



Tutorial

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

Updated on: April 12th, 2024

Tested with: SDC Verifier 2023 R2

Femap version 2023.2

- 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 Femap \(sdcverifier.com\)](https://sdcverifier.com)

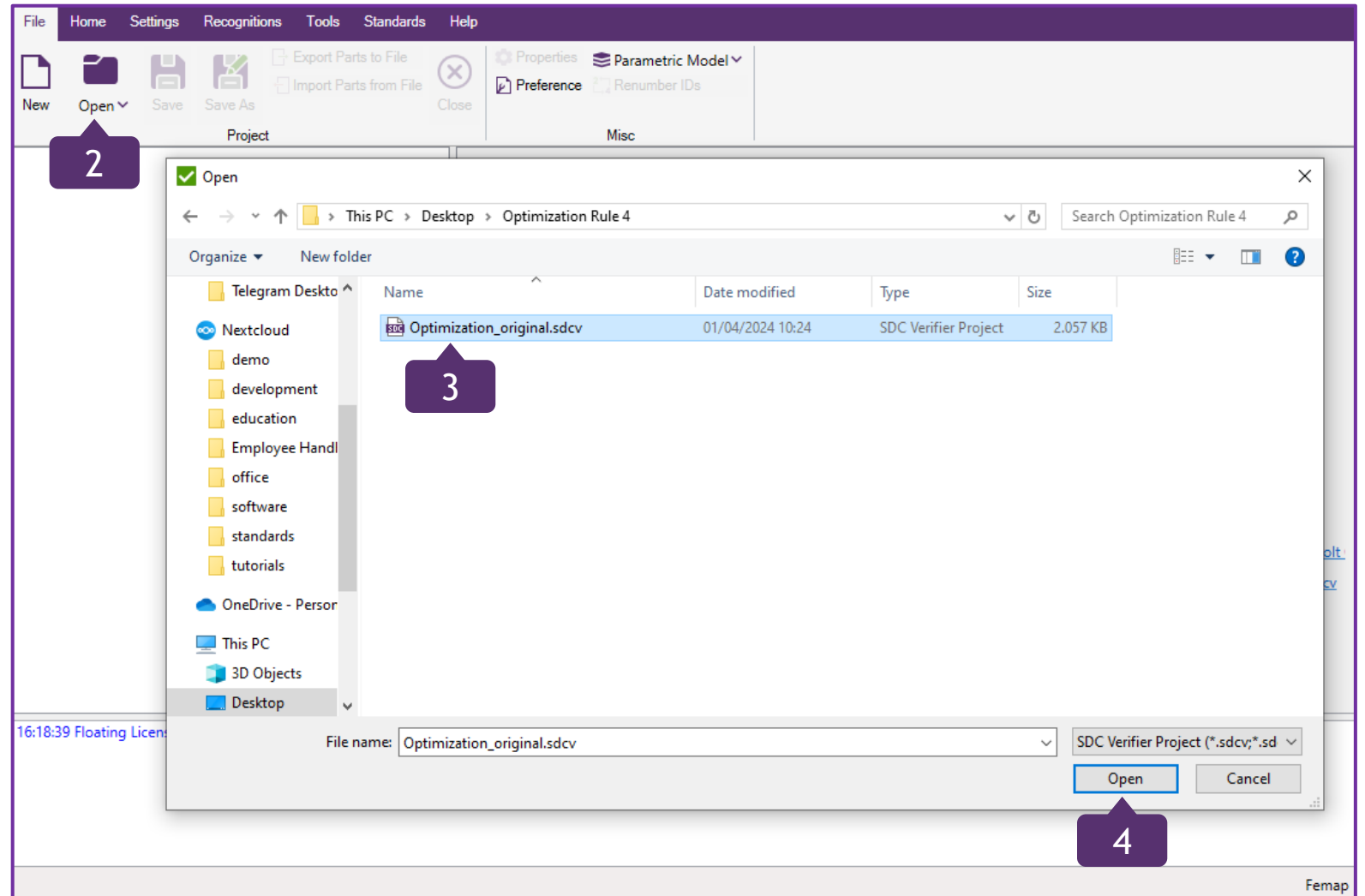
# Open the Starter Model

1 Launch SDC Verifier for Femap

2 In *File* section, press *Open*



















3 Select a project  
*Optimization\_original.sdcv*

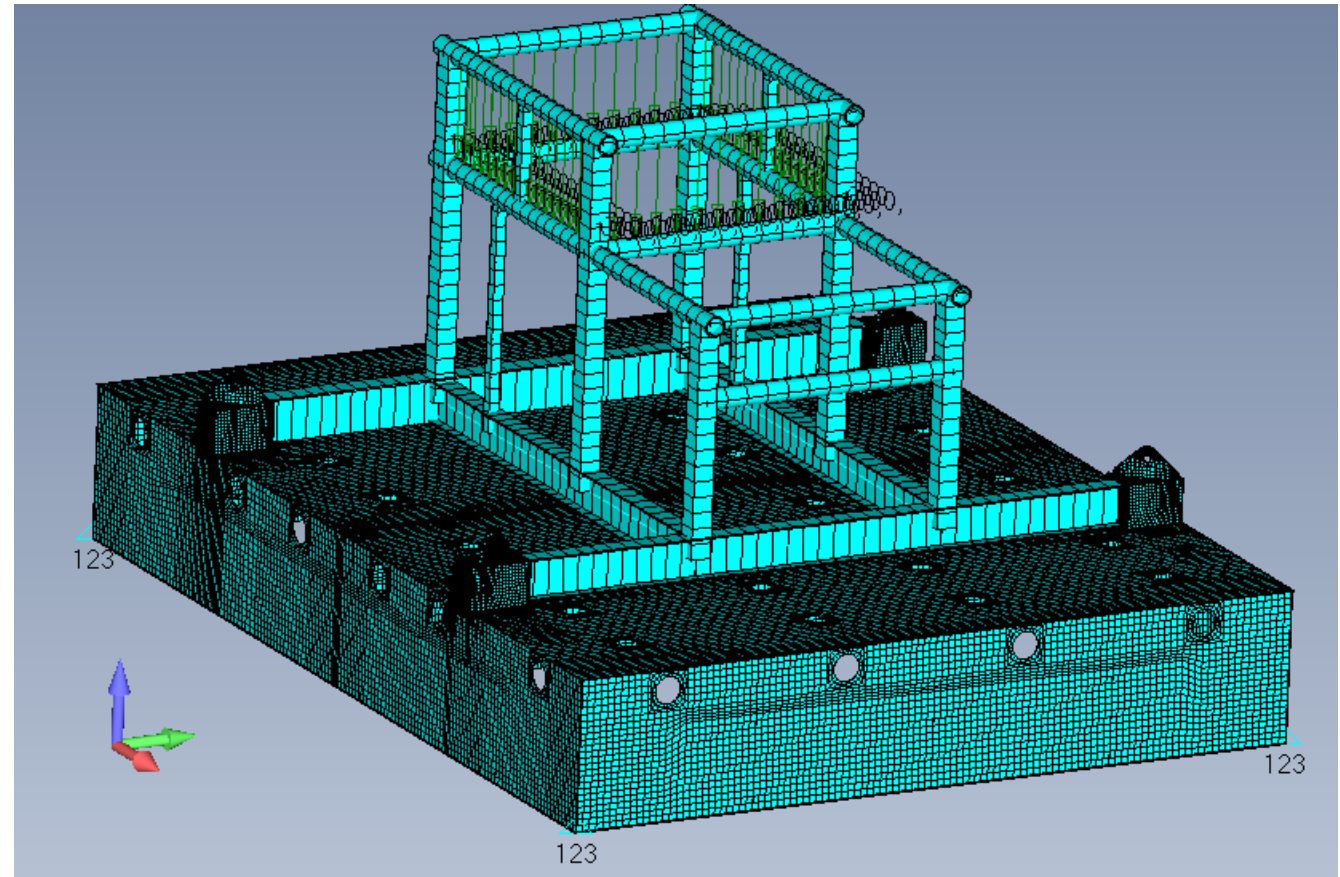
4 Press *Open*



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)

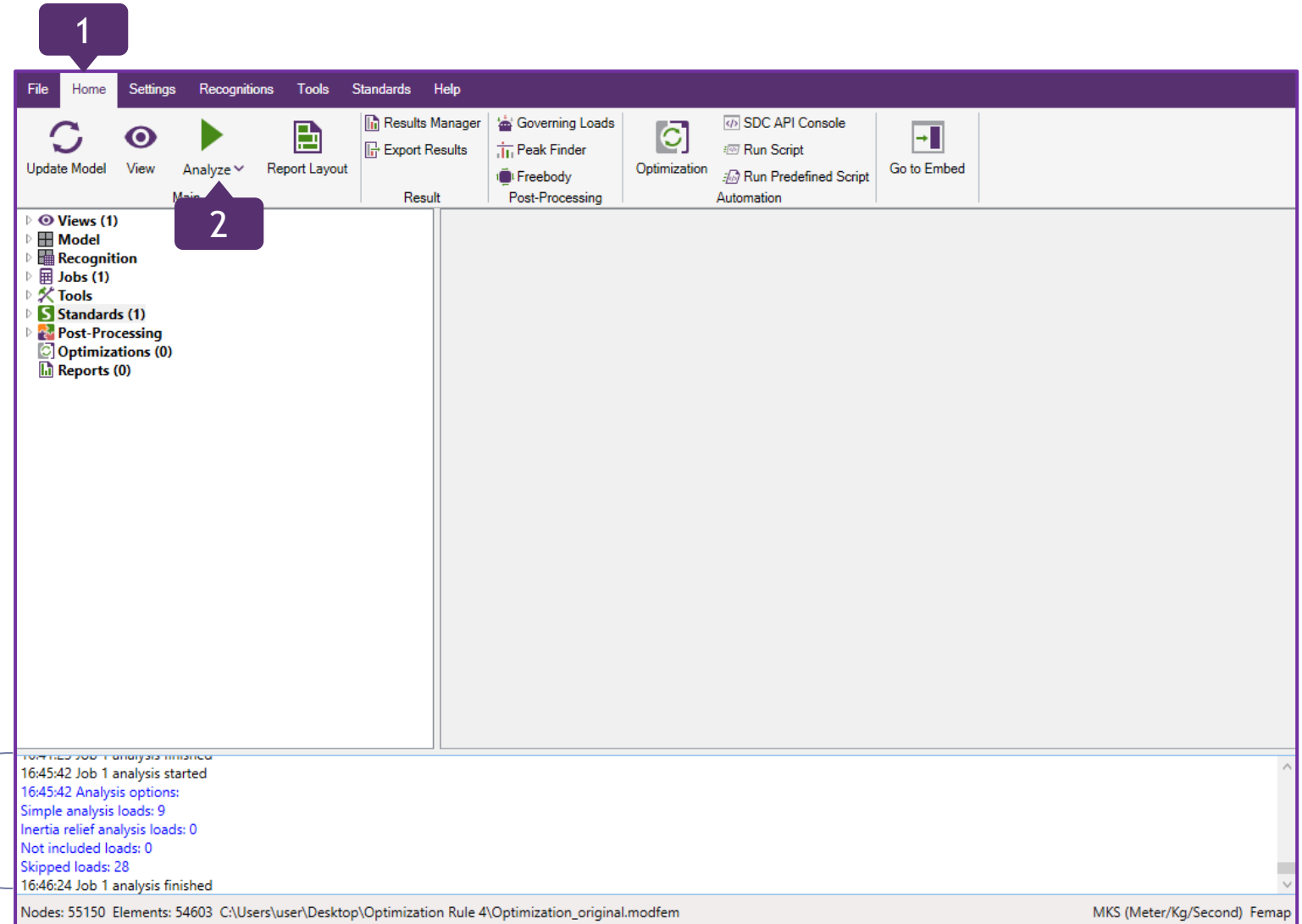


A separate Tutorial with detailed instructions on how to add, define and edit the Standard, can be found via this link:  
<https://sdcverifier.com/tutorials/weld-strength-check/>

# 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 (22) 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

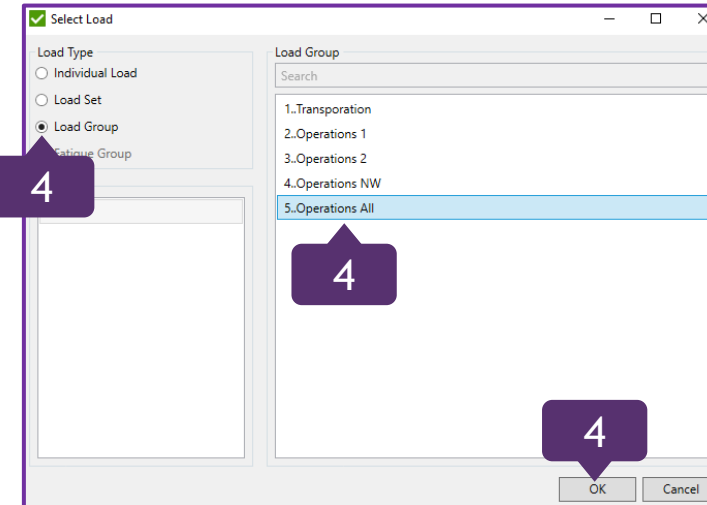
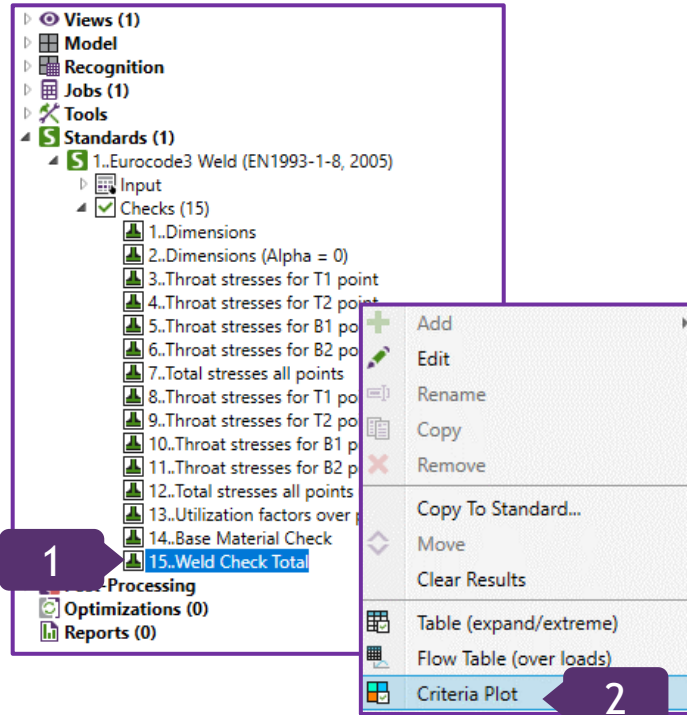
Parameter: *Uf Overall*;  
Direction: *All*

6

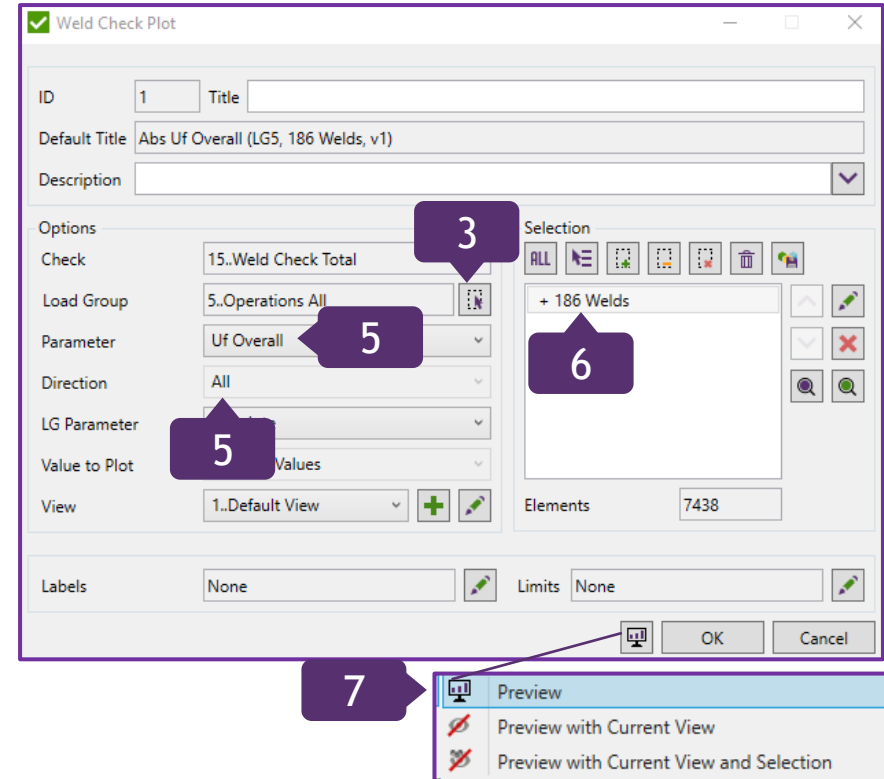
Selection: + 186 Welds

7

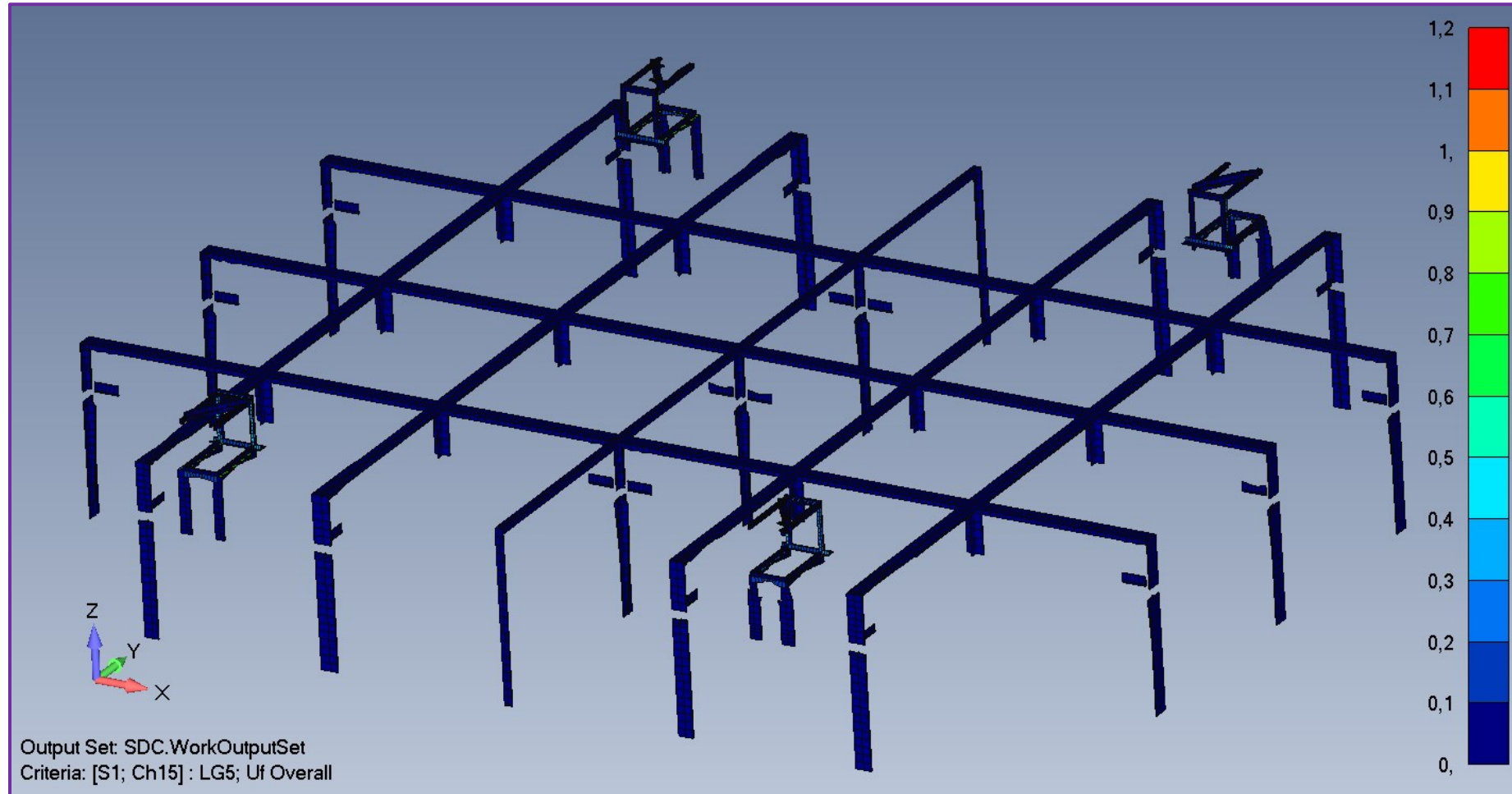
Press  and then Preview



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 Femap 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



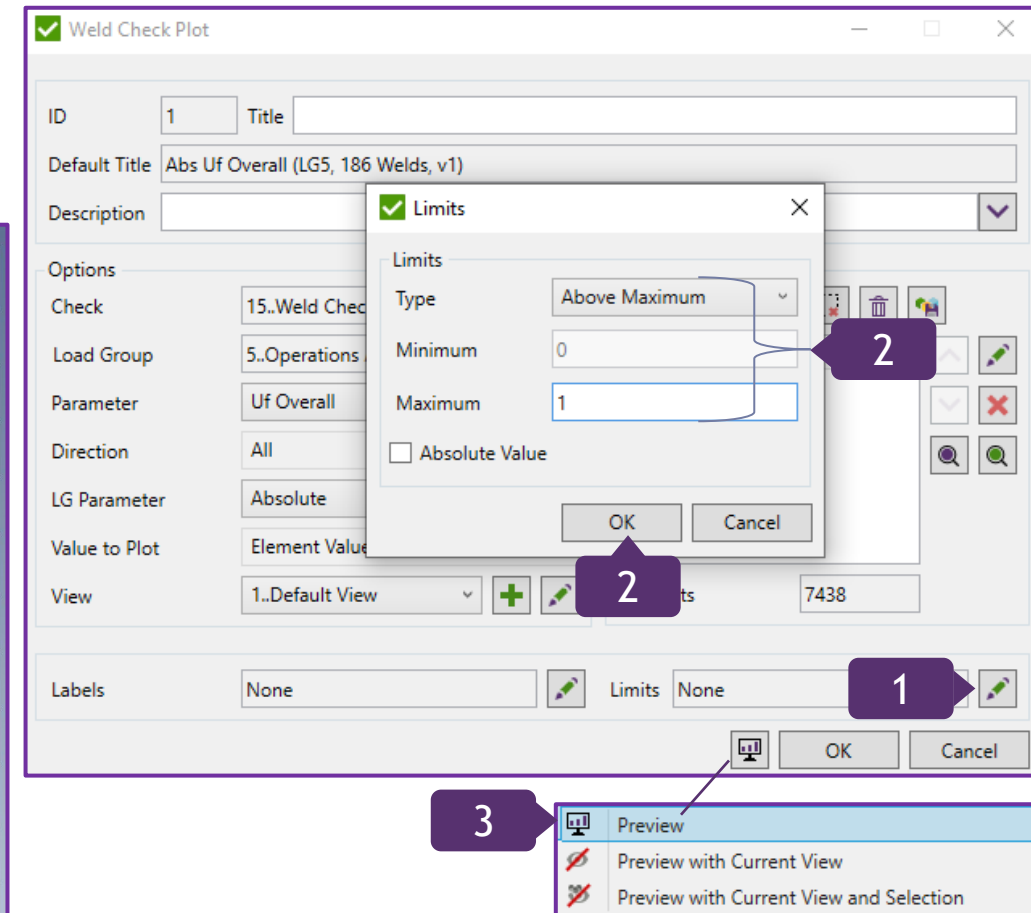
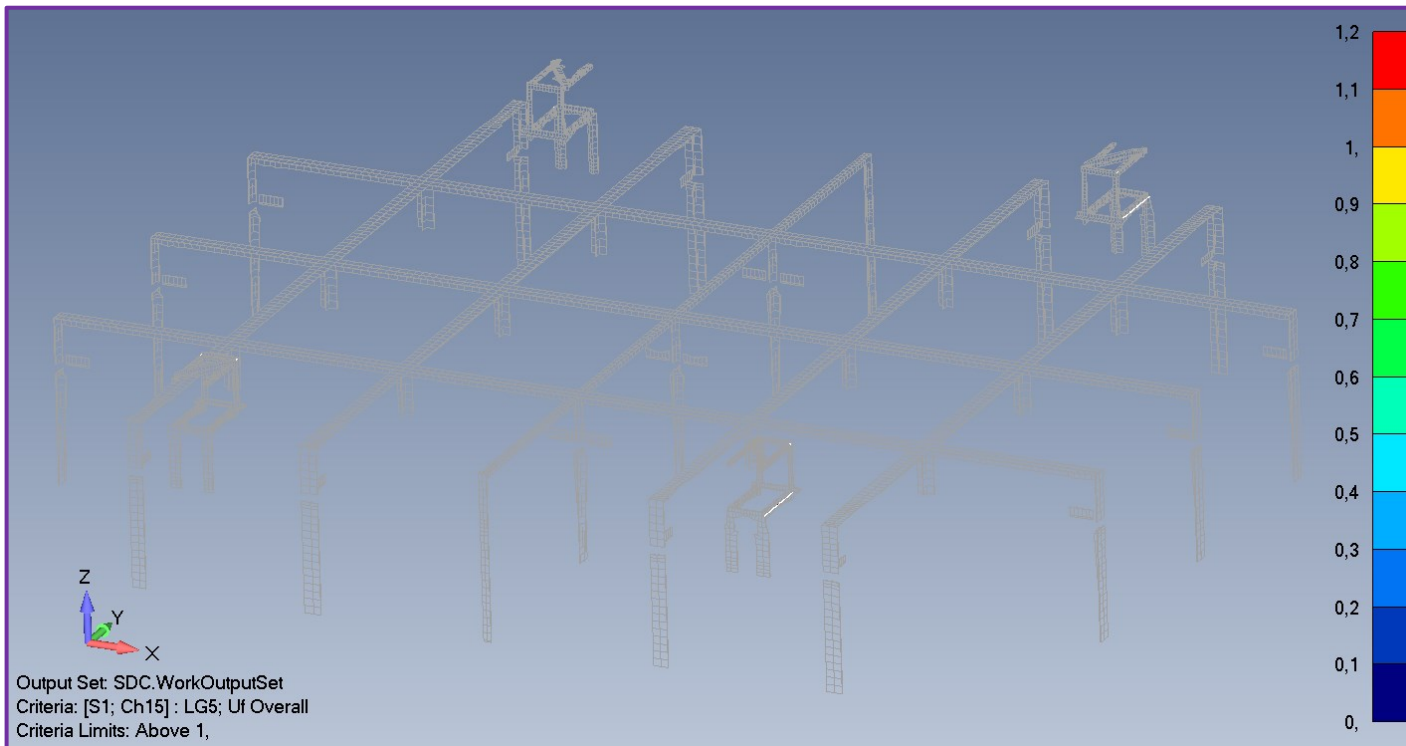
2

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

3

Press and then *Preview*

The Result





1

Select + 186 Welds and press  to remove them

2

Press  to add Condition;  
Select *Components*

3

Select 11..Welds for Optimization;  
Press OK

4

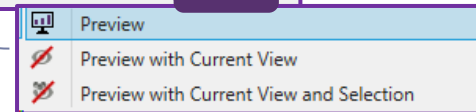
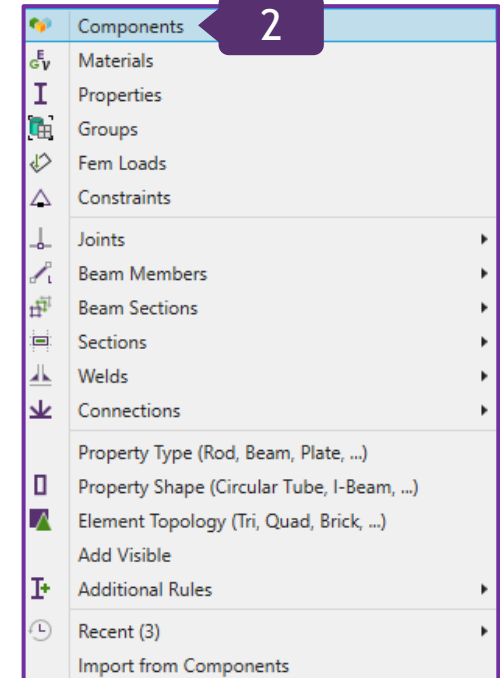
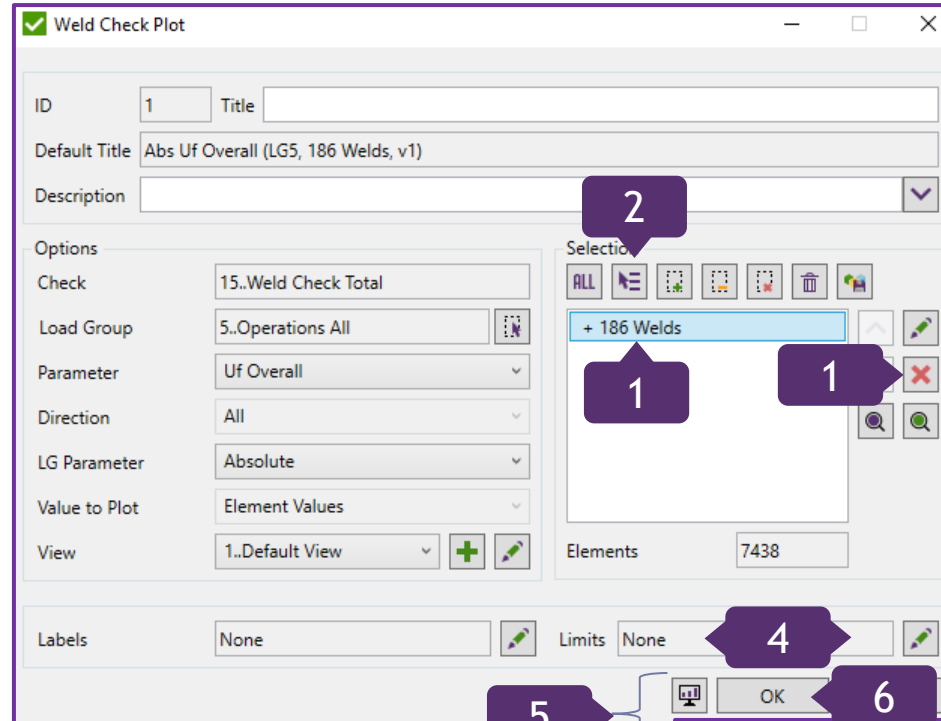
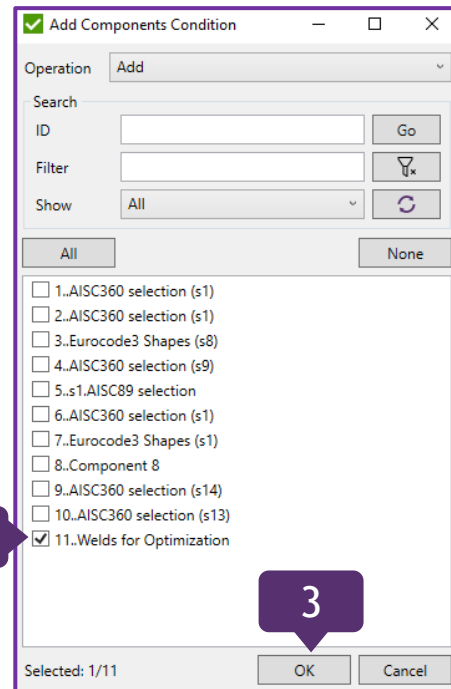
Limits: *None*

5

Press  and  
then *Preview*

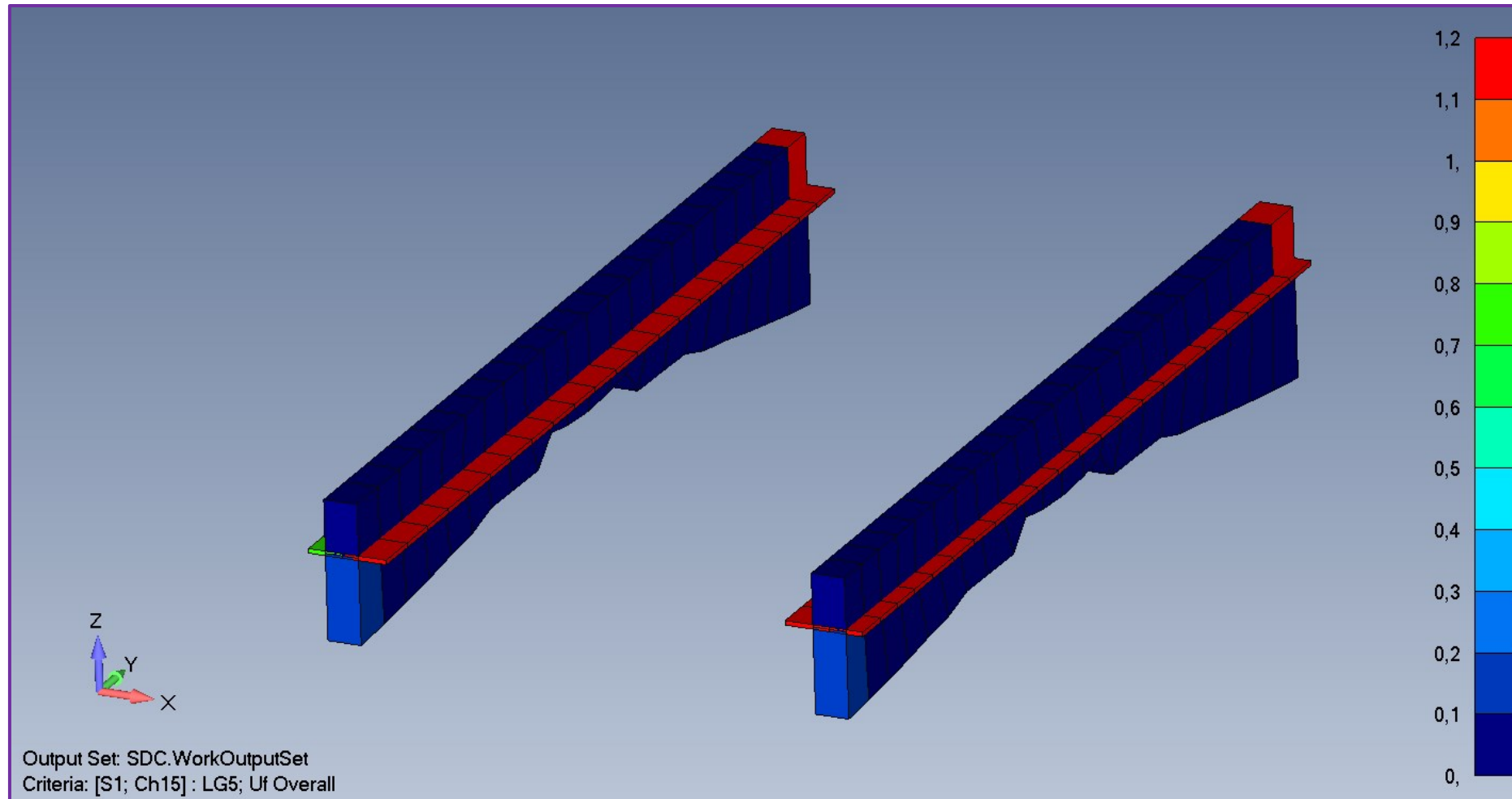
6

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.**

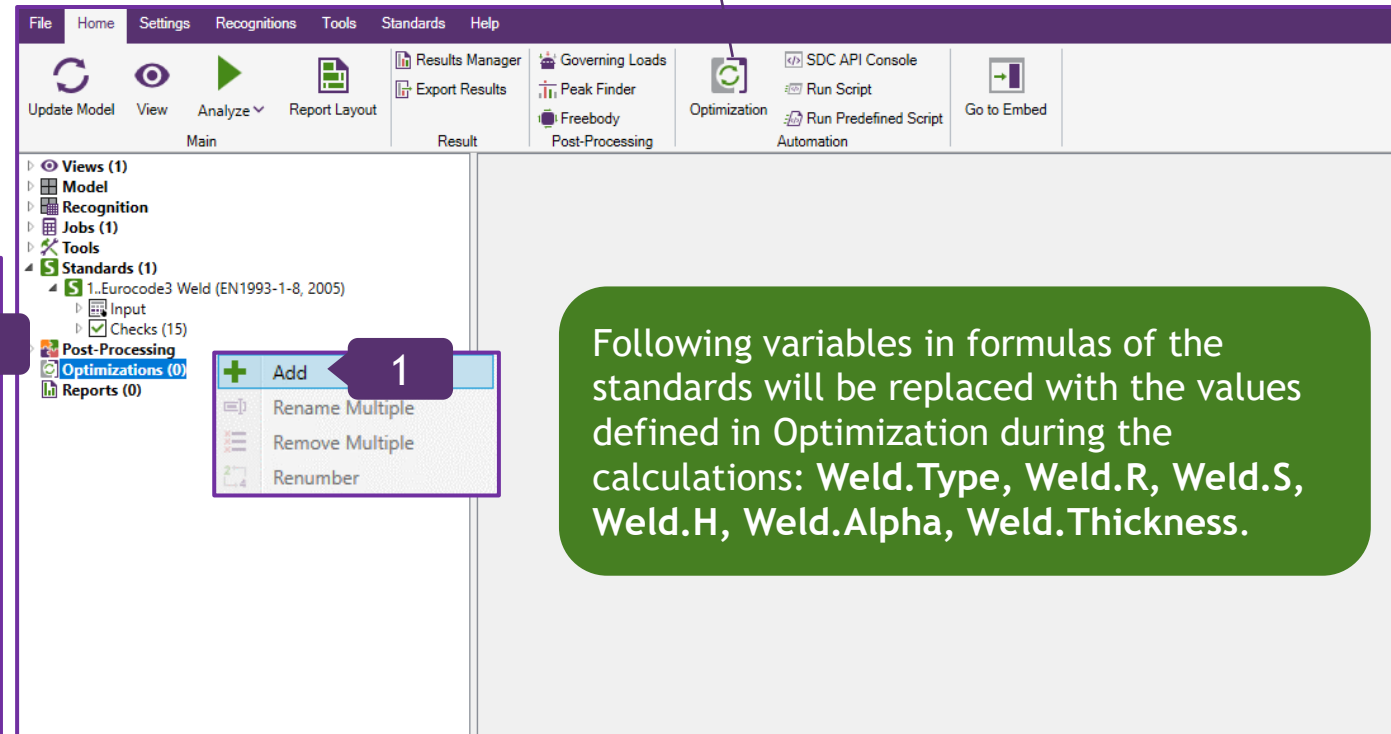
# Create Optimization Rule

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.



Eurocode3 Weld (EN1993-1-8, 2005) Standard, along with its Checks and Parameters, can be optimized by Weld Strength Rule.

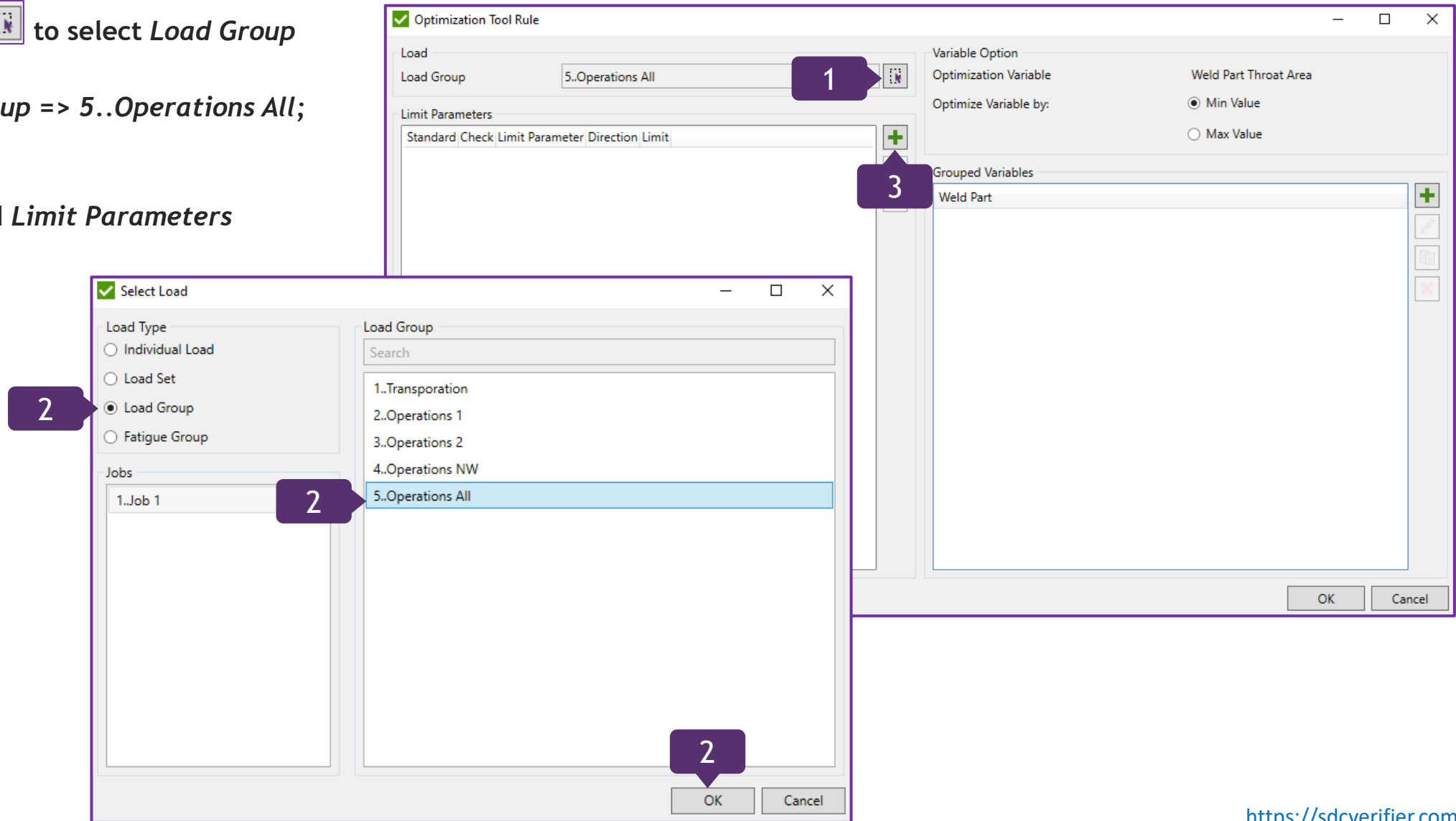
Weld Strength Rule is used to optimize weld parts, weld type and dimensions (leg size, throat thickness etc.). It is typically used for Weld Strength Standards. Common options are described in Optimization Rule.

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*;

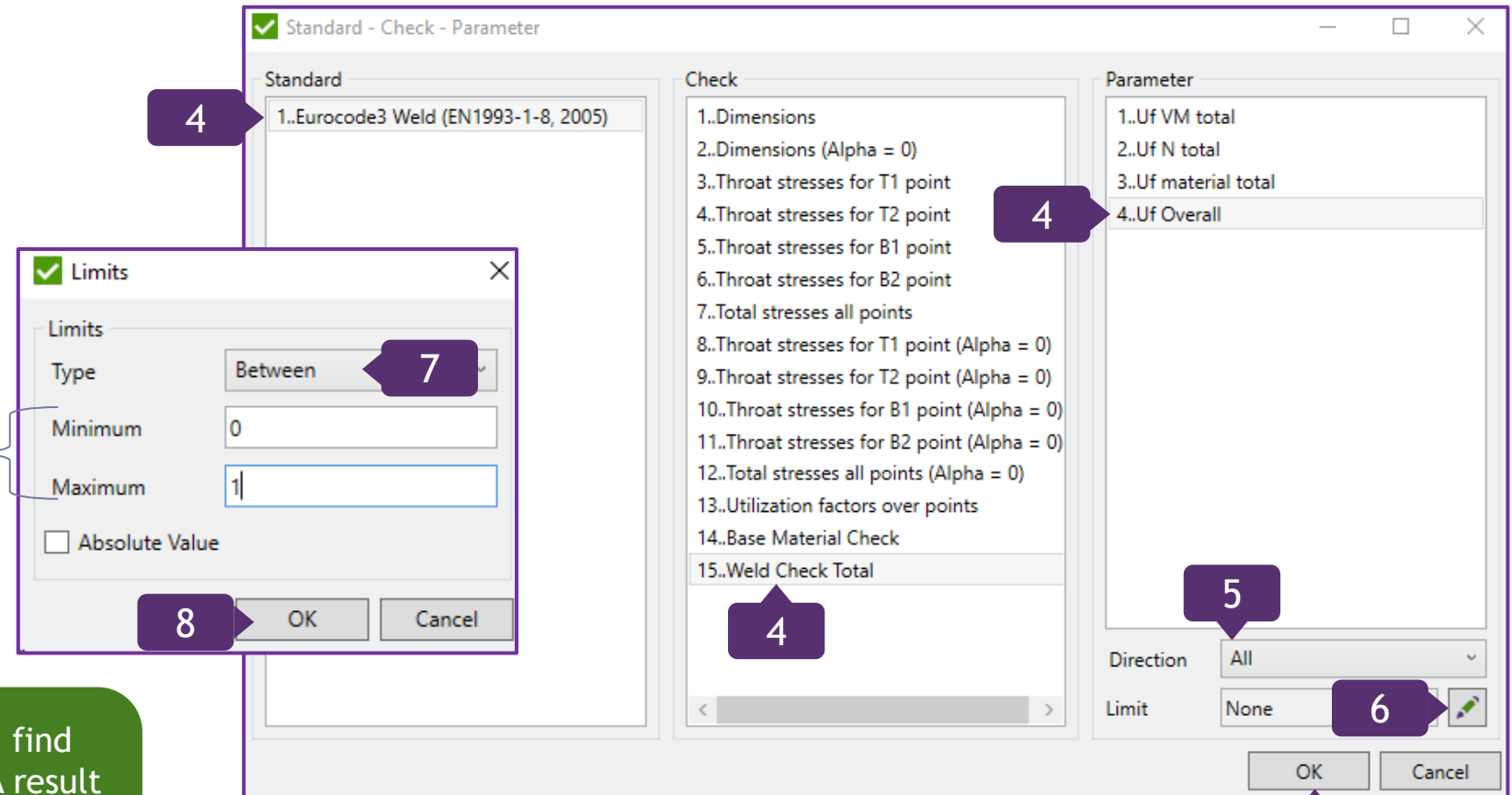
8

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.



**Standard - Check - Parameter**

**Standard**

1..Eurocode3 Weld (EN1993-1-8, 2005)

**Check**

1..Dimensions  
2..Dimensions (Alpha = 0)  
3..Throat stresses for T1 point  
4..Throat stresses for T2 point  
5..Throat stresses for B1 point  
6..Throat stresses for B2 point  
7..Total stresses all points  
8..Throat stresses for T1 point (Alpha = 0)  
9..Throat stresses for T2 point (Alpha = 0)  
10..Throat stresses for B1 point (Alpha = 0)  
11..Throat stresses for B2 point (Alpha = 0)  
12..Total stresses all points (Alpha = 0)  
13..Utilization factors over points  
14..Base Material Check  
15..Weld Check Total

**Parameter**

1..Uf VM total  
2..Uf N total  
3..Uf material total  
4..Uf Overall

Direction: All

Limit: None

OK Cancel

**Limits**

Limits

Type: Between

Minimum: 0

Maximum: 1

☐ Absolute Value

OK Cancel

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

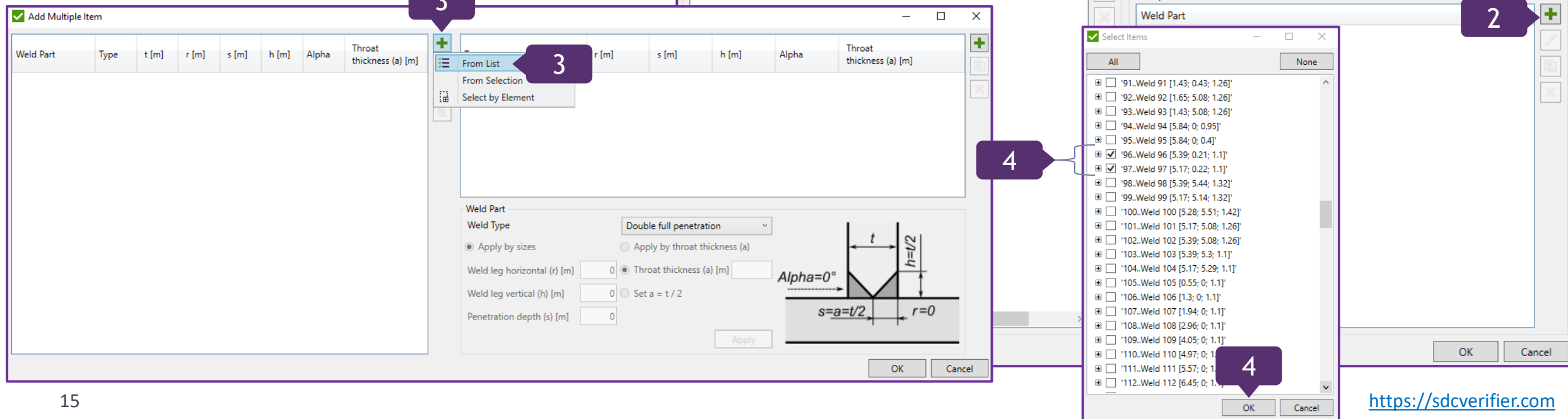
Press  and select *From List*

4

Select '96..Weld 96 [5.39; 0.21; 1.1]';  
'97..Weld 97 [5.17; 0.22; 1.1]'  
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) [m]: *0.00075*;  
Weld leg vertical (h) [m]: *0.00075*;  
Penetration depth (s) [m]: *0.00075*

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) [m] 0.00125 ☒ Throat thickness (a) [m]

Weld leg vertical (h) [m] 0.00125 ☐ Set a = t / 2

Penetration depth (s) [m] 0.00075

4

Weld Part

Weld Type **3** Double partial penetration

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

Weld leg horizontal (r) [m] 0.003 ☒ Throat thickness (a) [m]

Weld leg vertical (h) [m] 0.003 ☐ Set a = t / 2

Penetration depth (s) [m] 0.001

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

✓ Add Multiple Item

| Weld Part             | Type      | t [m] | r [m] | s [m] | h [m] | Alpha | Throat thickness (a) [m] |
|-----------------------|-----------|-------|-------|-------|-------|-------|--------------------------|
| 3..Weld Part 96.3 [5] | Double fi | 0.002 | 0     | 0.001 | 0.001 | 0     | 0.001                    |
| 4..Weld Part 96.4 [5] | Double fi | 0.002 | 0     | 0.001 | 0.001 | 0     | 0.001                    |
| 3..Weld Part 97.3 [5] | Double fi | 0.002 | 0     | 0.001 | 0.001 | 0     | 0.001                    |
| 4..Weld Part 97.4 [5] | Double fi | 0.002 | 0     | 0.001 | 0.001 | 0     | 0.001                    |

Weld Part

Weld Type **1** Double partial penetration

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

Weld leg horizontal (r) [m] 0.001 ☒ Throat thickness (a) [m]

Weld leg vertical (h) [m] 0.001 ☐ Set a = t / 2

Penetration depth (s) [m] 0.00075

Weld Part

Weld Type Double partial penetration

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

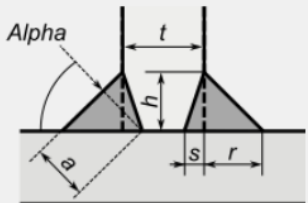
Weld leg horizontal (r) [m] 0.00075 ☒ Throat thickness (a) [m]

Weld leg vertical (h) [m] 0.00075 ☐ Set a = t / 2

Penetration depth (s) [m] 0.00075

Apply

OK Cancel



✓ Add Multiple Item

| Weld Part             | Type      | t [m] | r [m] | s [m] | h [m] | Alpha | Throat thickness (a) [m] |
|-----------------------|-----------|-------|-------|-------|-------|-------|--------------------------|
| 3..Weld Part 96.3 [5] | Double fi | 0.002 | 0     | 0.001 | 0.001 | 0     | 0.001                    |
| 4..Weld Part 96.4 [5] | Double fi | 0.002 | 0     | 0.001 | 0.001 | 0     | 0.001                    |
| 3..Weld Part 97.3 [5] | Double fi | 0.002 | 0     | 0.001 | 0.001 | 0     | 0.001                    |
| 4..Weld Part 97.4 [5] | Double fi | 0.002 | 0     | 0.001 | 0.001 | 0     | 0.001                    |

Weld Part

Weld Type Double partial penetration

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

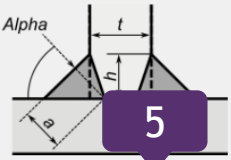
Weld leg horizontal (r) [m] 0.003 ☒ Throat thickness (a) [m]

Weld leg vertical (h) [m] 0.003 ☐ Set a = t / 2

Penetration depth (s) [m] 0.001

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, showing a table of limit parameters. The 'Optimization' window is in the foreground, showing a table of optimization results. A small 'SDC Verifier' dialog box is also visible, indicating that 1 of 1 rules have a result.

**Optimization Tool Rule Window:**

- Load: 5..Operations All
- Limit Parameters:

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

**Optimization Window:**

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

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

**SDC Verifier Dialog:**

- 1 of 1 rules have result
- OK

**Grouped Variables Window:**

- Variable Option: Weld Part Throat Area
- Optimize Variable by: ☒ Min Value
- Grouped Variables:

| Weld Part   |
|---|
| 3..Weld Part 96.3 [5.39; 0.21; 1.1]   |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.003; Alpha=45.00; r=0.003; s=0 |
| 4..Weld Part 96.4 [5.38; 0.21; 1.1]   |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.003; Alpha=45.00; r=0.003; s=0 |
| 3..Weld Part 97.3 [5.16; 0.22; 1.1]   |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.003; Alpha=45.00; r=0.003; s=0 |
| 4..Weld Part 97.4 [5.17; 0.22; 1.1]   |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |
| Double partial penetration; Throat Thickness (a)=0.001; Alpha=45.00; r=0.001; s=0 |

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 [m])                   | 1..Eurocode3 Weld (EN1993-1-8, 2005)<br>15..Weld Check Total<br>4..Uf Overall |
|---------------------------------------|---|---|
| '3..Weld Part 96.3 [5.39; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.00 | 0.81  |
| '4..Weld Part 96.4 [5.38; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.00 | 0.51  |
| '3..Weld Part 97.3 [5.16; 0.22; 1.1]' | Original Model (Double full penetration; alpha= | 0.75  |
| '4..Weld Part 97.4 [5.17; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.00 | 0.88  |

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

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)<br>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 [m])                   | 1..Eurocode3 Weld (EN1993-1-8, 2005)<br>15..Weld Check Total<br>4..Uf Overall |
|---------------------------------------|---|---|
| '3..Weld Part 96.3 [5.39; 0.21; 1.1]' | Original Model (Double full penetration; alpha: | 3.21  |
| '3..Weld Part 96.3 [5.39; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 2.15  |
| '3..Weld Part 96.3 [5.39; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 1.85  |
| '3..Weld Part 96.3 [5.39; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 1.61  |
| '3..Weld Part 96.3 [5.39; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.81  |
| '4..Weld Part 96.4 [5.38; 0.21; 1.1]' | Original Model (Double full penetration; alpha: | 1.98  |
| '4..Weld Part 96.4 [5.38; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 1.38  |
| '4..Weld Part 96.4 [5.38; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 1.18  |
| '4..Weld Part 96.4 [5.38; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 1.03  |
| '4..Weld Part 96.4 [5.38; 0.21; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.51  |
| '3..Weld Part 97.3 [5.16; 0.22; 1.1]' | Original Model (Double full penetration; alpha: | 0.75  |
| '3..Weld Part 97.3 [5.16; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.61  |
| '3..Weld Part 97.3 [5.16; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.52  |
| '3..Weld Part 97.3 [5.16; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.45  |
| '3..Weld Part 97.3 [5.16; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.22  |
| '4..Weld Part 97.4 [5.17; 0.22; 1.1]' | Original Model (Double full penetration; alpha: | 1.26  |
| '4..Weld Part 97.4 [5.17; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.88  |
| '4..Weld Part 97.4 [5.17; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.75  |
| '4..Weld Part 97.4 [5.17; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.66  |
| '4..Weld Part 97.4 [5.17; 0.22; 1.1]' | Double partial penetration; alpha=45.00; a=0.0  | 0.32  |

2,3

OK Cancel

Optimal Result

All Result

2

Close

# Plot Optimization Results

1

Activate the section

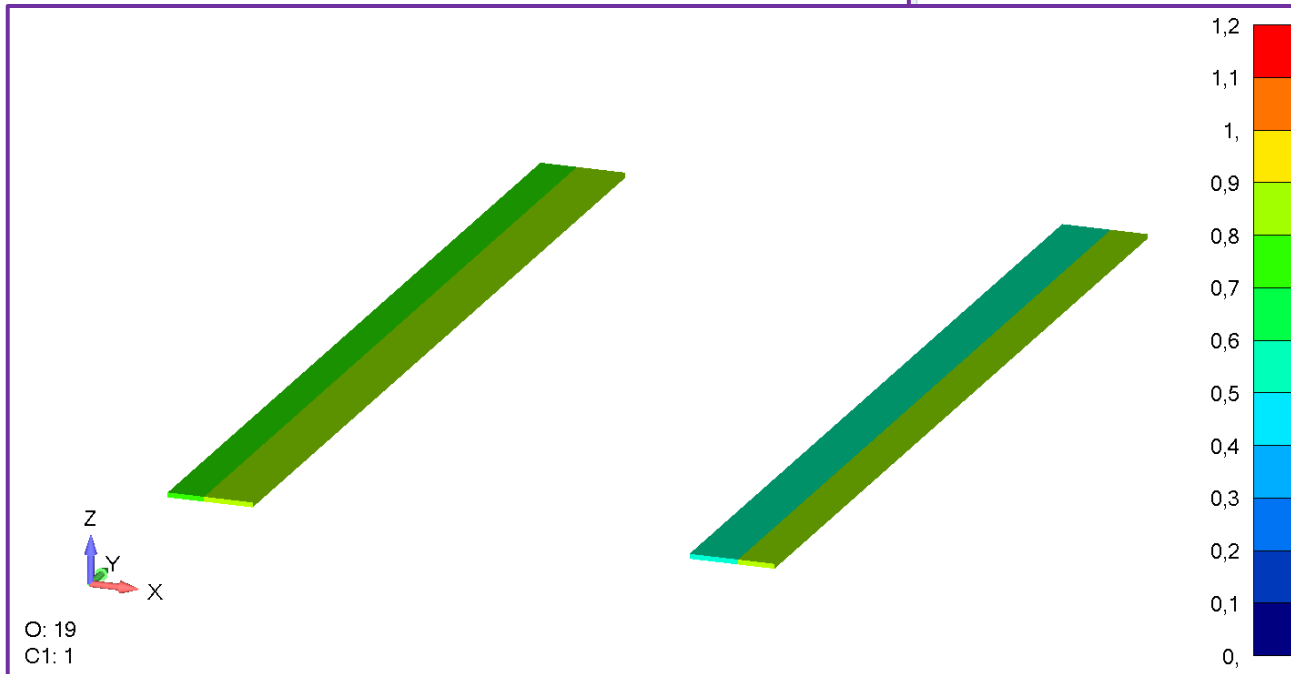
2

Press  to plot optimal result on the model

3

Press *OK*

The Result



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)<br>15..Weld Check Total - 4..Uf Overall, Limit: [0;1] | Min Weld Part Throat Area | Calculated |

1

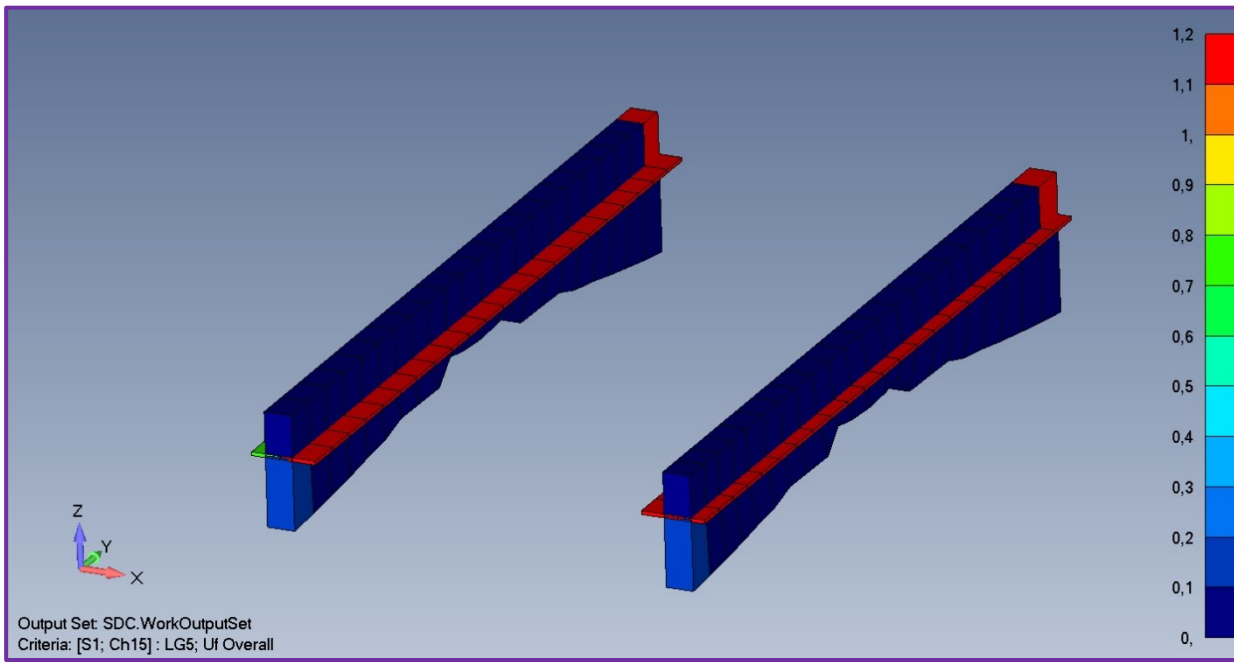
2

3

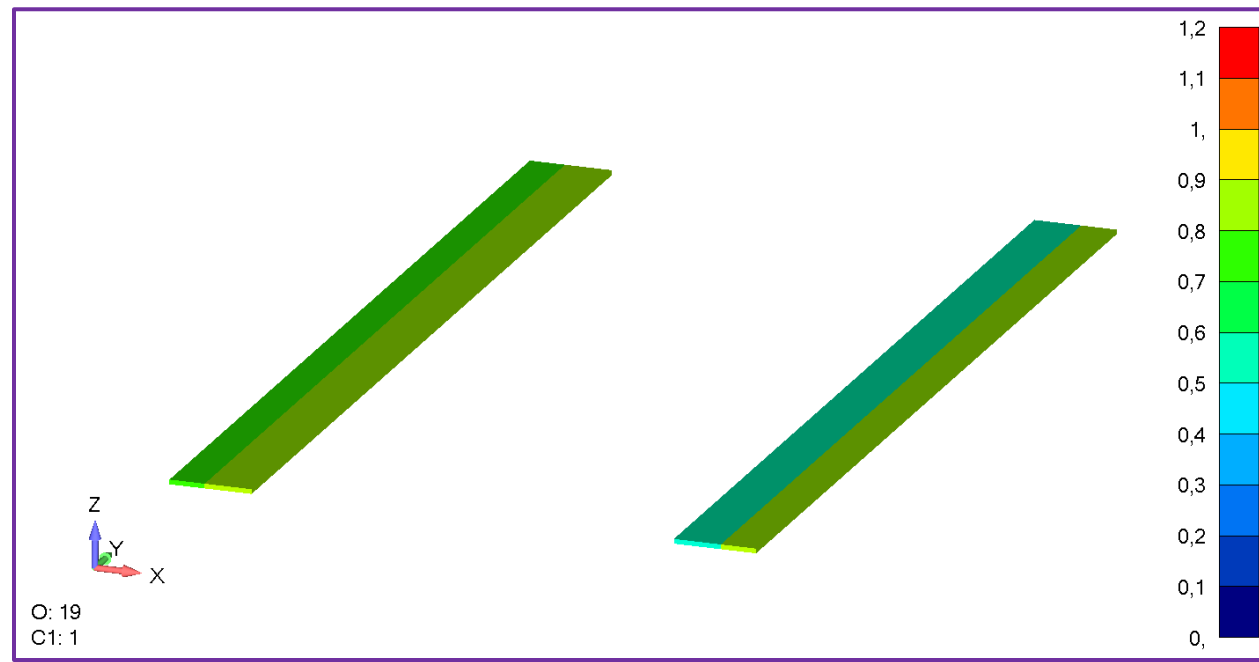
OK Cancel

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.



# New Weld Part Sizes Applied in Weld Finder Tool

1 Activate the section

2 Press *Change Model*

3 Press *Yes*

4 Press *OK*

5 Press *OK*

The Result

