



# Tutorial

## **API 2A RP/ISO 19902/Norsok N004**

17.01.2020  
version 5.3

- ▶ In this tutorial, an API 2A RP Beam Design Checks are reviewed in details.
- ▶ 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.

# Open Project

1

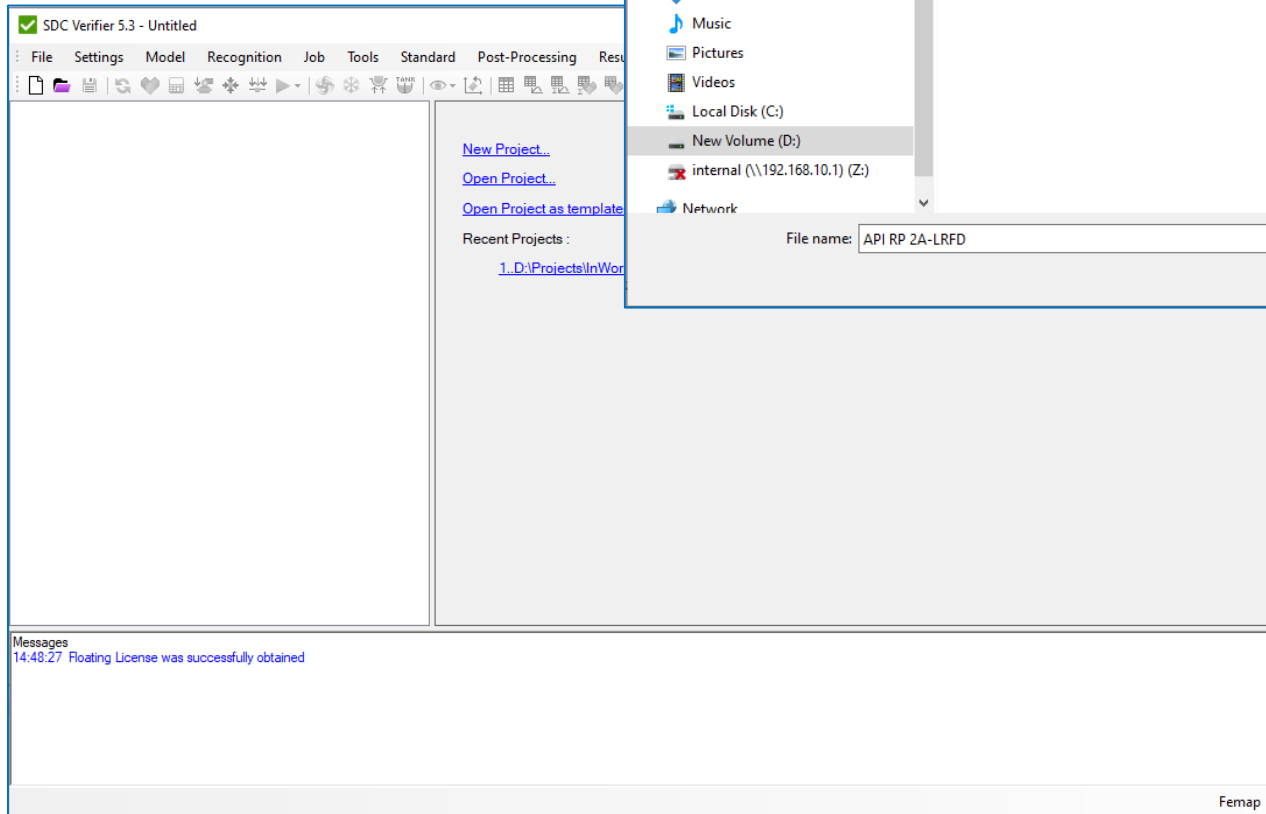
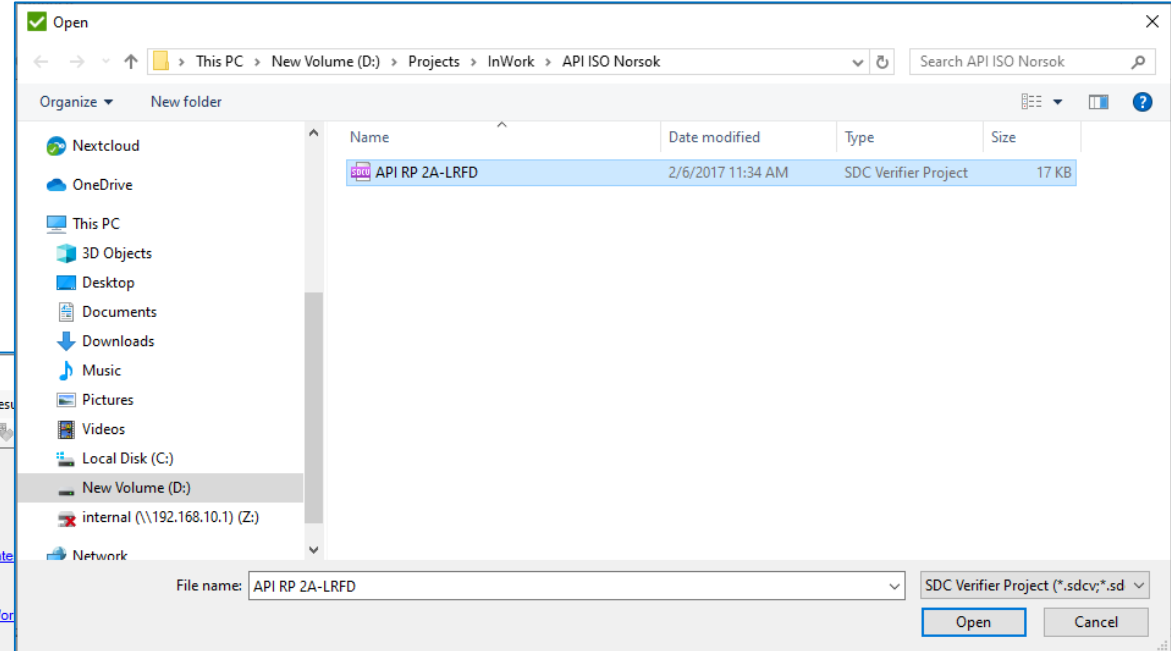
Launch **SDC Verifier** 

2

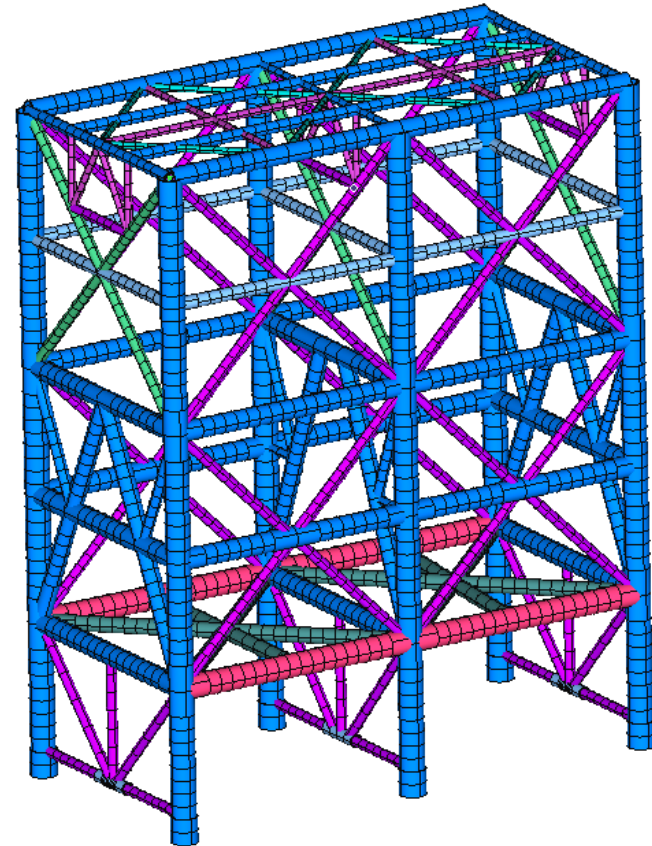
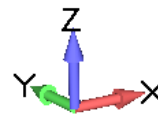
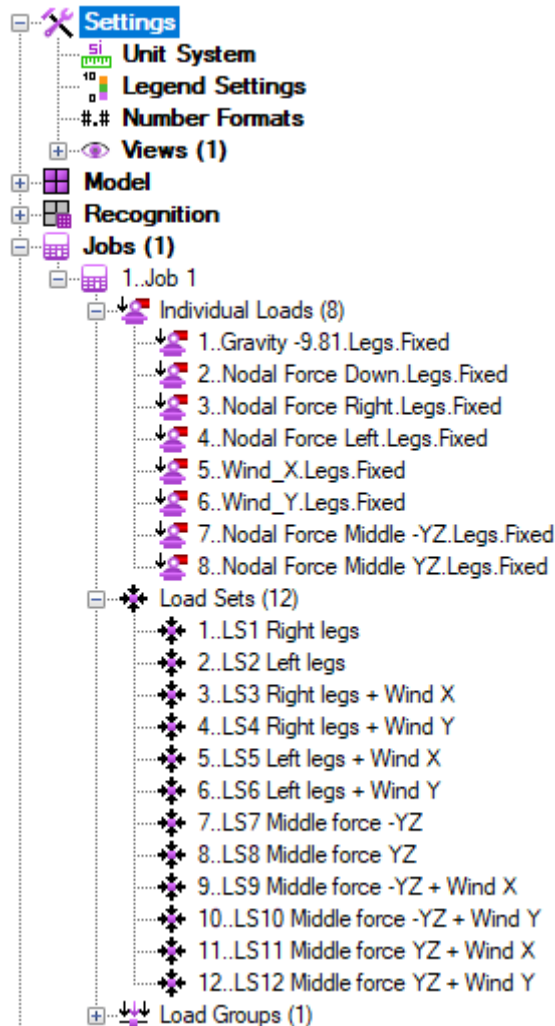
Execute *File - Open Project*.

3

Project: **API RP 2A-LRFD.sdcv**



# Predefined project

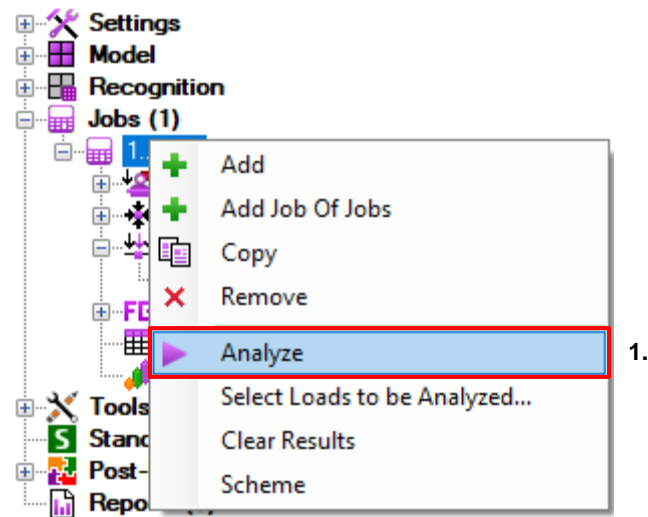


This tutorial uses predefined project with the following created data: individual loads, load sets and load group. The focus of this tutorial is to check the cylindrical members and create the basic report.

# Analyze Job

1

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



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;

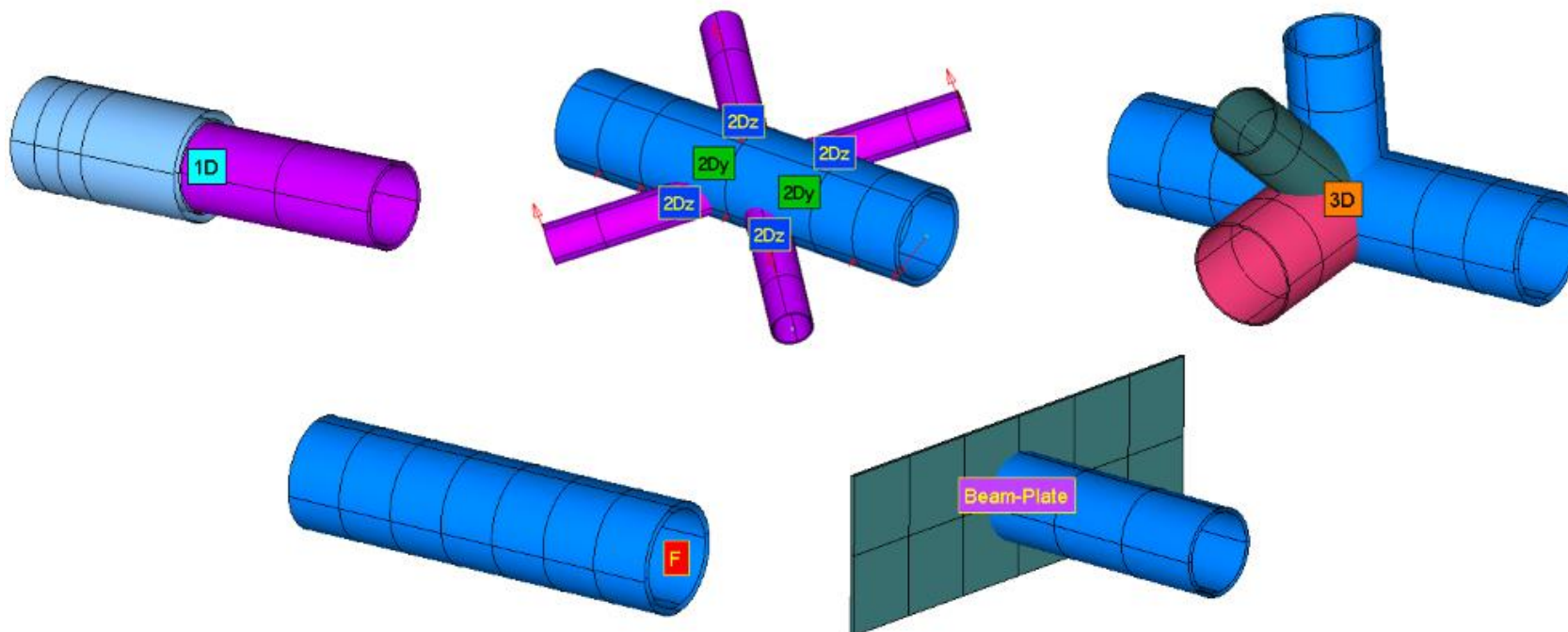
2D Joint – beam members connected in one plane;

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;



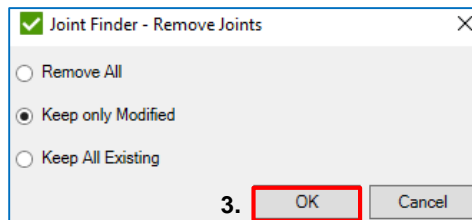
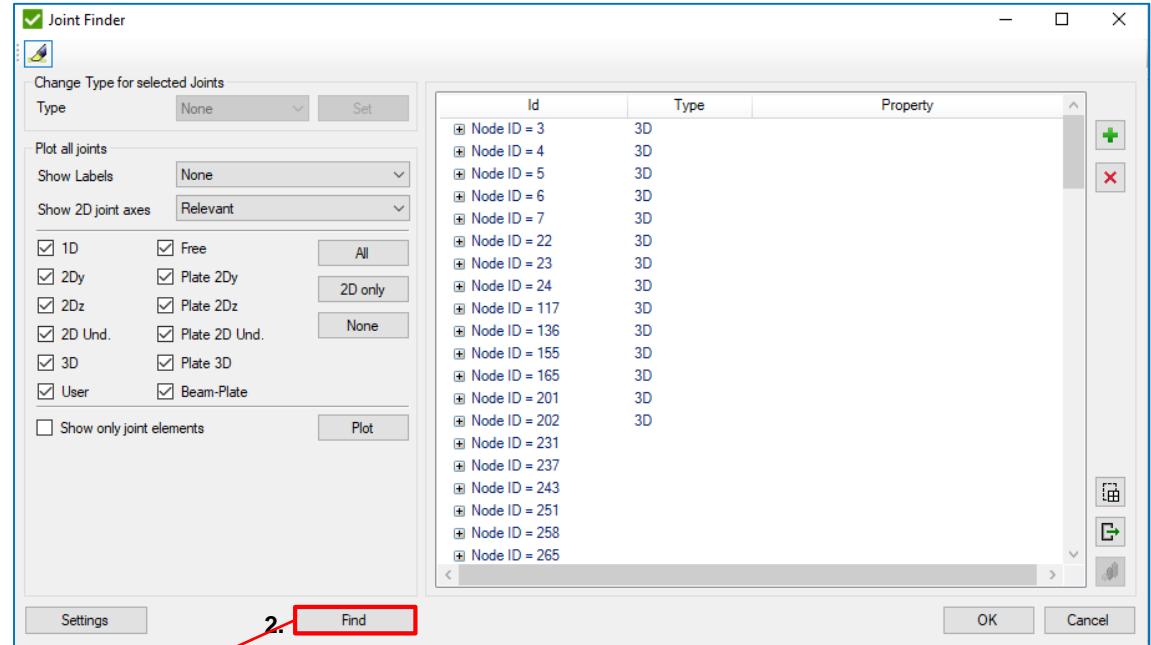
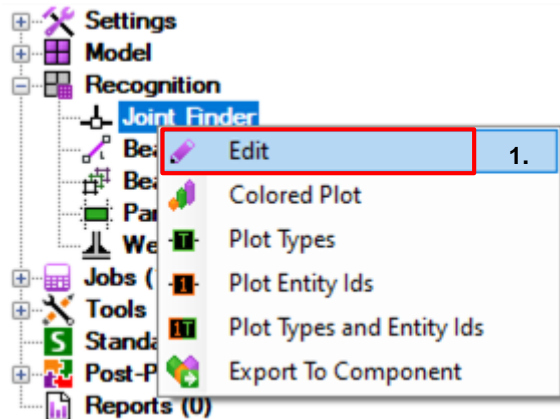
# Joint Recognition

1 Execute *Edit* from *Joints* context menu

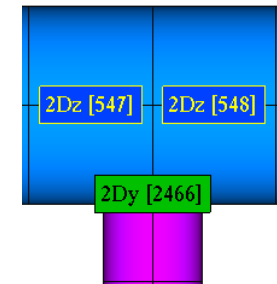
2 Press *Find*.

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.




Node ID = 719			
Element ID = 547	2Dz	8..400x19	
Element ID = 548	2Dz	8..400x19	
Element ID = 2466	2Dy	14..200x10	



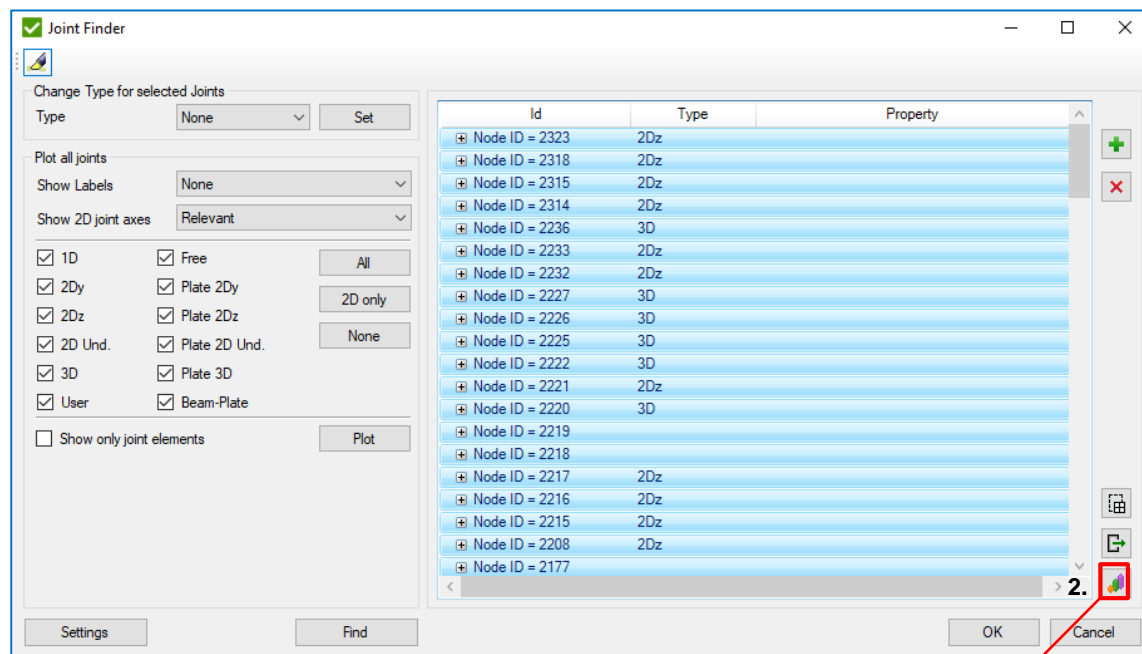
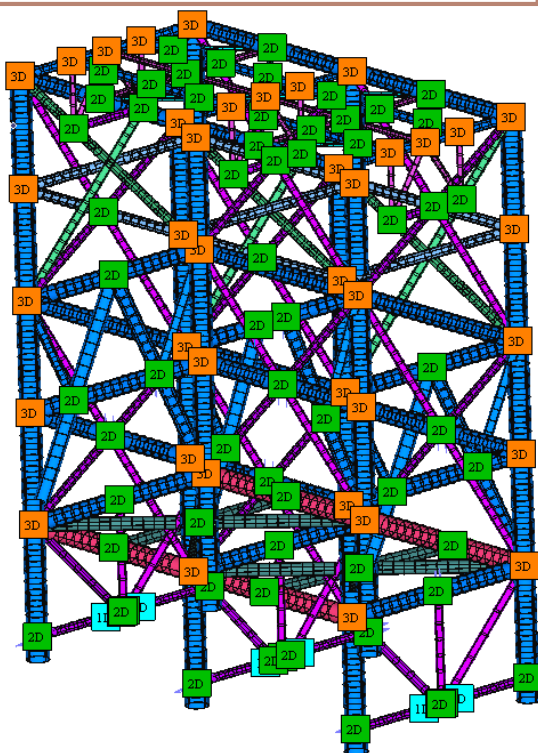
# Joints Plot

1 Select All Joints (Ctrl+A).

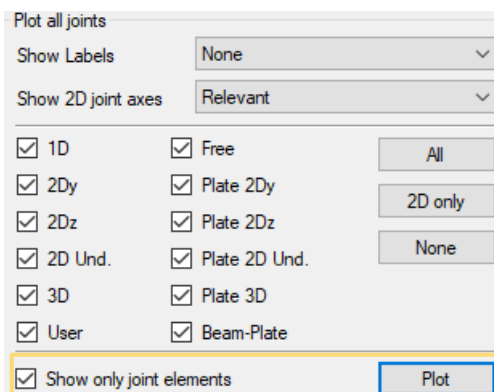
2 Press 



3 Press  Plot Joint Type Labels

4 Press OK

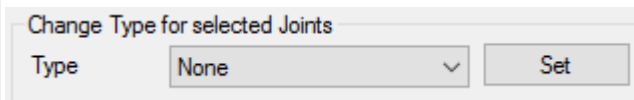


Plot Joints of specific type:



3.  Plot Joint Type Labels  
 Plot Joint Type in colors

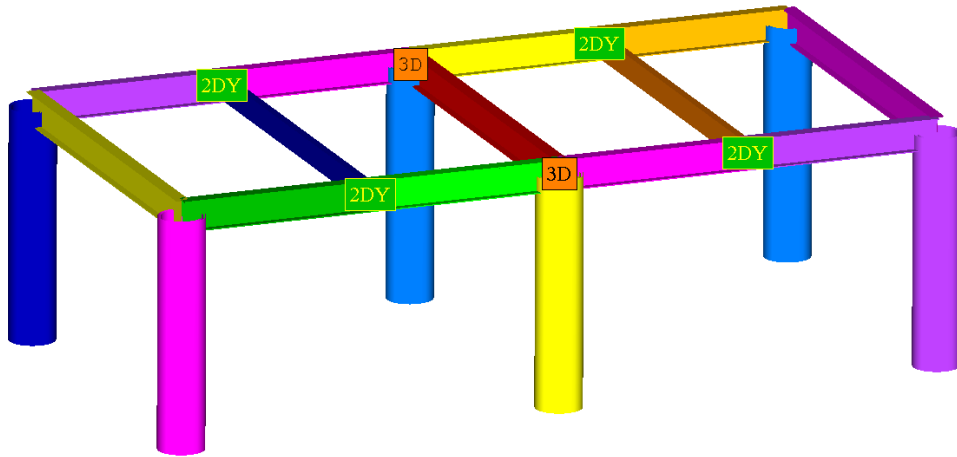
Modify Joint Type:



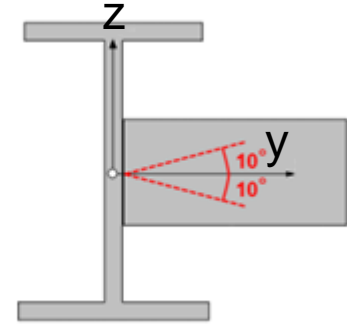


# Beam Member Lengths in 2 directions

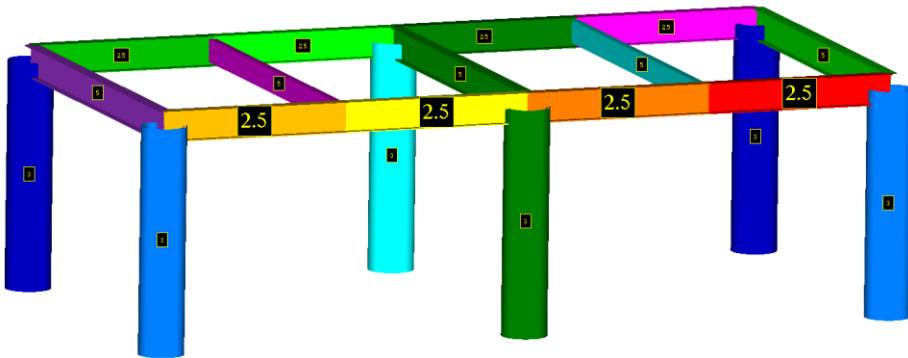
Beam Member Finder recognizes beam members and (buckling) lengths for different directions (Y, Z and Torsional).



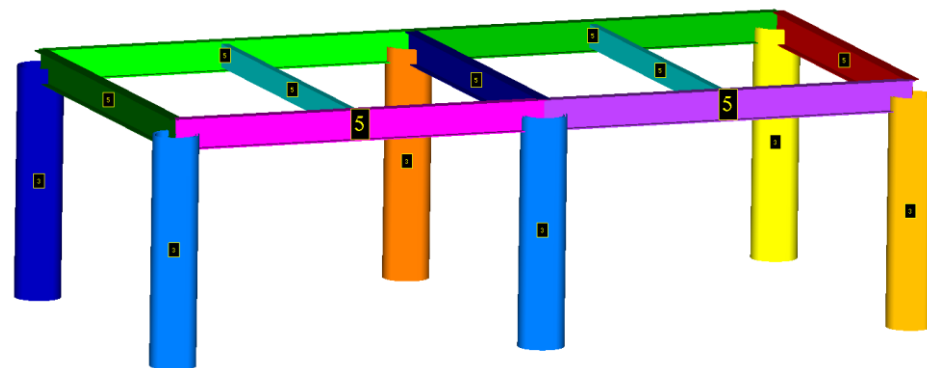
2DY  
Joint



Length Y – 4 Beam Members with  $L = 2.5$



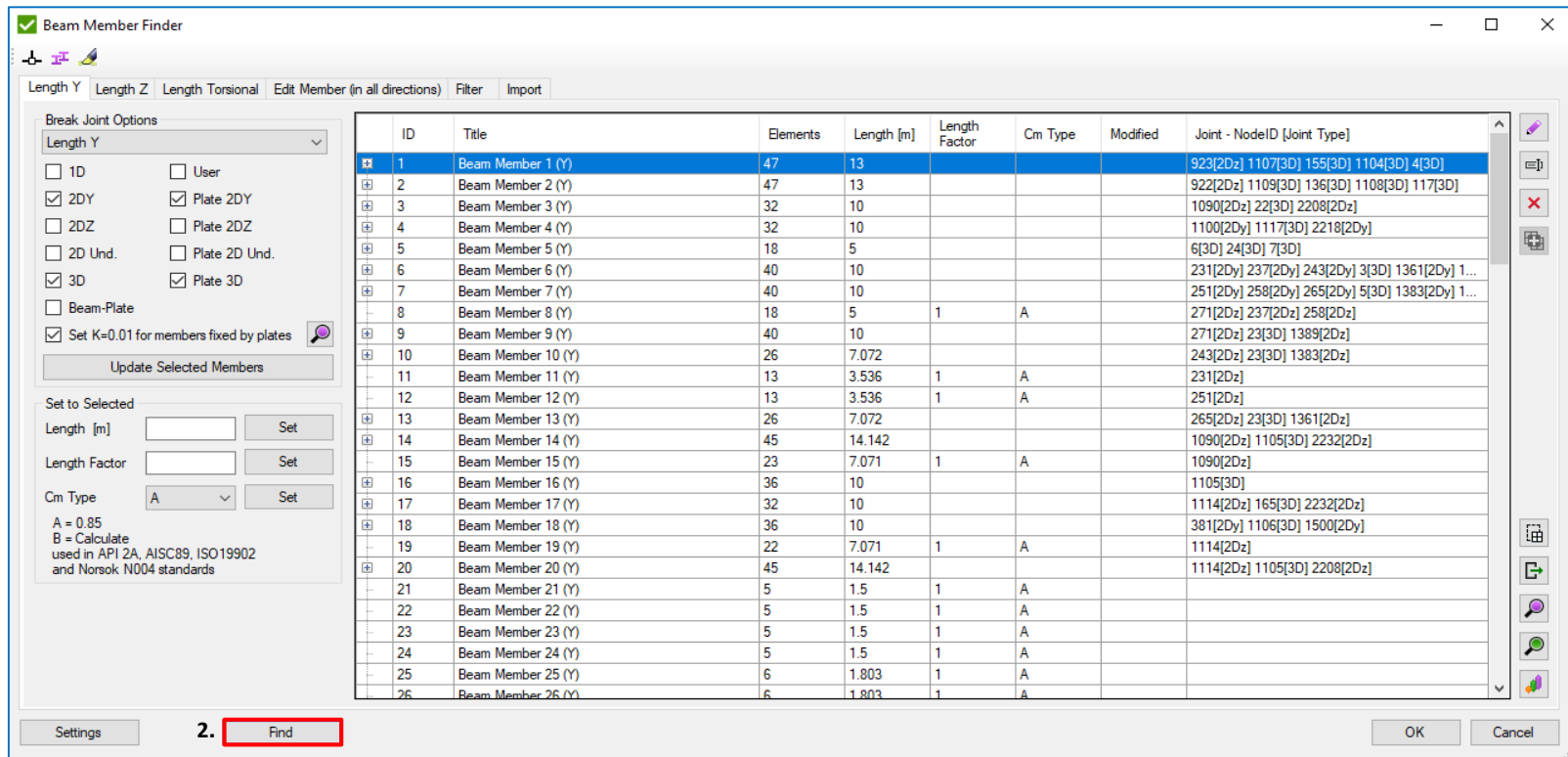
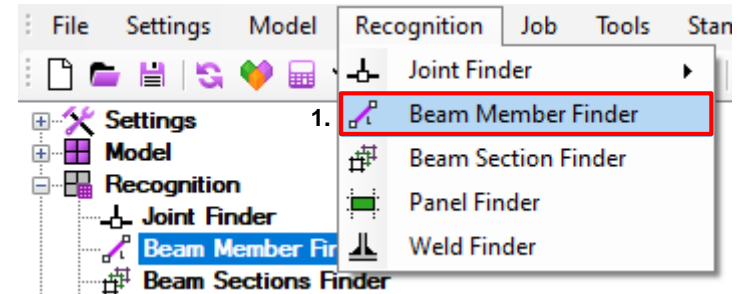
Length Z – 2 Beam Members with  $L = 5$



# Recognize Length

1 Execute *Recognition – Beam Member Finder*

2 Press *Find*.



# Beam Member Finder interface

Beam Member Finder

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

Break Joint Options  
Torsion (Lb)  
☐ 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, ISO 19902  
 and Norsok N004 standards

ID	Title	Elements	Length [m]	Length Factor	Cm Type	Modified	Joint - NodeID [Joint Type]
1	Beam Member 1 (T)	47	13				923[2Dz] 1107[3D] 155[3D] 1104[3D] 4[3D]
2	Beam Member 2 (T)	47	13				922[2Dz] 1109[3D] 136[3D] 1108[3D] 117[3D]
3	Beam Member 3 (T)	32	10				1090[2Dz] 22[3D] 2208[2Dz]
4	Beam Member 4 (T)	32	10				1100[2Dz] 1117[3D] 2218[2Dz]
5	Beam Member 5 (T)	18	5				6[3D] 24[3D] 7[3D]
6	Beam Member 6 (T)	40	10				231[2Dz] 237[2Dz] 243[2Dz] 3[3D] 1361[2Dz] 1...
7	Beam Member 7 (T)	40	10				251[2Dz] 258[2Dz] 265[2Dz] 5[3D] 1383[2Dz] 1...
8	Beam Member 8 (T)	18	5				271[2Dz] 237[2Dz] 258[2Dz]
9	Beam Member 9 (T)	40	10				271[2Dz] 237[3D] 1389[2Dz]
10	Beam Member 10 (T)	26	7.07				243[2Dz] 23[3D] 1383[2Dz]
11	Beam Member 11 (T)	13	3.535				231[2Dz]
12	Beam Member 12 (T)	13	3.535				251[2Dz]
13	Beam Member 13 (T)	26	7.07				265[2Dz] 23[3D] 1361[2Dz]
14	Beam Member 14 (T)	45	14.144				1090[2Dz] 1105[3D] 2232[2Dz]
15	Beam Member 15 (T)	23	7.072				1090[2Dz]
16	Beam Member 16 (T)	36	10				1105[3D]
17	Beam Member 17 (T)	32	10				1114[2Dz] 165[3D] 2232[2Dz]
18	Beam Member 18 (T)	36	10				381[2Dz] 1106[3D] 1500[2Dz]
19	Beam Member 19 (T)	22	7.072				1114[2Dz]
20	Beam Member 20 (T)	45	14.144				1114[2Dz] 1105[3D] 2208[2Dz]
21	Beam Member 21 (T)	5	1.5	1	A		
22	Beam Member 22 (T)	5	1.5	1	A		
23	Beam Member 23 (T)	5	1.5	1	A		
24	Beam Member 24 (T)	5	1.5	1	A		
25	Beam Member 25 (T)	6	1.803	1	A		
26	Beam Member 26 (T)	6	1.803	1	A		

Settings Find OK Cancel

Break Options define what joints are used to split beam members

Change Length/Length Factor for selected beam members

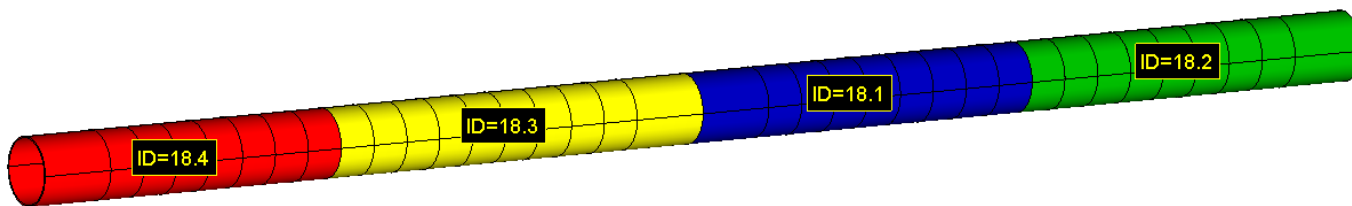
Cm Type is used in API 2A, AISC89, ISO 19902 and Norsok N004 standards

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

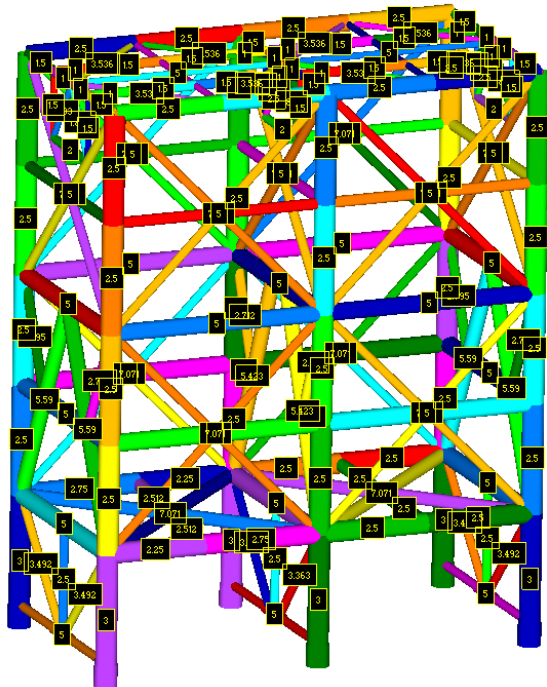
- Plot selected members
- Plot Members ID labels
- Plot Full Members ID labels
- Plot Length labels
- Plot Cm Type labels
- Plot Length Factor labels
- Plot Joints for Selected Members
- Plot Members Y and Z axes

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


ID	Title	Elements	Length [m]	Length Factor	Cm Type	Modified	Joint - NodeID [Joint Type]
18	Beam Member 18 (T)	36	10				381[2Dz] 1106[3D] 1500[2Dz]
18.1	Beam Member 18.1 (T)	9	2.5	1	A		
18.2	Beam Member 18.2 (T)	9	2.5	1	A		
18.3	Beam Member 18.3 (T)	10	2.75	1	A		
18.4	Beam Member 18.4 (T)	8	2.25	1	A		



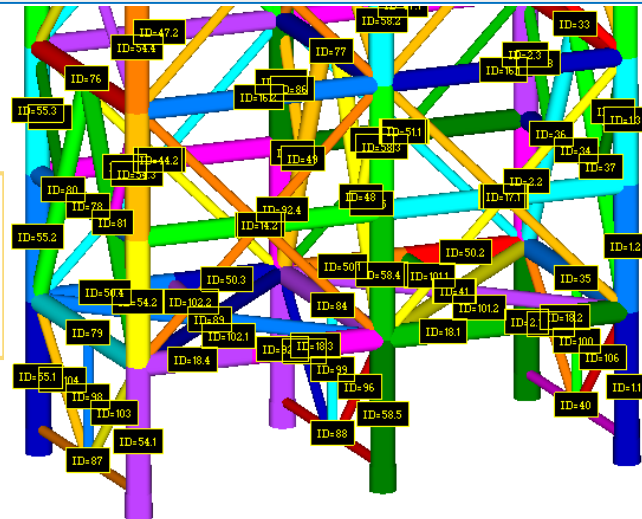
- 4 ) Press *OK*



- 1 Plot Members ID labels

4. 

- Plot selected members
- 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



# Cm – reduction factors

Cmy and Cmz reduction factors are used in combined axial and bending check:

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

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

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

Cm Type A Set

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

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

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

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

Situation	Effective Length Factor K	Reduction Factor $C_m^{(1)}$
<b>Superstructure Legs</b>		
Braced	1.0	(a)
Portal (unbraced)	$K^{(2)}$	(a)
<b>Jacket Legs &amp; Piling</b>		
Grouted Composite Section	1.0	(c)
Ungouted Jacket Legs	1.0	(c)
Ungouted Piling Between Shim Points	1.0	(b)
<b>Jacket Braces</b>		
Face-to-face Length of Main Diagonals	0.8	(b) or (c)
Face of Leg to Centerline of Joint Length of K-Braces <sup>(3)</sup>	0.8	(c)
Longer Segment Length of X-Braces <sup>(3)</sup>	0.9	(c)
Secondary Horizontals	0.7	(c)
Deck Truss Chord members	1.0	(a),(b) or (c)
<b>Deck Truss Web Members</b>		
In-Plane Action	0.8	(b)
Out-of-Plane Action	1.0	(a) or (b)

API RP\*2A-LRFD 93 ■ 0732290 0507612 001 ■

## **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 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.

API RP\*2A-LRFD 93 ■ 0732290 0507613 T48 ■

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) 748-3641.  
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.

OFFICIAL PUBLICATION



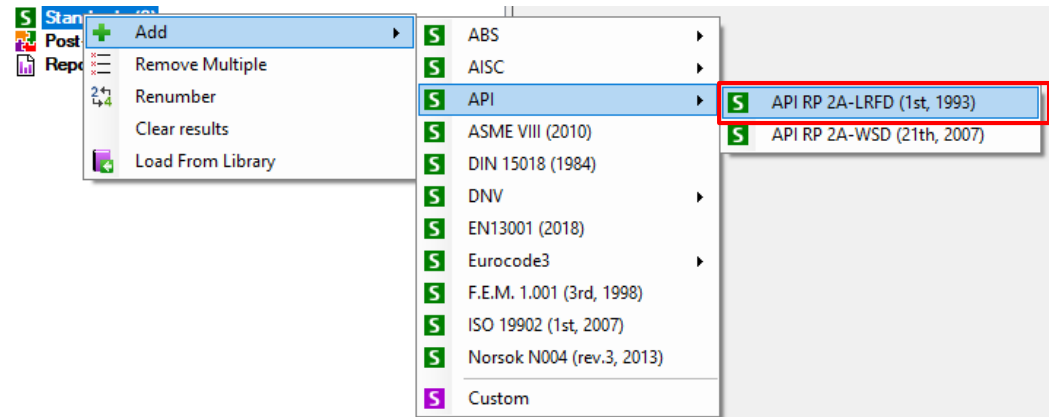
REG. U.S. PATENT OFFICE

Copyright © 1993 American Petroleum Institute

# Add API RP 2A-LRFD standard

1

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



1.

## SECTION D

### CYLINDRICAL MEMBER DESIGN

$C_x$  = critical elastic buckling coefficient

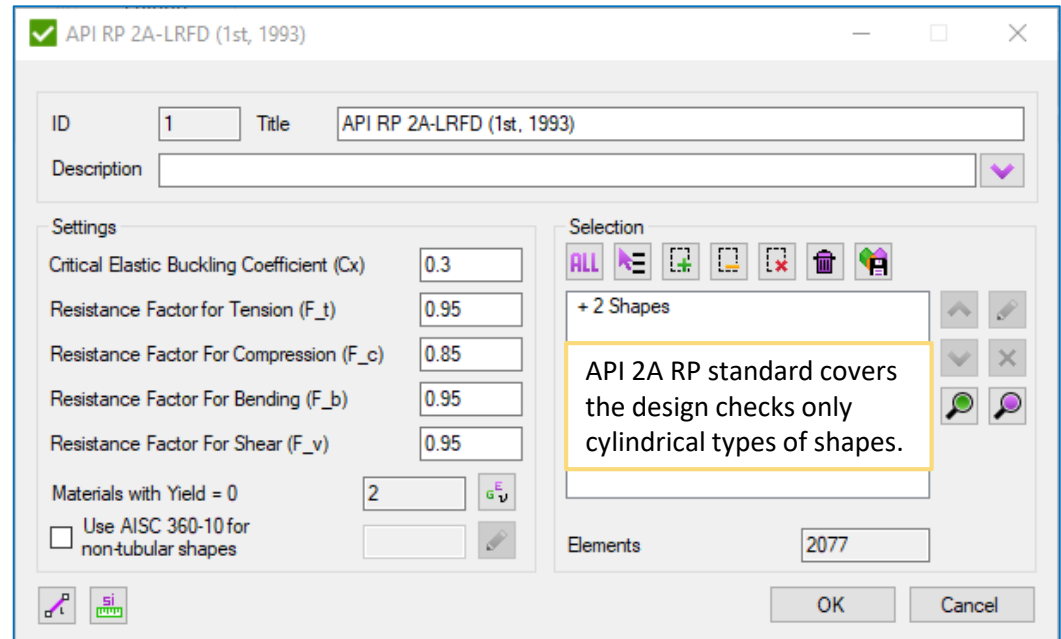
The theoretical value of  $C_x$  is 0.6. However, a reduced value of  $C_x = 0.3$  is recommended for use in Equation D.2.2-3 to account for the effect of initial geometric imperfections within API Spec 2B tolerance limits, Reference D2.

$\phi_t$  = resistance factor for axial tensile strength, 0.95

$\phi_c$  = resistance factor for axial compressive strength, 0.85


$\phi_b$  = resistance factor for bending strength, 0.95.

$\phi_v$  = resistance factor for beam shear strength, 0.95



# Define Material Characteristics

1

Press  to set the material yield stress and tensile strength

2

Select All Materials (Ctrl+A)

3

Tensile Strength: **360e+6 [Pa]**

4

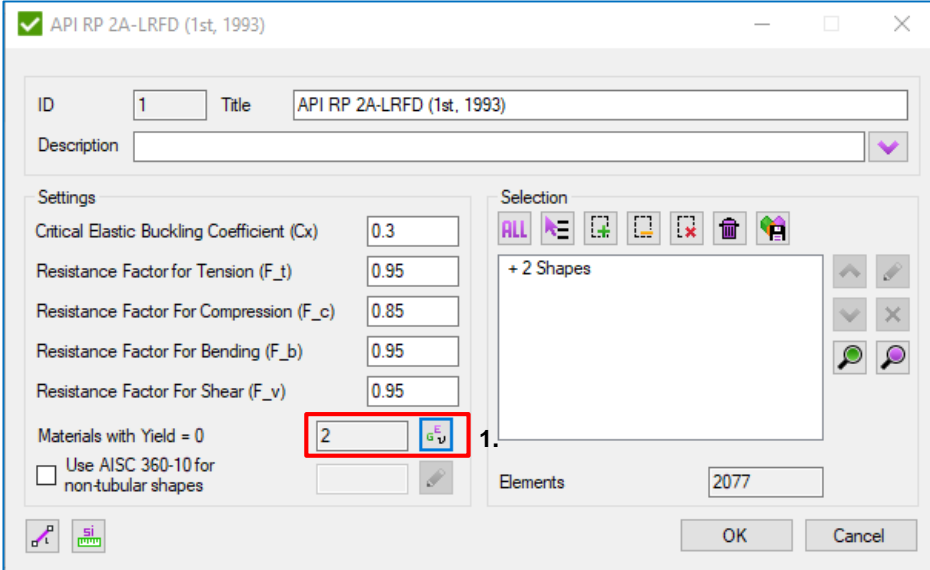
Yield Stress: **240e+6 [Pa]**

5

Press Set

6

Press OK



API RP 2A-LRFD (1st, 1993)

ID: 1 Title: API RP 2A-LRFD (1st, 1993)

Description:

Settings


Critical Elastic Buckling Coefficient (Cx): 0.3

Resistance Factor for Tension (F<sub>t</sub>): 0.95

Resistance Factor For Compression (F<sub>c</sub>): 0.85

Resistance Factor For Bending (F<sub>b</sub>): 0.95

Resistance Factor For Shear (F<sub>v</sub>): 0.95

Materials with Yield = 0: 2 

☐ Use AISC 360-10 for non-tubular shapes

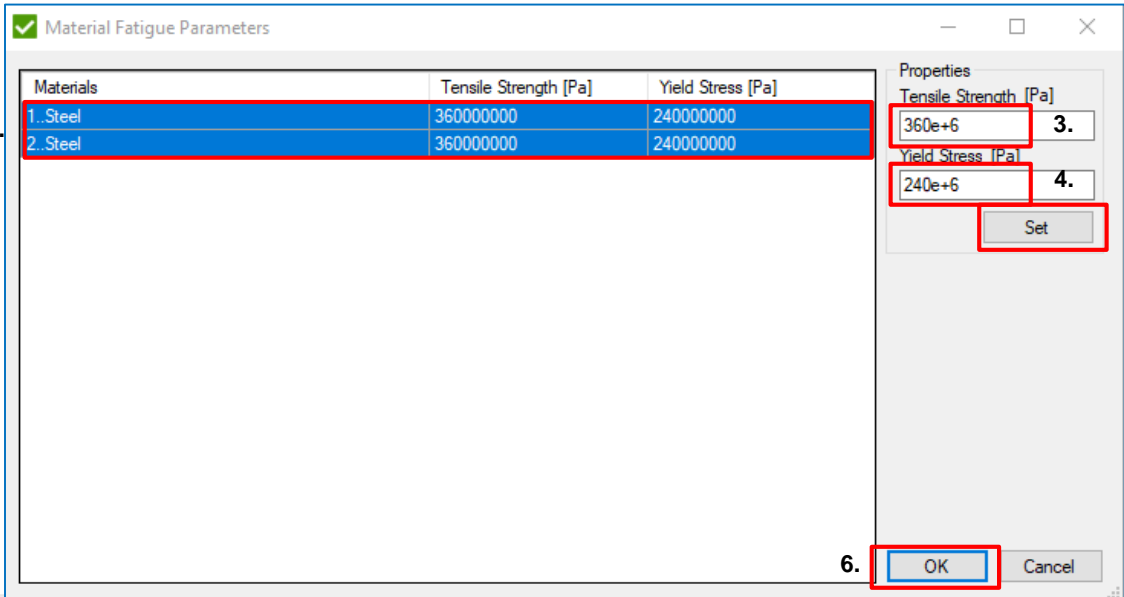
Selection

+ 2 Shapes

Elements: 2077

OK Cancel

2.



Material Fatigue Parameters

Materials	Tensile Strength [Pa]	Yield Stress [Pa]
1..Steel	360000000	240000000
2..Steel	360000000	240000000

Properties

Tensile Strength [Pa]: 360e+6 3.

Yield Stress [Pa]: 240e+6 4.

Set


6. OK Cancel





API RP 2A Standard is applicable to stiffened and unstiffened cylinders having  $t \geq 6\text{mm}$ ,  $D / t < 120$  and Yield Stress  $< 414\text{ MPa}$ . To validate this condition unit system used in the model should be specified in SDC Verifier.




Parameter = RequirementsValid (Requirements Valid)

All: `if((Units.GetInMillimeters(Thickness) >= 6) and (Units.GetInMPa(Yield) < 414) and (D / Thickness < 300), yes, no)`


By default MKS (Meter/Kg/Second) unit system is used. To change unit system press 

Materials with Yield = 0  

☐ Use AISI 360-10 for non-tubular shapes  

There are 7 predefined Unit Systems: MKS; MTS; MmKS; MmTS; MmKMs; IPS and FPS. Custom Unit System can be used in specific cases as well.

 Unit System

Unit System: **MKS (Meter/Kg/Second)** (selected)

Description: **MKS (Meter/Kg/Second)** (selected)

Length: **Meter** (selected)

Weight: **Kilogram** (selected)

Time: **Second** (selected)

Force: **Newton** (selected)

Stress: **Pa** (selected)

Buttons: Set as Default, OK, Cancel

In case the standard cannot perform verification of the model the results will display the value = **12345678**.

## All (All Entities)


Standard	1..API 2A RP		Check	7..Overall Check	
Individual Load	1..Gravity -9.81.Legs.Fixed		Selection	All Entities	
Extreme	Absolute Axial Uf	Absolute Bending Uf	Absolute Shear Uf	Absolute Axial and Bending Uf	Overall Utilization Factor
Minimum	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00
Maximum	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00
Absolute	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00

# 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

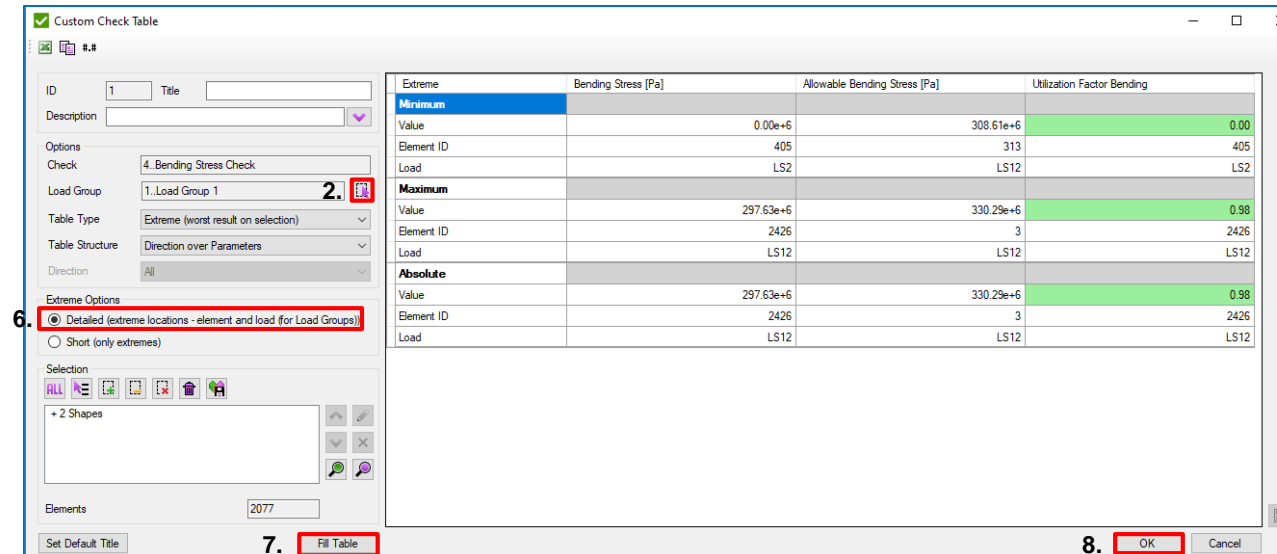
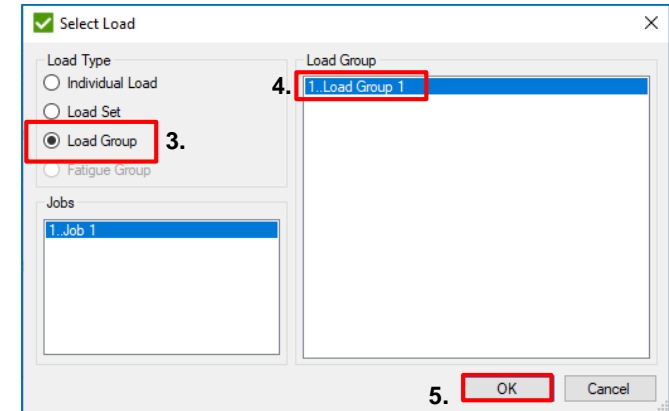
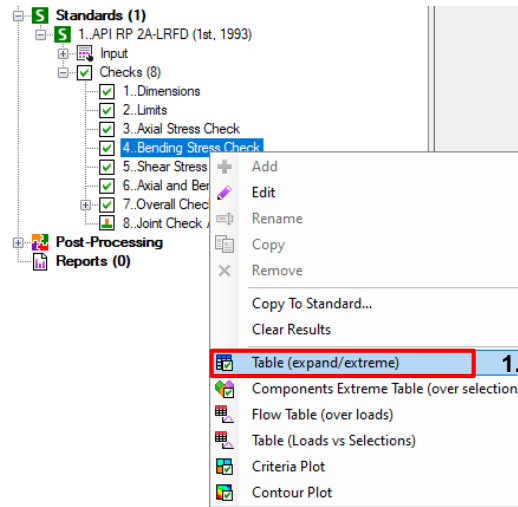
Extreme Options: **Detailed**

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

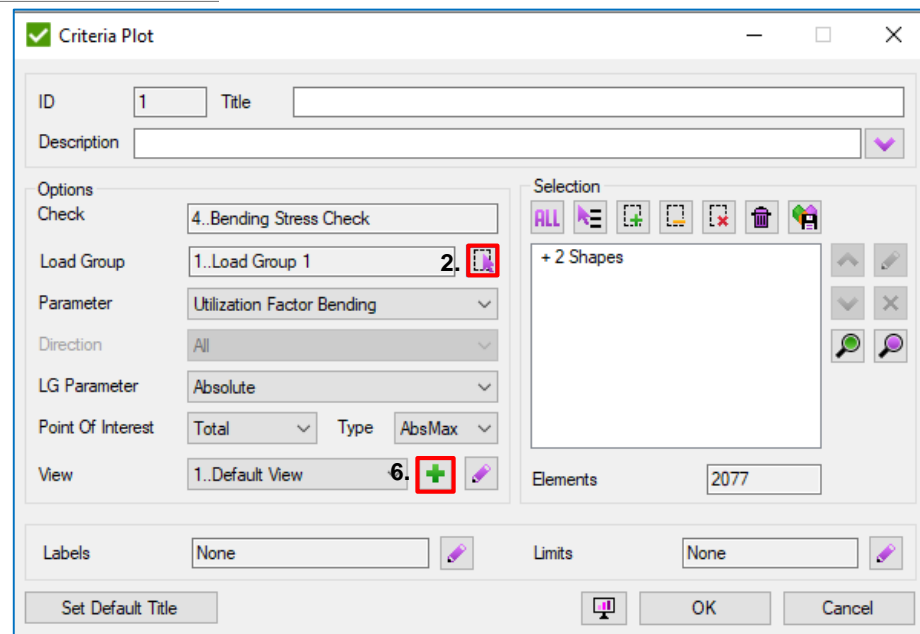
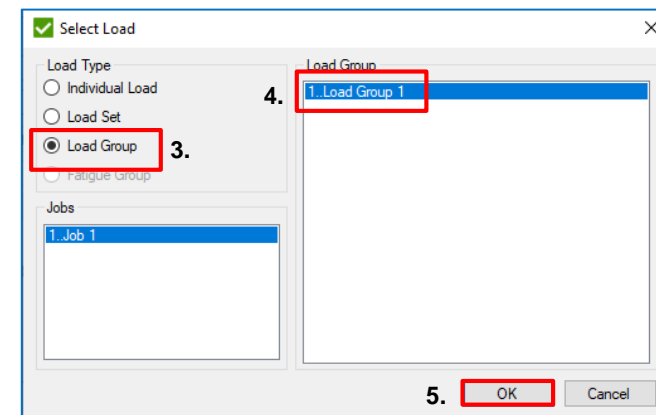
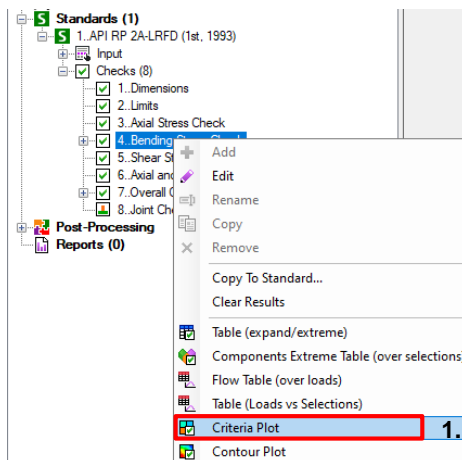
2 Press  to select load

3 Load Type: **Load Group**

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

5 Press *OK*

6 Press to add view



# Plot. Create View

1

Title: **Isometric**

2

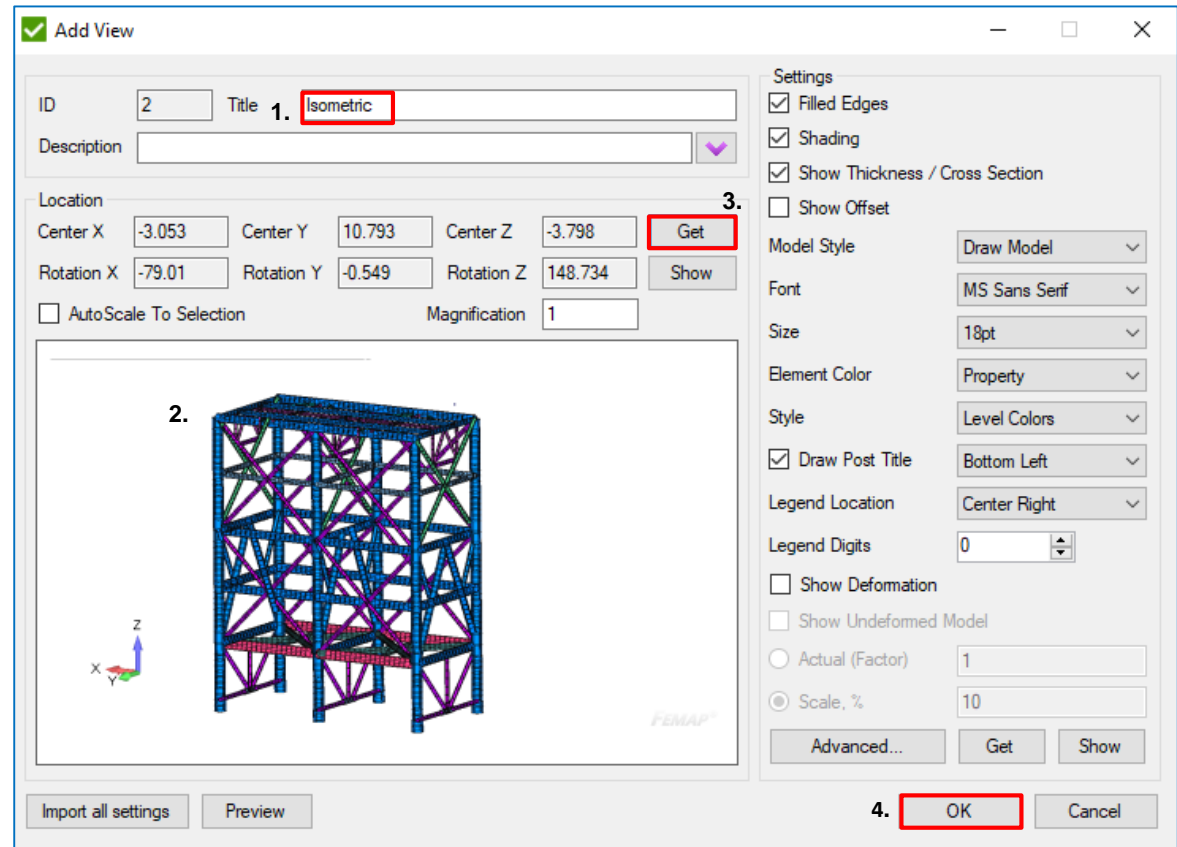
Orient model in Femap as shown on the picture

3

Press *Get*


4

Press *OK*



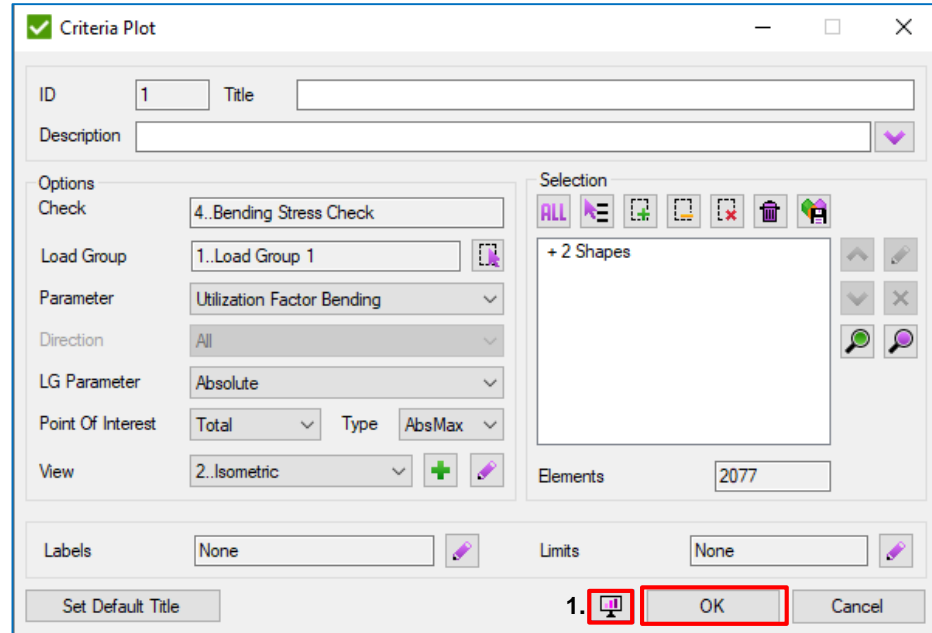
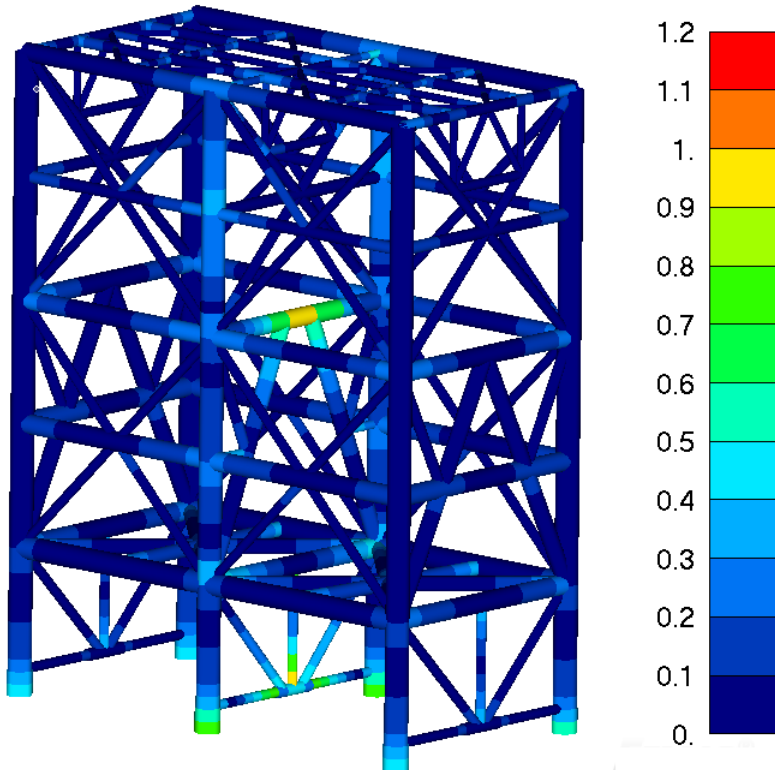
# Display Plot

1

Press  to display plot

2

Press OK

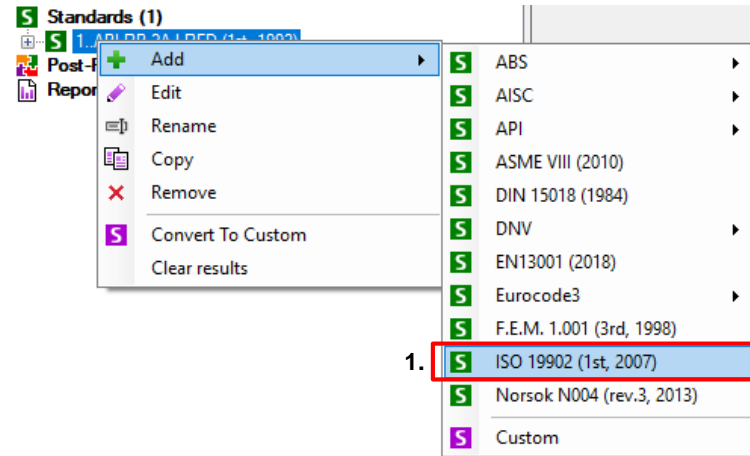


2.

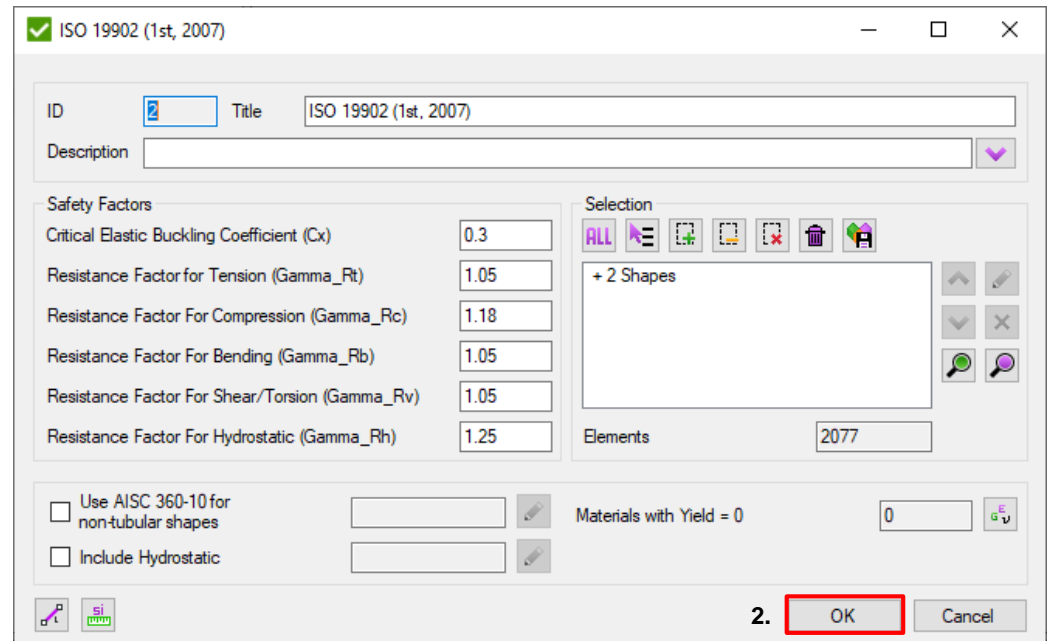
# Add ISO 19902 standard

1 Execute *Standards* => *Add* => *ISO 19902* (1<sup>st</sup>, 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  $U_f$  among all checks  $< 1$ .



$C_x$  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,  $\gamma_{R,b} = 1,05$ ;

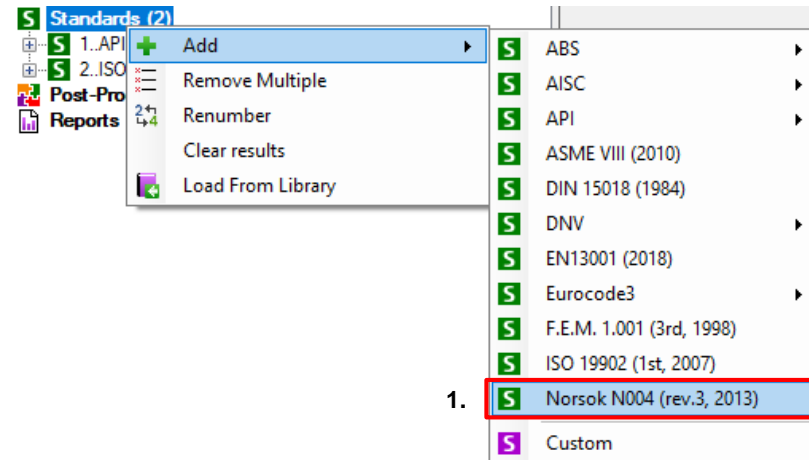
$\gamma_{R,v}$  is the partial resistance factor for shear strength,  $\gamma_{R,v} = 1,05$ ;

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

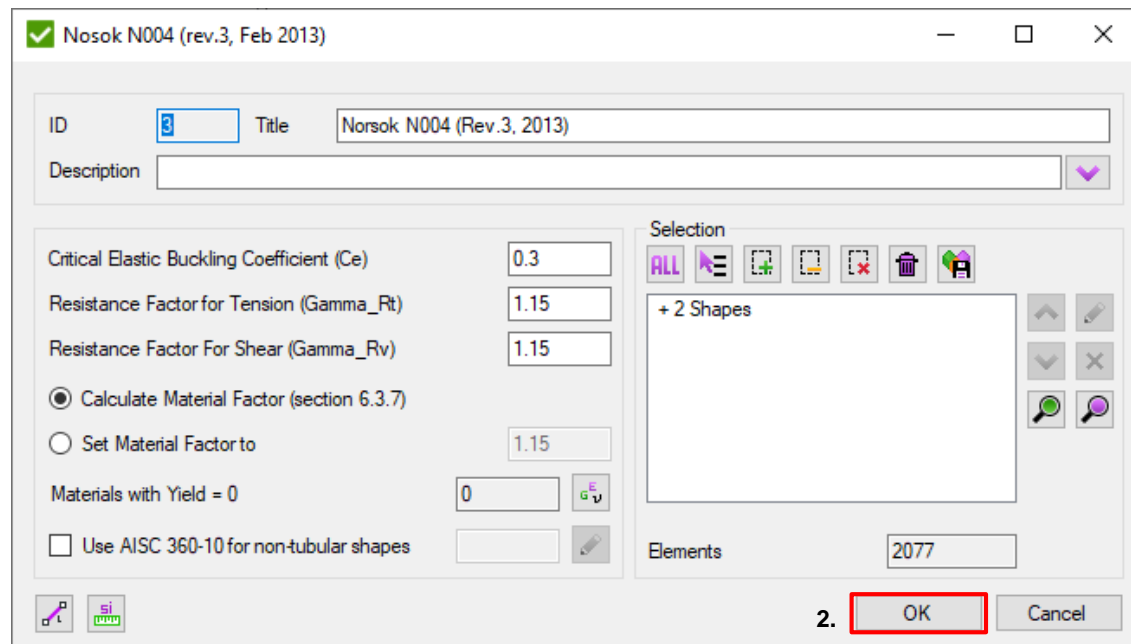
# Add Norsok N004 standard

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  $U_f$  among all checks  $< 1$ .





# Add Norsok N004 standard

$$\begin{aligned}
 C_e &= \text{critical elastic buckling coefficient} = 0.3 \\
 \gamma_{R,t} &= \text{material factor for tension} = 1.15 \\
 \gamma_{R,v} &= \text{material factor for shear} = 1.15 \\
 \gamma_M &= \text{see section 6.3.7} \\
 \gamma_M &= 1.15 \quad \text{for } \bar{\lambda}_s < 0.5 \\
 \gamma_M &= 0.85 + 0.60\bar{\lambda}_s \quad \text{for } 0.5 \leq \bar{\lambda}_s \leq 1.0 \\
 \gamma_M &= 1.45 \quad \text{for } \bar{\lambda}_s > 1.0
 \end{aligned} \tag{6.22}$$

where

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

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.

$$\lambda_c = \sqrt{\frac{f_y}{f_{cle}}}, \text{ and } \lambda_h = \sqrt{\frac{f_y}{f_{he}}} \tag{6.24}$$

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

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

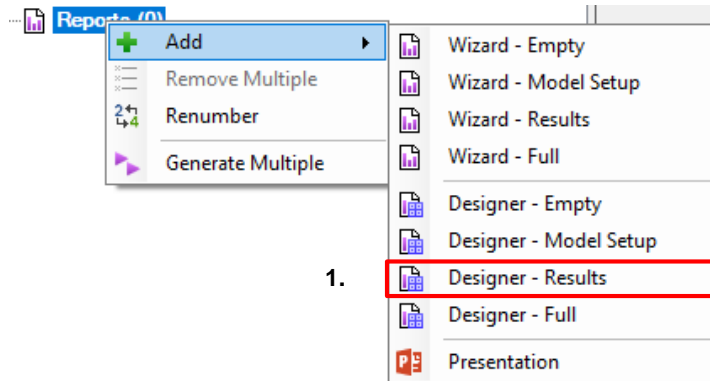
$$\sigma_{c,Sd} = \frac{N_{Sd}}{A} + \frac{\sqrt{M_{y,Sd}^2 + M_{z,Sd}^2}}{W} \tag{6.25}$$

$N_{Sd}$  is negative if in tension.

# Report

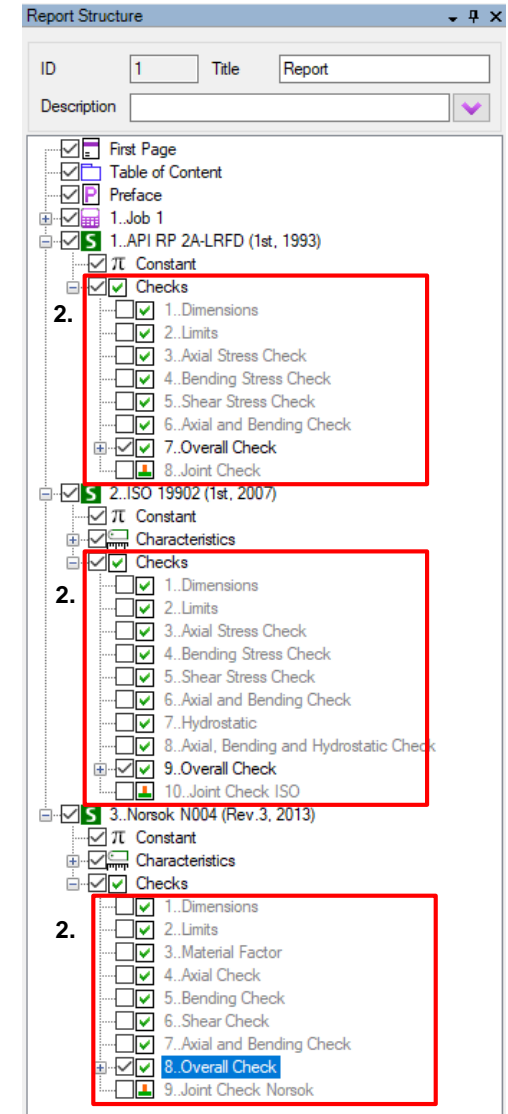
1. Execute *Add - Designer - Results* from *Reports* context menu.

2. Exclude all checks except the **Overall check** in each standard.




1.

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.



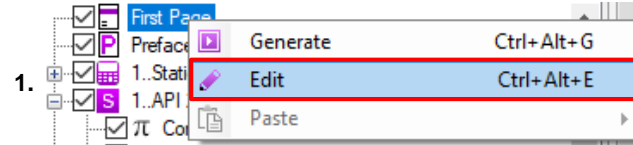
# Report. First Page

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

API 2A RP  
Overall Check

ISO 19902  
Overall Check

Norsok N004  
Overall Check

Report

SDC Verifier

Prepared by:  
SDC Verifier  
+31 15 30-10-310  
sdoverifier.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: 17/01/2020

Overall Check

Absolute Axial and Bending Utilization Factor	Overall Utilization Factor
0.00	0.00
4944	4971
IL4	IL4
1.83	1.83
6385	6385
IL6	IL6
1.83	1.83
6385	6385
IL6	IL6

Overall Utilization Factor

Company