



Tutorial

API 2A RP/ISO 19902/Norsok N004

ANSYS[®]

17 Jan 2020
version 5.3



- ▶ 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.

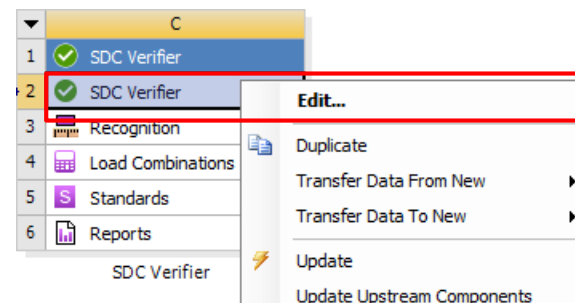
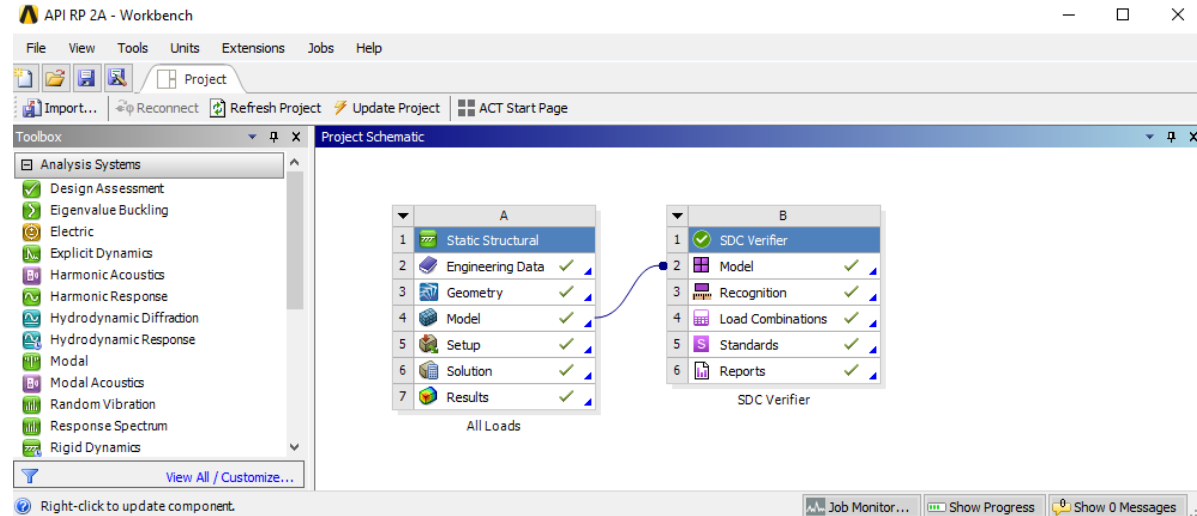
Launch SDC Verifier

1

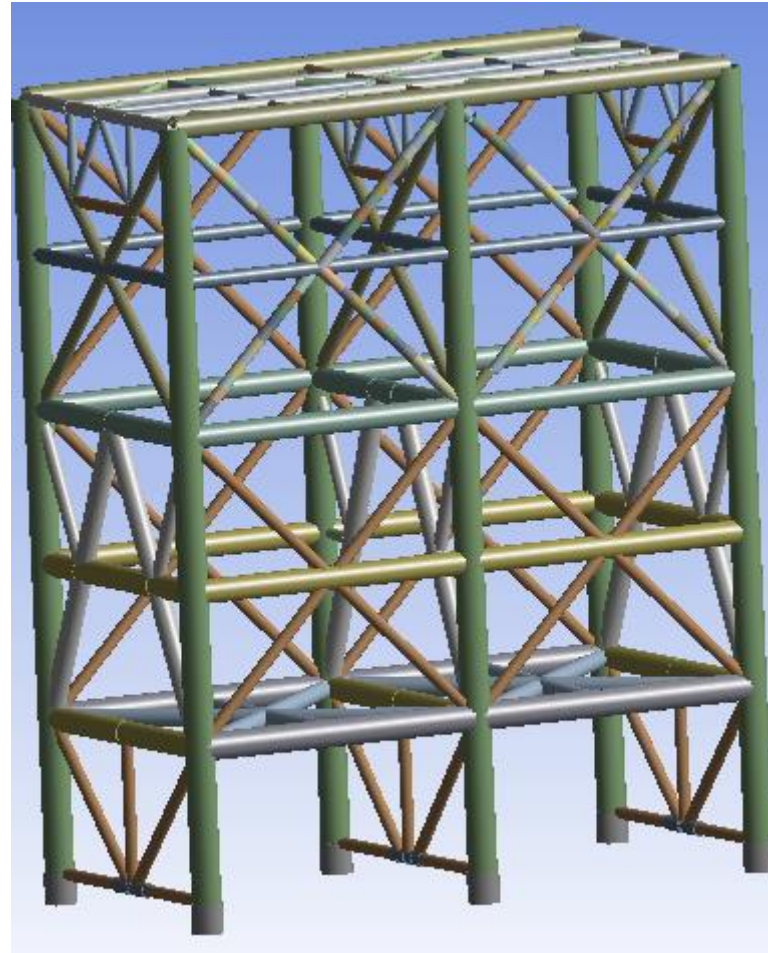
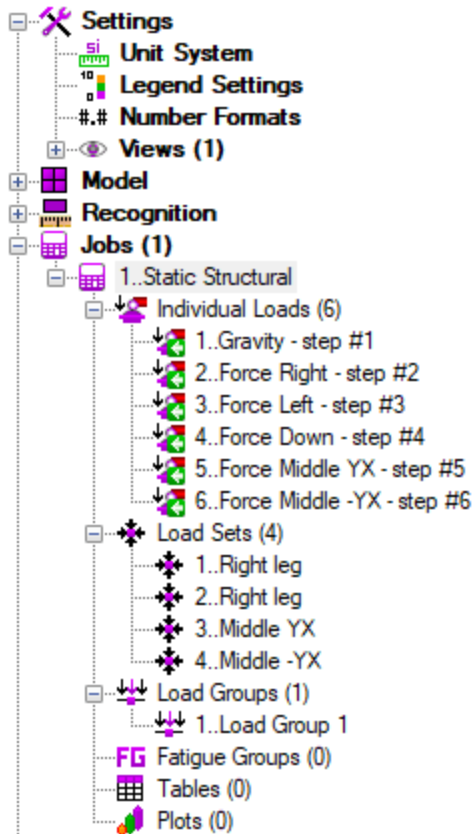
Open in **Ansys Workbench** 
API RP 2A.wbpj

2

Double Click on  **SDC Verifier** 
or in context menu click **Edit**



Predefined project

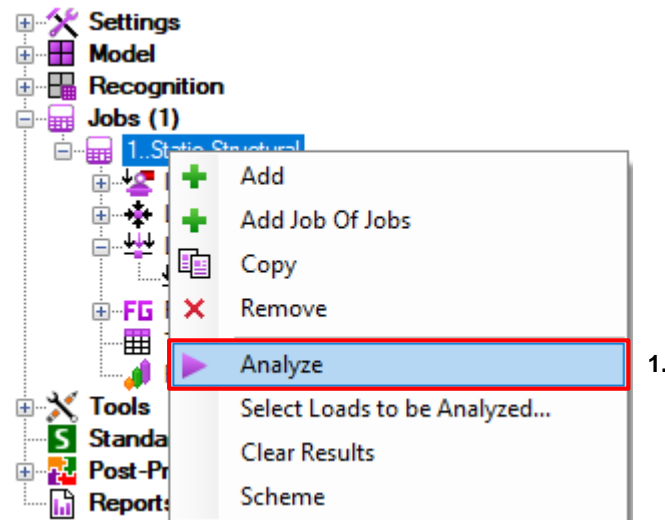


This tutorial uses project with predefined boundary condition, load combinations and load group. The model contains only circular tubes elements.

Analyze Job

1

Execute ► **Analyze** from *Static Structural* context menu



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;

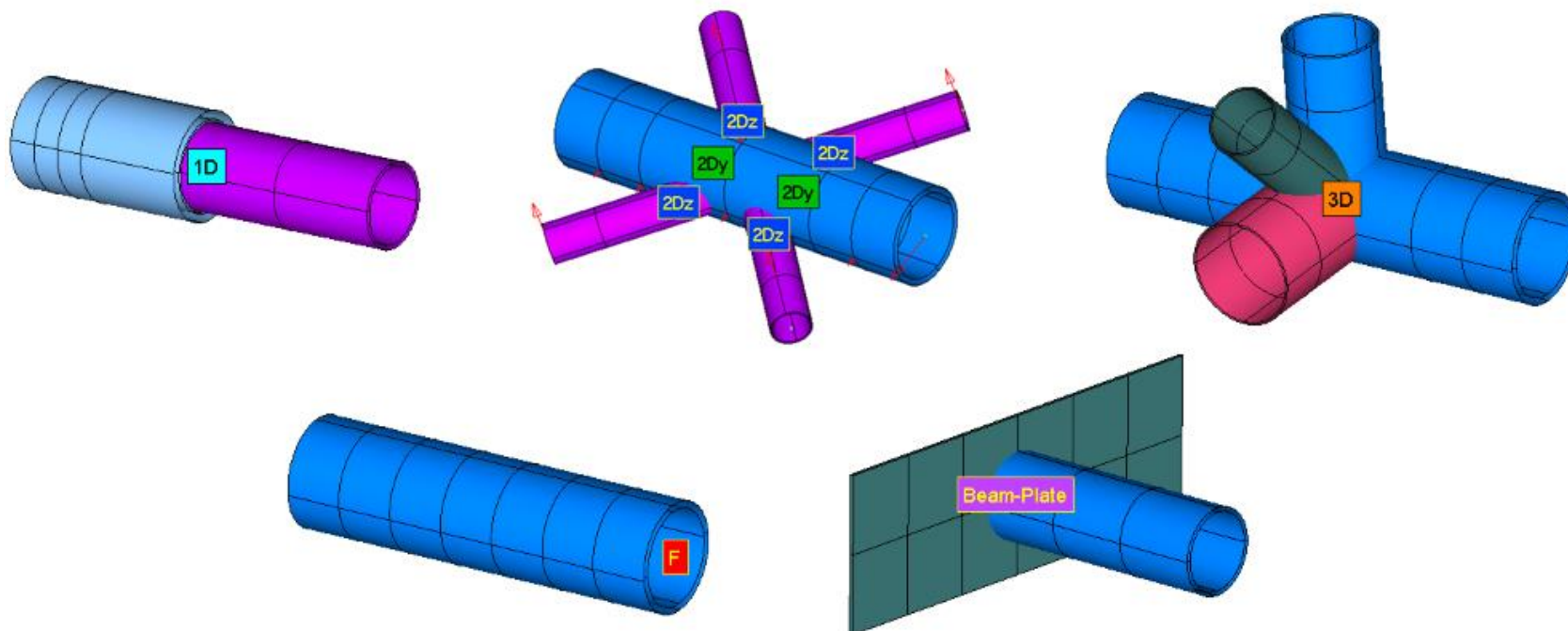
2D Joint – beam members connected in one plane;

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;



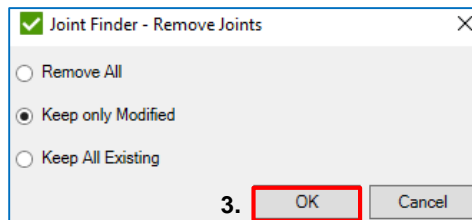
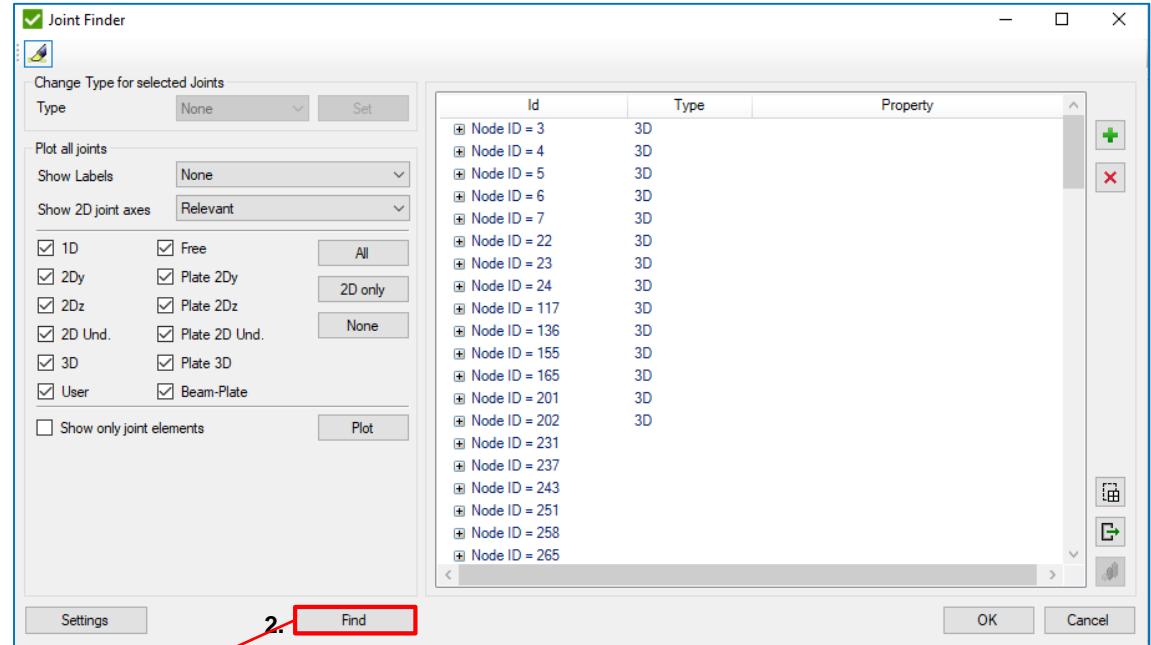
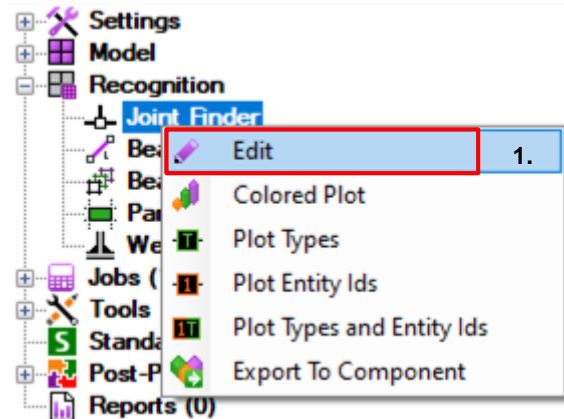
Joint Recognition

1 Execute *Edit* from *Joints* context menu

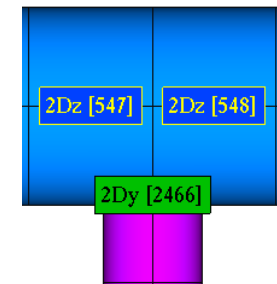
2 Press *Find*.

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	



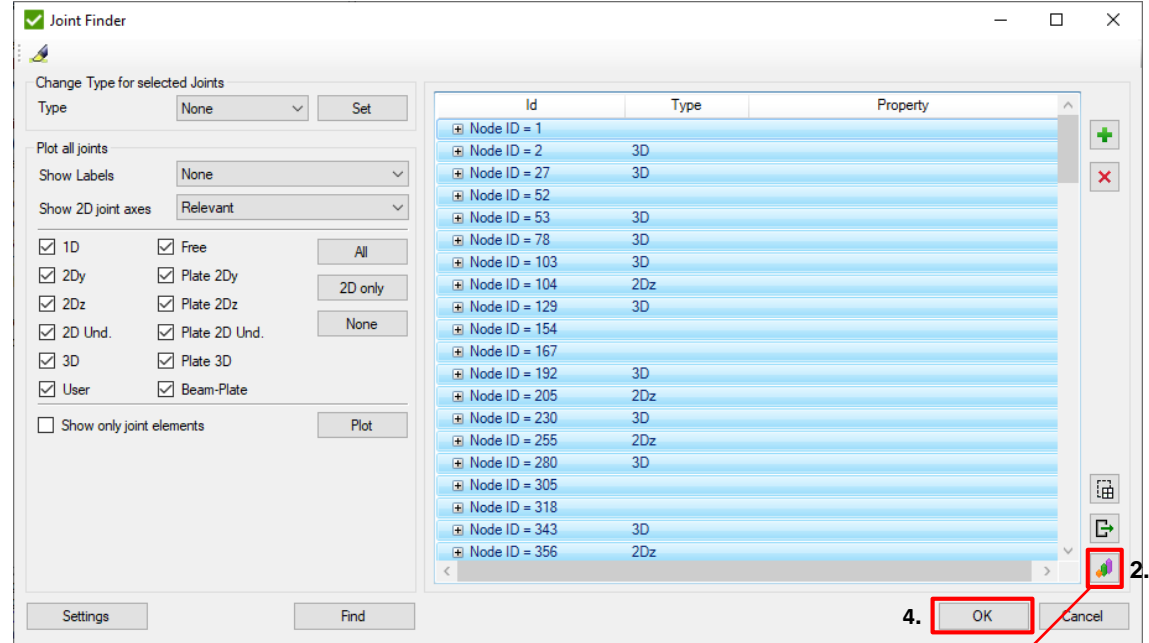
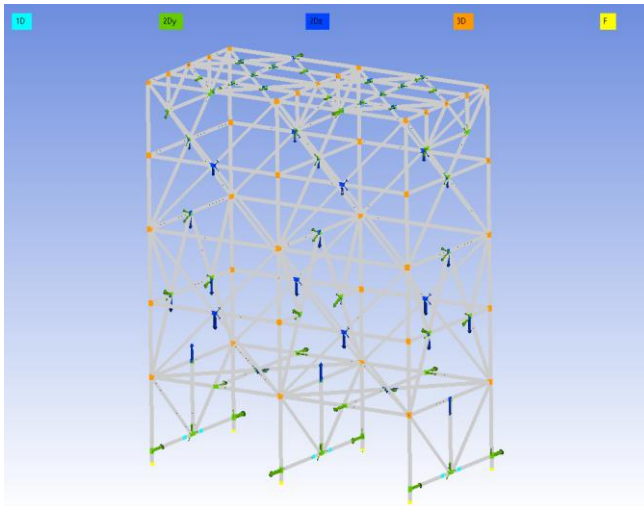
Joints Plot

1 Select All Joints (Ctrl+A).

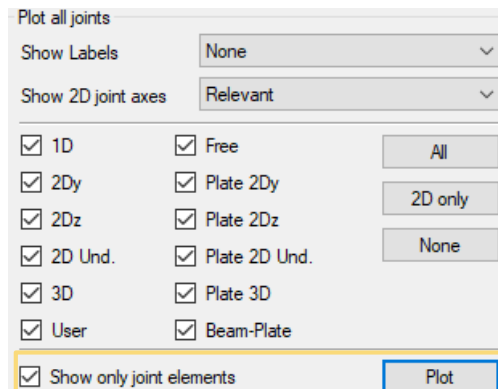
2 Press 


3 Press  Plot Joint Type Labels

4 Press OK



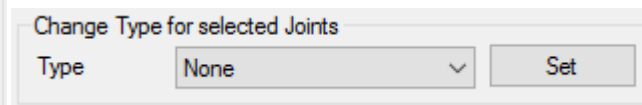
Plot Joints of specific type:



3.  Plot Joint Type Labels

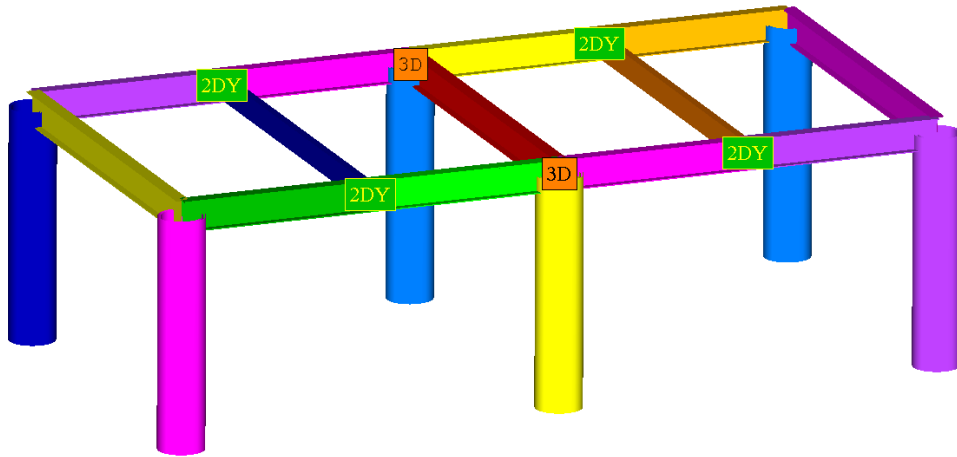
 Plot Joint Type in colors

Modify Joint Type:

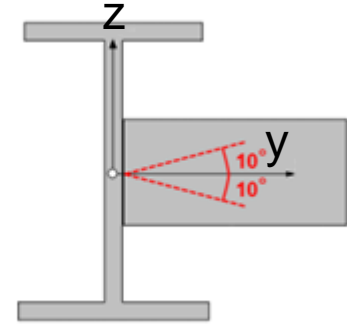


Beam Member Lengths in 2 directions

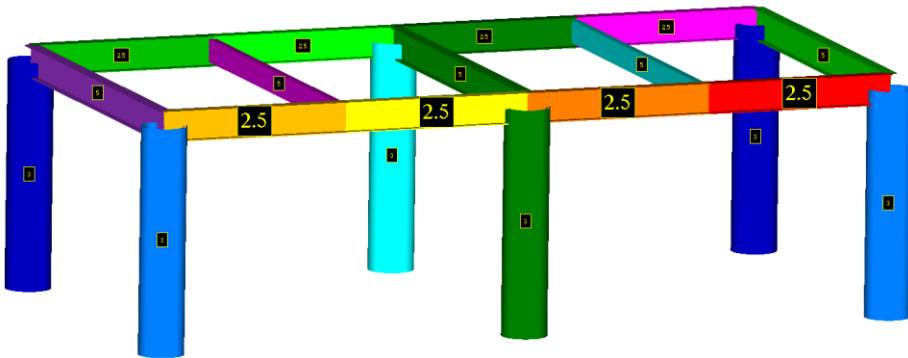
Beam Member Finder recognizes beam members and (buckling) lengths for different directions (Y, Z and Torsional).



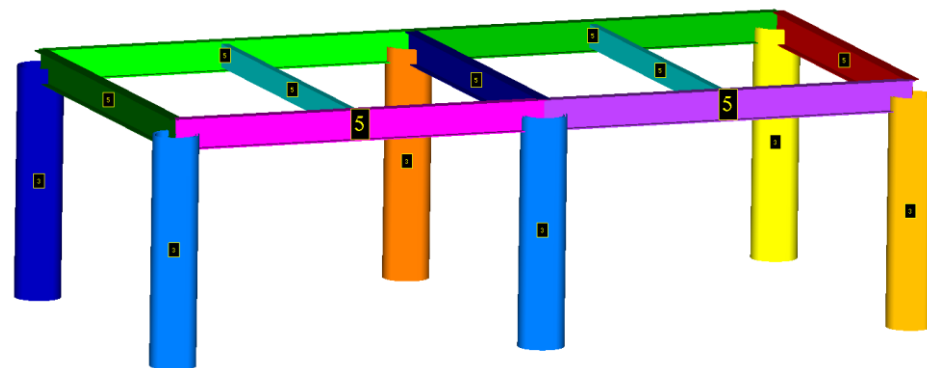
2DY
Joint



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



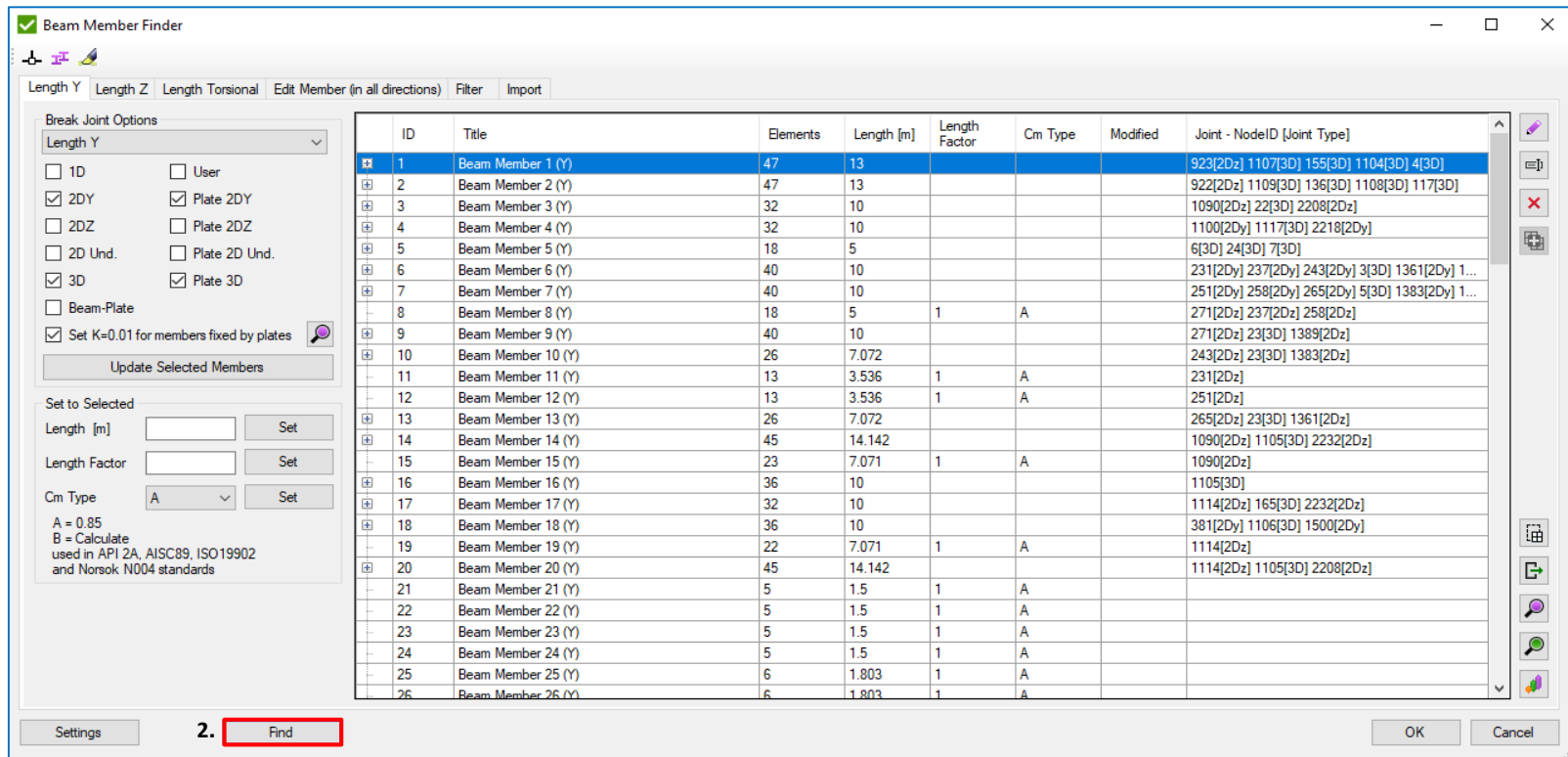
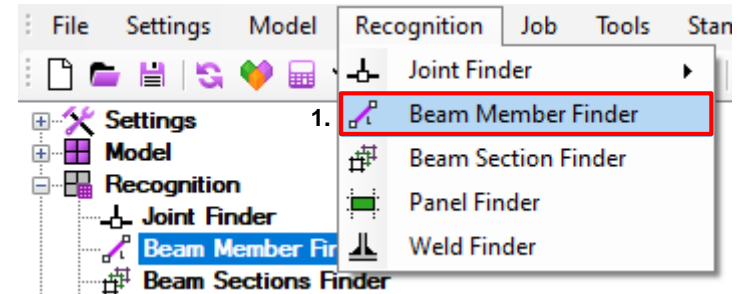
Length Z – 2 Beam Members with $L = 5$



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[2Dy] 1117[3D] 2218[2Dy]
5	Beam Member 5 (T)	18	5				6[3D] 24[3D] 7[3D]
6	Beam Member 6 (T)	40	10				231[2Dy] 237[2Dy] 243[2Dy] 3[3D] 1361[2Dy] 1...
7	Beam Member 7 (T)	40	10				251[2Dy] 258[2Dy] 265[2Dy] 5[3D] 1383[2Dy] 1...
8	Beam Member 8 (T)	18	5				271[2Dz] 237[2Dz] 258[2Dz]
9	Beam Member 9 (T)	40	10				271[2Dz] 23[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] 22[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[2Dy] 1106[3D] 1500[2Dy]
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

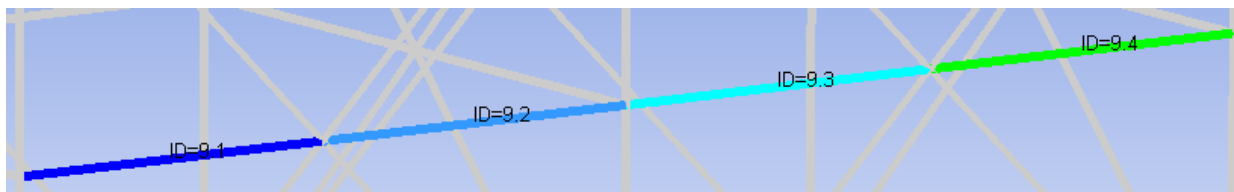
Cm Type is used in API 2A, AISC89, ISO 19902 and Norsok N004 standards

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

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		



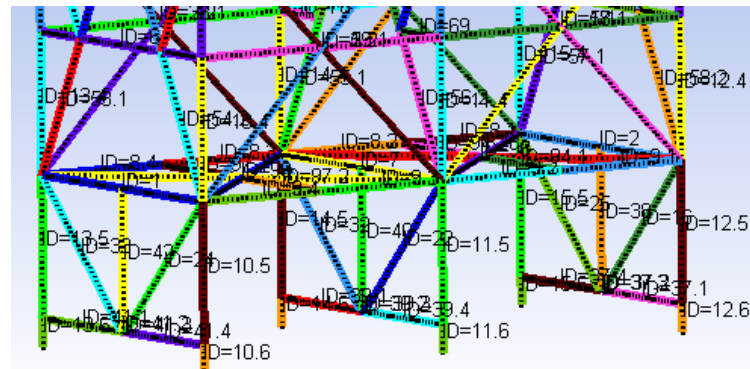
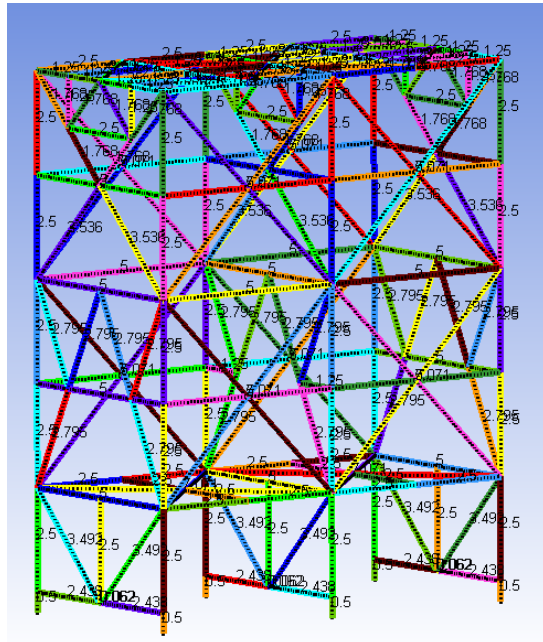
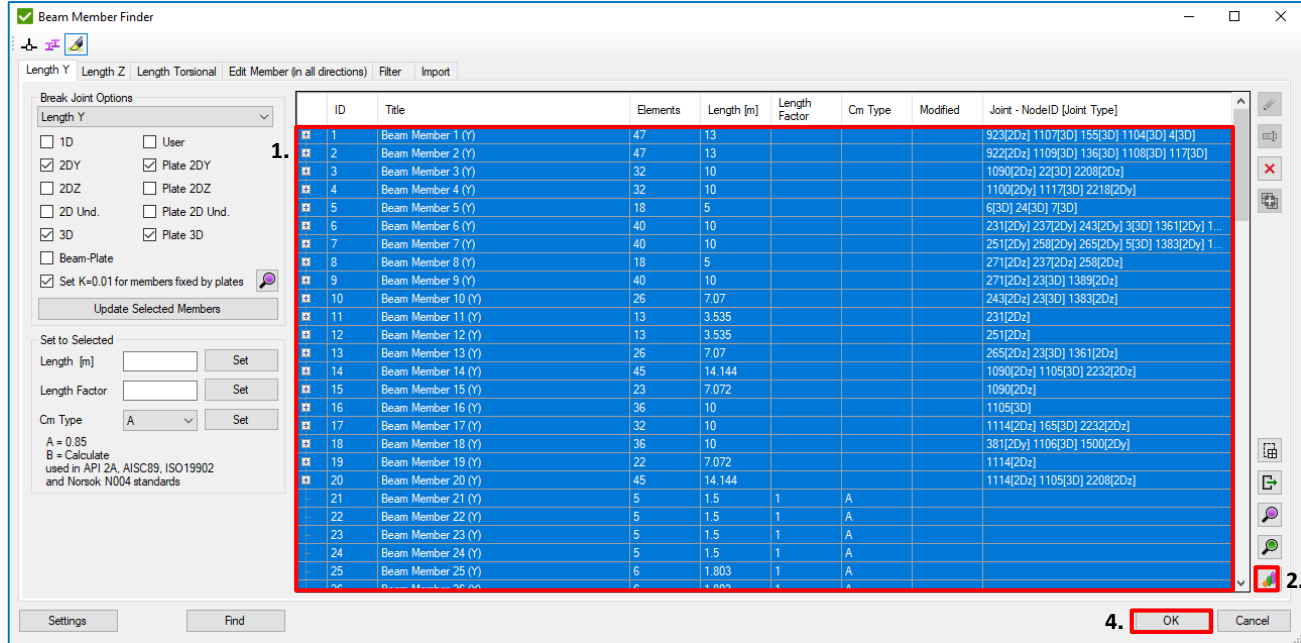
Beam Member's Length Plot

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

-  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. API RP 2A description:

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

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)
Ungouted Jacket Legs	1.0	(c)
Ungouted 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) $0.6 - 0.4 \left(\frac{M_1}{M_2} \right)$, 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

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

Cm Type

A = 0.85
B = Maximum (0.6 - 0.4 * (M1/M2),
1 - 0.4 * (fc / (PhiC * Fe)))

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 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 0507612 T48 ■

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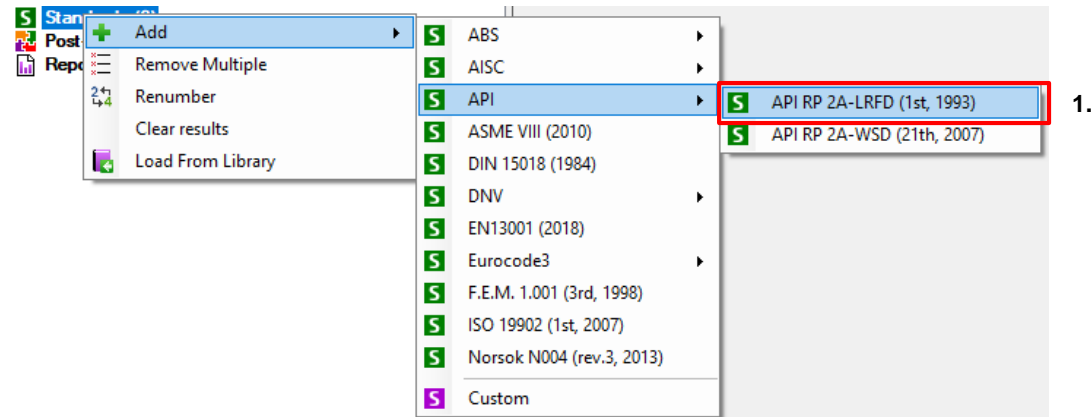
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Add API RP 2A-LRFD standard

1

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



SECTION D CYLINDRICAL MEMBER DESIGN

C_x = critical elastic buckling coefficient

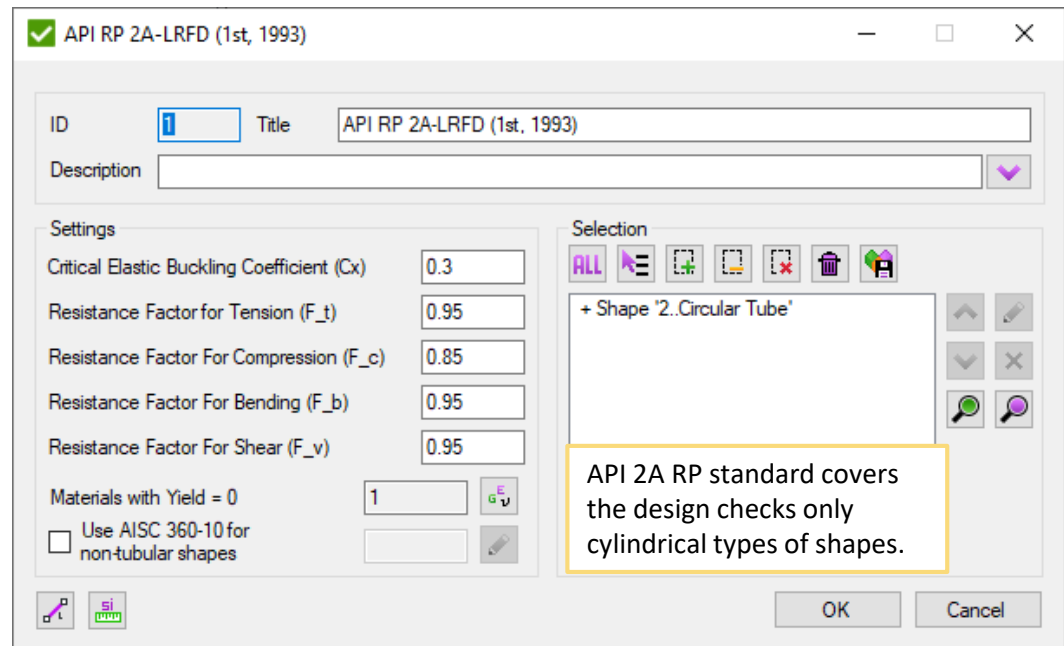
The theoretical value of C_x is 0.6. However, a reduced value of $C_x = 0.3$ is recommended for use in Equation D.2.2-3 to account for the effect of initial geometric imperfections within API Spec 2B tolerance limits, Reference D2.

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**

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

ID Title

Description

Settings


Critical Elastic Buckling Coefficient (Cx)

Resistance Factor for Tension (F_t)

Resistance Factor For Compression (F_c)

Resistance Factor For Bending (F_b)

Resistance Factor For Shear (F_v)

Materials with Yield = 0 1. 

☐ Use AISC 360-10 for non-tubular shapes

Selection

+ Shape '2..Circular Tube'

Elements

OK Cancel

Material Fatigue Parameters

Materials	Tensile Strength	Yield Stress
1..Structural Steel	360000000	240000000

Properties

Tensile Strength 2.

Yield Stress 3.

4.

Update from Ansys


5. Cancel

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

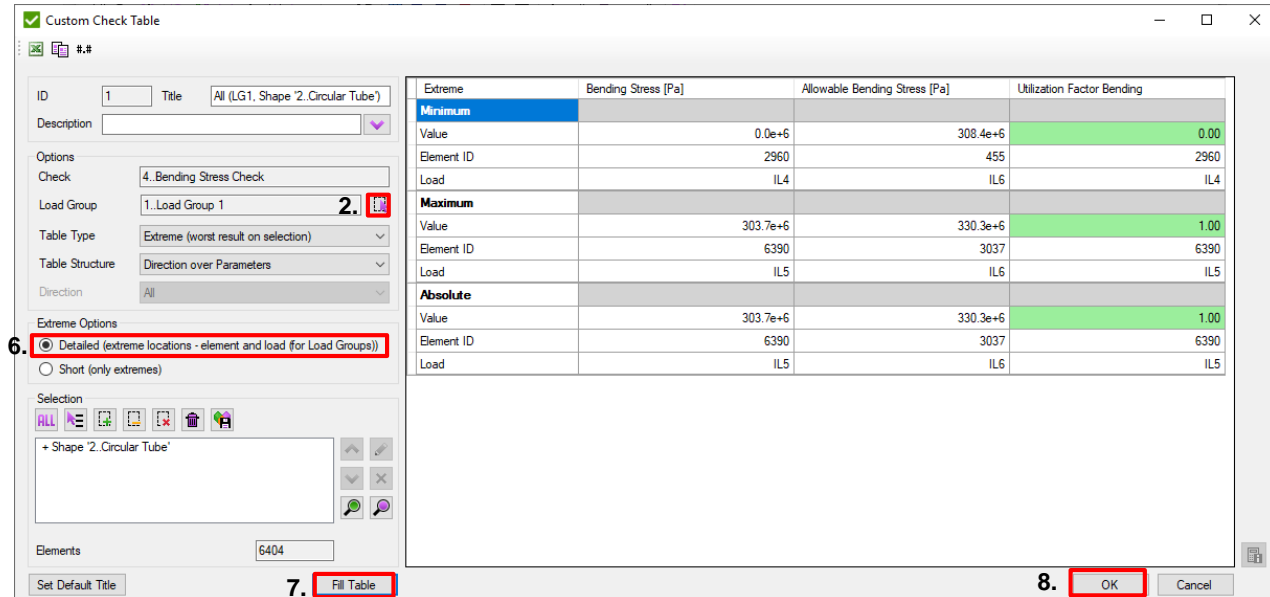
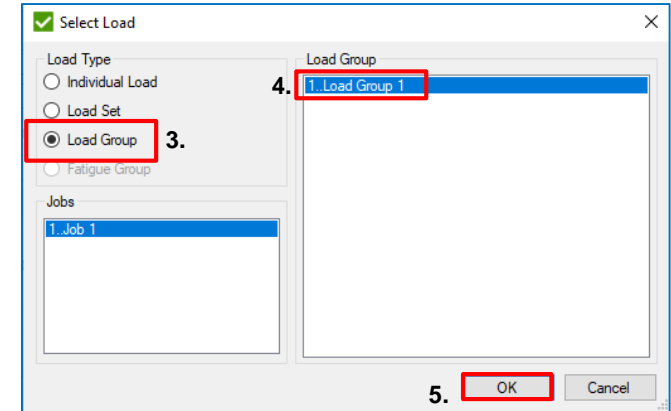
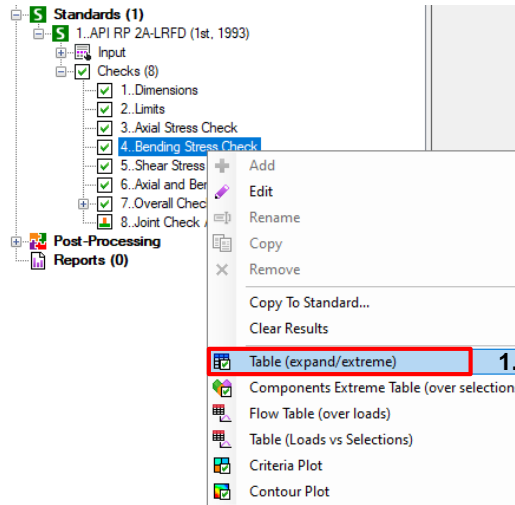
Extreme Options: **Detailed**

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 U_f among all checks.

Criteria Plot for Bending Stress Check

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

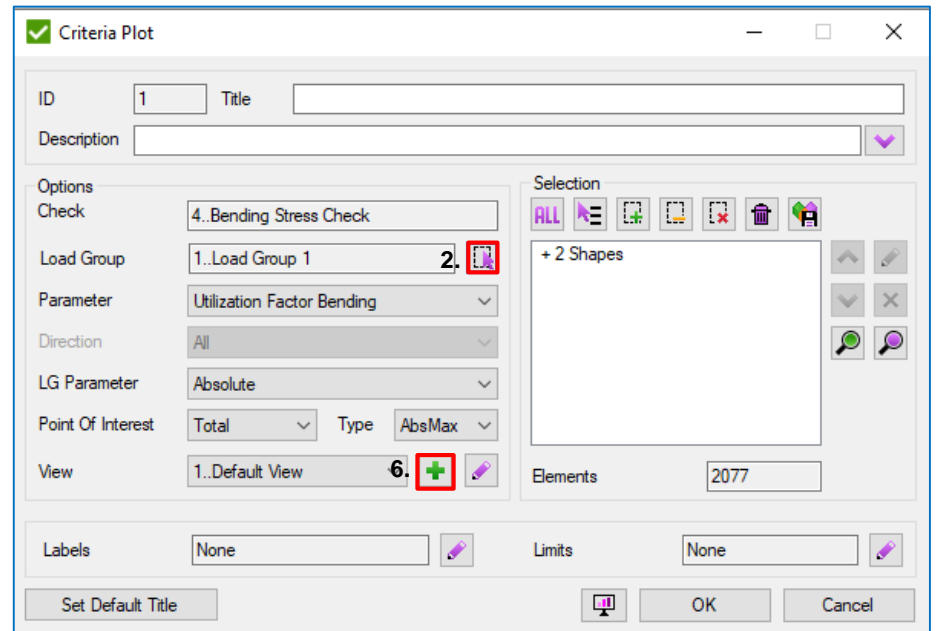
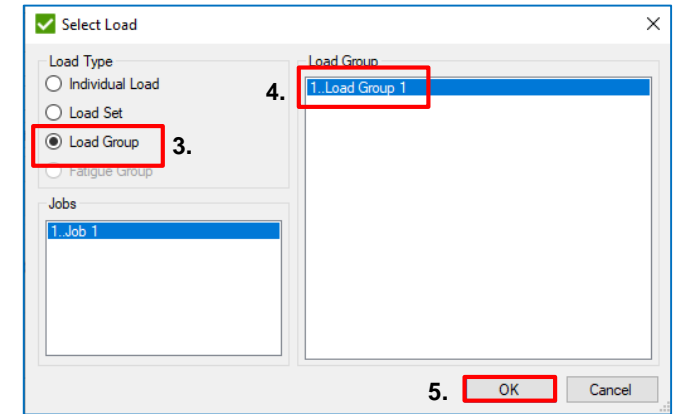
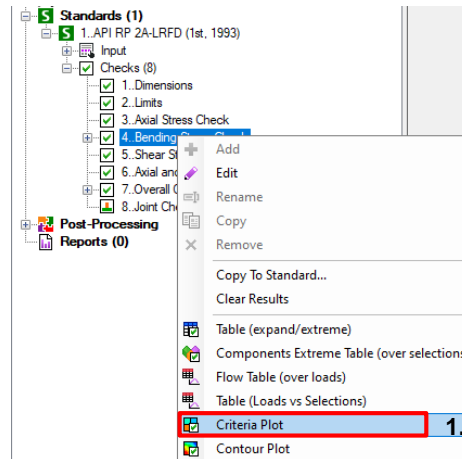
2 Press  to select load

3 Load Type: **Load Group**


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

5 Press *OK*

6 Press to add view



Criteria plot for overall check

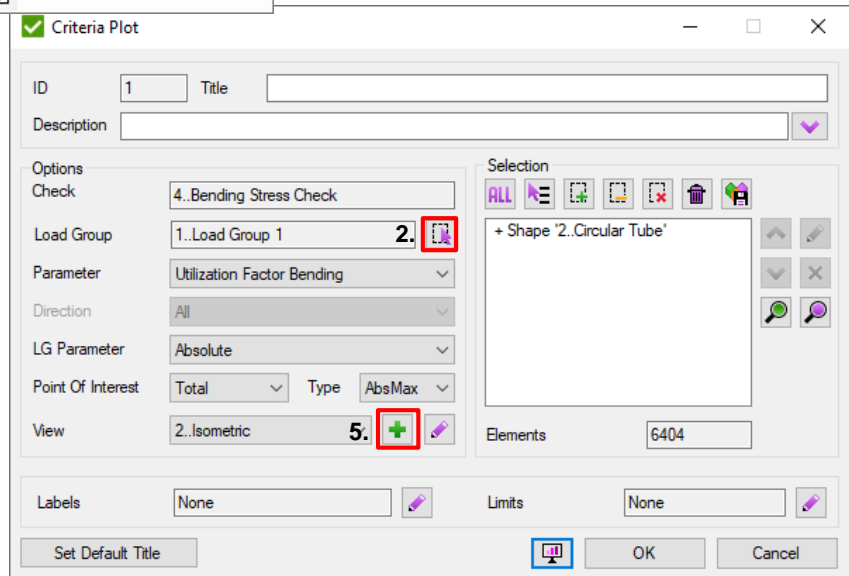
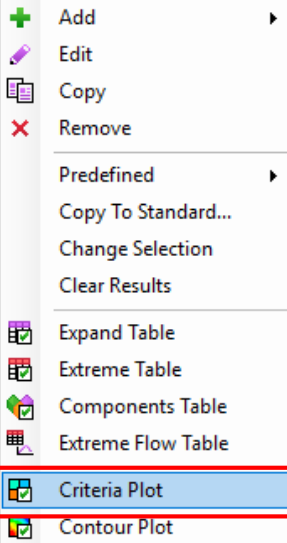
1 Execute  from **Overall Check** context menu

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*

Add/Edit View

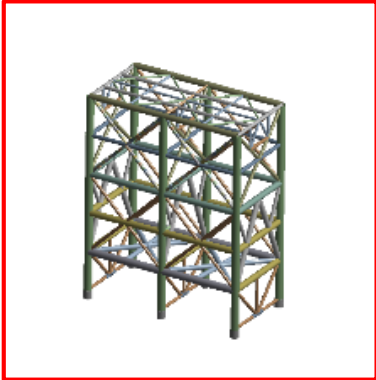
ID: 2 Title: **Isometric**

Description:

Location

Center X	2.50	Center Y	5.00	Center Z	-6.50
Rot X	1.83	Rot Y	2.50	Rot Z	-9.33
Loc X	10.15	Loc Y	-11.47	Loc Z	-1.60
Up Vec X	-4.17	Up Vec Y	6.51	Up Vec Z	16.26
View X	0.46	View Y	-0.78	View Z	0.43
Zoom	1.03E+000				

3. **Get** Show

2. 

Settings

Deformation 4. **Undeformed**

Geometry Exterior

Contours Contour Bands

Edges No WireFrame

Independent Bands None

Color Scheme Rainbow

Display on 4. **Result Only**

☐ Logarithmic Scale

☐ Min, Max on Colorbar

☐ Semi Transparency

☐ Date and Time

4. ☒ Show Legend ☒ Show Triad

☐ Show Ruler ☐ Show Mesh

☐ Show Wireframe

☒ Show Thick Shells and Beams

Get Show

Legend Limits

☒ Use limits from legend settings ☐ Use local limits

Mode Automatic

Min 0

Max 1


Number of levels 12

Format General

5. **OK** Cancel

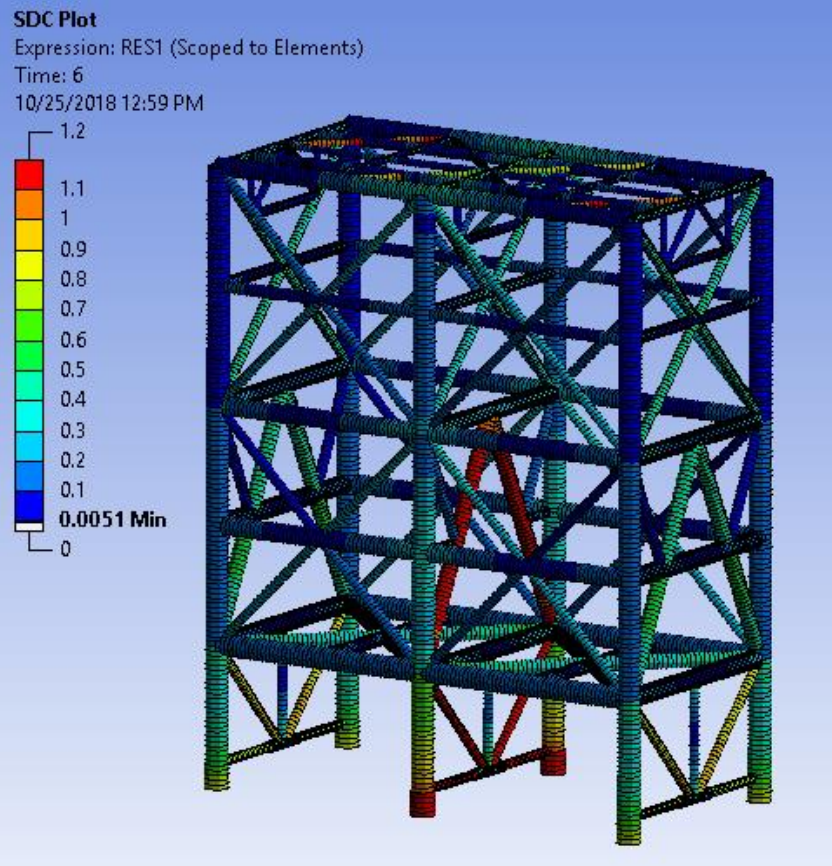
Display Plot

1

Press  to display plot

2

Press OK



Criteria Plot

ID: 1 Title:

Description:

Options

Check: 4..Bending Stress Check

Load Group: 1..Load Group 1

Parameter: Utilization Factor Bending

Direction: All

LG Parameter: Absolute

Point Of Interest: Total Type: AbsMax

View: 2..Isometric

Selection


ALL

+ Shape '2..Circular Tube'

Elements: 6404

Labels: None Limits: None

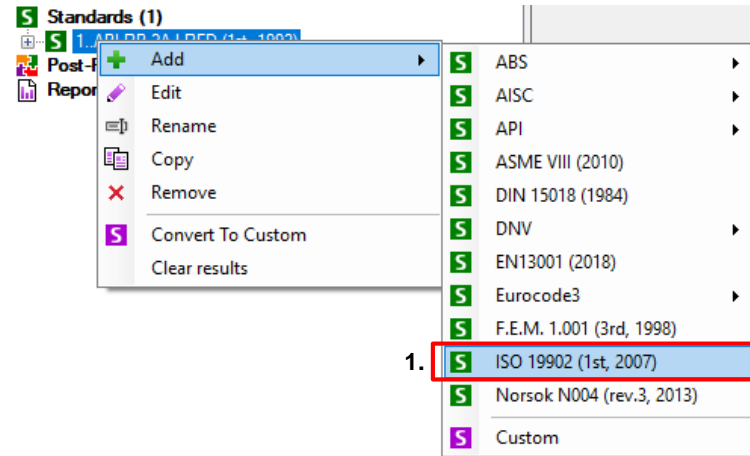
Set Default Title

1.  2. OK Cancel

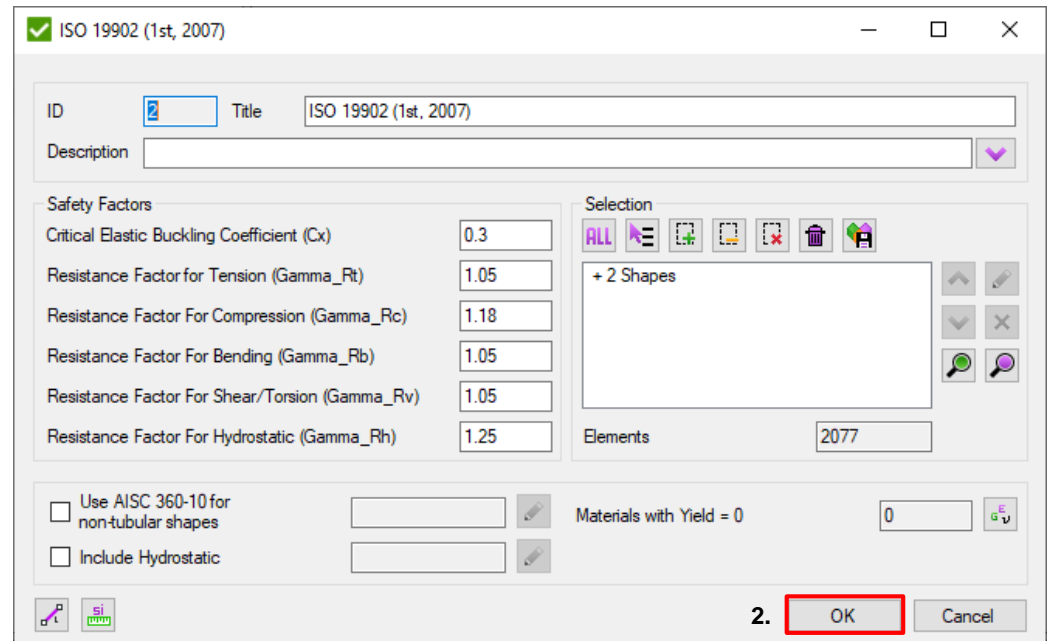
Add ISO 19902 standard

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

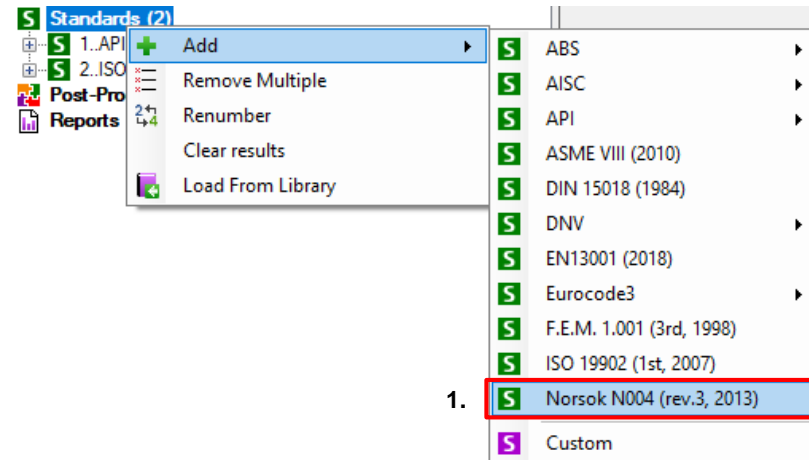
$\gamma_{R,v}$ is the partial resistance factor for shear strength, $\gamma_{R,v} = 1,05$;

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

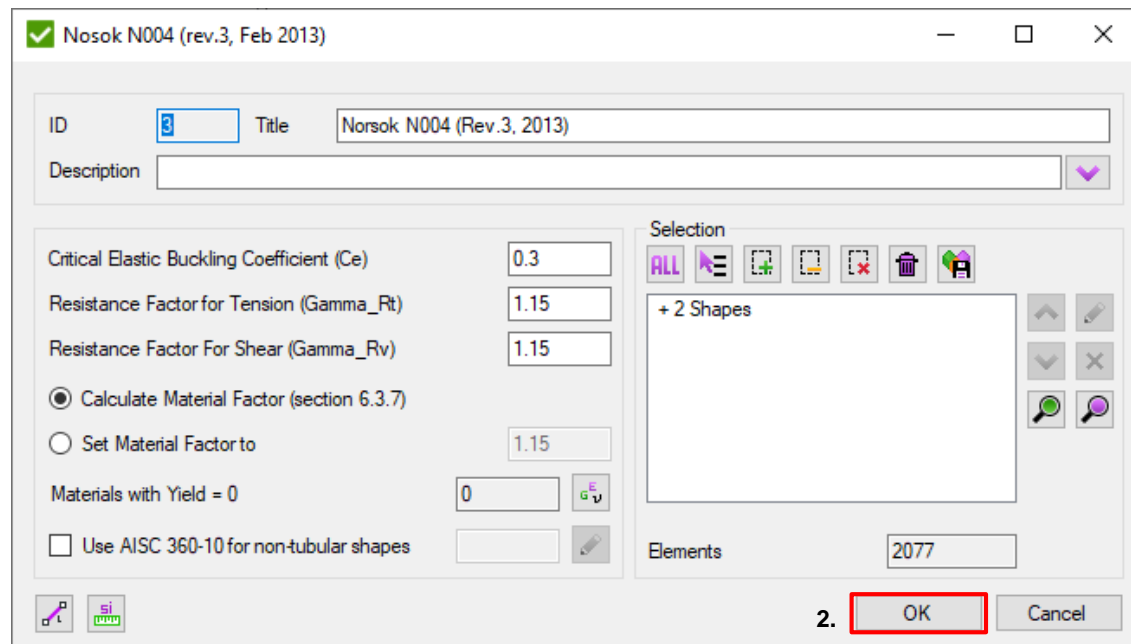
Add Norsok N004 standard

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

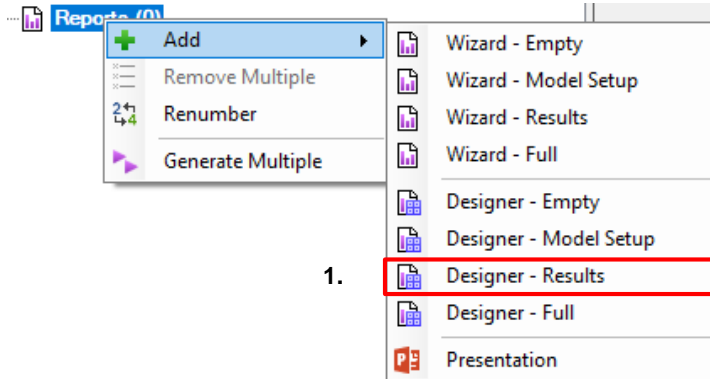
$$\sigma_{c,Sd} = \frac{N_{Sd}}{A} + \frac{\sqrt{M_{y,Sd}^2 + M_{z,Sd}^2}}{W} \tag{6.25}$$

N_{Sd} is negative if in tension.

Report

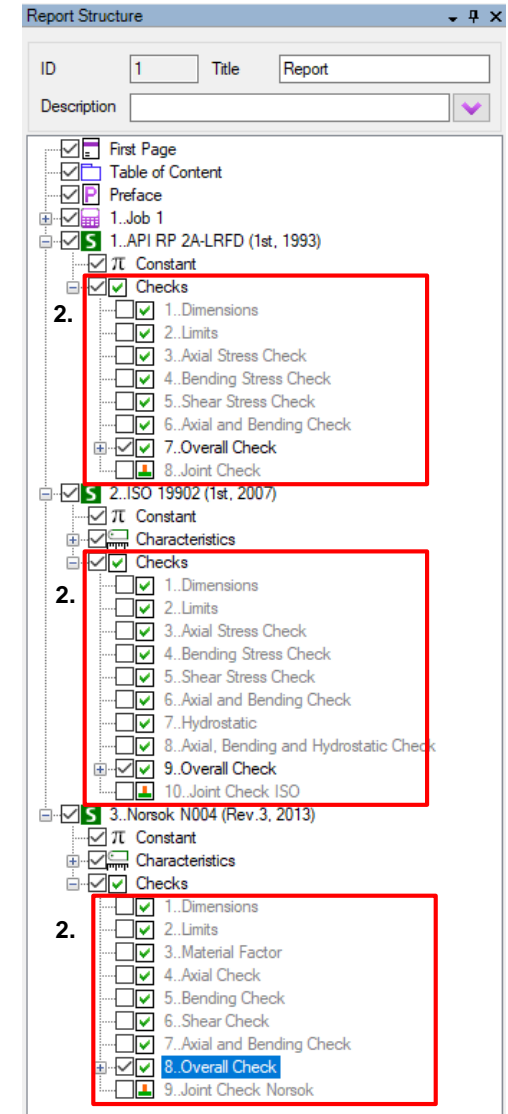
1. Execute *Add - Designer - Results* from *Reports* context menu.

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.



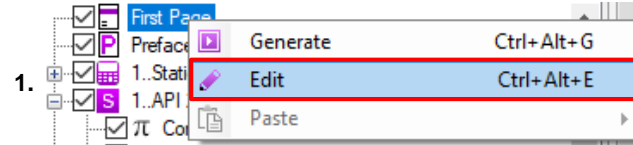
Report. First Page

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.

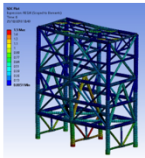


Press  to export to Word.

First page

Report

New Project



Prepared by:
SDC Verifier

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2011 VB Haarlem
The Netherlands

Engineer: Support
Customer: customer
Project Number:
Version: 1
Date: 25/10/2018

Table Profiles

Prepared for:
company

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2011 VB Haarlem
The Netherlands

API 2A RP

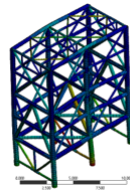
Page 10 of 32

Overall Check

Value					
Elemental Custom Check					
Shape '2_Circular Tube'					
6					
Circular Tube'					
Load Group 1					
Check Selection					
[S1] Z_Overall Check					
Shape '2_Circular Tube'					
Absolute Axial Util	Absolute Bending Util	Absolute Shear Util	Absolute Axial and Bending Util	Overall Utilization Factor	
0.00	0.00	0.00	0.00	0.00	0.00
4821	2958	2769	4844	4852	IL4
1.26	1.09	1.05	1.63	1.63	IL5
2661	6390	3405	6385	6385	IL6
1.26	1.09	1.05	1.63	1.63	IL5
2661	6390	3405	6385	6385	IL6

sents result plot profiles previously created in a job.

on Factor (LG1, Shape '2_Circular Tube', v1, Total)



Z_Overall Check
Load Group 1
Shape '2_Circular Tube'

Point
Parameter
View

Total
Absolute Overall Utilization Factor
1_Default View

Prepared by
SDC Verifier

Prepared for
company

Company

ISO 19902

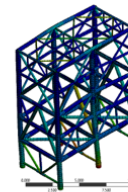
Page 20 of 32

Overall Check

Value					
Elemental Custom Check					
Shape '2_Circular Tube'					
6					
Circular Tube'					
Load Group 1					
Check Selection					
[S2] Z_Overall Check					
Shape '2_Circular Tube'					
Absolute Axial Util	Absolute Bending Util	Absolute Shear Util	Absolute Axial and Bending Util	Overall Utilization Factor	
0.00	0.00	0.00	0.00	0.00	0.00
4821	2958	2769	3162	4844	4852
1.26	1.09	1.05	1.14	1.63	1.63
2661	6390	3405	480	6385	6385
1.26	1.09	1.05	1.14	1.63	1.63
2661	6390	3405	480	6385	6385

sents result plot profiles previously created in a job.

on Factor (LG1, Shape '2_Circular Tube', v1, Total)



Z_Overall Check
Load Group 1
Shape '2_Circular Tube'

Point
Parameter
View

Total
Absolute Overall Utilization Factor
1_Default View

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Norsok N004

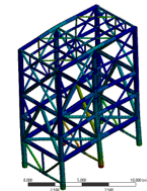
Page 31 of 32

Overall Check

Value					
Elemental Custom Check					
Shape '2_Circular Tube'					
6					
Circular Tube'					
Load Group 1					
Check Selection					
[S3] Z_Overall Check					
Shape '2_Circular Tube'					
Absolute Axial Util	Absolute Bending Util	Absolute Shear Util	Absolute Axial and Bending Util	Overall Utilization Factor	
0.00	0.00	0.00	0.00	0.00	0.00
4821	2958	2769	3162	4844	4852
1.26	1.09	1.05	1.14	1.63	1.63
2661	6390	3405	480	6385	6385
1.26	1.09	1.05	1.14	1.63	1.63
2661	6390	3405	480	6385	6385

sents result plot profiles previously created in a job.

Factor (LG1, Shape '2_Circular Tube', v1, Total)



Overall Check
Load Group 1
Shape '2_Circular Tube'

Point
Parameter
View

Total
Absolute Overall Utilization Factor
1_Default View

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