SDC VERIFIER

Tutorial
Plate Buckling DNV

ANSYS®

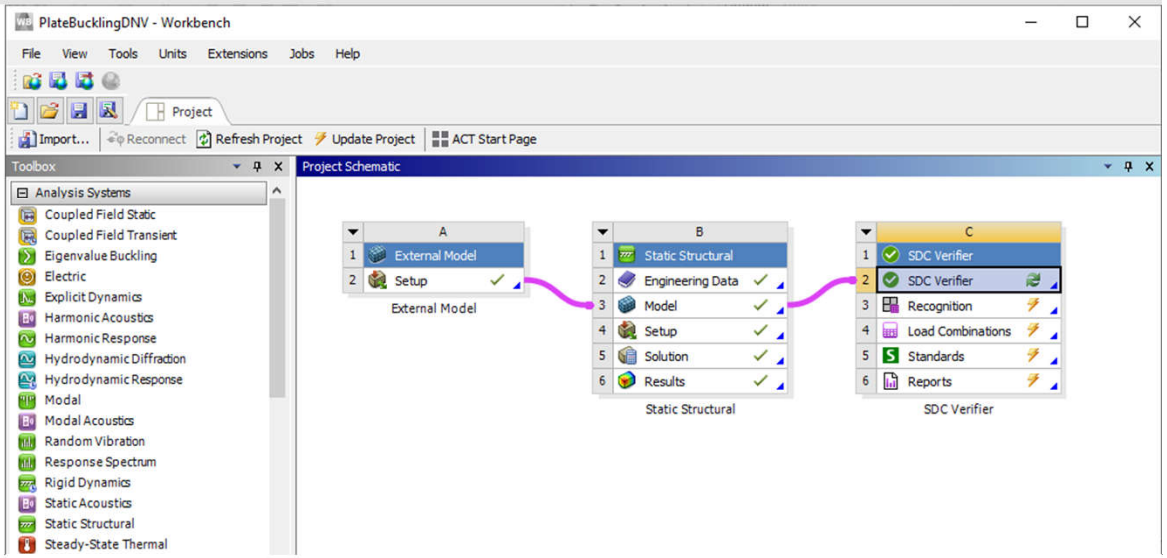
4 Dec 2020
version 2020.0.2

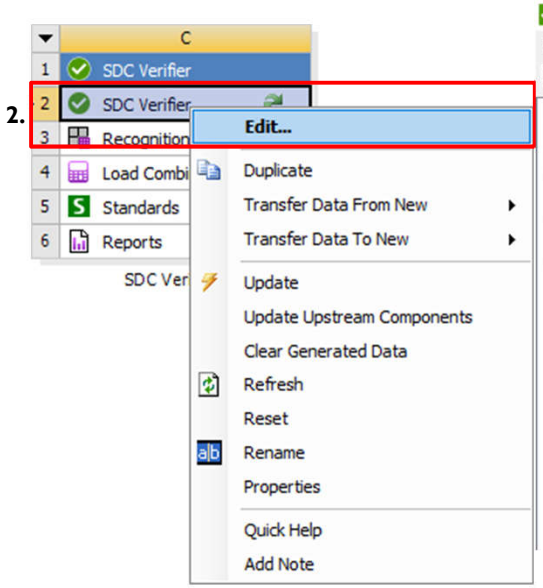
Content

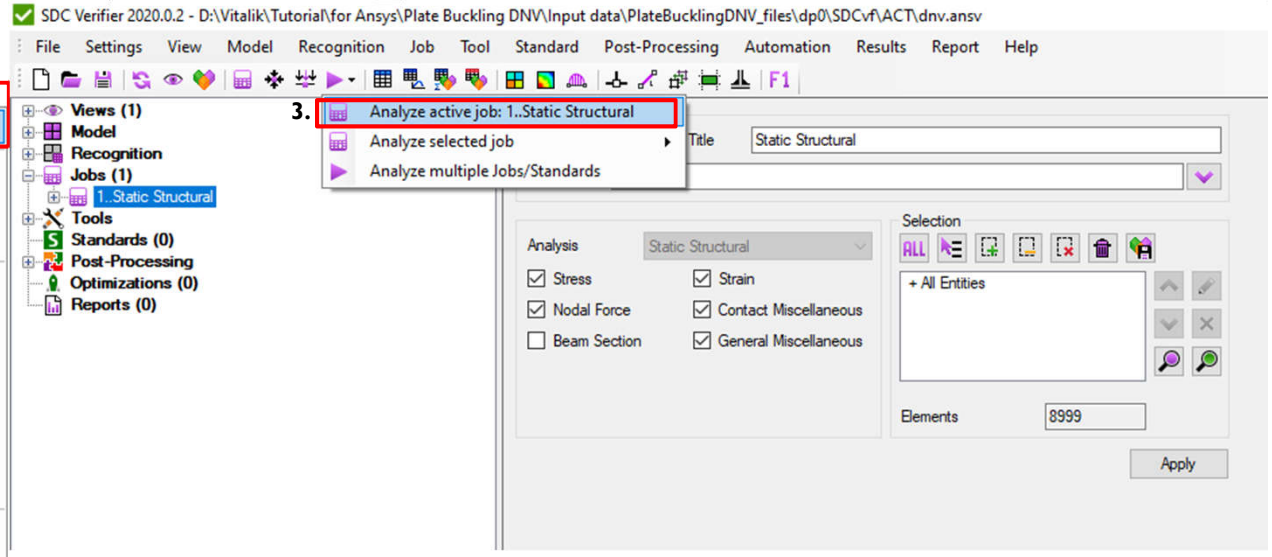
- In this tutorial an DNV 2010 Plate Buckling Check is reviewed in details.
- A part of a plate model of the ship has been used as a start FEM model.
- Load Sets and Load Group (Envelope) are created.
- Recognition of plates using Panel Finder.
- Plate Buckling tables and plots.
- Reporting: preparing and generating the final report.

Launch SDC Verifier

1. Open in **Ansys Workbench** **PlateBucklingDNV.wbpj**
2. Double Click on 2 SDC Verifier or execute *Edit* from context menu
3. Press ▶ on toolbar and "*Analyze active job: 1.. Static Structural*"

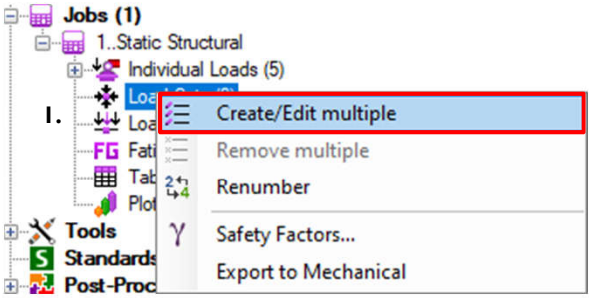


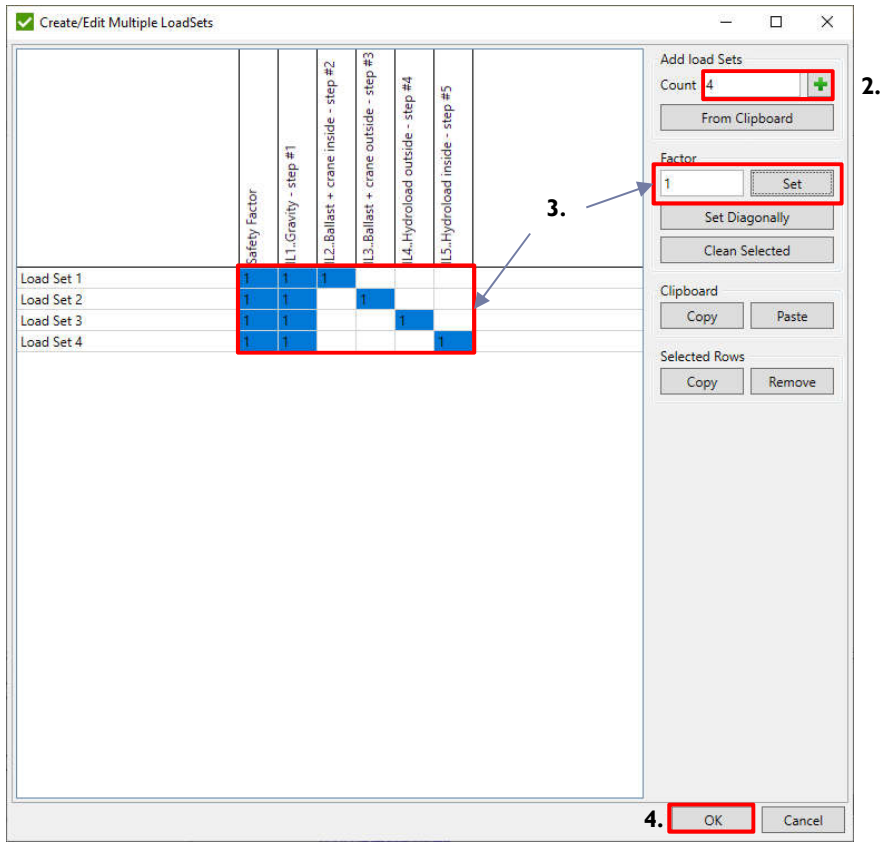




Load Sets

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*

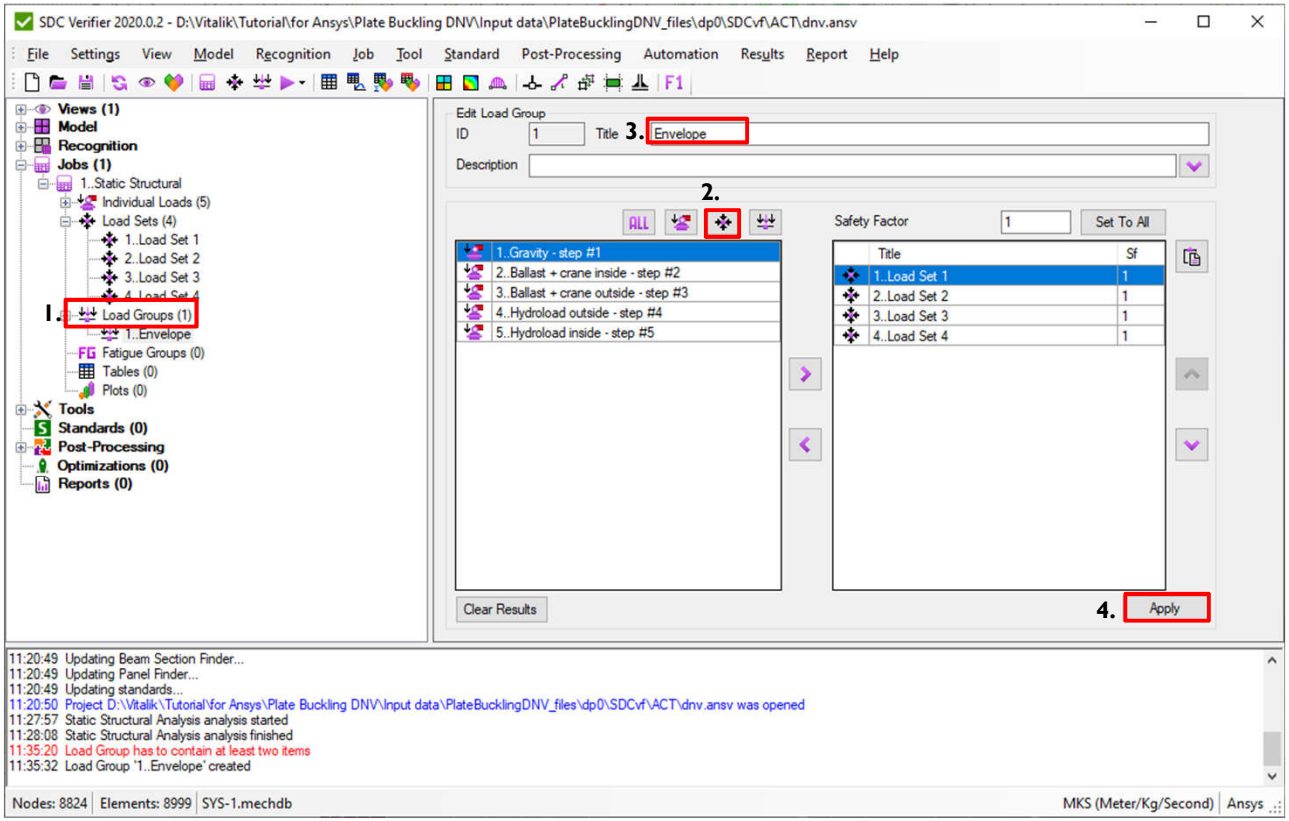




Load Sets are created with default titles "Load Set #". It is possible to rename them by double-click on the respective load set title. Alternatively, the titles and factors can be pasted from the Clipboard using *Paste* button.

Load Groups

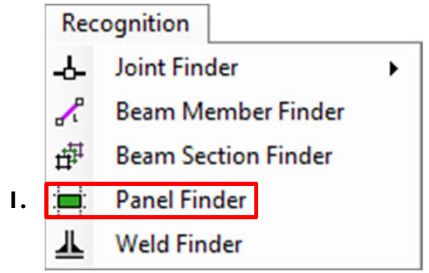
1. Click on *Load Groups.*
2. Press ✥ to select all Load Sets.
3. *Title*: **Envelope**
4. Press *Create*

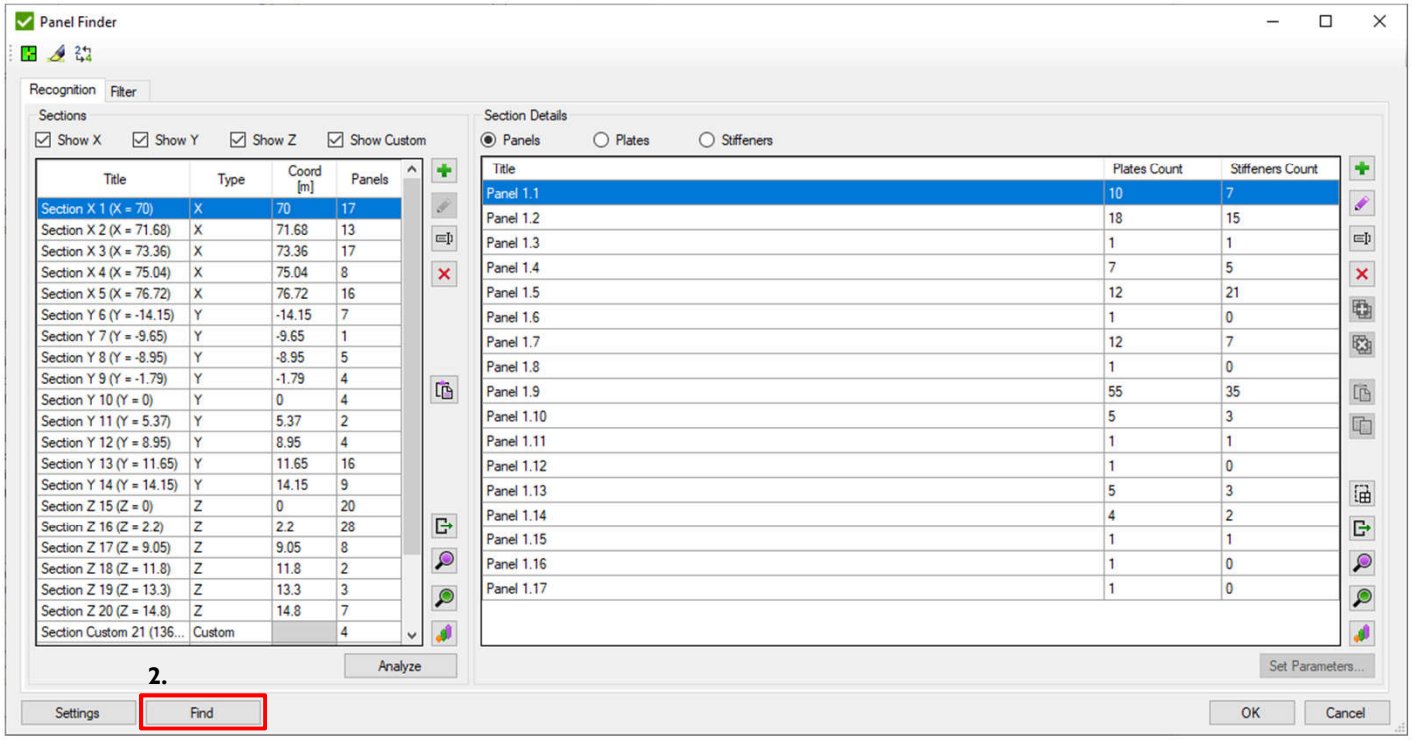


Load Sets and Load Groups are analyzed by SDC Verifier.

Panel Finder. Recognize Sections.

1. Execute *Recognition - Panel Finder* from main menu
2. Click on *Find*

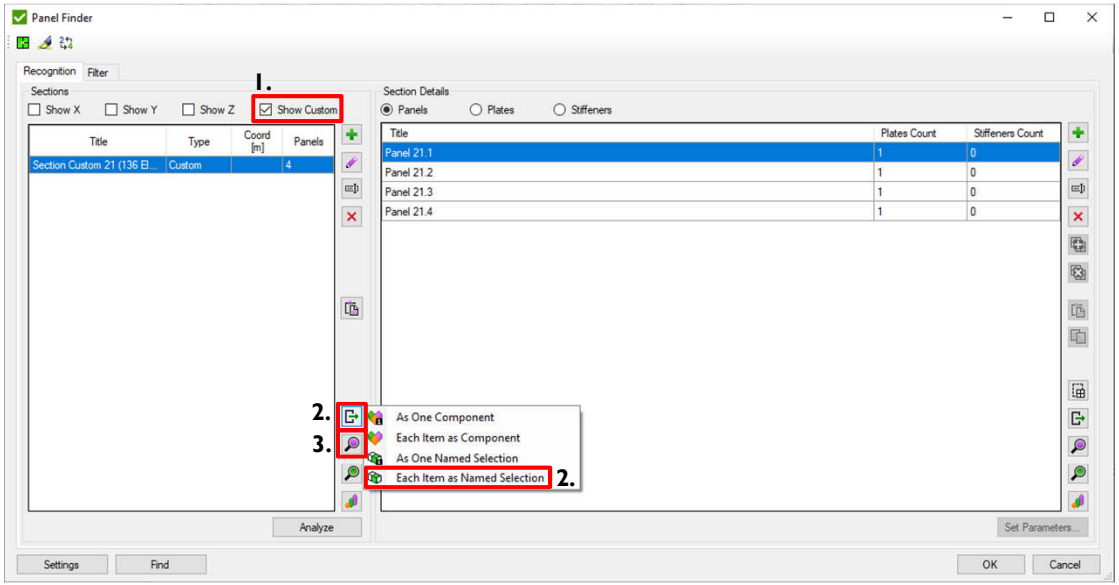


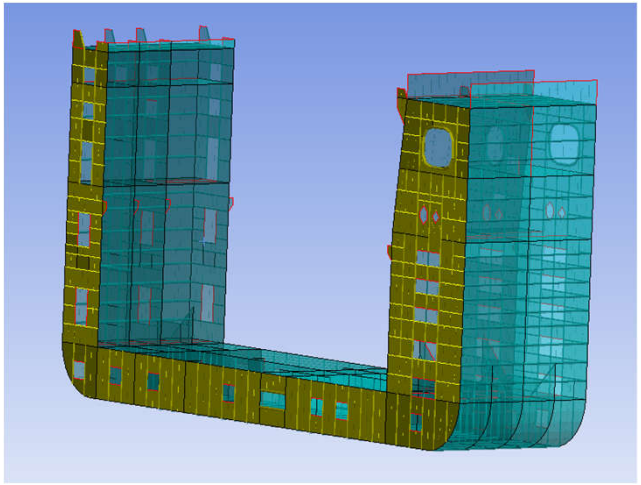


Panel Finder. Custom Section

1. Show Custom: **ON** (rest OFF)
2. Press  and  to export selected sections to Named Selection
3. Press 

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



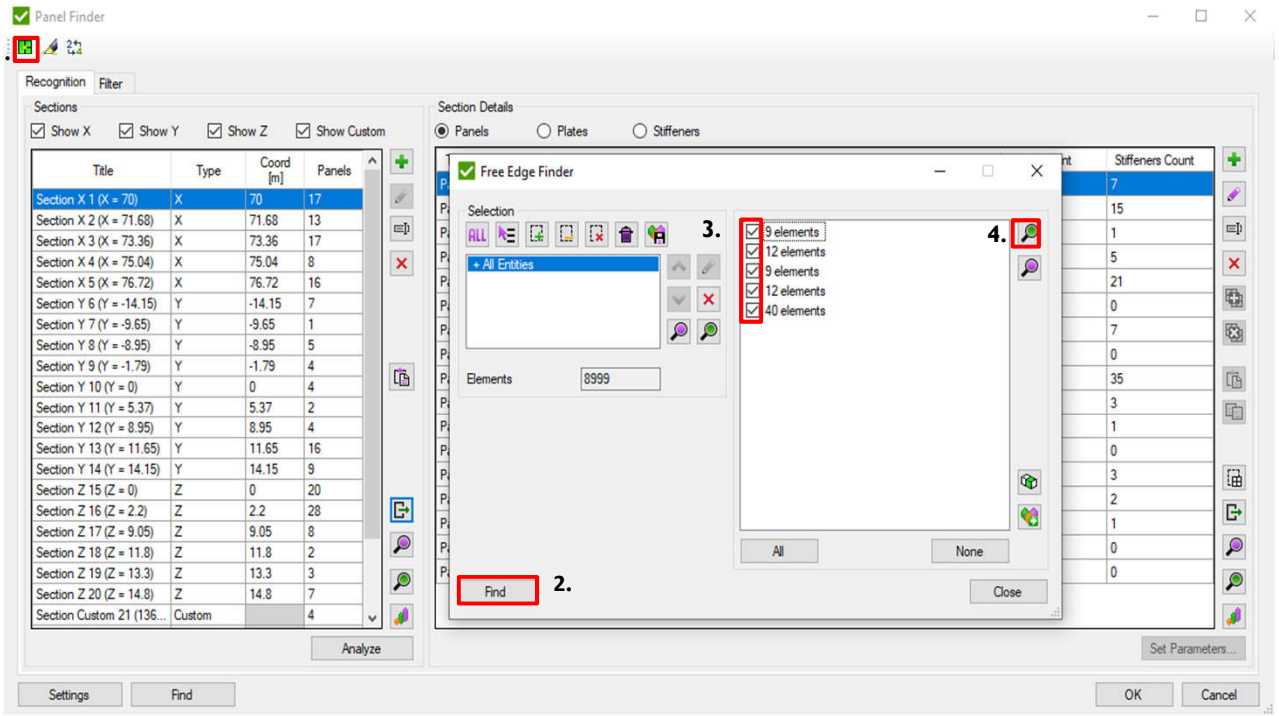


Example: It is possible to create custom section based on hull selection:

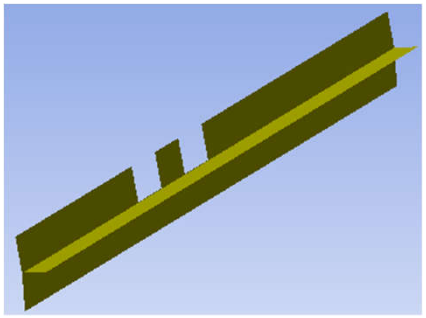
Panel Finder. Find Free Edges

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.

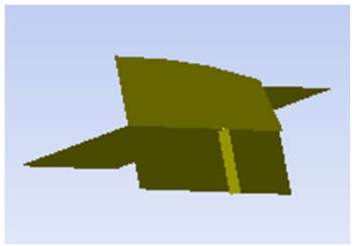
1. Click to find free edges
2. Press ***Find***
3. Select all free edges
4. Press to preview elements with free edges



2 elements connected to 1



Mesh does not coincide

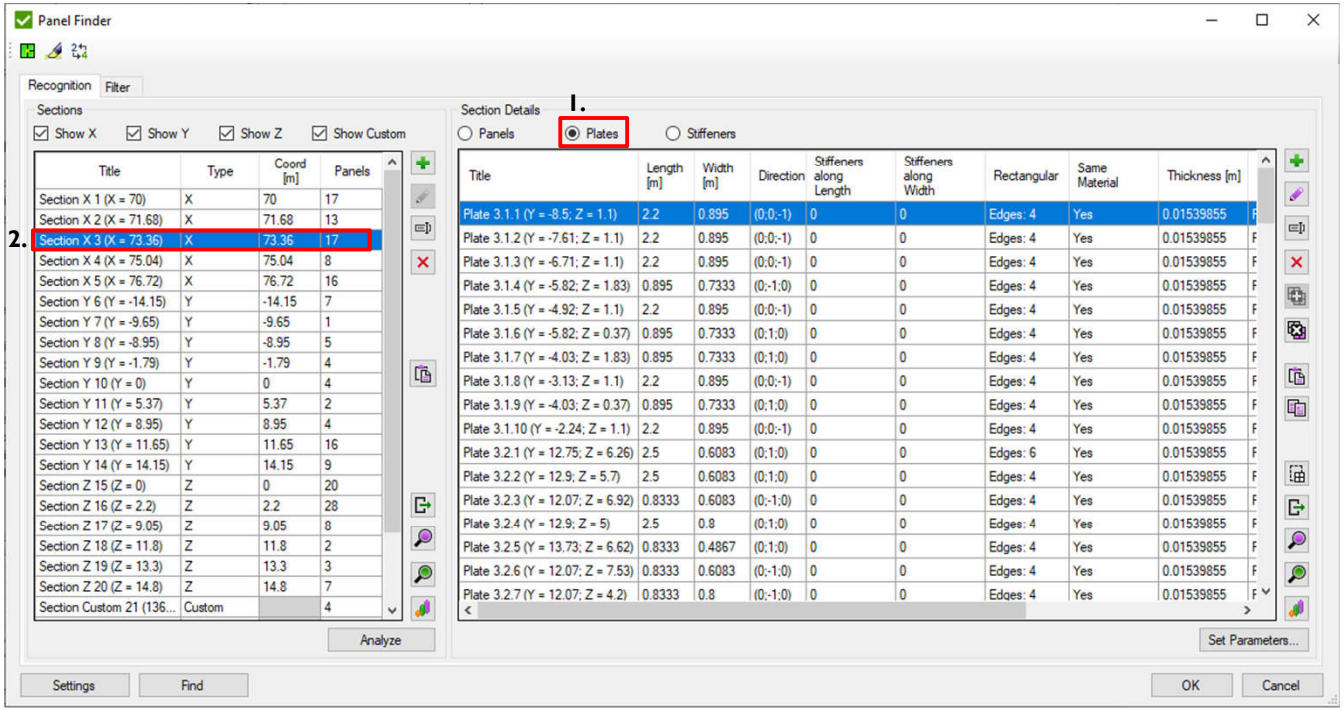


Note: Free edges should be fixed by remeshing the model and run recognition of plates. (In tutorial we skipped step with remeshing but for commercial project it is crucial step to do).

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 3.5.10 (Y = -2.24; Z = 1.1)	2.2	0.895	(0;0;-1)	0	0	Edges: 4	Yes	0.01539855
Plate 3.6.1 (Y = -0.89; Z = 0.37)	1.79	0.7333	(0;1;0)	0	0	Edges: 4	Yes	0.01539855

Section ID. Panel ID. Plate ID

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:

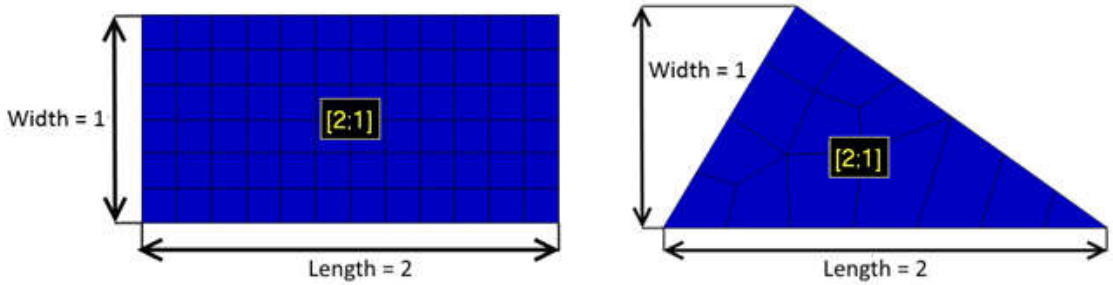


Plate Thickness: Calculations are performed on every element and thickness is taken directly from each element. It is possible to set thickness manually for plate, in this case element thickness will be ignored and user defined thickness will be used. Example: Plate with 2 properties 0.01 and 0.02 thicknesses.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

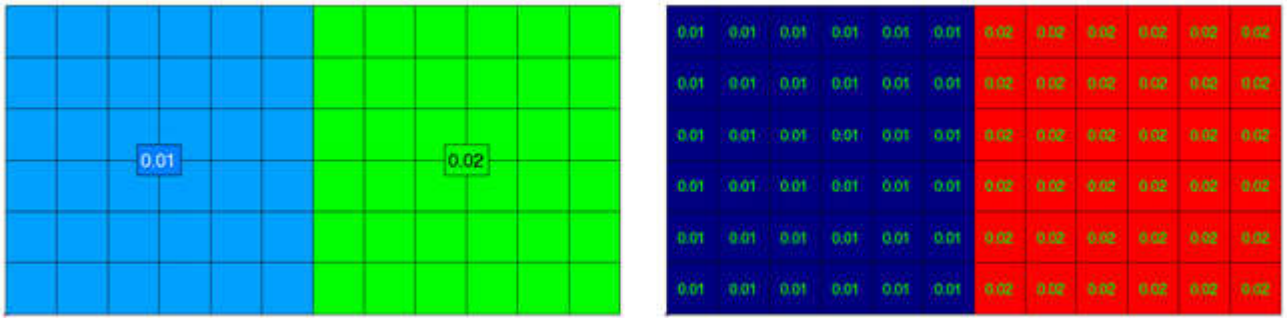
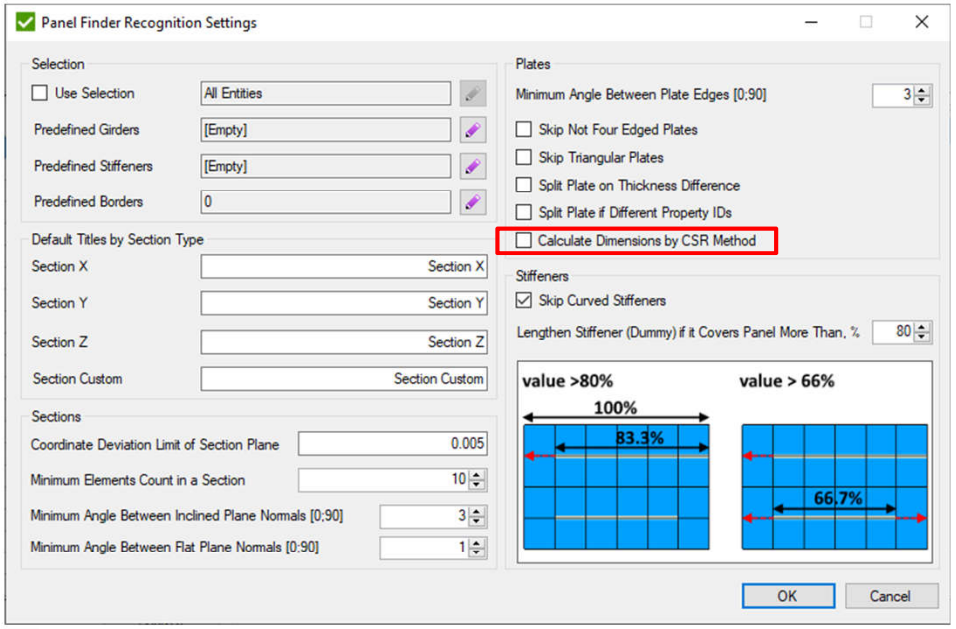


Plate Buckling Dimensions by CSR



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:

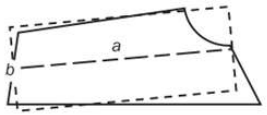
e) The length of shorter side, b in mm, is to be taken as:

$b = A/a$

where:

A : Area of the plate, in mm^2

a : length defined in (d), in mm

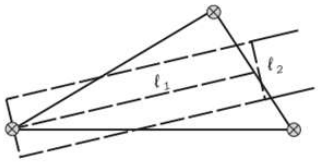


c) The width of the model, ℓ_2, in mm, is to be taken as:

$\ell_2 = A/\ell_1$

where:

A : Area of the plate, in mm^2

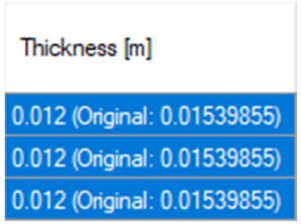


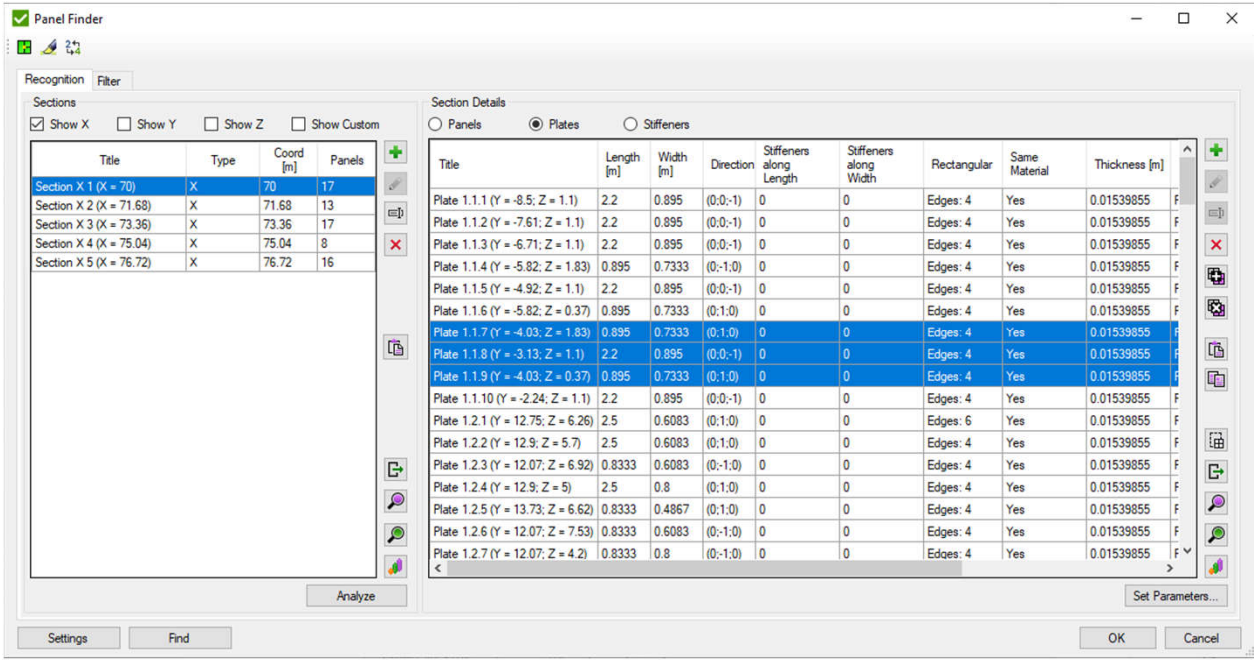
Editing plates manually

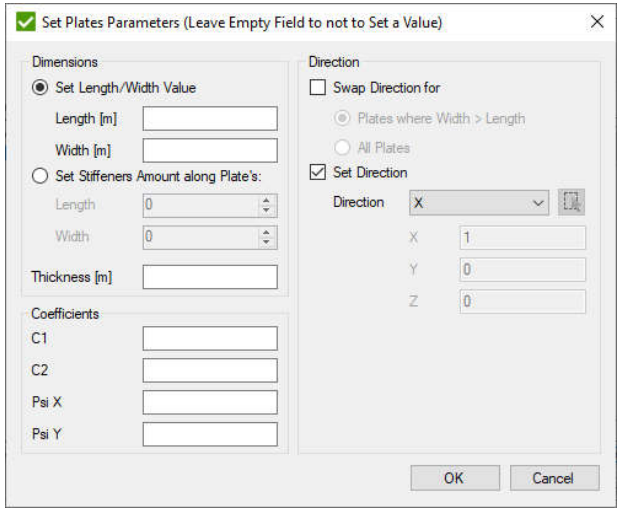
To modify plates select them from the list and press *Set Parameters*. It is possible to edit (Length / Width / Thickness / Coefficients / Direction).

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:



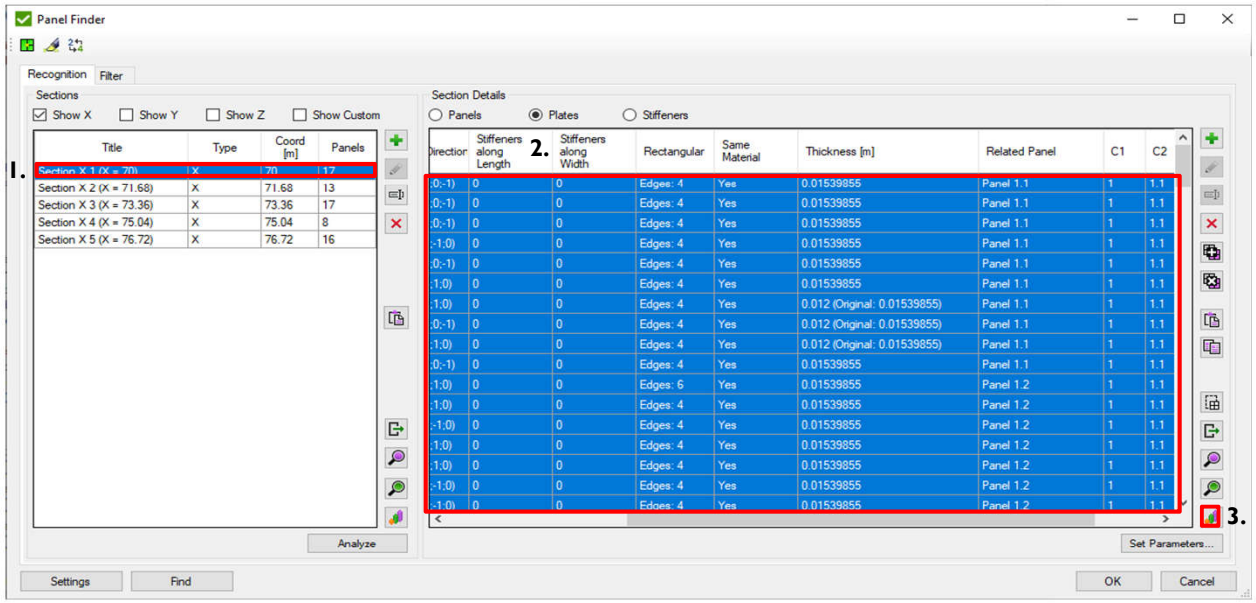


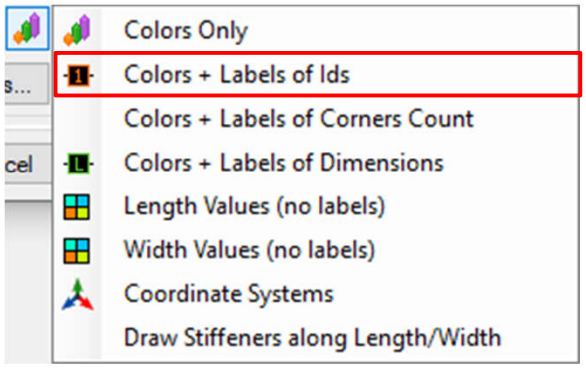


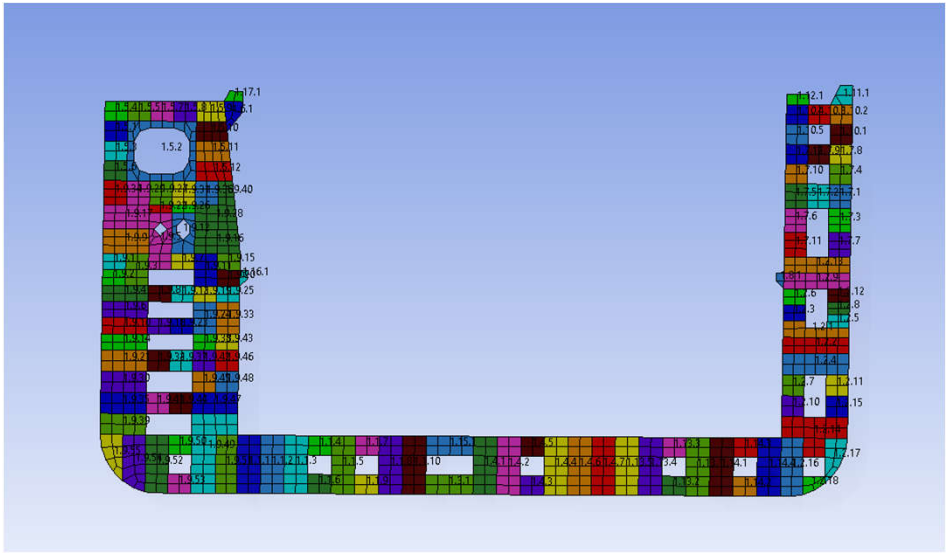
Usually you should not modify plate directions. But in case it is required press *Set Direction.*

Panel Finder. Plates Plot

1. Select **Section X1**
2. Select All *Plates (Ctrl+A)*
3. Press 
4. Click on  Colors + Labels of Ids

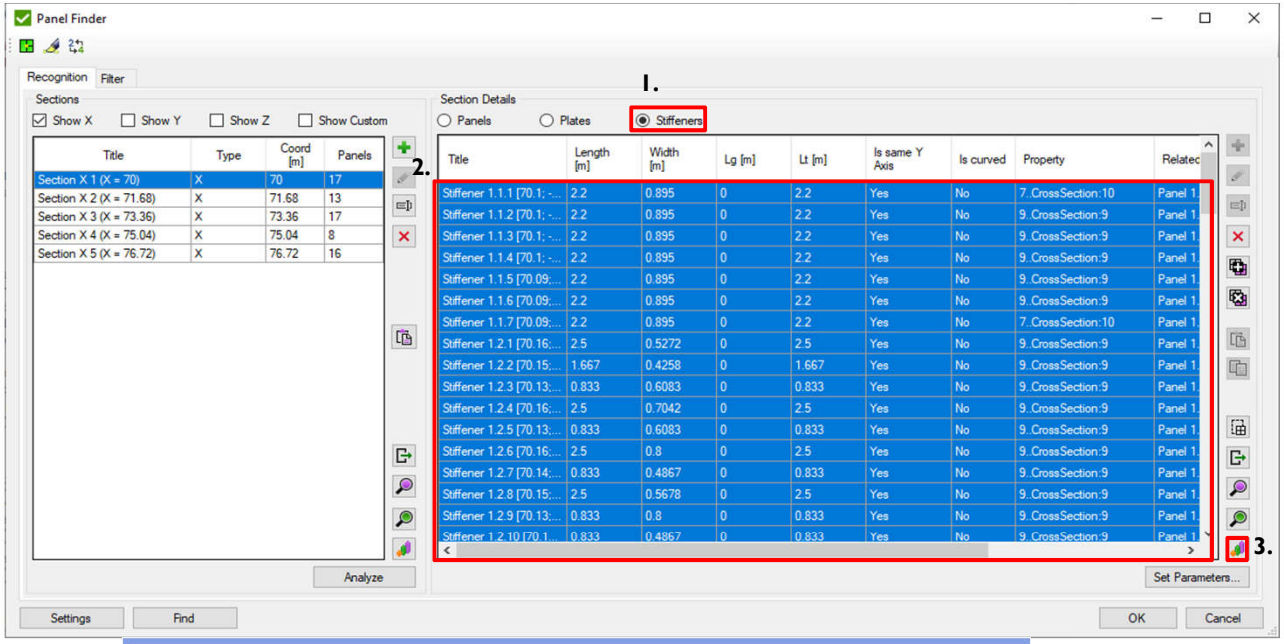


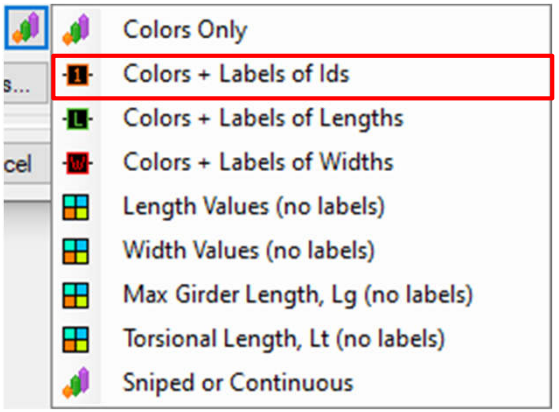


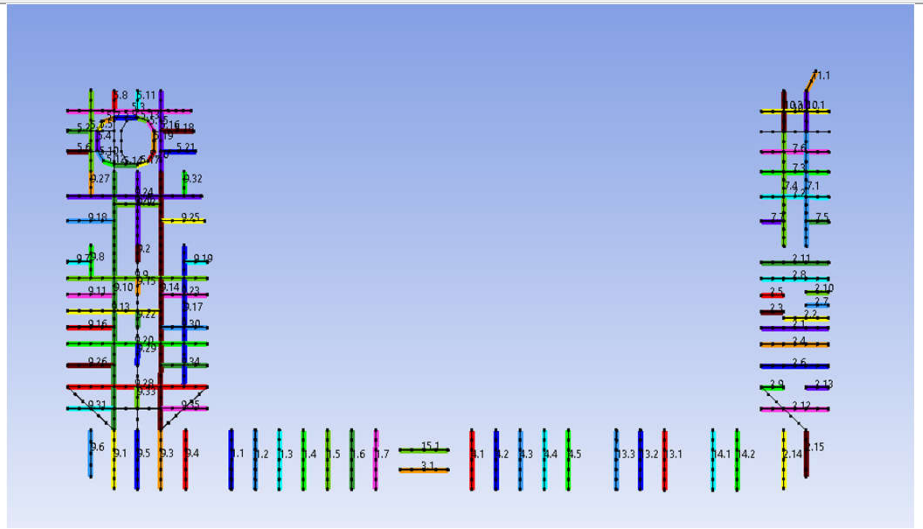


Panel Finder. Stiffeners Plot

1. Select *Stiffeners*
2. Select All *Stiffeners (Ctrl+A)*
3. Press 
4. Click on  Colors + Labels of Ids



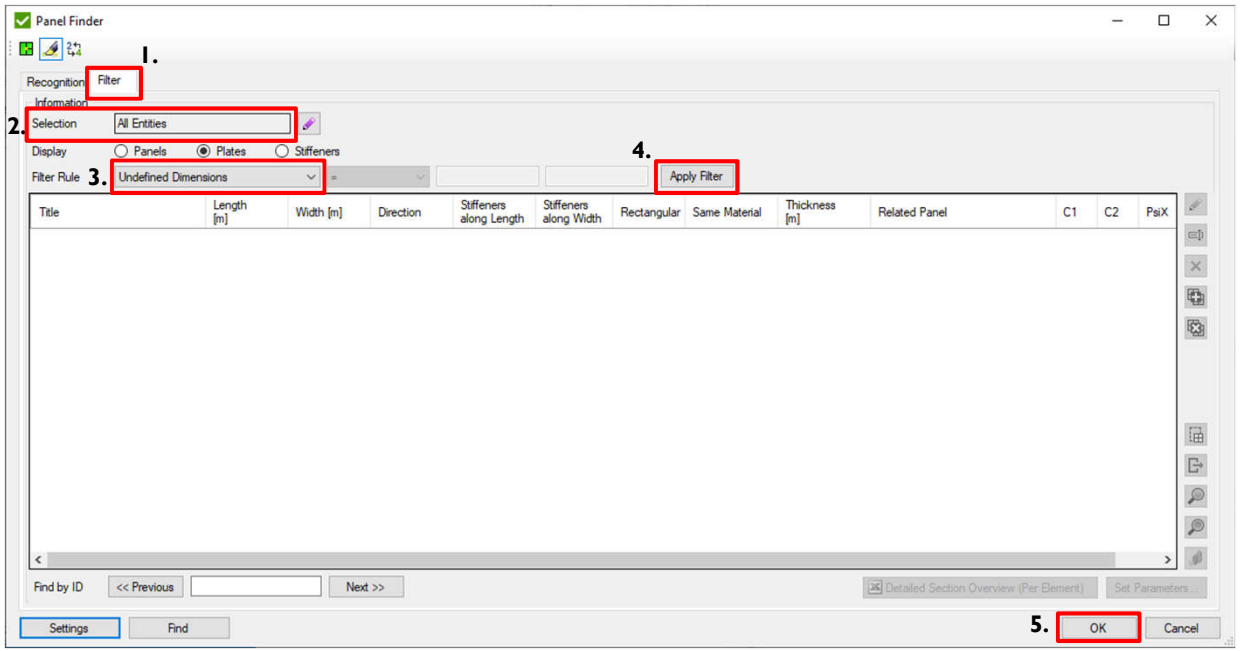




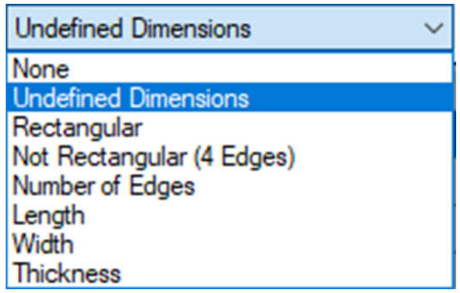
Panel Finder. Filter

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*

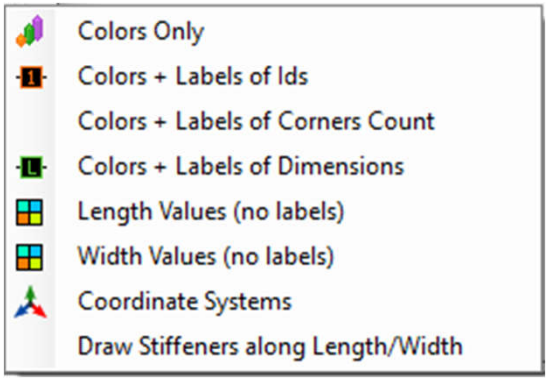


Tip: It is also possible to filter plates by shape (triangle, rectangular) or number of edges parameters.
E.g. Plates with numbers of edges > 4 can be displayed.
Control using Selection plates from which Sections should be filtered.

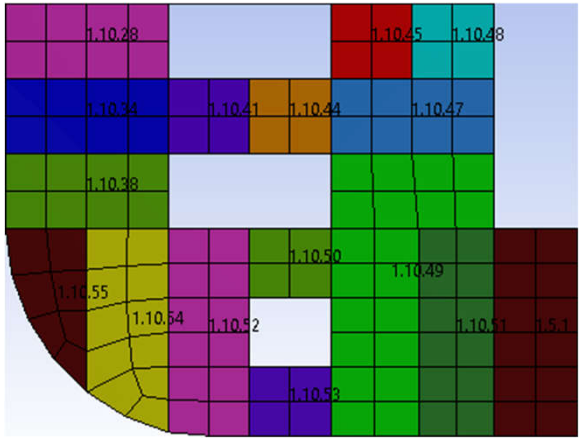


Panel Finder. Plot Options

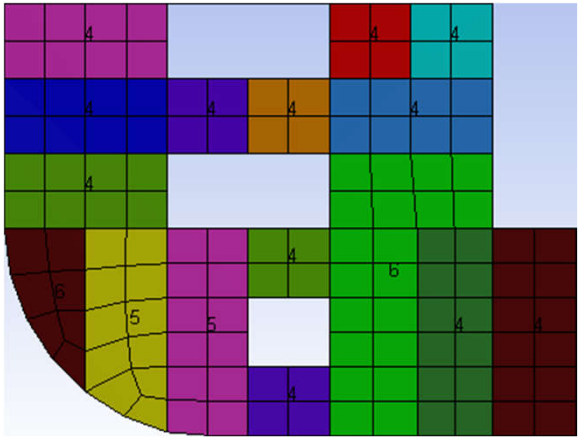
Note: Plate Plot can be displayed with different colors labels (labels of ids, labels of corners count or labels of dimensions). Also it is possible to show plates in length and width, coordinate systems etc.



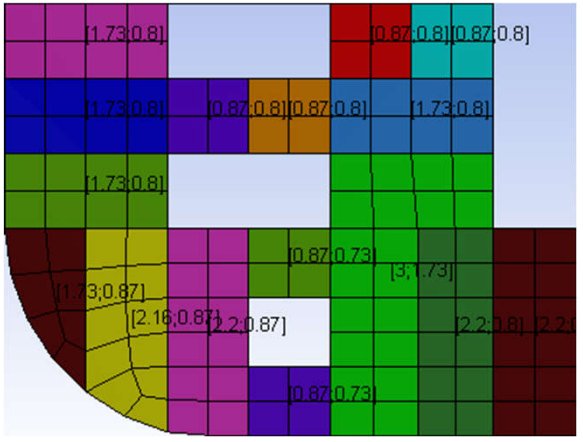
Labels of Ids



Labels of Corners Count

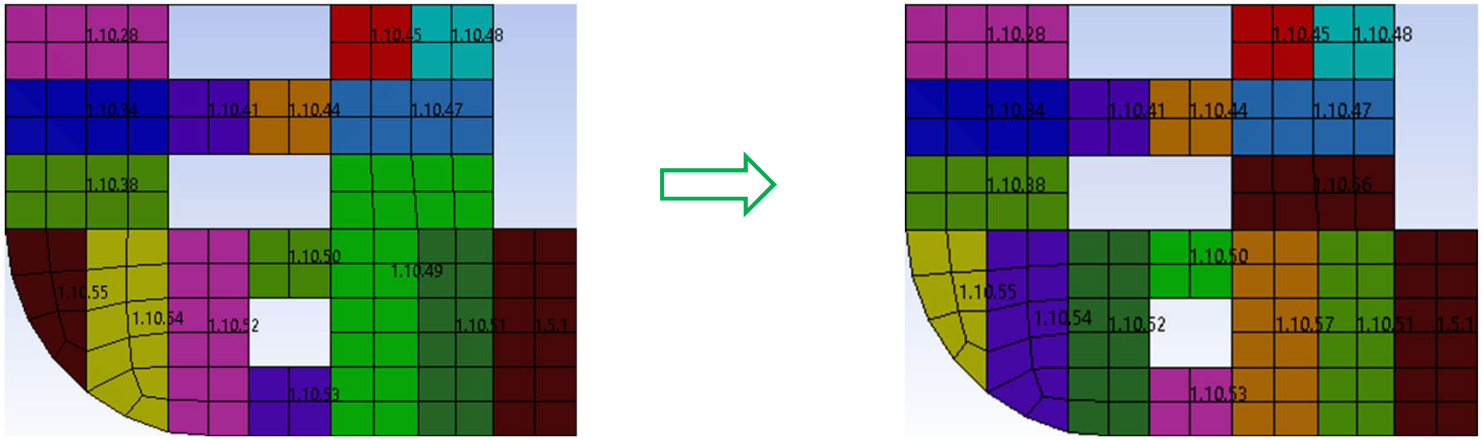


Labels of dimensions



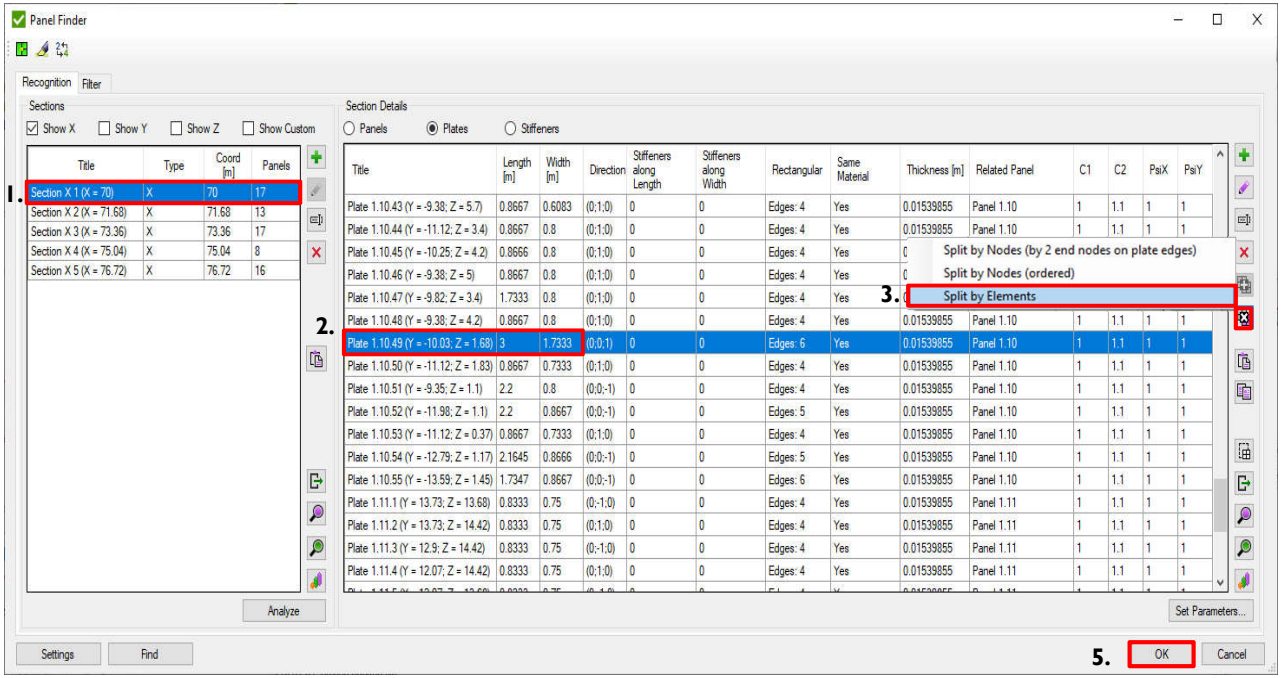
Panel Finder. Update Plates

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 X1 plate with Id = 1.10.49 should be split on 2 plates



Panel Finder. Split Plate

1. Select **Section X1**
2. Select **Plate 1.10.49**
3. Press  and ***Split by elements***
4. Selected plate is displayed in Ansys. Select elements for one plate and press *Yes*
5. Press *Ok*



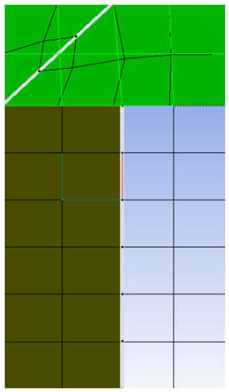
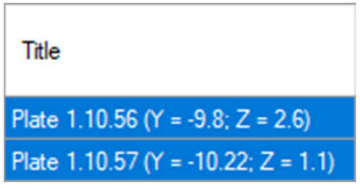
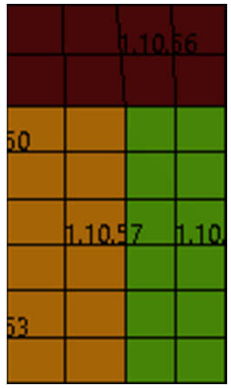


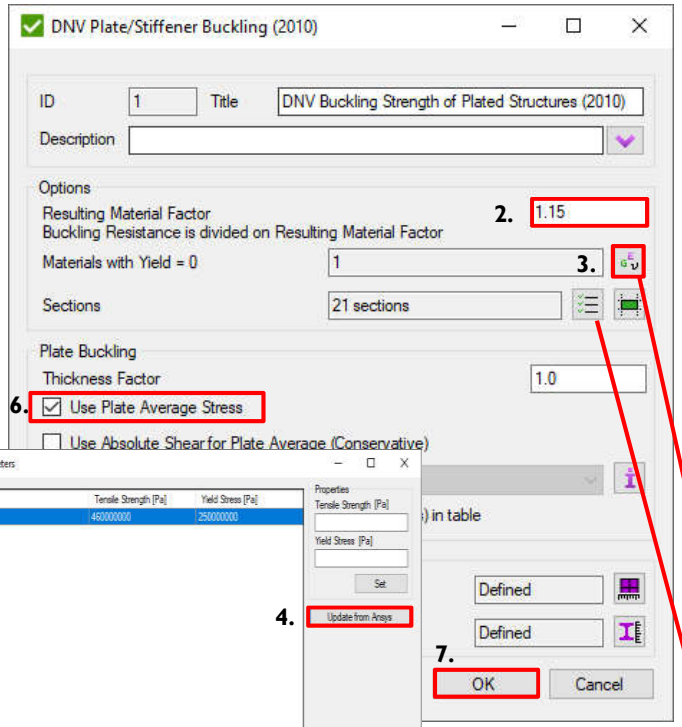
Plate 1.10.49 is replaced with Plates 1.10.56 and 1.10.57

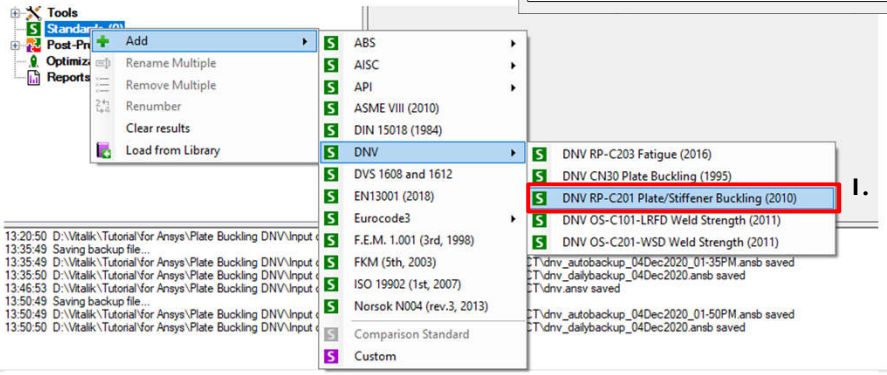




Add Plate Buckling DNV 2010 standard

1. In Standards Context menu execute *Add => DNV => DNV RP-C201 Plate/Stiffener Buckling (2010)*
2. Utilization Factor (Eta) = **1.15**
3. Press 
4. Press *Update from Ansys*
5. Press *OK*
6. Use Plate Average Stress: **On**
7. Press *OK*





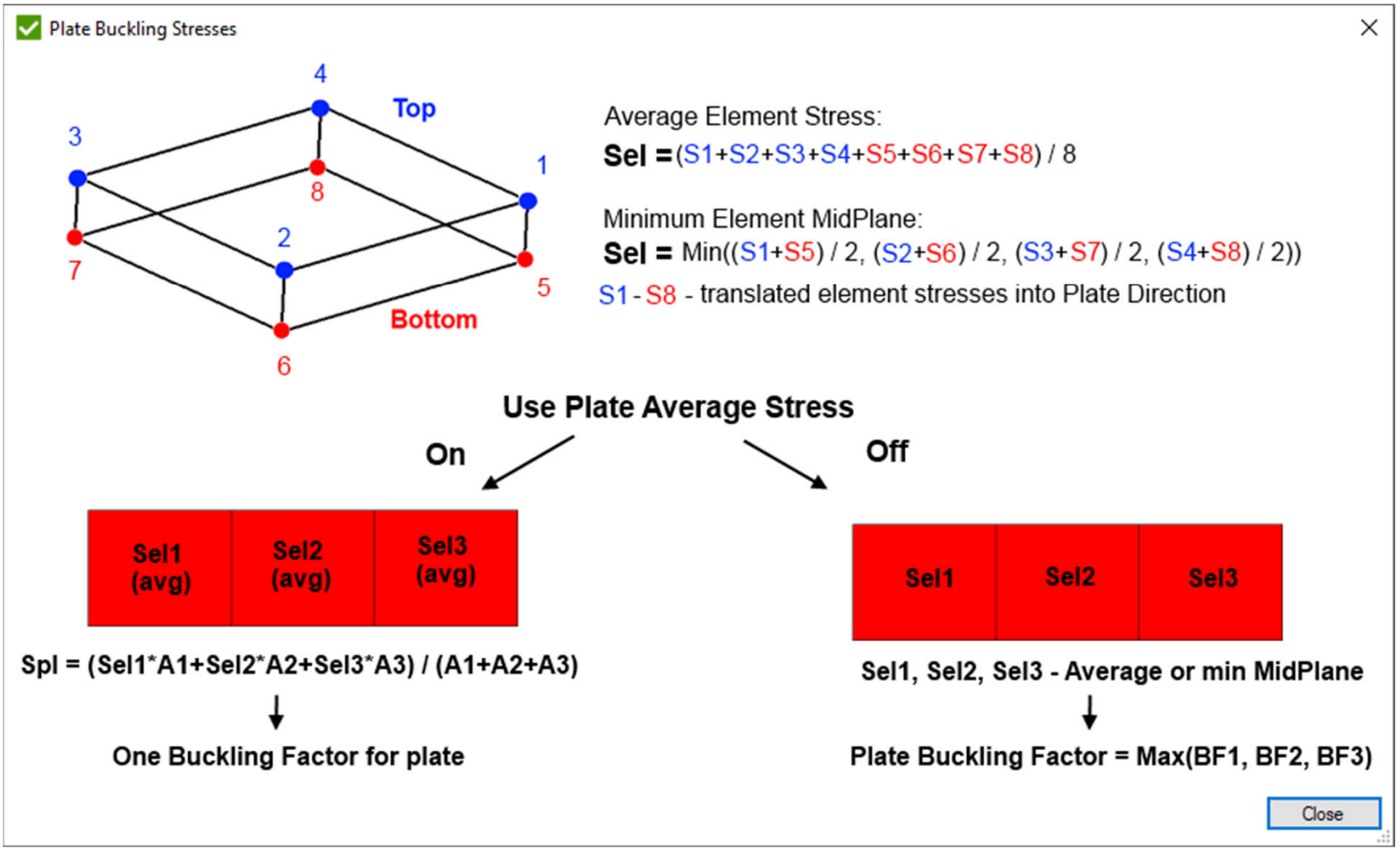
Thickness factor gives a possibility to increase / decrease all plates thicknesses without reanalyzing the model. E.g. 1.2 means increase thickness on 20% and decrease stresses

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

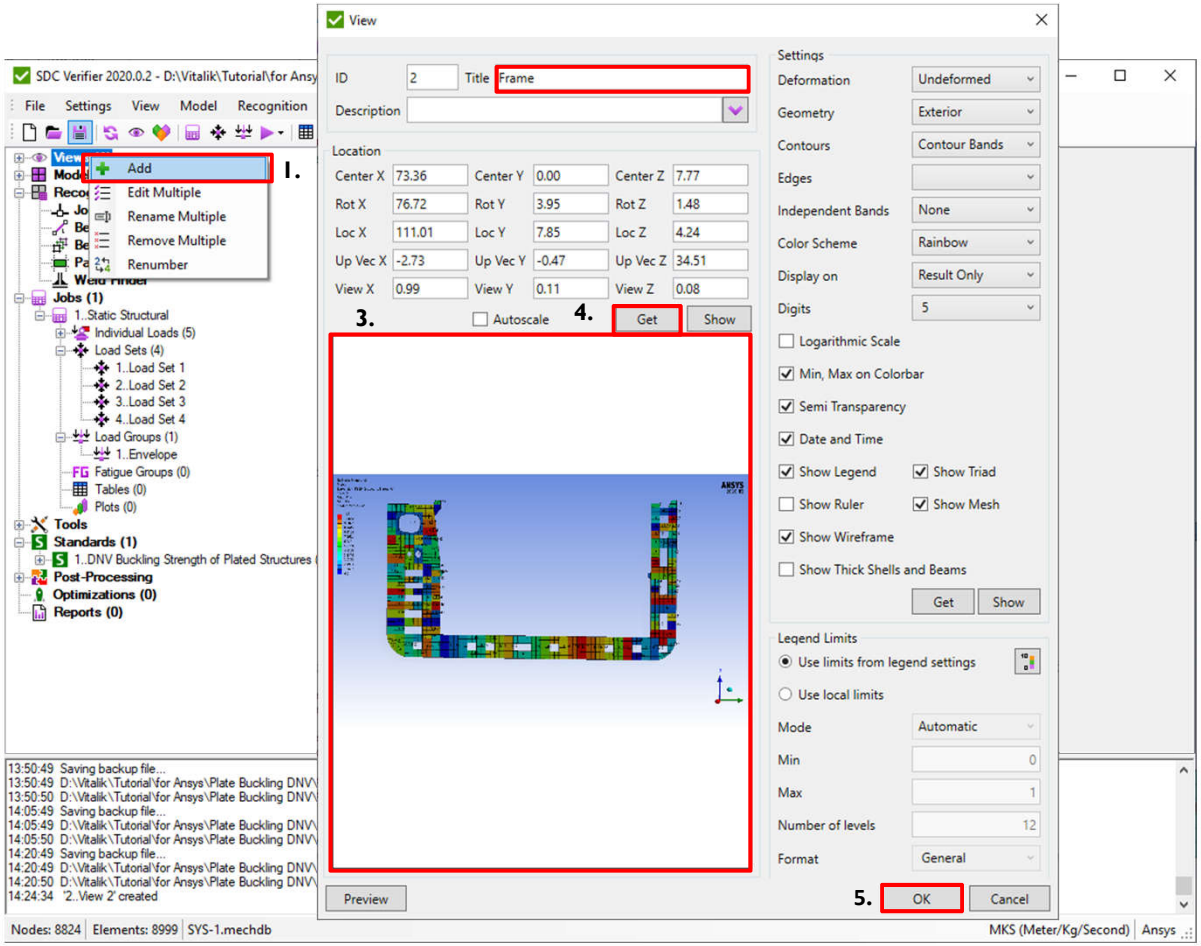
Plate Buckling Stresses



Views

1. Execute Views => **Add**
2. Title: **Frame**
3. Orient model in Ansys 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).



Views

1. Execute Views => **Add**
2. Title: **Stiffeners**
3. Orient model in Ansys 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).

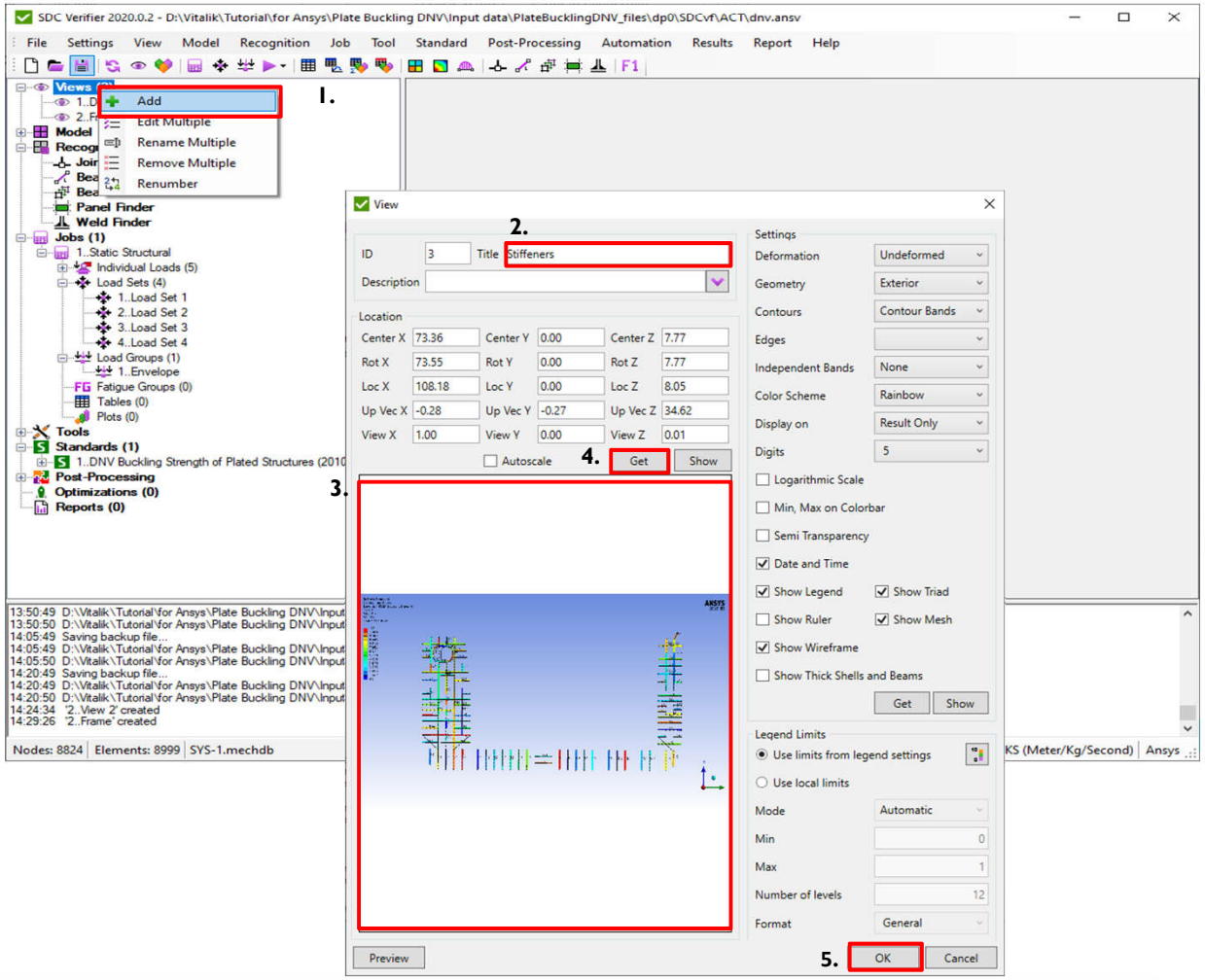
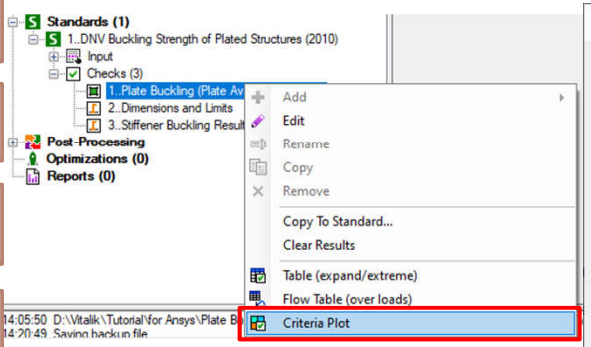
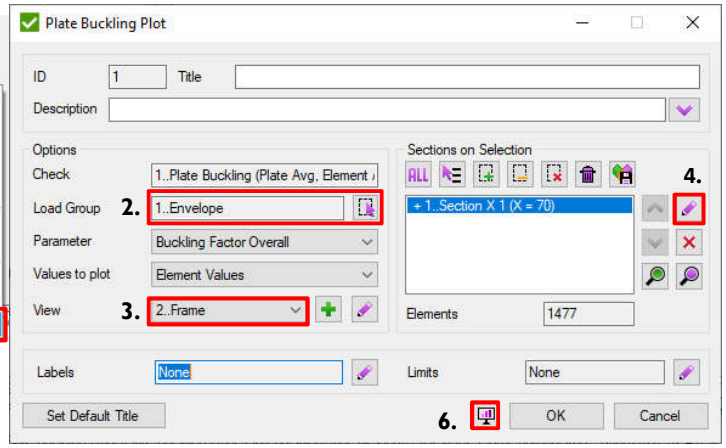
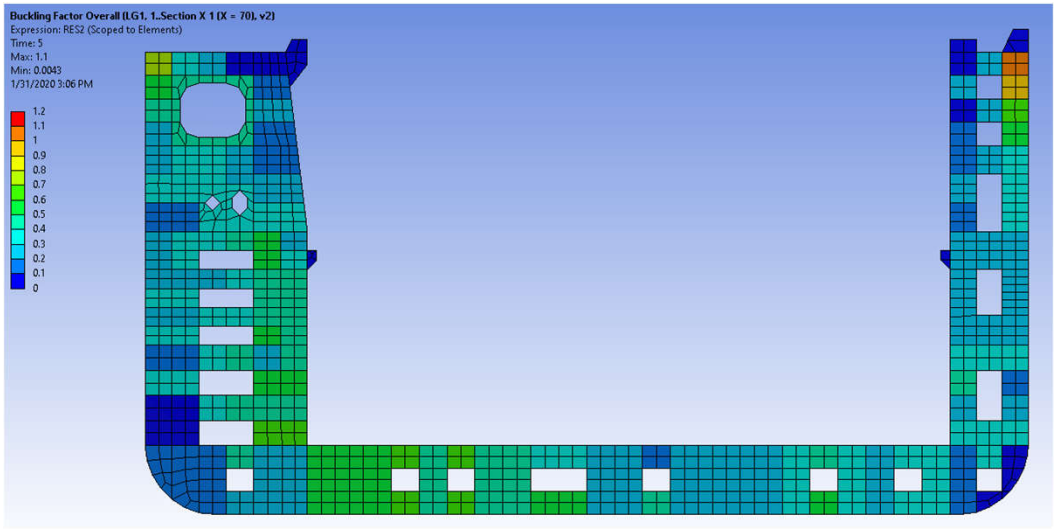


Plate Buckling Plot

1. Execute *Criteria Plot* from Plate Buckling DNV 2010 context menu
2. Load Group: **1..Envelop**
3. View: **2..Frame**
4. Press  and Select:**1..Section X1**
5. Press *OK*
6. Press  *Preview*







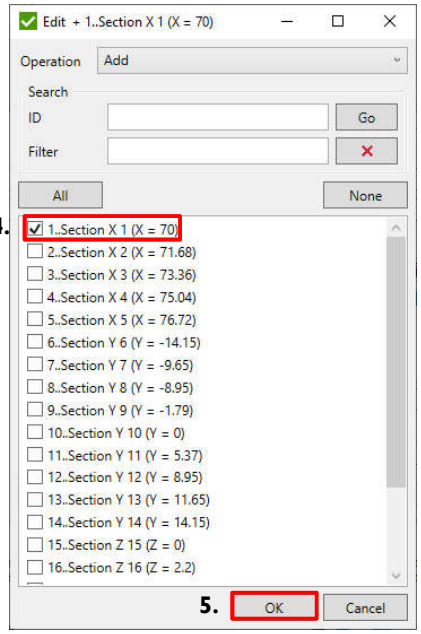
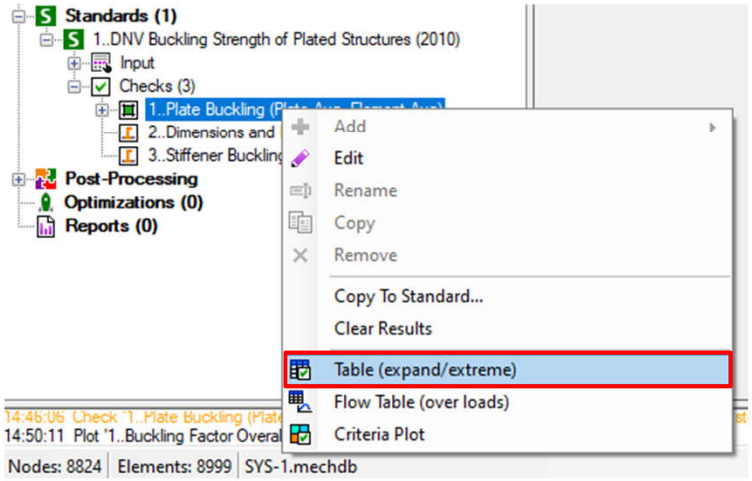
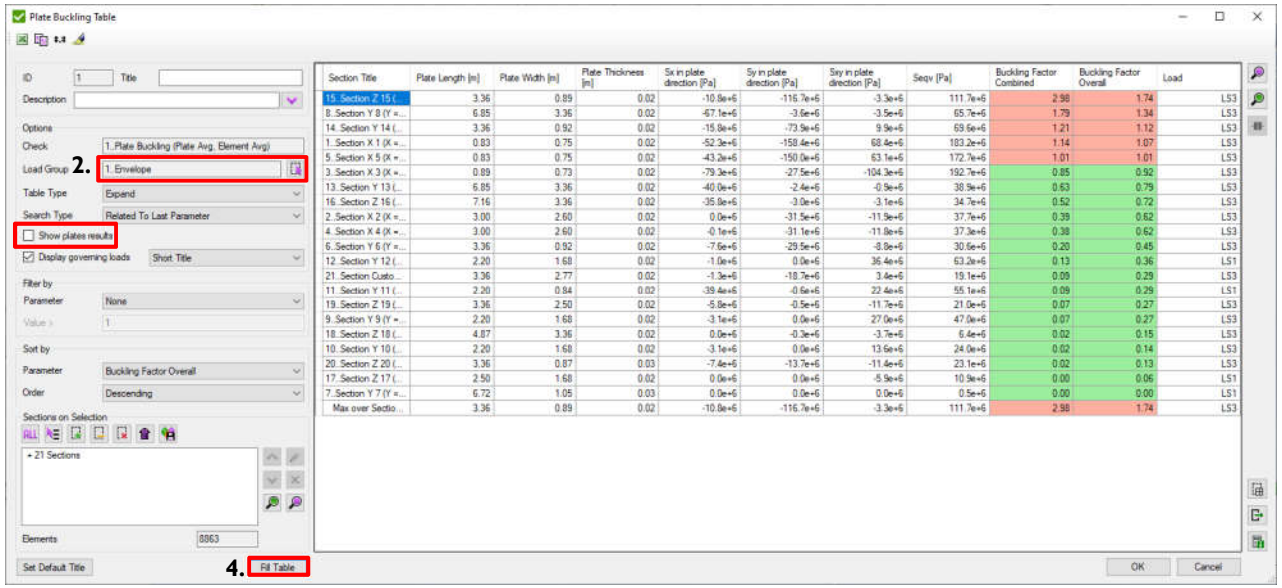


Plate Buckling Table

1. Execute *Table(expand/extreme)* from Plate Buckling DVN 2010 context menu
2. Load Group: **1..Envelop**
3. Show plates results: **OFF**
4. Press *Fill Table*

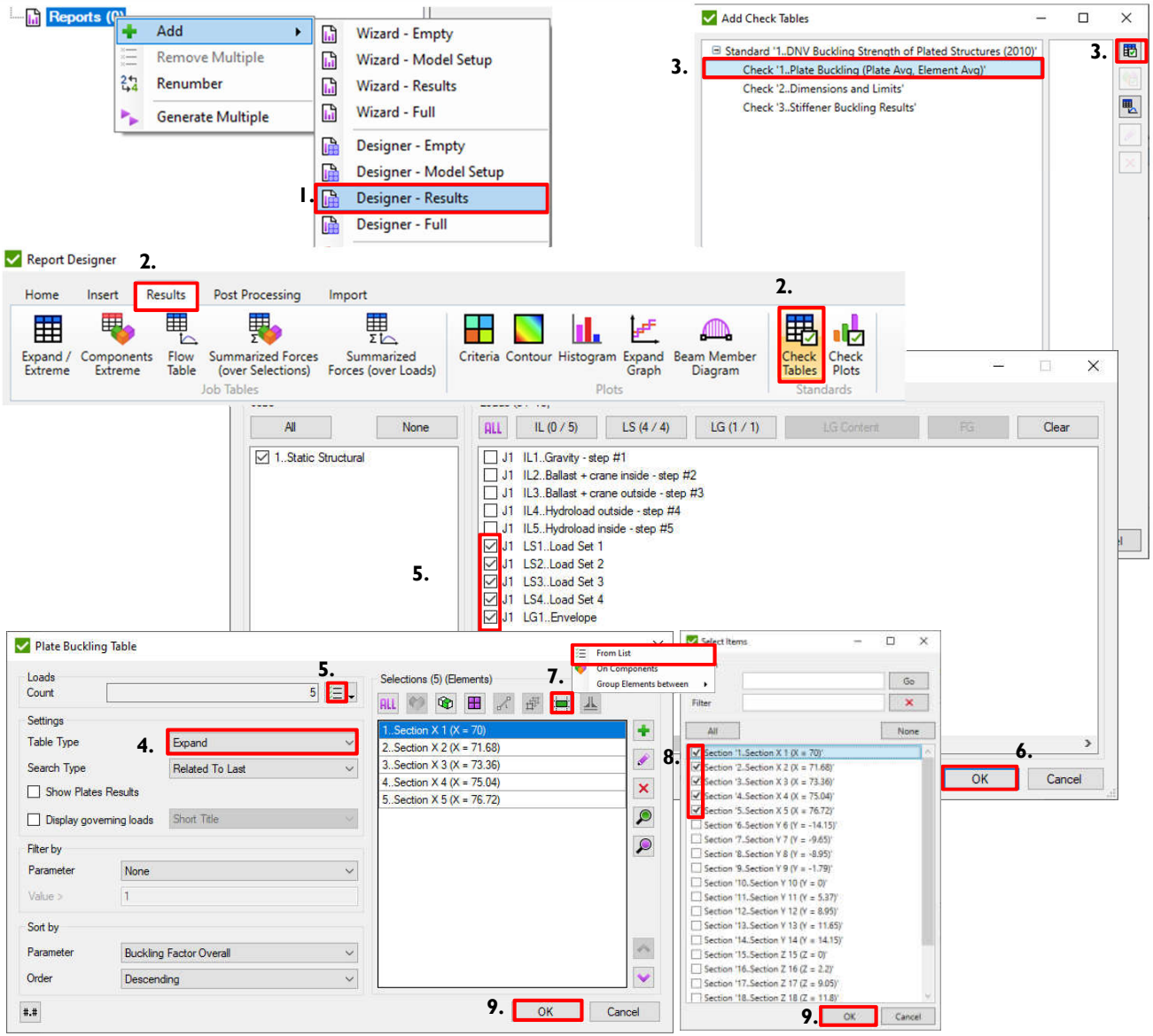


Use **Show plates results** for detailed table with results for all plates. Otherwise only the worst results over Sections will be shown.



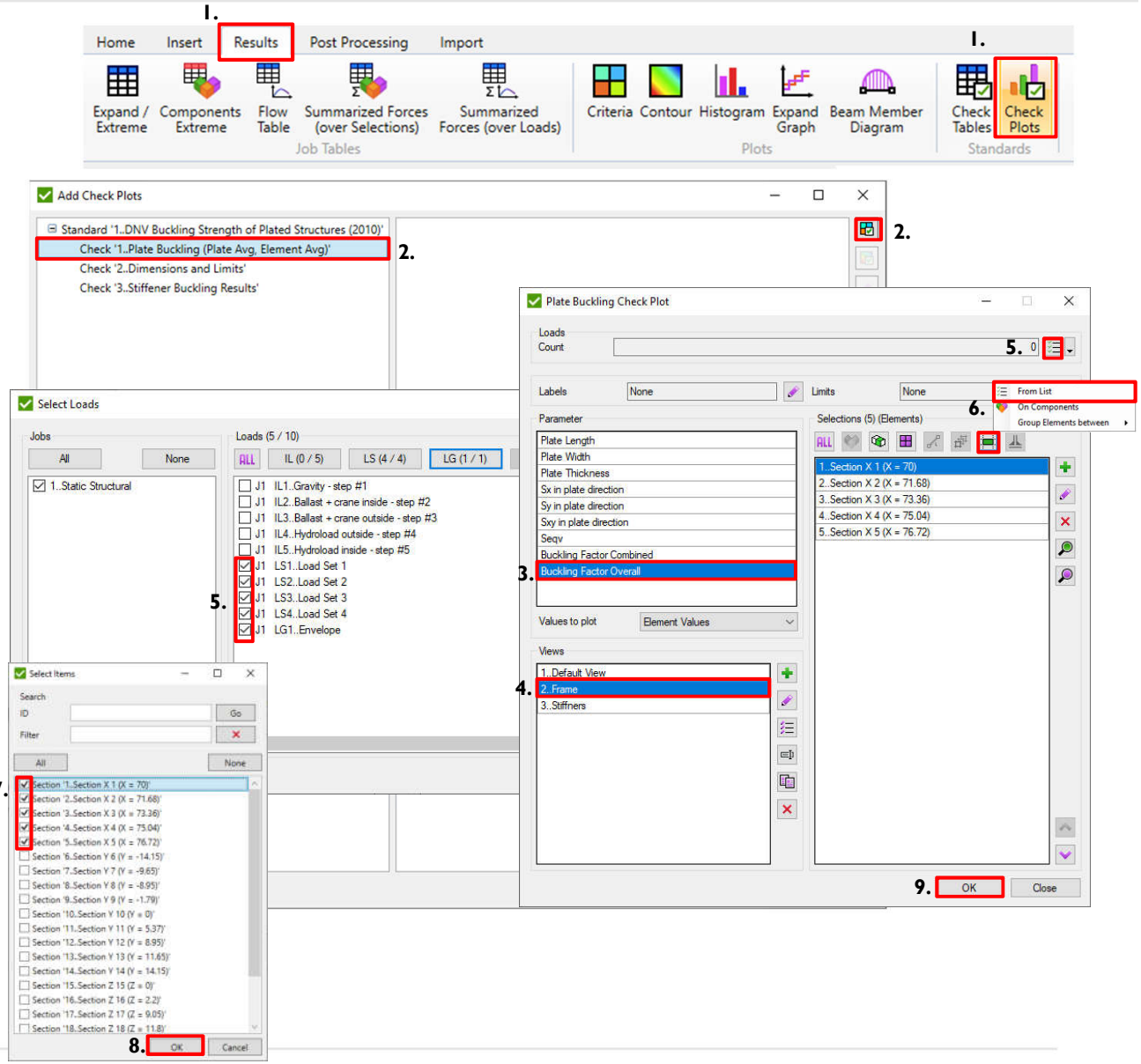
Report. Tables

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*



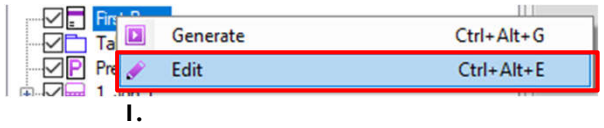
Report. Plots

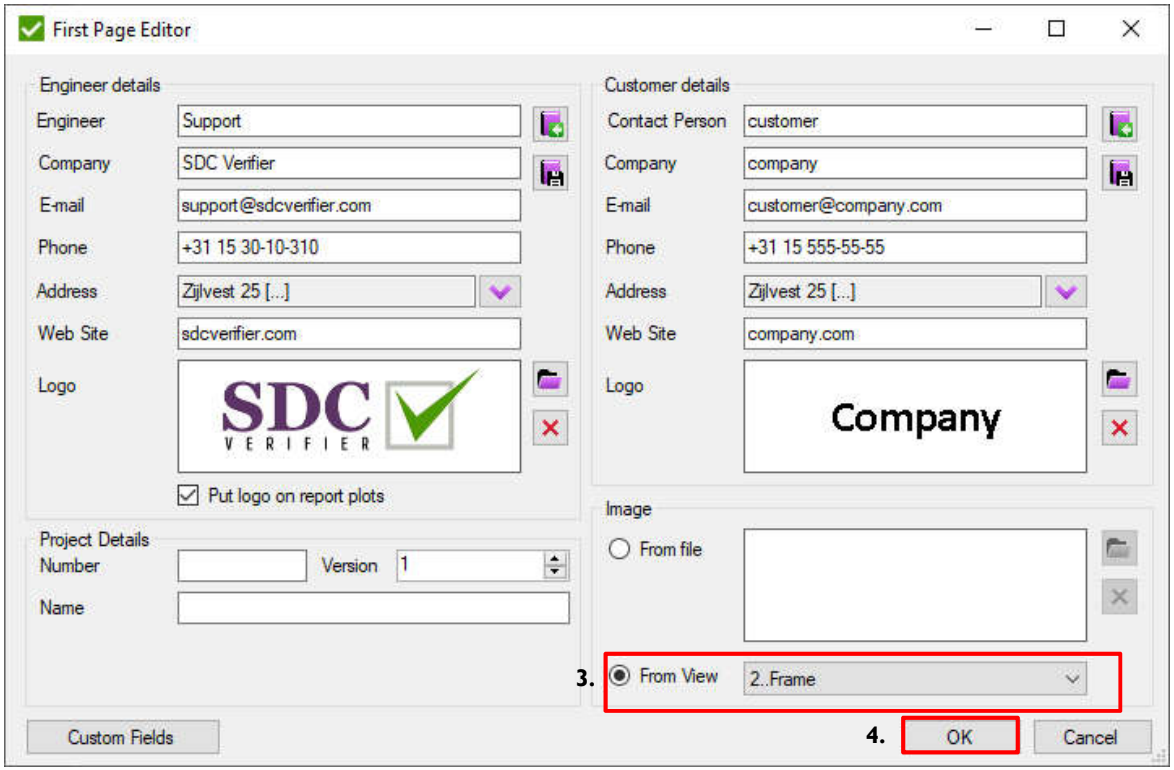
1. Results => *Check Plots*
2. *Press => Check '1..Plate Buckling' =>*
3. Parameter: **Buckling Factor Overall.**
4. Views: **Frame**.
5. Press , select **LS**; **LG** Loads and Press *OK*.
6. Press and Execute From List
7. Select all **X sections**.
8. Press *OK*.
9. Press *OK*.



Report. First Page

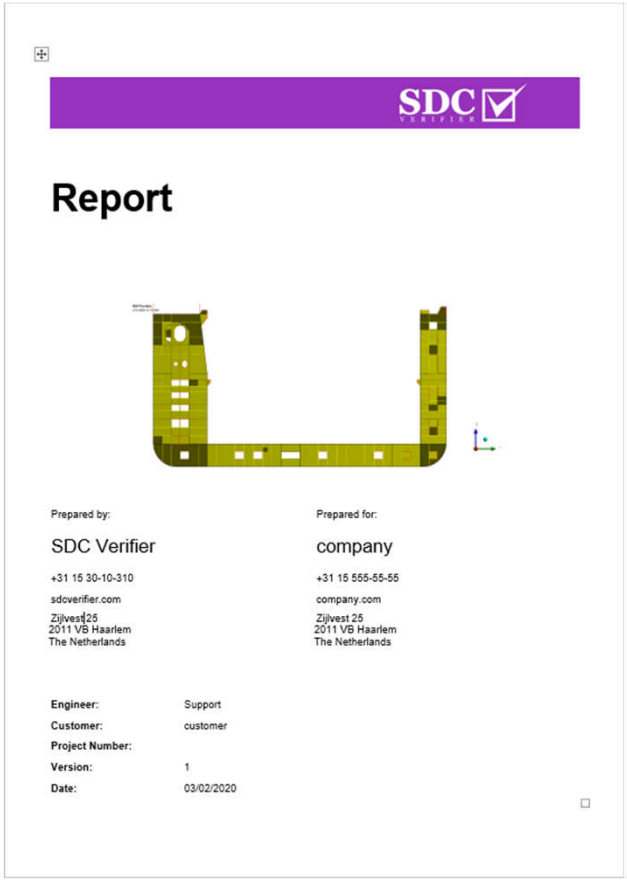
1. Right click on *First Page* => ***Edit***.
2. Fill in information about project.
3. Select Image *From View* and pick '*2..Frame*'.
4. Press *OK*.





Report

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



SDC VERIFIER

Report

Prepared by:

SDC Verifier

+31 15 30-10-310

sdcverifier.com

Zijlvest 25
2011 VB Haarlem
The Netherlands

Prepared for:

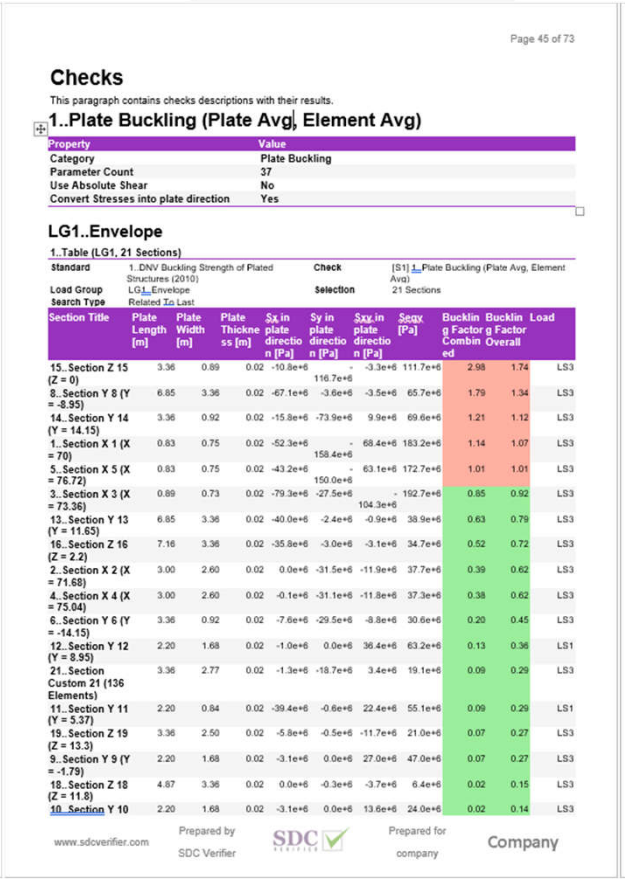
company

+31 15 555-55-55

company.com

Zijlvest 25
2011 VB Haarlem
The Netherlands

Engineer:	Support
Customer:	customer
Project Number:	
Version:	1
Date:	03/02/2020



Checks

This paragraph contains checks descriptions with their results.

1..Plate Buckling (Plate Avg, Element Avg)

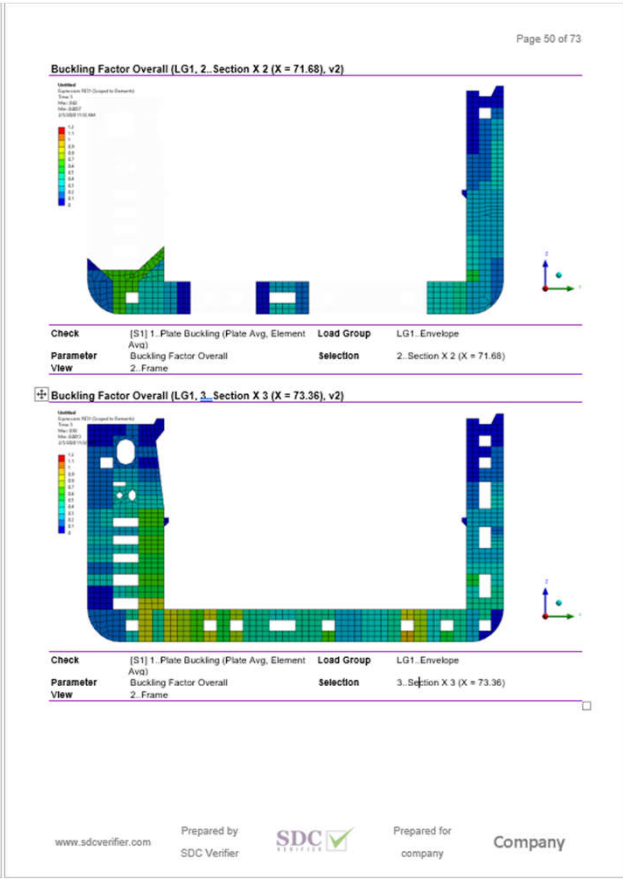
Property	Value
Category	Plate Buckling
Parameter Count	37
Use Absolute Shear	No
Convert Stresses into plate direction	Yes

LG1..Envelope

1..Table (LG1, 21 Sections)

Standard	1..DNV Buckling Strength of Plated Structures (2010)	Check	[S1] 1..Plate Buckling (Plate Avg, Element Avg)
Load Group	LG1..Envelope	Selection	21 Sections
Search Type	Related To Last		

Section Title	Plate Length [m]	Plate Width [m]	Plate Thickness [m]	Sx in plate direction [Pa]	Sy in plate direction [Pa]	Sxy in plate direction [Pa]	Seqv [Pa]	Buckling Factor Combined	Buckling Factor Overall	Load
15..Section Z 15 (Z = 0)	3.36	0.89	0.02	-10.8e+6	-116.7e+6	-3.3e+6	111.7e+6	2.98	1.74	LS3
8..Section Y 8 (Y = -8.95)	6.85	3.36	0.02	-67.1e+6	-3.6e+6	-3.5e+6	65.7e+6	1.79	1.34	LS3
14..Section Y 14 (Y = 14.15)	3.36	0.92	0.02	-15.8e+6	-73.9e+6	9.9e+6	69.6e+6	1.21	1.12	LS3
1..Section X 1 (X = 70)	0.83	0.75	0.02	-52.3e+6	-158.4e+6	68.4e+6	183.2e+6	1.14	1.07	LS3
5..Section X 5 (X = 76.72)	0.83	0.75	0.02	-43.2e+6	-150.0e+6	63.1e+6	172.7e+6	1.01	1.01	LS3
3..Section X 3 (X = 73.36)	0.89	0.73	0.02	-79.3e+6	-27.5e+6	-104.3e+6	192.7e+6	0.85	0.92	LS3
13..Section Y 13 (Y = 11.65)	6.85	3.36	0.02	-40.0e+6	-2.4e+6	-0.9e+6	38.9e+6	0.63	0.79	LS3
16..Section Z 16 (Z = 2.2)	7.16	3.36	0.02	-35.8e+6	-3.0e+6	-3.1e+6	34.7e+6	0.52	0.72	LS3
2..Section X 2 (X = 71.68)	3.00	2.60	0.02	0.0e+6	-31.5e+6	-11.9e+6	37.7e+6	0.39	0.62	LS3
4..Section X 4 (X = 75.04)	3.00	2.60	0.02	-0.1e+6	-31.1e+6	-11.8e+6	37.3e+6	0.38	0.62	LS3
6..Section Y 6 (Y = -14.15)	3.36	0.92	0.02	-7.6e+6	-29.5e+6	-8.8e+6	30.6e+6	0.20	0.45	LS3
12..Section Y 12 (Y = 8.95)	2.20	1.68	0.02	-1.0e+6	0.0e+6	36.4e+6	63.2e+6	0.13	0.36	LS1
21..Section Custom 21 (136 Elements)	3.36	2.77	0.02	-1.3e+6	-18.7e+6	3.4e+6	19.1e+6	0.09	0.29	LS3
11..Section Y 11 (Y = 5.37)	2.20	0.84	0.02	-39.4e+6	-0.6e+6	22.4e+6	55.1e+6	0.09	0.29	LS1
19..Section Z 19 (Z = 13.3)	3.36	2.50	0.02	-5.8e+6	-0.5e+6	-11.7e+6	21.0e+6	0.07	0.27	LS3
9..Section Y 9 (Y = -1.79)	2.20	1.68	0.02	-3.1e+6	0.0e+6	27.0e+6	47.0e+6	0.07	0.27	LS3
18..Section Z 18 (Z = 11.8)	4.87	3.36	0.02	0.0e+6	-0.3e+6	-3.7e+6	6.4e+6	0.02	0.15	LS3
10..Section Y 10	2.20	1.68	0.02	-3.1e+6	0.0e+6	13.6e+6	24.0e+6	0.02	0.14	LS3



Buckling Factor Overall (LG1, 2..Section X 2 (X = 71.68), v2)

Check	[S1] 1..Plate Buckling (Plate Avg, Element Avg)	Load Group	LG1..Envelope
Parameter	Buckling Factor Overall	Selection	2..Section X 2 (X = 71.68)
View	2..Frame		

Buckling Factor Overall (LG1, 3..Section X 3 (X = 73.36), v2)

Check	[S1] 1..Plate Buckling (Plate Avg, Element Avg)	Load Group	LG1..Envelope
Parameter	Buckling Factor Overall	Selection	3..Section X 3 (X = 73.36)
View	2..Frame		