Tutorial
API 2A RP/ISO 19902/Norsok N004

ANSYS®

8 Dec 2020
version 2020.0.2

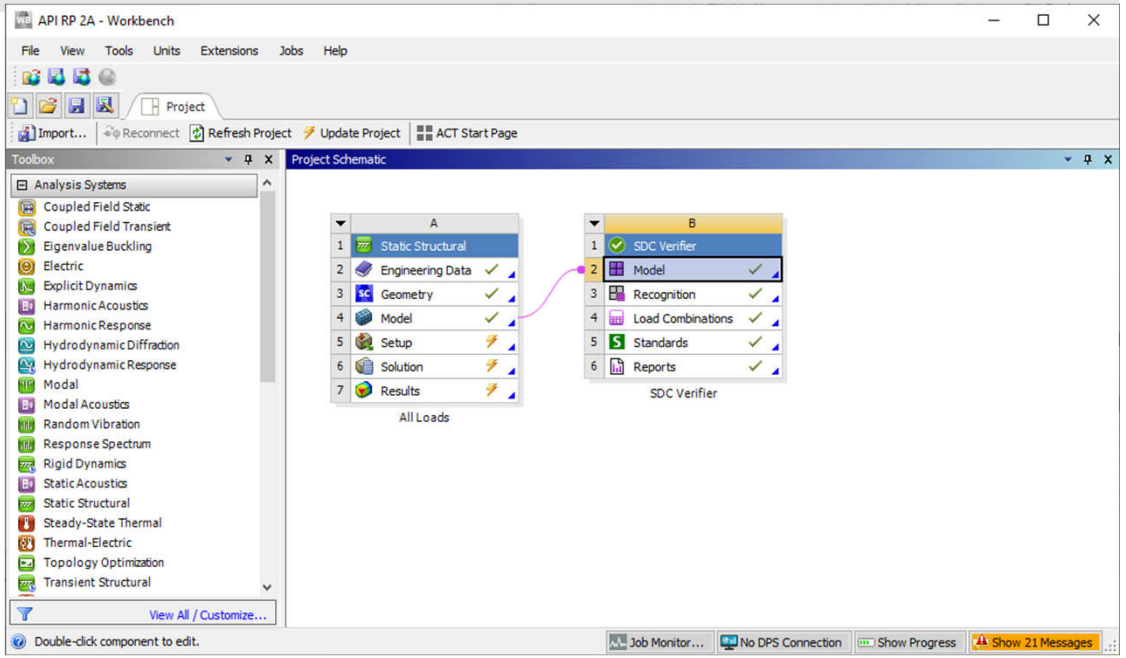
Content

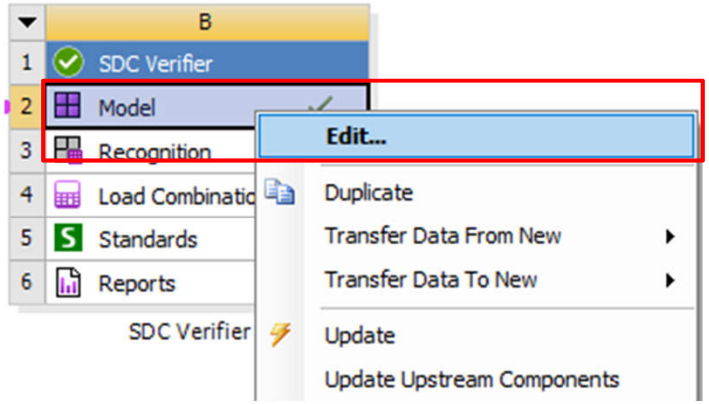
- In this tutorial, API 2A RP/ISO 19902/Norsok N004 Beam Design Checks are reviewed.
- A beam model of a steel frame has been used as a start FEM model.
- Beam member finder was used to recognize beam member length in 3 directions.
- The report was generated with the help of report designer.

Launch SDC Verifier

1. Open in **Ansys Workbench** **API RP 2A.wbpj**

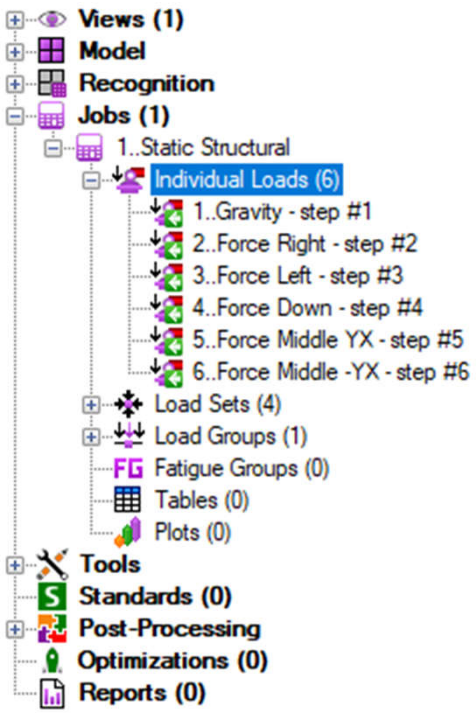
2. Double Click on 2 Model or in context menu click *Edit*

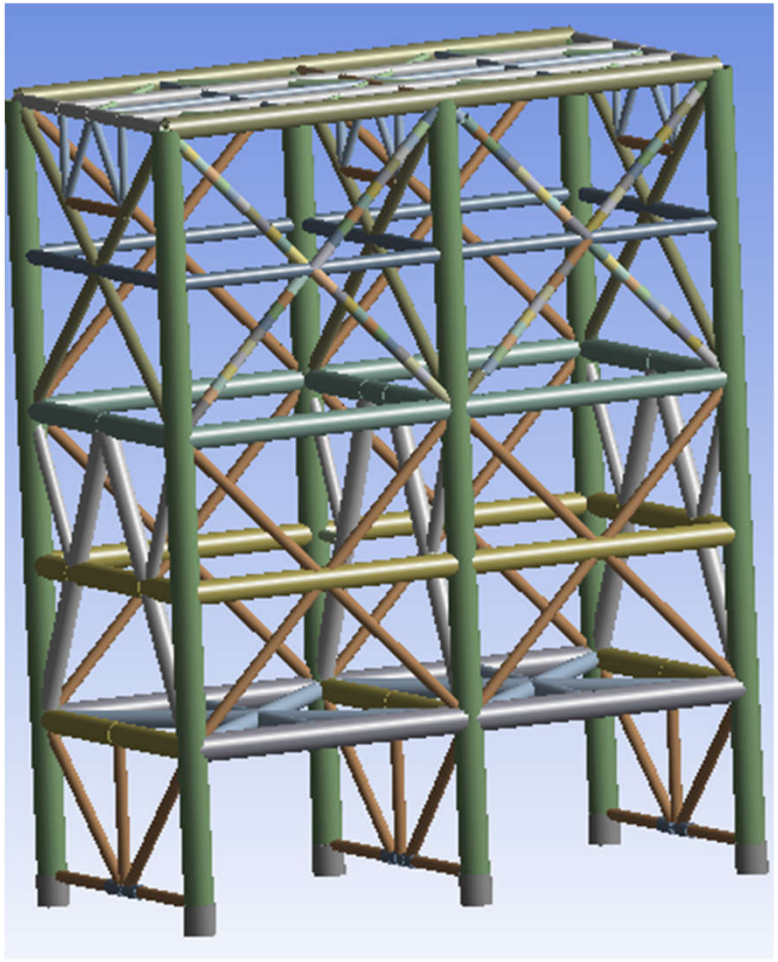




2.

Predefined project

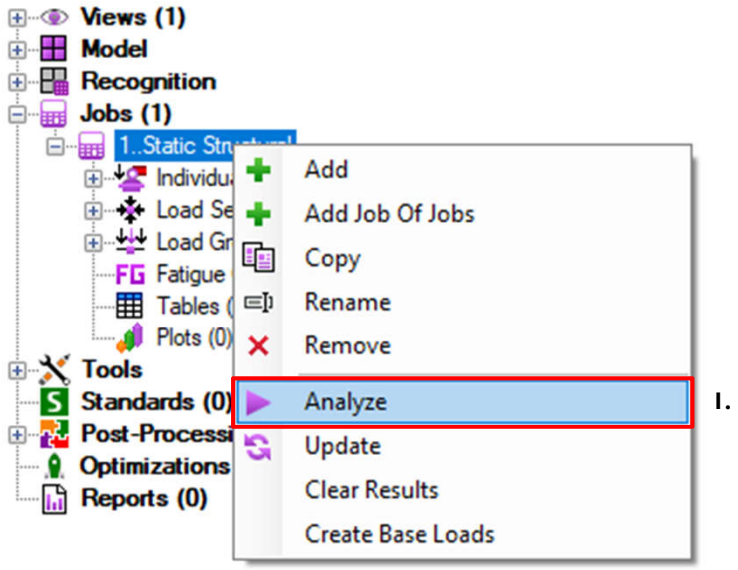




This tutorial uses project with predefined boundary condition, load combinations and load group.
The model contains only circular tubes elements.

Analyze Job

1. Execute ▶ **Analyze** from *Static Structural* context menu

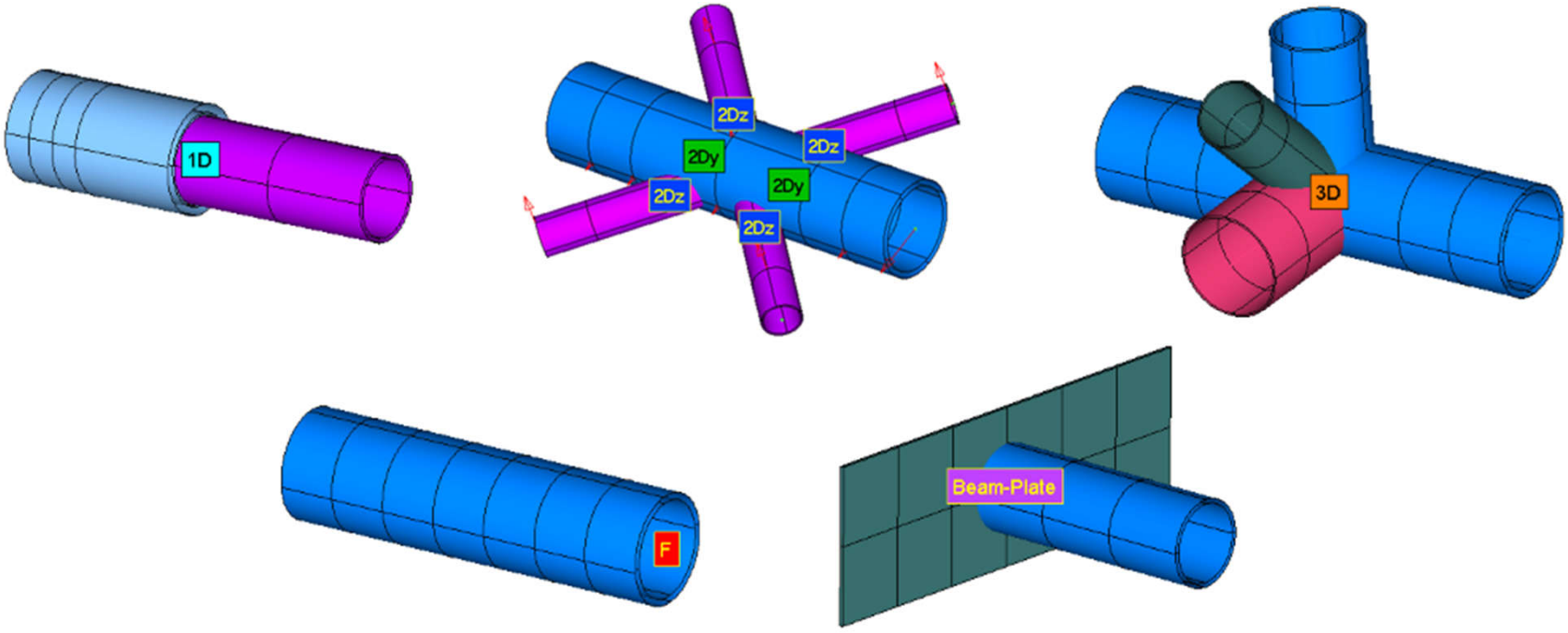


I.

Explanation of Joints

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

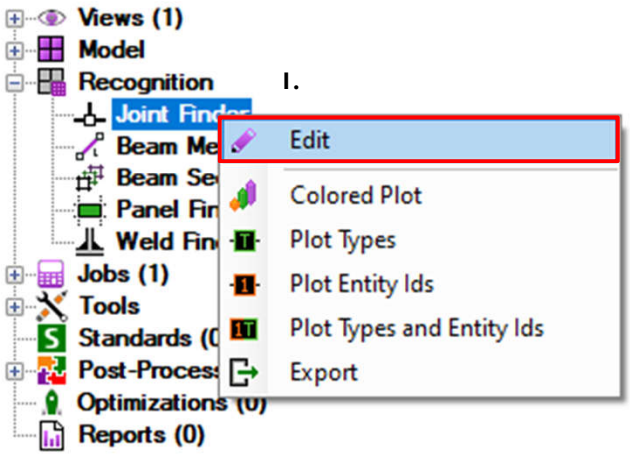
There are 6 types of Joints:
1D Joint – 2 beam members that lie on the curve but with different properties;
2D Joint – beam members connected in one plane;
3D Joint – beam members connected in space;
Free Joint – node which belongs only to one element (free);
Beam-Plate Joint – beam member connected to plates (perpendicularly);
User Defined;

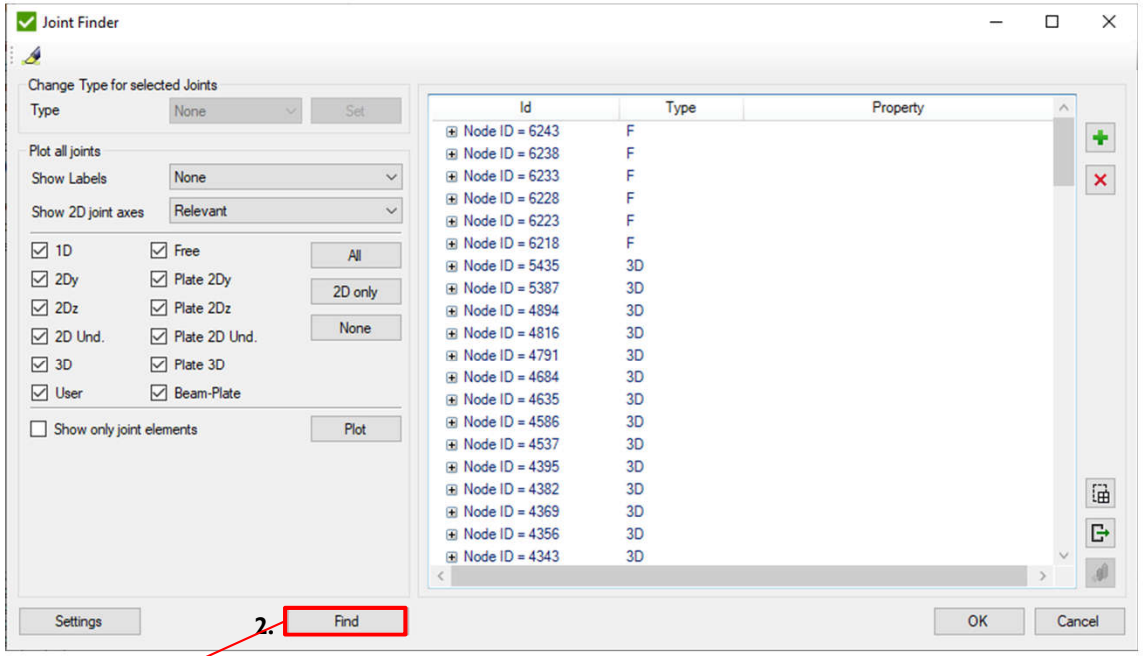


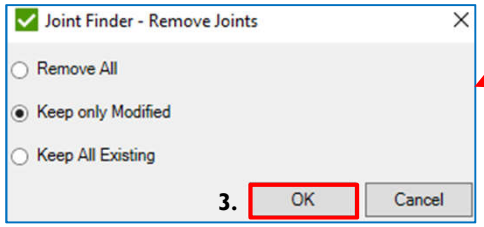
Joint Recognition

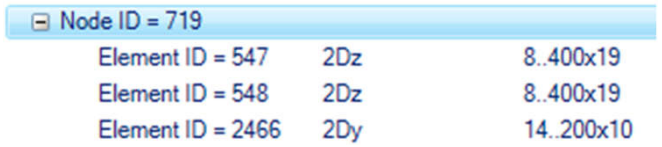
1. Execute *Edit* from *Joints* context menu
2. Press *Find*.
3. Press *Ok*.

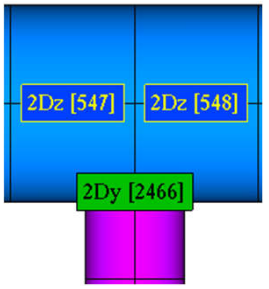
When performing the joint recognition there are 3 options for existing joints. Default option: Keep only modified– remove all joints except edited by user. Keep all existing options should be used when additional elements were added to the model.



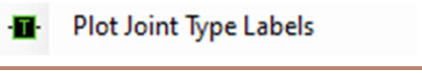


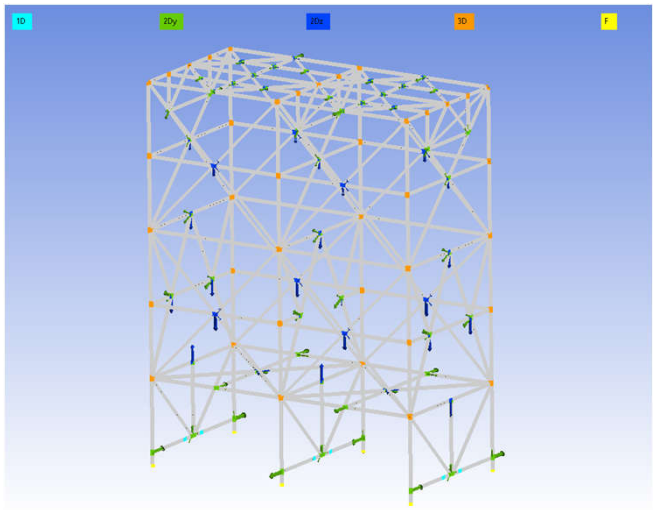


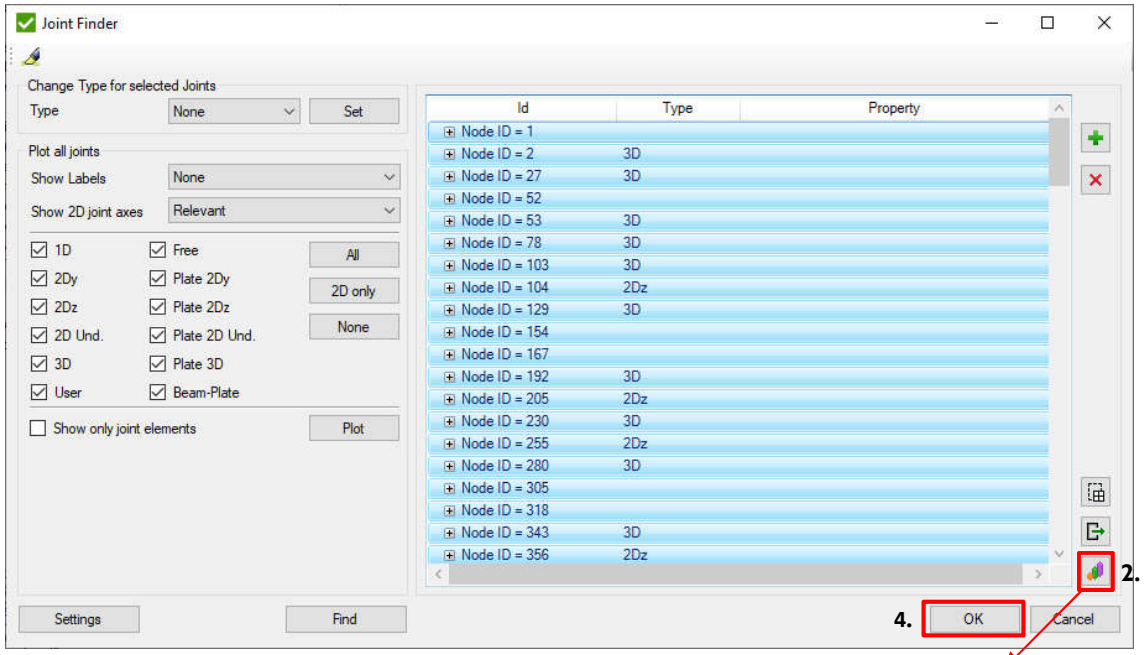




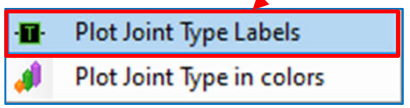
Joints Plot

1. Select All Joints (Ctrl+A).
2. Press 
3. Press  Plot Joint Type Labels
4. Press *OK*

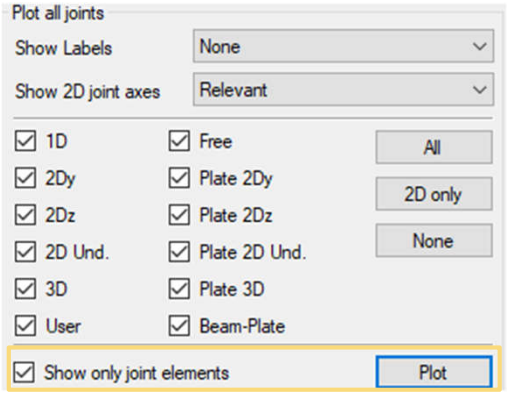




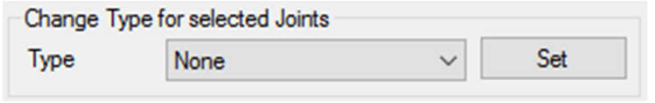
3.



Plot Joints of specific type:

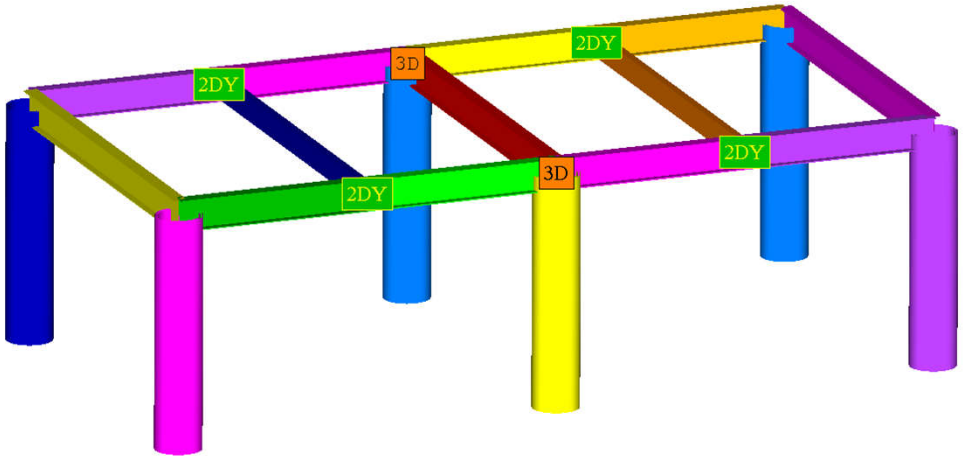


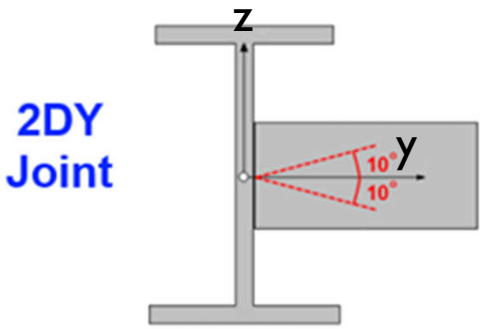
Modify Joint Type:



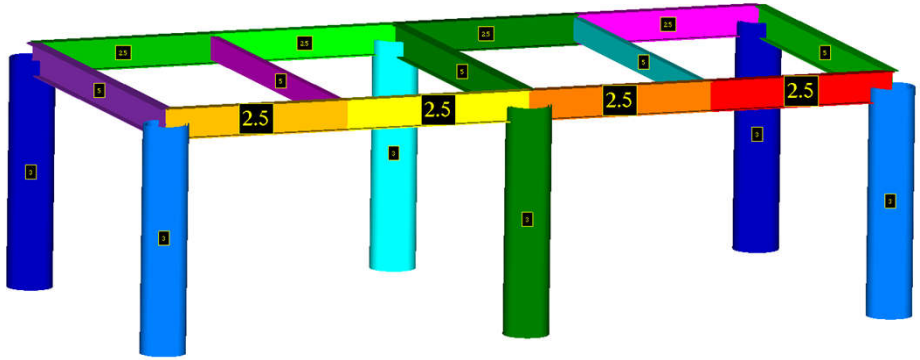
Beam Member Lengths in 2 directions

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

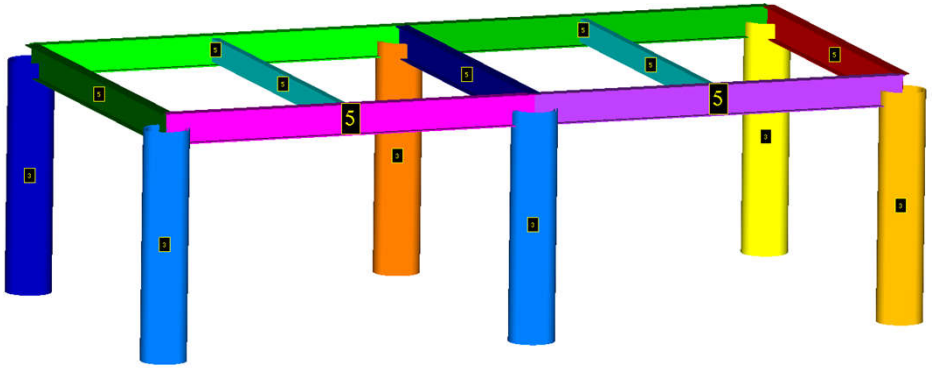




Length Y – 4 Beam Members with L = 2.5

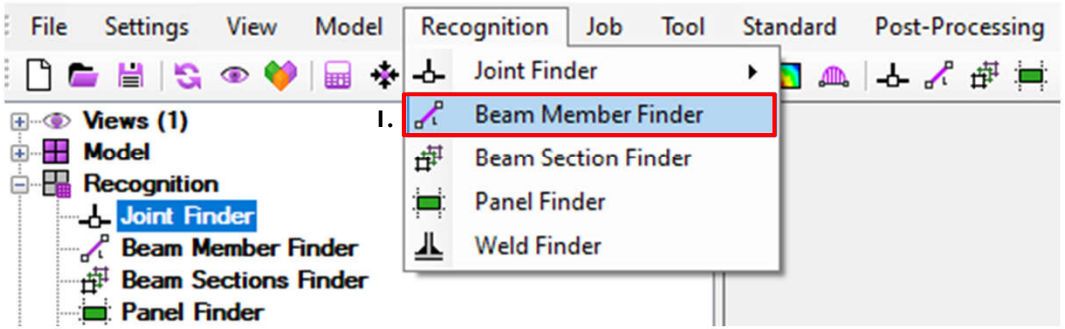


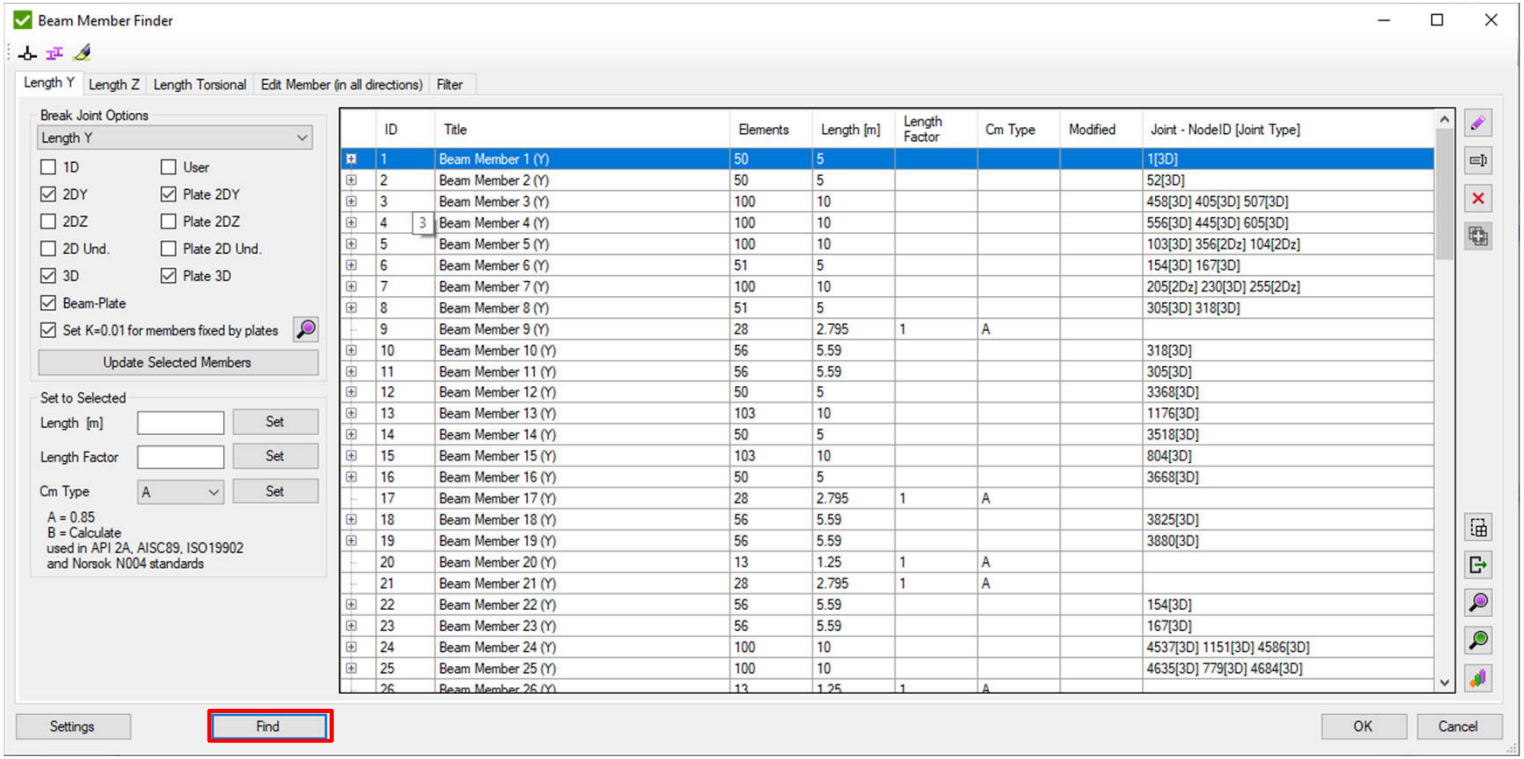
Length Z – 2 Beam Members with L = 5



Recognize Length

1. Execute *Recognition – Beam Member Finder*
2. Press *Find*.



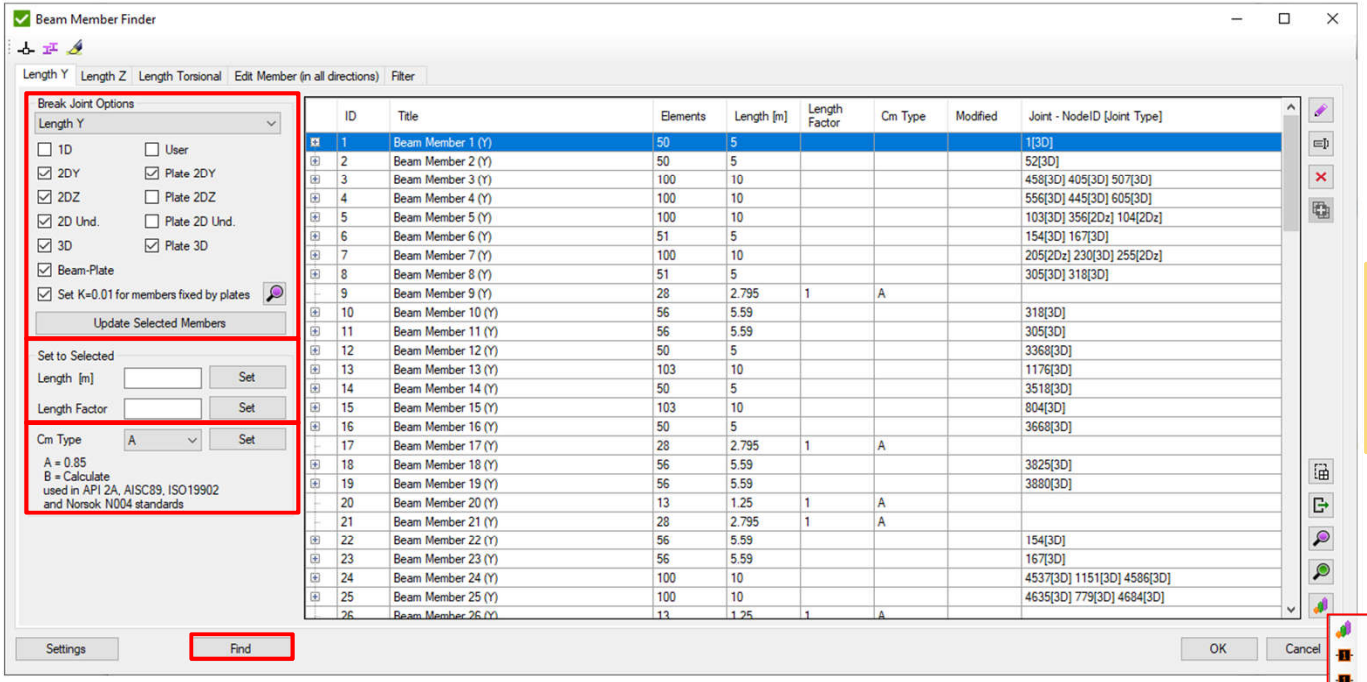


Beam Member Finder interface

Break Options define what joints are used to split beam members

Change Length/ Length Factor for selected beam members

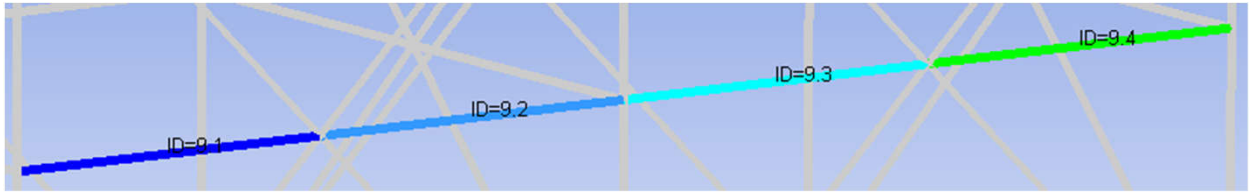
Cm Type is used in API 2A, AISC89, ISO 19902 and Norsok N004 standards



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

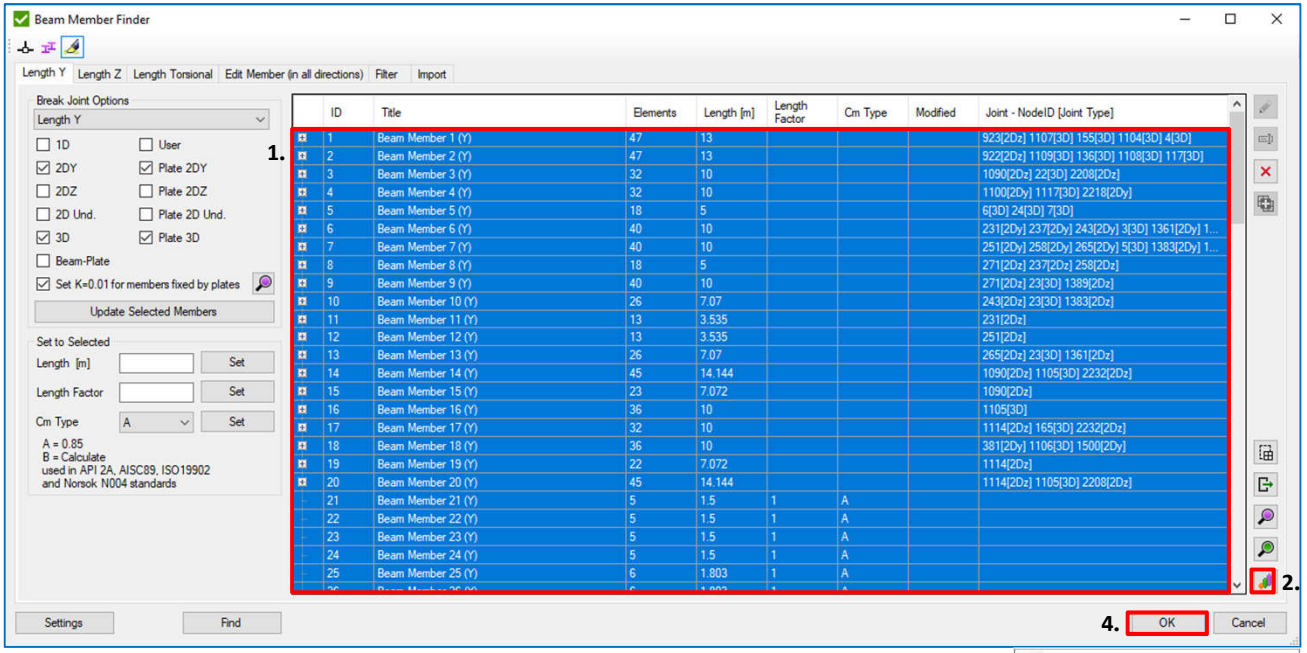
Beam Member – straight line. If it contains joints it is split on sub members

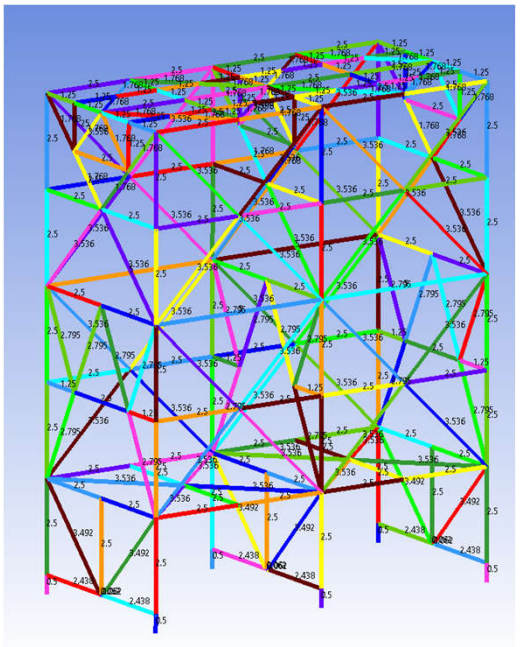
9	Beam Member 9	32	10				1103[2Dz] 201[3D] 2221[2Dz]
9.1	Sub Member 9.1	8	2.5	1	A		
9.2	Sub Member 9.2	8	2.5	1	A		
9.3	Sub Member 9.3	8	2.5	1	A		
9.4	Sub Member 9.4	8	2.5	1	A		

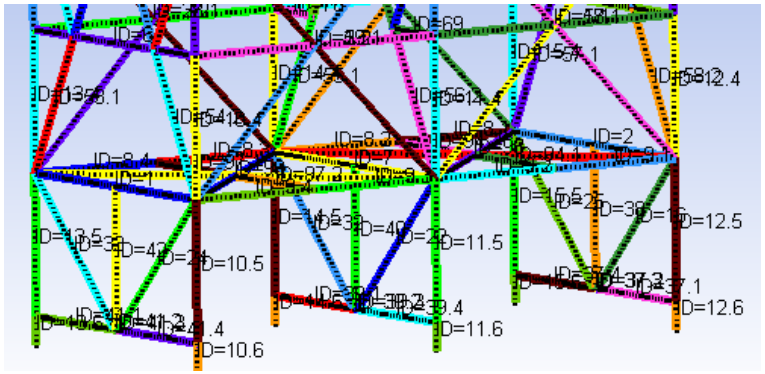


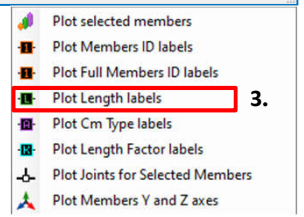
Beam Member's Length Plot

1. Select All Beam Members (Ctrl+A)
2. Press 
3. Press Plot Length labels
4. Press *OK*









Also it is possible to display beam members IDs by pressing
Plot Members ID labels

Cm – reduction factors

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

$$\frac{f_c}{\phi_c F_{cn}} + \frac{1}{\phi_b F_{bn}}\left\{\left[\frac{C_{my} f_{by}}{\left(1 - \frac{f_e}{\phi_c F_{ey}}\right)}\right]^2 + \left[\frac{C_{mz} f_{bz}}{\left(1 - \frac{f_e}{\phi_c F_{ez}}\right)}\right]^2\right\}^{0.5} \leqq 1.0 \quad \ldots\ldots \text{(D.3.2-1)}$$

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)

Notes to Table D.3-1:

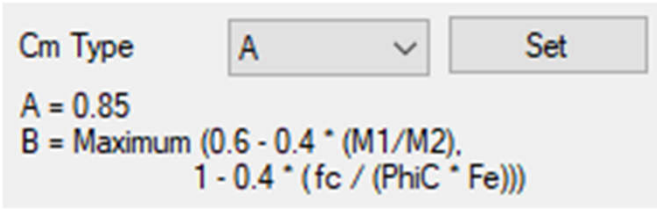
(1) Use whichever is more applicable to a specific situation. Values of the reduction factor C_m referred to in the above table are as follows:

(a) 0.85

(b) $0.6 - 0.4\frac{(M_1)}{M_2}$, 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) $1.0 - 0.4\frac{(f_c)}{\phi_c F_e}$, or 0.85, whichever is less

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

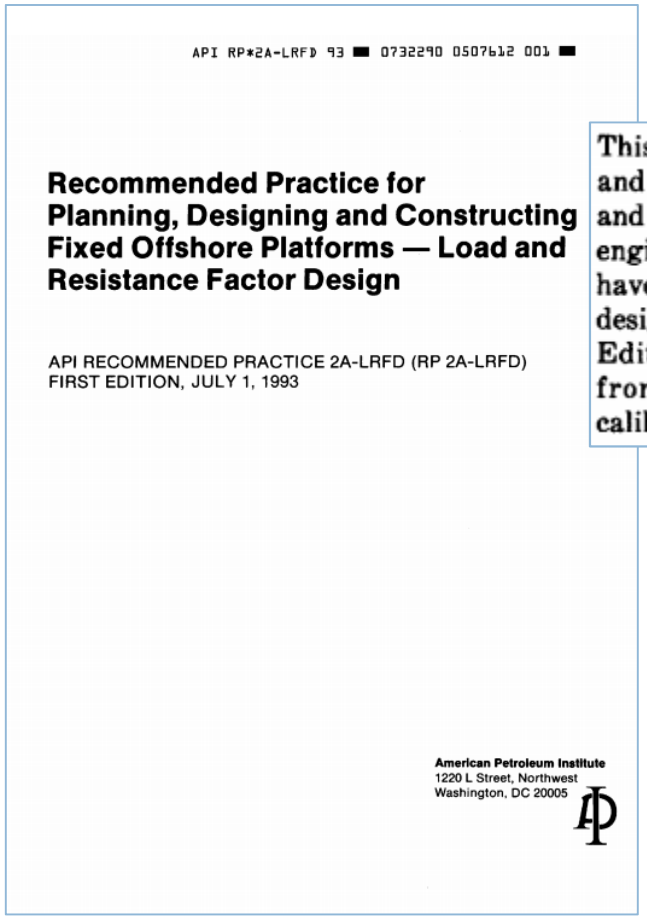


In SDC Verifier B = minimum from (b) and (c)

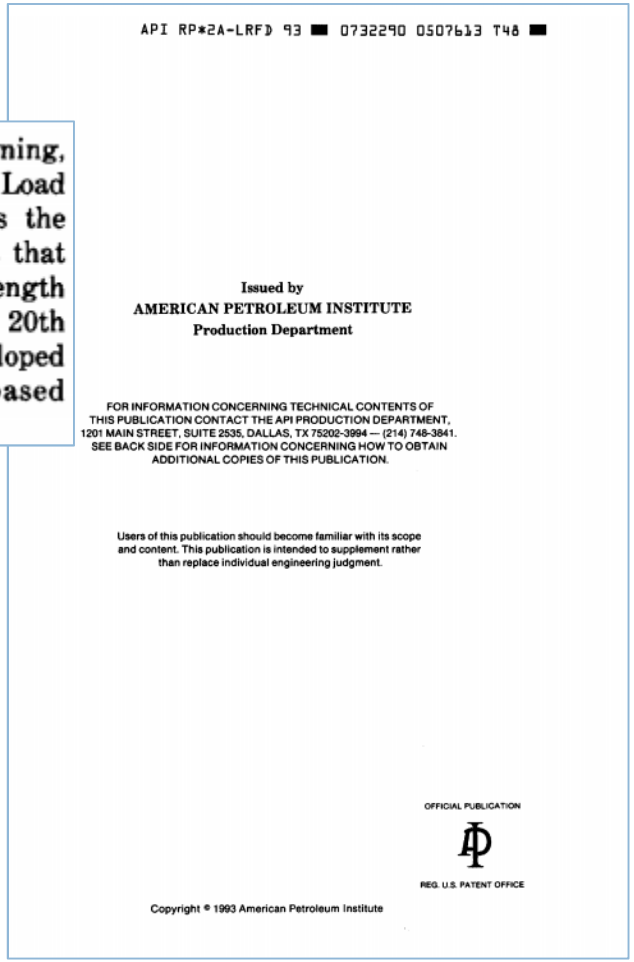
Cmy and Cmz factors for ISO 19902 can be found in the Table 13.5-1 and are used in the formula 13.3-3.

Cmy and Cmz factors for Norsok N004 Rev3 can be found in the Table 6-2 and are used in the formula 6.27

API RP 2A-LRFD

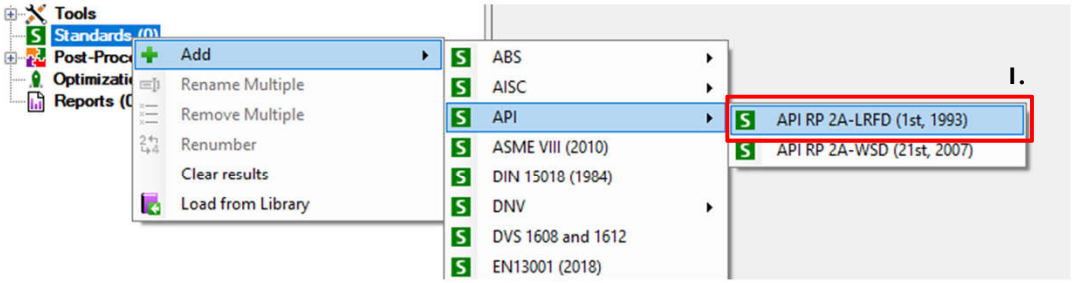


This "Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms — Load and Resistance Factor Design" (LRFD) contains the engineering design principles and good practices that have been the basis of the API RP2A working strength design (WSD) recommended practice, now in its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



Add API RP 2A-LRFD standard

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



SECTION D
CYLINDRICAL MEMBER DESIGN

C_x = critical elastic buckling coefficient

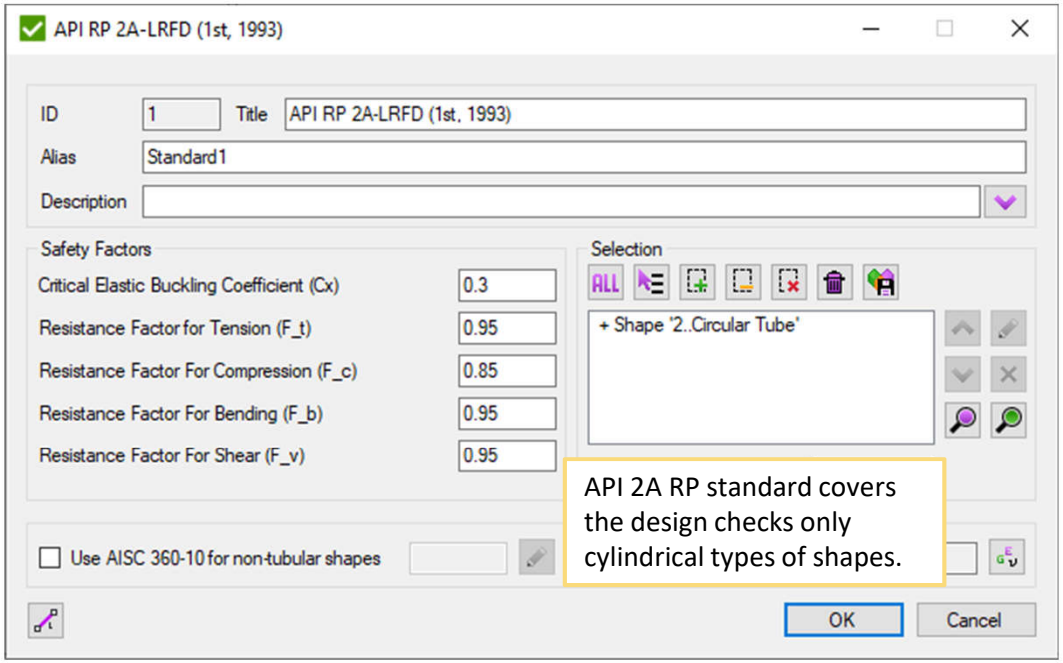
The theoretical value of C_x is 0.6. However, a reduced value of C_x = 0.3 is recommended for use in Equation D.2.2-3 to account for the effect of initial geometric imperfections within API Spec 2B tolerance limits, Reference D2.

ϕ_t = resistance factor for axial tensile strength, 0.95

ϕ_c = resistance factor for axial compressive strength, 0.85

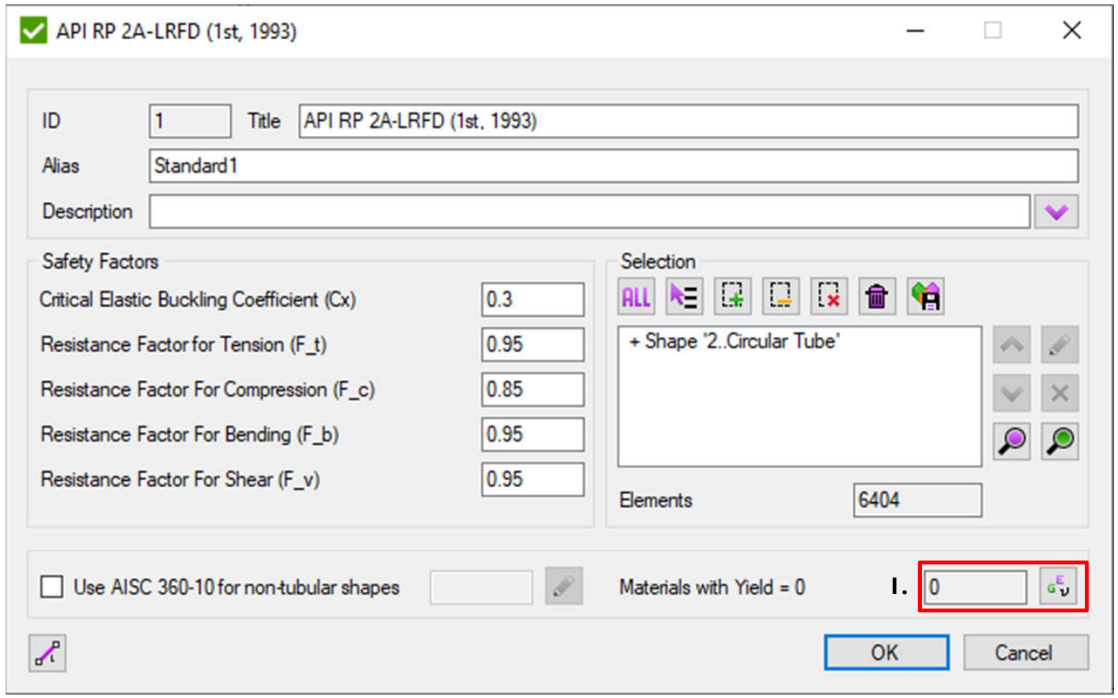
ϕ_b = resistance factor for bending strength, 0.95.

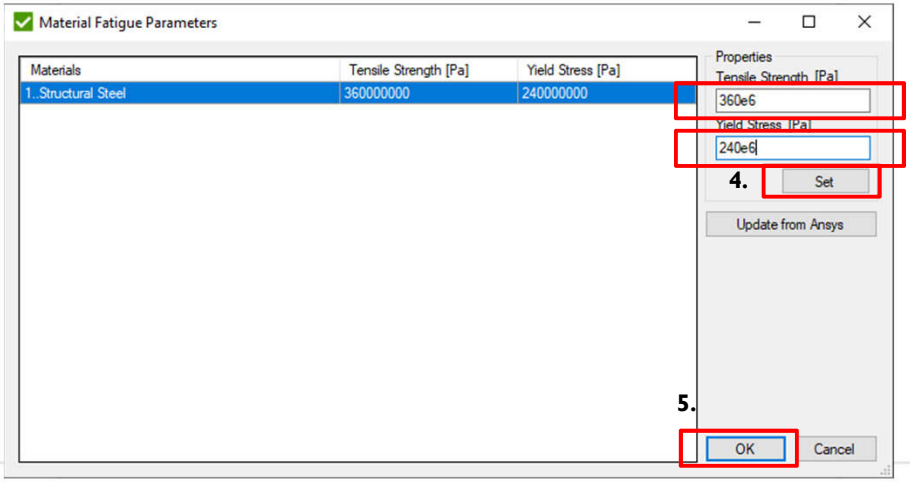
ϕ_v = resistance factor for beam shear strength, 0.95



Define Material Characteristics

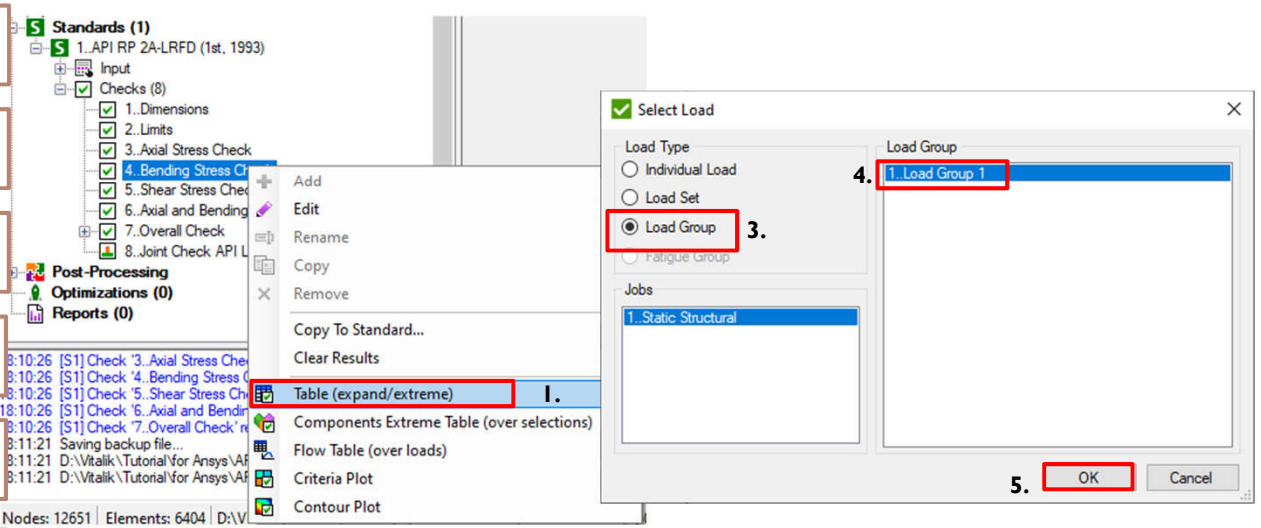
1. Press  to set the material yield stress and tensile strength
2. Tensile Strength: **360e6**
3. Yield Stress: **240e6**
4. Press *Set*
5. Press *OK*

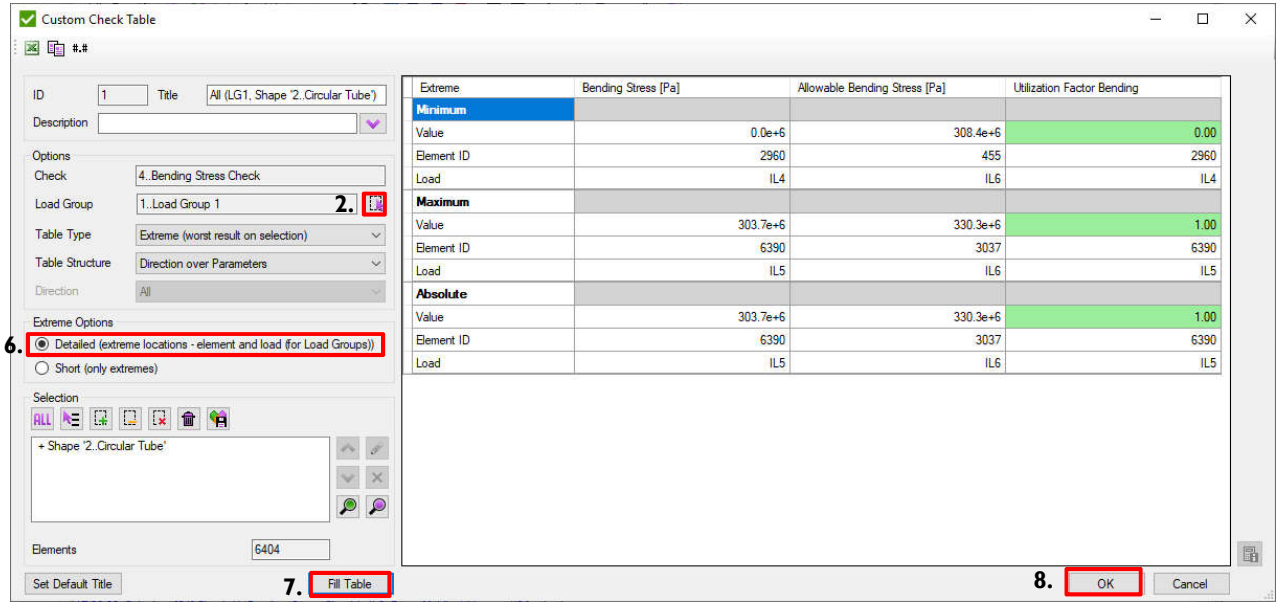




Extreme table for bending check

1. Execute *Table* from the **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*

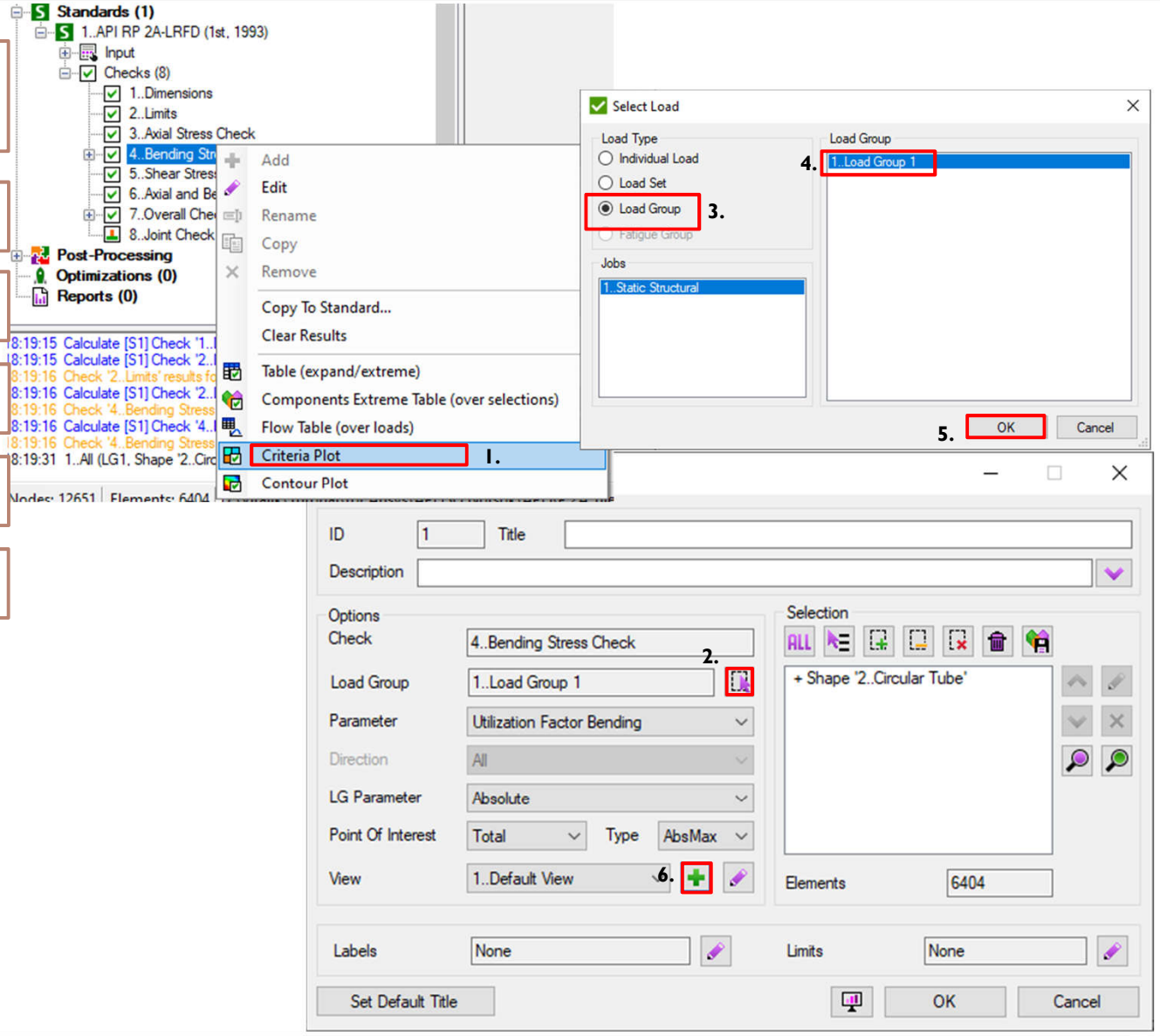




Overall Check contains results from all checks. With the help of one table/plot it is possible to verify if the model passes the checks (< 1). Overall Utilization Factor = worst Uf among all checks.

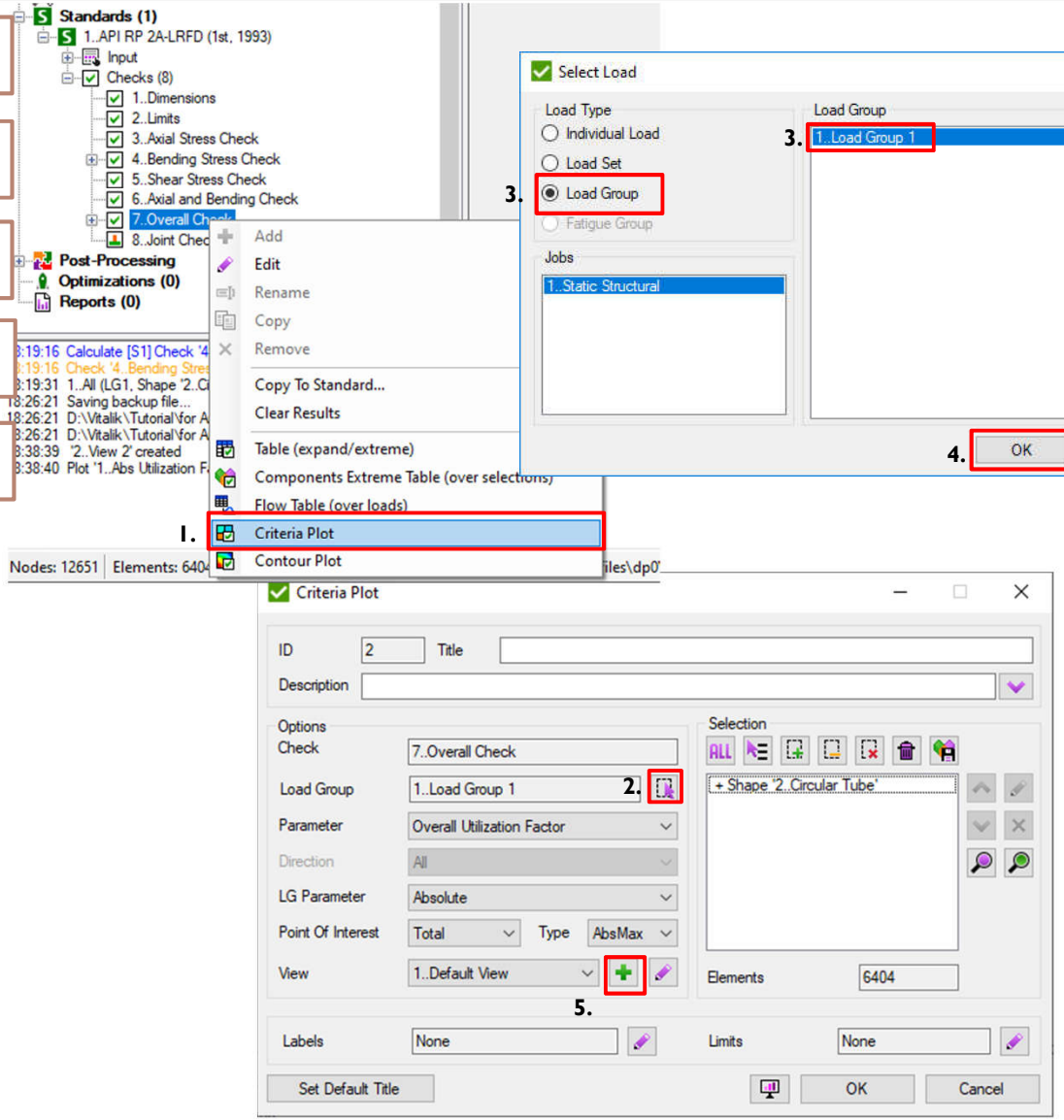
Criteria Plot for Bending Stress Check

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



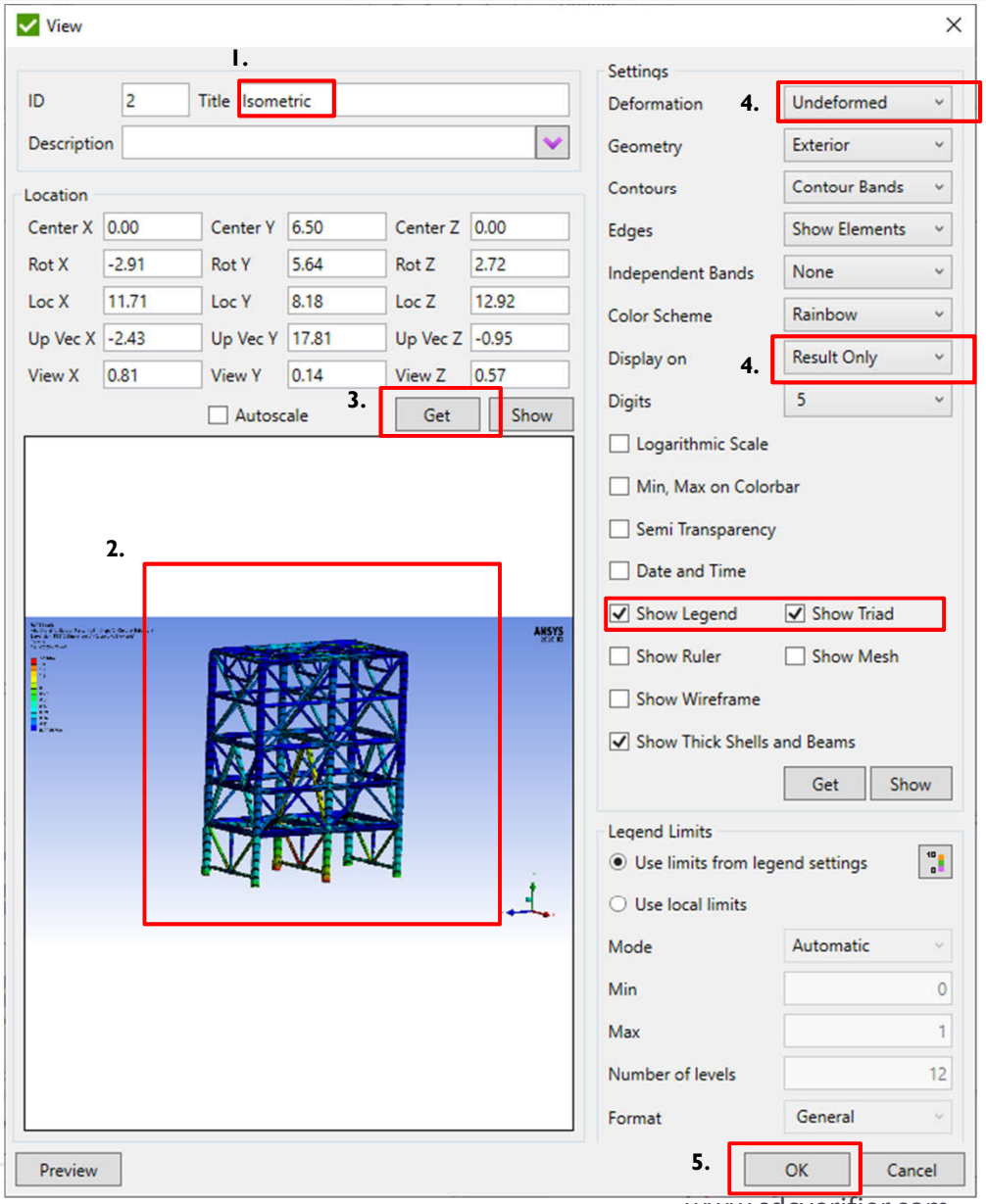
Criteria plot for overall check

1. Execute from **Overall Check** context menu
2. Press to select load
3. Load Type: **Load Group.** Load: **1..Load Group 1**
4. Press *OK*
5. Press to add view



Plot. Create View

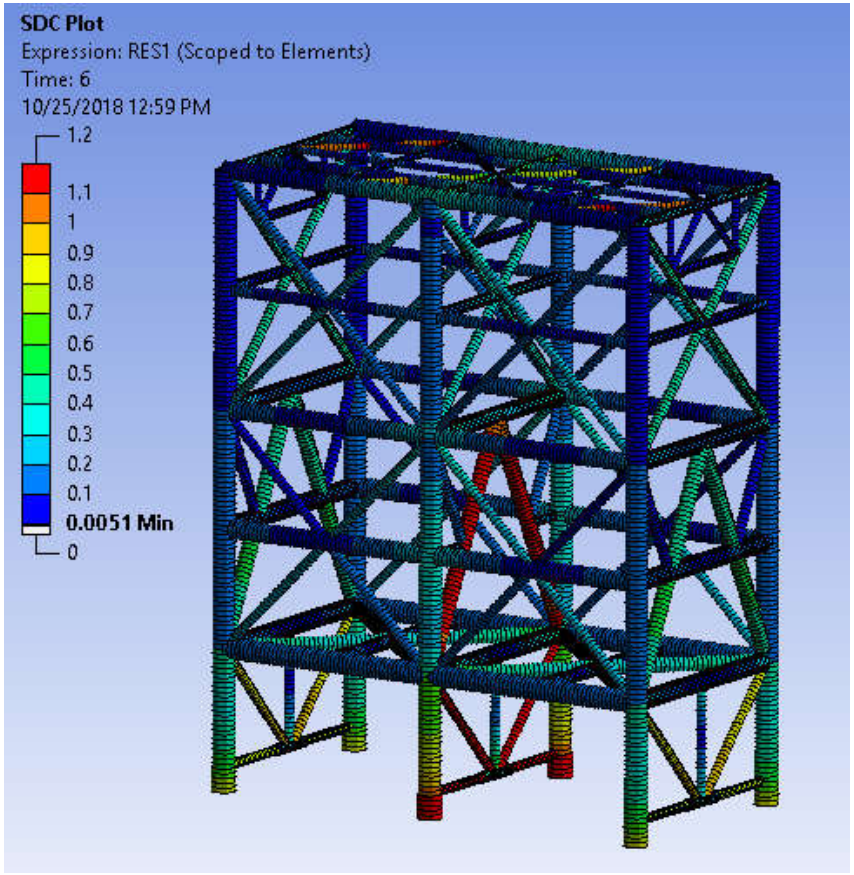
1. Title: **Isometric**
2. Orient model in Ansys Mechanical as shown on the picture
3. Press *Get*
4. Deformation: **Undeformed**
   Display on: **Result Only**
   Show Legend: **On**
   Show Triad: **On**
5. Press *OK*

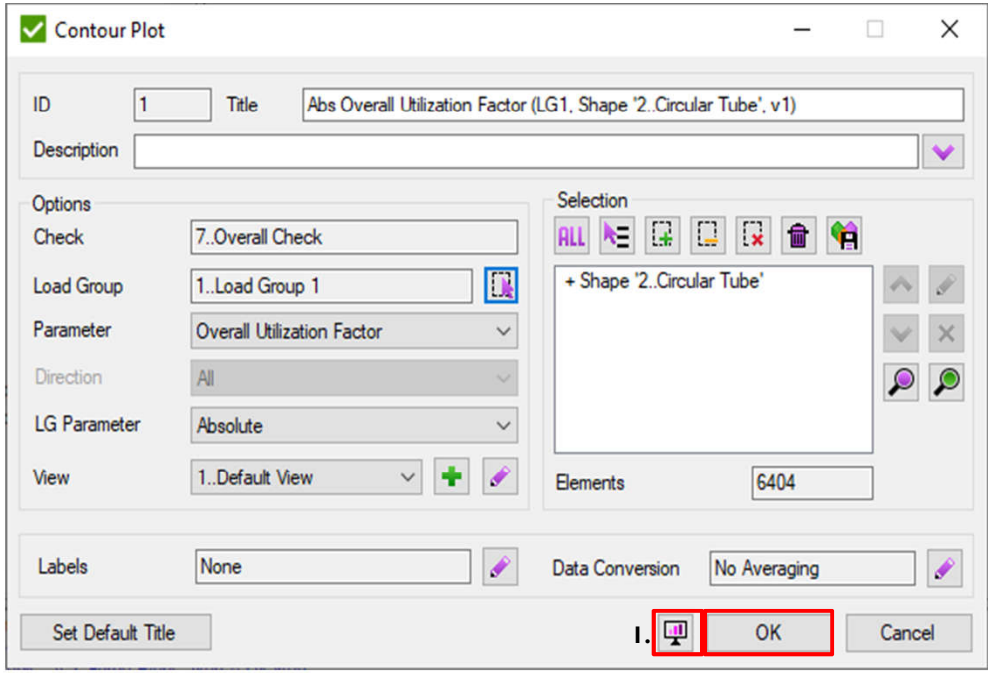


Display Plot

1. Press  to display plot

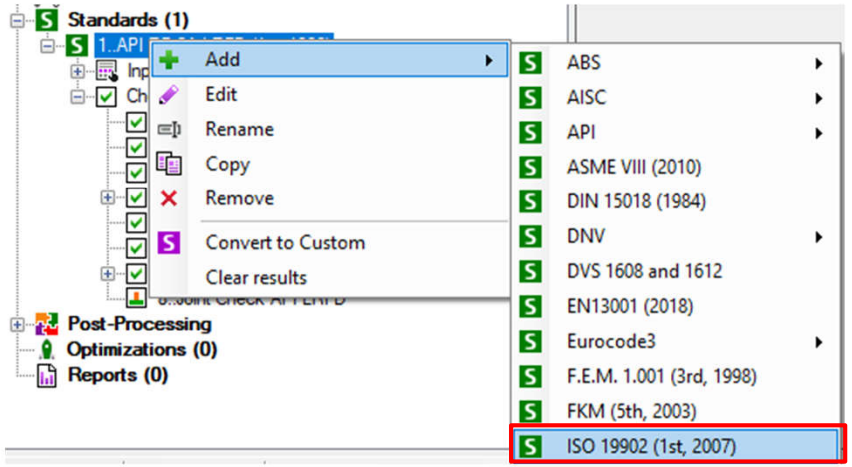
2. Press *OK*



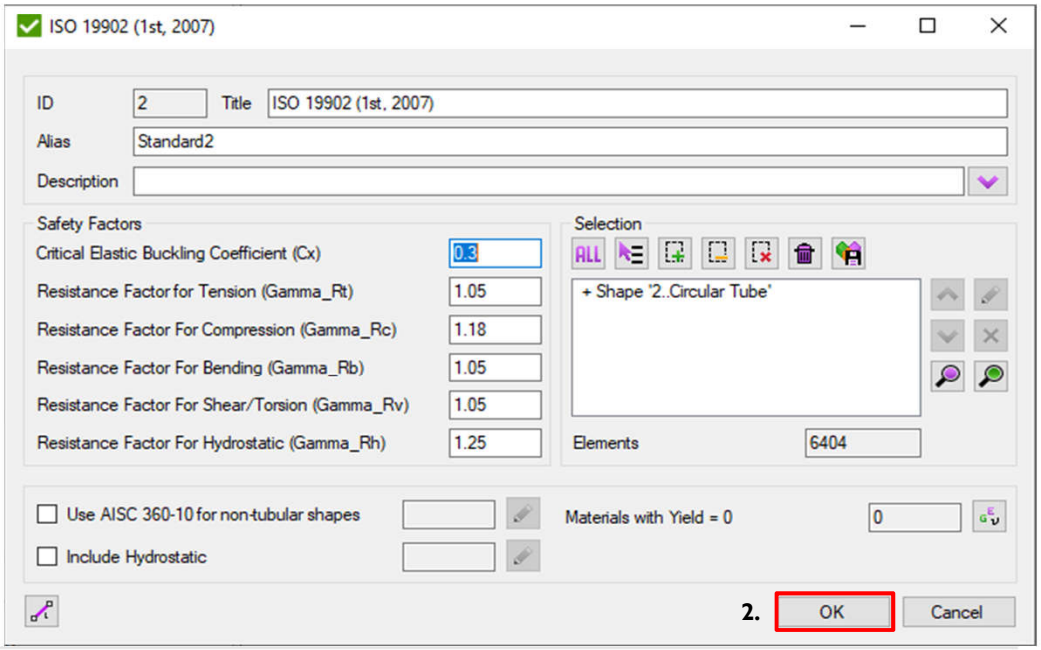


Add ISO 19902 standard

1. Execute *Standards => Add => ISO 19902 (1st, Dec 2007).*
2. Press *OK*



1.



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.

ISO 19902 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, $\gamma_{R,c} = 1,18$.

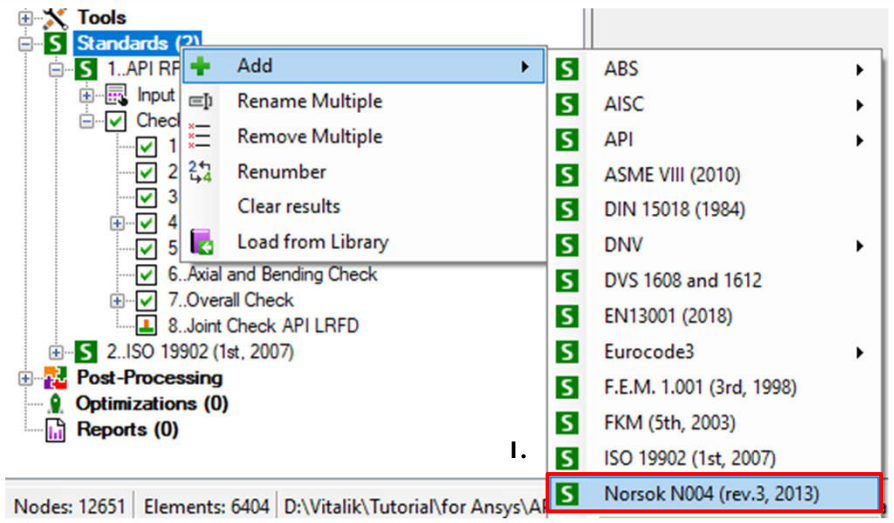
$\gamma_{R,b}$ is the partial resistance factor for bending strength, $\gamma_{R,b} = 1,05$;

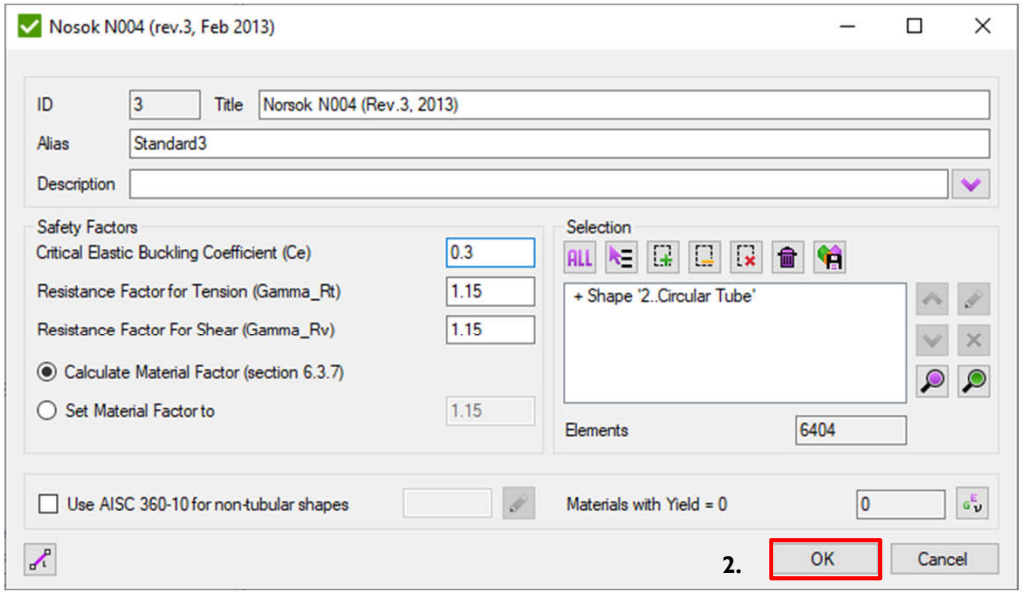
$\gamma_{R,v}$ is the partial resistance factor for shear strength, $\gamma_{R,v} = 1,05$;

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

Add Norsok N004 standard

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





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.

Add Norsok N004 standard

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

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

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

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

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.

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

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

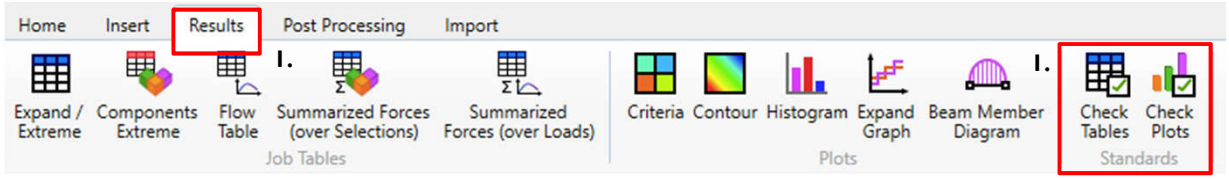
$\sigma_{p,Sd}$ is obtained from Equation (6.16) and

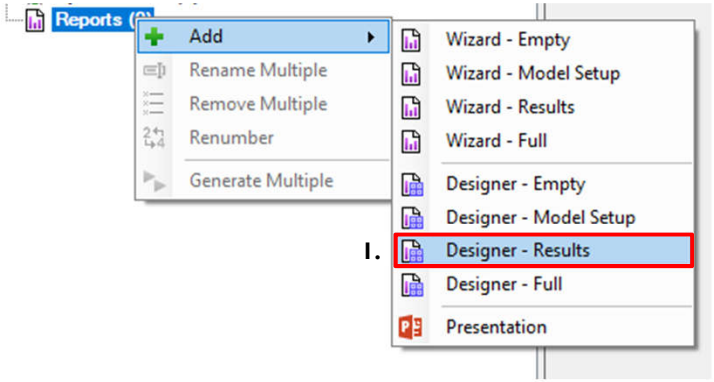
$$\sigma_{c,Sd} = \frac{N_{Sd}}{A} + \frac{\sqrt{M_{y,Sd}^2 + M_{z,Sd}^2}}{W} \qquad (6.25)$$

N_{Sd} is negative if in tension.

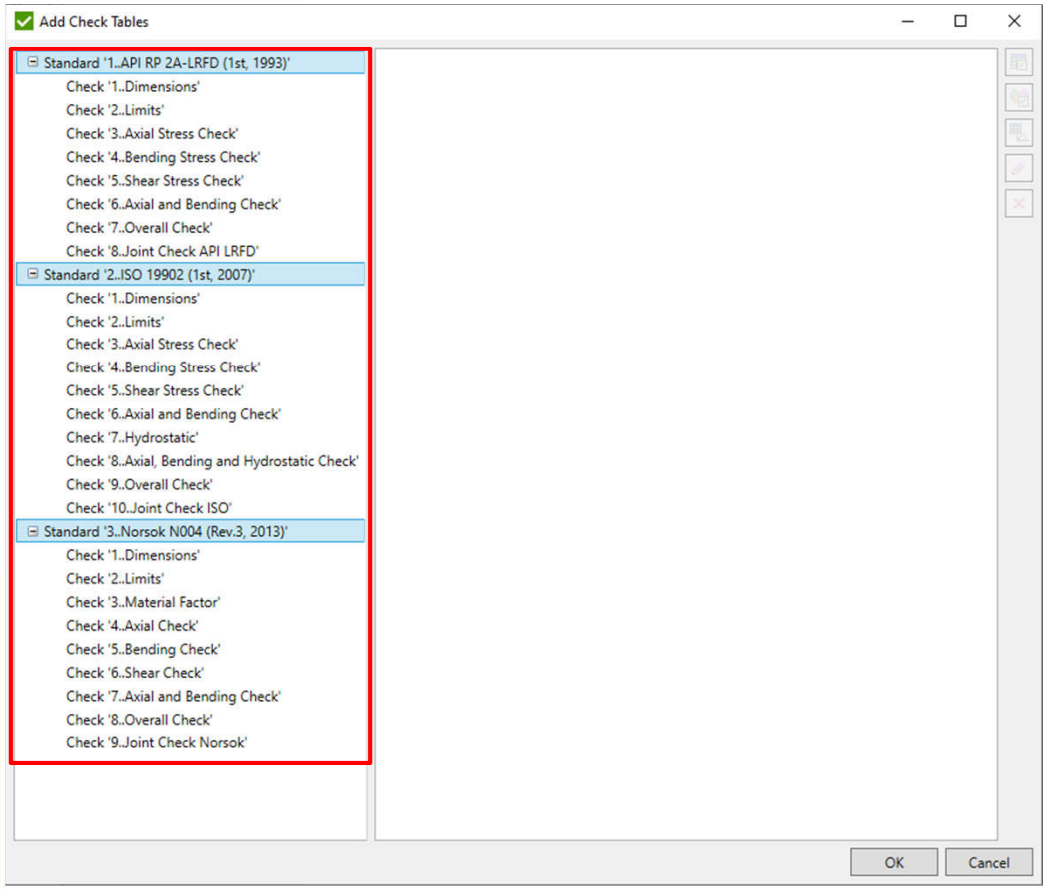
Report

1. Execute *Reports – Add* – Designer – Results.
2. Results – Check Tables/Check Plots - all checks except the **'8.Overall check'** in each standard.





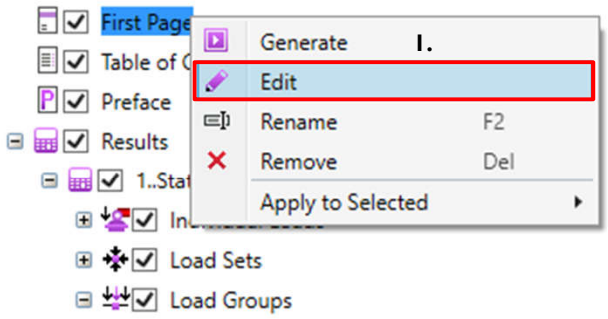
2.

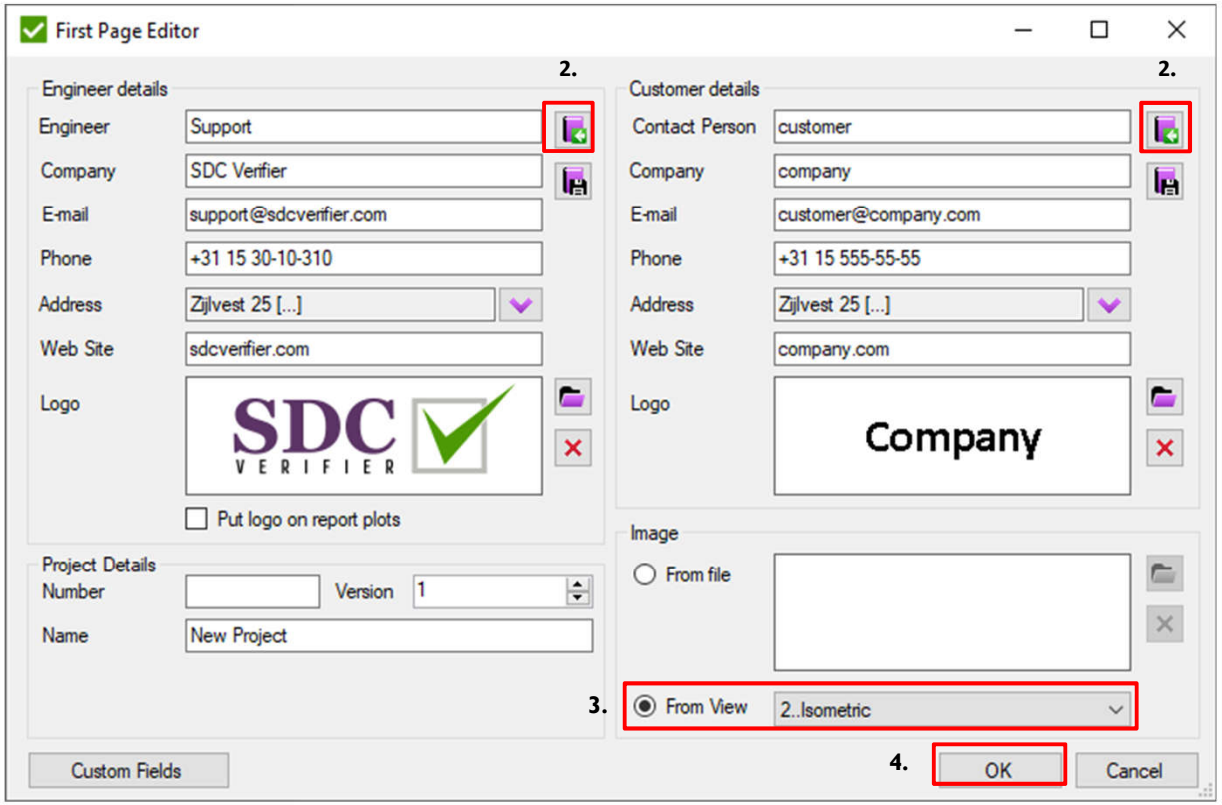


There are 4 templates of the reports:
Empty – only first page and preface items are included;
Model Setup – description of the model data (materials, properties, components, boundary conditions) is included;
Results – for each load extreme displacement tables, stress and displacement plots are included.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

Report. First Page

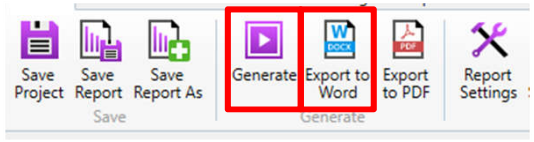
1. Right click on *First Page => Edit.*
2. Press  to load engineer and customer info from library
3. Select Image *From View* and pick '*2..Isometric*'.
4. Press *OK*.





Report exported to Microsoft Word

Press to generate complete report.



Press to export to Word.

First page

Report

New Project

Prepared by: SDC Verifier +31 15 30-10-310 sdcverifier.com Zijlvest 25 2011 VB Haarlem The Netherlands

Prepared for: company +31 15 555-55-55 company.com Zijlvest 25 2011 VB Haarlem The Netherlands

Engineer: Support
Customer: customer
Project Number:
Version: 1
Date: 07/12/2020

API 2A RP

Overall Check

Plot Profiles

ISO 19902

Norsok N004