SDC VERIFIER

Tutorial

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

Updated on: April 12th, 2024

Tested with: SDC Verifier 2023 R2

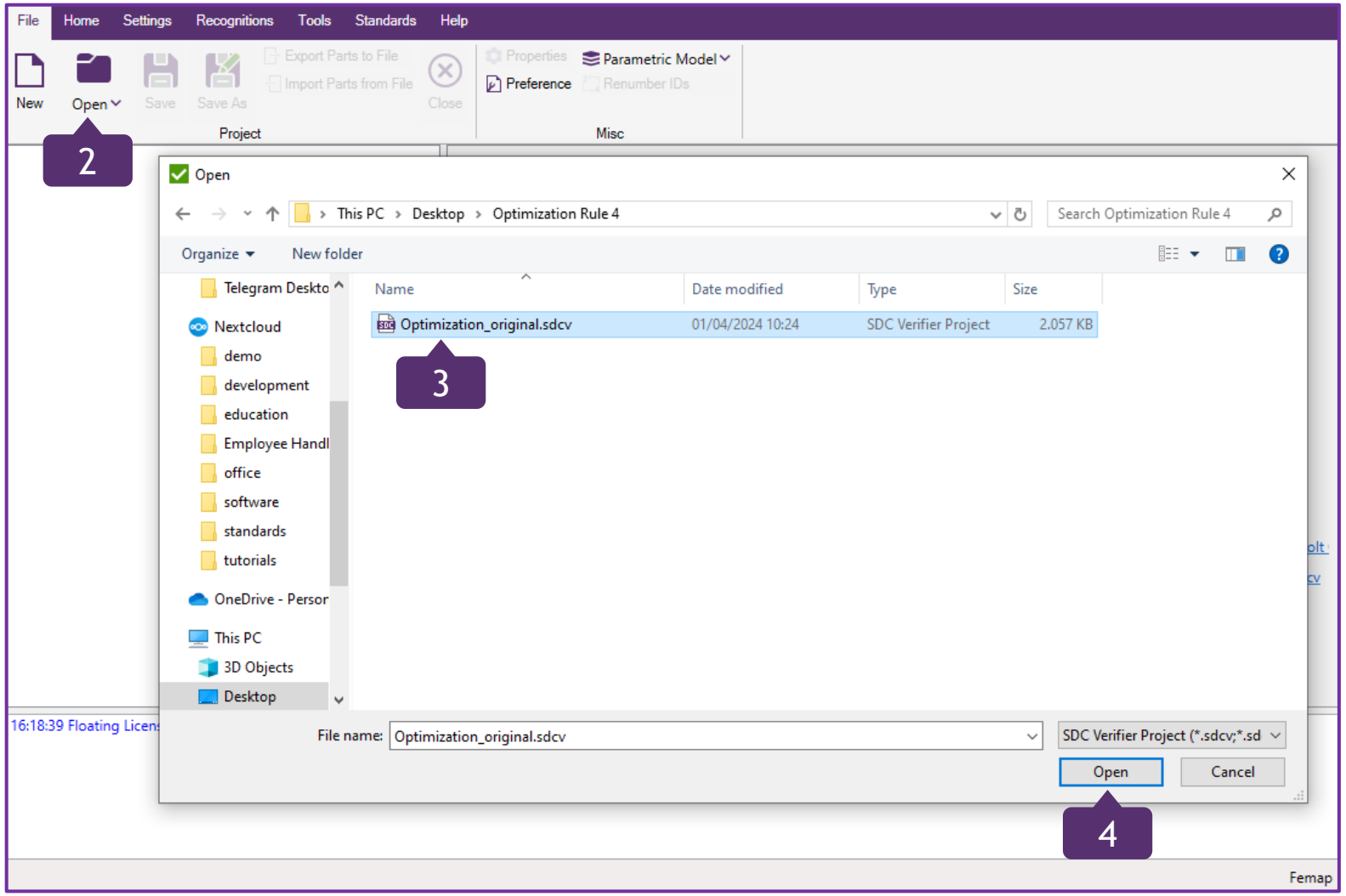
Femap version 2023.2

Content

- 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)

Open the Starter Model

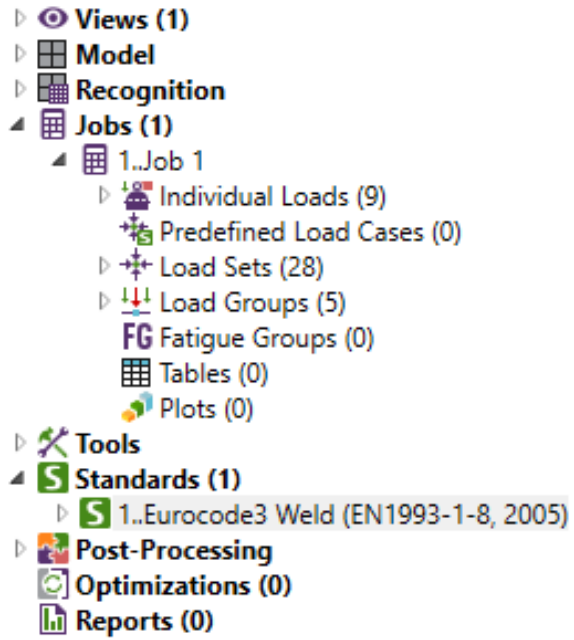
1. **Launch SDC Verifier for Femap**
2. In *File* section, press *Open*
3. Select a project *Optimization_original.sdcv*
4. Press *Open*

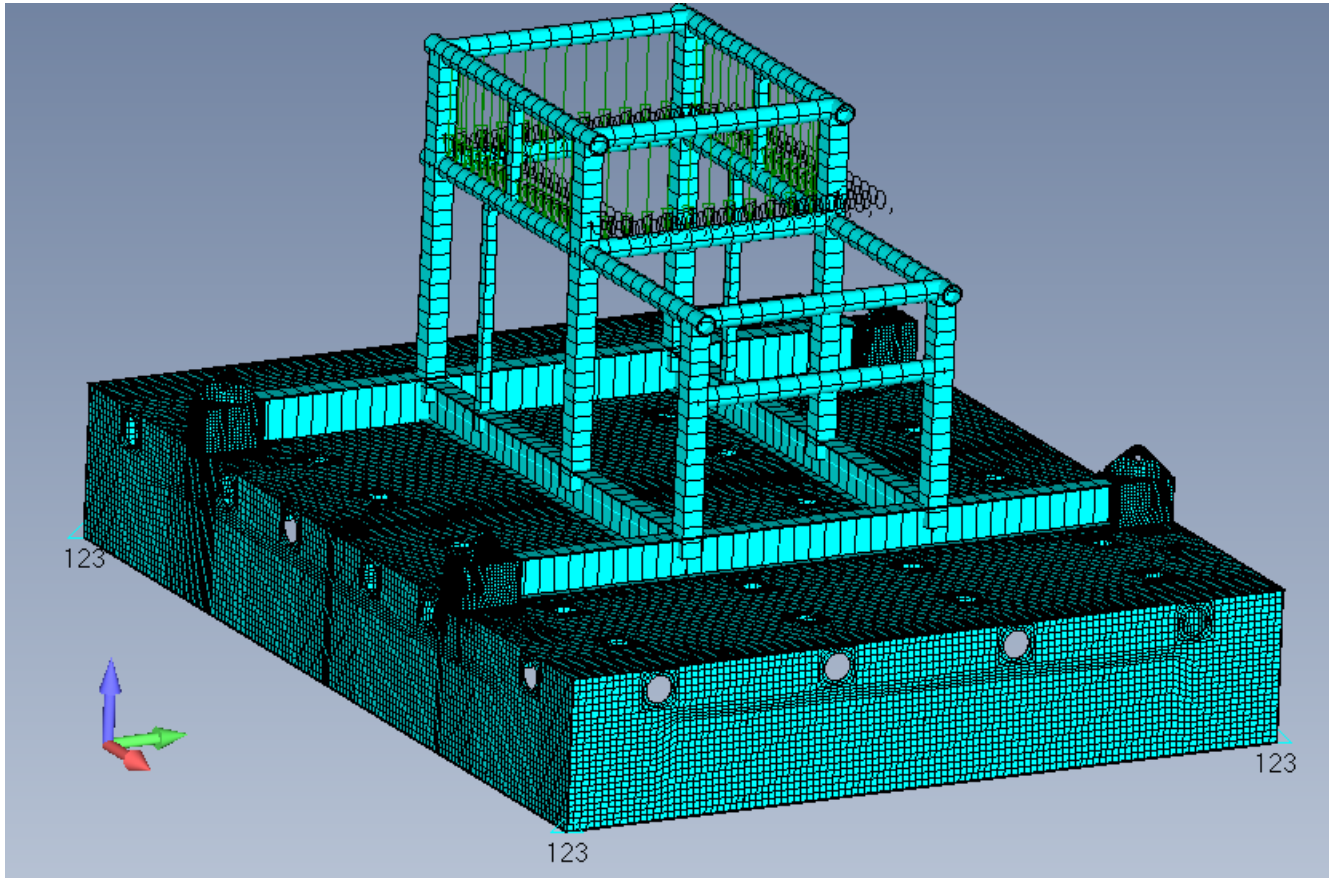


Predefined Project

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.

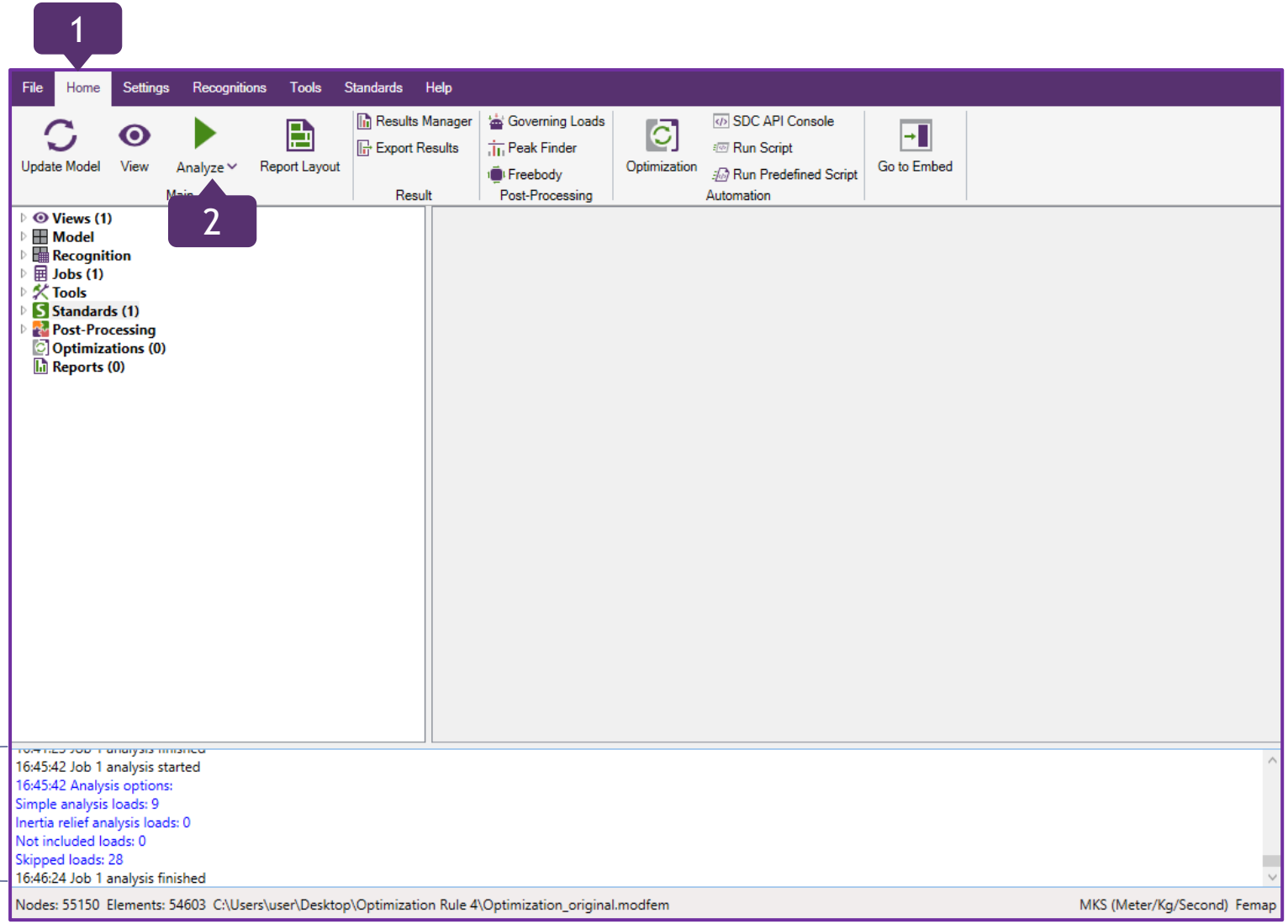




A separate Tutorial with detailed instructions on how to add, define and edit the Standard, can be found via this link: https://sdcverifier.com/tutorials/weld-strength-check/

Run Analysis

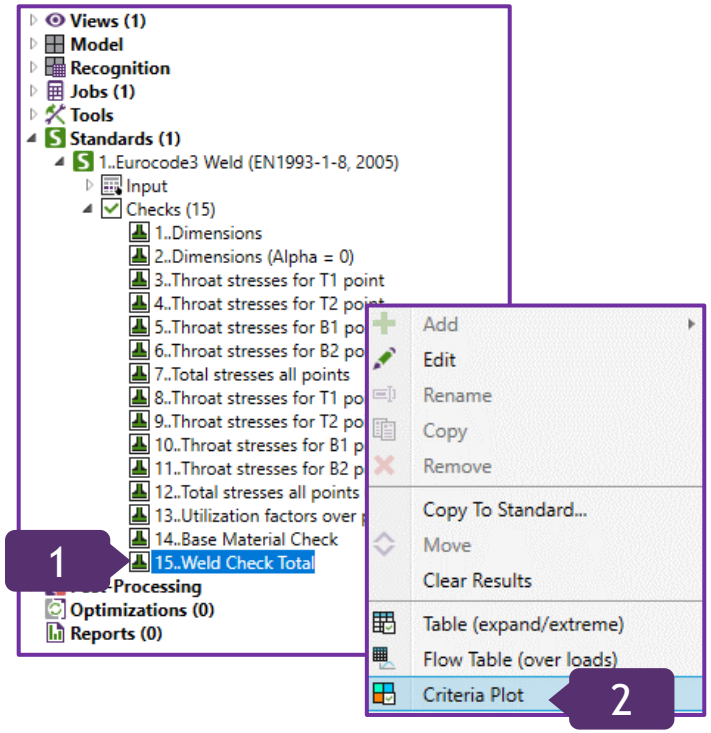
1. Go to *Home* section on the Ribbon
2. Press on the toolbar to analyze Job

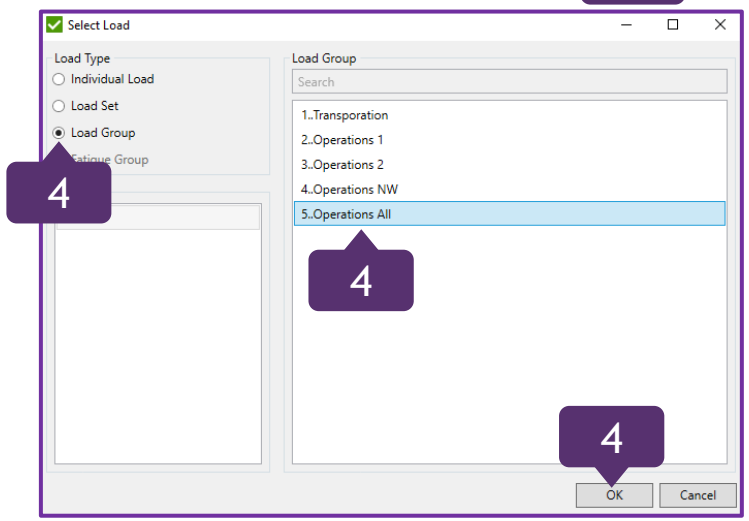


Job 1 analysis started and finished.

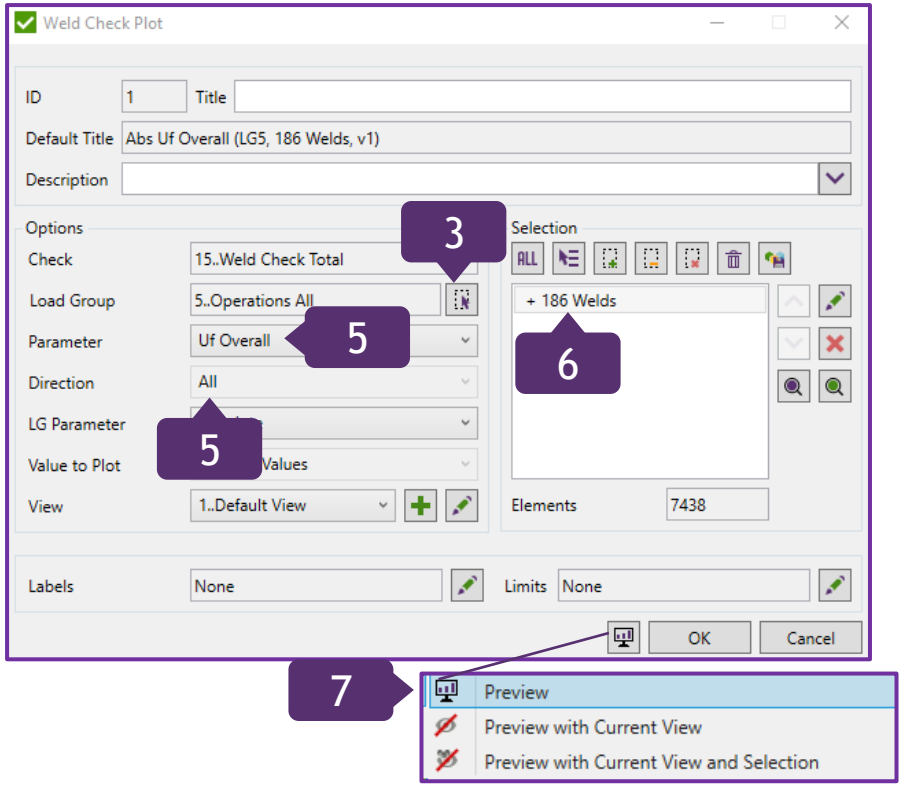
Eurocode3 Weld (EN1993-1-8,2005) Criteria Plot

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*



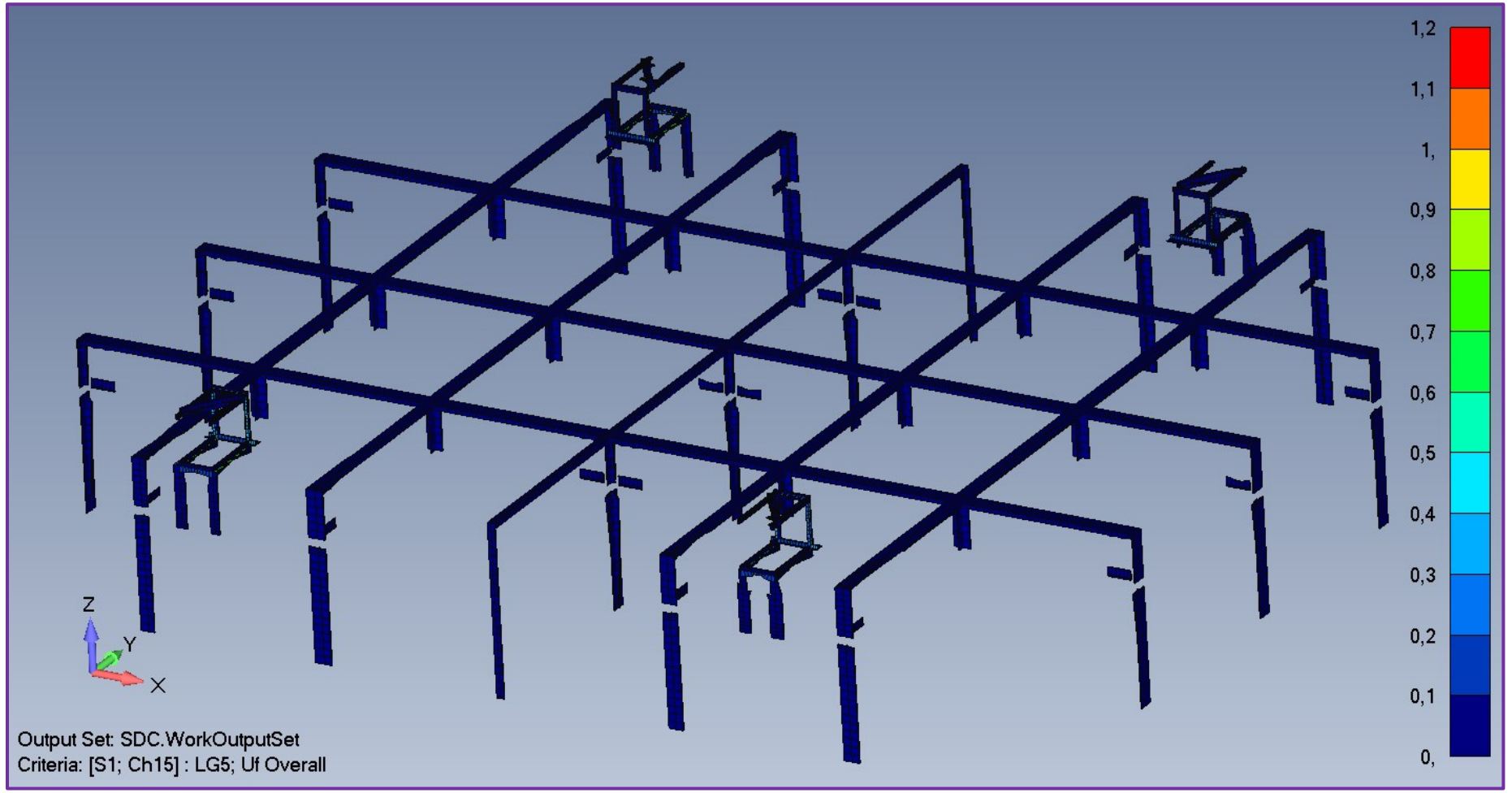


The purpose of creating Criteria Plot is to preview the results of Eurocode3 Fatigue Check and pick the members for Optimization.



Eurocode3 Fatigue (EN1993-1-9,2005) Criteria Plot (Continuation)

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

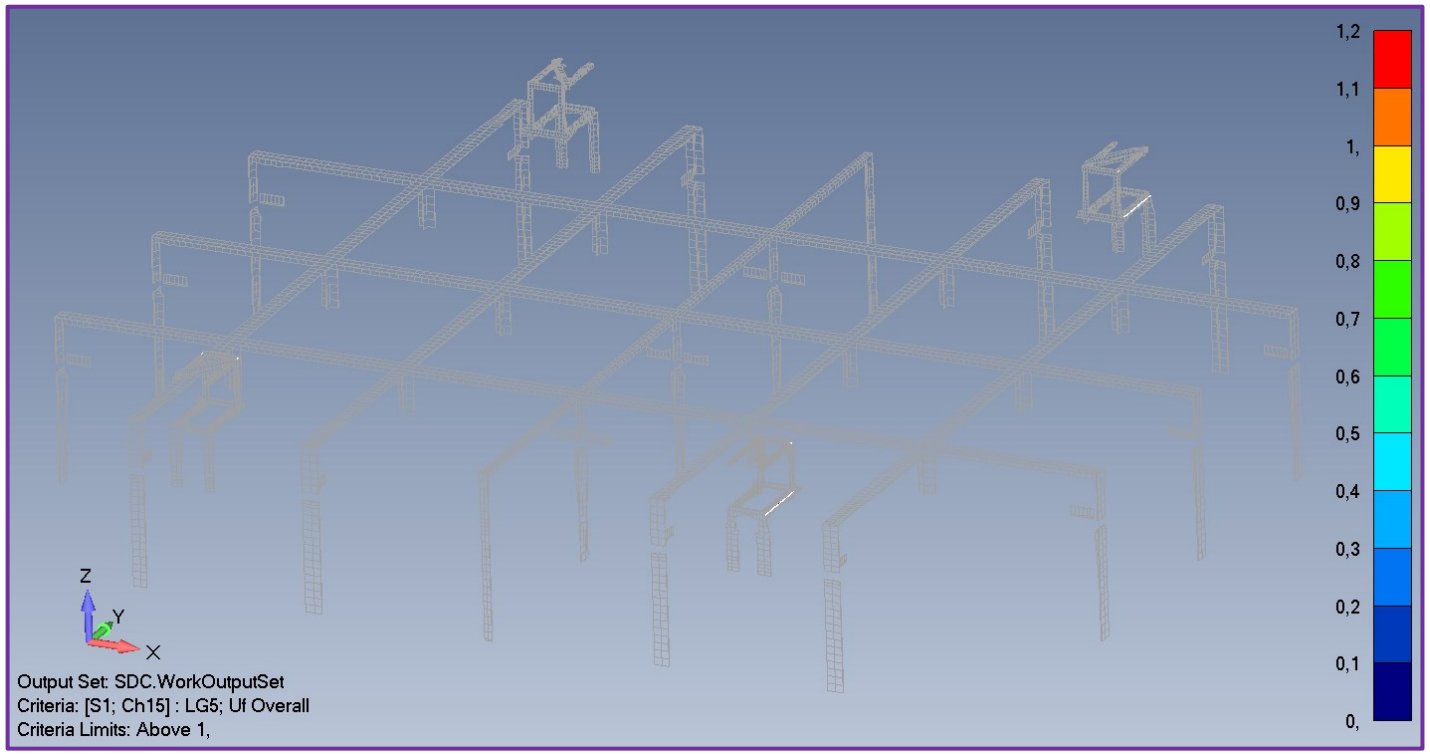


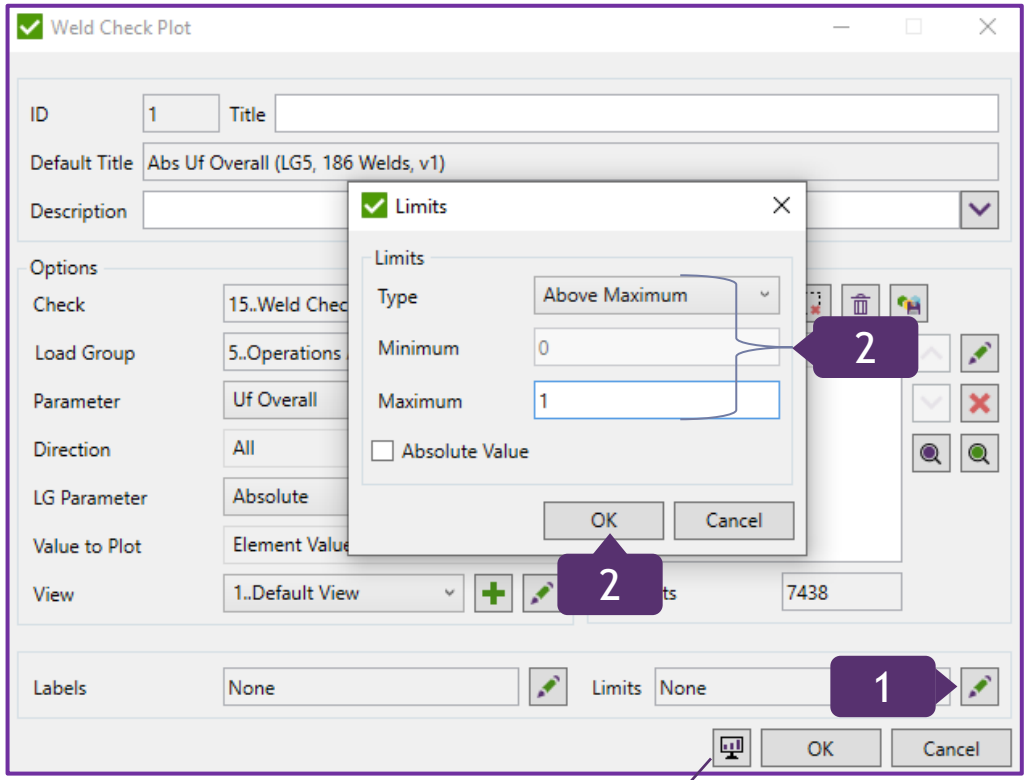
Set Limits for Criteria Plot (Additional Functionality)

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*

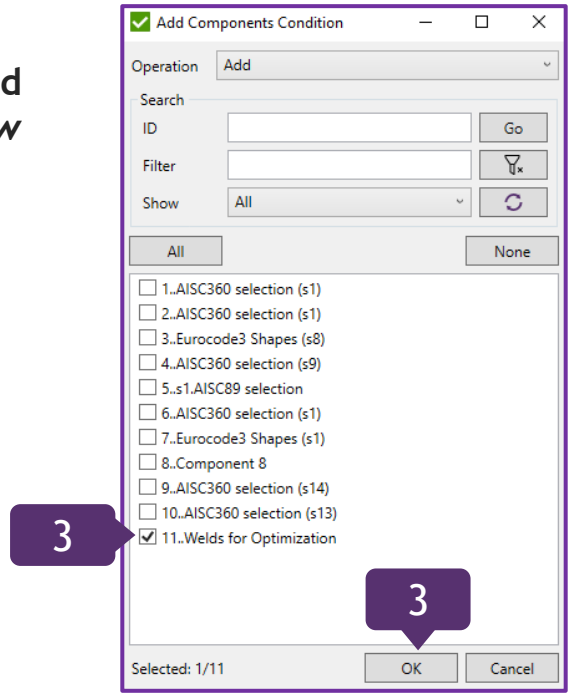
The Result

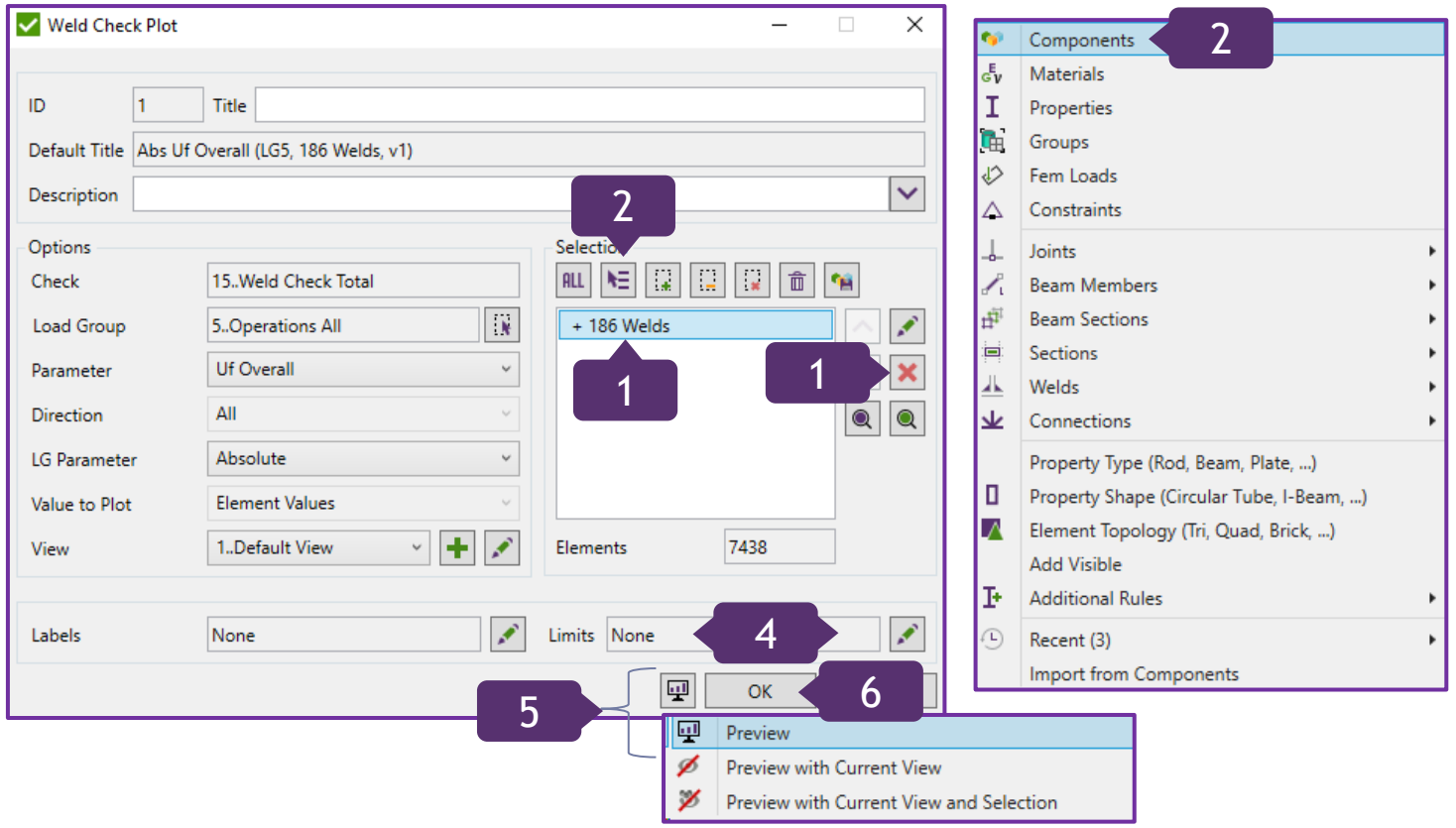




Eurocode3 Fatigue (EN1993-1-9,2005) Criteria Plot for One Property

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*

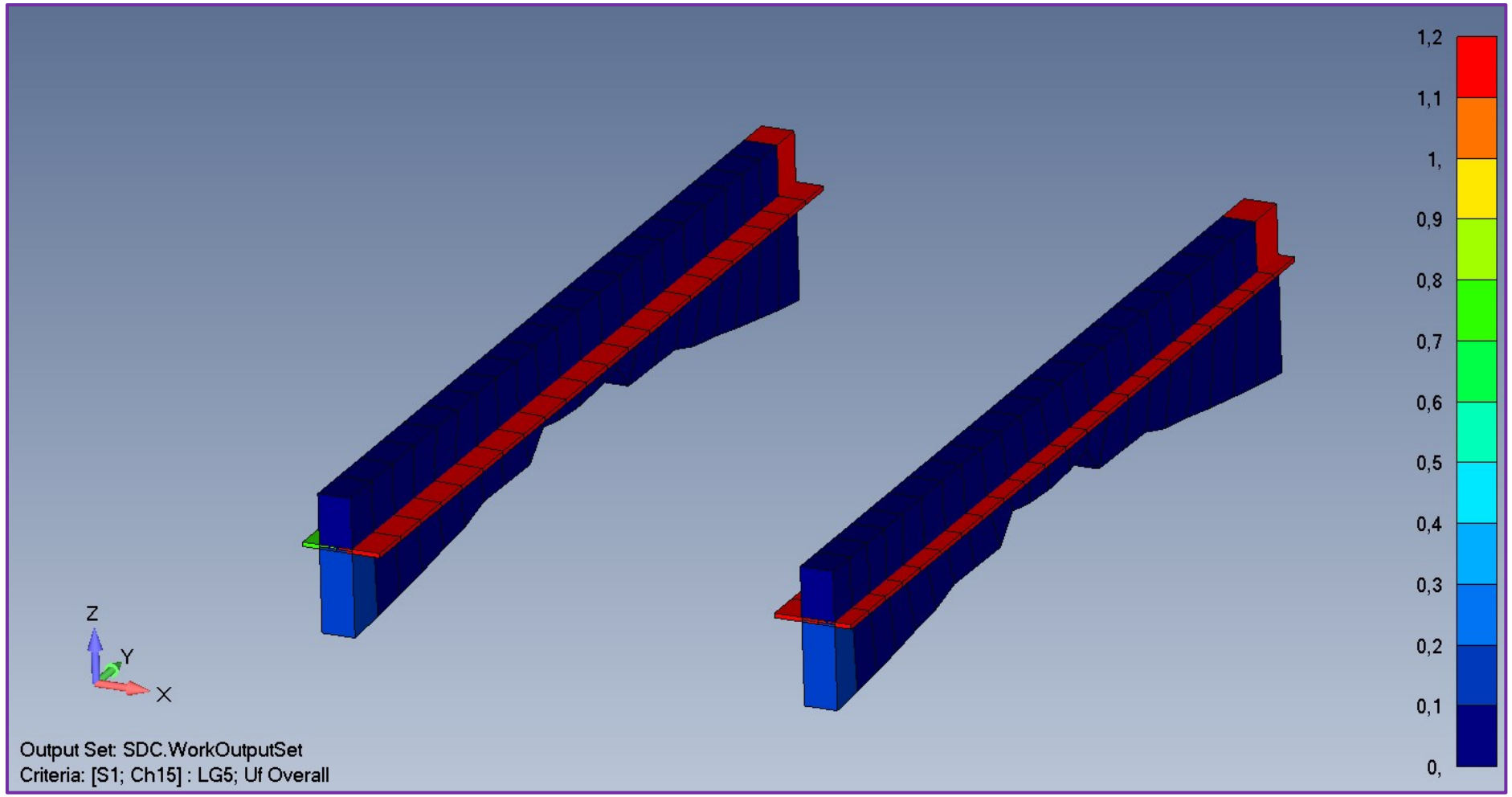




The members of Components have UF Overall value above 1. An Optimization Rule for these members will be created.

Eurocode3 Fatigue Criteria Plot for One Property(Continuation)

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



Optimization Tool and Optimization Rule. Theoretical Aspects

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;

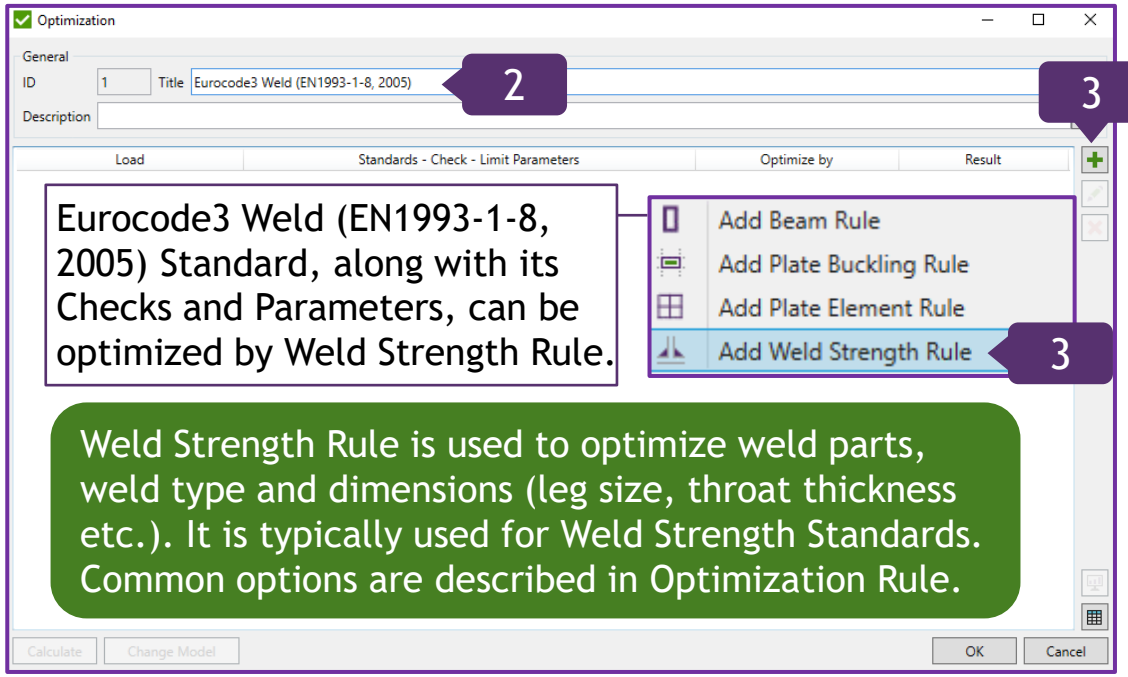
Plate Buckling Rule - plate buckling plate thickness, yield stress and young modulus can be optimized;

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

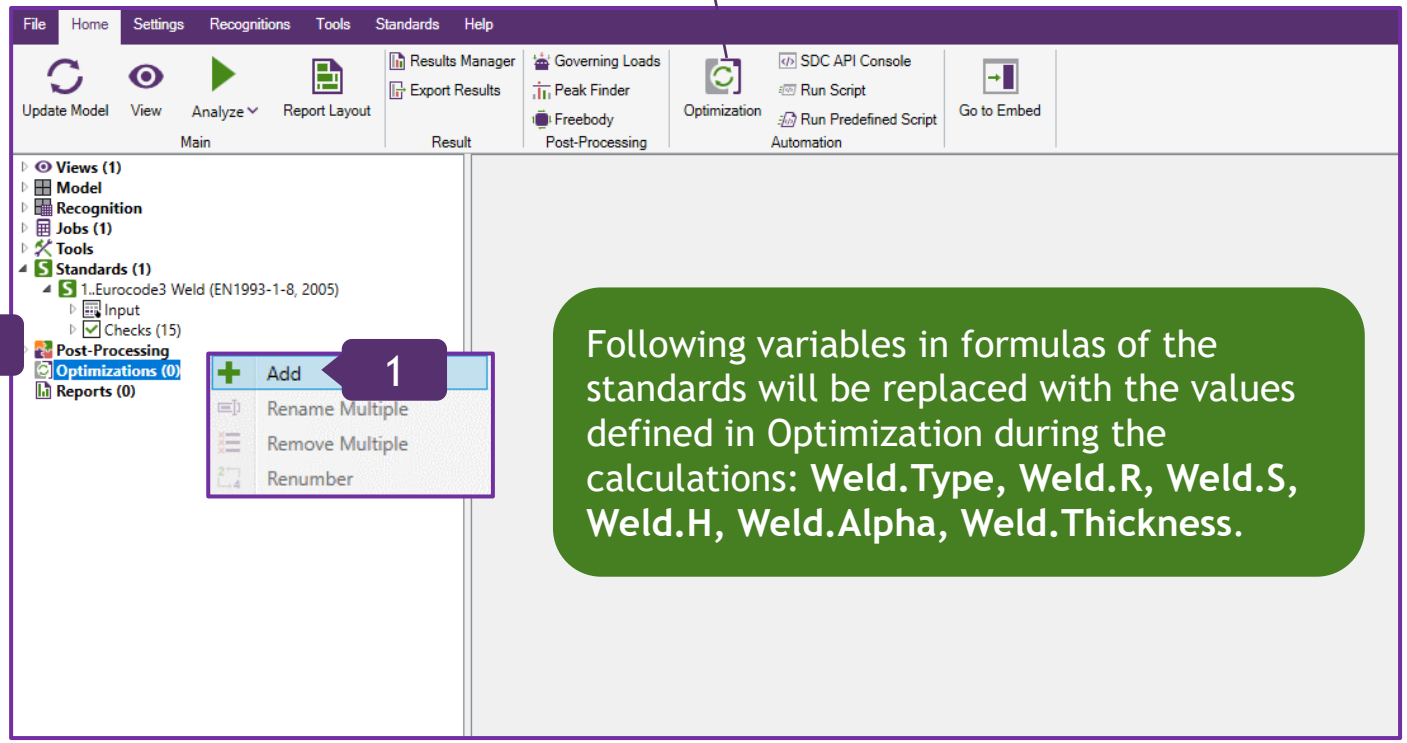
1. In the Model Tree, execute right click on *Optimizations* and select *Add*
2. Title: *Eurocode3 Weld (EN1993-1-8, 2005)*
3. Press + to create first *Optimization Rule*; Select *Add Weld Strength Rule*



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.

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

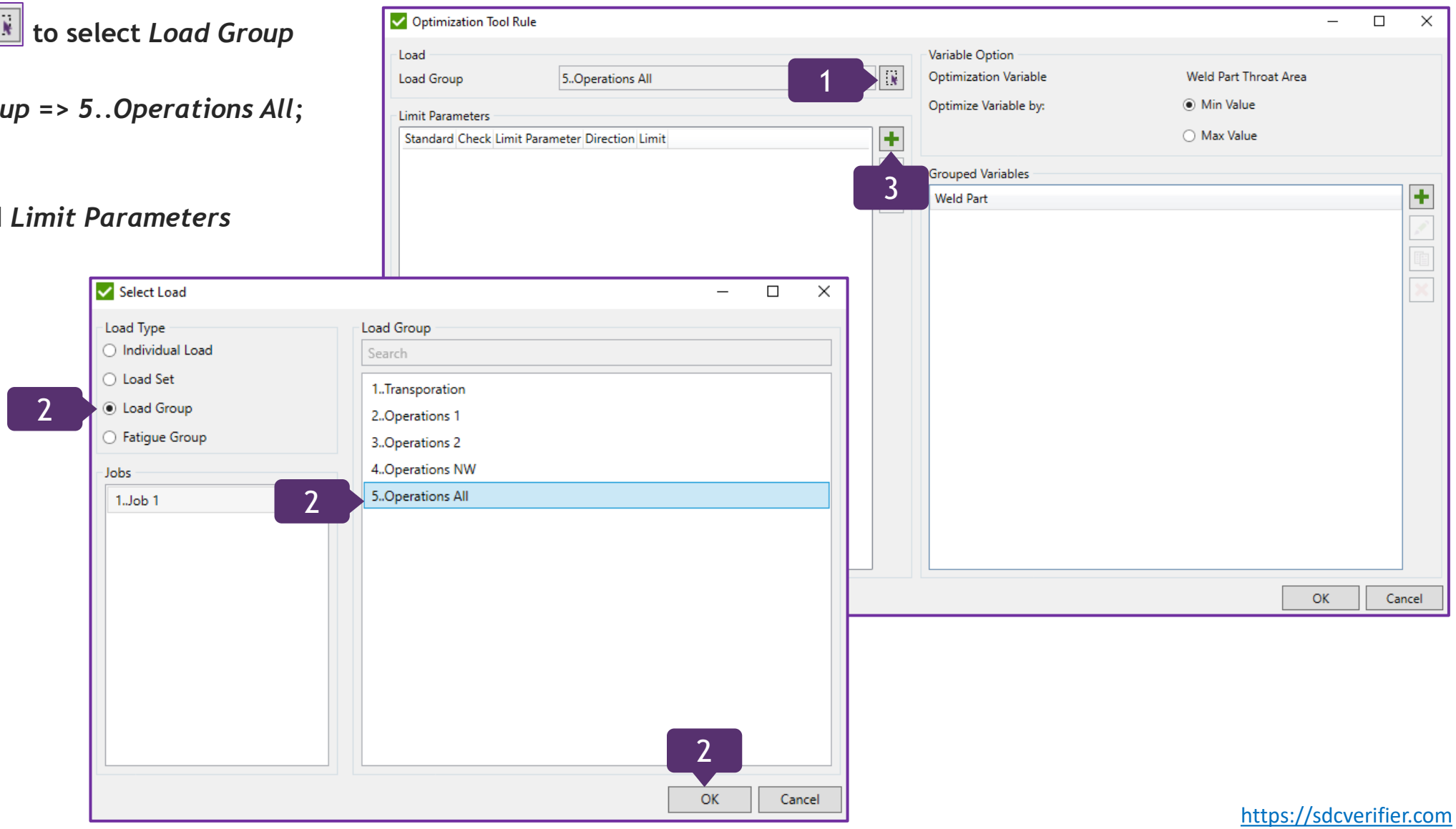


Following variables in formulas of the standards will be replaced with the values defined in Optimization during the calculations: **Weld.Type, Weld.R, Weld.S, Weld.H, Weld.Alpha, Weld.Thickness.**

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

Optimization Tool Rule. DNV Buckling Strength of Plated Structures

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*

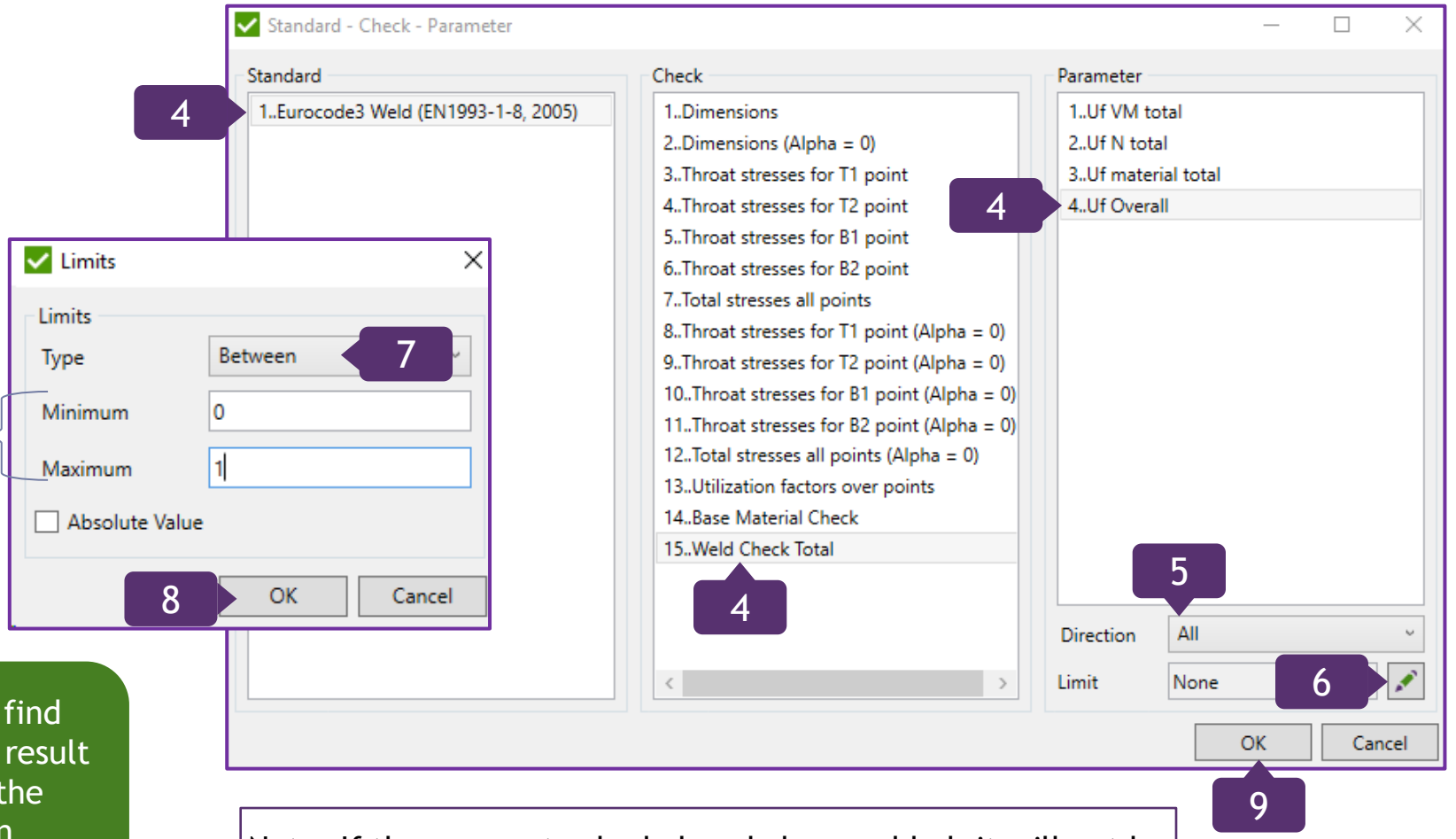
6 In Limit, press

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.

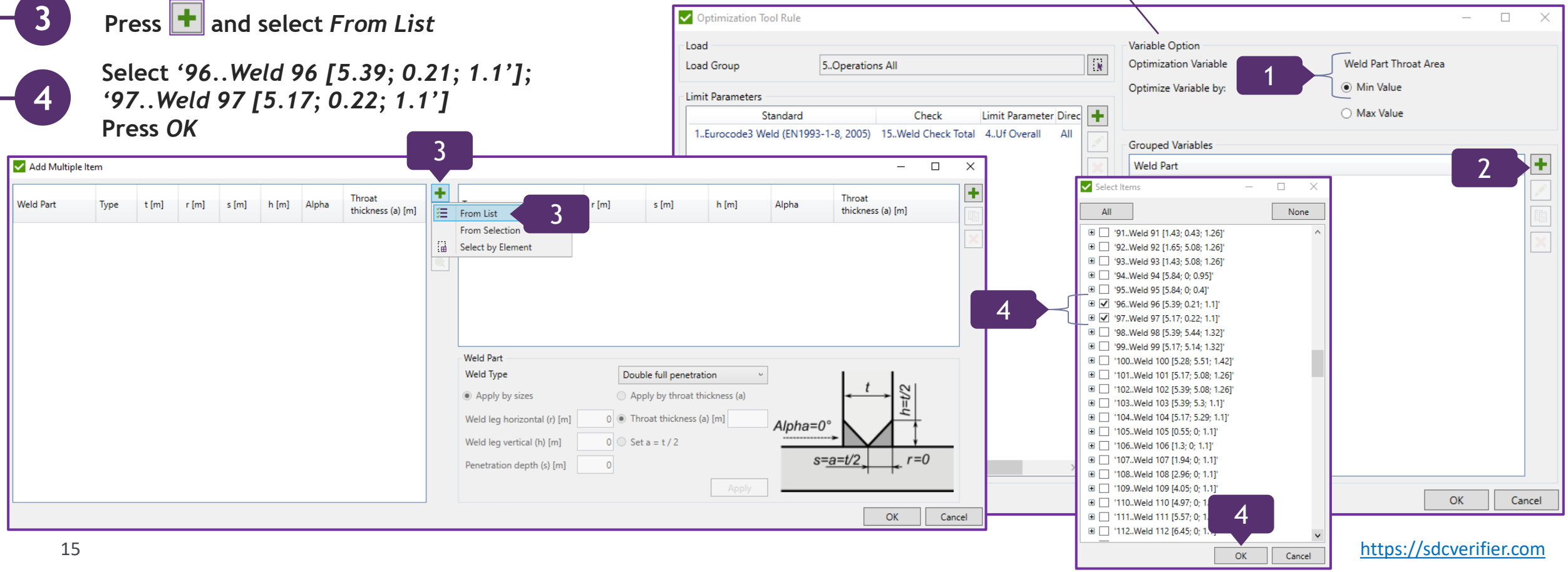
Note: If the parameter had already been added, it will not be shown in the list when adding other parameters.

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 *'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;

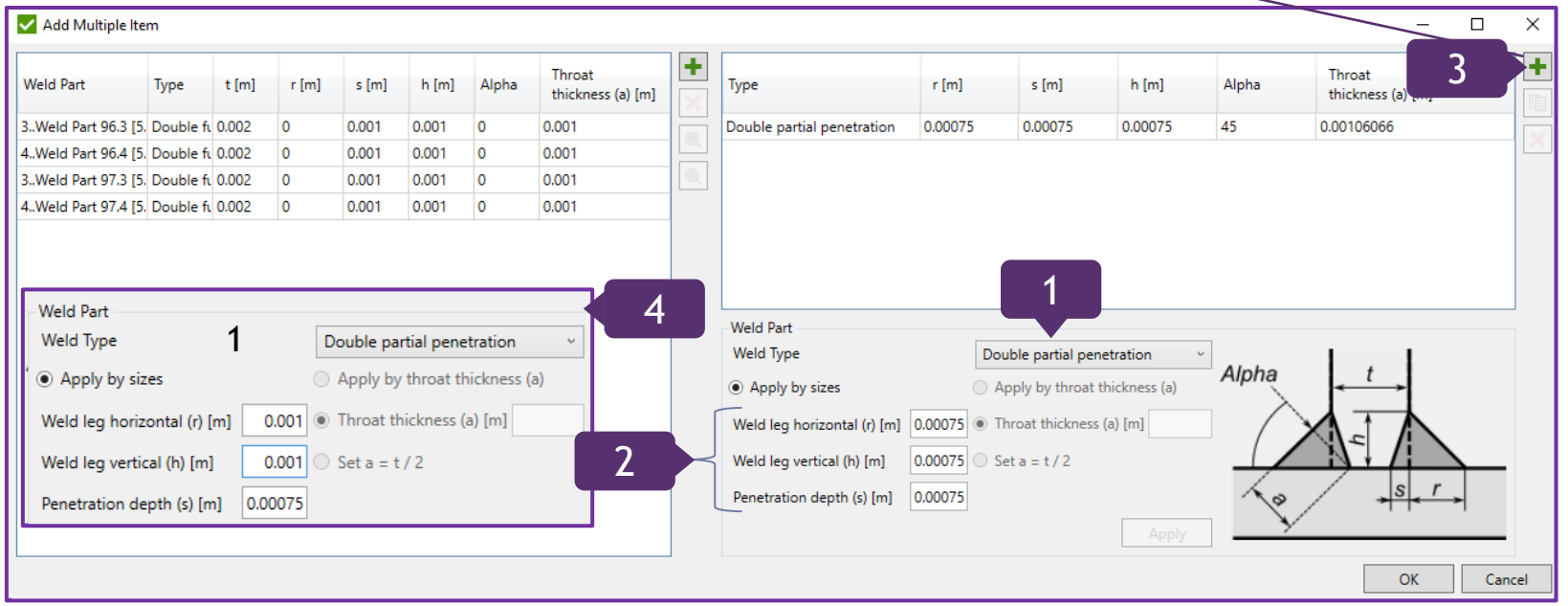
Optimize Variable by - find an optimal result based the on min/max value of the weld part throat. For example to optimize the weld according to the lowest material usage - select Min Value.

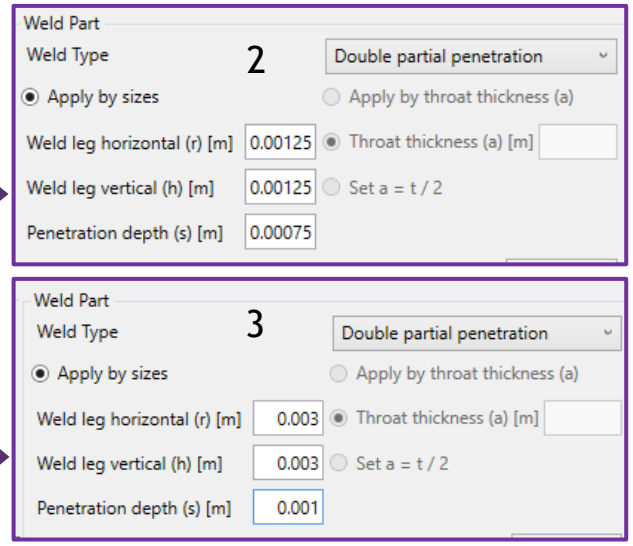


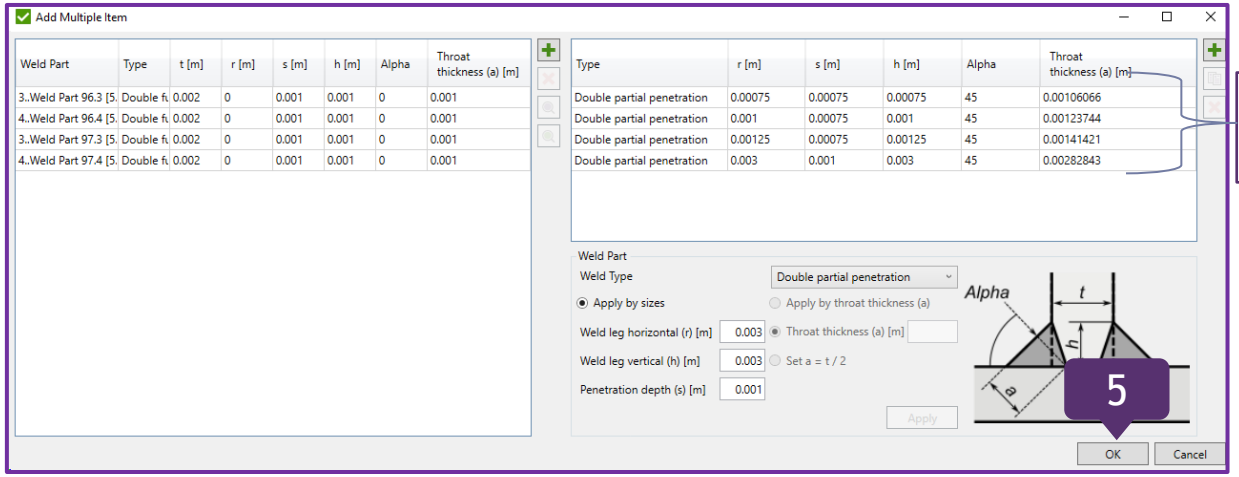
Add Multiple Item Part 2

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*

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



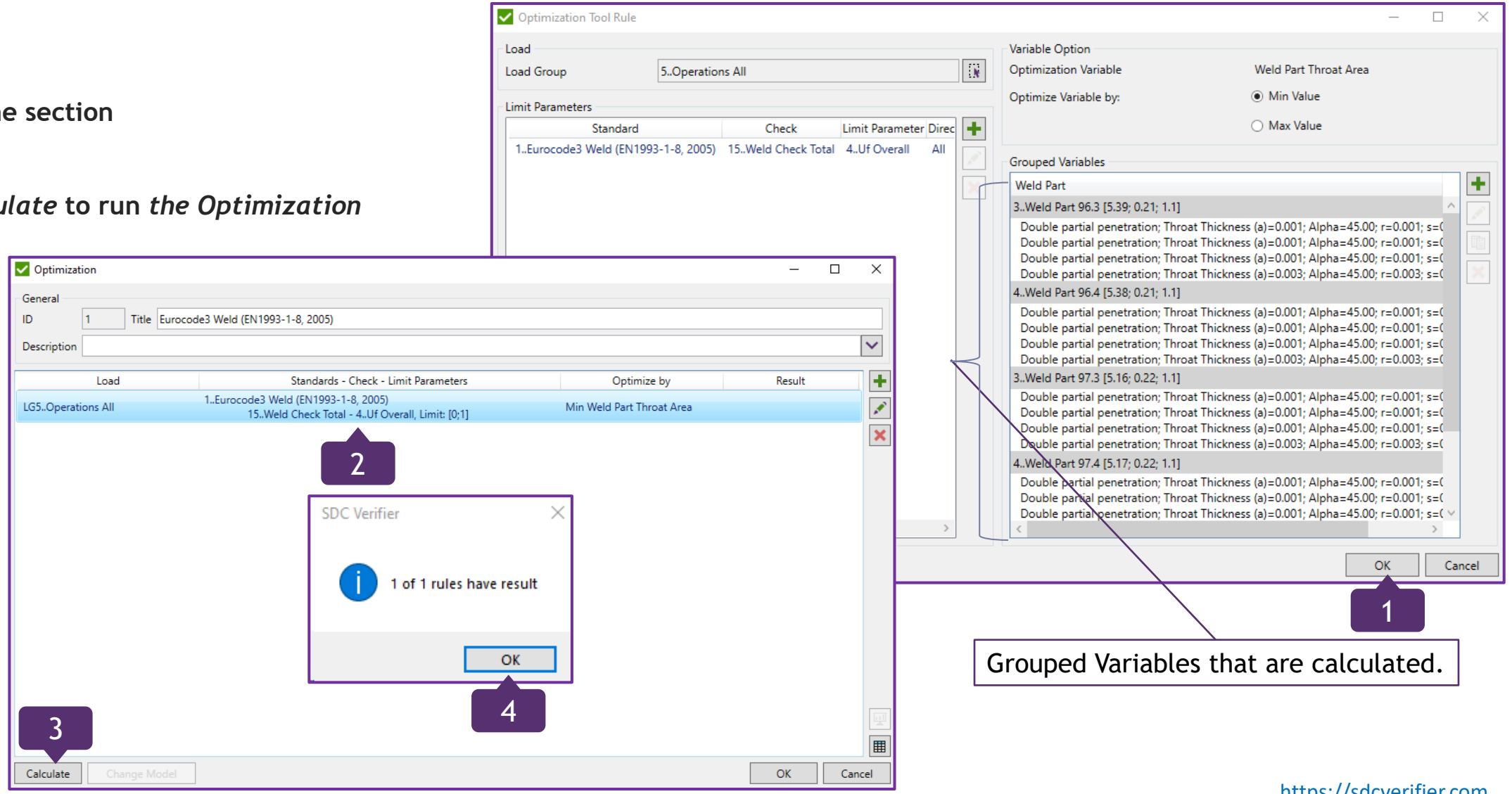




Total list of types, that will be calculated.

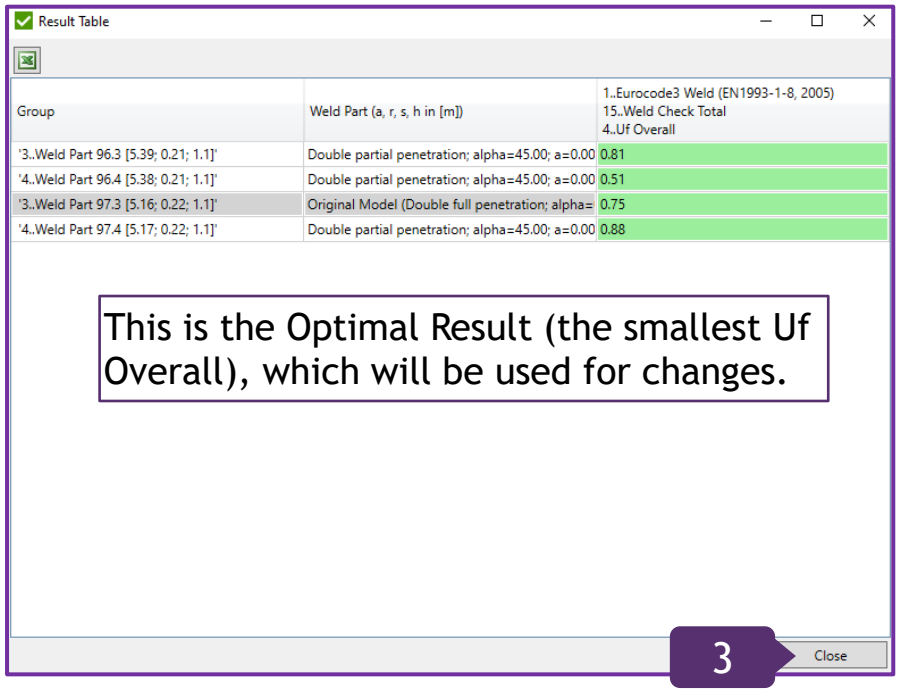
Selection of Grouped Variables; Calculation

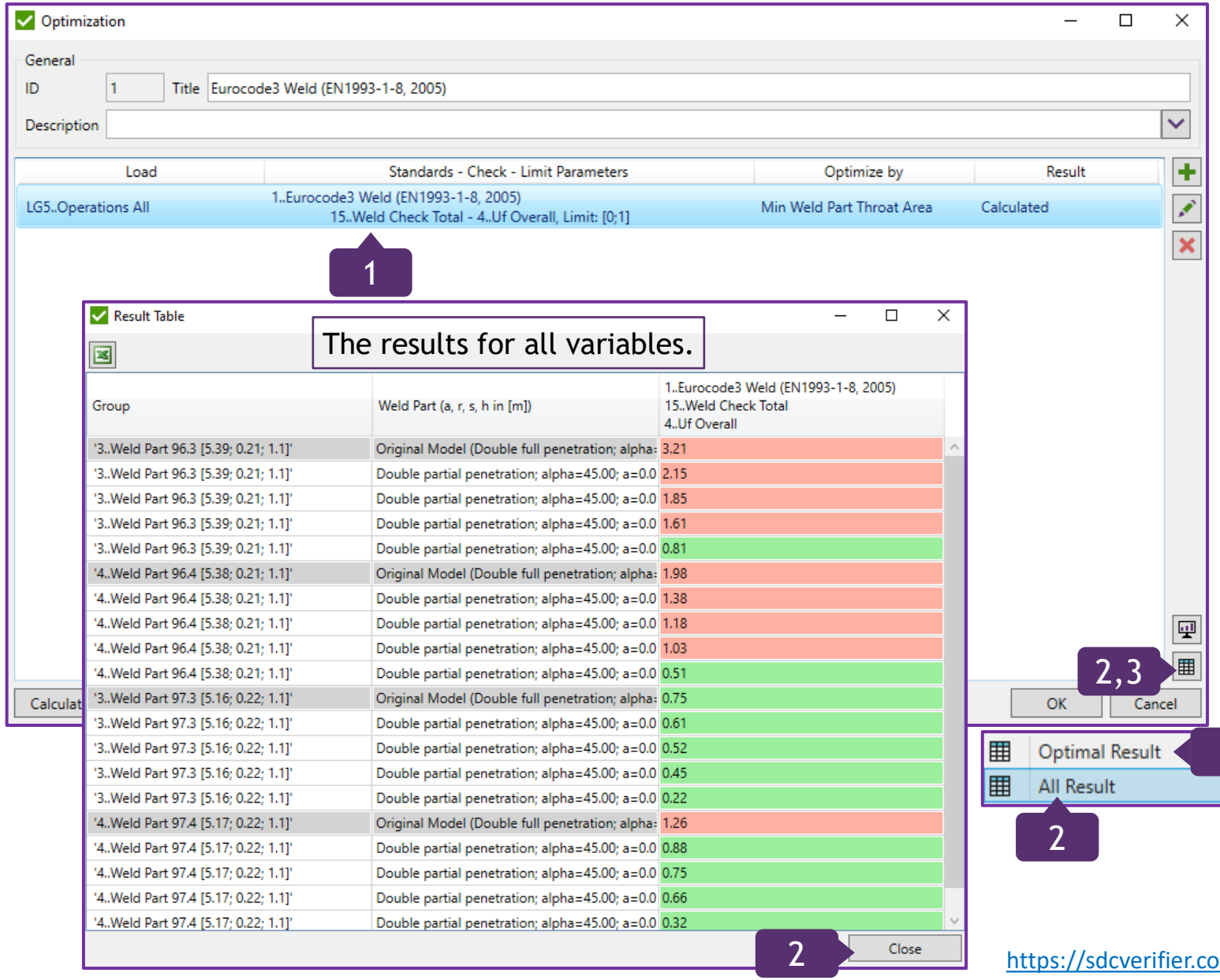
1. Press *OK*
2. Activate the section
3. Press *Calculate* to run *the Optimization*
4. Press *OK*



Optimization Results in a Table

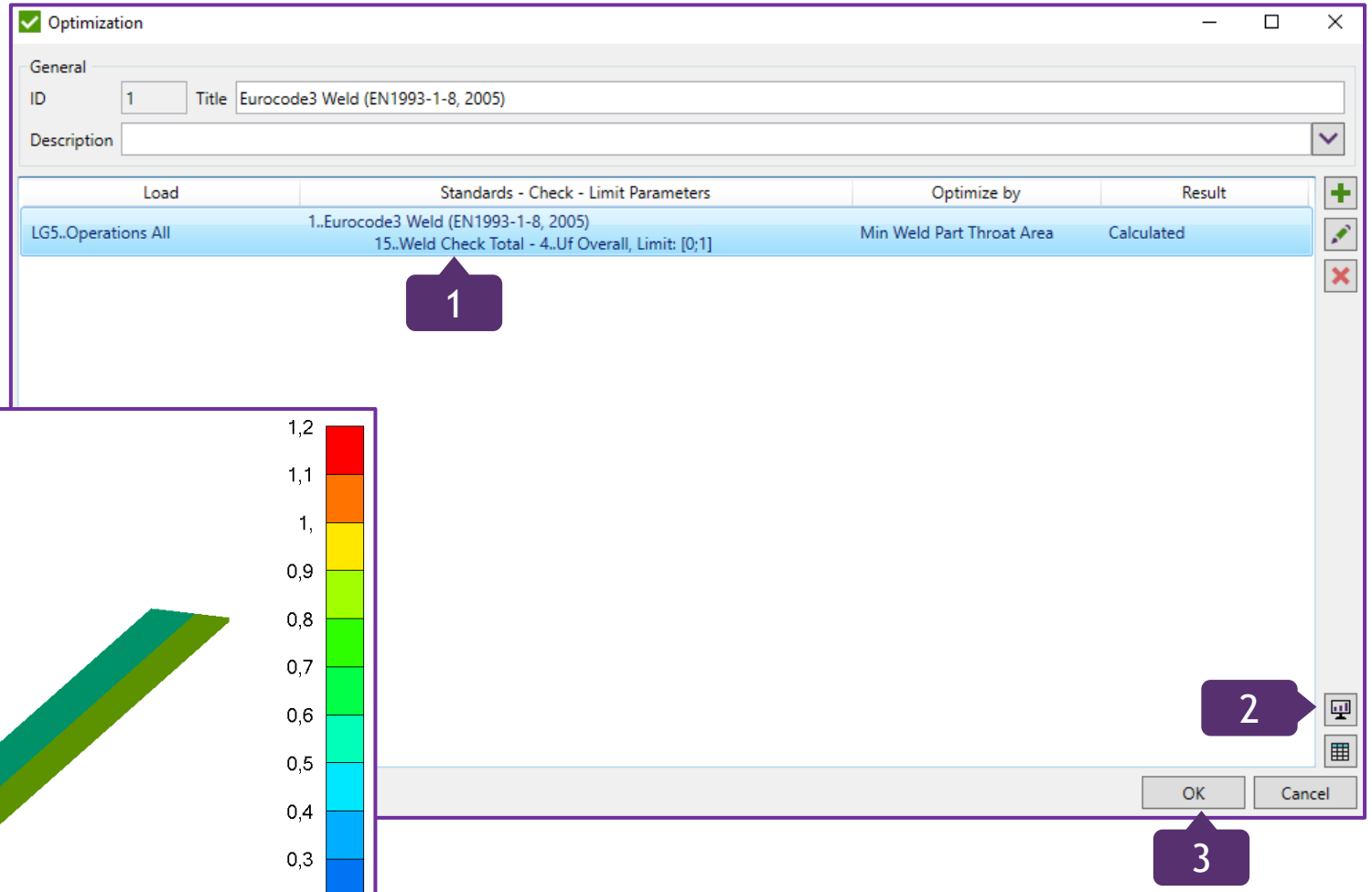
1. Activate the section
2. Press and select *All Results*; Press *Close*
3. Press and select Optimal Result; Press *Close*



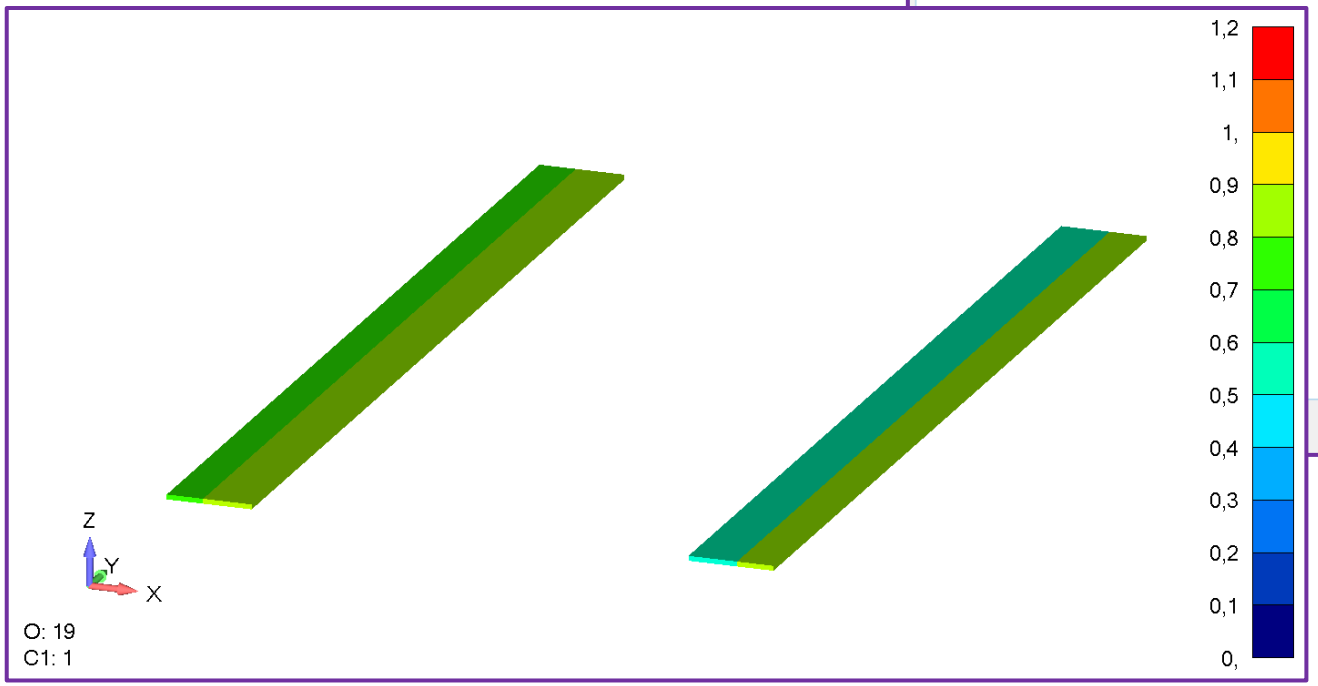


Plot Optimization Results

1. Activate the section
2. Press to plot optimal result on the model
3. Press *OK*



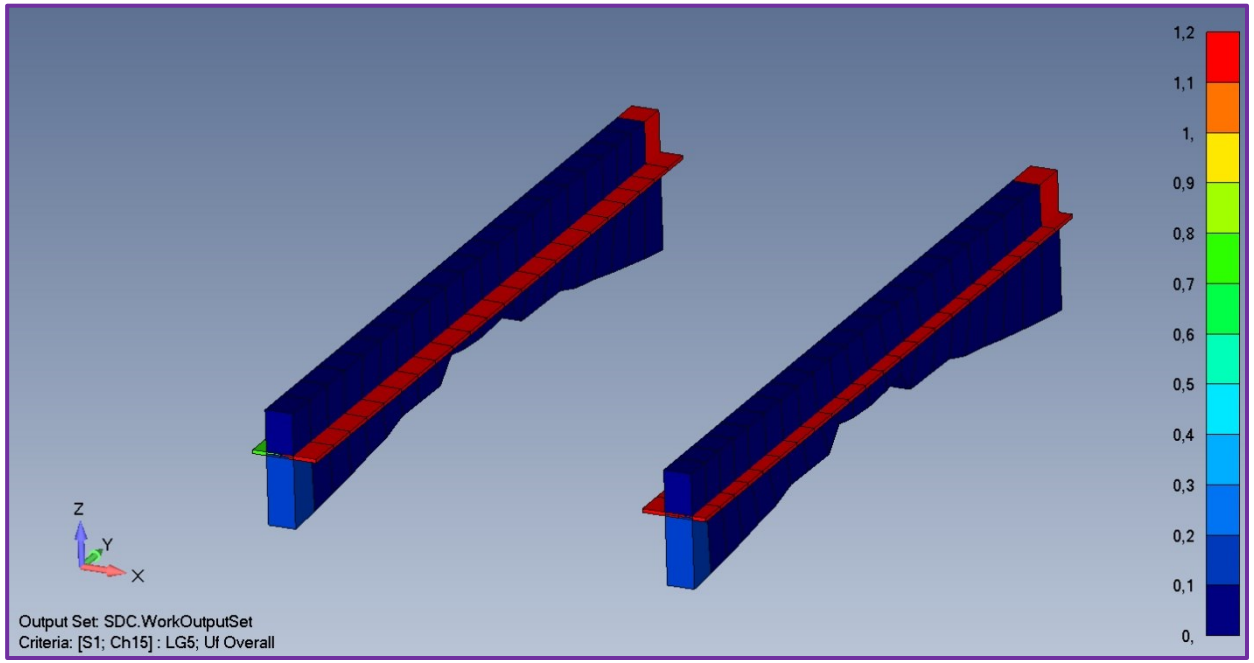
The Result



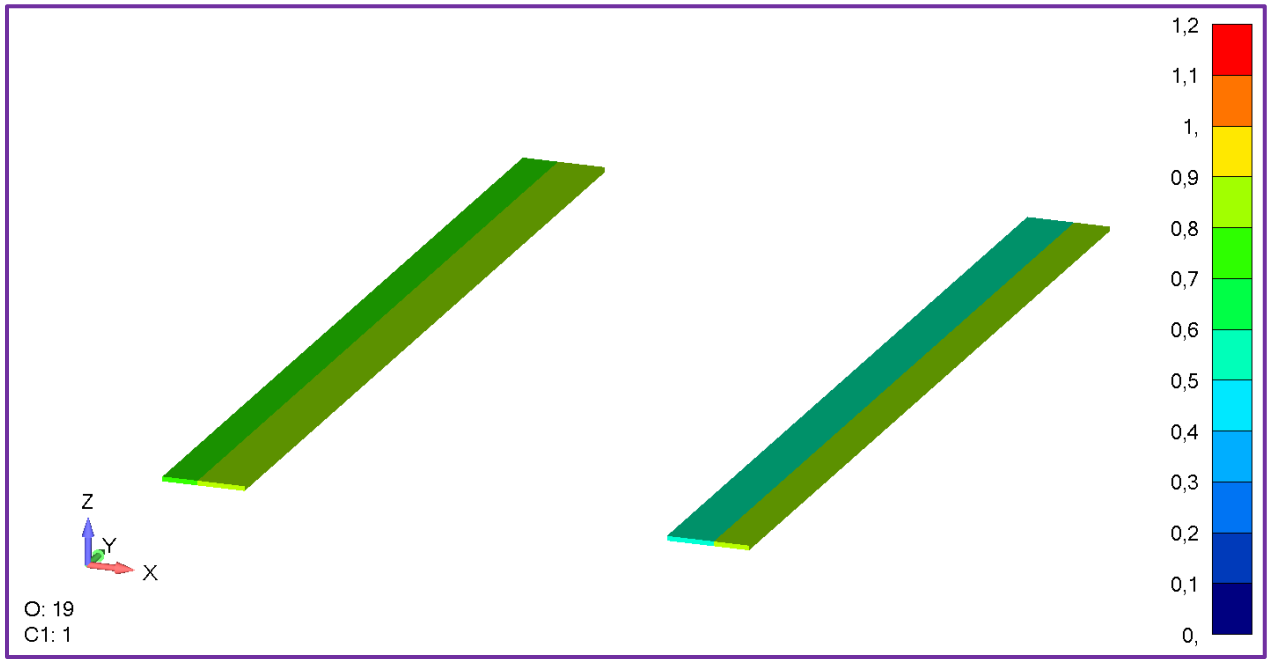
Compare the Results

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.

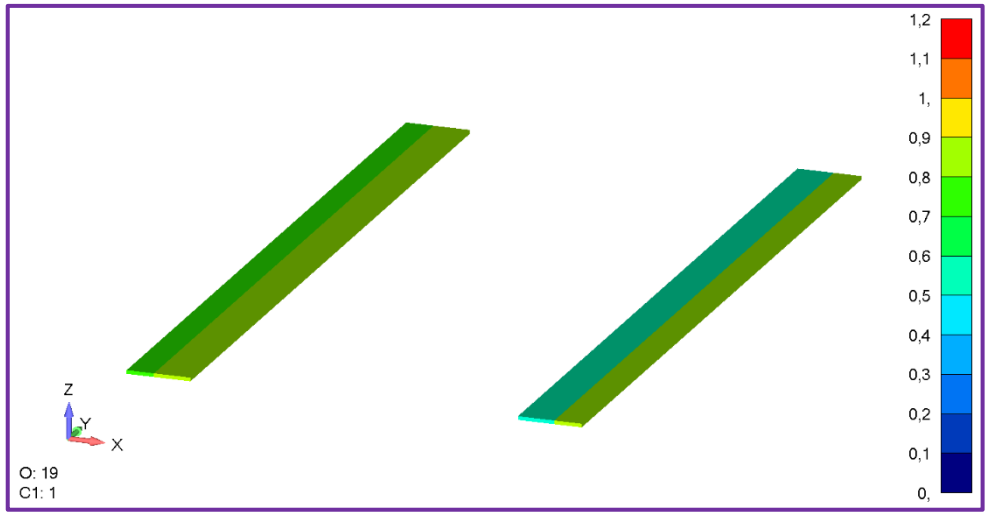
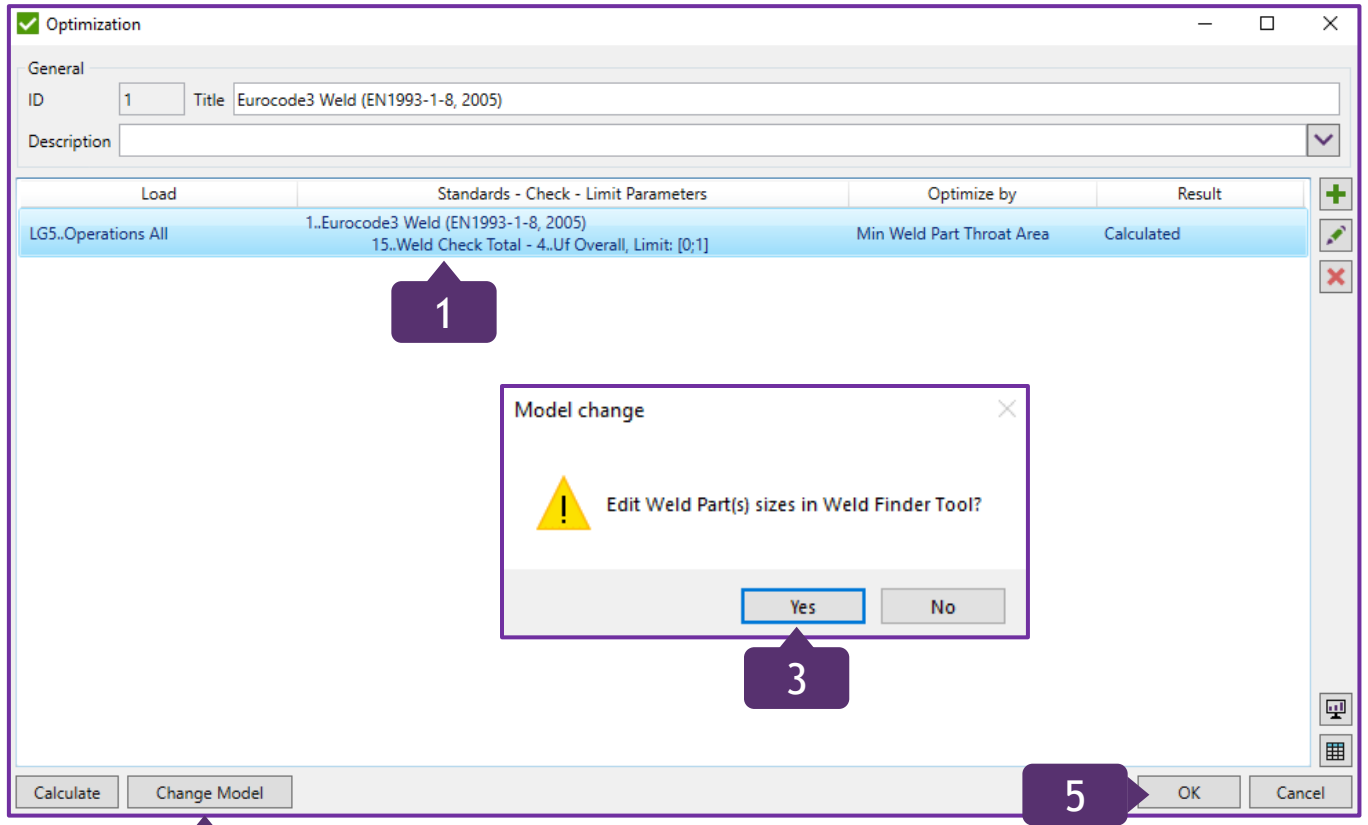
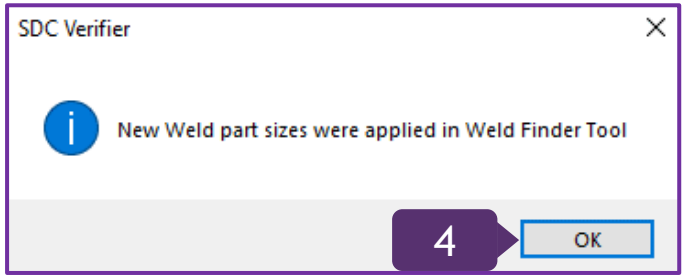
The Result before the Optimization.



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