4 Diubal

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Add-on Module **RF-TIMBER AWC**

Design of Timber Members According to ANSI/AWC NDS-2012

Program **Description**

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. Introduction

1.1 Add-on Module RF-TIMBER AWC

The National Design Specification for Wood Construction (ANSI/AWC NDS-2012) incorporates design provisions for both allowable stress design (ASD) and load and resistance factor design (LRFD). This specification is adopted in all model building codes in the United States and is used to design wood structures worldwide. With the RFEM add-on module RF-TIMBER AWC from the company DLUBAL all users obtain a powerful tool for the design of timber structures modeled with member elements according to this standard.

RF-TIMBER AWC performs all cross-section resistance designs, stability analyses, and deformation analyses provided by the standard. The stability analysis is carried out according to the equivalent member method or the second-order analysis. When the equivalent member method is applied, the program considers stability factors based on effective buckling lengths and effective lengths for lateral buckling. Second order analysis requires definition of imperfections in RFEM and calculates with unit stability factors for compression with buckling. In addition to this, the fire resistance design for allowable stress design (ASD) is possible.

In timber construction, the serviceability limit state represents an important design. In this connection, chosen load cases, load combinations, and result combinations can be checked for limit deflection. The conservative limit deformation is preset, but can be modified, if necessary. In addition to this, it is possible to specify reference lengths and precambers that will be considered accordingly in the design.

If necessary, you can optimize standardized or parametric cross-sections and export them to RFEM. Separate design cases allow for a separate design of large systems or analysis of variants.

RF-TIMBER AWC is one of the add-on modules integrated in the RFEM environment. Thus, the design-relevant input data is preset when you open the module. Subsequent to the design, you can use the graphical RFEM user interface to evaluate the results. Last but not least, you can document the checks from the analysis of internal forces to the design in the global print-out report.

We hope you will enjoy working with RF-TIMBER AWC.

Your DLUBAL Team





1.2 RF-TIMBER AWC - Team

The following people were involved in the development of RF-TIMBER AWC:

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1.3 Using the Manual

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

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

At the end of the manual, you find the index. However, if you still cannot find what you are looking for, please check the DLUBAL blogs at **https://www.dlubal.de/blog/en** where you can search the articles by specific terms.

1.4 Open the Add-on Module RF-TIMBER AWC

RFEM provides the following options to start the add-on module RF-TIMBER AWC.

Menu

۲

To start the program in the RFEM menu bar, click

Add-on Modules \rightarrow Design - Timber \rightarrow RF-TIMBER AWC.

Add	I-on Modules Window	He	elp	
* 0	Current Module	- [🝸 🍳 > 🕑 🕎 💯 🐓 📾 🛤 🗄 🎬 羅 🤹 🕼 🏛 🎾 🗞 中 /
	Design - Steel	÷	4	ba ba 🚳 🐁 - 🛯 💐 🔍 🔍 🗇 🗗 🕅 🕅 🛱 🖏 - 🛯 🗐 - 🗍 17 =
	Design - Concrete	٠Į		
	Design - Timber	•	2	RF-TIMBER Design of timber members
	Design - Aluminium	•	24	RF-TIMBER Pro Design of timber members
	Dynamic		AWC	RF-TIMBER AWC Design of timber members according to AWC (LRFD or ASD)
	Connections	٠Î		
	Foundations	$\left \right $		
	Stability	$\left \right $		
	Towers	$\left \right $		
	Others	$\left \right $		
	External Modules	•		
	Stand-Alone Programs	×		

Figure 1.1: Menu: Add-on Modules \rightarrow Design - Timber \rightarrow RF-TIMBER AWC



Navigator

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

```
Add-on Modules \rightarrow RF-TIMBER AWC.
```

Project Navigator - Data	×
🗄 🛅 Loads	
🖶 💼 Results	
🔁 Sections	
🛅 Average Regions	
🛅 Printout Reports	
🗄 💼 🛅 Guide Objects	Ξ
🖕 💼 Add-on Modules	
🖕 🛅 Favorites	
RF-TIMBER AWC - Design of timber members according to AWC (LRFD or ASD)	
- 🚂 RF-STEEL AISC - Design of steel members according to AISC (LRFD or ASD)	Ŧ
Data 🖆 Display 🔏 Views	

Figure 1.2: Data navigator: Add-on Modules \rightarrow RF-TIMBER AWC

Panel

If results from RF-TIMBER AWC are already available in the RFEM model, you can also open the design module in the panel:

Set the relevant RF-TIMBER AWC design case in the load case list of the RFEM toolbar. Then click the [Show results] button to graphically display the design criterion on the members.

When the results display is activated, the panel is available, too. Now you can click the button [RF-TIMBER AWC] in the panel to open the module.

Panel ×	
Max	
Design Ratio [-]	
1.00 0.90 0.80 0.70 0.50 0.50 0.40 0.30 0.20 0.10	
- 0.00	
Max : 0.88 Min : 0.00	
RF-TIMBER AWC	
1 🖉 🖉	

Figure 1.3: Panel button [RF-TIMBER AWC]



RF-TIMBER AWC



2. Input Data

When you have started the add-on module, a new window opens. In this window a Navigator is displayed on the left, managing the available windows that can be currently selected. The drop-down list above the navigator contains the design cases (see Chapter 7.1, page 62).

The design relevant data is defined in several input windows. When you start RF-TIMBER AWC for the first time, the following parameters are imported automatically:

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

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

To save the results, click [OK]. Thus, you exit RF-TIMBER AWC and return to the main program. To exit the module without saving the new data, click [Cancel].

2.1 General Data

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

d 🔹	1.1 General Data	
vid Data (Central Data) - Materiala - Cross-Sections - Load Duration - In-Service Conditions - Set of Me - Effective Lengtha - Members - Effective Lengtha - Members - Effective Lengtha - Sets of Mem- - Additional Design Parameters - Serviceability Data - Fire Resistance - Members - Fire Resistance - Sets of Memb-	Design of Design According to Members: 1:24 Image: Construction of the second of the se	RF-TIMBER AWC Allowable Stress Design (ASD) Load and Resistance Factor Design (LFD)
	Comment	4

Figure 2.1: Window 1.1 General Data

```
- 1
```

Cancel

OK



Design of

Design of			
Members:	174,176,177,186-196,198-206,351-362	🍾 🗙	🔲 All
Sets:	1-18	🖏 🗙 🎦	🔽 All

Figure 2.2: Design of members and sets of members



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

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



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

Design according to

Design According to	
ASD 🔽 🐼	
ASD Allowable Stress Design	
📕 LRFD Load and Resistance Fact	or Design

Figure 2.3: Design according to ASD or LRFD

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

Comment

Comment	
Design according to Allowable Stress Design (ASD)	*
	-

Figure 2.4: User-defined comment

In this text box, you can enter user-defined notes describing, for example, the current design method.





2.1.1 Ultimate Limit State

D LC1	Self-weight			2.3	BC1	Section 2.3 (LBED)
s LC2	Snow					
W LC3	Wind					
L LC4	Live load					
E LC5	Seismic					
Imp LC6	Imperfection					
.3 1 CO1	1.4*LC1		>>			
.3 2 CO2	1.2*LC1 + 1.6*LC4					
.3 2 CO3	1.2*LC1 + 0.5*LC2 + 1.6*LC4					
.3 3 CO4	1.2*LC1 + 1.6*LC2 + LC4					
.3 3 CO5	1.2*LC1 + 1.6*LC2	Ξ				
.3 3 CO6	1.2*LC1 + 1.6*LC2 + 0.8*LC3					
.3 4 CO7	1.2*LC1 + 0.5*LC2 + 1.6*LC3 + LC					
.3 4 CO8	1.2*LC1 + 1.6*LC3 + LC4					
.3 4 CO9	1.2*LC1 + 0.5*LC2 + 1.6*LC3					
.3 4 CO10	1.2*LC1 + 1.6*LC3					
.3 5 CO11	1.2*LC1 + LC5					
.3 5 CO12	1.2*LC1 + LC4 + LC5					
.3 5 CO13	1.2*LC1 + 0.2*LC2 + LC4 + LC5					
.3 5 CO14	1.2*LC1 + 0.2*LC2 + LC5	۳				
.3 6 CO15	0.9*LC1 + 1.6*LC3					
.37 CO16	0.9*LC1 + LC5					
.46 CO17	LC1 + 0.75*LC2 + 0.75*LC4 + 0.52	-				

Figure 2.5: Window 1.1 General Data, tab Ultimate Limit State

Existing Load Cases and Combinations

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

To transfer selected entries to the *Selected for Design* list on the right, click $[\blacktriangleright]$. Alternatively, you can double-click the items. To transfer the complete list to the right, click $[\blacktriangleright \blacktriangleright]$.

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

Load cases highlighted in red, like LC 6 in Figure 2.5, cannot be designed: This happens when the load cases are defined without any load data or the load cases contain only imperfections. When you transfer the load cases, a corresponding warning appears.

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

	Selects all load cases in the list
đđ	Inverts the selection of load cases

Table 2.1: Buttons in the tab Ultimate Limit State

Selected for Design

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

The design of an enveloping max/min result combination is performed faster than the design of all contained load cases and load combinations.

However, the analysis of a result combination has also disadvantages: First, the influence of the contained actions is difficult to discern. Second, for the determination of the volume factor C_{ν} for structural glued laminated timber, the envelope of the moment distributions is analyzed.





>

≫



From that, the most unfavorable distribution (max or min) is applied. However, this distribution only rarely reflects the moment distribution in the individual load combinations. Thus, in the case of RC design, more unfavorable values of the factor C_v are to be expected, leading to higher ratios.

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

2.1.2 Serviceability Limit State

Ultimate Limit State Serviceability Limit State	Fire Resistance			
Existing Load Cases / Combinations		Selected for De	Design	
D LC1 Dead LC2 Live		C01	1.5D + L	
	>			
	\$			
				-
All (3) 👻			ă∛ (à	52

Figure 2.6: Window 1.1 General Data, tab Serviceability Limit State

Existing Load Cases and Combinations

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

Selected for Design

Load cases, load combinations, and result combinations can be added or removed (see Chapter 2.1.1).

The limit value of the deformation is controlled by the settings in the *Details* dialog box (see Figure 3.3, page 40) which you can call up by clicking the [Details] button.

In the 1.10 *Serviceability Data* window, the reference lengths decisive for the deformation check are managed (see Chapter 2.11, page 33).



Details..



2.1.3 Fire Resistance

This tab is only available when the ASD design method has been set.

Ultimate Limit S	tate Serviceability Limit State	Fire Resistance			
Existing Load (Cases / Combinations		Selected for D	<u>D</u> esign	
D LC1	Dead		2.4 RC1	CO1/p or to CO9	
L LC2	Live				
s LC3	Snow				
W LC4	Wind				
2.4 1 CO1	LC1				
2.4 2 CO2	LC1 + LC2				
2.4 3 CO3	LC1 + LC3	>>			
2.44 CO4	LC1 + 0.75*LC2 + 0.75*LC3				
2.4 5 CO5	LC1 + LC4				
2.4 6 CO6	LC1 + 0.75*LC2 + 0.75*LC3 + I	0.75*LC			
2.4 6 CO7	LC1 + 0.75*LC2 + 0.75*LC4				
2.4 6 CO8	LC1 + 0.75*LC3 + 0.75*LC4	~			
2.4 7 CO9	0.6*LC1 + LC4				
All (14)	- B				18

Figure 2.7: Window 1.1 General Data, tab Fire Resistance

Existing Load Cases and Combinations

All load cases, load combinations, and result combinations created in RFEM are listed here.

Selected for Design

Load cases, load and result combinations can be added or removed (see Chapter 2.1.1).

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 dialog boxes *Standard* (see Figure 2.9, page 13) and *Details*, tab *Fire Resistance* (see Figure 3.4, page 41).

2.1.4 Standard

The drop-down lists in the 1.1 *General Data* window allow you to select the method of design whose parameters are to be applied to the design.

Design According to	
ASD	- 🔤
ASD Allowable	Stress Design
LRFD Load and	Resistance Factor Design
Figure 2.8: Design	method



To check and, if necessary, adjust the preset parameters, click [Edit] (see the following figure).

Alternatively you can use the [Standard] button in all input windows in order to open the *Standard* dialog box consisting of three tabs. The content of the dialog box depends on the selected design method.





General

andard - ANSI/A	WC NDS-2012:2012					×
General Others	Used Standards					
Load Duration Fa	ctor Acc. to Table 2.3.2	Temperature Factor A	.cc. to Table 2.3	.3		
Load Duration:		Ref. Design	In-Service	T≤100°F	100°F <t≤125°f< td=""><td>125°F<t≤150°f< td=""></t≤150°f<></td></t≤125°f<>	125°F <t≤150°f< td=""></t≤150°f<>
- Permanent	CD: 0.900	Values	Moisture Conditions			
- Ten years	CD: 1.000					
- Two months	CD: 1.150	Ft, Emin	Wet/Dry	Ct: 1.000 ≑	0.900 🜩	0.900 ≑
- Seven days	CD: 1.250					
- Ten minutes	CD: 1.600		Dry	Ct: 1.000 🚔	0.800	0.700 🚔
- Impact	CD: 2.000	Fb, Fv, Fc, and Fcp	Wet	Ct: 1.000	0.700	0.500 🗢
Wet Service Fac	tors Acc. to NDS Suppleme	nt		Data for Fire Design A	cc. to 16.2.1, and `	Table 16.2.2
Property:	Dimension Lumber Ti and Decking:	mbers: Glulam:		Design Stress to Mer	nber Strength Fact	or
E.				Property:		
гь	CM: 0.850	1.000 - 0.800 -		гь 2.850		
Ft	См: 1.000 🚔	1.000 🖨 0.800 🖨		Emin 2.030	÷	
Fv	См: 0.970 🚔	1.000 🚔 0.875 🚔		Ft 2.850	-	
Fcp	См: 0.670 ≑	0.670 ≑ 0.530 ≑		Fc 2.580		
Fo	См: 0.800 🚔	0.910 🖨 0.730 🖨		Nominal char rate:		
Emin	См: 0.900 🚔	1.000 🚔 0.833 🚔		βn: 1.500		
						Care -
					0	Cancel

andard - ANSI/A	WC NDS-2012:2012						
General Others	Used Standards						
Time Effect Fact	or		Temperature Factor Ac	c. to Table 2.3	.3		
Load Duration:	1.	o codi All	Ref. Design Values	In-Service Moisture	T≤100°F	100°F <t≦125°f< td=""><td>125°F<t≤150°f< td=""></t≤150°f<></td></t≦125°f<>	125°F <t≤150°f< td=""></t≤150°f<>
- Ten years	λ:	0.700 🗢		Conditions			
- Two months	λ:	0.800 🚔	Ft, Emin	Wet/Dry	Ct: 1.000	0.900 ≑	0.900 ≑
- Seven days	λ:	0.900 ≑					
- Ten minutes - Impact	λ: λ:	1.000 🚔	Fb, Fv, Fc, and Fcp	Dry	Ct: 1.000 💼	0.800 🚔	0.700 💼
		<u></u>		Wet	Ct: 1.000	0.700 🌩	0.500 🛫
Wet Service Fac Property:	ctors Acc. to NDS Sup Dimension Lumber and Decking:	plement Timbers:	Glulam:		Format Conv. and Res Property:	sist. Factors Acc. to	2.3.5 and 2.3.6
Fb	См: 0.850 🚔	1.000	0.800		Fb KF: 2	540 🌩 👲 Б :	0.850 ≑
Ft	См: 1.000 🚔	1.000	0.800 ≑		Ft KF: 2	.700 🌩 🛛 🗣 t :	0.800 ≑
Fv	См: 0.970 🚔	1.000	0.875		Fv, Frt KF: 2	.880 ⊕ v :	0.750 🚔
Fcp	См: 0.670 🚔	0.670	0.530 🚔		Fc KF: 2	.400 ⊕ c :	0.900 ≑
Fc	C _M : 0.800 €	0.910	0.730 🚔		Fop KF: 1	.670 🌩 🗣 c :	0.900 ≑
Emin	См: 0.900 🚔	1.000	0.833		Emin KF: 1	.760 🌧 🗣 s :	0.850 🚔
🧿 🐻 🤇						0	Cancel

Figure 2.10: Dialog box Standard, tab General for LRFD design method

Figure 2.9: Dialog box Standard, tab General for ASD design method



In the dialog box sections, you can check or, if necessary, modify, the *Wet Service Factors* and the *Temperature Factor* (prescribed for both ASD and LRFD method), the *Load Duration* or *Time Effect Factor* (different for ASD and LRFD method), and the *Format Conversion and Resistance Factors* (LRFD only).

The Data for Fire Design section manages the parameters Design Stress to Member Strength Factor and Nominal charring rate β_n . The fire design is applied only for the ASD design method.

The buttons in the *Standard* dialog box have the following functions:

Button	Function
\mathbf{i}	Resets the program's default settings
	Imports user-defined standard settings
	Saves the current settings as default
×	Deletes a user-defined Standard

Table 2.2: Buttons in dialog box Standard

Others

In the second tab of the *Standard* dialog box, you find several factors significant for the design. These factors are prescribed for both ASD and LRFD methods and can be also modified, if necessary.

Standard - ANSI/AV	WC NDS-2012:2012				×
General Others	Used Standards				
Repetitive Membe	r Factor Acc. to 4.3.9		Incising Factor Acc. to	4.3.8	
Property:			Property:	Ci : Di	050
			Fb. Ft. Fc. Fv	Ci: 0.	S0 -
			Fcp	Ci: 1	
Chase Daduation	Factor A an 10 5 2 40				
Property:	Factor Acc. to 5.5.10		1		
Fv	Cvr: 0.720 🚔				
Condition Treatme	ent Factor Acc. to 6.3.	5	Load Sharing Factor A	Acc. to 6.3.11	
Condition Treatme	ent:		Property:	No. of piles in	n group:
Air Dried		Cct: 1.000		2	Cls: 1.050
Kiln Dried		Cct: 0.900	Fb	3	Cls: 1.070
Boulton Drying	-0	Cct: 0.950		4 or more	Cls: 1.080
Steaming (Norm	ne)	Cet: 0.800		2	Cls: 1.060
Citoaning (Mah	,	0.740	Fc	3	Cls: 1.090
				4 or more	Cls: 1.110
					OK Cancel
					Cander

Figure 2.11: Dialog box Standard, tab Others



Used Standards

The third tab of the *Standard Settings* dialog box informs you about the Standards according to which the design will be performed.

ndard - ANSI/AWC NDS-2012:2012	
Loui Uhad Standarda	
ieneral Others Used Standards	
No. Standard	Standard Description
 ANSI/AWC NDS-2012:2012 	National Design Specification for Wood Construction
[2] NDS-2012 Supplement	Design Values for Wood Construction
[3] ASCE/SEI 7-10	Minimum Design Loads for Buildings and Other Structures
) 🚾 🕥 🖪 🖷	ОК Салог

Figure 2.12: Dialog box Standard, tab Used Standards



2.2 Materials

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

	A		В			Special Settings for	
Material	Material					Special settings for	alularn acc. to
No.	Description		Comr	nent		footnotes in Table 5	B and Table 5D:
2	Alaska Cedar, 2"-4" Thick, 2" and Wider, Select					Destruction of D	has no dùin làsann has
3	Steel A36 ANSI/AISC 360-05:2005-03					neuccion of F6	x by multipliying by
4	Beech-Birch-Hickory, 5"x5" and Larger, Beams a					than 15 in. deep	inembers greater
5	16F-1.3E, 16F-V2, SP/SP, Loaded Perp. to Wi						
6	Visually Graded Hardwoods (H2), A, N2, 3 Lams						
7	Pacific Coast Douglas Fir (Treated Round Timbe						
(🛃 😼 🔕		
Aaterial Pr	roperties						
🖃 Main P	roperties						
— Mod	ulus of Elasticity	E	1500.000	ksi			
- Shea	ar Modulus	G	93.750	ksi			
- Spec	cific Weight	γ	0.0	kip/ft ³			
- Coef	fficient of Thermal Expansion	QL	2.7778E-06	1/°F			
- Parti	ial Safety Factor	γм	1.00				
🖃 Additio	nal Properties						
- Refe	erence Tension Design Value Parallel to Grain	Ft	1.000	ksi			
- Refe	erence Compression Design Value Parallel to Grain	Fo	1.300	ksi		Material No. 5 used	in
- Refe	erence Bending Design Value	Fbx+	1.600	ksi		-	
- Refe	erence Bending Design Value	Fbx'	1.400	ksi		Cross-sections No.:	
- Refe	erence Bending Design Value (Bending Parallel to Wide Faces	Fby	1.450	ksi		8	
- Refe	erence Shear Design Value Parallel to Grain	Fvx	0.300	ksi			
- Refe	erence Shear Design Value Parallel to Grain	Fvy	0.260	ksi		Members No :	
- Refe	erence Compression Design Value Perpendicular to Grain	Fcpx,ten.face	0.740	ksi		F	
- Refe	erence Compression Design Value Perpendicular to Grain	Fopx,comp.fac	0.650	ksi		2	
- Refe	erence Compression Design Value Perpendicular to Grain	Fopy	0.650	ksi			
- Refe	erence Modulus of Elasticity for Stability Calculations	Exmin	790.000	ksi		Sets of members N	0.1
- Refe	erence Modulus of Elasticity for Stability Calculations	Ey min	740.000	ksi			
— Туре	e of Structural Glued Laminated Timber		Softwoods				
- Com	bination Symbol		16F-V2			Σ Length:	Σ Weight:
- Spec	cies Outer/Core	SP/SP			La cong (W)	D riogne	
						13.000 [ft]	0.095 [tor

Figure 2.13: Window 1.2 Materials

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

The material properties required for the determination of internal forces are described in Chapter 4.3 of the RFEM manual (*Main Properties*). The material properties required for design are stored in the global material library. These values are preset (*Additional Properties*).

To adjust the units and decimal places of material properties and stresses, select from the module's menu **Settings** \rightarrow **Units and Decimal Places** (see Chapter 7.3, page 66).

Material Description

The materials defined in RFEM are preset, but you can always modify them: To select the field, click the material in column A. Then click [▼] or press function key [F7] to open the material list.

📕 Alaska Cedar, 2"-4" Thick, 2" and Wider, Sele(🚬	
Alaska Cedar, 2"-4" Thick, 2" and Wider, Select Structural	ANSI/AWC NDS-2012
Alaska Cedar, 2°-4″ Thick, 2″ and Wider, No.1	ANSI/AWC NDS-2012
Alaska Cedar, 2°-4″ Thick, 2″ and Wider, No.2	ANSI/AWC NDS-2012
Alaska Cedar, 2°-4″ Thick, 2″ and Wider, No.3	ANSI/AWC NDS-2012
Alaska Cedar, 2"-4" Thick, 2"-8" Wide, Stud	ANSI/AWC NDS-2012
Alaska Cedar, 2"-4" Thick, 8" and Wider, Stud	ANSI/AWC NDS-2012
Alaska Cedar, 2"-4" Thick, 2"-4" Wide, Construction	ANSI/AWC NDS-2012
Alaska Cedar, 2°-4″ Thick, 2°-4″ Wide, Standard	ANSI/AWC NDS-2012
Alaska Cedar, 2"-4" Thick, 2"-4" Wide, Utility	ANSI/AWC NDS-2012
Alaska Hemlock, 2"-4" Thick, 2" and Wider, Select Structural	ANSI/AWC NDS-2012 👻

Figure 2.14: List of materials



According to the design concept of ANSI/AWC NDS-2012 [1] and its Supplement [2], the list includes only materials of the U.S. standard. Visually graded decking (i.e. material according to [2] "Table 4E") is not included in RF-TIMBER AWC.

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

If you change the material description manually and the entry is stored in the material library, RF-TIMBER AWC will import the material properties, too.

It is not possible to edit the material properties in the add-on module RF-TIMBER AWC.

Material Library

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

Edit \rightarrow Material Library

or click the button shown on the left.

	Material to Select			
Material category group:	Material Description		Standard	
Timber 🔹	 Southern Pine, 5"x5" and Larger, Dense Seler 	ct Structural	ANSI/AWC ND	S-2012
	Southern Pine, 5"x5" and Larger, Select Struct	tural	ANSI/AWC ND	S-2012
Material category:	Southern Pine, 5"x5" and Larger, No.1 Dense		ANSI/AWC ND	S-2012
Wood (North America)	Southern Pine, 5"x5" and Larger, No.1		ANSI/AWC ND	S-2012
	Southern Pine, 5"x5" and Larger, No.2 Dense		ANSI/AWC ND	S-2012
Standard group:	Southern Pine, 5"x5" and Larger, No 2	ANSI/AWC ND	5-2012	
ANSI/AWC •	Southern Pine, 5"x5" and Larger Dense Selev	et Structural 86	ANSI/AWC ND	5-2012
Standard	Southern Pine, 5"x5" and Larger, Dense Selev	et Structural 72	ANSI/AWC ND	5-2012
Stanuaru.	Southern Pine, 5"x5" and Larger, Dense Selec	at Structural 65		S-2012
ANSI/AWC NDS-2012	Conside Pine Fir FireFi and Larger, Dense Select	Chingson Coloct C		C 2012
Special application:	Spruce-Fine-Fir, 5 X5 and Larger, beams and	Chingers, Select 5		5-2012
Table 4D Marselly Canded Ted	Spruce-Fine-Fir, 5 x5 and Larger, Beams and	Chingers, No. 1		5-2012
Table 4D - Visually Graded Tim	Spruce-Pine-Fir, 5 x5 and Larger, Beams and	T Stringers, No.2	ANSI/AWC ND:	5-2012
_	Spruce-Pine-Fir, 5 x5 and Larger, Posts and	Timbers, Select Stru	ANSI/AWC ND	5-2012
🔲 Include invalid 🛛 🔤	Spruce-Pine-Fir, 5"x5" and Larger, Posts and	Timbers, No.1	ANSI/AWC ND	S-2012
🔲 Favorites only 💽	A 🎦 📼			
Material Properties	Southern Dina, 5*×5*	and Larger Select 1	Structural L ANSI/AM	
Main Properties	Southern Fille, o Xo	und Eurger, Geleer		0 1100-2
 Modulus of Elasticity 		E	1500.000	ksi
Modulus of Elasticity Shear Modulus		E G	1500.000 93.750	ksi ksi
Modulus of Elasticity Shear Modulus Specific Weight		E G γ	1500.000 93.750 0.0	ksi ksi kip/ft ³
Modulus of Basticity Shear Modulus Specific Weight Coefficient of Thermal Expans	ion	Ε G γ α	1500.000 93.750 0.0 2.7778E-06	ksi kip/ft ³ 1/°F
Modulus of Elasticity Shear Modulus Specific Weight Coefficient of Thermal Expans El Additional Properties	ion	Ε G γ α	1500.000 93.750 0.0 2.7778E-06	ksi ksi kip/ft ³ 1/°F
Modulus of Easticity Shear Modulus Specific Weight Coefficient of Themal Expans Additional Properties Reference Modulus of Elasticit	ion ity for Stability Calculations	E G γ α Emin	1500.000 93.750 0.0 2.7778E-06	ksi ksi kip/ft ³ 1/°F ksi
Modulus of Easticity Shear Modulus Specific Weight Coefficient of Thermal Expans Additional Properties Reference Bending Design Ve Persence Tension Design Ve	ion ity for Stability Calculations alue	E G γ α. Emin Fb E.	1500.000 93.750 0.0 2.7778E-06 550.000 1.500	ksi kip/ft ³ 1/°F ksi ksi
Modulus of Elasticity Shear Modulus Specific Weight Coefficient of Thermal Expans Additional Properties Reference Modulus of Elastici Reference Bending Design Va Reference Shear Design Va	ion Ity for Stability Calculations alue Parallel to Grain Barallel to Grain	E G γ α Emin Fb Ft	1500.000 93.750 0.0 2.7778E-06 550.000 1.500 1.000	ksi ksi kip/ft ³ 1/°F ksi ksi ksi
Modulus of Elasticity Shear Modulus Specific Weight Coefficient of Themal Expans Additional Properties Reference Modulus of Elastici Reference Bending Design Va Reference Shear Design Vau Reference Compression Desi	ion ity for Stability Calculations alue alue Parallel to Grain e Parallel to Grain (Horizontal Shear) no Value Perendro Jacto Grain	E G γ α Emin Fb Ft Fv Ema	1500.000 93.750 0.0 2.7778E-06 550.000 1.500 1.500 0.165 0.275	ksi kip/ft ³ 1/°F ksi ksi ksi ksi ksi
Modulus of Easticity Shear Modulus Specific Weight Coefficient of Thermal Expans Additional Properties Reference Modulus of Elastici Reference Bending Design Va Reference Tension Design Va Reference Compression Design Pai Reference Compression Design Design Reference Compression Design D	ion ity for Stability Calculations alue Jaue Parallel to Grain ue Parallel to Grain (Horizontal Shear) gn Value Perpendicular to Grain un Value Perpendicular to Grain	E G γ α Emin Fb Ft Fv Fcp Fc	1500.000 93.750 0.0 2.7778E-06 550.000 1.500 0.165 0.375 0.950	ksi kip/ft ³ 1/°F ksi ksi ksi ksi ksi ksi
Modulus of Easticity Shear Modulus Specific Weight Coefficient of Themal Expans Additional Properties Reference Bending Design Va Reference Tension Design Va Reference Compression Desig Reference Compression Desig Reference Compression Desig Type of Wood Product	ion ity for Stability Calculations alue Jaue Parallel to Grain ie Parallel to Grain (Horizontal Shear) gn Value Perpendicular to Grain gn Value Parallel to Grain	E G γ α Emin Fb Ft Fv Fop Fo	1500.000 93.750 0.0 2.7778E-06 550.000 1.500 0.165 0.375 0.950 Visually Graded	ksi kip/ft ³ 1/°F ksi ksi ksi ksi ksi ksi timbers
Modulus of Easticity Shear Modulus Specific Weight Coefficient of Themal Expans Additional Properties Reference Bending Design Va Reference Tension Design Va Reference Compression Desig Reference Compression Desig Type of Wood Product Species	ion ity for Stability Calculations alue Parallel to Grain e Parallel to Grain (Horizontal Shear) gn Value Perpendicular to Grain gn Value Parallel to Grain	E G γ α Emin Fb Ft Fv Fo Fo	1500.000 93.750 0.0 2.7778E-06 550.000 1.500 0.165 0.375 0.355 Visually Graded Southem Pine	ksi kip,/ft ³ 1/°F ksi ksi ksi ksi ksi ksi timbers
Modulus of Easticity Shear Modulus Specific Weight Coefficient of Thermal Expans ☐ Additional Properties Reference Bending Design Va Reference Tension Design Va Reference Shear Design Valu Reference Compression Desig Reference Compression Desig Reference Compression Desig Commercial Grade	ion Ity for Stability Calculations alue Parallel to Grain e Parallel to Grain (Horizontal Shear) pr Value Perpendicular to Grain gn Value Parallel to Grain	E G γ α Emin Fb Ft Fc Fc Fc	1500.000 93.750 0.0 2.7778E-06 550.000 1.500 0.165 0.375 0.950 Visually Graded Southem Pine Select Structur	ksi kip/ft ³ 1/°F ksi ksi ksi ksi ksi f Timbers
Modulus of Easticity Shear Modulus Specific Weight Coefficient of Thermal Expans Additional Properties Reference Modulus of Elasticit Reference Bending Design Va Reference Shear Design Val Reference Compression Desig Type of Wood Product Species Commercial Grade Cross-Section Classification	ion ity for Stability Calculations alue alue Parallel to Grain we Parallel to Grain (Horizontal Shear) pr Value Perpendicular to Grain gn Value Parallel to Grain	E G γ α Emin Fb Ft Fv Fo Fo	1500.000 93.750 0.0 2.7778E-06 550.000 1.500 0.165 0.375 0.950 Visually Graded Southem Pine Select Structur	ksi kip/ft ³ 1/°F ksi ksi ksi ksi ksi ksi f Timbers al
Modulus of Easticity Shear Modulus Specific Weight Coefficient of Themal Expans Additional Properties Reference Bending Design Va Reference Compression Desig Reference Compression Desig Type of Wood Product Species Commercial Grade Cross-Section Classification	ion ity for Stability Calculations alue alue Parallel to Grain e Parallel to Grain (Horizontal Shear) gn Value Perpendicular to Grain gn Value Parallel to Grain	E G γ α Emin Fb Ft Fv Fcp Fc	1500.000 93.750 0.0 2.7778E-06 550.000 1.500 0.165 0.375 0.950 Visually Graded Southem Pine Select Structure 5'x5" and Large	ksi kip/ft ³ 1/°F ksi ksi ksi ksi ksi ksi t Timbers al er

Figure 2.15: Dialog box Material Library

In the *Filter* section, *ANSI/AWC* is preset as Standard. Select the material quality that you want to use for the design in the *Material to Select* list. You can check the corresponding properties in the dialog section below.

Click [OK] or press [,] to transfer the selected material to Window 1.2 of RF-TIMBER AWC.

Chapter 4.3 of the RFEM manual describes in detail how materials can be filtered, added, or rearranged.

OK



Material Properties

The lower section of Window 1.2 contains the reference design values for bending F_{b} , tension parallel F_{t} , shear F_{v} , compression parallel F_{c} , compression perpendicular F_{cp} , as well as modulus of elasticity for stability calculations E_{min} .

The reference bending, shear and compression perpendicular design values and reference modulus of elasticity for stability calculations for structural glued laminated timber are extended for cases of bending perpendicular and parallel to wide faces of laminations and bending to F_{bx} and F_{by} . When structural laminated timber material stressed primarily in bending (i.e. material of "Table 5A" and "Table 5C" special application) is chosen, value F_{bx} is doubled for the case of positive F_{bx}^+ and negative F_{bx}^- bending. In addition, for such a softwood timber (i.e. material of "Table 5A" special application), value F_{cp} is doubled for tension $F_{cpx,ten,face}$ and compression $F_{cpx,comp,face}$ face of cross-section.

The design values of the material strengths are to be determined with the modification factors. Those factors can be modified in the *Standard Settings* dialog box (see Figure 2.9 and Figure 2.10, page 13).

Special Settings

For cross-sections greater than 15 in. deep, where structural glued laminated timber stressed primarily in axial tension or compression (i.e. material of "Table 5B" and "Table 5D" special application) is used, the reference bending design value F_{bx} can be considered to be reduced by multiplying by a factor of 0.88.

If you select this option, the program reduces the mentioned bending design value automatically.

2.3 Cross-Sections

This window manages the cross-sections used for design. You can also specify parameters for the optimization here.

5 01055-	sections						
	A	В	C	D	E	*	17 - Dimension Lumber 3x8 ANSI/AWC
Section	Material	Cross-Section	Opti-				
No.	No.	Description	mize	Note	Commen		
10	7	T-Rectangle 10.25/6.35	No	9)			
11	7	T-Circle 8	No				
12	3	I IPE 120	No	8)			
13	2	E IUH 24/18/4/4/12/4	No	9)		=	
14	2	T-Rectangle 4/12	No	1)			
15	2	Post and Timber 12x14 ANSI/AWC	No				x
16	2	Beams and Stringers 8x20 ANSI/AW	No	8)			
17	2	Dimension Lumber 3x8 ANSI/AWC	From Current R	ow [2]		*	
	[table will be used.				• •	У
Uross-Se	ection Prop	erties					4
El Size F	actor		C (F)	1.000		1.100	
Ber	nding Desig	gn Value Adjustment	UF (Fb)	1.200 stand	dard-defined	acc. to 4.3.6	🔒 🖾 📰 🖾 🗖
ler	ision Desig	n Value Adjustment		1.200 stand	dard-defined	acc. to 4.3.6	
	npression r	araliei to Grain Design Value Adjustment	CF (FC)	1.050 stand	ara-derined	acc. to 4.3.6	Cross-section No. 17 used in
E riat U	se nactor	an Mahan Anti-Anti-Anti-Anti-Anti-Anti-Anti-Anti-	C/	1.150 - ++++	danal da Consul	200 to 4.2.7	Manhan Na .
Der	iung Desig	in value Aujustment	Сти	1.100 starit	Jaru-uerineu	acc. 10 4.3.7	Members No
							13
							Sets of members No.:
							Σ Length: Σ Weight:
							13.000 [ft] 0.023 [to
							Material:
							2 · Alaska Cedar, 2"-4" Thick, 2" and W

Figure 2.16: Window 1.3 Cross-Sections

Spec For cre

Special settings for glulam acc. to footnotes in Table 5B and Table 5D:

Special Settings for

Standard..

Reduction of F_{bx} by multipliyng by a factor 0.88 for members greater than 15 in. deep



Axis System

In RF-TIMBER AWC, the cross-sectional axis system is applied according to [1]. That system is different to the one used in RFEM: The module's axis \mathbf{x} corresponds to axis y of RFEM, and axis \mathbf{y} to axis z accordingly. Sometimes the axis' symbols y/x and z/y are used in RF-TIMBER AWC.



Figure 2.17: Axis systems used in RFEM and RF-TIMBER AWC

Cross-Section Description

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

The design is possible for the parametric timber rectangular and circular cross-section and for standardized timber rectangular cross-section according to ANSI/AWC NDS-2012 [1].



The table *Cross-Section Properties* below displays the size factors C_F and flat use factors C_{fu} of each cross-section. For standardized timber cross-sections (see Figure 2.19), you can define the values automatically or manually by using the $[\bullet]$ button.

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

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

Chapter 4.13 of the RFEM manual describes how cross-sections can be selected from the library.

/ `` Dlubal

Timber Cross-Sections - Rectangle		×
Cross-Section Type Image: Construction of the section of the	Parameters b: 5.5 m/s h: 9.5 m/s	y y c Iz
Favorites Group	A	T-Rectangle 5.5/9.5

Figure 2.18: Parametric timber cross-sections of the cross-section library





Figure 2.19: Standardized timber cross-sections of the cross-section library

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

A modified cross-section will be highlighted in blue.

If cross-sections specified in RF-TIMBER AWC are different from the ones used in RFEM, both cross-sections are displayed in the graphic on the right. The designs will be performed with the internal forces of RFEM for the cross-section selected in RF-TIMBER AWC.



Max. Design Ratio

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

Optimize

Details...

0

You can optimize all rectangular and circular cross-sections: For the RFEM internal forces, the program searches the cross-section that comes as close as possible to a user-defined maximum utilization ratio. You can define the maximum ratio in the *Other* tab of the *Details* dialog box, (see Figure 3.5, page 42).

If you want to optimize a cross-section, open the drop-down list in column D or E. Recommendations for optimizing cross-sections can be found in Chapter 7.2 on page 63.

Remark

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

A warning might appear before the calculation: *Cross-section does not have a valid material*! This means that this cross-section is not allowed to be used in combination with the defined material. In RF-TIMBER AWC, it is not possible to use rectangular cross-sections with structural round timber poles and piles material (i.e. material of [2] Table 6A and Table 6B), and circular cross-sections with dimensional lumber or structural glued laminated timber (i.e. material of [2] Table 4A, Table 4B, Table 4C, Table 4D, Table 4F, Table 5A, Table 5B, Table 5C and Table 5D).

Info About Cross-Section

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



Figure 2.20: Dialog box Info About Cross-Section

The right part of the dialog box shows the currently selected cross-section.



The buttons below the graphic have the following functions:

Button	Function
I	Displays or hides the stress points
123	Displays or hides the numbers of stress points
	Shows the details of the stress points (see Figure 2.21)
X	Displays or hides the dimensions of the cross-section
1	Displays or hides the principal axes of the cross-section
	Resets the full view of the cross-section graphic
	Prints the cross-section values and cross-section graphic

Table 2.3: Buttons of cross-section graphic

Click [Details] to call up specific information on the stress points (distances to center of gravity, statical moments, etc.).



Figure 2.21: Dialog box Stress Points

Member with tapered cross-section

For tapered members with different cross-sections at both member ends, the module displays the two cross-sections numbers in separate table rows, in accordance with the definition in RFEM.

RF-TIMBER AWC is also able to design tapered members if the same cross-section type is defined for the start and the end cross-section. Additional specifications are required in Window 1.14 (see Chapter 2.14, page 36).

Q



2.4 Load Duration

In Window 1.4, you define the load duration to consider factors reflecting the different load duration for all chosen load cases, load and result combinations as well as dynamic combinations.

	A	В	C	D	E	F
oad-		Load		Factor	Loading Condition	
ng	Description	Туре	Load Duration	λ	(Radial Stress Design)	Comments
.C1	Permanent	Dead	Permanent	0.6000	Other Types of Loading	
.C2	Live	Live	Ten Years	0.7000	Other Types of Loading	
.C3	Snow	Snow	Two Months	0.8000	Other Types of Loading	
.C4	Wind	Wind	Ten Minutes	1.0000	Wind or Earthquake Loading	
:01	1.4*LC1	-	Permanent	0.6000	Other Types of Loading	
:02	1.2*LC1 + 1.6*LC2	-	Ten Years	0.7000	Other Types of Loading	
:03	1.2*LC1 + 1.6*LC2 + 0.5*LC3	-	Two Months	0.8000	Other Types of Loading	
:04	1.2*LC1 + 0.5*LC3	-	Two Months	0.8000	Other Types of Loading	
:05	1.2*LC1 + LC2 + 1.6*LC3	-	Two Months	0.8000	Other Types of Loading	
:06	1.2*LC1 + 1.6*LC3	-	Two Months	0.8000	Other Types of Loading	
:07	1.2*LC1 + 1.6*LC3 + 0.8*LC4	-	Ten Minutes	1.0000	Wind or Earthquake Loading	
:08	1.2*LC1 + 0.8*LC4	-	Ten Minutes	1.0000	Wind or Earthquake Loading	
:09	1.2*LC1 + LC2 + 0.5*LC3 + 1.6*LC4		Ten Minutes	1.0000	Wind or Earthquake Loading	
D10	1.2*LC1 + LC2 + 1.6*LC4	-	Ten Minutes	1.0000	Wind or Earthquake Loading	
011	1.2*LC1 + 0.5*LC3 + 1.6*LC4	-	Ten Minutes	1.0000	Wind or Earthquake Loading	
012	1.2*LC1 + 1.6*LC4	-	Ten Minutes	1.0000	Wind or Earthquake Loading	
D13	0.9*LC1 + 1.6*LC4	-	Ten Minutes	1.0000	Wind or Earthquake Loading	
pply time	e effect	bination				

Figure 2.22: Window 1.4 Load Duration

Loading

All actions selected in the 1.1 *General Data* window are listed here. For combinations, included load cases are listed, too.

Description

The load case descriptions make the classification easier.

Load Type

This table column shows the load cases' types of action as defined while creating them in RFEM. They are the basis for the presetting in the subsequent table column.

Load Duration

Loads and their superpositions must be assigned to the load duration for the design. The classification of actions is specified for example in [1] Table 2.3.2.

For load cases and variable result combinations, the load duration can be changed by using the list shown on the left: Click the cell in column C, thus selecting the field. The $[\bullet]$ button becomes available. For load combinations and *Or* result combinations, RF-TIMBER AWC performs the classification automatically taking into account the shortest load duration action of included load cases. When the bottom-side button is switched to *User-defined settings*, load combinations and *Or* result combinations are user-changeable as well.

The class of the load duration is required for the determination of the load duration factor C_D in the ASD method and time effect factor λ in the LRFD method.





Factor C_D / λ

The impact of the load duration on the strength properties is taken into account by means of the load duration factor C_D (ASD) or the time effect factor λ (LRFD) (see [1] Table 2.3.2 and N3).

The factors can be checked and, if necessary, adjusted in the Standard Settings dialog box (see

Standard...



Loading Condition (Radial Stress Design)

Figure 2.9 and Figure 2.10, page 13).

In the table, column E is activated only when at least one tapered or curved member is selected for the design. In this case, the loading conditions must be assigned so that the radial tension stress, Frt, can be determined (see [1] Table 5.2.8).

2.5 In-Service Conditions - Members

The determination of moisture and temperature service conditions makes it possible to assign the temperature factors C_T and wet service factors C_M to each member. The moisture service conditions can be specified individually for each material according to [2][1], the temperature conditions according to [1] Table 2.3.3.

	۵	B	C	Mainture Comine Condition
ember	Moisture Service		<u> </u>	Mulsure Service Condition
No.	Condition	Temperature	Comments	Dry Service Conditions:
1	Drv	T ≤ 100°F		Moisture content in service is less
2	Wet	100°F < T ≤ 125°F		than 19% for lumber (less than
3	Wet	125°F < T ≤ 150°F		16% for glulam)
4	Dry	T ≤ 100°F		
5	Wet	100°F < T ≤ 125°F		
	Dry	100°F < T ≤ 125°F		Wet Service Conditions:
,	Dry	T ≤ 100°F		Moisture content in service is 19%
3	Wet	125°F < T ≤ 150°F		or greater for lumber (16% and
				greater for gradinij
				Temperature Effects:
				Structural members experience sustaine exposure to elevated temperatures up to 100°F
				Structural members experience sustaine exposure to elevated temperatures between 100'F and 125'F
				Structural members experience sustaine exposure to elevated temperatures between 125°F and 150°F
Set input	for members No.:			
		A N A	- S	S

Figure 2.23: Window 1.5 In-Service Conditions - Members

By default, the program assigns dry service conditions and temperatures below 100 °F. If you want to allocate different moisture or temperature conditions to specific members, use the [▼] button to open the lists.

Below the *Settings* table, you find the *Set inputs for members No.* check box. If it is selected, the settings entered <u>afterward</u> will be applied to the selected or to *All* members. Members can be selected by entering their numbers or by selecting them graphically using the [[\]] button. That option is useful when you want to assign identical conditions to several members. Please note that settings that have been already defined cannot be changed subsequently by this function.



Temperature T ≤ 100°F Temp. up to 100°F Temp. between 100°F and 125°

is .



The other buttons below the table have the following functions:

Button	Function
1	Export of table to MS Excel or OpenOffice.org Calc
₹₹	Option to select member graphically in RFEM window and set its row in table
۲	View mode for switching to RFEM work window

Table 2.4: Buttons in Window 1.5 In-Service Conditions - Members

2.6 In-Service Conditions - Set of Members

This window is only available if one or more sets of members have been selected in Window 1.1 *General Data*.

	A	B	C	Moisture Service Condition
Set	Moisture Service			
NO.	Condition	Temperature	Comments	Dry Service Conditions:
1	Dry	T ≤ 100°F		Moisture content in service is less
2	Wet	T ≤ 100°F		than 19% for lumber (less than
3	Dry	100°F < T ≤ 125°F		16% for glulam)
				Wet Service Conditions: Moisture content in service is 19% or greater for lumber (15% and greater for glulam)
				Temperature Effects:
				Structural members experience sustaine exposure to elevated temperatures up to 100°F
				Structural members experience sustaine exposure to elevated temperatures between 100°F and 125°F
				Structural members experience sustaine exposure to elevated temperatures between 125'F and 150'F
Set inpu	ut for members No.:			
		A V A		

Figure 2.24: Window 1.6 In-Service Conditions - Sets of Members

The set-up of this window is similar to the one of the previous Window 1.5 *In-Service Conditions* - *Members*. Here you can assign temperature and moisture service conditions to each set of members.

1.7 Effective Lengths - Members



Details...

2.7 Effective Lengths - Members

The appearance of the window depends on whether the stability analysis is carried out according to the equivalent member method or according to second-order analysis. You can specify that method in the *Stability* tab of the *Details* dialog box (see Figure 3.2, page 39). The following description refers to the equivalent member default method. For that, 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 1.7 is not shown.

The window consists of two parts. The table in the upper part lists the factors for the lengths of buckling and lateral-torsional buckling as well as the equivalent member lengths of the members selected for design. The effective lengths defined in RFEM are preset. In the *Settings* section, you can see further information on the member whose row is selected in the upper table.

R

....

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

	А	B	C	D	E	F	G	Н		1	J	K
Member	Buckling	Bu	ckling About A	dis x	B	uckling About A	dis y		Lateral-Torsional	Buckling	-	
No.	Possible	Possible	Kex	l _{ex} [in]	Possible	Key	ley [in]	Possible	Define I _e		le [in]	Comment
1	S	V	0.700	168.0	V	1.000	240.0	V	as member ler	ngth	240.0	
6	2		1.000	240.0		1.000	240.0	✓	manually		240.0	
7	V	 ✓ 	2.000	480.0		2.000	480.0		acc. to Table	3.3.3	415.2	
8	S		1.000	240.0		1.000	240.0		acc. to Table	3.3.3	433.2	
9	S	✓	0.500	120.0		0.500	120.0	✓	acc. to Table	3.3.3	433.2	
10	V	V	1.000	240.0	V	1.000	240.0		acc. to Table	3.3.3	448.2	
11	S	V	1.000	240.0		1.000	240.0		acc. to Table	3.3.3	448.2	
12			1.000	240.0	✓	1.000	240.0	V	acc. to Table	3.3.3	448.2	
											R	
Settings f	or member No	1							Г	2 T Dec	tenals 11/1C	
Croce-e	ection	. 1		2 7 0	ostonelo 11/	16				3 - 1-Ret	angle 11/16	
Length	ioolion .		1	3-1-14	2/1	10 10 in						
Bucklin	a Possible				240							
E Bucklin	ng About Axis x	Possible				2					11.00	
Effec	ctive Length C	oefficient	Kex		07	00					1	
Effec	ctive Length		lex		168	30 in				+		
Bucklin	ng About Axis y	Possible				ন						
Effec	ctive Length C	oefficient	Kev		1.0	00						
Effec	ctive Length		lev		240).0 in						
- Lateral	-Torsional Buc	kling Possible				7				00.		
Defir	nele			as	member lend	th				16		x
Comme	ent											
										Ļ	- i y	
Set inp	out for membe	rs No.:								0		(in)

Figure 2.25: Window 1.7 Effective Lengths - Members for equivalent member method

The effective lengths can be entered manually in the table and in the *Settings* tree, or defined graphically in the work window after clicking [...]. This button is available as soon as you have clicked in the text box (see Figure above).

The Settings tree manages the following parameters:

- Cross-Section
- Member Length
- Buckling Possible (corresponds to column A)
- Buckling About Axis x Possible (corresponds to columns B to D)
- Buckling About Axis y Possible (corresponds to columns E to G)
- Lateral-Torsional Buckling Possible (corresponds to columns H to J)

In this table, you can specify for the currently selected member whether to carry out a buckling or a lateral-torsional buckling analysis. In addition to this, you can adjust the *Effective Length*

2 Input Data



Coefficient for the respective directions. When a coefficient is modified, the equivalent member length is adjusted automatically, and vice versa.

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

pe of K Value		
Theoretical		
Recommended		
uckling About Axis y / x	Buckling About Axis z / y	Constantional suit sustant in this same is different
Ky = 0.5	© Kz = 0.5	than in the module.
) K _Y = 0.7	© K _z = 0.7	Note that Ky = Kex and Kz = Key
) K _Y = 1.0	© K _z = 1.0	
) K _Y = 1.0	• Kz = 1.0	
) K _Y = 2.0	© Kz = 2.0	·····
Ky = 2.0		·······
User-defined Ky =	© Uger-defined Kz = y	
) Import from add-on module RF-STABILI	TY O Import from add-on module RF-STABII	LITY Rotation fixed and translation fixed
		D>→ Rotation free and translation fixed
RESTABLLITECASE.		Botation fixed and translation free
Ruckling	Ruchling	
mode No.: 0	mode No.:	Notation free and translation free
port effective length ctor Ky : 0.800	Export effective length factor K _z : 1.000	

Figure 2.26: Dialog box Select Effective Length Factor

For each direction, you can select one of the buckling modes (theoretical and recommended values of buckling length factors according to [1] Table G1) or enter a *User-defined* effective length coefficient K_y.

If an eigenvalue analysis was carried out in the add-on module RF-STABILITY, you can also select a *Buckling Mode* to determine the factor.

Buckling Possible

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

The *Buckling Possible* check boxes in table column A and in the *Settings* tree enable you to classify members as compression members or to exclude them from the stability analysis.

15



Buckling About Axis x / Buckling About Axis y

With the check boxes in the *Possible* table columns, you decide whether a member is susceptible to buckling about the x-axis and/or y-axis (see Chapter 2.3, page 19 for the axis systems). Those axes represent the local member axes, with the **x**-axis as the "major" and the **y**-axis the "minor" member axis. The buckling length coefficients $K_{e,x}$ and $K_{e,y}$ for buckling about the major or the minor axis can be selected freely.

You can check the position of the member axes in the cross-section graphic in Window 1.3 *Cross-Sections* (see Figure 2.16, page 18).

To access the RFEM work window, click the [View Mode] button. In the work window, you can display the local member axes by using the member's context menu or the *Display* navigator.



Figure 2.27: Selecting the member axis systems in the Display navigator of RFEM

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

To specify the buckling lengths in the work window graphically, click [...]. This button becomes available when you click in a l_e text box (see Figure 2.25).

When you specify the buckling length coefficient K_e , the program determines the effective length I_e by multiplying the member length L by that buckling length coefficient. The text boxes for K_e and I_e are interactive.

Lateral-Torsional Buckling Possible

Table column H controls for which members a lateral-torsional buckling analysis is to be carried out.

Define I_e

The member lengths are preset in column I as equivalent member lengths relevant for lateraltorsional buckling. When you activate the check box in column I, you can specify the length for lateral-torsional buckling I_e in column J. You can also define it graphically after clicking [...] as the distance of the lateral supports. Thus, you can adjust the boundary conditions of a structural component if it consists of several members between the supports.

When the option *acc. to Table 3.3.3* is selected, you can determine the lateral-torsional buckling length in accordance with [1] Table 3.3.3. A new dialog box is opened in which you can select the relevant loading conditions (see figure below).

....

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۲

Define I e as member length as member length manually acc. to Table 3.3.3



Insupported Length, I_u			
lu manually			
lu = [m]			
ffeative Leasth Le			
Cantilever	where l _u / d < 7 [.]		where lu / d > 7
Uniformly distributed load	le = 1.33 lu		le = 0.90 lu + 3d
Concentrated load at unsupported end	le = 1.87 lu		le = 1.44 lu + 3d
Single Span Beam:	where I _u / d < 7:		where $I_u / d \ge 7$:
Uniformly distributed load	le = 2.06 lu		le = 1.63 lu + 3d
\odot Concentrated load at center with no intermediate lateral support	le = 1.80 lu		le = 1.37 lu + 3d
Concentrated load at center with lateral support at center		le = 1.11 lu	
\odot Two equal concentrated loads at 1/3 points with lateral support at 1/3 points		le = 1.68 lu	
\odot Three equal concentrated loads at 1/4 points with lateral support at 1/4 points		le = 1.54 lu	
igodown Four equal concentrated loads at 1/5 points with lateral support at 1/5 points		le = 1.68 lu	
\bigcirc Five equal concentrated loads at 1/6 points with lateral support at 1/6 points		le = 1.73 lu	
\odot Six equal concentrated loads at 1/7 points with lateral support at 1/7 points		le = 1.78 lu	
Seven or more equal concentrated loads, evenly spaced, with lateral support at points of load application		le = 1.84 lu	
© Equal end moment		le = 1.84 lu	
Single Span Beam or Cantilever:	where $I_u / d < 7$:	where $7 \le I_u / d \le 14.3$:	where $l_u / d > 14$
Other loading conditions	I _e = 2.06 I _u	le = 1.63 lu + 3d	le = 1.84 lu

Figure 2.28: Dialog box Effective Length for Bending Members acc. to Table 3.3.3

Below the *Settings* table, you find the *Set inputs for members No.* check box. If it is selected, the settings entered <u>afterward</u> will be applied to the selected or to *All* members. Members can be selected by entering their numbers or by selecting them graphically using the [⁵] button. That option is useful when you want to assign identical conditions to several members. Please note that settings that have been already defined cannot be changed subsequently by this function.

Comment

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

Please note that curved members are excluded from the stability analysis. The Design Specification [1] provides no rules how to design members of that kind of geometry.



B

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2.8 Effective Lengths - Sets of Members

This window is only available if one or more sets of members have been selected in Window 1.1 *General Data*. Additionally, the stability check must have been activated in the dialog box *Details*, tab *Stability* (see Figure 3.2, page 39).



Figure 2.29: Window 1.8 Effective Lengths - Sets of Members

The set-up of this window is similar to the one of the previous Window 1.7 *Effective Lengths -Members*. Here you can enter the effective lengths for buckling as well as for lateral-torsional buckling about the two principal axes of the set of members as described in Chapter 2.7. They determine the boundary conditions of the entire set of members which is to be treated as an equivalent member.

Please note that curved sets of members are excluded from the stability analysis.





2.9 Additional Design Parameters

This window allows you to assign the adjustment factors which depend on the material of each member. The factors can be modified by clicking the [▼] button in column B.

	A	В	C (D	E [F
mber		Adjustment Factors				
No.	Description	Definition	Symbol	Value [-]	acc. to	Comment
1	Condition Treatment Factor	Air Dried 💌	Cct	1.000	6.3.5	
	Load Sharing Factor	Single Pile	Cis	1.000, 1.000	6.3.11	
2	Incising Factor	Not Incised	Ci		4.3.8	
	Repetitive Factor	Not Repetitive	Cr		4.3.9	
3	Shear Reduction Factor	No Shear Reduction	Cvr		5.3.10	
	Shear Edge-Bonded Factor	Edge-Bonded	•		NDS Suppl.	
4	Shear Reduction Factor	Shear Reduction	Cvr	0.720	5.3.10	
	Shear Edge-Bonded Factor	Not Edge-Bonded (odd number of lams)	•	0.400	NDS Suppl.	
5	Shear Reduction Factor	No Shear Reduction	Cvr		5.3.10	
	Shear Edge-Bonded Factor	Not Edge-Bonded (even number of lams)	•	0.500	NDS Suppl.	
6	Shear Reduction Factor	No Shear Reduction	Cvr		5.3.10	
	Shear Edge-Bonded Factor	Edge-Bonded	•		NDS Suppl.	
7	Incising Factor	Not Incised	Ci		4.3.8	
	Repetitive Factor	Repetitive	Cr	1.150	4.3.9	
8	Incising Factor	Incised	Ci	0.950, 0.800, 1.000	4.3.8	
	Repetitive Factor	Not Repetitive	Cr		4.3.9	
Setin	put for members No.:	Material Category:				

Figure 2.30: Window 1.9 Additional Design Parameters

For sawn lumber members, you can determine whether the *Repetitive Factor C*_r and the *Incising Factor C*_i are to be applied in the calculation or not.

When a structural glued laminated timber member is used, you can specify the type of edge joint bonding and decide whether the *Shear Reduction Factor* C_{vr} is to be used.

For round timber poles and piles, it is necessary to specify the treatment condition (air-drying, kiln-drying, steam-conditioning, or boultonizing) and the load sharing condition (single pile or pile in group) so that the appropriate *Condition Treatment Factor C*_{ct} and *Load Sharing Factor C*_{ls} are applied.

The members can be filtered by *Material Category* via the list box below the table.

The other buttons have the following functions:

Button	Function
	Export of table to MS Excel or OpenOffice.org Calc
1	Option to select member graphically in RFEM window and set its row in table
۲	View mode for switching to RFEM work window

Table 2.5: Buttons in Window 1.9 Additional Design Parameters

If the *Set inputs for members No.* check box has been activated, the settings entered <u>afterward</u> will be applied to the selected or to *All* members. Members can be selected by entering their numbers or by selecting them graphically using the [[\]] button. That option is useful when you want to assign identical conditions to several members.





2.10 Curved Members

This window is available when you have selected at least one member with a curved shape in Window 1.1 *General Data* for the design. Curved members can be defined, for example, by using the line types "spline" or "arc".

The design of curved members is possible only for rectangular cross-sections and materials according to [2] Table 5A, Table 5B, Table 5C and Table 5D (i.e. structural glued laminated timber).

	A I	B	С	D	E	F
lember	Laminate	Minimum Rad	lius of Curvature (Insid	de Face)	Radial Stress	
No.	t [in]	R _{MIN} [ft]	t/R		Design	Comment
2	1.5	46.69	1 / 373.534	≤ 1 / 100.000	2	
Set inpu	t for members No.:					
			TA VAL			

Figure 2.31: Window 1.10 Curved Members

Laminate

In this column, you have to specify the thickness t of the lamellas.

Minimum Radius of Curvature (Inside Face)

The program checks the ratio of the thicknesses of the lamellas and the minimal radius of curvature (inside face of member). According to [1] 5.3.8, the design is allowed only for ratios not exceeding 1/100 (hardwoods and Southern Pine) or 1/125 (other softwoods).

Radial Stress Design

Optionally RF-TIMBER AWC performs a check of the radial stresses. Where the bending moment is in the direction tending to increase the radius, the radial stress shall not exceed the adjusted radial tension design value, unless mechanical reinforcing sufficient to resist all radial stress is used. Where the bending moment is in the direction tending to decrease the radius, the radial stress shall not exceed the adjusted radial compression design value.

2.11 Serviceability Data

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

	A	В	C	D	E	F	G	Н	
		Member	Reference Length		Direc-	Precamber			
lo.	Reference to	No.	Manually	L [ft]	tion	w _{o,x} [in]	w _{o,y} [in]	Beam Type	Comment
1	Member 👱	1		5.50	x; y	0.0	0.0	Cantilever End Free	
2	Member	2		14.00	у		0.0	Beam	
3	Member	3		8.00	у		0.0	Beam	
4	Member	4		8.00	у		0.0	Beam	
5	Member	5		8.00	R	0.0	0.0	Cantilever End Free	
6	Member	6		8.00	у		0.0	Beam	
7	Member	7		5.00	у		1.0	Beam	
8	Member	8		5.50	X; y	0.0	1.0	Beam	
9	Set of Members	1		32.00	x	0.0		Beam	
0	Set of Members	2		16.00	x	0.0		Beam	
1	Set of Members	3		14.00	R	0.0	0.0	Beam	
2	List of Members	102,121		32.00	у		0.0	Beam	
13	List of Members	2,85,8,26		16.00	у		0.0	Beam	
4									
15									
6									
17									
8									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									

Reference to
Set of Members
List of Members
Set of Members

Figure 2.32: Window 1.11 Serviceability Data

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

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

Column E controls the governing *Direction* for the deformation analysis. You can select the directions of the local member axes x and y (see Chapter 2.3, page 19 for the axis systems) and the resultant direction R.

In columns F and G, you can allow for some Precamber $w_{c,x}$ and $w_{c,y}$.

The *Beam Type* is important to correctly determine the limit deformations. Column H controls whether there is a beam or a cantilever and which end is not supported.

The settings in the *Serviceability* tab of the *Details* dialog box control whether the deformations are related to the undeformed initial model or to the shifted ends of members or sets of members (see Figure 3.3, page 40).



....



Details...



2.12 Fire Resistance - Members

This window manages the different fire resistance parameters. It is only available if you have set relevant entries in the *Fire Resistance* tab of Window 1.1 *General Data* (see Chapter 2.1.3, page 12).

	A	B	C	D	E	F	G
		Exp. to Fire		Exp. ti	o Fire		
0.	Members No.	Four Sides	Тор	Bottom	Left	Right	Comment
	3-6			V	2	I	
2	2,7,8		~	2			
}	1	V	1	I	1	1	
ŀ							
i							
;							
3							
9							
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
0							
1							
2							
3							
							*

Figure 2.33: Window 1.12 Fire Resistance - Members

...

Table column A contains the members that are to be taken into account for the fire resistance design. Click [...] to graphically select the members in the RFEM work window.

In column B you specify if there is an *Exposure 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 columns become available in which you can specify the sides that are exposed to fire. The ideal remaining cross-section is then computed with those assumptions.

Details...

The general parameters of the fire resistance analysis are managed in the *Details* dialog box, tab *Fire Resistance Design* (see Figure 3.4, page 41).



2.13 Fire Resistance - Sets of Members

This window manages the fire resistance parameters of sets of members. It is displayed when you have selected one or more sets of members in Window 1.1 *General Data* and have allocated specific load cases or combinations in the *Fire Resistance* tab of that window.

	A	B	C	D	E	F	G
		Exp. to Fire		Exp.	to Fire		
h	Sets of Members No.	Four Sides	Тор	Bottom	Left	Right	Comment
1				V	2	•	
2		- T	<u> </u>	<u> </u>	Ē	- F	
3	2		2		2	2	
)							
2							
3							
1							
5							
5							
7							
3							
3							
)							
2							
3							
1							
5							
6							
7							
3							
3							
)							
2							
3							
							*

Figure 2.34: Window 1.13 Fire Resistance - Sets of Members

The set-up of this window is similar to the one of the previous Window 1.12 *Fire Resistance - Members*. Here you can define the sides of the cross-section that are exposed to fire for the relevant set of members (see Chapter 2.12).



2.14 Tapered Members

This window is only available when you have selected at least one member with different cross-sections on both member ends for the design in Window 1.1 *General Data*. This window manages criteria such as the angle of taper of variable cross-sections, for example.

The design of curved members with variable cross-sections is possible only for rectangular sections and materials according to [2] Table 5A, Table 5B, Table 5C and Table 5D.

Figure 2.35: Window 1.14 Tapered Members

Cross-Section

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

Length L

In this column, you can check the length of each tapered member.

Angle of Taper θ

RF-TIMBER AWC determines the inclination of the taper on the basis of geometric conditions. This angle is displayed for your information.

Grain Parallel to Edge

In column E, you specify the side of the member to which the direction of the grain is parallel. The "top" and "bottom" edges are clearly determined by the orientation of the local member axes z and y (see Figure 2.27, page 28).

In most cases, the grain runs parallel to the edge that is located in the direction of the positive axis + z/+y ("bottom"). This means that the beam is cut at its top side (see figure below).




Figure 2.36: Grain parallel to edge in direction +z/+y

If the grain is parallel to the negative axis -z/-y ("top"), then the tapered member is cut at the bottom side. This case is an exception because taper cuts on the tension face of beams are not recommended according to [1] Chapter 5.3.9.

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Figure 2.37: Grain parallel to edge in direction -z/-y



3. Calculation

3.1 Detail Settings

Details...

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

The Details dialog box contains the following tabs:

- Resistance
- Stability
- Serviceability
- Fire Resistance (ASD only)
- Other

3.1.1 Resistance

tails														X
Resistance	Stability	Serviceability	Fire Resistance	Other										
Considerati	on of Conr	rections												1
Reduct	ion of limit	tension stresses	3											
At nodes N	lo.:													
1,3-6,8-10			1											
Connection	length:	Г	0.80 🛋 🖽											
Stress ratio	inside		0.00 • [1]											
connection	IS:		60.00 🚔 [%]											
Stress ratio	outside		100.00 🚔 [%]											
connection	5.													
Positive or I	Vegative B	ending About y	/x-Axis											
Bottom	of member	rs is considered	in local +z/y-axis											
Bottom	of membe	rs is considered	in local -z/v-axis											
0														
Limit Value	for Specia	Cases												
Torgion														
 Allow fu 	uther desid	n if shear stres	s due to torsion											
does n	ot exceed	limit:												
ftor/Fv	≤	0.05 🚔												
Ignore t	orsion													
														1
									_		_			
2 0.00	3	h ur								ОК		C	ancel	

Figure 3.1: Dialog box Details, tab Resistance

Consideration of Connections

Often zones near member connections imply some weakening of the cross-section. It is possible to take into account this effect by a *Reduction of limit tension stresses*.

The numbers of the relevant *nodes* can be entered manually or selected graphically by clicking the [[\]] button.

\$



The *Connection length* defines the zone on the member where reduced stresses are considered. In the text box below, enter the allowable stress ratio for *Inside connections* in percent. If necessary, you can define the maximum design ratio for *Outside connections* of the connection zone.

Positive or Negative Bending About y/x-Axis

Structural glued laminated timber members stressed in bending about the y/x-axis have different reference bending design values for positive bending (bottom of beam stressed in tension) and negative bending (top of beam stressed in tension), see [2] Table 5A and Table 5C.

For RF-TIMBER AWC to apply the correct bending design value, you have to specify where the bottom side of members is located in the positive direction of the local z/y-axis or opposite.

Limit Value for Special Cases

Torsion design is not specified in ANSI/AWC NDS-2012. It is possible to ignore shear stresses due to torsion if a user-defined ratio of the torsional shear resistance is not exceeded (default: 5%). If the limit is exceeded, a note appears in the result window. This limit setting is not part of the Design Specification [1]. Changing the limit is the responsibility of the user.

It is also possible to completely *Ignore torsion*.

3.1.2 Stability

ails							2
Resistance	Stability	Serviceability	Fire Resistance	Other			
tability An	alysis						
Check s	tability						
 Stability 	analysis a	ccording to equi	ivalent member me	thod	-		
(requires	definition	of buckling leng	gths)				
Stress/s	tability and	alysis according	to second order th	ieory			
(requires	Gennicion	or imperiections	S III I'\FEM)				
and the second se							_

Figure 3.2: Dialog box Details, tab Stability

Stability Analysis

The *Check Stability* check box controls whether to run, in addition the cross-section design, a stability analysis. If you clear the check box, the input windows 1.7 and 1.8 will not be shown.

3 Calculation



Method of Analysis

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

Equivalent member method: Setting method of analysis in RFEM



The *equivalent member method* uses the internal forces determined in RFEM. In this method, make sure that the **Geometrically linear static analysis** has been set (the default setting for load combinations is the 2nd order analysis). When you perform the stability analysis according to the equivalent member method, the effective lengths of the members and sets of members subject to compression or compression and bending must be specified in windows 1.7 and 1.8.

If the bearing capacity of the model is significantly affected by its deformations, we recommend selecting a calculation according to the *second order theory*. This approach additionally requires the definition of imperfections in RFEM and their consideration for the load combinations. The flexural buckling analysis is carried out during the calculation of the load combinations in RFEM.

The lateral-torsional buckling design must also be carried out for second order calculations. Thus, the lateral-torsional buckling lengths of members or sets of members must be specified in windows 1.7 and 1.8 *Effective Lengths* manually. This provision ensures that the lateral-torsional buckling analysis is performed with the appropriate factors (for example 1.0).

3.1.3 Serviceability

etails	
Resistance Stability Serviceability Fire Resistance Other	
Servicability (Deflections)	
Limiting deflection: L/ 360	
Deformation relative to:	
Shifted members ends / set of member ends	
Onderormed system	
	OK Cancel

Figure 3.3: Dialog box Details, tab Serviceability

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

With the options, you can decide whether the deformations is to be related to the *Shifted ends* of members or sets of members (i.e. connection line between start and end nodes of the deformed system) or to the initial *Undeformed system*. As a rule, the deformations have to be checked relative to the displacements in the entire structural system.



3.1.4 Fire Resistance

This tab manages the detailed settings for the fire resistance design (ASD only).

tails	
Resistance Stability Serviceability Fire Resistance Other	
Required Fire Resistance	
Exposure time:	
1 1/2-hour	
© 2-hour	
45 ÷ [min]	
2 🚾 🕥 🕼 🕼	OK Cancel

Figure 3.4: Dialog box Details, tab Fire Resistance

be set in the Standard dialog box (see Figure 2.9, page 13).

The *Exposure time* can be selected directly or defined individually by specifying the duration of the fire.

Additionally, some standard-specific parameters significant for the fire resistance design can

Standard...



3.1.5 Other

Details	×
Resistance Stability Serviceability Fire Resistance Other	
Cross-Section Optimization	Display Result Windows
Max allowable design ratio:	2.1 Design by Load Case
	✓ 2.2 Design by Cross-Section
Check of Member Slendernesses	☑ 2.3 Design by Set of Members
- Flexure RB < 50 🚔	2.4 Design by Member
	✓ 2.5 Design by x-Location
	☑ 3.1 Governing Internal Forces by Member
	3.2 Governing Internal Forces by Set of Members
	3.3 Member Slendemesses
	✓ 4.1 Parts List by Member
	✓ 4.2 Parts List by Set of Members
	Only for members / sets to be designed
	Of all members / sets of members
	OK Cancel

Figure 3.5: Dialog box Details, tab Other

Cross-Section Optimization

The optimization is targeted at the maximum design ratio of 1.00. If necessary, you can specify a different limit value in this text box.

Check of Member Slendernesses

In the two text boxes, you can specify the limit values of the member slenderness. You can define the rations separately for members with bending, R_B , and for members with compression, I_{ei}/d_i .

The limit values are compared to the real member slendernesses in Window 3.3. This window is available after the calculation (see Chapter 4.8, page 51) when the corresponding check box is selected in the *Display Result Windows* section of this dialog box.

Display Result Windows

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

The 3.3 Member Slendernesses window is deactivated by default.



3.2 Start Calculation

Calculation

To start the calculation, click the [Calculation] button which is available in all input windows of the RF-TIMBER AWC add-on module.

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

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

To Calculate					
Load Cases / (Combinations / Module Cases Result Tables				
Not Calculated	1			Selected for C	Calculation
No.	Description	-		No.	Description
No. 2 D LC1 L LC2 S LC3 W LC4 FES C01 FES C02 FES C03 FES C04 FES C05 FES C06 FES C06 FES C07 FES C08 FES C01 FES C05 FES C06 FES C07 FES C01 FES C01 FES C05 FES C06 FES C07 FES C01 FES C07 FES C01 FES C07 FES C01 FES C07 FES C01 FES C07 FES C01 FES C07 FES C01 FES	Dead Live Snow Wind 1.4*LC1 1.2*LC1 + 1.6*LC2 1.2*LC1 + 1.6*LC2 1.2*LC1 + 1.6*LC2 1.2*LC1 + 1.6*LC3 1.2*LC1 + 1.6*LC3 1.2*LC1 + 1.6*LC3 + 0.8*LC4 1.2*LC1 + 1.6*LC3 + 0.8*LC4 1.2*LC1 + 1.6*LC3 + 0.8*LC4 1.2*LC1 + 1.6*LC3 + 1.6*LC4 1.2*LC1 + 1.6*LC3 + 1.6*LC4 1.2*LC1 + 1.6*LC4 1.2*LC1 + 1.6*LC4 LC1 + LC3 LC1 + LC3 LC1 + LC3 LC1 + LC3 LC1 + 0.7*LC2 + 0.75*LC3 + 0.75*LC3	III	A X Q	No. CA1	RF-TIMBER AWC -
2.4 CO19 2.4 CO20	LC1 + 0.75*LC3 + 0.75*LC4	Ŧ	-		-
All	•	٩			
Ø P I					OK Cancel



Figure 3.6: Dialog box To Calculate

If the RF-TIMBER AWC cases are missing in the *Not Calculated* section, select *All* or *Add-on Mod-ules* in the drop-down list below the section.

To transfer the selected RF-TIMBER AWC cases to the list on the right, use the [▶] button. Click [OK] to start the calculation.

To calculate a design case directly, use the list in the toolbar. Select the RF-TIMBER AWC case in the toolbar list, and then click [Show Results].

<u>O</u> ptions	<u>A</u> dd-on Modules	<u>W</u> indow <u>H</u> elp	
🔳 💁	RF-TIMBER AWC C	A1 - Design Accord	ir 🝸 🗢 👂 🎦 🎦 🔗 💴 🕼 🕼 🛤 🕸 -
🗟 - 🌔	🖞 - I 🕽 - 🎙 I	🍇 🏂 🗐 🖏 -	🗄 💥 🔍 🍳 🗊 🗗 Show Results 就 - 🛂 - 🌚 -

Figure 3.7: Direct calculation of a RF-TIMBER AWC design case in RFEM

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



4. Results

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

File Edit Settings Help															-
Cál - Design áccording to ANS	2.1 Desia	n by Load Case													
land Data															
General Data		A	B	C	D	E				F				G	4
- General Data	Load	1.21	Member	Location										Load	
Materials	ing	Description	No.	x [ft]	Design				Desig	n According	g to Formula			Duration	
- Lross-Sections		Ultimate Limit State Design													
Load Duration	CO1		3	8.00	0.16	≤1	131) - Cr	ross-section resista	ance - Sti	ength in be	ending about y	/x-axis acc. to 3.3	P	ermanent	
In-Service Conditions - Member	C02		7	2.50	0.96	≤ 1	311) - St	tability - Bending a	bout y/x-	axis with L1	FB acc. to 3.3		T	en Years	
- In-Service Conditions - Set of M	CO3		7	2.50	0.84	≤1	311) - St	tability - Bending a	bout y/x-	axis with L1	FB acc. to 3.3		T	vo Month	
Effective Lengths - Members	C04		3	8.00	0.66	≤ 1	131) - Cr	ross-section resista	ance - Sti	ength in be	ending about y	/x-axis acc. to 3.3	Ts	vo Month	
Effective Lengths - Sets of Men	C05		3	8.00	0.66	≤1	131) · Cr	ross-section resista	ance - Sti	rength in be	ending about y	/x-axis acc. to 3.3	Tu	vo Month	
- Additional Design Parameters	C06		3	8.00	0.53	≤ 1	131) - Cr	ross-section resista	ance - Sti	ength in be	ending about y	/x-axis acc. to 3.3	Te	en Minute	
esuits	C07		7	2.50	0.43	≤1	311) - St	tability - Bending a	bout y/x-	axis with L1	FB acc. to 3.3		Te	en Minute	
- Design by Load Lase	C08		7	2.50	0.43	≤1	311) - St	tability - Bending ai	bout y/x-	axis with L1	FB acc. to 3.3		Te	an Minute	
- Design by Cross-Section	C09		3	8.00	0.22	≤ 1	131) - Cr	ross-section resista	ance - Sti	rength in be	ending about y	/x-axis acc. to 3.3	Te	en Minute	
— Design by Set of Members — Design by Member				Max:	0.96	≤ 1	3			[%	🛼 🗞 🔮	1	1	
- Design by x-Location	Dataila I	Mambar 2 x 9.00 € CO1										4 T Bartanda 62	00.405		i
Coverning Internal Forces by M	Detens - i	al Data - 24E-1 7E - 24E3/1 - S	P/SP Loa	Hed Pern to \	Vide Faces	oflam	e A or M	fore Lame				1 - T-Rectangle 5/.	0.125		
Parts List by Manhar	E Froes	section Data - T-Rectandle 5	/26.125	souri cip. to s	10010000	or Lan	15, 4 01 14	TOTO Editio							
Parts List by Melliber	Desig	social Para Theodal gib a	20.120												
- Paits List by Set of Mellibers	A direct	ment Factors													
	E Desig	Batio										+	5.0		
	Ber	ding Moment					bd	22400.1	ILEFFE						
	Sec	tion Modulus					Su	568.8	in3						
	Act	ual Rending Stress					fin.	472.61	nei	_					
	Pw	tially Adjusted Rending Design	Value				ELLE	2109.96	pei						
		co.Section Breadth	i value				b.	5100.50	in			5			
	Cro	ss-Section Depth					d	201	in			26			
	Lor	ath Potween Points of Zoro k	Iomonto				1	20.1	6						
	Cor	vetant	romonta					20	IX.						
	Vol	me Factor					0.2	0.943		_	Fa (5.3.1		1		
	Ada	unter actor ustad Randing Davian Value					Eur	2021.64	nei		Eq. (5.54	+	T		
	Der	view Disting					1 DX	2001.04	Pa	<1	Fa (2.2.1		÷ .		
	- 06	ayri nado					η	0.15		21	EQ. (3.3.1		У		
												0	X	T I	
	-									1					
	Calculatio	on <u>D</u> etails Sta	ndard		Gra	aphics						0	K 🗌 🛛	Cance	į

Figure 4.1: Results window with designs and intermediate values

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

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



OK

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

To save the results, click [OK]. You exit RF-TIMBER AWC and return to the main program.

Chapter 4 *Results* describes the different results windows one by one. Evaluating and checking results is described in Chapter 5 *Evaluation of Results* starting on page 54.

As there are different axis systems in RFEM and RF-TIMBER AWC (see Chapter 2.3, page 18), there are also different names of the internal forces, deformations and cross-section values.

I	NTERNAL FORCES		DEFORMATIONS	cross section ch	aracteristic v	alue
RFEM	RF-TIMBER AWC	RFEM	RF-TIMBER AWC		RFEM	AWC
N	P (compression); T (tension)	u _x	uz	Moment of inertia	ly	l _x
Vy	Vy	uy	u _x	Moment of inertia	ا _z	l _y
Vz	V _x	Uz	u _y	Elastic section modul	us S _y	Sx
MT	M _{tor}	fi _x	fiz	Elastic section modul	us S _z	Sy
My	M _x	fi _y	fi _y	Statical moment of an	ea Q _y	Qx
Mz	My	fiz	fi _x	Statical moment of an	ea Q _z	Qy
				Section modulus for to	orsion S _t	Stor

Figure 4.2: Comparison between RFEM and RF-TIMBER AWC internal forces, deformations and cross-section values





4.1 Design by Load Case

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

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

1 Desig	in by Load Case														
	A	В	C	D	E				F					(à
Load-		Member	Location											Lo	ad
ing	Description	No.	x [ft]	Design				Des	ign Accordi	ng to Formula				Dur	ation
	Ultimate Limit State Design														
C013		7	2.50	0.92	≤ 1	311) - Stab	oility · Bending a	bout y/x	-axis with L1	B acc. to 3.3				Ten	Years
C014		3	8.00	0.65	≤ 1	131) · Cros	s-section resist	ance - St	rength in be	nding about y.	/x-axis acc	c. to 3.3		Two h	vionth
	Serviceability Limit State Des	ign													
C012		3	8.00	0.36	≤1	401) · Serv	/iceability - Defl	ection in	z/y-directior	n (Beam)				Perm	anen
	Fire Resistance Design														
C012		3	8.00	0.87	≤ 1	811) - Fire	resistance - Bei	nding ab	out y/x-axis	with LTB acc.	to 3.3			Perm	anen
			May	0.92	21					»/ (<u>e</u> . (9		2.6	9		
			max.	0.52	21	•						·>1 [-
hataile -	Member 7 - v: 2.50 ft - CO13										2 TRo	ctencie i	544		
⊡ Mater	rial Data - Ponderosa Pine, 5"v	5″ and Lar	ier Reams ar	d Stringers	No 1						2 - 1-100	cialigie .	3/14		
El Cross	-section Data - T-Bectangle 5/	/14	joi, boanis ai	ia o angoro,	110.1										
El Desig	in Internal Forces	14													
⊡ Dosig ⊞ ∆dius	tment Factors														
El Desir	in Batio											+	5.0 +		
Be	ndina Moment					Mx	11319.9	lbfft							
- Se	ction Modulus					Sy	163.3	in ³							
- Ac	tual Bending Stress					fbx	831.67	DSi							
- Pa	rtially Adjusted Bending Design	Value				Eh*	909.29	DSi							
- Eff	ective Span Length					le	5.00	ft				4.0			
- Sle	nderness Ratio					Re	5.80	-		Eq. (3.3-5		-			x
Ad	justed Modulus of Elasticity for	Stability Ca	lculations			Emin'	400000.00	psi							
- Crit	tical buckling design value for t	pending me	mbers			Fbe	14285.70	psi		3.3.3.8					
Be	am Stability Factor					CL	0.997			Eq. (3.3-E					
— Adi	justed Bending Design Value					Fbx'	906.22	psi					1		
- De	sign Ratio					η	0.92		≤ 1	3.3.1			y		
	-														
															fie."
													_		ĮIN,
											0			≤ (†÷	X
						1	1	-							

Figure 4.3: Window 2.1 Design by Load Case

Description

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

Member No.

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

Location x

The column shows the x-location at which the maximum design ratio of each member occurs. For the table output, the program uses the following member x-locations:

- Start and end node
- Division points according to possibly defined member division (see RFEM table 1.16)
- Member division according to specification for member results (RFEM dialog box *Calculation parameters*, tab *Global Calculation Parameters*)
- Extreme values of internal forces

Design

Columns D and E show the design conditions according to ANSI/AWC NDS-2012 [1].

The lengths of the colored scales represent the respective utilizations.



0.85 ≤1 🥹

Max:



Design According to Formula

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

Load Duration

In table column G, the load duration classes defined in Window 1.4 are listed (see Chapter 2.4, page 23).

4.2 Design by Cross-Section

2.2 Desig	n by Cros	s-Section													
	A	В	С	D	E					F					*
Section	Member	Location	Load												
No.	No.	x [ft]	ing	Design					Design A	According to	Formula				
2	T-Rectar	igle 5/14													
	2	5.50	CO13	0.34	≤ 1	111) · Cross-section	resistance	 Strength in sh 	ear due I	to shear for	ce Vz/Vx acc.	to 3.4			
	7	2.50	CO13	0.91	≤ 1	131) - Cross-section	resistance	 Strength in be 	nding ab	out y/x-axis	acc. to 3.3				
	7	2.50	CO13	0.92	≤ 1	311) - Stability - Ben	ding about	y/x-axis with L1	B acc. t	o 3.3					
	2	5.50	CO12	0.02	≤ 1	611) - Fire resistance	e - Strength	n in shear due to) shear fo	orce Vz/Vx	acc. to 3.4				-
	7	2.50	CO12	0.02	≤ 1	631) - Fire resistance	e - Strength	in bending abo	out y/x-a:	kis acc. to 3	.3				=
	7	2.50	CO12	0.02	≤1	811) - Fire resistance	e · Bending	about y/x-axis	with LTB	acc. to 3.3	}				_
	T.O. 1. 4														_
3	I-Lircle I	2 14.00	0014	0.07	21	102) Creat continu		Chanath in an		us marallal ta	arnin nee te '	26			_
		14.00	LU14	0.07	21	TU2J · Cross-section	resistance	 strength in co 	mpressio	n parallel to	grain acc. to .	5.6			+
			Max	0.92	≤ 1	•					Y 😜 🤋	5	751 😂] 🖪 🐧	۲
Details - I	Member 2	- x: 5.50 ft -	CO13									2 - T-Re	ctangle 5/14	4	
🕀 Materi	al Data - F	onderosa Pir	ne, 5°x5° a	and Larger, B	eam	and Stringers, No.1							-		
⊕ Cross-	section Da	ata - T-Recta	ngle 5/14												
🕀 Design	n Internal F	orces													
🕀 Adjust	ment Fact	ors											6	0	
🕀 Desig	n Ratio													<u> </u>	
- She	ear Force						Vx	2079.8	lbf				+		
- Cro	ss-Section	al Area					A	70.0	in ²						
Act	ual Shear	Stress Paralle	l to Grain				fv	44.57	psi						
Adj	usted She	ar Design Val	ue Paralle	l to Grain			Fv'	130.00	psi		F (0.4.4		- I		
- Des	sign Hatio						η	U.34		51	Eq. (3.4.1		ž 🛛 🕅		··• x
							ļ								
								-							
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							-						+		
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<u> </u>								+							[in]
												0		👗 芹	X

Figure 4.4: Window 2.2 Design by Cross-Section

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

For tapered members, both cross-section descriptions are displayed in the table row next to the cross-section number.



4.3 Design by Set of Members

Set No. Member No. Load- ing Design Design According to Formula 1 (Member No. 36) 0.42 51 111) - Cross-section resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4 3 8.00 C014 0.65 51 131) - Cross-section resistance - Strength in shear due to shear force Vz/Vx acc. to 3.3 5 8.00 C012 0.00 51 400) - Serviceability - Dediction in 2/ydirection (Beam) 5 8.00 C012 0.03 51 611) - Fire resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4 3 8.00 C012 0.03 51 611) - Fire resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4 3 8.00 C012 0.02 51 631) - Fire resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4 3 8.00 C012 0.02 51 631) - Fire resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4 3 8.00 C012 0.027 51 811) - Fire resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4 3 8.00 C012 0.027 51										E	D	L	в	A		
No. x [N] ing Design Design According to Formula 1 (Member No. 34)												Load-	Location	Member	Set	
1 (Member No. 3-6) 5 8.00 C014 0.42 ≤ 1 111) - Cross-section resistance - Strength in hear due to shear force V2/Vx acc. to 3.4 3 8.00 C014 0.65 ≤ 1 131) - Cross-section resistance - Strength in hearding about y/x-axis acc. to 3.3 3 8.00 C014 0.65 ≤ 1 131) - Cross-section resistance - Strength in hearding about y/x-axis acc. to 3.3 5 8.00 C012 0.03 ≤ 1 401) - Serviceability - Negligible deformations 3 8.00 C012 0.33 ≤ 1 401) - Serviceability - Negligible deformations 3 8.00 C012 0.37 ≤ 1 11) - Fire resistance - Strength in heard due to shear force Vz/Vx acc. to 3.4 3 8.00 C012 0.37 ≤ 1 11) - Fire resistance - Strength in heard about y/x-axis with LTB acc. to 3.3 3 8.00 C012 0.87 ≤ 1 11) - Fire resistance - Strength in bending about y/x-axis with LTB acc. to 3.3 Max 0.92 ≤ 1 11) - Fire resistance - Strength in bending about y/x-axis with LTB acc. to 3.3 Colspan="2">Stort - Colspan="2">Stort - Colspan="2">Colspan="2">Colspan= Stort - Colspan="2">Colspan= Colspan="2">Colspan="2"				Formula	ccording to	Design A					Design	ing	x [ft]	No.	lo.	
5 8.00 C014 0.42 ≤1 111) - Cross-section resistance - Strength in bend ue to shear force V2/Vx acc. to 3.3 3 8.00 C014 0.65 ≤1 131) - Cross-section resistance - Strength in bending about y/x-axis acc. to 3.3 5 8.00 C014 0.05 ≤1 131) - Cross-section resistance - Strength in bending about y/x-axis acc. to 3.3 5 8.00 C012 0.03 ≤1 401) - Serviceability - Deletiction in z/y direction (Beam) 5 8.00 C012 0.23 ≤1 401) - Serviceability - Deletiction in z/y direction (Beam) 5 8.00 C012 0.23 ≤1 811) - Fire resistance - Strength in bending about y/x-axis with LTB acc. to 3.3 3 8.00 C012 0.27 ≤1 811) - Fire resistance - Strength in bending about y/x-axis with LTB acc. to 3.3 3 8.00 C012 0.87 ≤1 811) - Fire resistance - Strength in bending about y/x-axis with LTB acc. to 3.3 Max 0.92 ≤1 811) - Fire resistance - Strength in bending about y/x-axis with LTB acc. to 3.3 Max 0.92 ≤1 S11) - Fire resistance - Strength in bending about y/x-axis with LTB acc. to 3.3													No. 3-6)	(Member	1	
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alis - Member 3 - x 8.00 ft - CO12 Material Data - 24F-1.7E, 24F-V1, SP/SP, Loaded Perp, to Wide Faces of Lams, 4 or More Lams Cross-section Data - T-Rectangle 5/26.125 Definemations Deflection z Maximum V Deflection y Deflection n Deflection y Deflection n Deflection ne Inhe Middle Span Camber in the Middle Span Camber in the Middle Span Camber on K-0000 in Everence Span L X2000 ft Limiting Deflection (Relative) Limiting Deflection (Relative) Limiting Deflection (Relative) Limiting Deflection (Relative) Mation Design Ratio Mation	8	1 🛀 🖪) 🖹 🖄						9	≤ 1	0.92	Max:				
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Figure 4.5: Window 2.3 Design by Set of Members

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

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

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



4.4 Design by Member

	A	В	С	D						E						
vlember	Location	Load														
No.	x [ft]	Case	Design					De	esign Acc	c. to Formula	3					
1	Cross-sectio	n No. 3 -	T-Circle 12													
	14.00	C014	0.07	≤1	102)	 Cross-section resis 	tance - Strength in	compression	parallel I	o grain acc.	to 3.6					
	14.00	C014	0.09	≤1	303)	 Stability - Compres 	sion parallel to grair	n with bucklir	ng about	both axes a	cc. to 3.6 and	13.7				
	0.00	C012	0.01	≤1	602)	 Fire resistance - SI 	rength in compress	ion parallel to	o grain ac	c. to 3.6						
	0.00	C012	0.03	≤ 1	803)	 Fire resistance - C 	3.7									
2	Cross-sectio	n No. 2 -	T-Rectangle	5/14	ļ.											
	5.50	C013	0.34	≤1	111)	 Cross-section resis 	tance - Strength in	shear due to	shear fo	rce Vz/Vx a	cc. to 3.4					
	0.00	C013	0.91	≤ 1	131)	 Cross-section resis 	tance - Strength in	bending abo	ut y/x-ax	is acc. to 3.	3					
	0.00	C013	0.92	≤1	311)	 Stability - Bending 	about y/x-axis with	LTB acc. to	3.3							_
		Max:	0.92	≤ 1	۲					<	Y 😜 🤋	8	% 1	2	ه 🖌	
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E Desig ⇒ Adjus ⇒ Cor F 1 ((L	n Internal Ford timent Factors npression Stre Reference Cou Cemperature F Condition Trea Critical Section Load Sharing I	ces mpression Factor atment Fac n Factor Factor	ı Design Valu stor	e			Fo Ct (Fo) Cot (Fo) Cos (Fo) Cis (Fo)	1300.00 1.000 1.000 1.000 1.000	psi		Table 6A 6.3.4 6.3.5 6.3.9 6.3.11	12.0	_			
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Desig Adjust Cor F Co C C	n Internal Ford Iment Factors Reference Cor Temperature F Condition Trea Critical Section Load Sharing I Load Duration	ces mpression Factor atment Fac n Factor Factor Factor pression D	Design Valu ctor Design Value	e			Fo Ct (Fo) Cos (Fo) Cls (Fo) Cls (Fo) CD (Fo) Fo*	1300.00 1.000 1.000 1.000 1.000 1.150 1495.00	psi psi		Table 6A 6.3.4 6.3.5 6.3.9 6.3.11 6.3.2	12.0				
Desig Adjust Cor F Co F C C	n Internal For Iment Factors mpression Stre Reference Cou femperature F Condition Trea Critical Section Load Sharing I Load Duration Adjusted Comp n Ratio	ces mpression Factor h Factor Factor i Factor pression D	Design Valu ctor Design Value	ie			Fo Ct (Fo) Cos (Fo) Cis (Fo) CD (Fo) Fo [*]	1300.00 1.000 1.000 1.000 1.000 1.150 1495.00	psi psi		Table 6A 6.3.4 6.3.5 6.3.9 6.3.11 6.3.2	12.0				
Desig Adjust Cor F Cor C C C C C C C C C C	n Internal Foro Iment Factors npression Stre Reference Con femperature F Condition Tree Critical Section Load Sharing I Load Duration Adjusted Comp n Ratio npressive For-	ces mpression Factor atment Fac n Factor Factor Factor pression D ce	Design Valu ctor Design Value	ie			Fo Cr (Fo) Cat (Fo) Cos (Fo) Cls (Fo) CD (Fo) Fo*	1300.00 1.000 1.000 1.000 1.150 1495.00 12580.0	psi psi lbf		Table 6A 6.3.4 6.3.5 6.3.9 6.3.11 6.3.2	12.0				
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Desig Adjust Cor F O Cor C	In Internal Force iment Factors procession Stream Condition Tree Critical Section Coad Sharing I Load Duration Adjusted Compr In Ratio mpressive For ss-Sectional A ual Compress tially Adjusted sign Ratio	ces mpression Factor n Factor Factor Factor pression D ce Area ive Stress I Compres	Design Value Stor Design Value Parallel to G sive Design N	rain rain	Paral	iel to Grain	$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	1300.00 1.000 1.000 1.100 1.150 1495.00 112580.0 113.1 111.23 1495.00 0.07	psi psi lbf in ² psi psi	≤1	Table 6A 6.3.4 6.3.5 6.3.9 6.3.11 6.3.2 Eq. (3.6.5	12.0		Y		
Desig Adjust Cor F Cor F Cor Co	In Internal Force iment Factors procession Stream Condition Tree Zinical Section Load Sharing I Load Duration Adjusted Comp In Ratio mpressive For sss-Sectional / Jual Compress tially Adjusted sign Ratio	ces mpression Factor Factor Factor Factor Factor pression D ce Area ive Stress I Compres	Design Valu Stor Design Value Parallel to G sive Design \	rain /alue	Paral	iel to Grain	F₀ C₀ C₀	1300.00 1.000 1.000 1.000 1.150 1495.00 12580.0 113.1 111.23 1495.00 0.07	psi psi lbf in ² psi psi	<u></u>	Table 6A 6.3.4 6.3.5 6.3.9 6.3.11 6.3.2 Eq. (3.6.3	12.0		, i t		
Desig Adjust Cor F Cor F Cor Co	In Internal Foro Imment Factors Temperssion Stre Temperature F Condition Tree Condition Tree Condition Tree Condition Tree Condition Tree Condition Tree Condition Tree Condition Tree Condition The Condition The Condit	ces mpression Factor Factor Factor Factor Factor pression D ce Area ive Stress	Design Valu Stor Pesign Value Parallel to G sive Design ¹	rain /alue	Paral	iel to Grain	Fo Ct (Fo) Cot (Fo) Cjs (Fo) Cjs (Fo) Cin (Fo) Fo* P A Io Fo*	1300.00 1.000 1.000 1.000 1.150 1495.00 12580.0 113.1 111.23 1495.00 0.07	psi psi lbf in ² psi psi	≤1	Table 6A 6.3.4 6.3.5 6.3.9 6.3.11 6.3.2 Eq. (3.6.3	12.0		¥.		

Figure 4.6: Window 2.4 Design by Member

This results window presents the maximum ratios for the individual designs sorted by member number. The columns are described in detail in Chapter 4.1 on page 45.

4.5 Design by x-Location

.5 Desig	n by x-Loca	uon									
	A	В	С	D					E		
Member	Location	Load									
No.	x [ft]	Case	Design				De	esign Ac	c. to Formula	3	
2	Cross-sectio	n No. 2 -	T-Rectangle	5/14	1						
	0.00	C012	0.00	≤1	111) - Cross-section resistance	e - Strength i	in shear due to	shear fo	rce Vz/Vx a	cc. to 3.4	
	0.00	C012	0.03	≤1	131) - Cross-section resistance	e - Strength i	in bending abo	ut y/x-ax	is acc. to 3.	3	
0.00 C012 0.03 ≤ 1 311) - Stability - Bending about y/x-axis with LTB acc. to 3.3											
0.00 C012 0.00 ≤ 1 111) - Cross-section resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4											
0.00 C012 0.03 ≤ 1 131) - Cross-section resistance - Strength in bending about y/x-axis acc. to 3.3											
0.00 C012 0.03 ≤ 1 311) • Stability • Bending about y/x-axis with LTB acc. to 3.3											
	1.38	C012	0.01	≤1	111) - Cross-section resistance	e - Strength i	in shear due to	shear fo	rce Vz/Vx a	cc. to 3.4	
	1.38	C012	0.02	≤1	131) - Cross-section resistance	e - Strength i	in bending abo	ut y/x-ax	is acc. to 3.	3	
	1.38	C012	0.02	≤ 1	311) - Stability - Bending abou	ıt y∕x-axis wit	th LTB acc. to	3.3			
		Max	0.83	≤ 1	9				[Y 😜 🤋) 🖺 🏹 🕰 🖪 🙆
Details - I	Member 2 - x al Data - Pon section Data n Internal For	: 1.38 ft - iderosa Pi - T-Recta ces	CO12 ne, 5"x5" and ngle 5/14	d Larg	per, Beams and Stringers, No.1						2 - T-Rectangle 5/14
- Nor	mal Force					Na	0.0	lbf			1 0
— She	ear Force					Vx,d	-38.8	lbf			++
— She	ear Force					Vy,d	0.0	lbf			+
- Tor	sional Momer	nt				Td	0.0	lbfft			
— Ber	nding Momen	t				Mx,d	244.9	lbfft			
Ber	nding Momeni					My,d	0.0	lbfft			
🕀 Adjust	ment Factors										14.0
🖃 Desigr	n Ratio										*
— Ber	nding Momen	t				Mx	244.9	lbfft			
- Sec	tion Modulus					Sx	163.3	in ³			
- Act	ual Bending S	Stress				fbx	17.99	psi			
- Par	tially Adjusted	Bending	Design Valu	э		F _b *	818.36	psi			4
— Adji	usted Bendin	g Design ∖	/alue			Fbx'	818.36	psi			У
- Des	sign Ratio					η	0.02		≤1	Eq. (3.3.1	
										-	[in
											0 🛁 🗋 🖄

Figure 4.7: Window 2.5 Design by x-Location



This results window lists the maxima for each member at all *x*-locations resulting from the division points in RFEM:

- Start and end node
- Division points according to possibly defined member division (see RFEM table 1.16)
- Member division according to specification for member results (RFEM dialog box *Calculation Parameters*, tab *Global Calculation Parameters*)
- Extreme values of internal forces

4.6 Governing Internal Forces by Member

3.1 Governing Internal Forces by Member

	A	В	C	D	E	F	G	Н	
Member	Location	Load		Forces [lbf]		M	oments [lbfft]		· · · · · · · · · · · · · · · · · · ·
No.	× [ft]	Case	N	Vy	Vz	Mτ	My	Mz	Design According to Formula
1	Cross-sectio	n No. 3 - 1	T-Circle 12						
	14.00	C014	-12580.0	0.0	0.0	0.0	0.0	0.0	102) - Cross-section resistance - Strength in compression parallel to grain
	0.00	CO16	-2580.0	140.0	0.0	0.0	0.0	327.0	112) - Cross-section resistance - Strength in shear due to shear force Vy/
	14.00	C016	-2580.0	-140.0	0.0	0.0	0.0	327.0	152) - Cross-section resistance - Strength in bending about z/y-axis and c
	14.00	C014	-12580.0	0.0	0.0	0.0	0.0	0.0	303) - Stability - Compression parallel to grain with buckling about both aw
	14.00	CO16	-258 <mark>0.0</mark>	-140.0	0.0	0.0	0.0	327.0	343) - Stability - Bending about z/y-axis without LTB and compression with
2	Cross-sectio	n No. 2 - 1	T-Rectangle	5/14					
	5.50	C012	0.0	0.0	-80.0	0.0	0.0	0.0	111) - Cross-section resistance - Strength in shear due to shear force Vz/
	0.00	C012	0.0	0.0	-25.0	0.0	288.7	0.0	131) - Cross-section resistance - Strength in bending about y/x-axis acc. t
	0.00	C012	0.0	0.0	-25.0	0.0	288.7	0.0	311) - Stability - Bending about y/x-axis with LTB acc. to 3.3
- 2	Cross sostia	n No. 1	T Dootonalo I	5/00 105					
	0.00	C014	15.9	0.0	7500.0	0.0	0.0000	0.0	1111 - Cross-section resistance - Strength in shear due to shear force VzA
	8.00	C014	.0.1	0.0	2500.0	0.0	80000.0	0.0	131) - Cross-section resistance - Strength in bending about u/x-axis acc. t
	8.00	C014	-0.1	0.0	2500.0	0.0	80000.0	0.0	311) - Stability - Bending about v/x-axis with LTB acc. to 3.3
	0.00	0014	0.1	0.0	2000.0	0.0	00000.0	0.0	
4	Cross-sectio	n No. 1 -	T-Rectangle !	5/26.125					
	0.00	C014	0.1	0.0	2500.0	0.0	80000.0	0.0	111) - Cross-section resistance - Strength in shear due to shear force VzA
	0.00	C014	0.1	0.0	2500.0	0.0	80000.0	0.0	131) - Cross-section resistance - Strength in bending about y/x-axis acc. t
	0.00	C014	0.1	0.0	2500.0	0.0	80000.0	0.0	311) - Stability - Bending about y/x-axis with LTB acc. to 3.3
5	Cross-sectio	n No. 1 - 1	T-Rectangle	5/26.125					
	8.00	CO14	68.6	0.0	·12499.8	0.0	0.0	0.0	111) - Cross-section resistance - Strength in shear due to shear force VzA
	0.00	C014	48.1	0.0	- 2 499.8	0.0	60000.0	0.0	131) - Cross-section resistance - Strength in bending about y/x-axis acc. t
	0.00	CO14	48.1	0.0	- 2 499.8	0.0	60000.0	0.0	311) - Stability - Bending about y/x-axis with LTB acc. to 3.3
ь	Cross-sectio	n No. 1 -	I -Hectangle	5/26.125	10100.0	0.0			
	0.00	CU14	68.2	0.0	12499.8	0.0	0.0	0.0	1111 - Lross-section resistance - Strength in shear due to shear force VZ/
	8.00	CU14	47.1	0.0	7499.8	0.0	60000.0	0.0	131) - Cross-section resistance - Strength in bending about WX-axis acc. t
	8.00	CU14	47.6	0.0	7499.8	0.0	60000.0	0.0	311) - Stability - Bending about y/x-axis with LTB acc. to 3.3
7	Cross-sectio	n No. 2 -	I-Bectanole !	5/14					
	0.00	C012	0.0	0.0	25.0	0.0	288.7	0.0	111) - Cross-section resistance - Strength in shear due to shear force VzA

Figure 4.8: Window 3.1 Governing Internal Forces by Member

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

Location x

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

Load Case

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

Forces / Moments

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

Design According to Formula

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



4.7 Governing Internal Forces by Set of Members

	A	В	C	D	E	F	G	Н	
et	Location	Load		Forces [lbf]		М	oments [lbfft]		
D.	x [ft]	Case	N	Vy	Vz	MT	My	Mz	Design According to Formula
	(Member N	o. 3-6)							
	8.00	CO14	68.6	0.0	·12499.8	0.0	0.0	0.0	111) · Cross-section resistance · Strength in shear due to shear force Vz/V
	8.00	CO14	-0.1	0.0	2500.0	0.0	80000.0	0.0	131) - Cross-section resistance - Strength in bending about y/x-axis acc. to
	8.00	CO14	-0.1	0.0	2500 <mark>.0</mark>	0.0	80000.0	0.0	311) - Stability - Bending about y/x-axis with LTB acc. to 3.3
_	(Member N	o. 2,7,8j							
_	5.50	C012	0.0	0.0	-80.0	0.0	0.0	0.0	1111 - Lross-section resistance - Strength in shear due to shear force Vz/V
_	2.50	C012	0.0	0.0	0.0	0.0	320.0	0.0	[131] - Lross-section resistance - Strength in bending about y/x-axis acc. to 2113. Co. LTX - D. L. D. L. LTD.
_	2.50	CU12	0.0	0.0	U.U	0.0	320.0	0.0	311) - Stability - Bending about y/x-axis with LTB acc. to 3.3
	(Member N	n 1)							
	14.00	C014	-12580.0	0.0	0.0	0.0	0.0	0.0	102) - Cross-section resistance - Strength in compression parallel to grain a
	0.00	CO16	-2580.0	140.0	0.0	0.0	0.0	327.0	1121 - Cross-section resistance - Strength in shear due to shear force Vu/V
	14.00	CO16	-2580.0	-140.0	0.0	0.0	0.0	327.0	152) - Cross-section resistance - Strength in bending about z/y-axis and co
	14.00	C014	-12580.0	0.0	0.0	0.0	0.0	0.0	303) - Stability - Compression parallel to grain with buckling about both axe
	14.00	CO16	-2580.0	-140.0	0.0	0.0	0.0	327.0	343) - Stability - Bending about z/y-axis without LTB and compression with

Figure 4.9: Window 3.2 Governing Internal Forces by Set of Members

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



Member Slendernesses 4.8

	A	В	С	D	E	F	G	Н		J	K	L	M	N
1ember	Loss of Stability		Buckling A	bout Axis x			Buckling A	bout Axis y			La	teral Bucklir	ng 🛛	
No.	Under Stress	lex [ft]	d [in]	lex / d [-]	Ratio	ley [ft]	b [in]	ley / b [·]	Ratio	le [ft]	b [in]	d [in]	Rв[-]	Ratio
1	Compression	14.00	14.3	11.748	0.23	14.00	7.0	24.000	0.48		-			
2	Compression / Flexure	16.00	14.3	13.427	0.27	5.50	7.0	9.429	0.19	5.50	7.0	14.3	4.389	0.0
3	Compression / Flexure	32.00	26.0	14.769	0.30	8.00	5.0	19.200	0.38	8.00	5.0	26.0	9.992	0.2
4	Flexure									8.00	5.0	26.0	9.992	0.2
5	Compression / Flexure	32.00	26.0	14.769	0.30	8.00	5.0	19.200	0.38	8.00	5.0	26.0	9.992	0.2
6	Flexure	-	-	-	-	-	-	-		8.00	5.0	26.0	9.992	0.2
7	Compression / Flexure	16.00	14.3	13.427	0.27	5.00	7.0	8.571	0.17	5.00	7.0	14.3	4.185	0.0
8	Flexure									5.50	7.0	14.3	4.389	0.0
	Compression Members:			Ben	lina Mamba									
	Compression Members:	< 50		Bend	ling Membe	ers:	50 6	a						
	Compression Members: Max I _{ex} / d : 14.769	≤ 50	•	Bend Max	ding Membe Rв:	ers: 9.992 ≤	50 🤇	Ð						

2.2 Manahan Slandar

Figure 4.10: Window 3.3 Member Slendernesses



Details...

This results window is shown only when you have selected the respective check box in the Other tab of the Details dialog box (see Figure 3.5, page 42).

The table lists the effective slendernesses of the designed members which can lose their stability as compression members, bending members or combinations of both. They were determined depending on the type of load and occurrence of buckling or lateral-torsional buckling. At the end of the list, you find a comparison with the limit values that have been defined in the Details dialog box, tab Other (see Figure 3.5, page 42).

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



4.9 Parts List by Member

Finally, RF-TIMBER AWC provides a summary of all cross-sections that are included in the design case.

		B	C	D	E	F	G	H	
Part	Cross-Section	Number of	Length	Total Length	Surface Area	Volume	Unit Weight	Weight	Total Weigh
lo.	Description	Members	[ft]	[ft]	[ft ²]	[ft ³]	[Ib/ft]	[lb]	[ton]
1	2 - T-Rectangle 7/14.3	1	14.00	14.00	49.70	9.73	20.25	283.43	0.12
2	2 - T-Rectangle 7/14.3	4	5.50	22.00	78.10	15.29	20.25	111.35	0.19
3	1 - T-Rectangle 5/26	8	8.00	64.00	330.67	57.78	32.67	261.33	0.9
4	2 - T-Rectangle 7/14.3	2	5.00	10.00	35.50	6.95	20.25	101.23	0.0
5	3 - T-Circle 2.4	2	14.00	28.00	17.59	0.88	1.05	14.75	0.0
6	6 - Beams and Stringers 6x10 ANSI/AW/C NDS-20	2	5.50	11.00	27.04	3.89	12.78	70.31	0.0
7	5 - Glulam (WS) 2.5x6 ANSI/AWC NDS-2012	4	8.00	32.00	45.33	3.33	3.77	30.15	0.0
8	6 - Beams and Stringers 6x10 ANSI/AWC NDS-20	1	5.00	5.00	12.29	1.77	12.78	63.92	0.0
ium		24		186.00	596.23	99.62			1.5

Figure 4.11: Window 4.1 Parts List by Member

Details...

By default, the list contains only the designed members. If you need a parts list of all members of the model, select the corresponding option in the *Details* dialog box, tab *Other* (see Figure 3.5, page 42).

Part No.

The program automatically assigns item numbers to similar members.

Cross-Section Description

This column lists the cross-section numbers and descriptions.

Number of Members

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

Length

This column displays the respective length of an individual member.

Total Length

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

Surface Area

0

For each part, the program indicates the surface area relative to the total length. The surface area is determined from the *Surface Area* of the cross-sections that can be seen in Windows 1.3 and 2.1 to 2.5 (see Figure 2.20, page 21).



Volume

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

Unit Weight

The Unit Weight of the cross-section is relative to the length of one meter.

Weight

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

Total Weight

The final column indicates the total weight of each part.

Sum

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

4.10 Parts List by Set of Members

4.2 Parts L	ist by Set of Members								
	A	В	С	D	E	F	G	Н	
Part	Set of Members	Number	Length	Total Length	Surface Area	Volume	Unit Weight	Weight	Total Weight
No.	Description	of Set	[ft]	[ft]	[ft ²]	[ft ³]	[Ib/ft]	[lb]	[ton]
1	Continuous beam 1.1	1	32.00	32.00	165.33	28.89	32.67	1045.32	0.467
2	Continuous beam 2.1	1	16.00	16.00	56.80	11.12	20.25	323.92	0.145
3	Column 1.1	1	14.00	14.00	49.70	9.73	20.25	283.43	0.127
4	Continuous beam 1.2	1	32.00	32.00	45.33	3.33	3.77	120.61	0.054
5	Continuous beam 2.2	1	16.00	16.00	39.33	5.65	12.78	204.54	0.091
6	Column 1.2	1	14.00	14.00	8.80	0.44	1.05	14.75	0.007
7	Continuous beam 1.3	1	32.00	32.00	165.33	28.89	32.67	1045.32	0.467
8	Continuous beam 2.3	1	16.00	16.00	56.80	11.12	20.25	323.92	0.145
9	Column 1.3	1	14.00	14.00	8.80	0.44	1.05	14.75	0.007
Sum		9		186.00	596.23	99.62			1.507
								E 	. 🏹 💌

Figure 4.12: Window 4.2 Parts List by Set of Members

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

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



5. Evaluation of Results

You can evaluate the design results in different ways. For this, the buttons located below the upper results tables are very useful.

	A	B	C	D	E	F	
ection	Member	Location	Load-				
No.	No.	x [ft]	ing	Design		Design According to Formula	
1	Glulam (S	P) 6.75x24.7	5 ANSI/4	WC NDS-2	012		
	5	8.00	CO12	0.08	≤1	111) - Cross-section resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4	
	3	8.00	CO12	0.13	≤1	131) - Cross-section resistance - Strength in bending about y/x-axis acc. to 3.3	
	3	8.00	CO12	0.13	≤1	311) - Stability - Bending about y/x-axis with LTB acc. to 3.3	
	3	0.00	CO12	0.00	≤1	400) · Serviceability · Negligible deformations	
	4	4.00	CO12	0.05	≤1	401) · Serviceability · Deflection in z/y-direction (Beam)	
	5	8.00	CO12	0.89	≤1	403) - Serviceability - Deflection in z/y-direction (Cantilever)	
	5	8.00	CO12	0.17	≤1	611) - Fire resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4	
	3	8.00	CO12	0.10	≤1	631) - Fire resistance - Strength in bending about y/x-axis acc. to 3.3	
	3	8.00	CO12	0.11	≤1	811) - Fire resistance - Bending about y/x-axis with LTB acc. to 3.3	
			Marriel	1.05			
			Max.	1.00	21		
etails - I] Materi	Member 5 al Data - 2	- x: 8.00 ft - 0 4F-1.7E, 24F	0012 -V1, SP/S	P, Loaded F	erp. I	to Wide Faces of Lams, 4 or More Lams	ANSI/AVA
etails - I 3 Materi 3 Cross 3 Desig	Member 5 al Data - 2 section Da n Internal F	- x: 8.00 ft - (4F-1.7E, 24F ata - Glulam (9 Forces	0012 -V1, SP/S SP) 6.75x2	P, Loaded F 24.75 ANSI.	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams CNDS-2012	ANSI/AW
etails - I 3 Materi 3 Cross 3 Desig 3 Adjust	Member 5 al Data - 2 section Da n Internal F ment Facto	- x: 8.00 ft - (4F-1.7E, 24F ata - Glulam (S Forces ors	0012 -V1, SP/S SP) 6.75x2	P, Loaded F 24.75 ANSI.	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams CNDS-2012	ANSI/AW
etails - I 3 Materi 3 Cross 3 Desig 3 Adjust 3 Desig	Member 5 al Data - 2 section Da n Internal F ment Facto n Ratio	- x: 8.00 ft - (4F-1.7E, 24F- ata - Glulam (S Forces ors	0012 -V1, SP/S SP) 6.75x2	P, Loaded F 24.75 ANSI.	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams C NDS-2012	ANSI/AV
etails -] Materi] Cross-] Desig] Adjust] Desig She	Member 5 al Data - 2 section Da n Internal F ment Faction Ratio ear Force	- x: 8.00 ft - (4F-1.7E, 24F ata - Glulam (S Forces ors	0012 -V1, SP/S SP) 6.75x2	P, Loaded F 24.75 ANSI	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams C NDS-2012	ANSI/AW
etails - I Materi Cross Desig Adjust Desig Desig She Cro	Member 5 al Data - 2 section Da n Internal F ment Facto n Ratio ear Force ss-Section	- x: 8.00 ft - (4F-1.7E, 24F- ata - Glulam (S Forces ors al Area	0012 -V1, SP/S SP) 6.75x2	P, Loaded F 24.75 ANSI,	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams CNDS-2012	ANSI/AVA
etails -] Materi] Cross-] Desig] Adjust] Desig — She — Cro — Act	Member 5 al Data - 2 section Da n Internal F ment Facto n Ratio ear Force ss-Section ual Shear 1	- x: 8.00 ft - (4F-1.7E, 24F forces forces ors al Area Stress Paralle	-V1, SP/S SP) 6.75x2	P, Loaded F 24.75 ANSI.	'erp. I 'AW/(to Wide Faces of Lams, 4 or More Lams C NDS-2012 Vx 2500.0 bf A 167.1 m ² fv 22.45 psi	ANSI/AW
etails -] Materi] Cross] Desig] Adjust] Desig - She - Cro - Act - Adj	Member 5 al Data - 2 section Da n Internal F ment Facto n Ratio par Force ss-Section ual Shear usted Shear	- x: 8.00 ft - (4F-1.7E, 24F tata - Glulam (S Forces ors al Area Stress Paralle ar Design Vali	CO12 -V1, SP/S SP) 6.75x2 I to Grain ue Paralle	P, Loaded F 24.75 ANSI.	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams CNDS-2012	ANSI/AW
rtails - Materi Dross- Desig Adjust Desig Desig - Cro - Act - Adj - Des	Member 5 al Data - 2 section Da n Internal F ment Facto n Ratio ear Force ss-Section ual Shear usted Shear ign Ratio	- x: 8.00 ft - (4F-1.7E, 24F tata - Glulam (S Forces ors al Area Stress Paralle ar Design Vali	V1, SP/S P) 6.75x2	P, Loaded F 24.75 ANSI. I to Grain	'erp. I 'AW/(to Wide Faces of Lams, 4 or More Lams CNDS-2012 Vx 2500.0 bb/ A 167.1 in ² I/v 22.45 psi F _{VX} , 270.00 psi ↓ 0.08 ≤ 1 Eq. (3.4.1	ANSI/AV
etails - Materi Cross- Desig Adjust Desig - She - Cro - Act - Adj - Des	Vember 5 al Data - 2 section Da Internal F ment Facto n Ratio ear Force ss-Section ual Shear 1 usted Shear ign Ratio	- x: 8.00 ff - (4F-1.7E, 24F forces forces ors al Area Stress Paralle ar Design Vali	CO12 V1, SP/S SP) 6.75x2 I to Grain ue Paralle	P, Loaded F 24.75 ANSI. I to Grain	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams CNDS-2012 Vx 2500.0 bf A 167.1 in ² Fvx 270.00 psi Fvx 270.00 psi η 0.08 ≤ 1 Eq. (3.4.1	ANSI/AV
etails - Materi Cross- Desig Adjust Desig Cro - Cro - Act - Adj - Des	Member 5 al Data - 2 section Da n Internal F ment Facto n Ratio ear Force ss-Section ual Shear 1 usted Shear ign Ratio	- x: 8.00 ff - (4F-1.7E, 24F forces forces ors al Area Stress Paralle ar Design Val	CO12 -V1, SP/S SP) 6.75x2 I to Grain ue Paralle	IP, Loaded F 24.75 ANSI, 1 to Grain	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams CNDS-2012 Vx 2500.0 bf A 167.1 m ² Fvx 270.00 psi γ 0.08 ≤ 1 Eq. (3.4.1 γ 0.08 ≤ 1 eq. (3.4.1	ANSI/AV
rtails - Materi Cross Desig Adjust Desig - She - Cro - Act - Adj - Des	Member 5 al Data - 2 section Da n Internal F ment Facto n Ratio ear Force ss-Section ual Shear 1 usted Shear ign Ratio	- x: 8.00 ff - (4F-1.7E, 24F tata - Glulam (S Forces ors al Area Stress Paralle ar Design Val	CO12 -V1, SP/S SP) 6.75x2 I to Grain ue Paralle	P, Loaded F 24.75 ANSI. 24.75 ANSI.	'erp. I 'AW(to Wide Faces of Lams, 4 or More Lams C NDS-2012 V_x 2500.0 bf A 167.1 in ² f_v 2245 psi F_{vx} 22000 psi η 0.08 ≤ 1 Eq. (3.4.1	ANSI/AV
tails - Materi Cross- Desig Adjust Desig She Cro Act Adj	Member 5 al Data - 2 section Da n Internal F ment Facto n Ratio ear Force ss-Section ual Shear sign Ratio	- x: 8.00 ff - (4F-1.7E, 24F ta - Glulam (S Forces ors al Area Stress Paralle ar Design Val	CO12 -V1, SP/S SP) 6.75x2 I to Grain ue Parallel	P, Loaded F 24.75 ANSI.	'erp. 'AW(to Wide Faces of Lams, 4 or More Lams C NDS-2012 V_x 2500.0 bf A 167.1 in ² F _{vx} 270.00 psi η 0.08 ≤ 1 Eq. (3.4.1 η 0.08	ANSI/AV

Figure 5.1: Buttons for evaluation of results

The buttons have the following functions:

Button	Description	Function
•	ULS Design	Shows or hides the results of the ultimate limit state design
?	SLS Design	Shows or hides the results of the serviceability limit state design
8	Fire Resistance Design	Shows or hides the results of the fire resistance design
	Show Color Bars	Shows or hides the colored relation scales in the results windows
> 1.0 •	Filter Options	Displays only rows with ratios greater than the filter criterion set in list box: design ratios > 1, maximum, or user-defined limit
2	Result Diagrams	Opens the window <i>Result Diagram on Member</i> → Chapter 5.2, page 57
	Excel Export	Exports the table to MS Excel / OpenOffice → Chapter 7.4.3, page 67
₹ 3	Member Selection	Allows you to graphically select a member to display its results in the table
۲	View Mode	Jumps to the RFEM work window to change the view

Table 5.1: Buttons in results windows 2.1 through 2.5



5.1 Results in the RFEM Model

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

RFEM background graphic and view mode

The RFEM work window in the background is useful for finding the position of a particular member in the model: The member selected in the RF-TIMBER AWC results window is high-lighted in the selection color in the background graphic. Furthermore, an arrow indicates the member's x-location that is displayed in the selected window row.



RF-TIMBER AWC - [Tower Jung]							
<u>F</u> ile <u>E</u> dit <u>S</u> ettings <u>H</u> elp							
CA1 - Design According to ANS 💌	2.1 Desig	n by Load C	ase				
Input Data		A	В	С	D	E	F
General Data	Load-		Member	Location			
Materials	ing	Description	No.	x [ft]	Design	-	Design According t
Cross-Sections	C03		7	2.50	0.80	≤1	311) - Stability - Bending about y/x-axis with LTB acc. to
Load Duration	CO4		3	8.00	0.84	≤1	131) - Cross-section resistance - Strength in bending abo
- In-Service Conditions - Member	C05		3	8.00	0.84	≤1	131) - Cross-section resistance - Strength in bending abo
- In-Service Conditions - Set of M	C06		5	0.00	0.70	≤1	393) - Stability - Biaxial bending with LTB and compressio
- Effective Lengths - Members	C07		8	5.50	0.82	≤1	143) - Cross-section resistance - Strength in biaxial bendir
 Effective Lengths - Sets of Men 	C08		8	5.50	0.82	≤1	143) - Cross-section resistance - Strength in biaxial bendir
Additional Design Parameters	CO9		8	0.00	0.76	≤1	142) - Cross-section resistance - Strength in bending abo
Results	CO10		8	0.00	0.76	≤1	142) - Cross-section resistance - Strength in bending abo
 Design by Load Case 	C011		8	0.00	0.76	≤1	142) - Cross-section resistance - Strength in bending abo
- Design by Cross-Section	C012		3	8.00	0.14	≤1	131) - Cross-section resistance - Strength in bending abo
Design by Set of Members Design by Member				Max:	0.92	≤ 1	•

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

If you cannot improve the display by moving the RF-TIMBER AWC module window, click [Jump to Graphic] to activate the *View Mode*: Thus, you hide the module window so that you can modify the display in the RFEM user interface. In the view mode, you can use the functions of the *View* menu, for example zooming, moving, or rotating the display. The pointer remains visible.

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

RFEM work window

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

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

The RFEM tables are of no relevance for the evaluation of design results.

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









The graphical representation of the results can be set in the *Display* navigator by clicking *Results* \rightarrow *Members*. The ratios are shown *Two-Colored* by default.



Figure 5.3: *Display* navigator: Results → Members

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



Figure 5.4: Design ratios with display option Without Diagram

The graphics of the design results can be transferred to the printout report (see Chapter 6.2, page 60).

To return to the add-on module, click the [RF-TIMBER AWC] panel button.

RF-TIMBER AWC

Program RF-TIMBER AWC © 2014 Dlubal Software GmbH

4 Diubal

5.2 Result Diagrams

You can also graphically evaluate the member results in the result diagram.

To do this, select the member (or set of members) in the RF-TIMBER AWC results window by clicking in the table row of the member. Then open the *Result Diagram on Member* dialog box by clicking the button shown on the left. The button is located below the upper results table (see Figure 5.1, page 54).

To display the result diagrams, select the command from the RFEM menu

Results \rightarrow Result Diagrams for Selected Members

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

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



Figure 5.5: Dialog box Result Diagram on Member

Use the list in the toolbar above to select the relevant RF-TIMBER AWC design case.

This dialog box Result Diagram on Member is described in the RFEM manual, Chapter 9.5.





I,



5.3 Filter for Results

The RF-TIMBER AWC results windows allow you to sort the results by various criteria. In addition, you can use the filter options for graphical evaluation of the results as described in Chapter 9.9 of the RFEM manual.

You can use the *Visibility* option also for RF-TIMBER AWC (see RFEM manual, Chapter 9.9.1) to filter the members in order to evaluate them.

Filtering designs

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

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

or use the toolbar button shown on the left.

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



Figure 5.6: Filtering design ratios with adjusted color spectrum

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

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



1 -





Filtering members

1

In the *Filter* tab of the control panel, you can specify the numbers of particular members to display their results exclusively, that is, filtered. That function is described in detail in the RFEM manual, Chapter 9.9.3.



Figure 5.7: Member filter for ratios of diagonals

Unlike the partial view function (*Visibilities*), the model is displayed in the graphic completely. The figure above shows the ratios in the diagonals of a truss girder. The remaining members are displayed in the model but are shown without design ratios.



6. Printout

6.1 Printout Report

Similar to RFEM, the program generates a printout report for the RF-TIMBER AWC results, to which you can add graphics and descriptions. The selection in the printout report determines what data from the design module will be included in the printout.



The printout report is described in the RFEM manual. In particular, Chapter 10.1.3.4 *Selecting Data of Add-on Modules* describes how to select input and output data from add-on modules for the printout report.

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

6.2 Graphic Printout

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



Printing of graphics is described in the RFEM manual, Chapter 10.2.

Designs in the RFEM model

To print the currently displayed design ratios, click

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

or use the toolbar button shown on the left.

(\$	RF	EM	5.02.112	0 (64bit	:) - [Towe	er Jung*]		
	14	~	<u>F</u> ile	<u>E</u> dit	<u>V</u> iew	Insert	<u>C</u> alculate	<u>R</u> esults	<u>T</u> ools
	:[1	2	33	.		50	🔏 🍕	Q 🔁
	1	6	- 2	/ 🥢 -	• 1 7-	Prin	t Graphic	- <u>2×x</u> 🗖	i 堶 ·

Figure 6.1: Button Print in RFEM toolbar

Result diagrams



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

Result Diagram on Member
🕴 Members No.: 1 🛛 😳 🚱 🖉 🖓 😨 🔚 🗷
E RF-TIMBER AWC CA1
Navigator $P imes 0.00$ 1.64
✔ Design Ratio

Figure 6.2: Button Print in the Result Diagram on Member

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



Options					
Graphic Picture	Window To Print	Graphic Size			
Directly to a printer	Current only	As screen view			
To a printout report:	More	Window filling			
🗇 To the Clipboard	🔘 Mass print	○ To scale 1: 20 ▼			
∋ To 3D PDF					
Graphic Picture Size and Rotation	Options				
Use whole page width	Show results for selected x-location in result diagram				
问 Use whole page height	Lock graphic picture (without update)				
● Height: 49 🚔 [% of page]					
	Show printout report on [OK]				
Rotation: 0 🐳 [*]					
leader of Graphic Picture					
Result diagrams ULS - Member M7					

Figure 6.3: Dialog box Graphic Printout, tab General

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

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

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

Properties Options Color Scale	Factors Border and Str	etch Factors			
Script	Symbols		Frame		
Proportional	Proportional		None		
 Constant 	Constant		Framed		
Factor: 1	Factor: 1		Title box		
Print Quality		Color			
Standard (max 1000 x 1000 Pixel)	s)	Grayscale			
Maximum (max 5000 x 5000 Pixe	Texts are an area of the second se	Texts and lines in black			
O User-defined			All colored		
Max number of pixels:					

Figure 6.4: Dialog box Graphic Printout, tab Options

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



7. General Functions

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

7.1 Design Cases

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

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

To calculate a RF-TIMBER AWC design case, you can also use the load case list in the RFEM toolbar.

Create new design case

To create a new design case, use the RF- TIMBER AWC menu and click

File \rightarrow New Case.

The following dialog box appears:

lew RF-T	IMBER AWC Case
No.	Description
2	Design According to ASD -

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

Click [OK] to open the RF-TIMBER AWC window 1.1 *General Data* where you can enter the design data.

Rename design case

To change the description of a design case, use the RF-TIMBER AWC menu and click

File ightarrow Rename Case.

The following dialog box appears:

lename R	F-TIMBER AWC Case	×
No.	Description	
2	New Description	•

Figure 7.2: Dialog box Rename RF-TIMBER AWC-Case

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



Figure 7.1: Dialog box New RF-TIMBER AWC-Case



Copy design case

To copy the input data of the current design case, use the RF-TIMBER AWC menu

File \rightarrow Copy Case

The following dialog box appears:

Copy fro	om Case
CA2 - E	esign According to ASD 🔹
New Ca	se
No.:	Description:
3	Design According to LRFD

Figure 7.3: Dialog box Copy RF-TIMBER AWC-Case

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

Delete design case

To delete design cases, use the RF-TIMBER AWC menu

 $\textbf{File} \rightarrow \textbf{Delete Case}$

The following dialog box appears:

Availat	le Cases	
No.	Description	
1	Design According to ASD	
2	New Description	
3	Design According to LRFD	
		-
	ОК	Cancel

Figure 7.4: Dialog box Delete Cases

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





7.2 Cross-Section Optimization

The design module offers you the option to optimize overloaded or little utilized cross-sections. To do this, select in the column D or E of the relevant cross-sections in the 1.3 *Cross-Section* window the option *Yes* (for parametric rectangular or circular sections) or *From current row* (for standardized sections, see Figure 2.19, page 20).

You can also start the cross-section optimization in the results windows by using the context menu.

2.2 Desig	n by Cros	s-Section							
	A	В	С	D	E		F		
Section	Member	Location	Load-						
No.	No.	x [ft]	ing	Design			Design According to Formula		
1	T-Rectar	gle 5/26.125	5						
	19	0.00	CO12	0.00	0.00 ≤ 1 100) - Cross-section resistance - Negligible internal force				
	5	5 Section resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4					-section resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4		
	3		unicence	-section resistance - Strength in bending about y/x-axis acc. to 3.3					
	3	Info Abo	ut Cross-	Section			ity - Bending about y/x-axis with LTB acc. to 3.3		
2	T.Dec	<u>O</u> ptimize	Cross-S	ection		<u>_</u>			
2	18	Cross-Se	ction Op	timization <u>P</u>	aran	neters	-section resistance - Negligible internal force		
	1	0.00	CO13	0.04	≤1	102) - Cros	ss-section resistance - Strength in compression parallel to grain acc. to 3.6		
	2	5.50	CO13	0.13	≤ 1	111) - Cros	ss-section resistance - Strength in shear due to shear force Vz/Vx acc. to 3.4		
			Max	0.33	≤ 1	۲	🎱 😓 🗞 🛃 😂		

Figure 7.5: Context-menu for cross-section optimization

Details...

During the optimization process, the module determines the cross-section that fulfills the analysis requirements in the most optimal way, that is, comes as close as possible to the maximum allowable design ratio specified in the *Details* dialog box (see Figure 3.5, page 42). The required cross-section properties are determined with the internal forces from RFEM. If another crosssection proves to be more favorable, this cross-section is used for the design. Then, the graphic in Window 1.3 shows two cross-sections: the original cross-section from RFEM and the optimized one (see Figure 7.7).

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



Figure 7.6: Dialog box Timber Cross-Sections - Rectangle : Optimize

By selecting the check boxes in the *Optimize* column, you decide which parameter(s) you want to modify. This enables the *Minimum* and *Maximum* columns, where you can specify the upper

7 General Functions



and lower limits of the parameter. The *Increment* column determines the interval in which the size of the parameter varies during the optimization process.

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

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

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

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

The context menu available in Window 1.3 also provides options to export optimized crosssections to RFEM.

1.3 Cross-	Sections									
	A	В		C (D		E	6 - Beams and Stringers 6x101 ANSI/AW.		
Section	Material	Cross-Section	0	pti-				RF-TIMBER AVVC		
No.	No.	Description	m	ize	Note	Co	mment			
1	1	T-Rectangle 5/26.125	N	lo						
2	2	T-Rectangle 7/14.3	N	lo	1)			Y		
3	3 3		N	lo	1)					
4	4	HP 12x12x53 [AISC 13	N	lo	8)					
5	1	Glulam (WS) 8.75x30 ANSI/AWC ND	N	lo				*		
6	1	tringers 6x10 ANSI/AWC NDS-201	Info Abr	ut Crocc-co	ction		·			
			IIIO ADO	Jut Cross-se				6 - Beams and Stringers 8x12 ANSI/AVV REEM		
			Cross-Se	ection <u>L</u> ibrar	y					
			E <u>d</u> it List	'Design of N	1 embers	' in Table 1.1 →				
		I) The cross-section in RFEM is dir	Outinaia					·>y		
	1		opumz	e cross-sect	1011		💌 🕑 🤍			
			Cross-Se	ection Optin	nization	Parameters				
Cross-Se	ection Prop	erties	Export C	ross-Section	to RFEM	A N		* <u>.</u>		
E Size F	actor	an Mahar Arfantsant	Export A	II Crore-Soc	tions to	DEEM VS				
Ter	iung Desig	an Value Adjustment	- c.apoirt <u>A</u>	ii ciuss-sec	uons to	- 📵 🔺 🎦 🎞 🖾 🏘				
Cor	Compression Parallel to Grain Design Value Adjustment		Import Cross-Section from RFEM				acc. to 4.3.6	j		
E Flat II	Elat Lise Factor		Import A	All Cross-Sec	tions fro	om RFEM		Cross-section No. 6 used in		
Ber	ndina Desia	an Value Adjustment	Ufu 0.740 standard-defined acc. to 4.3.7				Members No.:			
								10.15.16		
								10,10,10		
								Cata af manham Mari		
								Sets of members No.:		
								5		
								T Lought T Mainleb		
								z Lengin. z weigni.		
								16.00 [ft] 0.062 [ton]		
								Material:		
								1 - Spruce-Pine-Fir (South), 5"x5" and Larr		

Figure 7.7: Context menu in Window 1.3 Cross-Sections

Before the changed materials are transferred to RFEM, a security query appears as to whether the RFEM results should be deleted.

RF-TIMBER AWC Information No. 28741
Do you want to transfer the changed cross-sections to RFEM?
If so, the results of RFEM and RF-TIMBER AWC will be deleted.

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

Calculation

By confirming the query, and then starting the [Calculation] in the RF-TIMBER AWC module, the RFEM internal forces as well as the designs will be determined in one single calculation run.



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

7.3 Units and Decimal Places

Units and decimal places for RFEM and the add-on modules are managed in one dialog box. To define the units in RF-TIMBER AWC, select menu

Settings \rightarrow Units and Decimal Places.

The following dialog box appears that is familiar from RFEM. RF- TIMBER AWC is preset in the *Program / Module* list.

Units and Decimal Places					×
Program / Module PLATE-BUCKLING RF-CONCRETE Surfac RF-CONCRETE Membi RF-CONCRETE Column RE BUNCH	RF-TIMBER AWC	Unit Dec. places	Parts List Lengths:	Unit ft •	Dec. places
RF-TIMBER Pro RF-TIMBER AWC RF-TIMBER RF-DYNAM RF-JOINTS RF-END-PLATE RF-CONNECT BEFERME JOINT Pro	Design ratios: Dimensionless:		Total lengths: Surface areas: Volumes: Weights per length: Weights:	ft • ft^2 • ft^3 • [b/ft •	
RF-FAMILY SUMMERTIN RF-FOUNDATION RF-FOUNDATION RF-FOUNDATION Pro RF-STABILITY RF-MOVE RF-MOVE RF-IMP RF-SOILIN RF-GLASS RF-LAMINATE RF-TOWER Structure			Total weights:	ton v	3
RF-TOWER Equipment RF-TOWER Loading RF-TOWER Effective L]			ОК	Cancel

Figure 7.9: Dialog box Units and Decimal Places



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



7.4 Data Transfer

7.4.1 Material Export to RFEM

If you have modified the materials in RF-TIMBER AWC for design, you can export the modified materials to RFEM in a similar way as you export cross-sections: Open the 1.2 *Materials* window, and then click

Edit \rightarrow Export All Materials to RFEM.

You can also export the modified materials to RFEM using the context menu of Window 1.2.

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

Figure 7.10: Context menu of window 1.2 Materials

Calculation

Before the changed materials are transferred to RFEM, a security query appears as to whether the results of RFEM should be deleted. When you have confirmed the query and then start the [Calculation] in RF-TIMBER AWC, the RFEM internal forces and designs are determined in one single calculation run.

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

7.4.2 Export of Effective Length to RFEM

If you have adjusted the materials in RF-TIMBER AWC for design, you can export the modified materials to RFEM in a similar way as you export cross-sections: Open the 1.7 *Effective Lengths - Members* window, and then select

```
Edit \rightarrow Export All Effective Lengths to RFEM
```

or use the corresponding option on the context menu of Window 1.7.

Import Effective Length from RFEM
Import <u>A</u> ll Effective Lengths from RFEM
Export Effective Length to RFEM
Expo <u>r</u> t All Effective Lengths to RFEM

Figure 7.11: Context menu of window 1.7 Effective Lengths - Members

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

If the modified effective lengths have not been exported to RFEM yet, you can reimport the original effective lengths to the design module by using the options shown in Figure 7.11. Please note, however, that this option is only available in the windows 1.7 *Effective Lengths - Members* and 1.8 *Effective Lengths - Sets of Members*.

7.4.3 Export of Results

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

Clipboard

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



Printout Report

You can print the data of the RF-TIMBER AWC add-on module into the global printout report (see Chapter 6.1, page 60) for export. Then, in the printout report, click

File \rightarrow Export to RTF

The function is described in the RFEM manual, Chapter 10.1.11.

Excel / OpenOffice

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

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

The following export dialog box appears.

Table Parameters	Application
With table header	Microsoft Excel
🔲 Only marked <u>r</u> ows	OpenOffice.org Calc
	© <u>C</u> SV file format
Transfer Parameters	
Export table to active workbook	
Export table to active worksheet	
Rewrite existing worksheet	
Selected Tables	
Astiva table	Export tables with details
Active table	
 All tables 	
 All tables Input tables 	

Figure 7.12: Dialog box Export - MS Excel

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

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F	ile	Home	Insert	Page La	iyout Fo	ormu	las D	ata	Revi	ew	View	Add-Ins	Acrobat		۵ 🕜		P 23
1	🔏 📡	Calib	ri -	8 -	= =		Te)	ĸt	Ŧ	🛃 Co	nditiona	al Formatting 🝷	¦ate Insert ≠	Σ -	A	<u>an</u>	
	L	в	<u> </u>	A A			e - 🦉	- %	,	📆 For	rmat as i	Table 🔻	<table-of-contents> Delete 🔻</table-of-contents>		ZI	unu	
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	B3 ▼ Glulam (SP) 5x27.5 ANSI/AWC NDS-2012																
	Α	В	С	D	E	F						G					E
1	Section	Member	Location	Load-													
2	No.	No.	x [ft]	ing	Design						Desi	ign According to	Formula				
3	1	Glulam (S	P) 5×27.5 Al	NSI/AWC N	IDS-2012												<u> </u>
4		19	0,00	C01	0,00	≤1	100) - Cro	ss-sectio	on res	istance - l	Negligibl	le internal force					
5		6	0,00	C07	0,01	≤1	101) - Cro	oss-sectio	on res	istance -	Strength	in tension paral	lel to grain acc. to 3	3.8			
6		5	8,00	CO4	0,60	≤1	111) - Cro	oss-sectio	on res	istance - S	Strength	in shear due to s	hear force Vz/Vx a	cc. to 3.	4		
7		6	0,00	C06	0,43	≤1	113) - Cro	oss-sectio	on res	istance - S	Strength	in shear due to s	hear force under b	iaxial b	ending a	cc. to 3.	4
8		з	8,00	CO4	0,89	≤1	131) - Cro	oss-sectio	on res	istance - S	Strength	in bending abou	t y/x-axis acc. to 3.	3			
9		5	0,00	C07	0,81	≤1	143) - Cro	oss-sectio	on res	istance - S	Strength	in biaxial bendir	ng and tension acc.	to 3.9.1			
10		5	8,00	CO11	0,53	≤1	152) - Cro	oss-sectio	on res	istance - S	Strength	in bending abou	t z/y-axis and comp	ression	acc. to 3	.9.2	
11		5	0,00	C07	0,80	≤1	153) - Cro	oss-sectio	on res	istance -	Strength	in biaxial bendir	ng and compression	n acc. to	3.9.2		
12		5	8,00	CO11	0,14	≤1	303) - Sta	bility - Co	ompre	ession par	rallel to g	grain with buckli	ng about both axes	acc. to	3.6 and 3	.7	
13		3	8,00	CO4	0,89	≤1	311)-Sta	bility - Be	ending	g about y/	'x-axis wi	ith LTB acc. to 3.3	3				
14		5	0,00	C07	0,81	≤1	323)-Sta	bility - Bi	axial I	bending v	vith LTB a	and tension acc.	to 3.9.1				-
14 4	()	2.1 De	esign by Loa	ad Case	2.2 De	sign	by Cros	s-Sect	ion ,	2.3	Design	by Set of Mer	nbers 🏑 🛙 🖣	I	11)	• 1
Rea	dy												100% (Э—		_	÷,

Figure 7.13: Results in Excel



8. Examples

8.1 Beam Column (LRFD Solution)

We perform the design according to ANSI/AWC NDS-2012 for a wood column that is restrained and subjected to compression and bending. It is embedded at the base providing approximate fixity, and it is free to undergo sidesway about the strong axis of bending at the top. There are wet ground conditions. Lateral bracing about the weak direction of bending is provided every 4 ft by wall girts. In case of major axis bending, the concentrated force at the top represents the spring force resulting from the approximate stiffness imparted by the building on a representative post.

The example is described in [4].

8.1.1 System and Loads



Cross-section:Nominal 4 in by 12 in
(Standard Dressed 3-1/2 in
by 11-1/4 in)Material:Southern Pine, No. 1 DenseMoisture Condition:WetTemperature Condition: $T \le 100^{\circ}F$

Load

Model

Load Combination:	1.2D + 1.6S + 0.8W
LC 1 Dead:	500 lbf
LC 2 Snow:	4200 lbf
LC 3 Wind:	160 lbf/ft and 300 lbf

Figure 8.1: System and loads according to [4]

8.1.2 Calculation with RFEM

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

We create the considered load combination with relevant factors from defined load cases. Then we calculate the model according to the linear static analysis.



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



Figure 8.2: Internal forces N, M_y , and V_z

8.1.3 Design with RF-TIMBER AWC

In Window 1.1 *General Data*, we select the result combination **CO1** for the *Ultimate Limit State* design.

We perform the design according to LRFD.

1 General Data						
Design of					Design According) to
M <u>e</u> mbers: Sets: 1			N	IļA 📄 🏹	LRFD	-
Ultimate Limit Sta	te Serviceability Limit St	ate				
Existing Load Ca	ses / Combinations		Selected for De	esign		
DLC1 D SLC2 S)ead inow		C01	1.2*LC1 + 1.6*LC	2 + 0.8*LC3	
W LC3 V	Vind					
			1			
		≫	í l			
		4)			
All (3)	.	87 82				

Figure 8.3: Window 1.1 General Data



The 1.2 Materials window presents the characteristic strengths of the selected material.

A			В	Special Settings for	
No No			Comment	Special settings for	glulam acc. to
Description			Comment	footnotes in Table 5	5B and Table 5D:
Southern Pine, 2"-4" Thick, 12" Wide, No.1 Dense [ANSI/4	AWC NDS-201	12 🔟		- Reduction of Fb	₈ by multipliyng by
				a factor 0.88 for than 15 in. deep	members greater)
			📲 🗣 🚱 🥯		
laterial Properties					
3 Main Properties					
 Modulus of Elasticity 	E	1800000.0	psi		
Shear Modulus	G	112500.0	psi		
— Specific Weight	γ	0.0	kip/ft ³		
 Coefficient of Thermal Expansion 	CL.	2.7778E-06	1/°F		
 Partial Safety Factor 	γM	1.00			
Additional Properties					
 Reference Modulus of Elasticity for Stability Calculations 	Emin	660000.0	psi		
 Reference Bending Design Value 	Fb	1350.0	psi	Material No. 1 used	in
Reference Tension Design Value Parallel to Grain	Ft	725.0	psi		
 Reference Shear Design Value Parallel to Grain (Horizontal Shear) 	Fv	175.0	psi	Cross-sections No.:	
 Reference Compression Design Value Perpendicular to Grain 	Fop	660.0	psi	1	
Reference Compression Design Value Parallel to Grain	Fo	1700.0	psi		
 Type of Wood Product 		Visually Grad	ed Southern Pine Dimension Lumber	Members No :	
Species		Southern Pin	e		
- Commercial Grade		No.1 Dense		1-3	
Thickness Classification		2"-4" Thick		-	
Width Classification		12" Wide		Sets of members No	D.:
				1	
				Σ Length:	Σ Weight:
				12.00 [8]	0.054 ftor
				12.00 [1]	0.004 [(0)

Figure 8.4: Window 1.2 Materials

In the 1.3 Cross-Sections window, the parameters of the cross-section can be checked.

	A	В		C	D		E	1 - Dimension Lur	nber 4x12 ANSI/AW/C
Section	Material	Cross-Section	(Opti-					
No.	No.	Description	I	mize	Note	Corr	iment		
1	1	Dimension Lumber 4x12 ANSI/AWC N		No				1 t	3.0
								11.3	ж
ross-Se	ction Prope	erties							y
3 Size F	actor		0 (5)						lir
Ben	iding Desigi	n Value Adjustment	CF (Fb)	1.100	standar	d-defined	acc. to 4.3.5	1	🎦 🎞 💷 🝳
- Ten	ision Design	n value Adjustment scallel te Grain Design Value Adjustment	Cr (Ft)	1.000	standar	d-derined	acc. to 4.3.6		
1 Flat LL	Pression F	araliei to drain Design valde Adjustment	CF (10)	1.000	stariuai	d-denned	400.004.0.0	Cross-section No.	1 used in
Ben	idina Desia	n Value Adjustment	Cfu	1.100	standar	d-defined	acc. to 4.3.7	Members No :	
								1.9	
								1-5	
								Sets of members h	10.:
								1	
								Σ Length:	Σ Weight:
								12.00 [ft]	0.054 [tor
								Material:	
								1 - Southern Pine	, 2°-4″ Thick, 12″ Wide

Figure 8.5: Window 1.3 Cross-Sections



In Window 1.4 *Load Duration*, we define the load duration. For LRFD it is recommended to assign a **user-defined** load duration also for a load combination because the choice according to shortest load duration in a combination does not always reflect the appropriate value of time effect factor λ according to Table N3 of [1].

		В	<u> </u>	D	E
.oad-		Load		Factor	
ing	Description	Туре	Load Duration	λ	Comments
LC1	Dead	Dead	Permanent	0.600	
LC2	Snow	Snow	Two Months	0.800	
LC3	Wind	Wind	Ten Minutes	1.000	
CO1 1	.2*LC1 + 1.6*LC2 + 0.8*LC3		Two Months	0.800	
actor λ according to:	Shortest load duration in a combined of the state of t	nation			

Figure 8.6: Window 1.4 Load Duration

In Window 1.6 *In-Service Conditions - Set of Members*, we define the moisture and temperature conditions. The factors C_M and C_T are determined as for **wet** service conditions and sustained exposure to elevated temperatures up to 100°F.

	A	B	С	Moisture Service Condition
iet 🗌	Moisture Service			
lo.	Condition	Temperature	Comments	Dry Service Conditions:
1	Wet	T ≤ 100°F		Moisture content in service is less
				than 19% for lumber (less than 16% for glulam)
				Wet Service Conditions:
				Moisture content in service is 19% or greater for lumber (16% and greater for glulam)
				Temperature Effects:
				Structural members experience sustaine exposure to elevated temperatures up to 100°F
				Structural members experience sustaine exposure to elevated temperatures between 100°F and 125°F
				Structural members experience sustaine exposure to elevated temperatures between 125'F and 150'F
Cabina	A (an anarah ana Mari			
set inpu	ut for members No.:			
		A V A	- TA	

Figure 8.7: Window 1.6 In-Service Conditions - Set of Members


In the 1.8 *Effective Lengths - Sets of Members* window we specify the buckling lengths of the column. The recommended value of buckling length coefficient $K_{ex} = 2.1$ is taken for the major axis stability calculation.

For the minor axis stability calculation we define directly the buckling length $l_{ey} = 4$ ft as the length between lateral bracing girts multiplied by a factor of **1.0**. The effective length for lateral buckling is calculated as unbraced length **4** ft associated with major axis bending multiplied by factor **2.06**, this equation is defined in footnote 1 in Table 3.3.3 in [1].

1.8 Effective Lengths - Sets of Memi

		See of men	iberb								
	A	B	С	D	E	F	G	Н		J	K
S	et Buckling	B	uckling About A	xis x	В	uckling About A	xis y	Lateral Buckling			
N	^{D.} Possible	Possible	Kex	lex [ft]	Possible	Key	ley [ft]	Possible	leManually	le [ft]	Comment
	Image: A state of the state	V	2.100	25.20		0.333	4.00	2	2	8.24	1
										_	
										E	🚭 🐴 💿

Figure 8.8: Window 1.8 Effective Lengths – Set of Members

In Window 1.9 Additional Design Parameters, the use of further adjustment factors is not required. No member is incised according to 4.3.8 or acts as repetitive according to 4.3.9 in [1].

						-
lombor	A	B Adjustmen	t Epotoro	D	E	F
No.	Description	Definiti	an Sumbol	Value [.]	acc to	Comment
4	Description	Denind	on Symbol	value [-]	4.2.0	Comment
	Departitive Easter	Not inci	Sed Li	•	4.3.8	
2	Inepetitive Factor	Not Repe		•	4.3.9	
2	Desetive Factor	Not Inci	sed Li	•	4.3.8	
	hepetitive Factor	Not Hepe	citive Cr	•	4.3.9	
3	Incising Factor	Not Inci	sed Li	•	4.3.8	
_	Repetitive Factor	Not Hepe	titive Lr	•	4.3.9	
Set in	nput for members No.:		Material Category:			
	1	All	Sawn Lumber	~		🛐 🐧 🖣

Figure 8.9: Window 1.9 Additional Design Parameters

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

Calculation



After the calculation, the governing design is presented in the 2.1 Design by Load Case window.

Desig	n by Load Ca	ise												
	A	В	C	D	E					F				G
Load-		Member	Location											Load
ing	Description	No.	x [ft]	Design	1				Design A	ccording to	Formula			Duratio
	Ultimate Limit	State Des	sign											
CO1		1	4.00	0.63	≤ 1	373) - Stabil	ity - Bending a	bout y/x-axis v	with LTB a	nd compres	sion with buc	kling	about both axes acc. to 3.9.2	Two Mo
			Max:	0.63	≤ 1	9					9	•	🛼 🍢 🕰 强	To
etails -	Member 1 - x:	4.00 ft - C	01										1 - Dimension Lumber 4×12	ANSI/A
] Adjus	tment Factors											-		
] Desig	n Ratio						1 -		1					
- Co	mpressive Forc	e					P	7320	lbf			-		
- Cro	ss-Sectional A	rea					A	39.38	in ²				. 3.50	
Ac	ual Compressi	ve Stress F	Parallel to G	àrain			fc	185.90	psi				++	
- Pa	tially Adjusted	Compressi	ve Design '	Value Para	allel to	Grain	Fc*	2350.08	psi				t (1000)	
Bei	nding Moment						Mx	6336	Ibfft					
- Se	ction Modulus						Sx	73.83	in ³					
- Ac	ual Bending S	tress					fbx	1029.85	psi			=		
- Pa	tially Adjusted	Bending D	esign Valu	е			Fb*	2180.16	psi					
Eff	ective Length						lex	25.20	ft					
- Eff	ective Length						ley	4.00	ft					
Sle	nderness Hatio)					lex / d	26.88			3.7.1.3			
Sle	nderness Hatio						ley / b	13.71			3.7.1.3			
- Ad	usted Modulus	of Elastici	ty for Stabi	lity Calcula	tions		E min'	888624.00	psi			-	÷	
- Unt	ical buckling d	esign valu	e for compr	ression me	mber	S	FoEx	1011.53	psi		3.7.1.5	4	У	
- Crit	ical buckling d	esign valu	e for compr	ression me	mber	S	FcEy	3885.89	psi		3.7.1.5	-		
- Fa	tor						c	U.80			3.7.1.5			
- Co	umn Stability F	actor					UPx	0.38			Eq. (3.7-1)			
- Co	umn Stability F	actor					CPy	0.83			Eq. (3.7-1)			
Eff	ective Span Le	ength					le	8.24	łt					
 Sle 	nderness Ratio	0					RB	9.53			Eq. (3.3-5)	Ŧ	O	4

Figure 8.10: Window 2.1 Design by Load Case

The Details displayed in the lower part of the window correspond to the designs in [4].

The column capacities, which are modified by adjustment factors, are calculated without consideration of stability factors. This calculation is done before the calculation of the design ratio.

Partially Adjusted Compression Design Value

$$\begin{split} F_c &= \lambda \times K_F \times \Phi \times F_c \times C_M \times C_t \times C_F \\ F_c &= 0.8 \times 2.4 \times 0.9 \times 1700 \times 0.8 \times 1.0 \times 1.0 \\ F_c &= 2350.08 \text{ psi} \end{split}$$

Partially Adjusted Bending Design Value

$$\begin{split} F_b^{\ *} &= \lambda \times K_F \times \Phi \times F_b \times C_M \times C_t \times C_F \\ F_b^{\ *} &= 0.8 \times 2.54 \times 0.85 \times 1350 \times 0.85 \times 1.0 \times 1.1 \\ F_b^{\ *} &= 2180.16 \text{ psi} \end{split}$$

Adjusted Modulus of Elasticity for Stability Calculations

$$\begin{split} & E_{min}' = K_F \times \Phi \times E_{min} \times C_M \times C_t \\ & E_{min}' = 1.76 \times 0.85 \times 660000 \times 0.9 \times 1.0 \\ & E_{min}' = 888624 \ psi \end{split}$$

Adjusted Shear Design Value

$$\begin{split} F_v &:= \lambda \times K_F \times \Phi \times F_v \times C_M \times C_t \\ F_v &:= 0.8 \times 2.88 \times 0.75 \times 175 \times 0.97 \times 1.0 \\ F_v &:= 293.33 \, \text{psi} \end{split}$$



The stress analysis is performed as follows.

Actual Compressive Stress Parallel to Grain

 $f_c = \frac{P}{A} = \frac{7320 \text{ lbf}}{39.38 \text{ in}^2} = 185.88 \text{ psi}$

Actual Bending Stress

 $f_{bx} = \frac{M_x}{S_x} = \frac{6336 \times 12 \text{ lbf.in}}{73.83 \text{ in}^3} = 1029.83 \text{ psi}$

Actual Shear Stress Parallel to Grain

 $f_v = \frac{V_x \times Q_x}{I_x \times b} = \frac{1296 \, \text{lbf} \times 55.37 \, \text{in}^3}{415.28 \, \text{in}^4 \times 3.5 \, \text{in}} = 49.37 \, \text{psi}$

The compressive design stress must be adjusted also by the column stability factor C_P. This factor depends on the critical buckling stress for compression which reflects the member slenderness of compression members.

The total axial capacity for the major axis is calculated as follows.

Slenderness Ratio

$$\frac{l_{ex}}{d} = \frac{302.40 \text{ in}}{11.25 \text{ in}} = 26.88 \le 50$$

Critical Buckling Design Value for Compression Members

$$F_{cEx} = 0.822 \times \frac{E_{min}'}{\left(\frac{l_{ex}}{d}\right)^2} = 0.822 \times \frac{888624}{26.88^2} = 1010.95 \text{ psi}$$

Column Stability Factor

$$C_{P_{X}} = \frac{1 + (F_{cE_{X}}/F_{c}^{*})}{2 \times c} - \sqrt{\left[\frac{1 + (F_{cE_{X}}/F_{c}^{*})}{2 \times c}\right]^{2} - \frac{F_{cE_{X}}/F_{c}^{*}}{c}}{C}$$

$$C_{P_{X}} = \frac{1 + (1010.95/2350.08)}{2 \times 0.8} - \sqrt{\left[\frac{1 + (1010.95/2350.08)}{2 \times 0.8}\right]^{2} - \frac{1010.95/2350.08}{0.8}}{0.8}}$$

$$C_{P_{X}} = 0.383$$

Adjusted Compressive Design Value Parallel to Grain

 F_{cx} '= F_{c} *× C_{px} = 2350.08 × 0.383 = 900.08 psi

The total axial capacity for the minor axis is calculated in the same way.

Slenderness Ratio

$$\frac{l_{ey}}{b} = \frac{48.00 \text{ in}}{3.5 \text{ in}} = 13.71 \le 50$$

Critical Buckling Design Value for Compression Members

$$F_{cEy} = 0.822 \times \frac{E_{min}'}{\left(\frac{I_{ey}}{b}\right)^2} = 0.822 \times \frac{888624}{13.71^2} = 3886.11 \text{ psi}$$

Column Stability Factor

$$C_{Py} = \frac{1 + (F_{cEy}/F_c^{*})}{2 \times c} - \sqrt{\left[\frac{1 + (F_{cEy}/F_c^{*})}{2 \times c}\right]^2 - \frac{F_{cEy}/F_c^{*}}{c}}$$
$$C_{Py} = \frac{1 + (3886.11/2350.08)}{2 \times 0.8} - \sqrt{\left[\frac{1 + (3886.11/2350.08)}{2 \times 0.8}\right]^2 - \frac{3886.11/2350.08}{0.8}}{0.8}$$
$$C_{Py} = 0.832$$

Adjusted Compressive Design Value Parallel to Grain

 F_{cy} '= F_{c} *× C_{py} = 2350.08×0.832 = 1955.27 psi

The bending design stress must also be adjusted by the beam stability factor C_L . This factor depends on the critical buckling stress for bending which reflects the member slenderness of bending members.

The total flexural capacity is calculated as follows.

Slenderness Ratio

$$R_{B} = \sqrt{\frac{I_{e} \times d}{b^{2}}} = \sqrt{\frac{(8.24 \times 12) \times 11.25}{3.50^{2}}} = 9.53$$

Critical Buckling Design Value for Bending Members

$$F_{bE} = \frac{1.20 \times E_{min}'}{R_{B}^{2}} = \frac{1.20 \times 888624}{9.53^{2}} = 11741.23 \text{ psi}$$

Beam Stability Factor

$$C_{L} = \frac{1 + (F_{bE}/F_{b}^{*})}{1.9} - \sqrt{\left[\frac{1 + (F_{bE}/F_{b}^{*})}{1.9}\right]^{2} - \frac{F_{bE}/F_{b}^{*}}{0.95}}$$

$$C_{L} = \frac{1 + (11741.23/2180.16)}{1.9} - \sqrt{\left[\frac{1 + (11741.23/2180.16)}{1.9}\right]^{2} - \frac{11741.23/2180.16}{0.95}}$$

$$C_{L} = 0.989$$

Adjusted Bending Design Value:

$$F_{bx}' = F_b * \times C_L = 2180.16 \times 0.989 = 2156.18 \text{ ps}$$

4 Diubal

Critical Design Values Check

Before combined bending and axial compression proportions are verified, critical design stresses must be compared according to Equation (3.9-4) and the next formulas mentioned in [1], Clause 3.9.2.

$$\frac{f_c}{F_{cEx}} = \frac{185.88}{1010.95} = 0.18 \le 1.00$$
$$\frac{f_c}{F_{cEy}} = \frac{185.88}{3886.11} = 0.05 \le 1.00$$
$$\frac{f_b}{F_{bE}} = \frac{1029.83}{11741.23} = 0.09 \le 1.00$$
$$\frac{f_c}{F_{cEy}} + \left(\frac{f_b}{F_{bE}}\right)^2 = \frac{185.88}{3886.11} + \left(\frac{1029.83}{11741.23}\right)^2 = 0.06 \le 1.00$$

Combined Bending and Axial Compression Design

Design of combined bending and axial compression according to [1], Equation (3.9-3):

Design 1 (buckling about x-x axis)

$$\left[\frac{f_{c}}{F_{cx}}\right]^{2} + \frac{f_{bx}}{F_{bx} \times \left[1 - \left(f_{c}/F_{cEx}\right)\right]} \le 1.00$$
$$\left[\frac{185.88}{900.08}\right]^{2} + \frac{1029.83}{2156.18 \times \left[1 - \left(185.88/1010.95\right)\right]} = 0.63 \le 1.00$$

Design 2 (buckling about y-y axis)

$$\left[\frac{f_c}{F_{cy}'}\right]^2 + \frac{f_{bx}}{F_{bx}' \times \left[1 - \left(f_c/F_{cEx}\right)\right]} \le 1.00$$
$$\left[\frac{185.88}{1955.27}\right]^2 + \frac{1029.83}{2156.18 \times \left[1 - \left(185.88/1010.95\right)\right]} = 0.59 \le 1.00$$

Shear Design

.

The shear design is performed according to [1], Clause 3.4.1:

Design

$$\frac{f_v}{F_v} = \frac{49.37}{293.33} = 0.17 \le 1.00$$



Glued Laminated Beam (ASD Solution) 8.2

We perform the design according to ANSI/AWC NDS-2012 for a structural glued laminated roof purlin that is restrained and subjected to biaxial bending. The beam is laterally supported at its ends only, and there are no intermediate lateral supports.

The example is described in [4].

System and Loads 8.2.1



Figure 8.11: System and loads according to [4]

Model

Cross-section:	6-3/4 in by 24 in	Load	Combination:	$D + L_r$
Material:	Douglas-fir 24F-V10	LC 1	Dead _x :	264 lbf/ft
Moisture Condition:	Dry	LC 1	Deady:	14 lbf/ft
Temperature Condition:	T ≤ 100°F	LC 2	Roof Live _x :	1053 lbf/ft
		LC 2	Roof Live _v :	52 lbf/ft

Loads

Calculation with RFEM 8.2.2

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

We create the considered load combination with relevant factors from defined load cases. Then we calculate the model according to the linear static analysis.



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



Figure 8.12: Internal forces M_y , M_z , V_z , and V_y



8.2.3 Design with RF-TIMBER AWC

8.2.3.1 Ultimate Limit State Design

In Window 1.1 *General Data*, we select the result combination **CO1** for the *Ultimate Limit State* design.

We perform the design according to **ASD**.



Figure 8.13: Window 1.1 General Data

The 1.2 Materials window presents the characteristic strengths of the selected material.

	A	В			Special Settings for
laterial	Material				Special settings for glularn acc. to
No.	Description	Comment			footnotes in Table 5B and Table 5D:
1	24F-1.7E, 24F-V10, DF/HF				Reduction of E. bu multipliana bu
					a factor 0.88 for members greater
					than 15 in. deep
				🍇 🚳 🤹	
aterial Pr	operties				
] Main Pr	roperties				
Mode	ulus of Elasticity	E	1800000.0	psi	
Shea	ar Modulus	G	112500.0	psi	
 Spec 	cific Weight	γ	29.3	lbf/ft ³	
- Coef	ficient of Thermal Expansion	α.	2.7778E-06	1/°F	
Partia	al Safety Factor	γM	1.00		
Additior	nal Properties				
Refe	rence Tension Design Value Parallel to Grain	Ft	1150.0	psi	_
Refe	rence Compression Design Value Parallel to Grain	Fc	1550.0	psi	Material No. 1 used in
Refe	rence Bending Design Value	Fbx+	2400.0	psi	Cross sections No :
Refe	rence Bending Design Value	Fbx1	2400.0	psi	Cross-sections No.:
Refe	rence Bending Design Value (Bending Parallel to Wide Faces of La	ms) Fby	1450.0	psi	1
Refe	rence Shear Design Value Parallel to Grain	Fvx	215.0	psi	
Refe	rence Shear Design Value Parallel to Grain	Fvy	200.0	psi	Members No.:
Refe	rence Compression Design Value Perpendicular to Grain	Fcpx,ten.face	650.0	psi	1
- Refe	rence Compression Design Value Perpendicular to Grain	Fopx,comp.face	650.0	psi	
Refe	rence Compression Design Value Perpendicular to Grain	Fcpy	375.0	psi	
Refe	rence Modulus of Elasticity for Stability Calculations	Ex min	950000.0	psi	Sets of members No.:
- Refe	rence Modulus of Elasticity for Stability Calculations	Eymin	790000.0	psi	
Туре	e of Structural Glued Laminated Timber		Softwoods		
Comb	bination Symbol		24F-V10		Σ Length: Σ Weight:
- Spec	cies Outer/Core		DF/HF		24.00 [8] 0.240 0
					24.00 [1] 0.346 [0

Figure 8.14: Window 1.2 Materials



In the 1.3 Cross-Sections window, the parameters of the cross-section can be checked.

B C D E Section Opi- mize Note Connert Image: Image Strate Image: Image Strate Image: Image Strate Image: Image: Image Strate Image:	1.3 Cross-	Sections							
Section No. Description mize Note Comment Image: Instrument instrument Image: Instrument instrument Image: Instrument instrument Image: Instrument instrument instrument Image: Instrument instrument instrument instrument Image: Instrument		A	В		C	D		E	1 - T-Rectangle 6.75/24
No. Description mize Note Comment I T T Fectangle 6.75/24 No Image: Comment Image: Commen	Section	Material	Cross-Section	(Opti-				
Image: Sign Value Adjustment Cruss-Section Properties Image: Sign Value Adjustment Cru Image: Sign Value Adjustme	No.	No.	Description	1	nize	Note	Co	mment	
Cross-Section Properties Flat Use Factor Bending Design Value Adjustment Cross-Section No. 1 used in Members No.: 1 Sets of members No.: 24.00 [N] 0.346 [nd] X Weight: 24.00 [N] 0.346 [nd]	1	1	T-Rectangle 6.75/24		No				+ 6.8 +
Cross-Section Properties Flat Use Factor Bending Design Value Adjustment Cru Cru Cru Cru Cru Cru Cru Cr									240 X
Cross-Section Properties □ Flat Use Factor □ Bending Design Value Adjustment Cru 1.066 standard-defined acc. to 5.3.7 Image: Cross-Section No.1 used in Members No.: 1 Sets of members No.: 24.00 [R] 0.346 [rc Material: 1.24F1.7E, 24F.V10, DF/HF, Loaded		(3	3	y
Bending Design Value Adjustment Cru 1 066 standard-defined acc. to 5.3.7 Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined Image: Standard-defined <	Cross-Se	ection Prop se Factor	erties						[in]
Σ Length: Σ Weight: 24.00 [ft] 0.346 [tz] 1 -24-1.7E, 24F-V10, DF/HF, Loaded 1	Ben	nding Desig	gn Value Adjustment	Cfu	1.0E	6 standa	d-defined	acc. to 5.3.7	
									Cross-section No. 1 used in Members No.: 1 Sets of members No.: Σ Length: Σ Veight: 24.00 [R] 0.346 1 Alteriat: 1 - 24F-1.7E, 24F-V10, DF/HF, Loaded Print

Figure 8.15: Window 1.3 Cross-Sections

In Window 1.4 *Load Duration*, we define the load duration. For ASD, the load duration for load combination is assigned according to the shortest load duration included in this combination. The load duration of CO1 is preset as **Seven Days**.

	Δ	B	0		Final Action States
.oad-		Load		Factor	
ing	Description	Type	Load Duration	Cn	Comments
LC1	Dead	Dead	Permanent	0.900	
102	Live	Live	Seven Daus	1.250	
C01	D+lr		Seven Days	1.250	

Figure 8.16: Window 1.4 Load Duration



In Window 1.5 *In-Service Condition - Members*, we define the moisture and temperature conditions. The factors C_M and C_T are determined for **dry** service conditions and sustained exposure to elevated temperatures up to 100°F.

	A	B	C	Moisture Service Condition
ember	Moisture Service			
NO.	Condition	Temperature	Comments	Dry Service Conditions:
1	Dry	T ≤ 100°F		Moisture content in service is less than 19% for lumber (less than 16% for glulam)
				Wet Service Conditions: Moisture content in service is 19% or greater for lumber (16% and greater for aluam)
				Temperature Effects: Structural members experience sustaine exposure to elevated temperatures up to 100°F
				Structural members experience sustaine exposure to elevated temperatures between 100'F and 125'F
				Structural members experience sustaine exposure to elevated temperatures between 125°F and 150°F
Set input	t for members No.:			

Figure 8.17: Window 1.5 In-Service Conditions - Members

In Window 1.7 *Effective Lengths - Members* we specify the buckling lengths. The beam is braced only at the ends. The effective buckling length for lateral-torsional buckling is automatically calculated according to [1] Table 3.3.3 for a single spam beam with uniformly distributed load where ratio of the unbraced length and the depth of the cross-section is higher than seven:

 $I_e = 1.63 \text{ x}$ unbraced length + 3 x depth of cross-section = **45.12 ft**.

	A	B	C	D	E	F	F G H			K	
Member	Buckling	Bu	uckling About A	dis x	Buckling About Axis y						
No.	Possible	Possible	Kex	lex [ft]	Possible	Key	ley [ft]	Possible	Define I _e	le [ft]	Comment
1	2	V	1.000	24.00	₹	1.000	24.00		acc. to Table 3.3.3	45.12	

Figure 8.18: Window 1.7 Effective Lengths - Members



In Window 1.9 Additional Design Parameters, the use of further adjustment factors is not required. There is no shear reduction to be applied.

1.9 Additi	onal Design Parameters						
	A	В		C	D	E	F
Member		Adjustmer	nt Factors				
No.	Description	Definiti	on	Symbol	Value [·]	acc. to	Comment
1	Shear Reduction Factor	No Shear Re	eduction	Cvr	•	5.3.10	
	Shear Edge-Bonded Factor	Edge-Bor	nded	•	•	NDS Suppl.	
Set in	nput for members No.:		Material Category:				
	S.	V Al	Structural Glued Lam	iinated Tim	ber 👻		🐴 🐧 💌

Figure 8.19: Window 1.9 Additional Design Parameters

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

Calculation

After the calculation, the governing design is presented in the 2.1 *Design by Load Case* window.

a Desig	n by Load Case											
	A	В	C	D	E				F			G
Load-		Member	Location	-								Load
ing	Description	No.	x [ft]	Design				Design Ac	cording to For	mula		Duration
	Liltimate Limit State Design											
C01	D+L (ASD)	1 1	12.00	0.91	≤ 1 313)	- Stability - Biax	ial bendin	a with LTB	acc. to 3.9			Seven Dav
	()				· · ·			-				
			Max:	0.91	≤1 🕲				1) 🖹 🕅 🏹 🕷	8
Detaile	Mambas 4, us 40,00 @ CO4										4 T Destantia 0 75 04	
Details -	member 1 - X. 12.00 IL - COT										1 - 1-Rectangle 6.75/24	
	n Potio											
E Desig	n nauu nding Moment				M	1127910	Ibfin					
Ber	nding Moment				M _M	57024	Ibfin					
Ser	etion Modulus				Su	648.0	in3					
Ser	ction Modulus				Su	182.2	in ³				6.75	
Act	tual Bending Stress				fby	1756.03	nsi				+ ···· +	
Act	tual Bending Stress				fby	312.89	nsi	_				
Par	tially Adjusted Bending Design	Value			Eby	3000.00	nsi					
- Par	tially Adjusted Bending Design	Value			Ebor	1812.50	psi					
Cro	iss-Section Breadth				b	6.75	in					
Cro	iss-Section Depth				d	24.00	in				54.0	•*x
Ler	ngth Between Points of Zero M	oments			L	24.00	ft					
- Cor	nstant				×	10				-		
- Vol	ume Factor				Cv	0.896			Eq. (5.3-1)			
- Fla	t Use Factor				Cfu	1.066			5.3.7	1	+	
- Effe	ective Span Length				le	45.12	ft			1	+	
- Sle	nderness Ratio				Re	16.89			Eq. (3.3-5)	1	У	
— Adj	usted Modulus of Elasticity for	Stability Ca	lculations		Eminy'	790000.00	psi			1		
- Crit	ical buckling design value for t	pending me	mbers		Fbe	3323.95	psi		3.3.3.8	1		
- Bea	am Stability Factor		CL	0.855			Eq. (3.3-6)	1				
— Adj	justed Bending Design Value	Fbx'	2565.81	psi								
— Adj	usted Bending Design Value	Fby'	1932.16	psi					[in]			
— De	sign (Critical Bending Design V	alue Check	4		fbx / FbB	0.53			3.9.2			[11]
De	sign Ratio				η	0.91		≤ 1	Eq. (3.9-3)	Ŧ	d 🎽	ž 🟹

Figure 8.20: Window 2.1 Design by Load Case



The Details displayed in the lower part of the window correspond to the designs in [4].

The beam capacities, which are modified by adjustment factors, are calculated without consideration of stability factors. This calculation is done before the calculation of the design ratio.

Partially Adjusted Bending Design Values

 $\begin{aligned} F_{bx} * &= F_{bx} \times C_M \times C_t \times C_D \\ F_{bx} * &= 2400 \times 1.0 \times 1.0 \times 1.25 \\ F_{bx} * &= 3000.00 \text{ psi} \end{aligned}$

 $F_{by} * = F_{by} \times C_M \times C_t \times C_D$ $F_{by} * = 1450 \times 1.0 \times 1.0 \times 1.25$ $F_{bv} * = 1812.50 \text{ psi}$

Adjusted Modulus of Elasticity for Stability Calculations

 $E_{min}' = E_{min} \times C_M \times C_t$ $E_{min}' = 790000 \times 1.0 \times 1.0$ $E_{min}' = 790000 \text{ psi}$

Adjusted Shear Design Values

 $F_{vx}' = F_{vx} \times C_M \times C_t \times C_D$ $F_{vx}' = 215 \times 1.0 \times 1.0 \times 1.25$ $F_{vx}' = 268.75 \text{ psi}$

 $F_{vy}' = F_{vy} \times C_M \times C_t \times C_D$ $F_{vy}' = 200 \times 1.0 \times 1.0 \times 1.25$ $F_{vv}' = 250.00 \text{ psi}$

The stress analysis is performed as follows.

Actual Bending Stresses

 $f_{bx} = \frac{M_x}{S_x} = \frac{1137910 \text{ lbf.in}}{648.00 \text{ in}^3} = 1756.03 \text{ psi}$

 $f_{by} = \frac{M_y}{S_y} = \frac{57024 \text{ lbf.in}}{182.25 \text{ in}^3} = 312.89 \text{ psi}$

Actual Shear Stress Parallel to Grain

$$f_{vx} = \frac{V_x \times Q_x}{I_x \times b} = \frac{15804 \,\text{lbf} \times 486.00 \,\text{in}^3}{7776.00 \,\text{in}^4 \times 6.75 \,\text{in}} = 146.33 \,\text{psi}$$
$$f_{vy} = \frac{V_y \times Q_y}{I_y \times b} = \frac{792 \,\text{lbf} \times 136.69 \,\text{in}^3}{615.09 \,\text{in}^4 \times 24.00 \,\text{in}} = 7.33 \,\text{psi}$$

The bending design stress must be adjusted also by the lesser of the beam stability factor, C_{L} , and volume factor, C_{V} .

The beam stability factor depends on the critical buckling stress for bending which reflects the member slenderness of bending members.



Slenderness Ratio

$$R_{B} = \sqrt{\frac{I_{e} \times d}{b^{2}}} = \sqrt{\frac{(45.12 \times 12) \times 24.00}{6.75^{2}}} = 16.89$$

Critical Buckling Design Value for Bending Members

$$F_{bE} = \frac{1.20 \times E_{min}'}{R_B^2} = \frac{1.20 \times 790000 \text{ psi}}{16.89^2} = 3323.93 \text{ psi}$$

Beam Stability Factor

$$C_{L} = \frac{1 + F_{bE}}{1.9} - \sqrt{\left[\frac{1 + (F_{bE}/F_{b}^{*})}{1.9}\right]^{2} - \frac{F_{bE}/F_{b}^{*}}{0.95}}$$
$$C_{L} = \frac{1 + (3323.93/3000.00)}{1.9} - \sqrt{\left[\frac{1 + (3323.93/3000.00)}{1.9}\right]^{2} - \frac{3323.93/3000.00}{0.95}}$$
$$C_{L} = 0.855$$

The volume factor depends on the cross-section dimensions [in] and the length of the bending member between points of zero moment [ft].

Volume Factor

$$C_{V} = \left(\frac{21}{L}\right)^{1/x} \times \left(\frac{12}{d}\right)^{1/x} \times \left(\frac{5.125}{b}\right)^{1/x}$$
$$C_{V} = \left(\frac{21}{24}\right)^{1/10} \times \left(\frac{12}{24}\right)^{1/10} \times \left(\frac{5.125}{6.75}\right)^{1/10}$$

 $C_V = 0.896$

The total flexural capacity is calculated as follows.

Adjusted Bending Design Values:

 $F_{bx}' = F_{bx} * \times min(C_L; C_V) = 3000.00 \times min(0.855; 0.896) = 2565.00 \text{ psi}$

 $F_{by}' = F_{by} * \times C_{fu} = 1812.50 \times 1.07 = 1939.38 \text{ psi}$

Critical Design Values Check

Before biaxial bending proportions are verified, critical design stresses must be compared according to formulas mentioned in [1] (Chapter 3.9.2).

$$\frac{f_{bx}}{F_{bE}} \!=\! \frac{1756.03}{3323.93} \!=\! 0.53 \!\leq\! 1.00$$

Biaxial Bending Design

The design of biaxial bending according to [1], Equation (3.9-3) is as follows:

$$\frac{f_{bx}}{F_{bx}'} + \frac{f_{by}}{F_{by}' \times \left[1 - \left(\frac{f_{bx}}{F_{bE}}\right)^2\right]} \le 1.00$$
$$\frac{1756.03}{2565.00} + \frac{312.89}{1939.38 \times \left[1 - \left(\frac{1756.03}{3323.93}\right)^2\right]} = 0.91 \le 1.00$$



Shear Design

The design of shear is performed according to [1], Clause 3.4.1:

Design 1 (Shear due to shear force V_x)

$$\frac{f_{vx}}{F_{vx}'} = \frac{146.33}{268.75} = 0.54 \le 1.00$$

Design 2 (Shear due to shear force V_y)

$$\frac{f_{vy}}{F_{vy}} = \frac{7.33}{250.00} = 0.03 \le 1.00$$

8.2.3.2 Serviceability Limit State Design

We check the deflection limit for the unfactored live load.

In the *Serviceability Limit State* tab of the 1.1 *General Data* window, we select the load case **LC2** *Live* for the design.

1.1 General Dat	ta					
Design of					Design According to	
Members:	1		1 (k)	🔽 Aļi	ASD	-
<u>S</u> ets:			🐧 🗙 📍			
Ultimate Limit	State Serviceability Limit Sta	ate Fire Resistance	e			
Existing Load	Cases / Combinations		Selected for Desi	ign		
D LC1 CO1	Dead D + L		LC2 L	ive		
		>>				
		4				
		4				
All (3)	•	84 82				X

Figure 8.21: Window 1.1 General Data, tab Serviceability Limit State

Then we enter member No. 1 in the 1.10 Serviceability Data window

L.10 Serv	riceability Data						
	A	B	C	D	E	F	G
		Member	Referen	ice Length	Direc-	Precamber	
No.	Reference to	No.	Manually	L [ft]	tion	we [in]	Beam Type
1	Member	1		24.00	у 🔳	0.00	Beam
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

Figure 8.22: Window 1.10 Serviceability Data

We do not modify the reference length but we restrict the *Direction* to **y**. As a simple span beam, we select the **Beam** in the *Beam Type* list.

8 Examples



In the dialog box *Details*, tab *Serviceability*, we change one setting: The deformation is to be relative to the **Undeformed system**.

bal

tails	
Resistance Stability Serviceability Fire Resistance Other	
Servicability (Deflections)	
Limiting deflection: L/ 360 🚔	
Deformation relative to: Shifted members ends / set of member ends Undeformed system	
2 🚾 🕥 🕒 📭	OK Cancel

Figure 8.23: Dialog box Details, tab Serviceability

The limiting deflection is L/360 according to Table 1604.3 in [6].

For the following equation, the modulus of elasticity of 1800000 psi is applied.

Deflection from moment

$$\Delta_{y}^{M} = \frac{5}{384} \times \frac{w_{\text{live}} \times L^{4}}{E \times I_{x}} = \frac{5}{384} \times \frac{87.75 \times 288^{4}}{1800000 \times 7776} = 0.56 \text{ in}$$

Deflection from shear force (approximate calculation)

$$\Delta_{y}{}^{V} = 0.96 \times \frac{E}{G} \times \left(\frac{d}{L}\right)^{2} \times \Delta_{y}{}^{M} = 0.96 \times \frac{1800000}{112500} \times \left(\frac{24}{288}\right)^{2} \times 0.56 = 0.06 \text{ in}$$

Final deflection

$$\Delta_y = \Delta_y^M + \Delta_y^V = 0.56 + 0.6 = 0.62$$
 in

Design

$$\frac{\Delta_y}{\Delta_{\text{lim},y}} = \frac{0.62 \text{ in}}{0.80 \text{ in}} = 0.78 < 1$$

8 Examples



Calculation

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

	А	B	C	D	E				F						G
bad-		Member	Location											L	oad
ng	Description	No.	x [ft]	Design				Design	According	g to Formula				Du	ratio
	Ultimate Limit State Design														
01	D+L	1	12.00	0.91	≤ 1 31	3) - Stability - B	iaxial bendi	ing with L1	TB acc. to	o 3.9				Seve	en D
	Serviceability Limit State Des	ign													
C2	Live	1	12.00	0.78	≤ 1 40	1) - Serviceabil	ity - Deflect	tion in z/y-	direction	(Beam)				Seve	en (
									6					a (*	1 0
			Max:	0.91	≤1 🤭							^Y >1		A 3	J
-															_
alls -	Memper 1 - X: 12.00 π - LC2		ded Deve te	Vicida Francis		A as blass I as					1 - T-B	tectangl	e 6.75/24		
viater	iai Dala • 24F•1.7E, 24F•V10, I	DEVER, LUG	ацец петр. то	while naces	s or carris	, 4 ULINUIE LAII	115								
1000	-section Dista - T-Rectangle 6	75/24													
Cross Defor	 section Data - T-Rectangle 6. 	75/24													
Dross Defor Desig	-section Data - T-Rectangle 6. mations m Batio	75/24													
Cross Defor Desig	-section Data - T-Rectangle 6. mations In Ratio flection	75/24					0.62 ir	n					+ 6.75		
Cross Defor Desig De	-section Data - T-Rectangle 6. mations In Ratio flection mber in the Middle Span	75/24			Δ	ky	0.62 ir	n					6.75	t	
Cross Defor Desig De Car Car	-section Data - T-Rectangle 6. mations In Ratio flection mber in the Middle Span mber at x-Location	75/24				Ay Acamp, 1/	0.62 ir 0.00 ir 0.00 ir	n n				t	6.75	r I	
Cross Defor Desig De Ca Ca To	-section Data - T-Rectangle 6. mations In Ratio filection mber in the Middle Span mber at x-Location tal Deflection	75/24				Ly Leamp, 1/	0.62 in 0.00 ir 0.00 ir 0.62 ir	n n n n				t	6.75	t	
Cross Defor Desig De Ca Ca Ca To Re	-section Data - T-Rectangle 6. mations In Ratio flection mber in the Middle Span mber at x-Location tal Deflection ference Span	75/24				Ay Acamp, 1/	0.62 ir 0.00 ir 0.00 ir 0.62 ir 24.00 ft	n n n n n t				t	6.75		
Defor Defor Desig Car Car Tol Re	-section Data - T-Rectangle 6. mations in Ratio flection mber in the Middle Span mber at x-Location tal Deflection ference Span itting Deflection (Relative)	75/24				Ly Leamp, 1/ Leamp, x, Ltot,y	0.62 ir 0.00 ir 0.00 ir 0.62 ir 24.00 ft 360.000	n n n n n t				4.00	6.75		
Defor Desig Desig Car Car Car Car Car Car Car Car Car Car	-section Data - T-Rectangle 6. mations n Ratio flection mber in t-Location tal Deflection ference Span niting Deflection (Alelative) niting Deflection (Alelative)	75/24				Ly Loamp, 1/ Leamp, 1/ Leamp, x, tot, y . / Alim, y	0.62 ir 0.00 ir 0.00 ir 0.62 ir 24.00 ft 360.000	n n n n n n n n n n n n n n n n n n n				24.00	6.75	•	
Defor Desig De Ca Ca Ca Ca Ca Ca Lin De	-section Data - T-Rectangle 6. mations in Ratio filection mber in the Middle Span mber at x-Location tal Deflection ference Span niting Deflection (Relative) niting Deflection (Absolute) sign Ratio	75/24			Δ Δ Δ Δ Δ Δ Δ Δ	Ly Leamp, 1/ Leamp, 1/ Leamp, x, Ltot,y - / ∆lim,y C	0.62 ir 0.00 ir 0.00 ir 0.62 ir 24.00 ft 360.000 0.80 ir 0.78	n n n n n n n n n n n n n n n n n n n	≤ 1			24.00	6.75		
Defor Desig De Car Car Tol Re Lim De	-section Data - T-Rectangle 6. mations in Ratio filection mber in the Middle Span mber at x-Location tal Deflection ference Span titing Deflection (Relative) titing Deflection (Absolute) sign Ratio	75/24			Δ Δ Δ Δ Δ Δ Δ Δ Δ	ky keamp, 1/ keamp, x, ktot,y . / Alim,y	0.62 ir 0.00 ir 0.02 ir 24.00 ft 360.000 0.80 ir 0.78	n n n n n n n t n n n n n n n n n n n n	≤1			24.00	6.75		
Cross Defor Desig Car Car Car Car Car Car Car Car Car Car	-section Data - T-Rectangle 6. mations n Ratio flection mber in tw-location tal Deflection ference Span niting Deflection (Absolute) sign Ratio	75/24			Δ Δ Δ Δ Δ Δ Δ Δ Δ	Agent participation of the second sec	0.62 ir 0.00 ir 0.62 ir 24.00 ft 360.000 0.80 ir 0.78	n	≤1			24.00	6.75		
Cross Defor Desig De Car Car Car Car Car Car Car Car Car Car	-section Data - T-Rectangle 6. mations in Ratio filection mber in the Middle Span mber at x-Location tal Deflection ference Span niting Deflection (Relative) niting Deflection (Absolute) sign Ratio	75/24			Δ Δ Δ Δ Δ Δ Δ Δ η	Ly Acamp, 1/ Acamp, x, Atot, y · / Δim, y Aim, y	0.62 ir 0.00 ir 0.02 ir 24.00 ft 360.000 0.80 ir 0.78	n n n n n n n n n n n n n n n n n n n	≤1			24.00	6.75		
Dross Defor Desig De Cai Cai Cai Cai Cai Cai Cai Cai Cai Cai	-section Data - T-Rectangle 6. mations in Ratio filection mber in the Middle Span mber at x-Location tal Deflection ference Span timing Deflection (Relative) timing Deflection (Absolute) sign Ratio	75/24			Δ Δ Δ Δ Δ Δ Δ Δ Δ	Ay Acamp, 1/ Acamp, 1/ Acamp, x, Atot,y . / Alim,y	0.62 ir 0.00 ir 0.62 ir 24.00 ft 360.000 0.80 ir 0.78	n n n n n n n n n n n n n n n n n n n	£1			24.00	6.75		
Cross Defor Desig De Car Car Tol Re Lim De	section Data - T-Rectangle 6. mations in Ratio flection mber at x-location mber at x-location ference Span riting Deflection (Relative) niting Deflection (Absolute) sign Ratio	75/24			Δ Δ Δ Δ Δ Δ Δ Δ η	Ay Acamp, 1/ Acamp, 1/ Acamp, x, Ator,y . / Alim,y	0.62 ir 0.00 ir 0.62 ir 24.00 ft 360.000 0.80 ir 0.78	n n n n n n n n n n n n n n n n n n n	≤1			24.00	6.75		•
Cross Defor Desig De Car Car Car Car Car Car Car Car Car Car	-section Data - T-Rectangle 6. mations in Ratio filection mber in the Middle Span mber at x-Location tal Deflection ference Span inting Deflection (Relative) niting Deflection (Absolute) sign Ratio	75/24			A A A L L L A M N	Ay Acamp, 1/ Acamp, 1/ Acamp, x, Atot, y	0.62 ir 0.00 ir 0.00 ir 0.62 ir 24.00 ft 360.000 0.80 ir 0.78	n n n n n t	≤1			24.00	6.75		,
Cross Defor Desig De Car Car Tol Re Lim Lim De	-section Data - T-Rectangle 6. mations in Ratio flection mber in the Middle Span mber at x-Location tal Deflection ference Span titing Deflection (Relative) titing Deflection (Absolute) sign Ratio	75/24				×y	0.62 ir 0.00 ir 0.02 ir 24.00 ft 360.000 0.80 ir 0.78	n	≤1			24.00	6.75		
Cross Defor Desig De Car Car Car Tol Re Lim De	-section Data - T-Rectangle 6. mations in Ratio flection mber in the Middle Span mber at x-Location tal Deflection ference Span iiting Deflection (Relative) iiting Deflection (Absolute) sign Ratio	75/24				ky kamp, 1/ keamp, x, totay	0.62 ir 0.00 ir 0.62 ir 24.00 ft 360.000 ir 0.80 ir 0.78 ir 0.78 ir	n	≤1			24.00	6.75		
Cross Defor Desig De Cai Cai Cai Cai Cai Cai Cai Cai Cai Cai	-section Data - T-Rectangle 6. mations in Ratio flection mber in the Middle Span mber at x-Location tal Deflection ference Span ference Span ference Span iting Deflection (Relative) iting Deflection (Absolute) sign Ratio	75/24				xy kaamp, t/ ktot,y . / Alum,y lilim,y	0.62 ir 0.00 ir 0.62 ir 24.00 f 360.000 0.80 ir 0.78	n n t n	≤ 1			24.00	6.75		

Figure 8.24: Window 2.1 Design by Load Case



8.3 Single Tapered Beam

According to the Design Specification [1], the strength of a tapered beam must be reduced depending on the loading (tensile bending or compressive bending). This usually applies to single tapered beams.

The single tapered beam of the following example is laterally supported over its entire length.



8.3.1 System and Loads

Figure 8.25: System and loads

Model

Material:	Southern Pine 24F-V5
Length:	40 ft
Cross-section 1:	5-1/2 in by 22 in (start)
Cross-section 2:	5-1/2 in by 49-1/2 in (end)
Moisture Condition:	Dry
Temperature Condition:	T ≤ 100°F

Loads

Load Combination:	D + S
LC 1 Dead:	Self-weight and 300 lbf/ft
LC 2 Snow:	300 lbf/ft

8.3.2 Calculation with RFEM

The system as well as the loads in all load cases is modeled in RFEM as a 3D model. We make sure that the automatic self-weight is activated in LC1.

We create the considered load combination with relevant factors from the defined load cases. Then we calculate the model according to the linear static analysis.

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



Figure 8.26: Internal forces M_{y} and V_{z}

8.3.3 Design with RF-TIMBER AWC

Ultimate Limit State Design

In Window 1.1 *General Data*, we select the result combination **CO1** for the *Ultimate Limit State* design.

We perform the design according to **ASD**.

esign of					Design According to
Members: 1			\$ X	V Al	ASD 👻
ets:			1 (k)	🎦 🗌 <u>A</u> I	
Illtimate Limit St	ate Constant line Conte	Des Desisteres			
Oitimate Limit St	Serviceability Limit State	Fire Resistance			
Existing Load C	ases / Combinations		Selected for D	esign	
S LC2	Snow		2.4 001	D+5	
		\gg			
		4			
All (2)	▼ 8	V 62			8 × 8

Figure 8.27: Window 1.1 General Data



The 1.2 Materials window presents the characteristic strengths of the selected material.

	A		В		Special Settings for	
Material	Material				Special settings for	dulam acc. to
No.	Description	Co	omment		footnotes in Table 5	B and Table 5D:
3 24	F-1.7E, 24F-V5, SP/SP, 4 or More Lams ANSI/AWC NDS-2012 🔳				Deduction of D	have an all for farming have
					Heduction of Fb;	by multipliying by
					than 15 in. deep	members greater
laterial Proper	ties					
🖃 Main Propert	ies					
 Modulus a 	f Elasticity	E	1700.000	ksi		
 Shear More 	dulus	G	106.250	ksi		
 Specific V 	/eight	γ	0.0	kip/ft ³		
 Coefficient 	t of Thermal Expansion	α	2.7778E-06	1/°F		
 Partial Saf 	ety Factor	γM	1.00			
Additional Pr	operties					
Reference	Modulus of Elasticity (Axial Loading)	Ez	1680.000	ksi		
Reference	Shear Modulus (Axial Loading)	Gz	105.000	ksi		
Reference	Modulus of Elasticity (Loading Perpendicular to Wide Faces of Lams)	Ex	1700.000	ksi		
Reference	Shear Modulus (Loading Perpendicular to Wide Faces of Lams)	Gx	106.250	ksi		
Reference	Modulus of Elasticity (Loading Parallel to Wide Faces of Lams)	Ey	1600.000	ksi		
Reference	Shear Modulus (Loading Parallel to Wide Faces of Lams)	Gy	100.000	ksi		
- Modulus a	f Elasticity Perpendicular	E90	56.667	ksi	Material No. 3 used	in
- Shear Mor	dulus Perpendicular	G 90	10.625	ksi	-	
Reference	Tension Design Value Parallel to Grain	Ft	1150.00	psi	Cross-sections No.:	
Reference	Compression Design Value Parallel to Grain	Fo	1600.00	psi	1,2	
Reference	Bending Design Value (Bending Perpendicular to Wide Faces of Lams)	Fbx+	2400.00	psi		
Reference	Bending Design Value (Bending Perpendicular to Wide Faces of Lams)	F _{bx} -	2400.00	psi	Members No :	
Reference	Bending Design Value (Bending Parallel to Wide Faces of Lams)	Fby	1700.00	psi		
Reference	Shear Design Value Parallel to Grain	Fvx	300.00	psi	1	
Reference	Shear Design Value Parallel to Grain	Fvv	260.00	psi		
Reference	Compression Design Value Perpendicular to Grain	Foox ten face	740.00	DSI	Sets of members No	2
Reference	Compression Design Value Perpendicular to Grain	Fopx.comp.fac	740.00	psi		
Reference	Compression Design Value Perpendicular to Grain	Fcpy	650.00	psi		
Reference	Modulus of Elasticity for Stability Calculations	Exmin	900.000	ksi	∑ Longth:	∑ Moisht:
Reference	Modulus of Elasticity for Stability Calculations	Evmin	850.000	ksi	2 Length.	2 weight.
Type of St	ructural Glued Laminated Timber		Softwoods		40.00 [ft]	0.882 [to
Combinati	on Symbol		24F-V5			
Section (liter/Core		CD/CD			

Figure 8.28: Window 1.2 Materials

In the 1.3 Cross-Sections window, the parameters of the two cross-sections can be checked.

	A	В	C	D	E	1 - T-Rectangle 5.5/22
ection	Material	Cross-Section	Opti-			
No.	No.	Description	mize	Note	Comment	
1	3	T-Rectangle 5.5/22	No			+ 0.0 +
2	3	T-Rectangle 5.5/49.5	No			+
oss-Se	ection Prope	erties				
Ren	ding Design	Value Adjustment	C fu	1.091_standard.def	ined acc to 537	
						Cross-section No. 1 used in Members No.: 1 Sets of members No.: Σ Length: Σ 40.00 [ft] 0.882 [to Material:
						0 24 1.72, 24 40, 01701, 401 Mole

Figure 8.29: Window 1.3 Cross-Sections



In Window 1.4 *Load Duration*, we define the load duration. For ASD, the load duration for load combination is assigned according to the shortest load duration included in this combination. The load duration of CO1 is preset as **Two Months**.

As the beam is not loaded by any wind or earthquake load, the load condition for radial stress design according to [1] Table 5.2.8 is set as **Other Types of Loading**.

	A	I B	I C		E	
ad-		Load		Factor	Loading Condition	
ng	Description	Туре	Load Duration	CD	(Radial Stress Design)	Comments
C1	Dead	Dead	Permanent	0.900	Other Types of Loading	
22	Snow	Snow	Two Months	1.150	Other Types of Loading	
D1	D + S	-	Two Months	1.150	Other Types of Loading	

Figure 8.30: Window 1.4 Load Duration

In Window 1.5 *In-Service Condition - Members*, we define the moisture and temperature conditions. The factors C_M and C_T are determined for **dry** service conditions and sustained exposure to elevated temperatures up to 100°F.

ro tu-pervic	e Conditions - Members			
	A	B	C	Moisture Service Condition
Member	Moisture Service	<u> </u>		
NO.	Condition	Temperature	Comments	Dry Service Conditions:
	Dıy	I ≤ 100%		Moisture content in service is less than 19% for lumber (less than 16% for glulam)
				Wet Service Conditions: Moisture content in service is 19% or greater for lumber (15% and greater for glulam)
				Temperature Effects: Structural members experience sustained exposure to elevated temperatures up to 100°F
				Structural members experience sustained exposure to elevated temperatures between 100°F and 125°F
				Structural members experience sustained exposure to elevated temperatures between 125°F and 150°F
🔲 Set inpu	t for members No.:	T All		

Figure 8.31: Window 1.5 In-Service Conditions - Members



In Window 1.7 *Effective Lengths - Members* we specify the buckling lengths. The beam is laterally supported over its entire length continuously. Therefore, there is no risk of instability. We clear the two check boxes **Buckling Possible** and **Lateral-Torsional Buckling**.

1.7 Effective Lengths - Member

		B	C	D	E	F	G	H		J	K
ember	Buckling	Bu	uckling About A	cis x	Bu	uckling About A	xis y		Lateral-Torsional Bucklin	ng	
No.	Possible	Possible	Kex	lex [ft]	Possible	Key	ley [ft]	Possible	Define I _e	le [ft]	Comment
1			1.000	40.00		1.000	40.00		as member length	40.00	

Figure 8.32: Window 1.7 Effective Lengths - Members

In Window 1.9 *Additional Design Properties*, the use of further adjustment factors is not required. There is no shear reduction to be applied.

	A	В	C (D	E	F
1ember		Adjustment Factors				
No.	Description	Definition	Symbol	Value [·]	acc. to	Comment
1	Shear Reduction Factor	No Shear Reduction	Cvr		5.3.10	
	Shear Edge-Bonded Factor	Edge-Bonded	-		NDS Suppl.	
Setin	put for members No.:	Material Catego	ry:			
		All Structural Glue	d Laminated Timber	-		

Figure 8.33: Window 1.9 Additional Design Parameters



The tapered member is automatically listed in Window 1.14 *Tapered Members*, including the preset angle of taper which is 3.28°.

1.14	Tape	ered N	/lembers

-							
		A	В	C	D		F
1	Member	Cross-S	Section	Length	Angle of Taper	Grain Parallel	
	No.	Member Start	Member End	L [ft]	Θ[°]	to Edge	Comment
	1	T-Rectangle 5.5/22	T-Rectangle 5.5/49.5	40.00	3.28	+z/+y - axis 💌	

Figure 8.34: Window 1.14 Tapered Members

The grain runs parallel to the edge which is located in the direction of the **positive** z/y-axis (this is the bottom side of the member). Thus, the cut face of the beam is in the compressive bending area (it would also be possible to design taper cuts on the tension face, but those cuts are not recommended for structural glued laminated timber beams).

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

After the calculation, the governing design is presented in the 2.1 *Design by Load Case* window.

			-		-					v. I v		
		0.	46			07					0.21	
					0.0	67						
Desig	gn by Load Ca	ase										
	A	B	C	D	E					F		G
Load-		Member	Location					-				Load
ing	Description	No.	x [tt]	Design				Des	gn Ac	cording to Formula		Duration
001	Ultimate Limi	t State Des	sign		2 4 4 4 4			-				
01	D+S	1	12.00	0.67	51 11.	31) Cross-section re	sistance -	Tapen	ed Mer	mber - Strengtn in bending about	y/x-axis acc. to 3.	I I wo Months
			Max:	0.67	≤1 🕲					🎬 😤 👏 🖺 ≽	1.0 🔻) 🗳 🛃 💊 💌
etails -	Member 1 - X	12.00 π -	CO1								1 - 2: T-Rectang	e 5.5/22 - T-Rectangle 5.
- Mate	nai Data - 24F-											
	and an Date	T.D	V5, SP/SP, 4	4 or More La	ams							
Cross	-section Data	T-Rectan	v5, SP/SP, 4 gle 5.5/30.2	4 or More La 5	ams							
] Cross] Desig] Adius	section Data - In Internal Force	T./E, 24F- - T-Rectang ces	v5, SP/SP, 4 gle 5.5/30.2	4 or More La 5	ams							
] Cross] Desig] Adjus] Desig	s-section Data on Internal Force tment Factors	- T-Rectan	v5, SP/SP, 4 gle 5.5/30.2	4 or More La 5	ams							
Cross Desig Adjus Desig Be	s-section Data gn Internal Forc tment Factors gn Ratio nding Moment	T.7E, 24F- T-Rectan	v5, SP/SP, 4 gle 5.5/30.2	4 or More La 5	ams	Mx	108833	lbfft				
Cross Desig Adjus Desig Be Se	s-section Data on Internal Force timent Factors on Ratio nding Moment ction Modulus	T.7E, 24F- - T-Rectan es	v5, SP/SP, 4 gle 5.5/30.2	4 or More La 5	ams	M _x S _x	108833	Ibfft in ³				+ ^{5.5} +
Cross Desig Adjus Desig Be Be Se	section Data gn Internal Force tment Factors gn Ratio nding Moment ction Modulus tual Bending S	T.Rectan - T-Rectan es	v5, SP/SP, 4 gle 5.5/30.2	4 or More La 5	ams	M _x S _x f _{bx}	108833 838.8 1556.96	lbfft in ³ psi				<u>55</u> †
Cross Desig Adjus Desig Desig Be Se Ac Pa	section Data on Internal Force triment Factors on Ratio nding Moment ction Modulus tual Bending S rtially Adjusted	tress Bending D	v5, SP/SP, 4 gle 5.5/30.2 lesign Value	4 or More La 5	ams	M _x S _x f _{bx} F _{bx*}	108833 838.8 1556.96 2760.00	lbfft in ³ psi psi			-	<u>↑^{5.5}</u>
Cross Desig Adjus Desig Be Se Ac Pa Cro	esection Data on Internal Force transmither Factors on Ratio nding Moment ction Modulus tual Bending S ritially Adjusted oss-Section Bre	T./E, 24F- T-Rectany ces itress Bending D eadth	v5, SP/SP, 4 gle 5.5/30.2 lesign Value	4 or More La 5	ams	M _x S _x F _{bx} F _{bx} *	108833 838.8 1556.96 2760.00 5.5	lbfft in ³ psi psi in			t	1 ^{5.5}
Cross Desig Adjus Desig Desig Be Se Ac Pa Cro	esection Data - gn Internal Forc trment Factors gn Ratio nding Moment ction Modulus tual Bending S rtially Adjusted pss-Section Bre pss-Section De	tress Bending D adth	v5, SP/SP, 4 gle 5.5/30.2 lesign Value	4 or More La 5	ams	M _x S _x f _{bx} b d	108833 838.8 1556.96 2760.00 5.5 30.3	lbfft in ³ psi in in				* ^{5.5}
Cross Desig Adjus Desig Desig Be Se Ac Pa Cro Cro Le	esection Data gn Internal Forc tment Factors gn Ratio nding Moment ction Modulus tual Bending S trially Adjusted sss-Section Bre sss-Section Den pgth Between	tress Bending D adth Points of Z	v5, SP/SP, , gle 5.5/30.2 lesign Value	4 or More La 5 s	ams	M _x S _x f _{bx} b d L	108833 838.8 1556.96 2760.00 5.5 30.3 40.00	lbfft in ³ psi in in ft			808	55
Cross Desig Adjus Desig Be Se Ac Pa Cro Cro Cro Cro Cro Cro	esection Data gn Internal Forc tment Factors gn Ratio nding Moment ction Modulus tual Bending S trially Adjusted uss-Section Bre uss-Section Der ngth Between nstant	T. /E, 24F- - T-Rectany tress Bending D eadth pth Points of Z	V5, SP/SP, 4 gle 5.5/30.2 lesign Value lero Momenta	4 or More La 5 s	ams	Mx Sx Fbx Fbx* b d L x	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20	lbfft in ³ psi psi in ft			30.3	•55
Cross Desig Adjus Desig Desig Be Se Ac Pa Cro Cro Cro Cro Cro Cro Cro Cro Cro Cro	esection Data on Internal Force timent Factors on Ratio nding Moment ction Modulus tual Bending S trially Adjusted oss-Section Bre oss-Section De ngth Between nstant lume Factor	tress Bending D eadth pth Points of Z	vo, SP/SP, - gle 5.5/30.2 lesign Value	4 or More La 5 s	ams	Mx Sx Fbx Fbx* d L X Cv	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921	lbfft in ³ psi in in ft		Eq. (5.3-1)	30.3	5.5.
Cross Desig Adjus Desig Desig Be Se Ac Pa Cro Cro Cro Cro Cro Cro Cro Cro Cro Cro	esection Data on Internal Force trenent Factors nding Moment ction Modulus tual Bending S trially Adjusted sss-Section Dre sss-Section Dre ssss-Section Dre ssss-Section Dre ssss-Section Dre ssss-Section Dre ssss-Section Dre ssss-Section Dre ssss-Section Dre sssss-Section Dre sssss-Section Dre sssss-Section Dre ssssss-Section Dre ssssssssssssssssssssssssssss	tress Bending D eadth pth Points of Z	V5, 5P/5P, 4 gle 5.5/30.2 lesign Value	4 or More La 5 s	ams	M _x S _x F _{bx} F _{bx} * b d L L X Cγ Θ	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921 3.28	Ibfft in ³ psi in in ft		Eq. (5.3-1)	30.3	55.
Cross Desig Adjus Desig Desig Be Se Ac Pa Cro Cro Cro Cro Cro Cro Cro Cro Cro Cro	esection Data on Internal Force trenent Factors on Ratio noling Moment ction Modulus tual Bending S ritially Adjusted ses-Section Dre pagth Between onstant lume Factor gle of Taper rameters for St	tress Bending D eadth pth Points of Z	V5, 5P/5P, 4 gle 5.5/30.2 lesign Value iero Momenta	s	ams	M _x S _x f _{bx} F _{bx} * b d d L k C V Θ	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921 3.28	Ibfft in ³ psi psi in ft		Eq. (5.3-1)	30.5	55
Cross Desig Adjus Desig Desig Be Se Ac Pa Cro Cro Cro Cro Cro Cro Cro Cro Cro Cro	esection Data in Internal Forci timent Factors in Ratio nding Moment ction Modulus stual Bending S tritally Adjusted bass-Section De ngth Between ngth Between ngth Between gle of Taper rameters for St Reference Ber	tress Bending D eadth pth Points of Z ress Interac	v5, 5P/5P, . gle 5.5/30.2 lesign Value ero Momente ction Factor yn Value	s	ams	Mx Sx Fbx* b d L X Cv 0 Fb	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921 3.28 2400.00	lbfft in ³ psi in in ft \$		Eq. (5.3-1) Table 5A	30.5	5.5
Crosss] Desig] Adjus] Desig] Desig Be Se Se Ac Pa Crr Crr Crr Crr Cr Cr Cr Pa Cr Cr Cr Pa Cr Pa	-section Data in Internal Force timent Factors in Ratio nating Moment citon Modulus tual Bending S strially Adjusted bass-Section De ass-Section De ngth Between nstart Jume Factor gle of Taper rameters for St. Reference Ber Shear Reductii	tress Bending D adth pth Points of Z ress Interac	v5, 5P/5P, 4 gle 5.5/30.2 lesign Value ero Moments ction Factor in Value	4 or More Lz 5 s	ams	Mx Sx Fax Fbx* b d L x Cy Θ Fb Cyr	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921 3.28 2400.00 0.720	lbfft in 3 psi in in ft psi		Eq. (5.3-1) Table 5A 5.3.10	30.3	5.5 7 7
] Cross] Desig] Adjus] Desig Be Se Acc Pa Crr Crr Le Co Vo An □ Pa	-section Data - in Internal Force ment Factors in Ratio nding Moment ction Modulus tual Bending S rtially Adjusted sss-Section Bre sss-Section Dre sss-Section Dre ssss-Section Dre sss-Section Dre ssss-Secti	tress Bending D adth pth Points of Z ress Interaction ading Desig on Factor	V5, 5P/5P, 4 gle 5.5/30.2 lesign Value ero Momenta ction Factor yn Value Value	4 or More Lz 55	ams	Mx Sx fbx Fbx* b d L X Cv 0 Fb Cvr Fv	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921 3.28 2400.00 0.720 300.00	lbfft in 3 psi in in ft \$ \$ \$		Eq. (5.3-1) Table 5A 5.3.10 Table 5A	30.3	6.5
] Cross] Desig] Adjus] Desig Be Se Acc Pa Crc Crc Crc Crc Cr Cr Pa Crc Pa Crc Pa	-section Data - in Internal Force timent Factors on Ratio nation Moment citom Modulus tual Bending S titally Adjusted sus-Section De pigh Between ngth Between ngth atteres for Taper randers for S Reference Ber Shear Reductit Reference She Reference She	tress Bending D sadth Points of Z ress Interac dding Desig on Factor sar Design npression d	V5, 5P/5P, , gle 5.5/30.2 lesign Value ero Momenta ction Factor yn Value Value lesign value	4 or More Lz 5 s	ams	Mx Sx Fbx b d L x Cv Ø Fb Fy Fy Fopr, comp. face	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921 3.28 2400.00 0.720 300.00 740.00	lbfft in 3 psi psi in ft psi psi psi		Eq. (5.3-1) Table 5A 5.3.10 Table 5A Table 5A	30.3	5.5 * x
] Cross] Desig] Adjus] Desig] Desig Be Se Acc Pa Crr Crr Le Co Vo An ■ Pa Crr Str	-aection Data in Internal Force timent Factors on Ratio nding Moment citon Modulus tutal ally Adjusted bass-Section De nstant Jume Factor gile of Taper Raference Ber Raference She Reference She Reference con ess Interaction	tress Bending D eadth Points of Z ress Interaction on Factor ear Design pression d Factor	V5, SP/SP, J gle 5.5/30.2 lesign Value ero Moments ction Factor yn Value Value lesign value	4 or More Lz 5 s	ams	Mx Sx Fex b d L X Cy Θ Fb Cyr Fy For, cmp, face C1	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921 3.28 2400.00 0.720 300.00 740.00 0.844	lbfft in 3 psi psi in in ft psi psi psi		Eq. (5.3-1) Table 5A 5.3.10 Table 5A Table 5A Table 5A Table 5A Eq. (5.34),ERRATA-2013-11	30.3	55 7 7 9
] Cross] Desig] Adjus] Desig] Desig Be Se Acc Pa Crr Crr Le Co Vo An ■ Pa Str Ad	-section Data - in Internal Force timent Factors on Ratio Addition Factors titally Adjusted sss-Section Re- sss-Section De- night Between night Between night Between night Between night Between night Between night Between night Between Shear Reductit Reference Ber Shear Reductit Reference con ses Interaction justed Bending	tress Bending D adth pth Points of Z ress Interac ding Design npression d Factor a Design Va	V5, 5P/5P, , gle 5.5/30.2 lesign Value ero Momente ction Factor jn Value Value lesign value	4 or More Lz 5 s	ams	Mx Sx Fbx Fbx d L x Cv Ø Fb For, cmp, cmp, face C1 Fbx, ten, face	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 20 0.921 3.28 2400.00 0.720 300.00 740.00 0.844 2542.77	Ibfft in ³ psi in in ft \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$		Eq. (5.3-1) Table 5A 5.3.10 Table 5A Table 5A Table 5A Eq. (5.3-4),ERRATA-2013-11	30.3	5.5
☐ Crosss ☐ Desig ☐ Adjus ☐ Desig ☐ Desig ☐ Desig ☐ Bes Se Ac Pa Crc Crc Crc Crc Crc Crc Crc Crc Crc Crc	-section Data in Internal Force furthernal Force furthernal Force furthernal Force furthernal Force furthernal Force furthernal Force furthernal Force for Moment furthernal Force f	tress Bending D adth pth Points of Z ress Interac ding Desig on Factor ar Design ppression d Factor J Design Va 1 Design Va	V5, 5P/5P, and the second seco	4 or More Lz 5 s	ams	Mx Sx Fbx b d L x Cv Ø Fbx Fy Fop, omp. face C1 Fbx, ten. face Fbx, ten, face	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 0.921 3.28 2400.00 0.720 300.00 740.00 0.844 2542.77 2328.19	Ibfft in ³ psi in in ft \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$		Eq. (5.3-1) Table 5A 5.3.10 Table 5A Table 5A Table 5A Eq. (5.3-4),ERRATA-2013-11	30.3	5.5 * *
Cross	-action Data in Internal Force timent Factors on Ratio nding Moment citoln Modulus tual Bending S ritally Adjusted sss-Section Der nstant liume Factor gie of Taper rameters for St. Reference She Reference She Reference son usted Bending justed Bending usted Bending usted Bending usted Bending sign Patio (Ter	tress Bending D adth pth Points of Z ress Interaction par Design par Design Va J Design Va J Design Va J Design Va J Design Va S Design Va	V5, 57/57, 2 gle 5.5/30.2 lesign Value ero Moments ction Factor yn Value Value lesign value j	4 or More Lz 5 s	ams arto grain	Mx Sx Fex b d L X Cy Ø Fb Cyr Fo Fyr For, cmp, face T1	108833 838.8 1556.96 2760.00 5.5 30.3 40.00 0.921 3.28 2400.00 0.720 300.00 0.740.00 0.844 2542.77 2328.19 0.61	lbfft in 3 psi in ft psi psi psi psi psi	<u></u>	Eq. (5.3-1) Table 5A 5.3.10 Table 5A Table 5A Eq. (5.34),ERRATA-2013-11 3.3.1	30.3	5.5 1 1 y

Figure 8.35: Window 2.1 Design by Load Case

Calculation



The beam capacities, which are modified by adjustment factors, are calculated as follows:

Partially Adjusted Bending Design Value

 $F_{bx}^{*} = F_{bx} \times C_{M} \times C_{t} \times C_{D}$ $F_{bx}^{*} = 2400 \times 1.0 \times 1.0 \times 1.15$ $F_{bx}^{*} = 2760.00 \text{ psi}$

Adjusted Shear Design Value

 $F_{vx}' = F_{vx} \times C_M \times C_t \times C_D$ $F_{vx}' = 300 \times 1.0 \times 1.0 \times 1.15$ $F_{vx}' = 345.00 \text{ psi}$

The stress analysis is performed as follows.

Actual Bending Stress

 $f_{bx} = \frac{M_x}{S_x} = \frac{1305990 \text{ lbf.ft}}{838.81 \text{ in}^3} = 1556.96 \text{ psi}$

Actual Shear Stress Parallel to Grain

$$f_{vx} = \frac{V_x \times Q_x}{I_x \times b} = \frac{12879 \,\text{lbf} \times 332.75 \,\text{in}^3}{4880.3 \,\text{in}^4 \times 5.5 \,\text{in}} = 159.66 \,\text{psi}$$

The bending design stress must be adjusted also by the lesser of the stress interaction factor, C_{l} , and volume factor, C_{v} .

The stress interaction factor depends on the face of taper. For members tapered on the compression side, this factor is calculated as follows.

Stress Interaction Factor

$$C_{I} = \frac{1}{\sqrt{1 + (\frac{F_{b} \times \tan \theta}{F_{v} \times C_{vr}})^{2} + (\frac{F_{b} \times \tan^{2} \theta}{F_{c_{\Box}}})^{2}}}$$

$$C_{I} = \frac{1}{\sqrt{1 + (\frac{2400 \times \tan 3.28^{\circ}}{300 \times 0.72})^{2} + (\frac{2400 \times \tan^{2} 3.28^{\circ}}{740})^{2}}}$$

$$C_{I} = 0.844$$

The volume factor depends on the cross-section dimensions at the verified point on the beam (dimensions and length of bending member between points of zero moment in ft).

Volume Factor

$$C_{V} = (\frac{21}{L})^{1/x} \times (\frac{12}{d})^{1/x} \times (\frac{5.125}{b})^{1/x}$$
$$C_{V} = (\frac{21}{40})^{1/20} \times (\frac{12}{30.25})^{1/20} \times (\frac{5.125}{5.50})^{1/20}$$

 $C_V = 0.921$



With this factor, the total flexural capacity can be calculated as follows.

Adjusted Bending Design Values

 $F_{bx}' = F_{bx} * \times min(C_1; C_V) = 2760.00 \times min(0.844; 0.921) = 2329.44 \text{ psi}$

Bending Design

Design of bending according to [1] Chapter 3.3.1:

Design

 $\frac{f_{bx}}{F_{bx}'} \!=\! \frac{1556.96}{2329.44} \!=\! 0.67 \!\leq\! 1.00$

Shear Design

Design of shear according to [1] Chapter 3.4.1:

Design 1 (Shear due to shear force V_x)

$$\frac{f_{vx}}{F_{vx}} = \frac{159.66}{345.00} = 0.46 \le 1.00$$



8.4 Curved Beam (LRFD Solution)

According to the Design Specification [1], the cross-section resistance design can be also performed for curved sections of bending members. The cross-section must be constant in those parts. In RF-TIMBER AWC, members of that type are not allowed for stability calculations, however.

8.4.1 System and Loads



Figure 8.36: System and loads

Model

Material:	Douglas Fir-Larch 16F-V3
Length:	66 ft
Radius of Curvature at Centerline:	50 ft
Cross-section:	8-3/4 in by 51 in
Thickness of Lamination	1-1/2 in
Moisture Condition:	Dry
Temperature Condition:	T ≤ 100°F
Loads	

Load Combination:	1.2D + 1.6S
LC 1 Dead:	85 lbf/ft
LC 2 Snow:	350 lbf/ft

8.4.2 Calculation with RFEM

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

We create the considered load combination with relevant factors from the defined load cases. Then we calculate the model according to the linear static analysis.

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

8 Examples

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Figure 8.37: Internal forces N, M_y and V_z

8.4.3 Design with RF-TIMBER AWC

Ultimate Limit State Design

In Window 1.1 *General Data*, we select the result combination **CO1** for the *Ultimate Limit State* design. We perform the design according to **LRFD**.

sign of					Design According to	
embers:			🐴 🗙	Al	LRFD	-
ts:	1		x 🖉	1 🔽 🔁		
lltimate Limit	State Serviceability Limit	State				
xisting Load	d <u>Cases</u> / Combinations	1	Selected for D)esign		
D LC1 s LC2	Dead Snow		2.3 CO1	1.20D + 1.60S		
		>	ון			
		>>				
		4	ור			
All (3)		- 24 62				2 1

Figure 8.38: Window 1.1 General Data



The 1.2 Materials window presents the characteristic strengths of the selected material.

A		В		Special Settings for	
Material Material				Special settings for	dularn acc. to
No. Description		Comment		footnotes in Table 5	B and Table 5D:
3 6F-1.3E, 16F-E6, DF/DF, 4 or More Lams ANSI/AWC NDS-2012	1				1 N. P. 1
				Heduction of Hb	x by multipliying by
				a ractor 0.88 ror than 15 in, deen	members greater
		1			
laterial Properties					
∃ Main Properties					
Modulus of Elasticity	E	1600.000	ksi		
- Shear Modulus	G	100.000	ksi		
Specific Weight	γ	0.0	kip/ft ³		
Coefficient of Thermal Expansion	α	2.7778E-06	1/°F		
Partial Safety Factor	7M	1.00			
Additional Properties					
Reference Modulus of Elasticity (Axial Loading)	Ez	1575.000	ksi		
Reference Shear Modulus (Axial Loading)	Gz	98.438	ksi		
Reference Modulus of Elasticity (Loading Perpendicular to Wide Faces of Lams) E _x	1600.000	ksi		
 Reference Shear Modulus (Loading Perpendicular to Wide Faces of Lams) 	Gx	100.000	ksi		
 Reference Modulus of Elasticity (Loading Parallel to Wide Faces of Lams) 	Ey	1500.000	ksi		
 Reference Shear Modulus (Loading Parallel to Wide Faces of Lams) 	Gy	93.750	ksi		
Modulus of Elasticity Perpendicular	E90	53.333	ksi	Material No. 3 used	in
- Shear Modulus Perpendicular	G 90	10.000	ksi		
 Reference Tension Design Value Parallel to Grain 	Ft	1000.00	psi	Cross-sections No.:	
 Reference Compression Design Value Parallel to Grain 	Fo	1600.00	psi	1	
 Reference Bending Design Value (Bending Perpendicular to Wide Faces of Lar 	ms) F _{bx} +	1600.00	psi		
Reference Bending Design Value (Bending Perpendicular to Wide Faces of Lar	ms) F _{bx} -	1600.00	psi	Members No ·	
 Reference Bending Design Value (Bending Parallel to Wide Faces of Lams) 	Fby	1550.00	psi	1.2	
Reference Shear Design Value Parallel to Grain	Fvx	265.00	psi	1-3	
Reference Shear Design Value Parallel to Grain	Fvy	230.00	psi		
 Reference Compression Design Value Perpendicular to Grain 	Fopx,ten.face	560.00	psi	Sets of members No	0.5
Reference Compression Design Value Perpendicular to Grain	Fcpx,comp.fac	560.00	psi	1	
Reference Compression Design Value Perpendicular to Grain	Fcpy	560.00	psi		
Reference Modulus of Elasticity for Stability Calculations	Exmin	850.000	ksi	∑ Length:	∑ Weight:
Reference Modulus of Elasticity for Stability Calculations	Evmin	790.000	ksi	2 Longuit.	2 weight.
Type of Structural Glued Laminated Timber	-	Softwoods		67.71 [ft]	3.105 [to
Combination Symbol		16F-E6			
Species Outer/Core		DE/DE			

Figure 8.39: Window 1.2 Materials

In the 1.3 Cross-Sections window, the parameters of the glulam section can be checked.

	Δ	R	1	C		F	1 Chulam (MR) 9 75vE1 LANSHAWC N
Section	Material	Cross-Section		Opti-		E	1 - Giulaili (WS) 6.75x51 ANSI/AWC N
No.	No.	Description		mize	Note	Comment	
1	3	Glulam (WS) 8.75x51 ANSI/AWC	NDS-2012	No			+ ^{8.8} †
Fross-Se Flat U: Ben	ection Prop se Factor ding Desig	n Value Adjustment	Cfu	1.036 s	tandard-defined	d acc. to 5.3.7	
							Cross-section No. 1 used in
							Marker Mark
							Members No.:
							1-3
							Sate of members No :
							Σ Length: Σ Weight:
							67.71 [ft] 3.105 [ton
							Material:
							3 - 16F-1.3E, 16F-E6, DF/DF, 4 or More

Figure 8.40: Window 1.3 Cross-Sections



In Window 1.4 *Load Duration*, we define the load duration. For LRFD, **User-defined settings** are recommended for load combinations because the choice according to the shortest load duration within a combination does not always reflect the appropriate value of the time effect factor λ according to [1] Table N3.

As the beam is not loaded by any wind or earthquake load, the load condition for radial stress design according to Table 5.2.8 in [1] is set as **Other Types of Loading**.

		B	С	D	E	F
oad-		Load		Factor	Loading Condition	
ing	Description	Туре	Load Duration	λ	(Radial Stress Design)	Comments
C1	Dead	Dead	Permanent	0.600	Other Types of Loading	
C2	Snow	Snow	Two Months	0.800	Other Types of Loading	
01	1.20D + 1.60S		Two Months	0.800	Other Types of Loading	
pply time effect	Shortest load duration in a c	ombination				
ctor λ according	to:					

Figure 8.41: Window 1.4 Load Duration

In window 1.6 *In-Service Condition - Set of Members*, we define the moisture and temperature conditions. The factors C_M and C_T are determined as for **dry** service conditions and sustained exposure to elevated temperatures up to 100°F.

o in-Servi	ice Conditions - Set of Membe	irs		
	A	В	С	Moisture Service Condition
Set	Moisture Service			
No.	Condition	Temperature	Comments	Dry Service Conditions:
1	Dry	T ≤ 100°F		Moisture content in service is less than 19% for lumber (less than 16% for glulam)
				Wet Service Conditions: Molsture content in service is 19% or greater for dumber (16% and greater for glulam)
				Temperature Effects:
				Structural members experience sustained exposure to elevated temperatures up to 100°F
				Structural members experience sustained exposure to elevated temperatures between 100°F and 125°F
				Structural members experience sustained exposure to elevated temperatures between 125°F and 150°F
Set inp	out for members No.:			
		Aļi	🛃 🐧 📀	

Figure 8.42: Window 1.6 In-Service Conditions - Set of Members

8 Examples



Details...

Since the beam is laterally supported, we deactivate the **stability analysis** in the *Details* dialog box.

Details	×
Resistance Stability Serviceability Fire Resistance Other	
Stability Analysis	
Perform stability analysis	
 Stability analysis according to equivalent member method (requires definition of effective lengths) 	
 Stress/stability analysis according to second order theory (requires definition of imperfections in RSTAB) 	

Figure 8.43: Dialog box Details, tab Stability

In Window 1.9 *Additional Design Properties*, the use of further adjustment factors is not required. There is no shear reduction to be applied.

	A	В	C	D	E	F
lember		Adjustment Factors				
No.	Description	Definition	Symbol	Value [-]	acc. to	Comment
1	Shear Reduction Factor	No Shear Reduction	Cvr	-	5.3.10	
	Shear Edge-Bonded Factor	Edge-Bonded	-	-	NDS Suppl.	
2	Shear Reduction Factor	No Shear Reduction	Cvr	-	5.3.10	
	Shear Edge-Bonded Factor	Edge-Bonded	-	-	NDS Suppl.	
3	Shear Reduction Factor	No Shear Reduction	Cvr	-	5.3.10	
	Shear Edge-Bonded Factor	Edge-Bonded	-	-	NDS Suppl.	
Set in	put for members No.:	Material Catego	ory:			

Figure 8.44: Window 1.9 Additional Design Parameters



Window 1.11 Curved Members controls the input of the curved sections.

1.11 Cur	ved Members					
	A	В	С	D	E	F
Membe	r Laminate	Minimum R	adius of Curvature (Inside	Face)	Radial Stress	
No.	t [in]	RMIN [ft]	t/R		Design	Comment
2	1.5	47.88	1 / 383.005	≤ 1 / 125.000	✓	

Figure 8.45: Window 1.11 Curved Members

The thickness of the lamellas is set as **1.5 in**. This value is directly reflected in the check of the minimum radius of curvature (inside face of curved member).

We tick the check box in the **Radial Stress Design** column so that RF-TIMBER AWC performs a check of the radial stresses.

Calculation

Then we start the calculation by clicking the [Calculation] button.

After the calculation, the governing design ratios are shown in the 2.3 *Design by Set of Members* window.

	A	B	С	D	E											
Set	Member	Location	Load-													
No.	No.	x [ft]	ing	Design					Design /	According	to Formula					
1	(Member No. 1-3)															
	1	0.00	CO1	0.00	≤1	102) Cross-section n	esistance - St	trength in corr	pression p	parallel to	grain acc. to 3	6				
	1	0.00	CO1	0.16	≤1	111) Cross-section n	esistance - St	trength in she	ar due to s	shear forc	e Vz/Vx acc. te	3.4				
	1	20.77	CO1	0.48	≤1	151) Cross-section n	esistance - St	trength in ben	ding abou	t y/x-axis	and compressi	on acc. to	3.9.2			
	2	0.00	CO1	0.06	≤1	2111) Cross-section	resistance - (Curved Memb	er - Streng	gth in shea	ar due to shear	force Vz/\	/x acc. to	o 3.4		
	2	13.09	CO1	0.58	≤1	2131) Cross-section	resistance - (Curved Memb	er - Streng	gth in ben	ding about y/x-	axis acc. to	o 3.3			
	2	1.64	CO1	0.51	≤1	2151) Cross-section	resistance - (Curved Memb	er - Streng	jth in ben	ding about y/x-	axis and co	ompressi	on acc.	to 3.9.2	
	2	13.09	CO1	0.94	≤1	2201) Cross-section	resistance - (Curved Memb	er - Radia	l tension p	perpendicular to	grain acc	. to 5.4.1			
				0.04					GT	•		0 -			()	
			Max:	0.94	≤1	9				÷		,u •		~	1	5
tails -	Member 2	- x: 13.09 ft	- CO1									1 - Glula	m (WS)	8.75×5	1 LANSI/A	w
Mater	rial Data - 1	I6F-1.3E. 16F	-E6. DF/C)F. 4 or More	e Lam	s										
] Mater] Cross	ial Data - 1 -section Da	16F-1.3E, 16F ata - Glulam (\	-E6, DF/E NS) 8.75x	0 F. 4 or More :51 ANSI/A	ELam	s NDS-2012+ADDEND	UM:2013-08									
] Mater] Cross] Desig	rial Data - 1 -section Da In Internal F	I6F-1.3E, 16F ata - Glulam (\ Forces	-E6, DF/D NS) 8.75x	0F, 4 or More 51 ANSI/A	WC 1	s NDS-2012+ADDEND	UM:2013-08									
] Mater] Cross] Desig] Adjus	rial Data - 1 -section Da In Internal F tment Facto	IGF-1.3E, 1GF ata - Glulam (\ Forces ors	-E6, DF/D NS) 8.75x	0F, 4 or More 51 ANSI/A	WC 1	s NDS-2012+ADDEND	UM:2013-08									
Mater Cross Desig Adjus	rial Data - 1 -section Da In Internal F tment Facto ference Ra	16F-1.3E, 16F ata - Glulam () Forces ors adial Tension	-E6, DF/E WS) 8.75x Stress	0F, 4 or More 51 ANSI/A	WC N	s NDS-2012+ADDEND	UM:2013-08							+ ^{8.8} †		
Mater Cross Desig Adjus	rial Data - 1 -section Da In Internal F tment Facto ference Ra Reference	16F-1.3E, 16F ata - Glulam (\ Forces ors adial Tension Radial Tension	-E6, DF/E WS) 8.75x Stress on Stress	0F, 4 or More	WC 1	s NDS-2012+ADDEND	UM:2013-08	15.00	psi		5.2.8		+	***		
Mater Cross Desig Adjus	rial Data - 1 -section Da In Internal P tment Factor ference Ra Reference I Wet Service	IGF-1.3E, 1GF ata - Glulam () Forces ors adial Tension Radial Tensio e Factor	-E6, DF/E WS) 8.75x Stress on Stress	DF, 4 or More	WC 1	s NDS-2012+ADDEND	UM:2013-08	15.00	psi		5.2.8		+	* ^{8.8}		
Mater Cross Desig Adjus	ial Data - 1 -section Da In Internal F tment Facto ference Ra Reference Wet Service Temperatur	IGF-1.3E, 1GF ata - Glulam () Forces ors adial Tension Radial Tensio re Factor re Factor	-E6, DF/L WS) 8.75x Stress on Stress	0F, 4 or More	WC 1	s NDS-2012+ADDENDI	UM:2013-08	15.00 1.000 1.000	psi		5.2.8 5.3.3 5.3.4		t	***		
] Mater] Cross] Desig] Adjus 🖸 Re	ial Data - 1 -section Da In Internal F tment Facto ference Ra Reference I Wet Service Temperatur Format Con	16F-1.3E, 16F ata - Glulam () Forces ors adial Tension Radial Tensio e Factor re Factor re Factor	-E6, DF/L WS) 8.75x Stress on Stress	0F, 4 or More	WC 1	s NDS-2012+ADDENDI	UM:2013-08	15.00 1.000 1.000 2.880	psi		5.2.8 5.3.3 5.3.4 5.3.14		t	***		
] Mater] Cross] Desig] Adjus E] Re	ial Data - 1 -section Da In Internal F tment Facto ference Ra Reference I Wet Service Temperatur Format Con Resistance	16F-1.3E, 16F forces ors adial Tension Radial Tension Radial Tensio e Factor re Factor iversion Factor	-E6, DF/L NS) 8.75x Stress on Stress or)F, 4 or More	WC 1	s NDS-2012+ADDENDI	UM:2013-08	15.00 1.000 1.000 2.880 0.750	psi		5.2.8 5.3.3 5.3.4 5.3.14 5.3.14 5.3.15		1.0	***		
] Mater] Cross] Desig] Adjus E Re	ial Data - 1 -section Da In Internal F tment Factor ference Ra Reference Ra Reference Ra Wet Service Temperatur Format Con Resistance Time Effect	16F-1.3E, 16F forces ors adial Tension Radial Tension Radial Tension re Factor re Factor wersion Factor Factor	-E6, DF/L NS) 8.75x Stress on Stress or)F, 4 or More	WC 1	s NDS-2012+ADDENDI	UM:2013-08 Frt CM (Fv) Ct (Fv) KF (Fv) & (Fv) \$\$ (Fv) \$\$ (Fv) \$\$ (Fv) \$\$ (Fv)	15.00 1.000 1.000 2.880 0.750 0.800	psi		5.2.8 5.3.3 5.3.4 5.3.14 5.3.15 5.3.15 5.3.16		51.D	* ^{8.8}		
Mater Cross Desig Adjus	tial Data - 1 section Da In Internal F tment Factor ference Ra Reference Wet Service Temperatur Format Con Resistance Time Effect Adjusted Ra	IGF-1.3E, 1GF tata - Glulam () Forces ors adial Tension Radial Tension Radial Tension Factor Version Factor - Factor t Factor adial Tension	-E6, DF/L NS) 8.75x Stress on Stress or Stress	2F, 4 or More	WC 1	s NDS-2012+ADDENDI	UM:2013-08 Frt C _M (F _v) C _t (F _v) K _F (F _v) \pm (F _v) \pm (F _v) Frt	15.00 1.000 1.000 2.880 0.750 0.800 25.92	psi		5.2.8 5.3.3 5.3.4 5.3.14 5.3.15 5.3.16		51.0	* ^{8.8}		
] Mater] Cross] Desig] Adjus E Re	ial Data - 1 -section Da In Internal F tment Facto ference Ra Reference R Wet Service Temperatur Format Con Resistance Time Effect Adjusted Ra In Ratio	16F-1.3E, 16F ata - Glulam () Forces ors adial Tension Radial Tension Radial Tension re Factor re Factor re Factor i Factor t Factor adial Tension	-E6, DF/E WS) 8.75x Stress on Stress or Stress)F, 4 or More	VC 1	s NDS-2012+ADDENDI	UM:2013-08 Frt C M (F v) C t (F v) K F (F v) Φ (F v) λ (F v) Frt'	15.00 1.000 2.880 0.750 0.800 25.92	psi		5.2.8 5.3.3 5.3.4 5.3.14 5.3.15 5.3.16		51.0	* ^{8.8} -		
Mater Cross Desig Adjus Re	ial Data - 1 -section Da In Internal F timent Factor ference Ra Reference I Wet Service Temperatur Format Con Resistance Time Effect Adjusted Ra In Ratio In Ratio	16F-1.3E, 16F ata - Glulam () Forces ors adial Tension Radial Tension Radial Tension e Factor re Factor re Factor t Factor adial Tension ent	-E6, DF/E WS) 8.75x Stress on Stress or Stress)F, 4 or More	VC 1	s NDS-2012+ADDENDI	UM:2013-08 Frt CM (Fv) Ct (Fv) KF (Fv) Φ (Fv) λ (Fv) Frt M _x	15.00 1.000 2.880 0.750 0.800 25.92 361534.0	psi psi		5.2.8 5.3.3 5.3.4 5.3.14 5.3.15 5.3.16		51.0	*8.8 •		
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Figure 8.46: Window 2.3 Design by Set on Members



The capacities of the curved member, which are modified by adjustment factors, are calculated as follows:

Curvature Factor

 $C_c = 1 - 2000 \times (t/R)^2$ $C_c = 1 - 2000 \times (1.5/574.56)^2$ $C_c = 0.986373 \text{ psi}$

Partially Adjusted Bending Design Value

$$\begin{split} F_{bx} * &= \lambda \times K_F \times \Phi \times F_{bx} \times C_c \times C_M \times C_t \\ F_{bx} * &= 0.8 \times 2.54 \times 0.85 \times 1600 \times 0.986373 \times 1.0 \times 1.0 \\ F_{bx} * &= 2725.86 \text{ psi} \end{split}$$

Adjusted Shear Design Values

$$\begin{split} F_{vx}' = & F_{vx} \times C_M \times C_t \times K_F \times \Phi \times \lambda \\ F_{vx}' = & 265 \times 1.0 \times 1.0 \times 2.88 \times 0.75 \times 0.8 \\ F_{vx}' = & 457.92 \, psi \end{split}$$

Adjusted Radial Tension Stress

$$\begin{split} F_{rt}' &= F_{rt} \times C_M \times C_t \times \Phi \times \lambda \\ F_{rt}' &= 15 \times 1.0 \times 1.0 \times 2.88 \times 0.75 \times 0.8 \\ F_{rt}' &= 25.92 \text{ psi} \end{split}$$

The stress analysis is performed as follows.

Actual Bending Stresses

 $f_{bx} = \frac{M_x}{S_x} = \frac{361534 \text{ lbf.ft}}{3793.1 \text{in}^3} = 1143.76 \text{ psi}$

Actual Shear Stress Parallel to Grain

$$f_{vx} = \frac{V_x \times Q_x}{I_x \times b} = \frac{211861bf \times 2844.84 \text{ in}^3}{96724.70 \text{ in}^4 \times 8.75 \text{ in}} = 71.21\text{ psi}$$

Actual Radial Stress

$$f_r = \frac{3 \times M_x}{2 \times R \times b \times d} = \frac{3 \times 361534 \text{ lbf.ft}}{2 \times 50.0 \times 8.75 \times 51.0} = 24.30 \text{ psi}$$

The bending design stress must be adjusted also by the volume factor, C_{v} . This factor depends on the cross-section dimensions at the verified point on the beam (dimensions and length of bending member between points of zero moment in ft.).

Volume Factor

$$C_{V} = \left(\frac{21}{L}\right)^{1/x} \times \left(\frac{12}{d}\right)^{1/x} \times \left(\frac{5.125}{b}\right)^{1/x}$$
$$C_{V} = \left(\frac{21}{67.72}\right)^{1/10} \times \left(\frac{12}{51.0}\right)^{1/10} \times \left(\frac{5.125}{8.75}\right)^{1/10}$$

 $C_V = 0.7296$



With this factor, the total flexural capacity can be calculated as follows.

Adjusted Bending Design Values

 F_{bx} '= F_{bx} *× C_V = 2725.86 × 0.7296 = 1988.79 psi

Bending Design

Design of bending according to [1] Chapter 3.3.1:

Design

$$\frac{f_{bx}}{F_{bx}'} = \frac{1143.76}{1988.79} = 0.58 \le 1.00$$

Shear Design

Design of shear according to [1] Chapter 3.4.1:

Design

$$\frac{f_{vx}}{F_{vx}'} = \frac{71.21}{457.92} = 0.16 \le 1.00$$

Radial Tension Design

Design of radial stress according to [1] Chapter 5.4.1.3:

Design

$$\frac{f_r}{F_{rt}} = \frac{24.30}{25.92} = 0.94 \le 1.00$$



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