



Tutorial  
**Plate Buckling ABS 2014**

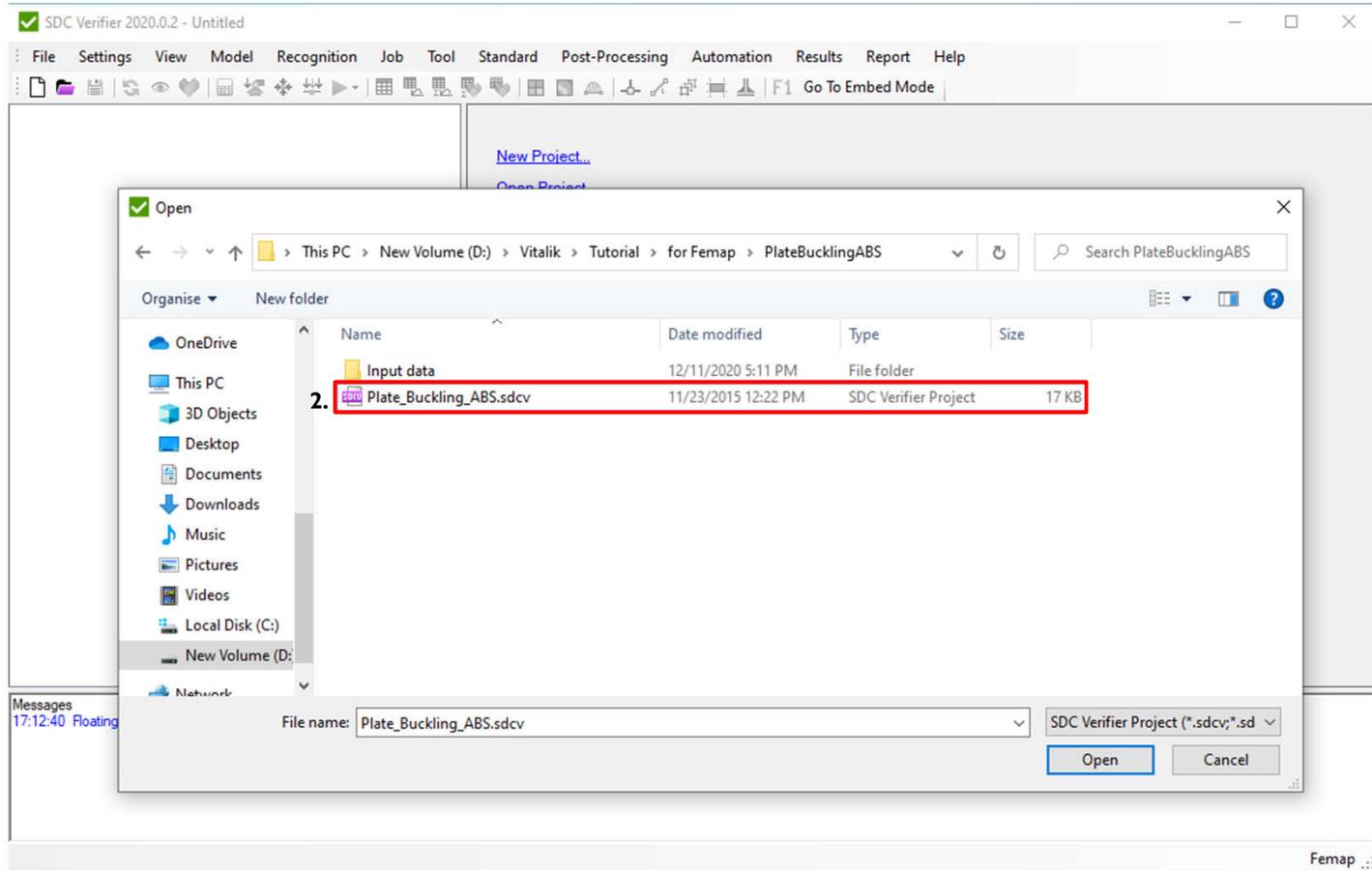
11 Dec 2020  
version 2020.0.2

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

# Open the starter model

1 Launch **SDC Verifier** 

2 Open project *Plate\_Buckling\_ABS*



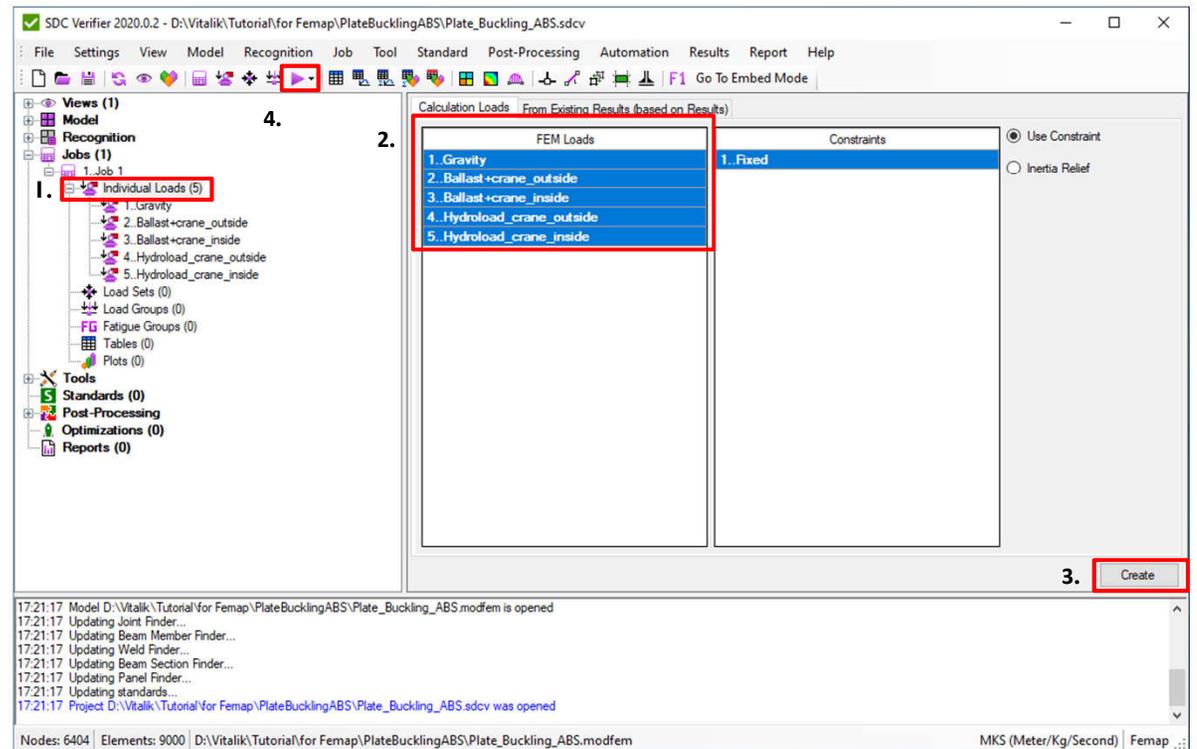
# Individual Loads

1 Click on **Individual Loads**

2 Choose 5 FEM Loads:

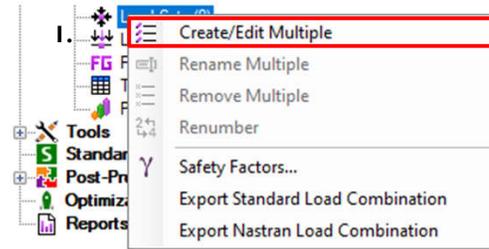
3 Press **Create**

4 Press  on toolbar to analyze job

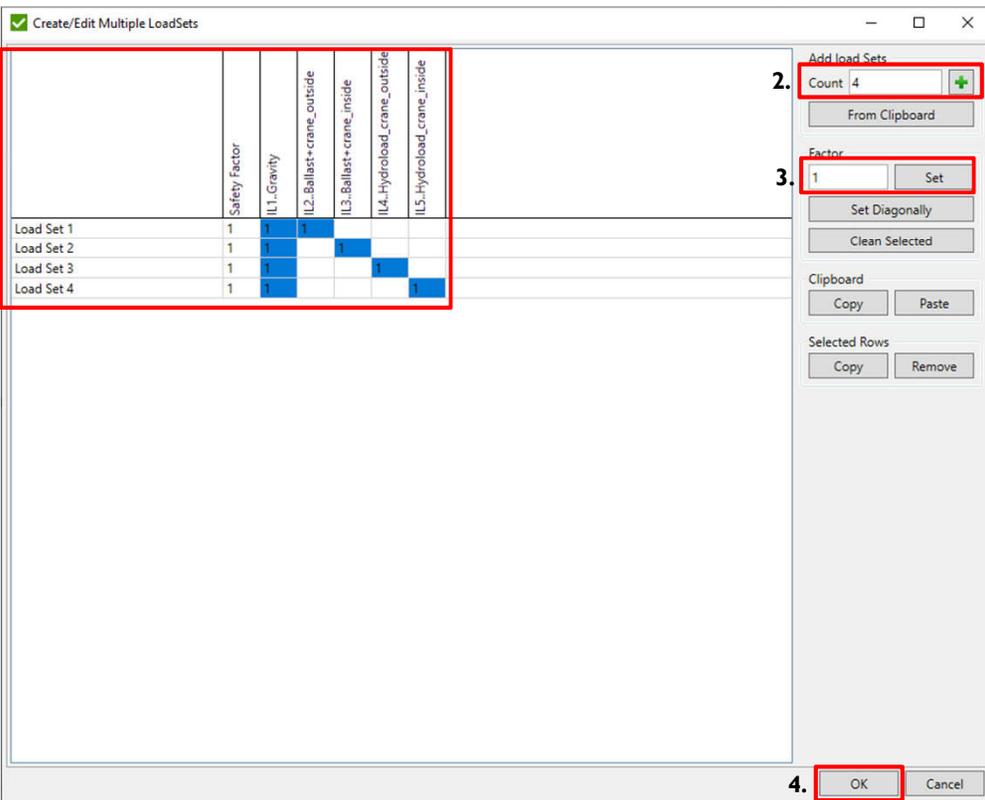


# Load Sets

- 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 table like shown on the picture and press *Set* to define Factors of Load Sets.
- 4 Press *OK*.



3.



2. Count 4 

3. 1 Set

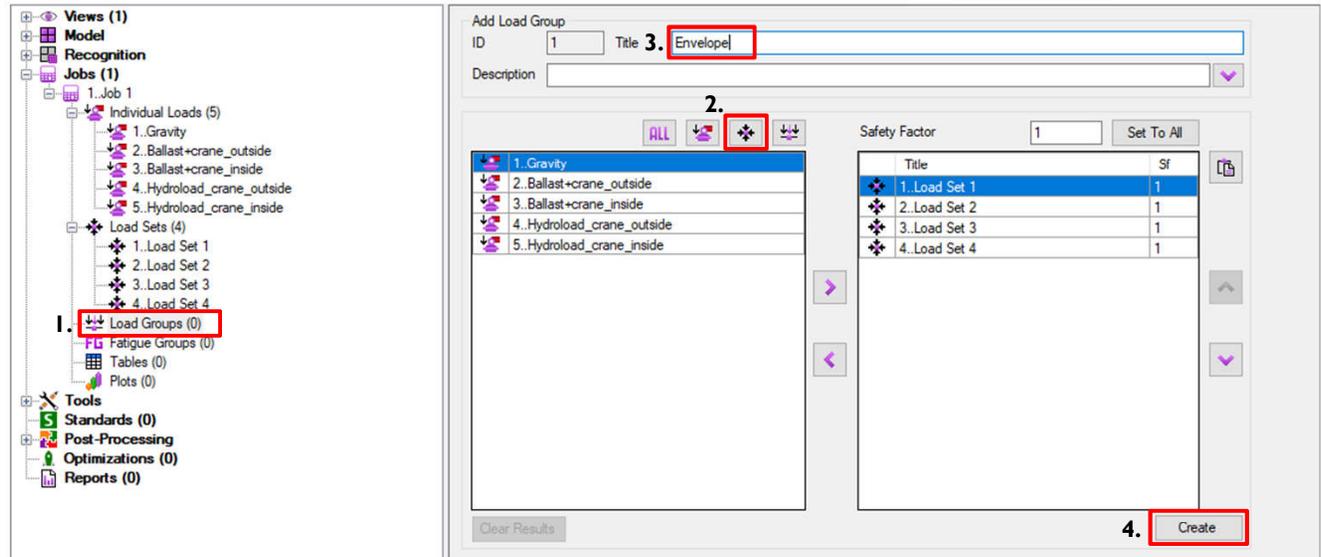
	Safety Factor	IL1.Gravity	IL2.Ballast+crane_outside	IL3.Ballast+crane_inside	IL4.Hydroload_crane_outside	IL5.Hydroload_crane_inside
Load Set 1	1	1	1			
Load Set 2	1	1		1		
Load Set 3	1				1	
Load Set 4	1	1				1

4. OK Cancel

**Note:** Load Sets are created with default titles "Load Set #". It is possible to rename them. Alternatively titles and factors can be pasted from Clipboard using *Paste* button.

# Load Groups

- 1 Click on **Load Groups**
- 2 Press  to select all Load Sets
- 3 **Title: Envelope;**
- 4 Press **Create**



The screenshot shows the SDC Verifier interface. On the left is a project tree with 'Load Groups (0)' highlighted. On the right is the 'Add Load Group' dialog. The 'Title' field contains 'Envelope'. The 'Safety Factor' is set to 1. A table lists the load sets to be included in the group.

Title	Sf
1..Load Set 1	1
2..Load Set 2	1
3..Load Set 3	1
4..Load Set 4	1

The 'Create' button is highlighted in the bottom right corner of the dialog.

**Note:** Load Sets and Load Groups are analyzed by SDC Verifier.

# Panel Finder. Recognize Sections.

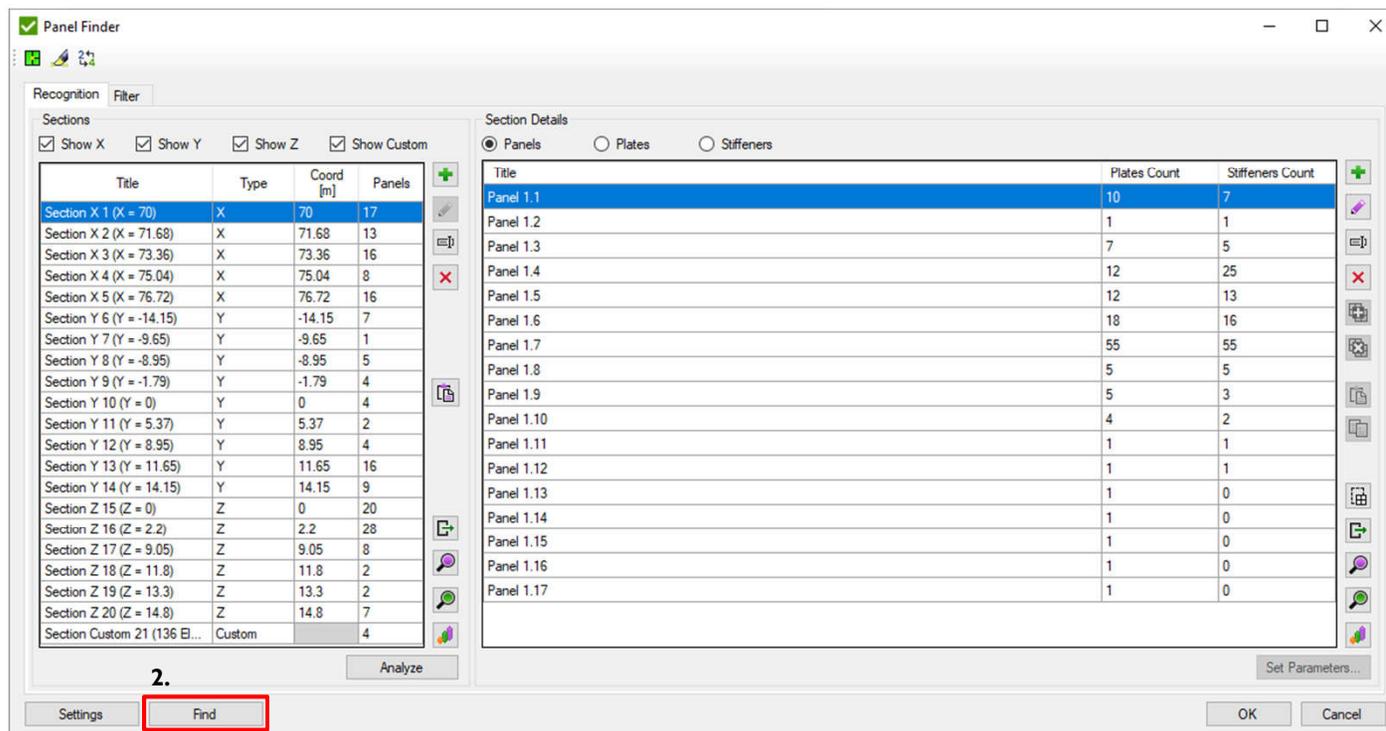
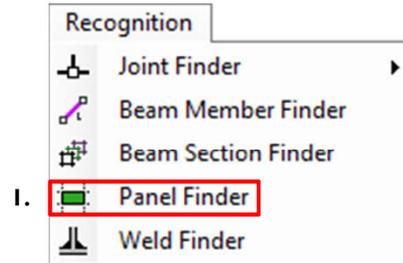
1

Execute *Recognition - Panel Finder* from main menu

2

Click on *Find*

All Frames, Longitudinals and Desks were automatically.



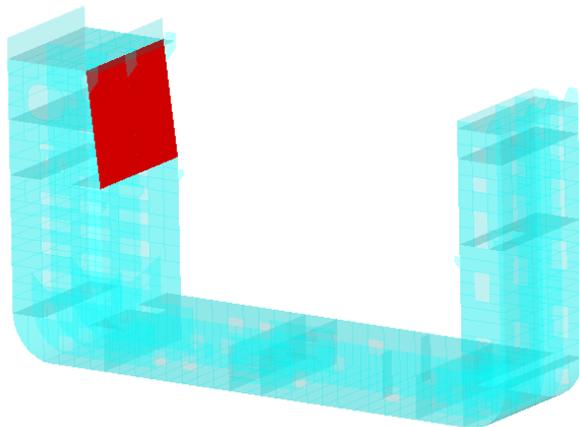
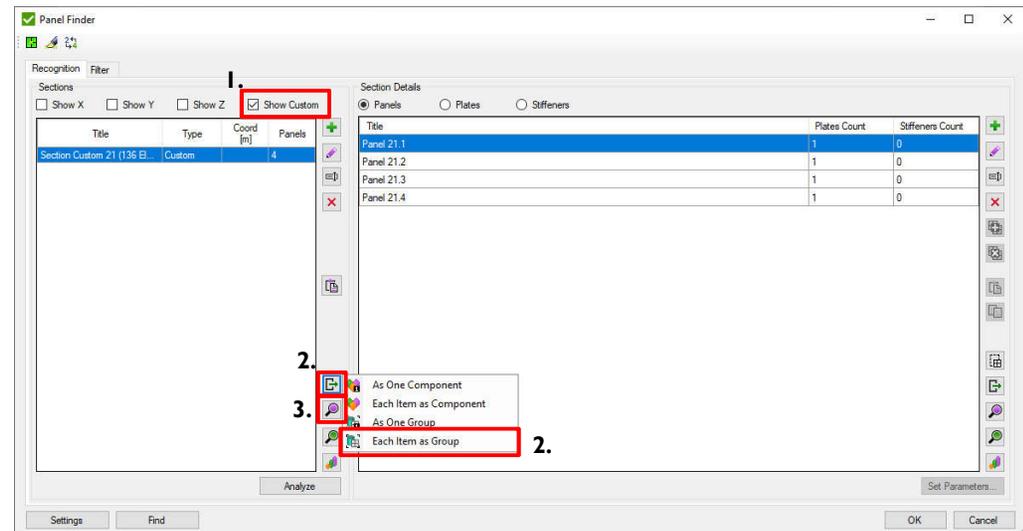
# Panel Finder. Custom Section

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

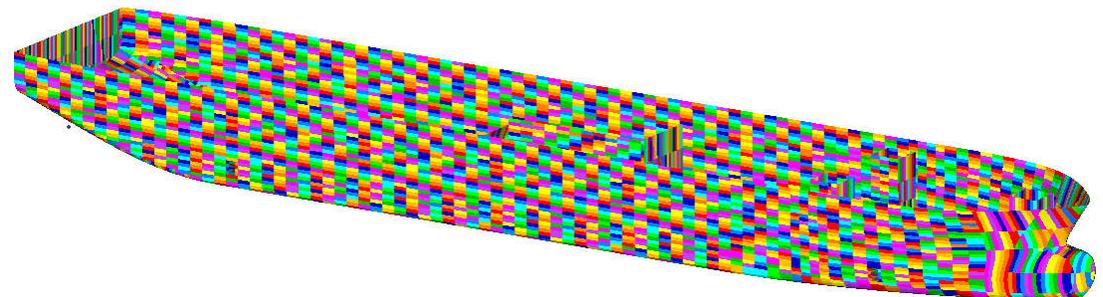
2 Press  and  to export selected sections to groups

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. Find Free Edges

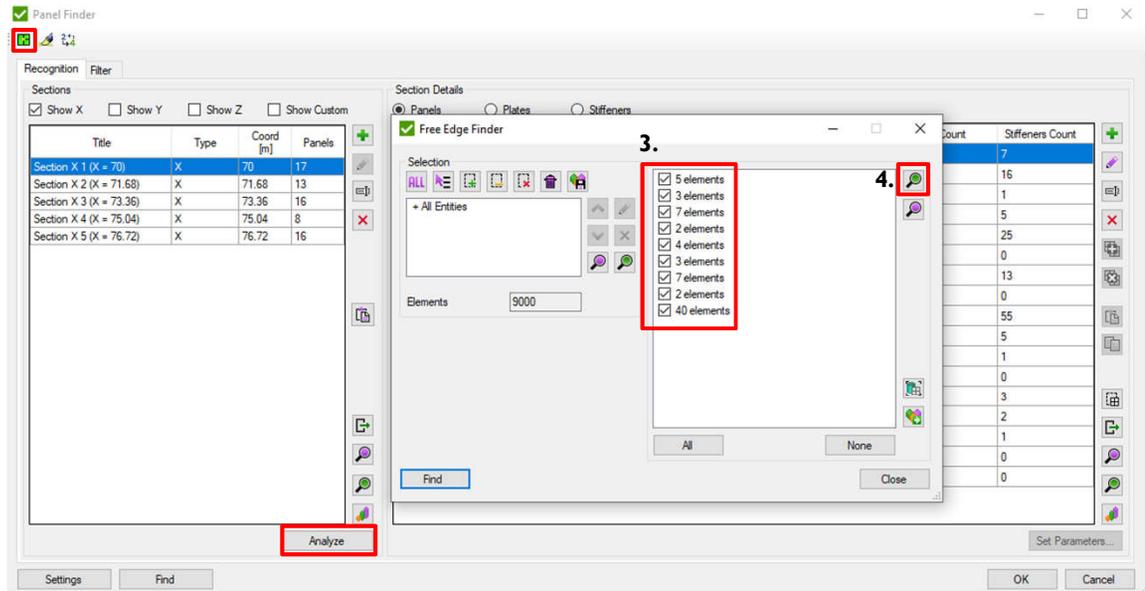
**Note:** Before plates recognition, the model should be checked on free edges. Not correct plate dimensions/direction, plates with undefined dimensions and as result wrong buckling factor – possible consequences of free edges.

1 Click  to Find Free edges

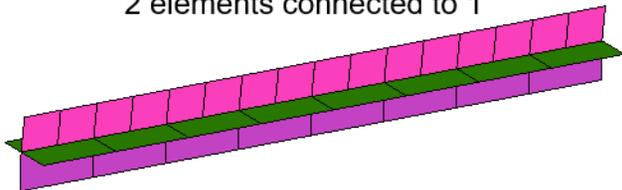
2 Press **Find**

3 Select all free edges

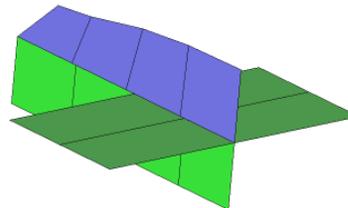
4 Press  to preview elements with free edges



2 elements connected to 1



Mesh does not coincide



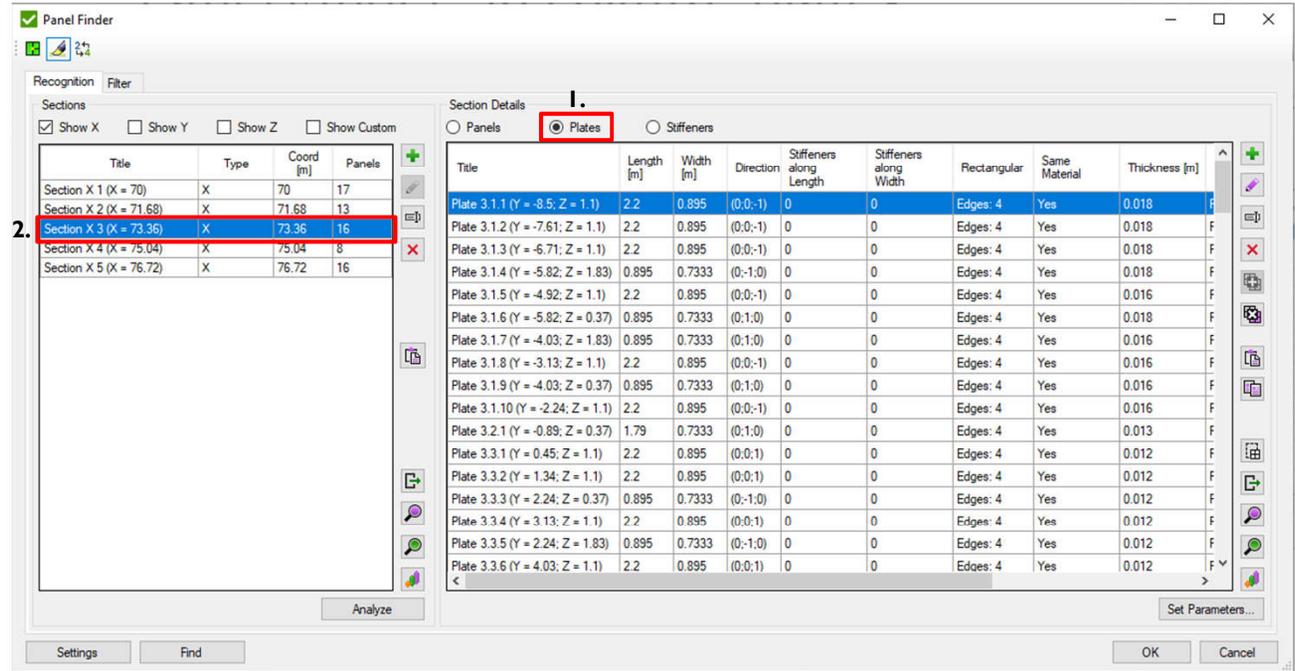
**Note:** Free edges should be fixed by remeshing the model and run recognition of plates. (In tutorial we skipped step with remeshing but for commercial project it is crucial step to do).

# Panel Finder. Recognize plates

1 In Selection details 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

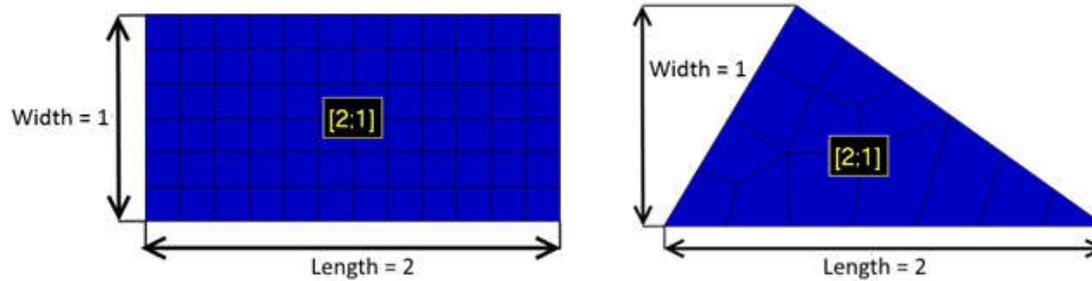
Section ID. Panel ID. Plate ID

Plate is rectangle with all corners = 90 degrees

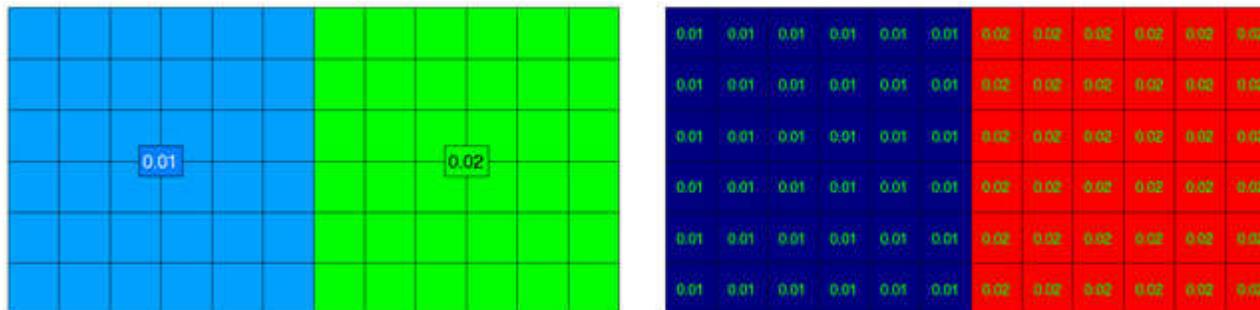
Plate has elements more than from one property

# Plate Dimensions and Thicknesses

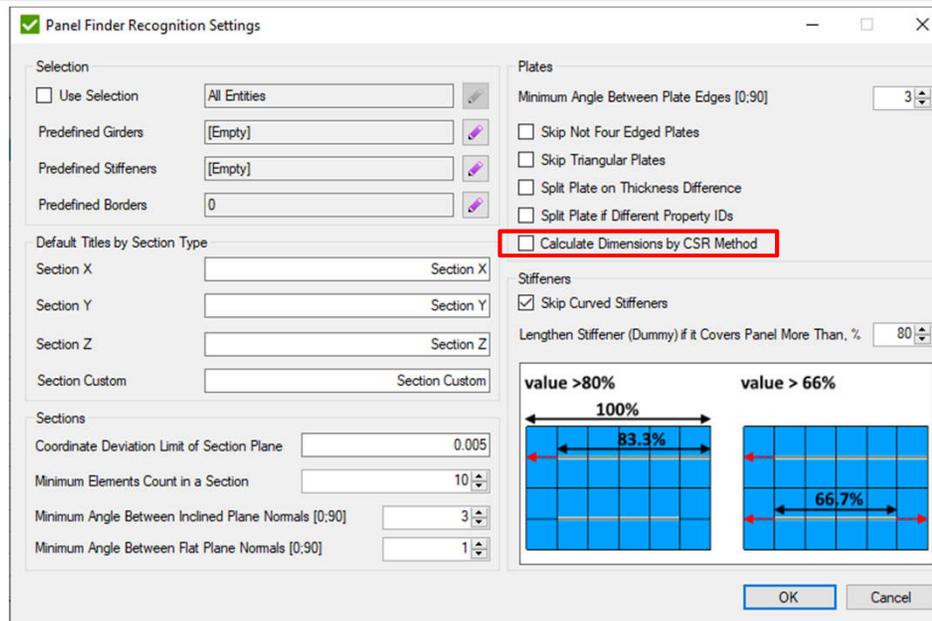
**Dimensions:** Results depend on plate dimensions and direction and it is important to understand how Panel Finder performs recognition. Length is considered the longest edge of plate and width the longest perpendicular to the longest edge:



**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:



# Plate Buckling Dimensions by CSR



## 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:

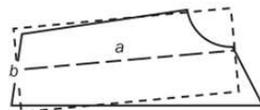
e) The length of shorter side,  $b$  in mm, is to be taken as:

$$b = A/a$$

where:

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

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

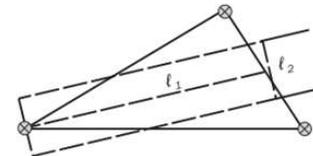


c) The width of the model,  $\ell_2$ , in mm, is to be taken as:

$$\ell_2 = A/\ell_1$$

where:

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



# Editing plates manually

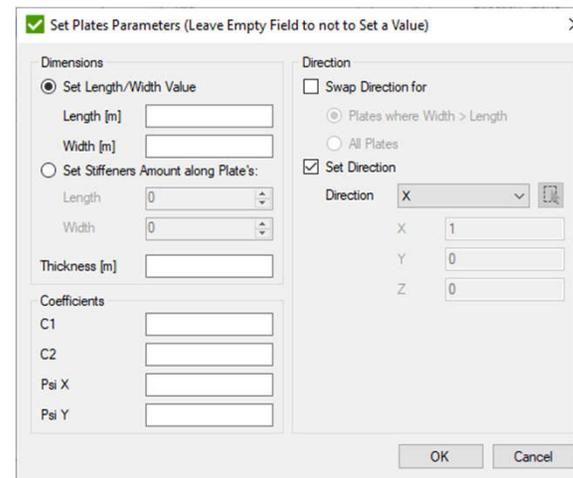
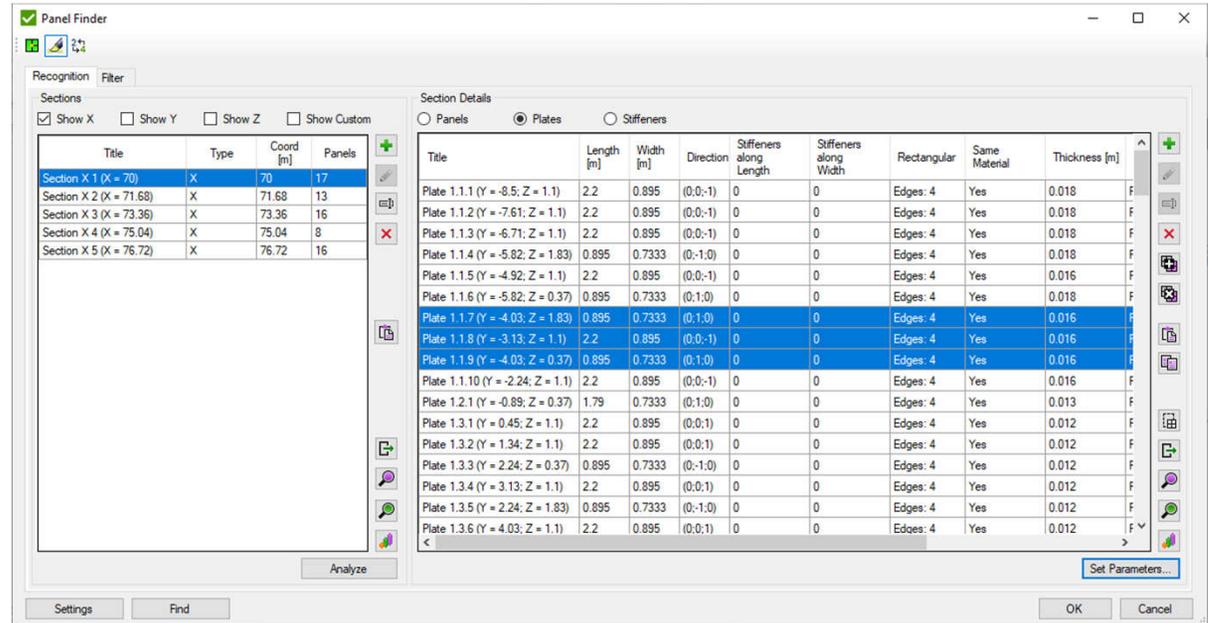
To modify plates select them from the list and press *Set Parameters*. It is possible to edit (Length / Width / Thickness / Coefficients / Direction).

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*.

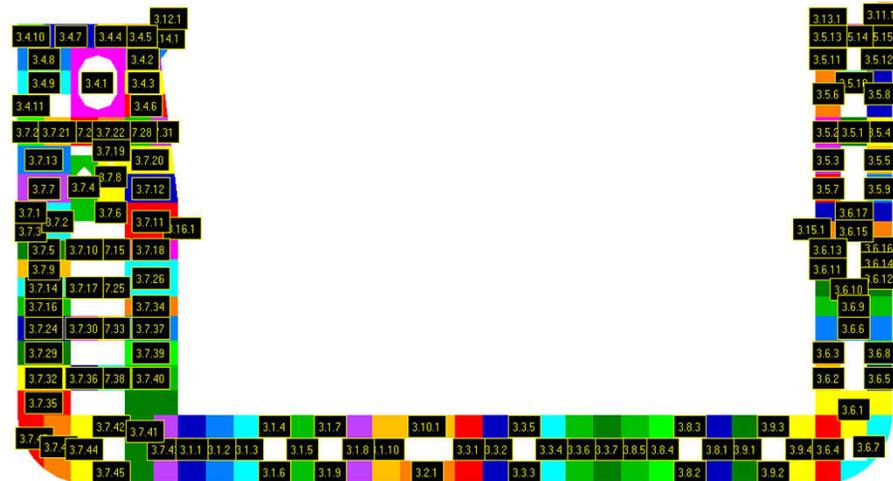


# Panel Finder. Plates Plot

- 1 Select Section X3
- 2 Select All Plates
- 3 Press
- 4 Click on Colors + Labels of Ids.

Title	Length [m]	Width [m]	Direction	Stiffeners along Length	Stiffeners along Width	Rectangular	Same Material	Thickness [m]
Plate 3.1.1 (Y = -8.5; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.018
Plate 3.1.2 (Y = -7.61; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.018
Plate 3.1.3 (Y = -6.71; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.018
Plate 3.1.4 (Y = -5.82; Z = 1.83)	0.895	0.7333	(0,-1,0)	0	0	Edges: 4	Yes	0.018
Plate 3.1.5 (Y = -4.92; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.016
Plate 3.1.6 (Y = -5.82; Z = 0.37)	0.895	0.7333	(0,1,0)	0	0	Edges: 4	Yes	0.018
Plate 3.1.7 (Y = -4.03; Z = 1.83)	0.895	0.7333	(0,1,0)	0	0	Edges: 4	Yes	0.016
Plate 3.1.8 (Y = -3.13; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.016
Plate 3.1.9 (Y = -4.03; Z = 0.37)	0.895	0.7333	(0,-1,0)	0	0	Edges: 4	Yes	0.016
Plate 3.1.10 (Y = -2.24; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.016
Plate 3.2.1 (Y = -0.89; Z = 0.37)	1.79	0.7333	(0,1,0)	0	0	Edges: 4	Yes	0.013
Plate 3.3.1 (Y = 0.45; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.012
Plate 3.3.2 (Y = 1.34; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.012
Plate 3.3.3 (Y = 2.24; Z = 0.37)	0.895	0.7333	(0,-1,0)	0	0	Edges: 4	Yes	0.012
Plate 3.3.4 (Y = 3.13; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.012
Plate 3.3.5 (Y = 2.24; Z = 1.83)	0.895	0.7333	(0,-1,0)	0	0	Edges: 4	Yes	0.012
Plate 3.3.6 (Y = 4.03; Z = 1.1)	2.2	0.895	(0,0-1)	0	0	Edges: 4	Yes	0.012

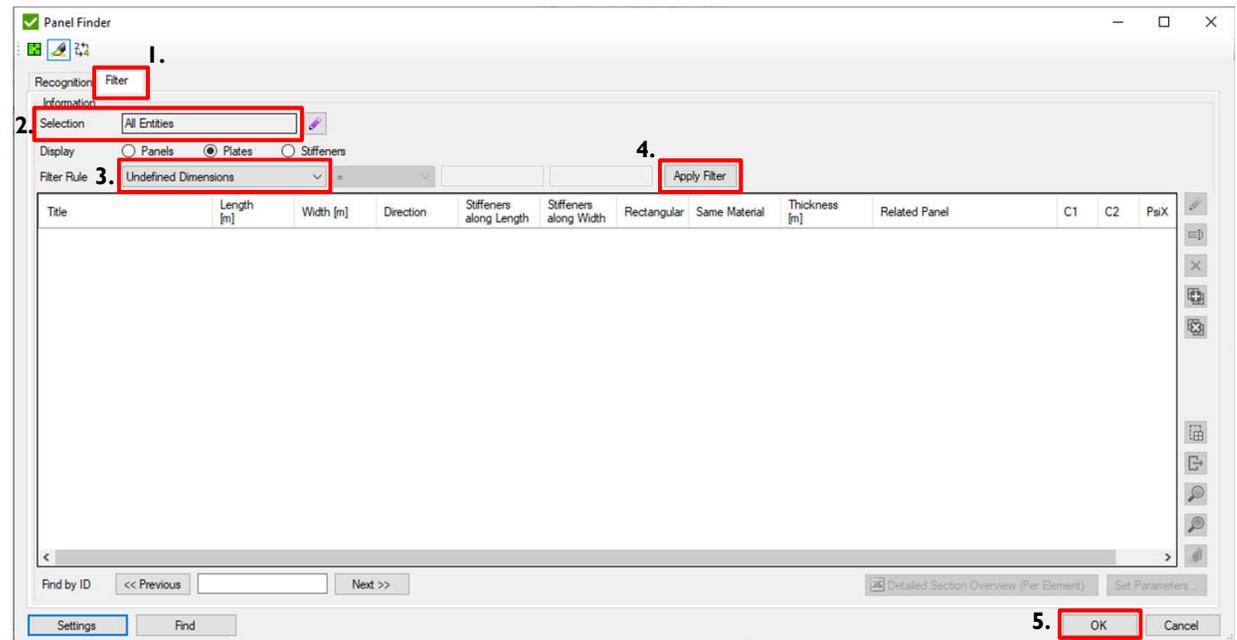
- Colors Only
- Colors + Labels of Ids**
- Colors + Labels of Corners Count
- Colors + Labels of Dimensions
- Length Values (no labels)
- Width Values (no labels)
- Coordinate Systems
- Draw Stiffeners along Length/Width



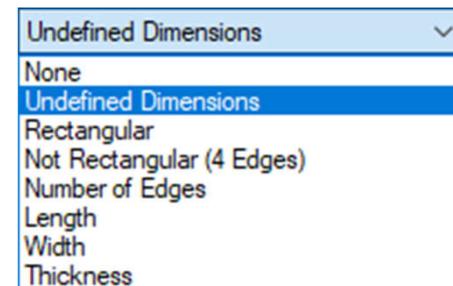
# Panel Finder. Filter

**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*

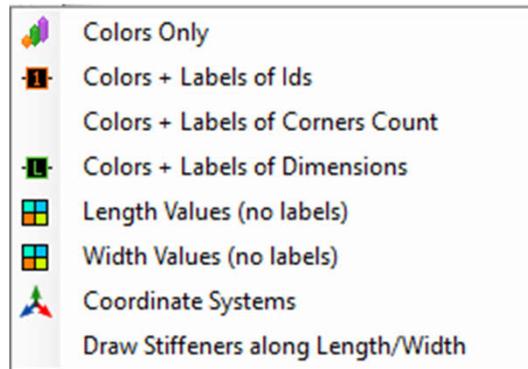


**Tip:** It is also possible to filter plates by shape (triangle, rectangular) or number of edges parameters.  
E.g. Plates with numbers of edges > 4 can be displayed.  
Control using Selection plates from which Sections should be filtered.

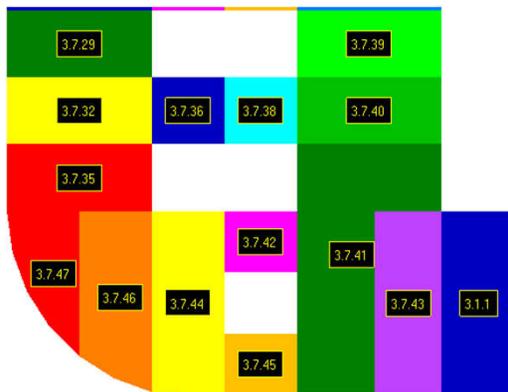


# Panel Finder. Plot Options

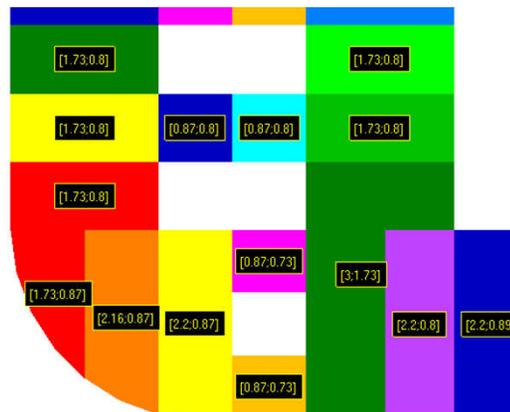
**Note:** Plate Plot can be displayed with different colors labels (labels of ids, labels of corners count or labels of dimensions). Also it is possible to show plates in length and width, coordinate systems etc.



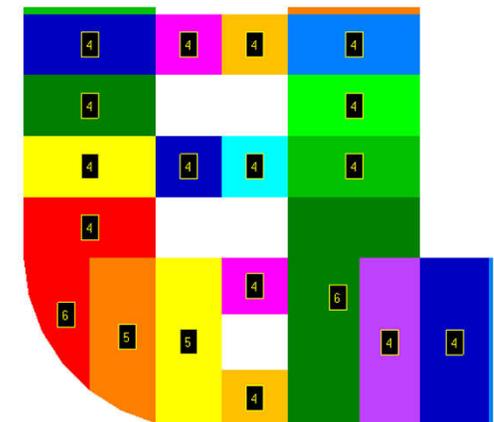
Labels of Ids



Labels of dimensions

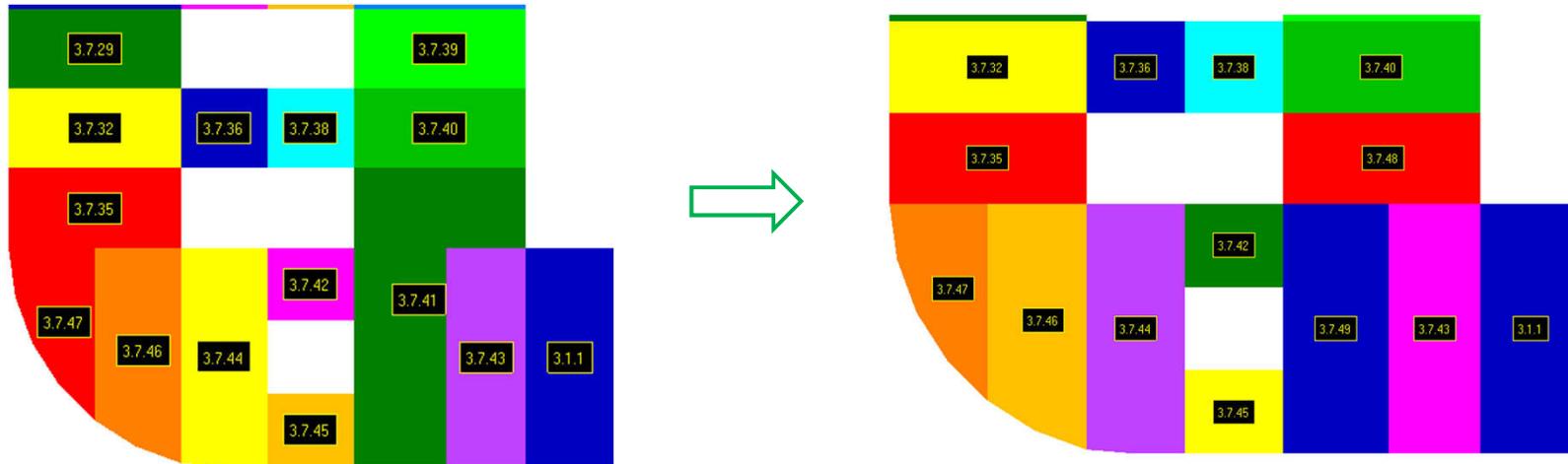


Labels of Corners Count



# Panel Finder. Update Plates

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 X3 plate with Id = 3.7.41 should be split on 2 plates



Note: if plates were modified manually and later user decided to run recognition of plates - Panel Finder will ask what to do with modified plates:

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



# Panel Finder. Split Plate

- 1 Select **Section X1 (X = 70)**.
- 2 Select **Plate 1.9.48**.
- 3 Press **Split by elements**
- 4 Selected plate is displayed in Femap. Select elements for one plate. And press **OK**

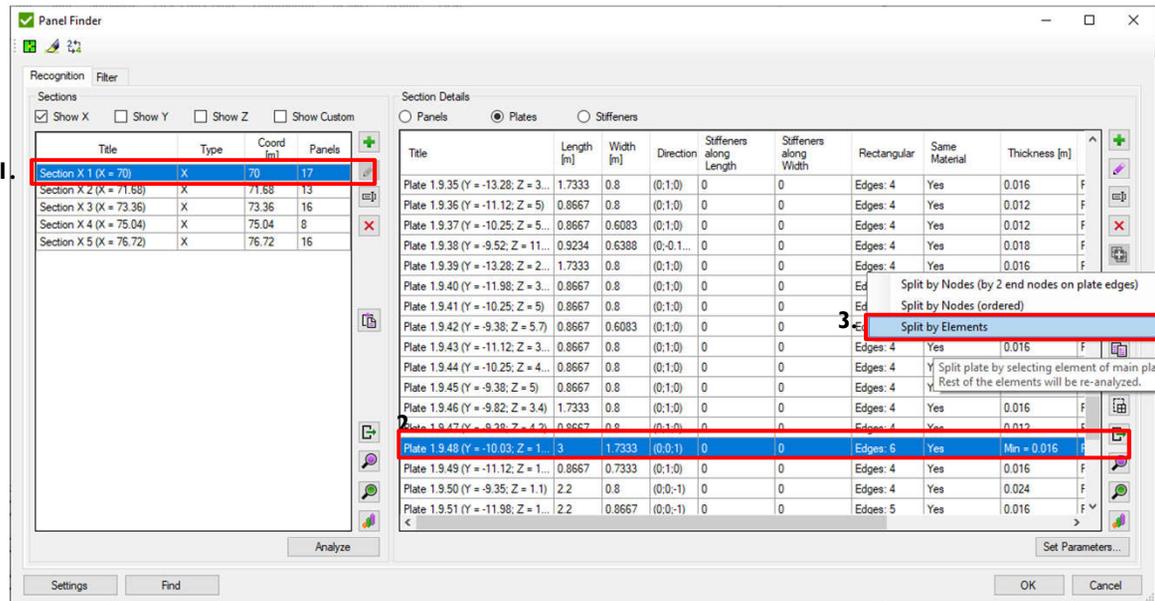
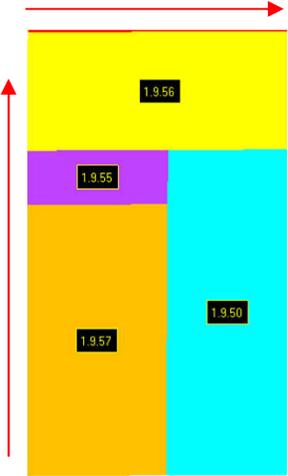


Plate 1.9.48 is replaced with Plates 1.9.55; 1.9.56 and 1.9.57  
 Dimensions and directions are updated automatically



Title
Plate 1.7.55 (Y = -9.8; Z = 2.6)
Plate 1.7.56 (Y = -10.22; Z = 1...)



# 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

Use Plate Average Stress: **On**

4

Press *OK*

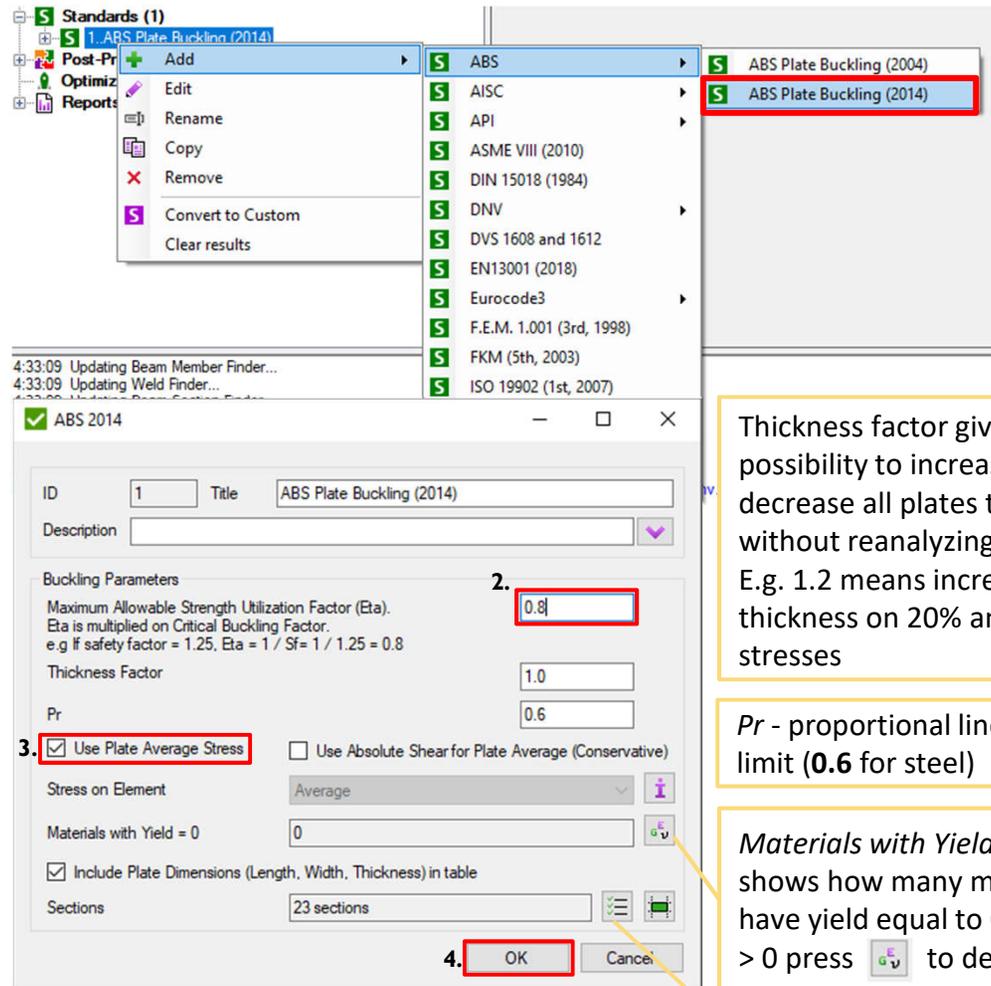


Plate Buckling transforms stresses automatically into plate direction. Options about element stresses and plate stresses are described on the next slide

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

✓ Plate Buckling Stresses

Average Element Stress:  
 $S_{el} = (S1+S2+S3+S4+S5+S6+S7+S8) / 8$

Minimum Element MidPlane:  
 $S_{el} = \text{Min}((S1+S5) / 2, (S2+S6) / 2, (S3+S7) / 2, (S4+S8) / 2)$

S1 - S8 - translated element stresses into Plate Direction

**Use Plate Average Stress**

**On**

Sel1 (avg)	Sel2 (avg)	Sel3 (avg)
------------	------------	------------

$S_{pl} = (Sel1 \cdot A1 + Sel2 \cdot A2 + Sel3 \cdot A3) / (A1 + A2 + A3)$

One Buckling Factor for plate

**Off**

Sel1	Sel2	Sel3
------	------	------

Sel1, Sel2, Sel3 - Average or min MidPlane

Plate Buckling Factor =  $\text{Max}(BF1, BF2, BF3)$

Close

# Views

1 Execute Views => **Add**

2 Title: **Frames**

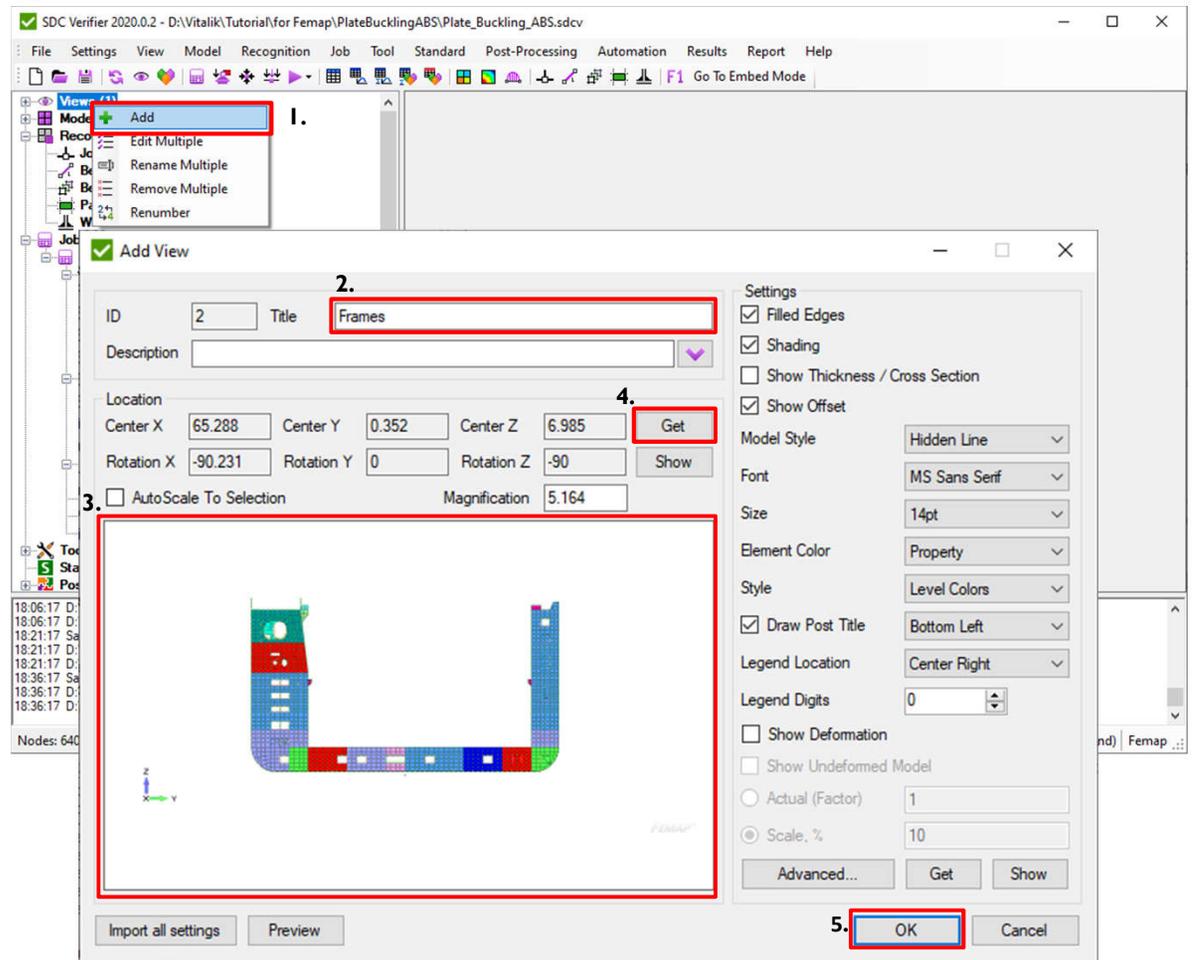
3 Orient model in Femap as shown on picture below (ZY plane)

4 Press *Get*

5 Press *OK*.

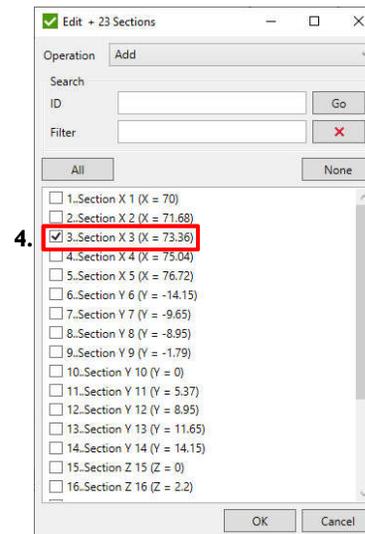
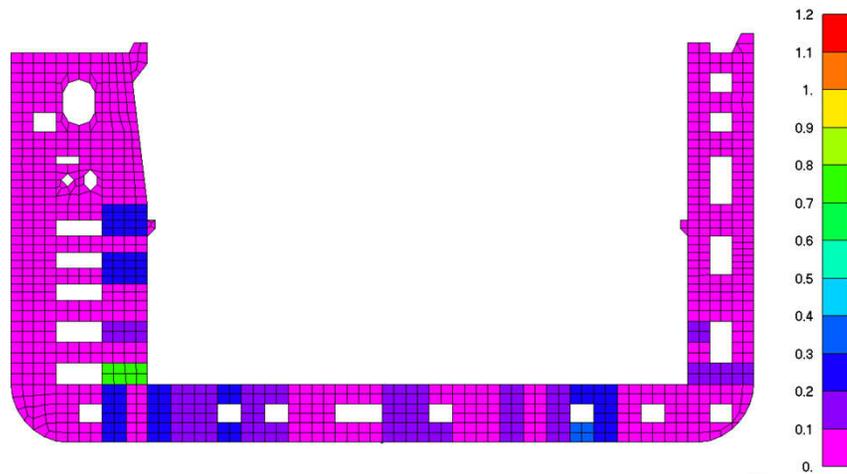
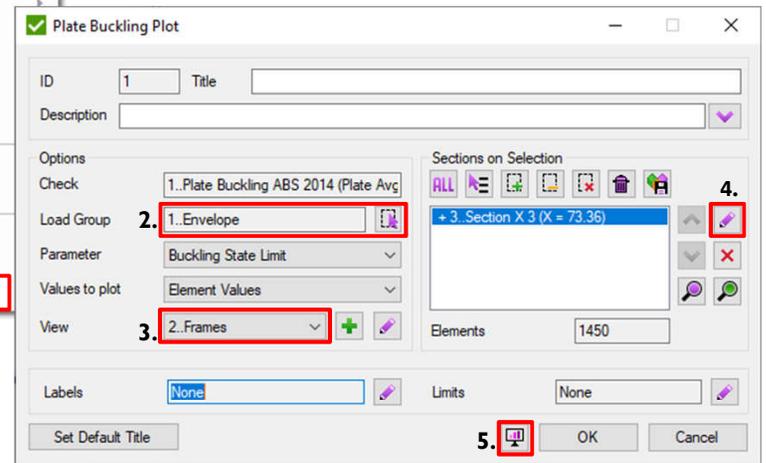
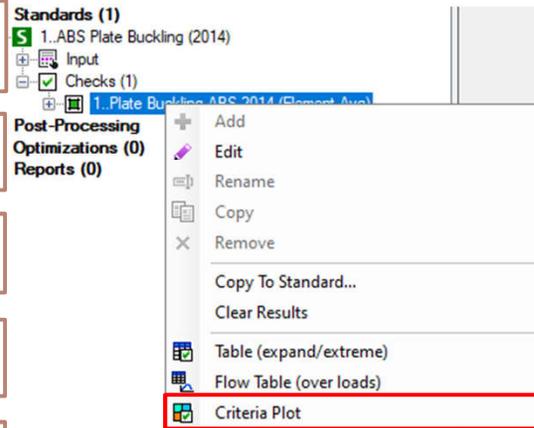
To make nice plots first Views should be created (set of settings how to display plot).

Repeat Steps 1-5 2 times to create view for Longitudinals (plane ZX) and Decks (plane XY)



# Plate Buckling Plot

- 1 Execute *Criteria Plot* from Plate Buckling ABS 2014 context menu
- 2 Load Group: 1..**Envelope**
- 3 View: **Frames**
- 4 Press  Select: **Section X3**
- 5 Press  *Preview*



# 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.

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
1..Section X 1 (X = 70)	3.00	1.73	0.02	-4.42e+6	-17.43e+6	-21.13e+6	40.11e+6	0.12	0.55

All results(dimensions, stresses) are from the plate which cause highest BF=0.55 because Search Type = Related to Last Parameter

# Report. Tables

- 1 Execute Reports => Add => **Designer - Results**
- 2 Results => Check Tables
- 3 Press => Check '1..Plate Buckling' =>
- 4 Type: **Expand**
- 5 Press and select **LS; LG** loads.
- 6 Press **OK**
- 7 Press and Execute **From List**
- 8 Select all **X Sections**
- 9 Press **OK**
- 9 Press **OK**

The screenshot illustrates the workflow for generating report tables in SDC Verifier. It shows the 'Reports' menu, the 'Report Designer' window, the 'Plate Buckling Table' configuration dialog, and the 'Select Items' dialog.

**1.** The 'Reports' menu is open, and 'Designer - Results' is selected.

**2.** The 'Report Designer' window is shown with the 'Results' tab active. The 'Check Tables' icon is highlighted.

**3.** The 'Add Check Tables' dialog is open, and 'Check '1..Plate Buckling (Element Avg)' is selected.

**4.** The 'Plate Buckling Table' dialog is open, and the 'Table Type' is set to 'Expand'.

**5.** The 'Plate Buckling Table' dialog is open, and the 'From List' button is highlighted.

**6.** The 'Select Items' dialog is open, and the 'OK' button is highlighted.

**7.** The 'Select Items' dialog is open, and the 'From List' button is highlighted.

**8.** The 'Select Items' dialog is open, and all 'X' sections are selected.

**9.** The 'Select Items' dialog is open, and the 'OK' button is highlighted.

# Report. Plots

- 1 Results => Check Plots
- 2 Press => Check '1..Plate Buckling' =>
- 3 Parameter: **Buckling Factor Overall.**
- 4 Views: **Frame.**
- 5 Press , select **LS; LG** Loads and Press **OK.**
- 6 Press and Execute **From List**
- 7 Select all **X sections.**
- 8 Press **OK.**
- 9 Press **OK.**

The screenshot shows the SDC Verifier software interface with several windows open and specific elements highlighted with red boxes and numbered callouts (1-9) corresponding to the instructions on the left.

- 1:** The **Results** tab is selected in the top ribbon.
- 2:** The **Check Plots** icon in the Standards group is highlighted.
- 3:** In the **Add Check Plots** dialog, the check **'1..Plate Buckling ABS 2014 (Element Avg)'** is selected.
- 4:** In the **Plate Buckling Check Plot** dialog, the **From List** button is highlighted.
- 5:** In the **Select Loads** dialog, the **LG (1 / 1)** load set is selected.
- 6:** In the **Plate Buckling Check Plot** dialog, the **From List** button is highlighted.
- 7:** In the **Select Items** dialog, all **X sections** (1 through 5) are selected.
- 8:** The **OK** button in the **Select Items** dialog is highlighted.
- 9:** The **OK** button in the **Plate Buckling Check Plot** dialog is highlighted.

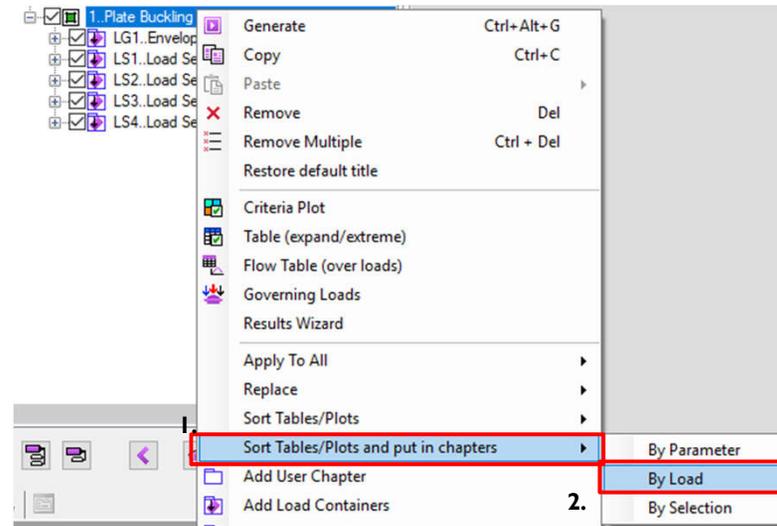
# Report. Sort tables and plots by Load

1

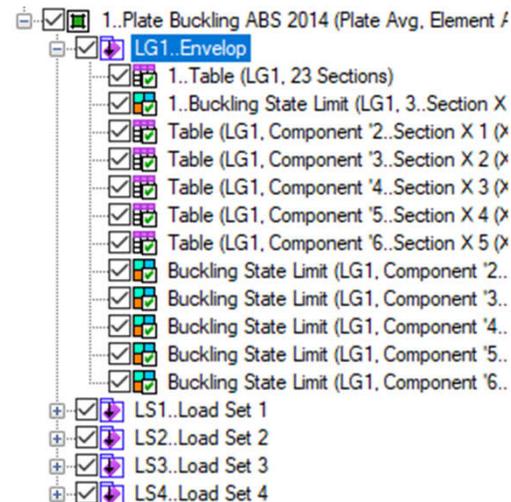
Execute *Plate Buckling ABS 2014*  
=> *Sort Tables/Plots and put in chapters*

2

Click => *By Load*

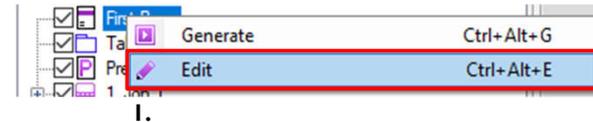


All tables and plots are sorted by loads. It is possible to sort it *By Parameter; By Selection; By section* as well.



# Report. First Page

- 1 Right click on *First Page* => **Edit**.
- 2 Press to select engineer and custom from library
- 3 Select Image *From View* and pick '*2..Frame*'.
- 4 Press **OK**.



**First Page Editor**

**Engineer details**

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Logo:

Put logo on report plots

**Customer details**

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Web Site: company.com

Logo:

**Image**

From file

From View 2..Frame 3.

Custom Fields

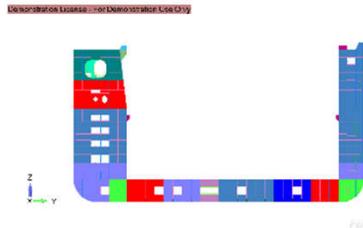
4. **OK** Cancel

# Report

Press to generate complete report and press to convert report to word



## Report



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Engineer: Support  
Customer: customer  
Project Number:  
Version: 1  
Date: 11/12/2020

### Checks

This paragraph contains checks descriptions with their results.

#### 1..Plate Buckling ABS 2014 (Plate Avg, Element Avg)

Property	Value
Category	Plate Buckling
Parameter Count	26
Use Absolute Shear	No
Convert Stresses into plate direction	Yes

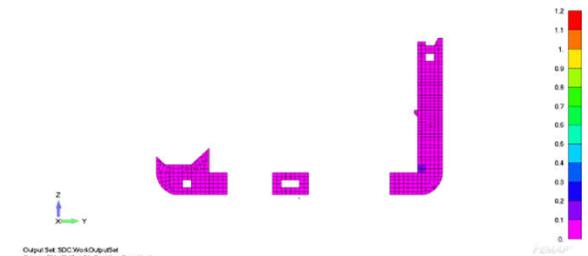
#### LG1..Envelop

##### 1..Table (LG1, 23 Sections)

Standard	1..ABS Plate Buckling (2014)	Check	[S1] 1..Plate Buckling ABS 2014 (Plate Avg, Element Avg)	23 Sections						
Load Group	LG1..Envelop	Selection								
Search Type	Related To Last									
Section Title	Plate Length [m]	Plate Width [m]	Plate Thickness [m]	Stress x Direction [Pa]	Stress y Direction [Pa]	Stress xy in Plate Direction [Pa]	Equivalent Stress [Pa]	Ultimate Strength	Buckling State Limit	Load
8..Section Y 8 (Y = -8.95)	9.05	3.38	0.01	-35.43e+6	-1.84e+6	1.77e+6	34.69e+6	0.89	21.38	LS4
13..Section Y 13 (Y = 11.65)	2.20	1.68	0.01	-27.71e+6	-2.49e+6	7.94e+6	26.58e+6	0.42	13.02	LS3
16..Section Z 16 (Z = 2.2)	7.16	3.38	0.02	-25.81e+6	-2.19e+6	4.34e+6	24.91e+6	0.22	3.66	LS4
15..Section Z 15 (Z = 0)	3.38	0.89	0.01	-9.74e+6	-49.70e+6	-0.94e+6	42.67e+6	0.54	1.00	LS4
2..Section X 2 (X = 71.68)	3.00	2.60	0.02	-0.79e+6	-18.97e+6	-7.14e+6	22.84e+6	0.10	0.68	LS4
4..Section X 4 (X = 75.04)	3.00	2.60	0.02	-0.77e+6	-18.60e+6	-7.08e+6	22.27e+6	0.09	0.84	LS4
3..Section X 3 (X = 73.36)	3.00	1.73	0.02	-4.77e+6	-20.86e+6	-24.64e+6	47.23e+6	0.17	0.78	LS4
14..Section Y 14 (Y = 14.15)	3.38	0.92	0.01	-5.69e+6	-33.05e+6	-7.71e+6	31.32e+6	0.30	0.73	LS4
5..Section X 5 (X = 76.72)	3.00	1.73	0.02	-4.50e+6	-17.64e+6	-21.42e+6	40.64e+6	0.12	0.57	LS4
1..Section X 1 (X = 70)	3.00	1.73	0.02	-4.42e+6	-17.43e+6	-21.13e+6	40.11e+6	0.12	0.55	LS4
19..Section Z 19 (Z = 13.3)	3.38	2.50	0.01	-2.08e+6	-0.18e+6	11.91e+6	20.63e+6	0.04	0.42	LS1
11..Section Y 11 (Y = 5.37)	2.20	0.84	0.01	-17.84e+6	-0.36e+6	7.70e+6	22.24e+6	0.06	0.36	LS4
21..Section Custom 21 (136 Elements)	3.38	2.77	0.02	-0.52e+6	-11.94e+6	1.34e+6	11.62e+6	0.03	0.19	LS4
22..Section Custom 22 (64 Elements)	2.72	1.68	0.01	-11.21e+6	-3.77e+6	3.44e+6	11.54e+6	0.02	0.10	LS1
17..Section Z 17 (Z = 9.05)	2.50	1.68	0.01	-1.54e+6	-2.95e+6	-3.13e+6	6.00e+6	0.01	0.07	LS1
18..Section Z 18 (Z = 11.8)	4.87	3.38	0.01	-0.10e+6	0.00e+6	2.79e+6	4.83e+6	0.00	0.06	LS1
12..Section Y 12 (Y = 8.95)	2.20	1.68	0.01	-0.95e+6	-1.14e+6	15.88e+6	27.51e+6	0.03	0.05	LS3

#### Buckling State Limit (LS1, Component '3..Section X 2 (X = 71.68)', v2)

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Output Set: SDC WorkOutputSet

Check: [S1] CH3: LS1: Buckling State Limit

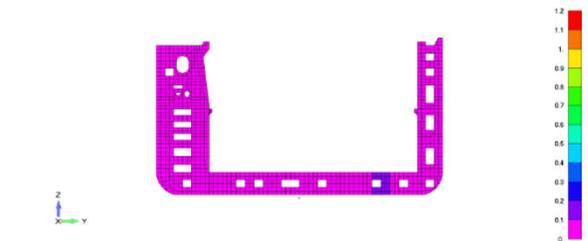
Check: [S1] 1..Plate Buckling ABS 2014 (Plate Avg, Element Avg)

Parameter: Buckling State Limit Selection: Component '3..Section X 2 (X = 71.68)'

View: 2..Frames

#### Buckling State Limit (LS1, Component '4..Section X 3 (X = 73.36)', v2)

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Output Set: SDC WorkOutputSet

Check: [S1] CH3: LS1: Buckling State Limit

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

Parameter: Buckling State Limit Selection: Component '4..Section X 3 (X = 73.36)'

View: 2..Frames