



Tutorial

Eurocode3 Members (EN1993-1-1, 2005) Optimization. Beam Rule

Updated on: September 5th, 2024

Tested with: SDC for Ansys 2024 R2

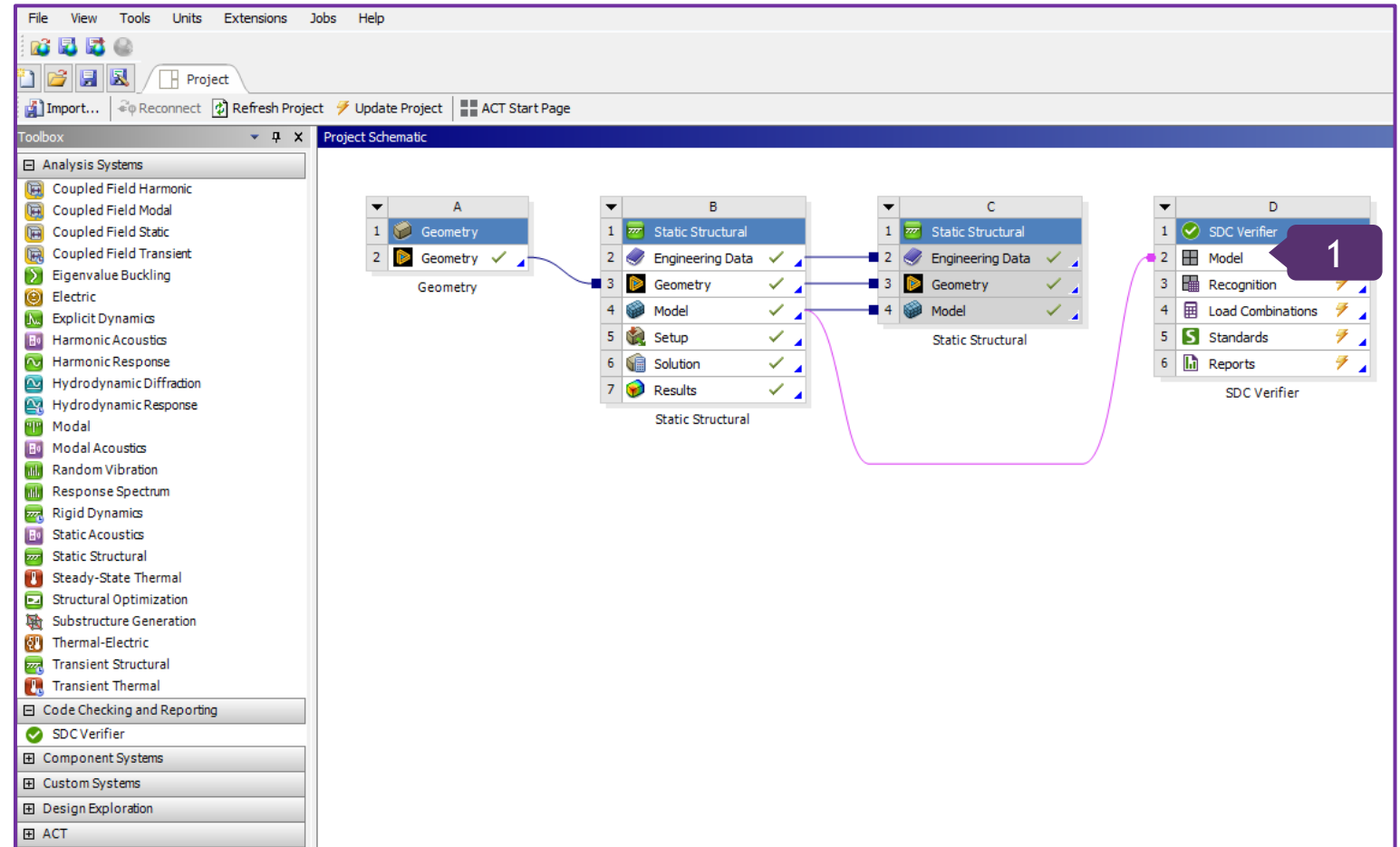
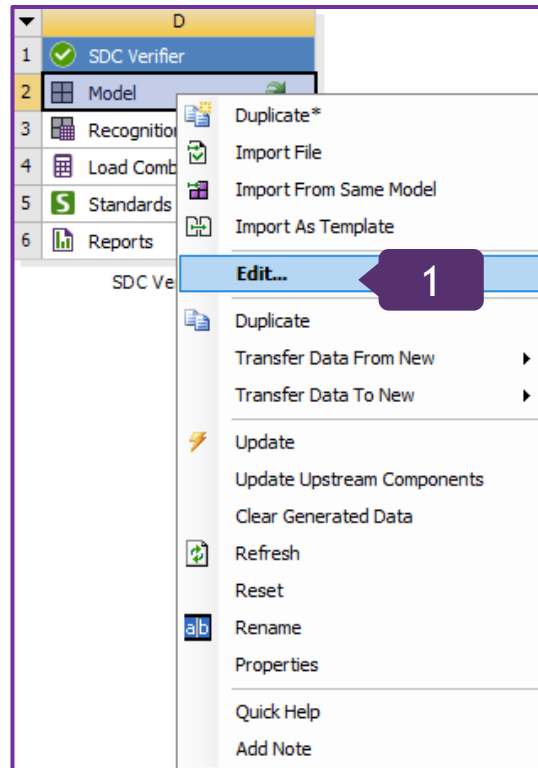
ANSYS Workbench 2024 R2

- This step-by-step tutorial demonstrates the functionality of SDC Verifier Optimization Tool, incorporating Beam Rule;
- Model members are Optimized based on Criteria Plot results;
- Shape Library Overview;
- Optimization Rules Overview;
- Optimization results in Tables and Plots;
- Results Comparison;
- Automatic Beam Cross-section Change
- The model change by adding Beam Properties
- Complete information on Optimization Tool may be found on our website via this link: [Optimization Tool | Help | SDC for Ansys \(sdcverifier.com\)](https://sdcverifier.com)

Open the Starter Model

1

Double Click or right click on  Model
If right click, in context menu press *Edit*

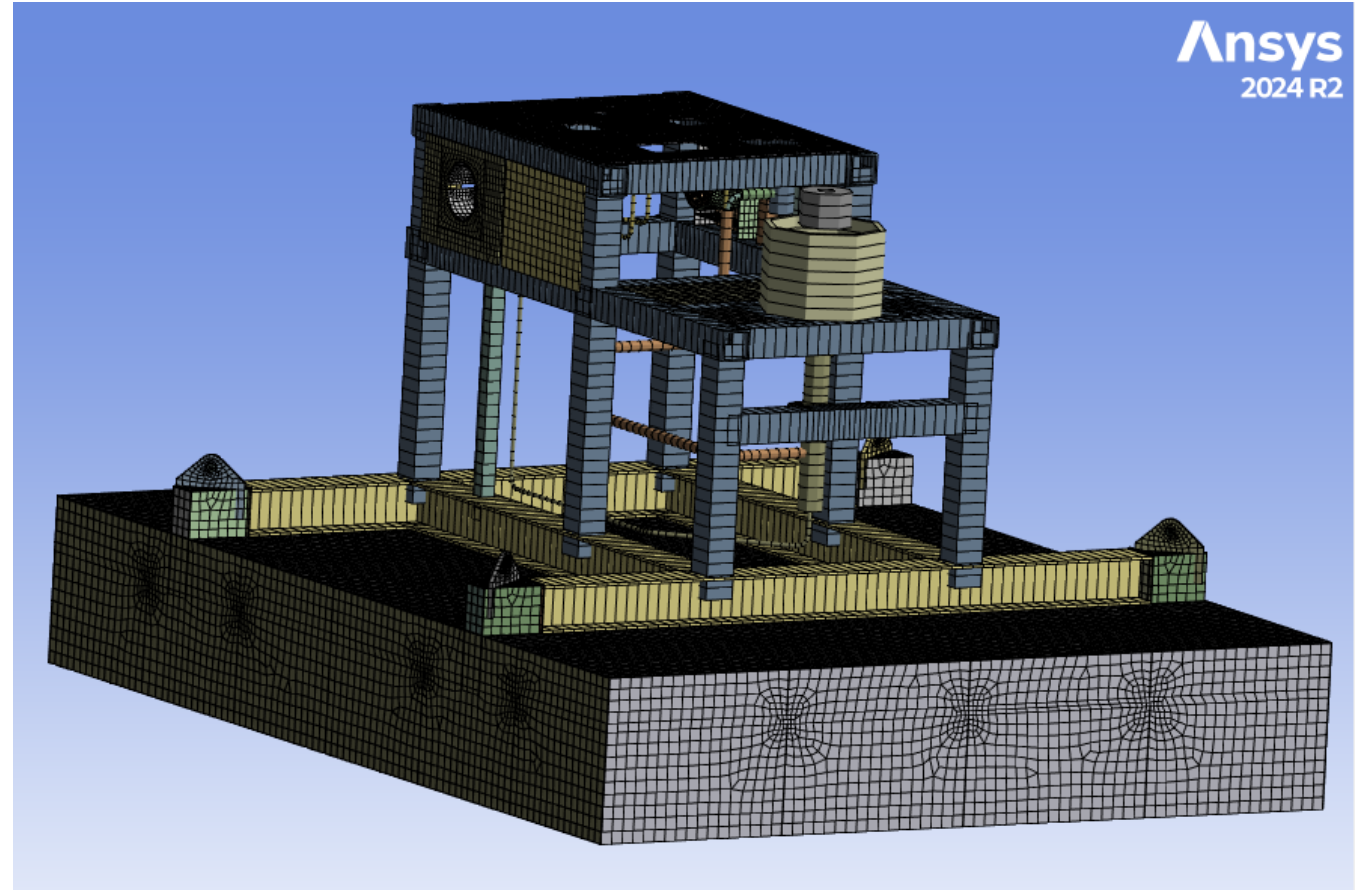


This tutorial uses a Project with predefined Individual Loads, Load Sets and Load Groups.

The model contains Plates, Beam elements and Welds.

Also, a relevant Standard has been previously added.

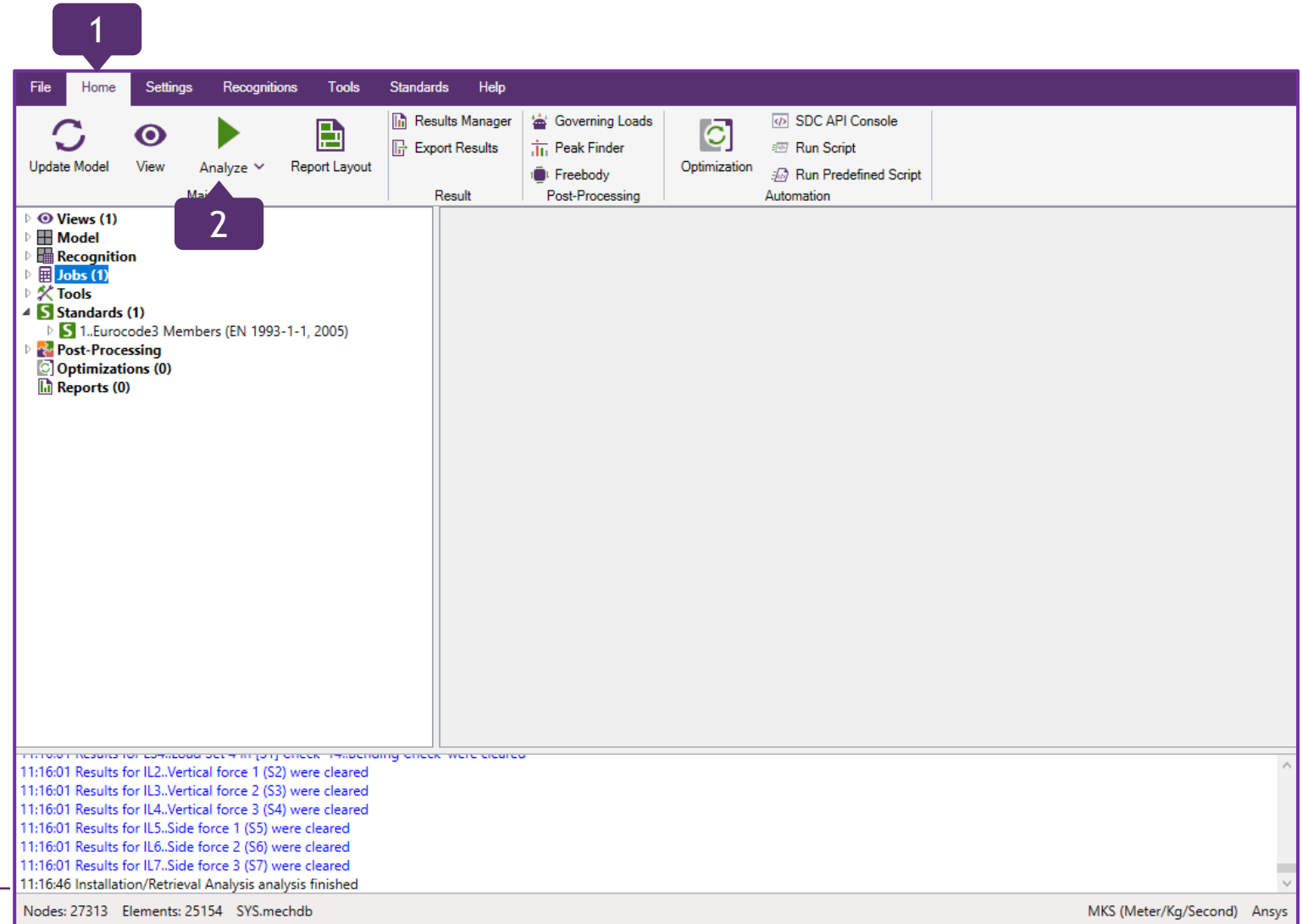
- Views (1)
 - 1..Default View
- Model
- Recognition
- Jobs (1)
 - 1..Installation/Retrieval
 - Individual Loads (7)
 - Predefined Load Cases (1)
 - Load Sets (12)
 - Load Groups (2)
 - FG Fatigue Groups (0)
 - Tables (0)
 - Plots (0)
- Tools
- Standards (1)
 - 1..Eurocode3 Members (EN 1993-1-1, 2005)
- 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/aisc-360-10/>

1 Go to *Home* section on the Ribbon

2 Press  on the toolbar to analyze Job



Installation/Retrieval Analysis analysis finished.

Eurocode3 Members Criteria Plot

1

Expand Standards => 3..Eurocode3 Members (EN1993-1-1, 2005) => Checks (22) and select 22. *Buckling and Overall*

2

Execute right click on 22. *Buckling and Overall* and select *Criteria Plot*

3

Press  to select Load Group

4

In Load Type, select Load Group, and then 2..*Envelope*; Press *OK*

5

Parameter: *Uf Overall*

6

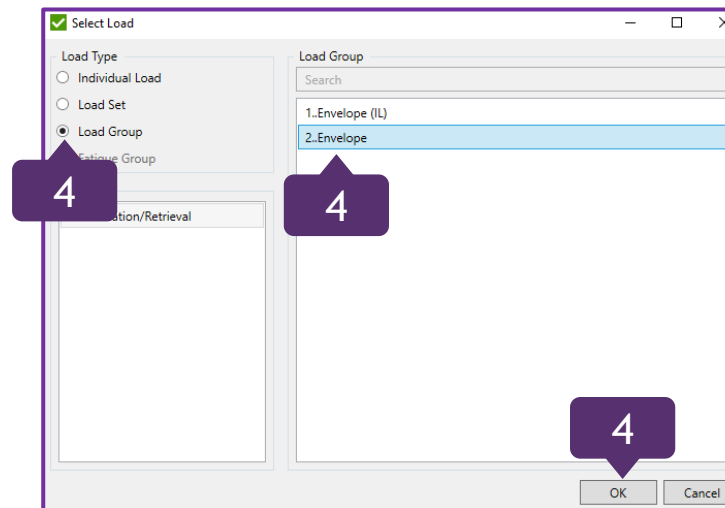
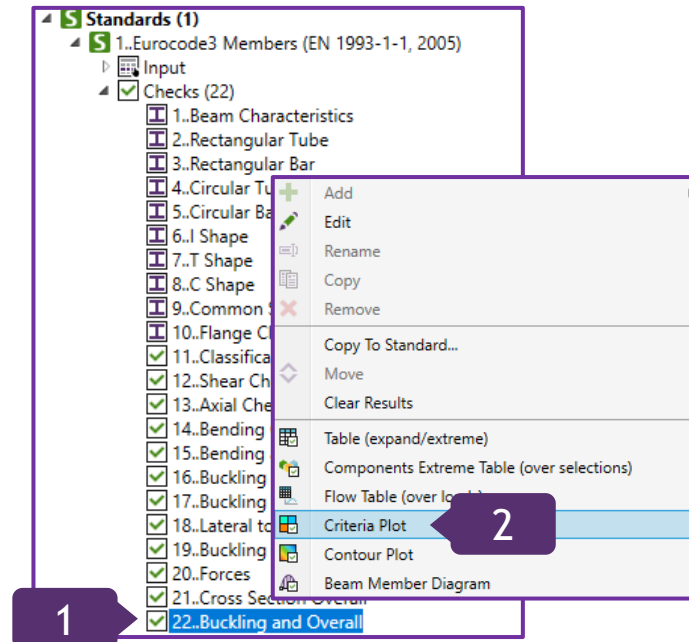
LG Parameter: *Absolute*

7

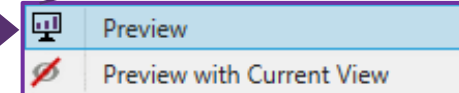
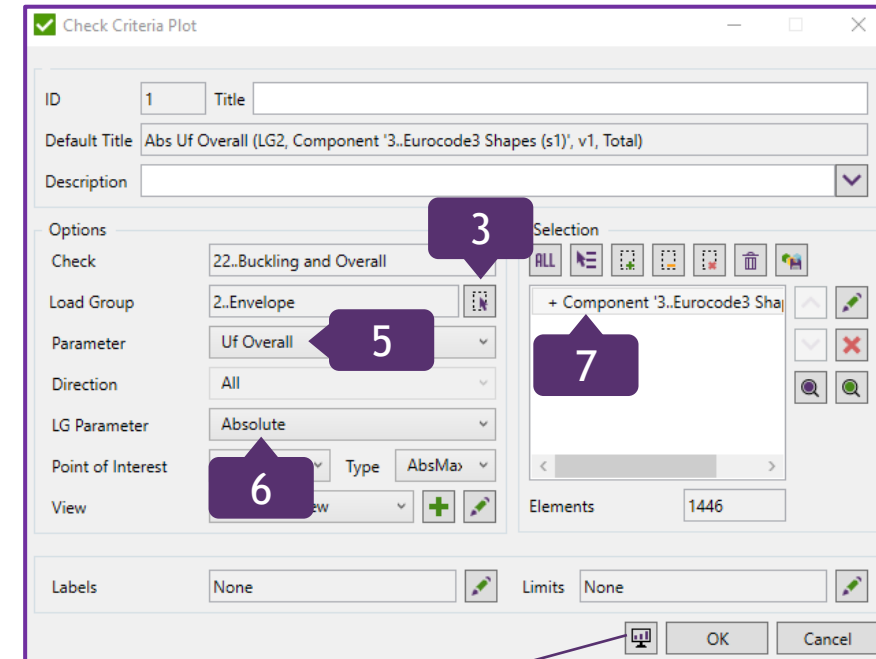
Selection: + *Component '3..Eurocode3 Shapes (s1)'*

8

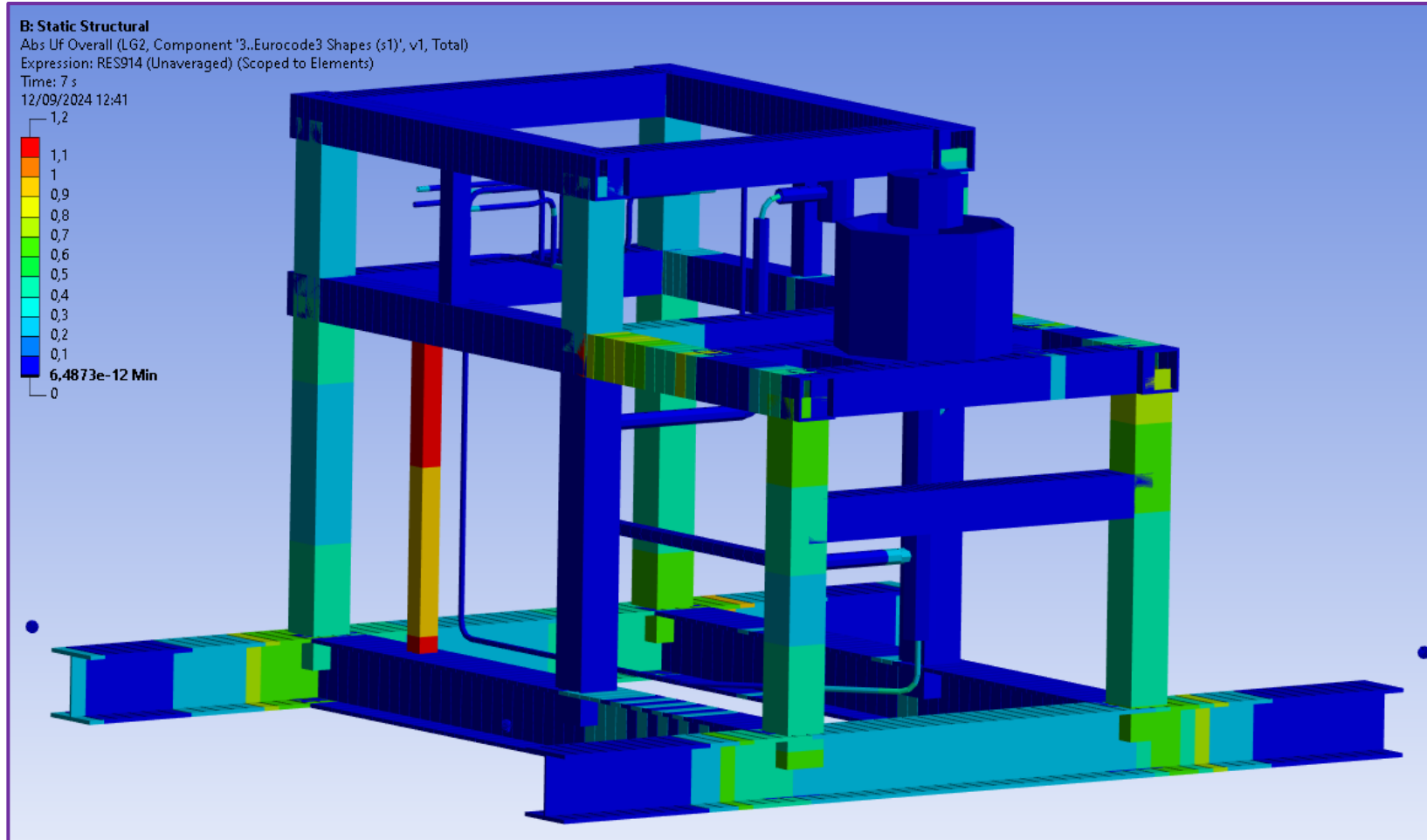
Press  and then *Preview*



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



The Plot has been created to see the UF Overall on Beam members.
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. The settings of Check Criteria Plot from Slide 6 should remain the same.

1

In Limits, press



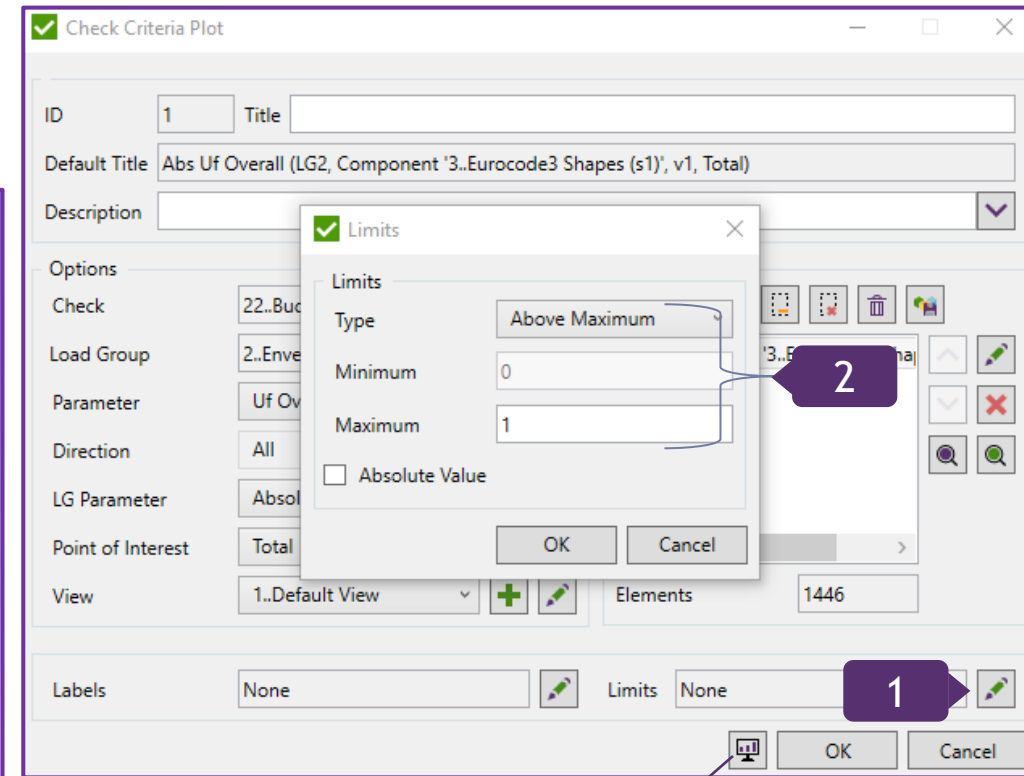
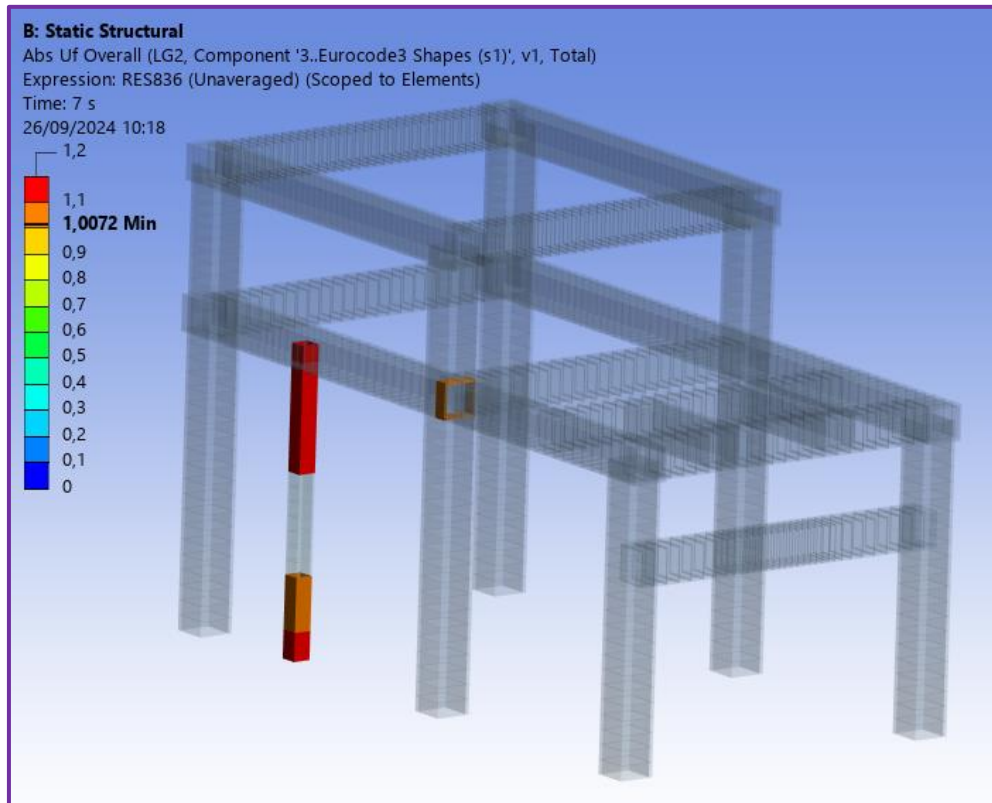
2

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

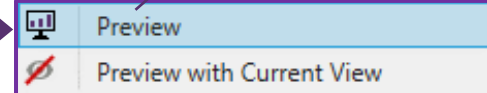
3

Press  and then *Preview*

The Result



3



Eurocode3 Members Criteria Plot for One Property

1

Select + Component '3..Eurocode3 Shapes (s8)' and press  to remove it

2

Press  to add Condition;
Select *Properties*

3

Select 3..Rectangular Tube 100x100x8;
Press OK

4

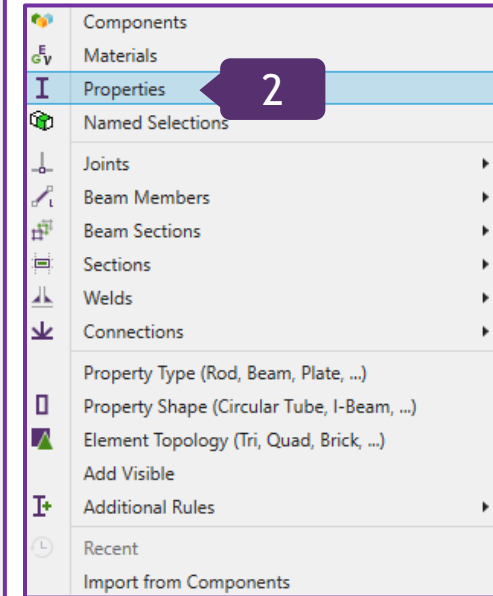
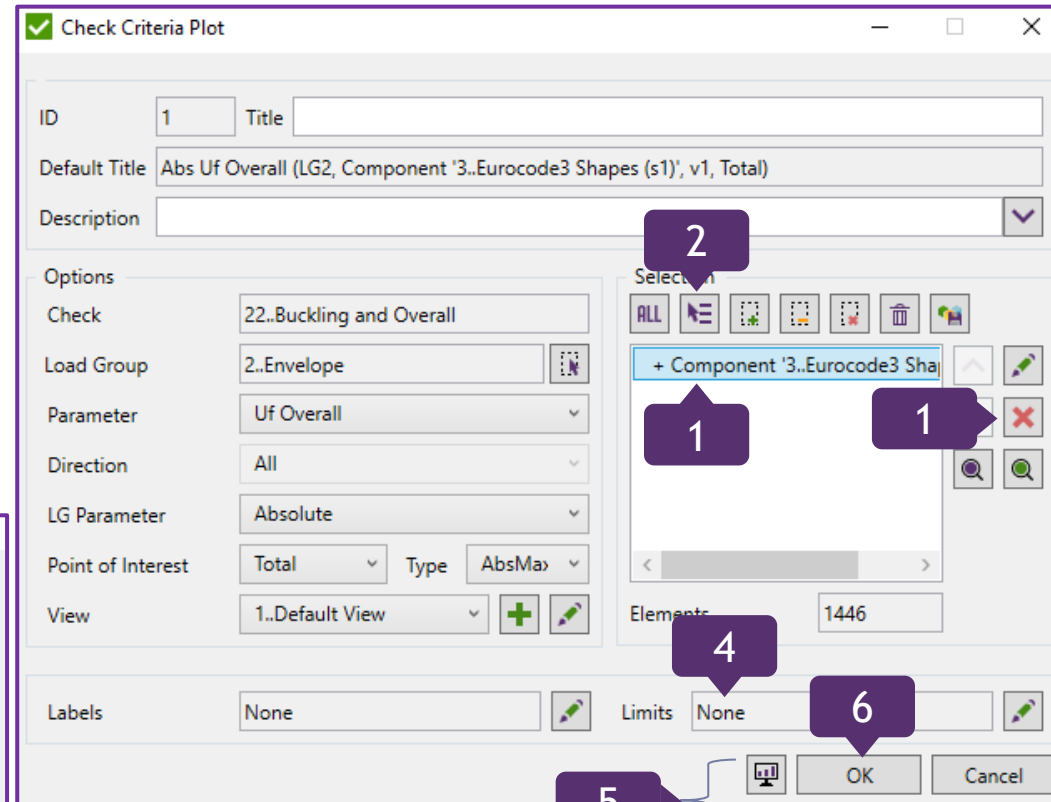
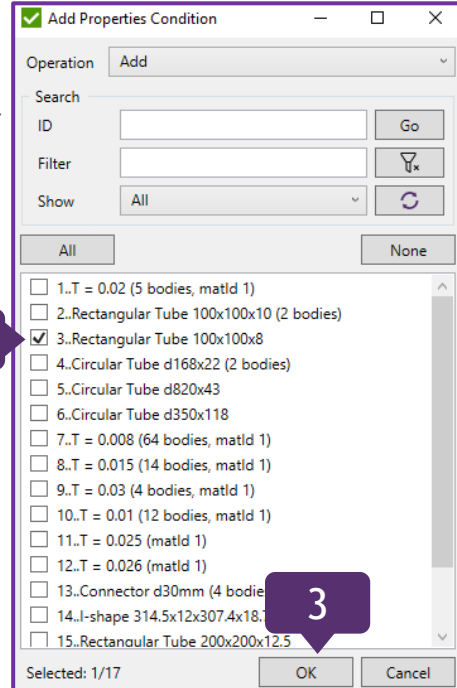
Limits: *None*

5

Press  and then *Preview*

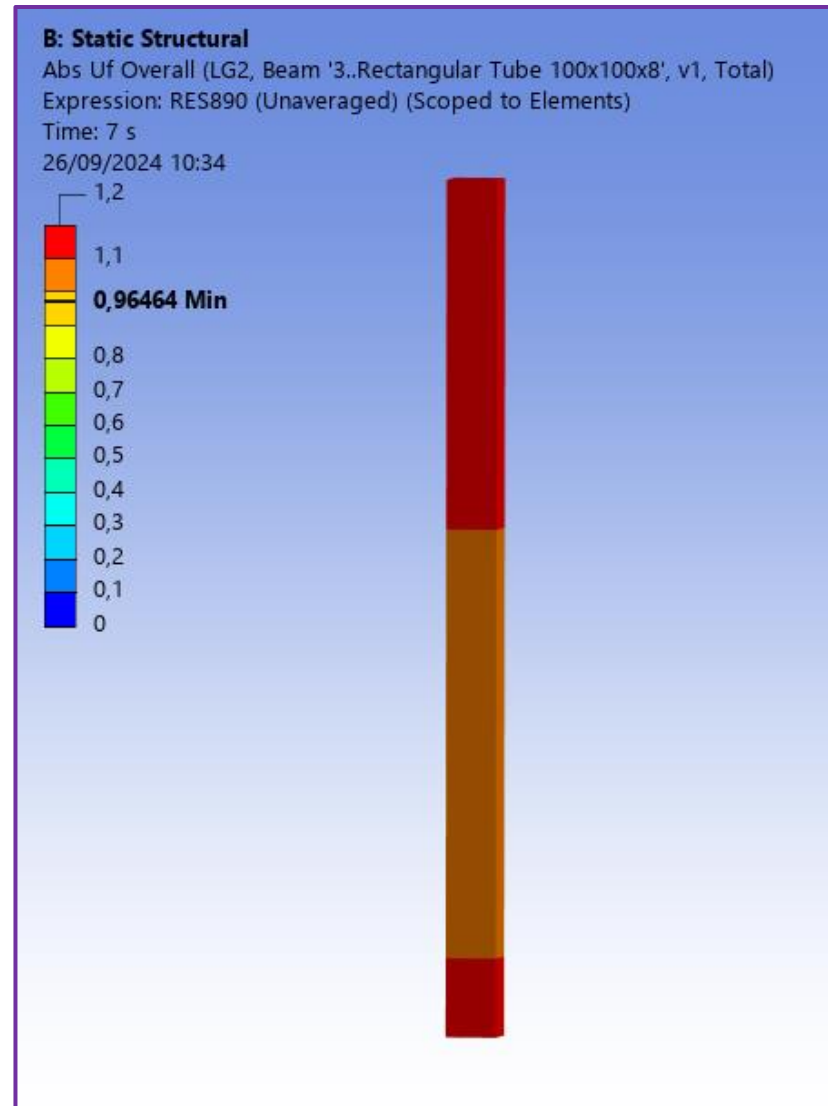
6

Press OK



The member of 3..Rectangular Tube 100x100x8 Property has UF Overall value above 1.
An Optimization Rule for this member will be created.

The Plot has been created to see the UF 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.

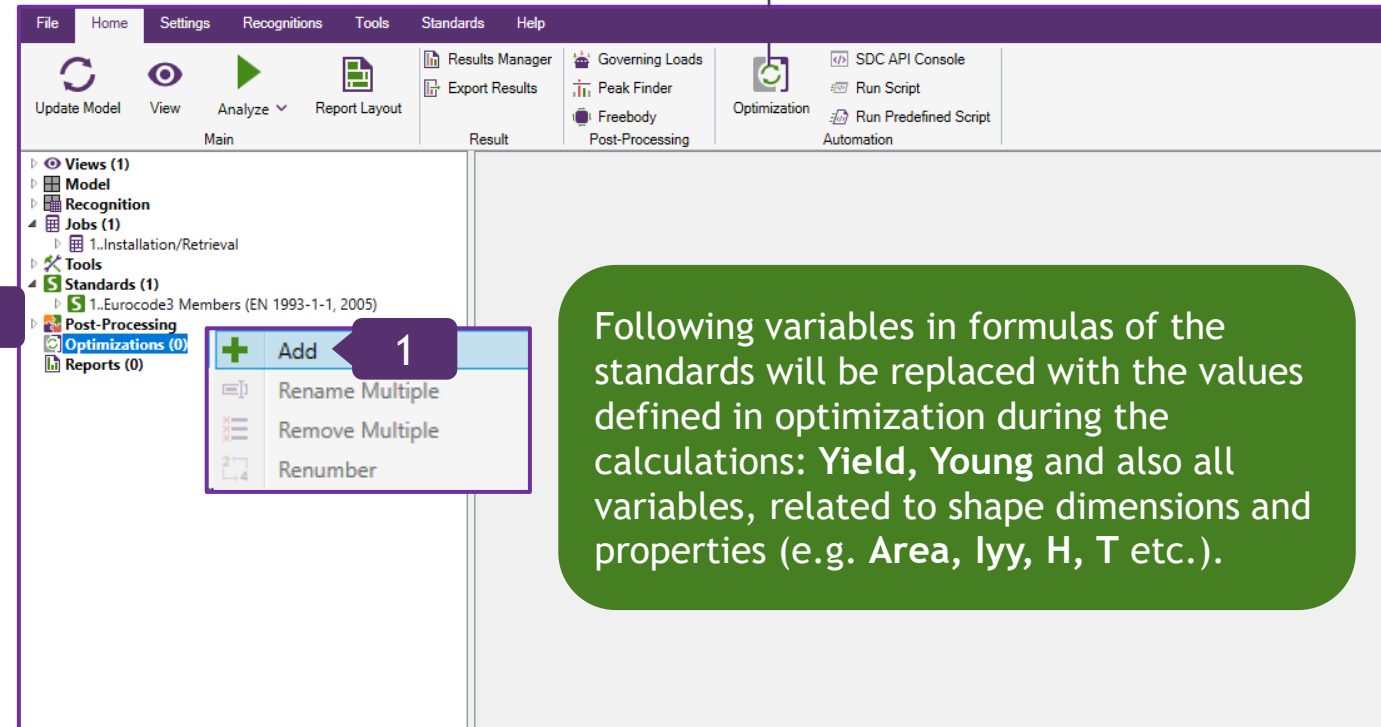
Create Optimization Rule

1 In the Model Tree, execute right click on *Optimization* and select *Add*

2 Title: *Eurocode3 Members Optimization*

3 Press  to create first *Optimization Rule*; Select *Add Beam Rule*

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



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

Beam Rule is used to optimize beam/bar element cross section, Yield Stress and/or Young Modulus. It is typically used for Beam Buckling Standards.

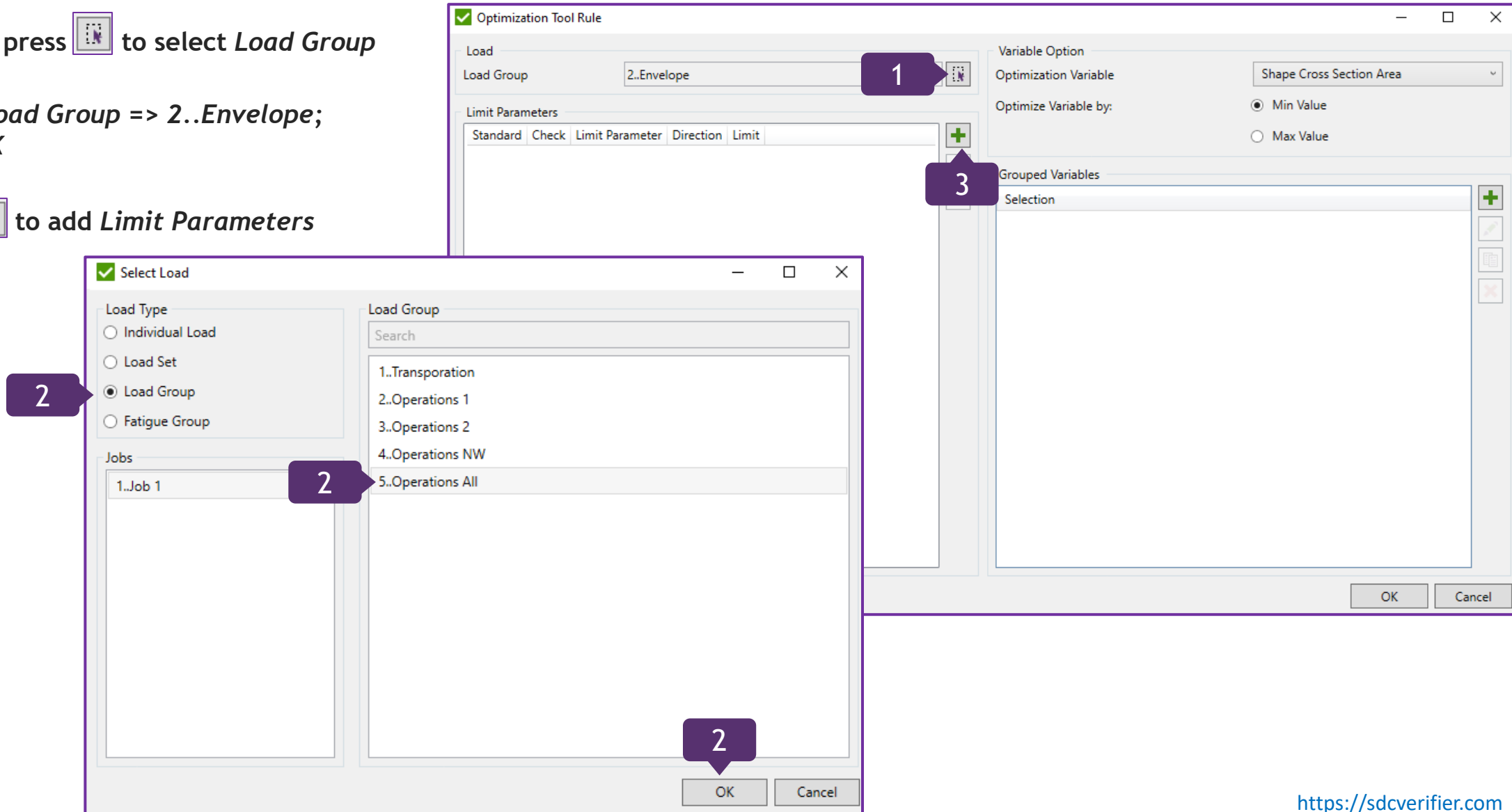
Note: If there are multiple Standards, calculated in the SDC Verifier Project, all of them will be listed in Select Limit Parameters.

Optimization Tool Rule. Eurocode3 Members

1 In Load, press  to select *Load Group*

2 Select *Load Group* => *2..Envelope*;
Press *OK*

3 Press  to add *Limit Parameters*



The screenshot shows the 'Optimization Tool Rule' dialog box. The 'Load' section has 'Load Group' set to '2..Envelope', with callout 1 pointing to the selection icon. The 'Limit Parameters' table is empty, with callout 3 pointing to the '+' button to add parameters. The 'Variable Option' section shows 'Optimization Variable' as 'Shape Cross Section Area' and 'Optimize Variable by' set to 'Min Value'. The 'Grouped Variables' section is empty. Below this, the 'Select Load' dialog box is open, showing 'Load Type' with 'Load Group' selected (callout 2), 'Jobs' with '1..Job 1' selected, and 'Load Group' with '2..Envelope' selected (callout 2). The 'OK' button in the 'Select Load' dialog is also labeled with callout 2.

Optimization Tool Rule. Eurocode3 Members (Continuation)

4

Standard: 3..*Eurocode3 Members (EN1993)-1-1, 2005*);
Check: 22..*Buckling and Overall*;
Parameter: 7..*Uf Overall*

5

In Limit, press 

6

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

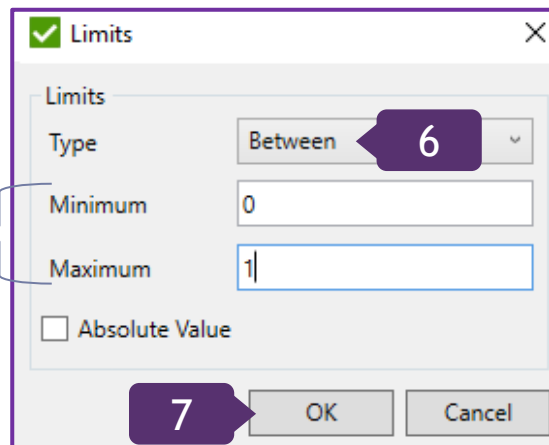
7

Press OK

8

Press OK

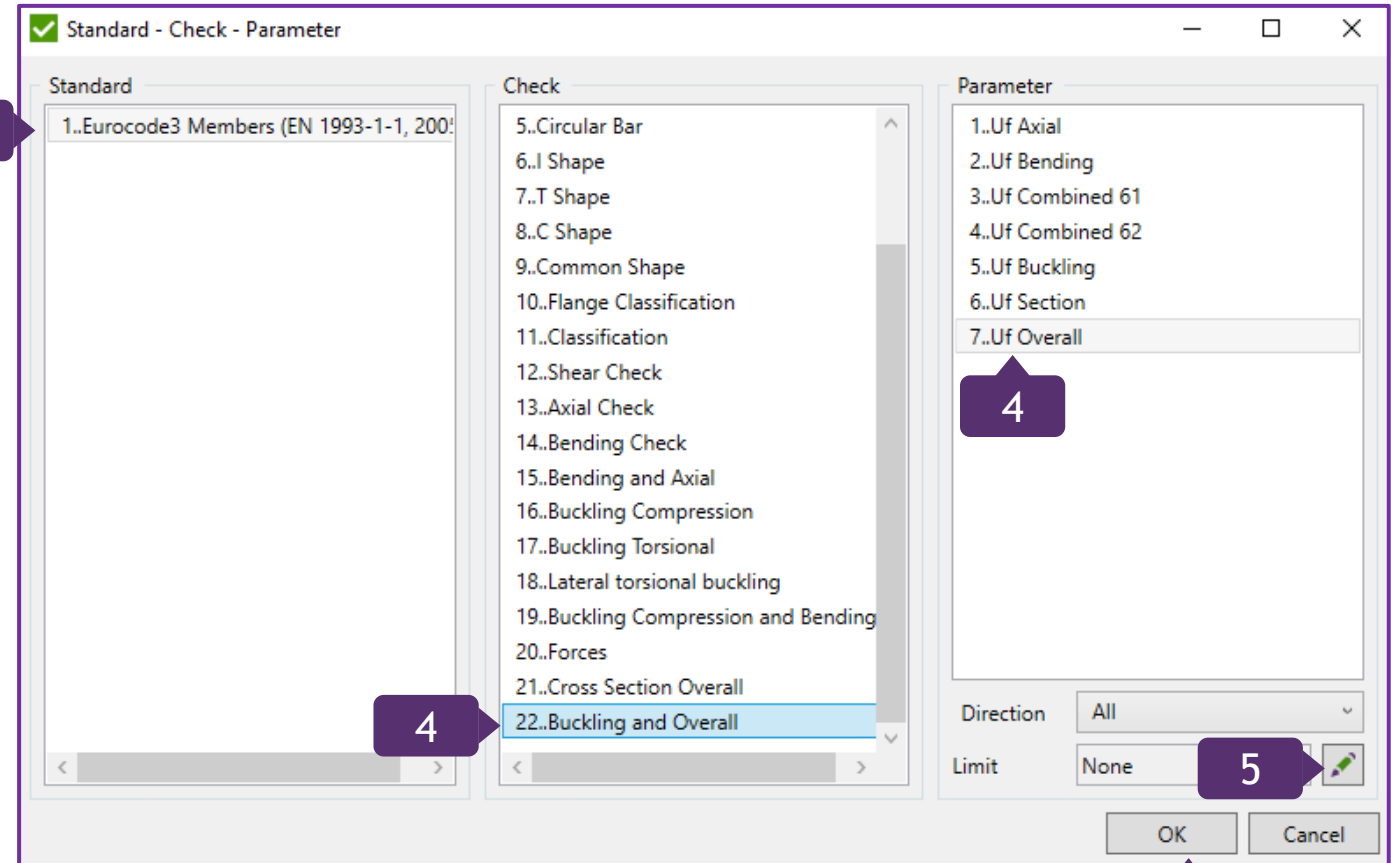
Limits are used to filter results and find the best matching optimal result. A result that passes the limits and matches the variable type (e.g. Min Cross Section Area) will be chosen as an optimal result.



The Limits dialog box is shown with the following settings:

- Limits: ☒
- Type: **Between** (indicated by callout 6)
- Minimum: 0
- Maximum: 1
- ☐ Absolute Value
- Buttons: OK (indicated by callout 7), Cancel

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



The Standard - Check - Parameter dialog box is shown with the following settings:

- Standard: 1..*Eurocode3 Members (EN 1993-1-1, 2005)* (indicated by callout 4)
- Check: 22..*Buckling and Overall* (indicated by callout 4)
- Parameter: 7..*Uf Overall* (indicated by callout 4)
- Direction: All
- Limit: None (indicated by callout 5 and a pencil icon)
- Buttons: OK (indicated by callout 8), Cancel

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

Add Properties from List

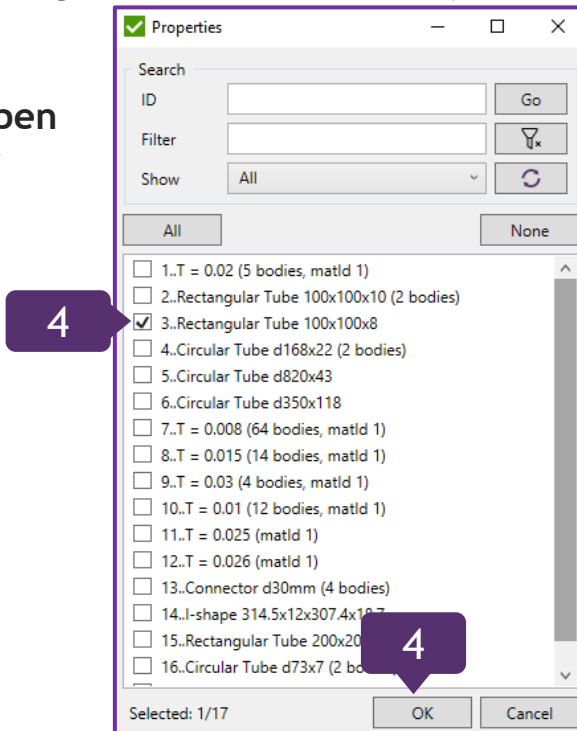
1 Optimization Variable: *Shape Cross Section Area*;
Optimize Variable by: *Min Value* is ON

2 Press  to add multiple Grouped Variables

3 Press  and select Properties from List

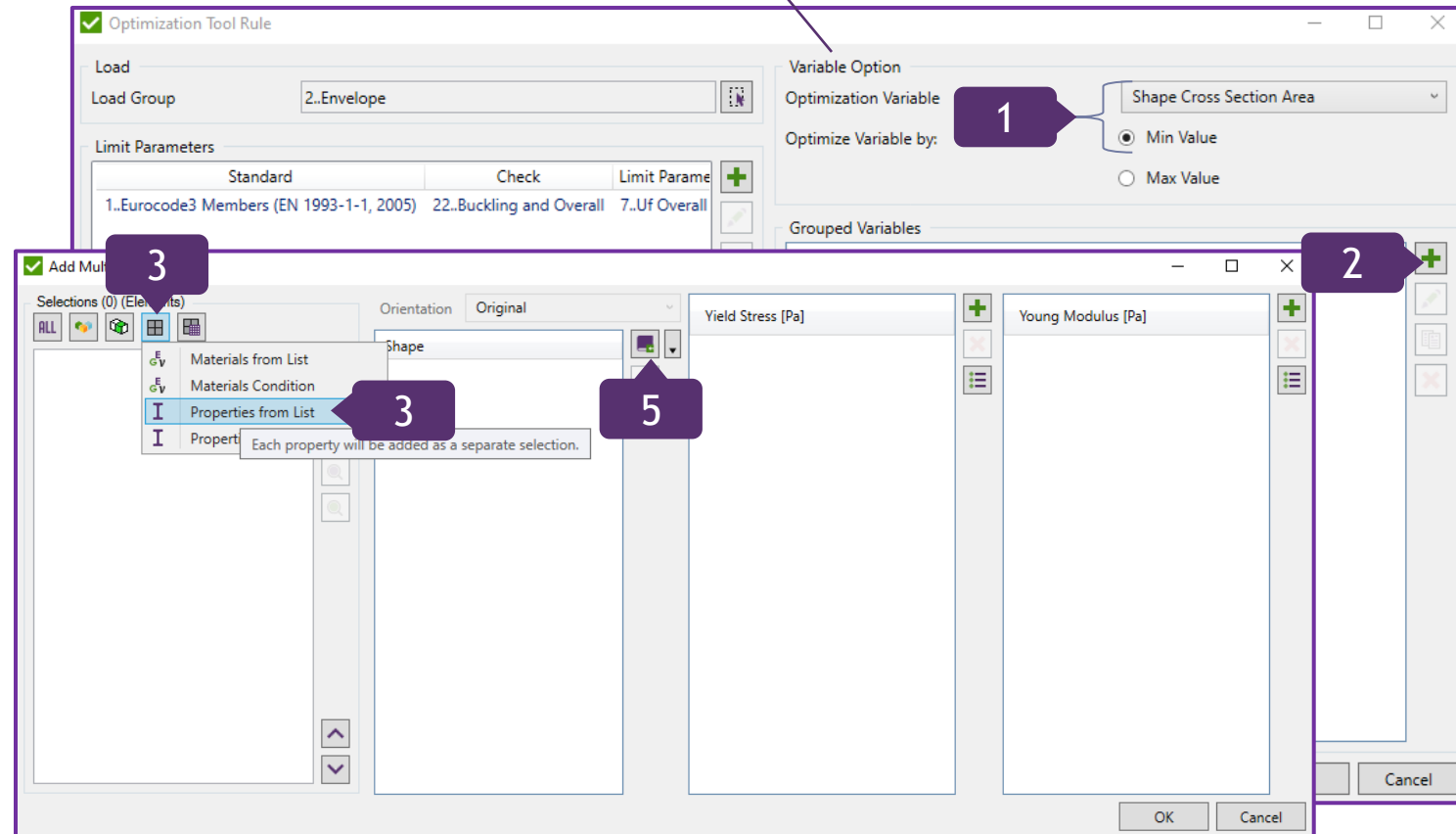
4 Select 3.. *Rectangular Tube 100x100x8*;
Press OK

5 Press  to open
Shape Library

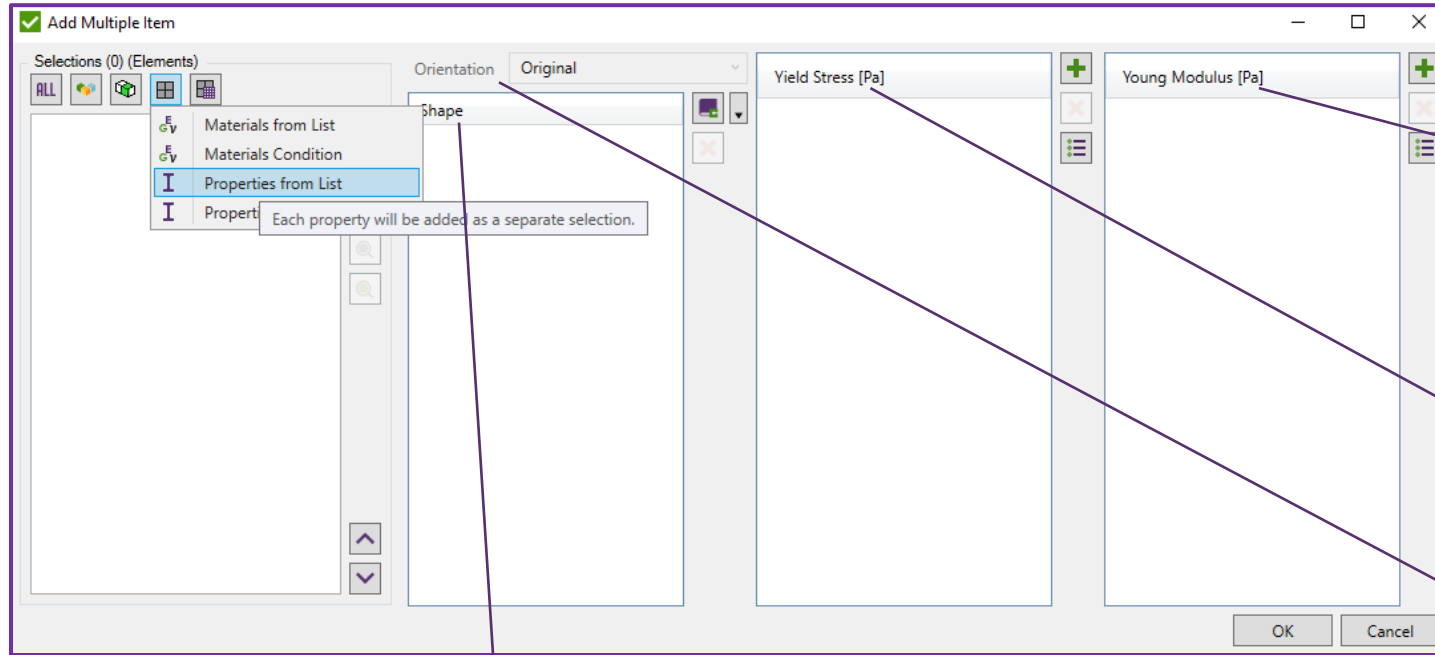


Optimization Variable - select the type of the variable to be optimized
(Shape Cross Section Area, Young Modulus, Yield Stress);

Optimize Variable by - find an optimal result based the on min/max value
of the variable type. For example, to optimize the structure according to
the lowest weight - select Min Value of Shape Cross Section Area.



Additional Information on Add Multiple Item Window



Shape - add a list of shapes that will be replaced for selected selections from the Shape Library. It is possible to use a different type of shape than in the existing model;

Orientation - Select Left, Right, Up, Down or Original (the same orientation as current cross section in the model) cross section orientation that is applied for all selected shapes from the library. For example H cross section can be used as I with modified orientation.

Young Modulus - create a list of variables that will replace Young Modulus of the material in all defined selections;

Yield Stress - create a list of variables that will replace Yield Stress of the material in all defined selections;

Note: Optimization result will be calculated for all combinations of Selection + Shape + Yield Stress + Young Modulus.

1

Select the cross-sections, as shown on the screen

2

Press *OK*

3

Press *OK*

Shape Library contains a list of predefined or user-defined shapes that can be used in the Optimization. Shapes can be filtered, organized, added or modified.

The Shapes can be filtered by Name in this section.

Shape Library

Filter by: Name Shape Lists: All

Name	Type	Width, [m]	Height, [m]	Area, [m^2]	Iyy, [m^4]	Izz, [m^4]
<input checked="" type="checkbox"/> HSS20X12X.625	Rectangular Tube	0.30	0.51	0.02	8.168e-04	3.669e-04
<input type="checkbox"/> HSS20X12X.500	Rectangular Tube	0.30	0.51	0.02	6.670e-04	3.014e-04
<input type="checkbox"/> HSS20X12X.375	Rectangular Tube	0.30	0.51	0.01	5.107e-04	2.322e-04
<input checked="" type="checkbox"/> HSS20X12X.313	Rectangular Tube	0.30	0.51	0.01	4.301e-04	1.961e-04
<input type="checkbox"/> HSS20X8X.625	Rectangular Tube	0.20	0.51	0.02	6.343e-04	1.463e-04
<input type="checkbox"/> HSS20X8X.500	Rectangular Tube	0.20	0.51	0.02	5.192e-04	1.214e-04
<input checked="" type="checkbox"/> HSS20X8X.375	Rectangular Tube	0.20	0.51	0.01	3.985e-04	9.452e-05
<input type="checkbox"/> HSS20X8X.313	Rectangular Tube	0.20	0.51	0.01	3.360e-04	8.026e-05
<input type="checkbox"/> HSS20X4X.500	Rectangular Tube	0.10	0.51	0.01	3.715e-04	2.526e-05
<input checked="" type="checkbox"/> HSS20X4X.375	Rectangular Tube	0.10	0.51	0.01	2.863e-04	2.029e-05
<input type="checkbox"/> HSS20X4X.313	Rectangular Tube	0.10	0.51	0.01	2.419e-04	1.750e-05
<input type="checkbox"/> HSS20X4X.250	Rectangular Tube	0.10	0.51	0.01	1.963e-04	1.449e-05
<input checked="" type="checkbox"/> HSS18X6X.625	Rectangular Tube	0.15	0.46	0.02	4.126e-04	6.872e-05
<input type="checkbox"/> HSS18X6X.500	Rectangular Tube	0.15	0.46	0.01	3.390e-04	5.770e-05
<input type="checkbox"/> HSS18X6X.375	Rectangular Tube	0.15	0.46	0.01	2.612e-04	4.541e-05
<input checked="" type="checkbox"/> HSS18X6X.313	Rectangular Tube	0.15	0.46	0.01	2.206e-04	3.877e-05
<input type="checkbox"/> HSS18X6X.250	Rectangular Tube	0.15	0.46	0.01	1.790e-04	3.178e-05
<input type="checkbox"/> HSS16X16X.625	Rectangular Tube	0.41	0.41	0.02	5.918e-04	5.918e-04
<input type="checkbox"/> HSS16X16X.500	Rectangular Tube	0.41	0.41	0.02	4.842e-04	4.842e-04
<input type="checkbox"/> HSS16X16X.375	Rectangular Tube	0.41	0.41	0.01	3.715e-04	3.715e-04
<input type="checkbox"/> HSS16X16X.313	Rectangular Tube	0.41	0.41	0.01	3.131e-04	3.131e-04
<input type="checkbox"/> HSS16X12X.625	Rectangular Tube	0.30	0.41	0.02	4.768e-04	3.038e-04
<input type="checkbox"/> HSS16X12X.500	Rectangular Tube	0.30	0.41	0.02	3.907e-04	2.499e-04
<input type="checkbox"/> HSS16X12X.375	Rectangular Tube	0.30	0.41	0.01	3.003e-04	1.928e-04
<input type="checkbox"/> HSS16X12X.313	Rectangular Tube	0.30	0.41	0.01	2.533e-04	1.629e-04
<input type="checkbox"/> HSS16X8X.625	Rectangular Tube	0.20	0.41	0.02	3.618e-04	1.196e-04

Add Multiple Item

Selections (1) (Elements)

Beam 3: Rectangular Tube 100x100x6

Shape

- HSS20X12X.625
- HSS20X12X.313
- HSS20X8X.375
- HSS20X4X.375
- HSS18X6X.625
- HSS18X6X.313

The result

Selected Shape HSS20X12X.625

Area, [m^2]: 0.02 Y Shear Area, [m^2]: 0

Moment of Inertia, Izz, [m^4]: 3.669e-04 Z Shear Area, [m^2]: 0

Moment of Inertia, Iyy, [m^4]: 8.168e-04 Nonstructural Mass/length, [kg/m]: 0

Moment of Inertia, Ixy, [m^4]: 0 Warping Constant, [m^6]: 7.206e-07

Torsional Constant, [m^4]: 7.861e-04 Perimeter, [m]: 0

Dimensions: 0.3048 x 0.508

Offset: 0.015875

1

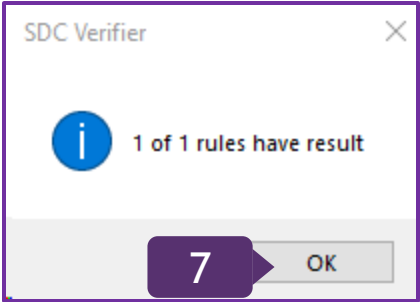
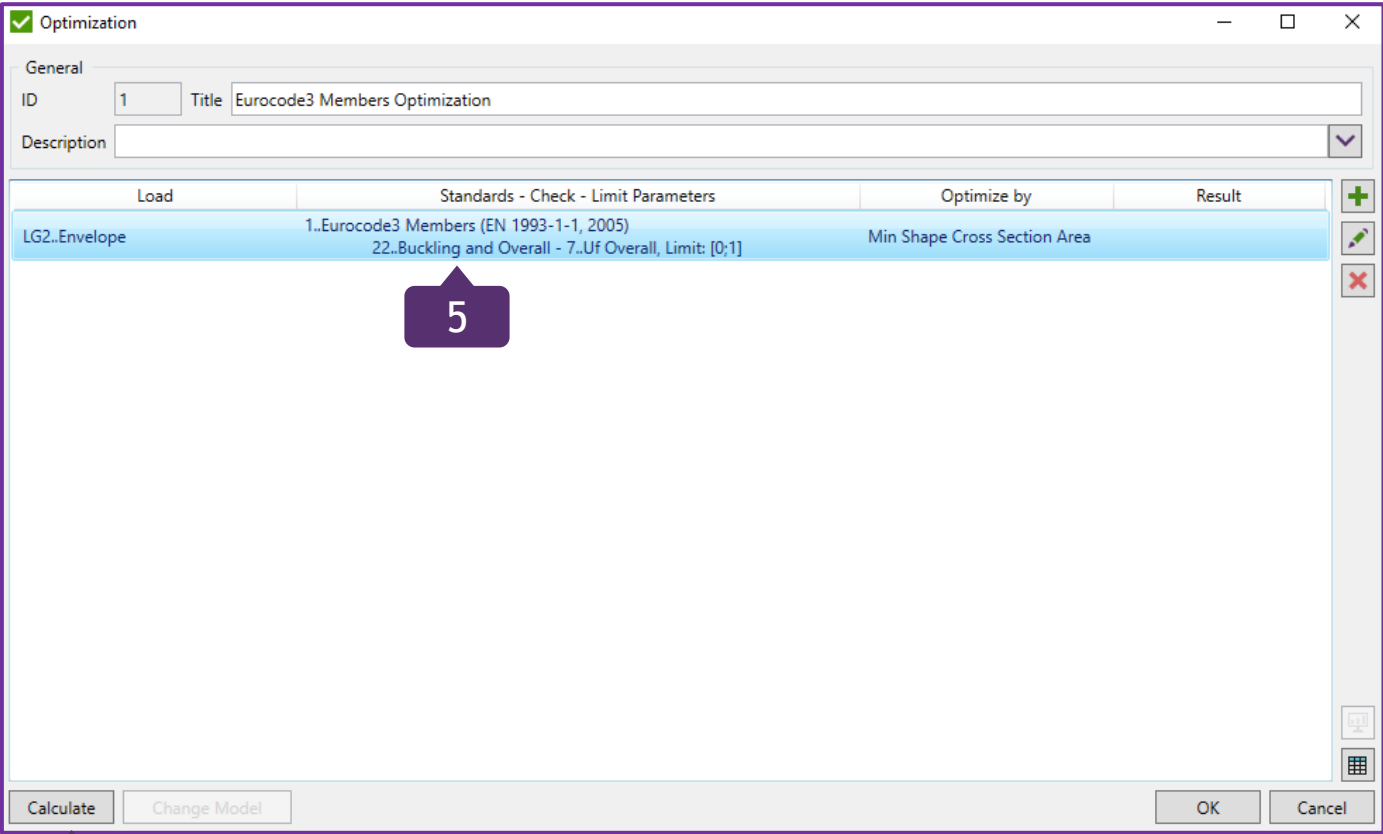
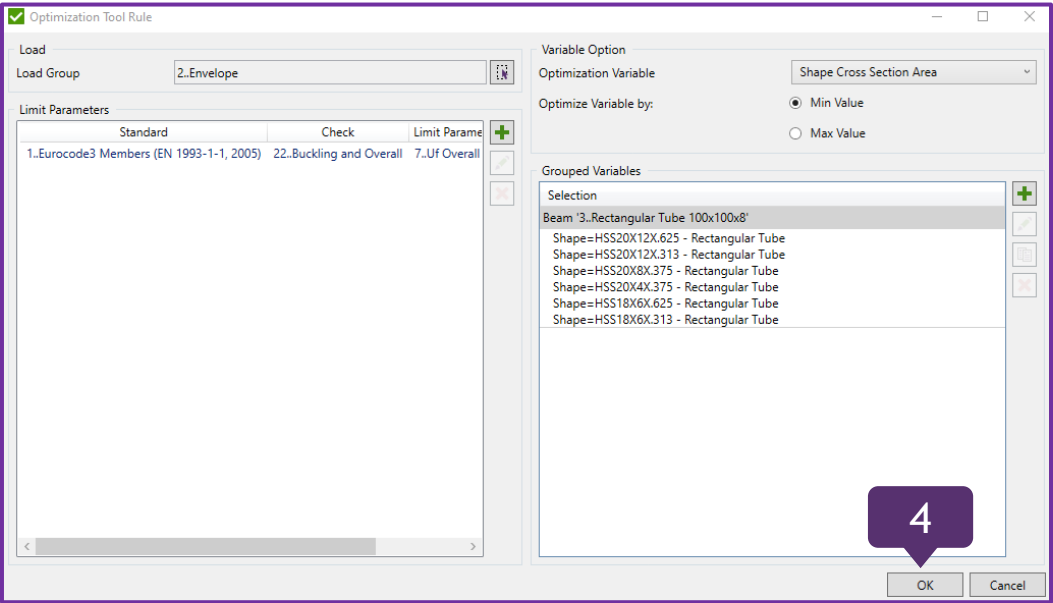
2

3

Show Selected Shapes (6) Displaying 990 of 6744 shapes

OK Cancel

- 4 Press **OK**
- 5 Activate the section
- 6 Press *Calculate* to run the Optimization
- 7 Press **OK**



-

2

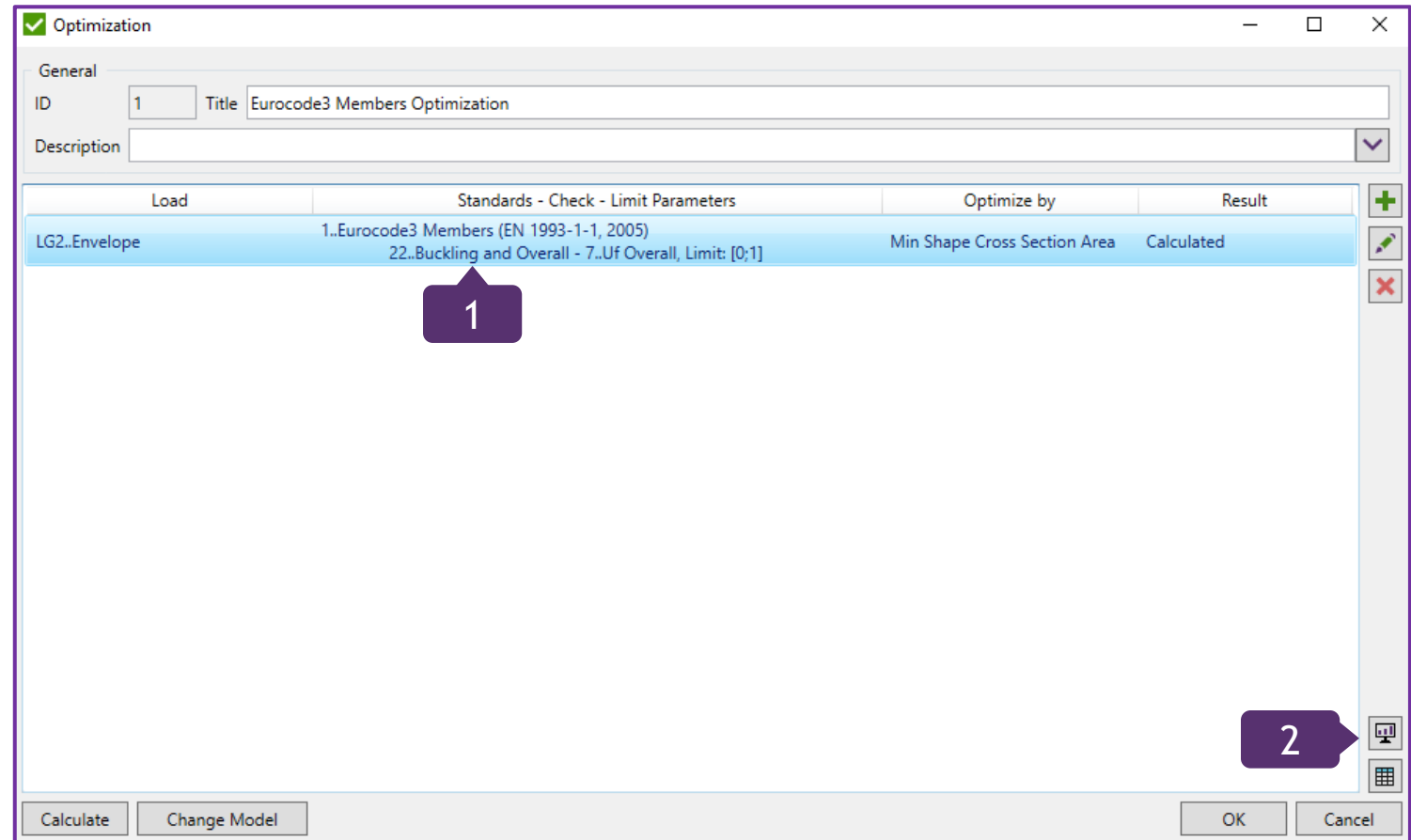
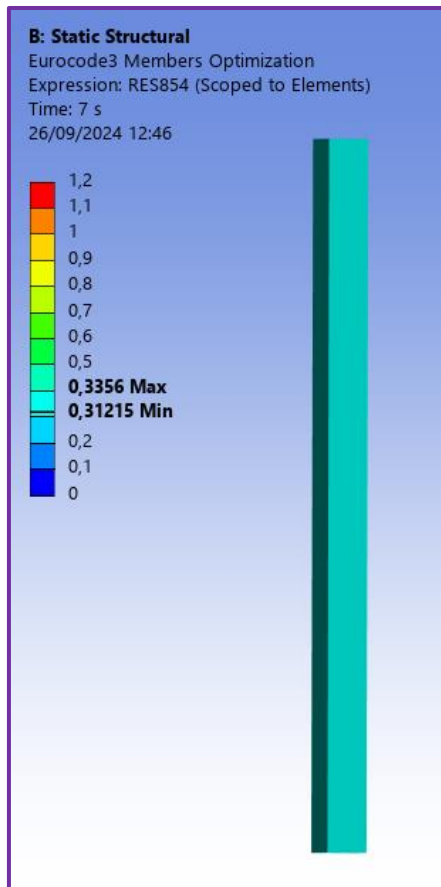
1

Activate the section

2

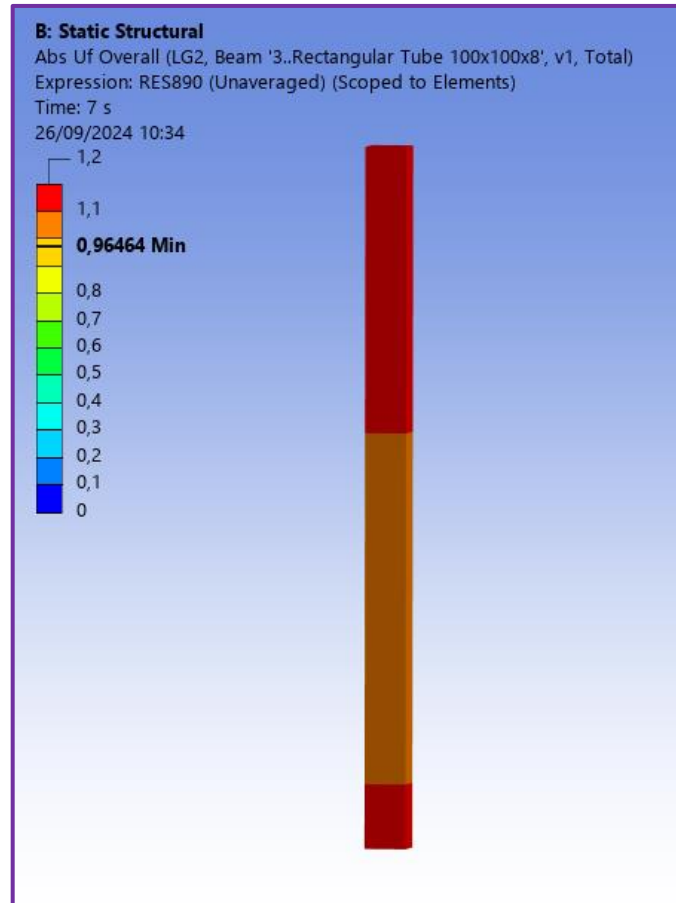
Press  to plot optimal result on the model

The Result

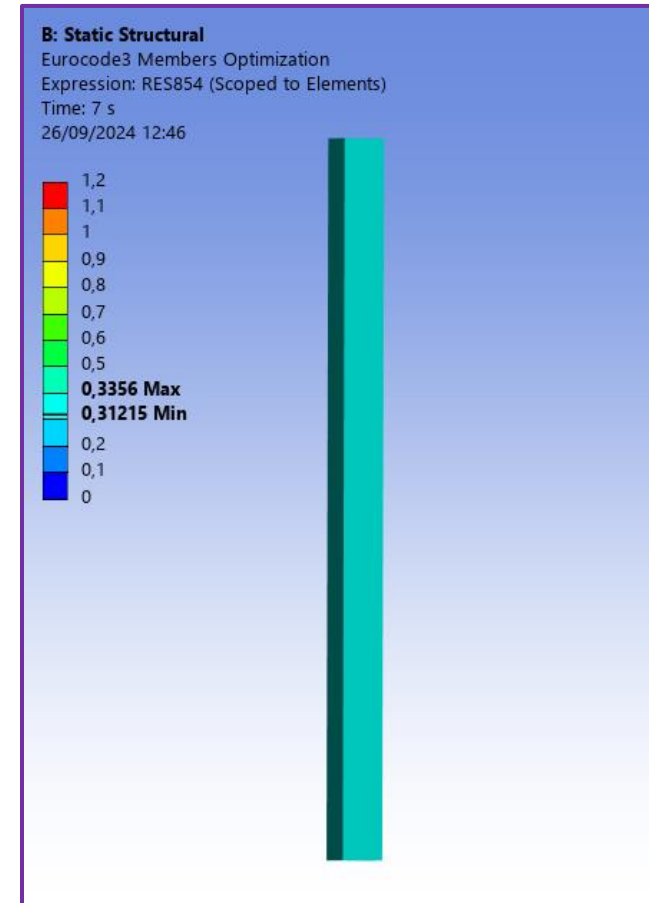


This Tutorial demonstrates only the workflow with the Optimization Tool. Optimization Rule can be set even more precisely. For example, using the Peak Finder you can group only the overshooting elements into a Component and run the Optimization on this Component. Multiple rules with different variables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

The Result before the Optimization



The Result after the Optimization



Add Beam Properties

1 Activate the section

2 Press *Change Model*

3 Press *Yes*

4 Press *OK*

5 Press *OK*

The Result

