SDC VERIFIER

Tutorial

API ISO Norsok

|	
Updated on:	18 Apr 2023
Tested with:	SDC Verifier 2023 R1
	Ansys version 2022

- In this tutorial, API 2A RP/ISO 19902/Norsok N004 Beam Design Checks are reviewed.

- A beam model of a steel frame has been used as a start FEM model.

- Beam member finder was used to recognize beam member length in 3 directions.

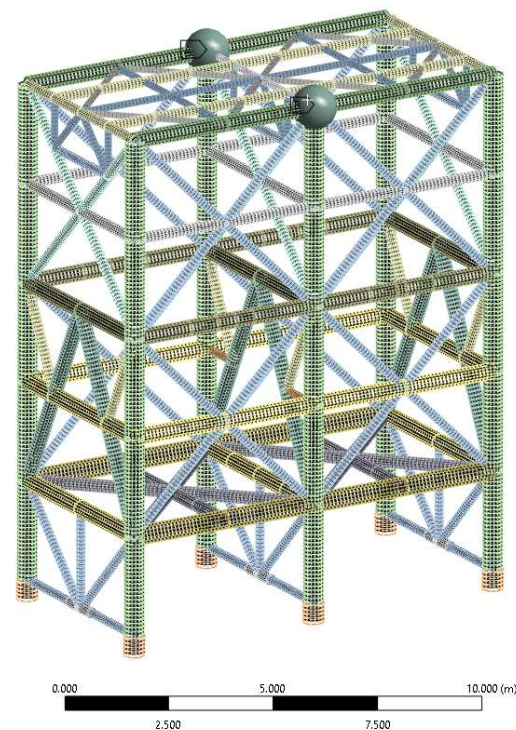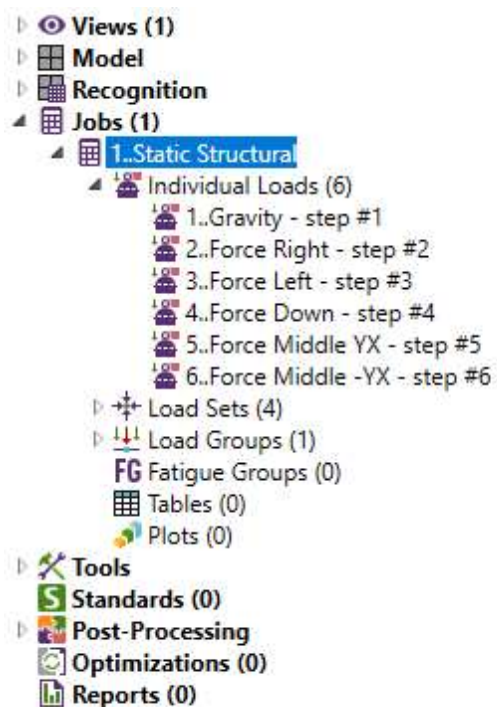- The report was generated with the help of report designer.

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1 Open in Ansys **Workbench**
AISC360 and Eurocode3.wbpj

2 Click on 2 Model
or in context menu click **Edit**
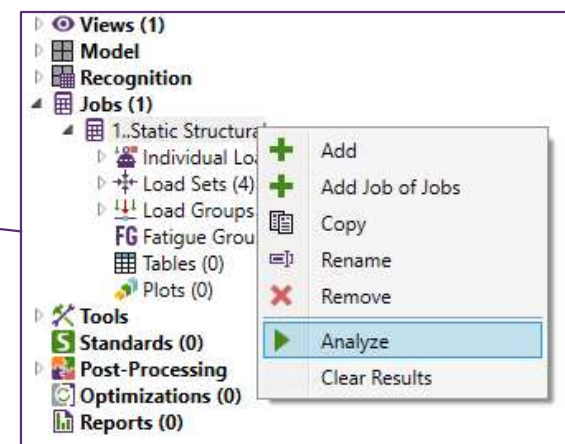
1

2
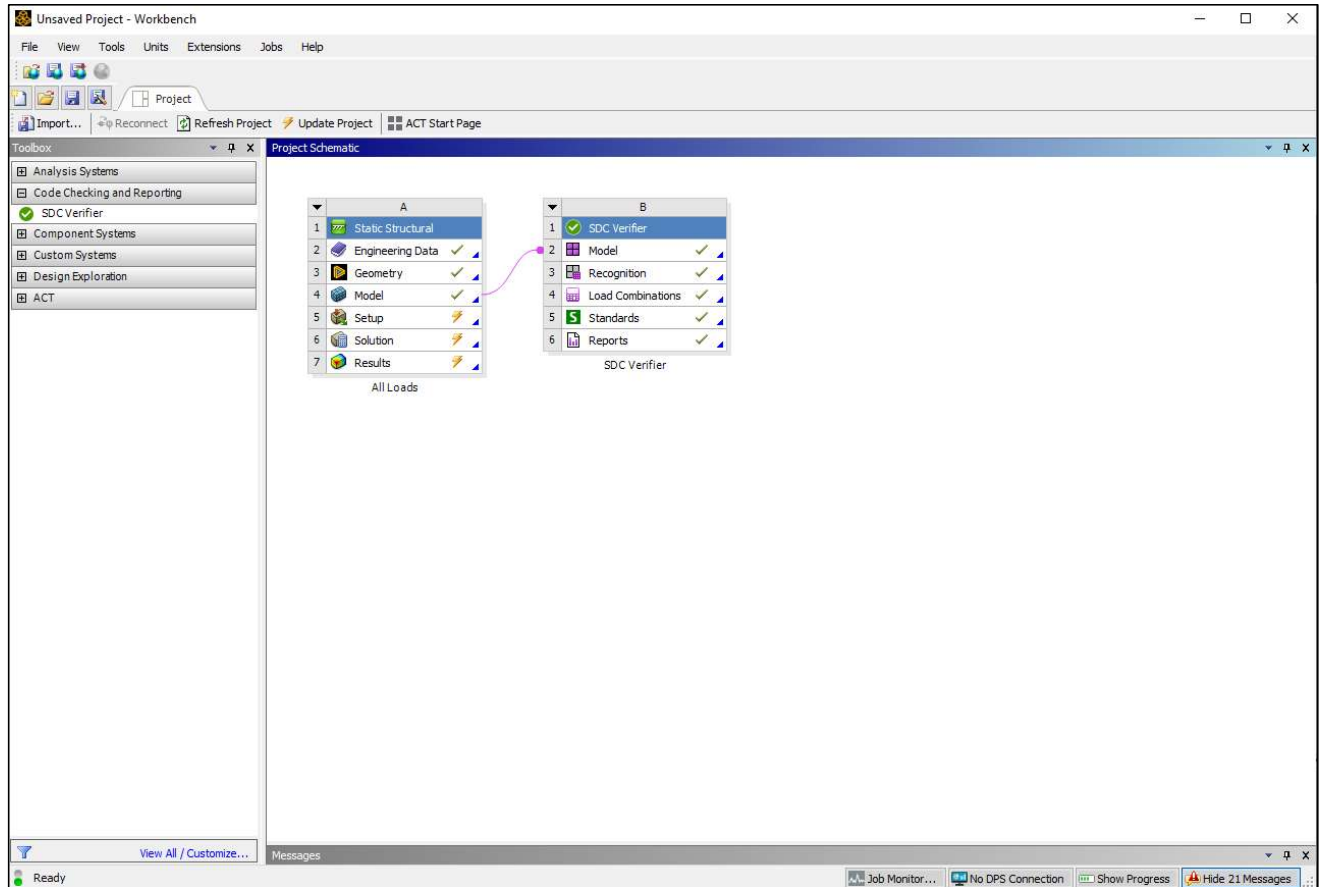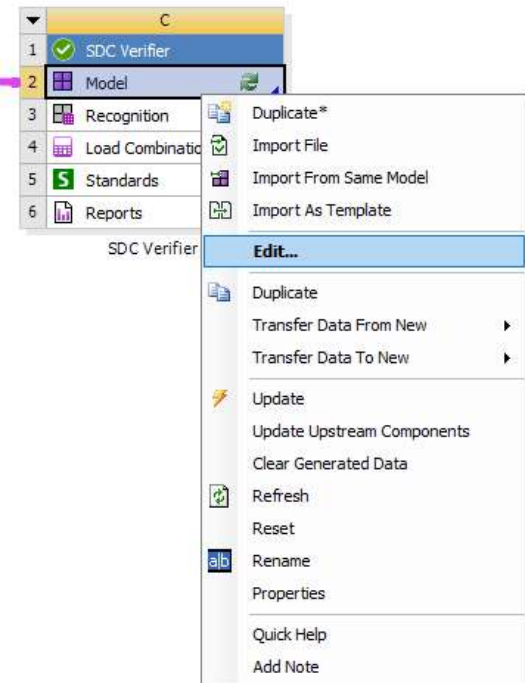
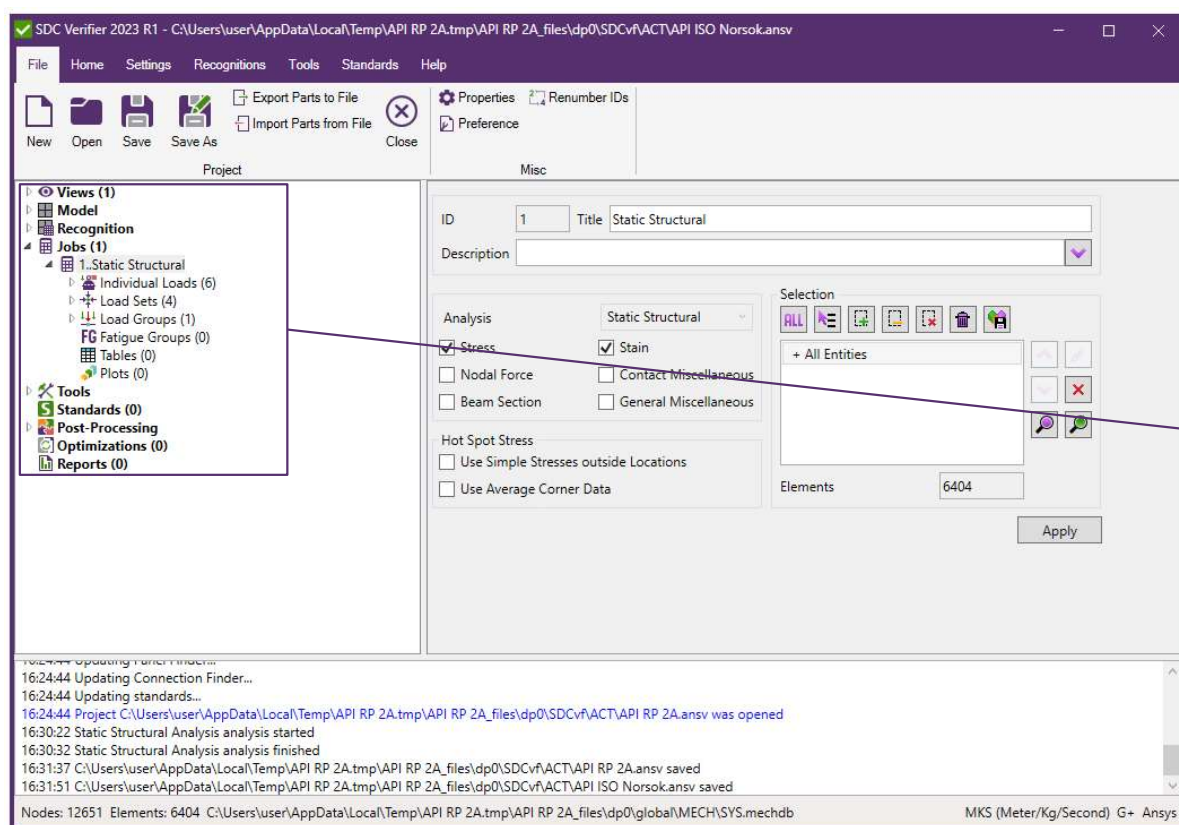This tutorial uses project with predefined boundary condition, load combinations and load group. The model contains only circular tubes elements.

1 Press [Analyze] and select Analyze active job: *1..Static Structural*

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Joint – location where different beam members connect. They are used to recognize beam member
length by Beam Member Finder Tool.

There are 6 types of Joints:
1D Joint – 2 beam members that lie on the curve but with different properties;
2D Joint – beam members connected in one plane;
3D Joint – beam members connected in space;

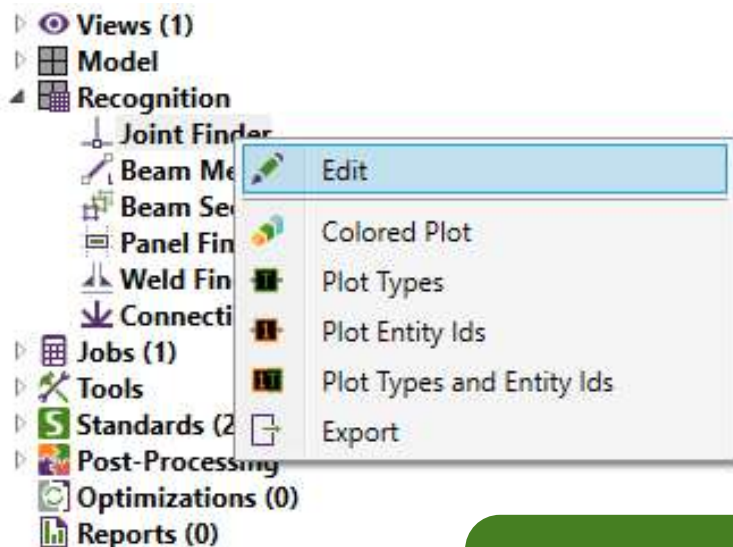Free Joint – node which belongs only to one element (free);
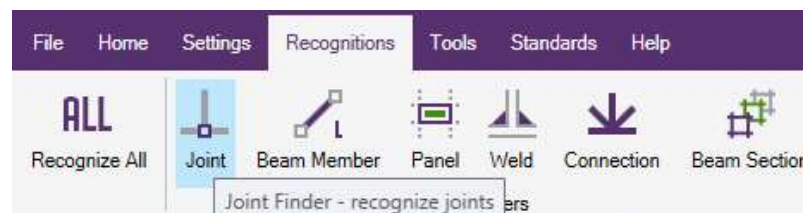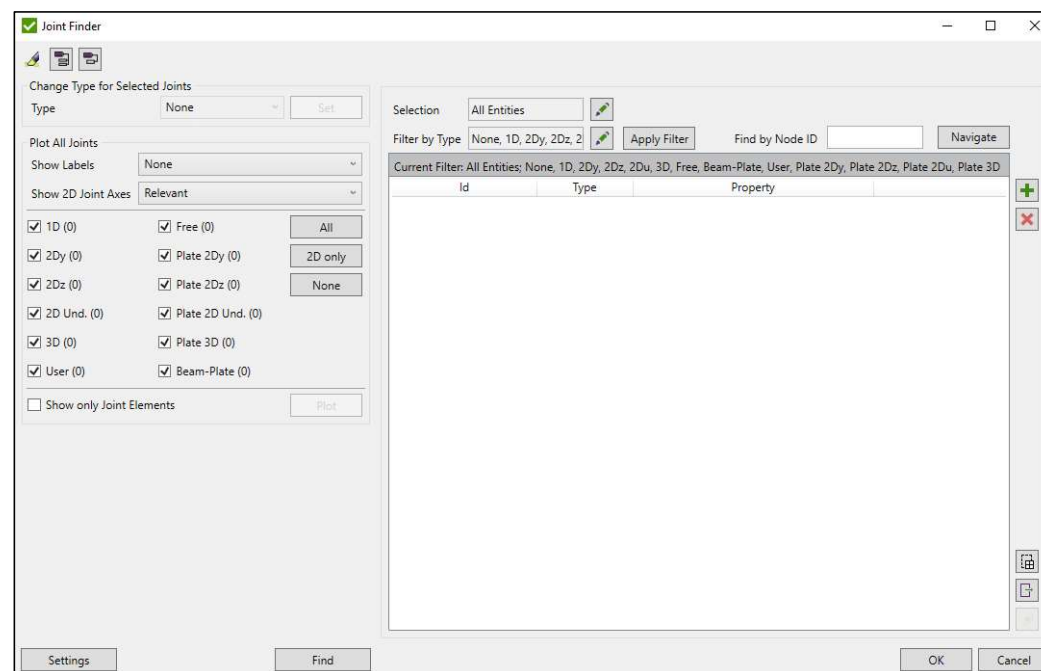Beam-Plate Joint – beam member connected to plates (perpendicularly); User Defined;

https://sdcverifier.com
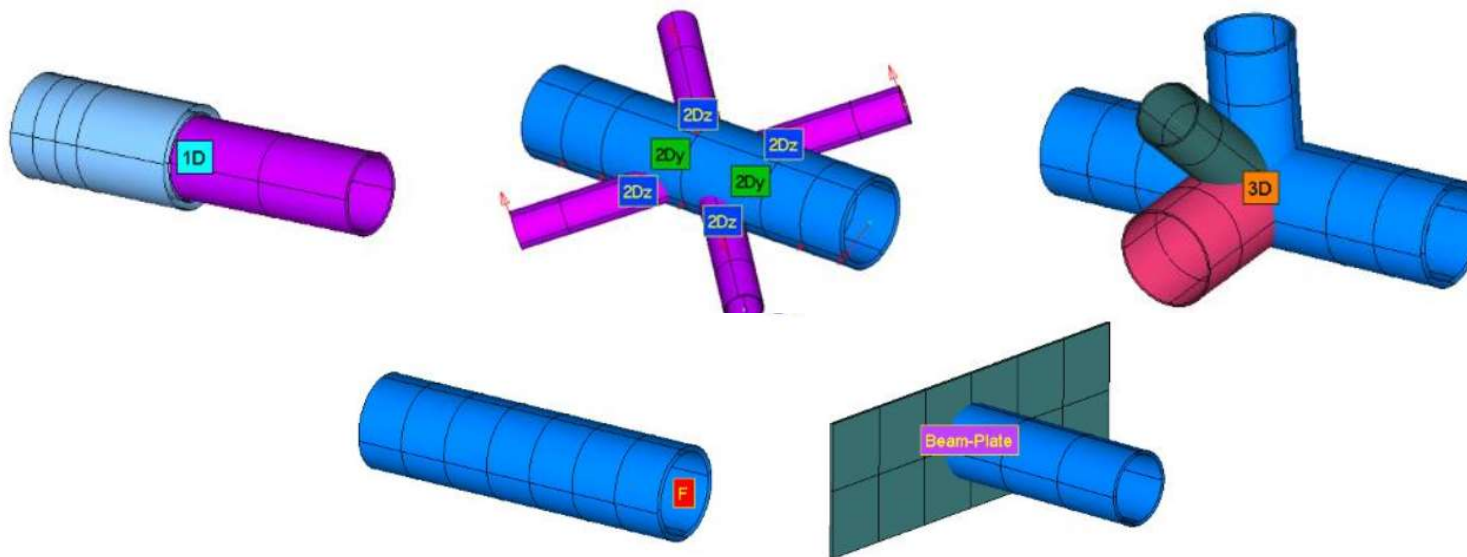
1 Execute *Edit* from *Joint Finder* context menu

2 Press *Find*.

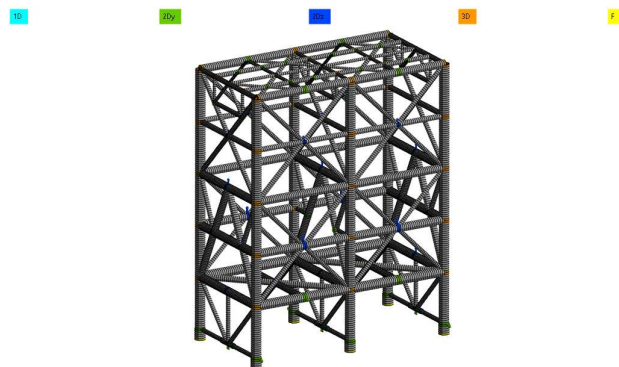It is possible go to *Recognitions* on Ribbon tab and press *Joint:*
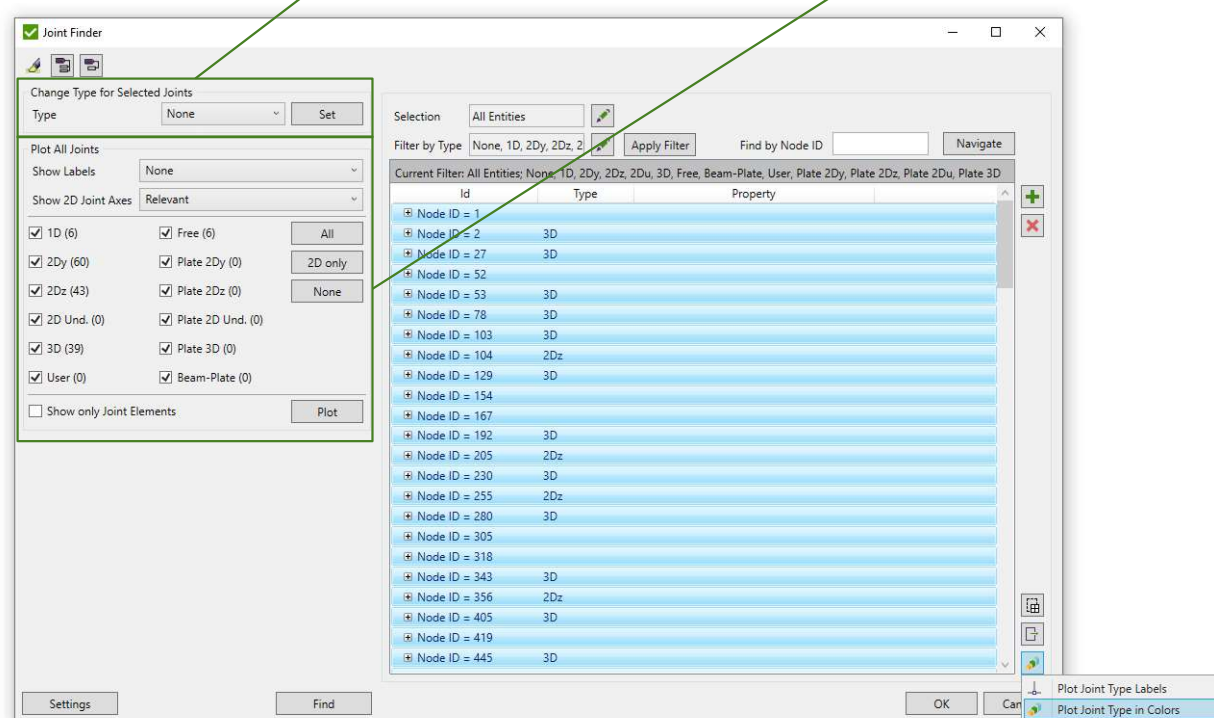
Joints Plot

1 Select All Joints (Ctrl+A).

2 Press [icon] and execute [icon] Plot Joint Type in Colors

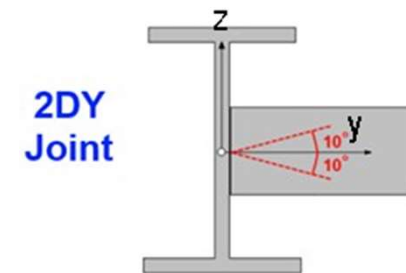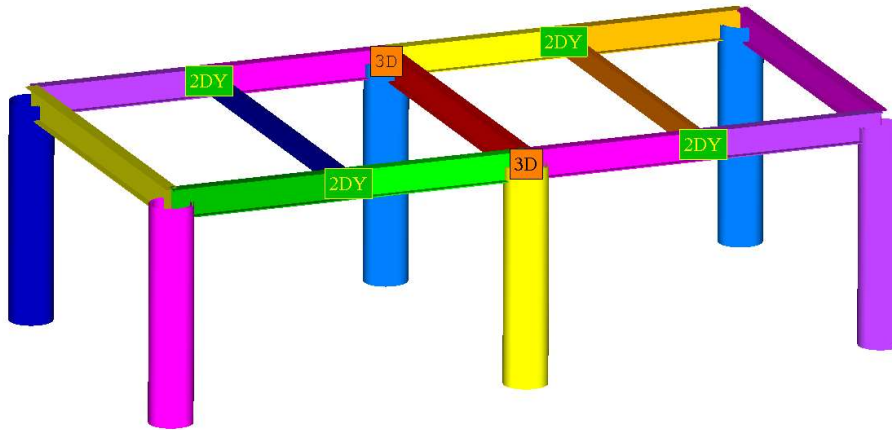**3** Press *OK*.

Modify Joint Type
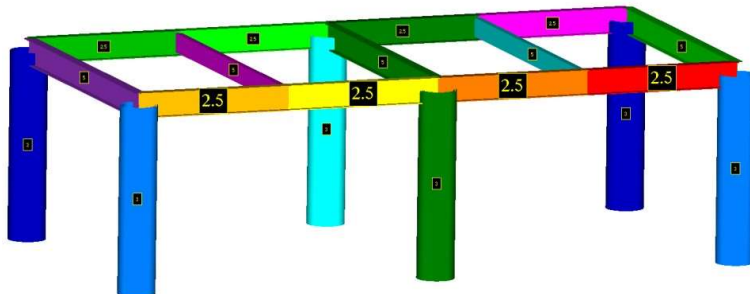
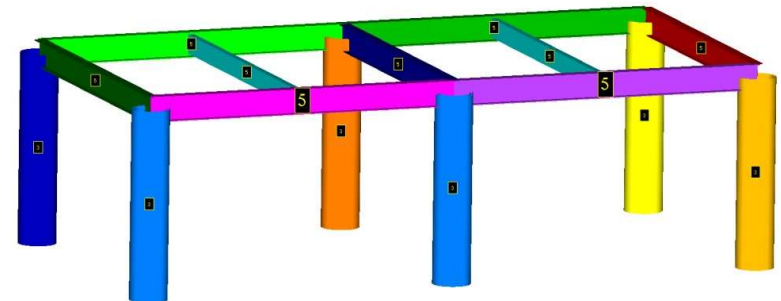Plot Joints of specific type

Beam Member Lengths in 2 directions

Beam Member Finder recognizes beam members and (buckling) lengths for different directions (Y, Z and Torsional).
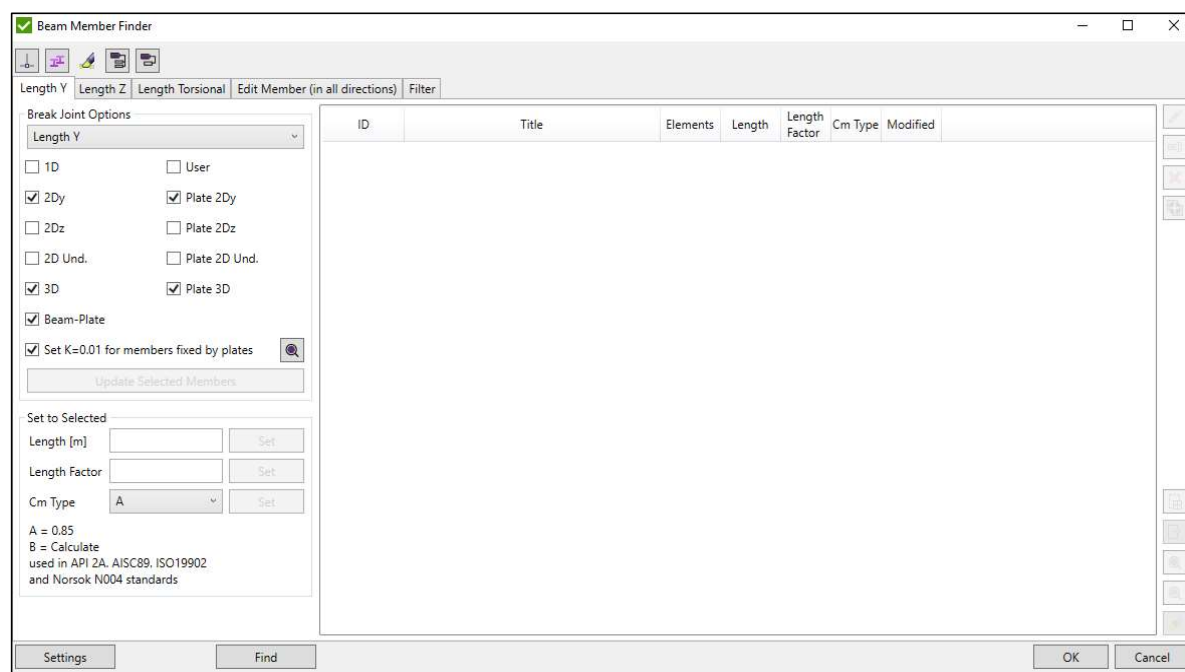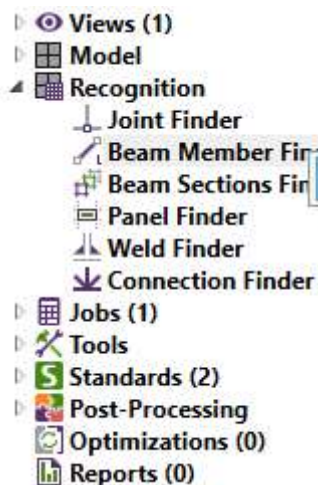
2DY Joint

Length Y – 4 Beam Members with L = 2.5
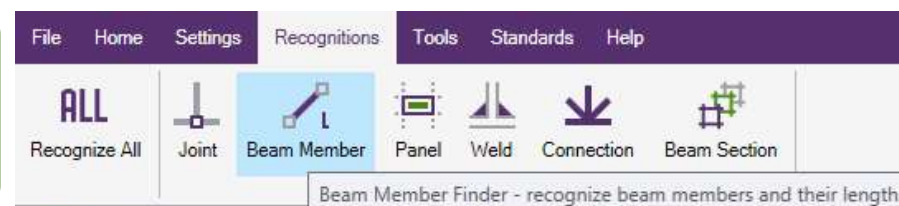
Length Z – 2 Beam Members with L = 5

Recognize Length

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1 Execute *Edit* from *Beam Member Finder* context menu

2 Press *Find*.

- ▷ ⊙ Views (1)
- ▷ ⊞ Model
- ▽ 🏢 Recognition
  - ⊥ Joint Finder
  - 📏 Beam Member Finder
  - Beam Sections Finder
    - 🖉 Edit   **1**
  - ▱ Panel Finder
  - ⊥ Weld Finder
  - ⊻ Connection Finder
- ▷ ⊞ Jobs (1)
- ▷ 🛠 Tools
- ▷ 🗒 Standards (2)
- ▷ 🖼 Post-Processing
  - 🔃 Optimizations (0)
  - 📊 Reports (0)

Beam Member Finder

Length Y | Length Z | Length Torsional | Edit Member (in all directions) | Filter

Break Joint Options
Length Y

- ☐ 1D   ☐ User
- ☑ 2Dy   ☑ Plate 2Dy
- ☐ 2Dz   ☐ Plate 2Dz
- ☐ 2D Und.   ☐ Plate 2D Und.
- ☑ 3D   ☑ Plate 3D
- ☑ Beam-Plate
- ☑ Set K=0.01 for members fixed by plates

Update Selected Members

Set to Selected
- Length [m]   Set
- Length Factor   Set
- Cm Type   A   Set

A = 0.85
B = Calculate
used in API 2A, AISC89, ISO19902
and Norsok N004 standards

Table columns: ID | Title | Elements | Length | Length Factor | Cm Type | Modified

Settings   Find   OK   Cancel

2

Default *Break Joint Options* for Tabs:
Length Y: **2DY, 3D, Plate 2DY, Plate 3D**
Length Z: **2DZ, 3D, Plate 2DZ, Plate 3D**
Length Torsional: **2DY, 2DZ, 2D Und, 3D**

It is possible to open it another way - go to *Recognitions* tab in Ribbon and press *Beam Member*:

File | Home | Settings | Recognitions | Tools | Standards | Help

ALL Recognize All | Joint | Beam Member | Panel | Weld | Connection | Beam Section

Beam Member Finder - recognize beam members and their length

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Beam Member Finder interface

Beam Member - a straight line. If it contains joints it is split on sub members.

Break Options define what joints are used to split beam members

Change Length/Factor for selected beam members

Cm Type is used in API 2A, ISO 19902 and Norsok N004 standards

Press Settings to define recognition options: selection, default title

Press Find to automatically recognize Beam Members and Sub Members for all 3 directions (Y, Z and torsional)

Colored Plot of members with labels (ID, Length, Factor or Cm Type).

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Beam Member Finder interface

Break Joint Options define which types of joints will be used to split Beam Member on sub members. There are 3 predefined Break Joint Options (Length Y, Length Z, and Torsional) and custom.

Sub members from table on a plot:

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1 Select all Beam Members (Ctrl+A)

2 Press 🔵 and execute
to display *Length Plot* [L] Plot Length labels

3 Press *OK*.

Beam Member Finder

Length Y | Length Z | Length Torsional | Edit Member (in all directions) | Filter

Break Joint Options
Length Y

☐ 1D   ☐ User
☑ 2Dy   ☑ Plate 2Dy
☐ 2Dz   ☐ Plate 2Dz
☐ 2D Und.   ☐ Plate 2D Und.
☑ 3D   ☑ Plate 3D
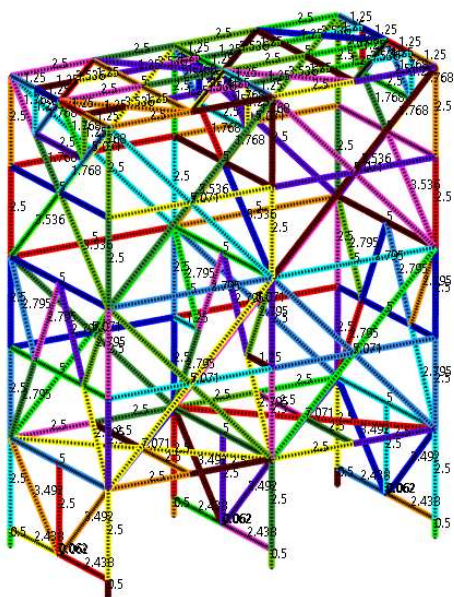☑ Beam-Plate
☑ Set K=0.01 for members fixed by plates

Update Selected Members

Set to Selected
Length [m] [   ] Set
Length Factor [   ] Set
Cm Type [A] Set

A = 0.85
B = Calculate
used in API 2A, AISC89, ISO19902
and Norsok N004 standards

| ID	Title	Elements	Length	Length Factor	Cm Type	Modified	Joint - NodeID [Joint Type]
1	Beam Member 1 (Y)	50	5	1	A		1[2Dz]
2	Beam Member 2 (Y)	50	5	1	A		52[2Dz]
⊟ 3	Beam Member 3 (Y)	100	10				458[2Dy] 405[3D] 507[2Dy]
3.1	Beam Member 3.1 (Y)	25	2.5	1	A		
3.2	Beam Member 3.2 (Y)	25	2.5	1	A		
3.3	Beam Member 3.3 (Y)	25	2.5	1	A		
3.4	Beam Member 3.4 (Y)	25	2.5	1	A		
⊞ 4	Beam Member 4 (Y)	100	10				556[2Dy] 445[3D] 605[2Dy]
⊞ 5	Beam Member 5 (Y)	100	10				103[3D] 356[2Dz] 104[2Dz]
6	Beam Member 6 (Y)	51	5	1	A		154[2Dz] 167[2Dz]
⊞ 7	Beam Member 7 (Y)	100	10				205[2Dz] 230[3D] 255[2Dz]
8	Beam Member 8 (Y)	51	5	1	A		305[2Dz] 318[2Dz]
9	Beam Member 9 (Y)	28	2.795	1	A		
⊞ 10	Beam Member 10 (Y)	56	5.59				318[2Dy]
⊞ 11	Beam Member 11 (Y)	56	5.59				30
12	Beam Member 12 (Y)	50	5	1	A		33
⊞ 13	Beam Member 13 (Y)	103	10				11
14	Beam Member 14 (Y)	50	5	1	A		35
⊞ 15	Beam Member 15 (Y)	103	10				80
16	Beam Member 16 (Y)	50	5	1	A		36
17	Beam Member 17 (Y)	28	2.795	1	A		
⊞ 18	Beam Member 18 (Y)	56	5.59				38

Settings | Find | OK

2 (context menu)
- 🔵 Plot selected members
- Plot Length Criteria
- Plot Members ID Labels
- Plot Full Members ID Labels
- Plot Length Labels
- Plot Cm Type Labels
- Plot Length Factor Labels
- Plot Joints for Selected Members
- Plot Members Y and Z axes
- Plot Length Labels in Y and Z axes

3 **2**

2 (legend)
- 🔵 Plot selected members
- 🟦 Plot Length Criteria
- Plot Members ID Labels
- Plot Full Members ID Labels
- [L] Plot Length Labels
- Plot Cm Type Labels
- [K] Plot Length Factor Labels
- Plot Joints for Selected Members
- Plot Members Y and Z axes
- Plot Length Labels in Y and Z axes

13

Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms — Load and Resistance Factor Design

API RECOMMENDED PRACTICE 2A-LRFD (RP 2A-LRFD)
FIRST EDITION, JULY 1, 1993

American Petroleum Institute
1220 L Street, Northwest
Washington, DC 20005

This "Recommended Practice for Planning. Designing. and Constructing Fixed Offshore Platforms Load - and Resistance Factor Design" (LRFD) contains the d and engineering design principles and good practices that have been the basis of the API RP2A working strength design (WSD) recommended practice, now in its 20th Edition. The LRFD provisions have been developed from the WSD provisions using reliability based calibration.

Issued by
AMERICAN PETROLEUM INSTITUTE
Production Department

FOR INFORMATION CONCERNING TECHNICAL CONTENTS OF THIS PUBLICATION CONTACT THE API PRODUCTION DEPARTMENT, 1201 MAIN STREET, SUITE 2535, DALLAS, TX 75202-3994 — (214) 748-3841. SEE BACK SIDE FOR INFORMATION CONCERNING HOW TO OBTAIN ADDITIONAL COPIES OF THIS PUBLICATION.

Users of this publication should become familiar with its scope and content. This publication is intended to supplement rather than replace individual engineering judgment.

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$$\frac{f_c}{\phi_c F_{cn}} + \frac{1}{\phi_b F_{bn}} \left\{ \left[\frac{C_{my} f_{by}}{\left(1 - \frac{f_c}{\phi_c F_{ey}}\right)}\right]^2 + \left[\frac{C_{mz} f_{bz}}{\left(1 - \frac{f_c}{\phi_c F_{ez}}\right)}\right]^2 \right\}^{0.5} \leq 1.0$$

...... (D.3.2-1)

TABLE D.3-1
EFFECTIVE LENGTH AND BENDING
REDUCTION FACTORS FOR
MEMBER STRENGTH CHECKING

Situation	Effective Length Factor K	Reduction Factor Cm[1]
Superstructure Legs		
Braced	1.0	(a)
Portal (unbraced)	K[2]	(a)
Jacket Legs & Piling		
Grouted Composite Section	1.0	(c)
Ungrouted Jacket Legs	1.0	(c)
Ungrouted Piling Between Shim Points	1.0	(b)
Jacket Braces		
Face-to-face Length of Main Diagonals	0.8	(b) or (c)
Face of Leg to Centerline of Joint Length of K-Braces[3]	0.8	(c)
Longer Segment Length of X-Braces[3]	0.9	(c)
Secondary Horizontals	0.7	(c)
Deck Truss Chord members	1.0	(a),(b) or (c)
Deck Truss Web Members		
In-Plane Action	0.8	(b)
Out-of-Plane Action	1.0	(a) or (b)

Cmy and Cmz reduction factors are used in combined axial and bending check. API RP 2A description:

By default **Cm Type** is equal to A = 0.85 for all members. It is possible to modify Cm Type for selected members:

In SDC Verifier B = minimum from (b) and (c)

- Cmy and Cmz factors for ISO 19902 can be found in the Table 13.5-1 and are used in the formula 13.3-3.
- Cmy and Cmz factors for Norsok N004 Rev3 can be found in the Table 6-2 and are used in the formula 6.27

Notes to Table D.3-1:

(1) Use whichever is more applicable to a specific situation. Values of the reduction factor C_m referred to in the above table are as follows:

(a) 0.85

(b) $0.6 - 0.4 \left(\frac{M_1}{M_2}\right)$, no more than 0.85, or less than 0.40, where M_1/M_2 is the ratio of smaller to larger moments at the ends of that portion of the member unbraced in the plane of bending under consideration. M_1/M_2 is positive when the number is bent in reverse curvature, negative when bent in single curvature.

(c) $1.0 - 0.4 \left(\frac{f_c}{\phi_c F_e}\right)$, or 0.85, whichever is less

Cm Type | A | Set

A = 0.85
B = Calculate
used in API 2A. AISC89. ISO19902 and Norsok N004 standards

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1 Execute *Standards => Add => API RP 2A-LRFD (1st, Jul 1993)*.

API 2A RP standard covers the design checks only cylindrical types of shapes.
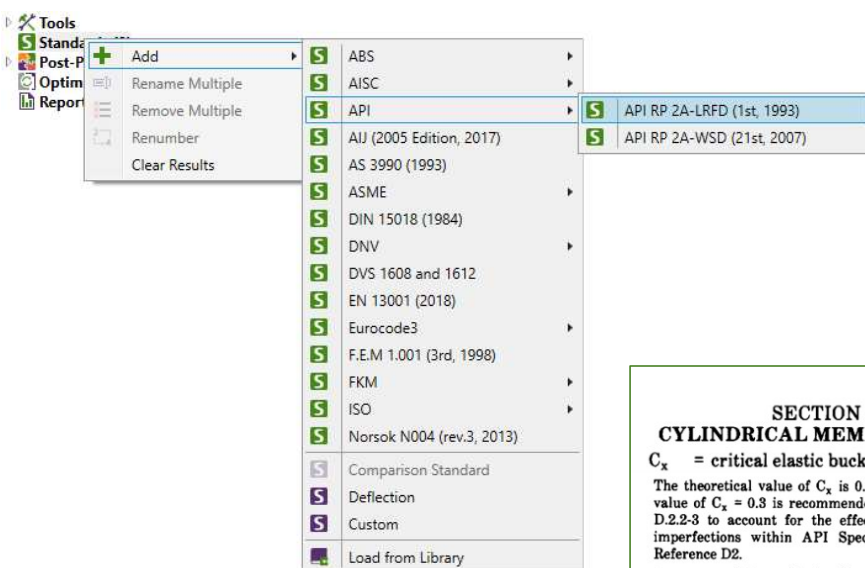
SECTION D
CYLINDRICAL MEMBER DESIGN

C_x = critical elastic buckling coefficient

The theoretical value of C_x is 0.6. However, a reduced value of C_x = 0.3 is recommended for use in Equation D.2.2-3 to account for the effect of initial geometric imperfections within API Spec 2B tolerance limits, Reference D2.

ϕ_t = resistance factor for axial tensile strength, 0.95

ϕ_c = resistance factor for axial compressive strength, 0.85

ϕ_b = resistance factor for bending strength, 0.95.

ϕ_v = resistance factor for beam shear strength, 0.95

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Define Material Characteristics
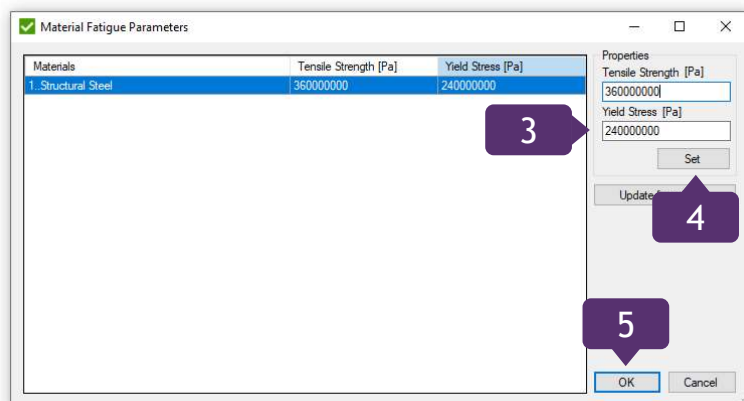
1 Press 🔧 to set the material yield stress and tensile strength

2 Tensile Strength: **360e+6**

3 Yield Stress: **240e+6**

4 Press *Set*

5 Press *OK*

Extreme table for bending check

1 Execute *Table* from *Bending Stress Check* context menu

2 Press 🔲 to select load

3 Load Type: **Load Group**

4 Load: **1..Load Group 1**

5 Press *OK*

6 Extreme Options: **Detailed**

7 Press *Fill Table*

8 Press *OK*
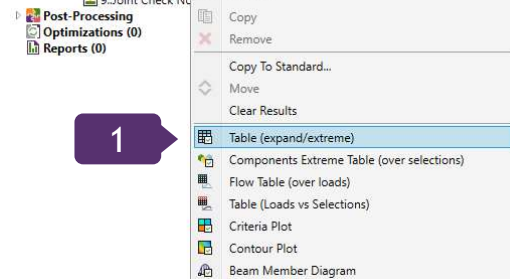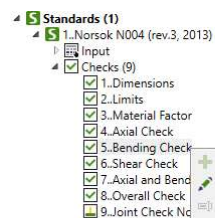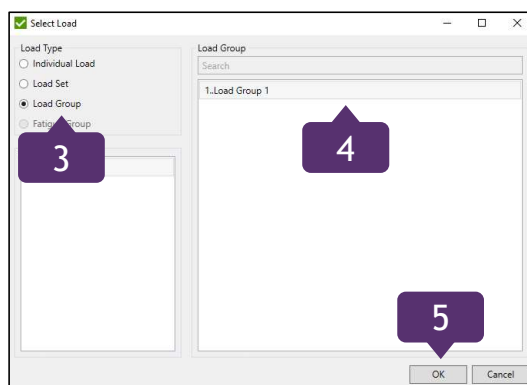
Overall Check contains results from all checks. With the help of one table/plot it is possible to verify if the model passes the checks (< 1). Overall Utilization Factor = worst Uf among all checks.

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1 Execute *Criteria Plot* from *Bending Stress Check* context menu

2 Press ▦ to select load

3 Load Type: **Load Group**

4 Load: **1..Load Group 1**

5 Press *OK*

6 Press to add view ➕
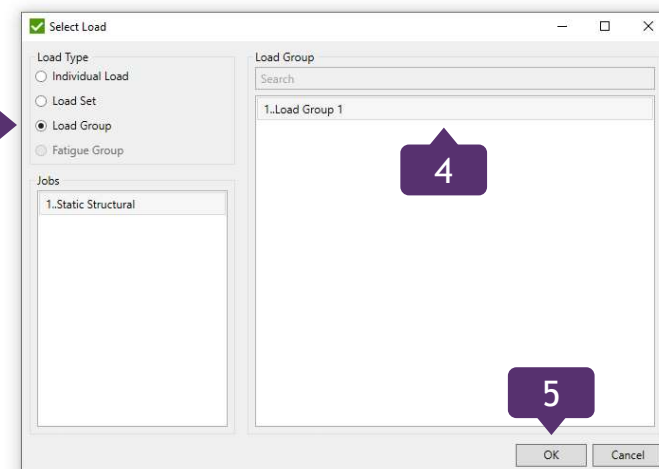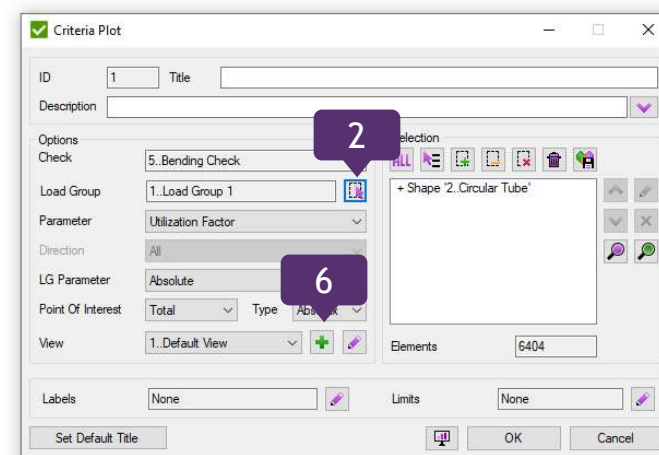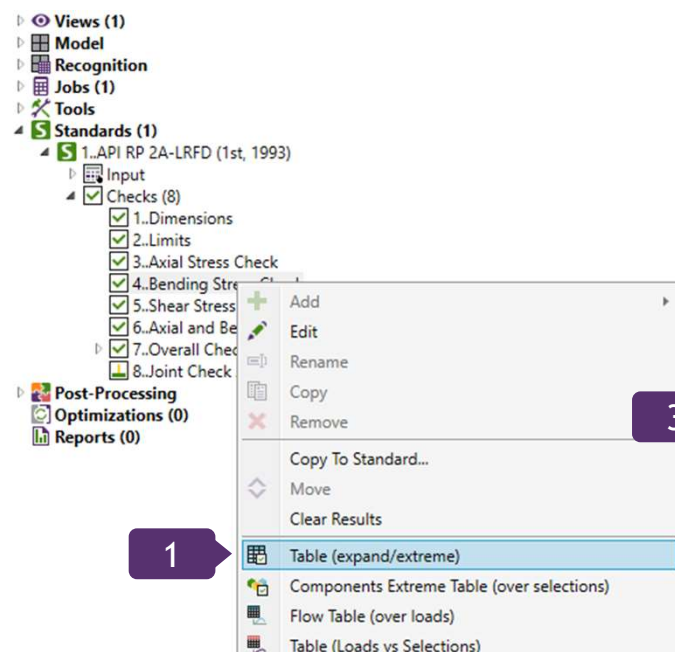
Plot. Create View

1. Title: *Isometric*

2. Orient model in Ansys Mechanical as shown on the picture

3. Press *Get*

4. Set parameters from notice 4

5. Press *OK*

4

Deformation: **Undeformed**
Display on: **Result Only** Show
Legend: **On**
Show Triad: **On**

20
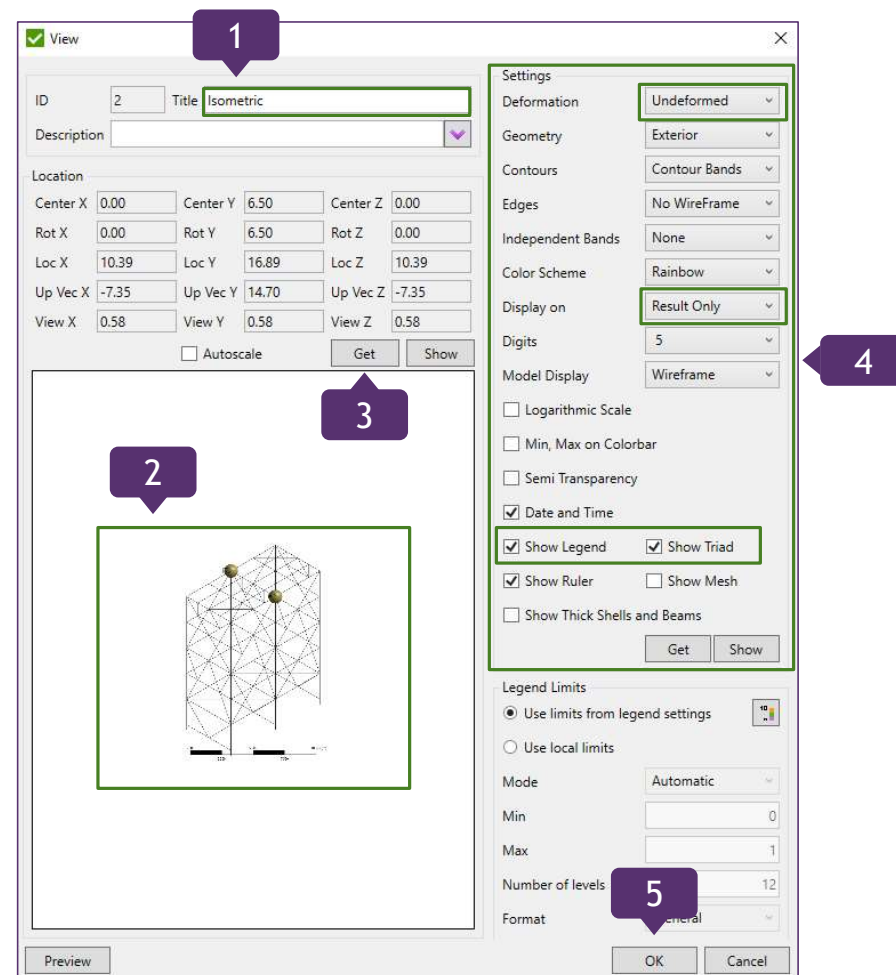
1 Execute ⊞ from *Overall Check* context menu

2 Press ▣ to select load

3 Load Type: **Load Group**

4 Load: **1..Load Group 1**

5 Press *OK*

6 Select *Isometric* view

7 Press *OK*
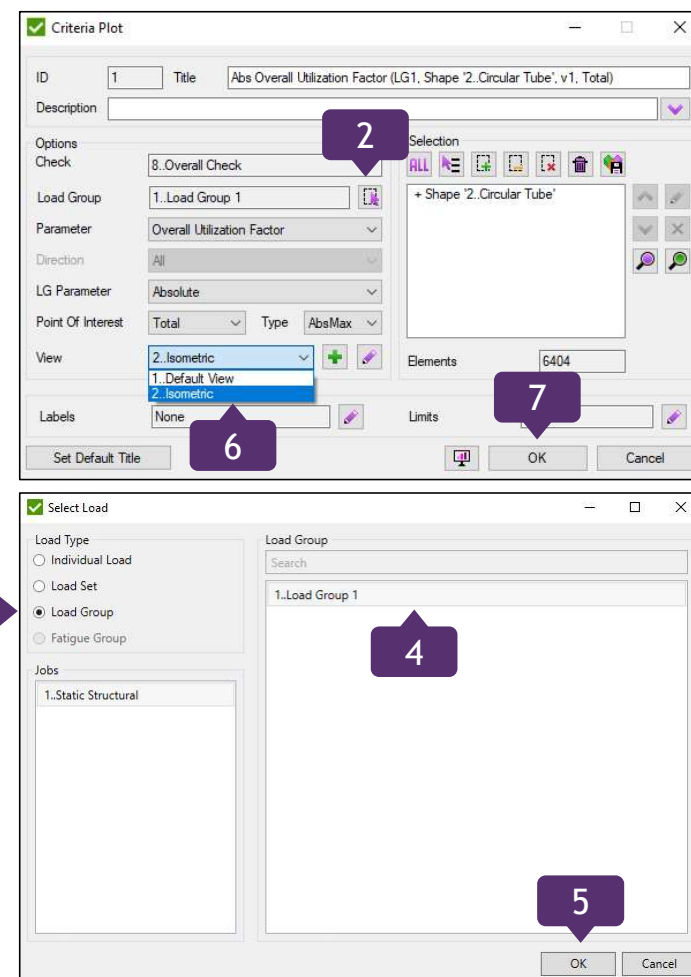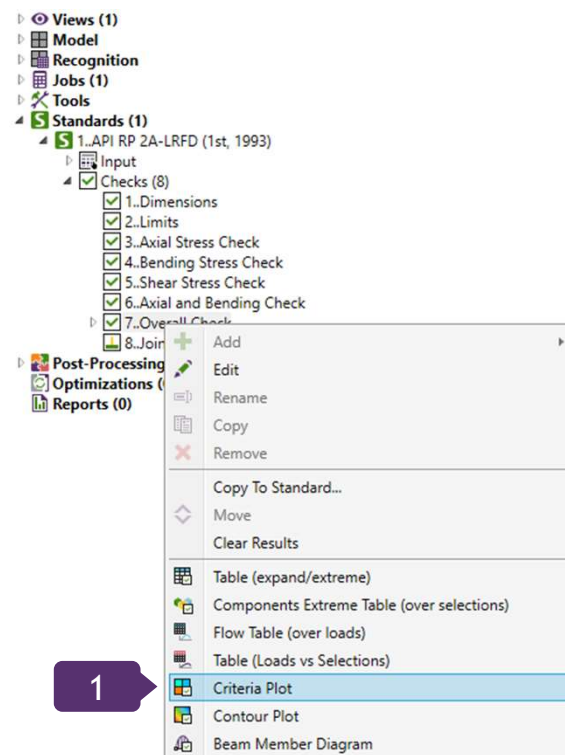
1 Press ⊡ to display plot

2 Press *OK*
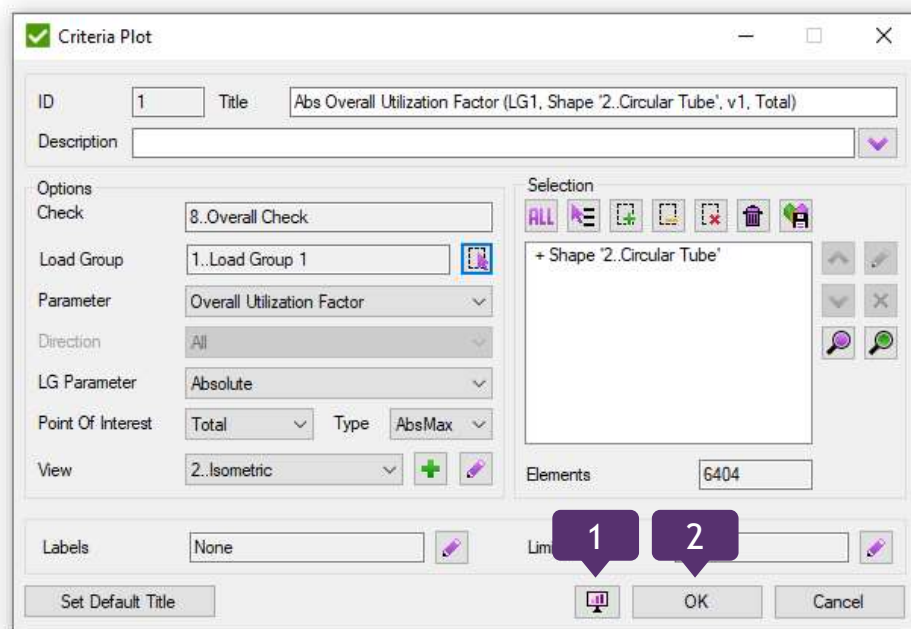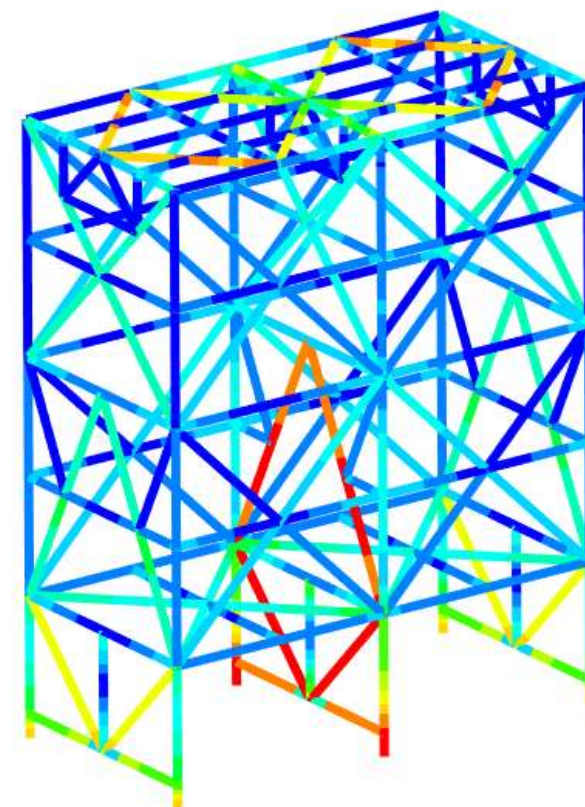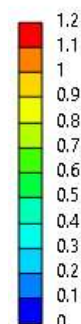
Add ISO 19902 standard

1 Execute *Standards => Add => ISO 19902 (1st, Dec 2007)*

2 Press *OK*
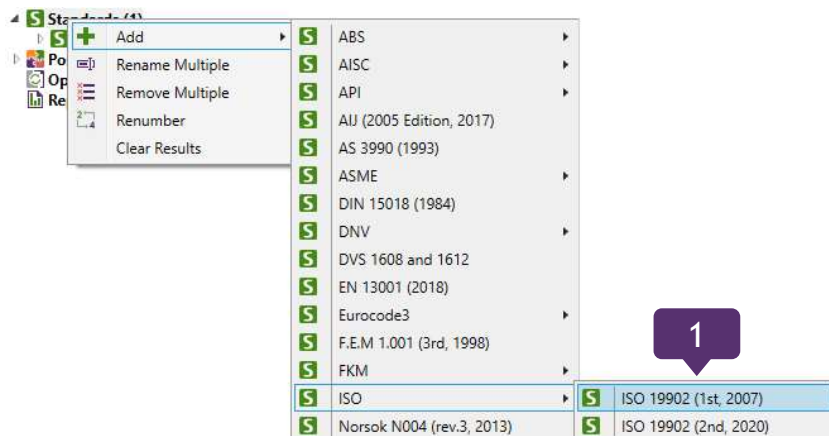
ISO 19902 procedure is similar to API 2A RP. In overall check it is possible to verify if the structure passes all checks : Overall Utilization Factor = worst Uf among all checks < 1.
Add extreme table and criteria plot for '1..**Load Group 1**' the same as for API standard.
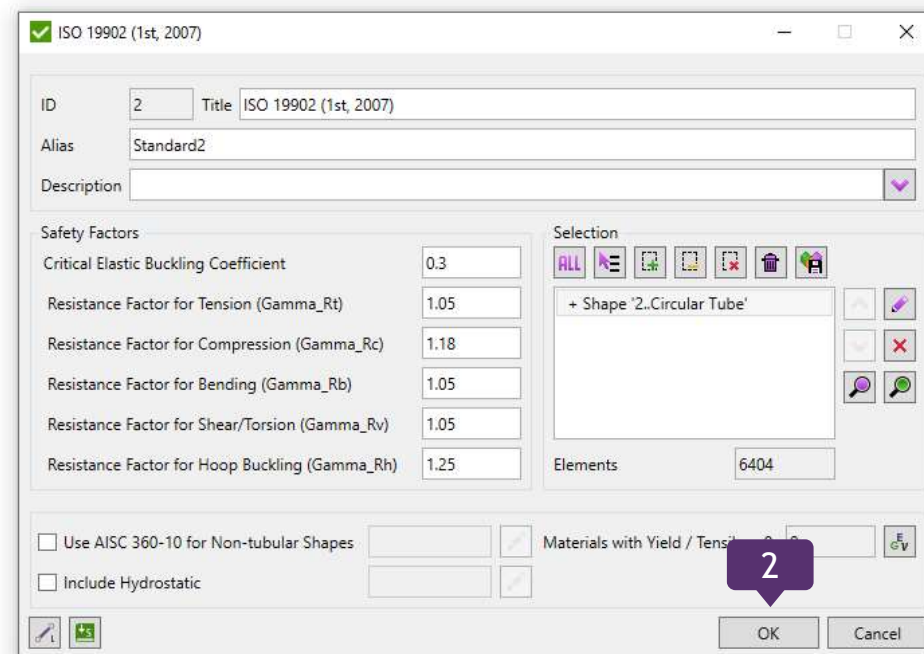
C_x is the elastic critical buckling coefficient, see below;

The theoretical value of C_x for an ideal tubular is 0,6. However, a reduced value of $C_x = 0,3$ should be used in Equation (13.2-10) to account for the effect of initial geometric imperfections within the tolerance limits given in Clause 21. A reduced value of $C_x = 0,3$ is implicit in the value of f_{xe} used in Equations (13.2-8) and (13.2-9).

$\gamma_{R,t}$ is the partial resistance factor for axial tensile strength, $\gamma_{R,t} = 1,05$.

$\gamma_{R,c}$ is the partial resistance factor for axial compressive strength, $\gamma_{R,c} = 1,18$.

$\gamma_{R,b}$ is the partial resistance factor for bending strength, $\gamma_{R,b} = 1,05$;

$\gamma_{R,v}$ is the partial resistance factor for shear strength, $\gamma_{R,v} = 1,05$;

$\gamma_{R,h}$ is the partial resistance factor for hoop buckling strength, $\gamma_{R,h} = 1,25$.

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1 Execute *Standards => Add => Norsok N004 (rev.3, Feb 2013)*.

2 Press *OK*
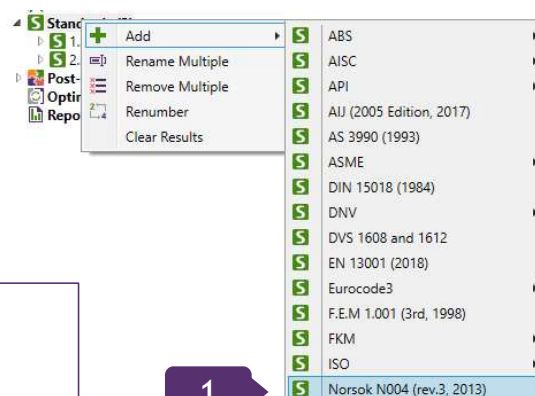
Norsok N004 procedure is similar to API 2A RP. In overall check it is possible to verify if the structure passes all checks : Overall Utilization Factor = worst Uf among all checks < 1.

C_e = critical elastic buckling coefficient = 0.3

$\gamma_{R,t}$ = material factor for tension = 1.15

$\gamma_{R,v}$ = material factor for shear = 1.15

γ_M = see section 6.3.7

$$\gamma_M = 1.15 \qquad \text{for } \bar{\lambda}_s < 0.5 \qquad (6.22)$$

$$\gamma_M = 0.85 + 0.60\bar{\lambda}_s \qquad \text{for } 0.5 \leq \bar{\lambda}_s \leq 1.0$$

$$\gamma_M = 1.45 \qquad \text{for } \bar{\lambda}_s > 1.0$$

where

$$\bar{\lambda}_s = \frac{|\sigma_{c,Sd}|}{f_{cl}} \cdot \lambda_c + \left(\frac{\sigma_{p,Sd}}{f_h}\right)^2 \cdot \lambda_h \qquad (6.23)$$

where f_{cl} is calculated from Equation (6.6) or Equation (6.7) whichever is appropriate and f_h from Equation (6.17), Equation (6.18), or Equation (6.19) whichever is appropriate.

$$\lambda_c = \sqrt{\frac{f_y}{f_{cle}}} \quad , \text{and} \qquad \lambda_h = \sqrt{\frac{f_y}{f_{he}}} \qquad (6.24)$$

f_{cle} and f_{he} is obtained from Equation (6.8), and Equation (6.20) respectively.

$\sigma_{p,Sd}$ is obtained from Equation (6.16) and

$$\sigma_{c,Sd} = \frac{N_{Sd}}{A} + \frac{\sqrt{M_{y,Sd}^2 + M_{z,Sd}^2}}{W} \qquad (6.25)$$

N_{Sd} is negative if in tension.

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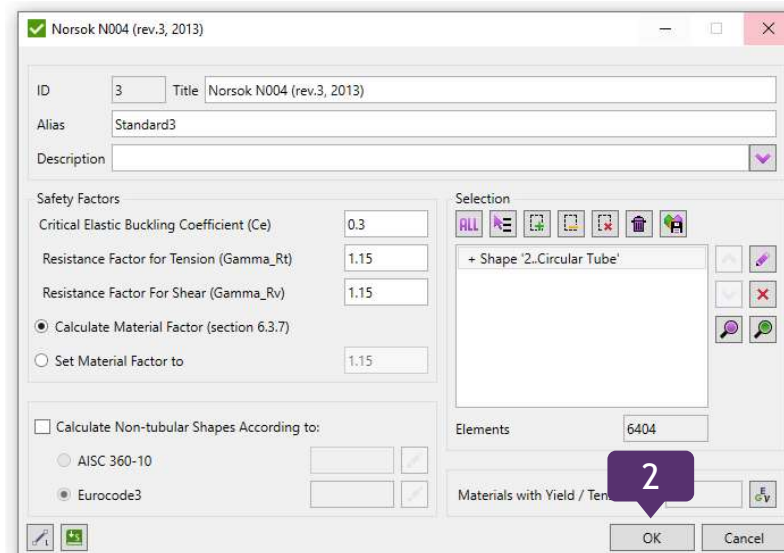
Report - Tables

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

2 *Results => Check Tables*. Select *Overall Check* and press *Add Check Tables*
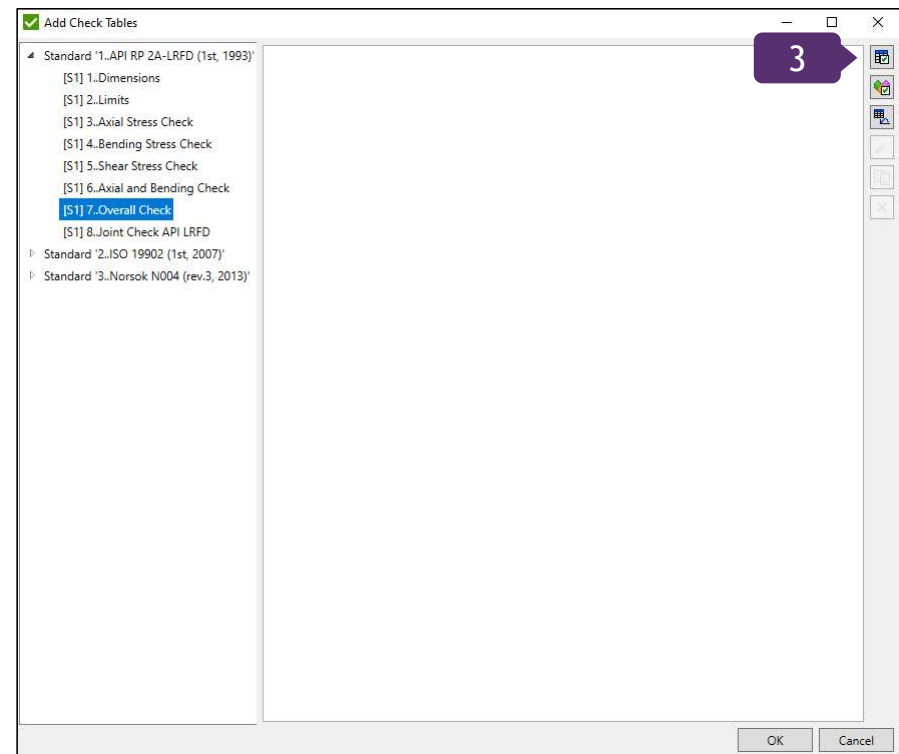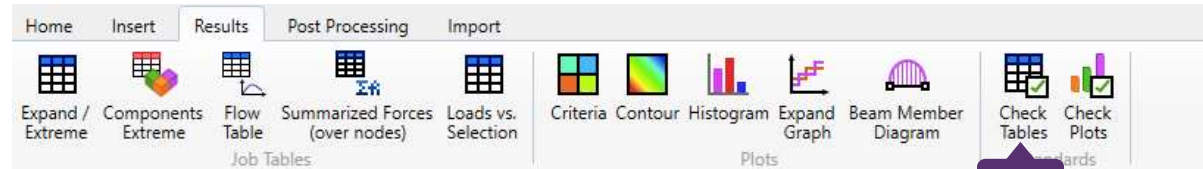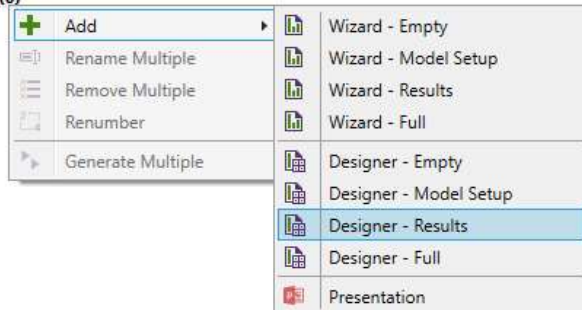
There are 4 templates of the reports:
- *Empty* – only first page and preface items are included;
- *Model Setup* – description of the model data (materials, properties, components, boundary conditions) is included;
- *Results* – for each load extreme displacement tables, stress and displacement plots are included. Predefined tables: sum of reaction forces, stresses/displacements summary tables;
- *Full* – Model Setup + Results + all tables created in Job.

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1 Select *Load Group 1*

2 Apply *All Entities*

3 Select *Detailed*

4 Press *Ok*

5 Repeat 1-4 step for Standard *ISO 19902* and *Norsok N004*

Report - Plots

1 Execute *Results => Check Plots*

2 Select Standard *API RP 2A-LRFD* and press *Add Criteria Plot*

3 Select *Load Group 1*

4 Select *All Entities*

5 Press *OK*

6 Repeat 1-5 step for Standards *ISO 19902* and *Norsok N004*

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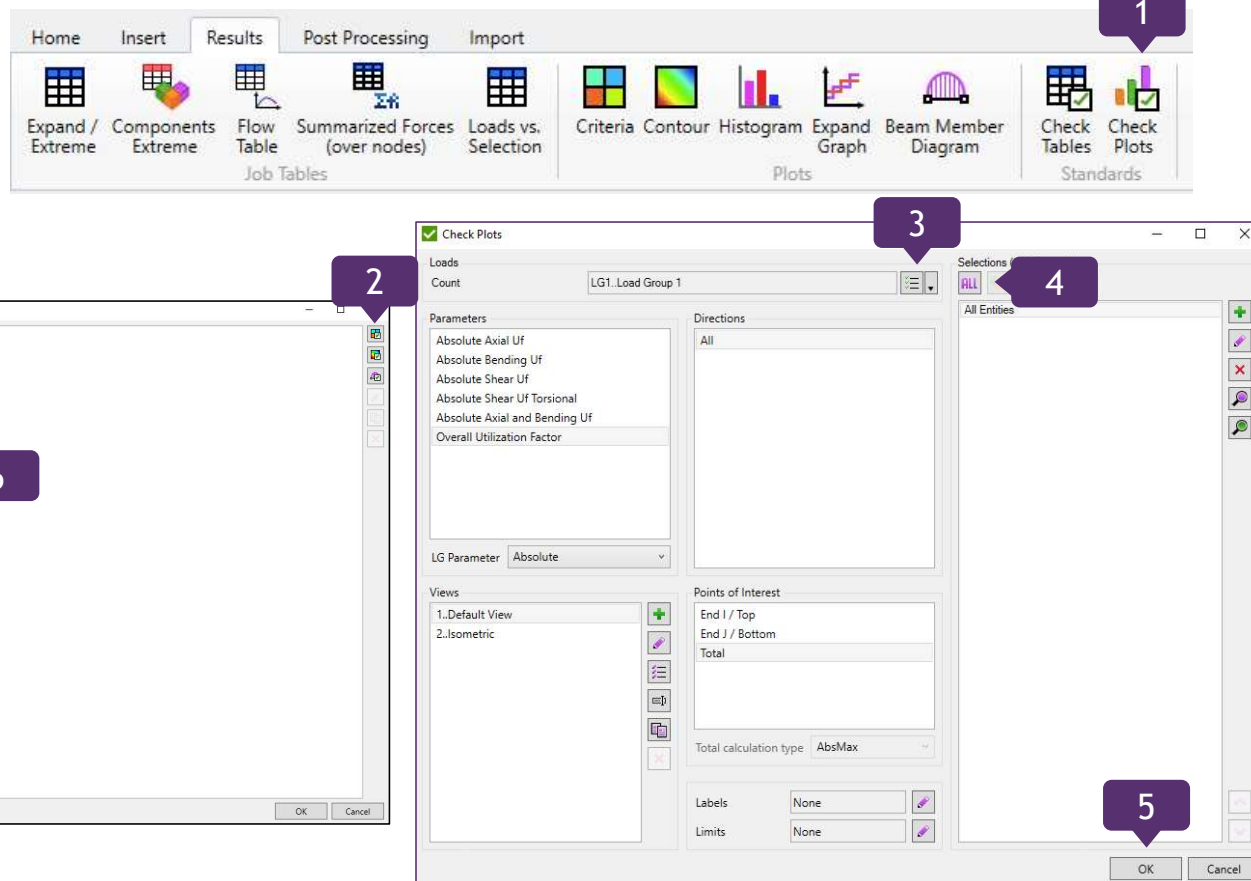
1. Select plot in *API RP 2A-LRFD => Abs UF Utilization Factor*

2. Select *Break Page Before* and press *No*

3. Select plot in *API RP 2A-LRFD => Abs UF Utilization Factor*

4. Select *Break Page Before* and press *No*

5. Repeat 1-4 step for Standards *ISO 19902* and *Norsok N004*

28
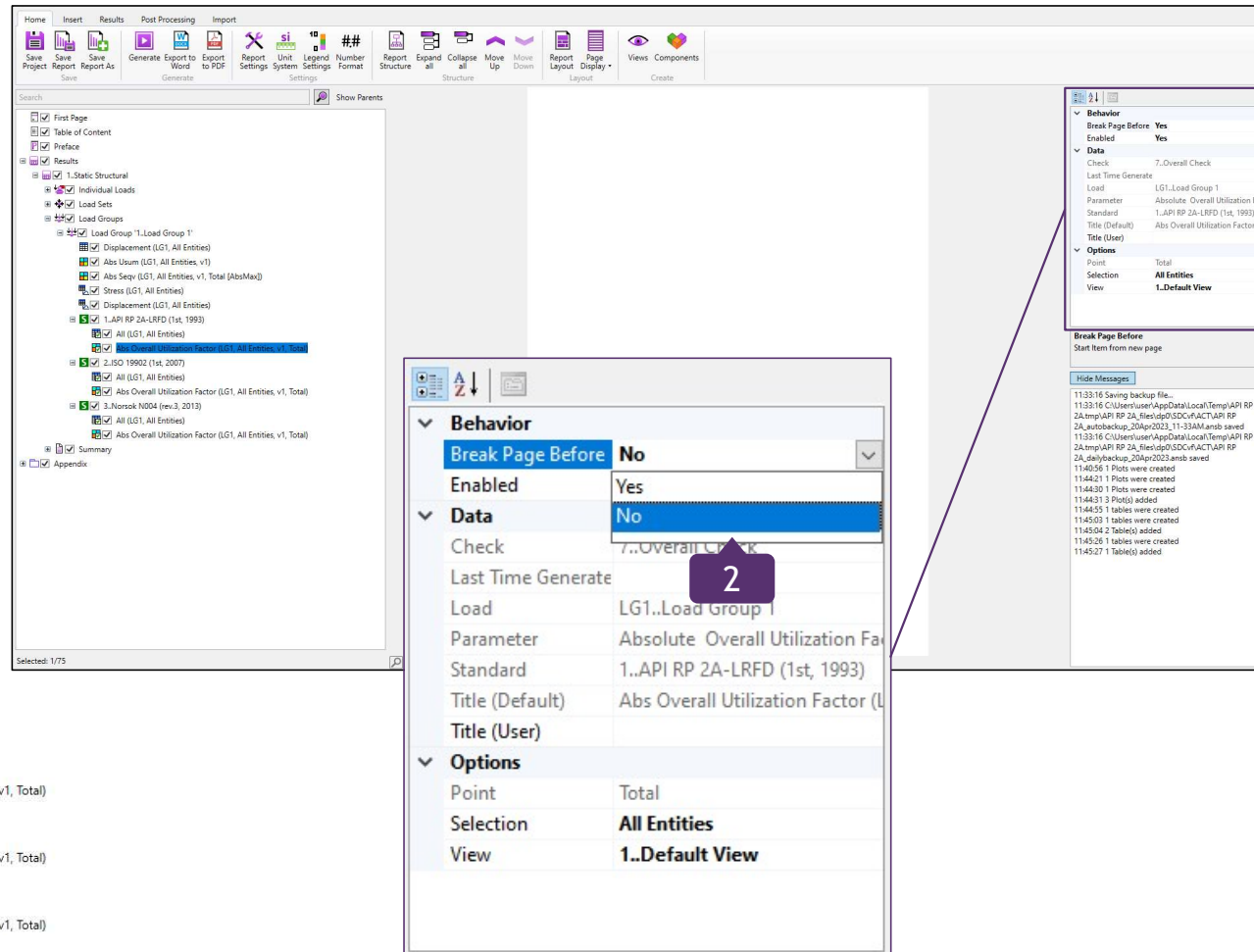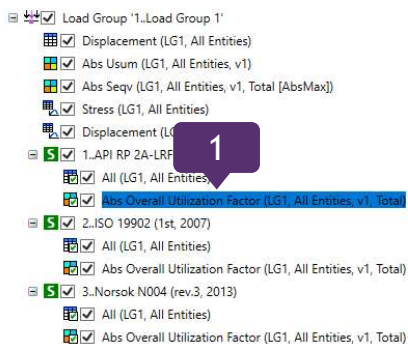
1   Right click on *First Page => Edit*

2   Press 🔳 to load engineer and customer info from library

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

4   Press *OK*.

Report exported to Microsoft Word

1 Press ▶ to generate complete report

2 Press 📄 to export to Word