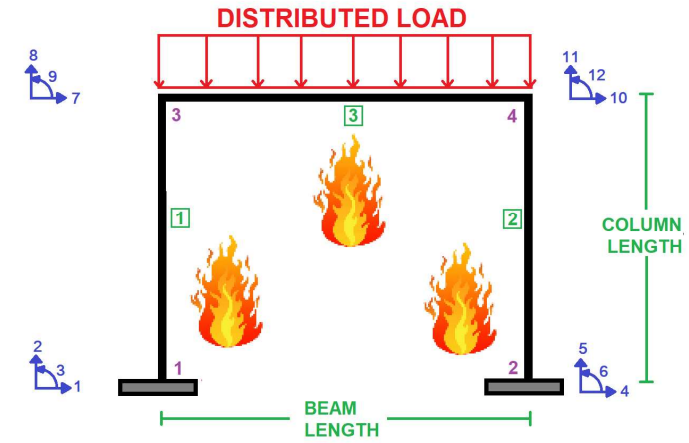
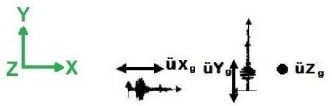
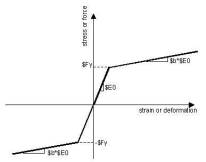
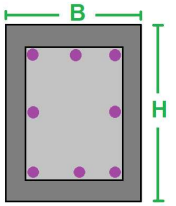




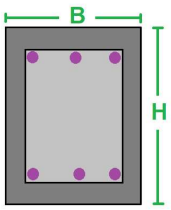
Concrete02 Thermal Material - Linear Tension Softening



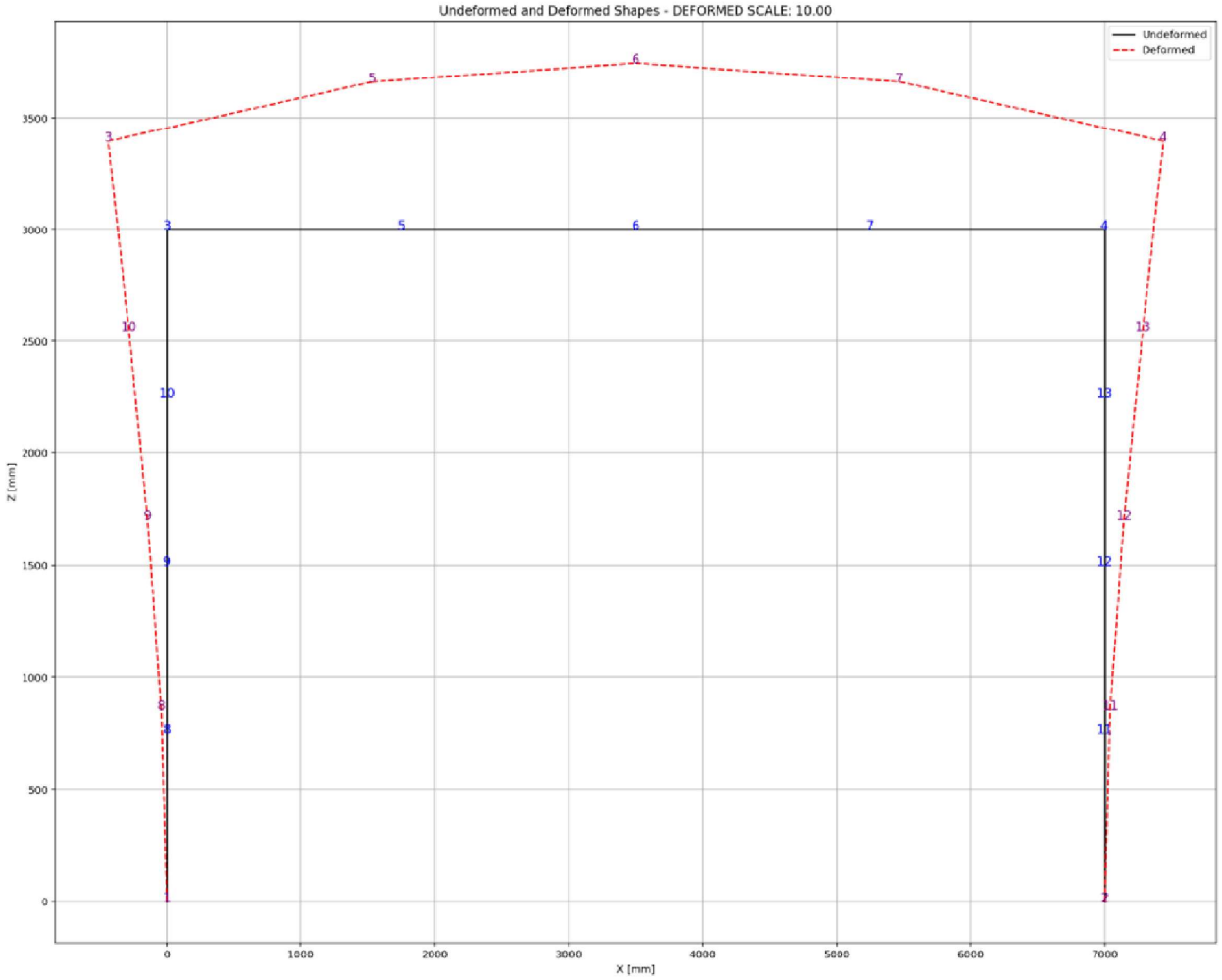
Steel01 Thermal Material



COLUMN SECTION



BEAM SECTION



IN THE NAME OF ALLAH

SEQUENTIAL THERMAL LOAD AND SEISMIC ANALYSIS OF A CONCRETE FRAME USING OPENSEES.
THERMAL LOAD APPLIED THERMAL LOAD ON ALL ELEMENTS

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

Spyder (Python 3.12)

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C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA..._ELEMENTS\CONCRETE_FRAME_THERMAL_LOAD-SEISMSIC.py

CONCRETE_FRAME_THERMAL_LOAD-SEISMSIC.py

```
#############################################################################################################
#                                          IN THE NAME OF ALLAH
#                    SEQUENTIAL THERMAL AND SEISMIC ANALYSIS OF A CONCRETE FRAME USING OPENSEES
#                                          APPLY THERMAL LOAD ON ALL ELEMENTS
#-------------------------------------------------------------------------------------------------------------
#                              THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                          EMAIL: salar.d.ghashghaei@gmail.com
#############################################################################################################

"""
Models and analyzes a 2D concrete frame subjected to both thermal gradients
 and distributed mechanical loads using OpenSees.

Key Features:
[1] Model Definition:
   - A two-dimensional frame is defined with user-specified nodal coordinates for multiple stories and bays.
   - Base supports are fixed.
   - Concrete material properties, including thermal expansion effects, are defined.
   - Beam and column cross-sections are modeled using fiber sections with rectangular concrete patches to capt

[2] Element and Load Assignment:
   - Beam-column elements are created with corotational geometric transformations to accommodate large displace
   - Lobatto integration is used for accurate numerical integration of the fiber sections.
   - Uniformly distributed loads are applied to beam elements.
   - A thermal gradient is imposed on the beams of the first story to simulate temperature-induced effects.

[3] Analysis Configuration:
   - Static analysis is conducted using load control with incremental thermal loading.
   - A Newton-Raphson solution algorithm is employed for iterative convergence.
   - Analysis tolerances and maximum iteration limits are set to ensure stability and accuracy.

[4] Output and Post-processing:
   - Node displacements, support reactions, and element deformations are recorded throughout the analysis.
   - Output data is post-processed to extract and plot base reactions (axial force, shear force, and bending mo
```

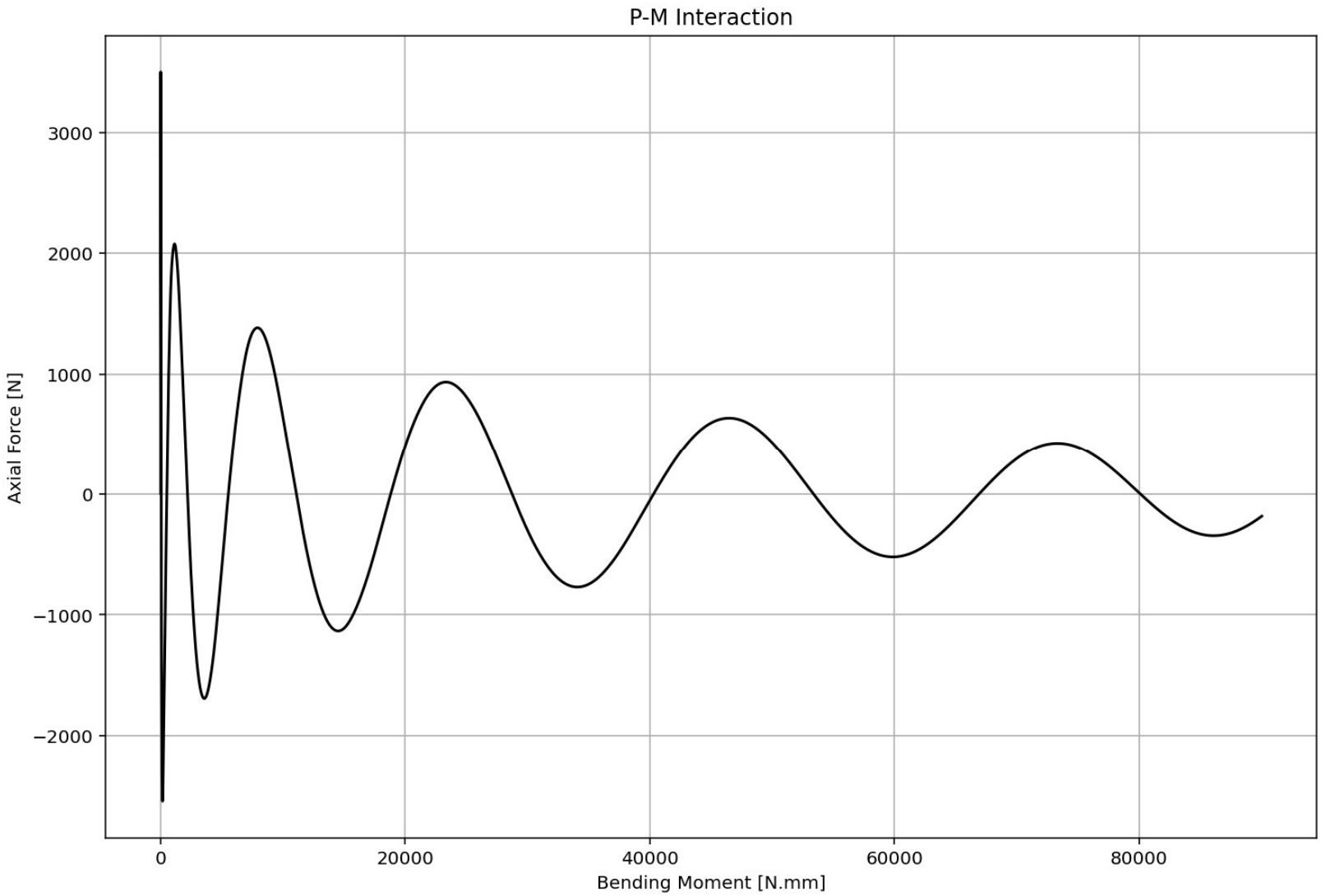
Help | Variable Explorer | Debugger | Plots | Files

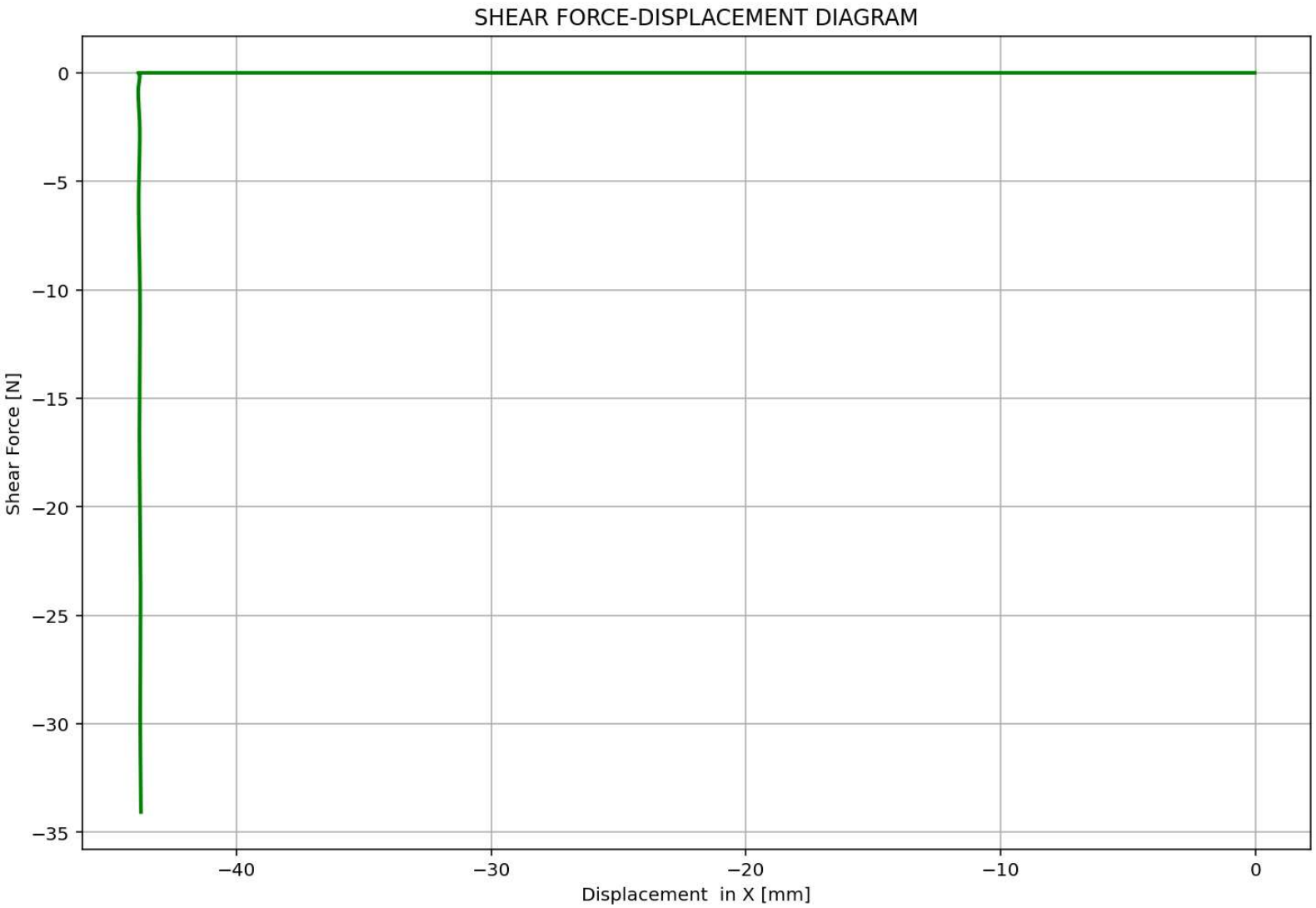
Console 1/A

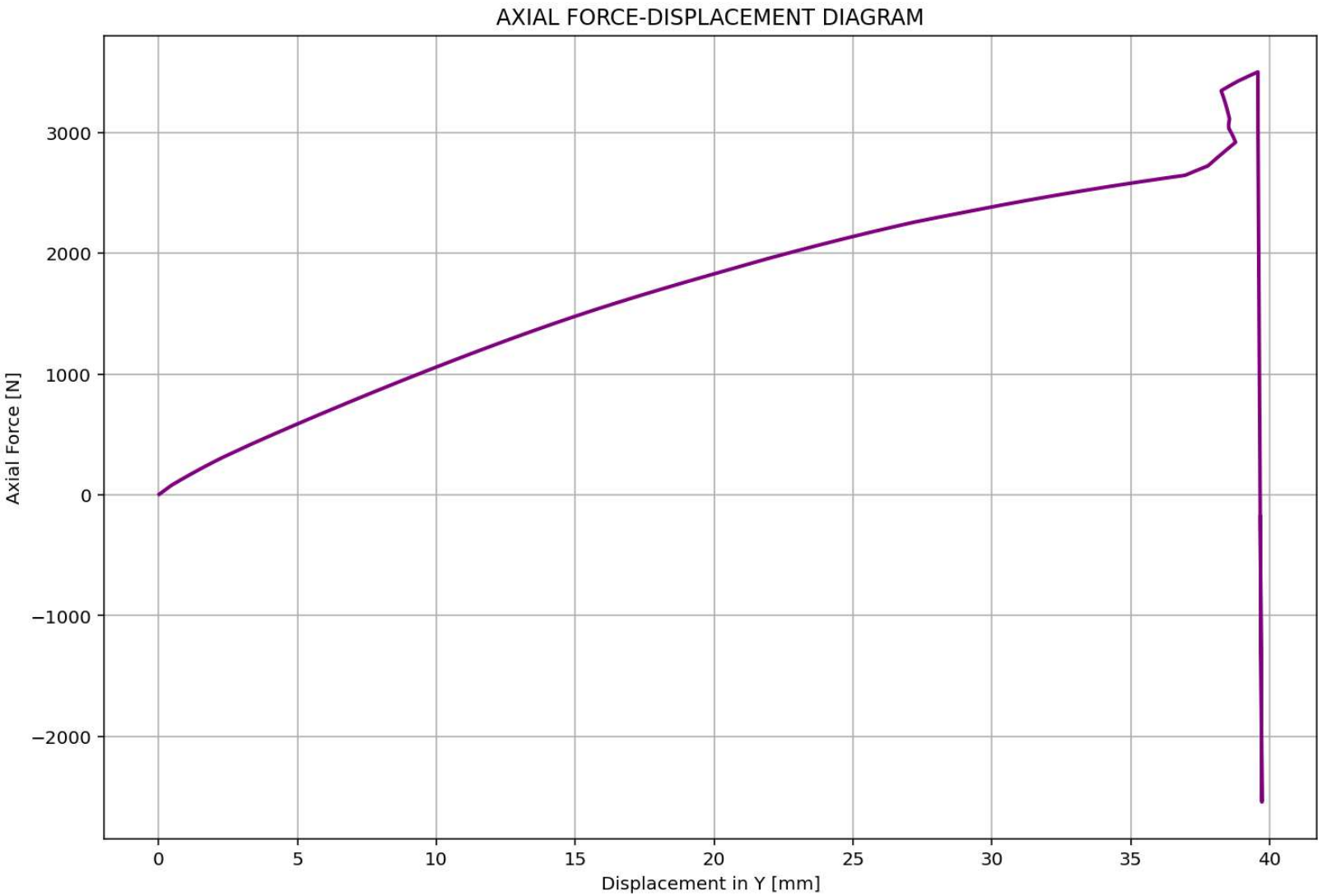
```
11.579999999999798 -43.76793744042821 -21.329543260388164
11.589999999999797 -43.767654589860925 -21.368216455837683
11.599999999999797 -43.76737505085171 -21.40689266584741
11.609999999999797 -43.76709888287001 -21.445571672553342
11.619999999999797 -43.7668261441725 -21.484253260252444
11.629999999999797 -43.766556891786294 -21.522937214669582
11.639999999999796 -43.76629118149259 -21.56162332345957
11.649999999999796 -43.766029067810685 -21.600311375808815
11.659999999999796 -43.76577060398248 -21.63900116311561
11.669999999999796 -43.76551584195745 -21.677692478226163
11.679999999999795 -43.76526483237797 -21.71638511643323
```

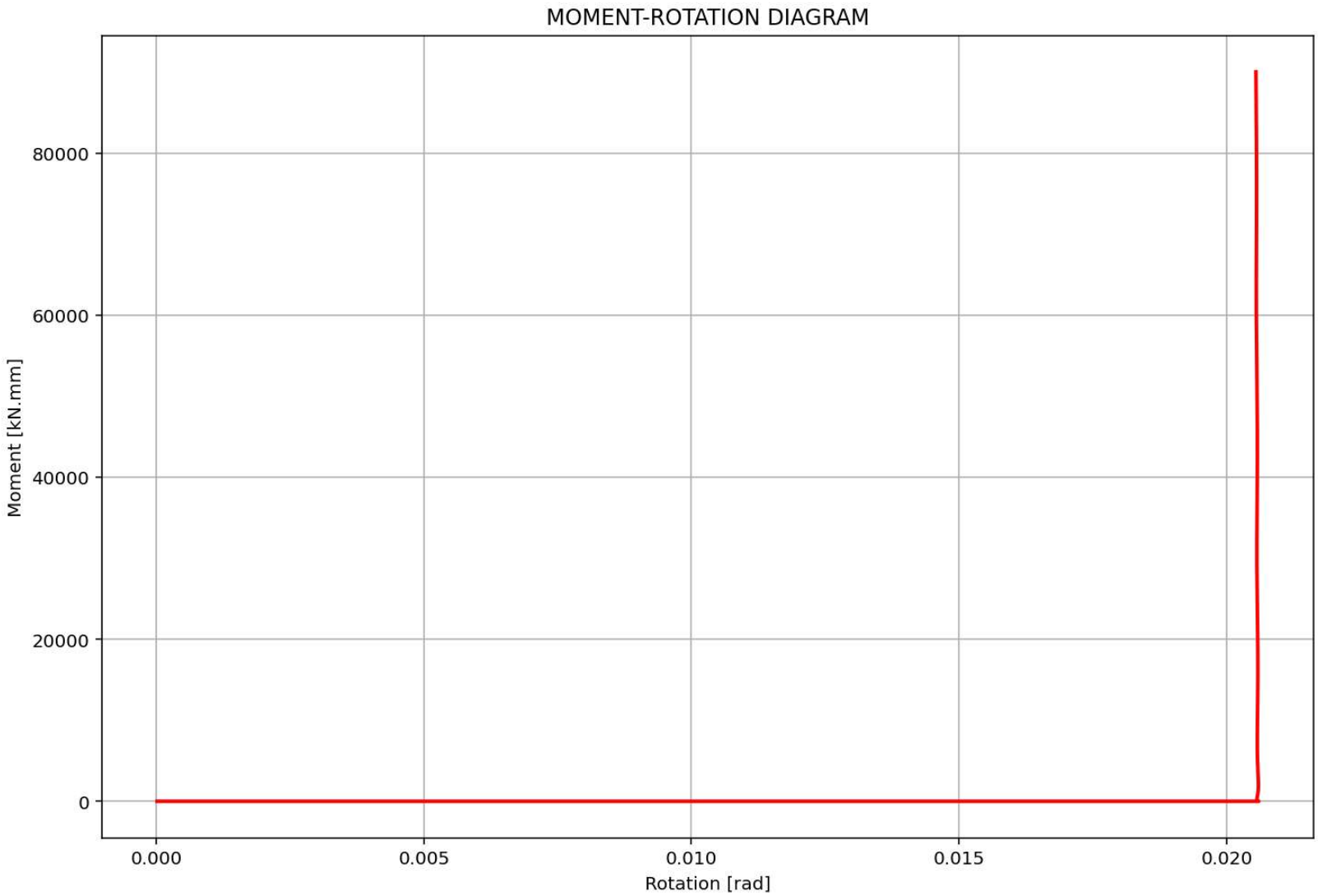
IPython Console | History

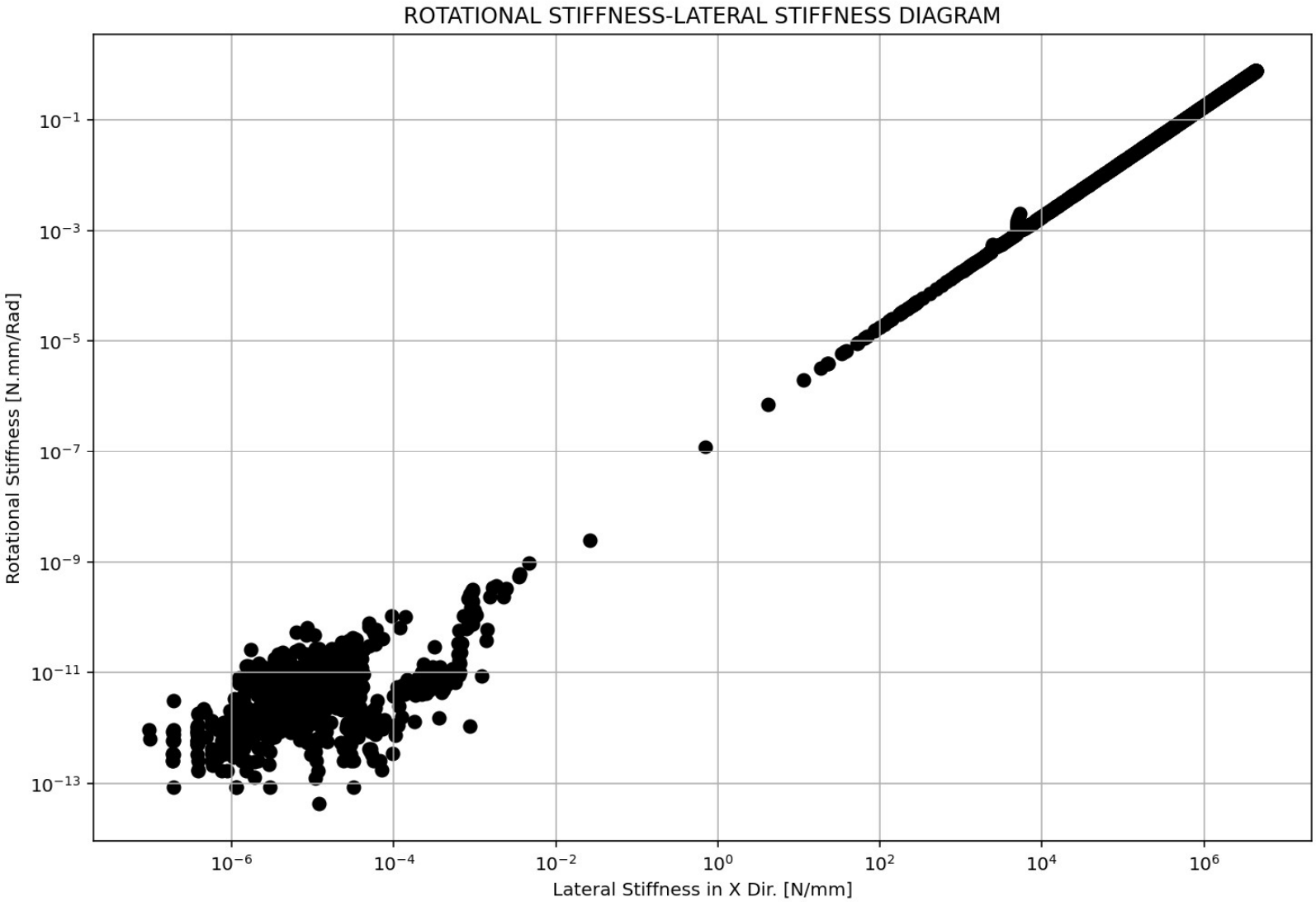
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 116, Col 18 UTF-8 CRLF RW Mem 41%

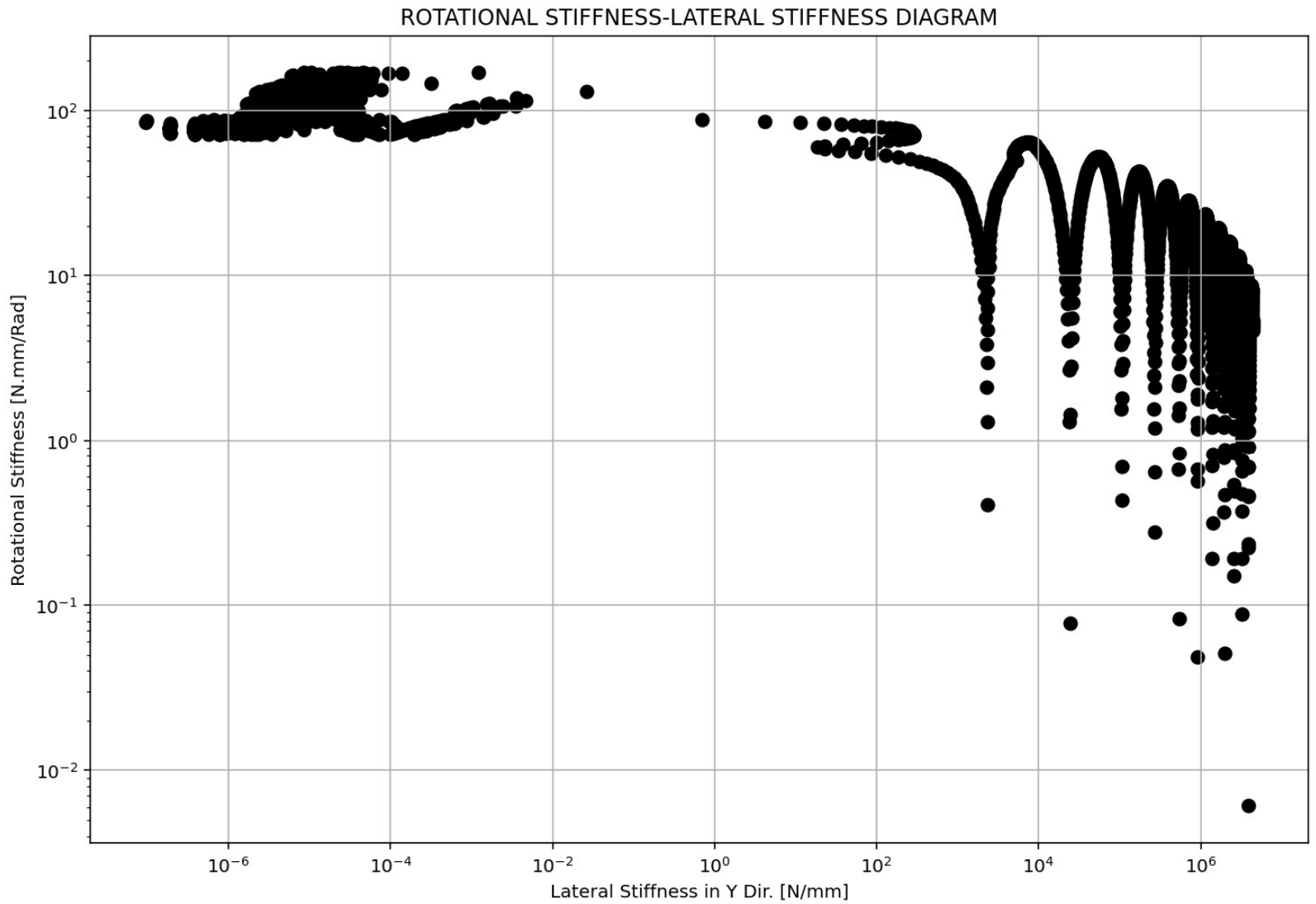

P-M Interaction
Axial Force [N]
3000
2000
1000
0
−1000
−2000
0
20000
40000
60000
80000
Bending Moment [N.mm]

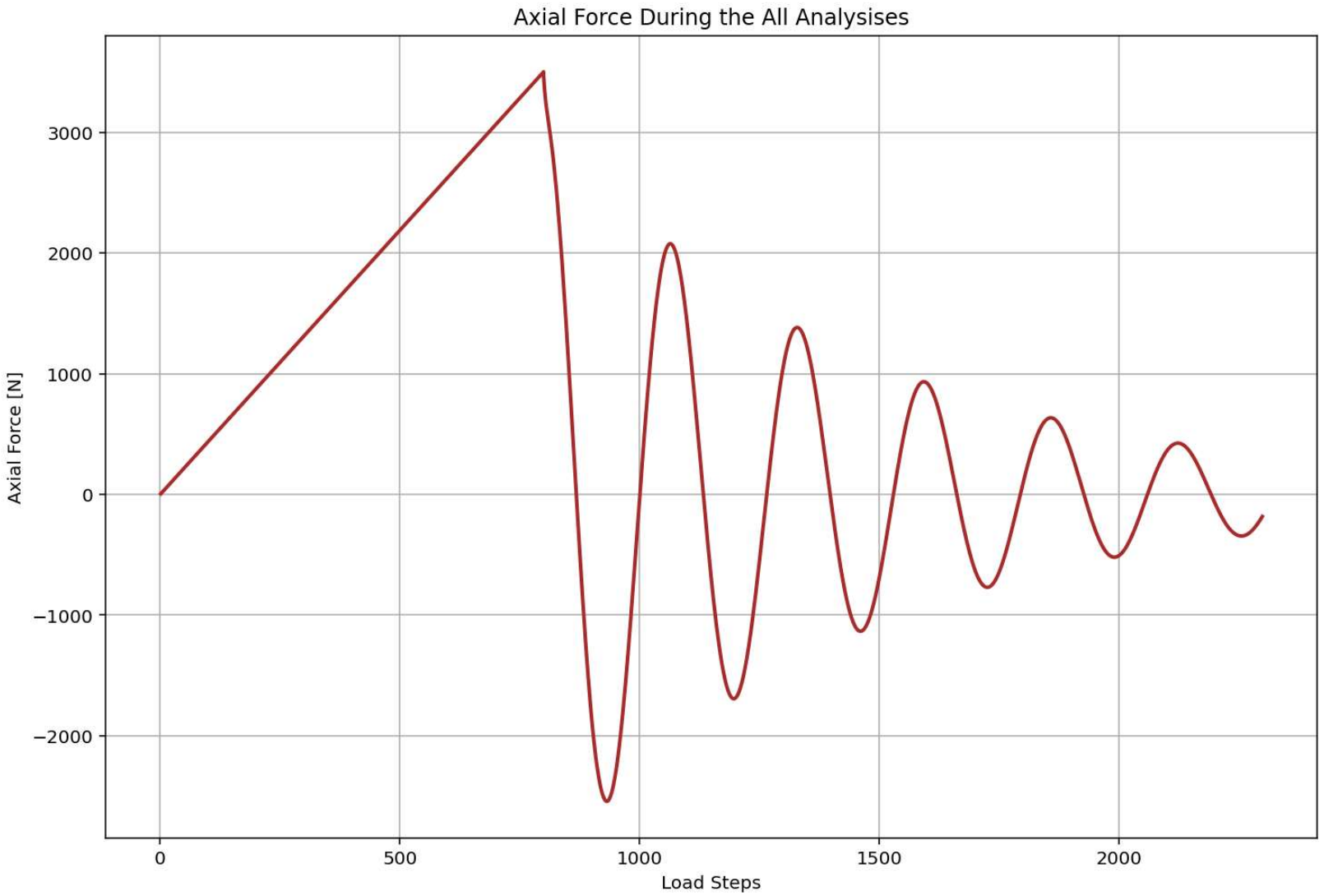

SHEAR FORCE-DISPLACEMENT DIAGRAM
Shear Force [N]
0
−5
−10
−15
−20
−25
−30
−35
−40
−30
−20
−10
0
Displacement in X [mm]

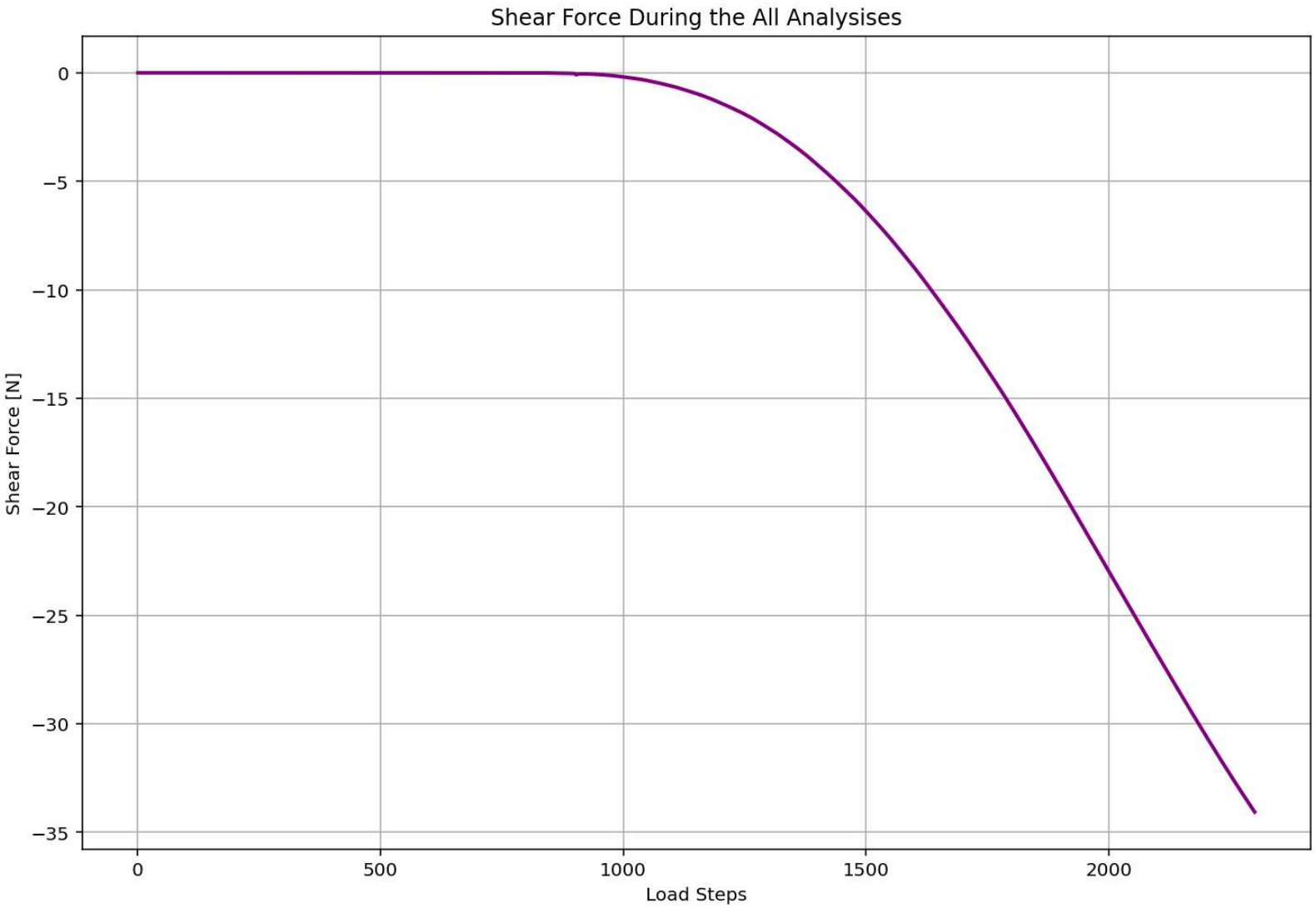

AXIAL FORCE-DISPLACEMENT DIAGRAM
Axial Force [N]
3000
2000
1000
0
−1000
−2000
0
5
10
15
20
25
30
35
40
Displacement in Y [mm]

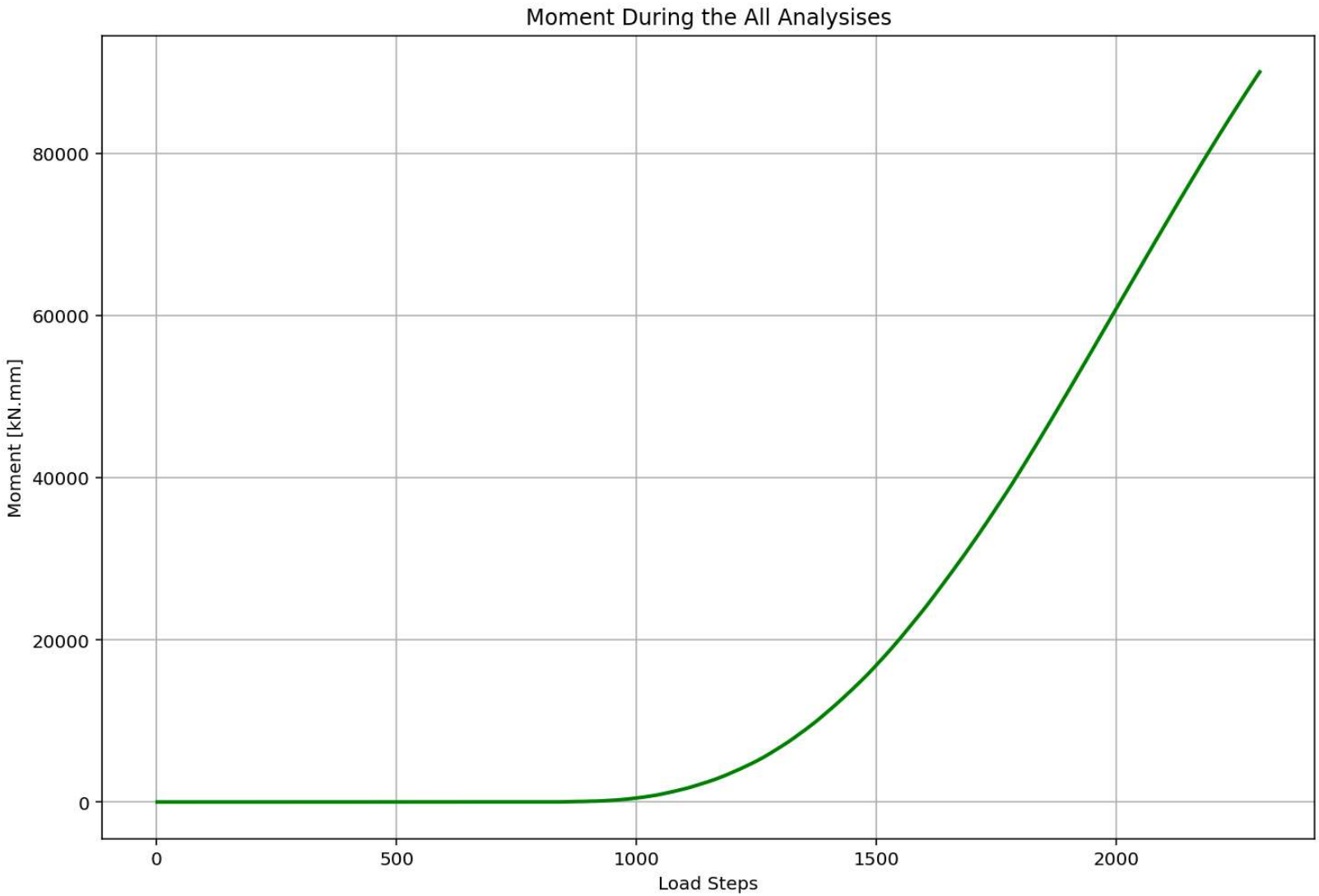

MOMENT-ROTATION DIAGRAM
Moment [kN.mm]
80000
60000
40000
20000
0
0.000
0.005
0.010
0.015
0.020
Rotation [rad]

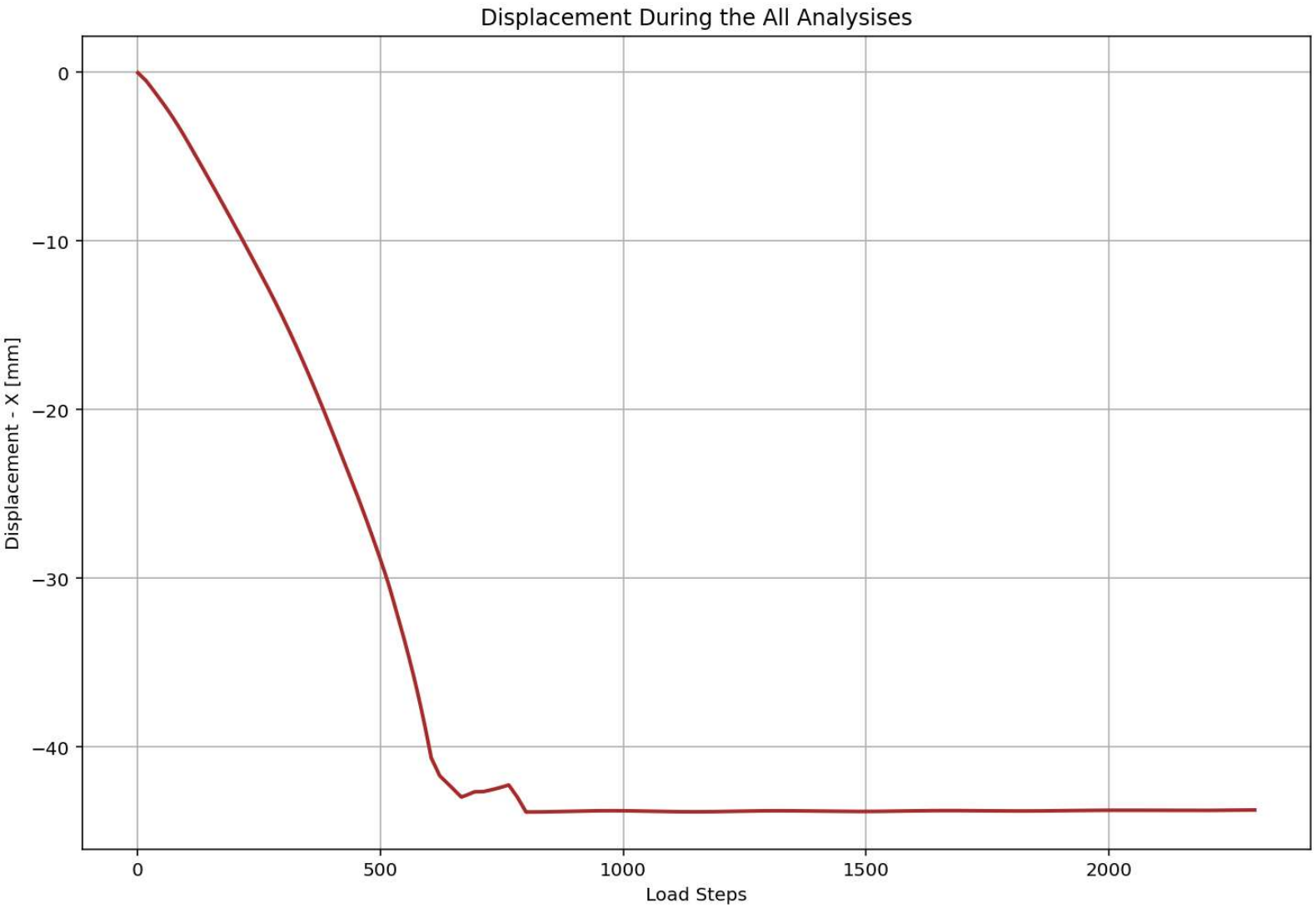

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
10^{-1}
10^{-3}
10^{-5}
10^{-7}
10^{-9}
10^{-11}
10^{-13}
10^{-6}
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
10^{6}
Lateral Stiffness in X Dir. [N/mm]

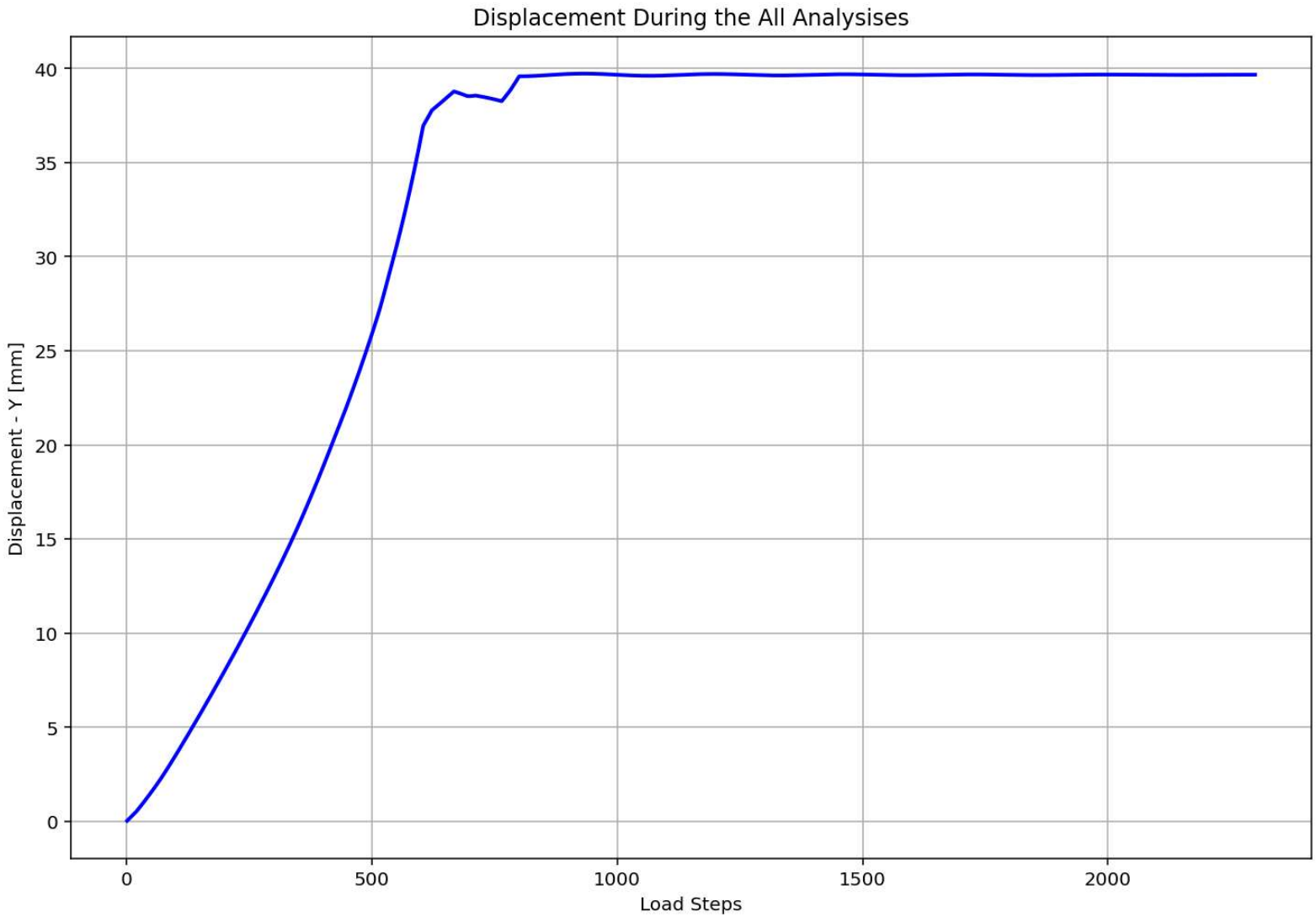

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-6}
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
10^{6}
Lateral Stiffness in Y Dir. [N/mm]

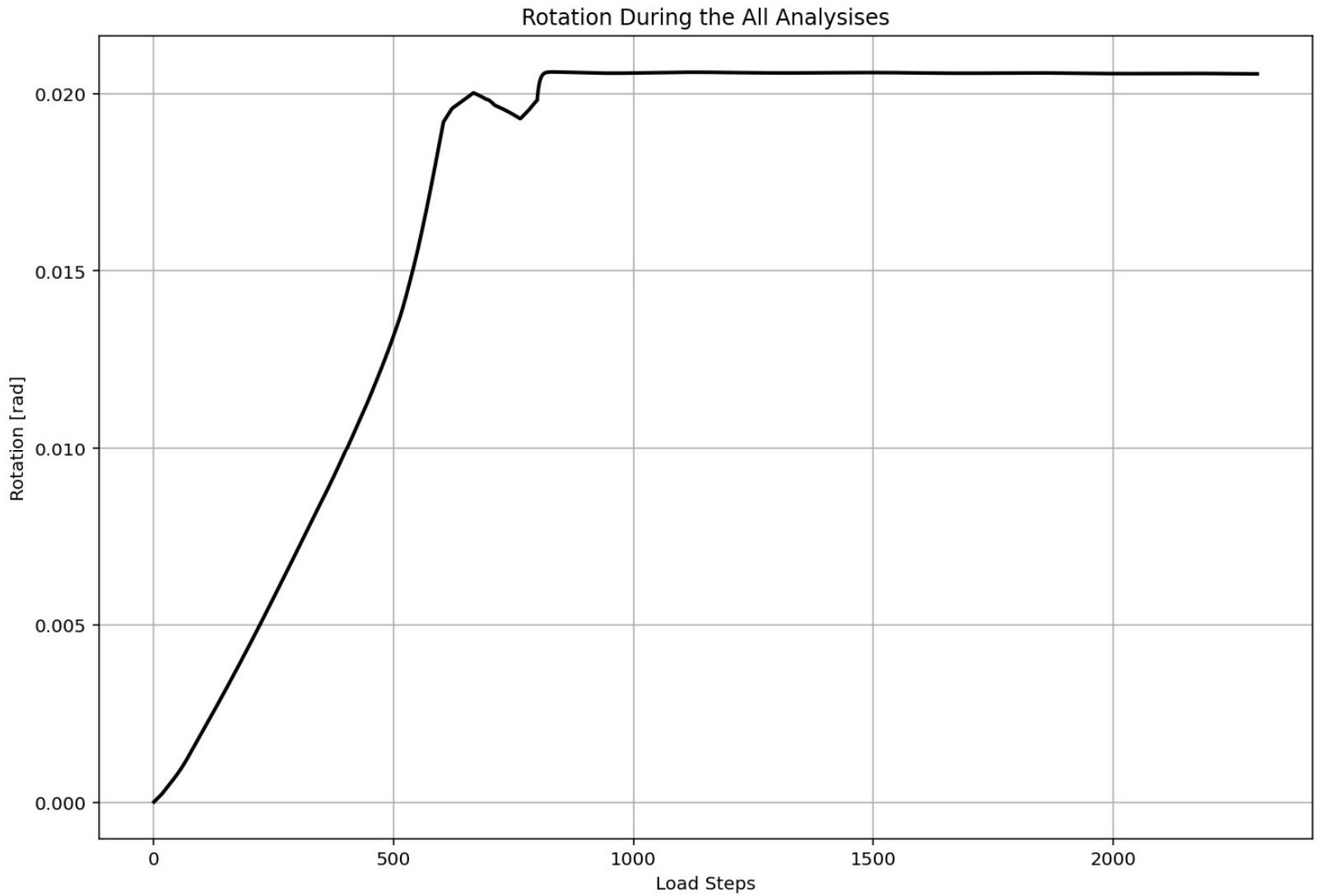

Axial Force During the All Analysises
Axial Force [N]
3000
2000
1000
0
−1000
−2000
0
500
1000
1500
2000
Load Steps


Shear Force During the All Analysises
Shear Force [N]
0
−5
−10
−15
−20
−25
−30
−35
0
500
1000
1500
2000
Load Steps

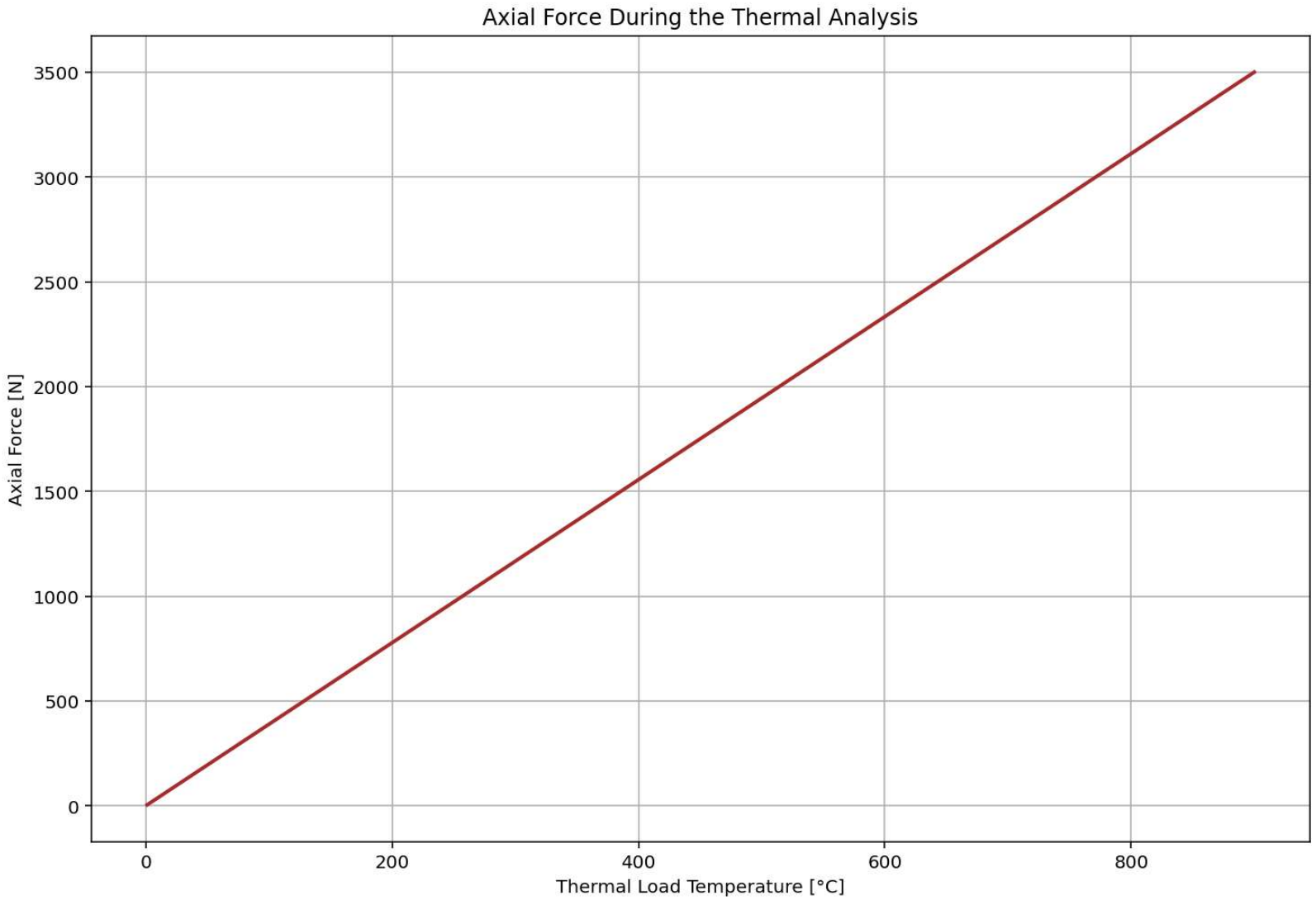

Moment During the All Analysises
Moment [kN.mm]
80000
60000
40000
20000
0
0
500
1000
1500
2000
Load Steps

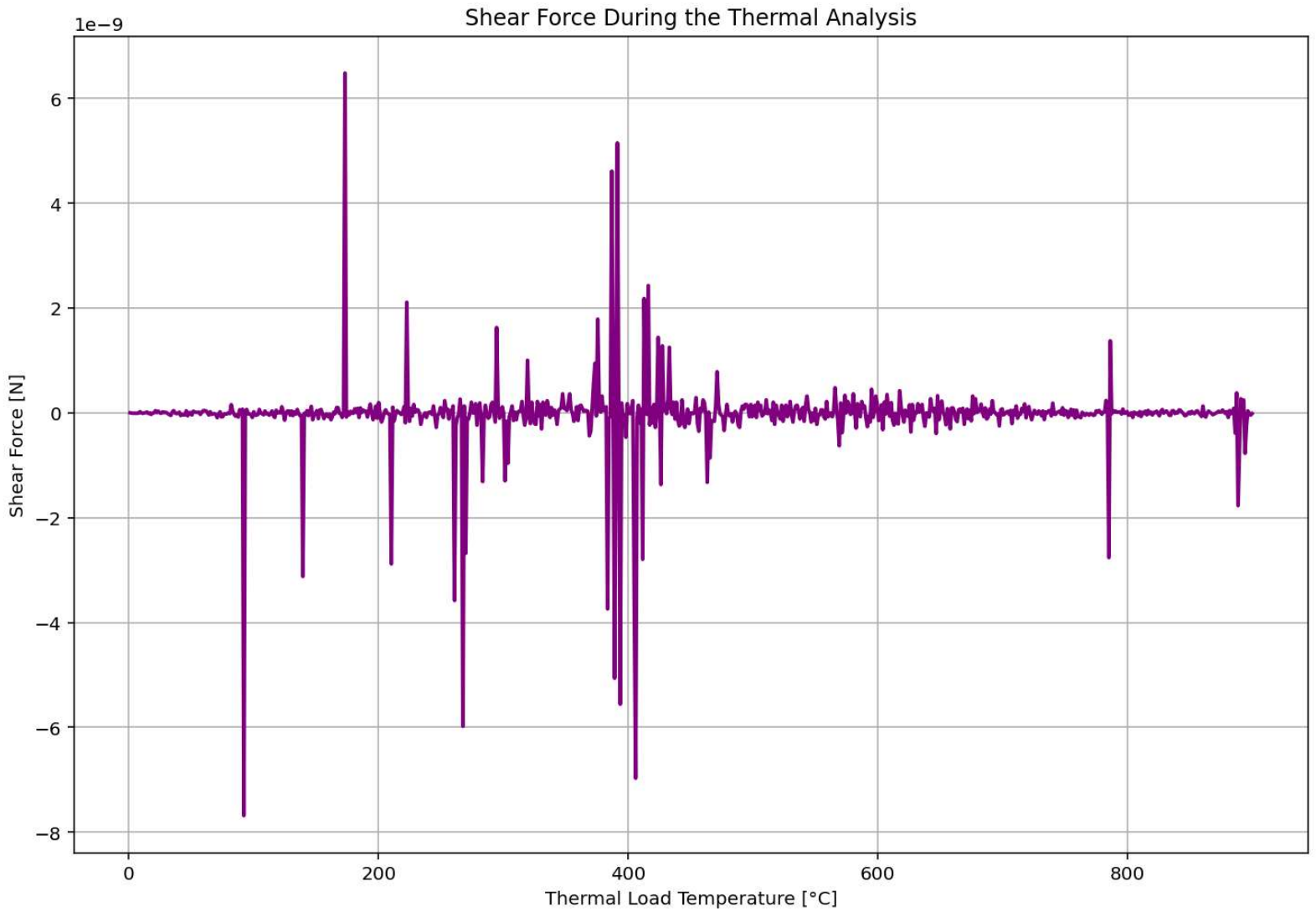

Displacement During the All Analysises
0
−10
−20
−30
−40
Displacement - X [mm]
0
500
1000
1500
2000
Load Steps

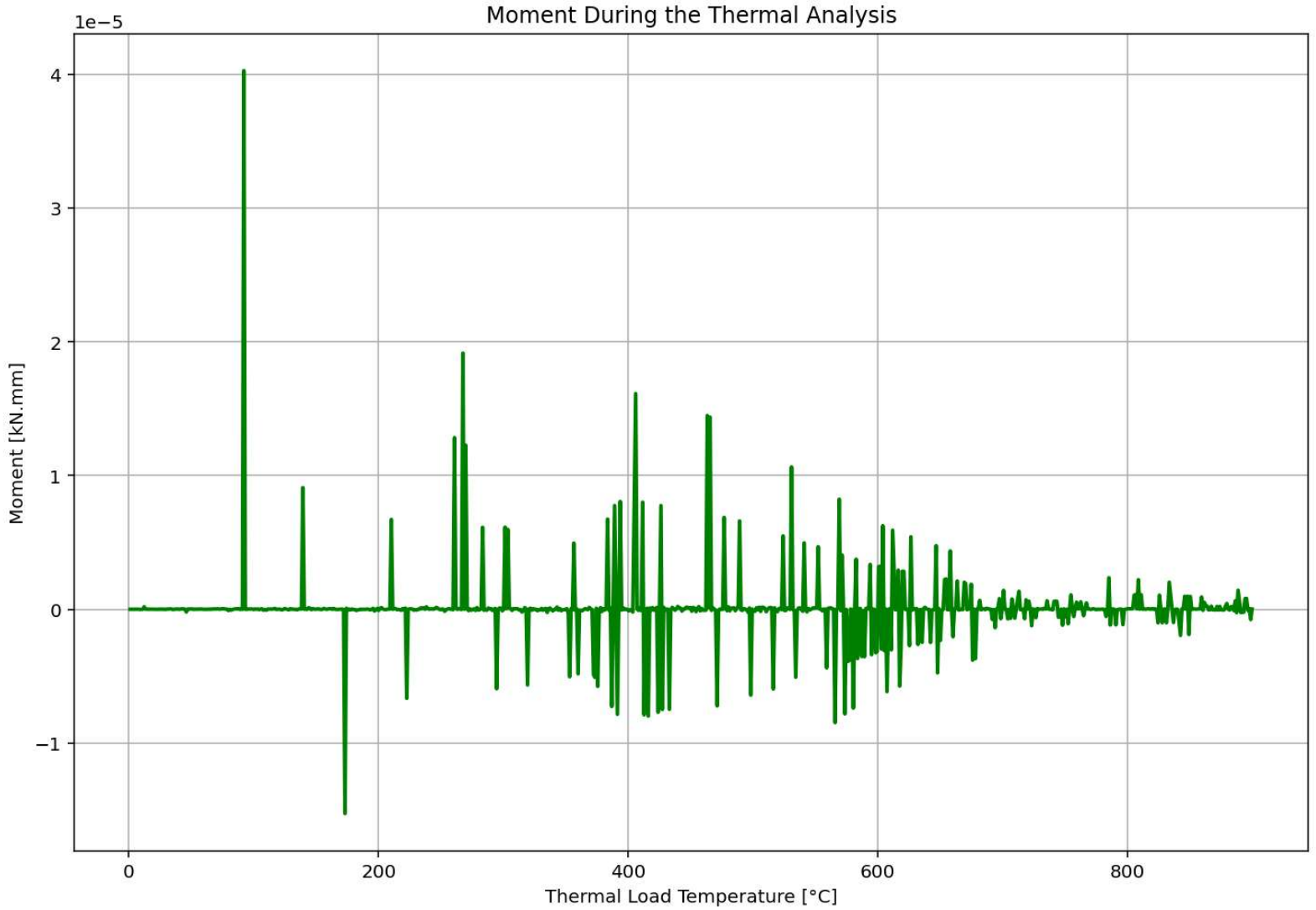

Displacement During the All Analysises
Displacement - Y [mm]
Load Steps
0
5
10
15
20
25
30
35
40
0
500
1000
1500
2000

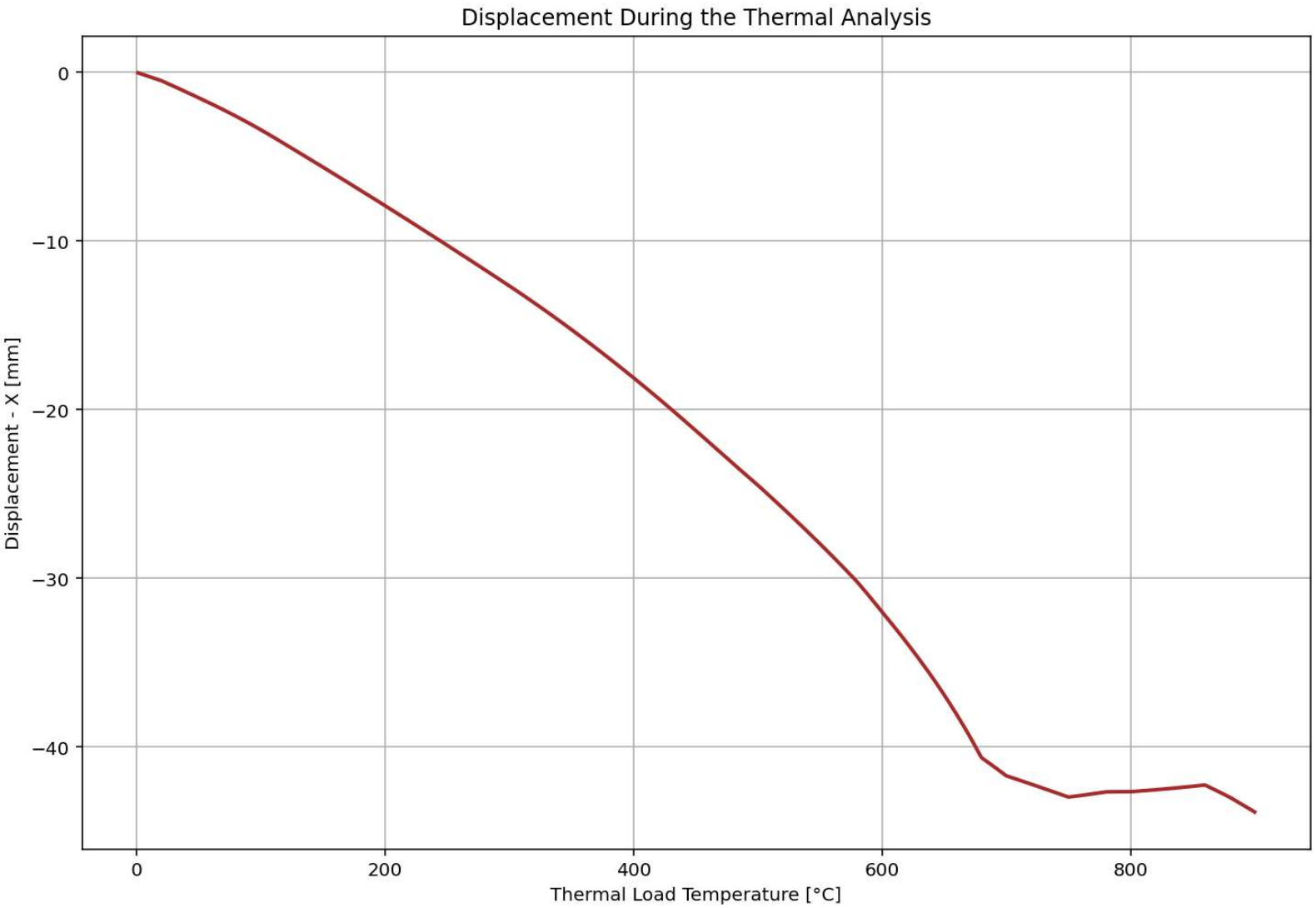

Rotation During the All Analysises
Rotation [rad]
0.020
0.015
0.010
0.005
0.000
0
500
1000
1500
2000
Load Steps

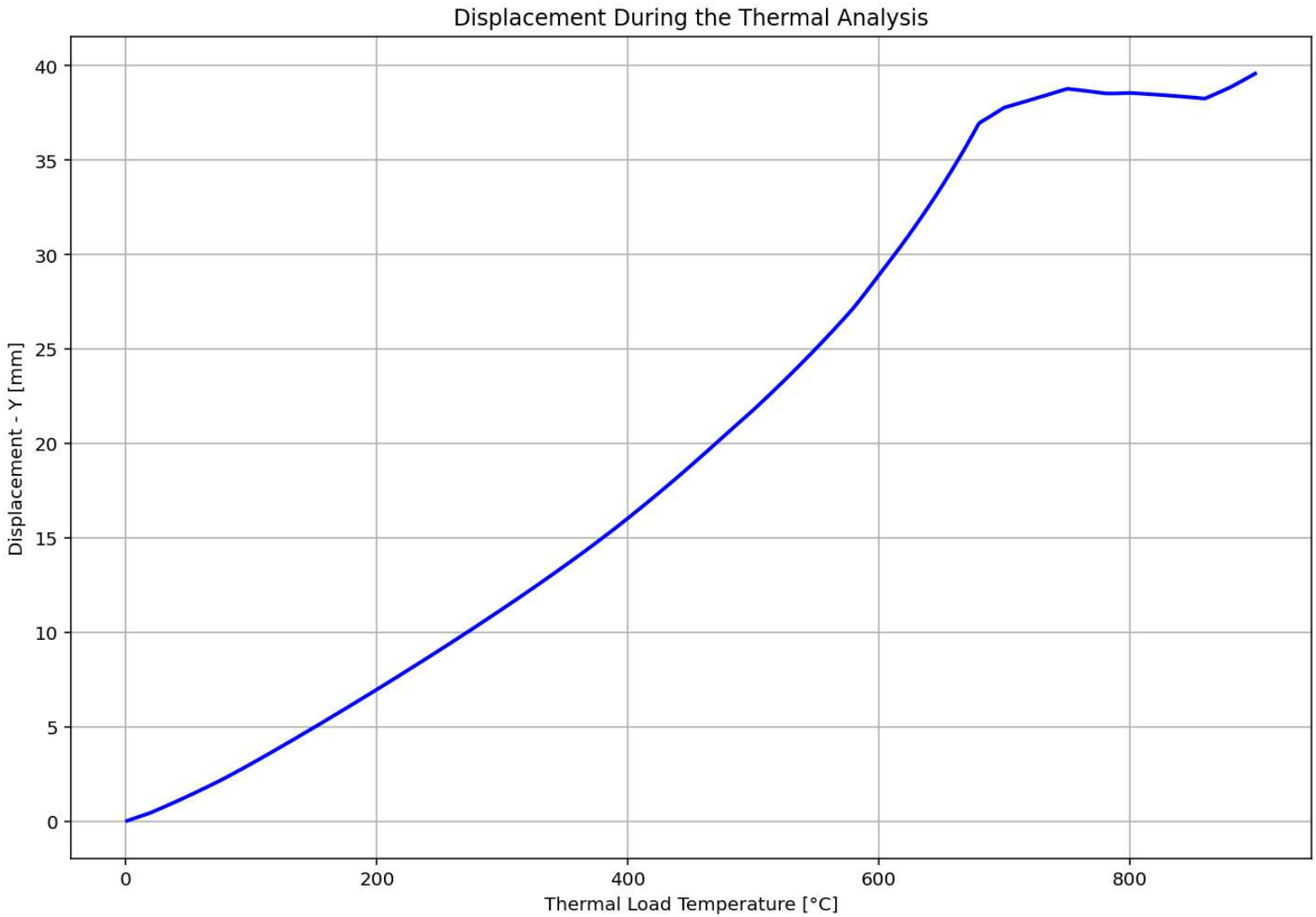
THERMAL
ANALYSIS RESULTS

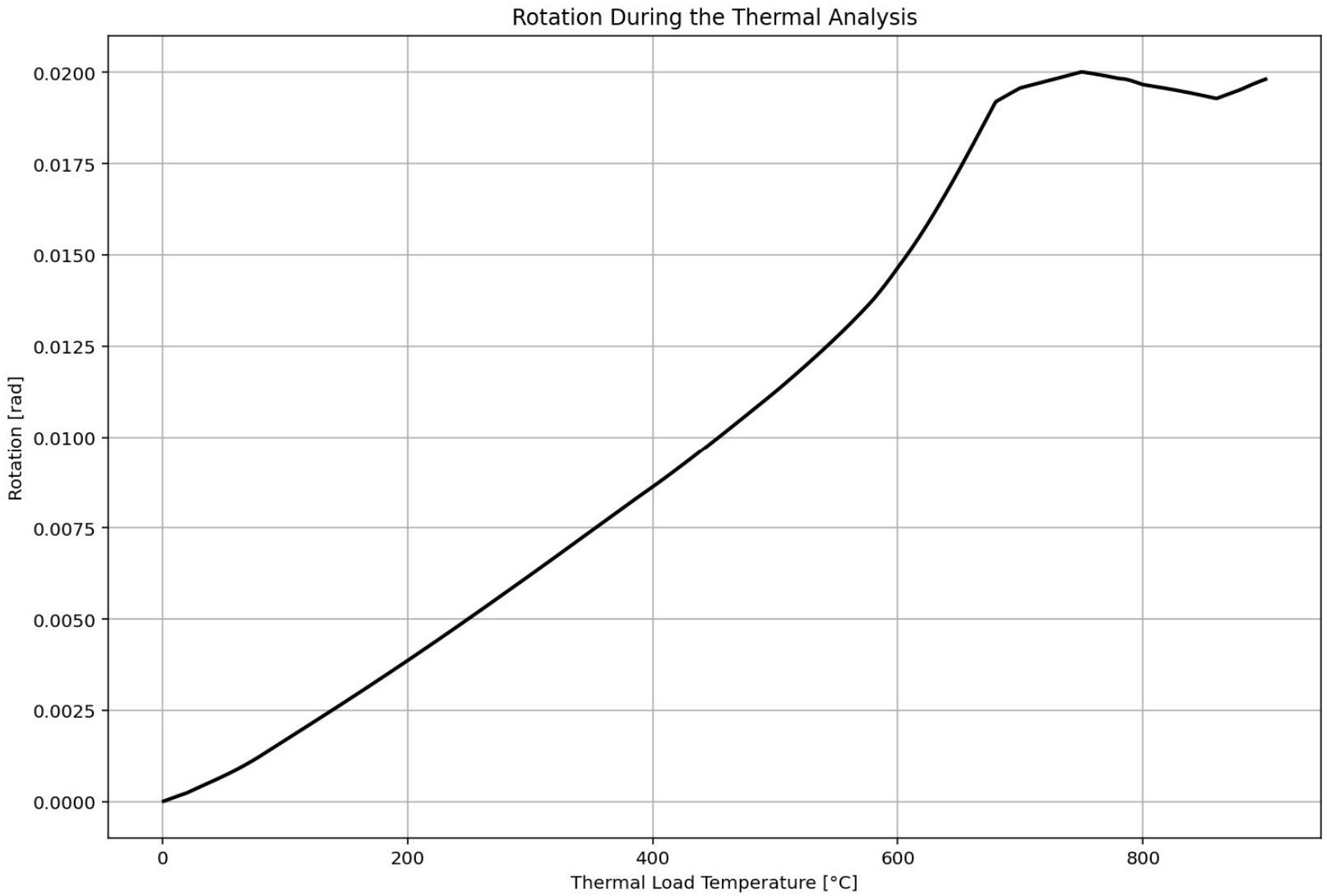

Axial Force During the Thermal Analysis
Axial Force [N]
3500
3000
2500
2000
1500
1000
500
0
0
200
400
600
800
Thermal Load Temperature [°C]


Shear Force During the Thermal Analysis
1e−9
6
4
2
0
−2
−4
−6
−8
Shear Force [N]
0
200
400
600
800
Thermal Load Temperature [°C]

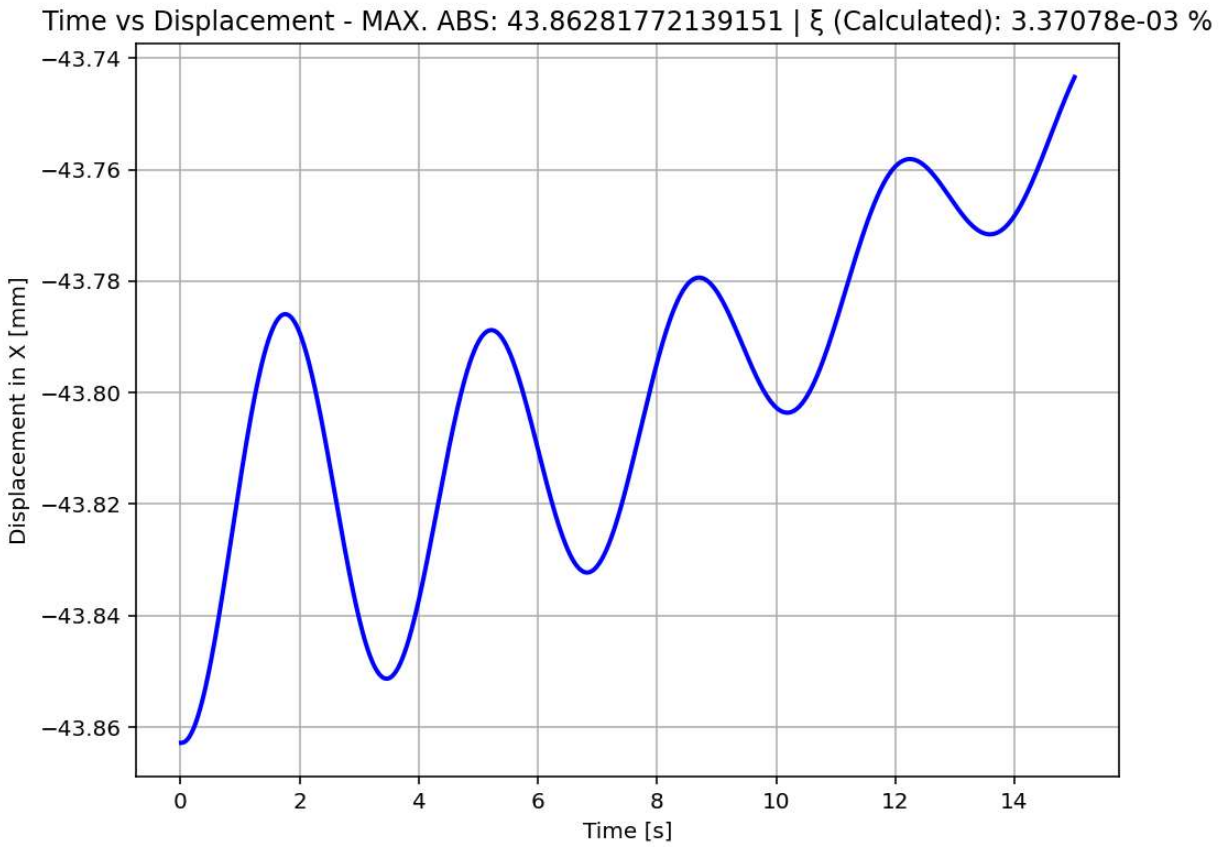

Moment During the Thermal Analysis
1e−5
4
3
2
1
0
−1
Moment [kN.mm]
0
200
400
600
800
Thermal Load Temperature [°C]

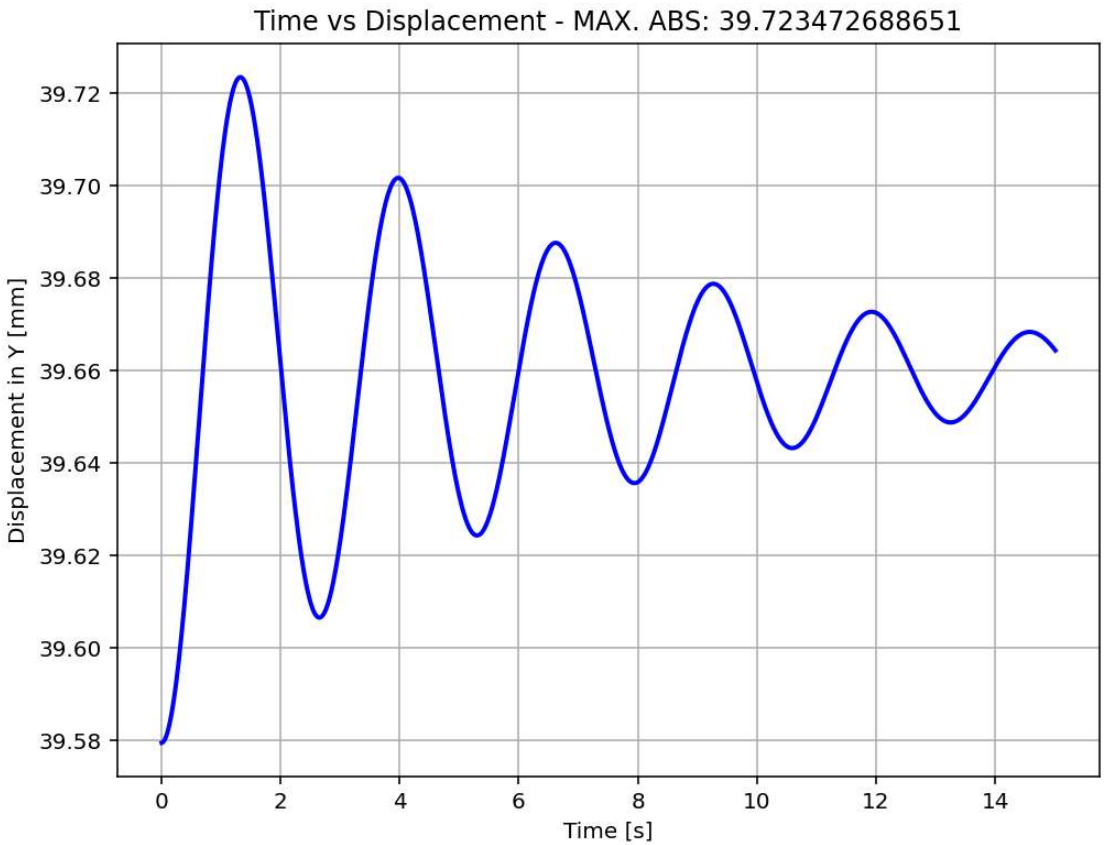

Displacement During the Thermal Analysis
Displacement - X [mm]
0
−10
−20
−30
−40
0
200
400
600
800
Thermal Load Temperature [°C]

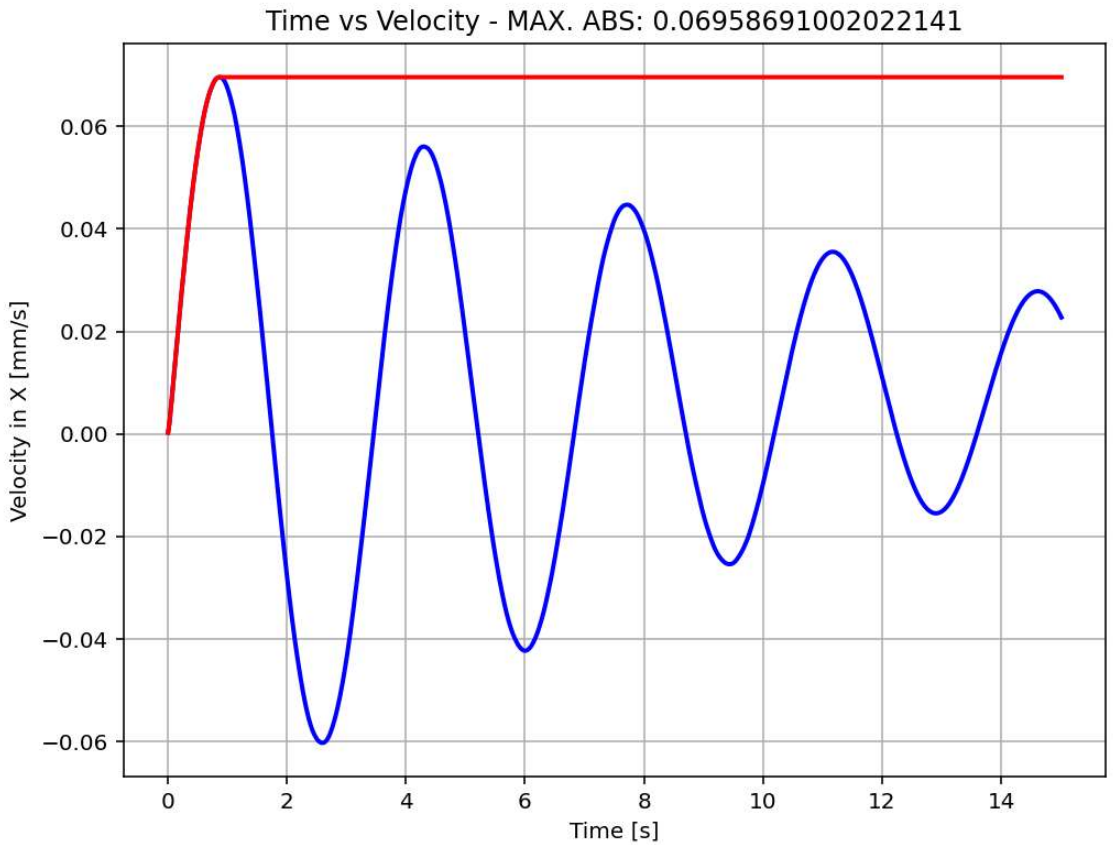

Displacement During the Thermal Analysis
Displacement - Y [mm]
0
5
10
15
20
25
30
35
40
0
200
400
600
800
Thermal Load Temperature [°C]

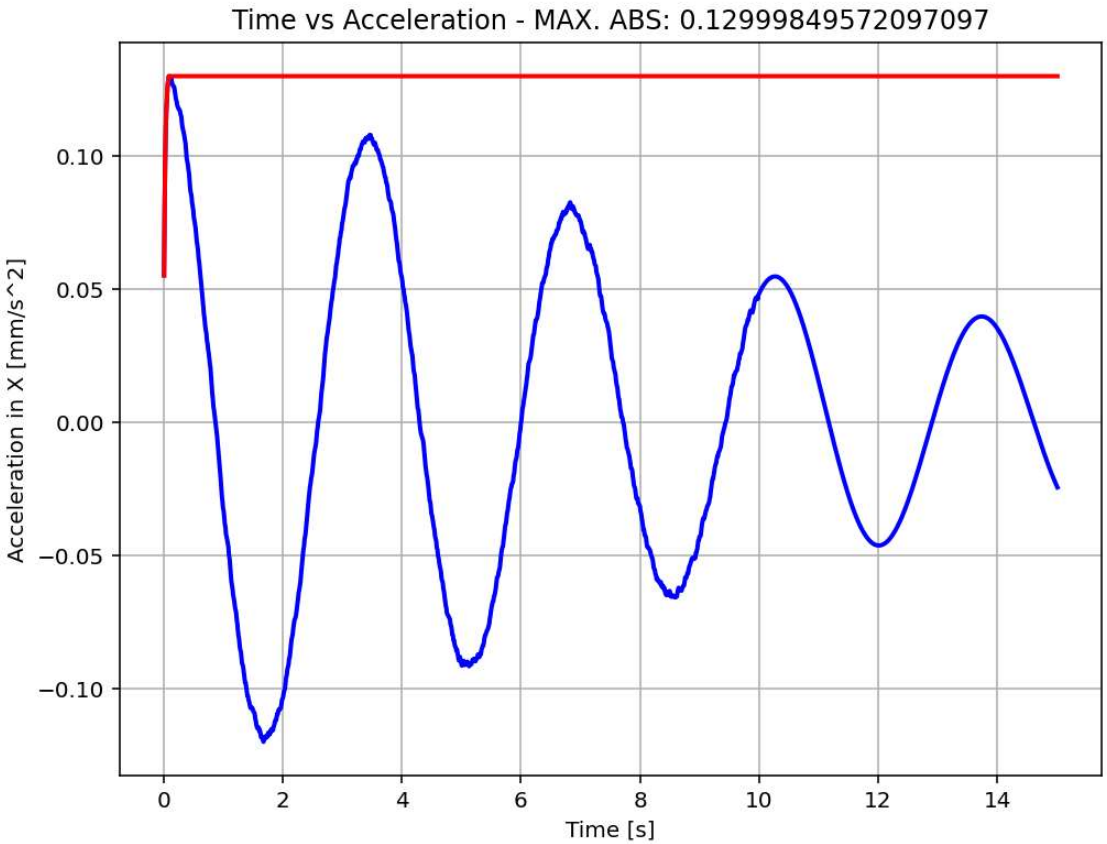

Rotation During the Thermal Analysis
Rotation [rad]
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0
200
400
600
800
Thermal Load Temperature [°C]

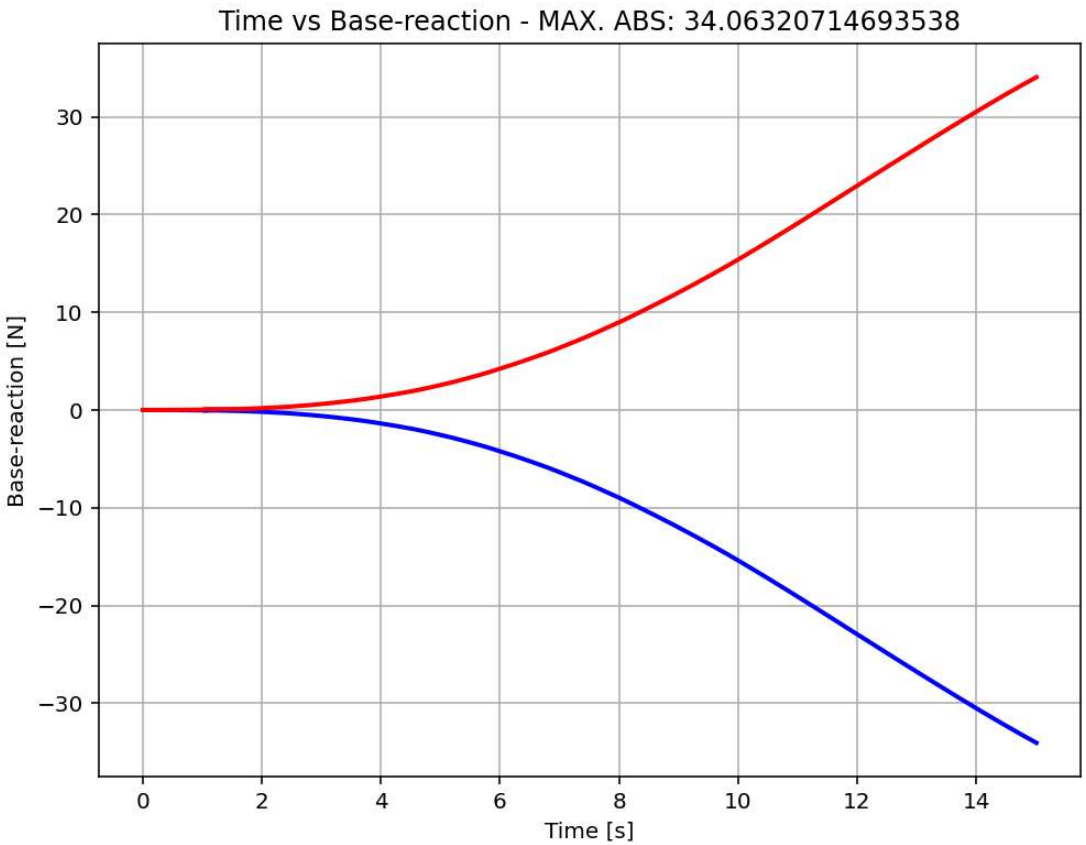
SEISMIC ANALYSIS RESULTS

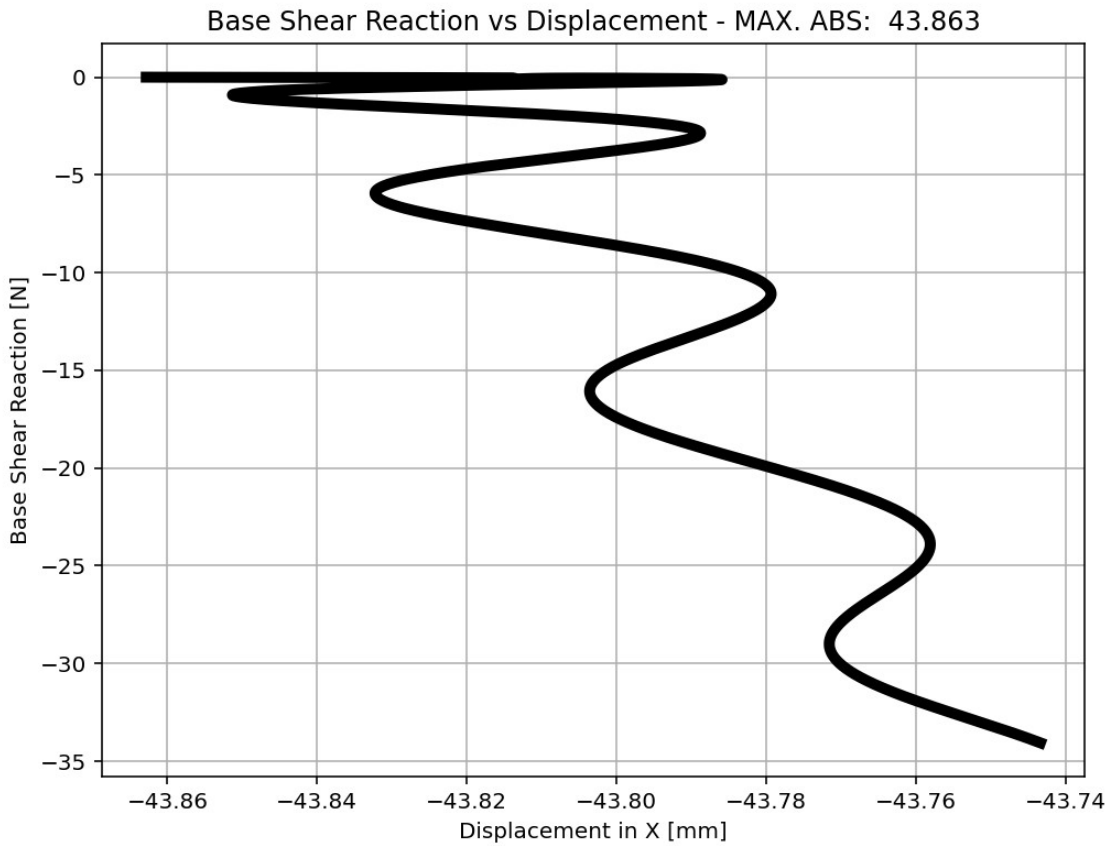

Time vs Displacement - MAX. ABS: 43.86281772139151 | ξ (Calculated): 3.37078e-03 %
−43.74
−43.76
−43.78
−43.80
−43.82
−43.84
−43.86
Displacement in X [mm]
0
2
4
6
8
10
12
14
Time [s]

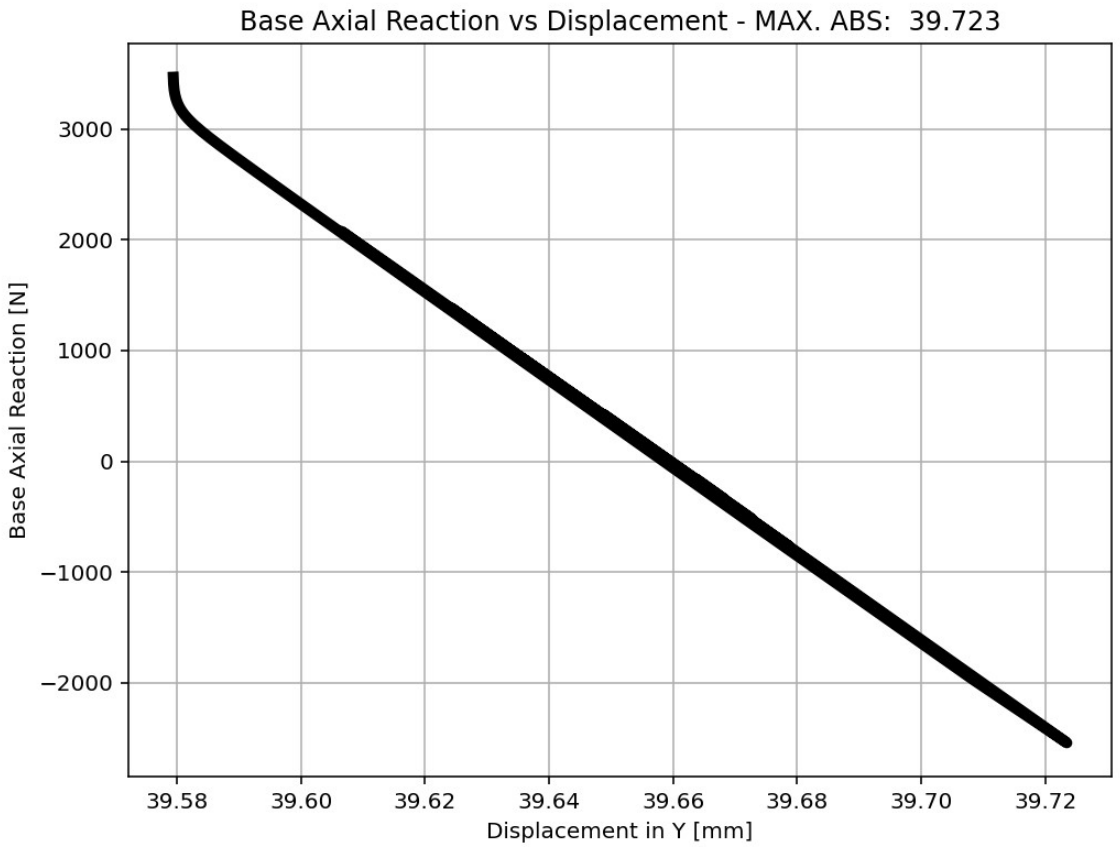

Time vs Displacement - MAX. ABS: 39.723472688651
Displacement in Y [mm]
39.72
39.70
39.68
39.66
39.64
39.62
39.60
39.58
0
2
4
6
8
10
12
14
Time [s]


Time vs Velocity - MAX. ABS: 0.06958691002022141
Velocity in X [mm/s]
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
0
2
4
6
8
10
12
14
Time [s]

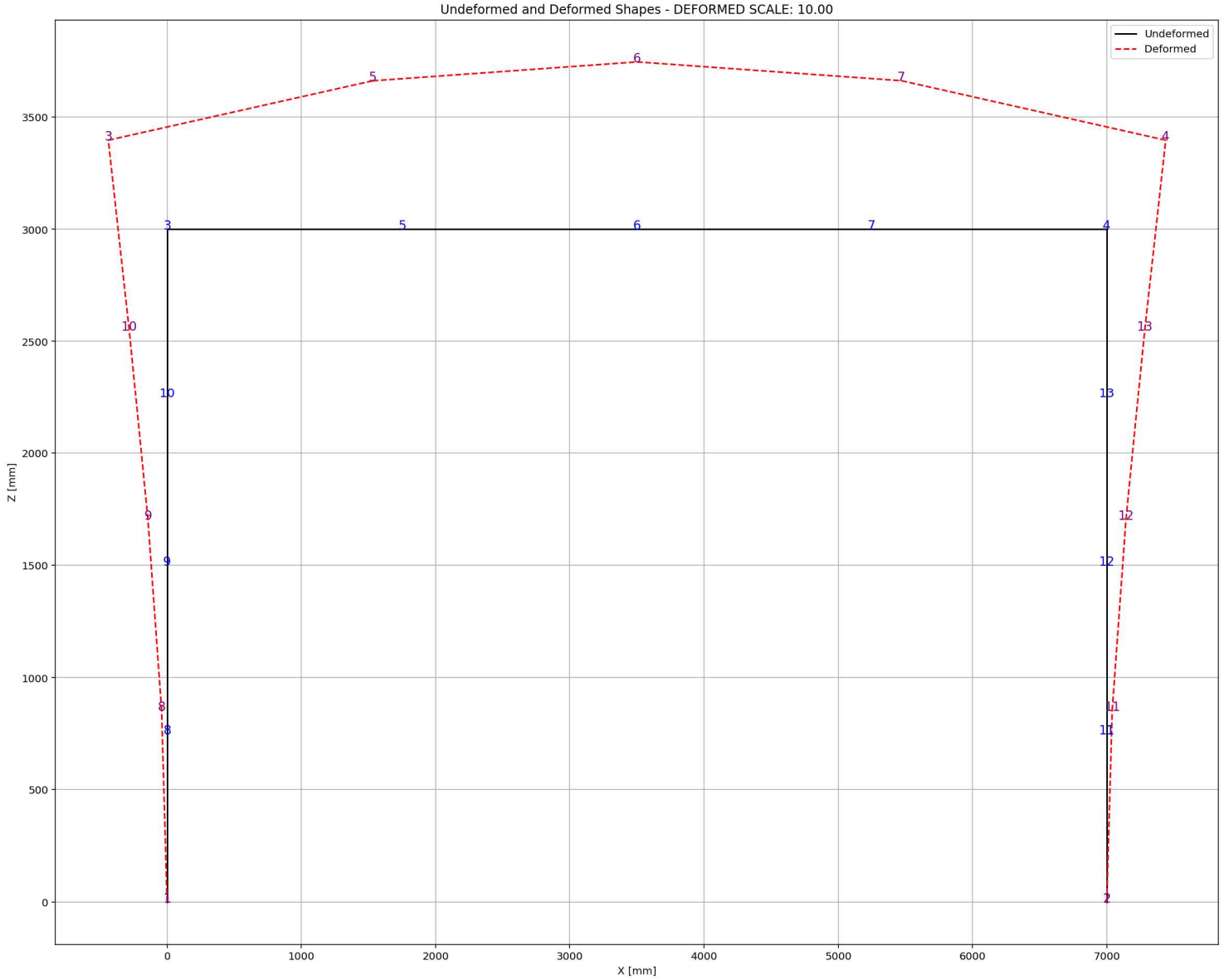

Time vs Acceleration - MAX. ABS: 0.12999849572097097
Acceleration in X [mm/s^2]
0.10
0.05
0.00
−0.05
−0.10
0
2
4
6
8
10
12
14
Time [s]


Time vs Base-reaction - MAX. ABS: 34.06320714693538
Base-reaction [N]
30
20
10
0
−10
−20
−30
0
2
4
6
8
10
12
14
Time [s]


Base Shear Reaction vs Displacement - MAX. ABS: 43.863
0
−5
−10
−15
−20
−25
−30
−35
Base Shear Reaction [N]
−43.86
−43.84
−43.82
−43.80
−43.78
−43.76
−43.74
Displacement in X [mm]


Base Axial Reaction vs Displacement - MAX. ABS: 39.723
Base Axial Reaction [N]
3000
2000
1000
0
−1000
−2000
39.58
39.60
39.62
39.64
39.66
39.68
39.70
39.72
Displacement in Y [mm]


Base Axial Reaction vs Displacement - MAX. ABS: 39.723
Base Axial Reaction [N]
3000
2000
1000
0
−1000
−2000
0
5
10
15
20
25
30
35
40
Displacement in Y [mm]


Undeformed and Deformed Shapes - DEFORMED SCALE: 10.00
Undeformed
Deformed
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
3500
0
1000
2000
3000
4000
5000
6000
7000
1
2
3
4
5
6
7
8
9
10
11
12
13