



Tutorial

Optimization

Updated on: 05.10.2021

Tested with: SDC Verifier 2021R1.1

Ansys Workbench 2020R2

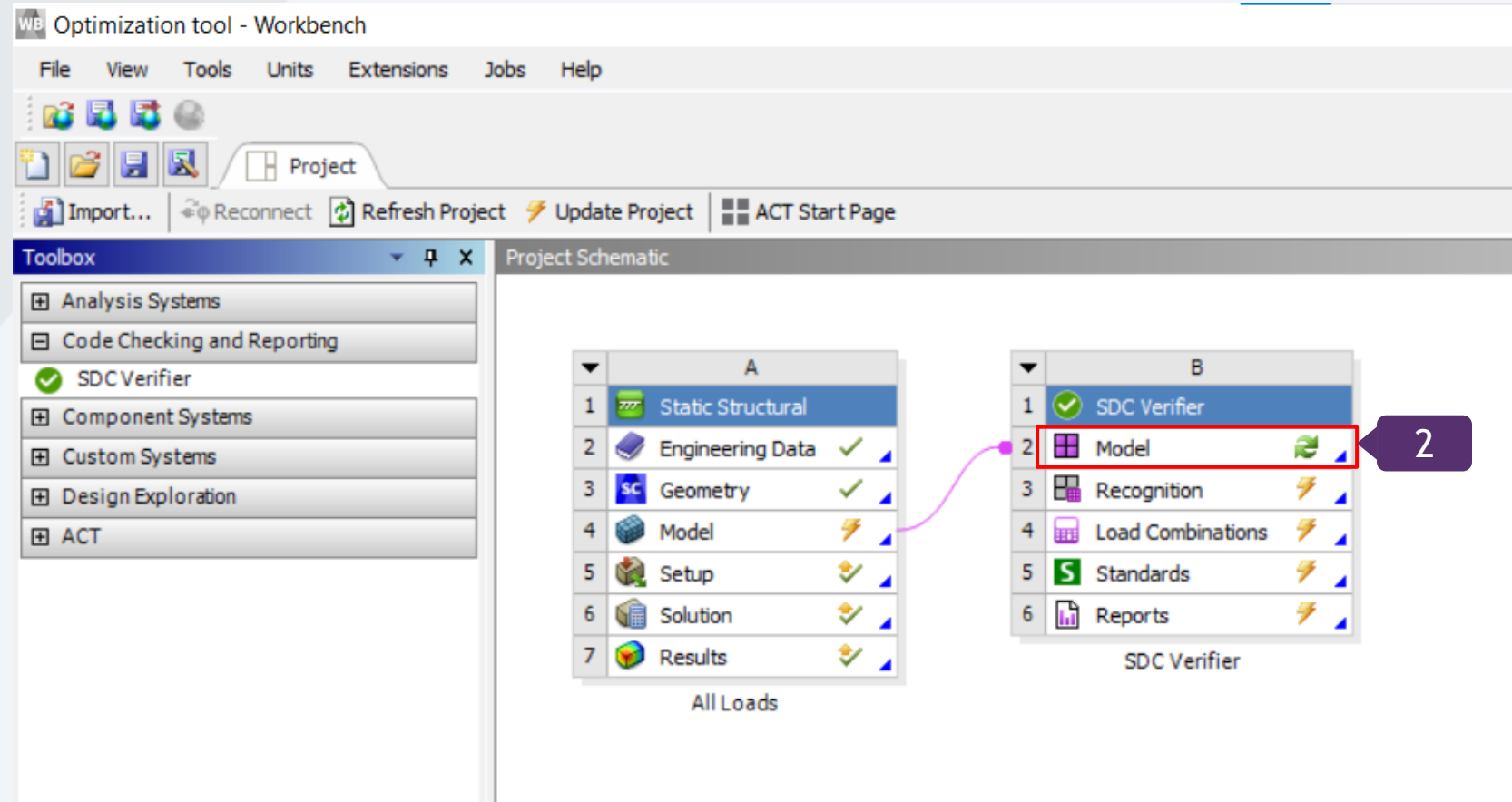
Content

- This step-by-step tutorial demonstrates the interface of SDC Verifier Optimization
- Jacket Model members are Optimized based on AISC 360-10 results;
- Shape Library Overview;
- Optimization Rules Overview;
- Results Comparison;
- Automatic Beam Cross Section Change.

Open the starter model

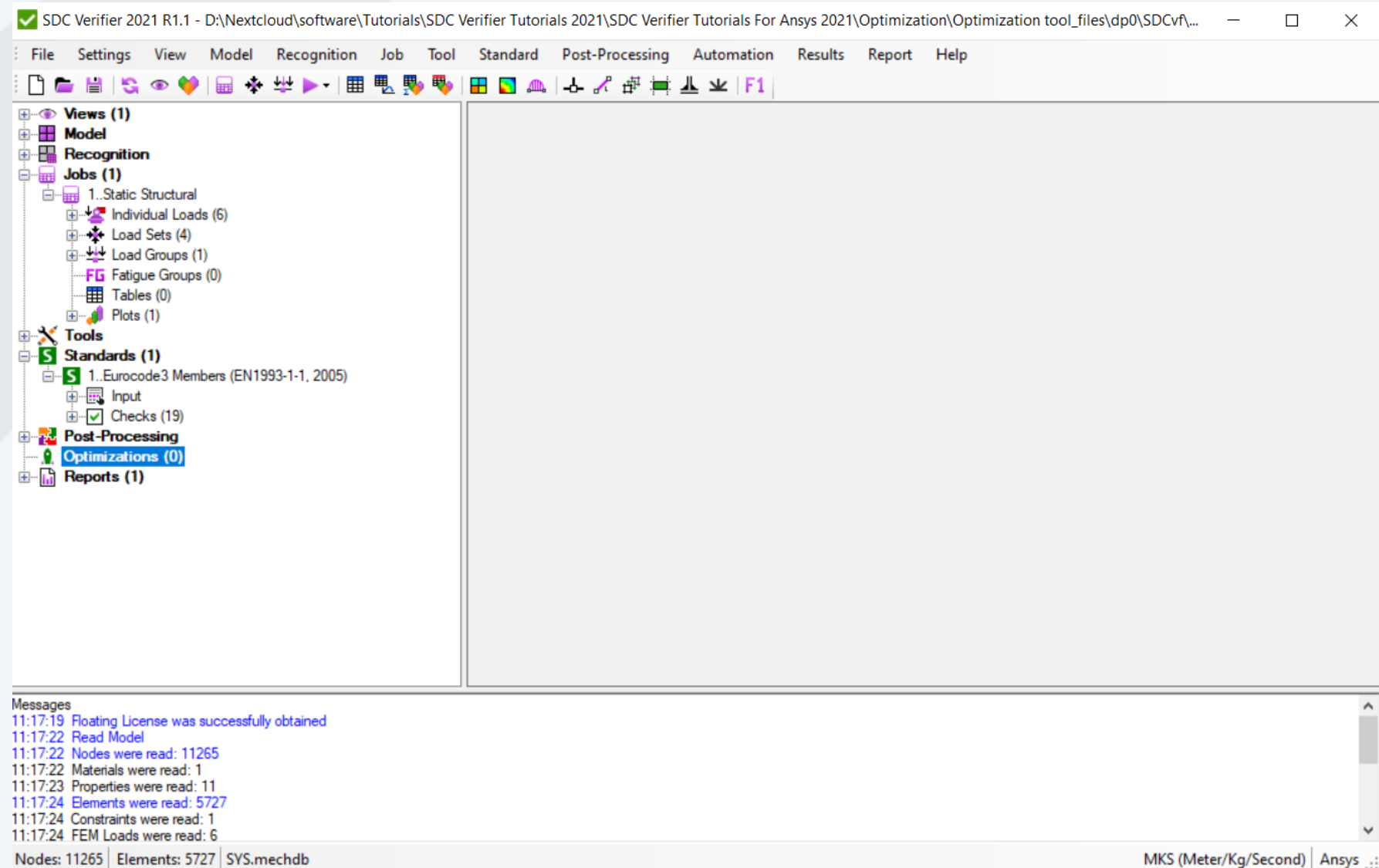
1 Open in ANSYS Workbench the following file **Optimization_tool.wbpz**

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



Project Description

Ansys analysis in this file is already solved. This SDC Verifier project has predefined loading combinations, recognition of beam members, and AISC 360-10 Members check.

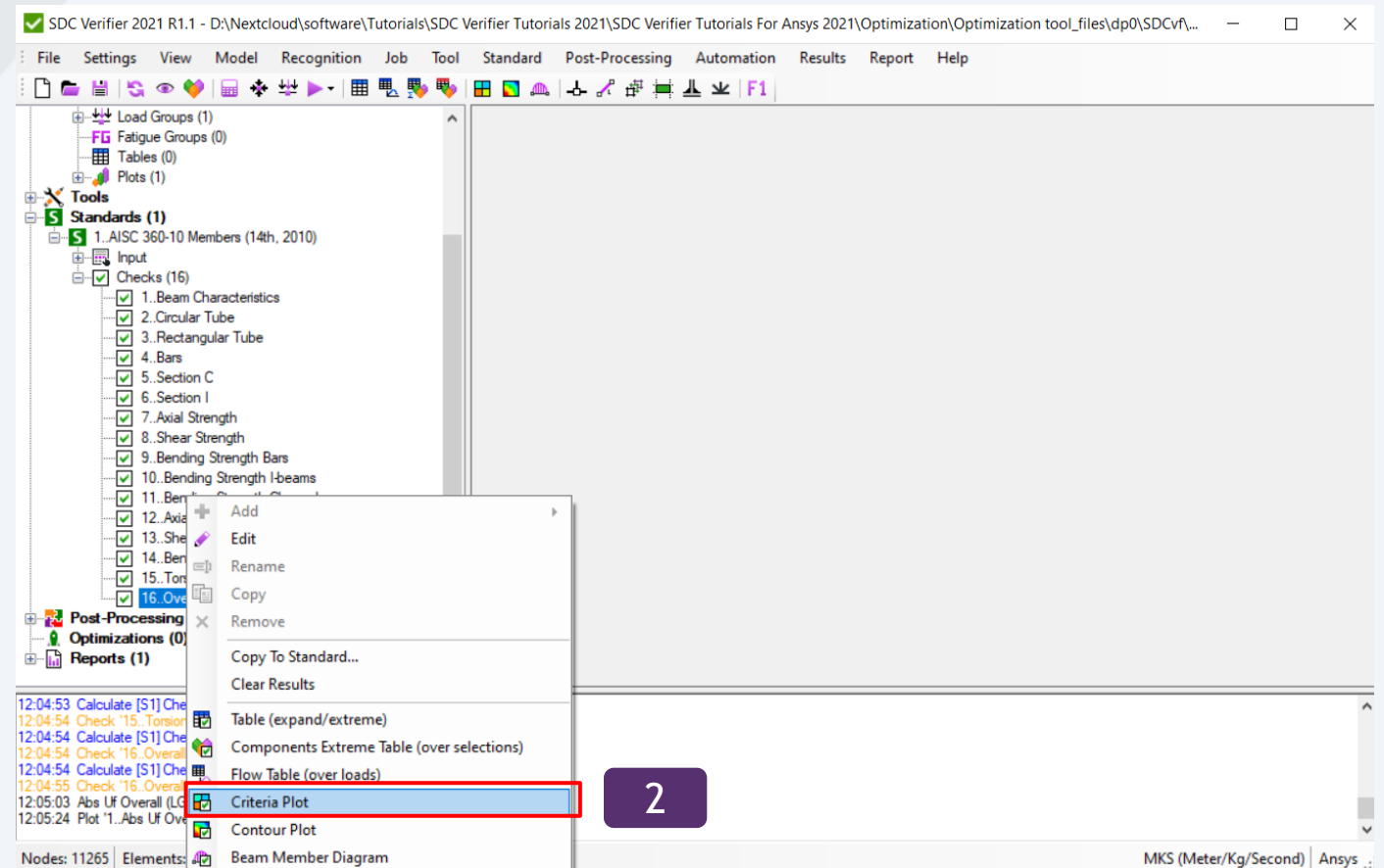


AISC Results Plot

1 Select AISC 360-10 Members > Checks > Overall

2 Right Click and Select Criteria Plot

Let's create a plot to preview the results of AISC Members check and pick the members for Optimization



2

AISC Results Plot

1 Selection: All Entities

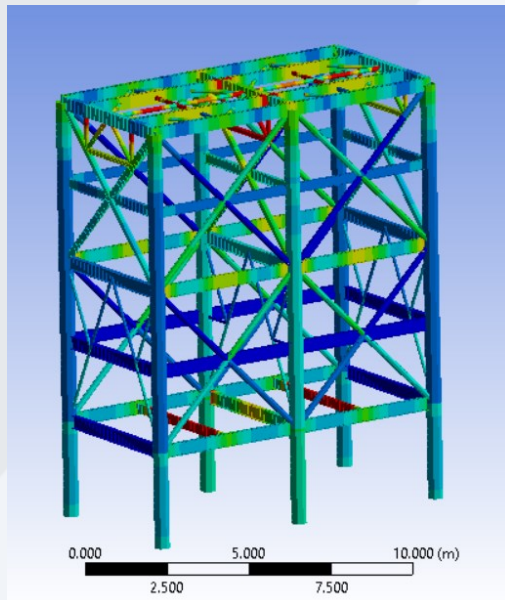
2 Parameter: UF Overall

Creating a plot to see the Overall UF result on a full model

3 Press Plot



Plot will be displayed in Ansys Mechanical Window



Criteria Plot

ID: 1 Title: Description:

Options

Check: 16..Overall

Load Group: 1..Overall

Parameter: **Uf Overall**

Direction: All

LG Parameter: Absolute

Point Of Interest: Total Type: AbsMax

View: 1..Default View

Selection

+ All Entities

Elements: 5727

Labels: None Limits: None

Set Default Title

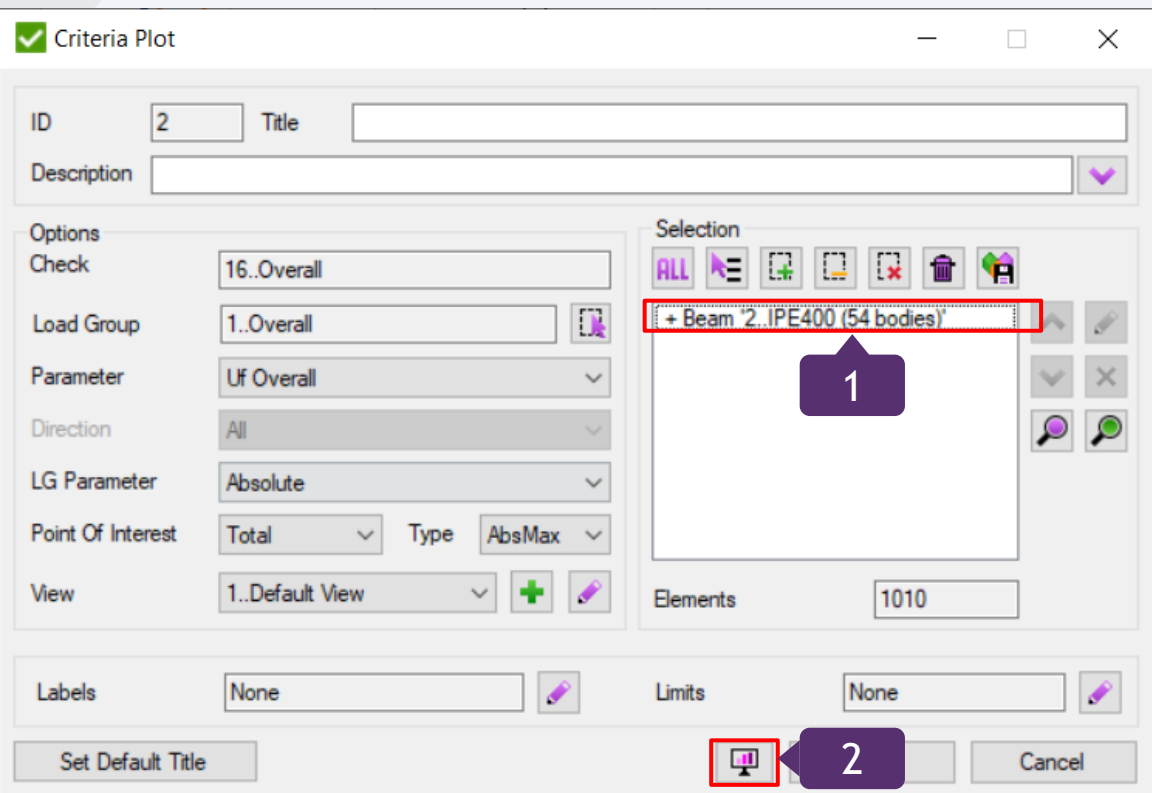
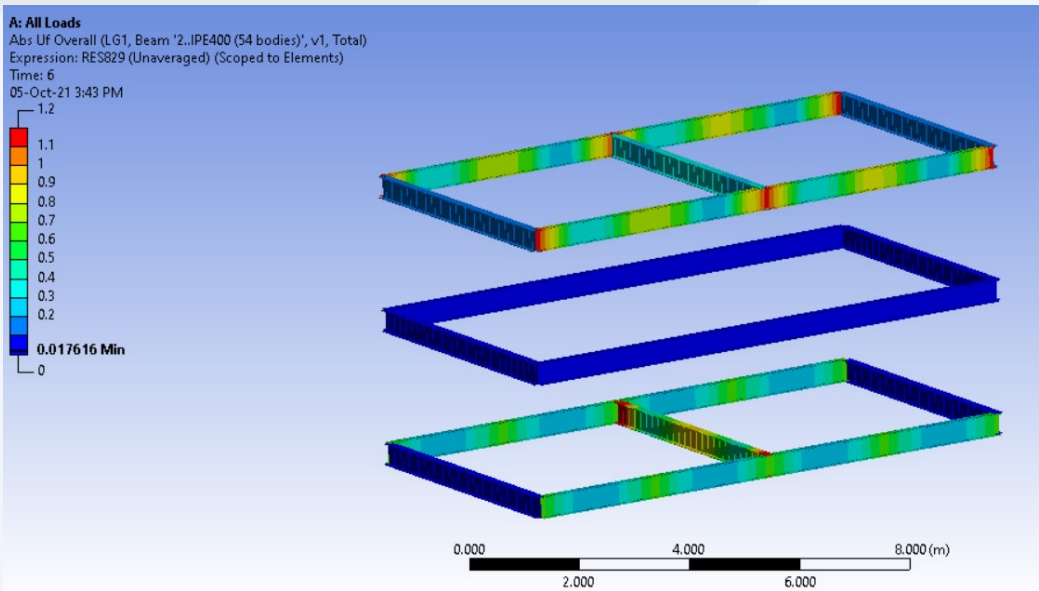
Plot Cancel

Let's preview the plot for one property

1 Selection: Property Beam 2..IPE400

2 Press Plot 

Plot will be displayed in Ansys Mechanical Window



Some members of property '2..IPE400' have UF Overall value above 1.
We're now going to create an Optimization rule for this members

Optimization Rule


1

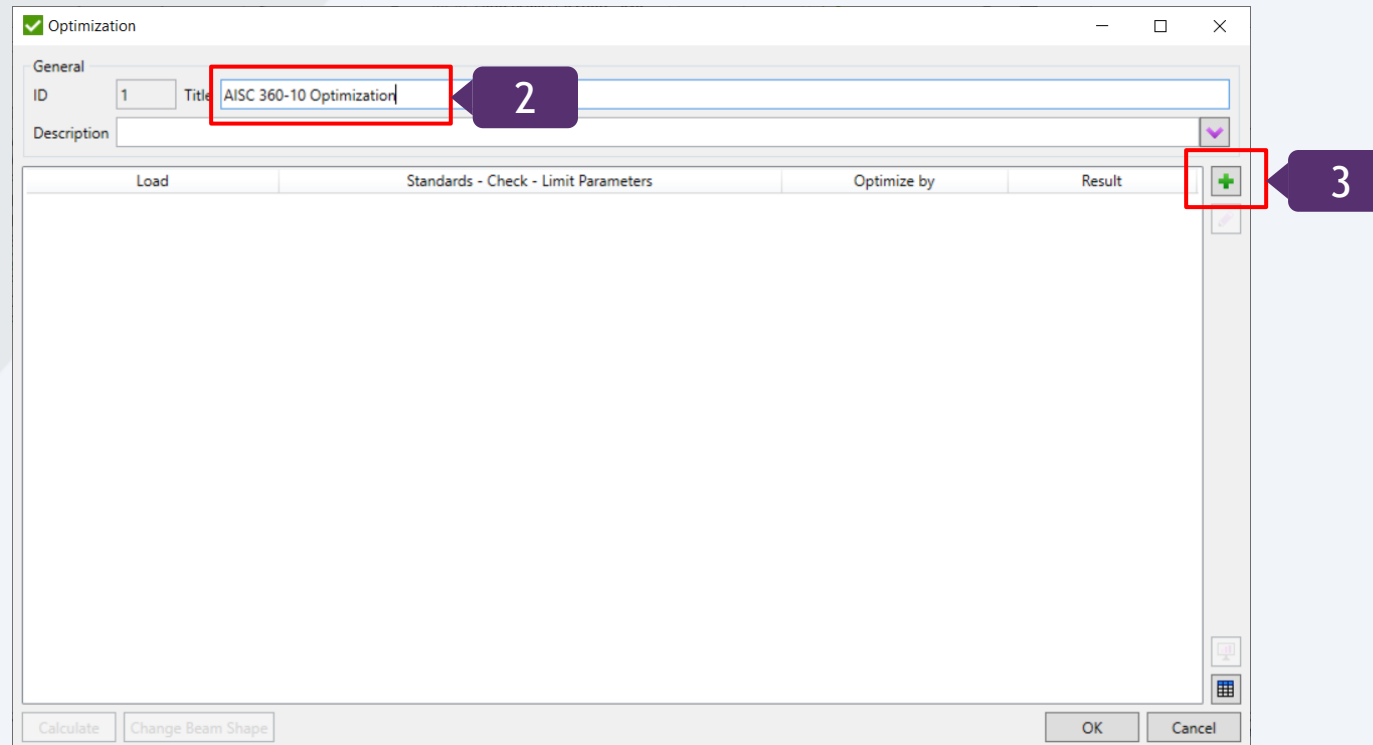
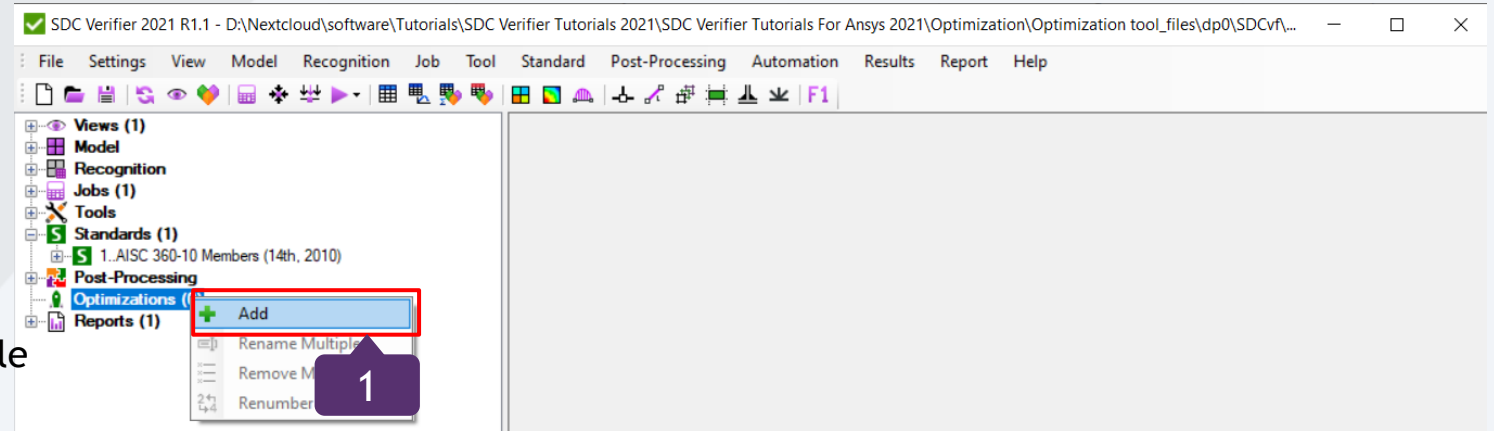
Select Optimizations > Add

2

Title: AISC 360-10 Optimization


3

Press  To create your first Optimization Rule



Optimization Rule

1

Click on **Select Load** 
In the opened window select Load Group 1

2

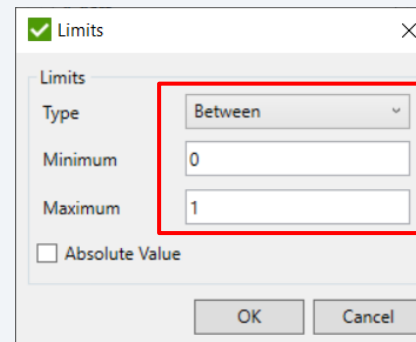
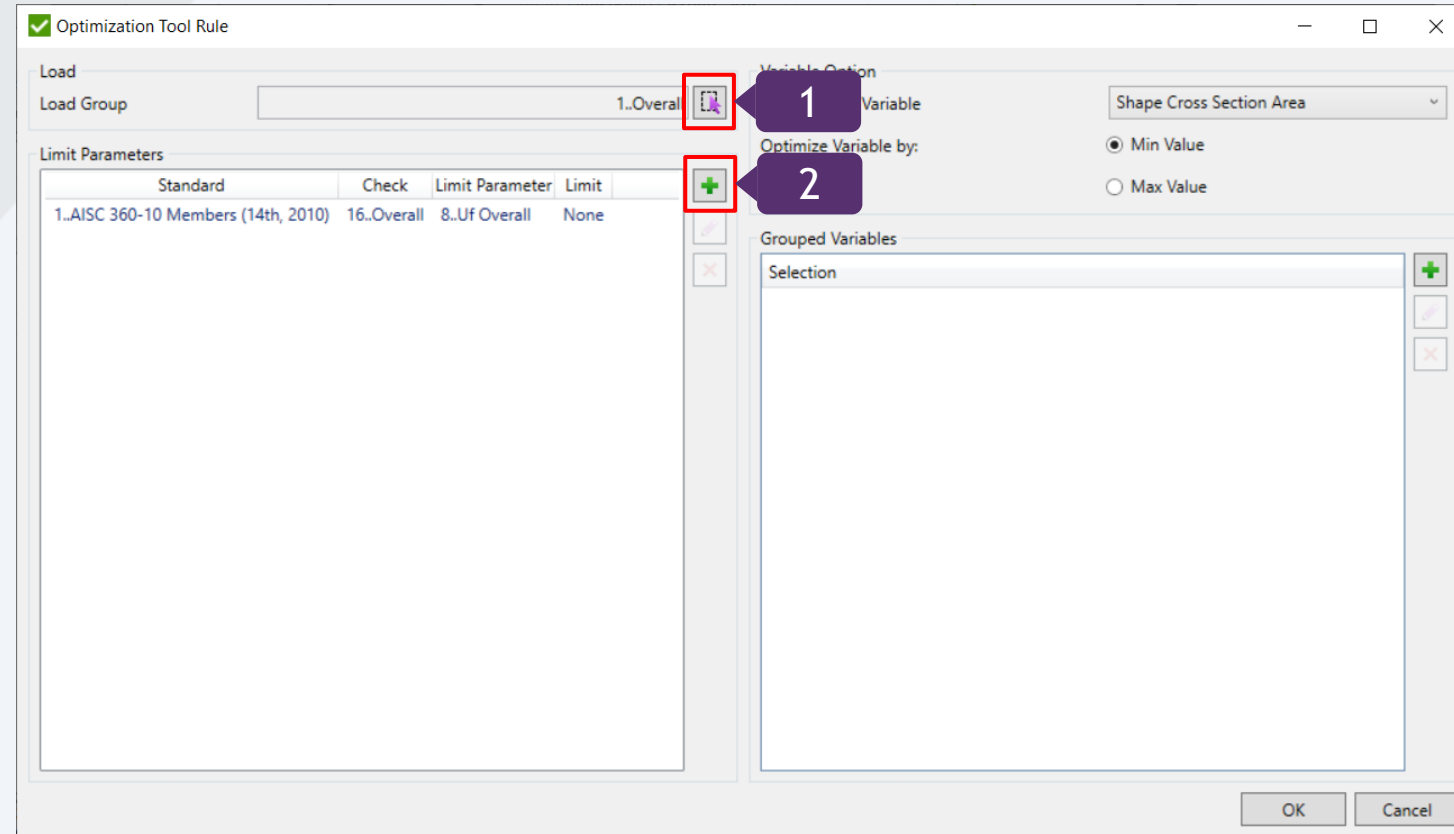
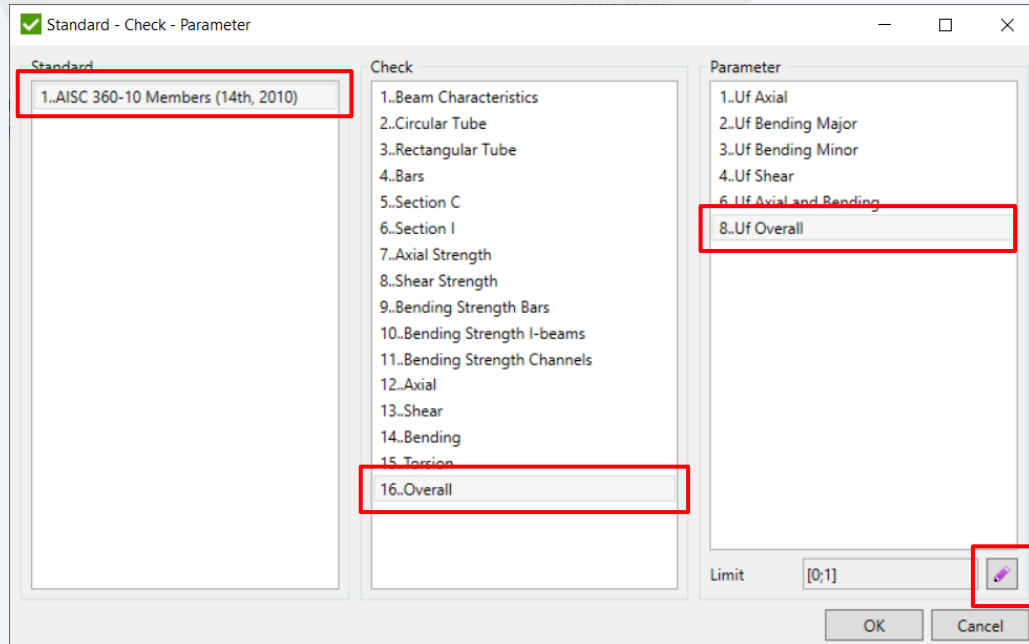
Click on **Select Limit Parameters** 

3

In the opened window select Standard /
Check / Parameter as shown below

4

Click on **Limits**. Set Between 0 and 1



Note: If you have multiple Standards calculated in your SDC Verifier Project you will have all of them listed in **Select Limit Parameters**

Optimization Rule


1

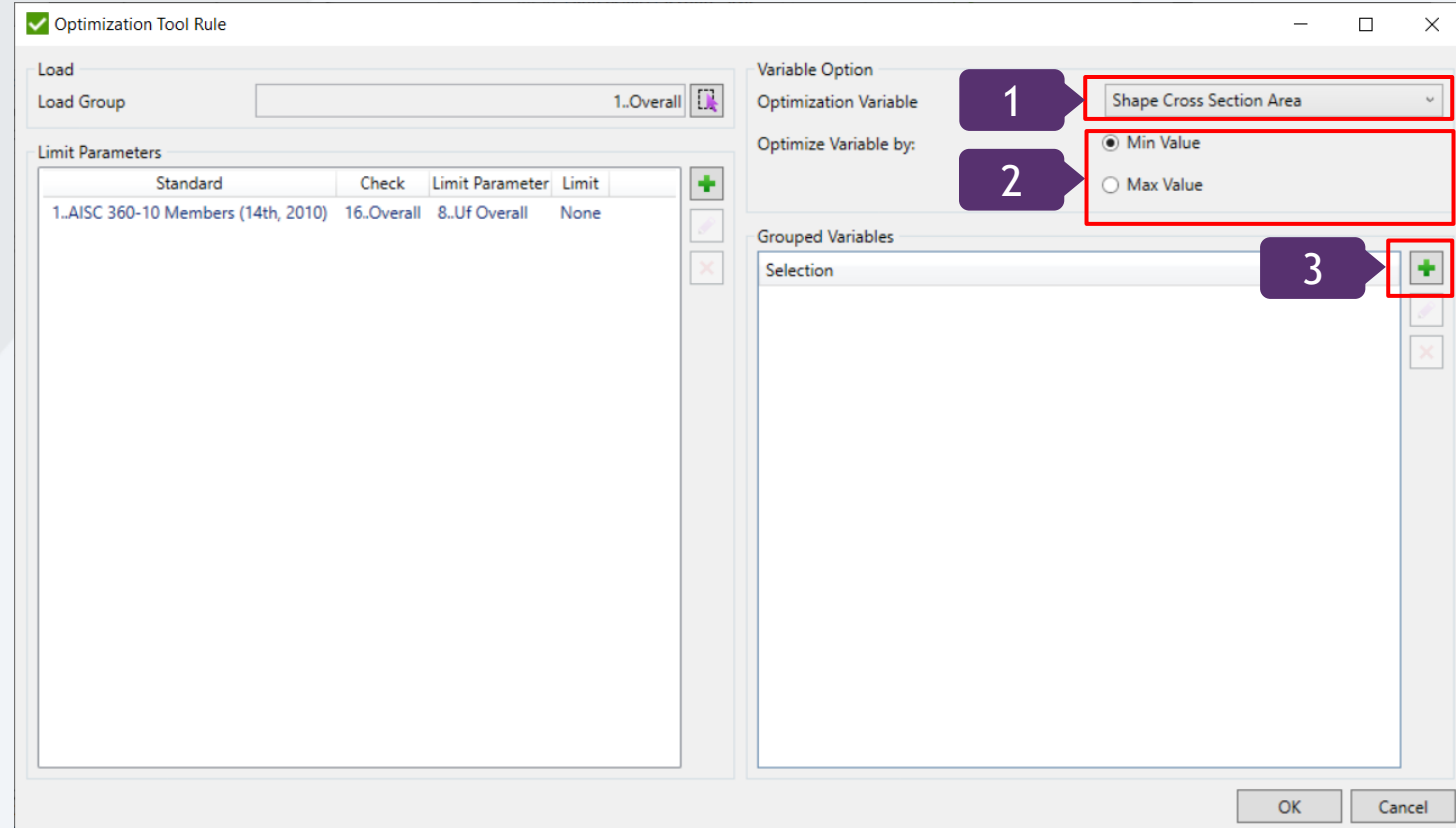
Set **Optimization Variable**:
Shape Cross Section Area

2

Set **Optimize Variable By**:
Min Value

3

Click on  to Select the
Variables to be Optimized



The screenshot shows the 'Optimization Tool Rule' dialog box. It has a title bar with a green checkmark and the text 'Optimization Tool Rule'. The dialog is divided into several sections:


- Load Section:** Contains a 'Load' field and a 'Load Group' dropdown menu set to '1..Overall'.
- Limit Parameters Section:** Contains a table with columns 'Standard', 'Check', 'Limit Parameter', and 'Limit'. The table has one row: '1..AISC 360-10 Members (14th, 2010)' | '16..Overall' | '8..Uf Overall' | 'None'. To the right of the table are three buttons: a green plus button, a red minus button, and a red X button.
- Variable Option Section:** Contains two fields: 'Optimization Variable' and 'Optimize Variable by:'.
 - The 'Optimization Variable' dropdown is set to 'Shape Cross Section Area' (indicated by callout 1).
 - The 'Optimize Variable by:' section has two radio buttons: 'Min Value' (selected, indicated by callout 2) and 'Max Value'.
- Grouped Variables Section:** Contains a 'Selection' list box and a green plus button (indicated by callout 3).

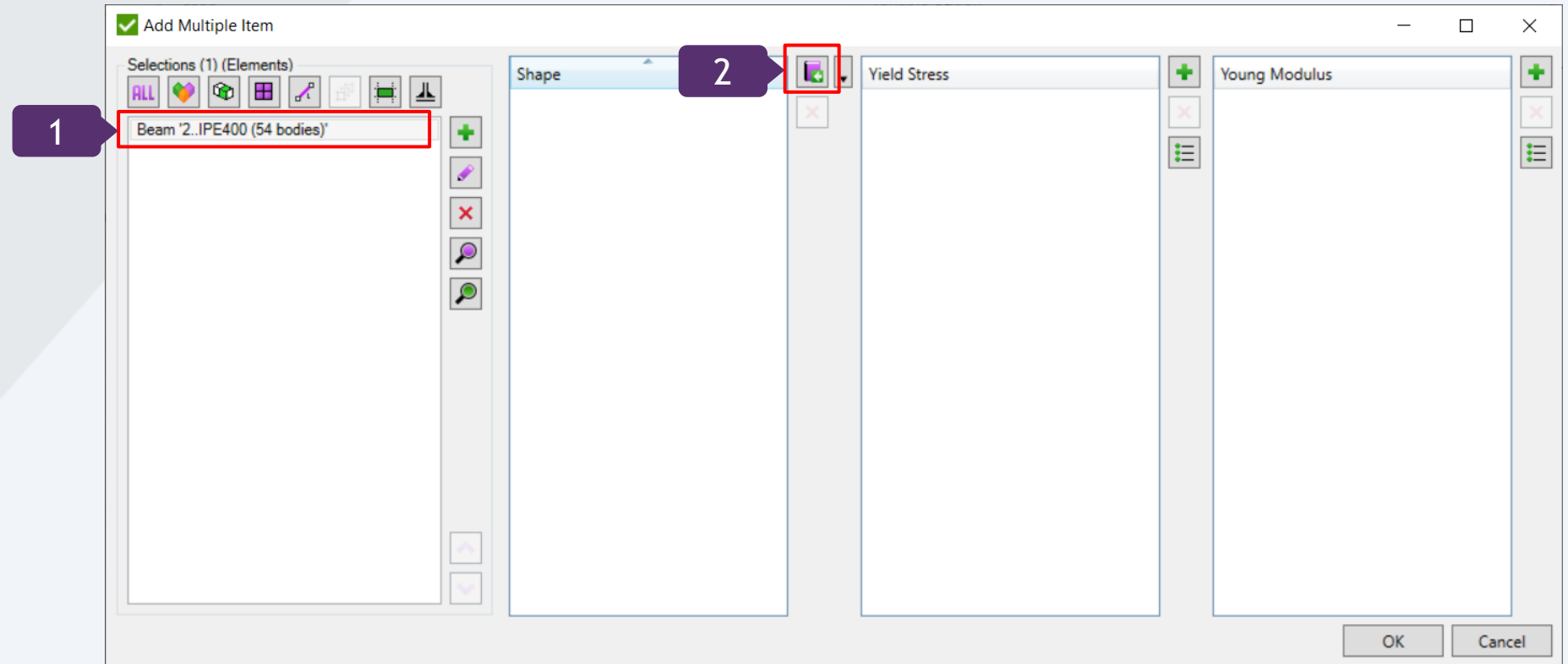
At the bottom right of the dialog are 'OK' and 'Cancel' buttons.

1

Using *Rule Based Selector*
Pick Property '2..IPE400'

2

Click on  to open
Shape Library



Shape Library contains a list of predefined or user defined shapes that can be used in the Optimization, Shapes can be filtered, Organized in Lists, Added or Modified.

Shape Library

Filter by
Name Shape Lists

| | Name | Type | Width, [m] | Height, [m] | Area, [m ²] | I _{yy} , [m ⁴] | I _{zz} , [m ⁴] |
|-------------------------------------|---------|--------|------------|-------------|-------------------------|-------------------------------------|-------------------------------------|
| <input type="checkbox"/> | W44X335 | I-Beam | 0.40 | 1.12 | 0.06 | 0.01 | 4.952e-04 |
| <input type="checkbox"/> | W44X290 | I-Beam | 0.40 | 1.11 | 0.06 | 0.01 | 4.333e-04 |
| <input type="checkbox"/> | W44X262 | I-Beam | 0.40 | 1.10 | 0.05 | 0.01 | 3.893e-04 |
| <input type="checkbox"/> | W44X230 | I-Beam | 0.40 | 1.09 | 0.04 | 0.01 | 3.344e-04 |
| <input type="checkbox"/> | W40X593 | I-Beam | 0.42 | 1.09 | 0.11 | 0.02 | 1.052e-03 |
| <input type="checkbox"/> | W40X503 | I-Beam | 0.42 | 1.07 | 0.10 | 0.02 | 8.498e-04 |
| <input type="checkbox"/> | W40X431 | I-Beam | 0.41 | 1.05 | 0.08 | 0.01 | 6.996e-04 |
| <input checked="" type="checkbox"/> | W40X397 | I-Beam | 0.41 | 1.04 | 0.08 | 0.01 | 6.396e-04 |
| <input type="checkbox"/> | W40X372 | I-Beam | 0.41 | 1.03 | 0.07 | 0.01 | 5.959e-04 |
| <input type="checkbox"/> | W40X362 | I-Beam | 0.41 | 1.03 | 0.07 | 0.01 | 5.733e-04 |
| <input type="checkbox"/> | W40X324 | I-Beam | 0.40 | 1.02 | 0.06 | 0.01 | 5.063e-04 |
| <input type="checkbox"/> | W40X297 | I-Beam | 0.40 | 1.01 | 0.06 | 0.01 | 4.528e-04 |
| <input type="checkbox"/> | W40X277 | I-Beam | 0.40 | 1.01 | 0.05 | 0.01 | 4.333e-04 |
| <input type="checkbox"/> | W40X249 | I-Beam | 0.40 | 1.00 | 0.05 | 0.01 | 3.893e-04 |
| <input type="checkbox"/> | W40X215 | I-Beam | 0.40 | 0.99 | 0.04 | 0.01 | 3.344e-04 |
| <input type="checkbox"/> | W40X199 | I-Beam | 0.40 | 0.98 | 0.04 | 0.01 | 2.933e-04 |
| <input type="checkbox"/> | W40X392 | I-Beam | 0.31 | 1.06 | 0.07 | 0.01 | 3.375e-04 |
| <input type="checkbox"/> | W40X331 | I-Beam | 0.31 | 1.04 | 0.06 | 0.01 | 2.710e-04 |
| <input type="checkbox"/> | W40X327 | I-Beam | 0.31 | 1.04 | 0.06 | 0.01 | 2.643e-04 |
| <input type="checkbox"/> | W40X294 | I-Beam | 0.30 | 1.03 | 0.06 | 0.01 | 2.332e-04 |
| <input type="checkbox"/> | W40X278 | I-Beam | 0.30 | 1.02 | 0.05 | 0.01 | 2.187e-04 |
| <input type="checkbox"/> | W40X264 | I-Beam | 0.30 | 1.02 | 0.05 | 0.01 | 2.037e-04 |
| <input type="checkbox"/> | W40X235 | I-Beam | 0.30 | 1.01 | 0.04 | 0.01 | 1.857e-04 |
| <input type="checkbox"/> | W40X211 | I-Beam | 0.30 | 1.00 | 0.04 | 0.01 | 1.626e-04 |
| <input type="checkbox"/> | W40X183 | I-Beam | 0.30 | 0.99 | 0.03 | 0.01 | 1.373e-04 |
| <input type="checkbox"/> | W40X167 | I-Beam | 0.30 | 0.98 | 0.03 | 4.841e-03 | 1.180e-04 |

Selected Shape W40X397

Area, [m²] 0.08 Y Shear Area, [m²] 0

Moment of Inertia, I_{zz}, [m⁴] 6.396e-04 Z Shear Area, [m²] 0

Moment of Inertia, I_{yy}, [m⁴] 0.01 Nonstructural Mass/length, [kg/m] 0

Moment of Inertia, I_{zy}, [m⁴] 0 Warping Constant, [m⁶] 1.530e-04

Torsional Constant, [m⁴] 6.039e-05 Perimeter, [m] 0

OK Cancel

☐ Show Selected Shapes (0) Displaying 6744 of 6744 shapes

1 Type In **Filter by Name:** IPE
(With the SPACE after E, to filter out the Pipe sections)

2 Select Following Cross Sections:
IPE 360, 400, 450, 500, 550, 600

3 Click OK to close the Shape Library

4 Click OK to close the Variables Selector And OK to close Optimization Rule

Now Optimization Rule is ready to be calculated

Shape Library

Filter by: IPE

| Name | Type | Width, [m] | Height, [m] | Area, [m^2] | Iyy, [m^4] | Izz, [m^4] |
|---|--------|------------|-------------|-------------|------------|------------|
| <input type="checkbox"/> IPE O 330 | I-Beam | 0.16 | 0.33 | 0.01 | 1.391e-04 | 9.604e-06 |
| <input type="checkbox"/> IPE A 360 | I-Beam | 0.17 | 0.36 | 0.01 | 1.452e-04 | 9.443e-06 |
| <input checked="" type="checkbox"/> IPE 360 | I-Beam | 0.17 | 0.36 | 0.01 | 1.627e-04 | 1.043e-05 |
| <input type="checkbox"/> IPE O 360 | I-Beam | 0.17 | 0.36 | 0.01 | 1.905e-04 | 1.251e-05 |
| <input type="checkbox"/> IPE A 400 | I-Beam | 0.18 | 0.40 | 0.01 | 2.030e-04 | 1.171e-05 |
| <input checked="" type="checkbox"/> IPE 400 | I-Beam | 0.18 | 0.40 | 0.01 | 2.313e-04 | 1.318e-05 |
| <input type="checkbox"/> IPE O 400 | I-Beam | 0.18 | 0.40 | 0.01 | 2.675e-04 | 1.564e-05 |
| <input type="checkbox"/> IPE A 450 | I-Beam | 0.19 | 0.45 | 0.01 | 2.976e-04 | 1.502e-05 |
| <input checked="" type="checkbox"/> IPE 450 | I-Beam | 0.19 | 0.45 | 0.01 | 3.375e-04 | 1.676e-05 |
| <input type="checkbox"/> IPE O 450 | I-Beam | 0.19 | 0.46 | 0.01 | 4.093e-04 | 2.085e-05 |
| <input type="checkbox"/> IPE A 500 | I-Beam | 0.20 | 0.50 | 0.01 | 4.294e-04 | 1.939e-05 |
| <input checked="" type="checkbox"/> IPE 500 | I-Beam | 0.20 | 0.50 | 0.01 | 4.821e-04 | 2.142e-05 |
| <input type="checkbox"/> IPE O 500 | I-Beam | 0.20 | 0.51 | 0.01 | 5.778e-04 | 2.622e-05 |
| <input type="checkbox"/> IPE A 550 | I-Beam | 0.21 | 0.55 | 0.01 | 5.999e-04 | 2.432e-05 |
| <input checked="" type="checkbox"/> IPE 550 | I-Beam | 0.21 | 0.55 | 0.01 | 6.713e-04 | 2.668e-05 |
| <input type="checkbox"/> IPE O 550 | I-Beam | 0.21 | 0.56 | 0.02 | 7.917e-04 | 3.224e-05 |
| <input type="checkbox"/> IPE A 600 | I-Beam | 0.22 | 0.60 | 0.01 | 8.293e-04 | 3.116e-05 |
| <input checked="" type="checkbox"/> IPE 600 | I-Beam | 0.22 | 0.60 | 0.02 | 9.210e-04 | 3.387e-05 |
| <input type="checkbox"/> IPE O 600 | I-Beam | 0.22 | 0.61 | 0.02 | 1.183e-03 | 4.521e-05 |
| <input type="checkbox"/> IPE 750 x 134 | I-Beam | 0.26 | 0.75 | 0.02 | 1.507e-03 | 4.766e-05 |
| <input type="checkbox"/> IPE 750 x 147 | I-Beam | 0.27 | 0.75 | 0.02 | 1.661e-03 | 5.289e-05 |
| <input type="checkbox"/> IPE 750 x 173 | I-Beam | 0.27 | 0.76 | 0.02 | 2.058e-03 | 6.873e-05 |
| <input type="checkbox"/> IPE 750 x 196 | I-Beam | 0.27 | 0.77 | 0.03 | 2.403e-03 | 8.175e-05 |
| <input type="checkbox"/> IPE A 160 | I-Beam | 0.08 | 0.16 | 1.548e-03 | 6.546e-06 | 5.430e-07 |
| <input type="checkbox"/> IPE A 180 | I-Beam | 0.09 | 0.18 | 1.888e-03 | 1.018e-05 | 8.175e-07 |
| <input type="checkbox"/> IPE A 200 | I-Beam | 0.10 | 0.20 | 2.224e-03 | 1.494e-05 | 1.168e-06 |

Selected Shape IPE AA 80

Area, [m^2] 6.306e-04 Y Shear Area, [m^2] 0

Moment of Inertia, Izz, [m^4] 6.850e-08 Z Shear Area, [m^2] 0

Moment of Inertia, Iyy, [m^4] 6.410e-07 Nonstructural Mass/length, [kg/m] 0

Moment of Inertia, Izy, [m^4] 0 Warping Constant, [m^6] 0

Torsional Constant, [m^4] 3.922e-09 Perimeter, [m] 0

0.078 0.046 0.0042 0.0032 0.046 0.0042

3 OK Cancel

1

Execute *Calculate* to run the Optimization

The screenshot shows the 'Optimization' dialog box in SDC Verifier. The 'General' tab is active, showing 'ID' as 1 and 'Title' as 'AISC 360-10 Optimization'. Below this is a table with the following data:

| Load | Standards - Check - Limit Parameters | Optimize by | Result |
|--------------|--|------------------------------|--------|
| LG1..Overall | 1..AISC 360-10 Members (14th, 2010) 16..Overall - 8..Uf Overall, Limit: [0;1] | Min Shape Cross Section Area | |

At the bottom of the dialog, the 'Calculate' button is highlighted with a red box and a purple callout bubble containing the number 1. Other buttons visible are 'Change Beam Shape', 'OK', and 'Cancel'.

1

Click on *Table* > *All results*

Results for all variables

| Result Table | | | | |
|------------------------------|----------------|----------------|------------------|--|
| Group | Yield Stress | Young Modulus | Shape | 1..AISC 360-10 Members (16..Overall 8..Uf Overall) |
| Beam '2..IPE400 (54 bodies)' | Original Model | Original Model | Original Model | 1.4996 |
| Beam '2..IPE400 (54 bodies)' | | | IPE 360 - I-Beam | 1.8925 |
| Beam '2..IPE400 (54 bodies)' | | | IPE 400 - I-Beam | 1.3989 |
| Beam '2..IPE400 (54 bodies)' | | | IPE 450 - I-Beam | 1.0489 |
| Beam '2..IPE400 (54 bodies)' | | | IPE 500 - I-Beam | 0.7906 |
| Beam '2..IPE400 (54 bodies)' | | | IPE 550 - I-Beam | 0.6087 |
| Beam '2..IPE400 (54 bodies)' | | | IPE 600 - I-Beam | 0.4686 |

Optimization

General

ID1TitleAISC 360-10 OptimizationDescription

| Load | Standards - Check - Limit Parameters | Optimize by | Result |
|--------------|--|------------------------------|------------|
| LG1..Overall | 1..AISC 360-10 Members (14th, 2010) 16..Overall - 8..Uf Overall, Limit: [0;1] | Min Shape Cross Section Area | Calculated |

CalculateChange Beam Shape

Optimal ResultAll Result

Optimal result is Beam IPE 500. It will be used for changing the Beam shape

1

Click on *Plot Optimal Result*

Optimization

General

ID: 1 Title: AISC 360-10 Optimization

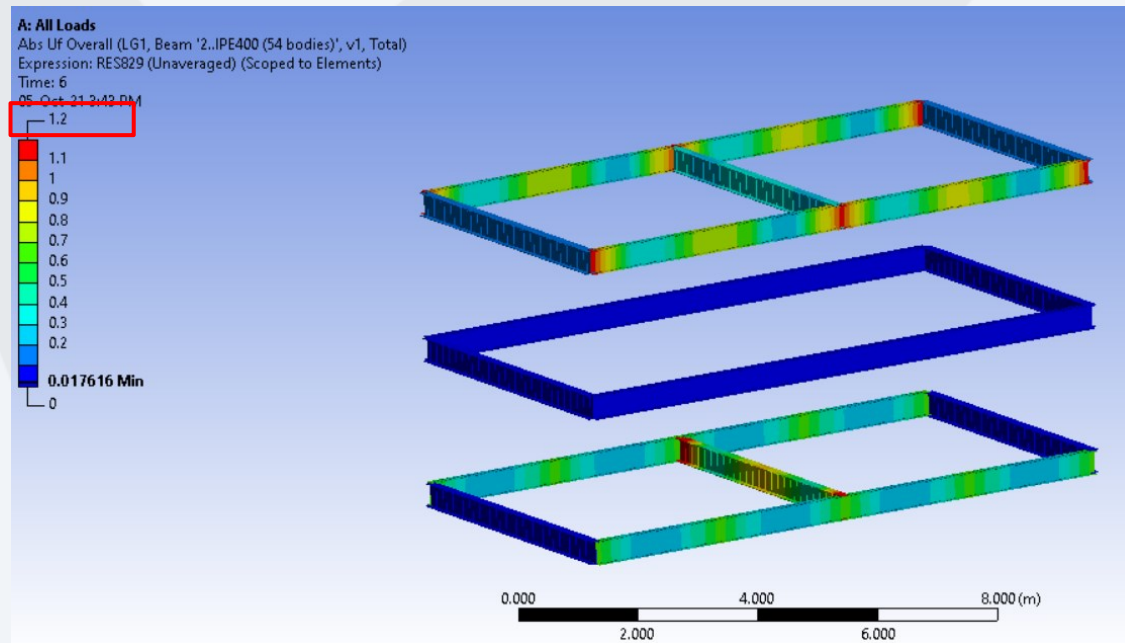
Description:

| Load | Standards - Check - Limit Parameters | Optimize by | Result |
|--------------|--|------------------------------|------------|
| LG1..Overall | 1..AISC 360-10 Members (14th, 2010) 16..Overall - 8..Uf Overall, Limit: [0;1] | Min Shape Cross Section Area | Calculated |

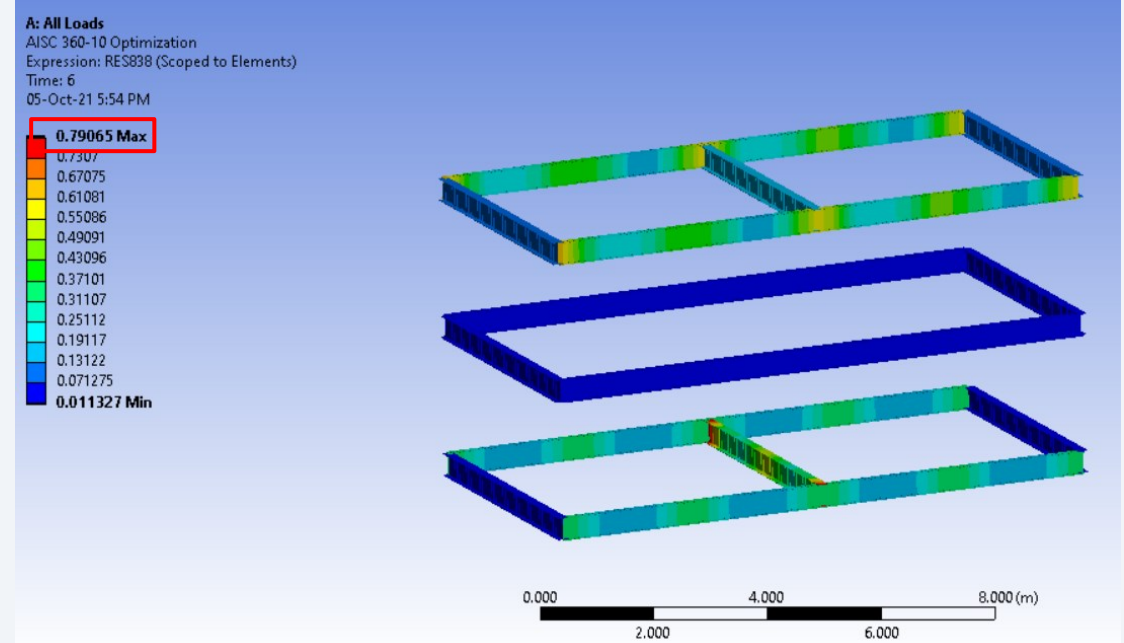
1

Calculate Change Beam Shape OK Cancel

Result Before the Optimization



Result After the Optimization

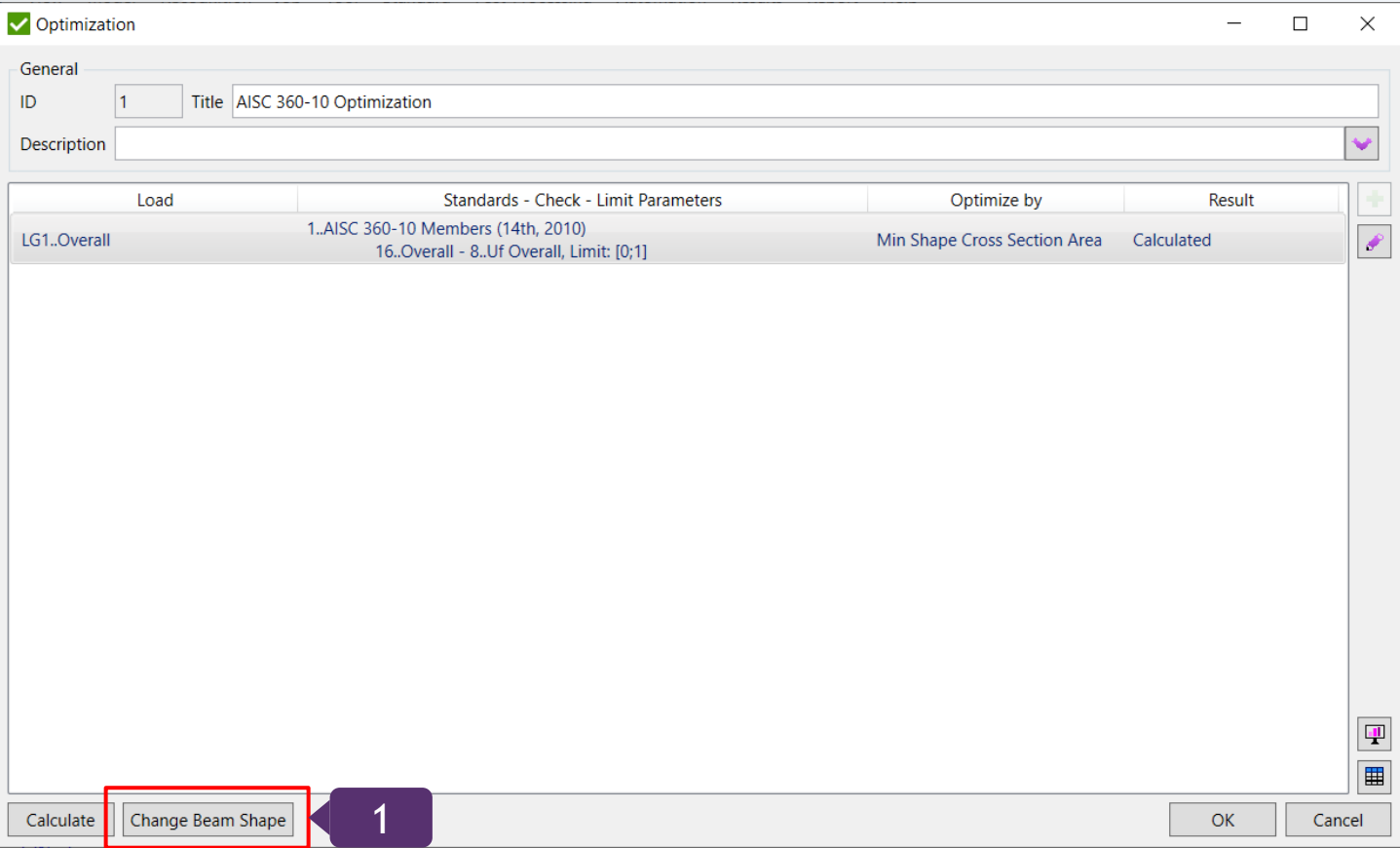
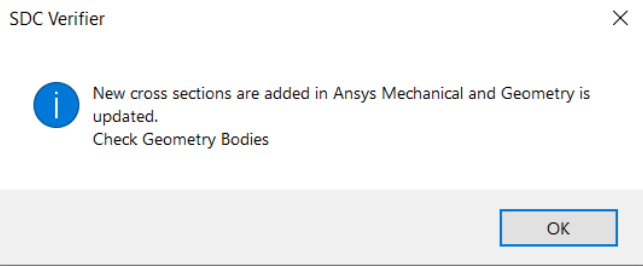


This Tutorial only demonstrates the workflow with Optimization Tool.
Optimization rule can be set more precisely. For Example, using the Peak Finder you can group only the overshooting elements into a Component and run the optimization on this Component. Multiple rules with different variables can be set.

Changing the Beam Shape

1

Click on *Change Beam Shape*



Property IPE400 is automatically replaced by IPE 500 (Optimal Result)