



Tutorial

Weld Strength Eurocode3, DNV OS-C101 and C201

14 Dec 2020
version 2020.0.2

This step-by-step tutorial demonstrates how to perform the weld strength check according to Eurocode 3, DNV OS-C101-LRFD, DNV OS-C201-WSD standards in SDC Verifier.

The following steps are covered:

- ▶ Weld Finder Tool detailed review;
- ▶ Weld Stress calculations;
- ▶ Standards creation;
- ▶ Report preparation and results.

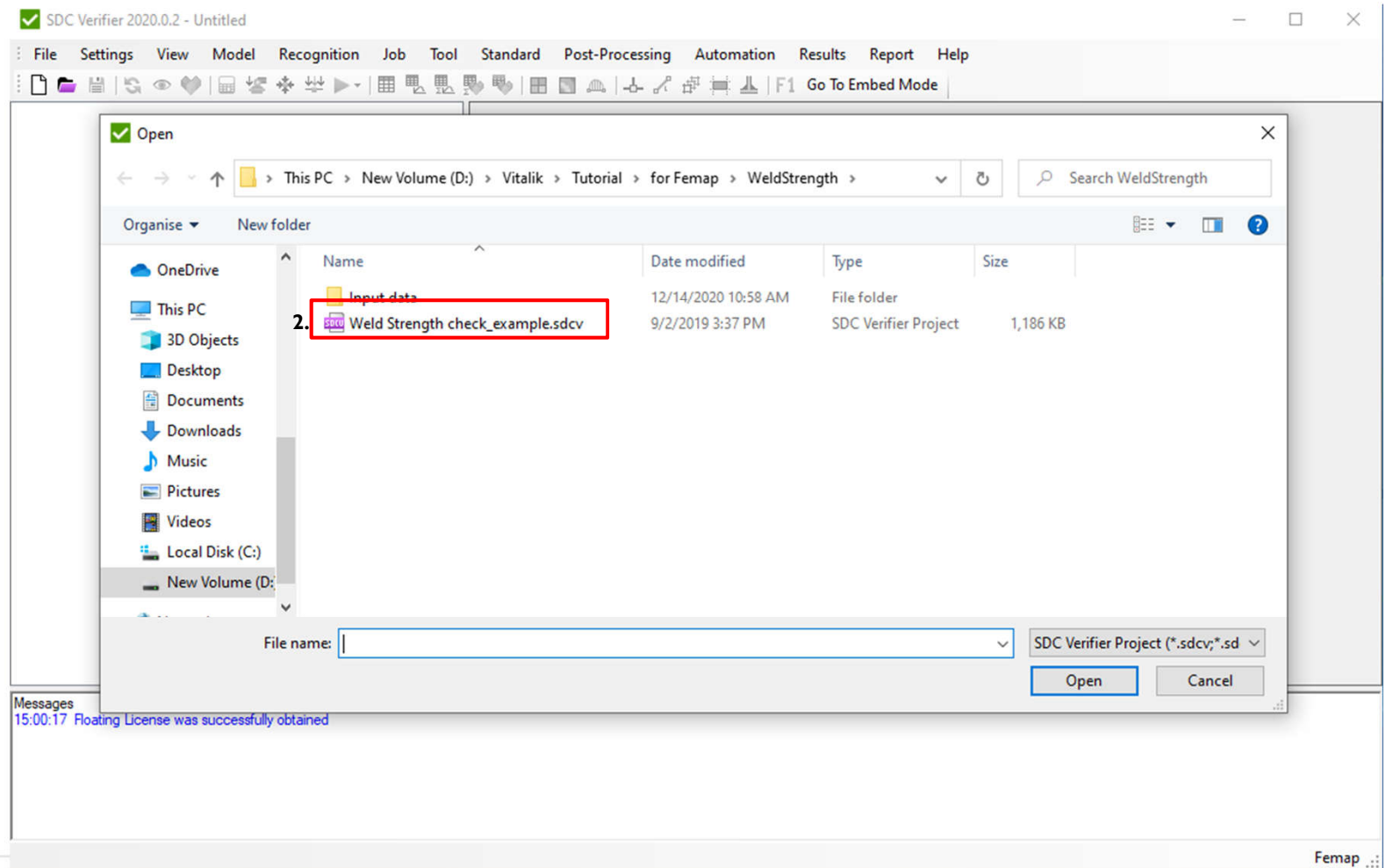
Open Project

1

Launch **SDC Verifier** 

2

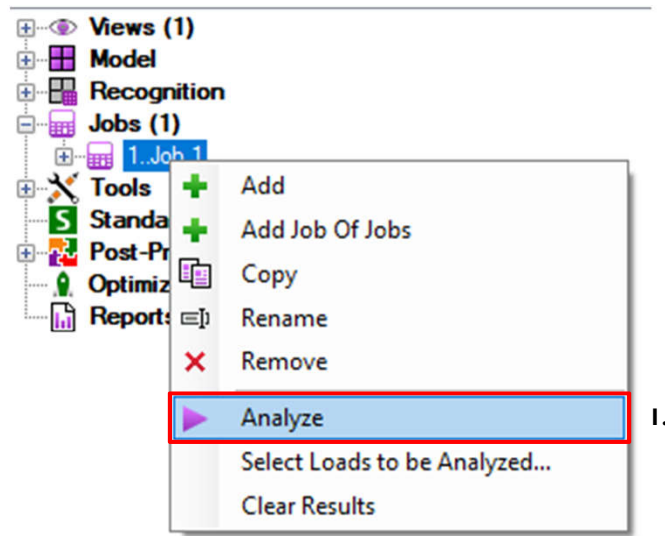
Open the project **Weld Strength
check_example**



Run Analysis

1

Execute ► **Analyze** from *Job1*
context menu



Weld Finder – General overview

1

Execute **Recognition =>Weld Finder => Edit.**

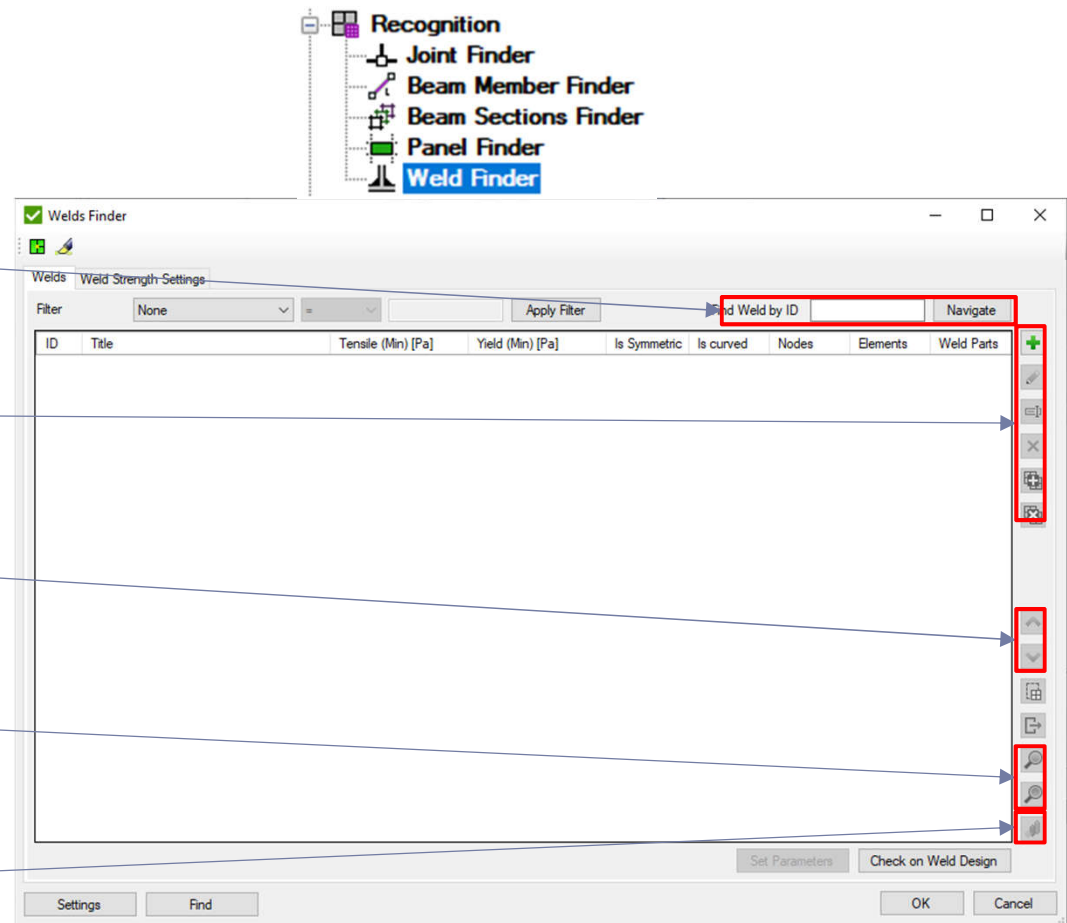
Navigate option in order to find weld by ID.

Add, Edit, Combine, Split and Remove Weld(s).

Move Welds. Order is important when the same element belongs to 2 welds.

Preview selected weld(s).

Plot of selected weld(s) in colors and with labels of IDs (drop-down menu).



Add exception rule for recognition

1 Press *Settings*

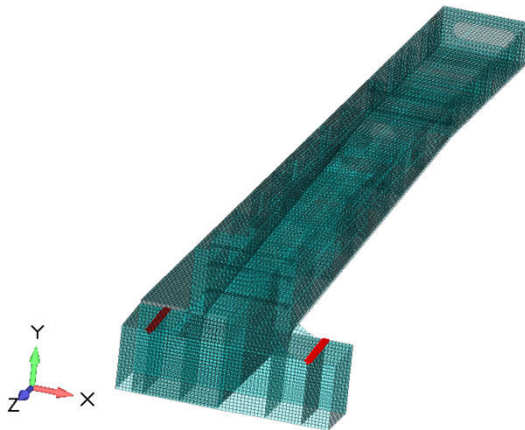
2 Press *Edit* for **Not weld** properties.

3 Select **property ID4**.

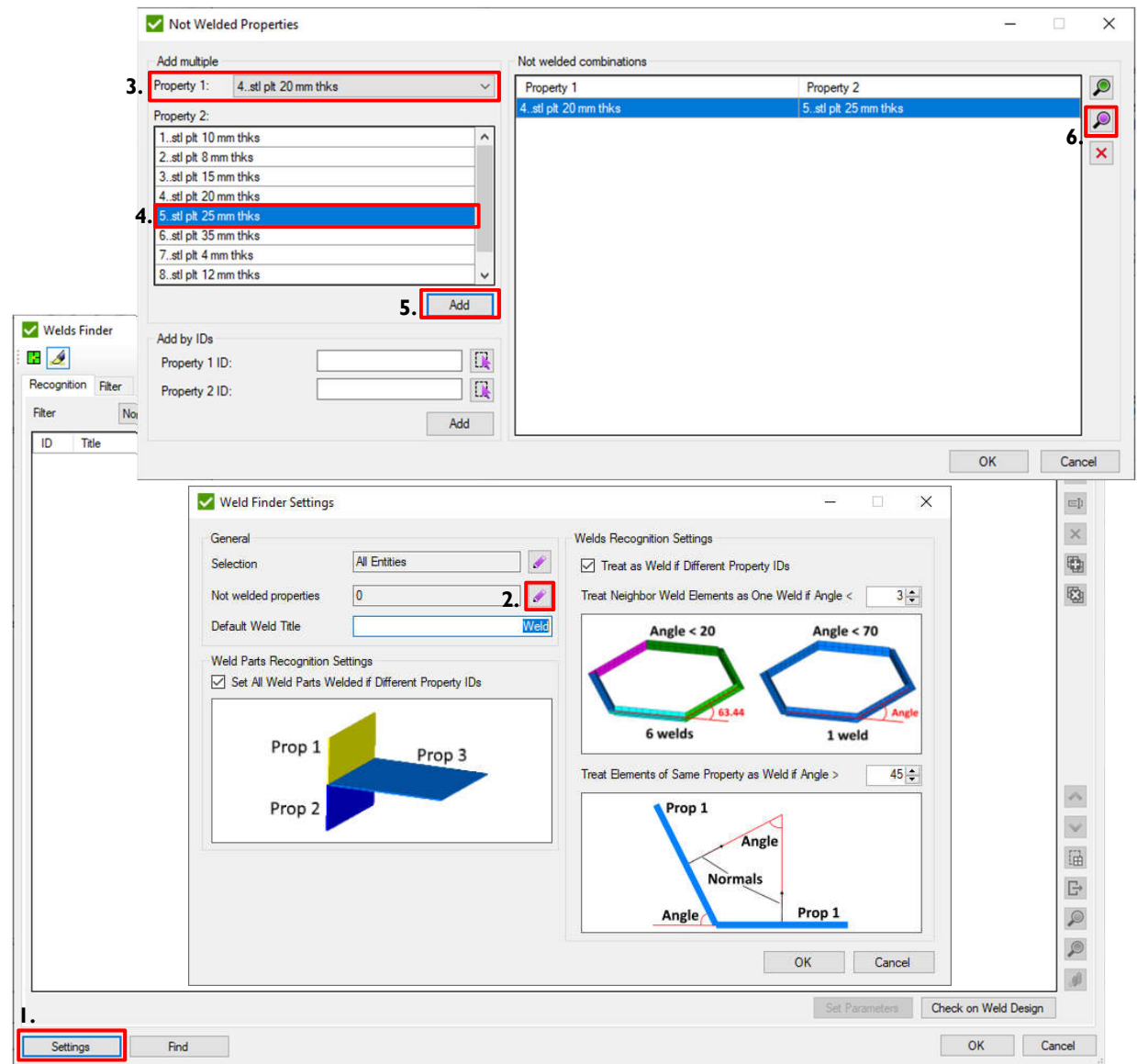
4 Select **property ID5**.

5 Press *Add*.

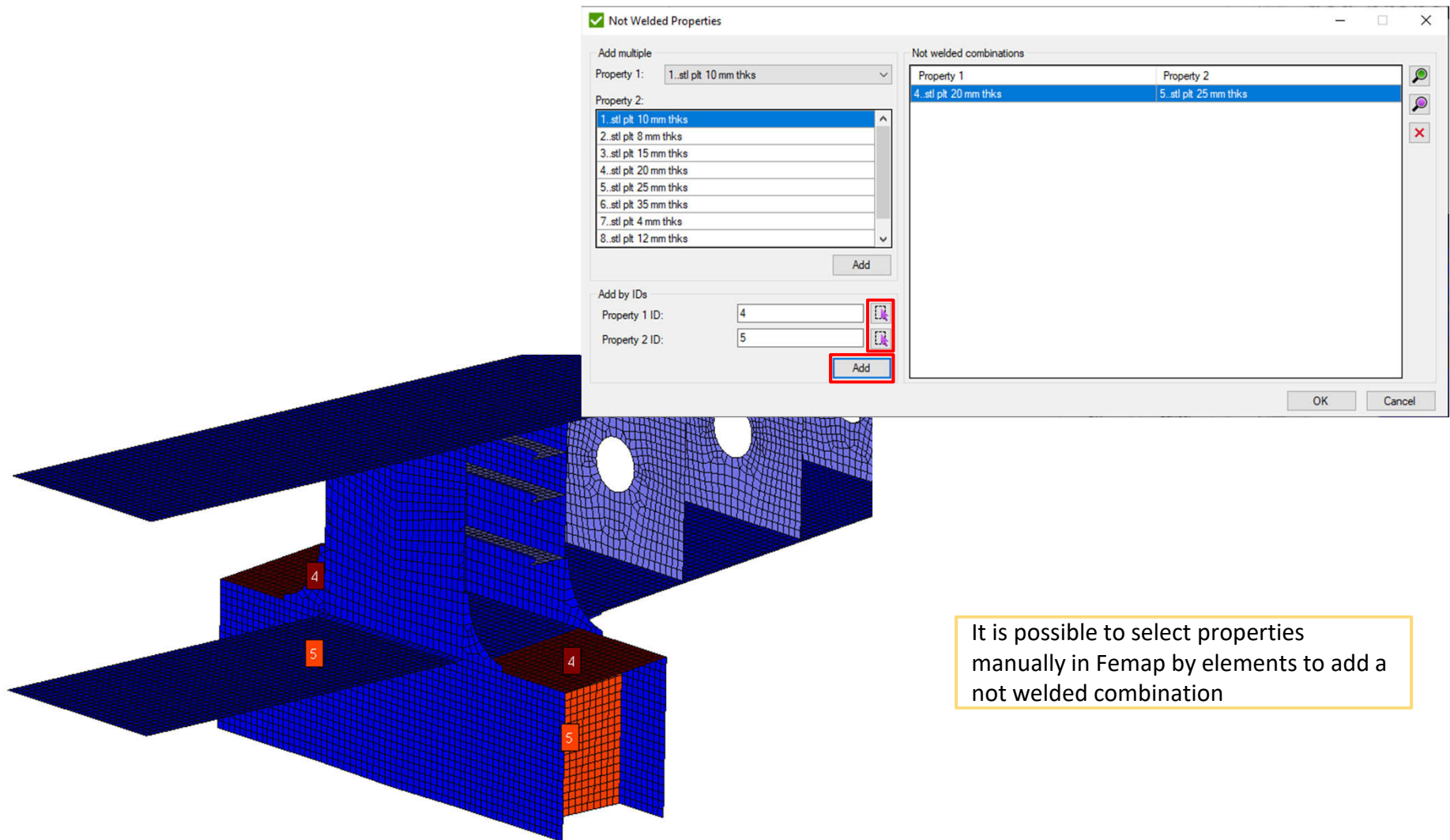
6 Press 



Connections with properties 4 and 5 are not treated as welds



Not welded properties. Option2



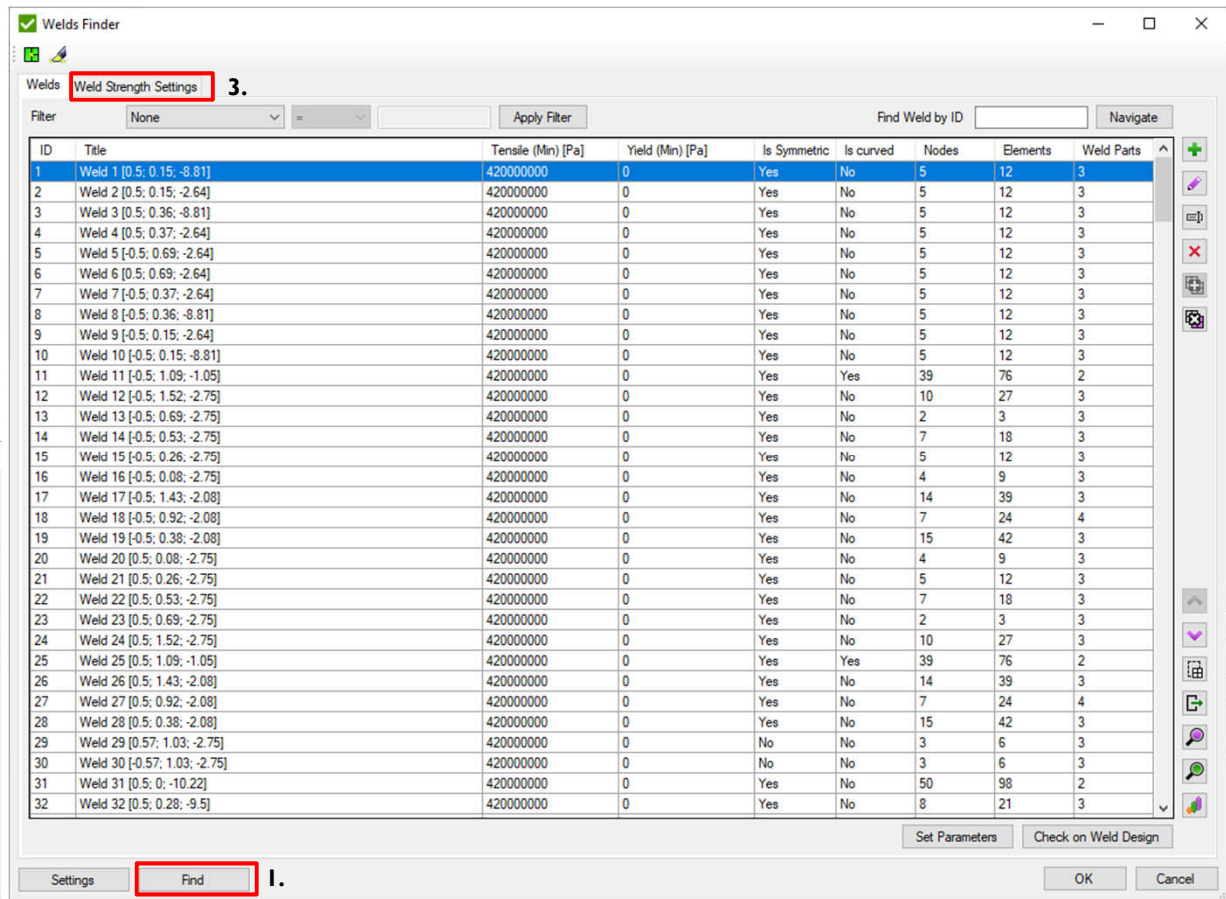
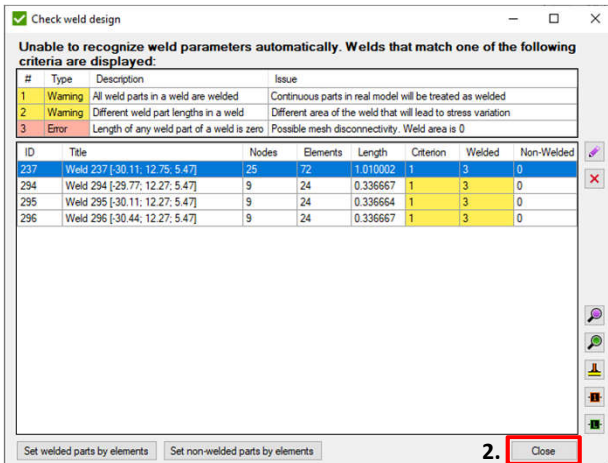
It is possible to select properties manually in Femap by elements to add a not welded combination

Recognize welds

1 Press *Find*.

2 Press *Close*.

3 Press *Weld Strength Settings*.



Weld Finder – Details

Selection gives a possibility to select a part of the model (group, component) for making changes.

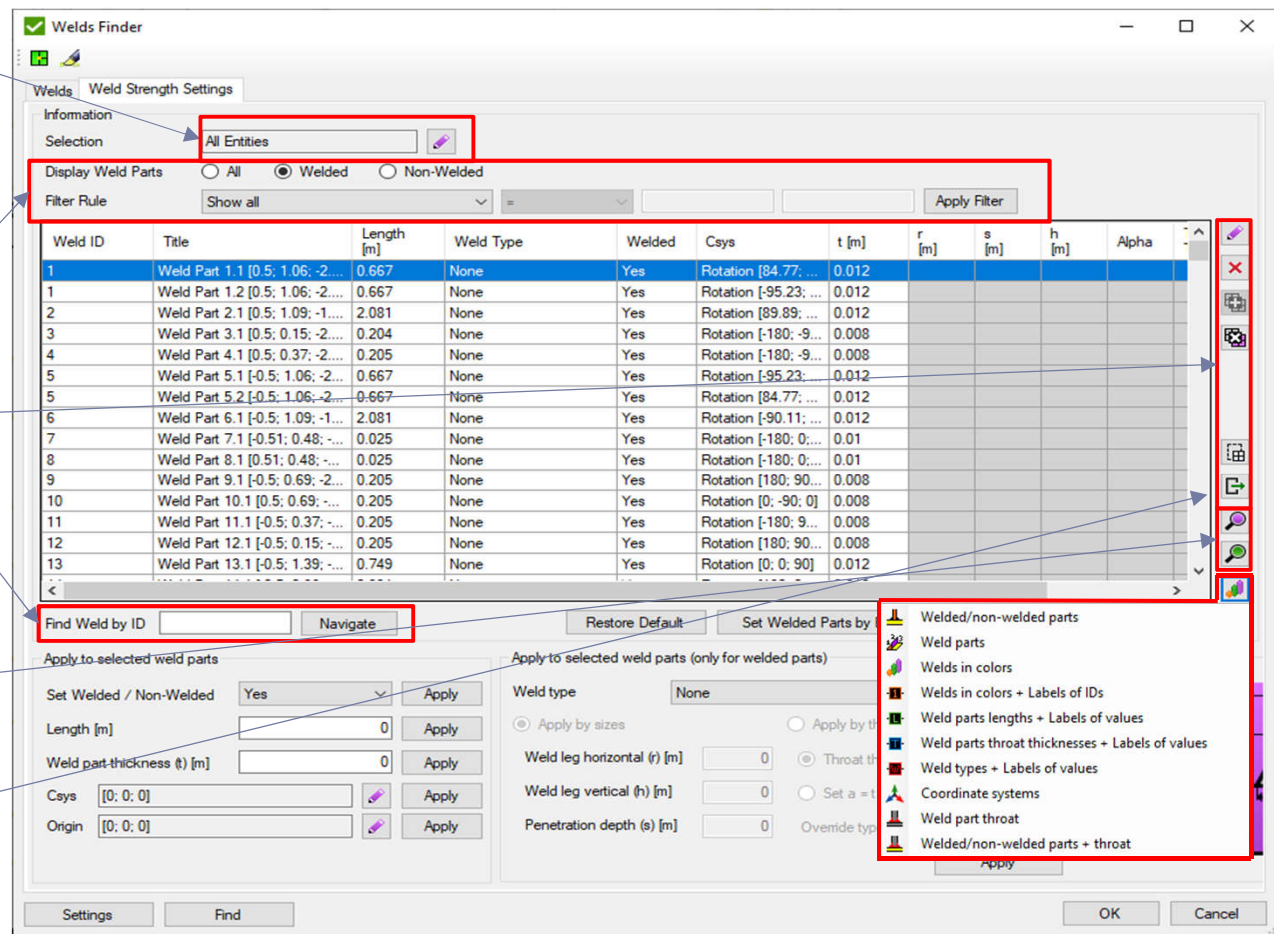
This filter can be used to search the weld(s) due to different parameters (length, thickness, area, weld only, non weld only etc.).

Edit, Combine, Split, Export and Remove Weld(s).

Navigate option in order to find a weld by ID.

Preview selected weld(s).

Plot of selected weld(s) in colors and with labels of IDs (drop-down menu).



Possibility to modify or change length, thickness, coordinate system and origin to all selected weld(s) parts.

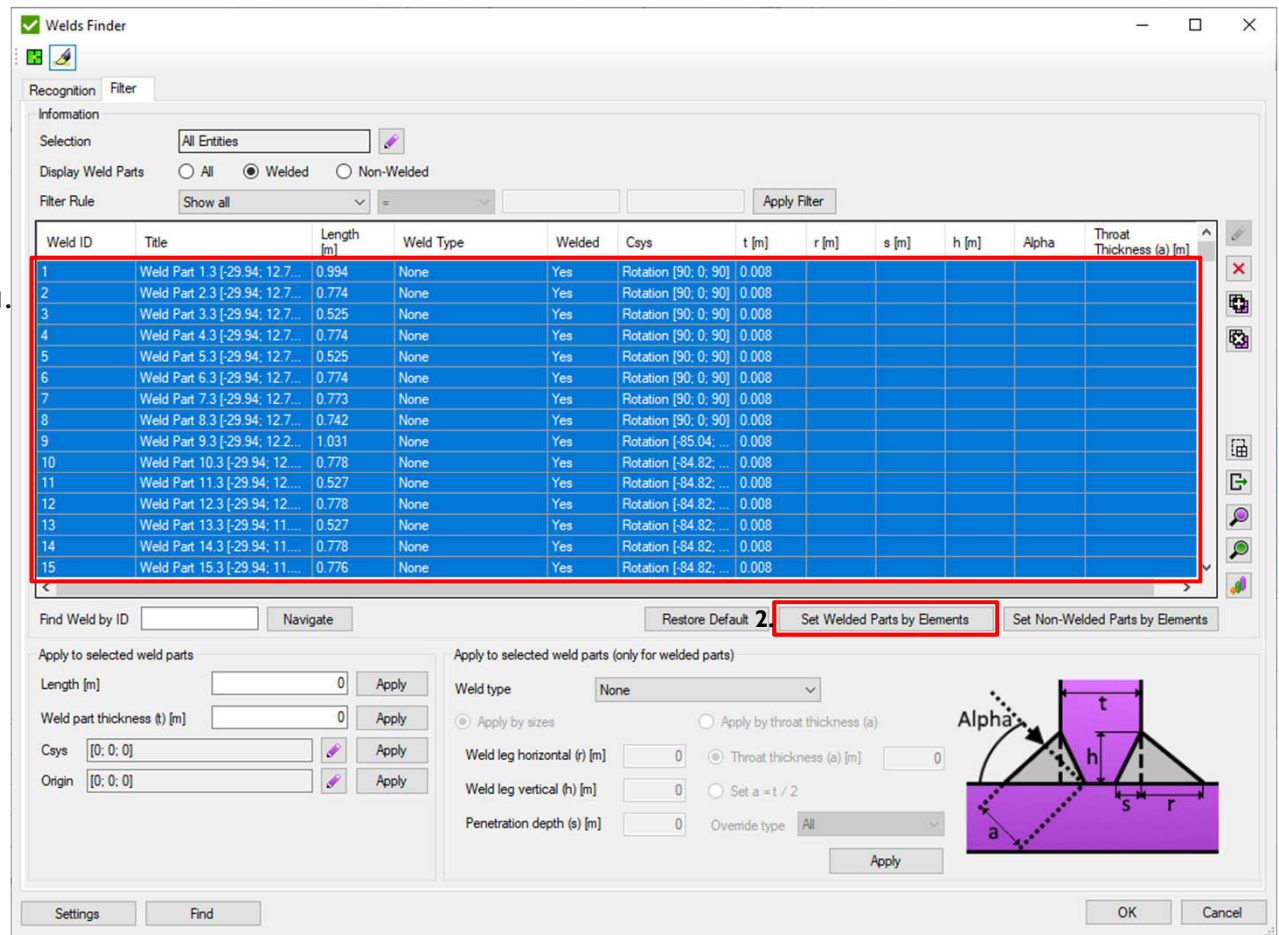
Set welded parts by elements

1

Select all welds part by pressing **Ctrl+A** keys combination.

2

Press **Set welded parts by elements** to find weld parts by elements and include them in weld strength calculations (also this command could be performed for few or single weld part).



Set weld part type welded (manually)

1

Select **Non-Welded** element(s) which should be changed to **Welded** element(s).

It is sufficient to select only one element from a weld part to pick full part automatically.

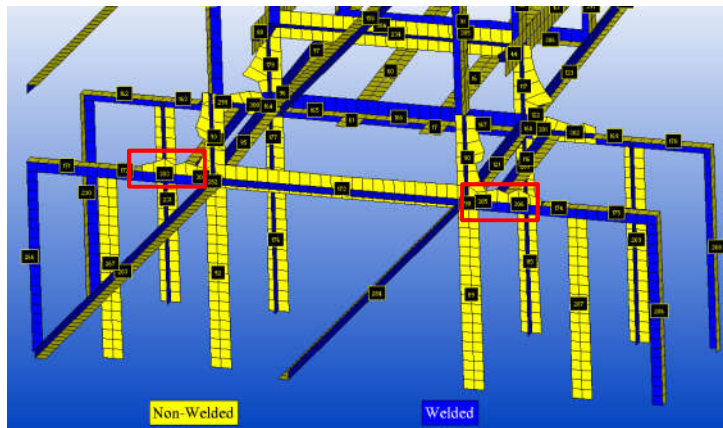
2

Press **OK**.

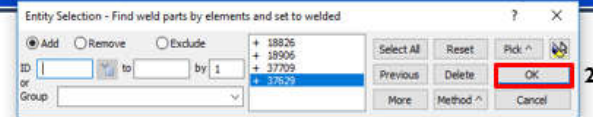
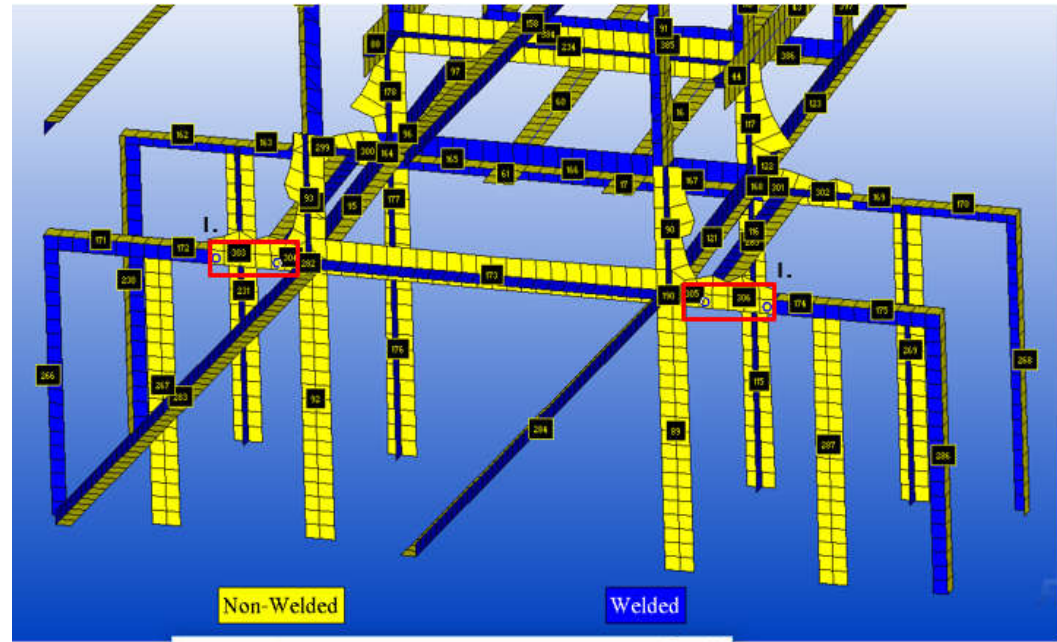
3

Press **Cancel**.

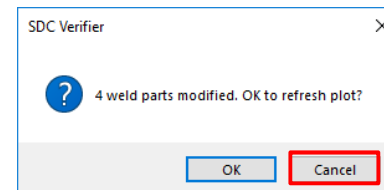
Updated plot shown below



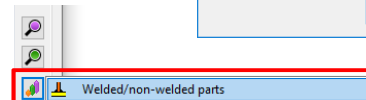
In order to get refreshed plot of the weld(s), select all weld parts by using **Ctrl+A** keys combination and choose command **Welded/non-welded parts**



2.



3.



Set weld parameters

1 Select all weld parts by pressing **Ctrl+A** keys combination.

2 Select the type of weld **Double fillet**.

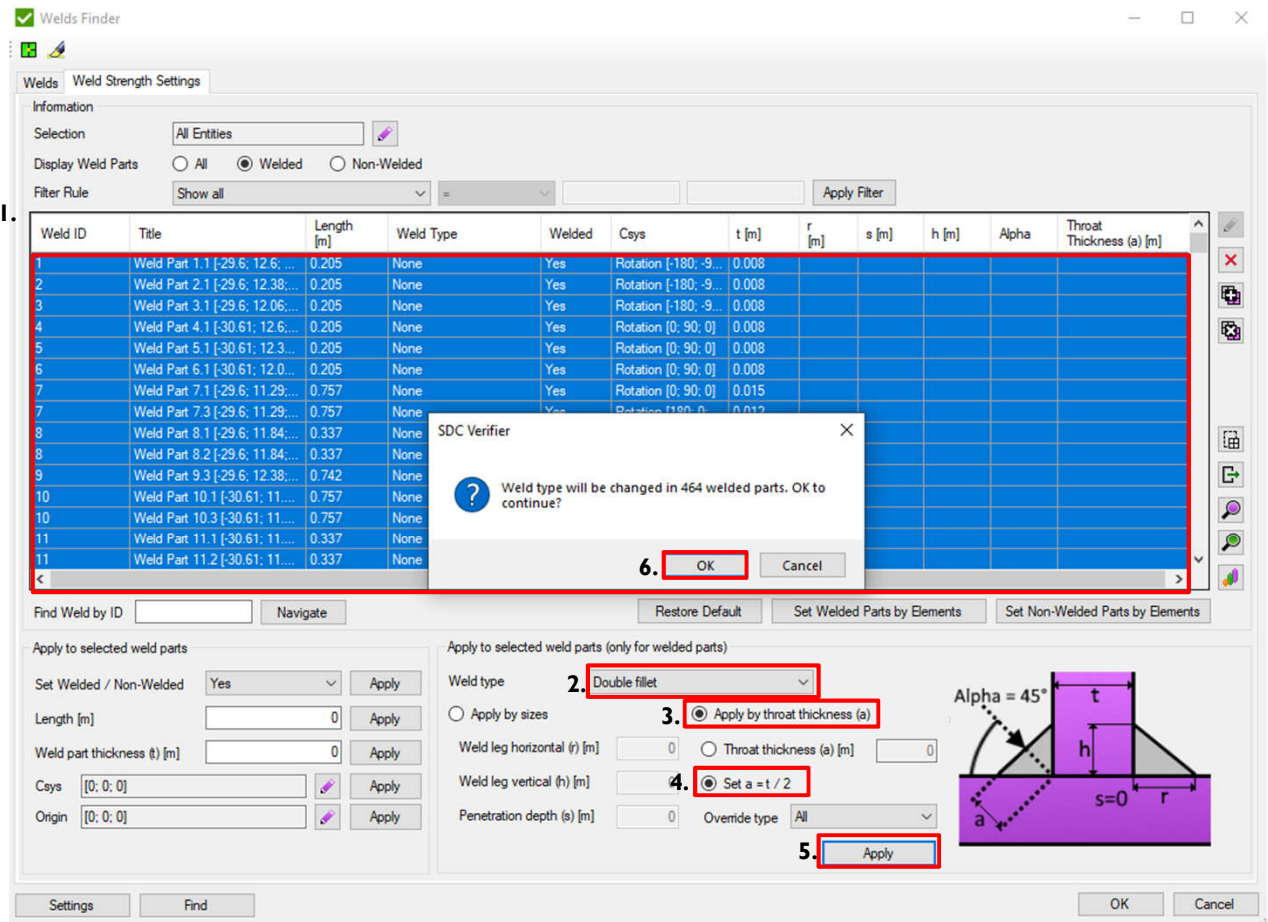
3 Choose the method: **Apply by throat thickness**.

4 Select **Set $a = t / 2$** type (half of thickness welded plate).

5 Press **Apply**.

6 Press **OK**.

For beams elements t is the minimum thickness of shape. For bars element t is the minimum of height/width. For plates element t is a plate thickness.



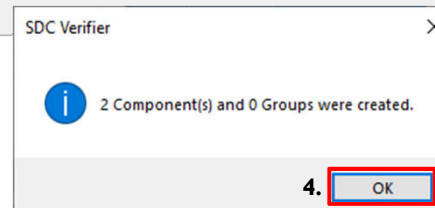
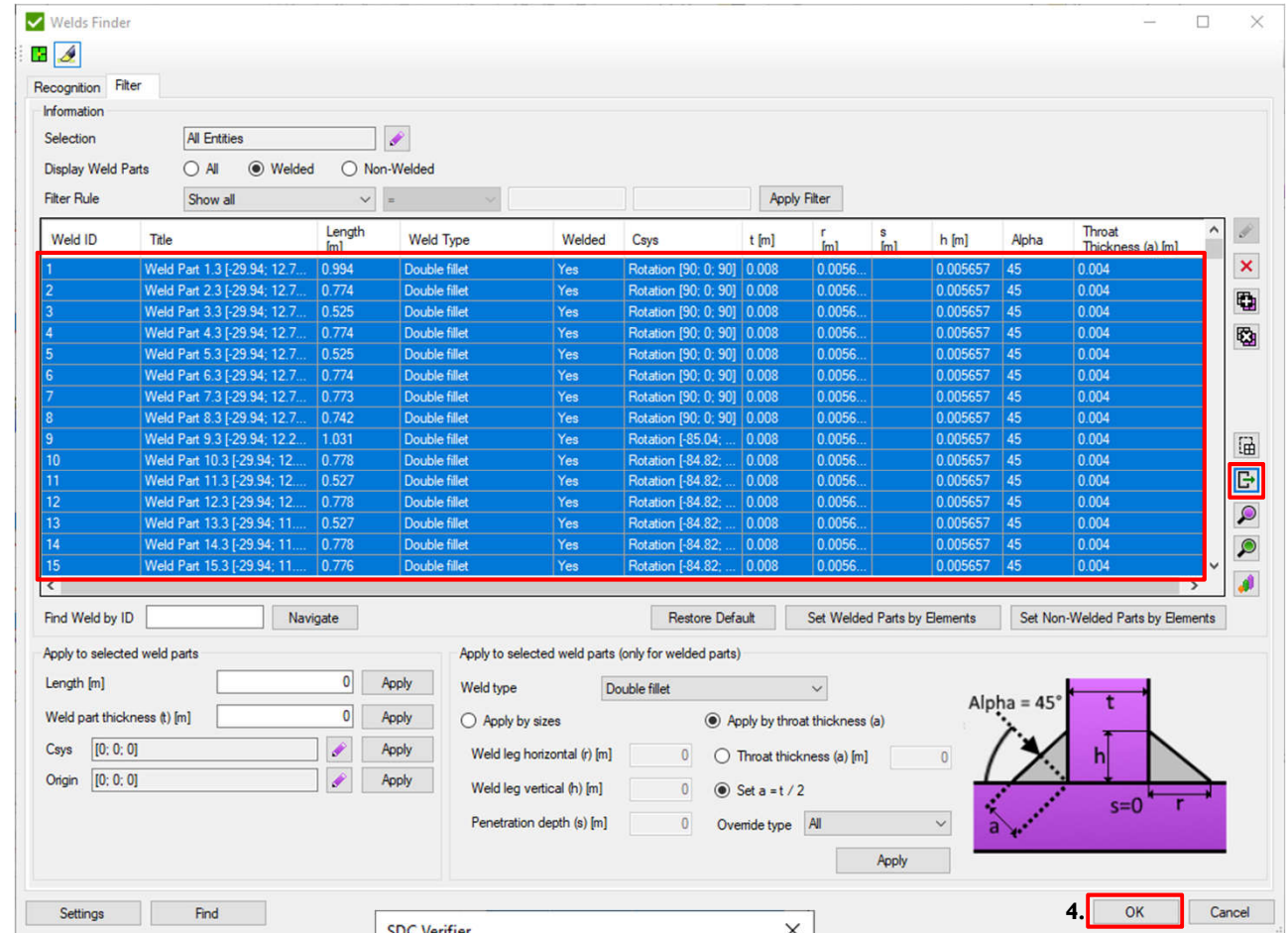
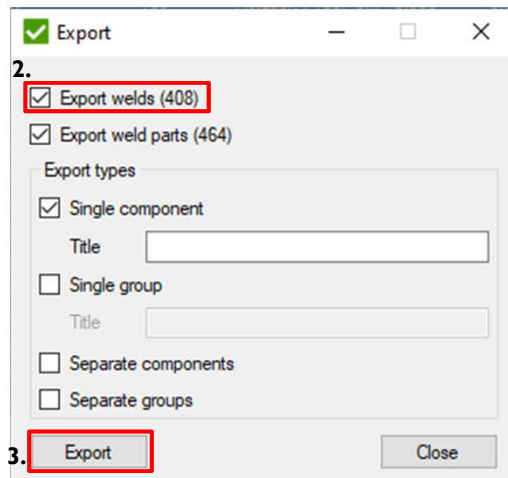
Export Welds

1 Press *Export weld*.

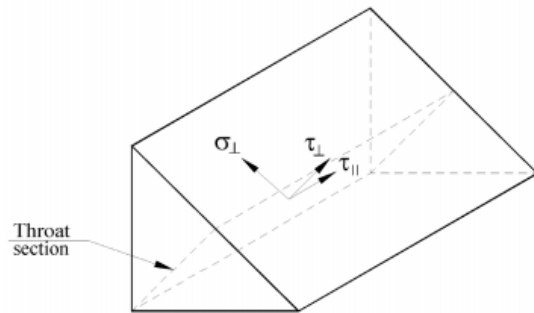
2 Select **Export welds**.

3 Press *Export*.

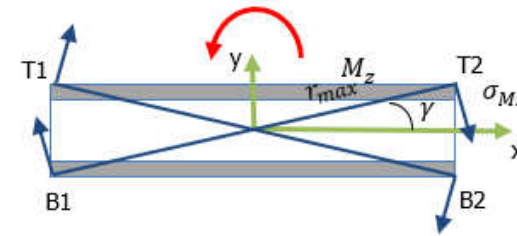
4 Press *OK* twice.



Weld Stresses Calculation



Moments depend on the axis in a weld plane and are also included in the weld strength calculations

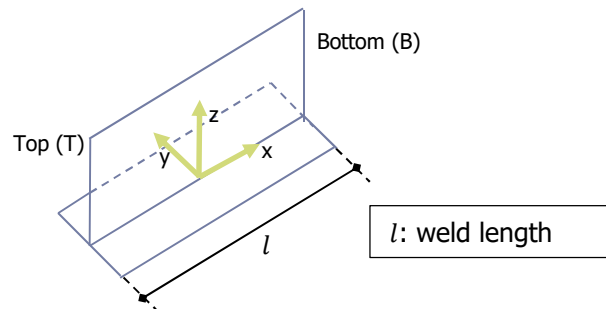


$\tau_{||}$ = shear design stress (in plane of the throat) parallel to the axis of the weld (equal to X direction in the check);
 σ_{\perp} = normal design stress perpendicular to the throat (equal to Y direction of the check);
 τ_{\perp} = shear design stress (in plane of the throat) perpendicular to the axis of the weld (equal to XY direction of the check)

The stresses $\tau_{||}$, σ_{β} and τ_{β} are evaluated at the points T1, T2, B1 and B2 as follows:

Angles matrix of rotations due to weld throat plane.

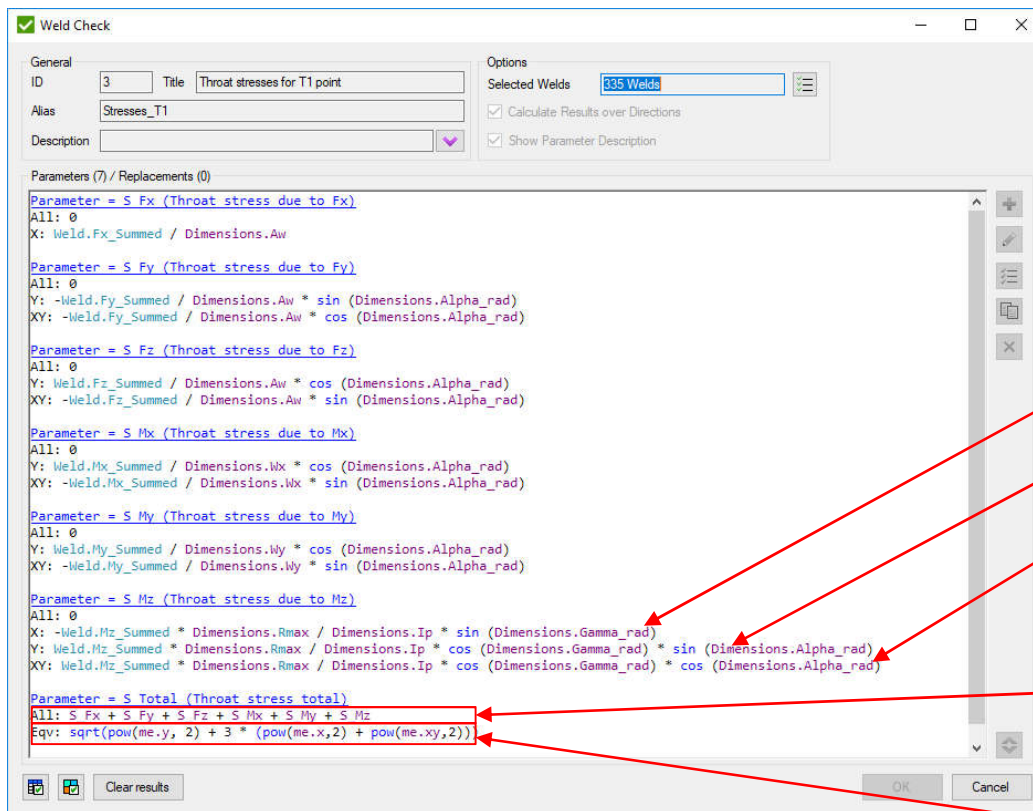
Stress calculations



$\tau_{ ,T1}$	1	0	0	0	0	$-\sin \gamma$
$\sigma_{\perp,T1}$	0	$-\sin \alpha$	$\cos \alpha$	$\cos \alpha$	$\cos \alpha$	$\cos \gamma * \sin \alpha$
$\tau_{\perp,T1}$	0	$-\cos \alpha$	$-\sin \alpha$	$-\sin \alpha$	$-\sin \alpha$	$\cos \gamma * \cos \alpha$
$\tau_{ ,T2}$	1	0	0	0	0	$-\sin \gamma$
$\sigma_{\perp,T2}$	0	$-\sin \alpha$	$\cos \alpha$	$\cos \alpha$	$-\cos \alpha$	$-\cos \gamma * \sin \alpha$
$\tau_{\perp,T2}$	0	$-\cos \alpha$	$-\sin \alpha$	$-\sin \alpha$	$\sin \alpha$	$-\cos \gamma * \cos \alpha$
$\tau_{ ,B1}$	1	0	0	0	0	$\sin \gamma$
$\sigma_{\perp,B1}$	0	$\sin \alpha$	$\cos \alpha$	$-\cos \alpha$	$\cos \alpha$	$-\cos \gamma * \sin \alpha$
$\tau_{\perp,B1}$	0	$\cos \alpha$	$-\sin \alpha$	$\sin \alpha$	$-\sin \alpha$	$-\cos \gamma * \cos \alpha$
$\tau_{ ,B2}$	1	0	0	0	0	$\sin \gamma$
$\sigma_{\perp,B2}$	0	$\sin \alpha$	$\cos \alpha$	$-\cos \alpha$	$-\cos \alpha$	$\cos \gamma * \sin \alpha$
$\tau_{\perp,B2}$	0	$\cos \alpha$	$-\sin \alpha$	$\sin \alpha$	$\sin \alpha$	$\cos \gamma * \cos \alpha$

$$= \begin{matrix} \frac{F_x}{A_w} \\ \frac{F_y}{A_w} \\ \frac{F_z}{A_w} \\ \frac{M_x}{I_x} d_y \\ \frac{M_y}{I_y} d_x \\ \frac{M_z * r_{max}}{I_p} \end{matrix} *$$

Implementation of weld stresses



$\tau_{||,Mz}$

$\sigma_{\beta,Mz}$

$\tau_{\beta,Mz}$

$$\begin{aligned}\tau_{||} &= \tau_{||,Fx} + \tau_{||,Fy} + \tau_{||,Fz} + \tau_{||,Mx} + \tau_{||,My} + \tau_{||,Mz} \\ \sigma_{\beta} &= \sigma_{\beta,Fx} + \sigma_{\beta,Fy} + \sigma_{\beta,Fz} + \sigma_{\beta,Mx} + \sigma_{\beta,My} + \sigma_{\beta,Mz} \\ \tau_{\beta} &= \tau_{\beta,Fx} + \tau_{\beta,Fy} + \tau_{\beta,Fz} + \tau_{\beta,Mx} + \tau_{\beta,My} + \tau_{\beta,Mz}\end{aligned}$$

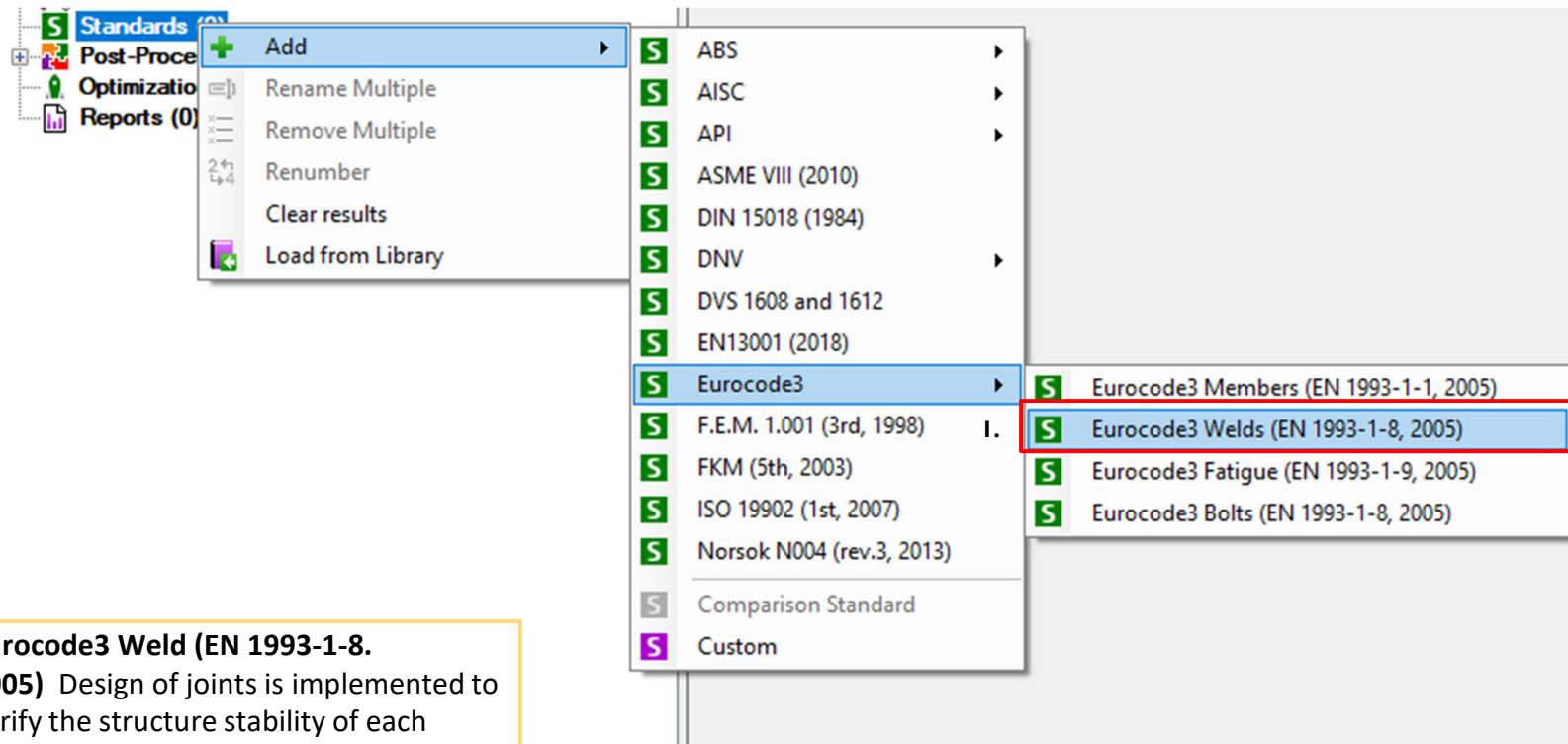
$$\sigma_{VM} = \sqrt{\sigma_{\perp}^2 + 3 * (\tau_{\perp}^2 + \tau_{||}^2)}$$

Von Mises stress at certain point.

Add Eurocode3 (EN1993-1-8)

1

Execute **Add => Eurocode3 Weld**
(EN 1993-1-8. 2005) in the Standards
context menu.



Eurocode3 Weld (EN 1993-1-8. 2005) Design of joints is implemented to verify the structure stability of each structural member (weld).

Eurocode3 Correction Factor

Weld Selection gives a possibility to include or exclude weld(s), preview chosen weld(s) or go to weld finder.

1

Press the button  to select the **Correction factor**.

2

Select the material for which the **Correction factor** will be applied.

3

Input value of the **Correction factor** according to the table 4.1, and press **Apply to selected**.

4

Press **OK**.

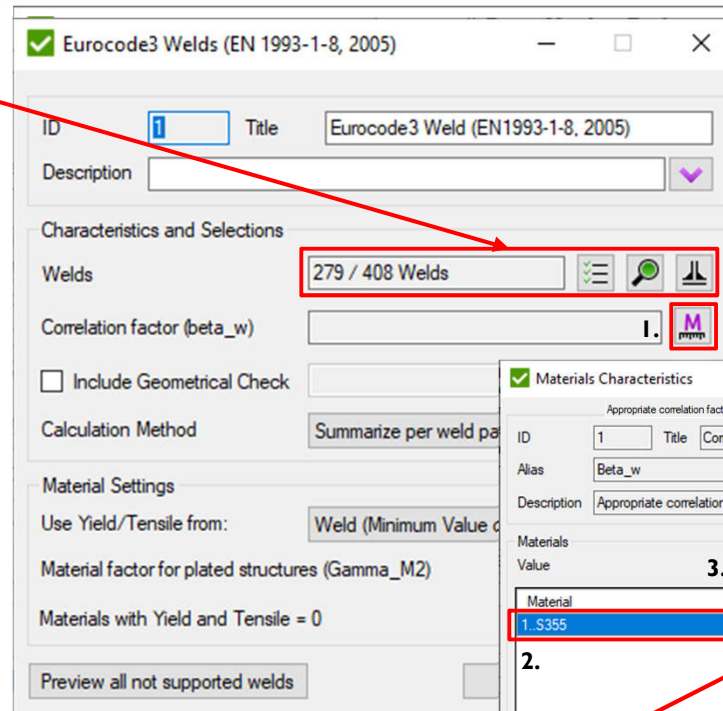
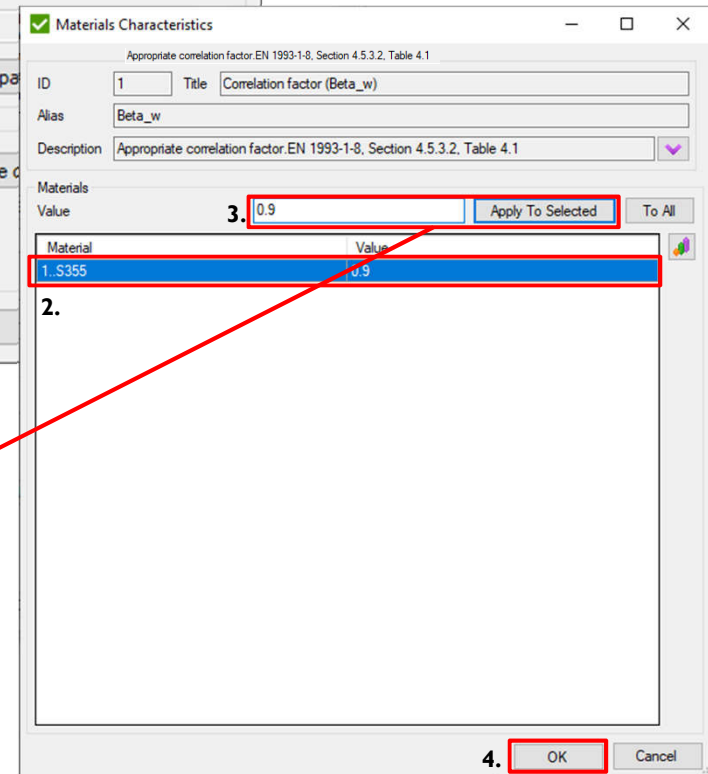



Table 4.1: Correlation factor β_w for fillet welds

Standard and steel grade			Correlation factor β_w
EN 10025	EN 10210	EN 10219	
S 235 S 235 W	S 235 H	S 235 H	0,8
S 275 S 275 N/NL S 275 M/ML	S 275 H S 275 NH/NLH	S 275 H S 275 NH/NLH S 275 MH/MLH	0,85
S 355 S 355 N/NL S 355 M/ML S 355 W	S 355 H S 355 NH/NLH	S 355 H S 355 NH/NLH S 355 MH/MLH	0,9
S 420 N/NL S 420 M/ML		S 420 MH/MLH	1,0
S 460 N/NL S 460 M/ML S 460 Q/QL/QL1	S 460 NH/NLH	S 460 NH/NLH S 460 MH/MLH	1,0

Eurocode3 Weld Strength

1 Press the button  to apply **Material Yield and Tensile** parameters.

2 Select the material for which the **Properties** will be applied.

3 Input value of the **Material Yield and Tensile** parameters, and press **Set**.

4 Press **OK**.

5 Press **OK**.

Material Fatigue Parameters

Materials	Tensile Strength [Pa]	Yield Stress [Pa]
1..S355	470000000	355000000

2.

3.

Properties

Tensile Strength [Pa]
470e6

Yield Stress [Pa]
355e6

Set

4.

OK Cancel

Eurocode3 Welds (EN 1993-1-8, 2005)

ID 1 Title Eurocode3 Weld (EN1993-1-8, 2005)

Alias Standard1

Description

Characteristics and Selections

Welds 279 / 408 Welds

Correlation factor (beta_w) Defined

☐ Include Geometrical Check

Calculation Method Summarize per weld part

Material Settings

Use Yield/Tensile from: Weld (Minimum Value or User Defined)

Material factor for plated structures (Gamma_M2) 1.25

Materials with Yield and Tensile = 0 1

Preview all not supported welds

5. OK Cancel

Gamma_M2 - material resistance factor for plated structures is a constant value (=1.25) and used in calculations to check a base material strength.

Create extreme table

1 Execute **Extreme Table** in the **Weld Check Total** context menu.

2 Press the  button and select **Load Group 1**

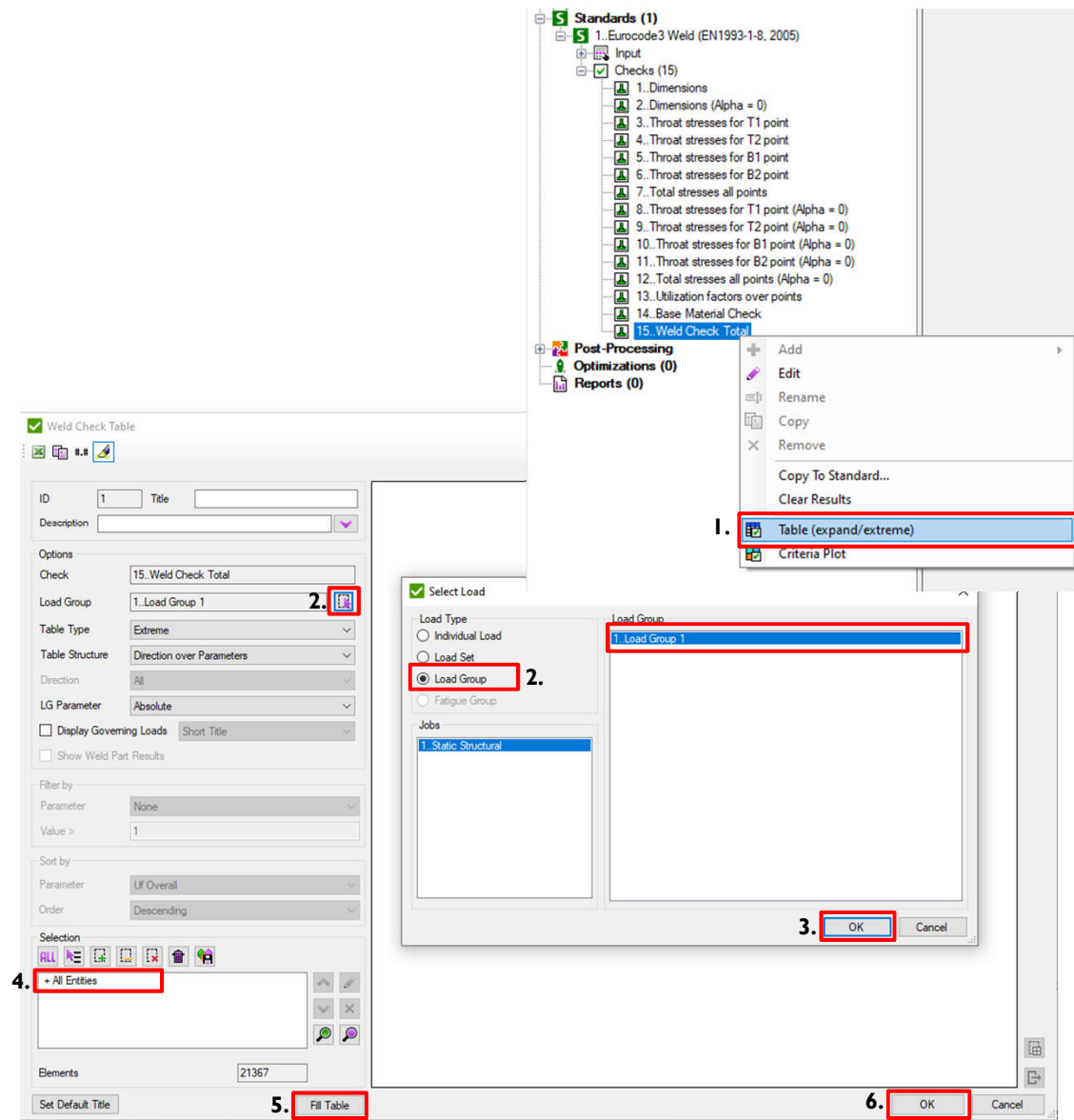
3 Press **OK**.

4 Selection: **All Entities**.

5 Press **Fill Table**.

6 Press **OK**.

Extreme table for '1..Load Group 1' can be added to DNV OS-C101 and DNV OS-C201 standards respectively.




The screenshot illustrates the steps to create an extreme table in SDC Verifier. The main window shows the 'Weld Check Table' dialog with '1..Load Group 1' selected. A context menu is open over the '15..Weld Check Total' item, with 'Table (expand/extreme)' highlighted. A 'Select Load' dialog is also open, showing '1..Load Group 1' selected. The 'Selection' section at the bottom shows '+ All Entities' selected. The 'Fill Table' button is highlighted at the bottom right.

Create criteria plot

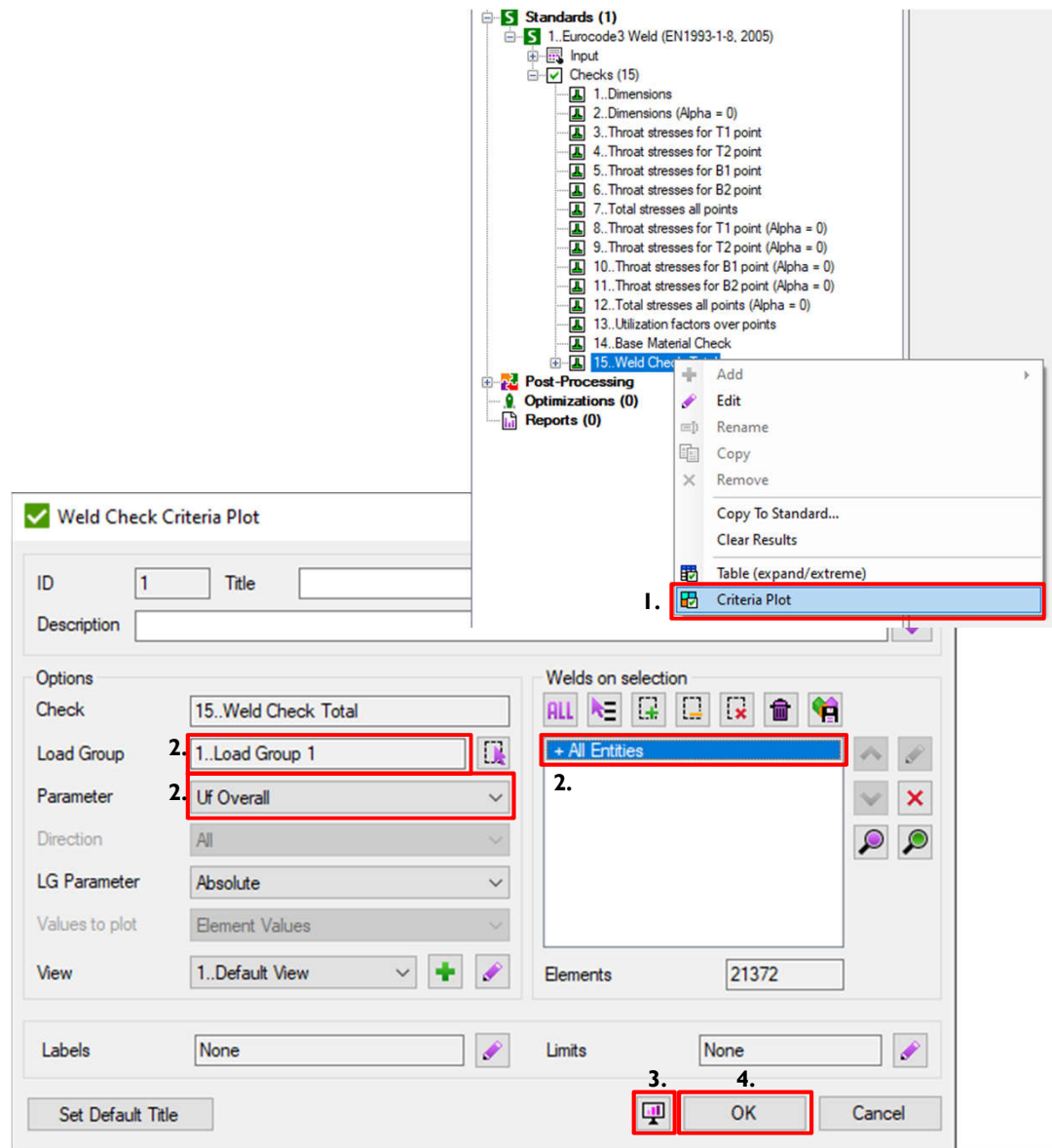
1 Execute **Criteria Plot** in the **Weld Strength Check** context menu

2 Load: **Load Group 1**;
Parameter: **UF Overall**;
Selection: **All Entities**.

3 Press the  to preview Plot in Femap

4 Press **OK**.

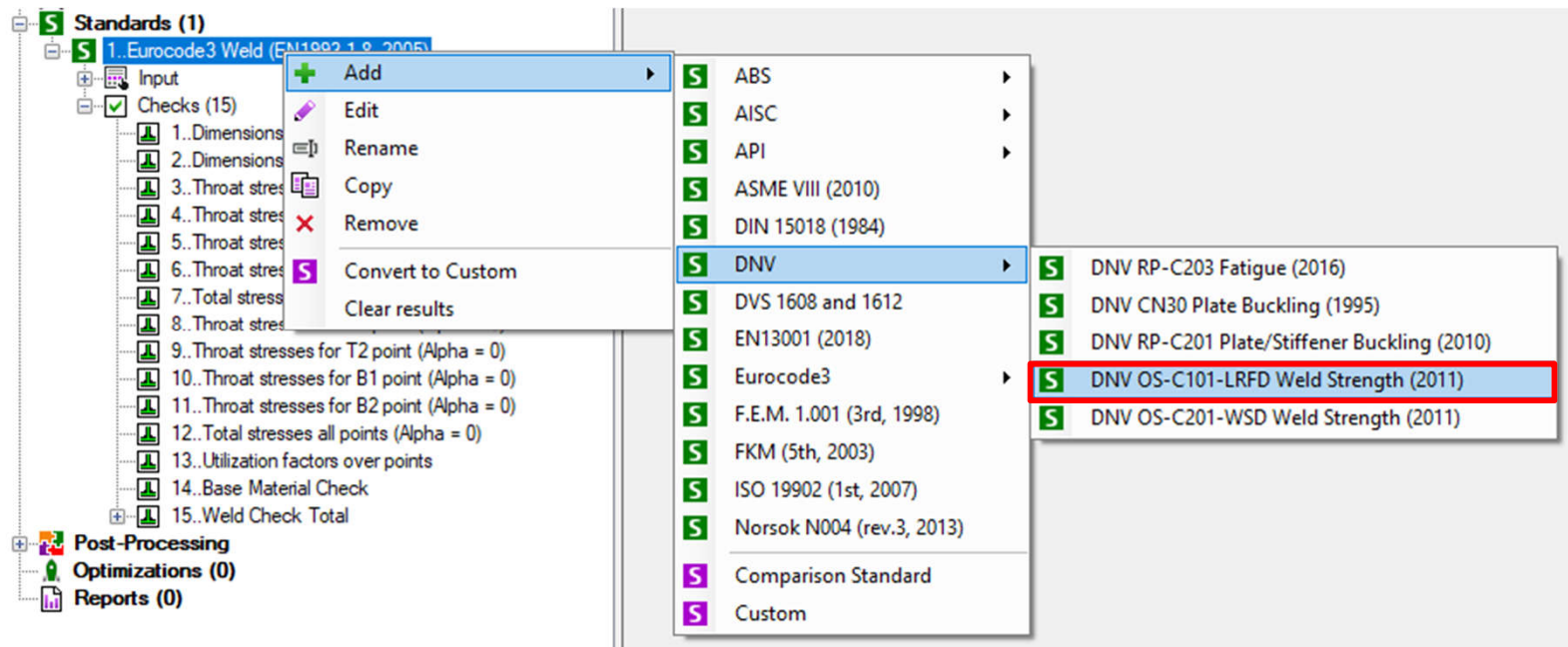
Criteria plot for '1..Load Group 1' can be added to DNV OS-C101 and DNV OS-C201 standards respectively.



Add DNV OS-C101-LRFD

1

Execute **Criteria Plot** in the **Weld Strength Check** context menu



The offshore standard **DNV OS-C101 (released in April, 2011)** verifies structural stability for each structural member (weld).

DNV OS-C101. Correction Factor

Weld Selection gives a possibility to include or exclude weld(s), preview chosen weld(s) or go to weld finder.

1

Press the button  select **Correction factor**.

2

Select the material for which the **Correction factor** will be applied.

3

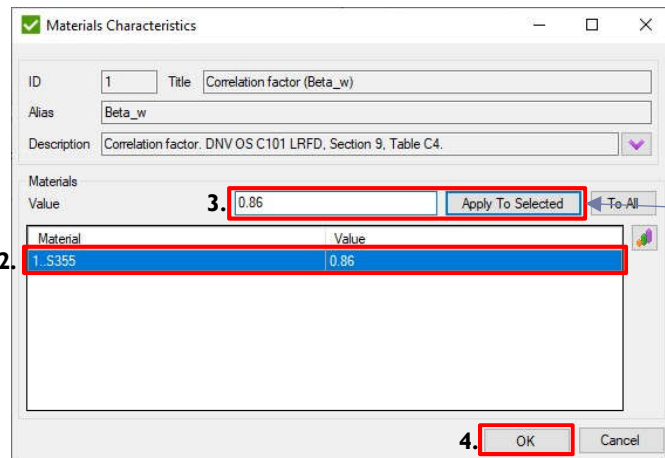
Input value of the **Correction factor** according to the table, and press *Apply to selected*.

4

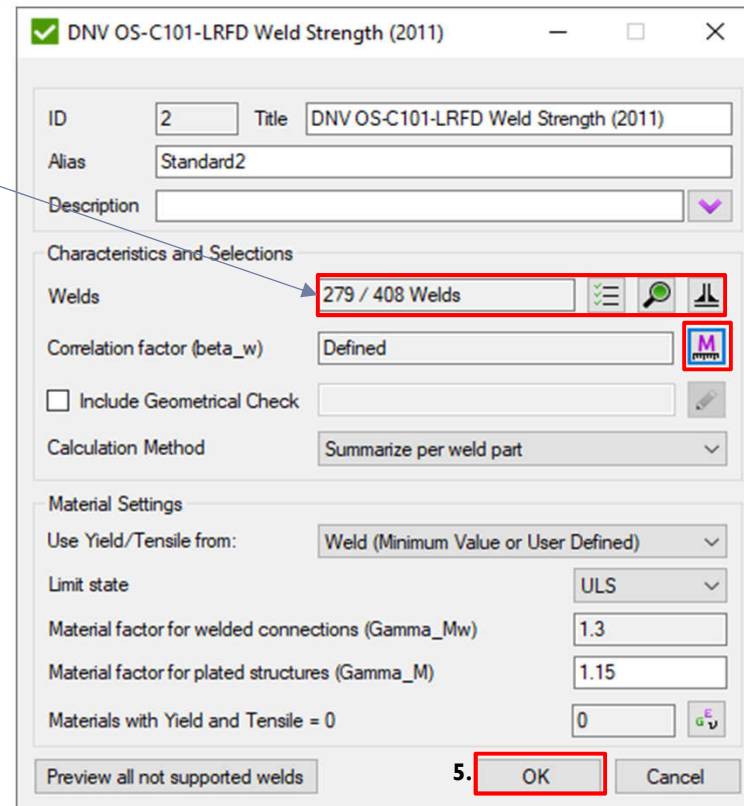
Press *OK*.

5

Press *OK*.



The dialog box 'Materials Characteristics' is shown. It has fields for ID (1), Title (Correlation factor (Beta_w)), Alias (Beta_w), and Description (Correlation factor, DNV OS C101 LRFD, Section 9, Table C4). Below these is a table with two columns: 'Material' and 'Value'. The first row is highlighted in blue, showing '1.S355' and '0.86'. A red box highlights the '0.86' value. To the right of the table is a button labeled 'Apply To Selected'. At the bottom right, there are 'OK' and 'Cancel' buttons. A red box highlights the 'OK' button.



The dialog box 'DNV OS-C101-LRFD Weld Strength (2011)' is shown. It has fields for ID (2), Title (DNV OS-C101-LRFD Weld Strength (2011)), Alias (Standard2), and Description. Below these is a section 'Characteristics and Selections' with a 'Welds' field showing '279 / 408 Welds'. To the right of this field is a red box containing an 'M' icon. Below this is a 'Correlation factor (beta_w)' field set to 'Defined'. There is an unchecked checkbox for 'Include Geometrical Check' and a 'Calculation Method' dropdown set to 'Summarize per weld part'. Below this is a 'Material Settings' section with a dropdown for 'Use Yield/Tensile from:' set to 'Weld (Minimum Value or User Defined)', a 'Limit state' dropdown set to 'ULS', and input fields for 'Material factor for welded connections (Gamma_Mw)' (1.3), 'Material factor for plated structures (Gamma_M)' (1.15), and 'Materials with Yield and Tensile = 0' (0). At the bottom right, there are 'OK' and 'Cancel' buttons. A red box highlights the 'OK' button.

Steel grade	Lowest ultimate tensile strength f_u	Correlation factor β_w
NV NS	400	0.83
NV 27	400	0.83
NV 32	440	0.86
NV 36	490	0.89
NV 40	510	0.9
NV 420	530	1.0
NV 460	570	1.0

DNV OS-C101. Safety Factors

DNV OS-C101-LRFD Weld Strength (2011)

ID: 2 Title: DNV OS-C101-LRFD Weld Strength (2011)

Alias: Standard2

Description:

Characteristics and Selections

Welds: 279 / 408 Welds

Correlation factor (beta_w): Defined

☐ Include Geometrical Check

Calculation Method: Summarize per weld part

Material Settings

Use Yield/Tensile from: Weld (Minimum Value or User Defined)

Limit state: ULS

Material factor for welded connections (Gamma_Mw): 1.3

Material factor for plated structures (Gamma_M): 1.15

Materials with Yield and Tensile = 0

Preview all not supported welds

OK Cancel

Gamma_Mw - material factor that is used for DNV OS C 101 calculation can be found in Table C1, section 9 of the standard.

101 The material factors γ_{Mw} for welded connections are given in Table C1.

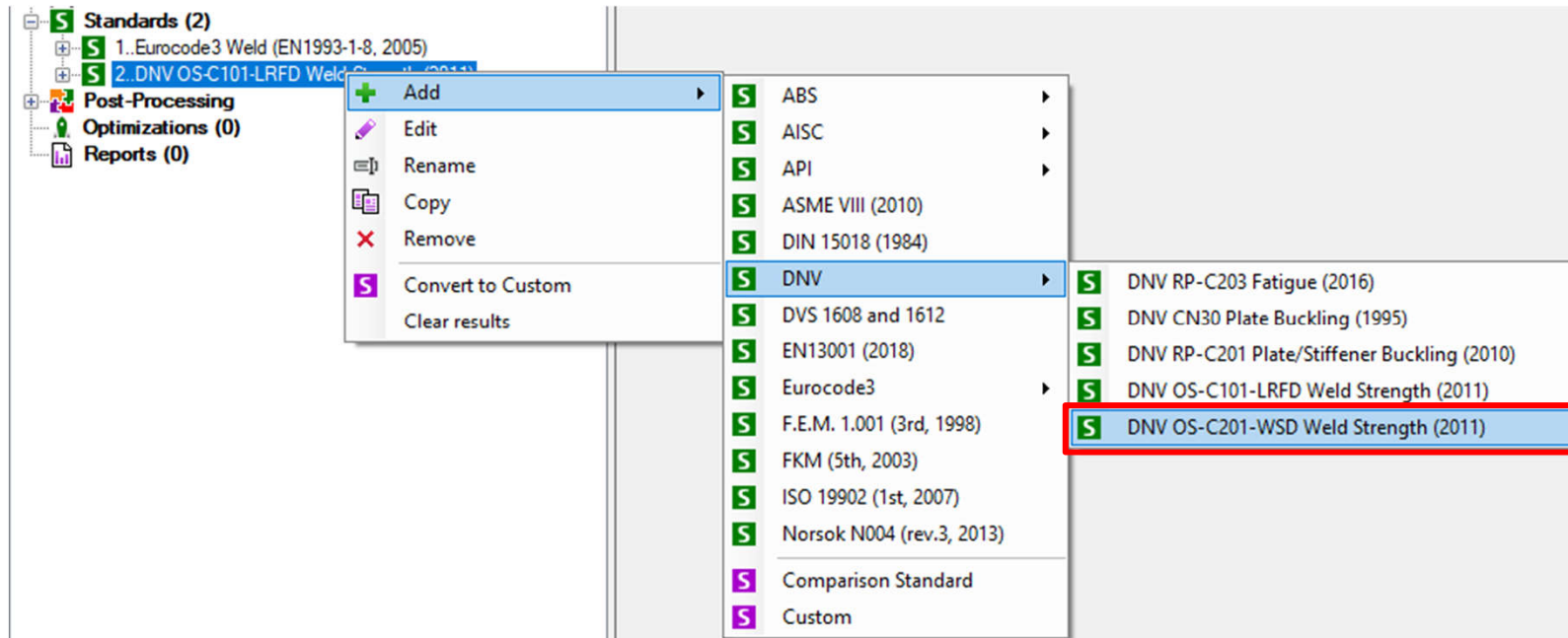
Table C1 Material factors γ_{Mw} for welded connections	
Limit states	Material factor
ULS	1.3
ALS	1.0

Gamma_M - material resistance factor for plated structures is a constant value (=1.15) and used in calculations to check base material strength.

Add DNV OS-C201 WSD

1

Execute Add => DNV OS-C201 WSD
Weld Strength (2011) in the Standards
context menu.



The offshore standard **DNV OS-C201**
(released in April, 2011) verifies
structural stability for each structural
member (weld)

DNV OS C201. Correction Factor

Weld Selection gives a possibility to include or exclude weld(s), preview chosen weld(s) or go to weld finder.

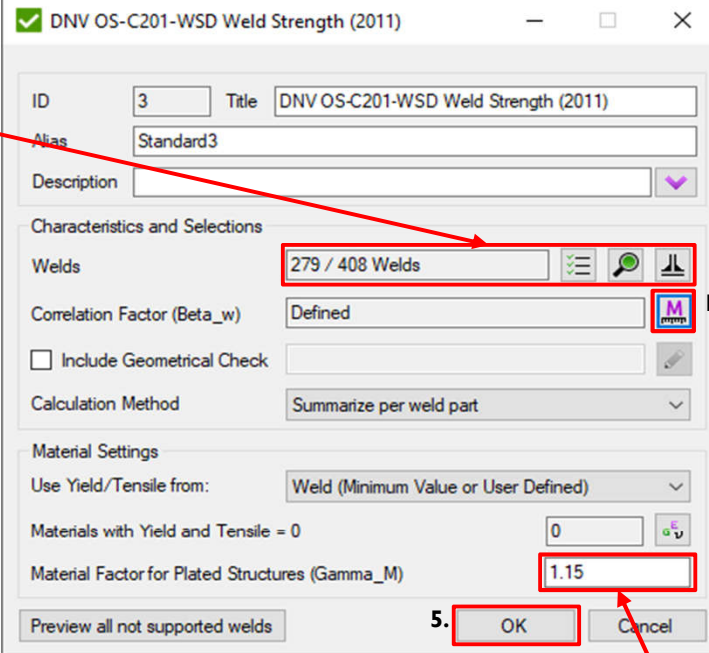
1 Press the button  to select **Correction factor**.

2 Select the material for which the **Correction factor** will be applied.

3 Input value of the **Correction factor** according to the table, and press *Apply to selected*.

4 Press *OK*.

5 Press *OK*.



DNV OS-C201-WSD Weld Strength (2011)

ID: 3 Title: DNV OS-C201-WSD Weld Strength (2011)

Alias: Standard3

Description:

Characteristics and Selections

Welds: 279 / 408 Welds

Correlation Factor (Beta_w): Defined

☐ Include Geometrical Check

Calculation Method: Summarize per weld part

Material Settings

Use Yield/Tensile from: Weld (Minimum Value or User Defined)

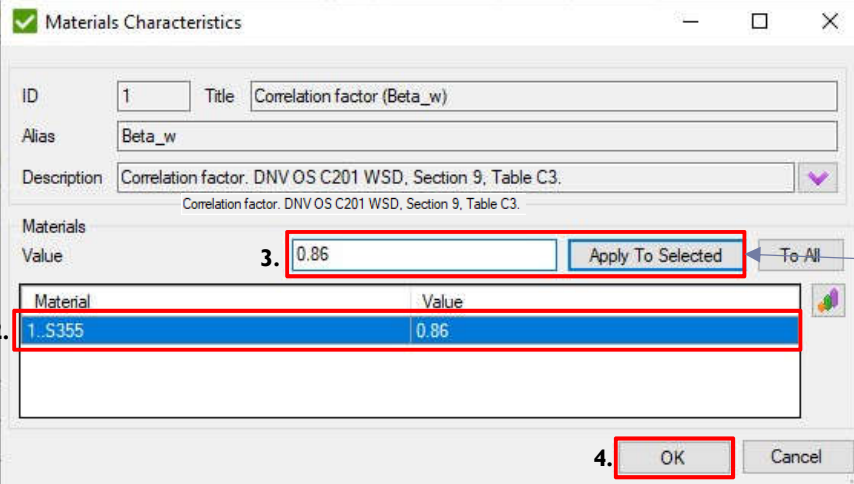
Materials with Yield and Tensile = 0: 0

Material Factor for Plated Structures (Gamma_M): 1.15

Preview all not supported welds

5. OK Cancel

Gamma_M - material resistance factor for plated structures is a constant value (=1.15) and used in calculations to check base material strength.



Materials Characteristics

ID: 1 Title: Correlation factor (Beta_w)

Alias: Beta_w

Description: Correlation factor. DNV OS C201 WSD, Section 9, Table C3.

Materials

Value: 3. 0.86

Apply To Selected To All


Material Value

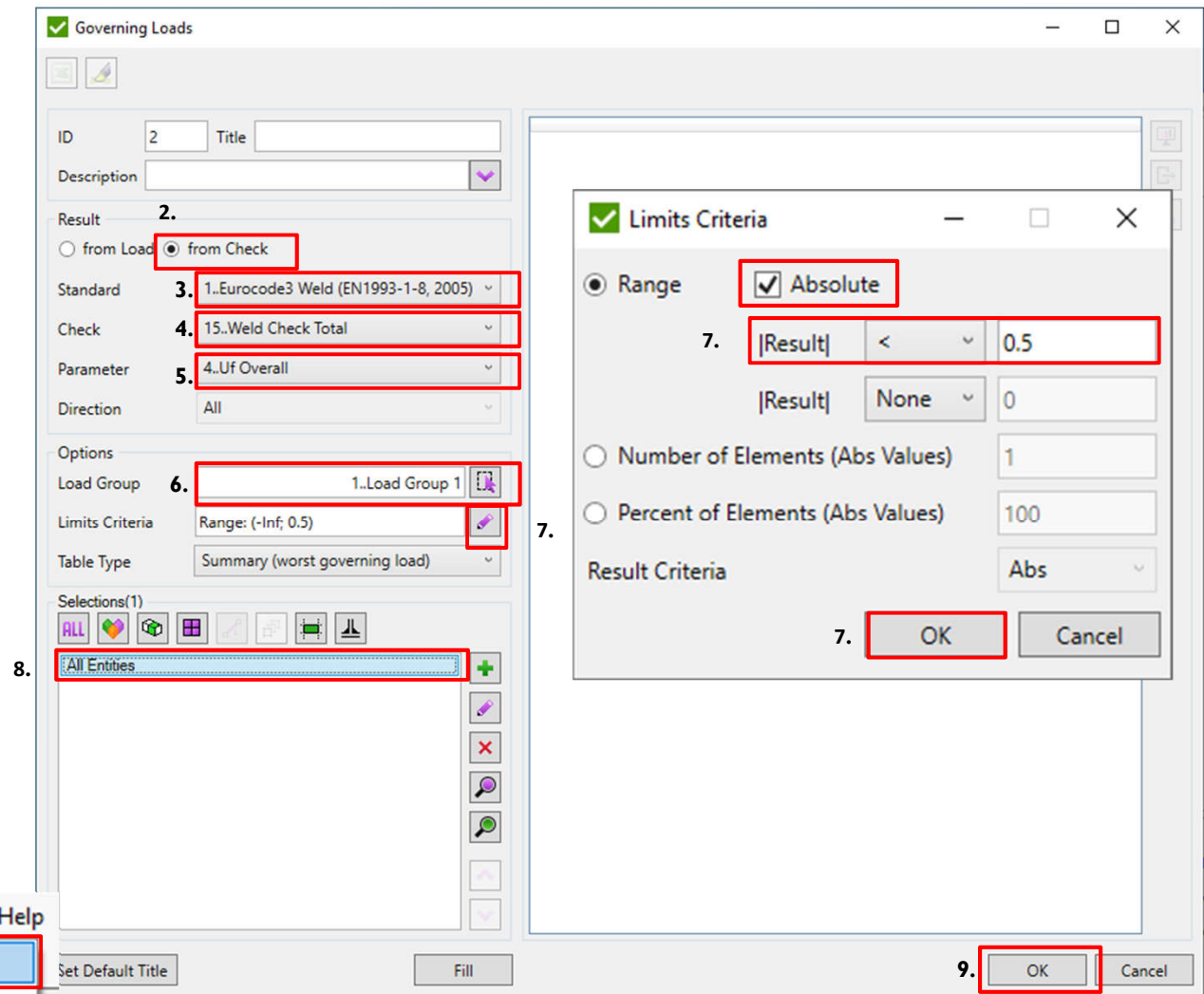
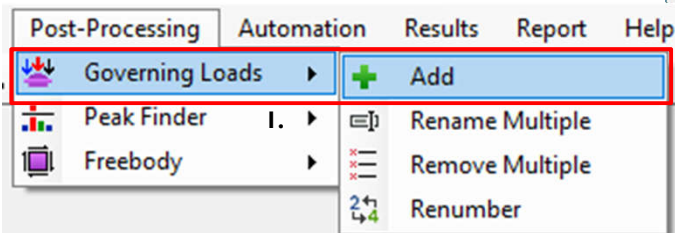
1. S355 0.86

4. OK Cancel

Steel grade	Lowest ultimate tensile strength f_u	Correlation factor β_w
NV NS	400	0.83
NV 27	400	0.83
NV 32	440	0.86
NV 36	490	0.89
NV 40	510	0.9
NV 420	530	1.0
NV 460	570	1.0

Add Governing Load

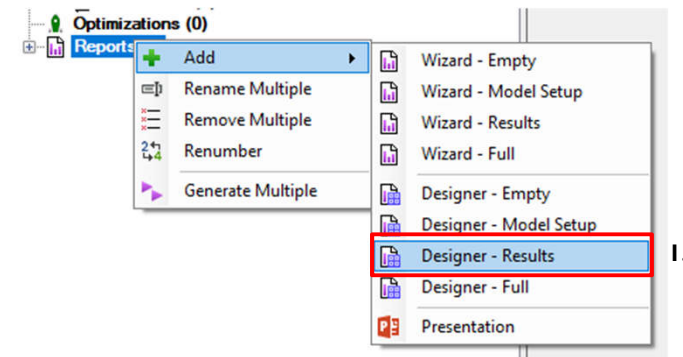
- 1 Post Processing => Governing Loads => Add
- 2 Result: from Check;
- 3 Standard: Eurocode 3 Weld.
- 4 Check: Weld Check Total.
- 5 Parameter: Uf Overall.
- 6 Load Group: Load Group 1.
- 7 Press  in Limits Criteria => Absolute; Result < 0.5 => OK
- 8 Selection: All Entities.
- 9 Press OK.



Add Report

1

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



There are 4 templates of the reports:

Empty – only first page and preface items are included;

Model Setup – description of the model data (materials, properties, components, boundary conditions) is included;

Results – for each load extreme displacement tables, stress and displacement plots are included. Predefined tables: sum of reaction forces, stresses/displacements summary tables. In addition all standards are included with a set of tables/plots created in the project;

Full – Model Setup + Results + all tables/plots created in jobs.

Report - Governing Load

1 Post Processing => Governing Loads
=> Import

2 Select Governing Loads(LG1) => OK

3 Include Plot: **Yes**.
Show only welds: **Yes**.

Add Governing Load for '1..Load Group 1' also possible for DNV OS-C101 and DNV OS-C201 standards.

2.

Select Items

Search

ID Go

Filter X

Show All Refresh

All None

☒ 1..Governing Loads (LG1; All Entities)

2. OK Cancel

Report Designer

Home Insert Results **Post Processing** Import

Peak Finders Governing Loads Freebodies

Add Governing Loads Tables

1. Import Governing Loads Tables

Behavior

Break Page Before Yes

Enabled Yes

Data

Load LG1..Load Group 1

Title (Default) 2..Governing Loads (LG1; All Entities)

Title (User) 2..Governing Loads (LG1; All Entities)

Misc

Standard

Options

Include Descriptor Yes

Limits Criteria Range: (-Inf; 0.5)

Table Type Summary (worst governing load)

Plot 3.

Include Plot Yes

Show Max Label None

Show only welds Yes

Views 1 selected...

Report - First Page

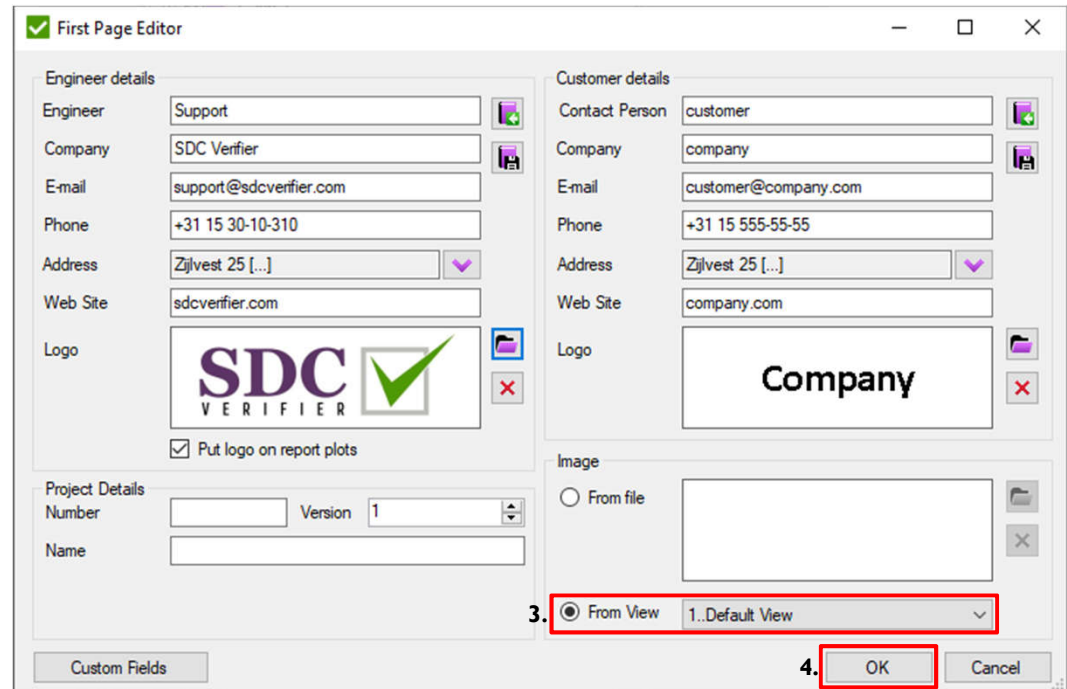
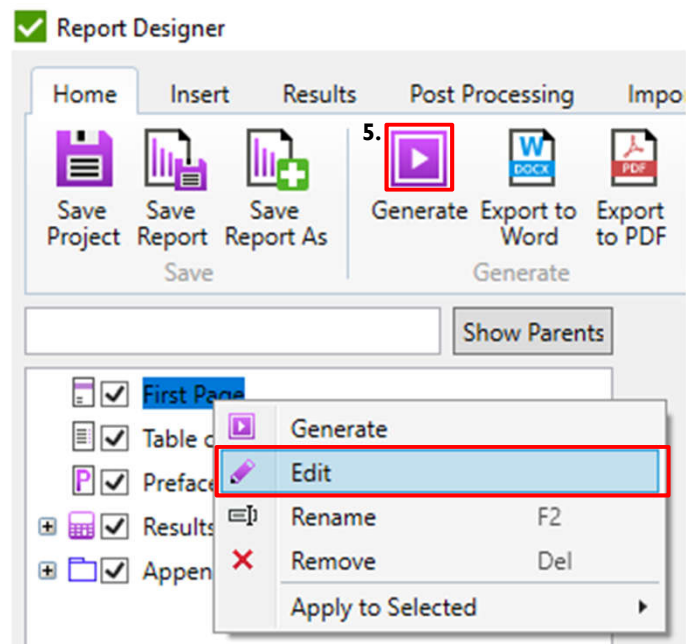
1 Right click on *First Page* => **Edit**.

2 Fill in information about project.

3 Select Image **From View** and pick.

4 Press **OK**.

5 Press button  to generate report.



The 'First Page Editor' dialog box is shown with two main sections: 'Engineer details' and 'Customer details'. The 'Engineer details' section includes fields for Engineer (Support), Company (SDC Verfier), E-mail (support@sdcverfier.com), Phone (+31 15 30-10-310), Address (Zijlvest 25 [...]), Web Site (sdcverfier.com), and Logo (SDC VERIFIER logo). The 'Customer details' section includes fields for Contact Person (customer), Company (company), E-mail (customer@company.com), Phone (+31 15 555-55-55), Address (Zijlvest 25 [...]), Web Site (company.com), and Logo (Company logo). The 'Image' section has a radio button for 'From file' and a dropdown menu for 'From View' (labeled '3.') with '1..Default View' selected. The 'OK' button is highlighted with a red box and labeled '4.'. There is also a 'Generate' button at the bottom left.

Report - Results

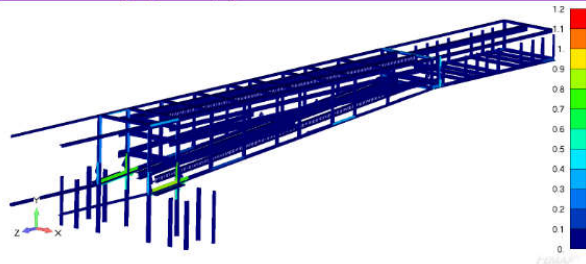
Eurocode3

15..Weld Check Total

Property	Value
Category	Weld Check
Parameter Count	4

1..Weld Extreme (LG1, 335 Welds)					
Standard	1..Eurocode3 Weld (EN1993-1-8, 2005)	Check	[S1] 15..Weld Check Total		
Load Group	LG1..Load Group 1	Welds	335		
Extreme	UF VM total	UF N total	UF material total	UF Overall	
Minimum	0.00	0.00	0.00	0.00	
Maximum	0.81	0.47	0.70	0.81	
Absolute	0.81	0.47	0.70	0.81	

1..Absolute UF Overall (LG1, 335 Welds, v1)

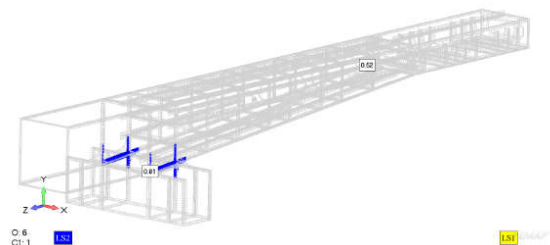


Check	[S1] 15..Weld Check Total	Load Group	LG1..Load Group 1
Parameter	Absolute UF Overall	Welds	335
View	1..Default View		

Governing Loads (LG1: All Entities)

Standard	1..Eurocode3 Weld (EN1993-1-8, 2005)	Direction	All
Check	15..Weld Check Total	Parameter	4..UF Overall
Criteria	Abs(value) > Abs(0.5)		

Load	Element Count	Peak Element Id	Peak Value
LS2..Load Set 2	144	36318	0.81
LS1..Load Set 1	2	1318	0.52



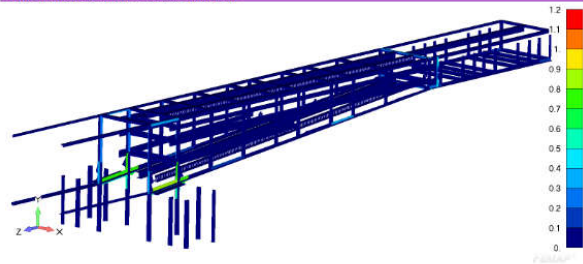
DNV OS-C101

15..Weld Check Total

Property	Value
Category	Weld Check
Parameter Count	4

1..Weld Extreme (LG1, 335 Welds)					
Standard	2..DNV OS C101 LRFD	Check	[S2] 15..Weld Check Total		
Load Group	LG1..Load Group 1	Welds	335		
Extreme	UF VM total	UF N total	UF material total	UF Overall	
Minimum	0.00	0.00	0.00	0.00	
Maximum	0.81	0.44	0.65	0.81	
Absolute	0.81	0.44	0.65	0.81	

1..Absolute UF Overall (LG1, 335 Welds, v1)

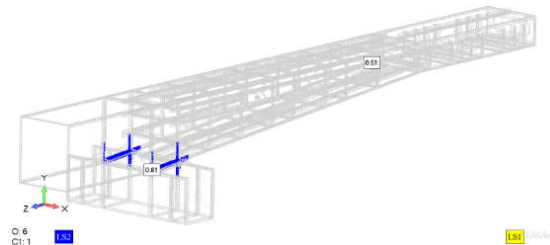


Check	[S2] 15..Weld Check Total	Load Group	LG1..Load Group 1
Parameter	Absolute UF Overall	Welds	335
View	1..Default View		

Governing Loads (LG1: All Entities)

Standard	2..DNV OS C101 LRFD	Direction	All
Check	15..Weld Check Total	Parameter	4..UF Overall
Criteria	Abs(value) > Abs(0.5)		

Load	Element Count	Peak Element Id	Peak Value
LS2..Load Set 2	144	36318	0.81
LS1..Load Set 1	2	1318	0.51



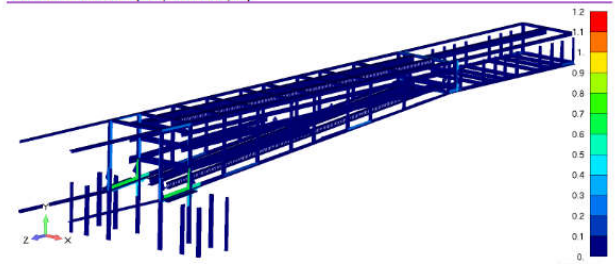
DNV OS-C201

15..Weld Check Total

Property	Value
Category	Weld Check
Parameter Count	4

1..Weld Extreme (LG1, 335 Welds)					
Standard	3..DNV OS C201 WSD	Check	[S3] 15..Weld Check Total		
Load Group	LG1..Load Group 1	Welds	335		
Extreme	UF VM total	UF N total	UF material total	UF Overall	
Minimum	0.00	0.00	0.00	0.00	
Maximum	0.82	0.34	0.65	0.85	
Absolute	0.82	0.34	0.65	0.85	

1..Absolute UF Overall (LG1, 335 Welds, v1)



Check	[S3] 15..Weld Check Total	Load Group	LG1..Load Group 1
Parameter	Absolute UF Overall	Welds	335
View	1..Default View		

Governing Loads (LG1: All Entities)

Standard	3..DNV OS C201 WSD	Direction	All
Check	15..Weld Check Total	Parameter	4..UF Overall
Criteria	Abs(value) > Abs(0.5)		

Load	Element Count	Peak Element Id	Peak Value
LS2..Load Set 2	72	36318	0.85

