SDC VERIFIER

Tutorial

API 2A RP/ISO 19902/Norsok N004

Updated on: January 25th 2024

Tested with: SDC Verifier 2023 R2

Simcenter3D 2306

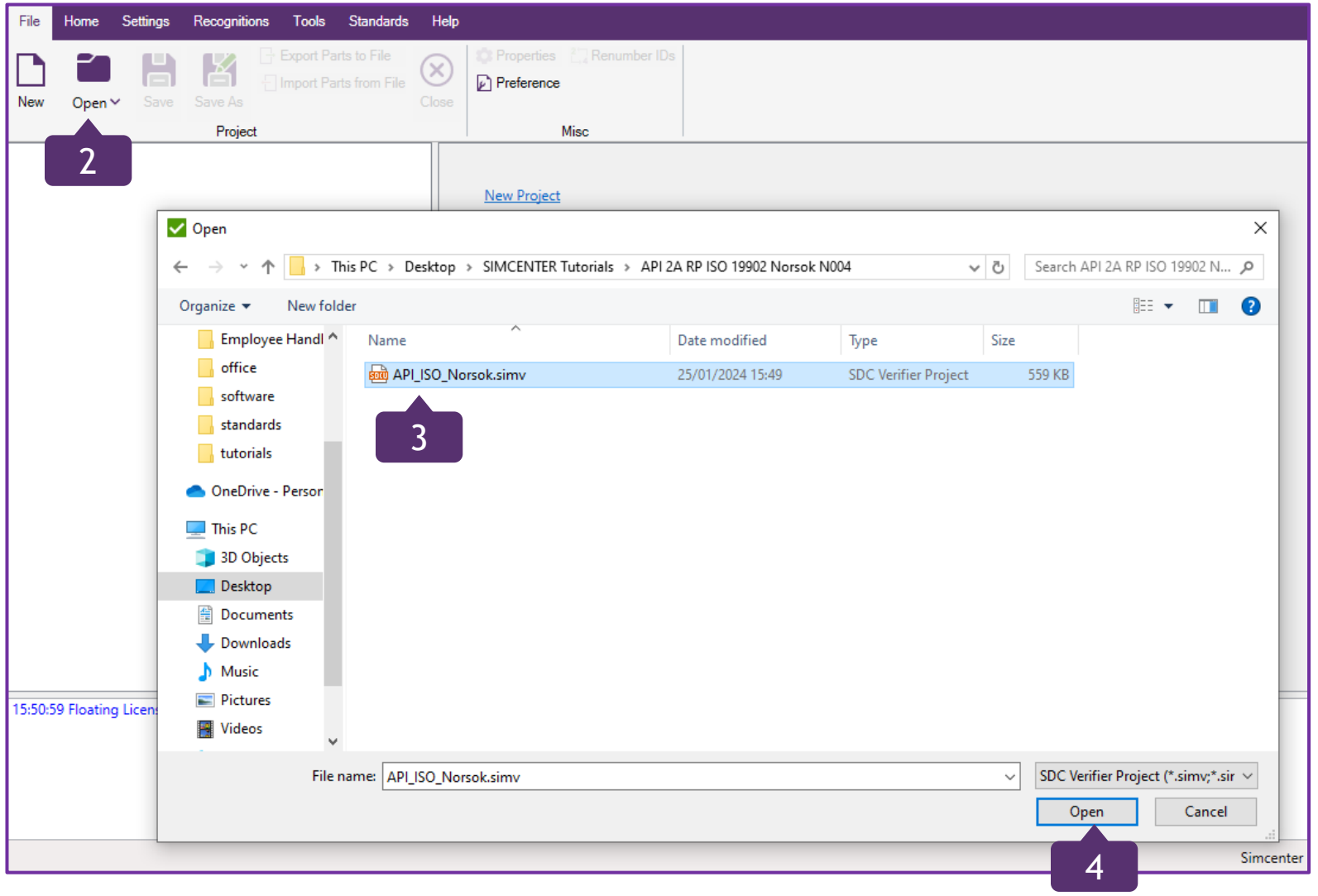
Content

SDC Verifier is a powerful Simcenter add-on that helps verify structures according to standards and generates full calculations reports.

- In this tutorial, API 2A RP/ISO 19902/Norsok N004 Beam Design Checks are reviewed.
- 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 functionality of SDC Verifier Report Designer can be checked via the link to a separate tutorial (Slide 27).

Open the Starter Model

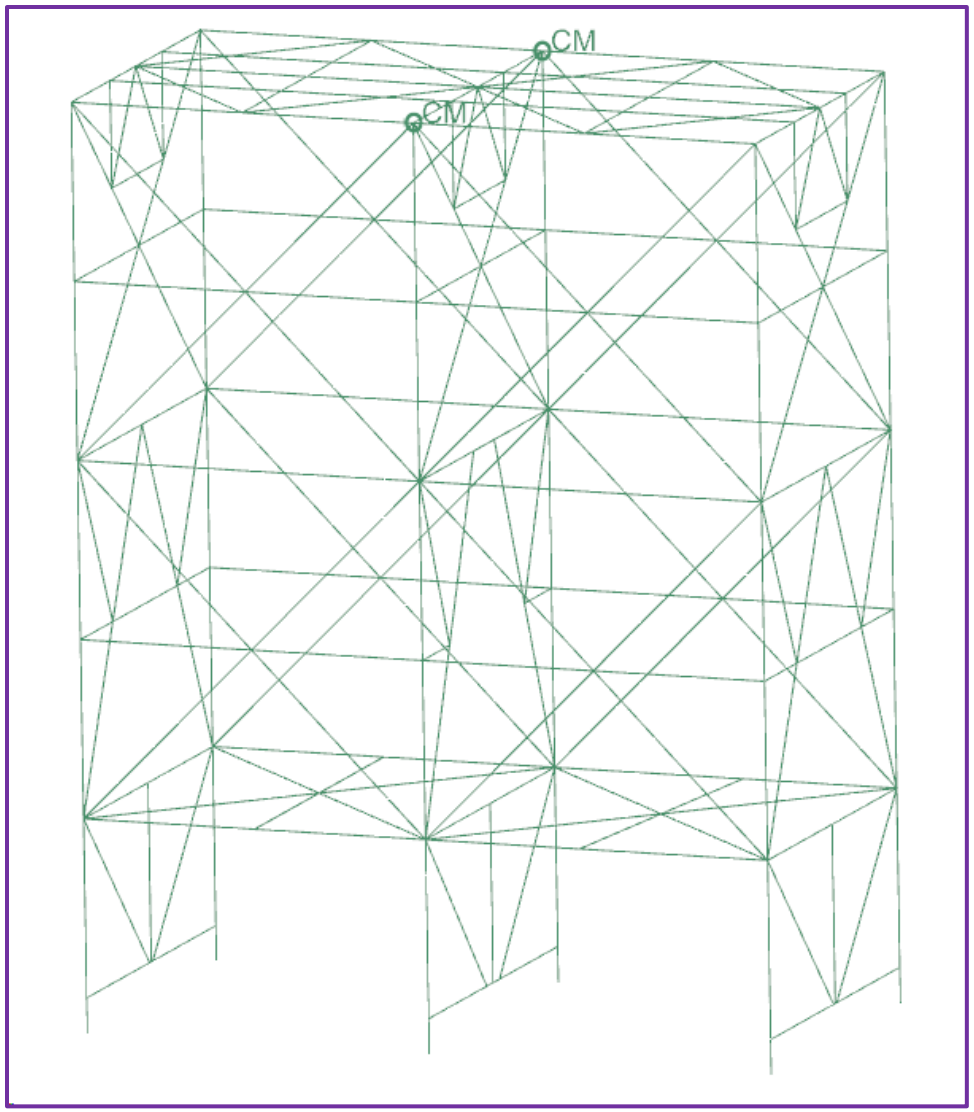
1. Launch SDC Verifier for Simcenter 3D
2. In *File* section, press *Open*
3. Select a project *API_ISO_Norsok.simv*
4. Press *Open*



Predefined Project

This tutorial presents a predefined project with the following created data: Individual Loads, Load Sets and a Load Group. The focus of this tutorial is to check the cylindrical members and create the basic report.

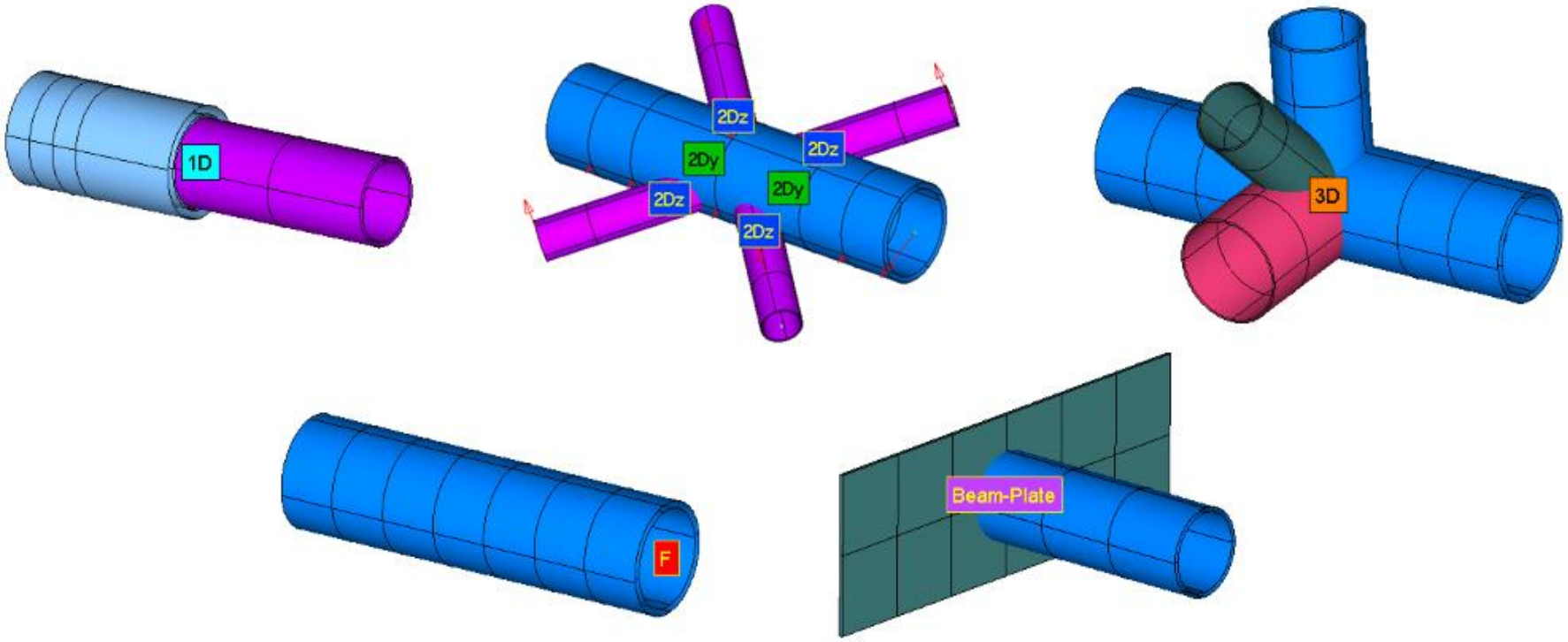
- Views (1)
- Model
- Recognition
- Jobs (1)
  - 1..Linear Static Analysis
    - Individual Loads (9)
      - 1..Nodal Force Down.Legs
      - 2..Nodal Force Down.Legs
      - 3..Nodal Force Right.Legs
      - 4..Nodal Force Left.Legs
      - 5..Nodal Force Middle -YZ.Legs
      - 6..Nodal Force Middle YZ.Legs
      - 7..Wind X.Legs
      - 8..Wind Y.Legs
      - 9..Nodal Force Top.Legs
    - Predefined Load Cases (0)
    - Load Sets (8)
      - 1..Load Set 1
      - 2..Load Set 2
      - 3..Load Set 3
      - 4..Load Set 4
      - 5..Load Set 5
      - 6..Load Set 6
      - 7..Load Set 7
      - 8..Load Set 8
    - Load Groups (1)
      - 1..Load Group 1
    - Fatigue Groups (0)
    - Tables (0)
    - Plots (0)
- Tools
- Standards (0)
- Post-Processing
- Optimizations (0)
- Reports (0)



Explanation of Joints

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



Joints Recognition. Settings

1. In the *Model Tree*, expand *Recognition* and select *Joint Finder*
2. Execute right click on *Joint Finder* and select *Edit*
3. Press *Settings*
4. *Take into account all constraints in the model* is *ON*
5. Press *OK*

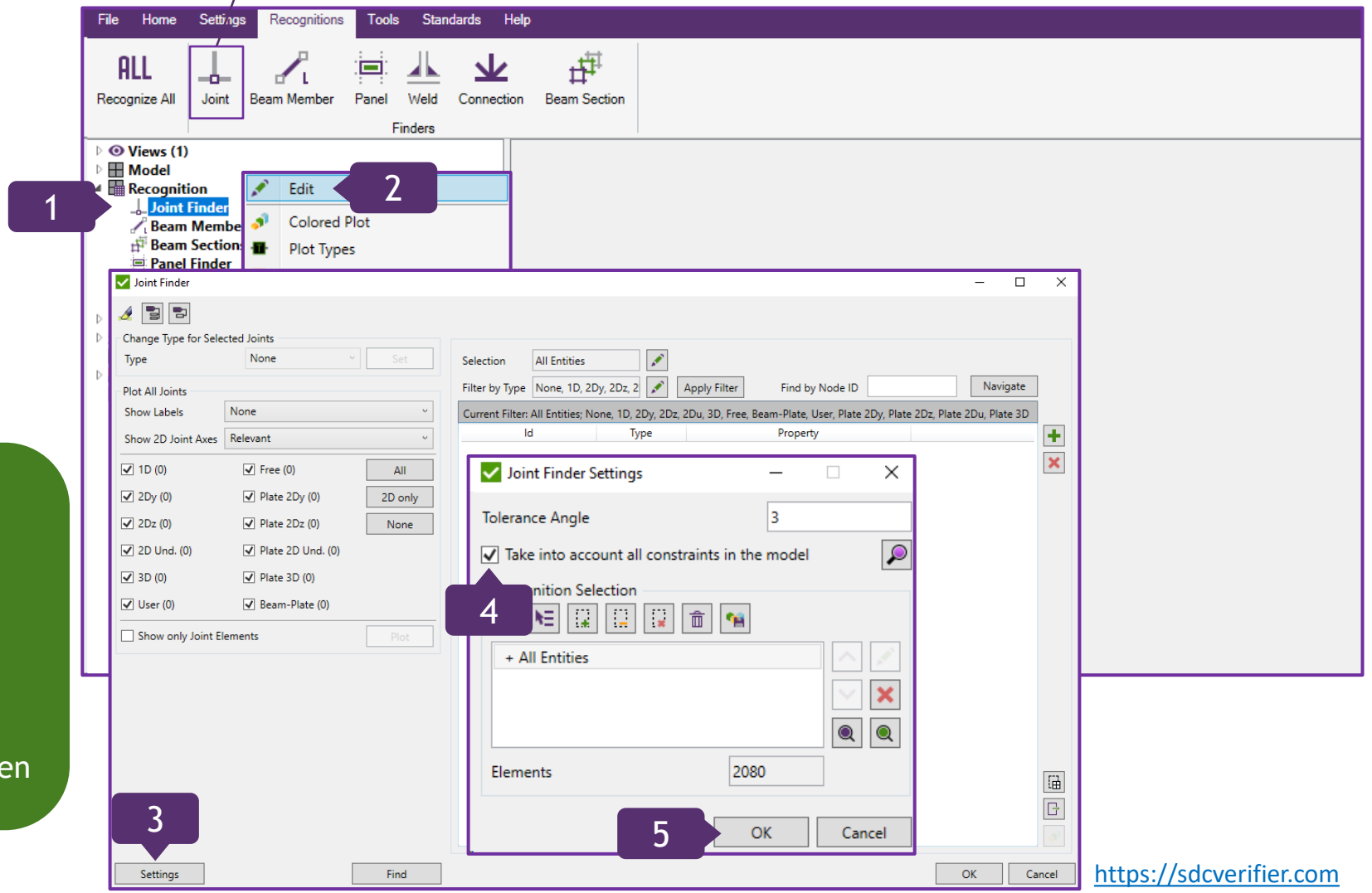
When performing Joint Recognition, there are 3 options for existing joints:

Default option - Keep only modified;

Remove All joints (except for those, edited by a user);

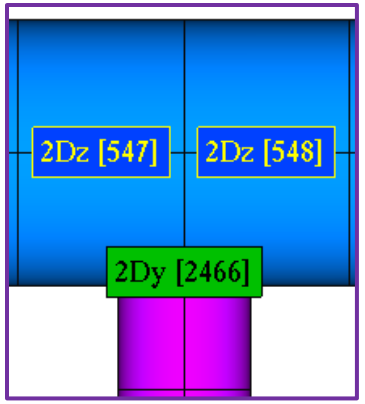
Keep All Existing options - it should be used, when additional elements were added to the model.

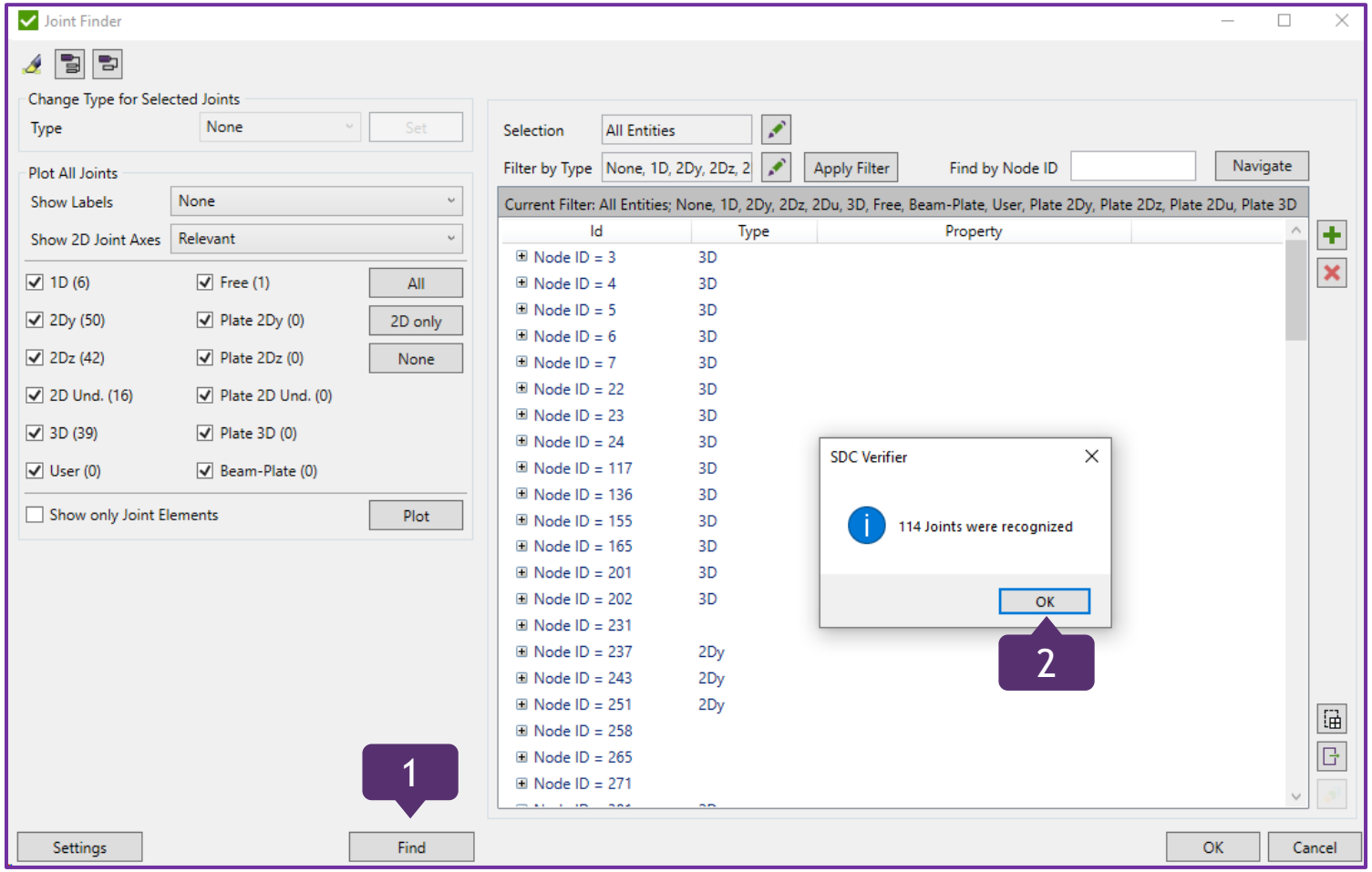
An alternative method of using a Joint Finder Tool is to press Joint in the Recognition section of the Toolbar.

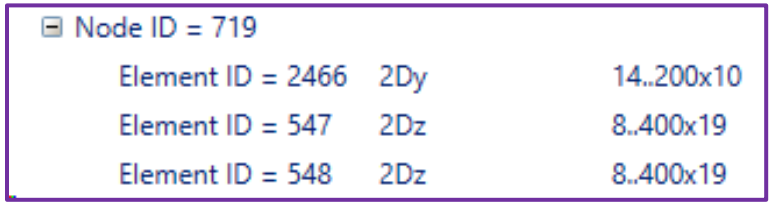


Joints Recognition. Find

1. Press *Find*
2. Press *OK*

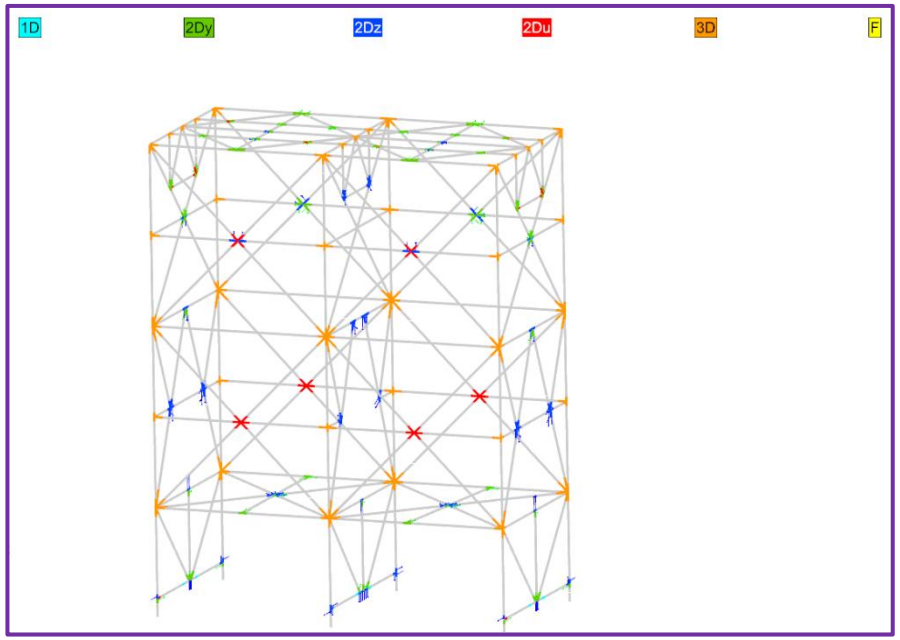


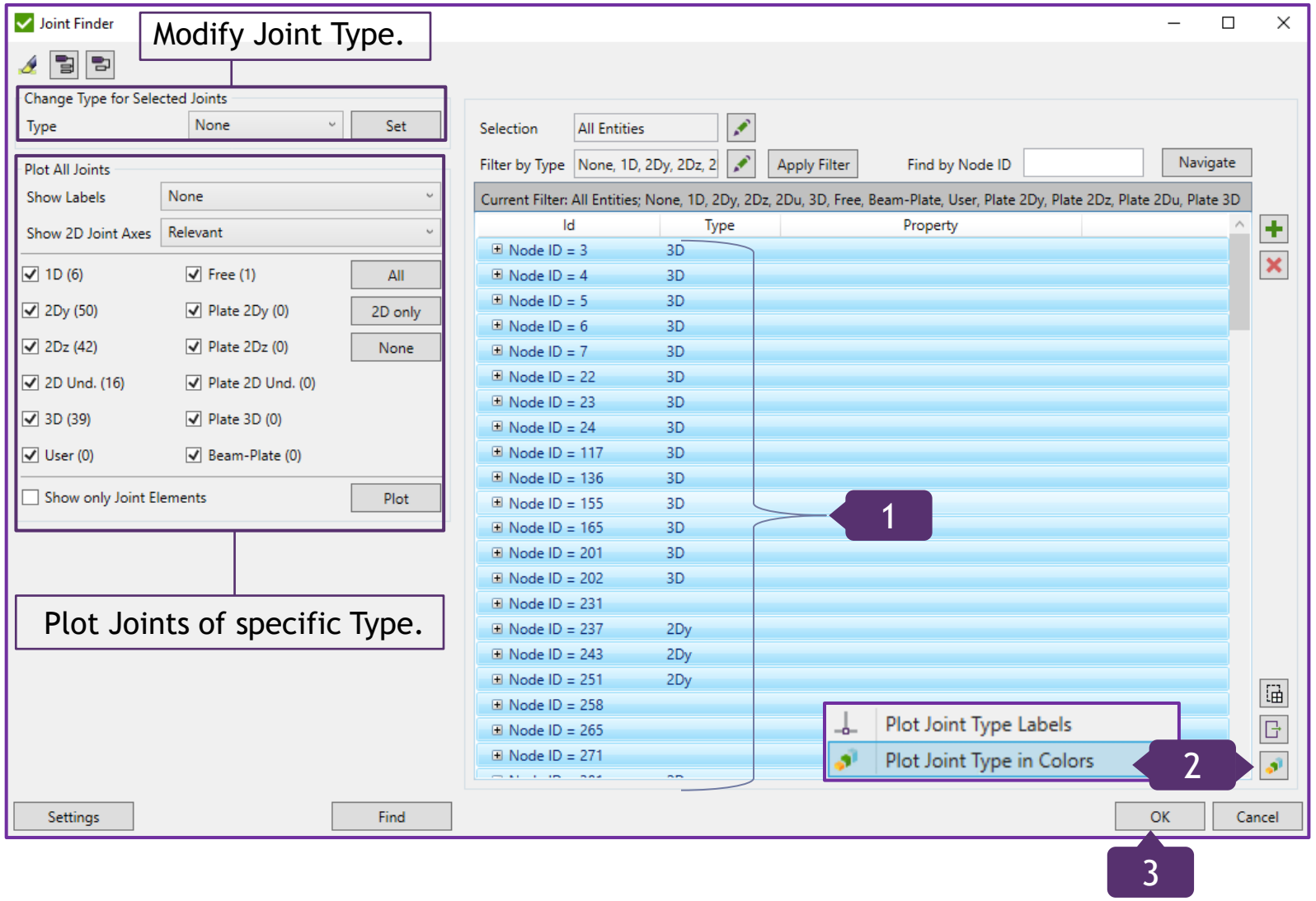




Plot Joints

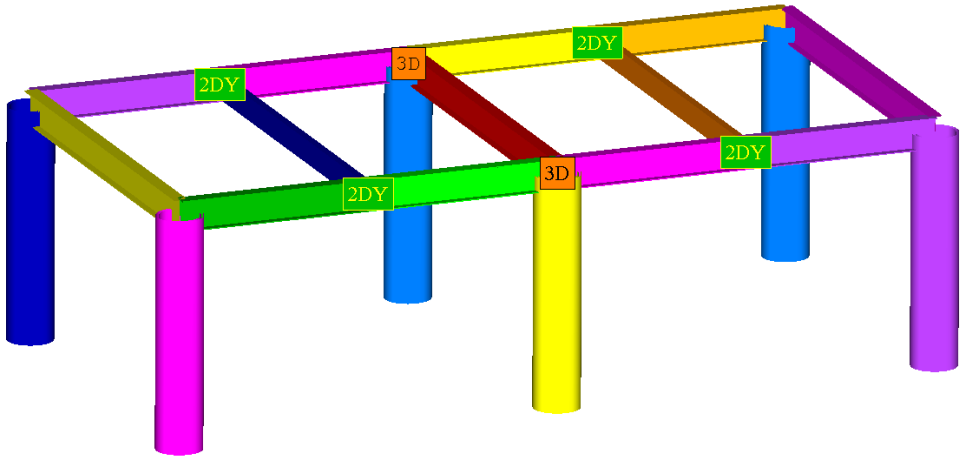
1. Select all Joints *(Ctrl+A)*
2. Press  and select *Plot Joint Type in Colors*
3. Press *OK*

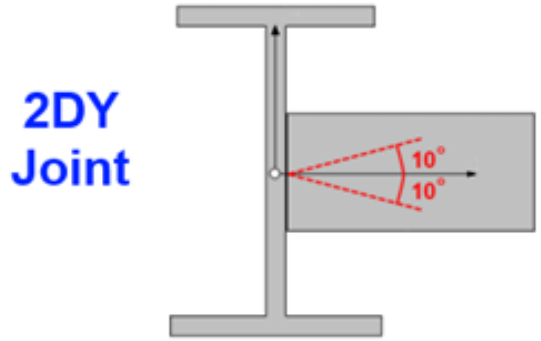




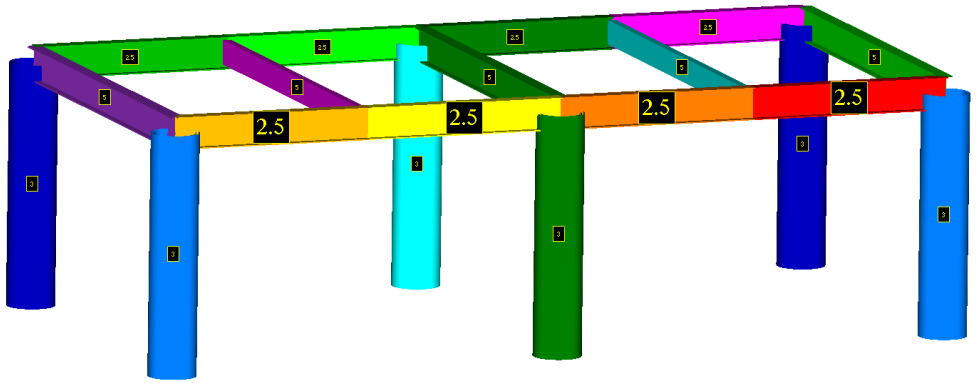
Beam Member Lengths in two Directions

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

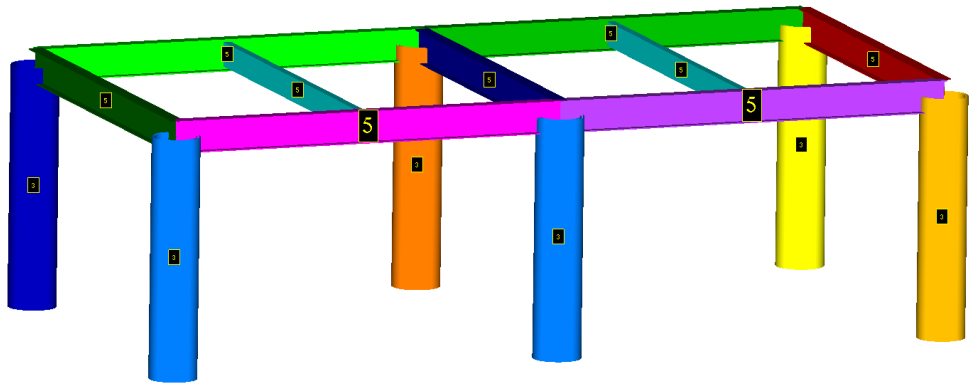




Length Y – 4 Beam Members with L = 2.5



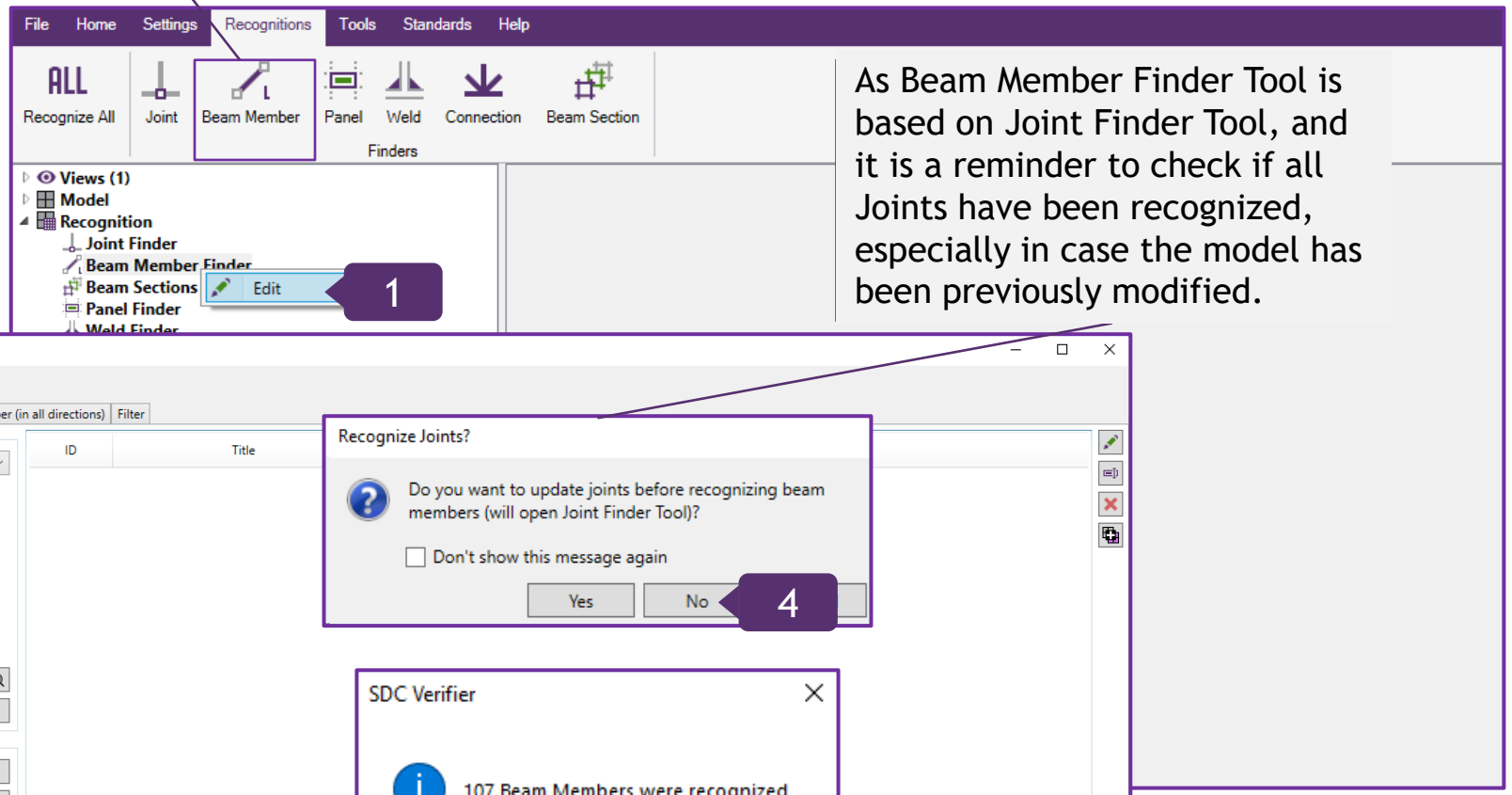
Length Z – 2 Beam Members with L = 5



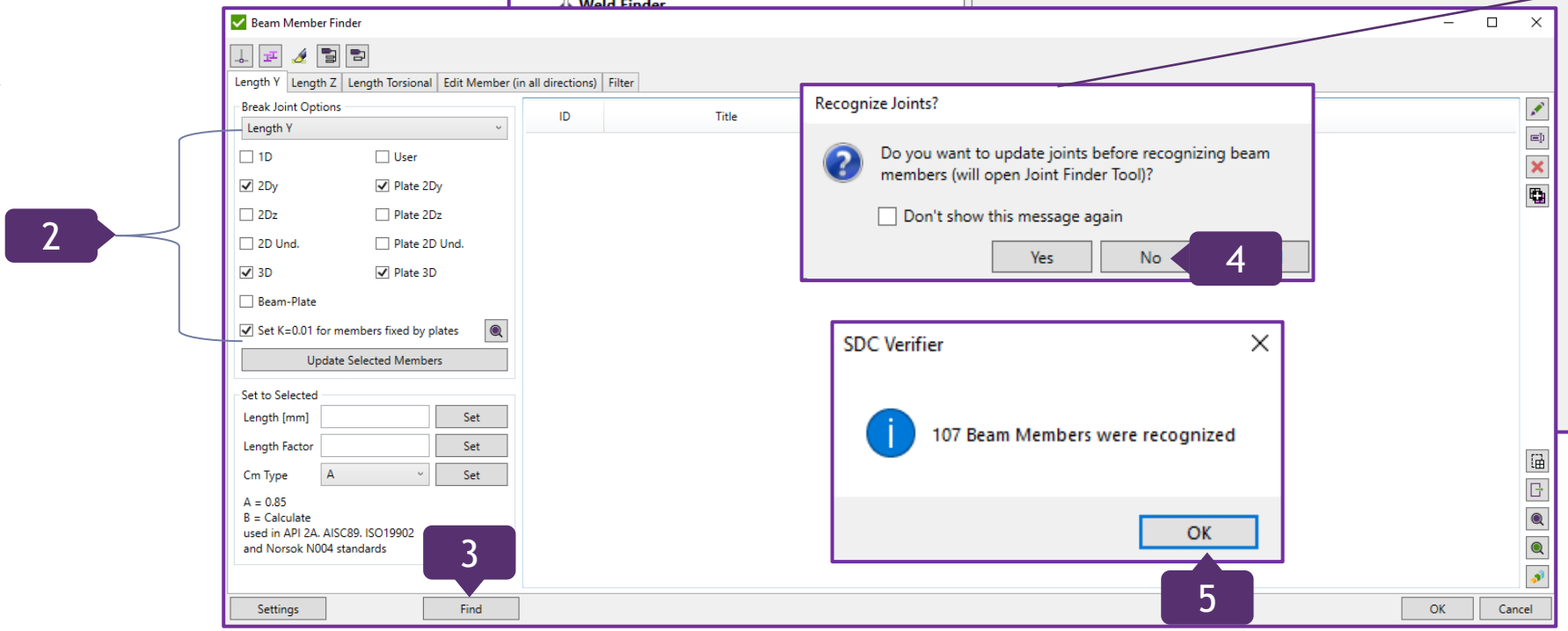
Recognize Length Y

1. In *Recognition* section of the *Model Tree*, execute right click on *Beam Member Finder* and press *Edit*
2. ***Length Y*** **- 2Dy, 3D, Plate 2Dy, Plate 3D**
   Length Z **- 2Dz, 3D, Plate 2Dz, Plate 3D**
   Torsion (Lb) **- 2Dy, 2Dz, 2D Und., 3D**
3. Press *Find*
4. Press *No*
5. Press *OK*

An alternative method of using a Beam Member Finder Tool is to press Beam Member in the Recognition section of the Toolbar.



As Beam Member Finder Tool is based on Joint Finder Tool, and it is a reminder to check if all Joints have been recognized, especially in case the model has been previously modified.



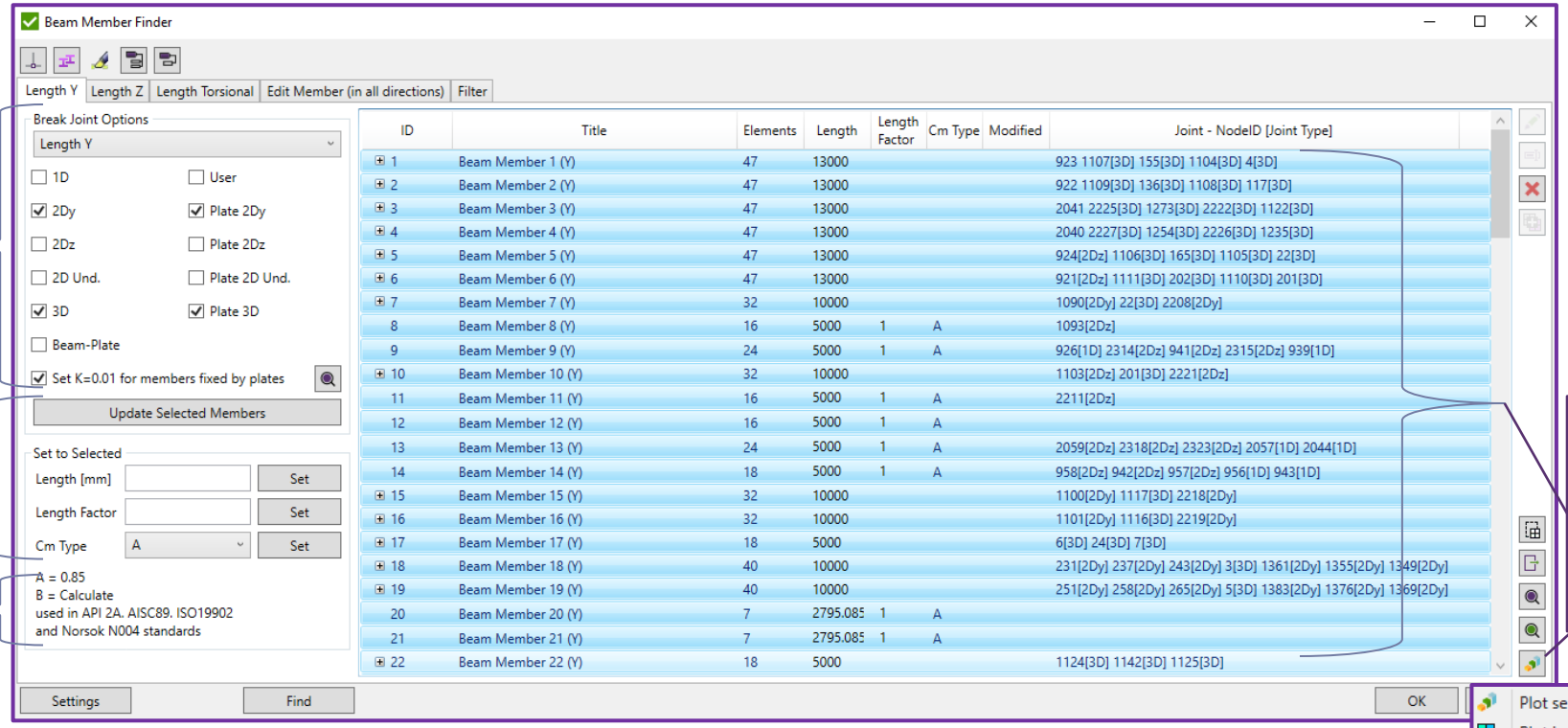
Beam Member Finder Interface Explanation

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

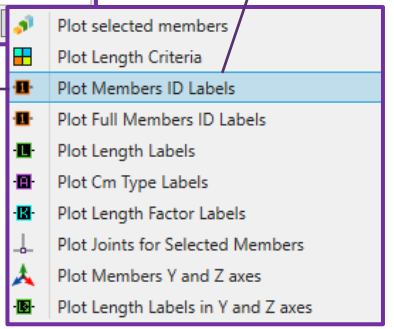
Break Joint Options define what joints are used to split Beam Members.

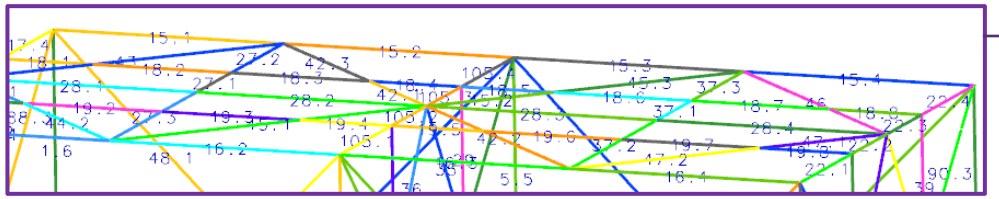
Change Length/Factor for selected beam members.

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



Select all Beam Members and press Select Plot Members ID Labels.

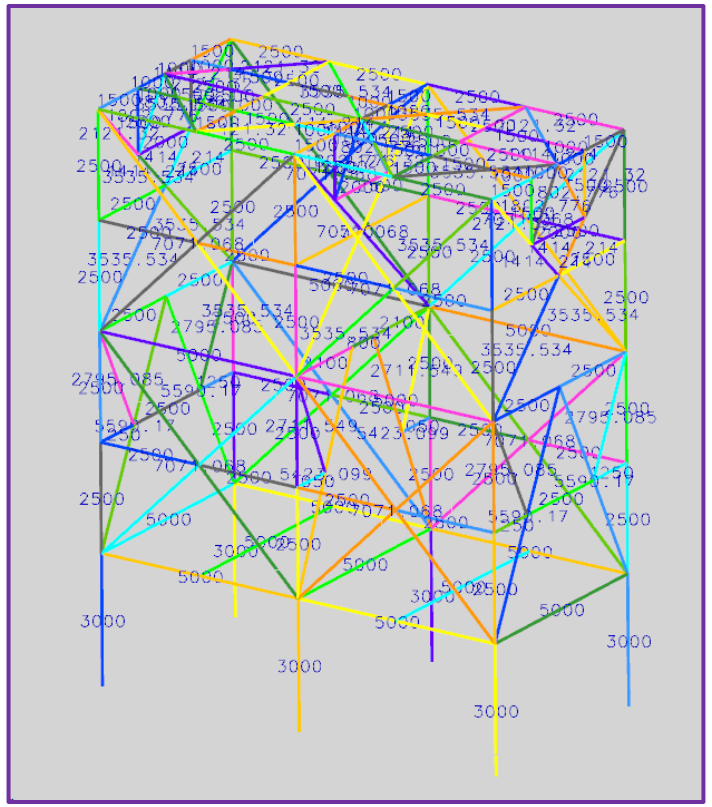


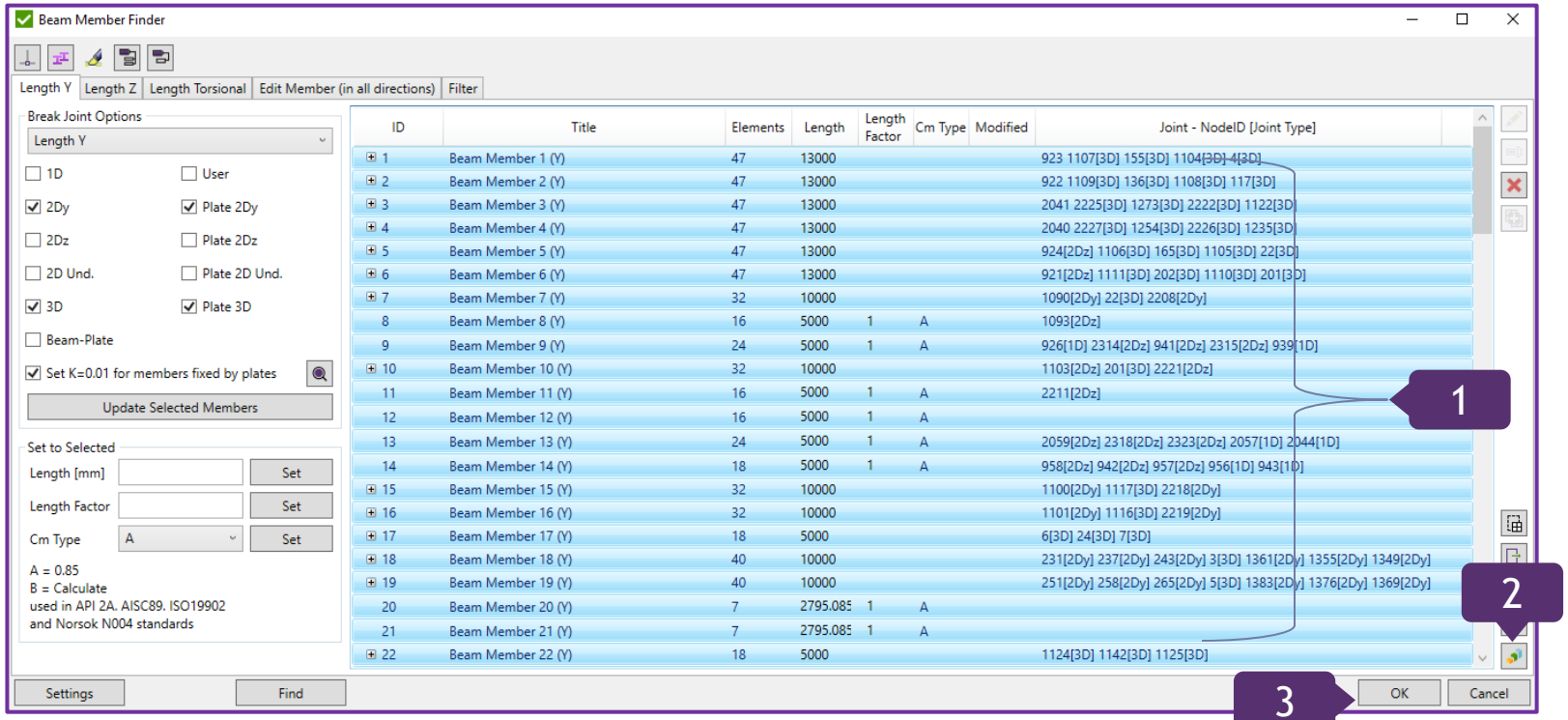


15	Beam Member 15 (Y)	32	10000			1100[2Dy] 1117[3D] 2218[2Dy]
15.1	Beam Member 15.1 (Y)	8	2500	1	A	
15.2	Beam Member 15.2 (Y)	8	2500	1	A	
15.3	Beam Member 15.3 (Y)	8	2500	1	A	
15.4	Beam Member 15.4 (Y)	8	2500	1	A	

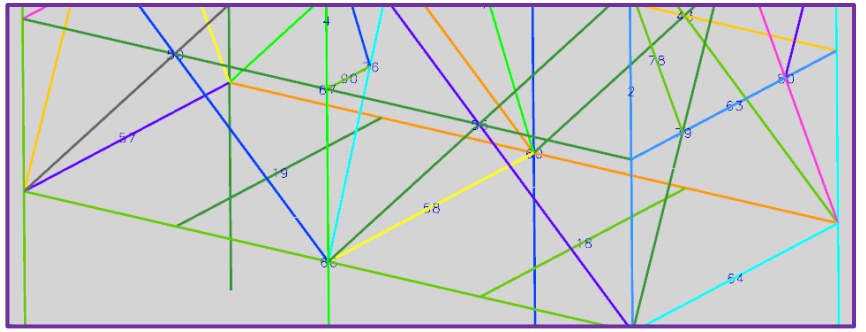
Beam Member's Length Plot

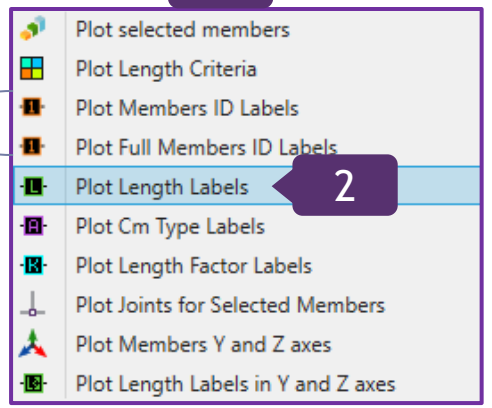
1. Select all Beam Members *(Ctrl+A)*
2. Press  and select *Plot Length Labels*
3. Press *OK*





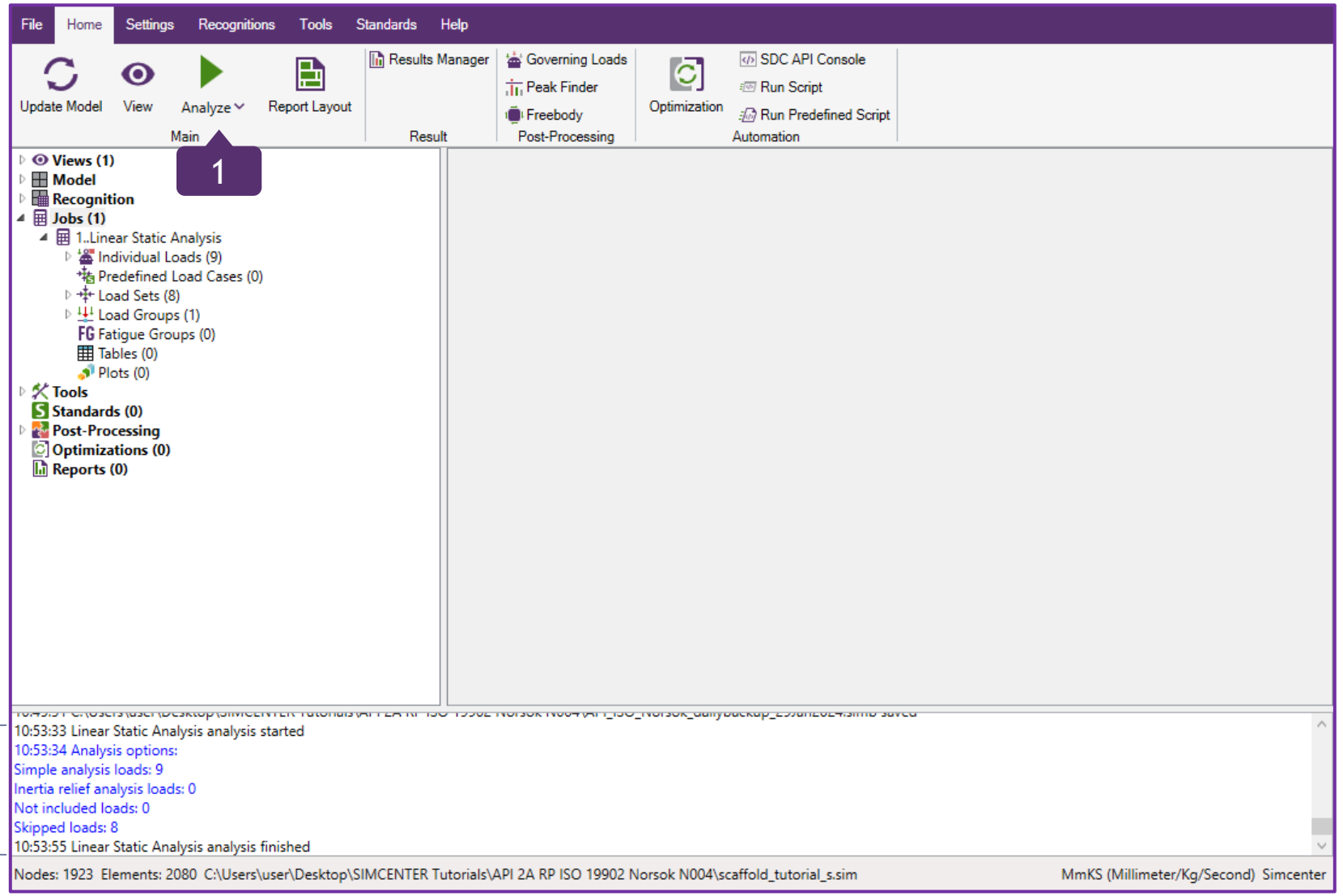
Also, it is possible to display Beam Members IDs by pressing 





Analyze Job

1 In *Home* section, press *Analyze*



Linear Static Analysis started and finished.

Cm Reduction Factors

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

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

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:

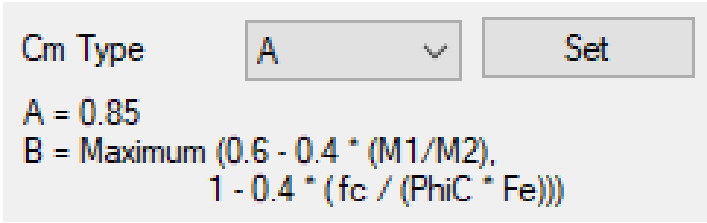
(1) Use whichever is more applicable to a specific situation. Values of the reduction factor C_m referred to in the above table are as follows:

(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.

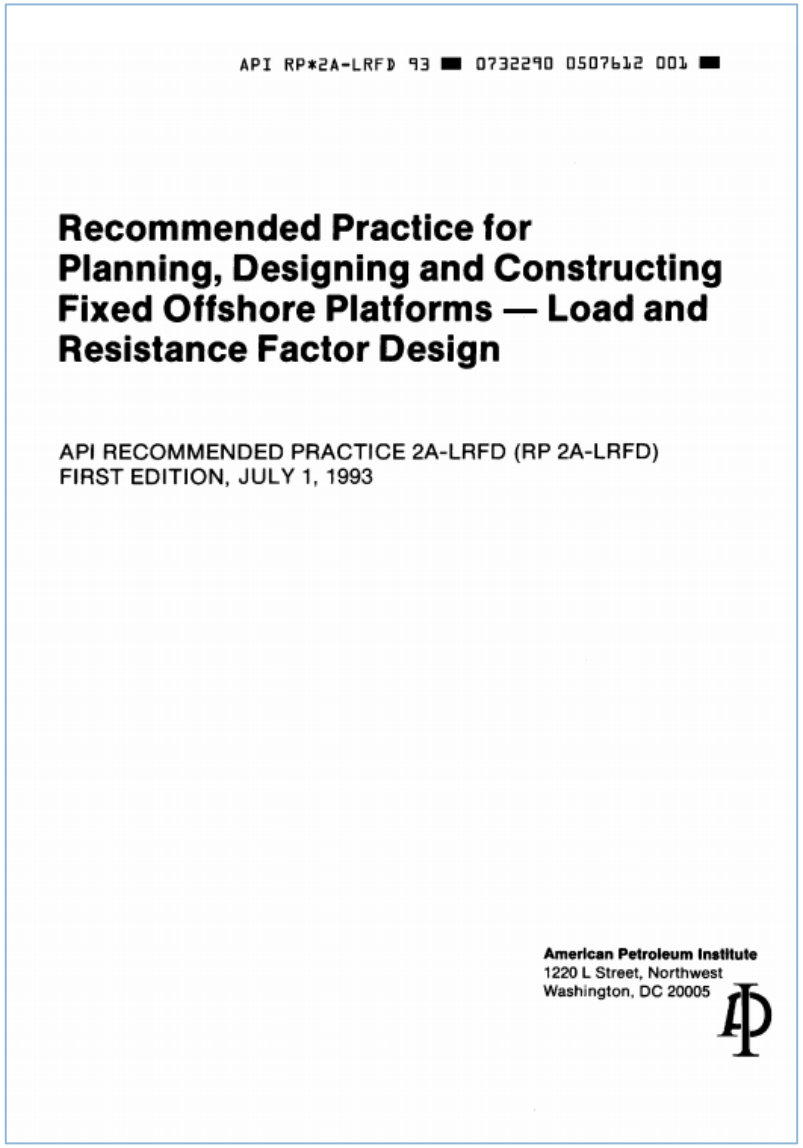
(c) $1.0 - 0.4\frac{(f_c)}{\phi_c F_e}$, or 0.85, whichever is less

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)

API RP 2A-LRFD



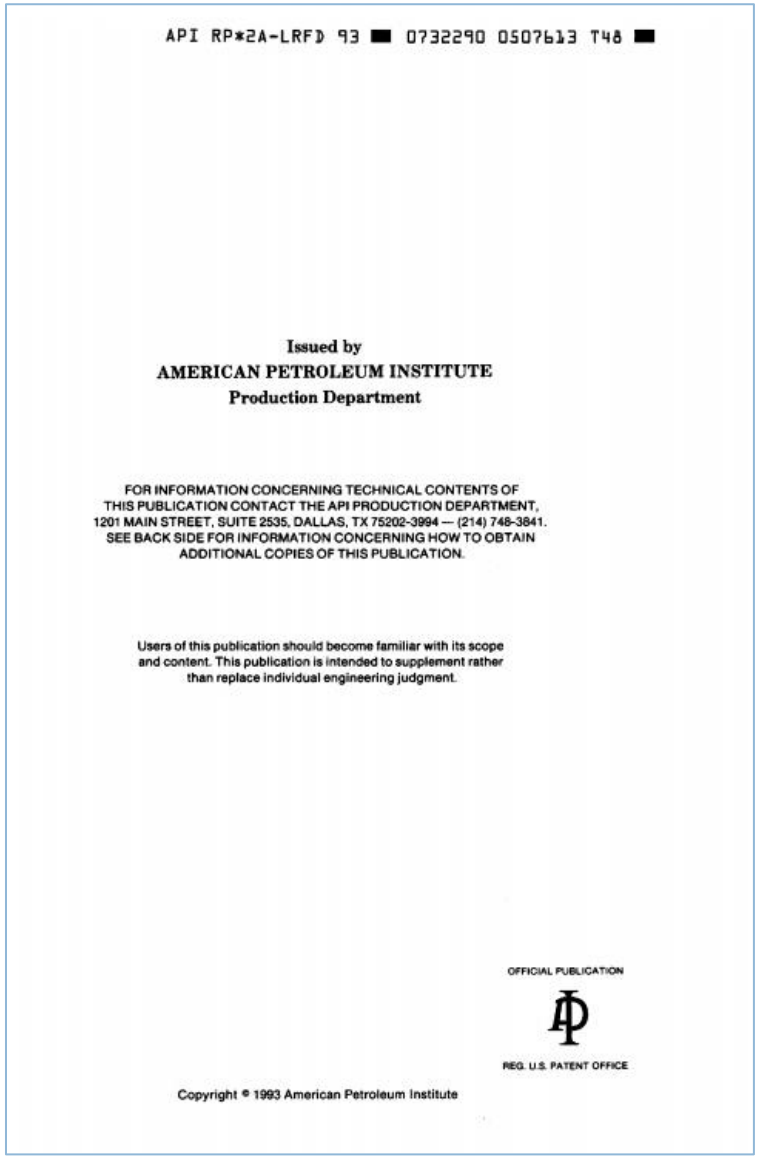
API RP*2A-LRFD 93 ■ 0732290 0507612 001 ■

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 ■

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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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Add API RP 2A-LRFD Standard

1 Execute right click on *Standards* and select *Add => API => API RP 2A-LRFD (1st, 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.

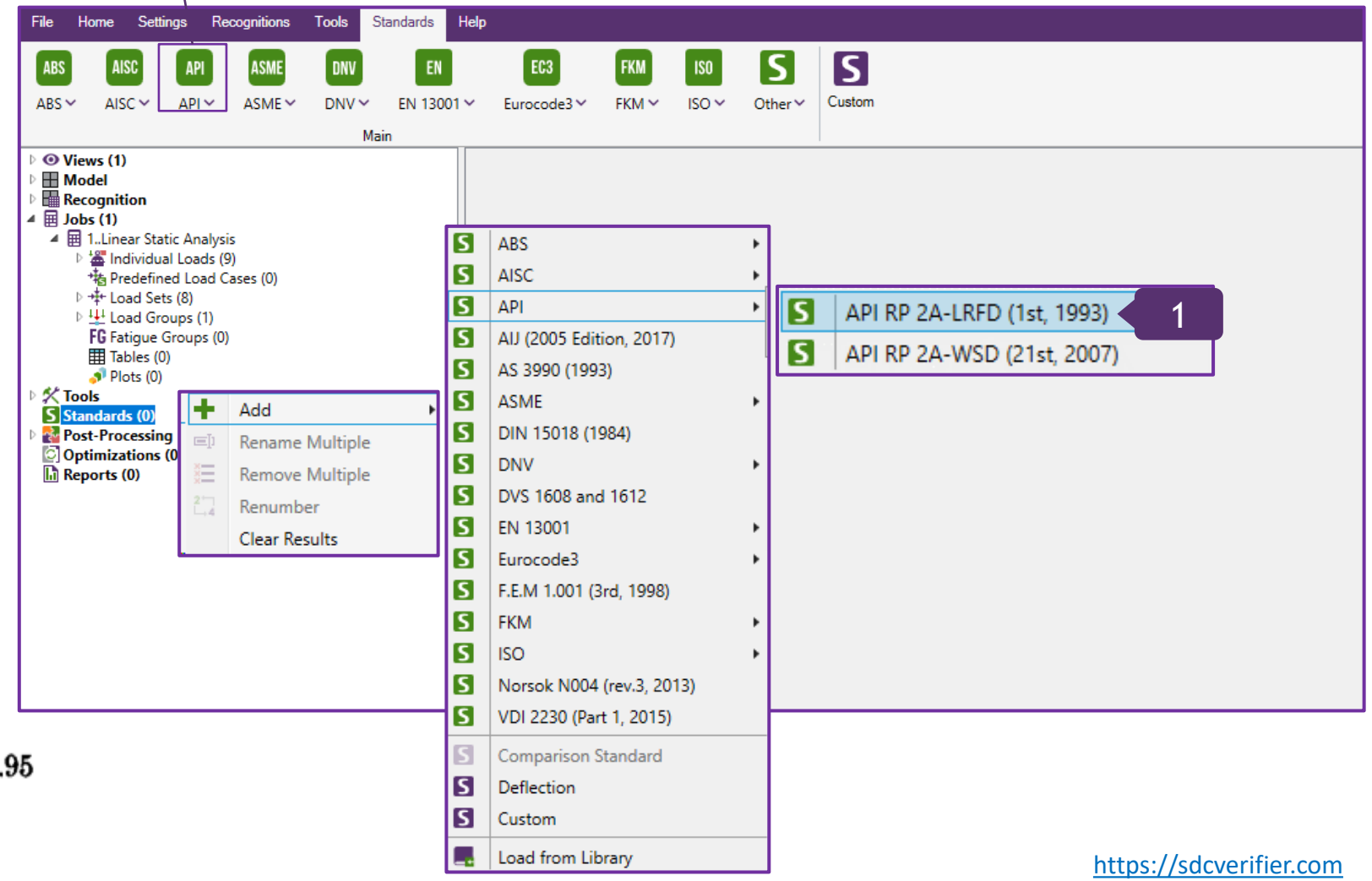
ϕ_t = resistance factor for axial tensile strength, 0.95

ϕ_c = resistance factor for axial compressive strength, 0.85

ϕ_b = resistance factor for bending strength, 0.95.

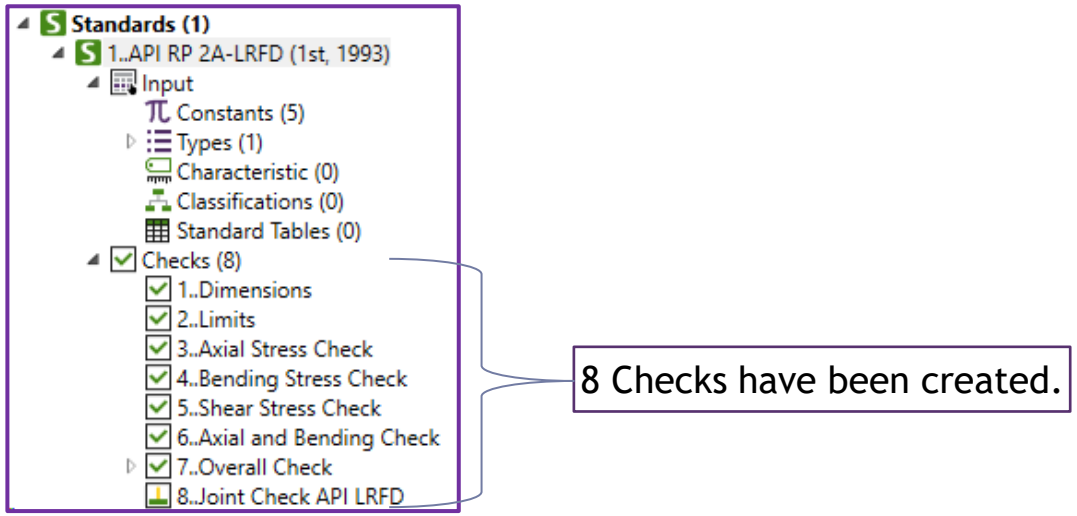
ϕ_v = resistance factor for beam shear strength, 0.95

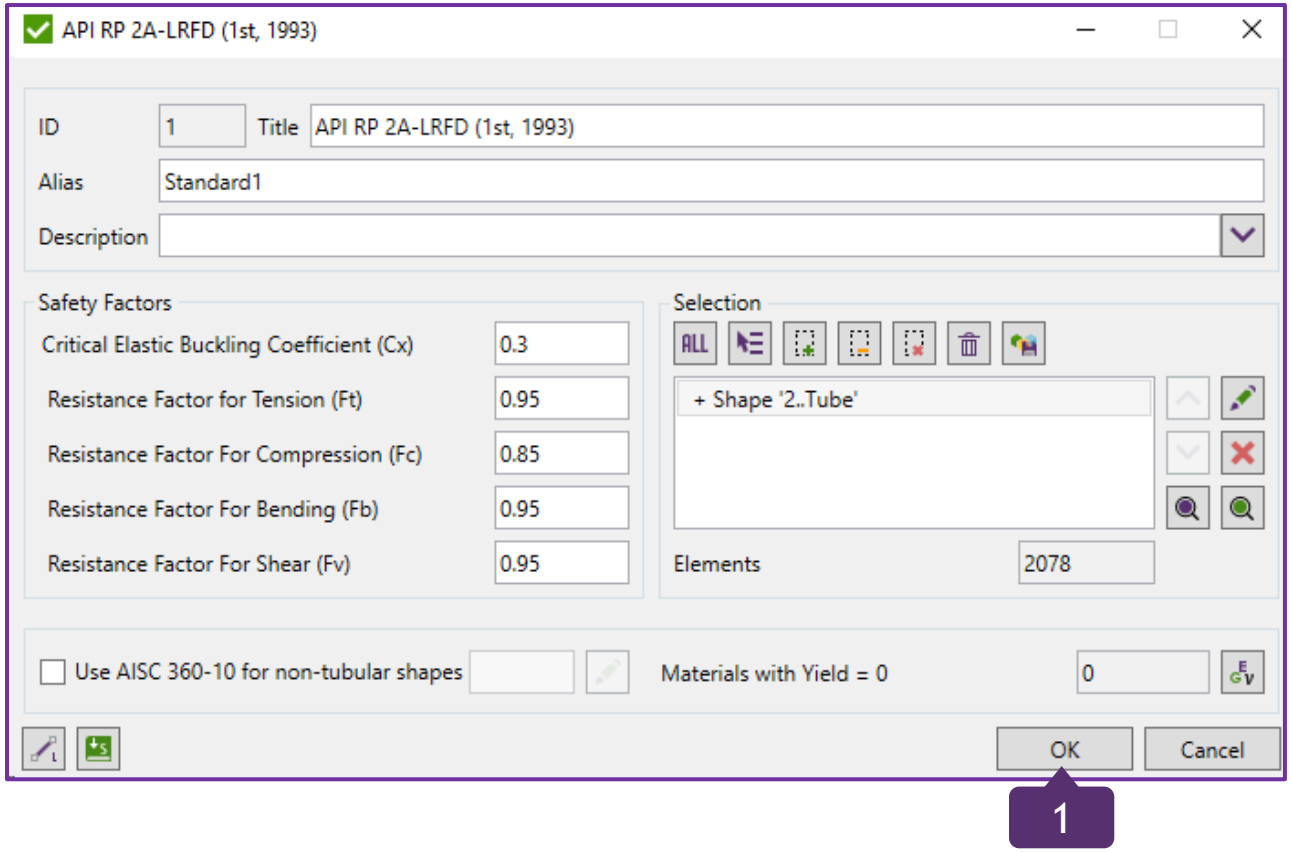
An alternative method of adding Standards is to select API (in this case) in the Standards section of the Toolbar.



Standard has been added

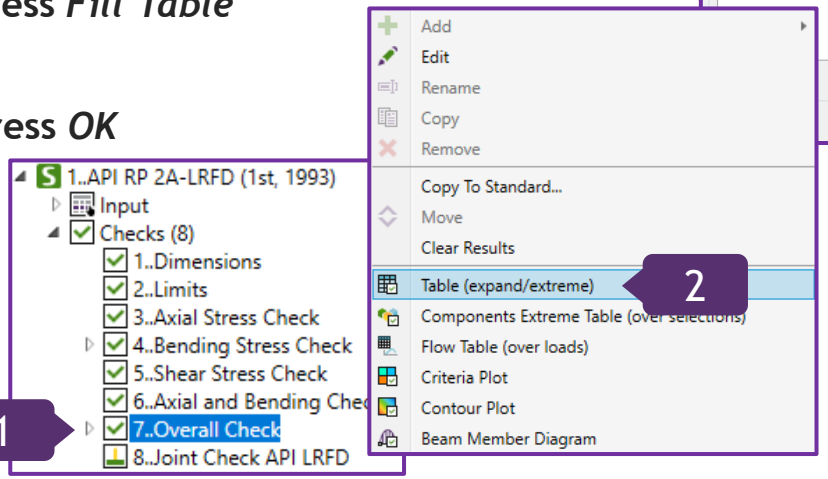
1 **Press *OK***

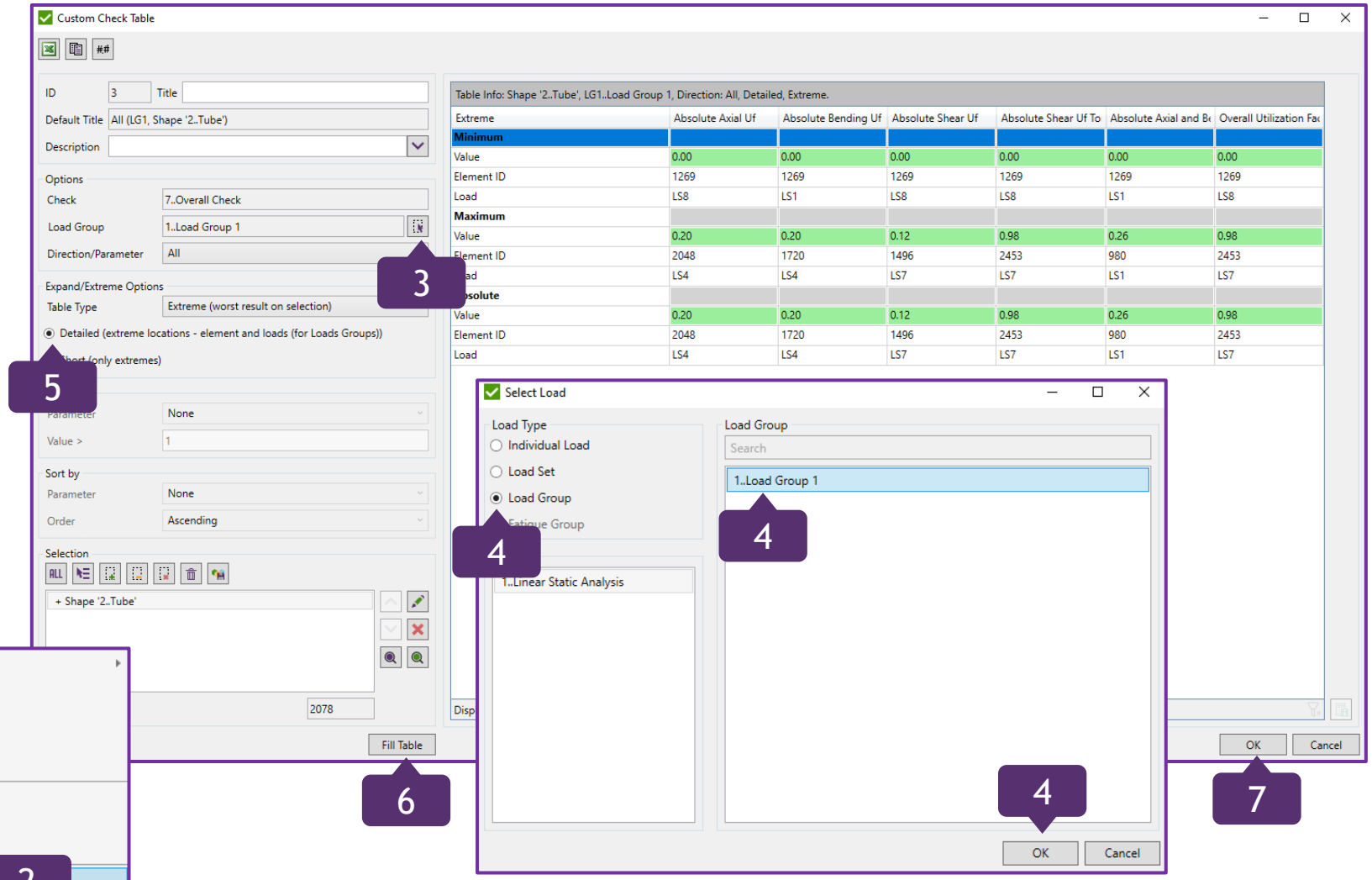




Preview Table Results for Overall Check

1. In *Checks* section, select *7..Overall Check* and execute right click
2. Select *Table (expand/extreme)*
3. In Load Group, press 
4. Select *Load Group => 1..Load Group 1* and press *OK*
5. *Detailed (extreme locations - element and loads (for Loads Groups))* is *ON*
6. Press *Fill Table*
7. Press *OK*





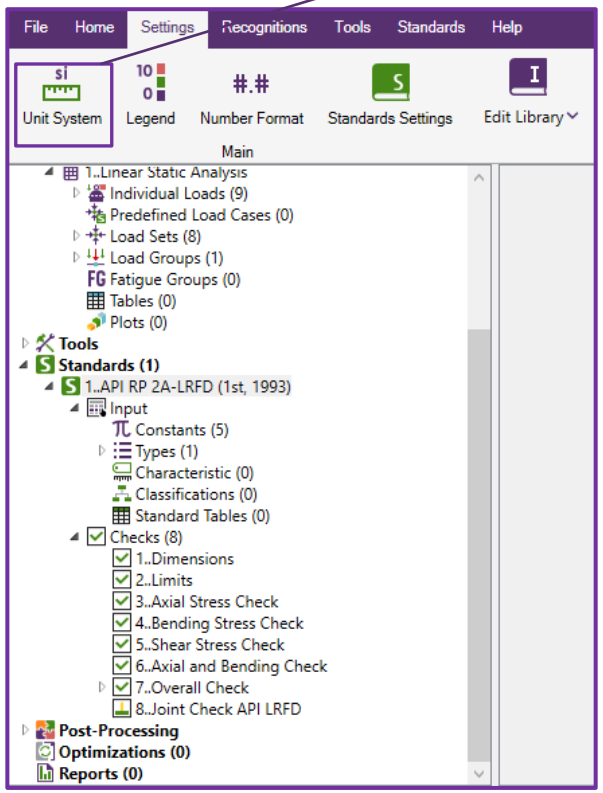
Overall Check contains results from all Checks. With the help of one table/plot, it is possible to verify if the model passes the checks (< 1).
Overall Utilization Factor = the worst Uf among all checks.

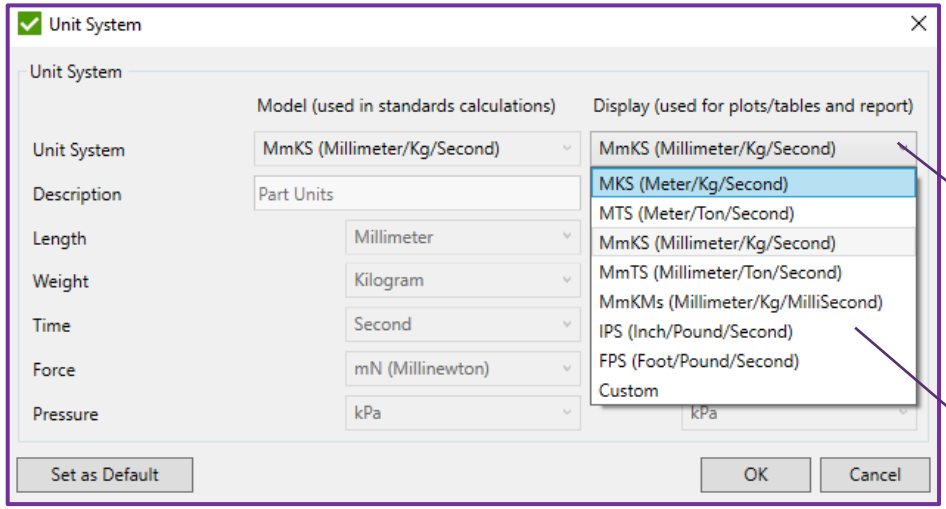
Unit System

API RP 2A Standard is applicable to stiffened and unstiffened cylinders having t >= 6mm, D / t < 120 and Yield Stress < 414 MPa. To validate this condition, the Unit System, which is used in the model, should be specified in SDC Verifier.

```
Parameter = RequirementsValid (Requirements Valid)
if((Units.GetInMillimeters(Thickness) >= 6) and (Units.GetInMPa(Yield) < 414) and (D / Thickness < 300), yes, no)
```

Unit System can be found in Settings section of the Ribbon.





By default, MKS (Meter/Kg/Second) unit system is used. To change unit system, expand this section.

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.

Results on 7..Overall Check

Table Info: Shape '2..Tube', LG1..Load Group 1, Direction: All, Short, Extreme.

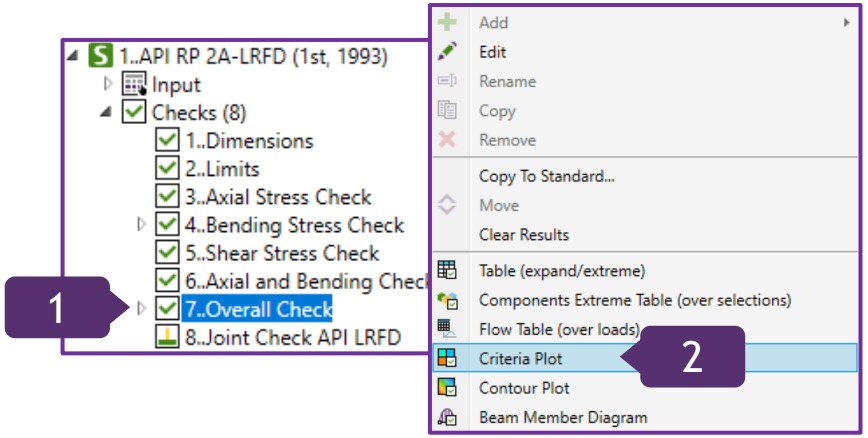
Extreme	Absolute Axial Uf	Absolute Bending Uf	Absolute Shear Uf	Absolute Shear Uf To	Absolute Axial and Be	Overall Utilization Fa
Minimum	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00
Maximum	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00
Absolute	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00	12345678.00

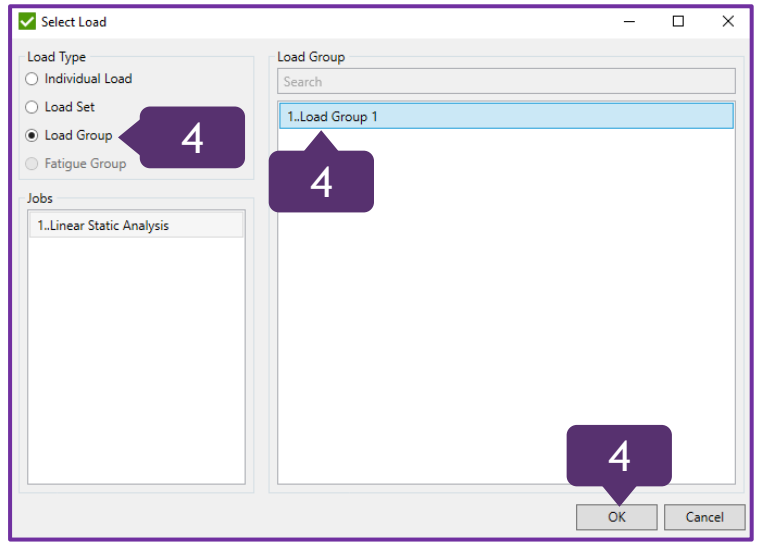
In case the standard cannot perform verification of the model, the results will display the value = **12345678.**

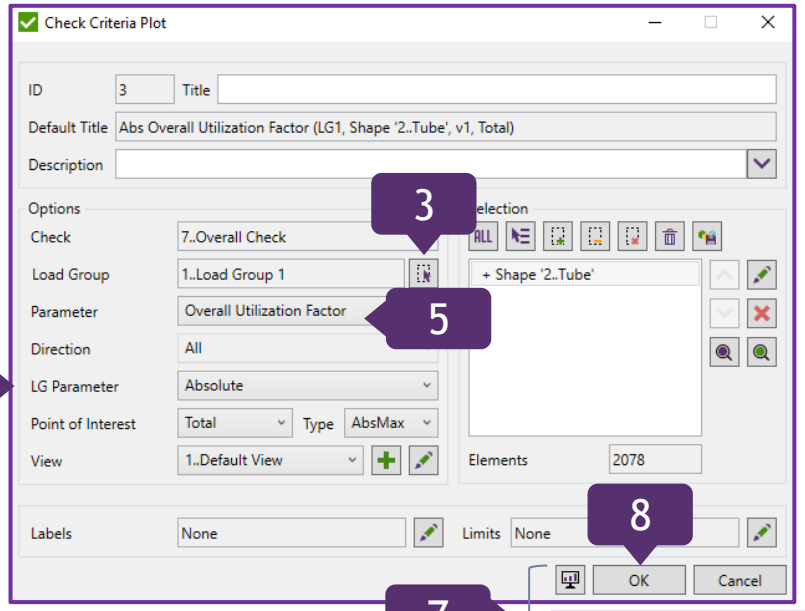
Criteria Plot for OverallCheck

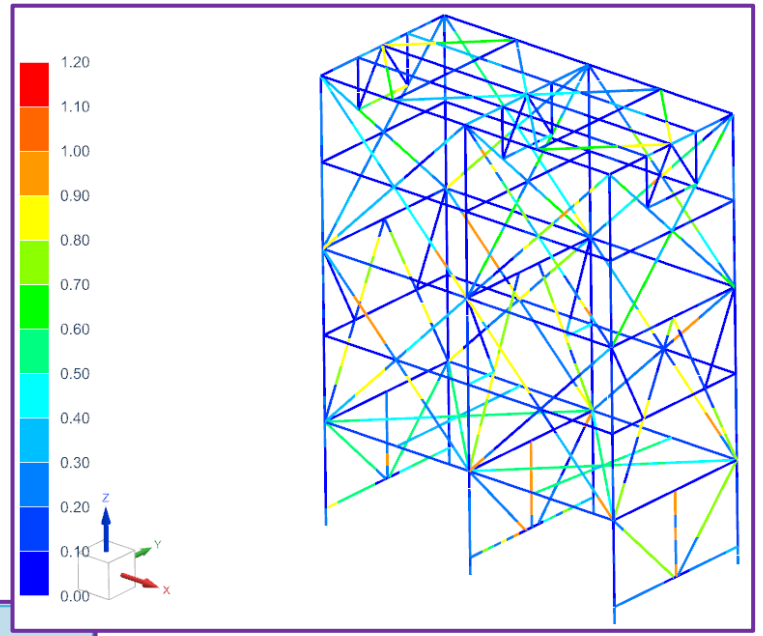
1. In Checks section, select *7..Overall Check* and execute right click
2. Select *Criteria Plot*
3. In Load Group, press 
4. Select *Load Group => 1..Load Group 1* and press *OK*
5. Parameter: Overall *Utilization Factor*
6. LG Parameter: Absolute
7. Press  , and then *Preview*
8. Press *OK*

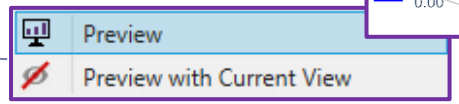
SDC Verifier uses Legend from 0.00 to 1.20 for Utilization Factor. Elements in orange and red do not pass the check.











ISO 19902 (1st, 2007) Standard (Theoretical Aspects)

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

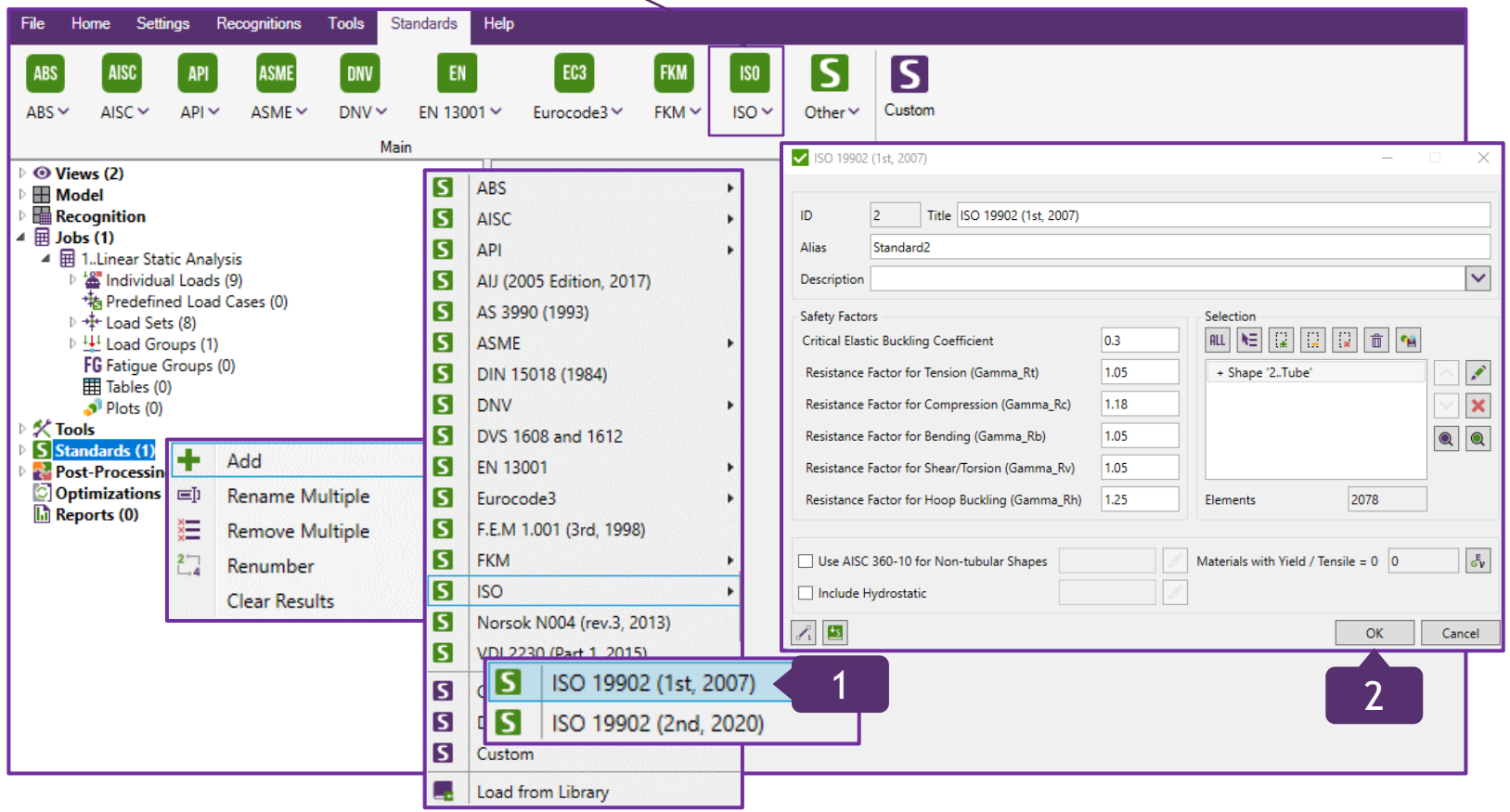
$\gamma_{R,v}$ is the partial resistance factor for shear strength, $\gamma_{R,v} = 1,05$;

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

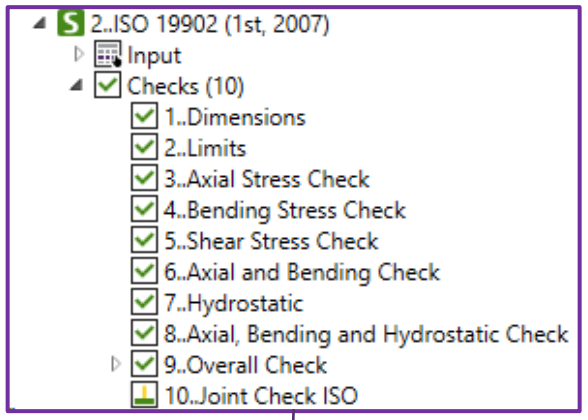
Add ISO 19902 (1st, 2007) Standard

1. **Execute right click on *Standards* and select *Add* => *ISO* => *ISO 19902 (1st, 2007)***
2. **Press *OK***

An alternative method of adding Standards is to select ISO (in this case) in the Standards section of the Toolbar.



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 = the worst Uf among all checks < 1.



10 Checks have been created.

It is also possible to preview Table Results and Criteria Plot from Overall Check by following the steps from slides 18 and 20.

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.

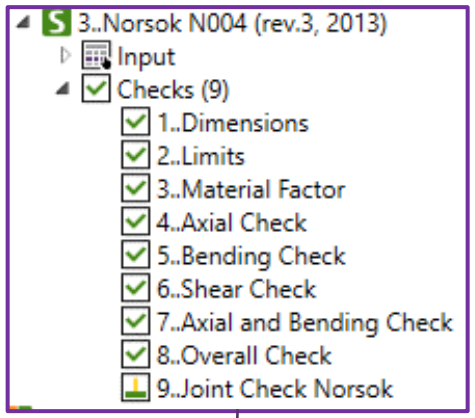
Add Norsok N004 (rev.3, 2013) Standard

1. Execute right click on *Standards* and select *Add => Norsok N004 (rev.3, 2013)*

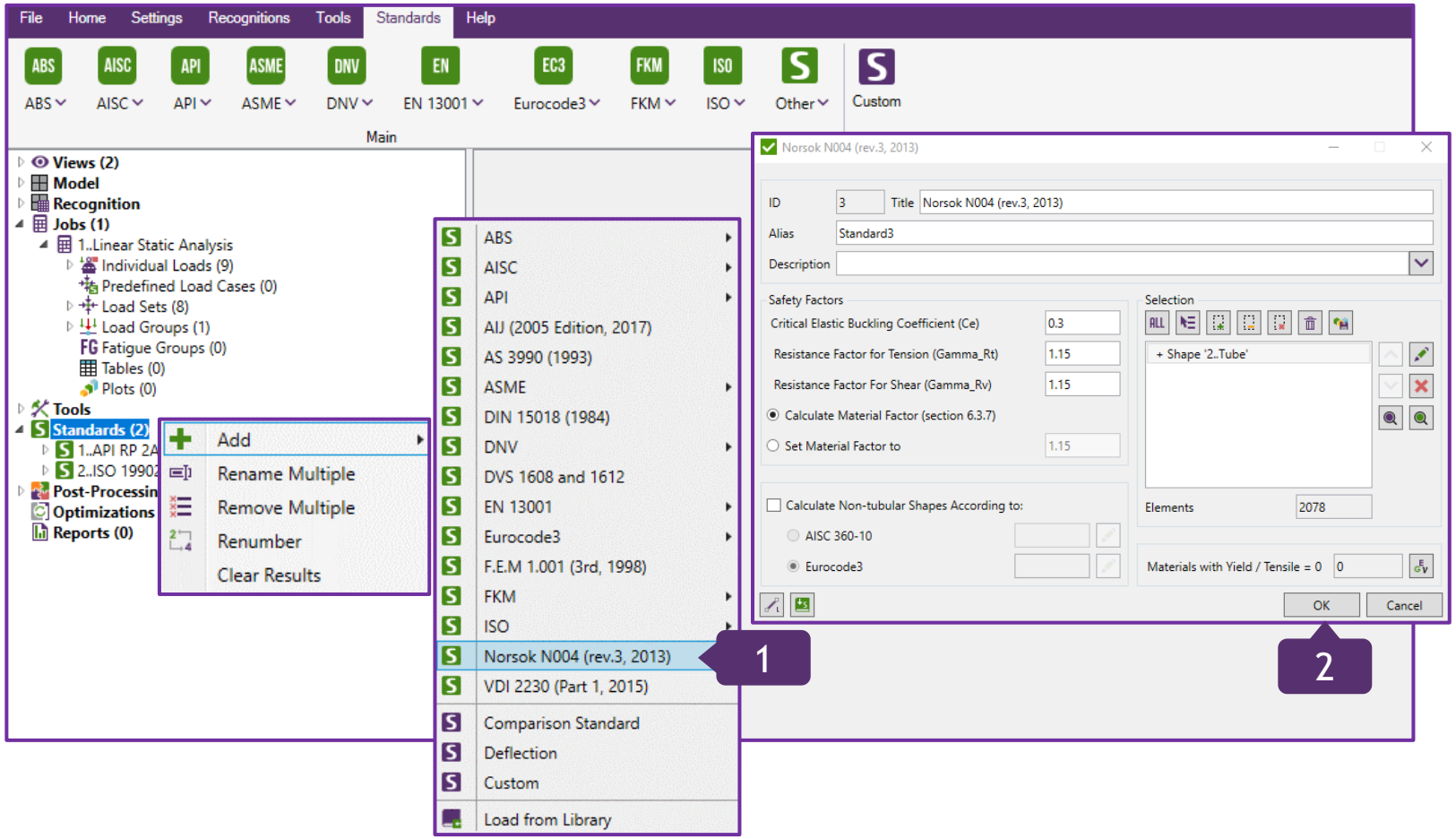
2. Press *OK*

It is also possible to preview Table Results and Criteria Plot from Overall Check by following the steps from slides 18 and 20.

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 = the worst Uf among all checks < 1.



9 Checks have been created.



Extreme Tables on Overall Checks

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

Table Info: Shape '2..Tube', LG1..Load Group 1, Direction: All, Detailed, Extreme.

Extreme	Absolute Axial Uf	Absolute Bending Uf	Absolute Shear Uf	Absolute Shear Uf To	Absolute Axial and Be	Overall Utilization Fac
Minimum						
Value	0.00	0.00	0.00	0.00	0.00	0.00
Element ID	1500	1500	1500	1500	1500	1500
Load	LS8	LS1	LS8	LS8	LS1	LS8
Maximum						
Value	0.20	0.20	0.12	0.98	0.26	0.98
Element ID	1874	1720	1850	2157	980	2157
Load	LS4	LS4	LS7	LS7	LS1	LS7
Absolute						
Value	0.20	0.20	0.12	0.98	0.26	0.98
Element ID	1874	1720	1850	2157	980	2157
Load	LS4	LS4	LS7	LS7	LS1	LS7

ISO 19902 (1st, 2007) Standard

Table Info: Shape '2..Tube', LG1..Load Group 1, Direction: All, Detailed, Extreme.

Extreme	Axial Um	Bending Um	Shear Um	Shear Torsional Um	Axial and Bending Ur	Overall Utilization Fac
Minimum						
Value	0.00	0.00	0.00	0.00	0.00	0.00
Element ID	1500	1500	1500	1500	1500	1500
Load	LS8	LS1	LS8	LS8	LS1	LS8
Maximum						
Value	0.21	0.19	0.12	0.98	0.29	0.98
Element ID	1874	1720	1850	2157	980	2157
Load	LS4	LS4	LS7	LS7	LS1	LS7
Absolute						
Value	0.21	0.19	0.12	0.98	0.29	0.98
Element ID	1874	1720	1850	2157	980	2157
Load	LS4	LS4	LS7	LS7	LS1	LS7

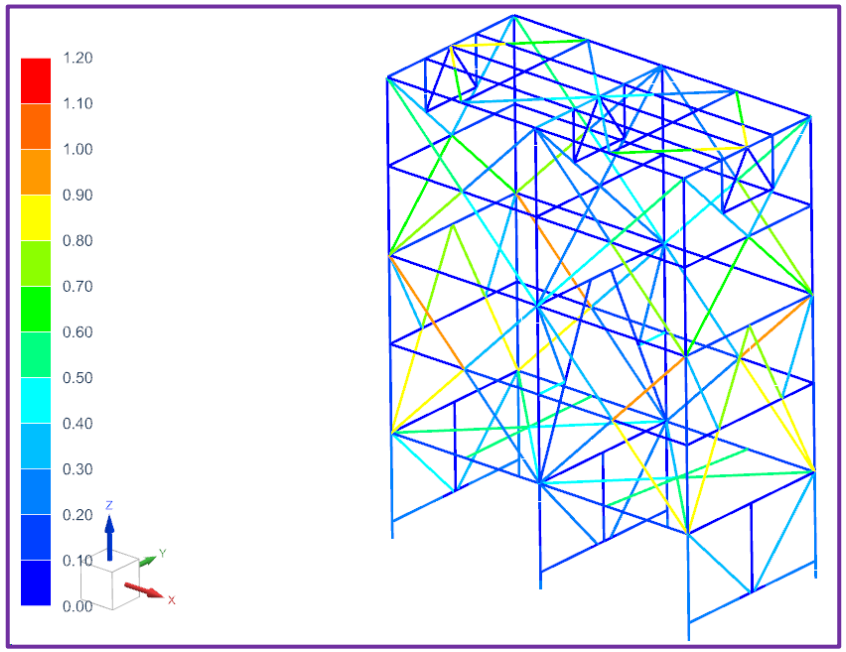
Norsok N004 (rev.3, 2013) Standard

Table Info: Shape '2..Tube', LG1..Load Group 1, Direction: All, Detailed, Extreme.

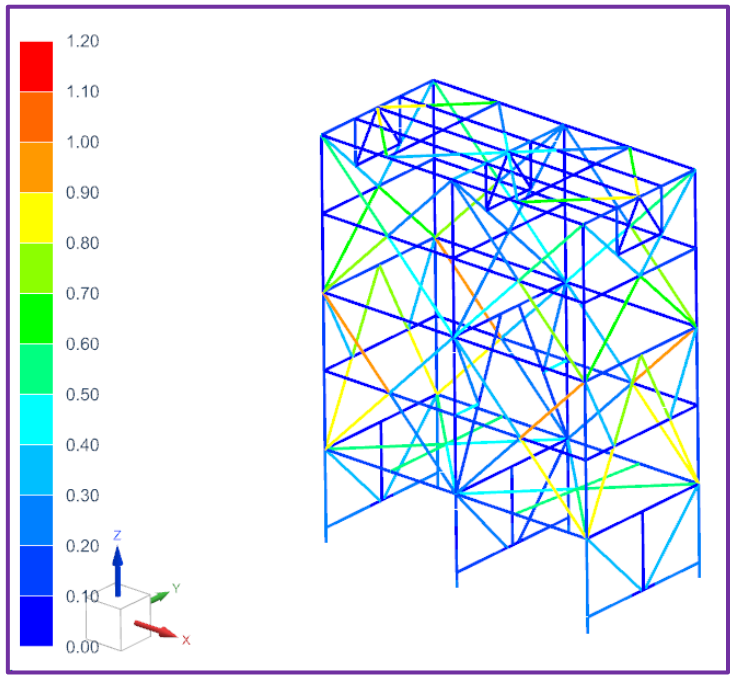
Extreme	Absolute Axial Uf	Absolute Bending Uf	Absolute Shear Uf	Absolute Shear Torsic	Absolute Axial and Be	Overall Utilization Fac
Minimum						
Value	0.00	0.00	0.00	0.00	0.00	0.00
Element ID	1500	1500	1500	1500	1500	1500
Load	LS8	LS1	LS8	LS8	LS1	LS8
Maximum						
Value	0.21	0.21	0.13	1.07	0.31	1.07
Element ID	1874	1720	1850	2157	980	2157
Load	LS4	LS4	LS7	LS7	LS1	LS7
Absolute						
Value	0.21	0.21	0.13	1.07	0.31	1.07
Element ID	1874	1720	1850	2157	980	2157
Load	LS4	LS4	LS7	LS7	LS1	LS7

Criteria Plots on Overall Checks

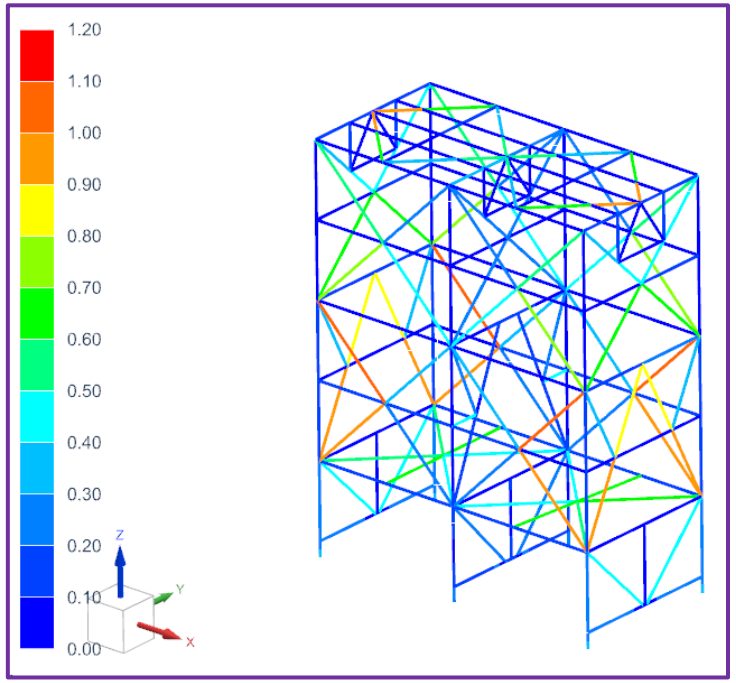
API RP 2A-LRFD (1st, 1993) Standard



ISO 19902 (1st, 2007) Standard



Norsok N004 (rev.3, 2013) Standard



Create Reports in Report Designer

To learn how to obtain reports, please check a separate Tutorial that depicts the functionality of SDC Verifier Report Designer. It may be downloaded via this link:

https://sdcverifier.com/tutorials/report-designer/