




Tutorial

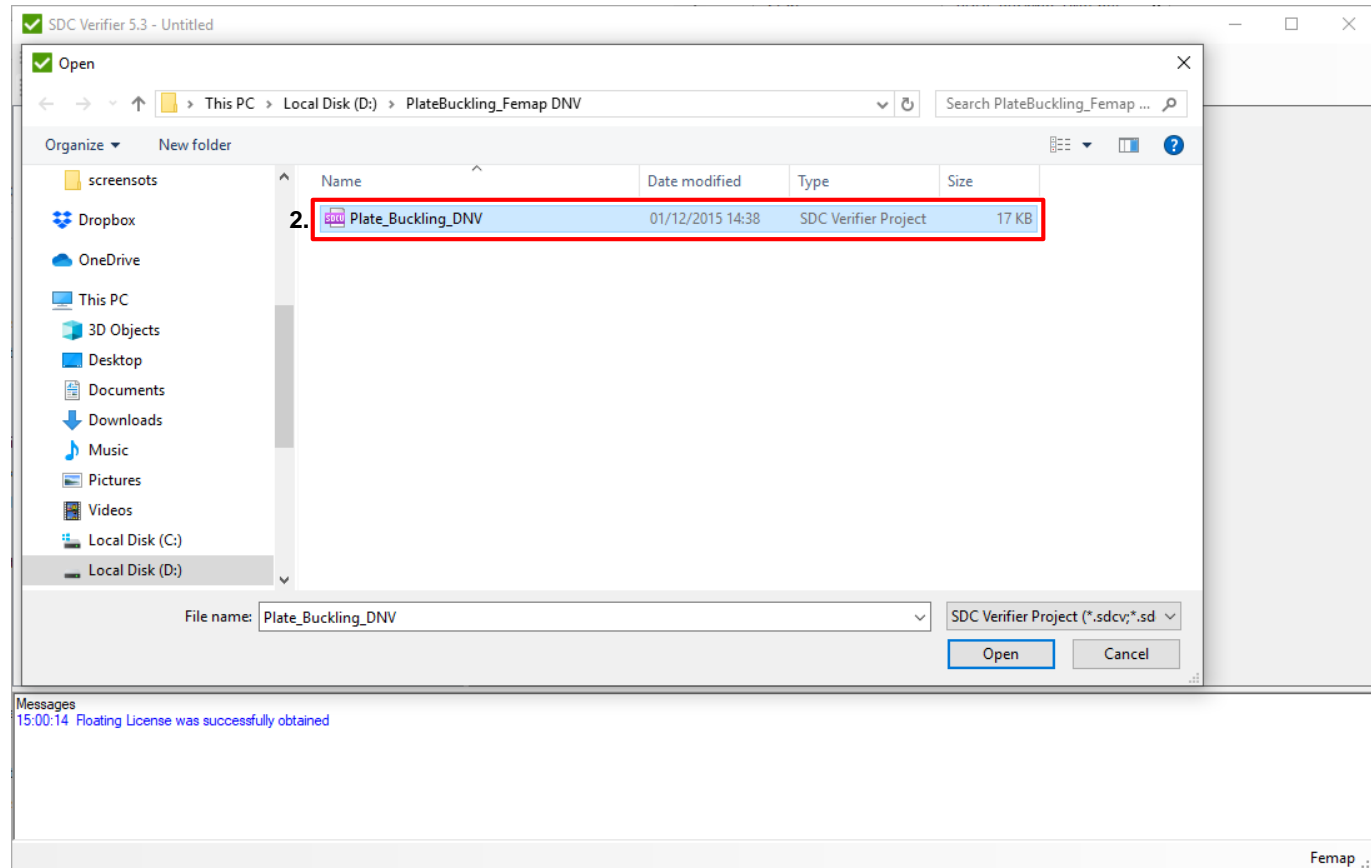
Plate Buckling DNV 2010

23 Jan 2020
version 5.3

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

Open the starter model

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



Individual Loads

1

Click on **Individual Loads**


2

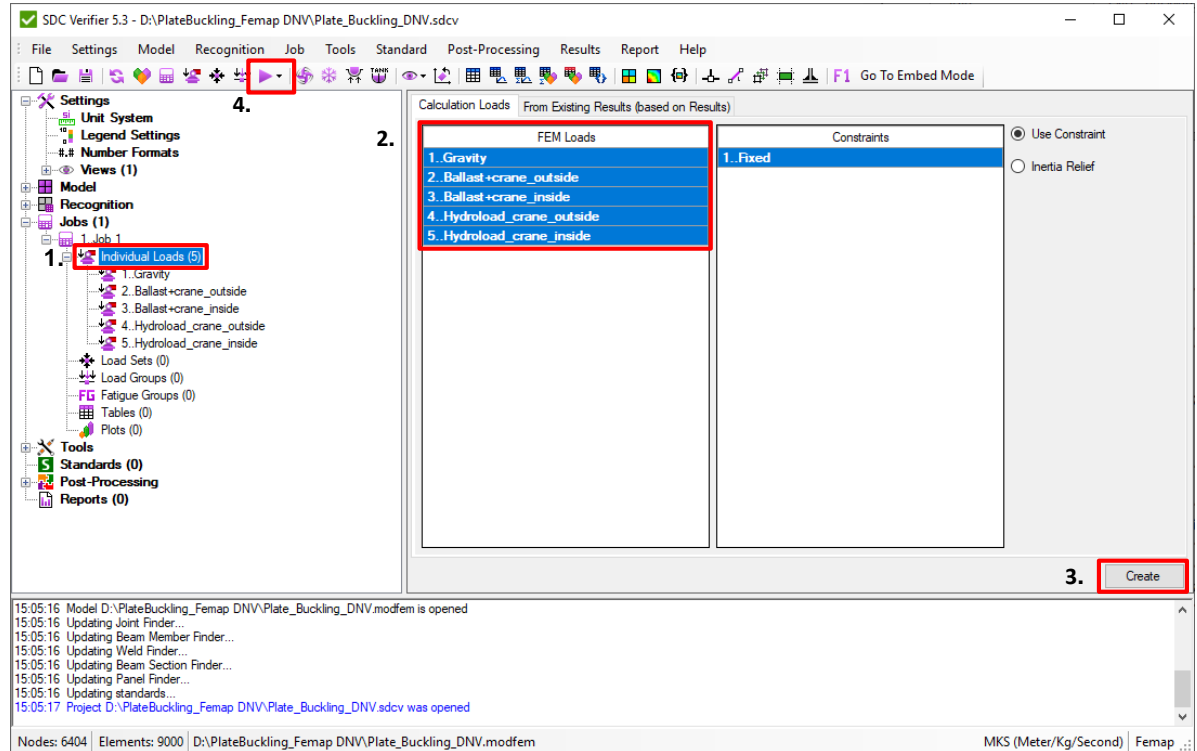
Choose 5 FEM Loads:

3


Press *Create*

4

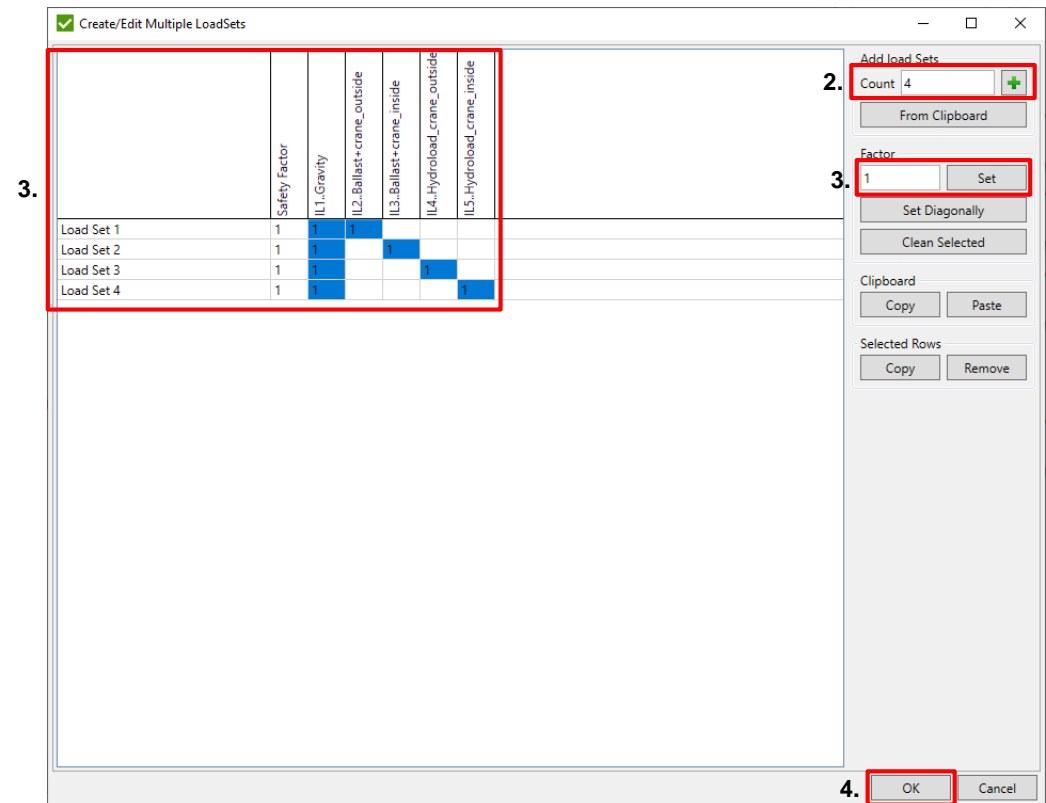
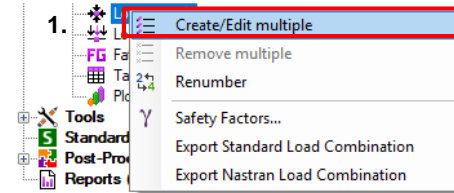
Press  on toolbar to analyze job



Load Sets


- 1 Right click on *Load Sets* => **Create/Edit multiple**
- 2 Fill in "4" into *Count* and press  to add four Load Sets.
- 3 Select highlighted cells in table like shown on the picture and press *Set* to define Factors of Load Sets.
- 4 Press *OK*.

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



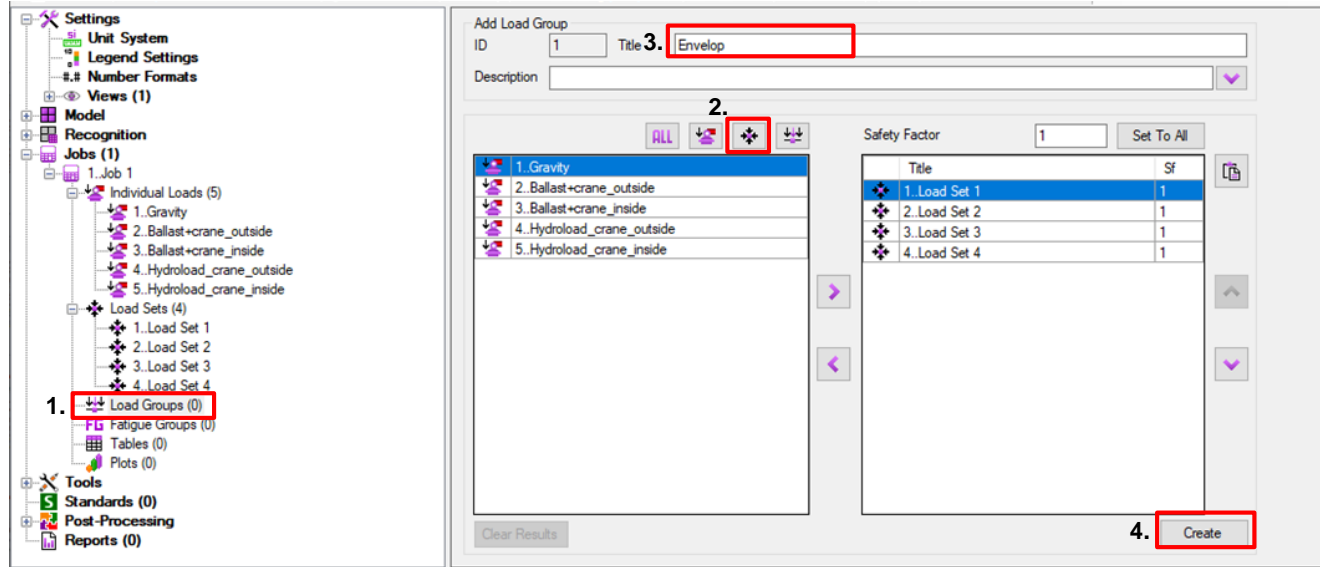
Load Groups

1 Click on **Load Groups**

2 Press  to select all Load Sets

3 **Title: Envelop;**

4 Press **Create**



The screenshot shows the SDC Verifier interface. On the left is a project tree with a red box around 'Load Groups (0)' and a '1.' next to it. On the right is the 'Add Load Group' dialog. The 'Title' field contains 'Envelop' with a '3.' next to it. The 'ALL' button is selected with a '2.' next to it. The 'Create' button at the bottom right is highlighted with a '4.' next to it. The dialog also shows a list of load sets and a safety factor table.

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

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

Panel Finder. Recognize Sections.

1

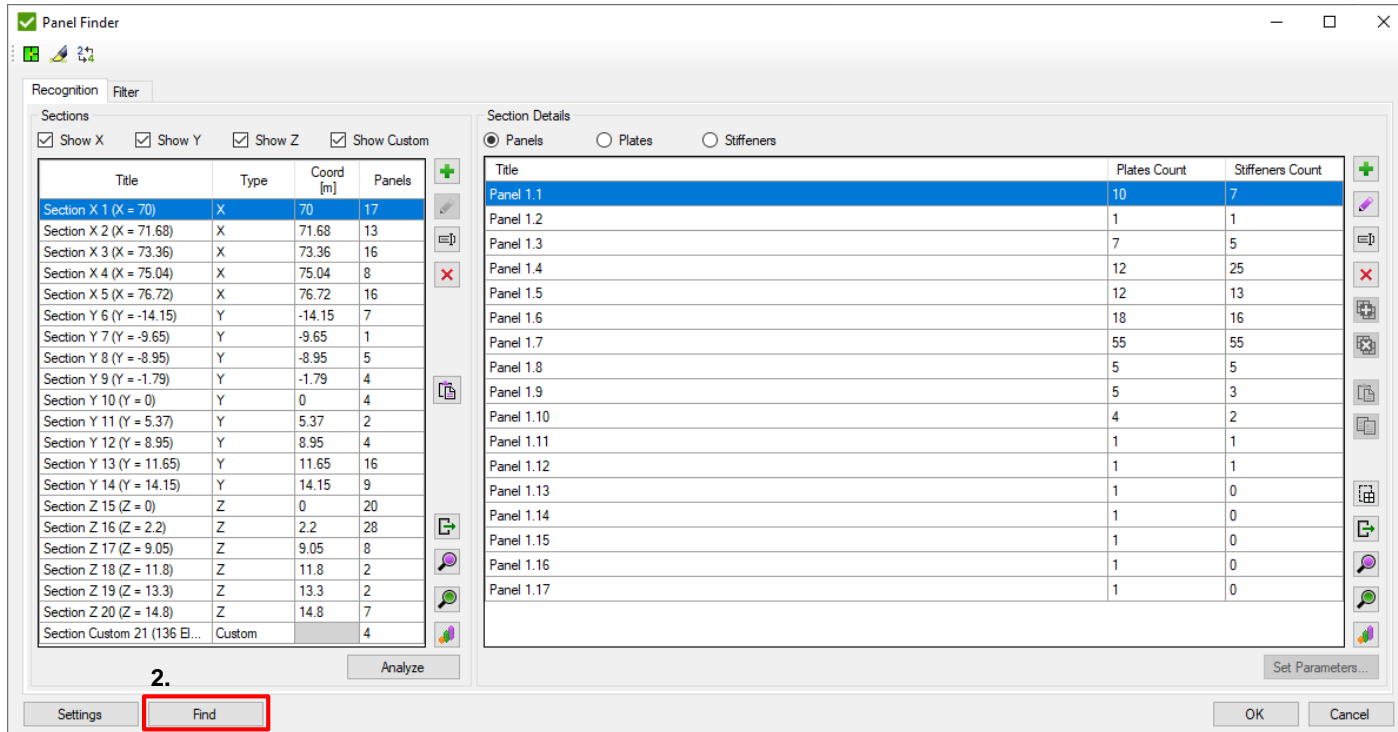
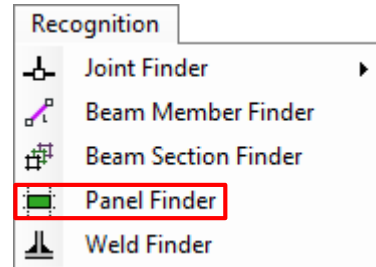
Execute *Recognition - Panel Finder* from main menu

2

Click on *Find*



All Frames, Longitudinals and Decks were automatically.

1.



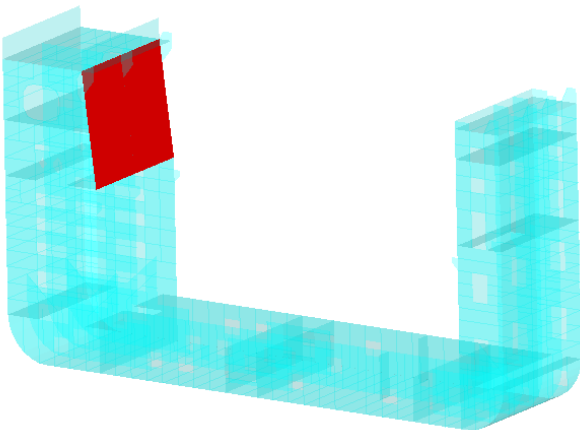
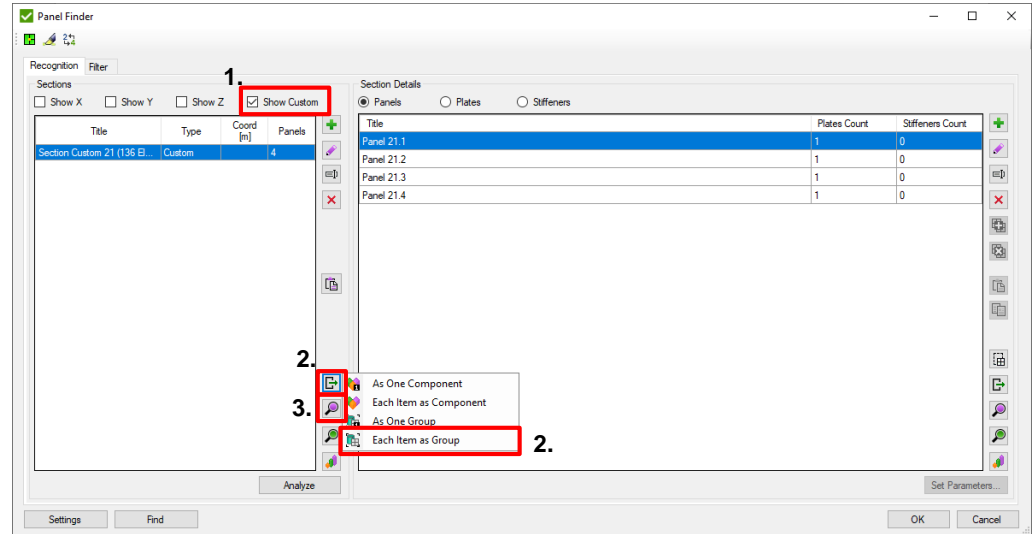
Panel Finder. Custom Section

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

2 Press  and  to export selected sections to groups

3 Press 

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



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


Panel Finder. Find Free Edges

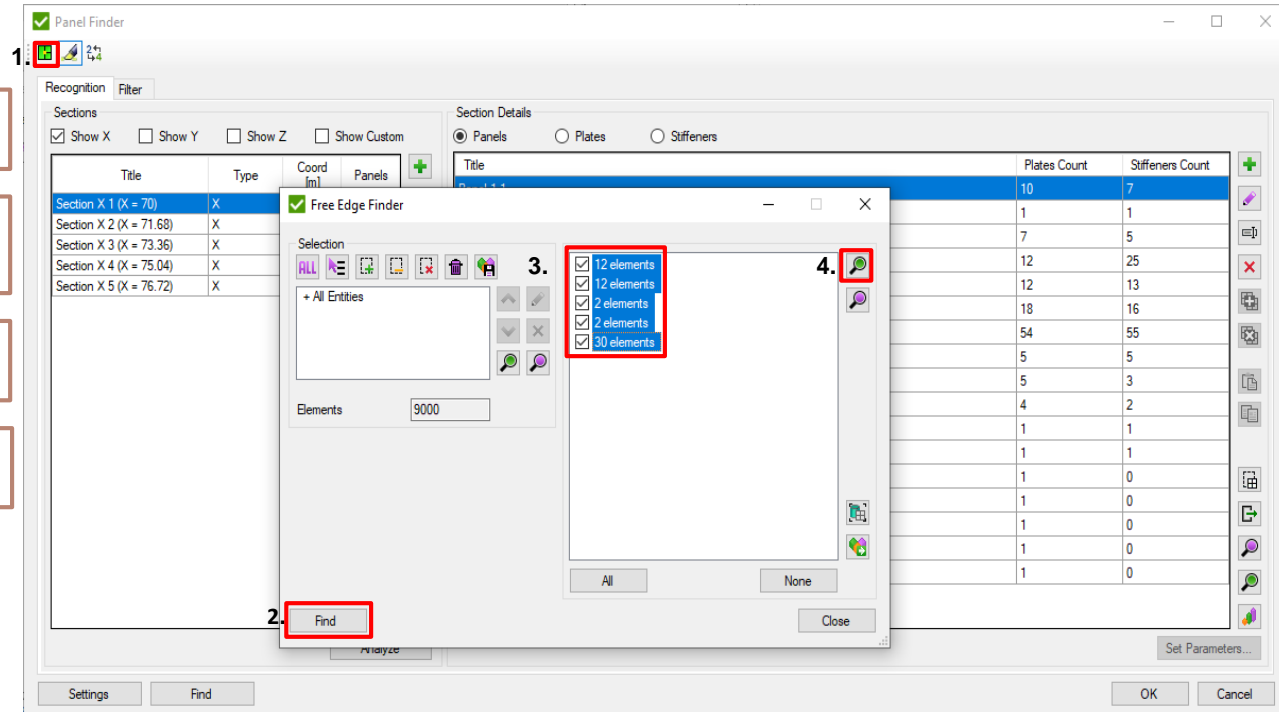
Note: Before plates recognition, the model should be checked on free edges. Not correct plate dimensions/direction, plates with undefined dimensions and as result wrong buckling factor – possible consequences of free edges.

1. Click **Find Free edges**

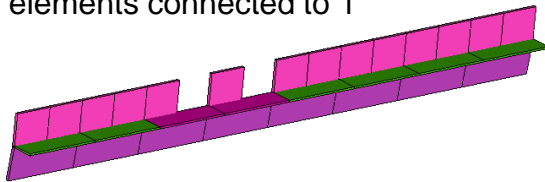
2. Press **Find**

3. Select all free edges

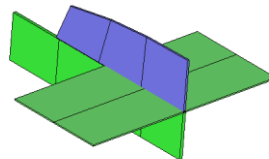
4. Press  to preview elements with free edges



2 elements connected to 1



Mesh does not coincide



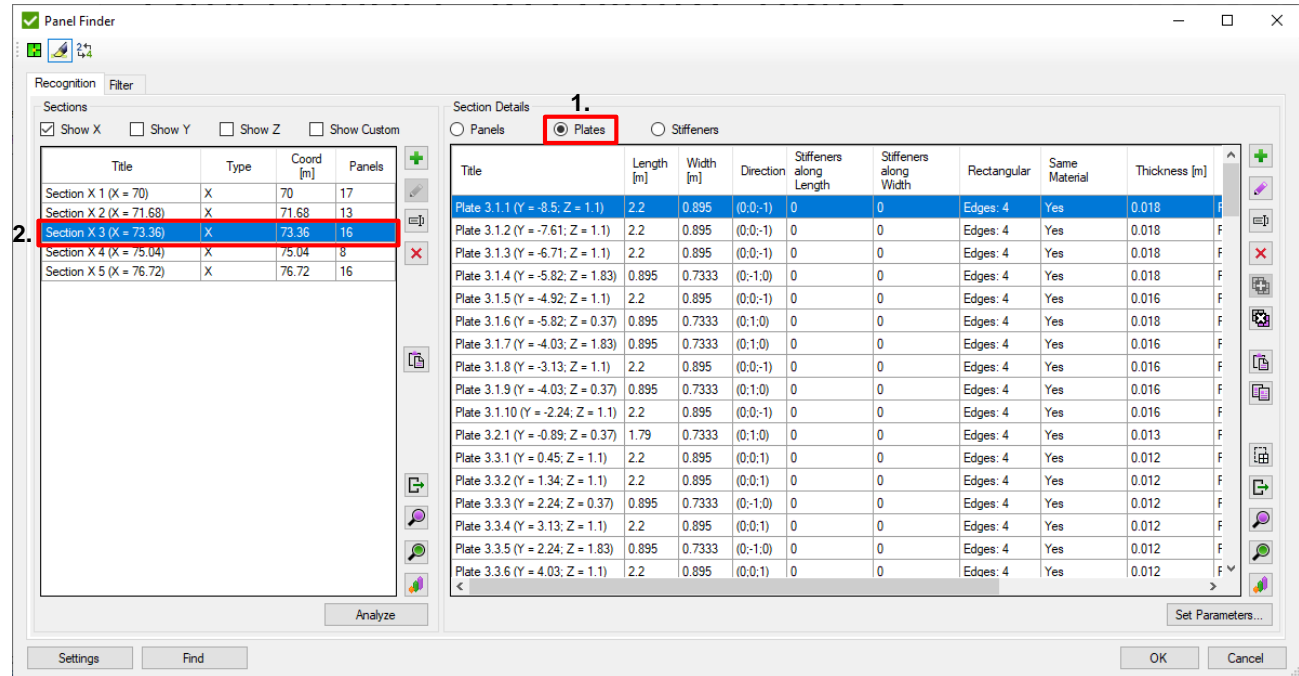
Note: Free edges should be fixed by remeshing the model and run recognition of plates. (In tutorial we skipped step with remeshing but for commercial project it is crucial step to do).

Panel Finder. Recognize plates

1 In Selection details Press **Plates**

2 Select **Section X3**.

Tip: If it is necessary to recognize plates only for one section press *Analyze*



Title	Length [m]	Width [m]	Direction	Stiffeners along Length	Stiffeners along Width	Rectangular	Same Material	Thickness [m]
Plate 3.5.15 (Y = 13.73; Z = 1...	0.8333	0.75	(0;1;0)	0	0	Edges: 4	Yes	0.012
Plate 3.6.1 (Y = 12.9; Z = 2.39)	2.5	1.5333	(0;1;0)	0	0	Edges: 8	Yes	Min = 0.016

Section ID. Panel ID. Plate ID

Plate is rectangle with all corners = 90 degrees

Plate has elements more than from one property

Plate Dimensions and Thicknesses

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

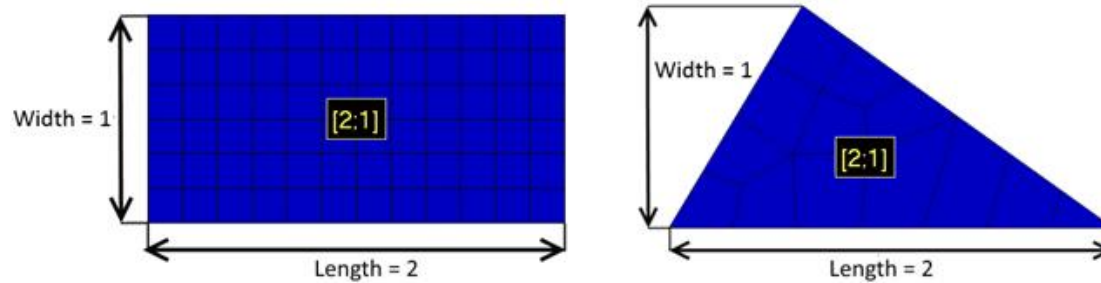


Plate Thickness: Calculations are performed on every element and thickness is taken directly from each element. It is possible to set thickness manually for plate, in this case element thickness will be ignored and user defined thickness will be used. Example: Plate with 2 properties 0.01 and 0.02 thicknesses.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

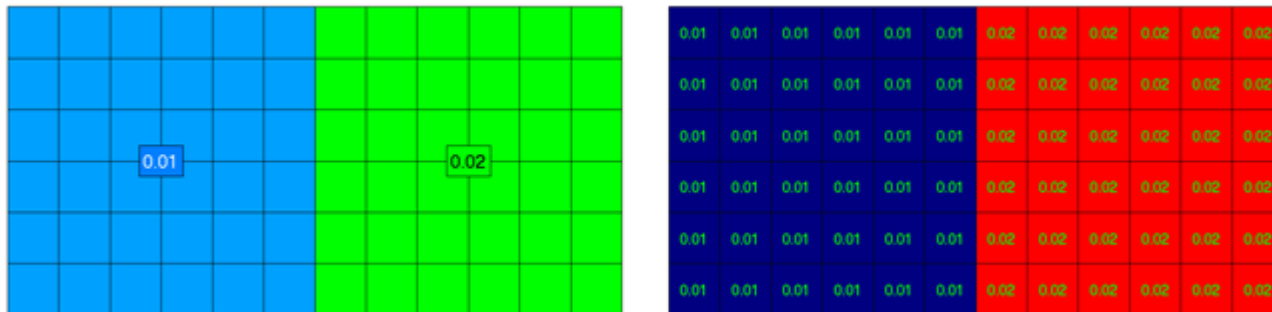


Plate Buckling Dimensions by CSR

☒ Panel Finder Recognition Settings

Selection

☐ Use Selection

Predefined Girders

Predefined Stiffeners

Predefined Borders

Plates

Minimum Angle Between Plate Edges [0:90]

☐ Skip Not Four Edged Plates

☐ Skip Triangular Plates

☒ Skip Curved Stiffeners

☐ Split Plate on Thickness Difference

☐ Calculate Dimensions by CSR Method

Default Titles by Section Type

Section X

Section Y

Section Z

Section Custom

Sections

Coordinate Deviation Limit of Section Plane

Minimum Elements Count in a Section

Minimum Angle Between Inclined Plane Normals [0:90]

OK Cancel

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:

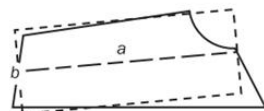
- e) The length of shorter side, b in mm, is to be taken as:

$$b = A/a$$

where:

A : Area of the plate, in mm²

a : length defined in (d), in mm

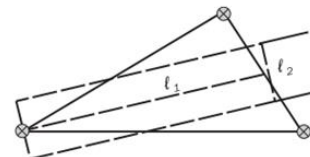


- c) The width of the model, ℓ_2 , in mm, is to be taken as:

$$\ell_2 = A/\ell_1$$

where:

A : Area of the plate, in mm²



Editing plates manually

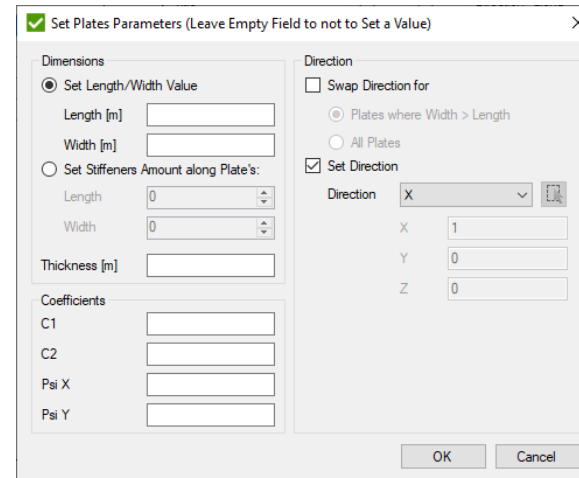
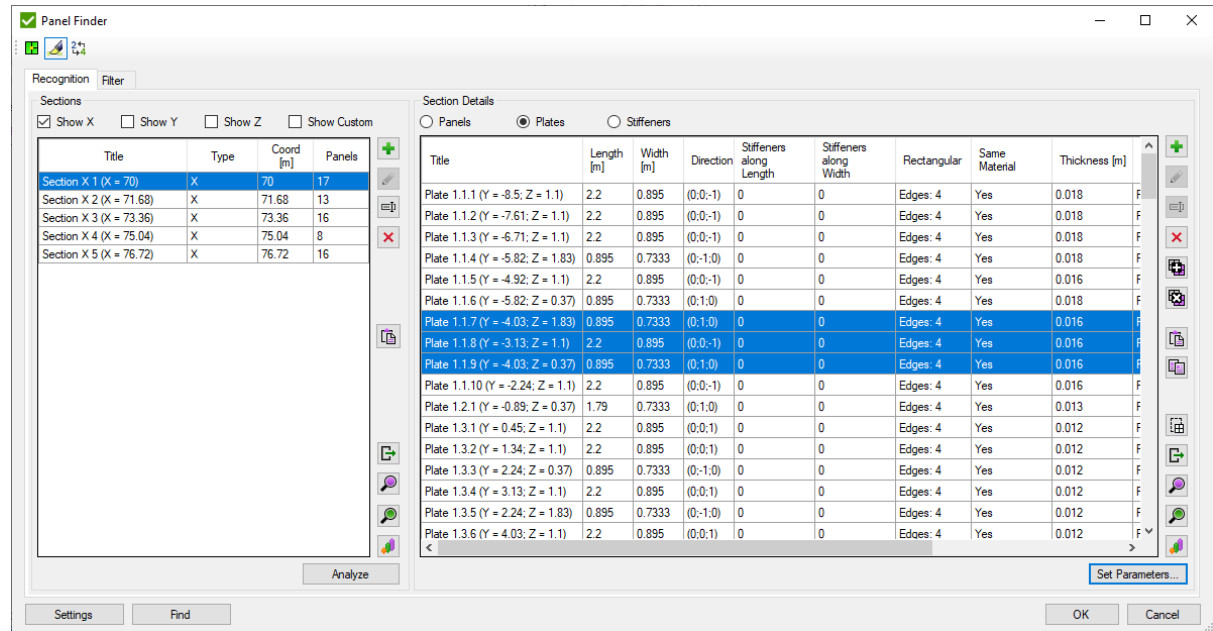
To modify plates select them from the list and press *Set Parameters*. It is possible to edit (Length / Width / Thickness / Coefficients / Direction).

It is possible to define parametric stiffeners along the Length and Width.


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

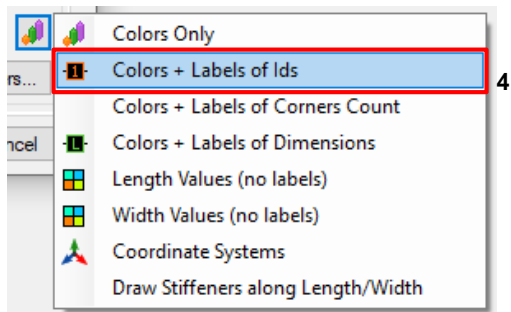
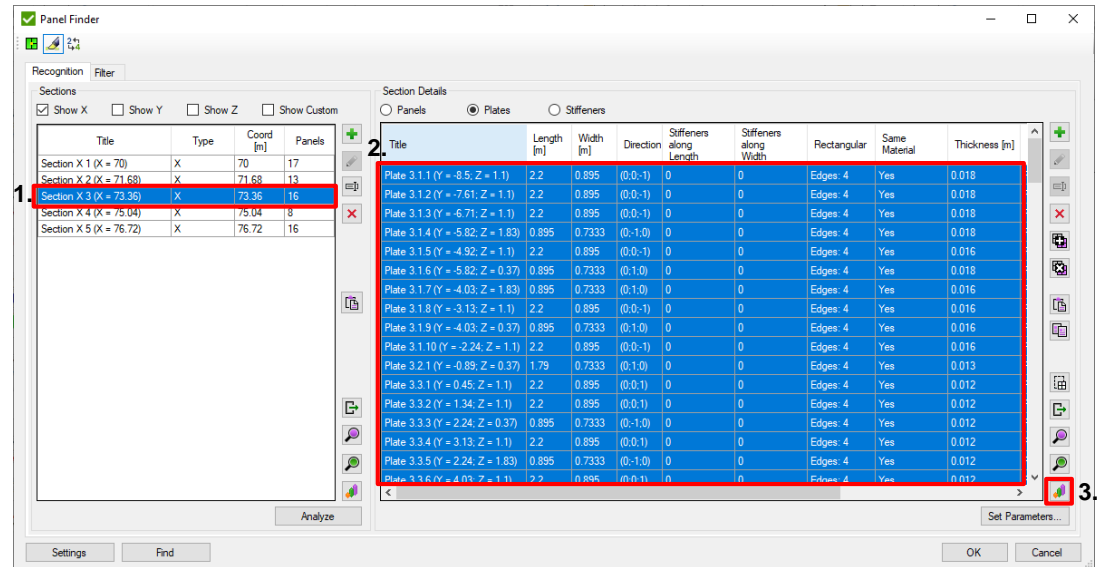
Thickness
0.016 (Original: 0.012)
0.016 (Original: 0.012)
0.016 (Original: 0.012)

Usually you should not modify plate directions. But in case it is required 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. Stiffeners Plot

1

Select *Stiffeners*

2

Select All *Stiffeners*

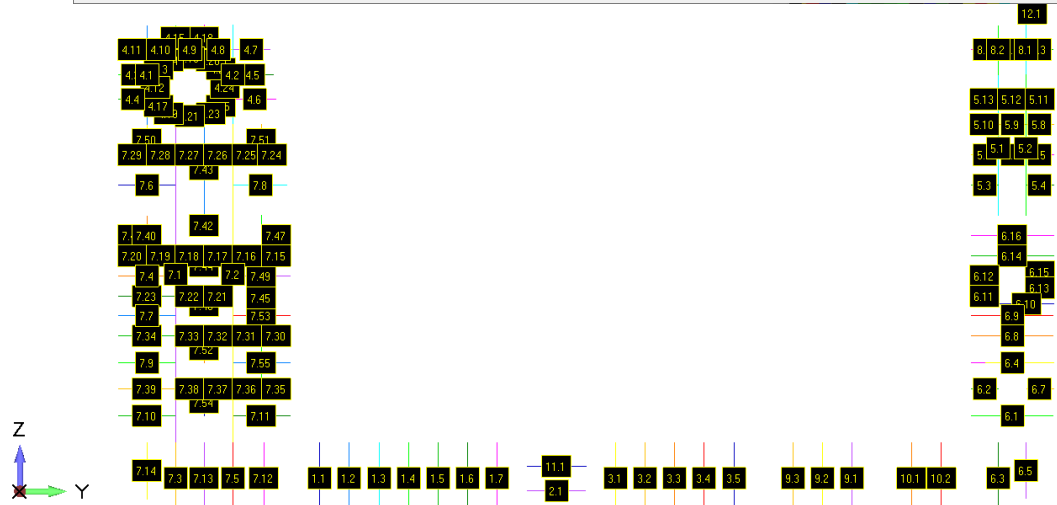
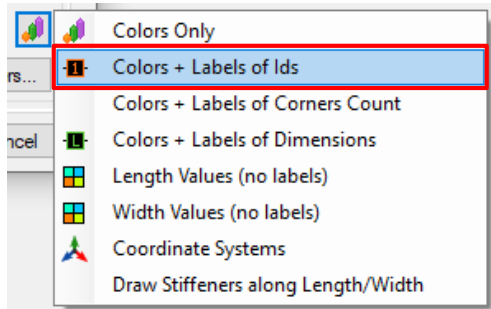
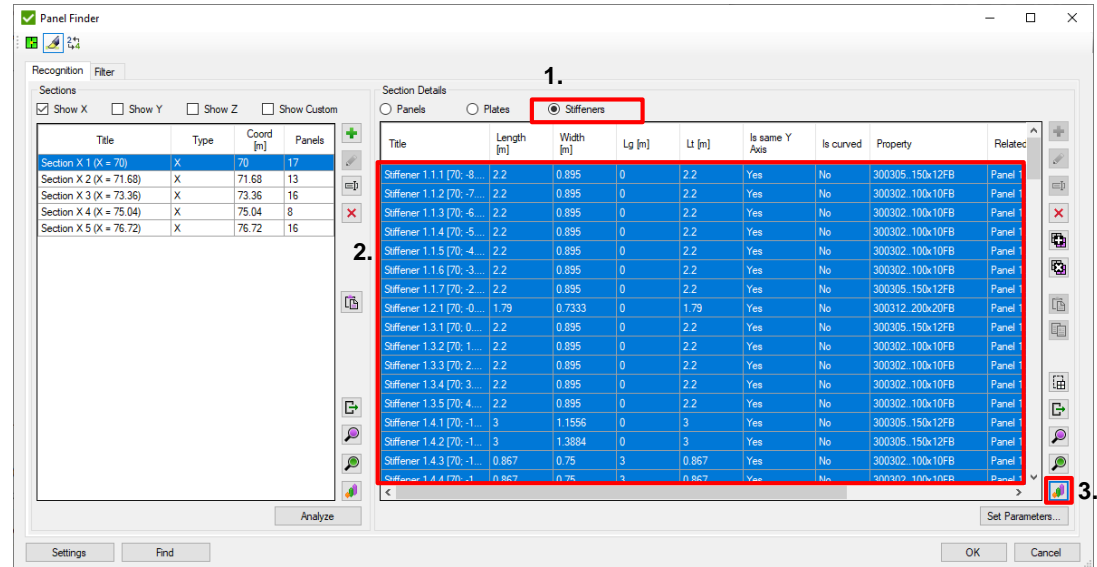
3

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

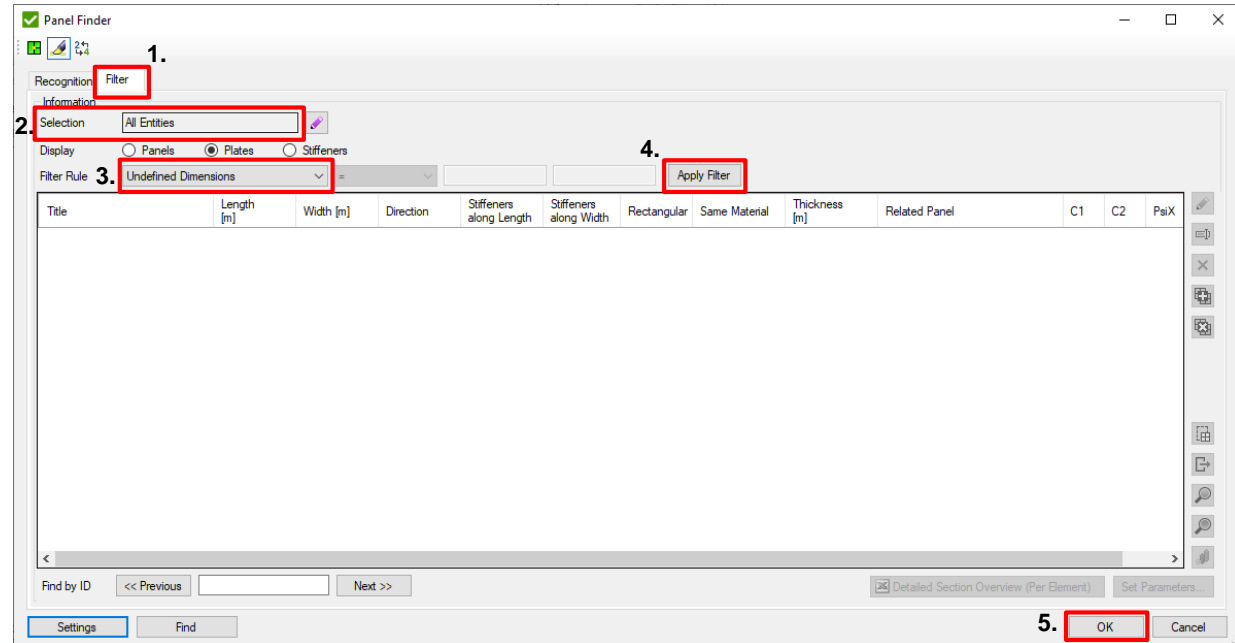
Filter: **Undefined dimensions**

4

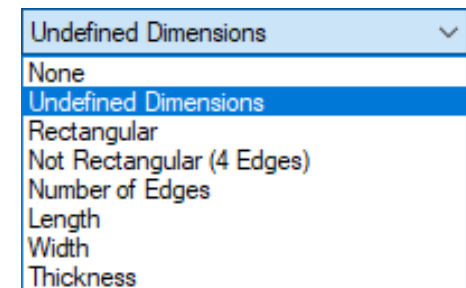
Press *Apply Filter*

5




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



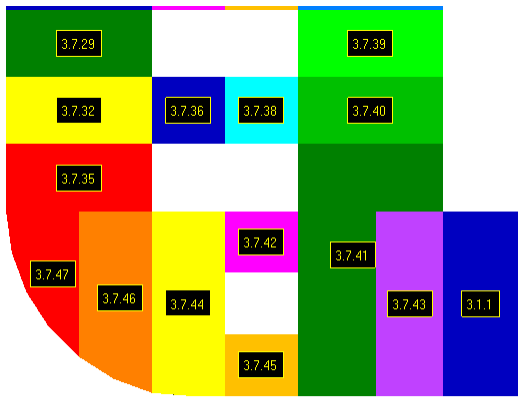
Tip: It is also possible to filter plates by shape (triangle, rectangular) or number of edges parameters.
E.g. Plates with numbers of edges > 4 can be displayed.
Control using Selection plates from which Sections should be filtered.



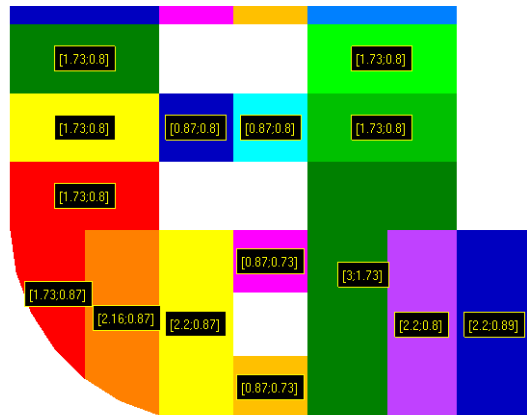
Note: Plate Plot can be displayed with different colors labels (labels of ids, labels of corners count or labels of dimensions). Also it is possible to show plates in length and width, coordinate systems etc.

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

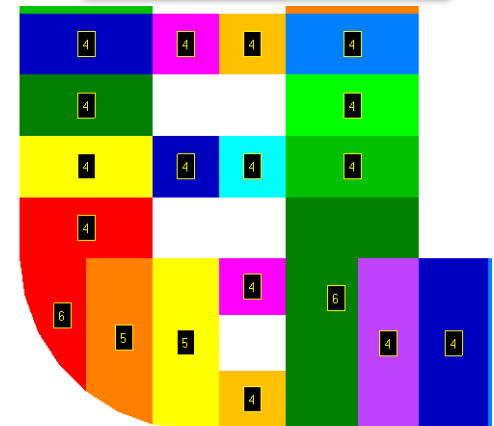
Labels of Ids



Labels of dimensions

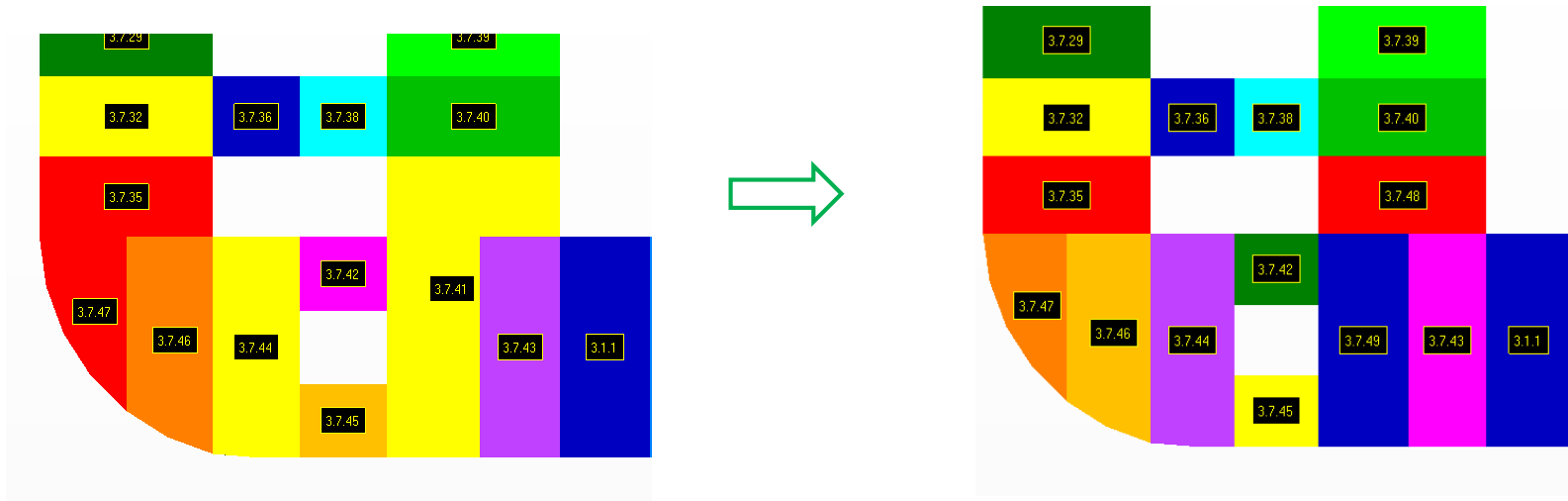


Labels of Corners Count



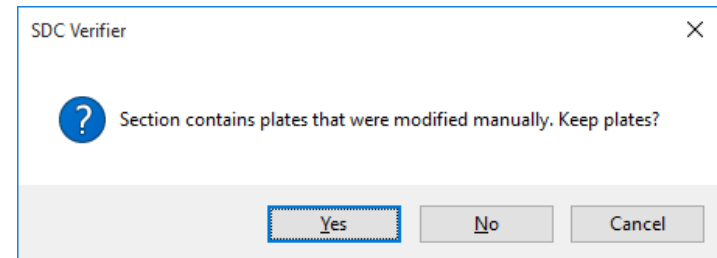
Panel Finder. Update Plates

In some cases (e.g. stiffener is not modeled) plate is recognized not correctly, dimensions are bigger than in reality which leads to wrong results. Plate has to be updated manually. In Section X3 plate with Id = 3.7.41 should be split on 2 plates



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

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



Panel Finder. Split Plate

1

Select **Section X3**

2

Select **Plate 3.7.41**.

3

Press ***Split by elements***

4

Selected plate is displayed in Femap. Select elements for one plate. And press **OK**

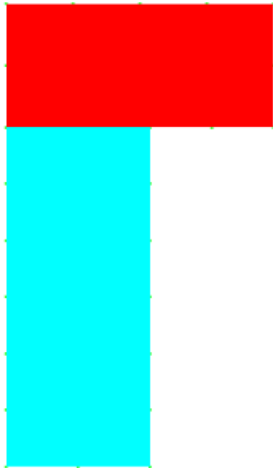
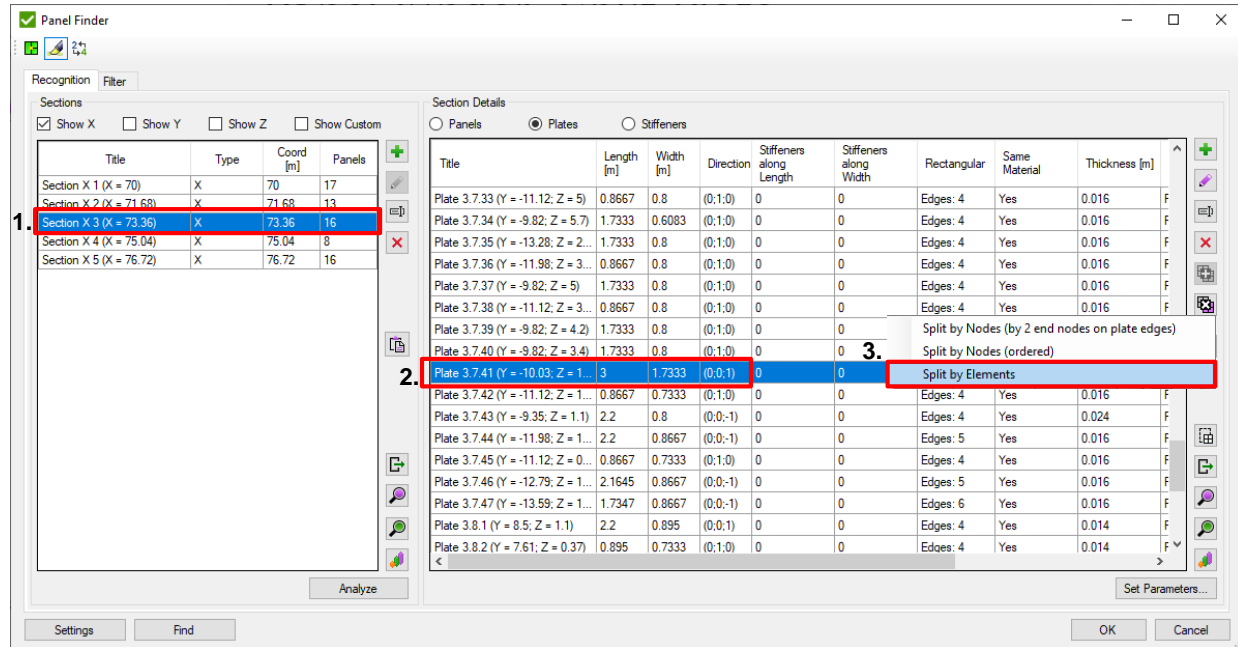
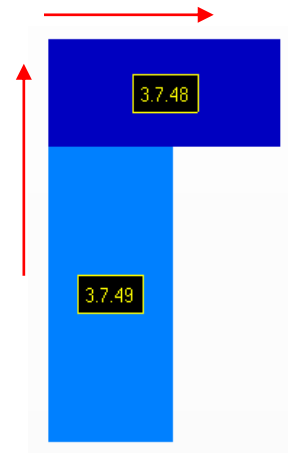


Plate 3.7.41 is replaced with Plates 3.7.48 and 3.7.49
Dimensions and directions are updated automatically



Title
Plate 3.7.48 (Y = -9.8; Z = 2.6)
Plate 3.7.49 (Y = -10.22; Z = 1...)



Add Plate Buckling DNV 2010 standard

1 In Standards Context menu execute
Add => DNV Plate/Stiffener Buckling
(2010)

2 Utilization Factor (Eta) = 1.15

3 Use Plate Average Stress: **On**

4 Press OK

DNV Plate/Stiffener Buckling (2010)

ID: 1 Title: DNV Buckling Strength of Plated Structures (2010)

Description:

Options

Resulting Material Factor: 1.15

Buckling Resistance is divided on Resulting Material Factor

Materials with Yield = 0: 0

Sections: 20 sections

Plate Buckling

Thickness Factor: 1.0

3. ☒ Use Plate Average Stress

☐ Use Absolute Shear for Plate Average (Conservative)

Stress on Element: Average

☒ Include Plate Dimensions (Length, Width, Thickness) in table

Stiffener Buckling

Psi: Defined

Z* - distance from neutral axis to axial force point: Defined

4. OK Cancel

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.

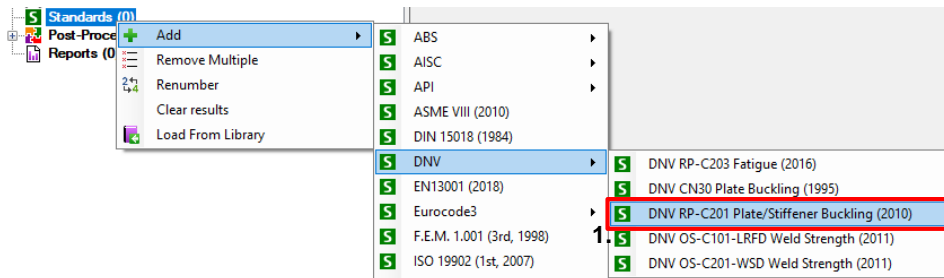
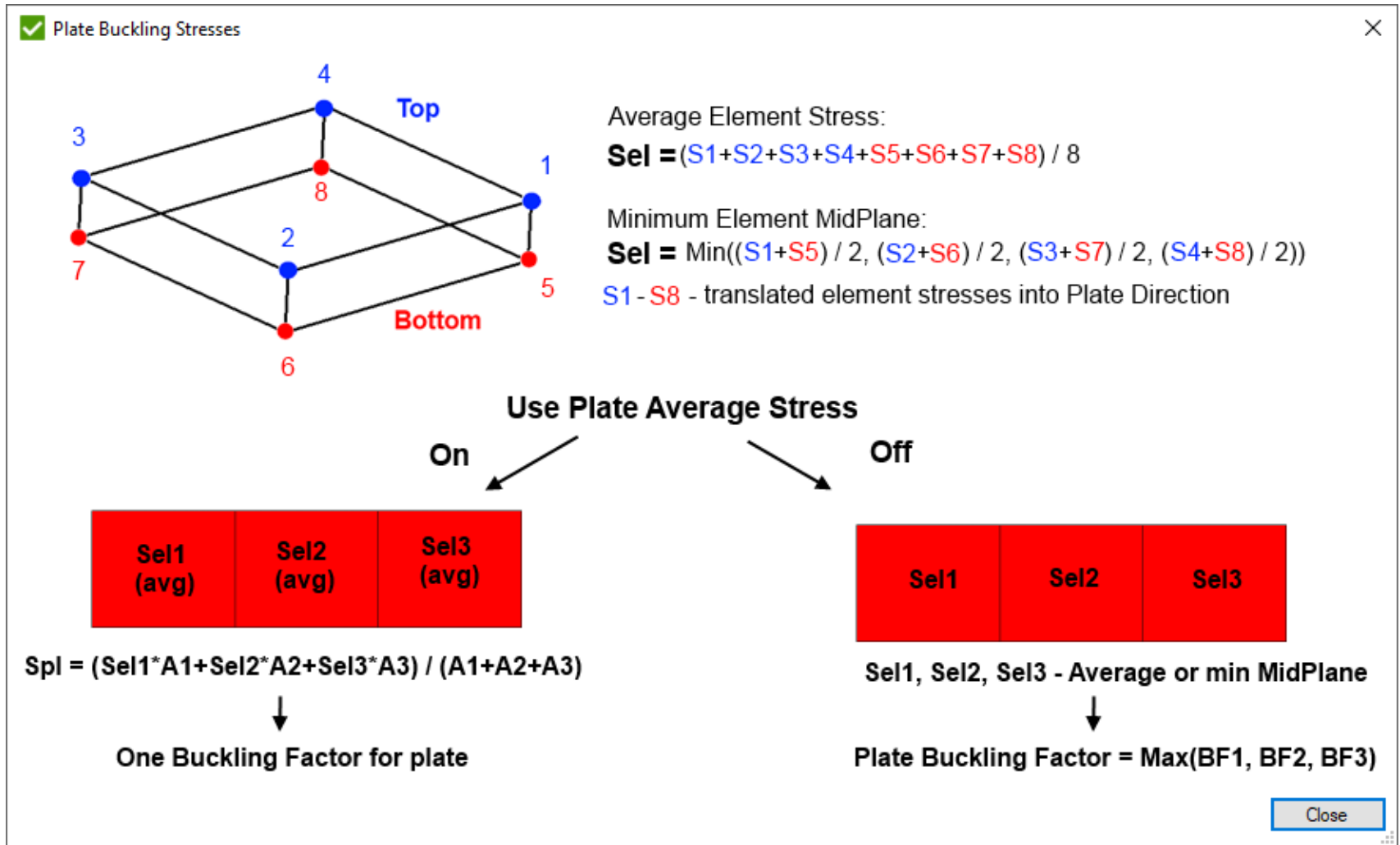


Plate Buckling transforms stresses automatically into plate direction.
Options about element stresses and plate stresses are described on the next slide

Plate Buckling Stresses



- 5) Press *OK*

SDC Verifier 5.3-3 - D:\PlateBuckling_Femap DNV\PlateBuckling_DNV.sdcv

File Settings Model Recognition Job Tools Standard Post-Processing Results Report Help

Go To Embed Mode

Settings

- Unit System
- Legend Settings
- Number Formats
- Views**
 - Add
 - Edit Multiple
- Model
- Recognition
- Jobs (1)
 - 1.Job 1
 - 1.1. Ind 1
 - 1.2. Ind 2
 - 1.3. Ind 3
 - 1.4. Ind 4
 - 1.5. Ind 5
 - 1.6. Load 1
 - 1.7. Load 2
 - 1.8. Load 3
 - 1.9. Load 4
 - 1.10. Load 5
 - 1.11. Load 6
 - 1.12. Load 7
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 - 1.222. Load 217
 - 1.223. Load 218
 - 1.224. Load 219
 - 1.225. Load 220
 - 1.226. Load 221
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 - 1.228. Load 223
 - 1.229. Load 224
 - 1.230. Load 225
 - 1.231. Load 226
 - 1.232.

www.sdcverifier.com

Views

1 Add view

2 Title: **Stiffeners**

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

4 Press **Get**

5 Press **OK**

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

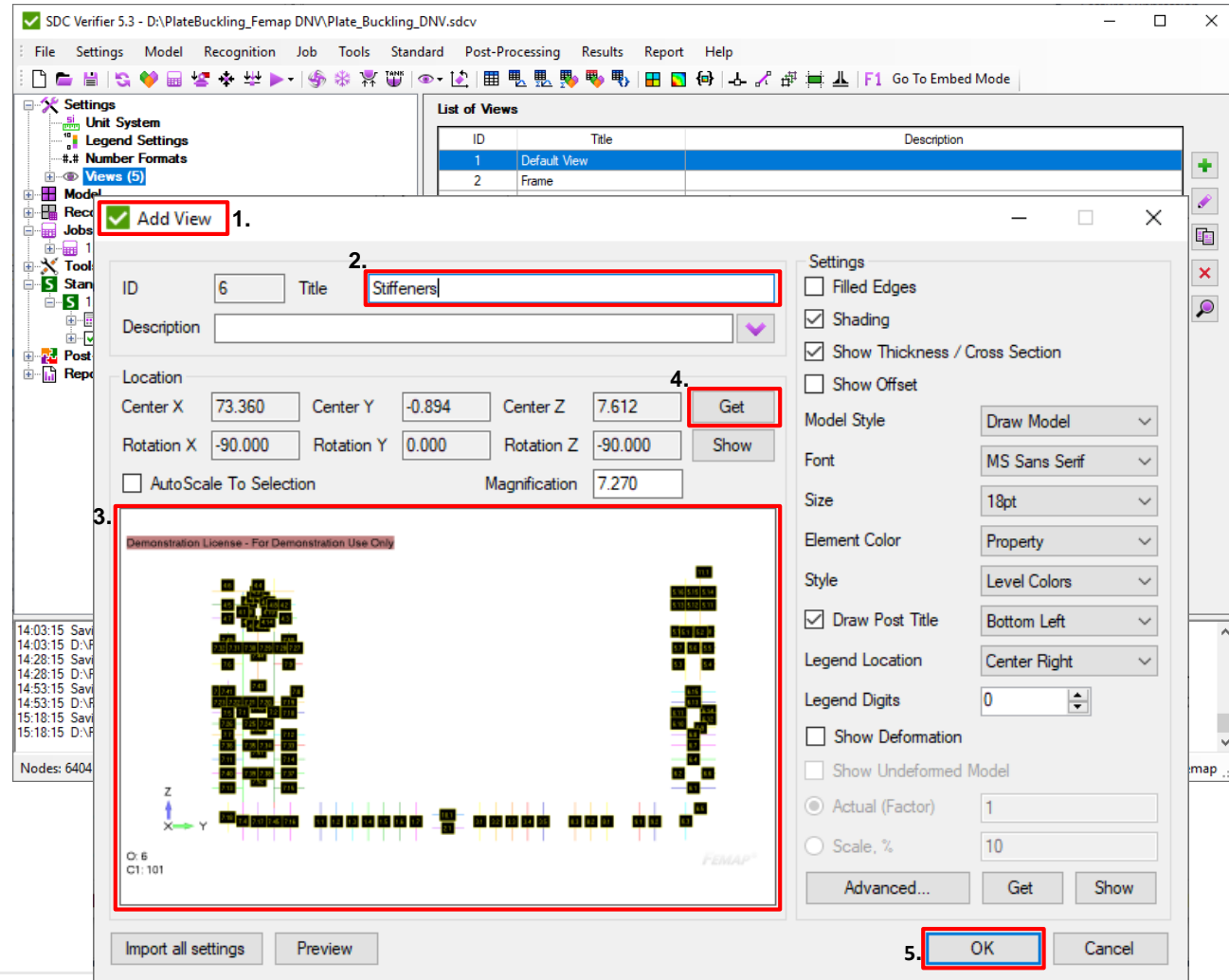


Plate Buckling Plot

1

Execute *Criteria Plot* from Plate Buckling DNV 2010 context menu

2

Load Group: **1..Envelop**

3

View: **2..Frame**

4

Press  Select: **Section X3**

5

Press  *Preview*

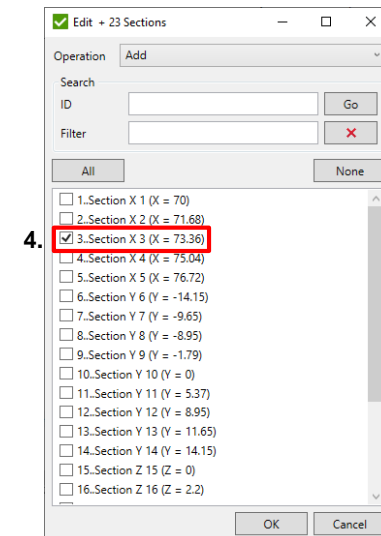
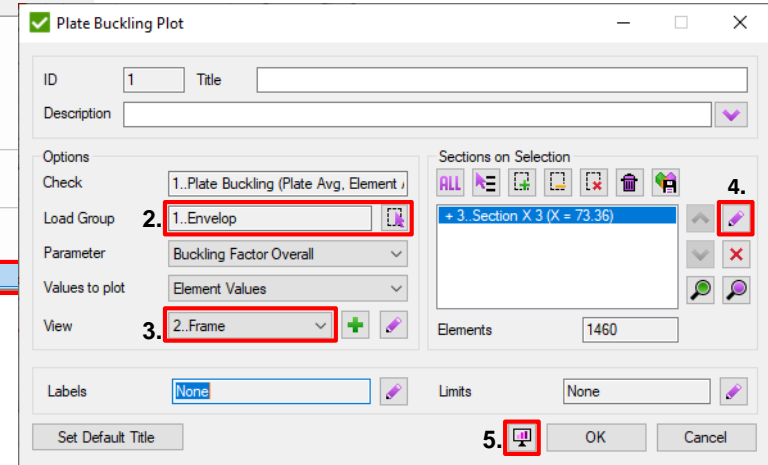
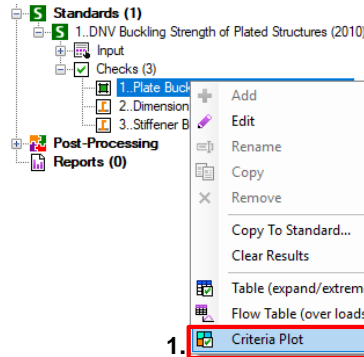


Plate Buckling Table

1

Execute *Table(expand/extreme)* from Plate Buckling DVN 2010 context menu

2

Load Group: **1..Envelop**

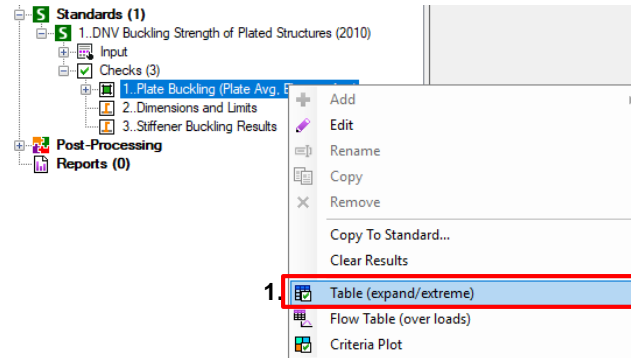
3

Show plates results: **OFF**

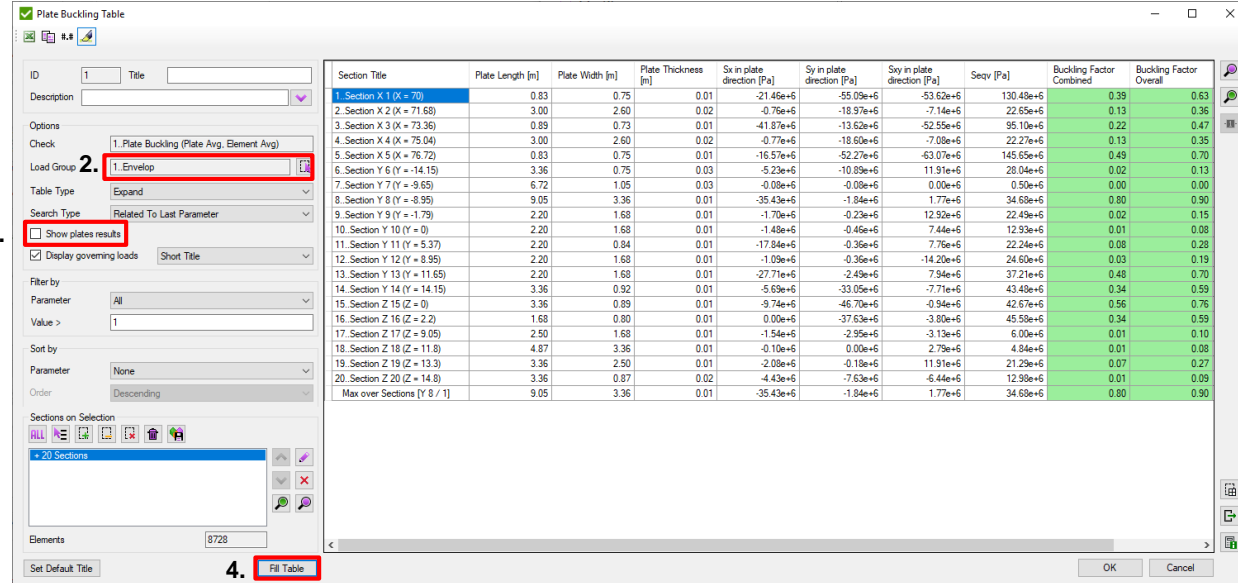
4

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.



3.



4.

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
1..Section X 1 (X = 70)	3.00	2.25	0.05	0.00e+6	0.00e+6	40.46e+6	130.48e+6	0.39	0.63

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

Stiffener Buckling Plot

1

Execute *Criteria Plot* from Stiffener Buckling results context menu

2

Load Group: **1..Envelop**

3

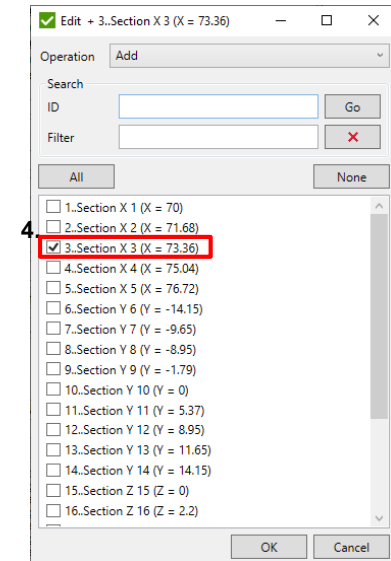
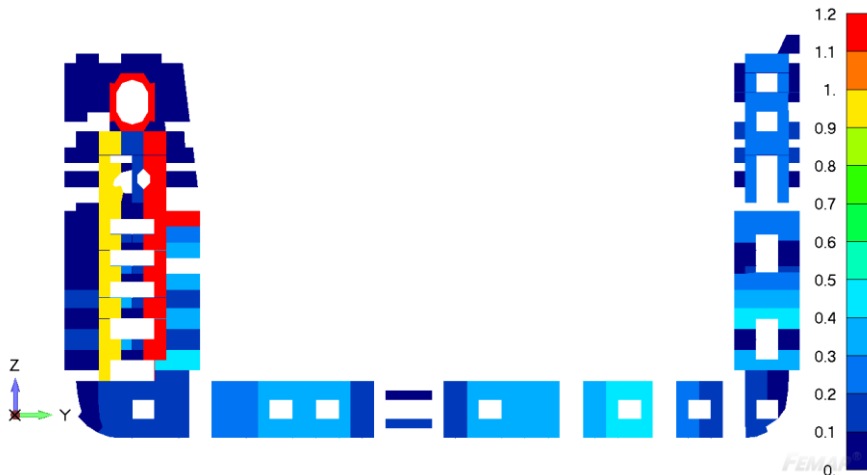
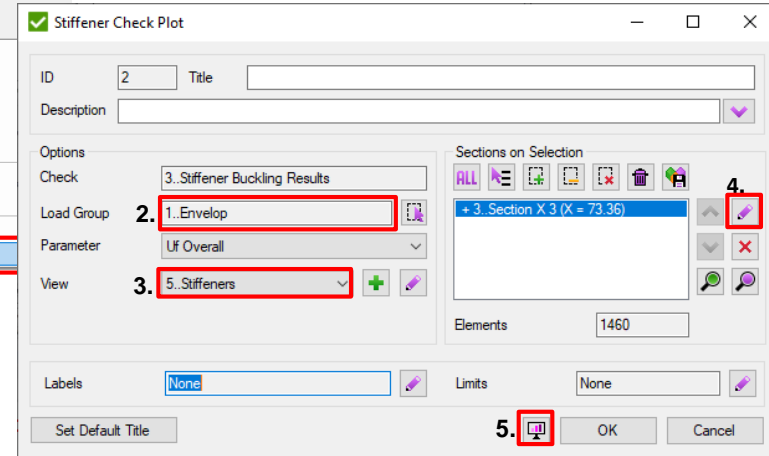
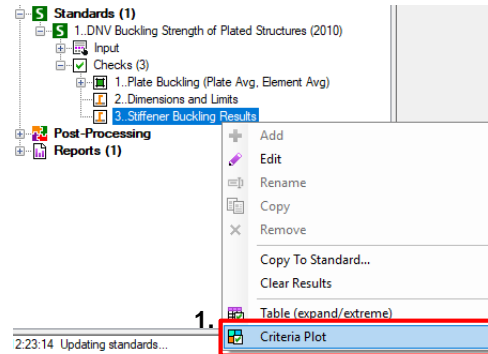
View: **5..Stiffeners**

4

Press  Select: **Section X3**

5

Press  *Preview*



Stiffener Buckling Table

1

Execute *Table(expand/extreme)* from Stiffener Buckling Results context menu

2

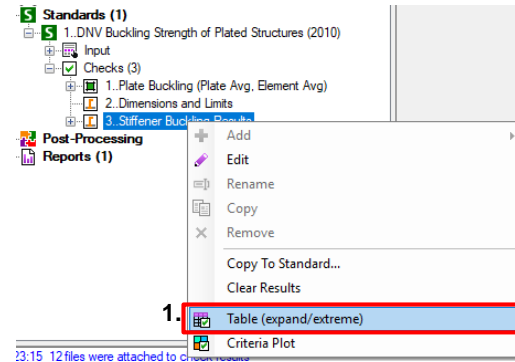
Load Group: **1..Envelop**

3

Show stiffeners results: **ON**

4

Press *Fill Table*



3. **Show Stiffeners results**

2. **1..Envelop**

4. **Fill Table**

Stiffener / Element	Gsd	Nsd [N]	Vsd [N]	M1Sd [N.m]	M2Sd [N.m]	Uf Shear	Uf Plate Side	Uf Stiffener Side	Uf Overall
1. Section X 1 (X = 70)	74105990...	-61681702	2463.8	34737184.0	17368592.0	12345678...	12345678...	12345678...	12345678...
1. Stiffener 1.1.1 [70; -8.06; 1.1]	4998.00	77777.3	35.6	2015.9	1007.9	0.00	0.19	0.14	0.19
2. Stiffener 1.1.2 [70; -7.16; 1.1]	2759.77	14561.1	26.6	1113.1	556.6	0.00	0.18	0.18	0.18
3. Stiffener 1.1.3 [70; -6.26; 1.1]	3136.38	31802.6	19.2	1265.0	632.5	0.00	0.25	0.24	0.25
4. Stiffener 1.1.4 [70; -5.37; 1.1]	3072.16	40890.1	119.8	1239.1	619.6	0.00	0.27	0.24	0.27
5. Stiffener 1.1.5 [70; -4.48; 1.1]	3126.18	41917.1	73.3	1260.9	630.4	0.00	0.28	0.25	0.28
6. Stiffener 1.1.6 [70; -3.58; 1.1]	2944.26	37406.1	77.4	1187.5	593.8	0.00	0.26	0.24	0.26
7. Stiffener 1.1.7 [70; -2.68; 1.1]	2993.36	39277.8	130.6	1207.3	603.7	0.00	0.12	0.09	0.12
1. Stiffener 1.2.1 [70; -0.89; 0.73]	1317.88	343572.8	-722.3	351.9	175.9	0.00	0.17	0.17	0.17
1. Stiffener 1.3.1 [70; 0.89; 1.1]	3424.18	31970.0	-46.9	1381.1	690.5	0.00	0.10	0.07	0.10
2. Stiffener 1.3.2 [70; 1.79; 1.1]	3214.96	40016.6	38.8	1296.7	648.3	0.00	0.24	0.19	0.24
3. Stiffener 1.3.3 [70; 2.68; 1.1]	3346.21	43202.5	71.4	1349.6	674.8	0.00	0.25	0.19	0.25
4. Stiffener 1.3.4 [70; 3.58; 1.1]	2814.75	54433.7	69.4	1135.3	567.6	0.00	0.23	0.17	0.23
5. Stiffener 1.3.5 [70; 4.48; 1.1]	3051.75	42925.3	41.0	1230.9	615.4	0.00	0.23	0.18	0.23
1. Stiffener 1.4.1 [70; -13.28; 13.3]	3160.65	-552274.4	-152.4	2370.5	1185.2	0.00	0.32	0.27	0.32
2. Stiffener 1.4.2 [70; -10.68; 13.3]	992.83	147981.1	-82.2	744.6	372.3	0.00	0.10	0.08	0.10
3. Stiffener 1.4.3 [70; -13.72; 13.3]	3683.63	-9126.7	40.2	230.7	115.4	0.00	0.03	0.04	0.04
4. Stiffener 1.4.4 [70; -13.72; 12.55]	2615.06	110563.0	10.7	163.8	81.9	0.00	0.05	0.05	0.05
5. Stiffener 1.4.5 [70; -10.08; 13.3]	398.42	101469.9	43.0	49.1	24.5	0.00	0.05	0.05	0.05
6. Stiffener 1.4.6 [70; -10.03; 12.55]	867.72	-93358.2	31.5	123.5	61.8	0.00	0.03	0.03	0.03
7. Stiffener 1.4.7 [70; -10.12; 14.05]	283.68	160545.5	-34.7	29.9	15.0	0.00	0.06	0.06	0.06
8. Stiffener 1.4.8 [70; -11.12; 14.05]	1992.71	978620.1	21.1	124.8	62.4	0.00	0.24	0.23	0.24
9. Stiffener 1.4.9 [70; -11.98; 14.05]	29.22	788793.8	21.7	1.8	0.9	0.00	0.19	0.19	0.19

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

Report. Tables

1

Execute *Reports => Add => Designer - Results*

2

Plate Buckling DNV 2010 check context menu in model tree => *Table(expand/extreme)*

3

Type: **Expand**

4

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

5

Press *OK*.

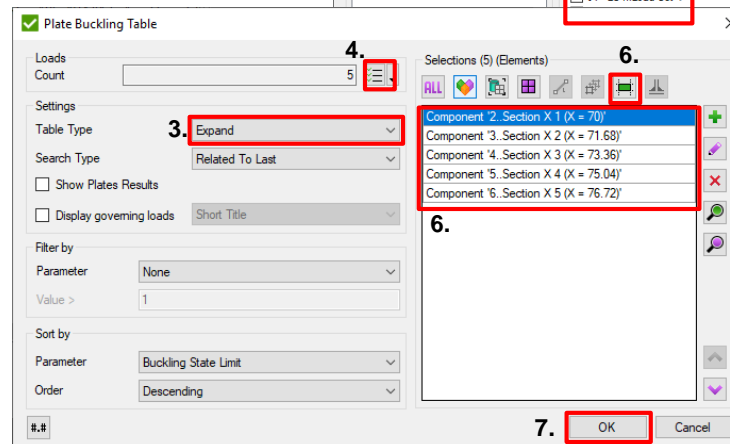
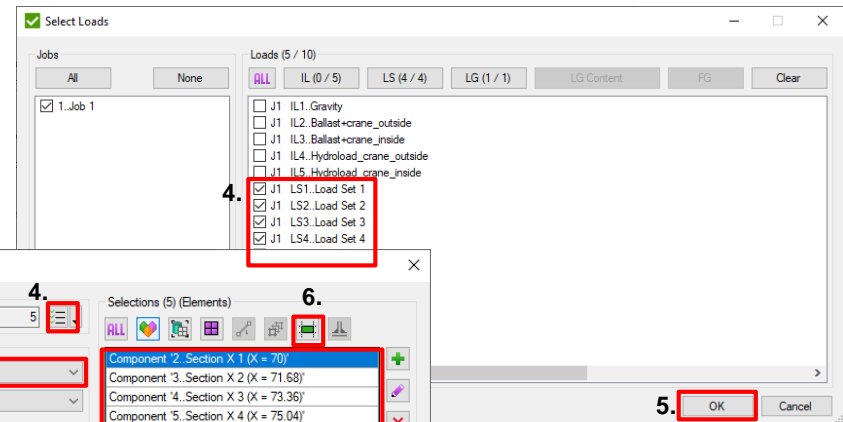
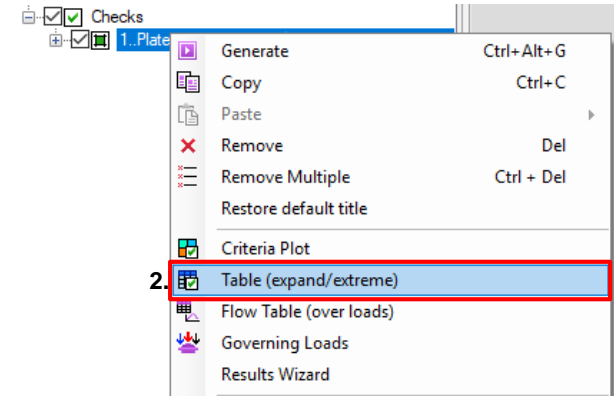
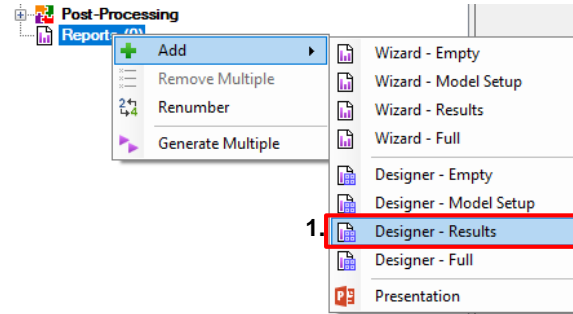
6

Press  and select all **X Sections**

7

Press *OK*.

Repeat steps 1-7 for **Stiffener Buckling Results** check





Report. Plots

1 Click **Criteria Plot** in *Plate Buckling DNV 2010* check context menu

2 Parameter: **Buckling Factor Overall.**

3 Views: **Frame.**

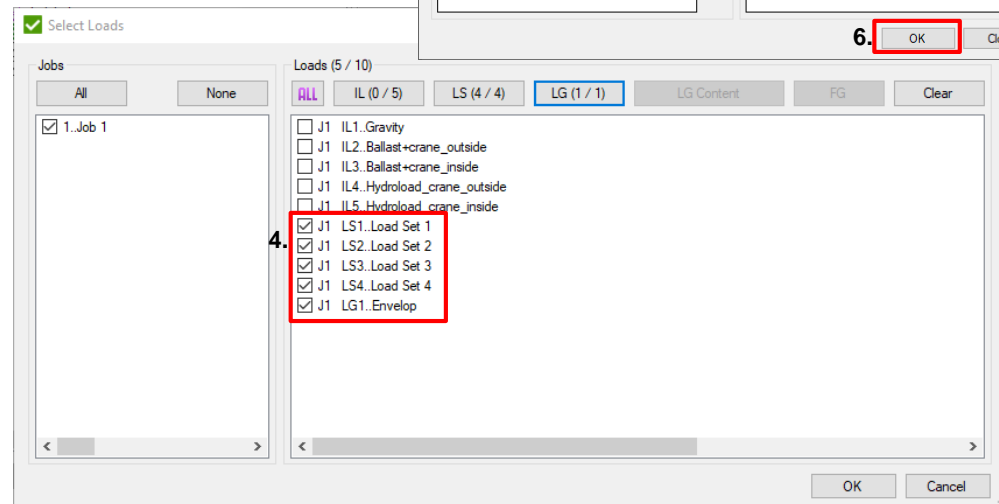
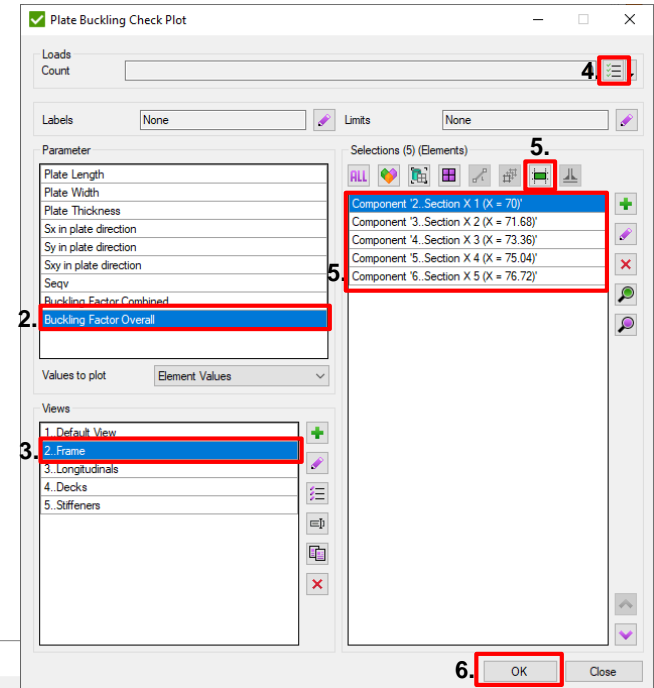
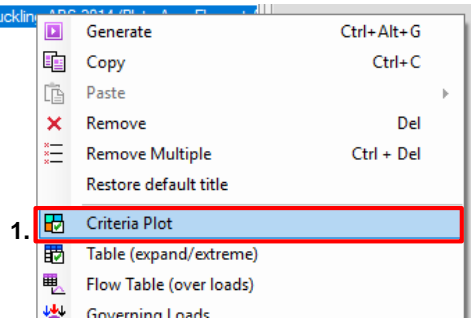
4 Press , select **LS; LG** Loads and Press **OK.**

5 Press  and select all **X Sections**

6 Press **OK.**

Repeat steps 1-6 for **Stiffener Buckling Check** with Stiffeners View

Repeat steps 1-6 for Sections Y with Longitudinals View and Sections Z with Decks View



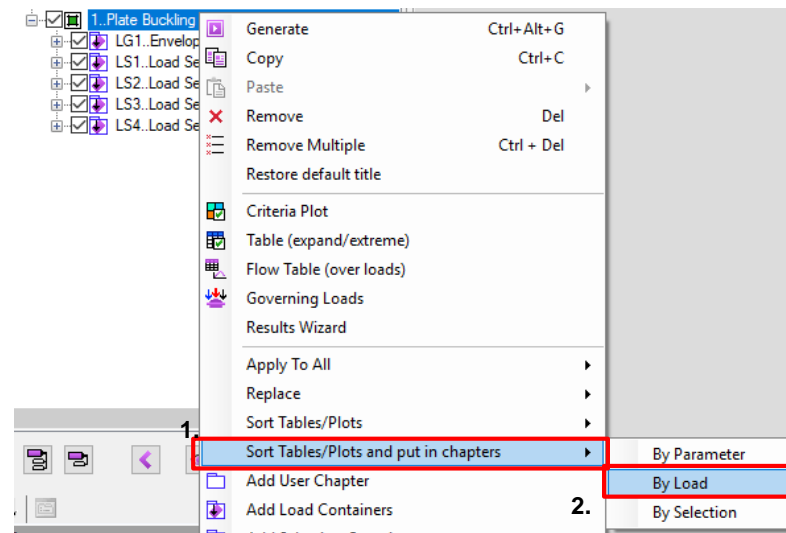
Report. Sort tables and plots by Load

1

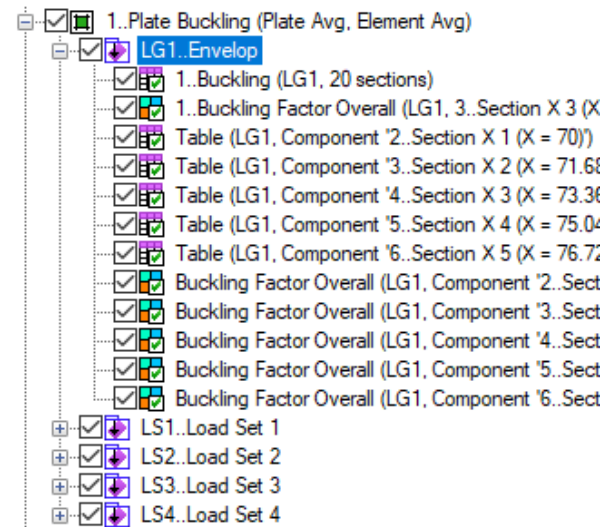
Right click on *Plate Buckling DNV 2010* => *Sort Tables/Plots and put in chapters*

2

Click => *By Load*



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



Report. First Page

1

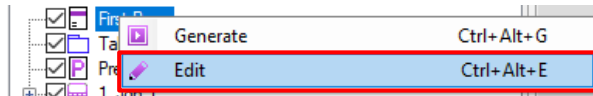
Right click on *First Page* => **Edit**.

2

Fill in information about project.

3

Press **OK**.



1.

First Page Editor

Engineer details

Engineer: Wouter van den Bos


Company: SDC Verifier

E-mail: wouter@sdcverifier.com

Phone: +31 15 30-10-310

Address: Zijvest 25

Web Site: sdcverifier.com

Logo: 

☒ Put logo on report plots

Customer details

Contact Person:

Company: Femto Engineering

E-mail: info@femto.eu

Phone:

Address:

Web Site: www.femto.nl

Logo:

Project Details

Number: Version: 1

Name: Plate Buckling_DNV

Image

☐ From file

☒ From View: 2..Frame

Custom Fields

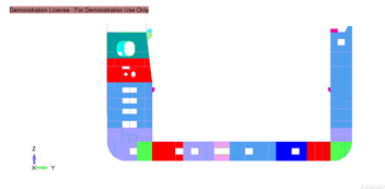
3. OK Cancel

Press  to generate complete report.



Report

Plate Buckling_DNV



Prepared by:

SDC Verifier

+31 15 30-10-310

sdccverifier.com

Zilverst 25

Prepared for:

Femto Engineering

www.femto.nl

Engineer:

Wouter van den Bos

Customer:

Project Number:

Version:

1

Date:

24/01/2020



24/01/2020

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3..Stiffener Buckling Results

Property	Value
Category	Stiffener Buckling
Parameter Count	77

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..Envelop

1..Buckling (LG1, 20 sections)									
Standard	1..DNV Buckling Strength of Plated Structures (2010)					Check	[S1] 1..Plate Buckling (Plate Avg, Element Avg)		
Load Group	LG1..Envelop					Selection	20 Sections		
Search Type	Maximum								
Section Title	Plate Length [m]	Plate Width [m]	Plate Thickness [mm]	S _y in plate direction [Pa]	S _y in plate direction [Pa]	S _y in plate direction [Pa]	S _y in plate direction [Pa]	Buckling Factor g	Load g Factor Overall
1..Section X 1 (X = 70)	3.00	2.25	0.05	0.00e+0	0.00e+0	40.48e+6	130.48e+6	0.39	0.83
2..Section X 2 (X = 71.68)	5.35	2.60	0.03	0.00e+0	0.00e+0	34.81e+6	73.33e+6	0.13	0.36
3..Section X 3 (X = 73.36)	2.50	1.73	0.05	0.00e+0	0.00e+0	53.53e+6	95.10e+6	0.22	0.47
4..Section X 4 (X = 75.04)	3.00	2.60	0.02	0.00e+0	0.00e+0	34.46e+6	81.40e+6	0.13	0.36
5..Section X 5 (X = 76.72)	3.00	2.60	0.05	0.00e+0	0.00e+0	46.82e+6	145.85e+6	0.49	0.70
6..Section Y 6 (Y = -9.65)	0.72	1.05	0.03	0.00e+0	0.00e+0	11.91e+6	28.04e+6	0.02	0.13
7..Section Y 7 (Y = -9.65)	0.72	1.05	0.03	-0.08e+6	-0.08e+6	0.00e+0	0.50e+6	0.00	0.00
8..Section Y 8 (Y = -8.95)	9.05	3.36	0.01	-1.85e+6	-1.85e+6	10.11e+6	36.12e+6	0.80	0.90
9..Section Y 9 (Y = -1.79)	2.20	1.68	0.01	-1.70e+6	-0.23e+6	12.92e+6	22.40e+6	0.02	0.15
10..Section Y 10 (Y = 0)	2.20	1.68	0.01	-1.48e+6	-0.02e+6	7.44e+6	12.93e+6	0.01	0.08
11..Section Y 11 (Y = 5.37)	2.20	0.84	0.01	-13.04e+6	-0.38e+6	7.78e+6	22.24e+6	0.08	0.28
12..Section Y 12 (Y = 8.95)	2.20	1.68	0.01	-0.72e+6	-0.30e+6	15.88e+6	27.57e+6	0.03	0.19
13..Section Y 13 (Y = 11.65)	0.85	3.36	0.01	-0.42e+6	-0.07e+6	8.51e+6	44.41e+6	0.48	0.70
14..Section Y 14 (Y = 14.15)	3.36	0.97	0.03	0.00e+0	-1.00e+6	44.18e+6	98.72e+6	0.34	0.59
15..Section Z 15 (Z = 0)	3.36	0.93	0.02	0.00e+0	0.00e+0	11.40e+6	54.08e+6	0.56	0.78
16..Section Z 16 (Z = 2.2)	8.95	3.36	0.02	0.00e+0	-0.87e+6	17.09e+6	45.58e+6	0.34	0.59
17..Section Z 17	3.36	2.60	0.01	-0.30e+6	-0.05e+6	0.28e+6	6.00e+6	0.01	0.10



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Buckling Factor Overall (LG1, Component '3..Section X 2 (X = 71.68)', v2)

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Check	[S1] 1..Plate Buckling (Plate Avg, Element Avg)	Load Group	LG1..Envelop
Parameter View	Buckling Factor Overall	Selection	Component '3..Section X 2 (X = 71.68)'

Buckling Factor Overall (LG1, Component '4..Section X 3 (X = 73.36)', v2)

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Check	[S1] 1..Plate Buckling (Plate Avg, Element Avg)	Load Group	LG1..Envelop
Parameter View	Buckling Factor Overall	Selection	Component '4..Section X 3 (X = 73.36)'