



Tutorial

AISC 360-10

20.10.2017
version 4.7

- ▶ In this tutorial, AISC 360-10 Beam Design Checks are reviewed in details.
- ▶ A beam model structure has been used as a start FEM model.
- ▶ Beam member finder was used to recognize beam member dimensions.
- ▶ Report was automatically generated in SDC Verifier Report to represent beam checks results according AISC 360-10 standard.

Open Project

1

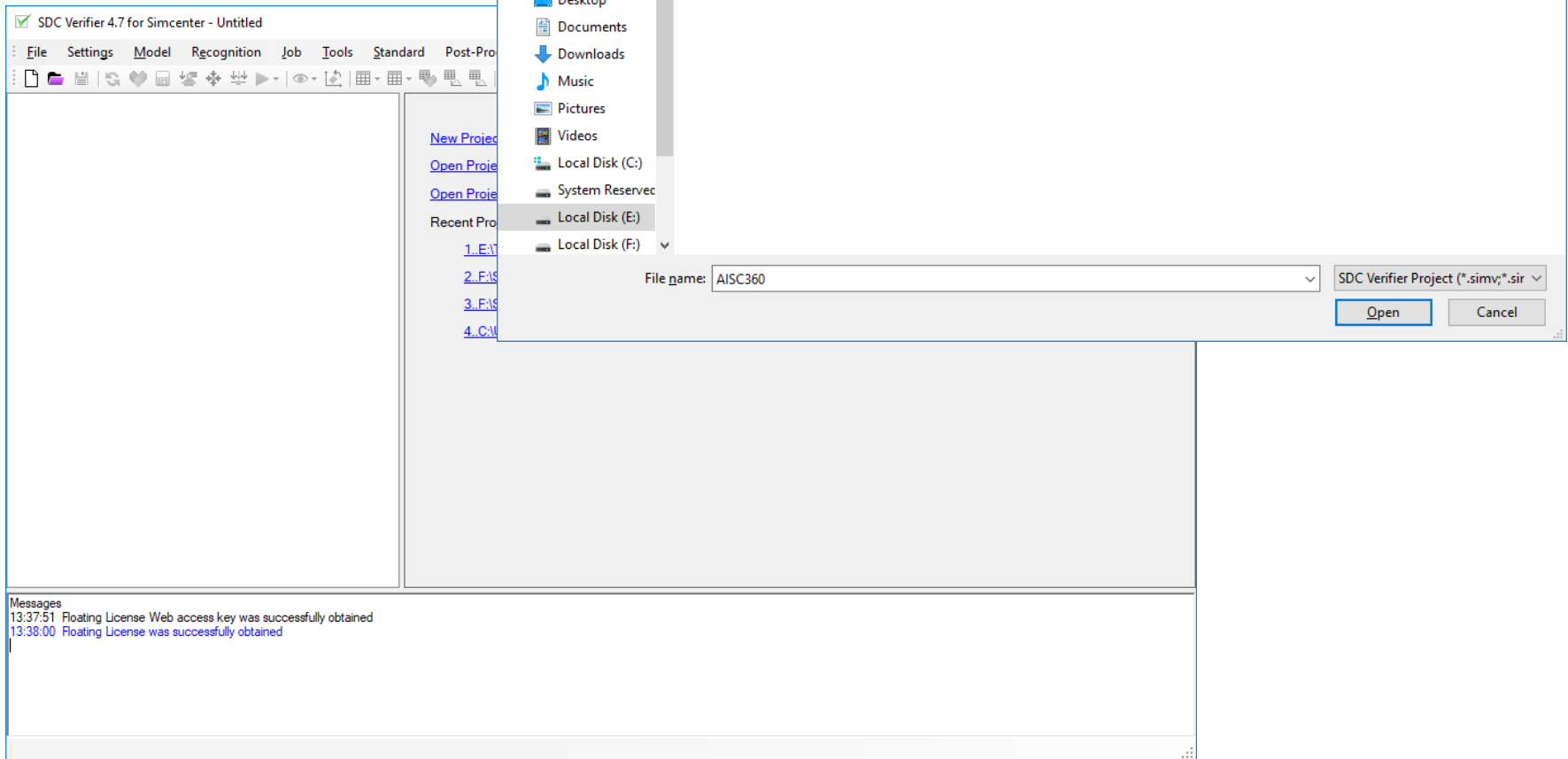
Launch **SDC Verifier** 

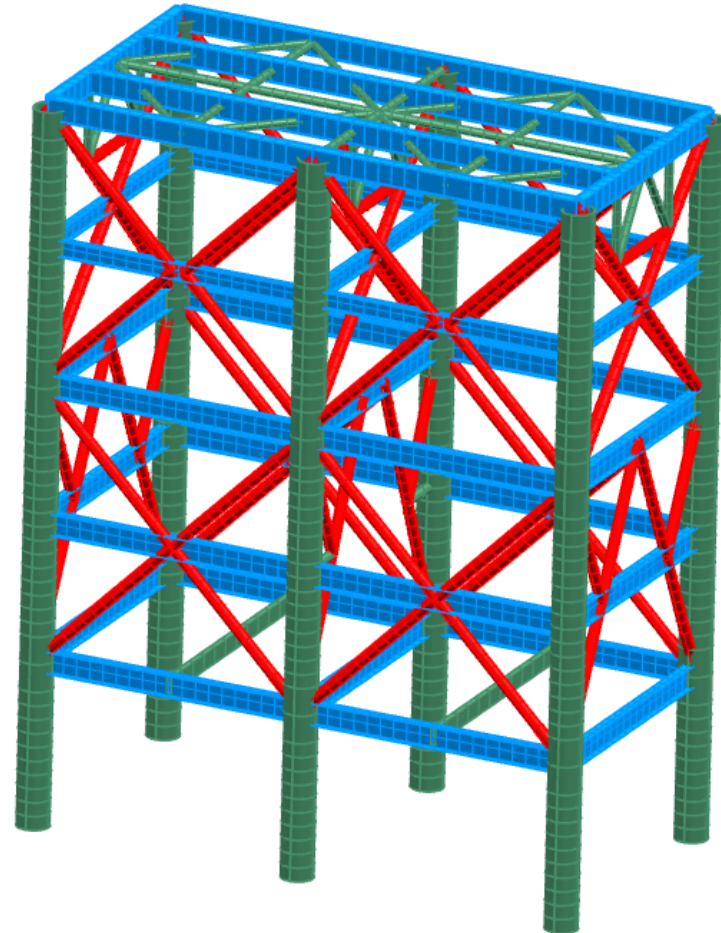
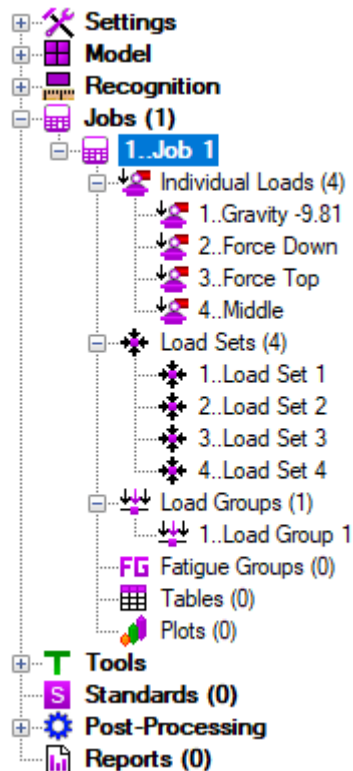
2

Execute *File - Open Project*.

3

Project: **AISC360.simv**





This tutorial uses project with predefined boundary condition, load combinations and load group.
The model contains only beam elements of the following types: I-Beam, Circular and Rectangular Tubes

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;

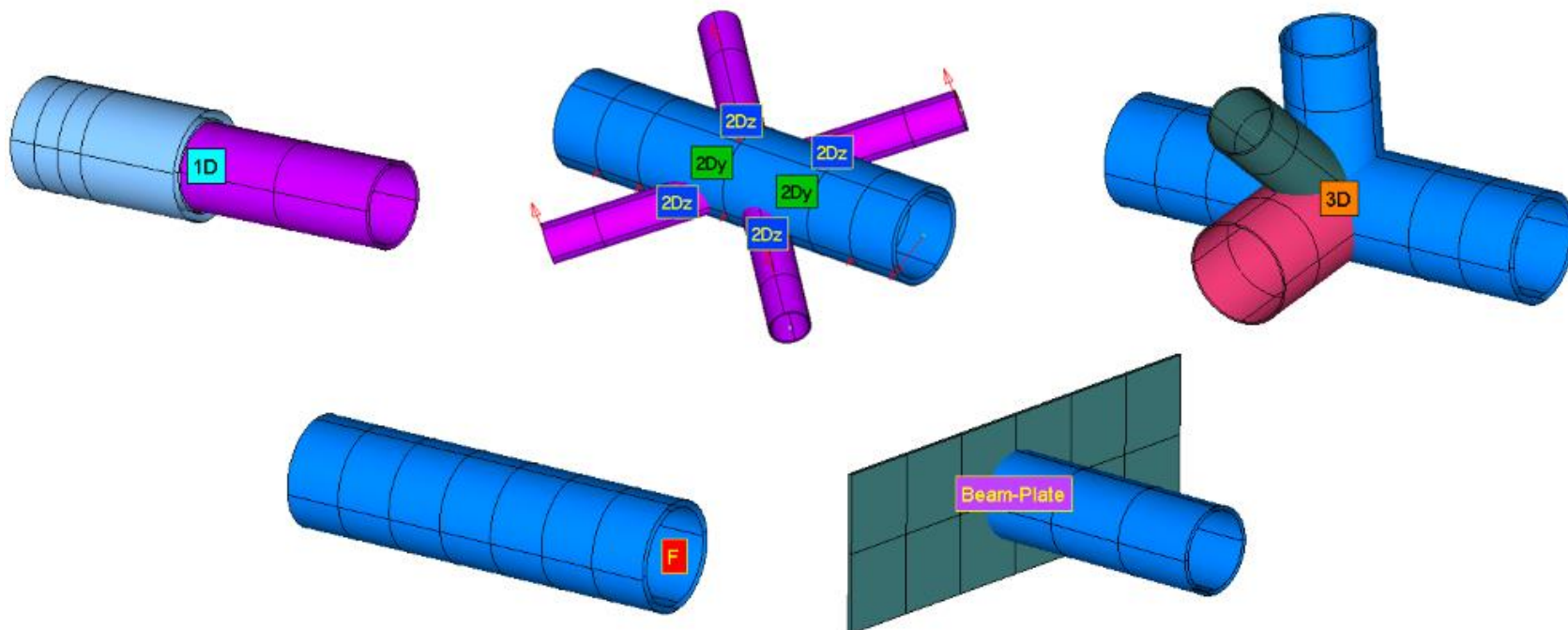
2D Joint – beam members connected in one plane;

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;

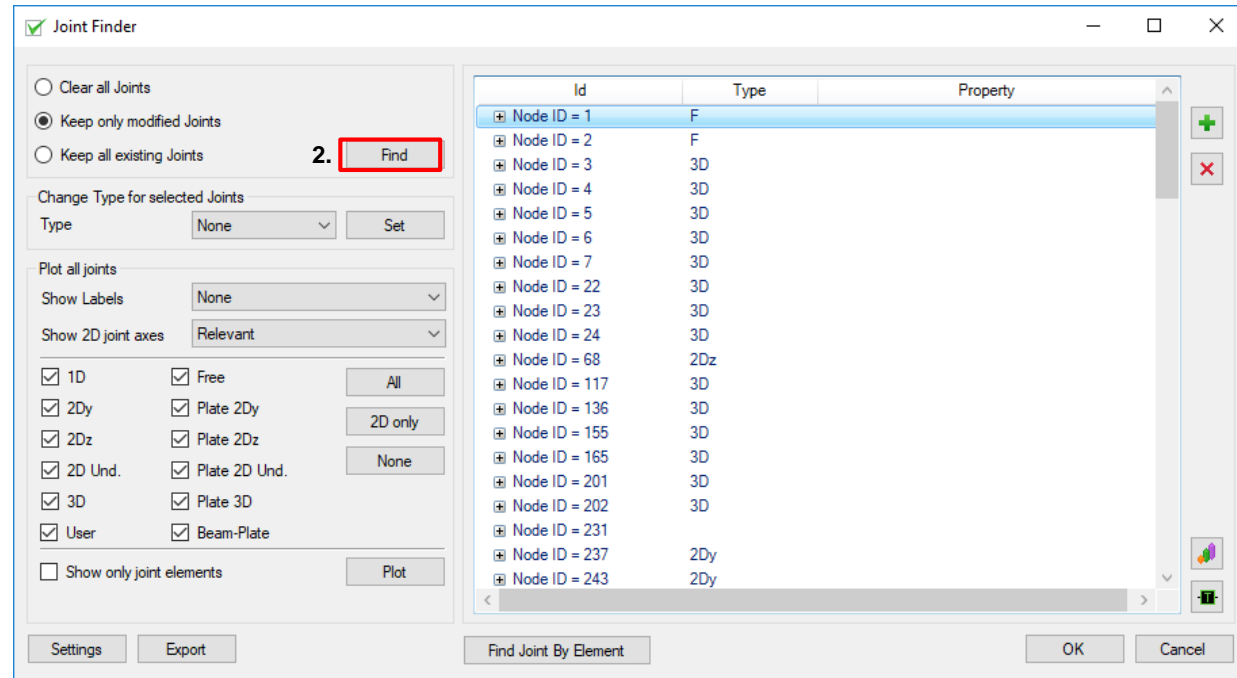
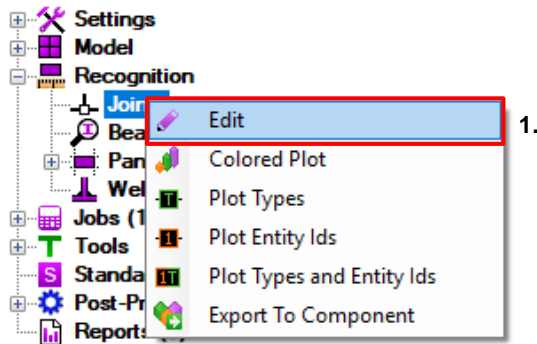


Joint Recognition

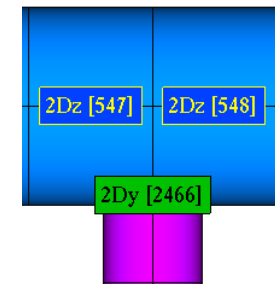
1 Execute *Edit* from *Joints* context menu

2 Press *Find*.

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	

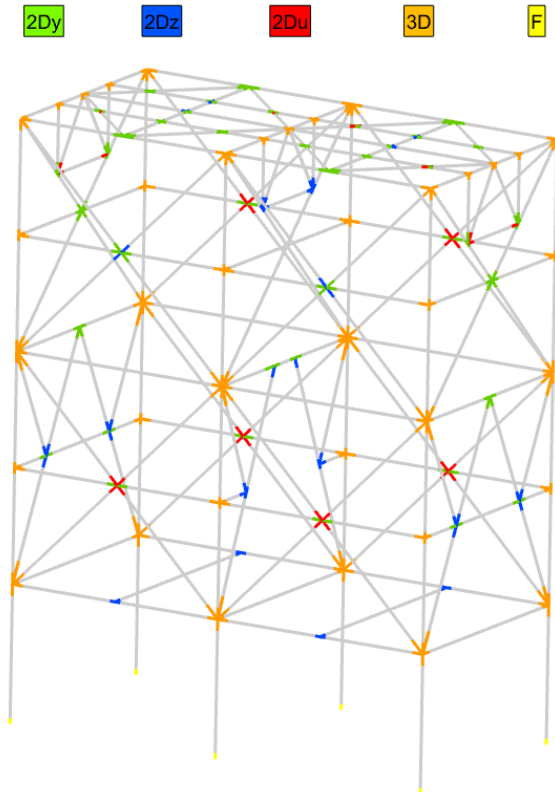


Joints Plot

1 Select All Joints (Ctrl+A).

2 Press 

3 Press OK



☒ Joint Finder

☐ Clear all Joints
☒ Keep only modified Joints
☐ Keep all existing Joints

Find

Change Type for selected Joints

Type: None Set

Plot all joints

Show Labels: None

Show 2D joint axes: Relevant

☒ 1D ☒ Free
☒ 2Dy ☒ Plate 2Dy
☒ 2Dz ☒ Plate 2Dz
☒ 2D Und. ☒ Plate 2D Und.
☒ 3D ☒ Plate 3D
☒ User ☒ Beam-Plate

☐ Show only joint elements

Settings Export

Id	Type	Property
Node ID = 1	F	
Node ID = 2	F	
Node ID = 3	3D	
Node ID = 4	3D	
Node ID = 5	3D	
Node ID = 6	3D	
Node ID = 7	3D	
Node ID = 22	3D	
Node ID = 23	3D	
Node ID = 24	3D	
Node ID = 68	2Dz	
Node ID = 117	3D	
Node ID = 136	3D	
Node ID = 155	3D	
Node ID = 165	3D	
Node ID = 201	3D	
Node ID = 202	3D	
Node ID = 231		
Node ID = 237	2Dy	
Node ID = 243	2Dy	

Find Joint By Element

3.

Plot Joints of specific type:

Plot Joints By Type

Type: None

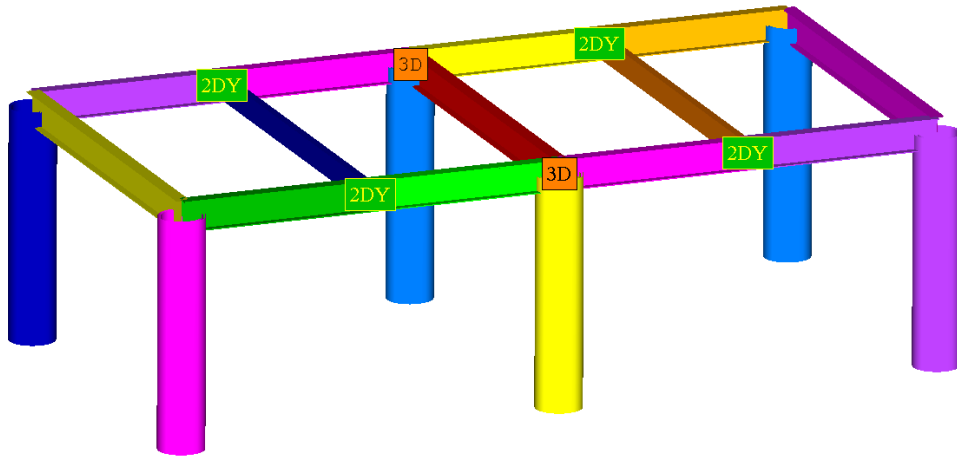
Modify Joint Type:

Change Type for selected Joints

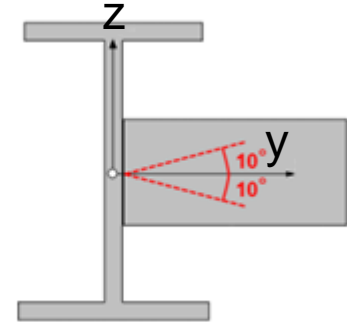
Type: None

Beam Member Lengths in 2 directions

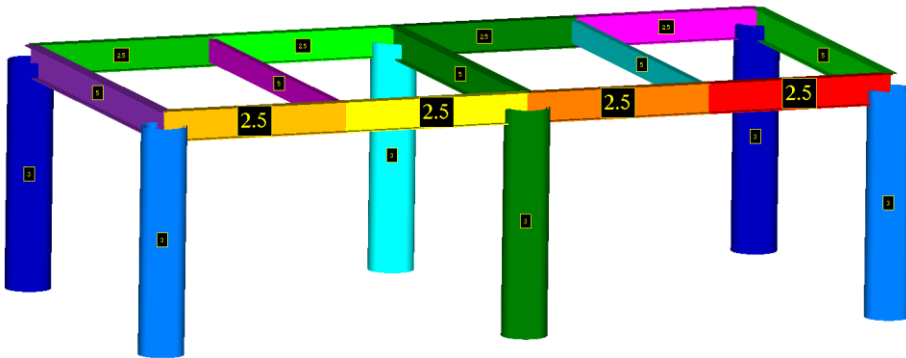
Beam Member Finder recognizes beam members and (buckling) lengths for different directions (Y, Z and Torsional).



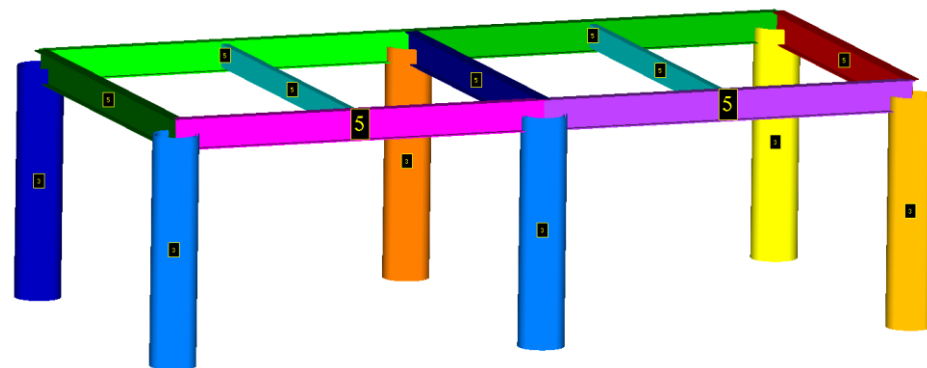
2DY
Joint



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



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

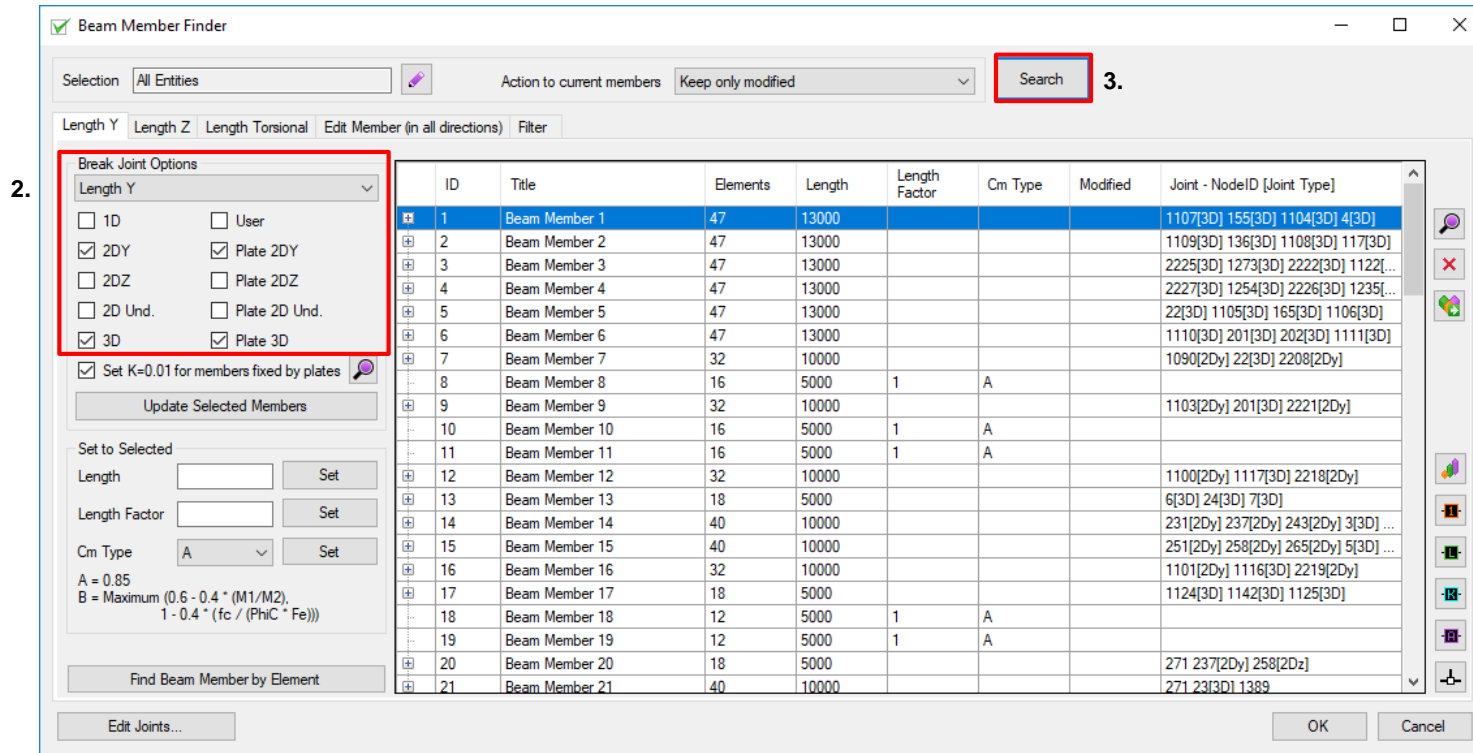
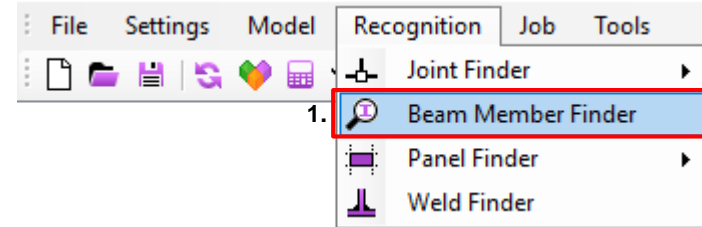


Recognize Length

1 Execute *Recognition – Beam Member Finder*

2 Break Joint Options:
Length Y – 2DY, 3D, Plate 2DY, Plate 3D
Length Z – 2DZ, 3D, Plate 2DZ, Plate 3D
Length Y – 2DY, 2DZ, 2D Und, 3D

3 Press *Search*.



Beam Member Finder interface

Beam Member Finder

Selection: All Entities Action to current members: Remove all Search

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

Break Joint Options

Torsion (Lb)

☐ 1D ☐ User

☒ 2DY ☐ Plate 2DY

☒ 2DZ ☐ Plate 2DZ

☒ 2D Und. ☐ Plate 2D Und.

☒ 3D ☐ Plate 3D

☐ Set K=0.01 for members fixed by plates

Update Selected Members

Set to Selected

Length Set

Length Factor Set

Cm Type A Set

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

Find Beam Member by Element

Edit Joints...

ID	Title	Elements	Length	Length Factor	Cm Type	Modified	Joint - NodeID [Joint Type]
1	Beam Member 1	47	13000				4[3D] 1104[3D] 155[3D] 1107[3D]
2	Beam Member 2	47	13000				1109[3D] 136[3D] 1108[3D] 117[3D]
3	Beam Member 3	47	13000				1111[3D] 202[3D] 1110[3D] 201[3D]
4	Beam Member 4	47	13000				2227[3D] 1254[3D] 2226[3D] 1235[3D]
5	Beam Member 5	47	13000				1122[3D] 2222[3D] 1273[3D] 2225[3D]
6	Beam Member 6	47	13000				22[3D] 1105[3D] 165[3D] 1106[3D]
7	Beam Member 7	32	10000				1103[2Dy] 201[3D] 2221[2Dy]
8	Beam Member 8	16	5000	1	A		
9	Beam Member 9	32	10000				22[3D] 2208[2Dy] 1090[2Dy]
9.1	Sub Member 9.1	8	2500	1	A		
9.2	Sub Member 9.2	8	2500	1	A		
9.3	Sub Member 9.3	8	2500	1	A		
9.4	Sub Member 9.4	8	2500	1	A		
10	Beam Member 10	16	5000	1	A		
11	Beam Member 11	16	5000	1	A		
12	Beam Member 12	18	5000				6[3D] 24[3D] 7[3D]
13	Beam Member 13	32	10000				1117[3D] 2218[2Dy] 1100[2Dy]
14	Beam Member 14	40	10000				5[3D] 1383[2Dy] 1376[2Dy] 1369[2Dy]
15	Beam Member 15	32	10000				2219[2Dy] 1116[3D] 1101[2Dy]
16	Beam Member 16	18	5000				1125[3D] 1142[3D] 1124[3D]
17	Beam Member 17	40	10000				3[3D] 1361[2Dy] 1355[2Dy] 1349[2Dy]

OK Cancel

Break Options define what joints are used to split beam members

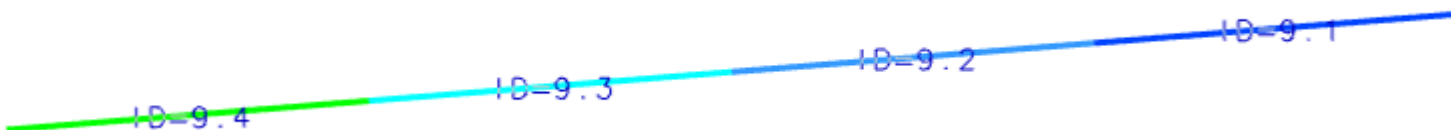
Change Length/Factor for selected beam members

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

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	10000				1103[2Dz] 201[3D] 2221[2Dz]
9.1	Sub Member 9.1	8	2500	1	A		
9.2	Sub Member 9.2	8	2500	1	A		
9.3	Sub Member 9.3	8	2500	1	A		
9.4	Sub Member 9.4	8	2500	1	A		

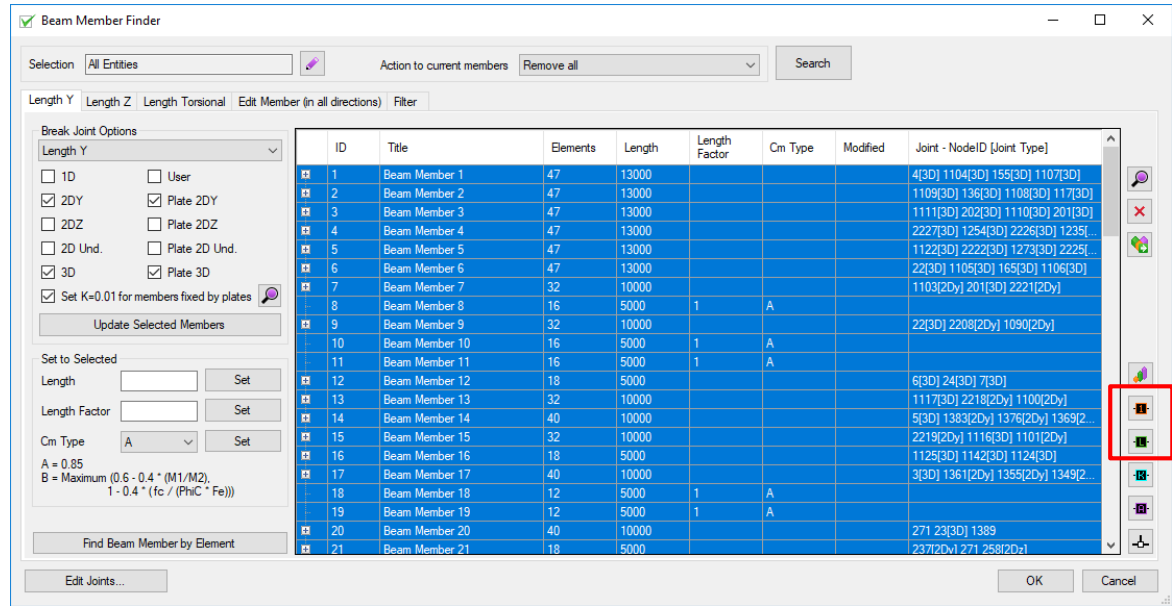



Beam Member's Length Plot

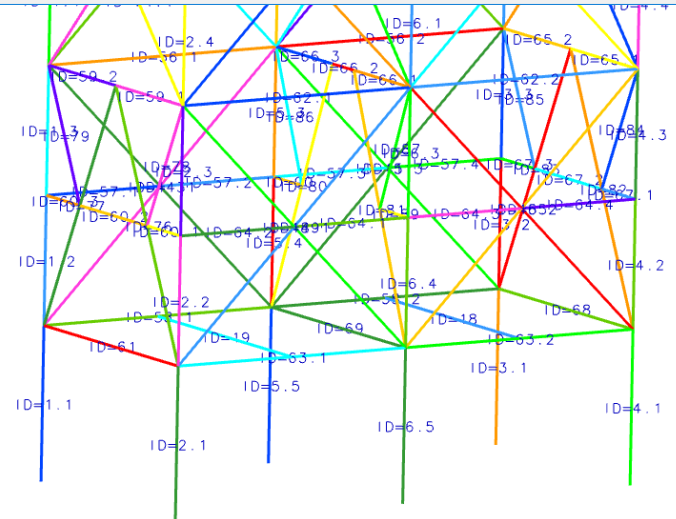
1 Select All Beam Members (Ctrl+A)

2 Press  to display Length Plot

3 Press OK



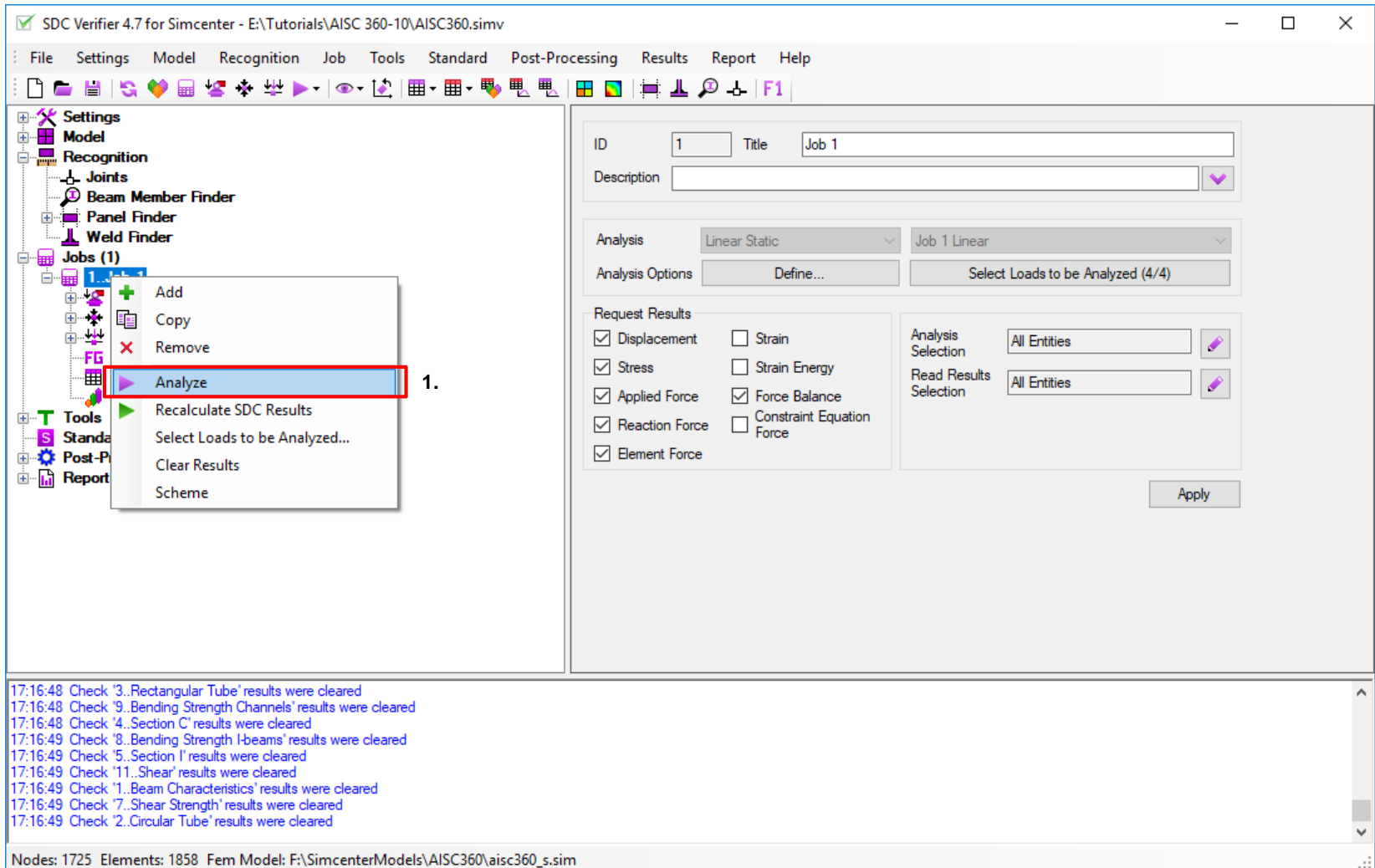
Also it is possible to display beam members IDs by pressing 



Analyze Job

1

Execute **Analyze** from Job1 context menu



STEEL CONSTRUCTION



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THIRTEENTH EDITION

ANSI/AISC 360-10 - an American national standard "Specification for Structural Steel Buildings", released on June 22, 2010. Checks are performed according to the provisions for load and resistance factor design (LRFD) and allowable strength design (ASD). The standard implements checks for design of members for tension, compression, bending, shear and combined.

Specification for Structural Steel Buildings

March 9, 2005

Supersedes the *Load and Resistance Factor Design Specification for Structural Steel Buildings* dated December 27, 1999, the *Specification for Structural Steel Buildings—Allowable Stress Design and Plastic Design* dated June 1, 1989, including Supplement No. 1, the *Specification for Allowable Stress Design of Single-Angle Members* dated June 1, 1989, the *Load and Resistance Factor Design Specification for Single-Angle Members* dated November 10, 2000, and the *Load and Resistance Factor Design Specification for the Design of Steel Hollow Structural Sections* dated November 10, 2000, and all previous versions of these specifications.

Approved by the AISC Committee on Specifications and issued by the AISC Board of Directors



AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.
One East Wacker Drive, Suite 700
Chicago, Illinois 60601-1802

It is possible to check a design according to load and resistance factor design (LRFD) or allowable strength design (ASD). The difference between 2 designs is in load combinations and resistance factors:

Resistance Factors

☒ LRFD
 ☐ ASD

Tension (F _t)	0.9
Tensile Rupture (F _{tr})	0.75
Compression (F _c)	0.9
Shear (F _v)	0.9
Bending (F _b)	0.9

Resistance Factors

☐ LRFD
 ☒ ASD

Tension (F _t)	0.6
Tensile Rupture (F _{tr})	0.5
Compression (F _c)	0.6
Shear (F _v)	0.6
Bending (F _b)	0.6

Design for Strength Using Load and Resistance Factor Design (LRFD)

Design will be performed in accordance with Equation B3-1:

$$R_u \leq \phi R_n \text{ (B3-1)},$$

where:

R_u = required strength using LRFD load combinations;

R_n = nominal strength, specified in Chapters B through K;

ϕ = resistance factor, specified in Chapters B through K;

ϕR_n = design strength.

Design for Strength Using Allowable Strength Design (ASD)

Design will be performed in accordance with Equation B3-2:

$$R_a \leq R_n / \Omega \text{ (B3-2)},$$

where:

R_a = required strength using ASD load combinations;

R_n = nominal strength, specified in Chapters B through K;

Ω = safety factor, specified in Chapters B through K;

R_n / Ω = allowable strength.

According to the standard Design Strength is multiplied by LRFD factor and divided by ASD factor.

For tensile yielding in the gross section:

$$P_n = F_y A_g \quad (D2-1)$$

$$\phi_t = 0.90 \text{ (LRFD)} \quad \Omega_t = 1.67 \text{ (ASD)}$$

In SDC Verifier multiplication is always used ASD factor is converted to $1 / \Omega$ (ASD). For example: tensile resistance factor (F_t) = $1 / 1.67 = 0.6$.

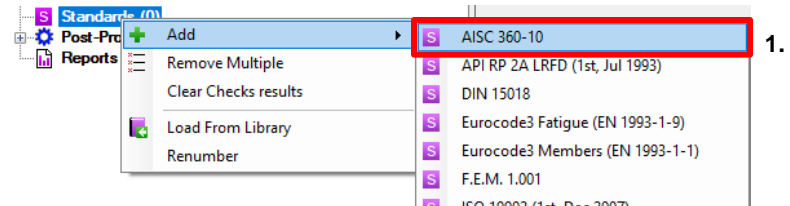
Add AISC360-10 standard

1

Execute **Standards** => **Add** =>
AISC360-10 from context menu

2

Resistance Factors: **LRFD**



✓ AISC 360-10

ID Title

Description

Section Type and Cb

Section Build Type Define

☐ Calculate Cb based moments diagram

☒ Define Cb manually Define

Materials with Yield and Tensile = 0

Loads for Tables/Plots

Selection

+ 8 Shapes

Elements

Resistance Factors

☒ LRFD 2. ☐ ASD

Tension (F_t)

Tensile Rupture (F_{tr})

Compression (F_c)

Shear (F_v)

Bending (F_b)

Second order effects (APPENDIX 8)

☐ Take into account second-order effects (B1 multiplier)

☐ Use $C_m = 1$ (conservative)

☒ Calculate C_m : case a = $0.6 - 0.4 \cdot M_1 / M_2$, case b = 1.0

Not subject to transverse loading (case a) when
Shear Force < Percent of Axial Force

Preview Not Supported Elements

OK Cancel

Section Build Type

1 Press *Define* for Section Build Type

2 Select All Properties (Ctrl+A)

3 Value: **Rolled**. Press *Apply*

4 Press *OK*

✓ AISC 360-10

ID Title Description

Section Type and Cb

Section Build Type Define

☐ Calculate Cb based moments diagram

☒ Define Cb manually Define

Materials with Yield and

Loads for Tables/Plots

Resistance Factors

☒ LRFD

Tension (F_t)

Tensile Rupture (F_{tr})

Compression (F_c)

Shear (F_v)

Bending (F_b)

Properties Characteristics

ID Title Alias Description

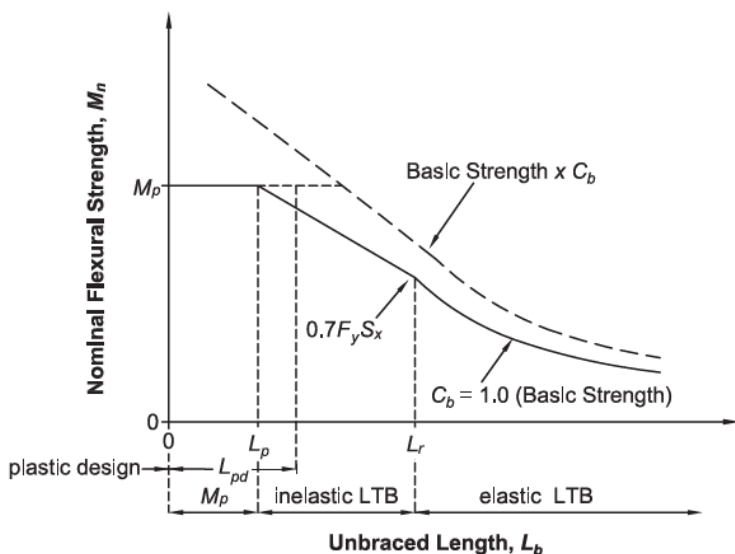
Characteristic BuildType Rolled **Apply**

Property	Value
1..150x8	Rolled
2..130x7	Rolled
3..400x200x20	Rolled
4..160x8	Rolled
5..Main Vertical 480x30	Rolled
8..IPE 400	Rolled
9..220x12	Rolled
11..300x10	Rolled
12..200x10	Rolled
13..180x9	Rolled
14..IPE 300	Rolled
15..100x10	Rolled

OK **Cancel**

Lateral-torsional buckling factor (C_b)

SDC Verifier follows conservative approach and uses $C_b = 1.0$. C_b is implemented as a characteristic which can be modified. For the details see Chapter F “Design of members for Flexure”, F1 General Provisions



✓ AISC 360-10

ID: 1 Title: AISC 360-10

Description:

Section Type and C_b

Section Build Type: 1..Section Build Type Define

☐ Calculate C_b based moments diagram

☒ Define C_b manually 1..Cb Define

Materials with Yield and Tensile = 0 2

Loads for Tables/Plots 0

Resistance Factors

☒ LRFD ☐ ASD

Tension (F_t) 0.9

Tensile Rupture (F_{tr}) 0.75

Compression (F_c) 0.9

Shear (F_v) 0.9

Bending (F_b) 0.9

Selection

+ 8 Shapes

Elements 1856

Second order effects (APPENDIX 8)

☐ Take into account second-order effects (B1 multiplier)

☐ Use $C_m = 1$ (conservative)

☒ Calculate C_m : case a = $0.6 - 0.4 \cdot M_1 / M_2$, case b = 1.0


Not subject to transverse loading (case a) when Shear Force < 0.1 Percent of Axial Force

Preview Not Supported Elements

OK Cancel

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**

4

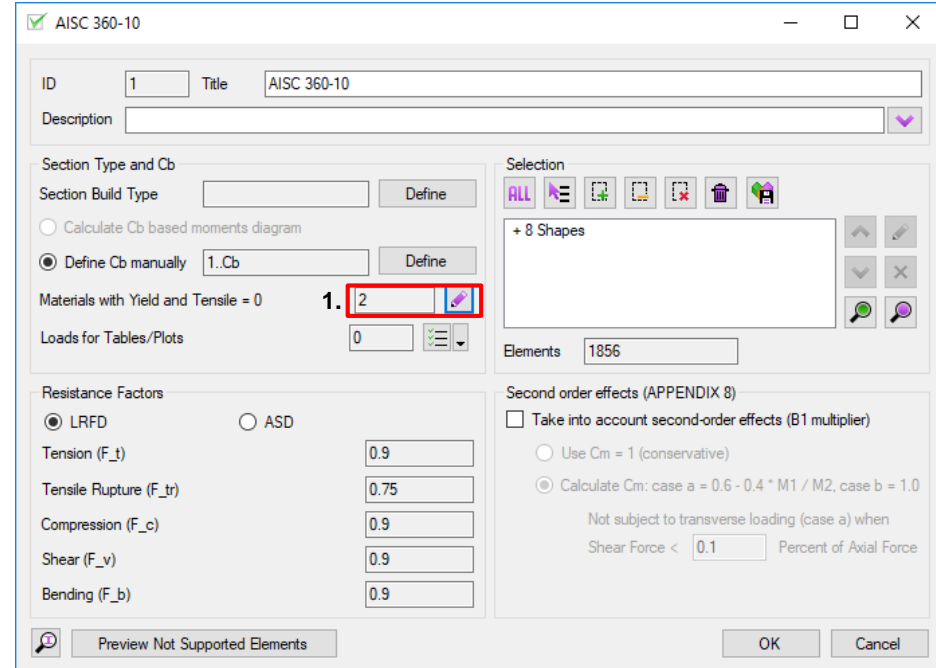
Yield Stress: **240e+6**

5

Press Set

6

Press OK



✓ AISC 360-10

ID: 1 Title: AISC 360-10


Description:


Section Type and Cb

Section Build Type: Define

☐ Calculate Cb based moments diagram

☒ Define Cb manually 1..Cb Define

Materials with Yield and Tensile = 0 1. 2 

Loads for Tables/Plots 0 

Resistance Factors

☒ LRFD ☐ ASD

Tension (F_t) 0.9

Tensile Rupture (F_{tr}) 0.75

Compression (F_c) 0.9

Shear (F_v) 0.9

Bending (F_b) 0.9

Selection

+ 8 Shapes

Elements 1856


Second order effects (APPENDIX 8)

☐ Take into account second-order effects (B1 multiplier)

☐ Use Cm = 1 (conservative)

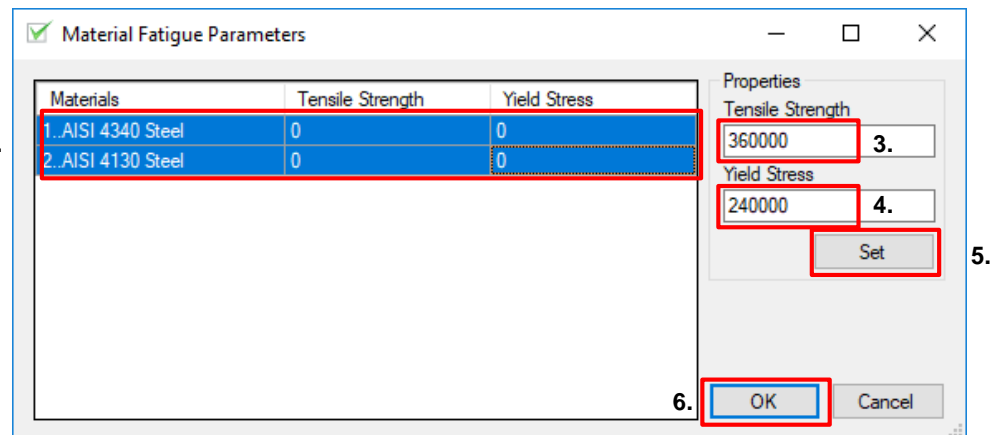
☒ Calculate Cm: case a = 0.6 - 0.4 * M1 / M2, case b = 1.0

Not subject to transverse loading (case a) when Shear Force < 0.1 Percent of Axial Force

 Preview Not Supported Elements

OK Cancel

2.



✓ Material Fatigue Parameters

Materials	Tensile Strength	Yield Stress
1..AISI 4340 Steel	0	0
2..AISI 4130 Steel	0	0

Properties

Tensile Strength 360000 3.


Yield Stress 240000 4.

Set 5.

OK 6. Cancel

Create default plots/tables

1

Press  to select loads for default plots/tables

2

Press **LS (4 / 4)** to select all load sets

3

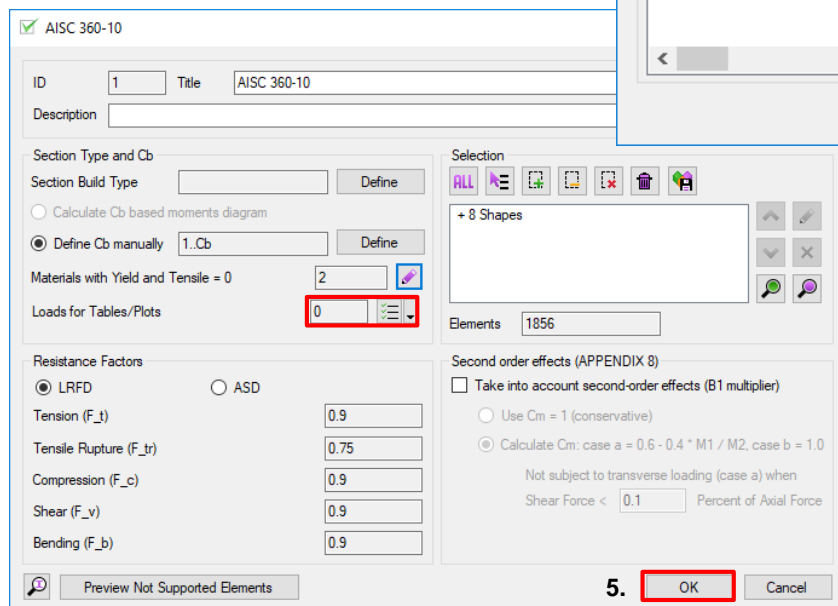
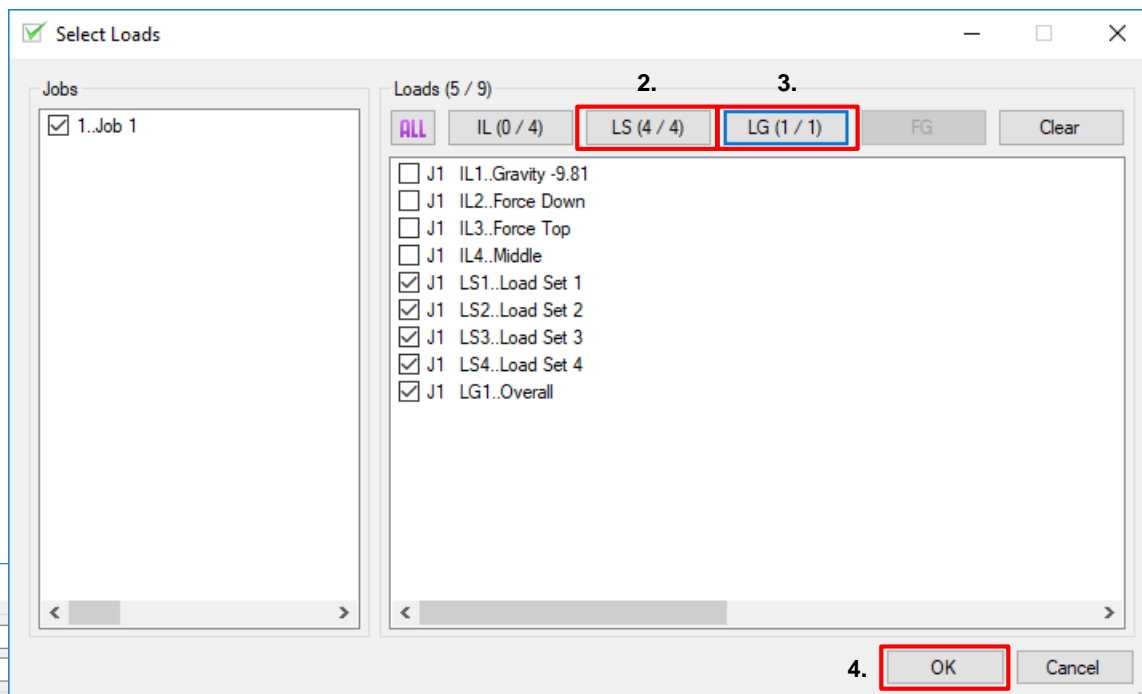
Press **LG (1 / 1)** to select all load groups

4

Press **OK**

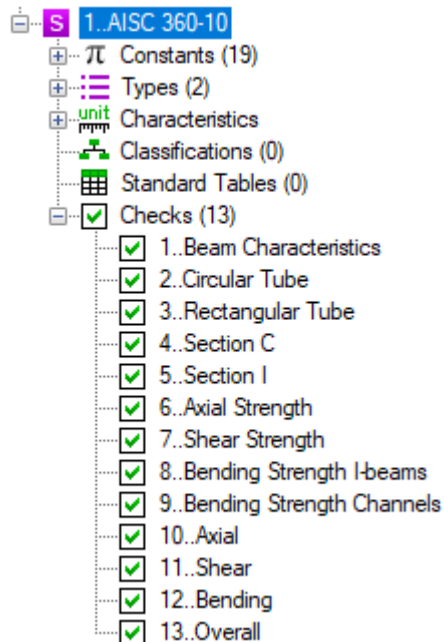
5

Press **OK**

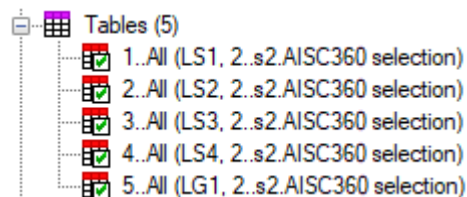


Standard is created!

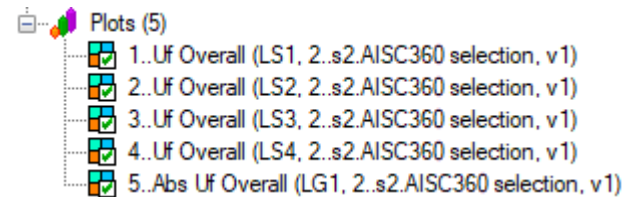
Standard



Default Tables



Default Plots




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.


Extreme	Uf Axial	Uf Bending Major	Uf Bending Minor	Uf Shear	Uf Axial and Bending	Uf Overall
Minimum						
Value	0.00	0.00	0.00	0.00	0.00	0.00
Element ID	59	1895	1134	1877	207	207
Load	LS3	LS4	LS4	LS4	LS4	LS4
Maximum						
Value	0.32	0.65	1.81	0.48	1.82	1.82
Element ID	955	171	1854	59	1854	1854
Load	LS3	LS3	LS3	LS4	LS4	LS4
Absolute						
Value	0.32	0.65	1.81	0.48	1.82	1.82
Element ID	955	171	1854	59	1854	1854
Load	LS3	LS3	LS3	LS4	LS4	LS4

Extreme envelop results for overall check

1

Execute  from the **Overall** check context menu

2

Press  to select load

3

Load Type: **Load Group**

4

Load: **1..Overall**

5

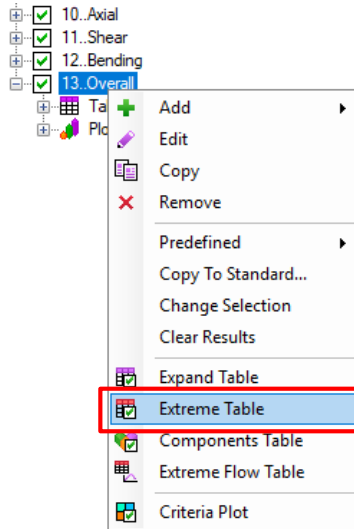
Press *OK*

6

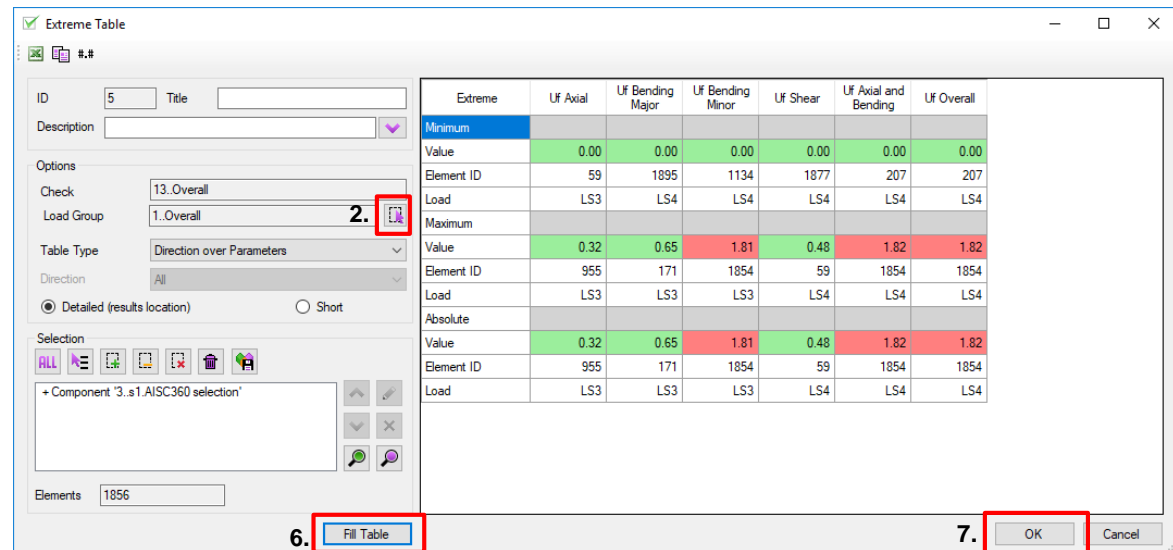
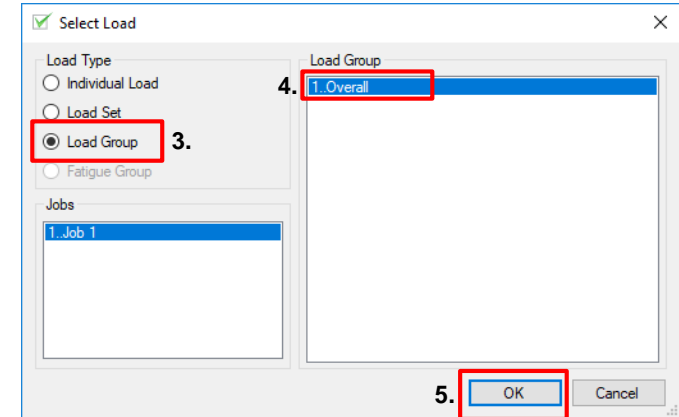
Press *Fill Table*

7

Press *OK*




1.




Overall Utilization Factor criteria plot

1

Execute  from **Overall** check context menu

2

Press  to select load

3

Load Type: **Load Group**

4

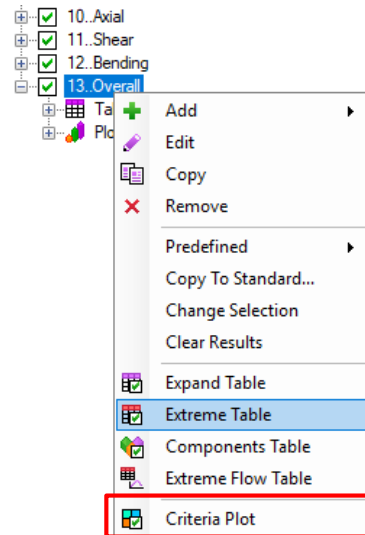
Load: **1..Overall**

5

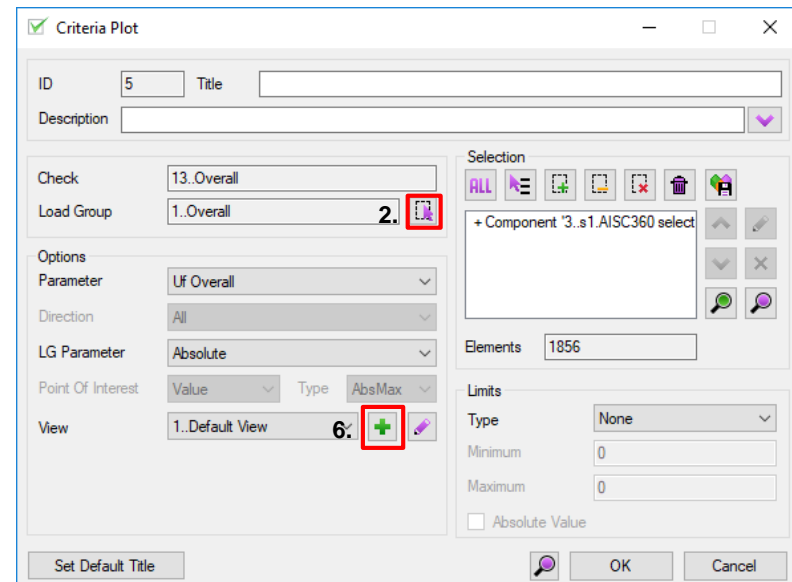
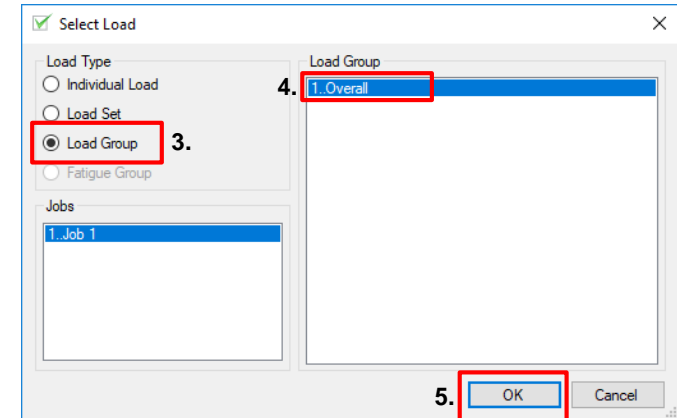
Press *OK*

6

Press to add view



1.



Plot. Create View

1 Title: **Isometric**

2 Orient model in Simcenter as shown on the picture

3 Press *Get*

4 Press *OK*

✓ Add/Edit View

ID 2 Title **Isometric** 1.

Description

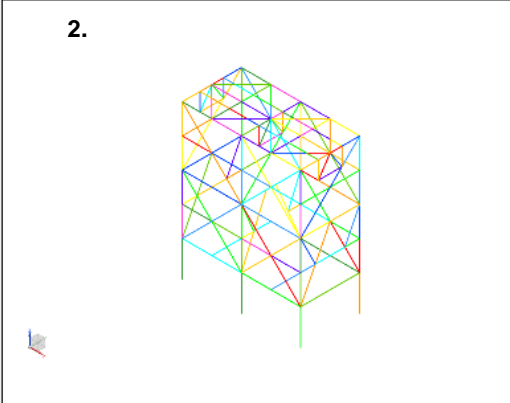
Location
Origin X -4544.57 Origin Y 4002.16 Origin Z 4718.97

Rotation Matrix

XX	0.71	XY	0.71	XZ	0.00
YX	-0.41	YY	0.41	YZ	0.82
ZX	0.58	ZY	-0.58	ZZ	0.58

Scale 1.10E-002 3. **Get** Show

2.



Preview

Settings

Rendering Style Shaded with Edge

Edges External

Edges Color Silver Gray

☒ Lighted

Color Display Banded

☐ Show Cross Section and Plate Thickness

☐ Show Deformation

☐ Show undeformed model

Legend Text Color Deep Steel

☒ Automatic Font Scaling

Text Scale Factor

Legend Header None

Legend Position None

Get Show

Legend Limits

☒ Use limits from legend settings

☐ Use local limits

Mode Automatic

Min 0

Max 1


Number of levels 12

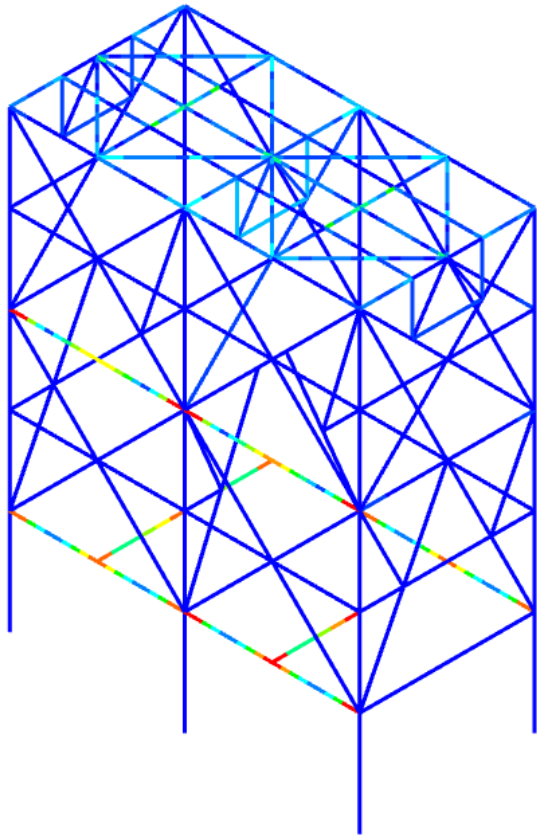
Format General

4. **OK** Cancel

Display Plot

1

Press  to display plot



Criteria Plot

ID: 5 Title:

Description:

Check: 13..Overall

Load Group: 1..Overall

Options

Parameter: Uf Overall

Direction: All

LG Parameter: Absolute

Point Of Interest: Value Type: AbsMax

View: 2..Isometric

Selection

ALL

+ Component '3..s1.AISC360 select

Elements: 1856

Limits


Type: None

Minimum: 0

Maximum: 0

☐ Absolute Value

Set Default Title


1.  OK Cancel

Report

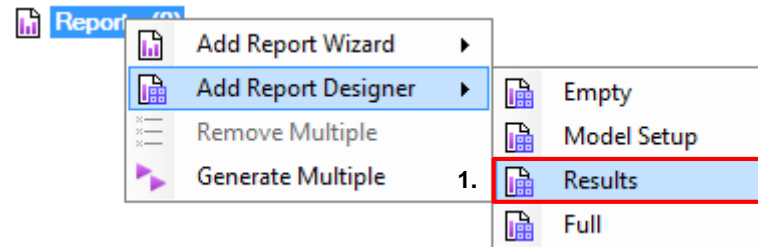
1 Execute *Add Report Designer* => *Results* from *Report* context menu.

2 Title: **Example**

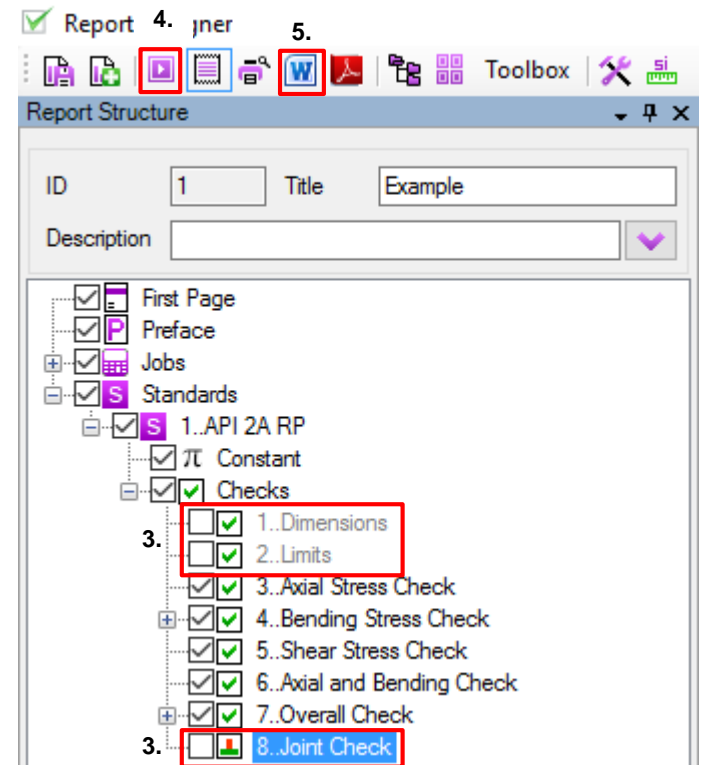
3 Checks with ID from 1 to 9 : **OFF**

4 Press  to generate report

5 Press  to export report to Word

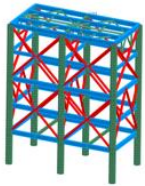


There are 4 templates of the reports:
Empty – only first page and preface items are included;
Model Setup – description of the model data (materials, properties, components, boundary conditions) is included;
Results – for each load extreme displacement tables, stress and displacement plots are included.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



Report exported to Microsoft Word

Report



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Engineer:
Customer:
Project Number:
Version:
Date:

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20 Oct 2017

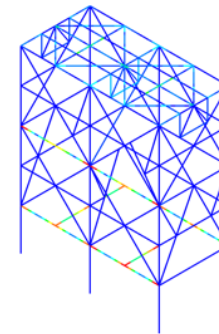
2..Bending

Property	Value								
Category	Elemental Custom Check								
Selection	Component '3..s1.AISC360 selection'								
Parameters	12								
II (LS1, 3..s1.AISC360 selection)									
Standard	1. AISC 360-10				Check	[S1] 12. Bending			
Load Set	LS1. Load Set 1				Direction	All			
Selection	3..s1.AISC360 selection								
Extreme	Mn Major	Mn Minor	Bending Major	Bending Minor	Bending Major with Effect	Bending Minor with Effect	Uf Major	Uf Minor	
Minimum	25.4e+9	25.4e+9	-87.8e+9	-148.5e+9	-87.8e+9	-148.5e+9	0.00	0.00	0.00
Maximum	3015.7e+9	3015.7e+9	87.8e+9	147.7e+9	87.8e+9	147.7e+9	0.65	1.81	1.81
Absolute	3015.7e+9	3015.7e+9	-87.8e+9	-148.5e+9	-87.8e+9	-148.5e+9	0.65	1.81	1.81
II (LS2, 3..s1.AISC360 selection)									
Standard	1. AISC 360-10				Check	[S1] 12. Bending			
Load Set	LS2. Load Set 2				Direction	All			
Selection	3..s1.AISC360 selection								
Extreme	Mn Major	Mn Minor	Bending Major	Bending Minor	Bending Major with Effect	Bending Minor with Effect	Uf Major	Uf Minor	
Minimum	25.4e+9	25.4e+9	-62.4e+9	-76.9e+9	-62.4e+9	-76.9e+9	0.00	0.00	0.00
Maximum	3015.7e+9	3015.7e+9	61.6e+9	88.2e+9	61.6e+9	88.2e+9	0.02	1.81	1.81
Absolute	3015.7e+9	3015.7e+9	-62.4e+9	88.2e+9	-62.4e+9	88.2e+9	0.02	1.81	1.81
II (LS3, 3..s1.AISC360 selection)									
Standard	1. AISC 360-10				Check	[S1] 12. Bending			
Load Set	LS3. Load Set 3				Direction	All			
Selection	3..s1.AISC360 selection								
Extreme	Mn Major	Mn Minor	Bending Major	Bending Minor	Bending Major with Effect	Bending Minor with Effect	Uf Major	Uf Minor	
Minimum	25.4e+9	25.4e+9	-87.8e+9	-148.5e+9	-87.8e+9	-148.5e+9	0.00	0.00	0.00
Maximum	3015.7e+9	3015.7e+9	87.8e+9	147.7e+9	87.8e+9	147.7e+9	0.65	1.81	1.81
Absolute	3015.7e+9	3015.7e+9	-87.8e+9	-148.5e+9	-87.8e+9	-148.5e+9	0.65	1.81	1.81
II (LS4, 3..s1.AISC360 selection)									
Standard	1. AISC 360-10				Check	[S1] 12. Bending			
Load Set	LS4. Load Set 4				Direction	All			
Selection	3..s1.AISC360 selection								
Extreme	Mn Major	Mn Minor	Bending Major	Bending Minor	Bending Major with Effect	Bending Minor with Effect	Uf Major	Uf Minor	
Minimum	25.4e+9	25.4e+9	-62.4e+9	-76.9e+9	-62.4e+9	-76.9e+9	0.00	0.00	0.00
Maximum	3015.7e+9	3015.7e+9	61.6e+9	88.2e+9	61.6e+9	88.2e+9	0.02	1.81	1.81
Absolute	3015.7e+9	3015.7e+9	-62.4e+9	88.2e+9	-62.4e+9	88.2e+9	0.02	1.81	1.81

Overall

Property		Value					
Category		Elemental Custom Check					
Selection		Component '3..s1.AISC360 selection'					
Parameters		6					
(LG1, 3..s1.AISC360 selection)							
Standard		1. AISC 360-10		Check selection		[S1] 13. Overall	
Load Group		LG1. Overall		3..s1.AISC360 selection			
Extreme	Uf Axial	Uf Bending Major	Uf Bending Minor	Uf Shear	Uf Axial and Bending	Uf Overall	
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	0.32	0.65	1.81	0.48	1.82	1.82	1.82
Absolute	0.32	0.65	1.81	0.48	1.82	1.82	1.82

Uf Overall (LG1, 3..s1.AISC360 selection, v2)



Units = Unitless

Check	[S1] 13. Overall	Load Group	LG1. Overall
Parameter	Absolute Uf Overall	Selection	Component '3..s1.AISC360 selection'
Value	2. Isometric		