



Tutorial

# Plate Buckling ABS

Updated on: 20-04-23

Tested with: SDC Verifier 2023 R1

ANSYS 2022 R1

- ▶ In this tutorial an ABS 2014 Plate Buckling Check is reviewed in details.
- ▶ A part of a plate model of the ship has been used as a start FEM model.
- ▶ Load Sets and Load Group (Envelope) are created.
- ▶ Recognition of plates using Panel Finder.
- ▶ Plate Buckling tables and plots.
- ▶ Reporting: preparing and generating the final report.

# Launch SDC Verifier

1

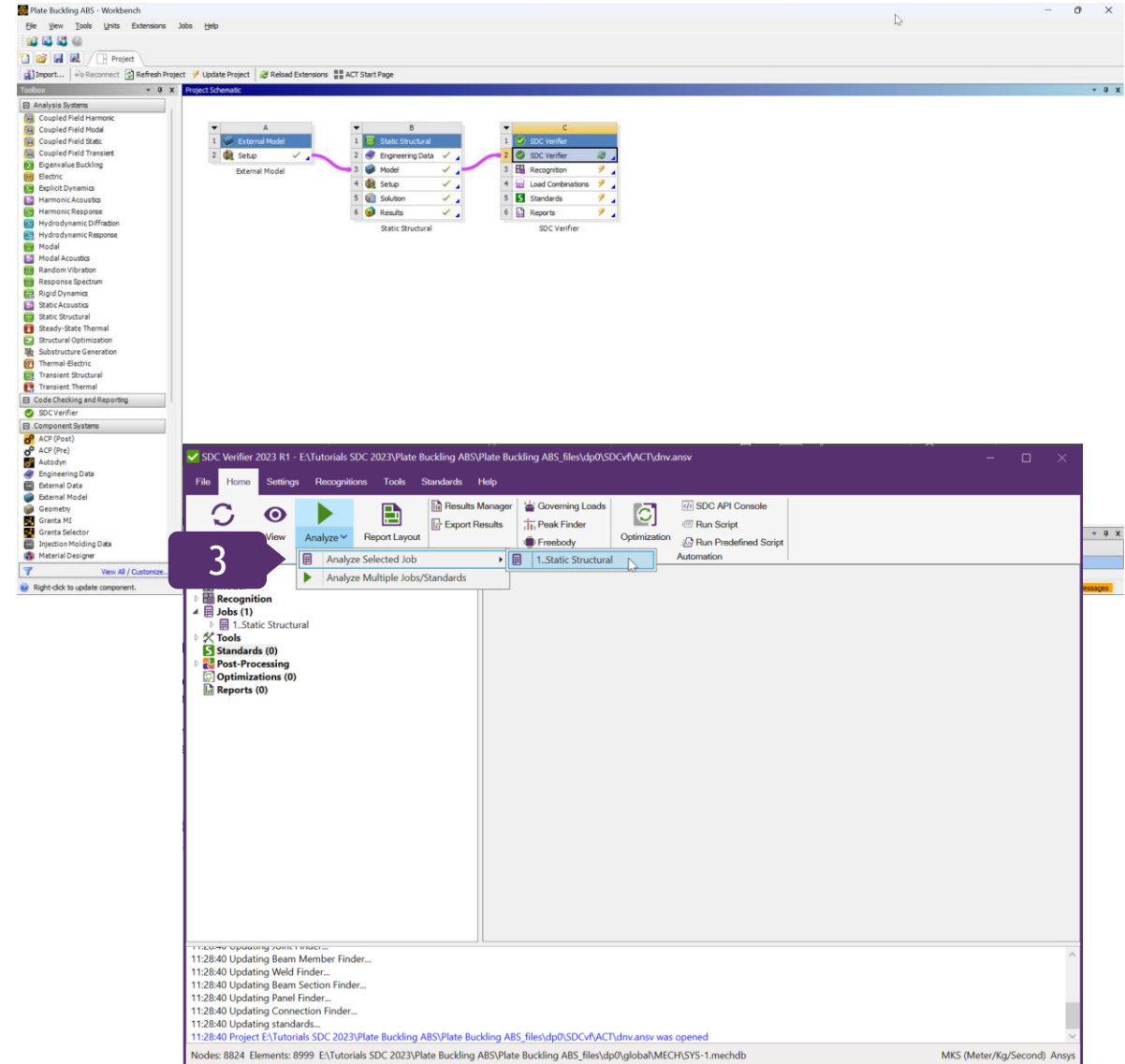
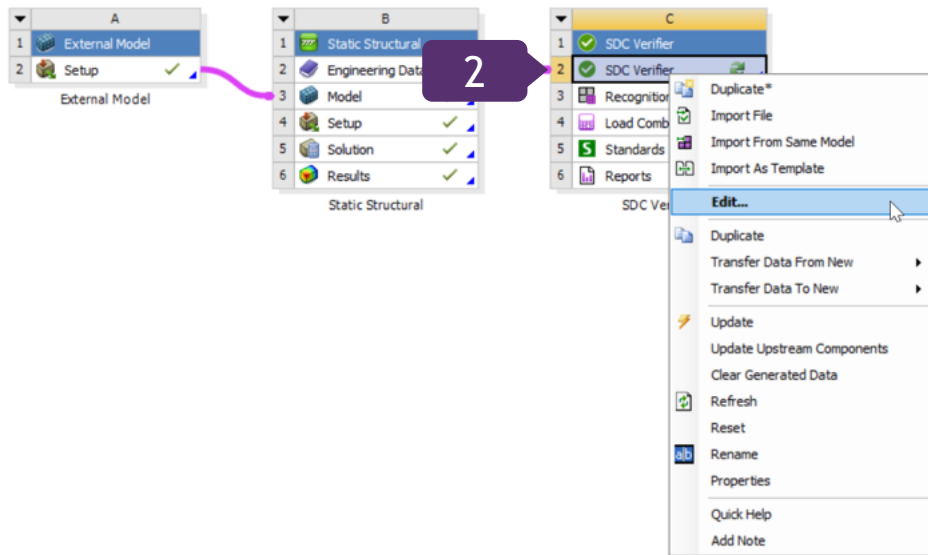
Open in Ansys Workbench   
Plate Buckling DNV.wbpz

2

Double Click on  or execute *Edit* from context menu

3


Press  on toolbar and select *Analyze selected job*



1

Right click on *Load Sets* => *Create/Edit multiple*.

2

Fill in “4” into *Count* and press  to add four Load Sets.

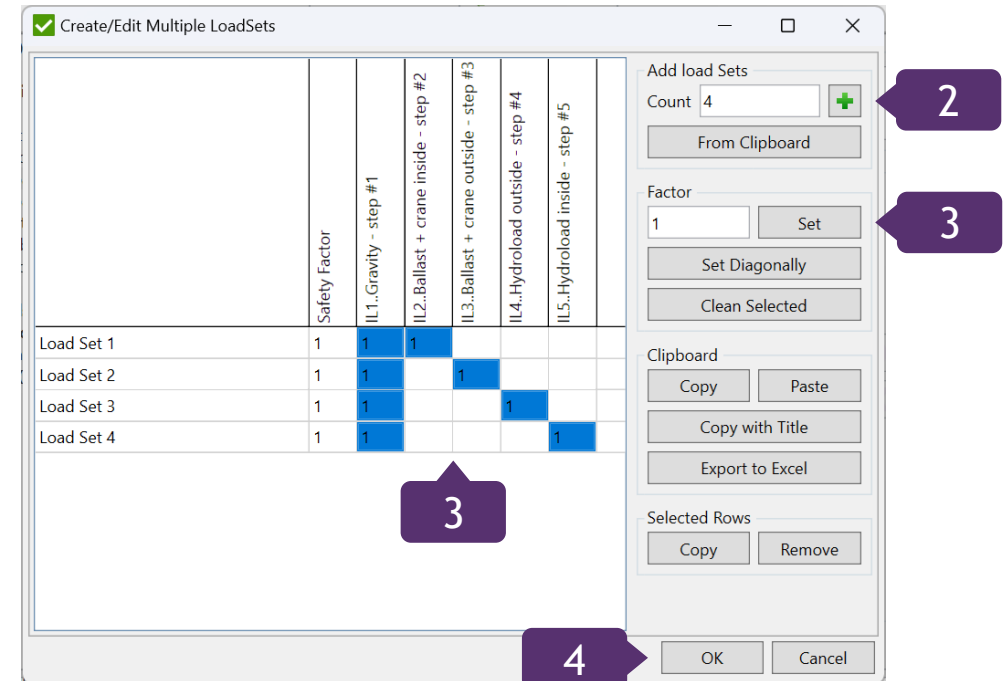
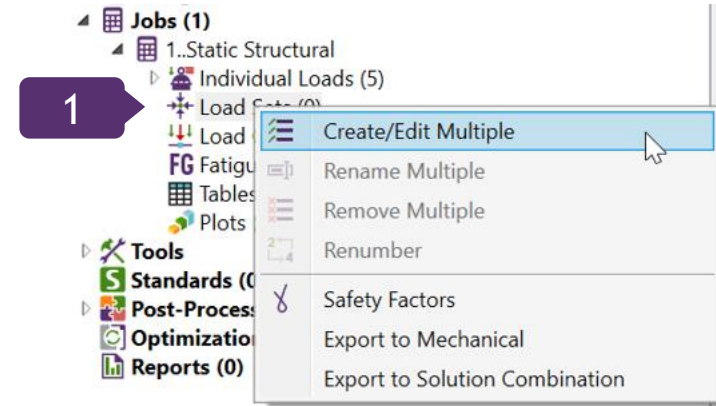
3

Select highlighted cells in the table like shown on the picture and press *Set* to define Factors of Load Sets. (By default LS Factor is 1)

4


Press *OK*

Load Sets are created with default titles “Load Set #”. It is possible to rename them by double-click on the respective load set title. Alternatively, the titles and factors can be pasted from the Clipboard using *Paste* button.



# Load Groups

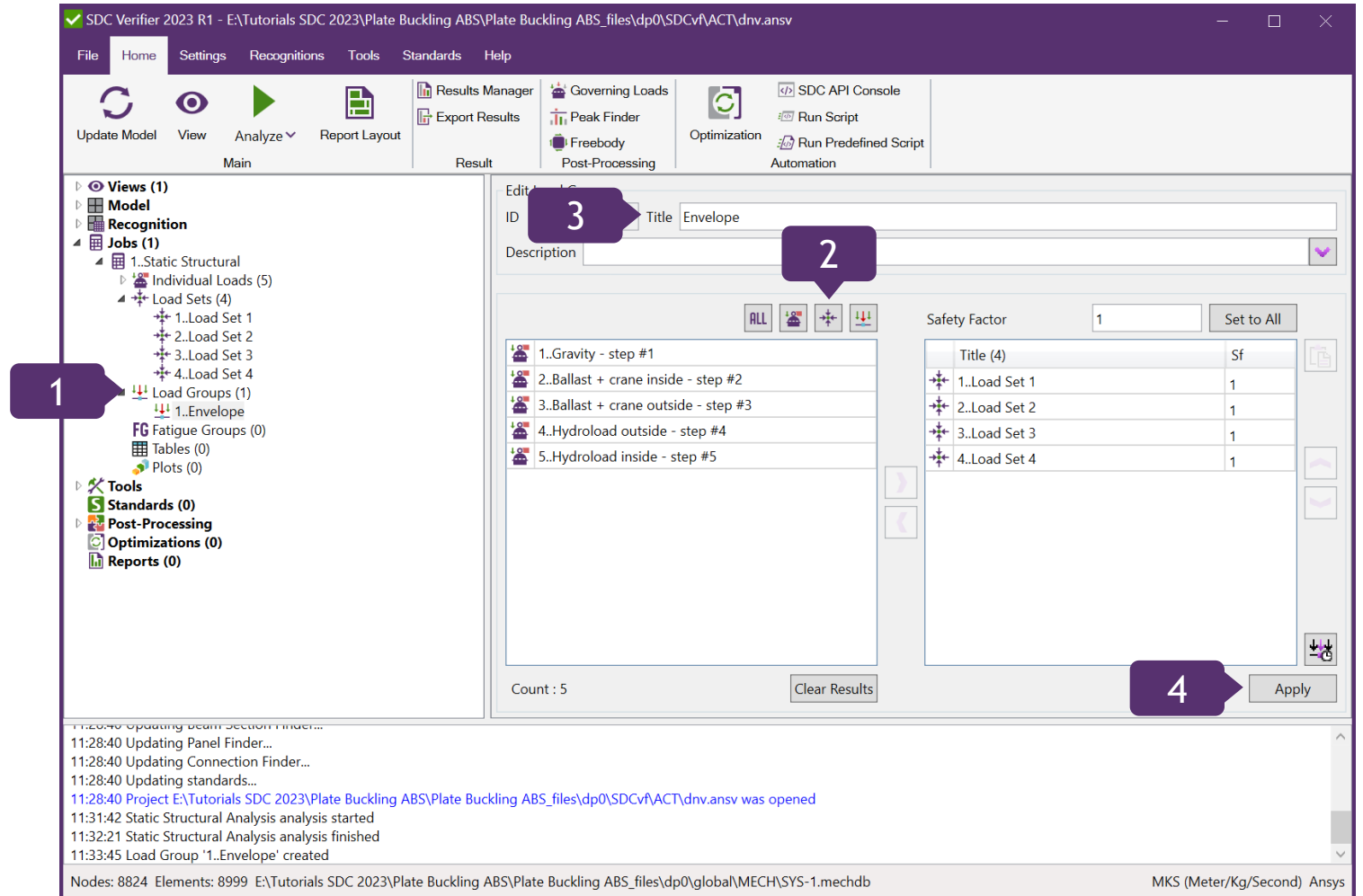
1 Click on *Load Groups*.

2 Press  to select all Load Sets.

3 *Title: Envelope*

4 Press *Create*

Load Sets and Load Groups are analyzed by SDC Verifier.



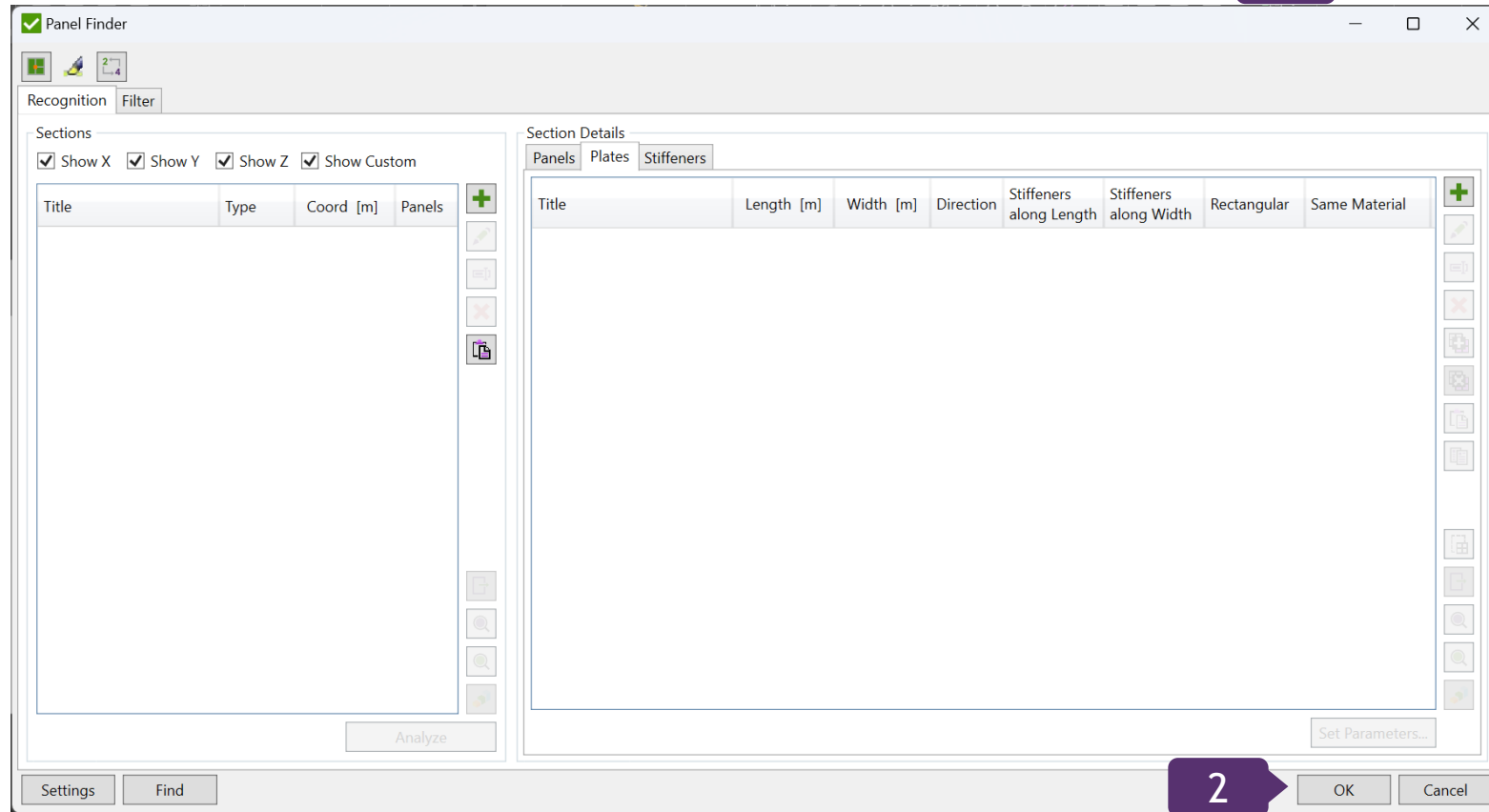
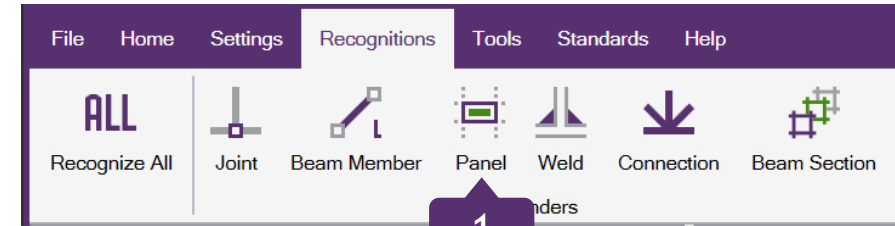
# Panel Finder. Recognize Sections.

1

Select *Recognition tab - Panel* on the toolbar menu

2

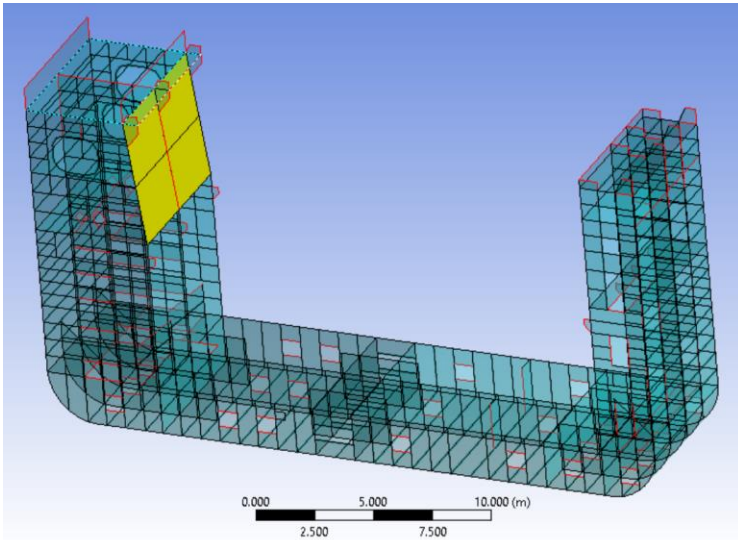
Click on *Find*



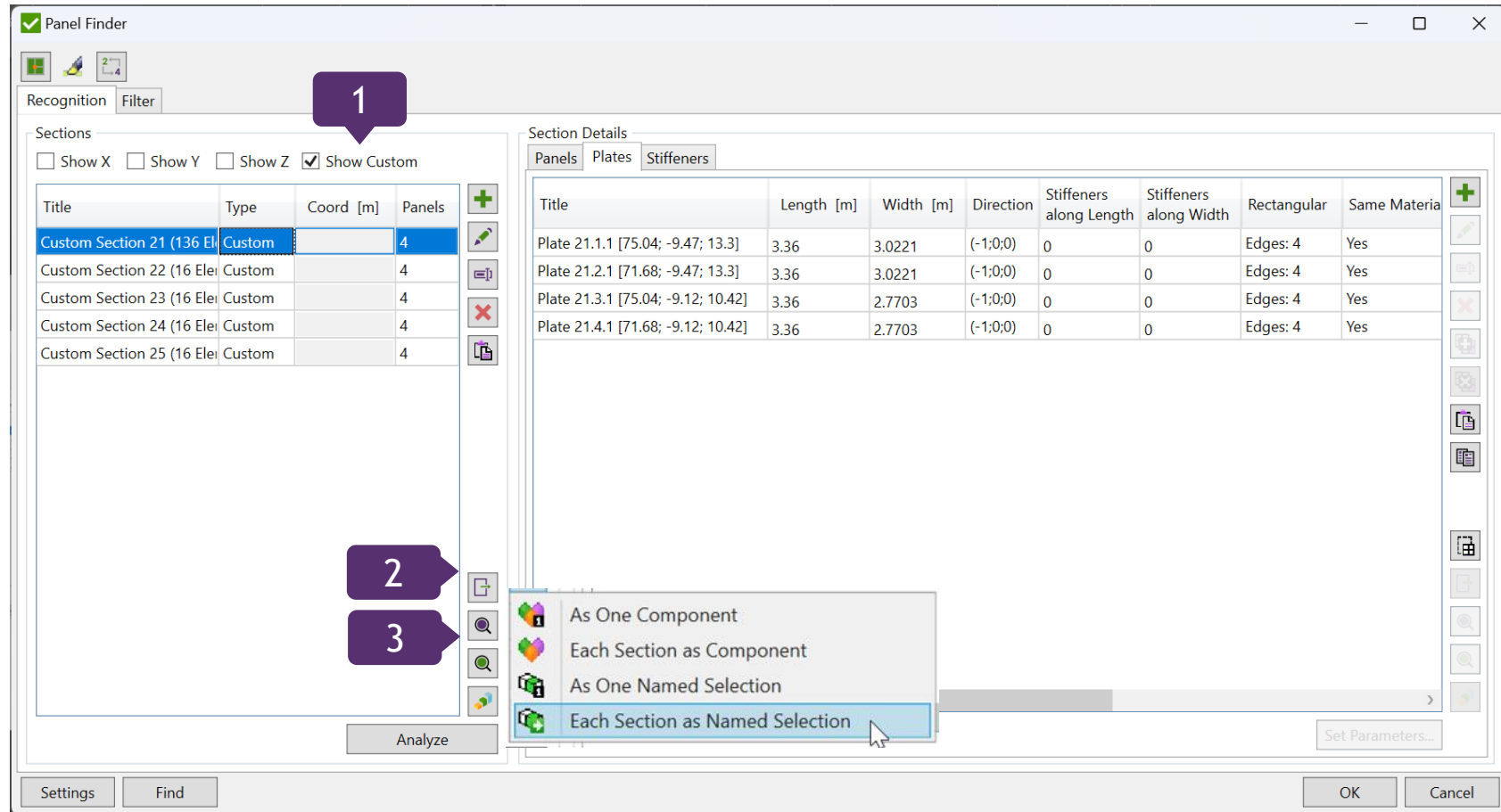
1 Show Custom: **ON** (rest OFF)

2 Press  and  to export selected sections to Named Selections

3 Press 



Example: It is possible to create custom section based on hull selection:




# Panel Finder. Find Free Edges

**Note:** Before plates recognition, the model should be checked on free edges. Not correct plate dimensions/direction, plates with undefined dimensions and as result wrong buckling factor - possible consequences of free edges.

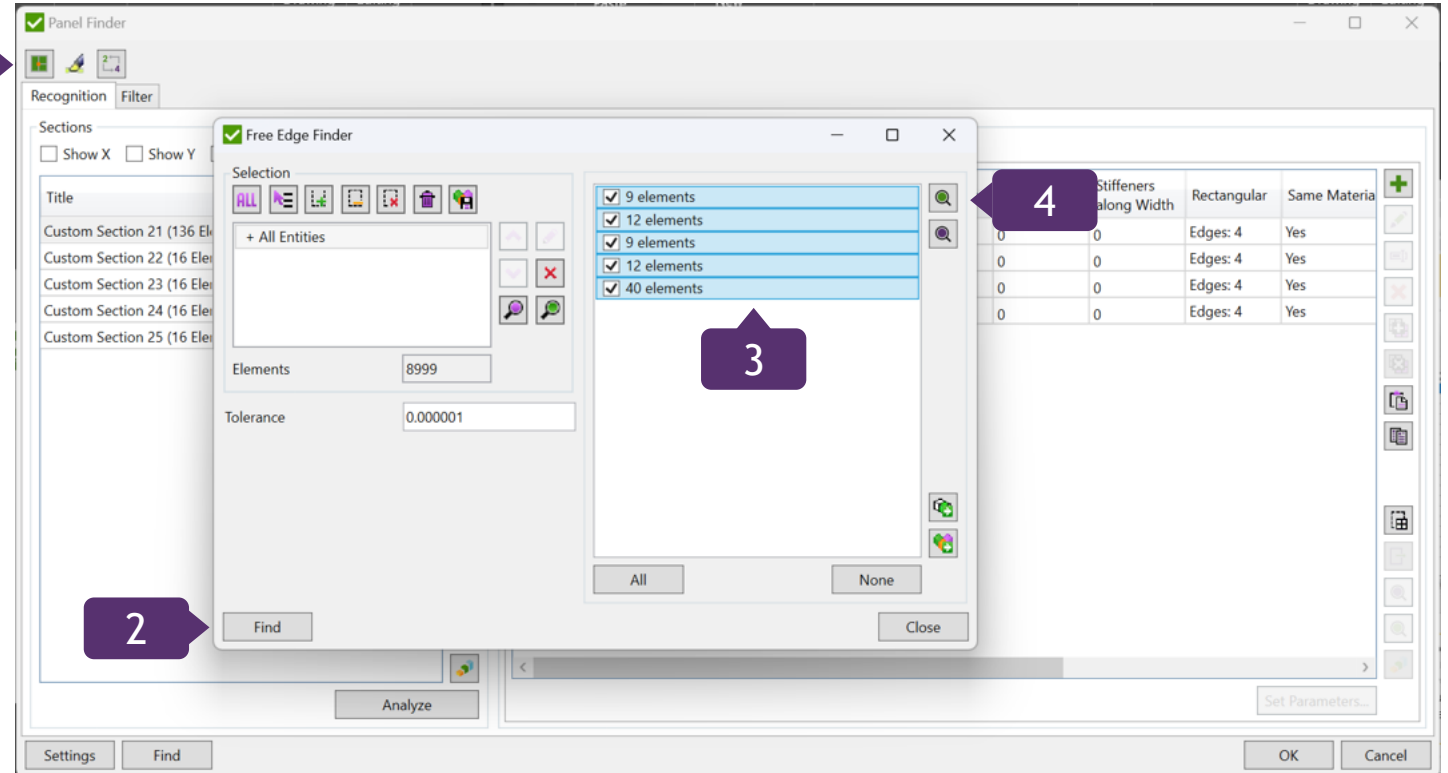
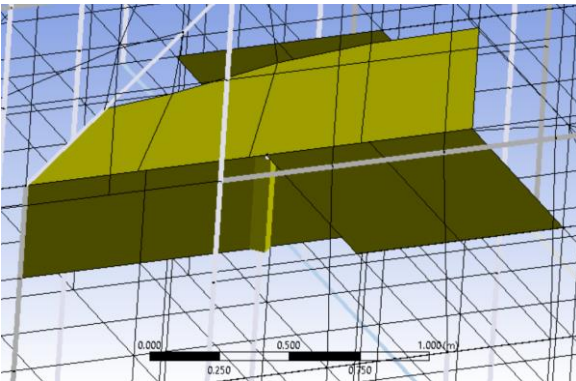
1 Click  to find free edges

2 Press **Find**

3 Select all free edges

4 Press  to preview elements with free edges

Mesh does not coincide



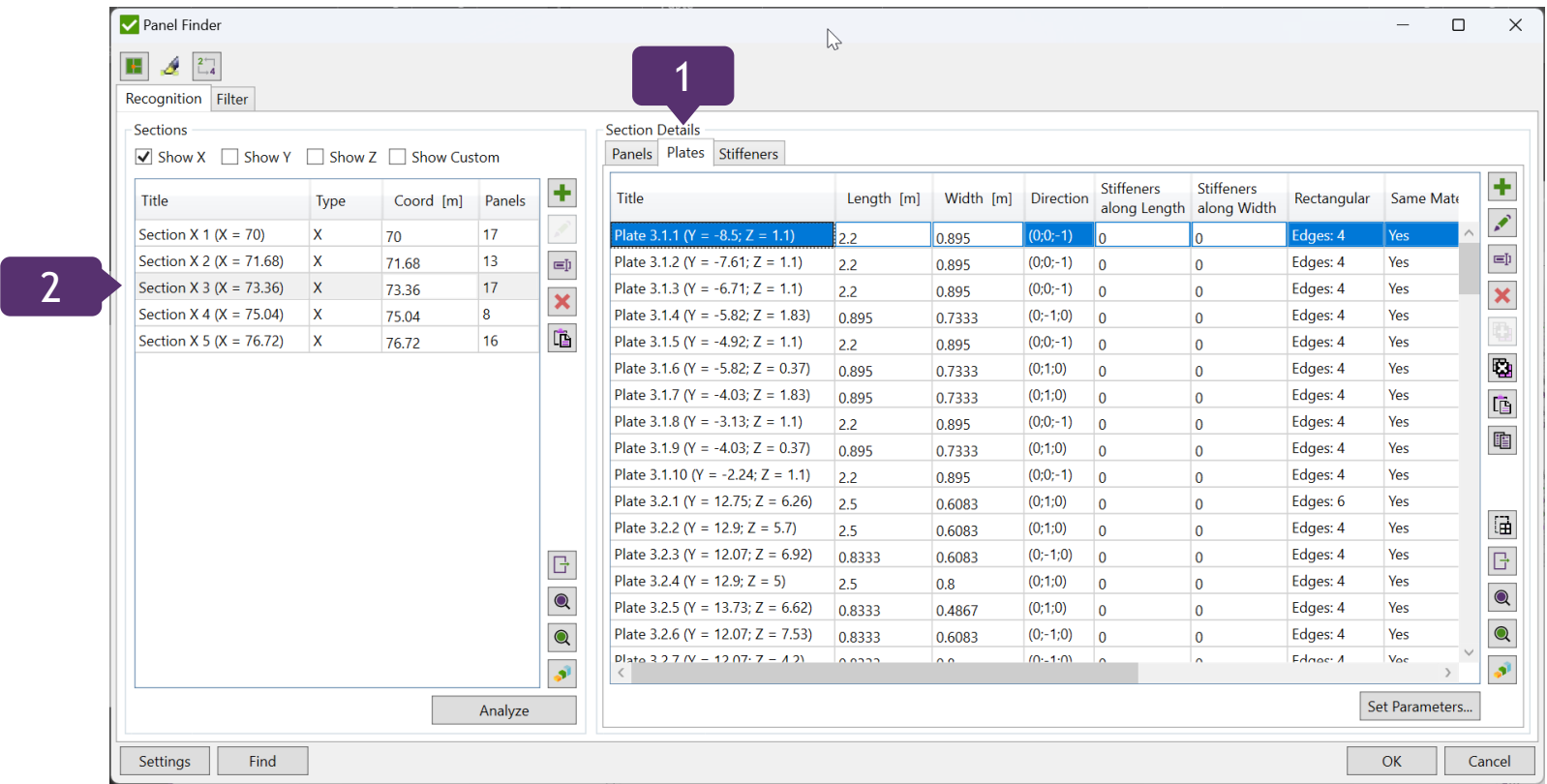
**Note:** Free edges should be fixed by remeshing the model and run recognition of plates. (In tutorial we skipped step with remeshing but for commercial project it is crucial step to do).



# Panel Finder. Recognize plates

1 In Selection details select **Plates Tab**

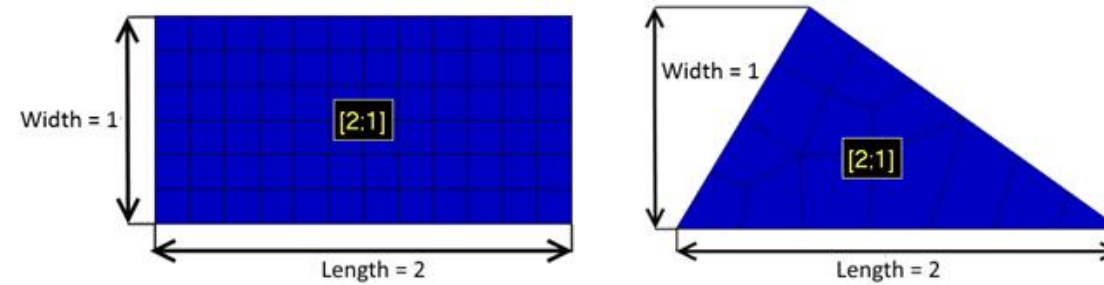
2 Select **Section X3**.



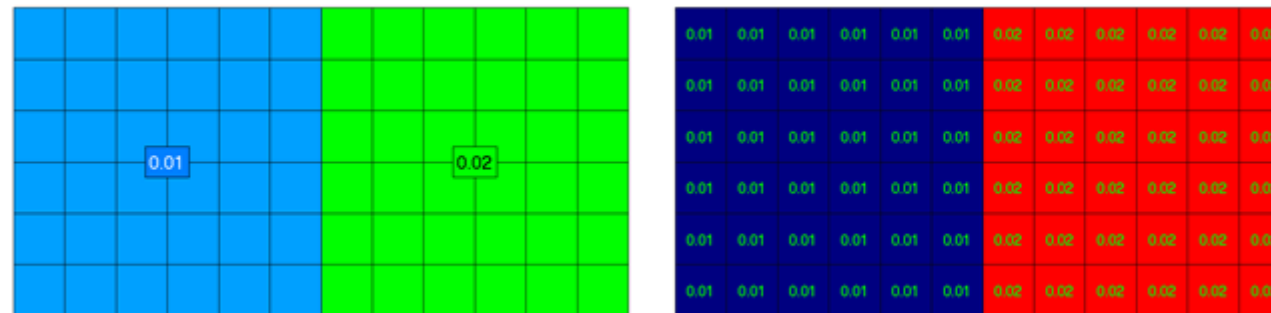
Section ID. Panel ID. Plate ID

Title	Length [m]	Width [m]	Direction	Stiffeners along Length	Stiffeners along Width	Rectangular
Plate 3.1.1 (Y = -8.5; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4
Plate 3.1.2 (Y = -7.61; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4
Plate 3.1.3 (Y = -6.71; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4

**Dimensions:** Results depend on plate dimensions and direction and it is important to understand how Panel Finder performs recognition. Length is considered the longest edge of plate and width the longest perpendicular to the longest edge:



**Plate Thickness:** Calculations are performed on every element and thickness is taken directly from each element. It is possible to set thickness manually for plate, in this case element thickness will be ignored and user defined thickness will be used. Example: Plate with 2 properties 0.01 and 0.02 thicknesses. Left picture displays property labels with property thicknesses and right presents plate buckling plot of thickness parameter:



☒ Panel Finder Recognition Settings

Selection

☐ Use Selection
 

All Entities

Predefined Girders

[Empty]

Predefined Stiffeners

[Empty]

Predefined Borders

0

Default Titles by Section Type

Section X

Section X

Section Y

Section Y

Section Z

Section Z

Section Custom

Custom Section

☒ Include Section Number in Title

Sections

Coordinate Deviation Limit of Section Plane

0.005

Minimum Elements Count in a Section

10

Minimum Angle Between Inclined Plane Normals [0;90]

3

Minimum Angle Between Flat Plane Normals [0;90]

1

Plates

Minimum Angle Between Plate Edges [0;90]

3

☐ Skip Not Four Edged Plates

☐ Skip Triangular Plates

☐ Split Plate on Thickness Difference

☐ Split Plate if Different Property IDs

☐ Calculate Dimensions by CSR Method

Stiffeners

☒ Skip Curved Stiffeners

Treat Stiffener as Straight if Angle <

3

Lengthen Stiffener (Dummy) if it Covers Panel More Than, %

80

If selected:

Value > 80%

83,3%

66,7%

Value > 60%

83,3%

66,7%

OK

Cancel

## 2.3.2 Modelling of an unstiffened panel with irregular geometry

Unstiffened panels with irregular geometry are to be idealised to equivalent panels for plate buckling assessment according to the following procedure:

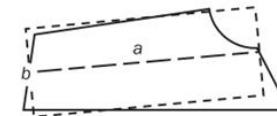
e) The length of shorter side,  $b$  in mm, is to be taken as:

$$b = A/a$$

where:

$A$  : Area of the plate, in mm<sup>2</sup>

$a$  : length defined in (d), in mm

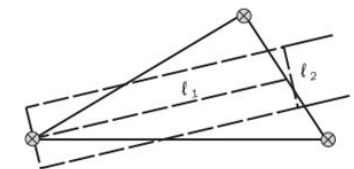


c) The width of the model,  $\ell_2$ , in mm, is to be taken as:

$$\ell_2 = A/\ell_1$$

where:

$A$  : Area of the plate, in mm<sup>2</sup>



# Editing plates manually

To modify plates select them from the list and press *Set Parameters*. It is possible to edit (Length / Width / Thickness / Coefficients / Direction).

It is possible to define parametric stiffeners along the Length and Width.

If thickness is changed you can see in table what was the original thickness recognized from model:

Thickness [m]

0.012 (Original: 0.01539855)

0.012 (Original: 0.01539855)

0.012 (Original: 0.01539855)

The screenshot shows the 'Panel Finder' window with a list of sections and the 'Section Details' window showing a table of plate parameters.

Title	Type	Coord [m]	Panels
Section X 1 (X = 70)	X	70	17
Section X 2 (X = 71.68)	X	71.68	13
Section X 3 (X = 73.36)	X	73.36	17
Section X 4 (X = 75.04)	X	75.04	8
Section X 5 (X = 76.72)	X	76.72	16

Title	Length [m]	Width [m]	Direction	Stiffeners along Length	Stiffeners along Width	Rectangular	Same Mat
Plate 1.1.1 (Y = -8.5; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4	Yes
Plate 1.1.2 (Y = -7.61; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4	Yes
Plate 1.1.3 (Y = -6.71; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4	Yes
Plate 1.1.4 (Y = -5.82; Z = 1.83)	0.895	0.7333	(0;-1;0)	0	0	Edges: 4	Yes
Plate 1.1.5 (Y = -4.92; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4	Yes
Plate 1.1.6 (Y = -5.82; Z = 0.37)	0.895	0.7333	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.1.7 (Y = -4.03; Z = 1.83)	0.895	0.7333	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.1.8 (Y = -3.13; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4	Yes
Plate 1.1.9 (Y = -4.03; Z = 0.37)	0.895	0.7333	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.1.10 (Y = -2.24; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4	Yes
Plate 1.2.1 (Y = 12.75; Z = 6.26)	2.5	0.6083	(0;1;0)	0	0	Edges: 6	Yes
Plate 1.2.2 (Y = 12.9; Z = 5.7)	2.5	0.6083	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.2.3 (Y = 12.07; Z = 6.92)	0.8333	0.6083	(0;-1;0)	0	0	Edges: 4	Yes
Plate 1.2.4 (Y = 12.9; Z = 5)	2.5	0.8	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.2.5 (Y = 13.73; Z = 6.62)	0.8333	0.4867	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.2.6 (Y = 12.07; Z = 7.53)	0.8333	0.6083	(0;-1;0)	0	0	Edges: 4	Yes
Plate 1.2.7 (Y = 12.07; Z = 4.2)	0.8333	0.8	(0;-1;0)	0	0	Edges: 4	Yes

The dialog box is titled 'Set Plates Parameters (Leave Empty Field to not to Set a Value)'. It has two main sections: 'Dimensions' and 'Direction'.

**Dimensions:**

- ☒ Set Length/Width Value
  - Length [m]:
  - Width [m]:
- ☐ Set Stiffeners Amount along Plate's:
  - Length:
  - Width:
  - Thickness [m]:

**Coefficients:**

- C1:
- C2:
- Psi X:
- Psi Y:

**Direction:**

- ☐ Swap Direction for
  - ☒ Plates where Width > Length
  - ☐ All Plates
- ☐ Set Direction
  - Direction:
  - X:
  - Y:
  - Z:

Buttons: OK, Cancel

Usually you should not modify plate directions. But in case it is required press *Set Direction*.

# Panel Finder. Plates Plot

1

Select Section X1


2

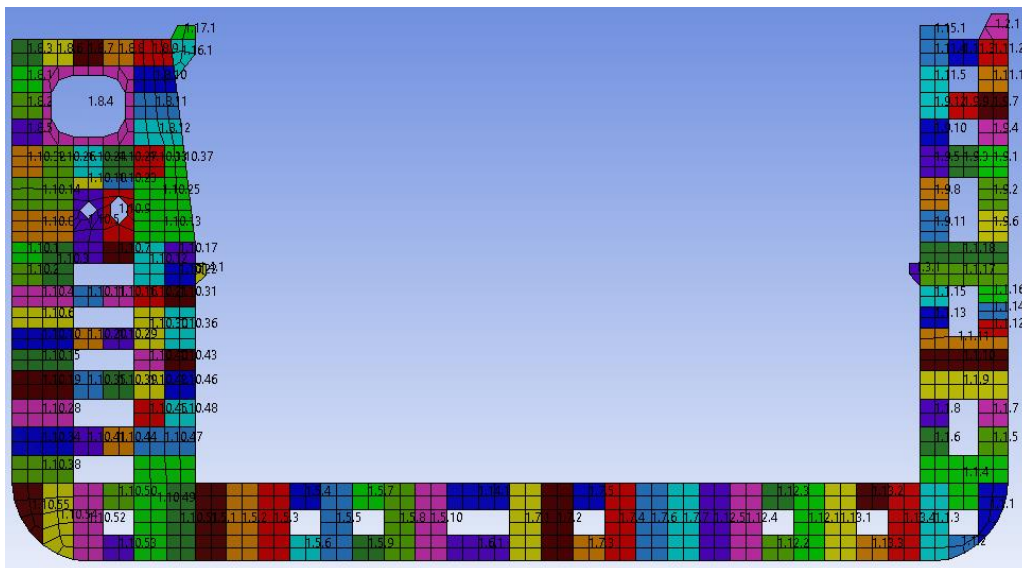
Select All Plates (Ctrl+A)

3

Press 

4

Click on  Colors + Labels of Ids



Panel Finder

Recognition Filter

Sections

☒ Show X ☐ Show Y ☐ Show Z ☐ Show Custom

Title	Type	Coord [m]	Panels
Section X 1 (X = 70)	X	70	17
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Section X 3 (X = 73.36)	X	73.36	17
Section X 4 (X = 75.04)	X	75.04	8
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Section Details

Panels Plates Stiffeners

Title	Length [m]	Width [m]	Direction	Stiffeners along Length	Stiffeners along Width	Rectangular	Same Mat
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Plate 1.1.9 (Y = -4.03; Z = 0.37)	0.895	0.7333	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.1.10 (Y = -2.24; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4	Yes
Plate 1.2.1 (Y = 12.75; Z = 6.26)	2.5	0.6083	(0;1;0)	0	0	Edges: 6	Yes
Plate 1.2.2 (Y = 12.9; Z = 5.7)	2.5	0.6083	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.2.3 (Y = 12.07; Z = 6.92)	0.8333	0.6083	(0;-1;0)	0	0	Edges: 4	Yes
Plate 1.2.4 (Y = 12.9; Z = 5)	2.5	0.8	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.2.5 (Y = 13.73; Z = 6.62)	0.8333	0.4867	(0;1;0)	0	0	Edges: 4	Yes
Plate 1.2.6 (Y = 12.07; Z = 7.53)	0.8333	0.6083	(0;-1;0)	0	0	Edges: 4	Yes
Plate 1.2.7 (Y = 12.07; Z = 4.2)	0.8333	0.6083	(0;-1;0)	0	0	Edges: 4	Yes

Analyze

Settings Find

OK Cancel

4

Colors Only

**Colors + Labels of Ids**

Colors + Labels of Corners Count

Colors + Labels of Dimensions

Length Values (no labels)

Width Values (no labels)

Coordinate Systems

Draw Stiffeners along Length/Width

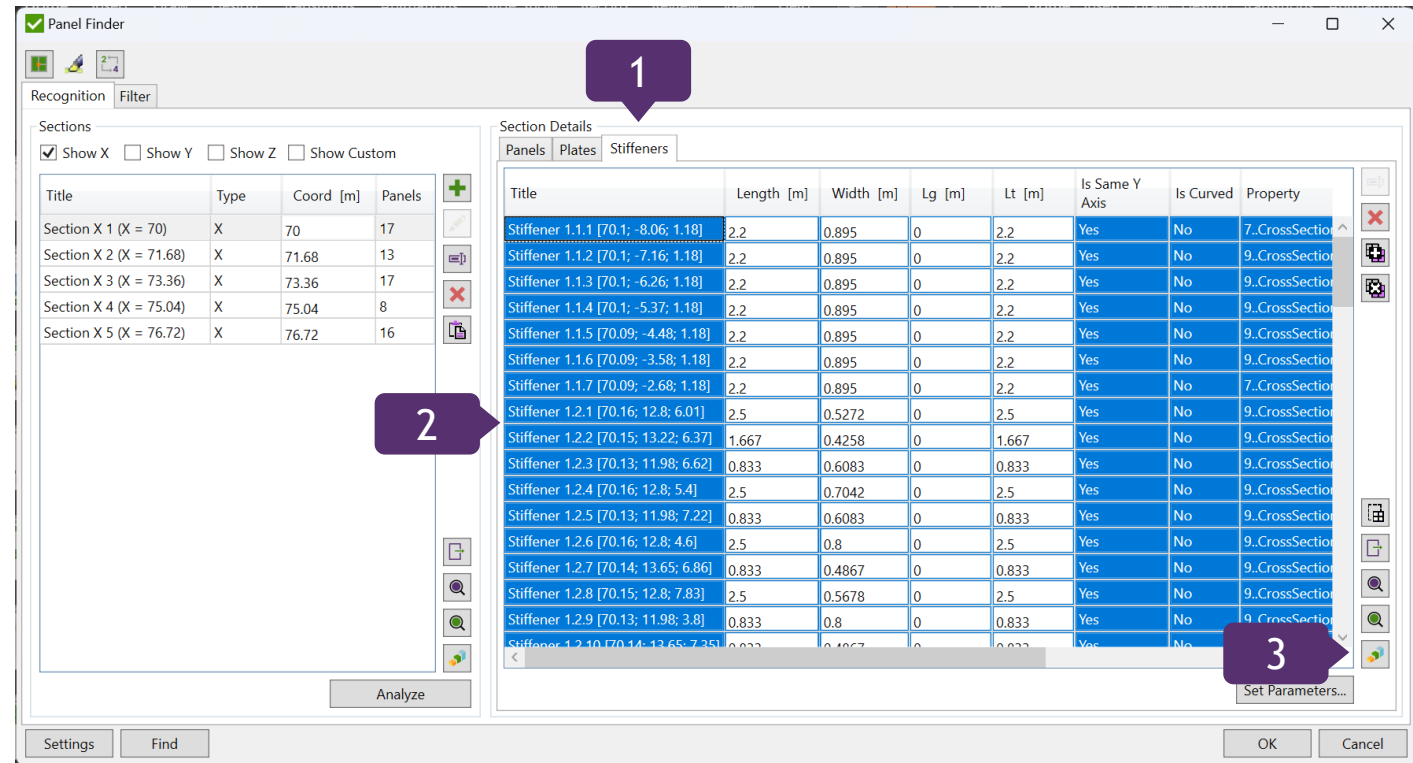
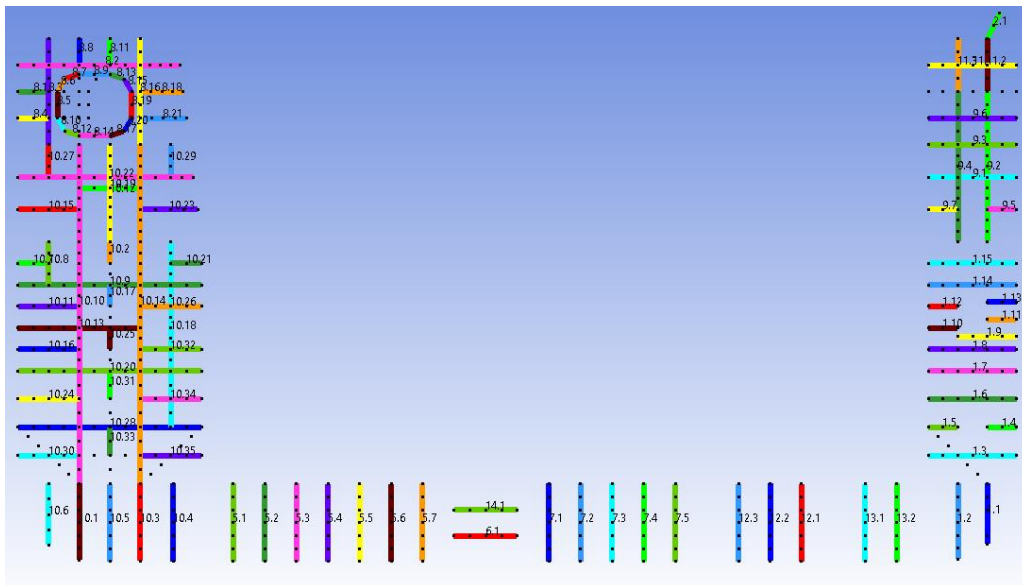
# Panel Finder. Stiffeners Plot

1 Select *Stiffeners tab*

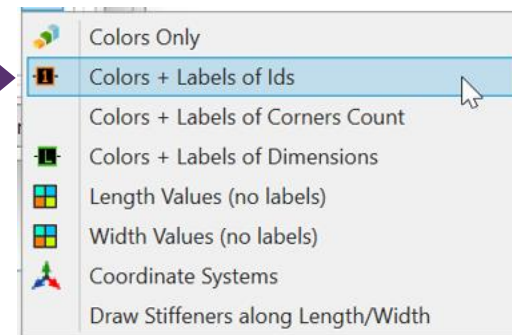
2 Select *All Stiffeners (Ctrl+A)*

3 Press 

4 Click on  Colors + Labels of Ids



4





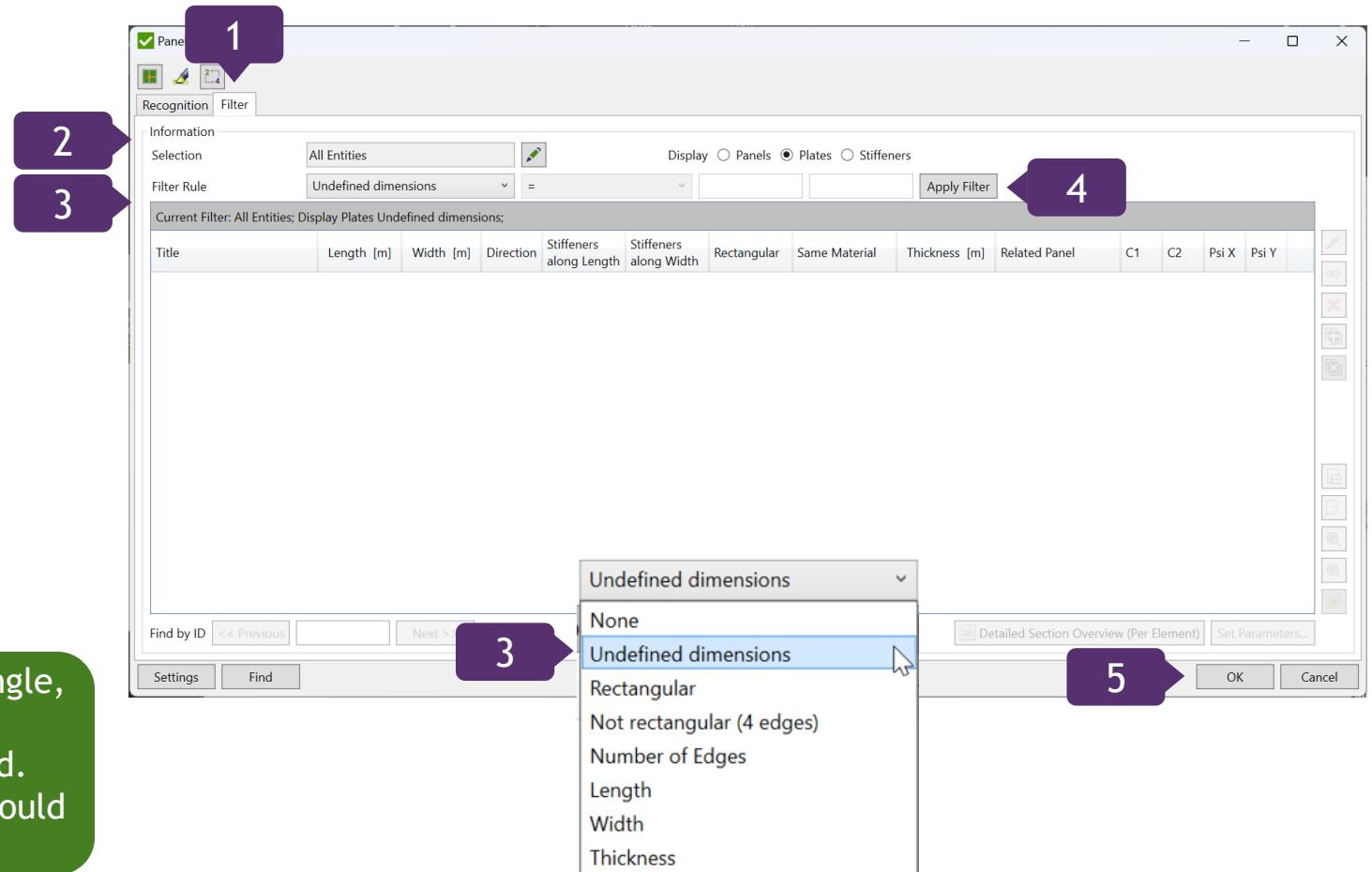
**Note:** Before plates recognition, the model should be checked on free edges. Not correct plate dimensions/direction, plates with undefined dimensions and as result wrong buckling factor - possible consequences of free edges.

- 1 Click on *Filter tab*
- 2 Selection: **All Entities**
- 3 Filter: **Undefined dimensions**

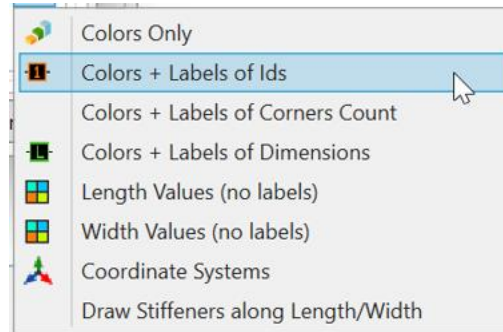
4 Press *Apply Filter*

5 Table with plates is empty means that there is no plates with undefined dimensions. Press OK

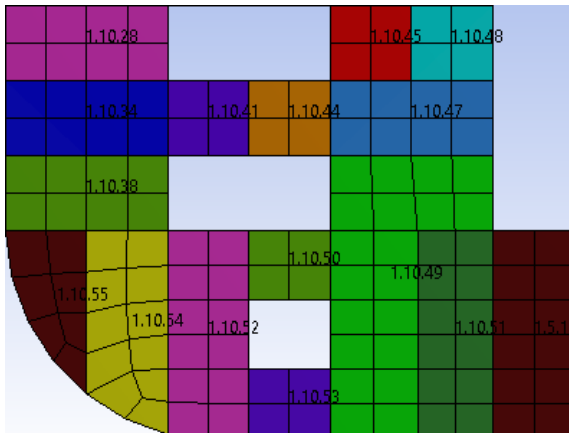
**Tip:** It is also possible to filter plates by shape (triangle, rectangular) or number of edges parameters. E.g. Plates with numbers of edges > 4 can be displayed. Control using Selection plates from which Sections should be filtered.



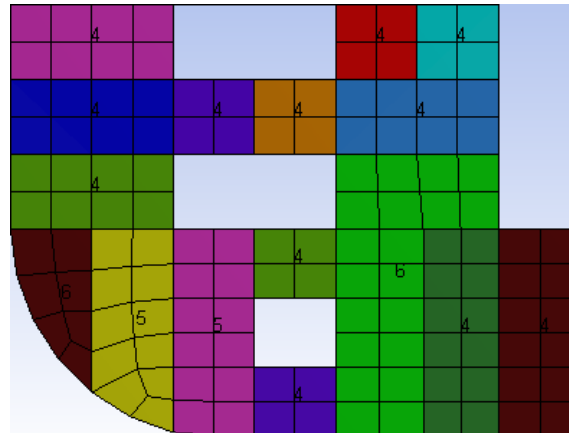
**Note:** Plate Plot can be displayed with different colors labels (labels of ids, labels of corners count or labels of dimensions). Also it is possible to show plates in length and width, coordinate systems etc.



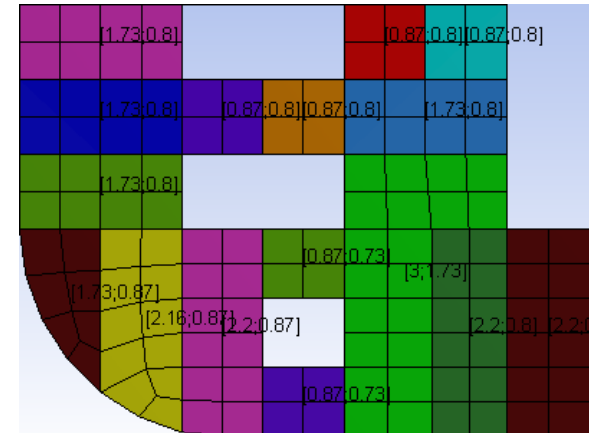
## Labels of Ids



## Labels of Corners Count

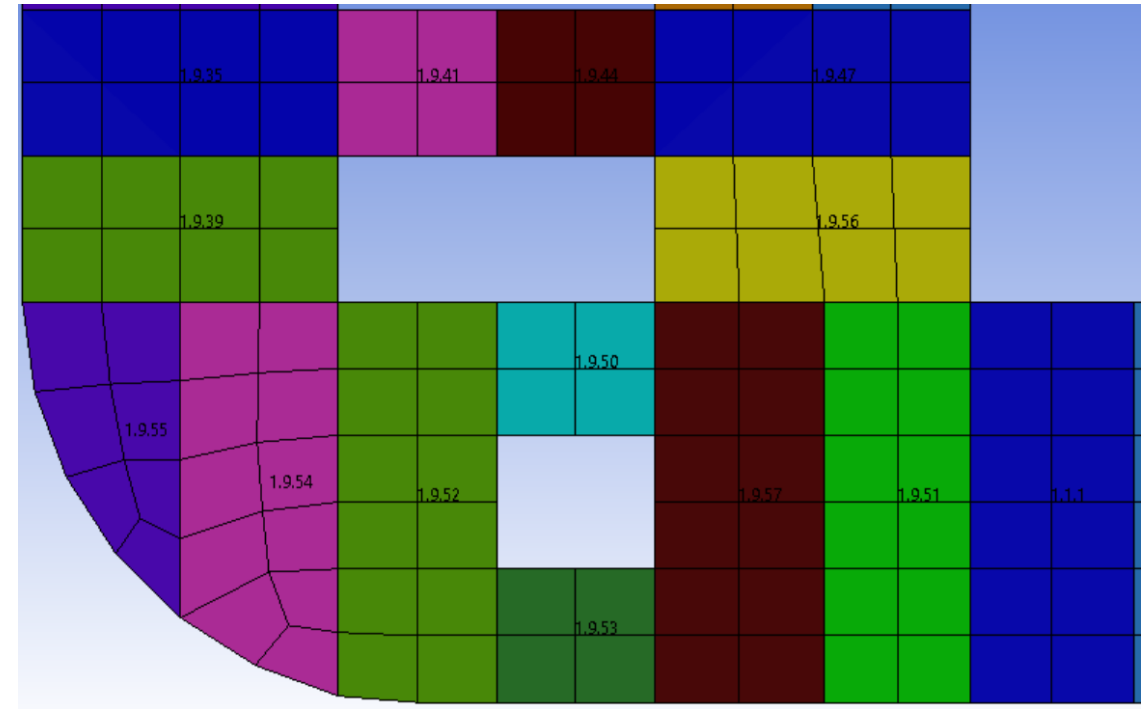
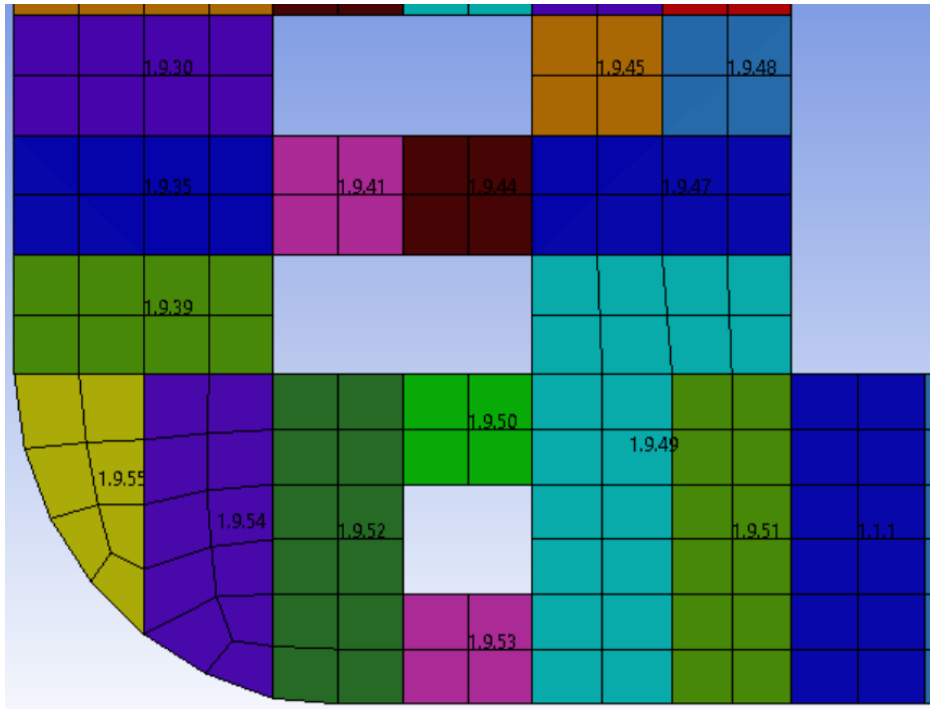


## Labels of dimensions





In some cases (e.g. stiffener is not modeled) plate is recognized not correctly, dimensions are bigger than in reality which leads to wrong results. Plate has to be updated manually. In Section X1 plate with Id = 1.9.49 should be split on 2 plates



# Panel Finder. Split Plate

1

Select Section X1

2

Select Plate 1.9.49

3

Press  and *Split by elements*

4

Selected plate is displayed in Ansys.  
Select elements for one plate and press  
Yes

5

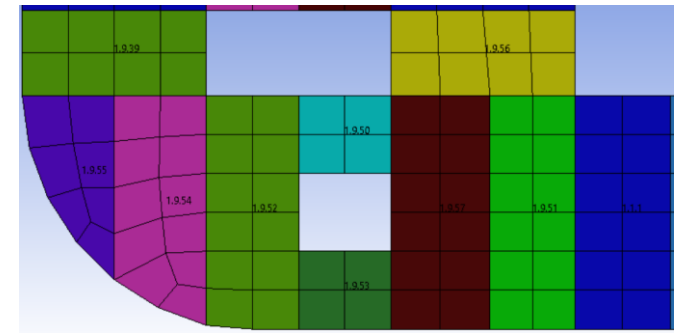
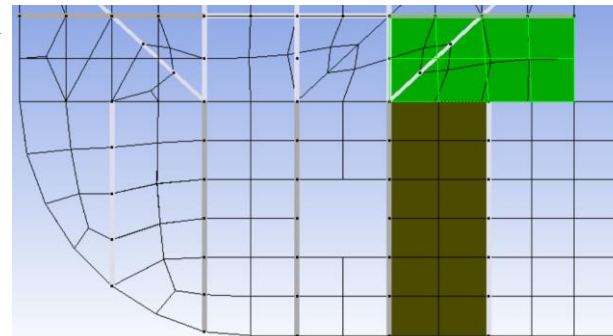
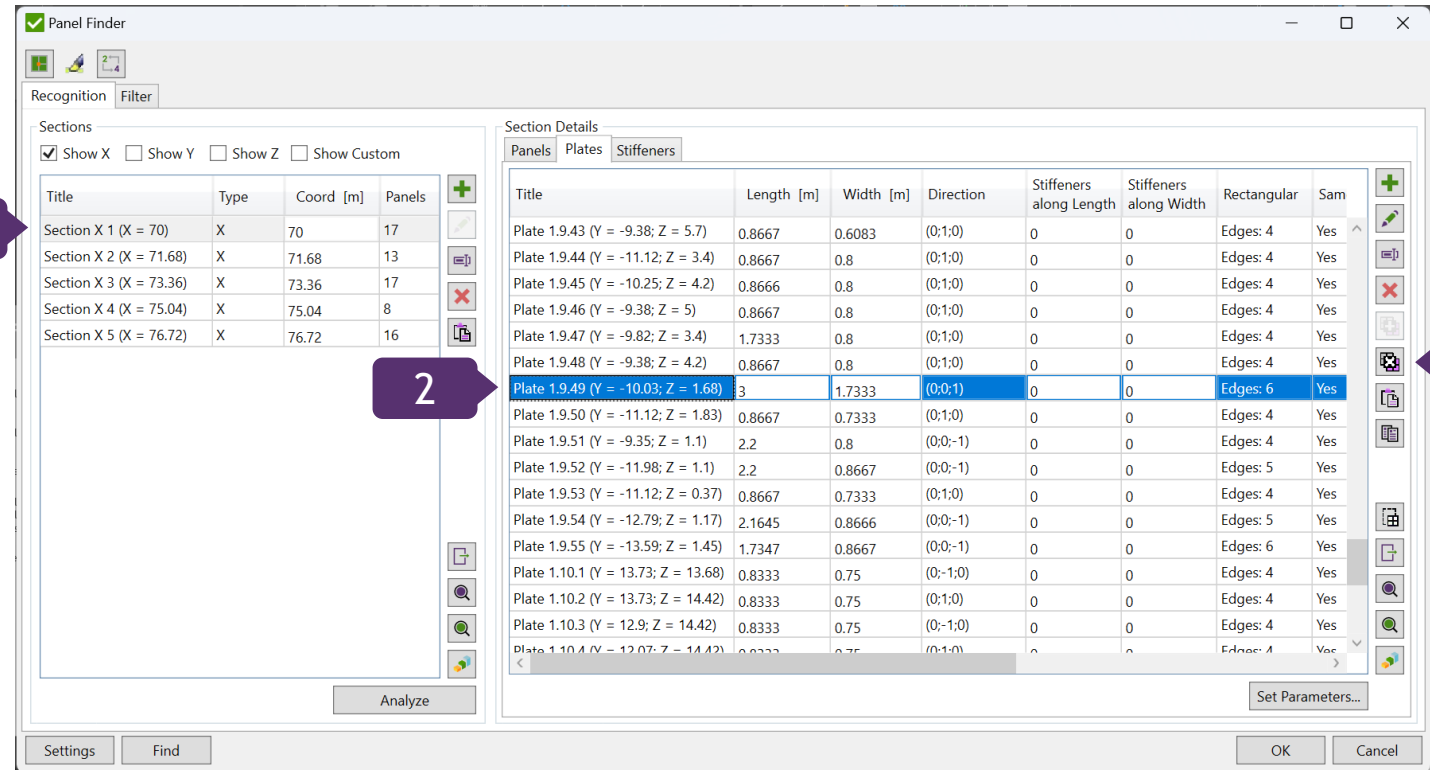
Press *Ok*

3

Split by Nodes (by 2 end nodes on plate edges)  
Split by Nodes (ordered)  
Split by Elements

4

Plate 1.9.49 is replaced with Plates 1.9.56 and 1.9.57



# Add Plate Buckling ABS 2014 standard

1

In Standards Context menu execute *Add*  
=> *ABS* => *ABS Plate Buckling (2014)*

2

Utilization Factor (Eta) = 0.8

3

Press 

4

Press *Update from Ansys*

5

Press *OK*

6


Use Plate Average Stress: On

7

Press *OK*

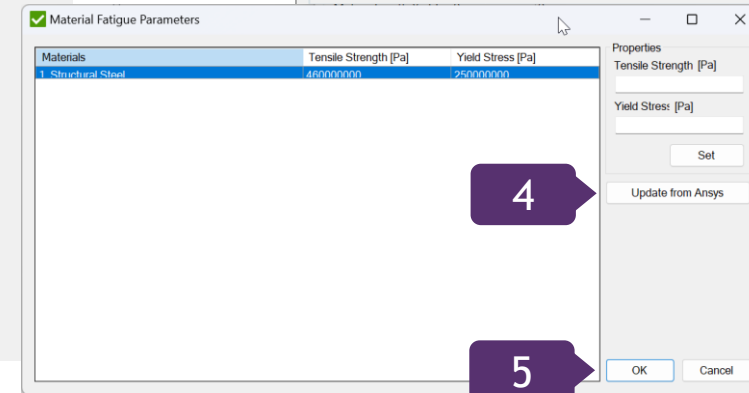
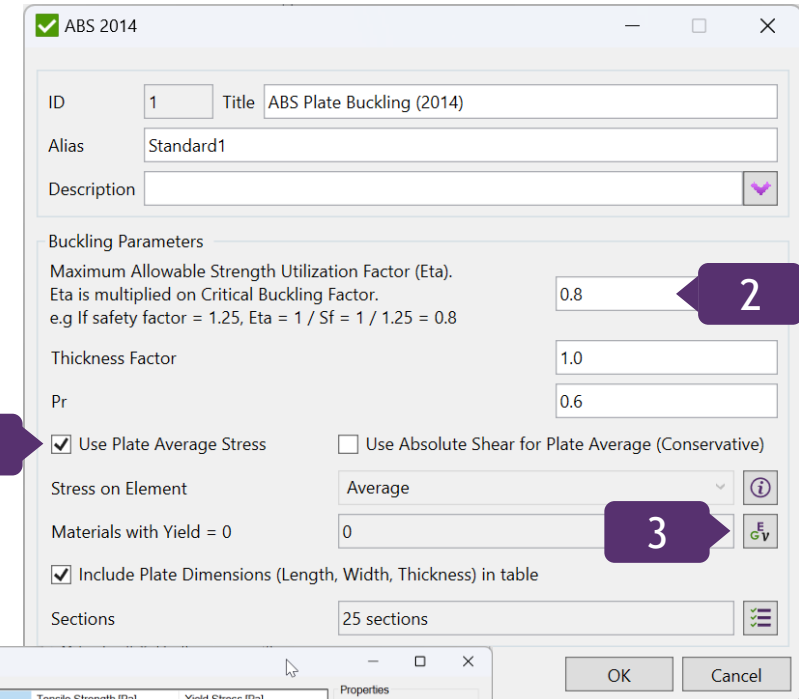
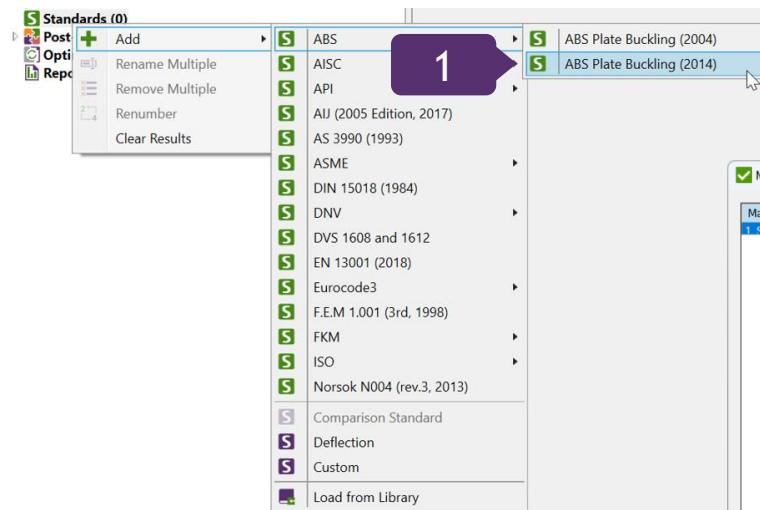
Plate Buckling transforms stresses automatically into plate direction. Options about element stresses and plate stresses are described on the next slide

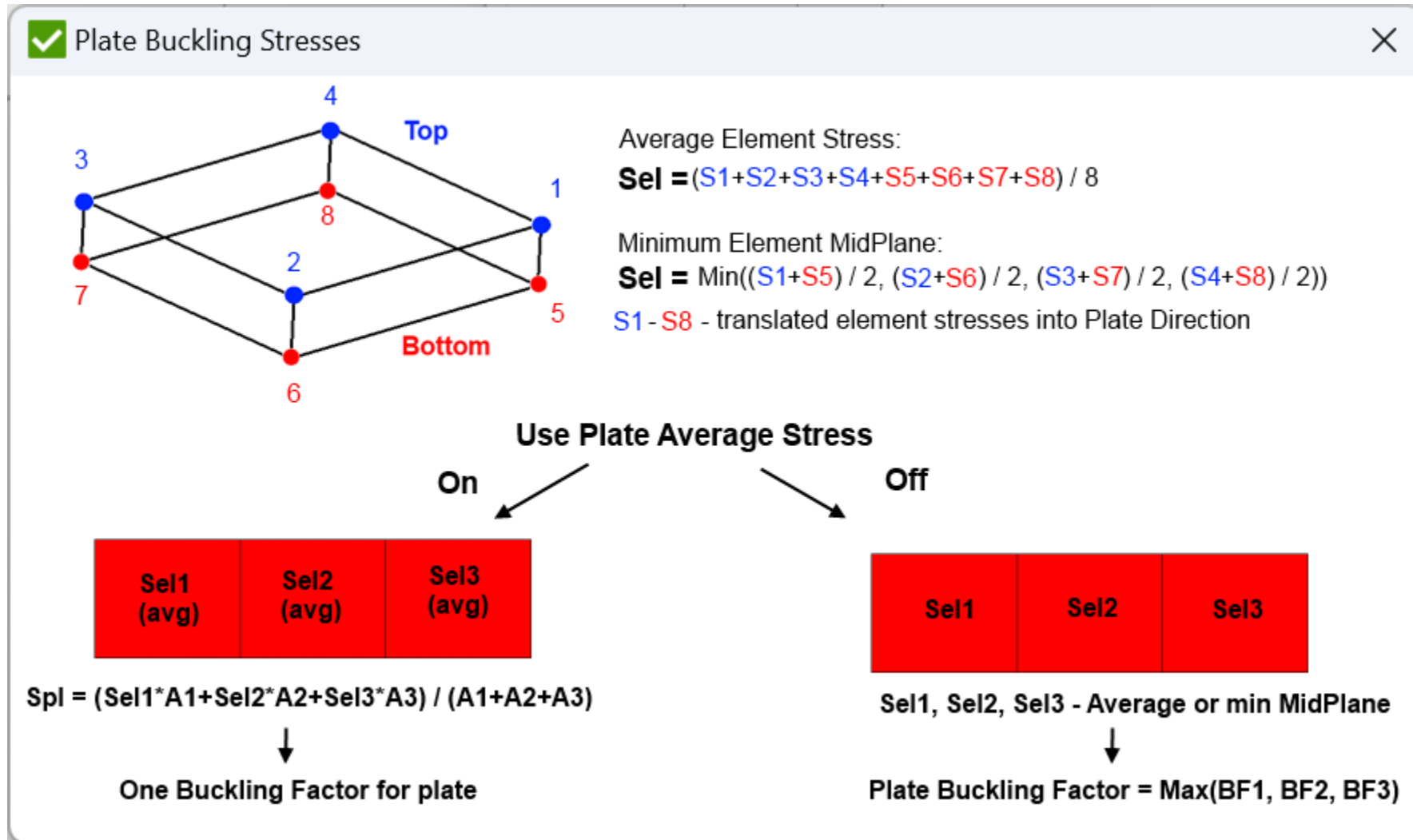
Thickness factor gives a possibility to increase / decrease all plates thicknesses without reanalyzing the model. E.g. 1.2 means increase thickness on 20% and decrease stresses.

Materials with Yield Stress = 0 shows how many materials have yield equal to 0. If value is > 0 press  to define yield.

By default all sections will be checked. Click  to modify.

Pr - proportional linear elastic limit (0.6 for steel)





To make nice plots first Views should be created (set of settings how to display plot).

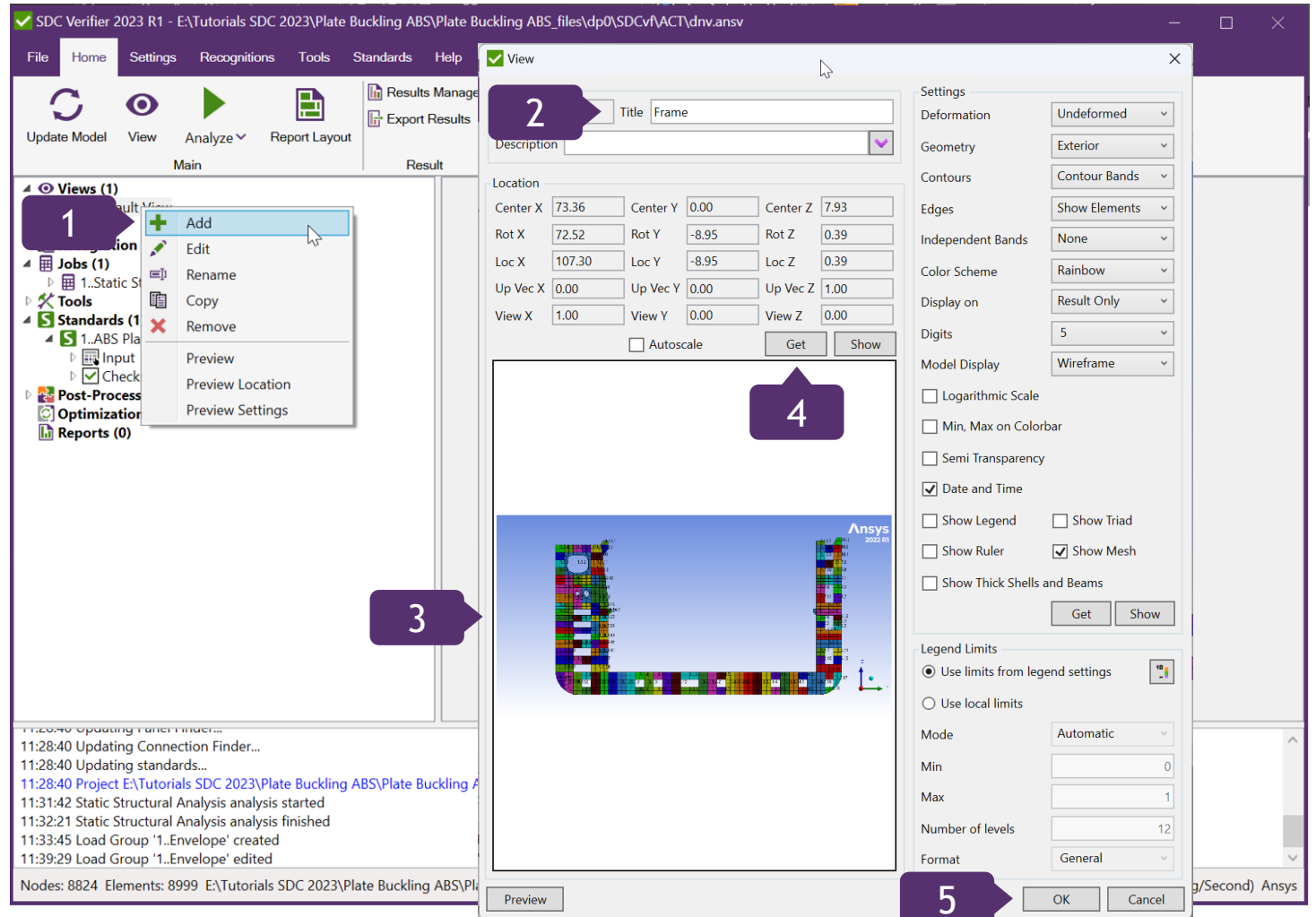
1 Execute Views => Add

2 Title: Frame

3 Orient model in Ansys as shown on picture below (ZY plane)

4 Press *Get*

5 Press *OK*



# Plate Buckling Plot

1

Execute *Criteria Plot* from Plate Buckling ABS 2014 context menu

2

Load Group: 1..Envelop

3

View: 2..Frame

4

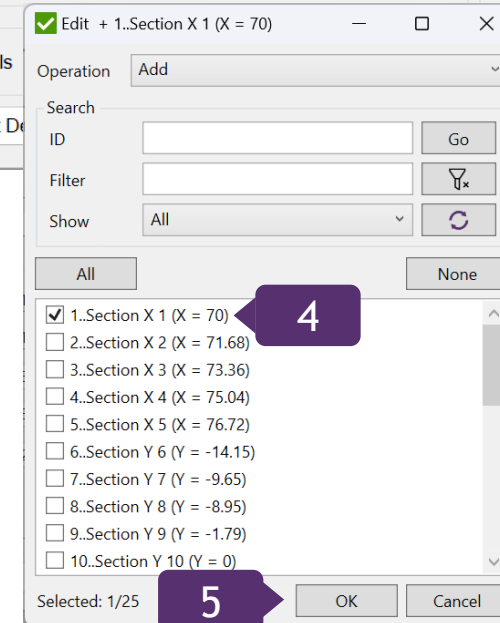
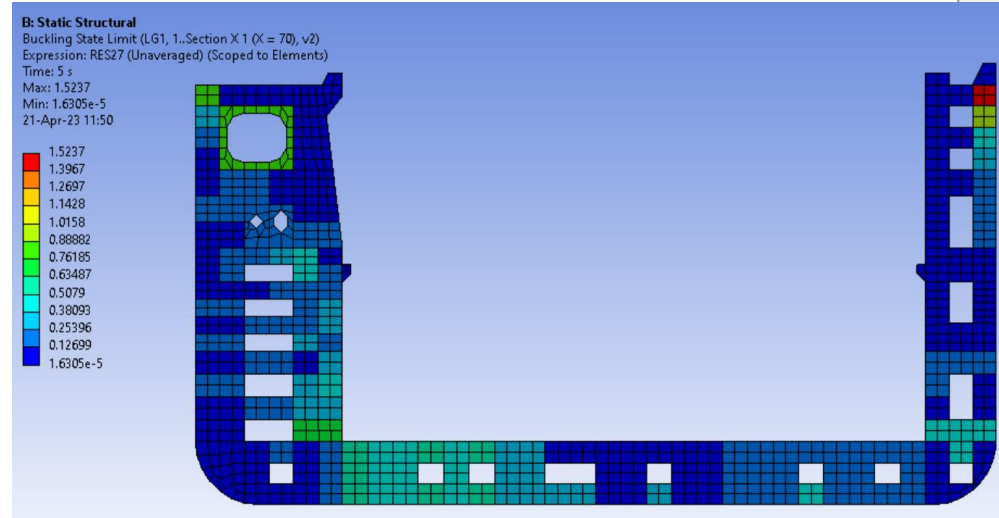
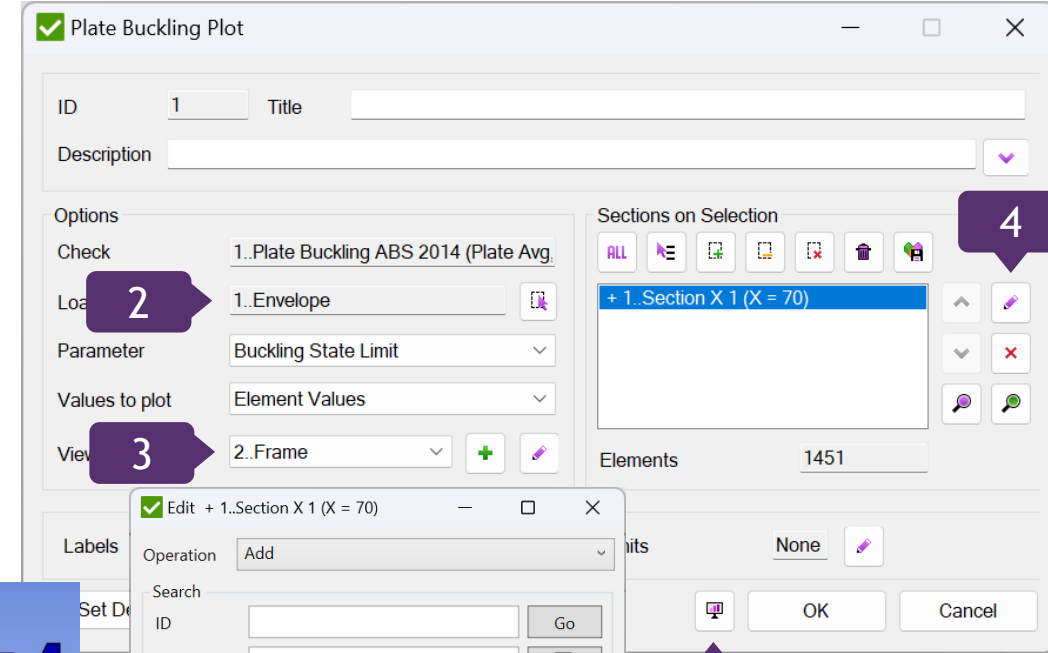
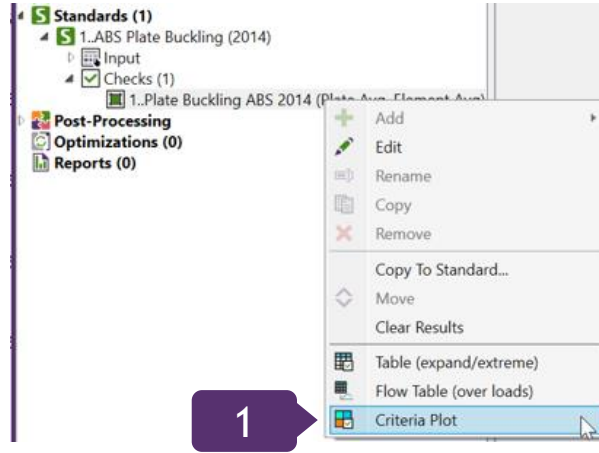
Press  and Select: 1..Section X1

5

Press *OK*

6

Press  *Preview*



6

# Plate Buckling Table

1

Execute *Table(expand/extreme)* from Plate Buckling ABS 2014 context menu

2

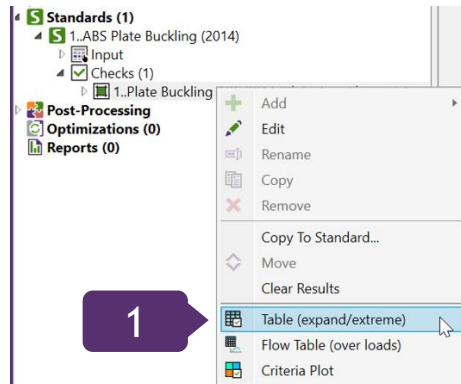
Load Group: 1..Envelop

3

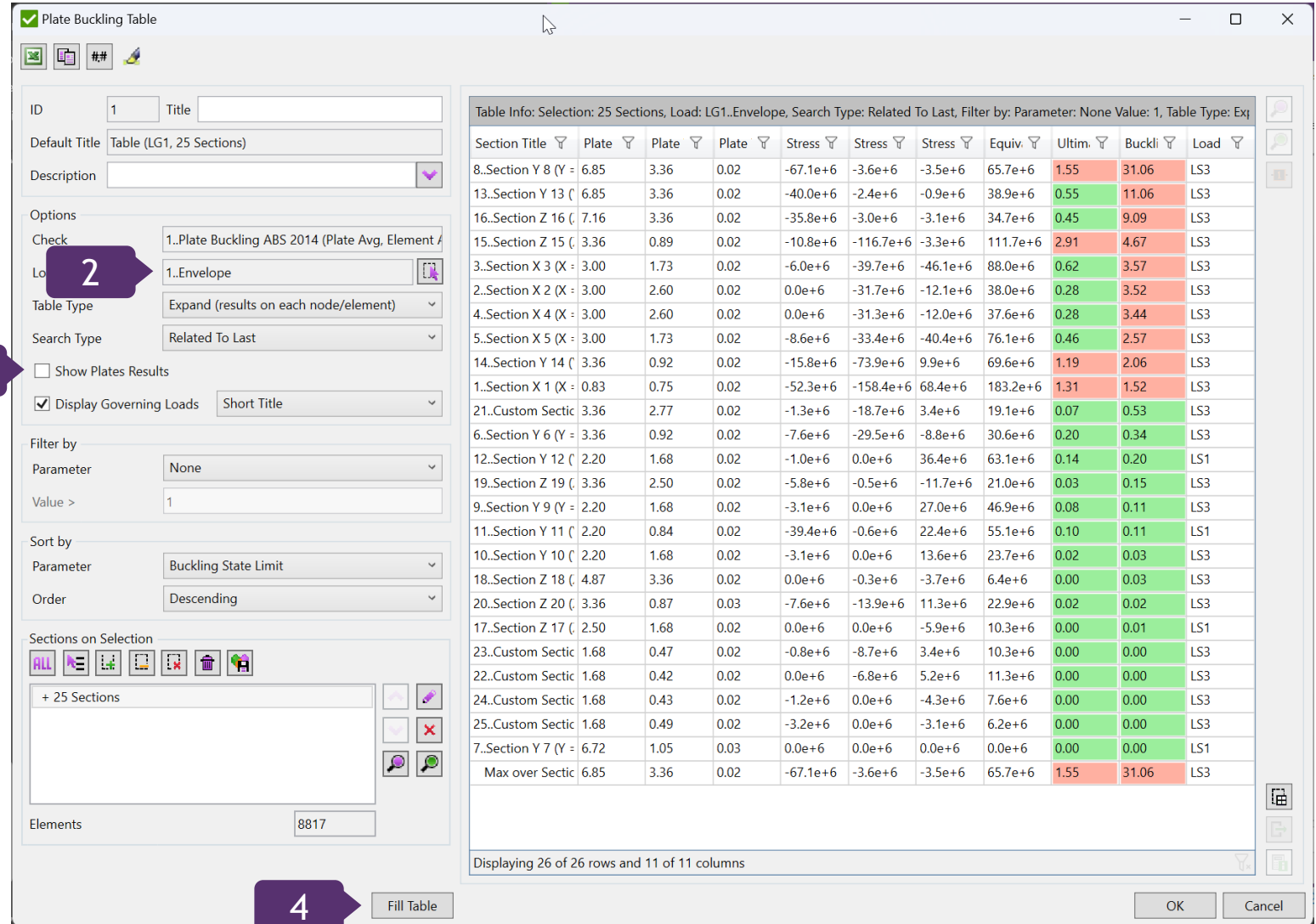
Show plates results: OFF

4

Press *Fill Table*



Use Show plates results for detailed table with results for all plates. Otherwise only the worst results over Sections will be shown.





# Results report

1

Execute *Reports => Add => Designer - Empty*

2

Select on Toolbar *Import tab => Standard Results*

3

Select *All*

4

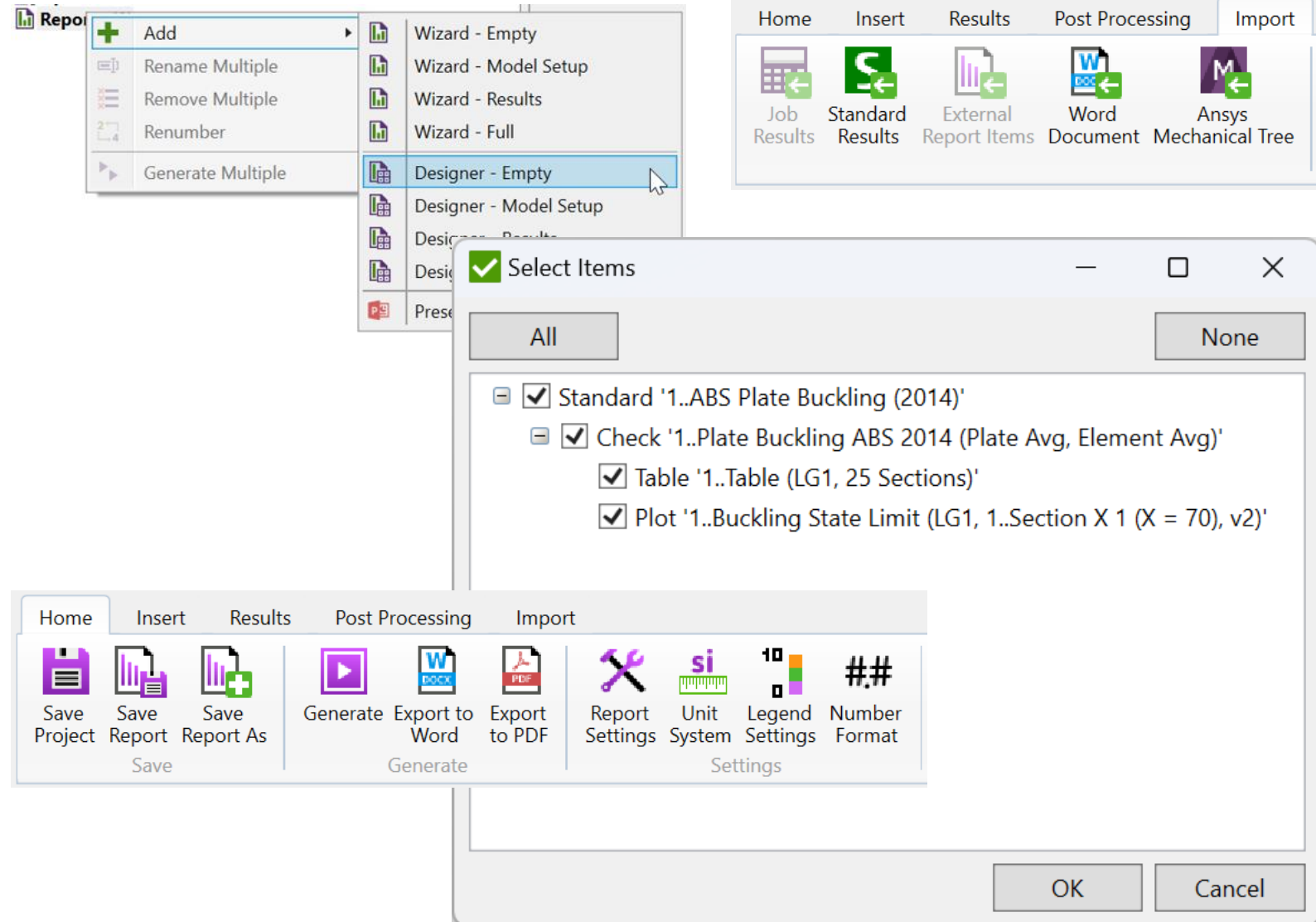
Press *Ok*

5

Select on Toolbar *Home tab => Generate*

6

Select on Toolbar *Home tab => Export to Word*





## Results

### 1..Static Structural

#### Load Groups

In this paragraph the influence of the different load groups is described. Load group represents extreme values (min, max, abs) among its items.

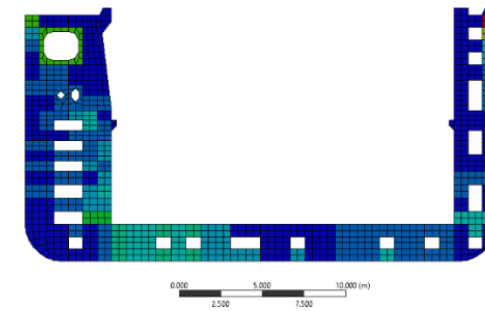
#### Load Group '1..Envelope'

##### 1..ABS Plate Buckling (2014)

###### 1..Table (LG1, 25 Sections)

Standard	1..ABS Plate Buckling (2014)			Check			[S1] 1..Plate Buckling ABS 2014 (Plate Avg, Element Avg)		
Load Group	LG1..Envelope			Selection			25 Sections		
Search Type	Related To Last								
Section Title	Plate Length [m]	Plate Width [m]	Plate Thickness	Stress x in Plate Direction [Pa]	Stress y in Plate Direction [Pa]	Stress xy in Plate Direction [Pa]	Equivalent Stress [Pa]	Ultimate Strength	Buckling State Limit
8..Section Y 8 (Y = -8.95)	6.85	3.36	0.02	-67.1e+6	-3.6e+6	-3.5e+6	65.7e+6	1.55	31.06
13..Section Y 13 (Y = 11.65)	6.85	3.36	0.02	-40.0e+6	-2.4e+6	-0.9e+6	38.9e+6	0.55	11.06
16..Section Z 16 (Z = 2.2)	7.16	3.36	0.02	-35.8e+6	-3.0e+6	-3.1e+6	34.7e+6	0.45	9.09
15..Section Z 15 (Z = 0)	3.36	0.89	0.02	-10.8e+6	-116.7e+6	-3.3e+6	111.7e+6	2.91	4.67
3..Section X 3 (X = 73.36)	3.00	1.73	0.02	-6.0e+6	-39.7e+6	-46.1e+6	88.0e+6	0.62	3.57
2..Section X 2 (X = 71.68)	3.00	2.60	0.02	0.0e+6	-31.7e+6	-12.1e+6	38.0e+6	0.28	3.52
4..Section X 4 (X = 75.04)	3.00	2.60	0.02	0.0e+6	-31.3e+6	-12.0e+6	37.6e+6	0.28	3.44
5..Section X 5 (X = 76.72)	3.00	1.73	0.02	-8.6e+6	-33.4e+6	-40.4e+6	76.1e+6	0.46	2.57
14..Section Y 14 (Y = 14.15)	3.36	0.92	0.02	-15.8e+6	-73.9e+6	9.9e+6	69.6e+6	1.19	2.06
1..Section X 1 (X = 70)	0.83	0.75	0.02	-52.3e+6	-158.4e+6	68.4e+6	183.2e+6	1.31	1.52
21..Custom Section 21 (136 Elements)	3.36	2.77	0.02	-1.3e+6	-18.7e+6	3.4e+6	19.1e+6	0.07	0.53
6..Section Y 6 (Y = -14.15)	3.36	0.92	0.02	-7.6e+6	-29.5e+6	-8.8e+6	30.6e+6	0.20	0.34
12..Section Y 12 (Y = 8.95)	2.20	1.68	0.02	-1.0e+6	0.0e+6	36.4e+6	63.1e+6	0.14	0.20
19..Section Z 19 (Z = 13.3)	3.36	2.50	0.02	-5.8e+6	-0.5e+6	-11.7e+6	21.0e+6	0.03	0.15
9..Section Y 9 (Y = -1.79)	2.20	1.68	0.02	-3.1e+6	0.0e+6	27.0e+6	46.9e+6	0.08	0.11
11..Section Y 11 (Y = 5.37)	2.20	0.84	0.02	-39.4e+6	-0.6e+6	22.4e+6	55.1e+6	0.10	0.11
10..Section Y 10 (Y = 0)	2.20	1.68	0.02	-3.1e+6	0.0e+6	13.6e+6	23.7e+6	0.02	0.03
18..Section Z 18 (Z = 11.8)	4.87	3.36	0.02	0.0e+6	-0.3e+6	-3.7e+6	6.4e+6	0.00	0.03

#### 1..Buckling State Limit (LG1, 1..Section X 1 (X = 70), v2)



Check	[S1] 1..Plate Buckling ABS 2014 (Plate Avg, Element Avg)	Load Group	LG1..Envelope
Parameter	Buckling State Limit	Selection	1..Section X 1 (X = 70)
View	2..Frame		