	165.2	19.751	1.000	45.4	71.793	
mpression / Flexure	3.262	1.000	165.2	19.751	1.000	45.4	71.793	
mpression / Flexure	3.262	1.000	165.2	19.751	1.000	45.4	71.793	
mpression / Flexure	3.546	1.000	129.3	27.432	1.000	63.5	55.865	
mpression / Flexure	3.000	1.000	129.3	23.208	1.000	63.5	47.263	
mpression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
mpression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
mpression / Flexure	3.546	1.000	86.2	41.123	1.000	52.1	68.012	
mpression / Flexure	3.000	1.000	86.2	34.791	1.000	52.1	57.540	
mpression / Flexure	5.000	1.000	30.7	162.938	1.000	30.7	162.938	
	mpression / Rexure mpression / Rexure	mpression / Rexure 5.000 mpression / Rexure 3.011 mpression / Rexure 6.250 mpression / Rexure 2.622 mpression / Rexure 3.262 mpression / Rexure 3.262 mpression / Rexure 3.262 mpression / Rexure 3.546 mpression / Rexure 5.000 mpression / Rexure 3.046 mpression / Rexure 3.046 mpression / Rexure 3.046 mpression / Rexure 3.000 mpression / Rexure 3.000 mpression / Rexure 3.046 mpression / Rexure 3.046 mpression / Rexure 3.000 mpression / Rexure 3.000 mpression / Rexure 3.000	mpression / Rexure 5.000 1.000 mpression / Rexure 6.000 1.000 mpression / Rexure 3.011 1.000 mpression / Rexure 6.274 1.000 mpression / Rexure 6.250 1.000 mpression / Rexure 6.250 1.000 mpression / Rexure 3.262 1.000 mpression / Rexure 3.546 1.000 mpression / Rexure 5.000 1.000 mpression / Rexure 5.000 1.000 mpression / Rexure 3.000 1.000 mpression / Rexure 5.000 1.000 mpression / Rexure 3.000 1.000 mpression / Rexure 3.000 1.000	Impression / Rexure 5.000 1.000 30.7 mpression / Rexure 6.000 1.000 184.3 mpression / Rexure 3.011 1.000 165.2 mpression / Rexure 6.274 1.000 165.2 mpression / Rexure 6.250 1.000 188.0 mpression / Rexure 3.262 1.000 165.2 mpression / Rexure 3.262 1.000 123.3 mpression / Rexure 3.546 1.000 30.7 mpression / Rexure 5.000 1.000 30.7 mpression / Rexure 3.546 1.000 86.2 mpression / Rexure 5.000<	mpression / Rexure 5.000 1.000 30.7 162.938 mpression / Rexure 6.000 1.000 184.3 32.550 mpression / Rexure 3.011 1.000 165.2 18.231 mpression / Rexure 6.274 1.000 165.2 18.231 mpression / Rexure 6.250 1.000 188.0 33.251 mpression / Rexure 3.262 1.000 165.2 19.751 mpression / Rexure 3.262 1.000 165.2 19.751 mpression / Rexure 3.262 1.000 165.2 19.751 mpression / Rexure 3.546 1.000 123.3 2.27.432 mpression / Rexure 5.000 1.000 30.7 162.388 mpression / Rexure 5.000 1.000 30.7	Impression / Rexure 5.000 1.000 30.7 If (2.938) 1.000 mpression / Rexure 6.000 1.000 184.3 32.550 1.000 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 mpression / Rexure 6.274 1.000 107.7 58.240 1.000 mpression / Rexure 6.250 1.000 188.0 33.251 1.000 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 mpression / Rexure 3.646 1.000 129.3 22.432 1.000 <td>Impression / Rexure 5.000 1.000 30.7 IE2.938 1.000 30.7 mpression / Rexure 6.000 1.000 184.3 32.550 1.000 45.5 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 mpression / Rexure 6.274 1.000 107.7 58.240 1.000 63.5 mpression / Rexure 6.250 1.000 188.0 33.251 1.000 47.0 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 45.4 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 45.4 mpression / Rexure 3.262 1.000 165.2</td> <td>Impression / Rexure 5.000 1.000 30.7 162.938 1.000 45.5 131.922 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 66.267 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 66.267 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 66.267 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 66.267 mpression / Rexure 6.274 1.000 107.7 58.240 1.000 45.4 66.267 mpression / Rexure 6.250 1.000 107.7 58.240 1.000 45.4 66.267 mpression / Rexure 6.250 1.000 188.0 33.251 1.000 45.4 71.733 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 45.4 71.793 mpression / Rexure 3.262 1.000</td>	Impression / Rexure 5.000 1.000 30.7 IE2.938 1.000 30.7 mpression / Rexure 6.000 1.000 184.3 32.550 1.000 45.5 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 mpression / Rexure 6.274 1.000 107.7 58.240 1.000 63.5 mpression / Rexure 6.250 1.000 188.0 33.251 1.000 47.0 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 45.4 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 45.4 mpression / Rexure 3.262 1.000 165.2	Impression / Rexure 5.000 1.000 30.7 162.938 1.000 45.5 131.922 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 66.267 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 66.267 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 66.267 mpression / Rexure 3.011 1.000 165.2 18.231 1.000 45.4 66.267 mpression / Rexure 6.274 1.000 107.7 58.240 1.000 45.4 66.267 mpression / Rexure 6.250 1.000 107.7 58.240 1.000 45.4 66.267 mpression / Rexure 6.250 1.000 188.0 33.251 1.000 45.4 71.733 mpression / Rexure 3.262 1.000 165.2 19.751 1.000 45.4 71.793 mpression / Rexure 3.262 1.000

Figure 4.9: Table 3.3 Member Slendernesses

4 Results



Details...

Details...

This results table is shown only if you select the respective check box in the dialog box *Details*, tab *Other* (see Figure 3.4, page 32).

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

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

This table is displayed only for information. No stability design of slendernesses is intended.

4.9 Parts List by Member

Finally, STEEL AS Cross-sections provides a summary of all members that are included in the design case.

Cross-Section Description	Number of	Length	T 1 1 1 1					
Description		Lengui	Total Length	Surface Area	Volume	Unit Weight	Weight	Total Weight
	Members	[m]	[m]	[m ²]	[m ³]	[kg/m]	[kg]	[t]
15 - IS 250/250/10/15/0	4	3.00	12.00	17.76	0.12	76.15	228.44	0.91
12 - TO 80/80/5/5/5/5	25	5.00	125.00	40.00	0.19	11.78	58.88	1.47
1 - IS 450/200/12/20/0	4	3.00	12.00	20.11	0.16	101.42	304.27	1.21
1 - IS 450/200/12/20/0	6	6.00	36.00	60.34	0.47	101.42	608.53	3.65
13 - Circle 24	4	7.81	31.24	2.36	0.01	3.55	27.74	0.11
2 - IS 400/200/10/15/0	8	3.01	24.09	38.06	0.23	76.15	229.30	1.83
7 - IS 250/250/10/15/0	4	6.27	25.10	37.14	0.24	76.15	477.72	1.91
9 - IS 450/200/10/20/0	8	6.25	50.00	84.00	0.61	94.99	593.66	4.74
13 - Circle 24	8	8.02	64.18	4.84	0.03	3.55	28.49	0.22
2 - IS 400/200/10/15/0	8	3.26	26.10	41.24	0.25	76.15	248.42	1.98
6 - IS 300/250/10/18/0	2	3.55	7.09	11.21	0.08	91.37	324.01	0.64
6 - IS 300/250/10/18/0	3	3.00	9.00	14.22	0.10	91.37	274.12	0.82
10 - IS 200/200/8/15/0	2	3.55	7.09	8.40	0.05	57,78	204.87	0.41
10 - IS 200/200/8/15/0	3	3.00	9.00	10.66	0.07	57.78	173.33	0.52
6 - IS 300/250/10/18/0	2	6.55	13.09	20.69	0.15	91.37	598.13	1.19
2 - IS 400/200/10/15/0	8	6.27	50.19	79.30	0.49	76.15	477.73	3.82
6 - IS 300/250/10/18/0	1	4.09	4.09	6.47	0.05	91.37	374.09	0.37
10 - IS 200/200/8/15/0	1	4.09	4.09	4.85	0.03	57.78	236.53	0.23
6 - IS 300/250/10/18/0	1	7.09	7.09	11.21	0.08	91.37	648.21	0.64
	102		516.46	512.84	3.41			26.75
	1-15 450/200/12/20/0 1-15 450/200/12/20/0 13 - Orcle 24 2-15 400/200/10/15/0 7-15 250/250/10/15/0 9-15 450/200/10/20/0 13 - Orcle 24 2-15 400/200/10/15/0 6-15 300/250/10/18/0 10-15 200/200/8/15/0 6-15 300/250/10/18/0 2-15 400/200/8/15/0 6-15 300/250/10/18/0 10-15 200/200/8/15/0 6-15 300/250/10/18/0 10-15 200/200/8/15/0 6-15 300/250/10/18/0 10-15 200/200/8/15/0 6-15 300/250/10/18/0	1-15 450/200/12/20/0 1 1-15 450/200/12/20/0 6 13 - Orcle 24 1 2-15 400/200/10/5/0 8 7-15 250/250/10/15/0 4 9-15 450/200/10/20/0 8 13 - Orcle 24 8 2-15 400/200/10/15/0 8 2-15 400/200/10/15/0 8 2-15 400/200/10/15/0 1 0-15 200/200/8/15/0 2 2-15 400/200/8/15/0 2 2-15 400/200/8/15/0 3 6-15 300/250/10/18/0 2 2-15 400/200/8/15/0 1 10-15 200/200/8/15/0 1 6-15 300/250/10/18/0 1 10-15 200/200/8/15/0 1 6-15 300/250/10/18/0 1 10-15 200/200/8/15/0 1 10-15 200/200/8/15/0 1 10-15 200/200/8/15/0 1 10-15 200/200/8/15/0 1 10-15 200/200/8/15/0 1 10-15 200/200/8/15/0 1 10-15 200/200/8/15/0 1 102 102	1-15 450/200/12/20/0 1 4 3.00 1-15 450/200/12/20/0 6 6.00 15 - Crede 24 4 7.81 2-15 400/200/10/15/0 8 3.01 7-15 250/250/10/15/0 4 6.27 9-15 450/200/10/20/0 8 6.25 13 - Crede 24 8 8.02 2-15 400/200/10/15/0 8 3.26 6 - 15 300/250/10/18/0 2 3.55 6 - 15 300/250/10/18/0 3 3.00 10 - 15 200/200/%/15/0 2 3.55 10 - 15 200/200/%/15/0 2 3.55 10 - 15 200/200/%/15/0 2 6.55 2 - 15 400/200/%/15/0 3 3.00 6 - 15 300/250/10/18/0 1 4.09 10 - 15 200/200/%/15/0 1 4.09 10 - 15 200/200/%/15/0 1 4.09 6 - 15 300/250/10/18/0 1 7.09	1-15 450/200/12/20/0 4 3.00 12.00 1-15 450/200/12/20/0 6 6.00 36.00 38.00 13 - Grade 24 4 7.81 31.24 2-15 400/200/10/15/0 8 3.01 24.09 7.15 250/250/10/15/0 4 6.25 50.00 3 - Grade 24 8 8.02 64.18 2-15 400/200/10/20/0 8 6.25 50.00 13 - Grade 24 8 8.02 64.18 2-15 400/200/10/15/0 8 3.26 25.10 2-15 400/200/10/15/0 2 3.55 7.09 6-15 300/250/10/18/0 3 3.00 9.00 10 - 15 200/200/8/15/0 2 3.55 7.09 10 - 15 200/200/8/15/0 2 6.55 13.09 2-15 400/200/18/0 2 6.55 13.09 2-15 400/200/18/15/0 1 4.09 4.09 6-15 300/250/10/18/0 1 4.09 4.09 6-15 300/250/10/18/0 1 7.09 7.09	1-15 4-11 3.00 1.2.00 2.0.11 1-15 450/200/12/20/0 6 6.00 36.00 60.34 13 -Crole 24 4 7.81 31.24 2.38 2-15 400/200/10/15/0 8 3.01 24.09 38.06 7 15 250/250/10/15/0 4 6.27 50.00 84.00 3-15 450/200/10/20/0 8 6.25 50.00 84.00 14.12 3-15 450/200/10/15/0 8 8.02 64.18 4.84 2 2-15 400/200/10/15/0 8 3.00 9.00 11.422 14.22 5-15 300/250/10/18/0 2 3.55 7.09 8.40 14.22 10-15 200/200/8/15/0 2 3.55 7.09 8.40 14.22	1-15 450/2007/22/20/0 6 6.00 36.00 60.34 0.47 13 - Grade 24 4 7.81 31.24 2.36 0.01 2 - 15 450/2007/15/0 8 3.01 24.09 38.06 0.23 7 15 250/250/10/15/0 8 6.25 50.00 84.00 0.61 13 - Grade 24 8 8.02 64.18 4.84 0.02 9 - 15 450/2007/07/20/0 8 6.25 50.00 84.00 0.61 13 - Grade 24 8 8.02 64.18 4.84 0.05 2 - 15 400/200/10/15/0 8 3.26 26.10 4.124 0.25 2 - 15 400/200/10/15/0 1 3 3.00 9.00 14.22 0.05 10 - 15 200/200/8/15/0 2 3.55 7.09 11.21 0.08 6 - 15 300/250/10/18/0 3 3.00 9.00 14.24 0.05 10 - 15 200/200/8/15/0 2 6.55 13.09 20.69 0.15 2 - 15 400/201/0/18/0 1 4.09 4.09 6.47 0.05 10 - 15 20	1-15 4-15 3-00 12/200 20.16 0.16 0.172 13-15 44 7.81 31.24 2.06 0.01 35.55 2-15 400/200/10/15/0 8 3.01 2.49 38.66 0.23 76.15 7.15 250/200/10/20/0 8 6.25 50.00 84.00 0.61 94.99 3-15 440/200/10/20/0 8 6.25 50.00 84.00 0.61 94.99 13-Crole 24 8 8.02 64.18 4.84 0.03 3.55 2-15 400/200/10/15/0 8 3.26 22.51.0 37.14 0.26 76.15 2-15 400/200/10/15/0 8 3.26 26.10 41.24 0.25 76.15 2-15 400/200/10/15/0 2 3.55 7.09 11.21 0.08 91.37 10-15 200/200/8/15/0 2 3.55 7.09 8.40 0.05 57.78 10-15 200/200/8/15/0 2 6.55 1.09 2.09 <td< td=""><td>1-15 450/200/12/20/0 6 600 20.11 0.16 001.42 304.27 15 450/200/12/20/0 6 600 36.00 60.34 0.47 101.42 608.53 13 - Grele 24 4 7.81 31.24 2.36 0.01 3.55 27.74 2 - 15 400/200/10/5/0 8 3.01 2.409 38.06 0.23 76.15 223.37 7 15 250/250/10/15/0 4 6.27 25.10 37.14 0.24 76.15 247.72 7 15 250/250/10/15/0 8 6.25 50.00 84.00 0.61 94.99 593.66 13 - Grele 24 8 8.00 64.18 4.84 0.03 3.55 28.49 2 15 400/200/10/15/0 8 3.26 25.10 41.24 0.25 76.15 248.42 6 15 300/250/10/18/0 2 3.55 7.09 11.21 0.08 91.37 274.12 10 -15 200/200/8/15/0 2 3.55 7.09 14.24 0.05 57.78 278.33 6 -15 300/250/10/18/0 3 3.00 9.00 10.66 0.07 57.78 204.87 10 -15 200/200/8/15/0 1 4.09 4.09 6.47 0.05 9</td></td<>	1-15 450/200/12/20/0 6 600 20.11 0.16 001.42 304.27 15 450/200/12/20/0 6 600 36.00 60.34 0.47 101.42 608.53 13 - Grele 24 4 7.81 31.24 2.36 0.01 3.55 27.74 2 - 15 400/200/10/5/0 8 3.01 2.409 38.06 0.23 76.15 223.37 7 15 250/250/10/15/0 4 6.27 25.10 37.14 0.24 76.15 247.72 7 15 250/250/10/15/0 8 6.25 50.00 84.00 0.61 94.99 593.66 13 - Grele 24 8 8.00 64.18 4.84 0.03 3.55 28.49 2 15 400/200/10/15/0 8 3.26 25.10 41.24 0.25 76.15 248.42 6 15 300/250/10/18/0 2 3.55 7.09 11.21 0.08 91.37 274.12 10 -15 200/200/8/15/0 2 3.55 7.09 14.24 0.05 57.78 278.33 6 -15 300/250/10/18/0 3 3.00 9.00 10.66 0.07 57.78 204.87 10 -15 200/200/8/15/0 1 4.09 4.09 6.47 0.05 9

Figure 4.10: Table 4.1 Parts List by Member

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

Part No.

The program automatically assigns item numbers to similar members.

Cross-Section Description

This column lists the cross-section numbers and descriptions.

Number of Members

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

Details...



Length

This column displays the respective length of an individual member.

Total Length

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

Surface Area

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

Volume

0

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

Cross-Section Mass

The *Cross-Section Mass* is related to the length of one meter. For tapered cross-sections, the program averages both cross-section properties.

Mass

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

Total Mass

The final column indicates the total mass of each part.

Sum

At the bottom of the list, you find a summary of the summed up values of column B, D, E, F, and I. The last data field of the column *Total Mass* gives information about the total amount of steel required.



4.10 Parts List by Set of Members

4.2 Parts List by Set of Members

		В	C	D	E	F	G	H	
Part	Set of Members	Number	Length	Total Length	Surface Area	Volume	Unit Weight	Weight	Total Weight
No.	Description	of Sets	[m]	[m]	[m ²]	[m ³]	[kg/m]	[kg]	[t]
1		2	37.10	74.19	119.53	0.80	84.32	3127.97	6.25
Sum		2		74.19	119.53	0.80			6.25

Figure 4.11: Table 4.2 Parts List by Set of Members

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

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



5. **Results Evaluation**

You can evaluate the design results in various manners. The buttons below the first table part can be helpful for the evaluation process.

	A	B	С	D				F			
ember	Location	Load	Design	-							
No.	x [m]	Case	Ratio				Design Acc	cording to	o Formula		
61	Cross-section	n No. 2 - IS	400/200/10	/15/							
	0.627	LC3	0.00	≤1	100) Negligible internal forces						
	5.378	LC5	0.00	≤1	102) Cross-section check - Compre	ssion acc. to 6					
	0.000	CO6	0.09	≤1	105) Cross-section check - Bendin	g about y-axis a	cc. to 5.1				
	0.000	CO2	0.00	≤1	126) Cross-section check - Shear b	ouckling acc. to	5.11.5 - Sł	near forc	e in z-axis		
	0.896	CO6	0.09	≤1	141) Cross-section check - Bendin	g about y-axis a	nd shear fo	rce acc.	to 5		
	0.627	CO2	0.24	≤1	171) Cross-section check - Axial fo	rce, bending ab	out y-axis a	and shea	r force acc. to 5		
	5.378	LC5	0.00	≤1	302) Stability analysis - Flexural bud	kling about y-a	xis acc. to	6.3			
	5.378	LC5	0.01	≤1	306) Stability analysis - Flexural bud	kling about z-a	xis acc. to (6.3			
	0.627	CO2	0.25	≤1	333) Stability analysis - Bending ab	out y/u-axis and	d compressi	ion acc.	to 8.4.2.2		
		Max	0.59	≤1	9				🎱 🚑	🖺 🏹 😂 强	\$
tails - I	Member 61 - :	x: 0.627 m -	C02				-			2 - IS 400/200/10/15/0	
Materi	al Values - St	eel 400 (Flat	ts and Section	ns)						1	
Cross-	Section Value	es - IS 400	/200/10/15/	0							
Desigr	n Internal Ford	ces									
Cross-	Section Type									200.0	
Effecti	ive Cross-Sec	tion Propert	ies							1 200.0	2.0
Desigr	n Ratio									+	÷
Bea	ат Туре				BTy	Beam				0.0	_
Con	npression Axia	al Force			N*	33.961	kN				
Ben	nding Moment				M [*] y	115.354	kNm				
 Yiel 	d Strength				fy	40.00	kN/cm ²		2.1		
Nor	ninal Member	Capacity			No	817.369	kN		6.3	10.0	
Equ	iivalent Mome	ent Factor			βmy	-1.000			8.4.2.2	0.0	
Nor	ninal Section	Capacity			Msy	529.322	kNm		5.2		
Nor	ninal Section	Capacity			Mry	523.872	kNm		8.3		
Nor	ninal In-plane	Capacity			Miy	504.885	kNm		8.4	• • • • • • • • • • • • • • • • • • •	
Сар	acity Factor				Φ	0.900			Tab. 3.4	ZEff	
Des	sign Ratio				η	0.25		≤1	8.4.2		
								1			
											(r

Figure 5.1: Buttons for results evaluation

The buttons are reserved for the following functions:

Button	Description	Function
`	Ultimate Limit State Designs	Turns on and off the results of the ultimate limit state design
2	Serviceability Limit State Designs	Turns on and off the results of the serviceability limit state design
	Show Colour Bars	Turns on and off the coloured reference scales in the results tables
7,1	Show Rows with Ratio > 1	Displays only the rows where the ratio is more than 1, and thus the design is failed
2	Result Diagrams	Opens the window <i>Result Diagram on Member</i> → chapter 5.2, page 47
4	Excel Export	Exports the table to MS Excel / OpenOffice → chapter 7.4.3, page 58
₹\$	Member Selection	Allows you to graphically select a member to display its results in the table
	View Mode	Jumps to the RSTAB work window to change the view

Table 5.1: Buttons in results tables 2.1 to 2.5



5.1 Results in the RSTAB Model

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

RSTAB background graphic and view mode

The RSTAB work window in the background is useful for finding the position of a particular member in the model: The member selected in the STEEL AS results table is highlighted in the selection colour in the background graphic. Furthermore, an arrow indicates the member's x-location that is displayed in the selected table row.



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

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

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

RSTAB work window

The ratios can also be checked graphically in the RSTAB model. Click [Graphics] to exit the design module. The ratios are displayed in the RSTAB work window like internal forces of a load case.

In the *Results* navigator of STEEL AS, you can choose which design ratios of the ULS or SLS analyses are to be displayed graphically.

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

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



X.XX



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

The graphical representation of the results can be controlled in the *Display* navigator by selecting *Results* \rightarrow *Members*. The display of ratios is *Two-Coloured* by default.



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

In case of a multicolour representation (options *With/Without Diagram* or *Cross-Sections*), the colour panel is available, providing common control functions. The functions are described in detail in the RSTAB manual, chapter 3.4.6.



Figure 5.4: Design ratios with display option Without Diagram

The graphics of the design results can be transferred to the printout report (see chapter 6.2, page 50) by clicking the panel button [STEEL AS].

STEEL AS



5.2 Result Diagrams

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

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

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

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

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

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



Figure 5.5: Dialog box Result Diagram on Member

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

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





2

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5.3 Filter for Results

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

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

Filtering designs

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

View ightarrow Control Panel (Colour Scale, Factors, Filter)

or use the toolbar button shown on the left.

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



Figure 5.6: Filtering design ratios with adjusted colour spectrum

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

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



× -



Filtering members

1

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



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

Unlike the partial view function, the model is now displayed completely in the graphic. The figure above shows the design ratios of a hall frame. The remaining members are displayed in the model but are shown without design ratios.



6. Printout

6.1 Printout report

Similar to RSTAB, the program generates a printout report for the STEEL AS results, to which graphics and descriptions can be added. In the printout report, you can select the data from the design module to be included in the printout.



The printout report is described in the RSTAB manual. In particular, chapter 10.1.3.4 *Selecting Data of Add-on Modules* provides information concerning the selection of input and output data in add-on modules for the printout.

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

6.2 STEEL AS Graphic Printout

In RSTAB, every picture that is displayed in the work window can be included in the printout report or send directly to a printer. Thus, the design ratios displayed in the RSTAB model can be prepared for the printout, too.



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

Designs in the RSTAB model

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

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

or use the toolbar button shown on the left.

ĺ	🗐 R	STAB	8.00 (6	4bit) - [Hall*]			
	:45	<u>F</u> ile	<u>E</u> dit	<u>V</u> iew	<u>I</u> nsert	<u>C</u> alculate	<u>R</u> esults	Tools
	: 🗅	2	33	.) 😡 🖻	50	🖉 🍕	@ 🔁
	1	- 🦻	: 🔉 :	V1 🐒	왕 Prin	t Graphic	8 i 🎮 -	<u>2×x</u> !

Figure 6.1: Button Print Graphic in RSTAB toolbar

Result Diagrams



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

肩 Result Diagram on	Member	
Members No.: 18	- < > 5	😡 😕 🔍 🔍 🗃 🖩
E 📷 STEEL AS	CA1 - Design c 🍸 🔌 >	Print
Navigator	д × 0.000	0.500
🔽 Design Ratio	· · · ·	

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



The following dialog box opens:

Graphic Printout		×
General Options Color Spectrum Factors		
Graphic Picture	Window To Print	Graphic Size
Graphic Picture Size and Rotation ✓ Use whole page width O Use whole page height Height: 61 ← [½ of page] Rotation: 0 ← [*]	Options Show results for selected; diagram Lock graphic picture (with Show printout report on [C]	k≟ocation in result out update))K]
Header of Graphic Picture STEEL AS - Members Design Ratio, CA1, Isomet	ric	

Figure 6.3: Dialog box Graphic Printout, tab General

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

A graphic can be moved anywhere within the printout report by using the drag-and-drop function.

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

Graphic Printout			(ж
General Options Color Spectrum	Factors			
Script	Symbols		Frame	
 Proportional Constant 	 Proportional Constant 		 <u>N</u>one Framed 	
Factor: 1	Factor: 1		Title box	
Print Quality		Color		
) Standard (max 1000 x 1000 Pixels))	© <u>G</u> rayscal	e	
○ Maximum (max 5000 x 5000 Pixels))	Texts an	d lines in <u>b</u> lack	
Oser-defined		All colore	d	
Ma <u>x</u> number of pixels:	1000			
			OK Cance	!

Figure 6.4: Dialog box Graphic Printout, tab Options

Remove from Printout Report
Start with New Page
Selection
Properties



7. General Functions

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

7.1 Design Cases

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

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

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

Create a New Design Case

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

File ightarrow New Case.

The following dialog box appears:

New STEE	L AS Case
<u>N</u> o. 2	Description Design of steel members according to AS
D	OK Cancel

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

Click [OK] to open the STEEL AS table 1.1 General Data where you can enter the design data.

Rename a Design Case

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

File \rightarrow Rename Case.

The following dialog box appears:

Rename	STEEL AS Case	×
<u>N</u> o. 1	Description New Description	•
٢		OK Cancel

Figure 7.2: Dialog box Rename STEEL AS-Case

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



Figure 7.1: Dialog box New STEEL AS-Case



Copy a Design Case

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

```
File \rightarrow Copy Case.
```

The following dialog box appears:

<u>C</u> opy fro	im Case
CA2 - D	esign of steel members according to AS
New Cas	se
<u>N</u> o.:	Description:
3	New Description .

Figure	7.3:	Dialog	box	Copy	' STEEL	AS-Case

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

Delete a Design Case

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

```
\textbf{File} \rightarrow \textbf{Delete Case}.
```

The following dialog box appears:

elete (Cases	2
Availal	ole Cases	
No.	Description	4
1	Design of steel members according to AS	
2	Design of steel members according to AS	
3	New Description	
		-
2	OK Cano	el

Figure 7.4: Dialog box Delete Case

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





7.2 Cross-Section Optimisation

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

	A	B	C	D	E		F				
Section	Member	Location	Load	Design							
No.	No.	x [m]	Case	Ratio		Design According to Formula					
1	IS 450/20	0/12/20/0									
	8	8 1 500 LC5 0.00 ≤ 1 100) Nedligible internal forces									
	94	Go to Cr	oss-Sectio	n	-section check - Compression acc. to 6						
	12	Info Abr	ut Cross-S	Section			-section check - Bending about y-axis acc. to 5.1				
	14	INO ADO	ut cross-c	Section			-section check - Bending about z-axis acc. to 5.1				
	93	<u>Optimiz</u>	e Cross-Se	ction			-section check - Shear force in z-axis acc. to 5.11.4				
	5	Cross-Se	ction Ont	imization Pa	rame	ters	-section check - Shear buckling acc. to 5.11.5 - Shear force in z-axis				
	14	0.000	- COL	0.00			-section check - Bending about y-axis and shear force acc. to 5				
	8	6.000	CO2	0.37	≤1	171) Cross	-section check - Axial force, bending about y-axis and shear force acc. to 5				
	14	5.700	CO8	0.17	≤1	191) Cross	-section check - Axial force, biaxial bending and shear force acc. to 5				

Figure 7.5: Context menu for cross-section optimisation

During the optimisation process, the module determines the cross-section within the same cross-section table that fulfils the analysis requirements in the most optimal way, that is, comes as close as possible to the maximum allowable stress ratio specified in the *Details* dialog box (see Figure 3.4, page 32). The required cross-section properties will be determined with the internal forces from RSTAB. If another cross-section proves to be more favourable, this cross-section will be used for the design. Then, the graphic in table 1.3 will show two cross-sections: the original cross-section from RSTAB and the optimised one (see Figure 7.7).

For a parameterised cross-section, the dialog box *Optimise* appears if you select the corresponding option.



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

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

7 General Functions



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

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

5

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

The modified cross-sections can be exported to RSTAB: Set table 1.3 *Cross-Sections*, and then click

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

The context menu in table 1.3 provides options to export optimised cross-sections to RSTAB.



Figure 7.7: Context menu in table 1.3 Cross-Sections

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

STEEL AS Information No. 26852					
Do you want to transfer the changed cross-sections to RSTAB?					
If so, the results of RSTAB and STEEL AS will be deleted.					

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

By confirming the query and starting the [Calculation] subsequently in the STEEL AS module, the internal forces of RSTAB and the designs will be determined in one single calculation run.

Calculation

7 General Functions



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

5

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

7.3 Units and Decimal Places

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

Settings \rightarrow Units and Decimal Places.

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

Units and Decimal Places						×
Units and Decimal Places Program / Module RSTAB STEEL STEEL EC3 STEEL AISC STEEL IS STEEL IS STEEL IS STEEL GB STEEL GB STEEL CS STEEL AS STEEL AS STEEL AS STEEL AS STEEL NT OF	•	STEEL AS Output Data Stresses: Design ratios: Dimensionless:	Unit Dec. place MPa	Parts List Lengths: Tgtal lengths: Surface greas: Volumes: Weight per length: Weight	Unit m • • m^2 • m^3 • kg/m •	Dec, places 2* 2* 2* 2* 2* 2* 2* 2* 2* 2* 2* 2* 2* 2* 2* 2*
- STEEL NTC-DF - ALUMINIUM - KAPPA - LTB - FE-LTB - EL-PL - C-TO-T - PLATE-BUCKLING - CRANEWAY - CONCRETE - CONCRETE - CONCRETE Columns - TIMBER AWC - TIMBER AWC - TIMBER - COMPOSITE-BEAM - DYNAM - JOINTS - END-PLATE	•			Weight: Total weight:	kg • t •	
	F				ОК	Cancel

Figure 7.9: Dialog box Units and Decimal Places



The settings can be saved as user profile to reuse them in other models. These functions are described in the RSTAB manual, chapter 11.1.3.



7.4 Data Transfer

7.4.1 Material Export to RSTAB

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

 $\textbf{Edit} \rightarrow \textbf{Export All Materials to RSTAB}.$

The modified materials can also be exported to RSTAB by using the context menu of table 1.2.

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

Figure 7.10: Context menu of table 1.2 Materials

Calculation

Before the modified materials are transferred to RSTAB, a security query appears as to whether the results of RSTAB should be deleted. After you confirm the query and start the [Calculation] subsequently in STEEL AS, the RSTAB internal forces and designs will be determined in one single calculation run.

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

7.4.2 Export Effective Lengths to RSTAB

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

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

The modified effective lengths can also be exported to RSTAB via the context menu of table 1.5.



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

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

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

7.4.3 Export of Results

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

Clipboard

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



Printout report

The data of the STEEL AS add-on module can be printed into the global printout report (see chapter 6.1, page 50) for export. Then, in the printout report, click

File \rightarrow Export to RTF.

The function is described in the RSTAB manual, 10.1.11.

Excel / OpenOffice

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

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

The following export dialog box appears.

	Application
🗸 With table header	Microsoft Excel
🔲 Only marked rows	OpenOffice.org Calc
	CSV file format
Transfer Parameters	
Export table to active workbook	
Export table to active worksheet	
Rewrite existing worksheet	
Selected Tables	
 Active table 	Export tables with details
All tables	
Input tables	
Besult tables	
THOUGH CADIOS	

Figure 7.12: Dialog box Export - MS Excel

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

	Image: Image						
F	ile	Home	Insert	Page Lay	out Fo	rmula	as Data Review View Add-Ins 🛆 🕜 🗖 🔂 🔀
Pas	$ \begin{array}{c c c c c c c c c c c c c c c c c c c $						
	B3 • (* 15 450/200/12/20/0						
	Α	В	С	D	E	F	G
1	Section	Member	Location	Load-	Desig	'n	
2	No.	No.	x [m]	ing	Ratio		Design According to Formula
3	3 1 IS 450/200/12/20/0						
4		8	1.500	LC5	0.00	≤1	100) Negligible internal forces
5		94	0.000	CO1	0.02	≤1	102) Cross-section check - Compression acc. to 6
6		12	5.700	LC3	0.02	≤1	105) Cross-section check - Bending about y-axis acc. to 5.1
7		14	3.000	LC4	0.01	≤1	106) Cross-section check - Bending about z-axis acc. to 5.1
8		93	1.200	CO9	0.09	≤1	115) Cross-section check - Shear force in z-axis acc. to 5.11.4
9		5	0.000	LC1	0.00	≤1	126) Cross-section check - Shear buckling acc. to 5.11.5 - Shear force in z-axis
10		14	6.000	LC2	0.05	≤1	141) Cross-section check - Bending about y-axis and shear force acc. to 5
11		8	6.000	CO2	0.37	≤1	171) Cross-section check - Axial force, bending about y-axis and shear force
12		14	5.700	CO8	0.17	≤1	191) Cross-section check - Axial force, biaxial bending and shear force acc. 1
13		100	0.000	CO9	0.15	≤1	302) Stability analysis - Flexural buckling about y-axis acc. to 6.3
14		100	0.000	CO9	0.07	≤1	306) Stability analysis - Flexural buckling about z-axis acc. to 6.3
14 4		2.1 Desig	in ph Foad	Case	2.2 Desig	n by	Cross-Section 🔁 🚺
Rea	dy						

Figure 7.13: Result in Excel



8. Example

In our example we perform the stability analyses of flexural buckling and lateral-torsional buckling for a column with double-bending, taking into account the interaction conditions.

Design values



Design values of the static loads

- $N_{d} \quad = 300 \; kN$
- $q_{z,d} = 5.0 \text{ kN/m}$
- $F_{y,d} = 7.5 \text{ kN}$

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

Internal forces according to linear static analysis



Figure 8.2: Internal forces



Design location (decisive x-location)

The design is performed for all x-locations (see chapter 4.5) of the equivalent member. The decisive location is x = 2.00 m. RSTAB determines the following internal forces:

N = -300.00 kN $M_y = 10.00 \text{ kNm}$ $M_z = 7.50 \text{ kNm}$ $V_y = 3.75 \text{ kN}$ $V_z = 0.00 \text{ kN}$

Cross-Section Properties HE-B 160, Steel 250

Property	Symbol	Value	Unit
Cross-section area	А	5425.00	mm²
Moment of inertia	ly	24920000.00	mm⁴
Moment of inertia	lz	8892000.00	mm⁴
Governing radius of gyration	r _y	67.80	mm
Governing radius of gyration	rz	40.50	mm
Polar radius of gyration	r _o	78.97	mm
Polar radius of gyration	r _{o,M}	419.00	mm
Cross-section mass	М	42.63	kg/m
Torsional constant	J	312400.00	mm⁴
Warping constant	C_{ω}	4794000000.00	mm⁵
Elastic section modulus	Zy	311500.00	mm³
Elastic section modulus	Zz	111200.00	mm³
Plastic section modulus	Sy	354000.00	mm³
Plastic section modulus	Sz	169960.00	mm³

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

 $N_{\text{om},z} = \frac{\pi^2 \cdot 200000 \cdot 8892000}{4000^2} = 1097.01 \text{kN}$

Cross-section class is compact, $A_e = A$, $k_f = 1.0$

$$\lambda_{n,z} = \left(\frac{l_{e,z}}{r_z}\right) \sqrt{k_f} \sqrt{\left(\frac{f_y}{250}\right)} = \left(\frac{4000}{40.5}\right) \sqrt{1.0} \sqrt{\left(\frac{250}{250}\right)} = 98.765$$

$$\alpha_{a,z} = \frac{2100 \cdot (\lambda_{n,z} - 13.5)}{\lambda_{n,z}^2 - 15.3\lambda_{n,z} + 2050} = \frac{2100 \cdot (98.765 - 13.5)}{98.765^2 - 15.3 \cdot 98.765 + 2050} = 17.395$$

The appropriate section constant α_b is given in Table 6.3.3(1).

 $\alpha_{\rm b}$ = 0.00 for hot-rolled I-section (t_f \leq 40 mm)

 $\lambda_z = \lambda_{n,z} + \alpha_{a,z} \cdot \alpha_b = 98.765 + 17.395 \cdot 0 = 98.765$

$$\eta_z = 0.00326 \cdot (\lambda_z - 13.5) = 0.00326 \cdot (98.765 - 13.5) = 0.278$$

$$\xi_{z} = \frac{\left(\frac{\lambda_{z}}{90}\right)^{2} + 1 + \eta_{z}}{2 \cdot \left(\frac{\lambda_{z}}{90}\right)^{2}} = \frac{\left(\frac{98.765}{90}\right)^{2} + 1 + 0.278}{2 \cdot \left(\frac{98.765}{90}\right)^{2}} = 1.031$$



$$\alpha_{c,z} = \xi_z \left(1 - \sqrt{\left[1 - \left(\frac{90}{\xi_z \lambda_z} \right)^2 \right]} \right) = 1.03 \left[1 - \sqrt{\left[1 - \left(\frac{90}{1.031 \cdot 98.765} \right)^2 \right]} \right] = 0.549$$

$$N_s = A_w \cdot f_{y,w} + A_f \cdot f_{y,f} = 1759 \cdot 260 + 3666 \cdot 250 = 1373.84 \text{ kN}$$

$$N_{c,z} = \alpha_{c,z} \cdot N_s = 0.549 \cdot 1373.84 = 754.50 \text{ kN}$$

$$\Phi = 0.9$$

 $\frac{\mathsf{N}^*}{\Phi \cdot \mathsf{N}_{\mathsf{c},\mathsf{z}}} = \frac{300}{0.9 \cdot 754.50} = \underline{0.442 \le 1}$

Result values from STEEL AS calculation

Manufacture		HR			
Compression Axial Force	N*	300	kN		
Nominal Section Capacity	N₅	1373.840	kN		
Form Factor	k f	1.000			6.2.2
Yield Strength	fy	250	MPa		2.1
Modulus of Elasticity	E	200000	MPa		
Gross Area	Ag	5425	mm²		
Second Moment of Area	lz	8892000	mm ⁴		
Radius of Gyration	r _z	40.486	mm		
Effective Length	l _{e,z}	4000	mm		
Geometrical Slenderness	$\lambda_{g,z}$	98.801			6.3.1
Elastic Flexural Buckling Load	N _{om,z}	1097.010	kN		4.6.2
Auxiliary Factor	α _{a,z}	17.392			6.3.3
Section Constant	ab	0			Tab. 6.3.3
Modified Slenderness	$\lambda_{n,z}$	98.801			6.3.3
Slenderness	λz	98.801			6.3.3
Auxiliary Factor	ηz	0.278			6.3.3
Auxiliary Factor	ξz	1.030			6.3.3
Reduction Factor	α _{c,z}	0.549			6.3.3
Capacity Factor	Φ	0.900			Tab. 3.4
Nominal Member Capacity	N _{c,z}	754.172	kN		6.3
Design Ratio	η	0.442		≤ 1	6.1



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

$$N_{\text{om},y} = \frac{\pi^2 \cdot 200000 \cdot 24920000}{4000^2} = 3074.38 \text{ kN}$$

Cross-section class is compact, $A_{\rm e}$ = A, $k_{\rm f}$ = 1.0

$$\lambda_{n,y} = \left(\frac{l_{e,y}}{r_y}\right) \sqrt{k_f} \sqrt{\left(\frac{f_y}{250}\right)} = \left(\frac{4000}{67.8}\right) \sqrt{1.0} \sqrt{\left(\frac{250}{250}\right)} = 58.997$$
$$\alpha_{a,y} = \frac{2100 \cdot (\lambda_{n,y} - 13.5)}{\lambda_{n,y}^2 - 15.3\lambda_{n,y} + 2050} = \frac{2100 \cdot (58.997 - 13.5)}{58.997^2 - 15.3 \cdot 58.997 + 2050} = 20.645$$

The appropriate section constant α_{b} is given in Table 6.3.3(1).

 $\alpha_{\rm b}$ = 0.00 for hot-rolled I-section (t_f \leq 40 mm)

$$\lambda_{y} = \lambda_{n,y} + \alpha_{a,y} \cdot \alpha_{b} = 58.997 + 20.645 \cdot 0 = 58.997$$

$$\eta_y = 0.00326 \cdot (\lambda_y - 13.5) = 0.00326 \cdot (58.997 - 13.5) = 0.148$$

$$\xi_{y} = \frac{\left(\frac{\lambda_{y}}{90}\right)^{2} + 1 + \eta_{y}}{2 \cdot \left(\frac{\lambda_{y}}{90}\right)^{2}} = \frac{\left(\frac{58.997}{90}\right)^{2} + 1 + 0.148}{2 \cdot \left(\frac{58.997}{90}\right)^{2}} = 1.836$$

$$\alpha_{c,y} = \xi_y \left(1 - \sqrt{\left[1 - \left(\frac{90}{\xi_y \lambda_y}\right)^2 \right]} \right) = 1.031 \left(1 - \sqrt{\left[1 - \left(\frac{90}{1.836 \cdot 58.997}\right)^2 \right]} \right) = 0.814$$

 $N_s = A_w \cdot f_{y,w} + A_f \cdot f_{y,f} = 1759 \cdot 260 + 3666 \cdot 250 = 1373.84 \text{ kN}$

 $N_{c,y} = \alpha_{c,y} \cdot N_s = 0.814 \cdot 1373.84 = 1118.63 \text{ kN}$

 $\Phi=\text{0.9}$

$$\frac{\mathsf{N}^{*}}{\Phi \cdot \mathsf{N}_{c,y}} = \frac{300}{0.9 \cdot 1118.63} = \underline{0.298 \le 1}$$

Result values from STEEL AS calculation

Manufacture		HR		
Compression Axial Force	N*	300	kN	
Nominal Section Capacity	Ns	1373.840	kN	
Form Factor	k f	1.000		6.2.2
Yield Strength	fy	250	MPa	2.1
Modulus of Elasticity	E	200000	MPa	
Gross Area	Ag	5425	mm²	



Second Moment of Area	ly	24920000	mm⁴		
Radius of Gyration	r _y	67.776	mm		
Effective Length	l _{e,y}	4000	mm		
Geometrical Slenderness	$\lambda_{g,y}$	59.018			6.3.1
Elastic Flexural Buckling Load	N _{om,y}	3074.380	kN		4.6.2
Auxiliary Factor	α _{a,y}	20.645			6.3.3
Section Constant	ab	0			Table 6.3.3
Modified Slenderness	$\lambda_{y,z}$	59.018			6.3.3
Slenderness	λ_y	59.018			6.3.3
Auxiliary Factor	η	0.148			6.3.3
Auxiliary Factor	ξ _y	1.835			6.3.3
Reduction Factor	α _{c,y}	0.814			6.3.3
Capacity Factor	Φ	0.900			Table 3.4
Nominal Member Capacity	N _{c,y}	1118.470	kN		6.3
Design Ratio	η	0.298		≤ 1	6.1

Lateral-torsional buckling

Effective length

Twist restraint factor $k_t = 1.0$

The point of load application is assumed to be in the shear centre. The application point for transverse loads can be adjusted in *Details* dialog box (see chapter 3.1.2, page 29).

Load height factor $k_l = 1.0$

Lateral rotation factor $k_r = 1.0$

Effective length according to clause 5.6.3

 $L_w = k_t \cdot k_l \cdot k_r \cdot L = 4000 mm$

Reference buckling moment

The reference buckling moment for lateral torsional buckling will be determined for this example according to Eq. 5.6.1.1(3), taking into account pinned supports free to warp.

$$M_{o} = M_{oa} = \sqrt{\left[\left(\frac{\pi^{2} \cdot E \cdot I_{z}}{L_{w}^{2}}\right)\left[G \cdot J + \left(\frac{\pi^{2} \cdot E \cdot I_{w}}{L_{w}^{2}}\right)\right]\right]}$$

$$M_{o} = \sqrt{\left[\left(\frac{\pi^{2} \cdot 2.0e5 \cdot 8892000}{4000^{2}}\right)\left[8.0e4 \cdot 312400 + \left(\frac{\pi^{2} \cdot 2.0e5 \cdot 4.794e10}{4000^{2}}\right)\right]\right]} = 184.132 \text{ kNm}$$



Nominal member moment capacity

The nominal member moment capacity of the segment without full lateral restraint, fully restrained at both ends of open cross-section with equal flanges constant along member is calculated according to Eq. 5.6.1.1(1).

The moment modification factor can be determined according to clauses 5.6.1.1 (a) (i) to (iv). We can use data from table 5.6.1 for a parabolic moment diagram: $\alpha_m = 1.13$.

The slenderness reduction factor is calculated according to Eq. 5.6.1.1(2).

The nominal section moment capacity is determined in accordance with clause 5.2 for the gross cross-section:

HEB-160, cross-section type "compact": $S_v = 354000 \text{ mm}^3$

 $M_{s,y} = f_y \cdot min(S_y; 1.5 \cdot Z_y) = 250 \cdot min(354000; 1.5 \cdot 311500) = 88.5 kNm$

STEEL AS calculates value of $M_{s,y}$, taking into account different yield strengths of the material depending on the material thickness. Therefore, we can use:

 $M_{s,y} = 88.86 kNm$

Now we can calculate the slenderness reduction factor:

$$\alpha_{s} = 0.6 \left[\sqrt{\left[\left(\frac{M_{s,y}}{M_{oa}} \right)^{2} + 3 \right]} - \left(\frac{M_{s,y}}{M_{oa}} \right) \right] = 0.6 \left[\sqrt{\left[\left(\frac{88.86}{184.132} \right)^{2} + 3 \right]} - \left(\frac{88.86}{184.132} \right) \right] = 0.789$$

Finally, we determine the nominal member moment capacity:

 $M_{b,y} = \alpha_m \cdot \alpha_s \cdot M_{s,y} = 1.13 \cdot 0.789 \cdot 88.86 = 79.25 \text{ lkNm}$

Interaction of biaxial bending and compression

The design ratio is determined according to clause 8.4.5.1.

Calculation of M_{i,y} M_{i,z} and M_{o,y}

Nominal in-plane member moment capacity M_{i,y} acc. to clause 8.4.2.2

$$M_{i,y} = M_{s,y} \cdot \left(1 - \frac{N^*}{\Phi N_{c,y}}\right) = 88.86 \cdot \left(1 - \frac{300}{0.9 \cdot 1118.63}\right) = 65.029 \text{kNm}$$

We can use the alternative calculation for doubly symmetric compact I-sections with $k_f = 1.0$:

$$\mathsf{M}_{i,y} = \mathsf{M}_{s,y} \cdot \left\{ \left[1 - \left(\frac{1 + \beta_{m,y}}{2}\right)^3 \right] \left(1 - \frac{\mathsf{N}^*}{\Phi\mathsf{N}_{c,y}} \right) + 1.18 \cdot \left(\frac{1 + \beta_{m,y}}{2}\right)^3 \sqrt{\left(1 - \frac{\mathsf{N}^*}{\Phi\mathsf{N}_{c,y}}\right)} \right\}$$

In this equation, we use the equivalent moment factor $\beta_{m,y} = -1.0$ according to clause 4.4.2.2(a).

$$M_{i,y} = 88.86 \cdot \left\{ \left[1 - \left(\frac{1-1}{2}\right)^3 \right] \left(1 - \frac{300}{0.9 \cdot 1118.63} \right) + 1.18 \cdot \left(\frac{1-1}{2}\right)^3 \sqrt{\left(1 - \frac{300}{0.9 \cdot 1118.63} \right)} \right\}$$

 $M_{i,y} = 62.381 \text{kNm}$



Nominal in-plane member moment capacity M_{i,z} acc. to clause 8.4.2.2

$$M_{s,z} = f_y \cdot min(S_z; 1.5 \cdot Z_z) = 250 \cdot min(170000; 1.5 \cdot 111200) = 41.70 kNm$$

$$M_{i,z} = M_{s,z} \cdot \left(1 - \frac{N^*}{\Phi N_{c,z}} \right) = 41.70 \cdot \left(1 - \frac{300}{0.9 \cdot 754.50} \right) = 25.119 \text{kNm}$$

We can use the alternative calculation for doubly symmetric compact I-sections with $k_f = 1.0$:

$$\mathsf{M}_{i,z} = \mathsf{M}_{s,z} \cdot \left\{ \left[1 - \left(\frac{1 + \beta_{m,z}}{2}\right)^3 \right] \left(1 - \frac{\mathsf{N}^*}{\Phi\mathsf{N}_{c,z}} \right) + 1.18 \cdot \left(\frac{1 + \beta_{m,z}}{2}\right)^3 \sqrt{\left(1 - \frac{\mathsf{N}^*}{\Phi\mathsf{N}_{c,z}}\right)} \right\}$$

In this equation, we use the equivalent moment factor $\beta_{m,z} = -1.0$ according to clause 4.4.2.2(a).

$$M_{i,z} = 41.70 \cdot \left\{ \left[1 - \left(\frac{1-1}{2}\right)^3 \right] \left(1 - \frac{300}{0.9 \cdot 754.50} \right) + 1.18 \cdot \left(\frac{1-1}{2}\right)^3 \sqrt{\left(1 - \frac{300}{0.9 \cdot 754.50} \right)} \right\}$$

M_{i.z} = 23.277kNm

Nominal out-of-plane member moment capacity $M_{o,y}$ acc. to clause 8.4.4.1

$$M_{oy} = M_{b,y} \cdot \left(1 - \frac{N^*}{\Phi N_{c,z}}\right) = 79.251 \cdot \left(1 - \frac{300}{0.9 \cdot 754.50}\right) = 47.740 \text{kNm}$$

Interaction design ratio acc. to clause 8.4.5.1

For $M_{c,y}$, the lesser value of the nominal in-plane member capacity $M_{i,y}$ and the nominal out-ofplane capacity $M_{o,y}$ has to be applied. In our example, $M_{o,y}$ is relevant.

$$\left(\frac{\mathsf{M}_{\mathsf{y}}^{*}}{\Phi \cdot \mathsf{M}_{\mathsf{c},\mathsf{y}}}\right)^{1.4} + \left(\frac{\mathsf{M}_{\mathsf{z}}^{*}}{\Phi \cdot \mathsf{M}_{\mathsf{i},\mathsf{z}}}\right)^{1.4} \le 1$$

$$\left(\begin{array}{c}10.00\\\end{array}\right)^{1.4} + \left(\begin{array}{c}7.50\\\end{array}\right)^{1.4} = 0.267$$

$$\left(\frac{10.00}{0.9 \cdot 47.74}\right)^{1.4} + \left(\frac{7.50}{0.9 \cdot 23.277}\right)^{1.4} = \underline{0.367 \le 1}$$



Result values from STEEL AS calculation

		1		-	
Beam Type		Beam			
Beam Type	BTz	Beam			
Compression Axial Force	N*	300.000	kN		
Nominal Member Capacity	Nc	754.172	kN		6.3
Bending Moment	M* _y	10.000	kNm		
Maximum Bending Moment	M* _{y,segm}	10.000	kNm		
Modulus of Elasticity	E	200000	MPa		
Shear Modulus	G	80000	MPa		
Second Moment of Area	lz	8892000	mm⁴		
Torsional Constant	J	312400.000	mm⁴		
Warping Constant	Iw	4.79400E+10	mm⁵		
Segment Length	I	4000	mm		
Twist Restraint Factor	k t	1.000			Table 5.6.3(1)
Load Height Factor	k,	1.000			Table 5.6.3(2)
Lateral Rotation Restraint Factor	k _r	1.000			Table 5.6.3(3)
Effective Length	l _e	4000	mm		5.6.2
Section Constant	β	0.000			5.6.1.2 or H.4
Modification Factor	α _m	1.130			5.6
Slenderness Reduction Factor	as	0.789			5.6
Amended Elastic Buckling Moment	M_{oa}	184.132	kNm		
Nominal Out-of-plane Capacity	M _{by}	79.268	kNm		5.6
Equivalent Moment Factor	β_{my}	-1.000			8.4.2.2
Nominal Section Capacity	M _{sy}	88.859	kNm		5.2
Nominal Section Capacity	M _{ry}	67.299	kNm		8.3
Nominal In-plane Capacity	Miy	62.377	kNm		8.4
Nominal Out-of-plane Capacity	Moy	44.233	kNm		8.4.2
Nominal Moment Capacity	My	44.233	kNm		8.4
Design Component for M _y	η_{My}	0.251			
Bending Moment	M*z	7.500	kNm		
Equivalent Moment Factor	β_{mz}	-1.000			8.4.2.2
Nominal Section Capacity	Msz	41.700	kNm		5.2
Nominal Section Capacity	M _{rz}	31.582	kNm		8.3
Nominal In-plane Capacity	M _{iz}	23.269	kNm		8.4
Design Component for Mz	η _{Mz}	0.358			
Capacity Factor	Φ	0.900			
Design Ratio	η	0.382		≤ 1	8.4.5.1



A Literature

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- [2] AS 4100 Supplement 1-1999: Steel Structures Commentary (Supplement to AS 4100-1998), Australian Standard, Steel Structures, Standards Australia, Second Edition, 1999
- [3] Steel Structures, Design Manual to AS 4100, First Edition, KIRKE B., AL-JAMEL, I.H., 2004



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