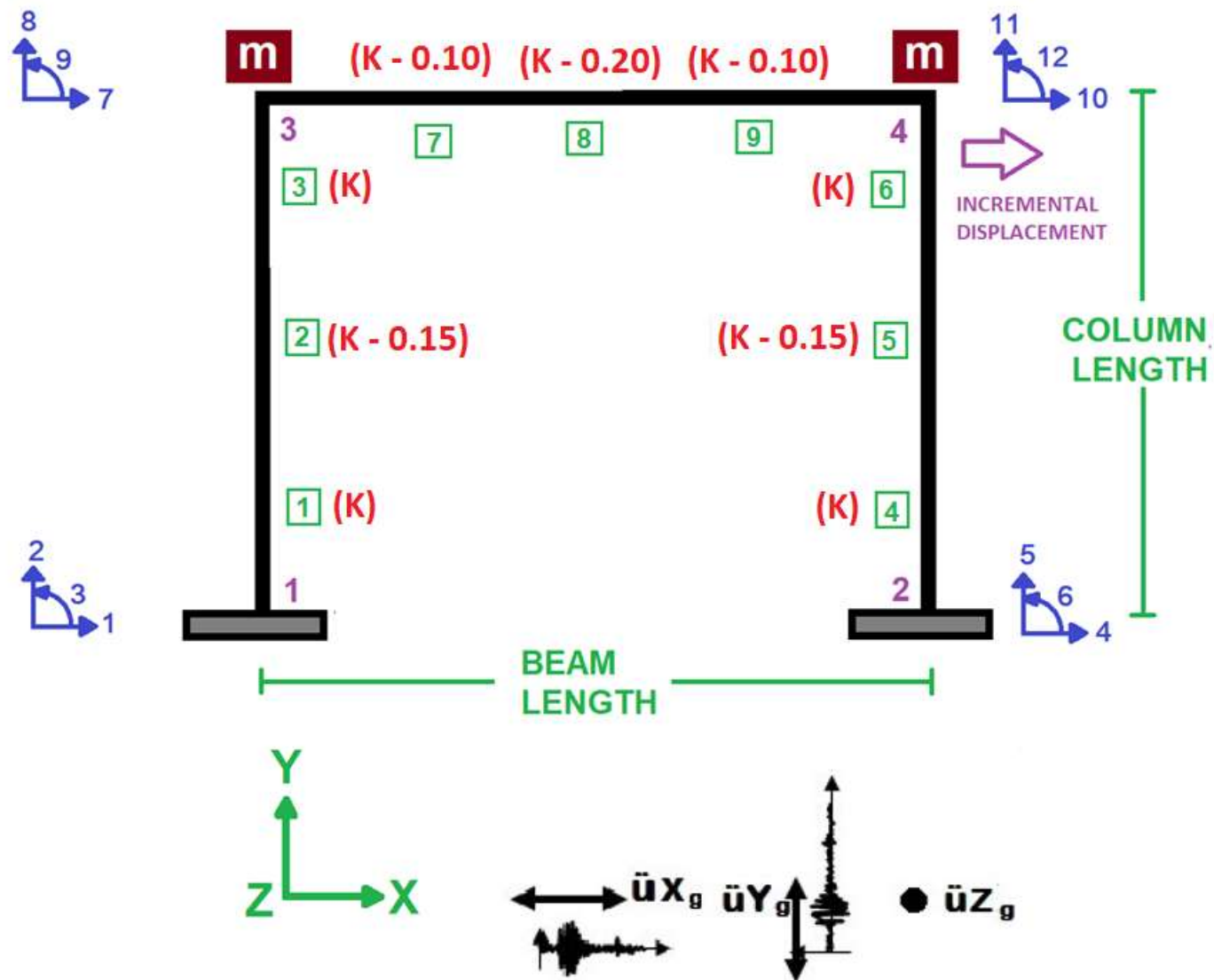
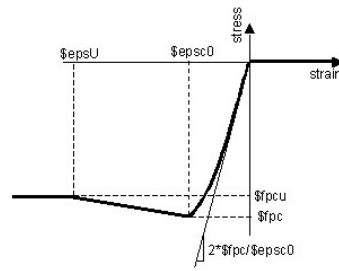


IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

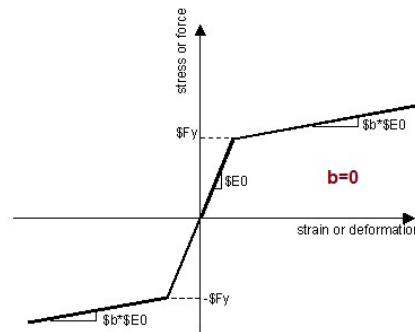
# **ASSESSMENTS OF THE STRUCTURAL DUCTILITY DAMAGE INDEX WITH DIFFERENT CONFINEMENT ENHANCEMENT RATIO OF CONCRETE FRAME USING OPENSEES**

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

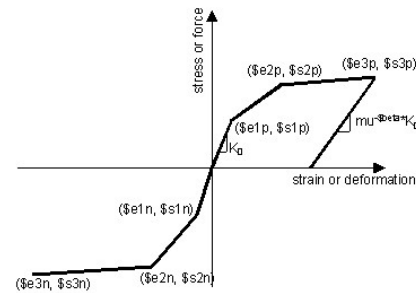




CORE AND COVER CONCRETE RELATION



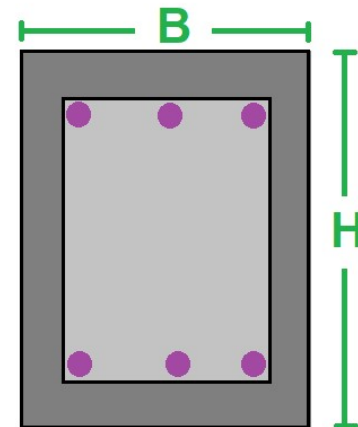
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

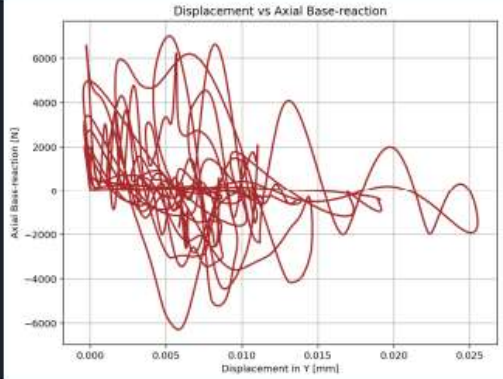
File Edit Search Source Run Debug Consoles Projects Tools View Help

C:\Users\ DELL\Desktop\OPENSEES\_FILES\CONCRETE\_FRAME\_ELEMENTS\_DAMAGE\_INDEX\_CONFINEMENT\_ENHANCEMENT\_RATIO.py

CONCRETE\_FRAME\_DUC...ANCEMENT\_RATIO.py X

```
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 ELEMENTS LIKE BEAM AND COLUMNS USING OPENSEES
5 #
6 # THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
7 # EMAIL: salar.d.ghashghaei@gmail.com
8 #####
9 """
10 [1] Nonlinear Frame Modeling: 2D RC frame with distributed plasticity (fiber sections) using `nonlinearBeamCol
11 [2] Material Laws:
12 - *Concrete*: `Concrete01` with confined (core) and unconfined (cover) properties.
13 - *Steel*: `Hysteretic` model with pinching, hardening, and cyclic degradation.
14 [3] Seismic Loads:
15 - Pushover: Displacement-controlled lateral loading to failure.
16 - Dynamic: Uniform excitation with user-defined ground motions (X/Y components).
17 [4] Damping: Rayleigh damping (a0, a1) calibrated via eigenvalue analysis (modes 1-2).
18 [5] Performance Metrics:
19 - Ductility Ratio ( $\mu$ ): Derived from bilinearized pushover curves.
20 - Overstrength ( $\Omega_0$ ): Yield vs. ultimate capacity.
21 - Damage Index (DI): Normalized displacement demand/capacity.
22 [6] Advanced Solver: HHT-a integrator (unconditionally stable) with Newton-Raphson iterations.
23 [7] Outputs:
24 - Hysteretic responses (P-M, V- $\Delta$ , M- $\theta$ ).
25 - Time-history plots (displacement, base shear).
26 - Stiffness degradation tracking.
27 [8] Validation: Logarithmic decrement method for damping ratio verification.
28 [9] Ductility Damage Index (DDI) Implementation:
29 DDI quantifies structural damage via normalized displacement demand.
30 # After bilinear fit (X[1] =  $\Delta_y$ , X[2] =  $\Delta_u$ ):
31 Dd = max(abs(DISPL_Xd)) # Max dynamic displacement demand
32 DI = (Dd - Dy) / (Du - Dy) # Ductility Damage Index (X-dir)
33 DI  $\approx$  0: Elastic response (no damage).
34 DI  $\geq$  1: Collapse (demand  $\geq$  ultimate capacity).
```

Displacement vs Axial Base-reaction



Help Variable Explorer Debugger Plots Files

Console 1/A X

Lobatto

End 1 Forces (P V M): 31.8152 -491.043 -831018

End 2 Forces (P V M): -31.8152 491.043 339975

Element: 3 Type: ForceBeamColumn2d Connected Nodes: 6 3

Number of Sections: 10 Mass density: 6.25

Lobatto

End 1 Forces (P V M): 9.2331 -482.525 -339975

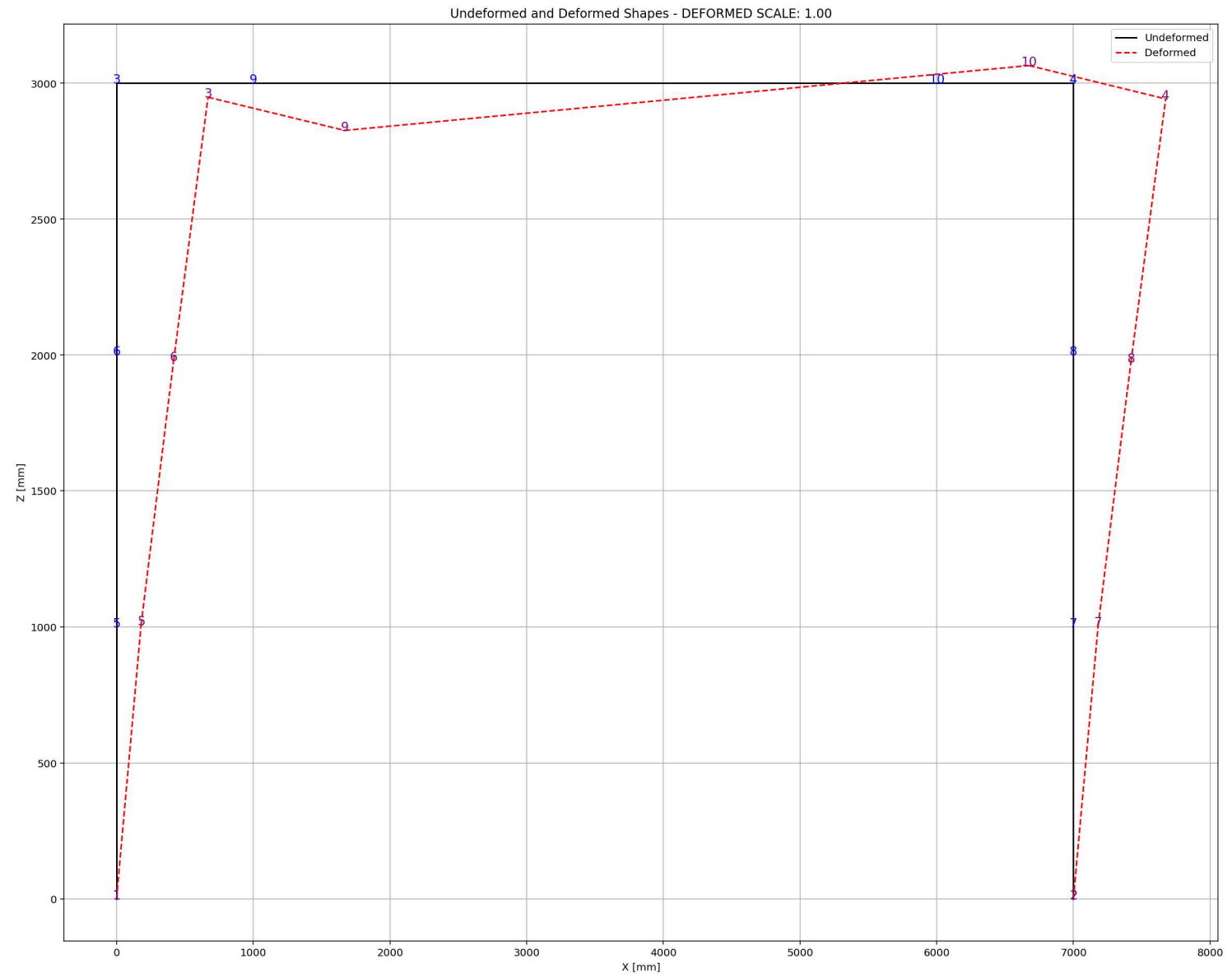
End 2 Forces (P V M): -9.2331 482.525 -142550

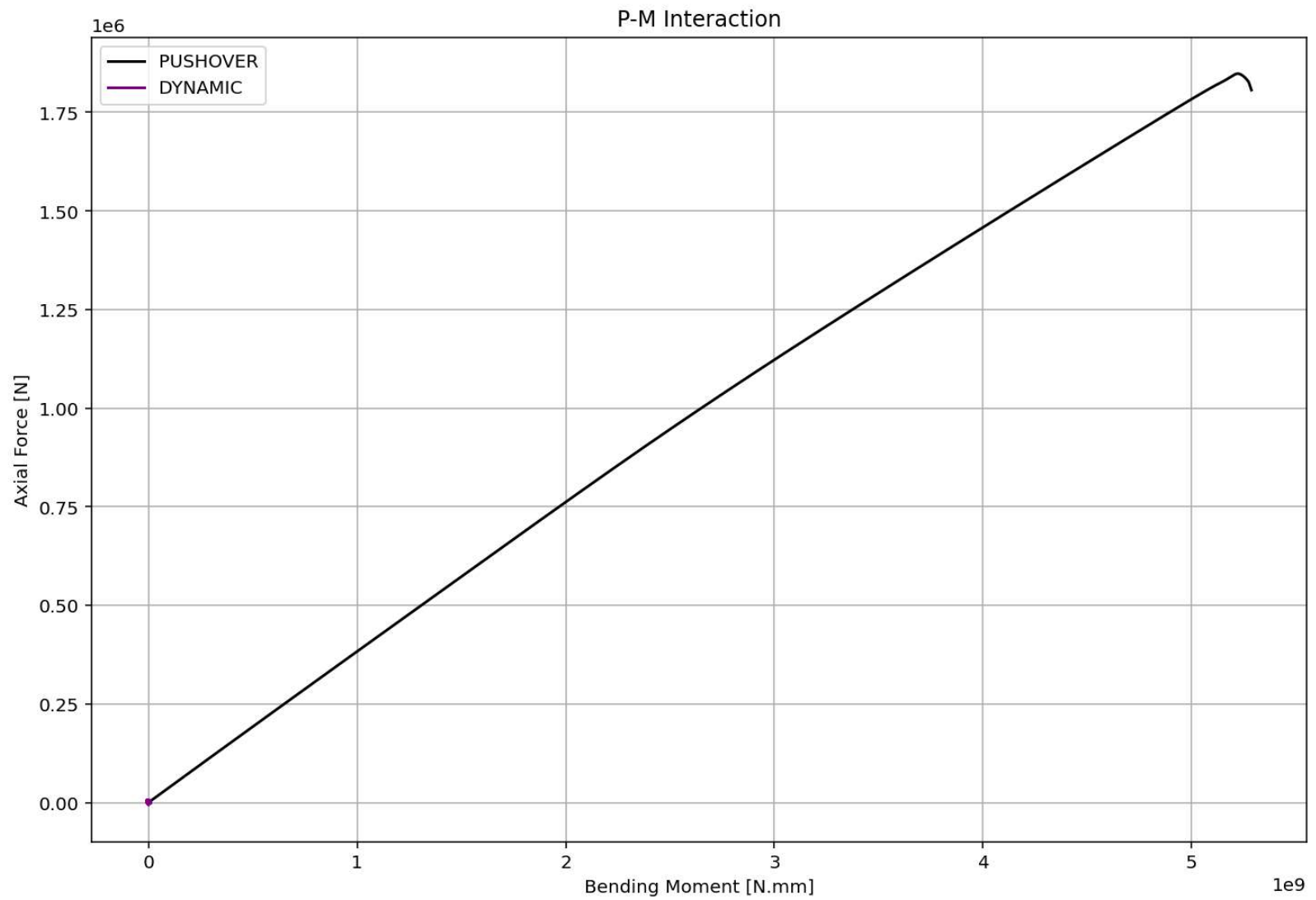
In [2]:

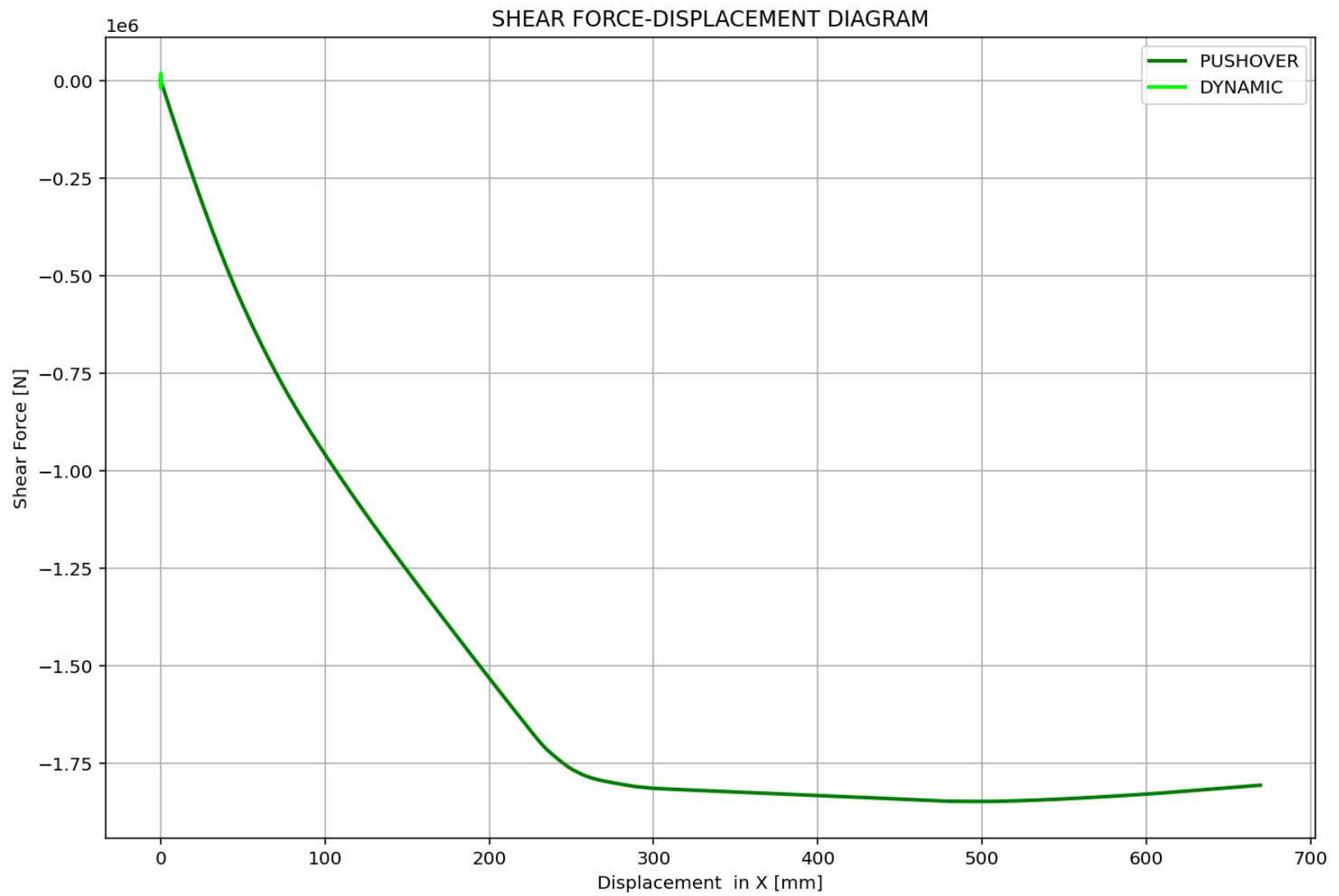
IPython Console History

Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 4, Col 118 UTF-8 CRLF RW Mem 41%

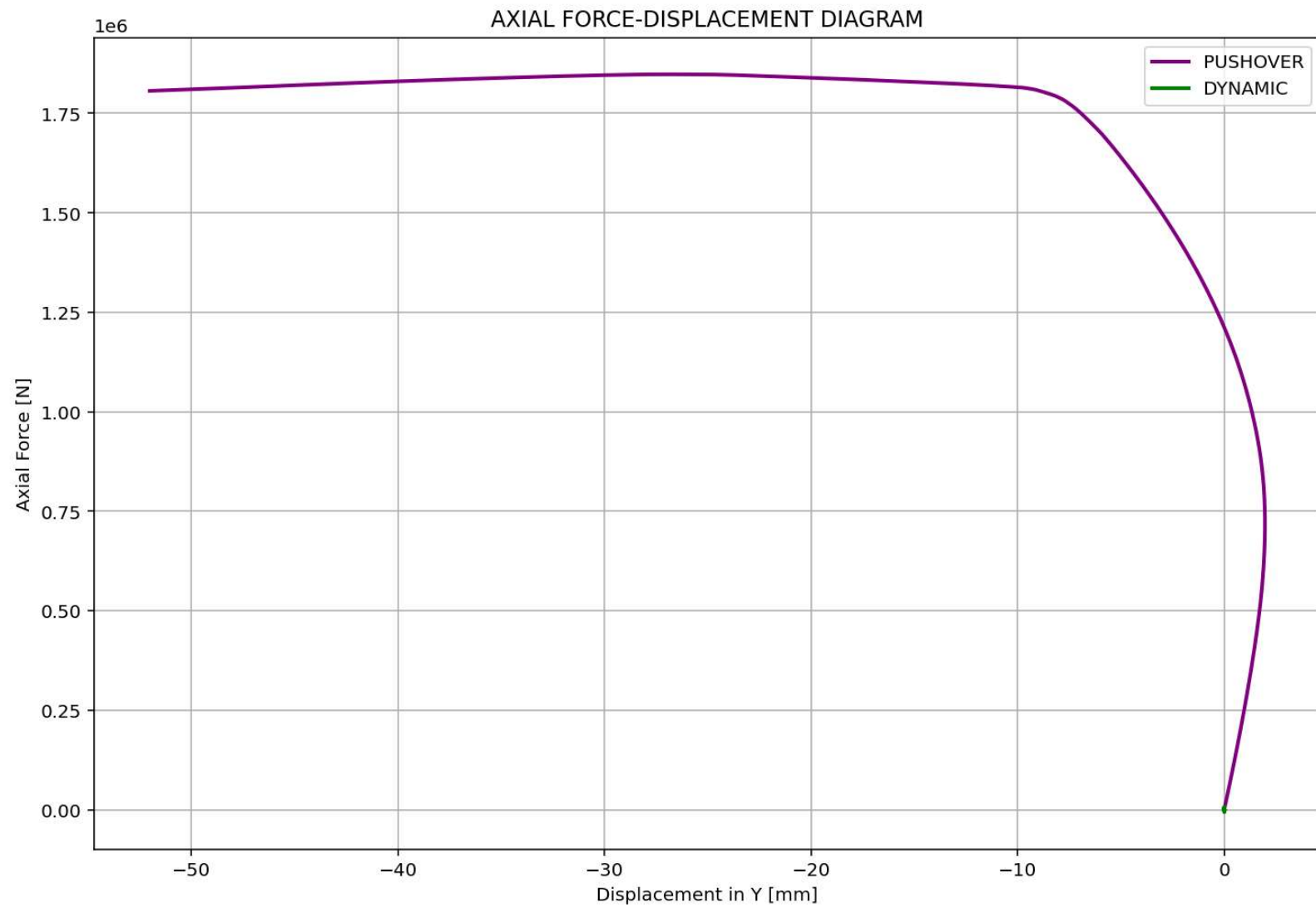
# **NONLINEAR STATIC ANALYSIS (PUSHOVER)**



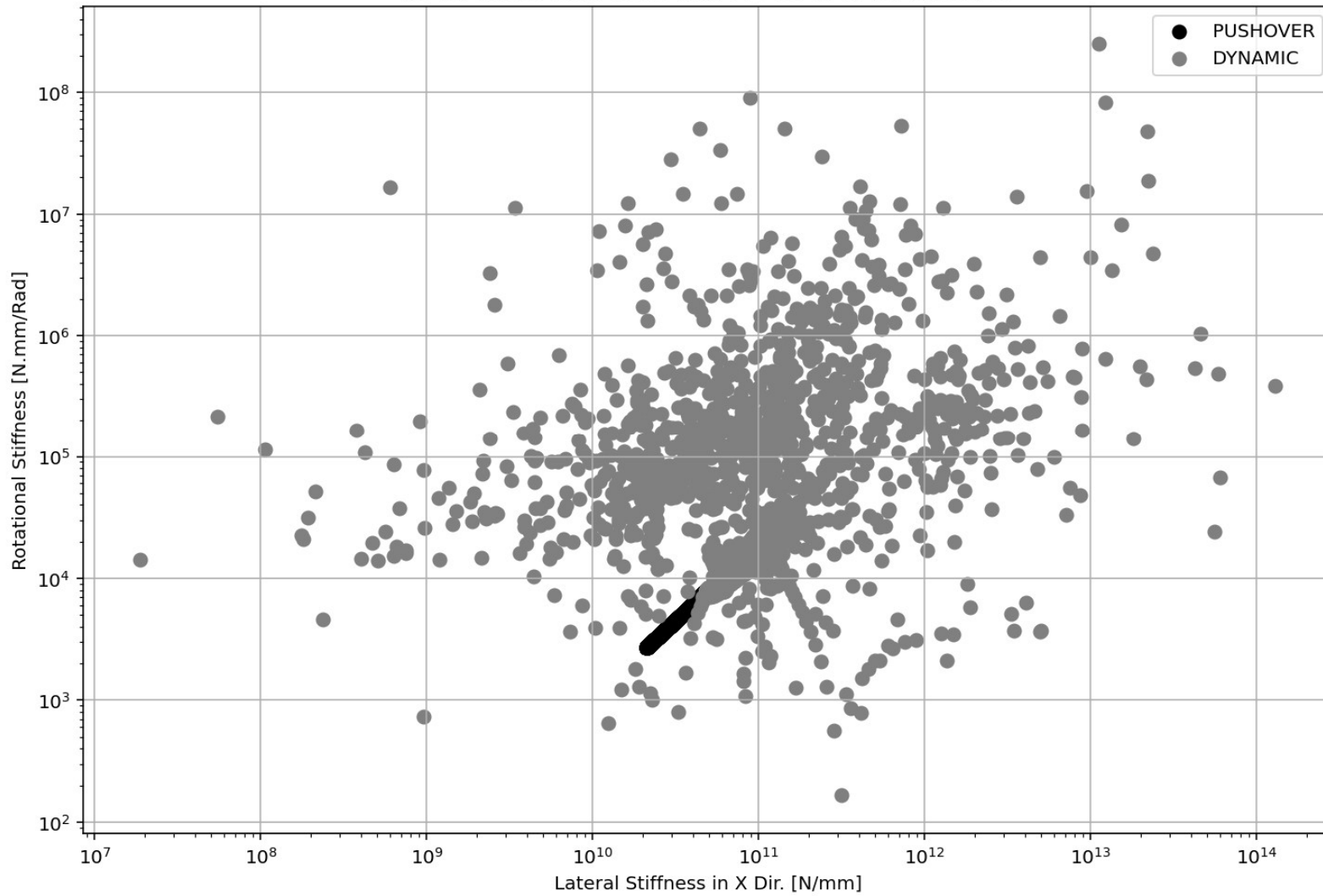




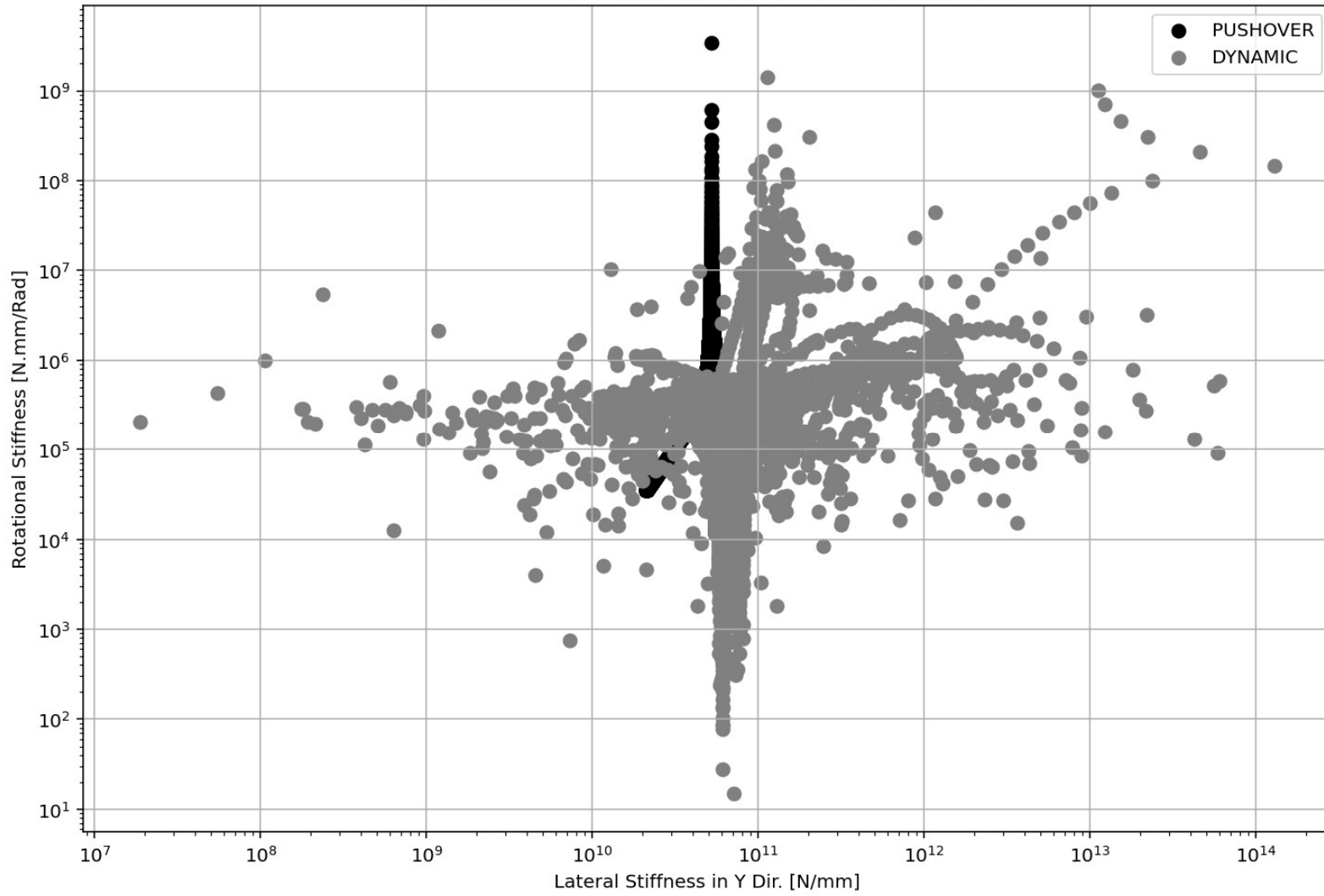


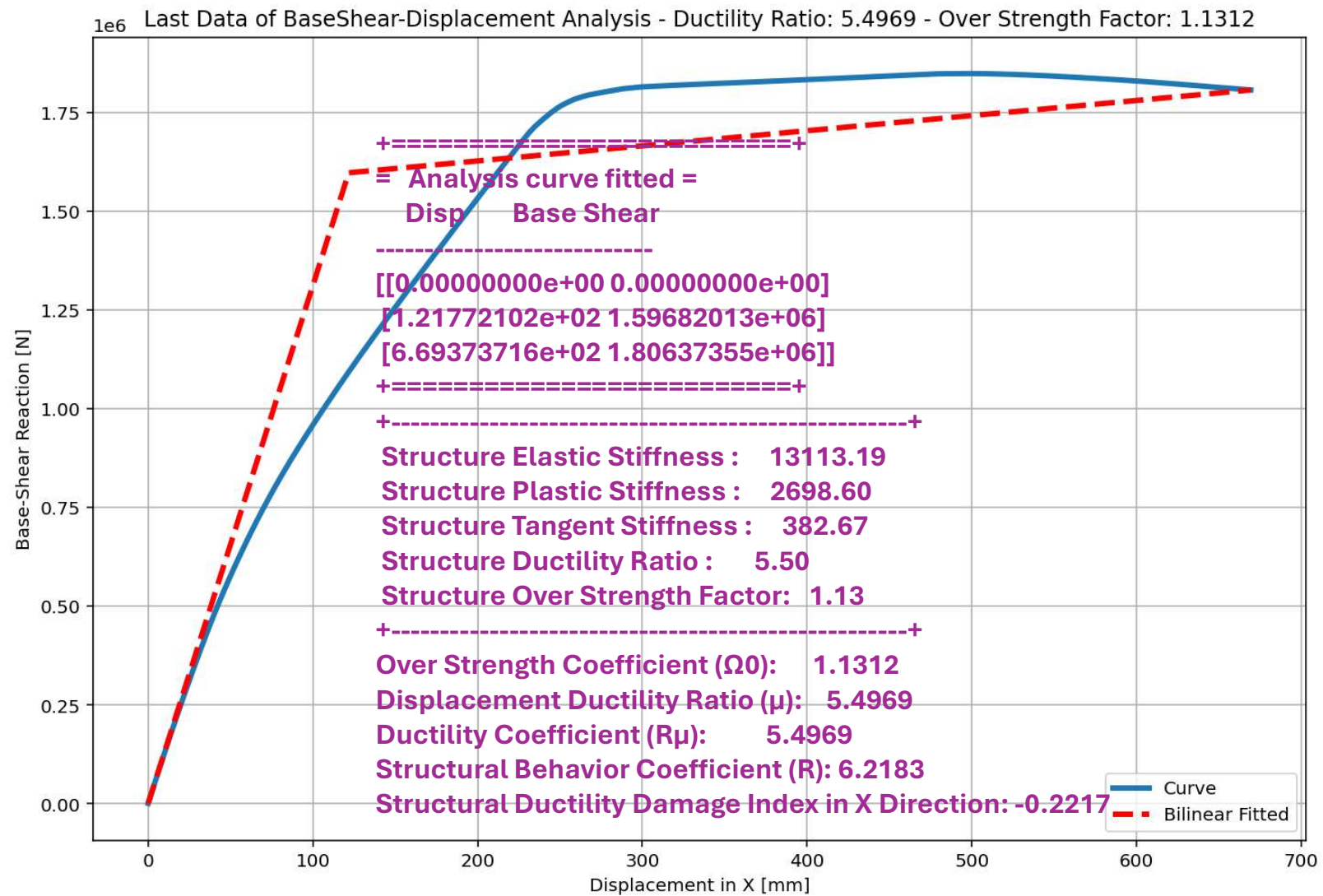


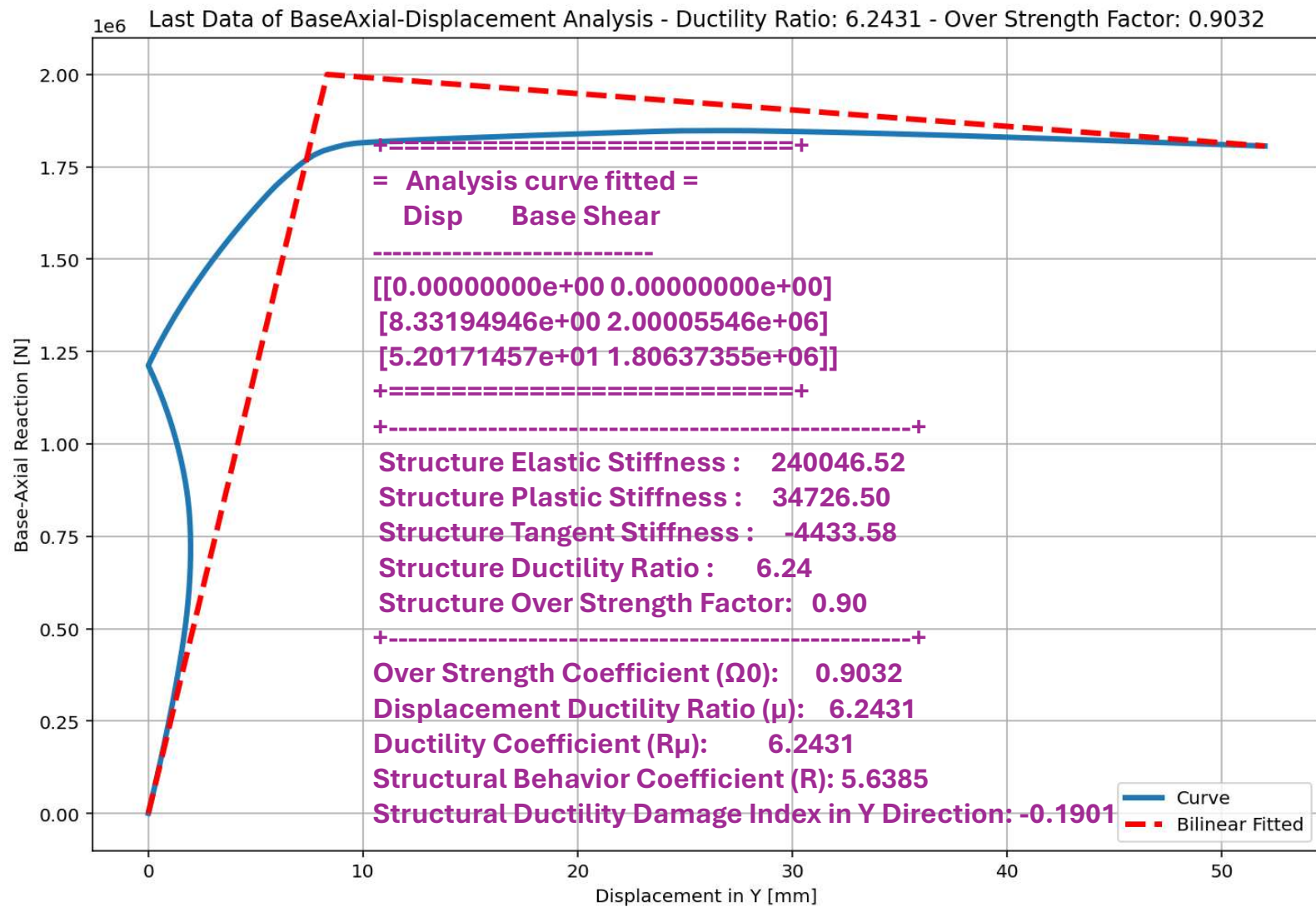
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM



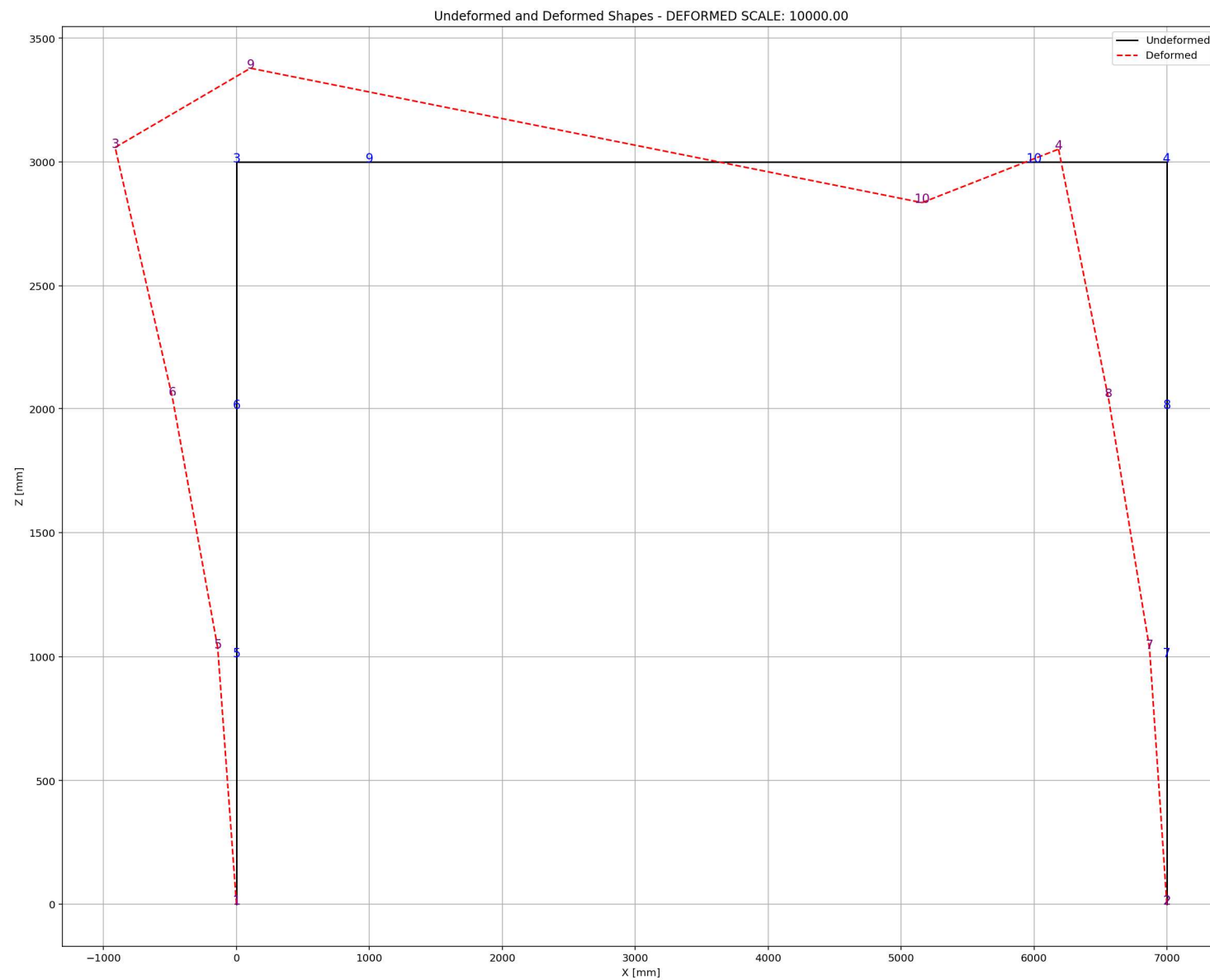
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM



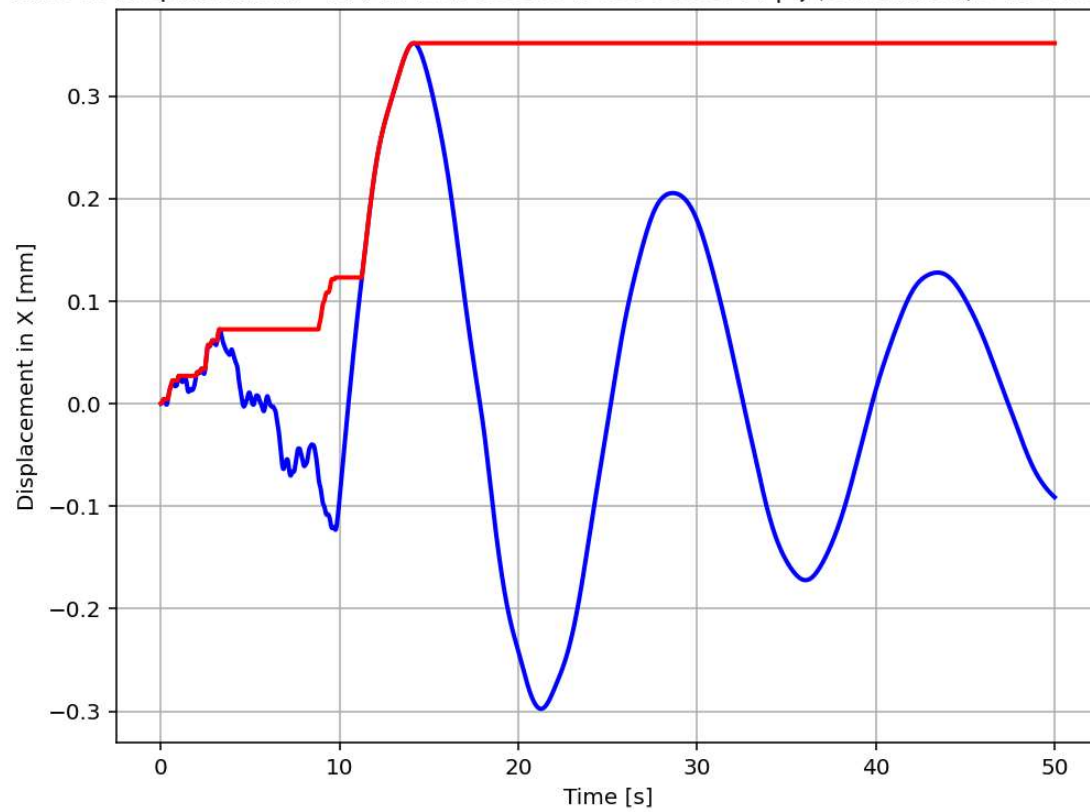




# NONLINEAR DYNAMIC ANALYSIS



Time vs Displacement - MAX. ABS: 0.3516474868005344 |  $\xi$  (Calculated): 1.00000e+02 %





Time vs Displacement - MAX. ABS: 0.025528740750356632

