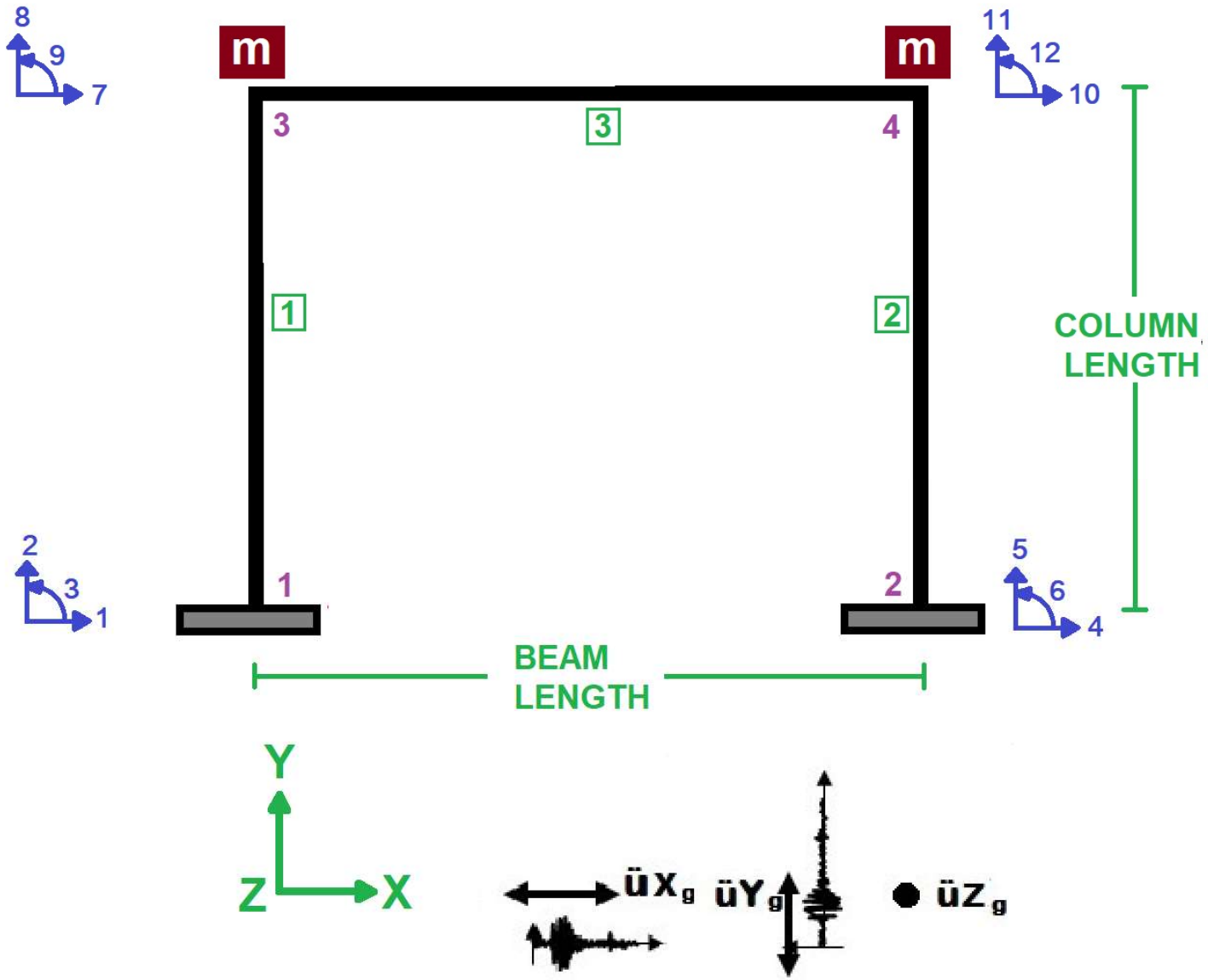
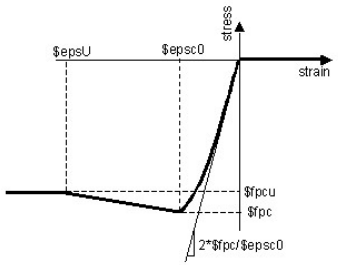
IN THE NAME OF ALLAH

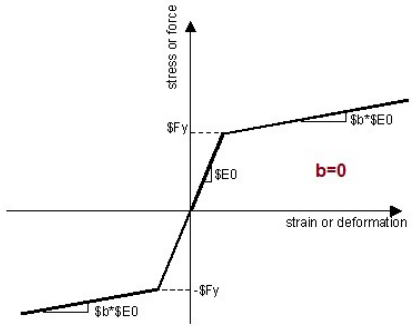
SEISMIC RESPONSE SPECTRUM ANALYSIS OF CONCRETE FRAME USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

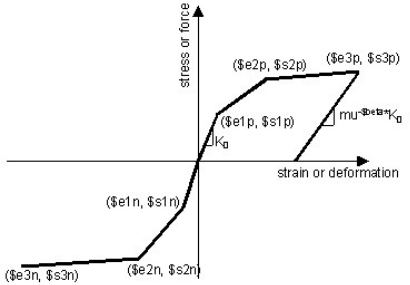

8
9
7
m
m
11
12
10
3
3
4
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH
Y
Z
X
üXg
üYg
üZg



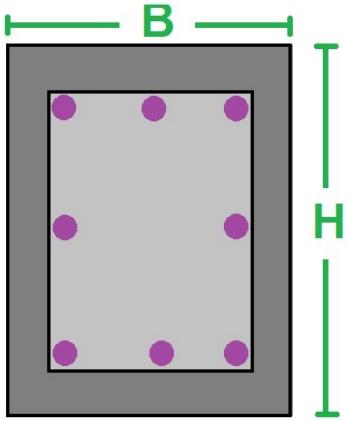
CORE AND COVER CONCRETE REALTION



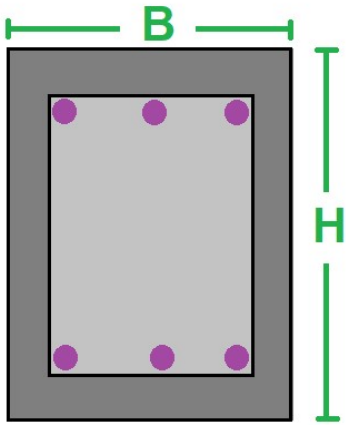
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

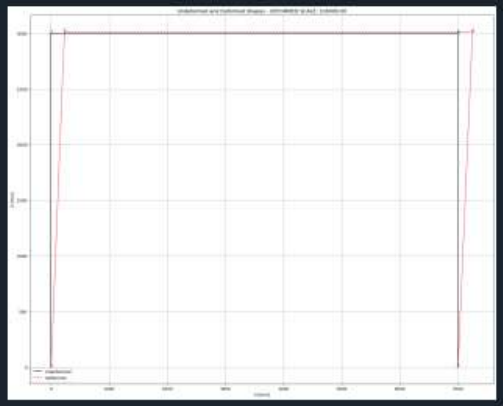
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...CTRUM\CONCRETE_FRAME_SEISMIC_RESPONSE_SPECTRUM.py

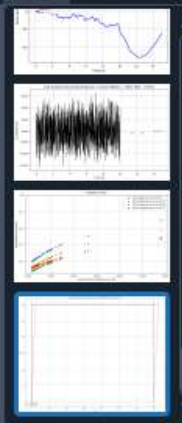
CONCRETE_FRAME_SEI...,SPONSE_SPECTRUM.py

```
################################################################################
#                          IN THE NAME OF ALLAH                                #
#   SEISMIC RESPONSE SPECTRUM ANALYSIS OF CONCRETE FRAME USING OPENSEES        #
#------------------------------------------------------------------------------#
#       THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)             #
#                EMAIL: salar.d.ghashghaei@gmail.com                           #
################################################################################
"""
1. Objective: The study evaluates the dynamic response of a concrete frame under
   seismic conditions, comparing two steel material models:
   - Hysteretic: Tri-linear with strain hardening, pinching, and stiffness degradation (*includes ultim

2. Model Setup:
   - Geometry: 2D frame with columns (500×500 mm) and beam (500×300 mm).
   - Materials: Confined/unconfined concrete (`Concrete01`) and steel rebars (either `Steel01` or `Hyst
   - Damping: Rayleigh damping (5% initial guess) calibrated via eigenvalue analysis.

3. Dynamic Response:
   - Period: Natural period (`T`) calculated from eigenanalysis (~0.28 s for fundamental mode).
   - Displacement Decay: Logarithmic decrement used to compute damping ratios (`ξ`). The *Hysteretic* m

4. Force-Displacement Behavior:
   - Shear (X-direction): The *Hysteretic* model exhibited pinching and reduced
   stiffness in hysteresis loops, while *Steel01* maintained symmetric, undegraded cycles.
   - Axial (Y-direction): Both models showed nonlinear coupling, but *Hysteretic*
   introduced residual displacements from cumulative damage.
   - Moment-Rotation: *Hysteretic* displayed strength decay under cyclic rotations,
   unlike *Steel01*'s stable post-yield plateau.

5. Stiffness Evolution:
   - Lateral Stiffness (X/Y): Degraded faster in the *Hysteretic* model due to rebar buckling/concrete
   - Rotational Stiffness: *Hysteretic*'s stiffness reduction was more pronounced, reflecting realistic

6. Damping Estimation:
```

C:\Users\Dell

19 %





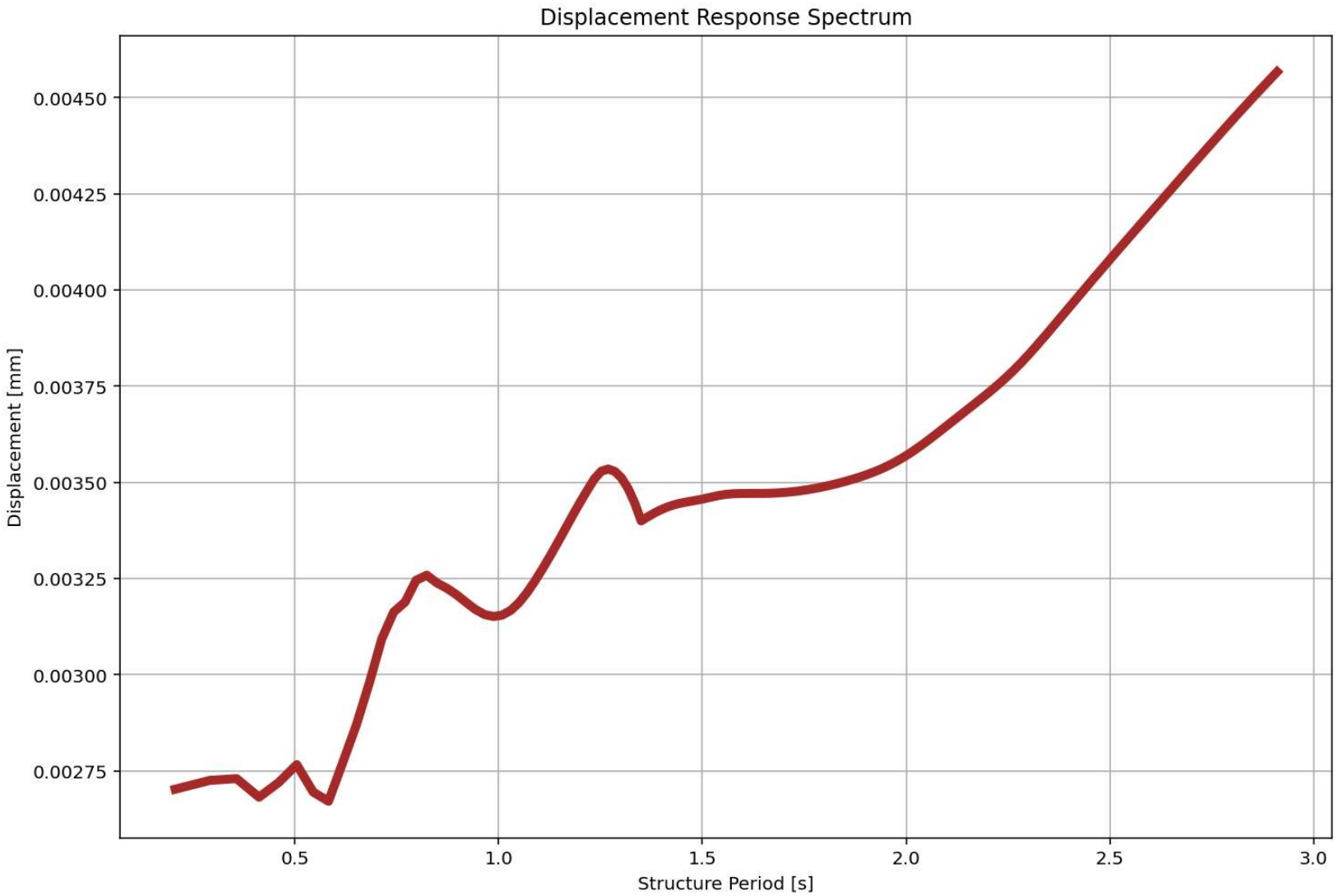
Help Variable Explorer Debugger Plots Files

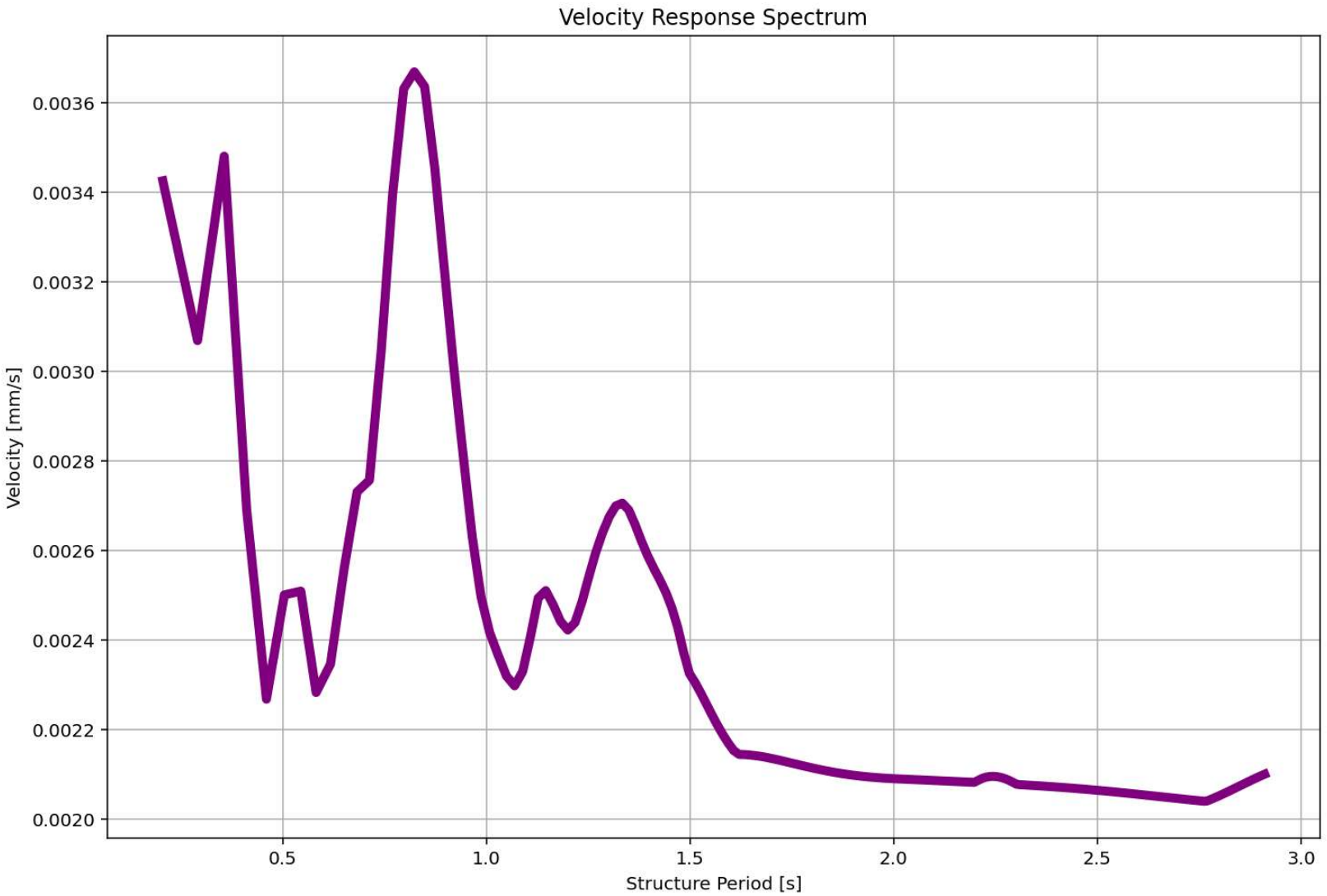
Console 1/A

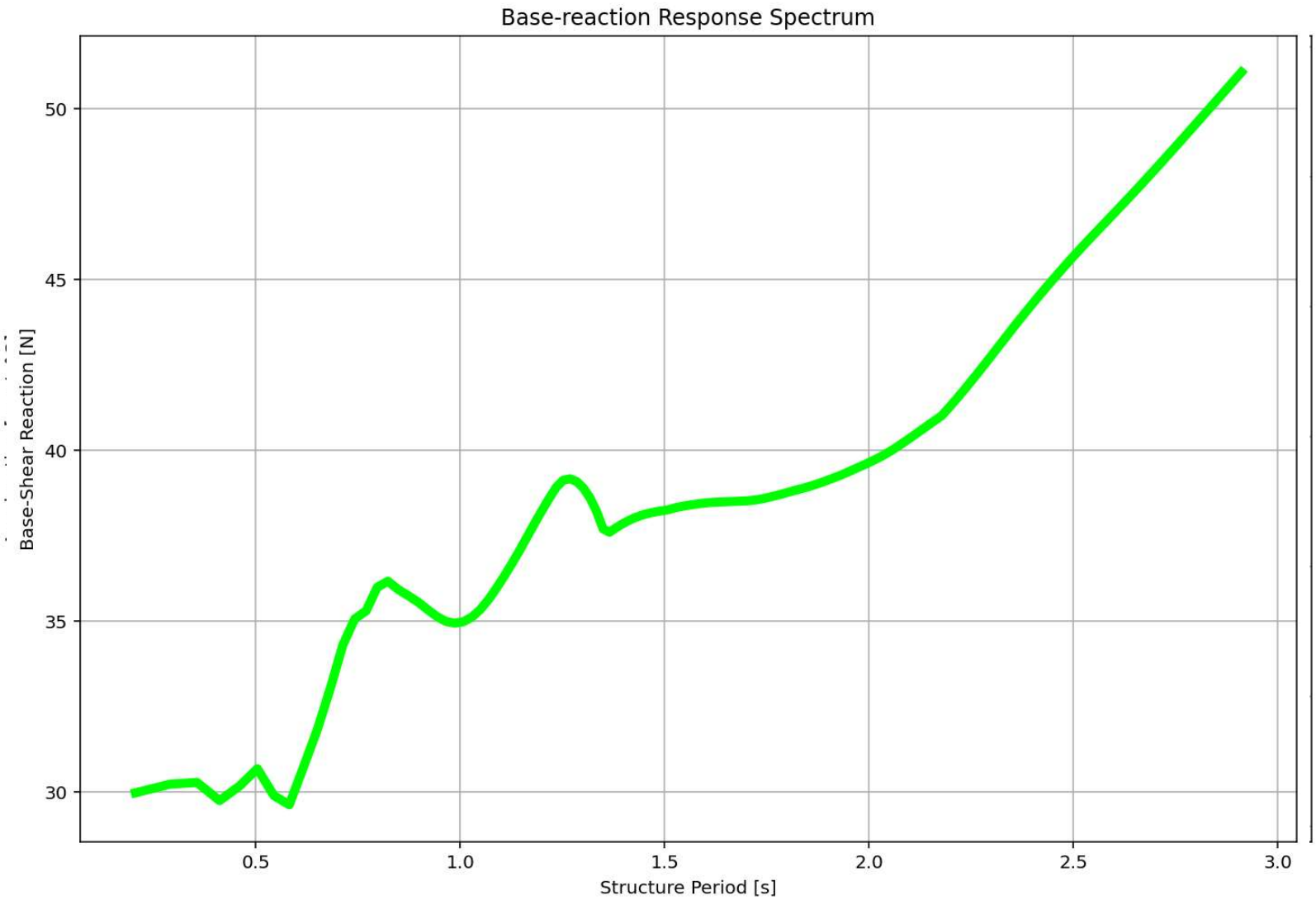
```
UserWarning: Attempt to set non-positive ylim on a log-scaled axis
will be ignored.
  plt.ylim(0, 1.0)
C:
\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRAME_EXAMPLES\SEISMIC_RE
SPONSE_SPECTRUM\PLOT_2D.py:43: UserWarning: Legend does not support
handles for Text instances.
See: https://matplotlib.org/stable/tutorials/intermediate/
legend_guide.html#implementing-a-custom-legend-handler
  ax.legend()
```

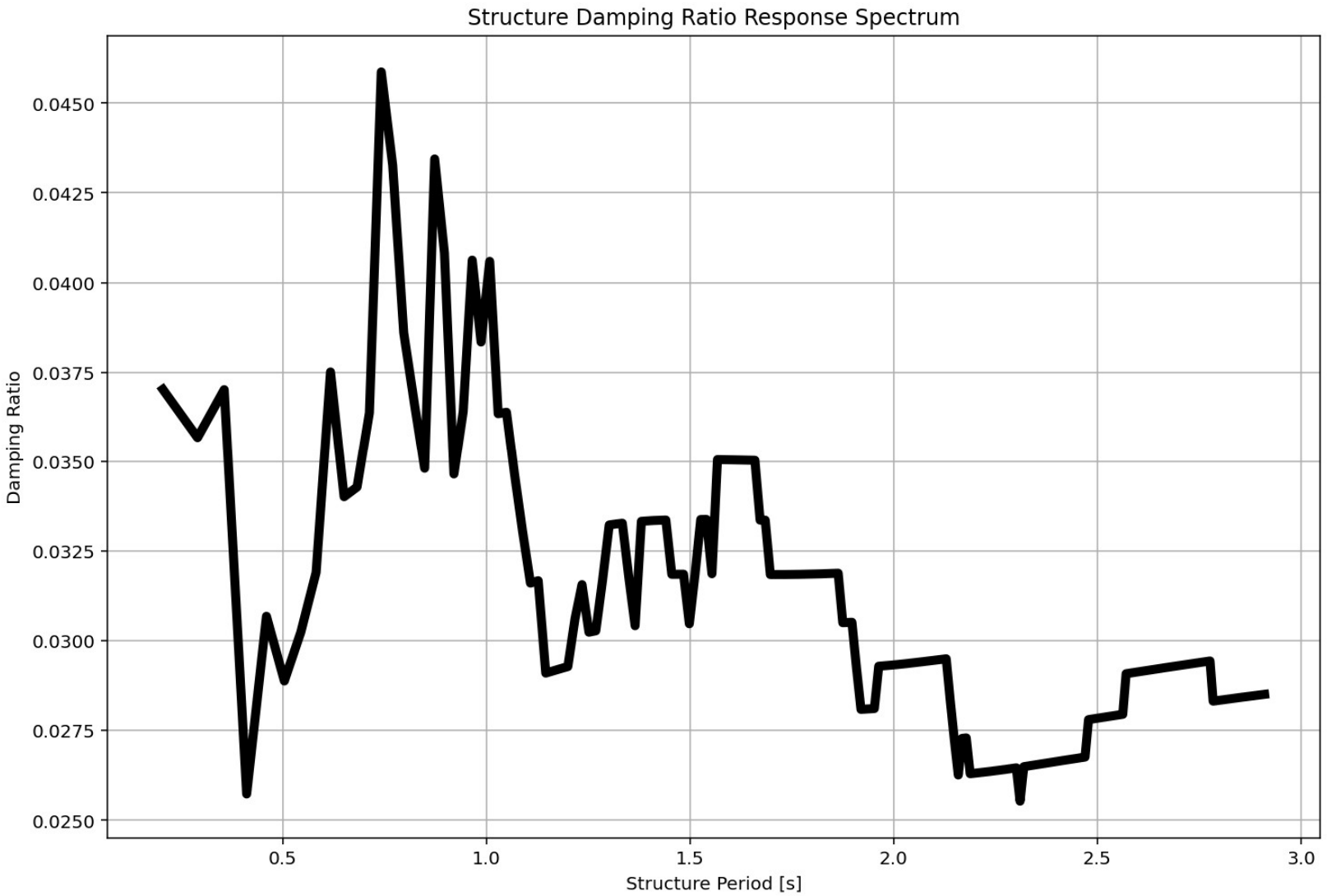
IPython Console History

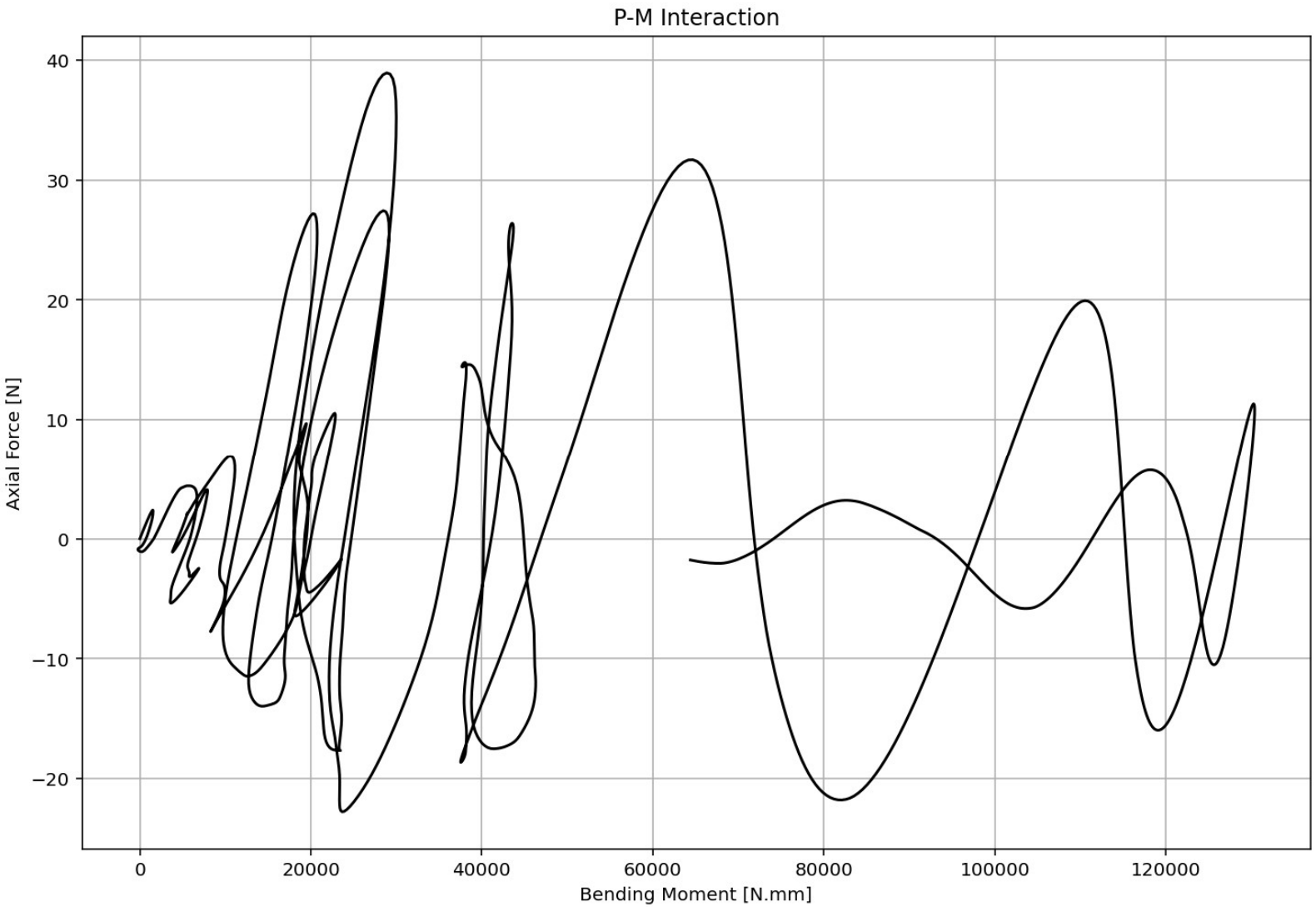
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 127, Col 18 UTF-8 CRLF RW Mem 46%

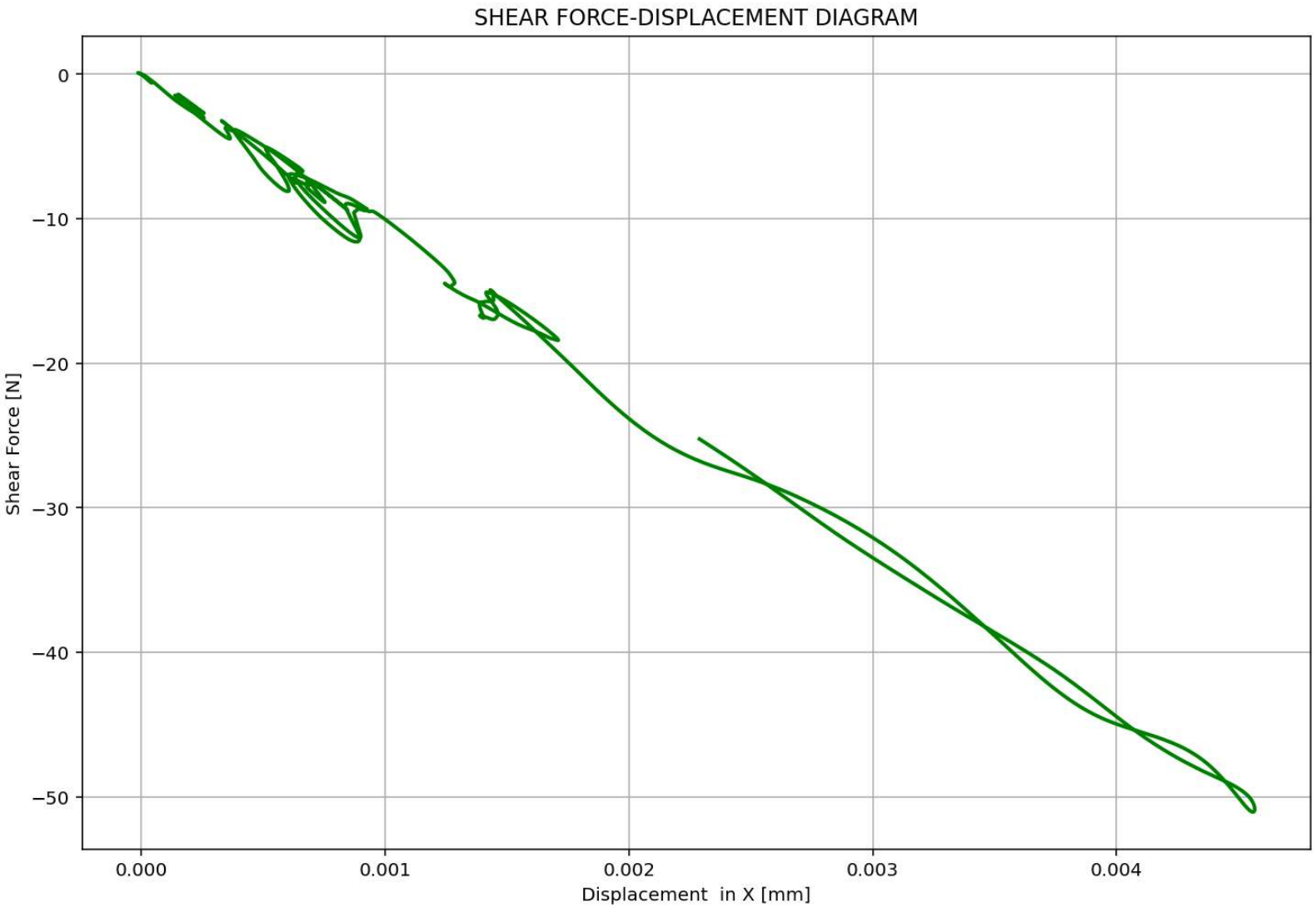

Displacement Response Spectrum
Displacement [mm]
0.00450
0.00425
0.00400
0.00375
0.00350
0.00325
0.00300
0.00275
0.5
1.0
1.5
2.0
2.5
3.0
Structure Period [s]

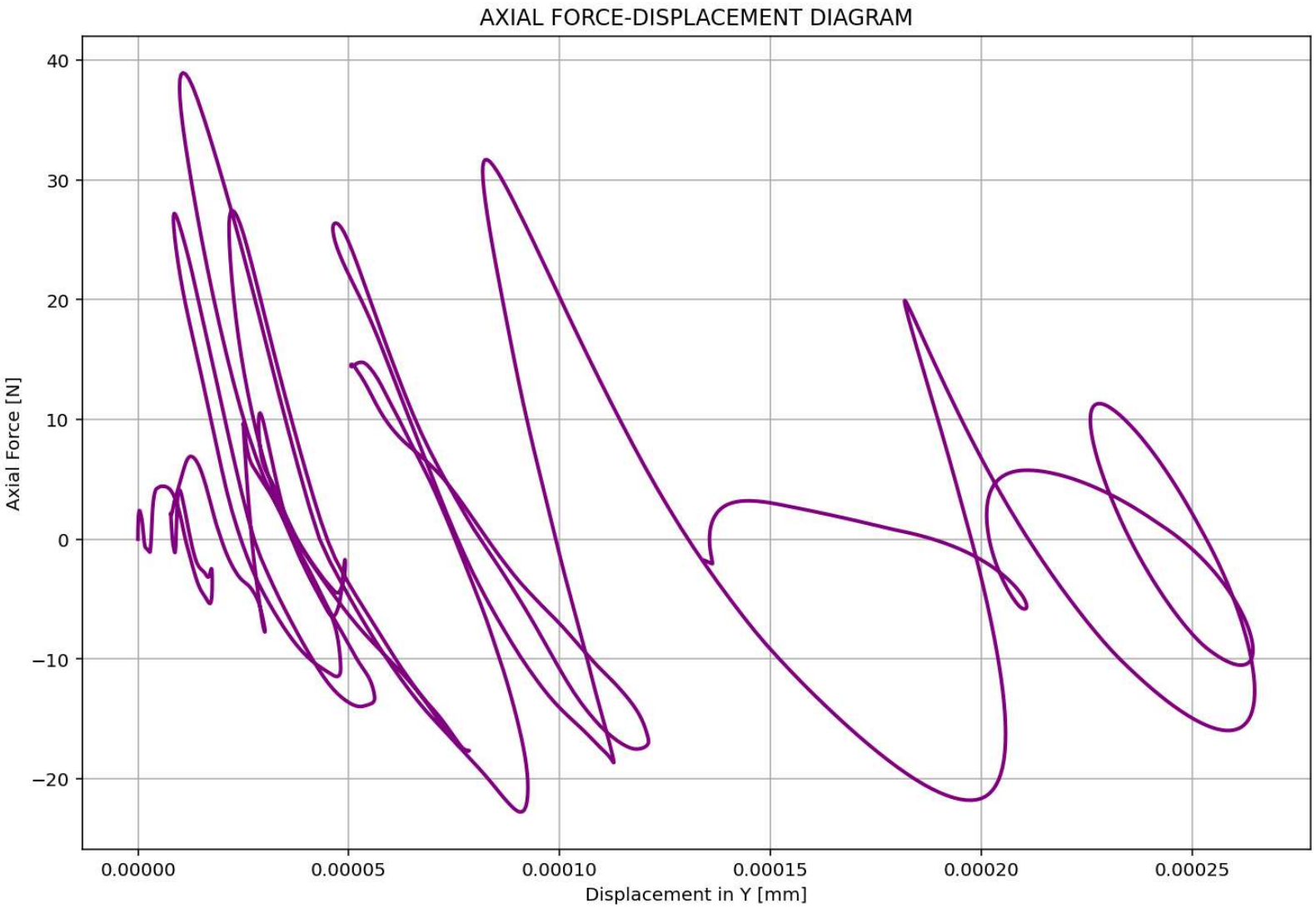

Velocity Response Spectrum
Velocity [mm/s]
0.0036
0.0034
0.0032
0.0030
0.0028
0.0026
0.0024
0.0022
0.0020
0.5
1.0
1.5
2.0
2.5
3.0
Structure Period [s]

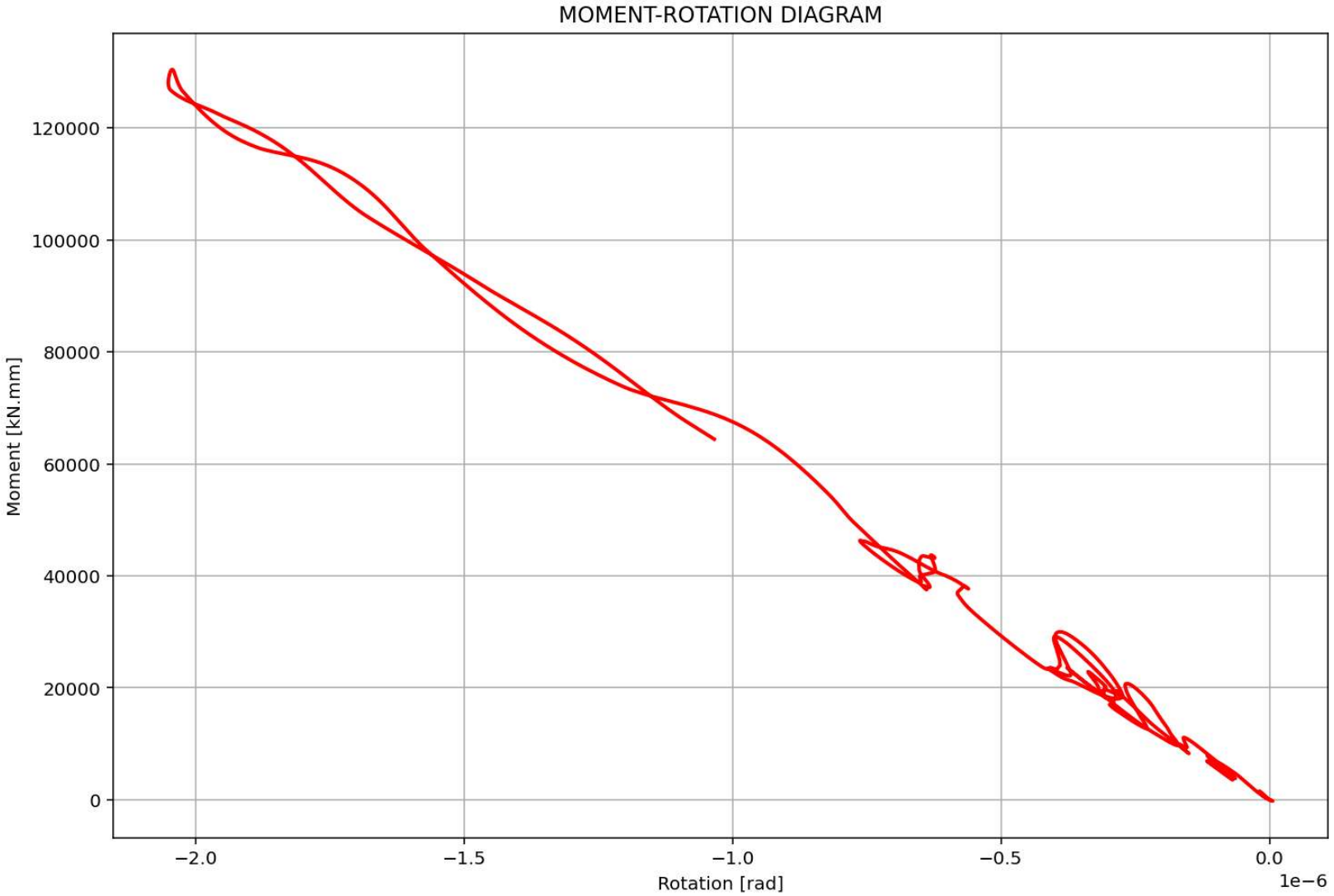

Base-reaction Response Spectrum
Base-Shear Reaction [N]
50
45
40
35
30
0.5
1.0
1.5
2.0
2.5
3.0
Structure Period [s]

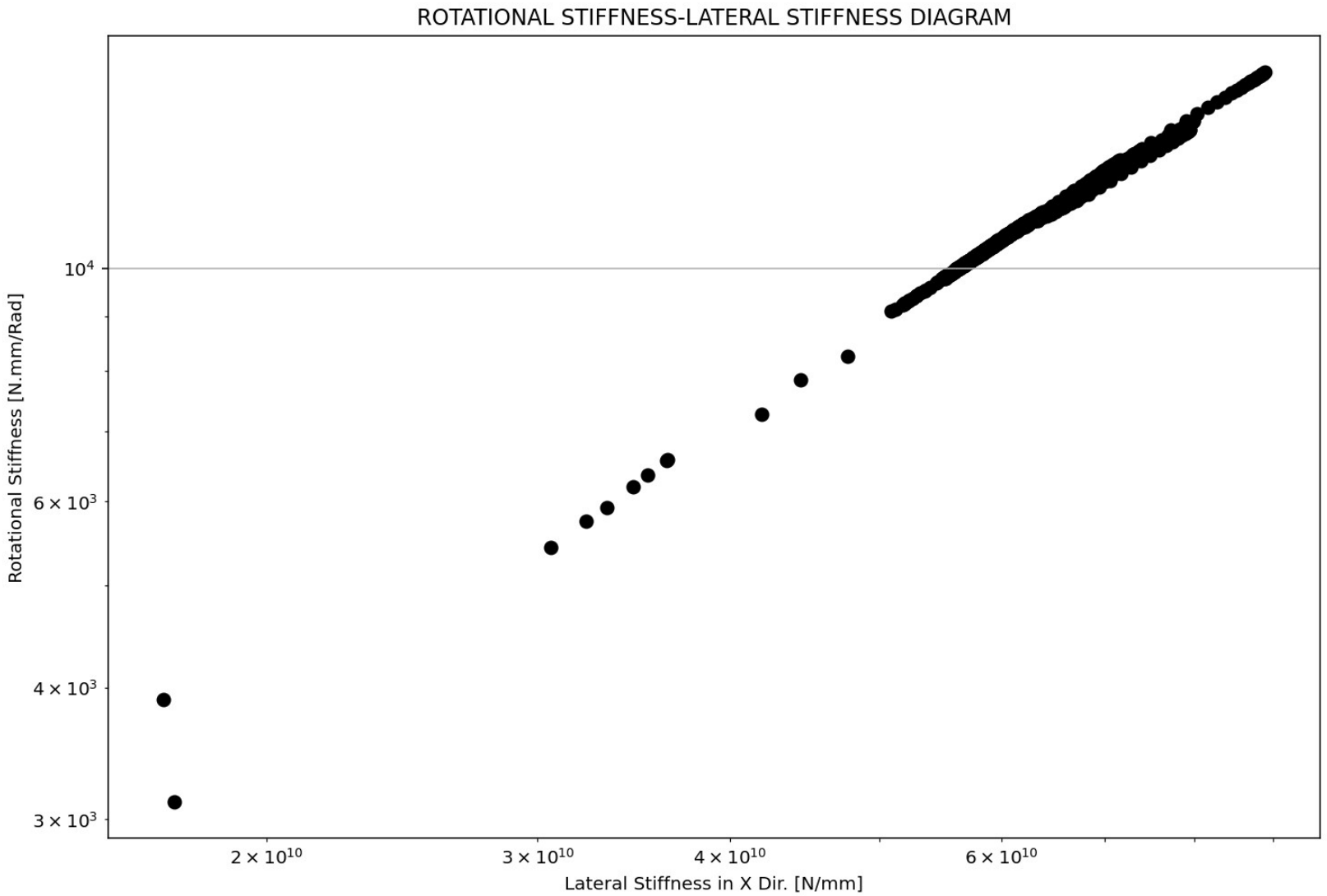

Structure Damping Ratio Response Spectrum
Damping Ratio
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.5
1.0
1.5
2.0
2.5
3.0
Structure Period [s]

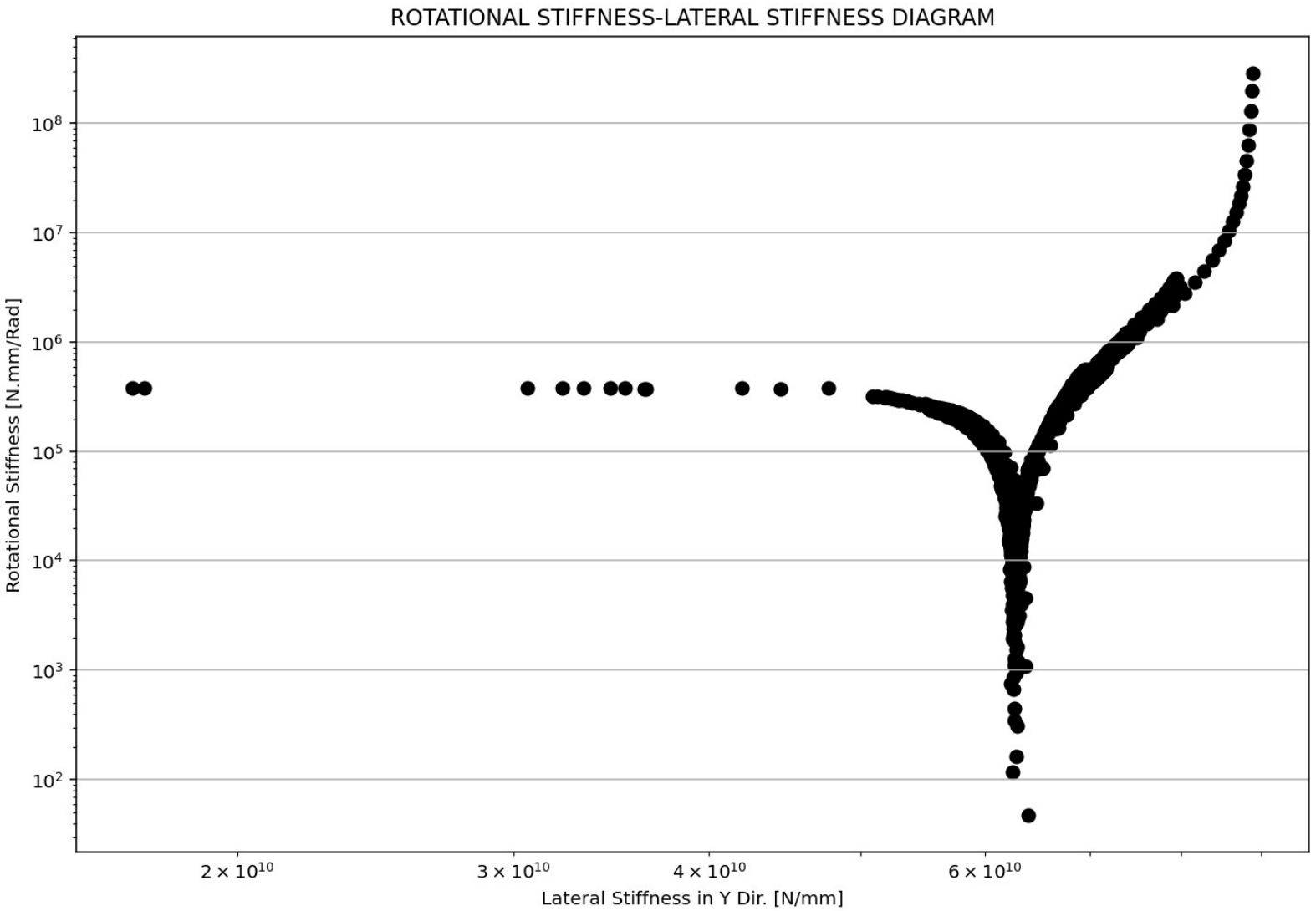

P-M Interaction
Axial Force [N]
Bending Moment [N.mm]
40
30
20
10
0
−10
−20
0
20000
40000
60000
80000
100000
120000

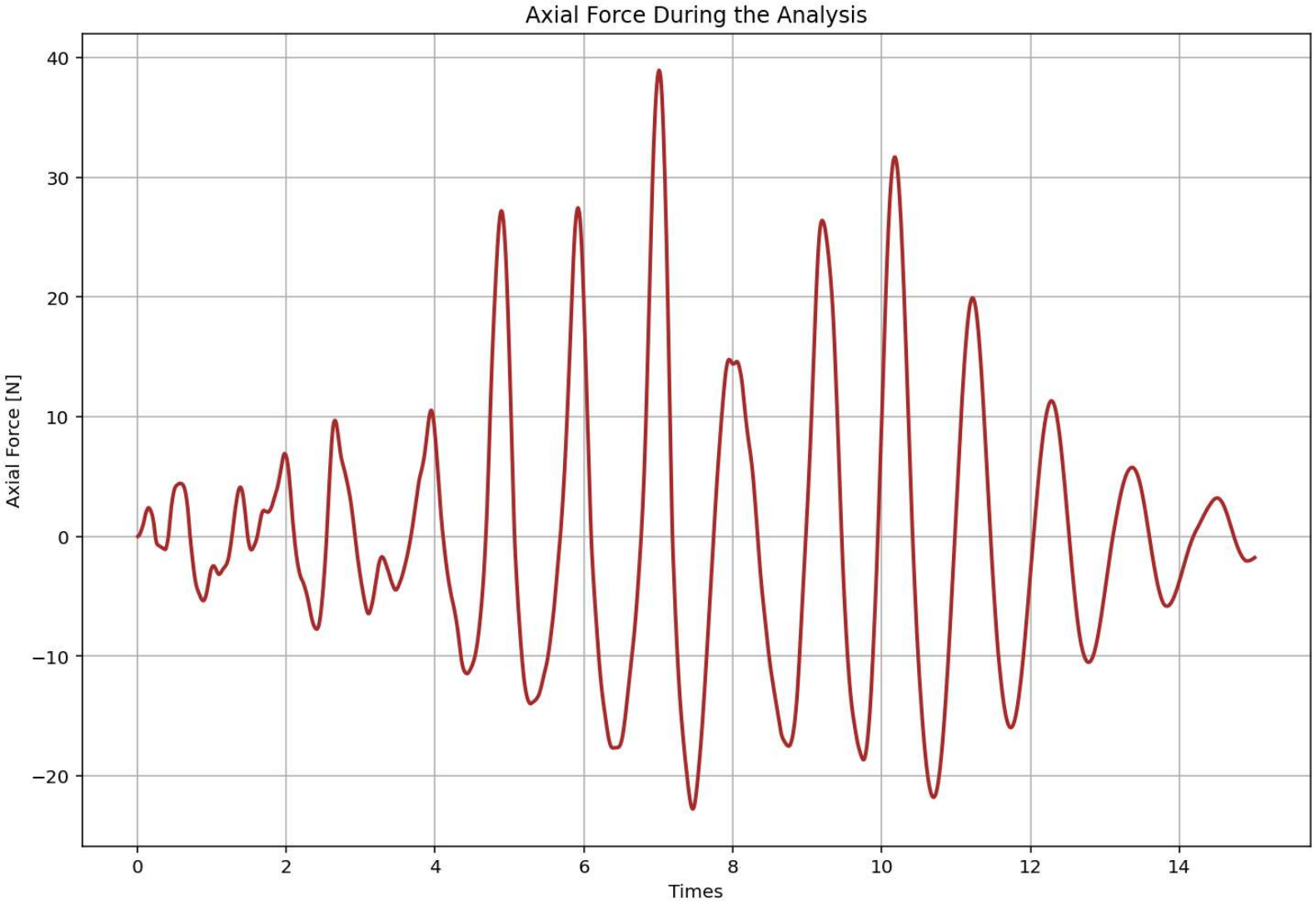

SHEAR FORCE-DISPLACEMENT DIAGRAM
0
−10
−20
−30
−40
−50
Shear Force [N]
0.000
0.001
0.002
0.003
0.004
Displacement in X [mm]

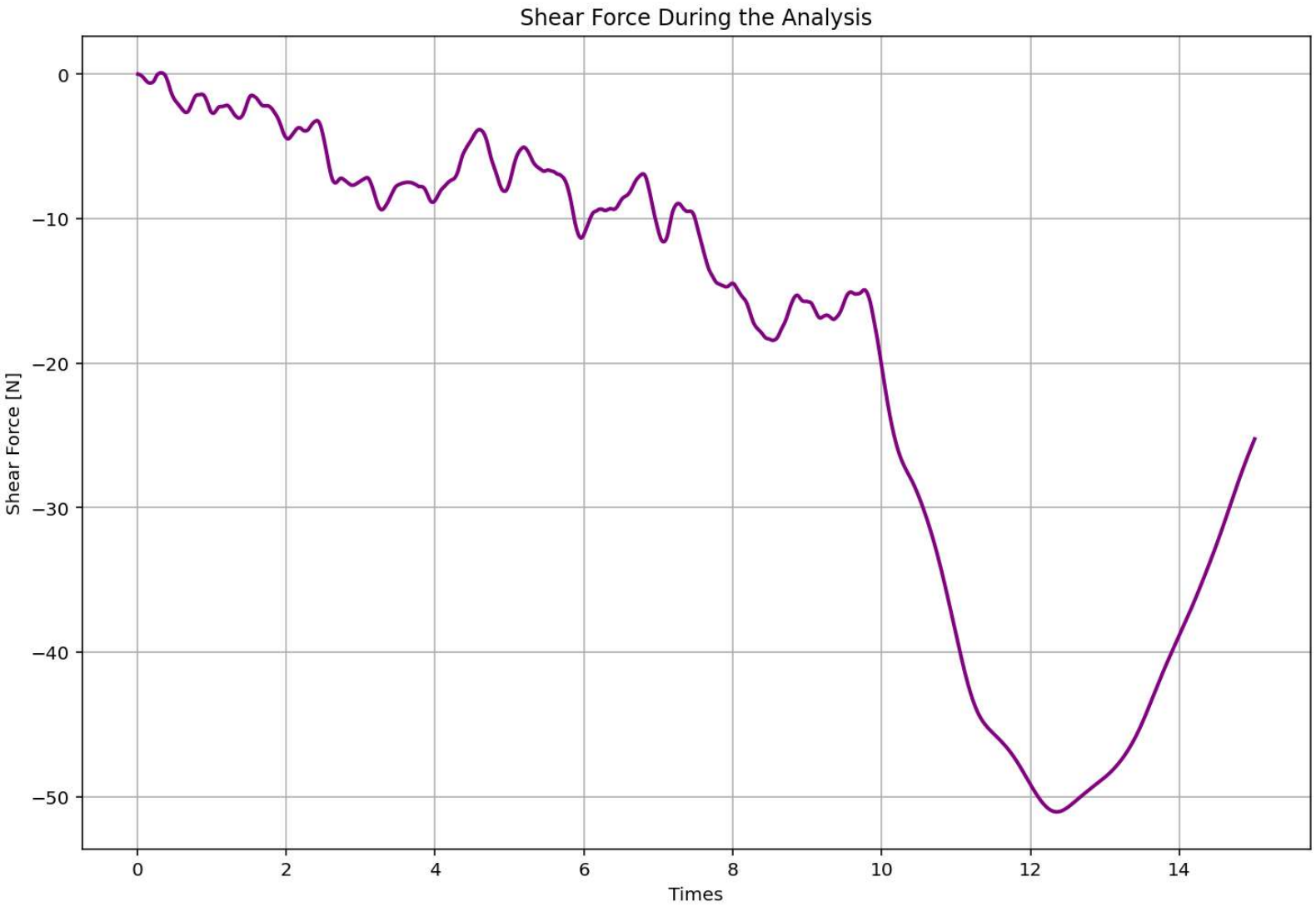

AXIAL FORCE-DISPLACEMENT DIAGRAM
Axial Force [N]
40
30
20
10
0
−10
−20
0.00000
0.00005
0.00010
0.00015
0.00020
0.00025
Displacement in Y [mm]

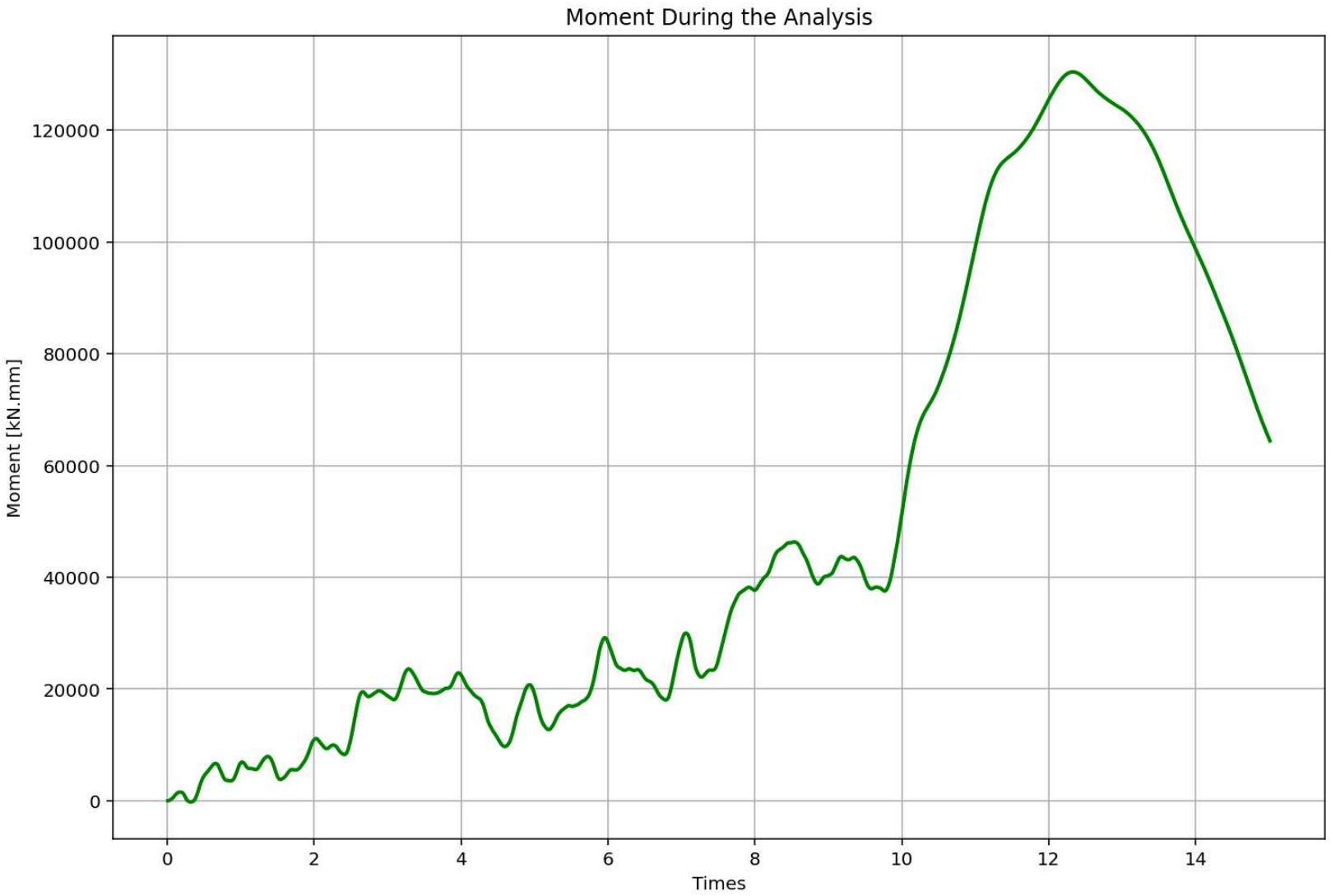

MOMENT-ROTATION DIAGRAM
Moment [kN.mm]
120000
100000
80000
60000
40000
20000
0
−2.0
−1.5
−1.0
−0.5
0.0
1e−6
Rotation [rad]

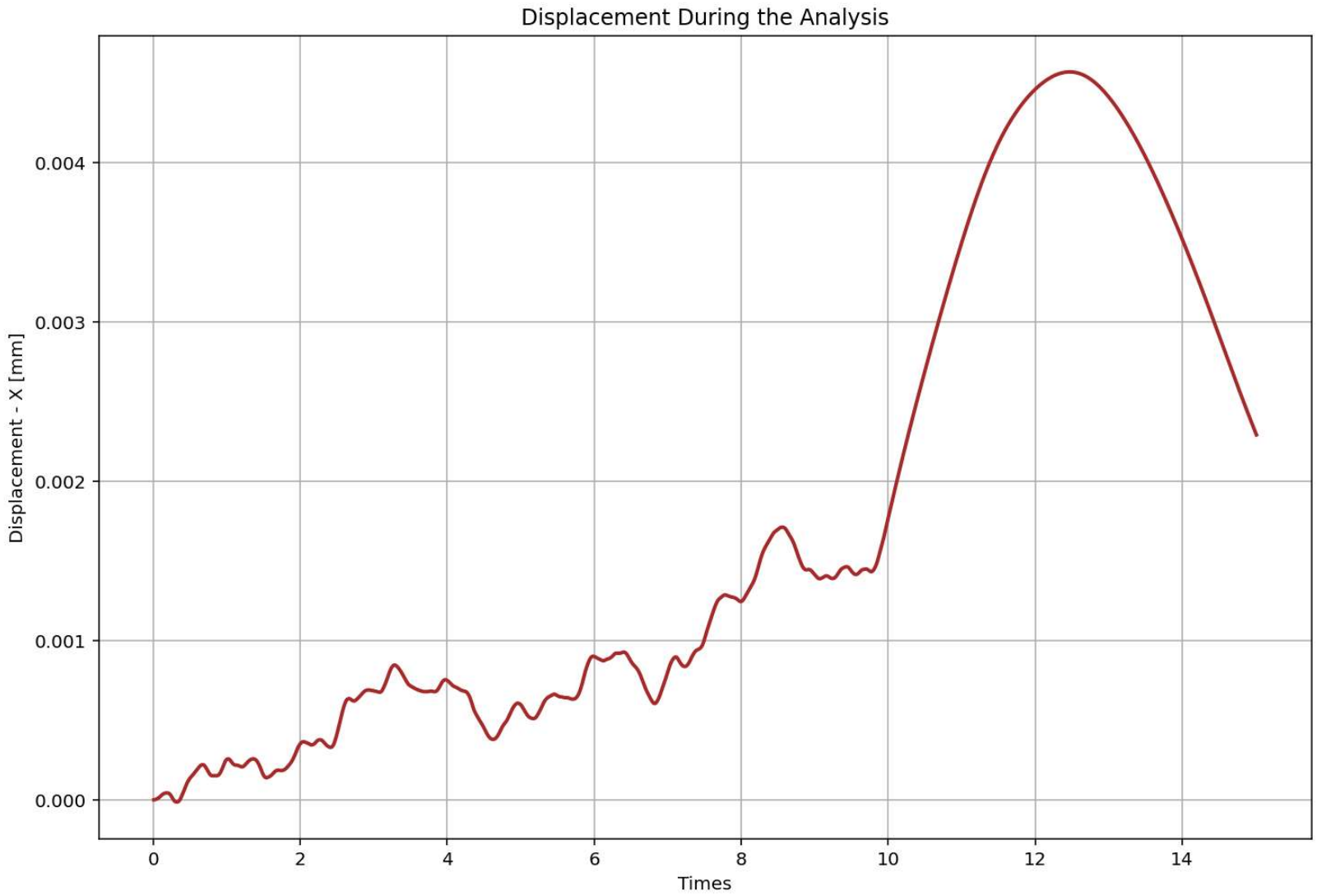

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
10^4
6×10^3
4×10^3
3×10^3
2×10^{10}
3×10^{10}
4×10^{10}
6×10^{10}
Lateral Stiffness in X Dir. [N/mm]

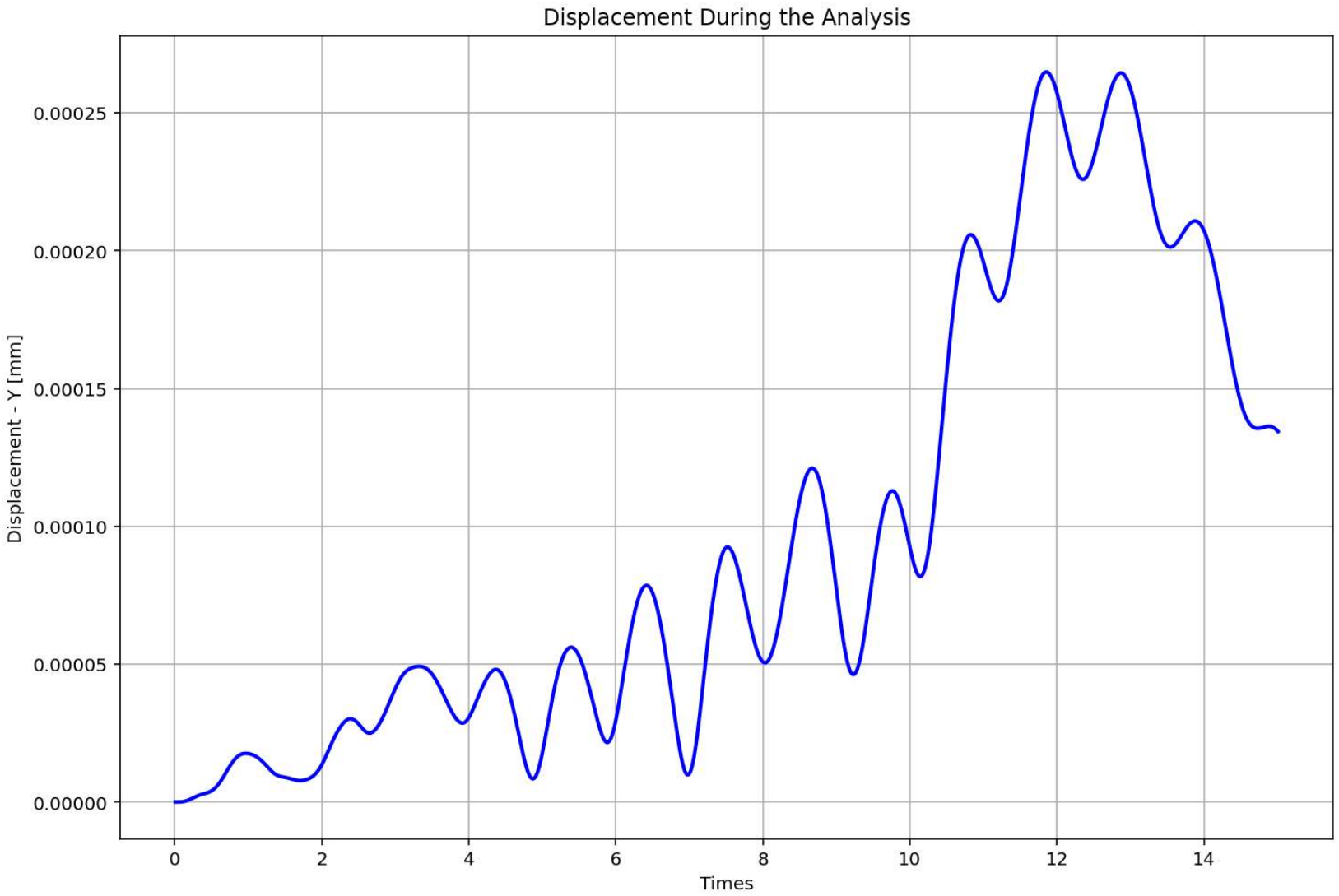

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
10^8
10^7
10^6
10^5
10^4
10^3
10^2
2×10^{10}
3×10^{10}
4×10^{10}
6×10^{10}
Lateral Stiffness in Y Dir. [N/mm]

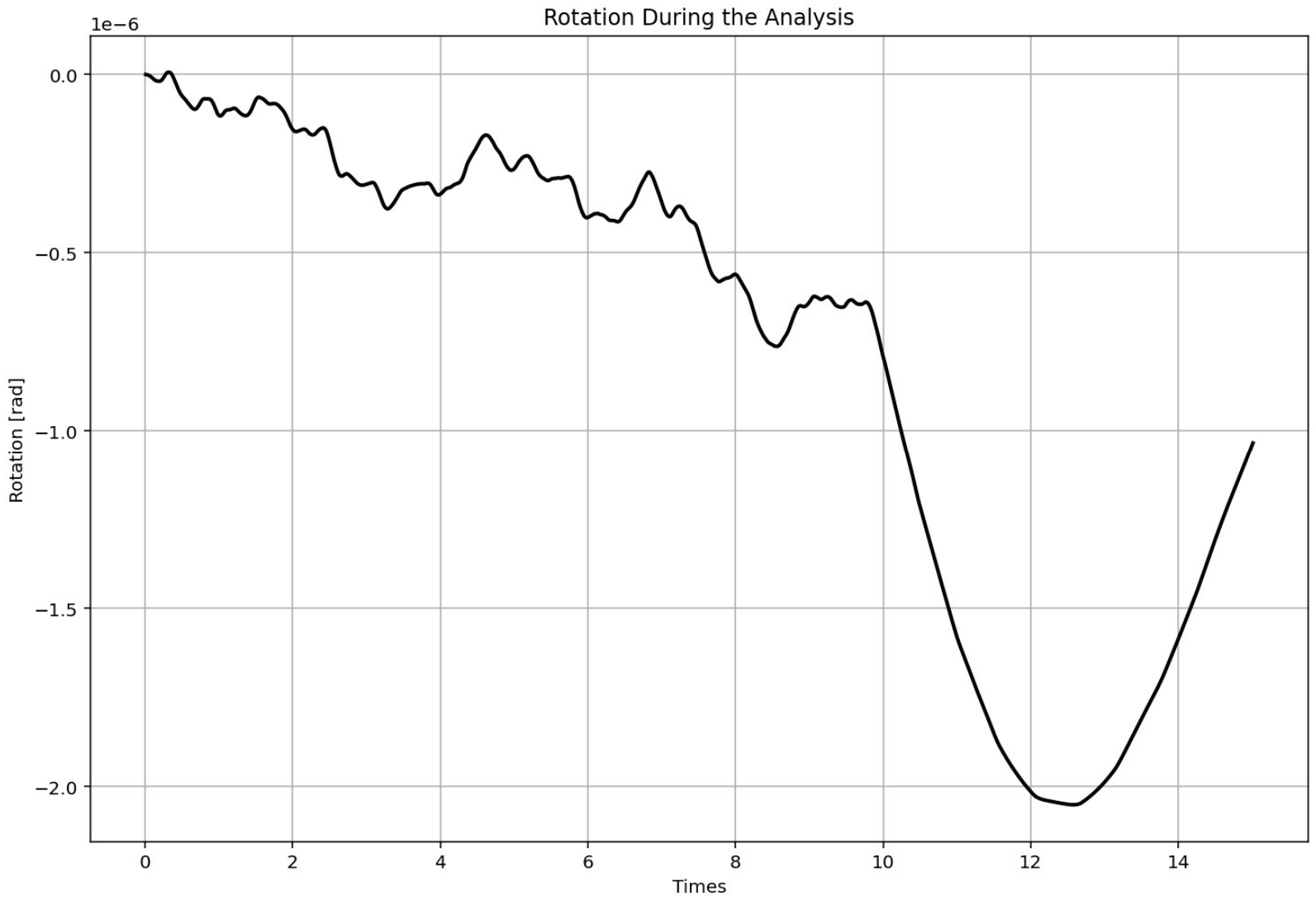

Axial Force During the Analysis
Axial Force [N]
Times
40
30
20
10
0
−10
−20
0
2
4
6
8
10
12
14

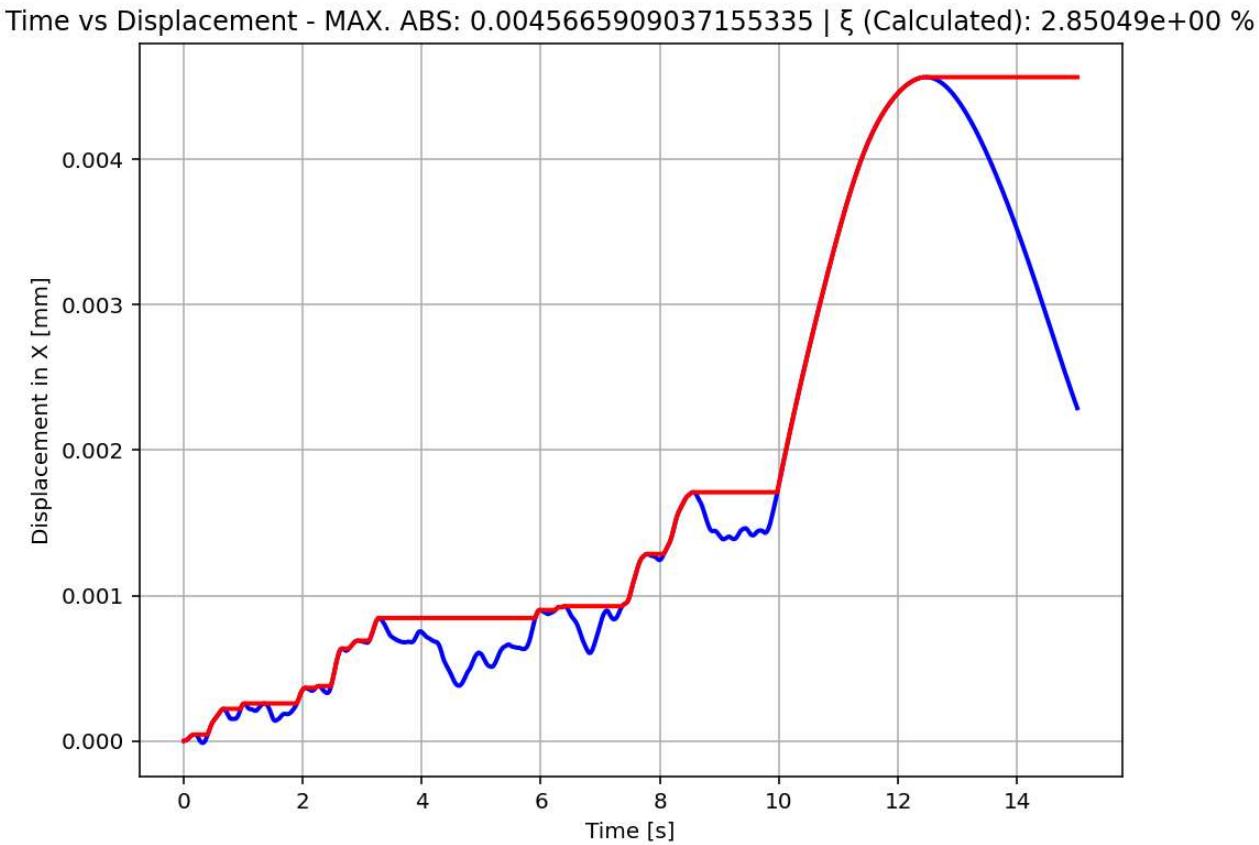

Shear Force During the Analysis
Shear Force [N]
0
−10
−20
−30
−40
−50
0
2
4
6
8
10
12
14
Times

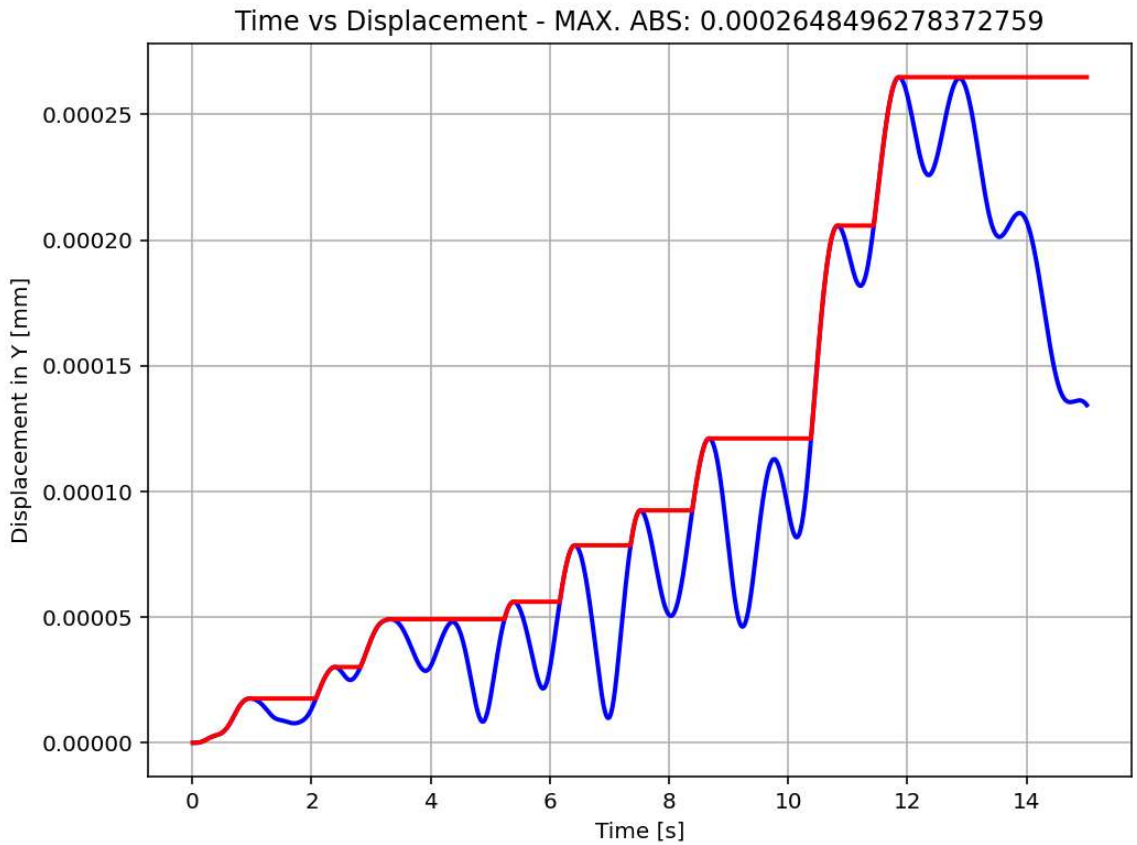

Moment During the Analysis
Moment [kN.mm]
120000
100000
80000
60000
40000
20000
0
0
2
4
6
8
10
12
14
Times

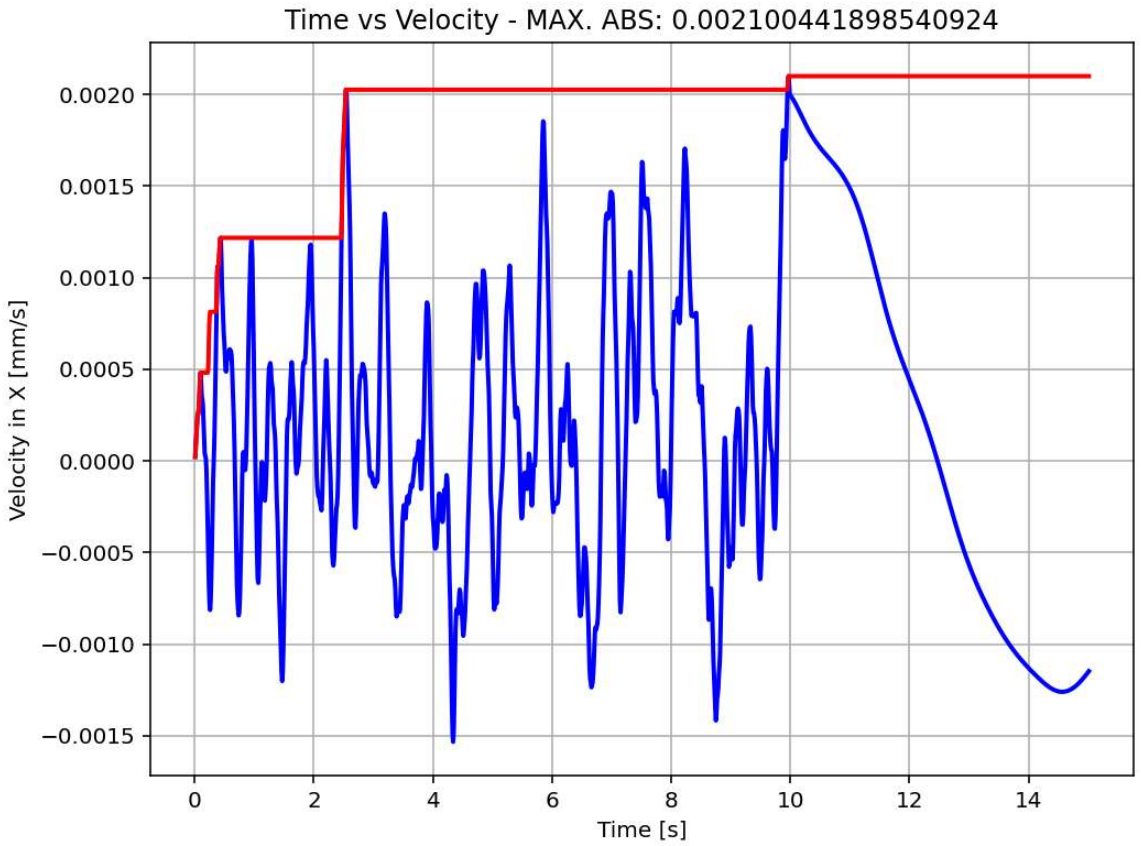

Displacement During the Analysis
Displacement - X [mm]
0.004
0.003
0.002
0.001
0.000
0
2
4
6
8
10
12
14
Times

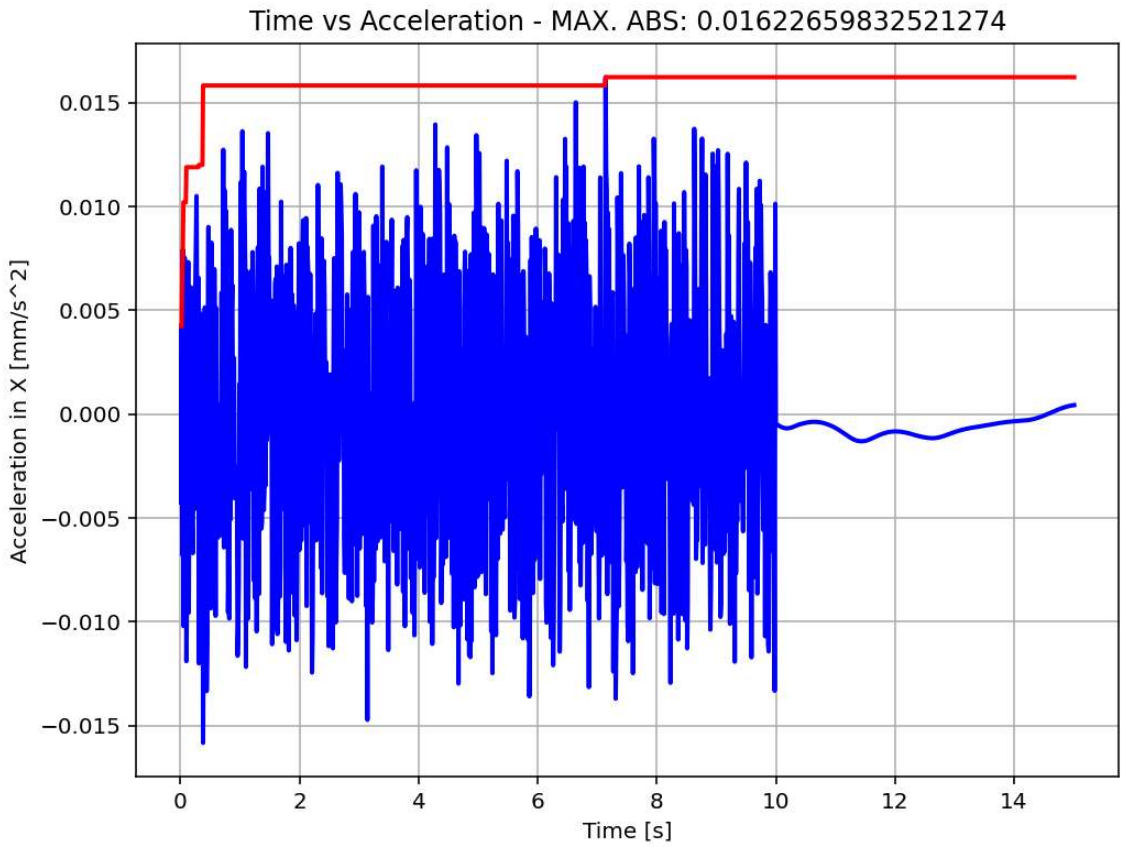

Displacement During the Analysis
Displacement - Y [mm]
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
0
2
4
6
8
10
12
14
Times

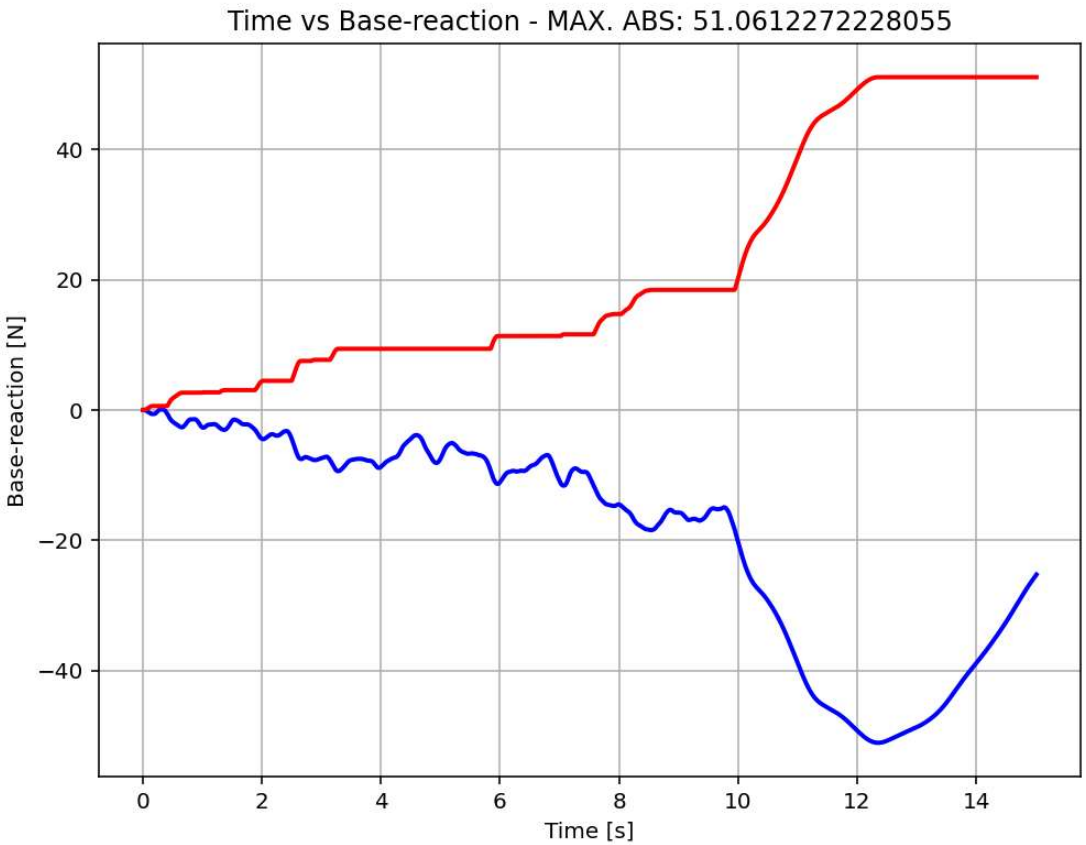

Rotation During the Analysis
1e−6
0.0
−0.5
−1.0
−1.5
−2.0
Rotation [rad]
0
2
4
6
8
10
12
14
Times

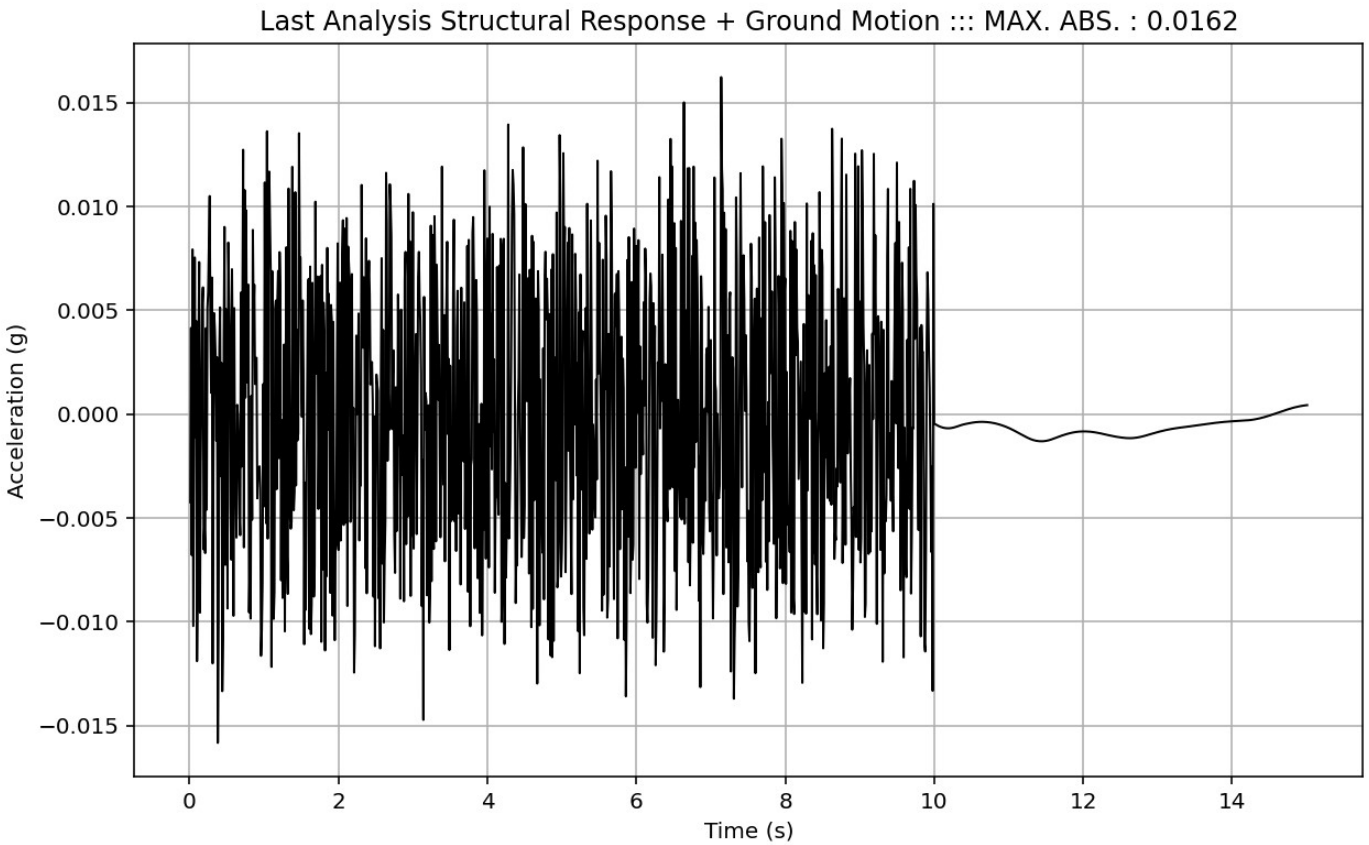

Time vs Displacement - MAX. ABS: 0.0045665909037155335 | ξ (Calculated): 2.85049e+00 %
Displacement in X [mm]
0.000
0.001
0.002
0.003
0.004
Time [s]
0
2
4
6
8
10
12
14

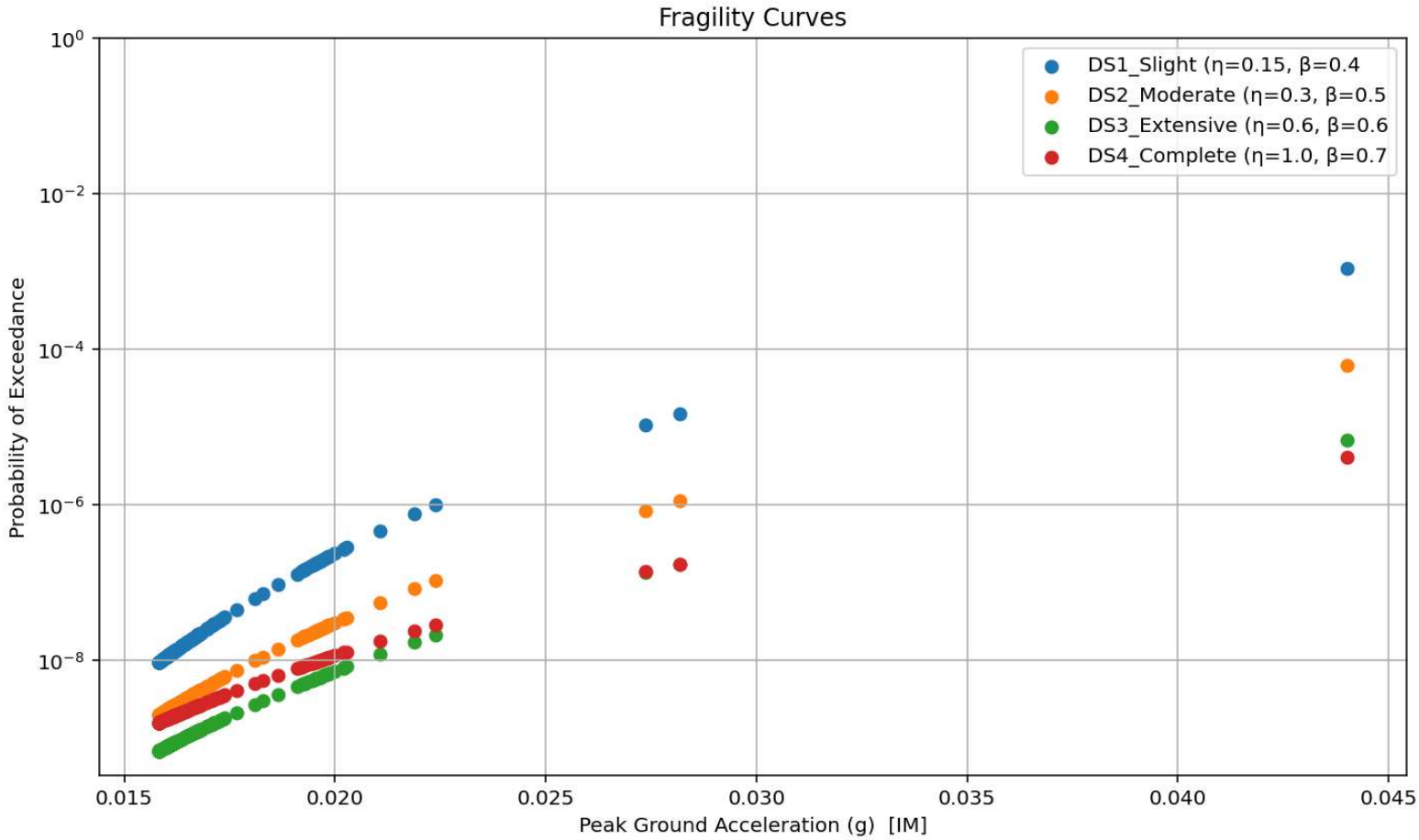

Time vs Displacement - MAX. ABS: 0.0002648496278372759
Displacement in Y [mm]
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
0
2
4
6
8
10
12
14
Time [s]

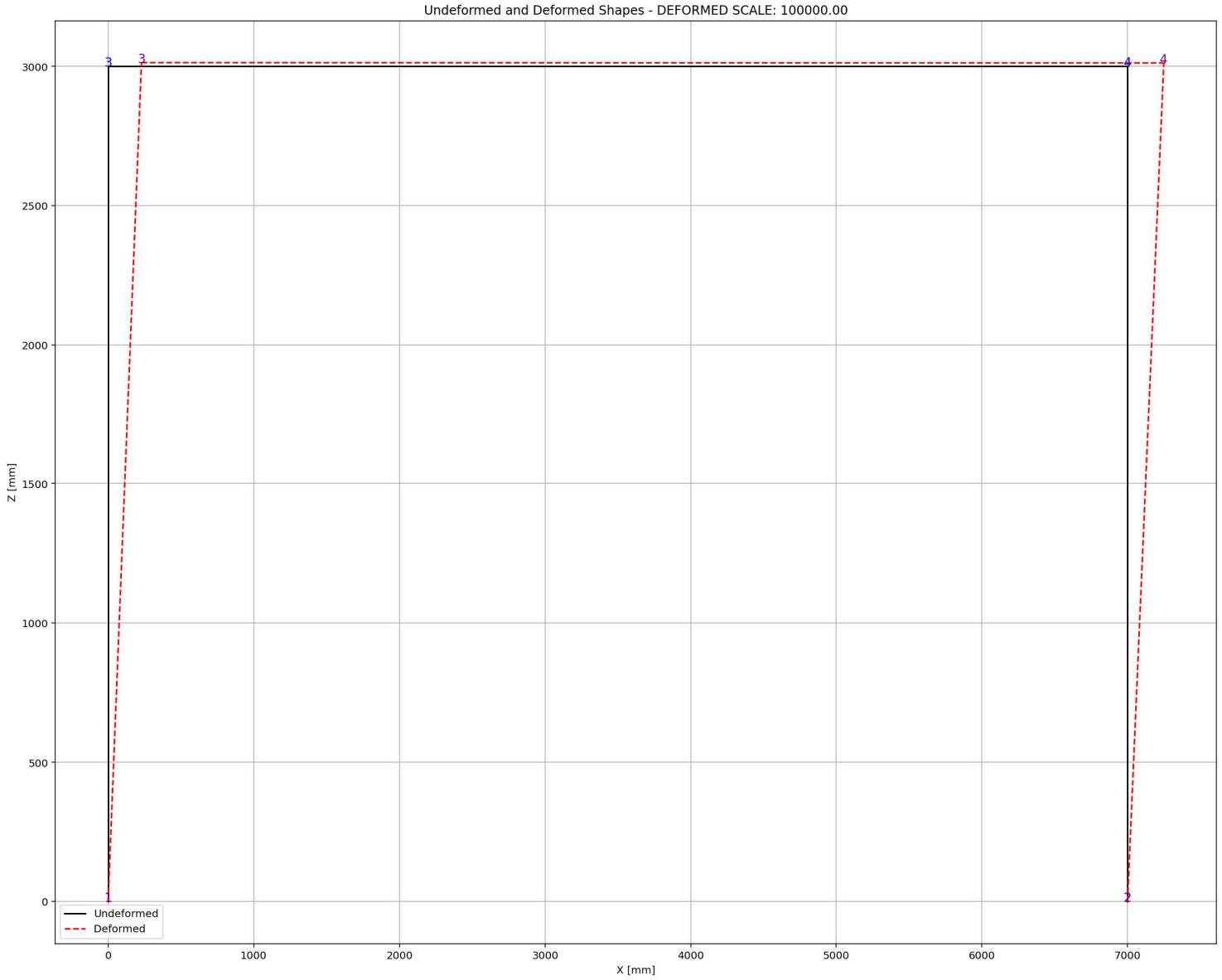

Time vs Velocity - MAX. ABS: 0.002100441898540924
Velocity in X [mm/s]
Time [s]
0.0020
0.0015
0.0010
0.0005
0.0000
−0.0005
−0.0010
−0.0015
0
2
4
6
8
10
12
14


Time vs Acceleration - MAX. ABS: 0.01622659832521274
Acceleration in X [mm/s^2]
Time [s]
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
0
2
4
6
8
10
12
14


Time vs Base-reaction - MAX. ABS: 51.0612272228055
Base-reaction [N]
40
20
0
−20
−40
0
2
4
6
8
10
12
14
Time [s]


Last Analysis Structural Response + Ground Motion ::: MAX. ABS. : 0.0162
Acceleration (g)
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
0
2
4
6
8
10
12
14
Time (s)


Fragility Curves
DS1_Slight (η=0.15, β=0.4
DS2_Moderate (η=0.3, β=0.5
DS3_Extensive (η=0.6, β=0.6
DS4_Complete (η=1.0, β=0.7
Probability of Exceedance
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
0.015
0.020
0.025
0.030
0.035
0.040
0.045
Peak Ground Acceleration (g) [IM]


Undeformed and Deformed Shapes - DEFORMED SCALE: 100000.00
Z [mm]
X [mm]
Undeformed
Deformed
3
3
4
4
1
2
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000