



Tutorial

Eurocode3 Weld (EN1993-1-8, 2005) Optimization. Weld Strength Rule

Updated on: May 16th, 2024

Tested with: SDC Verifier 2023 R2

Simcenter3D 2306

- This step-by-step tutorial demonstrates the functionality of SDC Verifier Optimization Tool, incorporating Weld Strength Rule;
- Model members are Optimized, based on Criteria Plot results;
- Shape Library Overview;
- Optimization Rules Overview;
- Optimization results in Tables and Plots;
- Results Comparison;
- Application of new weld part sizes in Weld Finder Tool
- Calculation of Selection of Grouped Variables
- Complete information on Optimization Tool may be found on our website via this link: [Optimization Tool | Help | SDC for Simcenter 3D \(sdcverifier.com\)](https://sdcverifier.com)

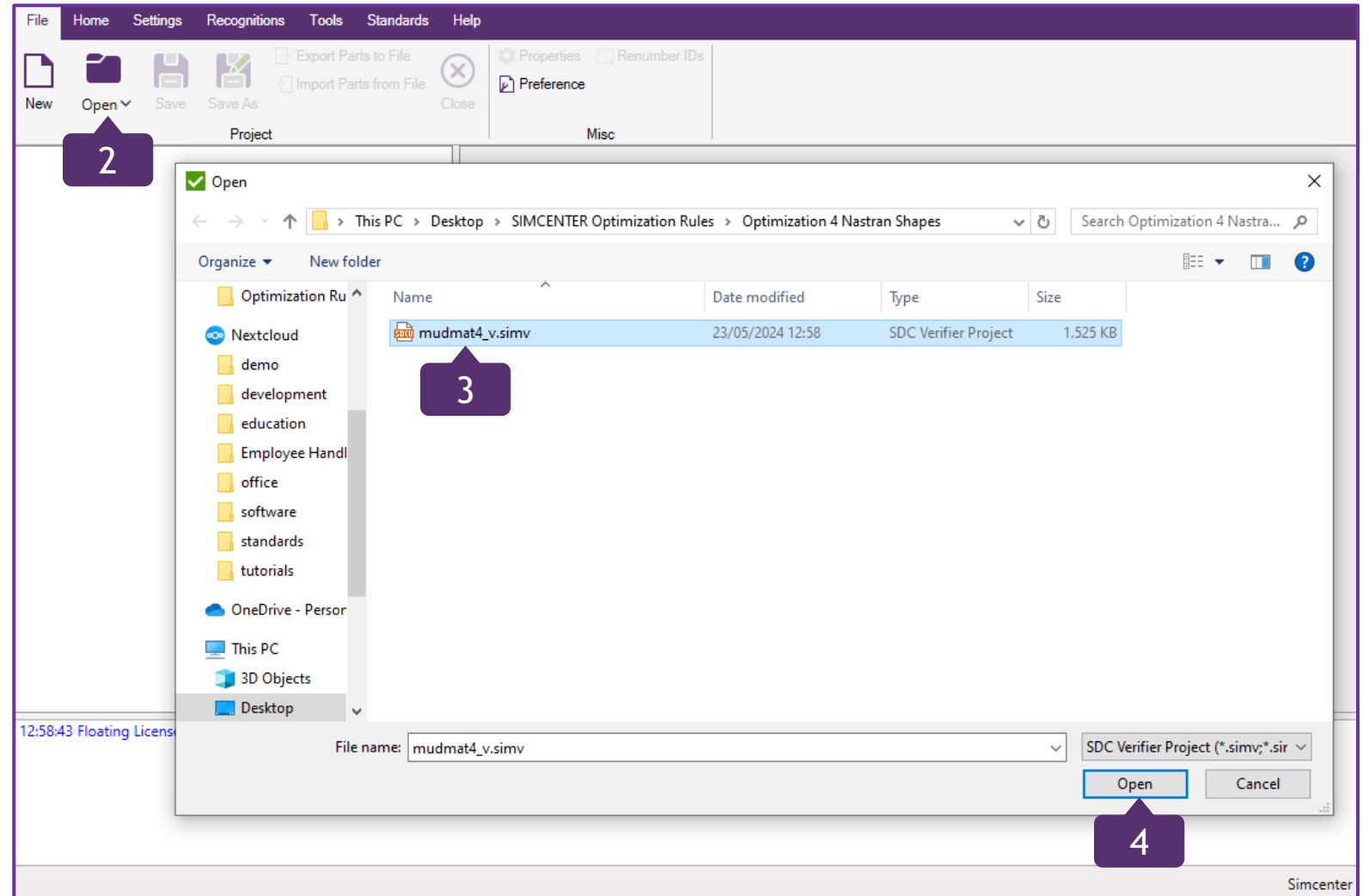
Open the Starter Model

1 Launch SDC Verifier for Simcenter 3D

2 In *File* section, press *Open*

3 Select a project *mudmat4_v.simv*

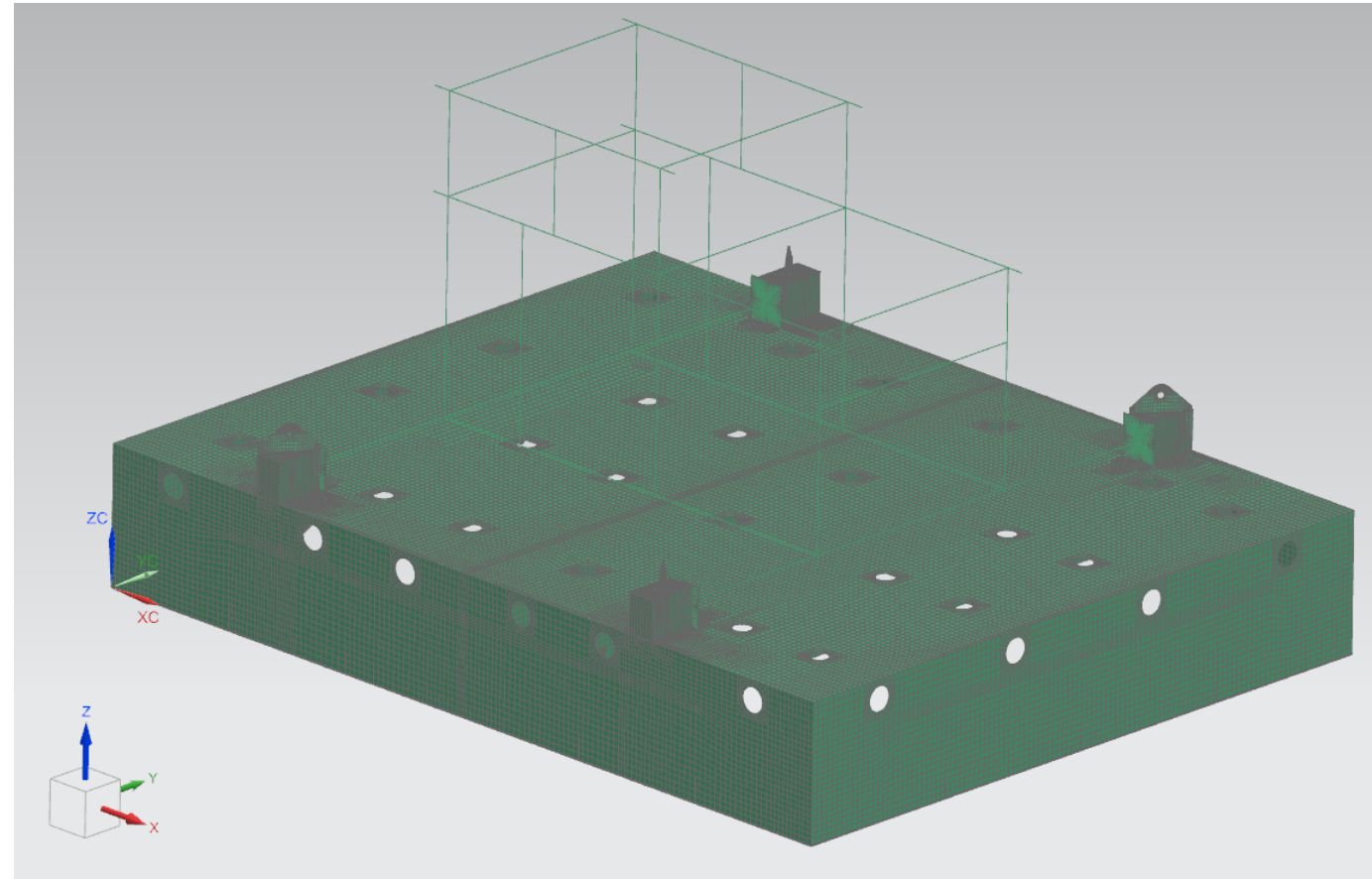
4 Press *Open*



This tutorial uses a Project with predefined Individual Loads, Load Sets and Load Groups.

The model contains Plate, Beam elements and Welds. Also, a relevant Standard has been previously added.

- ▶ Views (1)
- ▶ Model
- ▶ Recognition
- ▶ Jobs (1)
 - ▶ 1..Job 1
 - ▶ Individual Loads (9)
 - ▶ Predefined Load Cases (0)
 - ▶ Load Sets (28)
 - ▶ Load Groups (5)
 - ▶ FG Fatigue Groups (0)
 - ▶ Tables (0)
 - ▶ Plots (0)
- ▶ Tools
- ▶ Standards (1)
 - ▶ 1..Eurocode3 Weld (EN1993-1-8, 2005)
- ▶ Post-Processing
- ▶ Optimizations (0)
- ▶ Reports (0)



A separate Tutorial with detailed instructions on how to add, define and edit the Standard, can be found via this link:
<https://sdcverifier.com/tutorials/weld-strength-check/>

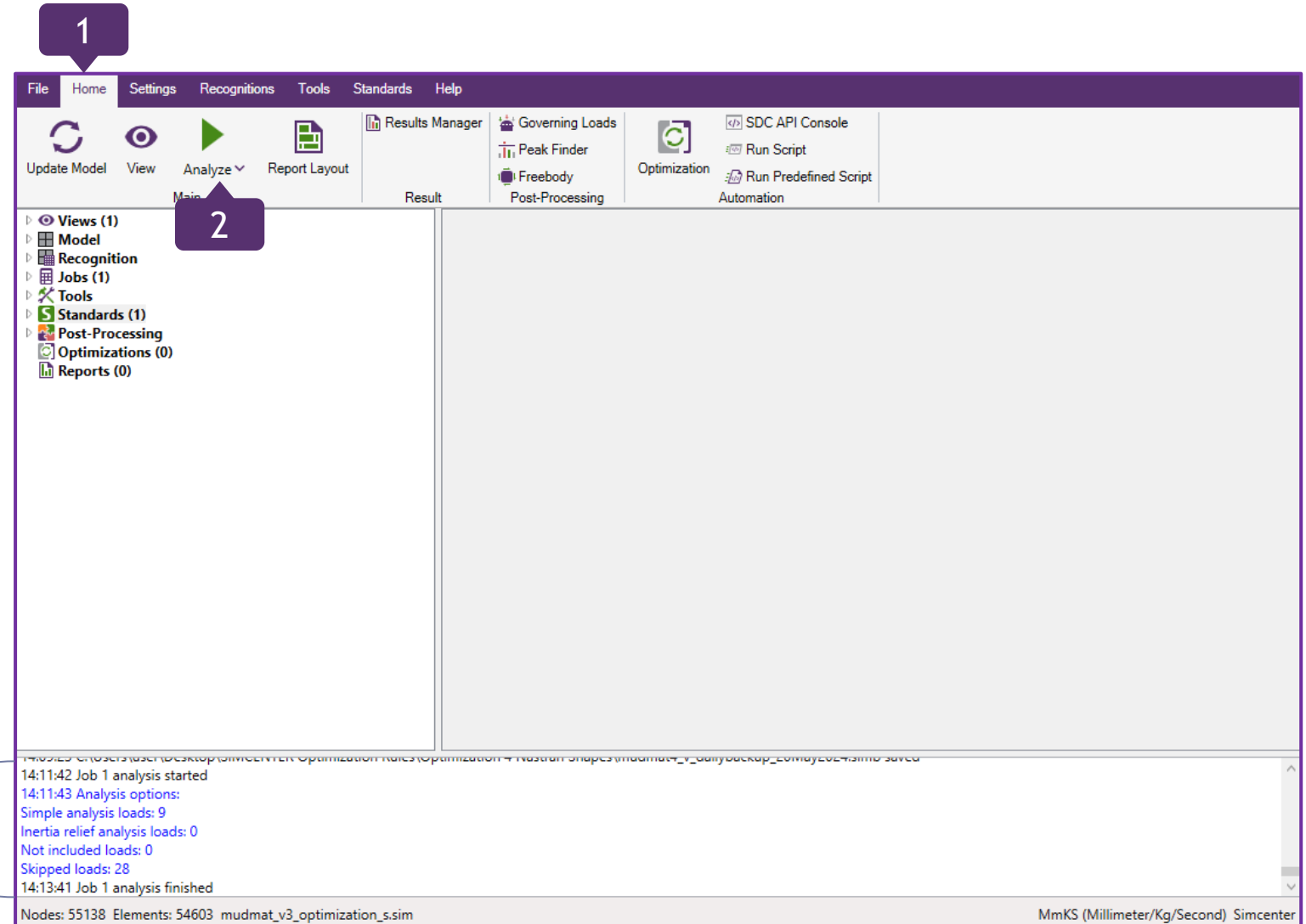
Run Analysis

1

Go to *Home* section on the Ribbon

2

Press  on the toolbar to analyze Job



Job 1 analysis started and finished.

Eurocode3 Weld (EN1993-1-8,2005) Criteria Plot

1

Expand Standards => 3..Eurocode3 Weld (EN1993-1-8, 2005) => Checks (15) and select 15..Weld Check Total

2

Execute right click on 15..Weld Check Total and select Criteria Plot

3

Press  to select Load Group

4

In Load Type, select Load Group, and then 5..Operations All; Press OK

5

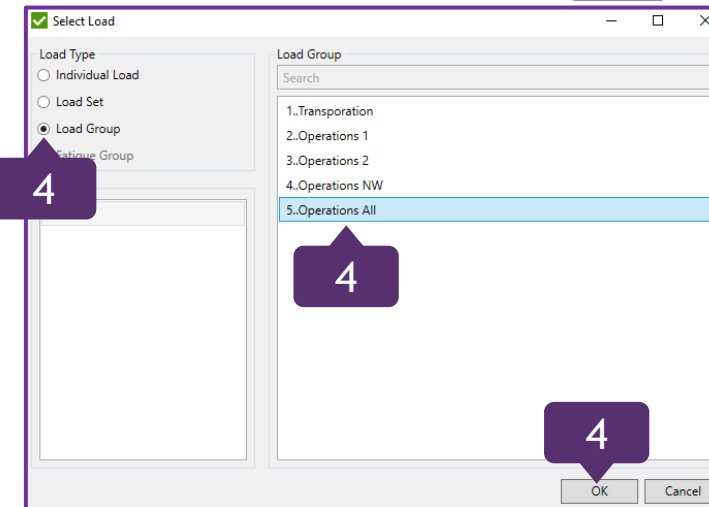
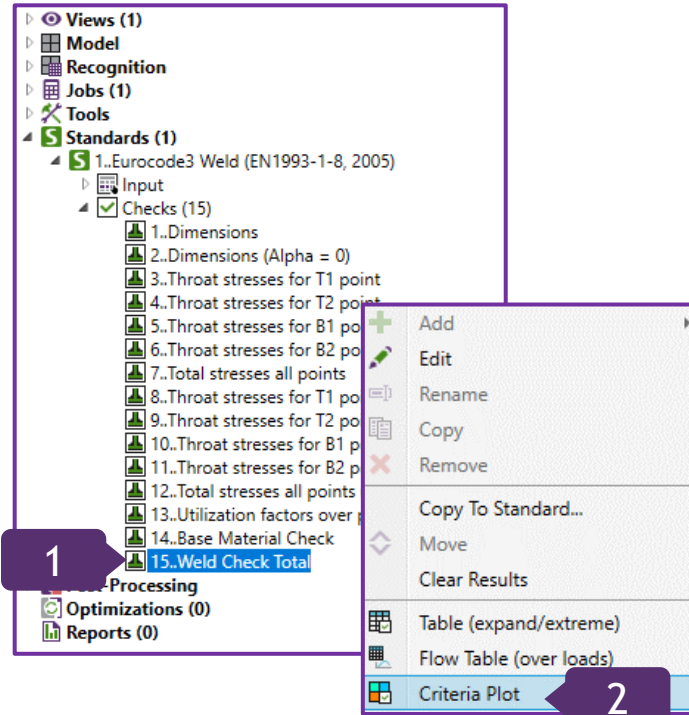
Parameter: *Uf Overall*;
Direction: *All*

6

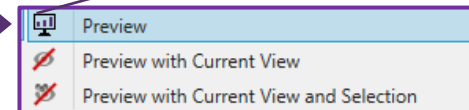
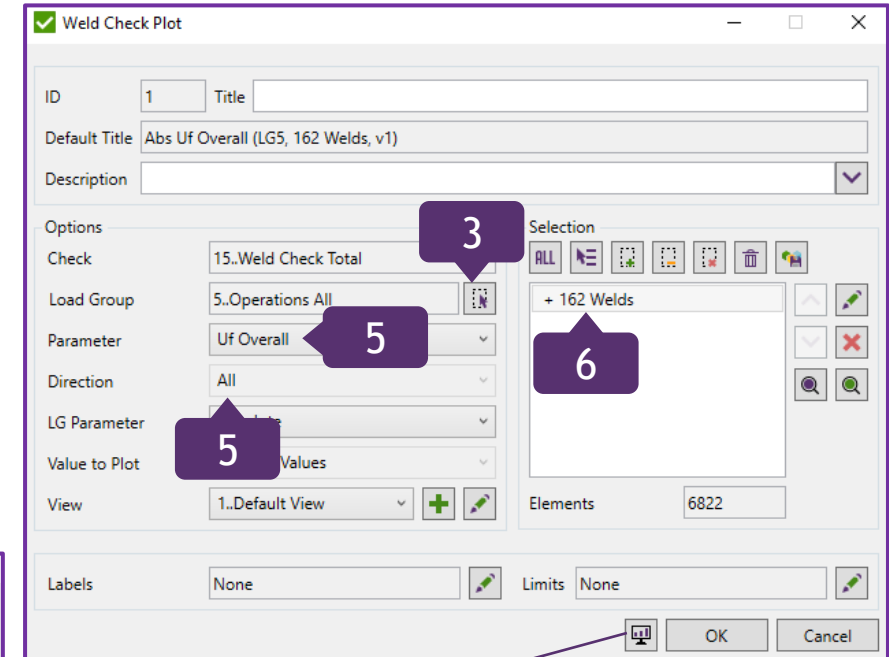
Selection: + 162 Welds

7

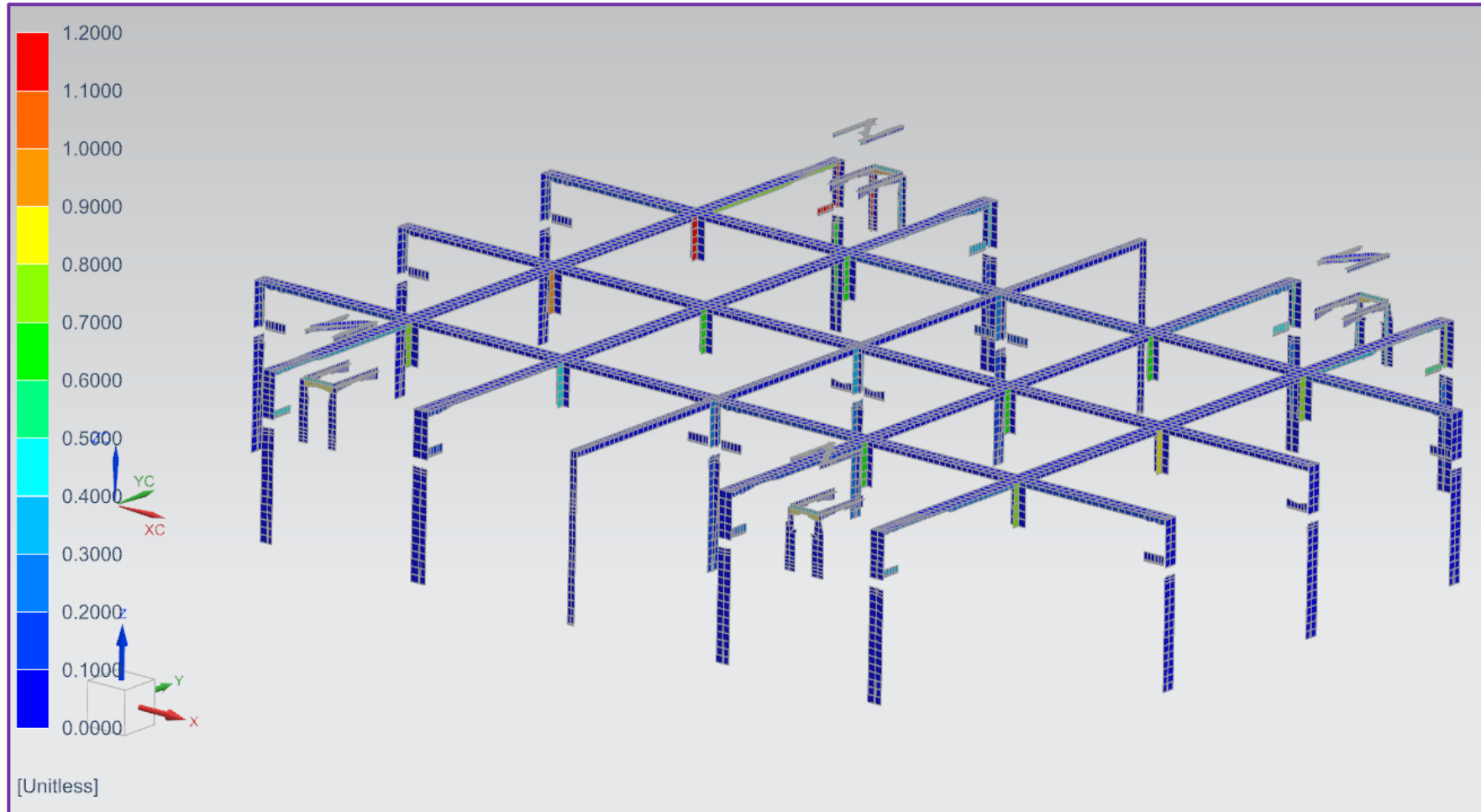
Press  and then *Preview*



The purpose of creating Criteria Plot is to preview the results of Eurocode3 Fatigue Check and pick the members for Optimization.



The Plot has been created to see the Overall Summed Damage on full model.
It is displayed in Simcenter 3D window.



Set Limits for Criteria Plot (Additional Functionality)

In order to single out the segments with high Utilization Factor, excluding the rest of the elements, Limits function serves for that purpose. The settings of Check Criteria Plot from Slide 6 should remain the same.

1

In Limits, press



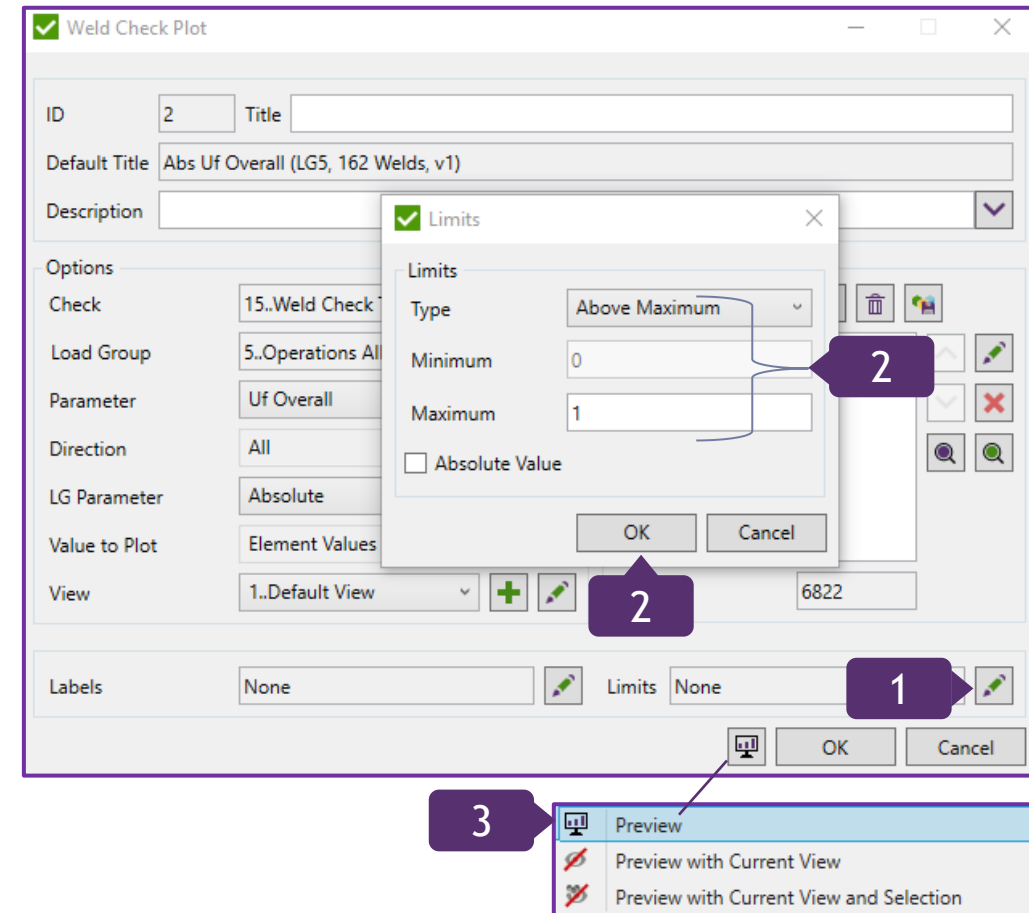
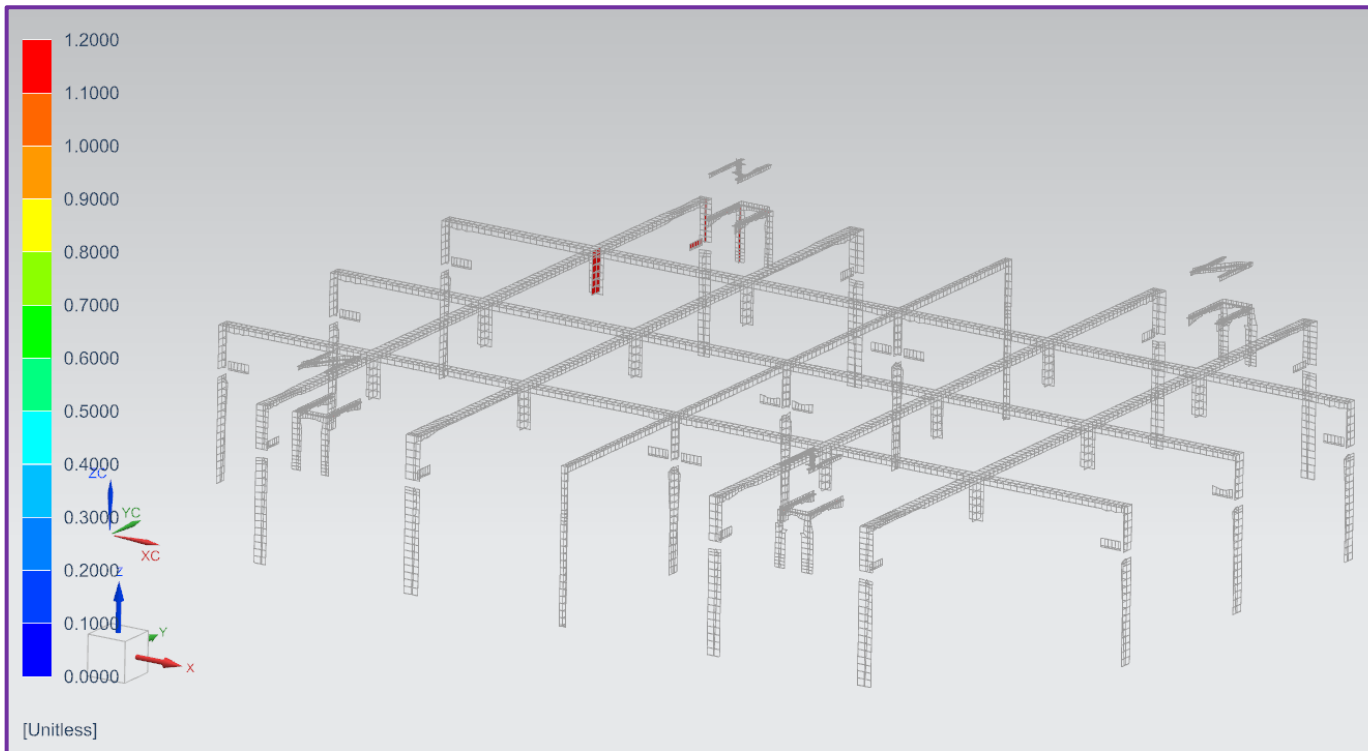
2

Type: *Above Maximum*;
Maximum: 1;
Press *OK*

3

Press  and then *Preview*

The Result



1

Select + 162 Welds and press  to remove them

2

Press  to add Condition;
Select *Components*

3

Select 2..Welds for Optimization;
Press OK

4

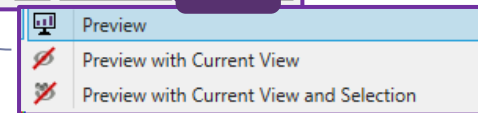
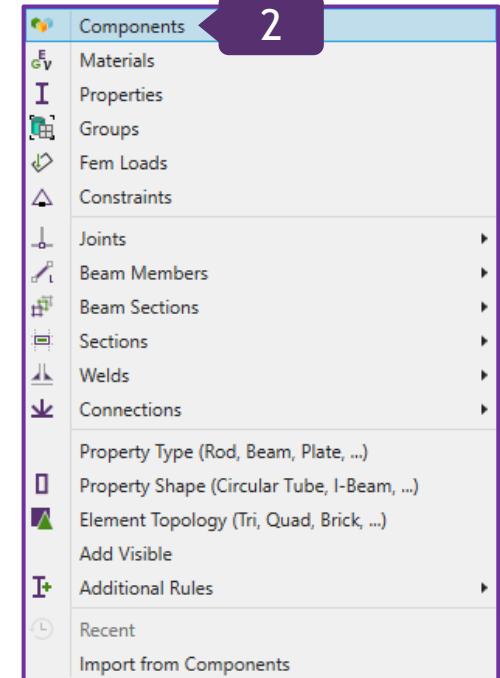
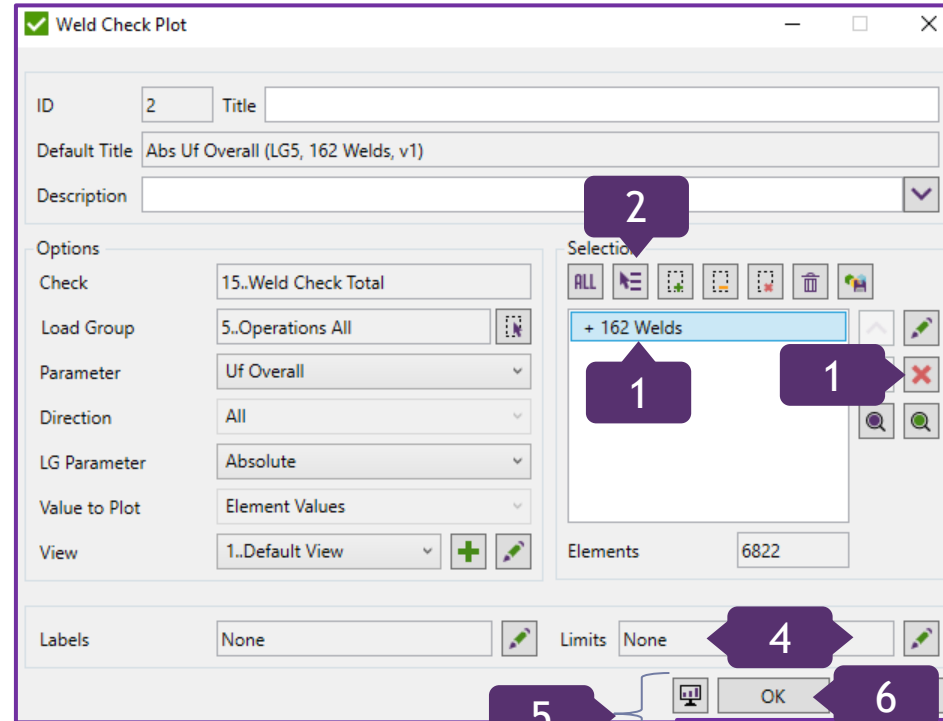
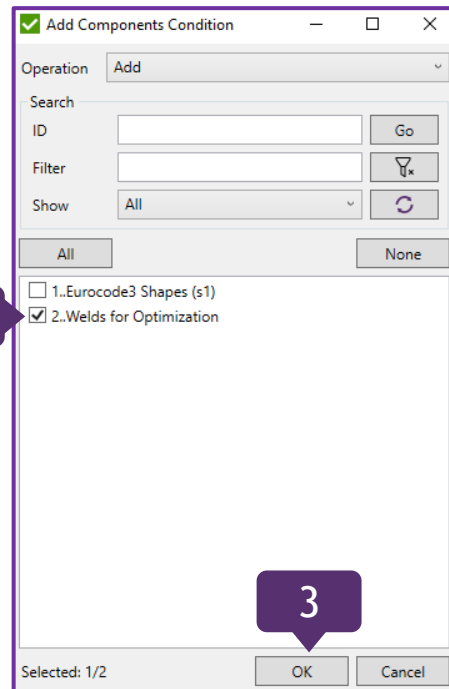
Limits: *None*

5

Press  and
then *Preview*

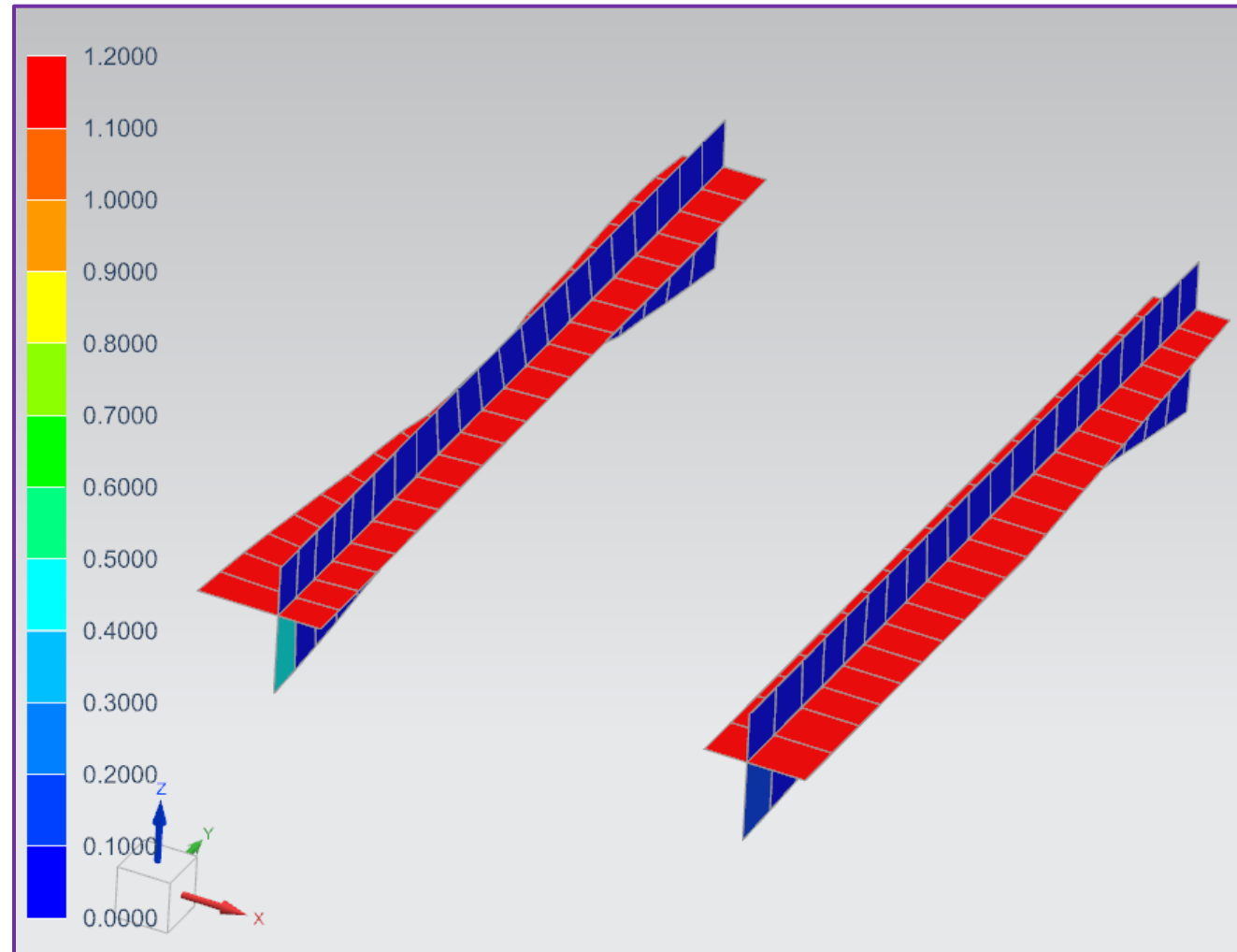
6

Press OK



The members of Components have UF Overall value above 1. An Optimization Rule for these members will be created.

The Plot has been created to see the Summed Damage Overall for one Property.



Optimization Tool allows to take the best design decision for the structure by calculating different combinations of design input.

Optimization Rule consists of a set of conditions that represent the part of the model, the type of optimization and the referring parameters (usually, Utilization Factors) of design standards to be optimized.

The following types of the rules can be created:

Beam Rule - beam/bar element cross section, yield stress and young modulus can be optimized;


Plate Element Rule - plate/shell element thickness, yield stress and young modulus can be optimized;

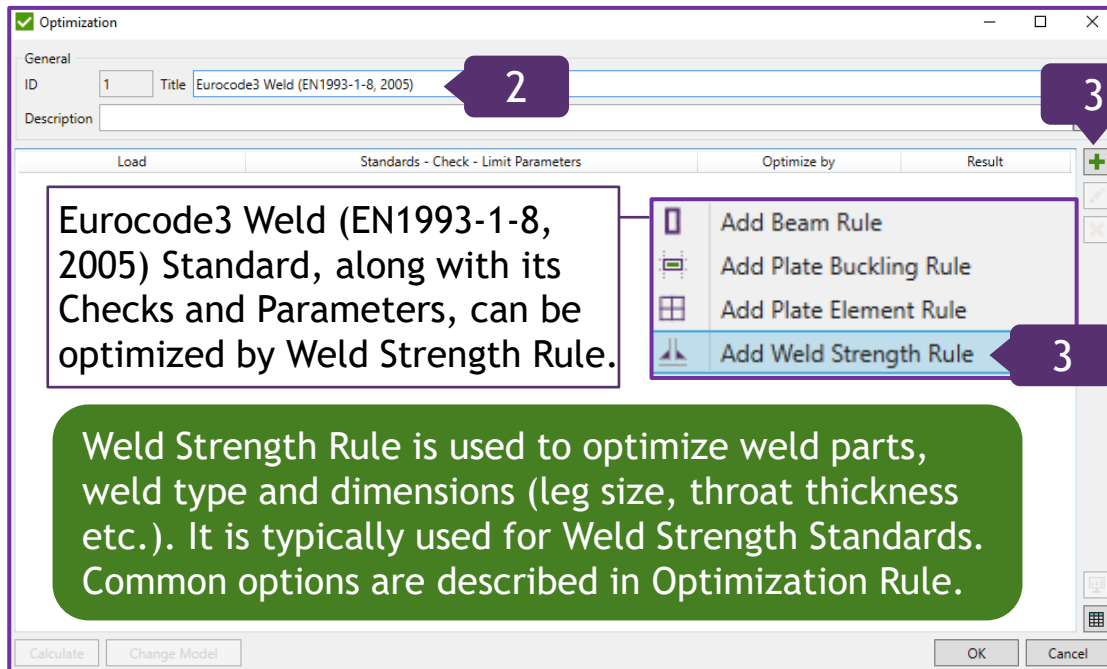
Plate Buckling Rule - plate buckling plate thickness, yield stress and young modulus can be optimized;

Weld Strength Rule - weld type and dimensions (leg sizes, throat thickness etc.) can be optimized.

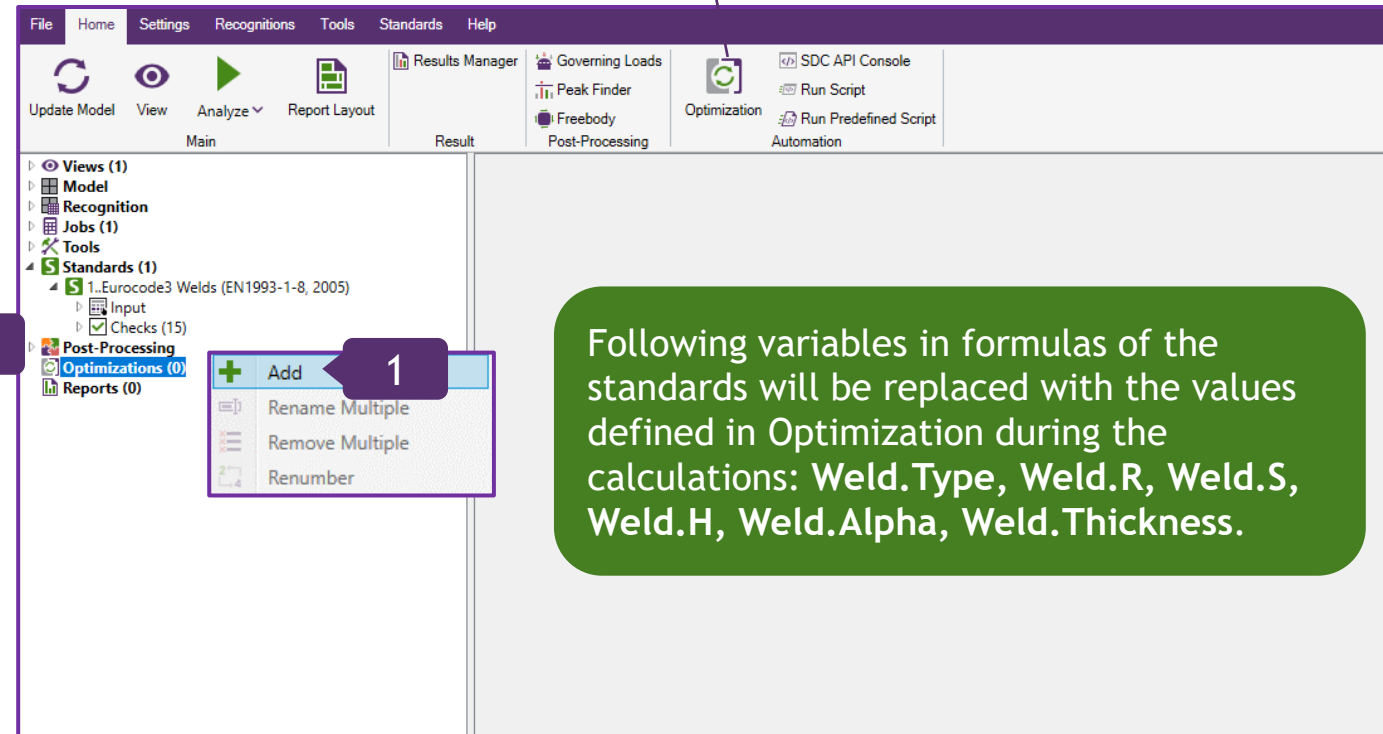
Note: Only one Rule of each type can be created within one optimization tool. Plate Element and Plate Buckling Rules cannot be created within one Optimization Tool.

Create Optimization Rule

- 1 In the Model Tree, execute right click on *Optimizations* and select *Add*
- 2 Title: *Eurocode3 Weld (EN1993-1-8, 2005)*
- 3 Press  to create first *Optimization Rule*; Select *Add Weld Strength Rule*



An alternative method of using Optimization Tool is placed in Home section of the Ribbon.

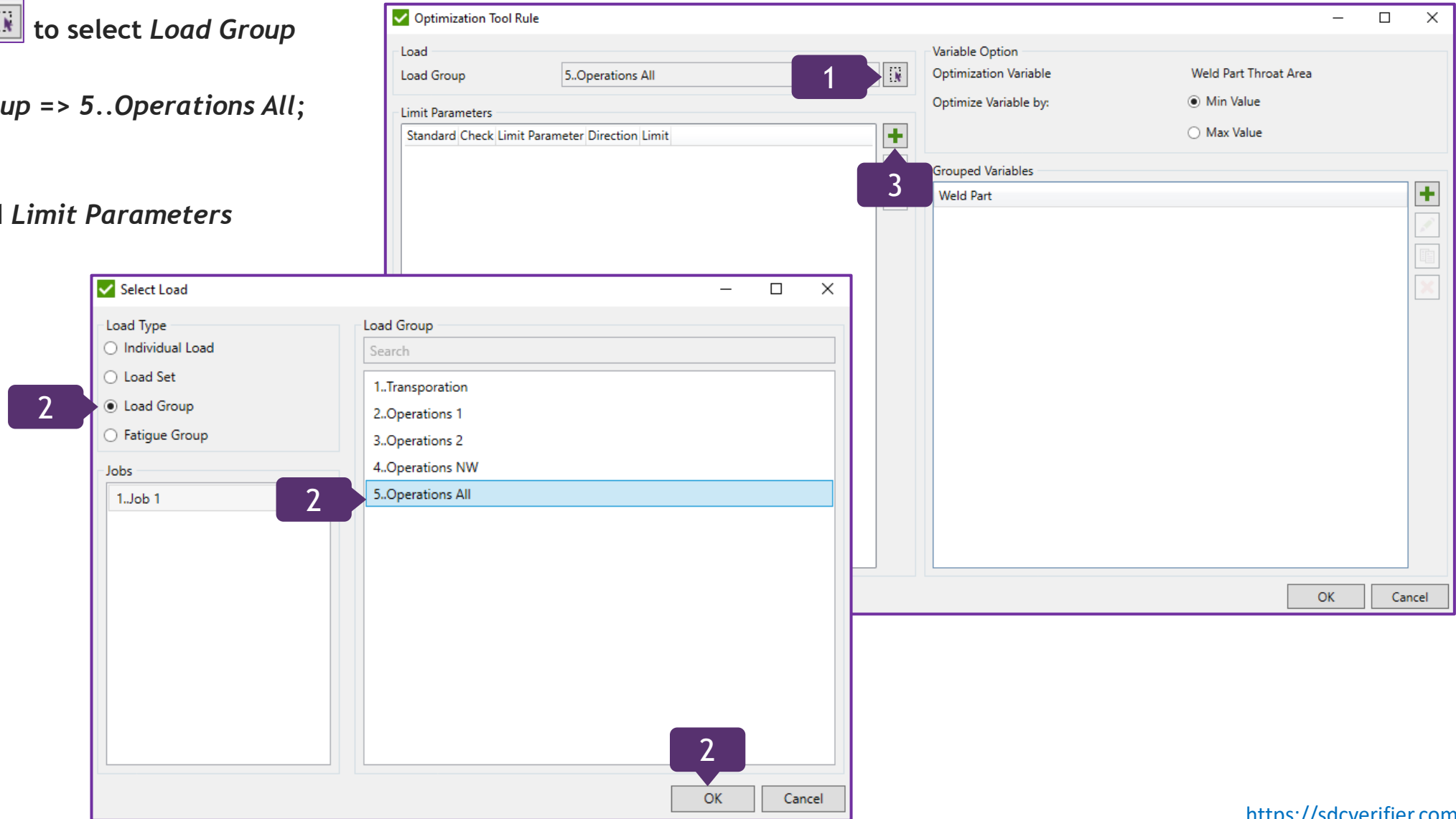


Note: If there are multiple Standards, calculated in the SDC Verifier Project, all of them will be listed in Select Limit Parameters.

1 In Load, press  to select *Load Group*

2 Select *Load Group* => *5..Operations All*;
Press *OK*

3 Press  to add *Limit Parameters*



Optimization Tool Rule. DNV Buckling Strength (Continuation)

4

Standard: *Eurocode3 Weld (EN1993-1-8, 2005)*;
Check: *15..Weld Check Total*;
Parameter: *4..Uf Overall*

5

Direction: *All*

6

In Limit, press 

7

Type: *Between*;
Minimum: *0* and Maximum: *1*;

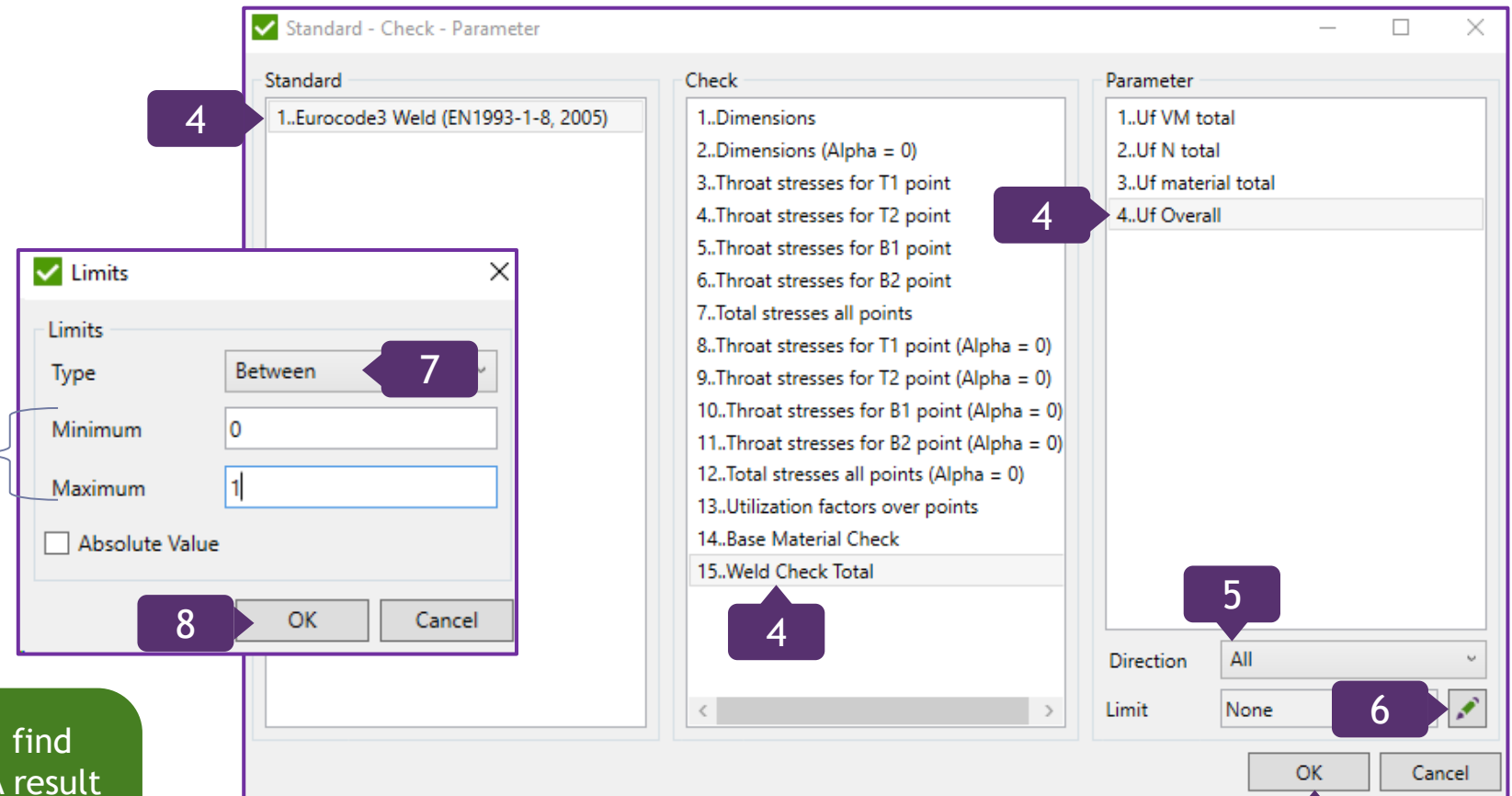
8

Press *OK*

9

Press *OK*

Note: Only checks that fit the type of the rule (beam, plate buckling etc.) will be displayed in the list.



Limits are used to filter results and find the best matching optimal result. A result that passes the limits and matches the variable type (e.g. Min Cross Section Area) will be chosen as an optimal result.

Note: If the parameter had already been added, it will not be shown in the list when adding other parameters.

Add Multiple Item Part 1

1 Optimization Variable: Weld Part Throat Area;
Optimize Variable by: *Min Value* is ON

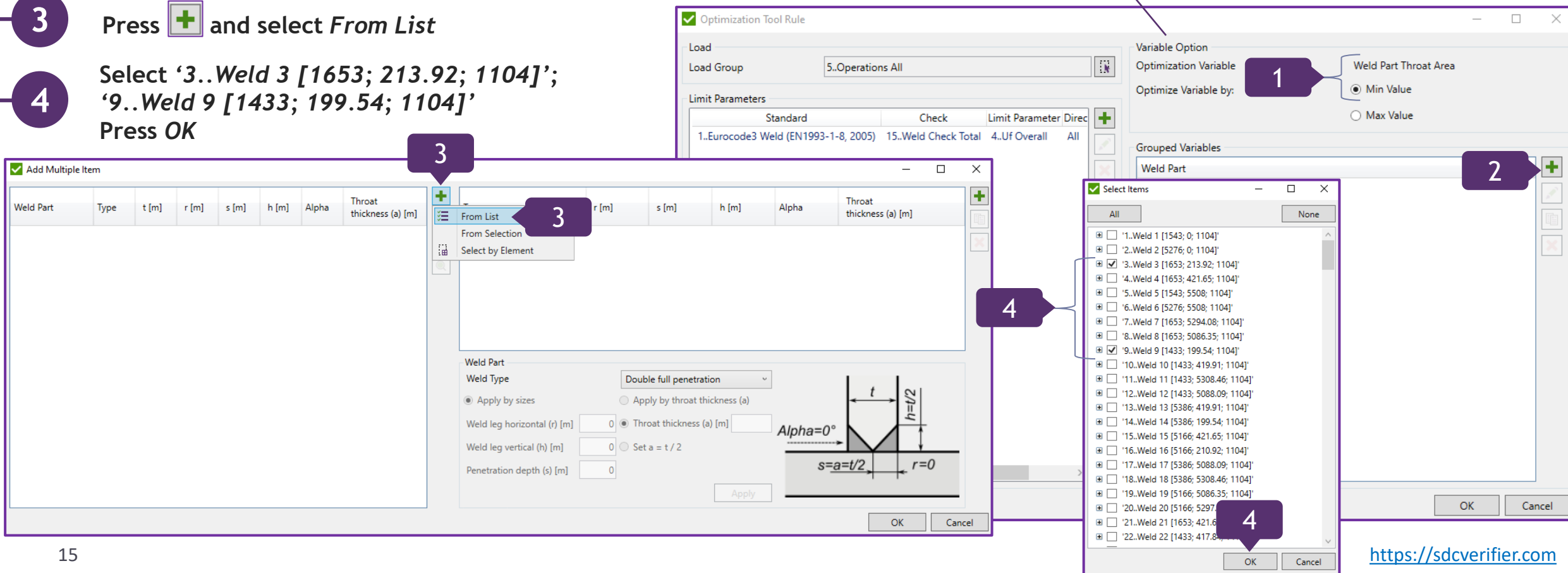
2 Press  to add multiple grouped variables

3 Press  and select *From List*

4 Select '3..Weld 3 [1653; 213.92; 1104]';
'9..Weld 9 [1433; 199.54; 1104]'
Press OK

Optimization Variable - Weld Part Throat Area is used to determine the optimal result;

Optimize Variable by - find an optimal result based the on min/max value of the weld part throat. For example to optimize the weld according to the lowest material usage - select Min Value.



15

<https://sdcverifier.com>

Add Multiple Item Part 2

1

Weld Type: *Double partial penetration*

2

Weld leg horizontal (r) [mm]: 0.75;
Weld leg vertical (h) [mm]: 0.75;
Penetration depth (s) [mm]: 0.75

3

Press  to add new weld part data to the list

4

Apply sizes for the rest of weld types, as defined on pictures 1, 2, 3; carry this out in sequence

5

Press *OK*

4

Weld Part

Weld Type 2 Double partial penetration

☒ Apply by sizes ☐ Apply by throat thickness (a)

Weld leg horizontal (r) [mm] 1.25 ☒ Throat thickness (a) [mm]

Weld leg vertical (h) [mm] 1.25 ☐ Set $a = t / 2$

Penetration depth (s) [mm] 0.75

4

Weld Part

Weld Type 3 Double partial penetration

☒ Apply by sizes ☐ Apply by throat thickness (a)

Weld leg horizontal (r) [mm] 3 ☒ Throat thickness (a) [mm]

Weld leg vertical (h) [mm] 3 ☐ Set $a = t / 2$

Penetration depth (s) [mm] 1

It is required to press  each time new weld data is added to the list.

✓ Add Multiple Item

Weld Part	Type	t [mm]	r [mm]	s [mm]	h [mm]	Alpha	Throat thickness (a) [mm]
1..Weld Part 3.1 [16]	Double fi. 2	0	1	1	0	1	
2..Weld Part 3.2 [16]	Double fi. 2	0	1	1	0	1	
1..Weld Part 9.1 [14]	Double fi. 2	0	1	1	0	1	
2..Weld Part 9.2 [14]	Double fi. 2	0	1	1	0	1	

Weld Part

Weld Type 1 Double partial penetration

☒ Apply by sizes ☐ Apply by throat thickness (a)

Weld leg horizontal (r) [mm] 1 ☒ Throat thickness (a) [mm]

Weld leg vertical (h) [mm] 1 ☐ Set $a = t / 2$

Penetration depth (s) [mm] 0.75

Weld Part

Weld Type Double partial penetration

☒ Apply by sizes ☐ Apply by throat thickness (a)

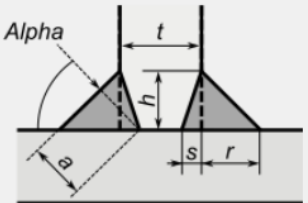
Weld leg horizontal (r) [mm] 0.75 ☒ Throat thickness (a) [mm]

Weld leg vertical (h) [mm] 0.75 ☐ Set $a = t / 2$

Penetration depth (s) [mm] 0.75

Apply

OK Cancel



✓ Add Multiple Item

Weld Part	Type	t [mm]	r [mm]	s [mm]	h [mm]	Alpha	Throat thickness (a) [mm]
1..Weld Part 3.1 [16]	Double fi. 2	0	1	1	0	1	
2..Weld Part 3.2 [16]	Double fi. 2	0	1	1	0	1	
1..Weld Part 9.1 [14]	Double fi. 2	0	1	1	0	1	
2..Weld Part 9.2 [14]	Double fi. 2	0	1	1	0	1	
	Double partial penetration	0.75	0.75	0.75	45		1.06066
	Double partial penetration	1	0.75	1	45		1.23744
	Double partial penetration	1.25	0.75	1.25	45		1.41421
	Double partial penetration	3	1	3	45		2.82843

Weld Part

Weld Type Double partial penetration

☒ Apply by sizes ☐ Apply by throat thickness (a)

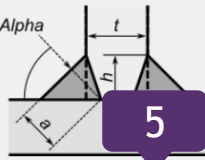
Weld leg horizontal (r) [mm] 3 ☒ Throat thickness (a) [mm]

Weld leg vertical (h) [mm] 3 ☐ Set $a = t / 2$

Penetration depth (s) [mm] 1

Apply

OK Cancel



Total list of types, that will be calculated.

Selection of Grouped Variables; Calculation

1 Press OK

2 Activate the section

3 Press *Calculate* to run the Optimization

4 Press OK

The image shows two windows from the SDC Verifier software. The 'Optimization Tool Rule' window is in the background, and the 'Optimization' window is in the foreground. The 'Optimization' window has a 'General' tab with fields for ID (1), Title (Eurocode3 Weld (EN1993-1-8, 2005)), and Description. Below this is a table with columns: Load, Standards - Check - Limit Parameters, Optimize by, and Result. The table contains one row: LG5..Operations All, 1..Eurocode3 Weld (EN1993-1-8, 2005) 15..Weld Check Total - 4..Uf Overall, Limit: [0;1], Min Weld Part Throat Area. A callout '2' points to the 'Standards - Check - Limit Parameters' column. Below the table is a 'Calculate' button (callout '3') and a 'Change Model' button. An 'OK' button is at the bottom right. A small 'SDC Verifier' dialog box is open in the center, showing '1 of 1 rules have result' and an 'OK' button (callout '4'). The 'Optimization Tool Rule' window in the background has a 'Load' section with 'Load Group' set to '5..Operations All'. It has a 'Limit Parameters' table with columns: Standard, Check, Limit Parameter, and Dire. The table contains one row: 1..Eurocode3 Welds (EN1993-1-8, 2005), 15..Weld Check Total, 4..Uf Overall, All. To the right of this window is a 'Variable Option' section with 'Optimization Variable' set to 'Weld Part Throat Area' and 'Optimize Variable by' set to 'Min Value'. Below this is a 'Grouped Variables' section with a list of variables. A callout '1' points to the 'OK' button at the bottom right of this section. A text box at the bottom right says 'Grouped Variables that are calculated.'

Optimization Tool Rule

Load

Load Group: 5..Operations All

Limit Parameters

Standard	Check	Limit Parameter	Dire
1..Eurocode3 Welds (EN1993-1-8, 2005)	15..Weld Check Total	4..Uf Overall	All

Variable Option

Optimization Variable: Weld Part Throat Area

Optimize Variable by: ☒ Min Value ☐ Max Value

Grouped Variables

Weld Part

- 1..Weld Part 3.1 [1660.5; 213.92; 1104]
 - Double partial penetration; Throat Thickness (a)=1.06; Alpha=45.00; r=0.75; s=0.7
 - Double partial penetration; Throat Thickness (a)=1.24; Alpha=45.00; r=1.00; s=0.7
 - Double partial penetration; Throat Thickness (a)=1.41; Alpha=45.00; r=1.25; s=0.7
 - Double partial penetration; Throat Thickness (a)=2.83; Alpha=45.00; r=3.00; s=1.0
- 2..Weld Part 3.2 [1645.5; 213.92; 1104]
 - Double partial penetration; Throat Thickness (a)=1.06; Alpha=45.00; r=0.75; s=0.7
 - Double partial penetration; Throat Thickness (a)=1.24; Alpha=45.00; r=1.00; s=0.7
 - Double partial penetration; Throat Thickness (a)=1.41; Alpha=45.00; r=1.25; s=0.7
 - Double partial penetration; Throat Thickness (a)=2.83; Alpha=45.00; r=3.00; s=1.0
- 1..Weld Part 9.1 [1440.5; 199.54; 1104]
 - Double partial penetration; Throat Thickness (a)=1.06; Alpha=45.00; r=0.75; s=0.7
 - Double partial penetration; Throat Thickness (a)=1.24; Alpha=45.00; r=1.00; s=0.7
 - Double partial penetration; Throat Thickness (a)=1.41; Alpha=45.00; r=1.25; s=0.7
 - Double partial penetration; Throat Thickness (a)=2.83; Alpha=45.00; r=3.00; s=1.0
- 2..Weld Part 9.2 [1425.5; 199.54; 1104]
 - Double partial penetration; Throat Thickness (a)=1.06; Alpha=45.00; r=0.75; s=0.7
 - Double partial penetration; Throat Thickness (a)=1.24; Alpha=45.00; r=1.00; s=0.7
 - Double partial penetration; Throat Thickness (a)=1.41; Alpha=45.00; r=1.25; s=0.7

OK Cancel

Optimization

General

ID: 1 Title: Eurocode3 Weld (EN1993-1-8, 2005)

Description:

Load	Standards - Check - Limit Parameters	Optimize by	Result
LG5..Operations All	1..Eurocode3 Weld (EN1993-1-8, 2005) 15..Weld Check Total - 4..Uf Overall, Limit: [0;1]	Min Weld Part Throat Area	

2

SDC Verifier

1 of 1 rules have result

OK

4

3

Calculate Change Model OK Cancel

1

Grouped Variables that are calculated.

Optimization Results in a Table

1 Activate the section

2 Press  and select *All Results*;
Press *Close*

3 Press  and select *Optimal Result*;
Press *Close*

Result Table

Group	Weld Part (a, r, s, h in [mm])	1..Eurocode3 Welds (EN1993-1-8, 2005) 15..Weld Check Total 4..Uf Overall
'1..Weld Part 3.1 [1660.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=2.83	0.63
'2..Weld Part 3.2 [1645.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=1.41	0.94
'1..Weld Part 9.1 [1440.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=1.06	0.95
'2..Weld Part 9.2 [1425.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=2.83	0.53

This is the Optimal Result (the smallest Uf Overall), which will be used for changes.

3 Close

Optimization

General

ID 1 Title Eurocode3 Weld (EN1993-1-8, 2005)

Description

Load	Standards - Check - Limit Parameters	Optimize by	Result
LG5..Operations All	1..Eurocode3 Weld (EN1993-1-8, 2005) 15..Weld Check Total - 4..Uf Overall, Limit: [0;1]	Min Weld Part Throat Area	Calculated

1

Result Table

The results for all variables.

Group	Weld Part (a, r, s, h in [mm])	1..Eurocode3 Welds (EN1993-1-8, 2005) 15..Weld Check Total 4..Uf Overall
'1..Weld Part 3.1 [1660.5; 213.92; 1104]'	Original Model (Double full penetration; alpha=	2.51
'1..Weld Part 3.1 [1660.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=1.0	1.70
'1..Weld Part 3.1 [1660.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=1.2	1.46
'1..Weld Part 3.1 [1660.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=1.4	1.27
'1..Weld Part 3.1 [1660.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=2.8	0.63
'2..Weld Part 3.2 [1645.5; 213.92; 1104]'	Original Model (Double full penetration; alpha=	1.90
'2..Weld Part 3.2 [1645.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=1.0	1.26
'2..Weld Part 3.2 [1645.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=1.2	1.08
'2..Weld Part 3.2 [1645.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=1.4	0.94
'2..Weld Part 3.2 [1645.5; 213.92; 1104]'	Double partial penetration; alpha=45.00; a=2.8	0.46
'1..Weld Part 9.1 [1440.5; 199.54; 1104]'	Original Model (Double full penetration; alpha=	1.48
'1..Weld Part 9.1 [1440.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=1.0	0.95
'1..Weld Part 9.1 [1440.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=1.2	0.81
'1..Weld Part 9.1 [1440.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=1.4	0.71
'1..Weld Part 9.1 [1440.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=2.8	0.35
'2..Weld Part 9.2 [1425.5; 199.54; 1104]'	Original Model (Double full penetration; alpha=	2.41
'2..Weld Part 9.2 [1425.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=1.0	1.55
'2..Weld Part 9.2 [1425.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=1.2	1.30
'2..Weld Part 9.2 [1425.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=1.4	1.12
'2..Weld Part 9.2 [1425.5; 199.54; 1104]'	Double partial penetration; alpha=45.00; a=2.8	0.53

2,3

Optimal Result

All Result

2 Close

Plot Optimization Results

1

Activate the section

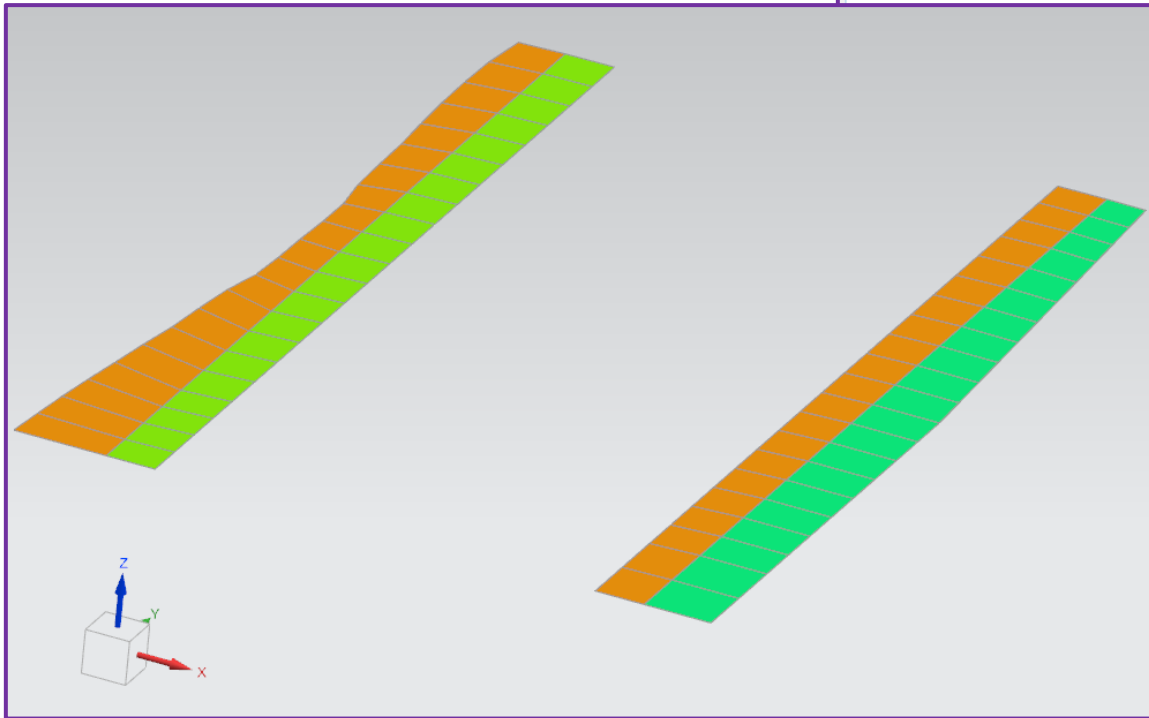
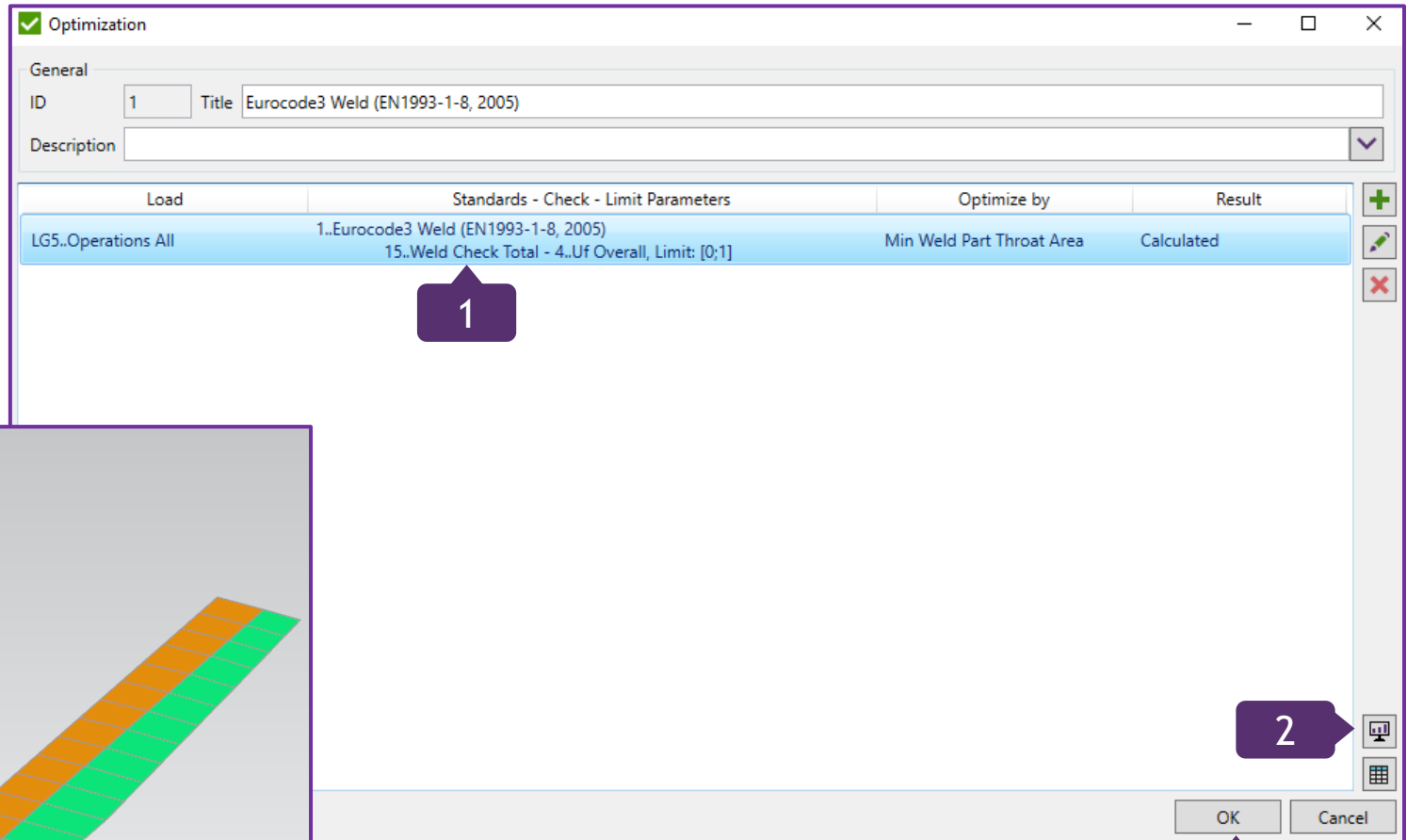
2

Press  to plot optimal result on the model

3

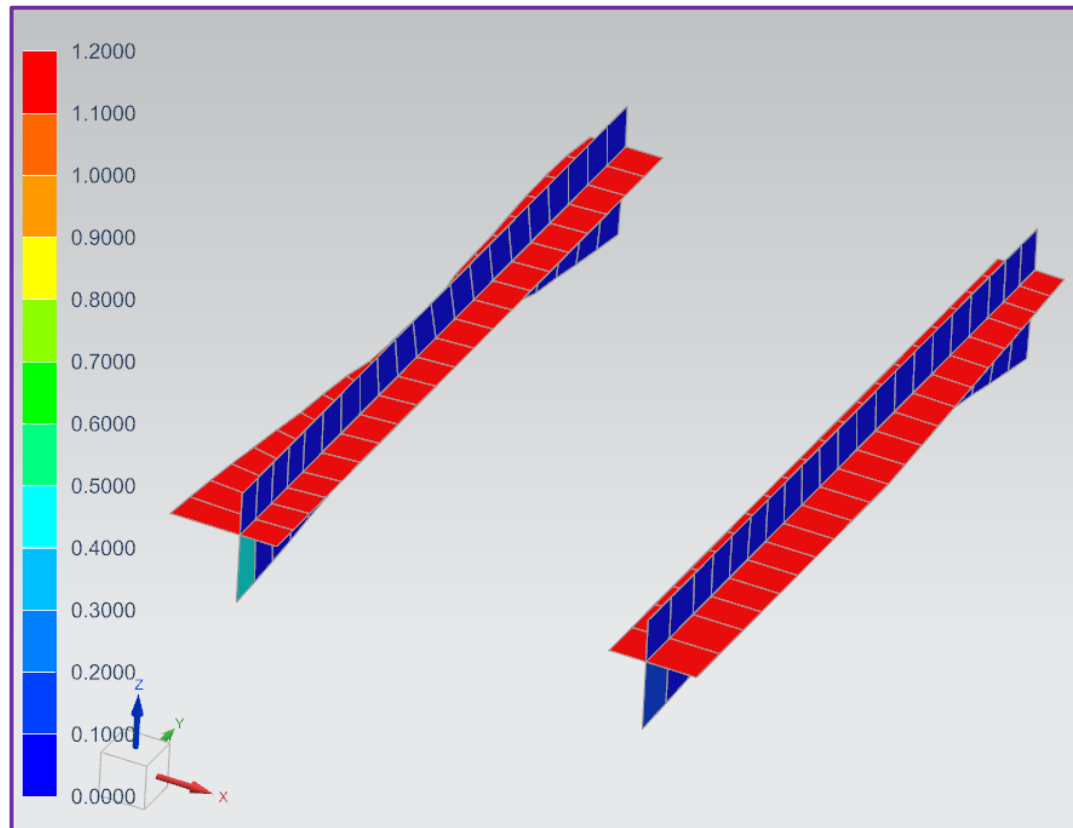
Press *OK*

The Result



This Tutorial demonstrates only the workflow with the Optimization Tool. Optimization Rule can be set even more precisely. For example, using the Peak Finder you can group only the overshooting elements into a Component and run the Optimization on this Component. Multiple rules with different variables can be set.

The Result before the Optimization.



The Result after the Optimization.

