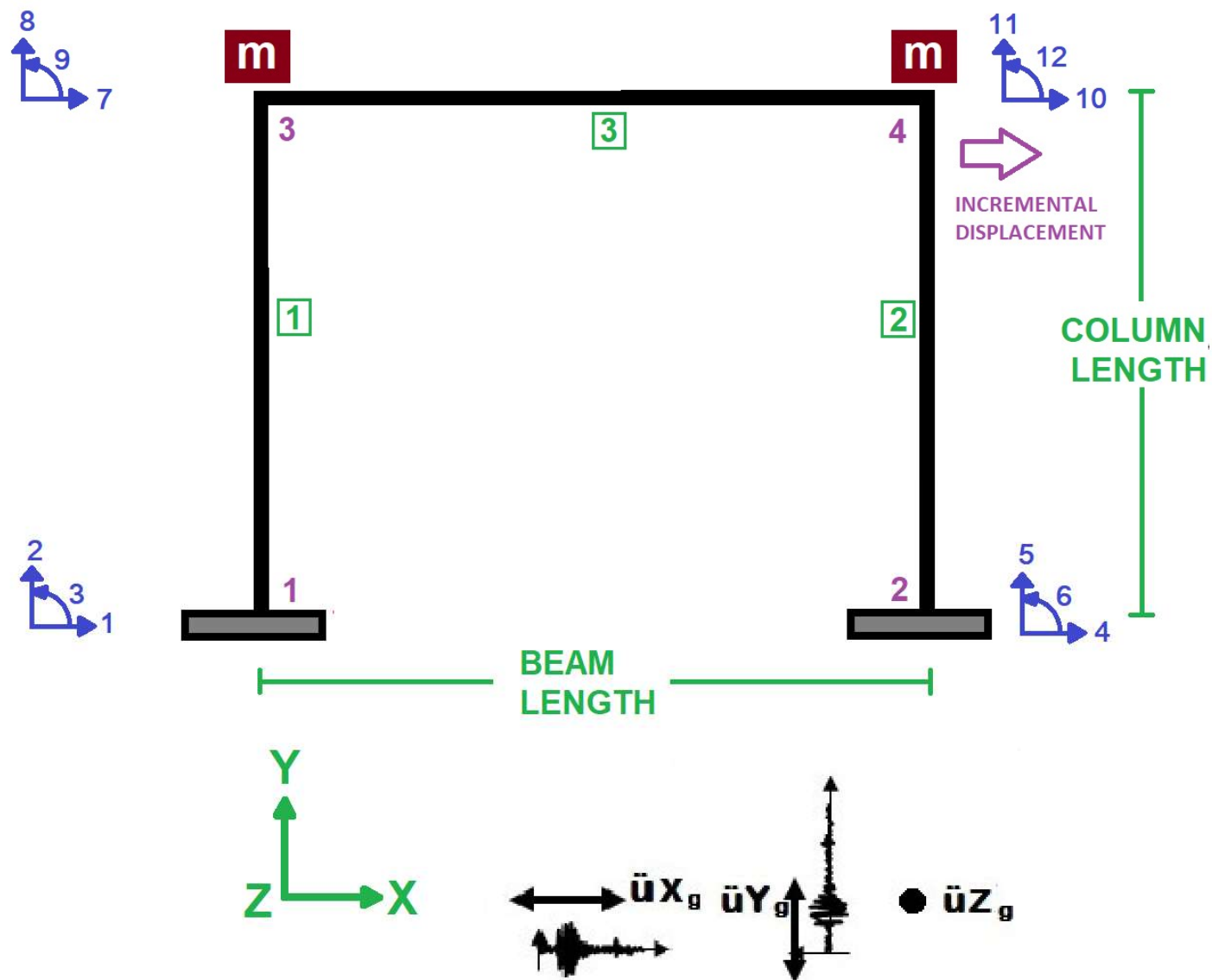
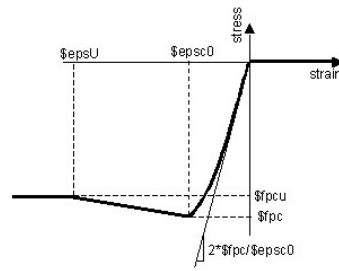


IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

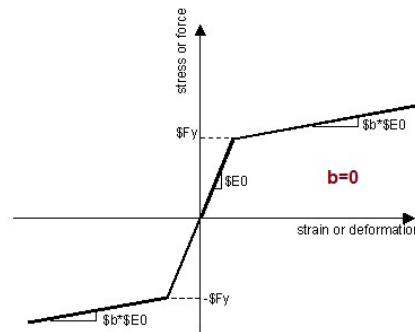
ASSESSMENTS OF THE STRUCTURAL DUCTILITY DAMAGE INDEX OF CONCRETE FRAME USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

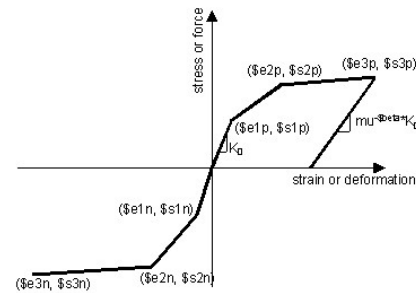




CORE AND COVER CONCRETE RELATION



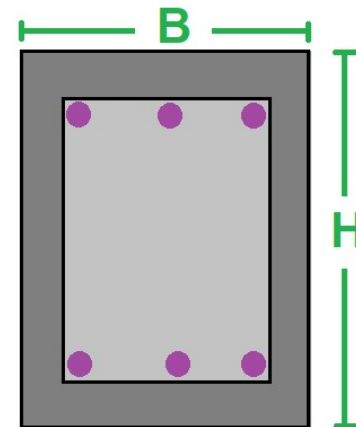
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

C:\Users\ DELL\Desktop\OPENSEES_FILES\CONCRETE_FRA...GE_INDEX\CONCRETE_FRAME_DUCTILITY_DAMAGE_INDEX.py

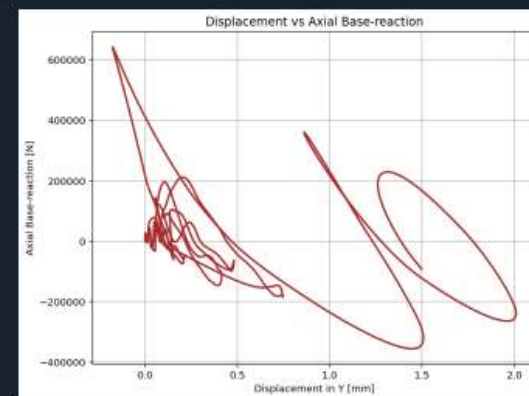
CONCRETE_FRAME_DUCTILITY_DAMAGE_INDEX.py

```

1 #####
2 #                               IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL
3 #                               ASSESSMENTS OF THE STRUCTURAL DUCTILITY DAMAGE INDEX OF CONCRETE FRAME US
4 # -----
5 #                               THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
6 #                               EMAIL: salar.d.ghashghaei@gmail.com
7 #####
8 """
9
10 [1] Nonlinear Frame Modeling: 2D RC frame with distributed plasticity (fiber sections) using
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 ( $\Omega_o$ ): Yield vs. ultimate capacity.
21     - Damage Index (DI): Normalized displacement demand/capacity.
22 [6] Advanced Solver: HHT- $\alpha$  integrator (unconditionally stable) with Newton-Raphson iteration
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      $D_d = \max(\text{abs}(\text{DISP\_Xd}))$  # Max dynamic displacement demand
32      $DI = (D_d - D_y) / (D_u - D_y)$  # Ductility Damage Index (X-dir)
33      $DI \approx 0$ : Elastic response (no damage).
34      $DI \geq 1$ : Collapse (demand  $\geq$  ultimate capacity).
35 Key Innovations:

```

...NSEES_FILES\CONCRETE_FRAME_EXAMPLES\DUCTILITY_DAMAGE_INDEX



Help Variable Explorer Debugger Plots Files

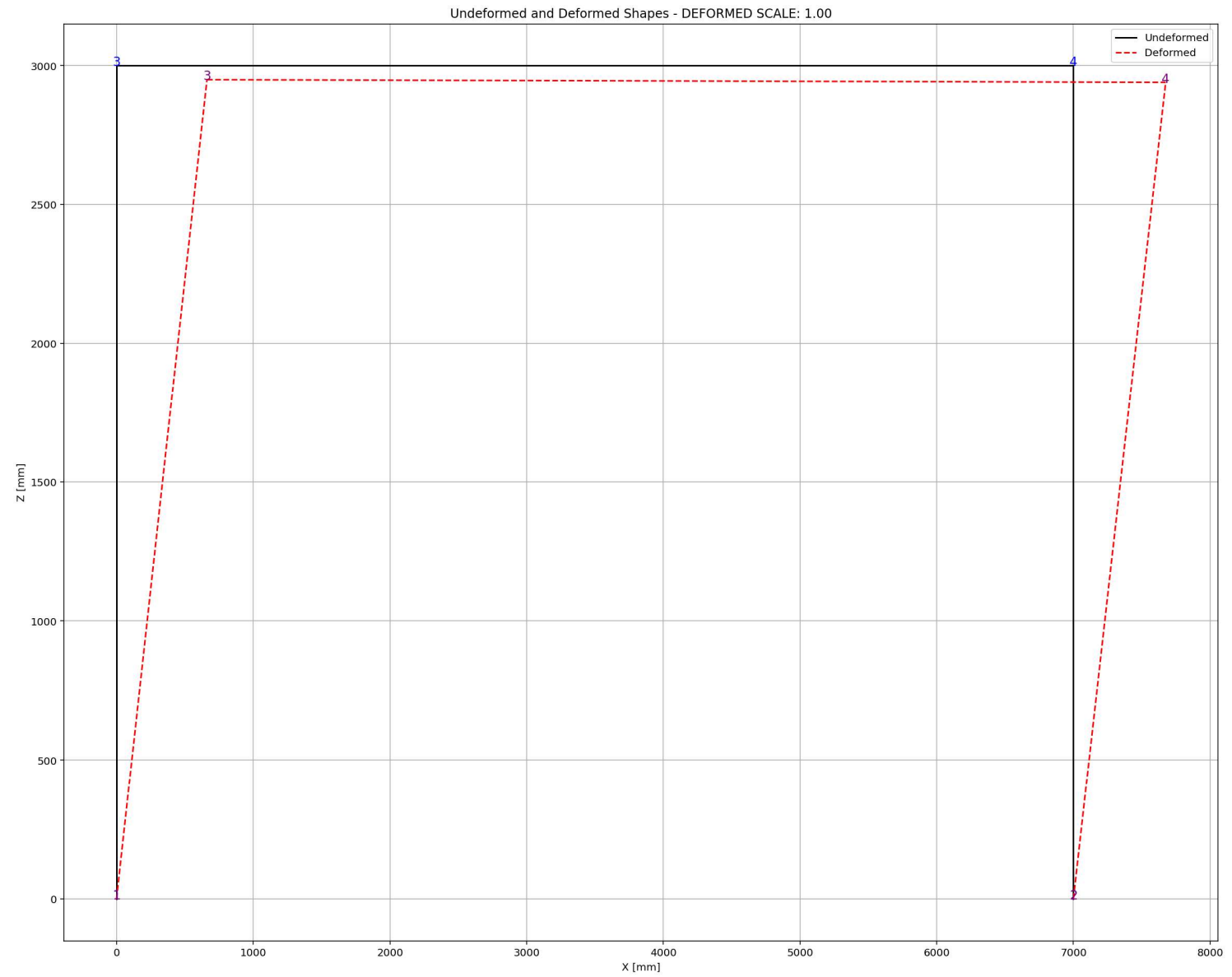
Console 1/A

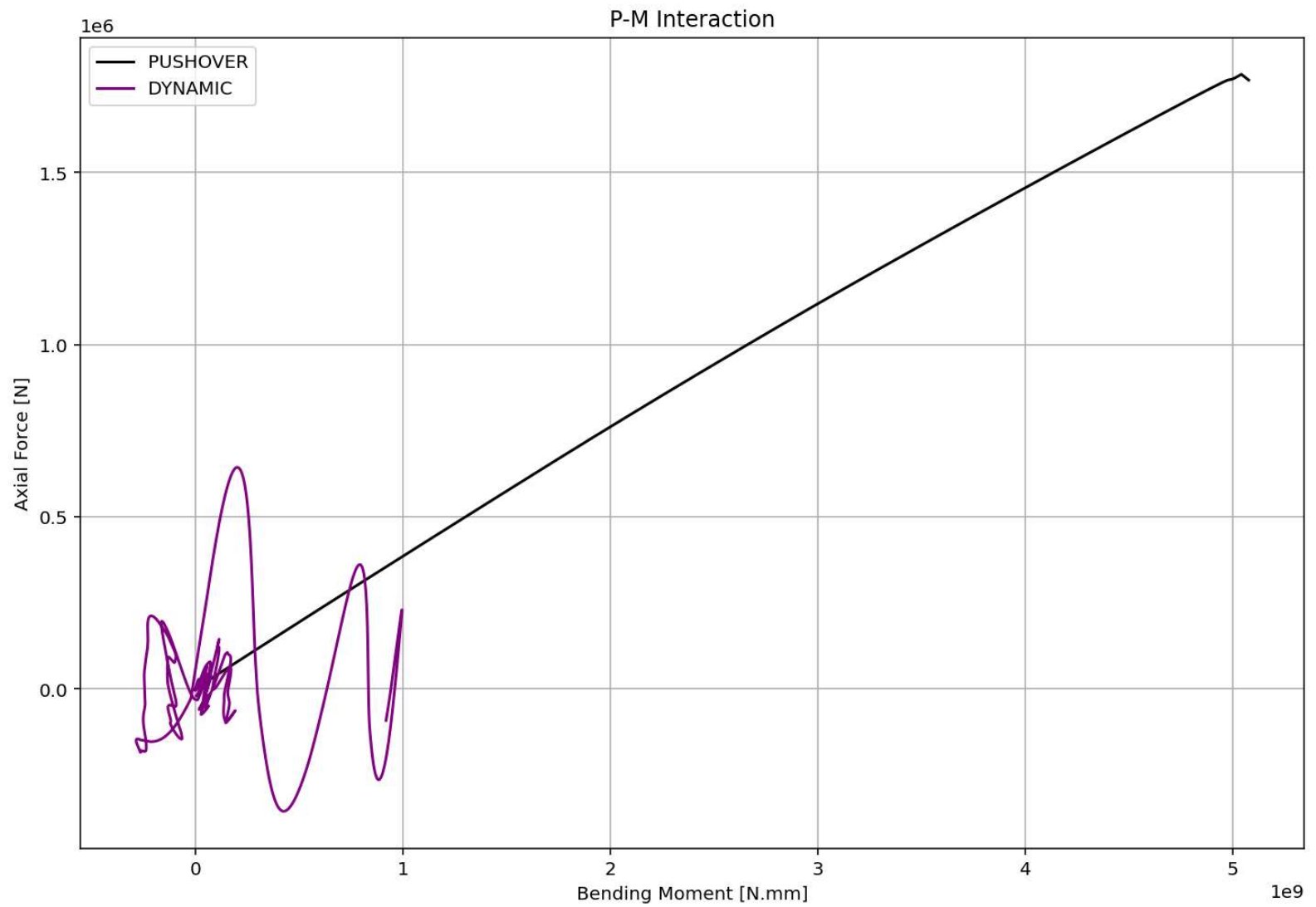
Structural Behavior Coefficient (R): 6.7662
Structural Ductility Damage Index in Y Direction: -0.1132

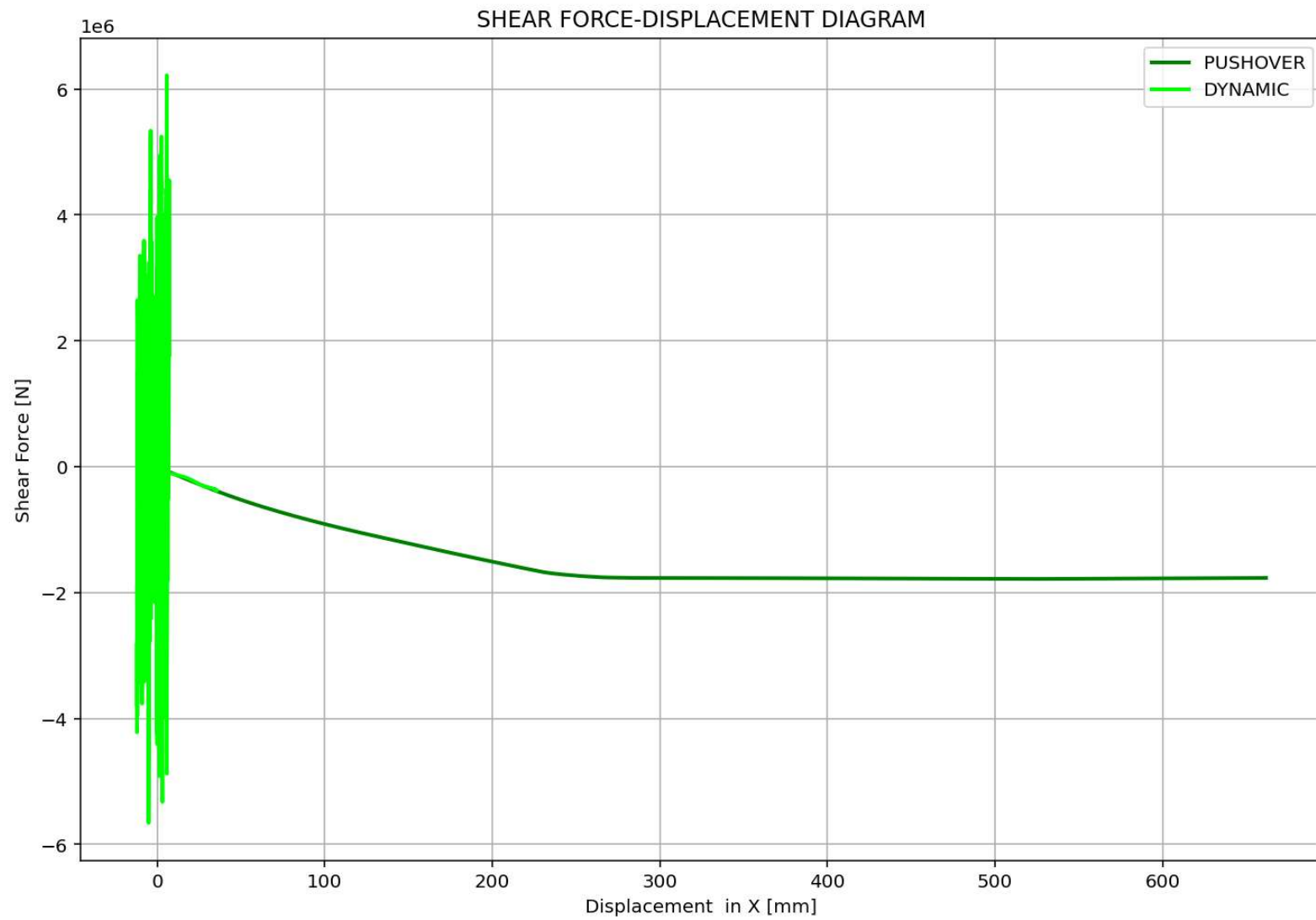
Node: 3
Coordinates : 0 3000
Disps: 34.7511 1.49893 -0.0156934
Velocities : -2.64641 0.944754 0.000678396
commitAccels: -2.99973 -0.0355111 -0.447358
unbalanced Load: 15.01 0 0
reaction: 106356 -9061.46 -2413.82
Mass :

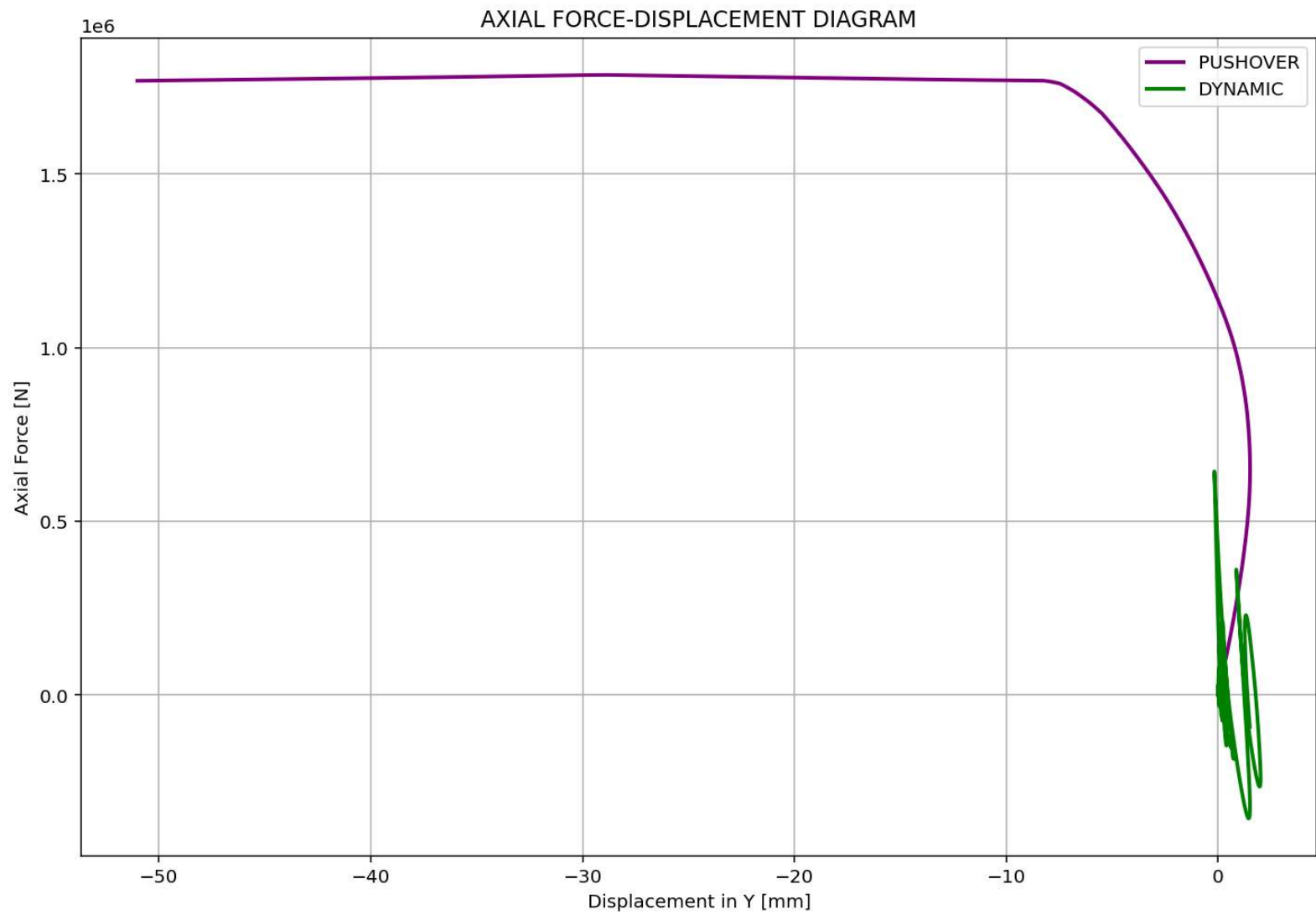
IPython Console History

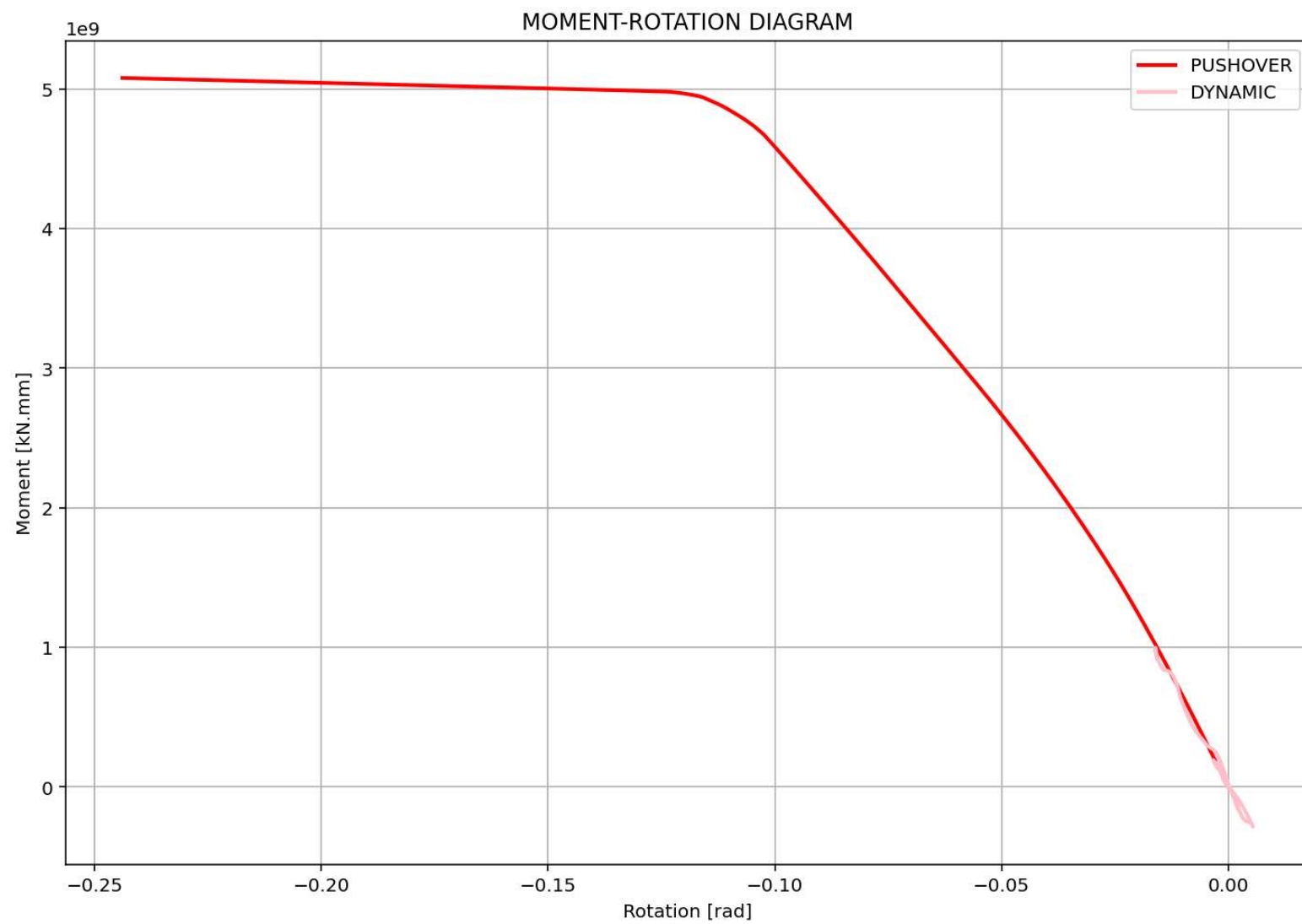
NONLINEAR STATIC ANALYSIS (PUSHOVER)



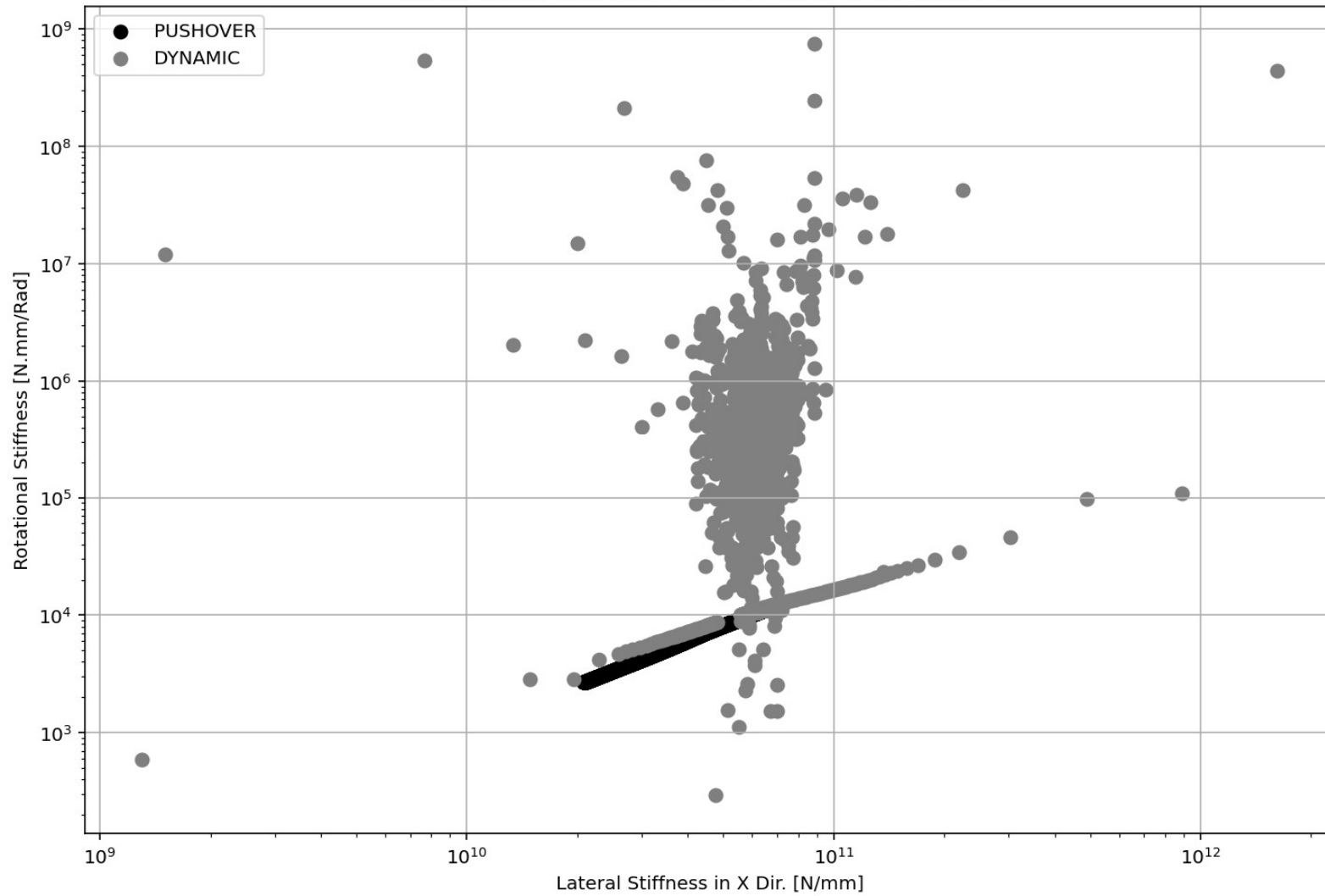




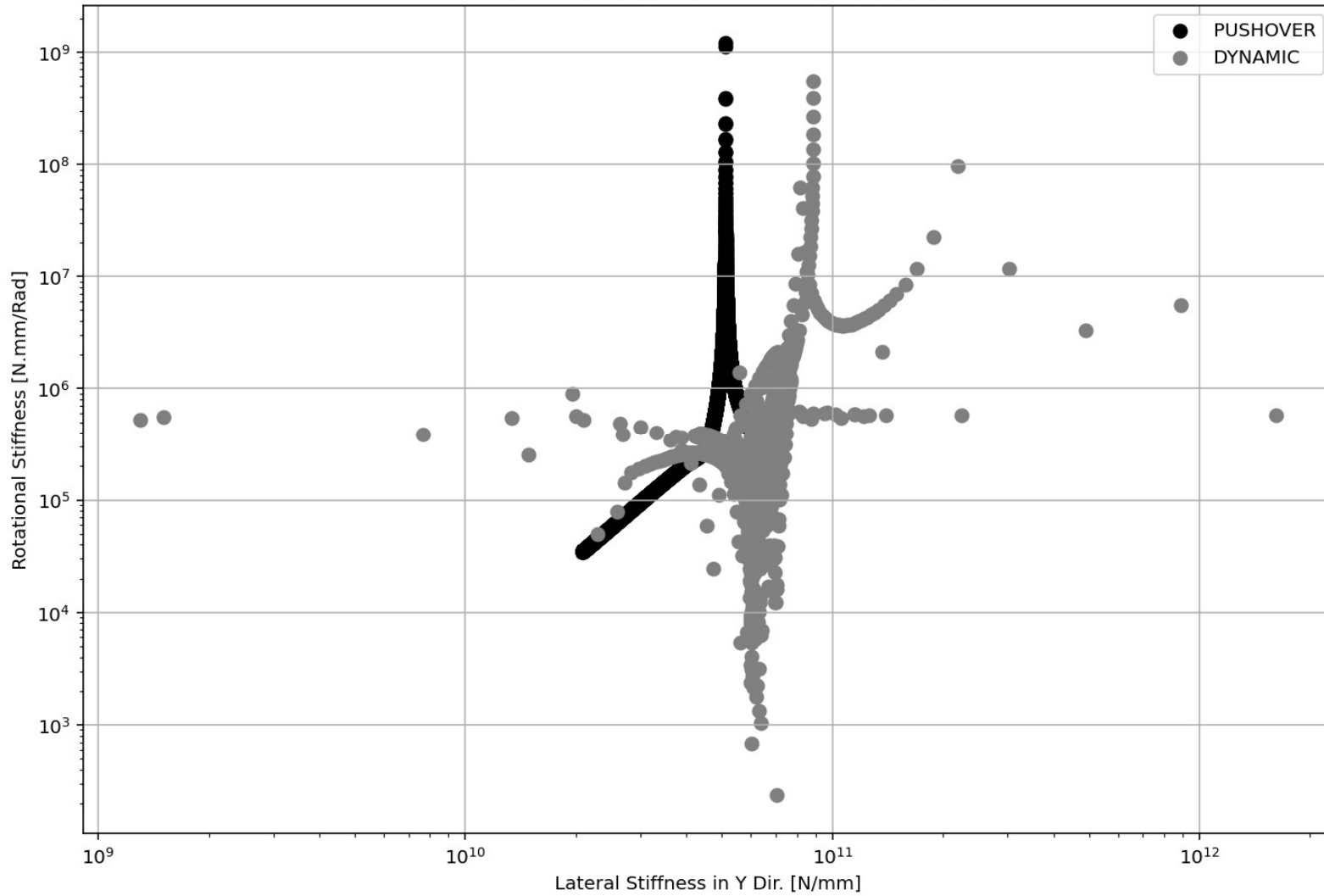


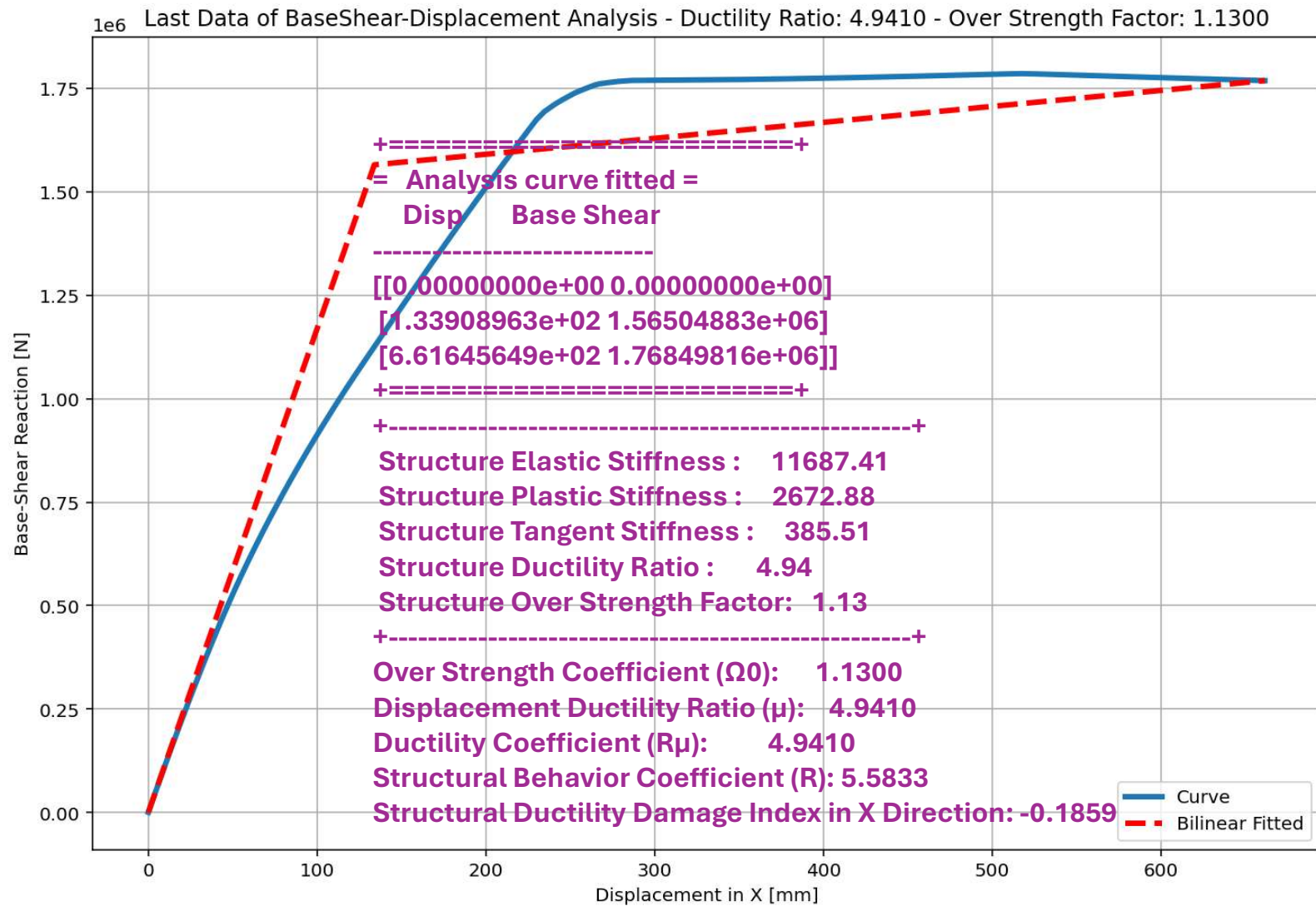


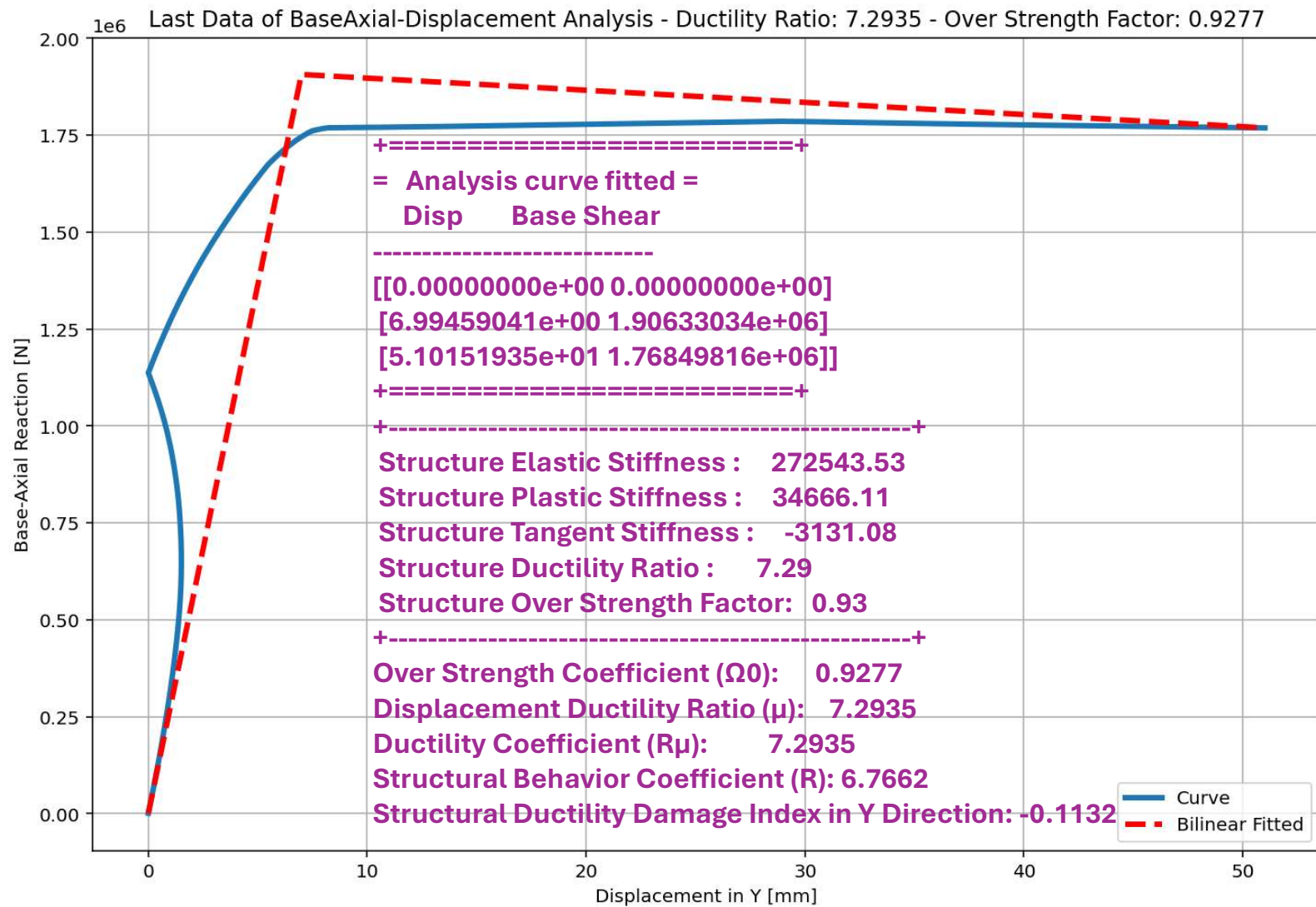
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM



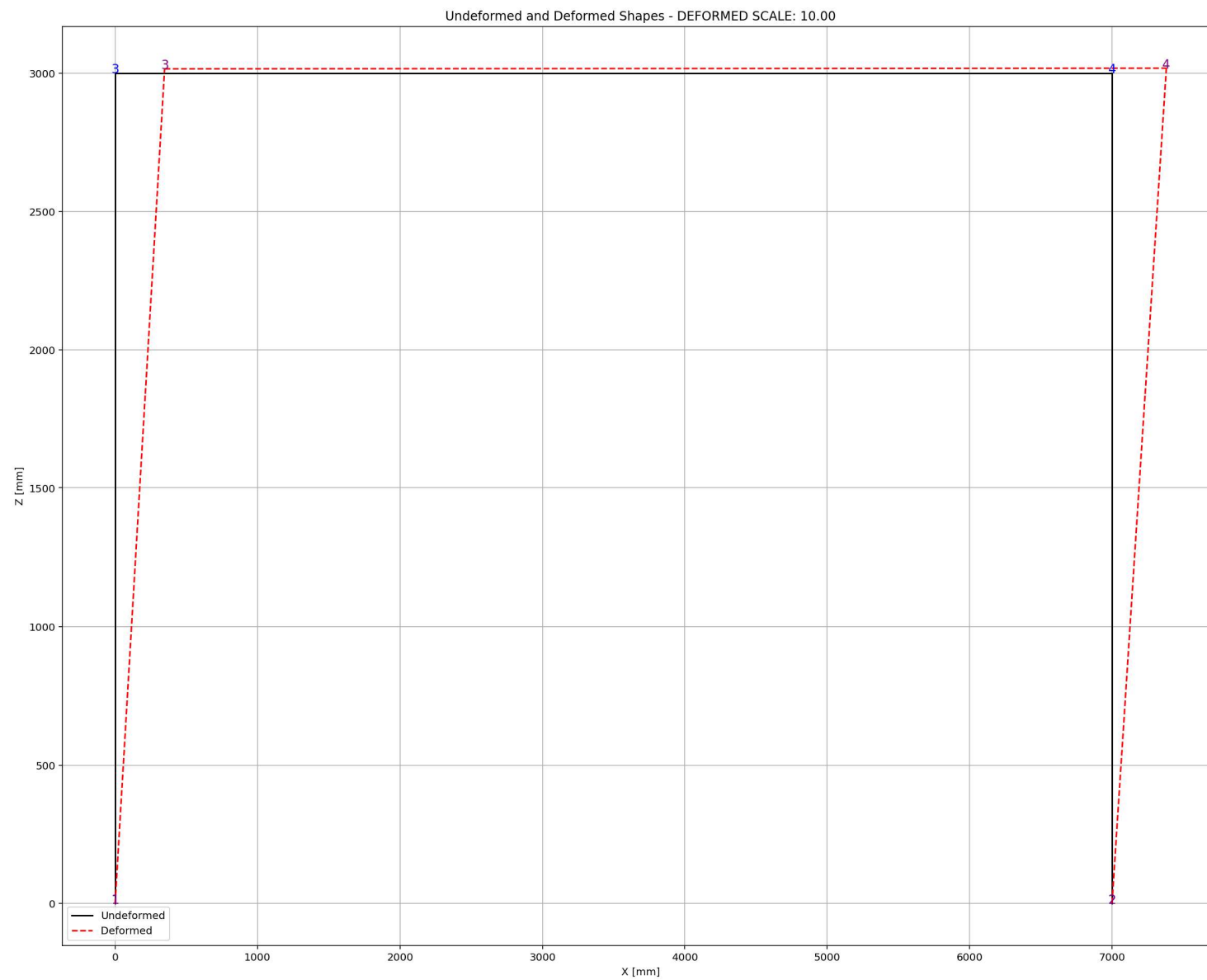
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM



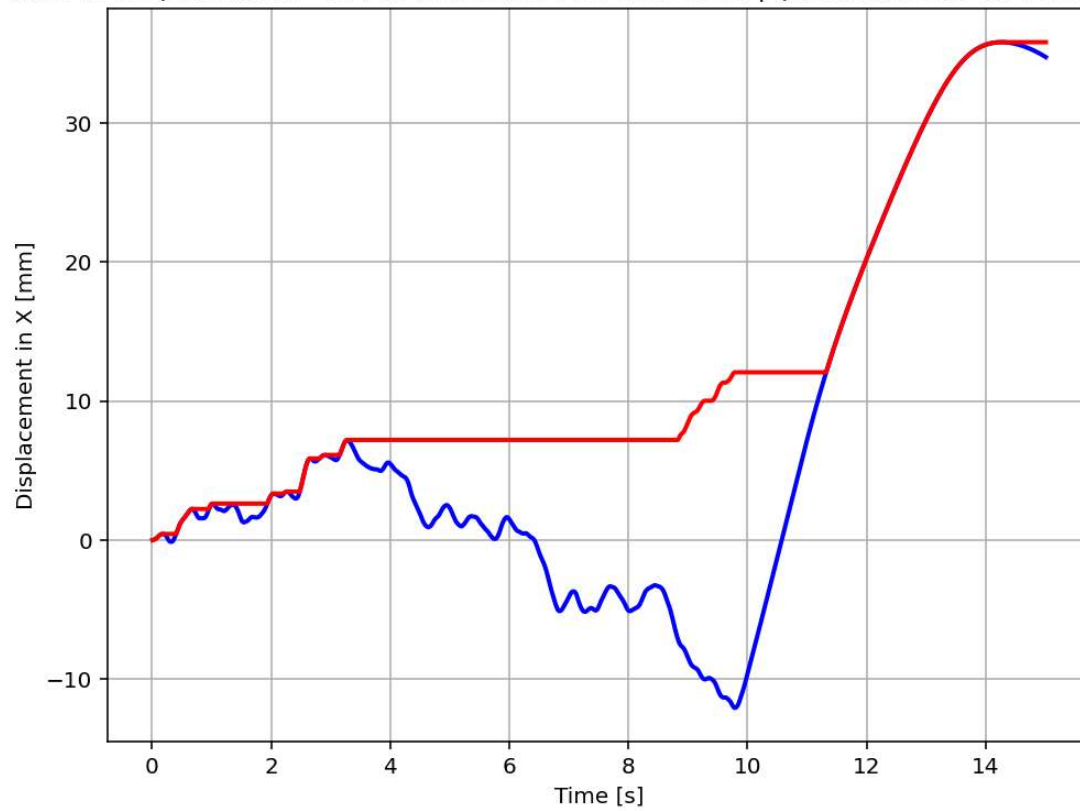


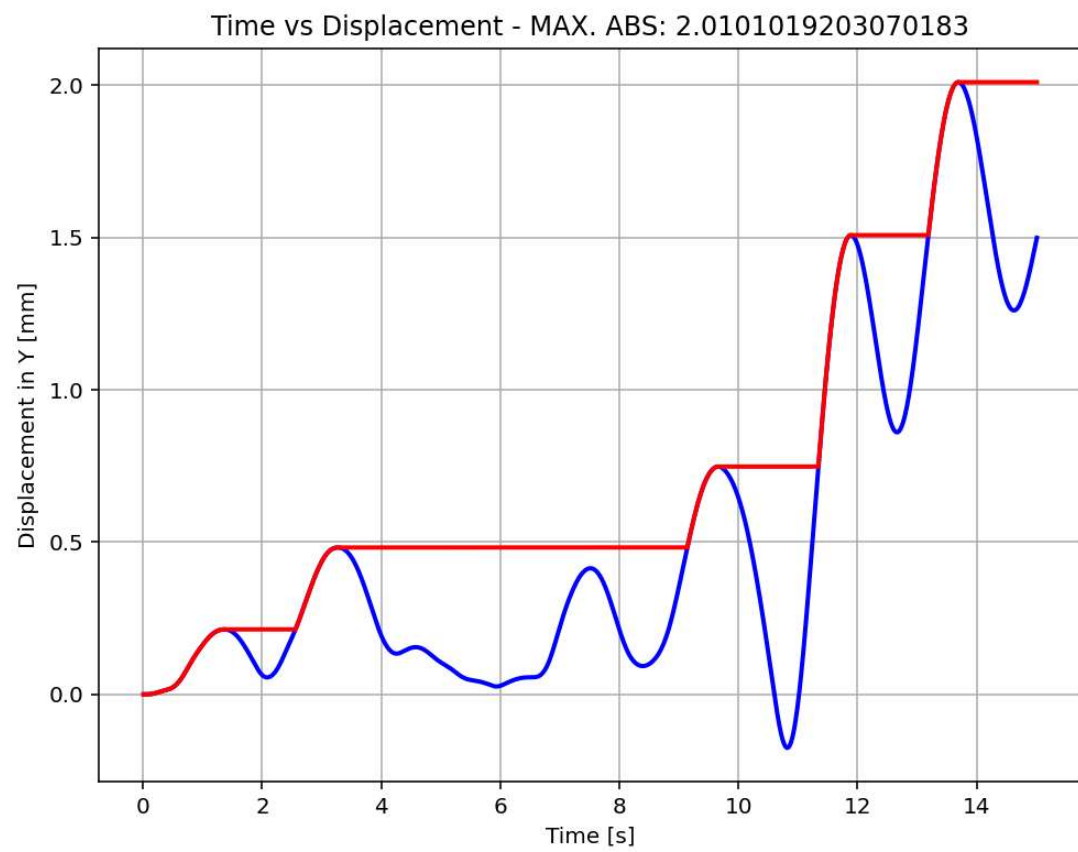


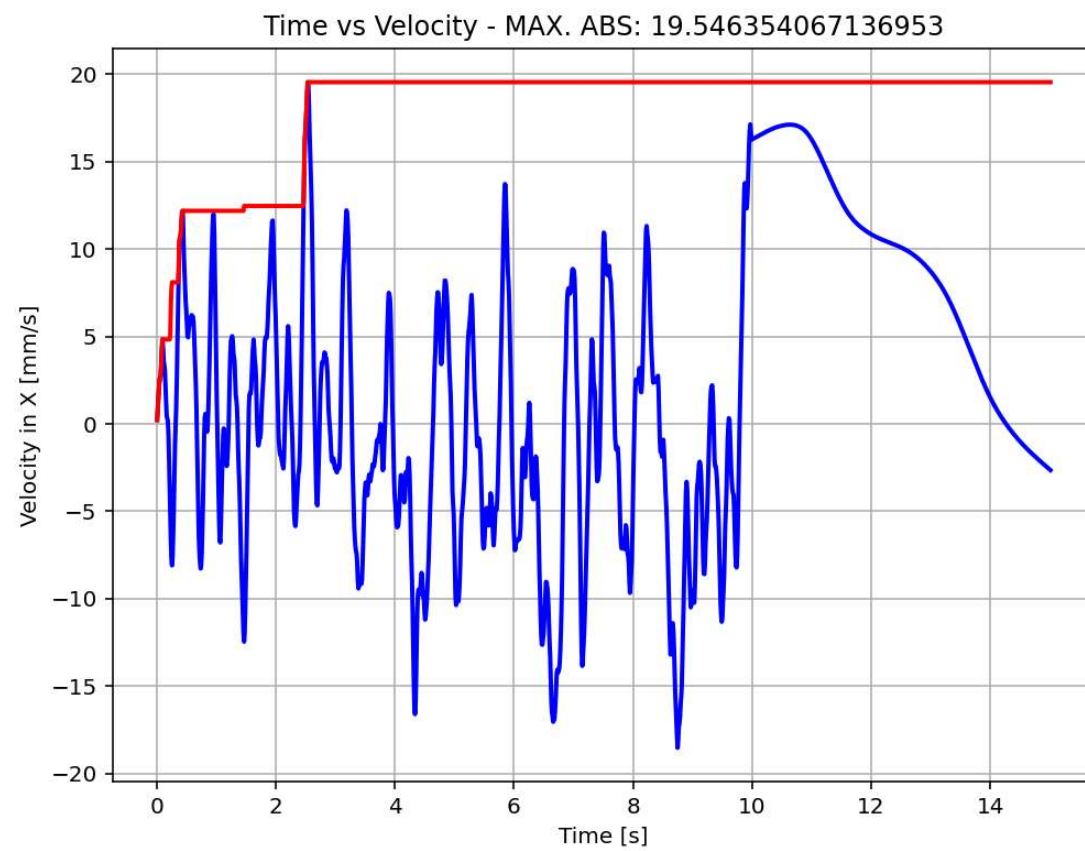
NONLINEAR DYNAMIC ANALYSIS



Time vs Displacement - MAX. ABS: 35.82445919396859 | ξ (Calculated): 1.00000e+02 %







Time vs Acceleration - MAX. ABS: 338.0568480136909

