




## SDC Verifier tutorials

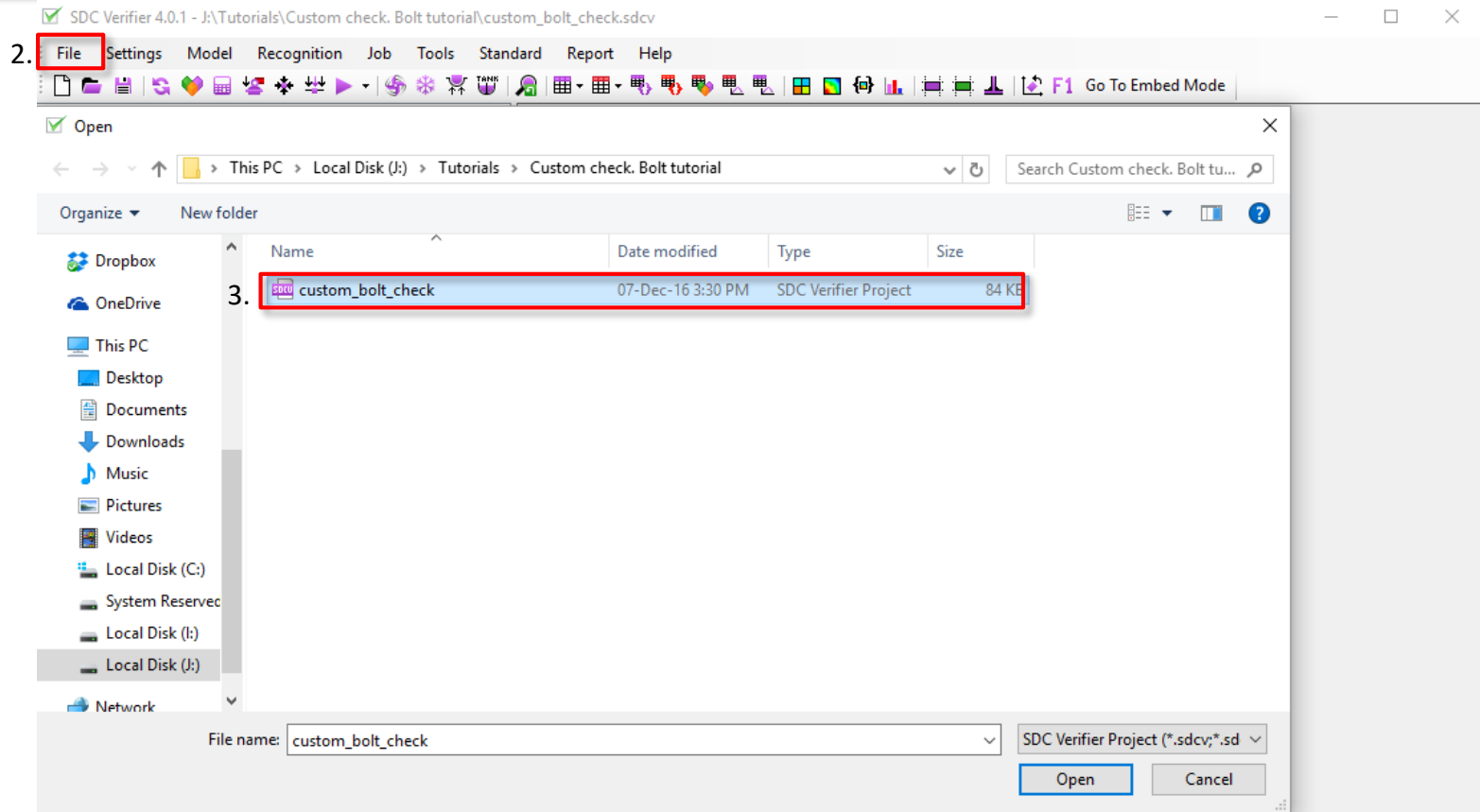
### **Custom Check. Bolt check**

08.12.2016  
version 4.0.1

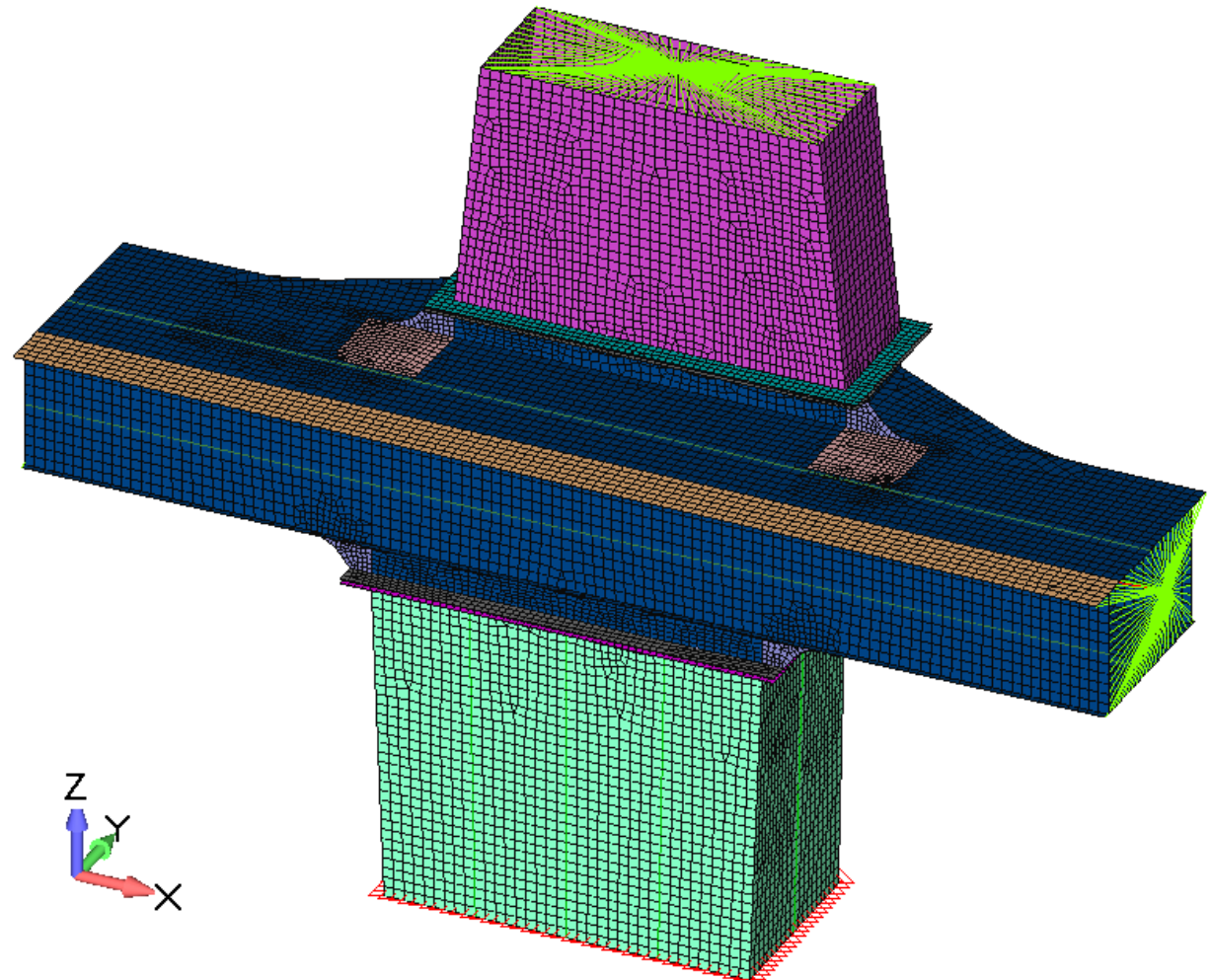
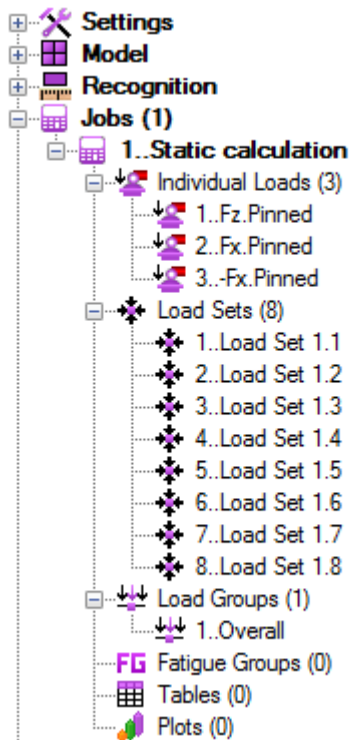
- ▶ In this tutorial the procedure of creation custom check using SDC Verifier is reviewed in details.
- ▶ Part of the gantry crane structure with bolted connection detail has been used as a start FEM model.
- ▶ Axial and Shear Bolt check were performed.
- ▶ Plots and tables are created to present the results.

# Open Project

- 1 Launch **SDC Verifier** 
- 2 Execute *File - Open Project*.
- 3 Project: ***custom\_bolt\_check***



# Predefined model and project



This tutorial uses predefined model with already created constraints, Individual Loads, Load Sets and Load Group.

# Creating Custom Standard

1

Execute *Add* => *Custom* from the Standards context menu

2

Standard Title: **Bolt Check**

3

Press *OK*

**Standard** is set of checks and items to perform calculations according to Code. It contains: Constants, Characteristics, Classification, Standard Tables, Checks, Variables.

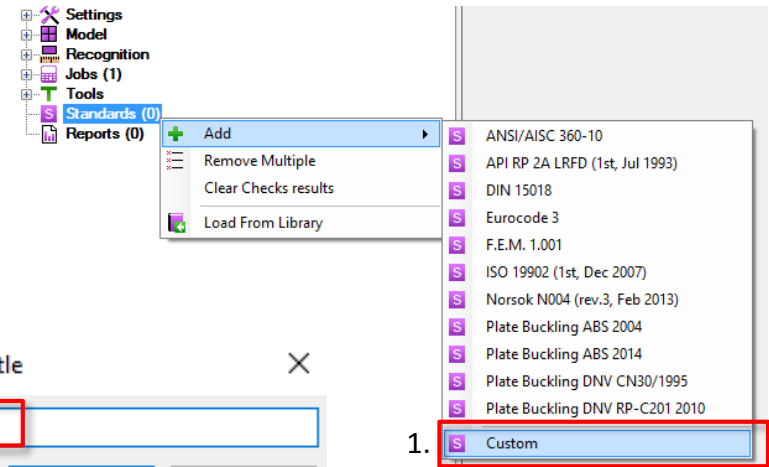
**Constants** is a static value which can be used in checks with help of Alias. It is useful to create constants and use them in formulas because in case of modifications (related to constants) it is required to make change in one place only.

SDC Verifier allows to add extra properties called **Characteristics** to use them in Standard check formulas. There are five types of characteristics: Material, Property, Node, Element, Linked and Loads.

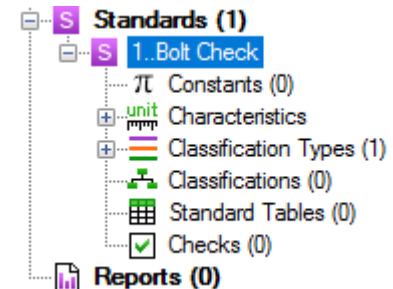
**Classification type** is a list of titles that can be used in classification or characteristic instead of numbers. It is available only in Custom standard.

**Classification** is an extra elements characteristic that can be set over directions and points of interest.

**Standard table** is a two dimensional matrix of static values.



1.



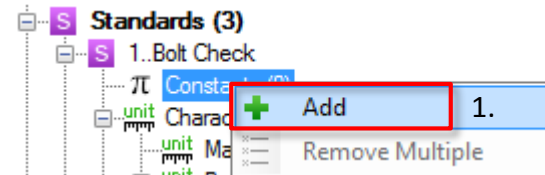
# Create Safety Factor Constant

1 Execute Constants – Add from context menu

2 Title (Alias): **SafetyFactor**

3 Value: **1.1**

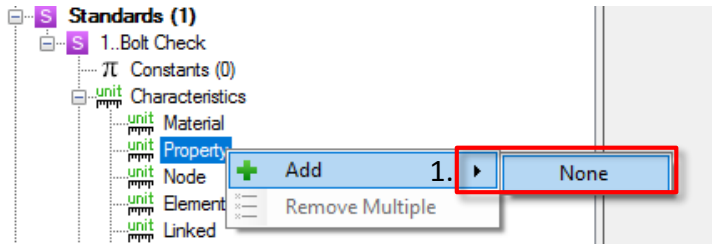
4 Press *OK*



Use Constants instead of numbers in your formulas. It helps to make the formulas more understandable. In case of change it should be modified in one place.

# Creating Characteristics

1. Execute *Property => Add => None* from the *Characteristics* context menu



2. Title: **Bolt Prestress**

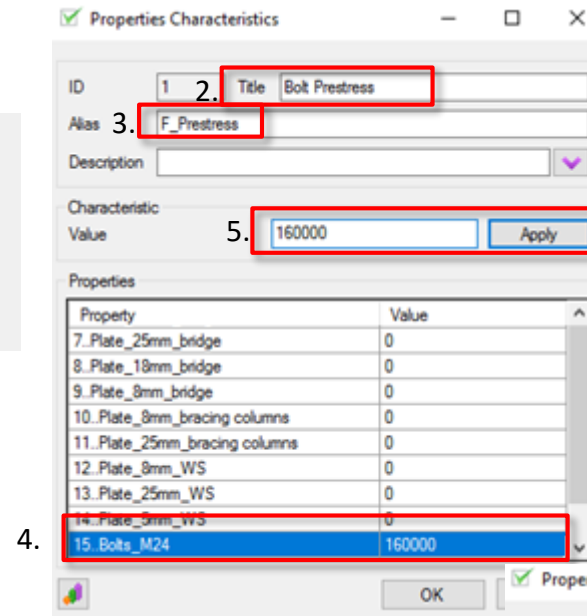
3. Enter Alias: **F\_Prestress**

Alias is a unique name for Standard items through which they can be accessed in Custom check formulas.

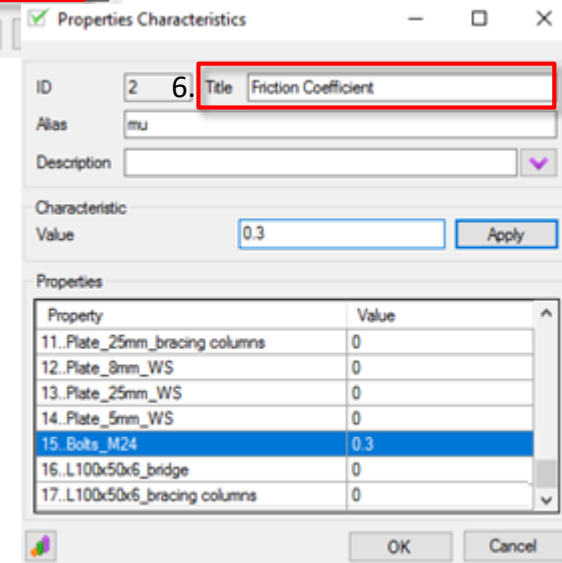
4. Select property 15.. Bolts\_M24 and enter the characteristic value: 160 000 N

5. Press Apply. Press OK

6. Create another Characteristic "Friction Coefficient" with alias – "mu" and value = 0.3



Characteristic is a predefined variable which is assigned to material, property or selection because it can't be read from Femap like properties or results values. In this case friction coefficient and bolt prestress has to be set.



# Create Custom Check

1 Execute *Add => Custom Check* in *Checks* context menu

2 Title: **Custom Bolt Check**

3 Alias: **boltcheck**

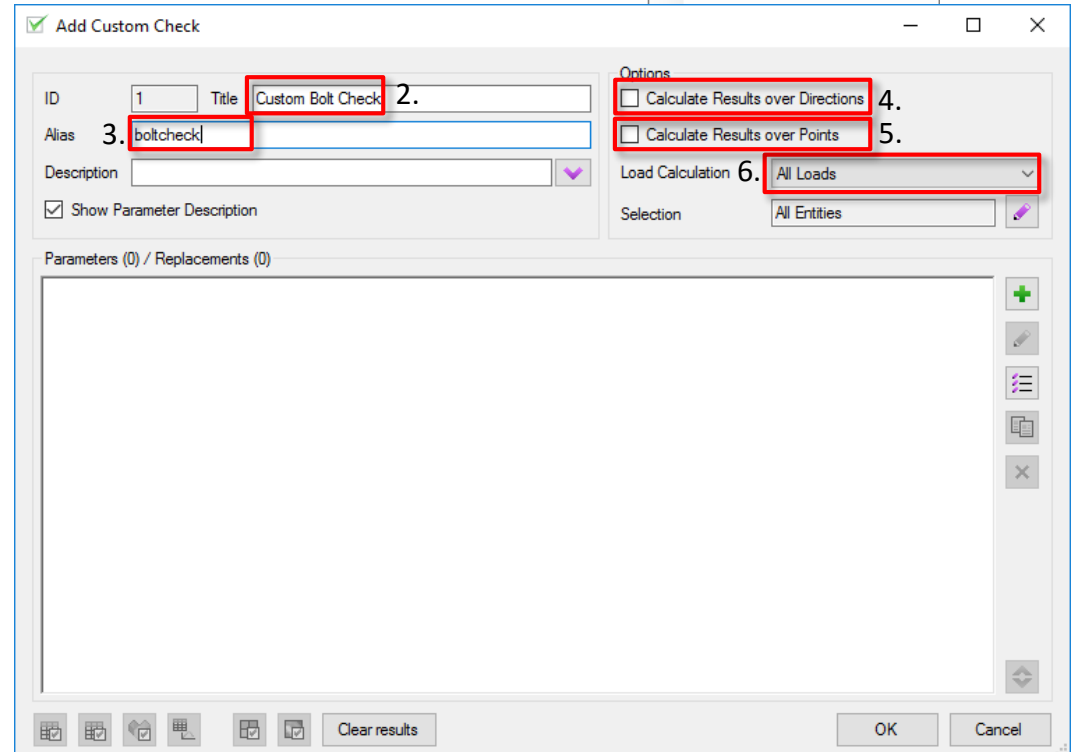
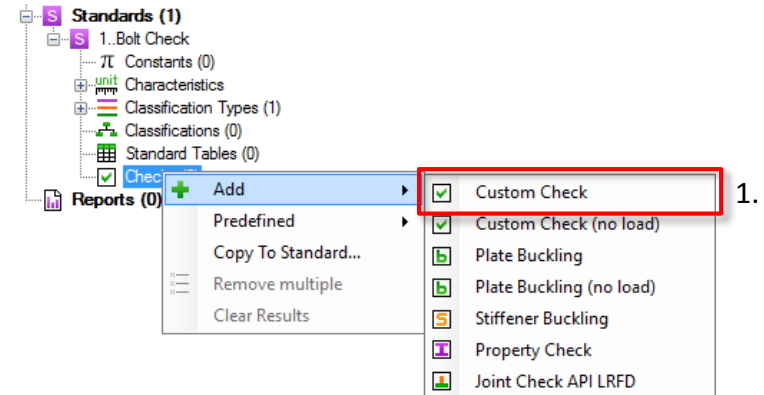
4 Calculate Results over Directions: **OFF**

5 Calculate Results over Points: **OFF**

6 Load Calculation: **All Loads**

Check Alias gives a possibility to use this check results by other checks.

All Loads: Individual Loads and Load Sets are calculated based on formulas and Load Group as envelope.  
Load Group Only: Check is calculated on Load Groups Results (e.g. Min/Max/Delta Stresses)





Allowable Axial Stress for Circular Tubes (ISO 19902 standard) requires calculation only in X direction.  
Calculate Results over Directions: **OFF**

Options

☐ Calculate Results over Directions

☐ Calculate Results over Points

Load Calculation All Loads

Selection All Entities

Allowable Static Stress for plates/solids (F.E.M 1.001 standard) requires to check normal (x,y,z) and shear (xy, yz, zx) stresses.  
Calculate Results over Directions: **ON**

☒ Add Parameter

Title <input type="text" value="Allowable Axial Stress"/>	Limits <input type="checkbox"/> Highlight <input type="checkbox"/> Absolute Value Value <input type="text"/> Category <input type="text" value="Stress"/>	Main Functions $\sqrt{x}$ $x^y$ Min    Max AbsMax    IF Average    Switch	Items $\pi$ $\pi$ $\frac{d}{dx}$ L I    unit $\frac{m}{s}$ 
--	---	---	---

All Directions

```
if(Saxial > 0, Yield, IsoLimits.Fc)
```

☒ Add Parameter

☒ Add Parameter

Title: Allowable Static Stress Alias: Sallow Description: <input type="checkbox"/> Replacement (without results)	<b>Limits</b> <input type="checkbox"/> Highlight <input type="checkbox"/> Absolute Value Value: Category: UtilizationFactor	<b>Main Functions</b> $\sqrt{x}$ , $x^y$ , Min, Max, AbsMax, IF, Average, Switch	<b>Items</b> $F_0$ , $\pi$ , $\pi$ , $G_c$ , $G_{cr}$ , L, I, unit, $\checkmark$
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All Directions:

- X:  $\min(\text{yield}, 0.7 * \text{tensile}) / L\text{GroupSafetyFactor}$
- Y:  $\min(\text{yield}, 0.7 * \text{tensile}) / L\text{GroupSafetyFactor}$
- Z:  $\min(\text{yield}, 0.7 * \text{tensile}) / L\text{GroupSafetyFactor}$
- ☒ XY:  $\min(\text{yield}, 0.7 * \text{tensile}) / \sqrt{3} / L\text{GroupSafetyFactor}$
- ☒ YZ:  $\min(\text{yield}, 0.7 * \text{tensile}) / \sqrt{3} / L\text{GroupSafetyFactor}$
- ☒ ZX:  $\min(\text{yield}, 0.7 * \text{tensile}) / \sqrt{3} / L\text{GroupSafetyFactor}$
- ☐ Equivalent
- ☐ Overall

Absolute Maximum: Set to Overall

OK Cancel

# Calculate Results over Points

Slenderness - single result per element.  
Calculate over Points: **OFF**

Options

☐ Calculate Results over Directions

☐ Calculate Results over Points

Load Calculation: All Loads

Selection: All Entities

Stresses for plate elements should be checked  
for every single point of interest.  
Calculate over Points: **ON**

Parameter =  $\lambda_z$  (Slenderness Z)

Description: (13.2-7)

All:  $\text{memberZ.K} * \text{memberZ.L} / (\text{PI} * \sqrt{\text{Iyy} / \text{Area}}) * \sqrt{\text{Fyc} / \text{Young}}$

## Slenderness Z (4 Elements)

Standard	1..ISO 19902 (1st, Dec 2007)	Check	2..Limits
Parameter	Slenderness Z	Selection	4 Elements
Element ID	Slenderness Z		
1941	0.190		
1943	0.190		
1945	0.220		
1946	0.220		

Parameter =  $U_f$  (Utilization Factor)

All:  $\text{Abs}(S / S_{allow})$

Overall:  $\text{Max}(m_e.x, m_e.y, m_e.z, m_e.xy, m_e.yz, m_e.zx, m_e.eqv)$

## X (LS4, 1 element(s))

Standard	1..ISO 19902 (1st, Dec 2007)	Check	9..Static Stress Check
Load Set	4..Load Set 4	Selection	1 element(s)
Element ID / Point	Stress	Allowable Stress	Utilization Factor
1945			
1 I / Top	-9.24e+6	168.00e+6	-0.06
2 I / Top	17.60e+6	168.00e+6	0.10
3 I / Top	44.45e+6	168.00e+6	0.26
4 I / Top	17.61e+6	168.00e+6	0.10
1 J / Bottom	14.52e+6	168.00e+6	0.09
2 J / Bottom	17.60e+6	168.00e+6	0.10
3 J / Bottom	20.69e+6	168.00e+6	0.12
4 J / Bottom	17.61e+6	168.00e+6	0.10
End I / Top	44.45e+6	168.00e+6	0.26
End J / Bottom	44.45e+6	168.00e+6	0.26
Total	44.45e+6	168.00e+6	0.26

# Change Check Selection

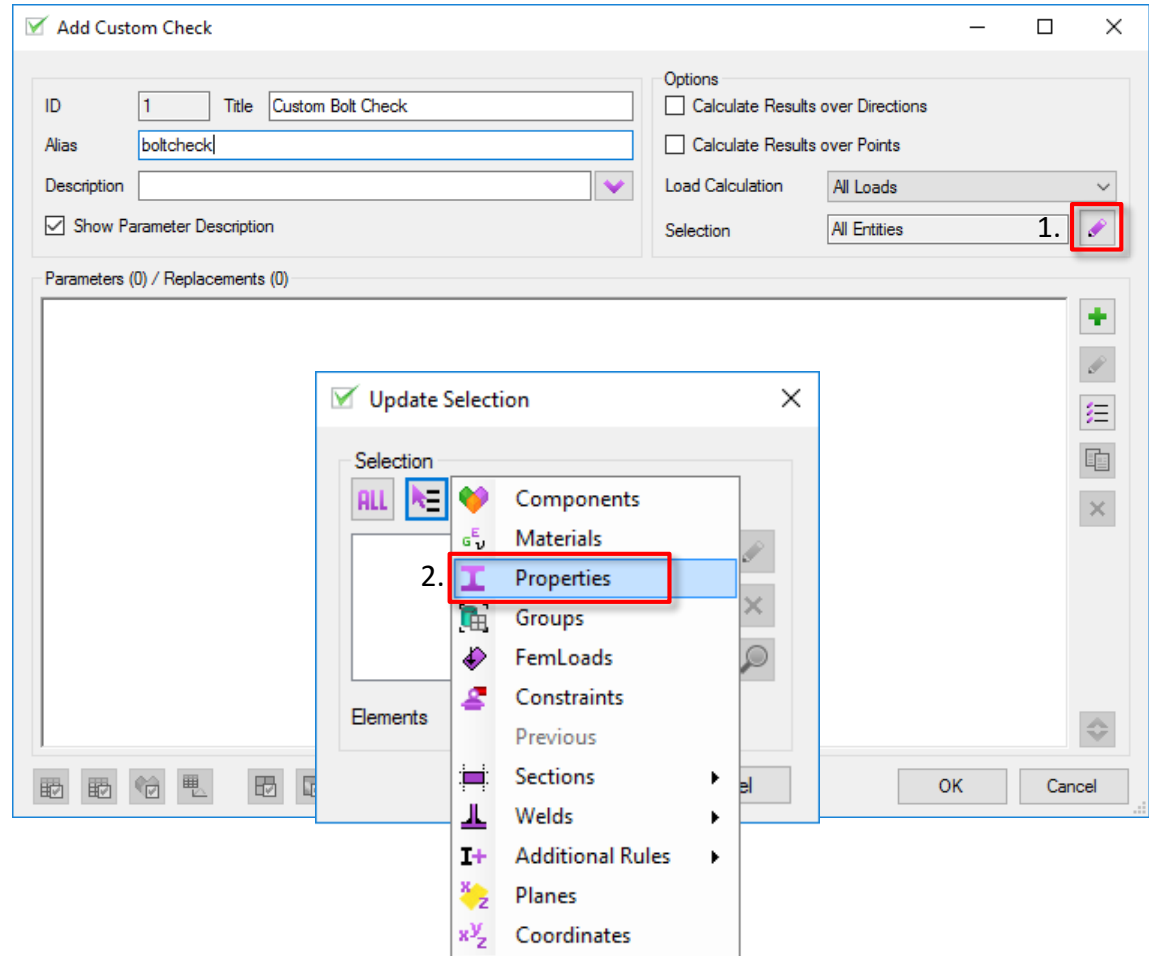
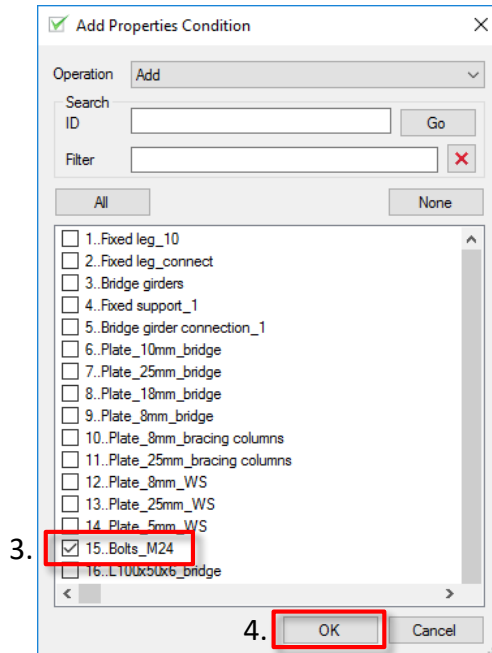
1 Press to edit selection

2 Press Properties

3 Select: 15..Bolts\_M24

4 Press OK 2 times

5 Press  to add parameter



By limiting check selection to elements of bolt property we reduce significantly the calculation time. (Full model is 28 183 elements, bolts – 154).

# Add Parameter

- 1 Title: **Allowable shear**
- 2 Alias: **F\_shear\_a**
- 3 Description: **Allowable shear force**

*Main functions* area contains quick access buttons with most used functions: Minimum, Maximum, Average, Absolute, IF, etc.

*Items* area contains quick access buttons for all the items and parameters available in formulas: Inner constants, Result variables, Characteristics, Parameters, Functions, Properties, etc.

✓ Add Parameter

Title: Allowable shear 1.

Alias: F\_shear\_a 2.

Description: Allowable shear force 3.

☐ Replacement (without results)

Limits

☐ Highlight

☐ Absolute Value

Value

Category: General

Main Functions

Items

All Directions

OK Cancel

*Replacement* – parameters for which outcome is not stored. It is not possible to plot their results or to display in table. Their purpose is to be used in other parameters of current check. Using replacement check consumes less memory and improve performance.

# Enter Formula

1 Press **Min** and put cursor: **Min(,)**

2 Press **unit** to add characteristic

3 Select: **Bolt Prestress** and press **OK**

4 Copy **F\_Prestress** and paste it after comma in **Min( F\_Prestress, ,)**, enter “-”

5 Press **AbsMax**, put cursor: **AbsMax(,)**

6 Select **Line Element Force, Axial force, Top**. Press **OK**.

7 Enter “**FAxial[Bot]**” in **AbsMax(, )**

8 Enter “**\* mu**” in the end

**Note:** All the formulas can be entered manually. If alias is highlighted with color it is written correctly. In case you don't remember alias refer to Items group box, it contain all available variables and functions

**Add Parameter**

Title: Allowable shear  
Alias: F\_shear\_a  
Description: Allowable shear force  
☐ Replacement (without results)

Limits  
☐ Highlight  
☐ Absolute Value  
Value: 1.  
Category: General

Main Functions  
Min, Max, AbsMax, IF, Average, Switch

Items  
F\_Prestress, unit, [grid icon]

All Directions  
Min( F\_Prestress, F\_Prestress - AbsMax( FAxial[Top], FAxial[Bot])) \* mu

OK Cancel

List of all characteristics

**Characteristics**

ID	Title	AliasName	Description
1	Bolt Prestress	F_Prestress	
2	Friction Coefficient	mu	

OK Cancel

All variables to access results are available in this dialog.

**Add Result**

Result Category  
Stress, Strain, Line Element Force, Plane Element Force

Group Parameter  
Min, Max, Abs

Directions  
Bending Plane Moment 1 (x), Bending Plane Moment 2 (y), Shear Plane 1 (x), Shear Plane 2 (y), Axial Force, Torque, Warping Torque

Points Of Interest  
End I / Top, End J / Bottom

Variable  
FAxial[Top]

OK Cancel

# Parameter Category

1 Category: **Forces**

2 Press **OK**

Parameter Category determines the displaying format in tables and legend settings for plots.

✓ Add Parameter

Title: Allowable shear  
Alias: F\_shear\_a  
Description: Allowable shear force  
☐ Replacement (without results)

Limits  
☐ Highlight  
☐ Absolute Value  
Value:   
Category 1. **Forces**

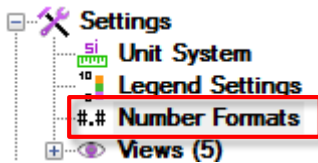
Main Functions  
√x, x<sup>y</sup>, Min, Max, AbsMax, IF, Average, Switch

Items  
F<sub>0</sub>, π, π<sub>0</sub>,  $\frac{1}{x}$ ,  $\frac{1}{x^2}$ ,  $\frac{1}{x^3}$ , unit,  $\frac{1}{m^2}$ ,  $\frac{1}{m^3}$

All Directions  
`Min( F_Prestress, F_Prestress - AbsMax( Faxial[Top], Faxial[Bot])) * mu`

2. **OK** Cancel

Number Format Settings are available under Settings on Main window. It also can be accessed from any table by pressing **##**



Utilization Factor	General	2				160000000.00
Buckling Factor	General	2				160000000.00
Forces	Scientific	1	1	<input checked="" type="checkbox"/>	3	160000.0e+3

## All (LG1, All Entities)

Standard	1..Bolt Check		Check	1..Custom Bolt Check	
Load Group	1..Overall		Direction	All	
Selection	All Entities				
Components	Allowable shear	Shear force	Bolt shear force check	Axial bolt force check	Overall bolt check
All Entities	48.0e+3	34.2e+3	1.15	0.79	1.15

# Shear force parameter

1 Press  to add parameter

2 Title: **Shear force**

3 Alias: **F\_shear**

4 Formula:  $\text{Sqrt}(\text{Pow}(\text{FShear1}[\text{Top}], 2) + \text{Pow}(\text{FShear2}[\text{Top}], 2))$

5 Category: **Forces**

6 Press OK

$\text{FShear1}[\text{Top}]$  and  $\text{FShear2}[\text{Top}]$  can be found in *Add results dialog* 

☒ Add Result

Result Category

- Stress
- Strain
- Line Element Force
- Plane Element Force

Directions

- Bending Plane Moment 1 (xy)
- Bending Plane Moment 2 (xz)
- Shear Plane 1 (xy)
- Shear Plane 2 (xz)
- Axial Force
- Torque
- Warping Torque

Points Of Interest

- All
- End I / Top
- End J / Bottom

Group Parameter

- Min
- Max
- Abs

Variable


$\text{FShear1}[\text{Top}]$

OK Cancel

☒ Add Parameter

Title 2. **Shear force**

Alias 3. **F\_shear**

Description 

☐ Replacement (without results)

Limits

☐ Highlight

☐ Absolute Value



Value

Category 5. **Forces**

Main Functions

- $\sqrt{x}$
- $x^y$
- Min
- Max
- AbsMax
- IF
- Average
- Switch

Items

- $F(x)$
- $\pi$
- $\pi e$
- $\frac{d}{dx}$
- $\frac{d^2}{dx^2}$
- $\frac{d^3}{dx^3}$
- unit
- 
- 

All Directions

4.  $\text{Sqrt}(\text{Pow}(\text{FShear1}[\text{Top}], 2) + \text{Pow}(\text{FShear2}[\text{Top}], 2))$

5. **OK** Cancel

# Shear Force Utilization Factor

1 Press  to add parameter

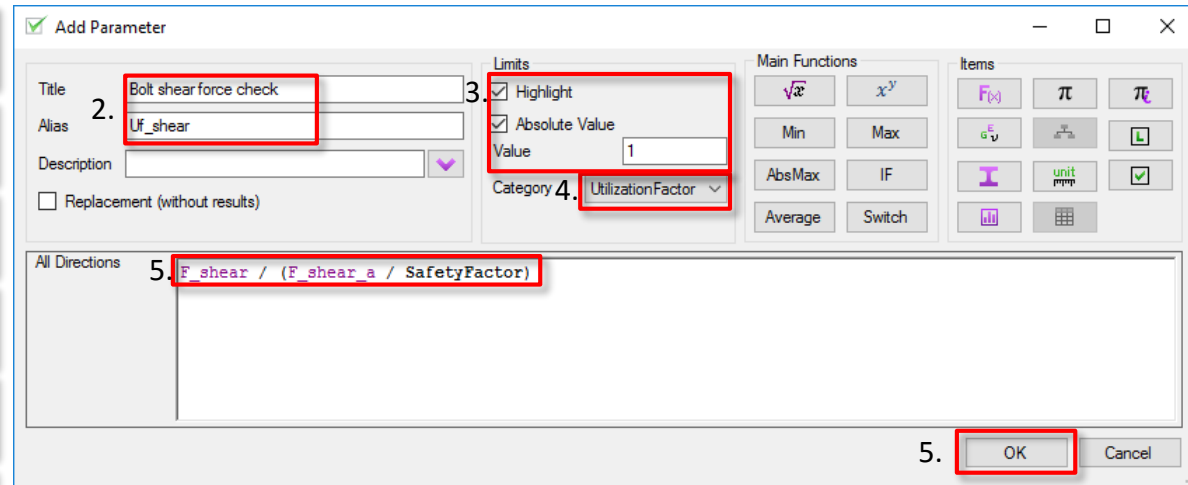
2 Title: **Bolt shear force check**  
Alias: **Uf\_shear**


3 Highlight: **ON**, Absolute value: **ON**,  
Value: **1**

4 Category: **Utilization Factor**

5 Formula:  $F_{shear} / (F_{shear\_a} / \text{SafetyFactor})$

6 Press **OK**



 List of constants

 List of local parameters (e.g.  $F_{shear}$ )

Limits highlights background of the cell in table. If Result is above value – red, below – green. If Absolute Value option is ON it means that also negative values higher than the limit Value will be highlighted with red (e.g. -1.1)

Local Parameters

ID	Title	AliasName	Description
1	Allowable shear	F_shear_a	Allowable shear force
2	Shear force	F_shear	

OK Cancel

## All (LG1, All Entities)

Standard	1..Bolt Check		Check	1..Custom Bolt Check	
Load Group	1..Overall		Direction	All	
Selection	All Entities				
Components	Allowable shear	Shear force	Bolt shear force check	Axial bolt force check	Overall bolt check
All Entities	48.0e+3	34.2e+3	1.15	0.79	1.15



# Axial Force Utilization Factor

1 Press  to add parameter

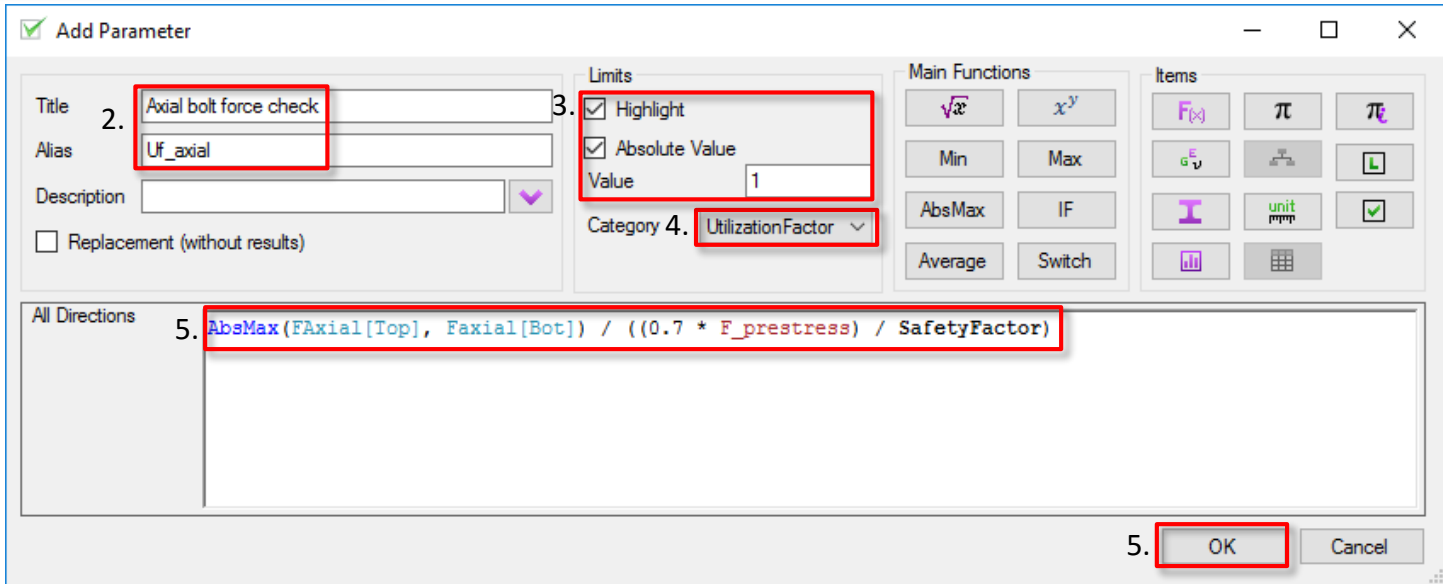
2 Title: **Axial bolt force check**  
Alias: **Uf\_axial**

3 Highlight: **ON**, Absolute value: **ON**,  
Value: **1**

4 Category: **Utilization Factor**

5 Formula: **AbsMax**(FAxial[Top], FAxial[Bot])  
/ ((0.7 \* F\_prestress) / **SafetyFactor**)

6 Press **OK**



☒ Add Parameter

Title 2. Axial bolt force check 3.

Alias Uf\_axial

Description

☐ Replacement (without results)

Limits

☒ Highlight

☒ Absolute Value

Value 1

Category 4. UtilizationFactor

Main Functions

Items

All Directions 5. AbsMax(FAxial[Top], FAxial[Bot]) / ((0.7 \* F\_prestress) / SafetyFactor)

5. OK Cancel

# Overall Bolt Check

1 Press  to add parameter

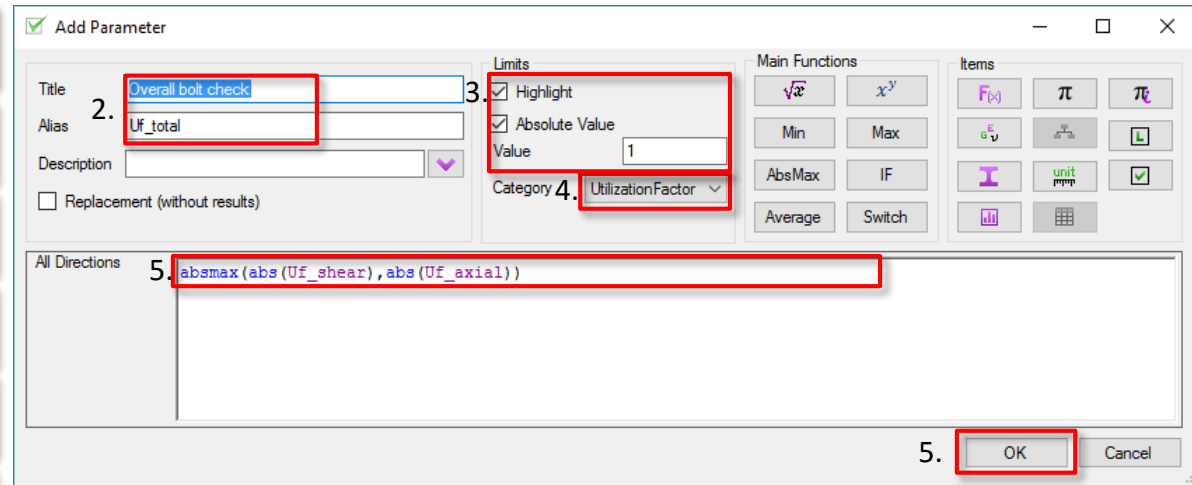
2 Title: **Overall bolt check**  
Alias: **Uf\_total**

3 Highlight: **ON**, Absolute value: **ON**,  
Value: **1**

4 Category: **Utilization Factor**

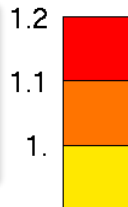
5 Formula: **Absmax(Abs(Uf\_shear),  
Abs(Uf\_axial))**

6 Press **OK**



Overall Bolt Check contains results from both axial and shear checks. It gives a possibility to verify the results using one plot.

Abs value of Shear and Axial check is used to make the values positive. In this case negative and positive values will have same color on plot.



Parameter = F\_shear\_a (Allowable shear)

Description: Allowable shear force

All:  $\text{Min}(\text{F\_Prestress}, \text{F\_Prestress} - \text{AbsMax}(\text{Faxial}[\text{Top}], \text{Faxial}[\text{Bot}])) * \mu$

Parameter = F\_shear (Shear force)

All:  $\text{Sqrt}(\text{Pow}(\text{FShear1}[\text{Top}], 2) + \text{Pow}(\text{FShear2}[\text{Top}], 2))$

Parameter = Uf\_shear (Bolt shear force check)

All:  $\text{F\_shear} / (\text{F\_shear\_a} / \text{SafetyFactor})$

Parameter = Uf\_axial (Axial bolt force check)

All:  $\text{AbsMax}(\text{Faxial}[\text{Top}], \text{Faxial}[\text{Bot}]) / ((0.7 * \text{F\_prestress}) / \text{SafetyFactor})$

Parameter = Uf\_total (Overall bolt check)


All:  $\text{absmax}(\text{abs}(\text{Uf\_shear}), \text{abs}(\text{Uf\_axial}))$

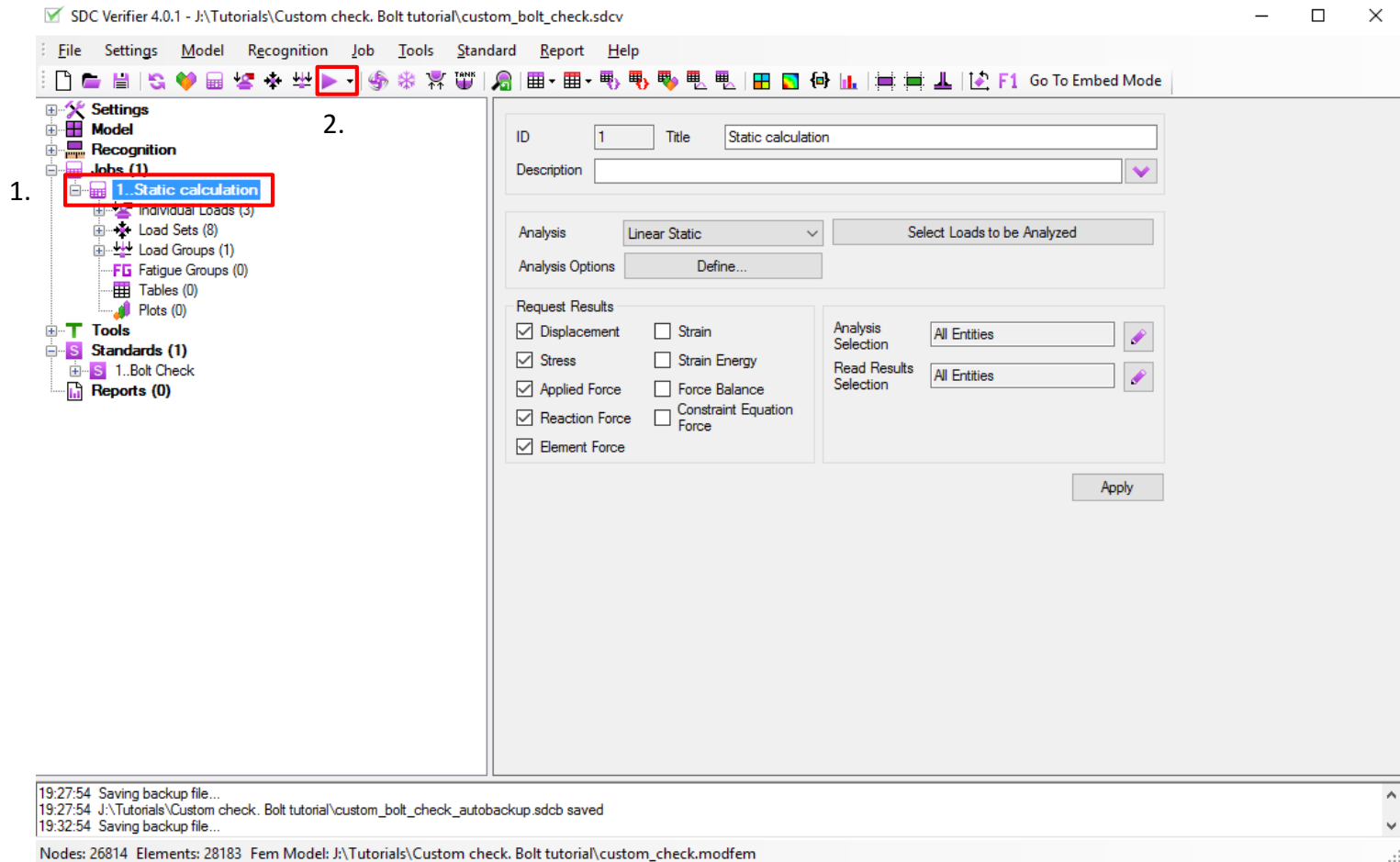
# Analyze Job

1

Select Job “**Static Calculation**” in the *Model Tree*

2

Press  on toolbar to analyze the job



# Results Table

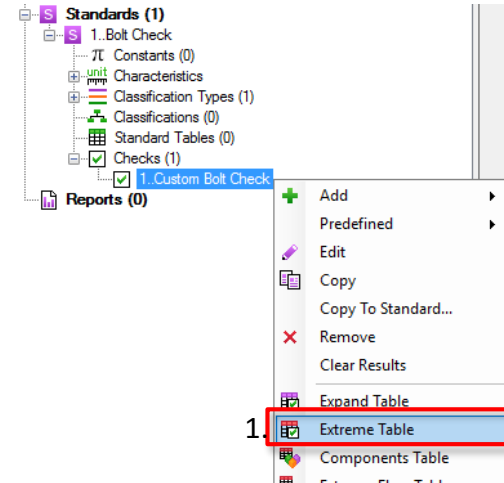
1 Execute *Extreme* table in *Custom Bolt Check* context menu

2 Load Group: **1..Overall**

3 Table type: **Direction over Parameters**

4 Selection: **Property 15.. Bolts**

5 Press *Fill Table*



**Extreme Table**

ID: 4 Title:

Description:

Options

Check: 1..Custom Bolt Check

Load Group: 2. 1..Overall

Table Type: 3. Direction over Parameters

Direction: All

Selection

ALL + Property 15.. Bolts\_M24

Elements: 154

5. Fill Table

Extreme	Allowable shear	Shear force	Bolt shear force check	Axial bolt force check	Overall bolt check
Minimum					
Value	21.5e+3	0.1e+3	0.00	-0.87	0.01
Element ID	86503	79922	79922	86503	79932
Load	LS4	LS5	LS5	LS5	LS5
Maximum					
Value	48.0e+3	34.2e+3	1.15	0.87	1.15
Element ID	79508	86567	86543	86503	86543
Load	LS8	LS5	LS4	LS4	LS4
Absolute					
Value	48.0e+3	34.2e+3	1.15	0.87	1.15
Element ID	79508	86567	86543	86503	86543
Load	LS8	LS5	LS4	LS4	LS4

# Results Plot

1 Execute *Criteria plot* in *Custom Bolt Check* context menu

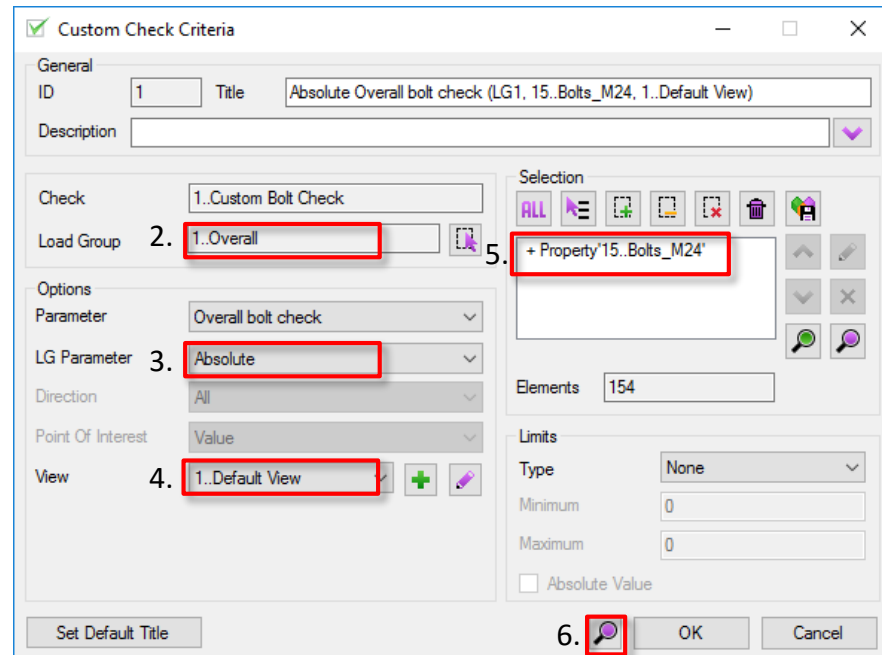
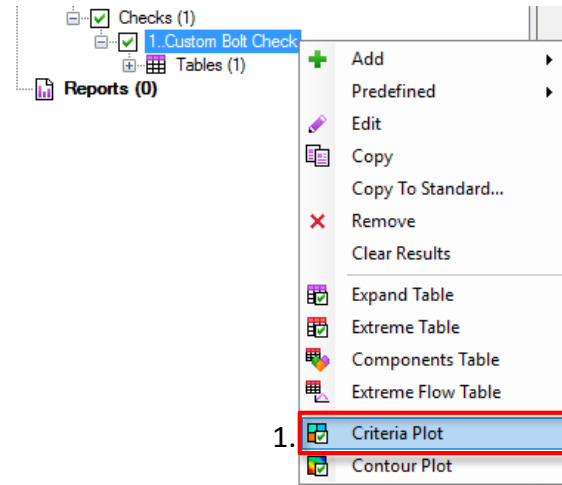
2 Load Group: **1..Overall**

3 LG Parameter: **Absolute**

4 View: **1..Default View**

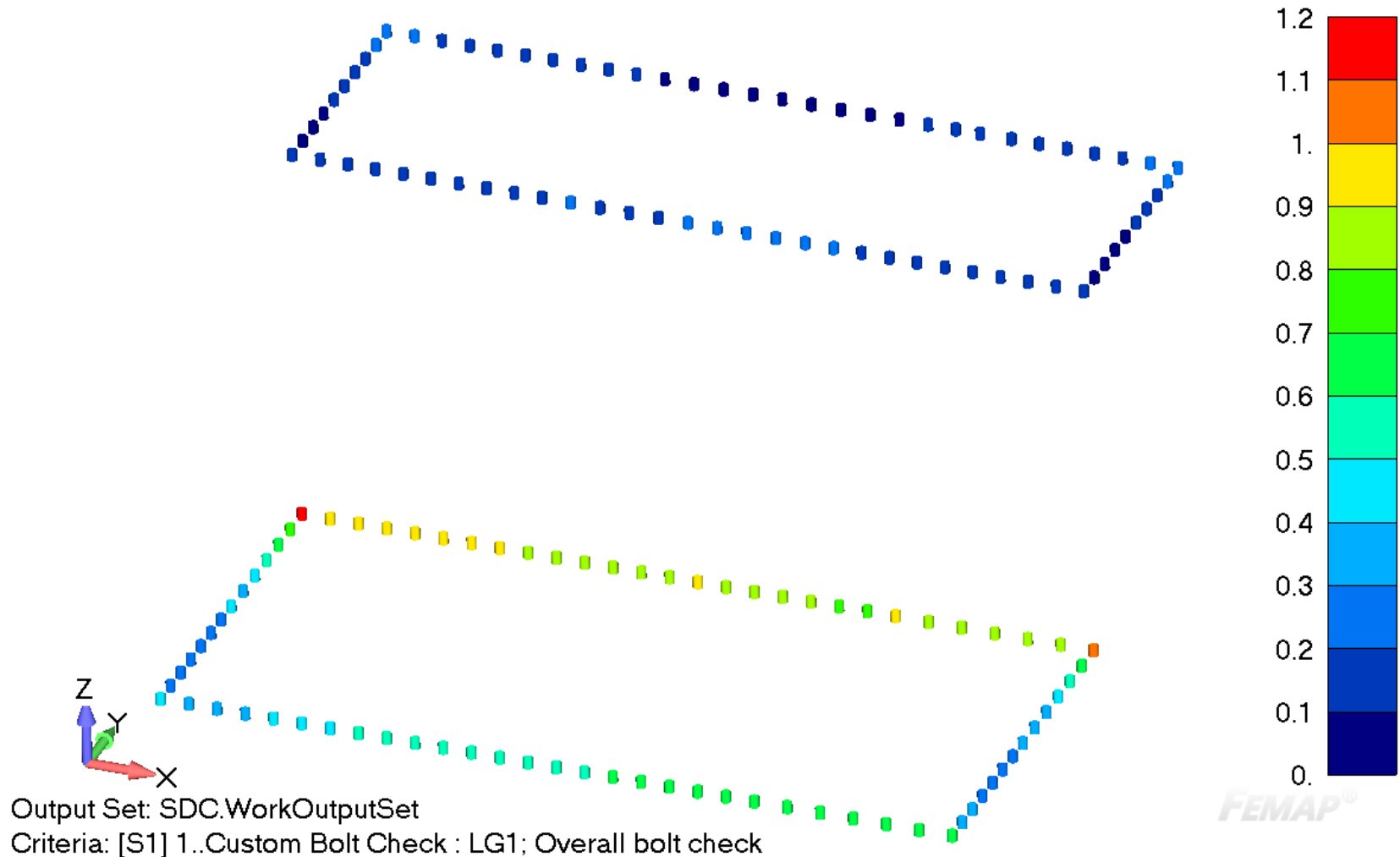
5 Selection: **Property 15.. Bolts**

6 Press 



# Results Plot

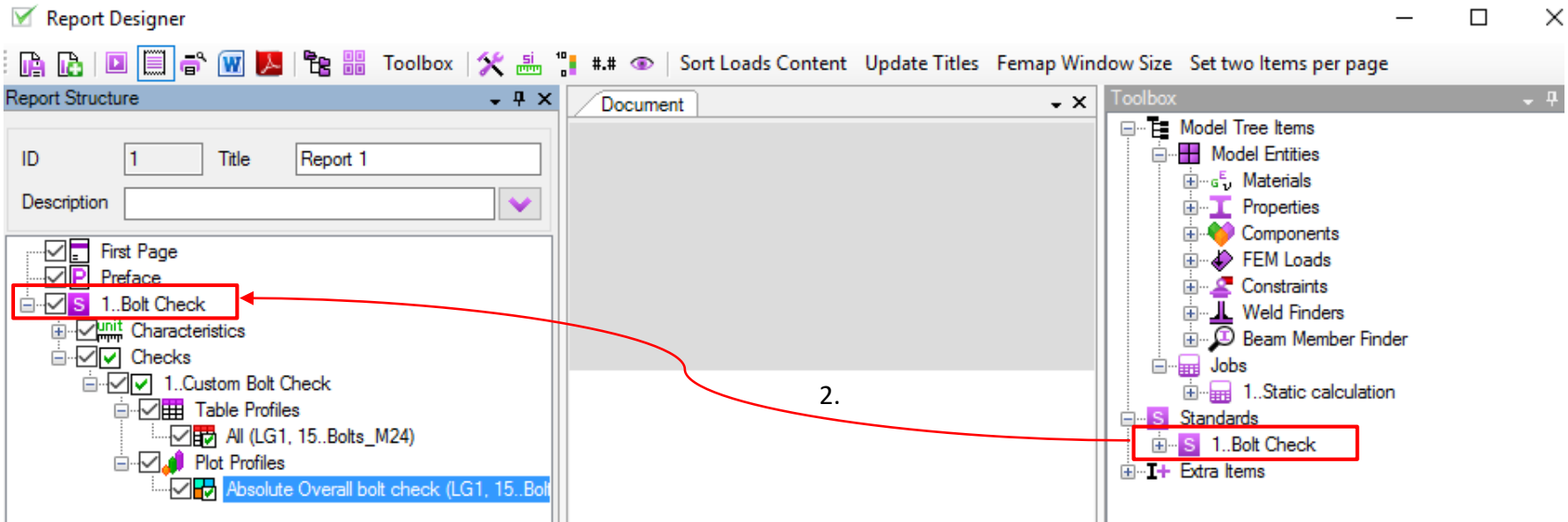
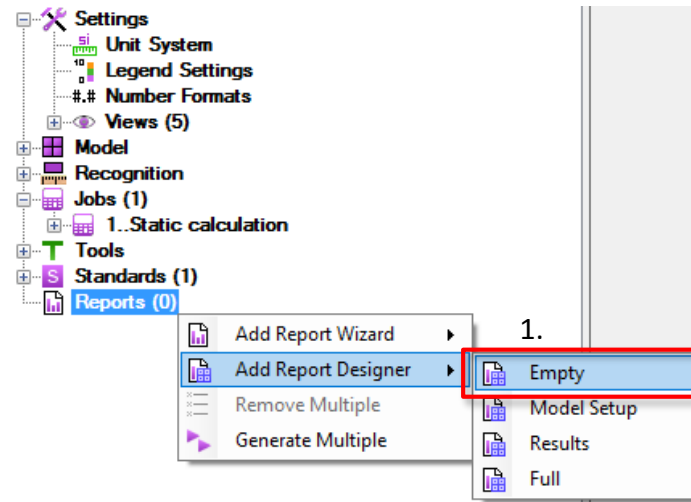
Overall bolt check plot is displayed. Elements with value more than 1 (orange and red) are not passing the check



# Creating Report

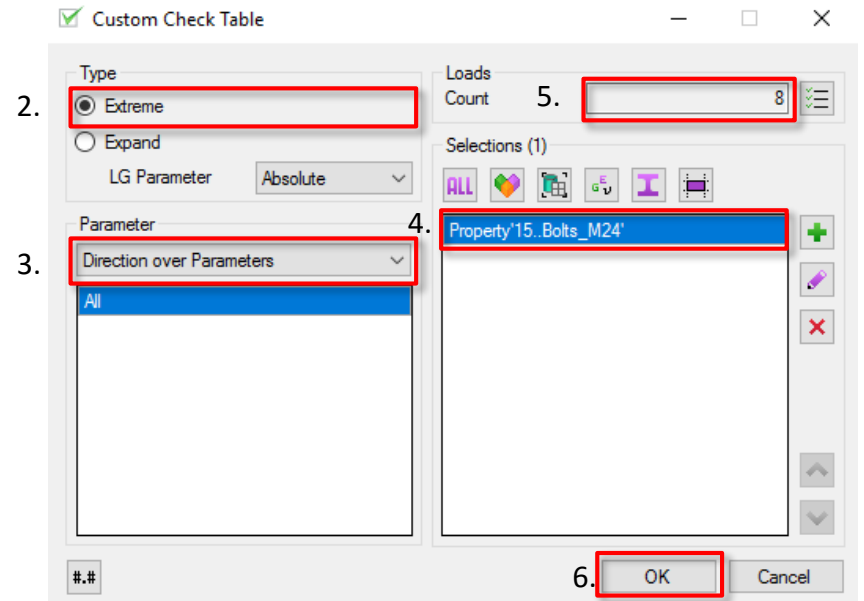
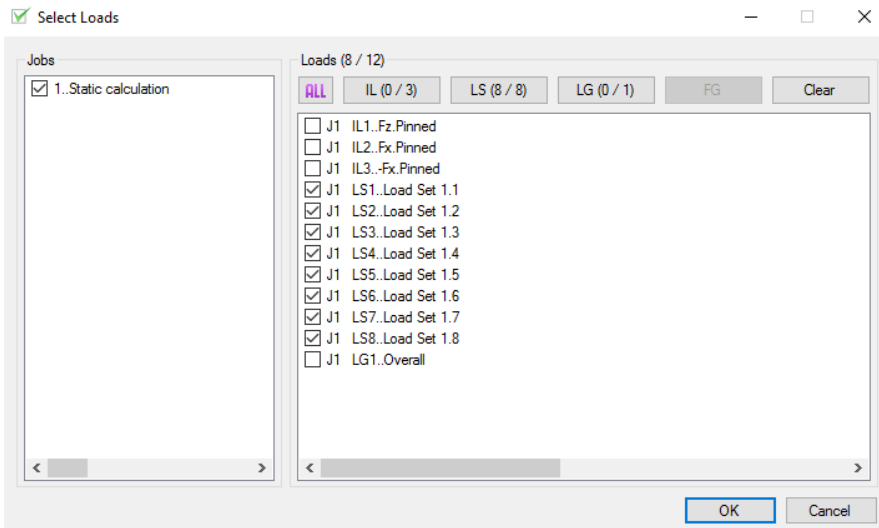
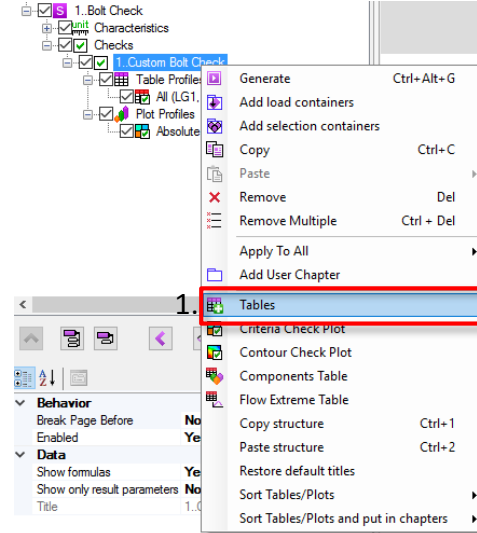
1 Execute *Add report designer* => *Empty* in *Reports* context menu

2 Drag NEN 2018\_2019 Standard from *Toolbox* to the *Report Structure*



# Add Tables in Report

- 1 Execute *Tables* in *Custom Bolt Check* context menu
- 2 Type: **Extreme**
- 3 Parameter: **Direction over Parameters**
- 4 Selection: **Property 15.. Bolts\_M24**
- 5 Loads: **All Load Sets**
- 6 Press *OK*





# Add Plots in Report

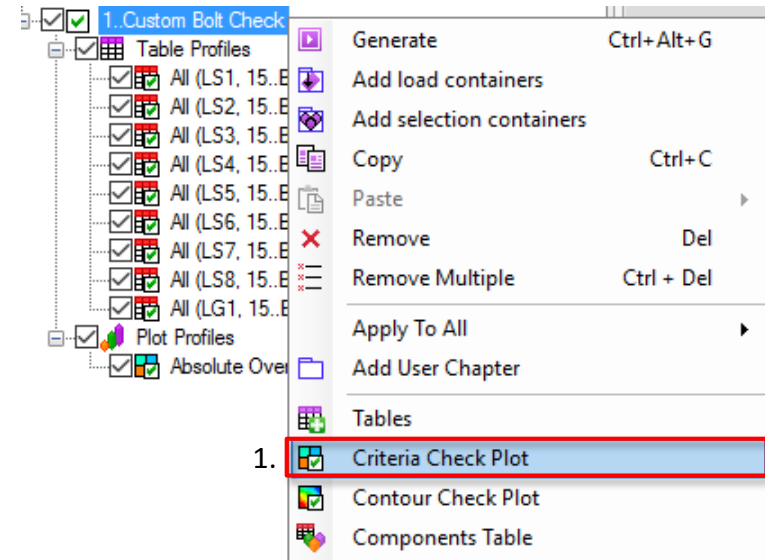
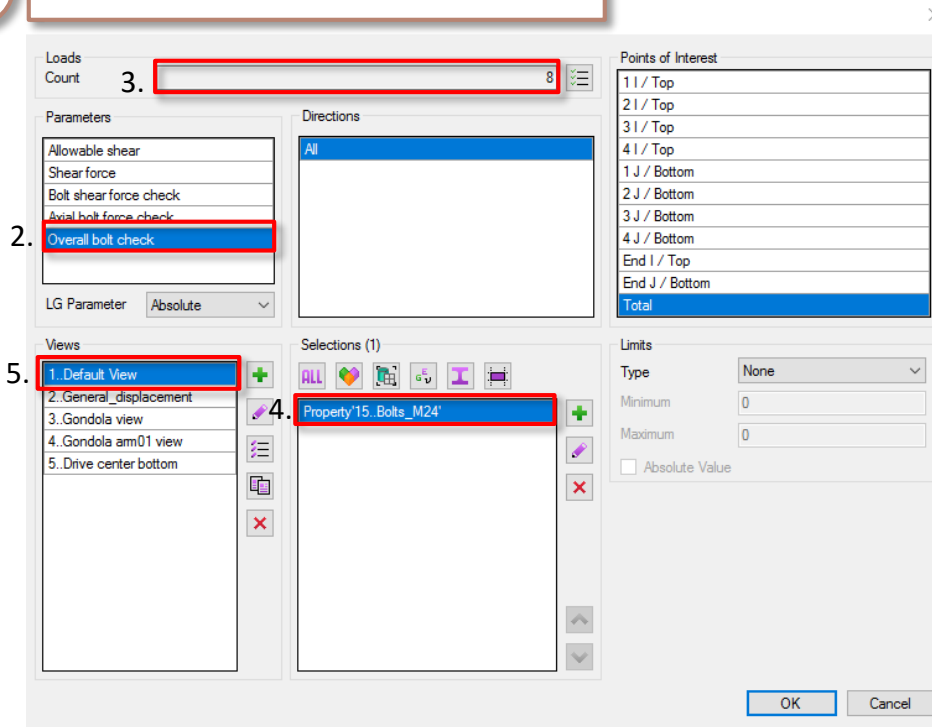
1 Execute *Criteria Check Plot* in *Custom Bolt Check* context menu

2 Parameter: **Overall bolt check**

3 Loads: **All Load Sets**

4 Selection: **Property 15.. Bolts\_M24**

5 View: **Default View.**



Click **Generate** and **Export to Word**

## Report

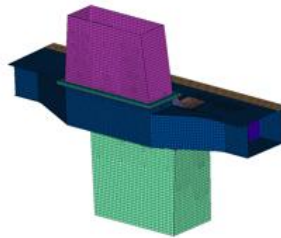
### Bolt Check



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Customer:  
Project Number:  
Version:  
Date:

Support  
1  
12 Dec 2016



Prepared for:

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#### All (LS4, 15..Bolts\_M24)

Standard	1..Bolt Check	Check	1..Custom Bolt Check
Load Set	4..Load Set 1.4	Selection	15..Bolts_M24
Extreme	Allowable shear	Shear force	Bolt shear force check
Minimum			Axial bolt force check
Value	21.5e+3	0.1e+3	0.00
Element ID	86503	79922	86530
Maximum			Overall bolt check
Value	48.0e+3	34.2e+3	1.15
Element ID	79917	86567	86543
Absolute			
Value	48.0e+3	34.2e+3	1.15
Element ID	79917	86567	86543

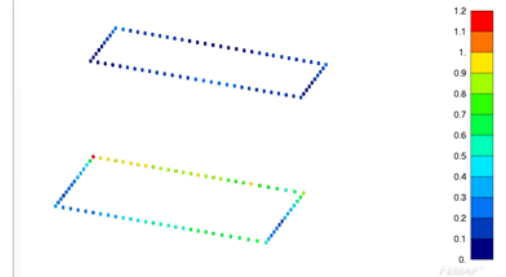
#### All (LS5, 15..Bolts\_M24)

Standard	1..Bolt Check	Check	1..Custom Bolt Check
Load Set	5..Load Set 1.5	Selection	15..Bolts_M24
Extreme	Allowable shear	Shear force	Bolt shear force check
Minimum			Axial bolt force check
Value	37.2e+3	0.1e+3	0.00
Element ID	86530	79922	86503
Maximum			Overall bolt check
Value	48.0e+3	34.2e+3	0.78
Element ID	79508	86567	86503
Absolute			
Value	48.0e+3	34.2e+3	0.78
Element ID	79508	86567	86503

#### All (LS6, 15..Bolts\_M24)

Standard	1..Bolt Check	Check	1..Custom Bolt Check
Load Set	6..Load Set 1.6	Selection	15..Bolts_M24
Extreme	Allowable shear	Shear force	Bolt shear force check
Minimum			Axial bolt force check
Value	23.2e+3	0.2e+3	0.00
Element ID	86543	79522	86490
Maximum			Overall bolt check
Value	48.0e+3	31.8e+3	1.01
Element ID	86490	86548	86503
Absolute			
Value	48.0e+3	31.8e+3	1.01
Element ID	86490	86548	86503

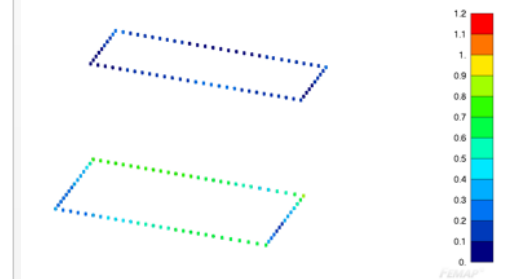
#### 15..Bolts\_M24, 1..Default View)



k: LS4 Overall bolt check

1 Bolt Check  
xlt check  
View

#### 15..Bolts\_M24, 1..Default View)



k: LS5 Overall bolt check

1 Bolt Check  
xlt check  
View

Prepared by  
SDC Verifier

