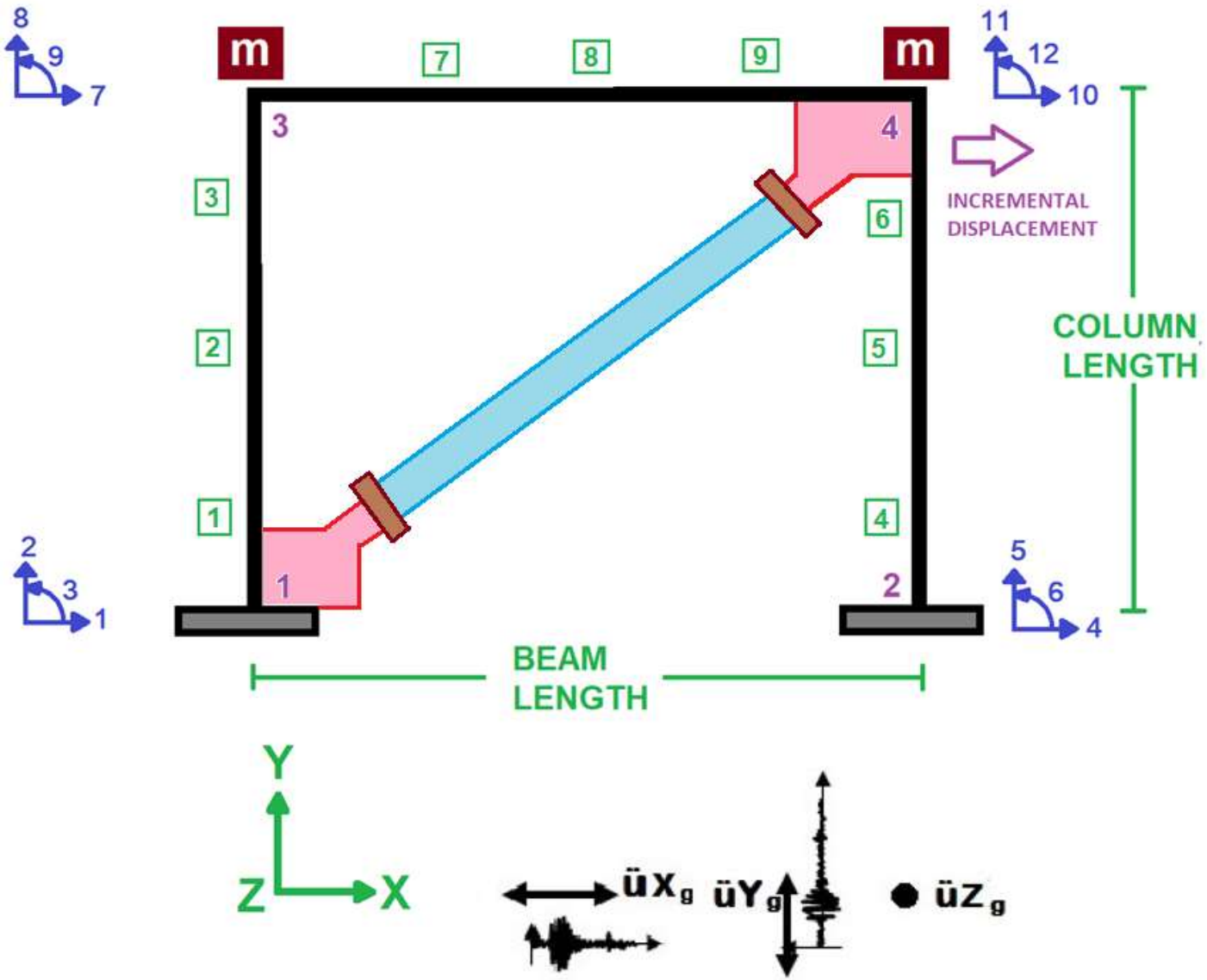
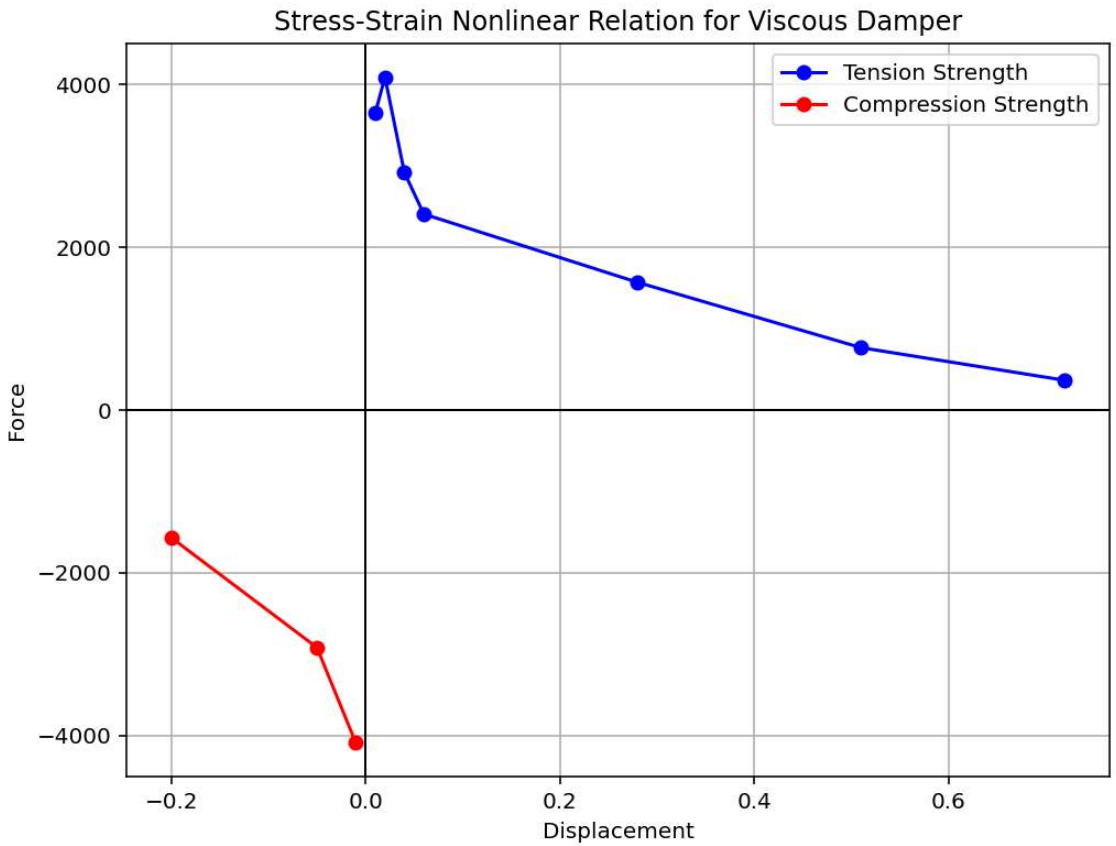
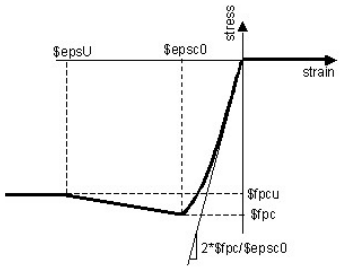
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

ASSESSMENTS OF THE STRUCTURAL DUCTILITY DAMAGE INDEX WITH DIFFERENT CONFINEMENT ENHANCEMENT RATIO OF CONCRETE FRAME WITH VISCOUS DAMPER USING OPENSEES

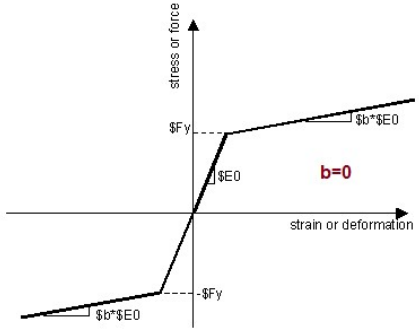
WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


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

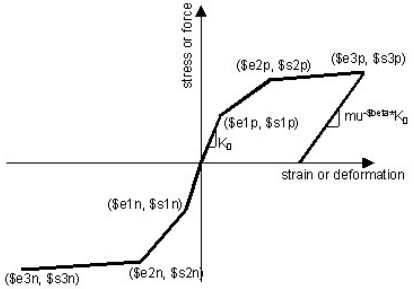

Stress-Strain Nonlinear Relation for Viscous Damper
Tension Strength
Compression Strength
4000
2000
0
−2000
−4000
Force
−0.2
0.0
0.2
0.4
0.6
Displacement



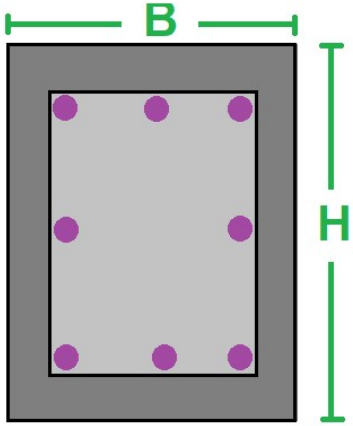
CORE AND COVER CONCRETE RELATION



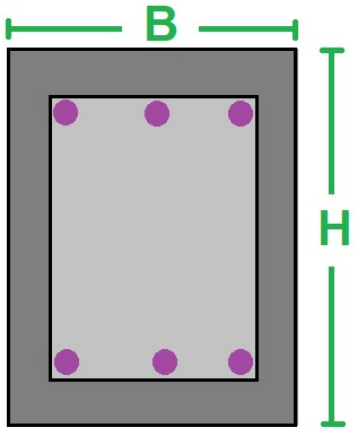
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

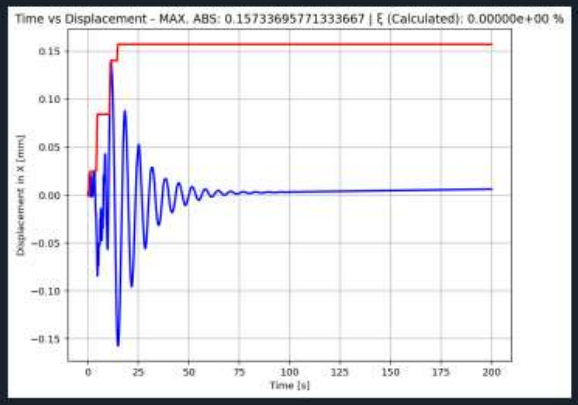
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...\+VISCOUS_DAMPER\CONCRETE_FRAME_VISCOUS_DAMPER.py

CONCRETE_FRAME_VISCOUS_DAMPER.py | TRUSS_ELEMENT_FUN.py

```
1  ##########################################################################################################
2  #                              >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
3  #                             ASSESSMENTS OF THE STRUCTURAL DUCTILITY DAMAGE INDEX WITH DIFFERENT
4  #       CONFINEMENT ENHANCEMENT RATIO OF CONCRETE FRAME WITH VISCOUS DAMPER LIKE BEAM AND COLUMNS
5  #--------------------------------------------------------------------------------------------------------
6  #                                THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
7  #                                      EMAIL: salar.d.ghashghaei@gmail.com
8  ##########################################################################################################
9  """
10 [1] Nonlinear Frame Modeling
11 - 2D RC frame with distributed plasticity using `nonlinearBeamColumn` elements.
12 - Fiber sections for beams/columns: confined core and unconfined cover concrete.
13
14 [2] Material Laws
15 - Concrete: `Concrete01` for confined/unconfined zones.
16 - Steel: `Hysteretic` model with pinching, hardening, and cyclic degradation.
17
18 [3] Seismic Loads
19 - Pushover: displacement-controlled lateral loading to failure.
20 - Dynamic: uniform excitation with user-defined ground motions (X/Y).
21
22 [4] Damping
23 - Rayleigh damping (a0, a1) calibrated via eigenvalue analysis (modes 1-2).
24
25 [5] Performance Metrics
26 - Ductility ratio μ: from bilinearized pushover curve.
27 - Overstrength Ω₀: yield vs. ultimate capacity.
28 - Damage Index (DI): normalized displacement demand/capacity.
29
30 [6] Advanced Solver
31 - HHT-α integrator (unconditionally stable) with Newton-Raphson iterations.
32
33 [7] Outputs
34 - Hysteretic responses: P-M, V-Δ, M-θ.
```

...top\OPENSEES_FILES\CONCRETE_FRAME_EXAMPLES\+VISCOUS_DAMPER

32 %



Help | Variable Explorer | Debugger | Plots | Files

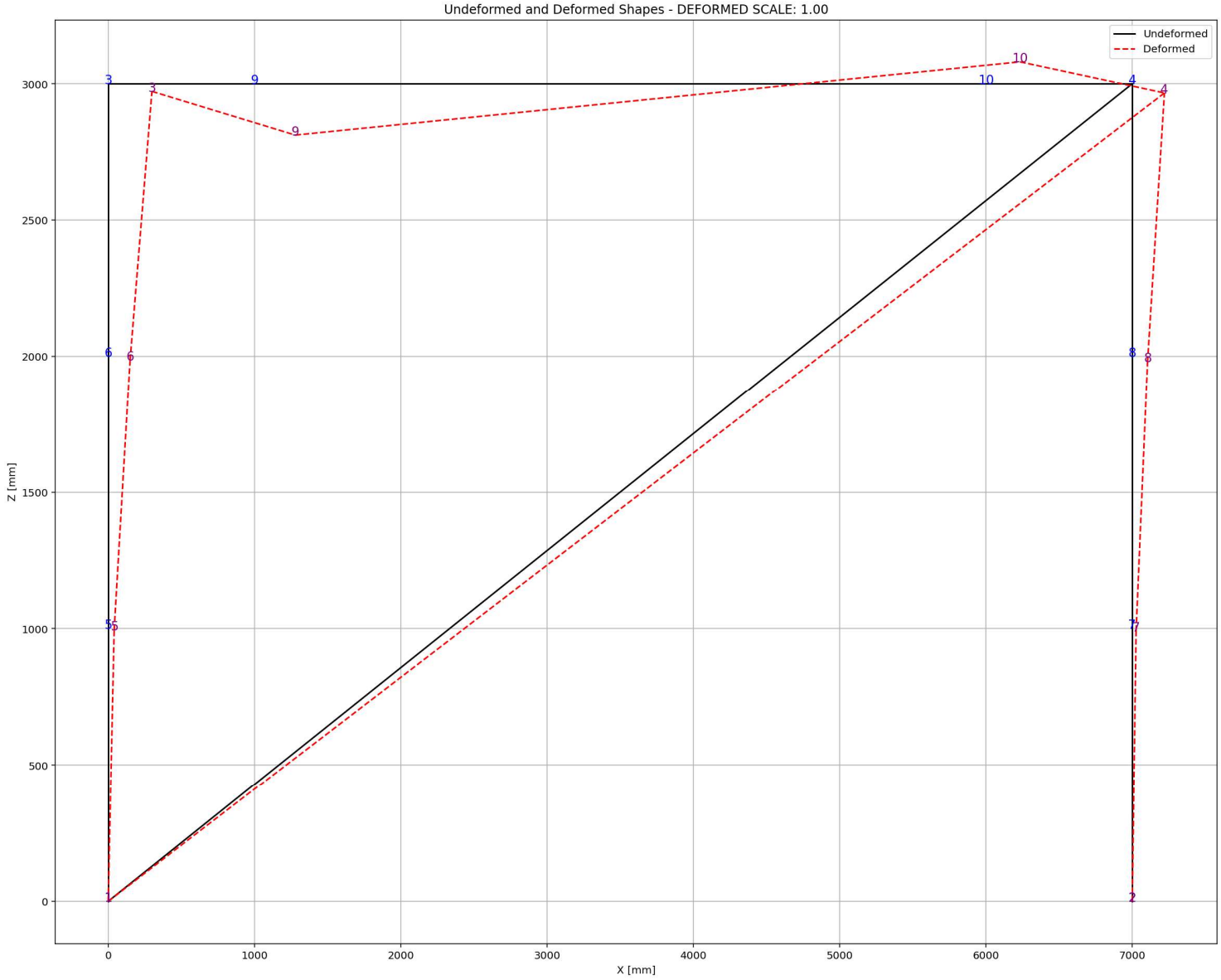
Console 1/A

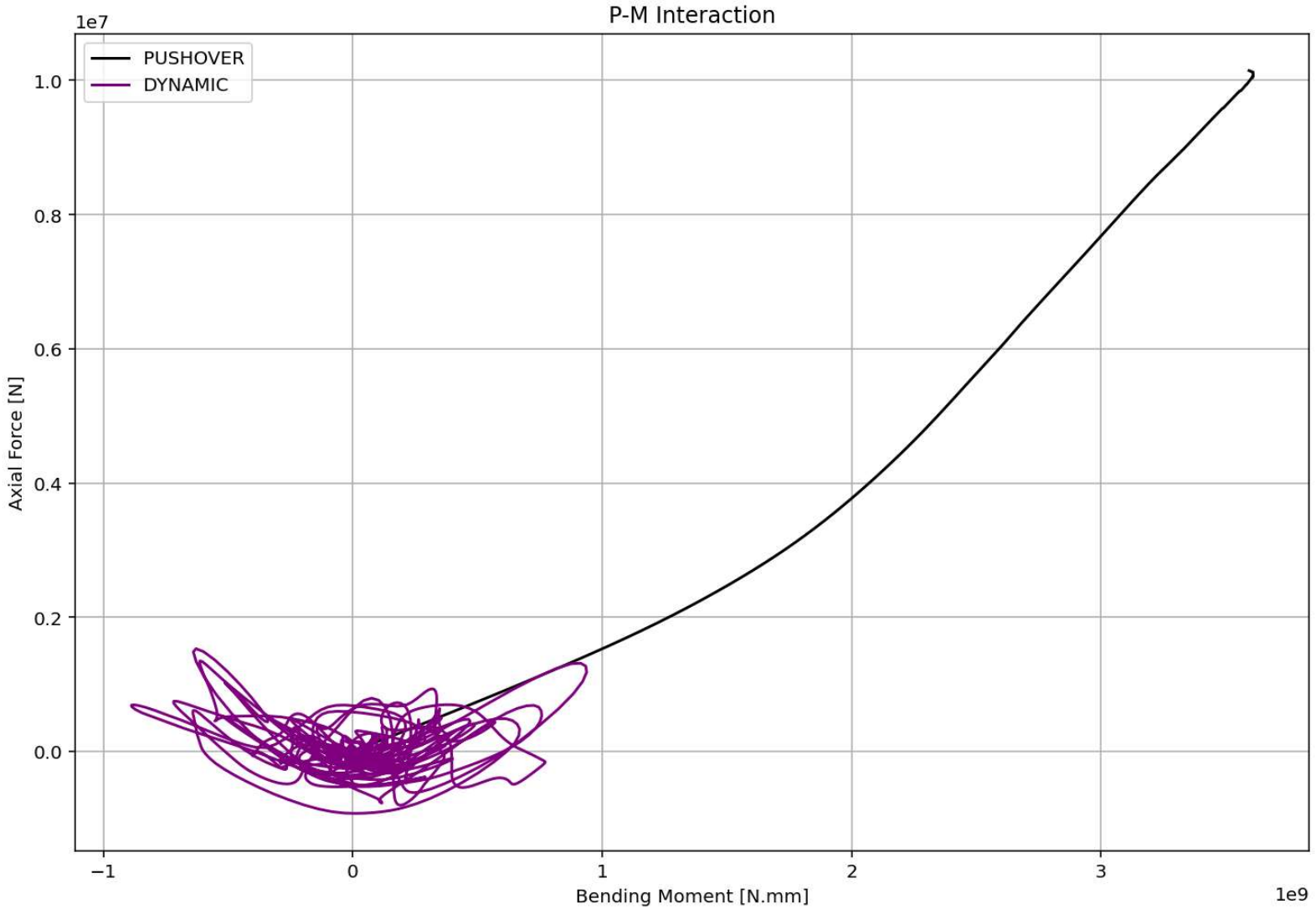
```
200.00999999996307 0.006174976937776194 -399.29621364504726

 Period 01: 5.2080e+00 (s) - Period 02: 2.4396e+00 (s)

Total time (s): 186.0938


C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRAME_EXAMPLES\
+VISCOUS_DAMPER\PLOT_2D.py:43: UserWarning: Legend does not support handles
for Text instances.
See: https://matplotlib.org/stable/tutorials/intermediate/
```

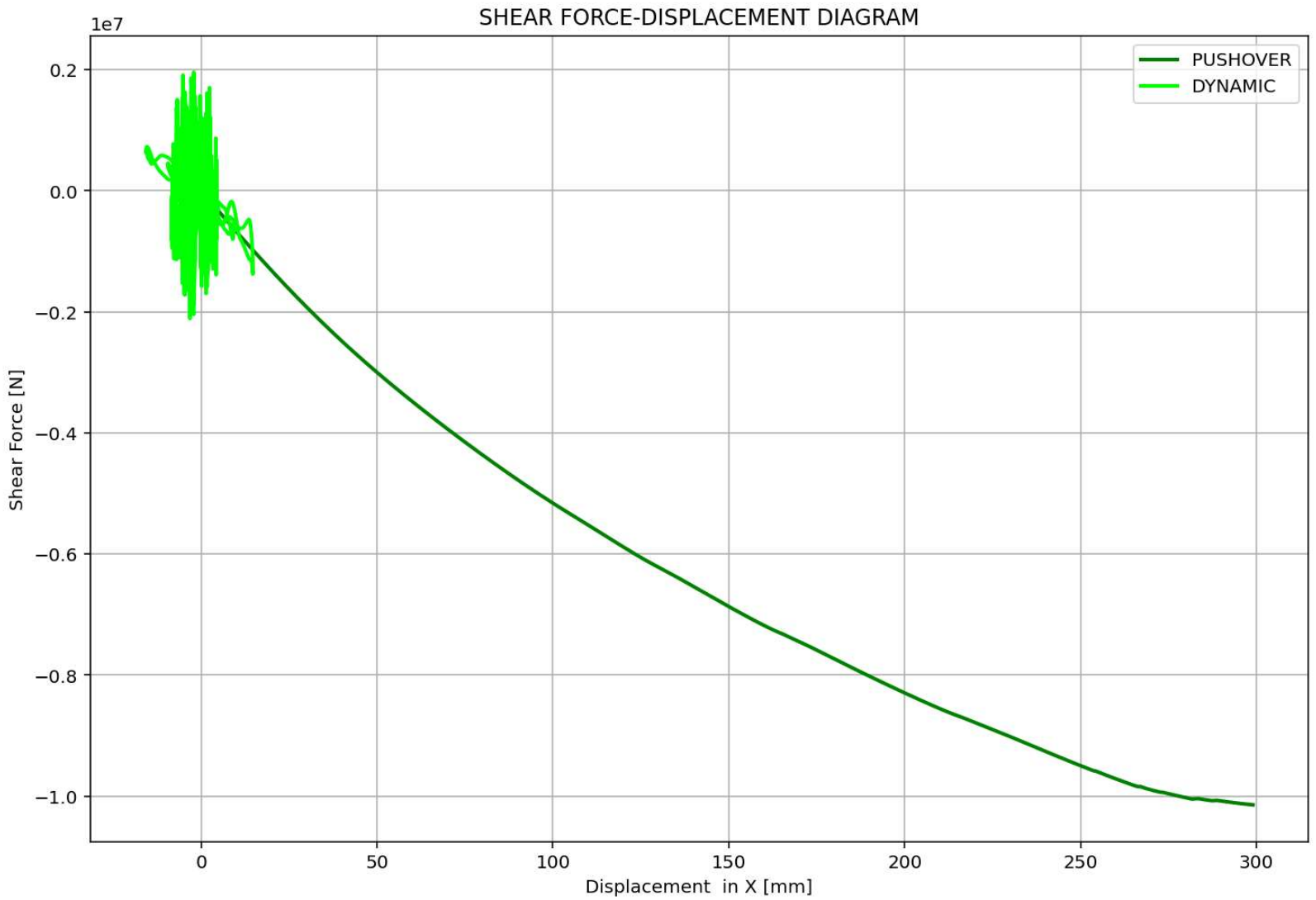
IPython Console | History

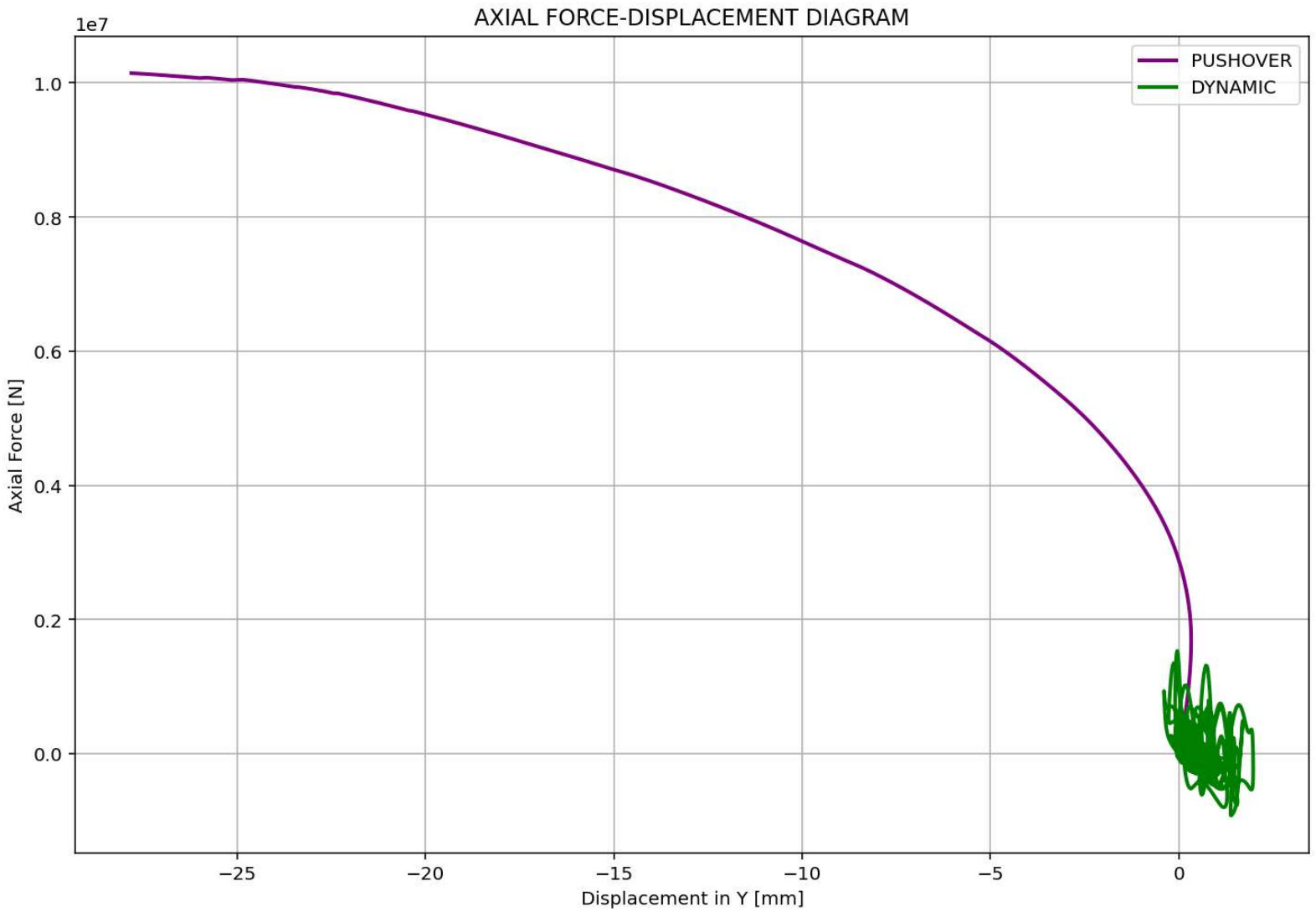
Inline | Conda: anaconda3 (Python 3.12.7) | LSP: Python | Line 4, Col 118 | UTF-8 | CRLF | RW | Mem 39%

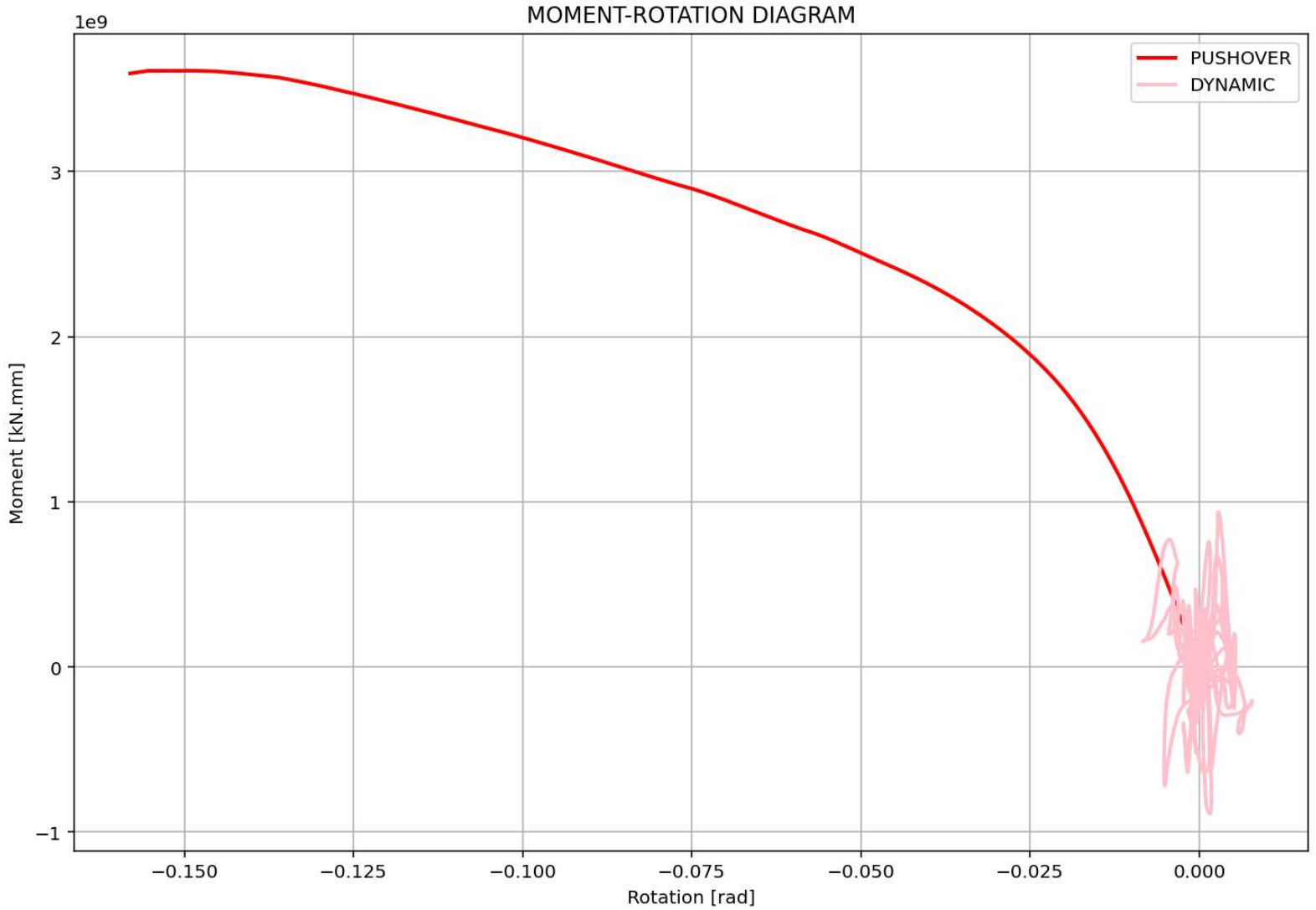
NONLINEAR STATIC ANALYSIS (PUSHOVER)

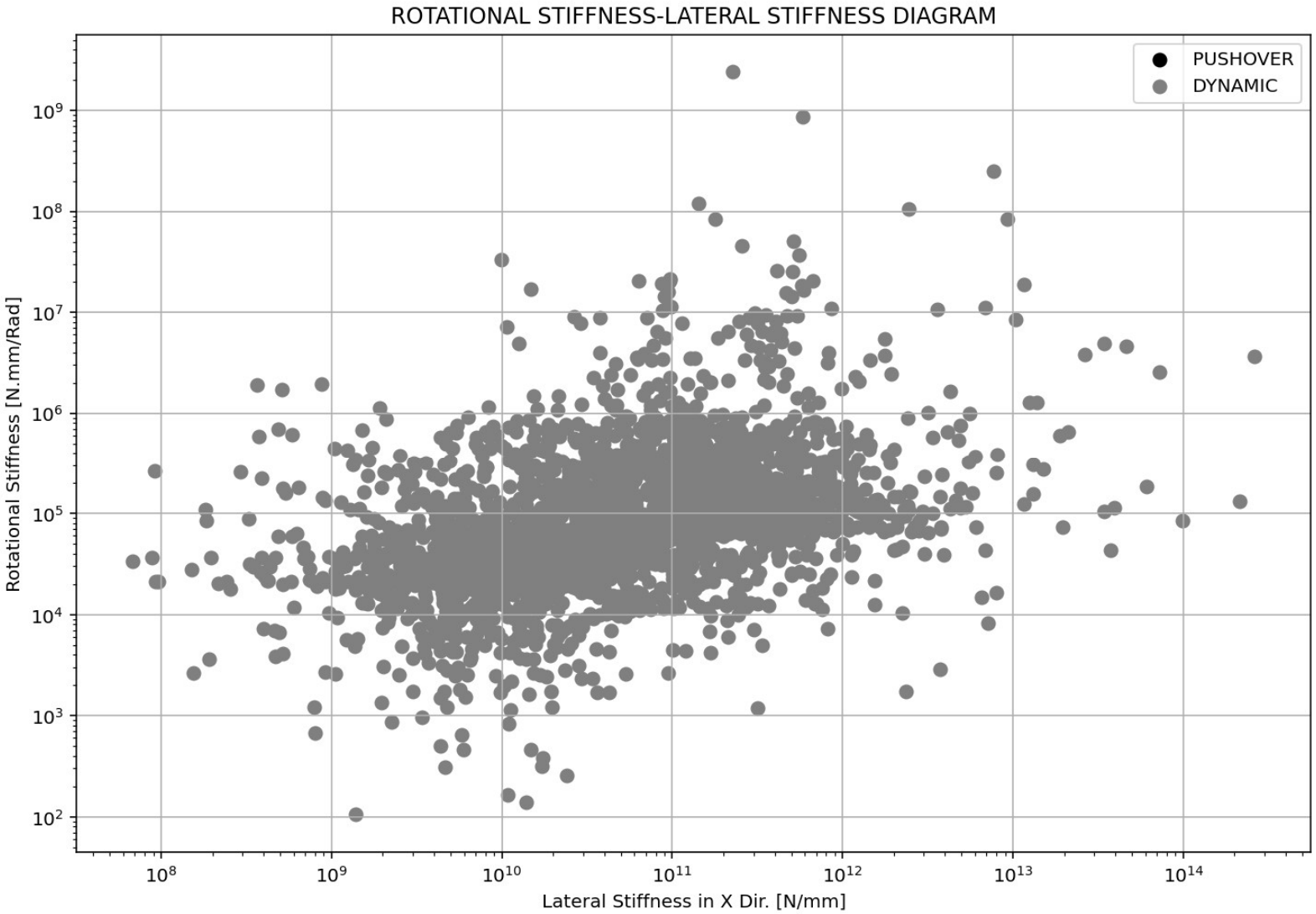

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000

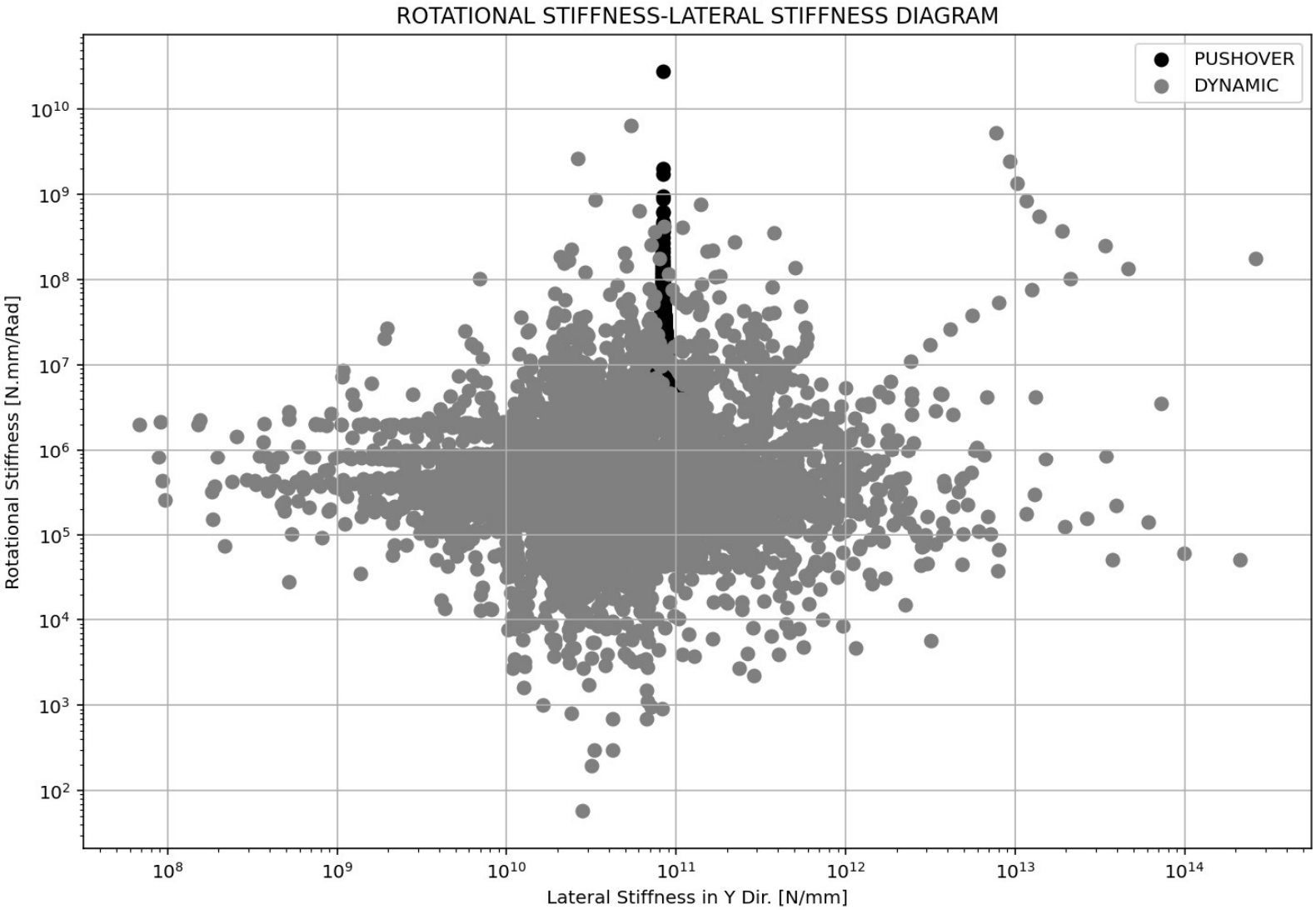

P-M Interaction
1e7
PUSHOVER
DYNAMIC
1.0
0.8
0.6
0.4
0.2
0.0
Axial Force [N]
−1
0
1
2
3
Bending Moment [N.mm]
1e9

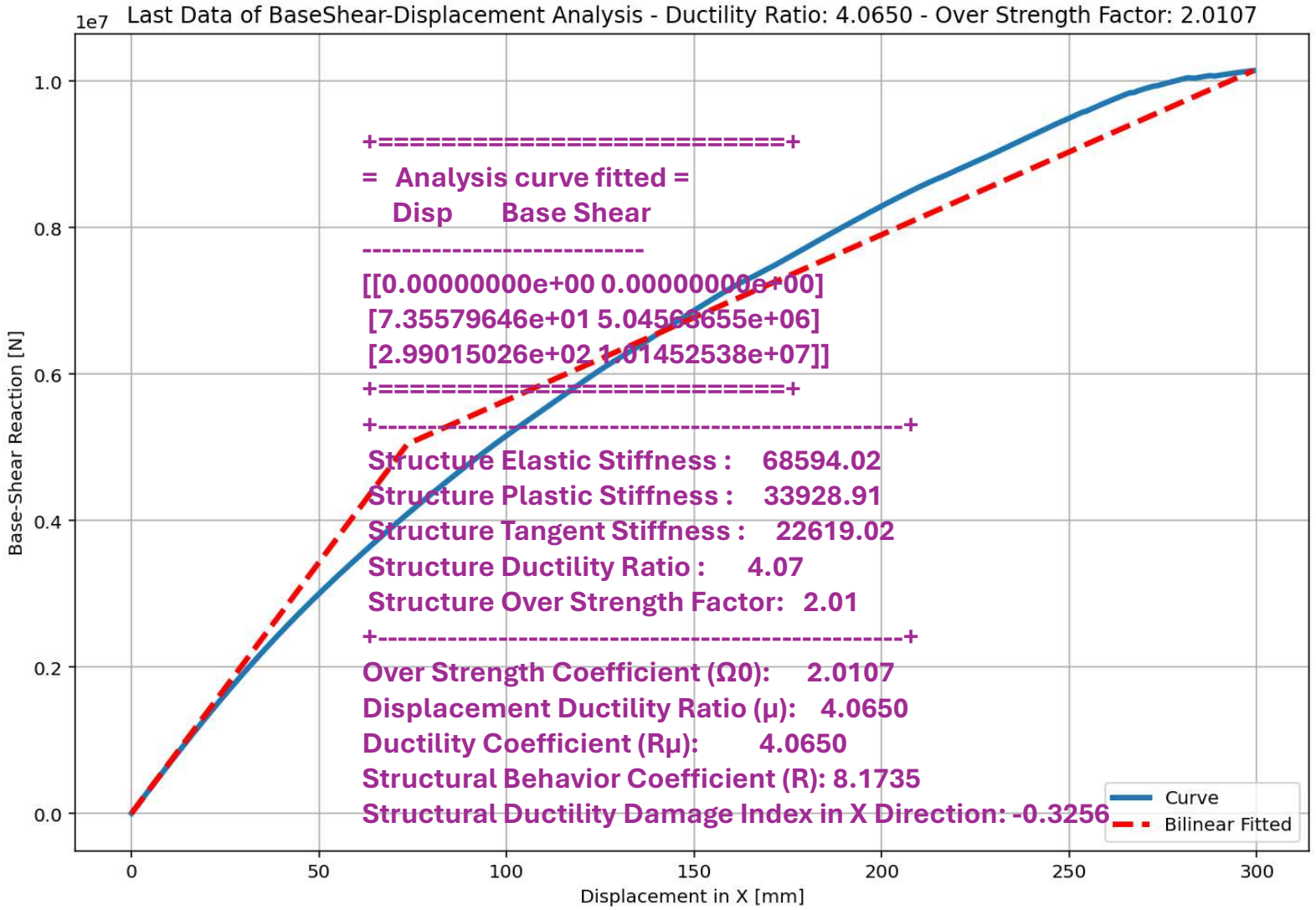

SHEAR FORCE-DISPLACEMENT DIAGRAM
1e7
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
Shear Force [N]
0
50
100
150
200
250
300
Displacement in X [mm]
PUSHOVER
DYNAMIC


AXIAL FORCE-DISPLACEMENT DIAGRAM
1e7
1.0
0.8
0.6
0.4
0.2
0.0
Axial Force [N]
−25
−20
−15
−10
−5
0
Displacement in Y [mm]
PUSHOVER
DYNAMIC

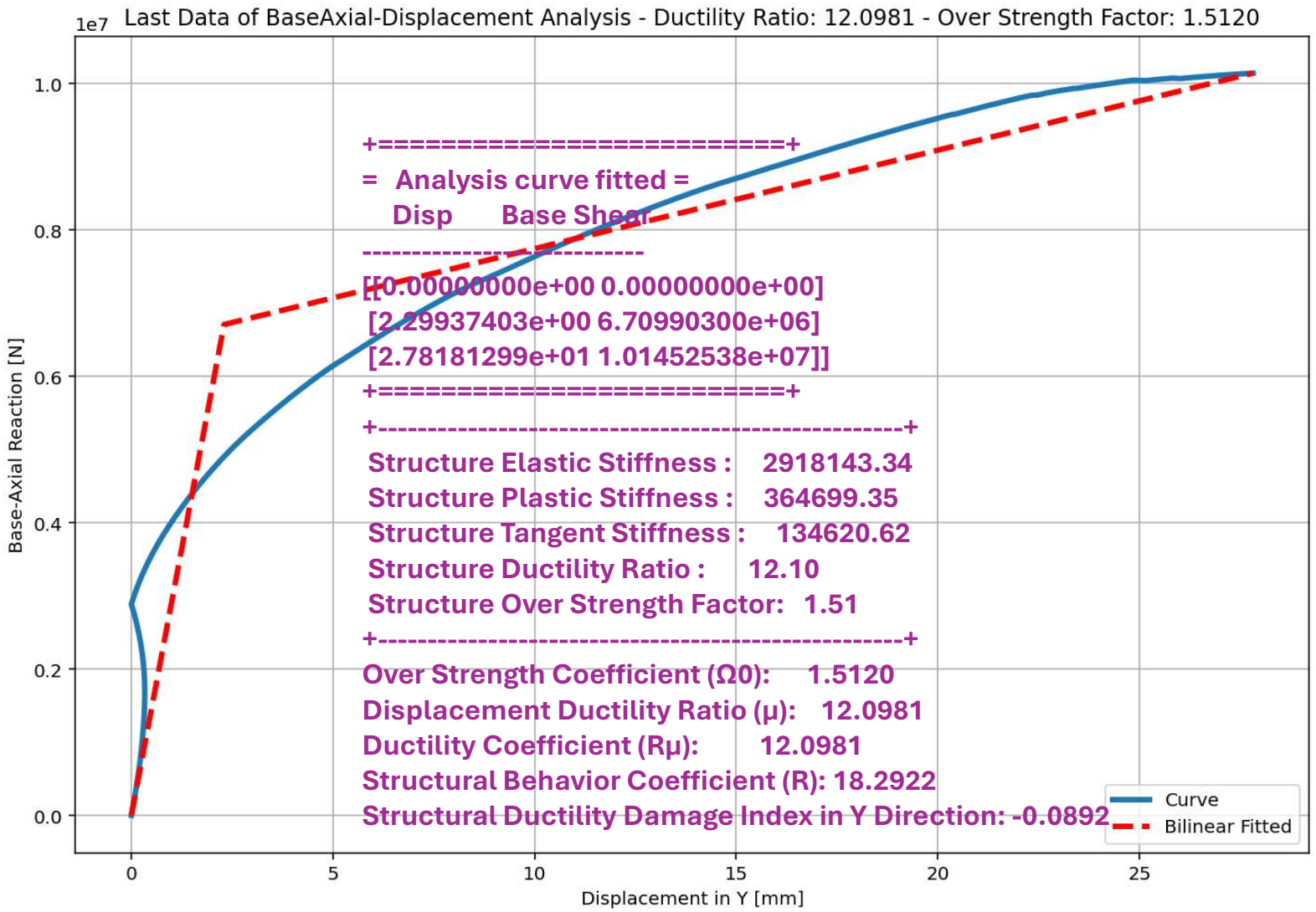

MOMENT-ROTATION DIAGRAM
1e9
PUSHOVER
DYNAMIC
Moment [kN.mm]
3
2
1
0
−1
−0.150
−0.125
−0.100
−0.075
−0.050
−0.025
0.000
Rotation [rad]

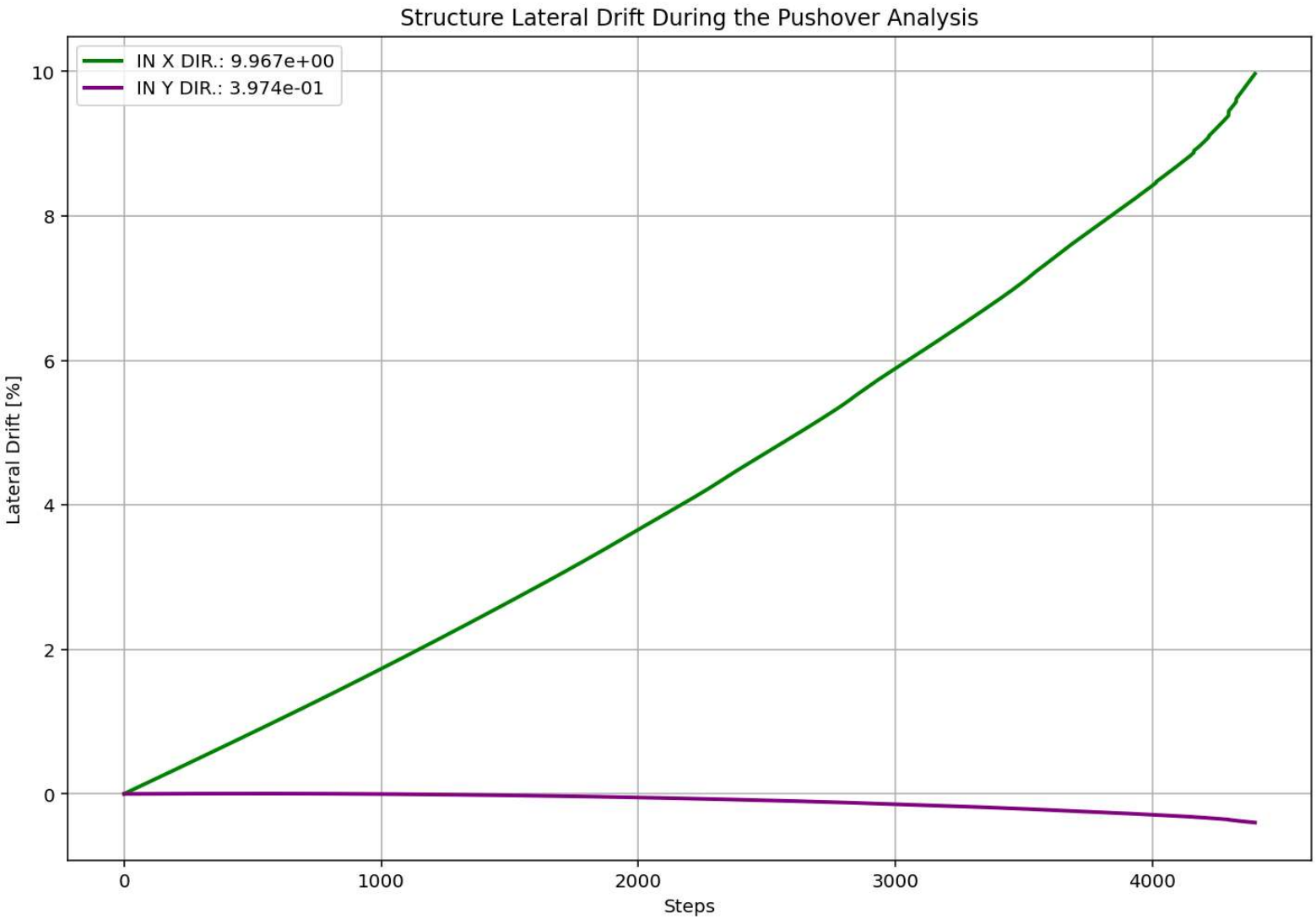

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
PUSHOVER
DYNAMIC
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in X Dir. [N/mm]
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}
10^{9}
10^{8}
10^{9}
10^{10}
10^{11}
10^{12}
10^{13}
10^{14}


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
PUSHOVER
DYNAMIC
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in Y Dir. [N/mm]
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{8}
10^{9}
10^{10}
10^{11}
10^{12}
10^{13}
10^{14}

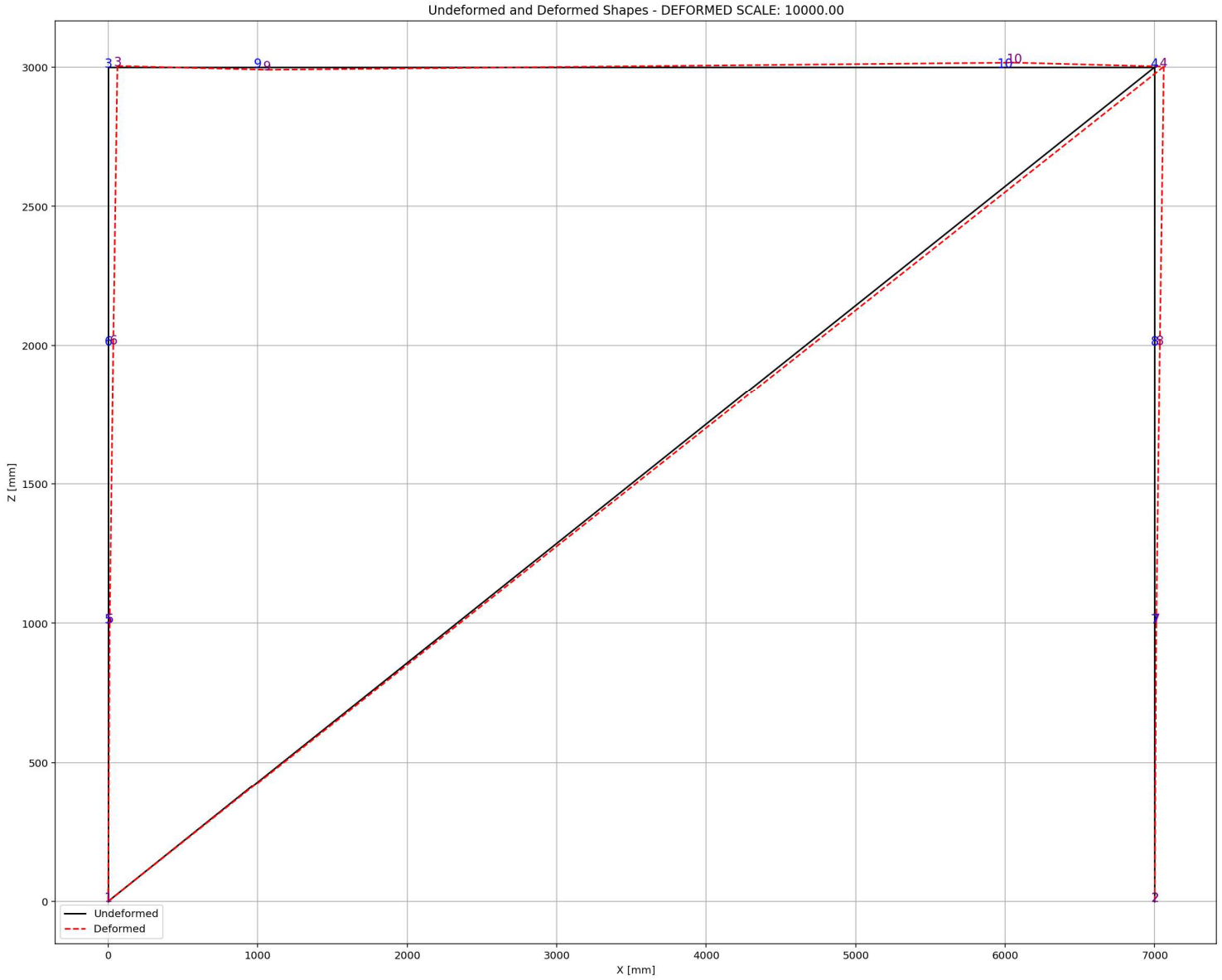

Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 4.0650 - Over Strength Factor: 2.0107
1e7
1.0
0.8
0.6
0.4
0.2
0.0
Base-Shear Reaction [N]
0
50
100
150
200
250
300
Displacement in X [mm]
+==========================+
= Analysis curve fitted =
Disp Base Shear

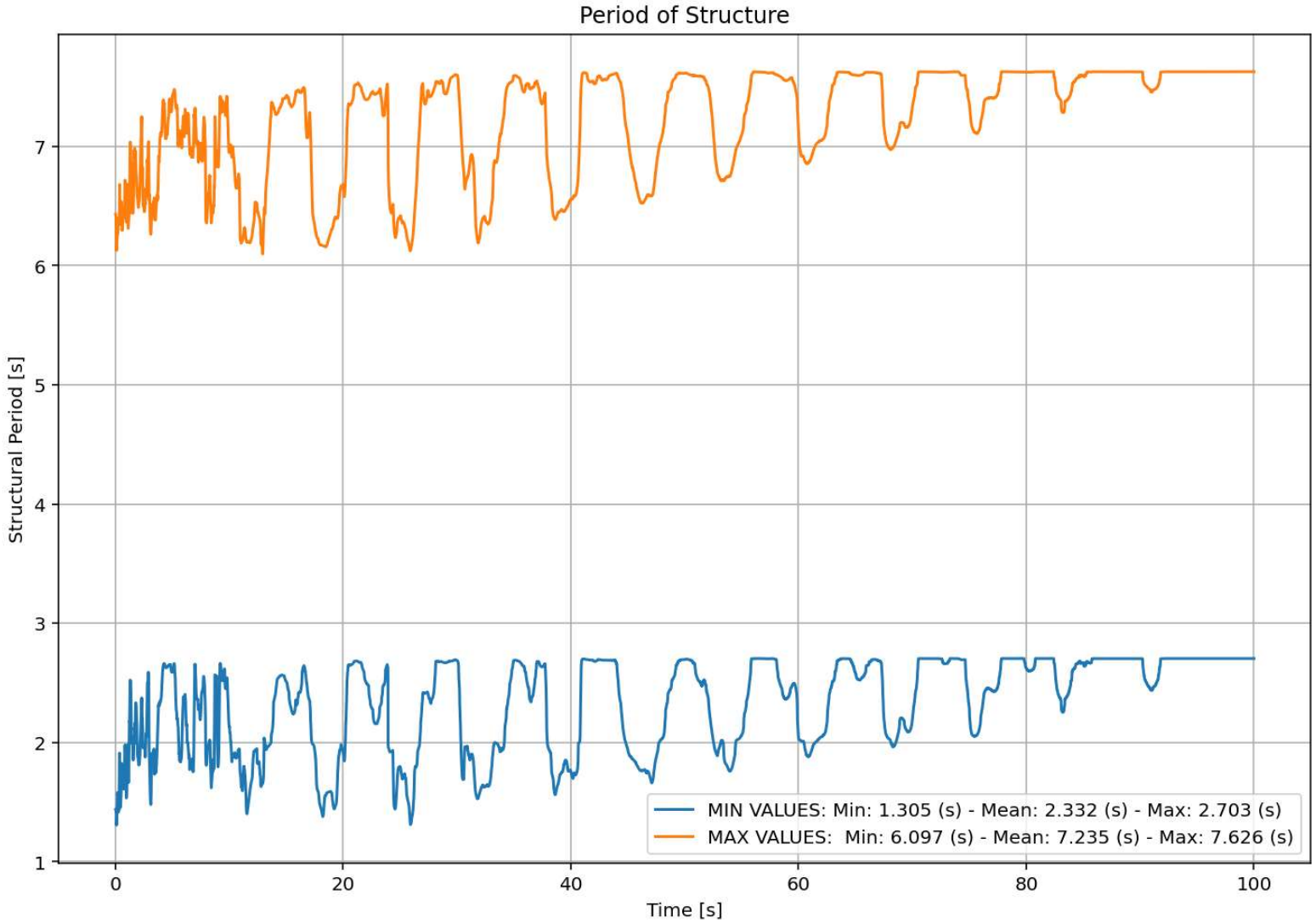
[[0.00000000e+00 0.00000000e+00]
[7.35579646e+01 5.04568655e+06]
[2.99015026e+02 1.01452538e+07]]
+==========================+
+----------+
Structure Elastic Stiffness : 68594.02
Structure Plastic Stiffness : 33928.91
Structure Tangent Stiffness : 22619.02
Structure Ductility Ratio : 4.07
Structure Over Strength Factor: 2.01
+----------+
Over Strength Coefficient (Ω0): 2.0107
Displacement Ductility Ratio (μ): 4.0650
Ductility Coefficient (Rμ): 4.0650
Structural Behavior Coefficient (R): 8.1735
Structural Ductility Damage Index in X Direction: -0.3256
Curve
Bilinear Fitted

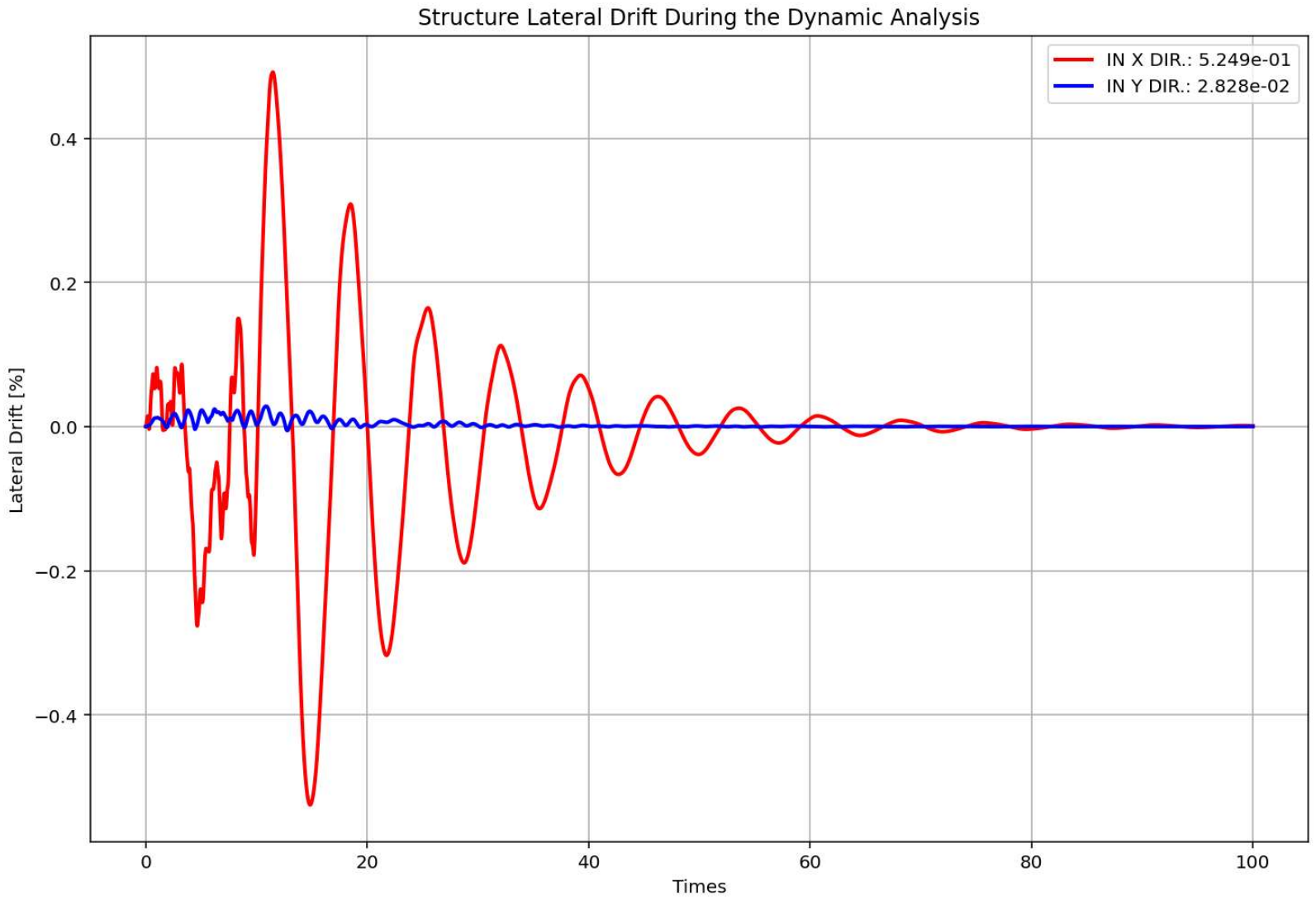

Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 12.0981 - Over Strength Factor: 1.5120
1e7
Base-Axial Reaction [N]
Displacement in Y [mm]
+==========================+
= Analysis curve fitted =
Disp Base Shear
---------- ----------
[[0.00000000e+00 0.00000000e+00]
[2.29937403e+00 6.70990300e+06]
[2.78181299e+01 1.01452538e+07]]
+==========================+
+--+
Structure Elastic Stiffness : 2918143.34
Structure Plastic Stiffness : 364699.35
Structure Tangent Stiffness : 134620.62
Structure Ductility Ratio : 12.10
Structure Over Strength Factor: 1.51
+--+
Over Strength Coefficient (Ω0): 1.5120
Displacement Ductility Ratio (μ): 12.0981
Ductility Coefficient (Rμ): 12.0981
Structural Behavior Coefficient (R): 18.2922
Structural Ductility Damage Index in Y Direction: -0.0892
Curve
Bilinear Fitted

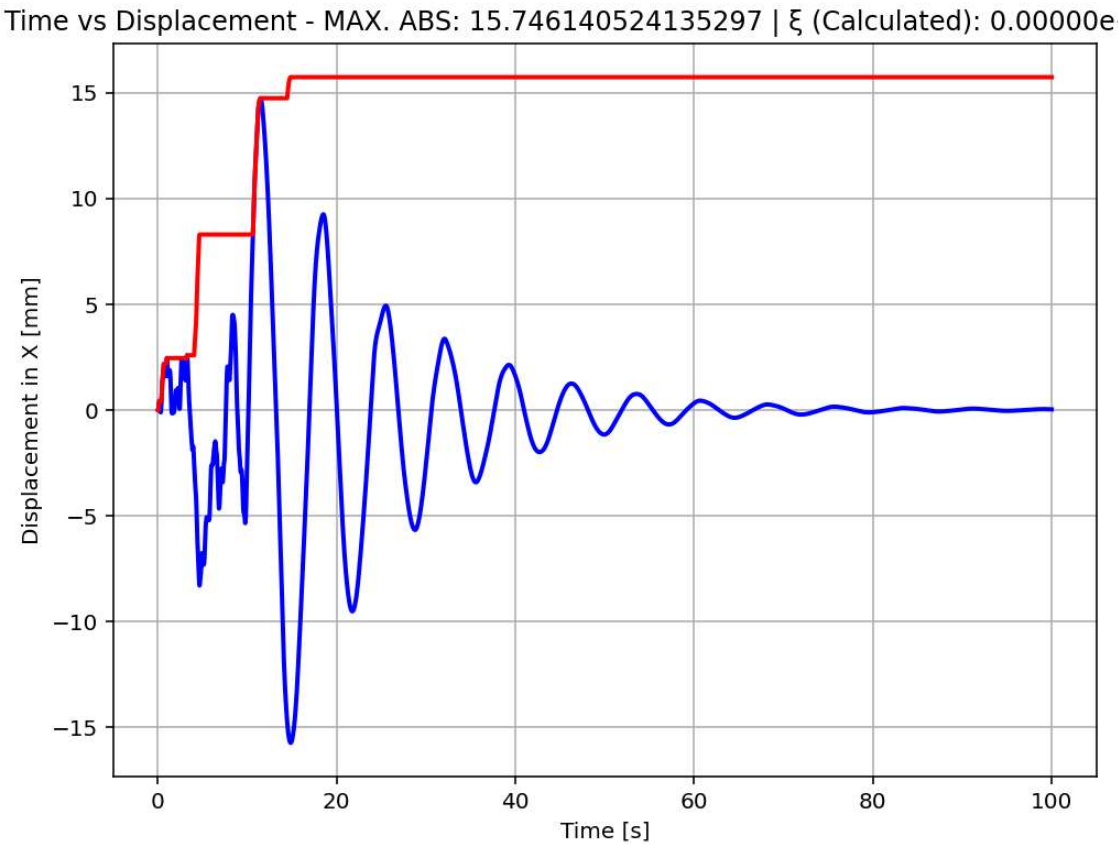

Structure Lateral Drift During the Pushover Analysis
IN X DIR.: 9.967e+00
IN Y DIR.: 3.974e-01
Lateral Drift [%]
Steps
0
2
4
6
8
10
0
1000
2000
3000
4000

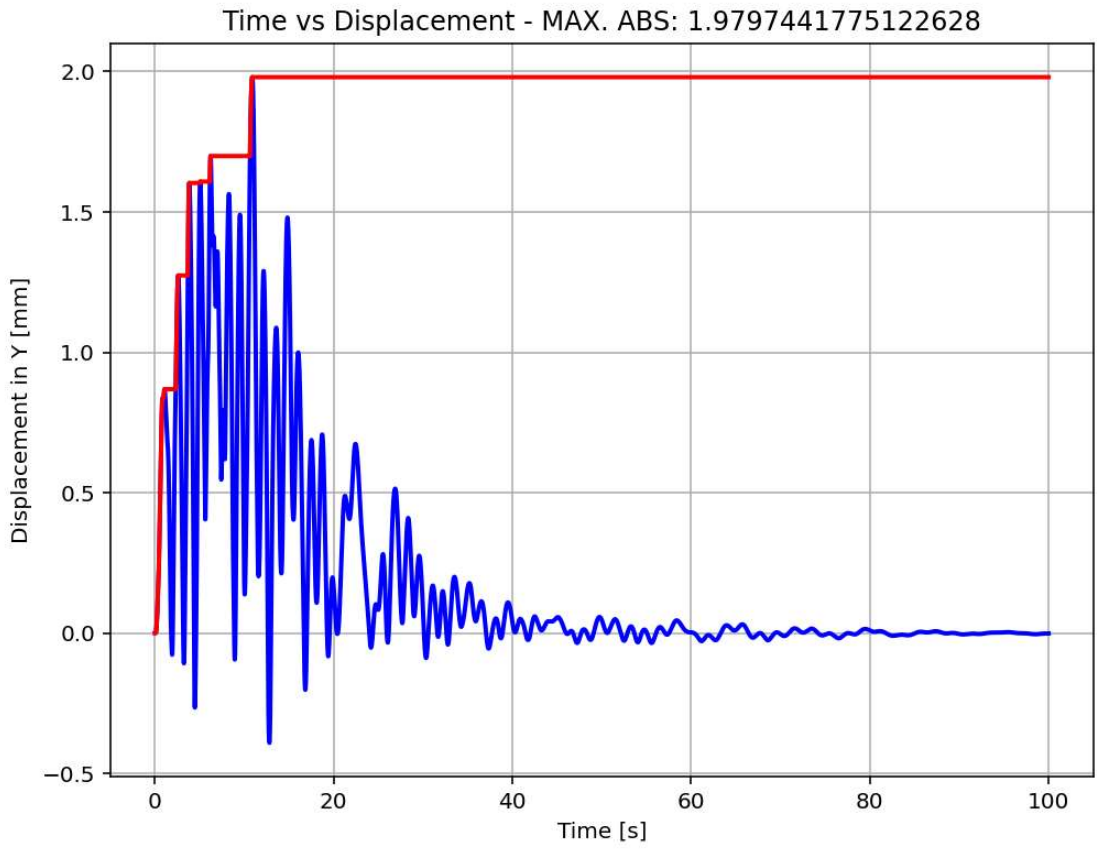
NONLINEAR DYNAMIC ANALYSIS

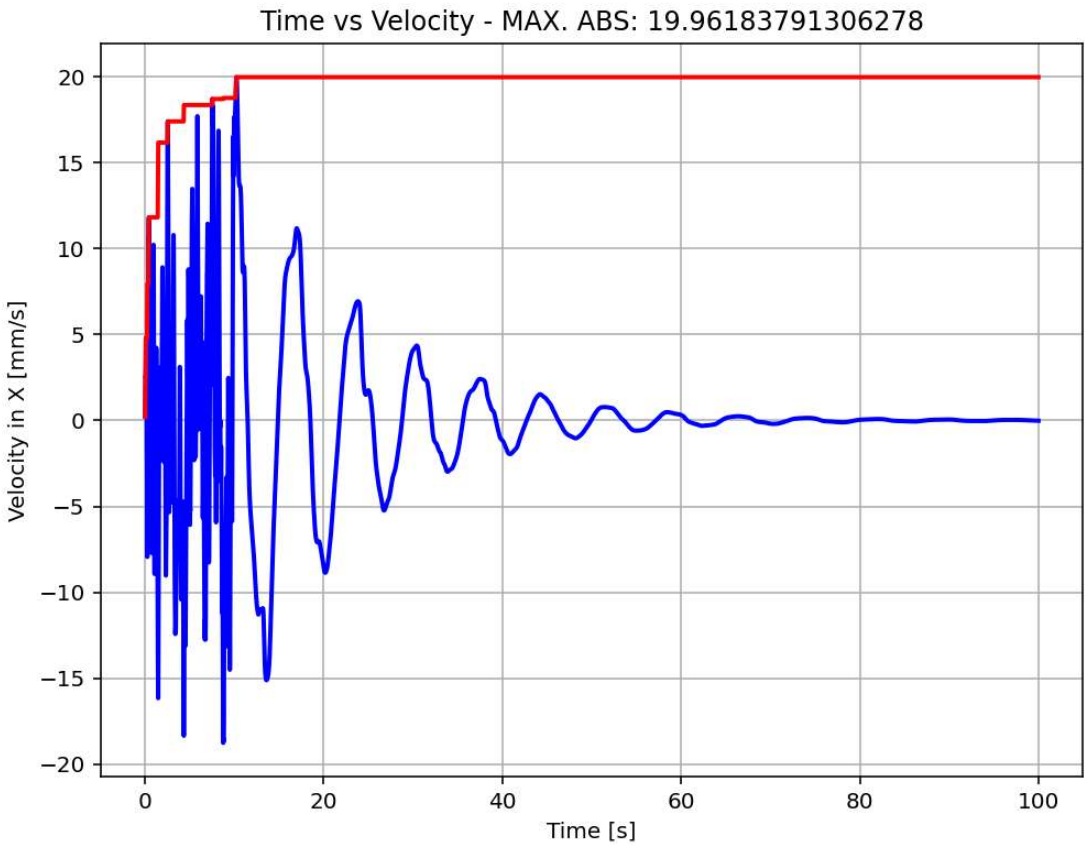

Undeformed and Deformed Shapes - DEFORMED SCALE: 10000.00
Z [mm]
X [mm]
Undeformed
Deformed
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000
1
2
3
4
5
6
7
8
9
10

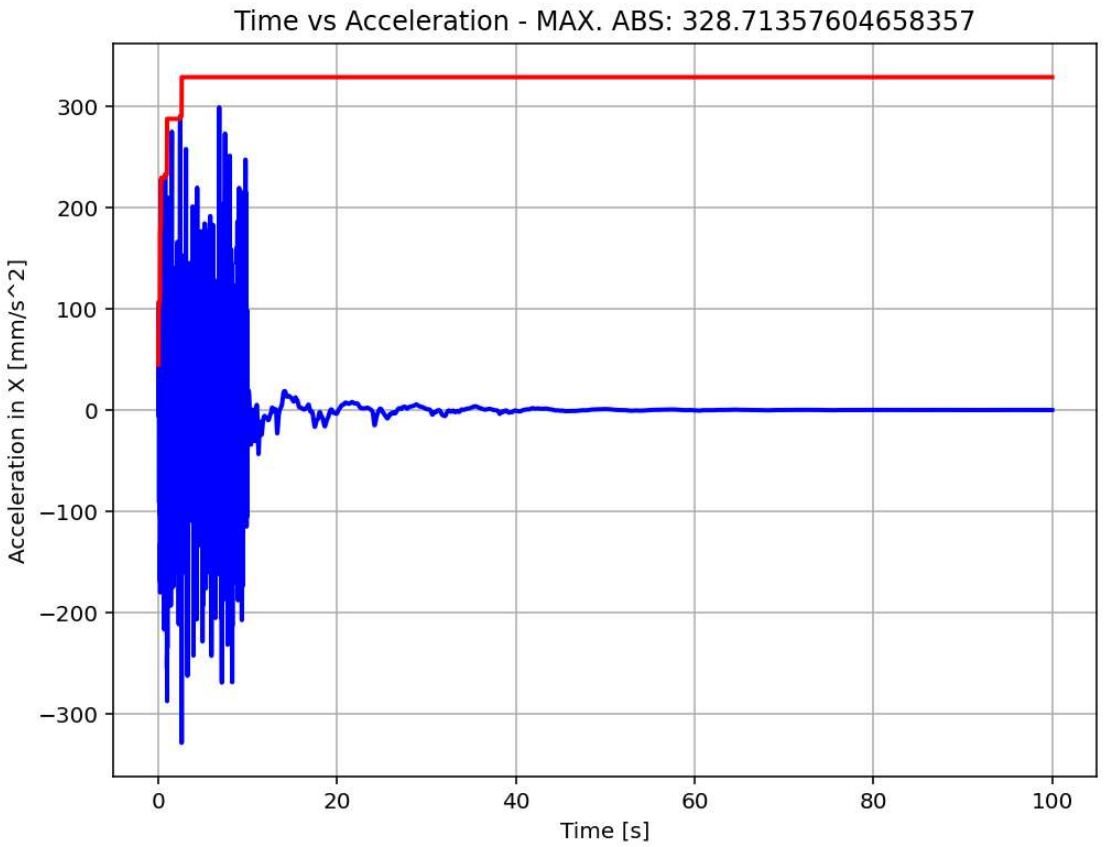

Period of Structure
Structural Period [s]
Time [s]
1
2
3
4
5
6
7
0
20
40
60
80
100
MIN VALUES: Min: 1.305 (s) - Mean: 2.332 (s) - Max: 2.703 (s)
MAX VALUES: Min: 6.097 (s) - Mean: 7.235 (s) - Max: 7.626 (s)

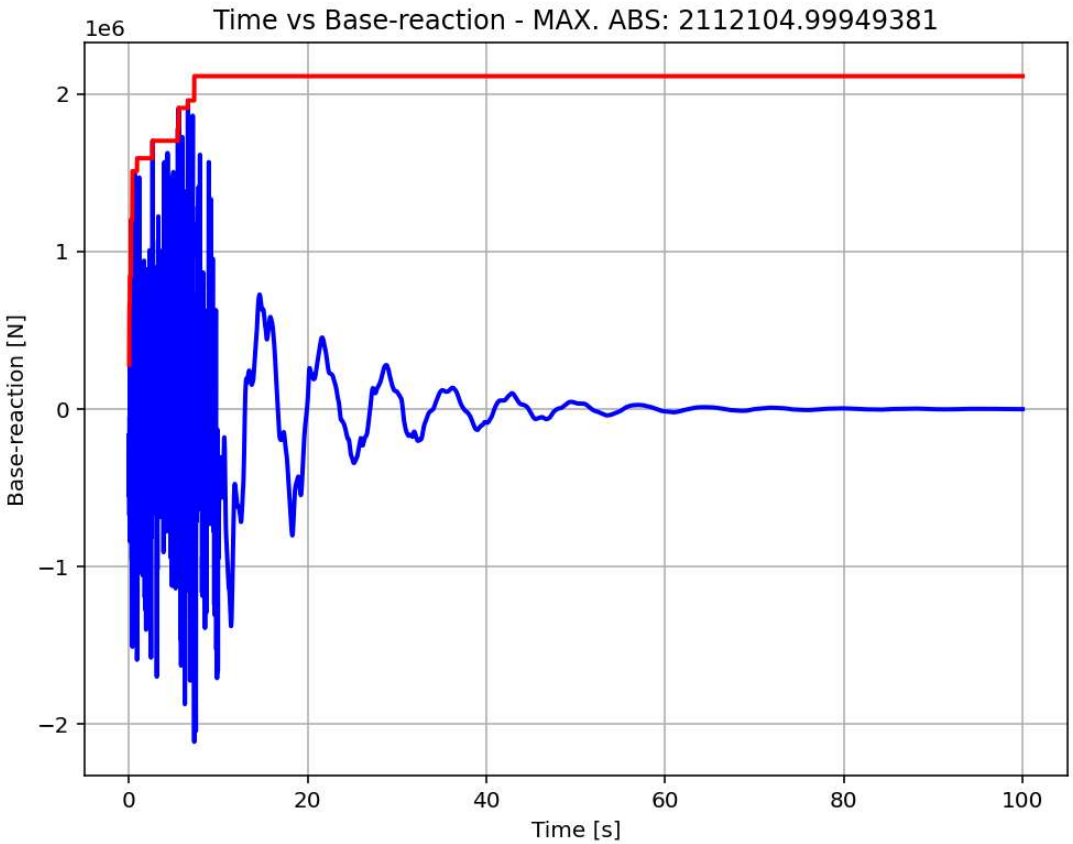

Structure Lateral Drift During the Dynamic Analysis
IN X DIR.: 5.249e-01
IN Y DIR.: 2.828e-02
Lateral Drift [%]
0.4
0.2
0.0
−0.2
−0.4
0
20
40
60
80
100
Times

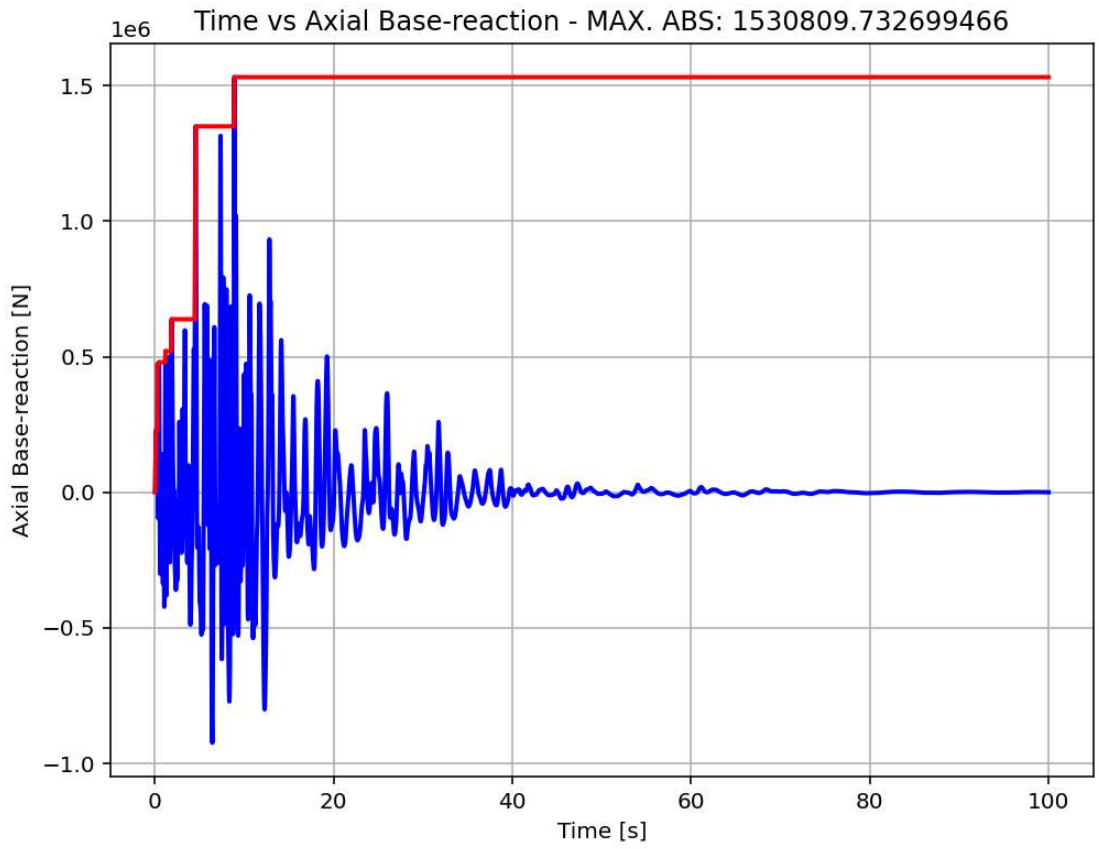

Time vs Displacement - MAX. ABS: 15.746140524135297 | ξ (Calculated): 0.00000e+00 %
Displacement in X [mm]
Time [s]
15
10
5
0
−5
−10
−15
0
20
40
60
80
100

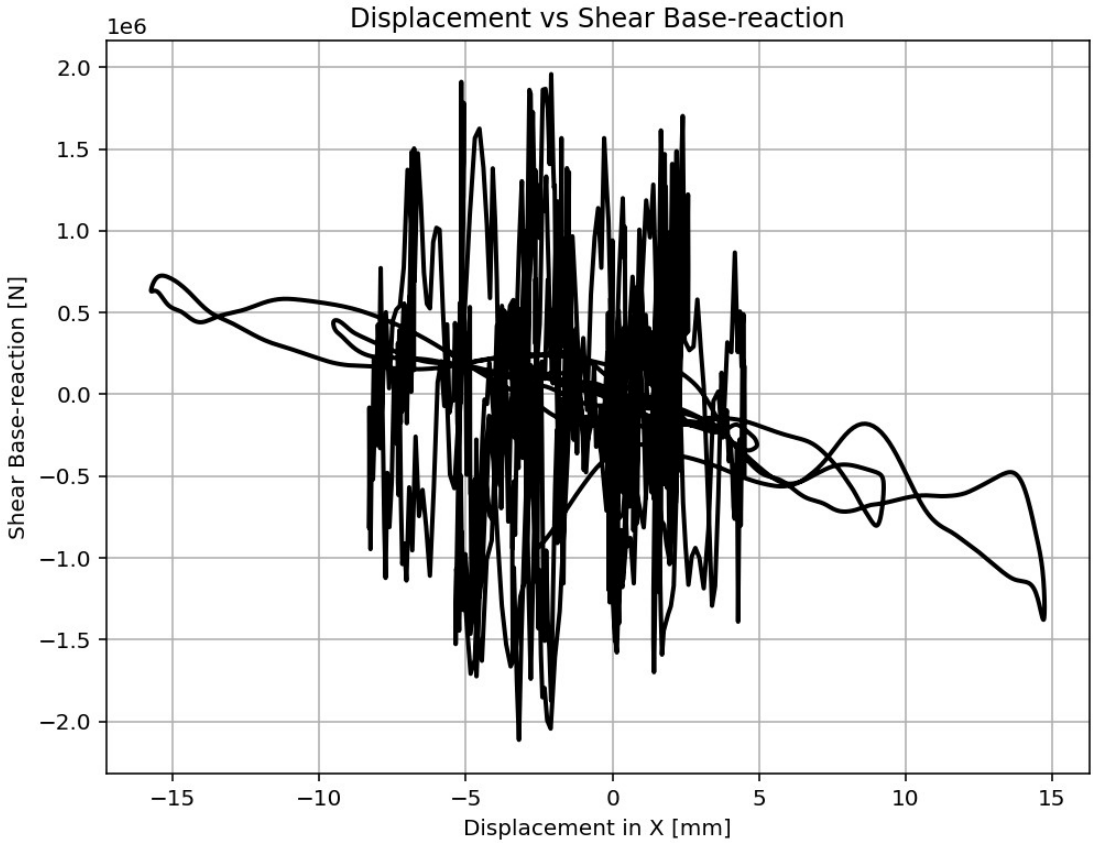

Time vs Displacement - MAX. ABS: 1.9797441775122628
Displacement in Y [mm]
Time [s]
2.0
1.5
1.0
0.5
0.0
−0.5
0
20
40
60
80
100

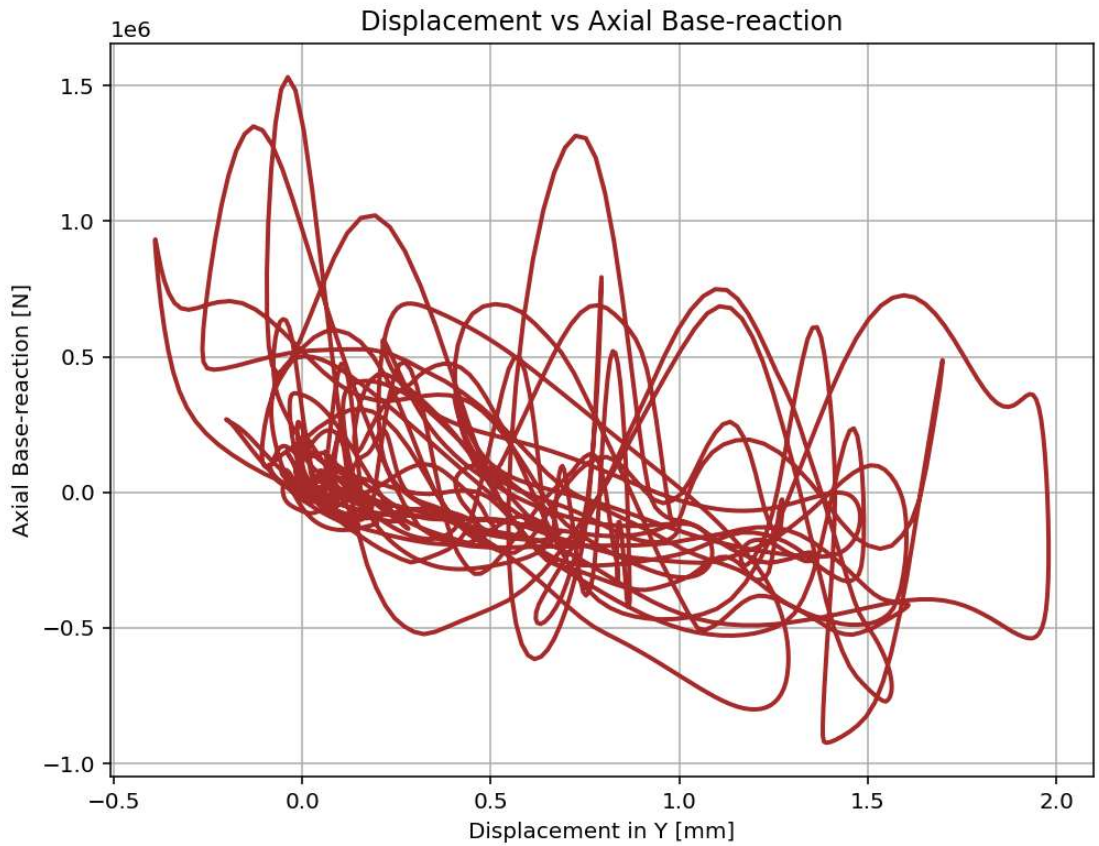

Time vs Velocity - MAX. ABS: 19.96183791306278
Velocity in X [mm/s]
Time [s]
20
15
10
5
0
−5
−10
−15
−20
0
20
40
60
80
100

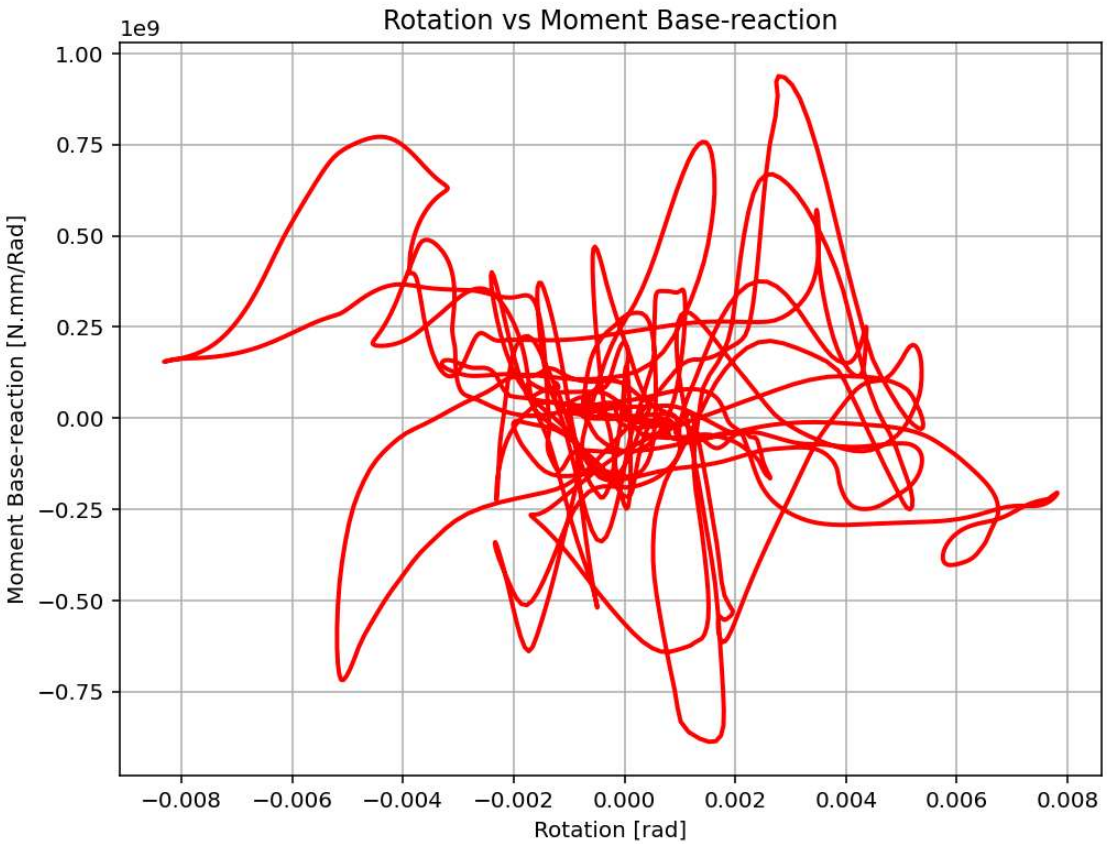

Time vs Acceleration - MAX. ABS: 328.71357604658357
Acceleration in X [mm/s^2]
300
200
100
0
−100
−200
−300
0
20
40
60
80
100
Time [s]


Time vs Base-reaction - MAX. ABS: 2112104.99949381
1e6
2
1
0
−1
−2
Base-reaction [N]
0
20
40
60
80
100
Time [s]


Time vs Axial Base-reaction - MAX. ABS: 1530809.732699466
1e6
1.5
1.0
0.5
0.0
−0.5
−1.0
Axial Base-reaction [N]
0
20
40
60
80
100
Time [s]


Displacement vs Shear Base-reaction
1e6
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
Shear Base-reaction [N]
−15
−10
−5
0
5
10
15
Displacement in X [mm]


Displacement vs Axial Base-reaction
1e6
1.5
1.0
0.5
0.0
−0.5
−1.0
Axial Base-reaction [N]
−0.5
0.0
0.5
1.0
1.5
2.0
Displacement in Y [mm]


Rotation vs Moment Base-reaction
1e9
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
Moment Base-reaction [N.mm/Rad]
−0.008
−0.006
−0.004
−0.002
0.000
0.002
0.004
0.006
0.008
Rotation [rad]