

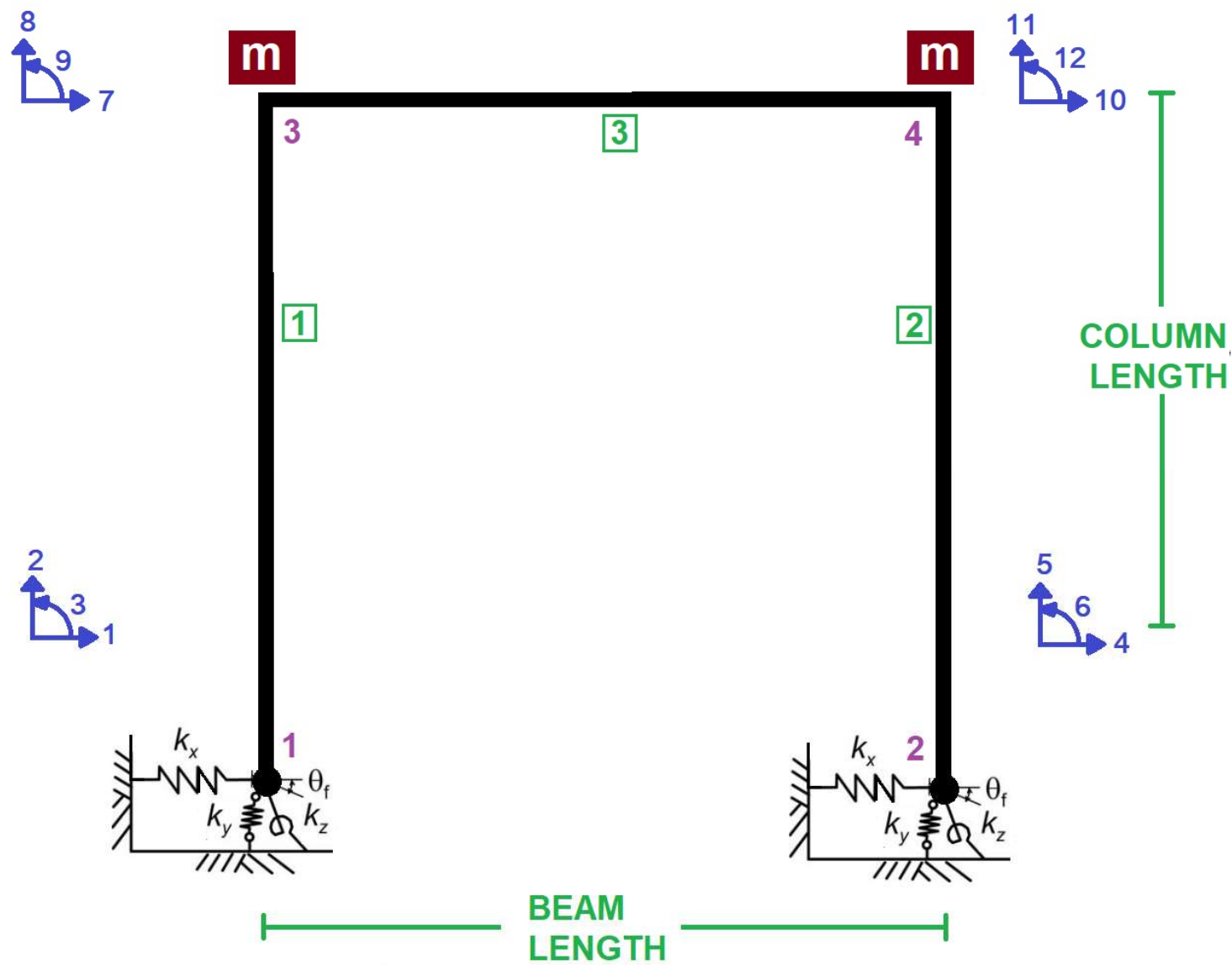
IN THE NAME OF ALLAH

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

SOIL-FOUNDATION INTERACTIONS SIMULATED WITH SIMPLE SPRINGS.

SOIL SPRINGS VALUES ARE NOT EXACT.

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

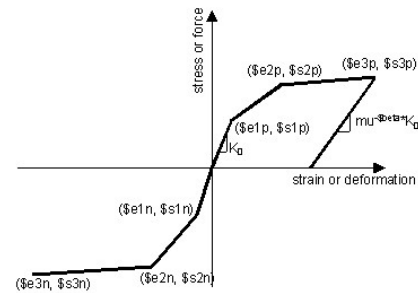




CORE AND COVER CONCRETE RELATION



WITHOUT HARDENING AND ULTIMATE STRAIN



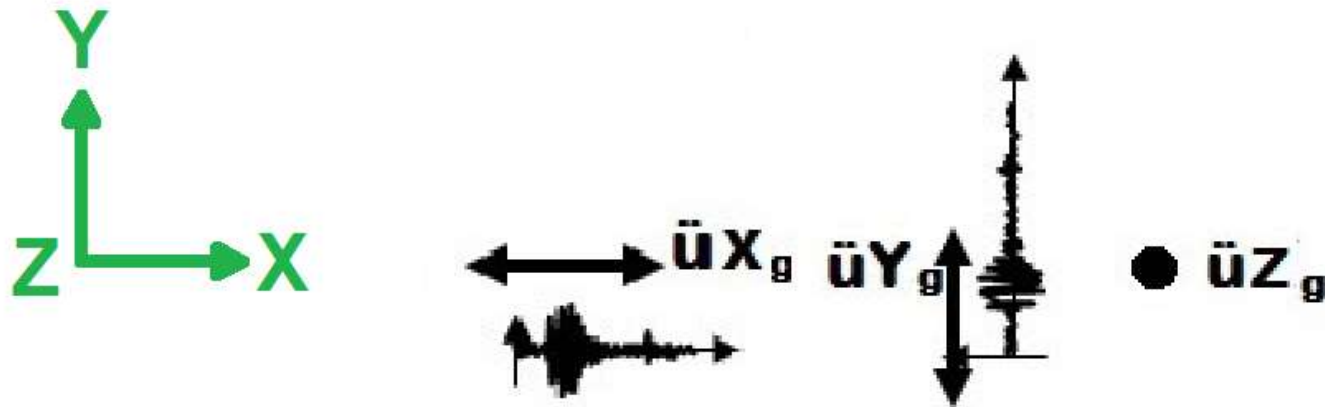
WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM 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)

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C:\Users\ DELL\Desktop\OPENSEES\_FILES\CONCRETE\_FRA...01\CONCRETE\_FRAME\_SOIL-FOUNDATION-STRUCTURE\_01.py

CONCRETE\_FRAME\_SOI...ON-STRUCTURE\_01.py x 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 01:
6 #                               SOIL-FOUNDATION INTERACTIONS SIMULATED WITH SIMPLE SPRINGS.
7 #                               |   SOIL SPRINGS VALUES ARE NOT EXACT.
8 #
9 #                               THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
10 #                               EMAIL: salar.d.ghashghaei@gmail.com
11 #####
12 """
13 [1] Nonlinear Frame Modeling: 2D RC frame with distributed plasticity (fiber sections) using `nonlinear`
14 [2] Material Laws:
15     - *Concrete*: `Concrete01` with confined (core) and unconfined (cover) properties.
16     - *Steel*: `Hysteretic` model with pinching, hardening, and cyclic degradation.
17 [3] Seismic Loads:
18     - Pushover: Displacement-controlled lateral loading to failure.
19     - Dynamic: Uniform excitation with user-defined ground motions (X/Y components).
20 [4] Damping: Rayleigh damping (a0, a1) calibrated via eigenvalue analysis (modes 1-2).
21 [5] Performance Metrics:
22     - Ductility Ratio ( $\mu$ ): Derived from bilinearized pushover curves.
23     - Overstrength ( $O_a$ ): Yield vs. ultimate capacity.
24     - Damage Index (DI): Normalized displacement demand/capacity.
25 [6] Advanced Solver: HHT-a integrator (unconditionally stable) with Newton-Raphson iterations.
26 [7] Outputs:
27     - Hysteretic responses (P-M, V- $\Delta$ , M- $\theta$ ).
28     - Time-history plots (displacement, base shear).
29     - Stiffness degradation tracking.
30 [8] Validation: Logarithmic decrement method for damping ratio verification.
31 [9] Ductility Damage Index (DDI) Implementation:
32     DDI quantifies structural damage via normalized displacement demand.
33     # After bilinear fit (X[1] =  $\Delta_y$ , X[2] =  $\Delta_u$ ):
34     Dd = max(abs(DISP Xd)) # Max dynamic displacement demand
```

Displacement vs Axial Base-reaction

Help Variable Explorer Debugger Plots Files

Console 1/A x

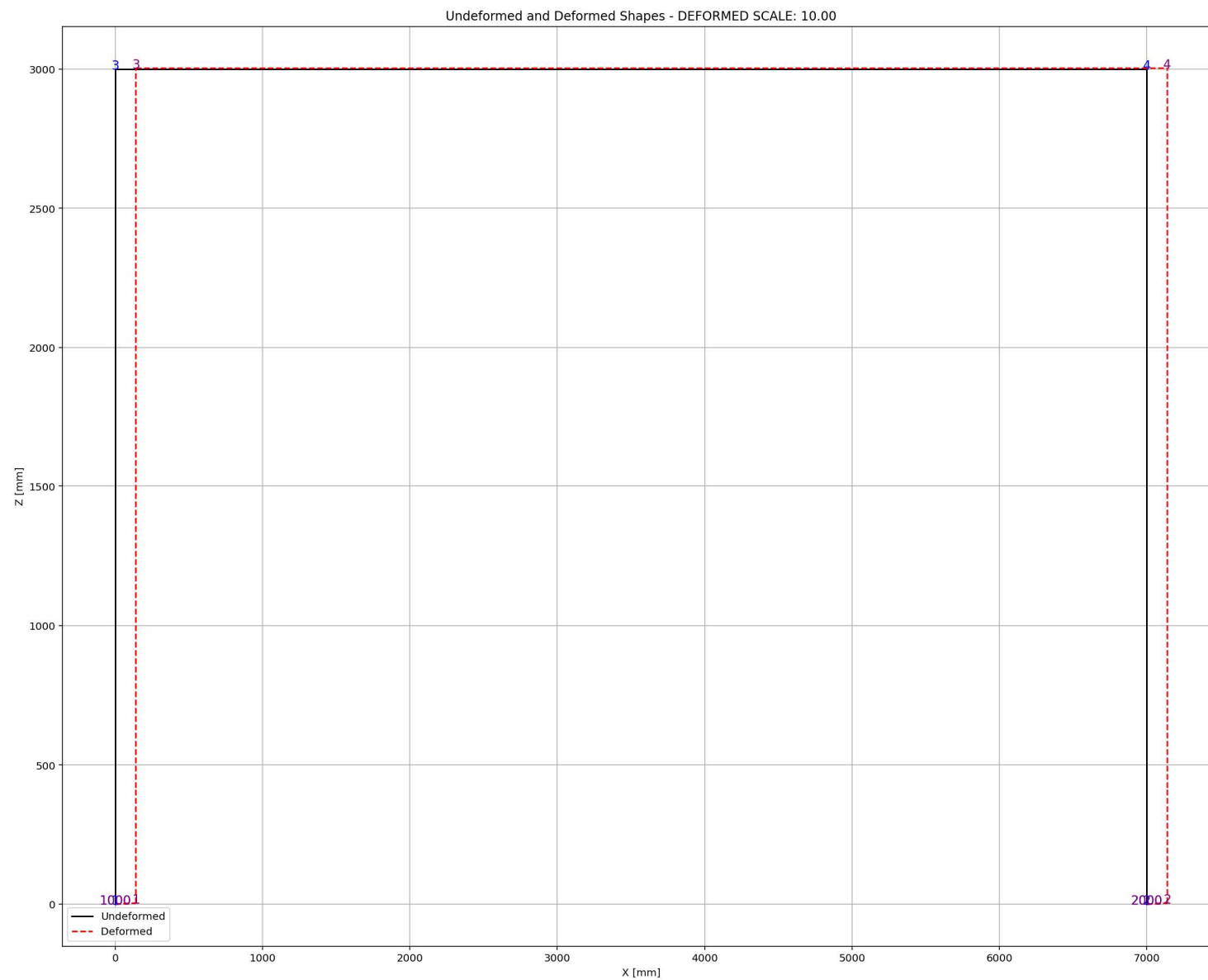
```
...: plt.show()
...:
...: plt.figure(7, figsize=(8, 6))
...: plt.plot(DISPLAY, FORCE_Ad, color='brown', linewidth=2)
...: plt.xlabel('Displacement in Y [mm]')
...: plt.ylabel('Axial Base-reaction [N]')
...: plt.title(f'Displacement vs Axial Base-reaction')
...: plt.grid()
...: plt.show()

In [5]:
```

IPython Console History

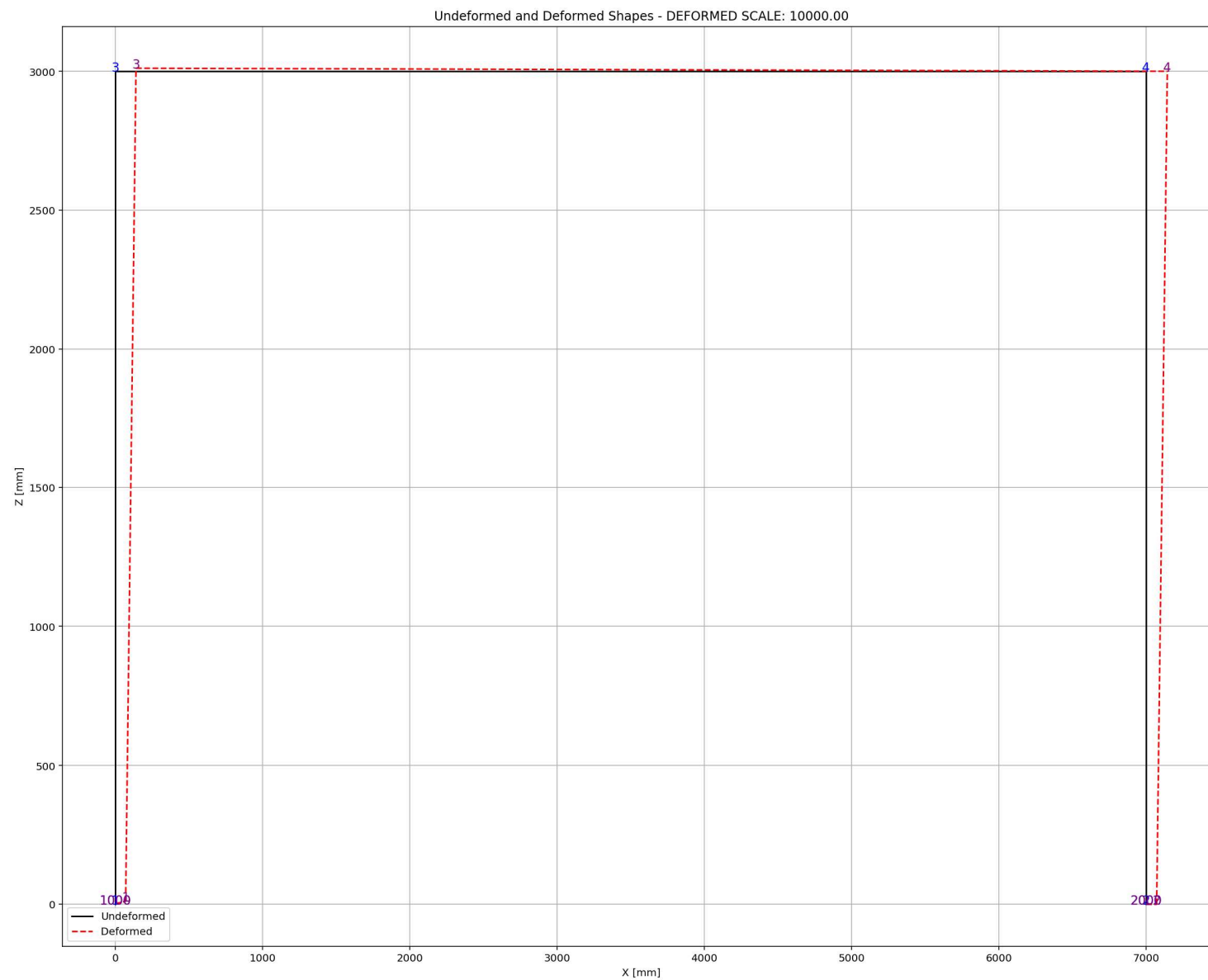
Inline Conda: anaconda3 (Python 3.12.7) ✓ LSP: Python Line 7, Col 36 UTF-8 CRLF RW Mem 42%

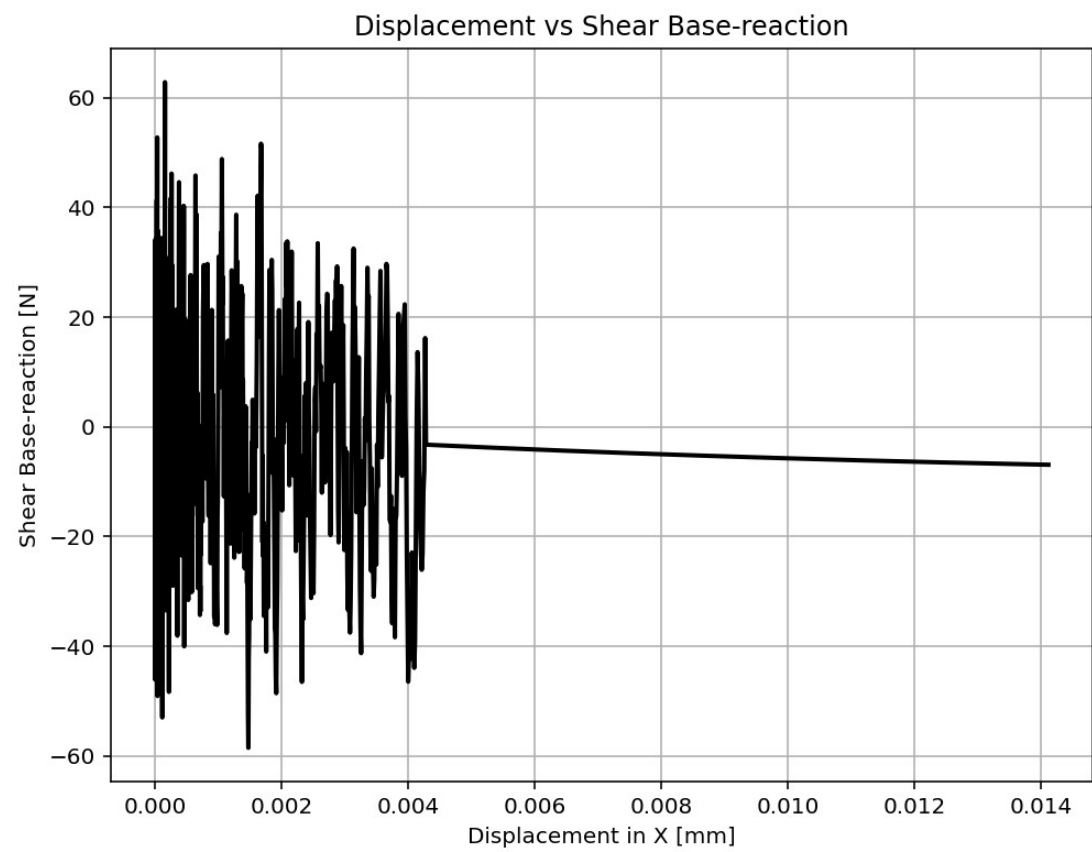
# **NONLINEAR STATIC ANALYSIS (PUSHOVER)**

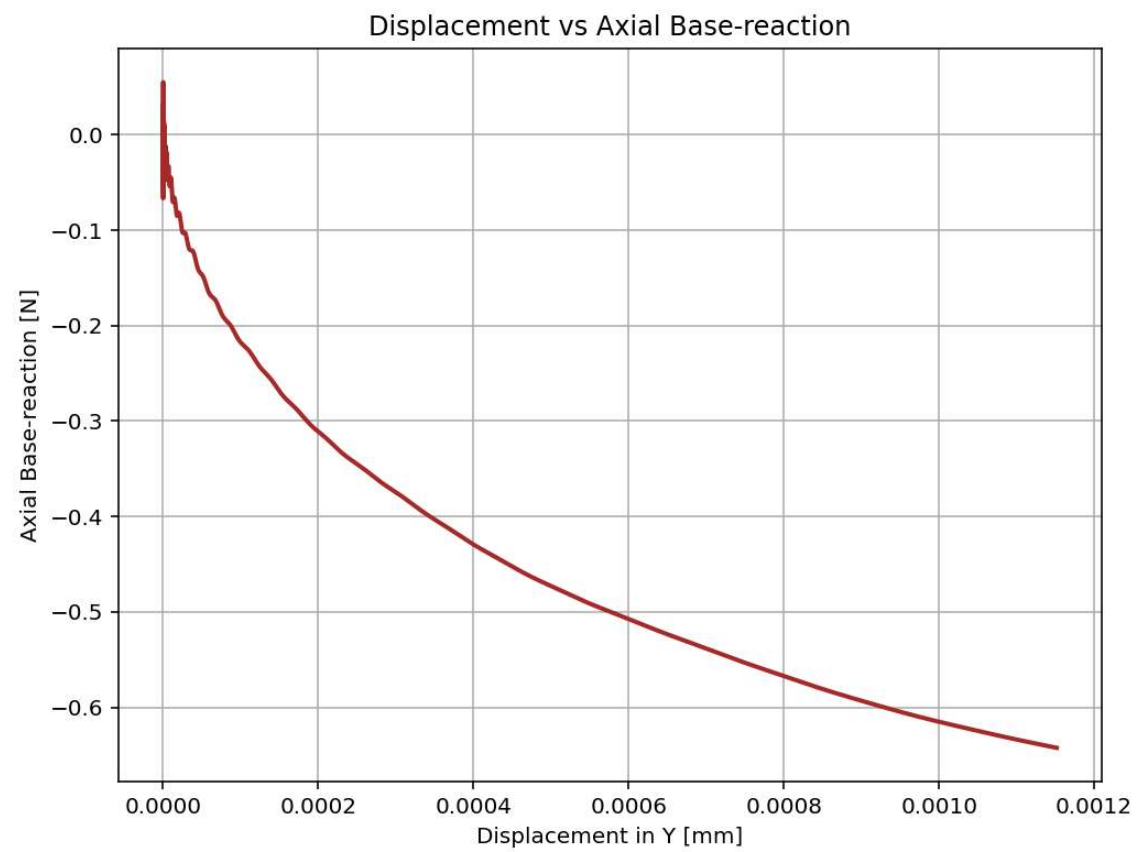


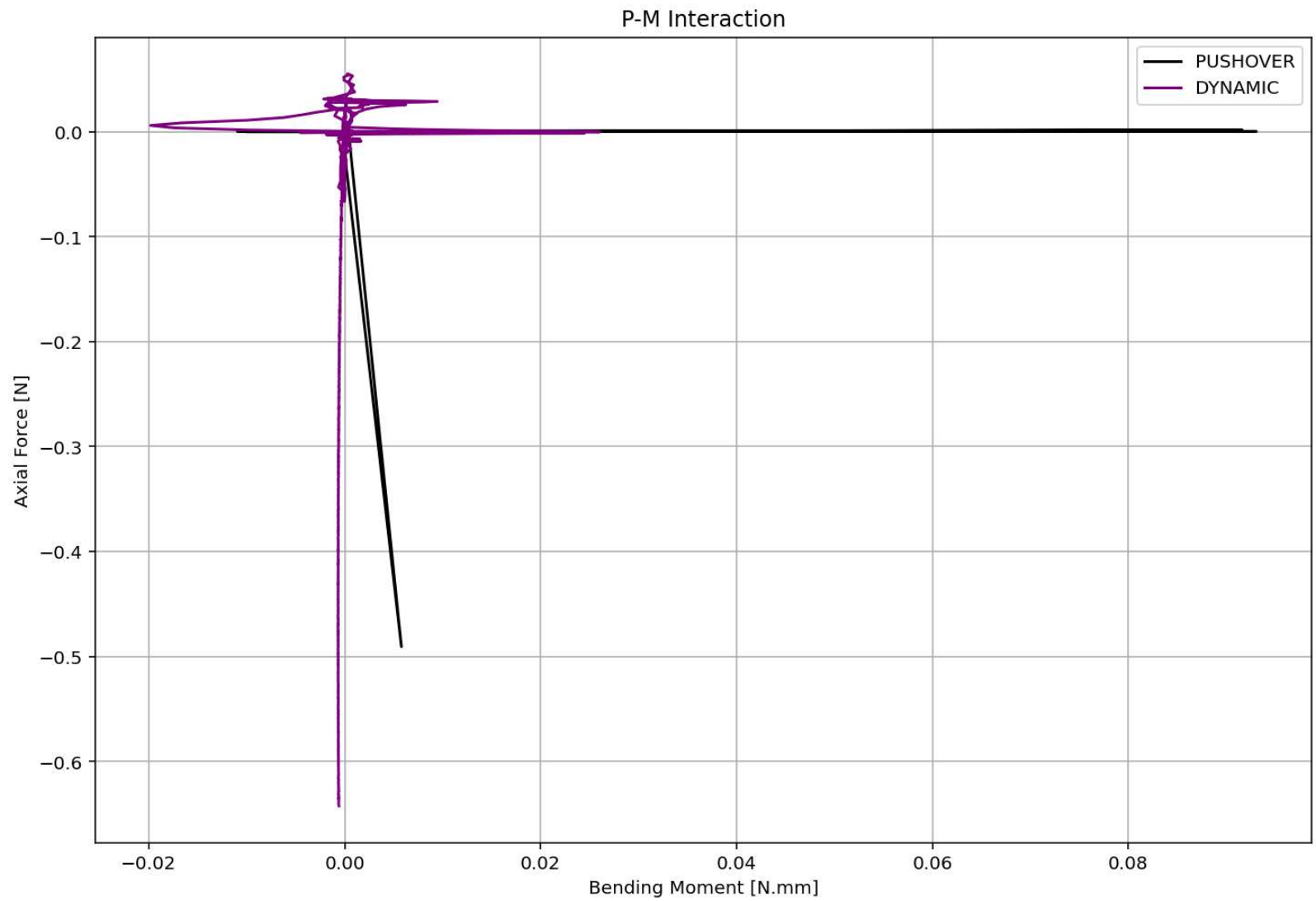
# **NONLINEAR DYNAMIC ANALYSIS**

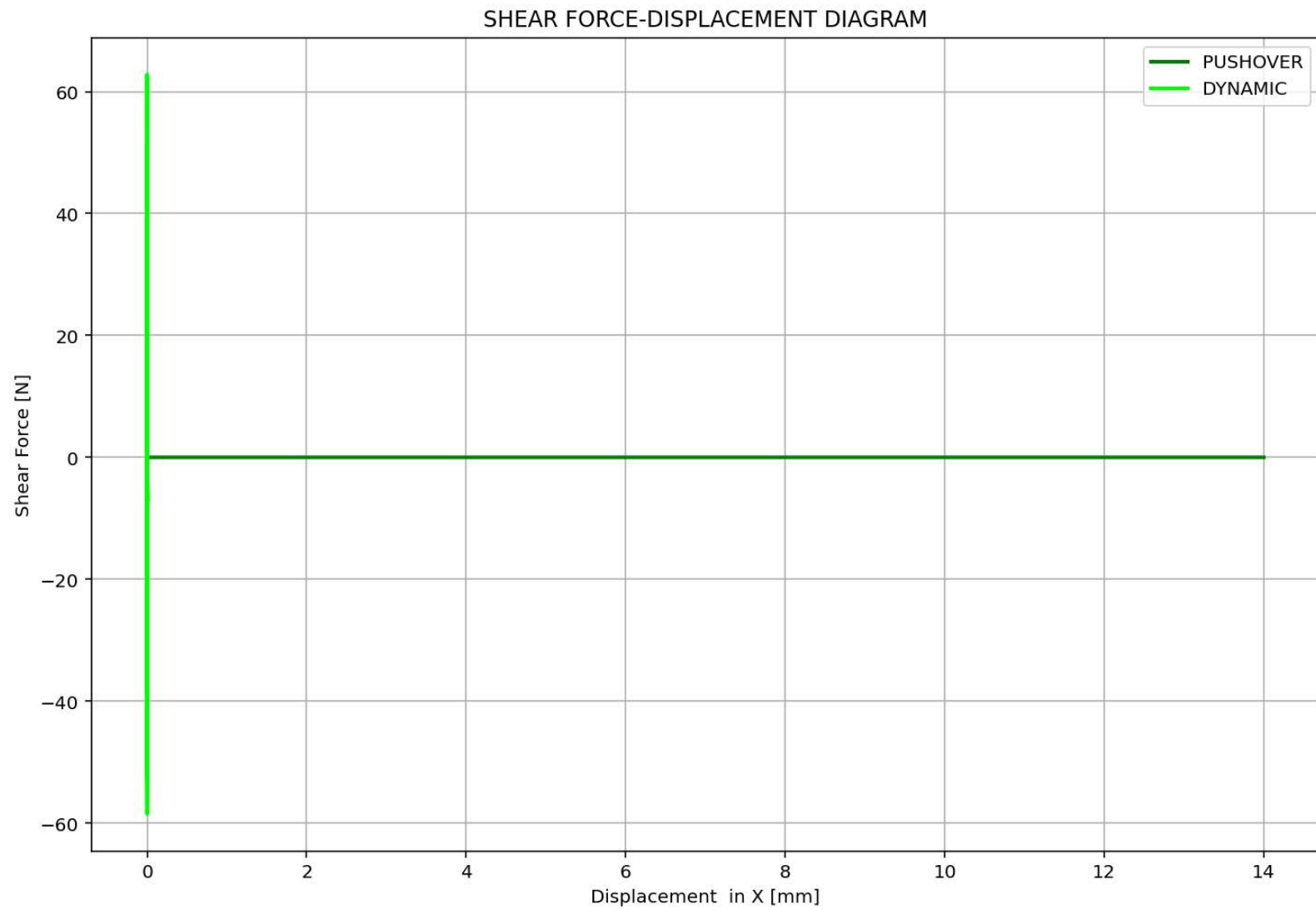


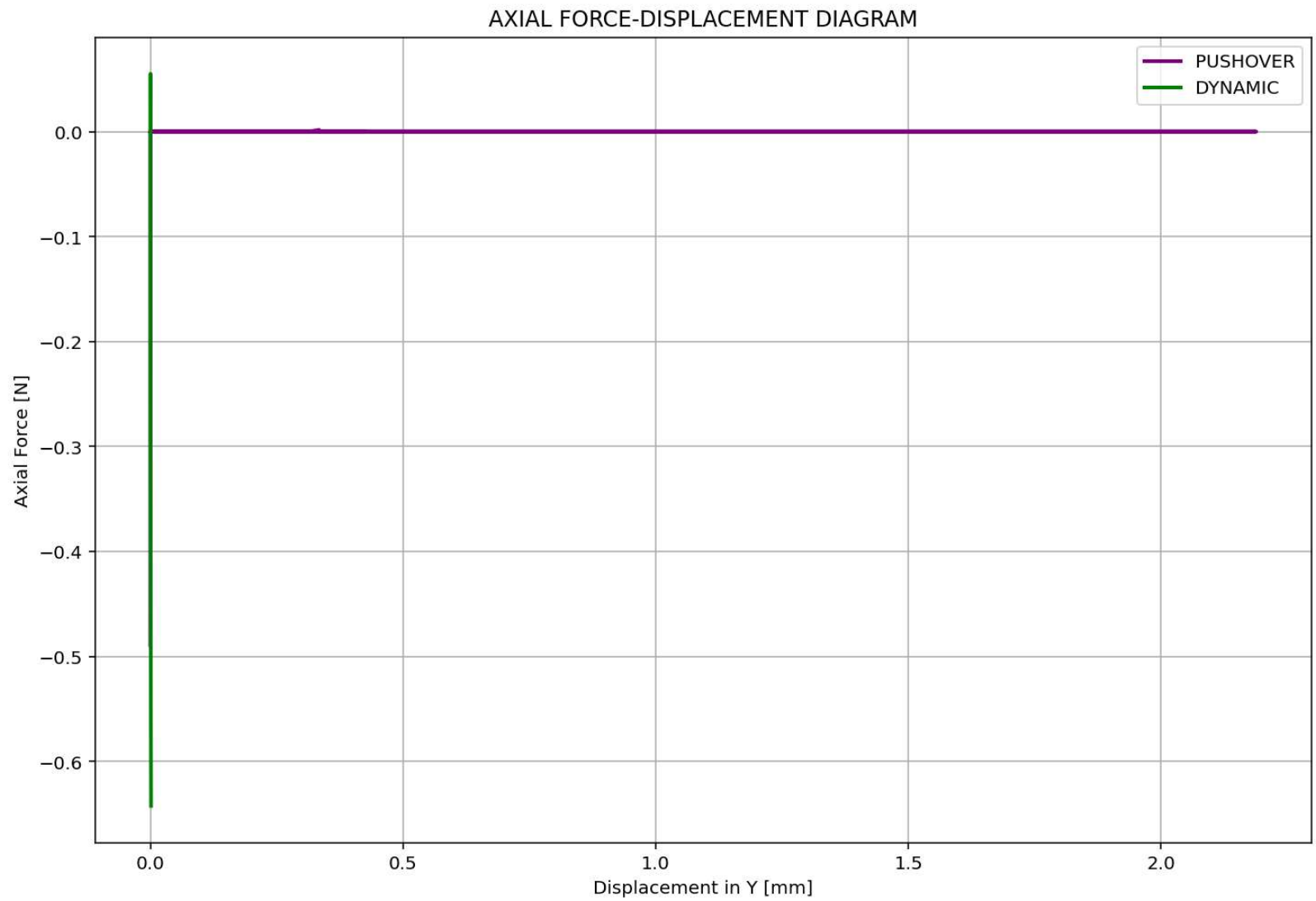


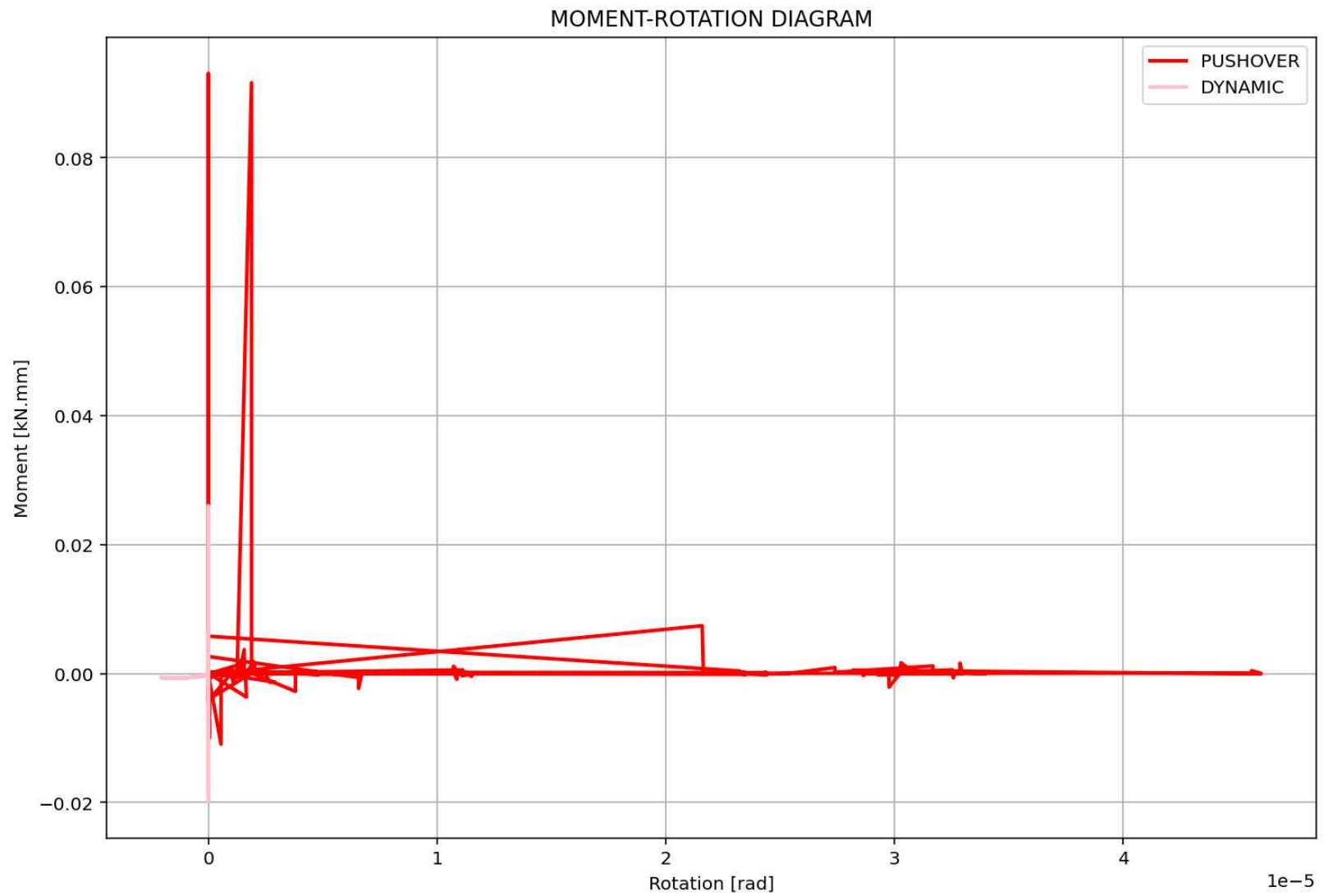




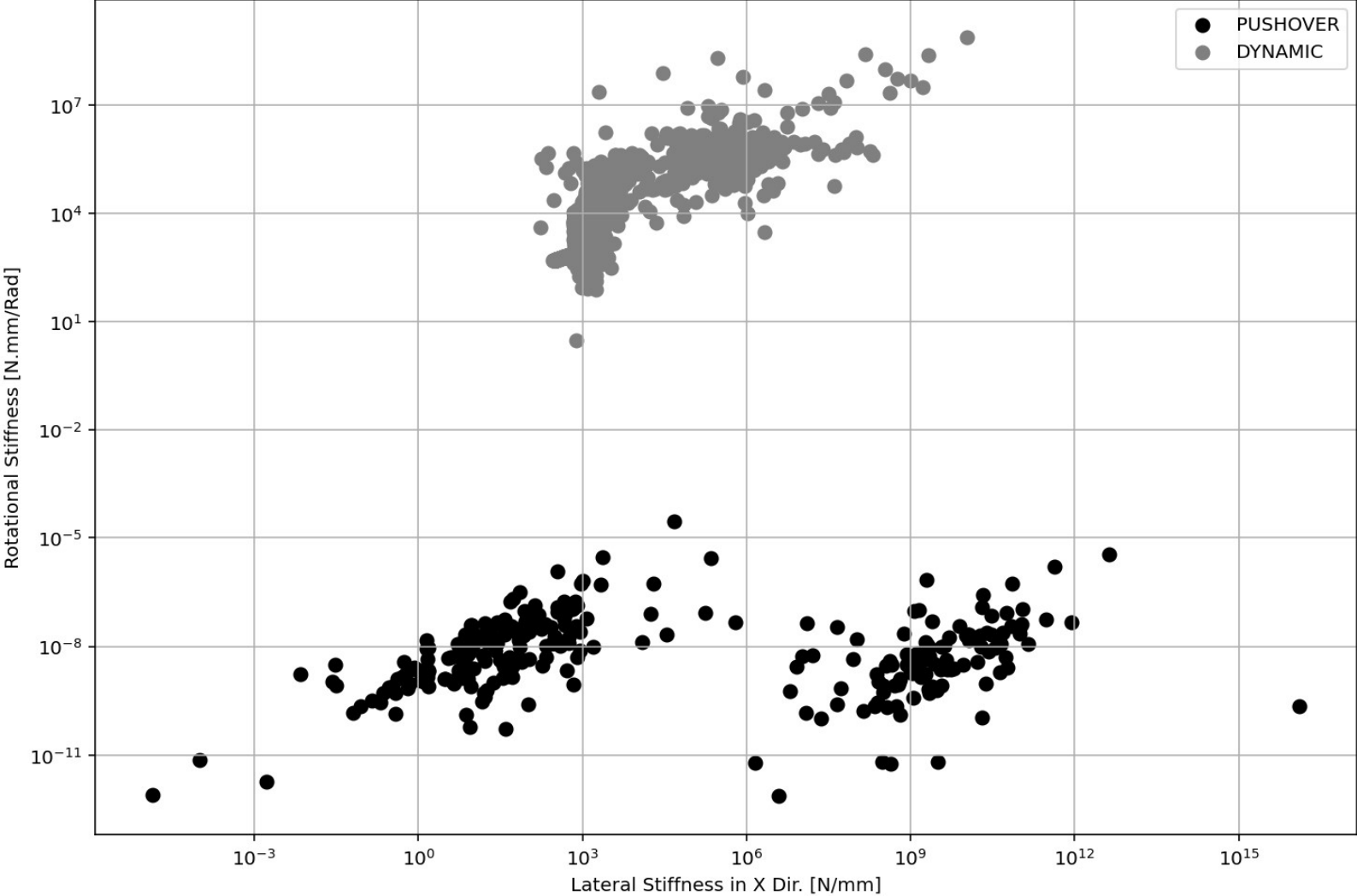






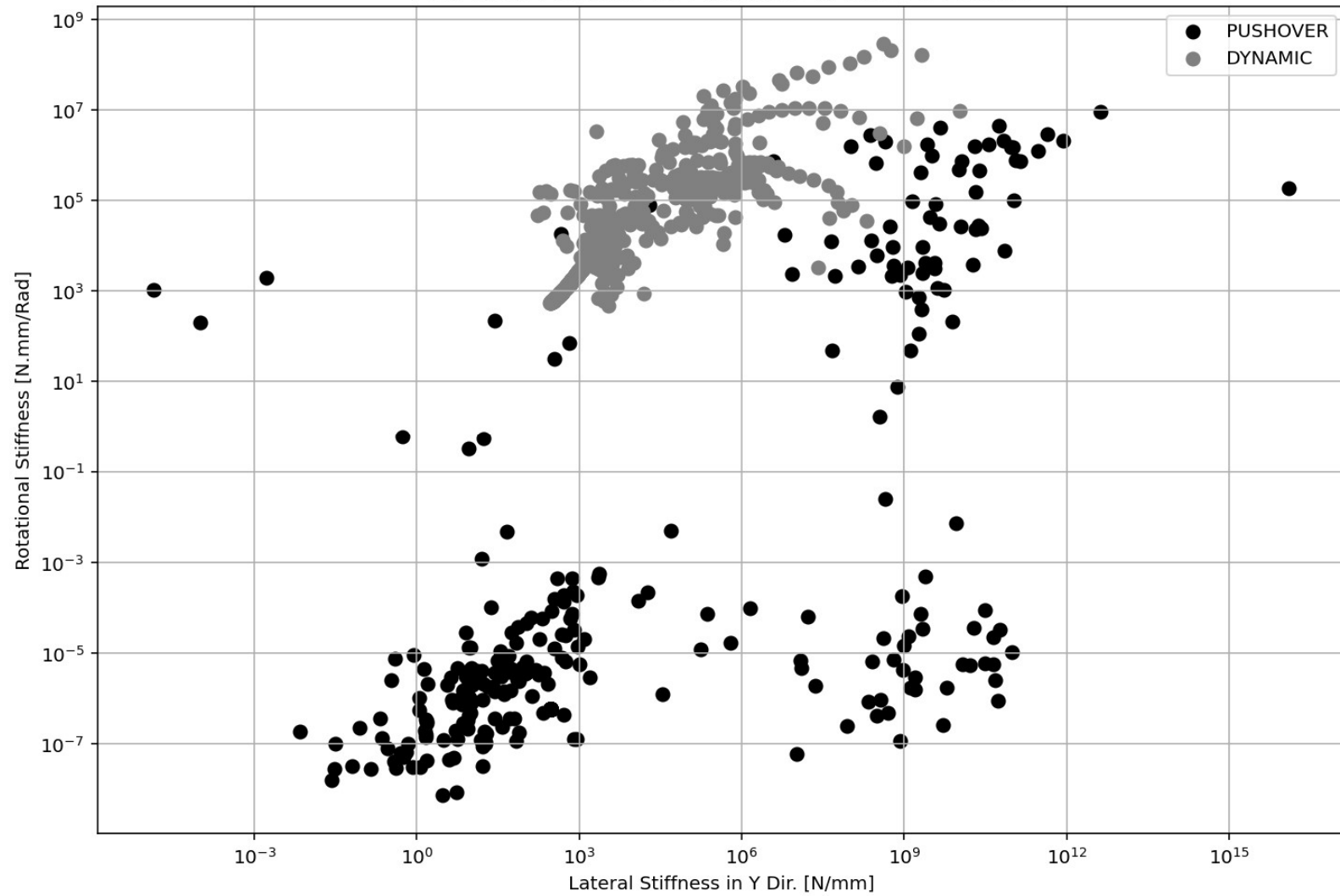


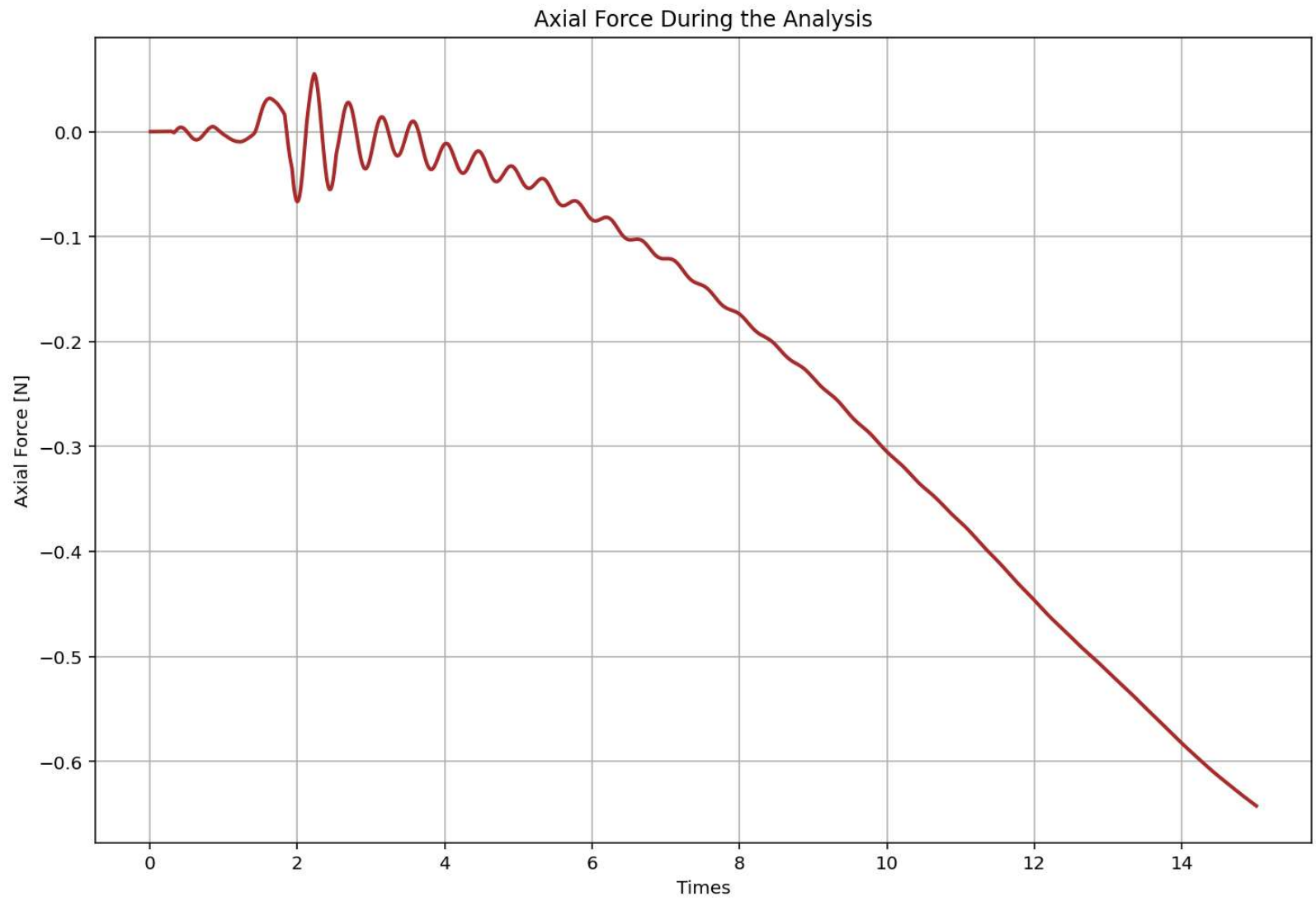
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM

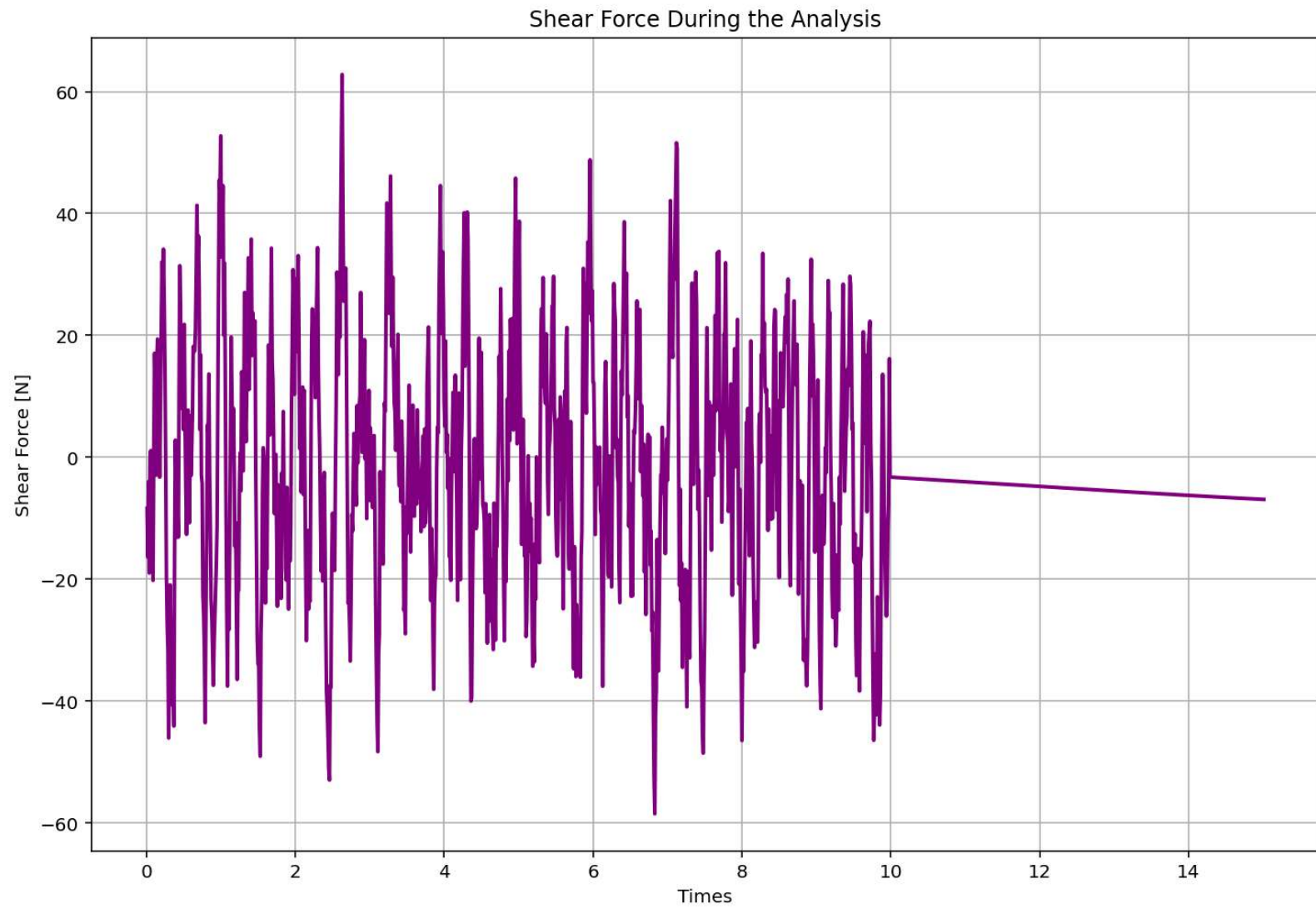


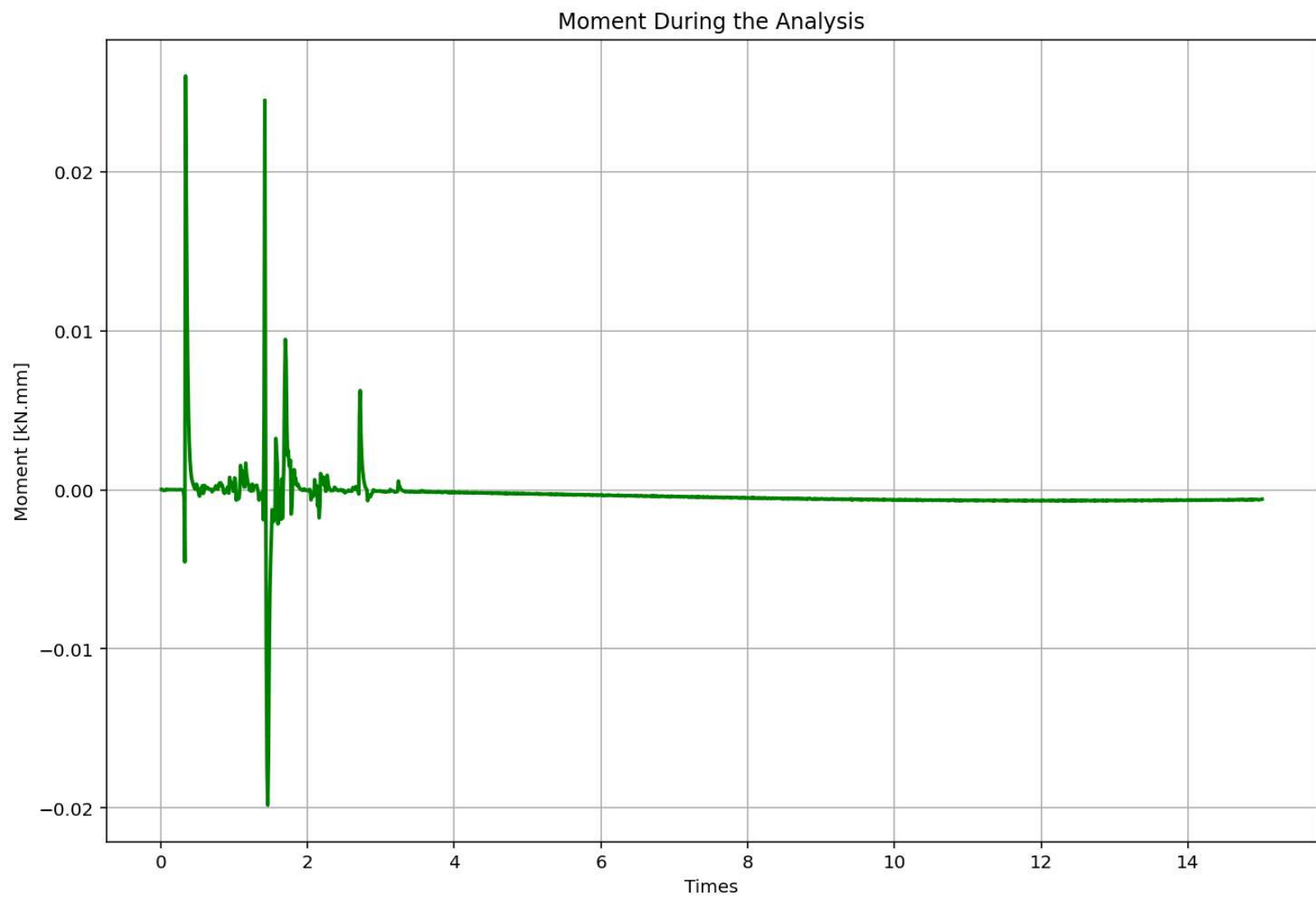


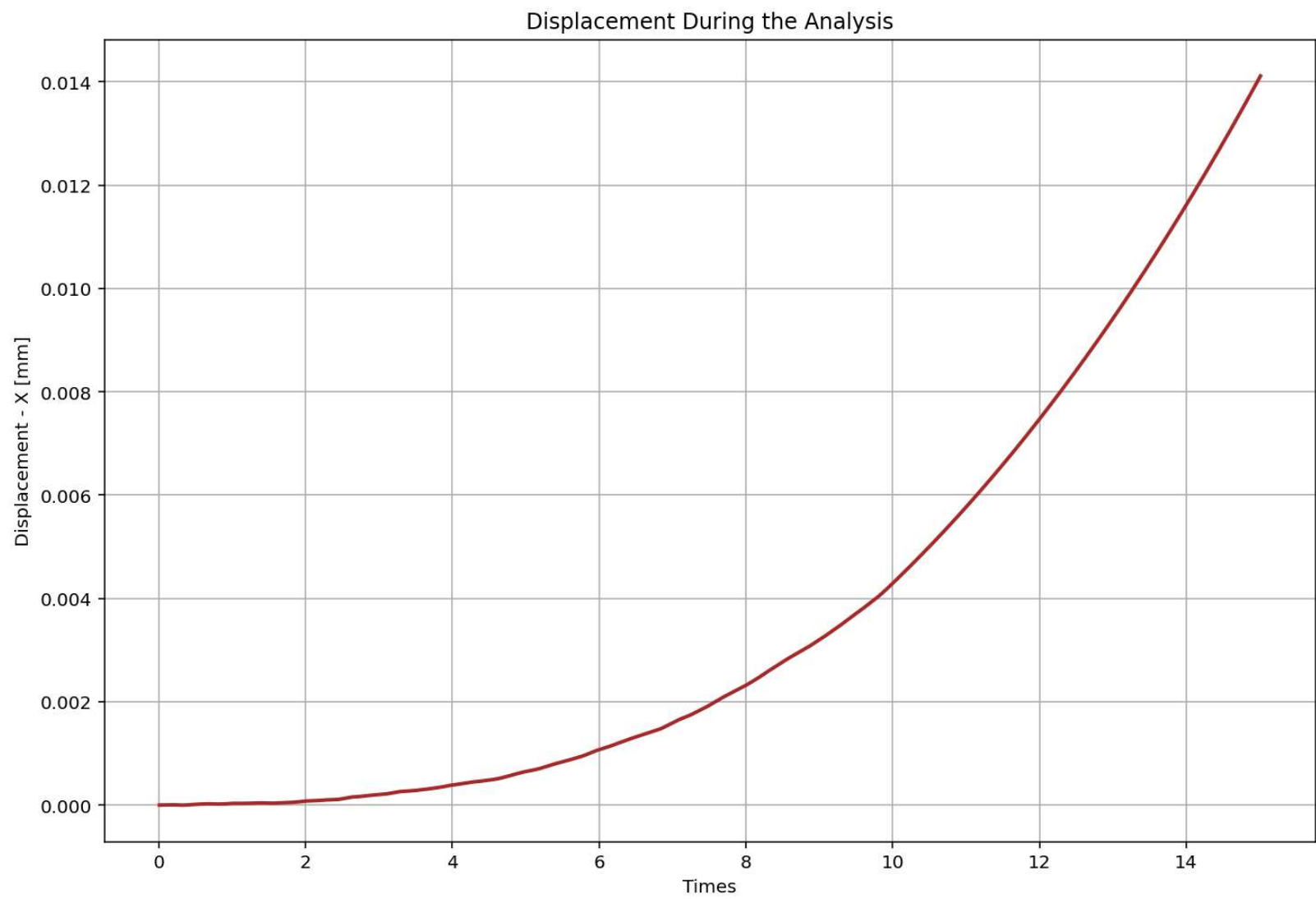
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM

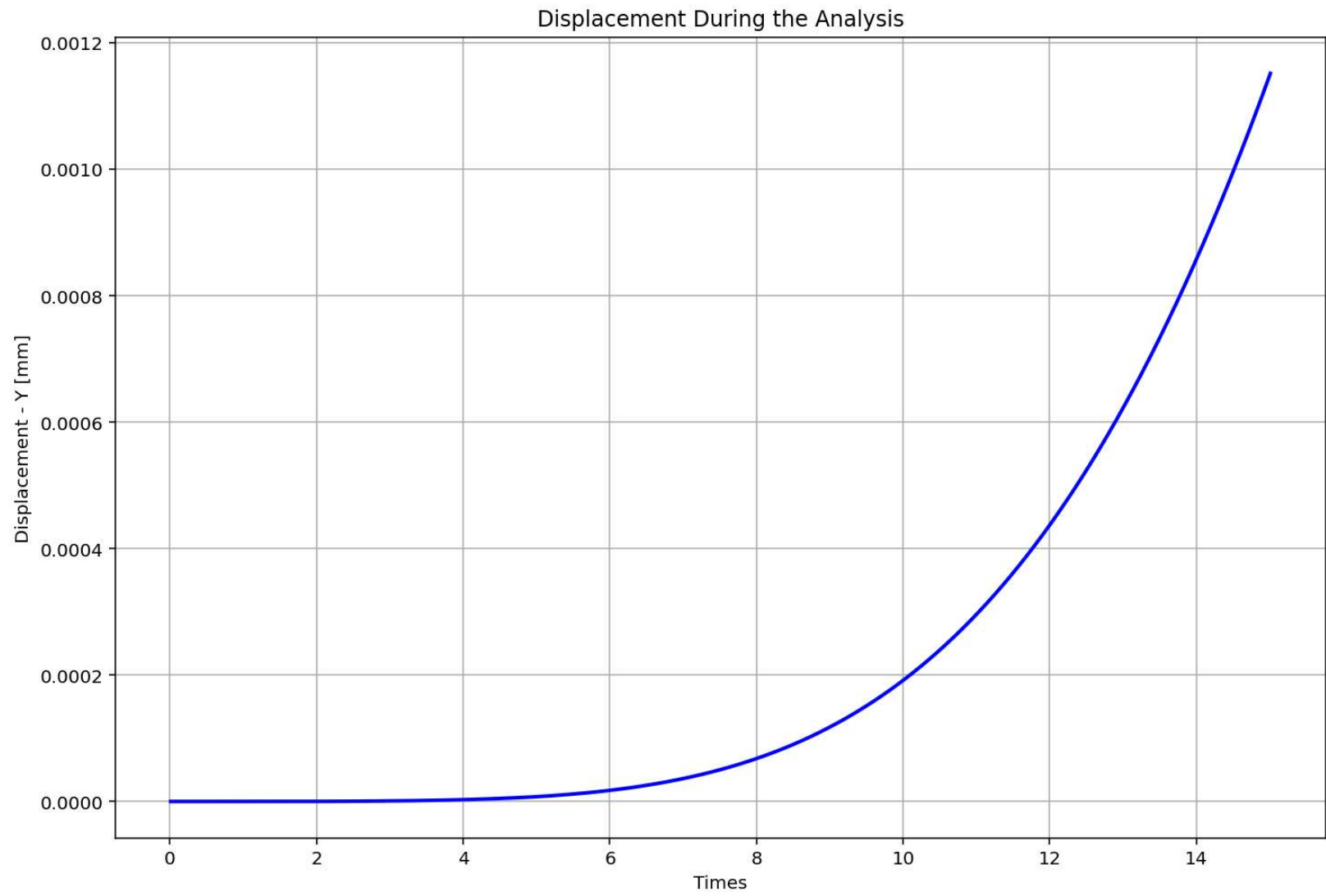


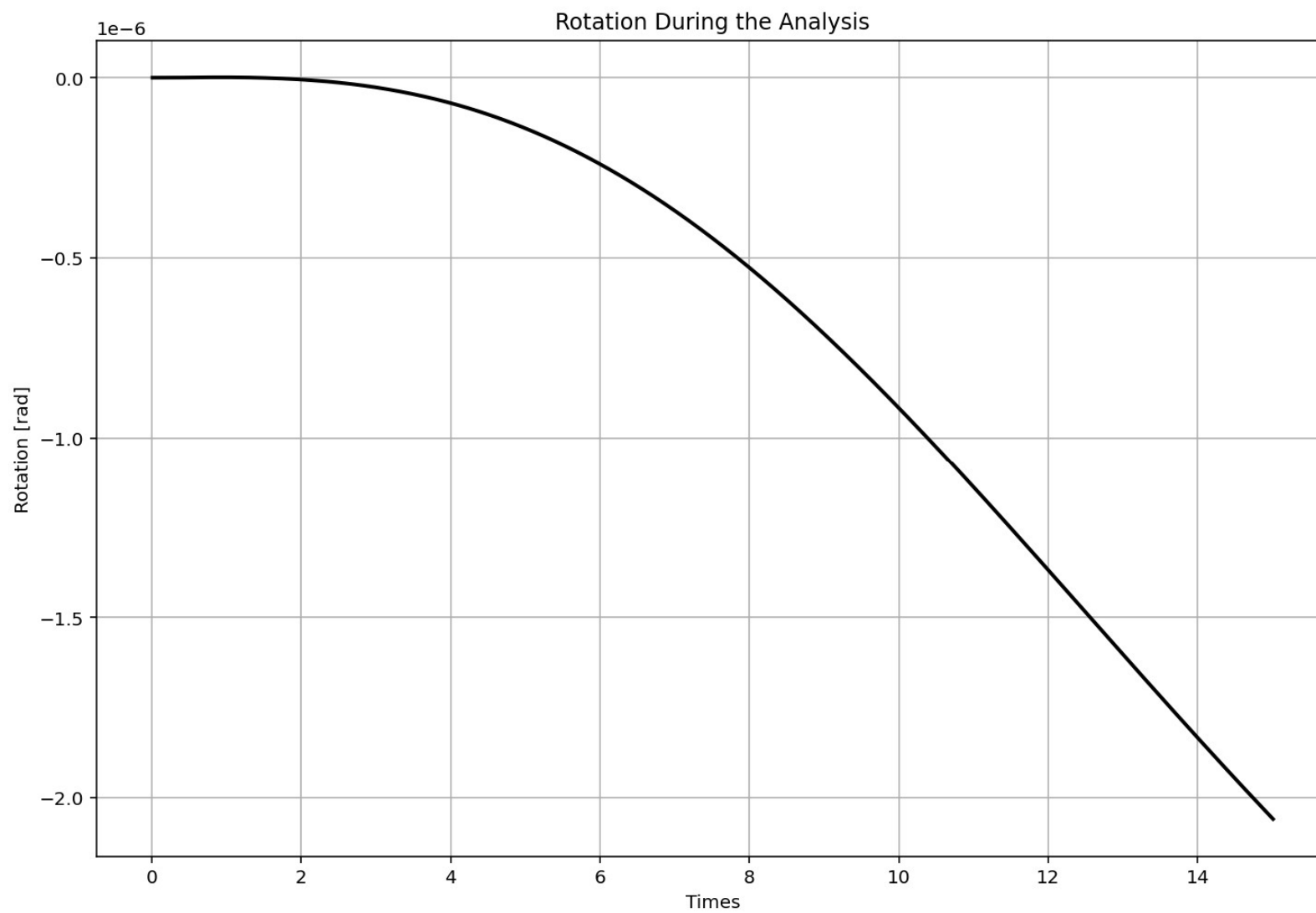












Time vs Displacement - MAX. ABS: 0.014115058269120523 |  $\xi$  (Calculated): 1.18040e+01 %

