



Tutorial

FKM (6th, 2012)

Updated on: March 26th, 2025

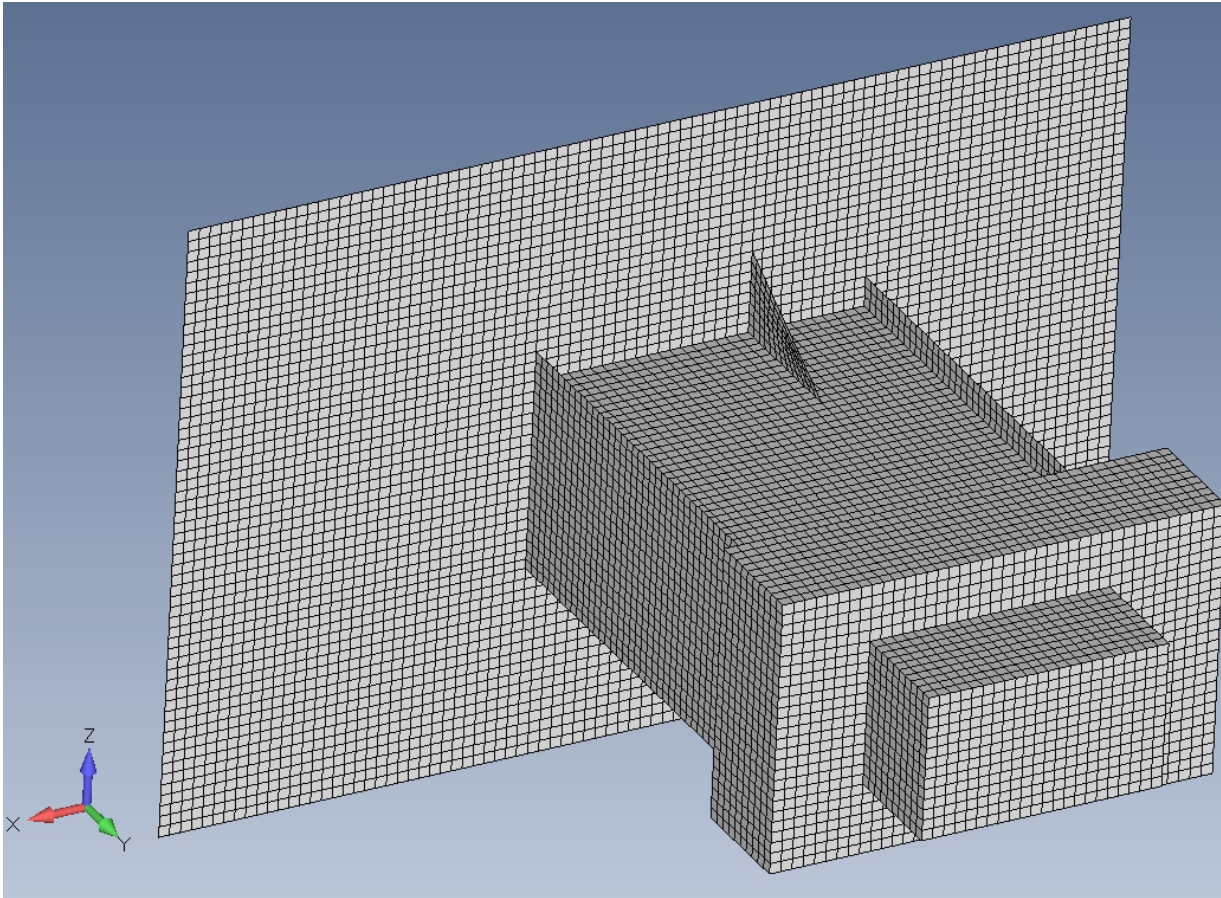
Tested with: SDC Verifier for Femap 2025 R1

Femap 2412

- ▶ This step-by-step tutorial demonstrates how to implement the check according to FKM (6th, 2012) in SDC Verifier.
- ▶ FKM (6th, 2012) detailed review;
- ▶ Weld Finder Tool overview;
- ▶ Fatigue tables and plots;

A simple model with shell and solid element types will be used. The following analysis was implemented:

- Fatigue load (will be used for the Fatigue check)



Fatigue check will be executed, based on results from fatigue load analysis.

Step 2-3: 100 000 cycles

Step 4-5: 100 000 cycles

Step 6-7: 1 000 000 cycles

Open the Starter Model

1

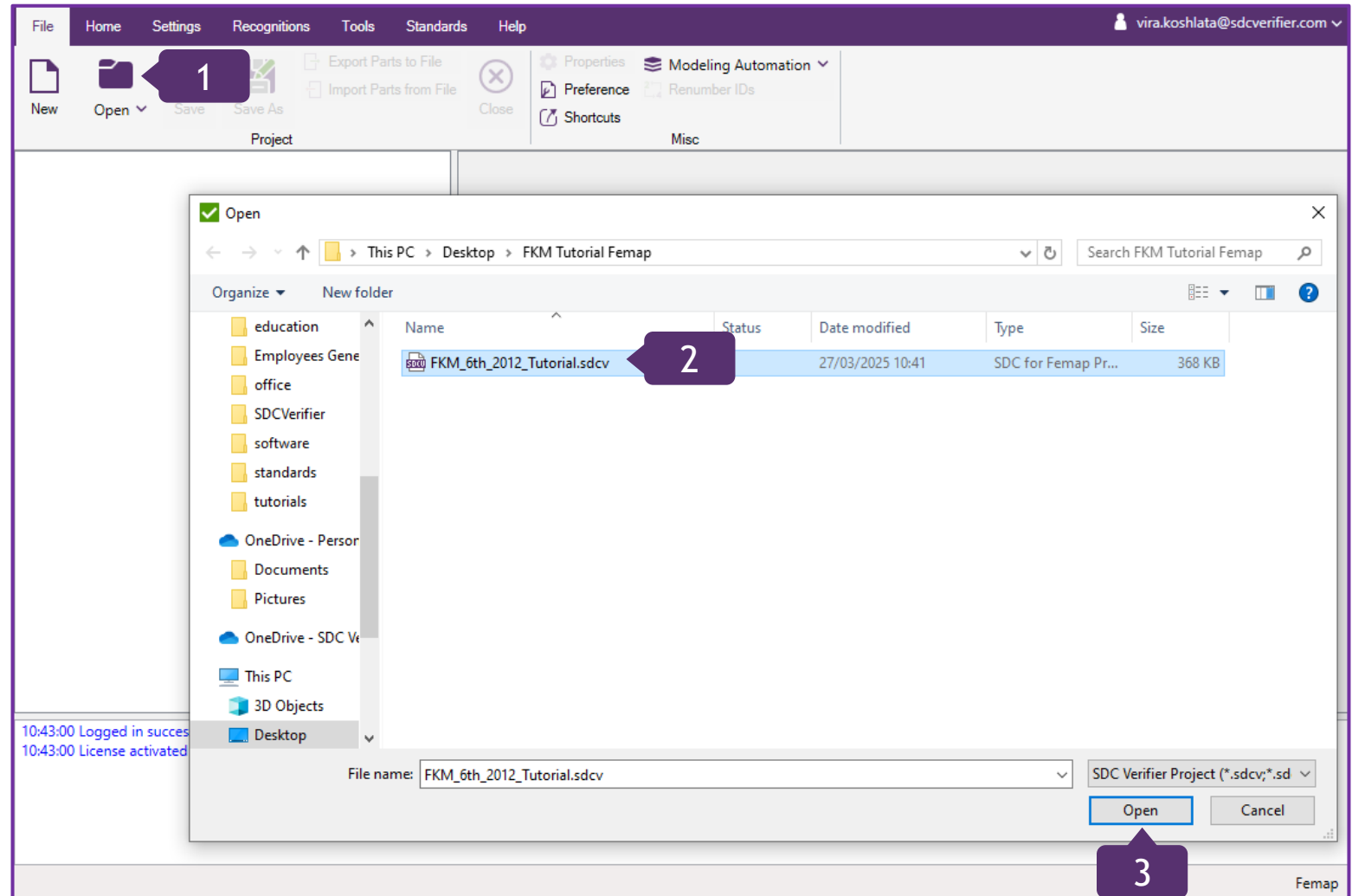
Launch SDC Verifier for FEMAP 
Press *Open*

2


Open project
FKM_6th_2012_Tutorial.sdcv

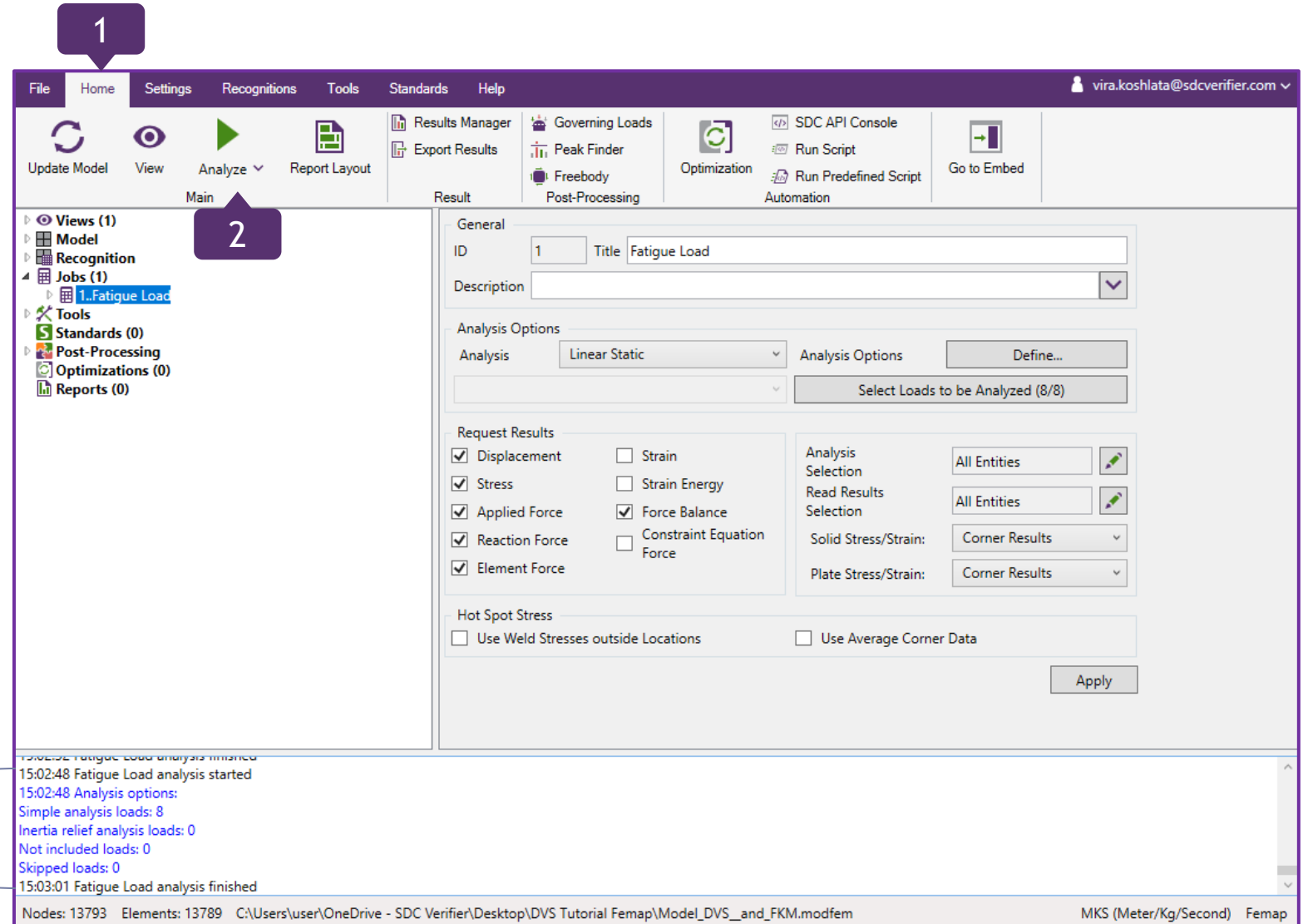
3

Press *Open*



1 Go to *Home* section on the Ribbon

2 Press  on the toolbar to analyze job



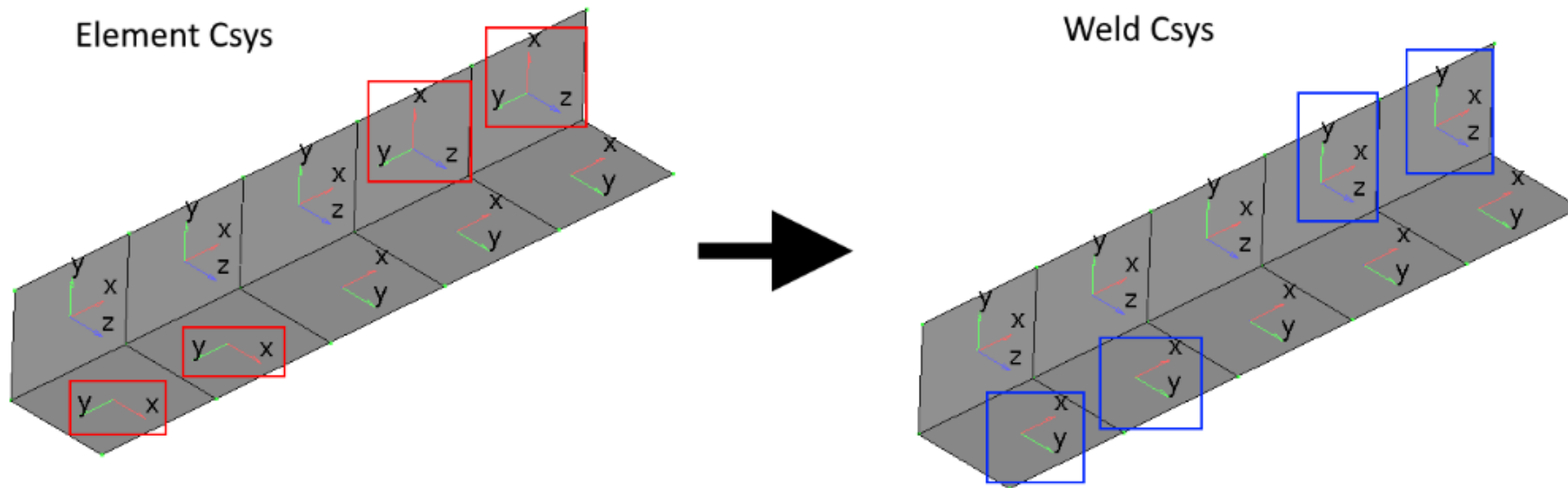
$$\sigma_{nn} = \frac{(\sigma_{xx} + \sigma_{yy})}{2} + \frac{(\sigma_{xx} - \sigma_{yy})}{2} * \cos 2\theta + \tau_{xy} * \sin 2\theta$$
$$\tau_{nt} = -\frac{(\sigma_{xx} - \sigma_{yy})}{2} * \sin 2\theta + \tau_{xy} * \cos 2\theta$$
$$\sigma_{tt} = \frac{(\sigma_{xx} + \sigma_{yy})}{2} - \frac{(\sigma_{xx} - \sigma_{yy})}{2} * \cos 2\theta - \tau_{xy} * \sin 2\theta$$

Stresses for Weld elements are automatically transformed in the direction of the corresponding Weld from Weld Finder Tool, using the wedge method. Stresses are transformed only for plate type elements.

$\sigma_{xx}, \sigma_{yy}, \tau_{xy}$ – original x,y and shear stress in local element x,y and shear directions

$\sigma_{tt}, \sigma_{nn}, \tau_{nt}$ – transformed x,y and shear stress in weld x,y and shear directions

θ – angle between the element and weld x directions.



Load Groups. Fatigue Check

1

Select Load Groups in 1..Fatigue Load in the model tree

2

Select Individual Loads from 2 till 3 and press 

3

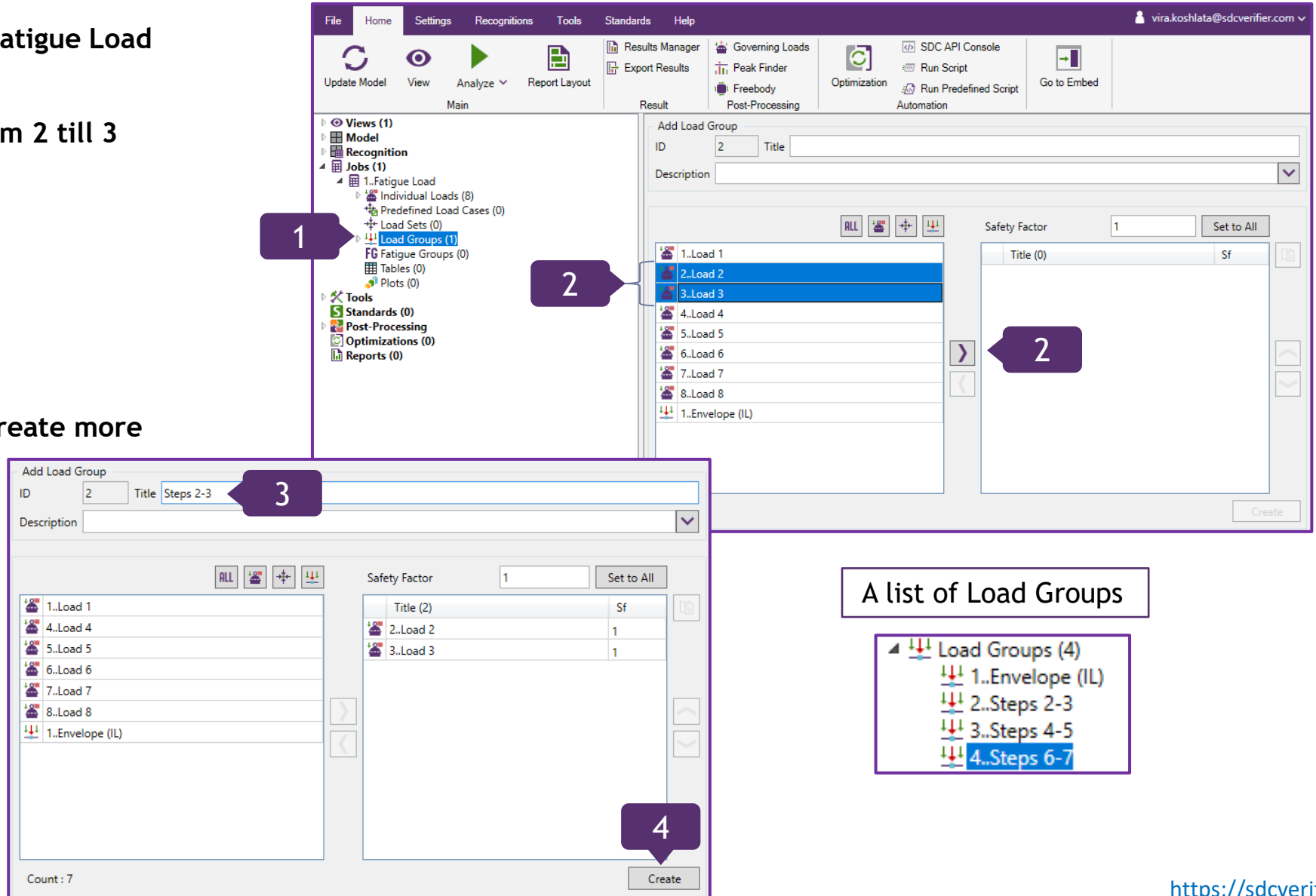
Title: *Steps 2-3*

4

Press *Create*

5

Repeat previous steps to create more LG



1

2

3


4

A list of Load Groups

- Load Groups (4)
 - 1..Envelope (IL)
 - 2..Steps 2-3
 - 3..Steps 4-5
 - 4..Steps 6-7

Fatigue Group. Fatigue Check

1 In the Model Tree, select *Fatigue Group*

2 Select *Load Groups* from 2 to 4 and press 

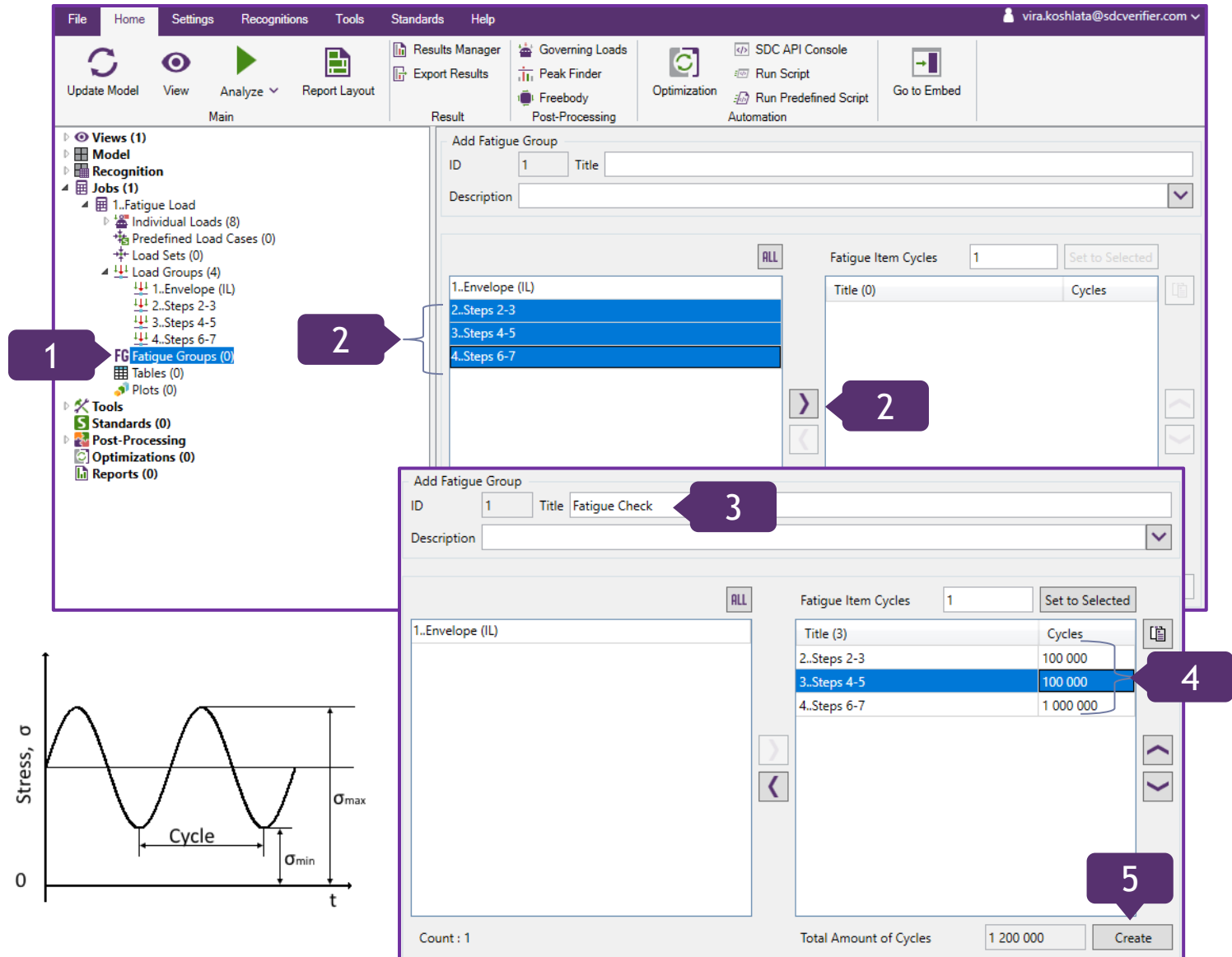
3 Title: *Fatigue Check*

4 Define fatigue item cycles

5 Press *Create*

Fatigue Groups is an envelope of Load Groups and their stress history (the number of cycles for stress range) which is used in fatigue standards.

1 Cycle = period of time where stress of the load varies from its minimum to maximum and back to minimum. Stress results for load will be summarized as many times as defined in item cycle and divided on total amount of cycles to calculate part of fatigue damage taken by Fatigue Group.



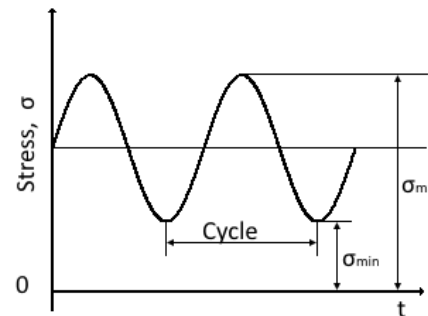
The screenshot shows the SDC Verifier software interface. The 'Add Fatigue Group' dialog is open, showing the 'Fatigue Item Cycles' table. The table has columns for 'Title' and 'Cycles'. The 'Fatigue Item Cycles' table is as follows:

Title	Cycles
1..Envelope (IL)	
2..Steps 2-3	100 000
3..Steps 4-5	100 000
4..Steps 6-7	1 000 000

The 'Total Amount of Cycles' is 1 200 000. The 'Create' button is visible at the bottom right.

Numbered callouts in the image indicate the following steps:

- 1: Select 'Fatigue Groups (0)' in the Model Tree.
- 2: Select '2..Steps 2-3', '3..Steps 4-5', and '4..Steps 6-7' in the 'Fatigue Item Cycles' table.
- 3: Enter 'Fatigue Check' in the 'Title' field.
- 4: Enter '100 000' in the 'Cycles' column for '3..Steps 4-5'.
- 5: Press the 'Create' button.

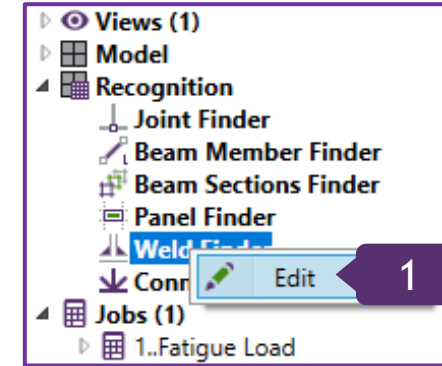


1

In the Model tree => Recognition, select *Weld Finder* and press *Edit*

2

In the Welds Finder window, press *Find*



Welds Finder

Welds Weld Strength Settings Hot Spot Stress

Filter: None = Apply Filter Find Weld by ID: Navigate

ID	Title	Tensile Strength (Min) [Pa]	Yield Stress (Min) [Pa]	Is Symmetric	Is Curved	Nodes	Elements	Weld Parts
1	Weld 1 [0.01; 0.04; 0.04]	460000000	250000000	Yes	No	42	123	3
2	Weld 2 [0.03; 0.01; 0.04]	460000000	250000000	Yes	No	14	39	3
3	Weld 3 [0.07; 0.04; 0.04]	460000000	250000000	Yes	No	42	123	3
4	Weld 4 [0.07; 0.04; 0.01]	460000000	250000000	Yes	No	42	123	3
5	Weld 5 [0.01; 0.04; 0.01]	460000000	250000000	Yes	No	42	123	3
6	Weld 6 [0.03; 0.01; 0.01]	460000000	250000000	Yes	No	14	39	3
7	Weld 7 [0.03; 0; 0.05]	460000000	250000000	Yes	No	9	24	3
8	Weld 8 [0.03; 0; 0]	460000000	250000000	Yes	No	9	24	3
9	Weld 9 [0.02; 0.12; 0.03]	460000000	250000000	Yes	No	15	28	2
10	Weld 10 [0.02; 0.11; 0.05]	460000000	250000000	Yes	No	11	20	2
11	Weld 11 [0.02; 0.11; 0.02]	460000000	250000000	Yes	No	11	20	2
12	Weld 12 [0.02; 0.1; 0.03]	460000000	250000000	Yes	No	15	42	3
13	Weld 13 [0.04; 0.08; 0.01]	460000000	250000000	Yes	No	41	80	2
14	Weld 14 [0.04; 0.08; 0.06]	460000000	250000000	Yes	No	41	80	2
15	Weld 15 [0; 0.08; 0.03]	460000000	250000000	Yes	No	27	52	2
16	Weld 16 [0; 0.1; 0.03]	460000000	250000000	Yes	No	27	52	2
17	Weld 17 [0; 0.09; 0.06]	460000000	250000000	Yes	No	11	20	2
18	Weld 18 [0; 0.09; 0.01]	460000000	250000000	Yes	No	11	20	2
19	Weld 19 [0.04; 0.1; 0.06]	460000000	250000000	Yes	No	41	80	2
20	Weld 20 [0.08; 0.09; 0.06]	460000000	250000000	Yes	No	11	20	2
21	Weld 21 [0.08; 0.1; 0.03]	460000000	250000000	Yes	No	27	52	2
22	Weld 22 [0.08; 0.09; 0.01]	460000000	250000000	Yes	No	11	20	2
23	Weld 23 [0.08; 0.08; 0.03]	460000000	250000000	Yes	No	27	52	2
24	Weld 24 [0.04; 0.1; 0.01]	460000000	250000000	Yes	No	41	80	2
25	Weld 25 [0.04; 0.1; 0.02]	460000000	250000000	Yes	No	23	66	3
26	Weld 26 [0.04; 0.1; 0.05]	460000000	250000000	Yes	No	23	66	3
27	Weld 27 [0.06; 0.1; 0.03]	460000000	250000000	Yes	No	15	42	3
28	Weld 28 [0.06; 0.1; 0.03]	460000000	250000000	Yes	No	15	28	2
29	Weld 29 [0.06; 0.1; 0.03]	460000000	250000000	Yes	No	11	20	2

Settings Find Set Parameter Check on Weld Design OK Cancel

Add, Edit, Combine and Remove Welds

Move Welds. Order is important when one element belongs to 2 Welds

Preview selected Welds

Plot of selected Welds in colors and with labels of IDs

Weld Finder Plotting Functions

1

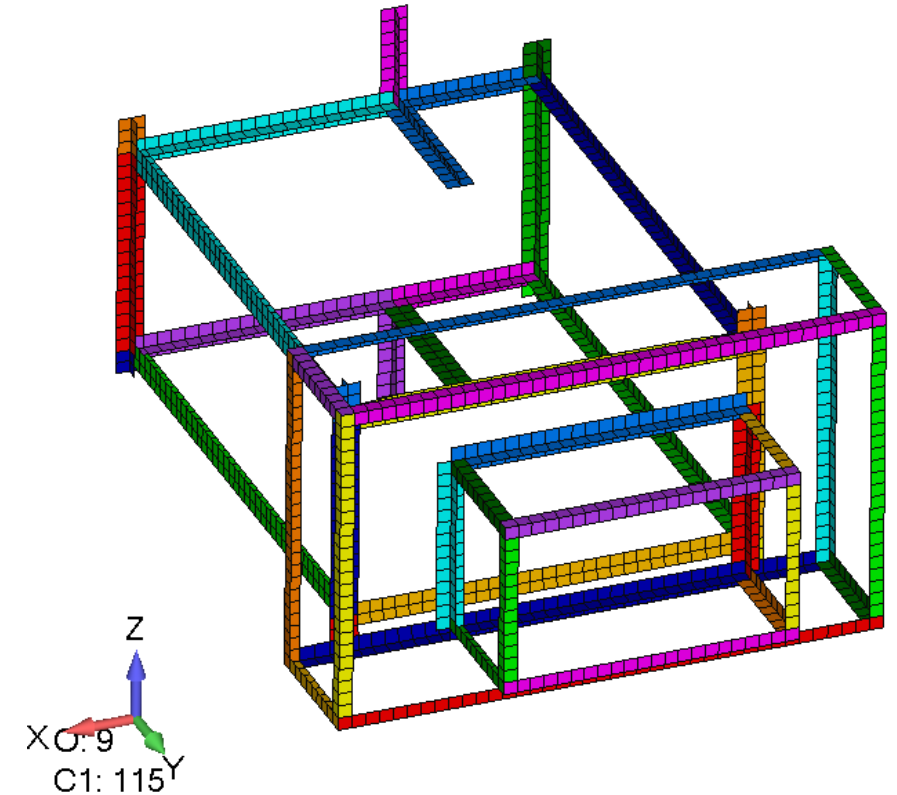
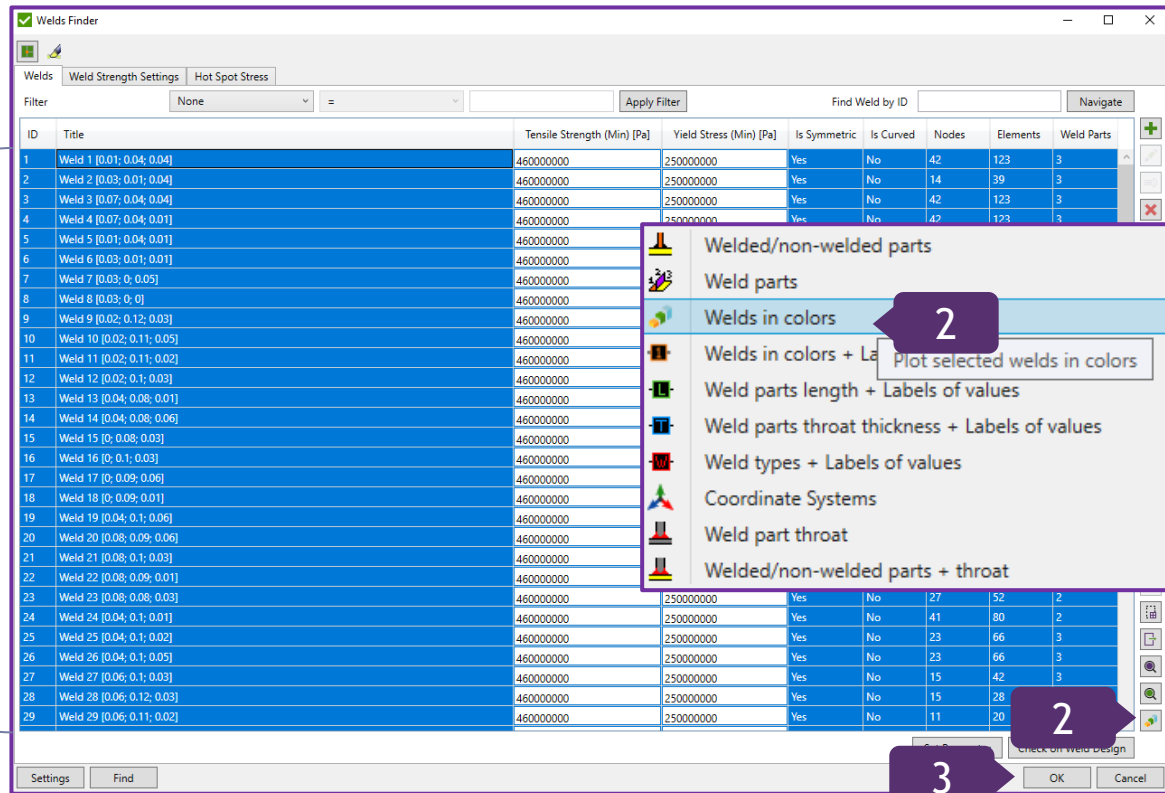
To plot all welds, in Welds Finder select them by combining Ctrl + A

2

Press  and select *Welds in colors*

3

Press OK



SDC Verifier offers an extensive variety of Plotting options that can be selected according to the user's objectives.

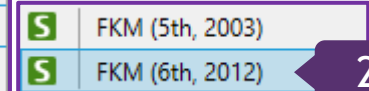
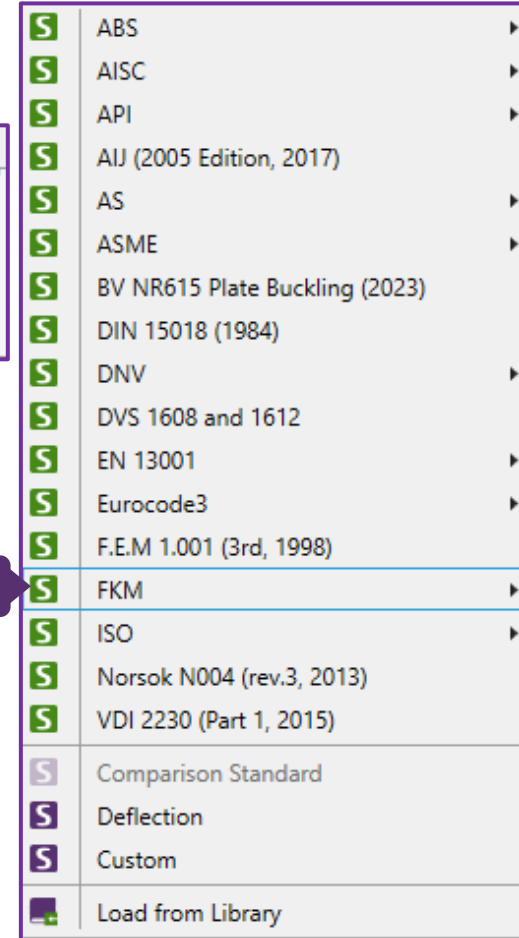
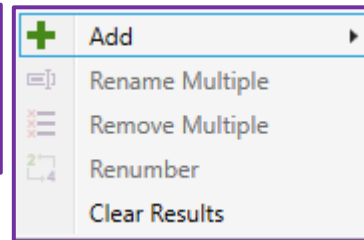
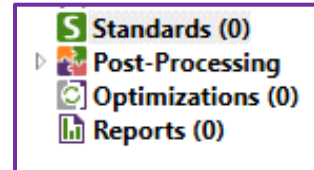
Add FKM (6th, 2012) Standard

1

In the *Model tree*, in Standards right click execute *Add* => *FKM*

2



Click on *FKM (6th, 2012)*

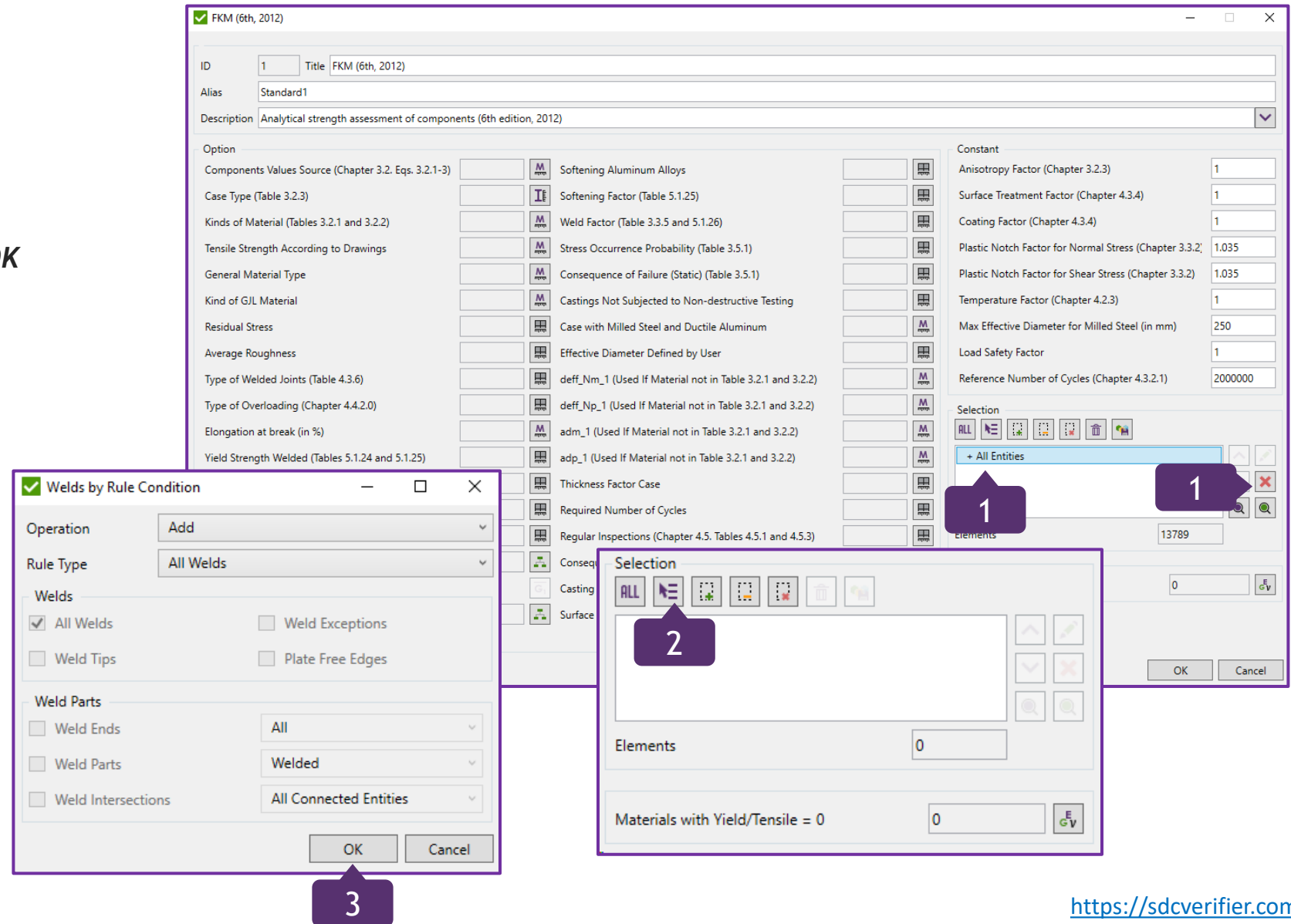
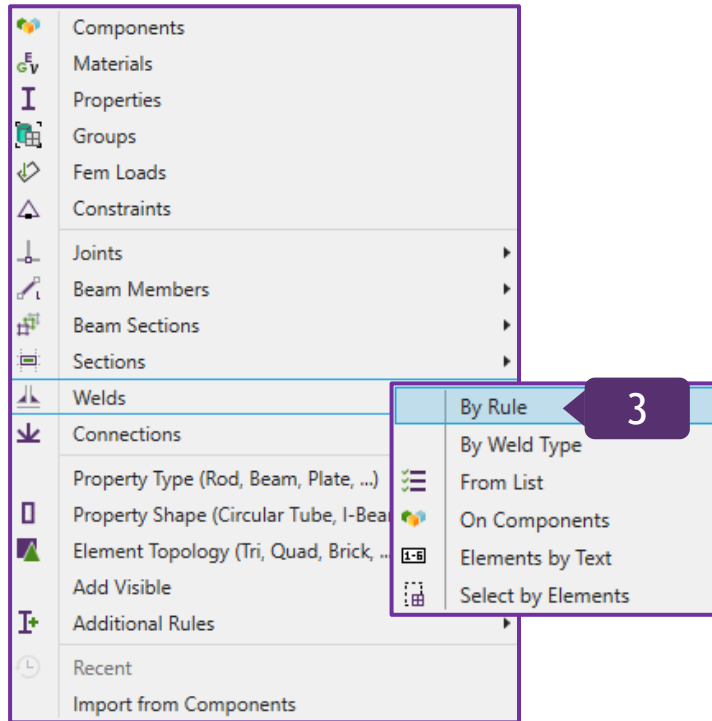


2

FKM (6th, 2012) is an analytical strength assessment of components in mechanical engineering.

Change Selection to All Welds

- 1 Select **+All Entities** and press  to remove them
- 2 In **Selection** => press 
- 3 Select **Welds** => **By Rule** and press **OK**



Define Components Values Source

1 Press  in *Components Values Source*

2 Materials CV: *Standards* and press *To All*

3 Press *OK*

$$R_m = K_{d,m} \cdot K_A \cdot R_{m,N} \quad (3.2.1)$$

$$R_p = K_{d,p} \cdot K_A \cdot R_{p,N}$$

R_m, R_p standard component values for tensile strength and yield strength;
 $K_{d,m}, K_{d,p}$ technological size factors, Chapter 3.2.1.4;
 K_A anisotropy factor, Chapter 3.2.1.5;
 $R_{m,N}, R_{p,N}$ standard values for semi-finished products or standard values for the test piece, respectively, Chapter 5.1.

Standard component values based on component values according to the drawings

$$R_m = 0,94 \cdot R_{m,Z} \quad (3.2.2)$$

R_m standard component value for tensile strength;
 $R_{m,Z}$ component value according to the drawings.

The yield strength R_p is calculated as follows:

$$R_p = \frac{K_{d,p}}{K_{d,m}} \cdot \frac{R_{p,N}}{R_{m,N}} \cdot R_m \quad (3.2.3)$$

$K_{d,p}, K_{d,m}$ technological size factors, Chapter 3.2.1.4;
 $R_{p,N}, R_{m,N}$ standard values for the semi-finished product or standard values for the test piece, respectively, Chapter 5.1.

Materials Characteristics

ID: 1 Title: Components Values Source

Alias: CompValues

Description: Chapter 3.2.1. Component values according to standards. Equations (3.2.1-3)

Materials CV: **Standards** (1) Apply To Selected To All (2)

Material	Value
1.Structural Steel	Standards

OK Cancel (3)


FKM (6th, 2012)


ID: 1 Title: FKM (6th, 2012)


Alias: Standard1


Description: Analytical strength assessment of components (6th edition, 2012)


Option


Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) (1) 


Case Type (Table 3.2.3) 


Kinds of Material (Tables 3.2.1 and 3.2.2) 


Tensile Strength According to Drawings 


General Material Type 


Kind of GJL Material 


Residual Stress 


Average Roughness 


Type of Welded Joints (Table 4.3.6) 


Type of Overloading (Chapter 4.4.2.0) 


Elongation at break (in %) 


Yield Strength Welded (Tables 5.1.24 and 5.1.25) 


Tensile Strength Welded (Tables 5.1.24 and 5.1.25) 


Special Case of Plastic Spot 

Sheet metal thickness 

FAT Classes (Tables 5.4.1 and 5.4.2) 

☐ Use Stress Gradient Tool 

☒ Related Stress Gradients (Chapter 4.3.2.1) 

☐ Use Hot Spot Stress 




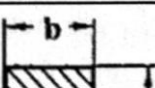
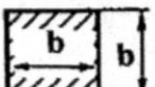
Define Case Type (Table 3.2.3)

1 Press  in Case Type (Table 3.2.3)

2 Properties CT: Case 1 and press To All

3 Press OK

Table 1.2.3 Effective diameter d_{eff}

No.	Cross-sectional shape	d_{eff} Case 1	d_{eff} Case 2
1		d	d
2		2s	s
3		2s	s
4		$\frac{2b \cdot s}{b + s}$	s
5		b	b

Case Type is used for defining effective diameter according to Table 3.2.3.

Properties Characteristics

ID: 2 Title: Case Type

Alias: CaseType

Description: Used for defining effective diameter according to Table 1.2.3

Properties CT: Case 1 Apply To Selected To All

Property	Value
1..Bottom plate t=6mm	Case 1
2..Front plate t=4mm	Case 1
3..Side plate t=6mm	Case 1
4..Flange t=4mm	Case 1
5..Upper plate t=6mm	Case 1
6..Front plate t=6mm	Case 1
7..Side plate t=6mm	Case 1

OK Cancel


FKM (6th, 2012)


ID: 1 Title: FKM (6th, 2012)


Alias: Standard1


Description: Analytical strength assessment of components (6th edition, 2012)


Option


Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) Defined 


Case Type (Table 3.2.3) 


Kinds of Material (Tables 3.2.1 and 3.2.2) 


Tensile Strength According to Drawings 


General Material Type 


Kind of GJL Material 


Residual Stress 


Average Roughness 


Type of Welded Joints (Table 4.3.6) 


Type of Overloading (Chapter 4.4.2.0) 


Elongation at break (in %) 


Yield Strength Welded (Tables 5.1.24 and 5.1.25) 


Tensile Strength Welded (Tables 5.1.24 and 5.1.25) 


Special Case of Plastic Spot 

Sheet metal thickness 

FAT Classes (Tables 5.4.1 and 5.4.2) 


☐ Use Stress Gradient Tool 

☒ Related Stress Gradients (Chapter 4.3.2.1) 

☐ Use Hot Spot Stress 

Define Kinds of Material (Tables 3.2.1 and 3.2.2)

1

Press  in *Kinds of Material* (Tables 3.2.1 and 3.2.2)

2

Materials KM1: *Non-alloyed structural steel DIN EN 10025* and press *To All*

3

Press *OK*

Kinds of Material - Kinds of material for defining constants d_{effN} and a_d according to tables 3.2.1 and 3.2.2.

Table 3.2.1 Constants $d_{eff,N,m}$, ... and $a_{d,m}$, ... for steel
Values in the respective upper row refer to R_m , while values in the lower row refer to R_p .

Material group $\diamond 1$	$d_{eff,N,m}$ $d_{eff,N,p}$ in mm	$a_{d,m}$ $a_{d,p}$ $\diamond 2$
Non-alloyed structural steel DIN EN 10025	40 40	0,15 0,3
Fine grain structural steel DIN 17102	70 40	0,2 0,3
Fine grain structural steel DIN EN 10113	100 30	0,25 0,3
Heat treatable steel, q&t DIN EN 10083-1	16 $\diamond 3$ 16	0,3 0,4
Heat treatable steel, n DIN EN 10083-1	16 16	0,1 0,2
Case hardening steel, bh DIN EN 10084	16 16	0,5 0,5
Nitriding steel, q&t DIN EN 10085	40 40	0,25 0,30
Stainless steel DIN EN 10088-2 $\diamond 4$	— —	— —
Steel for larger forgings, q&t SEW 550 $\diamond 5$	250 250	0,2 0,25
Steel for larger forgings, n SEW 550	250 250	0 0,15

Table 3.2.2 Constants $d_{eff,N,m}$, ... and $a_{d,m}$, ... for cast iron materials
Values in the respective upper row refer to R_m , while values in the lower row refer to R_p .

Material group	$d_{eff,N,m}$ $d_{eff,N,p}$ in mm	$a_{d,m}$ $a_{d,p}$
Cast steel DIN EN 10293	in accordance with Table 5.1.10	0,15 0,3
Heat treatable cast steel DIN EN 10293 $\diamond 1$	in accordance with Table 5.1.11	0,15 0,3
GJS DIN EN 1563	60 60	0,15 0,15
GJM DIN EN 1562	15 15	0,15 0,15

Materials Characteristics

ID: 3 Title: Kinds of Material

Alias: KindsMat1

Description: Kinds of material for defining constants d_{effN} and a_d according to tables 3.2.1 and 3.2.2

Materials: KM1

Non-alloyed structural steel DI 2 Apply To Selected To All

Material	Value
1..Structutal Steel	Non-alloyed structural steel DIN EN 10025

OK Cancel 3

FKM (6th, 2012)

ID: 1 Title: FKM (6th, 2012)

Alias: Standard1

Description: Analytical strength assessment of components (6th edition, 2012)

Option

Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) Defined M

Case Type (Table 3.2.3) Defined I

Kinds of Material (Tables 3.2.1 and 3.2.2) M 1

Tensile Strength According to Drawings M

General Material Type M

Kind of GJL Material M

Residual Stress M

Average Roughness M

Type of Welded Joints (Table 4.3.6) M

Type of Overloading (Chapter 4.4.2.0) M

Elongation at break (in %) M

Yield Strength Welded (Tables 5.1.24 and 5.1.25) M

Tensile Strength Welded (Tables 5.1.24 and 5.1.25) M

Special Case of Plastic Spot M

Sheet metal thickness M

FAT Classes (Tables 5.4.1 and 5.4.2) M

☐ Use Stress Gradient Tool

☒ Related Stress Gradients (Chapter 4.3.2.1)

☐ Use Hot Spot Stress

Define Tensile Strength According to Drawings

1

Press  in *Tensile Strength According to Drawings*

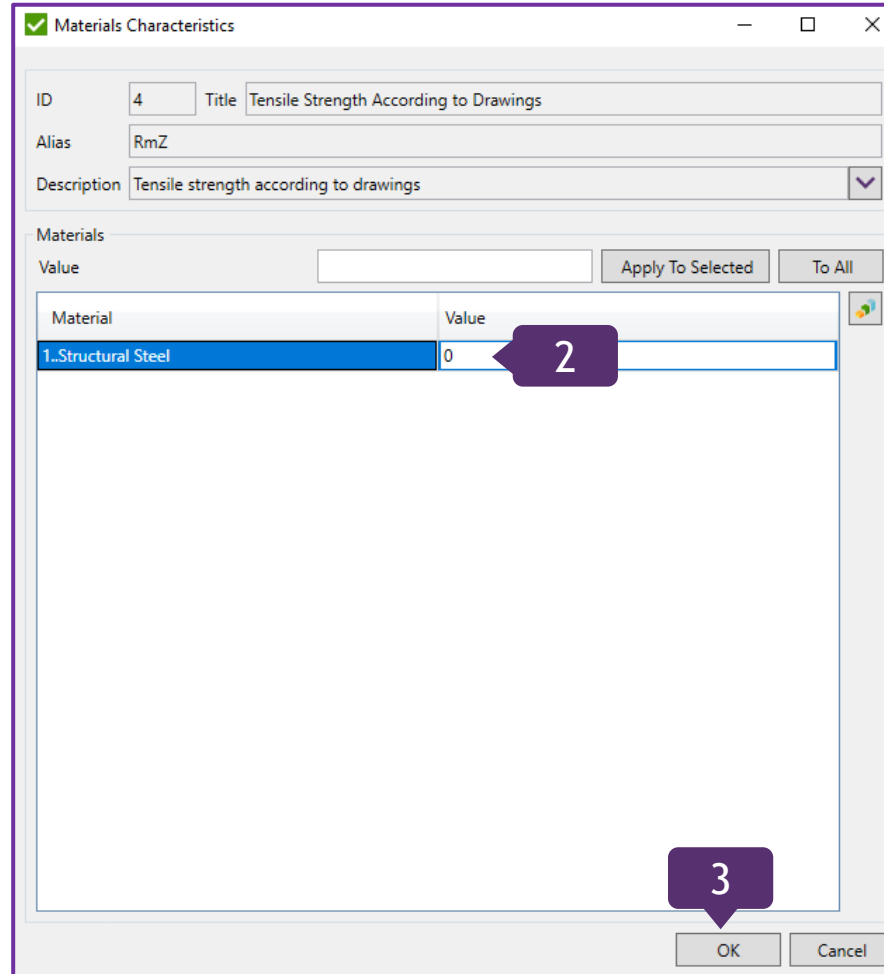
2

1..Structural Steel: *Value 0*

3

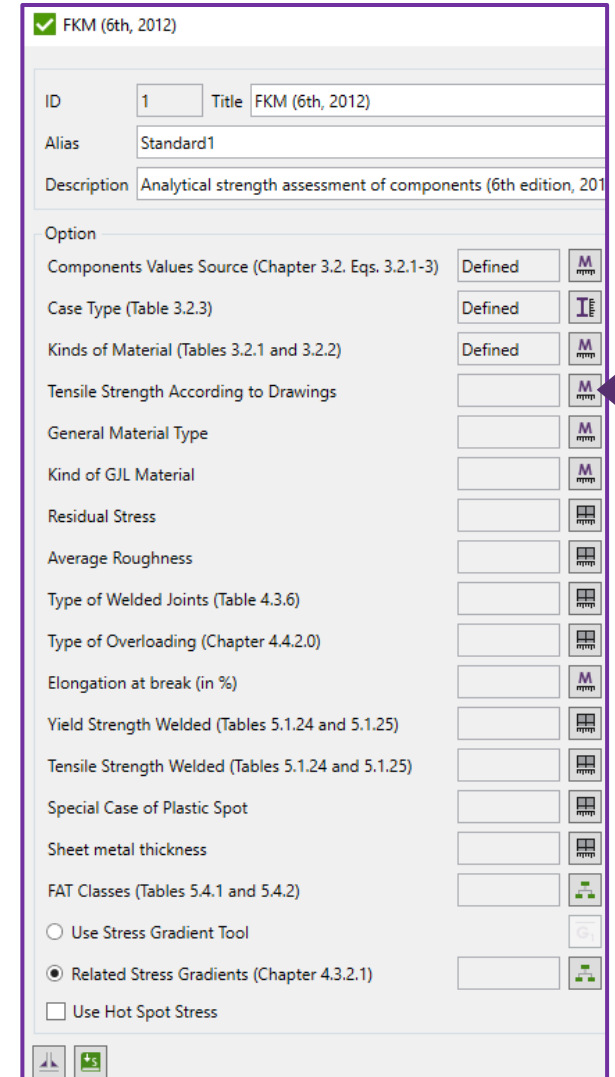
Press *OK*

If Components Values Source defined as Standard, this parameter will not be used in the calculations.



The 'Materials Characteristics' dialog box is shown. It has fields for ID (4), Title (Tensile Strength According to Drawings), Alias (RmZ), and Description (Tensile strength according to drawings). Below these is a 'Materials' section with a 'Value' field. A table lists materials, with '1..Structural Steel' selected and its value set to 0. Callout 1 points to the material icon in the title field, callout 2 points to the value 0, and callout 3 points to the OK button.

Material	Value
1..Structural Steel	0



The 'FKM (6th, 2012)' dialog box is shown. It has fields for ID (1), Title (FKM (6th, 2012)), Alias (Standard1), and Description (Analytical strength assessment of components (6th edition, 2012)). Below these is a list of parameters with checkboxes and icons. Callout 1 points to the material icon next to 'Tensile Strength According to Drawings'.

Option	Defined	Material Icon
Components Values Source (Chapter 3.2, Eqs. 3.2.1-3)	Defined	
Case Type (Table 3.2.3)	Defined	
Kinds of Material (Tables 3.2.1 and 3.2.2)	Defined	
Tensile Strength According to Drawings		
General Material Type		
Kind of G/L Material		
Residual Stress		
Average Roughness		
Type of Welded Joints (Table 4.3.6)		
Type of Overloading (Chapter 4.4.2.0)		
Elongation at break (in %)		
Yield Strength Welded (Tables 5.1.24 and 5.1.25)		
Tensile Strength Welded (Tables 5.1.24 and 5.1.25)		
Special Case of Plastic Spot		
Sheet metal thickness		
FAT Classes (Tables 5.4.1 and 5.4.2)		
<input type="radio"/> Use Stress Gradient Tool		
<input checked="" type="radio"/> Related Stress Gradients (Chapter 4.3.2.1)		
<input type="checkbox"/> Use Hot Spot Stress		

Define General Material Type

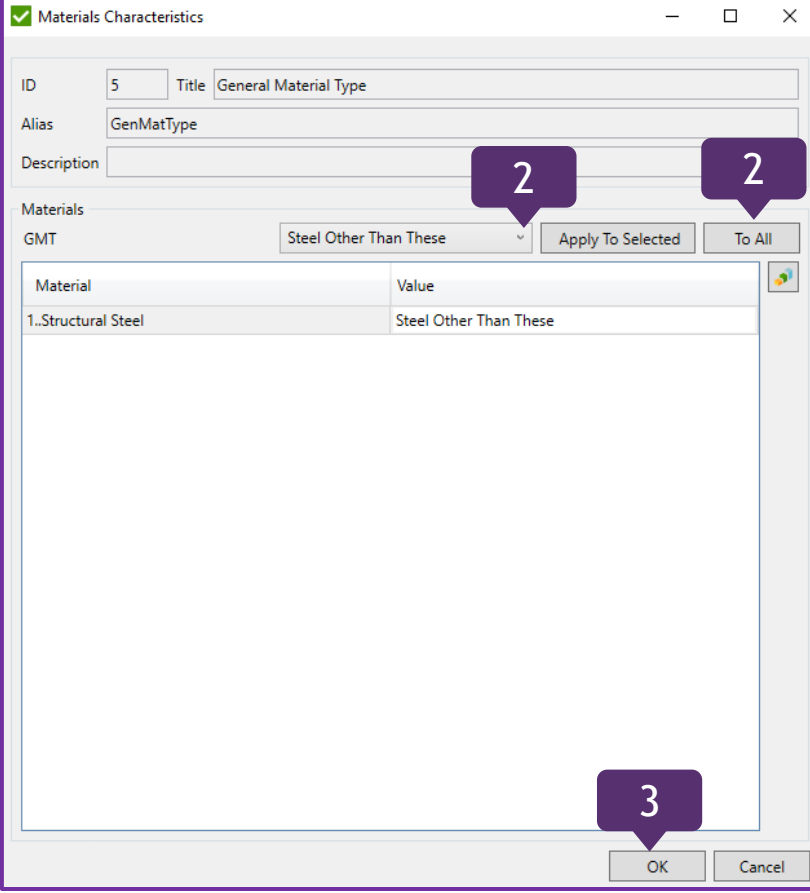
1 Press  in General Material Type

2 Materials GMT: *Steel Other Than These* and press *To All*

3 Press *OK*

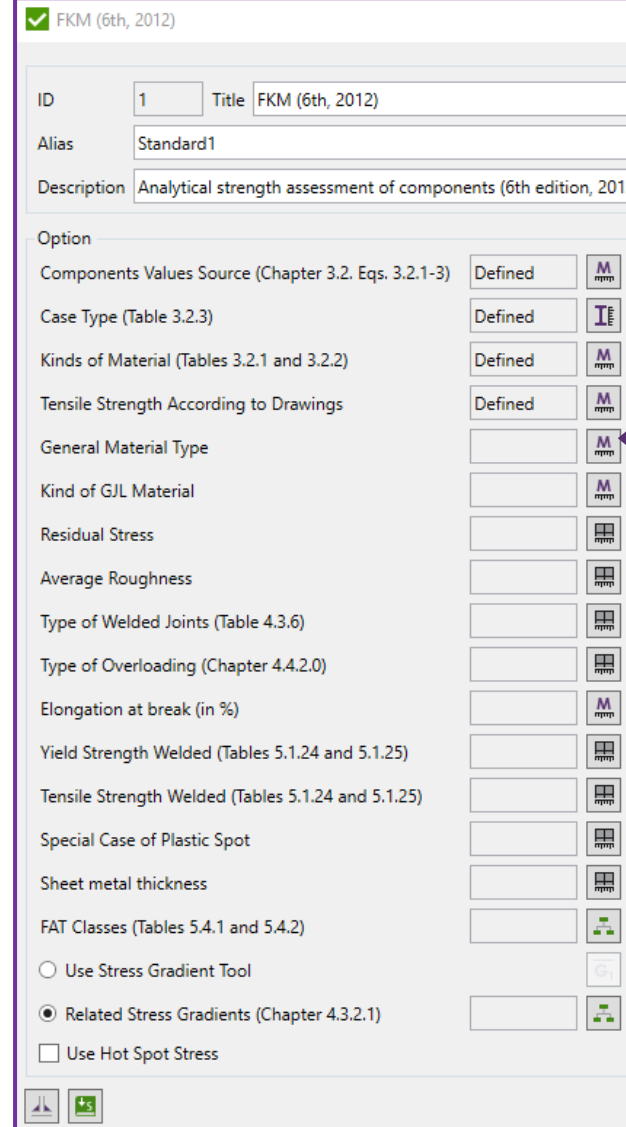
Material group
Case hardening steel
Stainless steel
Forging steel
Other kinds of steel
GS
GJS
GJM
GJL
Wrought aluminum alloys
Cast aluminum alloys

General material groups, used for all tables in the standard.



The dialog box 'Materials Characteristics' is shown. It has fields for ID (5), Title (General Material Type), Alias (GenMatType), and Description. Below these is a 'Materials' section with a dropdown menu set to 'Steel Other Than These'. To the right of the dropdown are buttons 'Apply To Selected' and 'To All'. Below the dropdown is a table with two columns: 'Material' and 'Value'. The first row shows '1..Structural Steel' under 'Material' and 'Steel Other Than These' under 'Value'. At the bottom right are 'OK' and 'Cancel' buttons. Numbered callouts: '2' points to the dropdown menu, '2' points to the 'To All' button, and '3' points to the 'OK' button.

Material	Value
1..Structural Steel	Steel Other Than These



The dialog box 'FKM (6th, 2012)' is shown. It has fields for ID (1), Title (FKM (6th, 2012)), Alias (Standard1), and Description (Analytical strength assessment of components (6th edition, 2012)). Below these is a list of options with checkboxes and icons. The options are: Components Values Source (Chapter 3.2. Eqs. 3.2.1-3), Case Type (Table 3.2.3), Kinds of Material (Tables 3.2.1 and 3.2.2), Tensile Strength According to Drawings, General Material Type, Kind of GJL Material, Residual Stress, Average Roughness, Type of Welded Joints (Table 4.3.6), Type of Overloading (Chapter 4.4.2.0), Elongation at break (in %), Yield Strength Welded (Tables 5.1.24 and 5.1.25), Tensile Strength Welded (Tables 5.1.24 and 5.1.25), Special Case of Plastic Spot, Sheet metal thickness, FAT Classes (Tables 5.4.1 and 5.4.2), Use Stress Gradient Tool, Related Stress Gradients (Chapter 4.3.2.1), and Use Hot Spot Stress. Numbered callout: '1' points to the 'General Material Type' option.

Define Kind of GJL Material

1

Press  in Kind of GJL Material

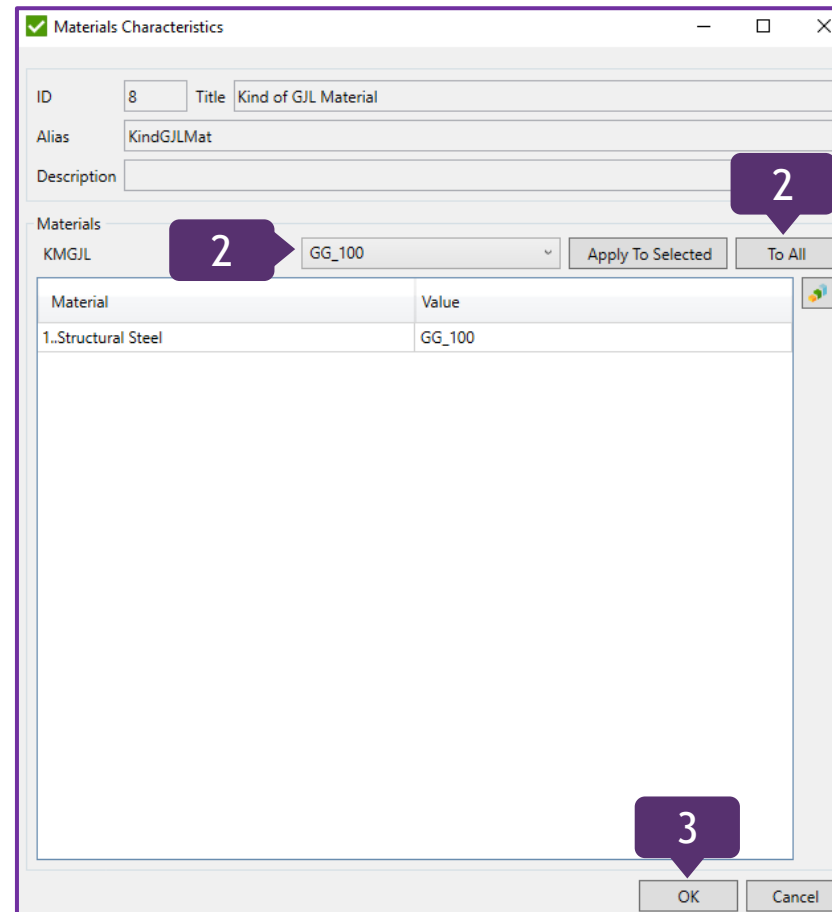
2

Materials KMGJL: GG_100 and press *To All*

3

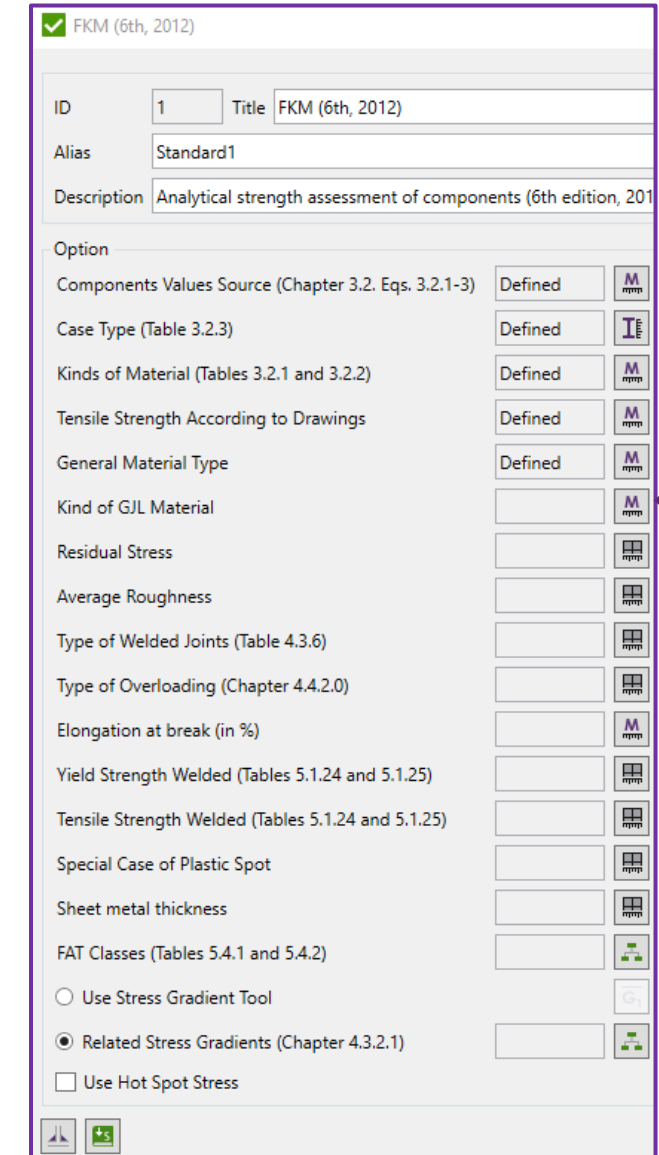
Press *OK*

Will be taken into account only
in case of GJL Material type.



The 'Materials Characteristics' dialog box is shown. It has fields for ID (8), Title (Kind of GJL Material), Alias (KindGJLMat), and Description. Below these is a 'Materials' section with a dropdown menu set to 'KMGJL' and a value 'GG_100'. There are buttons for 'Apply To Selected' and 'To All'. A table below shows 'Material' and 'Value' with one entry: '1..Structural Steel' and 'GG_100'. At the bottom are 'OK' and 'Cancel' buttons. Numbered callouts: 1 points to the 'To All' button, 2 points to the 'GG_100' value, and 3 points to the 'OK' button.

Material	Value
1..Structural Steel	GG_100



The 'FKM (6th, 2012)' dialog box is shown. It has fields for ID (1), Title (FKM (6th, 2012)), Alias (Standard1), and Description (Analytical strength assessment of components (6th edition, 201...)). Below these is a list of options with checkboxes and icons. Numbered callout: 1 points to the 'Kind of GJL Material' option.

Option	Value
Components Values Source (Chapter 3.2. Eqs. 3.2.1-3)	Defined
Case Type (Table 3.2.3)	Defined
Kinds of Material (Tables 3.2.1 and 3.2.2)	Defined
Tensile Strength According to Drawings	Defined
General Material Type	Defined
Kind of GJL Material	
Residual Stress	
Average Roughness	
Type of Welded Joints (Table 4.3.6)	
Type of Overloading (Chapter 4.4.2.0)	
Elongation at break (in %)	
Yield Strength Welded (Tables 5.1.24 and 5.1.25)	
Tensile Strength Welded (Tables 5.1.24 and 5.1.25)	
Special Case of Plastic Spot	
Sheet metal thickness	
FAT Classes (Tables 5.4.1 and 5.4.2)	
<input type="radio"/> Use Stress Gradient Tool	
<input checked="" type="radio"/> Related Stress Gradients (Chapter 4.3.2.1)	
<input type="checkbox"/> Use Hot Spot Stress	

Define Residual Stress

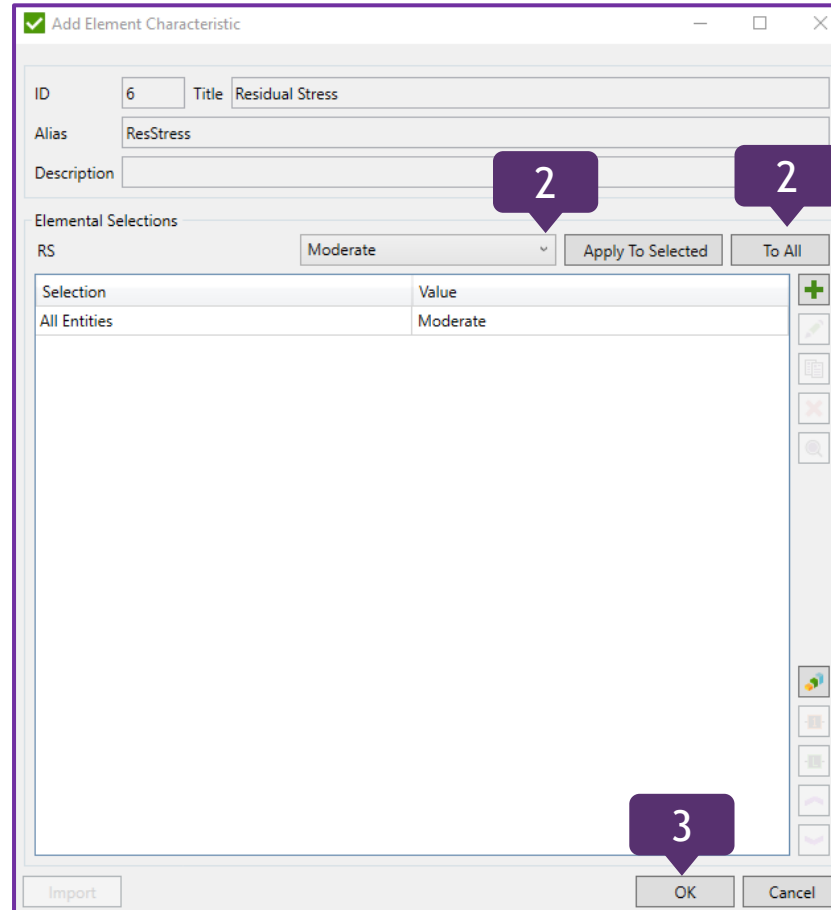
1 Press  in *Residual Stress*

2 Elemental Selections RS: *Moderate* and press *To All*

3 Press *OK*

Table 4.4.2 Residual stress factor $K_{E,\sigma}$, $K_{E,\tau}$ and mean stress sensitivity M_σ , M_τ for welded components

Residual stresses	$K_{E,\sigma}$	M_σ	$K_{E,\tau}$	$M_\tau \div 1$
high	1,00	0	1,00	0
moderate	1,26	0,15	1,15	0,09
low	1,54	0,30	1,30	0,17



✓ Add Element Characteristic

ID: 6 Title: Residual Stress

Alias: ResStress

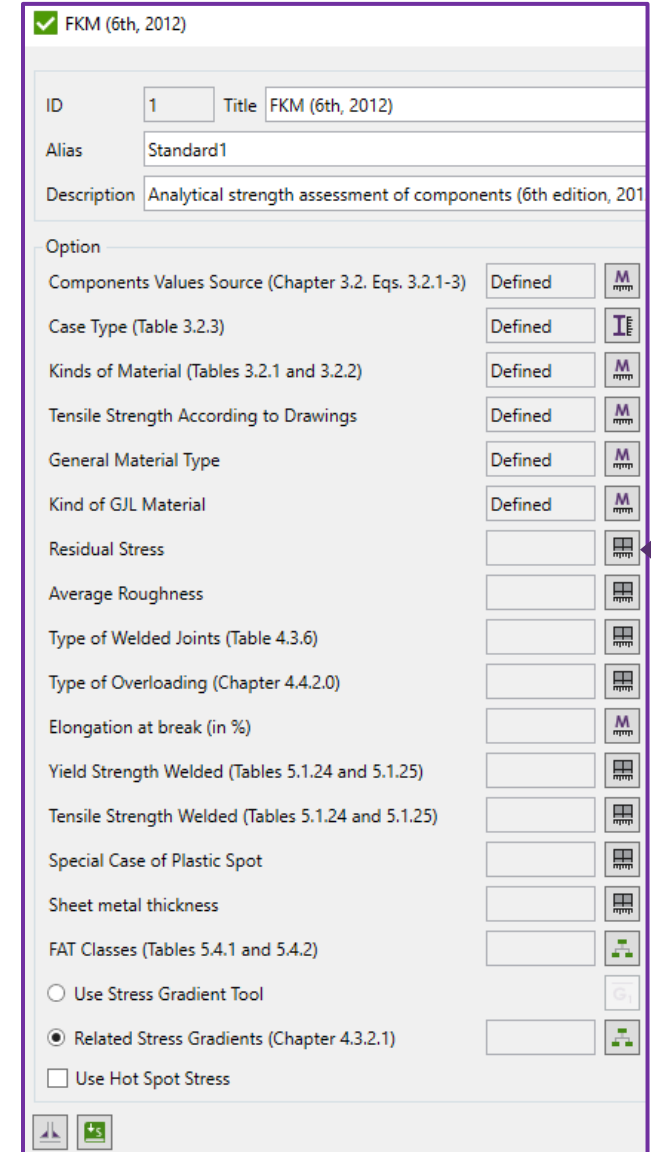
Description:

Elemental Selections

RS: Moderate Apply To Selected To All

Selection	Value
All Entities	Moderate

Import OK Cancel



✓ FKM (6th, 2012)

ID: 1 Title: FKM (6th, 2012)

Alias: Standard1

Description: Analytical strength assessment of components (6th edition, 2012)

Option

Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) Defined

Case Type (Table 3.2.3) Defined

Kinds of Material (Tables 3.2.1 and 3.2.2) Defined

Tensile Strength According to Drawings Defined

General Material Type Defined

Kind of GJL Material Defined

Residual Stress

Average Roughness

Type of Welded Joints (Table 4.3.6)

Type of Overloading (Chapter 4.4.2.0)

Elongation at break (in %)

Yield Strength Welded (Tables 5.1.24 and 5.1.25)

Tensile Strength Welded (Tables 5.1.24 and 5.1.25)

Special Case of Plastic Spot

Sheet metal thickness

FAT Classes (Tables 5.4.1 and 5.4.2)

☐ Use Stress Gradient Tool

☒ Related Stress Gradients (Chapter 4.3.2.1)

☐ Use Hot Spot Stress

Define Average Roughness

1

Press  in *Average Roughness*

2

Elemental Selections Value: 200

3

Press *OK*

Add Element Characteristic

ID: 7 Title: Average Roughness

Alias: R_z

Description: For polished surfaces R_z=1 (in micrometers)

Elemental Selections

Selection	Value
All Entities	200

Buttons: Apply To Selected, To All, OK, Cancel, Import

FKM (6th, 2012)

ID: 1 Title: FKM (6th, 2012)

Alias: Standard1

Description: Analytical strength assessment of components (6th edition, 2012)

Option

Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) Defined

Case Type (Table 3.2.3) Defined


Kinds of Material (Tables 3.2.1 and 3.2.2) Defined

Tensile Strength According to Drawings Defined

General Material Type Defined

Kind of GJL Material Defined

Residual Stress Defined

Average Roughness 

Type of Welded Joints (Table 4.3.6)

Type of Overloading (Chapter 4.4.2.0)

Elongation at break (in %) Defined

Yield Strength Welded (Tables 5.1.24 and 5.1.25) Defined

Tensile Strength Welded (Tables 5.1.24 and 5.1.25) Defined

Special Case of Plastic Spot

Sheet metal thickness

FAT Classes (Tables 5.4.1 and 5.4.2)

☐ Use Stress Gradient Tool

☒ Related Stress Gradients (Chapter 4.3.2.1)

☐ Use Hot Spot Stress

Define Type of Welded Joints (Table 4.3.6)

1

Press  in Type of Welded Joints (Table 4.3.6)

2

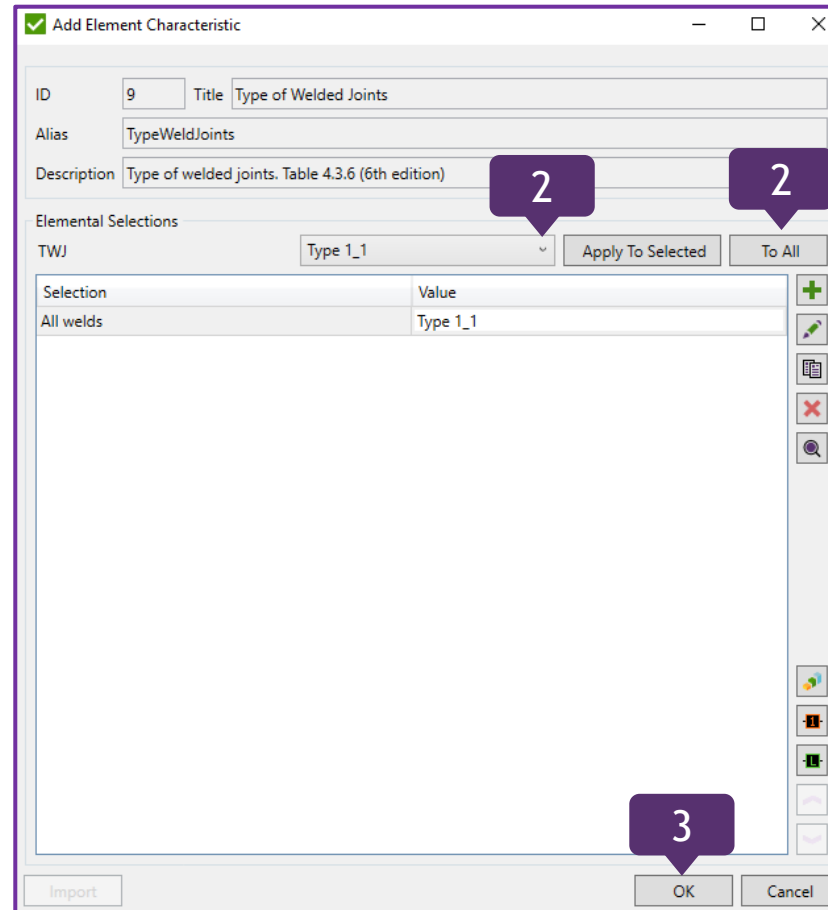
Elemental Selections TWJ: *Type 1_1* and press *To All*

3

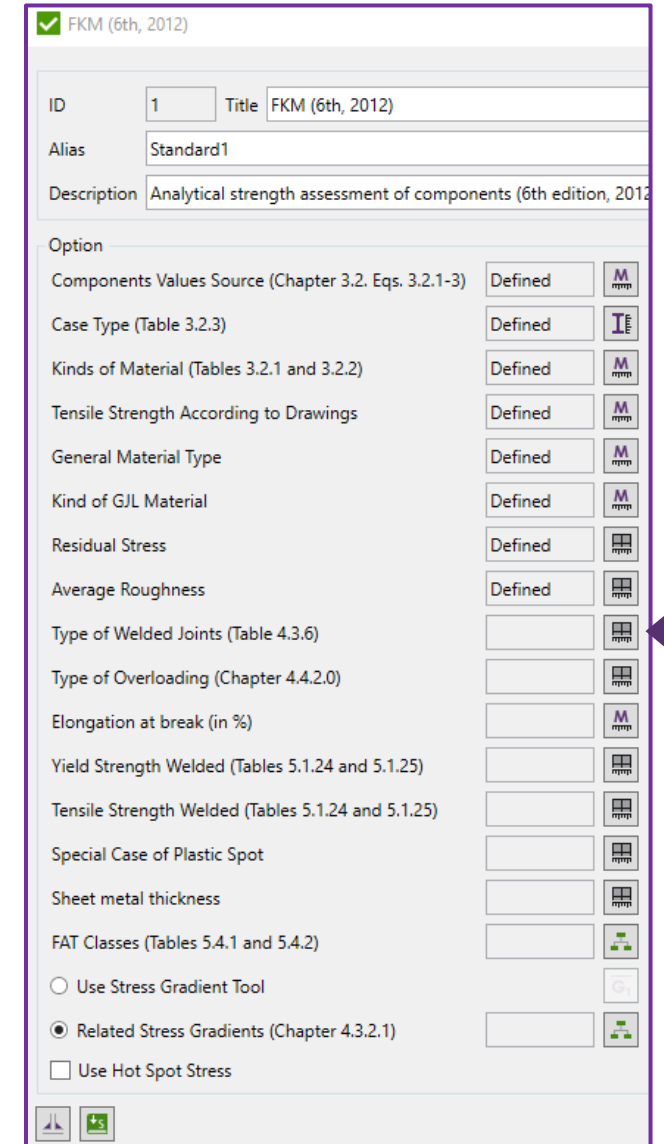
Press *OK*

Table 4.3.6 Exponent n for the thickness factor

Type of the welded joint	n
Cruciform joints, transversely loaded T-joints, sheets with transverse stiffeners, ends of longitudinal stiffeners	0,3
- as welded	0,2
- toe ground	0,2
Transversely loaded butt joints, as welded	0,2
Butt joints ground flush with the sheet, longitudinally loaded welds or gussets	0,1




The dialog box 'Add Element Characteristic' is shown. It has fields for ID (9), Title (Type of Welded Joints), Alias (TypeWeldJoints), and Description (Type of welded joints. Table 4.3.6 (6th edition)). Under 'Elemental Selections', the 'TWJ' dropdown is set to 'Type 1_1'. There are 'Apply To Selected' and 'To All' buttons. A table lists 'All welds' with 'Type 1_1' as the value. At the bottom are 'Import', 'OK', and 'Cancel' buttons. Numbered callouts: 1 points to the 'To All' button, 2 points to the 'Type 1_1' dropdown, and 3 points to the 'OK' button.



The 'FKM (6th, 2012)' dialog box is shown. It has fields for ID (1), Title (FKM (6th, 2012)), Alias (Standard1), and Description (Analytical strength assessment of components (6th edition, 2012)). Below is a list of options with checkboxes and icons. A table lists various parameters and their status: Components Values Source (Chapter 3.2, Eqs. 3.2.1-3) is Defined; Case Type (Table 3.2.3) is Defined; Kinds of Material (Tables 3.2.1 and 3.2.2) is Defined; Tensile Strength According to Drawings is Defined; General Material Type is Defined; Kind of GJL Material is Defined; Residual Stress is Defined; Average Roughness is Defined; Type of Welded Joints (Table 4.3.6) is empty; Type of Overloading (Chapter 4.4.2.0) is empty; Elongation at break (in %) is empty; Yield Strength Welded (Tables 5.1.24 and 5.1.25) is empty; Tensile Strength Welded (Tables 5.1.24 and 5.1.25) is empty; Special Case of Plastic Spot is empty; Sheet metal thickness is empty; FAT Classes (Tables 5.4.1 and 5.4.2) is empty; Use Stress Gradient Tool is empty; Related Stress Gradients (Chapter 4.3.2.1) is selected; Use Hot Spot Stress is empty. Numbered callout: 1 points to the 'Type of Welded Joints (Table 4.3.6)' row.

Define Type of Overloading (Chapter 4.4.2.0)

1

Press  in Type of Overloading (Chapter 4.4.2.0)

2

Elemental Selections TO: *Type F2*

3

Press **OK**

Type of overloading

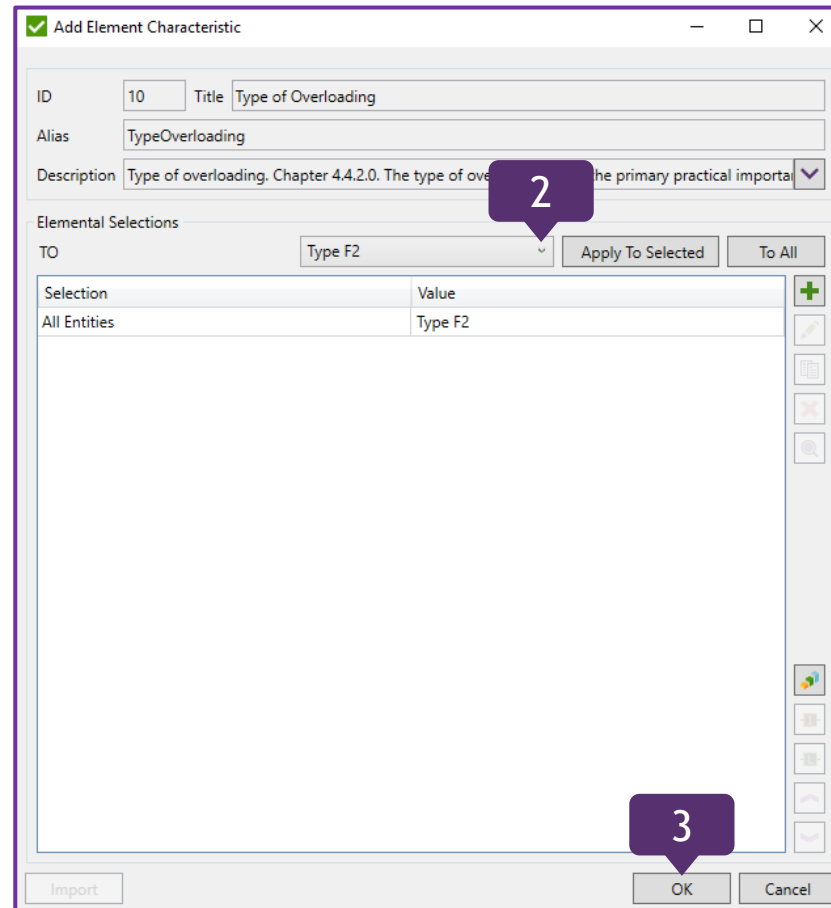
The mean stress factor K_{AK} depends on the type of overloading, F1 to F4. This shall be specified as a function of the stress behavior in the case of a possible load increase in service (not by crash), that is in the sense of „safety in service“. The types of overloading are as follows:

- Type F1: the mean stress σ_m remains constant;
- Type F2: the stress ratio R remains constant;
- Type F3: the minimum stress σ_{min} remains constant;
- Type F4: the maximum stress σ_{max} remains constant.

Intermediate types of overloading are possible. Depending on the type of overloading, the critical amplitude of the component fatigue limit is different, Figure 4.4-1.

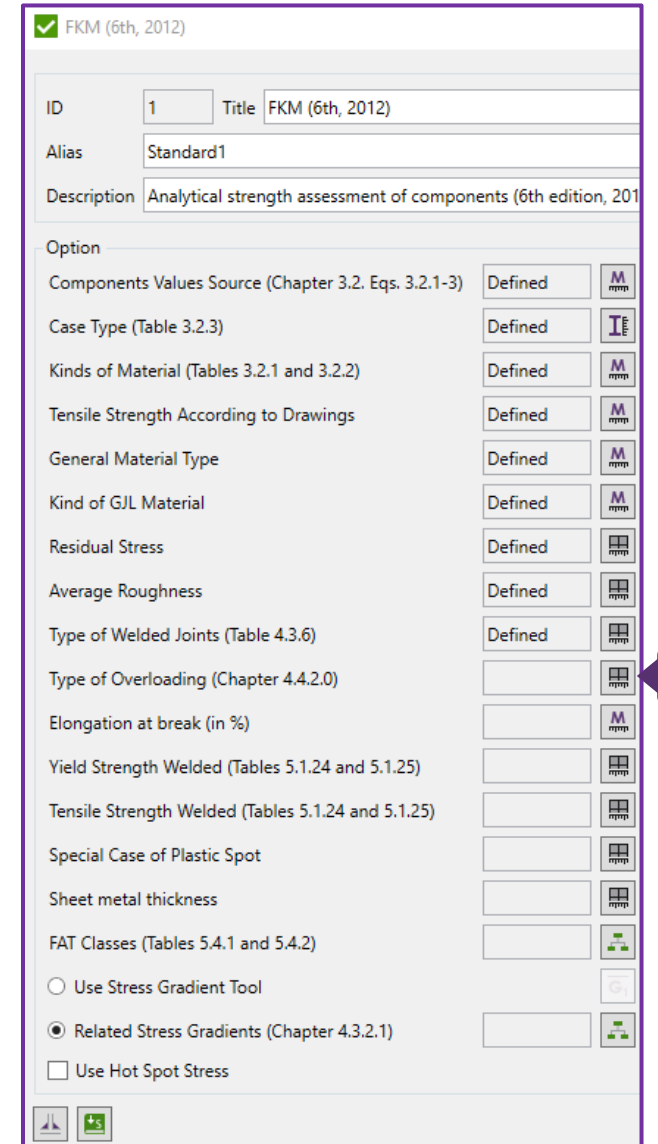
Calculation for type of overloading F2

The type of overloading F2 is described first, because it is of the highest practical importance. In the case of overloading in service, the stress ratio R remains constant.



2

3



1

Define Elongation at break (in %)

1 Press  in Elongation at break (in %)

2 Materials Value: 15 and press *To All*

3 Press *OK*

Table 5.1.2 Characteristic strength values, in MPa, and elongation at break A, in %, for non-alloyed structural steel in accordance with DIN EN 10025-2 (April 2005) ¹

Type	Material No.	Rm,N	Re,N ↗2	A	σW,zd,N	σSch,zd,N	σW,b,N	τW,s,N	τW,t,N
S185	1.0035	310	185	10	140	138	155	80	90
S235JR	1.0038	360	235	17	160	158	180	95	105
S235J0	1.0114								
S235J2	1.0117								
S275JR	1.0044	430	275	15	195	185	215	110	125
S275J0	1.0143								
S275J2G	1.0145								
S355JR	1.0045	510	355	14	230	215	255	130	150
S355J0	1.0553								
S355J2	1.0577								
S355K2	1.0596								
S450J0	1.0590	550	450	—	250	225	275	145	160
E295	1.0050	490	295	12	220	205	245	125	145
E335	1.0060	590	335	8	265	240	290	155	170
E360	1.0070	690	360	4	310	270	340	180	200

Materials Characteristics

ID: 11 Title: Elongation at break

Alias: A

Description: Elongation at break in %

Materials Value: 15

Apply To Selected To All

Material	Value
1..Structural Steel	15

OK Cancel

FKM (6th, 2012)

ID: 1 Title: FKM (6th, 2012)

Alias: Standard1

Description: Analytical strength assessment of components (6th edition, 2012)

Option

Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) Defined

Case Type (Table 3.2.3) Defined

Kinds of Material (Tables 3.2.1 and 3.2.2) Defined

Tensile Strength According to Drawings Defined

General Material Type Defined


Kind of GJL Material Defined


Residual Stress Defined


Average Roughness Defined


Type of Welded Joints (Table 4.3.6) Defined


Type of Overloading (Chapter 4.4.2.0) Defined


Elongation at break (in %) 


Yield Strength Welded (Tables 5.1.24 and 5.1.25) 


Tensile Strength Welded (Tables 5.1.24 and 5.1.25) 


Special Case of Plastic Spot 

Sheet metal thickness 

FAT Classes (Tables 5.4.1 and 5.4.2) 

☐ Use Stress Gradient Tool 

☒ Related Stress Gradients (Chapter 4.3.2.1) 

☐ Use Hot Spot Stress 

Define Yield Strength Welded (Tables 5.1.24 and 5.1.25)

1

Press  in Yield Strength Welded (Tables 5.1.24 and 5.1.25)

2

Select **+All Entities** and press  to remove them

Add Element Characteristic

ID: 12 Title: Yield Strength Welded

Alias: R_p_w

Description: Yield Strength. Tables 5.1.24 and 5.1.25

Elemental Selections

Value:

Apply To Selected To All

Selection	Value
All Entities	0

Import OK Cancel


FKM (6th, 2012)


ID: 1 Title: FKM (6th, 2012)


Alias: Standard1


Description: Analytical strength assessment of components (6th edition, 2012)


Option


Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) Defined 


Case Type (Table 3.2.3) Defined 


Kinds of Material (Tables 3.2.1 and 3.2.2) Defined 


Tensile Strength According to Drawings Defined 


General Material Type Defined 


Kind of GJL Material Defined 


Residual Stress Defined 


Average Roughness Defined 


Type of Welded Joints (Table 4.3.6) Defined 


Type of Overloading (Chapter 4.4.2.0) Defined 

Elongation at break (in %) Defined 

Yield Strength Welded (Tables 5.1.24 and 5.1.25) 

Tensile Strength Welded (Tables 5.1.24 and 5.1.25) 

Special Case of Plastic Spot 

Sheet metal thickness 

FAT Classes (Tables 5.4.1 and 5.4.2)

☐ Use Stress Gradient Tool

☒ Related Stress Gradients (Chapter 4.3.2.1)

☐ Use Hot Spot Stress

1.3 Static strength values for welded components made of steel

Table 5.1.24 Static strength of steel and cast iron in welded components, base material BM: yield stress R_e , tensile strength R_m , accordance with DIN 18800 (November 1990) and application guide on structural steelwork (December 2001) for S690 accordance with DIN EN 1993-1-12 (December 2010)


No.	Material type	t [mm]	R_e [MPa]	R_m [MPa]
Structural steel				
1	S235	40	240	360
2		40 ... 100	215	
3	S275	40	275	410
4		40 ... 80	255	
5	S355	40	360	470
6		40 ... 80	335	
7	S450	40	440	550
8		40 ... 80	410	
Fine grain structural steel				
9	S275 N, NL, M, ML	40	275	370
10	P275 NH, NL1, NL2	40 ... 80	255	
11	S355 N, NL	40	360	470
12	P355 N, NH, NL1, NL2, QH1	40 ... 80	335	
13	S355 M/ML	40	360	450
14		40 ... 80	335	
15	S420 N/NL	40	420	520
16		40 ... 80	390	
17	S420 M/ML	40	420	520
18		40 ... 80	390	
19	S460 N/NL	40	460	550
20		40 ... 80	430	
21	S460 M/ML	40	460	530
22		40 ... 80	430	
	S690	50 ... 100	690	770
Heat treatable steel				
23	C35+N	16	300	550
24		16 ... 100	270	520
25	C45+N	16	340	620
26		16 ... 100	305	580
Cast materials				
27	GS200	100	200	380
28	GS240	100	240	450
29	GE200	160	200	380
30		160	240	450
31	G17Mn5+QT	50	240	450
32	G20Mn5+N	30	300	480
33	G20Mn5+QT	100	300	500
34	EN-GJS-400-15	60	250	390
35	EN-GJS-400-18	60	250	390
36	EN-GJS-400-18-LT	60	230	390
37	EN-GJS-400-18-RT	60	250	390

Define Yield Strength Welded (Tables 5.1.24 and 5.1.25) Continuation

3

Press  and select **Group**

4

In Selection => press 

5

Select **Welds** => **By Rule** and press **OK**

6

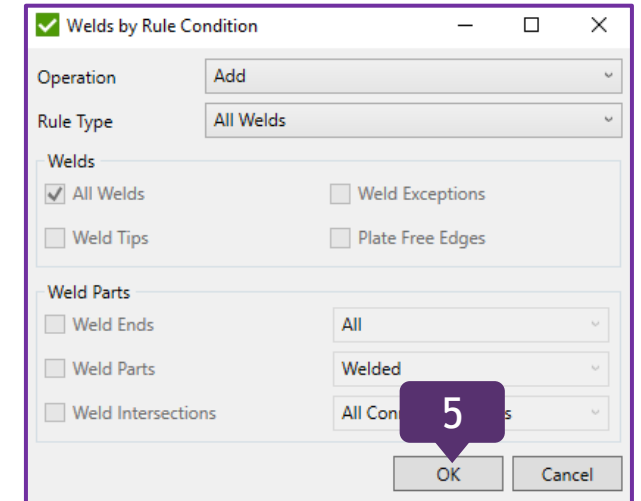
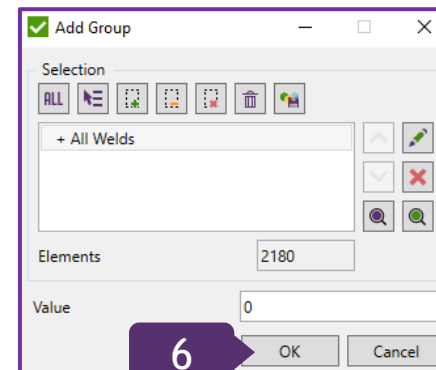
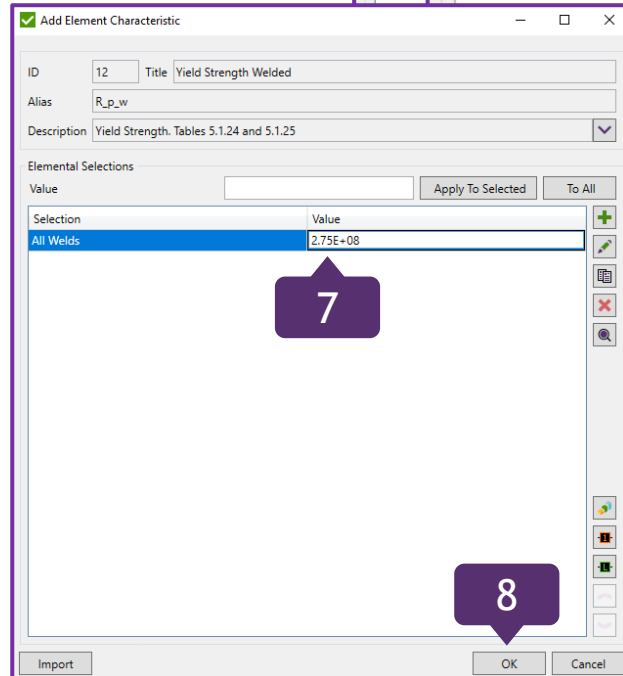
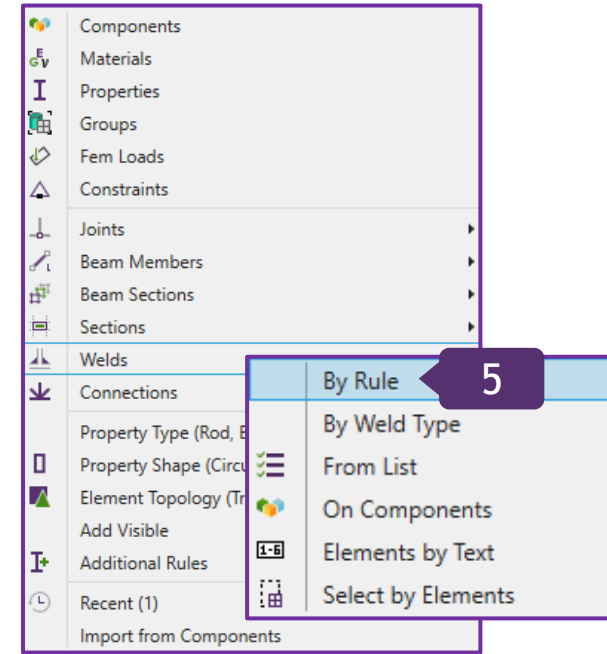
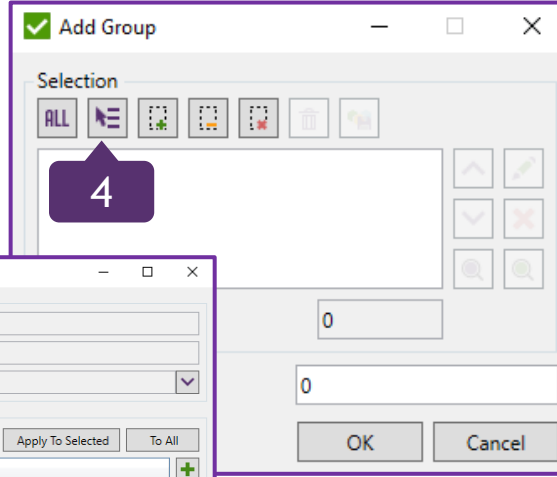
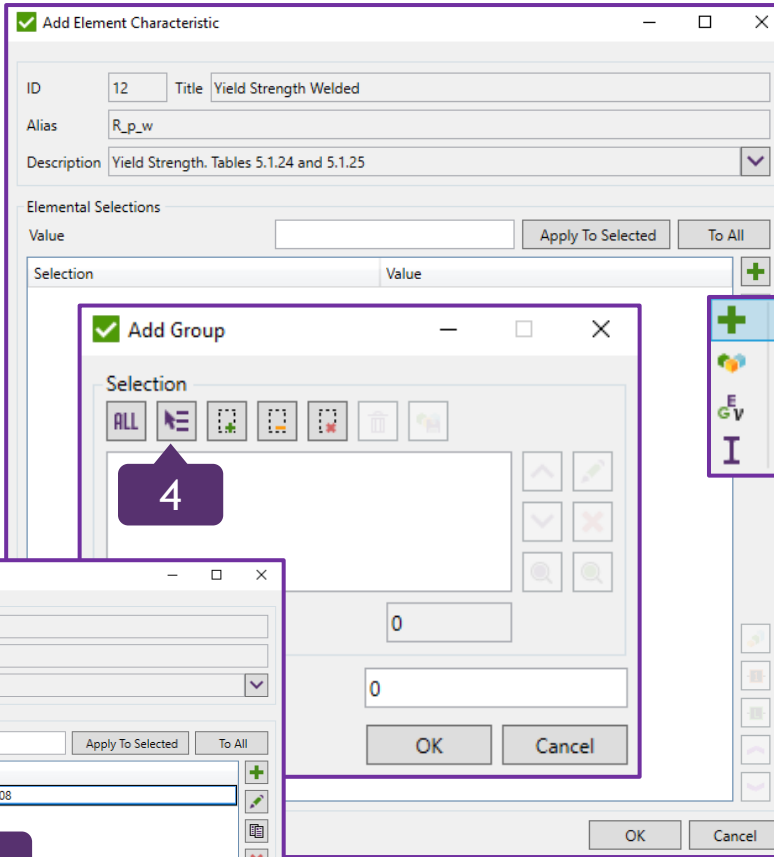
Press **OK**

7

All Welds: $2.75E+08$

8

Press **OK**



Define Tensile Strength Welded (Tables 5.1.24 and 5.1.25)

1

Press  in Tensile Strength Welded (Tables 5.1.24 and 5.1.25)

In order to define this Option, the user may repeat the steps 2-8 from the previous slides 23 and 24. Yet, the Value of the Selection has to be the following:
All Welds: 4.1E+08

Add Element Characteristic

ID: 13 Title: Tensile Strength Welded

Alias: R_m_w

Description: Yield Strength, Tables 5.1.24 and 5.1.25

Elemental Selections

Selection	Value
All Welds	4.1E+08

Apply To Selected To All

Import OK Cancel


FKM (6th, 2012)


ID: 1 Title: FKM (6th, 2012)


Alias: Standard1


Description: Analytical strength assessment of components (6th edition, 2012)


Option


Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) Defined 


Case Type (Table 3.2.3) Defined 


Kinds of Material (Tables 3.2.1 and 3.2.2) Defined 


Tensile Strength According to Drawings Defined 


General Material Type Defined 


Kind of GJL Material Defined 


Residual Stress Defined 


Average Roughness Defined 

Type of Welded Joints (Table 4.3.6) Defined 

Type of Overloading (Chapter 4.4.2.0) Defined 

Elongation at break (in %) Defined 

Yield Strength Welded (Tables 5.1.24 and 5.1.25) Defined 

Tensile Strength Welded (Tables 5.1.24 and 5.1.25)  **1**

Special Case of Plastic Spot



Sheet metal thickness

FAT Classes (Tables 5.4.1 and 5.4.2)

☐ Use Stress Gradient Tool

☒ Related Stress Gradients (Chapter 4.3.2.1)

☐ Use Hot Spot Stress

1.3 Static strength values for welded components made of steel

Table 5.1.24 Static strength of steel and cast iron in welded components, base material BM: yield stress R_e , tensile strength R_m accordance with DIN 18800 (November 1990) and application guide on structural steelwork (December 2001) for S690 accordance with DIN EN 1993-1-12 (December 2010)

No.	Material type	t [mm]	R_e [MPa]	R_m [MPa]
Structural steel				
1	S235	40	240	360
2		40 ... 100	215	
3	S275	40	275	410
4		40 ... 80	255	
5	S355	40	360	470
6		40 ... 80	335	
7	S450	40	440	550
8		40 ... 80	410	
Fine grain structural steel				
9	S275 N, NL, M, ML	40	275	370
10	P275 NH, NL1, NL2	40 ... 80	255	
11	S355 N, NL	40	360	470
12	P355 N, NH, NL1, NL2, QH1	40 ... 80	335	
13	S355 M/ML	40	360	450
14		40 ... 80	335	
15	S420 N/NL	40	420	520
16		40 ... 80	390	
17	S420 M/ML	40	420	520
18		40 ... 80	390	500
19	S460 N/NL	40	460	550
20		40 ... 80	430	
21	S460 M/ML	40	460	530
22		40 ... 80	430	
	S690	50 ... 100	690	770
Heat treatable steel				
23	C35+N	16	300	550
24		16 ... 100	270	520
25	C45+N	16	340	620
26		16 ... 100	305	580
Cast materials				
27	GS200	100	200	380
28	GS240	100	240	450
29	GE200	160	200	380
30	GE240	160	240	450
31	G17MnS+QT	50	240	450
32	G20MnS+N	30	300	480
33	G20MnS+QT	100	300	500
34	EN-GJS-400-15	60	250	390
35	EN-GJS-400-18	60	250	390
36	EN-GJS-400-18-LT	60	230	390
37	EN-GJS-400-18-RT	60	250	390

Define Special Case of Plastic Spot

1 Press  in Special Case of Plastic Spot

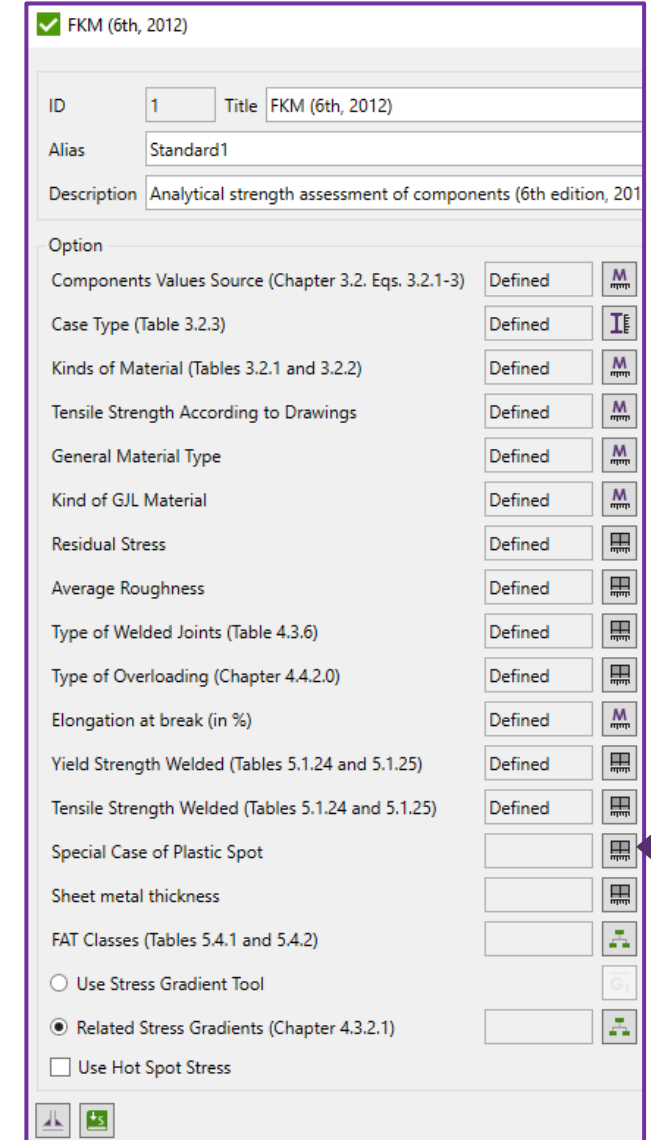
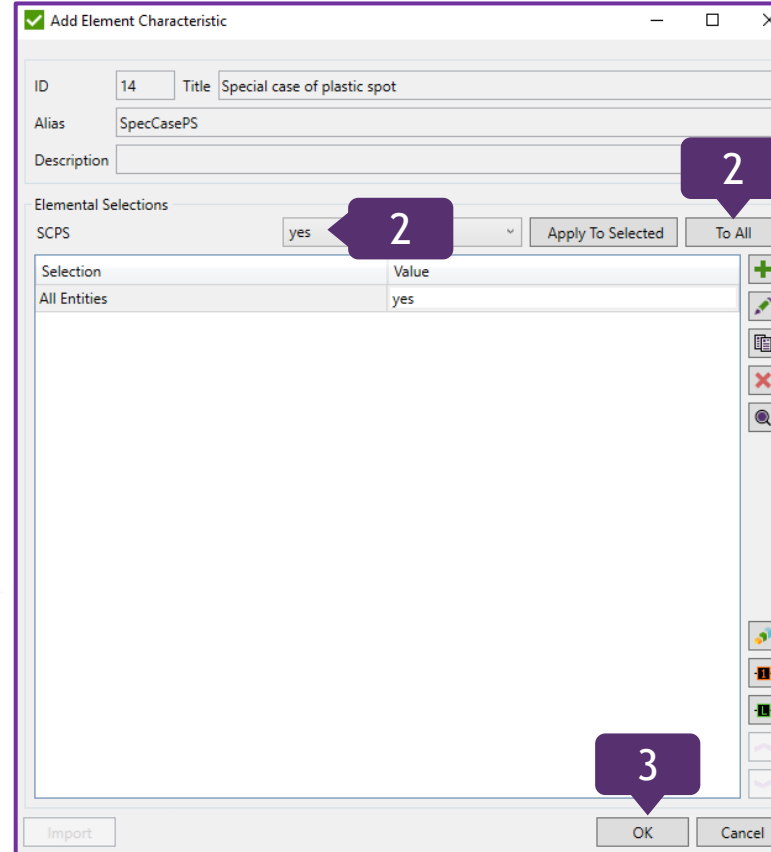
2 Elemental Selections SCPS: Yes and press *To All*

3 Press *OK*

Special case of "plastic spot"

In the special case of the plastic zone being surrounded by a large elastic area, resulting in a very high plastic limit load, only the critical strain is relevant.

$$n_{pl} = \sqrt{E \cdot \epsilon_{entr} / R_p} \quad (3.3.7)$$



Define Sheet metal thickness

1

Press  in *Sheet metal thickness*

2

Selection Value All Entities: 0

3

Press *OK*

Sheet metal thickness is the thickness of the sheet metal (should be defined in case of non plate/shell element types) for thickness factor calculation. In model units.

Add Element Characteristic

ID: 33 Title: Sheet metal thickness

Alias: t_sm

Description: Thickness of the sheet metal (should be defined in case of non plate element types) for thickness factor calculation

Elemental Selections

Value: 0 [Apply To Selected] [To All]

Selection	Value
All Entities	0

[Import] [OK] [Cancel]

FKM (6th, 2012)

ID: 1 Title: FKM (6th, 2012)

Alias: Standard1

Description: Analytical strength assessment of components (6th edition, 2012)

Option

Components Values Source (Chapter 3.2. Eqs. 3.2.1-3) [Defined] [M]

Case Type (Table 3.2.3) [Defined] [T]

Kinds of Material (Tables 3.2.1 and 3.2.2) [Defined] [M]

Tensile Strength According to Drawings [Defined] [M]

General Material Type [Defined] [M]

Kind of GJL Material [Defined] [M]

Residual Stress [Defined] [M]

Average Roughness [Defined] [M]

Type of Welded Joints (Table 4.3.6) [Defined] [M]

Type of Overloading (Chapter 4.4.2.0) [Defined] [M]

Elongation at break (in %) [Defined] [M]

Yield Strength Welded (Tables 5.1.24 and 5.1.25) [Defined] [M]

Tensile Strength Welded (Tables 5.1.24 and 5.1.25) [Defined] [M]

Special Case of Plastic Spot [Defined] [M]

Sheet metal thickness [] [M] **1**

FAT Classes (Tables 5.4.1 and 5.4.2) [] [M]

☐ Use Stress Gradient Tool

☒ Related Stress Gradients (Chapter 4.3.2.1)

☐ Use Hot Spot Stress


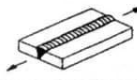
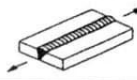


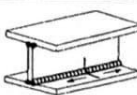
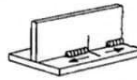
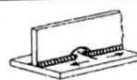
Along the welds (X-direction)

5.4 Fatigue classes for welded components
made of structural steel and of aluminum

169

5 Annexes

Table 5.4.1 Fatigue classes for nominal stress (normal stress), continued page 3 of 10

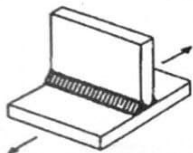
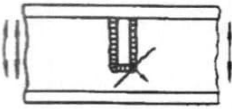
No.	Structural detail	Description	FAT Steel	FAT Al
300	Longitudinally loaded welds			
311		Automatic longitudinal weld in hollow sections, without stop/start positions with stop/start positions,	125 90	50 36
312		Longitudinally loaded butt weld, both sides ground flush parallel to load direction, 100 % NDT,	125	50
313		Longitudinally loaded butt weld, without stop/start positions, NDT, with stop/start positions.	100 90	40 36
321		Continuous automatic longitudinal fully penetrated K-butt weld without stop/start positions (based on stress range in flange), 100 % NDT.	125	50
322		Continuous automatic longitudinal double sided fillet weld without stop/start positions (based on stress range in flange).	100	40
323		Continuous manual longitudinal fillet or butt weld (based on stress range in flange).	90	36
324		Intermittent longitudinal fillet τ/σ , normal stress in flange σ and shear stress in web τ at weld ends.	τ/σ = 0 = 80 0,0 - 0,2 71 0,2 - 0,3 63 0,3 - 0,4 56 0,4 - 0,5 50 0,5 - 0,6 45 0,6 - 0,7 40 > 0,7 36	32 28 25 22 20 18 16 14
325		Longitudinal butt weld, fillet weld or intermittent weld with cope holes, cope holes not higher than 40 % of web, normal stress in flange σ and shear stress in web τ at weld ends.	τ/σ = 0 = 71 0,0 - 0,2 63 0,2 - 0,3 56 0,3 - 0,4 50 0,4 - 0,5 45 0,5 - 0,6 40 > 0,6 36	28 25 22 20 18 16 14

Perpendicular the welds (Y-direction)

5.4 Fatigue classes for welded components made of structural steel and of aluminum 172

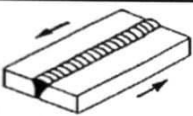
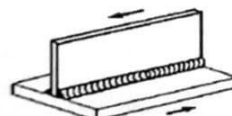
5 Annexe

Table 5.4.1 Fatigue classes for nominal stress (normal stress), continued page 6 of 10

No.	Structural detail	Description	FAT Steel	FAT Al
500	Non-load carrying attachments			
511		Transverse non-load carrying attachment, not thicker than main plate;		
		fillet weld, toe ground	100	36
		two-sided fillets, toe ground	100	36
		fillet weld(s), as welded, also single-sided	80	28
512		if attachment thicker than main plate,	71	25
		Transverse stiffener welded on girder web or flange, not thicker than main plate;		
		fillet weld, toe ground	100	36
		two-sided fillets, toe ground	100	36
		fillet weld(s), as welded, also single-sided	80	28
		if stiffener thicker than main plate	71	25
		For weld ends on web principle stress to be used!		


Shear (XY-direction)

Table 5.4.2 Fatigue classes for nominal stress (shear stress), according to *Hobbacher* /13/

No.	Structural detail	Description	FAT Steel	FAT Al
1		Full penetration butt welds.	100	36
2		Fillet welds, partial penetration butt welds.	80	28

Define FAT Classes (Tables 5.4.1 and 5.4.2)

1

Press  in FAT Classes (Tables 5.4.1 and 5.4.2)

2

Element(s) Classification: 0 and press *Apply*

3

Press  to add Condition

4

Press *Add all welds*

5

Select *Multiple Condition* options

6

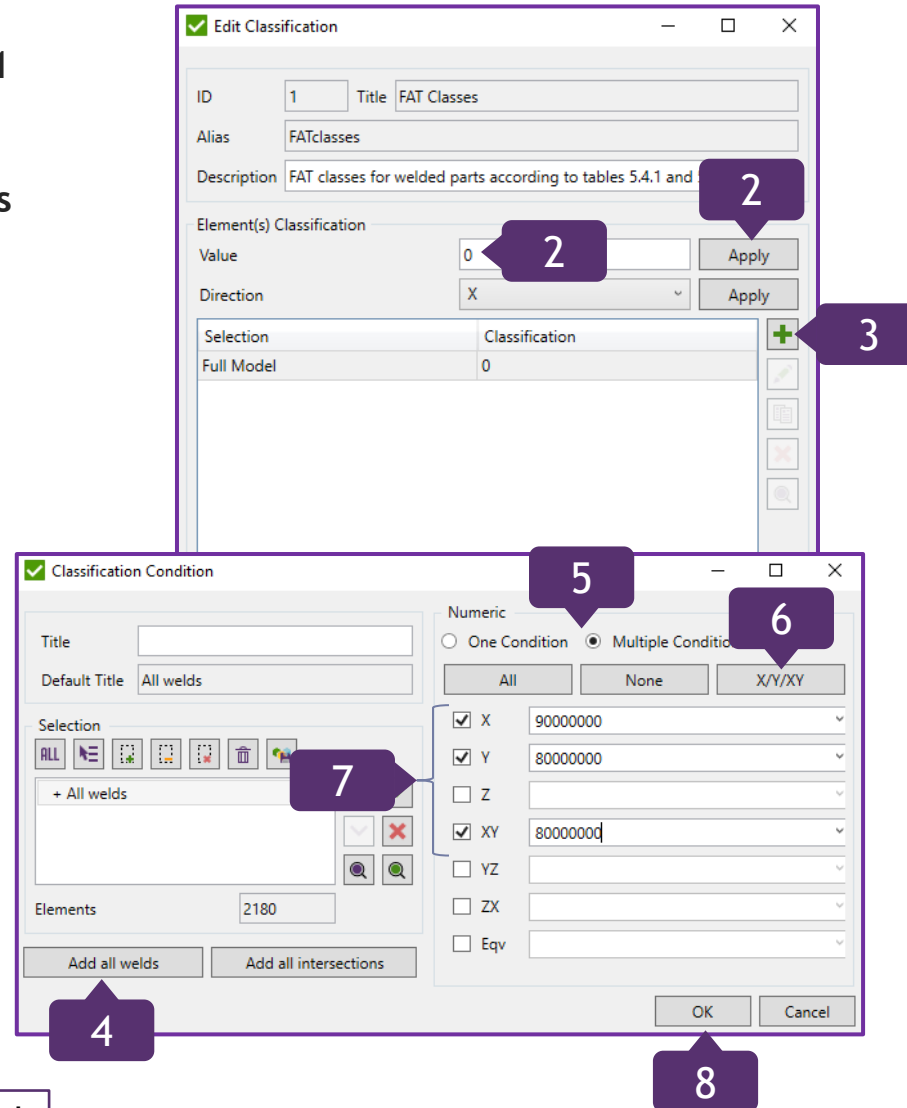
Press *X/Y/XY*

7

For All welds: X: 90000000;
Y/XY: 80000000

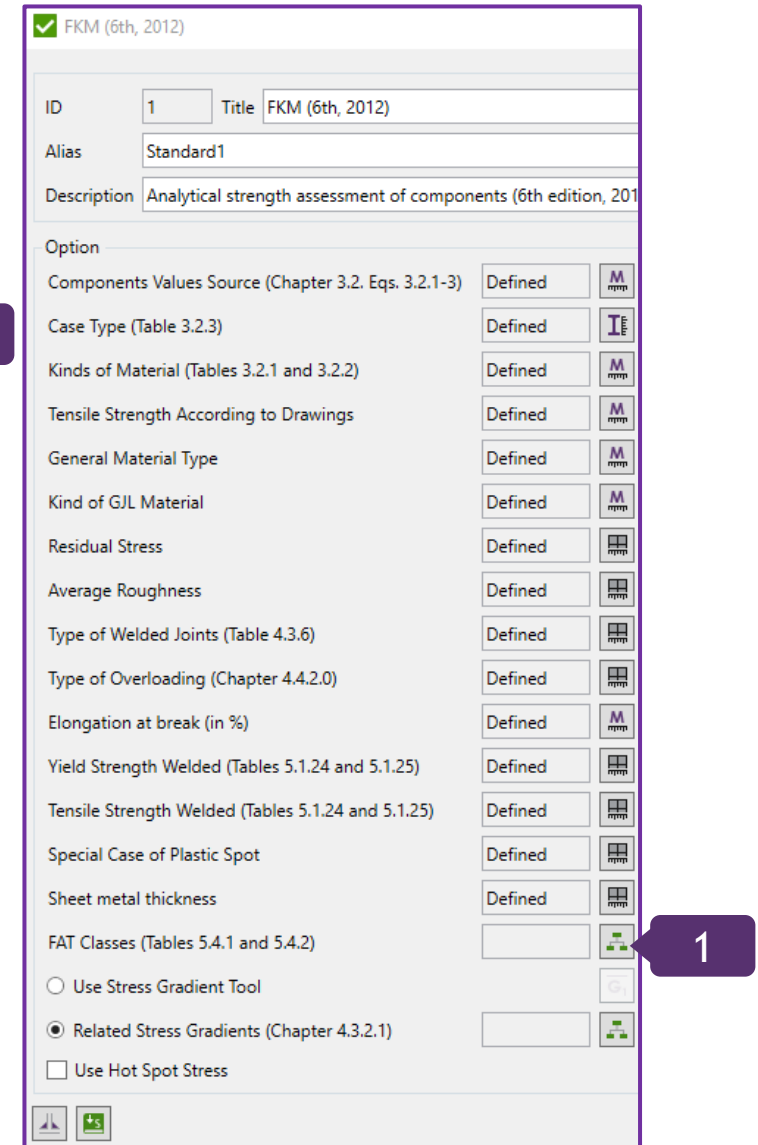
8

Press *OK*



The image shows two overlapping dialog boxes. The top box is 'Edit Classification' and the bottom box is 'Classification Condition'. Numbered callouts point to specific UI elements:

- 1: ID field in 'Edit Classification' (value: 1)
- 2: 'Element(s) Classification' dropdown in 'Edit Classification' (value: 0)
- 3: '+' button to add a condition in 'Edit Classification'
- 4: 'Add all welds' button in 'Classification Condition'
- 5: 'Multiple Condition' radio button in 'Classification Condition'
- 6: 'X/Y/XY' button in 'Classification Condition'
- 7: 'All' button in 'Classification Condition' selection area
- 8: 'OK' button in 'Classification Condition'



The image shows the 'FKM (6th, 2012)' dialog box. A numbered callout points to the 'FAT Classes (Tables 5.4.1 and 5.4.2)' option, which is highlighted with a green icon.

Note: FAT Classes should be defined in the unit system of the model.

Welds Intersections for FAT Classes (Tables 5.4.1 and 5.4.2)

1 Press **+** to Add Condition

2 Click *Add all intersections*

3 Value: 80000000

4 Direction: X

5 Press *OK*

1

2

3


4

5

Selection	Classification
Full Model	0
All welds	9E+07 (X)
All welds	8E+07 (Y, XY)
All welds intersections	8E+07 (X)

Define Related Stress Gradients (Chapter 4.3.2.1)

1

Press  in Related Stress Gradients (Chapter 4.3.2.1)

2

Element(s) Classification Value: 0.01 and press *Apply*

3

Direction: X

4

Press *OK*

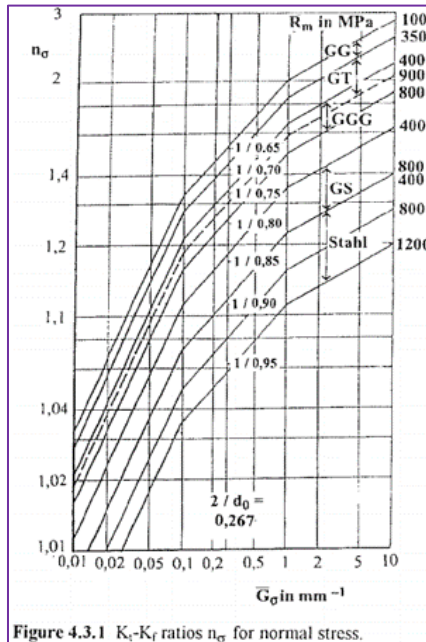


Figure 4.3.1 K_t - K_f ratios n_σ for normal stress.

Related Stress Gradient can be calculated automatically by Stress Gradient tool or defined by classification (Chapter 4.3.2.1). By default, the value 0.01 is used.

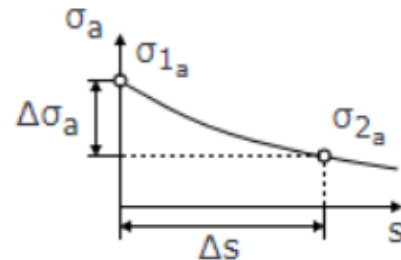
Related Stress Gradients is calculated to reduce peak stresses at the defined points of the model. Calculations are based on normal and shear stress amplitudes at the reference point and point below the surface according to Equation 4.3.16 of Analytical Strength Assessment of Components in Mechanical Engineering, 5th Edition, 2003

$$\overline{G}_{\sigma} = \frac{1}{\Delta s} * \left(1 - \frac{\sigma_{2a}}{\sigma_{1a}}\right)$$
$$\overline{G}_{\tau} = \frac{1}{\Delta s} * \left(1 - \frac{\tau_{2a}}{\tau_{1a}}\right), \text{ where}$$

σ_{1a}, τ_{1a} - stress amplitudes at the reference point;

σ_{2a}, τ_{2a} - stress amplitudes in a distance Δs ;

Δs - the distance between the reference point and the neighboring point below the surface;



Note: Stress Gradient is calculated on free edge nodes of shell elements for their top and bottom points of interest.

Define Softening Aluminum Alloys

1 Press  in Softening Aluminum Alloys

2 Elemental Selections SAA: *YES* and press *To All*

3 Press *OK*

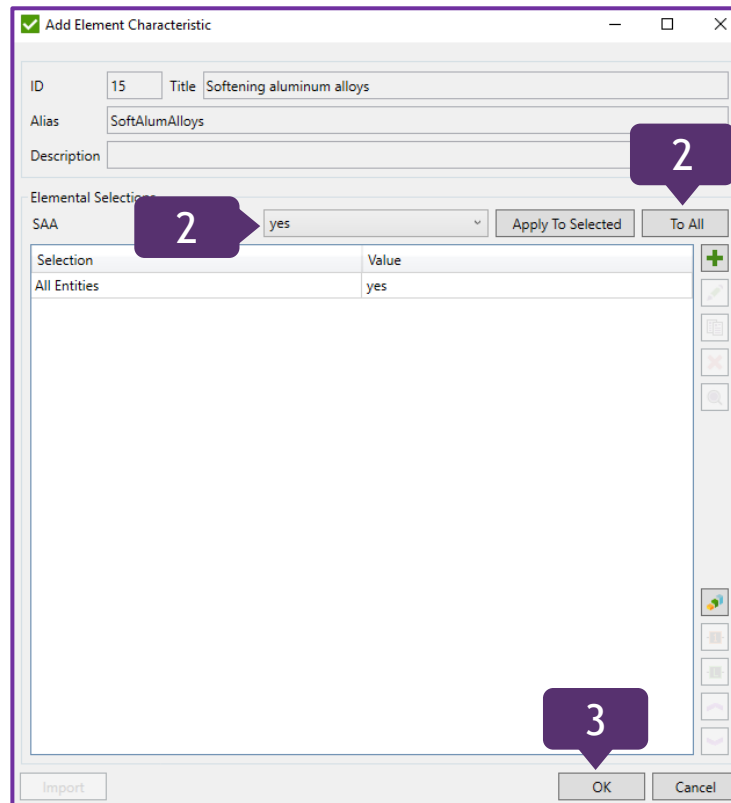
Steel and non-softening aluminum alloys

$$n_{pl} = \text{MIN} (\sqrt{E \cdot \epsilon_{entr} / R_p} ; K_p) \quad (3.3.13)$$

Softening aluminum alloys

$$n_{pl} = \text{MIN} (\sqrt{E \cdot \epsilon_{entr} / (\rho_{WEZ} \cdot R_p)} ; K_p) \quad (3.3.14)$$

E Young's modulus, Table 3.3.3;
 ϵ_{entr} total critical strain, Table 3.3.3;
 R_p yield strength, Tables 5.1.24 and 5.1.25;
 ρ_{WEZ} softening factor, Table 5.1.25;
 K_p, \dots plastic notch factors, Eq. (3.3.8).



✓ Add Element Characteristic

ID 15 Title Softening aluminum alloys

Alias SoftAlumAlloys

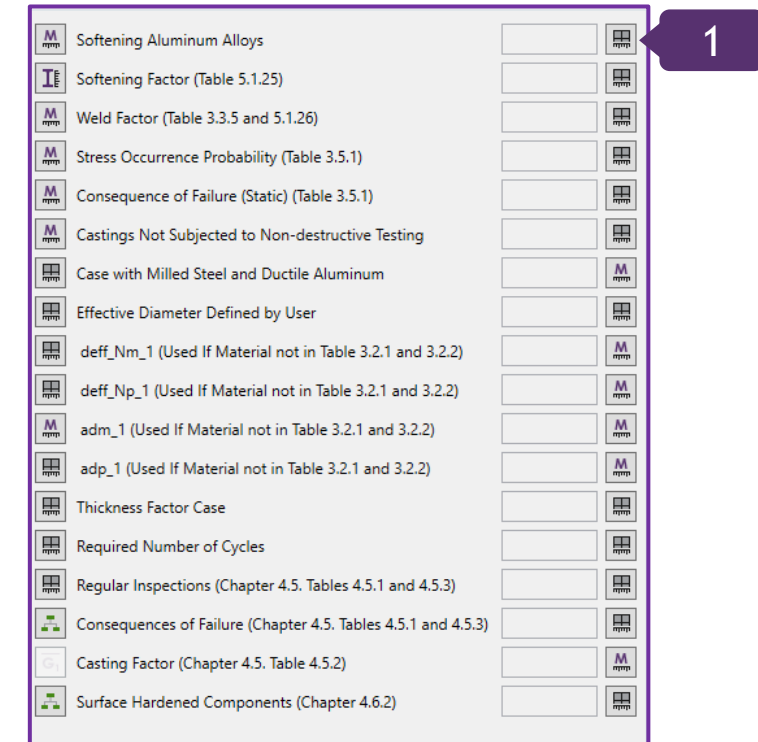
Description

Elemental Selections

SAA yes Apply To Selected To All

Selection	Value
All Entities	yes

Import OK Cancel



1

Softening Aluminum Alloys

Softening Factor (Table 5.1.25)

Weld Factor (Table 3.3.5 and 5.1.26)

Stress Occurrence Probability (Table 3.5.1)

Consequence of Failure (Static) (Table 3.5.1)

Castings Not Subjected to Non-destructive Testing

Case with Milled Steel and Ductile Aluminum

Effective Diameter Defined by User

deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)

deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)

adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)

adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)

Thickness Factor Case

Required Number of Cycles

Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)

Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)

Casting Factor (Chapter 4.5. Table 4.5.2)

Surface Hardened Components (Chapter 4.6.2)

Define Softening Factor (Table 5.1.25)

1 Press  in Softening Factor (Table 5.1.25)

2 Selection Value: 1

3 Press *OK*

Add Element Characteristic

ID: 16 Title: Softening factor

Alias: q_WEZ



















Description: Softening factor, Table 5.1.25

Elemental Selections

Value: Apply To Selected To All

Selection	Value
All Entities	1

Import OK Cancel

Softening Aluminum Alloys	Defined	
Softening Factor (Table 5.1.25)	<input type="text"/>	
Weld Factor (Table 3.3.5 and 5.1.26)	<input type="text"/>	
Stress Occurrence Probability (Table 3.5.1)	<input type="text"/>	
Consequence of Failure (Static) (Table 3.5.1)	<input type="text"/>	
Castings Not Subjected to Non-destructive Testing	<input type="text"/>	
Case with Milled Steel and Ductile Aluminum	<input type="text"/>	
Effective Diameter Defined by User	<input type="text"/>	
deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	<input type="text"/>	
deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)	<input type="text"/>	
adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	<input type="text"/>	
adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)	<input type="text"/>	
Thickness Factor Case	<input type="text"/>	
Required Number of Cycles	<input type="text"/>	
Regular Inspections (Chapter 4.5, Tables 4.5.1 and 4.5.3)	<input type="text"/>	
Consequences of Failure (Chapter 4.5, Tables 4.5.1 and 4.5.3)	<input type="text"/>	
Casting Factor (Chapter 4.5, Table 4.5.2)	<input type="text"/>	
Surface Hardened Components (Chapter 4.6.2)	<input type="text"/>	

Define Weld Factor (Table 3.3.5 and 5.1.26)

1

Press  in *Weld Factor (Table 3.3.5 and 5.1.26)*

2

Selection Value: 1

3

Press **OK**

Table 3.3.5 Weld factor α_W for steel

Weld	Weld quality $\diamond 1$	Stress type	S235 GS200 GS240 G17Mn5+ QT	S275 P27 P27 G20Mn5 +Q	S355 P355 G20Mn5 +N G20Mn5 +Q	S420 S460 S460 S460	S690 S690
full penetration weld or with back weld	all	compression	1,0	1,0	1,0	1,0	0,9
	verified	tension or shear					
partial penetration or fillet weld	not verified						
	all	compression/tension or shear	0,95	0,85	0,8	0,7	0,55

Add Element Characteristic

ID: 17 Title: Weld factor

Alias: a_W


Description: Weld factor. Table 3.3.5 and 5.1.26


Elemental Selections


Value: Apply To Selected To All


Selection	Value
All Entities	1


Import OK Cancel


Softening Aluminum Alloys Defined 


Softening Factor (Table 5.1.25) Defined 


Weld Factor (Table 3.3.5 and 5.1.26)  1


Stress Occurrence Probability (Table 3.5.1) 


Consequence of Failure (Static) (Table 3.5.1) 


Castings Not Subjected to Non-destructive Testing 


Case with Milled Steel and Ductile Aluminum 


Effective Diameter Defined by User 


deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


adm_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


adp_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


Thickness Factor Case 

Required Number of Cycles 

Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3) 


Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3) 

Casting Factor (Chapter 4.5. Table 4.5.2) 

Surface Hardened Components (Chapter 4.6.2) 

Define Stress Occurrence Probability (Table 3.5.1)

1

Press  in *Stress Occurrence Probability (Table 3.5.1)*

2

Elemental Selections POS: *High*

3

Press *OK*

Table 3.5.1 Basic safety factors

j_m j_p j_{mt} j_{pt}		Consequences of failure		
		high	mean	moderate $\diamond 1$
Probability of the occurrence of the stress or the stress combination $\diamond 2$	high	2,0	1,85	1,75
		1,5	1,4	1,3
		1,5	1,4	1,3
		1,0	1,0	1,0
	low $\diamond 3$	1,8	1,7	1,6
		1,35	1,25	1,2
		1,35	1,25	1,2
		1,0	1,0	1,0

Add Element Characteristic

ID: 18 Title: Probability of the occurrence of the stress or the stress combination

Alias: ProbOccrenStress


Description: Probability of the occurrence of the stress or the stress combination. Table 3.5.1


Elemental Selections:


POS: **high** Apply To Selected To All


Selection	Value
All Entities	high


3 OK Cancel


Softening Aluminum Alloys Defined 


Softening Factor (Table 5.1.25) Defined 


Weld Factor (Table 3.3.5 and 5.1.26) Defined 


Stress Occurrence Probability (Table 3.5.1) 


Consequence of Failure (Static) (Table 3.5.1) 


Castings Not Subjected to Non-destructive Testing 


Case with Milled Steel and Ductile Aluminum 


Effective Diameter Defined by User 


deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


adm_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


adp_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


Thickness Factor Case 

Required Number of Cycles 

Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3) 

Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3) 

Casting Factor (Chapter 4.5. Table 4.5.2) 

Surface Hardened Components (Chapter 4.6.2) 

1

Define Consequence of Failure (Static) (Table 3.5.1)

1 Press  in Consequence of Failure (Static) (Table 3.5.1)

2 Elemental Selections CF: *mean* and press *To All*

3 Press *OK*

Table 3.5.1 Basic safety factors

j _m j _p j _{mt} j _{pt}		Consequences of failure		
		high	mean	moderate ◇ ₁
Probability of the occurrence of the stress or the stress combination ◇ ₂	high	2,0	1,85	1,75
		1,5	1,4	1,3
		1,5	1,4	1,3
		1,0	1,0	1,0
	low ◇ ₃	1,8	1,7	1,6
		1,35	1,25	1,2
		1,35	1,25	1,2
		1,0	1,0	1,0

Add Element Characteristic

ID: 19 Title: Consequence of failure (Static strength)

Alias: ConsFailure_Static


Description: Consequence of failure. Table 3.5.1


Elemental Selections


CF: **mean** **To All**


Selection	Value
All Entities	mean


Import OK Cancel


Softening Aluminum Alloys Defined 


Softening Factor (Table 5.1.25) Defined 


Weld Factor (Table 3.3.5 and 5.1.26) Defined 


Stress Occurrence Probability (Table 3.5.1) Defined 


Consequence of Failure (Static) (Table 3.5.1)  1


Castings Not Subjected to Non-destructive Testing 


Case with Milled Steel and Ductile Aluminum 


Effective Diameter Defined by User 


deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


adm_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


adp_1 (Used If Material not in Table 3.2.1 and 3.2.2) 


Thickness Factor Case 

Required Number of Cycles 

Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3) 


Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3) 

Casting Factor (Chapter 4.5. Table 4.5.2) 

Surface Hardened Components (Chapter 4.6.2) 

Define Casting Not Subjected to Non-destructive Testing

1

Press  in Casting Not Subjected to Non-destructive Testing

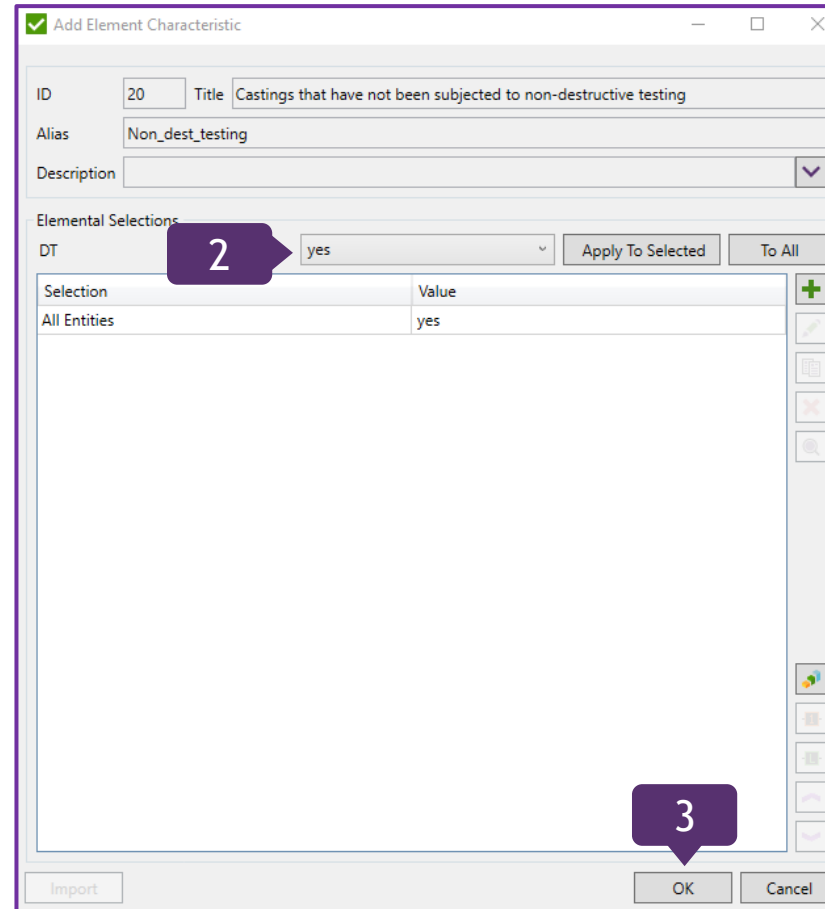
2

Elemental Selections DT: *yes*

3

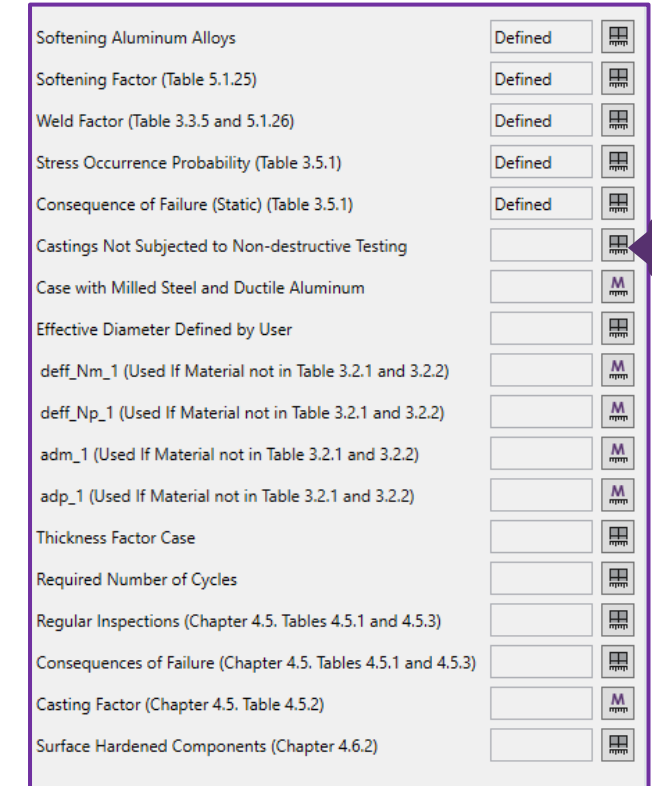
Press *OK*

$j_G = 1,4$ castings that have not been subjected to non-destructive testing;
 $j_G = 1,25$ castings that have been subject to non-destructive testing. (3.5.2)



The dialog box "Add Element Characteristic" is shown. It has fields for ID (20), Title ("Castings that have not been subjected to non-destructive testing"), Alias ("Non_dest_testing"), and Description. Under "Elemental Selections", the "DT" dropdown is set to "yes" (indicated by a purple arrow labeled 2). Below this is a table with "Selection" and "Value" columns, containing one row: "All Entities" with value "yes". At the bottom right, the "OK" button is highlighted with a purple arrow labeled 3.

Selection	Value
All Entities	yes




A list of material properties is shown, each with a status (Defined or Not Defined) and a corresponding icon. A purple arrow labeled 1 points to the "Castings Not Subjected to Non-destructive Testing" entry, which is currently "Not Defined".

Property	Status
Softening Aluminum Alloys	Defined
Softening Factor (Table 5.1.25)	Defined
Weld Factor (Table 3.3.5 and 5.1.26)	Defined
Stress Occurrence Probability (Table 3.5.1)	Defined
Consequence of Failure (Static) (Table 3.5.1)	Defined
Castings Not Subjected to Non-destructive Testing	Not Defined
Case with Milled Steel and Ductile Aluminum	Not Defined
Effective Diameter Defined by User	Not Defined
deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Not Defined
deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Not Defined
adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Not Defined
adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Not Defined
Thickness Factor Case	Not Defined
Required Number of Cycles	Not Defined
Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)	Not Defined
Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)	Not Defined
Casting Factor (Chapter 4.5. Table 4.5.2)	Not Defined
Surface Hardened Components (Chapter 4.6.2)	Not Defined

Define Case with Milled Steel and Ductile Aluminum

1

Press  in Case with Milled Steel and Ductile Aluminum

2

Materials MSandDA: *no* and press *To All*

3

Press *OK*

3.5.2 Total safety factor

From the individual safety factors, the total safety factor j_{ges} shall be determined (maximum value is relevant):

$$j_{ges} = j_s \cdot j_z \cdot \text{MAX} \left(\frac{j_m}{K_{T,m}} \cdot \frac{R_p}{R_m}, \frac{j_p}{K_{T,p}} \cdot \frac{j_{mt}}{K_{T,m}} \cdot \frac{R_p}{R_m}, \frac{j_{pt}}{K_{T,p}} \right) + \Delta j \quad (3.5.5)$$

j_s

load factor;

$j_m \dots$

individual safety factors, Table 3.5.1;

$K_{T,m} \dots$

temperature factors, Chapter 3.2.1.7;

R_m, R_p

tensile strength and yield strength, Eqs. (3.2.1) to (3.2.3);

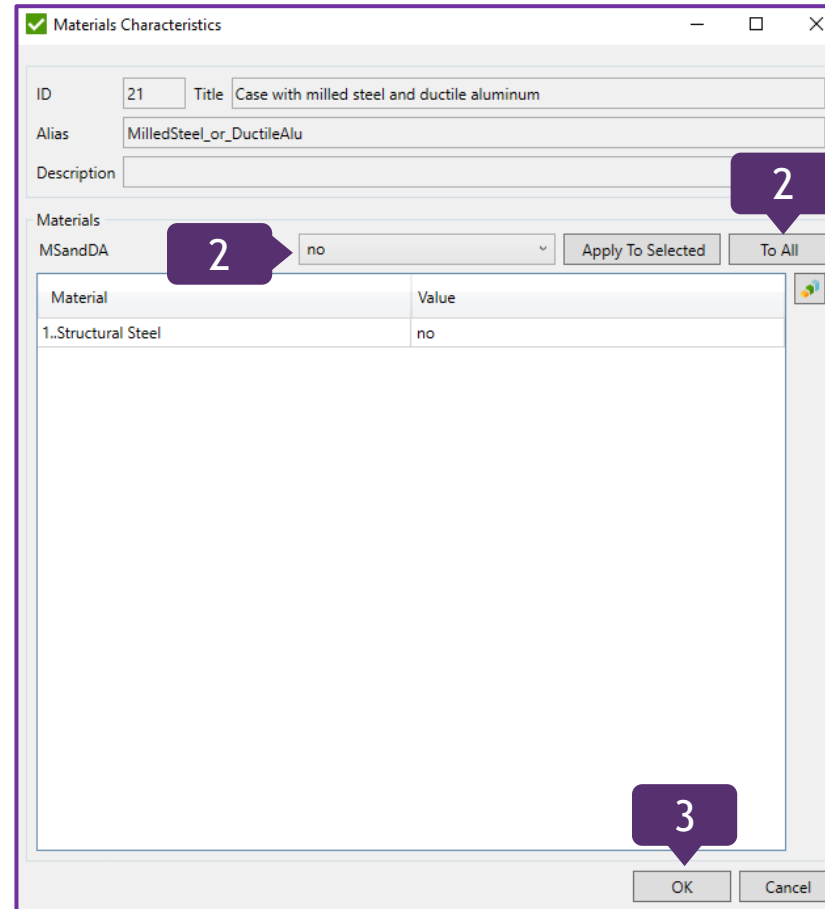
j_z

additional partial safety factor for cast or welded components, Table 3.5.2; here, j_G and j_w shall not be applied in combination, only j_G (BM and HAZ) or j_w (W);

Δj

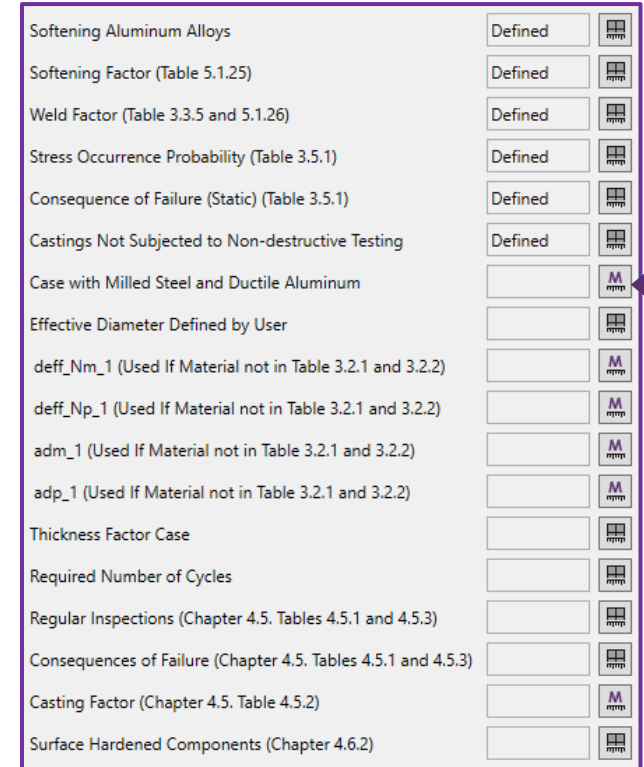
additional partial safety term for non-ductile material, Eq. (3.5.4).

- for milled steel and ductile aluminum alloys in welded components, proportions 1 and 3 are omitted.



The dialog box 'Materials Characteristics' is shown. It has fields for ID (21), Title ('Case with milled steel and ductile aluminum'), Alias ('MilledSteel_or_DuctileAlu'), and Description. Below these are 'Materials' and 'MSandDA' (set to 'no') with 'Apply To Selected' and 'To All' buttons. A table lists '1..Structural Steel' with a value of 'no'. At the bottom are 'OK' and 'Cancel' buttons. Numbered callouts 1, 2, and 3 point to the 'To All' button, the 'MSandDA' dropdown, and the 'OK' button respectively.

Material	Value
1..Structural Steel	no



A list of materials and their status is shown. Each item has a 'Defined' button and a material icon. Item 1, 'Case with Milled Steel and Ductile Aluminum', is highlighted with a callout 1 pointing to its icon.

Material	Status
Softening Aluminum Alloys	Defined
Softening Factor (Table 5.1.25)	Defined
Weld Factor (Table 3.3.5 and 5.1.26)	Defined
Stress Occurrence Probability (Table 3.5.1)	Defined
Consequence of Failure (Static) (Table 3.5.1)	Defined
Castings Not Subjected to Non-destructive Testing	Defined
Case with Milled Steel and Ductile Aluminum	Defined
Effective Diameter Defined by User	Defined
deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined
deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined
adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined
adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined
Thickness Factor Case	Defined
Required Number of Cycles	Defined
Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)	Defined
Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)	Defined
Casting Factor (Chapter 4.5. Table 4.5.2)	Defined
Surface Hardened Components (Chapter 4.6.2)	Defined

Define Effective Diameter Defined by User

1

Press  in Effective Diameter Defined by User

2

Selection Type '3..Solid' Value: 0

3

Press **OK**

This value is used in cases when effective diameter is not possible to be calculate automatically (e.g. for solid elements).

Add Element Characteristic

ID: 22 Title: Effective diameter defined by user

Alias: d_eff_user

Description: In case when d_eff can not be calculate automatically (for example in case with solid elements) w

Elemental Selections



















Value: Apply To Selected To All

Selection	Value
Type '3..Solid'	0

Import OK Cancel

2

3

Softening Aluminum Alloys	Defined	
Softening Factor (Table 5.1.25)	Defined	
Weld Factor (Table 3.3.5 and 5.1.26)	Defined	
Stress Occurrence Probability (Table 3.5.1)	Defined	
Consequence of Failure (Static) (Table 3.5.1)	Defined	
Castings Not Subjected to Non-destructive Testing	Defined	
Case with Milled Steel and Ductile Aluminum	Defined	
Effective Diameter Defined by User		
deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)		
deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)		
adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)		
adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)		
Thickness Factor Case		
Required Number of Cycles		
Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)		
Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)		
Casting Factor (Chapter 4.5. Table 4.5.2)		
Surface Hardened Components (Chapter 4.6.2)		

1

Define Constants deff_Nm_1; deff_Np_1; adm_1; adp_1

1

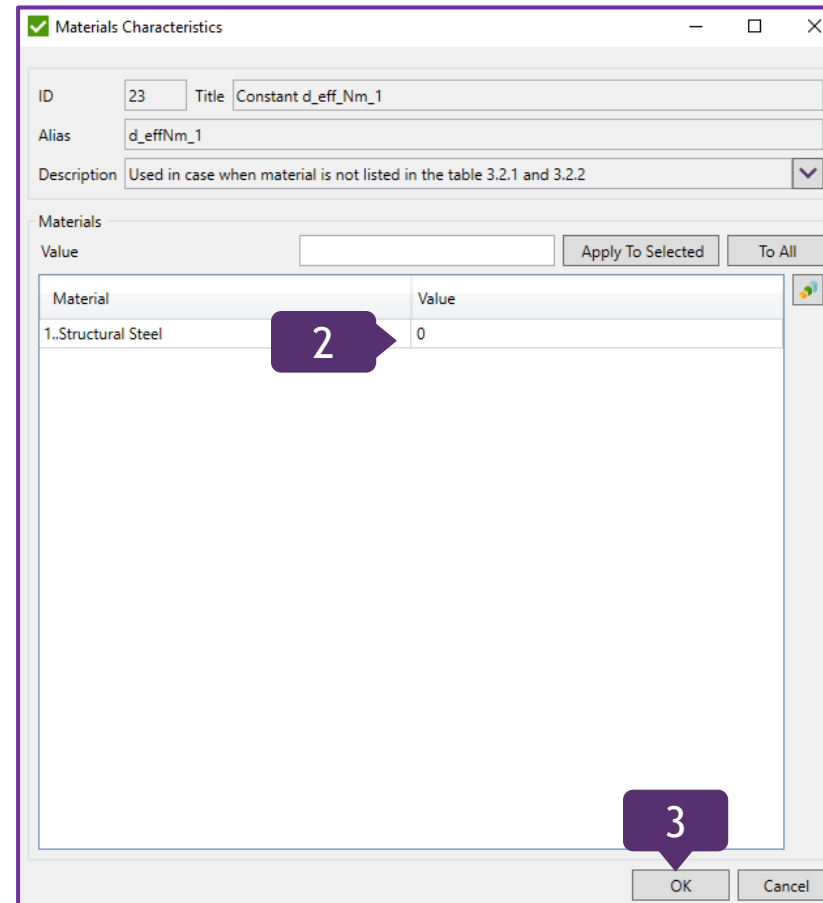
Press  in deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)

2

Material 1..Structural Steel Value: 0

3

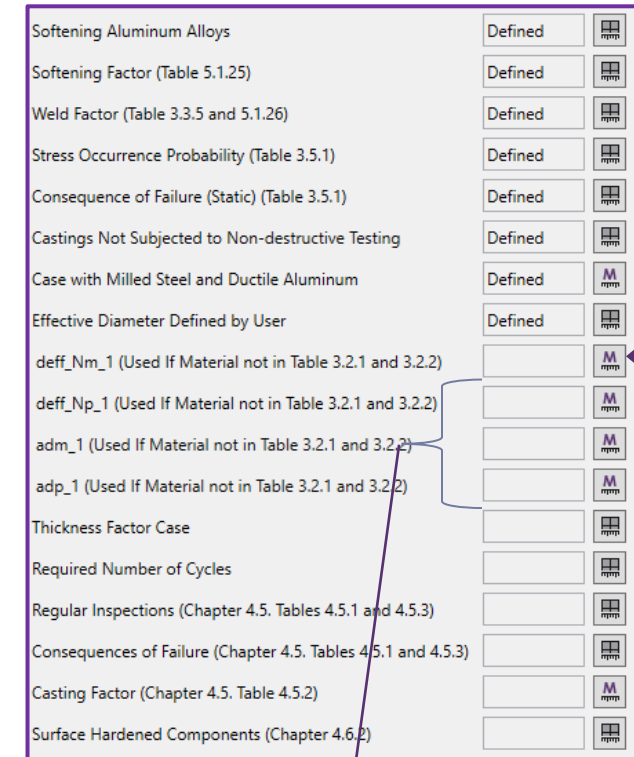
Press **OK**



The dialog box 'Materials Characteristics' is shown. It has fields for ID (23), Title (Constant d_eff_Nm_1), Alias (d_effNm_1), and Description (Used in case when material is not listed in the table 3.2.1 and 3.2.2). Below these is a 'Materials' section with a 'Value' field and buttons 'Apply To Selected' and 'To All'. A table lists materials and their values:

Material	Value
1..Structural Steel	0

At the bottom are 'OK' and 'Cancel' buttons.



A list of material constants with their status and icons:

Constant Name	Status	Icon
Softening Aluminum Alloys	Defined	
Softening Factor (Table 5.1.25)	Defined	
Weld Factor (Table 3.3.5 and 5.1.26)	Defined	
Stress Occurrence Probability (Table 3.5.1)	Defined	
Consequence of Failure (Static) (Table 3.5.1)	Defined	
Castings Not Subjected to Non-destructive Testing	Defined	
Case with Milled Steel and Ductile Aluminum	Defined	
Effective Diameter Defined by User	Defined	
deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)		
deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)		
adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)		
adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)		
Thickness Factor Case		
Required Number of Cycles		
Regular Inspections (Chapter 4.5, Tables 4.5.1 and 4.5.3)		
Consequences of Failure (Chapter 4.5, Tables 4.5.1 and 4.5.3)		
Casting Factor (Chapter 4.5, Table 4.5.2)		
Surface Hardened Components (Chapter 4.6.2)		

Repeat the same steps in deff_Np_1, adm_1 and adp_1 sections. Materials Value: 0

Define Thickness Factor Case

1 Press  in Thickness Factor Case

2 Elemental Selections TFC: *Case A*

3 Press **OK**

☒ Add Element Characteristic

ID: 27 Title: Thickness factor case

Alias: Thickness_factor



















Description: Case A corresponds with the general wording of the IIW recommendations and shall be used if t

Elemental Selections:

TFC: **2** Case A [Apply To Selected] [To All]

Selection	Value
All Entities	Case A

3 [Import] [OK] [Cancel]

Softening Aluminum Alloys	Defined	
Softening Factor (Table 5.1.25)	Defined	
Weld Factor (Table 3.3.5 and 5.1.26)	Defined	
Stress Occurrence Probability (Table 3.5.1)	Defined	
Consequence of Failure (Static) (Table 3.5.1)	Defined	
Castings Not Subjected to Non-destructive Testing	Defined	
Case with Milled Steel and Ductile Aluminum	Defined	
Effective Diameter Defined by User	Defined	
deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
1 Thickness Factor Case		
Required Number of Cycles		
Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)		
Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)		
Casting Factor (Chapter 4.5. Table 4.5.2)		
Surface Hardened Components (Chapter 4.6.2)		

Case A

This case corresponds with the general wording of the IIW recommendations and shall be used if the user has no experience or no sector-specific experience is available which would justify the application of case B.

The following applies to sheet metal thicknesses $t \leq 25$ mm:

$$f_t = 1 \quad (4.3.23)$$

The following applies to sheet metal thicknesses $t > 25$ mm:

$$f_t = \left(\frac{25 \text{ mm}}{t} \right)^n \quad (4.3.24)$$

with n according to Table 4.3.6.

Case B

The influence of the thickness on the fatigue strength of welds, including in the case of sheet metal thicknesses < 25 mm, is known; due to insufficient experimental proof, however, it has not yet been generally formulated.

If the user has experience or sector-specific experience is available, e.g. in automotive engineering and railway vehicle manufacturing (*technical rules DVS 1608, DVS 1612*), the thickness factor according to case B can be used.

The following applies to sheet metal thicknesses $t \leq 10$ mm:

$$f_t = 1,1 \quad (4.3.25)$$

The following applies to sheet metal thicknesses $10 \text{ mm} < t \leq 25 \text{ mm}$:

$$f_t = \left(\frac{25 \text{ mm}}{t} \right)^{0,1} \quad (4.3.26)$$

The following applies to sheet metal thicknesses $t > 25$ mm:

$$f_t = \left(\frac{25 \text{ mm}}{t} \right)^n \quad (4.3.27)$$

with n according to Table 4.3.6.

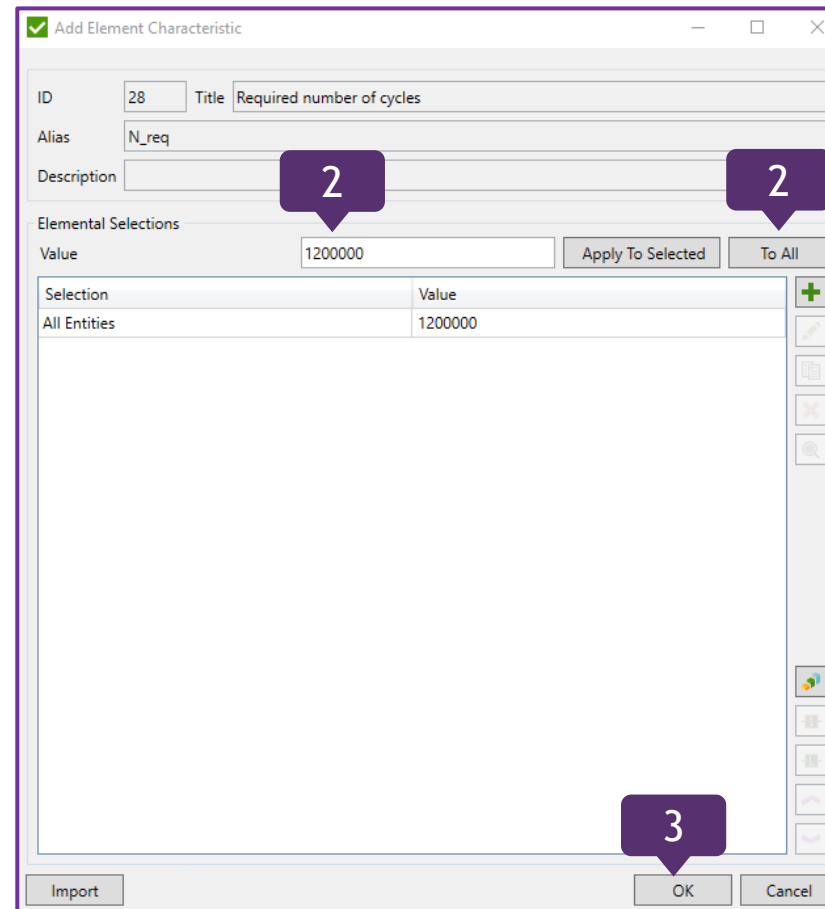
Define Required Number of Cycles

1 Press  in Required Number of Cycles

2 Elemental Selections Value: **1200000** and press *To all*

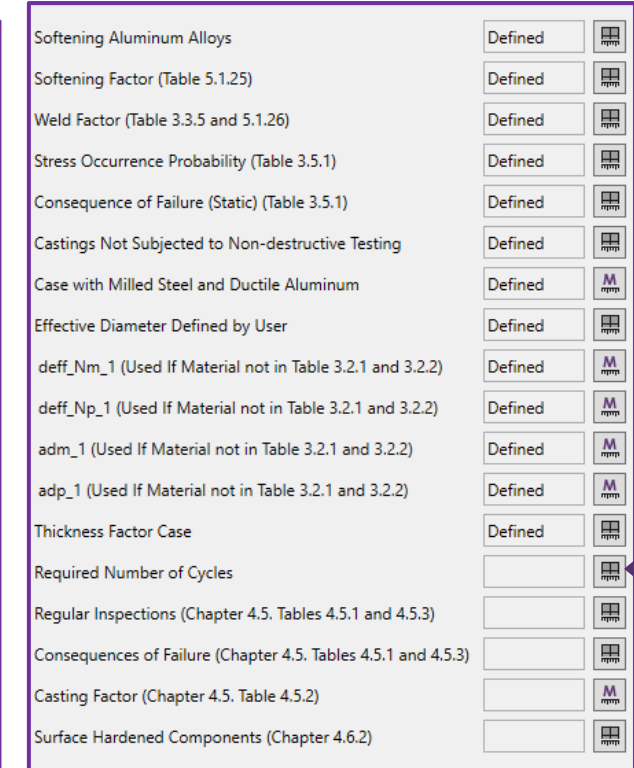
3 Press *OK*

This is a set of required number of cycles for full model or for individual components separately.





















The dialog box 'Add Element Characteristic' is shown. It has fields for ID (28), Title (Required number of cycles), Alias (N_req), and Description. Under 'Elemental Selections', the 'Value' is set to 1200000. A table below shows 'All Entities' with a value of 1200000. Buttons 'Apply To Selected' and 'To All' are present. At the bottom are 'Import', 'OK', and 'Cancel' buttons. Numbered callouts point to the 'Value' field (2), the 'To All' button (2), and the 'OK' button (3).

Selection	Value
All Entities	1200000



A list of material properties is shown, each with a 'Defined' status and a corresponding icon. The 'Required Number of Cycles' property is highlighted with a callout '1'.

Property	Status	Icon
Softening Aluminum Alloys	Defined	
Softening Factor (Table 5.1.25)	Defined	
Weld Factor (Table 3.3.5 and 5.1.26)	Defined	
Stress Occurrence Probability (Table 3.5.1)	Defined	
Consequence of Failure (Static) (Table 3.5.1)	Defined	
Castings Not Subjected to Non-destructive Testing	Defined	
Case with Milled Steel and Ductile Aluminum	Defined	
Effective Diameter Defined by User	Defined	
deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
Thickness Factor Case	Defined	
Required Number of Cycles		
Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)		
Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)		
Casting Factor (Chapter 4.5. Table 4.5.2)		
Surface Hardened Components (Chapter 4.6.2)		

Define Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)

1 Press  in Regular Inspections

2 Elemental Selections RI: Yes

3 Press OK

Table 4.5.1 Material safety factors j_F for non-welded steel and for wrought aluminum alloys

j_F		Consequences of failure \diamond^1		
		severe	mean	moderate
Regular inspections \diamond^2	no	1,5	1,4	1,3
	yes	1,35	1,25	1,2

Table 4.5.3 Material safety factors j_F for welded components

j_F		Consequences of failure \diamond^1		
		severe	mean	moderate
Regular inspections \diamond^2	no	1,4	1,25	1,15
	yes	1,2	1,1	1,0

✓ Add Element Characteristic

ID: 29 Title: Regular inspections

Alias: Regular_Inspections


Description: Chapter 4.5. Tables 4.5.1 and 4.5.3


Elemental Selections


RI: yes **2** Apply To Selected To All


Selection	Value
All Entities	yes


3 OK Cancel


Softening Aluminum Alloys Defined 


Softening Factor (Table 5.1.25) Defined 


Weld Factor (Table 3.3.5 and 5.1.26) Defined 


Stress Occurrence Probability (Table 3.5.1) Defined 


Consequence of Failure (Static) (Table 3.5.1) Defined 


Castings Not Subjected to Non-destructive Testing Defined 


Case with Milled Steel and Ductile Aluminum Defined 


Effective Diameter Defined by User Defined 


deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2) Defined 


deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2) Defined 

adm_1 (Used If Material not in Table 3.2.1 and 3.2.2) Defined 

adp_1 (Used If Material not in Table 3.2.1 and 3.2.2) Defined 

Thickness Factor Case Defined 

Required Number of Cycles Defined 

Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)  **1**

Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)

Casting Factor (Chapter 4.5. Table 4.5.2)

Surface Hardened Components (Chapter 4.6.2)

Define Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)

1 Press  in Consequences of Failure

2 Elemental Selections CFfatigue: *mean* and press *To All*

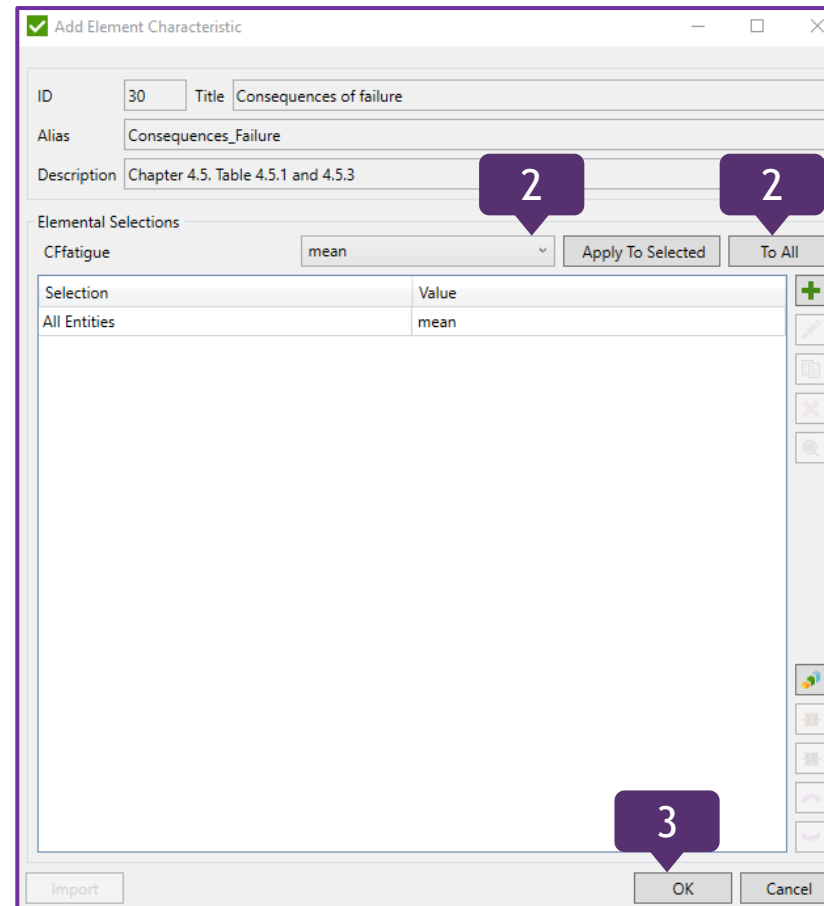
3 Press *OK*

Table 4.5.1 Material safety factors j_F for non-welded steel and for wrought aluminum alloys

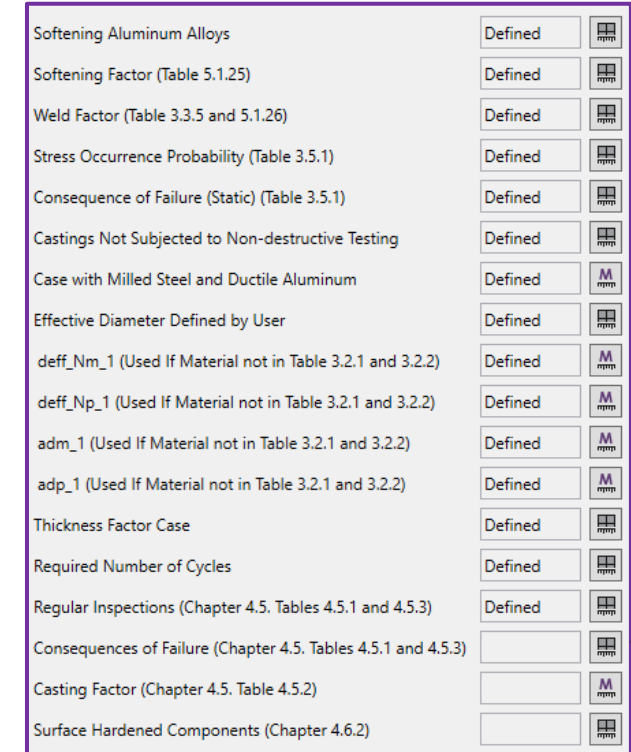
j_F		Consequences of failure \diamond^1		
		severe	mean	moderate
Regular inspections \diamond^2	no	1,5	1,4	1,3
	yes	1,35	1,25	1,2

Table 4.5.3 Material safety factors j_F for welded components

j_F		Consequences of failure \diamond^1		
		severe	mean	moderate
Regular inspections \diamond^2	no	1,4	1,25	1,15
	yes	1,2	1,1	1,0



The dialog box 'Add Element Characteristic' is shown. It has fields for ID (30), Title (Consequences of failure), Alias (Consequences_Failure), and Description (Chapter 4.5. Table 4.5.1 and 4.5.3). Under 'Elemental Selections', 'CFfatigue' is selected with a value of 'mean'. There are buttons for 'Apply To Selected' and 'To All'. A table below shows 'All Entities' with a value of 'mean'. At the bottom are 'Import', 'OK', and 'Cancel' buttons.



A list of material properties is shown, each with a 'Defined' status and a button. The items are: Softening Aluminum Alloys, Softening Factor (Table 5.1.25), Weld Factor (Table 3.3.5 and 5.1.26), Stress Occurrence Probability (Table 3.5.1), Consequence of Failure (Static) (Table 3.5.1), Castings Not Subjected to Non-destructive Testing, Case with Milled Steel and Ductile Aluminum, Effective Diameter Defined by User, deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2), deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2), adm_1 (Used If Material not in Table 3.2.1 and 3.2.2), adp_1 (Used If Material not in Table 3.2.1 and 3.2.2), Thickness Factor Case, Required Number of Cycles, Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3), Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3), Casting Factor (Chapter 4.5. Table 4.5.2), and Surface Hardened Components (Chapter 4.6.2).

Define Casting Factor (Chapter 4.5. Tables 4.5.2)

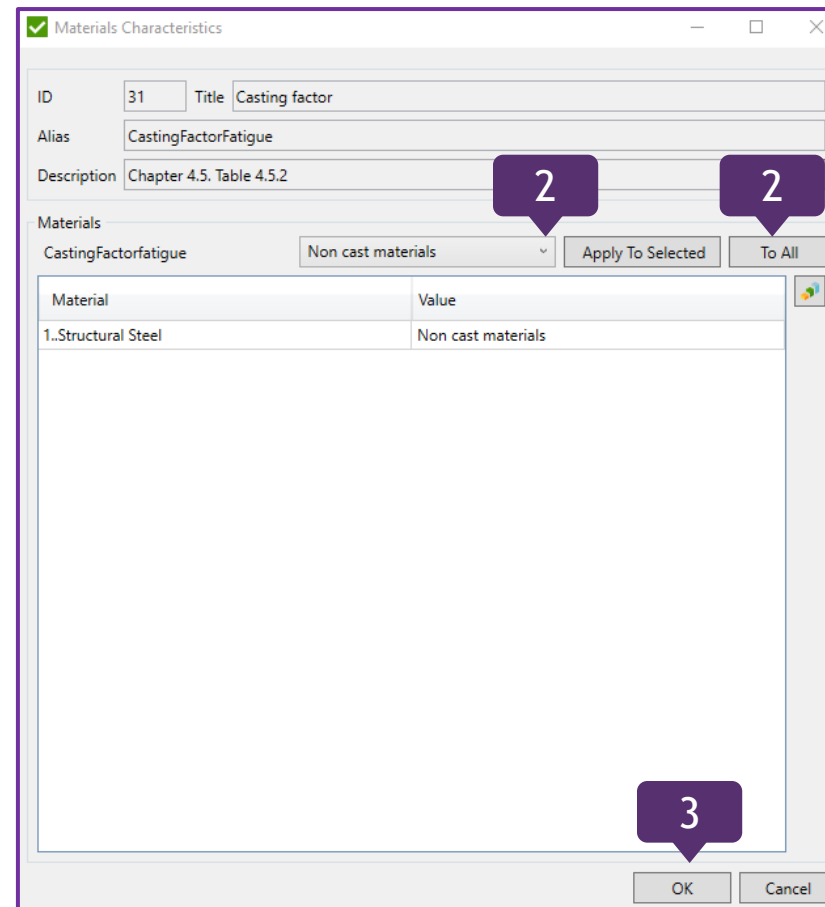
1 Press  in Casting Factor

2 Materials CastingFactorFatigue: *Non cast materials* and press *To All*

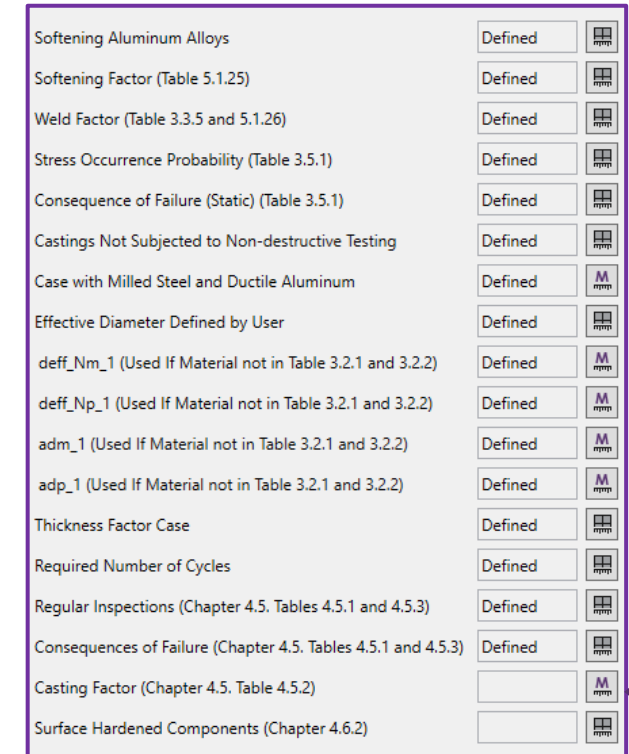
3 Press *OK*

Table 4.5.2 Casting factors j_G

	j_G
Castings not subject to non-destructive testing	1,4
Castings subject to non-destructive testing ✧1	1,25
High quality cast components ✧2	1,0



The dialog box 'Materials Characteristics' is shown. It has fields for ID (31), Title (Casting factor), Alias (CastingFactorFatigue), and Description (Chapter 4.5. Table 4.5.2). Under the 'Materials' section, 'CastingFactorFatigue' is selected, and 'Non cast materials' is chosen from the dropdown. There are 'Apply To Selected' and 'To All' buttons. A table below shows 'Material' and 'Value' with one entry: '1..Structural Steel' with value 'Non cast materials'. At the bottom are 'OK' and 'Cancel' buttons. Numbered callouts: 1 points to the 'Material' column header, 2 points to the 'Non cast materials' dropdown, and 3 points to the 'OK' button.



A list of material characteristics is shown, each with a status (Defined) and a material icon. The list includes: Softening Aluminum Alloys, Softening Factor (Table 5.1.25), Weld Factor (Table 3.3.5 and 5.1.26), Stress Occurrence Probability (Table 3.5.1), Consequence of Failure (Static) (Table 3.5.1), Castings Not Subjected to Non-destructive Testing, Case with Milled Steel and Ductile Aluminum, Effective Diameter Defined by User, deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2), deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2), adm_1 (Used If Material not in Table 3.2.1 and 3.2.2), adp_1 (Used If Material not in Table 3.2.1 and 3.2.2), Thickness Factor Case, Required Number of Cycles, Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3), Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3), Casting Factor (Chapter 4.5. Table 4.5.2), and Surface Hardened Components (Chapter 4.6.2). A numbered callout 1 points to the 'Casting Factor' entry.

Define Surface Hardened Components (Chapter 4.6.2)

1

Press  in Surface Hardened Components

2

Elemental Selections SH: *no*

3

Press **OK**

Special cases

The following applies to *non-ductile* wrought aluminum alloys (elongation at break $A < 6\%$):

$$q = 0,5$$

The following applies to *surface hardened* components (except for mechanical surface treatment):

$$q = 1$$

The following applies to *welded* components:

✓ Add Element Characteristic

ID: 32 Title: Surface hardened components

Alias: Surface_hardened_components

Description: Special cases of q value. Chapter 4.6.2



















Elemental Selections: SH: no

Selection	Value
All Entities	no

OK Cancel

2


3

Softening Aluminum Alloys	Defined	
Softening Factor (Table 5.1.25)	Defined	
Weld Factor (Table 3.3.5 and 5.1.26)	Defined	
Stress Occurrence Probability (Table 3.5.1)	Defined	
Consequence of Failure (Static) (Table 3.5.1)	Defined	
Castings Not Subjected to Non-destructive Testing	Defined	
Case with Milled Steel and Ductile Aluminum	Defined	
Effective Diameter Defined by User	Defined	
deff_Nm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
deff_Np_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
adm_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
adp_1 (Used If Material not in Table 3.2.1 and 3.2.2)	Defined	
Thickness Factor Case	Defined	
Required Number of Cycles	Defined	
Regular Inspections (Chapter 4.5. Tables 4.5.1 and 4.5.3)	Defined	
Consequences of Failure (Chapter 4.5. Tables 4.5.1 and 4.5.3)	Defined	
Casting Factor (Chapter 4.5. Table 4.5.2)	Defined	
Surface Hardened Components (Chapter 4.6.2)		

1

Create Extreme Table

1

Execute  *Table (expand/extreme)* in Standards => 4..Fatigue Summation context menu

2

Load: press  and select 1..Fatigue Check

3

Press OK

4

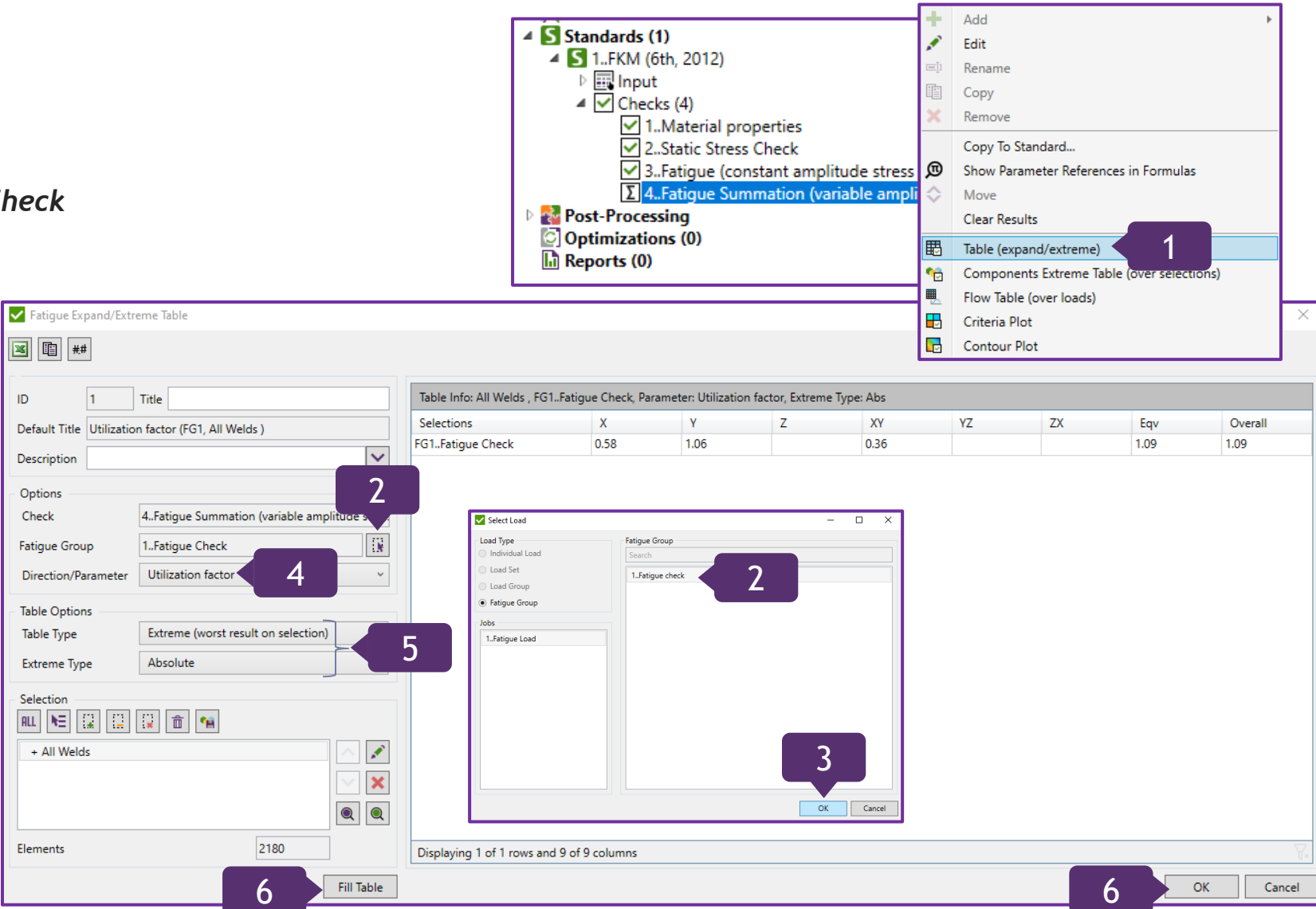
Direction/Parameter: Utilization factor

5

Table Type: *Extreme (worst results on selection)* and Extreme Type: *Absolute*

6

Press *Fill Table* and press OK



Standards (1)

- 1..FKM (6th, 2012)
 - Input
 - Checks (4)
 - 1..Material properties
 - 2..Static Stress Check
 - 3..Fatigue (constant amplitude stress)
 - 4..Fatigue Summation (variable amplitude)
 - Post-Processing
 - Optimizations (0)
 - Reports (0)

Table (expand/extreme)

- Components Extreme Table (over selections)
- Flow Table (over loads)
- Criteria Plot
- Contour Plot

Fatigue Expand/Extreme Table

ID: 1 Title: Utilization factor (FG1, All Welds)

Default Title: Utilization factor (FG1, All Welds)

Description:

Options

Check: 4..Fatigue Summation (variable amplitude)

Fatigue Group: 1..Fatigue Check

Direction/Parameter: Utilization factor

Table Options

Table Type: Extreme (worst result on selection)

Extreme Type: Absolute

Selection

+ All Welds

Elements: 2180

Fill Table

Table Info: All Welds , FG1..Fatigue Check, Parameter: Utilization factor, Extreme Type: Abs

Selections	X	Y	Z	XY	YZ	ZX	Eqv	Overall
FG1..Fatigue Check	0.58	1.06		0.36			1.09	1.09

Select Load

Load Type

- Individual Load
- Load Set
- Load Group
- Fatigue Group

Fatigue Group

1..Fatigue check

Jobs



1..Fatigue Load

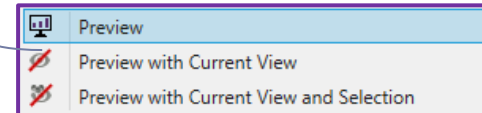
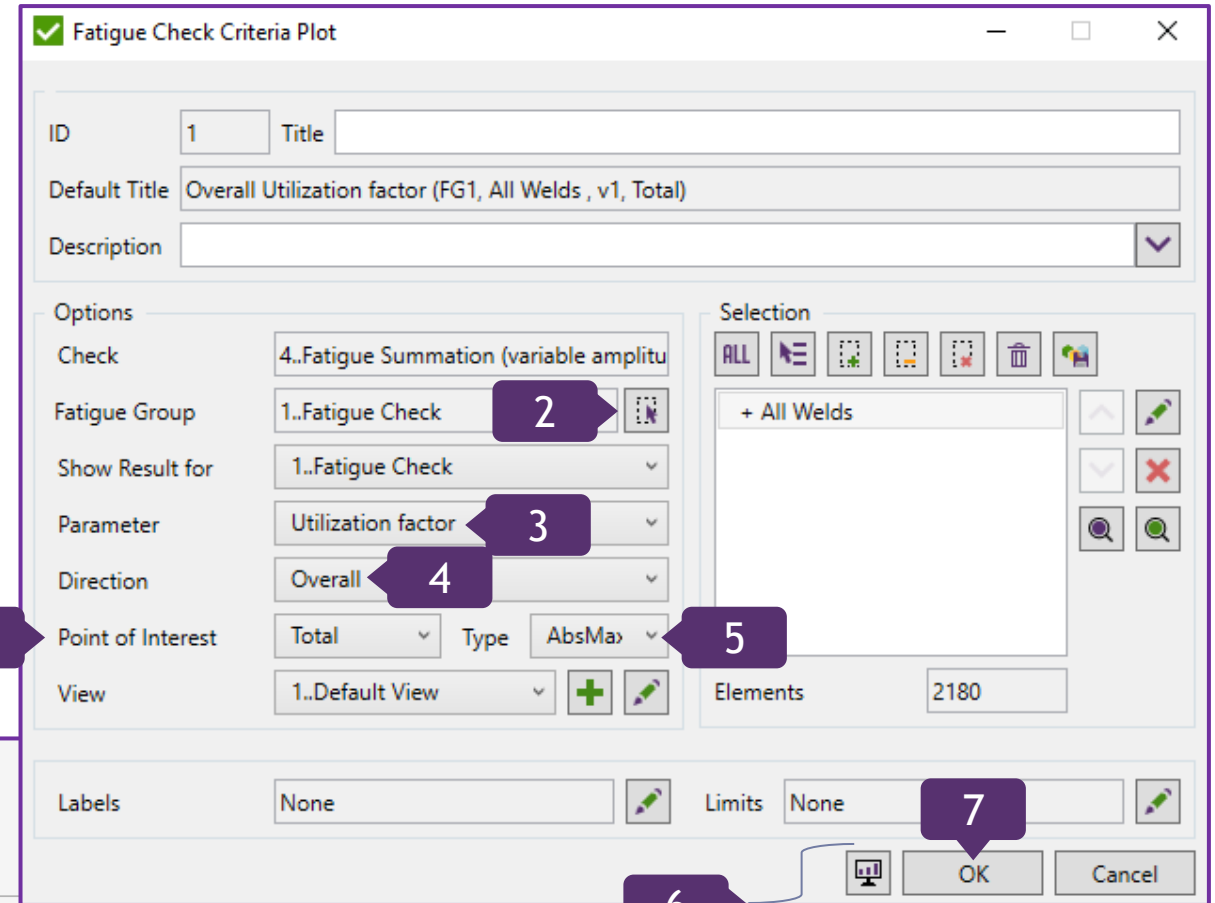
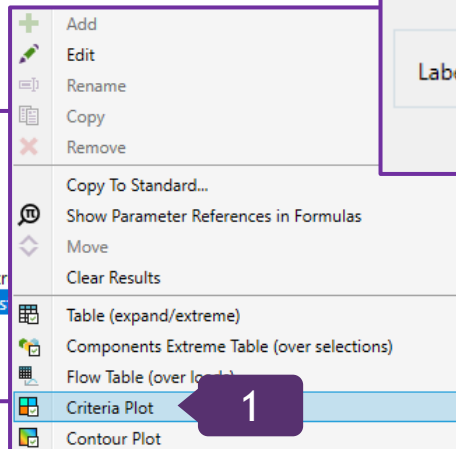
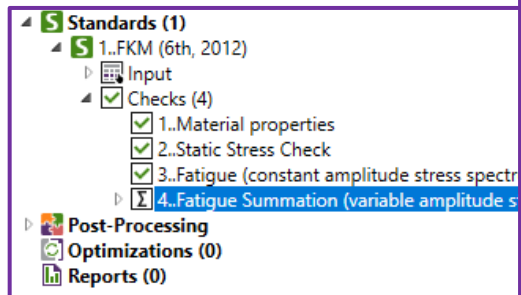
OK Cancel

Displaying 1 of 1 rows and 9 of 9 columns

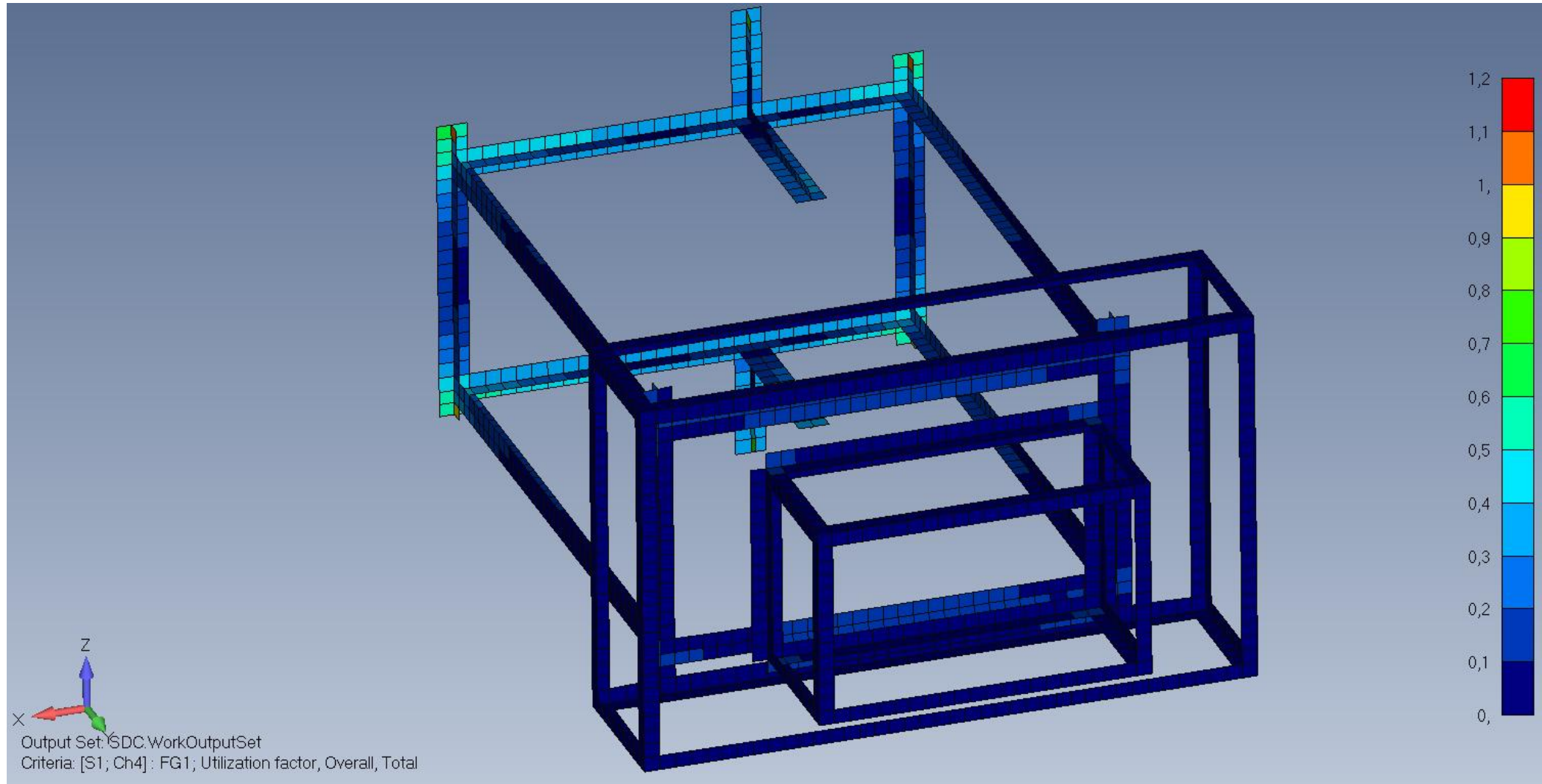
OK Cancel

Create Criteria Plot

- 1 Execute  **Criteria Plot** in Fatigue Summation context menu
- 2 Fatigue Group: *1..Fatigue Check*
- 3 Parameter: Utilization factor
- 4 Direction: *Overall*
- 5 Point of interest: Total; Type: *AbsMax*
- 6 Press  , and then *Preview*
- 7 Press **OK**



Point of interest = AbsMax Total is an absolute maximum of utilization factors among all point of interest.



To learn how to obtain reports, please check a separate Tutorial that depicts the functionality of SDC Verifier Report Designer. It may be downloaded via this link:

<https://sdcverifier.com/tutorials/report-designer/>