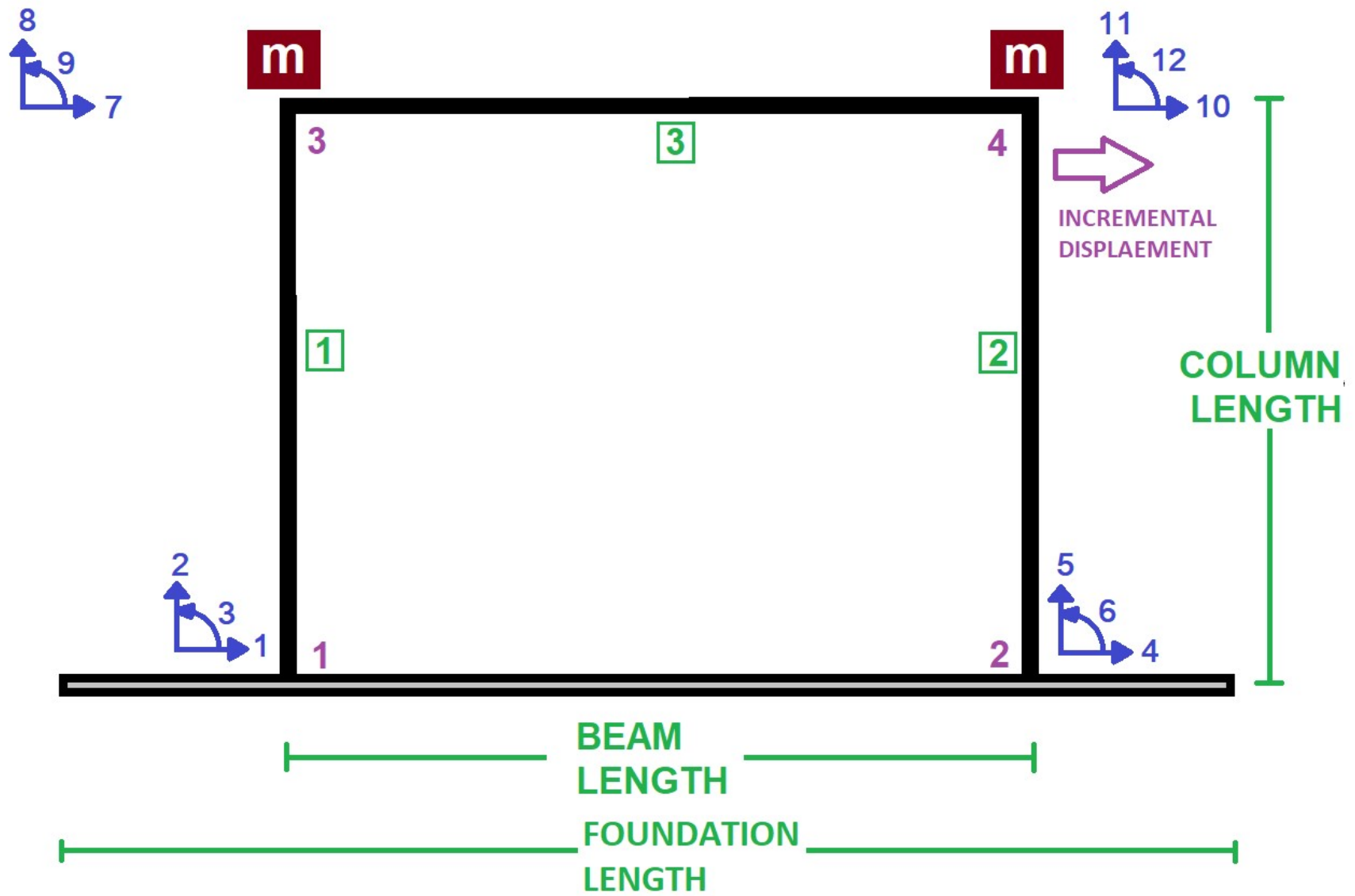


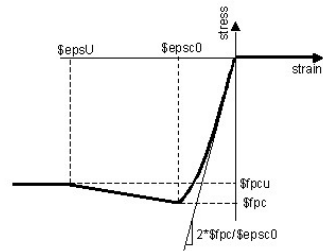
IN THE NAME OF ALLAH

# **SOIL-FOUNDATION-STRUCTURE INTERACTION USING OPENSEES**

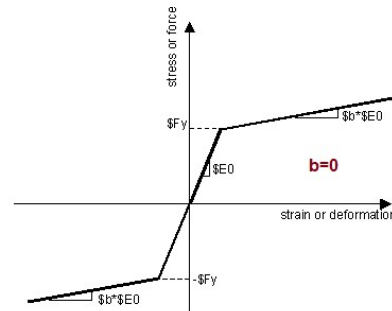
SOIL SIMULATED WITH SIMPLE SPRINGS AND THE SOIL SPRINGS VALUES IS NOT EXACT.

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

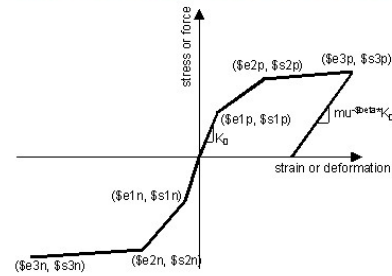




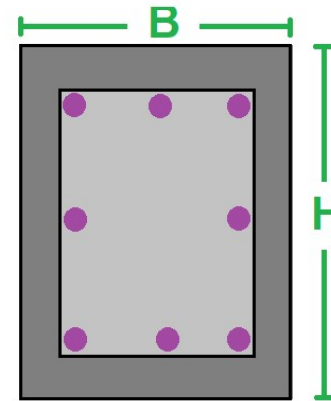
CORE AND COVER CONCRETE REALTION



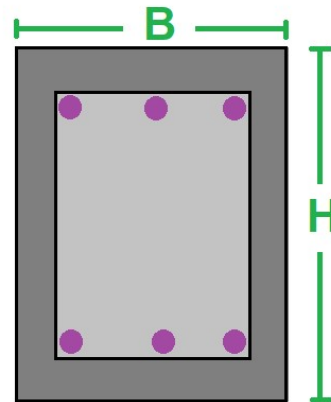
WITHOUT HARDENING AND ULTIMATE STRAIN



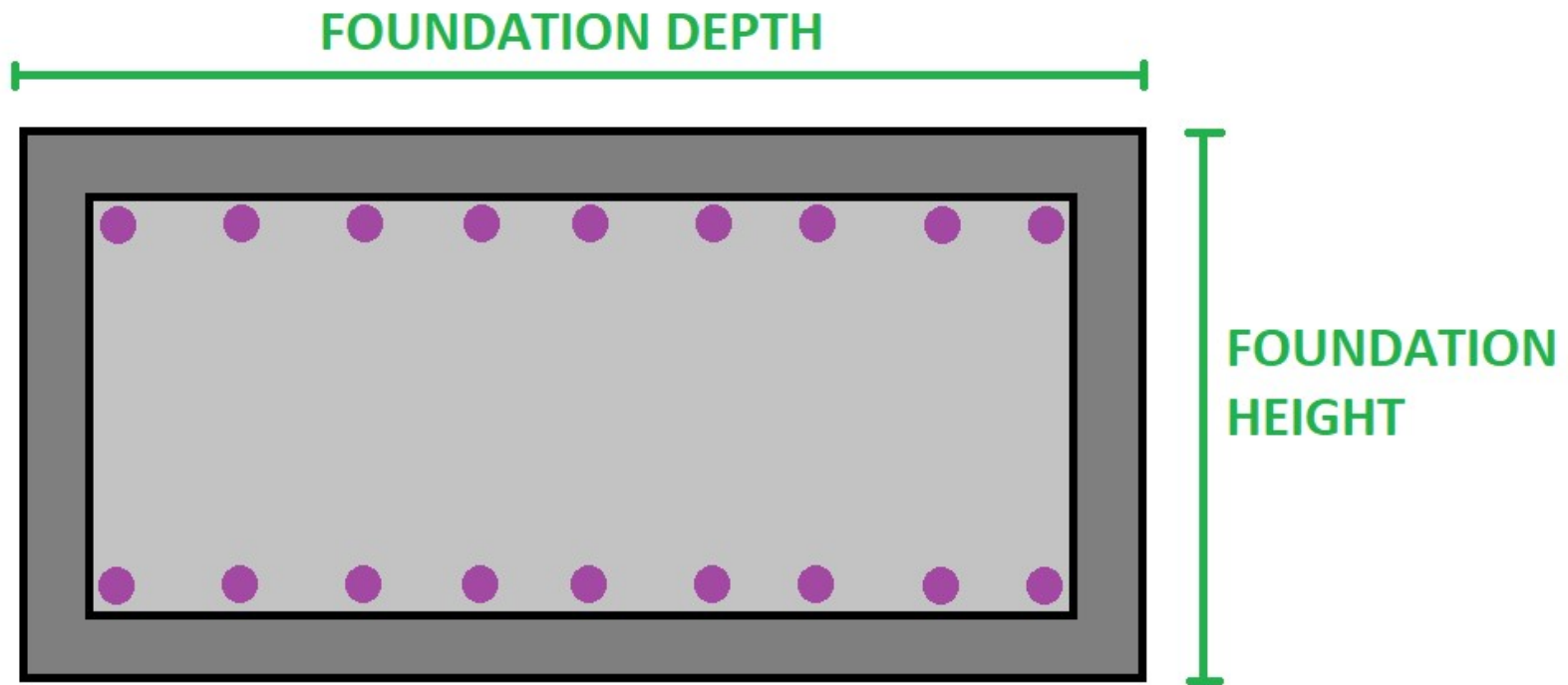
WITH HARDENING AND ULTIMATE STRAIN



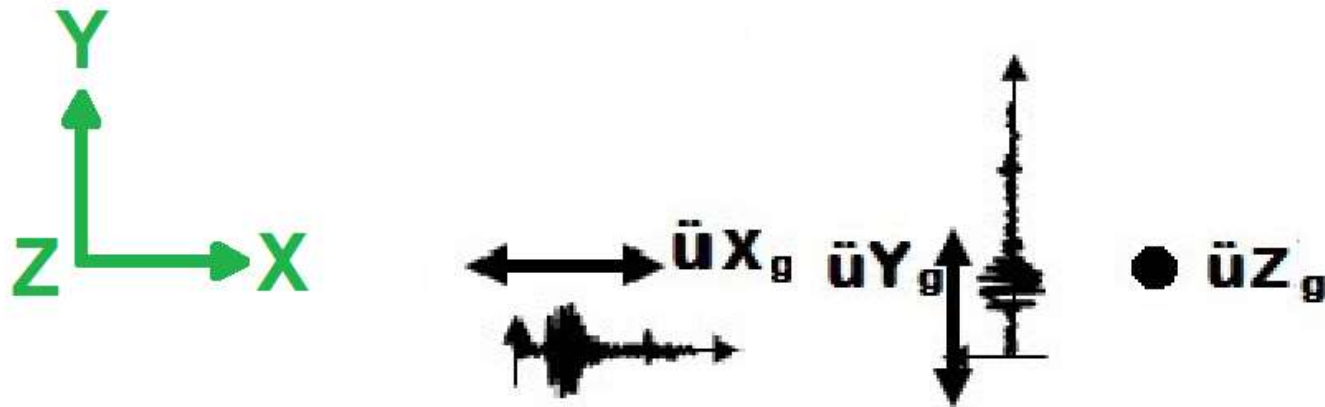
COLUMN SECTION



BEAM SECTION



FOUNDATION SECTION



$$\text{Structure Ductility Damage Index} = \frac{\Delta_d - \Delta_y}{\Delta_u - \Delta_y}$$

$\Delta_d$  = Lateral Displaement from Dynamic Analysis

$\Delta_y$  = Lateral Yield Displaement from Pushover Analysis

$\Delta_u$  = Lateral Ultimate Displaement from Pushover Analysis

Spyder (Python 3.12)

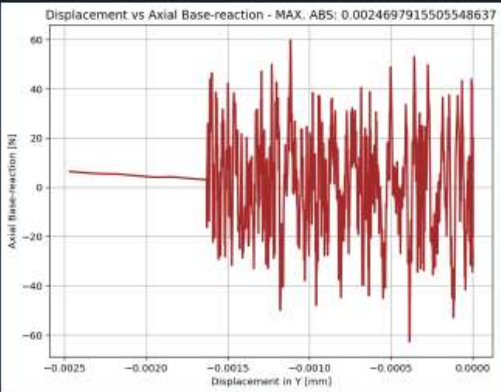
File Edit Search Source Run Debug Consoles Projects Tools View Help

C:\Users\Dell\Desktop\OPENSEES\_FILES\CONCRETE\_FRA...02\CONCRETE\_FRAME\_SOIL-FOUNDATION-STRUCTURE\_02.py

CONCRETE\_FRAME\_SOI...ON-STRUCTURE\_02.py X

```
1 #####
2                               IN THE NAME OF ALLAH
3                               SOIL-FOUNDATION-STRUCTURE INTERACTION USING OPENSEES
4                               -----
5                               EXAMPLE 02:
6                               SOIL SIMULATED WITH SIMPLE SPRINGS AND THE SOIL SPRINGS VALUES IS NOT EXACT.
7                               -----
8                               THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
9                               EMAIL: salar.d.ghashghaei@gmail.com
10                              #####
11                              "
12          ] Nonlinear Frame Modeling: 2D RC frame with distributed plasticity (fiber sections) using `nonlinearBc
13          ] Material Laws:
14          - *Concrete*: `Concrete01` with confined (core) and unconfined (cover) properties.
15          - *Steel*: `Hysteretic` model with pinching, hardening, and cyclic degradation.
16          ] Seismic Loads:
17          - Pushover: Displacement-controlled lateral loading to failure.
18          - Dynamic: Uniform excitation with user-defined ground motions (X/Y components).
19          ] Damping: Rayleigh damping (a0, a1) calibrated via eigenvalue analysis (modes 1-2).
20          ] Performance Metrics:
21          - Ductility Ratio ( $\mu$ ): Derived from bilinearized pushover curves.
22          - Overstrength ( $\Omega_o$ ): Yield vs. ultimate capacity.
23          - Damage Index (DI): Normalized displacement demand/capacity.
24          ] Advanced Solver: HHT-a integrator (unconditionally stable) with Newton-Raphson iterations.
25          ] Outputs:
26          - Hysteretic responses (P-M, V- $\Delta$ , M- $\theta$ ).
27          - Time-history plots (displacement, base shear).
28          - Stiffness degradation tracking.
29          ] Validation: Logarithmic decrement method for damping ratio verification.
30          ] Ductility Damage Index (DDI) Implementation:
31          DDI quantifies structural damage via normalized displacement demand.
32          # After bilinear fit ( $X[1] = \Delta_y$ ,  $X[2] = \Delta_u$ ):
33           $Dd = \max(\text{abs}(\text{DISP\_Xd}))$  # Max dynamic displacement demand
34           $DI = (Dd - Dy) / (Du - Dy)$  # Ductility Damage Index (X-dir)
```

Displacement vs Axial Base-reaction - MAX. ABS: 0.0024697915505548637



Help Variable Explorer Debugger Plots Files

Console 1/A X

Lobatto

End 1 Forces (P V M): 2.45202 2.88952 0.120247

End 2 Forces (P V M): -2.45202 -2.88952 8669.64

Element: 3 Type: ForceBeamColumn2d Connected Nodes: 3 4

Number of Sections: 5 Mass density: 3.75

Lobatto

End 1 Forces (P V M): 0.361746 -2.0028 -5349.95

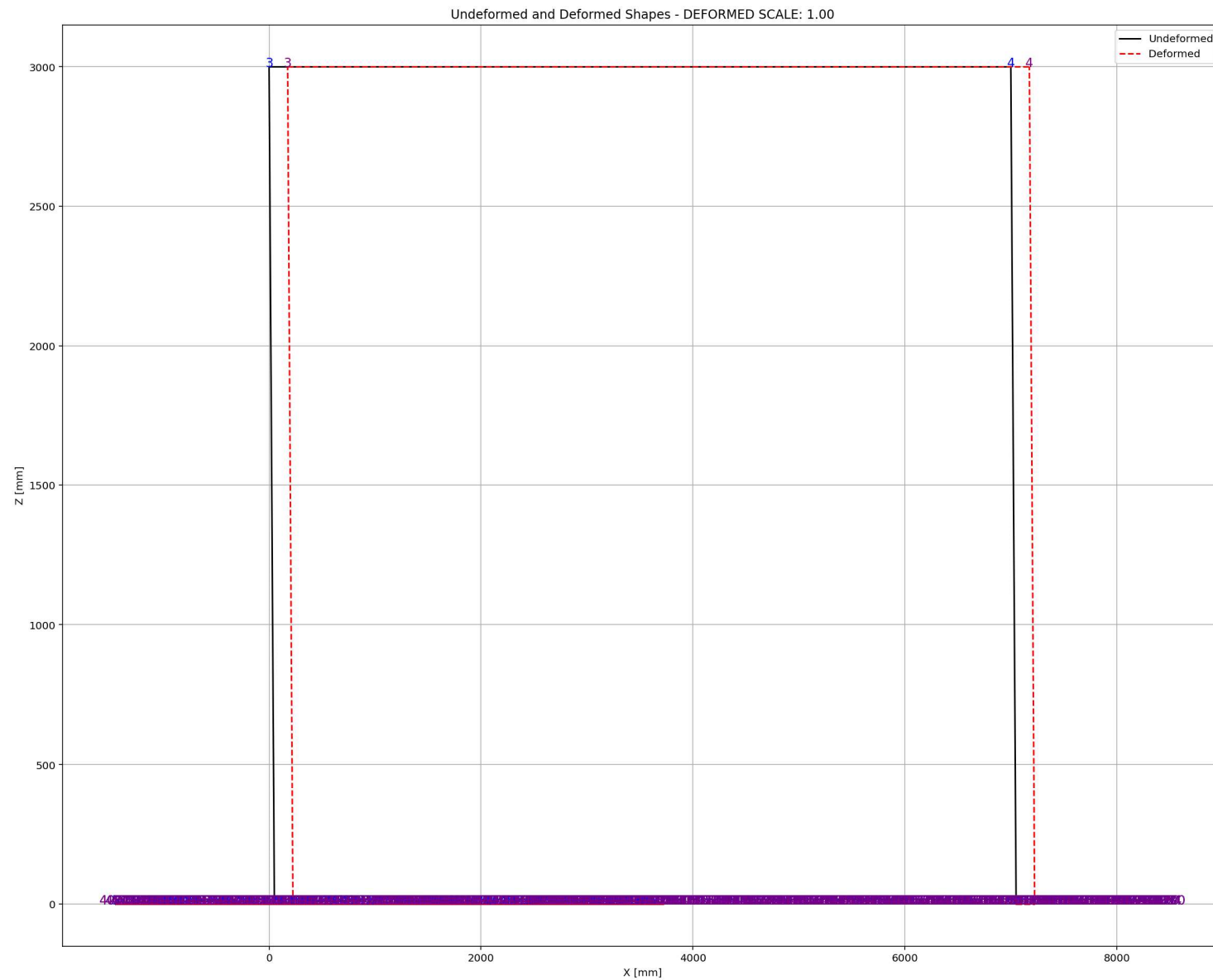
End 2 Forces (P V M): -0.361746 2.0028 -8669.64

In [2]:

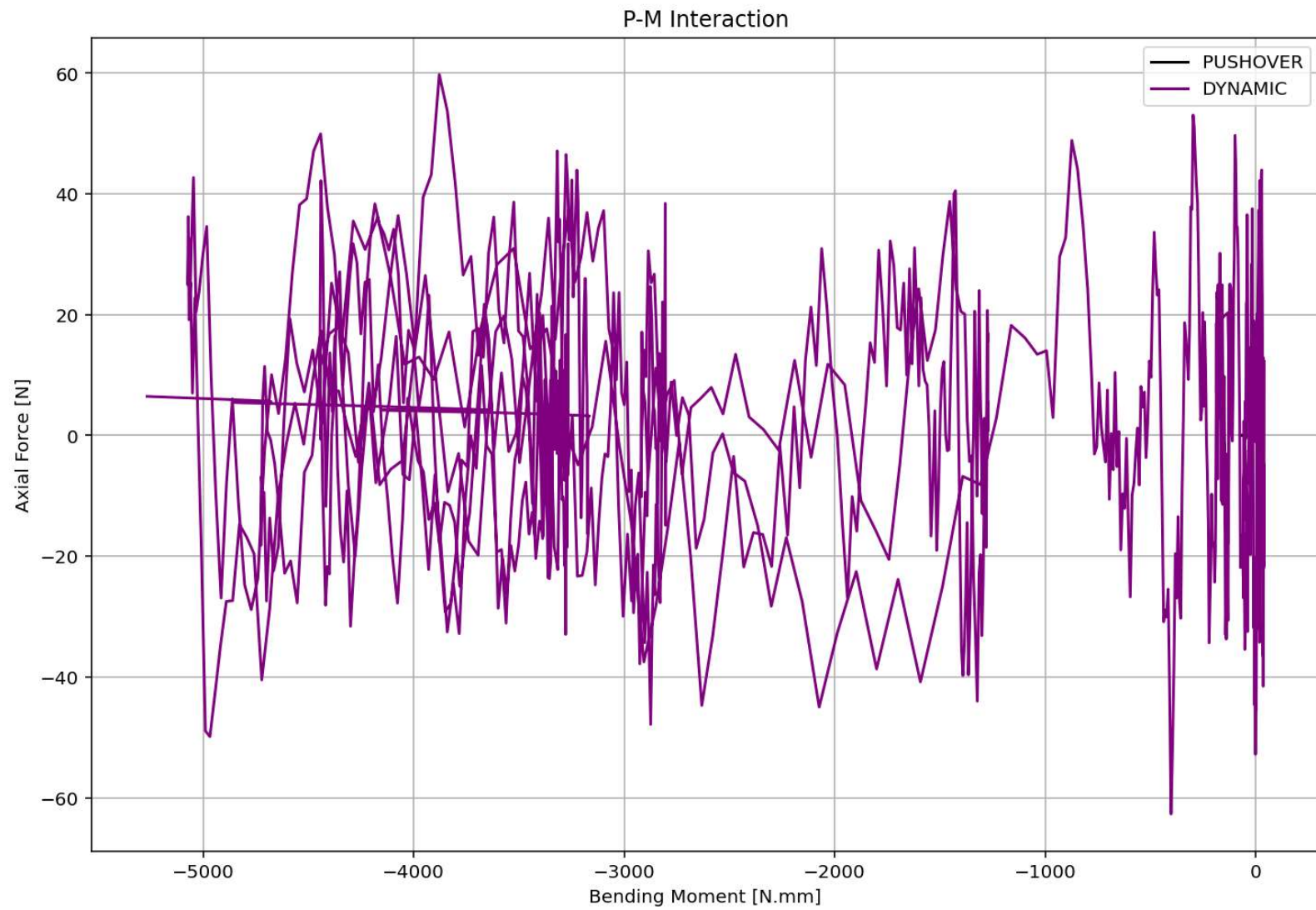
IPython Console History

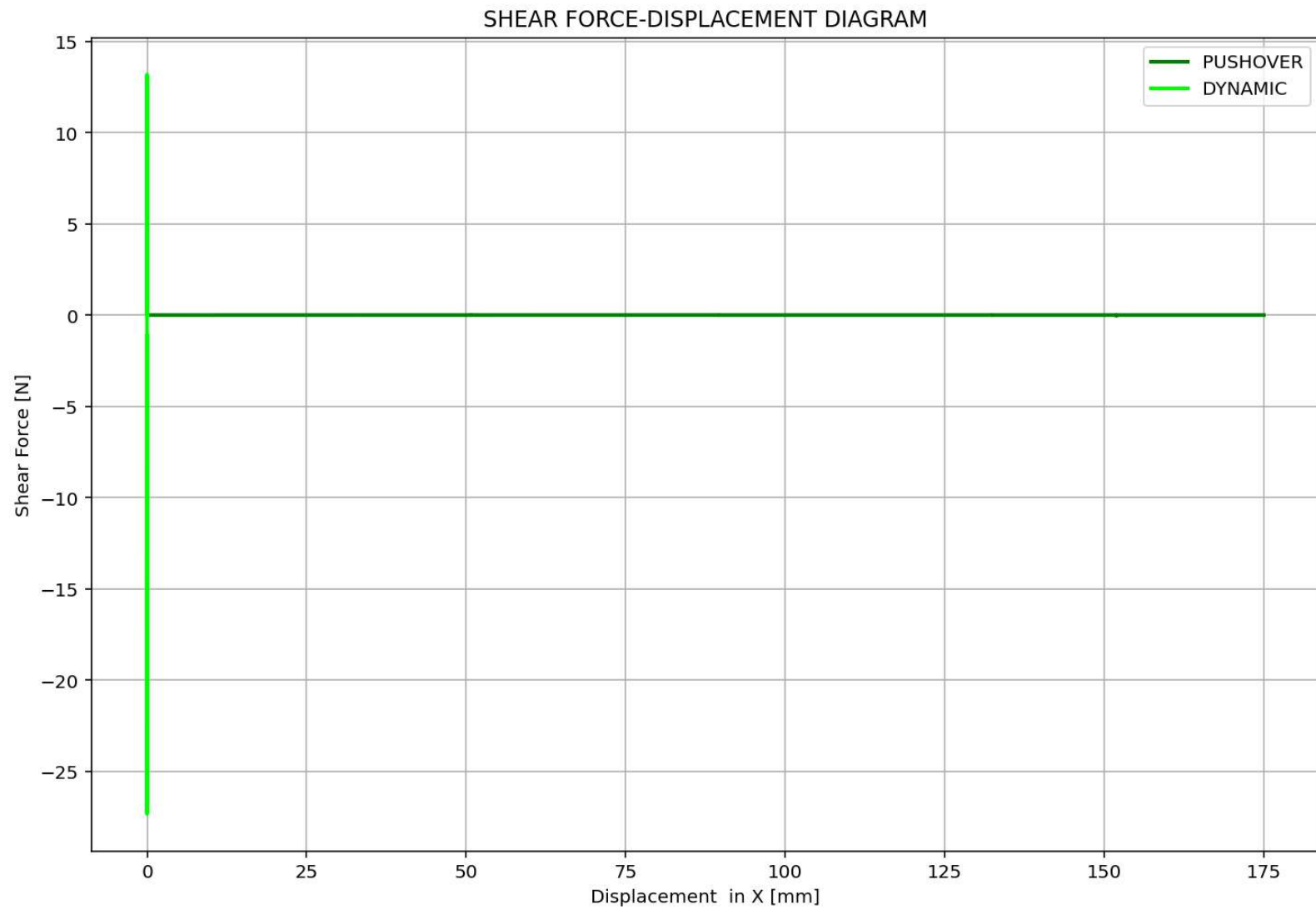
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 26, Col 33 UTF-8 CRLF RW Mem 44%

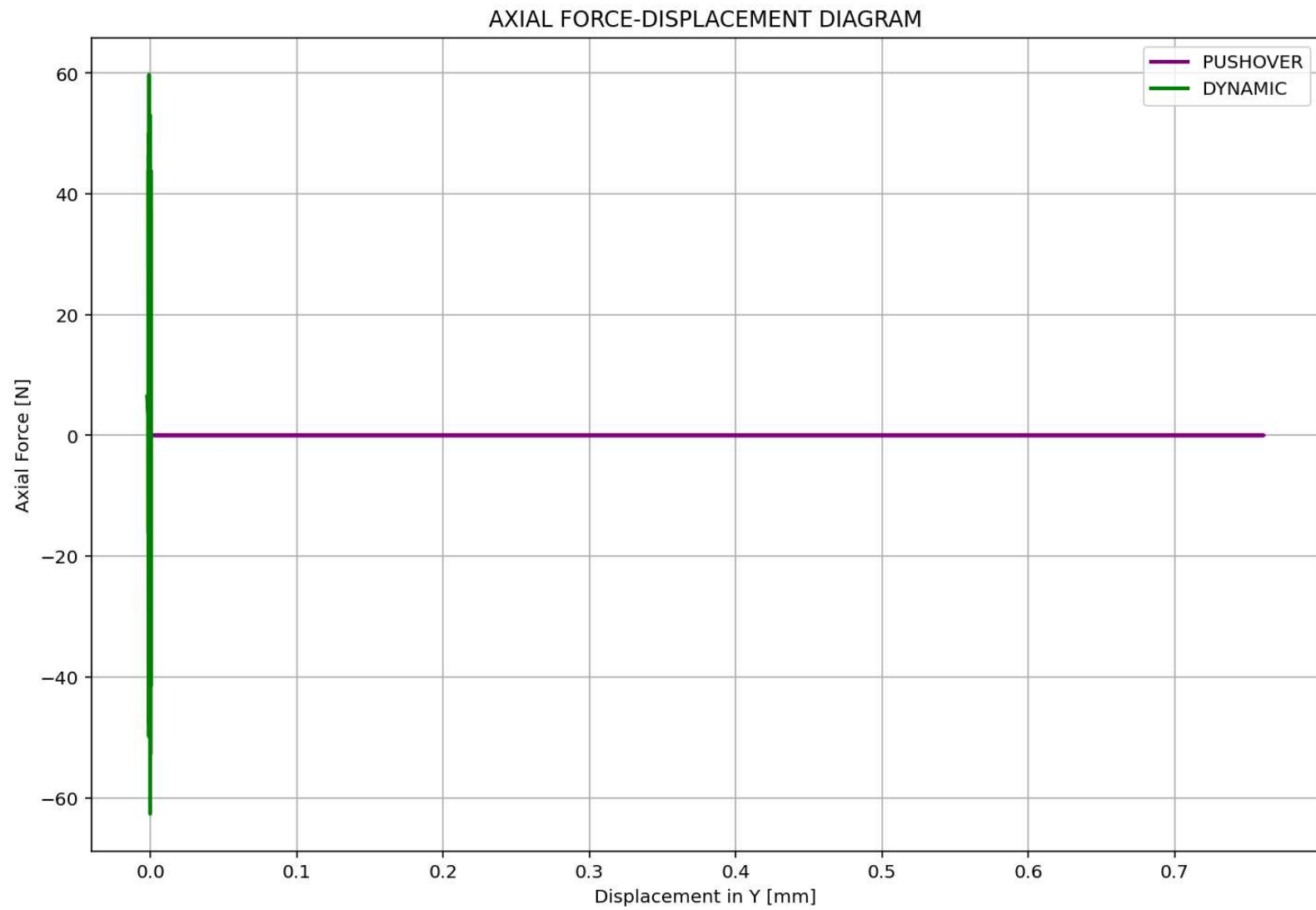
# **NONLINEAR STATIC ANALYSIS (PUSHOVER)**

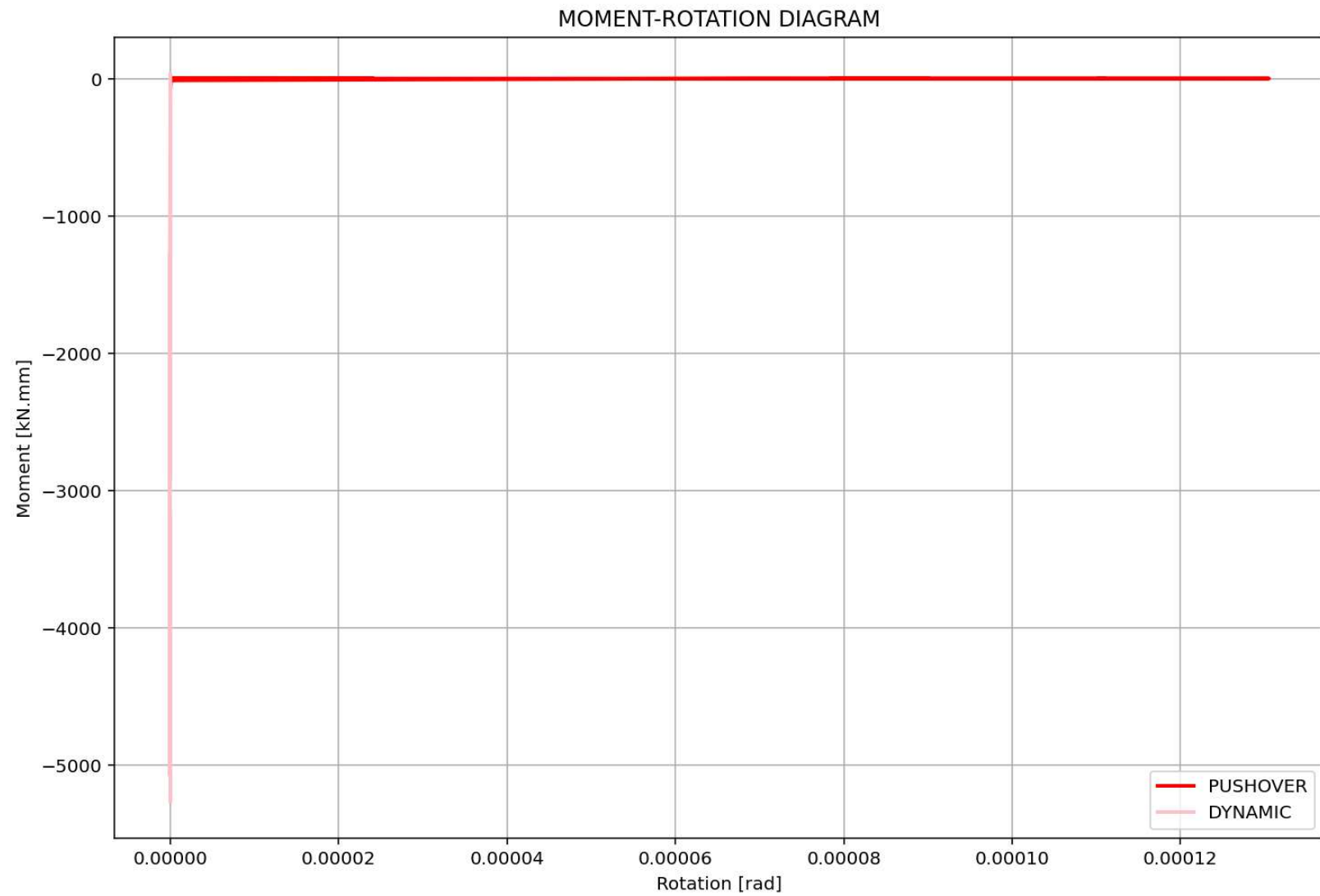




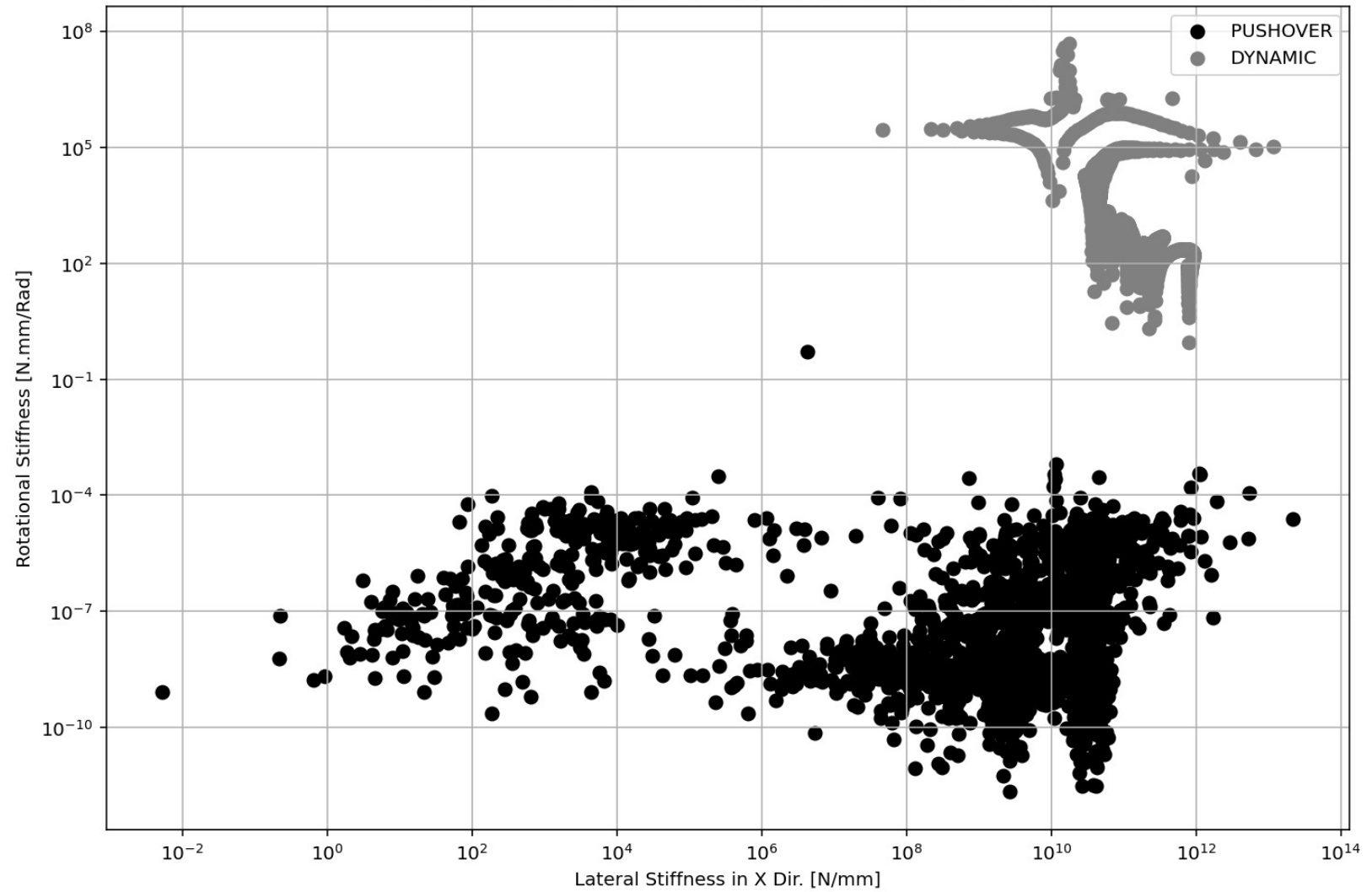




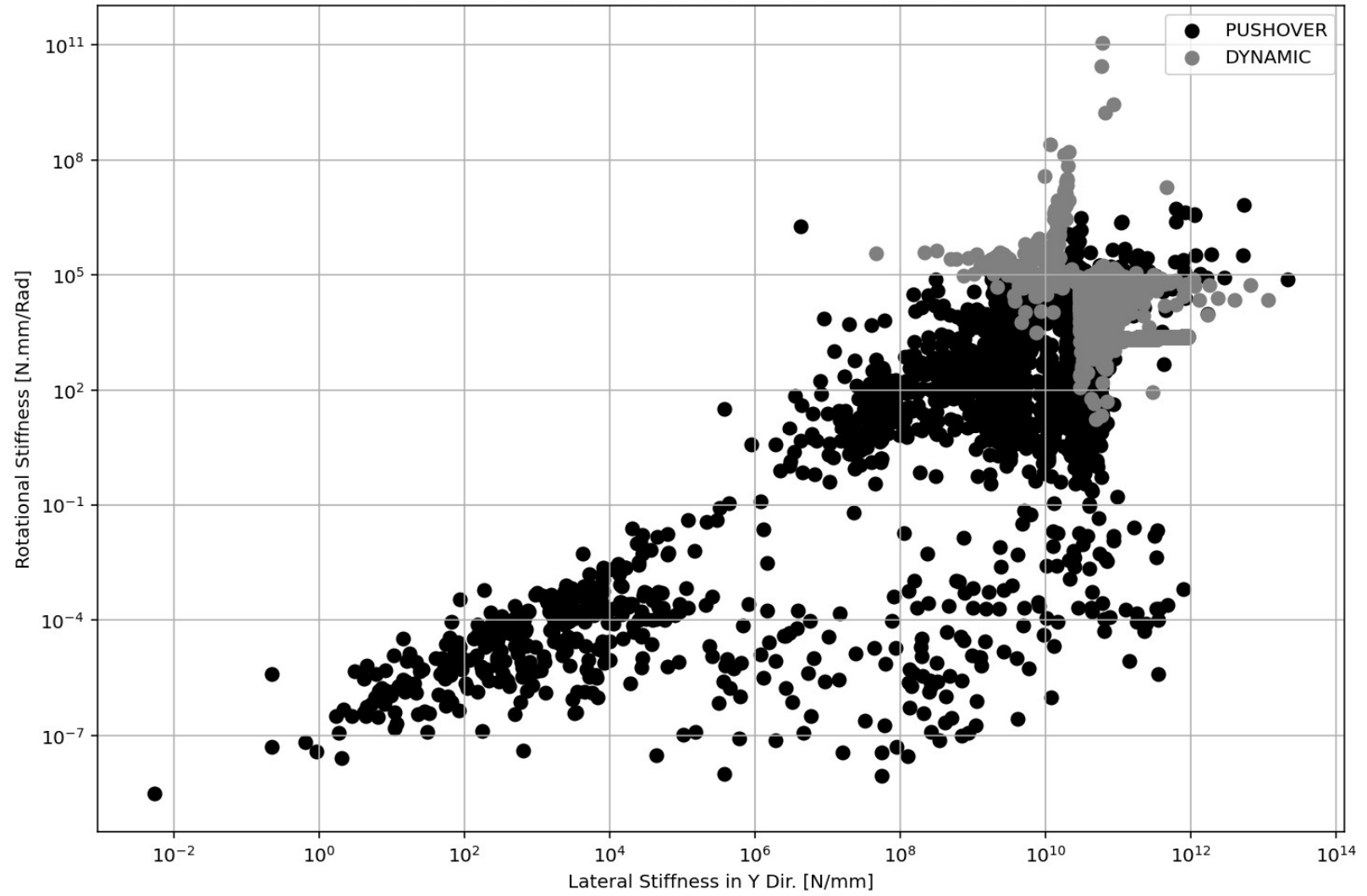




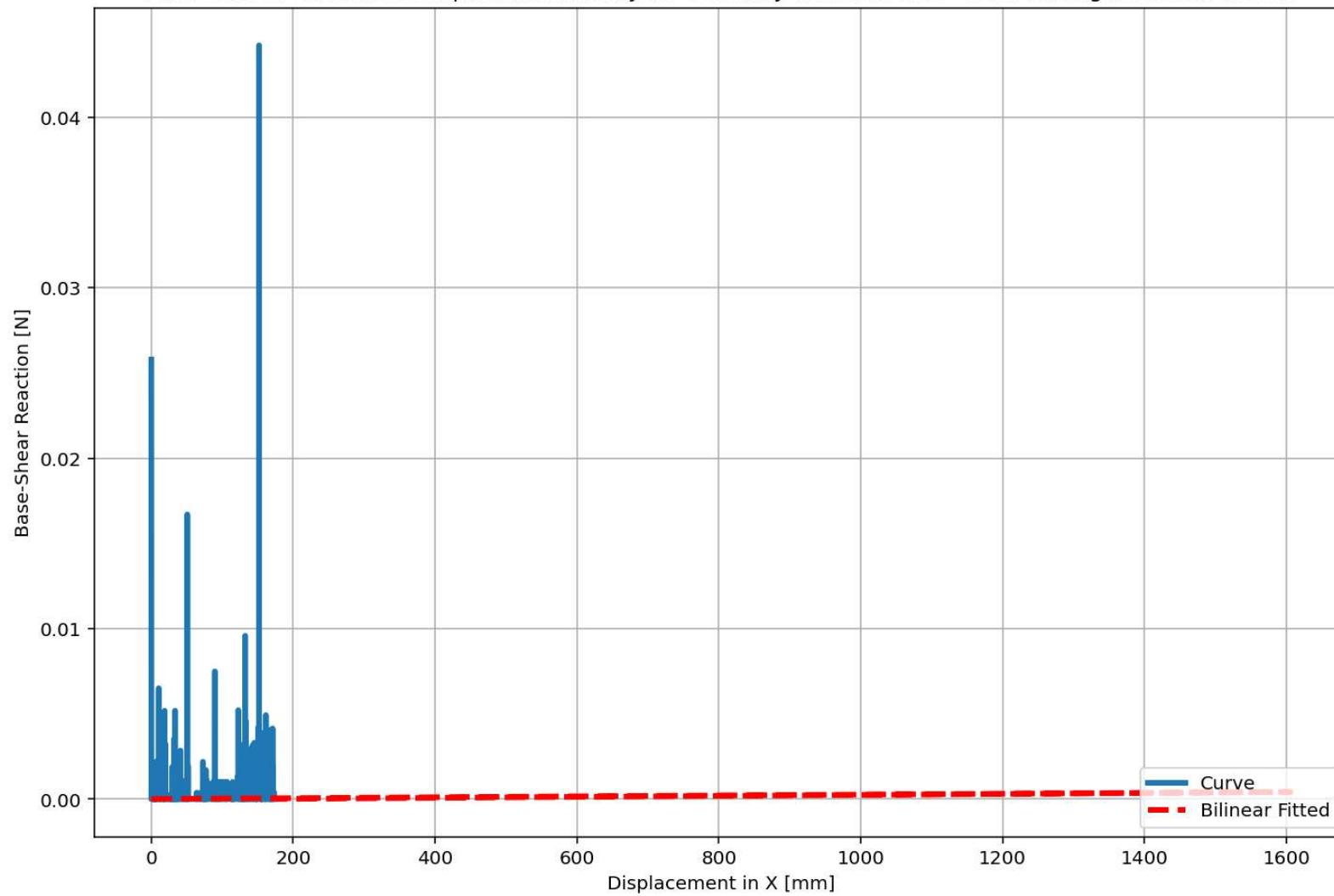
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM



ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM

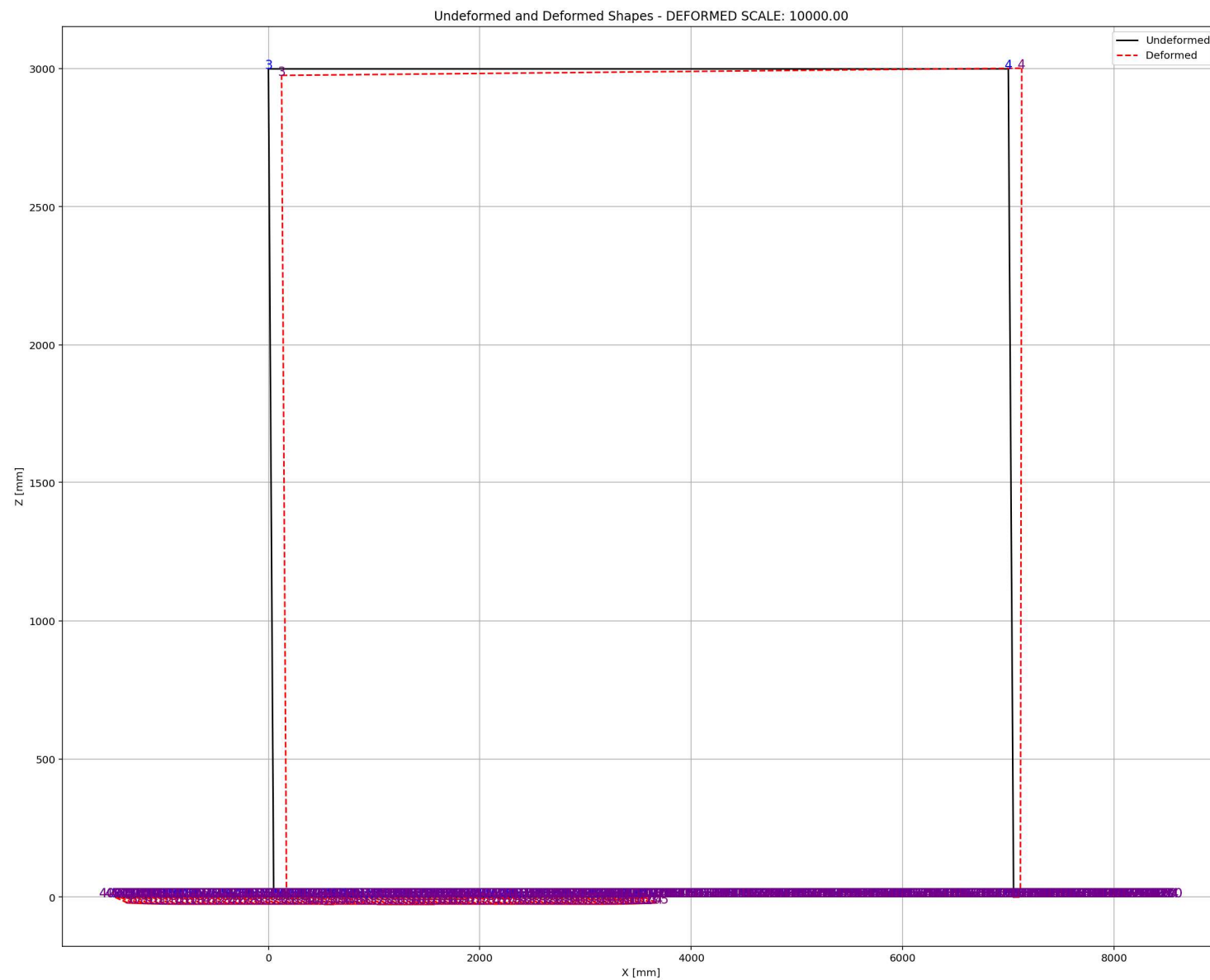


Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 0.1090 - Over Strength Factor: 0.0001

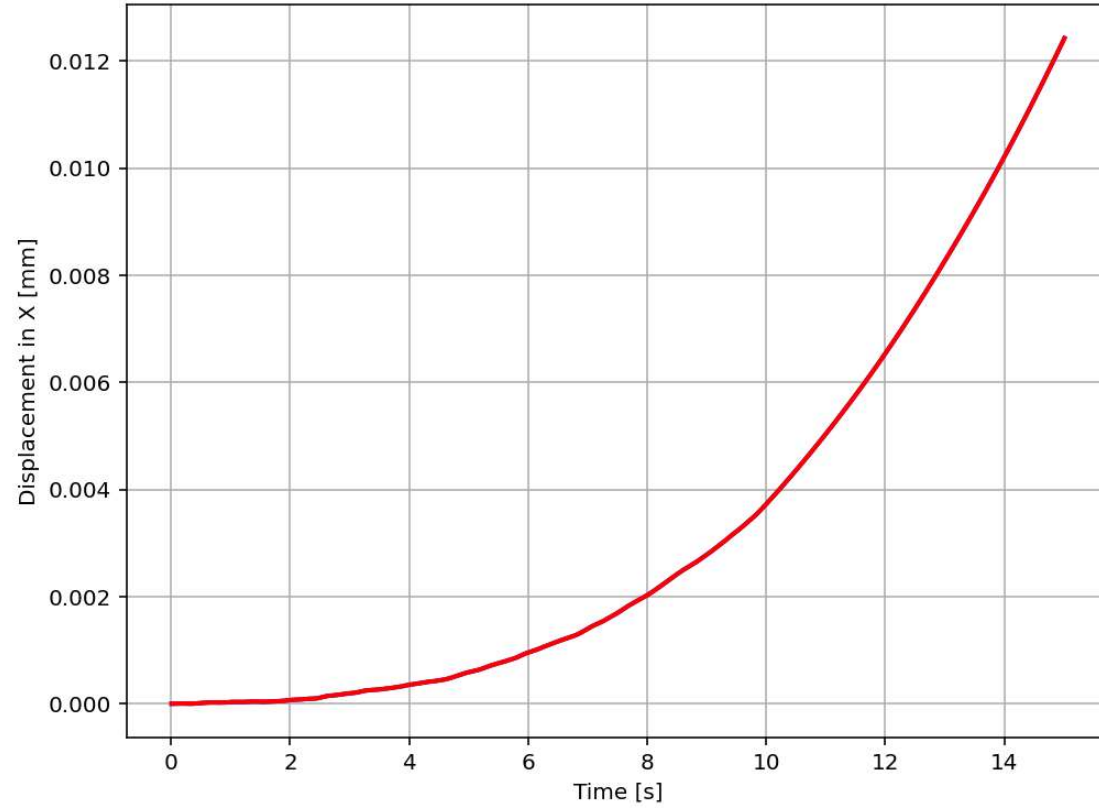


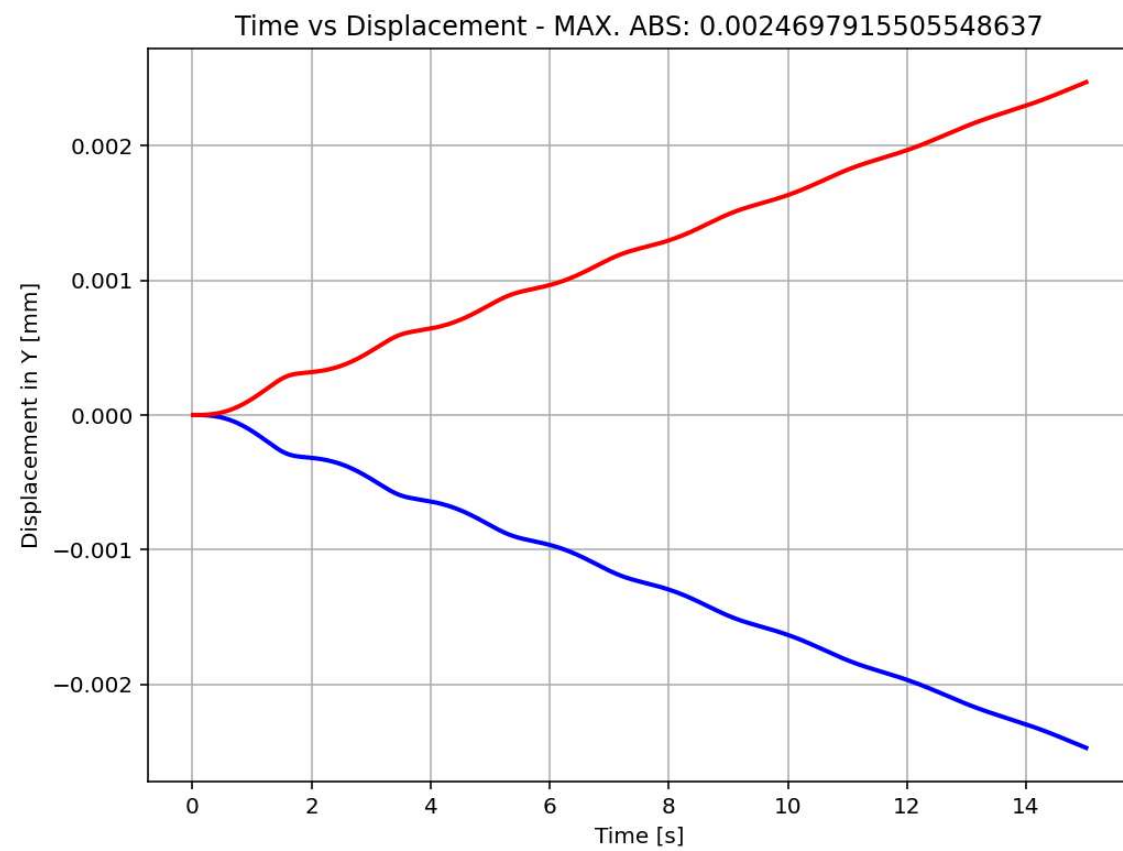
# **NONLINEAR DYNAMIC ANALYSIS**

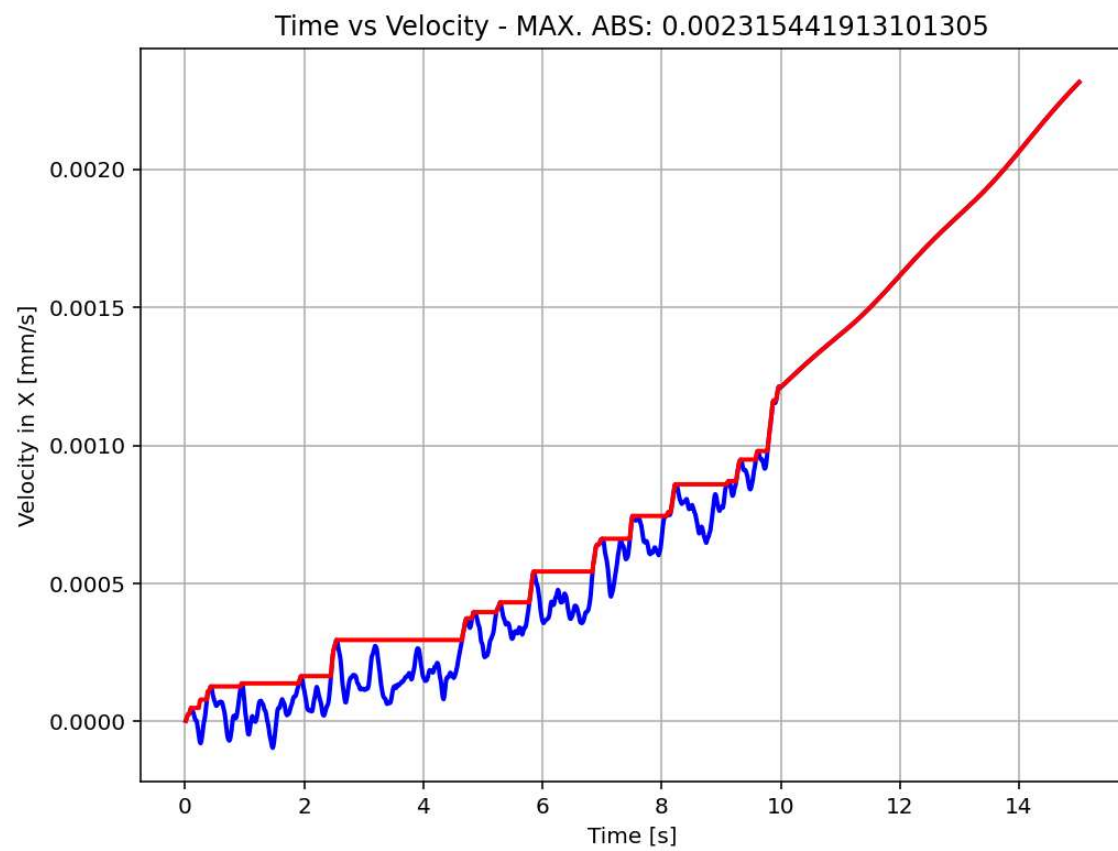


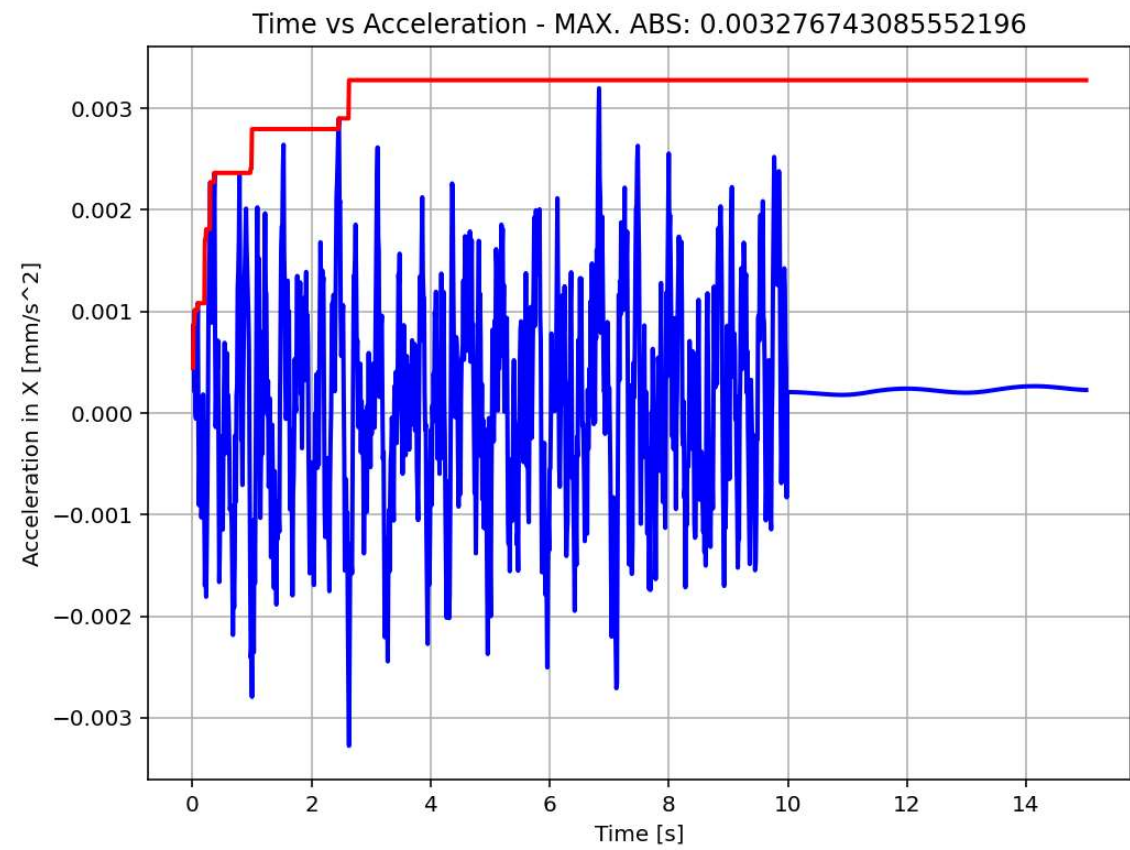


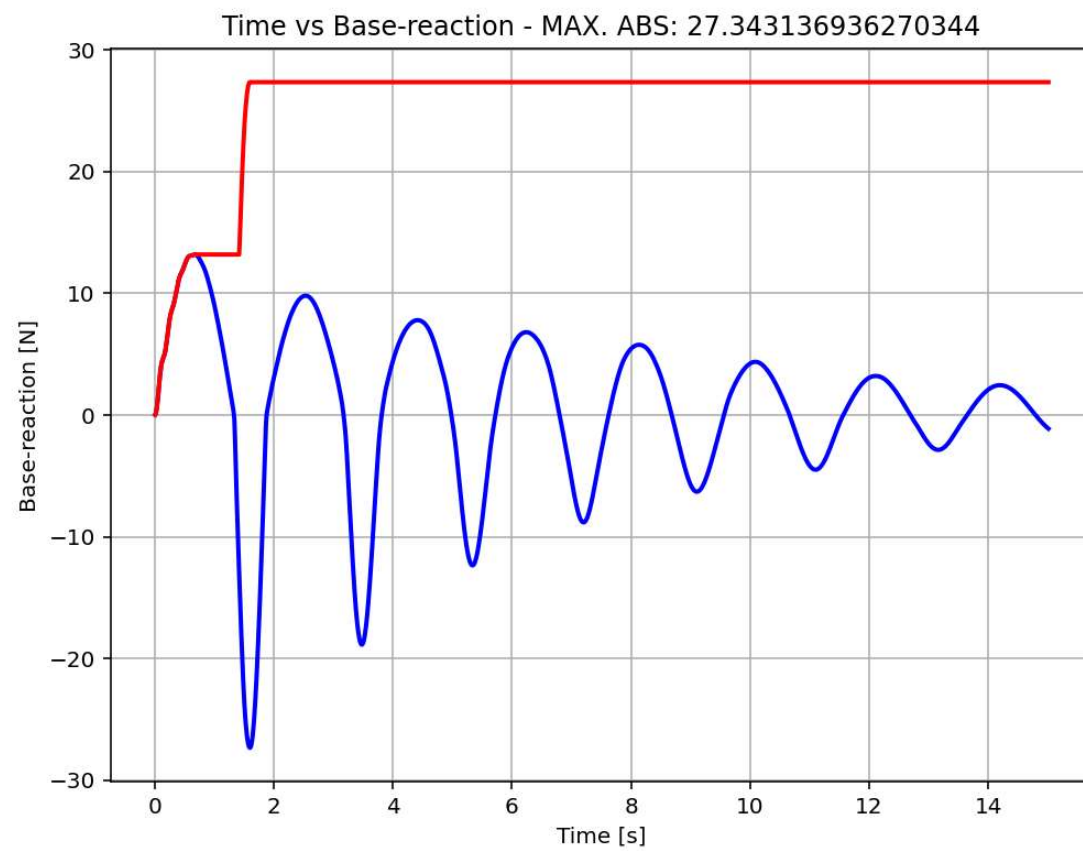
Time vs Displacement - MAX. ABS: 0.012426530254973176 |  $\xi$  (Calculated): 8.84944e+00 %

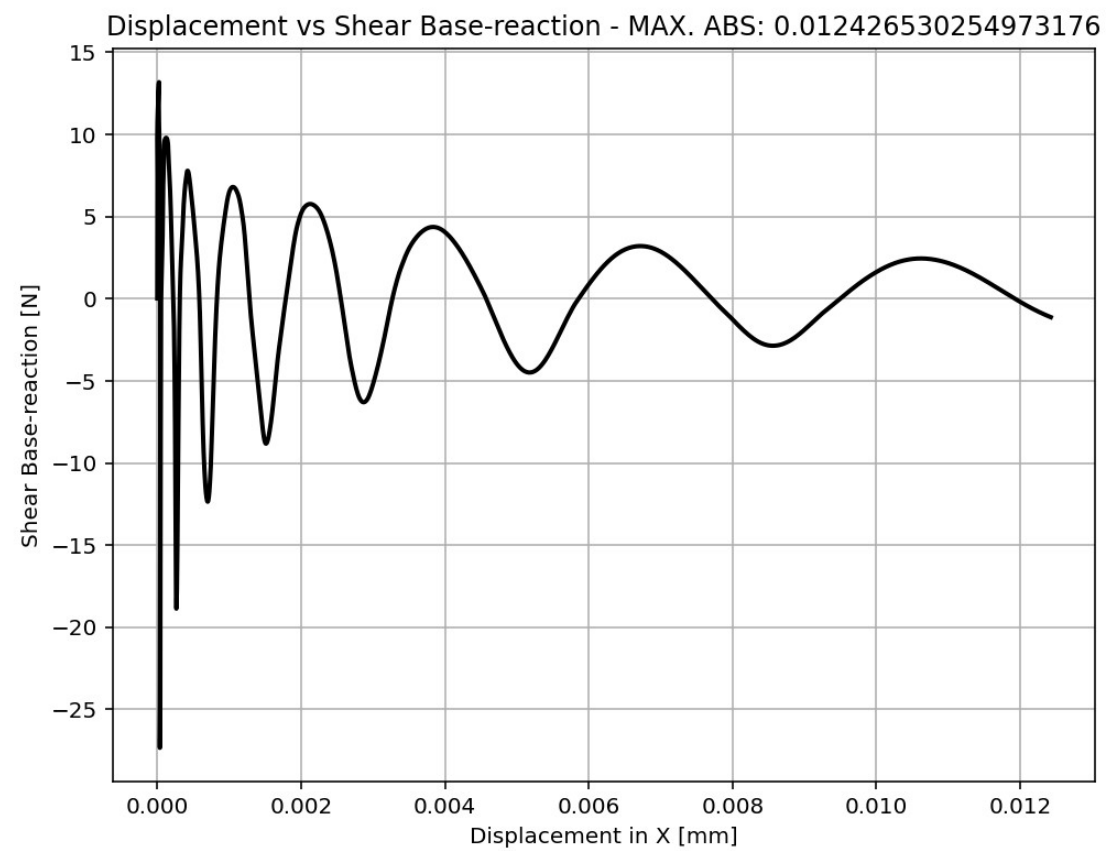












Displacement vs Axial Base-reaction - MAX. ABS: 0.0024697915505548637

