



Tutorial

Plate Buckling DNV

20.10.2017
version 4.7

- ▶ 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.

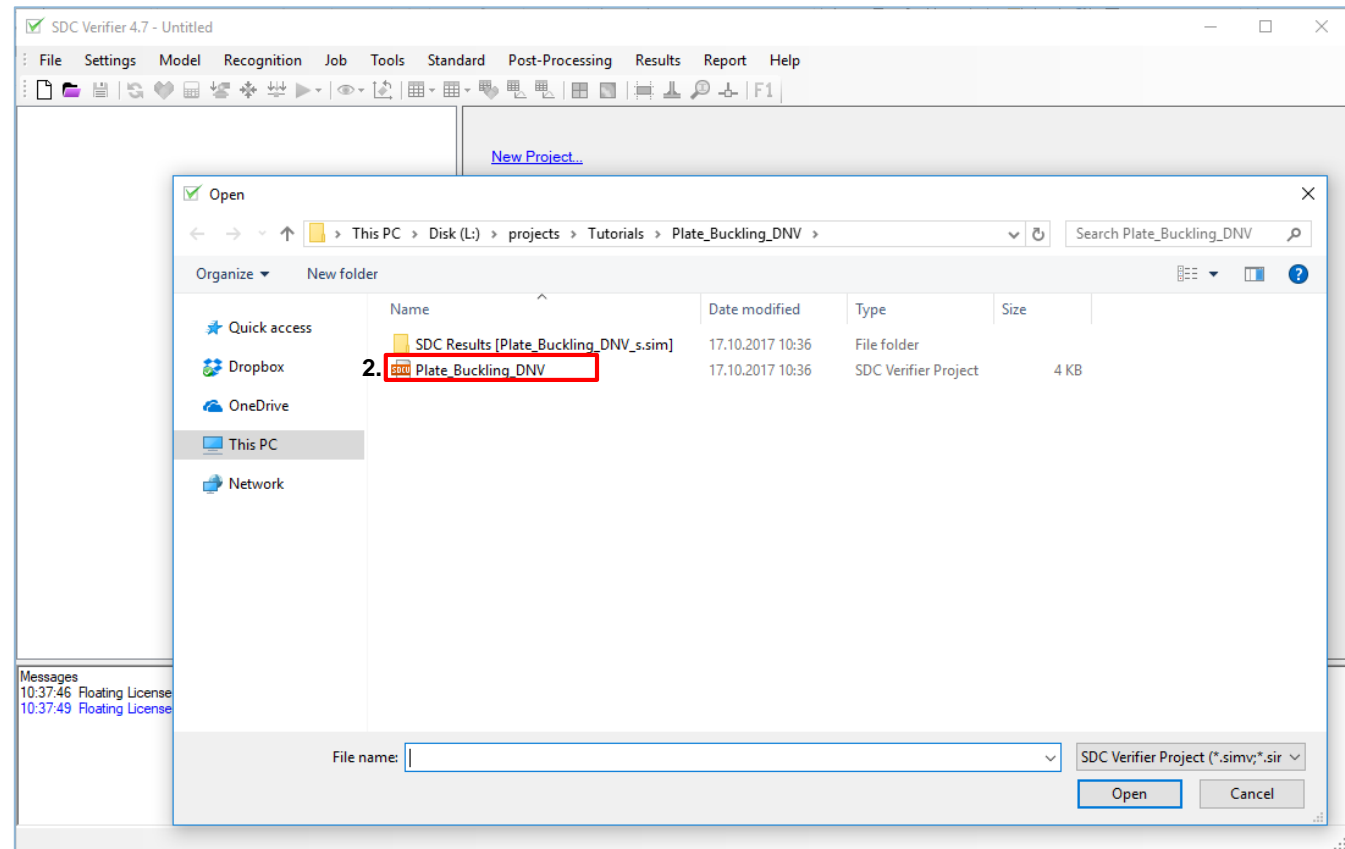
Open Project

1

Launch **SDC Verifier** 

2

Open project *Plate_Buckling_DNV* from the directory *Tutorials/Plate_Buckling_DNV*.



Individual Loads

1

Click on *Individual Loads*.

2


Select 5 *FEM Loads*:

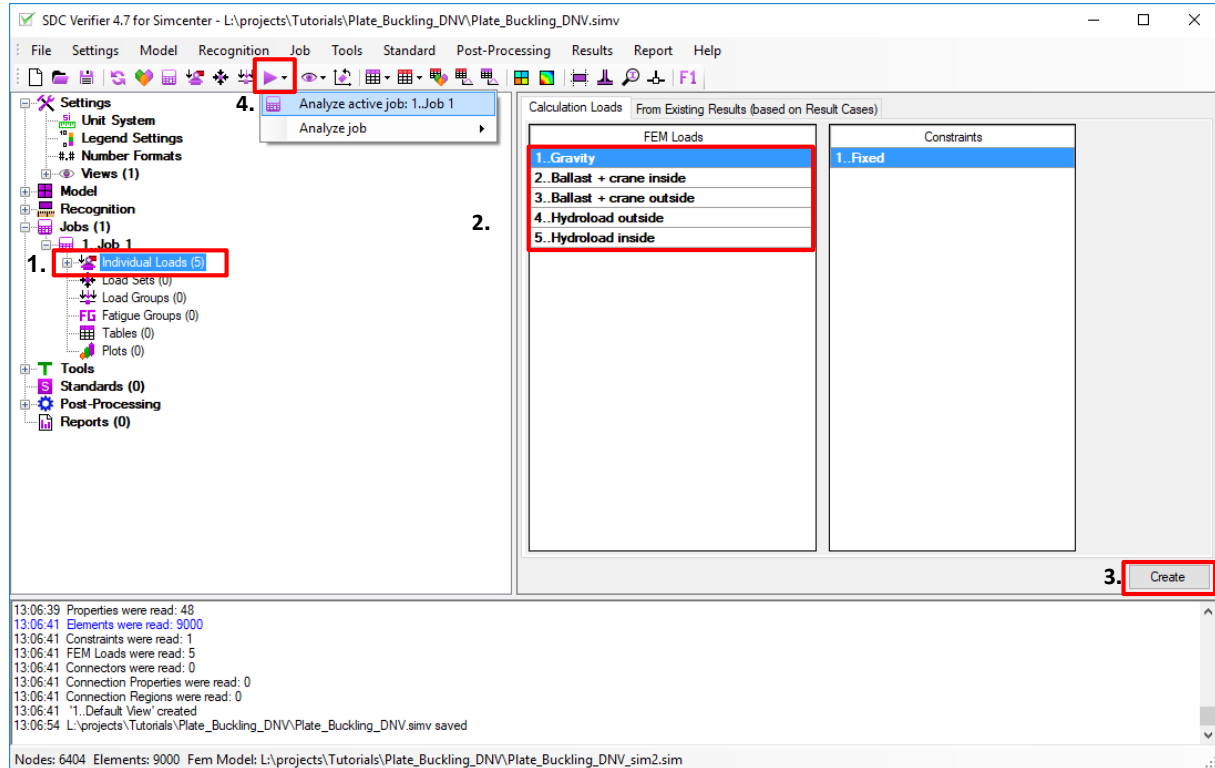
1. Gravity;
2. Ballast + crane inside;
3. Ballast + crane outside;
4. Hydroload outside;
5. Hydroload inside.

4

Press *Create* to create 5 Individual Loads.

5

Press  on toolbar and “*Analyze active job: 1..Job 1*”




Load Sets

1

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

2

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

3

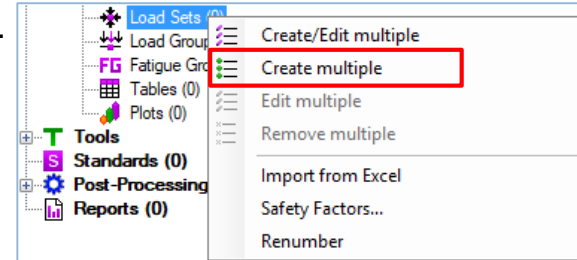
Select highlighted cells in the table like shown on the picture and press *Set* to define Factors of Load Sets. (By default LS Factor is 1)

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.

1.




2.

✓ Add Load Sets

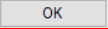

	Safety Factor	IL1..Gravity	IL2..Ballast + crane inside	IL3..Ballast + crane outside	IL4..Hydroload outside	IL5..Hydroload inside
Load Set 1	1	1	1			
Load Set 2	1	1		1		
Load Set 3	1	1			1	
Load Set 4	1	1				1

3.

Factor 1 

Clipboard
Copy Paste

Selected Rows
Copy Remove


4.  

Load Groups

1

Click on *Load Groups*.

2

Press  to select all Load Sets.

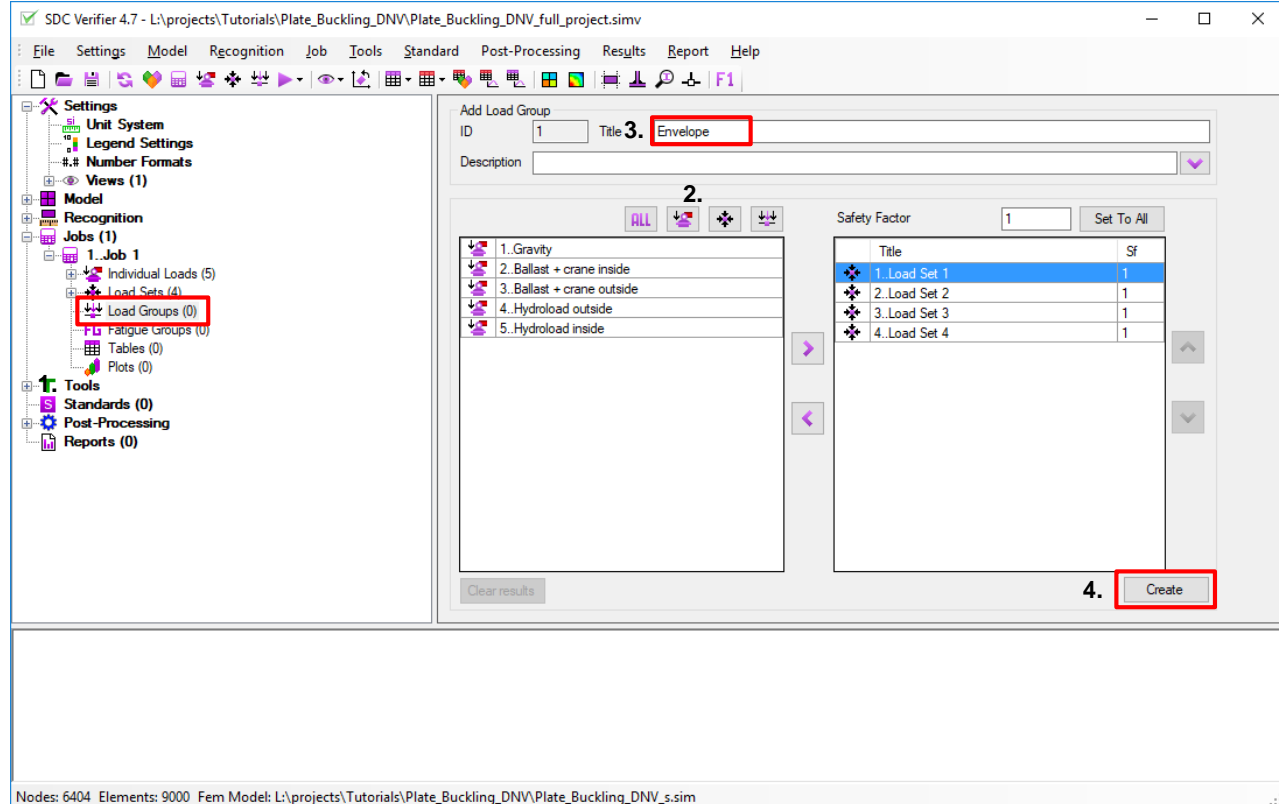
3

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*.

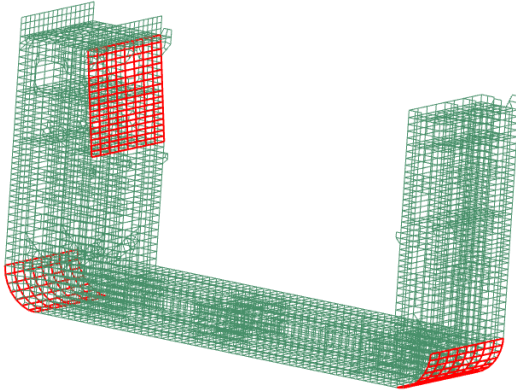
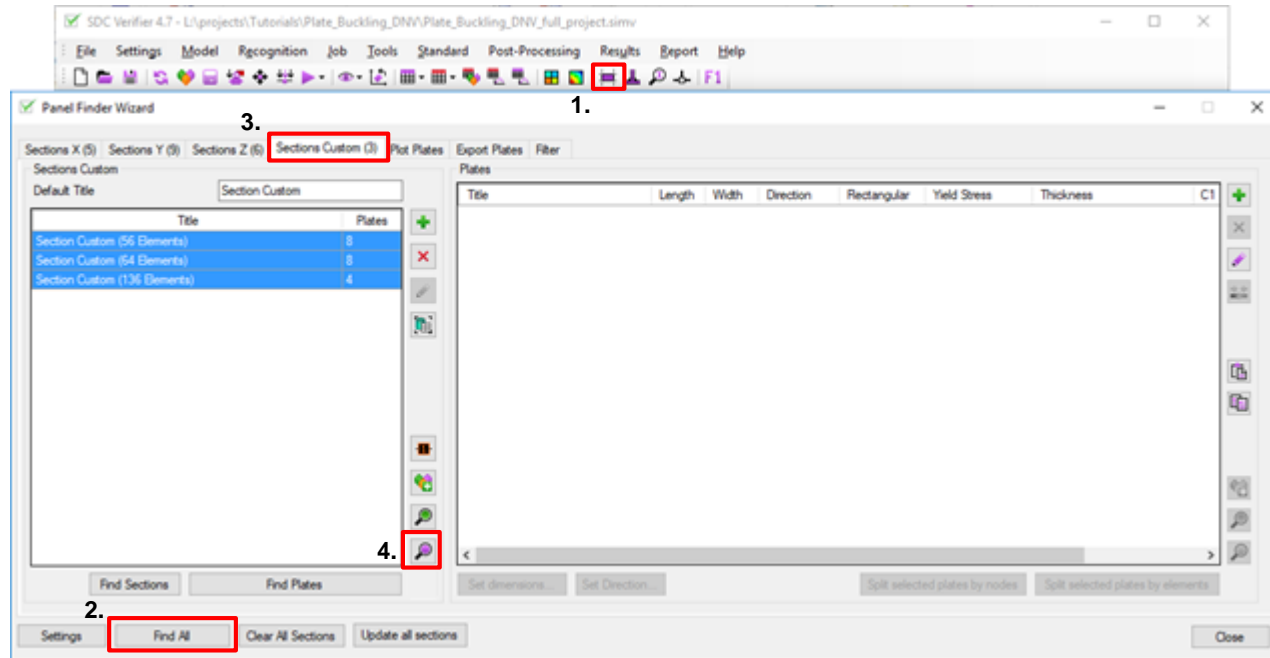
All sections were recognized and plates were analyzed automatically on the model.

3

Select *Sections 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

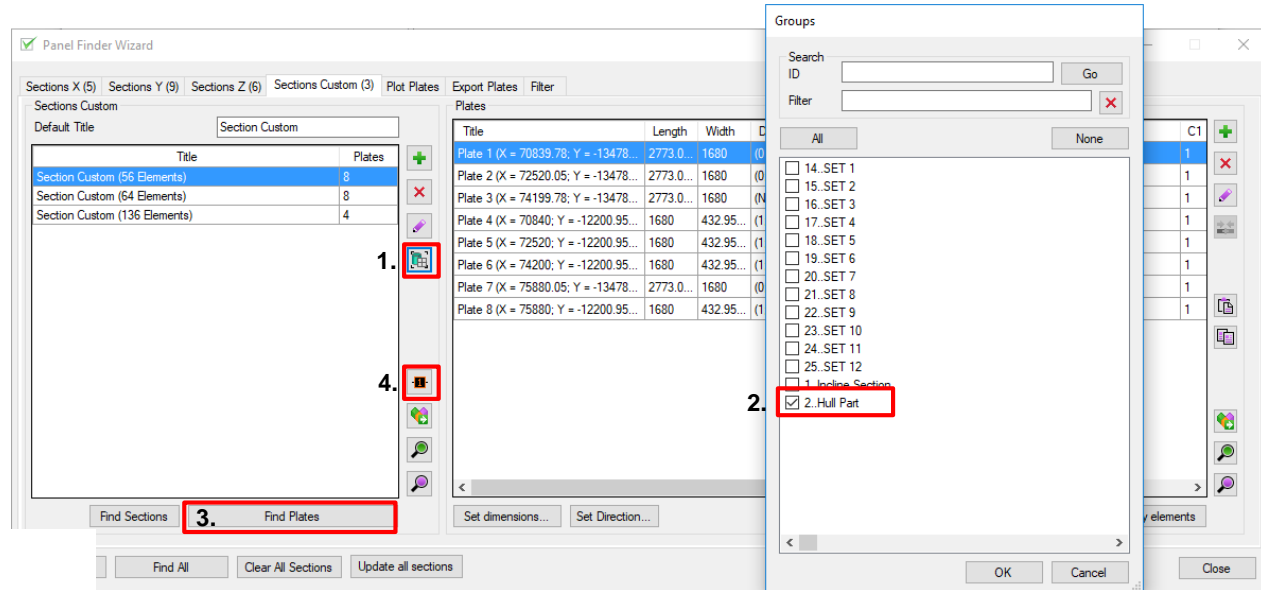
Select group '2..Hull Part'

3

Press *Find Plates*

4

Press *plot all plates with labels of IDs* 



Example: Recognized plates in colors of the hull of the full ship.

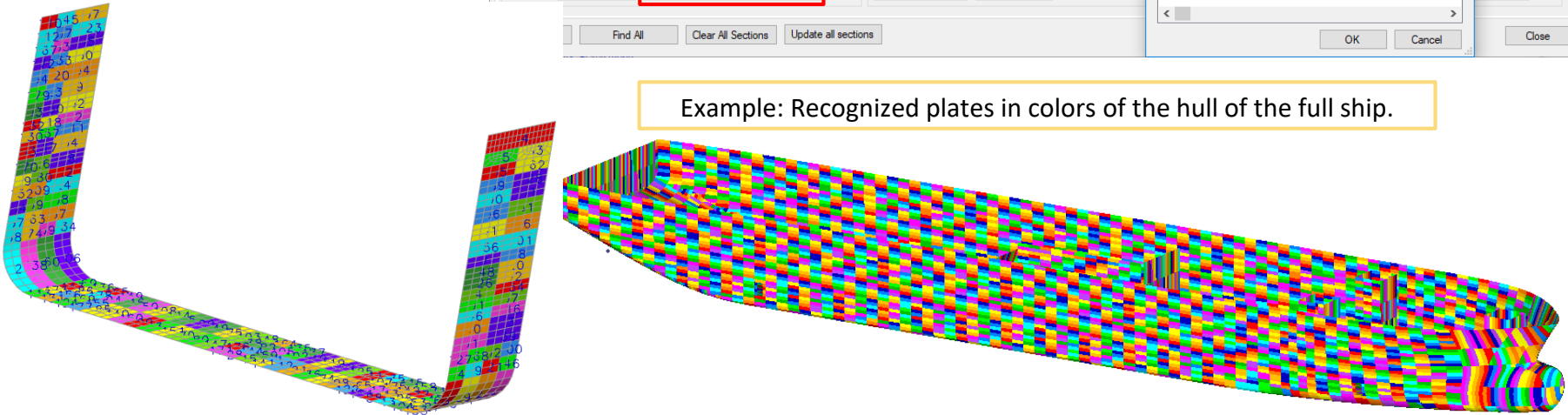


Plate Dimensions and Thicknesses

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:

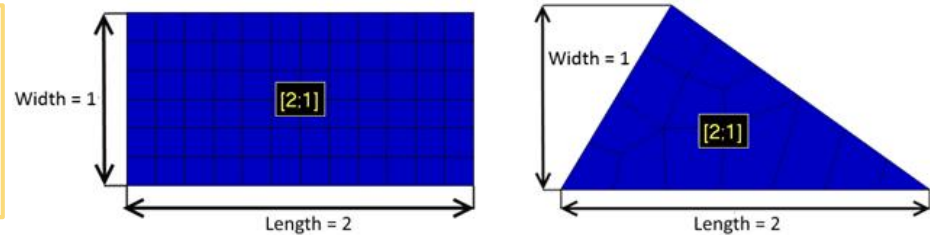
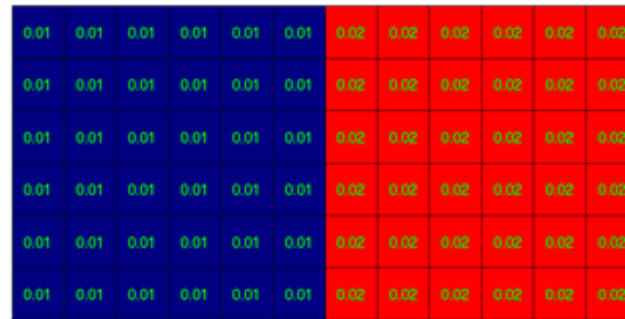
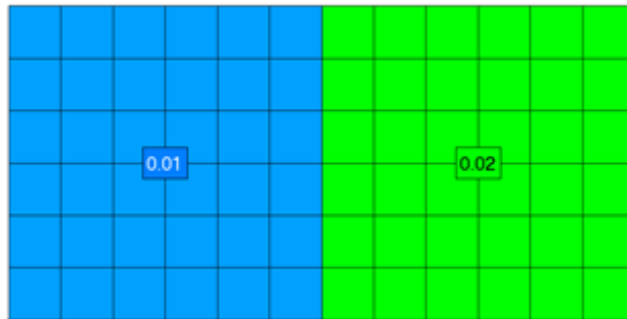


Plate Thickness: the calculations are performed on every element and thickness is taken directly from each element. It is possible to set thickness manually for a plate, in this case, the element thickness will be ignored and the user defined thickness will be used.

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:



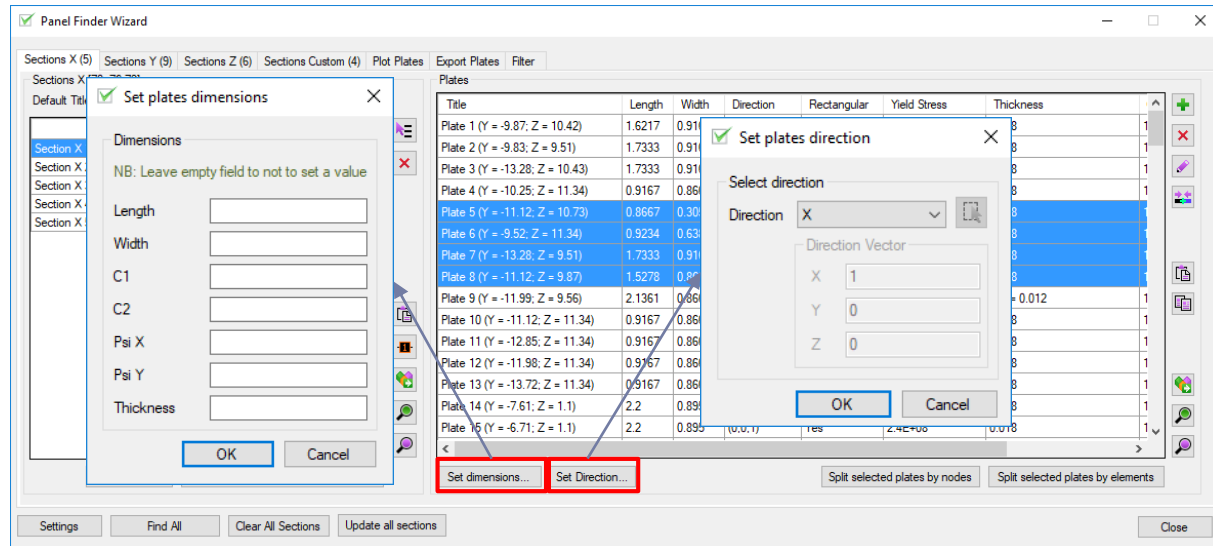
Editing plates manually

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:

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

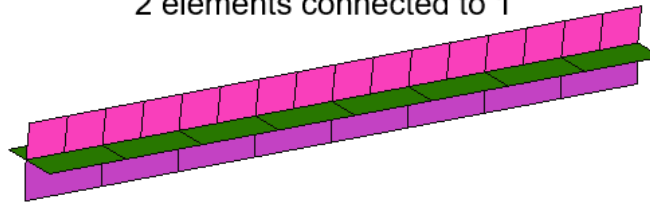
Usually, the plate directions should not be modified. But in case it is required, press *Set Direction*.

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).

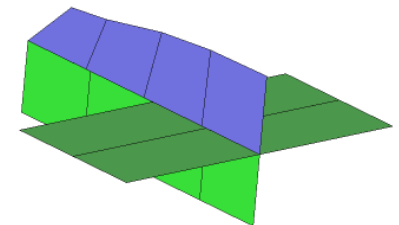


Incorrect plate dimensions/direction, plates with undefined dimensions and as result incorrect buckling factor – possible consequences of the free edges.

2 elements connected to 1

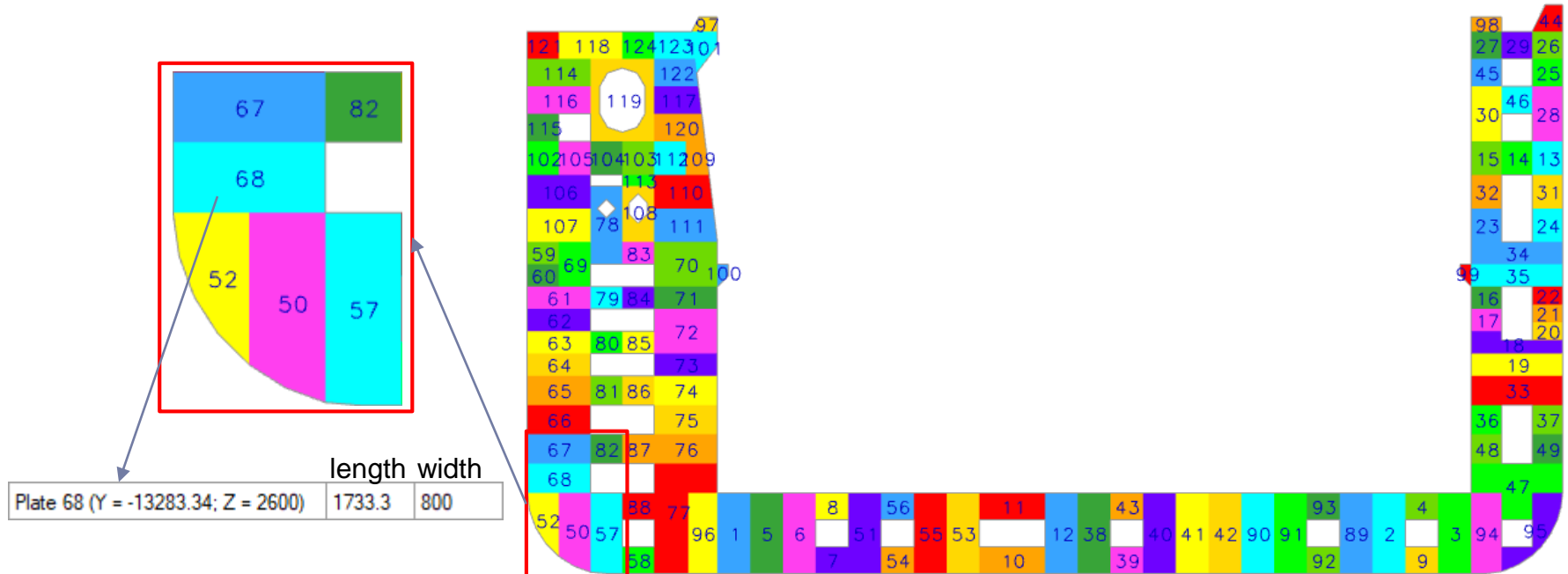
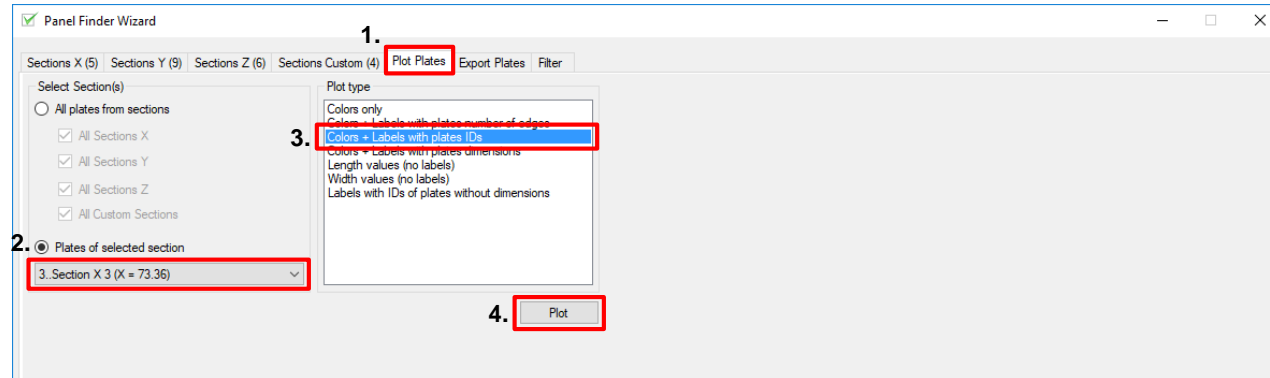


Mesh does not coincide



Panel Finder. Plates Plot

- 1 Press *Plot Plates* tab.
- 2 Select **Section X3**.
- 3 Pick *Colors + Labels with plates IDs*.
- 4 Click on *Plot*.



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

Plate IDs

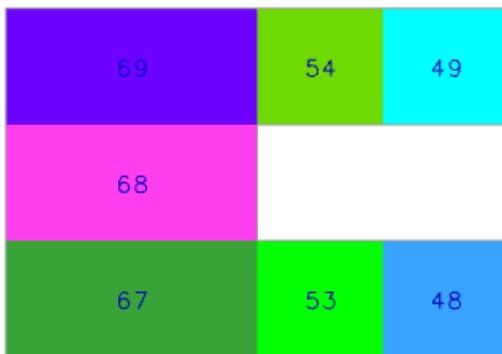


Plate dimensions

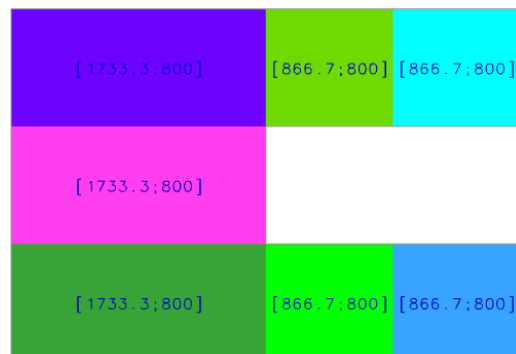
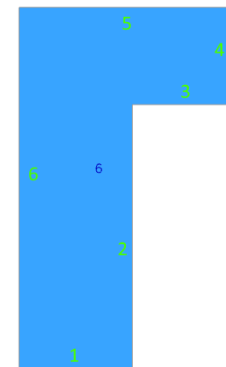
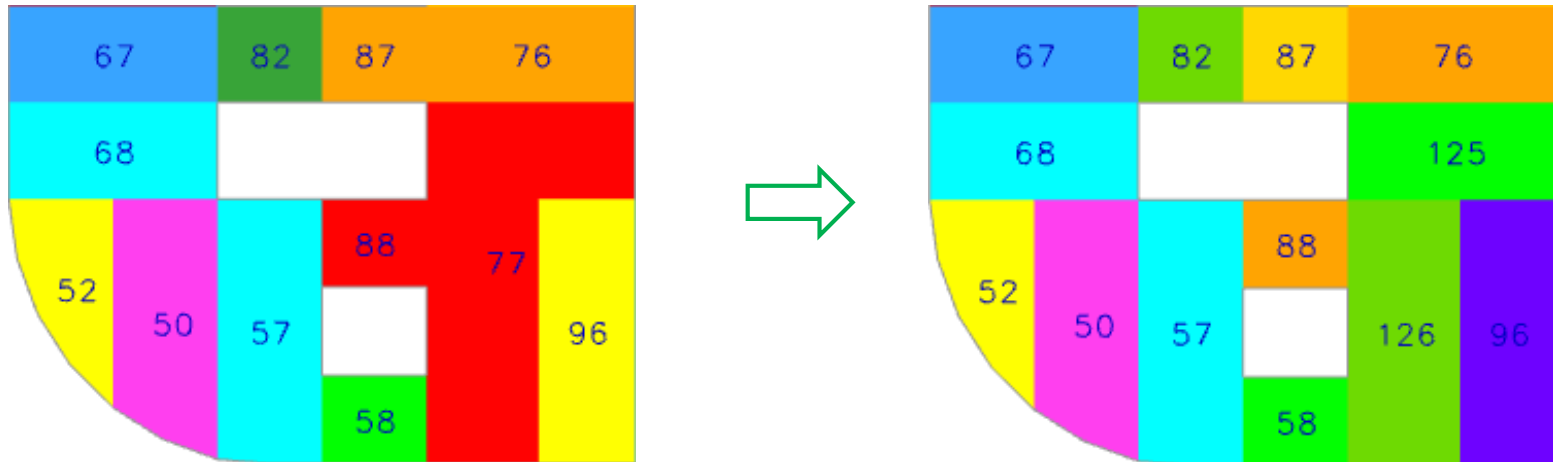


Plate # of edges



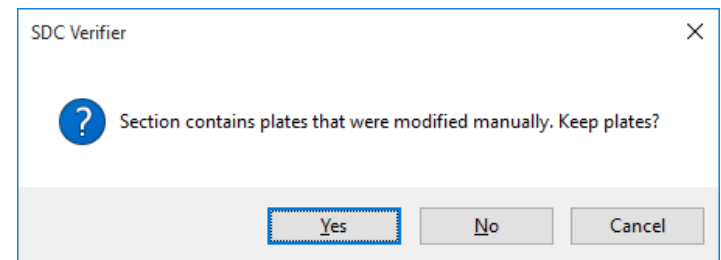
Panel Finder. Update Plates

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 = 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. Split Plate

1

Select **Section X 3 (X = 73.36)**.

2

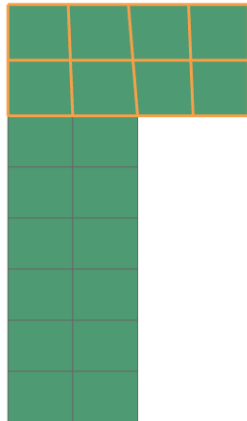
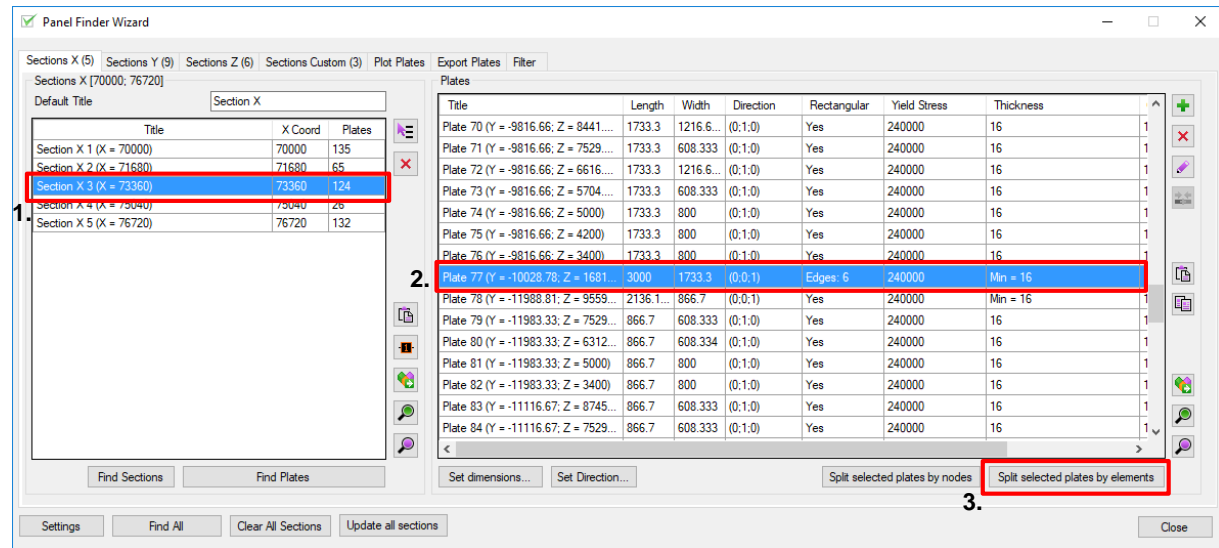
Select **Plate 77**.

3

Press **Split** selected plates by elements

4

Selected plate is displayed. Select elements for one plate and press **OK**.

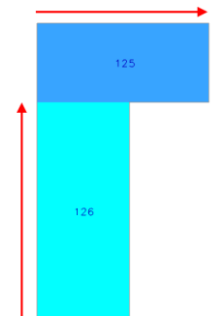


The plate 77 is replaced with the Plates 125 and 126. Dimensions and directions are updated automatically.

Title	Length	Width	Direction
Plate 77 (Y = -10028.78; Z = 1681...	3000	1733.3	(0;0;1)



Title	Length	Width	Direction
Plate 125 (Y = -9803.33; Z = 2600)	1733.3	800	(0;1;0)
Plate 126 (Y = -10216.67; Z = 1100)	2200	933.3	(0;0;1)



Panel Finder. Export Plates

1

Select *Export Plates* tab.

2

All Sections X: **ON**.

3

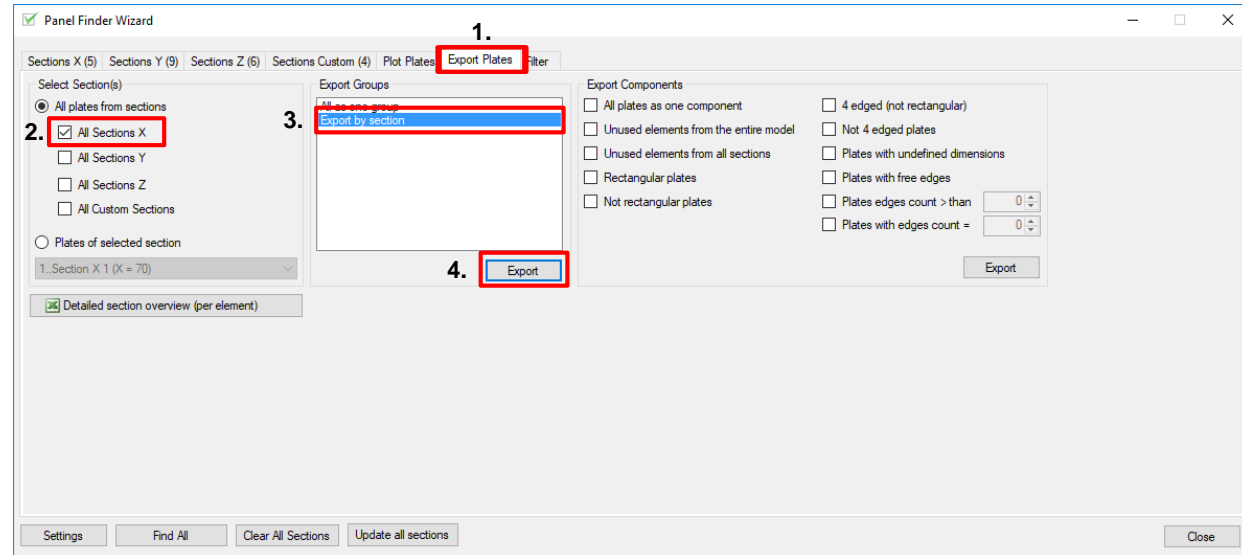
Pick *Export by section*.

4

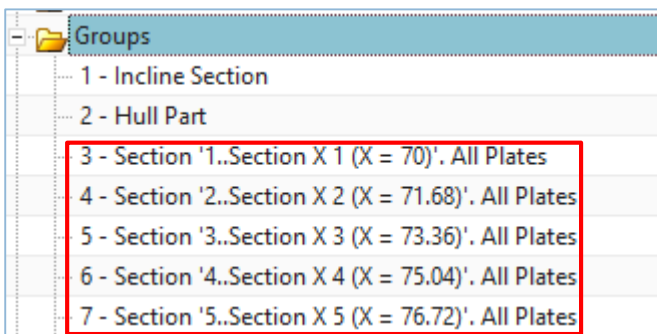
Click *Export*.

5

5 Groups will be created for 5 Sections .



5.



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 **All plates from sections**

3

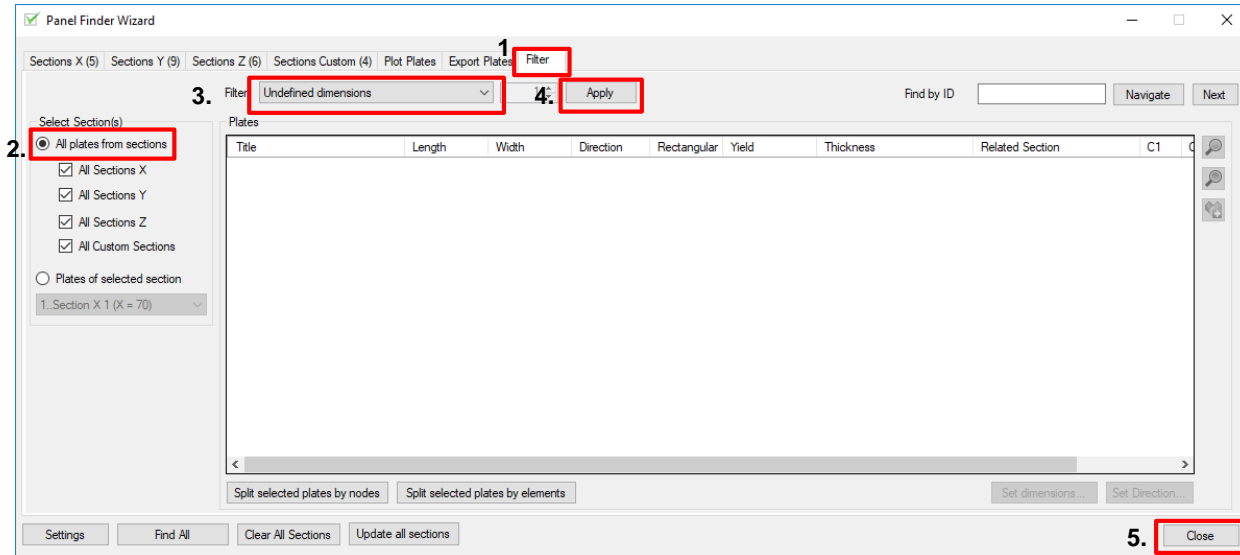
Filter: **Undefined dimensions**

4

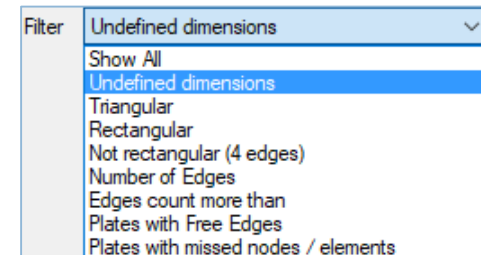
Press *Apply*.

5

Table with plates is empty means that there are no plates with undefined dimensions. Press *Close*.



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.
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 => Plate Buckling DNV RP-C-201 2010*.

2 Resulting Material Factor = **1.15**

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 increasing thickness on 20% and decreasing stresses

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.

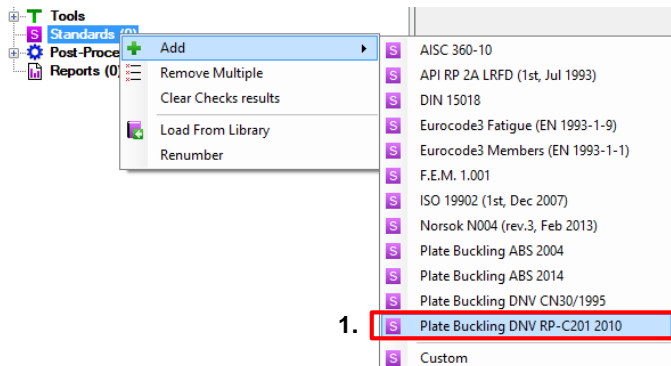
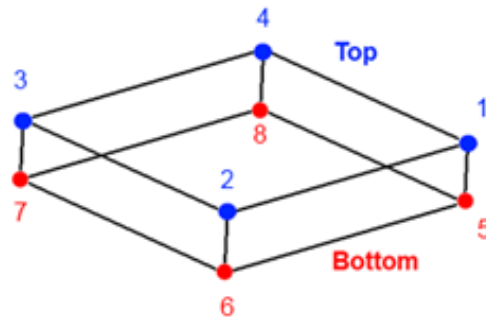


Plate Buckling transforms stresses automatically into plate direction.

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:

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

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

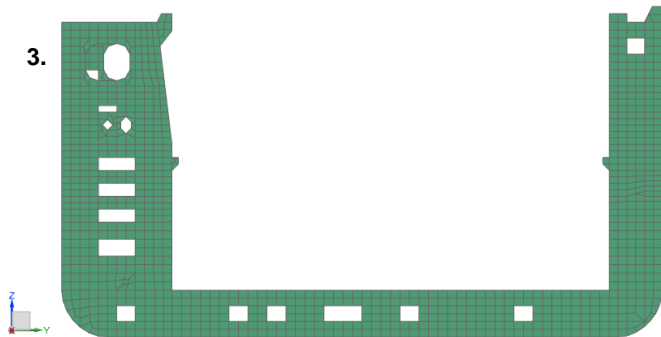
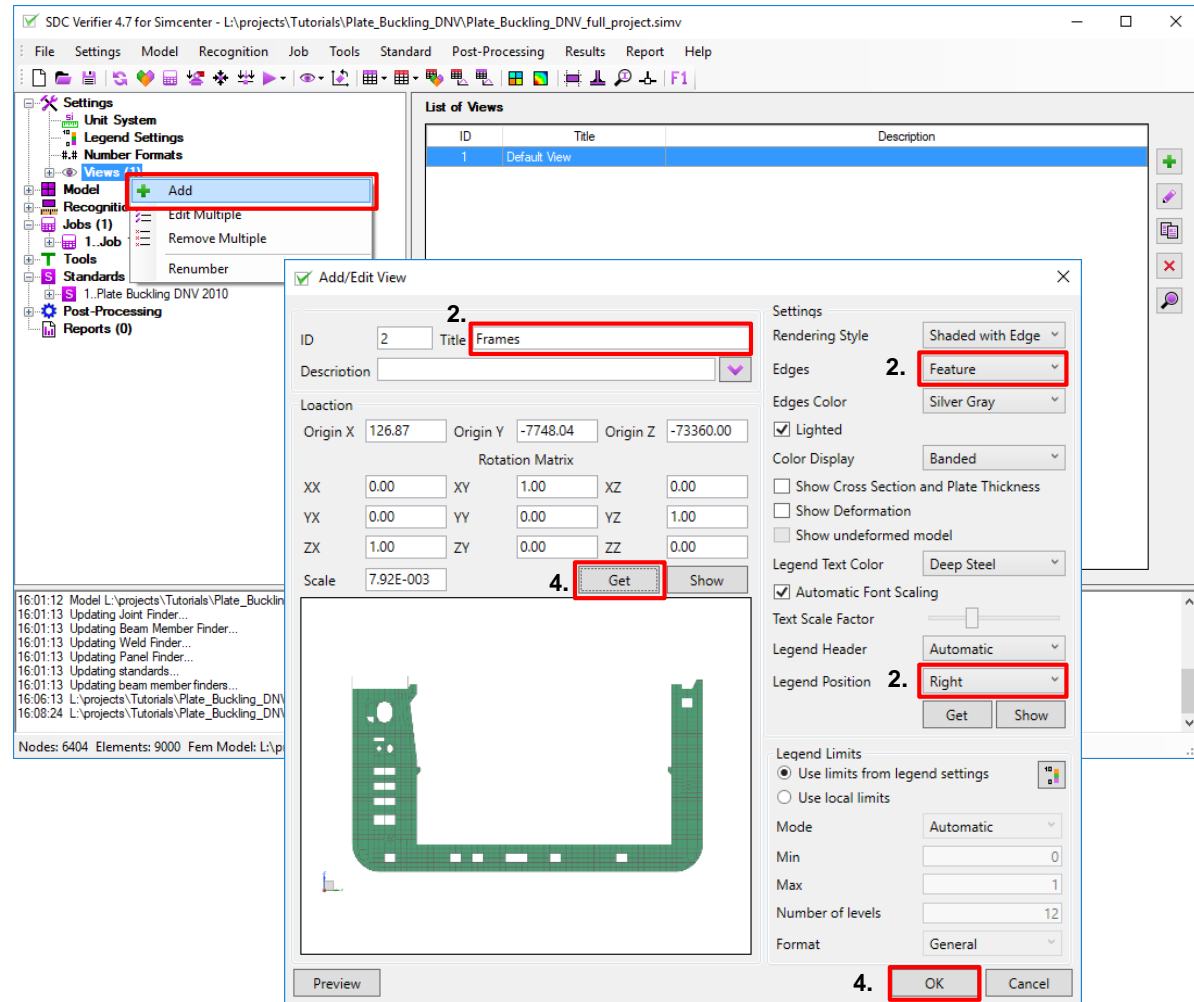
2. Title: **Frames**
Edges: **Feature**
Legend Position: **Right**

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).

1.




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

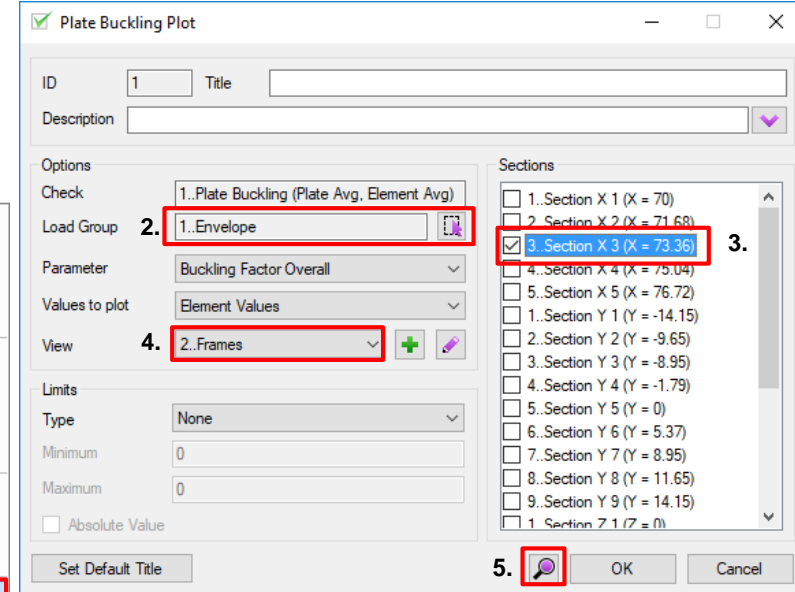
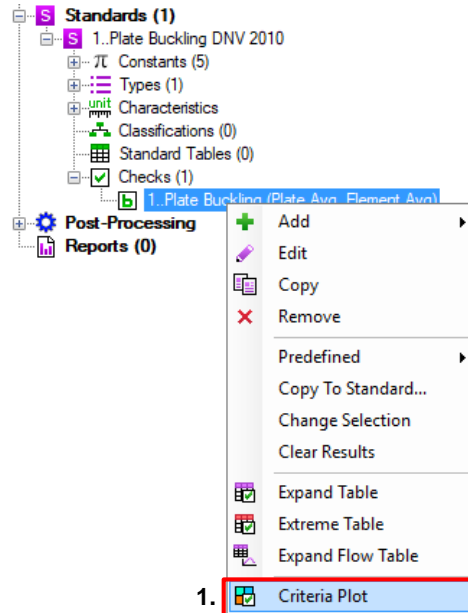
Select **Section X3**.

4

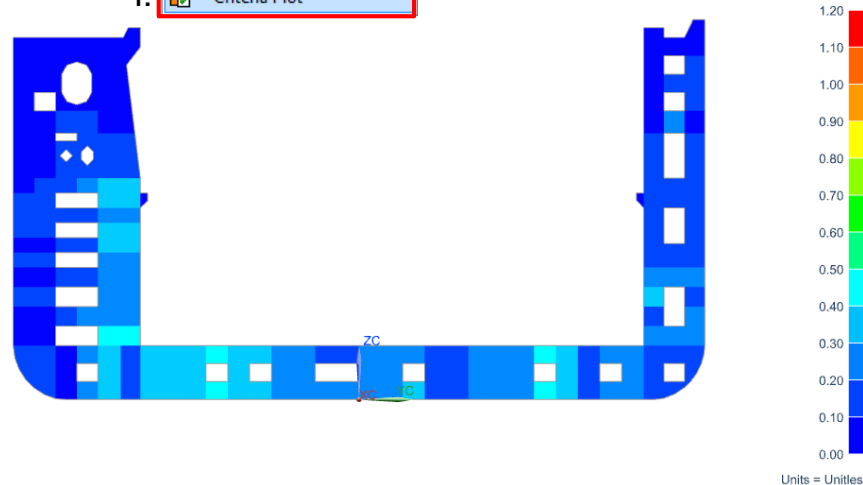
View: **Frames**

5

Press 




Parameter is automatically set to Buckling Factor Overall.



Units = Unitless

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*.

Expand Table

ID: 1 Title:

Description:

Options

Check: 1. Plate Buckling (Plate Avg. Element Avg)

Load Group: 2. Envelope

Selection: 24 sections

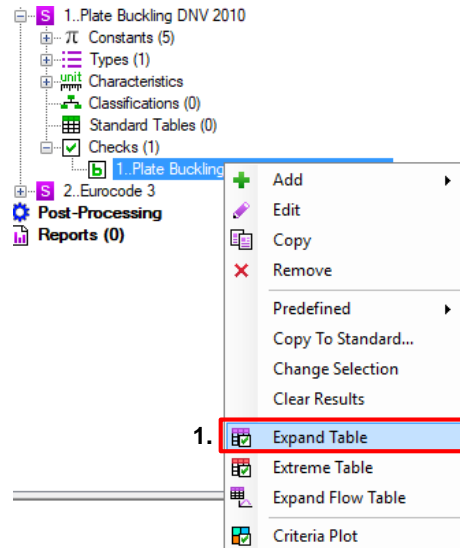
Search Type: Related To Last Parameter

☐ Show plates results

☐ Show only when last parameter > 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
4. Section X 4 (X = 75040) [MaxID=7]	3000.00	2600.00	16.00	0.00e+6	-0.02e+6	-0.01e+6	0.02e+6	0.12	0.34
5. Section X 5 (X = 76720) [MaxID=41]	833.33	750.00	12.00	-0.02e+6	-0.05e+6	-0.06e+6	0.11e+6	0.27	0.52
1. Section Y 1 (Y = -14150) [MaxID=36]	3360.00	916.67	21.00	0.00e+6	-0.01e+6	0.01e+6	0.01e+6	0.01	0.12
2. Section Y 2 (Y = -9650) [MaxID=1]	6720.00	1050.00	32.00	0.00e+6	0.00e+6	0.00e+6	0.00e+6	0.00	0.00
3. Section Y 3 (Y = -8950) [MaxID=2]	9050.00	3360.00	12.00	-0.04e+6	0.00e+6	0.00e+6	0.03e+6	0.79	0.89
4. Section Y 4 (Y = -1790) [MaxID=1]	2200.00	1680.00	13.00	0.00e+6	0.00e+6	0.01e+6	0.02e+6	0.02	0.15
5. Section Y 5 (Y = 0) [MaxID=1]	2200.00	1680.00	15.00	0.00e+6	0.00e+6	0.01e+6	0.01e+6	0.01	0.08
6. Section Y 6 (Y = 5370) [MaxID=1]	2200.00	840.00	6.00	-0.02e+6	0.00e+6	0.01e+6	0.02e+6	0.07	0.26
7. Section Y 7 (Y = 8950) [MaxID=2]	2200.00	1680.00	13.00	0.00e+6	0.00e+6	0.02e+6	0.03e+6	0.03	0.18
8. Section Y 8 (Y = 11650) [MaxID=14]	2200.00	1680.00	6.00	-0.03e+6	0.00e+6	0.01e+6	0.03e+6	0.48	0.69
9. Section Y 9 (Y = 14150) [MaxID=18]	3360.00	916.66	13.00	-0.01e+6	-0.03e+6	-0.01e+6	0.03e+6	0.34	0.59
1. Section Z 1 (Z = 0) [MaxID=17]	3360.00	895.00	14.00	-0.01e+6	-0.05e+6	0.00e+6	0.05e+6	0.65	0.82
2. Section Z 2 (Z = 2200) [MaxID=17]	1680.00	800.00	10.00	0.00e+6	-0.04e+6	0.00e+6	0.04e+6	0.31	0.55
3. Section Z 3 (Z = 9050) [MaxID=6]	2500.00	1680.00	10.00	0.00e+6	0.00e+6	0.00e+6	0.01e+6	0.01	0.08
4. Section Z 4 (Z = 11800) [MaxID=2]	4865.22	3360.00	11.00	0.00e+6	0.00e+6	0.00e+6	0.00e+6	0.01	0.08
5. Section Z 5 (Z = 13300) [MaxID=1]	3360.00	2500.00	10.00	0.00e+6	0.00e+6	0.01e+6	0.02e+6	0.07	0.27
6. Section Z 6 (Z = 14800) [MaxID=21]	3360.00	866.70	20.00	0.00e+6	-0.01e+6	-0.01e+6	0.01e+6	0.01	0.09
1. Section Custom (56 Elements) [MaxID=1]	2773.01	1680.00	14.00	0.00e+6	0.00e+6	0.00e+6	0.00e+6	0.00	0.04

4. 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 Report Designer => Results.

2

Plate Buckling check context menu in model tree => Expand/Extreme Tables.

3

Type: **Expand**

4

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

5

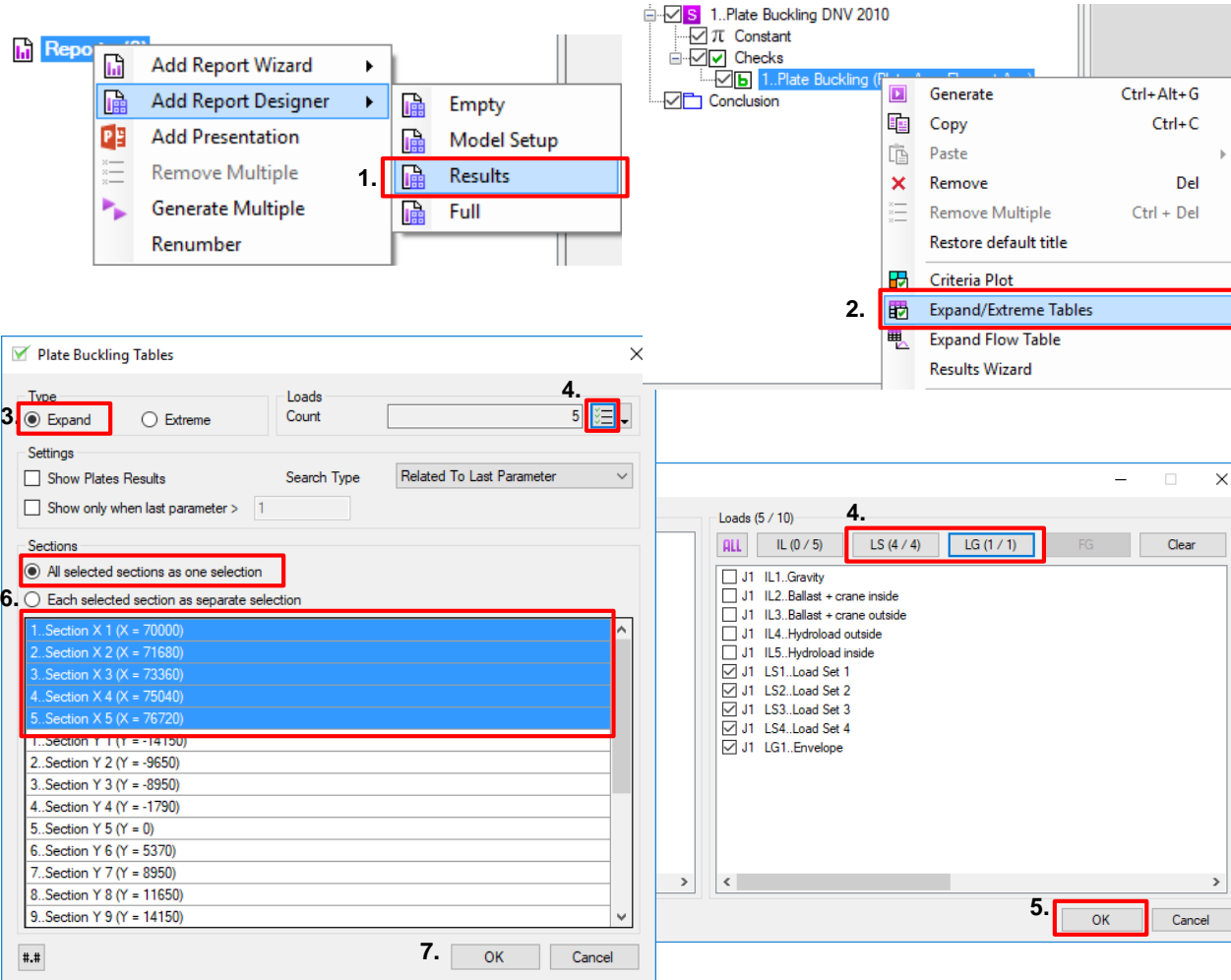
Press **OK**

6

Select **All selected sections as one selection** and select all **X Sections**.

7

Press **OK**



The screenshot illustrates the process of generating and expanding report tables in SDC Verifier. It shows the following steps:


- Report Wizard:** The 'Add Report Designer' menu is open, and the 'Results' option is selected.
- Context Menu:** The 'Expand/Extreme Tables' option is selected from the context menu for the '1..Plate Buckling DNV 2010' check.
- Plate Buckling Tables Dialog:** The 'Type' is set to 'Expand', and the 'Loads Count' is set to 5.
- Sections Selection:** The 'All selected sections as one selection' radio button is selected, and the 'X Sections' are highlighted in the list.
- Loads Selection:** The 'LS (4 / 4)' and 'LG (1 / 1)' load sets are selected in the 'Loads (5 / 10)' dialog.
- Final Confirmation:** The 'OK' button is pressed to generate the report.

Report. Plots

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

2 Parameter: **Buckling Factor Overall**.

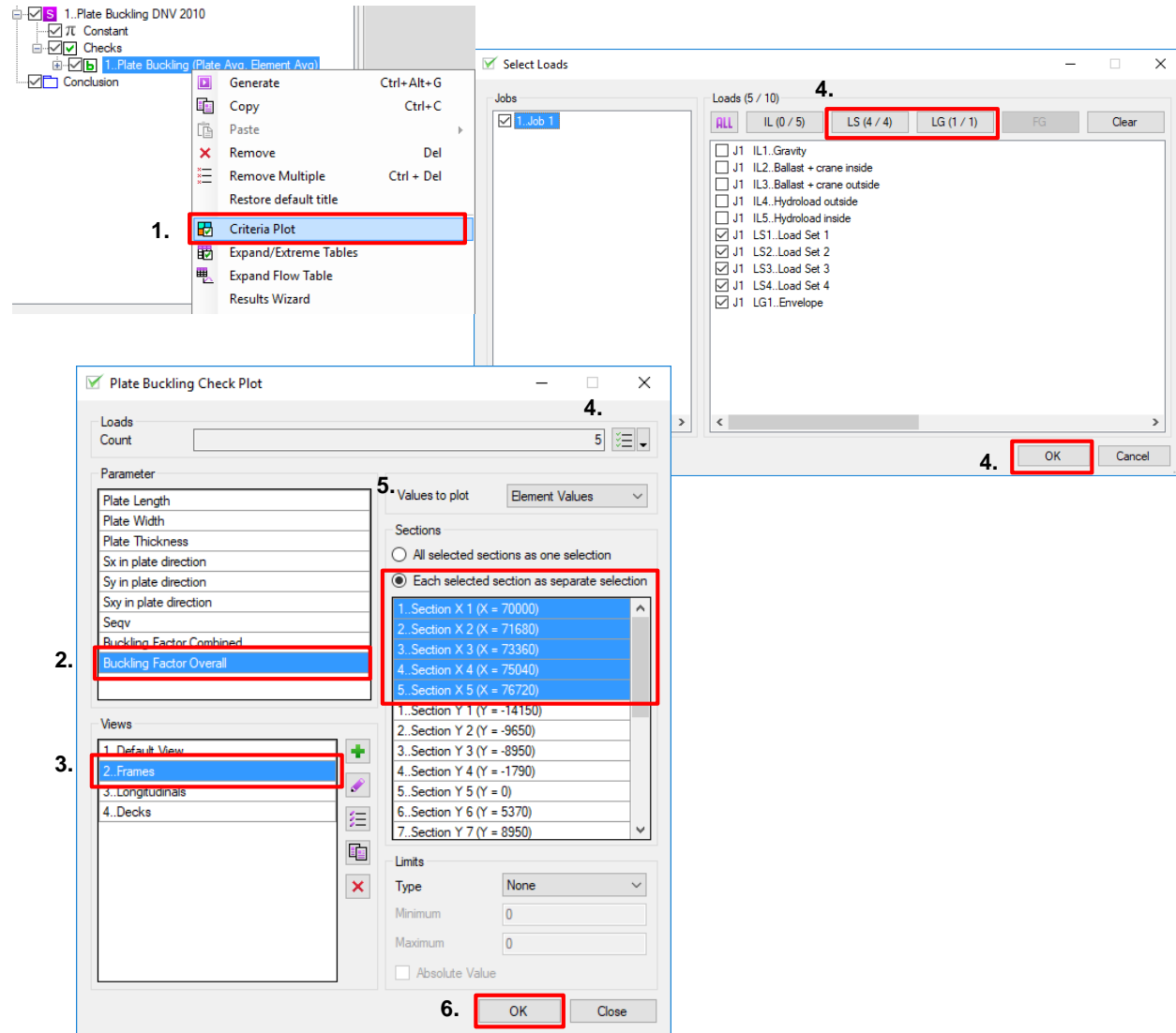
3 Views: **Frames**

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

5 Select *Each selected section as separate selection* and select all **X sections**.

6 Press **OK**.

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

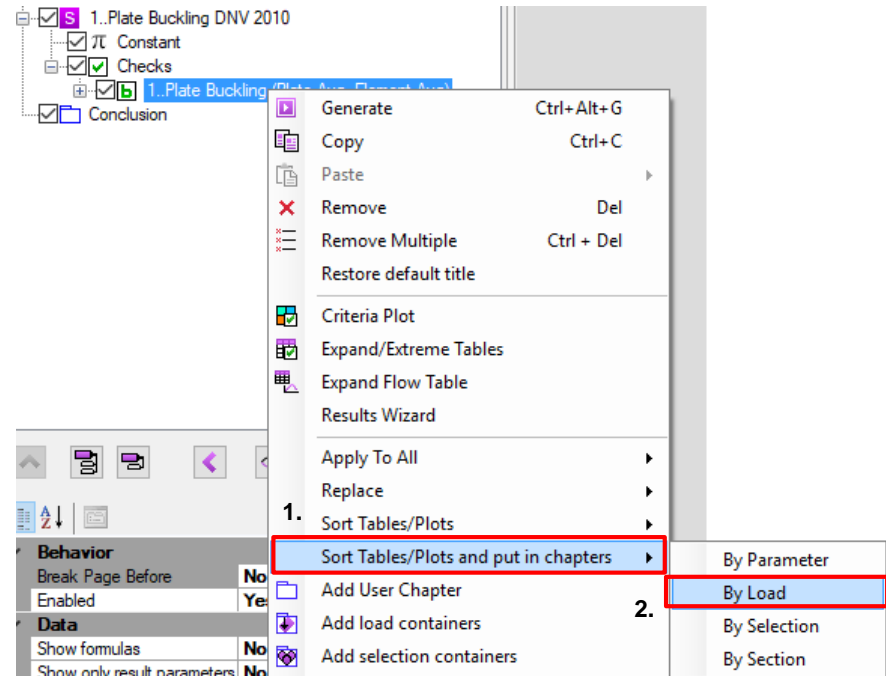
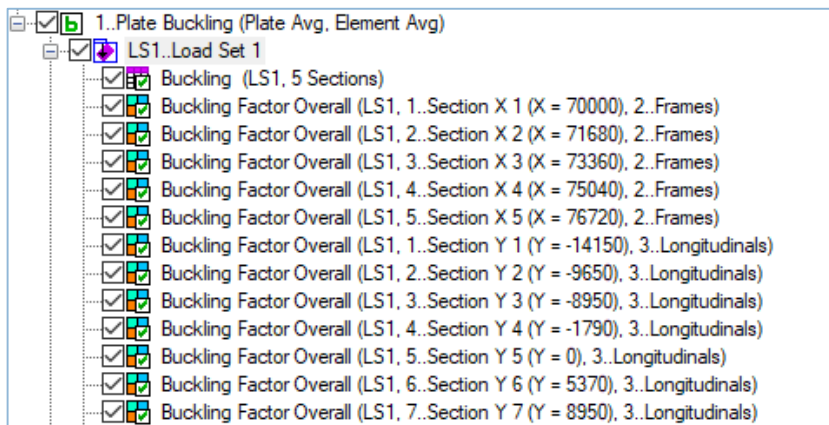


Report. Sort tables and plots by Load

1 Right click on *Plate Buckling* check
=> *Sort Tables/Plots and put in*
chapters.

2 Sorting method => *By Load.*

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



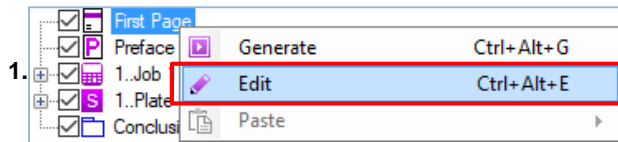
Report. First Page

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

2 Fill in information about project.

3 Select Image *From View* and pick '*2..Frames*'.

4 Press *OK*.



First Page Editor

Engineer details

Engineer: Support


Company: SDC Verifier

E-mail: support@sdcverfier.com

Phone: +31 15 30-10-310

Address: Zijlvest 25 [...]

Web Site: sdcverfier.com

Logo: 

☐ Put logo on report plots

Customer details

Contact Person: customer


Company: company

E-mail: customer@company.com

Phone: +31 15 555-55-55

Address: Zijlvest 25 [...]

Web Site: company.com

Logo: 

Image

☐ From file

☒ From View 2..Frames

3.

4.

Press  to generate complete report.



Press  to export to Word.



Report



Prepared by:
SDC Verifier
support@sdcverifier.com
+31 15 30-10-310
sdcverifier.com
Zijkvest 25
2011 VB Haarlem
The Netherlands

Engineer:
Customer:
Project Number:
Version:
Date:

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

Support
customer
1
23 Oct 2017

Page 3 of 7

Buckling (LG1, 5 Sections)


Standard	1. Plate Buckling DNV 2010	Check	[S1] 1. Plate Buckling (Plate Avg, Element Avg)						
Load Group	LG1_Envelope	Sections	5						
Search Type	Related To Last								
Section Title	Plate Length	Plate Width	Plate Thickness	Sx in plate direction	Sy in plate direction	Sxy in plate direction	Seqv	Buckling Factor	Buckling Factor Combine 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
4. Section X 4 (X = 75040) (MaxID=7)	3000.00	2600.00	16.00	0.00e+6	-0.02e+6	-0.01e+6	0.02e+6	0.12	0.34
5. Section X 5 (X = 76720) (MaxID=41)	833.33	750.00	12.00	-0.02e+6	-0.05e+6	-0.06e+6	0.11e+6	0.27	0.52
Max over Sections [5/41]	833.33	750.00	12.00	-0.02e+6	-0.05e+6	-0.06e+6	0.11e+6	0.27	0.52

Prepared by
SDC Verifier

Prepared for
company

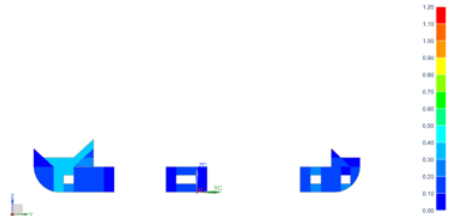
Page 5 of 6

Absolute Buckling Factor Overall (LG1, 3. Section X 3 (X = 73360), 2.Frames)



Check [S1] 1. Plate Buckling (Plate Avg, Element Avg) Load Group LG1_Envelope
Parameter Minimum Buckling Factor Overall Panels 3. Section X 3 (X = 73360)
View 2.Frames

Absolute Buckling Factor Overall (LG1, 4. Section X 4 (X = 75040), 2.Frames)



Check [S1] 1. Plate Buckling (Plate Avg, Element Avg) Load Group LG1_Envelope
Parameter Minimum Buckling Factor Overall Panels 4. Section X 4 (X = 75040)
View 2.Frames

Prepared by
SDC Verifier

Prepared for
company