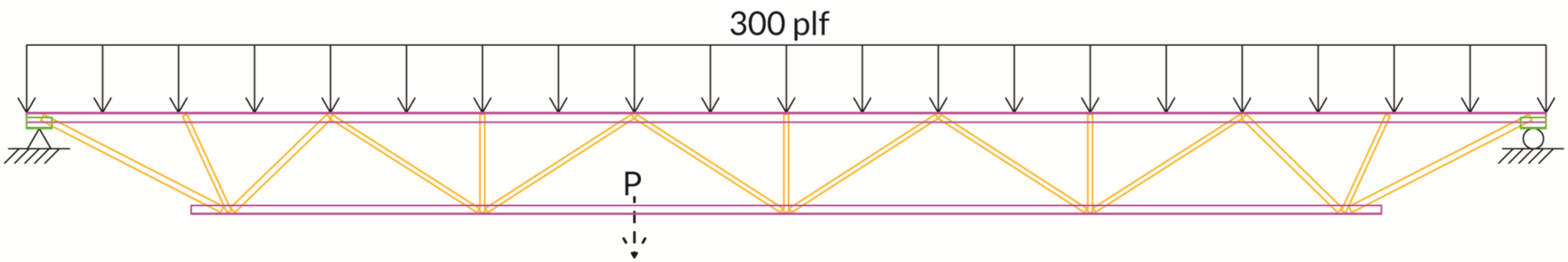
Tutorial for MASTAN2 v5.1 – Steel Joist



MASTAN2

MASTAN2

Department of Civil and Environmental Engineering
UNIVERSITY OF WISCONSIN–MADISON

Bucknell UNIVERSITY

NEW MILLENNIUM BUILDING SYSTEMS

American Iron and Steel Institute

STEEL JOIST INSTITUTE SJI

STEEL DECK INSTITUTE sdi

Credits

Published 2020

Developed by:

Edward J. Sippel, Ph.D. Student, University of Wisconsin – Madison

Hannah B. Blum, Assistant Professor, University of Wisconsin - Madison

Ronald D. Ziemian, Professor, Bucknell University

Joe Pote, Director of Research & Development, New Millennium Building Systems

Scott Morton, Research and Development Engineer, New Millennium Building Systems

Sponsored by:

American Iron and Steel Institute

New Millennium Building Systems

Steel Joist Institute

Steel Deck Institute

Tutorial Sections

Navigation

- – Skip to Previous Section Title Page
- – Previous Slide
- – Return to Tutorial Sections Page
- – Next Slide
- – Skip to Next Section Title Page

– Open screenshot of MASTAN2 or additional helpful information.

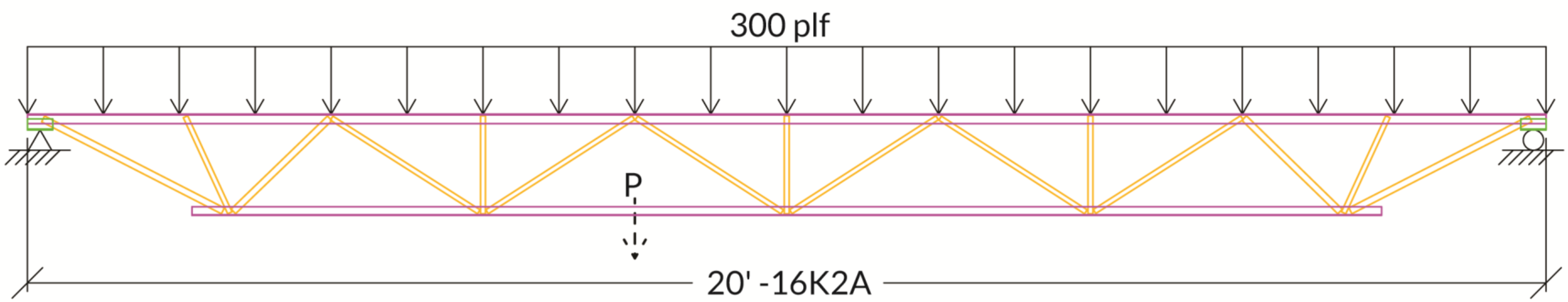
Section 1: Overview

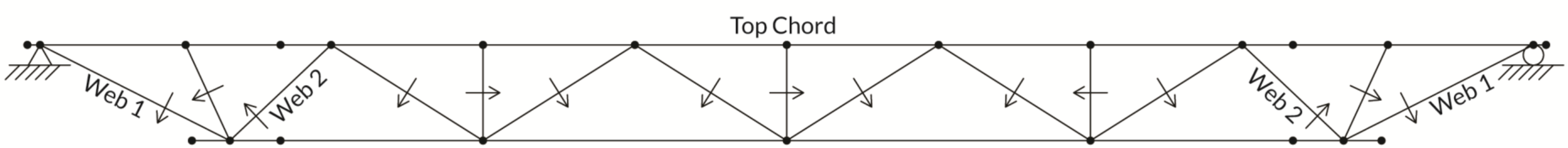
Overview

This tutorial provides step-by-step guidance for the sample joist structure. Enough details are provided that the example model with non-doubly symmetric sections can be completed following the instructions here. Not every feature available in MASTAN2 will be mentioned nor utilized in this tutorial. For further information on many of the features within MASTAN2 make use of other tutorials at http://www.mastan2.com/tutorial.html.

Problem Overview

This tutorial works with a single open-web steel joist. The model will be created to show how to analyze a joist for a uniform distributed load on the top chord accounting for the non-doubly symmetric section properties. This model will then be adjusted to allow for the application of an eccentric point load on the bottom chord. Further details of each model will be provided in the corresponding section.





Arrows indicate the open side of the web channels. Web members not otherwise labeled are Web 3

Section 2: Getting Started

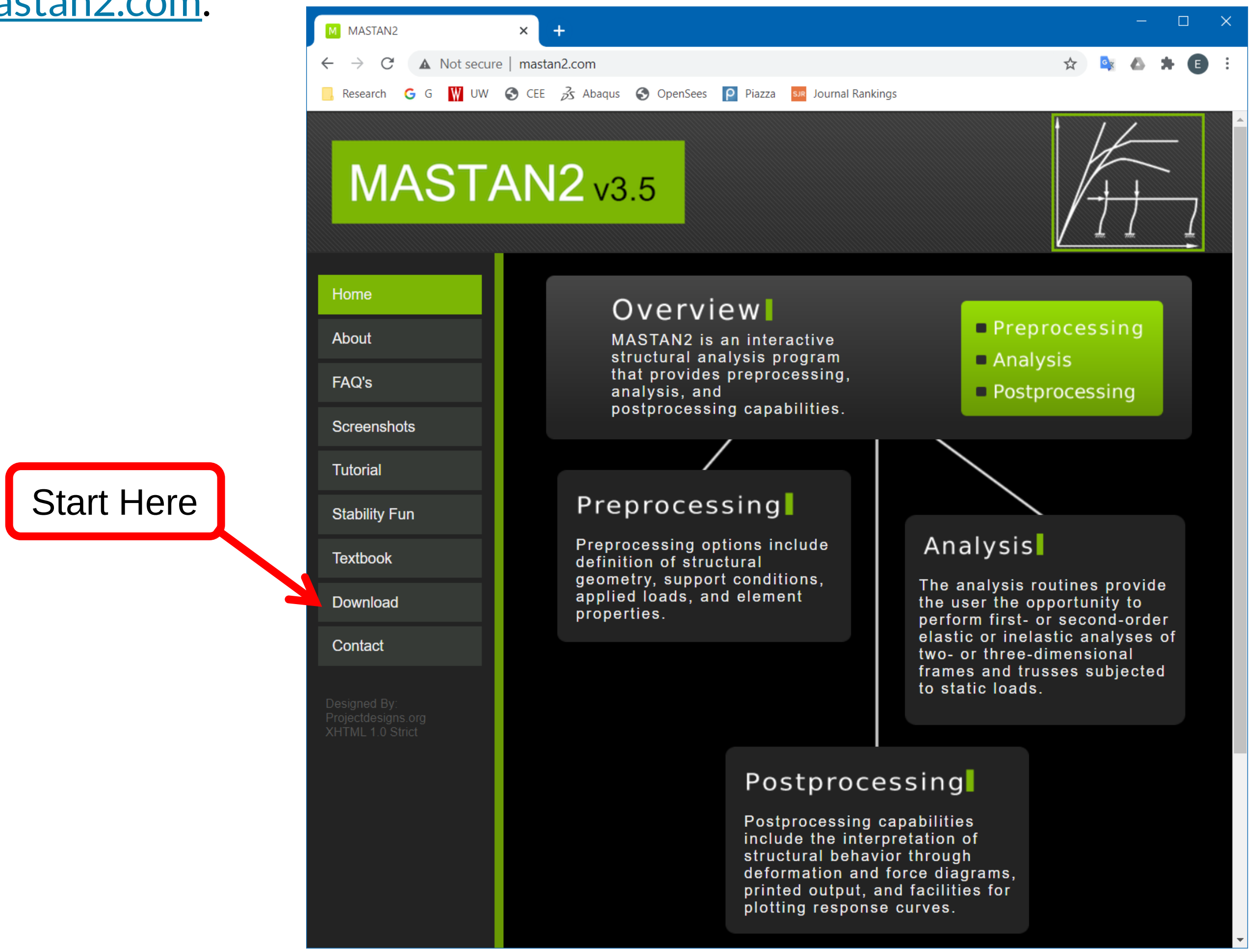
MASTAN2 General Information

MASTAN2 is an interactive graphics program that provides preprocessing, analysis, and postprocessing capabilities. Preprocessing options include definition of structural geometry, support conditions, applied loads, and element properties. The analysis routines provide the user the opportunity to perform first- or second-order elastic or inelastic analyses of two- or three-dimensional frames and trusses subjected to static and dynamic loads. Postprocessing capabilities include the interpretation of structural behavior through deformation and force diagrams, printed output, and facilities for plotting response curves. MASTAN2 is based on MATLAB®, a premier software package for numeric computing and data analysis.

In many ways, MASTAN2 is similar to today's commercially available software in functionality. The number of pre- and post-processing options, however, have been limited in order to minimize the amount of time needed for a user to become proficient at its use. The program's linear and nonlinear analysis routines are based on the theoretical and numerical formulations presented in the text *Matrix Structural Analysis, 2nd Edition*, by McGuire, Gallagher, and Ziemian. In this regard, the reader is strongly encouraged to use this software as a tool for demonstration, reviewing examples, solving problems, and perhaps performing analysis and design studies. Where MASTAN2 has been written in modular format, the reader is also provided the opportunity to develop and implement additional or alternative analysis routines directly within the program.

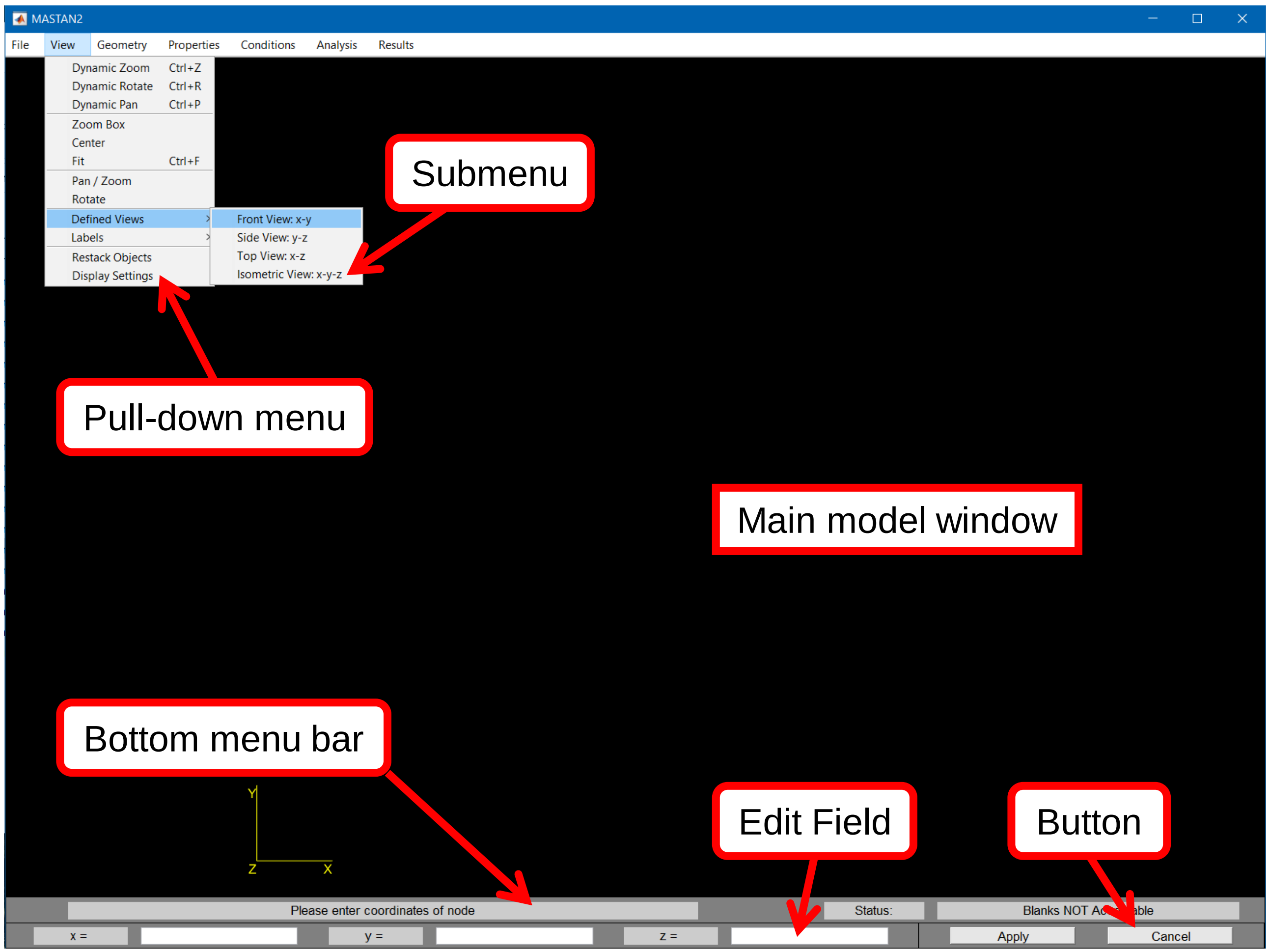
Launching MASTAN2

Two versions of MASTAN2 have been developed and may be installed. One requires you to have access to MATLAB and the other does not. Both versions provide the same functionality, except that the MATLAB version also provides the user an opportunity to develop and implement additional or alternative analysis routines that will directly interact with MASTAN2. Please see the Setup Guides at www.mastan2.com.



Base Layout

In order to minimize the learning time for MASTAN2, its graphical user interface (GUI) has been designed using a simple and consistent two menu approach. Using a pull-down menu at the top of the GUI, a command is selected. Parameters are then defined in the bottom menu bar and the command is executed by using the Apply button.



Section 3: Base Joist Geometry

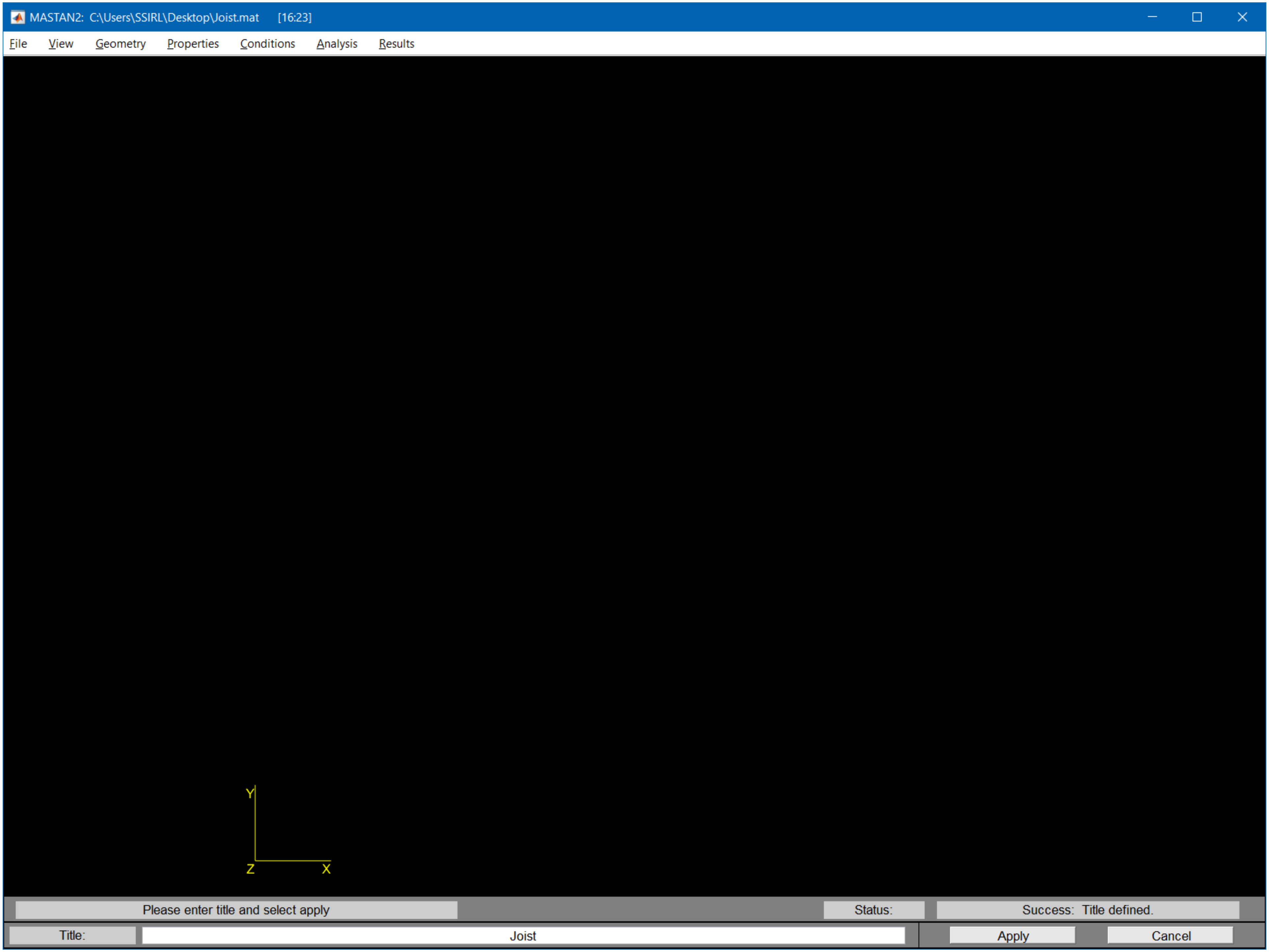
Naming and Saving

While you can build the model and complete the analysis without saving or applying a title, due to the complexity of the model we will create a save file immediately. For the remainder of this tutorial, there will not be a reminder to save. However, it can be useful to save the file as you go along, particularly before any action that is not easily reversed as there is no undo feature. A file can be reopened while still working in that file without saving it to revert to the previous save version of the model that is unaffected by your last steps.

1) Start with a new, empty model.

2) From the **File** menu select **Define title**. At the bottom menu bar, click in the edit box to the right of **Title:** and type in a brief description of this effort. This text might include the model title, your name, and/or the assignment number. Click on the **Apply** button.

3) From the **File** menu select **Save As …** . After selecting your destination folder, type in the filename **Joist** and click **Save**. Note that the top of the window has now changed to include the file name and directory as well as the time the file was last saved.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [16:23]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
Z
X
Please enter title and select apply
Status:
Success: Title defined.
Title:
Joist
Apply
Cancel

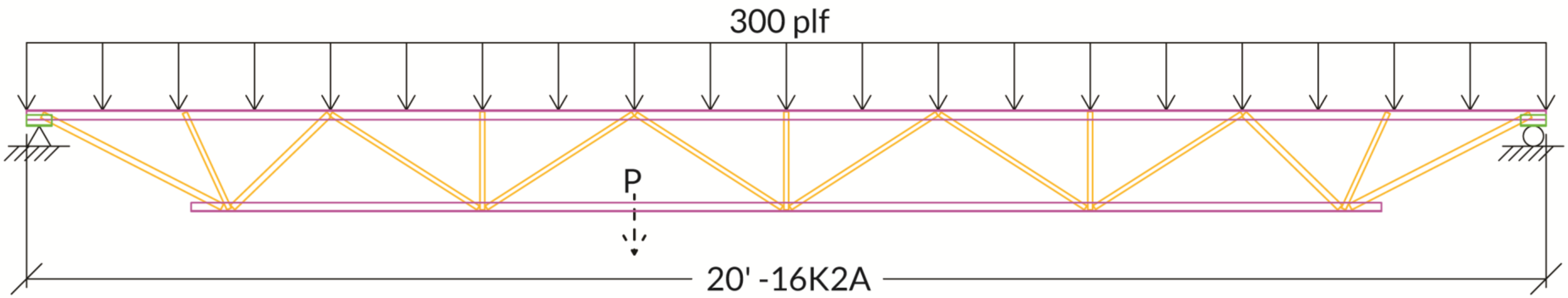
Defining the Joist

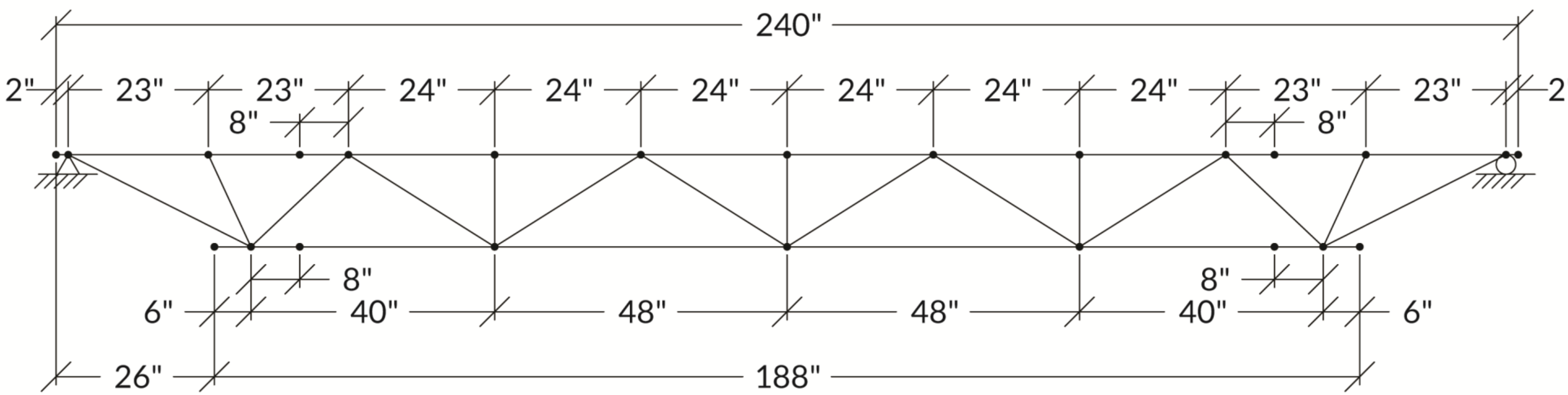
The joist will be modeled with the chords as two separate members to allow them to twist independently. The geometry could be input by defining individual nodes and then individual elements or making use of the extrude element tool extensively. Instead, the **Input Geometry** tool will be used to define most of the joist geometry. As a large part of creating the frame is the prep work, an explanation of what values were used is provided on this page and the next pages explain how to use the values and links to what the values are.

The joist was defined as a series of nodes along the top chord and then the bottom chord. The first set is for the chords set back in the negative z-direction. The second set is for the chords in the positive z-direction. The third set is on the x-y plane for member to member connections and the webs. The x position was defined based on the simple joist geometry.

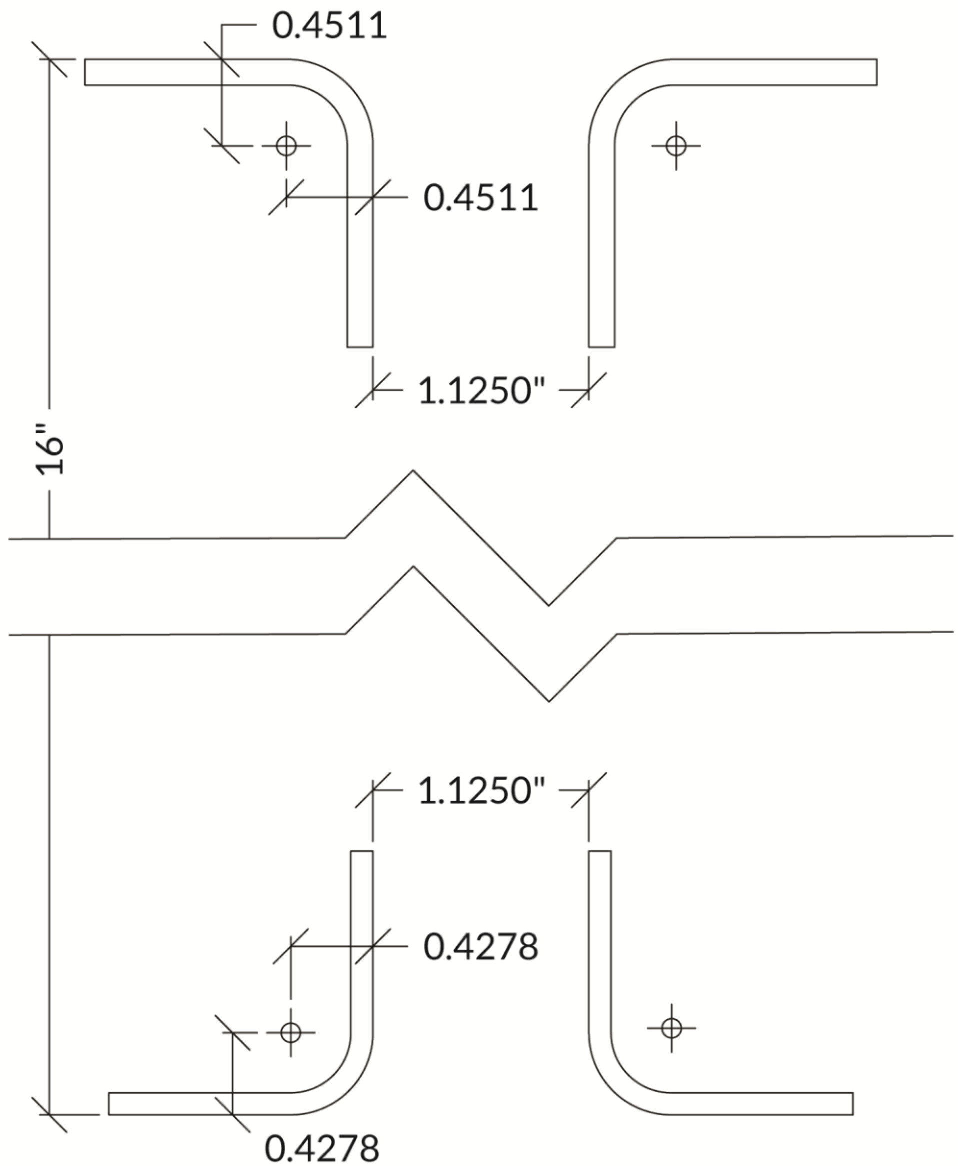
A node is defined for the end of the members, each web intersection, and where the joist bracing connects. The y position of the top chord nodes is set as 16” minus the centroid of the top chord angle while the bottom chord is 0” plus the centroid of the bottom chord angle. The z position similarly accounts for the centroid position plus a 1-1/8” gap between the chords.

The elements are defined in order to connect all back chords, all front chords, all webs, and then the connections in between.


300 plf
P
20' -16K2A


240"
2"
23"
23"
24"
24"
24"
24"
24"
24"
23"
23"
2"
8"
8"
8"
8"
6"
40"
48"
48"
40"
6"
26"
188"

MASTAN2



Defining Geometry

For entering the node coordinates and element information below, the values are provided in two different formats for your use. Node and element information needs to be copied only once.

A - Lists all the node information in separate readable segments to be copied in order.

B - Lists all the element information in separate readable segments to be copied in order.

C - Lists all the node and then all element information in small font lists to be copied all at once.

1) From the **Geometry** menu select **Input Geometry** .

2) At the bottom menu bar, **Nodes** should be already selected. In the edit box to the right of **X_coord Y_coord Z_coord**, enter manually or copy and paste the coordinate values.

3) Click on **Nodes** to open a pop-up menu. Click on **Elements** to update what information is imported.

4) In the edit box to the right of **Node_i Node_j Beta(deg)**, enter manually or copy and paste the element start and end nodes. When only 2 values are provided, beta is assumed to be 0.

5) Click on the **Apply** button.

Note: **Apply** button could be clicked before defining the **Element** list to just input the **Nodes** first. The **Element** list will then use the existing node information on the second use of **Apply** button.

Copy all 3 tables in order

Nodes 1

0	15.54894	-1.01356
2	15.54894	-1.01356
25	15.54894	-1.01356
40	15.54894	-1.01356
48	15.54894	-1.01356
72	15.54894	-1.01356
96	15.54894	-1.01356
120	15.54894	-1.01356
144	15.54894	-1.01356
168	15.54894	-1.01356
192	15.54894	-1.01356
200	15.54894	-1.01356
215	15.54894	-1.01356
238	15.54894	-1.01356
240	15.54894	-1.01356
26	0.42775	-0.99025
32	0.42775	-0.99025
40	0.42775	-0.99025
72	0.42775	-0.99025
120	0.42775	-0.99025
168	0.42775	-0.99025
200	0.42775	-0.99025
208	0.42775	-0.99025
214	0.42775	-0.99025

Nodes 2

0	15.54894	1.01356
2	15.54894	1.01356
25	15.54894	1.01356
40	15.54894	1.01356
48	15.54894	1.01356
72	15.54894	1.01356
96	15.54894	1.01356
120	15.54894	1.01356
144	15.54894	1.01356
168	15.54894	1.01356
192	15.54894	1.01356
200	15.54894	1.01356
215	15.54894	1.01356
238	15.54894	1.01356
240	15.54894	1.01356
26	0.42775	0.99025
32	0.42775	0.99025
40	0.42775	0.99025
72	0.42775	0.99025
120	0.42775	0.99025
168	0.42775	0.99025
200	0.42775	0.99025
208	0.42775	0.99025
214	0.42775	0.99025

Nodes 3

0	15.54894	0
2	15.54894	0
25	15.54894	0
40	15.54894	0
48	15.54894	0
72	15.54894	0
96	15.54894	0
120	15.54894	0
144	15.54894	0
168	15.54894	0
192	15.54894	0
200	15.54894	0
215	15.54894	0
238	15.54894	0
240	15.54894	0
26	0.42775	0
32	0.42775	0
40	0.42775	0
72	0.42775	0
120	0.42775	0
168	0.42775	0
200	0.42775	0
208	0.42775	0
214	0.42775	0

MASTAN2

Copy all 5 tables in order

1 B. Chord

1	2
2	3
3	4
4	5
5	6
6	7
7	8
8	9
9	10
10	11
11	12
12	13
13	14
14	15
16	17
17	18
18	19
19	20
20	21
21	22
22	23
23	24

2 F. Chord

25	26
26	27
27	28
28	29
29	30
30	31
31	32
32	33
33	34
34	35
35	36
36	37
37	38
38	39
40	41
41	42
42	43
43	44
44	45
45	46
46	47
47	48

3 Webs

50	65
51	65
53	65
53	67
54	67
55	67
55	68
56	68
57	68
57	69
58	69
59	69
59	71
61	71
62	71

4 B. Conn.

50	2
51	3
53	5
54	6
55	7
56	8
57	9
58	10
59	11
61	13
62	14
65	17
67	19
68	20
69	21
71	23

5 F. Conn.

50	26
51	27
53	29
54	30
55	31
56	32
57	33
58	34
59	35
61	37
62	38
65	41
67	43
68	44
69	45
71	47

Copy all values to the **Node** section

Nodes

0	15.54894	-1.01356
2	15.54894	-1.01356
25	15.54894	-1.01356
40	15.54894	-1.01356
48	15.54894	-1.01356
72	15.54894	-1.01356
96	15.54894	-1.01356
120	15.54894	-1.01356
144	15.54894	-1.01356
168	15.54894	-1.01356
192	15.54894	-1.01356
200	15.54894	-1.01356
215	15.54894	-1.01356
238	15.54894	-1.01356
240	15.54894	-1.01356
26	0.42775	-0.99025
32	0.42775	-0.99025
40	0.42775	-0.99025
72	0.42775	-0.99025
120	0.42775	-0.99025
168	0.42775	-0.99025
200	0.42775	-0.99025
208	0.42775	-0.99025
214	0.42775	-0.99025
0	15.54894	1.01356
2	15.54894	1.01356
25	15.54894	1.01356
40	15.54894	1.01356
48	15.54894	1.01356
72	15.54894	1.01356
96	15.54894	1.01356
120	15.54894	1.01356
144	15.54894	1.01356
168	15.54894	1.01356
192	15.54894	1.01356
200	15.54894	1.01356
215	15.54894	1.01356
238	15.54894	1.01356
240	15.54894	1.01356
26	0.42775	0.99025
32	0.42775	0.99025
40	0.42775	0.99025
72	0.42775	0.99025
120	0.42775	0.99025
168	0.42775	0.99025
200	0.42775	0.99025
208	0.42775	0.99025
214	0.42775	0.99025
0	15.54894	0
2	15.54894	0
25	15.54894	0
40	15.54894	0
48	15.54894	0
72	15.54894	0
96	15.54894	0
120	15.54894	0
144	15.54894	0
168	15.54894	0
192	15.54894	0
200	15.54894	0
215	15.54894	0
238	15.54894	0
240	15.54894	0
26	0.42775	0
32	0.42775	0
40	0.42775	0
72	0.42775	0
120	0.42775	0
168	0.42775	0
200	0.42775	0
208	0.42775	0
214	0.42775	0

Copy all values to the **Element** section

Elements

1	2
2	3
3	4
4	5
5	6
6	7
7	8
8	9
9	10
10	11
11	12
12	13
13	14
14	15
16	17
17	18
18	19
19	20
20	21
21	22
22	23
23	24
25	26
26	27
27	28
28	29
29	30
30	31
31	32
32	33
33	34
34	35
35	36
36	37
37	38
38	39
40	41
41	42
42	43
43	44
44	45
45	46
46	47
47	48
50	65
51	65
53	65
53	67
54	67
55	67
55	68
56	68
57	68
57	69
58	69
59	69
59	71
61	71
62	71
50	2
51	3
53	5
54	6
55	7
56	8
57	9
58	10
59	11
61	13
62	14
65	17
67	19
68	20
69	21
71	23
50	26
51	27
53	29
54	30
55	31
56	32
57	33
58	34
59	35
61	37
62	38
65	41
67	43
68	44
69	45
71	47

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Elements
Enter each element's data as 3 values separated by spaces per row (perhaps using paste)
Status:
Success: All geometry added.
Node_i Node_j Beta(deg)
Apply
Cancel

Lower Bridging Support

1) From the **Geometry** menu select **Extrude Element**.

2) Click on the nodes on the bottom chord closest to the joist bridging connection: Nodes **18**, **22**, **42**, and **46** to populate the nodes to be extruded.

3) Click in the edit box to the right of **Delta y =** and change **0** to **2.5**.

4) Click on the **Apply** Button.

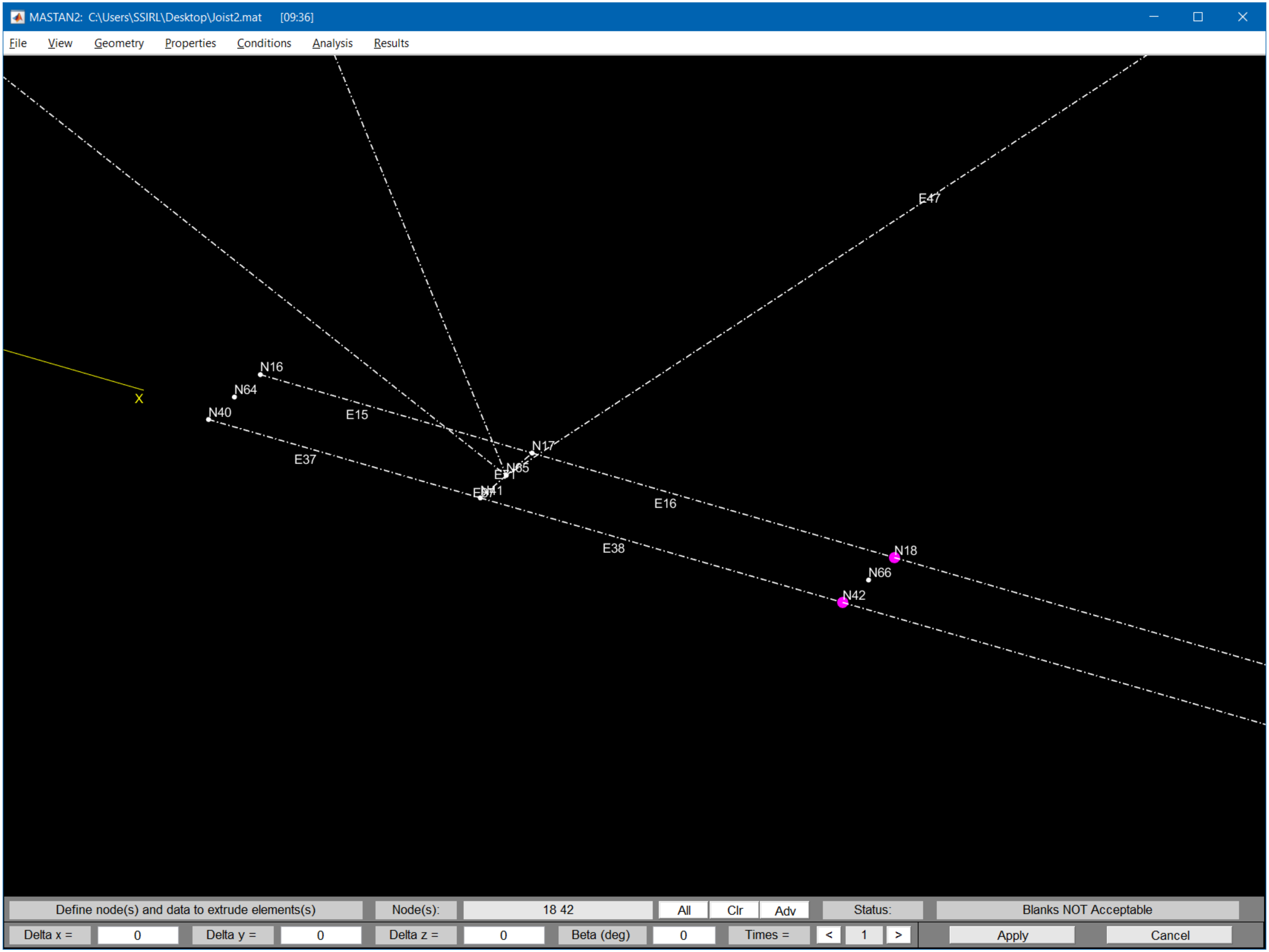
5) Click on the new nodes above the back, bottom chord to the joist bridging. Depending on the exact order you clicked the previous nodes, the node index may vary.

6) Click in the edit box to the right of **Delta z =** and change **0** to **0.99025**. Increase the **Times =** from **1** to **2** by clicking on the **>** button.

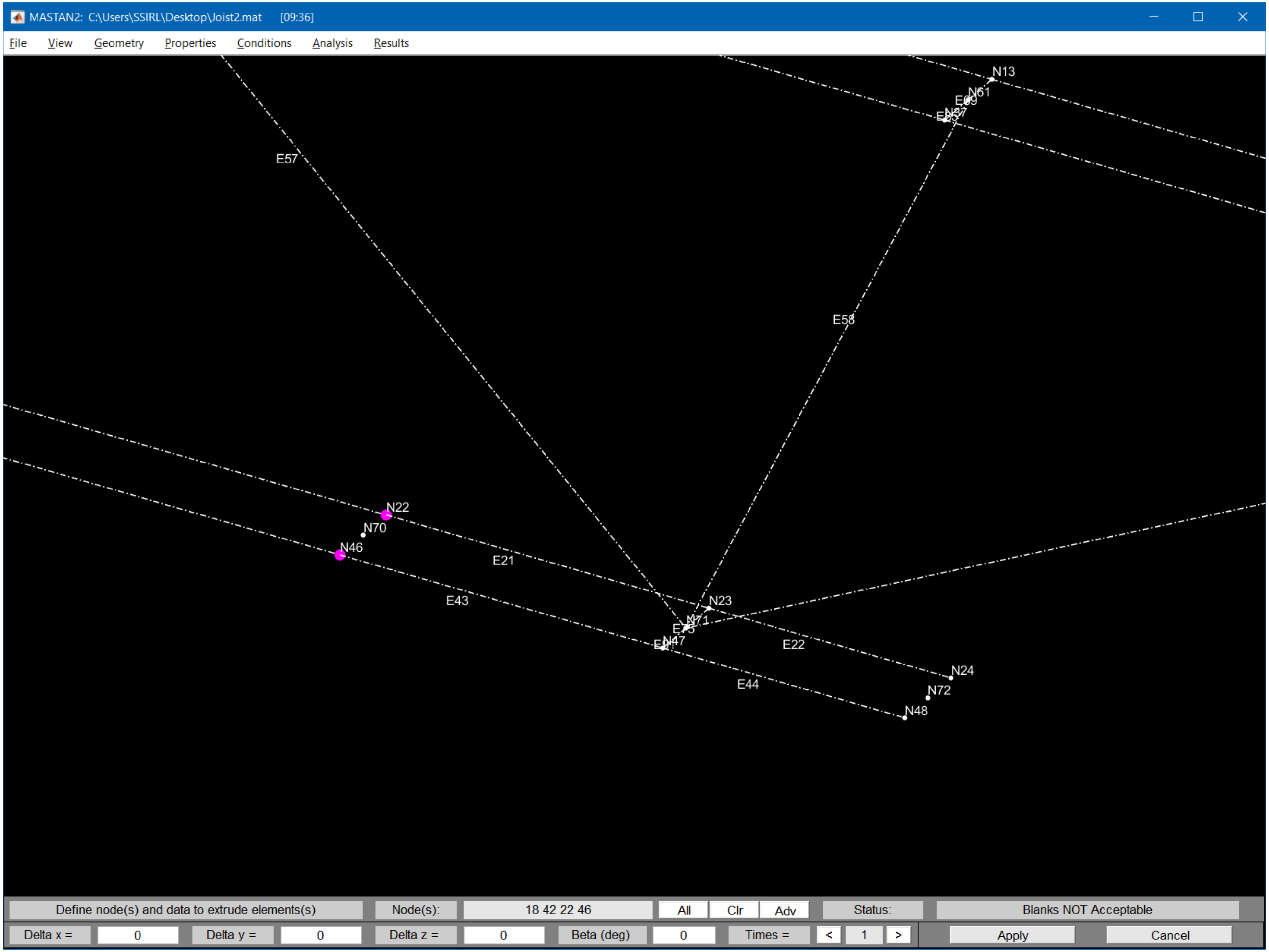
7) Click on the **Apply** Button.

Note: The elements created in Step 2 will need to be manually selected multiple times through this project. These 4 elements will be referenced as the vertical braces after this point.

MASTAN2



MASTAN2: C:\Users\SSIRL\Desktop\Joist2.mat [09:36]
File View Geometry Properties Conditions Analysis Results
E47
N16
N64
N40
X
E15
E37
N17
N65
E16
E38
N18
N66
N42
Define node(s) and data to extrude elements(s)
Node(s):
18 42
All
Clr
Adv
Status:
Blanks NOT Acceptable
Delta x =
0
Delta y =
0
Delta z =
0
Beta (deg)
0
Times =
<
1
>
Apply
Cancel


MASTAN2: C:\Users\SSIRL\Desktop\Joist2.mat [09:36]
File View Geometry Properties Conditions Analysis Results
N13
N61
E57
E58
N22
N70
N46
E21
E43
N23
N71
N47
E22
N24
N72
N48
E44
Define node(s) and data to extrude elements(s)
Node(s):
18 42 22 46
All
Clr
Adv
Status:
Blanks NOT Acceptable
Delta x =
0
Delta y =
0
Delta z =
0
Beta (deg)
0
Times =
<
1
>
Apply
Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Define node(s) and data to extrude elements(s)
Node(s):
All
Clr
Adv
Status:
Success: Element(s) Extruded.
Delta x =
0
Delta y =
0
Delta z =
0
Beta (deg)
0
Times =
<
1
>
Apply
Cancel


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Define node(s) and data to extrude elements(s)
Node(s):
All
Clr
Adv
Status:
Success: Element(s) Extruded.
Delta x =
0
Delta y =
0
Delta z =
0
Beta (deg)
0
Times =
1
Apply
Cancel

Top Chord Meshing

1) From the **Geometry** menu select **Subdivide Element(s)**. The top chord is to be meshed into approximately 8” segments.

2) Click on the 4 top chord sections near the cross-bracing support to be subdivided 2 times.

3) Click on the **Apply** button.

4) Click the **>** box to the right of **# of Segments =** to increase **2** to **3**.

5) In the bottom menu bar, use the buttons to the right of **Element(s):** to make the list of elements to be subdivided 3 times.

6) Click the **Adv** button to open pop-up menu. To select middle of the top chords, click the check box next to the **X-axis** option. Ensure the button to the right of **Range (Inclusive)** to change **Off** to **On**. Change the edit box to the left of **X** from **–Inf** to **48**. Change the edit box to the right of **X** from **Inf** to **192**. Change the edit box to the left of **Y** from **–Inf** to **8**. Click **Add** to select.

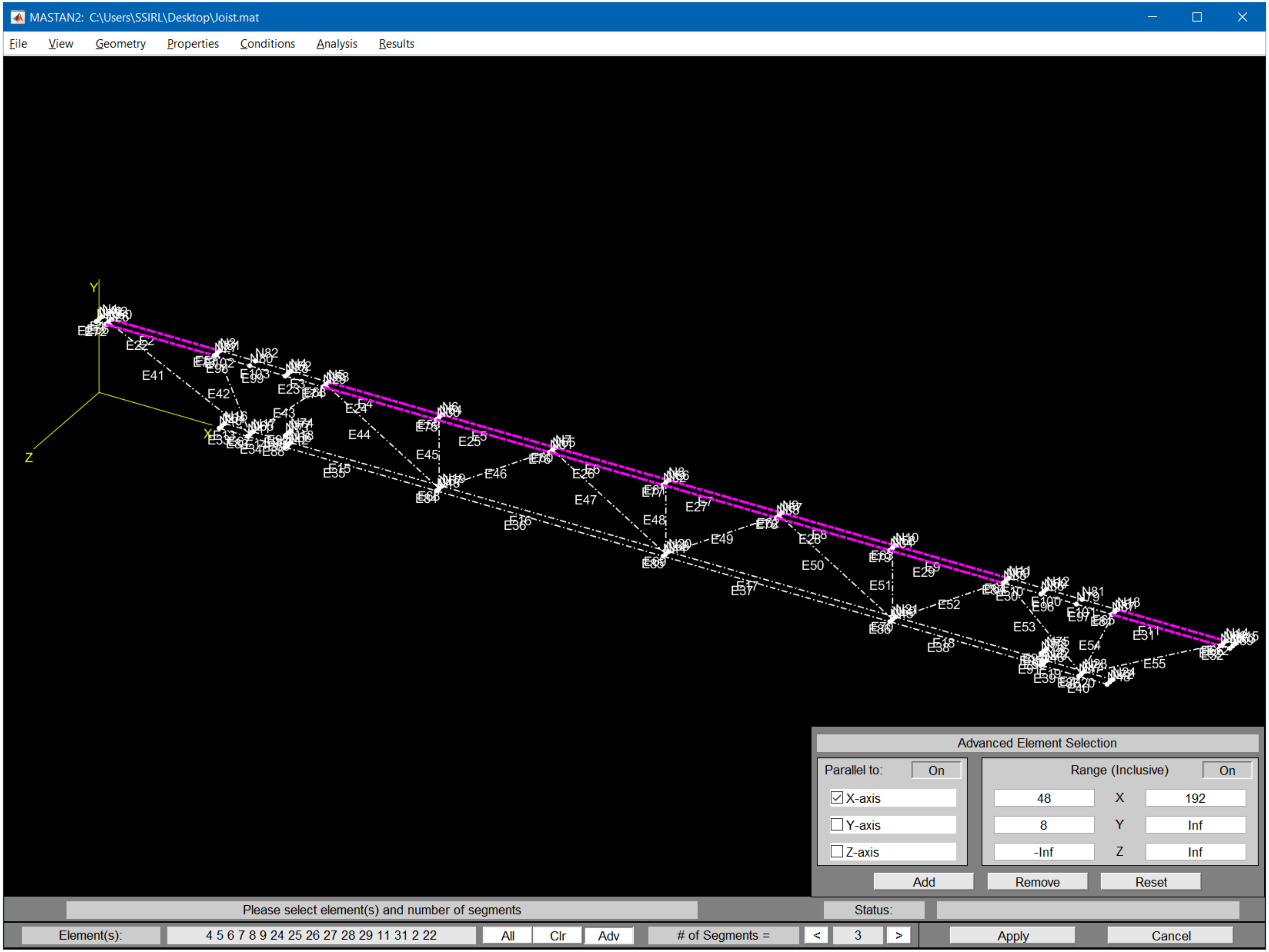
7) Click on the 4 remaining exterior top chord sections to be subdivided 3 times.

8) Click on the **Apply** button.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Please select element(s) and number of segments
Status:
Element(s):
25 3 34 12
All
Clr
Adv
# of Segments =
<
2
>
Apply
Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Advanced Element Selection
Parallel to:
On
X-axis
Y-axis
Z-axis
Range (Inclusive)
On
48
X
192
8
Y
Inf
-Inf
Z
Inf
Add
Remove
Reset
Please select element(s) and number of segments
Status:
Element(s):
4 5 6 7 8 9 24 25 26 27 28 29 11 31 2 22
All
Clr
Adv
# of Segments =
<
3
>
Apply
Cancel

Bottom Chord Meshing

1) The bottom chord is to be meshed into approximately 4” segments.

2) Click on the 4-32” long bottom chord elements.

3) Click the **>** box to the right of **# of Segments =** to increase **3** to **4**.

4) Click on the **Apply** button.

5) Click on the middle 4 bottom chord elements.

6) Click the **>** box to the right of **# of Segments =** to increase **4** to **6**.

7) Click on the **Apply** button.

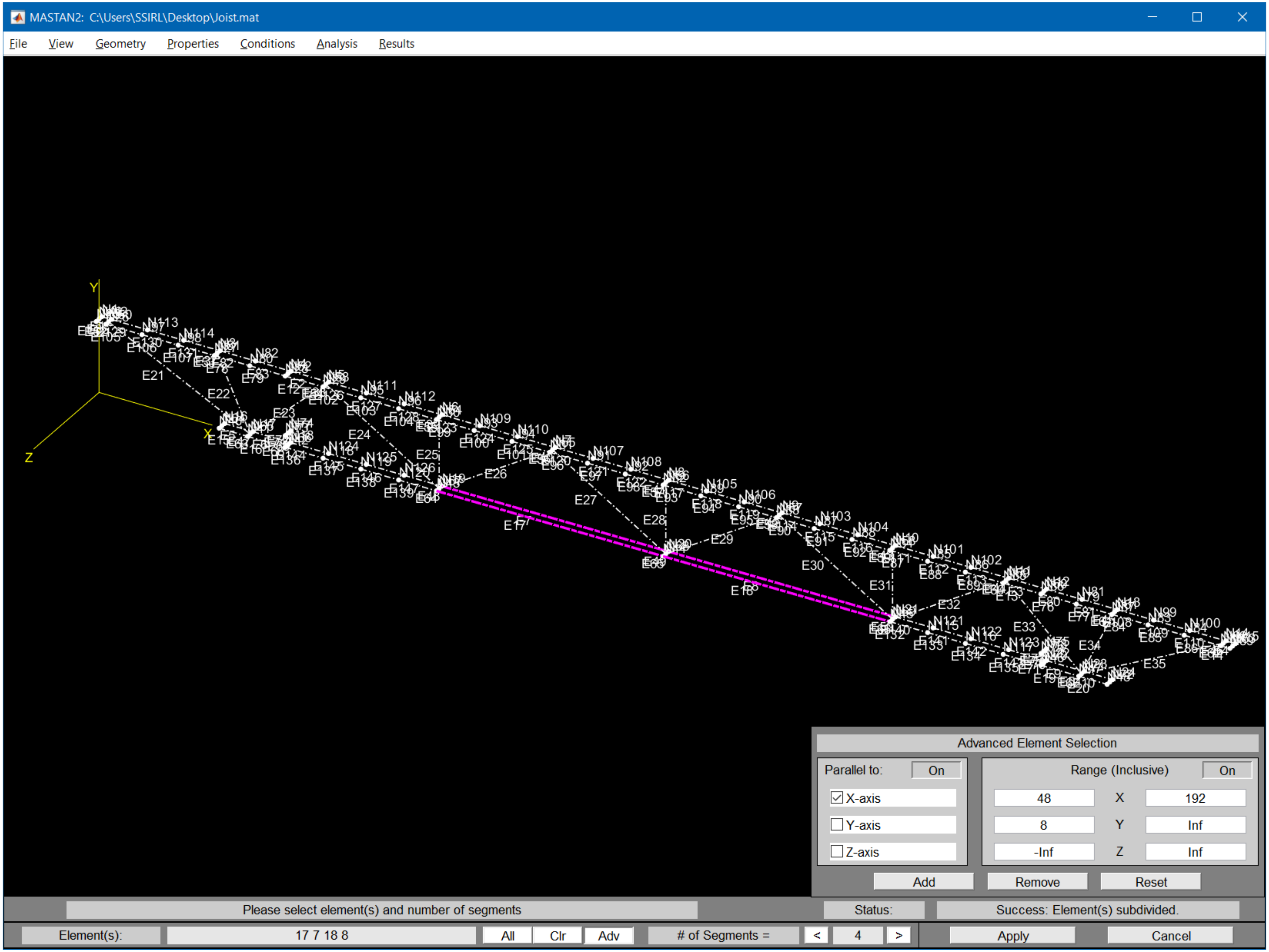
8) On the **Advanced Element Selection** pop-up, click the **Reset** button. Click the check box next to the **X-axis** option. Click the button to the right of **Range (Inclusive)** to change **Off** to **On**. Change the edit box to the right of **Y** from **Inf** to **8**. Click **Add** to select the entire bottom chord.

9) Click the **<** box to the left of **# of Segments =** to decrease **6** to **2**.

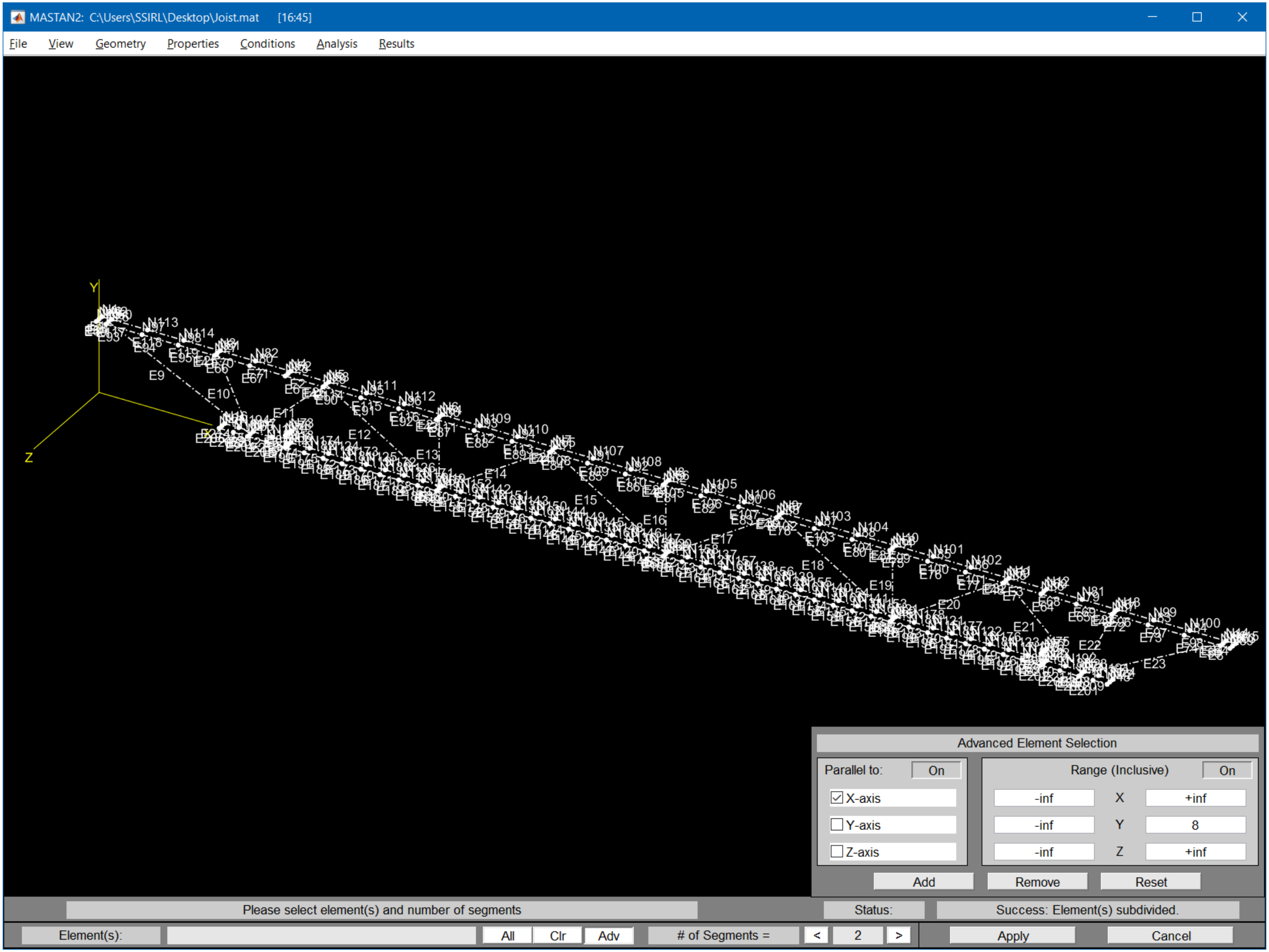
10) Click on the **Apply** button.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Advanced Element Selection
Parallel to:
On
X-axis
Y-axis
Z-axis
Range (Inclusive)
On
48
X
192
8
Y
Inf
-Inf
Z
Inf
Add
Remove
Reset
Please select element(s) and number of segments
Status:
Success: Element(s) subdivided.
Element(s):
19 7 22 10
All
Clr
Adv
# of Segments =
<
3
>
Apply
Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Advanced Element Selection
Parallel to:
On
X-axis
Y-axis
Z-axis
Range (Inclusive)
On
48
X
192
8
Y
Inf
-Inf
Z
Inf
Add
Remove
Reset
Please select element(s) and number of segments
Status:
Success: Element(s) subdivided.
Element(s):
17 7 18 8
All
Clr
Adv
# of Segments =
<
4
>
Apply
Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [16:45]
File View Geometry Properties Conditions Analysis Results
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) On
-inf X +inf
-inf Y 8
-inf Z +inf
Add Remove Reset
Please select element(s) and number of segments
Status:
Success: Element(s) subdivided.
Element(s):
All Clr Adv
# of Segments =
< 2 >
Apply Cancel

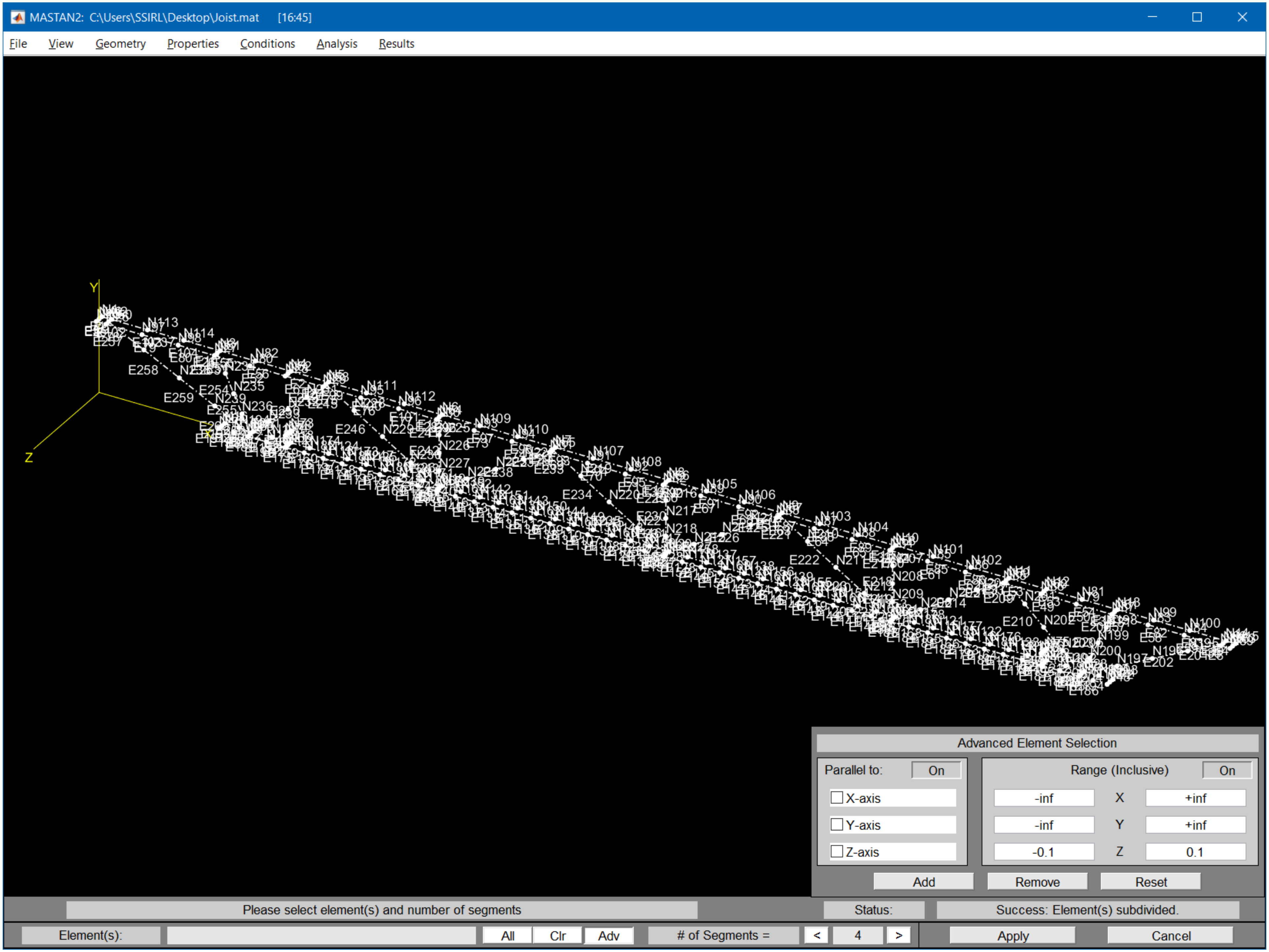
Web Meshing

1) The web is to be meshed into 4 equal segments.

2) Click the **>** box to the right of **# of Segments =** to increase **2** to **4**.

3) On the **Advanced Element Selection** pop-up, click the **Reset** button. Click the button to the right of **Range (Inclusive)** to change **Off** to **On**. Change the edit box to the left of **Z** from -**Inf** to **-0.1** and to the right of **Z** from **Inf** to **0.1**. Click **Add** to select all webs.

4) Click on the **Apply** button.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [16:45]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
Z
Advanced Element Selection
Parallel to:
On
X-axis
Y-axis
Z-axis
Range (Inclusive)
On
-inf
X
+inf
-inf
Y
+inf
-0.1
Z
0.1
Add
Remove
Reset
Please select element(s) and number of segments
Status:
Success: Element(s) subdivided.
Element(s):
All
Clr
Adv
# of Segments =
<
4
>
Apply
Cancel

Model Cleanup

1) From the **Geometry** menu select **Remove Node(s)**.

2) Click on **All Unattached** to select all unconnected nodes that were included for simplicity in the initial model construction.

3) Click on the **Apply** button to remove.

The next steps are not required; however, it will help make it easier to find results in the model.

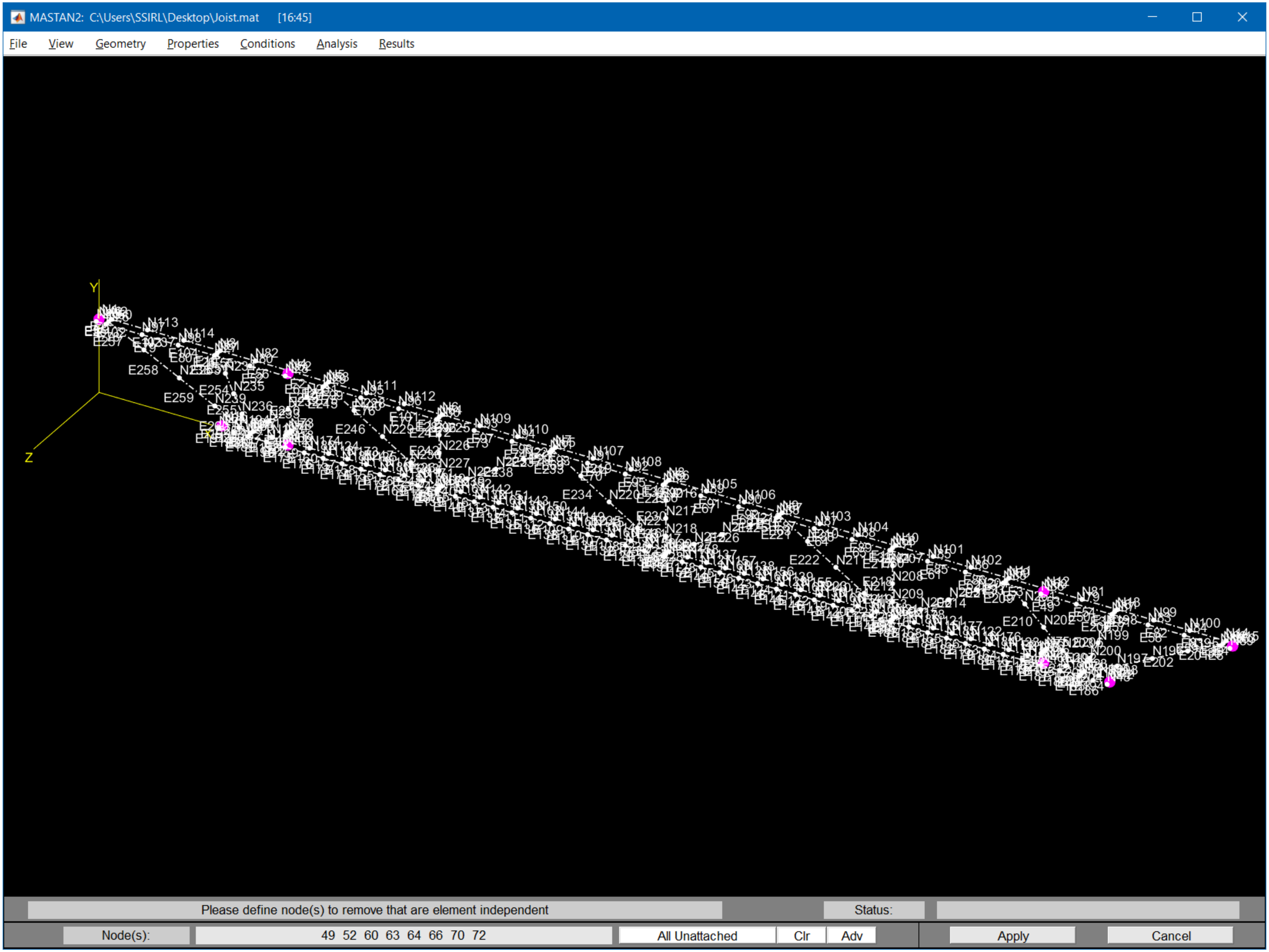
4) From the **Geometry** menu select **Renumber Elements**.

5) Click the checkbox to the left of **Y-X-Z (2D)**. Click on the **Apply** button.

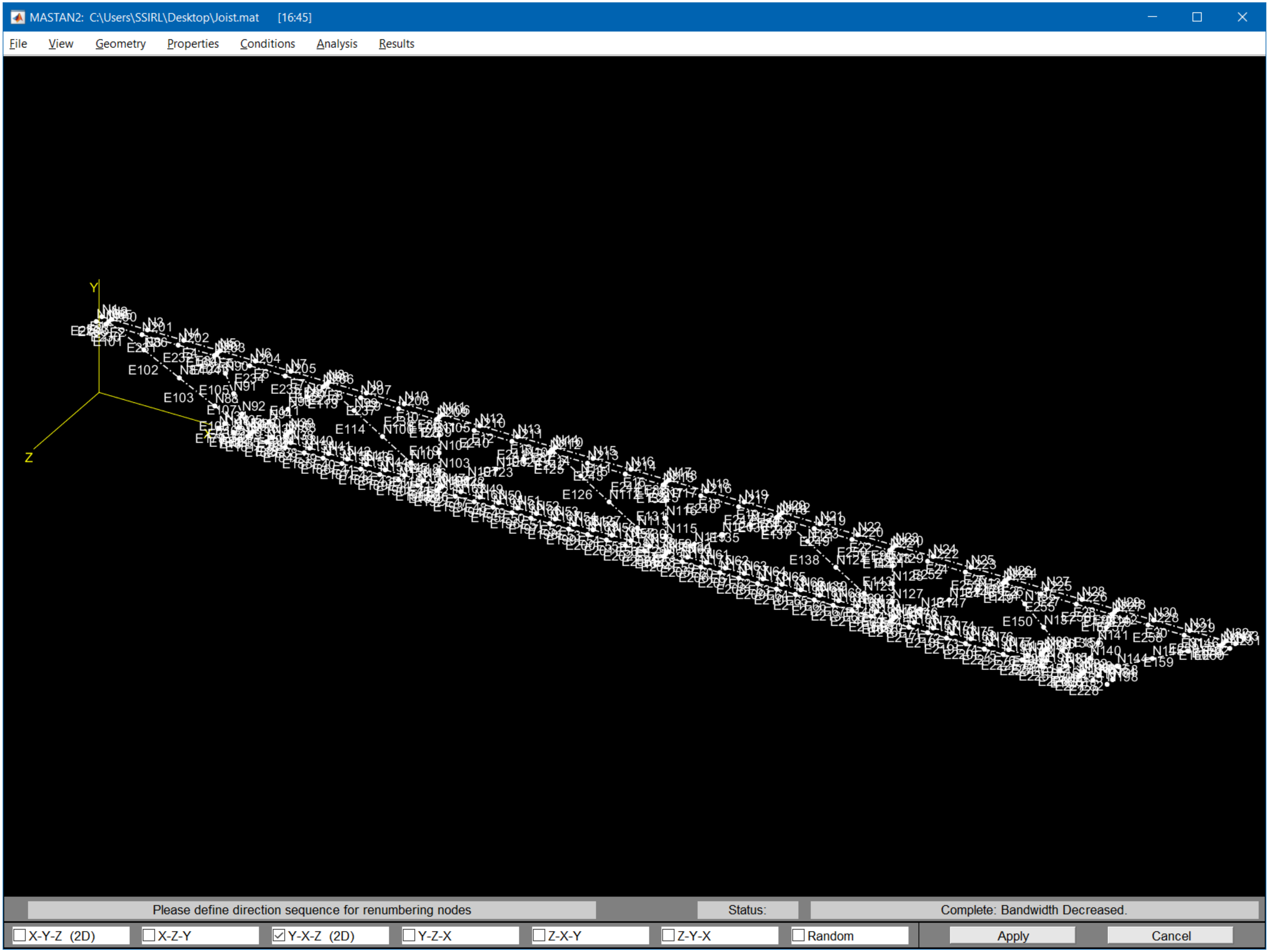
6) From the **Geometry** menu select **Renumber Nodes**.

7) Click the checkbox to the left of **Y-X-Z (2D)**. Click on the **Apply** button.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [16:45]
File View Geometry Properties Conditions Analysis Results
Please define node(s) to remove that are element independent
Status:
Node(s):
49 52 60 63 64 66 70 72
All Unattached
Clr
Adv
Apply
Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [16:45]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
Z
X
Please define direction sequence for renumbering nodes
Status:
Complete: Bandwidth Decreased.
X-Y-Z (2D)
X-Z-Y
Y-X-Z (2D)
Y-Z-X
Z-X-Y
Z-Y-X
Random
Apply
Cancel

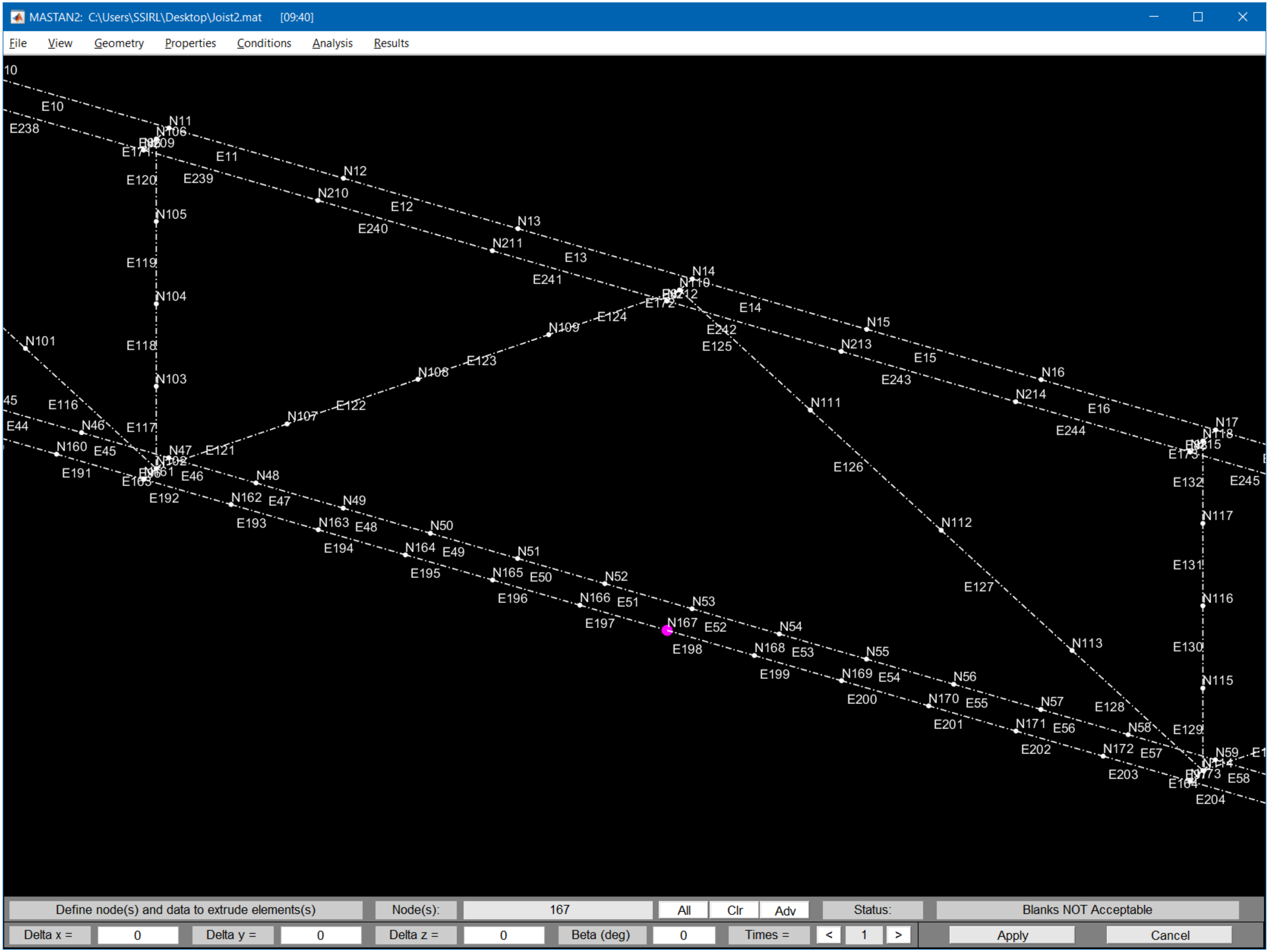
Eccentric Loading Location

1) From the **Geometry** menu select **Extrude Element**.

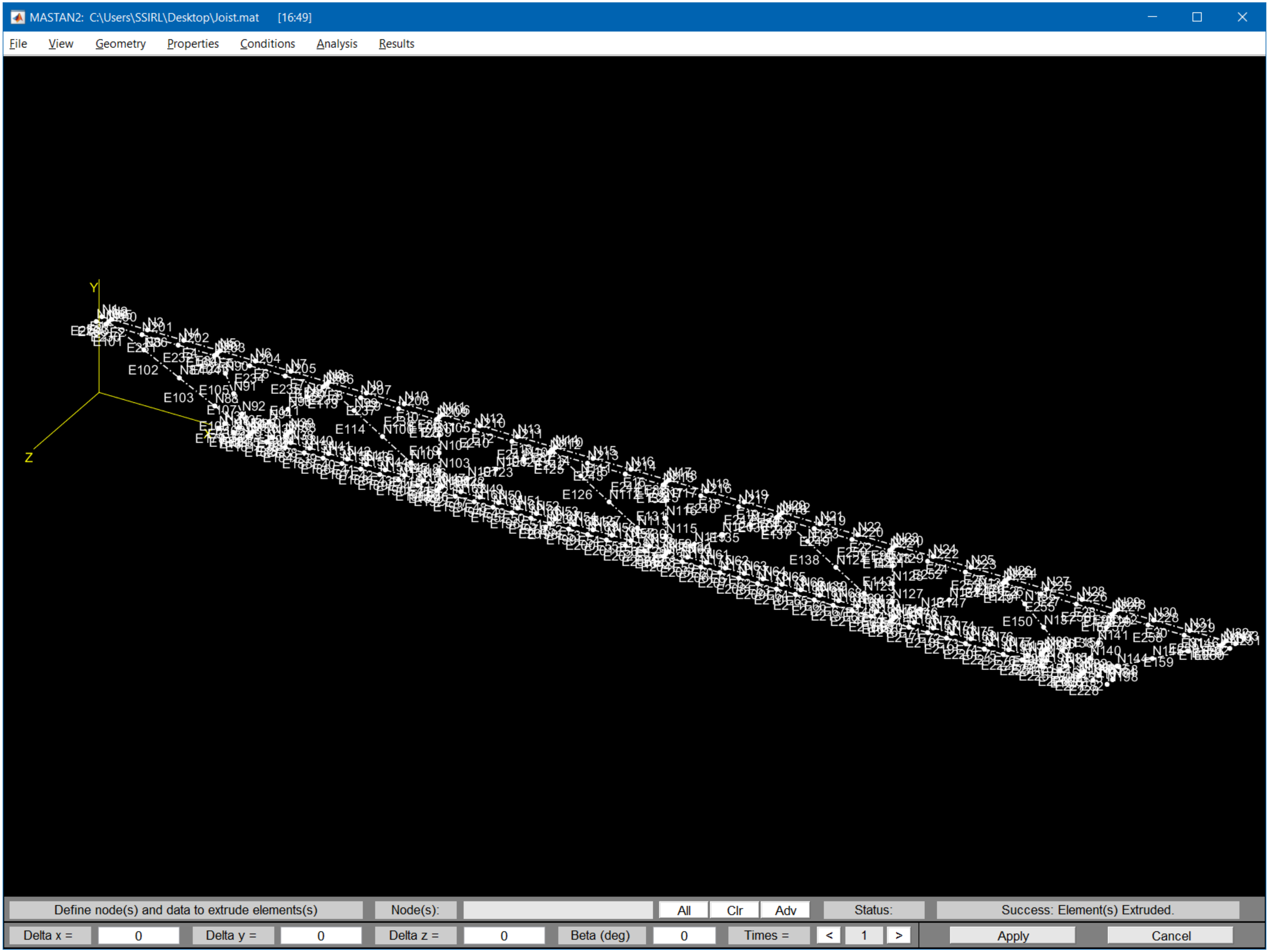
2) Click on the node at the middle of the bottom chord where the loading is to be applied. If you renumbered the model, this should be **Node 167**.

3) Click in the edit box to the right of **Delta z =** and change **0** to **1.5** to define the offset loading location.

4) Click on the **Apply** Button.


MASTAN2: C:\Users\SSIRL\Desktop\Joist2.mat [09:40]
File
View
Geometry
Properties
Conditions
Analysis
Results
Define node(s) and data to extrude elements(s)
Node(s):
167
All
Clr
Adv
Status:
Blanks NOT Acceptable
Delta x =
0
Delta y =
0
Delta z =
0
Beta (deg)
0
Times =
<
1
>
Apply
Cancel

MASTAN2



MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [16:49]
File
View
Geometry
Properties
Conditions
Analysis
Results
Define node(s) and data to extrude elements(s)
Node(s):
All
Clr
Adv
Status:
Success: Element(s) Extruded.
Delta x =
0
Delta y =
0
Delta z =
0
Beta (deg)
0
Times =
<
1
>
Apply
Cancel

Section 4: Member Properties and Connections

Section Properties

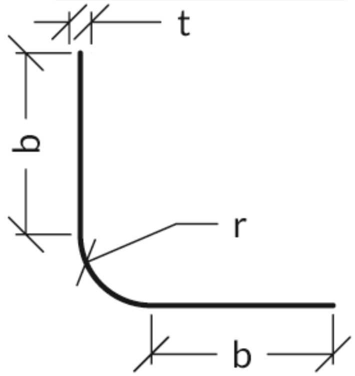
The steel joist model uses 6 sections. There is a separate entry for the top chord angle, the bottom chord angle, the three different web members, and a rigid link connector.

The information can be input by 3 methods. If the section properties are all previously calculated, values can be entered directly. The information can be input individually via the **Define Section** command after switching to the **Advanced** section properties interface or can be imported as a group via the **Input Properties** command. If the section properties need to be calculated, **MSASect** can be used calculate the information.

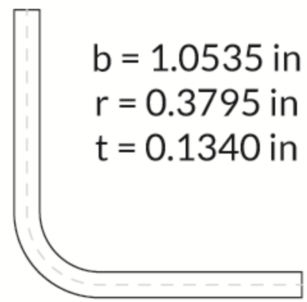
This tutorial will first import all the section property information via the **Input Properties** command. Then it will demonstrate how **MSASect** could have been used to calculate the same information. The top chord angle will be calculated and saved, but not used as part of this analysis.

Cross-Section Geometry

Chord Centerline

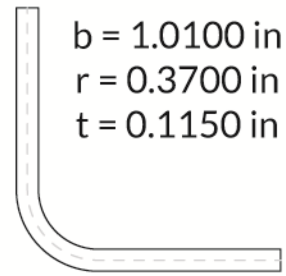


Top Chord

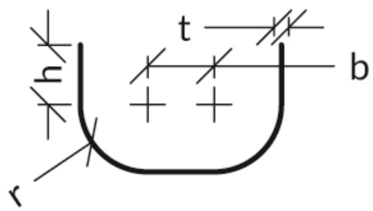


b = 1.0535 in
r = 0.3795 in
t = 0.1340 in

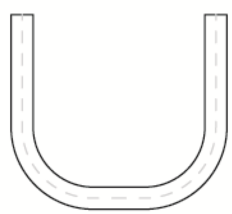
Bottom Chord



b = 1.0100 in
r = 0.3700 in
t = 0.1150 in

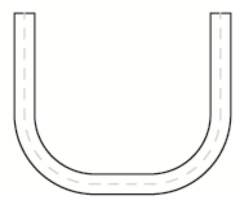


Web Centerline



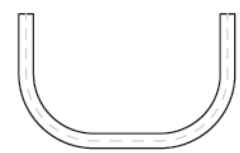
Web 1

h = 0.5844 in
b = 0.2700 in
r = 0.3700 in
t = 0.1150 in



Web 2

h = 0.5258 in
b = 0.2900 in
r = 0.3650 in
t = 0.1050 in



Web 3

h = 0.3102 in
b = 0.3466 in
r = 0.3509 in
t = 0.0767 in

Importing Section Properties

1) From the **Properties** menu select **Input Properties**.

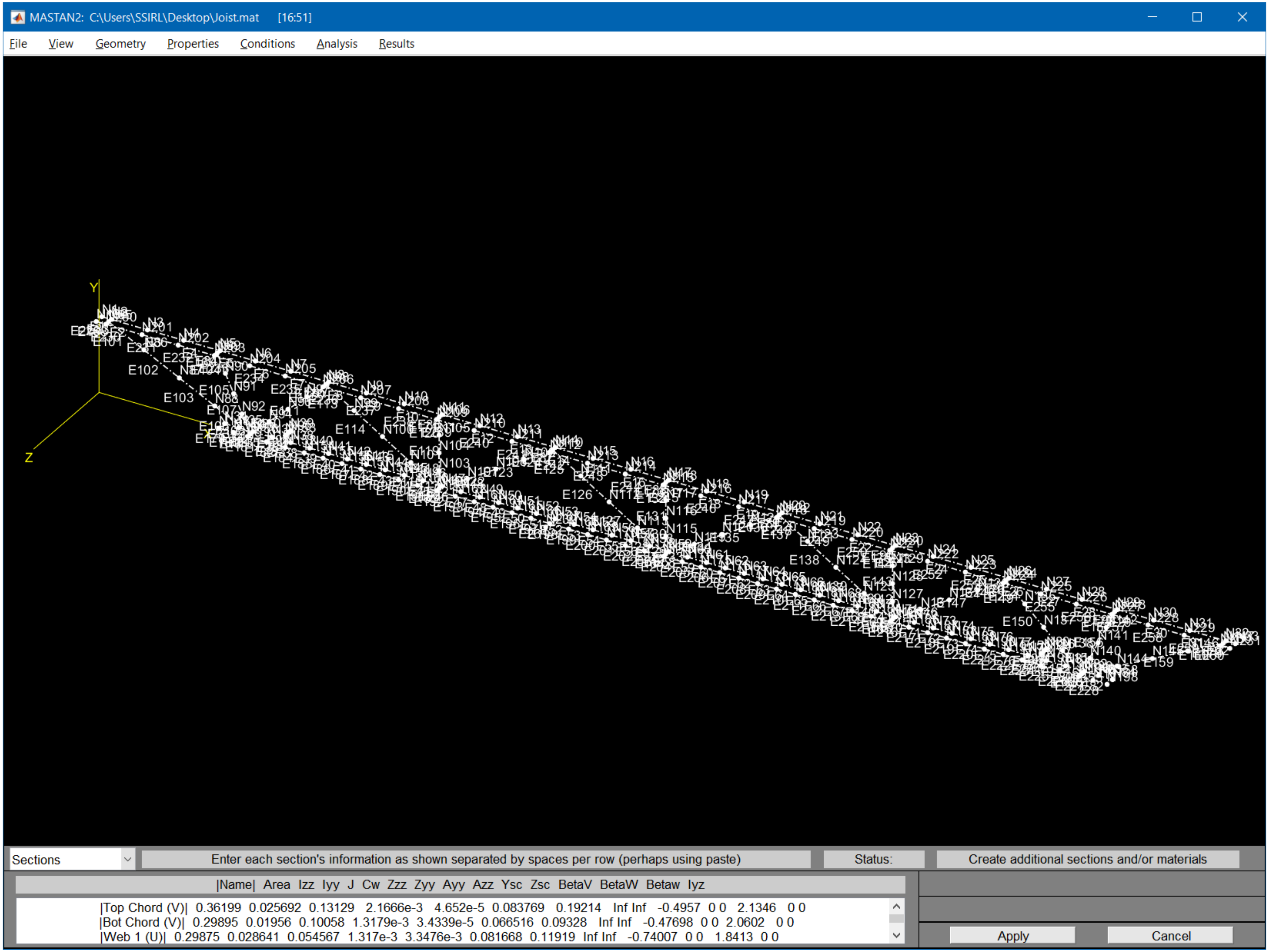
2) At the bottom menu bar, **Sections** should already be selected. Copy and paste the values below into the edit box below **|Name| Area Izz Iyy J Cw Zzz Zyy Ayy Azz Ysc Zsc BetaV BetaW Betaw Iyz**.

All members are entered in a principal orientation. The letter at the end of the name is to help remember the orientation with the corner of the angle members down and the opening of the channels up.

|Top Chord (V)|	0.36199	0.025692	0.13129	2.1666e-3	4.652e-5	0.083769	0.19214	Inf Inf	-0.4957	0 0	2.1346	0 0
|Bot Chord (V)|	0.29895	0.01956	0.10058	1.3179e-3	3.4339e-5	0.066516	0.09328	Inf Inf	-0.47698	0 0	2.0602	0 0
|Web 1 (U)|	0.29875	0.028641	0.054567	1.317e-3	3.3476e-3	0.081668	0.11919	Inf Inf	-0.74007	0 0	1.8413	0 0
|Web 2 (U)|	0.26093	0.021852	0.047564	9.589e-4	2.5185e-3	0.066672	0.10367	Inf Inf	-0.68065	0 0	1.7533	0 0
|Web 3 (U)|	0.15847	0.0072663	0.027533	3.1075e-4	7.4428e-4	0.029823	0.060575	Inf Inf	-0.46984	0 0	1.4813	0 0
|RIGID|	4	1.33	1.33	2.25	64	4	4	Inf Inf	0	0 0	0	0 0

3) Click on the **Apply** button.

The section properties of the rigid element are approximated based on a 2" x 2" solid square as it has larger section properties than the majority of the joist elements. Combined with the higher modulus of elasticity will provide the effective rigid link. Care must be taken as too stiff of a link can cause issues with the solver and too soft will add unintended deformations.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [16:51]
File View Geometry Properties Conditions Analysis Results
Sections
Enter each section's information as shown separated by spaces per row (perhaps using paste)
Status:
Create additional sections and/or materials
|Name| Area Izz Iyy J Cw Zzz Zyy Ayy Azz Ysc Zsc BetaV BetaW Betaw Iyz
|Top Chord (V)| 0.36199 0.025692 0.13129 2.1666e-3 4.652e-5 0.083769 0.19214 Inf Inf -0.4957 0 0 2.1346 0 0
|Bot Chord (V)| 0.29895 0.01956 0.10058 1.3179e-3 3.4339e-5 0.066516 0.09328 Inf Inf -0.47698 0 0 2.0602 0 0
|Web 1 (U)| 0.29875 0.028641 0.054567 1.317e-3 3.3476e-3 0.081668 0.11919 Inf Inf -0.74007 0 0 1.8413 0 0
Apply
Cancel

Calculating Section Properties

1) Outside of MASTAN2, create a text file that summarizes the node and segment data similar to the one shown here.

2) From the **Properties** menu select **Define Section**.

3) At the bottom menu bar, click on the pop-up menu on the far right that currently displays **Basic**. Click on **Advanced**.

4) Click on **MSASect**.

5) After the interface loads, click the radio button next to **General**.

6) Click **Next** to open the editable general section interface.

7) Click **Open** at the bottom of the screen.

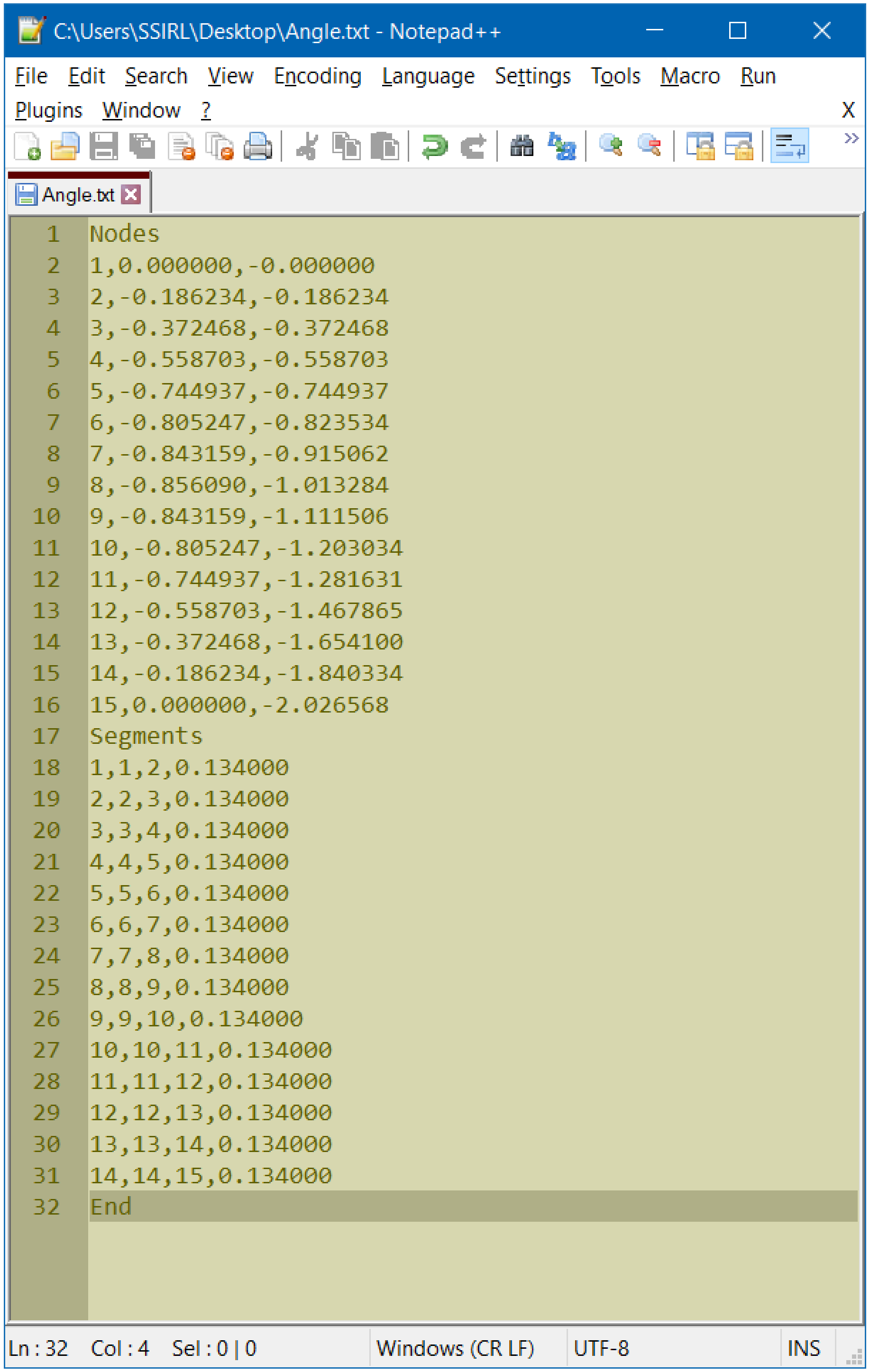
8) Navigate to the location of the text file. After selecting it, click **Open**.

9) Click **Calculate** to determine the properties.

10) Click edit box to right of **Name:** and enter **Top Chord Alt**.

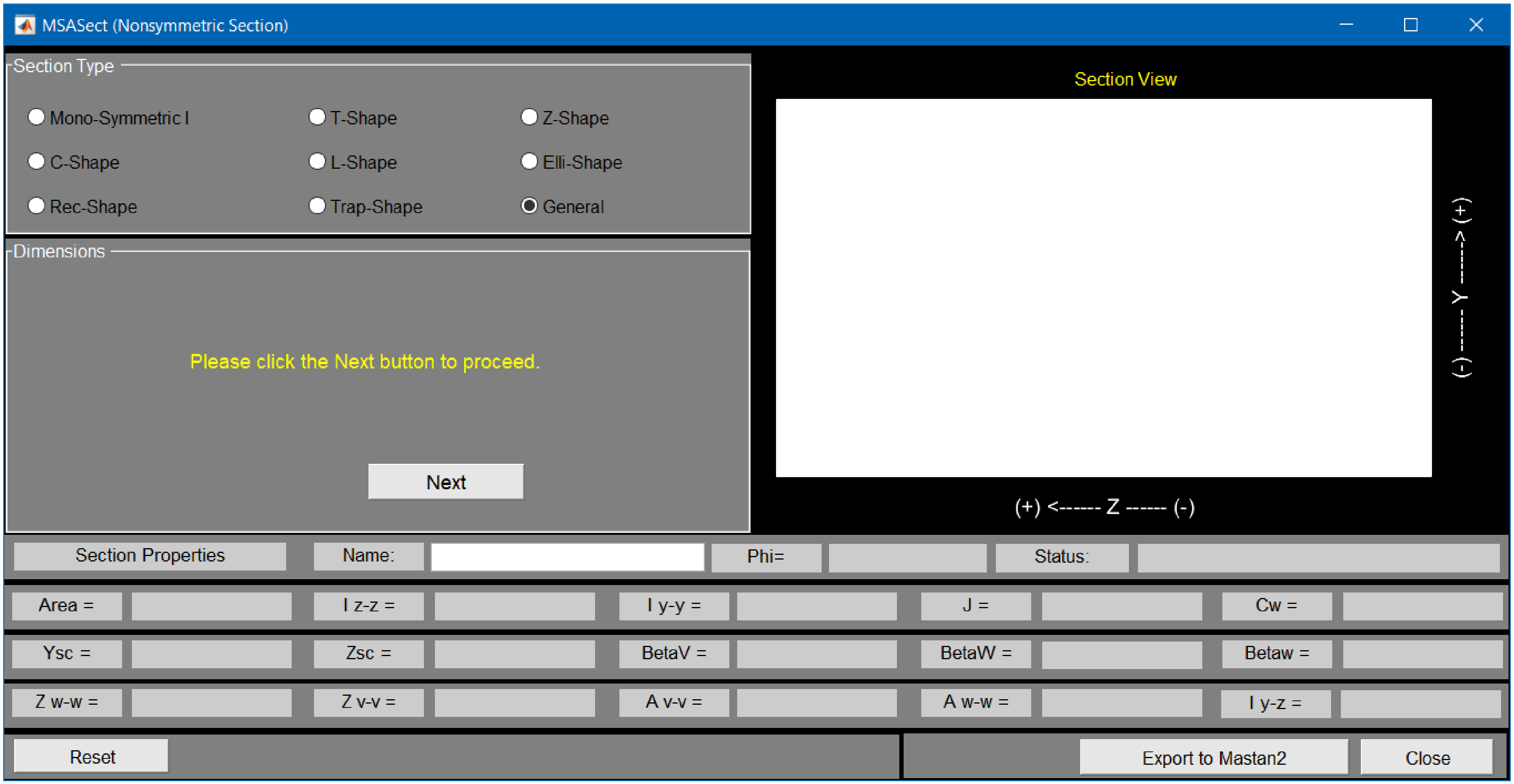
11) Click **Export to MASTAN2** to copy values to main program. Click **Close** to return to main program.

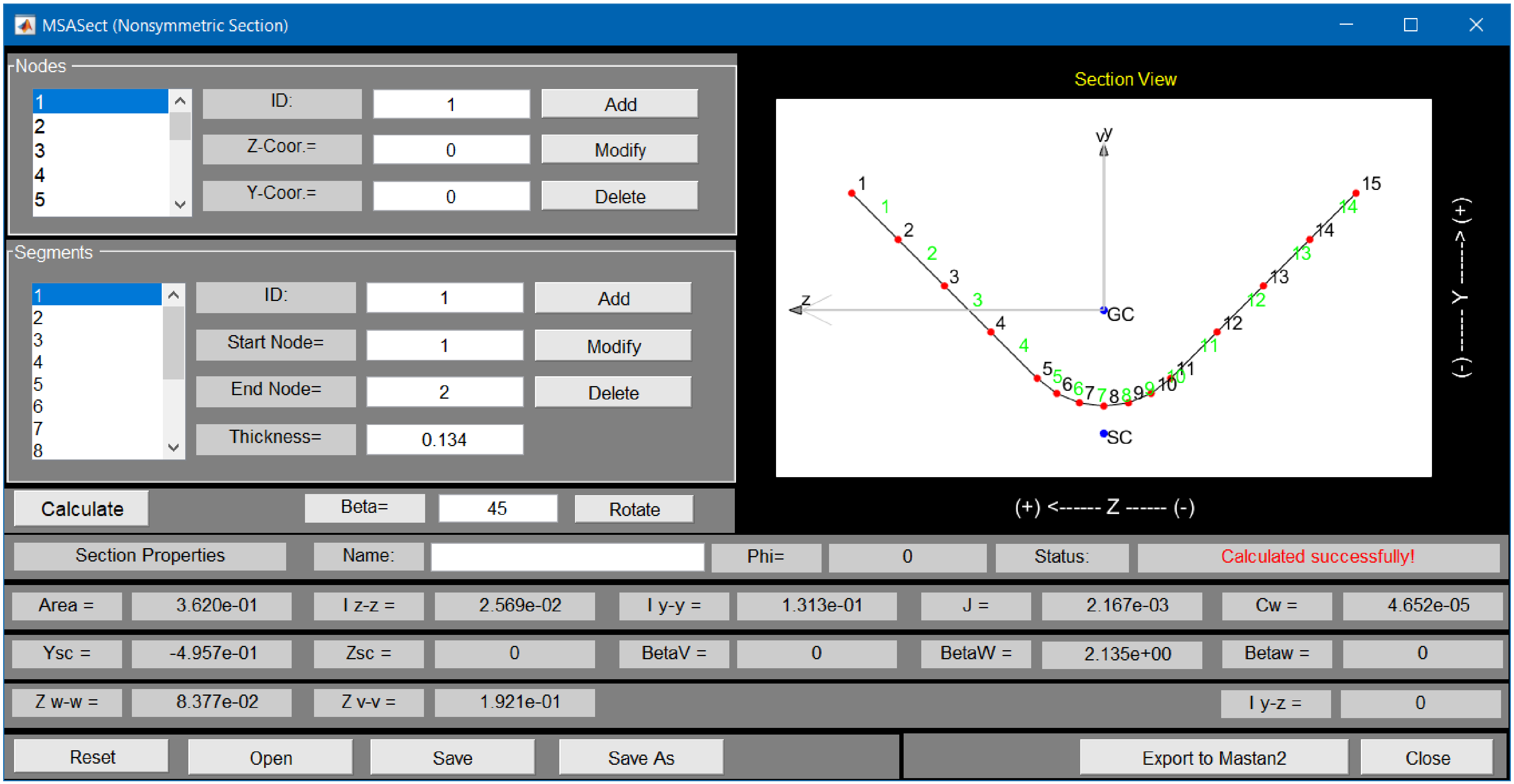
12) Click **Apply** to save Section 7.



Version to Copy for own Text File

```
Nodes
1,0.000000,-0.000000
2,-0.186234,-0.186234
3,-0.372468,-0.372468
4,-0.558703,-0.558703
5,-0.744937,-0.744937
6,-0.805247,-0.823534
7,-0.843159,-0.915062
8,-0.856090,-1.013284
9,-0.843159,-1.111506
10,-0.805247,-1.203034
11,-0.744937,-1.281631
12,-0.558703,-1.467865
13,-0.372468,-1.654100
14,-0.186234,-1.840334
15,0.000000,-2.026568
Segments
1,1,2,0.134000
2,2,3,0.134000
3,3,4,0.134000
4,4,5,0.134000
5,5,6,0.134000
6,6,7,0.134000
7,7,8,0.134000
8,8,9,0.134000
9,9,10,0.134000
10,10,11,0.134000
11,11,12,0.134000
12,12,13,0.134000
13,13,14,0.134000
14,14,15,0.134000
End
```


MSASect (Nonsymmetric Section)
Section Type
Mono-Symmetric I
T-Shape
Z-Shape
C-Shape
L-Shape
Elli-Shape
Rec-Shape
Trap-Shape
General
Dimensions
Please click the Next button to proceed.
Next
Section View
(+) <------ Z ------ (-)
(-) ------- Y -------> (+)
Section Properties
Name:
Phi=
Status:
Area =
I z-z =
I y-y =
J =
Cw =
Ysc =
Zsc =
BetaV =
BetaW =
Betaw =
Z w-w =
Z v-v =
A v-v =
A w-w =
I y-z =
Reset
Export to Mastan2
Close

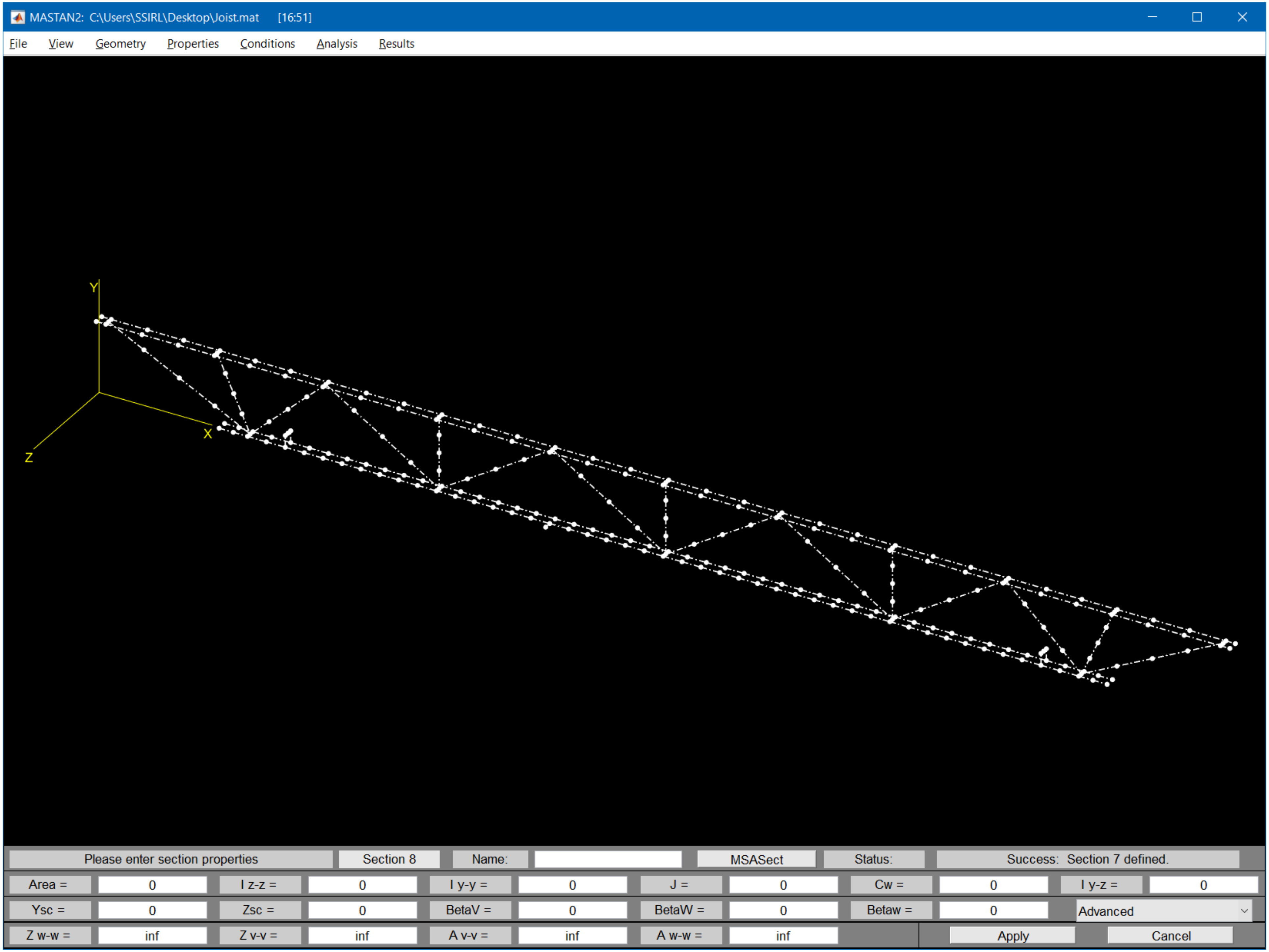

MSASect (Nonsymmetric Section)
Nodes
ID: 1
Z-Coor.= 0
Y-Coor.= 0
Add
Modify
Delete
Segments
ID: 1
Start Node= 1
End Node= 2
Thickness= 0.134
Section View
GC
SC
(+) <------ Z ------ (-)
(-) ------- Y ------> (+)
Calculate
Beta= 45
Rotate
Section Properties
Name:
Phi= 0
Status:
Calculated successfully!
Area = 3.620e-01
I z-z = 2.569e-02
I y-y = 1.313e-01
J = 2.167e-03
Cw = 4.652e-05
Ysc = -4.957e-01
Zsc = 0
BetaV = 0
BetaW = 2.135e+00
Betaw = 0
Z w-w = 8.377e-02
Z v-v = 1.921e-01
I y-z = 0
Reset
Open
Save
Save As
Export to Mastan2
Close

Improving Visual

Currently there are many elements and node labels that make it difficult to understand what is going on. While not necessary, this tutorial will turn off the labels. Following these steps again would allow the user to put the labels back into the model.

1) From the **View** menu select **Labels** and submenu option **Node #s**.

2) From the **View** menu select **Labels** and submenu option **Element #s**.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [16:51]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Please enter section properties
Section 8
Name:
MSASect
Status:
Success: Section 7 defined.
Area = 0
I z-z = 0
I y-y = 0
J = 0
Cw = 0
I y-z = 0
Ysc = 0
Zsc = 0
BetaV = 0
BetaW = 0
Betaw = 0
Advanced
Z w-w = inf
Z v-v = inf
A v-v = inf
A w-w = inf
Apply
Cancel

Section Properties – Assigning – 1

1) From the **Properties** menu select **Attach Section**.

2) At the bottom menu bar, use the buttons to the right of **Element(s):** to make the list of elements.

3) Click the **Adv** button to open pop-up menu. Click the **Reset** button. To select both top chords, click the check box next to the **X-axis** option. Click the button to the right of **Range (Inclusive)** from **Off** to **On**. Change the edit box to the left of **Y** to **8**.

4) Click **Add** to add the top chord elements to the element list.

5) Click on the **Apply** button to assign Section 1 to the top chord elements.

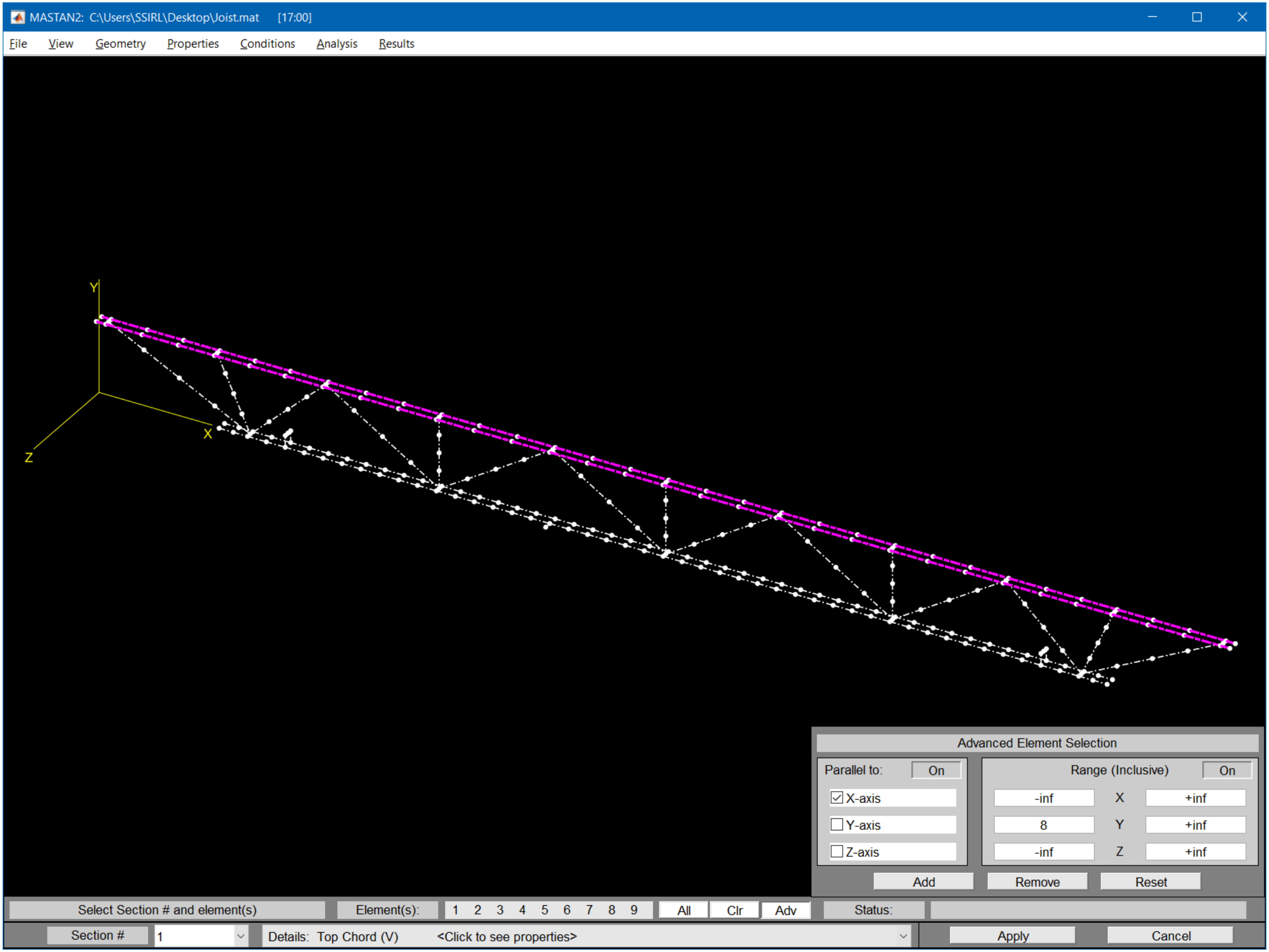
6) Change the **Section #** by clicking on the current section number just to the right to open a pop-up menu with all section numbers. Click on **2** to select the "Bot Chord (V)" section.

7) Select the **Clr** button located to the right of **Elements:** to clear the list of elements.

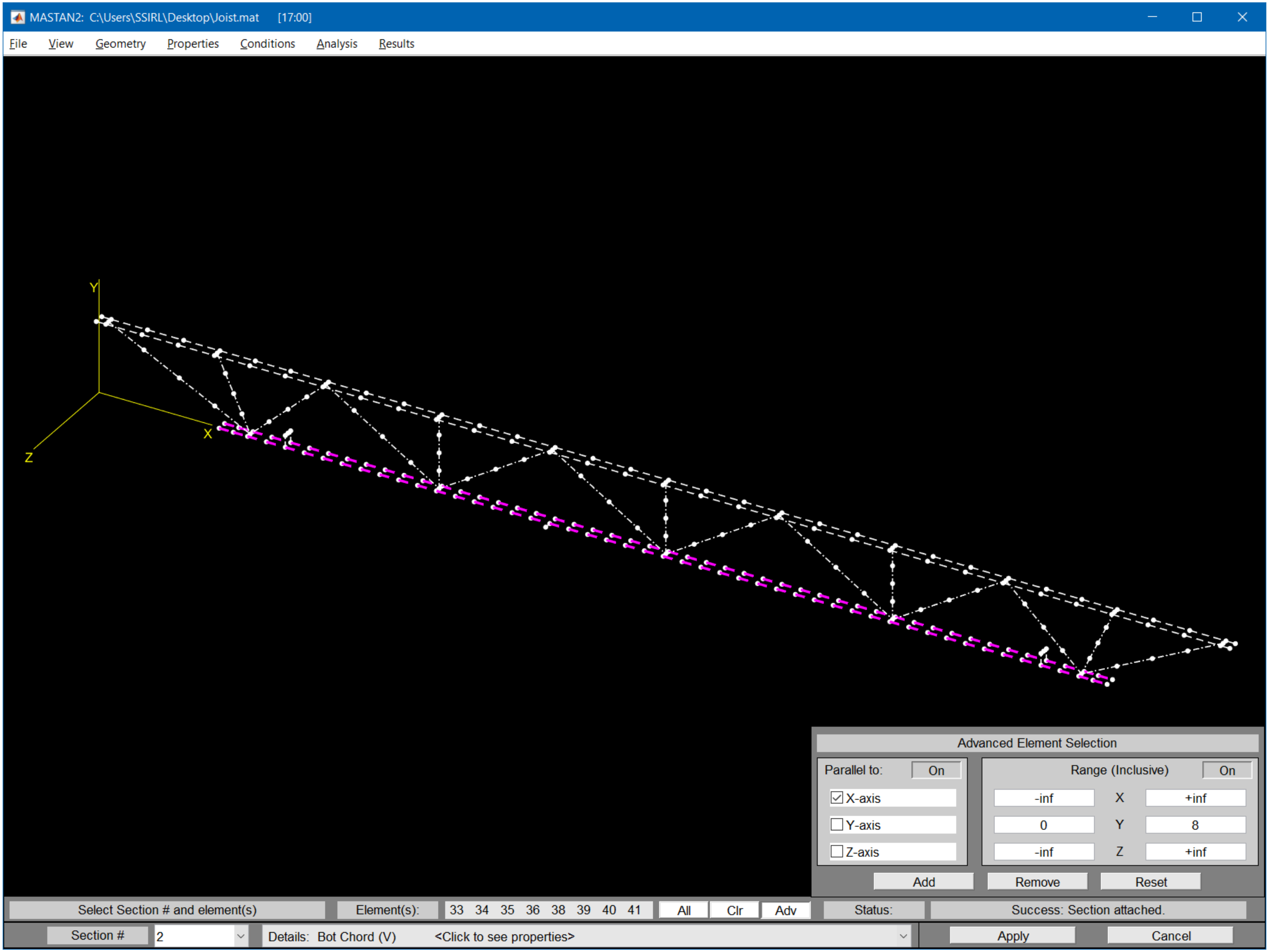
8) Change the edit box to the left of **Y** to **0**. Change the edit box to the right of **Y** to **8**.

9) Click **Add** to add the bottom chord elements to the element list.

10) Click on the **Apply** button to assign Section 2 to the bottom chord.

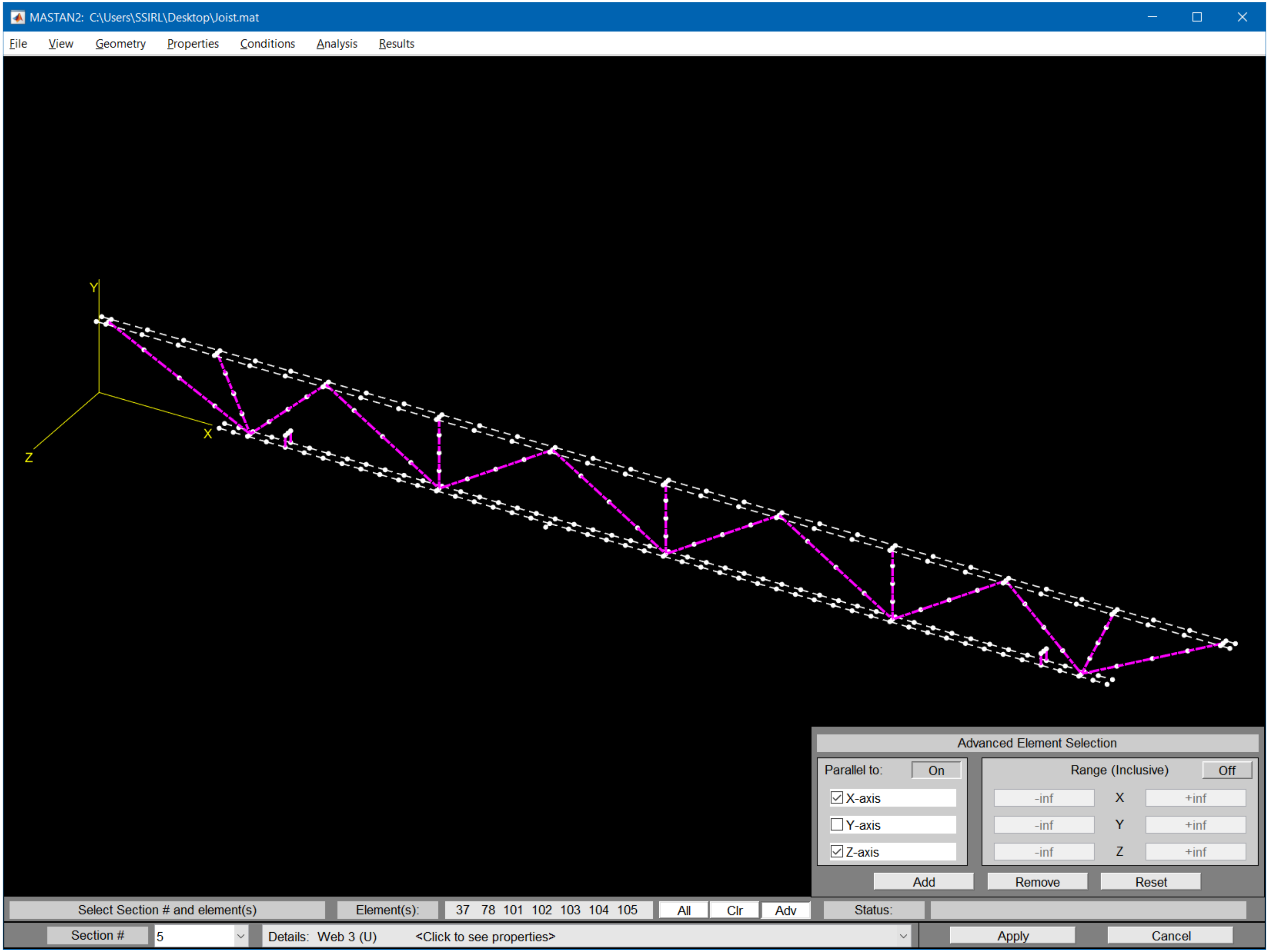

MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:00]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) On
-inf X +inf
8 Y +inf
-inf Z +inf
Add Remove Reset
Select Section # and element(s)
Element(s): 1 2 3 4 5 6 7 8 9 All Clr Adv
Status:
Section # 1
Details: Top Chord (V) <Click to see properties>
Apply Cancel

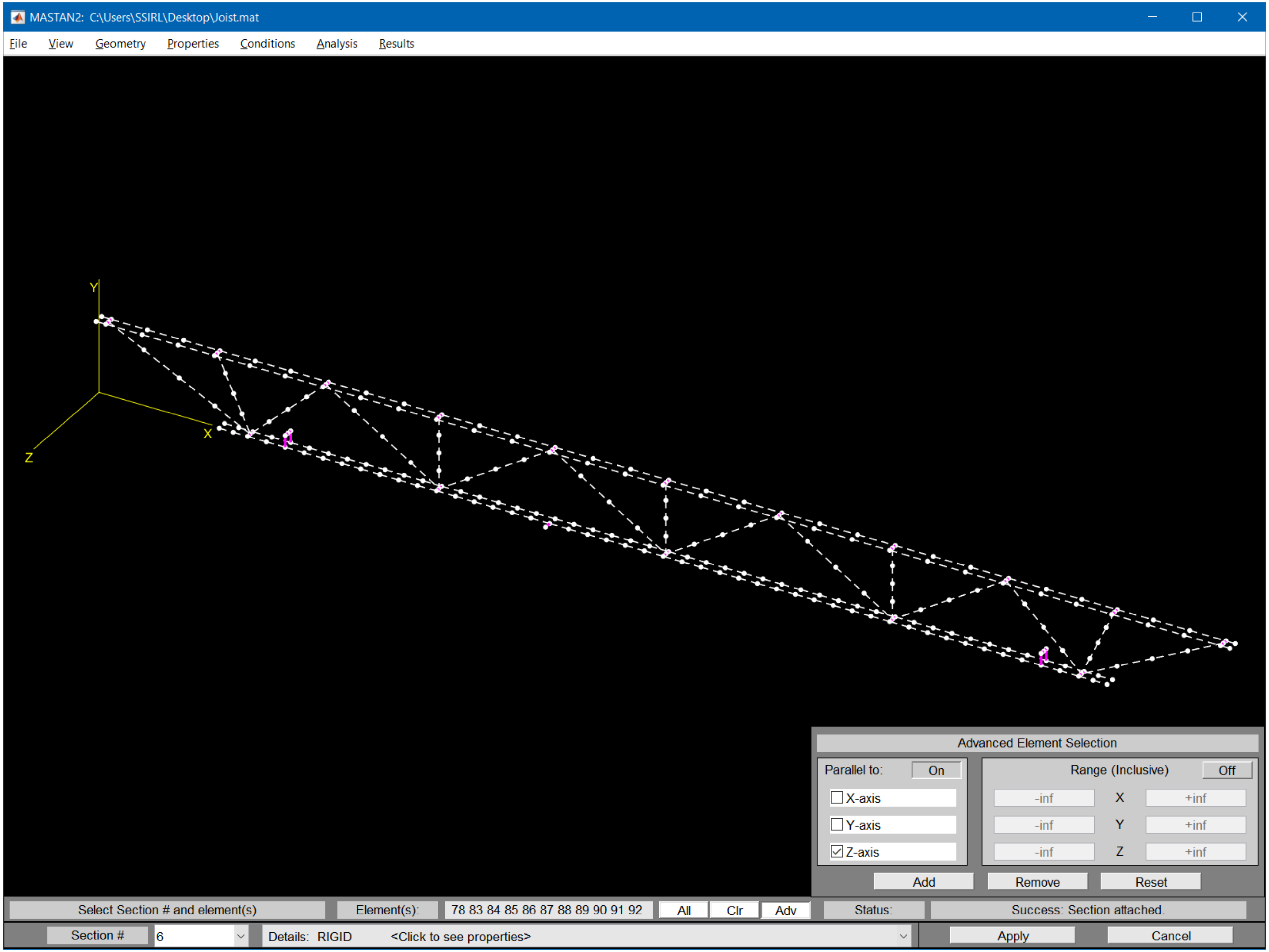
MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:00]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) On
-inf X +inf
0 Y 8
-inf Z +inf
Add Remove Reset
Select Section # and element(s)
Element(s): 33 34 35 36 38 39 40 41
All Clr Adv
Status: Success: Section attached.
Section # 2
Details: Bot Chord (V) <Click to see properties>
Apply Cancel

Section Properties - Assigning – 2

1) Change the **Section #** by clicking on the current section number just to the right to open a pop-up menu with all section numbers. Click on **5** to select the “Web 3 (U)” section.
2) Select the **Clr** button located to the right of **Elements:** to clear the list of elements. Click **Reset** at the bottom of the Advanced Element Section.
3) Click the check box next to **X-axis** and the check box next to **Z-axis**.
4) Click **All** to the right of **Element(s):** and then **Remove** to select all the webs.
5) Click on the **Apply** button to assign Section 5 to all webs temporarily.
6) Change the **Section #** by clicking on the current section number just to the right to open a pop-up menu with all section numbers. Click on **6** to select the “RIGID” section
7) Select the **Clr** button located to the right of **Elements:** to clear the list of elements.
8) Click the check box next to **X-axis**. **Z-axis** should still be selected.
9) Click **Add** to select all the rigid connectors. Additionally click on the 4 vertical braces.
10) Click on the **Apply** button to assign Section 6 to the rigid connectors.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Advanced Element Selection
Parallel to:
On
X-axis
Y-axis
Z-axis
Range (Inclusive)
Off
-inf
+inf
X
Y
Z
Add
Remove
Reset
Select Section # and element(s)
Element(s):
37 78 101 102 103 104 105
All
Clr
Adv
Status:
Section #
5
Details: Web 3 (U)
<Click to see properties>
Apply
Cancel


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Advanced Element Selection
Parallel to:
On
Range (Inclusive)
Off
X-axis
Y-axis
Z-axis
-inf
X
+inf
-inf
Y
+inf
-inf
Z
+inf
Add
Remove
Reset
Select Section # and element(s)
Element(s):
78 83 84 85 86 87 88 89 90 91 92
All
Clr
Adv
Status:
Success: Section attached.
Section #
6
Details: RIGID
<Click to see properties>
Apply
Cancel

Section Properties - Assigning – 3

1) Change the **Section #** by clicking on the current section number just to the right to open a pop-up menu with all section numbers. Click on **4** to select the "Web 2 (U)" section.

2) Select the **Clr** button located to the right of **Elements:** to clear the list of elements.

3) Click on all the elements to be assigned Web 2 section properties.

4) Assign Section 4 properties by clicking the **Apply** button.

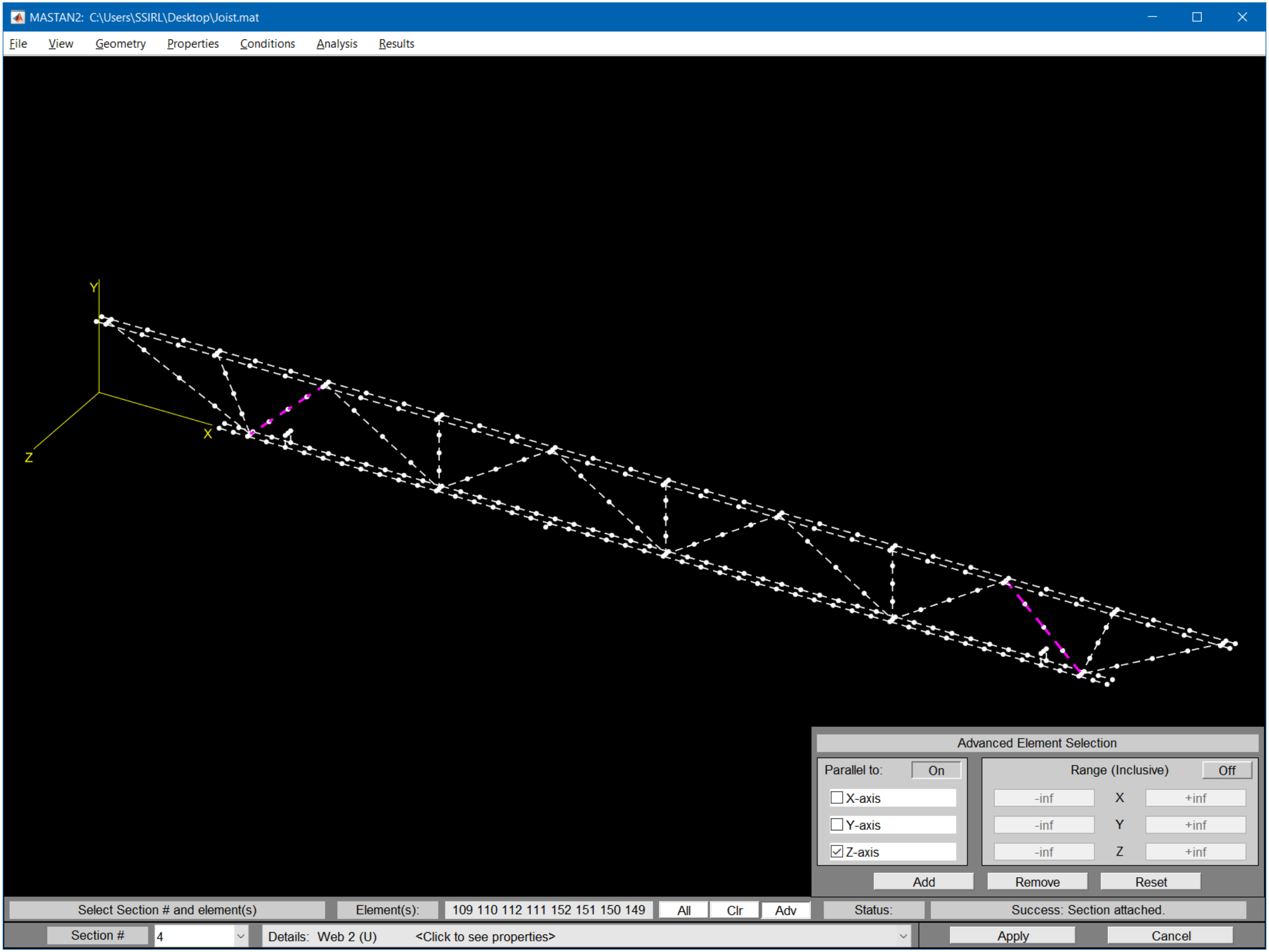
5) Change the **Section #** by clicking on the current section number just to the right to open a pop-up menu with all section numbers. Click on **3** to select the "Web 1 (U)" section.

6) Select the **Clr** button located to the right of **Elements:** to clear the list of elements.

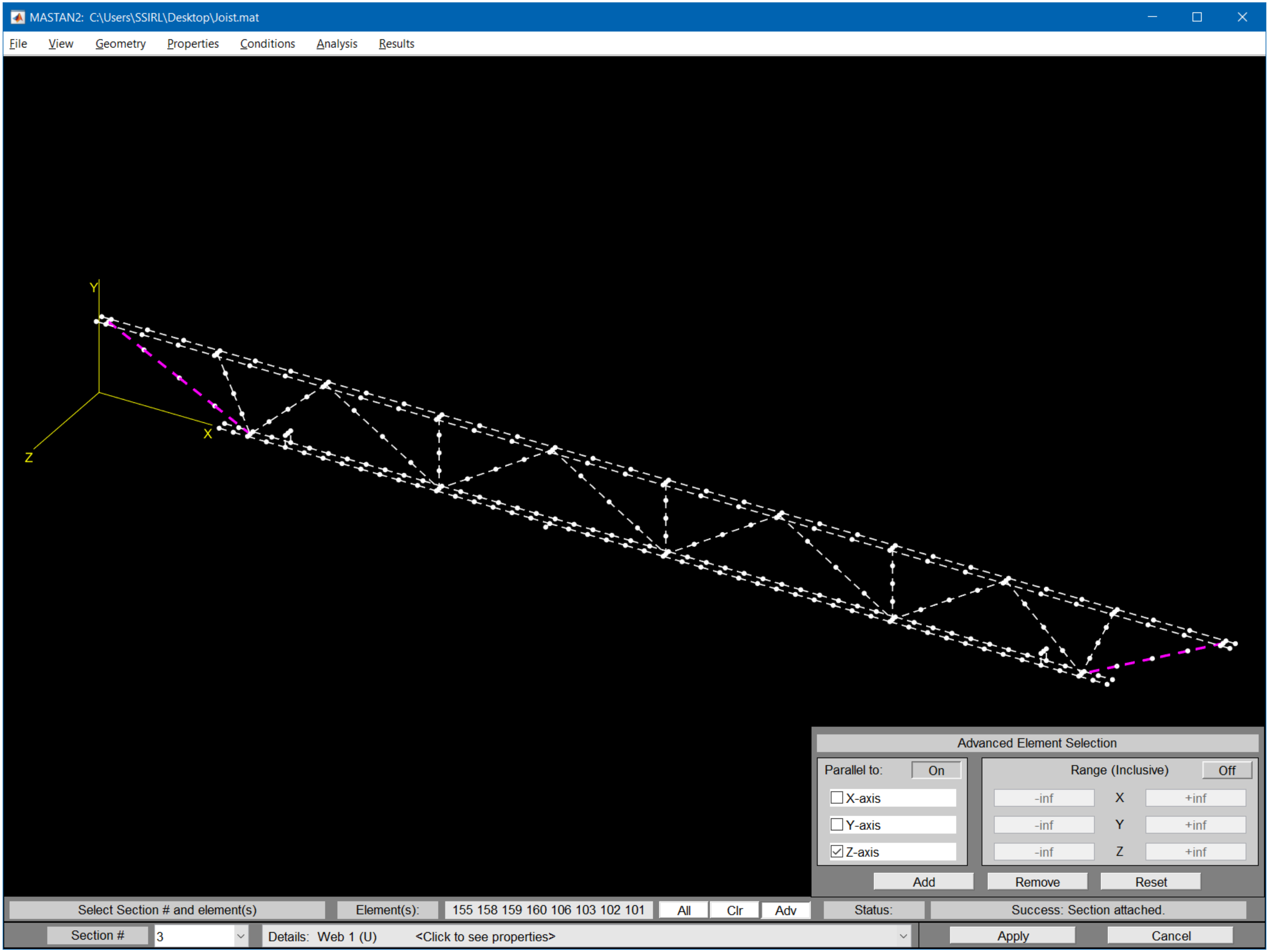
7) Click on all the elements to be assigned Web 1 section properties.

8) Assign Section 3 properties by clicking the **Apply** button.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Advanced Element Selection
Parallel to:
On
Range (Inclusive)
Off
X-axis
Y-axis
Z-axis
-inf
X
+inf
-inf
Y
+inf
-inf
Z
+inf
Add
Remove
Reset
Select Section # and element(s)
Element(s):
109 110 112 111 152 151 150 149
All
Clr
Adv
Status:
Success: Section attached.
Section #
4
Details: Web 2 (U)
<Click to see properties>
Apply
Cancel

MASTAN2



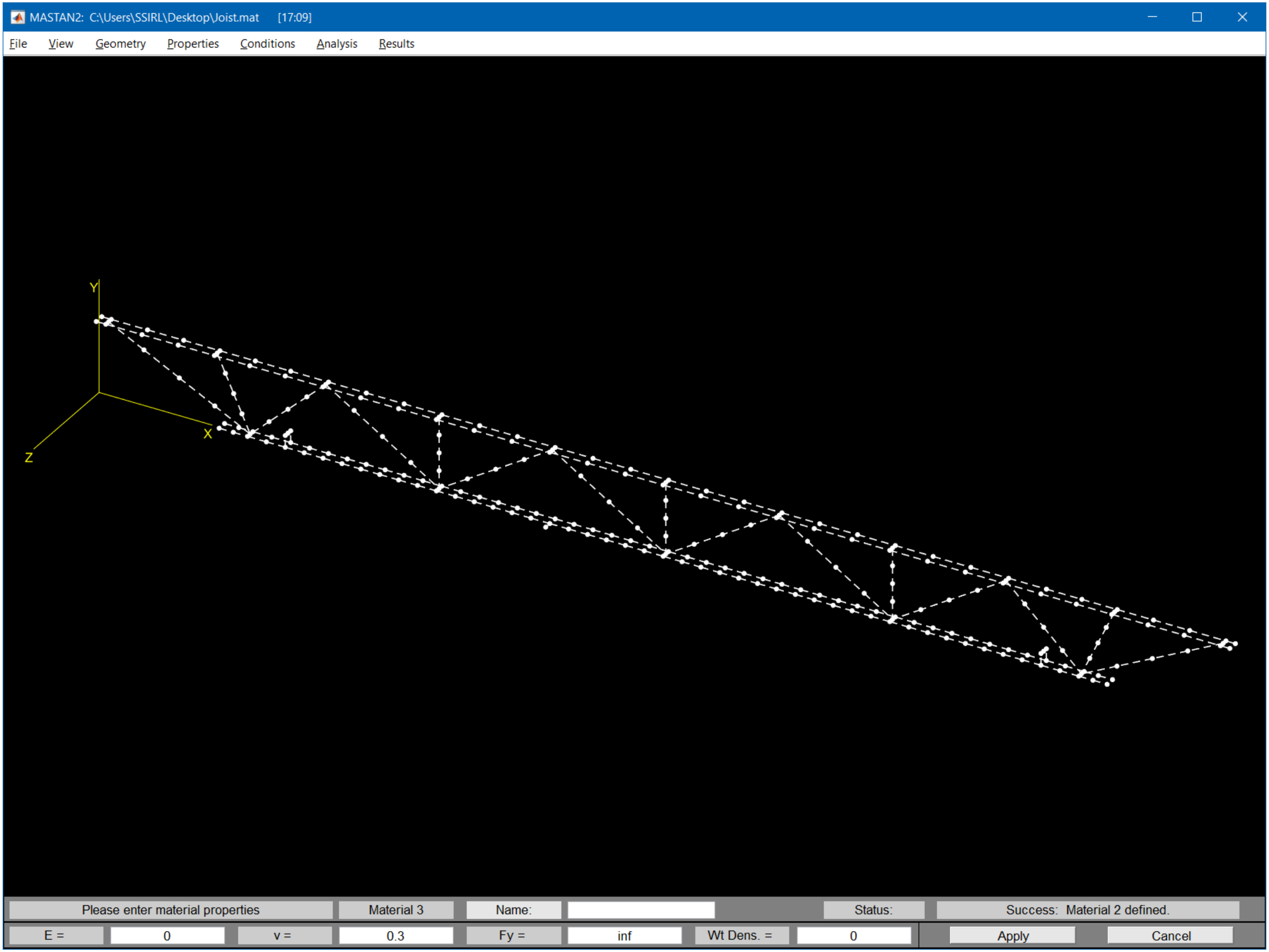
MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Advanced Element Selection
Parallel to:
On
X-axis
Y-axis
Z-axis
Range (Inclusive)
Off
-inf
+inf
Add
Remove
Reset
Select Section # and element(s)
Element(s):
155 158 159 160 106 103 102 101
All
Clr
Adv
Status:
Success: Section attached.
Section #
3
Details: Web 1 (U) <Click to see properties>
Apply
Cancel

Material Properties

1) From the **Properties** menu select **Define Material**.

2) At the bottom menu bar, click in the edit box just to the right of **E=** and change the **0** to **29000000** (not 29,000,000). Similarly, click in the edit box just to the right of **Fy=** and change the **inf** to **50000**. Next, click in the edit box to the right of **Name:** and type **Steel**. Click on the **Apply** button (Material #1 is now defined with the properties of steel).

3) At the bottom menu bar, click in the edit box just to the right of **E=** and change the **0** to **2900000000** (not 2,900,000,000). Next, click in the edit box to the right of **Name:** and type **Rigid**. Click on the **Apply** button. (Material #2 is now defined 100x stiffer and cannot yield.)


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Please enter material properties
Material 3
Name:
Status:
Success: Material 2 defined.
E =
0
v =
0.3
Fy =
inf
Wt Dens. =
0
Apply
Cancel

Material Properties - Assigning

1) From the **Properties** menu select **Attach Material**.

2) At the bottom menu bar, create the list of elements to be assigned the properties of Material 1 by clicking on the **All** button to the right of **Elements:**. Click on the **Apply** button. (Note that elements with assigned section and material properties turn solid.)

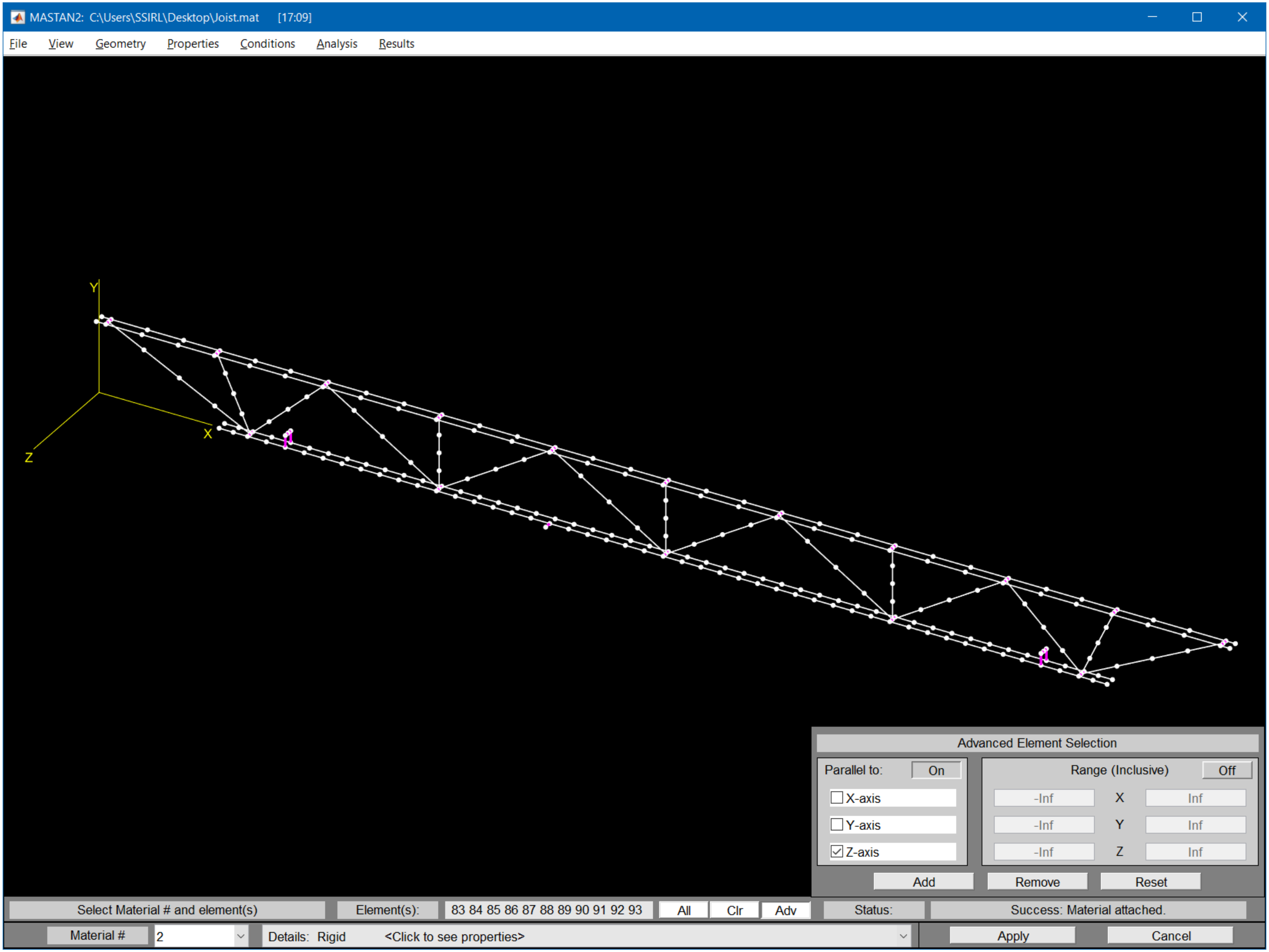
3) Change the **Material #** by clicking on the current material number just to the right to open a pop-up menu with all section numbers. Click on **2** to select the Rigid material.

4) Select the **Clr** button located to the right of **Elements:** to clear the list of elements.

5) Click the **Adv** button to open pop-up menu. **Z-axis** check box should be selected.

6) Click **Add** to select all the rigid connectors. Additionally click on the 4 vertical braces. Clicking **Adv** will close the pop-up menu making it easier to click all members.

7) Click on the **Apply** button to assign Material 2.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) Off
-Inf X Inf
-Inf Y Inf
-Inf Z Inf
Add Remove Reset
Select Material # and element(s)
Element(s): 83 84 85 86 87 88 89 90 91 92 93
All Clr Adv
Status: Success: Material attached.
Material # 2
Details: Rigid <Click to see properties>
Apply Cancel

Support Conditions - Bracing

1) From the **Conditions** menu select **Define Fixities**.

2) At the bottom menu bar, define the lateral support by clicking in the **check box** just to the left of **Z-disp.**

3) Click the **Adv** menu. Change the edit box to the left of **Y** from **-Inf** to **15**. Change the edit box to the left of **Z** from **-Inf** to **-0.1** and the edit box to the right of **Z** from **Inf** to **0.1**. Click the **Add** button.

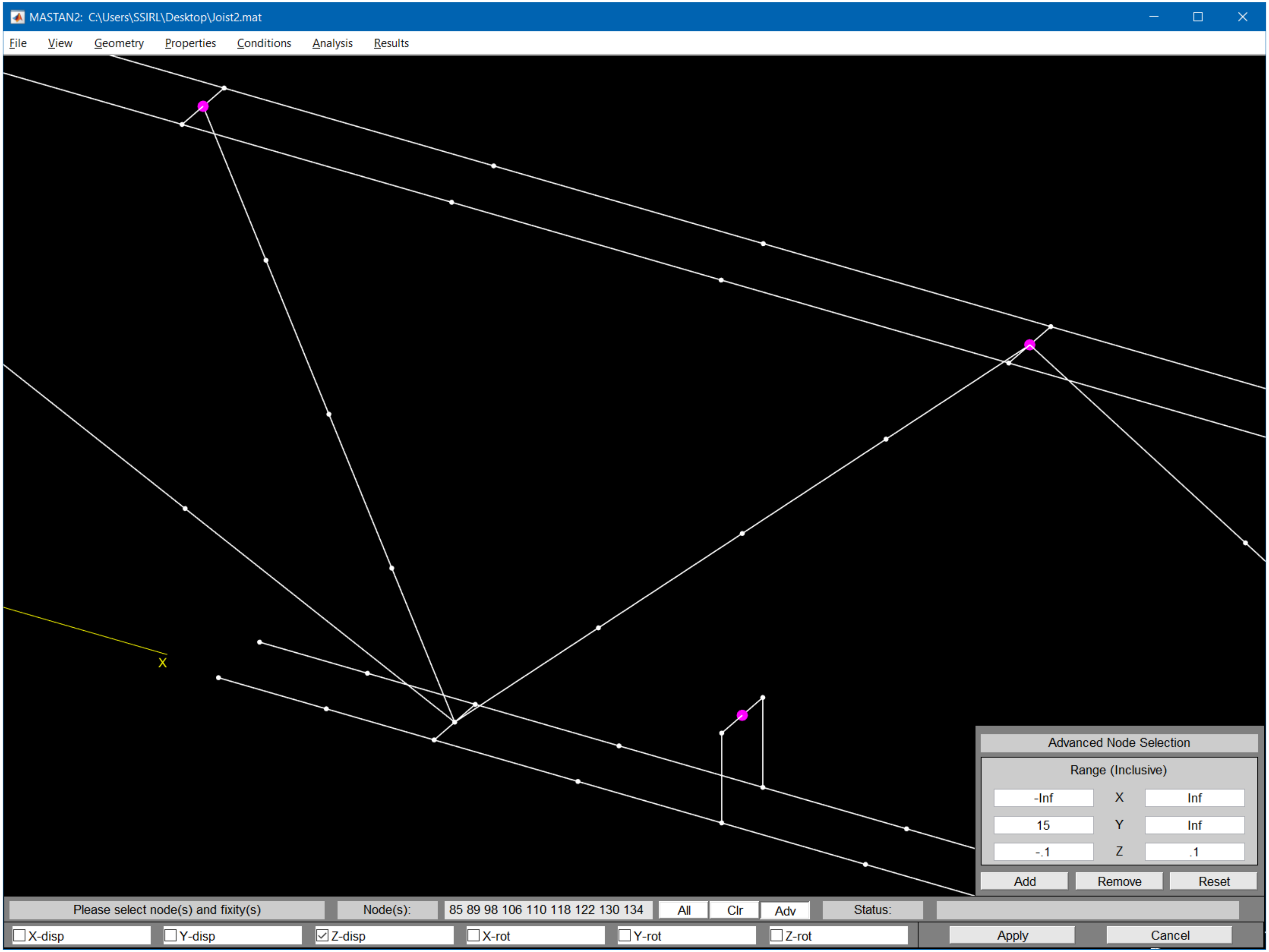
4) From the **View** menu select **Zoom Box**. Click to draw a small box around the brace connection on the bottom chord at one end. Click on the middle node to add to the list of nodes.

5) From the **View** menu select **Fit**. From the **View** menu select **Zoom Box**. Click to draw a small box around the brace connection at the other end. Click on the middle node to add to the list of nodes.

6) Click on the **Apply** button.

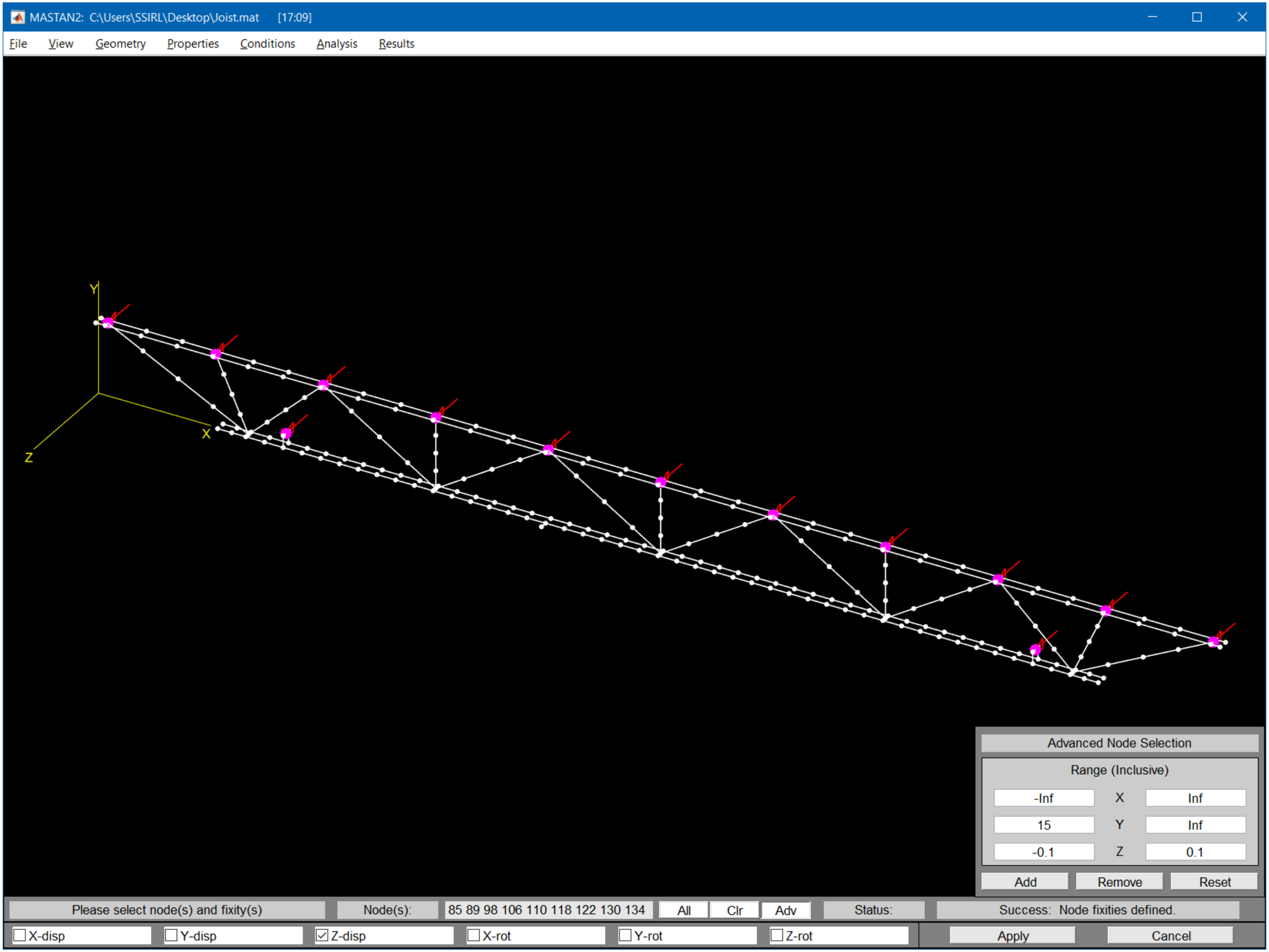
7) From the **View** menu select **Fit**.

MASTAN2



MASTAN2: C:\Users\SSIRL\Desktop\Joist2.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
X
Advanced Node Selection
Range (Inclusive)
-Inf X Inf
15 Y Inf
-.1 Z .1
Add
Remove
Reset
Please select node(s) and fixity(s)
Node(s):
85 89 98 106 110 118 122 130 134
All
Clr
Adv
Status:
X-disp
Y-disp
Z-disp
X-rot
Y-rot
Z-rot
Apply
Cancel

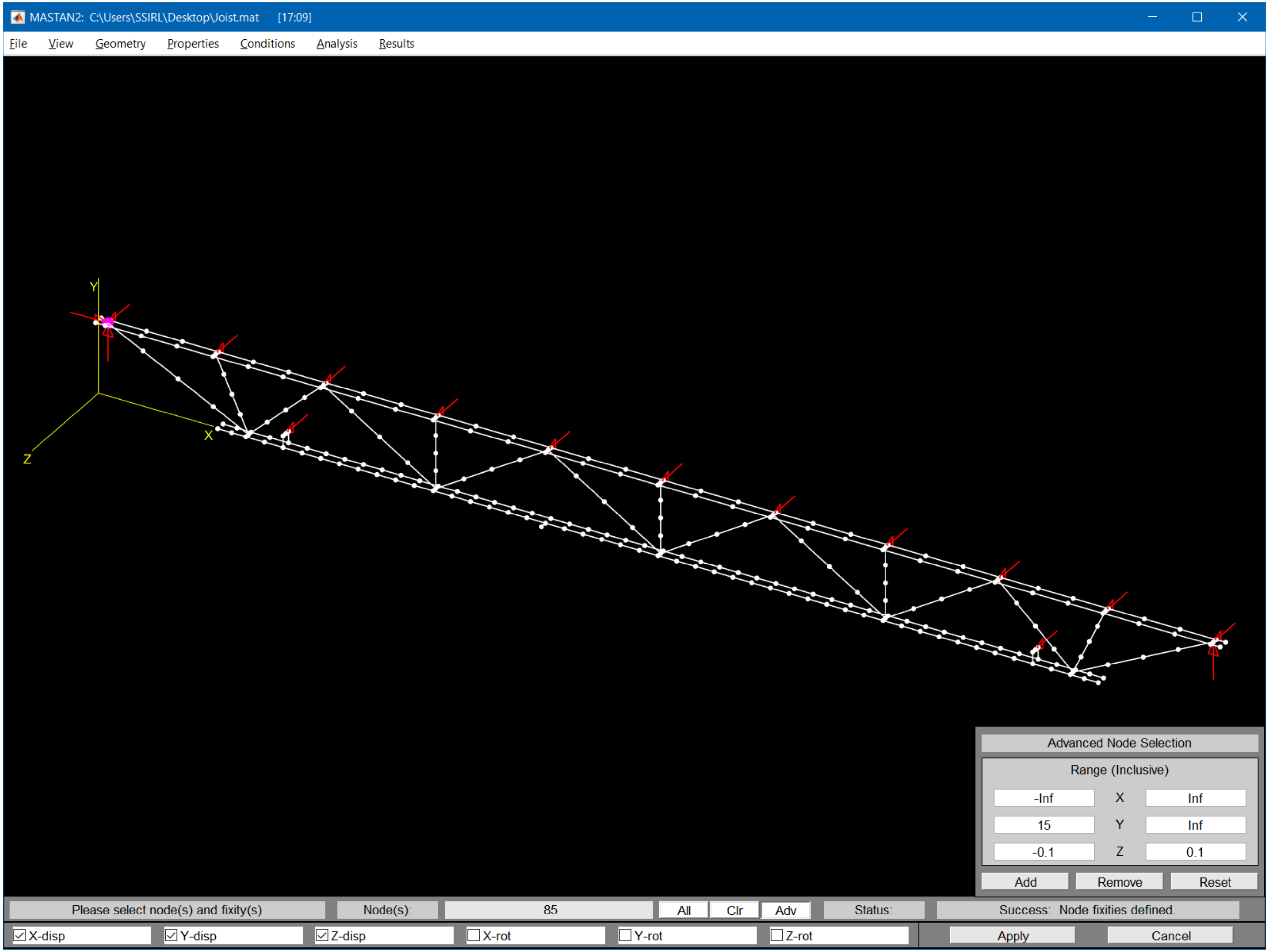
MASTAN2



MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Advanced Node Selection
Range (Inclusive)
-Inf
X
Inf
15
Y
Inf
-0.1
Z
0.1
Add
Remove
Reset
Please select node(s) and fixity(s)
Node(s):
85 89 98 106 110 118 122 130 134
All
Clr
Adv
Status:
Success: Node fixities defined.
X-disp
Y-disp
Z-disp
X-rot
Y-rot
Z-rot
Apply
Cancel

Support Conditions – Pin and Roller

1) To update the end nodes to provide pin supports, start by clicking **Clr** to empty the list of nodes.
2) From the **View** menu select **Zoom Box**. Click to draw a small box around the right roller node. It should currently just have a lateral support. Click on the node to add to the list of nodes.
3) Define a roller support by clicking in the **check box** just to the left of **Y-disp**. **Z-disp** should still be selected from before.
4) From the **View** menu select **Fit**.
5) Click on the **Apply** button.
6) From the **View** menu select **Zoom Box**. Click to draw a small box around the left pin node.
7) Click on the **Clr** button to empty the list of nodes. Click on the left pin.
8) Define a pin support by clicking in the **check box** just to the left of **X-disp**. **Y-disp** and **Z-disp** should still be selected from before.
9) From the **View** menu select **Fit**.
10) Click on the **Apply** button.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Node Selection
Range (Inclusive)
-Inf X Inf
15 Y Inf
-0.1 Z 0.1
Add Remove Reset
Please select node(s) and fixity(s)
Node(s):
85
All Clr Adv
Status:
Success: Node fixities defined.
X-disp Y-disp Z-disp X-rot Y-rot Z-rot
Apply Cancel

MASTAN2

Chord Member Orientation

1) From the **View** menu select **Labels** and submenu option **Element local (x'-y'-z') axes**. The purple line shows the positive x axis. The blue line shows the positive geometric y axis. The red line shows the positive geometric z axis. Based on the orientation of the angle sections as input, the y axis represents the direction from the centroid to the corner of the angle.

2) From the **Geometry** menu select **Re-orient Element(s)**.

3) At the bottom menu bar, click in the edit box to the right of **Beta (Deg)** and change **0.0** to **135**.

4) Click the **Adv** button to open pop-up menu. Click the **Reset** button. To select the +z top chord angle, click the check box next to the **X-axis** option. Click the button to the right of **Range (Inclusive)** to **On**. Change the edit box to the left of **Y** to **8**. Change the edit box to the left of **Z** to **0**.

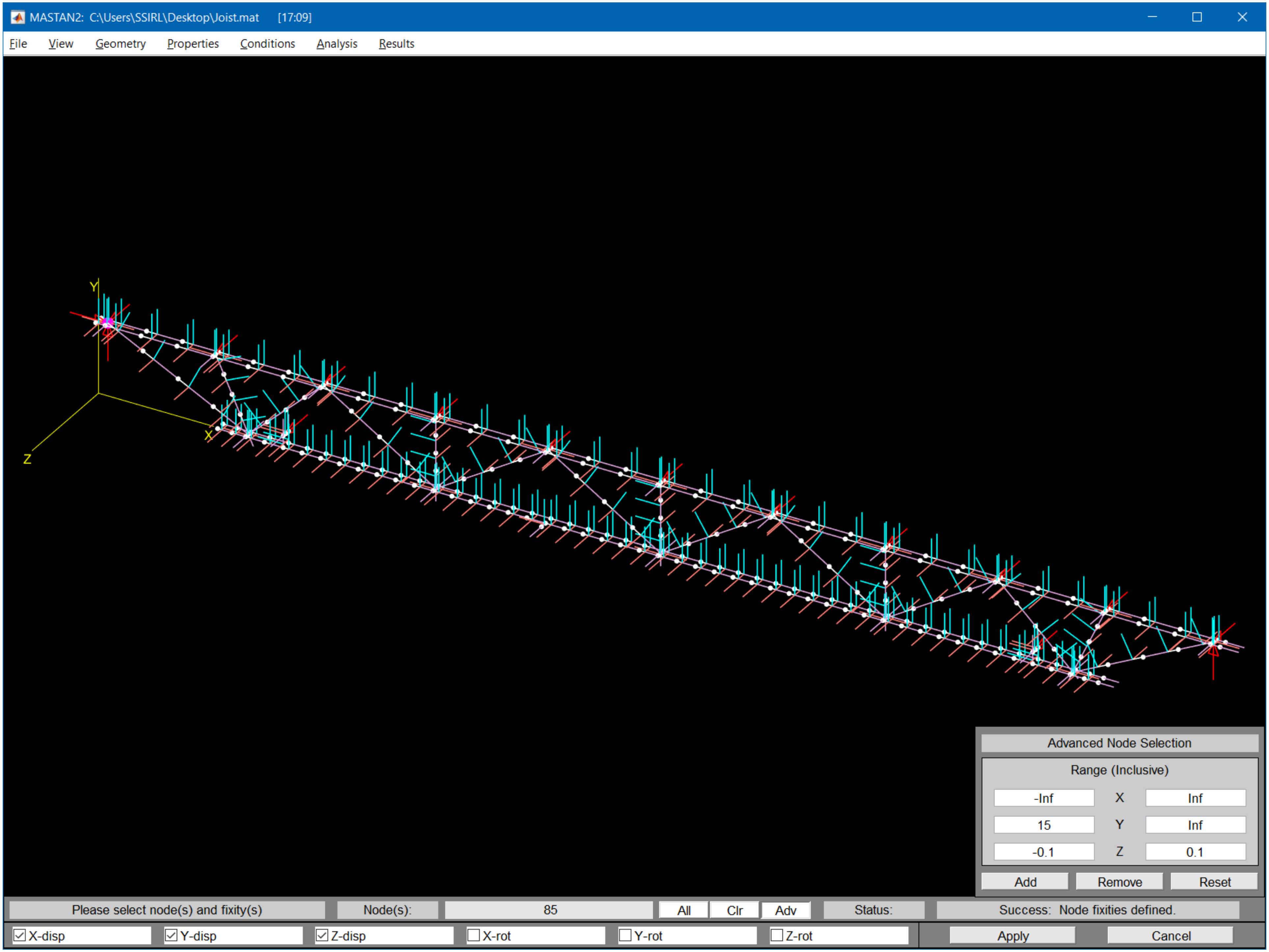
5) Click **Add** to add all these elements to the element list. Click on the **Apply** button to re-orient the elements.

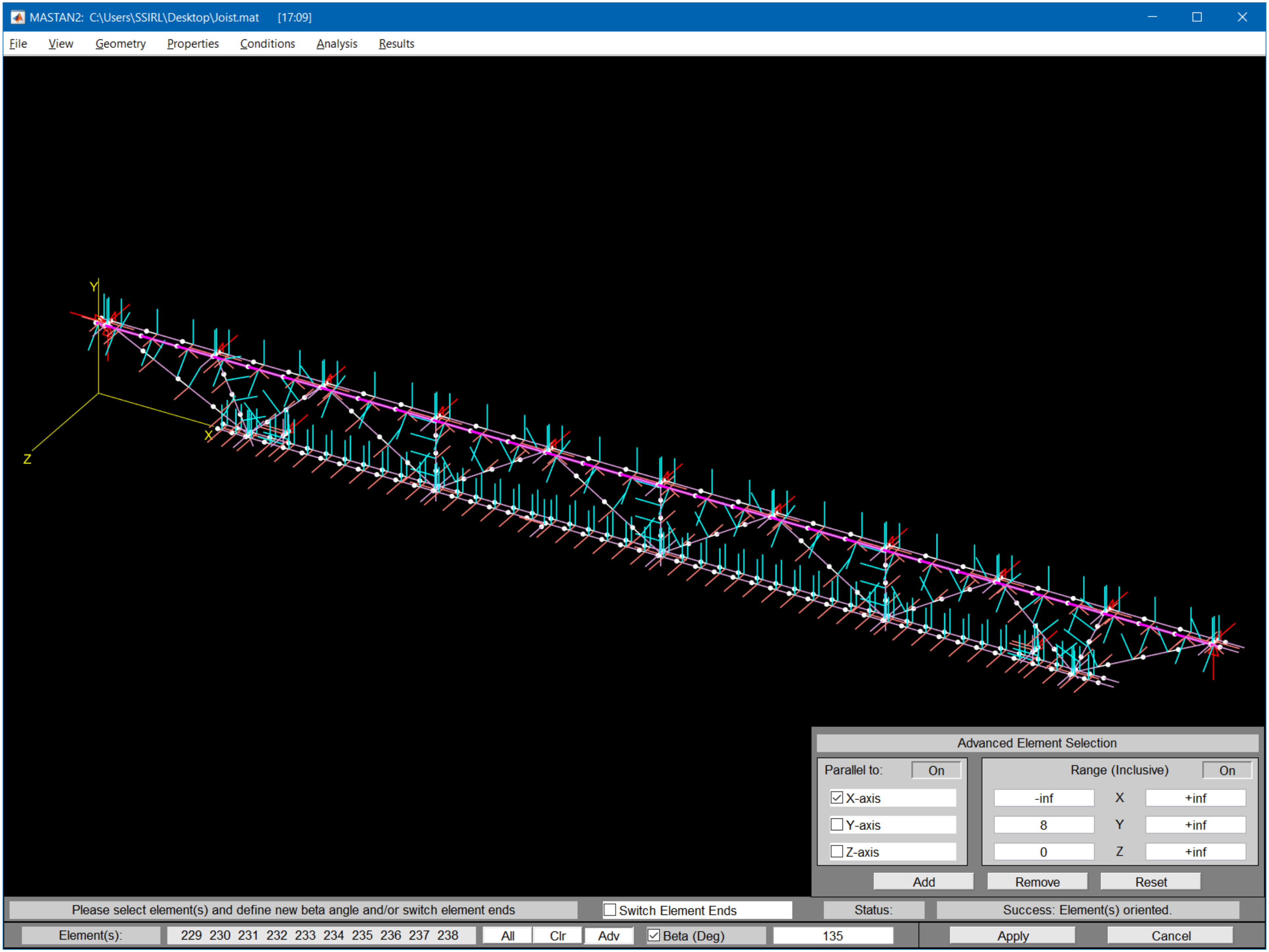
6) Repeat this for the remaining 3 angle members orienting in the correct direction with the values shown in the table:

Member	-Z Top	+Z Bottom	-Z Bottom
Beta	-135	45	-45
Y-Range	8 to inf	0 to 8	0 to 8
Z-Range	-2 to 0	0 to 2	-2 to 0

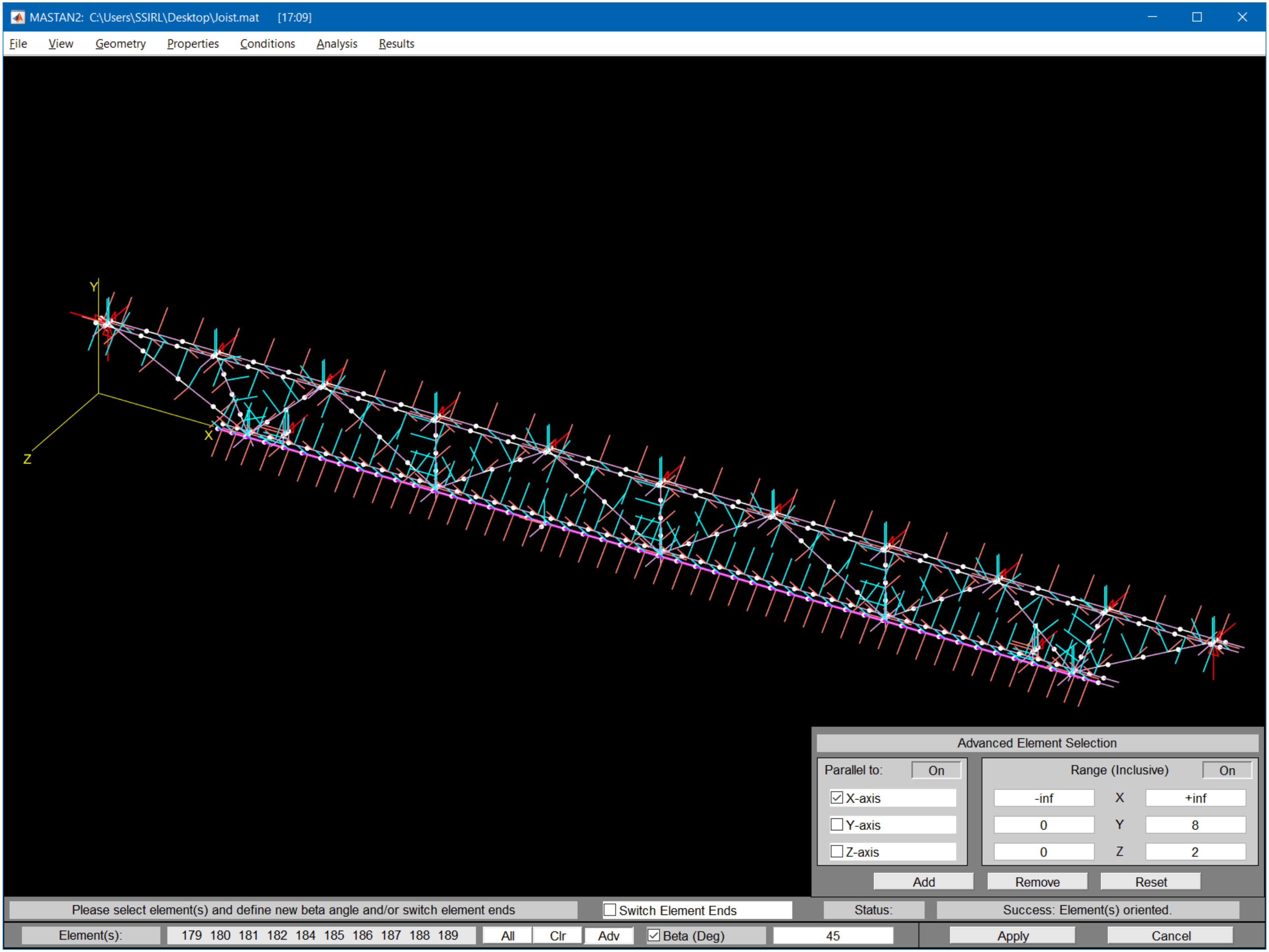
Iso. View

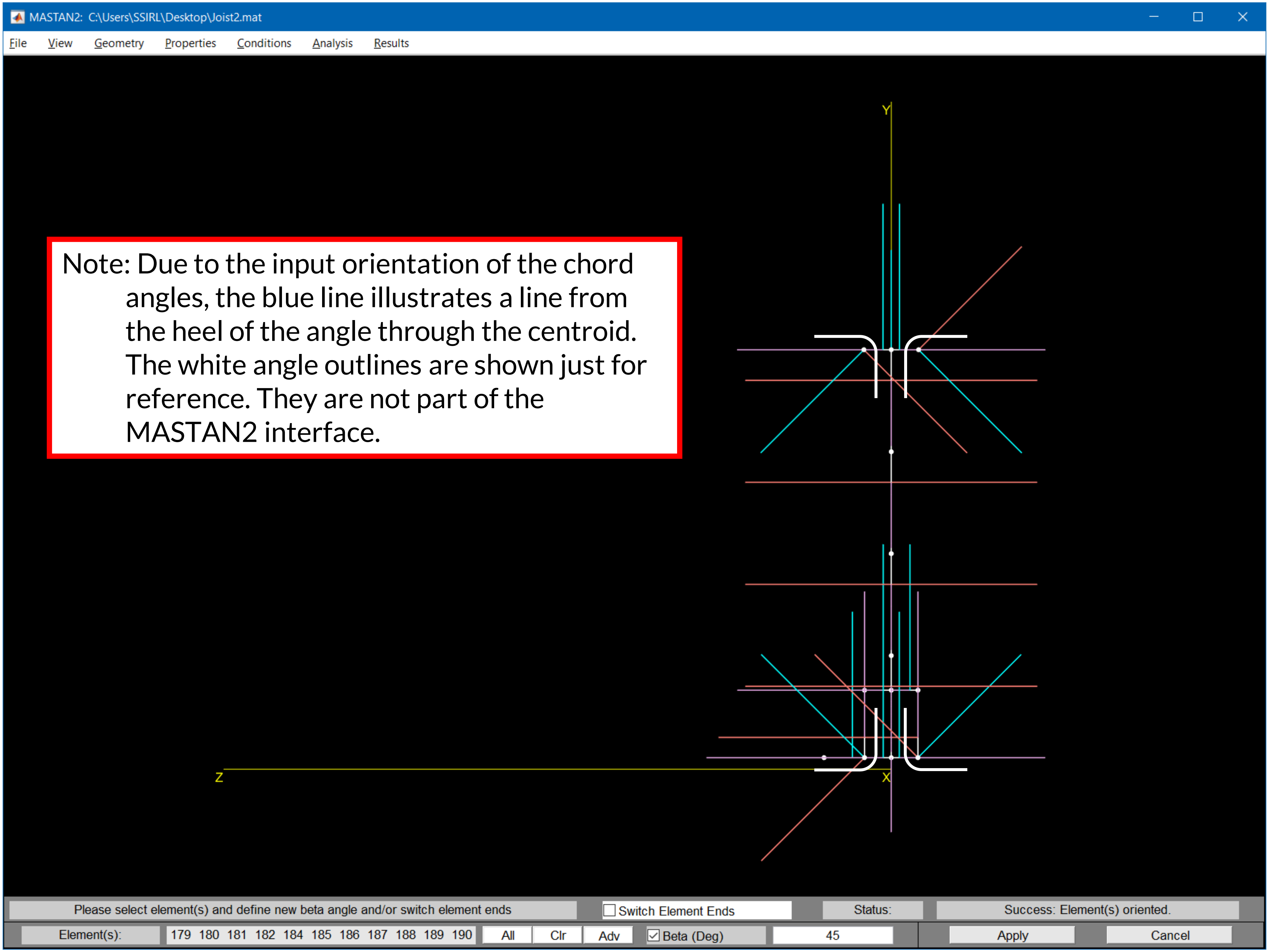
Side View


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Advanced Node Selection
Range (Inclusive)
-Inf
X
Inf
15
Y
Inf
-0.1
Z
0.1
Add
Remove
Reset
Please select node(s) and fixity(s)
Node(s):
85
All
Clr
Adv
Status:
Success: Node fixities defined.
X-disp
Y-disp
Z-disp
X-rot
Y-rot
Z-rot
Apply
Cancel


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) On
-inf X +inf
8 Y +inf
0 Z +inf
Add Remove Reset
Please select element(s) and define new beta angle and/or switch element ends
Switch Element Ends
Status:
Success: Element(s) oriented.
Element(s): 229 230 231 232 233 234 235 236 237 238
All Clr Adv
Beta (Deg) 135
Apply Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Advanced Element Selection
Parallel to:
On
X-axis
Y-axis
Z-axis
Range (Inclusive)
On
-inf
X
+inf
0
Y
8
0
Z
2
Add
Remove
Reset
Please select element(s) and define new beta angle and/or switch element ends
Switch Element Ends
Status:
Success: Element(s) oriented.
Element(s):
179 180 181 182 184 185 186 187 188 189
All
Clr
Adv
Beta (Deg)
45
Apply
Cancel



Note: Due to the input orientation of the chord angles, the blue line illustrates a line from the heel of the angle through the centroid. The white angle outlines are shown just for reference. They are not part of the MASTAN2 interface.

Web Member Orientation

Based on the orientation of the web sections as input, the y axis points in the direction of the opening of the channel.

1) At the bottom menu bar, click in the edit box to the right of **Beta (Deg)** and update it to **180**.

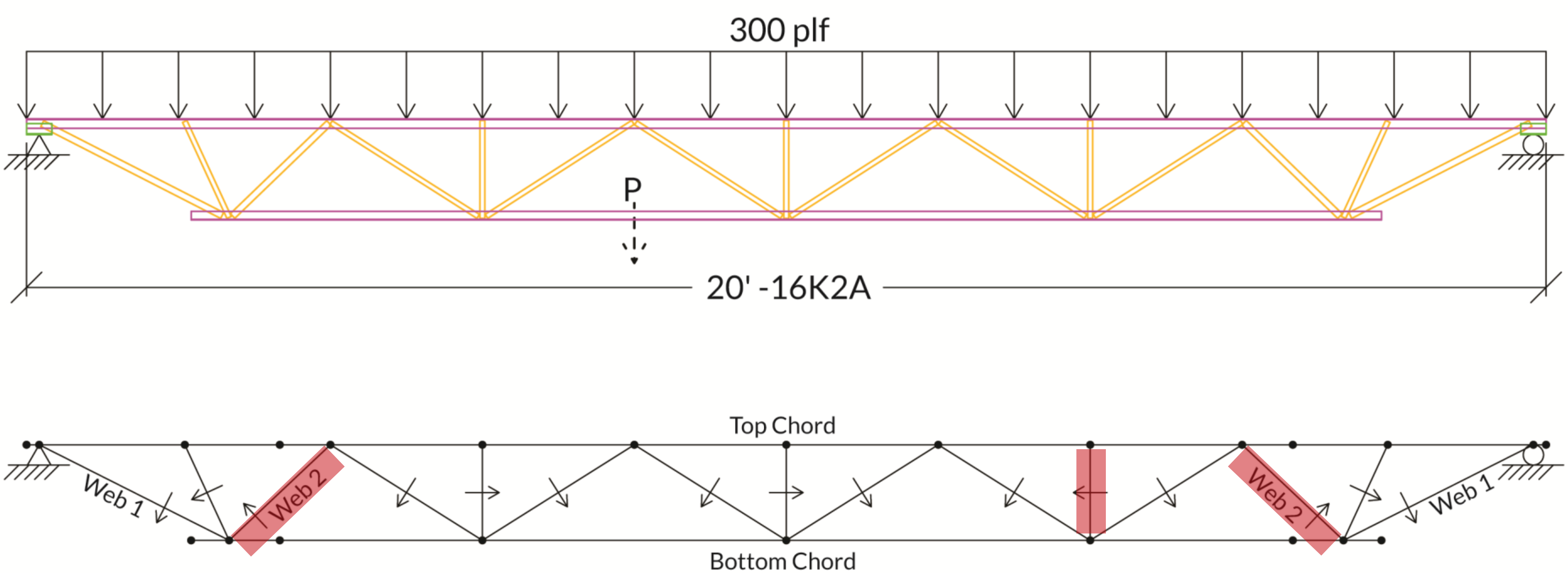
2) On the **Advanced Element Selection** pop-up, click the **Reset** button. Click the check box next to the **X-axis** and **Z-axis** option. Create the list of webs to be flipped by clicking on the **All** button to the right of **Elements:**. Then click on **Remove**.

3) Manually click the 4 vertical braces, the members assigned Web 2, and the vertical web to the right of center.

   Note: If you are having trouble seeing the webs that were unselected, look at the image associated with Step 5 now. The same elements are still selected without all the local axes information on the screen. Also, available again is the diagram with web orientations.

4) Click on the **Apply** button to re-orient the elements.

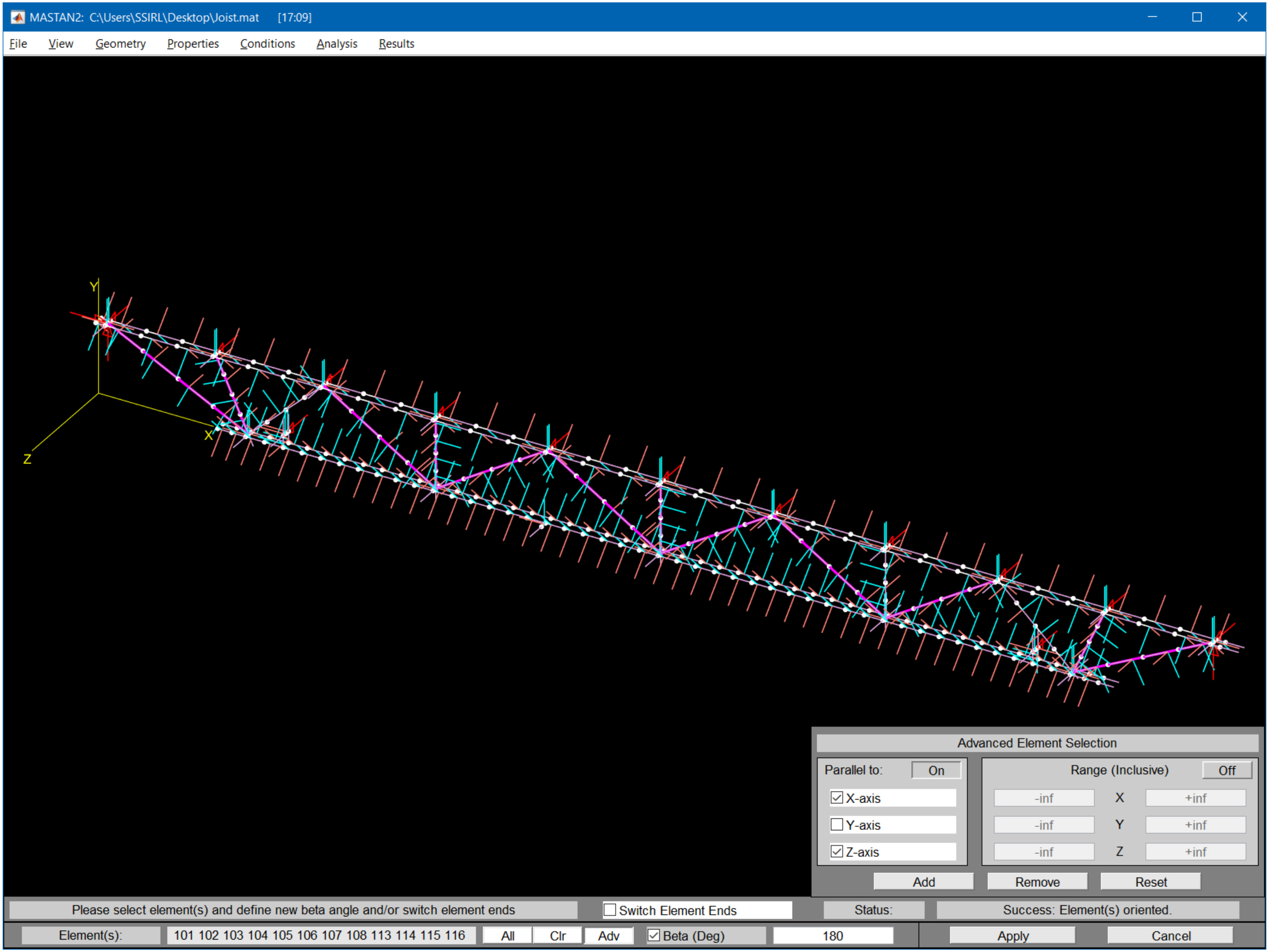
5) From the **View** menu select **Labels** and submenu option **Element local (x’-y’-z’) axes**.

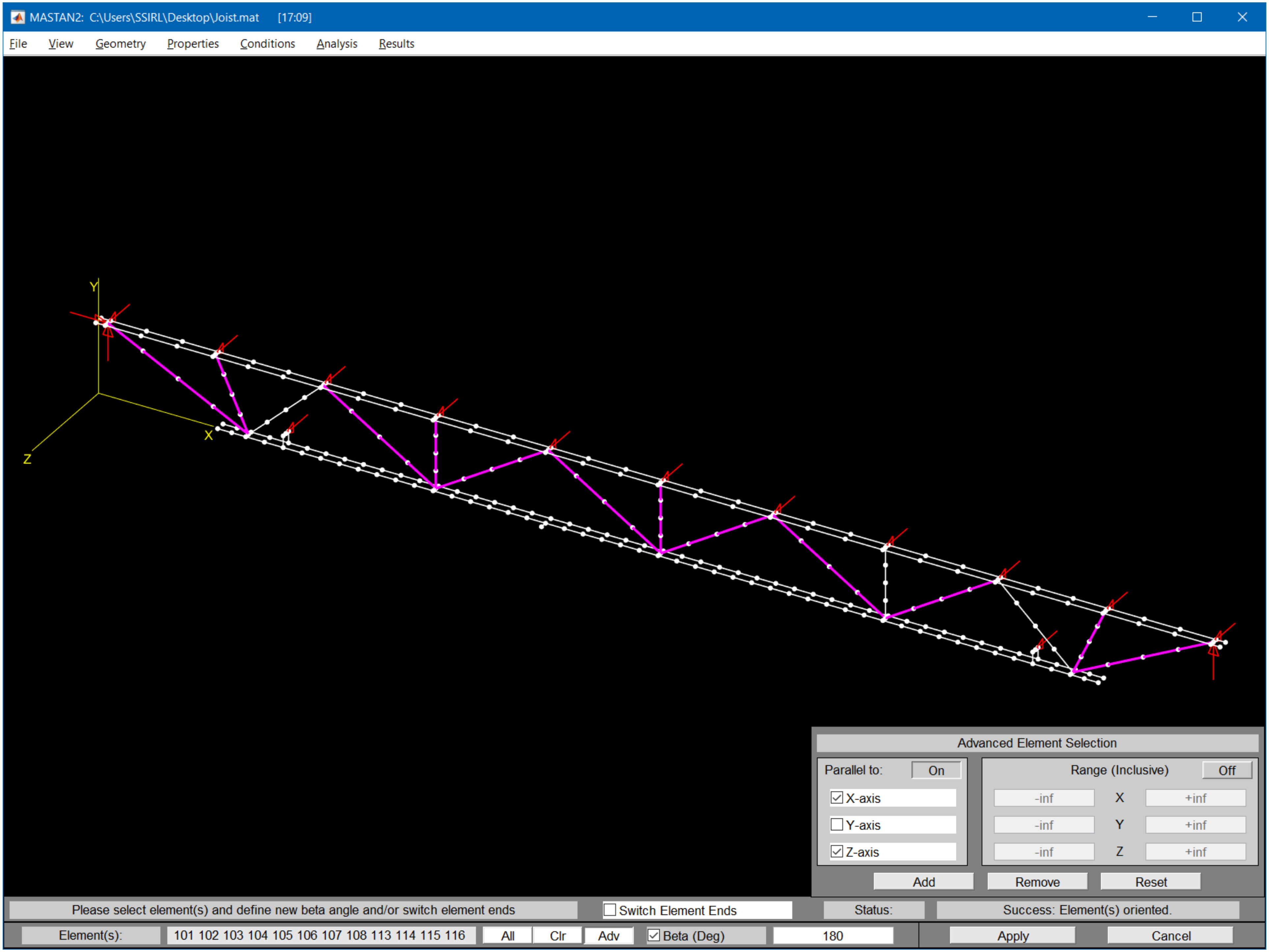


Arrows indicate the open side of the web channels. Web members not otherwise labeled are Web 3

Web members highlighted in red do not need to be flipped as the sections were defined. These are the members that are to be unselected.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) Off
-inf X +inf
-inf Y +inf
-inf Z +inf
Add Remove Reset
Please select element(s) and define new beta angle and/or switch element ends
Switch Element Ends
Status:
Success: Element(s) oriented.
Element(s):
101 102 103 104 105 106 107 108 113 114 115 116
All Clr Adv
Beta (Deg)
180
Apply Cancel


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:09]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) Off
-inf X +inf
-inf Y +inf
-inf Z +inf
Add Remove Reset
Please select element(s) and define new beta angle and/or switch element ends
Switch Element Ends
Status:
Success: Element(s) oriented.
Element(s):
101 102 103 104 105 106 107 108 113 114 115 116
All Clr Adv
Beta (Deg)
180
Apply Cancel

Adding Warping Effects

1) From the **Geometry** menu select **Define Connections** and submenu option **Torsion**.

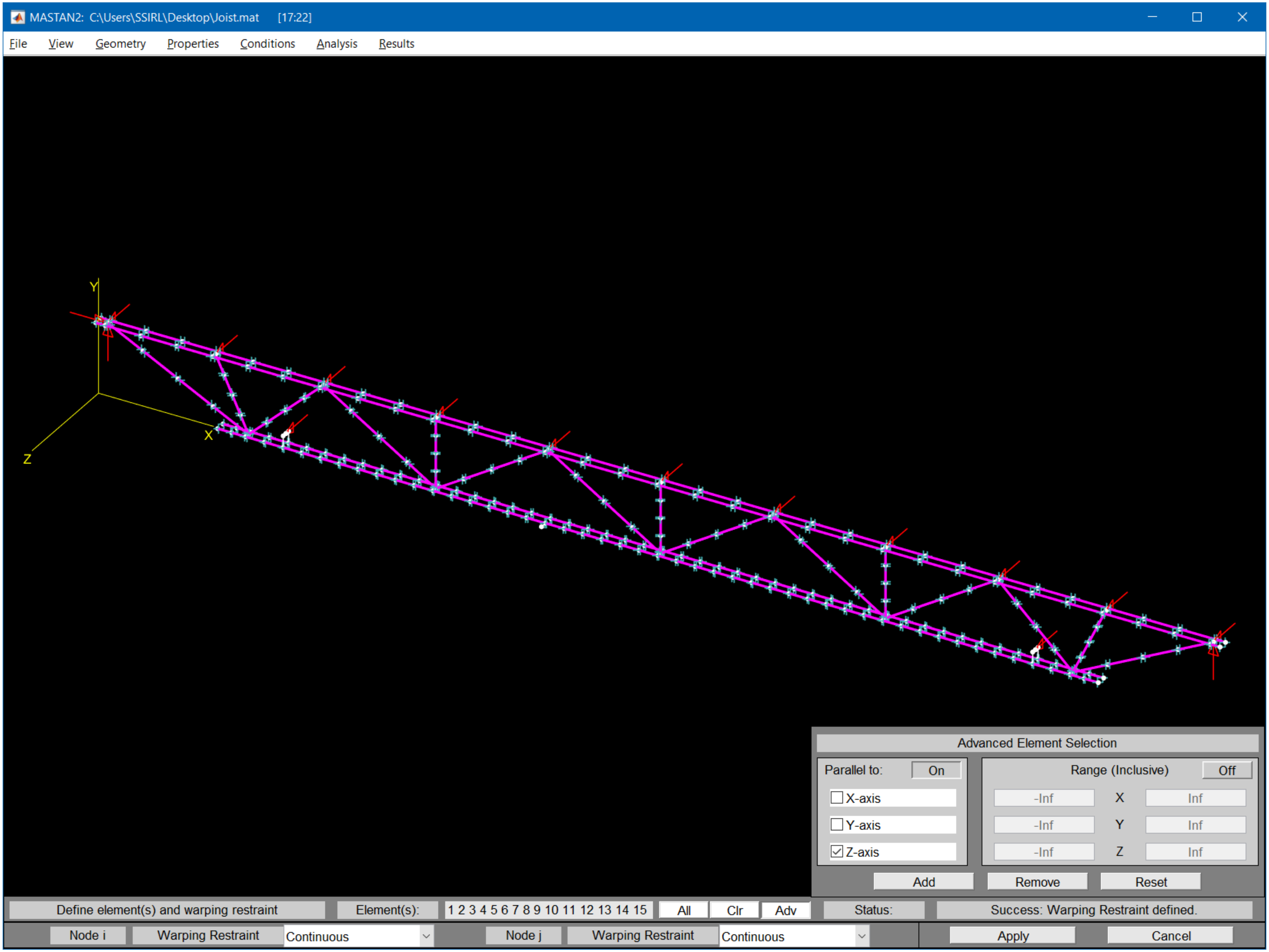
2) At the bottom menu bar, click on the menu to the right of **Warping Restraint for Node i** and set the value to **Continuous**. Repeat this for the **Warping Restraint for Node j**.

3) Click the **Adv** button to open pop-up menu. Unmark the check box next to the **X-axis** option. The check box next to the **Z-axis** option should still be selected.

4) Create the list of elements to be assigned continuous warping by clicking on the **All** button to the right of **Elements:**. Then click on **Remove**. Click on the 4 vertical braces to remove them.

5) Click on the **Apply** button.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:22]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) Off
-Inf X Inf
-Inf Y Inf
-Inf Z Inf
Add Remove Reset
Define element(s) and warping restraint
Element(s): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
All Clr Adv
Status: Success: Warping Restraint defined.
Node i Warping Restraint Continuous
Node j Warping Restraint Continuous
Apply Cancel

Adding Warping Effects – Starting Node

1) Click **Clr** to empty the list of elements.

2) Click on the menu to the right of **Warping Restraint for Node i** and set the value to **Free**. Node j is set from a previous step.

3) Click on the left most element of each chord.

4) Click on the **Apply** button.

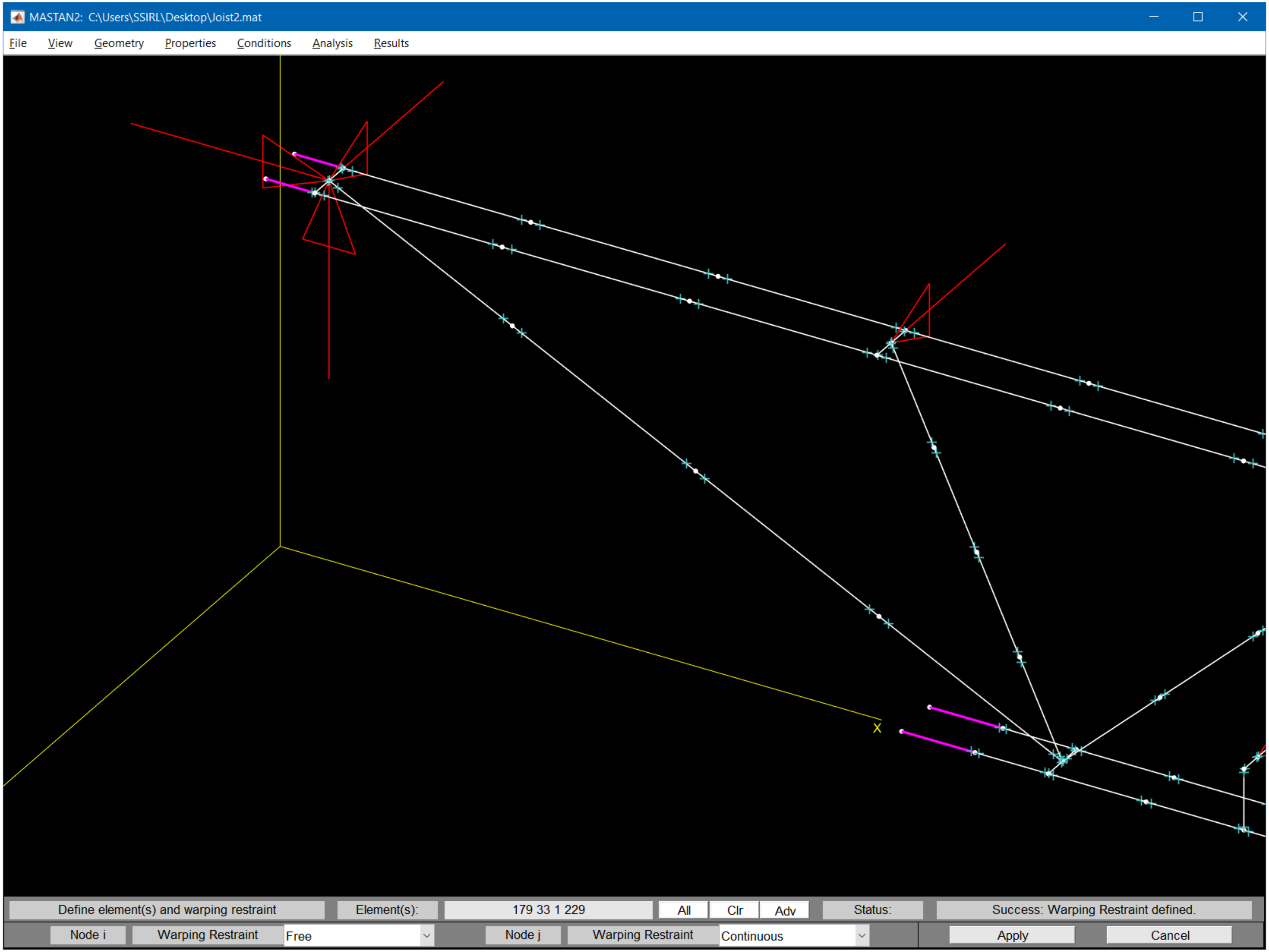
5) Click **Clr** to empty the list of elements.

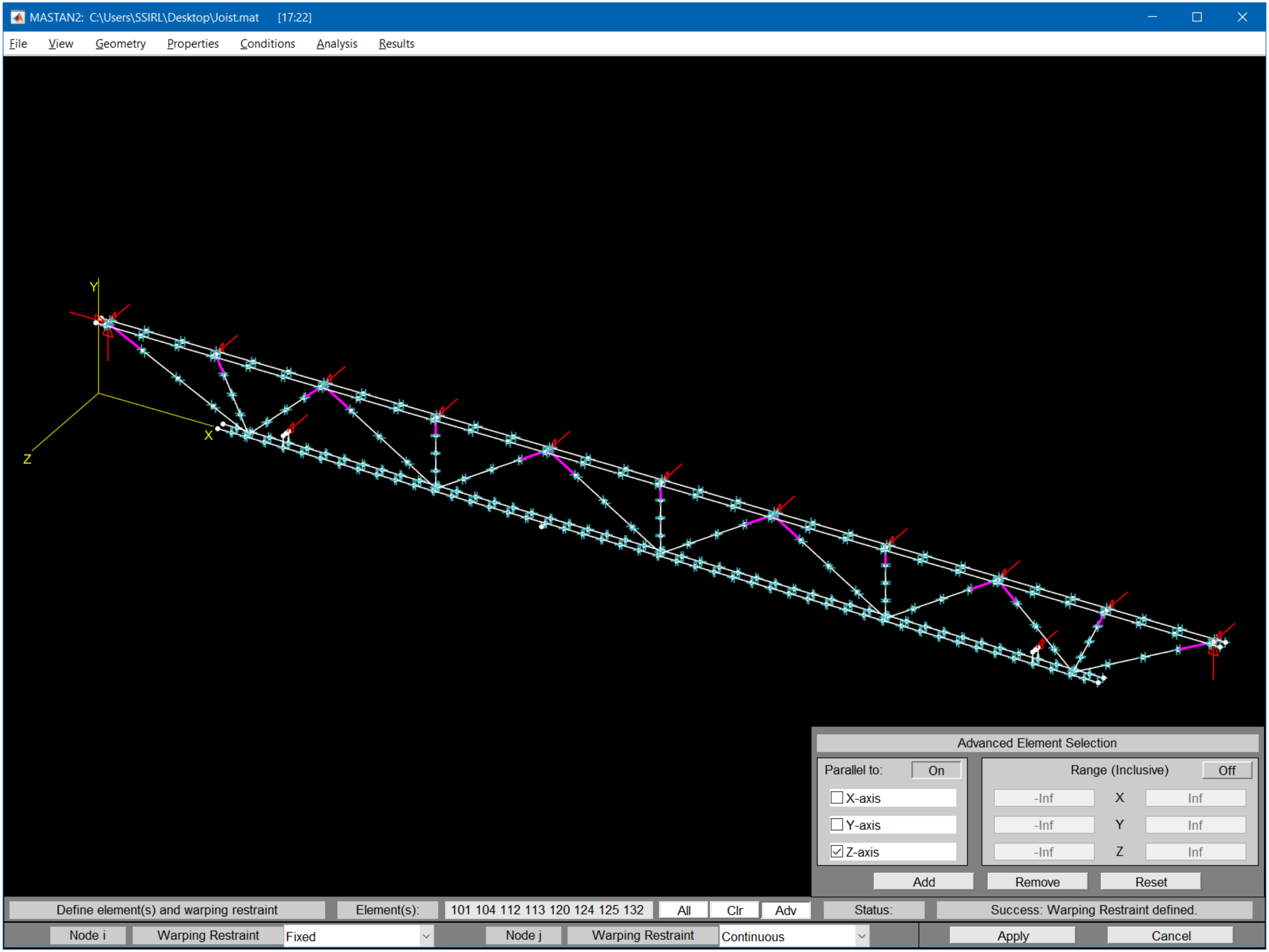
6) Click on the menu to the right of **Warping Restraint for Node i** and set the value to **Fixed**. Node j is set from a previous step.

7) Click on the top end of all 15 web members

8) Click on the **Apply** button.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist2.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
X
Define element(s) and warping restraint
Element(s):
179 33 1 229
All
Clr
Adv
Status:
Success: Warping Restraint defined.
Node i
Warping Restraint
Free
Node j
Warping Restraint
Continuous
Apply
Cancel


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:22]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) Off
-Inf X Inf
-Inf Y Inf
-Inf Z Inf
Add Remove Reset
Define element(s) and warping restraint
Element(s): 101 104 112 113 120 124 125 132
All Clr Adv
Status: Success: Warping Restraint defined.
Node i Warping Restraint Fixed
Node j Warping Restraint Continuous
Apply Cancel

Adding Warping Effects – Ending Node

1) Click **Clr** to empty the list of elements.

2) Click on the menu to the right of **Warping Restraint for Node i** and set the value to **Continuous**.
   Click on the menu to the right of **Warping Restraint for Node j** and set the value to **Free**.

3) Click on the right most element of each chord.

4) Click on the **Apply** button.

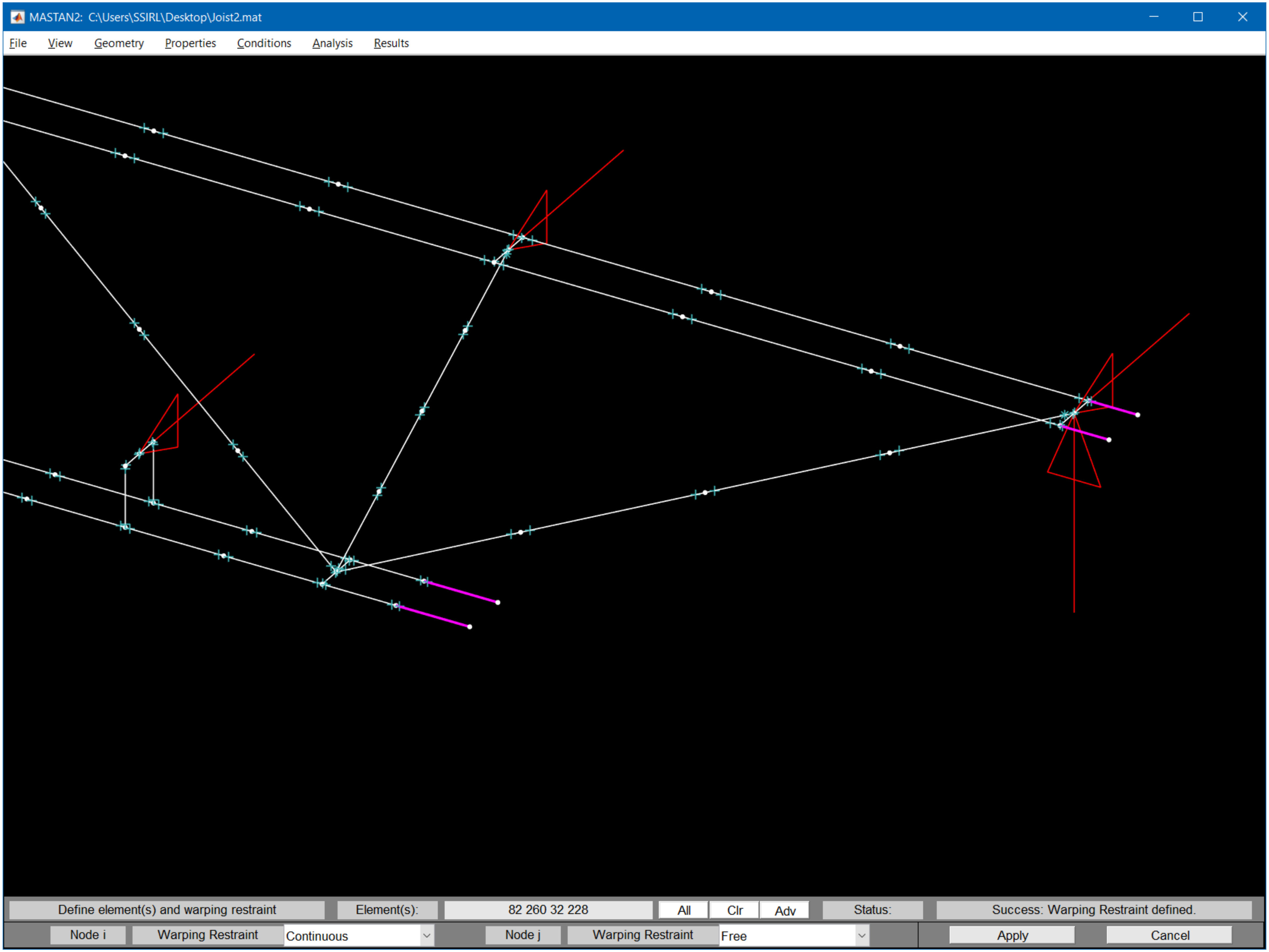
5) Click **Clr** to empty the list of elements.

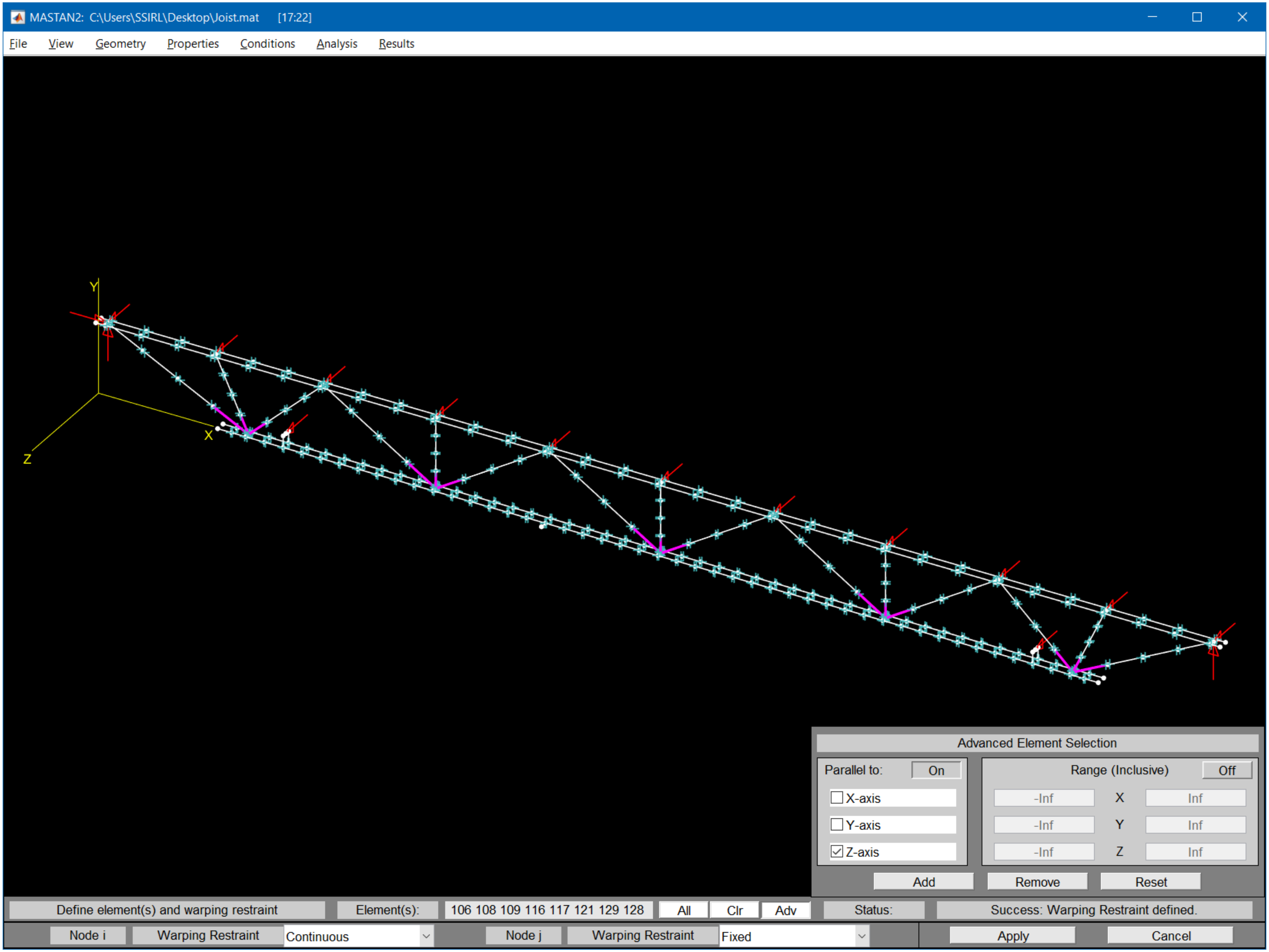
6) Click on the menu to the right of **Warping Restraint for Node j** and set the value to **Fixed**. Node i is set from a previous step.

7) Click on the bottom end of all 15 web members.

8) Click on the **Apply** button.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist2.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Define element(s) and warping restraint
Element(s):
82 260 32 228
All
Clr
Adv
Status:
Success: Warping Restraint defined.
Node i
Warping Restraint
Continuous
Node j
Warping Restraint
Free
Apply
Cancel


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:22]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) Off
-Inf X Inf
-Inf Y Inf
-Inf Z Inf
Add Remove Reset
Define element(s) and warping restraint
Element(s):
106 108 109 116 117 121 129 128
All Clr Adv
Status:
Success: Warping Restraint defined.
Node i Warping Restraint Continuous
Node j Warping Restraint Fixed
Apply Cancel

End Moment Release

1) From the **Geometry** menu select **Define Connections** and submenu option **Flexure**.

2) At the bottom menu bar, click on the menu to the right of **Type** for **Node i** and set the value to **Semi-Rigid**.

3) In the edit box to the right of **kz** change **inf** to **0.001**.

4) Click on the top end of all 15 web members to create the list of elements.

5) Click on the **Apply** button.

6) Click on the menu to the right of **Type** for **Node i** and set the value to **Rigid**. Click on the menu to the right of **Type** for **Node j** and set the value to **Semi-Rigid**.

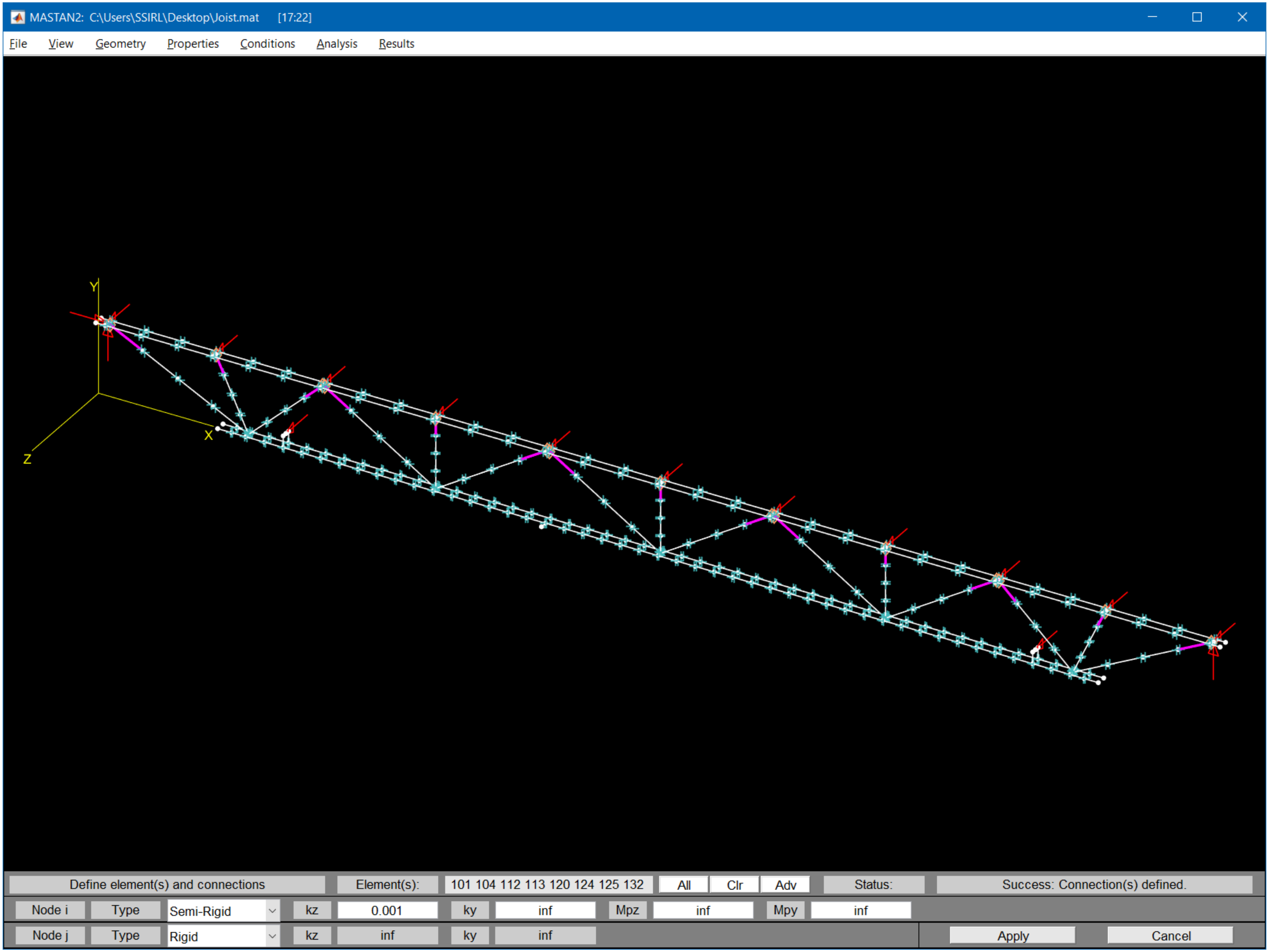
7) In the edit box to the right of **kz** change **inf** to **0.001**.

8) Click **Clr** to empty the list of elements.

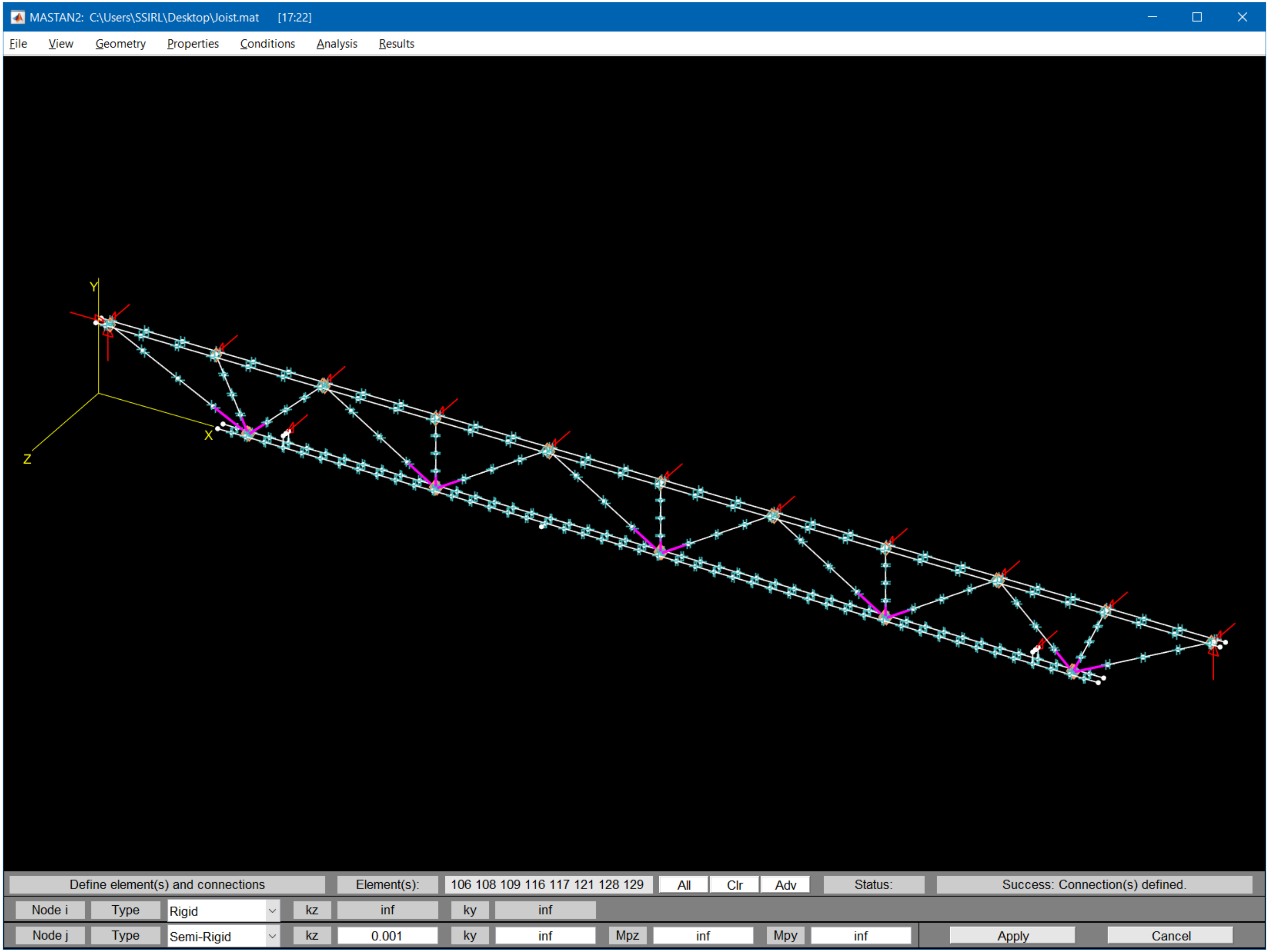
9) Click on the bottom end of all 15 web members to create the list of elements.

10) Click on the **Apply** button.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:22]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Define element(s) and connections
Element(s):
101 104 112 113 120 124 125 132
All
Clr
Adv
Status:
Success: Connection(s) defined.
Node i
Type
Semi-Rigid
kz
0.001
ky
inf
Mpz
inf
Mpy
inf
Node j
Type
Rigid
kz
inf
ky
inf
Apply
Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:22]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Define element(s) and connections
Element(s):
106 108 109 116 117 121 128 129
All
Clr
Adv
Status:
Success: Connection(s) defined.
Node i
Type
Rigid
kz
inf
ky
inf
Node j
Type
Semi-Rigid
kz
0.001
ky
inf
Mpz
inf
Mpy
inf
Apply
Cancel

Section 5: Loading and Analysis

Distributed Loading

1) From the **Conditions** menu select **Define Uniform Loads**.

2) At the bottom menu bar, click on **Element(s) local x'-y'-z'** to open the drop down menu. Select **System global X-Y-Z**. In the edit box just to the right of **wy =** change **0** to **-12.5**.

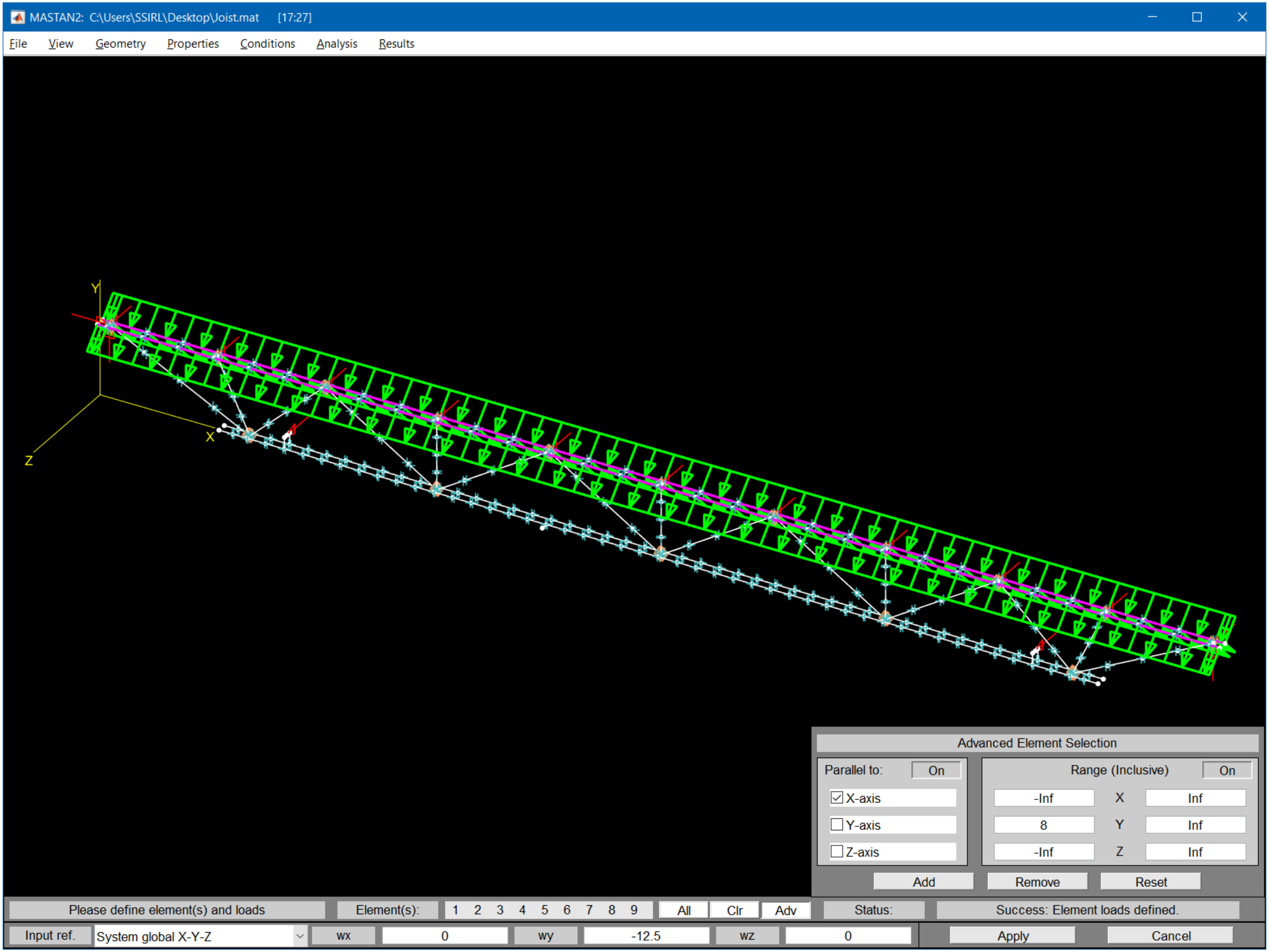
3) Click the **Adv** button to open pop-up menu. Click the check box next to the **Z-axis** option to remove it. Click the check box next to the **X-axis** option. Click the **Off** button to the right of **Range (Inclusive)** to change it to **On**. Change the edit box to the left of **Y** to **8**.

4) Click **Add** to add the top chord elements to the element list.

5) Click on the **Apply** button. The load will be split into the local element directions.

6) From the **View** menu select **Fit**.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Advanced Element Selection
Parallel to: On
X-axis
Y-axis
Z-axis
Range (Inclusive) On
-Inf X Inf
8 Y Inf
-Inf Z Inf
Add Remove Reset
Please define element(s) and loads
Element(s): 1 2 3 4 5 6 7 8 9 All Clr Adv
Status: Success: Element loads defined.
Input ref. System global X-Y-Z
wx 0 wy -12.5 wz 0
Apply Cancel

Uniform Loading Elastic Analysis

1) From the **Analysis** menu select **Static** and submenu option **2nd-Order Elastic**.

2) At the bottom menu bar, the **Analysis Type:** should already be set to **Space Frame** as desired.

3) Click on the **Apply** button to perform the analysis.

4) From the **Results** menu select **Diagrams** and submenu option **Deflected Shape**.

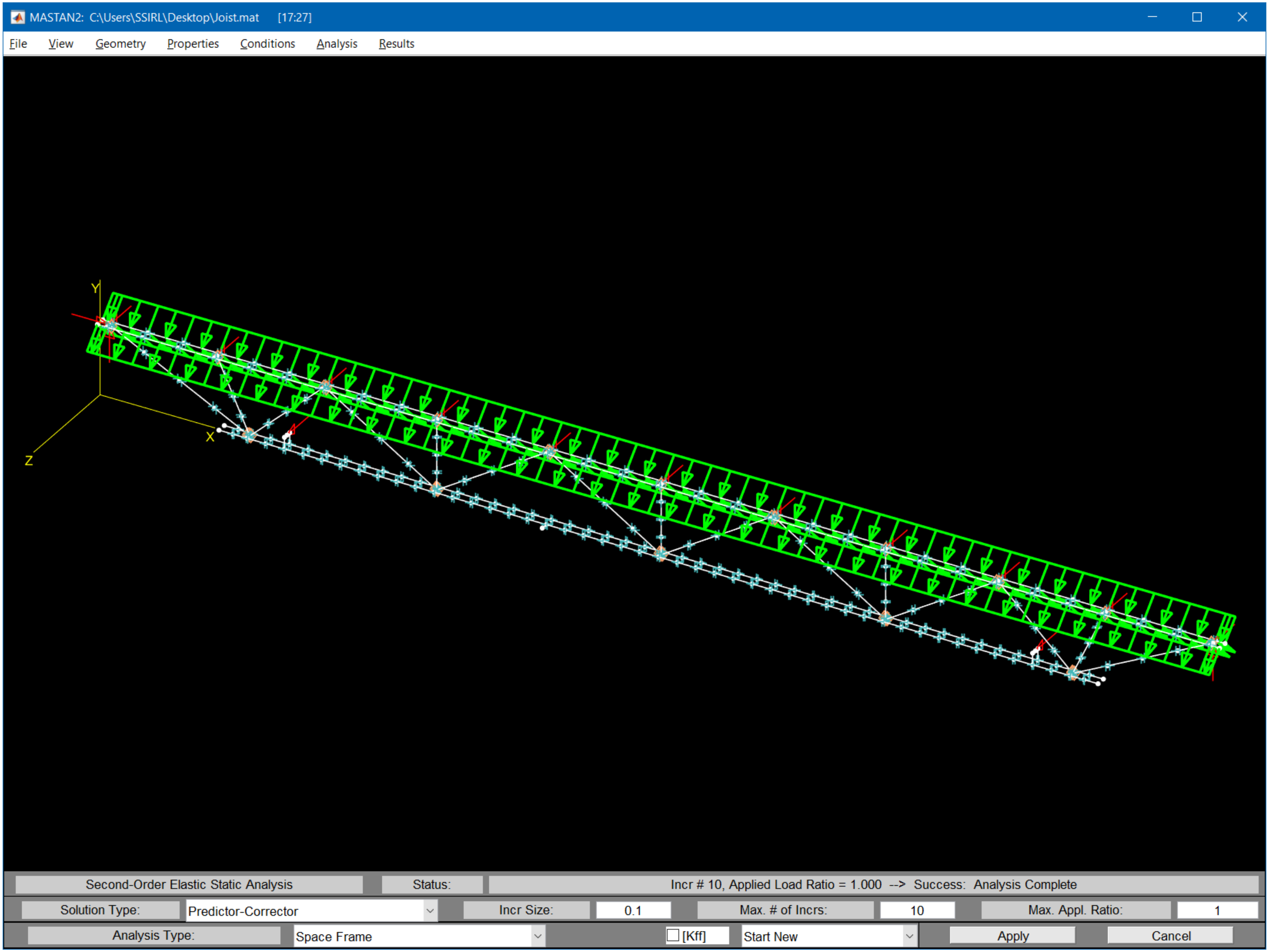
5) At the bottom menu bar, click on the **Apply** button.

To better see what deformation is occurring, it can be useful to make use of the other defined view. From the **View** menu select **Defined Views** and make use of the submenu options for these ideas.

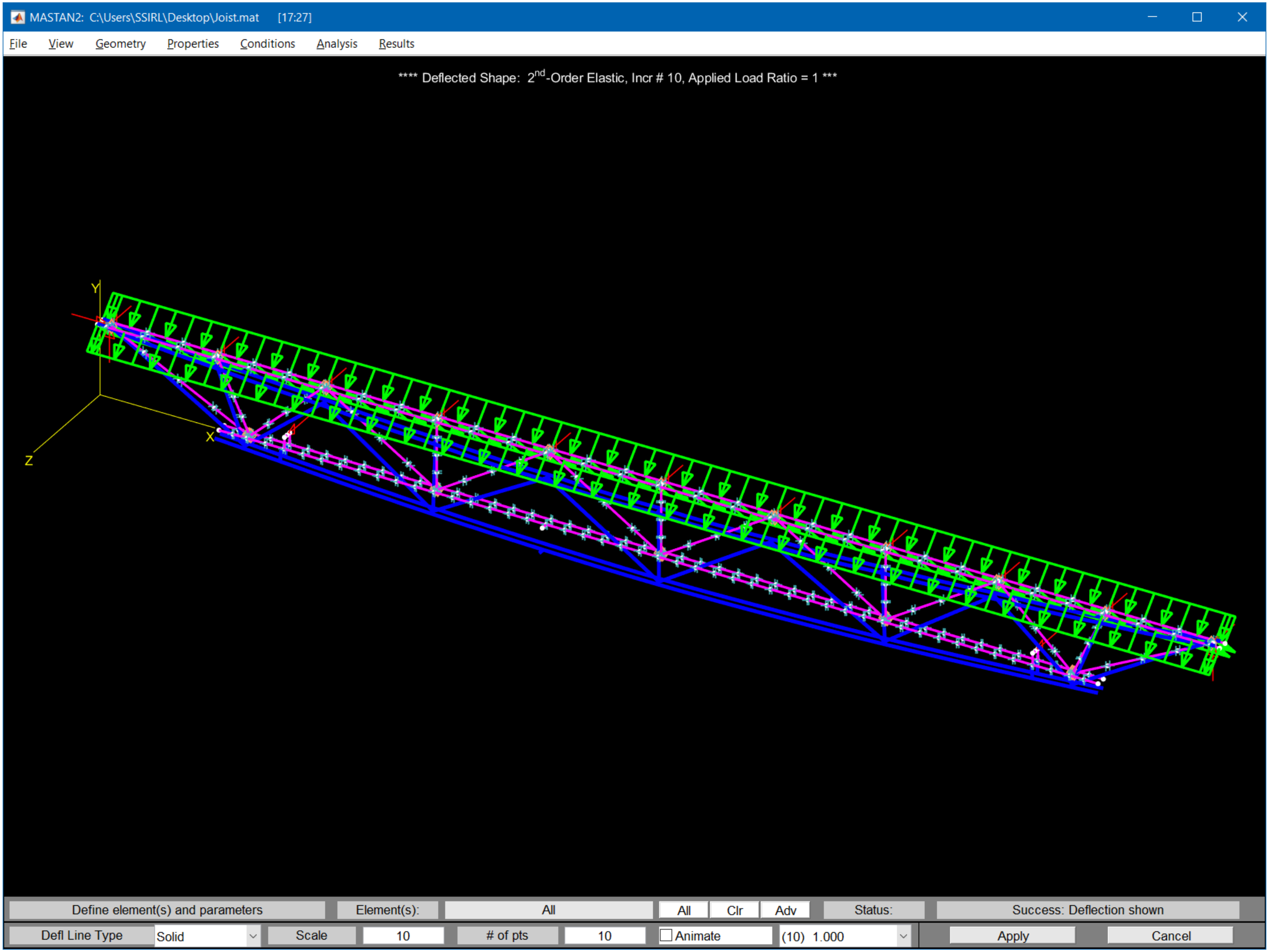
1) Option **Front view: x-y**.: How the vertical deflection is varying along the length
2) Option **Side view: y-z**.: How big the lateral deflection is compared to the joist
3) Option **Top view: x-z**.: How the lateral deflection varies along the length
4) Option **Isometric: x-y-z**.: Will return to the original view

It may be desired to update the deflected shape diagram with different scale factors during this process.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Second-Order Elastic Static Analysis
Status:
Incr # 10, Applied Load Ratio = 1.000 --> Success: Analysis Complete
Solution Type:
Predictor-Corrector
Incr Size:
0.1
Max. # of Incrs:
10
Max. Appl. Ratio:
1
Analysis Type:
Space Frame
[Kff]
Start New
Apply
Cancel

MASTAN2



MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File
View
Geometry
Properties
Conditions
Analysis
Results
**** Deflected Shape: 2nd-Order Elastic, Incr # 10, Applied Load Ratio = 1 ***
Y
X
Z
Define element(s) and parameters
Element(s):
All
All
Clr
Adv
Status:
Success: Deflection shown
Defl Line Type
Solid
Scale
10
# of pts
10
Animate
(10) 1.000
Apply
Cancel

Uniform Loading Results

1) From the **Results** menu select **Node Displacements**.

2) On the undeflected shape, click on the midspan node of interest, node **173**, and the displacements for base 6 degree of freedoms are provided in the bottom menu bar.

Calculated vertical deflection: 0.59 in

Estimated deflection using SJI recommendations:

$$I_j = 26.767 \cdot W \cdot L^3 \cdot 10^{-6} = 26.767 \cdot 297plf \cdot (20ft - 4in)^3 \cdot 10^{-6} = 60.47in^4$$

$$\delta = 1.15 \cdot \frac{5WL^4}{384EI} = 1.15 \cdot \frac{5 \cdot 300plf(20ft - 4in)^4}{384 \cdot 29000ksi \cdot 60.47in^4} = 0.66in$$

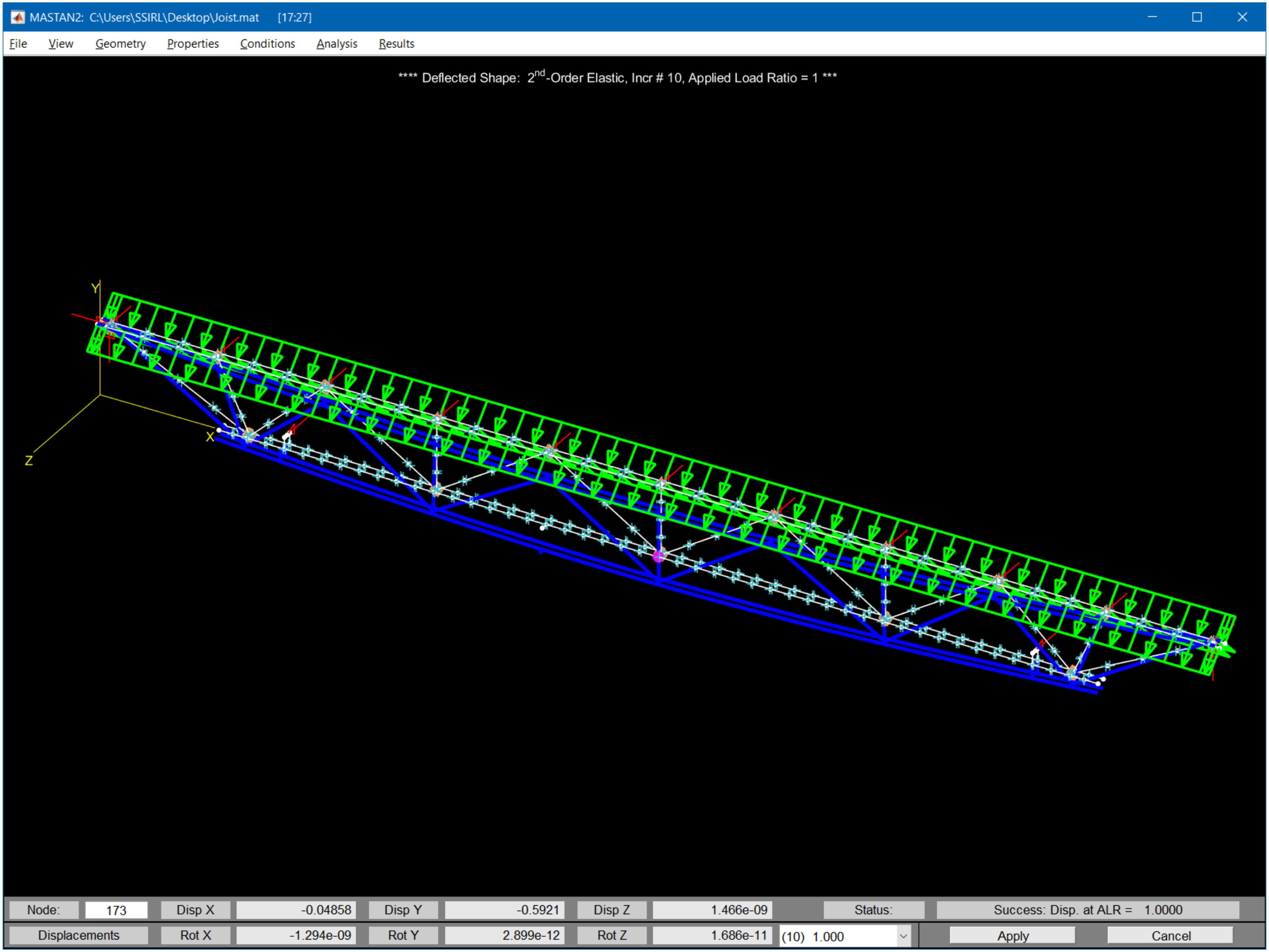
Estimation using area of chords to calculate I:

$$I_A = 2 \cdot (0.29895in^2 \cdot (8.282in)^2 + 0.36199in^2 \cdot (15.121in - 8.282in)^2) = 74.87in^4$$

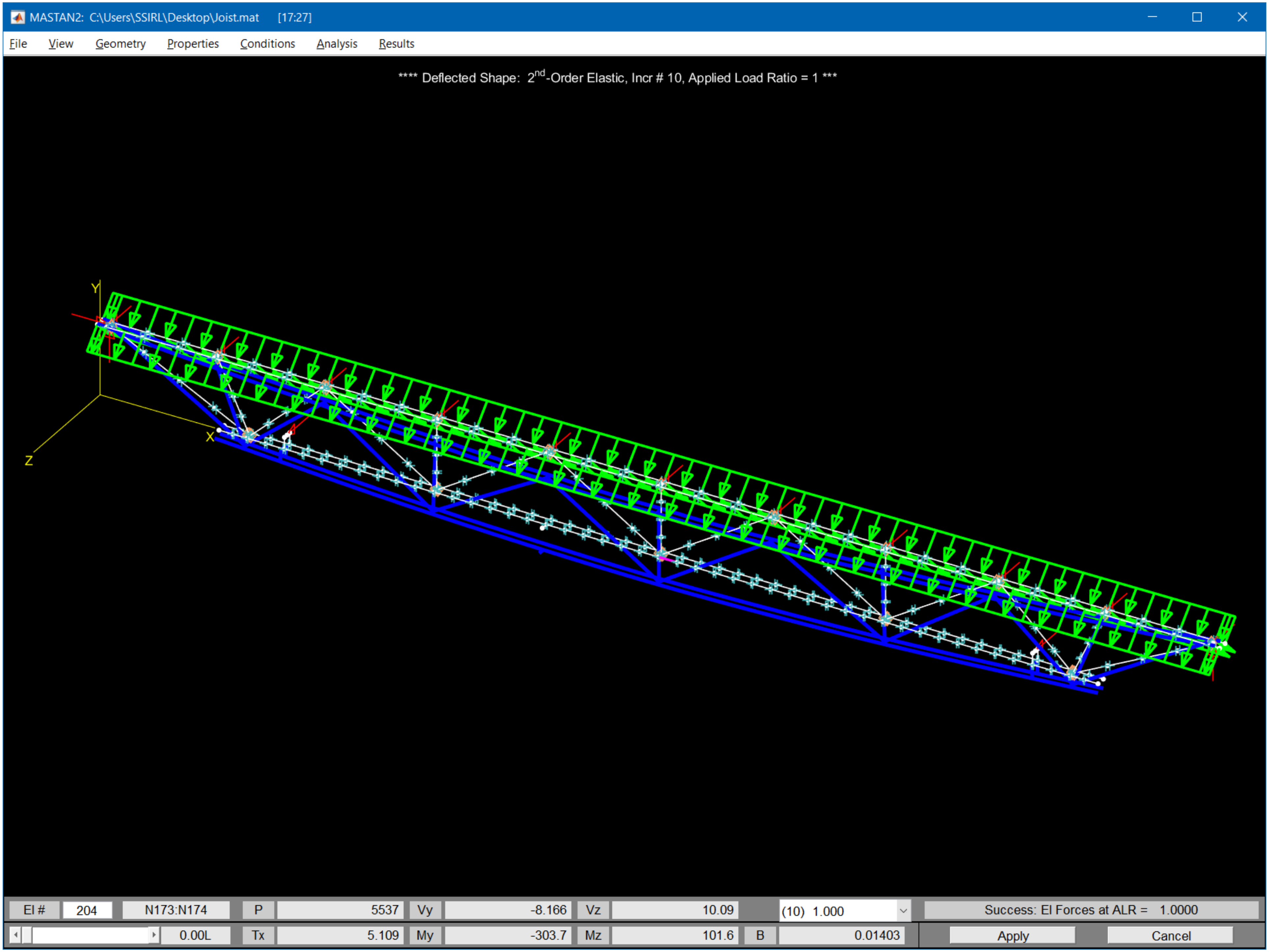
$$\delta = 1.15 \cdot \frac{5WL^4}{384EI} = 1.15 \cdot \frac{5 \cdot 300plf(20ft - 4in)^4}{384 \cdot 29000ksi \cdot 74.87in^4} = 0.53in$$

3) From the **Results** menu select **Element Forces**.

4) On the undeflected shape, click on the span element of interest, element **204**, and the internal forces are provided in the bottom menu bar. These are the forces at the start of the member.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File
View
Geometry
Properties
Conditions
Analysis
Results
**** Deflected Shape: 2nd-Order Elastic, Incr # 10, Applied Load Ratio = 1 ***
Y
X
Z
Node:
173
Disp X
-0.04858
Disp Y
-0.5921
Disp Z
1.466e-09
Status:
Success: Disp. at ALR = 1.0000
Displacements
Rot X
-1.294e-09
Rot Y
2.899e-12
Rot Z
1.686e-11
(10) 1.000
Apply
Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File View Geometry Properties Conditions Analysis Results
**** Deflected Shape: 2nd-Order Elastic, Incr # 10, Applied Load Ratio = 1 ***
Y
X
Z
El # 204 N173:N174 P 5537 Vy -8.166 Vz 10.09 (10) 1.000 Success: El Forces at ALR = 1.0000
0.00L Tx 5.109 My -303.7 Mz 101.6 B 0.01403 Apply Cancel

Section 6: Hanging Load Analysis

Eccentric Loading

1) From the **Results** menu select **Diagrams** and submenu option **None**.

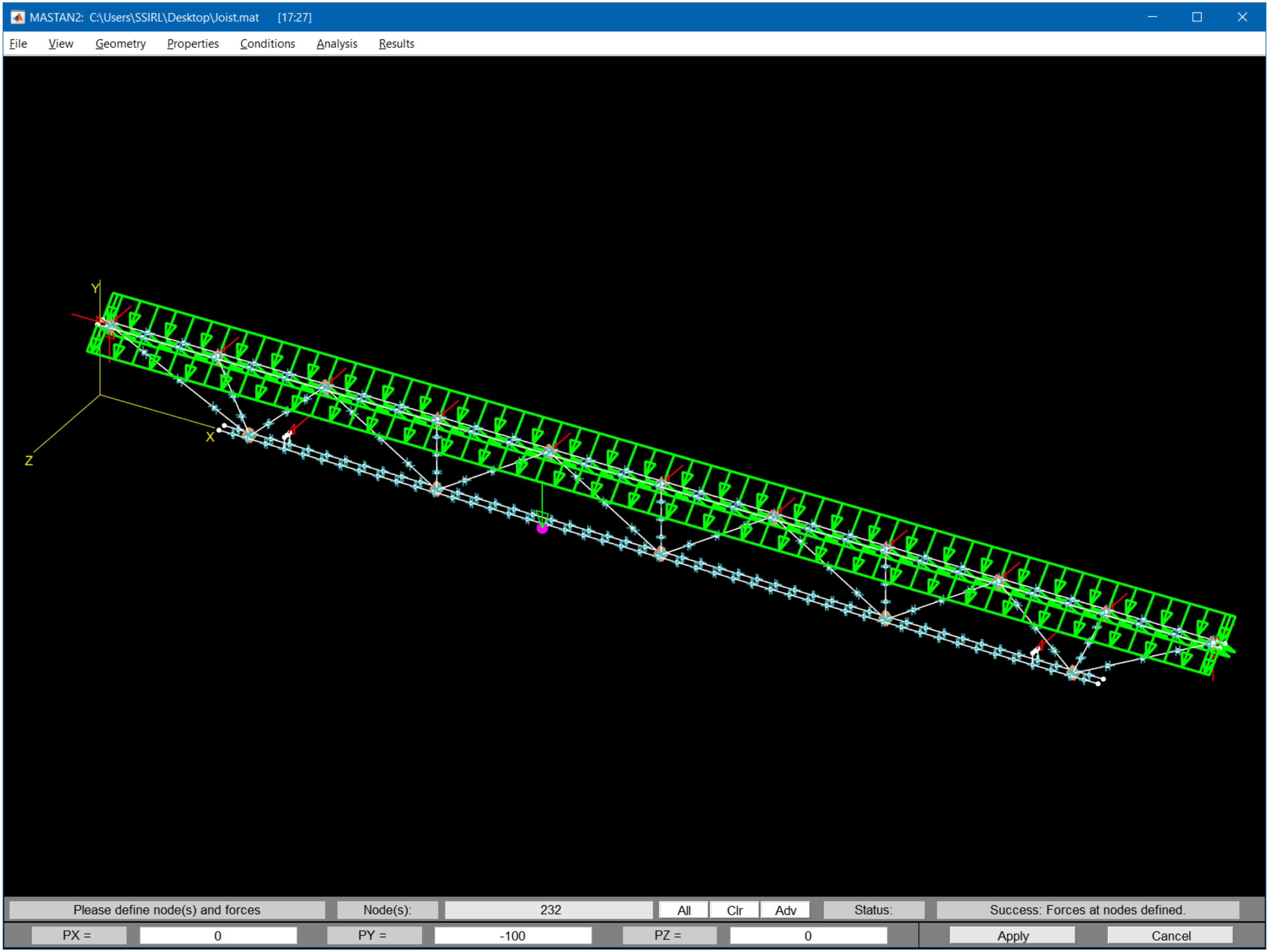
2) From the **Conditions** menu select **Define Forces**.

3) At the bottom menu bar, click in the edit box just to the right of **PY =** and change **0** to **-100** to create a handing load.

4) Click on the node at the tip of the eccentric arm created at the end of the geometry modeling, node **232**.

5) Click on the **Apply** button.

MASTAN2

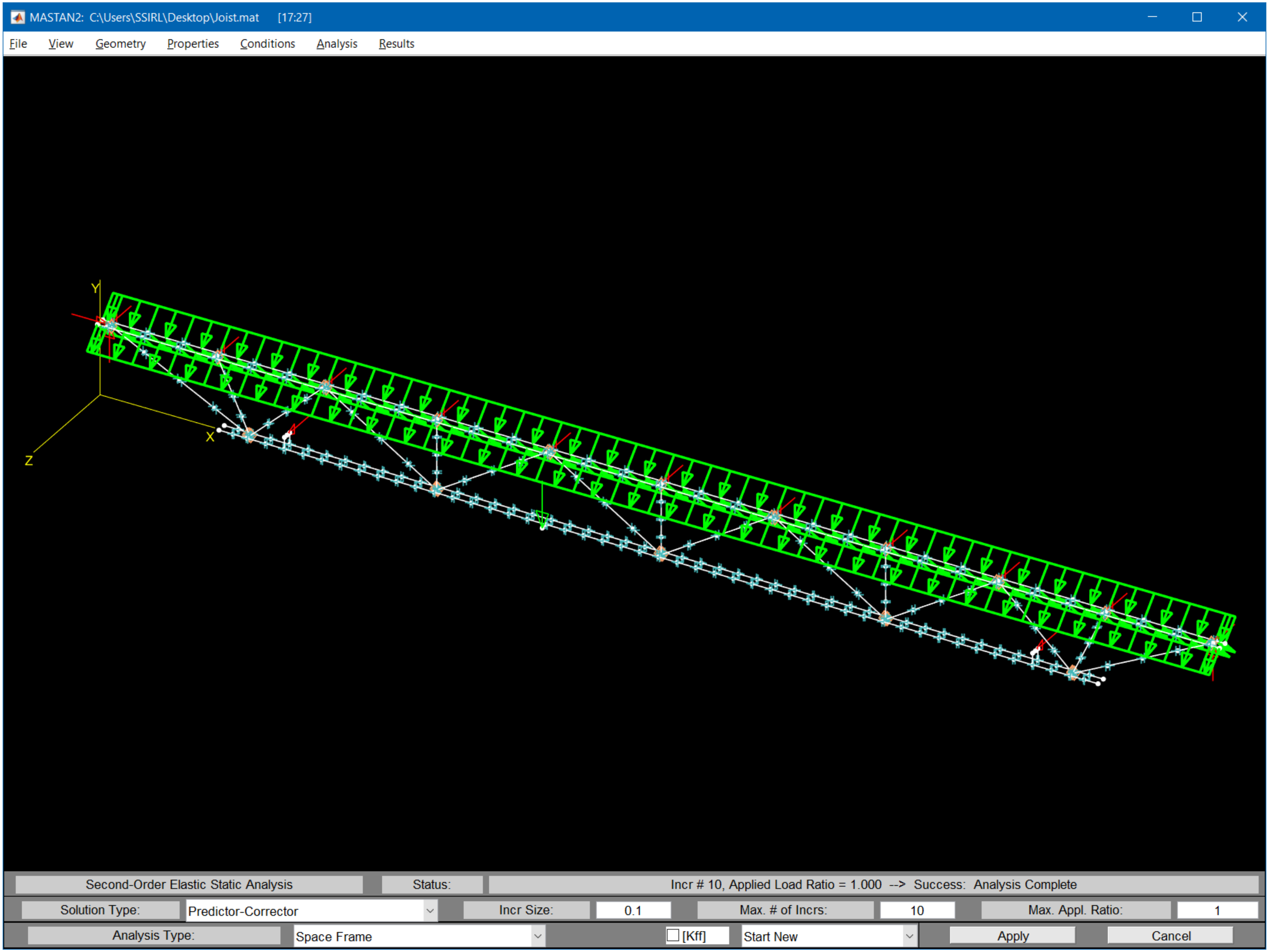

MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Please define node(s) and forces
Node(s):
232
All
Clr
Adv
Status:
Success: Forces at nodes defined.
PX =
0
PY =
-100
PZ =
0
Apply
Cancel

Eccentrically Loaded Joist Elastic Analysis

1) From the **Analysis** menu select **Static** and submenu option **2nd-Order Elastic**.

2) At the bottom menu bar, the **Analysis Type:** should already be set to **Space Frame** as desired.

3) Click on the **Apply** button to perform the analysis.


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Second-Order Elastic Static Analysis
Status:
Incr # 10, Applied Load Ratio = 1.000 --> Success: Analysis Complete
Solution Type:
Predictor-Corrector
Incr Size:
0.1
Max. # of Incrs:
10
Max. Appl. Ratio:
1
Analysis Type:
Space Frame
[Kff]
Start New
Apply
Cancel

Eccentrically Loaded Joist Elastic Results

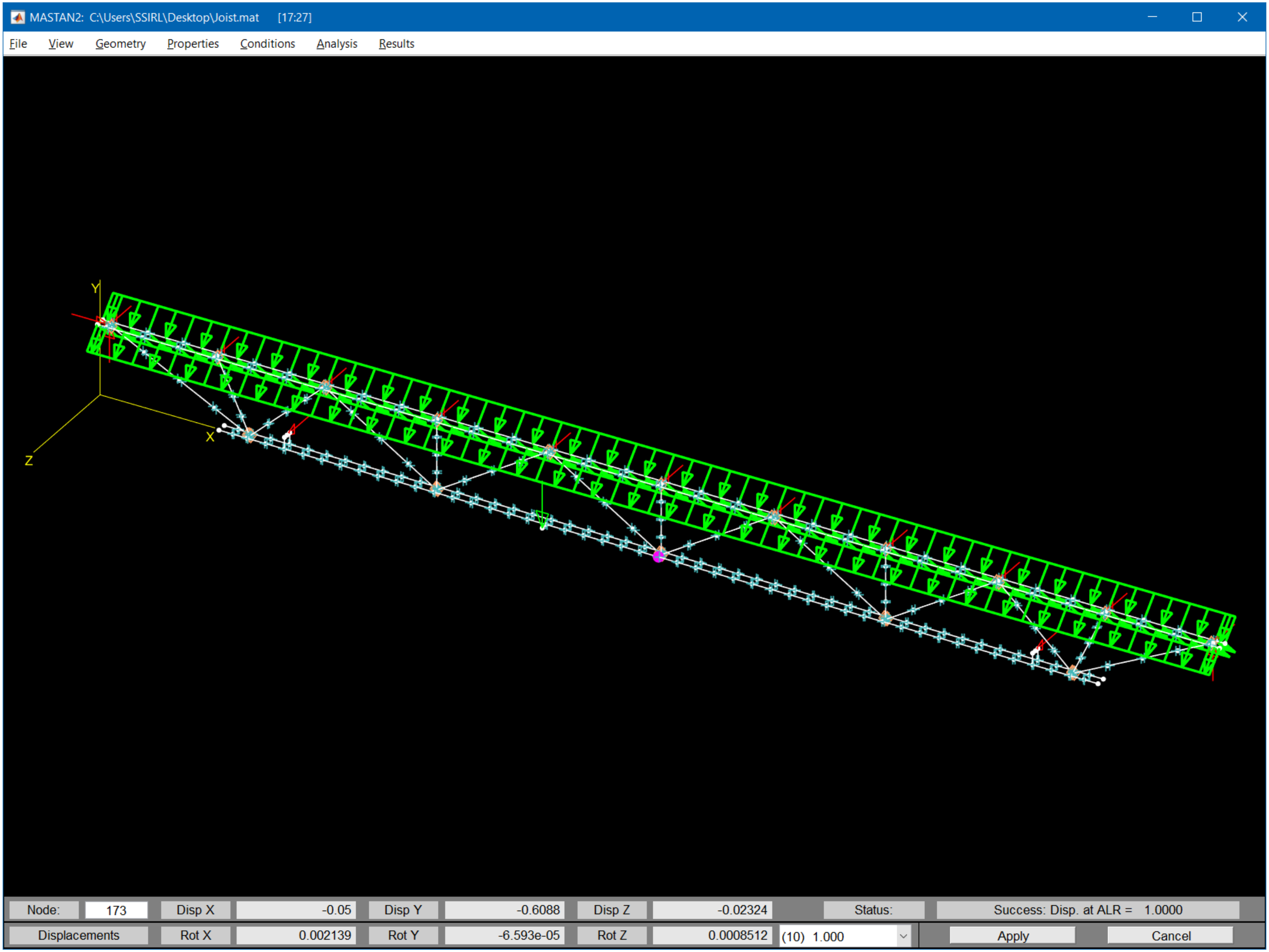
1) From the **Results** menu select **Node Displacements**.

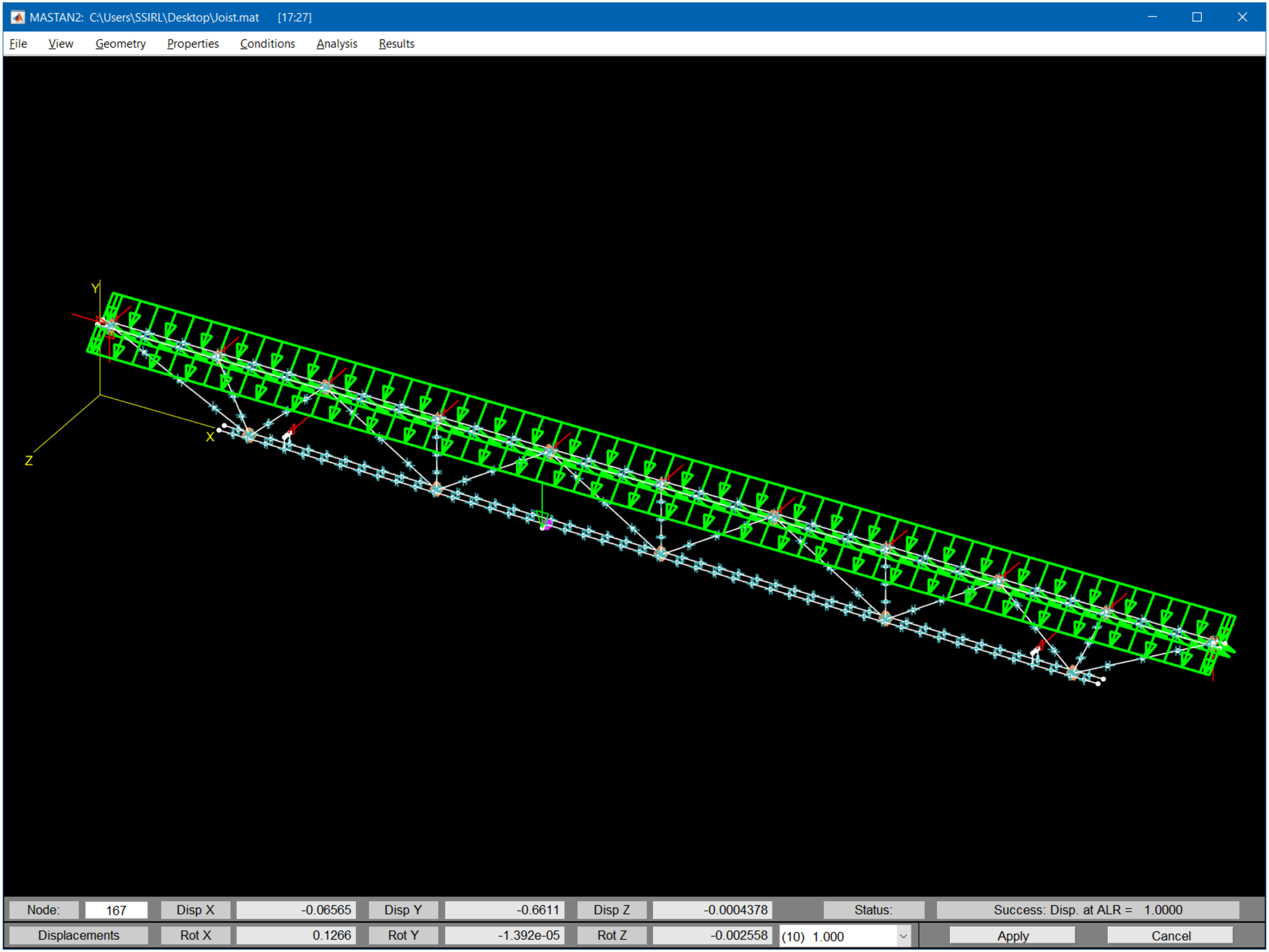
2) At the bottom menu bar, click on the **Apply** button.

3) On the undeflected shape, click on the midspan node of interest, node **173**, to see how the change to the midspan deflection from the eccentric load.

4) On the undeflected shape, click on the node of the bottom chord attached to the eccentric loading arm, node **167**, to see how the hanging load moved the chord.

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
Node:
173
Disp X
-0.05
Disp Y
-0.6088
Disp Z
-0.02324
Status:
Success: Disp. at ALR = 1.0000
Displacements
Rot X
0.002139
Rot Y
-6.593e-05
Rot Z
0.0008512
(10) 1.000
Apply
Cancel



MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
Node: 167 Disp X -0.06565 Disp Y -0.6611 Disp Z -0.0004378 Status: Success: Disp. at ALR = 1.0000
Displacements Rot X 0.1266 Rot Y -1.392e-05 Rot Z -0.002558 (10) 1.000 Apply Cancel

MASTAN2

Stress Calculations

Using the results available within the MASTAN2 model, it is possible to calculate the internal stresses that the members are experiencing. Provided in this tutorial are the steps to pull the necessary values from MASTAN2 and the resulting stresses.

Additional details on the necessary calculations are available in the “Pour Stop” tutorial.

Getting Internal Forces

1) From the **Results** menu select **Element Forces**.

2) On the undeflected shape, click on the midspan element of interest, element **198**, and the internal forces are provided in the bottom menu bar. These are the forces at the start of the member and the middle of the beam.

3) These forces will be used to calculate the stresses at the middle of the beam.

4) At the bottom menu bar, drag the slider in the over left-hand corner until the position indicator just to the right displays **1.00L**.

5) Click on the **Apply** button. These are the forces at the end of the member.

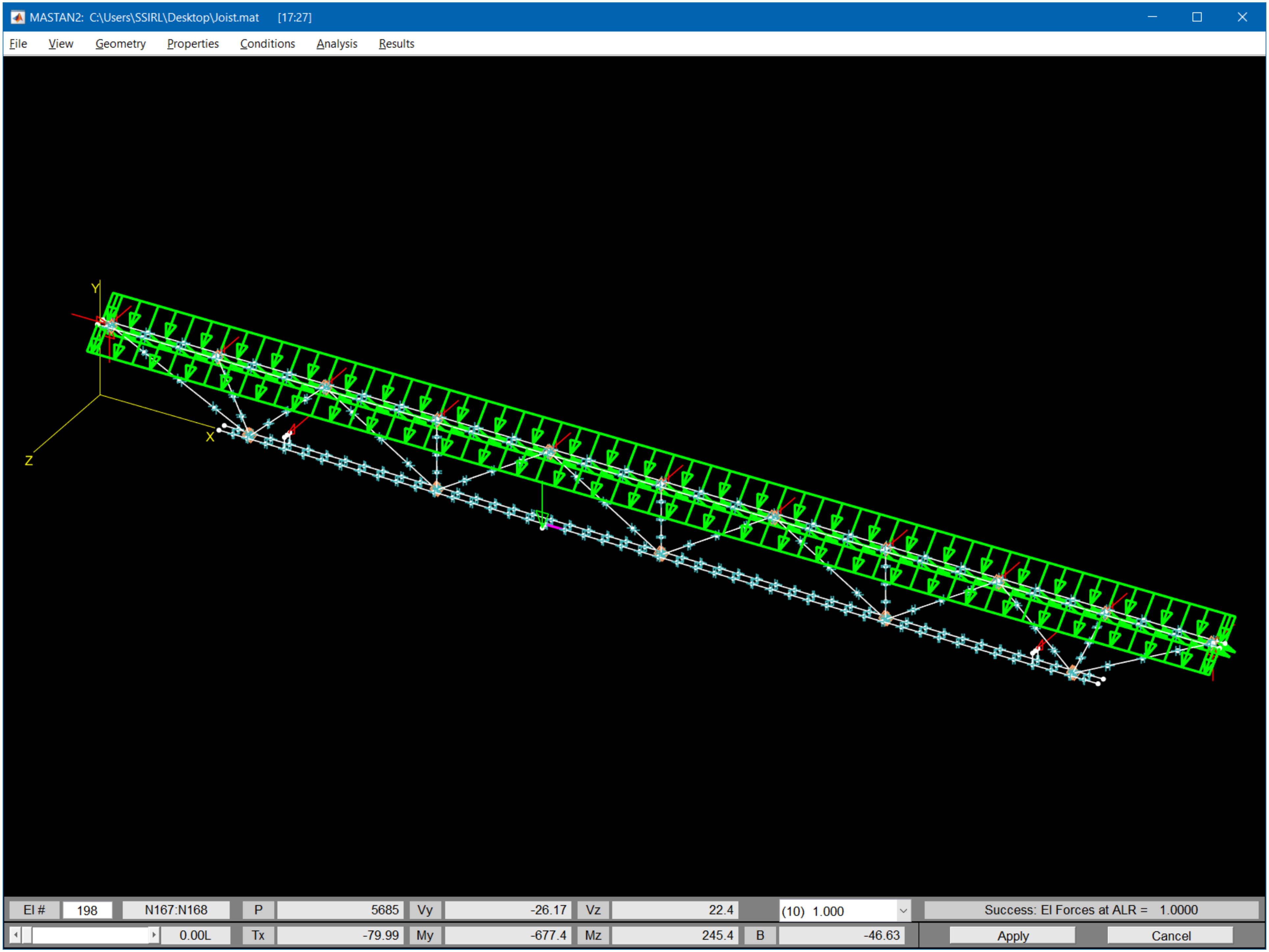
6) From this position, the bimoment is required to appropriately divide the longitudinal moment into the standard twisting and warping components for stress calculations.

7) Repeat these steps to get the internal forces in element **192**. This is where the larger negative moment on the bottom chord now occurs.

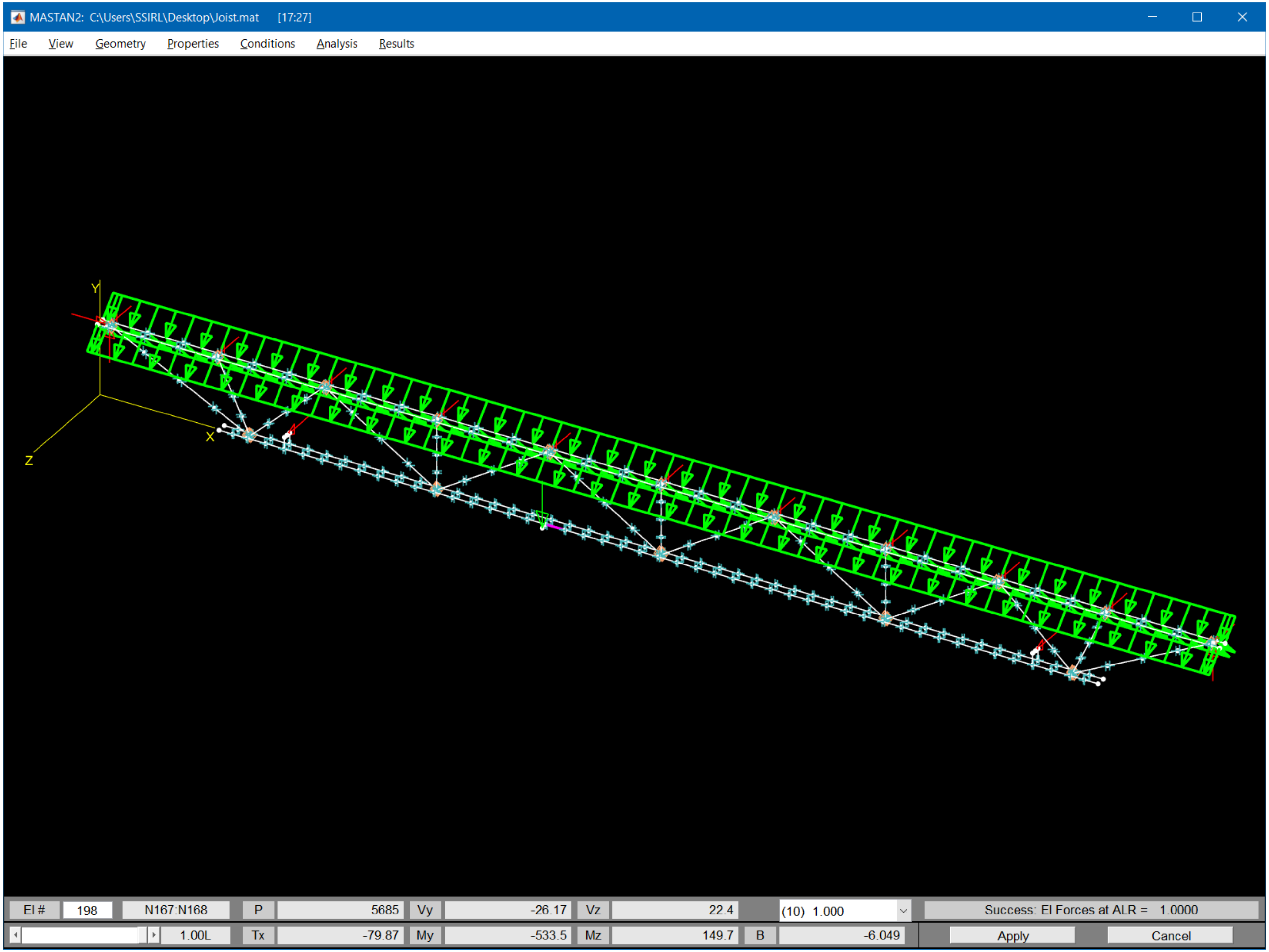
The forces at the start:

The forces at the end:

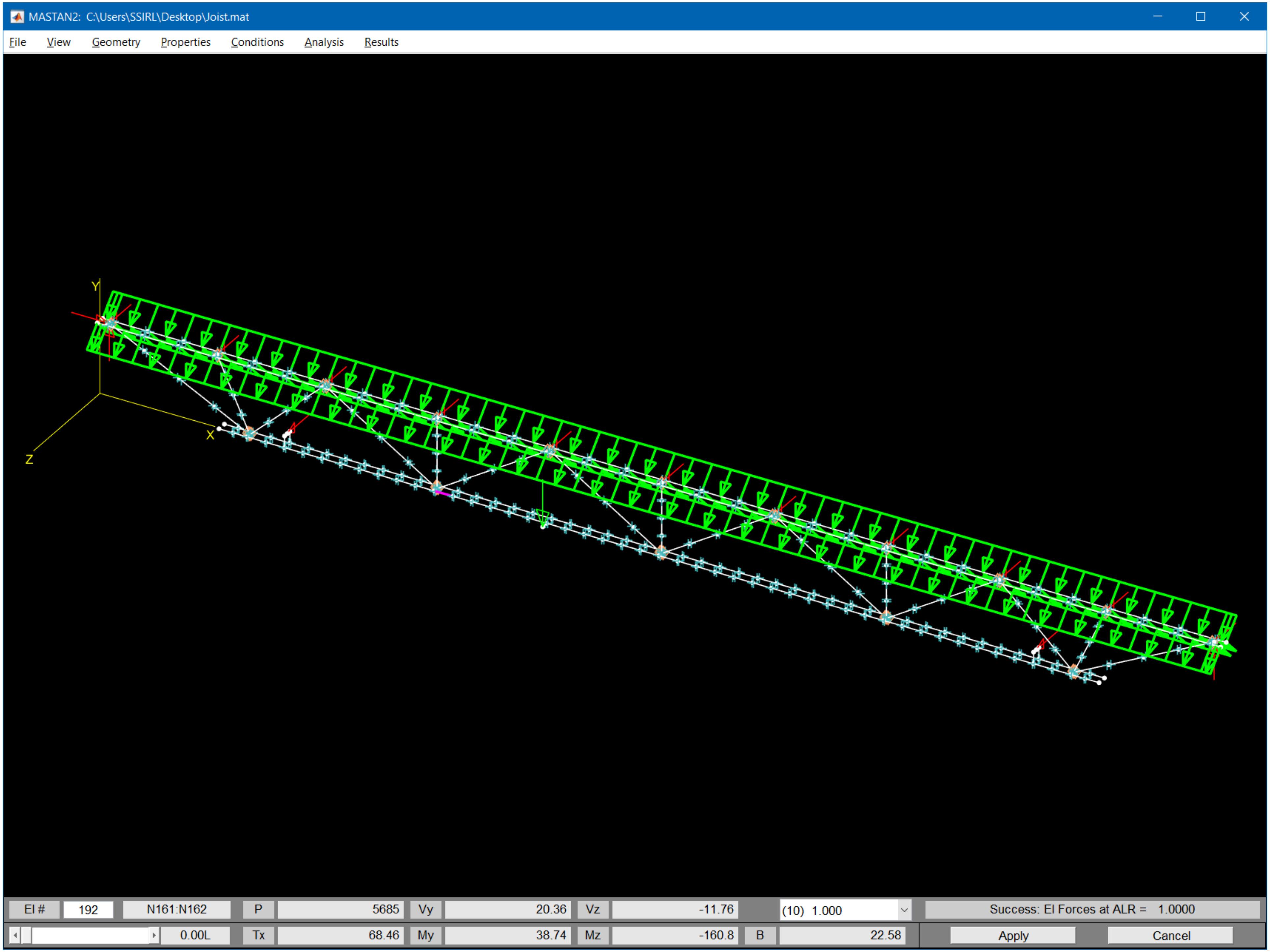
MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
El # 198 N167:N168 P 5685 Vy -26.17 Vz 22.4 (10) 1.000 Success: El Forces at ALR = 1.0000
0.00L Tx -79.99 My -677.4 Mz 245.4 B -46.63 Apply Cancel

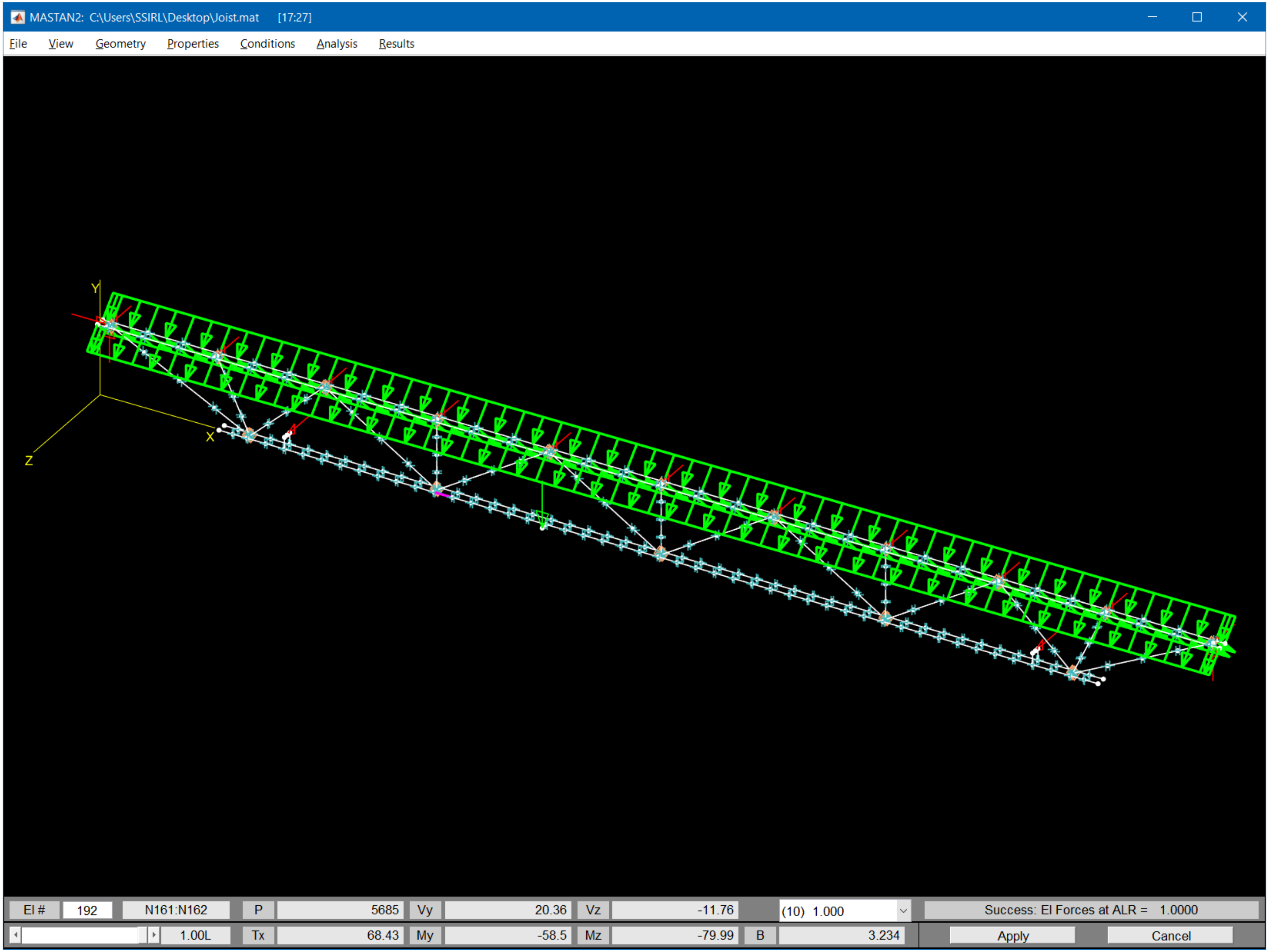
MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File View Geometry Properties Conditions Analysis Results
Y
X
Z
El # 198 N167:N168 P 5685 Vy -26.17 Vz 22.4 (10) 1.000 Success: El Forces at ALR = 1.0000
1.00L Tx -79.87 My -533.5 Mz 149.7 B -6.049 Apply Cancel

MASTAN2

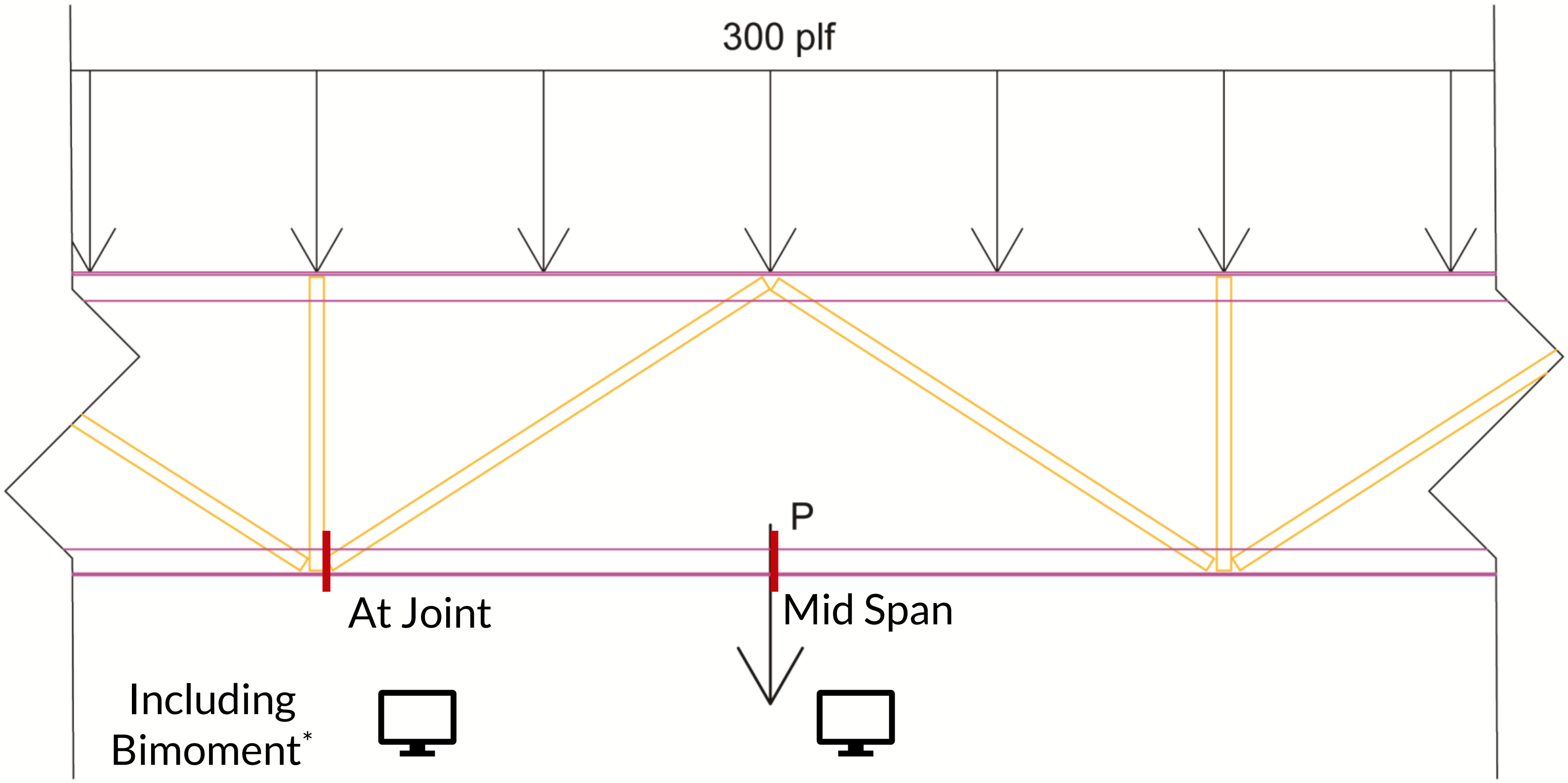

MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
El #
192
N161:N162
P
5685
Vy
20.36
Vz
-11.76
(10) 1.000
Success: El Forces at ALR = 1.0000
0.00L
Tx
68.46
My
38.74
Mz
-160.8
B
22.58
Apply
Cancel

MASTAN2


MASTAN2: C:\Users\SSIRL\Desktop\Joist.mat [17:27]
File
View
Geometry
Properties
Conditions
Analysis
Results
Y
X
Z
El #
192
N161:N162
P
5685
Vy
20.36
Vz
-11.76
(10) 1.000
Success: El Forces at ALR = 1.0000
1.00L
Tx
68.43
My
-58.5
Mz
-79.99
B
3.234
Apply
Cancel

Stress Calculation Results

The resulting stresses are available for the locations identified on the sketch. The forces are calculated immediately after the web connection node and after the point load.



Including Bimoment*

Excluding Bimoment*

* Numerically bimoment exists in the model because the warping constant, Cω, is non-zero. Additional meshing of the model would refine the distribution of bimoment, but bimoment would still exist locally in the model at applied torque or supports and rapidly decrease to approximately zero along the majority of the length of the bottom chord. Since the evaluation of angles would often excludes the effects of warping, the internal stresses are provided having been calculated using the forces observed in this model including and excluding the bimoment values.

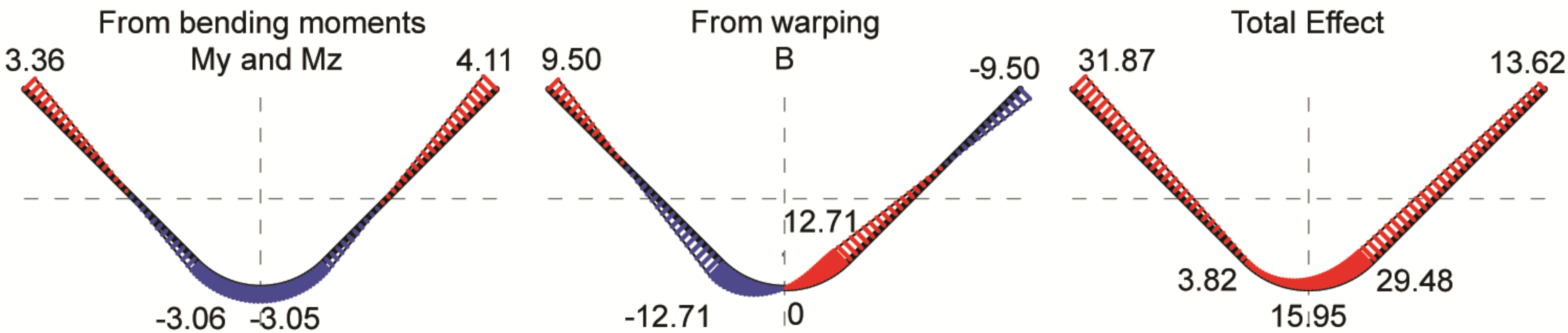
MASTAN2

Stresses at Joint including Bimoment

Normal Stresses (ksi)

Red - Tension, Blue - Compression

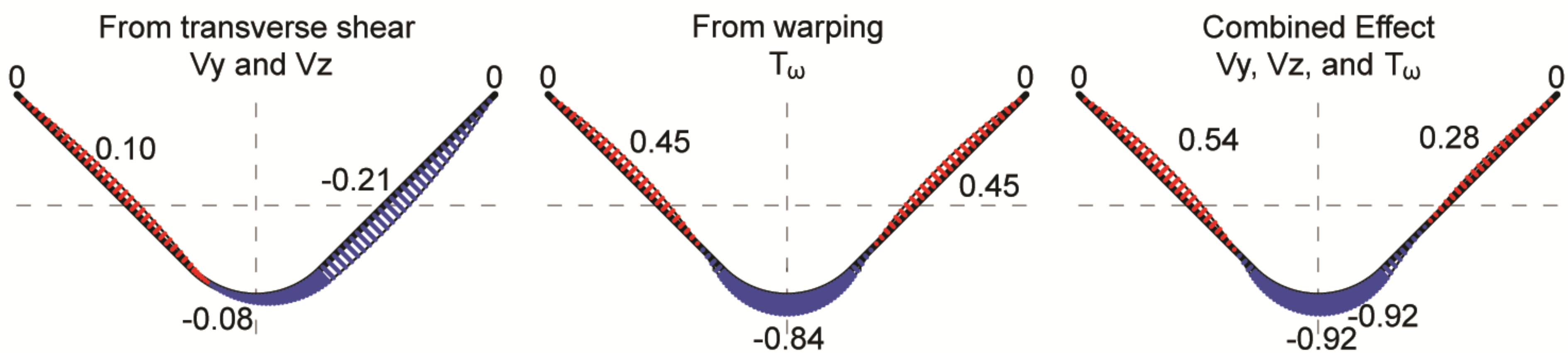
Diagram not shown: From axial force, P - Uniform 19.00 ksi tension



Shear Stresses (ksi)

Red - To the right, Blue - To the left

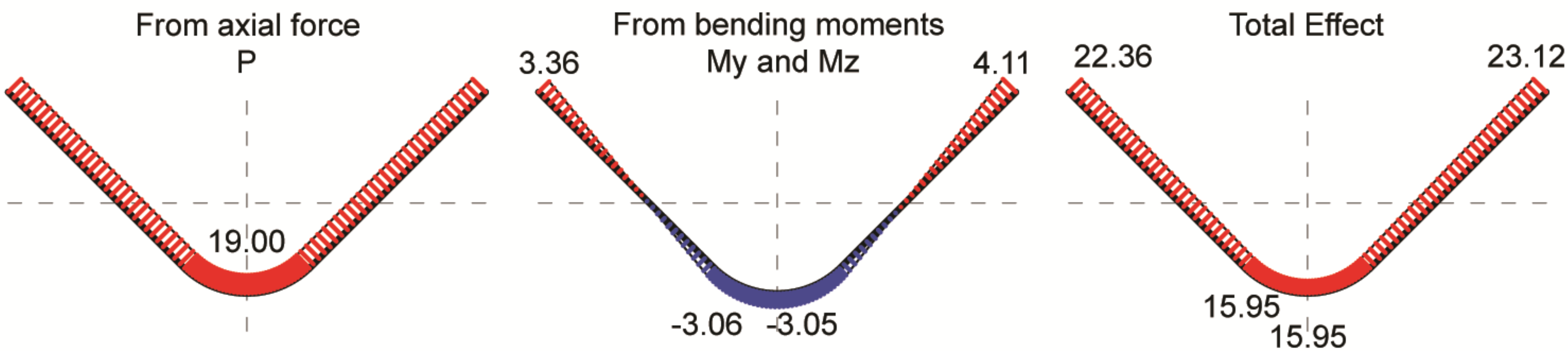
Diagram not shown: From torsional moment, T_T - Variable across thickness ±6.04 ksi



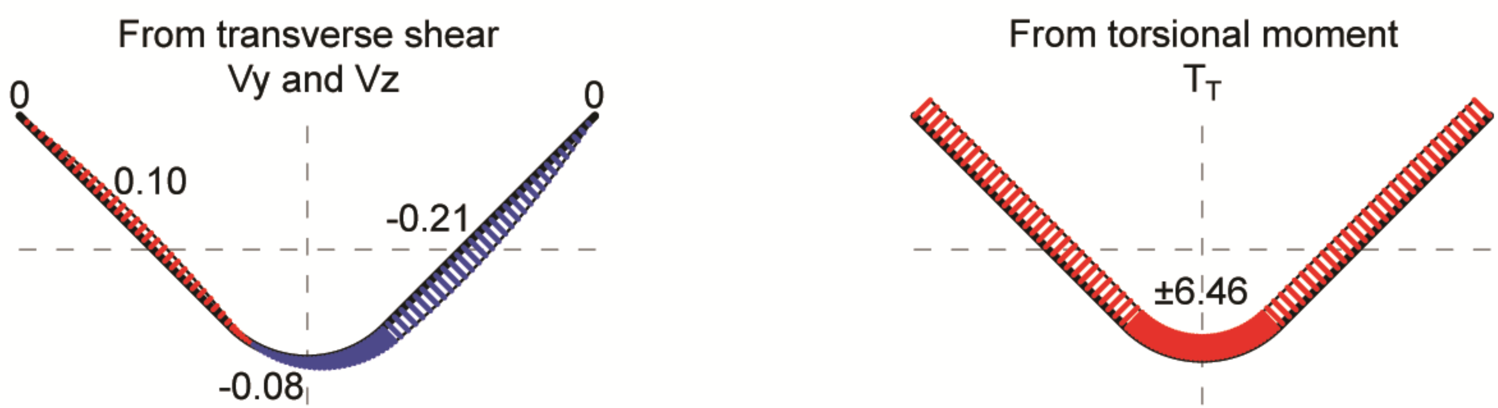
MASTAN2

Stresses at Joint excluding Bimoment

Normal Stresses (ksi)
Red - Tension, Blue - Compression



Shear Stresses (ksi)
Red - To the right, Blue - To the left

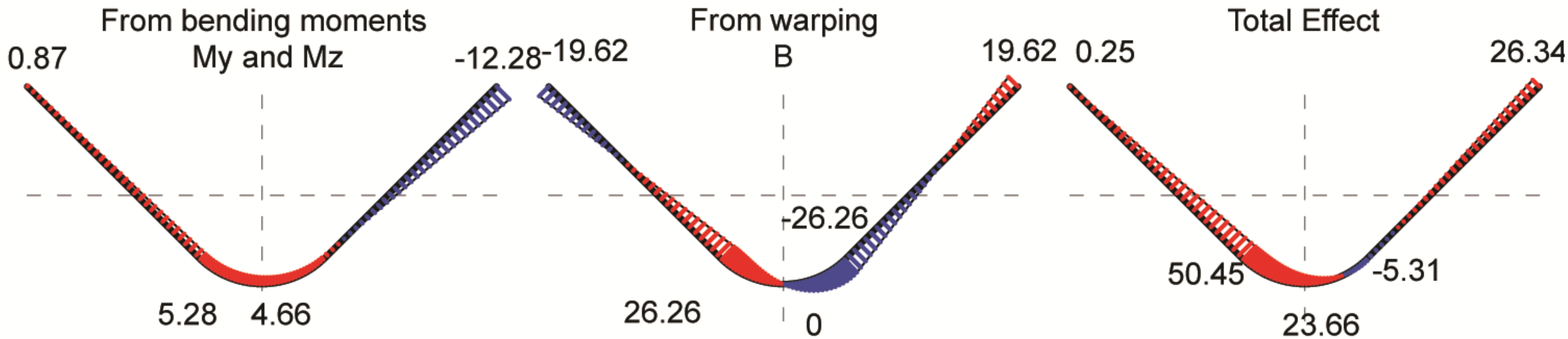


MASTAN2

Stresses at Midspan including Bimoment

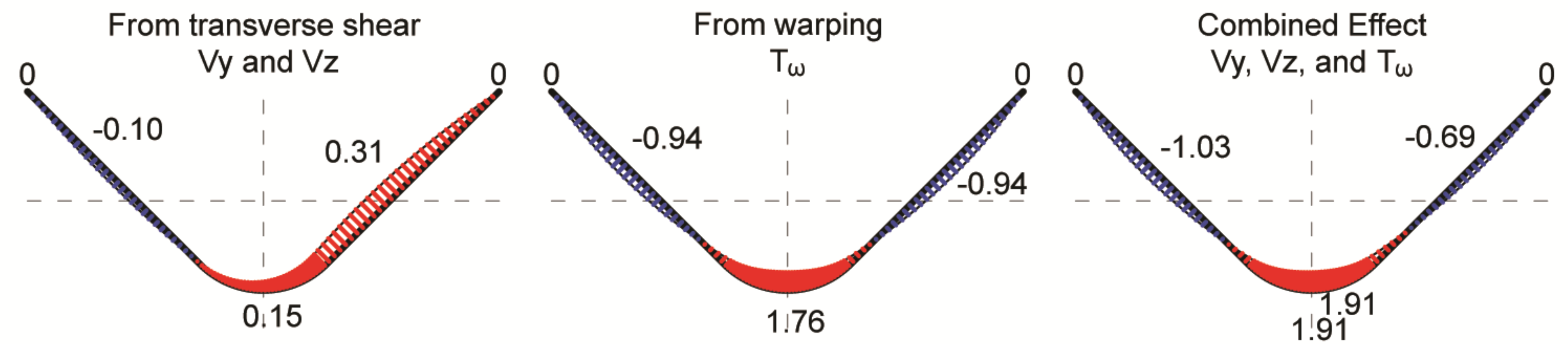
Normal Stresses (ksi)
Red - Tension, Blue - Compression

Diagram not shown: From axial force, P - Uniform 19.00 ksi tension

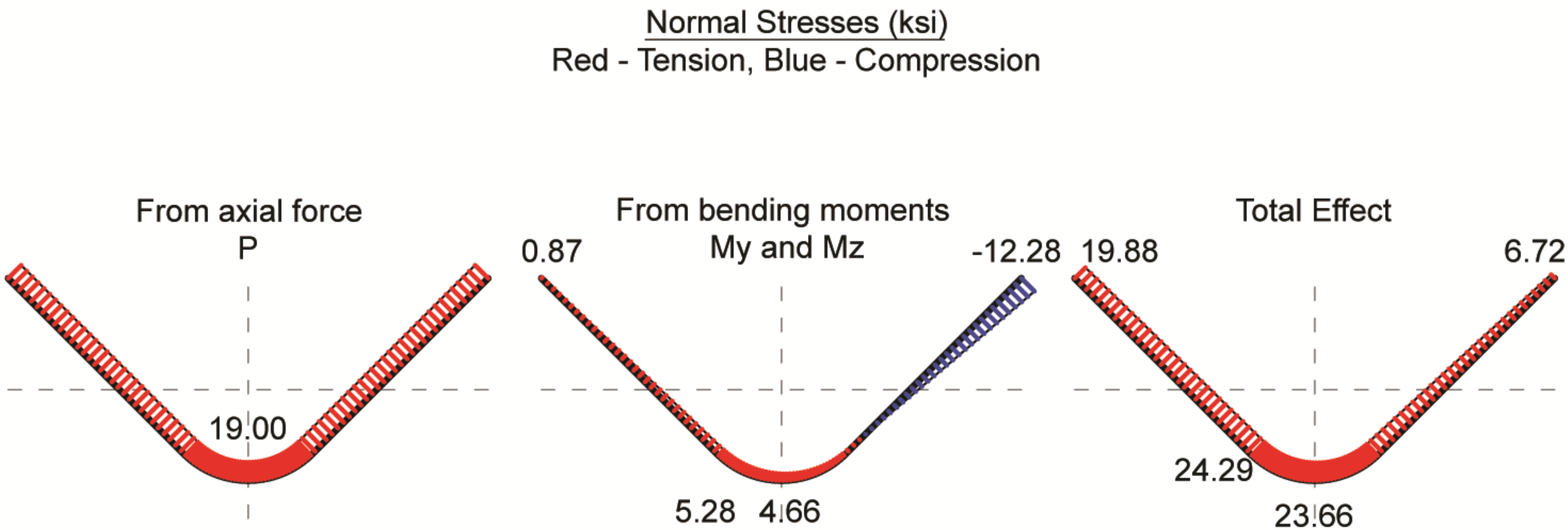


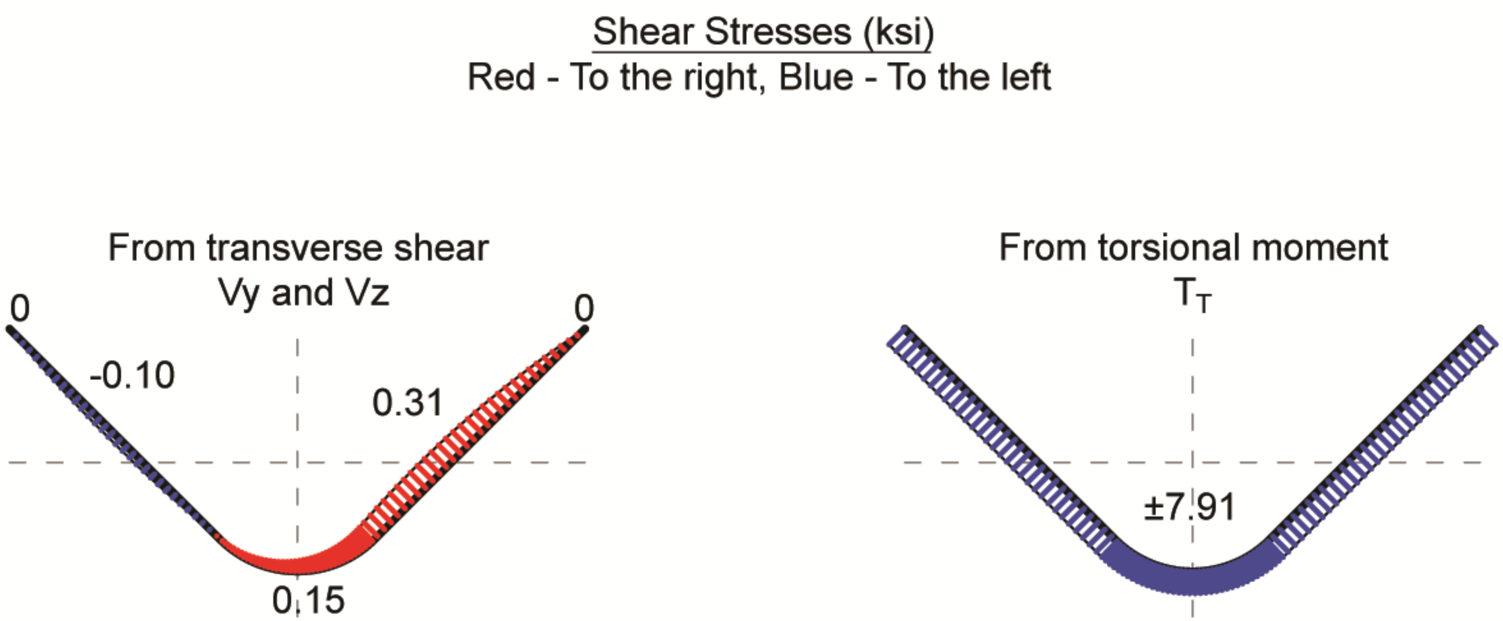
Shear Stresses (ksi)
Red - To the right, Blue - To the left

Diagram not shown: From torsional moment, T_T - Variable across thickness ±7.03 ksi



Stresses at Midspan <u>excluding</u> Bimoment





This completes the tutorial.