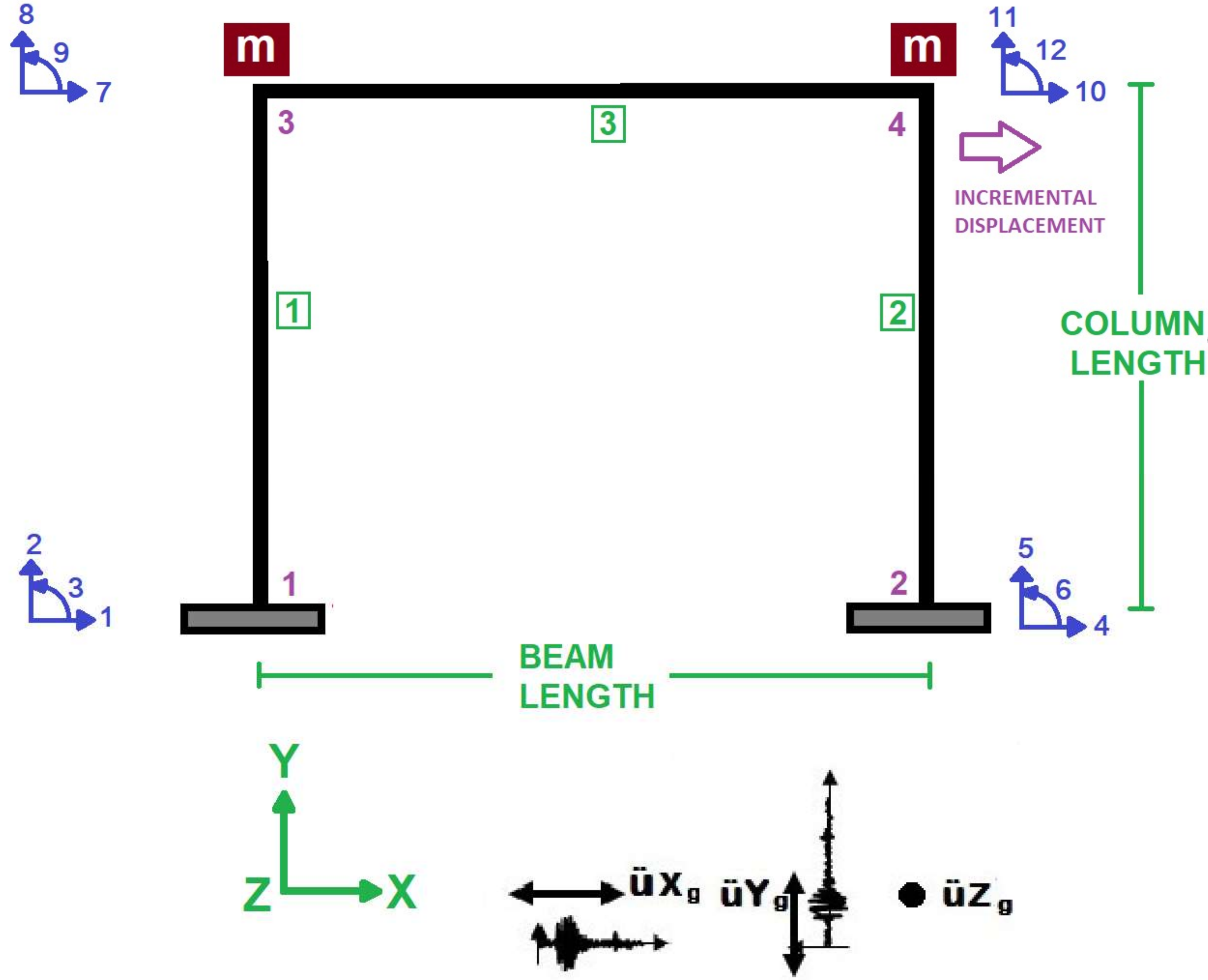
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

INCREMENTAL DYNAMIC SEISMIC ANALYSIS OF CONCRETE FRAME USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


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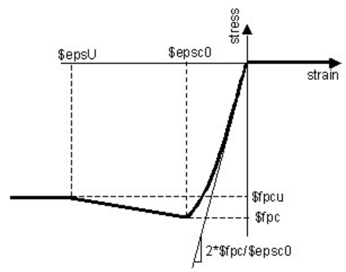
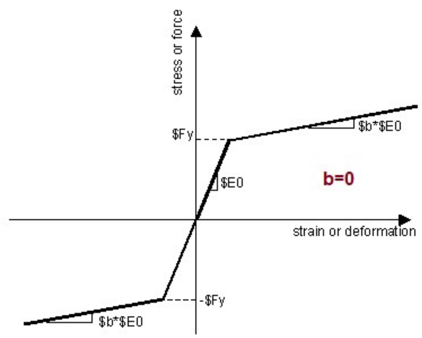
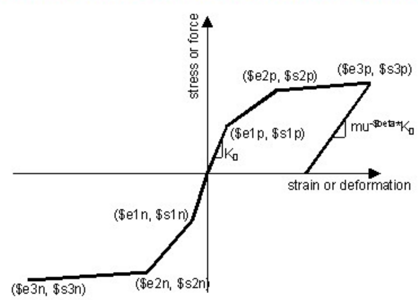
BEAM
LENGTH
Y
Z
X
üXg
üYg
üZg



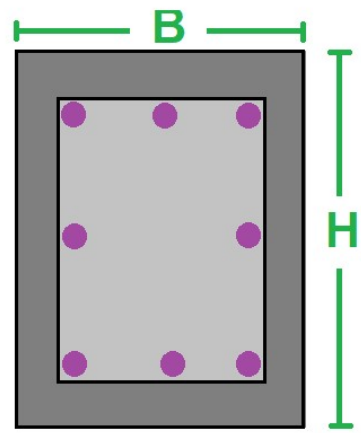
CORE AND COVER CONCRETE RELATION



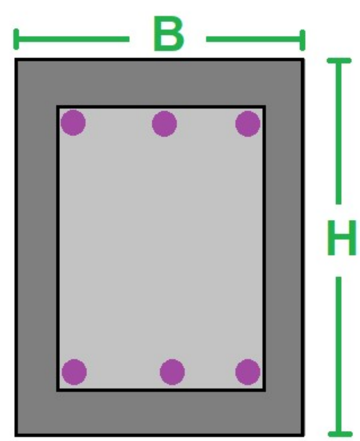
WITHOUT HARDENING AND ULTIMATE STRAIN



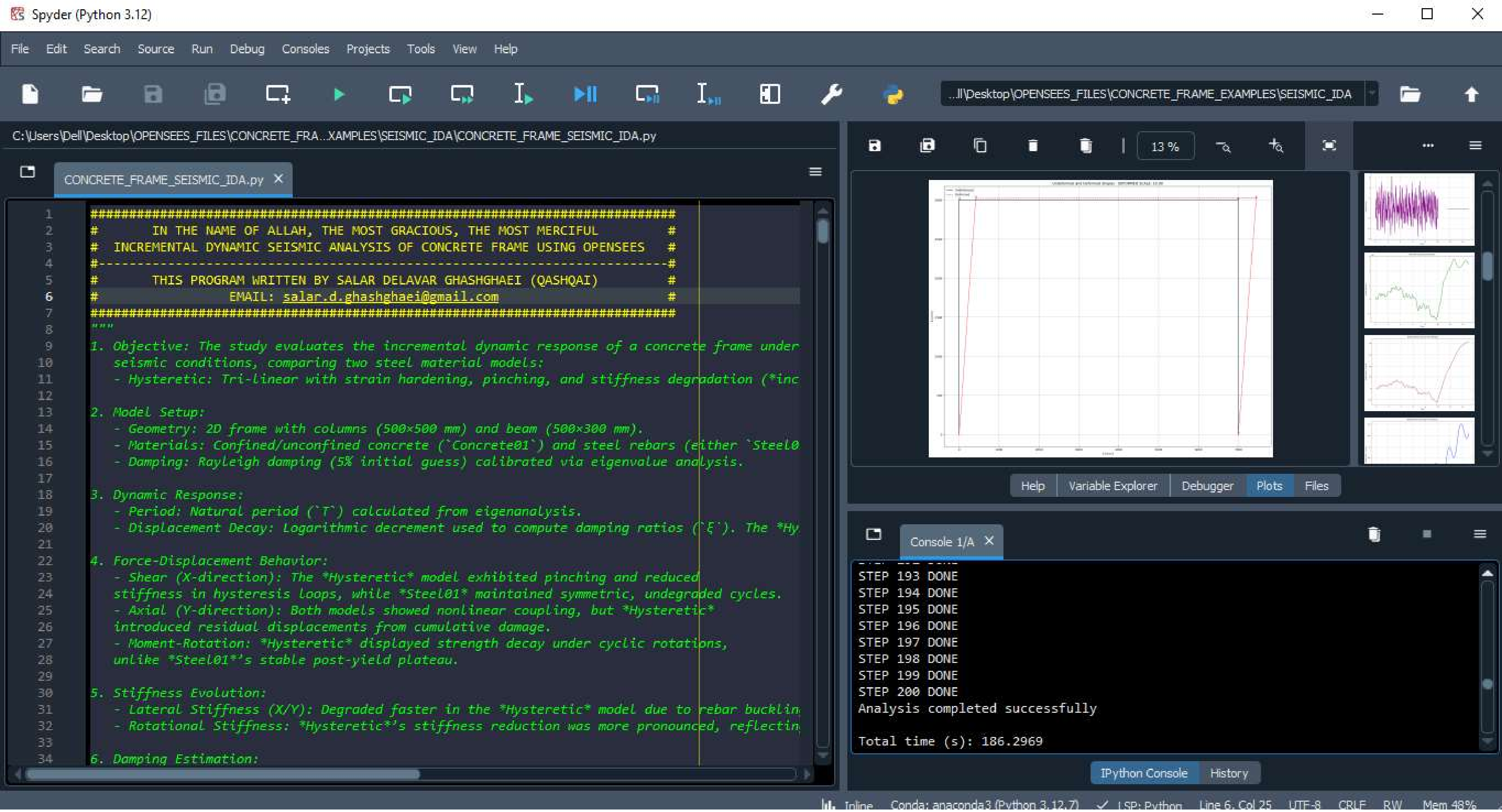
WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION


Spyder (Python 3.12)
File Edit Search Source Run Debug Consoles Projects Tools View Help
..ll\Desktop\OPENSEES_FILES\CONCRETE_FRAME_EXAMPLES\SEISMIC_IDA
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...XAMPLES\SEISMIC_IDA\CONCRETE_FRAME_SEISMIC_IDA.py
CONCRETE_FRAME_SEISMIC_IDA.py
###
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL
INCREMENTAL DYNAMIC SEISMIC 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 incremental dynamic response of a concrete frame under
   seismic conditions, comparing two steel material models:
   - Hysteretic: Tri-linear with strain hardening, pinching, and stiffness degradation (*inc

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 `Steel0
   - Damping: Rayleigh damping (5% initial guess) calibrated via eigenvalue analysis.

3. Dynamic Response:
   - Period: Natural period (`T`) calculated from eigenanalysis.
   - Displacement Decay: Logarithmic decrement used to compute damping ratios (`ξ`). The *Hy

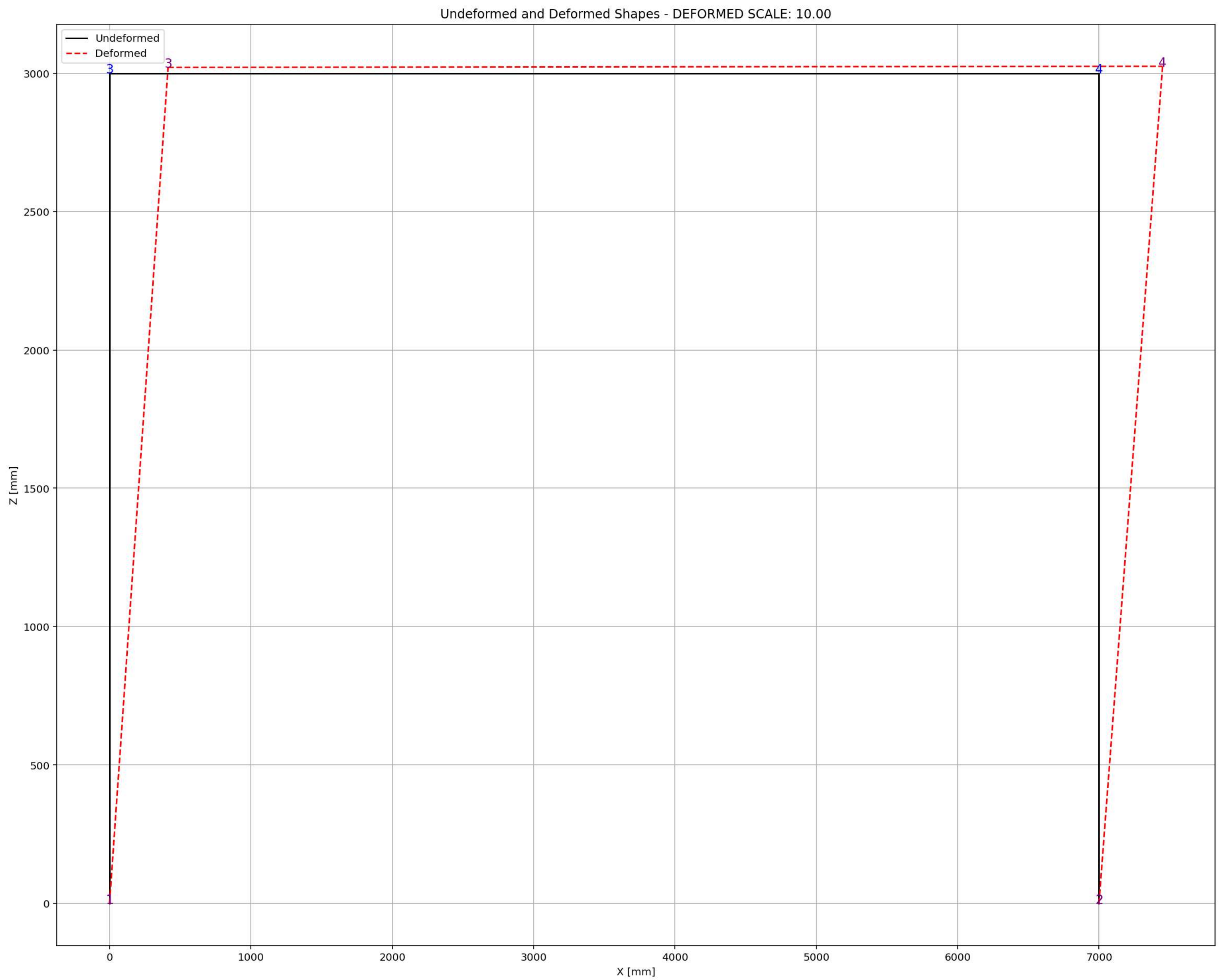
4. Force-Displacement Behavior:
   - Shear (X-direction): The *Hysteretic* model exhibited pinching and reduced
   stiffness in hysteresis loops, while *Steel01* maintained symmetric, undegraded cycles.
   - Axial (Y-direction): Both models showed nonlinear coupling, but *Hysteretic*
   introduced residual 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 bucklin
   - Rotational Stiffness: *Hysteretic*'s stiffness reduction was more pronounced, reflectin

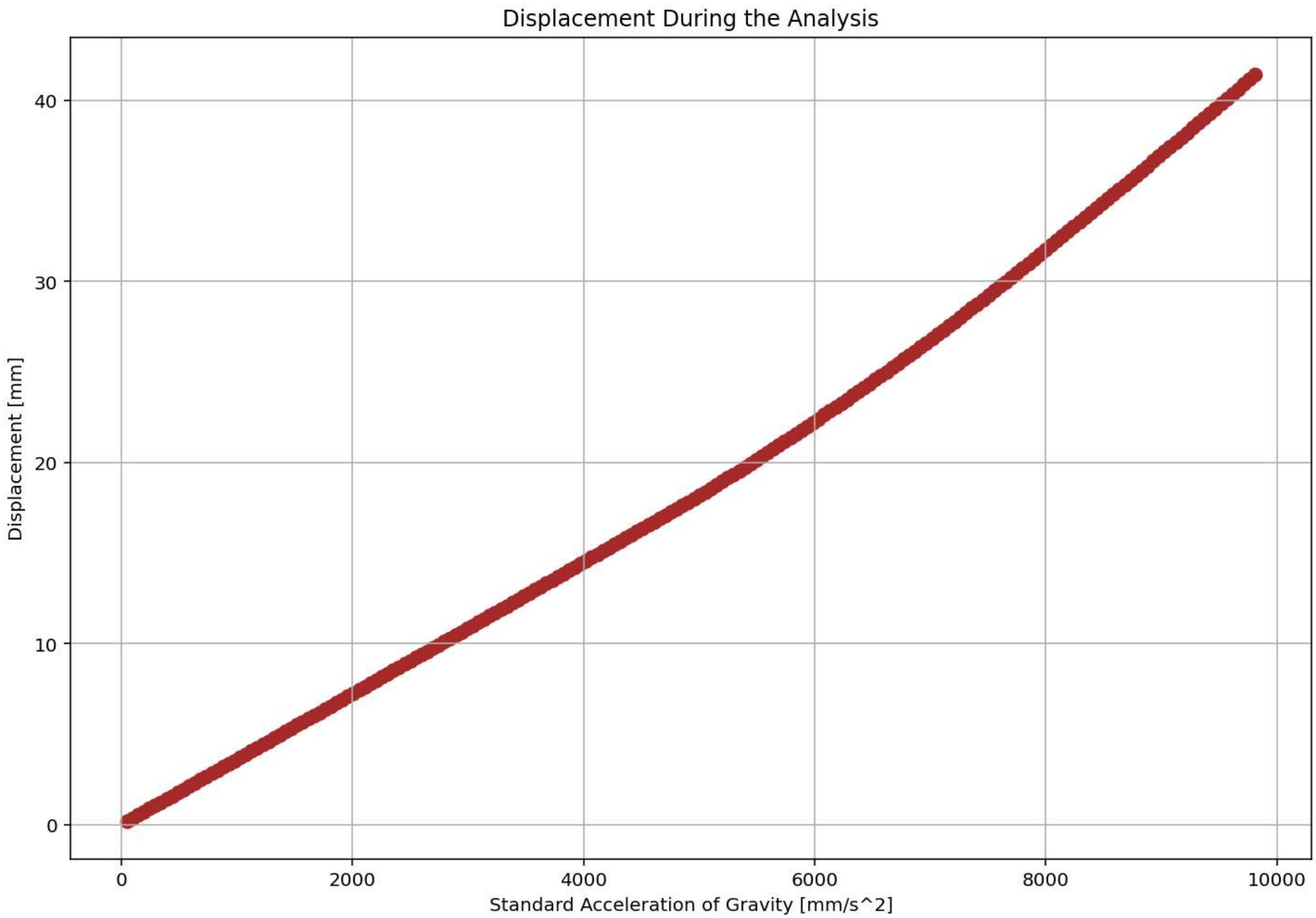
6. Damping Estimation:
13 %
Help Variable Explorer Debugger Plots Files
Console 1/A
STEP 193 DONE
STEP 194 DONE
STEP 195 DONE
STEP 196 DONE
STEP 197 DONE
STEP 198 DONE
STEP 199 DONE
STEP 200 DONE
Analysis completed successfully

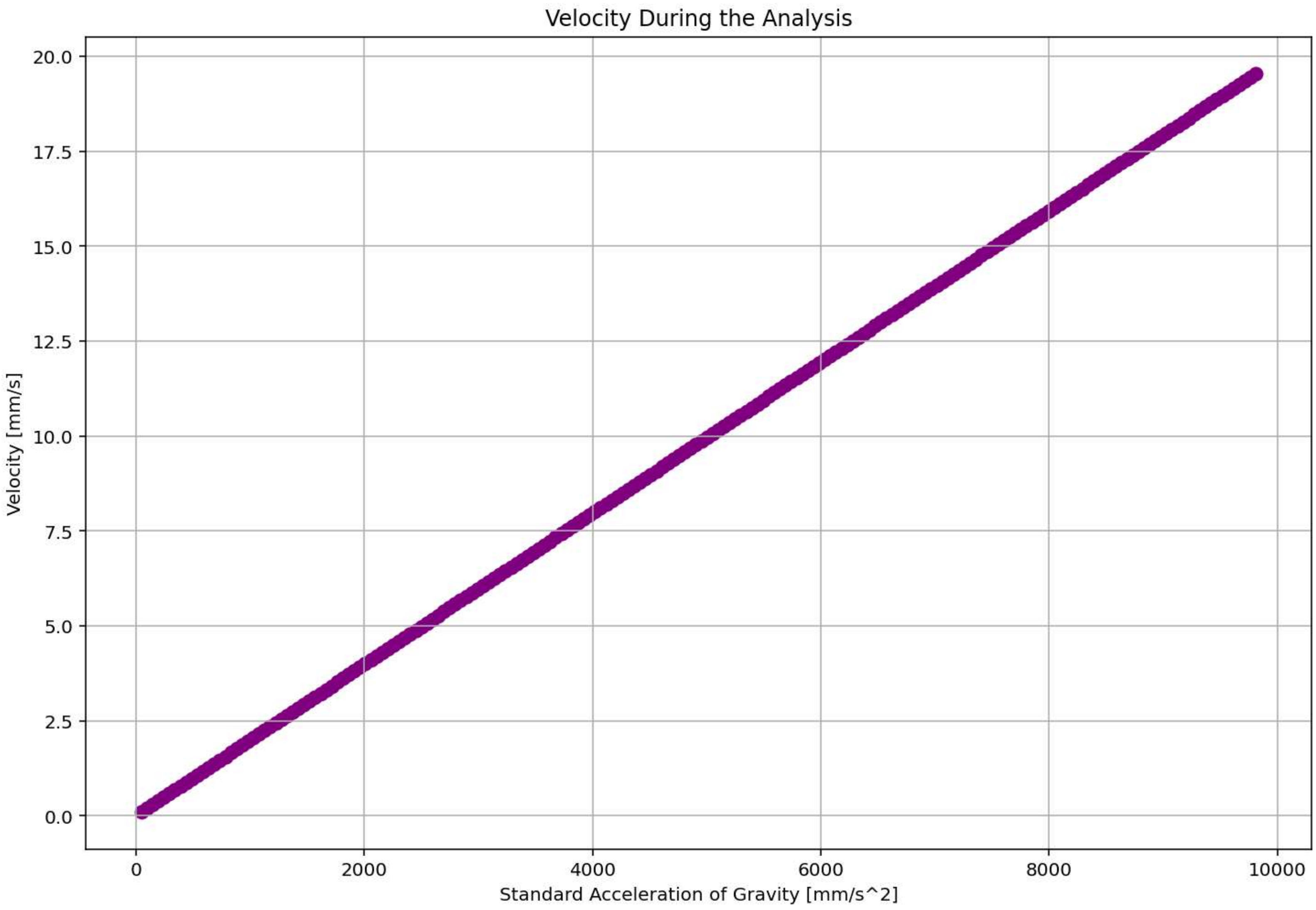
Total time (s): 186.2969
IPython Console History
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 6, Col 25 UTF-8 CRLF RW Mem 48%

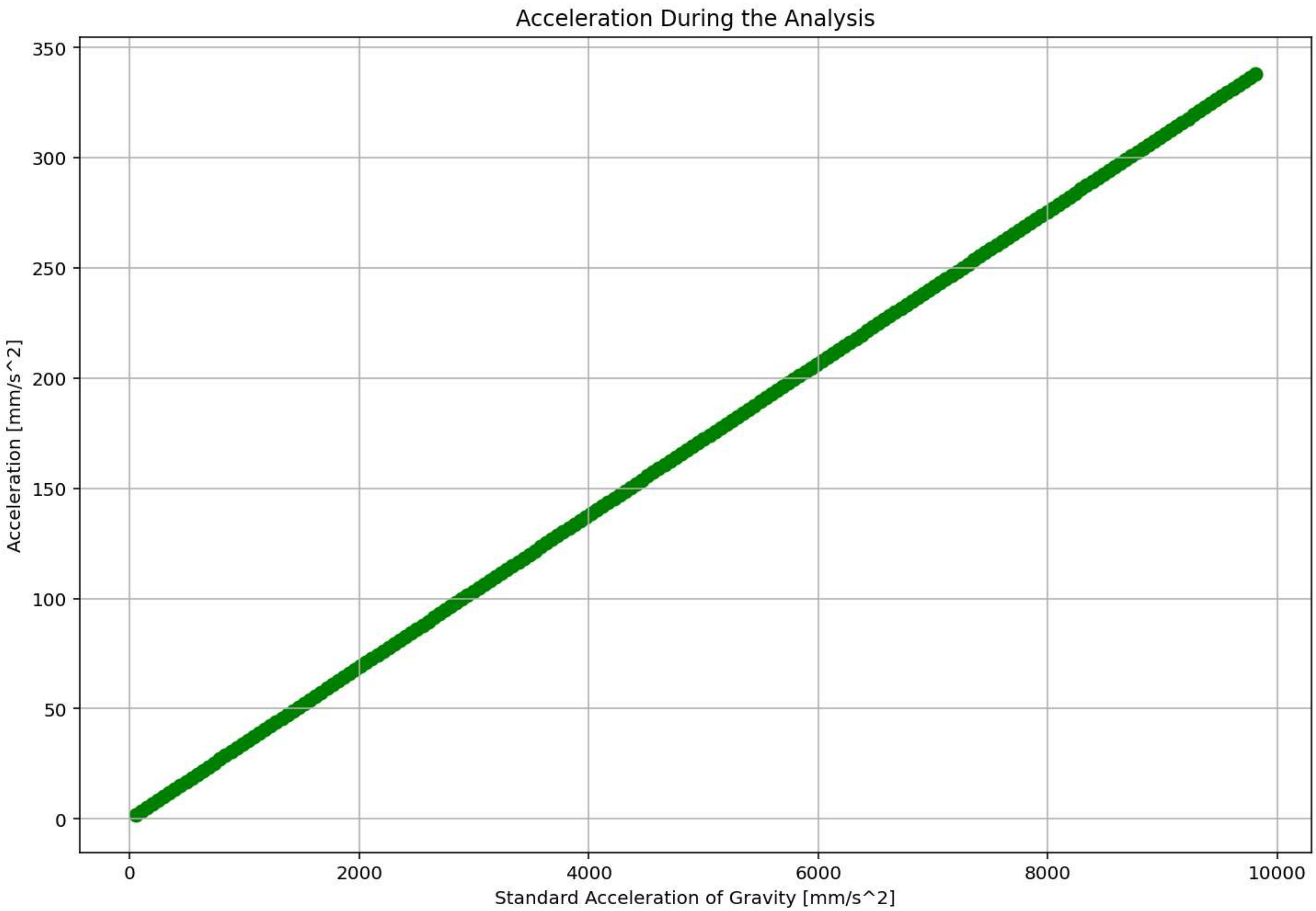
NONLINEAR DYNAMIC ANALYSIS



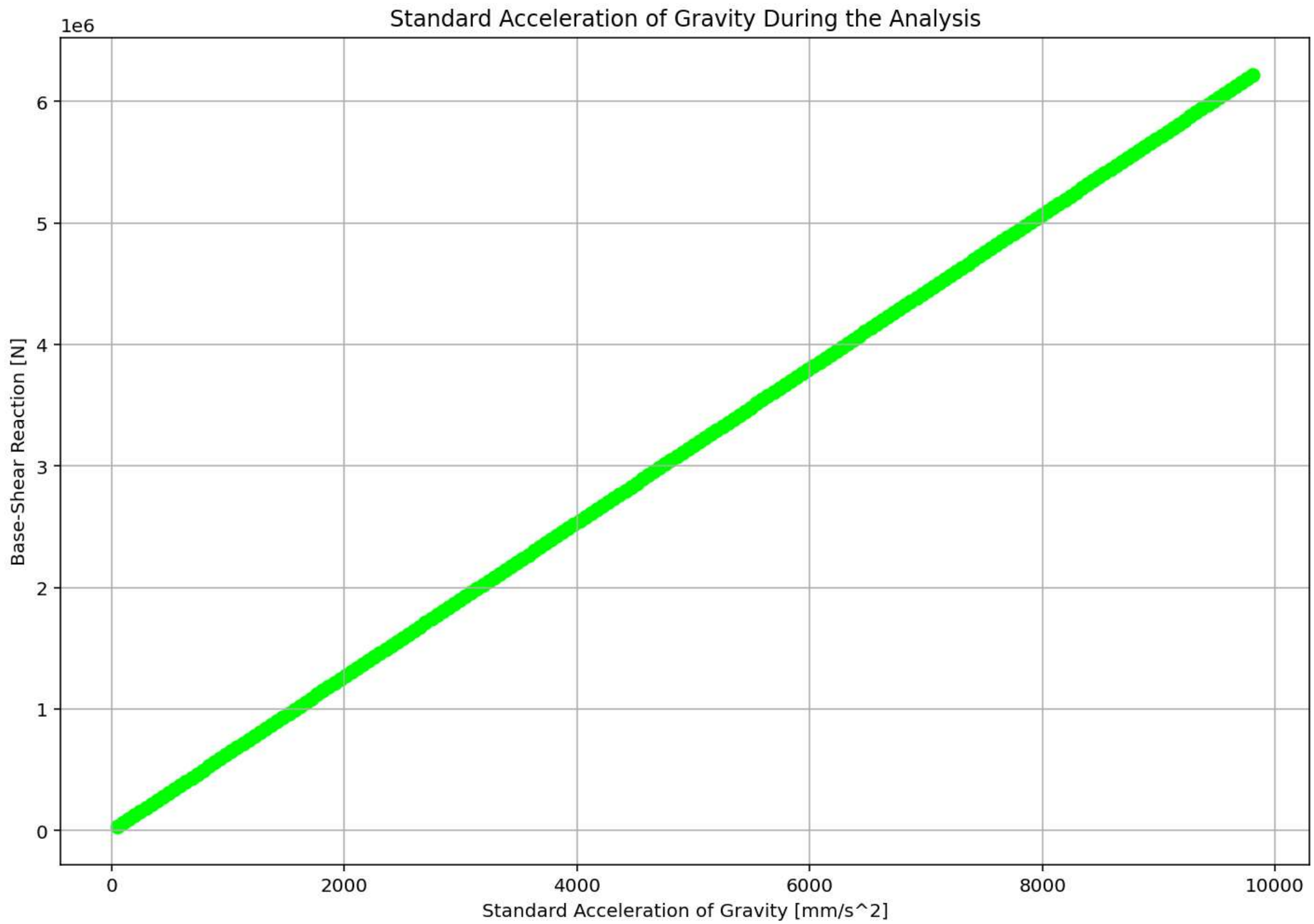
Undeformed and Deformed Shapes - DEFORMED SCALE: 10.00
Undeformed
Deformed
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000
1
2
3
4


Displacement During the Analysis
Displacement [mm]
Standard Acceleration of Gravity [mm/s^2]
0
10
20
30
40
0
2000
4000
6000
8000
10000

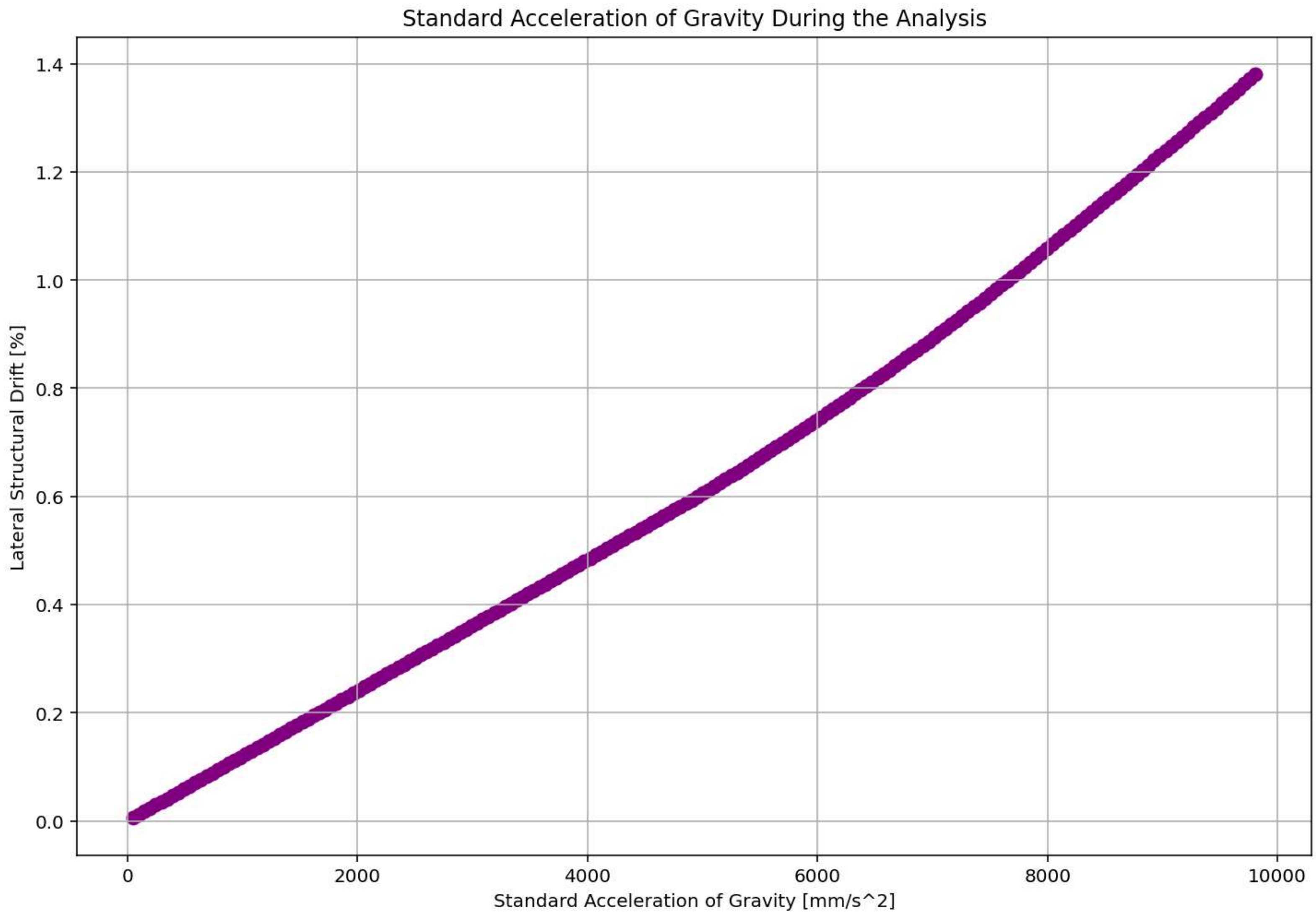

Velocity During the Analysis
Velocity [mm/s]
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
0
2000
4000
6000
8000
10000
Standard Acceleration of Gravity [mm/s^2]

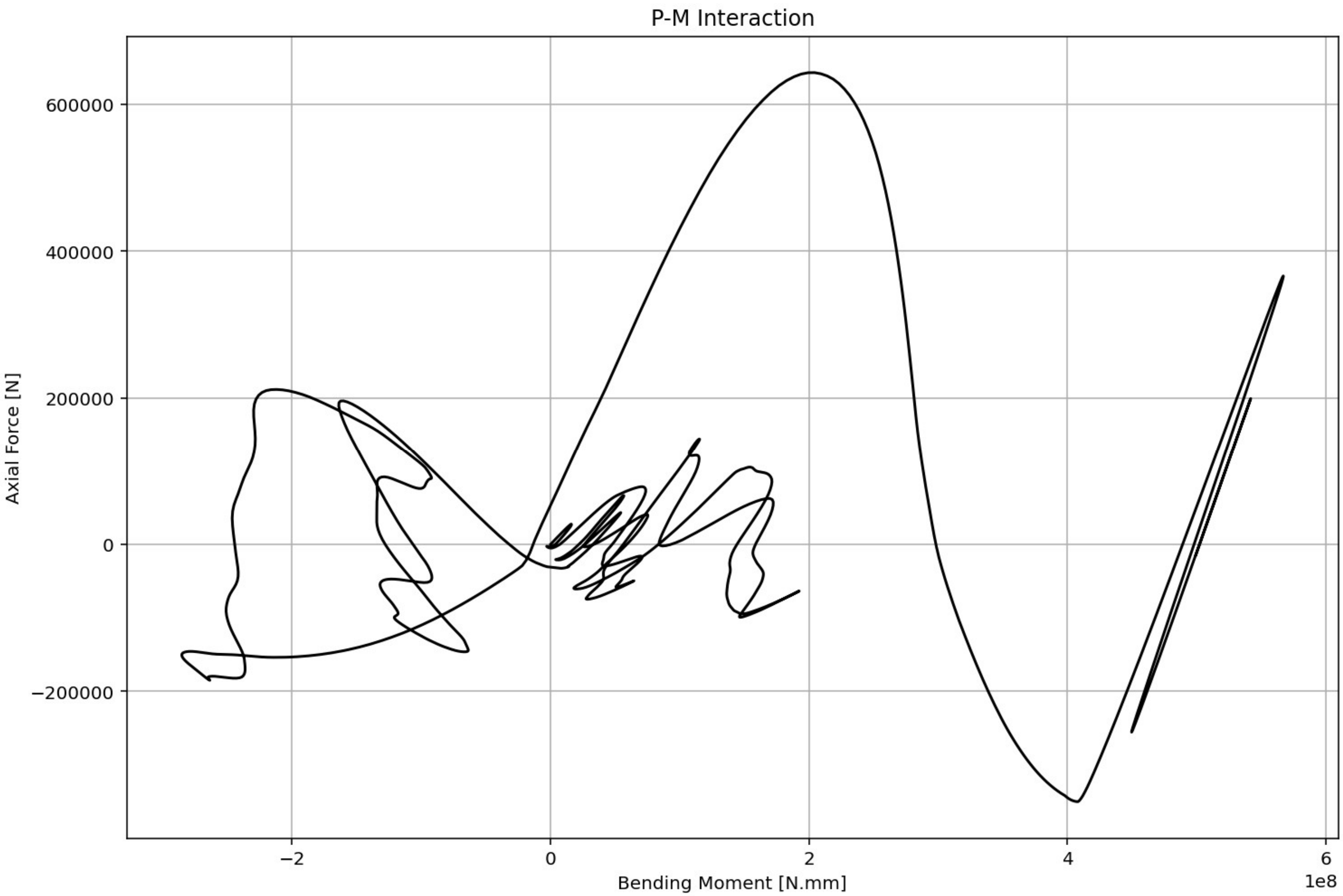


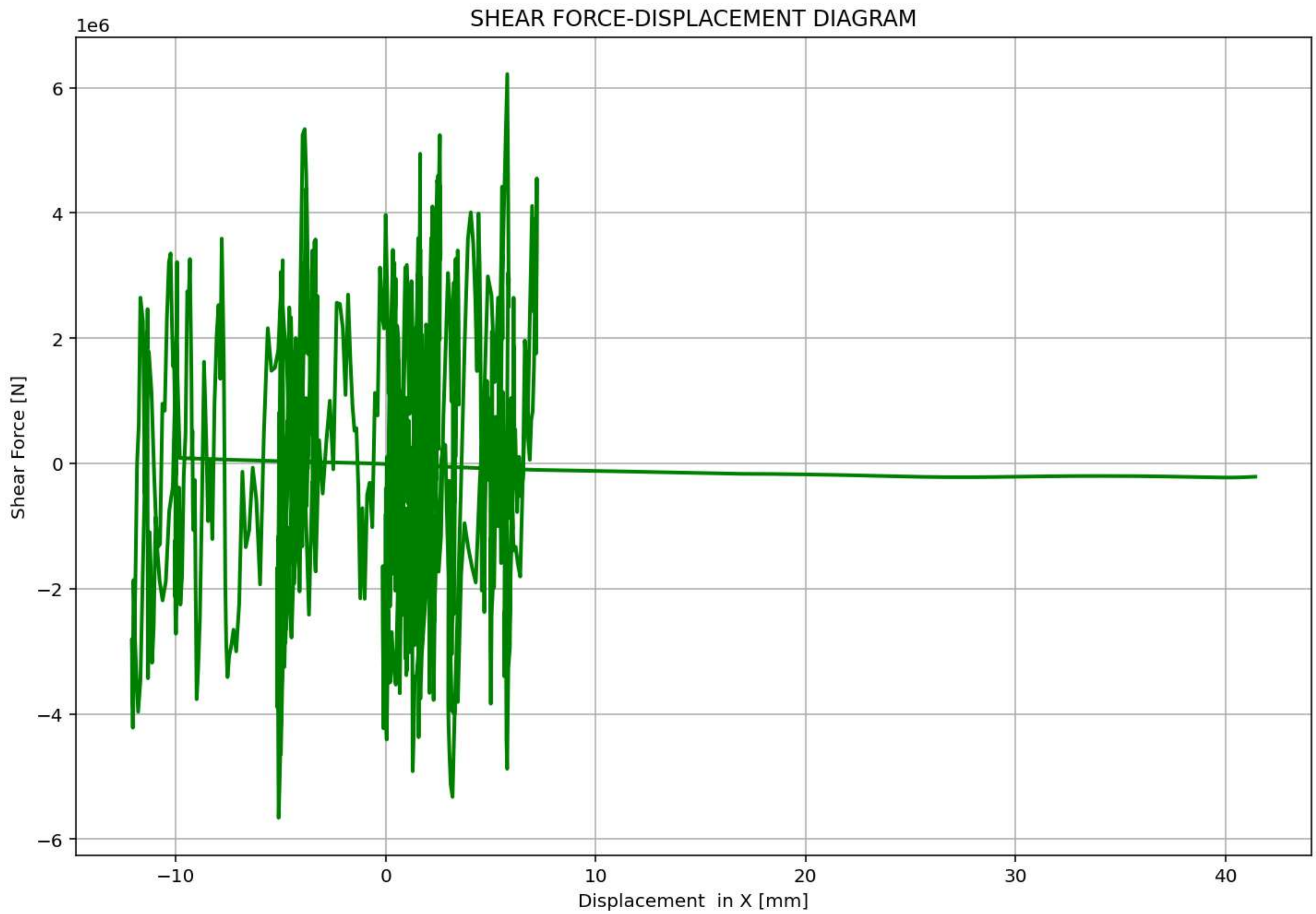
Acceleration During the Analysis
Acceleration [mm/s^2]
Standard Acceleration of Gravity [mm/s^2]
0
50
100
150
200
250
300
350
0
2000
4000
6000
8000
10000

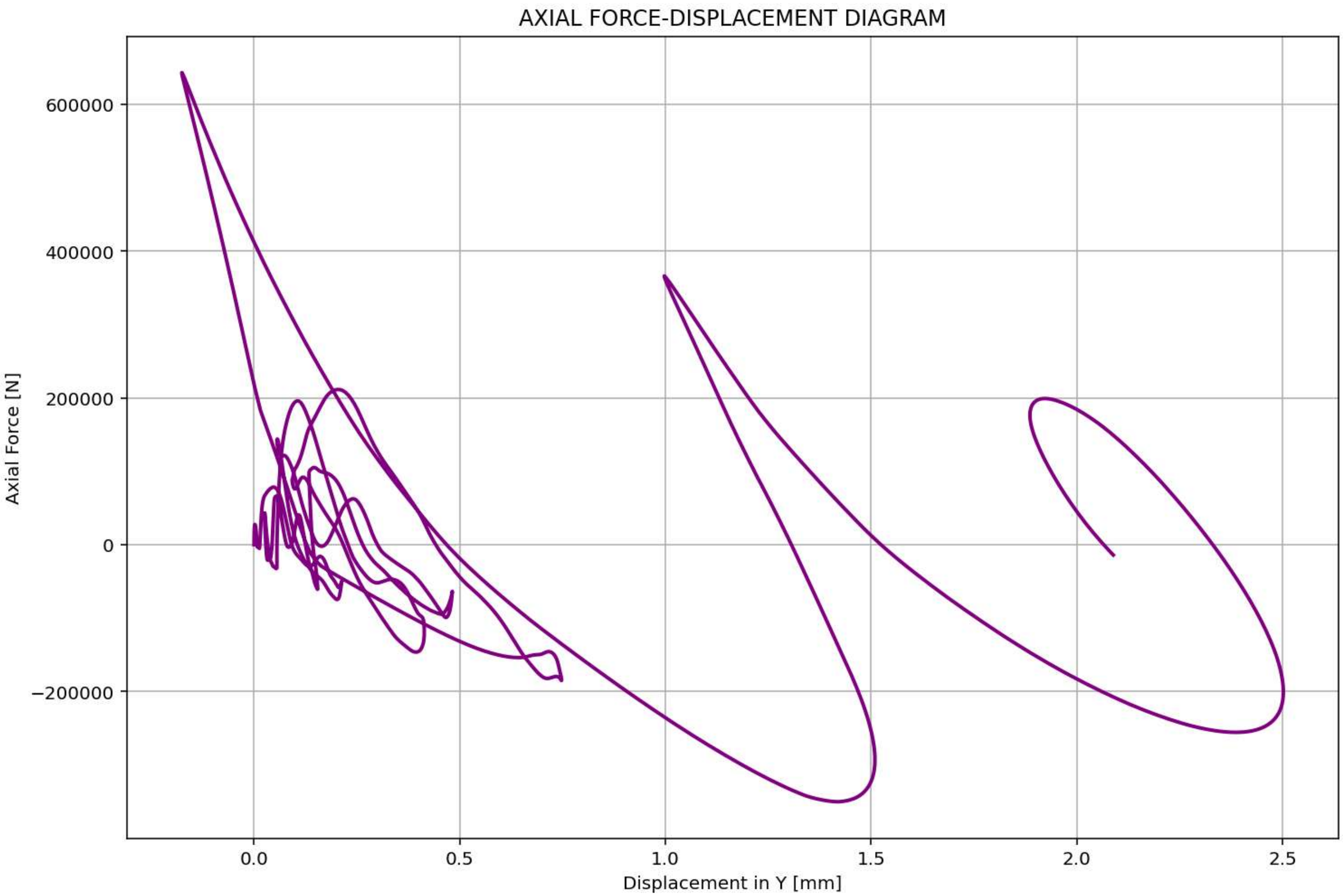


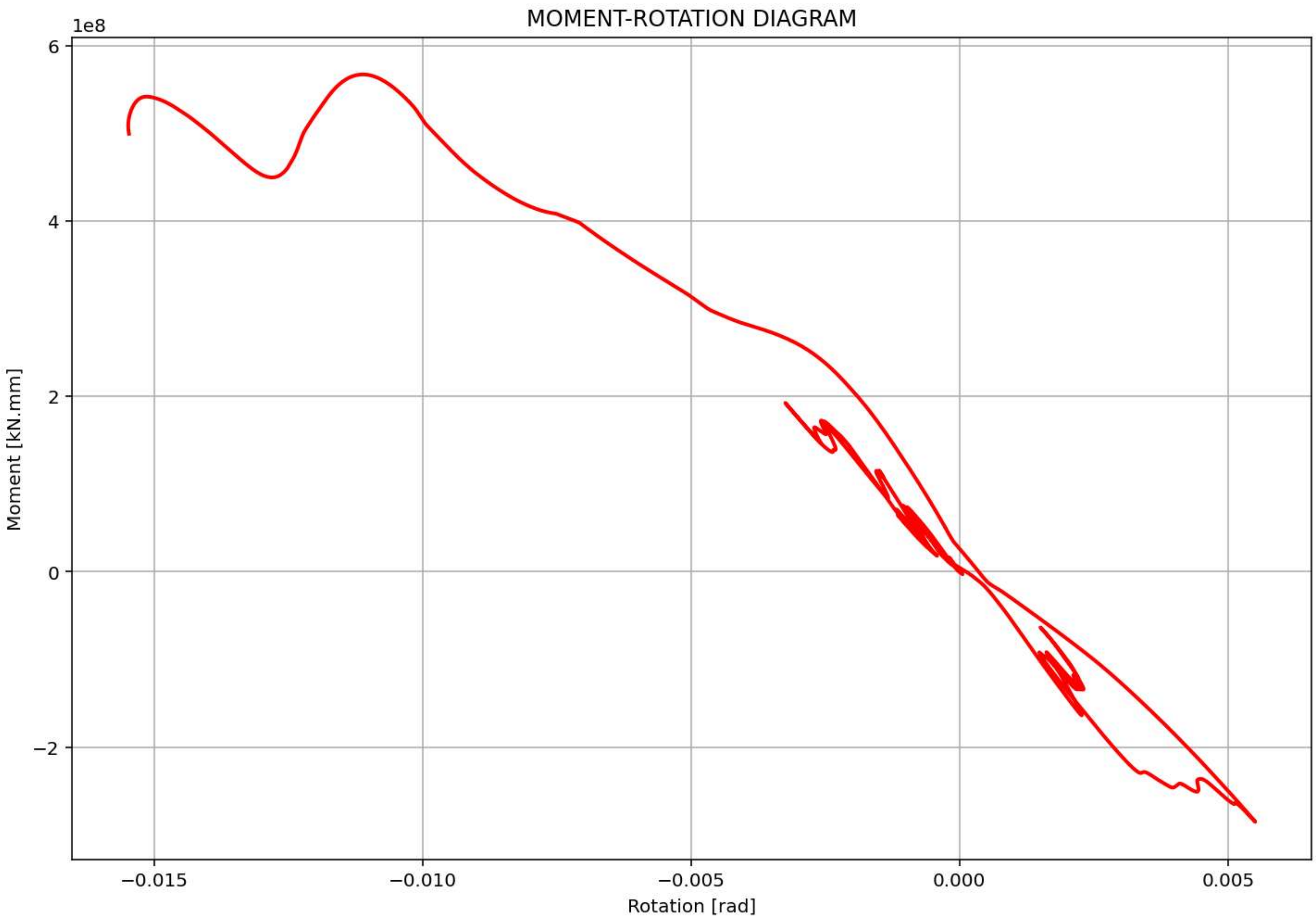
Standard Acceleration of Gravity During the Analysis
1e6
6
5
4
3
2
1
0
Base-Shear Reaction [N]
0
2000
4000
6000
8000
10000
Standard Acceleration of Gravity [mm/s^2]

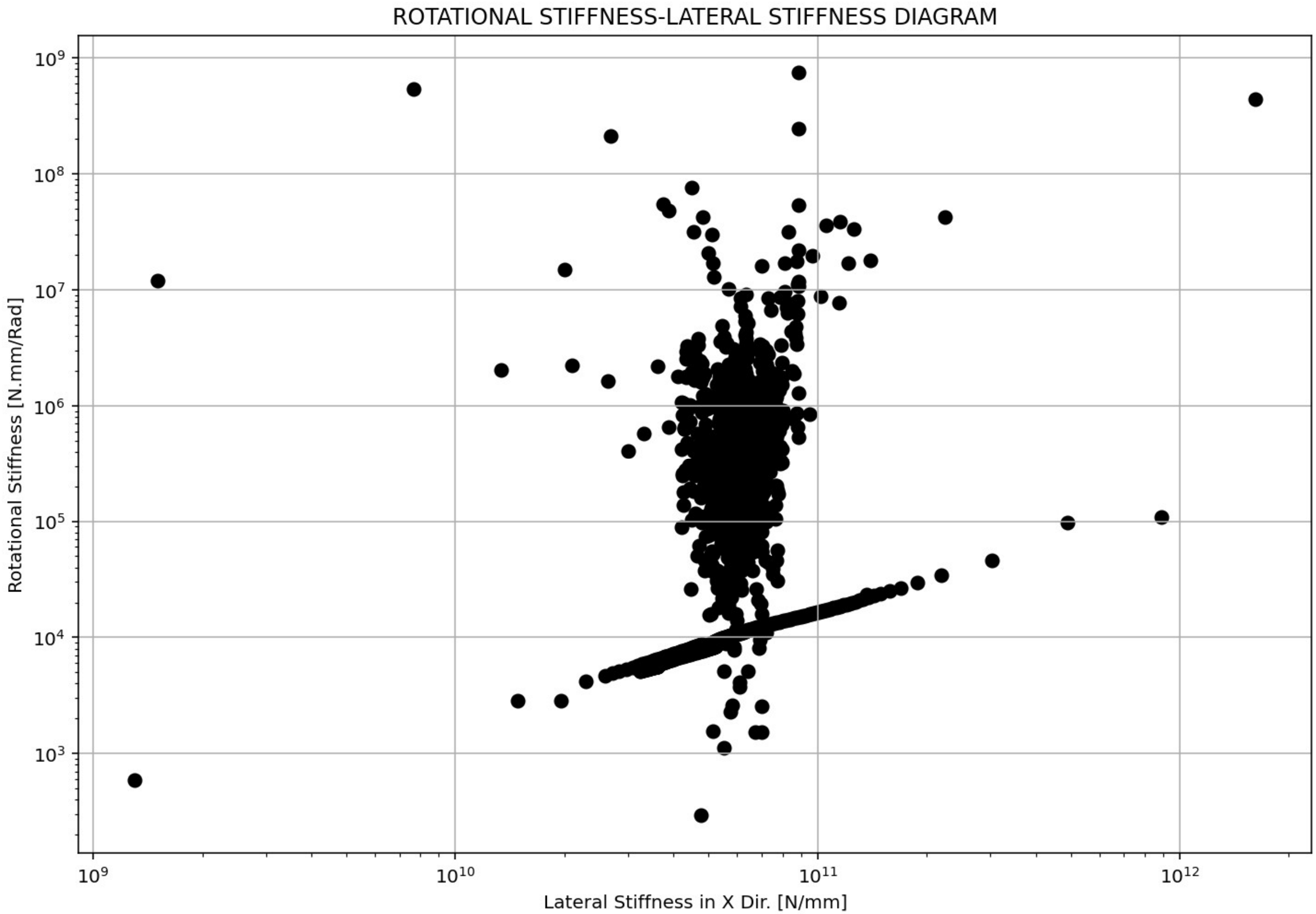

Standard Acceleration of Gravity During the Analysis
Lateral Structural Drift [%]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0
2000
4000
6000
8000
10000
Standard Acceleration of Gravity [mm/s^2]

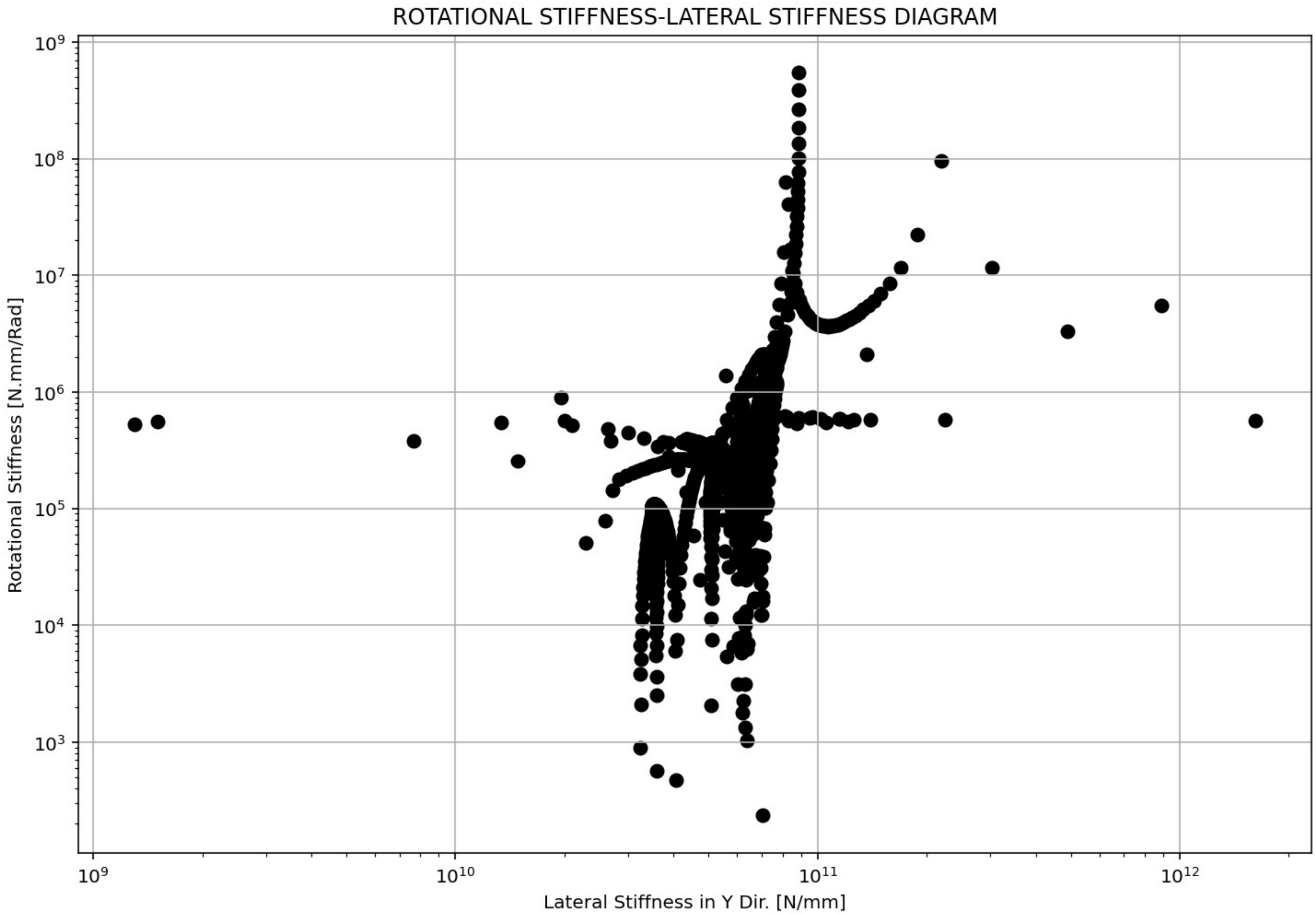

P-M Interaction
Axial Force [N]
600000
400000
200000
0
−200000
Bending Moment [N.mm]
−2
0
2
4
6
1e8


SHEAR FORCE-DISPLACEMENT DIAGRAM
1e6
6
4
2
0
−2
−4
−6
Shear Force [N]
−10
0
10
20
30
40
Displacement in X [mm]


AXIAL FORCE-DISPLACEMENT DIAGRAM
Axial Force [N]
600000
400000
200000
0
−200000
0.0
0.5
1.0
1.5
2.0
2.5
Displacement in Y [mm]

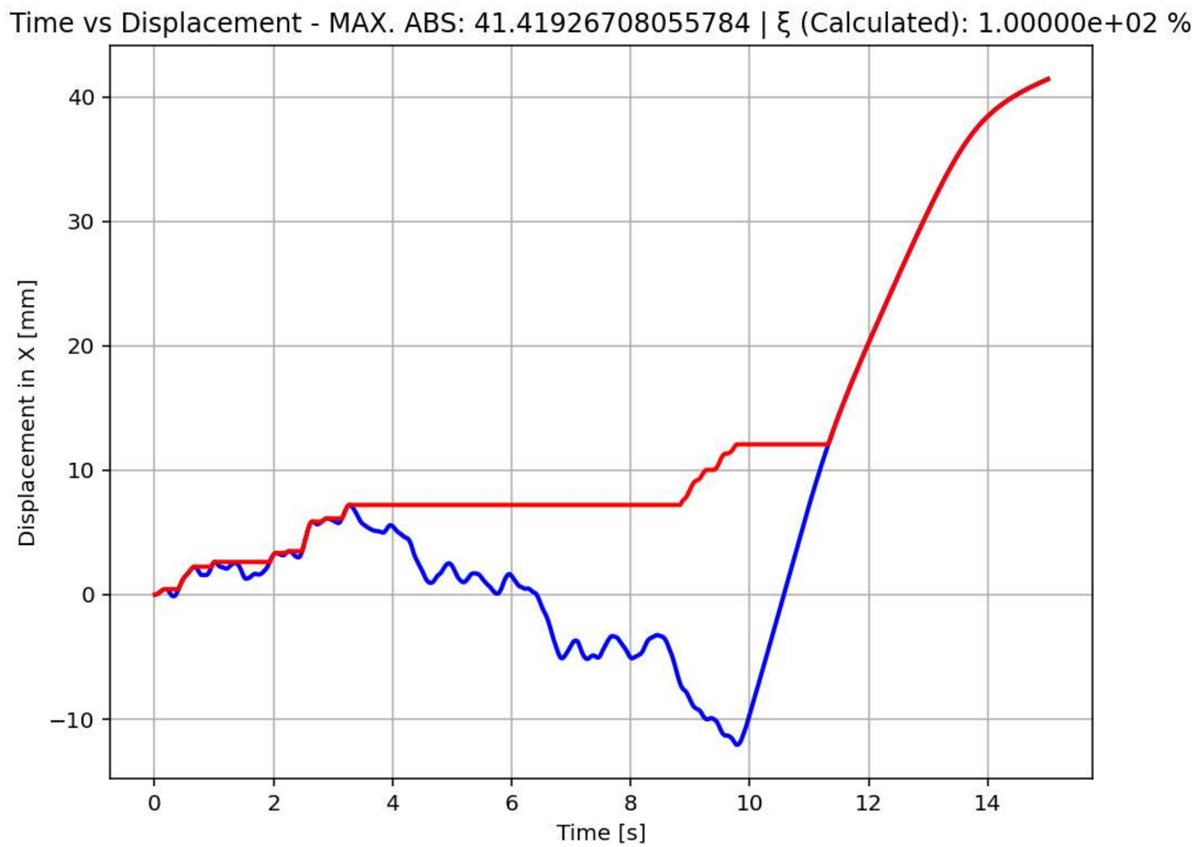

MOMENT-ROTATION DIAGRAM
1e8
6
4
2
0
−2
Moment [kN.mm]
−0.015
−0.010
−0.005
0.000
0.005
Rotation [rad]

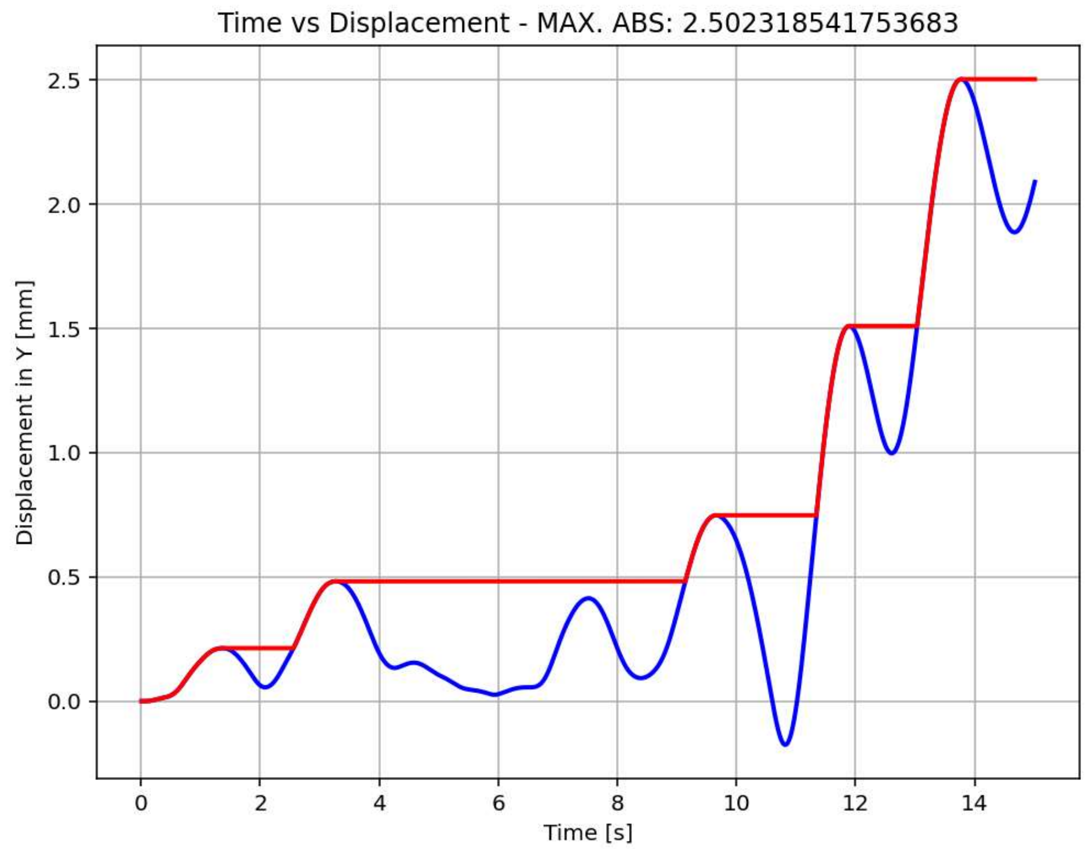

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in X Dir. [N/mm]
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^{10}
10^{11}
10^{12}

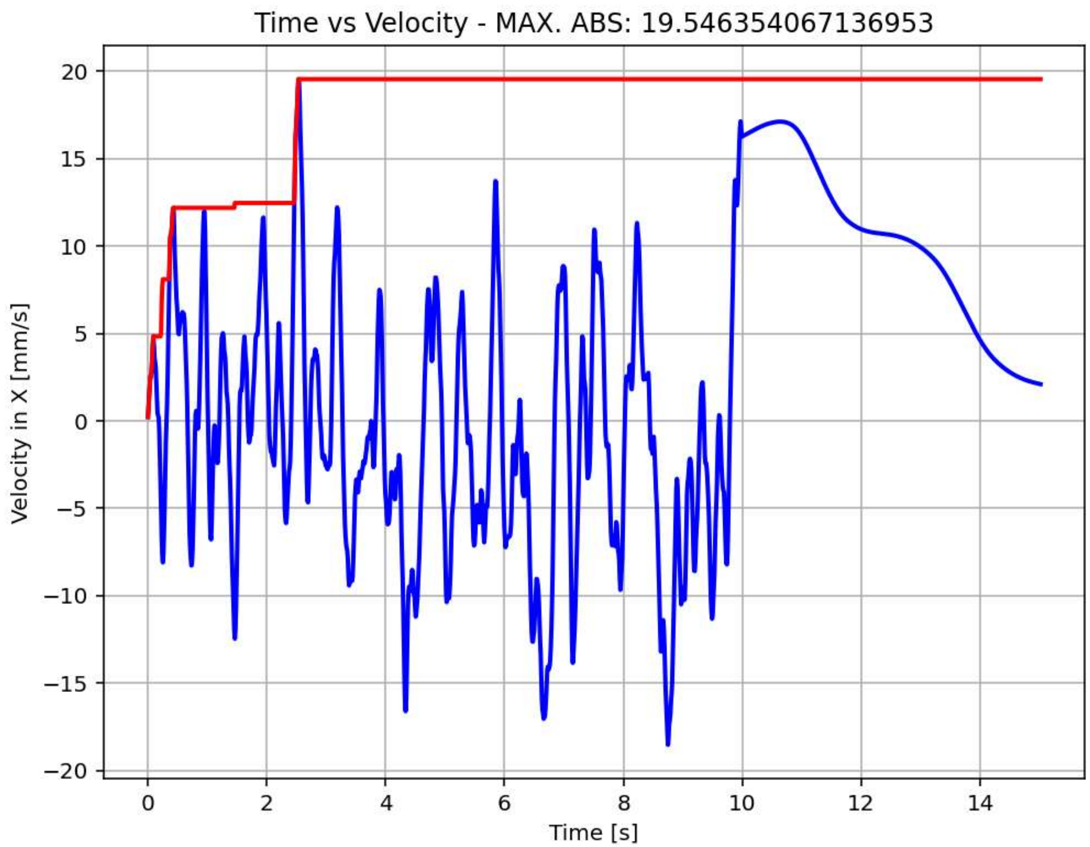


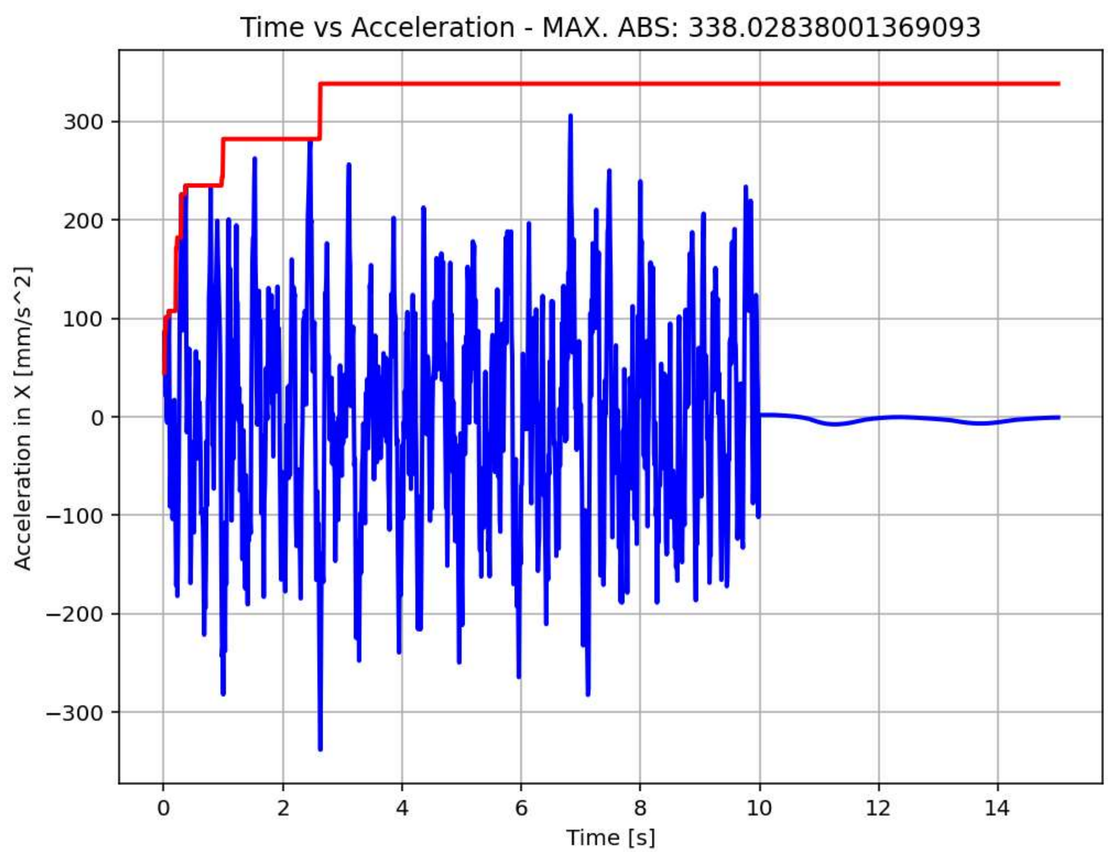
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in Y Dir. [N/mm]
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^9
10^{10}
10^{11}
10^{12}

Incorrect Damping Ratio Calculation

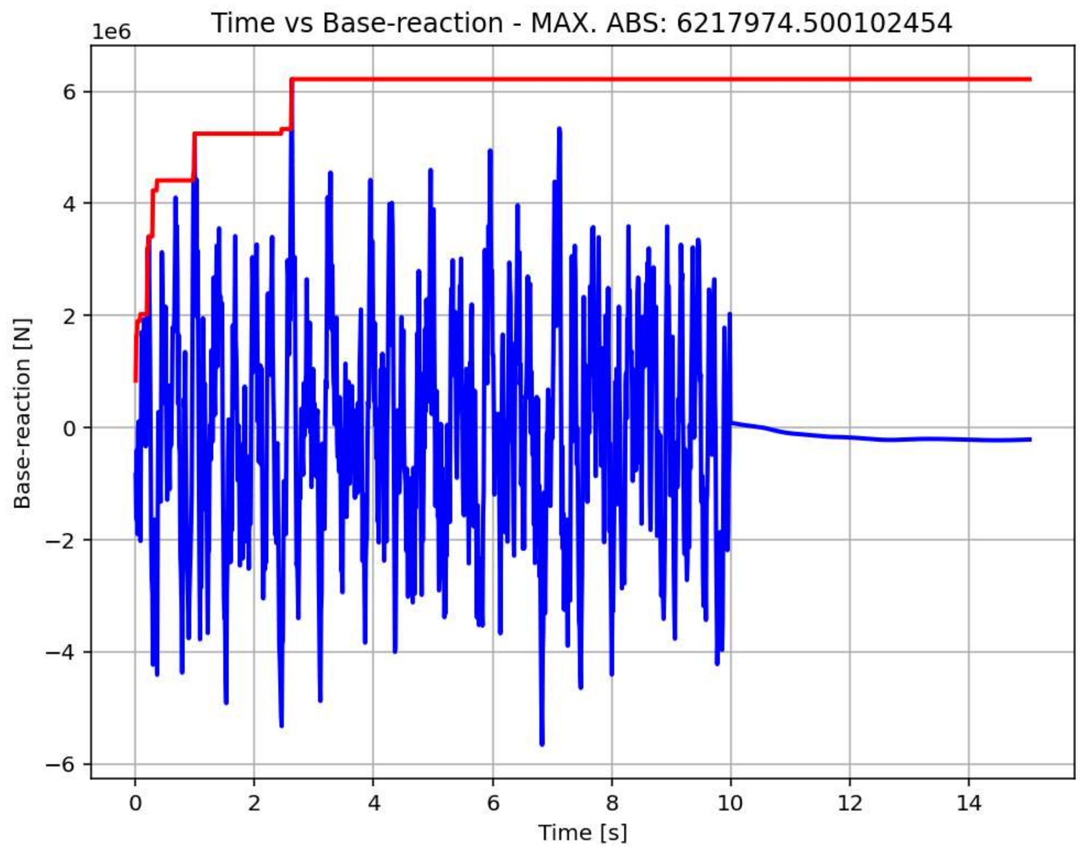


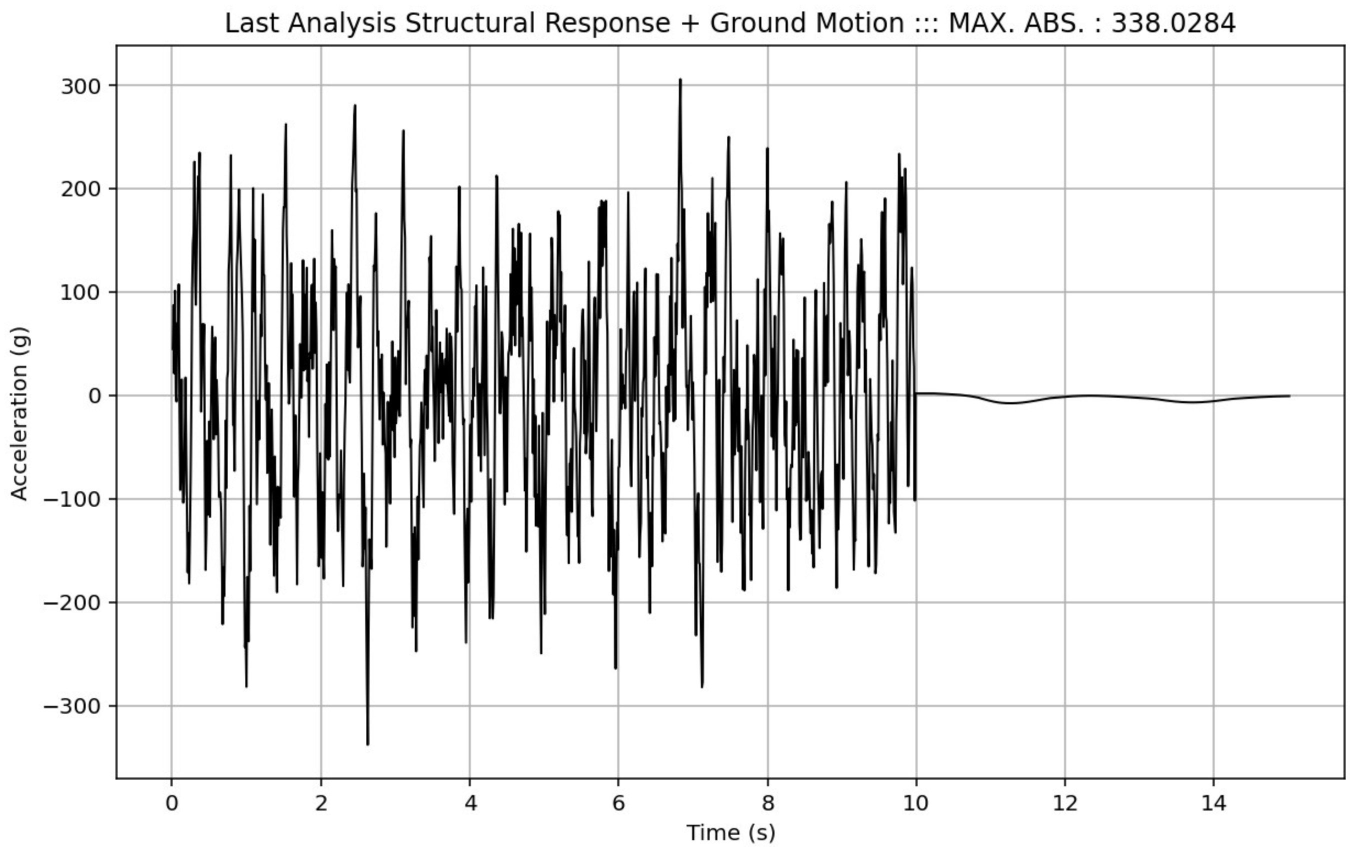

Time vs Displacement - MAX. ABS: 2.502318541753683
Displacement in Y [mm]
Time [s]
0.0
0.5
1.0
1.5
2.0
2.5
0
2
4
6
8
10
12
14

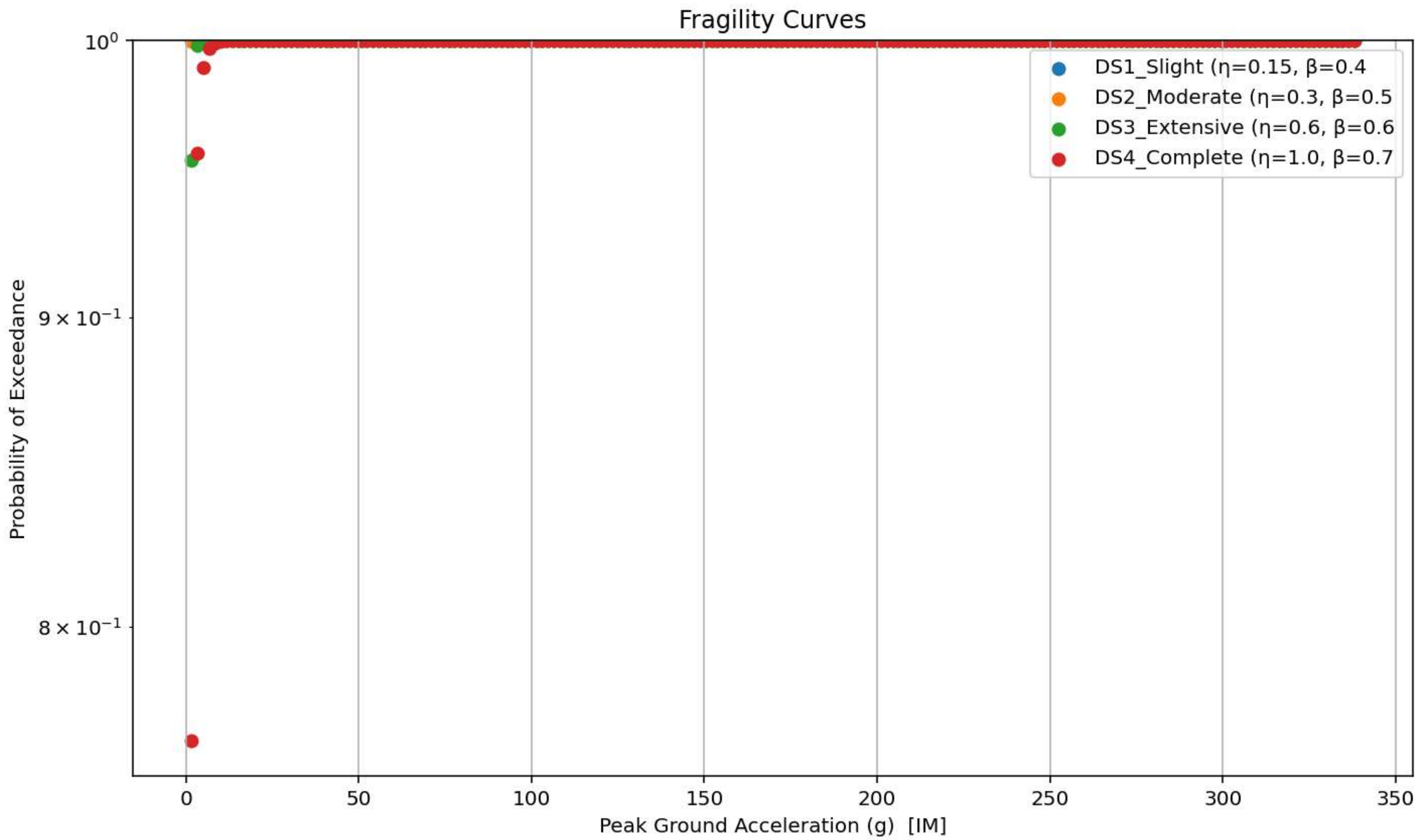

Time vs Velocity - MAX. ABS: 19.546354067136953
Velocity in X [mm/s]
Time [s]
20
15
10
5
0
−5
−10
−15
−20
0
2
4
6
8
10
12
14



Time vs Acceleration - MAX. ABS: 338.02838001369093
Acceleration in X [mm/s^2]
Time [s]
300
200
100
0
−100
−200
−300
0
2
4
6
8
10
12
14


Time vs Base-reaction - MAX. ABS: 6217974.500102454
1e6
6
4
2
0
−2
−4
−6
Base-reaction [N]
0
2
4
6
8
10
12
14
Time [s]


Last Analysis Structural Response + Ground Motion ::: MAX. ABS. : 338.0284
Acceleration (g)
300
200
100
0
−100
−200
−300
0
2
4
6
8
10
12
14
Time (s)


Fragility Curves
10^0
9×10^{-1}
8×10^{-1}
Probability of Exceedance
0
50
100
150
200
250
300
350
Peak Ground Acceleration (g) [IM]
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