Tutorial
Plate Buckling DNV

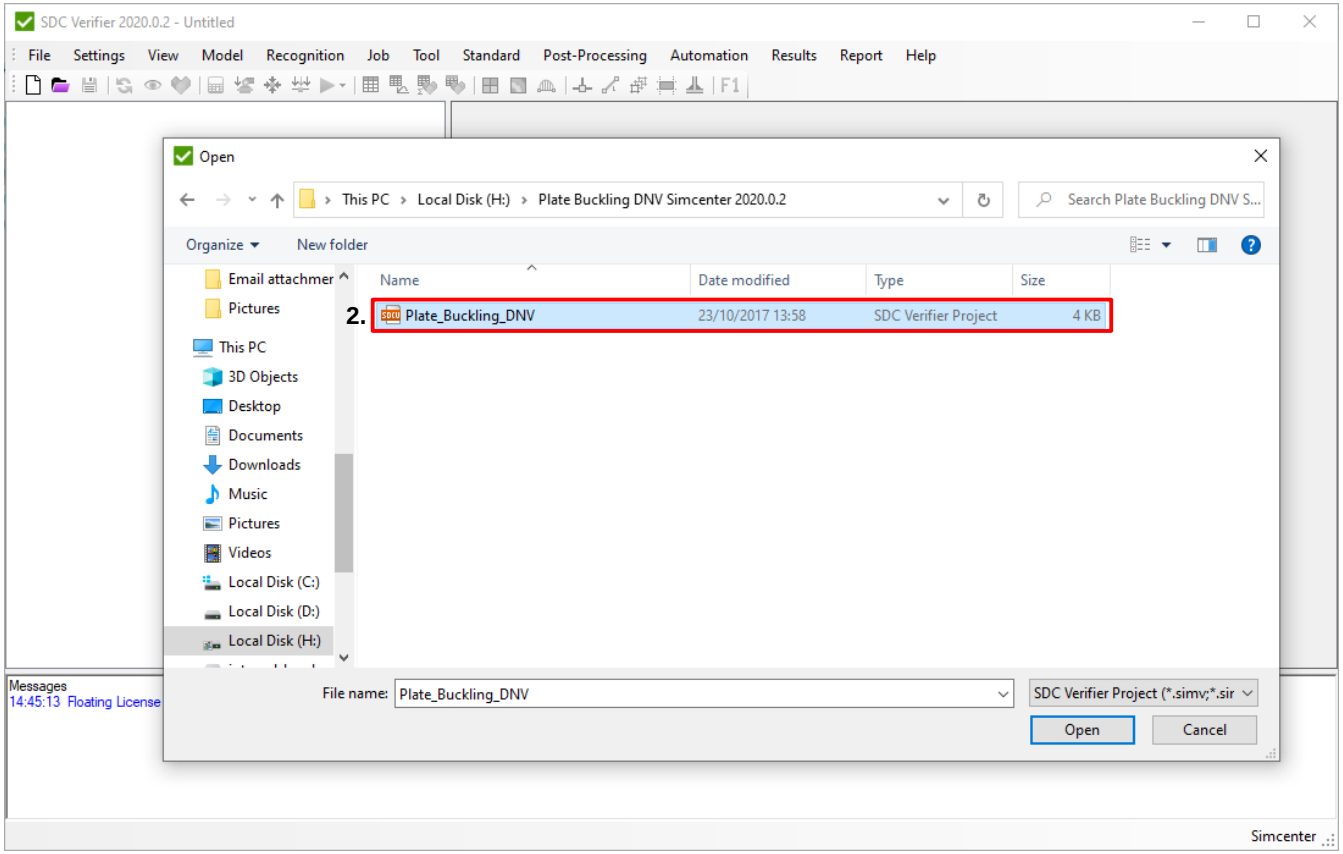
20.01.2021
version 2020.0.2

Content

- In this tutorial an DNV 2010 Plate Buckling Check is reviewed in details.
- A part of a 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 the final report.

Open Project

1. Launch **SDC Verifier**
2. Open project *Plate_Buckling_DNV.*



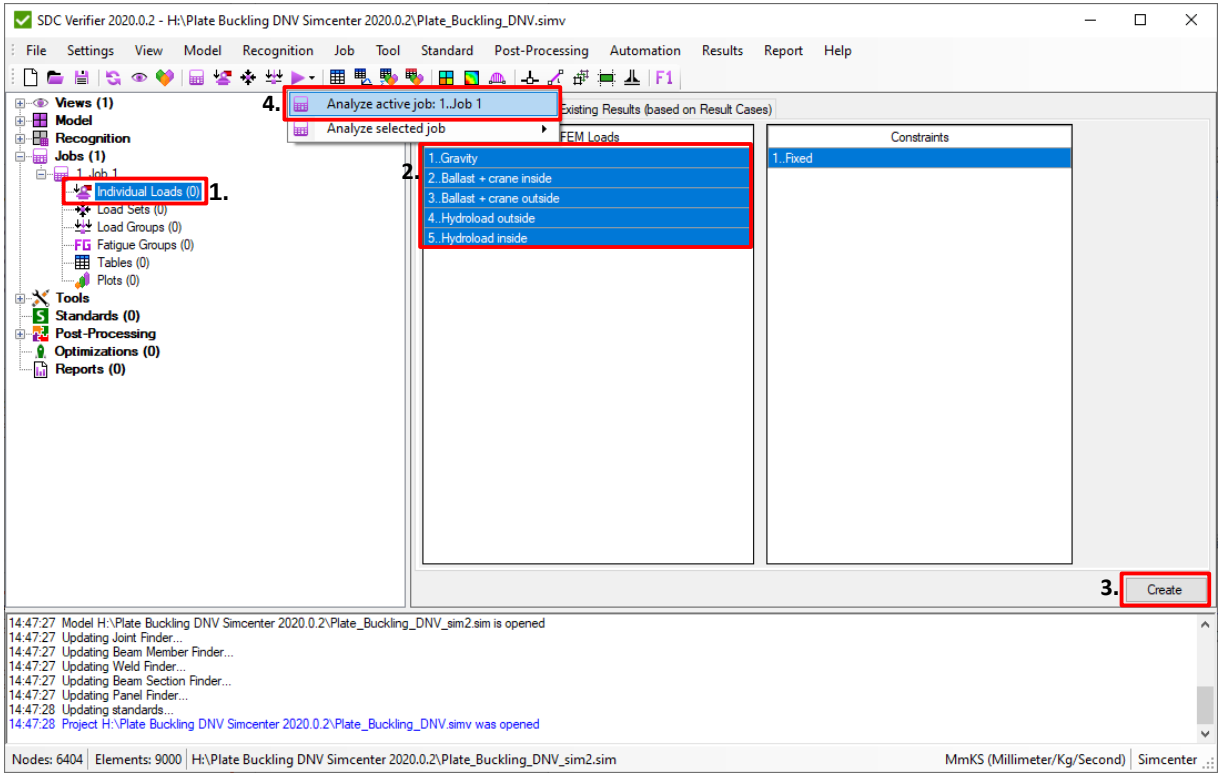
Individual Loads

1. Click on *Individual Loads*.

2. Select *5 FEM Loads*:
   1. Gravity;
   2. Ballast + crane inside;
   3. Ballast + crane outside;
   4. Hydroload outside;
   5. Hydroload inside.

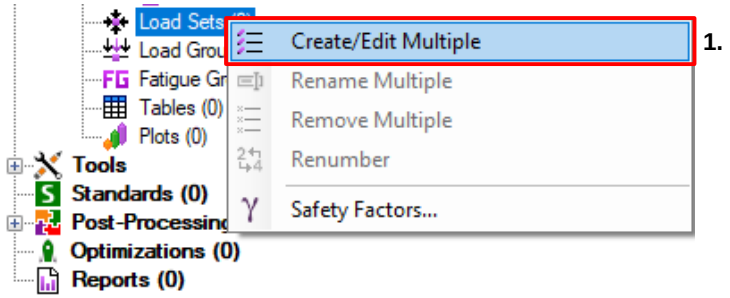
3. Press *Create* to create 5 Individual Loads.

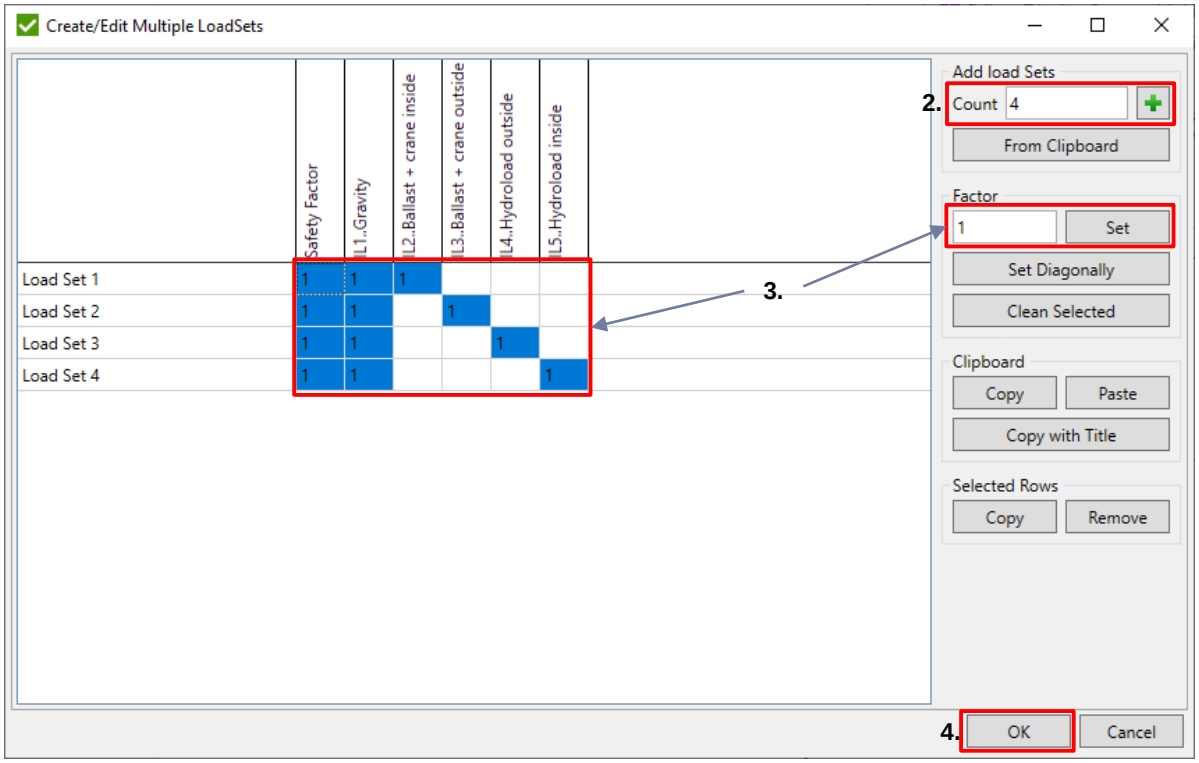
4. Press ▶ on toolbar and "*Analyze active job: 1..Job 1*"



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 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*



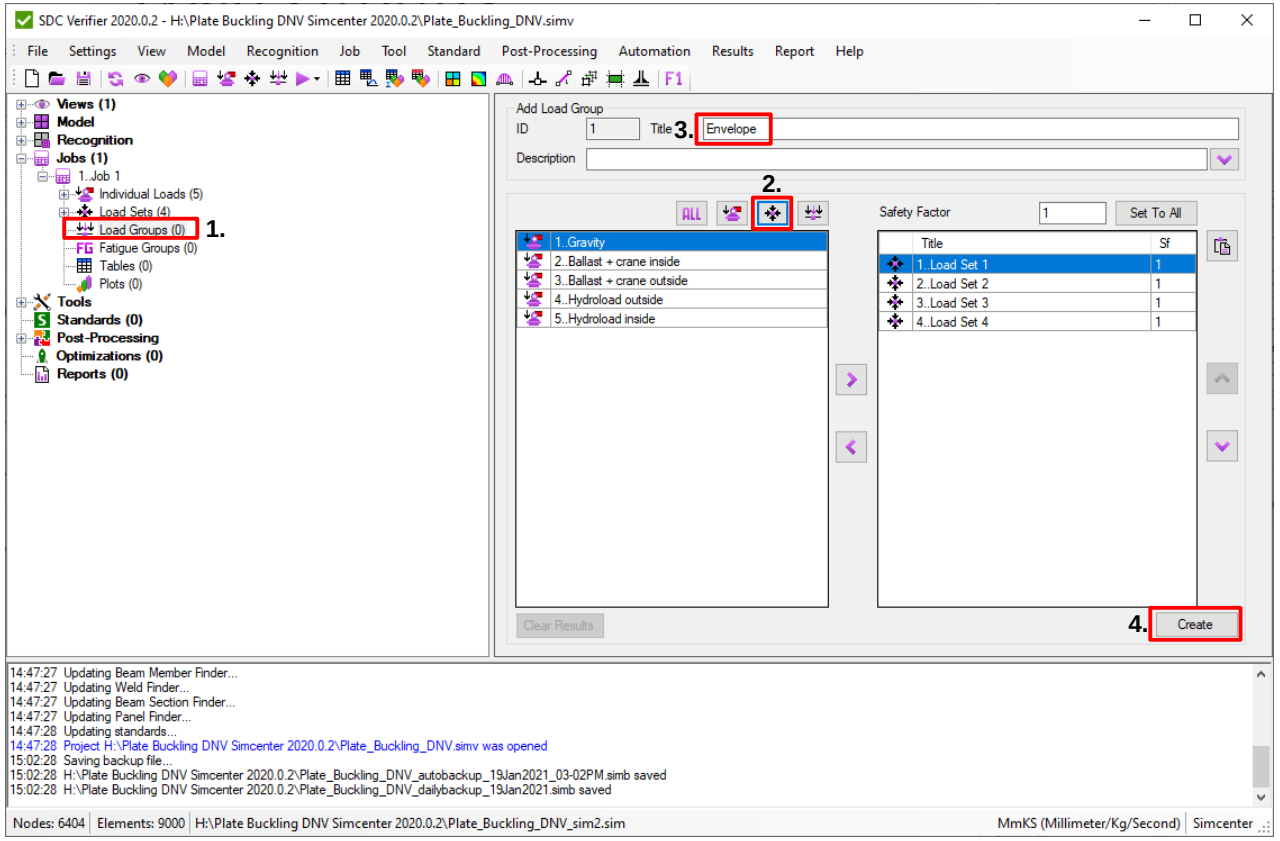


Load Sets are created with default titles "Load Set #". It is possible to rename them by double-click on the respective load set title. Alternatively, the titles and factors can be pasted from the Clipboard using *Paste* button.

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.

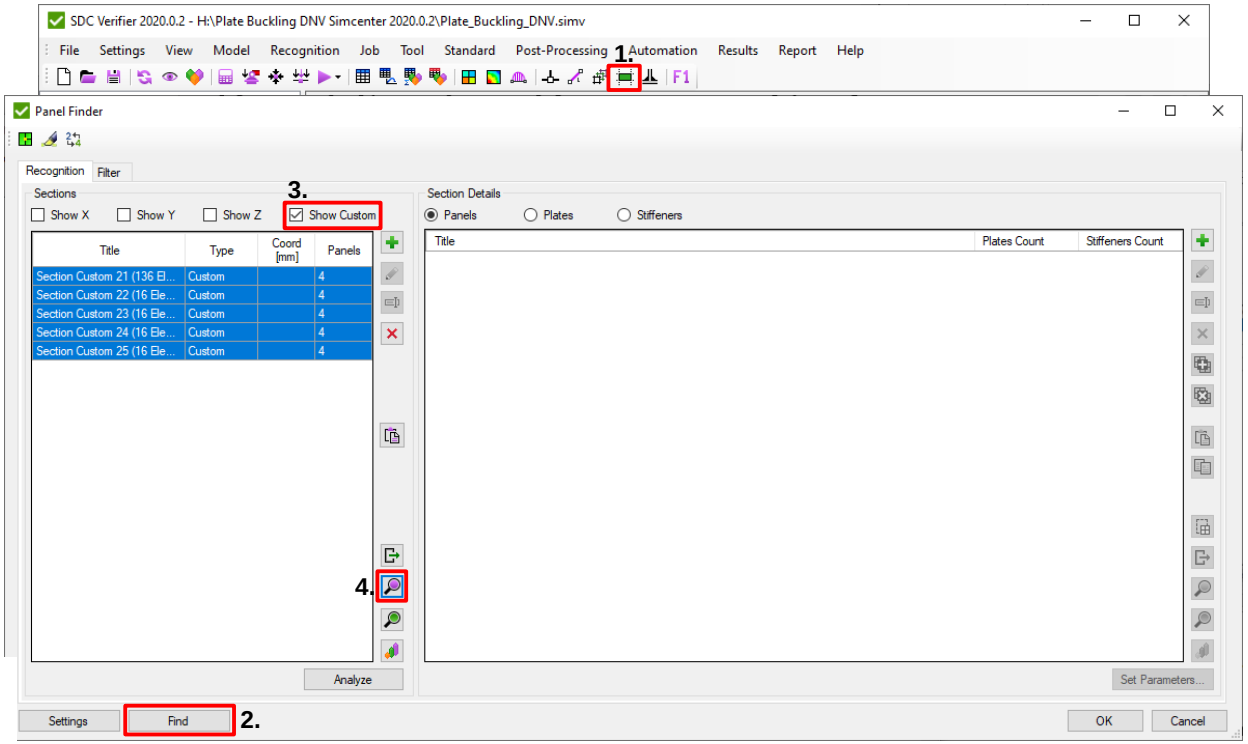


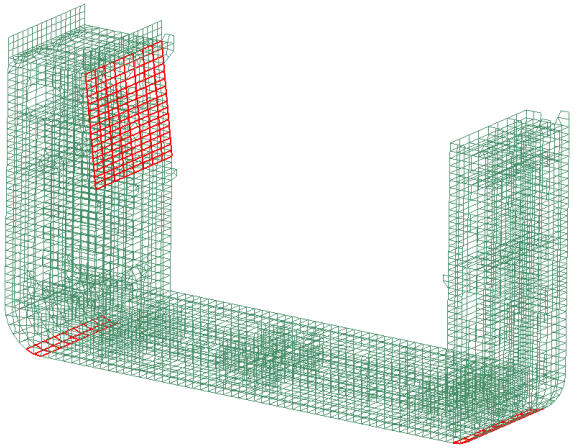
Panel Finder. Recognize Sections

1. Launch **Panel Finder**
2. Press *Find*

All sections were recognized and plates were analyzed automatically on the model.

3. Select Show *Custom*
4. Select all the sections and press 

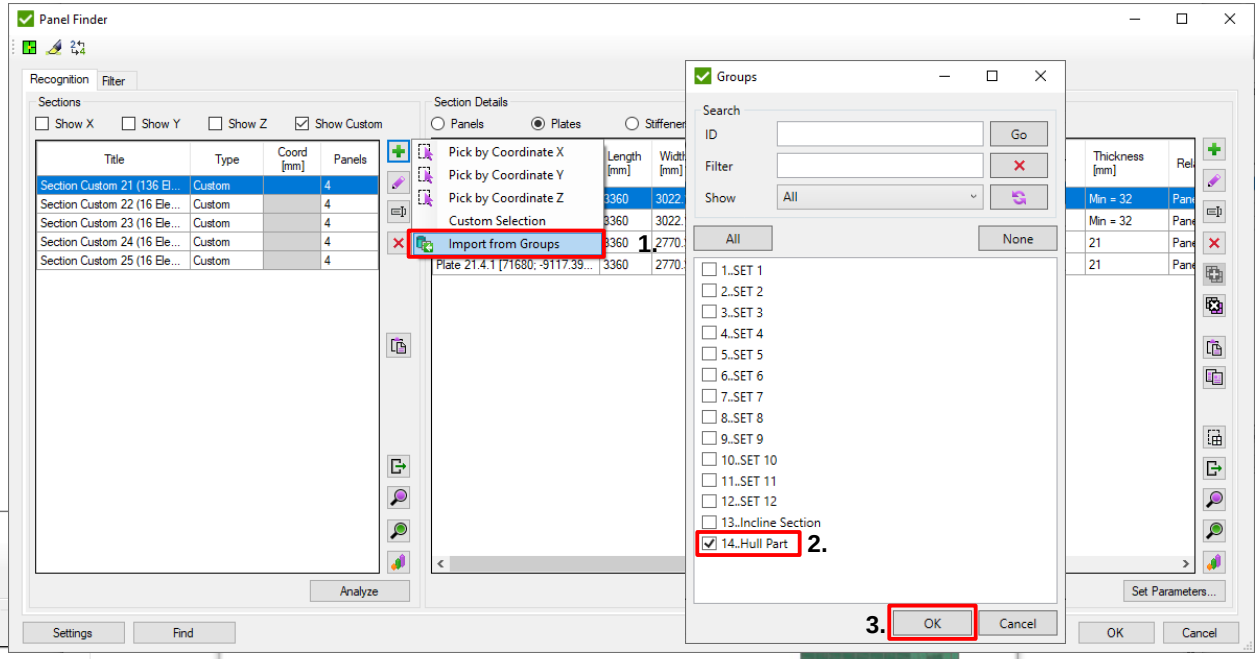


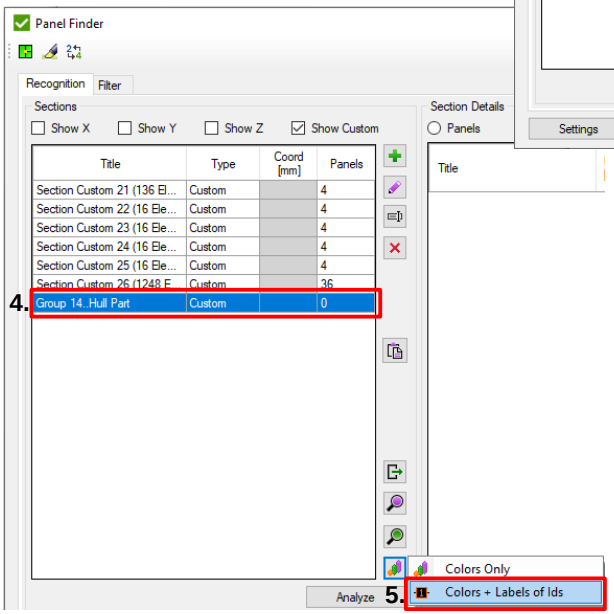


Custom sections are automatically recognized on the elements that do not belong to any other section (X, Y or Z) and grouped by the common edges. All the incline or curved (e.g. hull parts) sections belong to custom sections.

Panel Finder. Custom Section

1. Press ➕ - Import from Groups
2. Select group '***14..Hull Part***'
3. Press *OK*
4. Select '***14..Hull Part***'
5. Press to *plot selected item with Colors+Labels of IDs*





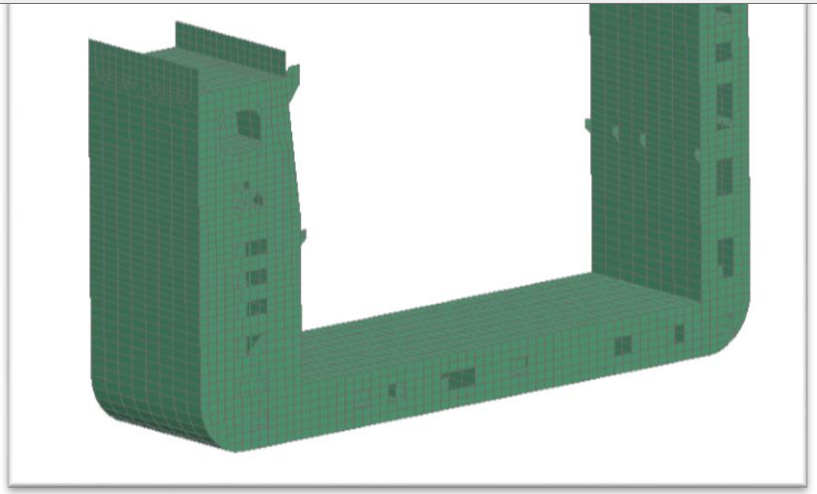


Plate Dimensions and Thicknesses

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:

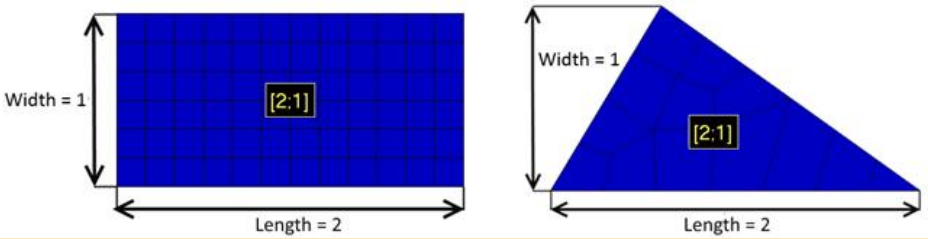
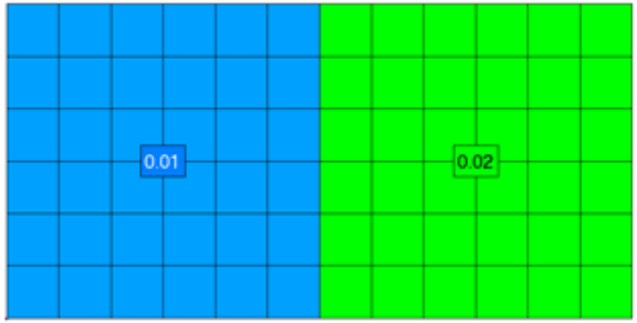
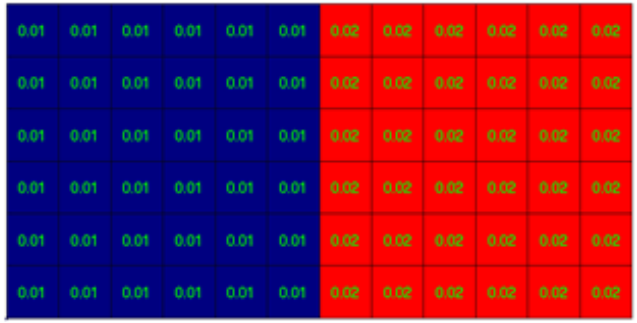


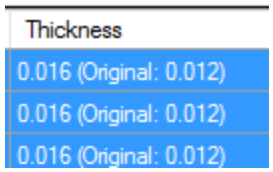
Plate Thickness: the calculations are performed on every element and thickness is taken directly from each element. It is possible to set thickness manually for a plate, in this case, the element thickness will be ignored and the user defined thickness will be used.
Example: Plate with 2 properties 0.01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





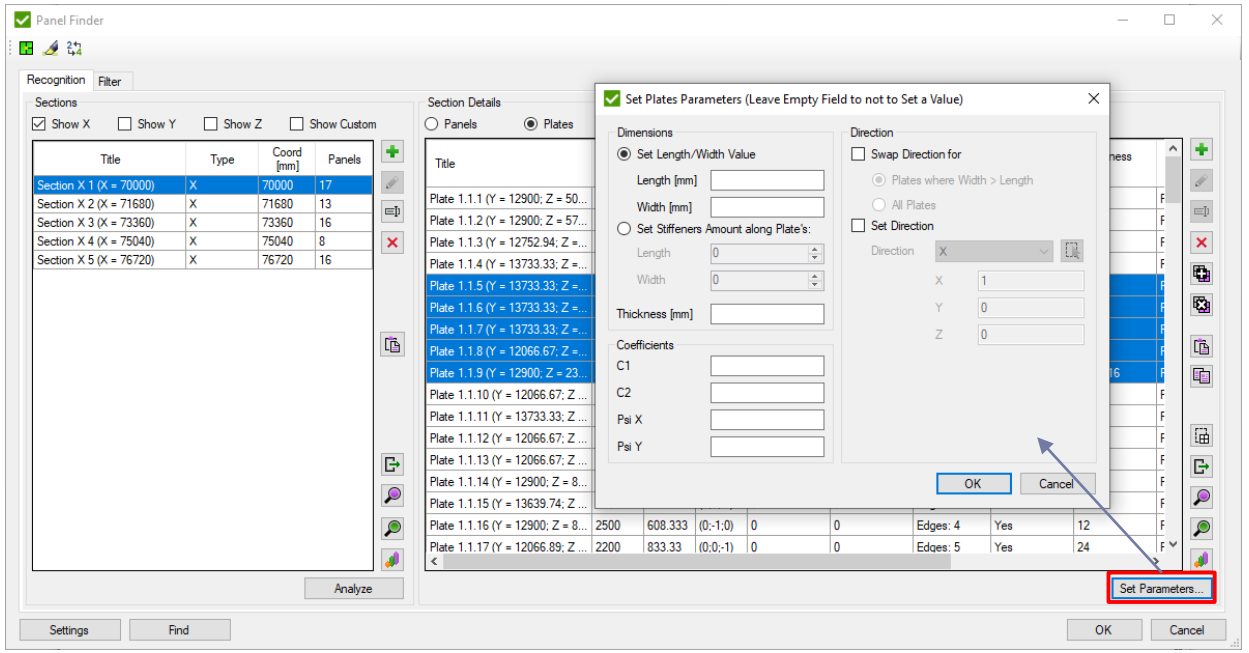
Editing plates manually

To modify plates select them from the list and press *Set dimensions*. It is possible to edit one parameter (Length / Width / Thickness) or few at once.
If thickness is changed, you can see in table what was the original thickness recognized from the model:

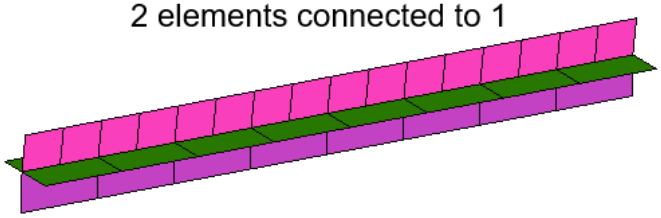


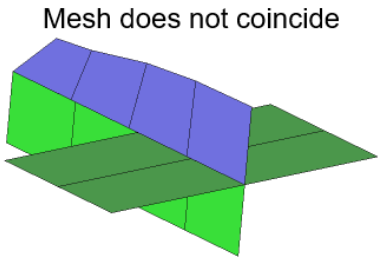
Usually, the plate directions should not be modified. But in case it is required, press *Set Direction.*

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



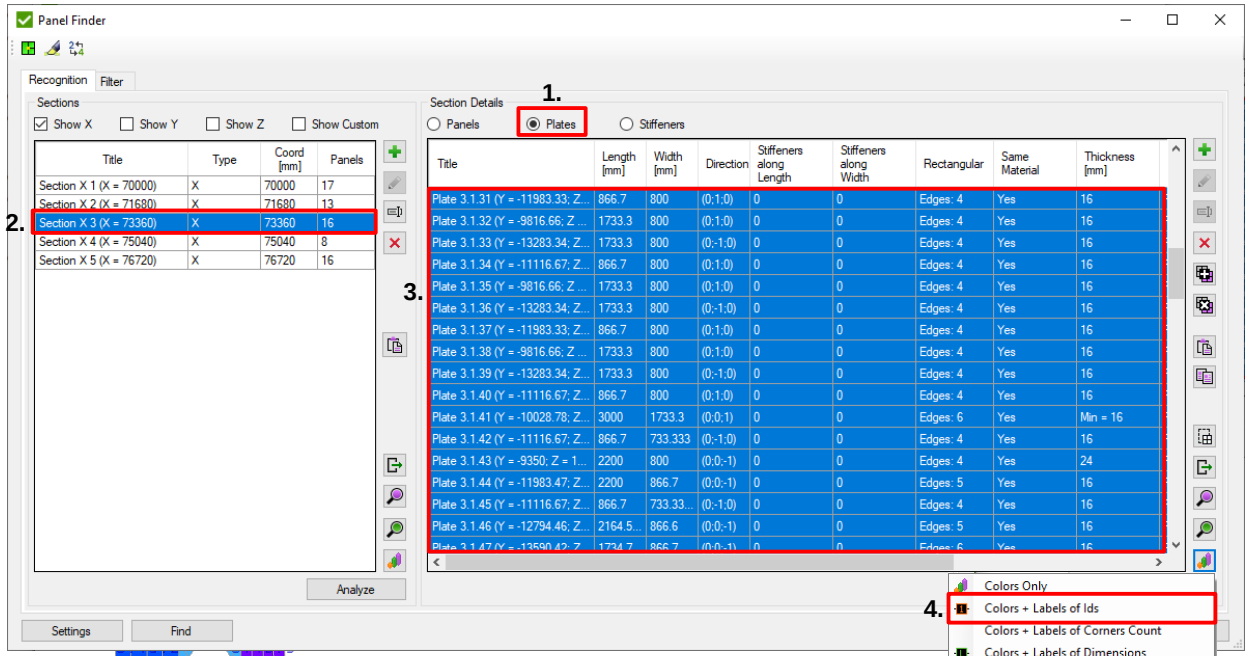
Incorrect plate dimensions/direction, plates with undefined dimensions and as result incorrect buckling factor – possible consequences of the free edges.

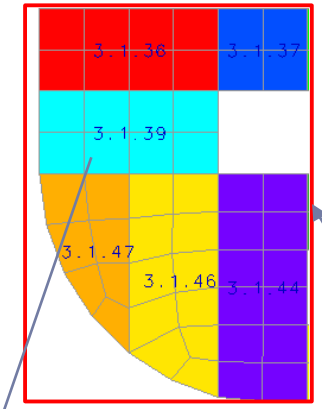




Panel Finder. Plates Plot

1. Press *Plates.*
2. Select **Section X3**.
3. Press Ctrl+A to select all Plates
4. Click and select Colors+Labels of IDs





	length	width	
Plate 3.1.39 (Y = -13283.34; Z...	1733.3	800	(0;-1;0)

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).

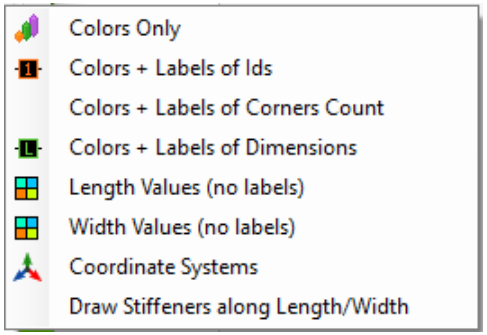


Plate IDs

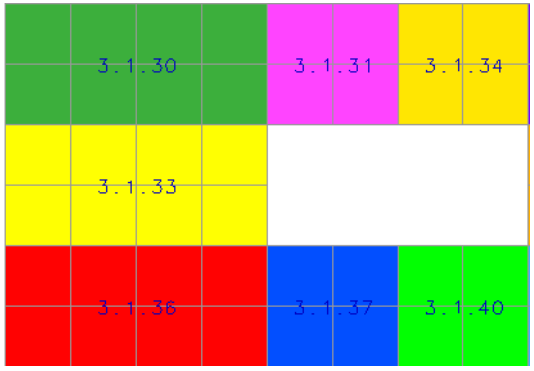


Plate dimensions

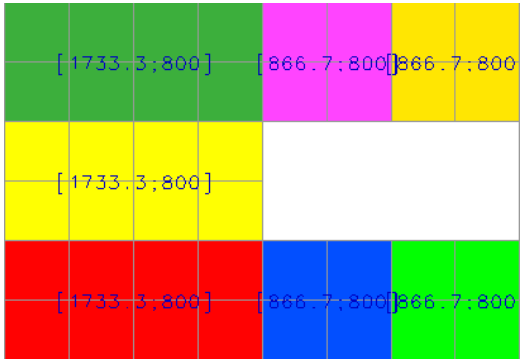
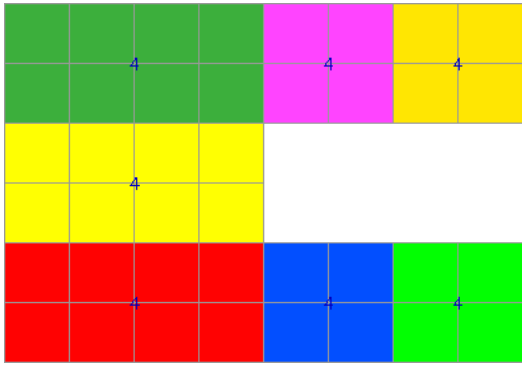
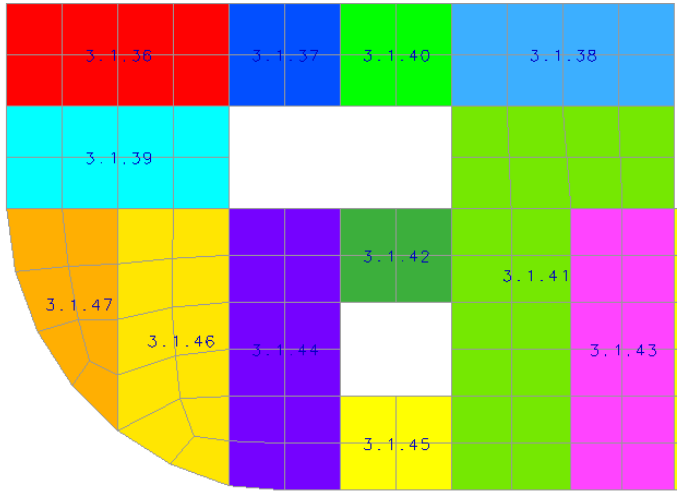


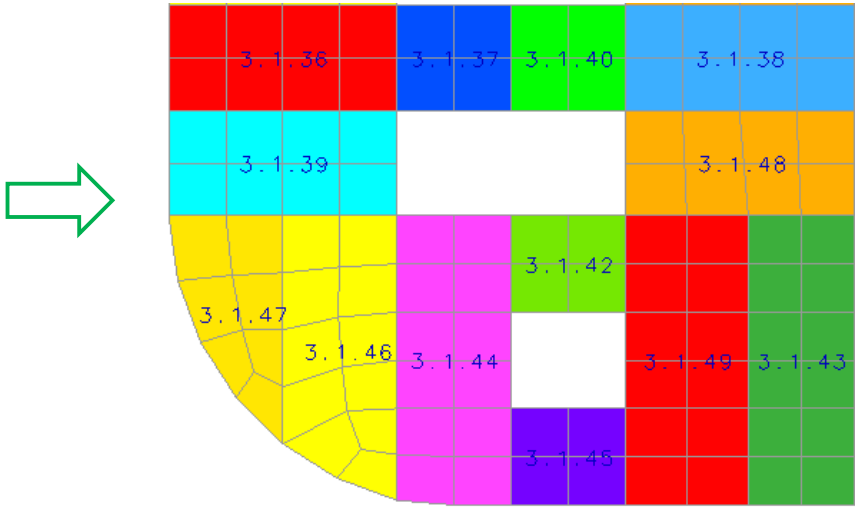
Plate # of edges



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 = 3.1.41 should be split in 2 plates.



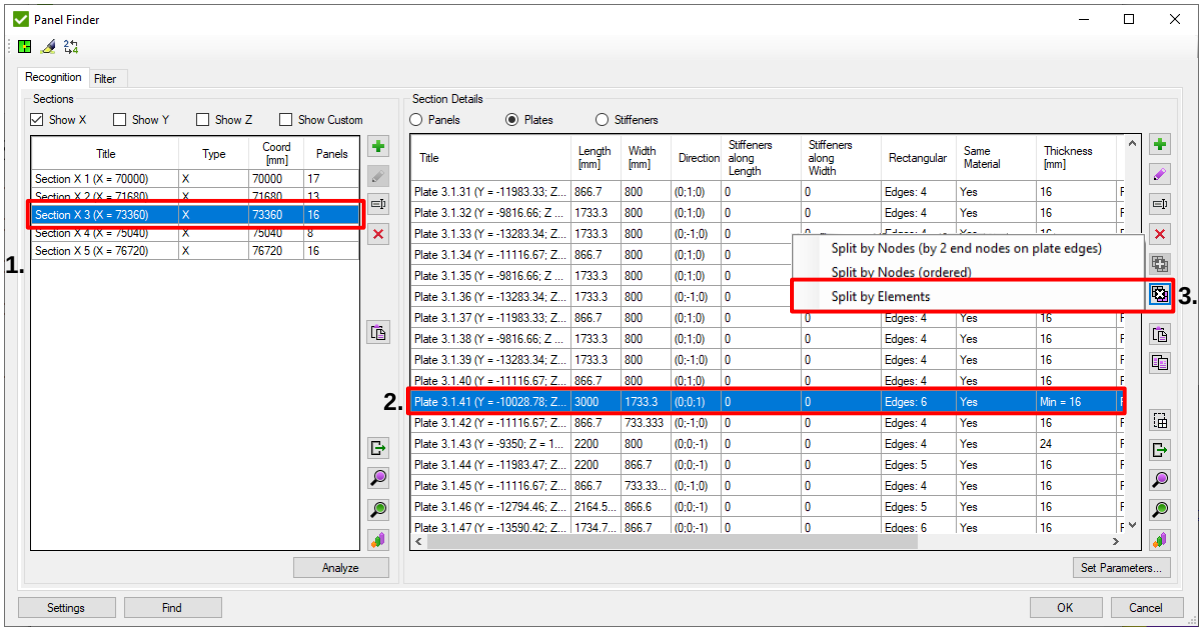


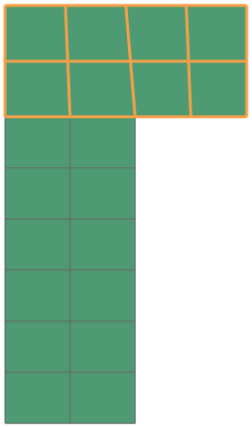
If plates were modified manually and later user decided to run recognition of plates, Panel Finder will ask what to do with the modified plates:

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

Panel Finder. Split Plate

1. Select **Section X 3 (X = 73360).**
2. Select **Plate 3.1.41**
3. Press *Split selected plates by elements*
4. Selected plate is displayed. Select elements for one plate and press *OK*.

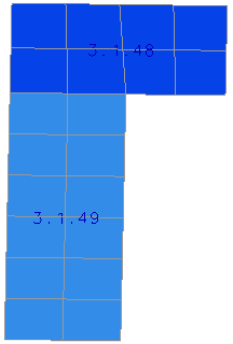




The plate 3.1.41 is replaced with the Plates 3.1.48 and 3.1.49. Dimensions and directions are updated automatically.

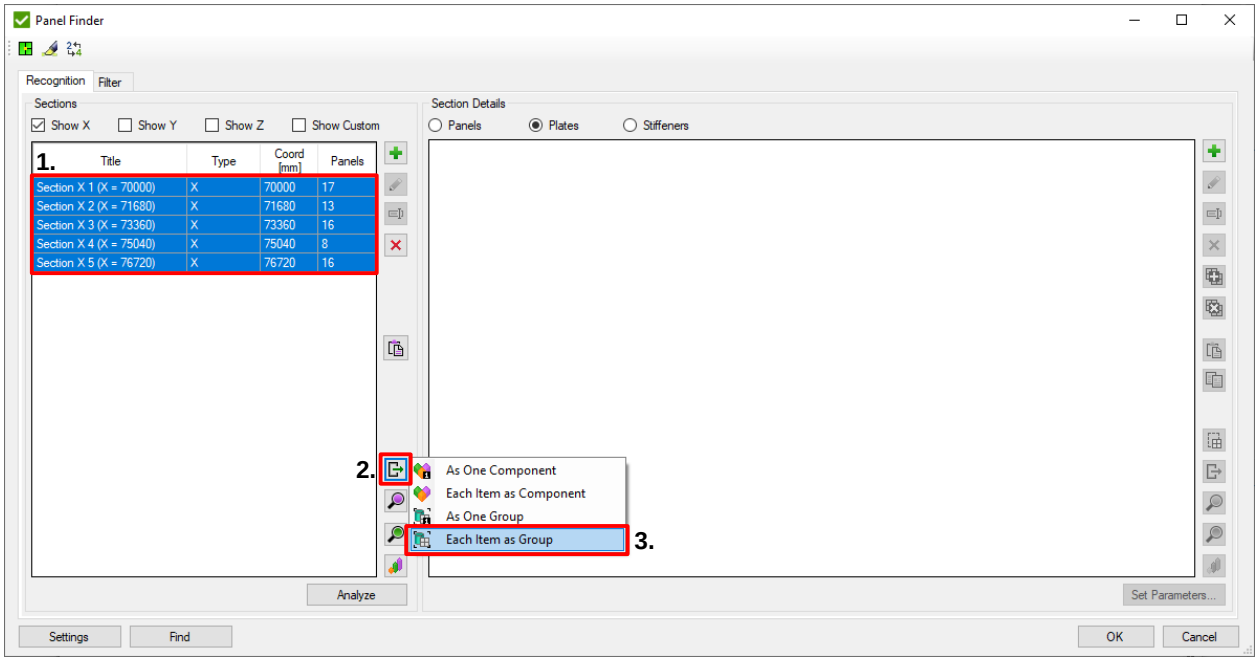
Title	Length [mm]	Width [mm]	Direction
Plate 3.1.41 (Y = -10028.78; Z...	3000	1733.3	(0;0;1)

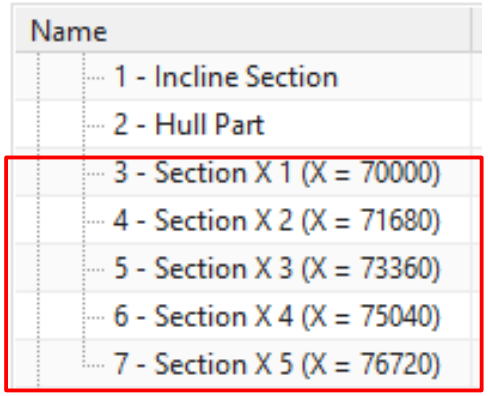
Title	Length [mm]	Width [mm]	Direction
Plate 3.1.48 (Y = -9803.33; Z ...	1733.3	800	(0;-1;0)
Plate 3.1.49 (Y = -10216.67; Z...	2200	933.3	(0;0;-1)

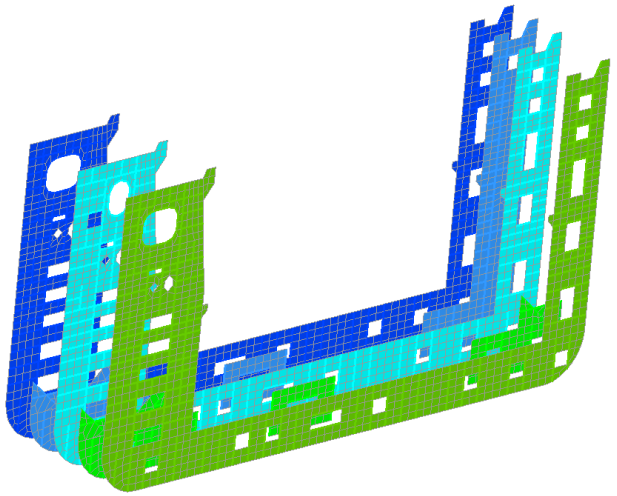


Panel Finder. Export Plates

1. Press Ctrl+A to select all Sections X
2. Select  to *Export Sections*
3. Pick *Each Item as Group*
4. 5 Groups will be created for 5 Sections .



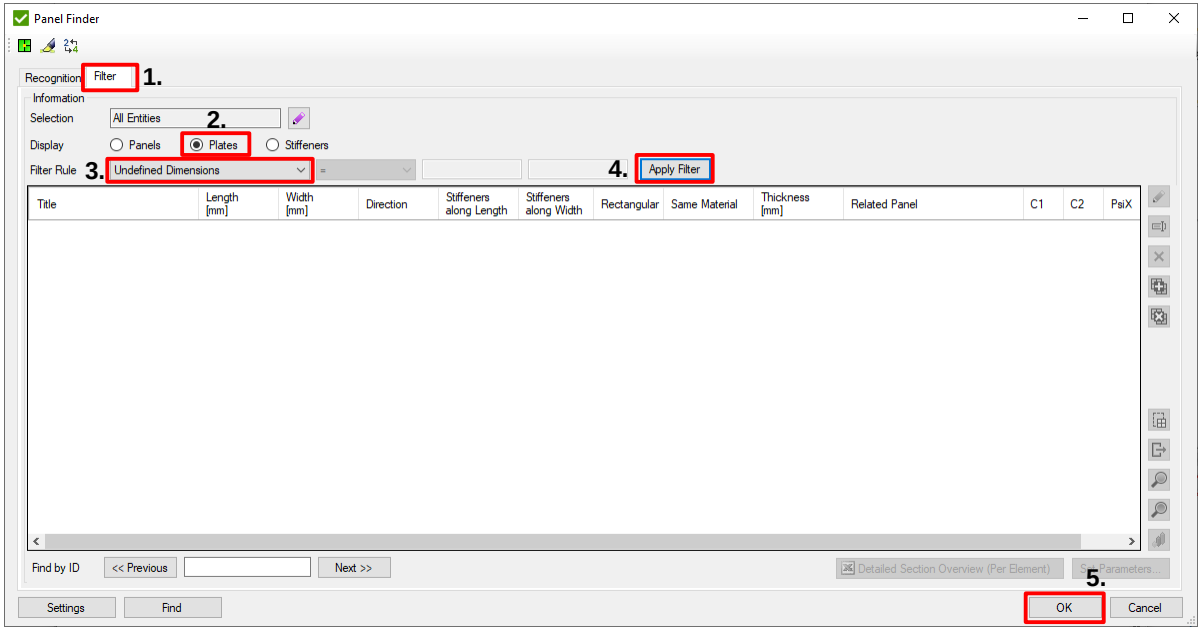




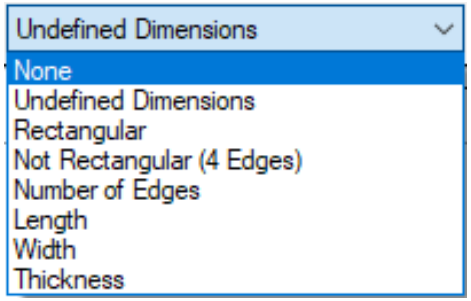
Panel Finder. Filter

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. Select **Plates**
3. Filter Rule: **Undefined dimensions**
4. Press *Apply Filter*.
5. Table with plates is empty means that there are no plates with undefined dimensions. Press *OK*.

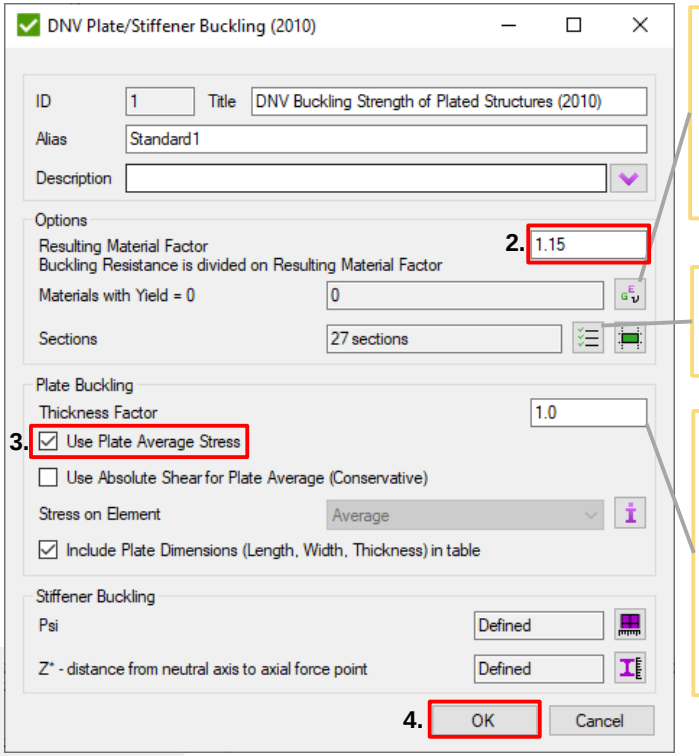


It is also possible to filter plates by shape (not rectangular, rectangular) or number of edges parameters.
E.g. Plates with numbers of edges > 4 can be displayed.
The filter can be applied to all Sections from X/Y/Z/Custom category or to single selected Section (option *Plates of selected section*)



Add Plate Buckling DNV 2010 standard

1. In Standards Context menu execute *Add => DNV => RP-C-201 Plate/Stiffener Buckling 2010*.
2. Resulting Material Factor = **1.15**
3. Use Plate Average Stress*:* **On**
4. Press *OK*.



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

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

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

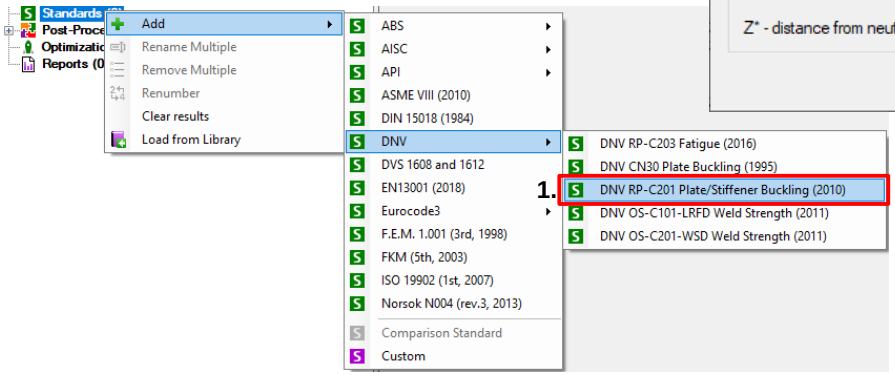
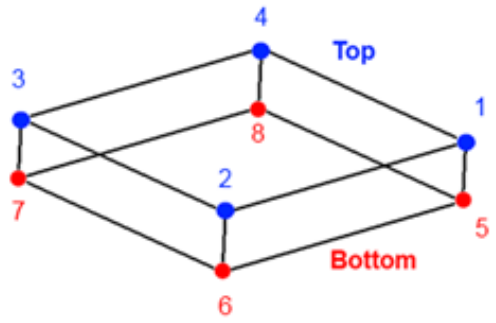


Plate Buckling transforms stresses automatically into plate direction.
The options about element stresses and plate stresses are described in the next slide

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 = 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)

Spl = (Sel1*A1+Sel2*A2+Sel3*A3) / (A1+A2+A3)

One Buckling Factor for plate

Off

Sel1	Sel2	Sel3

Sel1, Sel2, Sel3 - Average or min MidPlane

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

Views

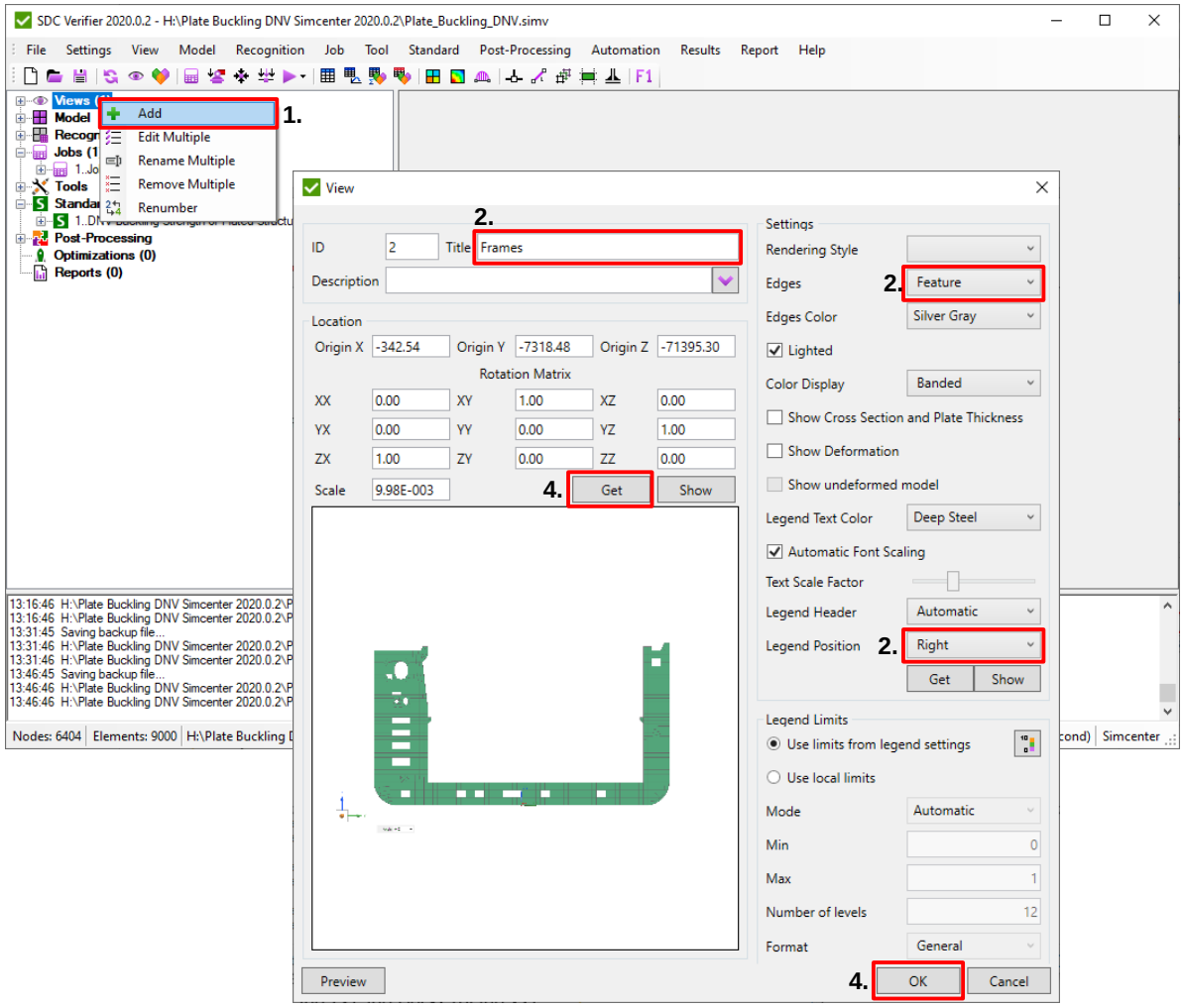
1. Execute Views => Add

2. Title: **Frames**
   Edges: **Feature**
   Legend Position: **Right**

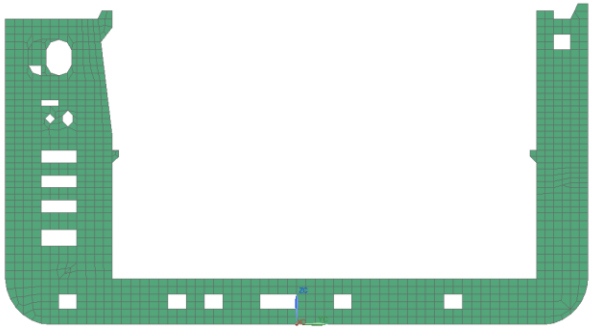
3. Orient model in Simcenter as shown on picture below (ZY plane)

4. Press *Get* and *OK*.

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



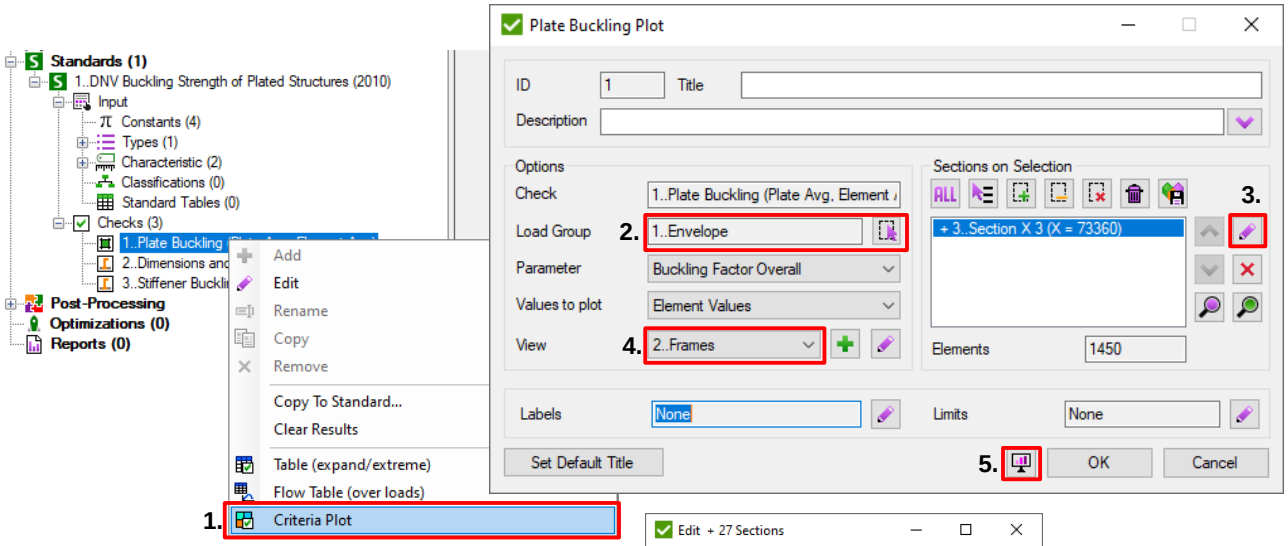
3.

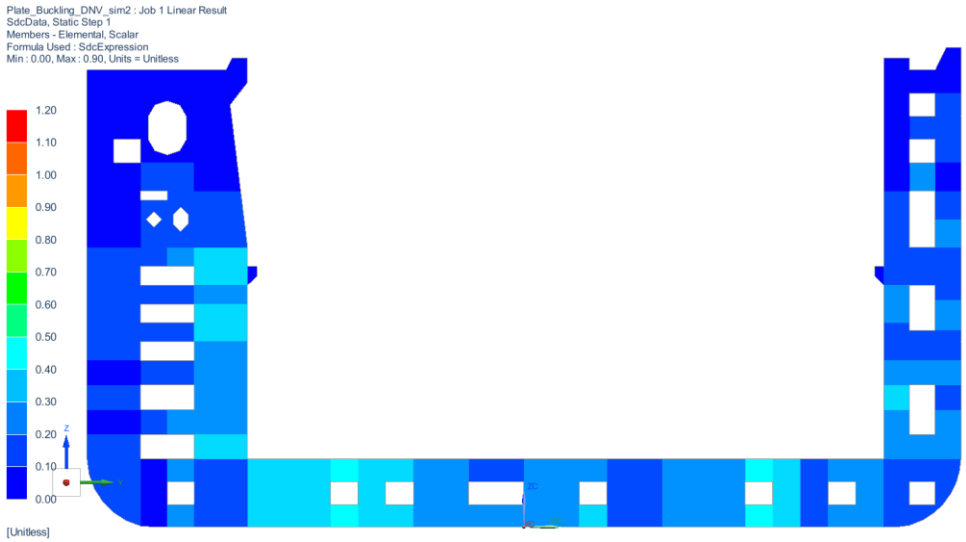


Repeat Steps 1-4 2 times to create a view for Longitudinals (plane ZX) and Decks (plane XY)

Plate Buckling Plot

1. Execute *Criteria Plot* from Plate Buckling check context menu
2. Press and select Load Group “Envelope”
3. Press and Select **Section X3**.
4. View: **Frames**
5. Press to Preview





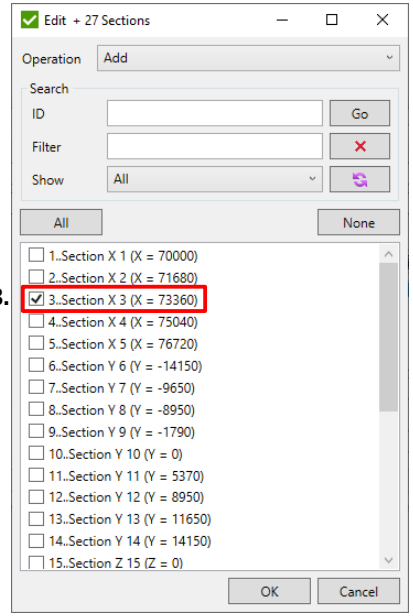
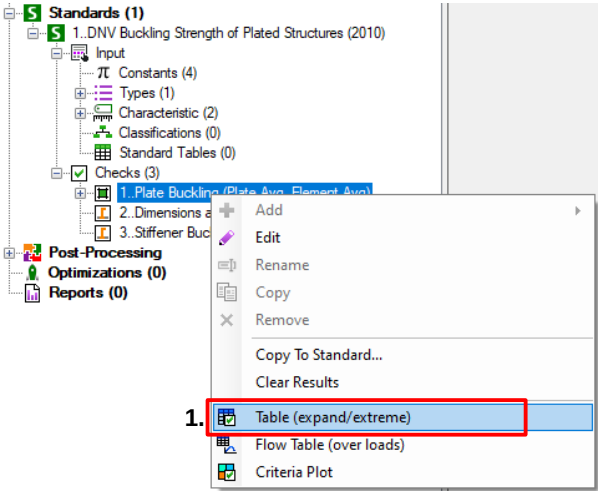
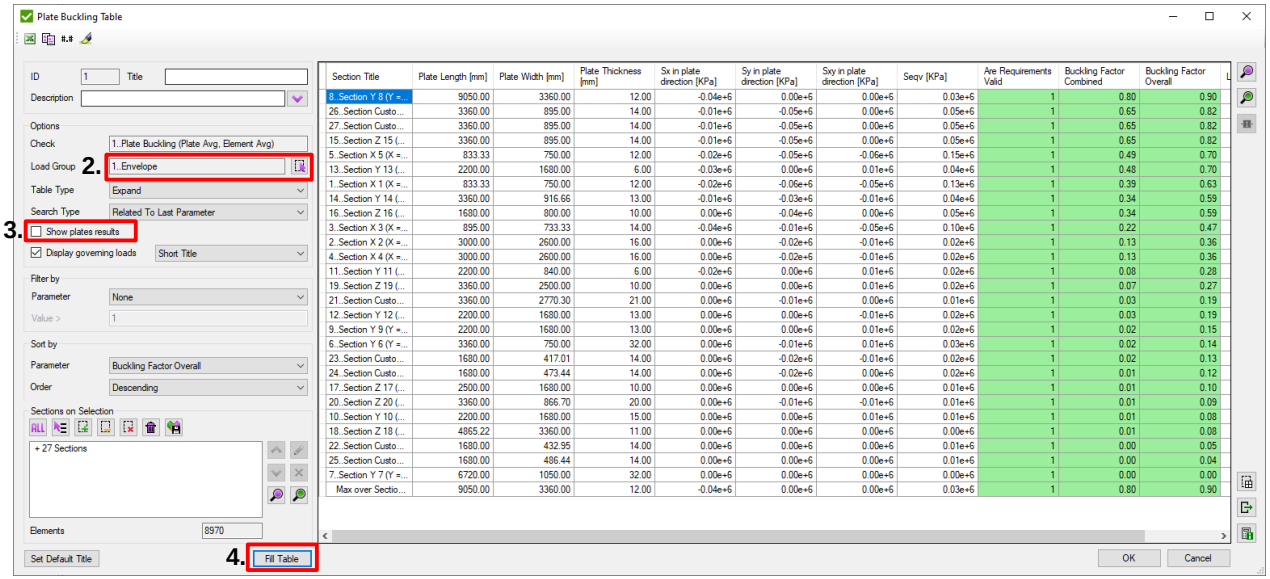


Plate Buckling Table

1. Execute *Table* from the Plate Buckling check context menu
2. Press  and select Load Group “Envelope”
3. Show plates results: **OFF**
4. Press *Fill Table.*





Section Title	Plate Length [mm]	Plate Width [mm]	Plate Thickness [mm]	Sx in plate direction [KPa]	Sy in plate direction [KPa]	Sxy in plate direction [KPa]	Seqv [KPa]	Are Requirements Valid	Buckling Factor Combined	Buckling Factor Overall
8..Section Y 8 (Y =...	9050.00	3360.00	12.00	-0.04e+6	0.00e+6	0.00e+6	0.03e+6	1	0.80	0.90
26..Section Custo...	3360.00	895.00	14.00	-0.01e+6	-0.05e+6	0.00e+6	0.05e+6	1	0.65	0.82
27..Section Custo...	3360.00	895.00	14.00	-0.01e+6	-0.05e+6	0.00e+6	0.05e+6	1	0.65	0.82
15..Section Z 15 (...	3360.00	895.00	14.00	-0.01e+6	-0.05e+6	0.00e+6	0.05e+6	1	0.65	0.82
5..Section X 5 (X =...	833.33	750.00	12.00	-0.02e+6	-0.05e+6	-0.06e+6	0.15e+6	1	0.49	0.70
13..Section Y 13 (...	2200.00	1680.00	6.00	-0.03e+6	0.00e+6	0.01e+6	0.04e+6	1	0.48	0.70
1..Section X 1 (X =...	833.33	750.00	12.00	-0.02e+6	-0.06e+6	-0.05e+6	0.13e+6	1	0.39	0.63
14..Section Y 14 (...	3360.00	916.66	13.00	-0.01e+6	-0.03e+6	-0.01e+6	0.04e+6	1	0.34	0.59
16..Section Z 16 (...	1680.00	800.00	10.00	0.00e+6	-0.04e+6	0.00e+6	0.05e+6	1	0.34	0.59
3..Section X 3 (X =...	895.00	733.33	14.00	-0.04e+6	-0.01e+6	-0.05e+6	0.10e+6	1	0.22	0.47
2..Section X 2 (X =...	3000.00	2600.00	16.00	0.00e+6	-0.02e+6	-0.01e+6	0.02e+6	1	0.13	0.36
4..Section X 4 (X =...	3000.00	2600.00	16.00	0.00e+6	-0.02e+6	-0.01e+6	0.02e+6	1	0.13	0.36
11..Section Y 11 (...	2200.00	840.00	6.00	-0.02e+6	0.00e+6	0.01e+6	0.02e+6	1	0.08	0.28
19..Section Z 19 (...	3360.00	2500.00	10.00	0.00e+6	0.00e+6	0.01e+6	0.02e+6	1	0.07	0.27
21..Section Custo...	3360.00	2770.30	21.00	0.00e+6	-0.01e+6	0.00e+6	0.01e+6	1	0.03	0.19
12..Section Y 12 (...	2200.00	1680.00	13.00	0.00e+6	0.00e+6	-0.01e+6	0.02e+6	1	0.03	0.19
9..Section Y 9 (Y =...	2200.00	1680.00	13.00	0.00e+6	0.00e+6	0.01e+6	0.02e+6	1	0.02	0.15
6..Section Y 6 (Y =...	3360.00	750.00	32.00	0.00e+6	-0.01e+6	0.01e+6	0.03e+6	1	0.02	0.14
23..Section Custo...	1680.00	417.01	14.00	0.00e+6	-0.02e+6	-0.01e+6	0.02e+6	1	0.02	0.13
24..Section Custo...	1680.00	473.44	14.00	0.00e+6	-0.02e+6	0.00e+6	0.02e+6	1	0.01	0.12
17..Section Z 17 (...	2500.00	1680.00	10.00	0.00e+6	0.00e+6	0.00e+6	0.01e+6	1	0.01	0.10
20..Section Z 20 (...	3360.00	866.70	20.00	0.00e+6	-0.01e+6	-0.01e+6	0.01e+6	1	0.01	0.09
10..Section Y 10 (...	2200.00	1680.00	15.00	0.00e+6	0.00e+6	0.01e+6	0.01e+6	1	0.01	0.08
18..Section Z 18 (...	4865.22	3360.00	11.00	0.00e+6	0.00e+6	0.00e+6	0.00e+6	1	0.01	0.08
22..Section Custo...	1680.00	432.95	14.00	0.00e+6	0.00e+6	0.00e+6	0.01e+6	1	0.00	0.05
25..Section Custo...	1680.00	486.44	14.00	0.00e+6	0.00e+6	0.00e+6	0.01e+6	1	0.00	0.04
7..Section Y 7 (Y =...	6720.00	1050.00	32.00	0.00e+6	0.00e+6	0.00e+6	0.00e+6	1	0.00	0.00
Max over Sectio...	9050.00	3360.00	12.00	-0.04e+6	0.00e+6	0.00e+6	0.03e+6	1	0.80	0.90

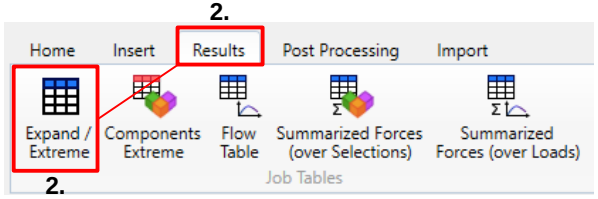
Use **Show plates results** for detailed table with results for all plates. Otherwise only the worst results over Sections will be shown.

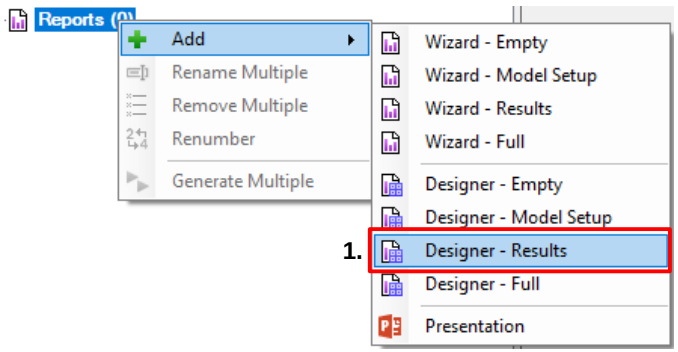
All results (dimensions, stresses) are from the plate which causes higher BF = 0.47 because Search Type = Related to Last Parameter

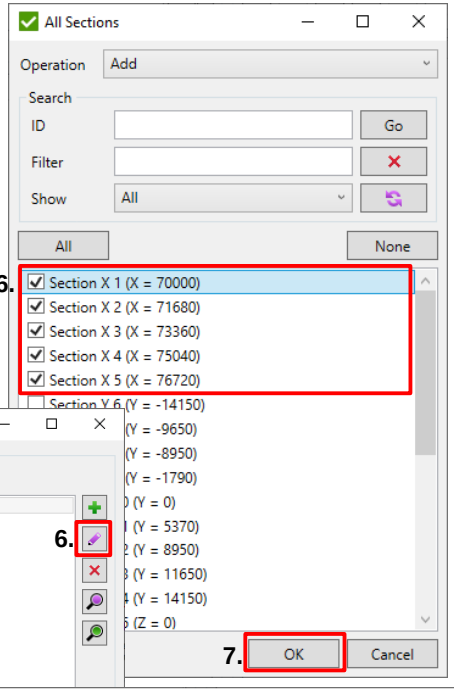
Section Title	Plate Length [mm]	Plate Width [mm]	Plate Thickness [mm]	Sx in plate direction [KPa]	Sy in plate direction [KPa]	Sxy in plate direction [KPa]	Seqv [KPa]	Are Requirements Valid	Buckling Factor Combined	Buckling Factor Overall
1..Section X 1 (X = 70000)	833.33	750.00	12.00	-0.02e+6	-0.06e+6	-0.05e+6	0.13e+6	1	0.39	0.63
2..Section X 2 (X = 71680)	3000.00	2600.00	16.00	0.00e+6	-0.02e+6	-0.01e+6	0.02e+6	1	0.13	0.36
3..Section X 3 (X = 73360)	895.00	733.33	14.00	-0.04e+6	-0.01e+6	-0.05e+6	0.10e+6	1	0.22	0.47
Max over Sections [X 1 / 2]	833.33	750.00	12.00	-0.02e+6	-0.06e+6	-0.05e+6	0.13e+6	1	0.39	0.63

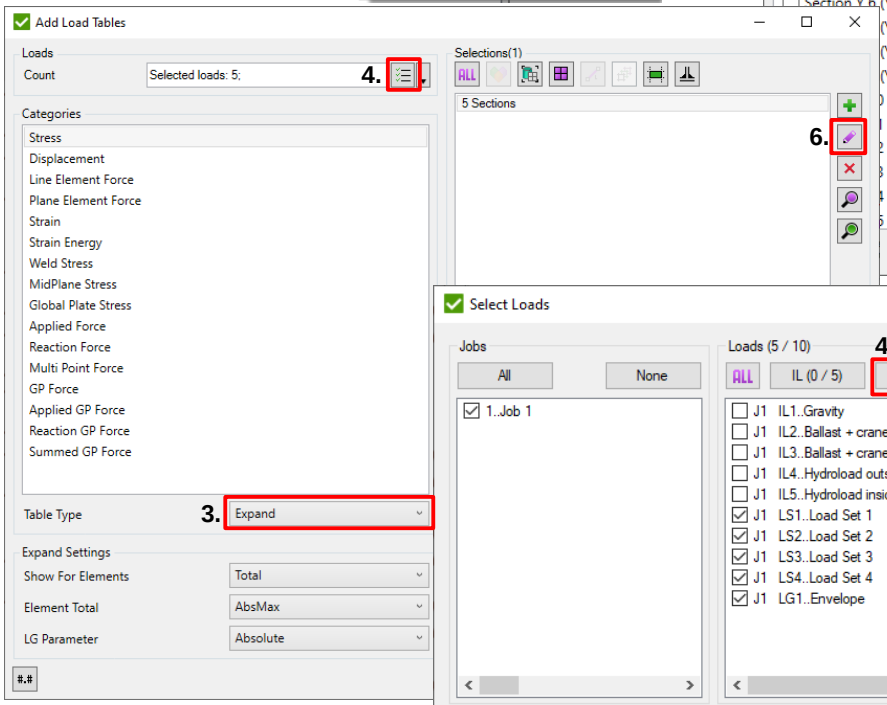
Report. Tables

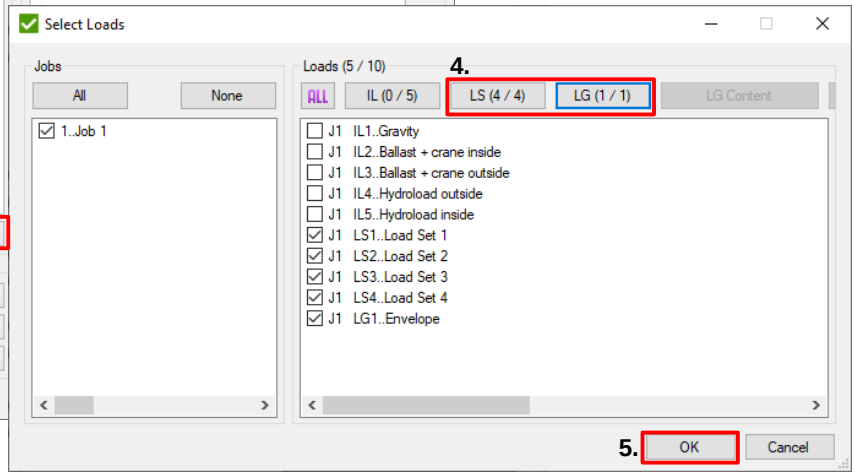
1. Execute *Reports => Add => Designer-Results.*
2. *Select Results* - Expand/Extreme *Tables.*
3. Type: **Expand**
4. Press  and select **LS**; **LG** loads.
5. Press *OK*
6. Press  *and select all X Sections*
7. Press *OK*







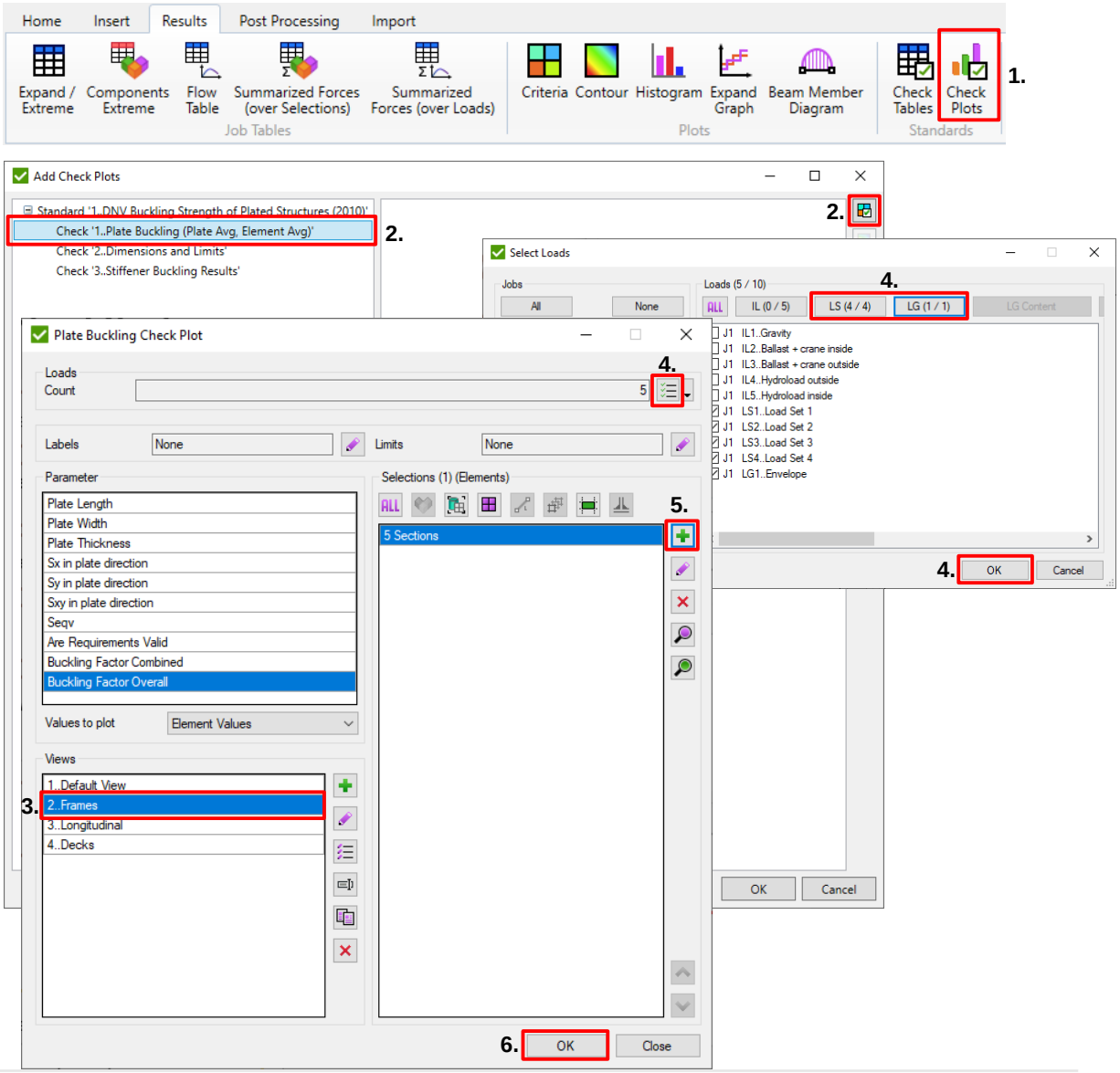




Report. Plots

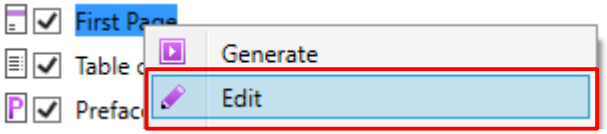
1. Select Check Plots *on Toolbar*
2. Select **Check 1 Plate Buckling** and press
3. Views: **Frames**
4. Press , select **LS**; **LG** Loads and Press *OK*.
5. Press *and select* all **X sections**.
6. Press *OK*.

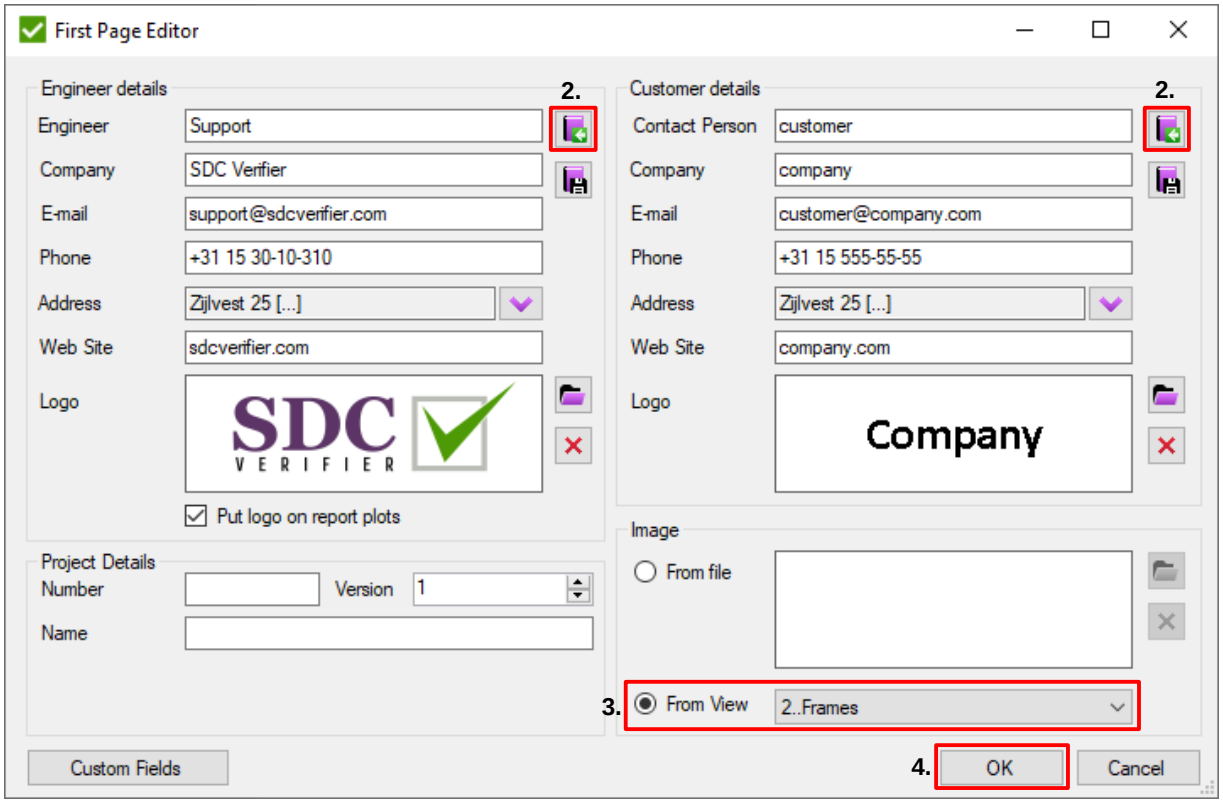
Repeat steps 1-5 for Sections Y with Longitudinals View and Sections Z with Decks View



Report. First Page

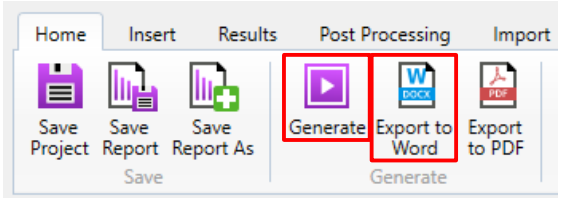
1. Right click on *First Page => Edit.*
2. Press to fill in information about project.
3. Select Image *From View* and pick '*2..Frames*'.
4. Press *OK*.



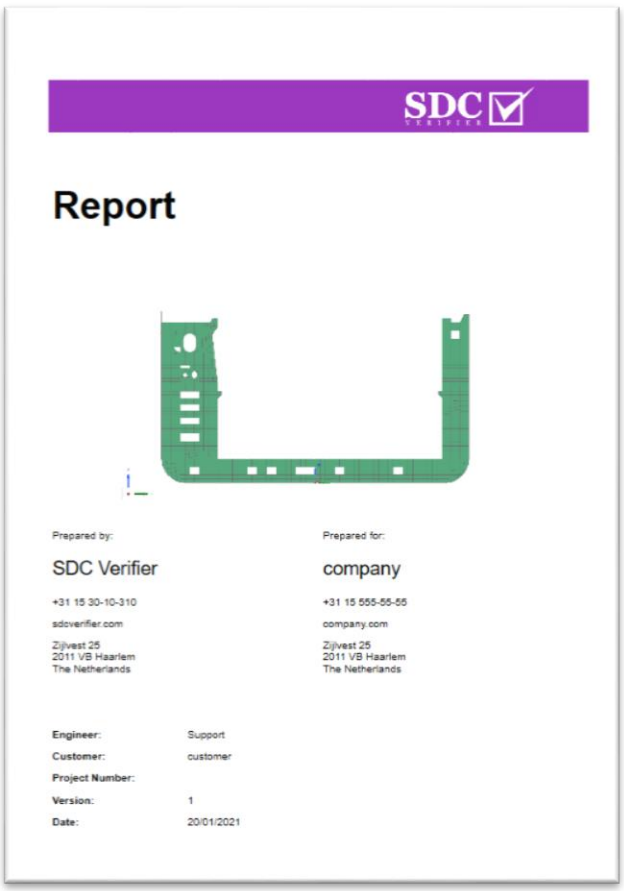


Report

Press to generate complete report.



Press to export to Word.



SDC VERIFIER

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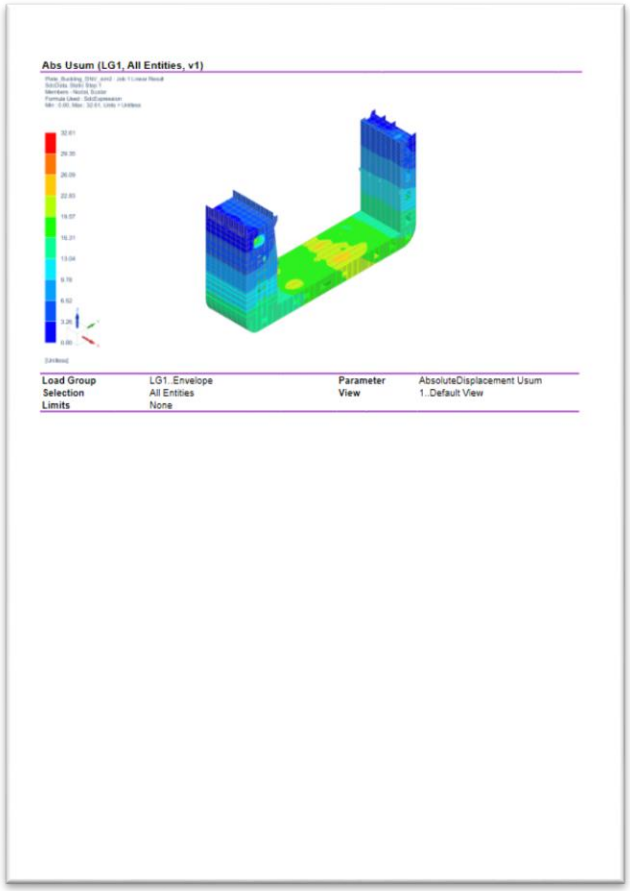
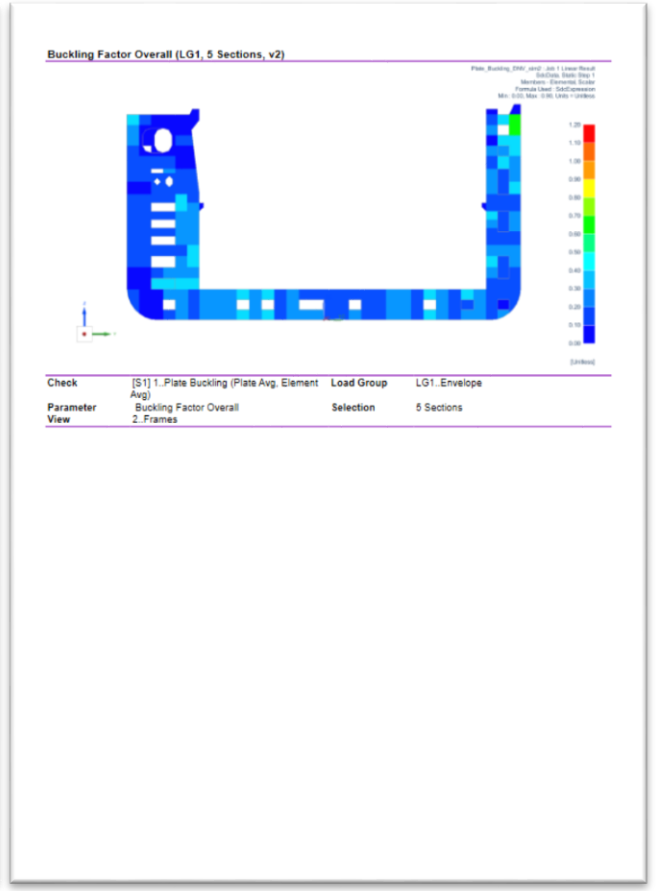
Engineer:	Support
Customer:	customer
Project Number:	
Version:	1
Date:	20/01/2021



Abs Usum (LG1, All Entities, v1)

Load Group	LG1..Envelope	Parameter	AbsoluteDisplacement Usum
Selection	All Entities	View	1..Default View
Limits	None		



Buckling Factor Overall (LG1, 5 Sections, v2)

Check	[S1] 1..Plate Buckling (Plate Avg, Element Avg)	Load Group	LG1..Envelope
Parameter	Buckling Factor Overall	Selection	5 Sections
View	2..Frames		