



# Tutorial

## **Plate Buckling ABS 2014**

**ANSYS<sup>®</sup>**

23 Jan 2020  
version 5.3

- ▶ 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

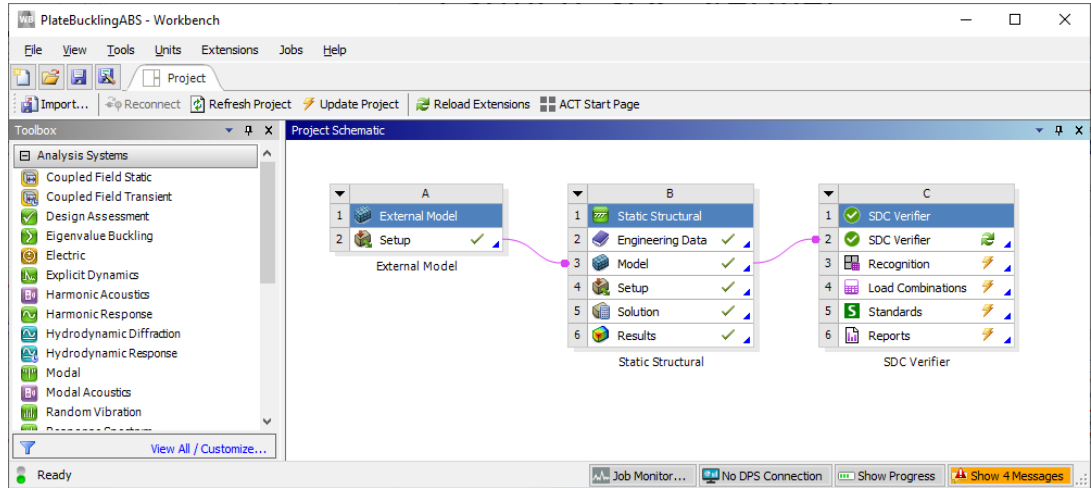
Open in Ansys Workbench  
**PlateBucklingABS.wbpj**

2

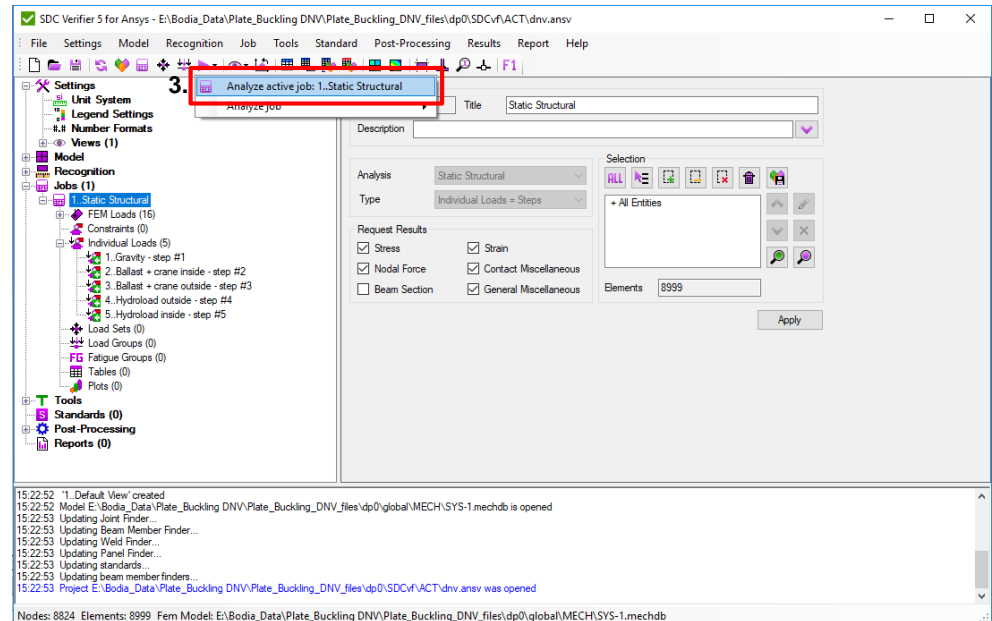
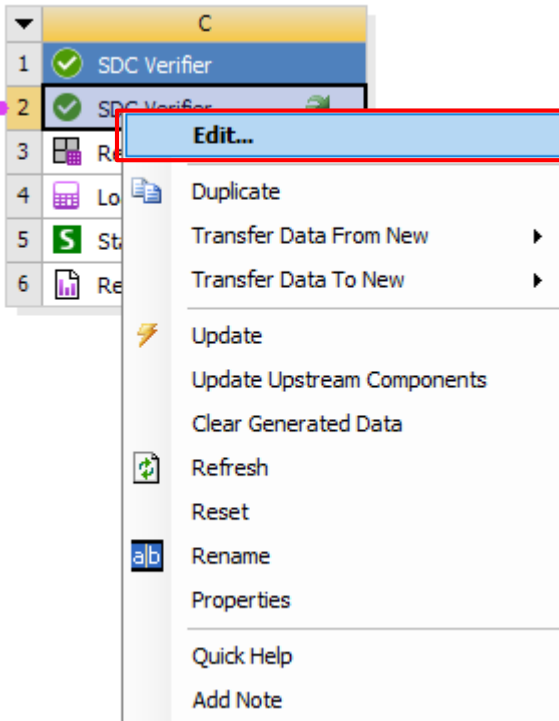
Double Click on  or execute *Edit* from context menu

3

Press  on toolbar and “Analyze active job: 1.. Static Structural”



2.



# Load Sets

1

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

2

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

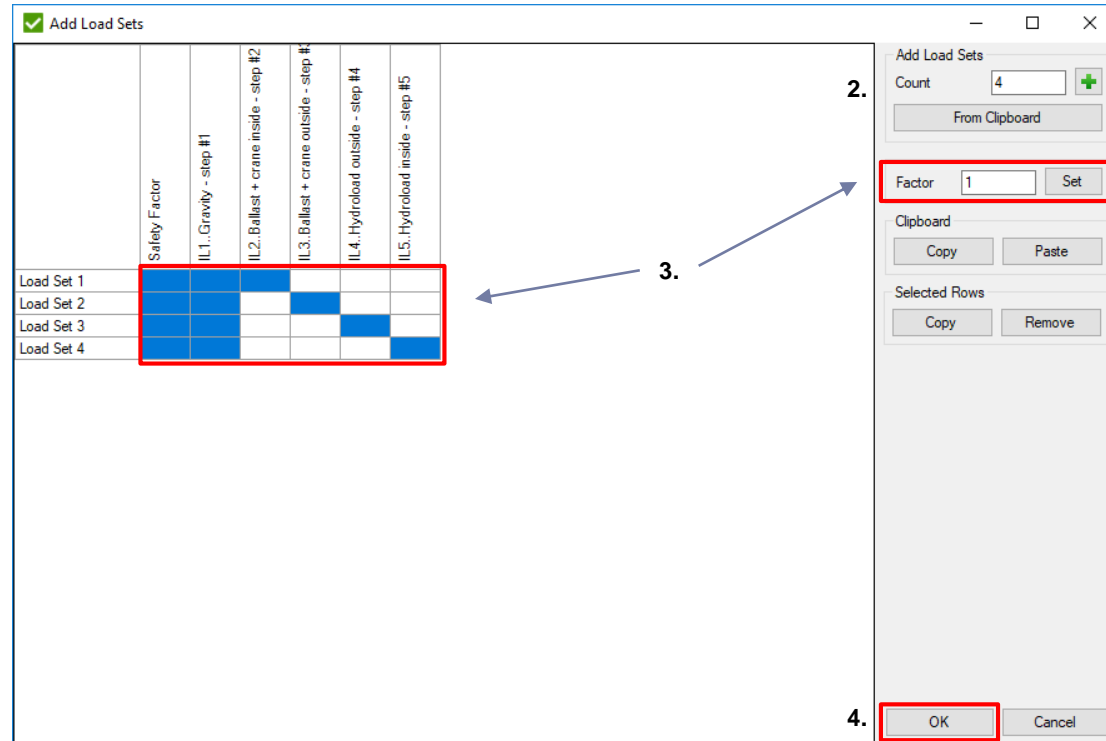
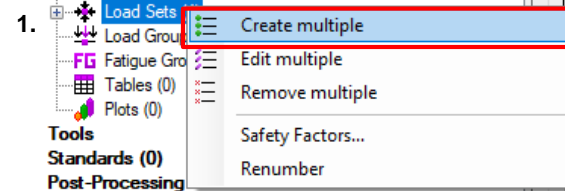
3

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.



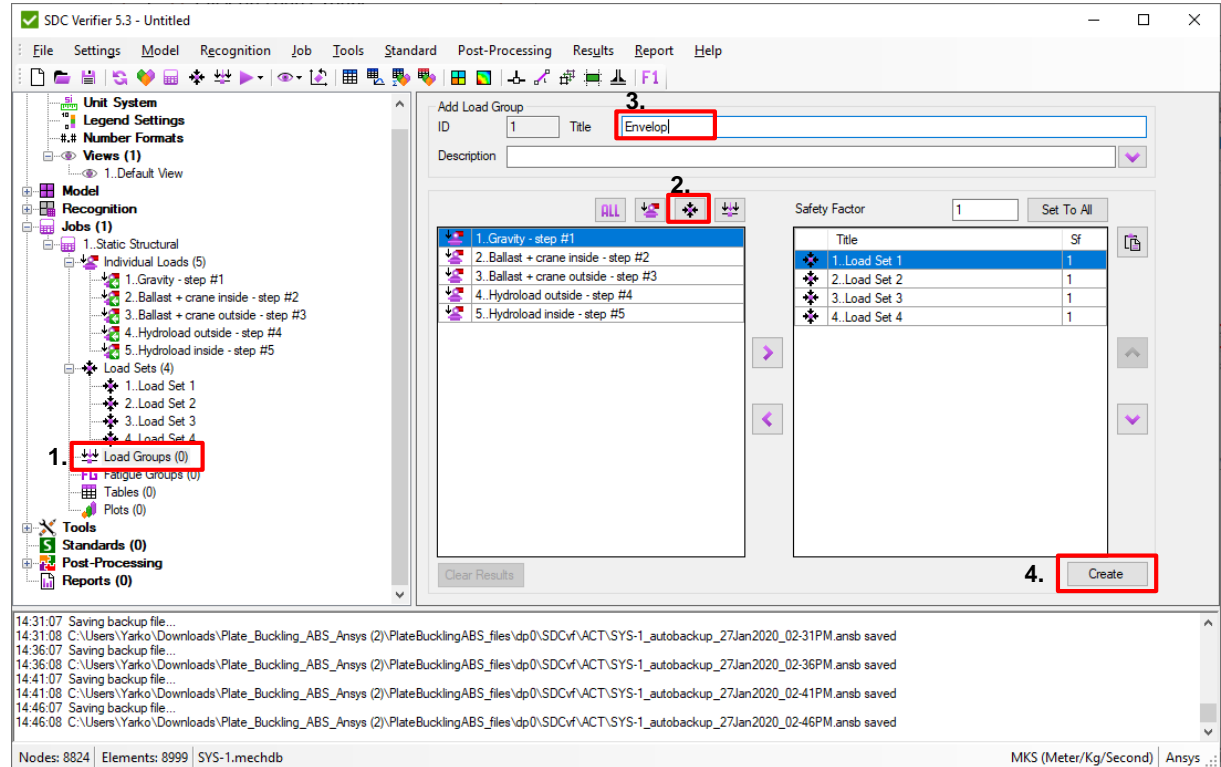
# Load Groups

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

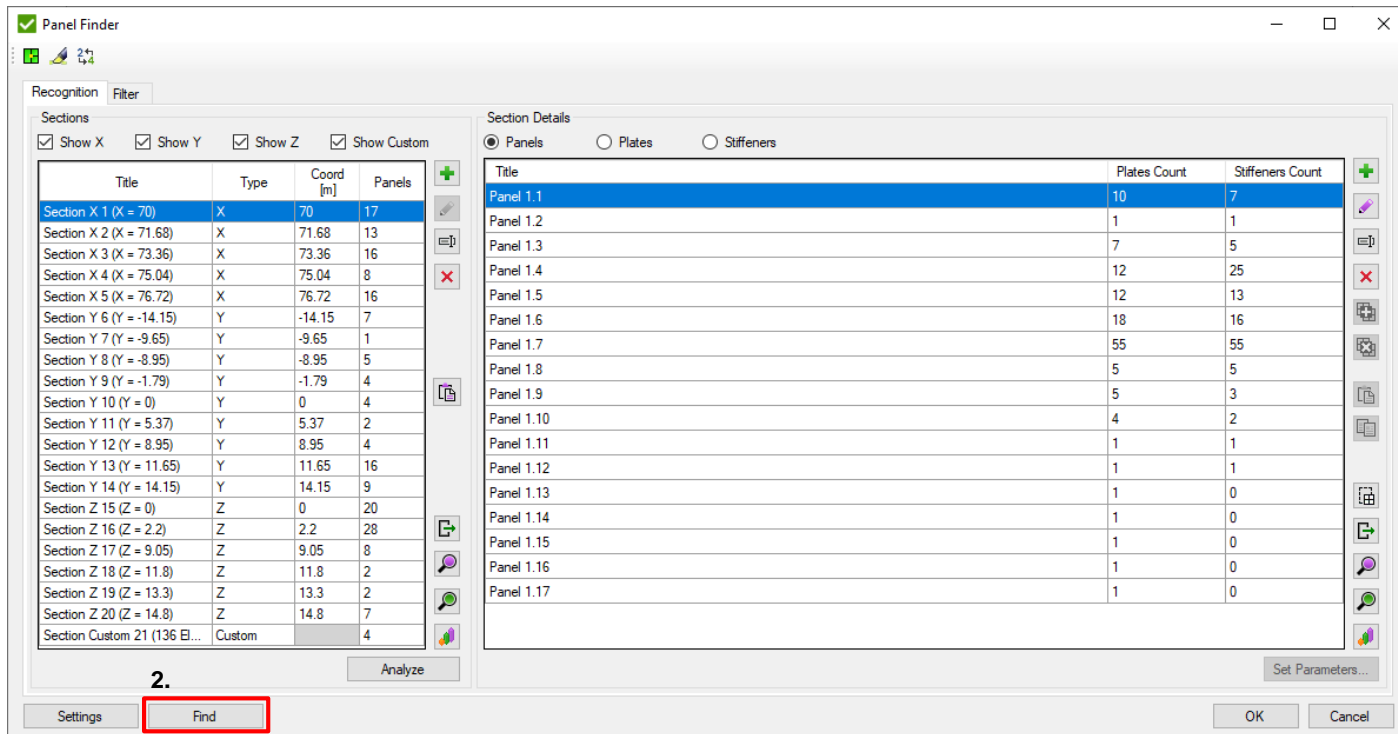
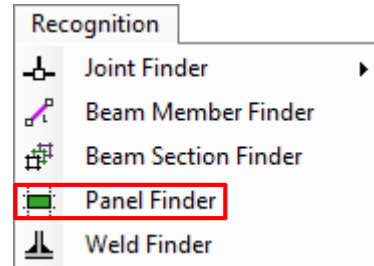
Execute *Recognition - Panel Finder* from main menu

2

Click on *Find*

All Frames, Longitudinals and Decks were automatically.

1.



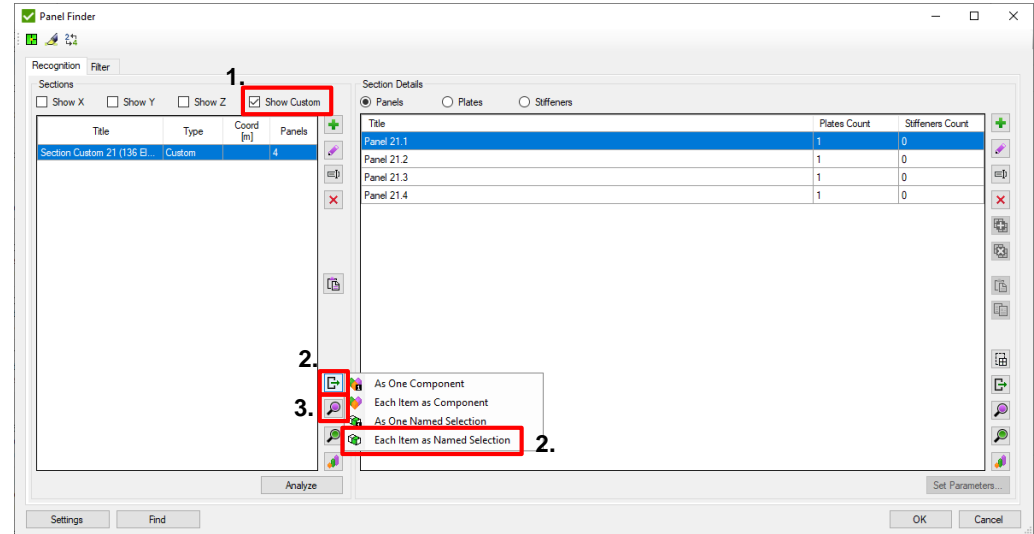
# Panel Finder. Custom Section

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

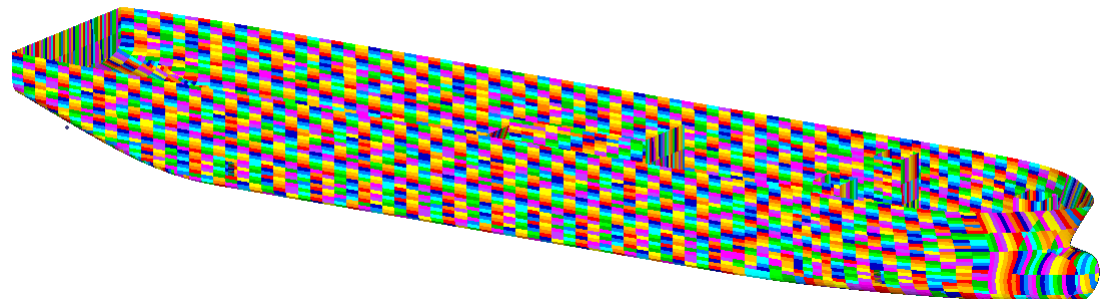
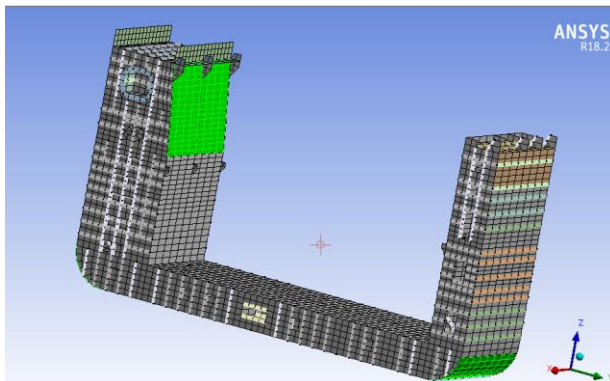
2 Press  and  to export selected sections to named sel.

3 Press 

Custom Section should be used for inclined/curved sections and selections like hull.



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

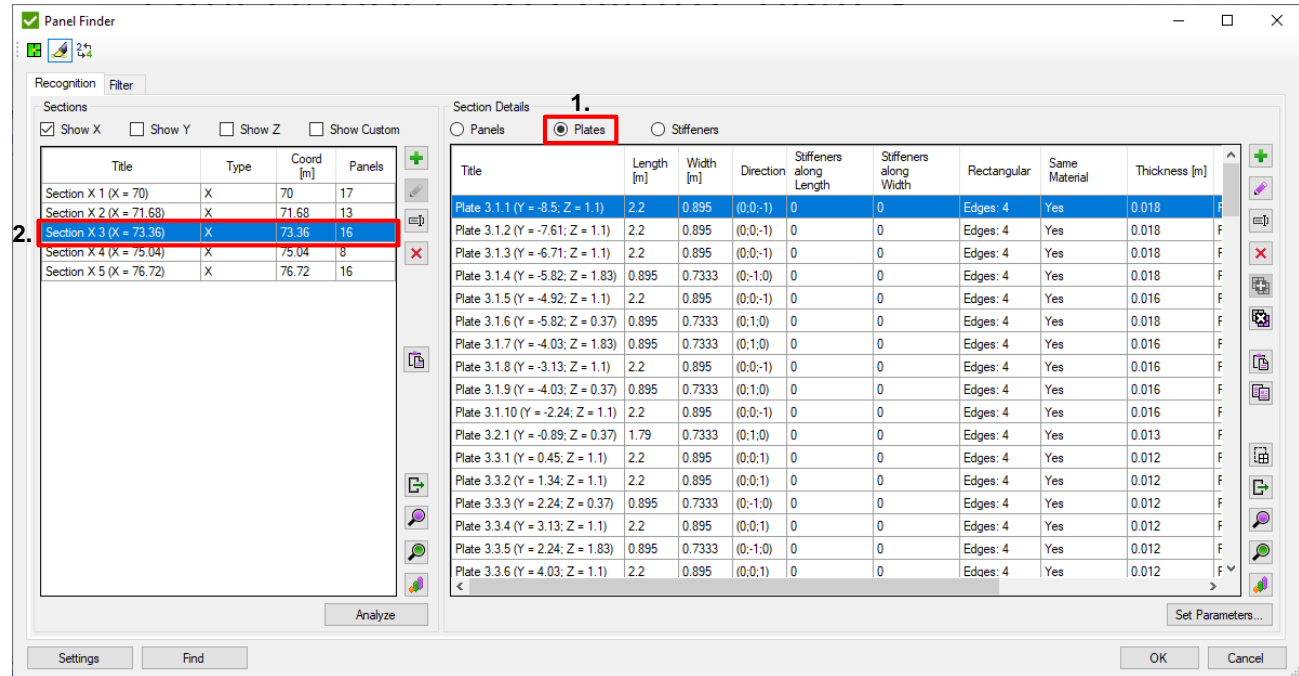


# Panel Finder. Recognize plates

1 In Selection details Press **Plates**

2 Select **Section X3**.

**Tip:** If it is necessary to recognize plates only for one section press *Analyze*



Title	Length [m]	Width [m]	Direction	Stiffeners along Length	Stiffeners along Width	Rectangular	Same Material	Thickness [m]
Plate 3.5.15 (Y = 13.73; Z = 1...	0.8333	0.75	(0;1;0)	0	0	Edges: 4	Yes	0.012
Plate 3.6.1 (Y = 12.9; Z = 2.39)	2.5	1.5333	(0;1;0)	0	0	Edges: 8	Yes	Min = 0.016

Section ID. Panel ID. Plate ID

Plate is rectangle with all corners = 90 degrees

Plate has elements more than from one property



# Plate Dimensions and Thicknesses

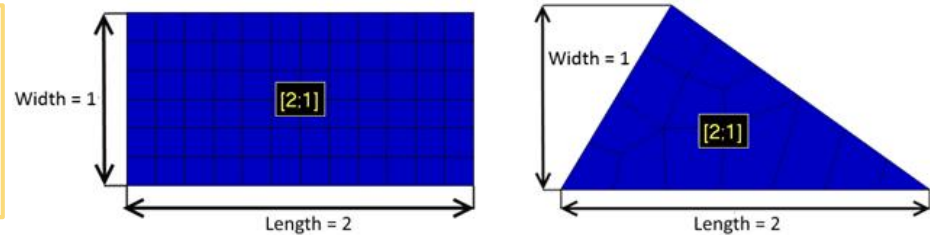
Title	Length	Width	Direction	Rectangular	Yield Stress	Thickness
Plate 9 (Y = 12.07; Z = 11.34)	0.9167	0.8333	(0;0;1)	Yes	2.4E+08	0.012
Plate 10 (Y = 12.9; Z = 2.39)	2.5	1.5333	(0;1;0)	Edges: 8	2.4E+08	Min = 0.016

Plate ID

Plate is rectangle with  
all corners = 90 degrees

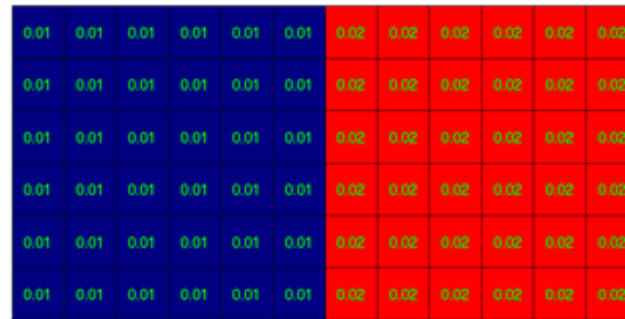
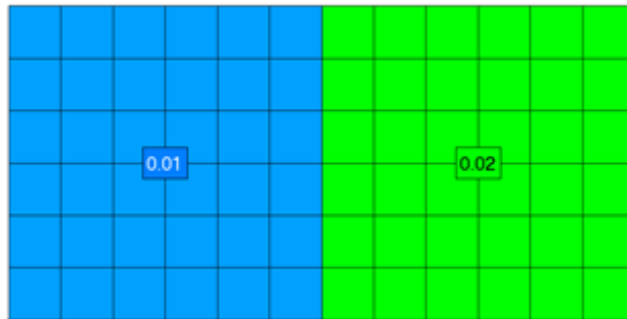
Plate has elements more than from  
one property

**Dimensions:** the 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:** the calculations are performed on every element and thickness is taken directly from each element. It is possible to set thickness manually for a plate, in this case, the element thickness will be ignored and the user defined thickness will be used.

Example: Plate with 2 properties 0.01 and 0.02 thicknesses. Left picture displays the property labels with property thicknesses and right presents the plate buckling plot of thickness parameter:



☒ Panel Finder Recognition Settings

**Selection**

☐ Use Selection

Predefined Girders

Predefined Stiffeners

Predefined Borders

**Plates**

Minimum Angle Between Plate Edges [0:90]

☐ Skip Not Four Edged Plates

☐ Skip Triangular Plates

☒ Skip Curved Stiffeners

☐ Split Plate on Thickness Difference

☐ Calculate Dimensions by CSR Method

**Default Titles by Section Type**

Section X

Section Y

Section Z

Section Custom

**Sections**

Coordinate Deviation Limit of Section Plane

Minimum Elements Count in a Section

Minimum Angle Between Inclined Plane Normals [0:90]

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

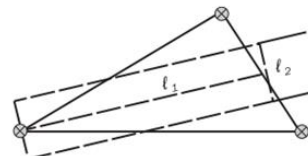


- c) The width of the model,  $\ell_2$ , in mm, is to be taken as:

$$\ell_2 = A/\ell_1$$

where:

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



# Editing plates manually

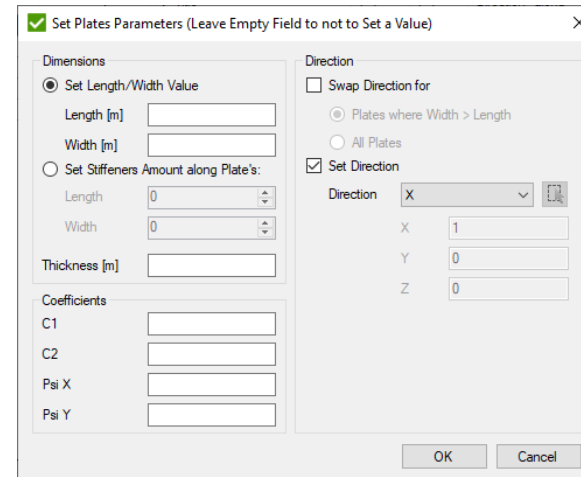
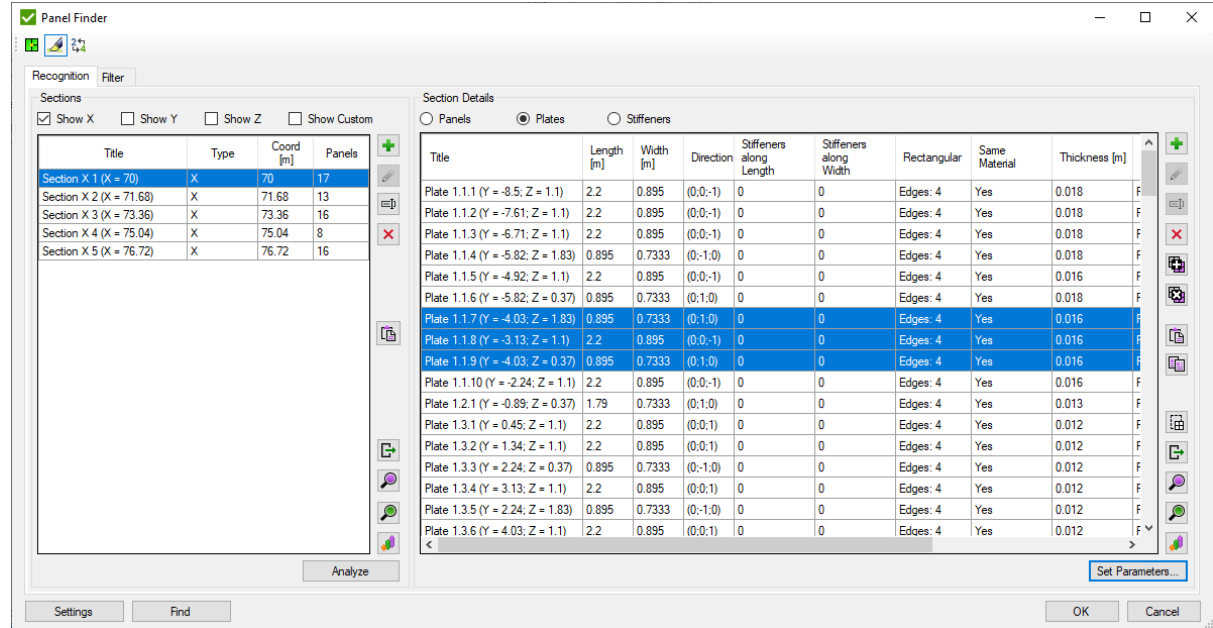
To modify plates select them from the list and press *Set Parameters*. It is possible to edit (Length / Width / Thickness / Coefficients / Direction).

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
0.016 (Original: 0.012)
0.016 (Original: 0.012)
0.016 (Original: 0.012)

If the direction of plate should be modified, define global axis or custom vector and press *Set Direction*.



# Panel Finder. Plates Plot


1

Select **Section X3**

2

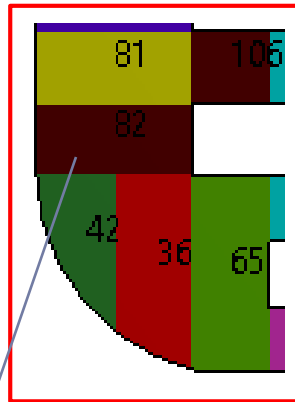
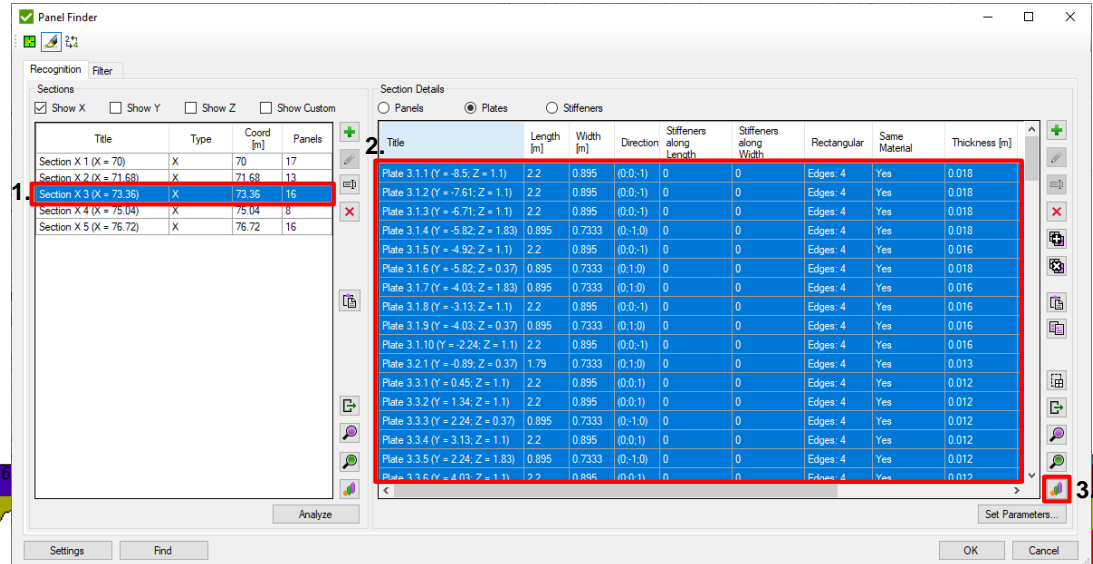
Select All *Plates*

3

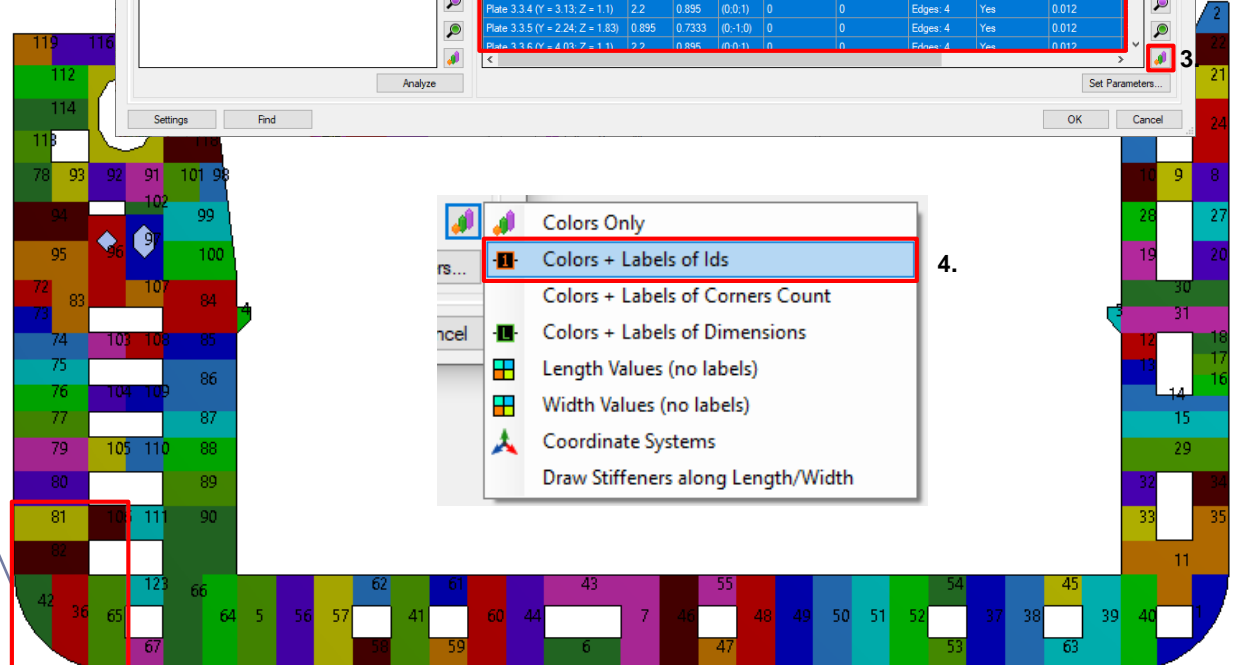
Press 

4

Click on *Colors + Labels of Ids*.



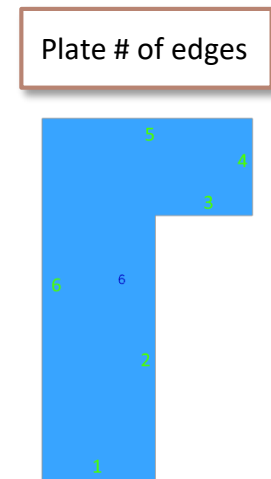
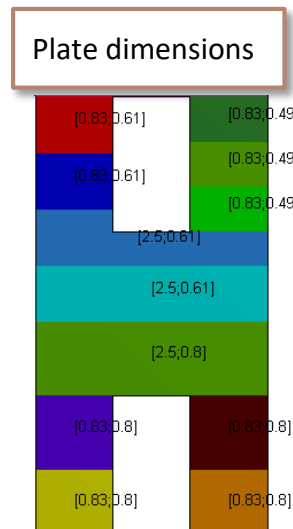
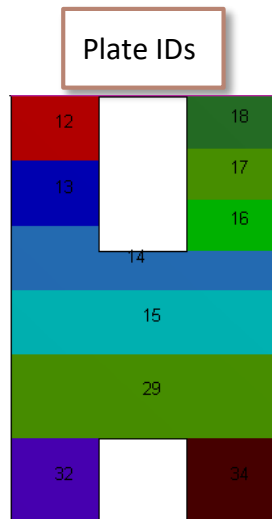
	Length	Width
Plate 82 (Y = -13.28; Z = 2.6)	1.7333	0.8



# Panel Finder. Plot Options

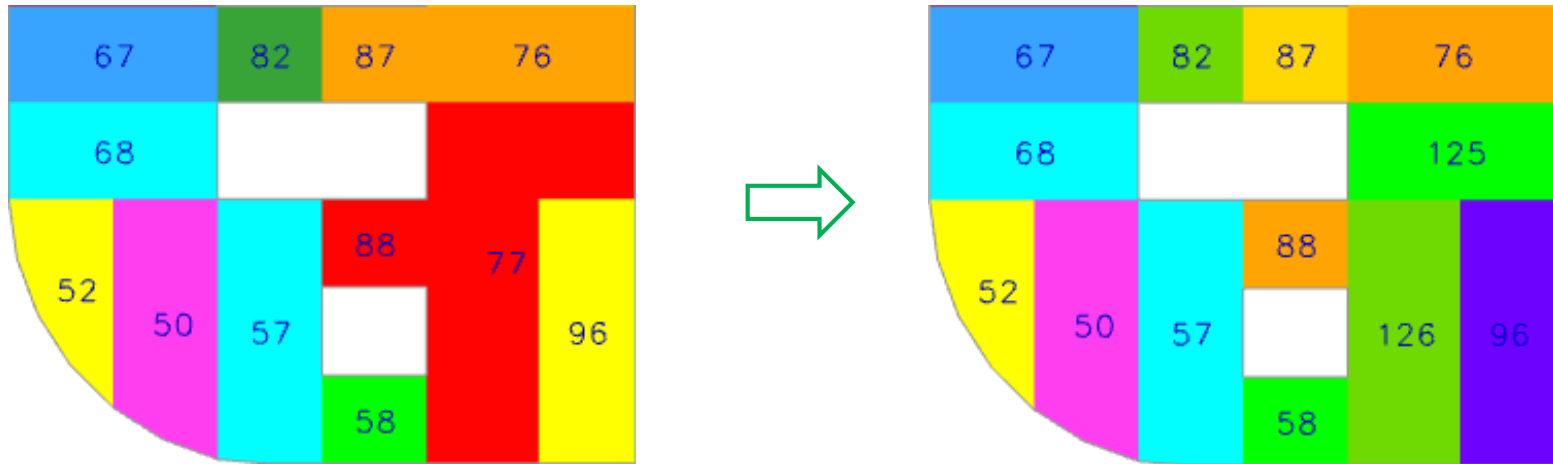
Plate Plot can be displayed with different labels (plate id, plate dimensions or plate number of edges). Also, it is possible to show plates in colors (no labels), length and width in colors (no labels).

Colors only  
Colors + Labels with plates number of edges  
Colors + Labels with plates IDs  
Colors + Labels with plates dimensions  
Length values (no labels)  
Width values (no labels)  
Labels with IDs of plates without dimensions



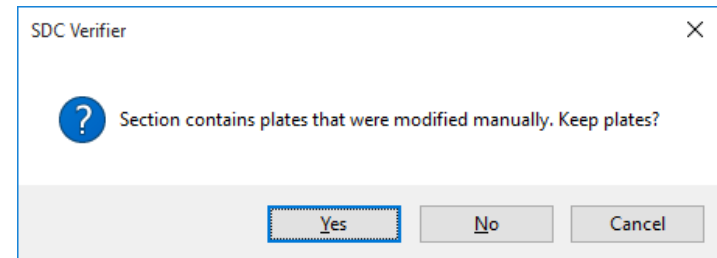
# Panel Finder. Update Plates

In some cases (e.g. stiffener is not modeled) a plate is recognized not correctly, dimensions are bigger than in reality which leads to incorrect results. The plate has to be updated manually. In Section X3 plate with Id = 77 should be split in 2 plates.



If plates were modified manually and later user decided to run recognition of plates, Panel Finder will ask what to do with the modified plates:

- Keep plates that was modified;
- Clear everything and recognize from scratch;



# Panel Finder. Export Plates

1

Select *Export Plates* tab.

2

All Sections X: **ON**.

3

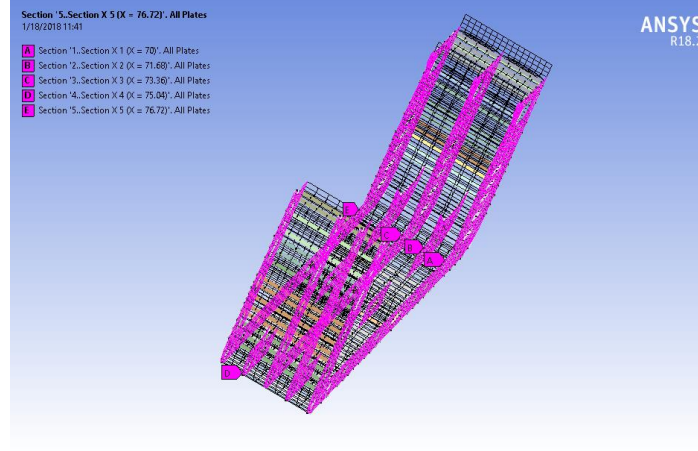
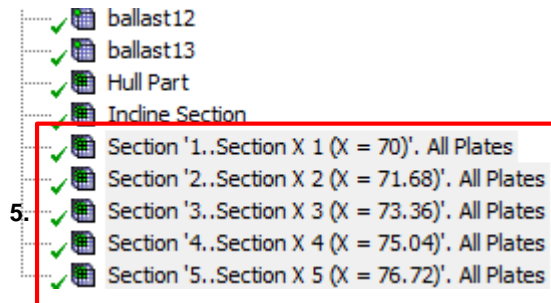
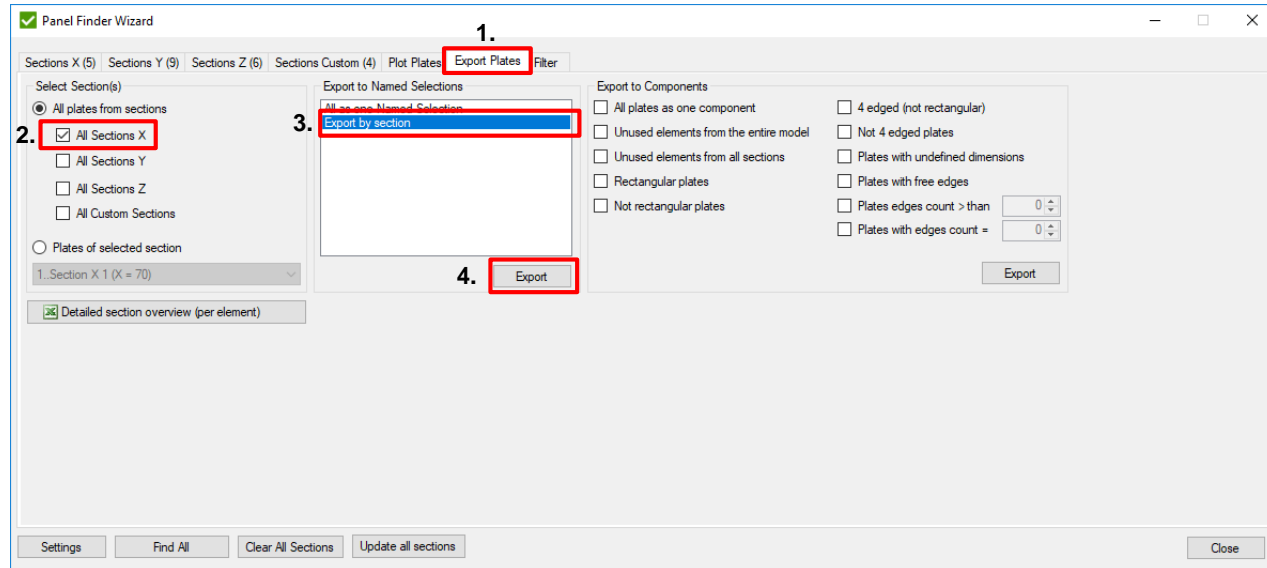
Pick *Export by section*.

4

Click *Export*.

5

5 Named Selection will be created for 5 Sections .



# Panel Finder. Filter

**Note:** It is very important to check that all plates dimensions were recognized. If in the model, there are coincident nodes, coincident elements or free edges Panel Finder cannot recognize plate dimensions.

1

Click on *Filter* tab

2

Selection: **All Entities**

3

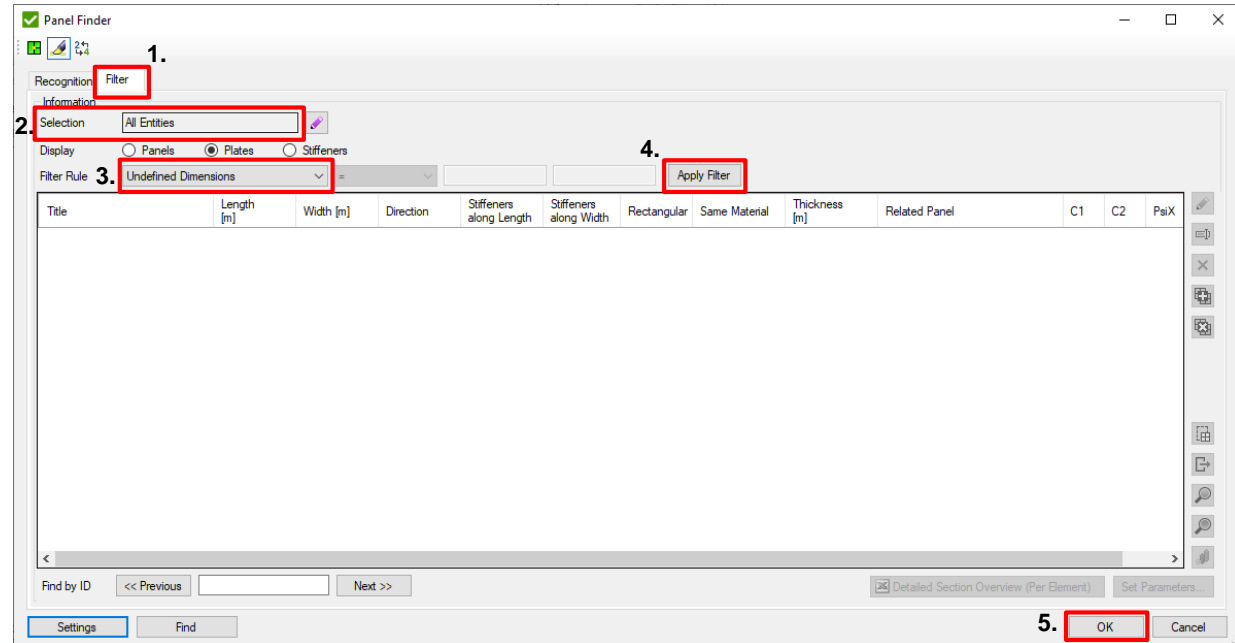
Filter: **Undefined dimensions**

4

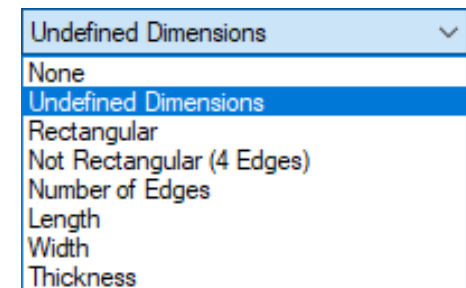
Press *Apply Filter*

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.





# Add Plate Buckling ABS 2014

1

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

2

Utilization Factor (Eta) = **0.8**

3

Use Plate Average Stress: **On**

4

Press *OK*

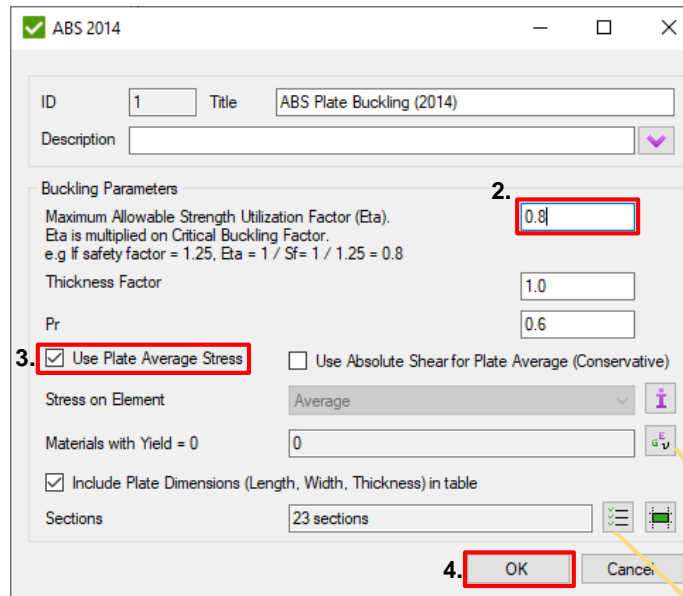
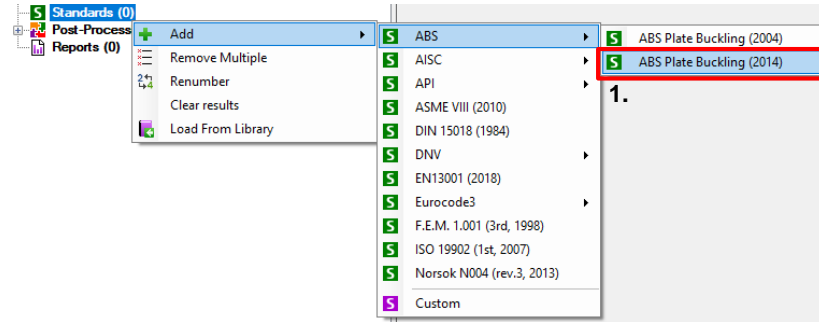


Plate Buckling transforms stresses automatically into plate direction.

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

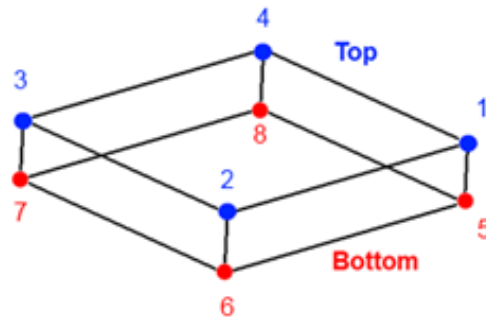
*Pr* - proportional linear elastic limit (**0.6** for steel)

*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.

# Plate Buckling Stresses

Calculations are performed for each element with converted stresses (into plate direction) or Plate Average Stresses and using Plate dimensions.



Average Element Stress:

$$Sel = (S1 + S2 + S3 + S4 + S5 + S6 + S7 + S8) / 8$$

Minimum Element MidPlane:

$$Sel = \text{Min}((S1 + S5) / 2, (S2 + S6) / 2, (S3 + S7) / 2, (S4 + S8) / 2)$$

S1 - S8 - translated element stresses into Plate Direction

Use Plate Average Stress

On

Off



$$Spl = (Sel1 \cdot A1 + Sel2 \cdot A2 + Sel3 \cdot A3) / (A1 + A2 + A3)$$



One Buckling Factor for plate



Sel1, Sel2, Sel3 - Average or min MidPlane



Plate Buckling Factor = Max(BF1, BF2, BF3)

# Views

1

Execute Views => Add

2

Title: **Frames**

Deformation: **Undeformed**

Display on: **Result Only**

Show Legend *and* Show Triad: **On**

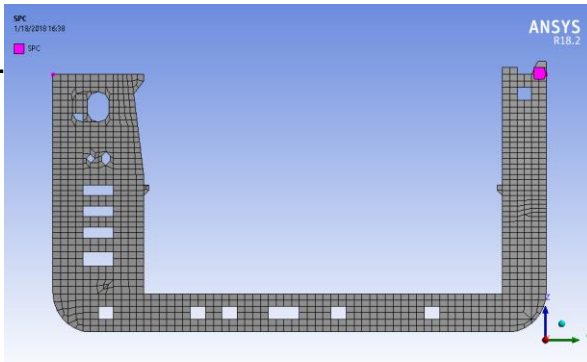
3

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

4

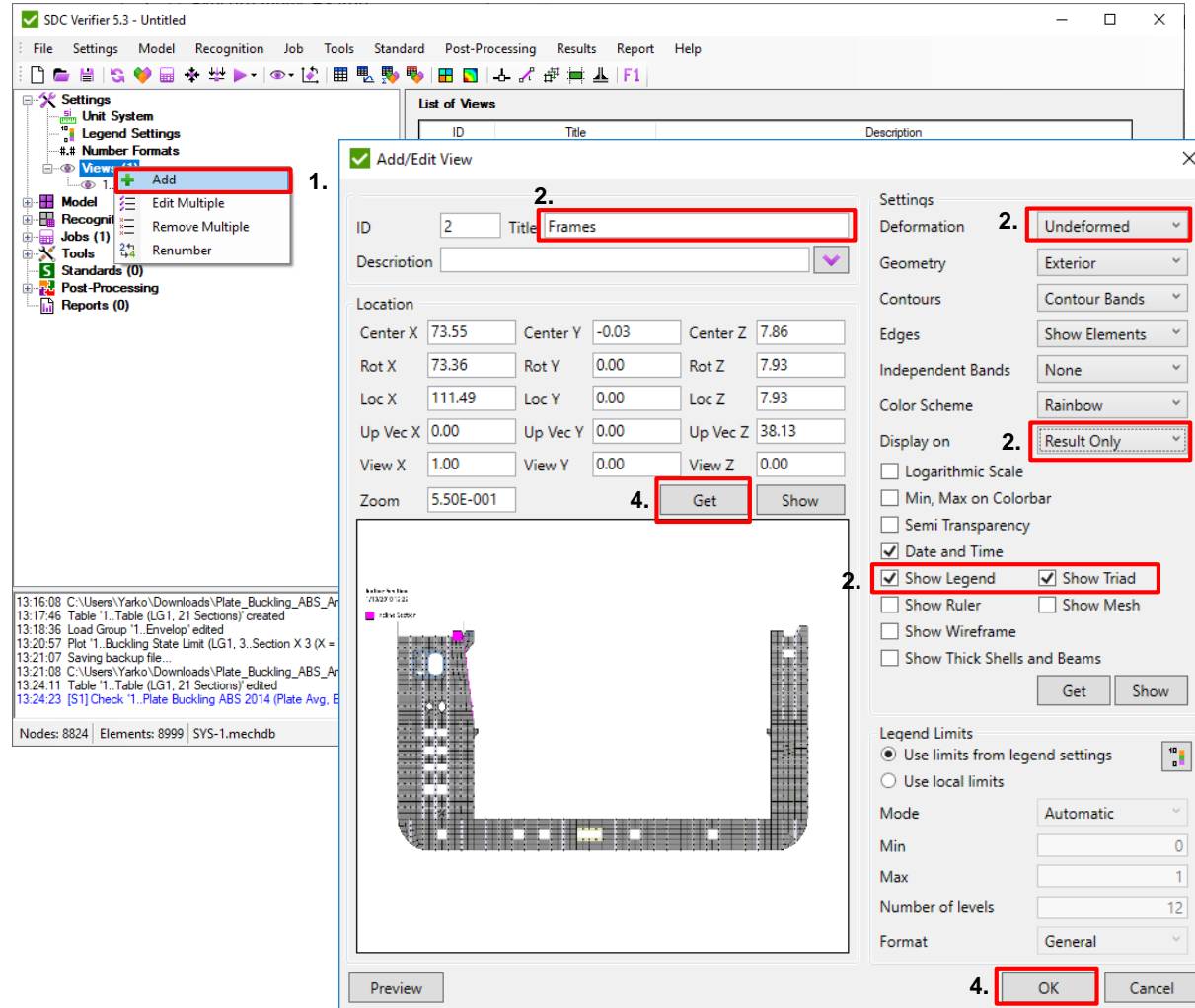
Press *Get* and *OK*.

3.



Repeat Steps 1-4 2 times to create a view for Longitudinals (plane ZX) and Decks (plane XY)

To make a plot Views should be created firstly (the set of settings how to display a plot).



# Plate Buckling Plot

1

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

2

Load Group: 1..**Envelop**

3

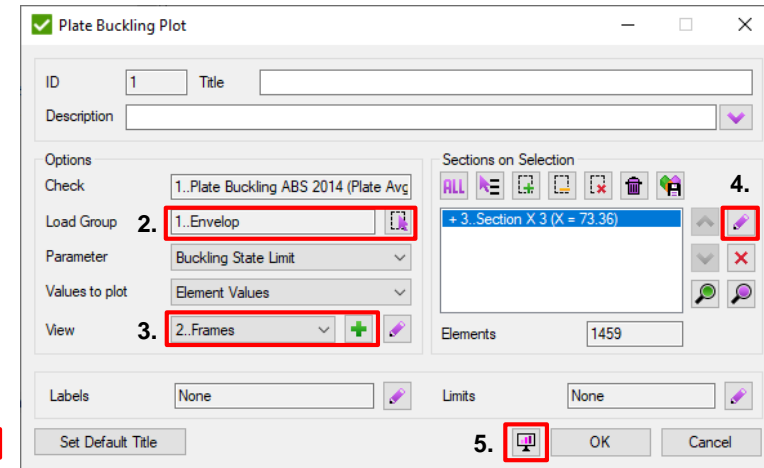
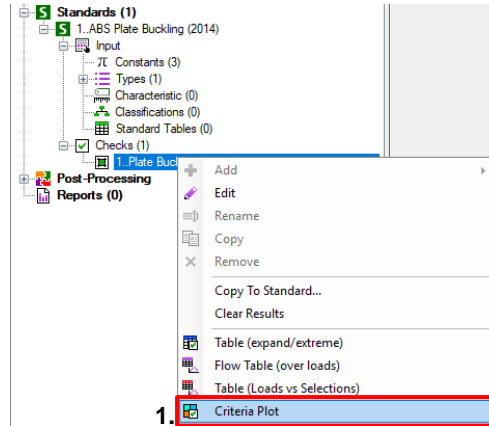
View: **Frames**

4

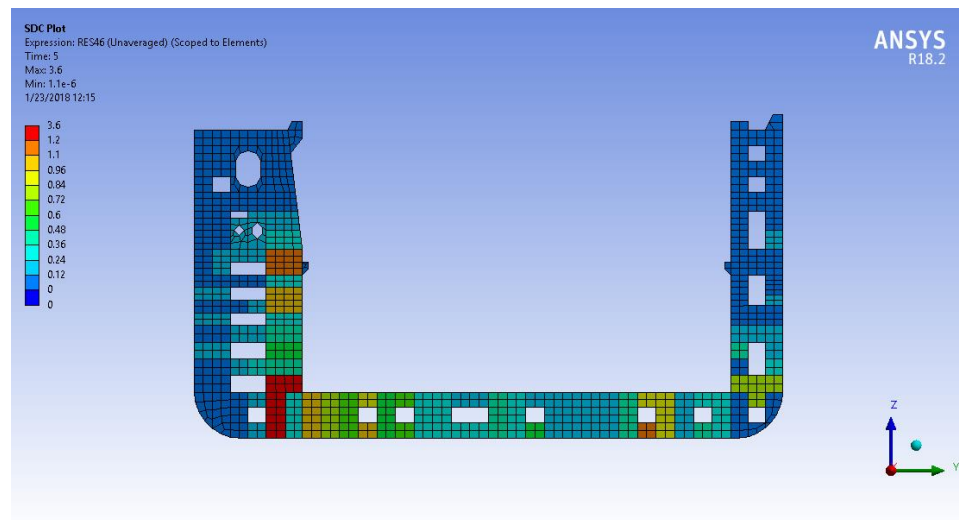
Press  Select: **Section X3**

5

Press  *Preview*




Parameter is automatically set to Buckling Factor Overall.



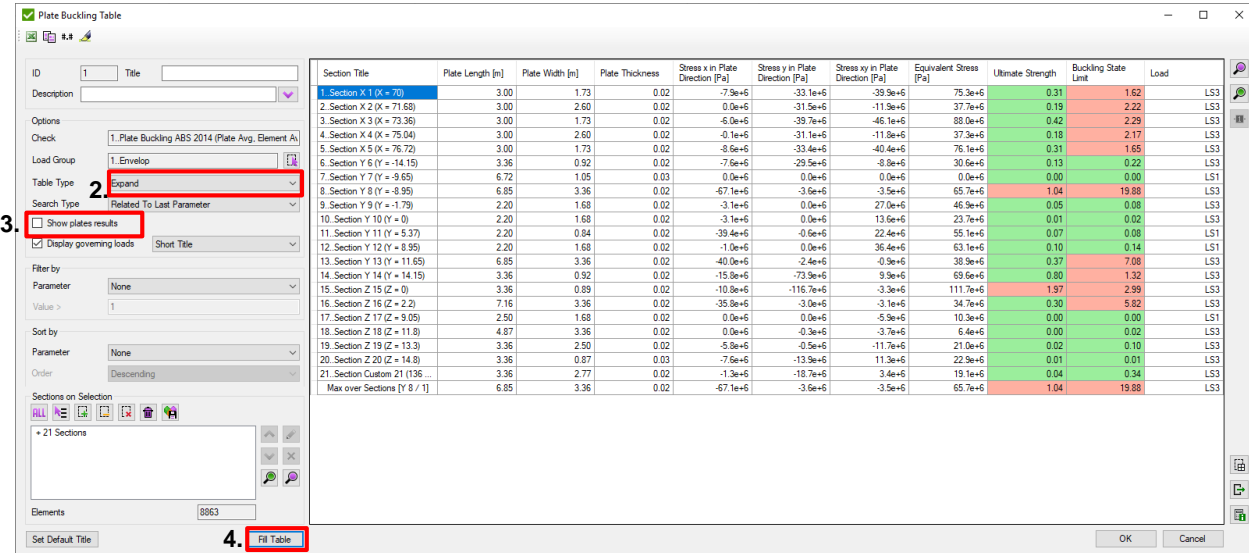
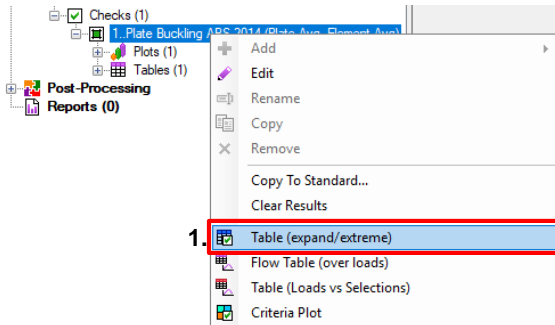
# Plate Buckling Table

1 Execute *Expand Table* from the Plate Buckling check context menu

2 Press  and select Load Group "Envelope"

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.

Plate with ID = 70 has the highest result in Section X 1

Section Title	Plate Length	Plate Width	Plate Thickness	Sx in plate direction	Sy in plate direction	Sxy in plate direction	Seqv	Buckling Factor Combined	Buckling Factor Overall
1. Section X 1 (X = 70000) [MaxID=70]	833.33	750.00	12.00	-0.02e+6	-0.06e+6	-0.05e+6	0.09e+6	0.22	0.47
2. Section X 2 (X = 71680) [MaxID=46]	3000.00	2600.00	16.00	0.00e+6	-0.02e+6	-0.01e+6	0.02e+6	0.12	0.35
3. Section X 3 (X = 73360) [MaxID=92]	895.00	733.33	14.00	-0.04e+6	-0.01e+6	-0.05e+6	0.10e+6	0.22	0.47
Max over Sections [3 / 92]	895.00	733.33	14.00	-0.04e+6	-0.01e+6	-0.05e+6	0.10e+6	0.22	0.47

Section ID = 3 / Plate ID = 92  
worst result among sections


All results (dimensions, stresses) are from the plate which causes  
higher BF = 0.47 because Search Type = Related to Last Parameter

# Report. Tables

1 Execute Reports => Add => **Designer - Results**

2 *Plate Buckling ABS 2014* check context menu in model tree => **Table(expand/extreme)**

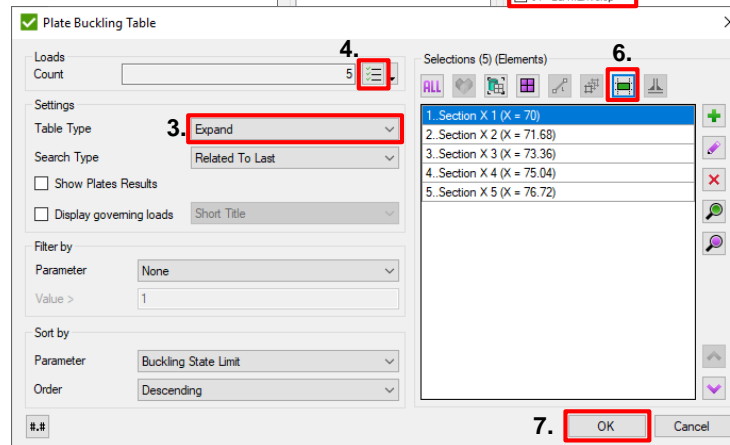
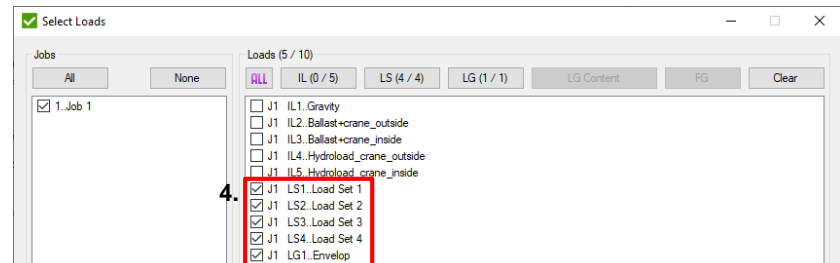
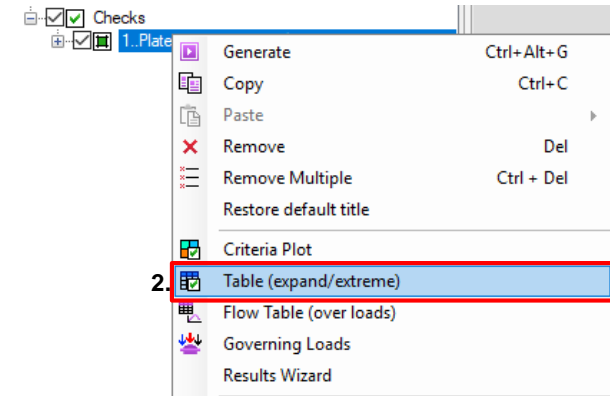
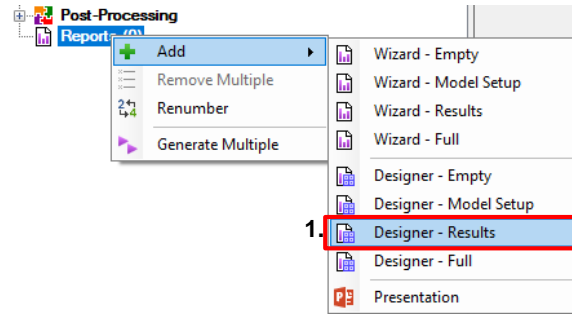
3 Type: **Expand**

4 Press  and select **LS; LG** loads.

5 Press **OK**.

6 Select all **X Sections** from List

7 Press **OK**.




# Report. Plots

1 Click **Criteria Plot** in *Plate Buckling ABS 2014* check context menu

2 Parameter: **Buckling State Limit**.

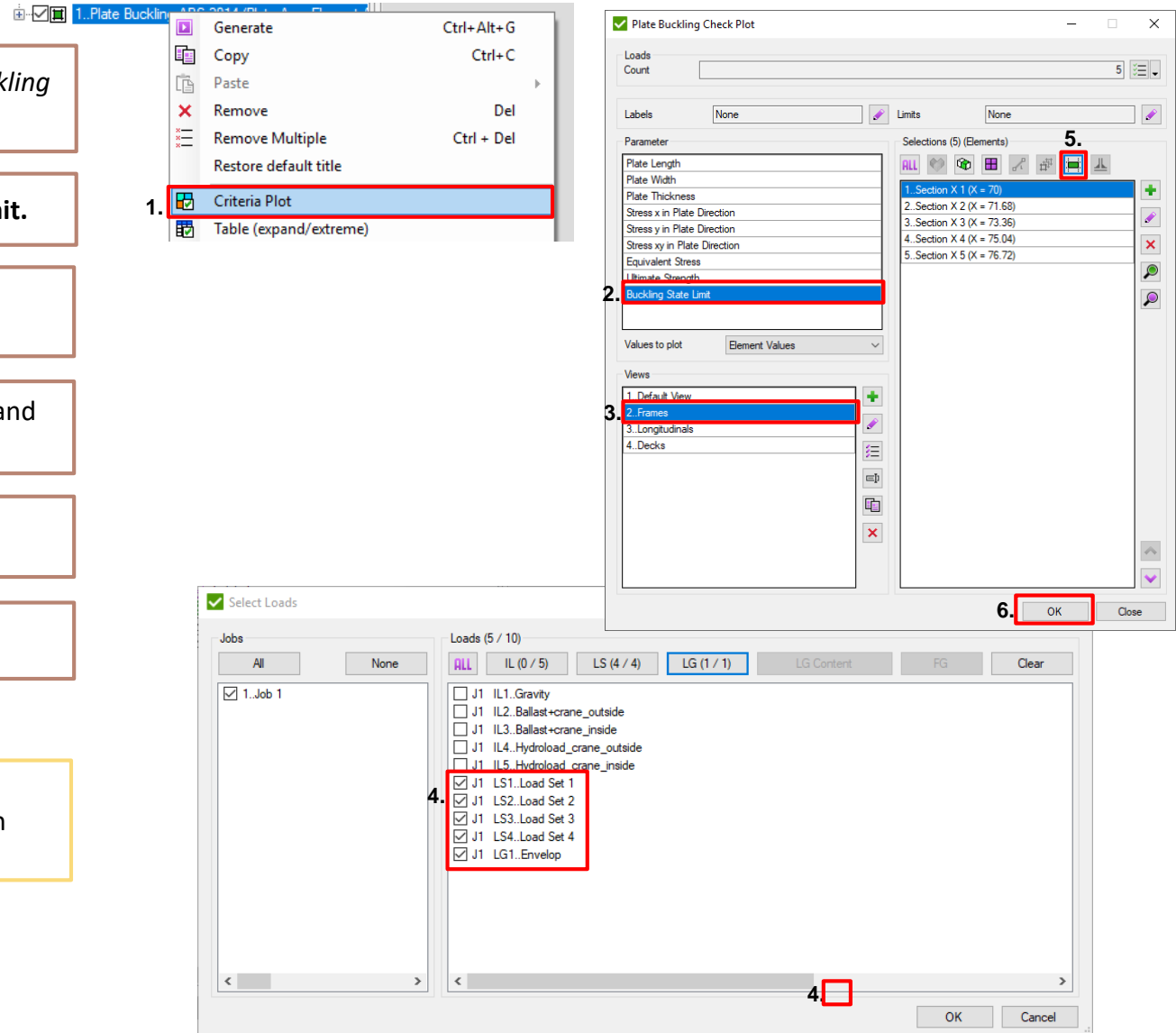
3 Views: **Frames**.

4 Press , select **LS; LG** Loads and Press **OK**.

5 Select all **X sections** from List

6 Press **OK**.

Repeat steps 1-5 for Sections Y with Longitudinals View and Sections Z with Decks View



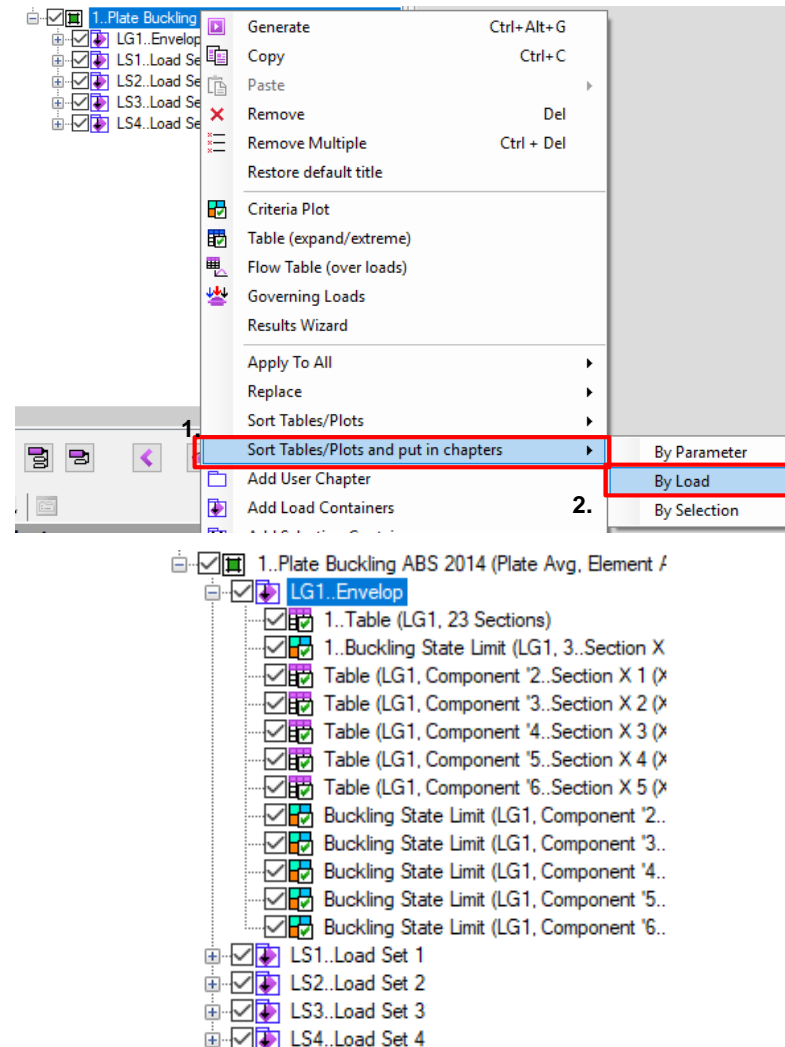
# Report. Sort tables and plots by Load

1

Execute *Plate Buckling ABS 2014*  
=> *Sort Tables/Plots and put in chapters*

2

Click => *By Load*



All tables and plots are sorted by loads. It is possible to sort it *By Parameter; By Selection; By section* as well.




# Report. First Page

1

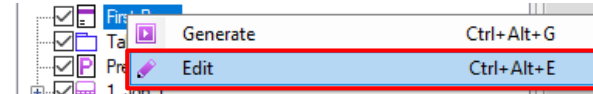
Right click on *First Page* => **Edit**.

2

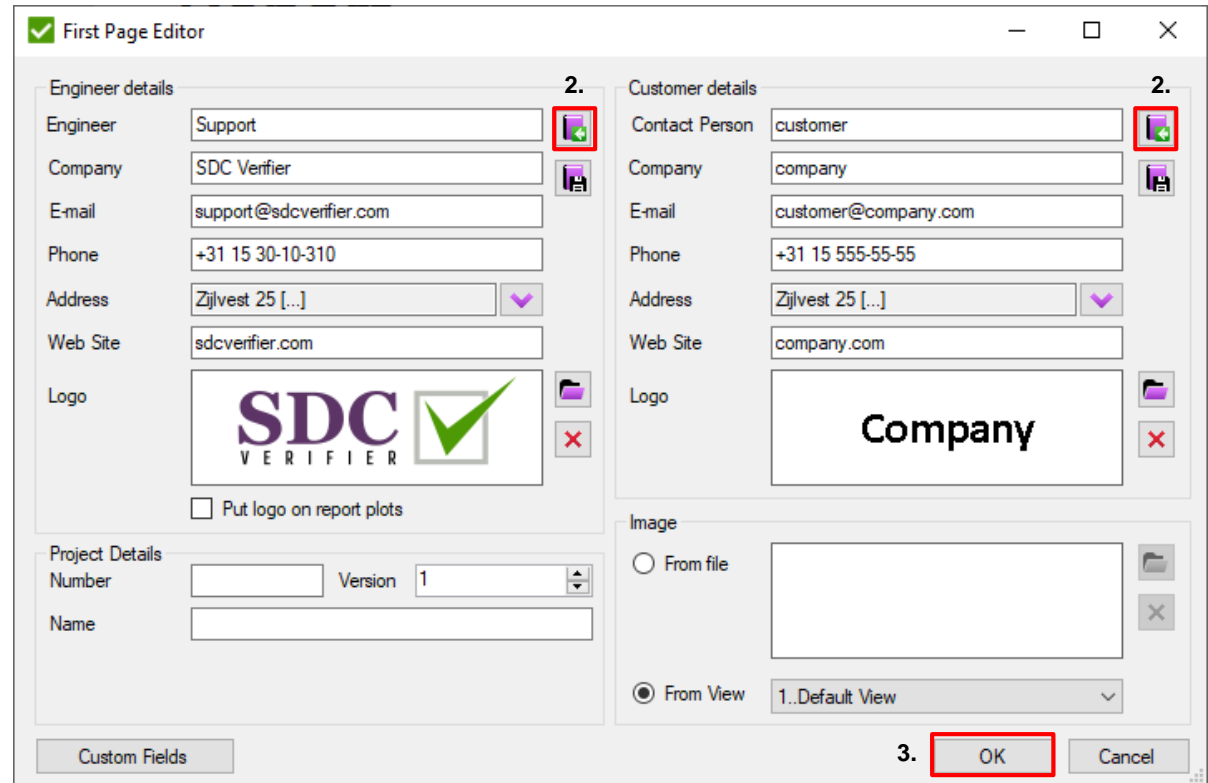
Press  to select engineer and custom from library

3

Press **OK**.



1.



The 'First Page Editor' dialog box is shown. It contains two main sections: 'Engineer details' and 'Customer details'. Both sections have a '2.' label and a red box around the library icon. The 'Engineer details' section includes fields for Engineer (Support), Company (SDC Verfier), E-mail (support@sdcverfier.com), Phone (+31 15 30-10-310), Address (Zijvest 25 [...]), Web Site (sdcverfier.com), and Logo (SDC Verfier logo). The 'Customer details' section includes fields for Contact Person (customer), Company (company), E-mail (customer@company.com), Phone (+31 15 555-55-55), Address (Zijvest 25 [...]), Web Site (company.com), and Logo (Company logo). There is also a 'Project Details' section with fields for Number, Version (1), and Name. At the bottom, there is a 'Custom Fields' button and 'OK' and 'Cancel' buttons. The 'OK' button is highlighted with a red rectangle.

Press  to generate complete report.



Press  to export to Word.

SDC  
VERIFIER

Report

Model  
1/10/2018 14:00



Prepared by:  
SDC Verifier  
+31 15 30-10-310  
sdcoverifier.com  
Zijlvest 25  
2011 VB Haarlem  
The Netherlands

Prepared for:  
company  
+31 15 555-55-55  
company.com  
Zijlvest 25  
2011 VB Haarlem  
The Netherlands

Engineer:  
Customer:  
Project Number:  
Version:  
Date:

Support  
company

1  
23/01/2018


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### 1..Plate Buckling ABS 2014

Property	Value
Title	Plate Buckling ABS 2014
Constants	3
Classifications	0
Standard Tables	0
Checks	1

Warning

The following 0 plate elements are not included in any Sections and are not checked according to Standard '1..Plate Buckling ABS 2014'.





Constant

Title	Value	Description
Eta	0.8	Maximum Allowable Strength Utilization Factor (Eta). Critical Buckling Factor is multiplied on Eta
Pr	0.8	Proportional linear elastic limit
T_Factor	1	Thickness Factor (increase thickness and reduce stresses)

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### LS1..Load Set 1

Buckling (LS1, 5 Sections)

Standard	1..Plate Buckling ABS 2014	Check	[S1] 1..Plate Buckling ABS 2014 (Plate Avg. Element Avg)
Load Set	LS1..Load Set 1	Sections	5
Search Type	Related To Last		

Section Title	Plate Length	Plate Width	Plate Thickness in Plate	Stress x Direction	Stress y in Plate	Stress xy in Plate	Equivalent Stress	Ultimate Strength	Buckling State Limit
1..Section X 1 (X = 3.00 70) [MaxID=69]	3.00	1.73	0.02	-	7635260.5	31817172.	38326332.00	0.42	2.33
2..Section X 2 (X = 3.00 71.68) [MaxID=3]	3.00	2.80	0.02	0.00	-	30500492.	11654974.00	0.28	3.28
3..Section X 3 (X = 3.00 73.36) [MaxID=86]	3.00	1.73	0.02	-	6008946.0	38442112.	44549200.00	0.58	3.35
4..Section X 4 (X = 3.00 75.04) [MaxID=4]	3.00	2.80	0.02	0.00	-	30311968.	11630252.00	0.28	3.21
5..Section X 5 (X = 3.00 76.72) [MaxID=36]	3.00	2.80	0.02	-	12070138.	17523600.	8711987.00	0.12	1.45
Max over Sections [X 3 / 86]	3.00	1.73	0.02	-	6008946.0	38442112.	44549200.00	0.58	3.35

Buckling State Limit (LS1, 1..Section X 1 (X = 70), 2..Frames)

SDC Plot

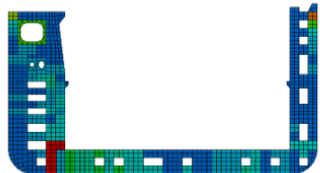
Equation: RE21 (Unwarped) (Ground to Element)


Time: 1

Max: 2.3

Min: 0.0

1/10/2018 14:00





Check

[S1] 1..Plate Buckling ABS 2014 (Plate Avg. Element Avg)

Load Set

LS1..Load Set 1

Parameter

Buckling State Limit

View

2..Frames

Panels

1..Section X 1 (X = 70)

26

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