## **RF-/TIMBER Pro**

Design of Timber Members According to EN 1995, DIN 1052, and SIA 265



14.7 13.1 11.5 9.8 8.2 6.5 4.9 3.3 1.6

9

Dlubal Software

# User Manual

Version

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## **Short Overview**

1	Introduction	RR	4
2	Input Data	AA	7
3	Calculation	AA	42
4	Results	AA	50
5	Results Evaluation	AA	61
6	Printout	AA	71
7	General Functions	AA	74
8	Examples	88	82

### A Literature

115



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### Using the Manual

The program description is organized in chapters which follow the order and structure of the input and result tables. The chapters present the individual tables column by column. They help to better understand the functioning of the add-on module. General functions are described in the manuals of the main program RFEM or RSTAB.



### Hint

The text of the manual shows the described buttons in square brackets, for example [OK]. In addition, they are pictured on the left. Expressions appearing in dialog boxes, tables, and menus are set in *italics* to clarify the explanation. You can also use the search function for the Knowledge Base 2 and FAQs 2 to find a solution in the posts about add-on modules.



Topicality

The high quality standards placed on the software are guaranteed by a continuous development of the program versions. This may result in differences between program description and the current software version you are using. Thank you for your understanding that no claims can be derived from the figures and descriptions. We always try to adapt the documentation to the current state of the software.

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### **Table of Contents**

1	Introduction	4
1.1	Add-on Module RF-/TIMBER Pro	4
1.2	Using the Manual	4
1.3	Open the Add-on Module RF-/TIMBER Pro	5

2	Input Data		7
2.1	General Data	;	7
2.1.1	Ultimate Limit State	(	9
2.1.2	Serviceability Limit State	1	1
2.1.3	Fire Resistance	12	2
2.1.4	Standard / National Annex	12	2
2.2	Materials	12	7
2.3	Cross-Sections	19	9
2.4	Load Duration and Service Class	2.	5
2.5	Effective Lengths - Members	22	7
2.6	Effective Lengths - Sets of Members	3	1
2.7	Tapered Members	32	2
2.8	Curved Members	34	4
2.9	Serviceability Data	3.	5
2.10	Fire Resistance - Members	30	6
2.11	Fire Resistance - Sets of Members	32	7
2.12	Parameters	38	8

3	Calculation	42
3.1	Detailed Settings	42
3.1.1	Resistance	42
3.1.2	Stability	44
3.1.3	Serviceability	45
3.1.4	Fire Resistance	46
3.1.5	Other Settings	47
3.2	Starting the Calculation	48

4	Results	50
4.1	Design by Load Case	50
4.2	Design by Cross-Section	52
4.3	Design by Set of Members	53
4.4	Design by Member	54
4.5	Design by x-Location	55
4.6	Governing Internal Forces by Member	55
4.7	Governing Internal Forces by Set of Members	57
4.8	Member Slendernesses	58
4.9	Parts List by Member	59
4.10	Parts List by Set of Members	60

5	Results Evaluation	<b>6</b> 1
5.1	Results on RFEM/RSTAB Model	62
5.2	Results on Cross-Section	65
5.3	Result Diagrams	68
5.4	Filter for Results	69

Τ

6	Printout	71
6.1	Printout Report	71
6.2	Graphic Printout	72

7	General Functions	74
7.1	Design Cases	74
7.2	Cross-Section Optimization	76
7.3	Units and Decimal Places	78
7.4	Data Exchange	79
7.4.1	Exporting Materials to RFEM/RSTAB	79
7.4.2	Exporting Effective Lengths to RFEM/RSTAB	79
7.4.3	Exporting Results	80

8	Examples	82
8.1	Timber Column	82
8.1.1	System and Loads	82
8.1.2	Calculation with RFEM/RSTAB	83
8.1.3	Design with RF-/TIMBER Pro	83
8.1.3.1	Ultimate Limit State Design	83
8.1.3.2	Serviceability Limit State Design	88
8.2	Built-up Cross-Section	91
8.2.1	System and Loads	91
8.2.2	Calculation with RFEM/RSTAB	94
8.2.3	Design with RF-/TIMBER Pro	97
8.2.3.1	Ultimate Limit State Design	97
8.2.3.2	Serviceability Limit State Design	101
8.3	Monopitch Roof Beam	104
8.3.1	System and Loads	104
8.3.2	Calculation with RFEM/RSTAB	105
8.3.3	Design with RF-/TIMBER Pro	105
8.4	Curved Beam	108
8.4.1	System and Loads	108
8.4.2	Calculation with RFEM	109
8.4.3	Design with RF-TIMBER Pro	110

9 Literature

### 1 Introduction



### 1.1

Standard / National Annex (NA)	
🔯 EN 1995-1-1:2004-11	-
💻 DIN 1052:2008-12 Germar	Ψ.
🔯 EN 1995-1-1:2004-11 Europe	an Union
SIA 265:2012 Switzer	land

### Add-on Module RF-/TIMBER Pro

Eurocode 5 (EN 1995-1-1:2010-12 [1] 2 + A1:2008) regulates the draft, design, and construction of timber structures in the member states of the European Union. With the add-on modules RF-TIMBER Pro (for RFEM) and TIMBER Pro (for RSTAB) Dlubal Software offers you powerful tools for the design of timber structures modeled with beam elements. Country-specific regulations are taken into account by different National Annexes (NA). In addition to the parameters included in the program, you can define your own limit values or create new National Annexes. Moreover, it is possible to perform designs according to DIN 1052:2008 [2] and SIA 265:2012 [3] in RF-/TIMBER Pro.

In the following, the add-on modules of both main programs are described in one manual and are referred to as **RF-/TIMBER Pro**.

RF-/TIMBER Pro performs the ultimate limit state designs, stability analyses, and deformation analyses provided by the standards. The stability analysis can be carried out according to the equivalent member method or a second-order analysis. If the equivalent member method is applied, the program considers regular axial compression parallel to the grain, bending without compression force, bending and compression, shear due to shear force, as well as bending and tension. Furthermore, the fire resistance design according to EN 1995-1-2 [5] , DIN 4102-4 [4] or SIA 265 [3] is possible.

In timber construction, the serviceability limit state represents an important design. Load cases, load combinations, and result combinations can be assigned to different design situations. The limit deformations are preset by the National Annex and can be adjusted, if necessary. In addition, it is possible to specify reference lengths and precambers that will be considered accordingly in the design.

The program provides an automatic cross-section optimization with the possibility to export modified cross-sections to RFEM or RSTAB. Separate design cases allow for a flexible analysis of structural components in complex models.

Like other add-on modules, RF-/TIMBER Pro is completely integrated in RFEM or RSTAB. Thus, the design-relevant input data is preset when you start the add-on module. Subsequent to the design, you can use the graphical user interface of the main program to evaluate the results. As they can be included in the global printout report, the entire verification can be presented in a consistent and appealing form.

We hope you will enjoy working with RF-/TIMBER Pro.

Your Dlubal Software team

### 1.2

### Using the Manual

Topics like installation, graphical user interface, results evaluation, and printout are described in detail in the manuals of the main programs RFEM and RSTAB. The present manual focuses on typical features of the RF-/TIMBER Pro add-on module.

The descriptions in this manual follow the sequence and structure of the input and result windows. In the text, the described **buttons** are given in square brackets, for example [Apply]. At the same time, they are pictured on the left. **Expressions** appearing in dialog boxes, windows, and menus are set in *italics* to clarify the explanation.

In the PDF manual, you can perform a full-text search as usual with [Ctrl]+[F]. However, if you cannot find what you are looking for, you can also go to the Knowledge Base  $\square$  on our website to find related articles about the timber add-on modules. Or consult the FAQs  $\square$  on our website.

1.3

### Open the Add-on Module RF-/TIMBER Pro

RFEM and RSTAB provide the following options to start the add-on module RF-/TIMBER Pro.

#### Menu

To start the program on the RFEM or RSTAB menu bar, select

#### Add-on Modules $\rightarrow$ Design - Timber $\rightarrow$ RF-/TIMBER Pro.

Add	I-on Modules Window	<u>H</u> e	lp						
400	Current Module			• < > <u>P</u> 🔭 🦻	2 🔛 🚳 🔊	a 🔛 🕷 🦊	1 🥵 🥵 🏦	æ	^≥ ∲ ⊿
	Design - Steel	►	+ 1	💥 🤻 🌂 🗊 🗗	TX YI TZ -X	- 🛛 - 🕲	- 17 🖘	1	ا 🍄 💽 <
	Design - Concrete	►							
-	Design - Timber	-	2	RF-TIMBER			Design of	timbe	er members
	Design - Aluminum	►	24	RF-TIMBER Pro			Design of	timbe	er members
	Dynamic	►	AWC	RF-TIMBER AWC	Design of tin	ber members ad	cording to A	VC (LR	FD or ASD)
	Connections	►	CSA	RF-TIMBER CSA		Design of tim	ber members	accord	ling to CSA
	Foundations	►	NBR	RF-TIMBER NBR		Design of time	er members a	iccord	ing to NBR
	Stability	►	SANS	RF-TIMBER SANS	Design of ti	mber members a	ccording to S	ANS (A	SD or LSD)
	Towers	►							
	Piping	►							
	Others	►							
	External Modules	•							
	Stand-Alone Programs	►							
F1	Manu Add on Ma	ماريامه		Design Timber -> PETU	ADED Dec				

#### Navigator

To start RF-/TIMBER Pro in the Data navigator, select

Add-on Modules  $\rightarrow$  RF-/TIMBER Pro.





### Panel

If any results from RF-/TIMBER Pro are already available in the model, you can open the design module on the panel:

Set the relevant design case in the load case list of the menu bar. Click the [Show Results] button to display the design criterion graphically on the members.

When the results display is activated, the panel appears showing the [RF-/TIMBER Pro] button which you can use to open the add-on module.





### 2 Input Data

When you have started the add-on module, a new window appears. In this window, a navigator is displayed on the left, managing the available module windows. The drop-down list above the navigator contains the design cases (see Chapter  $7.1 \square$ ).

The design-relevant data must be defined in several input windows. When you open RF-/TIMBER Pro for the first time, the following parameters will be imported automatically:

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

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

To save the entered data, click [OK]. You will exit RF-/TIMBER Pro and return to the main program. Click [Cancel] to exit the add-on module without saving the new data.

### **General Data**

In the 1.1 General Data window, you select the members, sets of members, and actions that you want to design. Three tabs are managing the load cases, load combinations, and result combinations for the ultimate limit state, the serviceability limit state, and the fire protection design.

ut Data General Data Materials Cross-Sections	Design of					
General Data Materials Cross-Sections					Standard / National Annex (NA)	
Cross-Sections	Members:	174, 176, 177, 186-196, 198-206, 351-30	2	15 🗙 🗖 🖬	EN 1995-1-1:2004-11	
						0
Load Duration and Service Clas	Sets:	1-18		3 🕅 🛅 🖂 🖌	📰 BS 🗸 🔁 🔤	<u> </u>
Effective Lengths - Members						
Effective Lengths - Sets of Mer	Ultimate Limit	State Serviceability Limit State Fire	Resistance	3		
Tapered Members	Existing Load	d Cases / Combinations		Selected for Design		N
Parameters	G LC1	Self-weight	~	STR RC4 ULS(EQU)	Persistent and Transient	
	Qs LC2	Snow				Ш
	Qi A LC3	Imposed load				
	Qw LC4	Wind				
	Imp LC5	Imperfection	>			
	STR CO1	1.35*LC1 + LC5	>>			
	STR CO2	1.35*LC1 + 1.5*LC2 + LC5				
	STR CO3	1.35°LC1 + 1.5°LC2 + 1.05°LC3 +				
	SIR CO4	1.35 LC1 + 1.5 LC2 + 1.05 LC3 +				
	STR COS	1.35 LC1 + 1.5 LC2 + 0.5 LC4 + L 1.25*LC1 + 1.5*LC2 + LC5				
		1.35 LC1 + 0.751 C2 + 1.51 C2 +	$\bigtriangledown$			1 I
	STRI CO8	1.35*1.C1 + 0.75*1.C2 + 1.5*1.C3 +	-			
	STR CO9	135°LC1 + 15°LC3 + 09°LC4 + 1	~			
	STR CO10	1.35*LC1 + 1.5*LC4 + LC5				
	STR CO11	1.35*LC1 + 0.75*LC2 + 1.5*LC4 +				
	STR CO12	1.35*LC1 + 0.75*LC2 + 1.05*LC3 +				
	STR CO13	1.35*LC1 + 1.05*LC3 + 1.5*LC4 +				
	S Ch CO14	LC1 + LC5				Design of timber
	S Ch CO15	LC1 + LC2 + LC5				members according to
	S Ch CO16	LC1 + LC2 + 0.7*LC3 + LC5				DIN 1052:2008-12
	S Ch CO17	LC1 + LC2 + 0.7*LC3 + 0.6*LC4 +				EN 1995-1-1:2004-11 SIA 265:2012
	S Ch CO18	] LC1 + LC2 + 0.6*LC4 + LC5	~			
	All (32	2) ~ 2	2		27 SB	and the second s
	Comment					
	Design acc. to	o NA Germany		^		
				~		
>						
	Calculation	Details Nat Anney		Graphics		OK Can
	Carculation	Not Alliex		Graphics		OK Caric



OK Cancel

2.1

X

1

 Design of

 Members:
 174,176,177,186-196,198-206,351-362

 Sets:
 1-18

 Sets:
 1-18

 Figure 2.2
 Design of members and sets of members

You can design Members as well as Sets of members. If you want to design only selected objects, clear the All check box: Then, you can access the text boxes to enter the numbers of the relevant members or sets of members. Use the [Delete] button to clear the list of preset numbers. Use the [Select] button to define the objects graphically in the RFEM or RSTAB work window.

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

To define a new set of members, click the [New] button. The dialog box known from RFEM or RSTAB appears where you can enter the parameters for the set of members.

### Standard / National Annex (NA)

In the drop-down list in the upper-right corner of the window, you can select the standard whose parameters apply to the design and to the deformation's limit values. You can select from:

- DIN 1052:2008-12 [2]
- EN 1995-1-1:2004-11 [1] 🗷
- SIA 265:2012 [3] 🗷

If you select EN 1995-1-1, you also have to specify the National Annex.

BS	<ul> <li></li></ul>
CEN	European Union
BDS	Bulgaria
副長 BS	United Kingdom
CSN	Czech Republic
CYS	Cyprus
🔳 DIN	Germany
DK	Denmark
I.S.	Ireland
LST	Lithuania
LU	Luxembourg
LVS	Latvia
NBN	Belgium
NEN	Netherlands
NF	France
횓 NP	Portugal
NS NS	Norway
CNOR	M Austria
PN	Poland
- SFS	Finland
SIST 🔤	Slovenia
SR 🛛	Romania
SS 🔄	Sweden
STN 🔤	Slovakia
UNE	Spain
UNI	Italy

#### **P**

Use the [Edit] button to open a dialog box where you can check and adjust, if necessary, the parameters of the current NA. The dialog box is described in Chapter  $2.1.4 \square$ .

Standard / National Annex (NA) EN 1995-1-1:2004-11 DIN 1052:2008-12 Germany EN 1995-1-1:2004-11 European Union SIA 265:2012 Switzerland

#### Comment

Comment Design According to Eurocode	
	-
Figure 2.4 User-defined comment	

In this text box, you can enter user-defined notes.





Figure 2.5 Window 1.1 General Data, tab Ultimate Limit State

### **Existing Load Cases / Combinations**

This column lists all load cases, load combinations, and result combinations that have been created in RFEM or RSTAB.

To transfer selected entries to the Selected for Design list on the right, click the Debutton. Alternatively, you can double-click the entries. To transfer the entrie list to the right, use the Debutton.

As common for Windows applications, selecting several load cases is possible by clicking them one by one while holding down the [Ctrl] key. Thus, you can transfer several load cases all at once.

If a load case's number is marked in red such as LC5 in Figure  $2.5 \boxtimes$ , you cannot design it: It indicates a load case without load data, or a load case that contains imperfections. A warning appears if you try to transfer it.

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

<sup>™</sup>	Selects all load cases in the list
	Inverts selection of load cases
Table 2.1 Butto	ns in Ultimate Limit State tab



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### **Selected for Design**

The column on the right lists the load cases as well as load and result combinations that have been selected for the design. To remove selected items from the list, click <a> or double-click the entries. To empty the entire list, click <<>> .</a>

You can assign the load cases as well as load and result combinations to the following design situations:

- Persistent and Transient
- Accidental

This classification controls the  $\gamma_M$  factor that is included in the determination of the R<sub>d</sub> resistances for the cross-section designs and stability analyses (see Figure 2.9  $\square$ ).

To change a design situation, use the list which you can access by clicking the 🗈 button at the end of the text box.

STR CO1	1.35*LC1 + LC5	Persistent and Transient
STR CO2	1.35*LC1 + 1.5*LC2 + LC5	Persistent and Transient
STR CO3	1.35*LC1 + 1.5*LC2 + 1.05*L	Accidental
STR CO4	1.35*LC1 + 1.5*LC2 + 1.05*L	Persistent and Transient
STR CO5	1.35*LC1 + 1.5*LC2 + 0.9*LC	Persistent and Transient
STR CO6	1.35*LC1 + 1.5*LC3 + LC5	Persistent and Transient

For a multiple selection, press the [Ctrl] key and click the corresponding entries. Thus, you can change several entries at once.

The analysis of an enveloping max/min result combination is faster than the analysis of all load cases and load combinations indiscriminately selected for design. However, when analyzing a result combination it is difficult to discern the influence of the included actions.





#### 2.1.2 Serviceability Limit State

Figure 2.7 Window 1.1 General Data, tab Serviceability Limit State

### **Existing Load Cases / Combinations**

This column lists all load cases and combinations that have been created in RFEM or RSTAB.

### **Selected for Design**

You can add or remove load cases as well as load and result combinations as described in Chapter 2.1.1  $\blacksquare$  .

It is possible to assign different limit values for deflection to the load cases, load and result combinations. The following design situations for EN 1995-1-1 are available for selection:

Characteristic 2.2.3(2):

winst : characteristic combination without creep component

Quasi-permanent 2.2.3(3):

wfin - wc : quasi-permanent combination with camber

Quasi-permanent 2.2.3(3):

wfin : quasi-permanent combination

Vibration Design:

Verification of natural frequency by means of limit value winst

To change the design situation, use the list which you can access by clicking the  $\blacksquare$  button at the end of the text box (see Figure 2.7  $\blacksquare$ ).



The limit values of the deformations are defined in the National Annex. They can be adjusted for the design situations in the Standard or National Annex Settings dialog box (see Figure 2.9 2) that you can open with the [Standard] or [Nat. Annex] button.

In Window 1.9 Serviceability Data, the reference lengths applying to the deformation analysis are managed (see Chapter 2.10 12).

» >





### Existing Load Cases / Combinations

This column lists all load cases and combinations that have been created in RFEM or RSTAB.

### **Selected for Design**

You can add or remove load cases as well as load and result combinations as described in Chapter 2.1.1 🗷 Here, you should select the actions that have been determined according to EN 1995-1-2 [5] 🗷 .

The fire resistance design is performed by means of a reduced cross-section. The general specifications for the fire resistance design are managed in the Fire Factors tab of the National Annex Settings dialog box (see Figure 2.13  $\square$ ) as well as in the Fire Resistance tab of the Details dialog box (see Figure 3.4  $\square$ ).

Fire protection designs are not possible for combined cross-sections: Since the neutral axis will be shifted during the cross-section reduction, the stiffness of the cross-section would have to be recalculated in each charring calculation. In addition, when determining the internal forces in RFEM or RSTAB, this change of stiffness would have to be taken into account by recalculating it.

### 2.1.4 Standard / National Annex





In the list in the upper right corner of the 1.1 General Data window, you can select the standard or, if EN 1995-1-1 is set, the National Annex whose parameters you want to apply to the design and the limit values of the deformation (see Figure 2.3 🗷).

Click the E button to check and adjust, if necessary, the preset parameters (see Figure 2.9 2). Use the E button to create a user-defined annex.

Moreover, in every input window you can find the [Nat. Annex] button (for EN 1995-1-1) or [Standard] (for DIN 1052 and SIA 265) which also opens the National Annex Settings or Standard dialog box. This dialog box consists of several tabs.



Nat. Annex...



aterial Factors Other Settings Other Set	tings 2/2 Deformation Limits	Fire Factors	Used Standa	rds		
Factor Category	Partial Factors Acc. to 2.4.1					
Solid Timber Glued Laminated Timber	Design situation:					
	Persistent and Transient :					
	- Timber member:		γм: 1	.300 ≑		
	- Connections:		γм: 1	.300 ≑		
	- Steel stiffeners: (EN 1993)	1	′M2: 1	.100 🜩		
	Accidental :		ум: 1	.000 ≑		
	Import from RFEM Table	'1.2 Materials'				
	Modification Factors Acc. to	Table 3.1				
	Load Duration Class (LDC)		1	Service Class 2	3	
	- Permanent	kmod :	0.600 🖨	0.600 🖨	0.500 🜩	
	- Long-term	kmod :	0.700 ≑	0.700 🖨	0.550 🜩	
	- Medium-term	kmod :	0.800 🜲	0.800 单	0.650 🜩	
	- Short-term	kmod :	0.900 ≑	0.900 ≑	0.700 🜩	
	- Instantaneous	kmod :	1.100 🖨	1.100 🜩	0.900 ≑	
7						
1						
					OK	anad

#### Material Factors



For each Factor Category (solid timber, glued laminated timber) the Partial Factors  $\gamma_M$  and Modification Factors  $k_{mod}$  are preset according to the standard for the different design situations as well as load duration and service classes. These values can be adjusted as needed.

### 7

Use the [Include Unused Material Categories] button to show all available timber material grades in the Factor Category column.

The buttons in the lower left corner of this dialog box have the following functions:

Button	Function
3	Resets the program's default settings
	Imports user-defined default settings
	Saves modified settings as default
×	Deletes user-defined National Annex





### **Other Settings**

The second tab (and also the third for EN 1995-1-1) of this dialog box provides various coefficients that are significant for the verification. They can be adjusted by selecting the User-defined option.

Material Factors Other Settings Other Settings 2/2 Deformation Limits Fire Factors Used Standards

Shear Factor		Reference Volume (Tapered Members 0	Only)
According to 6.1.7		According to 6.4.3	
O User-defined		O User-defined	
Solid wood	kor: 0.670 🚔 [-]	Solid wood	kvol : 1.000 🌩 [-]
Glued-laminated timber	kor: 0.670 🌲 [-]	Glued-laminated timber and LVL	kvol : 🔶 [-]
Other wood based products	kcr: 1.000 🜩 [-]		
Interaction Coefficient		Factor of Stress Distribution	
According to 6.1.6		According to 6.4.3	
O User-defined		O User-defined	
Rectangular cross-section	km: 0.700 ≑ [-]	Double tapered beams	kdis : 1.400 🌩 [-]
Other cross-sections	km: 1.000 ≠ [-]		
Other cross-sections - mean stress	km:		
Torsion Coefficient		Factor for Beams with Notch at the Sup	pport
According to 6.1.8		According to Eq. (6.63)	
O User-defined		O User-defined	
Rectangular cross-section	kshape :	Solid wood	kn : 5.000 ÷ [·]
Round cross-section	kshape : 1.200 ÷ [-]	Glued-laminated timber	kn : 6.500 ≑ [·]
Other massive cross-sections	kshape : 1.000 🗭 [-]	LVL	kn: 4.500 ÷ [-]
Maximum Cut-to-Grain Angle			
Used limitation			
α ≤ 20.00 <b>‡</b> [°]			

Figure 2.10 Dialog box National Annex Settings - BS, tab Other Settings

In this tab, it is also possible to adjust the Maximum Cut-to-Grain Angle  $\alpha$ .

If there are Beams with Notch at the Support, the coefficient  $k_n$  for sheathing material according to [1]  $\square$ , expression (6.63) will affect the design (see Chapter 2.12  $\square$ ).

Material Factors Other Settings Other Settings 2/2 Deformation Limits Fire Factors Used Standards

Increase of Bending, Shear and Tensile Strength

acc. to 3.2(3) for solid timber with h < 150 mm (Bending) or b < 150 mm (Tension)

 $\fbox$  acc. to 3.3(3) for glulam with h < 600 mm (Bending) or b < 600 mm (Tension)

acc. to ETA-14/0354 for BauBuche

☐ acc. to 5.1.3(1) EN 14080 for glulam t ≤ 40 mm (My)



Figure 2.11 Dialog box National Annex Settings - BS, tab Other Settings 2/2

With the Other Settings 2/2 tab you can control if an Increase of Bending, Shear and Tensile Strength according to [1]  $\square$  will be performed for small cross-sections: For those sections it is assumed, from a statistical point of view, that timber of a superior grade is distributed over the section. The strengths for the tension design (referring to the cross-section width) and the bending stress design (referring to the section height) can be increased by the  $k_h$  factors as follows.

14

Solid timber with h < 150 mm for bending or b < 150 mm for tension:

$$k_{h} = \min \begin{cases} \left(\frac{150}{h}\right)^{0.2} \\ 1.3 \end{cases}$$

Glulam timber with h < 600 mm for bending or b < 600 mm for tension:</p>

$$k_h = \min\left\{ \left(\frac{600}{h}\right)^{0.1} \\ 1.1 \right\}$$

Equation 2.2

RF-/TIMBER Pro recognizes the available material and automatically increases the strengths for activated options.

In accordance with the German annex for  $[1] \square$ , it is possible to increase the flexural strength of the lamellas by 20% if they are edgewise subjected to bending.

### **Deformation Limits**

In this dialog tab, you can check and adjust, if necessary, the *Limit Values* of *Deformation* for the different design situations and support conditions.

Material Factors Other Settings Other Settings 2/2 Deformation Limits Fire Factors Used Standards

Limit Values of Deformation	n Acc. to Table	7.2						
		Fixed on both sides	Overhanging					
Characteristic (Rare) Desig	Characteristic (Rare) Design Situation							
Characteristic :	Winst	≤L/ 300 🜩	≤ L <sub>k</sub> / 150 🜩					
Quasi-Permanent Design S	ituation							
Quasi-permanent 1 :	W fin - W c	≤L/ 250 🜩	≤ L <sub>k</sub> / 125 🜩 Eq. (7.2)					
Quasi-permanent 2 :	W fin	≤L/ 150 🜩	≤Lk/ 75 ♣					
Vibration Design								
Vibration Design :	Winst, lim	: 5.0 🖨 (mr	m]					
Figure 2.12 Dialog	box National	Annex Settings - BS, tab Def	ormation Limits					

The value  $w_{inst,lim}$  for the Vibration Design is explained by means of an example in the following technical article:

https://www.dlubal.com/en-US/support-and-learning/support/knowledge-base/000717 🗷



2

### **Fire Factors**

Naterial Factors	Other Settings	Other Settings 2	2 Deformation	Limits Fire Factors	S Used Standards			
Partial Factors Acc. to EN 1995-1-2, 2.3								
For fire situation		ум, fi : 1.0	000					
)ata for Fire Resi	stance Acc. to	o EN 1995-1-2, 2.3	, Table 3.1 and 4.	2.2				
		Softwood	Glulam	Hardwood	LVL	Plywood	Wood-based panels other than plywood	
Charring rate	βn:	0.80 ≑	0.70 🜩	0.55 🜩	0.70 🖨 🕫	3o: 1.00 ≑	0.90 ≑ [mm/mi	
Charring rate Increased charrin	βn: g do:	0.80 🜩	0.70 🜩	0.55 🜩	0.70 ÷ f	3o: 1.00 € 1o: 7.00 €	0.90 🖨 [mm/mi 7.00 🖨 [mm]	

This dialog tab manages the Partial Factors  $\gamma_{M,fi}$  for the case of fire according to [5]  $\square$  as well as additional Data for Fire Resistance (charring rate  $\beta_{n}$ , increased charring  $d_{0}$ ) for different types of timber. They are required for the determination of the ideal residual cross-section.

The Factor  $k_{\rm fi}$  is required to determine the 20% fractile value of the strength and stiffness from the 5% fractile value.

### **Used Standards**

The final tab of the National Annex Settings dialog box informs you about the standards according to which the designs will be performed.

Material Factors Other Settings Other Settings 2/2 Deformation Limits Fire Factors Used Standards

No.	Standard	Standard Description
[1]	BS EN 1995-1-1/NA:2009-10	Part 1-1: General - Common rules and rules for buildings
[2]	BS EN 1995-1-2/NA:2006-10	Part 1-2: General - Structural fire design
[3]	BS EN 14080:2013-08	Timber structures - Glued laminated timber and solid timber - Requirements
[4]	BS EN 338:2010-03	Structural timber - Strength classes

Figure 2.14 Dialog box National Annex Settings - BS, tab Used Standards

16

### 2.2

### Materials

This module window is subdivided into two parts. The upper part lists all materials created in RFEM or RSTAB. In the *Material Properties* section, the properties of the current material, i.e. the table row selected in the upper section, are shown.

	A	B		С			
laterial	Material	Factor					
No.	Description	Category		Comme	ent		
1	Concrete C16/20   EN 1992-1-1:2004/A1:2014						
2	Steel S 235   EN 10025-2:2004-11						
3	Poplar and Softwood Timber C30   EN 338:200	Solid Timber					
4	Steel S 235   EN 10025-2:2004-11						
5	Poplar and Softwood Timber C24   EN 338:2003	Solid Timber					
6	Steel S 235   EN 10025-2:2004-11						
7	Glulam Timber GL24h   EN 1194:1999-04	Glued Laminated Tir	mber				
	<u>2</u>			0	۵ 🗞		
laterial P	Properties						
7 Main F	mperties						
Mod	ulus of Easticity	F	1200.00	kN/cm <sup>2</sup>			
She	ar Modulus	G	75.00	kN/cm <sup>2</sup>			
Spe	cific Weight	y	4 60	kN/m <sup>3</sup>			
Coe	fficient of Thermal Expansion	α	5.0000E-06	1/K			
Part	ial Safety Factor	7M	1.30				
Additio	nal Properties	1.00					
Cha	racteristic Strength for Bending	fm.k	3.00	kN/cm <sup>2</sup>			
Cha	racteristic Strength for Tension	ft.0.k	1.80	kN/cm <sup>2</sup>		Material No. 3 used i	in
Cha	racteristic Strength for Tension Perpendicular	ft.90.k	0.06	kN/cm <sup>2</sup>		indernarite: e deeda	
- Cha	racteristic Strength for Compression	fc.0.k	2.30	kN/cm <sup>2</sup>		Cross-sections No.:	
Cha	racteristic Strength for Compression Perpendicular	fc.90,k	0.27	kN/cm <sup>2</sup>		2,3,5,6,9	
Cha	racteristic Strength for Shear/Torsion	fv.k	0.30	kN/cm <sup>2</sup>			
Mod	lulus of Elasticity Parallel	E0,mean	1200.00	kN/cm <sup>2</sup>		Members No.:	
Mod	lulus of Elasticity Perpendicular	E90,mean	40.00	kN/cm <sup>2</sup>		1 2 4 5 7 0 10 11	12 14 16 17 10 20
She	ar Modulus	Gmean	75.00	kN/cm <sup>2</sup>		1,2,4,5,7,8,10,11,	13, 14, 16, 17, 19, 20,
Mod	lulus of Elasticity Parallel	E0,05	800.00	kN/cm <sup>2</sup>			
Mod	lulus of Elasticity Perpendicular	E90,05	26.70	kN/cm <sup>2</sup>		Sets of members No.	.:
She	ar Modulus	G 05	50.00	kN/cm <sup>2</sup>			
Rolli	ing Shear Strength	fR,k	0.12	kN/cm <sup>2</sup>			
- Den	sity	Pk	380.0	kg/m <sup>3</sup>		∑ Length:	∑ Weight:
- Mea	in Value of Density	ρmean	460.0	kg/m <sup>3</sup>		Z congon	2 Weight
- Fac	tor Category		Solid Timber			308.37 [m]	9.542 [t]

Materials that won't be used in the design are grayed out. Materials that are not allowed are highlighted in red. Modified materials are displayed in blue.

Chapter 4.3 of the RFEM manual and Chapter 4.2 of the RSTAB manual describe the material properties that are used for the determination of the internal forces (*Main Properties*). The properties of the materials that are required for the design are also stored in the global material library. These values are preset (*Additional Properties*).

To adjust the units and decimal places of the characteristic values and stresses, select on the module menu **Settings**  $\rightarrow$  **Units and Decimal Places** (see Chapter 7.3  $\square$ ).

### **Material Description**

The materials defined in RFEM or RSTAB are preset but you can modify them anytime: Click the material in column A to activate the field. Then, click the 🖬 button, or press the function key [F7] to open the material list.

P	oplar and Softwood Timber C30   EN 338:200		
1	Poplar and Softwood Timber C14	BS EN 1995-1-1:2010-03	^
2	Poplar and Softwood Timber C16	BS EN 1995-1-1:2010-03	
3	Poplar and Softwood Timber C18	BS EN 1995-1-1:2010-03	-
4	Poplar and Softwood Timber C20	BS EN 1995-1-1:2010-03	
5	Poplar and Softwood Timber C22	BS EN 1995-1-1:2010-03	
6	Poplar and Softwood Timber C24	BS EN 1995-1-1:2010-03	
7	Poplar and Softwood Timber C27	BS EN 1995-1-1:2010-03	
8	Poplar and Softwood Timber C30	BS EN 1995-1-1:2010-03	
9	Poplar and Softwood Timber C35	BS EN 1995-1-1:2010-03	
10	Poplar and Softwood Timber C40	BS EN 1995-1-1:2010-03	¥





In accordance with the design concept of the timber standards, the list includes only materials of the *Timber* category.

After the material transfer, the design-relevant Material Properties are updated.

If you change the material description manually and the new entry is already listed in the material library, RF-/TIMBER Pro will import the material properties as well.

The material properties are generally not editable in the RF-/TIMBER Pro add-on module.

### **Material Library**

Many materials are stored in the database. To open the material library, select on the module menu

#### Edit $\rightarrow$ Material Library

or use the button shown on the left.

viaterial Library					
Filter	Material to Select				
Material category group:	Material Description		Standard		
Timber	Poplar and Softwood Timber	C14	I EN 199	5-1-1:2009-10	
- mber	Poplar and Softwood Timber	C16	EN 100	5-1-1-2009-10	
Material category:	Poplar and Softwood Timber	C10	EN 199	5 1 1.2000 10	
Softwood Timber		C10	EN 199	5-1-1:2009-10	
	Poplar and Softwood Timber	· C20	EN 199	5-1-1:2009-10	
Standard group:	Poplar and Softwood Timber	· C22	EN 199	95-1-1:2009-10	
EN	Poplar and Softwood Timber	C24	💽 EN 199	95-1-1:2009-10	
	Poplar and Softwood Timber	· C27	💽 EN 199	95-1-1:2009-10	
Standard:	Poplar and Softwood Timber	C30	🔯 EN 199	5-1-1:2009-10	
All	Poplar and Softwood Timber	C35	💽 EN 199	5-1-1:2009-10	
	Poplar and Softwood Timber	C40	I EN 199	5-1-1:2009-10	
	Poplar and Softwood Timber	C45	O FN 199	5-1-1:2009-10	
	Poplar and Softwood Timber	C 50	EN 100	5-1-1-2009-10	
	Poplar and Softwood Timber	C30	EN 195	5-1-1:2009-10	
	Poplar and Softwood Timber	C14 (Perpendicular to Gra	EN 199	95-1-1:2009-10	
	Poplar and Softwood Timber	C16 (Perpendicular to Gra	🔯 EN 199	95-1-1:2009-10	
	Poplar and Softwood Timber	C18 (Perpendicular to Gra	💿 EN 199	95-1-1:2009-10	
The state is set at the set of th	Poplar and Softwood Timber	C20 (Perpendicular to Gra	💽 EN 199	5-1-1:2009-10	
Include invalid	Poplar and Softwood Timber	C22 (Perpendicular to Gra	C EN 199	95-1-1:2009-10	
Favorites group:	Poplar and Softwood Timber	C24 (Perpendicular to Gra	E FN 199	5-1-1:2009-10	
~ • • •	💵 🍋 🖾 Search:			7	
Material Properties		Poplar and So	ftwood Timb	er C30   EN 199	5-1-1:2009
Main Properties					
Modulus of Elasticity		E		1200.00	kN/cm <sup>2</sup>
- Shear Modulus				75.00	kN/cm <sup>2</sup>
Specific Weight		7		4.60	kN/m <sup>3</sup>
Coefficient of Thermal Expan	nsion	0		5.0000E-06	1/K
Partial Safety Factor		7	М	1.30	
Additional Properties				2.00	LNI/mm 2
Characteristic Strength for T	ending		m,K	3.00	kN/cm <sup>2</sup>
Characteristic Strength for T	ension Pemendicular	E.	(U,K	1.00	kN/cm <sup>2</sup>
Characteristic Strength for C		F	.,90,K	2.20	kN/cm <sup>2</sup>
Characteristic Strength for C	ompression Pemendicular	E.	5,0,K	0.27	kN/cm <sup>2</sup>
Characteristic Strength for S	hear/Torsion	F	v k	0.40	kN/cm <sup>2</sup>
Modulus of Elasticity Parallel		E	0.mean	1200.00	kN/cm <sup>2</sup>
Modulus of Elasticity Perpen	dicular	E	90.mean	40.00	kN/cm <sup>2</sup>
- Shear Modulus		0	mean	75.00	kN/cm <sup>2</sup>
Modulus of Elasticity Parallel		E	0,05	800.00	kN/cm <sup>2</sup>
Modulus of Elasticity Perpen	dicular	E	90,05	26.70	kN/cm <sup>2</sup>
- Shear Modulus		G	05	50.00	kN/cm <sup>2</sup>
- Rolling Shear Strength		F	R,k	0.08	kN/cm <sup>2</sup>
- Density		p	k	380.0	kg/m <sup>3</sup>
				014	
0.00				OK	Cance

Figure 2.17 Dialog box Material Library

The Timber material category is preset in the Filter section. You can select the desired material grade from the Material to Select list; then you can check the properties in the dialog section below.

Click [OK] or use [] to transfer the selected material to Window 1.2 of RF-/TIMBER Pro.

Chapter 4.3 of the RFEM manual and Chapter 4.2 of the RSTAB manual describe how to filter, add, or reorganize materials.

ОК

### **Material Properties**

In the lower section of Window 1.2, the characteristic strength values for bending  $f_{m,k}$ , tension parallel  $f_{t,0,k}$ , tension perpendicular  $f_{t,90,k}$ , compression parallel  $f_{c,0,k}$ , compression perpendicular  $f_{c,90,k}$  as well as for shear and torsion  $f_{v,k}$  are specified.

The design values of the material strengths must be determined, as shown e.g. in [1]  $\square$ , Eq. (2.14), with the modification factors  $k_{mod}$  and the partial safety factors  $\gamma_{M}$ .

$$X_d = k_{\text{mod}} \cdot \frac{X_k}{\gamma_{\text{M}}}$$
Equation 2.3

Nat. Annex...

2.3

The modification and partial safety factors can be adjusted in the National Annex Settings dialog box (see Figure 2.9 12).

### **Cross-Sections**

This window lists the cross-sections used for the design. In addition, you can specify optimization parameters.









### **Cross-Section Description**

The cross-sections defined in RFEM or RSTAB are preset together with the assigned material numbers. The design is possible for parametric timber and solid sections of the library.

To modify a cross-section, click the entry in column B, setting the field active. Then, open the cross-section table of the current input field by clicking the [Cross-Section Library] button or the button at the end of the text box. You can also use the function key [F7] (see Figure 2.19 2).

In this dialog box, you can choose a different cross-section or even a different cross-section table. If you want to select a completely different cross-section category, click the [Back to Cross-Section Library] button that opens the general cross-section library.

Chapter 4.13 of the RFEM manual and Chapter 4.3 of the RSTAB manual describe how to select cross-sections from the library.

You can also enter a new cross-section description directly into the input field in column B. If the entry is already listed in the database, RF-/TIMBER Pro will import the cross-section properties. A modified cross-section is highlighted in blue.



2



If cross-sections set in RF-/TIMBER Pro are different from the ones used in RFEM or RSTAB, both crosssections are shown in the window graphic to the right. The designs will be performed with the internal forces from RFEM or RSTAB for the cross-section selected in RF-/TIMBER Pro.

If the cross-section is a built-up cross-section, the slip in the joint (Coefficient of compliance) due to fasteners can be taken into account.

Timber Cross-Sections - I-Section	with Horizontal Connection Lines		×
Cross-Section Type         I       I         III       III         IIII       III         IIII       IIII         IIII       IIII         IIII       IIII         IIII       IIII         IIII       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	Yearameters         h: $460.0 \Leftrightarrow i \pmod{mm}$ b1: $200.0 \Leftrightarrow i \pmod{mm}$ b1: $200.0 \Leftrightarrow i \pmod{mm}$ h1: $80.0 \Leftrightarrow i \pmod{mm}$ b2: $40.0 \Leftrightarrow i \pmod{mm}$ b3: $100.0 \Leftrightarrow i \pmod{mm}$ h3: $80.0 \doteqdot i \pmod{mm}$ h3: $80.0 \doteqdot i \pmod{mm}$ h3: $80.0 \doteqdot i \pmod{mm}$ h4: $80.0 \doteqdot i \pmod{mm}$		
Favorites Group GB		U IUH 460/200/80/40/100/80/0.500/0.500	Cancel

igure 2.20 Considering the slip of a built-up cross-section

The cross-section properties are computed by the so-called  $\gamma$ -procedure according to [1]  $\square$  Annex B.2. The following is assumed:

- A single-span or a continuous beam with hinged supports is used.
- The cross-section values are constant over the member length (that is, no tapered member).
- The loading is sinusoidal.
- Torsion of the cross-section is excluded.
- Lateral-torsional buckling is not analyzed.



Parametr	ic - Timbe	er	
	•		
000	1001	•	0
T	Т		Π
T	T	Ξ	π
		I	

### Non built-up cross-sections (collar tie connection)

Further restrictions exist for timber cross-sections that are non built-up sections. These concern the cross-section tables H-2B, H-3B and 4B.



 Figure 2.21
 Non built-up timber sections – cross-section tables H-2B, H-3B and 4B

If the distance between these cross-sections is a=0, the restrictions of the  $\gamma$ -procedure listed above apply. But if the distance is greater than 0, these cross-sections are considered to be non-contiguous sections and the cross-section values are calculated, for example, without the parallel axis theorem. The restrictions according to [1]  $\square$  clause B.1.2 still apply!

For better understanding, the cross-section values of a collar tie connection are compared below: without spacing (cross-section  $2B \ 160/0/40$ ) and with spacing (cross-section  $2B \ 160/10/40$ ).

2B 160/0/40	2B 160/10/40
$A = 2 \cdot h \cdot b = 2 \cdot 4 \cdot 16 = 128 \text{ cm}^2$	$A = 128 \text{ cm}^2$
$A_y = 5/6 \cdot A = 106.7 \text{ cm}^2$	$A_y = 5/6 \cdot 16 \cdot 4 = 53.3 \text{ cm}^2$
$I_{z,i} = 16 \cdot 4^3 / 12 = 85.3 \text{ cm}^4$	$I_{z,i} = 16 \cdot 4^3 / 12 = 85.3 \text{ cm}^3$
$I_{z,eff} = \Sigma(I_i + \gamma_i \cdot A_i \cdot a_i^2) = 2 \cdot (85.3 + 64 \cdot 2^2) = 682.7 \text{ cm}^4$	$I_{z,eff} = 2 \cdot I_{z,i} = 170.7 \text{ cm}^4$
$a_{i} = \frac{A_{1}(h_{1} + h_{2}) - 0}{2\Sigma\gamma_{i} \cdot A_{i}} = \frac{128 \cdot 8}{2 \cdot (128 + 128)} = 2$	$\alpha_i = 0$
Table 2.3         Comparison of cross-section values	

A factor  $\gamma=1$  (glued) is assumed for a cross-section without spacing. Calculations with the factor  $\gamma=0$  would result in the same values like for the cross-section with spacing.





#### **Max.** Design Ratio

This table column is displayed only after the calculation. It is intended to be a decision support for optimization: Looking at the design ratios and colored relation scales, you can clearly see which cross-sections are hardly utilized and thus oversized, or extremely stressed and thus undersized.

#### Optimize

Rectangular and circular cross-sections can undergo an optimization process: For the internal forces from RFEM or RSTAB, the program searches the cross-section that comes as close as possible to a user-defined maximum ratio. This ratio can be defined in the *Other* tab of the *Details* dialog box (see Figure 3.5 <sup>I</sup>).

To optimize a cross section, open the drop-down list in column D or E and select the desired entry: Yes or From favorites 'Description'. Recommendations for optimizing cross-sections can be found in Chapter 7.2 🛛 .

### Note

This column shows remarks in the form of footnotes. They are explained below the cross-section list.

#### Member with tapered cross-section

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

RF-/TIMBER Pro also designs tapered members if the start and end cross-section have the same cross-section type. This requires further specifications in module Window 1.7 (see Chapter 2.7 2).

### **Info About Cross-Section**

In the Info About Cross-Section dialog box, you can see the cross-section properties and stress points.



 Figure 2.22
 Dialog box Info About Cross-Section



0



The buttons below the cross-section graphic have the following functions:

Button	Function
Ξ	Displays or hides stress points
	Displays or hides numbers of stress points
	Shows details of stress points (see Figure 2.23 🖻 )
X	Displays or hides dimensions of cross-section
<b>[</b> **	Displays or hides principal axes of cross-section
a	Resets full view of cross-section
	Prints values and graphic of cross-section
Table 2.4 Buttons of cross-secti	on graphic

### 

Use the [Details] button to call up specific information about the stress points (centroid distances, statical moments of area, etc.).

	A	B	C	D	E	F	G	T-Rectangle 80/200
itressP	Coordin	nates	Statical Mom	ents of Area	Thickness	Warp	bing	
No.	y [mm]	z [mm]	Qy [cm <sup>3</sup> ]	Q <sub>z</sub> [cm <sup>3</sup> ]	t [mm]	W <sub>no</sub> [cm <sup>2</sup> ]	Qw [cm 4]	
1	40.0	100.0	0.00	0.00	80.0	0.00	0.00	
2	-40.0	100.0	0.00	0.00	80.0	0.00	0.00	
3	-40.0	-100.0	0.00	0.00	80.0	0.00	0.00	
4	40.0	-100.0	0.00	0.00	80.0	0.00	0.00	34
5	0.0	0.0	400.00	0.00	80.0	0.00	0.00	
6	0.0	0.0	0.00	160.00	200.0	0.00	0.00	
2								Close

Information about stress points with regard to the determination of shear stresses can be found in Chapter  $5.2 \, \mathbb{Z}$ .



2.4

### Load Duration and Service Class

In Window 1.4, you can define the load duration and the service classes of members and sets of members in order to determine the climatic conditions for the designs.

	A	B	С	Service Class (SECL)
_oad-		Load	Load Duration Class	Identical for all members
ing	Description	Туре	LDC	or sets of members
LC1	Self-weight	Permanent	Long-term	
LC2	Snow	Snow (H ≤ 1000 m a.s.l.)	Long-term	SECL: 2 V
LC3	Imposed load	Imposed - Category A: dome	Medium-term	
LC4	Wind	Wind	Long-term	O Different
CO1	1.35*LC1 + LC5	-	Long-term	
CO2	1.35*LC1 + 1.5*LC2 + LC5	-	Long-term	Service Class 1:
CO3	1.35*LC1 + 1.5*LC2 + 1.05*LC3 + LC5	-	Medium-term	Tomp, of 20°C and the rol, humidity of th
CO4	1.35*LC1 + 1.5*LC2 + 1.05*LC3 + 0.9*LC4 + LC5	-	Medium-term	surrounding air only exceeding 65 %
CO5	1.35*LC1 + 1.5*LC2 + 0.9*LC4 + LC5	-	Long-term	for a few weeks per year. The mean
CO6	1.35*LC1 + 1.5*LC3 + LC5	•	Medium-term	moisture content in most softwood
C07	1.35*LC1 + 0.75*LC2 + 1.5*LC3 + LC5	-	Medium-term	timber is ≤ 12 %.
CO8	1.35*LC1 + 0.75*LC2 + 1.5*LC3 + 0.9*LC4 + LC5	-	Medium-term	
CO9	1.35*LC1 + 1.5*LC3 + 0.9*LC4 + LC5		Medium-term	
CO10	1.35*LC1 + 1.5*LC4 + LC5	-	Long-term	
CO11	1.35*LC1 + 0.75*LC2 + 1.5*LC4 + LC5	-	Long-term	
CO12	1.35*LC1 + 0.75*LC2 + 1.05*LC3 + 1.5*LC4 + LC	-	Medium-term	Service Class 2:
CO13	1.35*LC1 + 1.05*LC3 + 1.5*LC4 + LC5	-	Medium-term	Temp. of 20°C and the rel. humidity of th
CO14	LC1 + LC5	-	Long-term	surrounding air only exceeding 85 %
CO15	LC1 + LC2 + LC5	-	Long-term	for a few weeks per year. The mean
CO16	LC1 + LC2 + 0.7*LC3 + LC5	-	Medium-term	moisture content in most softwood
CO17	LC1 + LC2 + 0.7*LC3 + 0.6*LC4 + LC5	-	Medium-term	timber is 5 20 %.
CO18	LC1 + LC2 + 0.6*LC4 + LC5	-	Long-term	
CO19	LC1 + LC3 + LC5	-	Medium-term	
CO20	LC1 + 0.5*LC2 + LC3 + LC5	-	Medium-term	Service Class 3:
021	LC1 + 0.5*LC2 + LC3 + 0.6*LC4 + LC5		Medium-term	Climatic conditions leading to higher
CO22	LC1 + LC3 + 0.6*LC4 + LC5		Medium-term	moisture contents than in Service Class
023	LC1 + LC4 + LC5		Long-term	
CO24	LC1 + 0.5*LC2 + LC4 + LC5		Long-term	
CO25	LC1 + 0.5*LC2 + 0.7*LC3 + LC4 + LC5	-	Medium-term	
CO26	LC1 + 0.7*LC3 + LC4 + LC5	-	Medium-term	

### Loading

The table column lists all actions that have been selected for design in the 1.1 General Data window. In case of combinations, included load cases are also displayed.

### Description

The load case descriptions make the classification easier.

### Load Type

This table column shows the action types of the load cases as they were defined in RFEM or RSTAB during their creation. They form the basis for the settings in the next table column.

### Load Duration Class LDC

The designs require the assignment of loads and their superpositions to particular load duration classes. Rules for the classification of actions can be found, for example, in [2]  $\square$  Table 4 or [1]  $\square$  Table 2.1.

For load cases and result combinations you can change the load duration with the list shown on the left: Click into the cell of column C to activate the field. The I button will be enabled. In case of load and Or-result combinations, RF-/TIMBER Pro carries out the classification automatically taking into account the respective governing action or the contained load cases.

The class of the load duration is required for the determination of the modification factor  $k_{mod}$  which



Nat. Annex...

affects the strength properties of the material (see [1]  $\square$  Table 3.1). The k<sub>mod</sub> factors can be checked and adjusted, if necessary, in the National Annex Settings dialog box (see Figure 2.9  $\square$ ).

If an automatic combination of actions was set in RFEM or RSTAB, the load duration classes are automatically taken into account according to the specifications in RFEM or RSTAB. Thus, a redefinition in RF-/TIMBER Pro is not necessary. However, you can adjust the classification of load cases in this table.

### Service Class (SECL)

The classification into service classes makes it possible to assign strength parameters and to calculate deformations by taking into account environmental conditions. The service classes are specified, for example, in [1]  $\square$  clause 2.3.1.3.

By default, all members and sets of members are assigned to the same service class. To classify objects into different service classes, activate the *Different* option. Use the B button to open the following dialog box.

Service Class M 1:	1embers No.		Temp. of 20°C and the rel. humidity of th surrounding air only exceeding 65 %
1: [·	1-14		
2.		🏷 📲 🥏	for a few weeks per year. The mean moisture content in most softwood
	101-114	🏷 📲 🥏	timber is ≤ 12 %.
3:		<b>1</b>	
			Service Class 2:
			Temp. of 20°C and the rel. humidity of th
			surrounding air only exceeding 85 % for a few weeks per year. The mean
ets of Memb	bers		moisture content in most softwood
Service	ats of Members No		timber is $\leq 20$ %.
1.	1.0		
1:	1-0	3 12 2	Service Class 3:
2:	10-18	3 12 2	Climatic conditions leading to higher
3:		🏷 🖉 🥏	moisture contents than in Service Class

Here, you can individually classify *Members* and Sets of *Members* into service classes. The buttons next to the text boxes facilitate the selection. They have the following functions:

Button	Function
۲¢	Allows for graphical selection of objects in RFEM/RSTAB work window
	Assigns all members/sets of members to respective service class
ŋ	Assigns all members/sets of members not yet assigned to respective service class

 Table 2.5
 Buttons in dialog box Assign Members/Sets of Members to Corresponding Service Classes



2.5

#### Details...

### **Effective Lengths - Members**

The layout of this module window depends on whether the stability analysis is carried out according to the equivalent member method or a second-order analysis. The method is to be defined in the Stability tab of the Details dialog box (see Figure 3.2 2) The following refers to the **equivalent member method** for which the parameters of buckling and lateral-torsional buckling must be defined.

If the stability analysis is deactivated in the Stability tab of the Details dialog box, Window 1.5 is not shown.

The window is subdivided into two parts. The table in the upper part shows compressed information on the buckling length factors and equivalent member lengths for buckling and lateral-torsional buckling of all members that are to be designed. The effective lengths defined in RFEM or RSTAB are preset. In the Settings section, you can see additional information on the member whose table row is selected in the upper part.

With the 🔊 button you can select a member graphically to activate its row in the table.

Changing entries is possible in the table as well as the Settings tree.

	A	B	С	D	E	F	G	Н		J	К	-
Member	Buckling	Bu	uckling About A	kis y	Bu	uckling About A	xis z		Lateral-Torsional Bucklin	ng		
No.	Possible	Possible	k or.y	Lor,y [m]	Possible	k or,z	Lor,z [m]	Possible	Define Lor	Lor [m]	Comment	
189	J		1.855	13.147	V	1.855	7.087	<ul><li>✓</li></ul>	As member length	7.087		
196	J		1.838	13.026	V	1.838	7.087		As member length	7.087		
197	J		1.837	13.019	V	1.837	13.019		As member length	7.087		
198	J	<b>V</b>	1.838	13.026	√	1.838	7.087		As member length	7.087		
199	J		1.835	13.005	√	1.835	7.087		As member length	7.087		
200	1	<b>v</b>	1.836	13.012	√	1.836	7.087	√	As member length	7.087		
201	1	<b>v</b>	1.839	13.033	√	1.839	7.087	√	As member length	7.087		
353	1	<b>v</b>	4.030	16.321	√	4.030	7.087	√	As member length	4.050		
354	1	<b>v</b>	4.104	16.621	√	4.104	7.087	√	As member length	4.050		
355	<b>v</b>	•	3.996	16.183	•	3.996	7.087	<b>V</b>	As member length	4.050		~



Figure 2.26 Window 1.5 Effective Lengths - Members

In both window parts, you can enter the effective lengths manually. You can also define them graphically in the work window by using the  $\Box$  button. It becomes active when the cursor is placed in the text box (see Figure 2.26  $\square$ ).

The Settings tree includes the following parameters:

- Cross-section
- Length of member
- Buckling Possible for member (corresponds to columns B, E, and H)
- Buckling About Axis y (corresponds to columns C and D)
- Buckling About Axis z (corresponds to columns F and G)
- Lateral-Torsional Buckling (corresponds to columns I to K)

In the Settings, you can define for the member selected above whether a buckling or a lateral-torsional buckling analysis is generally to be carried out. In addition, you can adjust the effective length coefficient for the respective directions. When changing this factor, the equivalent member length will be adjusted automatically, and vice versa.

It is also possible to define the effective length of a member in a dialog box that you open with the [Select effective length factor] button. You can find the button below the table.

For each direction, you can select one of the four Euler buckling modes. You can also set a *User-defined* effective length factor. If an eigenvalue analysis has been carried out by the RF-STABILITY or RSBUCK add-on module, it is also possible to define a *Buckling* mode for the determination of the factor.

### **Buckling Possible**

The stability analyses for flexural and lateral-torsional buckling require the ability to absorb compressive forces. Therefore, members for which such an absorption is not possible due to the member type (for example, tension members, elastic foundations, rigid connections) are excluded from the outset. The rows are grayed out in the table, and a corresponding note is shown in the Comment column.

Curved members (only RF-TIMBER Pro) are excluded as well from the stability analysis: Analyses performed according to the equivalent member method require for curved members a definition of the buckling length in the member third-points. In addition, stability analyses of curved members, for example according to [1] I clause 6.3.3, are valid only for single-span beams. Statically indeterminate systems or models with several supports require further analyses.

The Buckling Possible check boxes in table row A and in the Settings tree offer a control option for the stability analyses: They determine if these analyses are performed or omitted for the member.

### Buckling About Axis y / Buckling about Axis z

With the check boxes in the Possible columns, you decide if a member has the 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 effective length factors  $k_{cr,y}$  and  $k_{cr,z}$  for buckling about the major or minor axis can be selected freely.

**P** 

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The position of the member axes can be checked in the cross-section graphic of the 1.3 Cross-Sections window (see Figure 2.18 2). With the [Jump to graphic] button you can also access the RFEM or RSTAB work window where you can display the local member axes by using the member's shortcut menu or the *Display* navigator.



Figure 2.28 Activating the member axis systems in Display navigator of RFEM

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

To define the effective lengths graphically in the work window, use the  $\Box$  button. This button becomes available when the cursor is placed in a L<sub>cr</sub> input field (see Figure 2.26  $\square$ ).

When you specify the effective length factor  $k_{cr}$ , the program determines the effective length  $L_{cr}$  by multiplying the member length L by this factor. The input fields  $k_{cr}$  and  $L_{cr}$  are interactive.

### Lateral-Torsional Buckling Possible

Column H shows which members are included in the analysis of lateral-torsional buckling.

### **Define L**cr

The *member length* is set by default as equivalent member length for the lateral-torsional buckling analysis. More options become accessible when you click into a field in column H.

The lateral-torsional buckling length can be defined *Manually* by entering  $L_{cr}$  in column J. When clicking into this table column, the  $\Box$  function becomes available, and you can graphically determine the distance between the lateral supports. A manual adjustment may be useful for any structural component consisting of several members between the supports.

If you select the Acc. to Table 6.1 option (only available for DIN), a dialog box opens where you can define the lateral-torsional buckling parameters according to [1]  $\square$  Table 6.1 (see Figure 2.29  $\square$ ). In the DIN standard, the effective length is described as a quotient of the span length which depends on the type of bending member and the type of loading.





Insupported Length, L	
L manually L = [m]	
ffective Length, L_cr	
Simple Supported Beam:	
O Constant moment	L <sub>cr</sub> = 1.0 L
Uniformly distributed load	L <sub>cr</sub> = 0.9 L
$\bigcirc$ Concentrated force at the middle of the span	L <sub>cr</sub> = 0.8 L
Cantilever:	
O Uniformly distributed load	L <sub>cr</sub> = 0.5 L
$\bigcirc$ Concentrated force at the free end	L <sub>cr</sub> = 0.8 L
	OK Cancel
	Cancel

### Comment

In the final column, you can enter user-defined notes to describe, for example, the equivalent member lengths.

### Set input for members No.

Below the Settings table, you can find the check box Set input for members No. If you tick it, the **subsequently** made settings will apply to All members or to selected members (enter the member numbers manually or select them graphically with 🚵 ). This option may help you when assigning the same boundary conditions to several members (see Dlubal article https://www.dlubal.com/en-US/support-and-learning/support/knowledge-base/000726 🗷 ).

Settings which have already been defined cannot be changed subsequently with this function.







### **Effective Lengths - Sets of Members**

Details...

This window appears only if at least one set of members is set for design in the 1.1 General Data window and the stability analysis is activated in the Stability tab of the Details dialog box (see Figure 3.2 2).

	A	B	C	D	E	F	G	H		J	K	
Set	Buckling	Bu	ckling About Ax	is y	Bu	ckling About A	cis z		Lateral-Torsional Bucklin	ng		
No.	Possible	Possible	k or, y	Lor,y [m]	Possible	k or,z	Lor,z [m]	Possible	Define Lor	Lor [m]	Comment	
1	<b>I</b>	<b>J</b>	1.493	16.628	<b>V</b>	1,493	16.628	<b>V</b>	As member length	11,137		
2		3	1.472	16.394		1.472	16.394		As member length	11.137		
3		<b>J</b>	1.468	16.349	<b>V</b>	1.468	16.349	2	As member length	11.137		
4		<b>v</b>	1.460	16.260	<b>V</b>	1.460	16.260	2	As member length	11.137		
5		<b>V</b>	1.461	16.271	V	1.461	16.271	2	As member length	11.137		
6	<b>I</b>	<b>V</b>	1.484	16.527		1.484	16.527	<ul><li>✓</li></ul>	As member length	11.137		
7	<b>I</b>	<b>V</b>	1.475	16.427	<ul><li>✓</li></ul>	1.475	16.427	<ul><li>✓</li></ul>	As member length	11.137		
8	<b>I</b>	<b>V</b>	1.481	16.494	<ul><li>✓</li></ul>	1.481	16.494	<ul><li>✓</li></ul>	As member length	11.137		
9	<b>I</b>	<b>V</b>	1.465	16.316	<ul><li>✓</li></ul>	1.465	16.316		As member length	11.137		
10	<b>V</b>	<b>V</b>	1.492	16.617	V	1.492	16.617	2	As member length	11.137		٦,
ettings 1 Set of	for set of mem Members	bers No. 1		Set of I	Vembers				9 - T-Ci RE-TIM	rcle 254.5 BER Pro		
E Mer	mber 174			Secon	viembers					2.11110		
	Start			9 - T-Ci	cle 254.5							
E	Ind			6 - T-Ci	cle 240							
I Mer	mber 189			0.00	010 210							
- 5	Start			5 - T-Ci	cle 280						_	
E	End			9 - T-Ci	cle 254.5							
Lengt	h		L		11.13	7 m						
Buckli	ing Possible				5	0						
Buckli	ing About Axis	y Possible			5	0					·-•,	,
Effe	ective Length C	oefficient	k er.y		1.49	3					- T	
Effe	ective Length		L <sub>cr.y</sub>		16.62	8 m						
] Buckli	ing About Axis	z Possible			5	2						
Effe	ective Length C	oefficient	k cr.z		1.49	3				- T		
Effe	ective Length		L <sub>cr,z</sub>		16.62	8 m				*_		
] Latera	al-Torsional Buc	kling Possible			5	2				~		
Def	ine L <sub>or</sub>			As	member lengt	h						
Comm	ient											
-	put for sets No	o.:										
] Set in					4						X 👄	à



The concept of this window is similar to the previous Window 1.5 Effective Lengths - Members. Here, you can enter the effective lengths for buckling about both principal axes of the set of members, as described in Chapter 2.5 2. They define the boundary conditions of the set of members that is handled in its entirety as an equivalent member.

Please note that curved sets of members are excluded from the stability analysis: Analyses performed according to the equivalent member method require for curved beams a definition of the buckling length in the third-points. In addition, stability analyses of curved beams, for example according to [1] I clause 6.3.3, are valid only for single-span beams. Statically indeterminate systems or models with several supports require further analyses.



2.7

### **Tapered Members**

This window is displayed if at least one member with different cross-sections at both member ends is selected for design in the 1.1 General Data window. The window manages criteria like the cut-to-grain angle of the variable cross-sections.

	A	B	C	D	E	F	G	Н		J	K	L
mber	Cross	-Section	Length	Cut-to	-Grain		Ten	sion Perpen	idicular to Grain			
lo.	Member Start	Member End	L [m]	Angle α [°]		Grain Parallel to	With Ridge	Manually	V [m <sup>3</sup> ]	k vol	Note	Comme
74	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
76	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
77	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
B6	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
37	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
8	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
39	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
0	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
1	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
2	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
3	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
4	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
5	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
6	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
7	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
8	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
9	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
0	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
1	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
2	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
3	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
4	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
5	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
6	T-Rectangle 200/980	T-Rectangle 200/480	7.087	4.04	≤ 20.00	+z-Axis Edge						
1	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
2	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
3	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
4	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
5	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
<b>i</b> 6	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
7	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
58	T-Rectangle 200/480	T-Rectangle 200/200	4.050	3.96	≤ 20.00	+z-Axis Edge						
Seti	nput for members No.:	<i>k</i> i								[	×	\$

### **Cross-Section**

The first two table columns list the cross-sections that are defined at the Member Start and Member End.

### Length

The length of the tapered member is displayed for checking reasons.

### Cut-to-Grain Angle $\alpha$

**Grain Parallel to** 

Settings dialog box (see Figure 2.9 2).

RF-/TIMBER Pro determines the cut-to-grain angle from the geometric conditions. The equations used in the program are only valid for cutting angles of  $\alpha \le 24^{\circ}$  (for EN 1995-1-1 [1]  $\square$  and SIA 265 [3]  $\square$ ) or  $\alpha \le 10^{\circ}$  (for DIN 1052 [2]  $\square$ ).

The limit values given in column E can be checked and, if necessary, adjusted in the National Annex

Nat. Annex...



In table column F, you can specify the member edge to which the timber's grain direction is running parallel. The "top" or "bottom" edge is clearly defined by the orientation of the local member axis z

(see Figure 2.28 2). Alternatively, it is possible to align the grain with the Center line.

In most cases, the grain runs parallel to the edge that is located on the member side in the direction of the +z-axis ("bottom"). This means that the beam is cut at the top side.



If the grain runs parallel to the -z-axis ("top"), the tapered beam is cut at the bottom side. This case is an exception because cutting a grain in the bending tension area is avoided.



Both images apply to an orientation of the member axis in accordance with the global coordinate system.

### **Tension Perpendicular to Grain**

If the check box is ticked, designs for the maximum tensile stresses perpendicular to the grain, for example according to [2] a condition (85) or [1] a condition (6.50), and for shear due to shear force will be performed in the ridge cross-section.

The volume V required for the transversal tension analysis is determined by RF-/TIMBER Pro on the basis of the geometric conditions according to [1]  $\square$  Figure 6.9(a). The portion of the small "wedge" due to  $\alpha_{ap}$  is considered in a simplified way so that the volume subjected to transversal tension in the ridge zone is greater. However, because of the mostly low taper slope, this simplification has almost no impact on the analysis.

Alternatively, you can enter the specifications *Manually*. After selecting the check box, the fields for entering the volume V and the volume factor  $k_{vol}$  according to [1]  $\square$  expression (6.51) become accessible.



2.8

### **Curved Members**

Module Window 1.8 Curved Members is only available in the RFEM add-on module **RF**-TIMBER Pro: RSTAB does not allow for curved lines.

This window appears if at least one member with a curved shape is selected for design in the 1.1 General Data window. Curved members can be defined in RFEM, for example, by using the line types "spline" or "arc."

According to SIA 265 [3] , the design of curved members is not possible.

	A	B	С	D	E	F	G	H		J
		Laminate			Perp	endicular Tensi	ion			
D.	Member No.	t (mm)	Design	Manually	Member No.	l [m]	V [m <sup>3</sup> ]	k vol	k dis	Comment
	1	33.0	<ul><li>✓</li></ul>		1	12.035	1.64	0.361	1,400	r=8.417
2	4	33.0			4	8.502	1.16	0.387	1.400	r=8.632
			_							
)										
0										
1										
2										
3										
4										
5										
6										
7										
8										
9										
0										
1										
2										
3										
4										
5										
6										
7										
8										
9										
0										
1										
2										
3										
										<b></b>

### Member

This table column lists the numbers of all members that are aligned to curved lines and have a uniform cross-section.

### Laminate

If a glulam material is used, you can specify the thickness t of the lamellas.

### **Perpendicular Tension**

If you select the Design check box, RF-TIMBER Pro will perform an analysis of transversal tension. The factors  $k_{dis}$  and  $k_{vol}$  are preset according to [1]  $\square$  expression (6.51) or (6.52), but you can adjust them.

For EN 1995-1-1, columns F and G for adjusting the length *l* and the volume V are accessible after selecting the *Manually* check box.

### 2.9

### Serviceability Data

This window controls various settings for the serviceability limit state design. It is displayed if corresponding data has been set in the Serviceability Limit State tab of Window 1.1 (see Chapter 2.1.2 2).

/\	B	C	D	E	F	G	Н	
	Set of Members	Reference	e Length	Direc-	Preca	mber		
Reference to	No.	Manually	L [m]	tion	w <sub>o,y</sub> [mm]	w <sub>c,z</sub> [mm]	Beam Type	Comment
Set of Members	1		11.137	y; z	0.0	10.0	Beam	
Set of Members	2		11.137	y; z	0.0	10.0	Beam	
Set of Members	3		11.137	y; z	0.0	10.0	Beam	
Set of Members	4		11.137	y; z	0.0	10.0	Beam	
Set of Members	5		11.137	y; z	0.0	10.0	Beam	
Set of Members	6		11.137	y; z	0.0	10.0	Beam	
Set of Members	7		11.137	y; z	0.0	10.0	Beam	
Set of Members	8		11.137	y; z	0.0	10.0	Beam	
Set of Members	9	I I	7.087	z		0.0	Beam	
Set of Members	10	I I	7.087	z		0.0	Beam	
Set of Members	11	2	7.087	z		0.0	Beam	
Set of Members	12	2	7.087	z		0.0	Beam	
Set of Members	13	2	7.087	z		0.0	Beam	
Set of Members	14	2	7.087	z		0.0	Beam	
Set of Members	15	2	7.087	z		0.0	Beam	
Set of Members	16	Ū	7.087	z		0.0	Beam	
Set of Members	17	J	7.087	z		0.0	Beam	
Set of Members	18	J	7.087	z		0.0	Beam	
Member	315		1.691	z		0.0	Beam	
Member	316		1.691	z		0.0	Beam	
Member	317		1.691	z		0.0	Beam	
Member	318		1.691	z		0.0	Beam	
Member	329		1.691	z		0.0	Beam	
Member	330		1.691	z		0.0	Beam	
Member	331		1.691	z		0.0	Beam	
Member	332		1.691	z		0.0	Beam	
Member	279		1.000	z		0.0	Cantilever End Free	
Member	281		1.000	z		0.0	Cantilever End Free	
Member	307		1.000	z		0.0	Cantilever End Free	
Member	309		1.000	z		0.0	Cantilever End Free	
Member	311		1.000	z		0.0	Cantilever End Free	
Member	313		1.000	z		0.0	Cantilever End Free	
	Reference to Set of Members Set of Members Member	Reference to         No.           Set of Members         1           Set of Members         2           Set of Members         3           Set of Members         3           Set of Members         5           Set of Members         6           Set of Members         6           Set of Members         6           Set of Members         8           Set of Members         9           Set of Members         9           Set of Members         10           Set of Members         11           Set of Members         12           Set of Members         13           Set of Members         14           Set of Members         15           Set of Members         16           Set of Members         17           Set of Members         18           Member         316           Member         322           Member         331           Member         332           Member         332           Member         333           Member         307           Member         307           Member         307	Reference to         No.         Manually           Set of Members         1	Reference to         No.         Manually         L [m]           Set of Members         1         11.137           Set of Members         2         11.137           Set of Members         3         11.137           Set of Members         3         11.137           Set of Members         4         11.137           Set of Members         5         11.137           Set of Members         6         11.137           Set of Members         6         11.137           Set of Members         7         11.137           Set of Members         9         9         7.087           Set of Members         9         9         7.087           Set of Members         11         9         7.087           Set of Members         12         9         7.087           Set of Members         15         9         7.087           Set of Members         15         9         7.087           Set of Members         15         9         7.087           Set of Members         16         9         7.087           Set of Members         18         9         7.087           Set of Members         18	Reference to         No.         Manually         L [m]         tion           Set of Members         1         11.137         y; z           Set of Members         2         11.137         y; z           Set of Members         3         11.137         y; z           Set of Members         3         11.137         y; z           Set of Members         4         11.137         y; z           Set of Members         6         11.137         y; z           Set of Members         6         11.137         y; z           Set of Members         7         11.137         y; z           Set of Members         7         11.137         y; z           Set of Members         9         Ø         7.087         z           Set of Members         10         Ø         7.087         z           Set of Members         12         Ø         7.087         z           Set of Members         15         Ø         7.087         z           Set of Members         15         Ø         7.087         z           Set of Members         16         Ø         7.087         z           Set of Members         17	Reference to         No.         Manualy         L[m]         tion         wc.y [mm]           Set of Members         1         11.137         y.z         0.0           Set of Members         2         11.137         y.z         0.0           Set of Members         3         11.137         y.z         0.0           Set of Members         3         11.137         y.z         0.0           Set of Members         4         11.137         y.z         0.0           Set of Members         6         11.137         y.z         0.0           Set of Members         6         11.137         y.z         0.0           Set of Members         7         11.137         y.z         0.0           Set of Members         9         Ø         7.087         z         0.0           Set of Members         10         Ø         7.087         z         0.0         Set of Members         12         Ø         7.087         z         0.0           Set of Members         12         Ø         7.087         z         0.0         Set of Members         14         Ø         7.087         z         0.0         Set of Members         15         Ø	Reference to         No.         Manually         L [m]         tion         wc.y [mm]         wc.z [mm]           Set of Members         1         11.137         y; z         0.0         10.0           Set of Members         2         11.137         y; z         0.0         10.0           Set of Members         3         11.137         y; z         0.0         10.0           Set of Members         4         11.137         y; z         0.0         10.0           Set of Members         6         11.137         y; z         0.0         10.0           Set of Members         6         11.137         y; z         0.0         10.0           Set of Members         7         11.137         y; z         0.0         10.0           Set of Members         9         Ø         7.087         z         0.0           Set of Members         10         Ø         7.087         z         0.0           Set of Members         12         Ø         7.087         z         0.0           Set of Members         15         Ø         7.087         z         0.0           Set of Members         15         Ø         7.087         z	Reference to         No.         Manually         L [m]         tion         w c.y [mm]         w c.y [mm]         Beam Type           Set of Members         1         1         11.137         y; z         0.0         10.0         Beam           Set of Members         2         11.137         y; z         0.0         10.0         Beam           Set of Members         3         11.137         y; z         0.0         10.0         Beam           Set of Members         4         11.137         y; z         0.0         10.0         Beam           Set of Members         6         11.137         y; z         0.0         10.0         Beam           Set of Members         6         11.137         y; z         0.0         10.0         Beam           Set of Members         7         11.137         y; z         0.0         10.0         Beam           Set of Members         9         Ø         7.087         z         0.0         Beam           Set of Members         11         Ø         7.087         z         0.0         Beam           Set of Members         15         Ø         7.087         z         0.0         Beam

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

For a set or list of members, it is necessary that a uniform member orientation and rotation of all included members is given. Only in this way, the deformation components will be determined correctly.

In column B, you can enter the numbers of the members or sets of members that you want to design. You can also use the  $\Box$  button to select them graphically in the RFEM/RSTAB work window. Then, the Reference Length appears automatically in column D. The column presets the lengths of the members, sets of members, or lists of members. You can adjust the values *Manually* after selecting the check box in column C.

In column E, you define the governing *Direction* for the deformation analysis. You can choose the directions of the local member axes y and z as well as the resulting deformation R.

In columns F and G, a Precamber  $w_c$  can be taken into account. The two input options are related to the directions of the member axes y and z (see Figure 2.28  $\square$ ).

For a correct application of limit deformations, the Beam Type is of vital importance. In column H, you can specify whether a beam or a cantilever is to be designed and which end is free of support.

The setting in the Serviceability tab of the Details dialog box indicates whether the deformations are related to the undeformed system or to shifted members ends/set of members ends (see Figure 3.3 🗷).







Details...



### 2.10

### Fire Resistance - Members

This window manages the fire protection parameters for members. It is displayed if corresponding data has been set in the *Fire Resistance* tab of Window 1.1 (see Chapter 2.1.3 <sup>III</sup>).

	A	B	С	D	E	F	G
		Exp. to Fire		Exp.t	o Fire		
No.	Members No.	Four Sides	Тор	Bottom	Left	Right	Comment
1	174,177,186-196,198-206,351-362	2	1	<b>V</b>	1	2	
2	207,209,211,213,215,217,219,221			2	2	2	
	315,316,321-327,329-332		2	<b>V</b>			
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
1/							
18							
19							
20							
21							
22	-						
23							
24							
26							
27	1						
28							
29							
30							
31							
32							
33							
							5

Figure 2.36 Window 1.10 Fire Resistance - Members

In column A, you decide for which members you want to perform a fire resistance design. With the button you can select the members graphically in the work window of RFEM or RSTAB.

In column B, you can specify if they are *Exp.* to *Fire on Four Sides*. If the cross-section is not exposed to fire on all sides, clear the selection of the check-box. Thus, the following table columns become available where you can specify the sides of the cross-section that are exposed to fire by ticking the boxes. Based on your settings, the ideal remaining cross-section is computed.

Details...

The general parameters for the fire resistance design are managed in the Fire Resistance tab of the Details dialog box (see Figure 3.4 🗩).


## 2.11

## Fire Resistance - Sets of Members

This window manages the fire protection parameters for sets of members. It is displayed if at least one set of members is selected for design in the 1.1 General Data window and corresponding data is set in the Fire Resistance tab.

A	B	C	D	E	F	G
	Exp. to Fire		Exp.t	o Fire		
Sets of Members N	No. Four Sides	Тор	Bottom	Left	Right	Comment
1-9	2	2	2	2		
10-18		<u> </u>		2	<u> </u>	
						1

The concept of the window is similar to the previous Window 1.10 Fire Resistance - Members. Here, you can define the cross-section's sides of charring as described in Chapter 2.10 2.



## 2.12

## **Parameters**

In the final input window, you can define weakenings of the cross-section due to notches as well as parameters for the shear force reduction on supports.

Red       Member       No.       Reduction Type       Location       Comment         2       Member       53.55.57.59.61       Notch       Member Stat		A	В		C		D	E	
No.     Reference to     No.     Reduction Type     Location     Comment       1     Member     53,55,57,59,61     Notch     Member End     Immer       3     Set of Members     1     Shear Force Reduction     Inner Span       4     1     Immer     Shear Force Reduction     Inner Span       5     1     Immer     Immer     Immer       6     1     Immer     Immer     Immer       7     1     Immer     Immer     Immer       8     1     Immer     Immer     Immer       9     1     Immer     Immer     Immer       9     1     Immer     Immer     Immer       9     1     Immer     Immer     Immer       10     1     Immer     Imm	Red.		Member						
1       Member       53,55,75,95,61       Notch       Member Stat         2       Member       64,56,58,60,62       Notch       Member End         3       Set of Members       1       Shear Force Reduction       Inner Span         4	No.	Reference to	No.	Rec	luction Type	1	Location	Comment	
2         Member         54,56,58,60,62         Notch         Member End           3         Set of Members         1         Shear Force Reduction         Inner Span           5         1         1         Shear Force Reduction         Inner Span           5         1         1         1         Inner Span         Inner Span           6         1         1         1         Inner Span         Inner Span           7         1         1         1         Inner Span         Inner Span           8         1         1         1         Inner Span         Inner Span           9         1         1         1         1         Inner Span           10 cotation Type         Notch         1         1         1           10 cotation Type         Notch Stat         1         1         1           2 cotation Type         1         1         1         1	1	Member	53,55,57,59,61		Notch	Me	mber Sta	t	
3       Set of Members       1       Shear Force Reduction       Inner Span         4       1       1       Inner Span       Inner Span         5       1       1       Inner Span       Inner Span         6       1       1       Inner Span       Inner Span         7       1       1       Inner Span       Inner Span         8       1       1       Inner Span       Inner Span         9       Inner Span       Inner Span       Inner Span         1       1       1       Inner Span       Inner Span         2       Inner Span       Inner Span       Inner Span       Inner Span         9       Accuto of Depth       Inn       Span       Inner Span         9       Accuto for Edge       +z-axis       Inner Span       Inner Span         9       Accuto for Span       Inner Span       Inner Span       Inner Span     <	2	Member	54,56,58,60,62		Notch	Me	ember End	ł	
4       5	3	Set of Members	1	Shear F	orce Reduction	In	ner Span		
5	4								
6       7	5								
7     atart	6								
8     Image: Constraint of the second s	7								a <sub>start</sub>
ettings - Reduction No. 1       Reduction Type     Notch       JLocation     Member Start       Length Relatively (0. 1)     Image: Construction of the start       Distance from Member Start     a start       Distance from Member Start     Image: Construction of the start       Parameters     Image: Construction of the start       Orientation     Depth       Reduction of Depth     hn       Stother from Edge     +2-axis       JAdvanced Design     Image: Construction of the start       Stiffening Elements for Transversal Tension     Not Applied       Consider cross-sectional reduction for stability design     Image: Construction of the stability design	8								
Actings - Reduction No. 1         Reduction Type       Notch         2 Location       Member Start         2 Location       Member Start         3 Location       Member Start         - Distance from Member Start									
iettings - Reduction No. 1         Reduction Type       Notch         2 Location       Member Stat         2 Location       Member Stat         Distance from Member Statt       0 200 m         3 Parameters       0         Orientation       Depth         Reduction of Depth       hn         Notched from Edge       +z-axis         3 Advanced Design       Image: Acc. to 6.5.2         Stiffening Elements for Transversal Tension       Not Applied         Consider cross-sectional reduction for stability design       Image: Acc. to 6.5.2									
ettings - Reduction No. 1 Reduction Type I Notch Length Relatively (01) Destance from Member Start Length Relatively (01) Destance from Member Start Doientation Reduction of Depth Reduction of Depth Reduction of Depth Notch af time Support Notch at the Support Advanced Design Advanced Design Not A at the Support Not A at the Support Not A at the Support Consider cross-sectional reduction for stability design									
ettings - Reduction No. 1           Reduction Type         Notch           ]Location         Member Start           _Length Relatively (01)									
ettings - Reduction No. 1         Reduction Type       Notch         Icocation       Member Stat         Length Relatively (01)       astart       0.200 m         Distance from Member Statt       astart       0.200 m         3 Parameters									
Reduction Type     Natch       J Location     Member Stat       J Logth Relatively (01)     Image: Construction of the state of the stat	ettings	- Reduction No. 1							
	Redu	ction Type			1	lotch			
Length Relatively (0 . 1) a start 0.200 m Distance from Member Start a start 0.200 m Parameters Orientation b Depth An 50.0 mm Reduction of Depth An 50.0 mm Notched from Edge +2-axis Advanced Design Notch at the Support Not chait for Transversal Tension Not Applied Acc. to 6.5.2 Stiffening Elements for Transversal Tension Not Applied Acc. to DIN EN 1995-1-1/NA Consider cross-sectional reduction for stability design	E Locat	ion			Member	Start			
Distance from Member Start     a start     0.200 m       Parameters	- Lei	ngth Relatively (0 1)							
Parameters       Orientation     Depth       Netched from Edge     +2-axis       Advanced Design     -y       Notch et the Support     Image: Consider cross-sectional reduction for stability design	- Dis	tance from Member Start		astart	(	0.200	m		
Orientation     Depth       Reduction of Depth     hn       Stotched from Edge     +z-axis       Advanced Design	Parar	neters							
Reduction of Depth     hn     50.0     mm       Notched from Edge     +z-axis     -y       Advanced Design     Moth at the Support     Acc. to 6.5.2       Stiffening Bements for Transversal Tension     Not Applied     Acc. to DIN EN 1995-1-1/NA       Consider cross-sectional reduction for stability design     -y	— Ori	entation			[	)epth			
Notched from Edge     +z-axis       ] Advanced Design	- Re	duction of Depth		hn		50.0	mm		
Advanced Design Notch at the Support Stiffening Elements for Transversal Tension Consider cross-sectional reduction for stability design Consider cross-sectional reduction for stability design	— No	tched from Edge			+;	z-axis			
Notch at the Support     Acc. to 6.5.2     Stiffening Elements for Transversal Tension     Not Applied     Acc. to DIN EN 1995-1-1/NA     Consider cross-sectional reduction for stability design     Consider cross-sectional reduction for stability design	3 Adva	nced Design							
Stiffening Elements for Transversal Tension Not Applied Acc. to DIN EN 1995-1-1/NA Consider cross-sectional reduction for stability design	- No	tch at the Support				V		Acc. to 6.5.2	
Consider cross-sectional reduction for stability design	Sti	fening Elements for Transv	versal Tension		Not Ap	plied		Acc. to DIN EN 1995-1-1/NA	
Commont	Co	nsider cross-sectional redu	ction for stability design						
	Comn	nent							e e



In column A, you decide whether the next settings refer to single members or sets of members.

## Member/Set of Members No.

In column B, you can manually enter the numbers of the members or sets of members or select them graphically in the RFEM/RSTAB work window with the 🗔 button.

Please note for a set of members that all included members have the same member orientation and rotation. Moreover, the orientation of the set of members must be identical with the orientation of the members. These conditions apply to notches as well as shear force reductions.

### **Reduction Type**

The list offers a choice between Notch and Shear Force Reduction. Notches represent weakenings of the cross-section as they occur, for example, on supports or are caused by birdsmouth cuts for beam joints.

The parameters for shear force reduction in the support zone are specified in the German annex for  $[1] \boxtimes$  (NA.5) clause 6.1.7 as follows:

For bending beams with supports at the lower beam edge and a load application on the upper beam edge, it is allowed to perform the design of shear stresses and, if applicable, of shear connectors in the zone of end and intermediate supports, providing that there are no notches or cut-outs, with the governing shear force. The shear force in a distance h (h = beam depth over support center) to the support edge may be assumed.

Reference to Member Member Set of Members







#### Location

For the selected elements you have to define the position where the notch or the reduction zone is located. This location can refer to the start, the end, or the inner span of the member or set of members. A list with the corresponding options becomes accessible when you click into the input field.

The distances of the cross-section weakening or the shear force reduction along the member axis refer to the structural system, not to the real beam.

#### Comment

The final table column offers the possibility to enter user-defined notes.

#### Settings

In the window section below the table, you can define the details of the notch or the shear force reduction. The available parameters also depend on the specified *Location*. Figure 2.39 2 shows the parameters entered for a notch in the inner span of a set of members.

### Notch

Settings - Reduction No. 1				
Reduction Type		Notch		
□ Location		Inner Span		
Length Relatively (0 1)				
Direction of Input		From Member Start 💌		
Method of Input		Start and End		
- Start Location	Xstart	4.220	m	
- End Location	Xend	4.400	m	
Length	а	0.180	m	
Parameters				
Orientation		Depth		
<ul> <li>Reduction of Depth</li> </ul>	hn	50.0	mm	
Notched from Edge		+z-axis		
Comment				



The cross-section reduction itself can be defined by means of Parameters. You have to specify the axis direction where the weakening occurs. The *Depth* corresponds to the local member axis *z*, the *Width* to the axis y (see Figure 2.28 🗷).

The cross-section's reduction can then be entered in the input field for  $h_n$  or  $b_n$ .

If you want to reduce the cross-section in both its width and depth, the member in the table above must be selected twice. Then, you can define the orientation separately.

If the cross-section weakening is at the same time a notch on a support, it is possible to activate the Notch at the Support option (not available for inner span). In this way, a reduced shear strength, which depends on the geometry of the notch as the cross-section weakening, is taken into account on the reduced cross-section for the shear force design.

The depth factors  $k_n$  for beams with notches at the support can be set in the Other Settings tab of the National Annex Settings dialog box by user-defined specifications for solid wood, glued-laminated timber, and laminated veneer lumber (LVL) (see Chapter 2.1.4  $\square$ ).

For the design according to EN 1995-1-1 [1] I is possible to define additionally Stiffening Elements for Transversal Tension according to DIN EN 1995-1-1 NCI NA.6.8.3 or ÖNORM B 1995-1-1 Annex G.3 This possibility is mentioned only in these two annexes but is applicable in RF-/TIMBER Pro for each National Annex. The list offers different options for transversal tension stiffenings.

When calculating it is assumed that a crack occurs in the notch zone and the subjacent part is completely suspended on the upper part by fasteners.







Furthermore, you can Consider cross-sectional reduction for stability design to determine the slenderness ratio.

Notch at the Support				Acc. to 6.5.2
Stiffening Elements for Transversal Tension		Bonded Steel Bars		Acc. to DIN EN 1995-1-1/N
Number of Stiffening Elements		2		
Distance from Edge to Fastener	t	40.0	mm	
- 🖂 Size		M12		
Outside Diameter	dr	12.0	mm	
Tensile Stress Area	As	0.84	cm <sup>2</sup>	
🛱 Grade		4.6		
Ultimate Strength	fub	40.00	kN/cm	
Consider cross-sectional reduction for stability design		V		
Set Different Data for Fire Design		V		
Exposed to Fire				
Four Sides				
— Тор		<b>v</b>		
Bottom				
- Left		V		
Right		V		
Comment				

If a fire resistance design is performed, you can Set Different Data for Fire Design in order to correctly determine the sides of the reduced cross-sections that are exposed to fire.

## **Shear Force Reduction**

For reducing the shear force at the start of a member RF-/TIMBER Pro provides the input parameters shown in Figure 2.39 D. Thus, you can define the geometric area which should be irrelevant for the shear force design.

The possibility of a shear force reduction is given in the following National Annexes:

- DIN: NCI to 6.1.7 (NA.5)
- ÖNORM: 6.1.7(2)
- SFS: RIL 205-1-2009, 6.1.7

In case the design is performed according to a different annex, the rules according to DIN EN apply.

Settings - Reduction No. 4				
Reduction Type		Shear Force Reduction		
Location		Member Start		Acc. DIN EN 1995-1-1/NA NCI Zu 6.1.7 (NA.5)
<ul> <li>Length Relatively (0 1)</li> </ul>				
<ul> <li>Distance from Member Start until Support Edge</li> </ul>	Is	0.150	m	
Internal Force				
— Reduce Vy / Vu				
Reduce Vz / Vv		✓		
Comment				

Figure 2.41 Window section Settings for shear force reduction on support



It is possible to determine the width of the support by means of the Distance from Member Start to Support Edge I<sub>s</sub>. As described above, this distance refers to the structural system, not to the real beam.

Furthermore, it must be specified if only the Internal Force  $V_z$  or  $V_v$  in the direction of the "weak" axis (default) or also the shear force in the direction of the member axis y or u is to be considered for the reduction.



3

## **3** Calculation

3.1

Details...

## **Detailed Settings**

The designs are carried out with the internal forces and moments determined in RFEM or RSTAB.

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

The Details dialog box has the following tabs:

- Resistance
- Stability
- Serviceability
- Fire Resistance
- Other

### 3.1.1 Resistance

X Details Resistance Stability Serviceability Fire Resistance Other Consideration of Connections Reduction of limit tension stresses At nodes No.: 117,120,145,147,149,151,153,155 1 Connection length: 0.250 ≑ [m] Maximum stress ratio for - Inside connections: 60.00 ≑ [%] - Outside connections: 100.00 🚔 [%] Options Stress point design also for rectangular and circular cross-sections Design Settings  $\hfill Reduction of stiffness with coefficient 1 / (1 + k_{def})$ due to creep effects in Service Classes 2 and 3 according to DIN EN 1995-1-1/NA: 2010-12, NA: 5.9 At members No.: 1 🔉 🚾 🕥 📭 OK Cancel Figure 3.1 Dialog box Details, tab Resistance

⊿ ■ Dlubal

## **Consideration of Connections**

Often, zones near member connections show weakenings of the cross-section. It is possible to take this effect into account by a Reduction of limit tension stresses.

The numbers of the relevant *nodes* can be entered manually or selected graphically with the sutton.

The Connection length defines the zone of the members where reduced stresses are considered. In the input field below, you must specify the *Maximum stress ratio* within the connection zone in percent. If required, you can also limit the allowable design ratio outside the connection.

### **Options**

For biaxially bended rectangular cross-sections, the design standards specify a reduction of stresses: The loading is usually less than for uniaxial bending, for which the stresses are maximal over the entire cross-section width.

If you want to compare the stresses of different cross-sections, you can deactivate this reduction by selecting the option Stress point design also for rectangular and circular cross-sections. Then, the design will be carried out for each stress point of the cross-section.

The stress points of cross-sections are described in Chapter 2.3 2.

## **Design Settings**

According to German rules of NCI NA.5.9, a *Reduction of stiffness* has to be done in service classes 2 and 3 for permanent and quasi-permanent load contributions greater than 70% in order to take into account the influence of creeping:

$$f_{c,0,d} \cdot \frac{1}{1+k_{def}}$$

A modulus of elasticity of 1100 kN/cm<sup>2</sup> is reduced in SECL 2 to 1100 /  $(1 + 0.8) = 611.1 \text{ kN/cm}^2$ .

This reduced stiffness is considered according to the equivalent member method in the buckling analysis.



## **Stability Analysis**

The Check stability check box controls whether or not a stability analysis is performed in addition to the cross-section designs. If you clear it, the input Windows 1.5 and 1.6 won't be shown.

The equivalent member method uses the internal forces determined in RFEM or RSTAB. When applying this method, make sure that the **geometrically linear static analysis** has been set for load combinations (default setting is 2<sup>nd</sup> order analysis)! Then, to perform the stability analysis, the effective lengths of the members and sets of members subjected to compression or compression and bending must be specified in Windows 1.5 and 1.6.

If the load bearing capacity of a structural system is significantly affected by its deformations, it is recommended to select a calculation according to the Second-order analysis. This approach requires the definition of imperfections in RFEM or RSTAB and their consideration for load combinations. The flexural buckling analysis is carried out in the course of the successful calculation of these load combinations in RFEM or RSTAB.

The lateral-torsional buckling analysis must be carried also when calculating according to the secondorder analysis. For this you must specify the lengths L<sub>cr</sub> of the members or sets of members manually in Window 1.5 or 1.6 *Effective Lengths*. In this way, we can make sure that the lateral-torsional buckling analysis will be performed with the appropriate factors (for example 1.0).

Geometrically linear static analysis 

Geometrically linear static analysis
Second-order analysis (P-Delta)
Large deformation analysis
Postcritical analysis

Specifying mode of calculation in RFEM/RSTAB

Resistance Stability Serviceability Fire Resistance Other	
<ul> <li>Shifted members ends / set of members ends</li> <li>Undeformed system</li> </ul>	

The options 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. Generally, deformations must be designed relative to the displacements in the entire structural system.

You can find an example for relating deformations in the following Dlubal article: https://www.dlubal.com/en-US/support-and-learning/support/knowledge-base/001081 🗷

You can check and, if necessary, adjust the limit deformations in the National Annex Settings dialog box (see Figure 2.9 2).





## 3.1.4 Fire Resistance

This tab manages detailed settings for the fire resistance design.

Registance	Stability	Serviceshility	Fire Resistance	Other	
Tesistance	Judoliity	Serviceability		Outer	
Required Fi Fire classific	re Resista ation:	nce Duration R 30	)		
		OR 60	)		
		OR 90	)		
		OR	45 🌩 [min]		

The Fire classification can be selected directly or defined individually by specifying a time for the fire duration.

for the fire resistance design (see Figure 2.9 🗷 ).

The National Annex Settings dialog box manages the standard-specific parameters that are significant

Nat. Annex...





### **Cross-Section Optimization**

By default, the optimization is targeted on the maximum design ratio of 100%. If necessary, you can set a different upper limit in this field.

## **Check of Member Slendernesses**

The two fields define the limit values  $\lambda_{\text{limit}}$  to control the member slendernesses. Separate specifications are possible for members with tension forces only and for members with bending and compression.

In Window 3.3, the limit values are compared to the real member slendernesses. This window is available after the calculation (see Chapter 4.8 🗷 ) if the corresponding check box in the Display Result Windows dialog section to the right is ticked.

## **Setting of Stress-Point Verifications**

The check box Consider bending stress  $\sigma_{m,i}$  (centroid) controls whether the bending stress component available in the centroid is also considered when analyzing compression and bending (stress analysis and stability analysis for buckling).

An example described in Chapter 8.2 
illustrates how the stresses from bending are divided into tensile, compressive, and bending stresses.

The design of cross-sections of the "Parametric - Massive" category also include doubly unsymmetrical sections. When performing the shear stress design according to Equation  $5.1 \square$ , the thickness *t* may result for distinctive unbalances in stresses which are too low because it is related to the axes y and z.



Therefore, it is possible to limit the angle  $\alpha$  with the check box Allow further design if angle of principal axis does not exceed limit.

## **Display Result Windows**

In this dialog section, you can select which result windows including parts list are shown. The windows are described in Chapter 4 🛛 .

Window 3.3 Member Slendernesses is deactivated by default.

3.2

## Starting the Calculation

Calculation

In each input window of the RF-/TIMBER Pro add-on module, you can start the calculation by clicking the [Calculation] button.

RF-/TIMBER Pro searches for the results of the load cases, load combinations, and result combinations to be designed. If they cannot be found, the program starts the RFEM or RSTAB calculation to determine the design-relevant internal forces.

You can also start the RF-/TIMBER Pro calculation in the RFEM or RSTAB user interface: The To Calculate dialog box (menu **Calculate**  $\rightarrow$  **To Calculate**) lists the design cases of the add-on modules like load cases or load combinations.

	Combinations / Module Cases Result Tables					
Not Calculate	ed			Selected for	Calculation	
No.	Description	-		No.	Description	
C LC1     C2     C2     C4     C3     C5     C7     C7     C5     C7     C7     C7     C5     C7     C	$\label{eq:solution} \begin{array}{l} \text{Self-weigh} \\ \text{Snow} \\ \text{Live load} \\ \text{Wind} \\ \text{Imperfection} \\ 1.35^*\text{LC1} + 1.5^*\text{LC2} + 1.05^*\text{LC3} + 0.5^*\text{LC4} + 1.05^*\text{LC3} + 1.05^*\text{LC3} + 0.5^*\text{LC4} + 1.05^*\text{LC3} + 1.05^*\text{LC3} + 0.5^*\text{LC4} + 1.05^*\text{LC3} + 1.5^*\text{LC4} + 1.05^*\text{LC3} + 1.05^*\text{LC3} + 1.5^*\text{LC4} + 1.05^*\text{LC3} + 1.05^*\text{LC4} + 1.05^*\text{LC3} + 1.05^$	Ε	8	ACC CA2	RF-TIMBER Pro - Design According to Eurocode 5	

Figure 3.6 Dialog box To Calculate

If the RF-/TIMBER Pro design cases are missing in the Not Calculated section, select All or Add-on Modules in the drop-down list below the list.

To transfer the selected RF-/TIMBER Pro cases to the list on the right, use the button. Then, click [OK] to start the calculation.

You can also calculate a design case directly by using the list in the toolbar: Set the RF-/TIMBER Pro case and click the [Show Results] button.



9

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Subsequently, you can observe the calculation process in the solver dialog box.



## 4 Results

F-TIMBER Pro - [Tower Jung]																
File Edit Settings Help																
CA1 - Design according to Euror 🗸	2.1 Desig	n by Load Case														
Input Data		A	B	C	D	F	[			F				G	ГН	٦.
General Data	Load-		Member	Location												11
Materials	ing	Description	No.	x [m]	Design	1			Design Acc	cording to	Formula			DS	LDC	
- Cross-Sections		Ultimate Limit State Design														
Load Duration and Service Clas	LC1		252	1.058	0.15	≦1	152) Cross-se	ection resistar	nce - Uniax	ial bendin	ig about z-ai	xis acc. to	o 6.1.6	PT	Long-term	П
Effective Lengths - Members	CO1		252	1.058	0.23	≤1	152) Cross-se	ection resistar	nce - Uniax	ial bendin	ig about z-ai	xis acc. to	o 6.1.6	PT	Long-term	1
- Effective Lengths - Sets of Mer	LC2		207	0.000	0.29	≤1	152) Cross-se	ection resistar	nce - Uniax	ial bendin	ig about z-ai	xis acc. to	o 6.1.6	PT	Long-term	1
Tapered Members	CO2		252	1.058	0.53	≦1	152) Cross-se	ection resistar	nce - Uniax	ial bendin	ig about z-a	xis acc. to	o 6.1.6	PT	Long-term	ī
Serviceability Data	LC3		207	0.000	0.52	≦1	152) Cross-se	ection resistar	nce - Uniax	ial bendin	ig about z-a	xis acc. to	o 6.1.6	PT	Medium-ter	7
- Fire Resistance - Members	CO3		207	0.000	0.26	≦1	152) Cross-se	ection resistar	nce - Uniax	ial bendin	ig about z-ai	xis acc. to	o 6.1.6	PT	Medium-ter	7
Fire Resistance - Sets of Memb	RC3		252	1.058	0.30	≤1	328) Member	r with bending	g about z-a	is and co	mpression a	acc. to 6.	3.2 - Buck	ling PT	Long-term	1
Parameters	LC4		195	7.087	0.53	≤1	333) Member	r with biaxial b	pending and	d compres	ssion acc. to	6.3.2 - E	Buckling a	bou PT	Long-term	1
Results	CO4		215	0.000	0.51	≦1	152) Cross-se	ection resistar	nce - Uniax	ial bendin	ig about z-ai	xis acc. to	o 6.1.6	PT	Medium-ter	1
- Design by Load Case				Manu	0.99				<b>I</b>	<u>ی</u>		.10	~ ~	, 94	A	
Design by Cross-Section				MdX.	0.00	121	9		4			21,0	· 1		4	
Design by Set of Members	Detaile	Member 252 w 4.052 m L	04										Destant			_
- Design by Member	Details -	al Data Realay and Software	d Tenhor CC	4								1/-1	-Rectang	ile 90/200		
Design by x-Location		and an United Popular and Soltwood	0/200	.4								-				
Governing Internal Forces by M		a laternal Former	0/200													
Governing Internal Forces by S	Design	mal Forces					N.	0.10	L-M							
Parts List by Member	Cho	ind Force					Ng V	-0.10	L N					80.0	+1	
Parts List by Set of Members	Che	ar Force					Vy.a	-1.55	LN						4	
	Ton	sional Moment					VZ,0	0.01	k Nm					/	1	
	Ron	vding Moment					Mud	0.00	k Nm				1			
	Ber	iding Moment					My,d	0.00	k Nm							
	Deeice	a Ratio					192,0	0.71	KINII				0.0			
	Ber	vling Moment					Mad	0.71	k Nm				20	5		٠,
	Sec	tion Modulus					5- S-	213 33	cm <sup>3</sup>	-	_				0.84	
	Ber	iding Stress					Gmad	0.33	kN/cm <sup>2</sup>	-	-					
	Ber	iding Strength					fm z k	2 40	kN/cm <sup>2</sup>		Tab 1 El	N		- i	1/	
	Mor	dification Factor					k mod	0 700	KIN/GIII		Tab. 3.1	-	1		1	
	Par	tial Factor					1X MIQU	1 300			Tab. 2.3			•		
	Ber	iding Strength					Ferrad	1.000	kN/cm2		Fa (2.14	1	-0.64			
	Des	ion Ratio					11	0.15		<1	Eq. (6.12	í l				
												<u>^</u>				
										-		- 11				
												- 1				,m
												0		0	👗 🛟	Ċ
< >									-	-	1				ليت ا	
													_		_	
	Calculati	ion Details I	Nat. Annex.			Gr	raphics							OK	Cano	el



Figure 4.1 Result window with designs and intermediate values

The designs are shown in the result Windows 2.1 to 2.5, sorted by different criteria.

Windows 3.1 and 3.2 list the governing internal forces; Window 3.3 gives information on member slendernesses.

Windows 4.1 and 4.2 show the parts lists by members and sets of members.



ОК

Every window can be selected by clicking the corresponding entry in the navigator. To go to the previous or subsequent module window, use the buttons shown on the left. You can also use the function keys [F2] and [F3] to go through the windows.

Click [OK] to save the results. You will exit RF-/TIMBER Pro and return to the main program.

Chapter  $4 \square$  describes the result windows one by one. Evaluating and checking results is described in Chapter  $5 \square$ .

# 4.1

## **Design by Load Case**

The upper part of the window shows a summary of the governing designs, sorted by load case, load combination, and result combination. In addition, the table is subdivided into ultimate as well as serviceability limit state and fire resistance design.

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

	A	B	C	D	E				F					G	H
Load-		Member	Location												
ing	Description	No.	x [m]	Design				Design A	ccording to	o Formula				DS	LDC
	Ultimate Limit State Design	1													
CO3		207	0.000	0.60	≤1	152) Cross-se	ection resistar	nce - Uniax	ial bending	g about z-axis	acc. to	6.1.6		PT	Medium
CO4		207	0.000	0.60	≤1	152) Cross-se	ction resistar	nce - Uniax	ial bending	g about z-axis	acc.to	6.1.6		PT	Medium
	Serviceability Limit State D	esian													
:017	Convicedbinty Linit State Di	239	1.000	0.64	≤1	416) Services	ability - Design	n situation	Characteri	stic acc. to 7	.2 - Cant	tilever.	y-direct	ior SC	Medium
018		239	1.000	0.43	≤1	416) Services	ability - Design	n situation	Characteri	stic acc. to 7	.2 - Cant	tilever,	y-direct	ior SC	Long-te
	Fire Resistance Design					0001 0									
463	Brand	362	4.050	0.05	≤ 1	833) Fire resis	stance - Mem	ber with bia	axial bendi	ng and comp	ression	acc.to	6.3.2 -	В	Long-te
			Max:	0.64	≤1	۲		9	۰ چ	<u></u> 」>1	1.0	$\sim$	7	<u>*</u>	To .
4 - 11 -	Marshar 007 0.000 (														
She	ear Force					V.	2.47	LINI					+ 80	0.0	
She Tor Ber Ber	ear Force rsional Moment nding Moment nding Moment					Vy,d Vz,d Td My,d Mz,d	3.47 0.00 0.00 0.00 1.89	kN kNm kNm kNm				Q	1	4	
She Tor Ber Ber Desig	ear Force rsional Moment nding Moment nding Moment n Ratio					Vy,d Vz,d Td My,d Mz,d	3.47 0.00 0.00 0.00 1.89	kN kNm kNm kNm				200.0		4	
Ber Desig	ear Force rsional Moment nding Moment n Ratio nding Moment nding Moment					Vy.d Vz.d Td My.d Mz.d	3.47 0.00 0.00 1.89 1.89	kN kNm kNm kNm				200.0		5	
She Tor Ber Desig Ber Sec	ear Force rsional Moment nding Moment nding Moment n Ratio nding Moment ction Modulus nding Stress				*******	Vy,d Vz,d Td My,d Mz,d Sz	3.47 0.00 0.00 1.89 1.89 213.33 0.88	kN kNm kNm kNm cm <sup>3</sup> kN/cm <sup>2</sup>				200.0		5 0	88
She Tor Ber Desig Ber Sec Ber	ear Force noting Moment nding Moment ning Moment nding Moment ction Modulus nding Stress nding Stress nding Stress					Vy,d Vz,d Td My,d Mz,d Sz Gm,z,d fm,z,k	3.47 0.00 0.00 1.89 213.33 0.88 2.40	kN kNm kNm kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>		Tab.1. EN		200.0		5 0	88
She Tor Ber Desig Ber Sec Ber Ber Mo	ear Force rsional Moment nding Moment in Ratio nding Moment ction Modulus nding Stress nding Stress nding Strength dification Factor					Vy,d           Vz,d           Td           My,d           Mz,d           Sz           Gm,z,d           Fm,z,k           k mod	3.47 0.00 0.00 1.89 213.33 0.88 2.40 0.800	kN kNm kNm kNm cm <sup>3</sup> kN/cm <sup>2</sup>		Tab.1, EN Tab. 3, 1		200.0	2	4 5 0	88
She Tor Ber Desig Ber Sec Ber Ber Mo	ear Force sional Moment nding Moment in Ratio nding Moment ction Modulus of Modulus dring Strength dification Factor tial Factor					V <sub>2</sub> ,d T <sub>d</sub> M <sub>2</sub> ,d M <sub>z</sub> ,d S <sub>z</sub> σ <sub>m,z,d</sub> f <sub>m,z,k</sub> k mod γM	3.47 0.00 0.00 1.89 213.33 0.88 2.40 0.800 1.300	kN kNm kNm kNm cm <sup>3</sup> kN/cm <sup>2</sup>		Tab.1, EN Tab. 3, 1 Tab. 2, 3		200.0	2	5 0	88
She Tor Ber Desig Ber Sec Ber Ber Mo Par	ear Force rsional Moment nding Moment n Ratio nding Moment ction Modulus nding Stress nding Stress dification Factor tial Factor nding Strength					Vy,a Vz,d Td My,d Mz,d Sz Gm,z,d fm,z,k k mod YM fm,z,d	3.47 0.00 0.00 1.89 213.33 0.88 2.40 0.800 1.300 1.48	kN kNm kNm kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>		Tab.1, EN Tab.3.1 Tab.2.3 Eq. (2.14)		200.0	2,388	5 0	88
She Tor Ber Desig Ber Sec Ber Mo Par Ber Desig	ear Force rsional Moment inding Moment in Ratio trion Modulus nding Stress nding Stress nding Stresgth dification Factor tial Factor nding Strength sign Ratio					Vy,a Vz,d Td My,d Mz,d Sz σm,z,d fm,z,k k mod YM fm,z,d η	3.47 0.00 0.00 0.00 1.89 213.33 0.88 2.40 0.800 1.300 1.48 0.60	kN kNm kNm kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	  ≤1	Tab.1, EN Tab. 3, 1 Tab. 2, 3 Eq. (2, 14) Eq. (6, 12)		200.0	2	5 0 1 z	88
She Tor Ber Desig Ber Sec Ber Ber Mo Par Ber Des	ear Force rsional Moment Inding Moment In Ratio Inding Moment ction Modulus Inding Stress Inding Stress Inding Strength dification Factor Itial Factor Inding Strength sign Ratio					Vy,a Vz,d Td My,d Mz,d Sz σm,z,d fm,z,k k mod YM fm,z,d η	3.47 0.00 0.00 1.89 213.33 0.88 2.40 0.800 1.300 1.300 1.48 0.60	kN kNm kNm kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	≤1	Tab.1, EN Tab.3,1 Tab.2,3 Eq. (2.14) Eq. (6.12)		200.0	2	5 0 1	88
She Tor Ber Desig Ber Sec Ber Ber Des Des	ear Force rsional Moment nding Moment nding Moment in Ratio nding Moment ction Modulus ction Modulus ding Strength dification Factor nding Strength sign Ratio					Vy,a           Vz,d           Td           My,d           Mz,d           Sz           Gm,z,d           Fm,z,k           k mod           YM           fm,z,d	3.47 0.00 0.00 1.89 213.33 0.88 2.40 0.880 1.300 1.300 1.48 0.60	kN kN kNm kNm kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	≤1	Tab. 1, EP Tab. 3, 1 Tab. 2, 3 Eq. (2, 14) Eq. (6, 12)		200.0	2,388	5 0 1 2	88

Figure 4.2 Window 2.1 Design by Load Case

### Description

This column shows the descriptions of the load cases, load and result combinations for which the designs have been performed.

### Member No.

This column shows the number of the member with the maximum ratio for the designed action.

### Location x

This column shows the respective x-location of the member where the maximum design ratio occurs. The following member locations x are used for the table output:

- Start and end nodes
- Division points according to optionally set member division (RFEM Table 1.16 or RSTAB Table 1.6)
- Member division according to specification for member results (Calculation Parameters dialog box of RFEM/RSTAB, Global Calculation Parameters tab)
- Extreme values of internal forces

### Design

Max: 0.96 ≤1 🥹

Columns D and E show the design conditions conforming to standards ([1] , [2] or [3]).

The length of the colored bar represents graphically the respective design ratio.

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## **Design According to Formula**

This column displays the expressions of the standard from which the designs have been performed.

#### DS

Column G provides information on the design relevant situations (DS): PT or AC for the ultimate limit state (see Figure 2.6  $\square$ ), or one of the design situations SC, SF, SQ or SQ1 for serviceability according to the specifications in the 1.1 General Data window (see Figure 2.7  $\square$ ).

### LDC

Column H shows the load duration classes that have been defined in Window 1.4 (see Chapter 2.4  $\boxdot$ ). They affect the modification factors  $k_{mod}.$ 

## 4.2

## **Design by Cross-Section**

	A	B	С	D	E				F	
ction	Member	Location	Load-							
lo.	No.	x [m]	ing	Design				Design Acc	ording to Formula	a
2	T-Circle 2	00								
	4	0.196	CO3	0.03	≤1	102) Cross-section resistance	e - Compression al	ong the gra	in acc. to 6.1.4	
	124	0.000	CO4	0.06	≤1	113) Cross-section resistanc	e - Shear due to sh	near force u	nder biaxial bend	ding acc. to 6.1.7(1)
	172	0.000	CO4	0.37	≤1	173) Cross-section resistance	e - Biaxial bending	and compr	ession acc. to 6.	2.4
	4	0.196	CO3	0.00	≤1	303) Compression member v	vith axial compress	ion acc. to	6.3.2 - Buckling a	about both axes
	4	0.000	CO3	0.01	≤1	333) Member with biaxial be	nding and compres	ssion acc. to	o 6.3.2 - Buckling	g about both axes
3	T-Rectan	gle 80/200								
	2	0.000	CO3	0.00	≤1	101) Cross-section resistance	e - Tension along t	the grain ac	c. to 6.1.2	
	8	0.000	CO3	0.01	≤1	112) Cross-section resistance	e - Shear due to sł	near force \	/y acc. to 6.1.7	
				0.02		<b>a</b>			<b>I</b>	
			max.	0.52	21	•				
- Nor	mal Force ss-Sectiona	(Compression al Area	)			N d	8.34 314.16	kN cm <sup>2</sup>		1211 0:07 8 0.29 0.48
Cro Cor	npressive S	òtress				σc,0,d	0.03	kN/cm <sup>2</sup>		15 40.05 6 0.6
Cro Cor Mor	npressive S ment	itress				σc,0,d Md	0.03	kN/cm <sup>2</sup> kNm		15 40.05 6 6 0.6 15 40 28 4 0 17 40 39 10 48 0 10 48
Cro Cor Mor Sec	npressive S ment tion Modul	òtress us				σ.e.o.d Md W	0.03 5.32 785.40	kN/cm <sup>2</sup> kNm cm <sup>3</sup>		15 0.05 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Cro Cor Mor Sec Ber	npressive S ment ction Modul nding Stress	itress us s				σc.0,d Md W σm,d	0.03 5.32 785.40 0.68	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup>		
Cro Cor Moi Sec Ber Cor	npressive S ment stion Modul nding Stress npressive S	Otress Us s Otrength				σc,0,d Md W σm,d fc,0,k	0.03 5.32 785.40 0.68 2.30	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab.	
- Cro Cor Mor Sec Ber Cor Cor	npressive S ment ction Modul nding Stress npressive S aracteristic	Stress us s Strength Bending Stre	ngth			σc,0,6 Md W σm,d fc,0,k fm,k	0.03 5.32 785.40 0.68 2.30 3.00	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab.	
Cro Cor Sec Ber Cor Cha Moi	npressive S ment tion Modul nding Stress npressive S aracteristic dification Fa	Btress us s Btrength Bending Stre actor	ngth			σ c,0,0 M d W σ m,d f c,0,k f m,k k mod	0.03 5.32 785.40 0.68 2.30 3.00 0.800	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab.	1,EP 1
Cro Cor Sec Ber Cor Cha Moi Par	npressive S ment tion Modul nding Stress npressive S aracteristic dification Fi tial Factor	Diress us Strength Bending Stre actor	ngth			σ.0.0         Md           W         W           σm.d         f.o.0.k           fm,k         kmod           YM         Y	0.03 5.32 785.40 0.68 2.30 3.00 0.800 0.800 1.300	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab. Tab. Tab.	1.EP 1.EP 1.055 1.055 1.055 0.05
Cro Cor Sec Ber Cor Cha Moi Par Cor	npressive S ment ation Modul nding Stress npressive S aracteristic dification Fa tial Factor npressive S adias Stress	itress us Strength Bending Stre actor Strength	ngth			σc,0,0         Md           W         W           σm,d         fc,0,k           fm,k         K           YM         Fc,0,d           fc,0,k         Fc,0,d	0.03 5.32 785.40 0.68 2.30 3.00 0.800 1.300 1.42	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab. Tab. Tab. Tab. Eq. (	1, EP 3,1 2,3 2,3 2,14 3,1 2,3 2,14 3,1 2,3 2,14 3,1 2,3 1, EP 3,1 2,3 1, EP 3,1 2,3 1,5 1,5 1,5 1,5 1,5 1,5 1,5 1,5
Cro Cor Sec Ber Cor Cor Cha Par Cor Ber Ber	npressive S ment ction Modul nding Stress npressive S aracteristic dification Fis dification Fis npressive S nding Stren duction Fis	itress s strength Bending Stre actor itrength gth	ngth			σ c,0,6           Md           W           σm,d           f c,0,k           f m,k           Kmod           YM           f m,k           kmod           YM           f m,k           Kmod           YM           f m,k           Kmod           Kmod           Fm,k	0.03 5.32 785.40 0.68 2.30 3.00 0.800 1.300 1.42 1.42 1.000	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab. Tab. Tab. Eq. ( Eq. (	1, EP 2, 3 2, 14 2,
Cro Cor Sec Ber Cor Cha Moi Par Cor Ber Rec	npressive S ment ction Modul nding Stress npressive S aracteristic dification Fi tial Factor npressive S nding Stren duction Factor function Factor	Ditress us Strength Bending Stre actor Ditrength gth ctor	ngth			σ c,0,0           Md           W           σm,d           F,0,k           fm,k           Kmod           YM           fc,0,d           fm,k           kmod           YM           fc,0,d           kmod           YM	0.03 5.32 785.40 0.68 2.30 0.800 0.800 1.300 1.42 1.85 1.000 0.37	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab. Tab. Tab. Eq. ( Eq. ( 6.1.6	1.EP
Cro Con Sec Ber Con Cha Mon Par Con Ber Rec Des	npressive S ment tion Modul nding Stress npressive S aracteristic dification Fi tial Factor npressive S nding Stren duction Fac sign Ratio	itress s trength Bending Stre actor itrength gth stor	ngth			σ c,0,6           Md           W           σ m,d           f c,0,k           f c,0,d           f c,0,d           f m,d           f n           f n	1 0.03 5.32 785.40 0.68 2.30 3.00 1.300 1.42 1.85 1.000 0.37	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab. Tab. Tab. Eq. ( Eq. ( 6.1.6 ≤ 1 Eq. (	1. EP 3.1 2.14) 6.19
Cro Cor Sec Ber Cor Cha Moi Par Cor Ber Rec Des	npressive S ment tion Modul nding Stress npressive S aracteristic dification Fi tial Factor npressive S nding Stren duction Fac sign Ratio	itress ius s itrength Bending Stre actor itrength gth ttor	ngth			σ c,0,6           Md           W           σm,d           f c,0,k           f m,k           Kmod           YM           f m,k           Kmod           YM           f n,k           Kmod           f m,d           km           n	1 0.03 5.32 785.40 0.68 2.30 3.00 0.800 1.300 1.42 1.85 1.000 0.37	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab. Tab. Tab. Eq. ( Eq. ( 6.1.6 ≤ 1 Eq. (	1.EP 3.1 2.3 2.14) 6.19)
Cro Cor Sec Ber Cor Cha Moi Par Cor Ber Rec Des	npressive S ment tion Modul ading Stress npressive S aracteristic dification Fi tial Factor npressive S ading Stren duction Fac sign Ratio	itress s strength Bending Stre actor Strength gth stor	ngth			σ c,0,           Md           Øm,d           fc,0,k           Øm,d           fc,0,k           fm,k           kmod           YM           fc,0,d,0           fm,d           kmod           YM           fc,0,d,0           fm,d           kmod           Y           fc,0,d,0           fm,d           kmod           Y	1 0.03 5.32 785.40 0.68 2.30 0.800 1.300 1.42 1.85 1.000 0.37	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab. Tab. Tab. Eq. ( Eq. ( 6.1.6 ≤ 1 Eq. (	1.EP 1
Cro Cor Sec Ber Cor Cha Mo Par Cor Ber Rec Des	npressive S ment tion Modul iding Stress npressive S aracteristic dification F tial Factor pressive S ding Stren duction Fac sign Ratio	kiress s trength Bending Stre actor itrength gth tor	ngth			σ c,0,6           Mg           W           σm,d           fc,0,k           f.c,0,k           f.m,d           YM           f.c,0,d           f.m,d           Xmax           Xmax           Xmax           YM           f.c,0,d           F.m,d           Xmax           Xmax           Y	1 0.03 5.32 785.40 0.68 2.30 0.800 0.800 1.300 1.422 1.85 1.000 0.37	kN/cm <sup>2</sup> kNm cm <sup>3</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>	Tab. Tab. Tab. Eq. ( Eq. ( 6.1.6 ≤ 1 Eq. (	1. EP 3.1 2.14) 6.19

Figure 4.3 Window 2.2 Design by Cross-Section

In this results window, the maximum design ratios of all members and actions selected for design are listed by cross-section. The results are sorted by cross-section design and stability analysis as well as serviceability limit state design and fire resistance design.

If there is a tapered member, the cross-sections of the member start and end are listed separately.

Δ

1	2	
	•••	

## **Design by Set of Members**

		D (	C	D	E					c					
et	Member	Location	Load-							F					
0.	No.	x [m]	ina	Design	1				Desian A	cordina to	Formula				
	174	4.050	CO12	0.77	≤1	342) Flexural membe	r with compre	ssive force	DIN EN 1	995-1-1/N	A:2010-12 6.3.	3 (NA.8) -	Bending at	out z-ax	cis
	174	4.050	C011	0.76	≤1	343) Flexural membe	r with compre	ssive force a	acc. to DI	N EN 1995	-1-1/NA:2010-	12 6.3.3 (	VA.7)- Bend	ding abo	out both a
	174	4.050	CO16	0.00	≤1	400) Serviceability - I	Negligible def	omations							
	189	4.252	CO17	0.00	≤1	401) Serviceability - I	Design situati	on Character	istic acc.	to 7.2 - Inn	ier span, z-direc	tion			
	189	4.961	CO17	0.31	≤1	406) Serviceability - I	Design situati	on Character	istic acc.	to 7.2 - Inn	ier span, y-dired	tion			
	174	4.050	LC4	0.13	≤1	612) Fire resistance -	- Cross-section	n resistance	- Shear d	ue to shear	force Vy acc.	to 6.1.7			
	189	7.087	LC4	0.02	≤1	621) Fire resistance -	Cross-section	n resistance	- Shear di	ue to torsio	n acc. to 6.1.8				
	189	5.670	LC4	0.01	≤1	632) Fire resistance -	Cross-section	n resistance	- Shear di	ue to shear	force Vy and t	orsion acc	: to DIN El	N 1995-'	1-1/NA:2
	174	4.050	LC4	0.56	≤1	684) Fire resistance -	Cross-section	n resistance	<ul> <li>Biaxial b</li> </ul>	ending on	edge parallel to	the grain			
	174	4.050	LC4	0.56	≤1	704) Fire resistance ·	Cross-section	n resistance	<ul> <li>Biaxial b</li> </ul>	ending (co	mpression edge	e) on cut e	:dge		
			Max:	0.92	≤1	۲				[	Y 😜 🡻		V,1		3
ross efon Dire Dire	section Da mations ection x ection y	ta - T-Rectar	ngle 200/4	482			w <sub>x</sub> w <sub>y</sub>	-0.1 22.7	mm				+ 20	<u>0.0</u>	
iross- Dire Dire Dire Dire Design Def	section Da mations ection x ection y ection z n Ratio formation or ference Ler	n Inner Span	ngle 200/4	482			Wx Wy Wz Winst,y	-0.1 22.7 -0.1 11.6 11.137	mm mm mm mm			-		0.0	
ross Dire Dire Dire Dire Dire Ref Lim	section Da mations ection x ection y ection z n Ratio formation or ference Ler it Value Cri Value Cri	n Inner Span ngth terion	ngle 200/4	482			Wx Wy Wz Winst,y I I/(Winst,)	-0.1 22.7 -0.1 11.6 11.137 300.00	mm mm mm m					0.0	
iross Dire Dire Dire Dire Design Def Ref Lim	section Da mations ection x ection y ection z n Ratio formation or ference Ler it Value off it Value off	n Inner Span ngth terion Deformation	ngle 200/4	482			Wx Wy Wz Winst,y I I/(Winst,) Winst,limit	-0.1 22.7 -0.1 11.6 11.137 300.00 37.1	mm mm mm m m m			0.094	20	0.0	
ross- pefon Dire Dire Dire Design Def Ref Lim Lim	section Da mations ection x ection y ection z n Ratio formation or ference Ler it Value Crit it Value of sign Ratio	n Inner Span ngth lerion Deformation	ngle 200/4	482			Wx           Wy           Wz           I           I / (w inst.)           Winst,limit	-0.1 22.7 -0.1 11.6 11.137 300.00 37.1 0.31	mm mm mm mm mm	≤1	Tab. 7.2	L COM	20	0.0	
ross- efon Dire Dire lesig Def Ref Lim Des	section Da mations ection x ection y ection z n Ratio formation or ference Ler it Value Crit it Value of sign Ratio	n Inner Span ngth terion Deformation	ngle 200/4	482			Wx           Wy           Wz           Winst.y           I           / (Winst.)           Winst,limit           η	-0.1 22.7 -0.1 11.6 11.137 300.00 37.1 0.31	mm mm mm mm m m m m	≤1	Tab. 7.2	L COL		0.0	
iross iross Dire Dire Dire Dire Design Def Ref Lim Lim	section Da mations section x section z n Ratio formation or ference Ler it Value Crit it Value of sign Ratio	n Inner Span rgth ierion Deformation	ngle 200/	482			Wx           Wy           Winst.y           I           / (winst.)           Winst.limit           η	-0.1 22.7 -0.1 11.6 11.137 300.00 37.1 0.31	mm mm mm mm mm	≤1	Tab. 7.2	n con		0.0	
ross- efon Dire Dire esig Def Ref Lim Lim	section Da mations section x section y section z n Ratio formation or ference Ler it Value of sign Ratio	n Inner Span ngth Lerion Deformation	ngle 200/4	482			Wx           Wy           Wz           I           I / (Winst.y           I           // (Winst.junit.           η	-0.1 22.7 -0.1 11.6 11.137 300.00 37.1 0.31	mm mm mm mm mm	≤1	Tab. 7.2	L COP		0.0	
ross- ross- lefon Dire Dire lesig Def Lim Des	section Da mations section x action y section z n Ratio formation or ference Ler it Value cf sign Ratio	a - T-Rectar n Inner Span ngth Lerion Deformation	ngle 200/-	482			wx wy wz I/(winst;y I/(winst; η	-0.1 227 -0.1 11.6 11.137 300.00 37.1 0.31	mm mm m m m m	≤1	Tab. 72	U COP		0.0	

Figure 4.4 Window 2.3 Design by Set of Members

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

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

The output by set of members allows you to clearly present the design of an entire structural group (a chord, for example).

4.4

## **Design by Member**

	A	B	C	D				E						
/lember	Location	Load		-										_
No.	x [m]	Case	Design				De	sign acc. t	o Formula					
221	Cross-sectio	n No. 7 -	T-Rectangle	152/	60									
	1.000	CO12	0.00	≤1	100) Cross-section resistan	ce - Negligible int	emal forces							
	0.000	CO3	0.46	≤1	112) Cross-section resistan	ce - Shear due to	shear force	Vy acc. to	6.1.7					
	0.000	CO3	0.55	≤1	152) Cross-section resistan	ce - Uniaxial ben	ding about z-	axis acc. to	6.1.6					
	0.000	CO3	0.55	≤1	316) Flexural member witho	out compressive for	orce acc. to	6.3.3 - Beni	ding abou	ıt z-axis				
	0.000	LC4	0.00	≤1	600) Fire resistance - Negli	gible internal force	es							
223	Cross-sectio	n No. 7 -	T-Rectangle	152/	60									
	1.000	CO10	0.00	≤1	100) Cross-section resistan	ce - Negligible int	emal forces							
	0.000	CO3	0.46	≤1	112) Cross-section resistan	ce - Shear due to	shear force	Vy acc. to	6.1.7					
		Max:	0.92	≤1	•					Y 🚑 9	5	V, 😫	3	
±) Cross E) Desig	n Internal For	- I-riecta ces	ngie 152/60			N.	0.00	LIN	1					
No	mal Force					Nd	0.00	kN						
Sh	ear Force					V <sub>y.d</sub>	3.47	kN						
- 30													0.7	
Sh	ear Force					V <sub>z,d</sub>	0.00	kN				152.0	.07	
- Sh	ear Force rsional Momer	nt				V <sub>z,d</sub> T <sub>d</sub>	0.00	kN kNm				152.0	.07	
- Shi - Toi - Bei	ear Force rsional Momen nding Moment	nt.				V <sub>z,d</sub> T <sub>d</sub> M <sub>y,d</sub>	0.00 0.00 0.00	kN kNm kNm			+	152.0	.07	
- Shi - Toi - Bei Bei	ear Force rsional Momer nding Moment nding Moment	nt :				V <sub>z,d</sub> T <sub>d</sub> M <sub>y,d</sub> M <sub>z,d</sub>	0.00 0.00 0.00 1.89	kN kNm kNm kNm				152.9 5 60	.07	_,
Shi Shi Bei Bei Desig	ear Force rsional Momen nding Moment nding Moment yn Ratio	nt :				V <sub>z,d</sub> T <sub>d</sub> M <sub>y,d</sub> M <sub>z,d</sub>	0.00 0.00 0.00 1.89	kN kNm kNm kNm			0.09	152.8 6 60 4 9	.07 .07 .07 8	_,
Shi Shi Ber Ber Desig	ear Force rsional Momen nding Moment nding Moment an Ratio ear Force	nt :				Vz,d Td My,d Mz,d	0.00 0.00 0.00 1.89 3.47	kN kNm kNm kNm			90.09	152.9 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6	.07 .07 .07 .07 .07	-,
= Shi Ber ∃ Desig	ear Force rsional Moment nding Moment nding Moment gn Ratio ear Force pss-Section W	it : idth				Vz,d Td My,d Mz,d Vy,d b	0.00 0.00 1.89 3.47 152.0	kN kNm kNm kNm kN mm			0.09	152.0 6 00 4 9 3 2	.07 .07 .07 8	-,
Ber Ber Desig	ear Force rsional Moment nding Moment nding Moment gn Ratio ear Force oss-Section W oss-Section He	idth				V <sub>z,d</sub> T <sub>d</sub> M <sub>y,d</sub> M <sub>z,d</sub> V <sub>y,d</sub> b h	0.00 0.00 1.89 3.47 152.0 60.0	kN kNm kNm kNm kN mm mm			0.09	152.0 6 6 0 0 4 3 2 2	.07 .07 .07 .07 .07	-,
Ber Ber Desig Shu Cro Cro	ear Force rsional Moment nding Moment nding Moment gn Ratio ear Force oss-Section W oss-Section He ack Influence	idth Factor				V <sub>z,d</sub> T <sub>d</sub> M <sub>y,d</sub> M <sub>z,d</sub> V <sub>y,d</sub> b h k or	0.00 0.00 1.89 3.47 152.0 60.0 0.800	kN kNm kNm kNm kN mm		6.1.7 (2)	100 100		.07 .07 .07 .07	
Shi Shi Bei Desig Shi Cro Cro Cro Cro	ear Force rsional Moment nding Moment nn Ratio ear Force sss-Section W sss-Section He ack Influence ective Area	idth eight Factor				V <sub>z,d</sub> Td M <sub>y,d</sub> M <sub>z,d</sub> V <sub>y,d</sub> b h k or Aef	0.00 0.00 1.89 3.47 152.0 60.0 0.800 72.96	kN kNm kNm kNm mm mm cm <sup>2</sup>		6.1.7 (2)	0.09	152.9 6 80 6 75 75 75 75 75 75 75 75 75 75	.07 .07 .07 .07	-,
Shi Bei Desig Shi Cro Cro Cro Cra	ear Force rsional Moment nding Moment an Ratio ear Force siss-Section We siss-Section He ack Influence ective Area ear Stress	idth Factor				Vz,d Td My,d Mz,d Vy,d b h kor Aef Td	0.00 0.00 1.89 3.47 152.0 60.0 0.800 72.96 0.07	kN kNm kNm kNm mm mm cm <sup>2</sup> kN/cm <sup>2</sup>		6.1.7 (2)	60.0		.07 .07 .07 8	-,
Shi Shi Bei Desig Shi Cro Cro Cro Cro Shi	ear Force rsional Momer nding Moment nding Moment an Ratio ear Force siss-Section We ask Influence ective Area ear Stress ear Strength	it idth eight Factor				Vz,d Td My,d Mz,d b h k k cr A ef td fv,k	0.00 0.00 1.89 3.47 152.0 60.0 0.800 72.96 0.07 0.25	kN kNm kNm kNm mm mm cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>		6.1.7 (2) Tab.1, EP	+ 00.0		.07 .07 .07 8	-,
Shi Shi Bei Desig Shi Cro Cro Cro Cro Shi Shi Shi	ear Force rsional Moment nding Moment n Ratio ear Force bass-Section W bass-Section He ack Influence ective Area ear Stress ear Strength oldfication Fact	idth Factor				Vz,d Td My,d Mz,d b h h k cr Aef td fv,k k mod	0.00 0.00 1.89 3.47 152.0 60.0 0.800 72.96 0.07 0.25 0.800	kN kNm kNm kNm mm mm cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>		6.1.7 (2) Tab.1. EN Tab. 3.1	+ 00.0		07 07 07 8	-,
Shi Shi Bei Desig Shi Cro Cro Cro Cro Cro Shi Shi Mo Pai	ear Force rsional Moment nding Moment n Ratio ear Force bass-Section W sss-Section He ack Influence ective Area ear Strength odification Fact rtial Factor	idth eight Factor				Vz,d Td My,d Mz,d b h k cr Aef td fv,k k mod 7M	0.00 0.00 1.89 3.47 152.0 60.0 0.800 72.96 0.07 0.25 0.800 1.300	kN kNm kNm kNm mm cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>		6.1.7 (2) Tab.1, EN Tab. 3.1 Tab. 2.3	60.0 •		.07 .07 .07 .07	-•
Shi Shi Ber Desig Shi Cro Cro Cro Cro Cro Shi Shi Shi Shi Shi	ear Force rsional Moment nding Moment on Ratio ear Force bass-Section W bass-Section He ack Influence I ective Area ear Stress ear Strength diffication Fact rtial Factor ear Strength	idth eight Factor				Vz.d Td My,d Mz.d Vy,d b h k cr ta fv,k k mod fv,d fv,d	0.00 0.00 0.00 1.89 3.47 152.0 60.0 0.800 72.96 0.07 0.25 0.800 1.300 0.15	kN kNm kNm kNm mm cm <sup>2</sup> kN/cm <sup>2</sup> kN/cm <sup>2</sup>		6.1.7 (2) Tab.1, EN Tab. 3.1 Tab. 2.3 Eq. (2.14)	60.0		07 07 07 8	_,

Figure 4.5 Window 2.4 Design by Member

This results window shows the maximum design ratios for the individual designs sorted by member number. The columns are described in detail in Chapter 4.1 🗷 .



4.5	Des
	2.5 Design by
	Member Lo

## **Design by x-Location**

2.5 Desigr	by x-Locat	ion									
	A	B	C	D				F			•
Member	Location	Load									
No.	x [m]	Case	Design				De	sign acc. t	o Formula	а	
73	Cross-sectio	n No. 2 -	T-Circle 200	-	1			-			
	0.000	CO11	0.06	≤1	113) Cross-section resistance	e - Shear due t	to shear force	under biaxi	al bendin	g acc. to 6.1.7	7(1)
	0.000	CO10	0.40	≤1	173) Cross-section resistance	e - Biaxial ben	ding and comp	ression acc	. to 6.2.	4	
	0.000	CO2	0.01	≤1	333) Member with biaxial ben	iding and com	xes				
	0.196	CO11	0.06	≤1	113) Cross-section resistance	e - Shear due t	7(1)				
	0.196	CO10	0.38	≤1	173) Cross-section resistance						
	0.196	CO2	0.01	≤1	333) Member with biaxial ben	iding and com	pression acc.	to 6.3.2 - B	uckling a	about both axes	S
74	Cross-sectio	n No. 3 -	T-Rectangle	80/2	200						
	0.000	C01	0.01	≤1	112) Cross-section resistance	e - Shear due f	to shear force	Vy acc. to	6.1./		
		Max	0.92	≤1	•				[	Y 😜 🤋	8 🛃 😪 😂 🔹
Details - I	Member 73 -	x: 0.000 i	m - CO11								2 - T-Circle 200
Materia	al Data - Pop	lar and Co	oniferous Tim	ber C	230						
Cross-	section Data	- T-Circle	200								
Design	n Internal Ford	ces									
Design	n Ratio										
She	ar Force					V <sub>y.d</sub>	1.34	kN			1211 _109 8 _
She	ar Force					Vz,d	0.45	kN			13
Cros	ss-Section Di	ameter				d	200.0	mm			
Crac	ck Influence	Factor				Kor	0.667	-		6.1.7 (2)	12
Effe	ctive Area					Aef	209.44	cm <sup>2</sup>			
Sne	ar Stress					td	0.01	KIN/Cm <sup>2</sup>		7115	-0.01 I Y
Sne	ar Strength					Tv,k	0.30	KIN/Cm <sup>2</sup>		Tab. I, EP	21 35
- MOC	Incation Fact	lor				K mod	0.700			Tab. 3.1	23 33
Cha	ar Strength					7M	0.16	IsNI /nm 2		Tab. 2.3	202627 28293031
Dee	ian Batio					I V,d	0.10	KIN/GIII~	<1	Eq. (2.14)	1 <b>*</b>
Des	igit halio					_	0.00		21	Eq. (0.13)	-
-											
									1		
									1		
											[mm]
											ð 🛋 🎽 🕷

Figure 4.6 Window 2.5 Design by x-Location

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

- Start and end nodes
- Division points according to optionally set member division (RFEM Table 1.16 or RSTAB Table 1.6)
- Member division according to specification for member results (Calculation Parameters dialog box of RFEM/RSTAB, Global Calculation Parameters tab)
- Extreme values of internal forces

4.6

## **Governing Internal Forces by Member**

For each member, this window displays the governing internal forces, that is, the forces and moments that result in the maximum utilization in the individual designs.



31	Governing	Internal	Forces	by M	lemher
2.1	Governing	a interna	rorces	Dy Iv	lember

	A	B	C	D	E	F	G	H	
ember	Location	Load		Forces [kN]		Ma	oments [kNm]		
No.	x [m]	Case	N	Vy	Vz	MT	My	Mz	Design According to Formula
248	Cross-section	n No. 7 - 1	F-Rectangle	152/60					
	1.058	CO12	-0,70	-3.11	0.01	0.00	0.00	1.36	102) Cross-section resistance - Compression along the grain acc. to 6.
	1.058	CO7	-0.42	-3.91	0.01	0.01	0.00	1.68	112) Cross-section resistance - Shear due to shear force Vy acc. to 6.1
	1.058	C07	-0.42	-3.91	0.01	0.01	0.00	1.68	132) Cross-section resistance - Shear due to shear force Vy and torsion
	1.058	C07	-0.42	-3.91	0.01	0.01	0.00	1.68	172) Cross-section resistance - Uniaxial bending about z-axis and comp
	0.000	C07	-0.42	-1.73	0.01	0.01	-0.02	-1.22	173) Cross-section resistance - Biaxial bending and compression acc. to
	1.058	C07	-0.42	-3.91	0.01	0.01	0.00	1.68	328) Member with bending about z-axis and compression acc. to 6.3.2
	1.058	C07	-0.42	-3.91	0.01	0.01	0.00	1.68	346) Flexural member with compressive force acc. to 6.3.3 - Bending al
	0.000	C07	-0.42	-1.73	0.01	0.01	-0.02	-1.22	347) Flexural member with compressive force acc. to DIN EN 1995-1-1.
249	C	- N- 7 7	Destands 1	150/00					
243	LTOSS-SECTIO	0012	I-Rectangle	102/60	0.00	0.00	0.00	1 20	102) Cross-section resistance - Compression along the grain acc. to 6.1
	1.000	0012	0.40	-2.51	0.00	0.00	0.00	1.20	112) Cross-section resistance - Compression along the grain acc. to 6.1
	1.000	007	-0.33	-3.36	0.01	0.00	0.00	1.00	122) Cross-section resistance - Shear due to shear force Vy acc. to 0.1
	1.050	007	-0.33	-3.56	0.01	0.00	0.00	1.53	172) Cross-section resistance - Uniavial bending about z-avis and comm
	0.000	007	0.03	1.20	0.01	0.00	0.00	1.00	172) Cross-section resistance - Oritaxial bending about 2-axis and comp
	1.058	07	-0.33	-3.56	0.01	0.00	0.02	1.53	328) Member with bending about z-axis and compression acc. to 6.3.2
	1.050	07	-0.33	-3.56	0.01	0.00	0.00	1.53	346) Flexural member with compressive force acc. to 6.3.3 - Bending al
	0.000	C07	-0.39	-1.38	0.01	0.00	-0.02	-1.00	347) Flexural member with compressive force acc. to DIN EN 1995-1-1
250	Cross-section	n No. 7 - 1	F-Rectangle	152/60					
	1.058	CO8	-0.43	-3.47	0.01	0.00	0.00	1.49	102) Cross-section resistance - Compression along the grain acc. to 6.1
	1.058	C07	-0.39	-3.54	0.01	0.00	0.00	1.52	112) Cross-section resistance - Shear due to shear force Vy acc. to 6.1
	1.058	C07	-0.39	-3.54	0.01	0.00	0.00	1.52	132) Cross-section resistance - Shear due to shear force Vy and torsion
	1.058	CO1	-0.21	-1.63	0.01	0.00	0.00	0.79	152) Cross-section resistance - Uniaxial bending about z-axis acc. to 6.
	0.000	CO1	-0.21	-1.05	0.01	0.00	-0.01	-0.61	153) Cross-section resistance - Biaxial bending acc. to 6.1.6
	1.058	C07	-0,39	-3.54	0.01	0.00	0.00	1.52	172) Cross-section resistance - Uniaxial bending about z-axis and comp
	0.000	C07	-0.39	-1.36	0.01	0.00	-0.01	-0.99	173) Cross-section resistance - Biaxial bending and compression acc. to
	1.058	CO1	-0.21	-1.63	0.01	0.00	0.00	0.79	316) Flexural member without compressive force acc. to 6.3.3 - Bendin
	0.000	CO1	-0.21	-1.05	0.01	0.00	-0.01	-0.61	317) Flexural member without compressive force acc. to 6.3.3 - Bendin
	1.058	C07	-0.39	-3.54	0.01	0.00	0.00	1.52	328) Member with bending about z-axis and compression acc. to 6.3.2
	1.058	C07	-0.39	-3.54	0.01	0.00	0.00	1.52	346) Flexural member with compressive force acc. to 6.3.3 - Bending a
	0.000	C07	-0.39	-1.36	0.01	0.00	-0.01	-0.99	347) Flexural member with compressive force acc. to DIN EN 1995-1-1
									🖺 😂 🖪 🐧

Figure 4.7 Window 3.1 Governing Internal Forces by Member

## Location **x**

This column shows the respective x-location of the member where the maximum design ratio occurs.

## Load Case

This column shows the numbers of the load case as well as the load or result combination whose internal forces result in the maximum design ratio.

### Forces / Moments

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

## **Design According to Formula**

The final column gives information on the design types and equations used for performing the designs according to the selected standard.

Δ

4.7

## Governing Internal Forces by Set of Members

	A	В	С	D	E	F	G	H	
et	Location	Load		Forces [kN]		M	oments [kNm]		
0.	x [m]	Case	N	Vy	Vz	MT	My	Mz	Design According to Formula
	Continuous	Members	1 (Member N	o. 174,189)					
	4.050	CO6	- <mark>6.</mark> 80	0.07	0.04	0.00	0.01	-0.14	102) Cross-section resistance - Compression along the grain acc. to 6.
	4.050	CO1	-3.22	0.04	0.16	0.00	0.22	-0.07	111) Cross-section resistance - Shear due to shear force Vz acc. to 6.
	3.037	CO11	-4.31	3.95	0.10	0.00	0.02	-4.48	112) Cross-section resistance - Shear due to shear force Vy acc. to 6.
	4.050	CO11	-4.08	3.59	0.14	0.00	0.13	-7.77	113) Cross-section resistance - Shear due to shear force under biaxial
	6.733	CO10	- <mark>6</mark> .37	-0.07	0.36	0.27	0.17	-10.38	131) Cross-section resistance - Shear due to shear force Vz and torsion
	4.961	CO10	-7.33	0.69	0.20	0.27	-0.33	-9.84	132) Cross-section resistance - Shear due to shear force Vy and torsion
	7.087	CO10	-6.20	-0.22	0.38	0.27	0.30	-10.33	133) Cross-section resistance - Shear due to shear force Vy, Vz and to
	4.050	CO12	- <mark>6</mark> .57	3.61	0.06	0.00	-0.02	-7.81	172) Cross-section resistance - Uniaxial bending about z-axis and comp
	3.442	CO1	-3,37	0.04	0.13	0.00	0.14	-0.05	183) Cross-section resistance - Uniaxial bending about y-axis and com
	4.050	CO10	-3,08	3.58	0.18	0.00	0.24	-7.76	186) Cross-section resistance - Biaxial bending and compression on ed
	3.898	CO6	-14.68	0.03	0.10	-0.01	-0.54	-0.13	193) Cross-section resistance - Uniaxial bending about y-axis (tension e
	4.050	CO4	-7.62	2.20	0.01	0.00	-0.13	-4.75	196) Cross-section resistance - Biaxial bending (tension edge) and con
	3.442	CO1	-337	0.04	0.13	0.00	0.14	-0.05	203) Cross-section resistance - Uniaxial bending about y-axis (compres
	4.050	CO10	-3,08	3.58	0.18	0.00	0.24	-7.76	206) Cross-section resistance - Biaxial bending (compression edge) and
	2.835	C07	-8.10	0.08	-0.05	0.00	-0.07	-0.06	303) Compression member with axial compression acc. to 6.3.2 - Buck
	2.835	CO3	-8.02	0.08	-0.05	0.00	-0.11	-0.06	323) Member with bending and compression acc. to 6.3.2 - Buckling a
	2.835	CO3	-8.02	0.08	-0.05	0.00	-0.11	-0.06	341) Flexural member with compressive force acc. to 6.3.3 - Bending a
	4.050	CO12	-6.57	3.61	0.06	0.00	-0.02	-7.81	342) Flexural member with compressive force DIN EN 1995-1-1/NA:2
	4.050	CO11	-4.08	3.59	0.14	0.00	0.13	-7.77	343) Flexural member with compressive force acc. to DIN EN 1995-1-
	4.050	CO16	-5.38	0.05	0.01	0.00	-0.08	-0.10	400) Serviceability - Negligible deformations
	4.252	CO17	-10.29	0.44	0.10	0.11	-0.33	-3.75	401) Serviceability - Design situation Characteristic acc. to 7.2 - Inner s
	4.961	CO17	-9.97	0.29	0.15	0.11	-0.24	-4.01	406) Serviceability - Design situation Characteristic acc. to 7.2 - Inner s
	4.050	LC4	0.04	2.57	0.02	0.00	0.02	-5.53	612) Fire resistance - Cross-section resistance - Shear due to shear for
	7.087	LC4	-0.15	-0.11	-0.01	0.15	-0.08	-7.15	621) Fire resistance - Cross-section resistance - Shear due to torsion a
	5.670	LC4	-0.15	0.29	-0.01	0.15	-0.07	-7.03	632) Fire resistance - Cross-section resistance - Shear due to shear for
	4.050	LC4	0.04	2.57	0.02	0.00	0.02	-5.53	684) Fire resistance - Cross-section resistance - Biaxial bending on edg
	4.050	LC4	0.04	2.57	0.02	0.00	0.02	-5.53	704) Fire resistance - Cross-section resistance - Biaxial bending (compr
	Continuous	Members :	2 (Member N	o. 176,190)					
	4.050	CO6	-6.94	0.07	0.03	0.00	0.01	-0.12	102) Cross-section resistance - Compression along the grain acc. to 6.
_	6.733	C011	-11.86	-0.07	1.04	0.25	8.48	-9.76	111) Cross-section resistance - Shear due to shear force Vz acc. to 6.
_	4.050	C07	-7.92	0.07	-0.01	0.00	-0.09	-0.14	112) Cross-section resistance - Shear due to shear force Vy acc. to 6.
	4.050	C011	-5,11	3.36	-1.08	0.00	0.47	-7.29	113) Cross-section resistance - Shear due to shear force under biaxial

Figure 4.8 Window 3.2 Governing Internal Forces by Set of Members

For each set of members, this window shows the internal forces and moments that result in the maximum ratios for the individual designs.



4.8

## Member Slendernesses

#### 3.3 Member Slenderness

		B	C	D	E	F	G	Н
lember		Length		Major Axis y			Minor Axis z	
No.	Under Stress	L [m]	k <sub>y</sub> [-]	iy (mm)	λy[-]	k <sub>z</sub> [-]	iz [mm]	λ <sub>z</sub> [-]
1	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
2	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
4	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
5	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
7	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
8	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
10	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
11	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
13	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
14	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
16	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
17	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
19	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
20	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
22	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
23	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
25	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
26	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
28	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
29	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
31	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
32	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
34	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
35	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
37	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
38	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
40	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
41	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61
43	Compression / Flexure	0.196	1.000	50.0	3.929	1.000	50.0	3.92
44	Compression / Flexure	1.700	1.000	57.7	29.445	1.000	23.1	73.61



Figure 4.9 Window 3.3 Member Slendernesses

This result window is displayed if the corresponding check box is ticked in the Other tab of the Details dialog box (see Figure  $3.5 \square$ ).

Details...

The table lists the effective slendernesses of the designed members for both directions of the principal axes. They have been determined as a function of the load type. Below the list, you see a comparison with the limit values defined in the Other tab of the Details dialog box (see Figure 3.5  $\square$ ).

Members of the "Tension" or "Cable" type are not displayed in this window.

This window is only of an informative nature. It provides no stability analysis of slendernesses.



## 4.9

## **Parts List by Member**

Finally, there is a summary of all cross-sections included in the design case.

	A	B	С	D	E	F	G	H	
art	Cross-Section	Number of	Length	Total Length	Surface Area	Volume	Unit Weight	Weight	Total Weigh
No.	Description	Members	[m]	[m]	[m <sup>2</sup> ]	[m <sup>3</sup> ]	[kg/m]	[kg]	[t]
1	3 - T-Rectangle 80/220	57	1.70	96.90	58.14	1.71	6.16	10.47	0.59
2	2 - T-Circle 300	55	0.20	10.80	10.18	0.76	24.74	4.86	0.26
3	2 - T-Circle 300	1	0.07	0.07	0.07	0.01	24.74	1.77	0.00
4	2 - T-Circle 300	1	0.13	0.13	0.12	0.01	24.74	3.09	0.0
5	7 - T-Rectangle 180/200	18	1.00	18.00	13.68	0.65	12.60	12.60	0.2
6	7 - T-Rectangle 180/200	18	1.06	19.04	14.47	0.69	12.60	13.33	0.24
7	12 - T-Rectangle 80/200	18	1.00	18.00	10.08	0.29	5.92	5.92	0.10
8	12 - T-Rectangle 80/200	18	1.69	30.44	17.05	0.49	5.92	10.01	0.1
9	7 - T-Rectangle 180/200	19	1.70	32.30	24.55	1.16	12.60	21.42	0.4
um		205		225.68	148.33	5.75			2.0
								E R	<b>\$</b>

Figure 4.10 Window 4.1 Parts List by Member

Details...

By default, this list contains only the designed members. If you need a parts list for all members of the model, you can set it in the Other tab of the Details dialog box (see Figure  $3.5 \square$ ).

### Part No.

The program assigns part numbers to similar members.

### **Cross-Section Description**

This column lists the cross-section numbers and descriptions.

## **Number of Members**

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

### Length

This column shows the respective length of an individual member.

### **Total Length**

The values in this column are the product from the previous two columns.

### **Surface Area**

0

For each part, the program displays the surface areas relative to the total length. They are determined from the Surface of the cross-sections, which can be found in Windows 1.3 and 2.1 to 2.5 in the Info About Cross-Section (see Figure  $2.22 \square$ ).

## Volume

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

#### **Unit Weight**

The Unit Weight represents the cross-section weight relative to the length of one meter. For tapered cross-sections, the program averages both cross-section weights.

### Weight

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

## **Total Weight**

The final column indicates the total weight of each part.

#### Sum

At the bottom of the list, you find a summary of the values shown in columns B, D, E, F, and I. The last row of the Total Weight column gives information about the required total amount of timber.

### 4.10

## **Parts List by Set of Members**

Parts	List by Set of Members								
	A	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 Set	[m]	[m]	[m <sup>2</sup> ]	[m <sup>3</sup> ]	[kg/m]	[kg]	[t]
1	Set of Members 1	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
2	Set of Members 2	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
3	Set of Members 3	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
4	Set of Members 4	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
5	Set of Members 5	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
6	Set of Members 6	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
7	Set of Members 7	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
8	Set of Members 8	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
9	Set of Members 9	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
10	Set of Members 10	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
11	Set of Members 11	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
12	Set of Members 12	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
13	Set of Members 13	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
14	Set of Members 14	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
15	Set of Members 15	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
16	Set of Members 16	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
17	Set of Members 17	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
18	Set of Members 18	1	11.14	11.14	14.60	1.01	31.88	355.07	0.35
Sum		18		200.47	262.80	18.26			6.39
								<b>F</b>	\$

Figure 4.11 Window 4.2 Parts List by Set of Members

The last result window is displayed if at least one set of members has been selected for design. It gives an overview of the timber parts of entire structural groups such as chords.

The columns are described in the previous chapter. If there are different cross-sections within a set of members, the program averages the surface area, the volume, and the unit weight.

5

## **5** Results Evaluation

The buttons below the upper table may help you to evaluate the results.



Figure 5.1 Buttons for results evaluation

Button	Description	Function
<b>Y</b>	Ultimate limit state	Displays or hides results of ultimate limit state design
2	Serviceability limit state	Displays or hides results of serviceability limit state design
3	Fire resistance	Displays or hides results of fire resistance design
	Color bars	Displays or hides colored relation scales in result windows
> 1.0 ~ > 1.0 Max Define	Filter parameters	Describes criterion by which results are filtered in tables: ratios greater than 1, maximum value, or user-defined limit
7	Apply filter	Shows only rows to which filter parameters apply (ratios > 1, maximum, defined value)

(\$	Select member	Selects a member graphically to display its results in the table
۲	View mode	Jumps to RFEM or RSTAB work window to change the view

 Table 5.1
 Buttons in result Windows 2.1 to 2.5

5.1

## Results on RFEM/RSTAB Model

You can evaluate the design results also in the work window of RFEM or RSTAB.

## Background graphic and view mode

The RFEM/RSTAB work window in the background is useful when you want to find the position of a particular member in the model: The member selected in the result window of RF-/TIMBER Pro is highlighted in color in the background graphic. Moreover, an arrow indicates the member's x-location selected in the active table row.



Figure 5.2 Indication of member and current Location x in RFEM model



In case you cannot improve the model display by moving the RF-/TIMBER Pro module window, click the [Jump to graphic] button to activate the view mode: The function will hide the module window so that you can adjust the view in the RFEM/RSTAB work window. The view mode provides the functions of the View menu, for example, zooming, moving or rotating the model view. The indicating arrow remains visible.

Click [Back] to return to the RF-/TIMBER Pro add-on module.

Graphics

#### **RFEM/RSTAB** work window

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

In the Results navigator, you can select the design ratios separately for the ultimate and the serviceability limit state design as well as the fire protection design.



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RF-TIMBER Pro CA1 - Girder	~
LC1 - Self-weight	5
LC2 - Live load	
RC1 - 1.35*LC1/p + 1.5*LC2	
RF-TIMBER Pro CA1 - Girder	
RF-TIMBER Pro CA2 - Columns	

Similar to the display of internal forces, the [Show Results] button shows or hides the display of the design results. Click the [Show Result Values] button to the right in order to display the result values.

The RFEM/RSTAB tables are not relevant for the evaluation of the design results.

You can set the design cases in the drop-down list of the RFEM/RSTAB menu bar.

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



If you select a multicolor representation (options With/Without Diagram or Cross-Sections), the color panel becomes available, providing common control functions (see Figure 5.5 🗷 ). The functions are described in Chapter 3.4.6 of the RFEM or RSTAB manual.



It is possible to transfer the graphics of design results to the printout report (see Chapter 6.1 D). To return to the add-on module, click the [RF-/TIMBER Pro] button in the panel.

#### RF-TIMBER Pro

5.2

## Results on Cross-Section

In result Windows 2.1 to 2.5, the table results are illustrated by a dynamic stress graphic: This graphic shows the stress diagram on the cross-section at the current x-location for the selected design type. If a different x-location or design type is selected in the table, the display is updated.



**X** 

The display can be zoomed in or out by using the wheel button of the mouse. To move the stress graphic, use the drag-and-drop function. To reset the full view, click [Show All Graphic].

## **Extended display of stresses and ratios**

The [Show or Print] button allows for a specific evaluation of the results for each stress point. It opens the Cross-section dialog box.





The Position dialog section shows the current member number and location x on the member.

The Stress Points dialog section lists all stress points of the cross-section. A point selected in this table is highlighted in red in the graphic. The Coordinates columns show the centroidal distances y and z. The Stress column informs you about the stresses in the stress points.

The Stresses dialog section shows the stress components resulting from the internal forces at the current stress point (selected in the dialog section above).

In the Design Ratio dialog section, the maximum ratio of the available stress to the limit stress is shown for the current location x.

### **Determination of shear stresses**

For thin-walled cross-sections, we can assume as a simplification that the shear stress runs parallel to the wall of the cross-section. Therefore, we add the parts of the shear stresses resulting from both components of the shear forces. The sign of the statical moment defines here which parts are applied positively and which negatively.

The shear stress due to the torsional moment is to be considered differently for the total shear stress, depending on whether it is an open or closed cross-section. In the case of an open section, the torsional shear stress is added with the sign to that sum from the individual shear stresses that results in the greater absolute value of the sum.

For a closed section, however, the torsional shear stress is simply added to the sum resulting from the individual shear stresses. Here, the signs for core area and statical moments are set in such a way that they correspond to the program-specific sign conventions of the shear stress that is dependent on the loading.

Stress points lying within the cross-section do not permit the assumption mentioned above that the shear stress runs parallel to the wall of the cross-section. Here, a special method with twin stress points is used creating two stress points with identical coordinates in the cross-section. The one stress point considers the statical moment about the **y**-axis (parameter for shear stress due to vertical shear force according to Equation 5.1  $\square$ ), the other considers the statical moment about the **z**-axis (parameter for shear stress points, the complementary statical moment is equal to zero.

$$\tau = \frac{V_z \cdot S_y}{I_y \cdot t}$$

Equation 5.1 Shear stress due to shear force V<sub>z</sub>

Different thicknesses can be assigned to the twin stress points, which also have an influence on the calculation of the shear stress. The shear stresses are considered as interdependent components acting perpendicular to each other: they are two components of one stress state. For the determination of the total shear stress, both parts are quadratically added. The shear stress due to the torsional moment is not considered in these points.

The shear stresses of result combinations available in the twin stress points may **not** be combined linearly. Therefore, the extreme values of both components are evaluated with the corresponding complementary shear stresses in order to determine the greatest total shear stress.

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In the graphic, it is possible to show stresses as well as stress ratios.





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The buttons below the graphic (see Figure 5.7  $\square$  ) have the following functions:

Button	Description	Function			
61	Stress diagram	Shows or hides the display of stresses			
2	Stress ratio	Shows or hides the display of ratios			
xxx	Values	Shows or hides the results values			
max	Maximum values	Shows only extreme values or values in all points			
100 💌 [%]	Exaggeration	Enables scaling of the result diagrams			
Cross-section		Shows or hides the filled cross-section			
×	Dimension	Shows or hides the dimension lines			
<b>1</b>	Axes	Shows or hides the principle axes of the cross-section			
Ш.	Stress points	Shows or hides the stress points			
[23]	Numbering	Shows or hides the numbers of stress points			
0	Info	Opens the Info About Cross-Section dialog box			
<b>E</b>	Result diagrams	Opens the Result Diagram on Member window			
	Print	Allows for printing current result graphic			
	Show all graphic	Resets the full view of result graphic			

 Table 5.2
 Buttons in Cross-section dialog box



5.3

2

F

## **Result Diagrams**

You can evaluate the member results also graphically in the form of result diagrams.

Select the member (or set of members) in the RF-/TIMBER Pro result window by clicking in the member's table row. Then, open the *Result Diagram on Member* dialog box by clicking the button shown on the left. You can find it below the upper result table (see Figure 5.1 @).

To access the result diagrams in the RFEM/RSTAB graphic, select on the menu

#### Results $\rightarrow$ Result Diagrams for Selected Members

or use the corresponding button in the toolbar of RFEM or RSTAB.

A window opens which graphically shows the distribution of the design values on the member or set of members.

Result Diagram on Member × E 📷 | RF-TIMBER Pro CA1 - 🔄 😂 😋 😋 🔛 🔤 - < > <> 🐨 式 🗽 🥖 😽 📥 4 Members No.: 199 ۴. ۵ ator ņх 3.000 4.000 5.000 0.000 6.000 7.087 5.600 🖨 [m] 🗌 Fixed x: 🖃 🔲 Design 🚊 🛄 Ultimate Limit State Ulti ate Limit State - Cross-Section Design [-] ate Limit State Design 11Hi Cross-Section Design Stability Design x [m] [-] 0.03 0.000 ^ Deformations 0.000 0.03 0.03 0.06 0.10 0.13 0.16 0.20 0.709 0.03 0.27 0.31 Cross-Section Design 0.709 0.03 Stability Design 1.417 0.06 1.417 0.06 2.126 0.10 🗸 Max/min only Ends only Ultimate Limit State - Stability Design [-] Stability Design [·] (m) 0.000 0.11 -0.11 0.000 0.11 0.15 118 0.2 0 709 0.11 0.24 0.30 g 0.34 37 0.709 0.11 1.417 0.13 1,417 0.13 2.126 0.15 🗸 Ends only Max/min only Design - Serviceability Limit State [-] pility Limit State viceability Limit x [m] [-] 0.000 0.00 ~ 0.000 0.00 0.02 0.03 0.04 0.08 20 0.08 8 0.10 8 9.9 0.709 0.02 0.709 0.02 1.417 0.03 1.417 0.03 2.126 0.04 🗸 Max/min only Ends only Result 4 Þ -4.2, -1.5, 0.0 m End X,Y,Z: -3.2, -1.2, -7.0 art X,Y,Z

Figure 5.8 Dialog box Result Diagram on Member

Again, the Results navigator allows for a targeted selection among the designs of the ultimate and the serviceability limit state as well as of fire resistance.

Use the list in the toolbar to switch between the RF-/TIMBER Pro design cases.

The Result Diagram on Member dialog box is described in Chapter 9.5 of the RFEM or RSTAB manual.



5.4

## 

· 🖄

## **Filter for Results**

The arrangement of the RF-/TIMBER Pro result windows already provides a selection by various criteria. In addition, there are filter options for the tables (see Figure 5.1 🗷) in order to limit the numerical output by design ratios. This function is also described in the Knowledge Base 🗷 on our website.

Furthermore, you can use the filter options described in Chapter 9.9 of the RFEM manual and Chapter 9.7 of the RSTAB manual to evaluate the results graphically.

The possibilities offered by the *Visibility* function (see Chapter 9.9.1 in RFEM manual and Chapter 9.7.1 in RSTAB manual) are also available for RF-/TIMBER Pro in order to filter the members for the evaluation.

## **Filtering designs**

The design ratios can easily be used as filter criteria in the work window of RFEM or RSTAB that you can access with the [Graphics] button. To apply this function, the panel must be displayed. If it is not active, select on the RFEM/RSTAB menu

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

or use the corresponding toolbar button.

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



As shown in Figure 5.9 , the panel's scale of values can be set in such a way that only design ratios greater than 0.50 are displayed in a color range between blue and red.

Graphics

The function Display Hidden Result Diagram in the Display navigator (**Results**  $\rightarrow$  **Members** shows all design ratios which are beyond the value spectrum. Those diagrams are represented by dotted lines.

## **Filtering members**

In the *Filter* tab of the control panel, you can specify the numbers of particular members to display their results filtered. The function is described in Chapter 9.9.3 of the RFEM manual and Chapter 9.7.3 of the RSTAB manual.



In contrast to the visibility function, the model will be displayed completely in the graphic. The figure above shows the design ratios for the diagonals of a truss. The remaining members are shown in the model but are displayed without design ratios.



6

## 6 Printout

6.1

## **Printout Report**

A printout report is generated for the data of the RF-/TIMBER Pro add-on module, like in RFEM or RSTAB, to which you can add graphics and descriptions. The selection in the printout report determines which data from the design module will be included in the printout.

The printout report is described in the RFEM and RSTAB manual. Chapter 10.1.3.5 Selecting Data of Add-on Modules explains how to prepare input and output data of add-on modules for the printout.

RFEM RF-TIMBER Pro	Display			Set fil		
	☑ 2.1 Design by Load Case			Set fil		
	✓ 2.1 Design by Load Case					
			No. Selection (e.g. '1-5,20')			
	2.2 Design by Cross-Section	Cross-sections:	All 🗸 🗌			
	2.3 Design by Set of Members	Sets:	All 🗸	\$ 🔍		
	2.4 Design by Member	Members:	All 🗸	3 3		
	2.5 Design by x-Location	Members:	All 🗸 🗸			
	3.1 Governing Internal Forces	Members:	Al	1 A		
	3.2 Governing Internal Forces	Sets:	All 🗸 🗸	1. Contraction of the second s		
	3.3 Member Slendernesses	Members:	All 🗸 🖓	-		
	✓ 4.1 Parts List by Member	Select Intermediate	Results 🖌 🗸 🗸			
	4.2 Parts List by Set of Members	Printout Report				
	<b>D</b> 1	With intermediate	results Form:  Short			
	Filter settings	O Long				
	> 1,0 ~	Chapters to Display				
		Parameters for Fi	re Resistance Check			
		Cross-Section Pr	operties			
		Design Internal F	forces			
		Design				
isplay						
Cover sheet 📨						
Contents						
Info pictures		D	OK Cancel			
Uppercase titles		L				

Click the [Details] button to specify if the printout also includes intermediate results. They can be defined in a list and documented in a Short (compact representation) or Long form (list representation).

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



6.2

## **Graphic Printout**

In RFEM and RSTAB, you can transfer every image displayed in the work window to the printout report. It is also possible to send it directly to the printer. Thus, the design ratios displayed in the model can be prepared for the printout, too.

The printing of graphics is described in Chapter 10.2 of the RFEM or RSTAB manual.

## **Designs in RFEM/RSTAB model**

To print the current graphic of design ratios, select on the menu

#### File $\rightarrow$ Print Graphic

or use the correspondi	ing toolbar button.
------------------------	---------------------

<b>F</b>	RFEM 5	5.00 (64	4bit) - [1	Fower-Ju	ng*]			
84≥	<u>F</u> ile	<u>E</u> dit	<u>V</u> iew	Insert	<u>C</u> alculate	<u>R</u> esults	Tools	
: 🗋	2	33			<u>n</u>	\$ 🖓	Q 🔁	ď
9	- 2	22.5	V1 ዿ	💥 🎦 Trin	t Graphic	8   🎮 -	2×x   1	1
Figu	re 6.2	Bu	utton Pri	nt Graph	nic in RFEM	toolbar		

## **Result diagrams**

Also in the Result Diagram on Member dialog box, you can send the graphic with design values to the report by clicking the [Print] button. Alternatively, you can print it directly.

肩 Result Diagram on Member	
Members No.: 1	💽 < > 🗞 😡 🔁 🔍 🕰 📰
RF-TIMBER Pro CA1	✓ < > ↓ Print ▼
Navigator	0.000 0.500
Design Ratio	

Figure 6.3 Print button in Result Diagram on Member dialog box

#### The following dialog box opens:

Graphic P	rintout						×	
General	Options	Color Scale	Factors	Borde	er and Stretch Factors			
Graphic	Picture	nter	1		Window To Print		Graphic Scale	
● To a ○ To th	To a printout report:     PR1      To the Clipboard			More	2	Window filling     To scale 1: 20		
Graphic	Picture Si	ze and Rotatic	n		Options			
☑ Use ○ Use ● Heig	Use full page width Use full page height Height:				Show results for selected x-location in result diagram Lock graphic picture (without update) Show printout report on [OK]			
Rotation: 0 2 [1]								
Header of Graphic Picture           Design: Ultimate Limit State - Cross-Section Design								
D							OK Cancel	
Eiguno 6		aloa box Gr	anhia Pri	ntout I	rah Conoral			

#### 2 Diubal
Remove from Printout Report Start with New Page Selection... Properties... The Graphic Printout dialog box is described in Chapter 10.2 of the RFEM or RSTAB manual. There, you also find descriptions of the remaining dialog tabs.

To move a graphic within the printout report to another position, use the drag-and-drop function.

To adjust a graphic subsequently in the printout report, right-click the relevant entry in the report navigator. The *Properties* option in the shortcut menu opens again the *Graphic Printout* dialog box where you can adjust the settings.

General	Options	Color Scale	Factors	s Borde	er and Stretch	Factors		
Script			S	Symbols			Frame	
	ortional		(	Propo	rtional		<ul> <li>None</li> </ul>	
Cons	tant		(	Const	ant		◯ Framed	
Factor:	1	•	F	actor:	1+		Title box	
Print Qua	ality	4000 4000				Color		
⊖ Stan	dard (max	1000 x 1000 p	oixels)			Grayscal	e	
Maxi	mum (max	5000 x 5000 p	oixels)			Texts an	d lines in black	
O User Max	-defined number of	pixels:	100	00 🜲		○ All colore	d	
D							ОК	Cance

Figure 6.5 Dialog box Graphic Printout, tab Options



# 7 General Functions

7.1

## Design Cases

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

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

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

You can access the design cases of RF-/TIMBER Pro also in RFEM or RSTAB by using the load case list of the toolbar.

#### Create a new design case

To create a new design case, select on the RF-/TIMBER Pro menu

#### File $\rightarrow$ New Case.

The following dialog box appears.

Figure 7.1 Dialog box New RF-TIMBER Pro Case

In this dialog box, enter a No. (one that is not yet assigned) for the new design case. A Description will make the selection in the load case list easier.

After clicking [OK], the RF-/TIMBER Pro Window 1.1 General Data opens for entering the design data.

#### Rename a design case

To change the description of a design case, select on the RF-/TIMBER Pro menu

#### File $\rightarrow$ Rename Case.

The following dialog box appears.

lename l	RF-TIMBER Pro Case		X
No.	Description		
2	New Description		Ŧ
		OK Cancel	
			_

Figure 7.2 Dialog box Rename RF-TIMBER Pro Case

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



## Copy a design case

To copy the input data of the current design case, select on the RF-/TIMBER Pro menu

#### $\mathbf{File} \longrightarrow \mathbf{Copy} \ \mathbf{Case.}$

The following dialog box appears.

Copy fro	m Case
CA1 - D	esign Acc. to Eurocode 5 🔹 👻
New Ca	se
No.:	Description:
3	Design According to NA BS
	OK Cano

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

## Delete a design case

To delete a design case, select on the RF-/TIMBER Pro menu

#### File $\rightarrow$ Delete Case.

The following dialog box appears.

Availa	ble Cases
No.	Description
1	Design Acc. to Eurocode 5
2	New Description
3	Design According to INA BS

You can select the design case in the list of Available Cases. To delete the selected case, click [OK].



7.2

## **Cross-Section Optimization**

RF-/TIMBER Pro allows you to optimize overloaded or little utilized cross-sections. However, this is possible **only** for rectangular and circular cross-sections. In the case of built-up cross-sections, an automatic optimization would not be economical due to the large number of parameters, and problematic due to the slips.

In the 1.3 Cross-Sections window, you can define the sections for optimization by selecting the Yes entry in the drop-down list box of column C (or D) (see Figure 2.18  $\square$ ). You can also start the optimization in the result windows by using the shortcut menu.

	A	B	С	D	E		F				
ection	Member	Location	Load-								
No.	No.	x [m]	ing	Design			Design According to Formula				
2	T-Circle 2	00									
	118	0.000	LC2	0.00	≤1	100) Cross-s	ection resistance - Negligible internal forces				
	4	0.196	101	0.03	<1	102) Cross-s	ection resistance - Compression along the grain acc. to 6.1.4				
	166	Go to Cross-Section Doubleclick				oubleclick	ction resistance - Shear due to shear force under biaxial bending acc. to 6.1.7(1)				
	172	Info Ab	out Cross	it Cross-Section			ction resistance - Biaxial bending acc. to 6.1.6				
	37				h.		ction resistance - Biaxial bending and compression acc. to 6.2.4				
	4	<u>O</u> ptimiz	e Cross-S	Section	2		sion member with axial compression acc. to 6.3.2 - Buckling about both axes				
	4	Cross-S	ection O	ptimization	<u>P</u> ara	meters	with biaxial bending and compression acc. to 6.3.2 - Buckling about both axes				
3	T-Rectan	gle 80/220					-				
			Max:	1.02	> 1	8	🌱 🚑 🚷 🖺 🍢				

#### Details...

During the optimization process, the program finds the cross-section that fulfills the **ultimate limit state** design in the most "optimal way", that means comes as close as possible to the maximum allowable ratio specified in the *Details* dialog box (see Figure  $3.5 \square$ ). The required cross-section properties are determined with the internal forces and moments as available in RFEM or RSTAB. If another cross-section proves to be more favorable, this new cross-section is used for the design. Then, the graphic in Window 1.3 shows two cross-sections — the original cross-section from RFEM or RSTAB and the optimized cross-section (see Figure  $7.7 \square$ ).

After activating the Optimize function, the following dialog box appears:

Cross-Sectio	-Sections - Re	ectangle : Optin	nize		
Opti- mize □ b: □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □	Current 160.0 * h * k	Minimum	Maximum	Increment (mm) 20.0 + (mm)	
🔲 Keep curr	rent side propor	rtions			T-Rectangle 160/340
<b>D</b>					OK Cancel

You can determine the parameter(s) that you want to modify by ticking the Optimize check box(es). This enables the *Minimum* and *Maximum* columns where you can define the upper and lower limits of the parameter. The *Increment* column controls the interval in which the size of the parameter varies during the optimization process.

If you want to Keep current side proportions, activate the corresponding check box. In addition, you have to select the two parameters b and h for optimization.

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

You can export the modified cross-sections to RFEM or RSTAB: Go to the 1.3 Cross-Sections window and select on the menu

#### Edit $\rightarrow$ Export All Cross-Sections to RFEM/RSTAB.



You can also use the shortcut menu in Window 1.3 to export optimized cross-sections to RFEM or RSTAB.

Before the modified cross-sections are transferred, a query appears asking if the results of RFEM or RSTAB should be deleted.



After starting the [Calculation] in RF-/TIMBER Pro, the internal forces and design ratios are determined in one calculation run.

Calculation



If the modified cross-sections have not yet been exported to RFEM or RSTAB, it is possible to reimport the original cross-sections to the design module by using the options shown in Figure  $7.7 \square$ . Please note that this possibility is only available in the 1.3 Cross-Sections window.

If you optimize a tapered member, the program modifies the member start and end. Then, it linearly interpolates the second moments of area for the intermediate locations. Since 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 modeling the taper layout manually.

## Units and Decimal Places

The units and decimal places are managed for RFEM/RSTAB and the add-on modules in one dialog box. In RF-/TIMBER Pro, you can access this dialog box for adjusting the units by selecting on the menu

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

The dialog box known from RFEM or RSTAB appears. The RF-/TIMBER Pro add-on module is preset in the Program / Module list.

rogram / Module	RF-TIMBER Pro						
RF-REM     RF-STEEL Surfaces     RF-STEEL Members     RF-STEEL C3     RF-STEEL C3     RF-STEEL IS     RF-STEEL IS     RF-STEEL SIA     RF-STEEL BS     RF-STEEL GB     RF-STEEL CS     RF-STEEL CS     RF-ALUMINIUM     RF-KAPPA	Output Data Stresses: Design ratios: Dimensionless:	Unit kN/cm^2 ▼ - ▼	Dec. Places 2 Å 2 Å 3 Å	Parts List Lengths: Total lengths: Surface areas: Volumes: Weight per length: Weight: Total weight:	Unit m • • m^2 • m^3 • kg/m • kg •	Dec. Places 2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 *	
- RF-TIMBER AWC - RF-TIMBER - RX-TIMBER - RX-TIMBER - RX-TIMBER - RX-TIMBER							
2 🛛 🆻 😭 🖪	]				l	ОК	Cance



7.3

The modified settings can be saved as user profile and reused in other models. The functions are described in Chapter 11.1.3 of the RFEM or RSTAB manual.

## 7.4 Data Exchange

## 7.4.1 Exporting Materials to RFEM/RSTAB

If the materials have been adjusted for the design in RF-/TIMBER Pro, you can export the modified materials to RFEM or RSTAB in a similar way as you export cross-sections: Open the 1.2 Materials window, and then select on the menu

#### Edit $\rightarrow$ Export All Materials to RFEM/RSTAB.

You can also use the shortcut menu in Window 1.2 to export materials to RFEM/RSTAB.

	Material Library	
	Export Material to RFEM	
	Export <u>A</u> ll Materials to RFEM	
	Import Material from RFEM	
	Import All Materials from RFEM	
Fig	ure 7.10 Shortcut menu of Wind	low 1.2 Materials

#### Calculation

Before the modified materials are transferred, a query appears asking if the results of RFEM or RSTAB should be deleted. After starting the [Calculation] in RF-/TIMBER Pro, the internal forces and design ratios are determined in one calculation run.

If the modified materials have not yet been exported to RFEM or RSTAB, it is possible to reimport the original materials to the design module by using the options shown in Figure  $7.10 \square$ . Please note that this possibility is only available in the 1.2 Materials window.

## 7.4.2 Exporting Effective Lengths to RFEM/RSTAB

If the effective lengths have been adjusted for the designs in RF-/TIMBER Pro, you can also export these modified lengths to RFEM or RSTAB: Go to the 1.5 *Effective Lengths - Members* window, and then select on the menu

#### Edit $\rightarrow$ Export All Effective Lengths to RFEM/RSTAB.

You can also use the shortcut menu in Window 1.5 to export effective lengths to RFEM/RSTAB.



Before the modified effective lengths are transferred, a query appears asking if the results of RFEM/ RSTAB should be deleted.

If the modified effective lengths have not yet been exported to RFEM or RSTAB, it is possible to reimport the original effective lengths to the design module by using the options shown in Figure 7.11 D.



## 7.4.3 Exporting Results

The RF-/TIMBER Pro results can also be used by other programs.

### Clipboard

To copy cells selected in the results windows to the clipboard, use the keys [Ctrl]+[C]. To insert them, for example, in a word processing program, press [Ctrl]+[V]. The headers of the table columns won't be transferred.

#### **Printout report**

The data of RF-/TIMBER Pro can be printed into the printout report (see Chapter 6.1 🖻 ) where it can be exported. Then, in the printout report, select on the menu

#### File $\rightarrow$ Export to RTF.

This function is described in Chapter 10.1.11 of the RFEM or RSTAB manual.

### Excel

RF-/TIMBER Pro provides a function for directly exporting data to MS Excel or the CSV file format. To access this function, select on the menu

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

The following export dialog box opens.

Table Parameters	Application
✓ With table header Only marked rows	Microsoft Excel     CSV file format
Transfer Parameters	
Export table to active w	vorkbook
Rewrite existing worksh	eet
Rewrite existing worksh	eet
Rewrite existing worksh Selected Tables     All tables     Input tables     Result tables	ierksneet Export hidden columns Export tables with details

When you have selected the relevant data, you can start the export with [OK]. Excel will be started automatically, that is, you do not need to open the program first.

		- (21 - 1	Ŧ			S	iheet1 - Microso	oft Excel		
F	ile	Home	Insert Page Lay	/out	Formula	as	Data Rev	iew View Add-Ins		a 🕜 🗆 🗗 X
Pas	ste 🛷	Calibr	i v 8 v Z U v A^A Ready Font G		= = = =		Text ▼	Conditional Formatting *	Hard Select → Delete → Delete → Cells	∑ • Sort & Find & C • Filter • Select • Editing
B3 • (* Jx T-Circle 200										*
	А	В	С	D	E	F			G	
1	Section	Member	Location	Load	-					
2	No.	No.	x [m]	ing	Design			Desig	n According to For	mula
3	2	T-Circle 2	00							
4		118	0,000	LC2	0,00	≤1	100) Cross-sectio	on resistance - Negligible internal fo	rces	
5		4	0,196	LC1	0,03	≤1	102) Cross-sectio	on resistance - Compression along t	he grain acc. to 6.	1.4
6		166	0,000	LC4	0,06	≤1	113) Cross-sectio	on resistance - Shear due to shear fo	rce under biaxial	bending a
7		172	0,000	LC4	0,44	≤1	153) Cross-sectio	on resistance - Biaxial bending acc. t	0 6.1.6	
8		37	0,000	LC1	0,03	≤1	173) Cross-sectio	on resistance - Biaxial bending and c	ompression acc.	to 6.2.4
9		4	0,196	LC1	0,00	≤1	303) Compressio	n member with axial compression a	icc. to 6.3.2 - Buck	ling about
10		4	0,000	LC1	0,01	≤1	333) Member wit	h biaxial bending and compression	acc. to 6.3.2 - Bud	kling abou
11										
12	з	T-Rectang	le 80/220							
13		167	0,000	LC4	0,00	≤1	100) Cross-sectio	on resistance - Negligible internal fo	rces	
14		8	0,000	LC1	0,01	≤1	112) Cross-sectio	on resistance - Shear due to shear fo	rce Vy acc. to 6.1.	7
H A	I I I	2.2 Des	ign by Cross-Secti	on 🔬	2.3 Desig	gn b	y Set of Membe			
Rea	dy								비 100 % 🔶	

Figure 7.13 Results in Excel



Τ

8

# 8 Examples



## Timber Column

We perform designs according to EN 1995-1-1 [1]  $\square$  for a timber column that is restrained as well as subjected to compression and bending, and supported on the free end in direction Y.

The example is described in the German timber construction book [6] 2, page 236.



8.1

System and Loads



## Model

Cross-section:	b/d = 14/22 cm
Material:	Softwood C24
Height:	h = 3.20 m
Service class:	1
LDC:	Permanent
Load	
LC1 self-weight:	F = 45 kN
LC2 wind:	w = 1.5 kN/m

## **Dlubal**

### **Design values**

```
N_d = 1.35 · F = 1.35 · 45 kN = 60.75 kN (k_{mod} = 0.6)
```

 $q_d = 1.5 \cdot w = 1.5 \cdot 1.5 \text{ kN/m} = 2.25 \text{ kN/m} (k_{mod} = 0.9)$ 

### 8.1.2 Calculation with RFEM/RSTAB

The system as well as the loads in both load cases are modeled as a 3D model in RFEM or RSTAB. We deactivate the automatic consideration of the self-weight when we create LC1 because it is also neglected in the example of the German timber construction book.

We superimpose the load cases for the fundamental combination according to the geometrically linear analysis with the corresponding partial safety factors in a result combination. It is important for the designs in RF-/TIMBER Pro to define both load cases with the "permanent" criterion.



RFEM or RSTAB determines the diagrams of internal forces shown in the following figure.

The analyzed internal forces are equivalent to the ones mentioned in [6] D, page 237.

## 8.1.3 Design with RF-/TIMBER Pro

## 8.1.3.1 Ultimate Limit State Design

In the 1.1 General Data window, we select the result combination **RC1** for the Ultimate Limit State design.

Dlubal

We perform the design according to **EN 1995-1-1** with the German National Annex **DIN** (see Figure  $8.3 \square$ ).

sign of					Standard / Nationa	al Annex (NA)	
mbers:	1		\$ X	🔽 All	EN 1995-1-1:	2004-11 👻	
ts:			\$ X	🛅 📃 All	≡ DIN	- 🖰 💌	5
timate Limit	State Serviceability Limit State Fire Re	sistance					4
isting Load	Cases	Sel	ected for De	sign			~
G LC1 G LC2 RC2	Self-weight Wind in +X Serviceability Limit State		RC1	Ultimate Limit State	FU		iii ii
							2
		~					E
							4.7~~
		4					2
							Timber design of members and sets of members according to
							- DIN 1052:2008-12 - EN 1995-1-1:2004-11 - SIA 265:2012
All (4)							are a
ment							
mon				*			
				-			8

Windows 1.2 Materials and 1.3 Cross-Sections present the characteristic strengths of the selected material and the available cross-section.

	<u>_</u>		D		Special Settings for
laterial No.	Material Description		Comn	nent	Special settings acc.to Art. 3.2 or 3.3
1	Poplar and Coniferous Timber C24   EN 1995-1				-
					Increase of strength fm,k and ft,0,k
					according to:
					acc. to 3.2(3) for massive timber with h < 150 mm (Bending or b < 150 mm (Tension)
				🛐 🕏 🐧 🧕	acc. to 3.3(3) for glulam. Flat ended bending (My)
aterial Prop	perties				with h < 600 mm (Bendin
] Main Prop	perties				or b < 600 mm (1 ension)
Modulu	us of Elasticity	E	1100.00	kN/cm <sup>2</sup>	
Shear	Modulus	G	69.00	kN/cm <sup>2</sup>	
Specifi	c Weight	γ	4.20	kN/m <sup>3</sup>	I acc. to 3.3[NA.6], Edgewise bendi (Ma) for elulare timber
<ul> <li>Coeffic</li> </ul>	ient of Thermal Expansion	α	5.0000E-06	1/K	consisting of a minimum of four
Partial	Safety Factor	ΥM	1.30		side-by-side lamellas
] Additiona	Properties				
Charac	teristic Strength for Bending	fm,k	2.40	kN/cm <sup>2</sup>	
<ul> <li>Charac</li> </ul>	teristic Strength for Tension	ft,0,k	1.40	kN/cm <sup>2</sup>	Material No. 1 used in
Charac	teristic Strength for Tension Perpendicular	ft,90,k	0.04	kN/cm <sup>2</sup>	
<ul> <li>Charac</li> </ul>	teristic Strength for Compression	fo,0,k	2.10	kN/cm <sup>2</sup>	Lross-sections No.:
<ul> <li>Charac</li> </ul>	teristic Strength for Compression Perpendicular	fc,90,k	0.25	kN/cm <sup>2</sup>	1
Charac	teristic Strength for Shear/Torsion	fv,k	0.40	kN/cm <sup>2</sup>	
<ul> <li>Modulu</li> </ul>	us of Elasticity Parallel	E0,mean	1100.00	kN/cm <sup>2</sup>	Members No.:
- Modulu	us of Elasticity Perpendicular	E90,mean	37.00	kN/cm <sup>2</sup>	1
- Shear	Modulus	Gmean	69.00	kN/cm <sup>2</sup>	
<ul> <li>Density</li> </ul>	/	ρk	350.0	kg/m <sup>3</sup>	
- Modulu	us of Elasticity Parallel	E0.05	740.00	kN/cm <sup>2</sup>	Sets of members No.:
Modulu	us of Elasticity Perpendicular	E90,05	24.70	kN/cm <sup>2</sup>	
Shear	Modulus	G 05	46.40	kN/cm <sup>2</sup>	
Rolling	Shear Strength	fR,k	0.10	kN/cm <sup>2</sup>	Σ Length: Σ Weight:
					3.20 [m] 0.041 /



84

	A	В	C	D	E	1 - Rectangle 140/220
Section	Material	Cross-Section	Opti-			
No.	No.	Description [mm]	mize	Remark	Comment	140.0
	_ 1	Rectangle 140/220				
						🔒 🚰 🏹

In Window 1.4, we define load duration and service class. The factor  $k_{mod}$  of RC1 will be calculated from the load duration class (LDC) of the contained load cases by taking into account the service class (SECL).

	A	B		D	Service Class (SECL)
oad-		Load	Load Duration Class	Coefficient	Identical for all members
ng	Description	Туре	LDC	kmod	or sets of members
.C1	Self-weight	Permanent	Permanent	• 0.600	
.C2	Wind in +X	Permanent	Short-term	0.900	SECL: 1 🗸
RC1	Ultimate Limit State	-	Short-term	0.900	-
					<ul> <li>Service Class 1: Total moisture content 5-15 %. Mean moisture content in most conifers ≤12</li> </ul>
					Example: Buildings closed from all sides and heated buildings

In the 1.5 Effective Lengths - Members window, we specify the buckling lengths of the column. The example provides the Euler buckling modes 1 and 3 with the buckling length coefficients  $k_{cr,y} = 2.0$  and  $k_{cr,z} = 0.7$ .

Δ										
	B	C	D	E	F	G	Н		J	К
Buckling	Bu	ickling About A	cis y	Bu	uckling About A	xis z	Late	ral-Torsional Bu	ickling	
Possible	Possible	k <sub>or.y</sub>	L <sub>cr.y</sub> [m]	Possible	k or,z	Lor,z [m]	Possible	L <sub>or</sub> Manually	L <sub>or</sub> [m]	Comment
V	✓	2.000	6.400	√	0.700	2.240	✓		3.200	
									F	
	Possible	Possible	Possible kor.y 2.000	Possible         K.or.y         L.or.y         [m]           Image: Contract of the state of the s	Possible Kor, Lor, (m) Possible 2.000 6.400 2	Possible         Kor.y         Lor.y [m]         Possible         Kor.z           Image: Construction of the state	Possible         Kor.y         Lor.y [m]         Possible         Kor.z         Lor.z [m]           Image: Construction of the state	Possible     Kor.y     Lor.y [m]     Possible     Kor.z     Lor.z [m]     Possible       Image: Construction of the state of the stat	Possible     K <sub>cr.y</sub> L <sub>cr.y</sub> [m]     Possible     K <sub>cr.z</sub> L <sub>cr.z</sub> [m]     Possible     L <sub>cr.d</sub> Image: Construction of the state of the s	Possible         K.or.y         Lor.y [m]         Possible         K.or.z         L.or.z [m]         Possible         L.or Manually         L.or [m]           Image: Comparison of the state of the

Figure 8.7 Window 1.5 Effective Lengths - Members

Calculation

We start the calculation by clicking the [Calculation] button.

1 Desigi	n by Load Case															
	Α	B	C	D	E	1			F				-	G	н	
Load-		Member	Location													Coefficier
ing	Description	No.	x [m]	Design	1			Design Acc	ording to I	Formula				DS	LDC	kmod
	Ultimate Limit State Design															
RC1	Ultimate Limit State	1	0.000	1.065	>1	323) Mer	mber with ben	ding and co	mpression	acc. to 6.3	2 - B	uckling	tuode	ULS	Short-term	0.900
								-								
			64 mm	1.005		•				6/ 6	0			ا		
			Max.	1.065	>	•							<b>'</b> >'			3
Dotaila	Momber 1 x: 0.000 m BC1											4.0.0	to a cla	440/2	20	
Decialis -	n Batio											I - Ret	angie	140/2	20	
No	mal Force (Compression)					N.a.	60.75	kN.								
Cm	ss-Sectional Area					40	308.00	cm2								
Cor	noraceiva Strace						0.20	kN/cm2								
Ea	ivalent Member Length					vc,u,a	6,400	m					<u>, 0</u> ,	82 14	0.0	
Equ	ivalent Member Length				- 1	-cr,y	2 240	m					- <b>6</b> /		6 7	
Ra	dius of Inertia					-01,2	63.5	mm				· ·				
Ba	dius of Inertia					•	40.4	mm								
Sle	ndemess Degree					4	100 774									
Sle	ndemess Degree					.,	55 426				=	8				
- Cor	mpressive Strength					-0 k	2 10	kN/cm <sup>2</sup>		Tab 1 EN		8	0.20	-0.	20 -0.20	Y
Mo	dulus of Elasticity					E0.05	740.00	kN/cm <sup>2</sup>		Tab.1. EN						
Re	ative Slenderness Ratio					vel v	1.709		> 0.30	Eq. (6.21)						
Rel	ative Slenderness Ratio					relz	0.940		> 0.30	Eq. (6.22)						
Fac	tor				1	30	0.200			Eq. (6.29)			3		2 /1	
ALD	diary Buckling Coefficient				1	sv.	2.101			Eq. (6.27)			/		z 1.22	
ALD	diary Buckling Coefficient					(z	1.006			Eq. (6.28)						
Buc	ckling Coefficient					Co.v	0.301			Eq. (6.25)						
Buc	ckling Coefficient					Co.z	0.733			Eq. (6.26)						
Mo	dification Factor					Cmod	0.900			Tab. 3.1						(mar)
Par	tial Factor					(M	1.300			Tab. 2.3				_		[mm]
_							1 45	InNL/mm 2		E- (0.14)		A			X	P (*

After the calculation, the 2.1 Design by Load Case window appears showing the governing designs.



The Details displayed in the lower part of the window correspond to the designs described in [6] .

$$\sigma_{\rm m,d} = \frac{M_{\rm y}}{W_{\rm y}} = \frac{1152 \text{ kNcm}}{1129.33 \text{ cm}^3} = 1.02 \text{ kN/cm}^2$$
$$\sigma_{\rm c,0,d} = \frac{N}{A} = \frac{60,75 \text{ kN}}{308 \text{ cm}^2} = 0,197 \text{ kN/cm}^2$$

According to [1]  $\square$ , we have to reduce the allowable compressive stress by the buckling coefficient  $k_c$  for the stability analysis (buckling design). This coefficient depends on the slenderness ratio  $\lambda$ .

$$i_y = \frac{d}{\sqrt{12}} = \frac{22 \text{ cm}}{\sqrt{12}} = 6.35 \text{ cm}$$
  
 $i_z = \frac{b}{\sqrt{12}} = \frac{14 \text{ cm}}{\sqrt{12}} = 4.04 \text{ cm}$ 

The slenderness ratio is given as:

$$\lambda_z = \frac{s_k}{i_z} = \frac{224 \text{ cm}}{4.04 \text{ cm}} = 55.4$$
$$\lambda_y = \frac{s_k}{i_y} = \frac{640 \text{ cm}}{6.35 \text{ cm}} = 100.8$$

The buckling coefficient  $k_c$  according to [1]  $\square$ , clause 6.3.2 is (intermediate values may be interpolated linearly):

$$k_{c,z} = 0.733$$

 $k_{\rm c,y} = 0.301$ 

## **Stability analysis**

Design according to [1] 🗷 Eq. (6.23):

$$f_{m,d} = \frac{f_{m,k} \cdot k_{mod}}{\gamma_M} = \frac{2.4 \cdot 0.9}{1.3} = 1.66 \text{ kN/cm}^2$$

**Design:** 

$$\eta_{1} = \frac{\frac{N}{A}}{k_{c,y} \cdot f_{c,o,d}} + \frac{\frac{M}{W}}{k_{m} \cdot f_{m,y,d}} = \frac{0.197}{0.301 \cdot 1.45} + \frac{1.02}{1.66} = 1.066 > 1$$

## Shear design

Design of shear from transverse force according to [1] 🗵 clause 6.1.7:

$$f_{\rm v,d} = \frac{f_{\rm v,k} \cdot k_{\rm mod}}{\gamma_{\rm M}} = \frac{0.4 \cdot 0.9}{1.3} = 0.277 \, \rm kN/cm^2$$

The shear stresses can be determined by the stress point details with the corresponding statical moments of area (see Figure 2.23 🗷).

$$\tau_{\rm d} = \frac{V_{\rm y} \cdot S_{\rm z,i}}{I_{\rm z} \cdot t_{\rm i}} + \frac{V_{\rm z} \cdot S_{\rm y,i}}{I_{\rm y} \cdot t_{\rm i}} = \frac{7.2 \,\rm kN \cdot 847 \,\rm cm^3}{5030.67 \,\rm cm^4 \cdot 22 \,\rm cm} = 0.055 \,\rm kN/\rm cm^2$$

## Design:

$$\frac{\tau_{\rm d}}{f_{\rm v,d}} = \frac{0.055}{0.277} = 0.199 \le 1$$



## 8.1.3.2 Serviceability Limit State Design

We create another result combination in RFEM or RSTAB with different partial safety factors for the serviceability limit state design:

#### $RC2 = 1.0 \cdot LC1/s + 1.0 \cdot LC2/s$

In RF-/TIMBER Pro, we select the result combination **RC2** for the design in the Serviceability Limit State tab of the 1.1 General Data window and assign the design combination **Characteristic** according to 2.2.3(2).



#### Then, we enter member 1 in the 1.9 Serviceability Data window.

	A	B	C	D	E	F	G	Н
		Member	Referen	ice Length	Direc-	Preca	amber	
No.	Reference to	No.	Manually	L [m]	tion	w.c.y [mm]	w <sub>c,z</sub> [mm]	Beam Type
1	Member	1		3.200	z 💌		0.0	Cantilever End F
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								

Figure 8.10 Window 1.9 Serviceability Data

We do not modify the reference length but we restrict the direction to **z**. As the beam has no support in this direction, we select **Cantilever End Free** in the Beam Type list.

For the check calculation, we change one setting in the Serviceability tab of the Details dialog box: The deformation is to be related to the **Undeformed system**.



Resistance	Stability	Serviceability	Fire Resistance	Other		
Deformation	n Relative	to				
Shifted r ends	members e	nds / set of me	mbers			
<ul> <li>Undefor</li> </ul>	med syster	m				
2		BIN				Carro
		11) (M2)				CanCt

In [6] <sup>ID</sup>, a modulus of elasticity of 10 000 MN/m<sup>2</sup> is applied. Thus, a new material with corresponding characteristics would have to be defined in RFEM or RSTAB.

However, to simplify matters, we use the default value of 11 000 MN/m<sup>2</sup> for the following equation.

$$w_{\text{inst}} = \frac{w \cdot h^4}{8 \cdot E \cdot I_y} \le \frac{l}{150}$$
$$w_{\text{inst}} = \frac{1.5 \cdot 3.2^4}{8 \cdot 11000 \cdot 12422.70} \cdot \frac{10^{-1}}{10^{-8}} = 1.44 \text{ cm} \le 2.13 \text{ cm} = \frac{320}{150}$$

**Design:** 

$$\frac{w_{\text{inst}}}{w_{\text{zul}}} = \frac{1.44 \text{ cm}}{2.13 \text{ cm}} = 0.676 < 1$$

Calculation

The result of this deformation analysis is also displayed after the [Calculation] in the 2.1 Design by Load Case result window under the table entry Serviceability Limit State Design.

	A	В	C	D	E				F			G	H	
Load-		Member	Location											Coeff
ing	Description	No.	x [m]	Design			Des	sign Acco	ording to Fo	mula		DS	LDC	kn
	Ultimate Limit State Design													
RC1	Ultimate Limit State	1	0.000	1.065	>1	323) Member	with bending	; and co	mpression a	icc. to 6.3.2 - E	Buckling abo	ut ULS	Short-term	0
000	Serviceability Limit State Des	ign 1	2 200	0.074	5.1	(11) Convious	- hility Donia	n oituntia	n Characte	rintia non ta 7	2 Contilour	- CC	Charthann	
nuz	Serviceability Limit State		3.200	0.074	21	411) Services	soliity - Desig	n siludiiu		IISUC BCC. IO 7	.2 - Caritileve	a, 30	Short-term	
			May	1.065		0			[	or 🖭 🍳		7.	1	5
			max.	1.000	21	~						·>1		<u>a</u>
etails -	Member 1 - x: 3 200 m - RC2										1 Dectar	ole 140/3	20	
1 Mater	rial Data - Poplar and Coniferou	s Timber C	24								r - reootan	igio i i ion		
Cross	s-section Data - Rectangle 140/	/220												
Defor	mations													
Dir	ection x					Wx	-0.4	mm					0.0	
Dir	rection y					wy	0.0	mm				+	10.0	
- Dir	rection z					Wz	14.4	mm			+			
] Desig	n Ratio							•						
— De	formation at Cantilever					Winst,z	14.4	mm						
Re	eference Length					1	3.200	m						
Lin	nit Value Criterion					I/(Winst,a	150.000				20.0		/////	
— Lin	nit Value of Deformation					Winst,limit	21.3	mm			~			
De	esign Ratio					η	0.674		≤1	Tab. 7.2				
											+	/////	/////.	
													÷	
													z	
														r
														[

Figure 8.12 Window 2.1 Design by Load Case



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## 8.2

## **Built-up Cross-Section**

We perform the designs according to EN 1995-1-1 for a single-span beam with a length of 6.50 m. This example is taken from the lecture notes of the University of Wismar [7]  $\square$  (example 5.1).

## 8.2.1 System and Loads

The beam consists of softwood C30 and is built up of three identical square timbers 80 mm / 180 mm with nails. The parts of the cross-section subjected to compression are held in the middle against lateral displacement ( $l_{ef,z} = 3.25$  m).

## Model

Material:	Softwood C30
Span length:	l = 6.50 m
Service class:	1

Medium-term

LDC:

## Loading





## Slip - ultimate limit state

Due to the high compliance (slip) of the fasteners, very different stiffnesses of the cross-section result at the initial and the final state of loading. These can affect the ultimate and the serviceability limit state design.

Modulus of elasticity	$E_{0,mean} = 12000 \text{ N/mm}^2$
Slip modulus	$k_{1/3} = \frac{2}{3} \cdot k_{ser} = \frac{2}{3} \cdot 895 = 600 \text{ N/mm}$
Area of cross-section	$A_{1.3} = 180 \cdot 80 = 14.4 \cdot 10^3 \text{ mm}^2$
Second moment of area	$I_{y,1/3} = 180 \cdot 80^3 / 12 = 7.68 \cdot 10^6 \text{ mm}^4$
Second moment of area	$I_{y,2} = 80 \cdot 180^3 / 12 = 38.88 \cdot 10^6 \text{ mm}^4$
Effective distance fasteners	s <sub>ef</sub> = 60 mm

Slip in joint 1:

$$\gamma_1 = \frac{1}{1 + \frac{\pi^2 \cdot E_1 \cdot A_1 \cdot s_1}{k_1 \cdot l^2}} = \frac{1}{1 + \frac{\pi^2 \cdot 12 \cdot 10^3 \cdot 14.4 \cdot 10^3 \cdot \frac{60}{2}}{600 \cdot (6.5 \cdot 10^3)^2}} = 0.331$$

 $\gamma_2 = 1$ 

Slip in joint 2:

$$\gamma_{3} = \frac{1}{1 + \frac{\pi^{2} \cdot E_{3} \cdot A_{3} \cdot s_{3}}{k_{3} \cdot l^{2}}} = \frac{1}{1 + \frac{\pi^{2} \cdot 12 \cdot 10^{3} \cdot 14.4 \cdot 10^{3} \cdot \frac{60}{2}}{600 \cdot (6.5 \cdot 10^{3})^{2}}} = 0.331$$

## Slip - serviceability limit state

In the limit state of loading, the creep deformation of timber according to EN 1995-1-1 must be considered for the quasi-permanent design situation. The creep coefficient  $k_{def}$  is to be taken as 0.6 in service class 1. The slip of the joint changes as follows:

Modulus of elasticity	$E_{i} = \frac{E_{0,mean}}{1 + \psi_{2} \cdot k_{def,i}} = 12000 \text{ N/mm}^{2} = 8824 \text{ N/mm}^{2}$
Slip modulus	$k_{1/3} = \frac{2}{3} \cdot k_{ser} = \frac{2}{3} \cdot 895 = 600 \text{ N/mm}$
Area of cross-section	$A_{1-3} = 180 \cdot 80 = 14.4 \cdot 10^3 \mathrm{mm}^2$
Second moment of area	$I_{y,1/3} = \frac{180 \cdot 80^3}{12} = 7.68 \cdot 10^6 \mathrm{mm}^4$
Second moment of area	$I_{y,2} = \frac{80 \cdot 180^3}{12} = 38.88 \cdot 10^6 \mathrm{mm^4}$
Effective distance fasteners	s <sub>ef</sub> = 60 mm
Slip in joint 1	$\gamma_1 = \frac{1}{1 + \frac{\pi^2 \cdot 8824 \cdot 14.4 \cdot 10^3 \cdot \frac{60}{2}}{350 \cdot (6.5 \cdot 10^3)^2}} = 0.282$
	$\gamma_2 = 1$
Slip in joint 2	$\gamma_3 = 0.282$
Stiffnesses	

The difference in the slip is 0.331 to 0.282 and is, therefore, not very serious.

Now we calculate the stiffness values for the ultimate limit state only. The effects due to different slips are described in Chapter 8.2.3.2 🖻.

Bending stiffness about Y:

$$(E \cdot I_y)_{ef} = \sum_{1}^{3} (E_i \cdot I_{i,y} + \gamma_i \cdot E - i \cdot A_i \cdot a_i^2) = 2.586 \cdot 10^{12} \text{ Nmm}^2$$



Bending stiffness about Z:

$$E \cdot I_y = 12000 \cdot \left(2 \cdot \frac{80 \cdot 180^3}{12} + \frac{180 \cdot 80^3}{12}\right) = 1.025 \cdot 10^{12} \,\mathrm{Nmm^2}$$

RF-/TIMBER Pro uses the following cross-section values:

Cross-section description	Symbol	Value	Unit
Width	b1	18.00	cm
Height	h <sub>1</sub>	8.00	cm
Width	b <sub>2</sub>	8.00	cm
Height	h <sub>2</sub>	18.00	cm
Width	b₃	18.00	cm
Height	h₃	8.00	cm
Slip in joint	γ <sub>Joint 1</sub>	0.331	
Slip in joint	γ <sub>Joint 2</sub>	0.331	
Position of centroid	Zs	17.00	cm
Distance to stress lines	Zo	17.00	cm
Distance to stress lines	a1	-13.00	cm
Distance to stress lines	a <sub>2</sub>	0.00	cm
Distance to stress lines	a <sub>3</sub>	13.00	cm
Second moment of area about y-axis	I <sub>y,eff</sub>	21,534.40	cm <sup>4</sup>
Second moment of area about z-axis	I <sub>z,eff</sub>	8,544.00	cm <sup>4</sup>



Figure 8.15 Cross-section values in RF-/TIMBER Pro

With a modulus of elasticity of 12,000 N/mm<sup>2</sup>, the effective stiffness is given as:

Bending stiffness about Y:

 $(E \cdot I_y)_{ef} = 1200 \cdot 21534.4 = 2.58 \cdot 10^7 \text{ kNcm}^2$ 

Bending stiffness about Z:

 $E \cdot I_v = 12000 \cdot 8544 = 1.025 \cdot 10^{12} \,\mathrm{kNcm^2}$ 

Hence, the stiffnesses are identical.

## 8.2.2 Calculation with RFEM/RSTAB

The system and the loads are created in RFEM or RSTAB as a 3D model.

We specify the standard **EN 1990 + EN 1995** and the National Annex for **DIN** in the Classification of Loads and Combinations section of the New Model - General Data dialog box. The automatic generation of combinations is of no importance for this example.

Model Name	Description	
Built-up Cross-Section	Example Ch	apter 8
Project Name	Description	
TIMBER Pro	-	
Folder:		<b>*</b>
C:\Users\MitleiderA.DLU	IBAL-INTERN\Desktop\TI	MBER Pro\TIMBER Pro
Type of Model		Classification of Load Cases and Combinations
1D - in X		According to Standard: National annex:
2D - in XZ		🔯 EN 1990 + EN 1995 👻 💻 DIN 👻 🐻
2D - in XY	Z	
© 20		Create combinations automatically
0 30	1 1 T	Output Load combinations
		<ul> <li>Result combinations (for linear analysis only)</li> </ul>
Positive Orientation of Gl	obal Axis Z	Template
Upward		Open template model:
Ownward		
Comment		
		-

For the system shown in Figure 8.13  $\square$ , we define the cross-section in the library, taking into account the Coefficient of compliance (slip). We apply  $\gamma_1 = \gamma_2 = 0.331$  for the ultimate limit state design.

Timber Cross-Sections - I-Shape w	ith Horizontal Connection Lines	
Cross-Section Type	Parameters         h:       34.0 */* h       [mm]         b1:       18.0 */* h       [mm]         h1:       8.0 */* h       [mm]         b2:       8.0 */* h       [mm]         b3:       18.0 */* h       [mm]         h3:       8.0 */* h       [mm]         h3:       18.0 */* h       [mm]         h3:       0.31 */* h       [m]         10:       0.331 */* h       [-1]         72:       0.331 */* h       [-1]	$ \begin{array}{c}                                     $
	<u>)</u>	

We deactivate the automatic consideration of the self-weight when we create the load case because it is also neglected in the example from [7]  $\square$ . The Load Duration Class is **Medium-term**. The specification is also valid for RF-/TIMBER Pro.



define the ed Orenee	LONG Lond Ores Description	To Only	
Isting Load Cases	LC NO. Load Case Description	10 Solve	
	Design	▼	
	General Calculation Parameters		
	Action Type	EN 1990 + 1995   DIN	
	QIA Imposed - category A: domestic, residenti	al areas 🔹	
	Salf Wainht	Load Duration	
		Clase:	
	Factor in direction:	© Permanent	
	X:	C Long-term	
		Medium-term	
		Short-term	
		Short-term / Instantaneous	
		Instantaneous	1
	Comment		
	Comment Automatic self-weight inactive	•	

## We define a member load of 2.7 kN/m in the direction Global~Z.

No.	Reference to		On Members	s No.			Load Type 'Force'	
1	<ul> <li>Members</li> <li>List of meml</li> <li>Sets of mem</li> </ul>	bers nbers	1			s 👔 🦻	Load Distribution 'Uniform'	_ p
Load Type		Load Distribut	ion	Load Dire	ction			
<ul> <li>Force</li> <li>Moment</li> <li>Temperatu</li> <li>Axial strain</li> <li>Axial displa</li> </ul>	re icement	<ul> <li>Concentra</li> <li>P</li> <li>Uniform</li> <li>Trapezoida</li> <li>Tapered</li> </ul>	ted:	Local: Global:	© x © y © z © X ⊙ Y @ Z	© u ⊙ v	i	• • • • • • • • • • • • • • • • • • •
<ul> <li>Precamber</li> <li>Initial prestr</li> <li>Extra:</li> <li>Pipe control</li> </ul>	ress ent - full	<ul> <li>Parabolic</li> <li>Varying</li> </ul>		Reference True n Projece Projece Projece	e Length member le xtion in X xtion in Y xtion in Z	ngth	Load Direction 'Global Z' Ref. Length 'True Member Lengt	n' i y
Load Paramete	ers						2	ż
p: 2 p2: p: p2: Comment	Image: Non-State         Image: Non-State<	A: B: R L m	elative distar pad over tota ember	(m) (m) (m) (m) (m) (m) (m)		•	z, i	i
2							· 	IK Cance

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## 8.2.3 Design with RF-/TIMBER Pro

## 8.2.3.1 Ultimate Limit State Design

In the 1.1 General Data window, we select the load case LC1 for the Ultimate Limit State design.

We perform the design according to EN 1995-1-1 with the German National Annex DIN.



We check in the 1.4 Load Duration and Service Class window whether or not the LDC of the load case is preset as **Medium-term**.

1.4 Load [	Duration and Service Class				
Load- ing LC1	A Description Design	B Load Type Imposed - Category A	C Load Duration Class LDC Medium-term	D Coefficient k <sub>mod</sub> 0.800	Service Class (SECL) (a) Identical for all members or sets of members SECL: 1 Different
Figure	8.21 Window 1.4 Load Duration	and Service Class			

In the 1.5 Effective Lengths - Members window, we change the buckling lengths of the beam to **3.25** m. As the lateral-torsional buckling analysis for built-up cross-sections is not specified in the codes, the columns H to J are not shown for built-up cross-sections.

1.5 Effective Lengths - Members

-											
		A	B	C	D	E	F	G	Н		J
	Member	Buckling	B	uckling About A	xis y	B	uckling About A	xis z	Late	eral-Torsional Bu	uckling
	No.	Possible	Possible	k or, y	Lor,y [m]	Possible	k or,z	L <sub>or,z</sub> [m]	Possible	L <sub>cr</sub> Manually	L <sub>or</sub> [m]
	1	<b>V</b>	√	0.500	3.250	<b>V</b>	0.500	3.250			6.500

Figure 8.22 Window 1.5 Effective Lengths - Members



Cal	cul	latio	n

After the [Calculation], the 2.1 Design by Load Case window appears showing the governing designs.

	А	B	С	D	E	1			F				G	Н	
.oad-		Member	Location												Coeffic
ing	Description	No.	x [m]	Design				Design Acc	cording to	Formula			DS	LDC	km
	Ultimate Limit State Design														-
LC1	Design	1	3.250	0.54	≤1	3312) FI	exural member	without co	mpressive	force - Ben	ding a	bout y-axis -	ULS	Medium-ter	0.1
											_				
				0.54							1				e (
			Max	0.54	≤1	9				Ŭ -	1		1	1	3
etails -	Member 1 - x: 3.250 m - LC1											1 - IUH 34/18	3/8/8/1	8/8/0.331/0.3	31
Desig	n Internal Forces										^				
Desig	n Ratio						2					1			2
Stre	ess Point No.						3	LNL							/
Ber	nding Moment				_	™y,d	14.259	KINM						3	$\langle   \rangle$
	ment of inertia					ly .	21534.40	CM 7				-0.55		7	
- Cor	nnection efficiency factor		4			7y.1	0.331					1	6	0.28' 8	9
Dis	tance from the center of the ar	ea of memt	per I to the n	eutral axis		a1,z	-13.00	cm				-0.02		-0:02	
Dis	tance from center of area of pa	art 1 to the	edge of part			n1/2	-4.00	Cm				-	0-1 08.0	80	
- Me	an compressive bending stress	)			-	σc,y,d	-0.285	kN/cm <sup>2</sup>		Eq. (B. /)					
- Add	ditional bending stress				_	σm.y.d	-0.265	kN/cm <sup>2</sup>		Eq. (B.8)	-				
- Cor	npressive Strength					fc,0,k	2.300	KN/cm <sup>2</sup>		[8], Tab.1	-			13	
Ber	nding Strength					m,y,k	3.000	KN/cm4		[8], Iab.I			0	60 0.60	
- MO	dification Factor				_	K mod	0.800			Tab. 3.1				11	
- Par	tial Factor					γM	1.300	1.817 2		Tab. 2.3		0.02		0.02	_
- Cor	npressive Strength					fc,0,d	1.415	kN/cm <sup>2</sup>		Eq. (3)		18	15	0.28 17	22
Ber	nding Strength					fm,y,d	1.846	kN/cm <sup>2</sup>		Eq. (2.14)		0.5	5	-	
Mo	dulus of Elasticity				_	E0,05	800.000	KN/cm-		[8], Tab. I				20	1
- Equ	livalent Member Length					Lor,z	3.250	m				25			28
- Ka	dius of inertia				1	z	4.45	cm							
Sle	ndemess Degree					λz	/3.0/9			E (0.00)					
- Kel	ative Siendemess Ratio				_	λrel,z	1.247		> 0.30	Eq. (6.22)			E		
- Fac	tor					Be	0.200		1	Ea. (6.29)	-		1	a 🚔 I	



Details...

The governing design is the flexural buckling design with a design ratio of 54%. This value is obtained only if the option Consider bending stress  $\sigma_{m,i}$  (centroid) has been activated (see Figure 3.5  $\square$ ) in the Other tab of the Details dialog box.

The designs are additionally checked by manual calculation.

## Design of normal stresses according to expression (B.7)

$$N_{i,d} = \frac{M_{y,d}}{(EI)_{ef}} \cdot E_i \cdot \gamma_i \cdot a_i \cdot A_i$$

$$N_{1,d} = N_{3,d} = \frac{1426 \text{ kNcm}}{2.58 \cdot 10^7 \text{ kNcm}} \cdot 1200 \text{ kN/cm}^2 \cdot 0.331 \cdot 13 \text{ cm} \cdot 144 \text{ cm}^2 = 41.4 \text{ kN}$$

 $\sigma_{\rm c,1/3,d} = \frac{N}{A} = \frac{41.1 \,\rm kN}{144 \,\rm cm^2} = 0.285 \,\rm kN/cm^2$ 

## **Design of compression**

 $\frac{\sigma_{\rm c,1,d}}{f_{\rm c,0,d}} = \frac{0.285 \,\rm kN/cm^2}{1.42 \,\rm kN/cm^2} = 0.20 < 1$ 

## **Design of tension**

 $\frac{\sigma_{\rm c,3,d}}{f_{\rm t,0,d}} = \frac{0.285 \,\rm kN/cm^2}{1.11 \,\rm kN/cm^2} = 0.26 < 1$ 

The distribution of compressive and tensile stresses is as follows:



## Design of edge stresses according to expression (B.8)

$$\sigma_{\rm m,i,d} = \frac{M_{\rm y,d}}{(EI)_{\rm ef}} \cdot E_{\rm i} \cdot \frac{h_{\rm i}}{2}$$

 $\sigma_{\rm m,1,d} = \sigma_{\rm m,3,d} = \frac{1426 \,\rm kNcm}{2.58 \cdot 10^7 \,\rm kNcm} \cdot 1200 \,\rm kN/cm^2 \cdot \frac{8 \,\rm cm}{2} = 0.265 \,\rm kN/cm^2$ 

 $\sigma_{\rm m,2,d} = \frac{1426 \,\rm kNcm}{2.58 \cdot 10^7 \,\rm kNcm} \cdot 1200 \,\rm kN/cm^2 \cdot \frac{18 \,\rm cm}{2} = 0.596 \,\rm kN/cm^2$ 

## **Design of web**

 $\frac{\sigma_{\rm m,2,d}}{f_{\rm m,d}} = \frac{0.596}{1.85} = 0.32 < 1$ 

The stresses are graphically displayed in the Cross-section dialog box in RF-/TIMBER Pro which you can open by clicking [Show or Print Cross-section Values].





Design of shear stresses in the neutral plane of the web

$$\tau_{2,\max,d} = \frac{V_{\max,d} \cdot (\gamma_3 \cdot E_3 \cdot A_3 \cdot a_3 + 0.5 \cdot E_2 \cdot b_2 \cdot h^2)}{(EI)_{ef} \cdot b_2} = \frac{8.78 \text{ kN} \cdot \left(0.331 \cdot 1200 \text{ kN/cm}^2 \cdot 144 \text{ cm}^2 \cdot 13 \text{ cm} + 0.5 \cdot 1200 \text{ kN/cm}^2 \cdot 8 \text{ cm} \cdot \left(\frac{18}{2} + 0\right)^2\right)}{2.58 \cdot 10^7 \text{ kNcm}^2 \cdot 8 \text{ cm}}$$
  
= 0.048 kN/cm<sup>2</sup>  
$$\frac{\tau_{2,\max,d}}{f_{v,d}} = \frac{0.048}{0.123} = 0.39 < 1$$
  
Shear force in connecting joint  
$$F_{1,v,\text{Ed}} = \frac{V_{\max,d} \cdot \gamma_1 \cdot E_1 \cdot A_1 \cdot a_1 \cdot s_{1,\min}}{(E \cdot I)_{ef}} = \frac{8.78 \text{ kN} \cdot 0.331 \cdot 1200 \text{ kN/cm}^2 \cdot 144 \text{ cm}^3 \cdot 13 \text{ cm} \cdot 3 \text{ cm}}{2.58 \cdot 10^7 \text{ kNcm}^2} = 0.76 \text{ kN}$$

The shear force in the connecting joint is not shown in RF-/TIMBER Pro because the distances of the fasteners cannot be defined in the program.

## **Buckling coefficient**

According to [1]  $\square$ , we have to reduce the allowable compressive stress for the stability analysis (buckling design) by the buckling coefficient k<sub>c</sub>. This coefficient depends on the slenderness ratio  $\lambda$ .

$$i_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{21534.4 \,\mathrm{cm}^4}{432 \,\mathrm{cm}^2}} = 7.06 \,\mathrm{cm}$$

$$i_z = \sqrt{\frac{I_z}{A}} = \sqrt{\frac{8544 \text{ cm}^4}{432 \text{ cm}^2}} = 4.45 \text{ cm}$$

The slenderness ratio is given as:

$$\lambda_z = \frac{s_k}{i_z} = \frac{325 \text{ cm}}{4.45 \text{ cm}} = 73.03$$

The buckling coefficient  $k_c$  according to [1]  $\mathbb{P}$ , clause 6.3.2 is (intermediate values may be interpolated linearly):

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} = \frac{1}{1.37 + \sqrt{1.37^2 - 1.25^2}} = 0.51$$
$$\lambda_{rel,z}^2 = \frac{\lambda_z}{\pi} \cdot \sqrt{\frac{f_{c,0,k}}{E_{0.05}}} = \frac{73.03}{\pi} \cdot \sqrt{\frac{2.3 \text{ kN/cm^2}}{800 \text{ kN/cm^2}}} = 1.25$$
$$k_z = 0.5 \cdot (1 + \beta_c (\lambda_{rel,z} - 0.3) + \lambda_{rel,y}^2) = 0.5 \cdot (1 + 0.2(1.25 - 0.3) + 1.25^2) = 1.37$$

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### **Stability analysis**

Design according to [1] D Eq. (6.24):

$$\eta_1 = \frac{\sigma_{c,y,d}}{k_{c,z} \cdot f_{c,o,d}} + k_m \cdot \frac{\sigma_{m,y,d}}{f_{m,d}} = \frac{0.285}{0.51 \cdot 1.42} + 1.0 \cdot \frac{0.265}{1.85} = 0.54 < 100$$

Nat. Annex...

For this design, where the stresses from bending are additionally divided into compressive bending stresses, it can be legitimate to reduce the coefficient  $k_m$  in the National Annex Settings to 0.7 (see Figure 2.10  $\square$ ). The design ratio thus becomes a little smaller. On the other hand, the component of compressive bending has now a lesser strength.

## 8.2.3.2 Serviceability Limit State Design

The serviceability limit state design is usually carried out for a respective load combination. In this example, however, we want to illustrate the effects of the different stiffnesses. In Chapter 8.2.1  $\square$ , the  $\gamma$ -factors for the stiffnesses at the initial and final state of loading are determined as 0.331 or 0.282. In order to consider the resulting differences in the stiffnesses correctly, we must perform another calculation where also the ultimate limit state design is carried out with the end stiffness - the stiffness from the serviceability limit state calculation.

Thus, it becomes clear why no fire resistance design is possible for built-up cross-sections: The stiffnesses would also have to be recalculated for the fire resistance design. Furthermore, in the fire resistance design, the changed position of the neutral axis becomes computable only upon reducing the cross-section.

## Adjusting the model

We exit RF-/TIMBER Pro with [OK].

In RFEM or RSTAB, we create a copy of the model including loading: We select the member and loading and copy the selection by clicking on the menu



#### Edit $\rightarrow$ Move/Copy.

	N:         34.00 m/m is         [cm]           b1:         18.00 m/m is         [cm]           h1:         8.00 m/m is         [cm]           b2:         8.00 m/m is         [cm]           b3:         18.00 m/m is         [cm]           h3:         8.00 m/m is         [cm]			
	✓ Coefficient of compliance           γ1:         0.282 ★ b         [-]           γ2:         0.282 ★ b         [-]			
			Material I   Poplar and Coniferous Hybrid	Timber C30   DIN EN 1995-1-
,,		۱	IUH 34/18/8/8/18/8/0.282/0	.282

To consider the changed slip, we define a new cross-section with modified  $\gamma$  slip factors for the copied member.

**Figure 8.27** Library dialog box Timber Cross-Sections with  $\gamma_1 = \gamma_2 = 0.282$ 

We reopen the RF-/TIMBER Pro add-on module and copy design case 1 by clicking on the menu

#### File $\rightarrow$ Copy Case.

CA1	Case		-
			·
iew case			
No.:	Description:		
2	Serviceability Limit Stat	e	
2		ОК	Cancel

In design case 2, we specify member **2** for the design (see Figure 8.29 2).

We do not change LC1, which is preset for the design of the Ultimate Limit State.

In the Serviceability Limit State tab, we transfer **LC1** to the Selected for Design list (strictly speaking, a separate action combination should be defined). We assign this load case to the **Quasi-permanent** design combination: Thus, the deformation is compared with the limit value of the final deformation of 1/300 = 21.7 mm.

Design of					Standard / National Annex (NA)
Members:	2		🏠 🗙		EN 1995-1-1:2004-11 V
Gets:			$\propto$	All	🔤 🖂 🗸
Ultimate Lin	nit State Serviceability Limit State	Fire Resistance	e		
Existing Lo	ad Cases / Combinations		Selected for D	esign	
			QIA LC11	Design	Quasi-permanent 2
					Characteristic 2.2.3(2): w inst
					Quasi-permanent 1 2.2.3(3): w fin - w c
					Quasi-permanent 2 2.2.3(3): w fin
		>			Vibration Design
		>>			

Next, in the 1.5 Effective Lengths - Members window, we reduce the buckling lengths for member 2 to 3.25 m (see Figure 8.22 ₪).

In the 1.9 Serviceability Data window, we specify member 2.

195	envicea	hility	Data
1.5 5		DINCY	Data

	А	В	C	D	E	F	G	Н
		Member	Referen	ice Length	Direc-	Preca	amber	
No.	Reference to	No.	Manually	L [m]	tion	w <sub>c,y</sub> [mm]	w <sub>c,z</sub> [mm]	Beam Type
1	Member 🗾	2		6.500	z		0.0	Beam
2								
3								
4								
5								
6								

Figure 8.30 Window 1.9 Serviceability Data

#### Calculation

The [Calculation] shows that the deflection analysis is exceeded by 26%. The design ratio in the ultimate limit state designs also increases slightly: Due to the greater deformation/the smaller stiffness of the cross-section, each single cross-section part is more affected by bending.

	Location	Load	De-							
Section	x [m]	Case	sign		Design According to Formula					
1	IUH 34/18	/8/8/18/	8/ <b>0.33</b> 2	1/0.33	1					
	0.00	LC1	0.39	≤1	Shear due to shear force $V_{z}acc.$ to 6.1.7					
	3.25	LC1	0.32	≤1	Extreme compressive bending stress $M_y$ acc. to 6.1.6					
	3.25	LC1	0.18	≤1	Mean compressive bending stress $M_{\gamma}$ acc. to 6.1.4					
	3.25	LC1	0.40	≤1	Mean tensile bending stress $M_{\gamma}acc.$ to 6.1.2					
	3.25	LC1	0.32	≤1	Extreme tensile bending stress $M_y$ acc. to 6.1.6					
	3.25	LC1	0.54	≤1	Bending about y-axis; mean compressive bending stress $\ensuremath{M_{y}}$ acc. to 6.3.2					

Figure 8.31 Design ratios with γ-factors 0.331 in design case 1

Section	Location	Load	De-		Design According to Formula
No.	x [m]	Case	sign		
2	IUH 34/18/8/8/18/8 <b>/0.282/0.282</b>				
	0.00	LC1	0.40	≤1	Shear due to shear force $V_{\rm z}$ acc. to 6.1.7
	3.25	LC1	0.36	≤1	Extreme compressive bending stress $M_y$ acc. to 6.1.6
	3.25	LC1	0.20	≤1	Mean compressive bending stress My acc. to 6.1.4
	3.25	LC1	0.41	≤1	Mean tensile bending stress $M_{\gamma}$ acc. to 6.1.2
	3.25	LC1	0.36	≤1	Extreme tensile bending stress M <sub>y</sub> acc. to 6.1.6
	3.25	LC1	0.54	≤1	Bending about y-axis; mean compressive bending stress $M_y$ acc. to 6.3.2
	3.25	LC1	1.26	> 1	Serviceability - Quasi-permanent acc. to 7.2 - Inner span, z-direction



 Figure 8.32
 Design ratios with γ-factors 0.282 in design case 2





# Monopitch Roof Beam

According to current timber standards, the strength of a tapered beam must be reduced depending on the loading (tensile bending or compressive bending). This usually applies to monopitch roof beams.

8.3.1	System	and Loads
-------	--------	-----------

## Model

Material:	Softwood timber GL24h
Span length:	= 11.0 m
Cantilever:	l = 3.0 m
Service class:	2
LDC:	Short-term
Cross-section 1:	18/16 cm (start)
Cross-section 2:	18/110 cm (end)

Beam laterally supported (no stability problem)

### Load

LC1 self-weight:	g = 2.7 kN/m

RC1:

LC2 snow:

1.35 · LC1 + 1.5 · LC2

q = 5.7 kN/m



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## 8.3.2 Calculation with RFEM/RSTAB

The system as well as the loads in both load cases are modeled as a 3D model in RFEM or RSTAB. We deactivate the automatic consideration of the self-weight when we create LC1.

We superimpose the load cases for the fundamental combination according to the geometrically linear analysis with the corresponding partial safety factors in a result combination.

We obtain the following moment distribution:



### 8.3.3 Design with RF-/TIMBER Pro

In the 1.1 General Data window, we select the result combination **RC1** for the Ultimate Limit State design.

We perform the design according to EN 1995-1-1 with the German National Annex DIN.

In the 1.4 Load Duration and Service Class window, we select the Short-term LDC for RC1.

	A	B	С	D	Service Class (SECL)
oad-		Load	Load Duration Class	Coefficient	Identical for all monthem.
ing	Description	Туре	LDC	kmod	or sets of members
LC1	Self-weight	Permanent	Permanent	0.600	
LC2	Snow	Snow / ice	Short-term	0.900	SECL: 2 -
RC1	1.35*LC1/p + 1.5*LC2	-	Short-term 🗾	0.900	
			Permanent		O Different
			Long-term		
			Medium-term		Service Class 1:
			Short-term		Total a sister a sector 5.45 % Mass
			Short-term / Instantaneous		notal moisture content 5-15 %. Mean
			Instantaneous		molatore content in most contens 3 12



RF-/TIMBER Pro recognizes tapered members in the model. The cut-to-grain angle (taper angle) of 3.84° is preset in the 1.7 Tapered Members window.

1.7	7 Taper	ed Members										
Г		A	В	C	D	E	F	G	Н		J	K
N	lember	Cross-	Section	Length	Cut-to	-Grain		Ten	sion Perpen	dicular to G	irain	
	No.	Member Start	Member End	L [m]	Angle α [°]		Grain Parallel to	With Ridge	Manually	V [m <sup>3</sup> ]	k vol	Note
	1	T-Rectangle 18/16	T-Rectangle 18/36.1	3.000	3.84	≤ 24.00	+z-Axis Edge 💌					
	2	T-Rectangle 18/36.1	T-Rectangle 18/110	11.000	3.84	≤ 24.00	+z-Axis Edge					
_												

Figure 8.36 Window 1.7 Tapered Members

The grain runs parallel to the edge that is located in the direction of the positive z-axis (that is the member bottom side). Thus, the cut grains run through the compressive bending area (field) or the tensile bending area (cantilever column). Cut grains with tension have a significantly unfavorable effect on the bearing capacity of timber.



The limitation of the cut-to-grain angle is not specified in the global Eurocode but only in the National Application Documents. New studies show that an insufficient safety results only starting from a cut-to-grain angle of 24°. The limitation of this angle to 10° was handled more strictly in DIN 1052, but the design used there was slightly different, too. For further information, see [6] 2.

Since the beam is not prone to instability risk, we deactivate the stability analysis in the Details dialog box.

Resistance	Stability	Serviceability	Fire Resistance	Other
Stability An	alysis			
Check :	stability			
(require	s definition	of buckling leng	gths)	

Calculation

Details...

After the [Calculation], you can evaluate the reduction at the tensile and compressive edge in the 2.5 Design by x-Location window.



Figure 8.38 Window 2.5 Design by x-Location



## Design for compressive stresses of member 2, location x = 3.30 m

The design is carried out according to [1] 2 clause 6.4.2.

$$\sigma_{m,\alpha,d} = \frac{M_y}{W_y} = \frac{11652 \text{ kNcm}}{10196.7 \text{ cm}^3} = 1.14 \text{ kN/cm}^2$$

$$f_{m,d} = \frac{f_{m,k} \cdot k_{mod}}{\gamma_{M}} = \frac{2.4 \cdot 0.9}{1.3} = 1.66 \text{ kN/cm}^2$$

$$k_{m,\alpha} = \frac{1}{\sqrt{1 + \left(\frac{f_{m,d}}{1.5 \cdot f_{v,d}} \cdot \tan\alpha\right)^2 + \left(\frac{f_{m,d}}{f_{c,90,d}} \cdot \tan^2\alpha\right)^2}} = 0.955$$

**Design:** 

$$\frac{\sigma_{m,\alpha,d}}{k_{m,\alpha}} = \frac{1.14}{0.955 \cdot 1.66} = 0.72 < 1$$

With 4.5%, the strength reduction by the factor  $k_{m,\alpha}$  is small.

## Design for tensile stresses of member 2, location x = 0.00 m

The design location is above the support at the cantilever.

The design according to [1] 🗷 clause 6.4.2 is as follows.

$$\sigma_{\rm m,\alpha,d} = \frac{M_{\rm y}}{W_{\rm y}} = \frac{5488 \,\rm kNcm}{3918.9 \,\rm cm^3} = 1.40 \,\rm kN/cm^2$$

$$f_{\rm m,d} = \frac{f_{\rm m,k} \cdot k_{\rm mod}}{\gamma_{\rm M}} = \frac{2.4 \cdot 0.9}{1.3} = 1.66 \, \rm kN/\, cm^2$$

$$k_{m,\alpha} = \frac{1}{\sqrt{1 + \left(\frac{f_{m,d}}{0.75 \cdot f_{v,d}} \cdot \tan\alpha\right)^2 + \left(\frac{f_{m,d}}{f_{c,90,d}} \cdot \tan^2\alpha\right)^2}} = 0.83$$

Design:

$$\frac{\sigma_{\rm m,\alpha,d}}{k_{\rm m,\alpha} \cdot f_{\rm m,d}} = \frac{1.40}{0.83 \cdot 1.66} = 1.01 \approx 1$$

By the higher reduction of 17% the design in the cut area becomes governing.

A solution for this beam could be to move the cut grains to the bottom side. Find the corresponding input option in table column F of the 1.7 Tapered Members window (see Figure  $8.36 \square$ ).



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## **Curved Beam**

The designs are performed according to DIN EN 1995-1-1 for a beam curved in an S-shape. Due to this geometrical form, the beam has a very distinctive stability problem.

Beams of this shape are not explicitly specified in the standards. The characteristics for the stability analysis are not covered there. For this reason, the stability analysis was deactivated in this example.

Designing curved members is only possible in the add-on module **RF**-TIMBER Pro. RSTAB does not allow for curved lines.

## 8.4.1 System and Loads

## Model

Material:	Softwood timber GL28h
Span width field 1:	l = 11.90 m
Span width field 2:	l = 9.13 m
Service class:	1
LDC:	Short-term
k <sub>mod</sub> :	0.9
Cross-section:	20/68 cm
Beam laterally supported	$\Rightarrow$ no stability problem
Load	
LC1 self-weight:	g = 2.4 kN/m
LC2 snow:	q = 3.2 kN/m
RC1:	1.35 · LC1 + 1.5 · LC2
243 cV/m 12 03 m 12 03 m 11 87 g 11	240 INIM 240 INIM 0.13 m 21.00 m

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## 8.4.2 Calculation with RFEM

The system as well as the loads of both load cases are modeled as a 3D model in RFEM. We deactivate the automatic consideration of the self-weight for LC1.

We superimpose the load cases for the fundamental combination according to the geometrically linear analysis with the corresponding partial safety factors in a result combination.

RFEM determines the diagrams of internal forces shown in Figure 8.40 2.







### 8.4.3 Design with RF-TIMBER Pro

#### Ultimate limit state design

In the 1.1 General Data window, we select the result combination **RC1** for the Ultimate Limit State design.

We perform the design according to EN 1995-1-1 with the German National Annex DIN.



Figure 8.41 Window 1.1 General Data

The Windows 1.2 and 1.3 are not different from the ones in the previous examples.

In the 1.4 Load Duration and Service Class window, LDC and SECL of the load cases are preset based on the Load Duration defined in RFEM. We change the LDC of RC1 to **Short-term**.

	A	В	C	D	Service Class (SECL)
Load-		Load	Load Duration Class	Coefficient	Identical for all members
ing	Description	Туре	LDC	k mod	or sets of members
LC1	Self-weight	Permanent	Permanent	0.60000	
LC2	Snow	Snow (H $\leq$ 1000 m a.	Short-term	0.90000	SECL: 1 V
RC1	1.35*LF1/s + 1.5*LF2	Wind	Short-term	0.900	
			Permanent		O Different
			Long-term		
			Medium-term		10 C C 1
			Short-term		Service Liass 1:
			Short+erm / Instantaneous		Total moisture content 5-15 %. Mean
			Instantaneous		moisture content in most conifers ≤12 %.
					Example:
					Buildings closed from all sides
					and heated buildings
Figure	8.42 Window 1.4 Load Duration	and Service Class			

The 1.5 Effective Lengths window for the input of buckling and lateral-torsional buckling lengths for curved members is not shown, as the lateral-torsional design for this beam types is not clearly specified in the Standard [1] . There is a method only for single-span beams by which curved beams can be designed at a distance of one third of the smallest cross-section height.

## Dlubal

Since the beam is supported on all sides, we deactivate the stability analysis in the Details dialog box.

Resistance	Stability	Serviceability	Fire Resistance	e Other
Stability An	alysis			
Check s	tability			
<ul> <li>Stability (requires</li> <li>Stress/S</li> </ul>	analysis a definition Stability Ar	icc. to equivale of buckling len nalysis accordin	nt member metho gths) g to 2nd Order Ti	id neory (Require

#### Then, we set the input Window 1.8 Curved Members.

- A		B	С	D	E	F	G	H		J
		Laminate			Perp	endicular Tens	ion			
- Membe	er No.	t (mm)	Design	Manually	Member No.	l [m]	V [m <sup>3</sup> ]	k vol	k dis	Comment
1		33.0	2		1	12.03	1.64	0.36075	1.40000	
4	L I	33.0	2		4	8.50	1.16	0.38671	1.40000	
)										
2										
3										
1										
j i										
5										
7										
3										
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2										
3										
;										
5										
7										
3										
)										
2										
3										
							1			
										(*
										4



We check whether the thickness t of the lamellas is **33 mm**, limiting the beam's radius of curvature.

RF-TIMBER Pro performs the check of Perpendicular Tension, if the check box in the **Design** column is selected.

Calculation

We start the [Calculation]. Then, we select the 2.4 Design by Member window.



	A	В	C	D				E				
Member	Location	Load										
No.	x [m]	Case	Design				De	esign acc. t	o Formula			
1	Cross-section	n No. 1 -										
	0.00	RC1	0.01	≤1	2102) Cross-section resistance -	Compressi	on along the g	prain acc. to	o 6.1.4			
	0.00	RC1	0.20	≤1	2111) Cross-section resistance -	Shear due	to shear force	e Vzacc. to	6.1.7			
	5.42	RC1	0.37	≤1	2151) Cross-section resistance -	Curved be	am - Uniaxial I	pending ac	c. to 6.4.3			
	3.94	RC1	0.34	≤1	2171) Cross-section resistance -	Curved be	am - Uniaxial I	pending ab	out y-axis	and compress	sion acc. to 6.2.4 and 6.4.3	
	6.41	RC1	0.91	≤1	2221) Tensile stress perpendicula	ar to the gr	ain and shear	acc. to 6.4	4.3 (6),(7)			
2	Cross-section No. 1 - T-Rectangle 200/680											
	1.16	RC1	0.01	≤1	102) Cross-section resistance - C	ompression	n along the gr	ain acc. to	6.1.4			
	1.16	RC1	0.36	≤1	111) Cross-section resistance - S	hear due t	o shear force	Vz acc. to	6.1.7			
		Max:	0.91	≤1	•				0	1 🖲 🤋	ð 📘 🍡 😫 👔	3
Desigr     Desigr     Desigr	n Internal Ford n Ratio	es							1		, 200.0	
Ben	nding Moment					Mvd	106.66	kNm			200.0	
Sec	tion Modulus					Wv	15413.30	cm <sup>3</sup>			+	
- Fac	tor				1	ч,	1.032			Eq. (6.43)		
Fac	tor					¢1	1.000			Eq. (6.44)		
- Fac	tor					¢2	0.350			Eq. (6.45)		
- Fac	tor					<b>(</b> 3	0.600			Eq. (6.46)	8	
- Fac	tor				1	(r	1.000			Eq. (6.49)	9	
- Rad	dius				1		8.415	m				
Ben	nding Stress					om.y.d	7.14	N/mm <sup>2</sup>				
- Ben	nding Strength	1				m,y,k	28.00	N/mm <sup>2</sup>		[7], Tab.1		
- Moo	dification Fact	or				< mod	0.900			Tab. 3.1	÷	
- Part	tial Factor					/M	1.300			Tab. 2.3	Z	
Ben	nding Strength	I				m,y,d	19.38	N/mm <sup>2</sup>		Eq. (2.14)		
Des	sign Hatio					η	0.37		≤1	Eq. (6.41)		
												1
											A 🗟 🕰	₽)

For Member No. 1, the greatest design ratio due to bending is 0.37.

In the Details table, we can check the radius *r* among the design parameters for member 1. The program imports the member's curvature from the RFEM arc parameters.

General Arc - Three Nodes Options Effective Leng	ths Modify Stiffness
Line No.  1  Nodes at Arc  1: 28   2: 29   3: 33   4. C Parameters  r:  9:410    81.93    (1)	Line of Type 'Arc - 3 Nodes'
Center of Arc X: 6.452 ⊕ [m]	Option Subsequent adjustment by displacing
Y: 0.000 ↔ [m] Z: 5.404 ↔ [m]	Beginning of Arc
2 📝 👜 🚯	OK Cancel



The designs are additionally checked by manual calculation.

## Check of bending stress

Design according to [1]  $\square$  condition (6.41) for location x = 5.91 m:

$$\sigma_{\rm m,y,d} = k_1 \cdot \frac{M_{\rm y,d}}{W_{\rm y}} = 1.03 \cdot \frac{10666 \,\mathrm{kNcm}}{15413 \,\mathrm{cm}^3} = 0.71 \,\mathrm{kN/cm^2}$$

where

$$k_{1} = k_{1} + k_{2} \left(\frac{h}{r}\right) + k_{3} \left(\frac{h}{r}\right)^{2} + k_{4} \left(\frac{h}{r}\right)^{3} = 1.0 + 0.35 \cdot \left(\frac{0.68 \text{ m}}{8.42 \text{ m}}\right) + 0.6 \cdot \left(\frac{0.68 \text{ m}}{8.42 \text{ m}}\right)^{2} = 1.03$$

$$k_{1} = 1.0$$

$$k_{2} = 0.35$$

$$k_{3} = 0.6$$

$$k_{4} = 0$$

$$k_{r} = 0.76 + 0.001 \cdot \frac{r_{\text{inside}}}{t} = 0.76 + 0.001 \cdot \frac{8.075 \text{ m}}{0.033 \text{ m}} = 1.004$$

where

$$r_{\text{inside}} = r - 0.5 \cdot h = 8.417 - 0.5 \cdot 0.680 = 8.075 \text{ m}$$

As

$$\frac{r_{\text{inside}}}{t} > 240 \cdot k_r \implies k_r = 1.0$$

$$f_{m,y,k} = 2.8 \, \text{kN/cm}^2$$

$$f_{\rm m,y,d} = \frac{2.8 \,\rm kN/cm^2 \cdot 0.9}{1.3} = 1.94 \,\rm kN/cm^2$$

Design:

$$\eta = \frac{\sigma_{\rm m,y,d}}{k_{\rm r} \cdot f_{\rm m,y,d}} = \frac{0.71 \,\rm kN/cm^2}{1.0 \cdot 1.94 \,\rm kN/cm^2} = 0.36 < 100 \,\rm km^2$$

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## Design of perpendicular tension stress

Design according to [1]  $\square$  condition (6.53) for location x = 6.406 m:

$$\sigma_{\rm t,90,d} = k_{\rm p} \cdot \frac{6 \cdot M_{\rm y}}{b \cdot h^2} = 0.02 \cdot \frac{6 \cdot 10371 \text{ kNcm}}{20 \text{ cm} \cdot (68 \text{ cm})^2} = 0.0135 \text{ kN/cm}^2$$

where

$$k_{p} = k_{5} + k_{6} \left(\frac{h}{r}\right) + k_{7} \left(\frac{h}{r}\right) = 0.25 \cdot \frac{0.68 \text{ m}}{8.42 \text{ m}} = 0.0202$$
•  $k_{5} = k_{7} = 0$ 
•  $k_{2} = 0.25$ 
 $k_{ds} = 1.4$ 

$$k_{vol} = \left(\frac{V_{0}}{V}\right)^{2} = \left(\frac{0.01}{1.63}\right)^{2} = 0.361$$
 $f_{1,90,k} = 0.045 \text{ kN/cm}^{2}$ 
 $f_{1,90,d} = \frac{0.045 \text{ kN/cm}^{2} \cdot 0.9}{1.3} = 0.031 \text{ kN/cm}^{2}$ 
 $b_{eff} = k_{cr} \cdot b = 0.781 \cdot 20 = 15.62 \text{ cm}$ 
 $\tau_{d} = 1.5 \cdot \frac{V_{z,d}}{b_{eff} \cdot h} = 1.5 \cdot \frac{7.31}{15.62 \cdot 68} = 0.010 \text{ kN/cm}^{2}$ 
 $f_{v,k} = 0.35 \text{ kN/cm}^{2}$ 
 $f_{v,d} = \frac{0.35 \text{ kN/cm}^{2} \cdot 0.9}{1.3} = 0.24 \text{ kN/cm}^{2}$ 
 $p_{eign}$ 
 $\eta = \frac{\tau_{d}}{t_{v,d}} + \frac{\sigma_{t,90,d}}{k_{ds} \cdot k_{vd} \cdot f_{t,90,d}} = \frac{0.010 \text{ kN/cm}^{2}}{0.24 \text{ kN/cm}^{2}} + \frac{0.0135 \text{ kN/cm}^{2}}{1.4 \cdot 0.361 \cdot 0.031 \text{ kN/cm}^{2}} = 0.91 < 1$ 



114

# 9 Literature

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