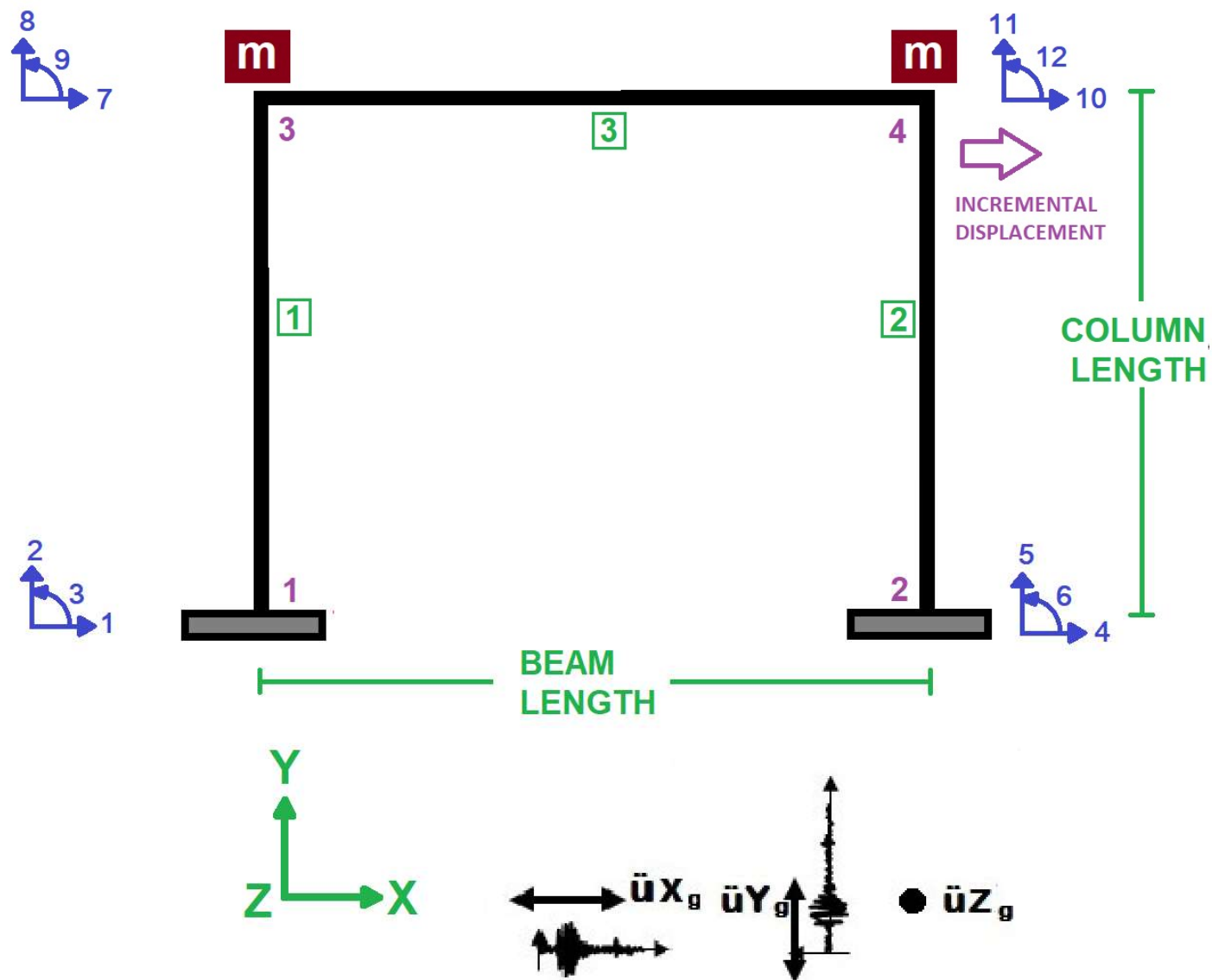
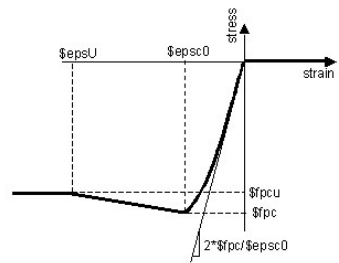


IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

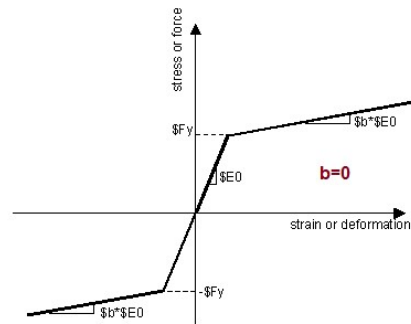
ASSESSMENTS OF THE STRUCTURAL DUCTILITY DAMAGE INDEX OF CONCRETE FRAME USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

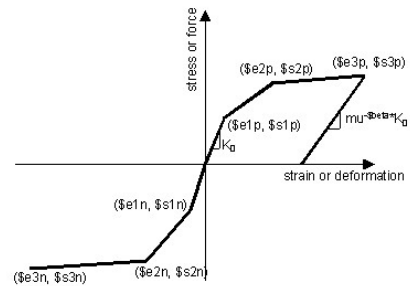




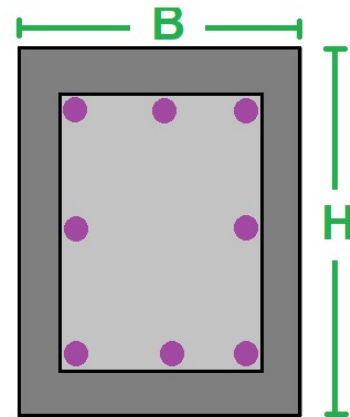
CORE AND COVER CONCRETE REALTION



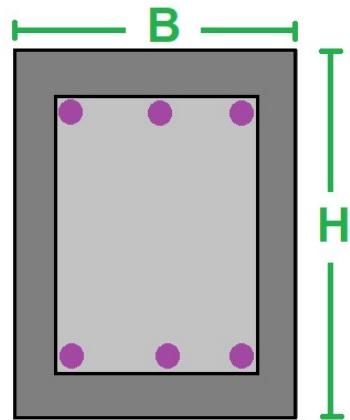
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

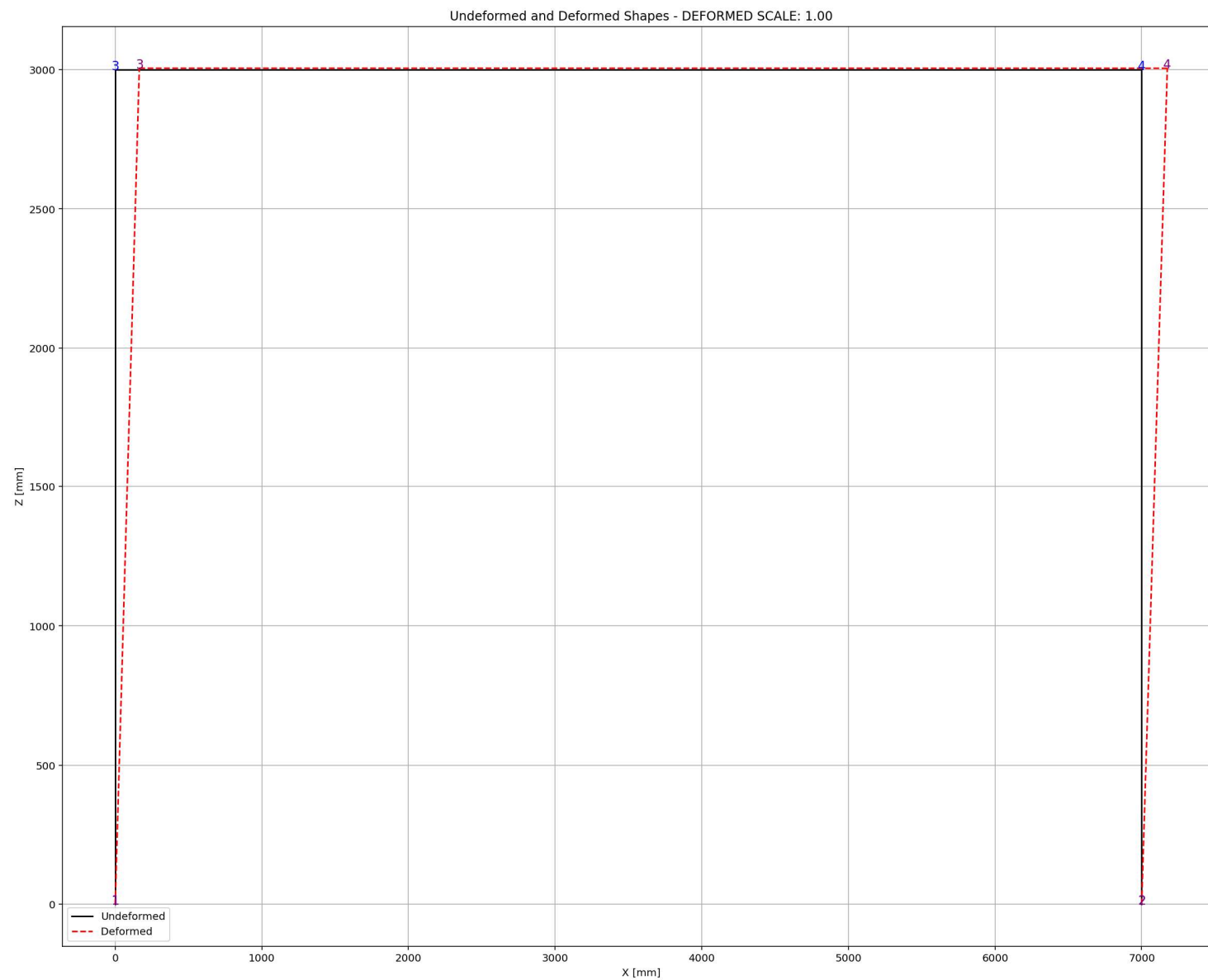
1#####
2#
3#
4#-----
5#
6#
7#####
8""
9[1] Nonlinear Frame Modeling: 2D RC frame with distributed plasticity (fiber sections) using `nonlinearB`
10[2] Material Laws:
11- *Concrete*: `Concrete01` with confined (core) and unconfined (cover) properties.
12- *Steel*: `Hysteretic` model with pinching, hardening, and cyclic degradation.
13[3] Seismic Loads:
14- Pushover: Displacement-controlled lateral loading to failure.
15- Dynamic: Uniform excitation with user-defined ground motions (X/Y components).
16[4] Damping: Rayleigh damping (a0, a1) calibrated via eigenvalue analysis (modes 1-2).
17[5] Performance Metrics:
18- Ductility Ratio (μ): Derived from bilinearized pushover curves.
19- Overstrength (Ω_0): Yield vs. ultimate capacity.
20- Damage Index (DI): Normalized displacement demand/capacity.
21[6] Advanced Solver: HHT- α integrator (unconditionally stable) with Newton-Raphson iterations.
22[7] Outputs:
23- Hysteretic responses (P-M, V- Δ , M- θ).
24- Time-history plots (displacement, base shear).
25- Stiffness degradation tracking.
26[8] Validation: Logarithmic decrement method for damping ratio verification.
27[9] Ductility Damage Index (DDI) Implementation:
28DDI quantifies structural damage via normalized displacement demand.
29# After bilinear fit (X[1] = Δ_y , X[2] = Δ_u):
30Dd = max(abs(DISPL_Xd)) # Max dynamic displacement demand
31DI = (Dd - Dy) / (Du - Dy) # Ductility Damage Index (X-dir)
32DI \approx 0: Elastic response (no damage).
33DI \geq 1: Collapse (demand \geq ultimate capacity).
34Key Innovations:

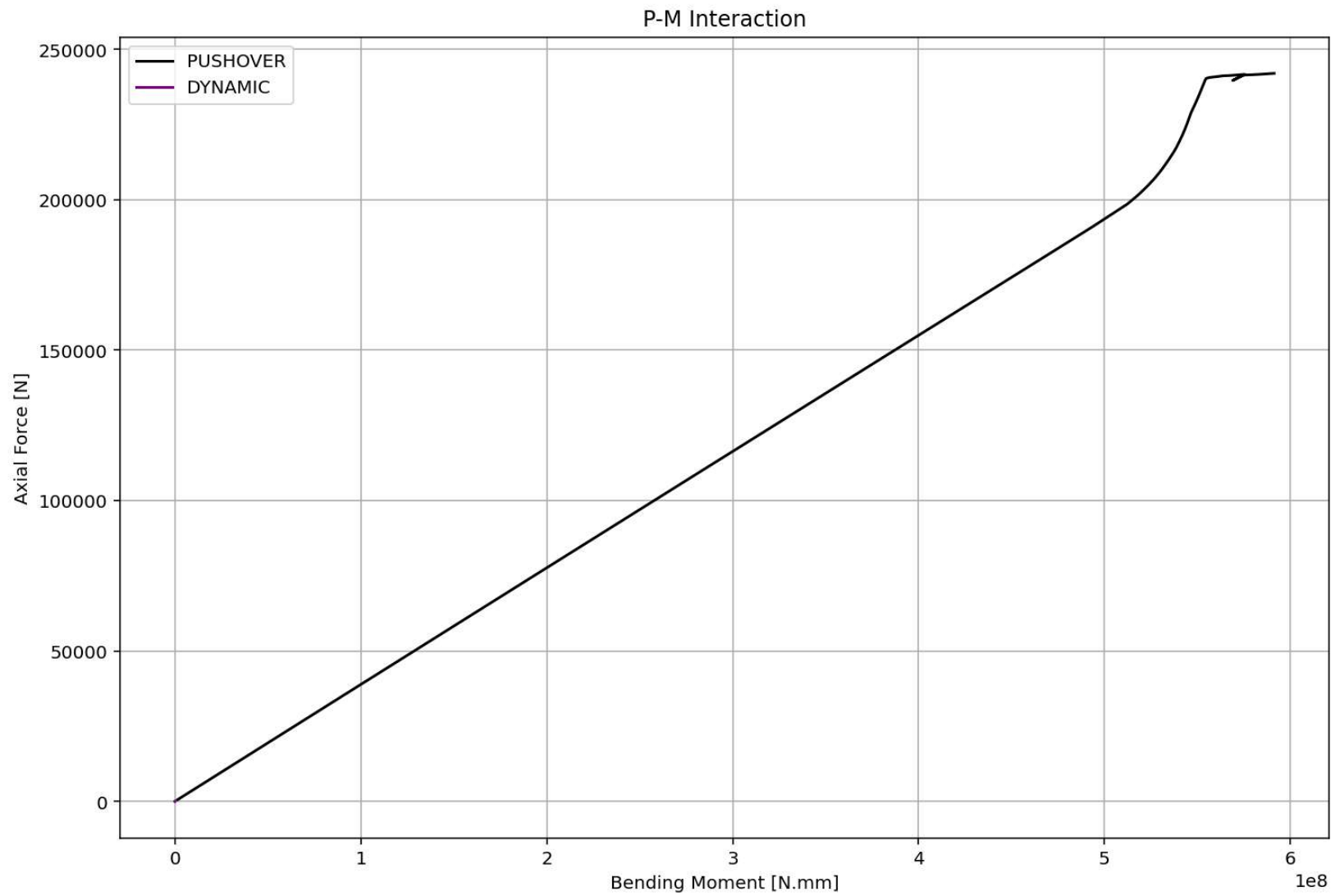
...NSEES_FILES\CONCRETE_FRAME_EXAMPLES\DUCTILITY_DAMAGE_INDEX
24 %
Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 6.4682 - Over Strength Factor: 1.0568
BaseAxial Reaction (N)
Displacement in Y (mm)
Curve
Bilinear Fitted
Help Variable Explorer Debugger Plots Files
Console 1/A
-----+
Over Strength Coefficient (Ω_0): 1.0568
Displacement Ductility Ratio (μ): 6.4682
Ductility Coefficient (R_μ): 6.4682
Structural Behavior Coefficient (R): 6.8357
Structural Ductility Damage Index in Y Direction: -0.1828

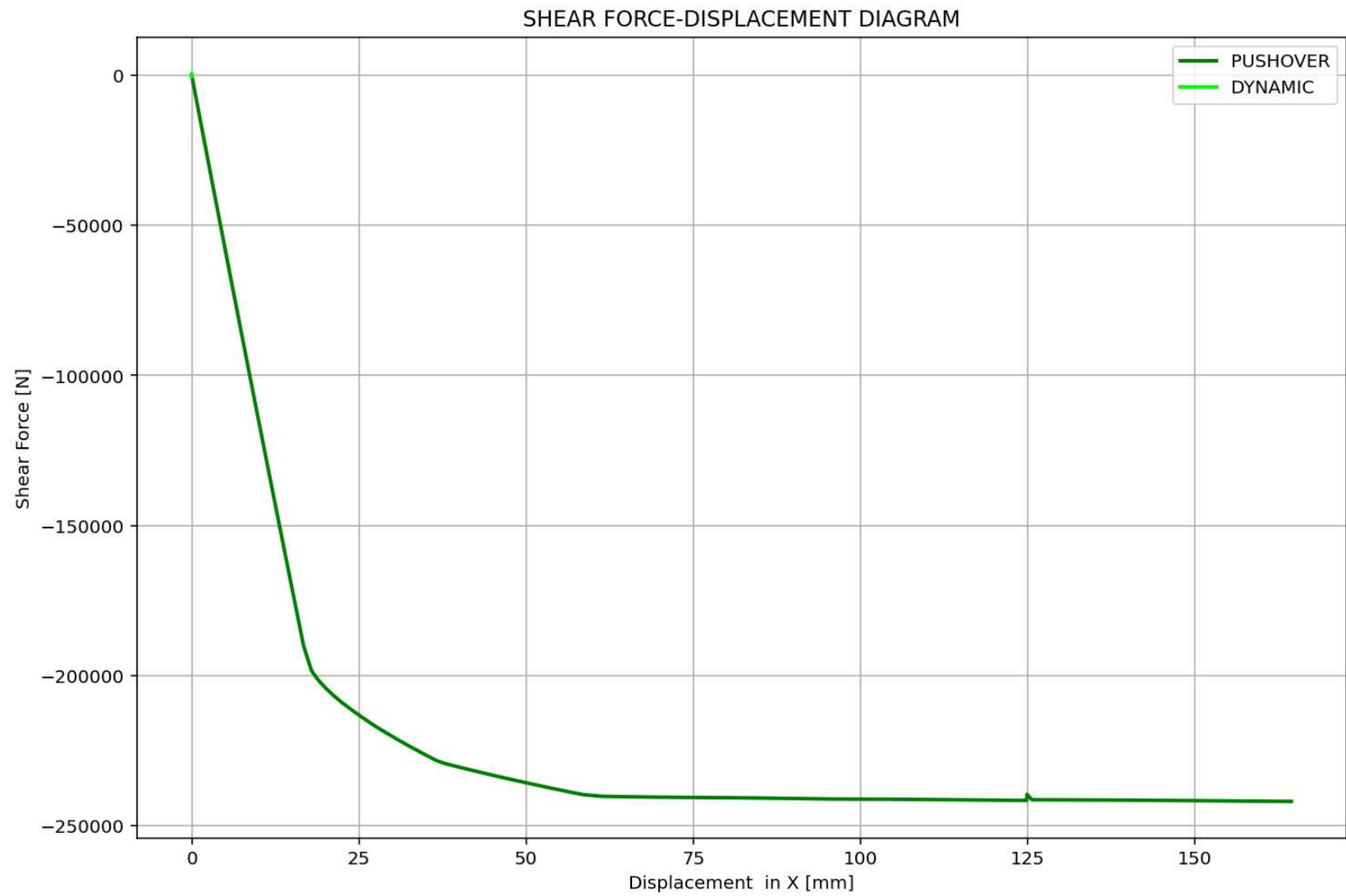
Node: 3
Coordinates : 0 3000
Disps: 0.00629225 0.000347875 -2.82838e-06
Velocities : -0.000316897 -2.73216e-05 1.07006e-07
IPython Console History

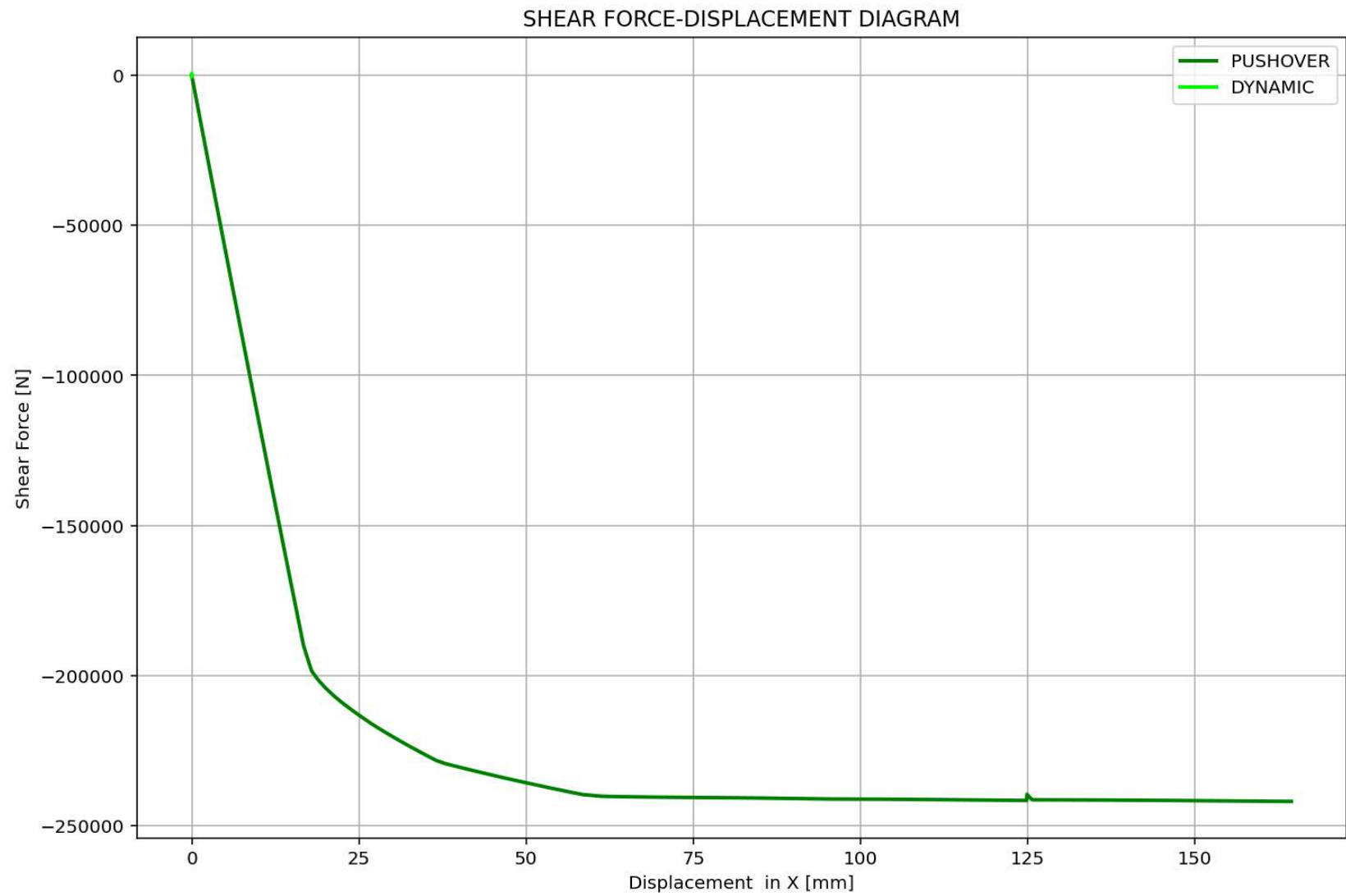
Inline Conda: anaconda3 (Python 3.12.7) ✓ LSP: Python Line 45, Col 84 UTF-8 CRLF RW Mem 40%

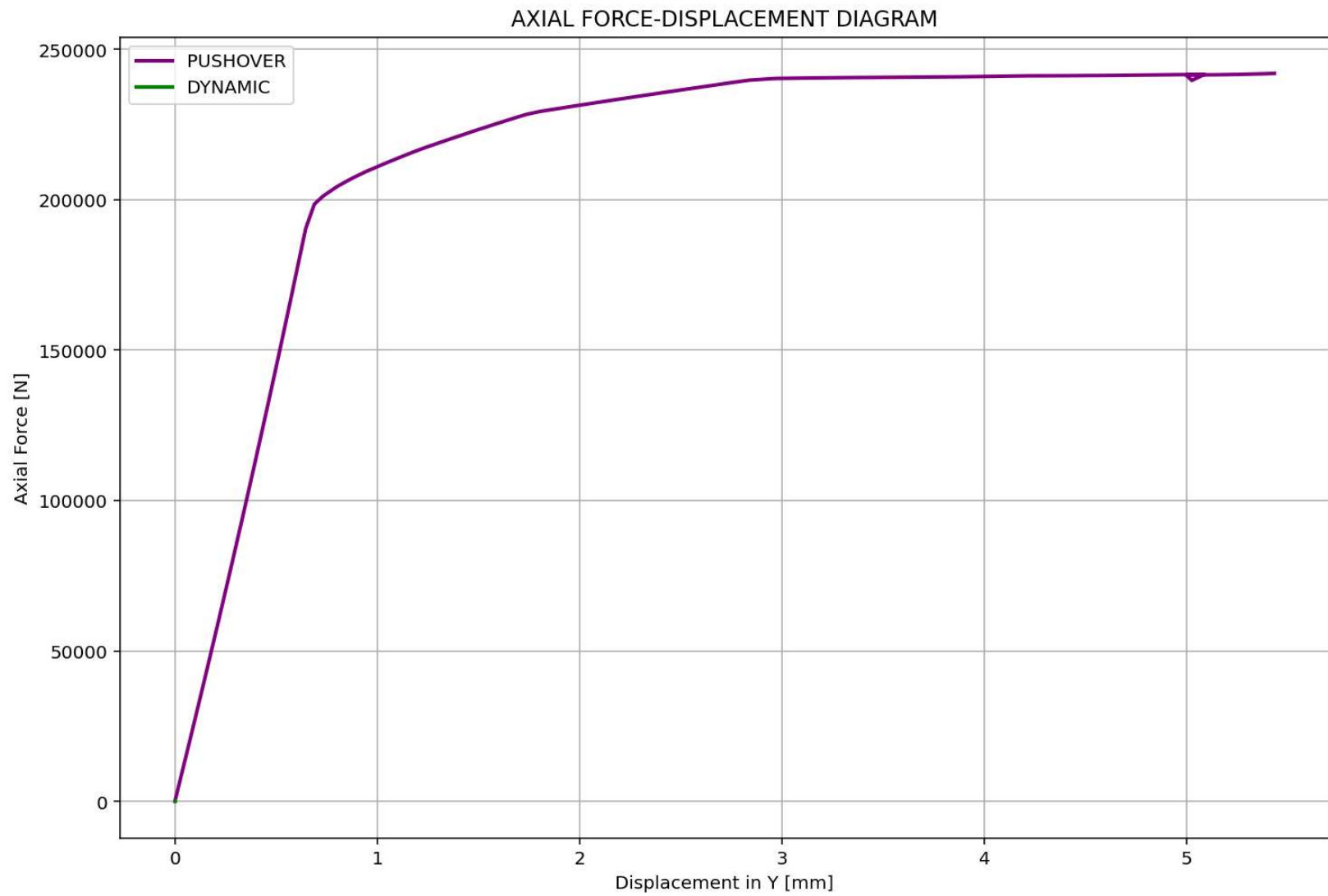
NONLINEAR STATIC ANALYSIS (PUSHOVER)

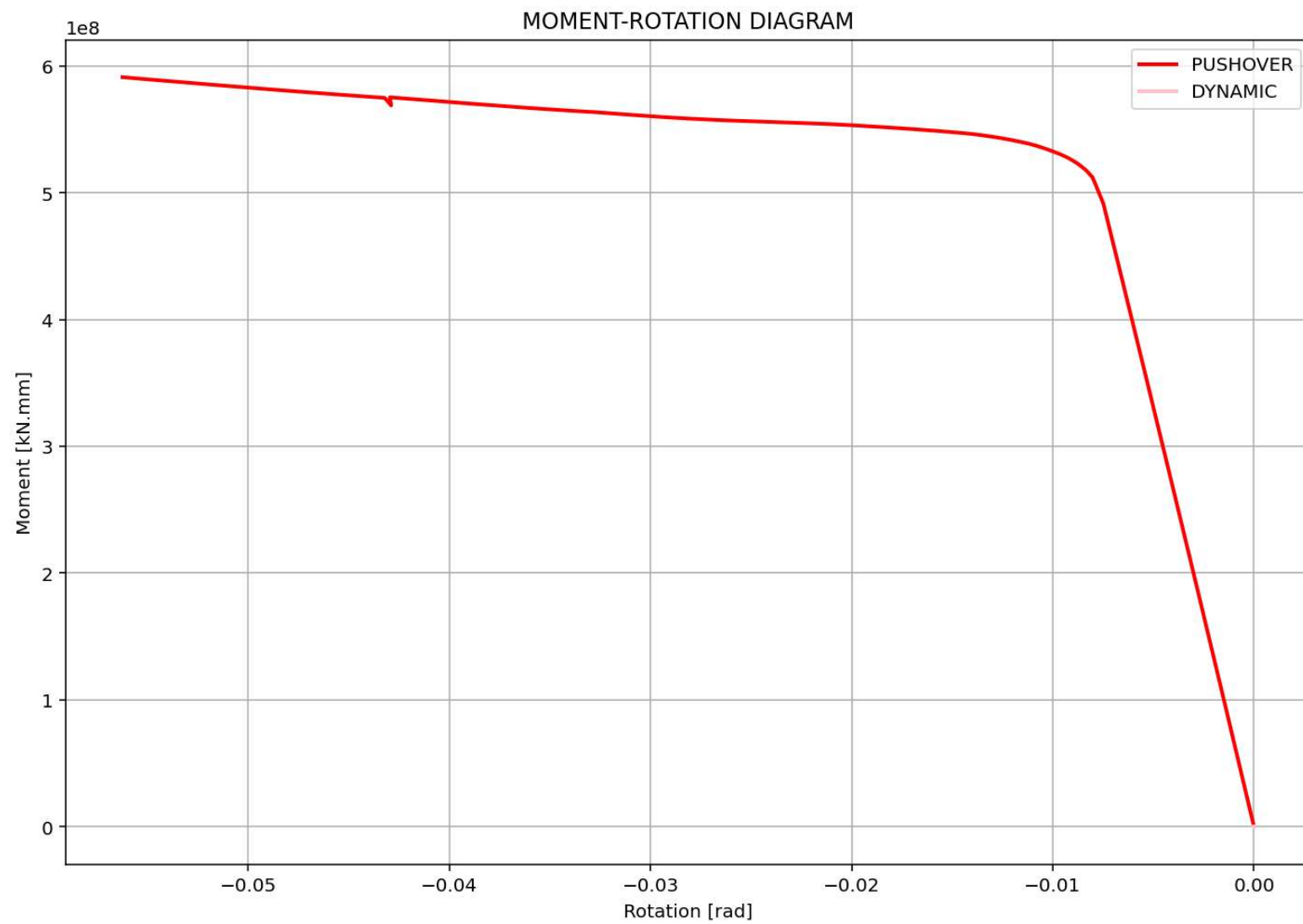




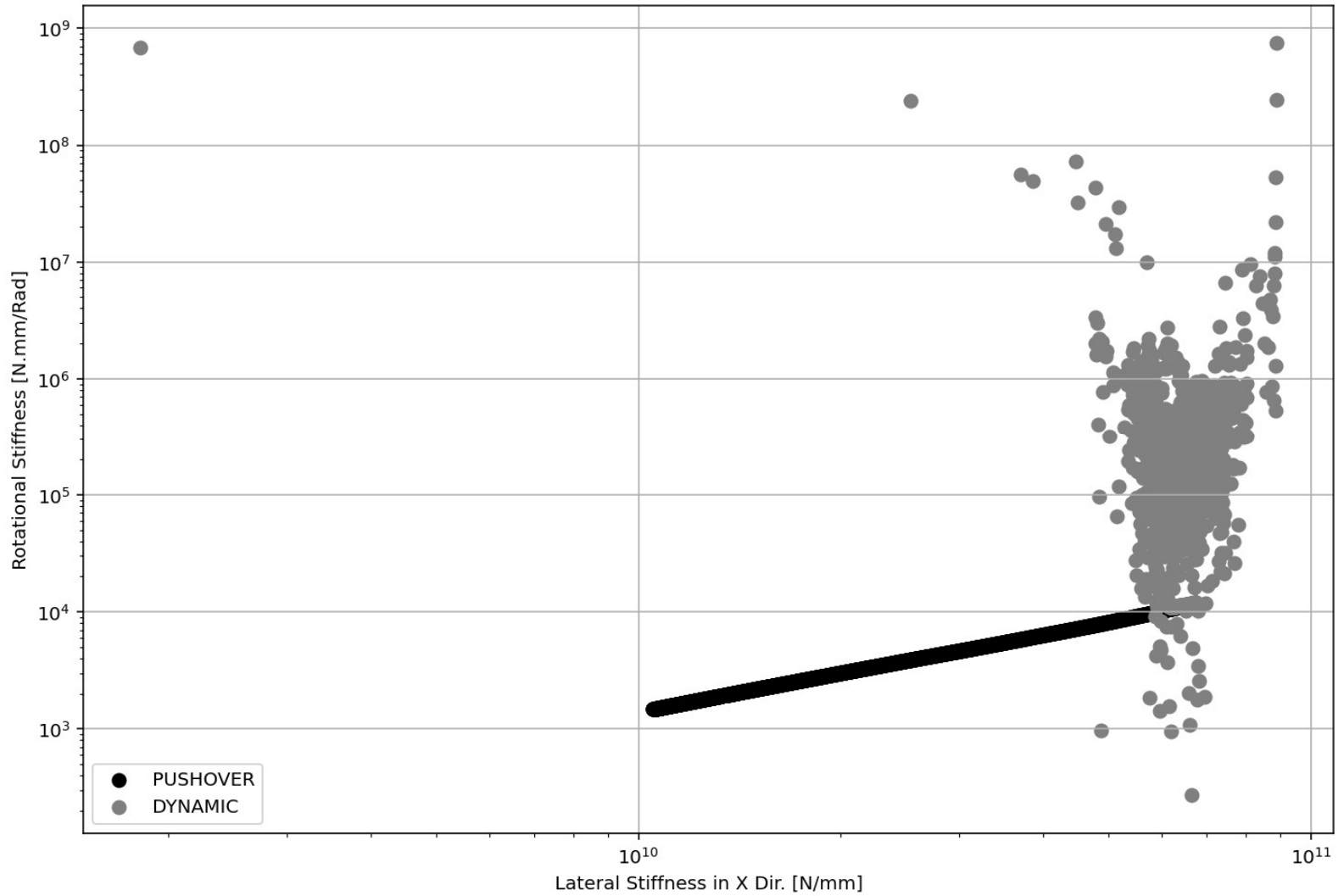




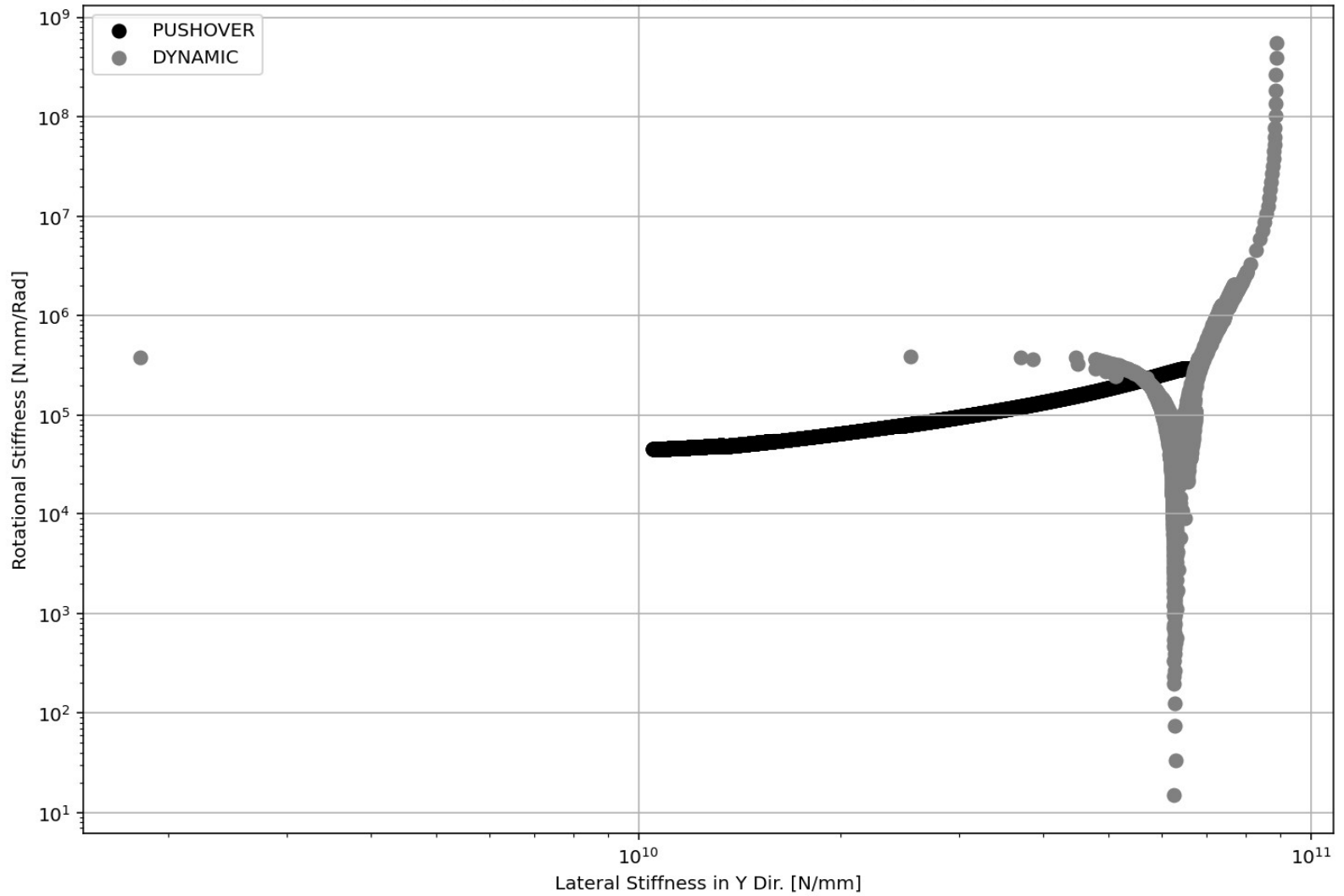




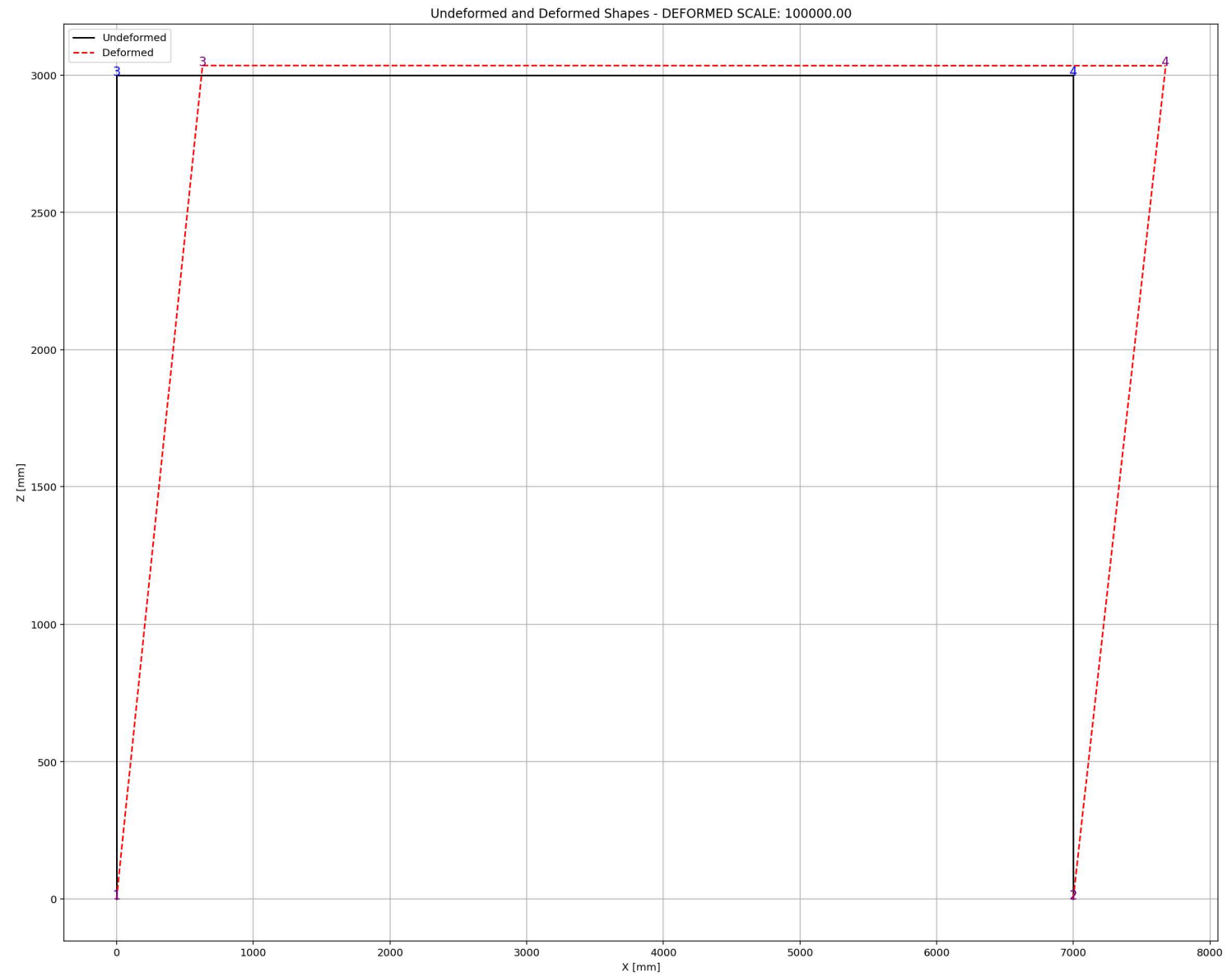
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM



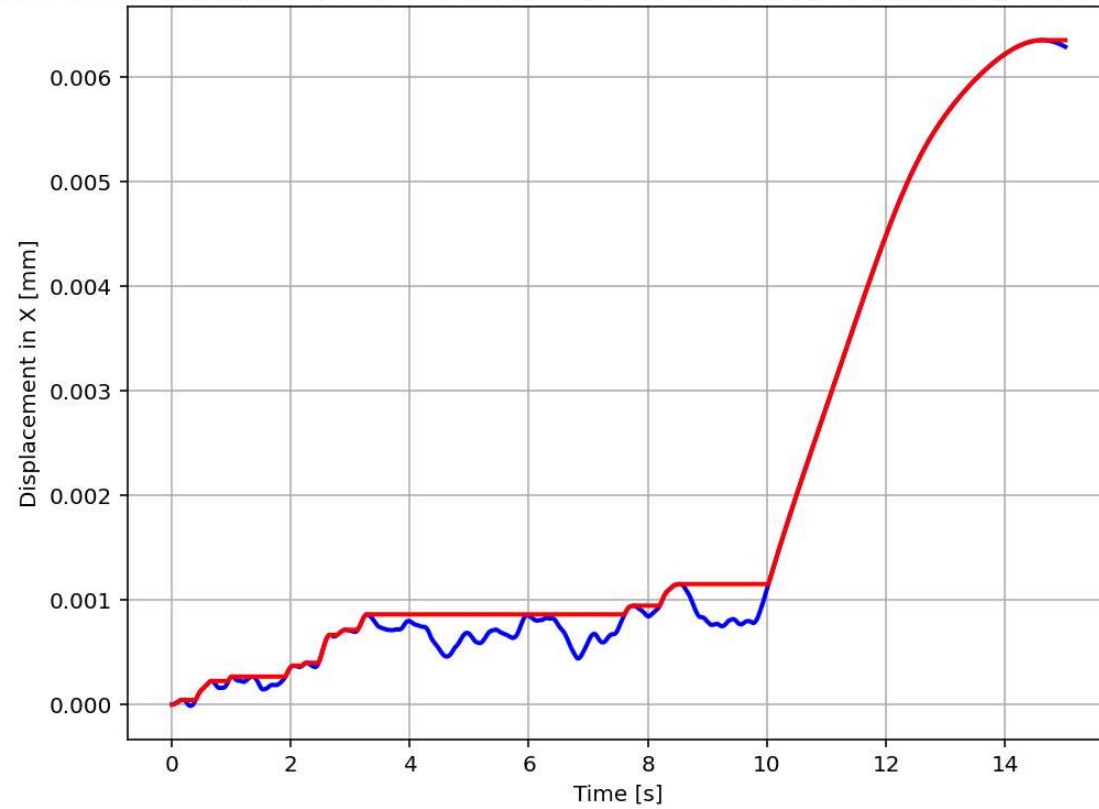
ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM

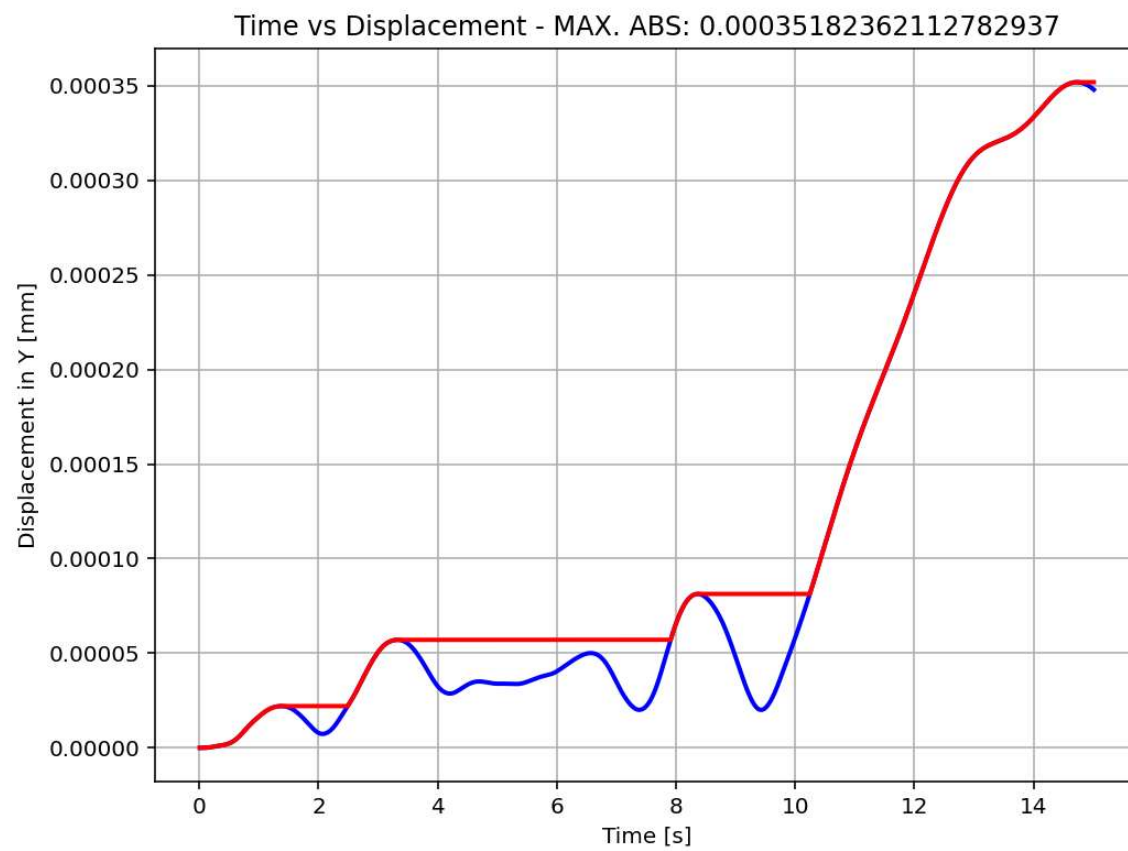


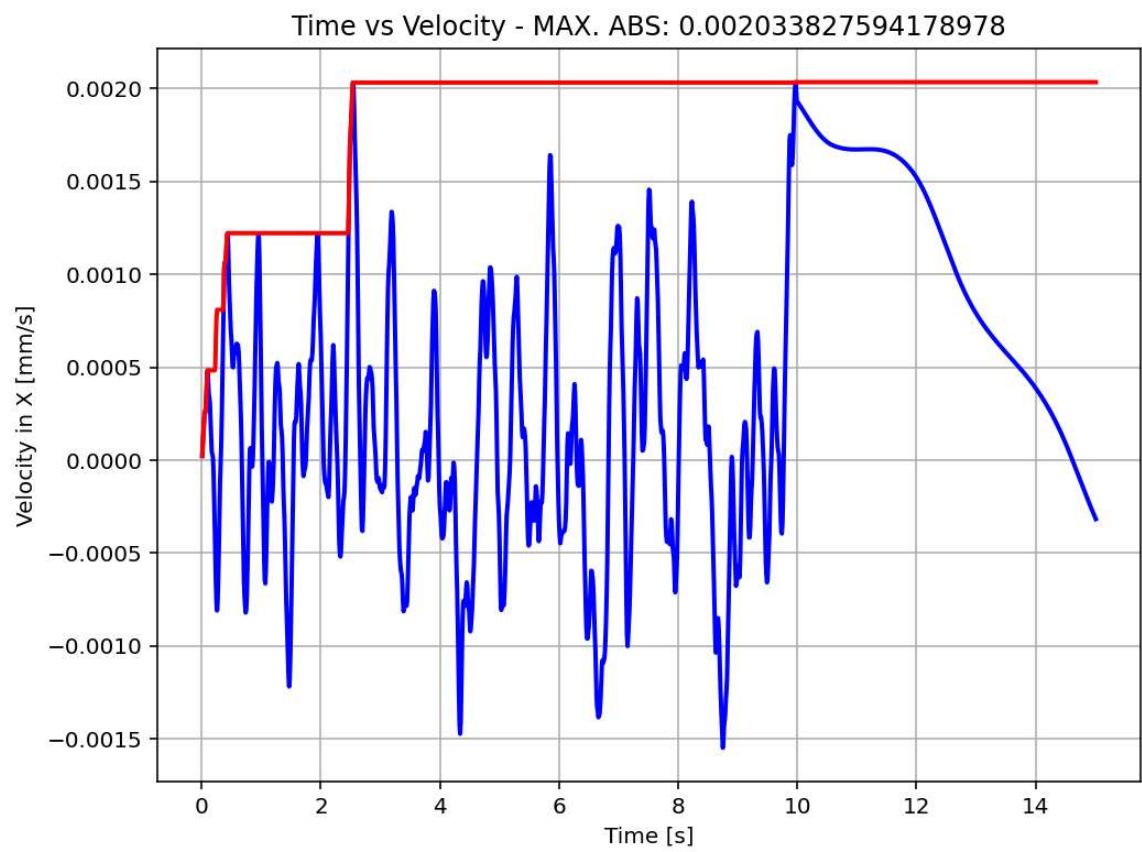
NONLINEAR DYNAMIC ANALYSIS

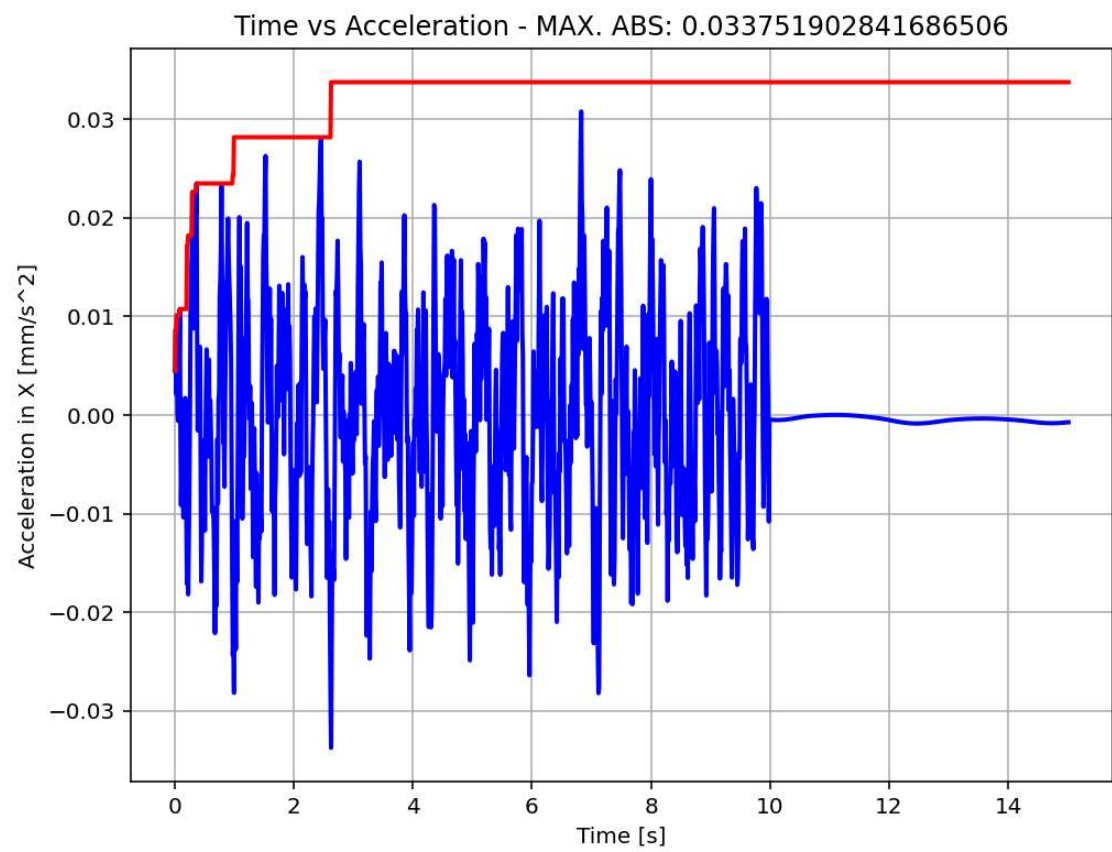


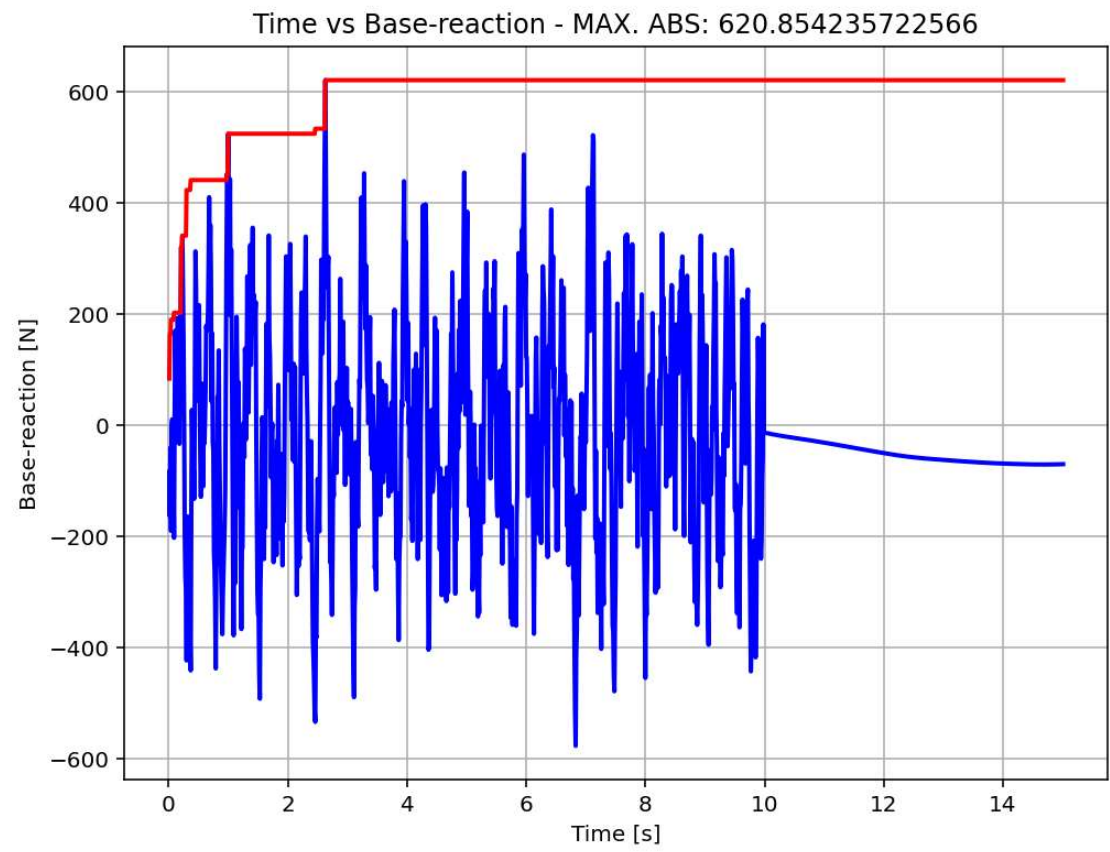
Time vs Displacement - MAX. ABS: 0.0063555360038611815 | ξ (Calculated): 3.04716e+00 %



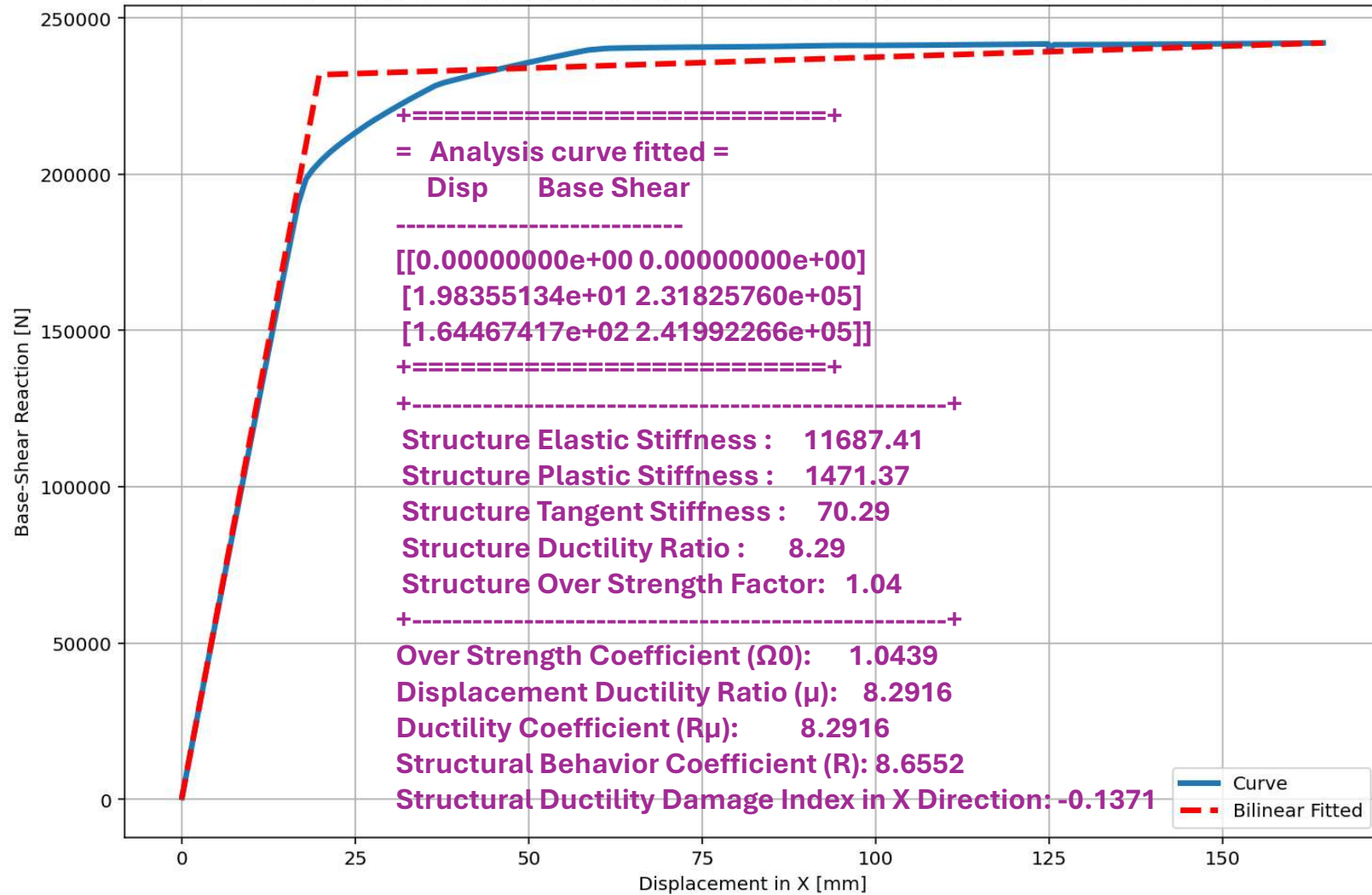








Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 8.2916 - Over Strength Factor: 1.0439



Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 6.4682 - Over Strength Factor: 1.0568

