



Tutorial

# **DNV Buckling Strength of Plated Structures (2010) Optimization. Plate Buckling Rule**

Updated on: October 2nd, 2024

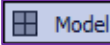
Tested with: SDC for Ansys 2024 R2

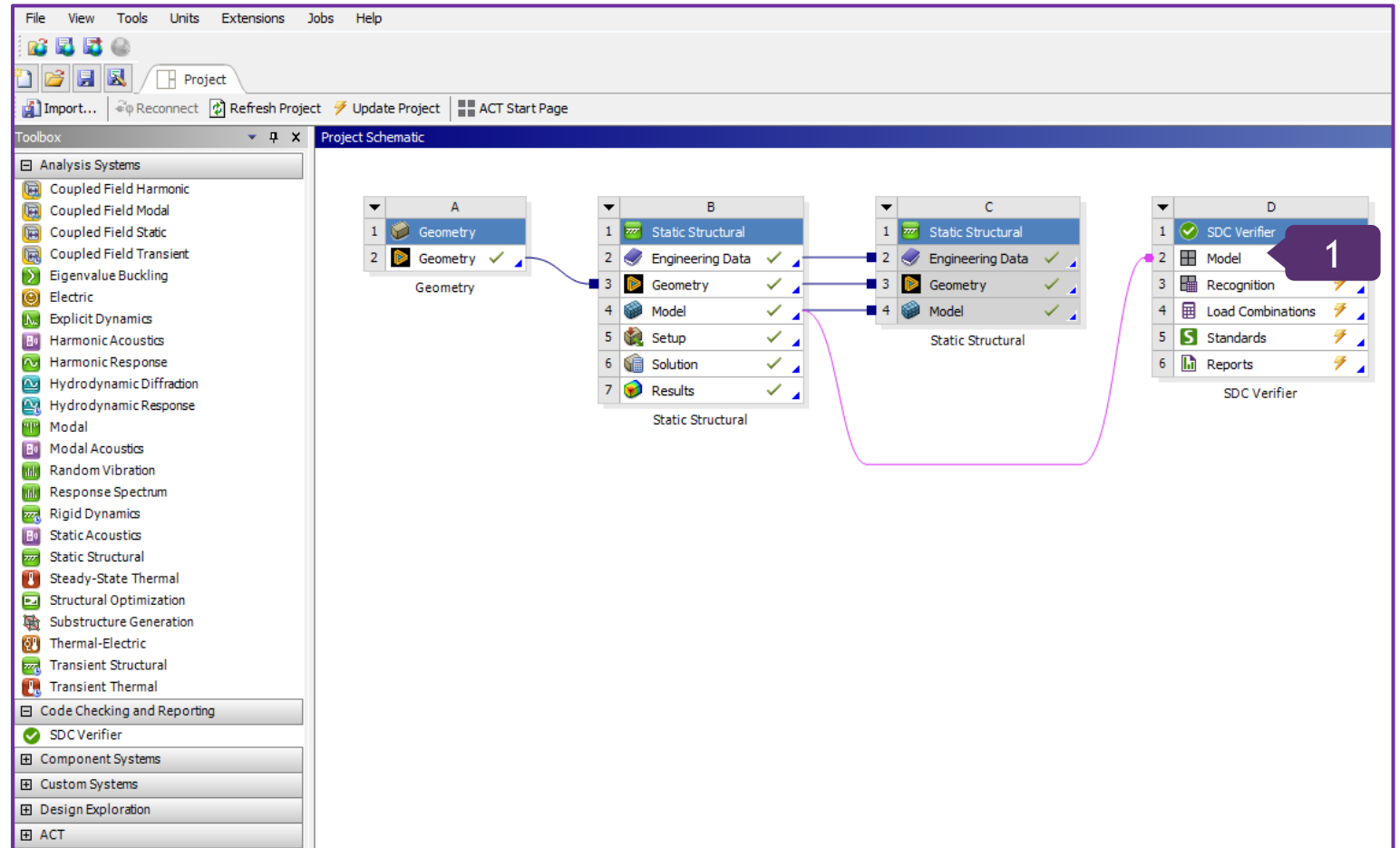
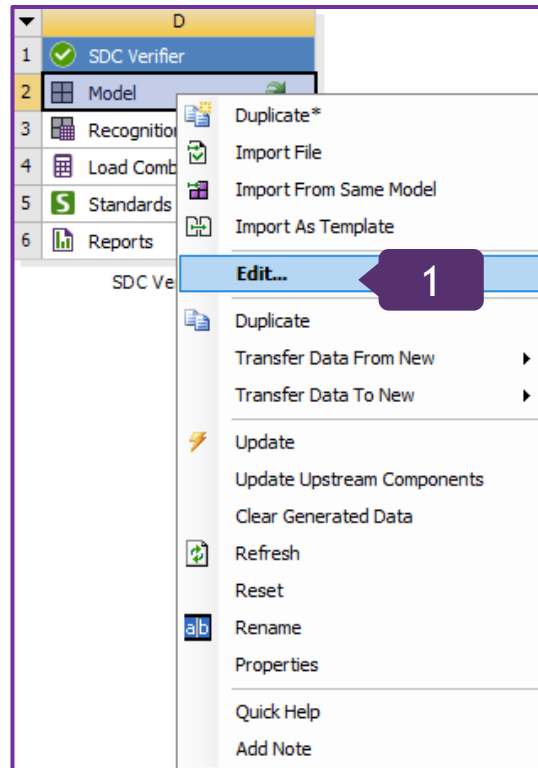
ANSYS Workbench 2024 R2

- This step-by-step tutorial demonstrates the functionality of SDC Verifier Optimization Tool, incorporating Plate Buckling Rule;
- Model structural members are Optimized based on Criteria Plot results;
- Shape Library Overview;
- Optimization Rules Overview;
- Optimization results in Tables and Plots;
- Results Comparison;
- Automatic Plate Property Change
- 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*

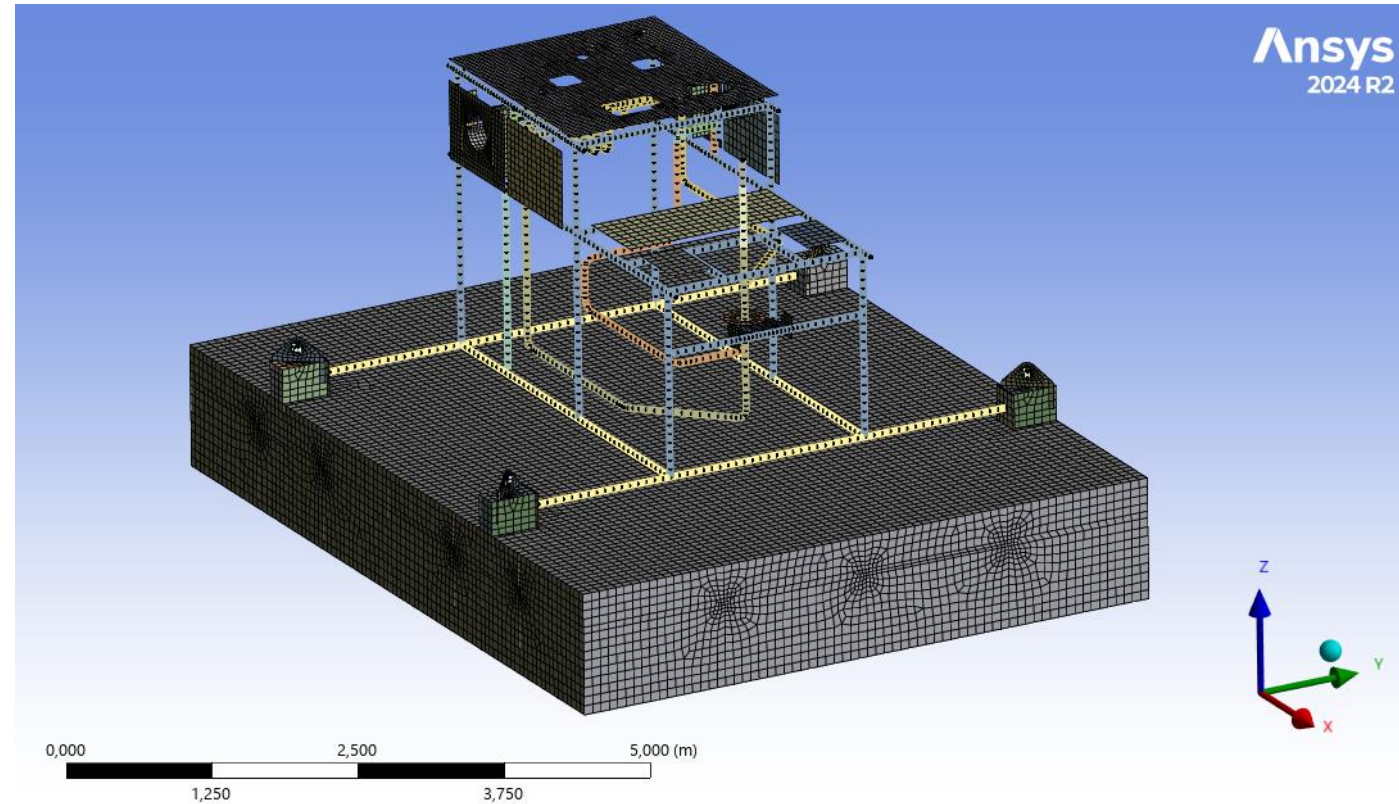


This tutorial uses a Project with predefined Individual Loads, Load Sets and Load Groups.

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 (0)
    - Load Sets (12)
    - Load Groups (2)
    - FG Fatigue Groups (0)
    - Tables (0)
    - Plots (0)
- Tools
- Standards (1)
  - 1..DNV RP-C201 Plate/Stiffener Buckling (2010)
- Post-Processing
  - Optimizations (0)
  - Reports (0)



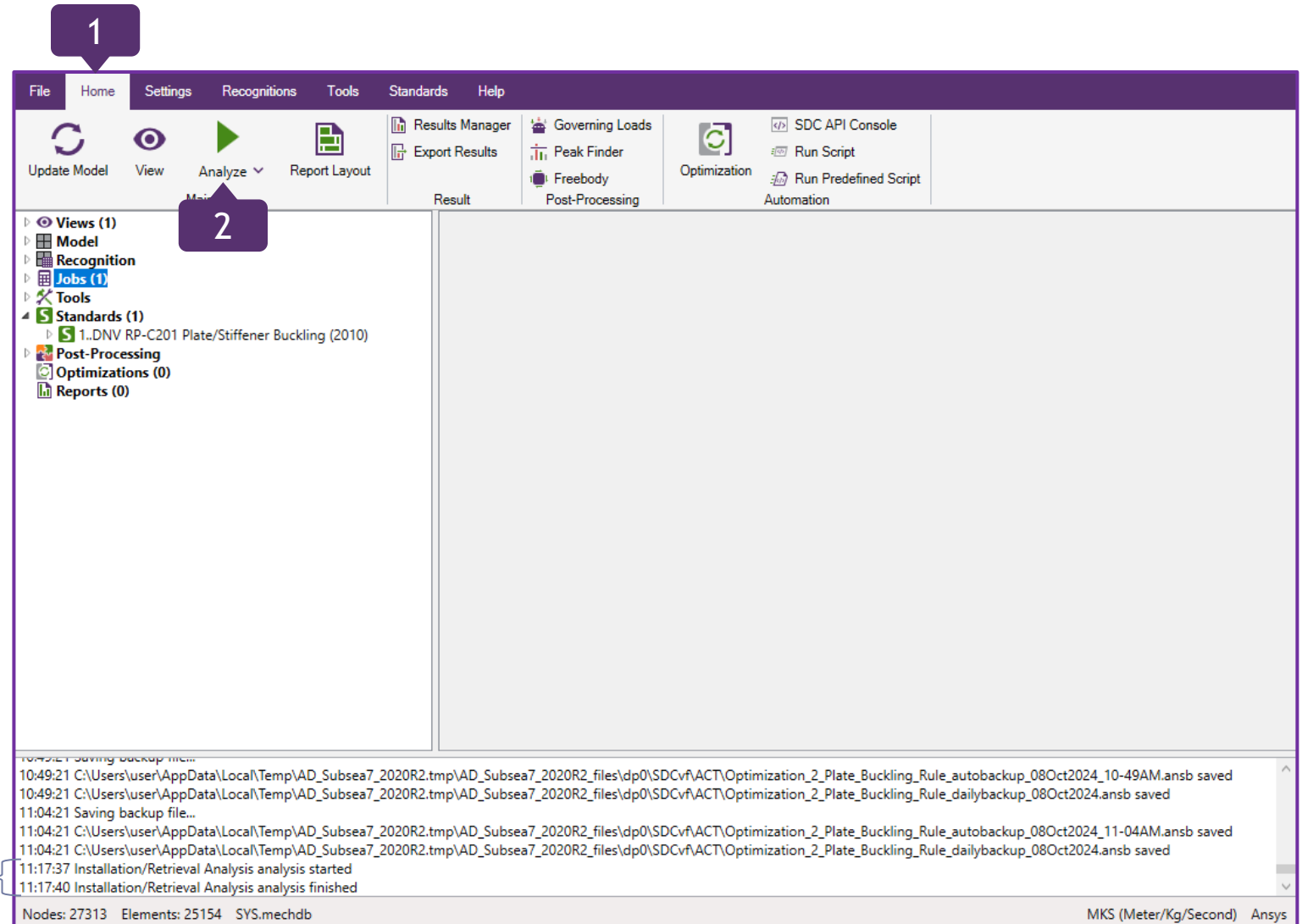
A separate Tutorial with detailed instructions on how to add, define and edit the Standard can be found via this link:  
<https://sdcverifier.com/tutorials/aisc-360-10/>

1

Go to *Home* section on the Ribbon

2

Press  on the toolbar to analyze Job



Installation/Retrieval Analysis analysis started and finished.

# DNV Buckling Strength of Plated Structures (2010) Criteria Plot

1

Expand Standards => 2..DNV Buckling Strength of Plated Structures (2010)=> Checks (3) and select 1..Plate Buckling

2

Execute right click on 1..Plate Buckling and select Criteria Plot

3

Press  to select Load Group

4

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

5

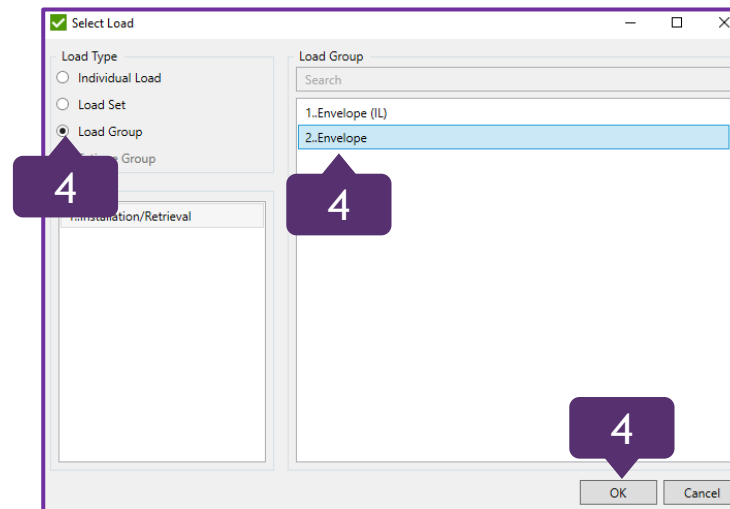
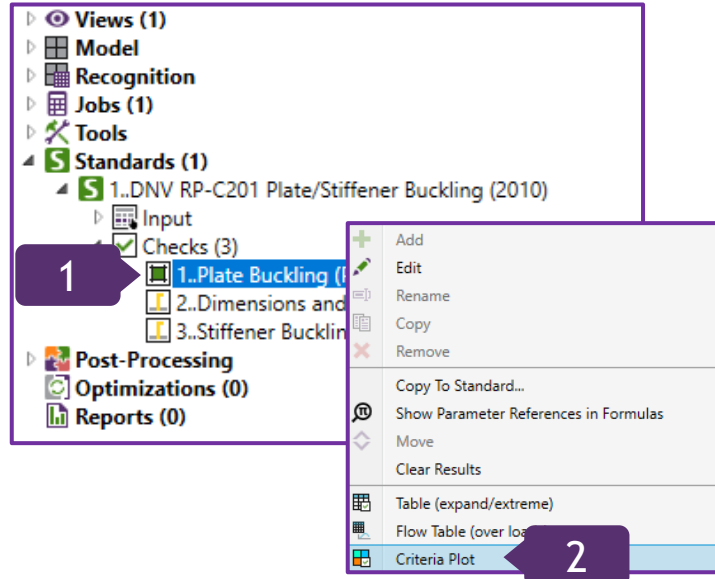
Parameter: *Buckling Factor Overall*

6

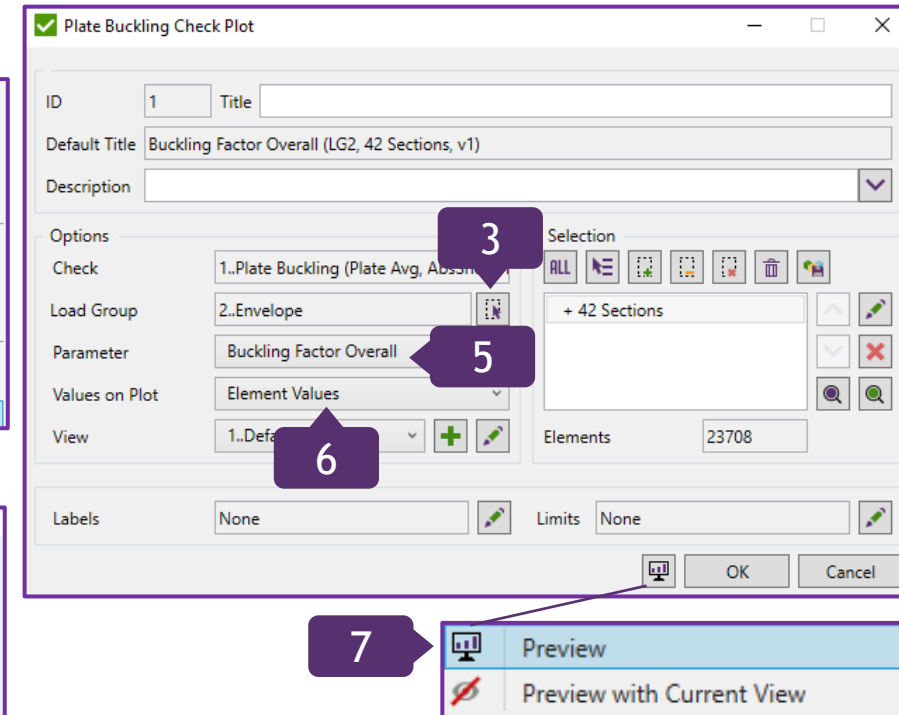
Values on Plot: *Element Values*

7

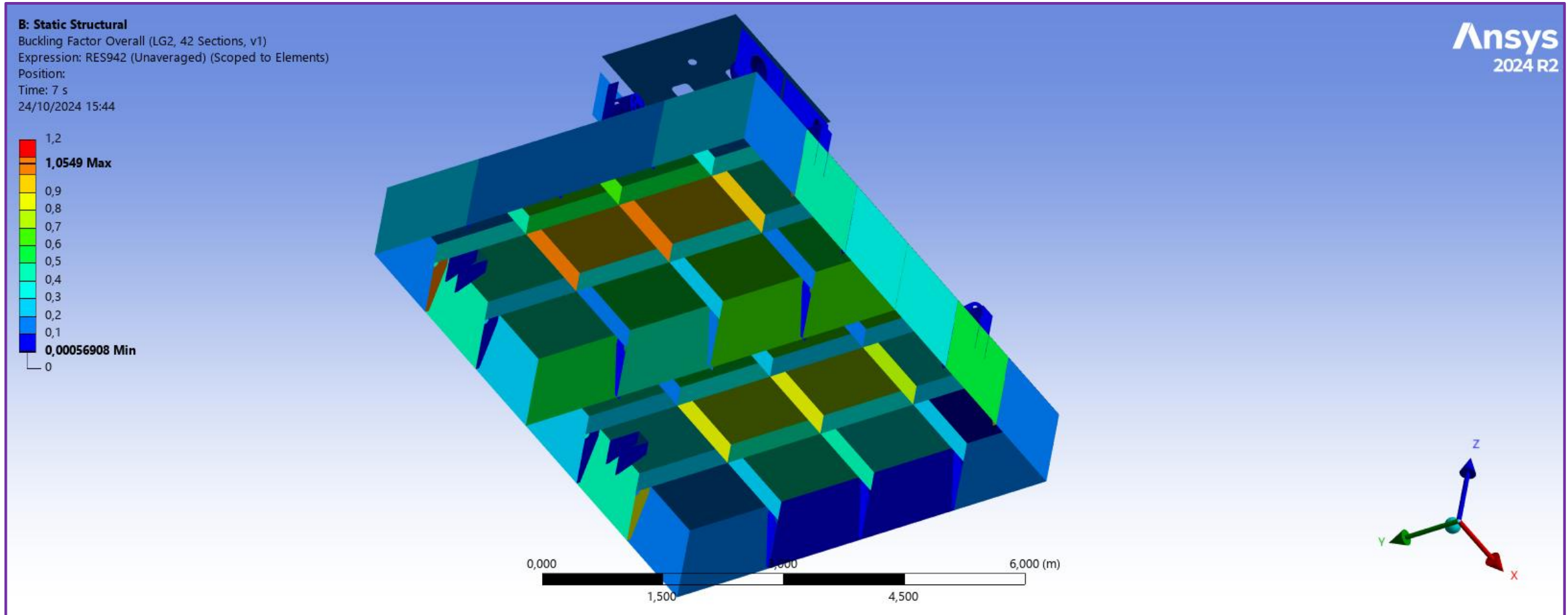
Press  and then *Preview*



The purpose of creating Criteria Plot is to preview the results of DNV Buckling Strength of Plated Structures Check and pick the members for Optimization.



The Plot has been created to see the Buckling Factor Overall on full model.  
It is displayed in Ansys window.





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- 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.

**B: Static Structural**  
Buckling Factor Overall (LG2, 42 Sections, v1)  
Expression: RES951 (Unaveraged) (Scoped to Elements)  
Position:  
Time: 7 s  
24/10/2024 15:52

1,2  
1,0549 Max  
1,0115 Min  
0,9  
0,8  
0,7  
0,6  
0,5  
0,4  
0,3  
0,2  
0,1  
0


0,000 1,000 2,000 (m)  
0,500 1,500

z  
y  
x





1

Select + 42 Sections and press  to remove them

2

Press  to add Condition;  
Select *Properties*

3

Select 7..T = 0.008 (64 bodies, matld 1);  
Press *OK*

4

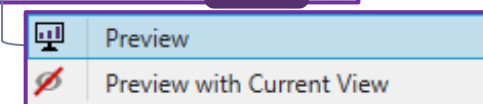
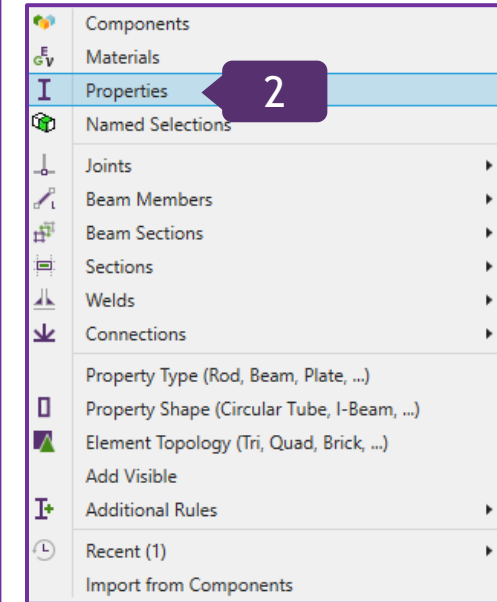
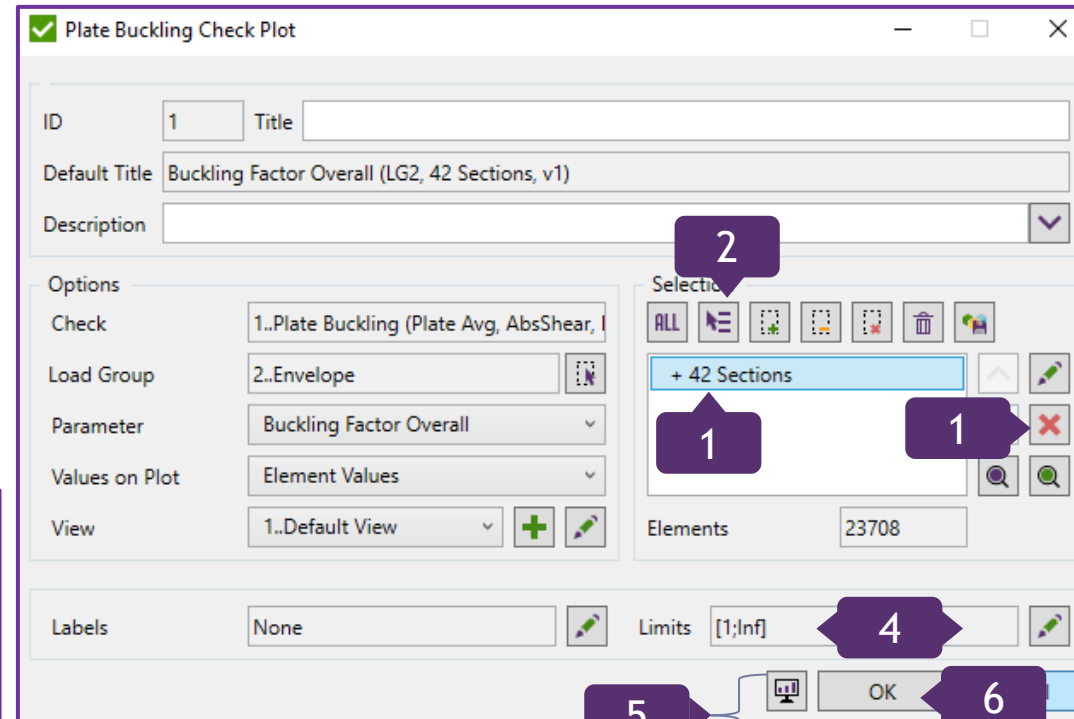
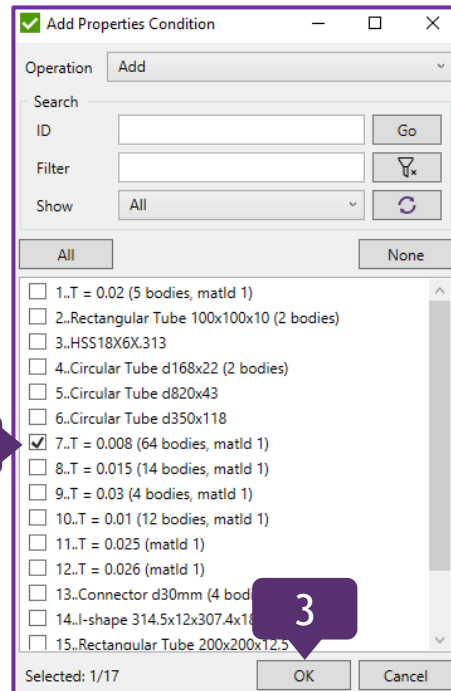
Limits: *None*

5

Press  and  
then *Preview*

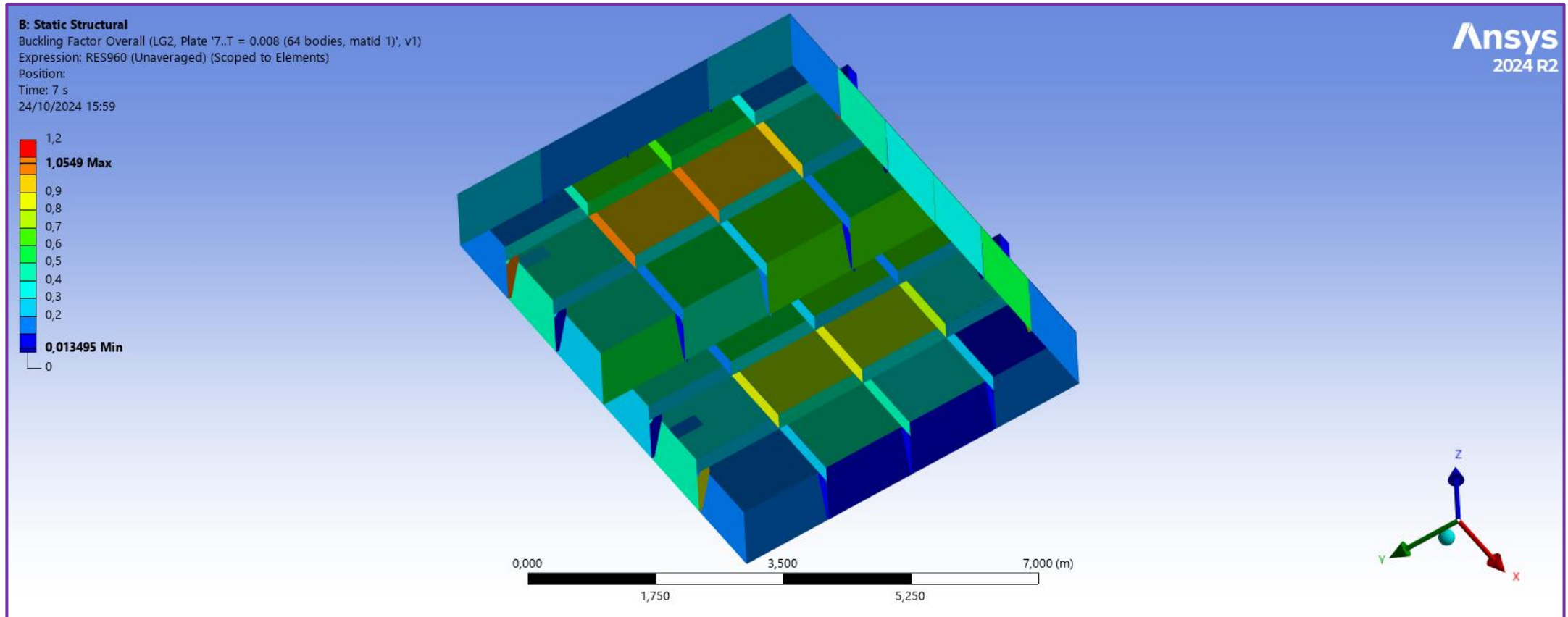
6

Press *OK*



The members of 7..T = 0.008 (64 bodies, matld 1) Property have UF Overall value above 1. An Optimization Rule for these members will be created.

The Plot has been created to see the Buckling Factor 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;

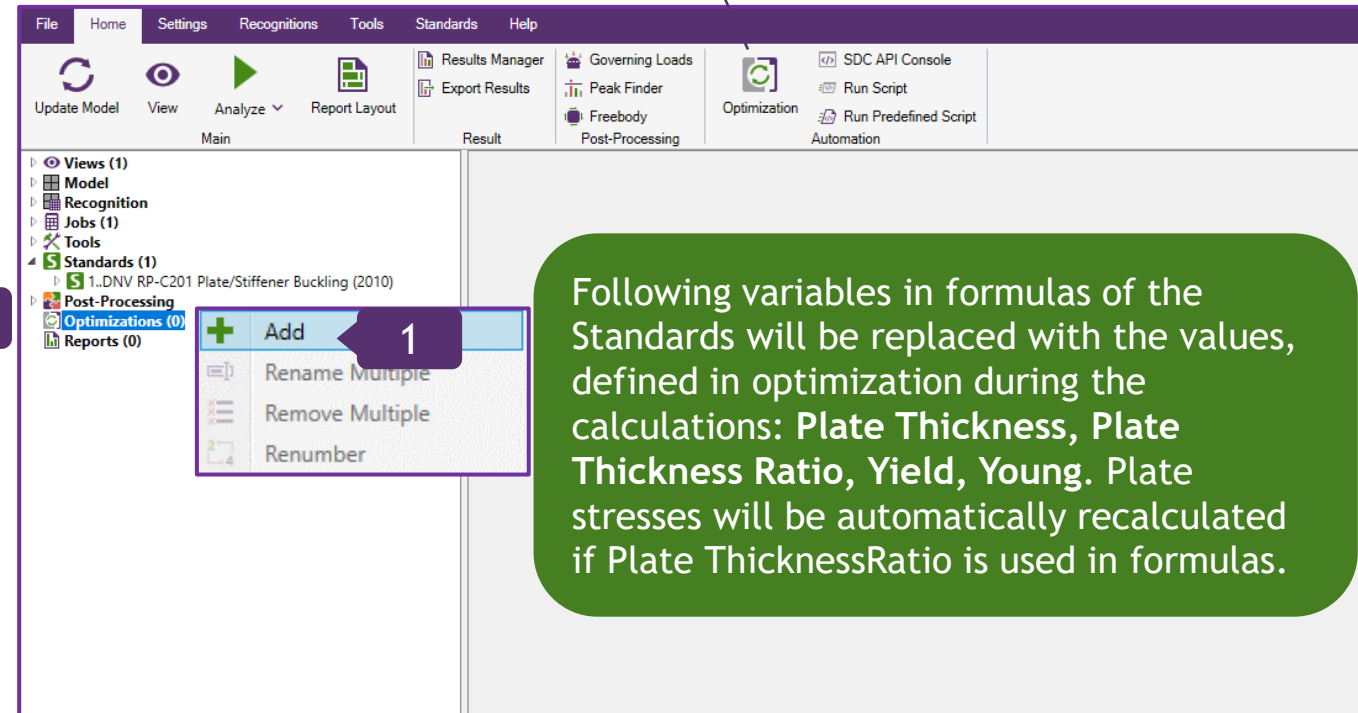
*Weld Strength Rule* - weld type and dimensions (leg sizes, throat thickness etc.) can be optimized.

**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: *DNV RP-C201 Plate/Stiffener Buckling (2010)*
- 3 Press  to create first *Optimization Rule*; Select *Add Plate Buckling Rule*

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



DNV RP-C201 Plate/Stiffener Buckling (2010) Standard, along with its Checks and Parameters, can be optimized by Plate Buckling Rule.

Add Beam Rule  
Add Plate Buckling Rule  
Add Plate Element Rule  
Add Weld Strength Rule

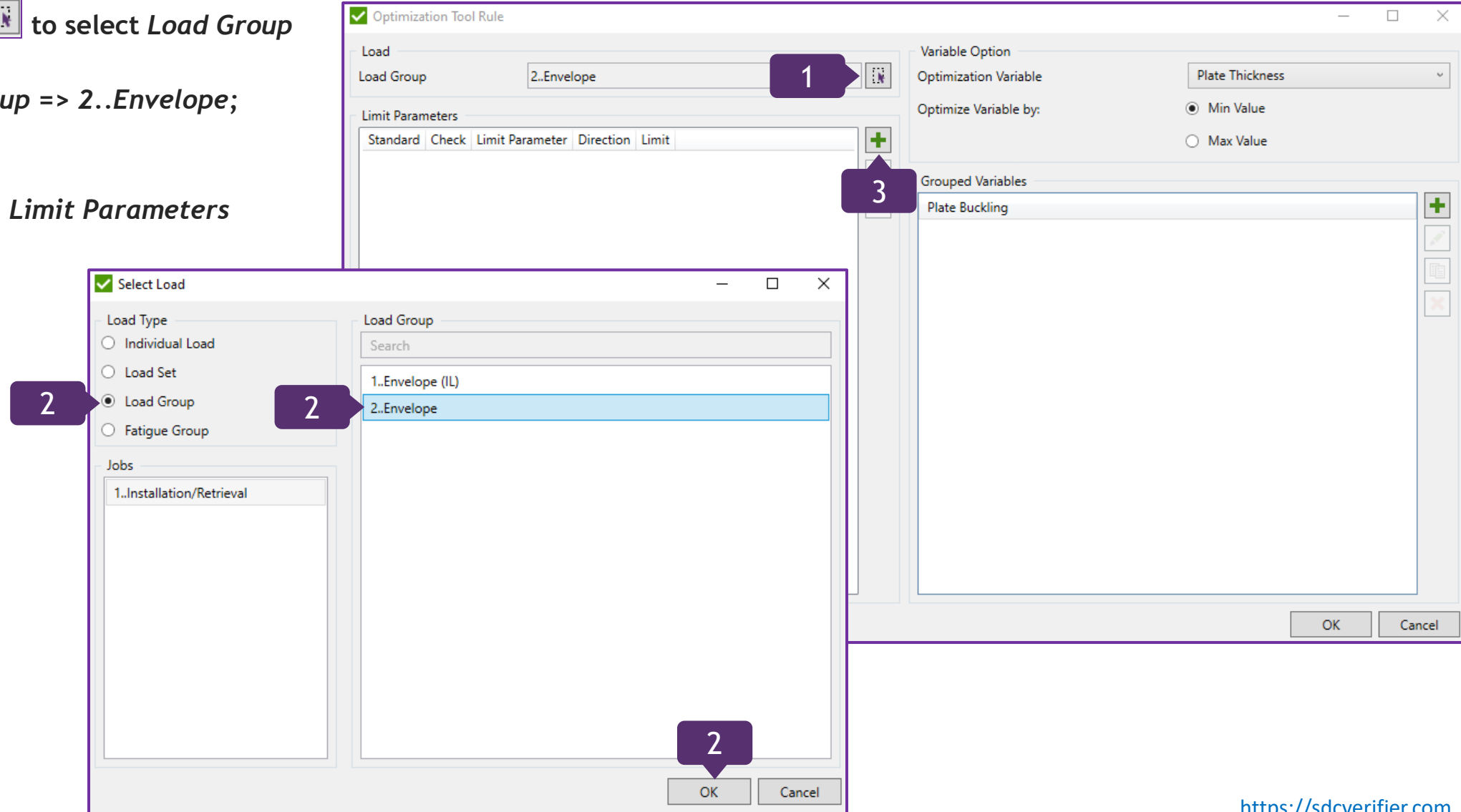
Plate Buckling Rule is used to optimize plate thickness, yield stress and/or Young Modulus of buckling plates, recognized by Panel Finder Tool. It is typically used for plate buckling Standards. Common options are described in Optimization Rule.

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* => 2..Envelope;  
Press OK

3 Press  to add *Limit Parameters*



# Optimization Tool Rule. DNV Buckling Strength (Continuation)

4

Standard: *1..DNV RP-C201 Plate/Stiffener Buckling (2010)*;  
Check: *1..Plate Buckling*;  
Parameter: *38..Buckling Factor Overall*

5

In Limit, press 

6

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

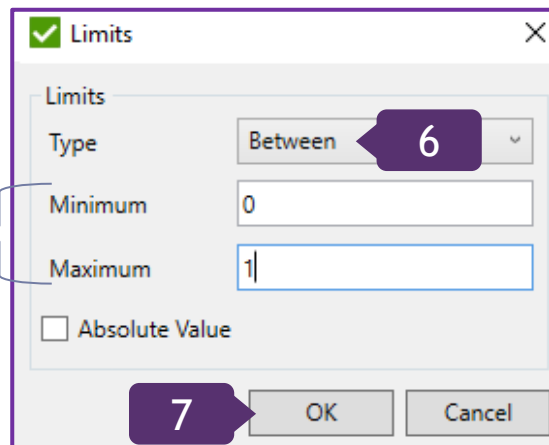
7

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.

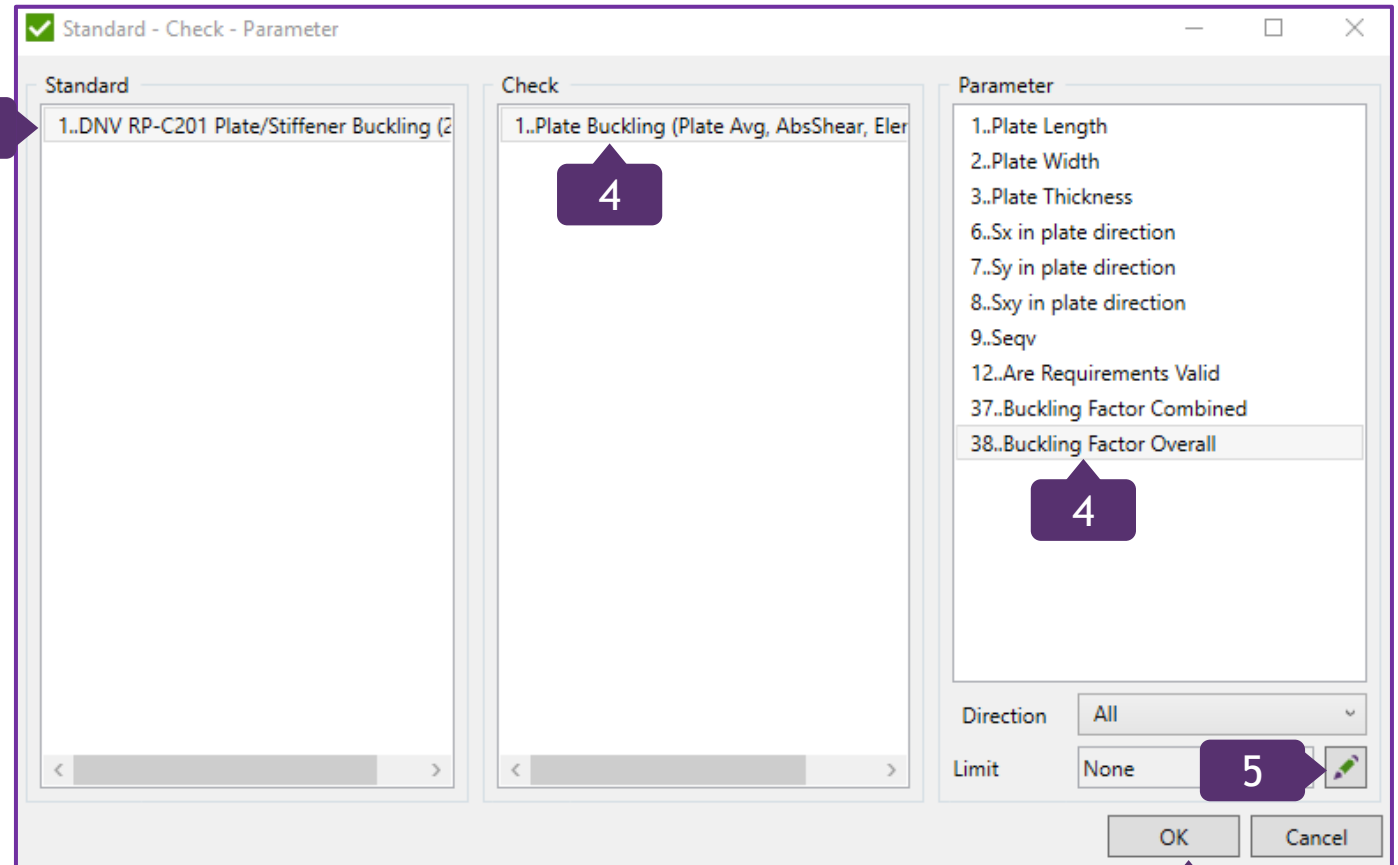


The Limits dialog box is shown with the following details:

- Title bar: Limits
- Section: Limits
- Type: Between (indicated by callout 6)
- Minimum: 0
- Maximum: 1 (indicated by callout 6)
- 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.

4





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

- Title bar: Standard - Check - Parameter
- Standard: 1..DNV RP-C201 Plate/Stiffener Buckling (2010) (indicated by callout 4)
- Check: 1..Plate Buckling (Plate Avg, AbsShear, Eler) (indicated by callout 4)
- Parameter: 38..Buckling Factor Overall (indicated by callout 4)
- Direction: All
- Limit: None (indicated by callout 5 and a pencil icon)
- Buttons: OK, Cancel (indicated by callout 8)

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

# Add Multiple Item

- 1 Optimization Variable: Plate Thickness;  
Optimize Variable by: *Min Value* is ON
- 2 Press  to add multiple Grouped Variables
- 3 Press  and select *From Selection*

*Optimization Variable* - select the type of the variable to be optimized (Plate Thickness, Young Modulus, Yield Stress);

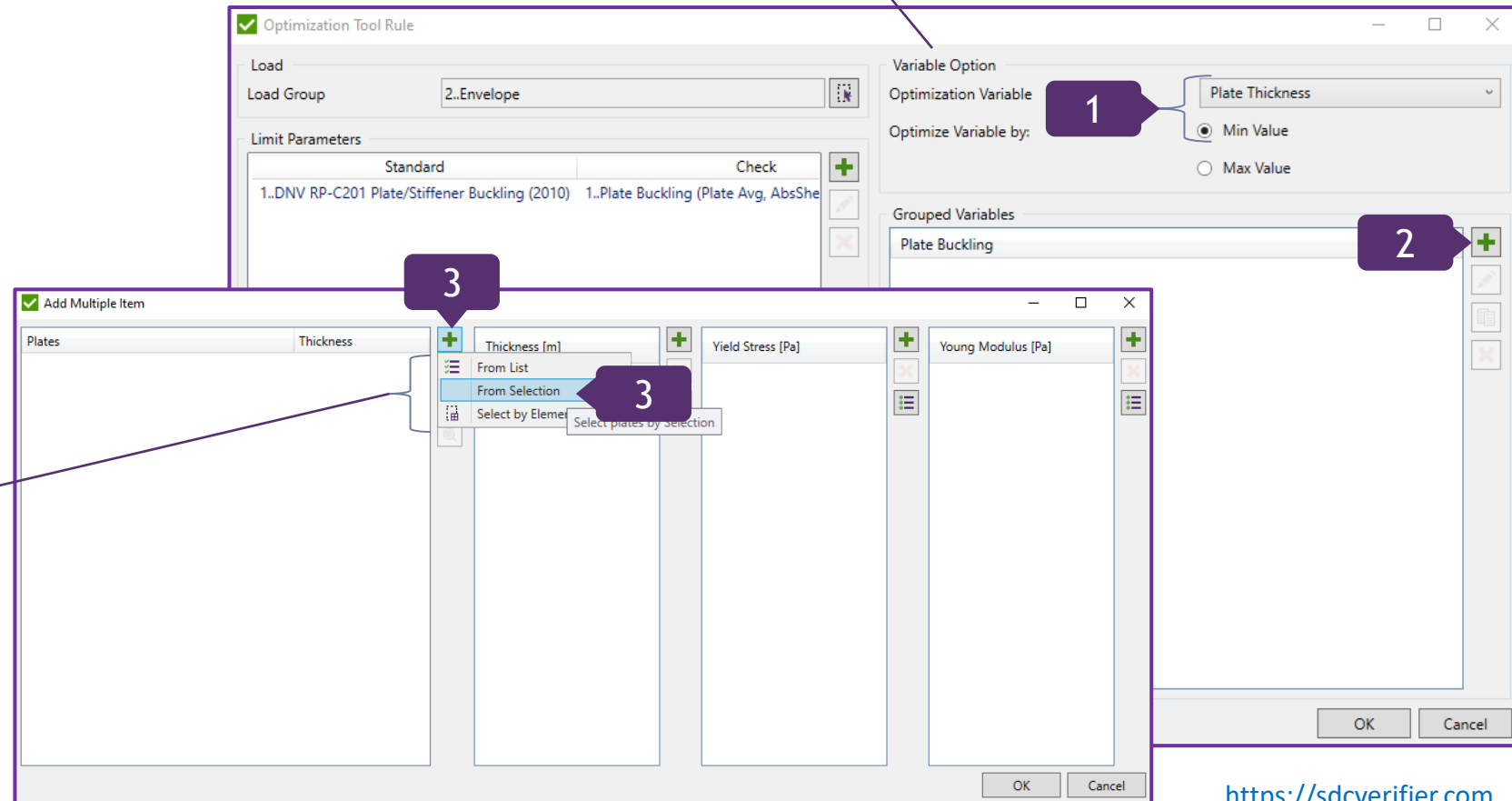
*Optimize Variable by* - find an optimal result based the on min/max value of the variable type. For example, to optimize the structure according to the lowest weight - select Min Value of Plate Thickness.

*From List* - select plates from the list of grouped plates by sections and panels;

**Note:** selected plates will not be displayed in the list of available next time the window is opened.

*From Selection* - select plates by picking custom selection, using Selector Control;

*Select by Element* - select plates by picking one element of the model.





# Add Multiple Item (Continuation)

4

Press  to add Condition

5

Select *Properties*


6

Select 7..T = 0.008 (64 bodies, matld 1); Press OK

7

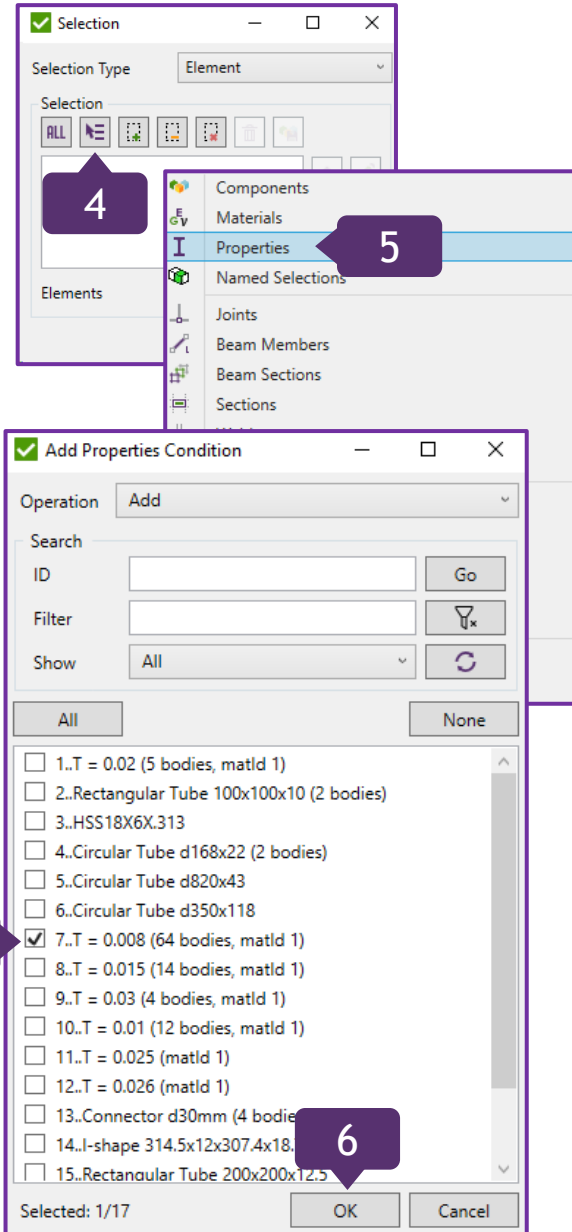
Press OK


8

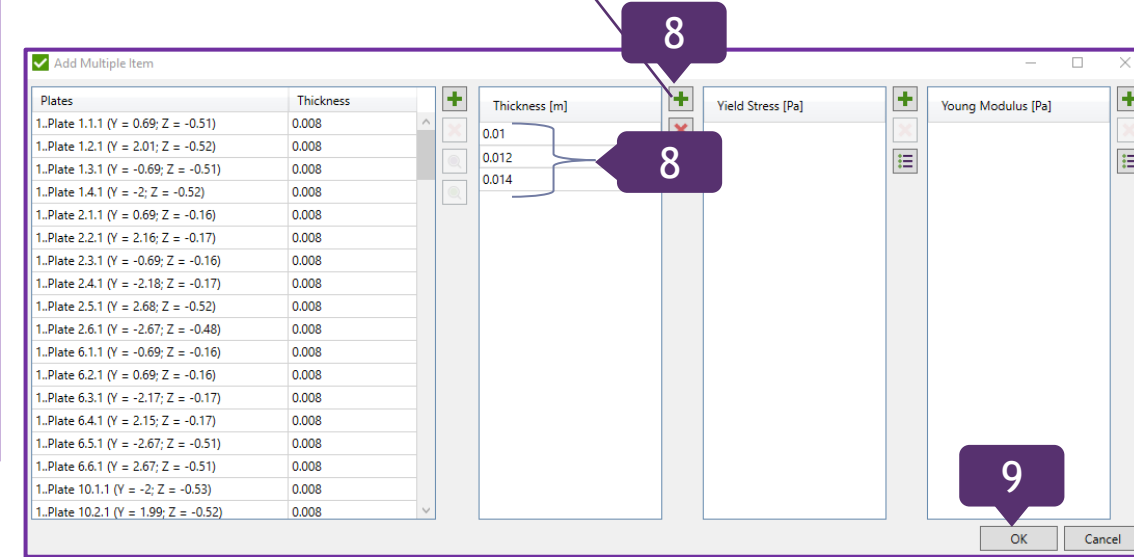
Press  to define Thickness [m]: 0.01; 0.012; 0.014

9

Press OK



Note: When defining Thickness [m], that refers to Step 8, it is required to press  each time the parameter is incorporated.



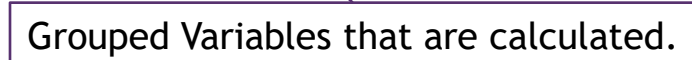
*Thickness* - create a list of variables that will replace thickness of buckling plate in all defined plates;

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

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

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- 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*

Result Table

Group	Yield Stress [Pa]	Young Modulus [Pa]	Plate Thickness [m]	1..DNV RP-C201 Plate/Stif 1..Plate Buckling (Plate Av 38..Buckling Factor Overall
Plate '1..Plate 1.1.1 (Y = 0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.12
Plate '1..Plate 1.2.1 (Y = 2.0	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.28
Plate '1..Plate 1.3.1 (Y = -0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.12
Plate '1..Plate 1.4.1 (Y = -2;	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.28
Plate '1..Plate 2.1.1 (Y = 0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.55
Plate '1..Plate 2.2.1 (Y = 2.1	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.38
Plate '1..Plate 2.3.1 (Y = -0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.52
Plate '1..Plate 2.4.1 (Y = -2.1	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.36
Plate '1..Plate 2.5.1 (Y = 2.6			0.010	0.85
Plate '1..Plate 2.6.1 (Y = -2.6			0.010	0.82
Plate '1..Plate 6.1.1 (Y = -0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.35
Plate '1..Plate 6.2.1 (Y = 0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.38
Plate '1..Plate 6.3.1 (Y = -2.1	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.28
Plate '1..Plate 6.4.1 (Y = 2.1	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.29
Plate '1..Plate 6.5.1 (Y = -2.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.01
Plate '1..Plate 6.6.1 (Y = 2.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.01
Plate '1..Plate 10.1.1 (Y = -2;	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.62
Plate '1..Plate 10.2.1 (Y = 1.5	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.50
Plate '1..Plate 10.3.1 (Y = 0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.48
Plate '1..Plate 10.4.1 (Y = -0.	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.62

This is the Optimal Result, which will  
be used for changing the Plate shape.

Optimization

General

ID 1 Title DNV RP-C201 Plate/Stiffener Buckling (2010)

Description

Load	Standards - Check - Limit Parameters	Optimize by	Result
LG2..Envelope	1..DNV RP-C201 Plate/Stiffener Buckling (2010) 1..Plate Buckling (Plate Avg, AbsShear, Element Avg) - 38..Bucklin	Min Plate Thickness	Calculated

1

The results for all variables.

Result Table

Group	Yield Stress [Pa]	Young Modulus [Pa]	Plate Thickness [m]	1..DNV RP-C201 Plate/Stif 1..Plate Buckling (Plate Av 38..Buckling Factor Overall
Plate '1..Plate 1.1.1 (Y = 0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.12
Plate '1..Plate 1.1.1 (Y = 0.6			0.010	0.07
Plate '1..Plate 1.1.1 (Y = 0.6			0.012	0.05
Plate '1..Plate 1.1.1 (Y = 0.6			0.014	0.04
Plate '1..Plate 1.2.1 (Y = 2.0	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.28
Plate '1..Plate 1.2.1 (Y = 2.0			0.010	0.16
Plate '1..Plate 1.2.1 (Y = 2.0			0.012	0.11
Plate '1..Plate 1.2.1 (Y = 2.0			0.014	0.08
Plate '1..Plate 1.3.1 (Y = -0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.12
Plate '1..Plate 1.3.1 (Y = -0.6			0.010	0.07
Plate '1..Plate 1.3.1 (Y = -0.6			0.012	0.05
Plate '1..Plate 1.3.1 (Y = -0.6			0.014	0.04
Plate '1..Plate 1.4.1 (Y = -2;	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.28
Plate '1..Plate 1.4.1 (Y = -2;			0.010	0.16
Plate '1..Plate 1.4.1 (Y = -2;			0.012	0.11
Plate '1..Plate 1.4.1 (Y = -2;			0.014	0.08
Plate '1..Plate 2.1.1 (Y = 0.6	Original Model (275.00e+6)	Original Model (200000.00e	Original Model (0.008)	0.55
Plate '1..Plate 2.1.1 (Y = 0.6			0.010	0.44
Plate '1..Plate 2.1.1 (Y = 0.6			0.012	0.36
Plate '1..Plate 2.1.1 (Y = 0.6			0.014	0.31

2,3

Optimal Result

All Result

2

# Plot Optimization Results

1

Activate the section

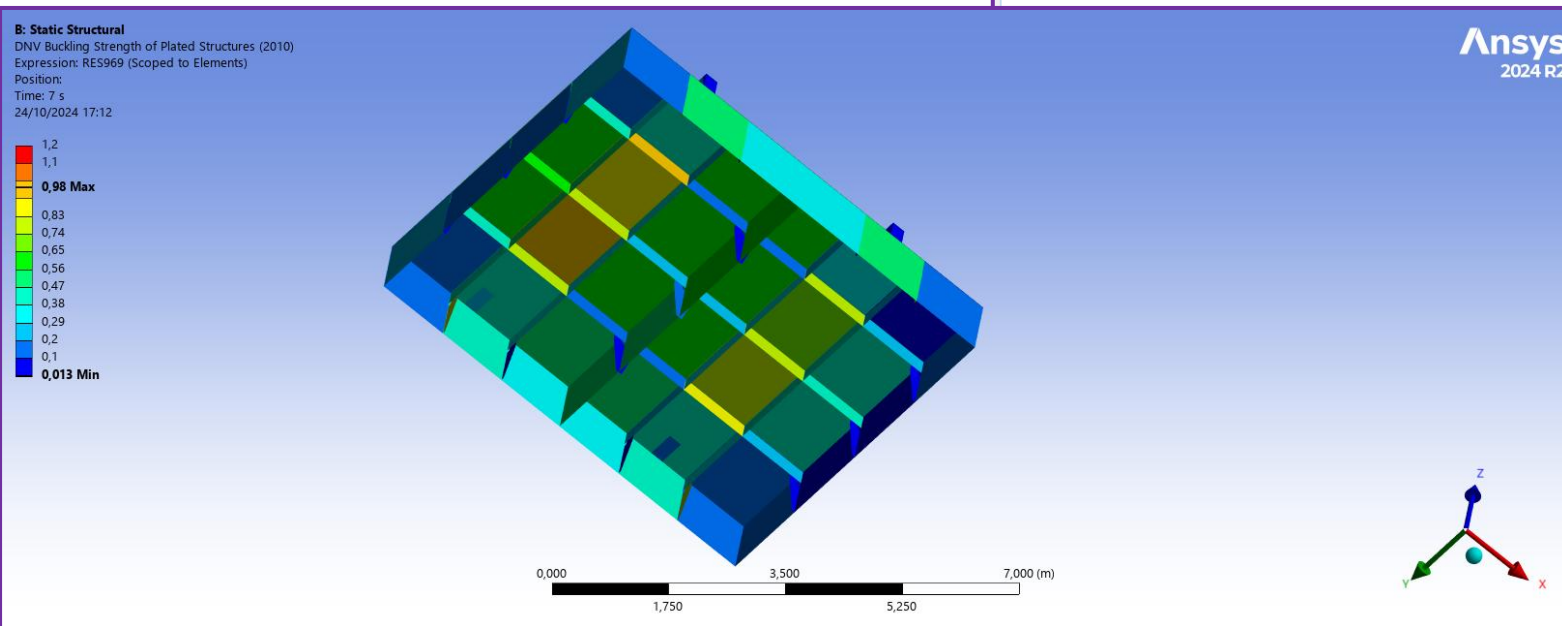
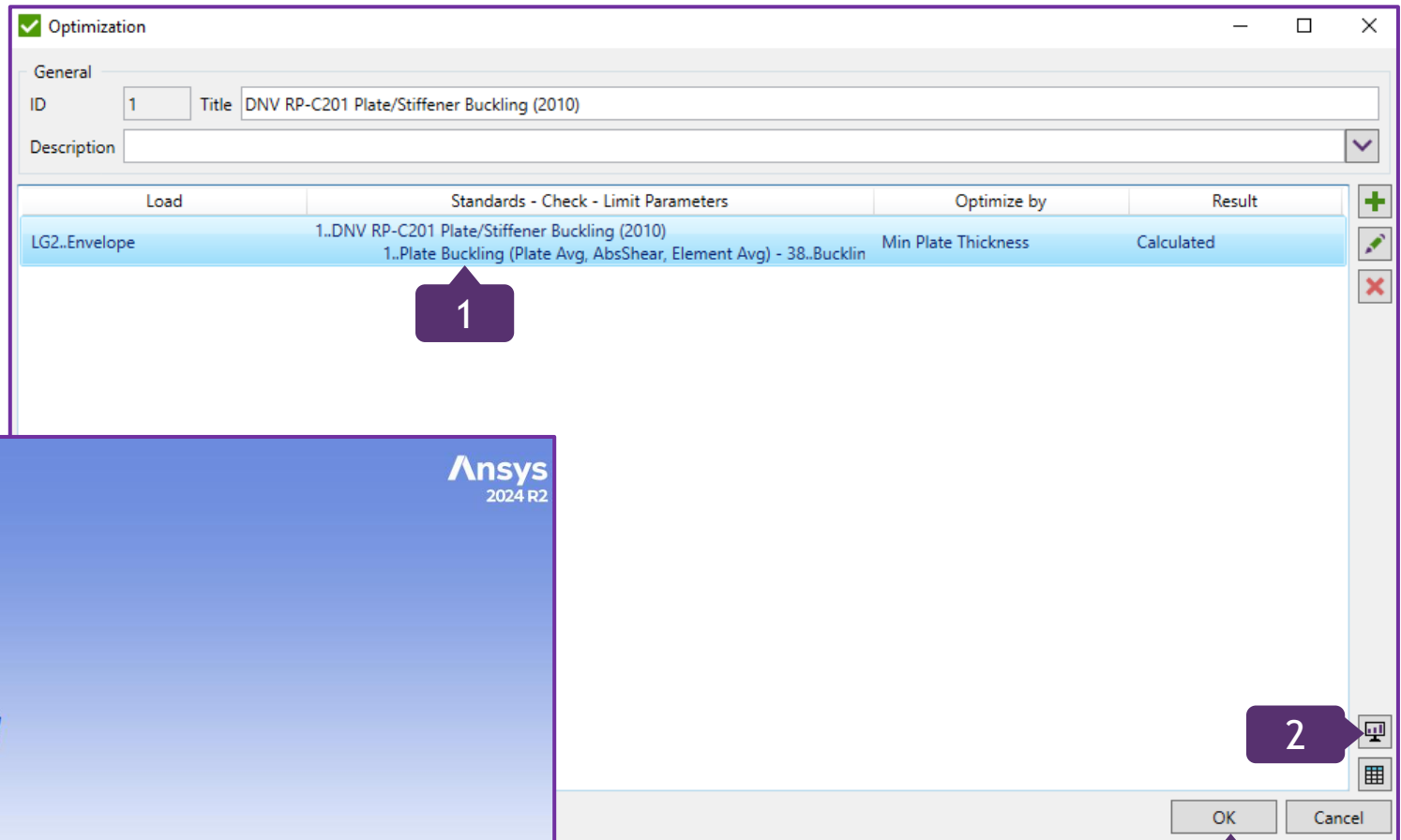
2

Press  to plot optimal result on the model

3

Press *OK*

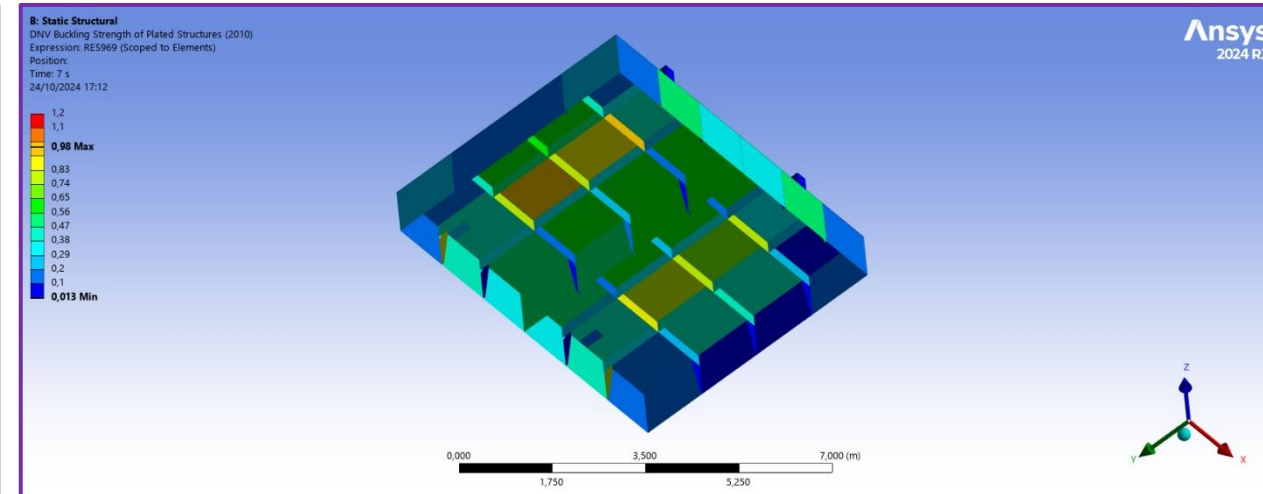
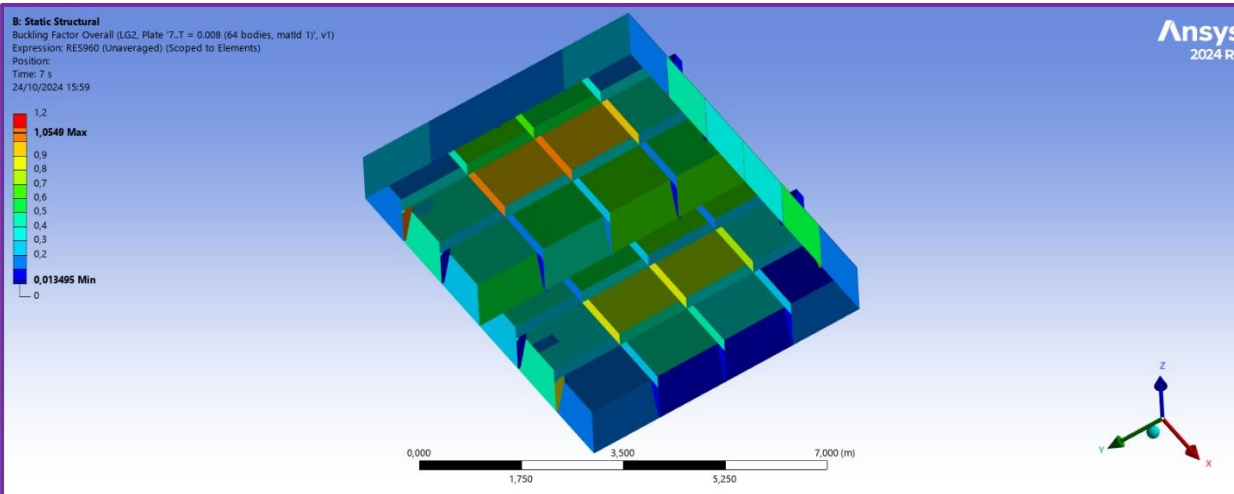
The Result



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



# Add Plate Properties

1 Activate the section

2 Press *Change Model*

3 Press *Yes*

4 Press *OK*

5 Press *OK*

The Result

