SDC VERIFIER

Tutorial

Plate Buckling ABS 2014

Updated on: 03 July 2023

Tested with: SDC Verifier 2023 R1

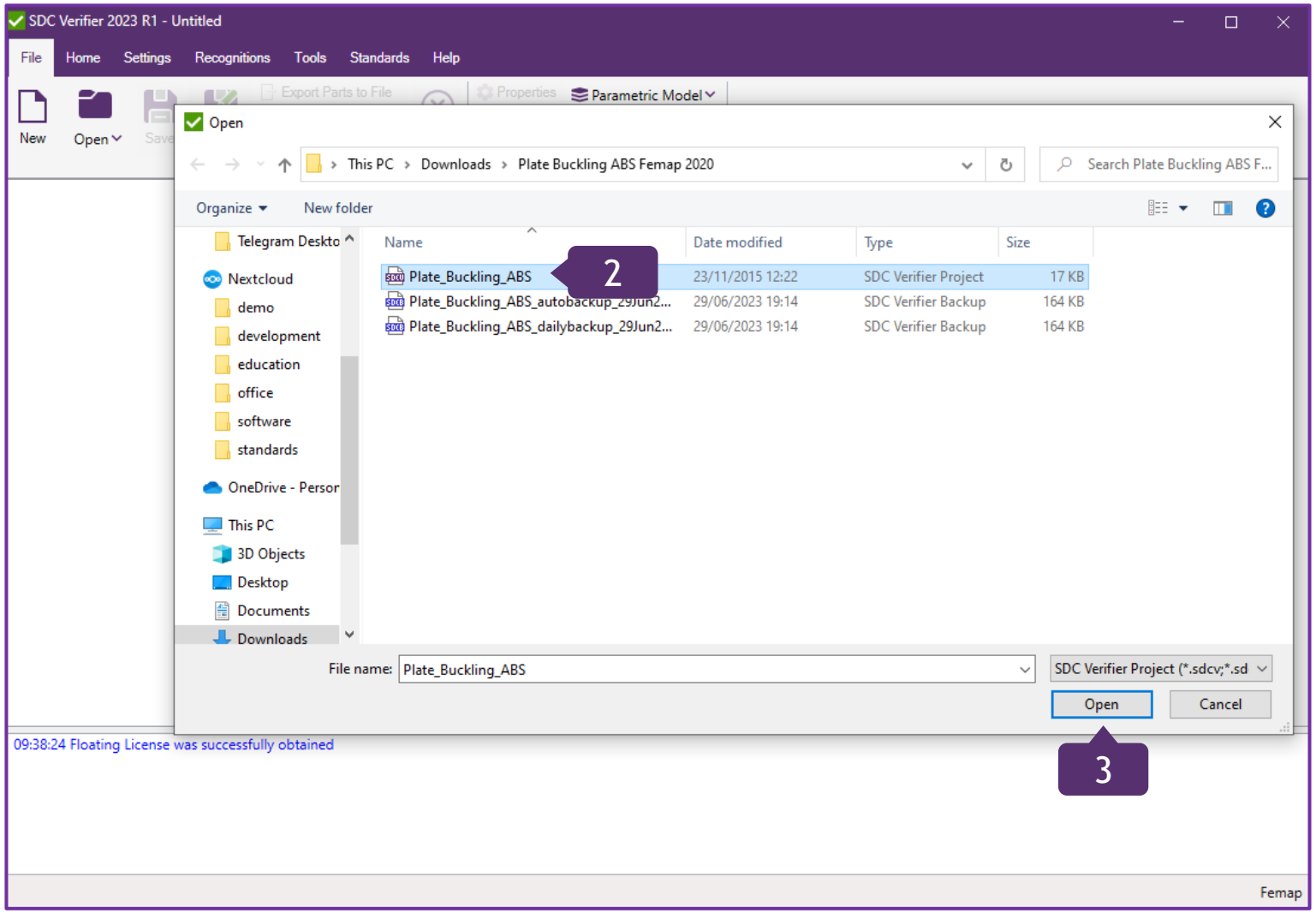
Simcenter Femap with Nastran 2022.2 MP2

Content

- 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.

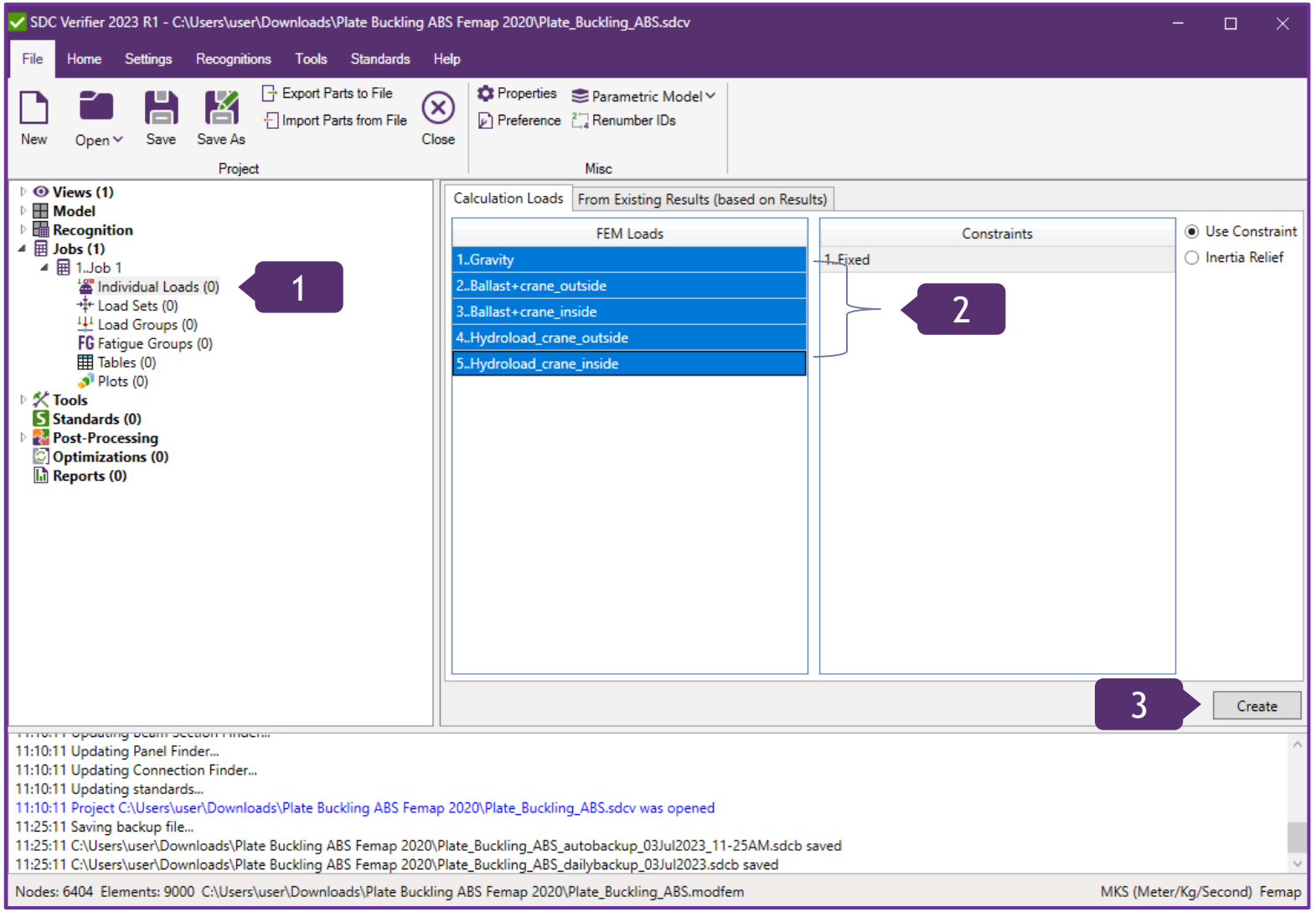
Open the Starter Model

1. **Launch SDC Verifier for FEMAP** ✅
2. **Select project *Plate_Buckling_ABS***
3. **Press *Open***



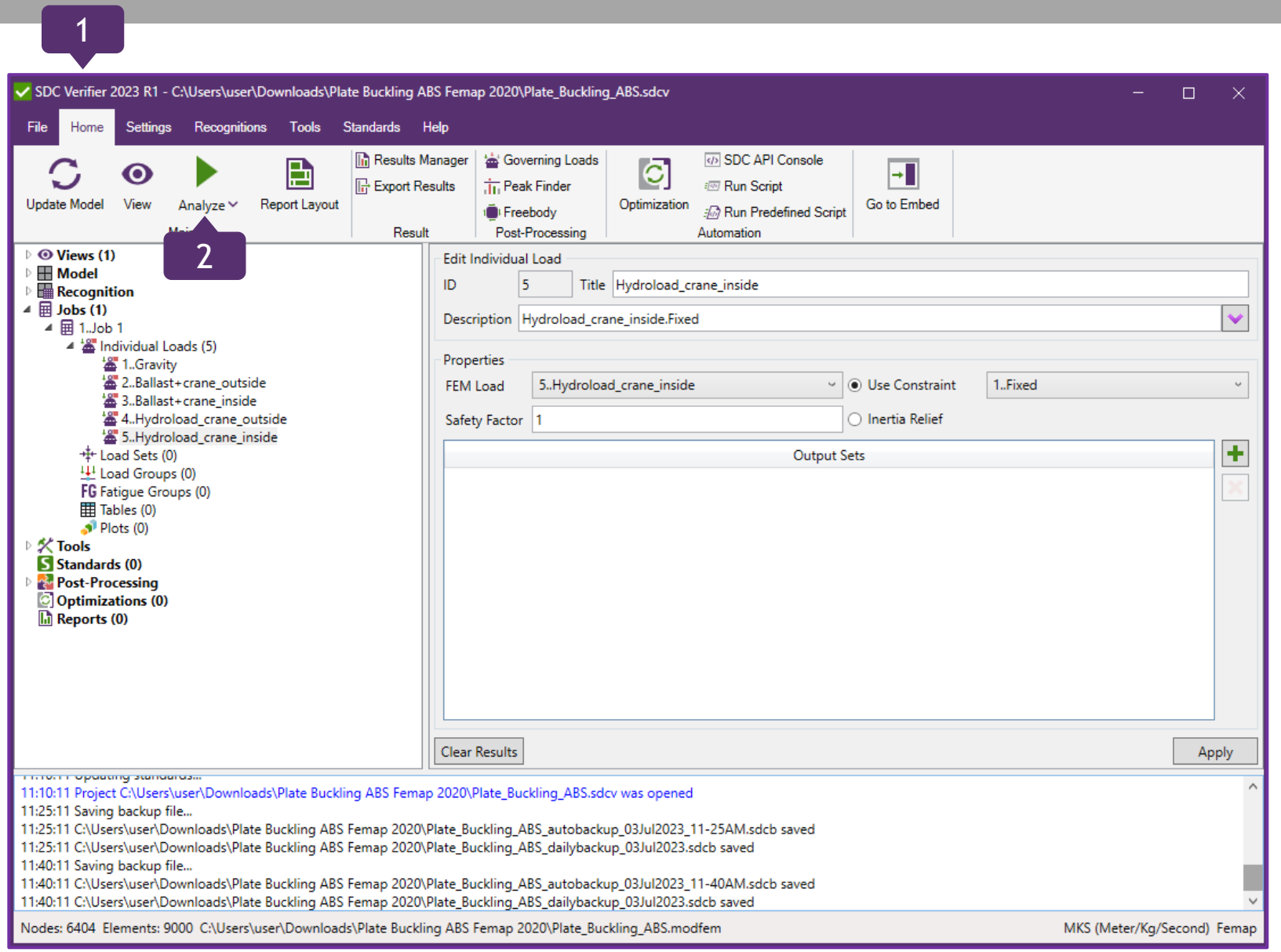
Individual Loads

1. Select *Individual Loads* in Jobs (1) => 1..Job 1 in the *Model Tree*
2. Select *5 FEM Loads*
3. Press *Create*



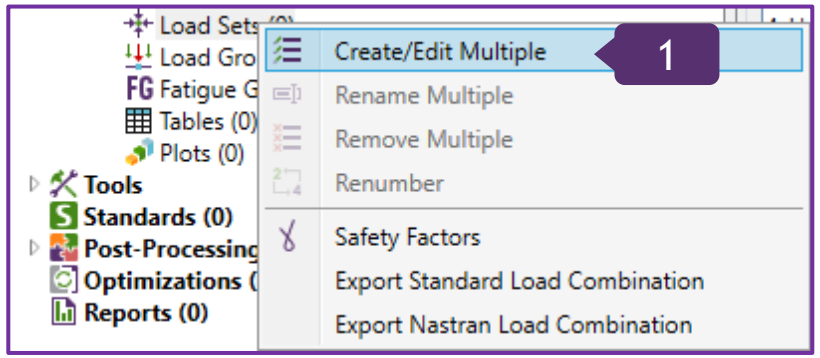
Analyze Job

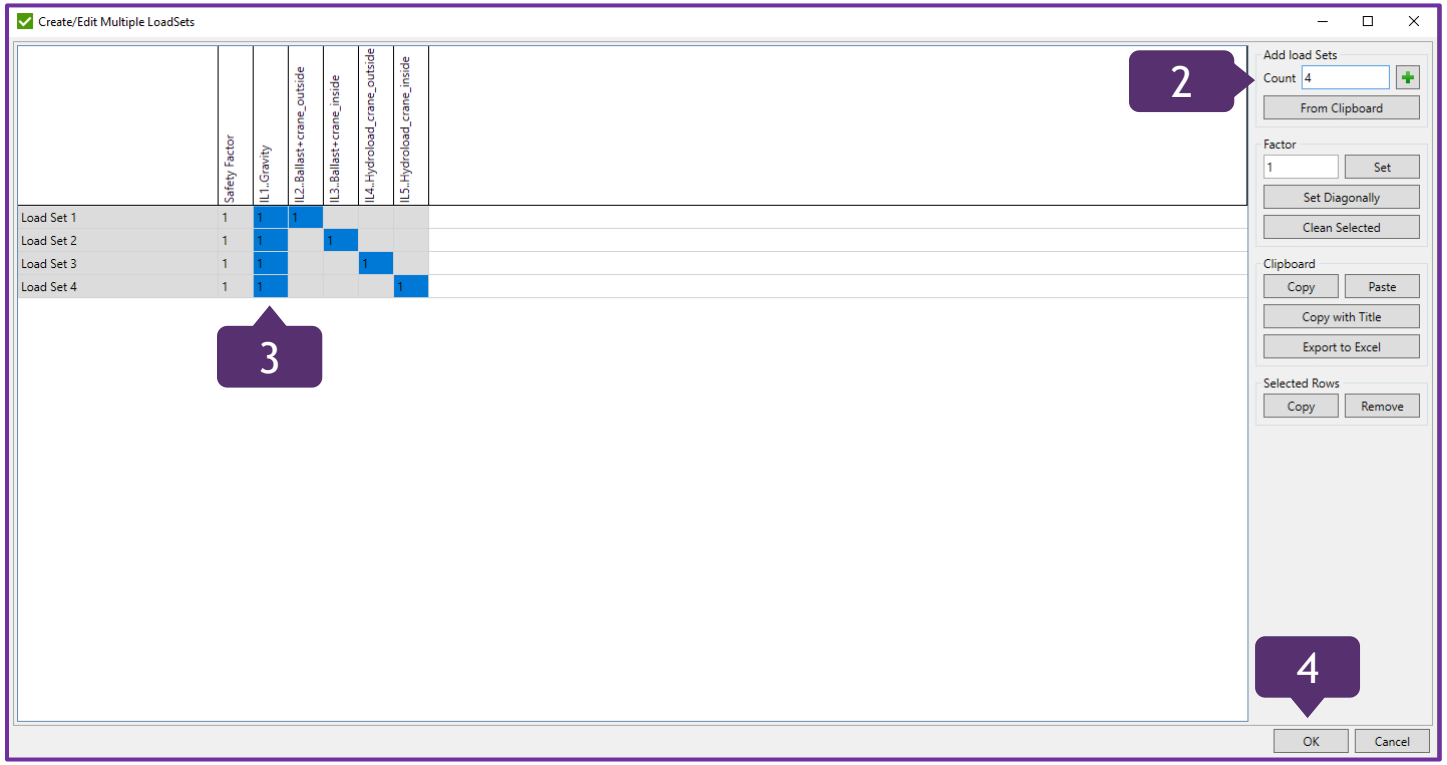
1. Go to *Home* section on the Ribbon
2. Press ▶ on the toolbar to analyze job.



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***



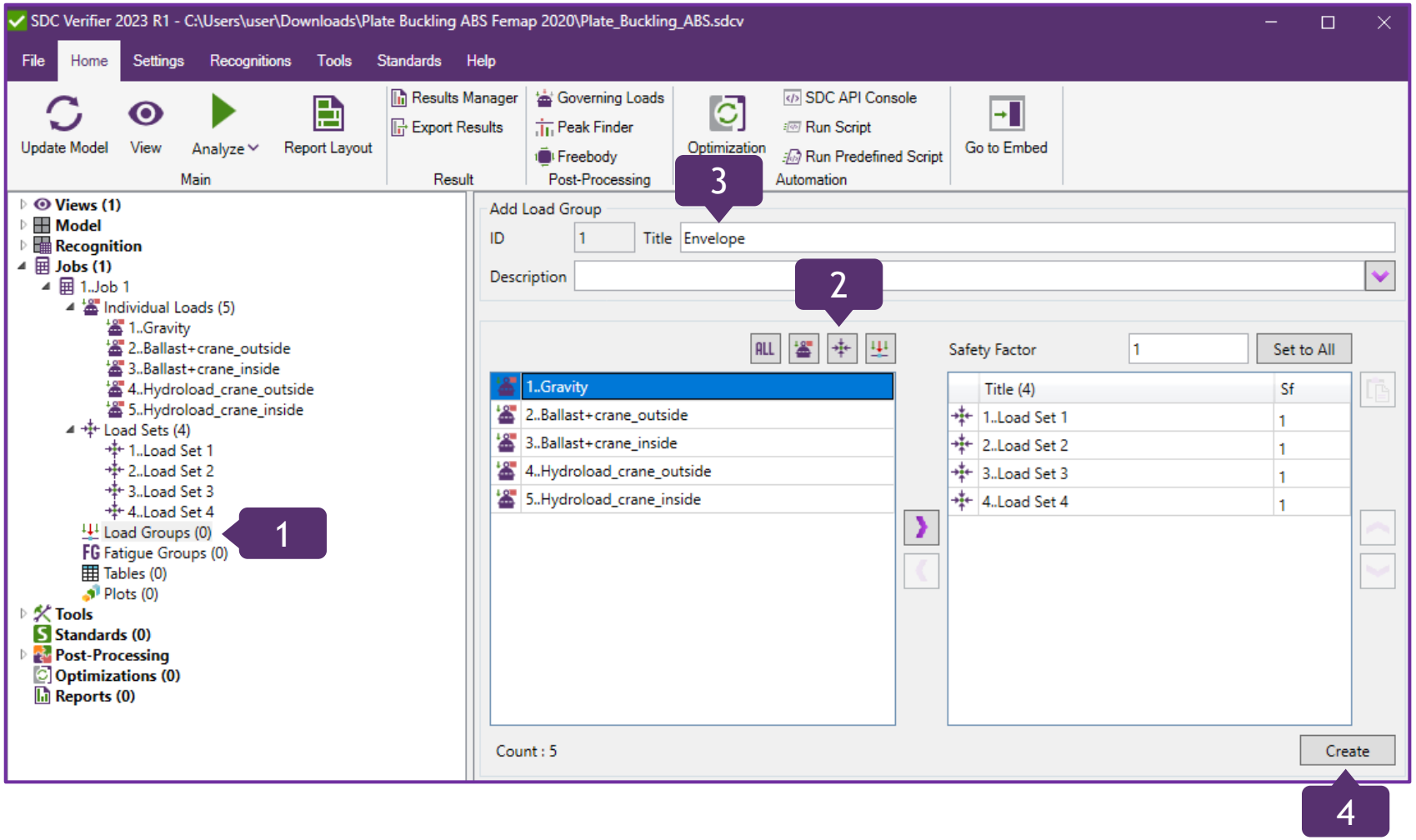


Note: Load Sets are created with default titles “Load Set #”. It is possible to rename them.

Alternatively titles and factors can be pasted from Clipboard using *Paste* button.

Load Groups

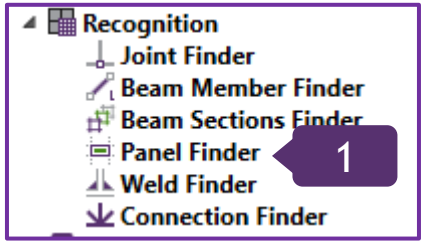
1. Click on *Load Groups (0)*
2. Press  to select *All Load Sets*
3. Title: *Envelope*
4. Press *Create*

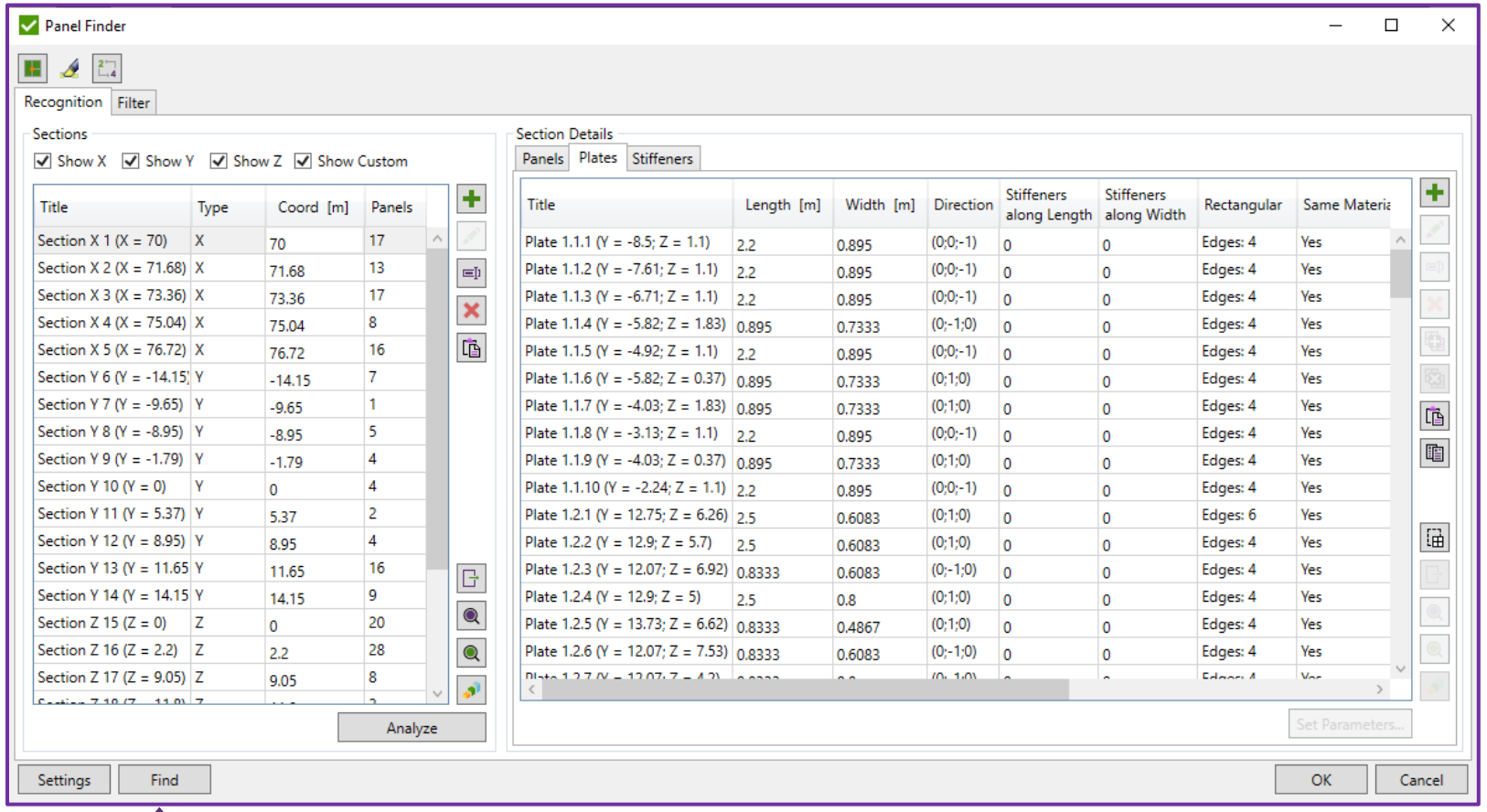


Note: Load Sets and Load Groups are analyzed by SDC Verifier.

Panel Finder. To recognize Sections.

1. Execute *Recognition - Panel Finder* from the Model Tree
2. Click on *Find*



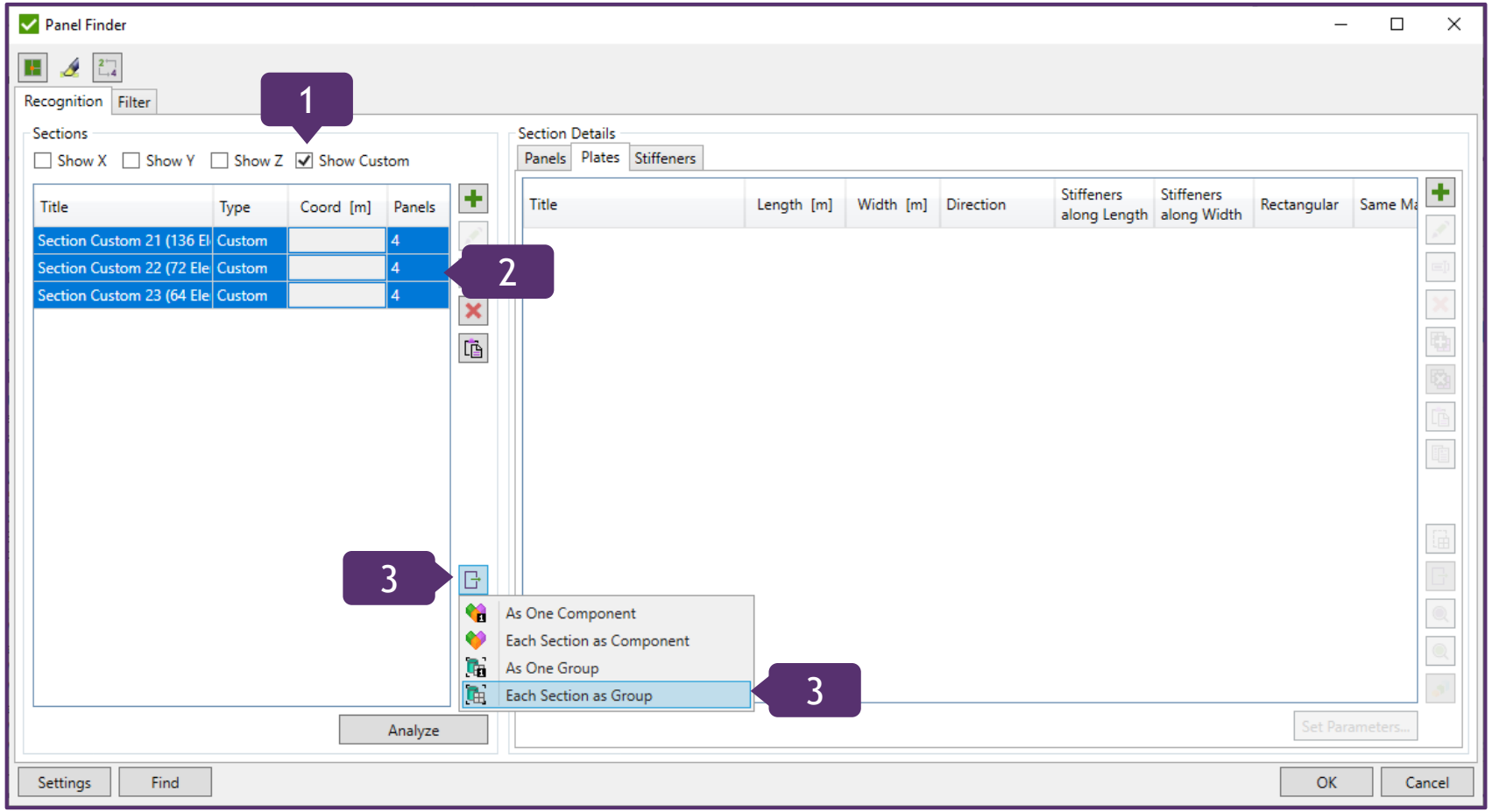


All Frames, Longitudinals and Desks are recognized automatically.

Panel Finder. Custom Section

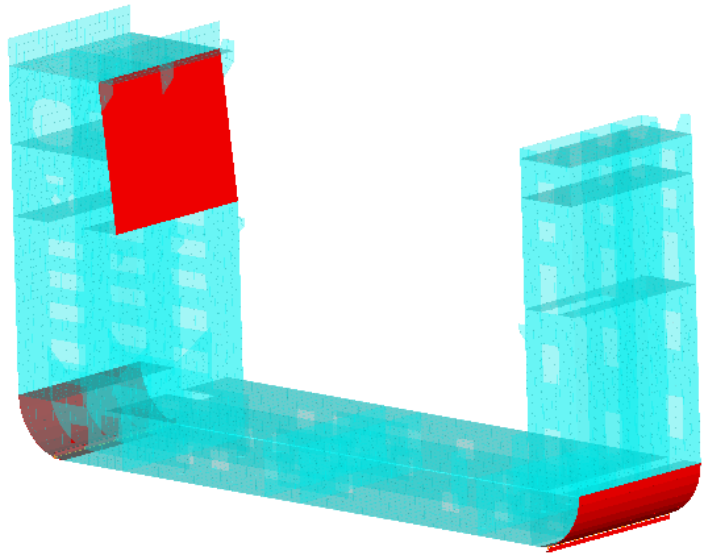
Custom Section should be used for inclined/curved sections and selections like hull.

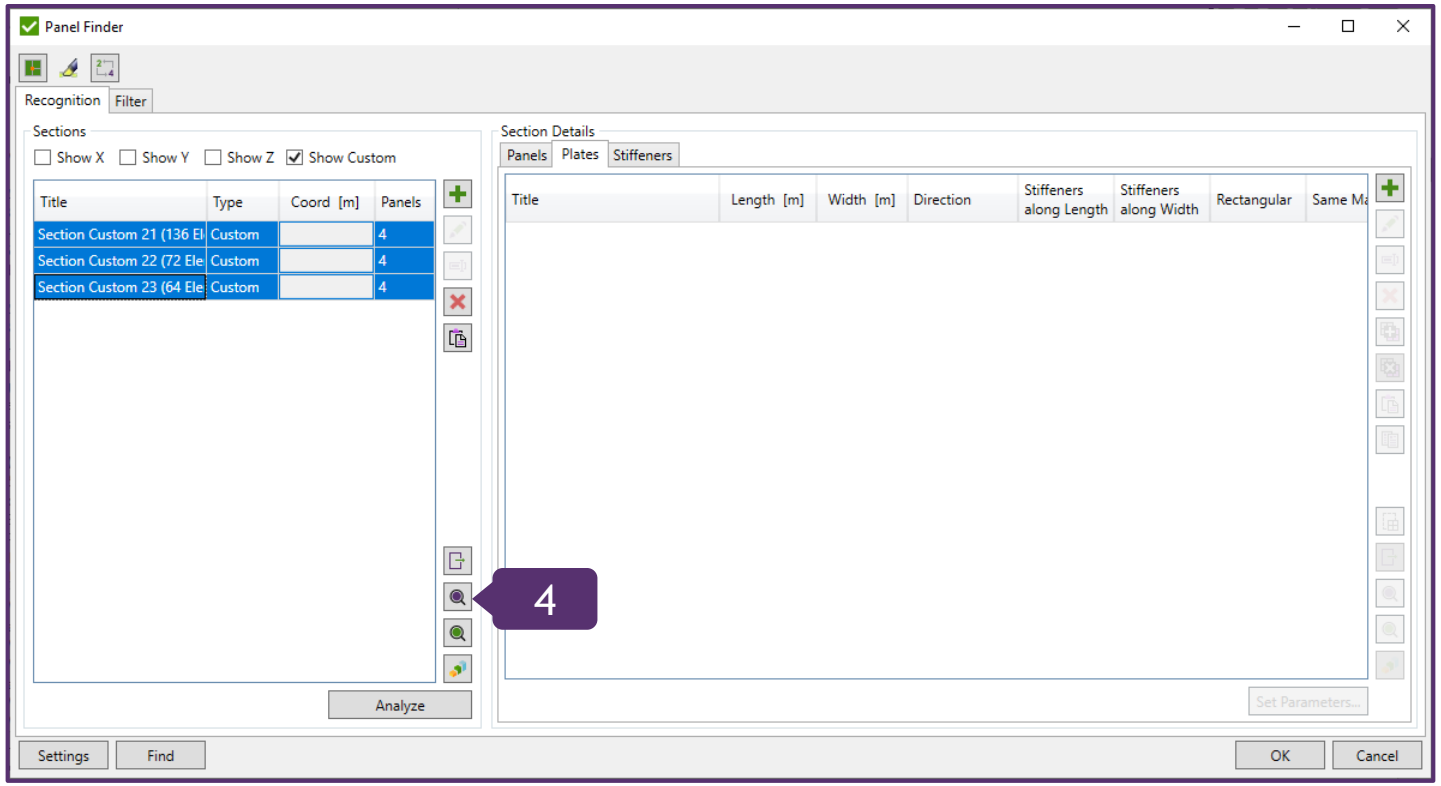
1. **Show Custom: *ON* (the rest are OFF)**
2. **Select all Sections in the list**
3. **Press**  **and**  **to export selected sections to groups**

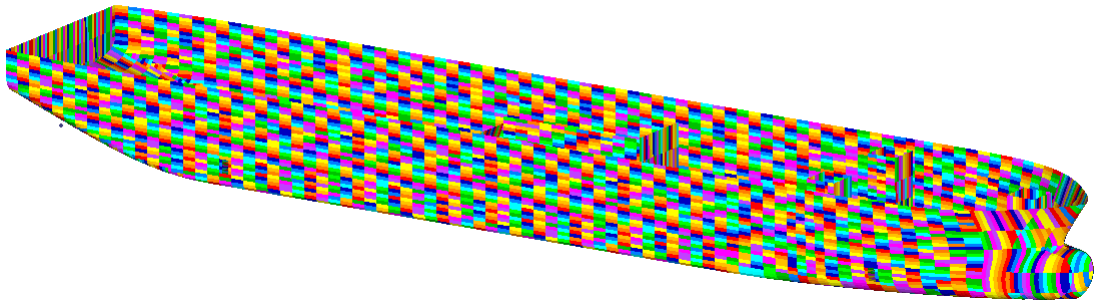


Panel Finder. Custom Section (Continuation)

4 Press 





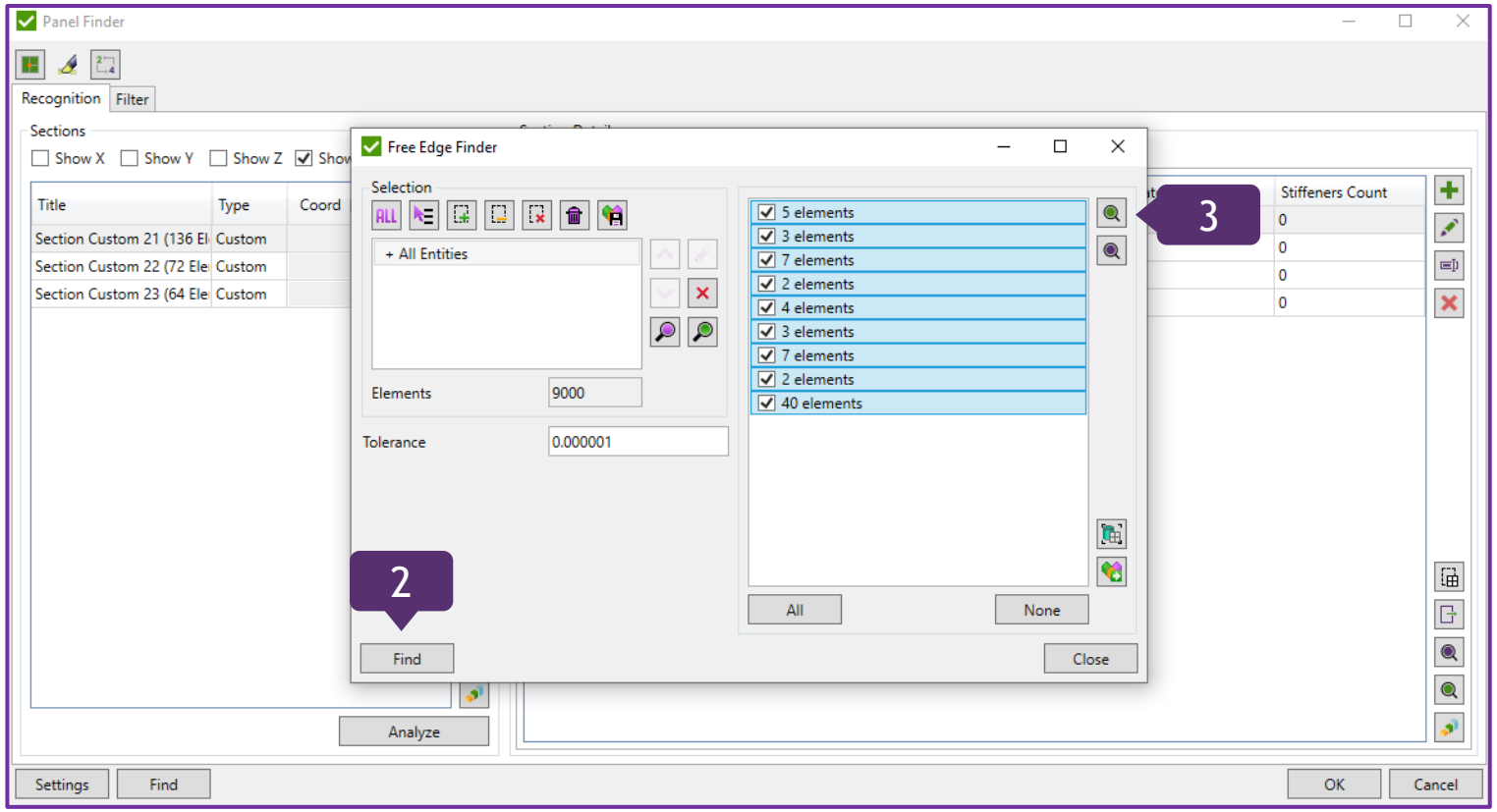


Example: It is possible to create custom section, based on hull selection:

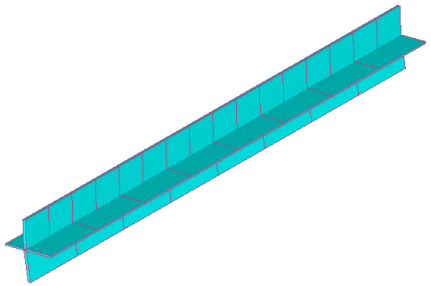
Panel Finder. To find Free Edges

Note: Before plates recognition, the model should be checked on free edges. Incorrect plate dimensions/direction, plates with undefined dimensions and, as result, wrong buckling factor may result in possible consequences of free edges.

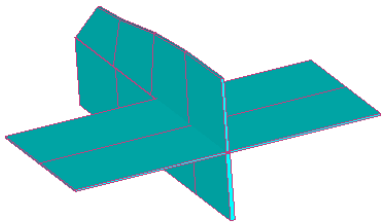
1. **Click**  **to detect Free edges**
2. **Press *Find***
3. **Press**  **to preview elements with free edges**



Two elements, connected to one



Mesh does not coincide

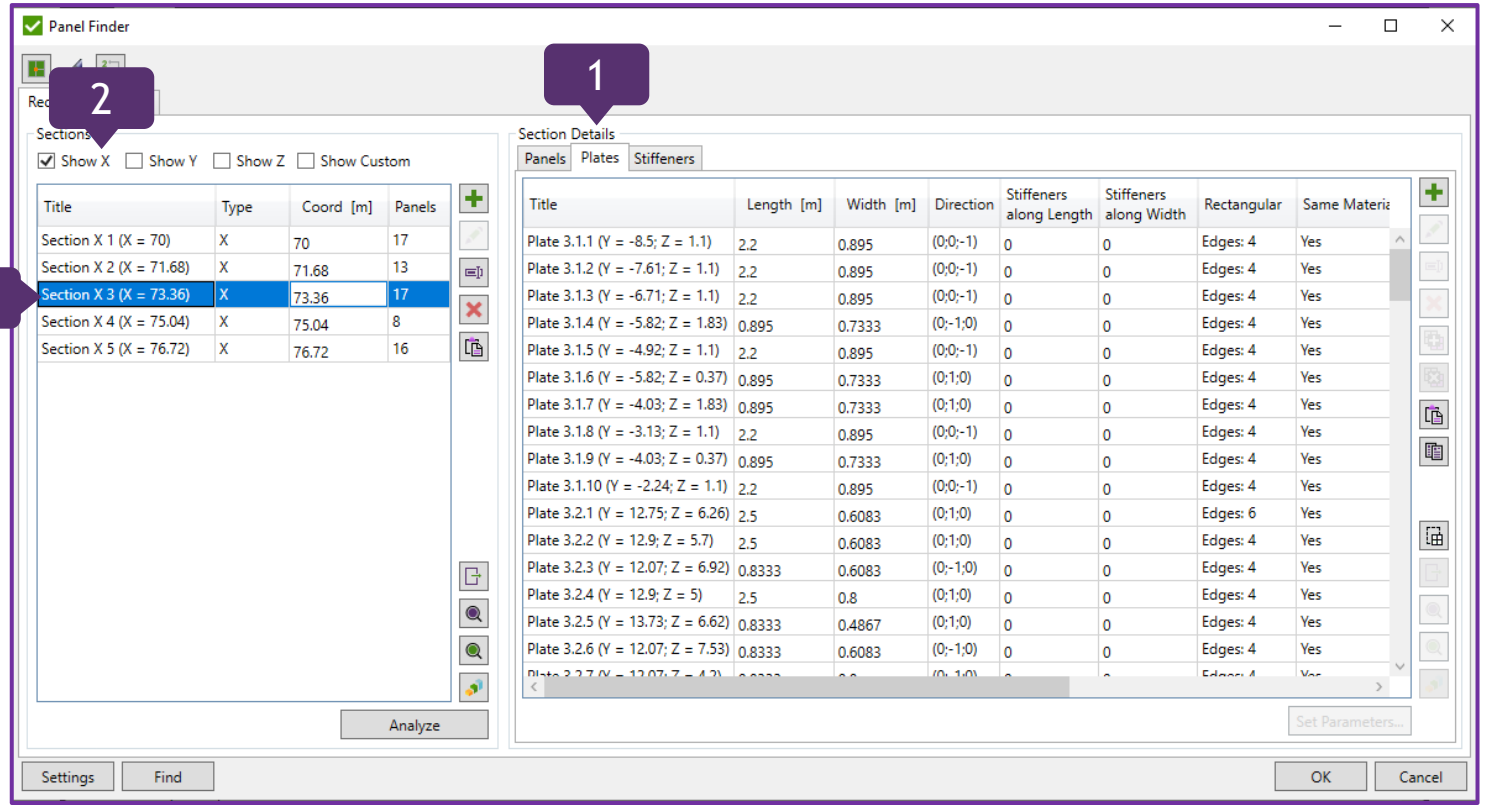


Note: Free edges should be fixed by remeshing the model and run recognition of plates. (In tutorial we skipped the step with remeshing, but for commercial project, it is a crucial step to do).

Panel Finder. To recognize plates

1. In Selection Details press *Plates*
2. Show X: *ON* (the rest is OFF)
3. 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]	Rela
Plate 3.2.13 (Y = 12.9; Z = 8.75)	2.5	0.6083	(0;1;0)	0	0	Edges: 4	Yes	0.012	Pane
Plate 3.2.14 (Y = 12.9; Z = 2.39)	2.5	1.5333	(0;1;0)	0	0	Edges: 8	Yes	Min = 0.016	Pane

Section ID. Panel ID. Plate ID

Plate is rectangle with all corners = 90°

Plate has elements more than from one property

Plate Dimensions and Thicknesses

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

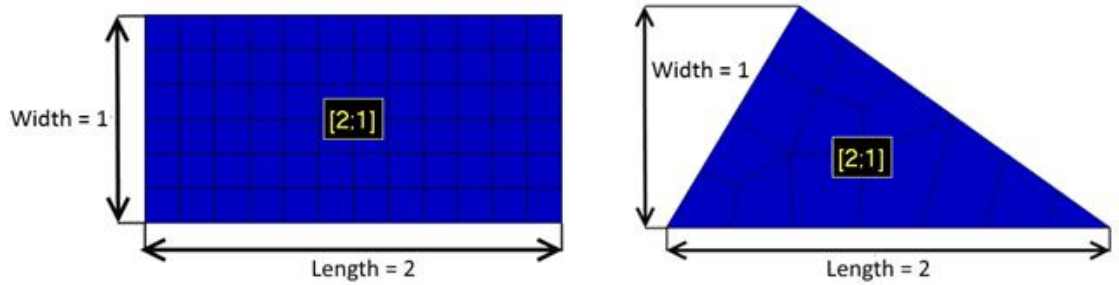


Plate Thickness: Calculations are performed on every element, and thickness is taken directly from each element. It is possible to set thickness manually for plate. In this case, element thickness will be ignored and user defined thickness will be used.
Example: a plate with 2 properties 0.01 and 0.02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

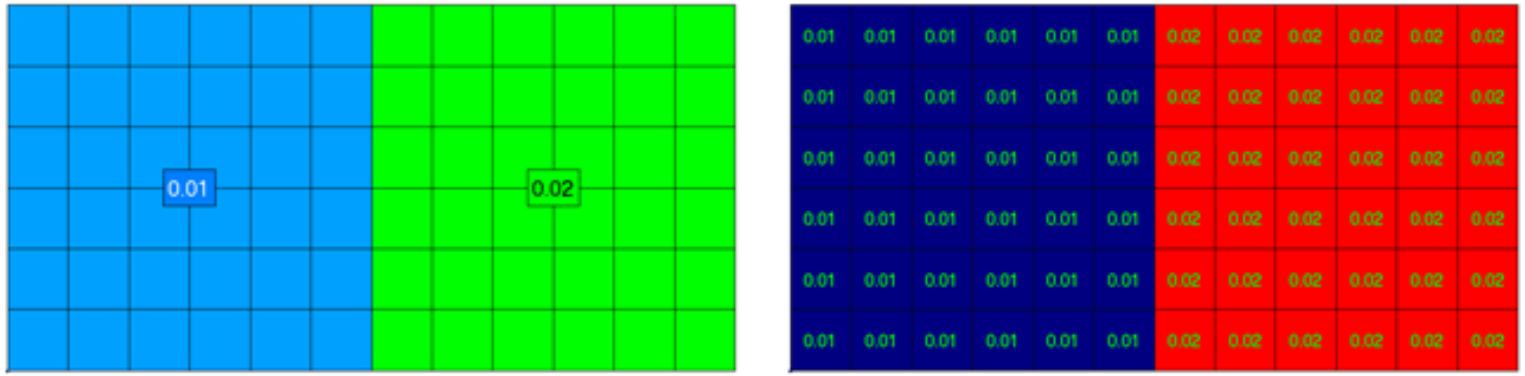


Plate Buckling Dimensions by CSR

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:

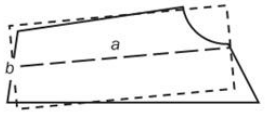
e) The length of shorter side, b in mm, is to be taken as:

$b = A/a$

where:

A : Area of the plate, in mm^2

a : length defined in (d), in mm

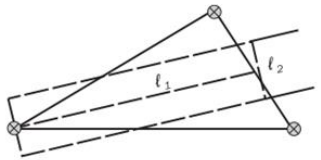


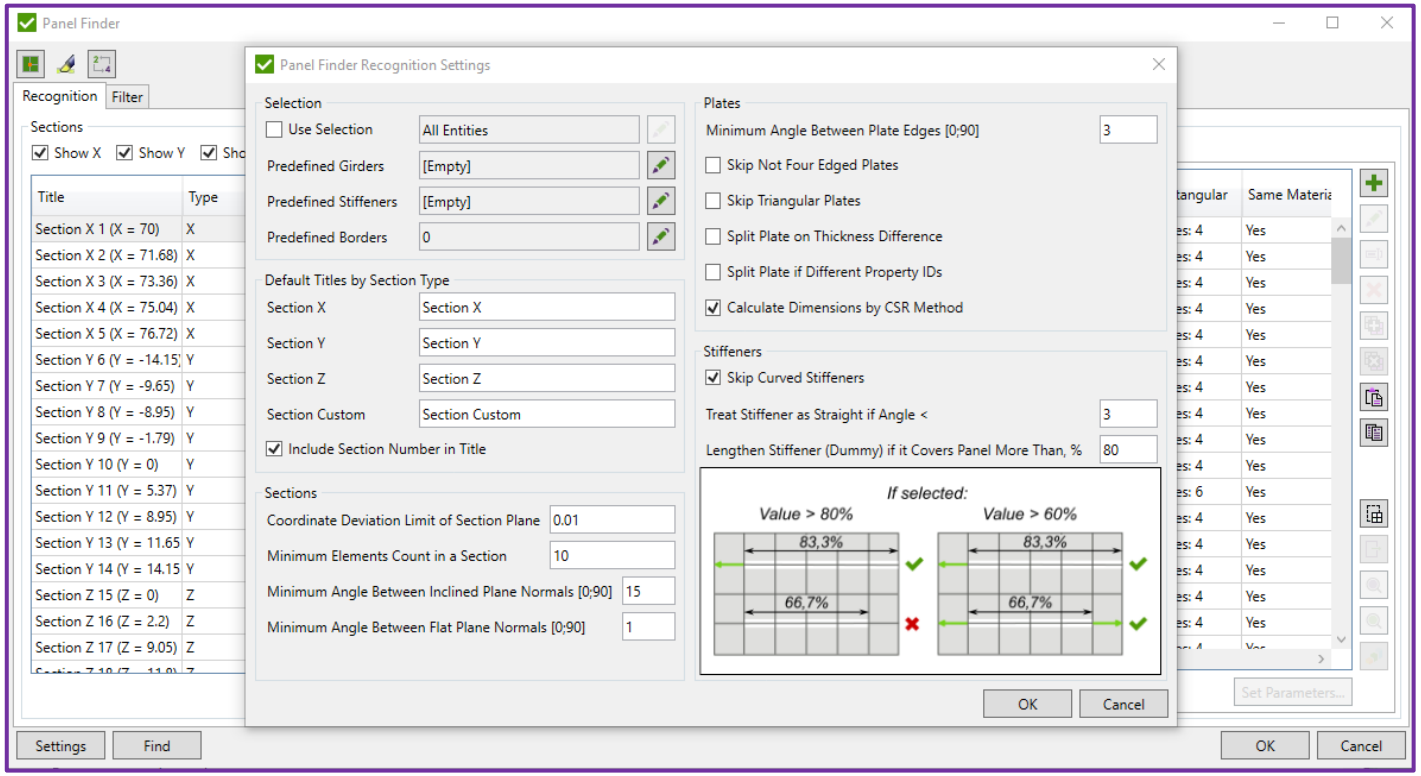
c) The width of the model, ℓ_2, in mm, is to be taken as:

$\ell_2 = A/\ell_1$

where:

A : Area of the plate, in mm^2





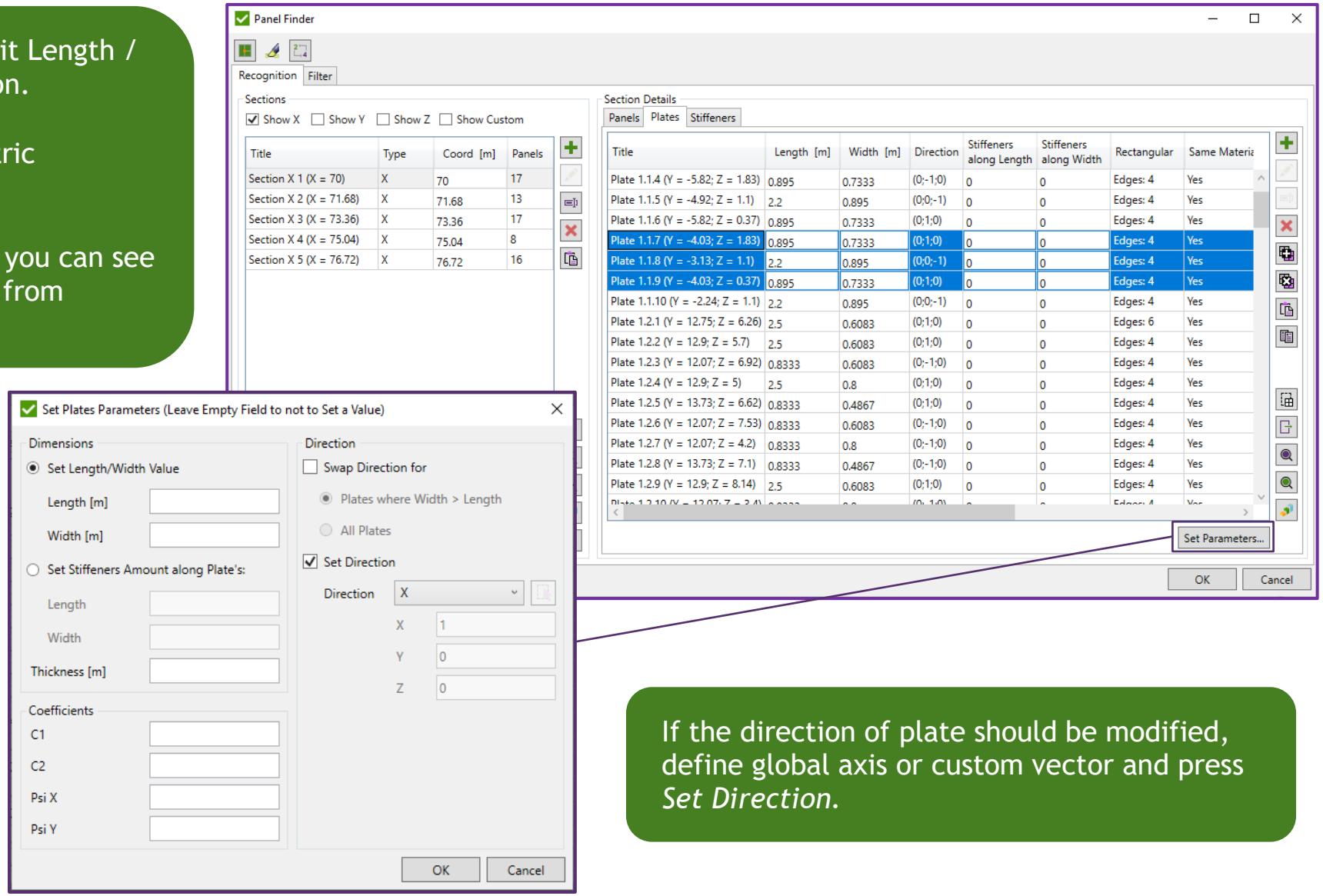
Editing plates manually

When modifying plates, it is possible to edit Length / Width / Thickness / Coefficients / Direction.

Also, there is possibility to define parametric stiffeners along the Length and Width.

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

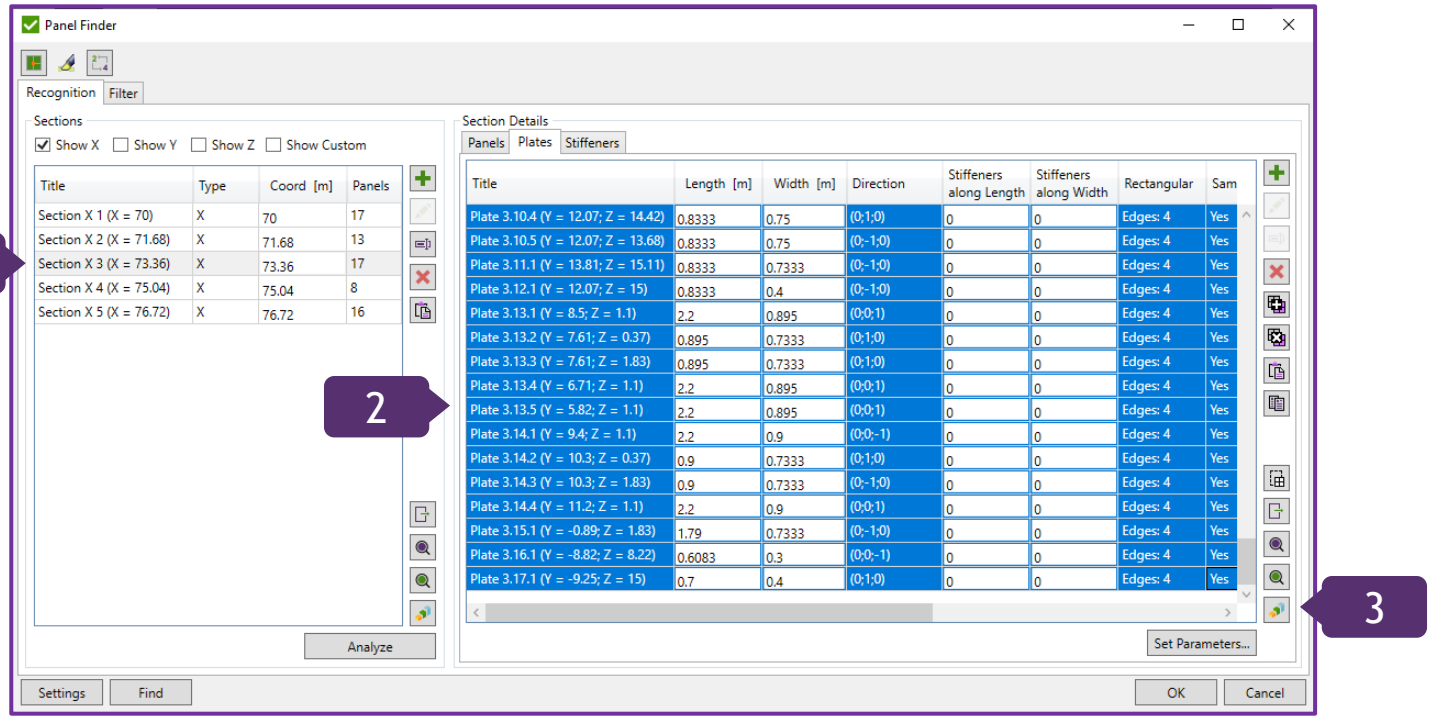
Thickness [m]
0.016
0.016
0.016
0.016
0.016 (Original: 0.012)
0.016 (Original: 0.012)
0.016 (Original: 0.012)



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

Panel Finder. Plates Plot

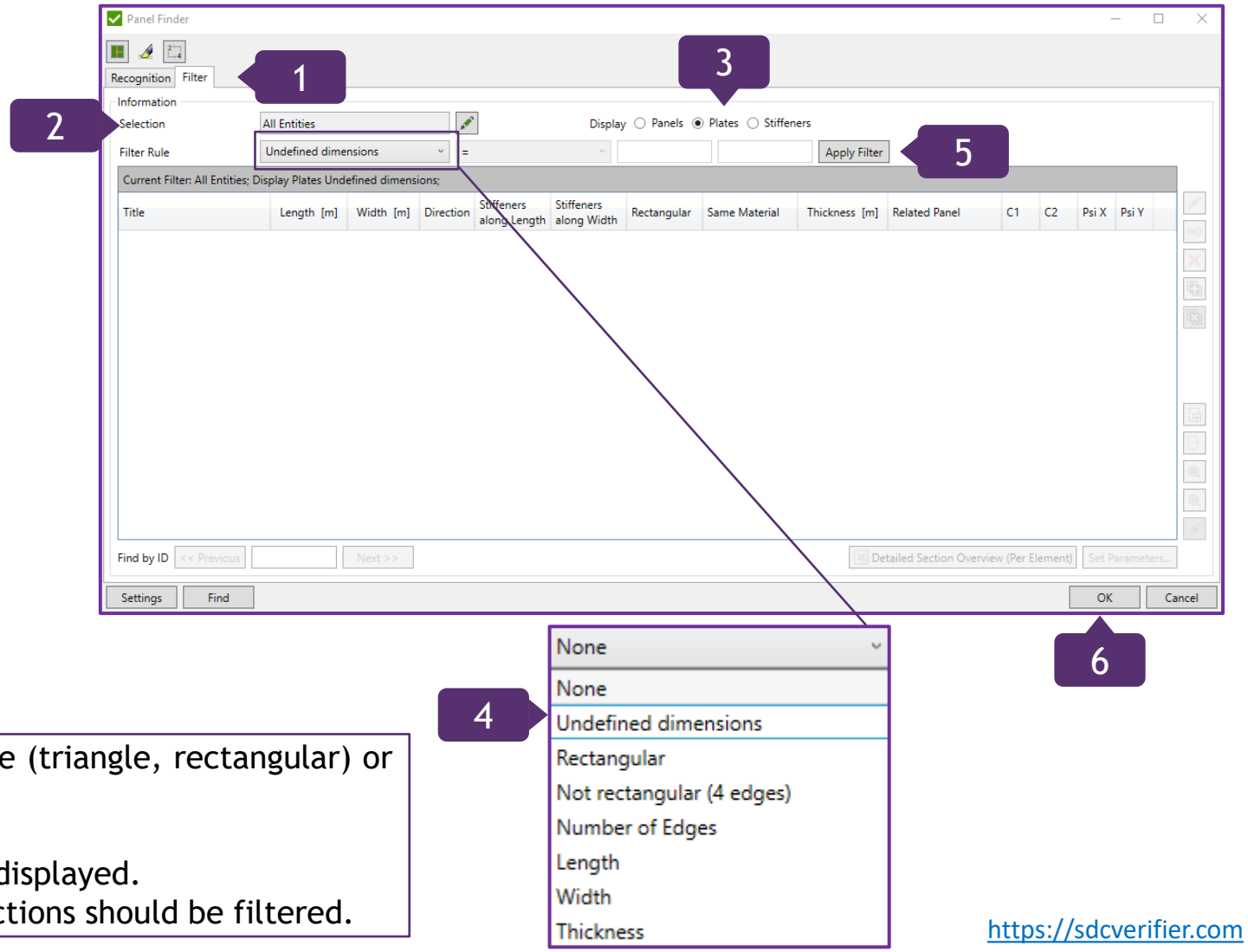
1. Select *Section X3*
2. Select *All Plates*
3. Press 
4. Click on *Colors + Labels of Ids*



Panel Finder. Filter

Note: It is very important to check if all plates dimensions were recognized. If in the model there are coincidental nodes, elements or free edges, Panel Finder will not be able to recognize plate dimensions.

1. **Click on *Filter* tab**
2. **Selection: *All Entities***
3. **Display: *Plates***
4. **Filter Rule: *Undefined dimensions***
5. **Press *Apply Filter***
6. **Empty table with plates means that there are no plates with undefined dimensions. Press *OK***

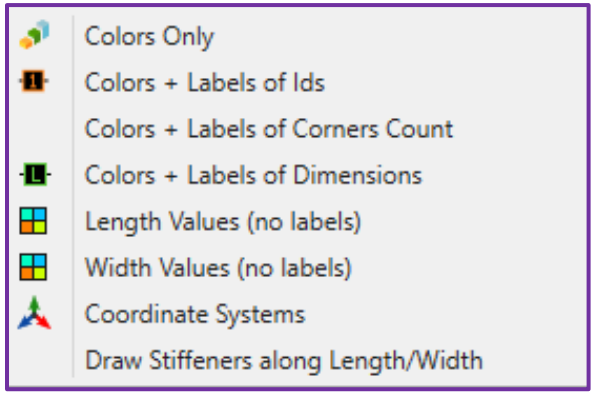


Tip: It is also possible to filter plates by shape (triangle, rectangular) or number of edges parameters.

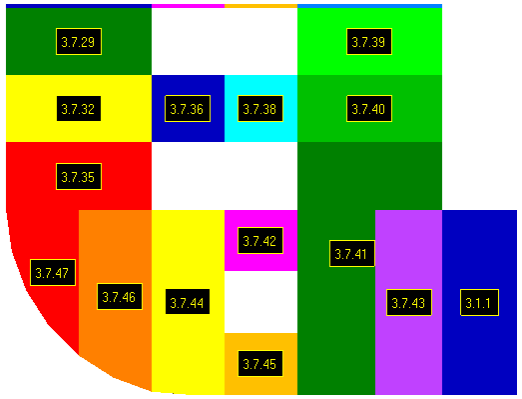
E.g. Plates with numbers of edges > 4 can be displayed.
Control, using Selection plates from which Sections should be filtered.

Panel Finder. Plot Options

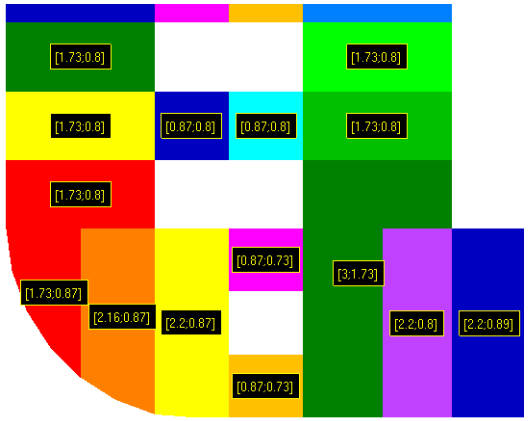
Note: Plate Plot can be displayed with different colors labels (labels of ids, labels of corners count or labels of dimensions). Also, it is possible to show plates in length and width, coordinate systems etc.



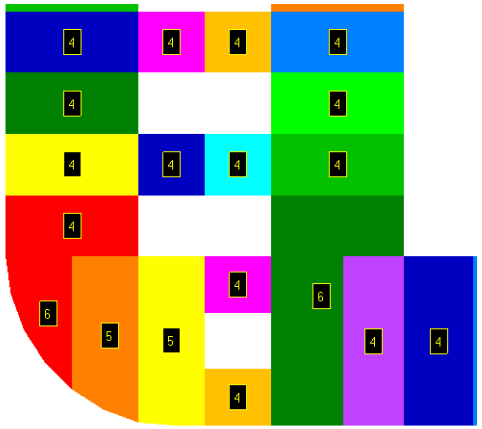
Labels of Ids



Labels of dimensions

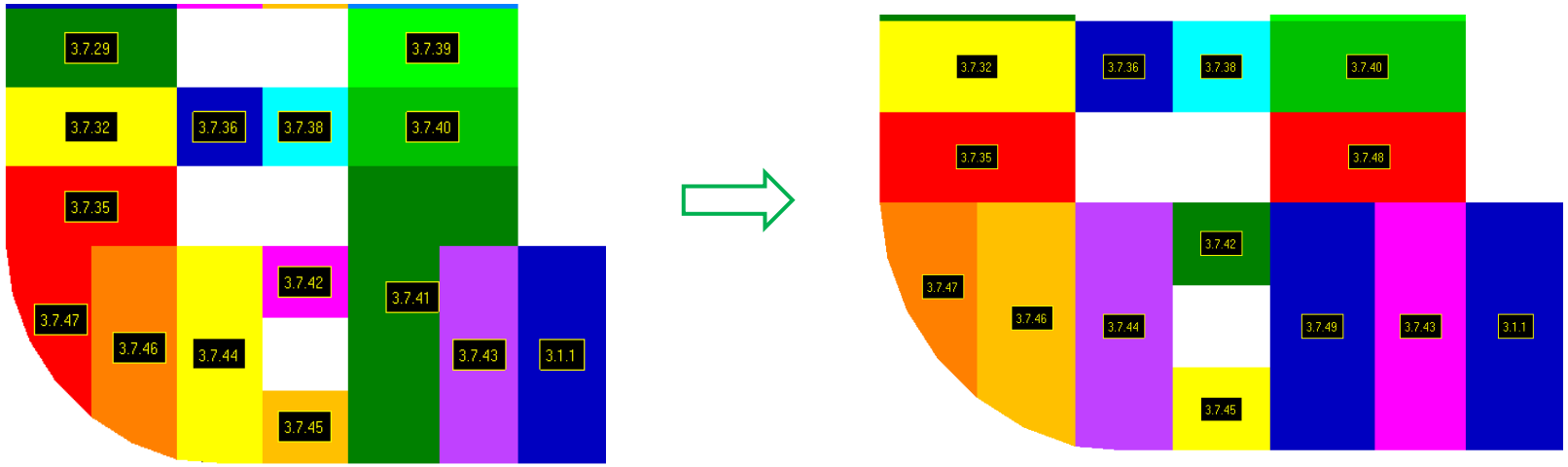


Labels of Corners Count



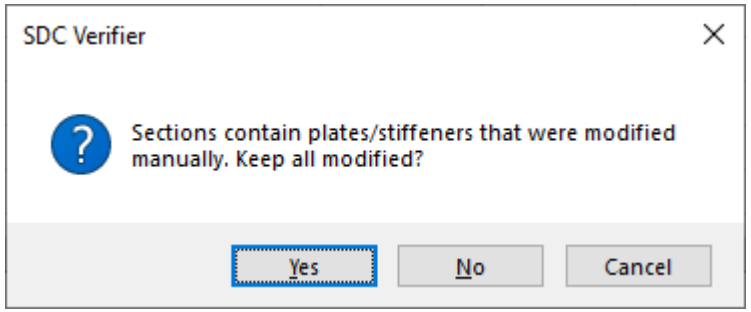
Panel Finder. To update Plates

In some cases (e.g. stiffener is not modeled), when a plate is recognized incorrectly, dimensions are bigger than in reality. Consequently, it leads to wrong results. A plate has to be updated manually. In Section X3 plate with Id = 3.7.41 should be split in two plates.



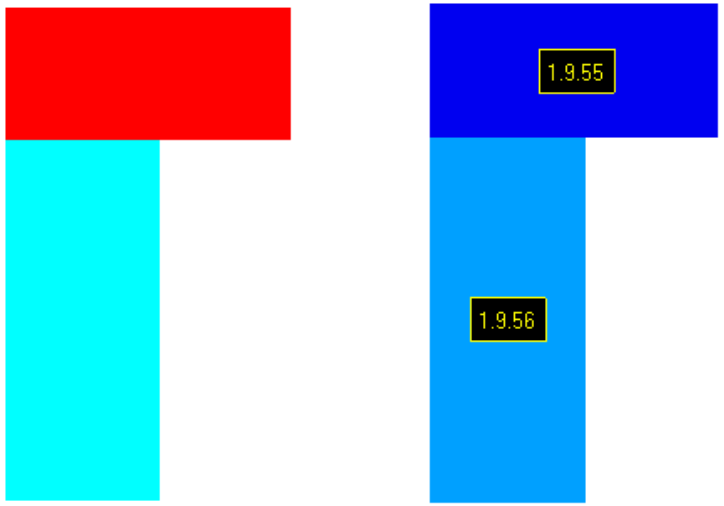
Note: if plates were modified manually, but then a user decided to run recognition of plates - Panel Finder will ask what to do with modified plates:

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



Panel Finder. To Split a Plate

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



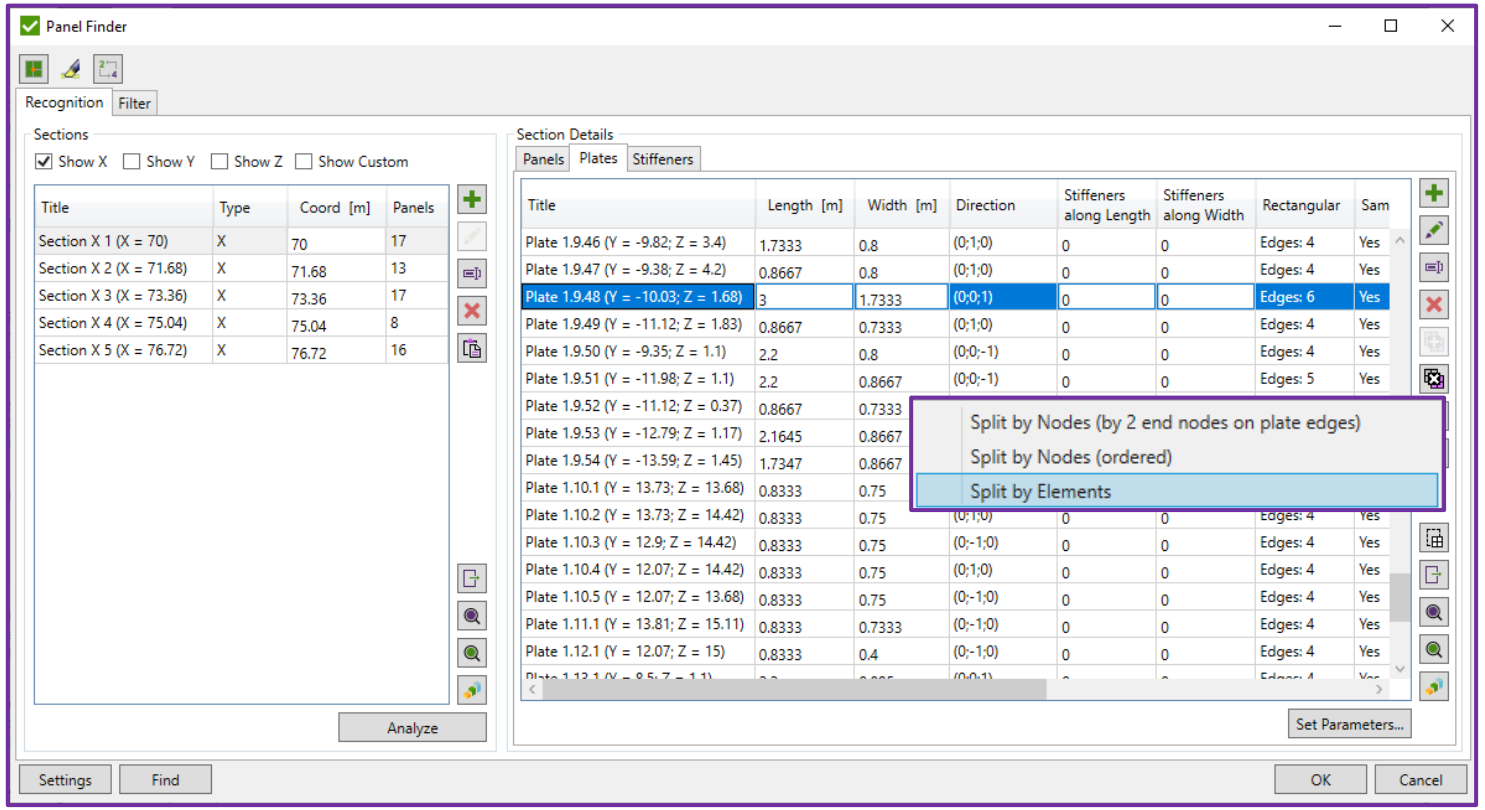
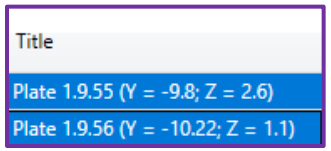
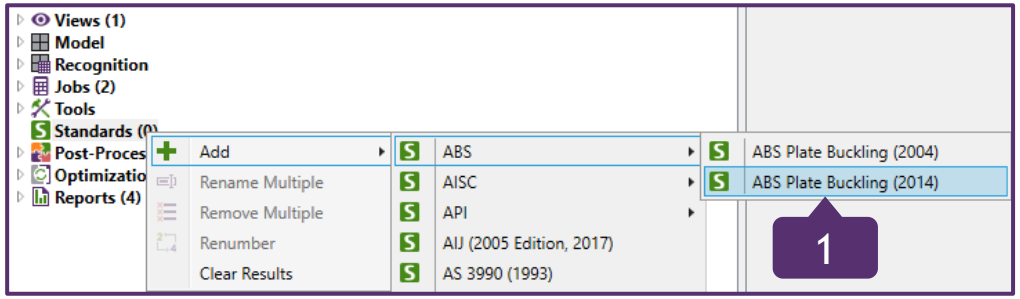


Plate 1.9.48 is replaced with Plates 1.9.55 and 1.9.56. Dimensions and directions are updated automatically.



To Add Plate Buckling ABS 2014 Standard

1. In the *Model tree* in Standards execute *Add => ABS => ABS Plate Buckling (2014)*
2. Utilization Factor (Eta) = 0.8
3. Use Plate Average Stress: On
4. Press *OK*

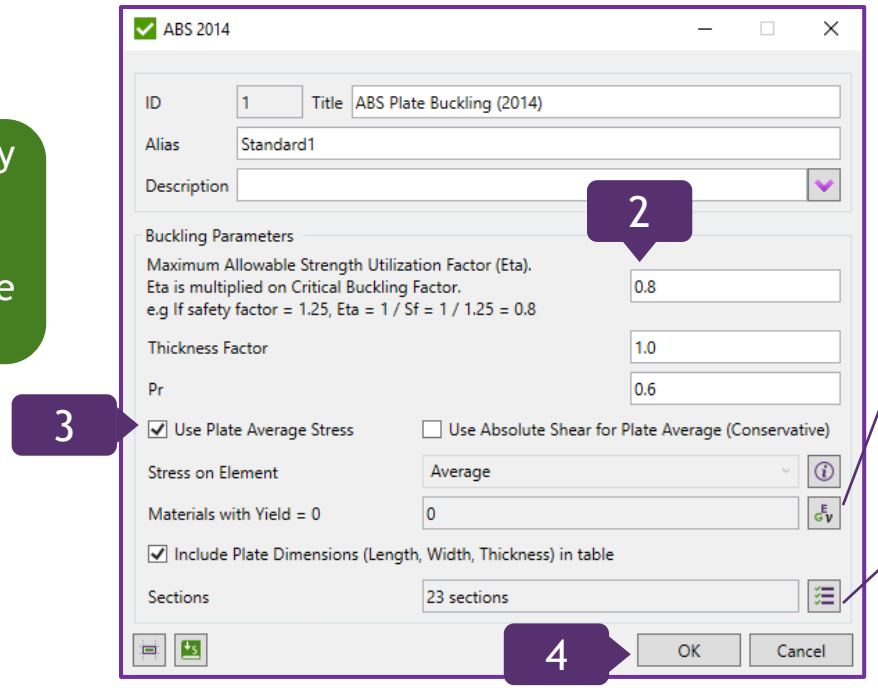


Thickness factor gives a possibility to increase / decrease all plates thicknesses without reanalyzing the model. E.g. 1.2 means to increase thickness on 20% and decrease stresses.

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

Plate Buckling transforms stresses automatically into plate direction.

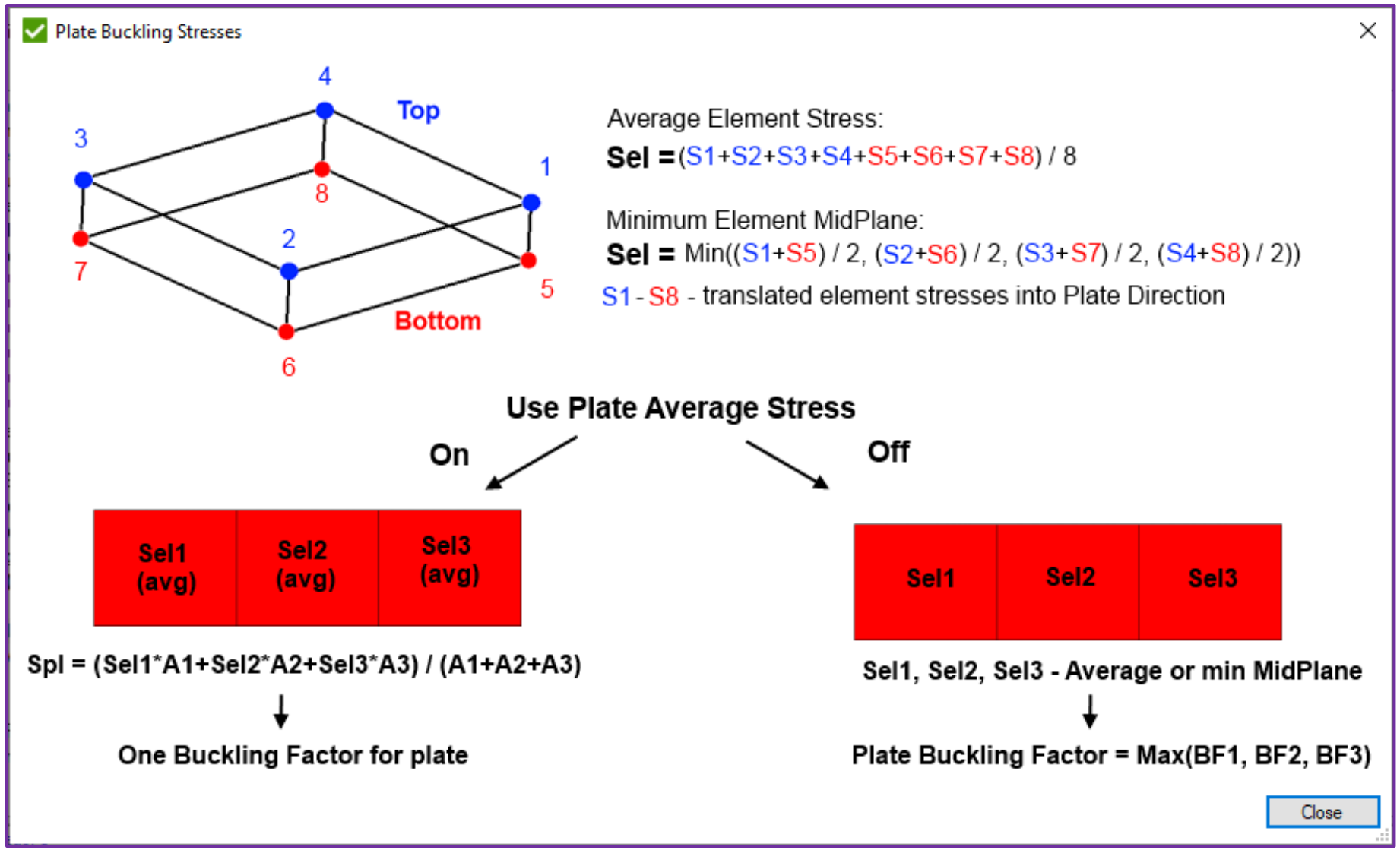
Options about element stresses and plate stresses are described in the next slide.



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 them.

Plate Buckling Stresses



Views

1. **Execute Views => Add**
2. **Orient model in Femap as shown on picture (ZY plane)**
3. **Title: *Frames***
4. **Press *Get***
5. **Press *OK***

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

To make relevant plots, in the first place Views should be created (a set of settings of how to display a plot).

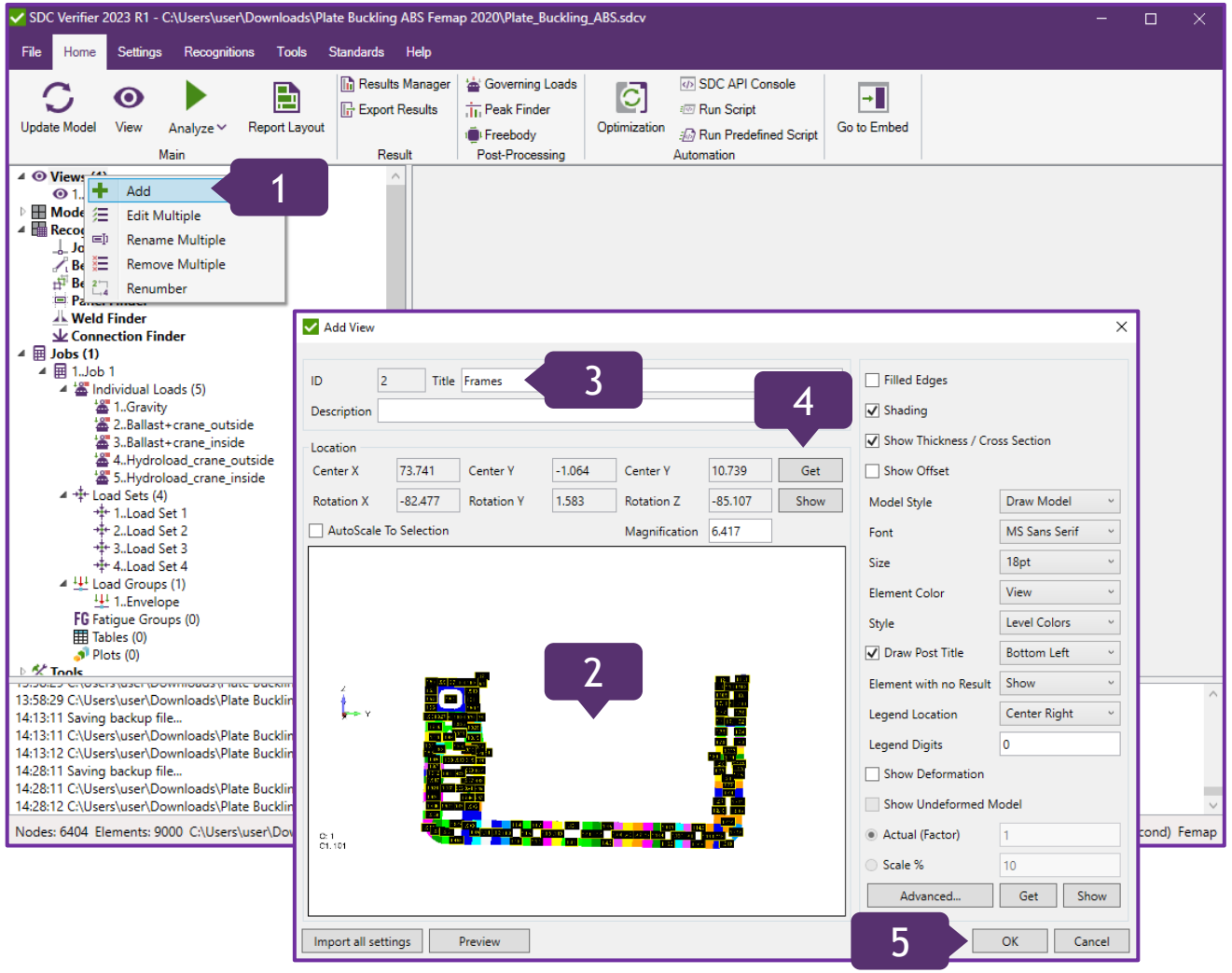
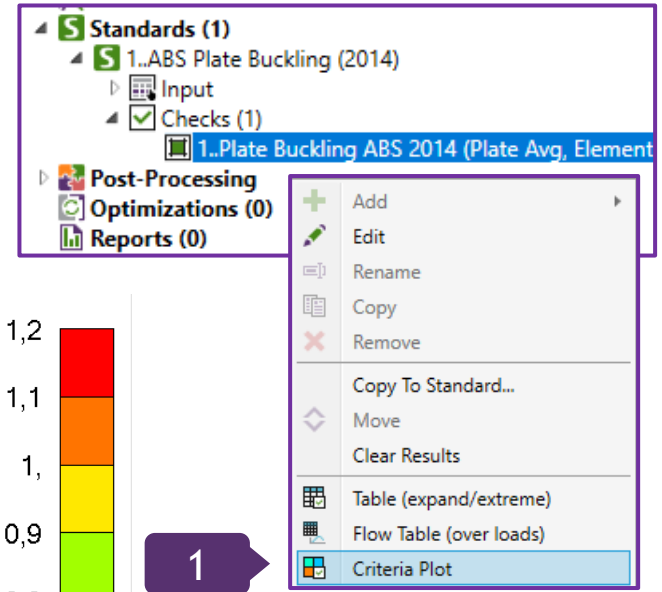
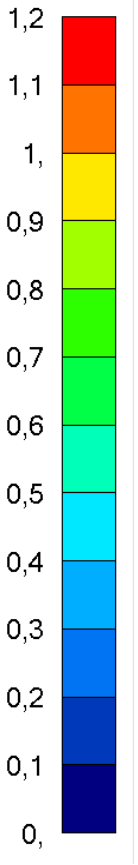
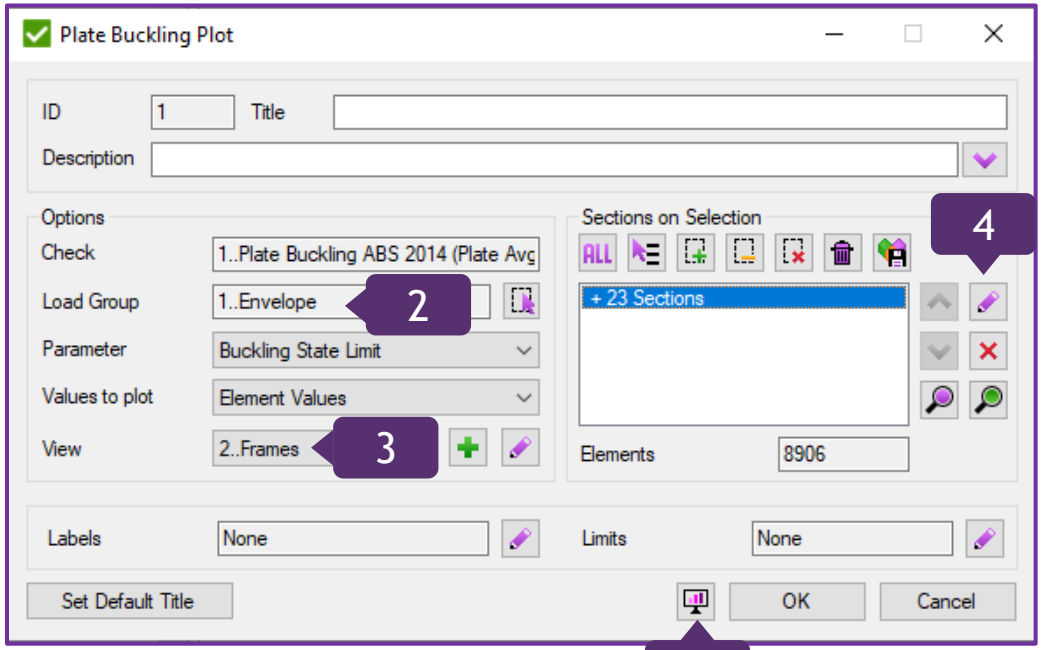


Plate Buckling Plot

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







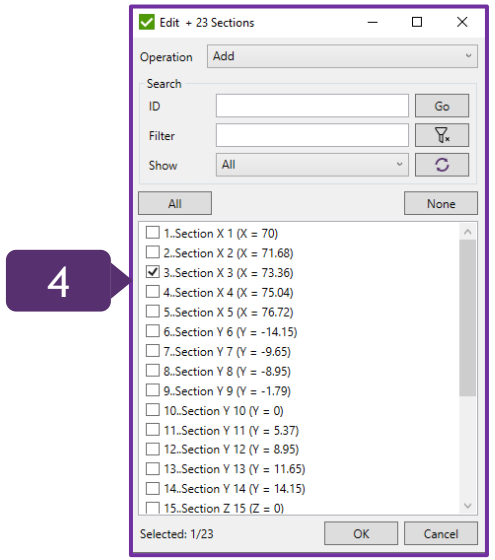
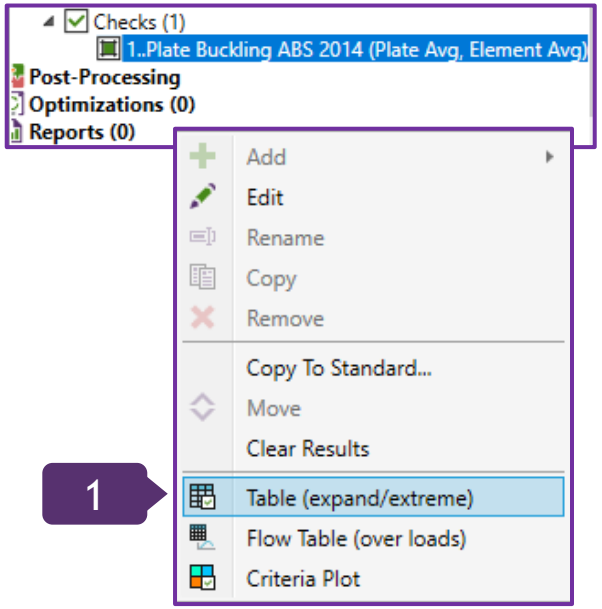


Plate Buckling Table

1. Execute *Table(expand/extreme)* from Plate Buckling ABS 2014 context menu
2. Show plates results: *OFF*
3. Select Load =>Load Group: *1..Envelop*
4. Press *OK* and *Fill Table*



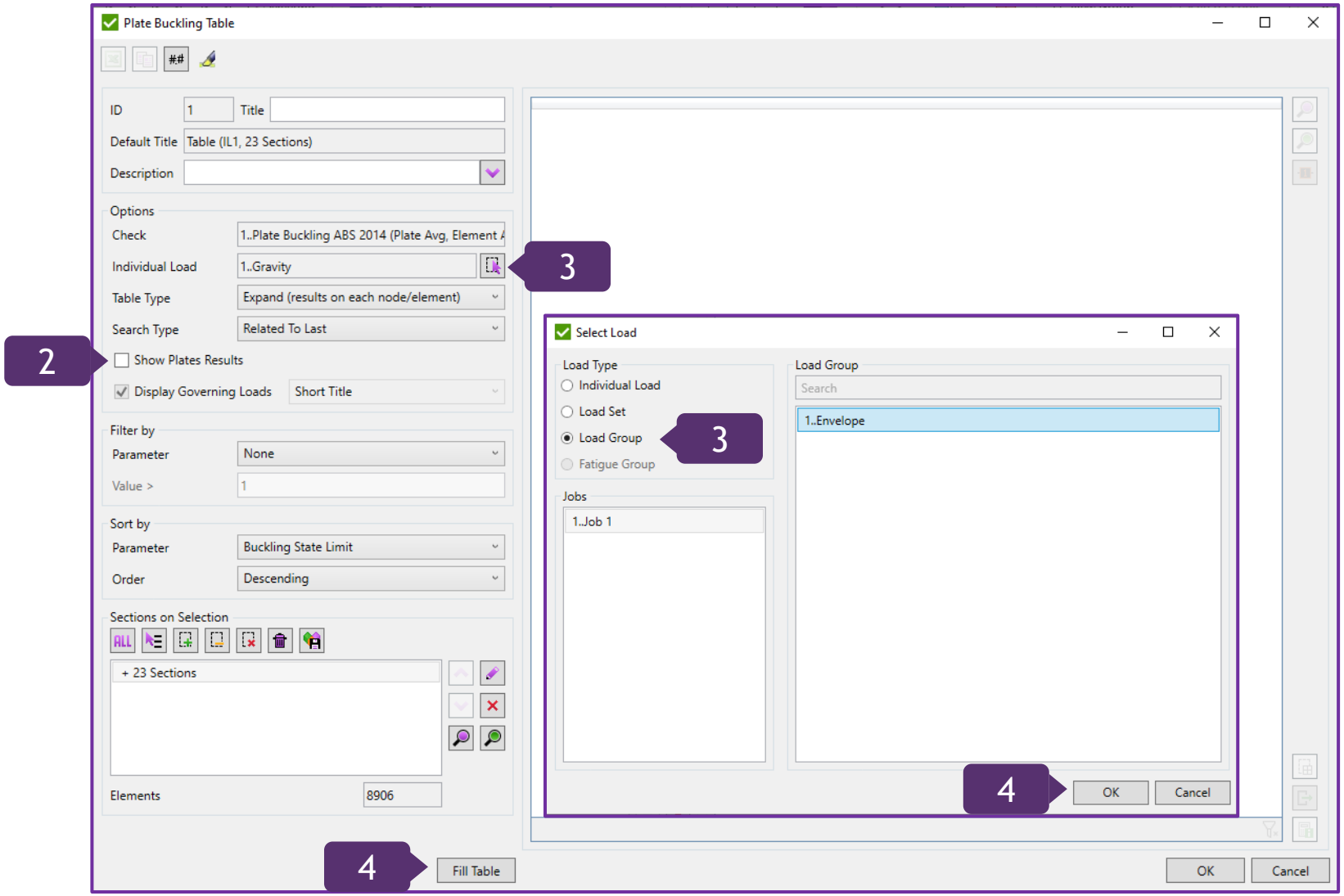
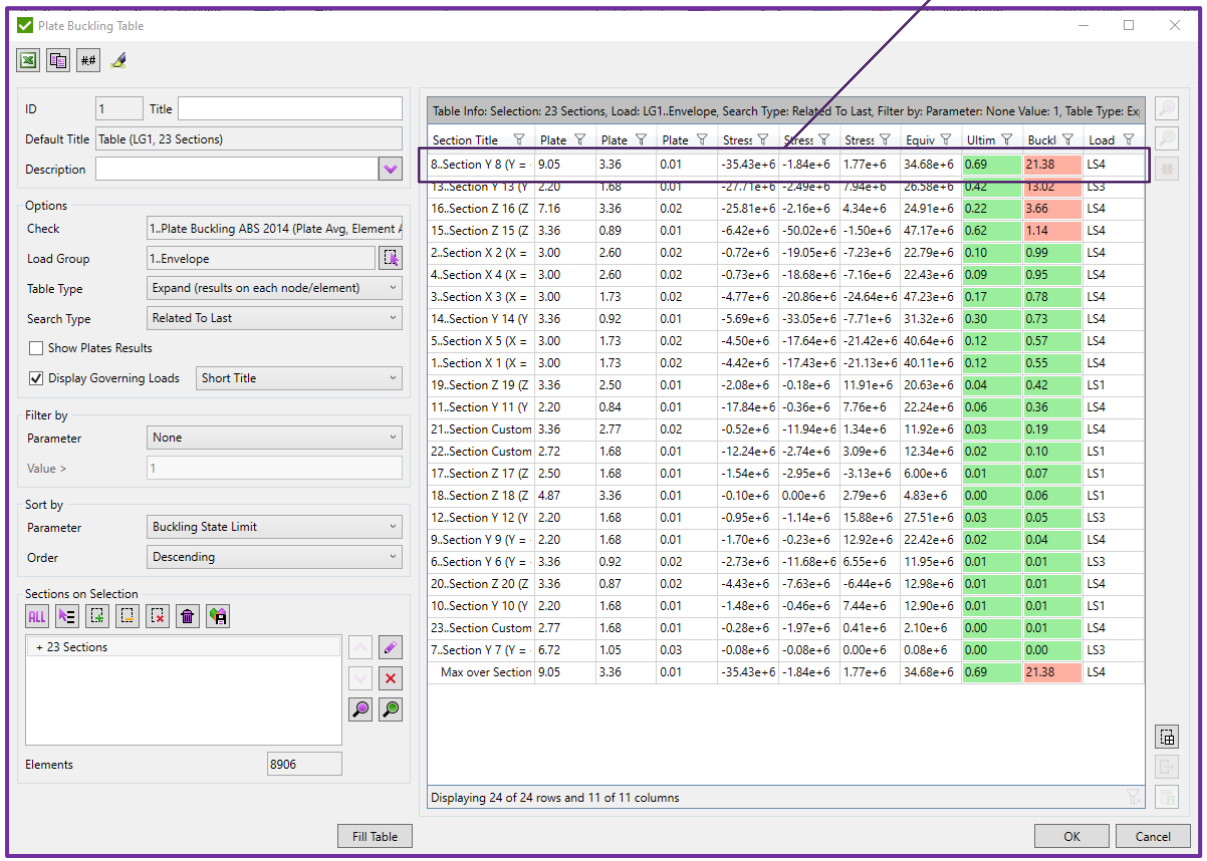


Plate Buckling Table (Continuation)

Section Title	Plate	Plate	Plate	Stress	Stress	Stress	Equiv	Ultim	Buckl	Load
8..Section Y 8 (Y =	9.05	3.36	0.01	-35.43e+6	-1.84e+6	1.77e+6	34.68e+6	0.69	21.38	LS4

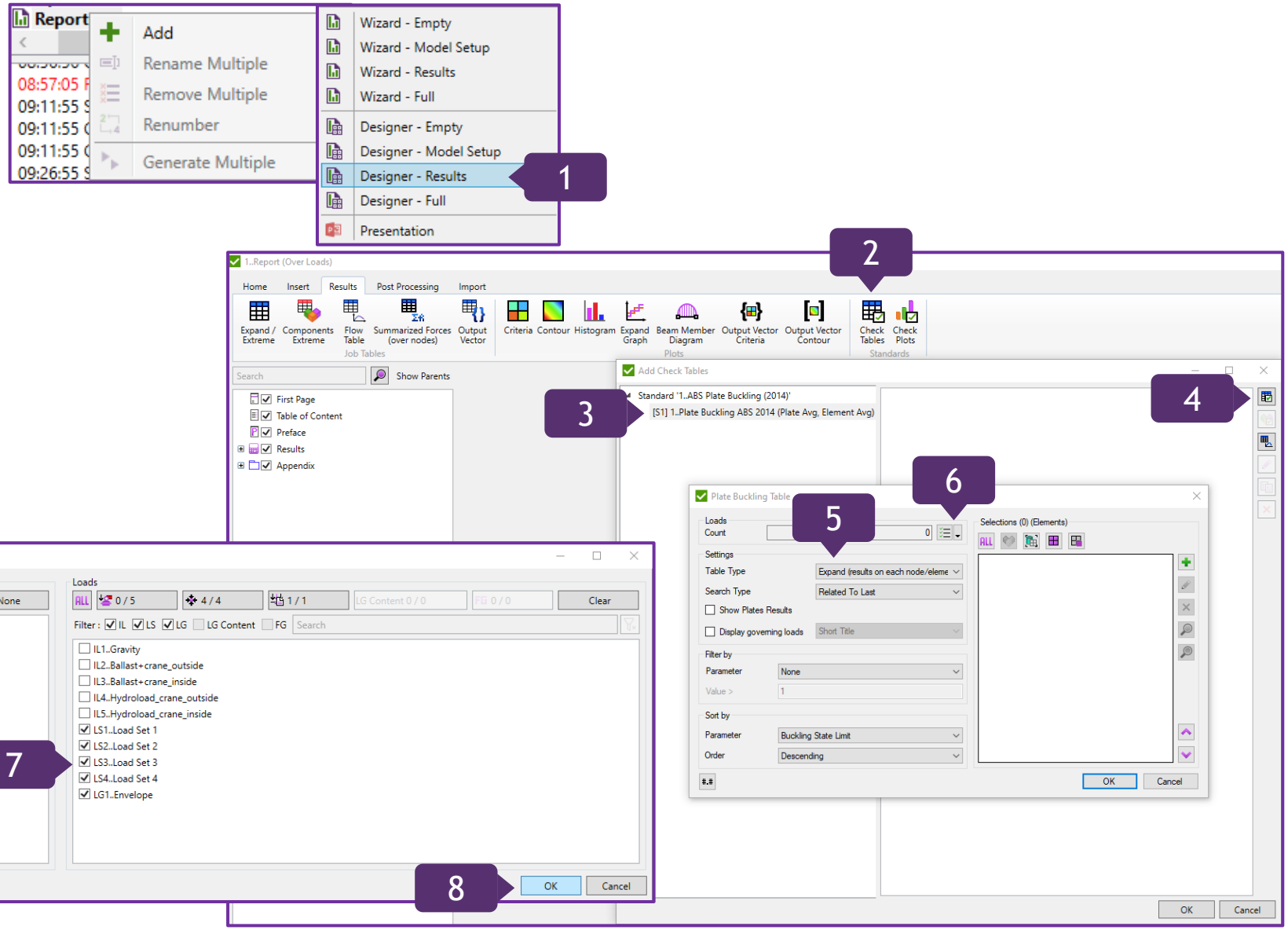


All results (dimensions, stresses) are from the plate, which causes highest BF=21.38, because Search Type = Related to Last Parameter.

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

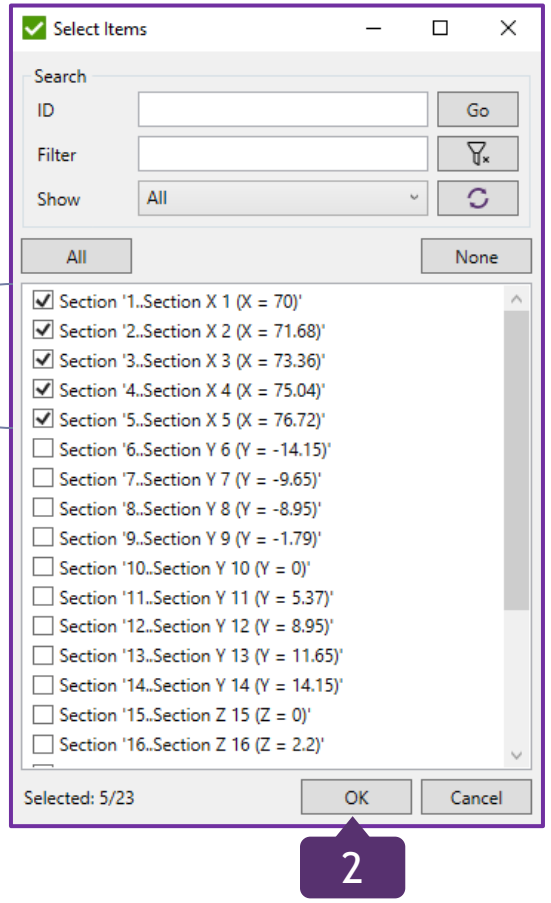
Report. Tables

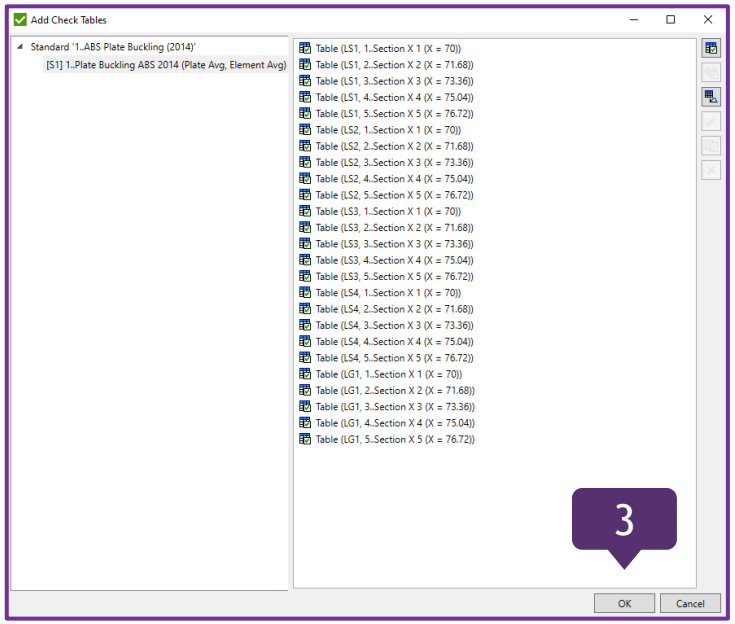
1. Execute *Reports* => *Add* => *Designer - Results*
2. In 1..Report (Over Loads) on the Ribbon, go to Results and click on Check Tables
3. Select Standard '1..ABS Plate Buckling (2014)' and activate [S1] 1..Plate Buckling ABS 2014
4. Press  button
5. Table Type: *Expand*
6. Press  to select loads
7. Select LS and LG1. Envelope
8. Press *OK*

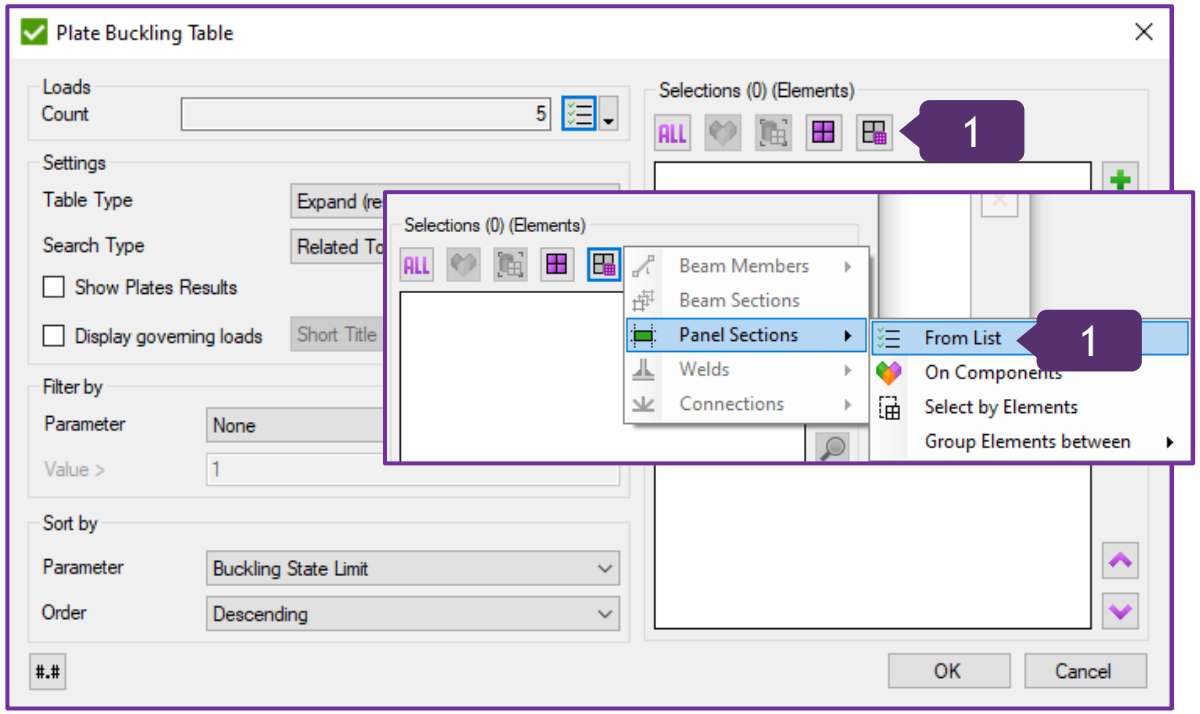


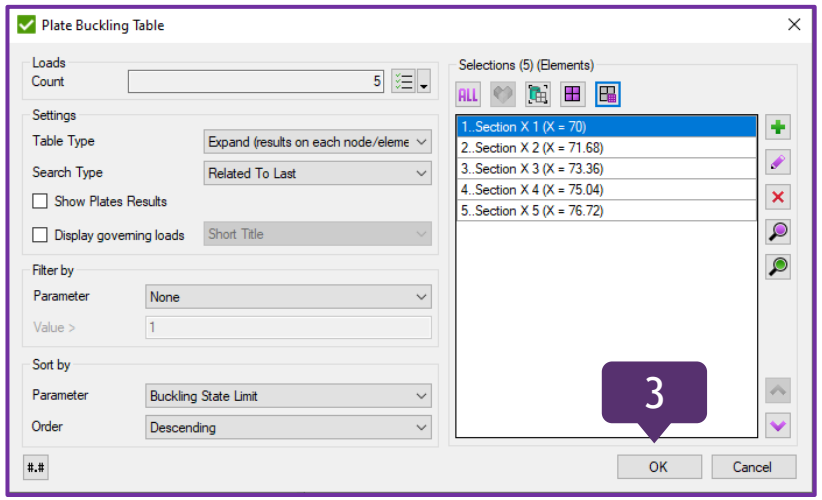
Report. Tables (Continuation)

1. In Selection (0) (Elements), press and select *From List*
2. Select Sections X 1-5 and press *OK*
3. Press *OK*



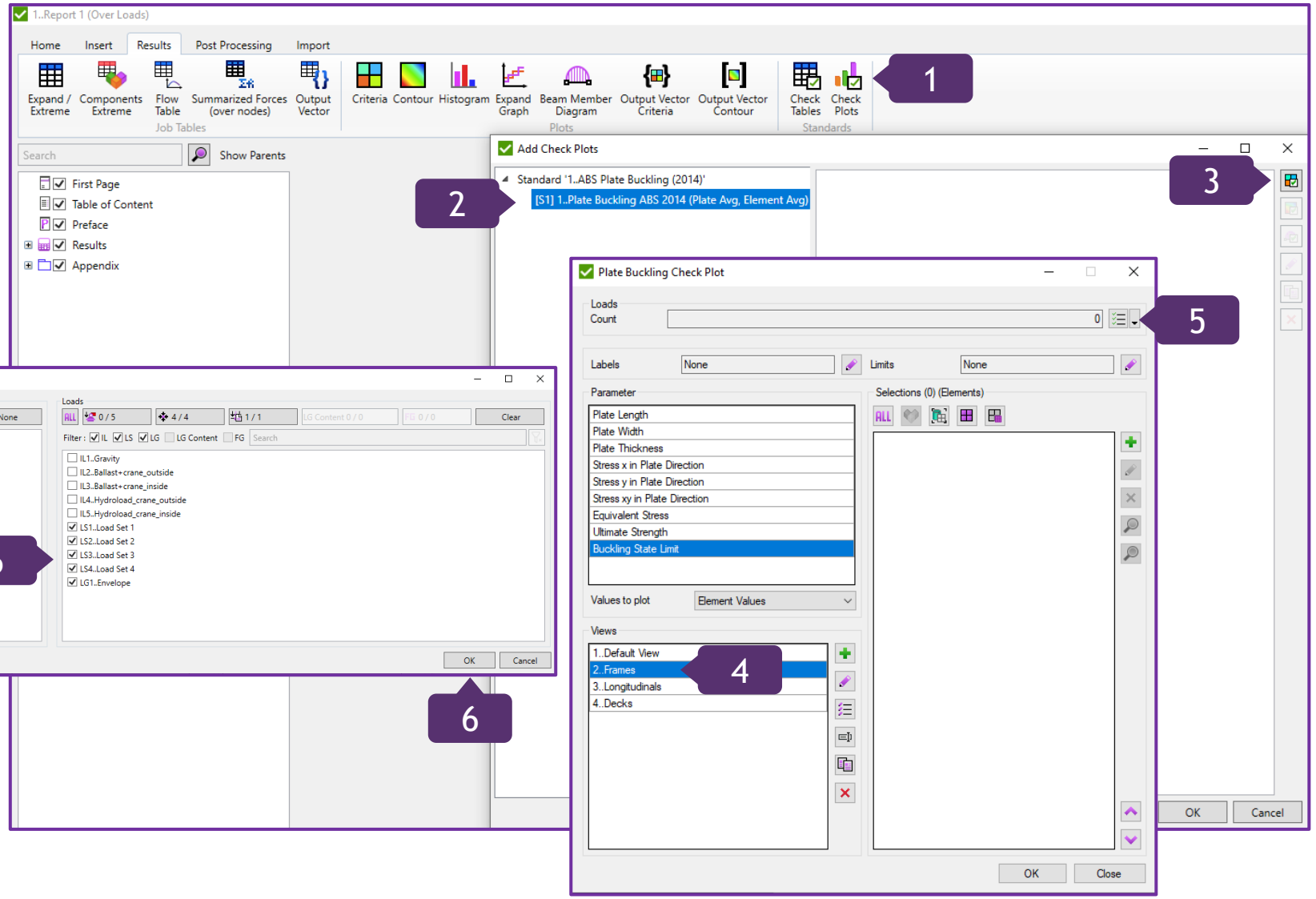






Report. Plots

1. **In 1.. Report 1(Over Loads), go to Ribbon => Results => Check Plots**
2. **Activate *Standard '1..ABS Plate Buckling (2014)* and activate [S1] 1..Plate Buckling ABS 2014**
3. **Press Add Criteria Plot buttonViews: *Frames***
4. **Views: *Frames***
5. Press in Loads Count
6. Select LS and LG1. Envelope and press *OK*



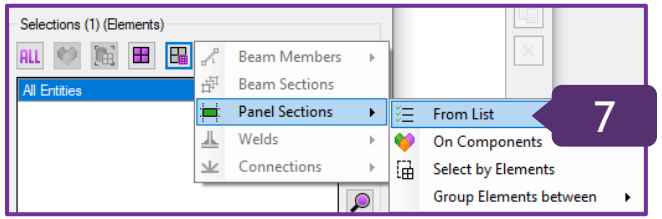
Repeat steps 1-5 for Sections Y with Longitudinals View and Sections Z with Decks View

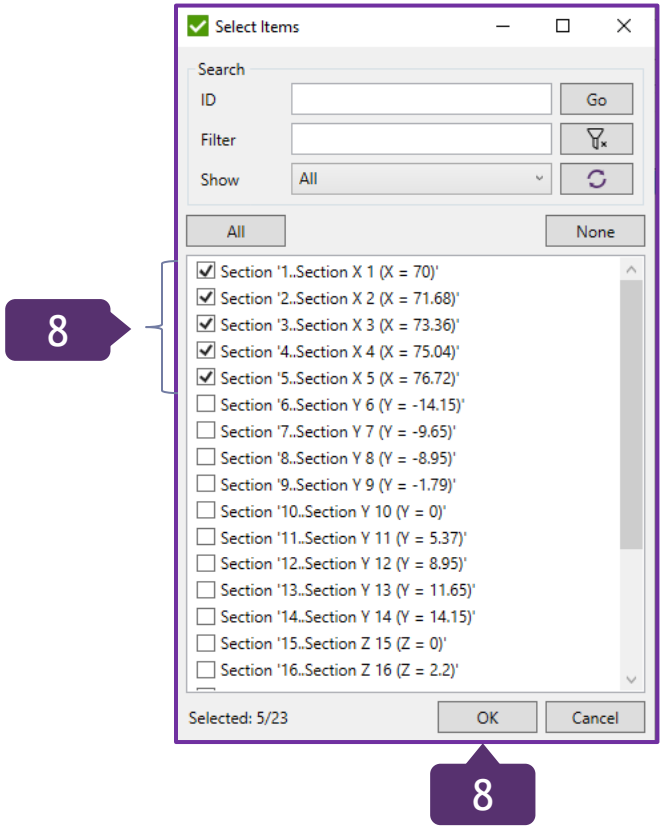
Report. Plots (Continuation)

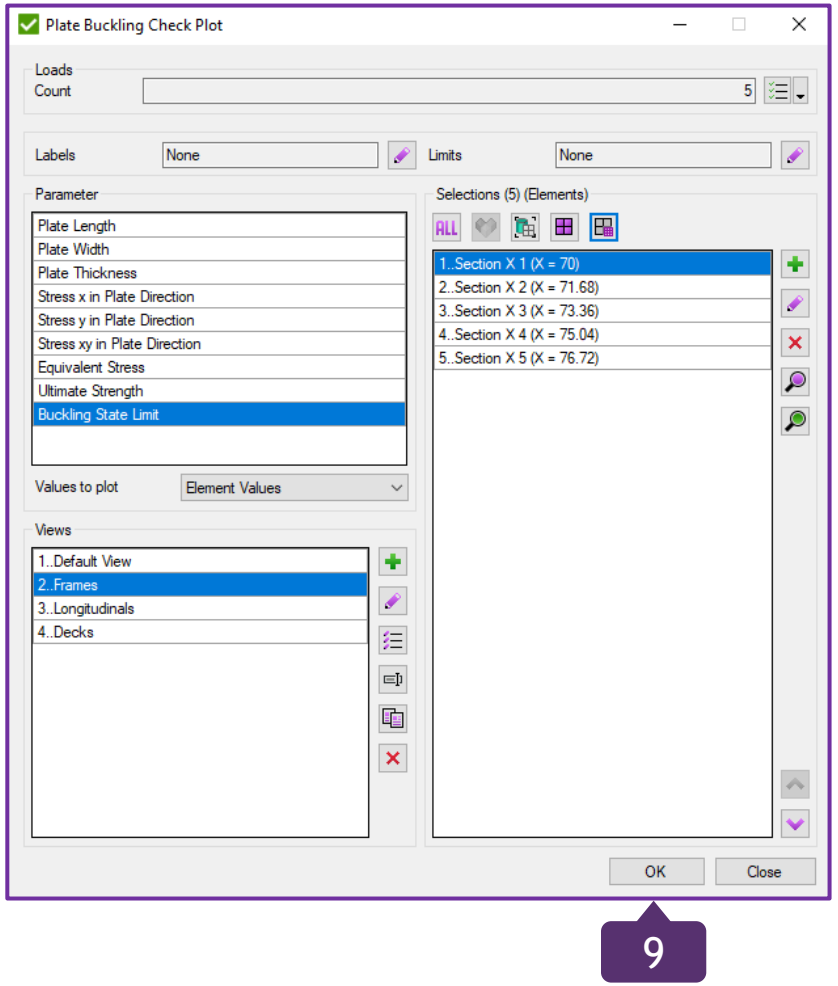
7 In Selection (1) (Elements), press and select *From List*

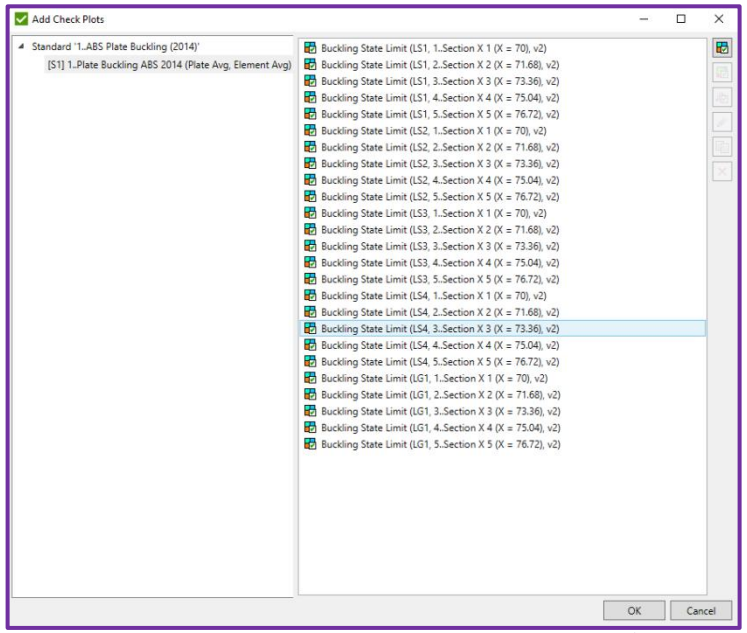
8 Select Sections X 1-5 and press *OK*

9 Press *OK*



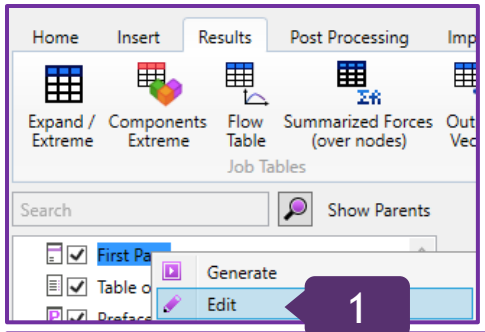


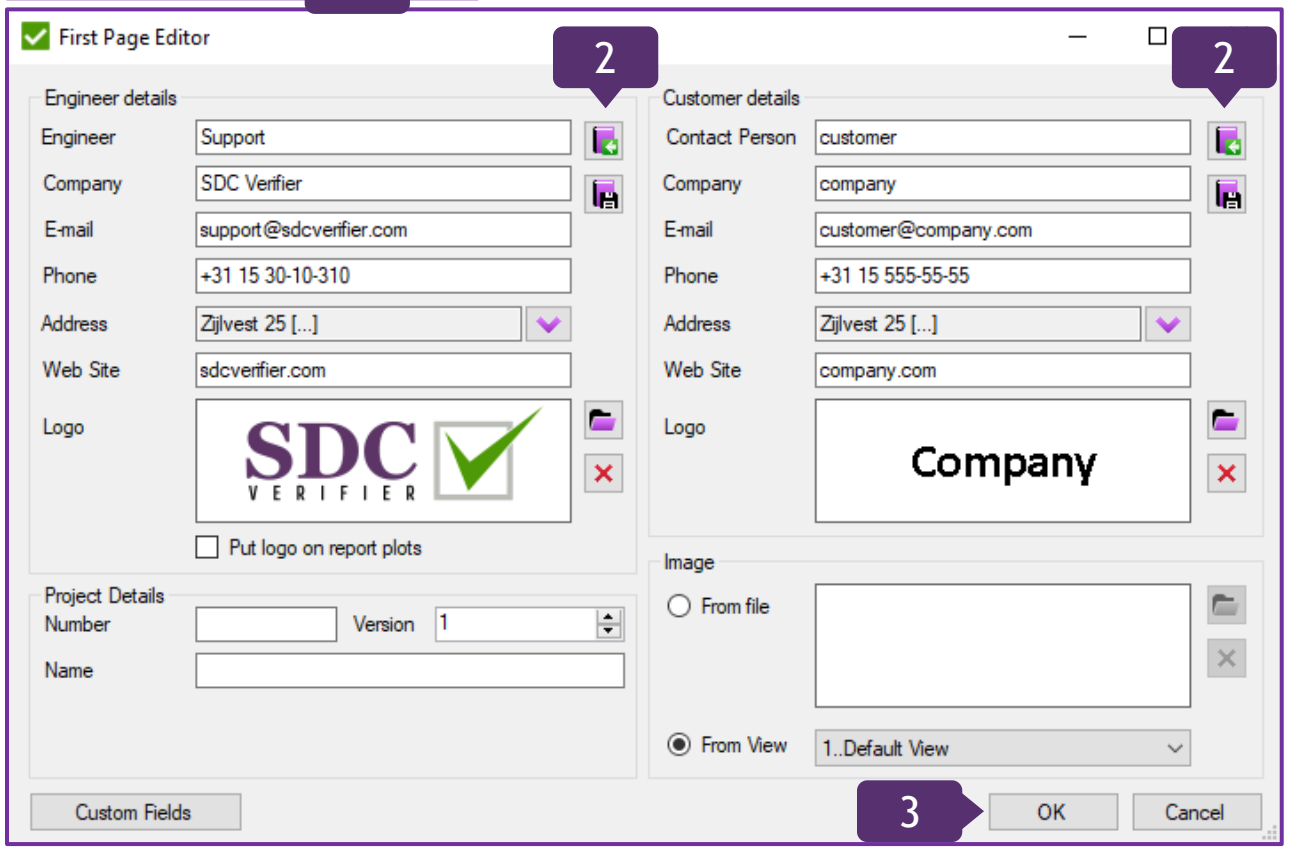




Report. First Page

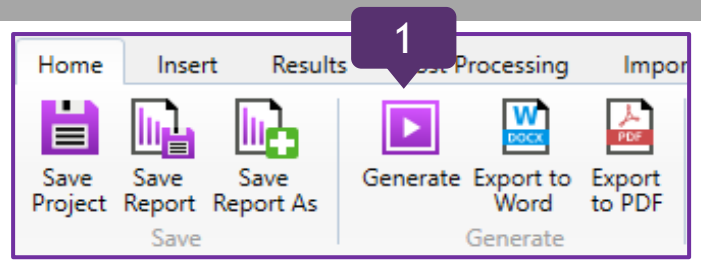
1. Right click on *First Page* => *Edit*
2. Press  to select Engineer and Customer details from the library
3. Press *OK*





Report

1 In Home section of the Ribbon, press to generate a report



SDC VERIFIER

Report 1

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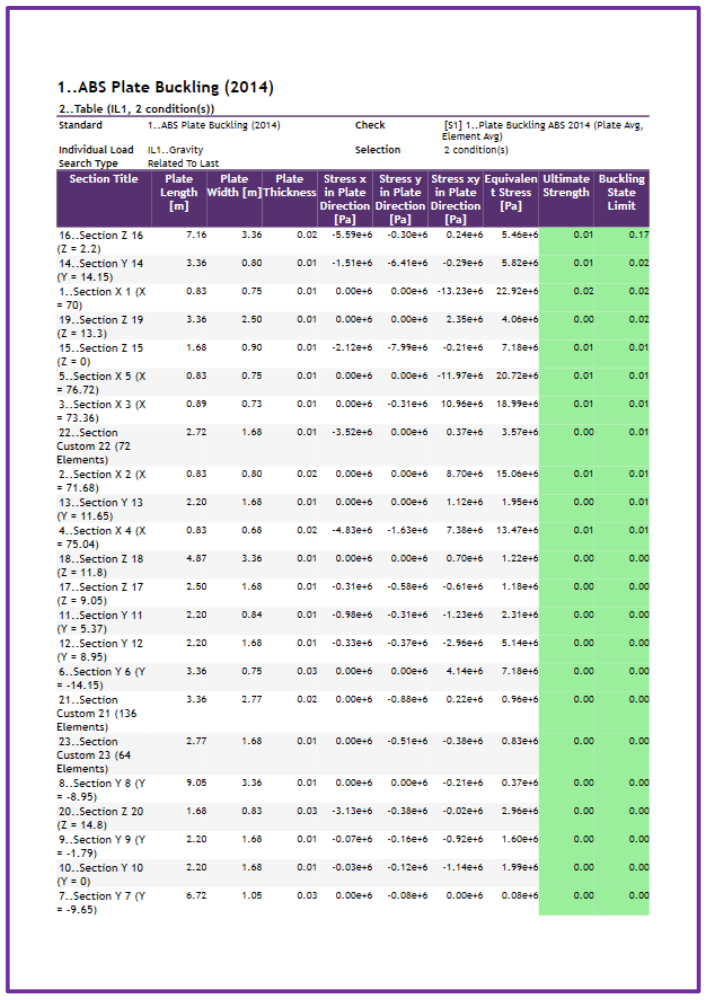
Engineer:	Support
Customer:	customer
Project Number:	
Version:	1
Date:	14/07/2023

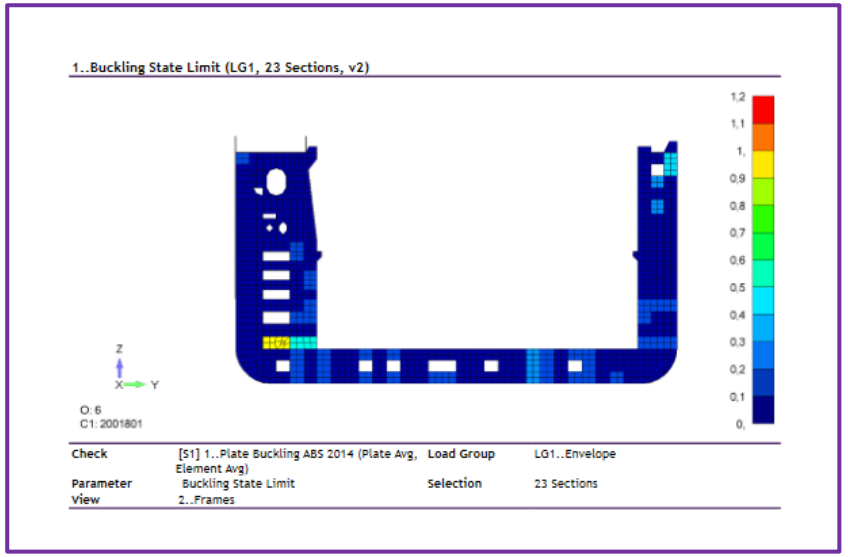


1..ABS Plate Buckling (2014)

2..Table (IL1, 2 condition(s))

Standard	1..ABS Plate Buckling (2014)	Check	[S1] 1..Plate Buckling ABS 2014 (Plate Avg, Element Avg)
Individual Load	IL1..Gravity	Selection	2 condition(s)
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
16..Section Z 16 (Z = 2.2)	7.16	3.36	0.02	-5.59e+6	-0.30e+6	0.24e+6	5.46e+6	0.01	0.17
14..Section Y 14 (Y = 14.15)	3.36	0.80	0.01	-1.51e+6	-6.41e+6	-0.29e+6	5.82e+6	0.01	0.02
1..Section X 1 (X = 70)	0.83	0.75	0.01	0.00e+6	0.00e+6	-13.23e+6	22.92e+6	0.02	0.02
19..Section Z 19 (Z = 13.3)	3.36	2.50	0.01	0.00e+6	0.00e+6	2.35e+6	4.06e+6	0.00	0.02
15..Section Z 15 (Z = 0)	1.68	0.90	0.01	-2.12e+6	-7.99e+6	-0.21e+6	7.18e+6	0.01	0.01
5..Section X 5 (X = 76.72)	0.83	0.75	0.01	0.00e+6	0.00e+6	-11.97e+6	20.72e+6	0.01	0.01
3..Section X 3 (X = 73.36)	0.89	0.73	0.01	0.00e+6	-0.31e+6	10.96e+6	18.99e+6	0.01	0.01
22..Section Custom 22 (72 Elements)	2.72	1.68	0.01	-3.52e+6	0.00e+6	0.37e+6	3.57e+6	0.00	0.01
2..Section X 2 (X = 71.68)	0.83	0.80	0.02	0.00e+6	0.00e+6	8.70e+6	15.06e+6	0.01	0.01
13..Section Y 13 (Y = 11.65)	2.20	1.68	0.01	0.00e+6	0.00e+6	1.12e+6	1.95e+6	0.00	0.01
4..Section X 4 (X = 75.04)	0.83	0.68	0.02	-4.83e+6	-1.63e+6	7.38e+6	13.47e+6	0.01	0.01
18..Section Z 18 (Z = 11.8)	4.87	3.36	0.01	0.00e+6	0.00e+6	0.70e+6	1.22e+6	0.00	0.00
17..Section Z 17 (Z = 9.05)	2.50	1.68	0.01	-0.31e+6	-0.58e+6	-0.61e+6	1.18e+6	0.00	0.00
11..Section Y 11 (Y = 5.37)	2.20	0.84	0.01	-0.98e+6	-0.31e+6	-1.23e+6	2.31e+6	0.00	0.00
12..Section Y 12 (Y = 8.95)	2.20	1.68	0.01	-0.33e+6	-0.37e+6	-2.96e+6	5.14e+6	0.00	0.00
6..Section Y 6 (Y = -14.15)	3.36	0.75	0.03	0.00e+6	0.00e+6	4.14e+6	7.18e+6	0.00	0.00
21..Section Custom 21 (136 Elements)	3.36	2.77	0.02	0.00e+6	-0.88e+6	0.22e+6	0.96e+6	0.00	0.00
23..Section Custom 23 (64 Elements)	2.77	1.68	0.01	0.00e+6	-0.51e+6	-0.38e+6	0.83e+6	0.00	0.00
8..Section Y 8 (Y = -8.95)	9.05	3.36	0.01	0.00e+6	0.00e+6	-0.21e+6	0.37e+6	0.00	0.00
20..Section Z 20 (Z = 14.8)	1.68	0.83	0.03	-3.13e+6	-0.38e+6	-0.02e+6	2.96e+6	0.00	0.00
9..Section Y 9 (Y = -1.79)	2.20	1.68	0.01	-0.07e+6	-0.16e+6	-0.92e+6	1.60e+6	0.00	0.00
10..Section Y 10 (Y = 0)	2.20	1.68	0.01	-0.03e+6	-0.12e+6	-1.14e+6	1.99e+6	0.00	0.00
7..Section Y 7 (Y = -9.65)	6.72	1.05	0.03	0.00e+6	-0.08e+6	0.00e+6	0.08e+6	0.00	0.00



1..Buckling State Limit (LG1, 23 Sections, v2)

Check	[S1] 1..Plate Buckling ABS 2014 (Plate Avg, Element Avg)	Load Group	LG1..Envelope
Parameter	Buckling State Limit	Selection	23 Sections
View	2..Frames		