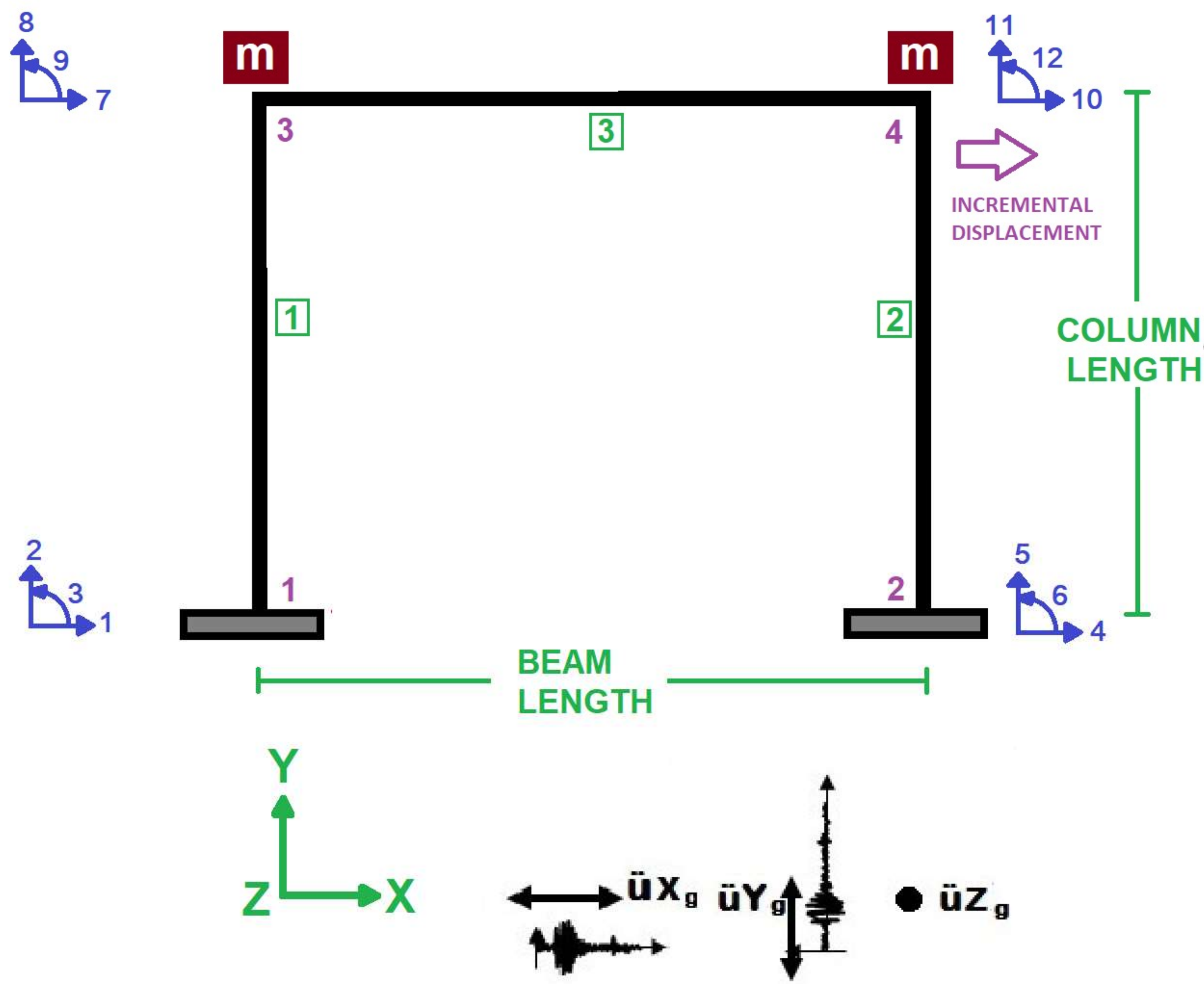
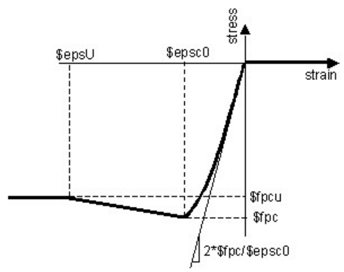
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

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

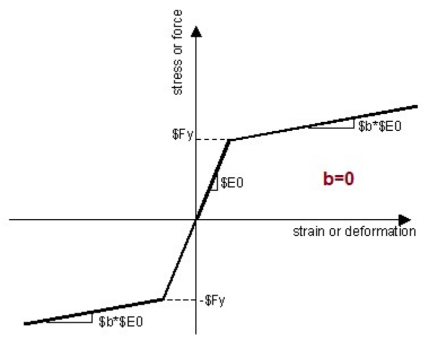
WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)



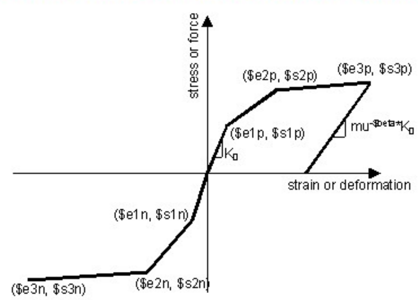
8
9
7
m
m
11
12
10
3
3
4
INCREMENTAL
DISPLACEMENT
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH
Y
Z
X
üX g
üY g
üZ g



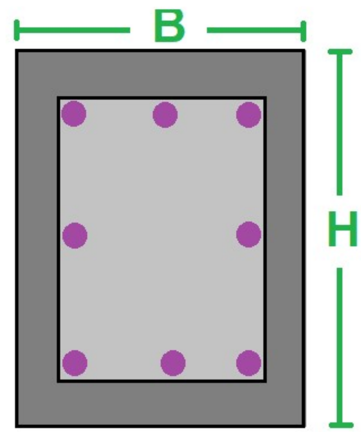
CORE AND COVER CONCRETE RELATION



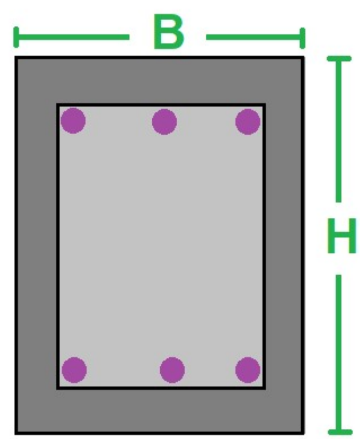
WITHOUT HARDENING AND ULTIMATE STRAIN



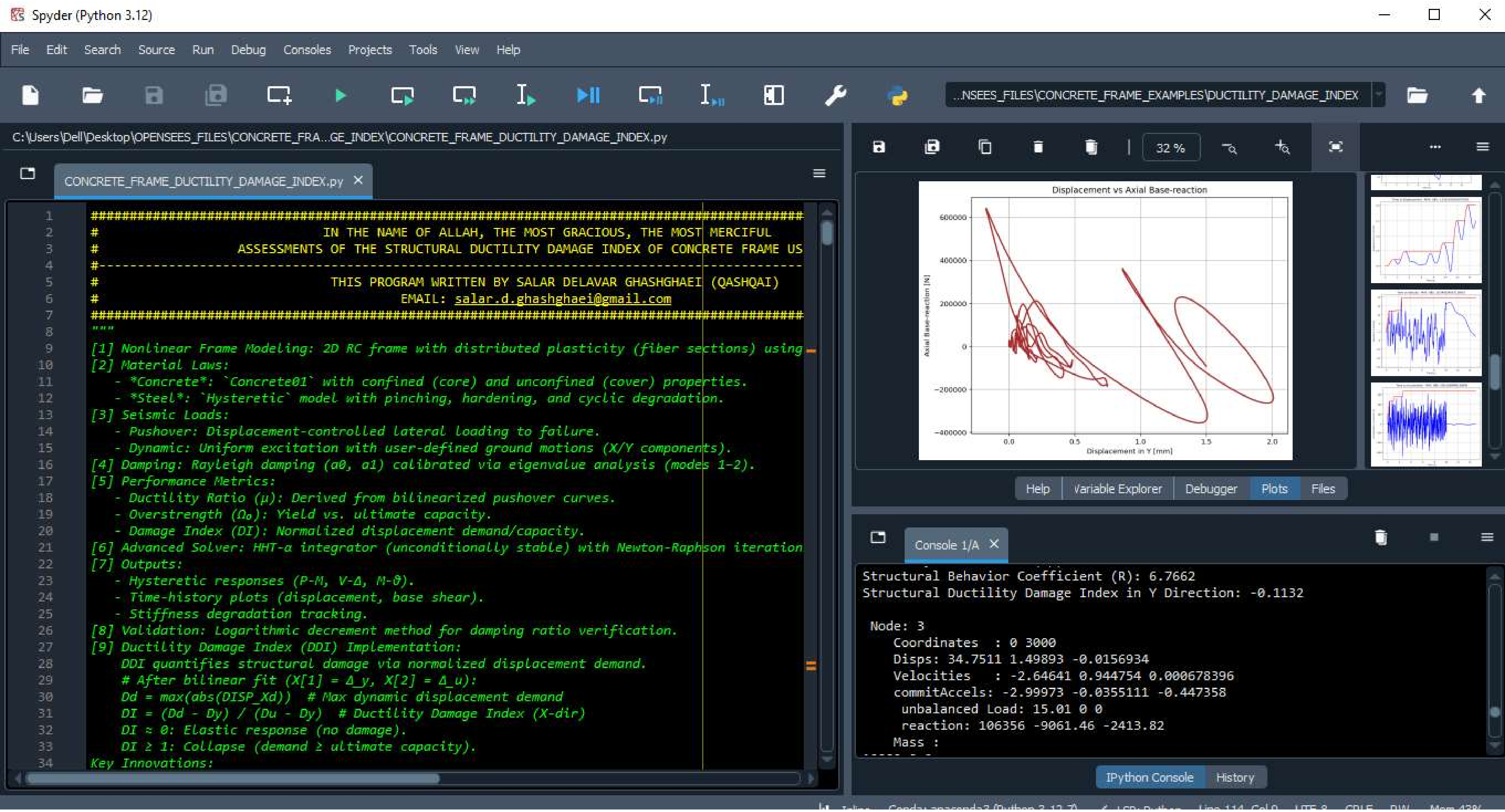
WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION


Spyder (Python 3.12)
File Edit Search Source Run Debug Consoles Projects Tools View Help
..NSEES_FILES\CONCRETE_FRAME_EXAMPLES\DUCTILITY_DAMAGE_INDEX
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...GE_INDEX\CONCRETE_FRAME_DUCTILITY_DAMAGE_INDEX.py
CONCRETE_FRAME_DUCTILITY_DAMAGE_INDEX.py
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL
ASSESSMENTS OF THE STRUCTURAL DUCTILITY DAMAGE INDEX OF CONCRETE FRAME US
THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
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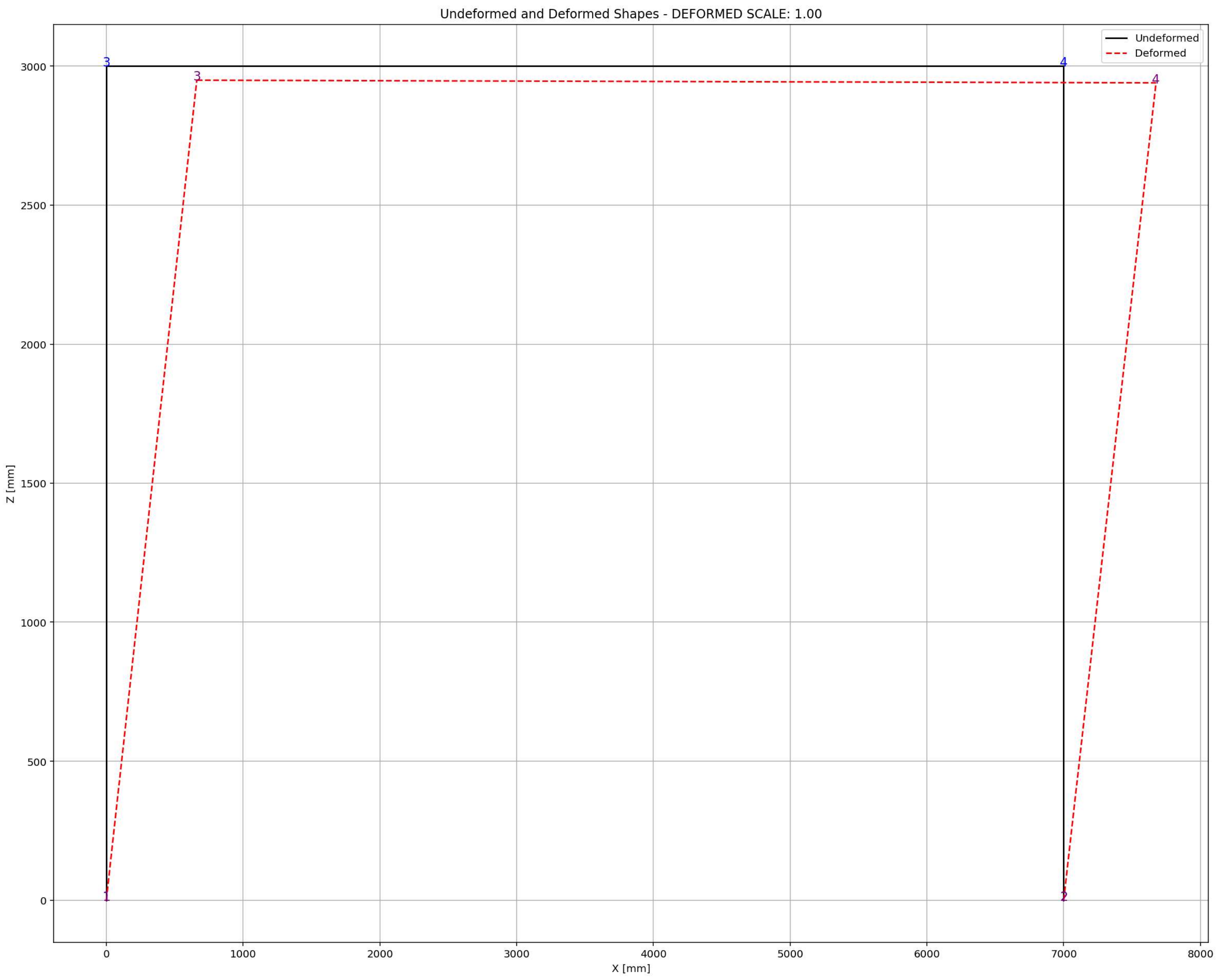
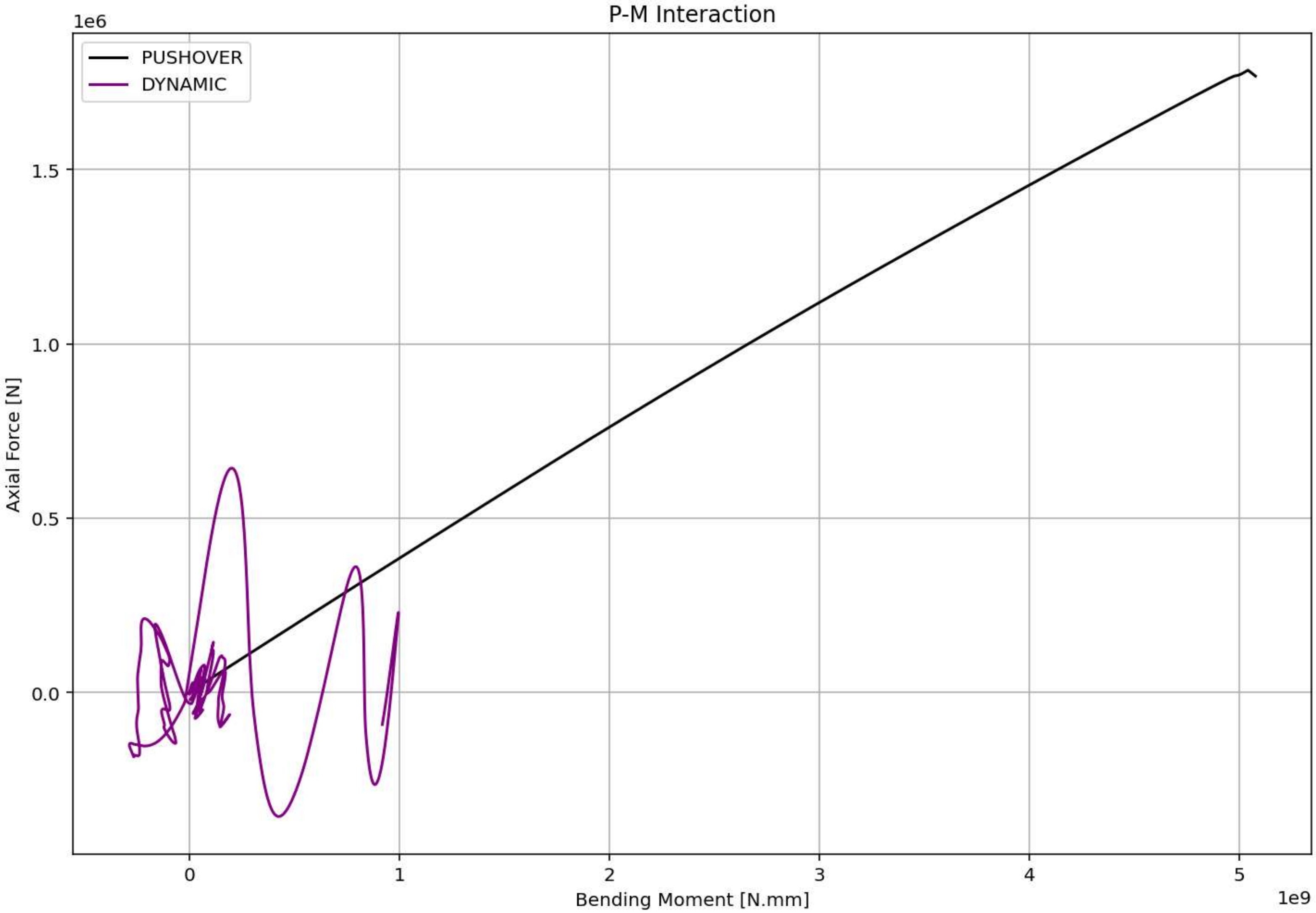
"""
[1] Nonlinear Frame Modeling: 2D RC frame with distributed plasticity (fiber sections) using
[2] Material Laws:
- *Concrete*: `Concrete01` with confined (core) and unconfined (cover) properties.
- *Steel*: `Hysteretic` model with pinching, hardening, and cyclic degradation.
[3] Seismic Loads:
- Pushover: Displacement-controlled lateral loading to failure.
- Dynamic: Uniform excitation with user-defined ground motions (X/Y components).
[4] Damping: Rayleigh damping (a0, a1) calibrated via eigenvalue analysis (modes 1-2).
[5] Performance Metrics:
- Ductility Ratio (μ): Derived from bilinearized pushover curves.
- Overstrength (Ω₀): Yield vs. ultimate capacity.
- Damage Index (DI): Normalized displacement demand/capacity.
[6] Advanced Solver: HHT-α integrator (unconditionally stable) with Newton-Raphson iteration
[7] Outputs:
- Hysteretic responses (P-M, V-Δ, M-θ).
- Time-history plots (displacement, base shear).
- Stiffness degradation tracking.
[8] Validation: Logarithmic decrement method for damping ratio verification.
[9] Ductility Damage Index (DDI) Implementation:
DDI quantifies structural damage via normalized displacement demand.
# After bilinear fit (X[1] = Δ_y, X[2] = Δ_u):
Dd = max(abs(DISP_Xd)) # Max dynamic displacement demand
DI = (Dd - Dy) / (Du - Dy) # Ductility Damage Index (X-dir)
DI ≈ 0: Elastic response (no damage).
DI ≥ 1: Collapse (demand ≥ ultimate capacity).
Key Innovations:
32 %
Displacement vs Axial Base-reaction
Axial Base-reaction [N]
Displacement in Y [mm]
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

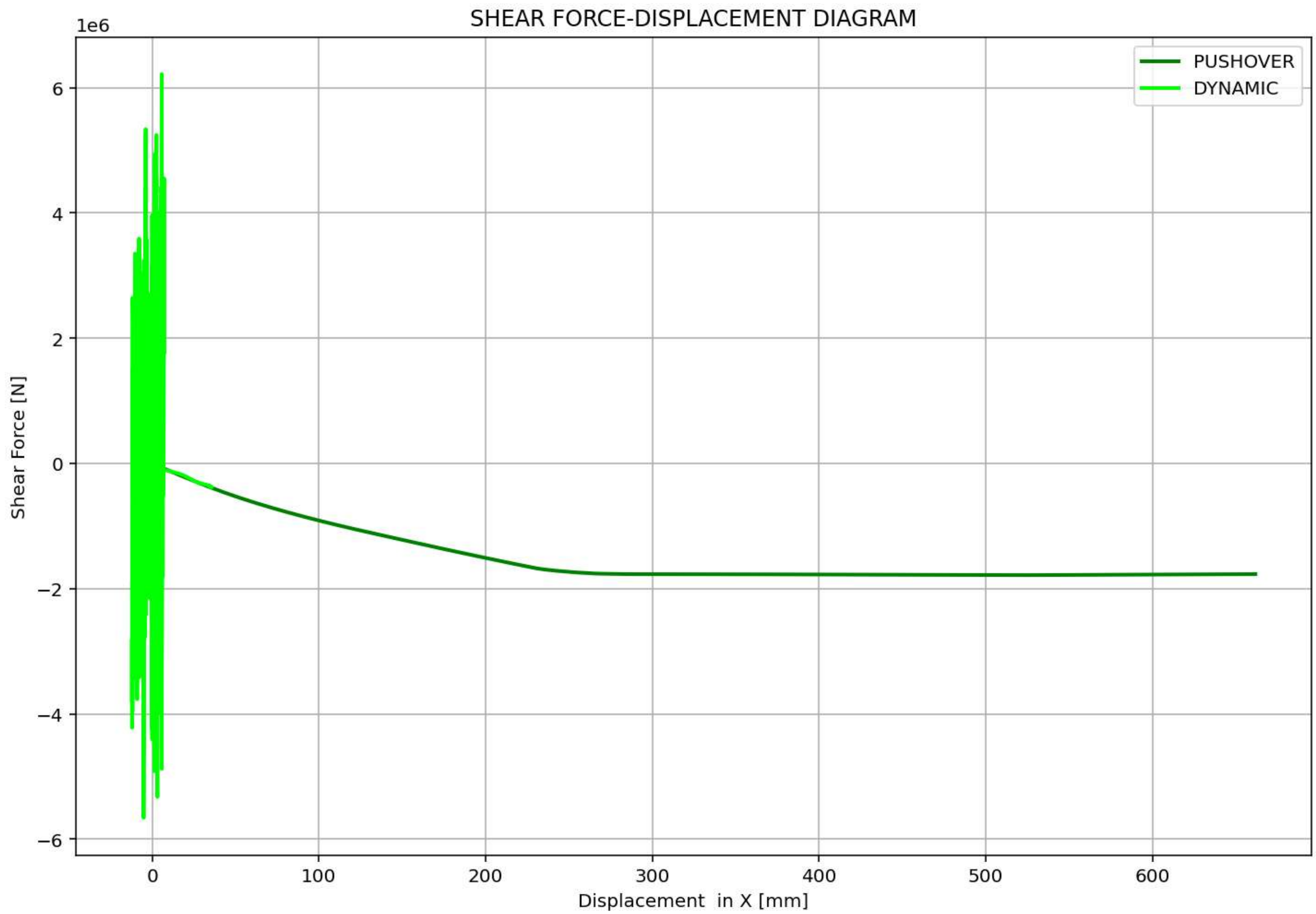
NONLINEAR STATIC ANALYSIS
(PUSHOVER)

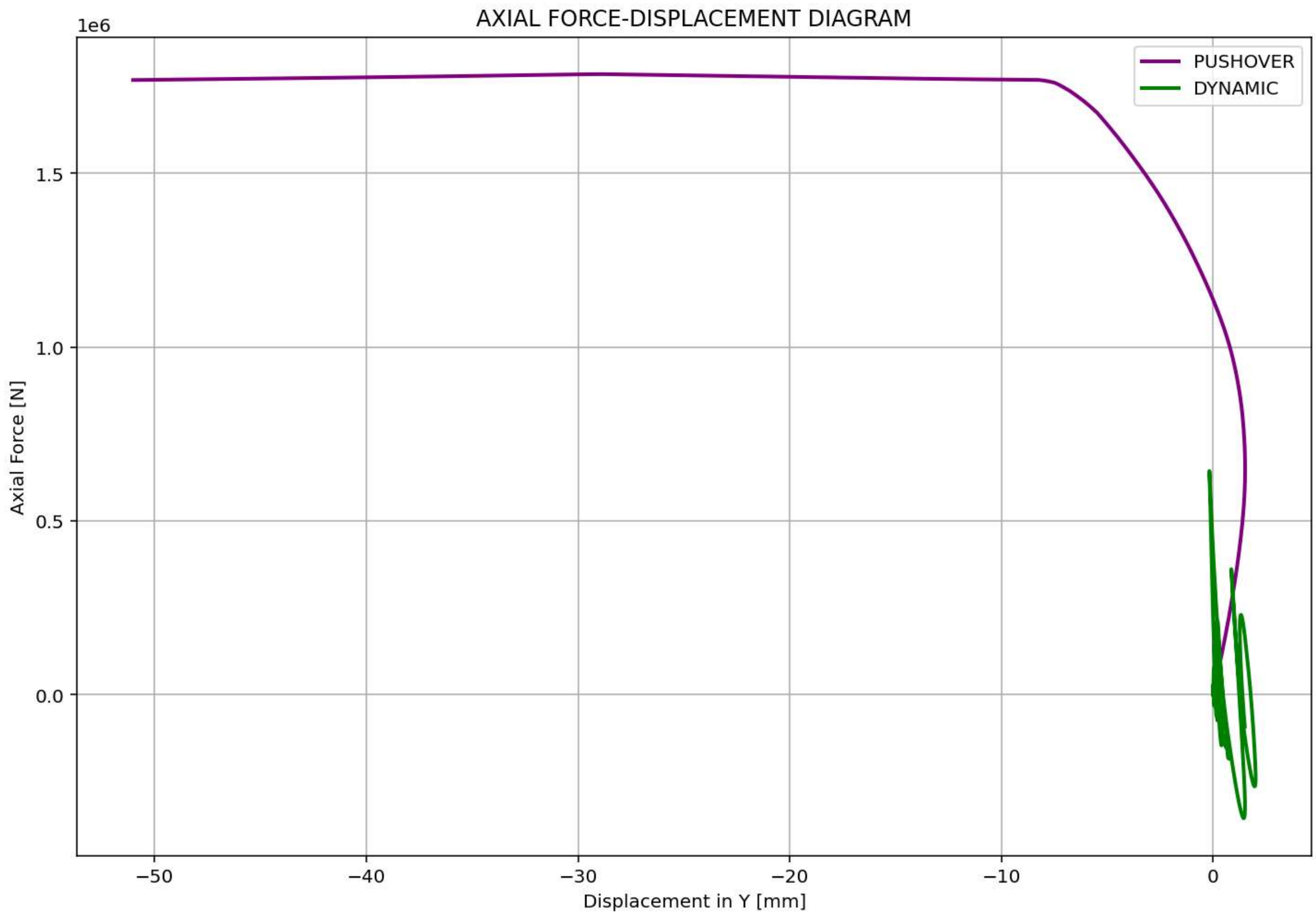


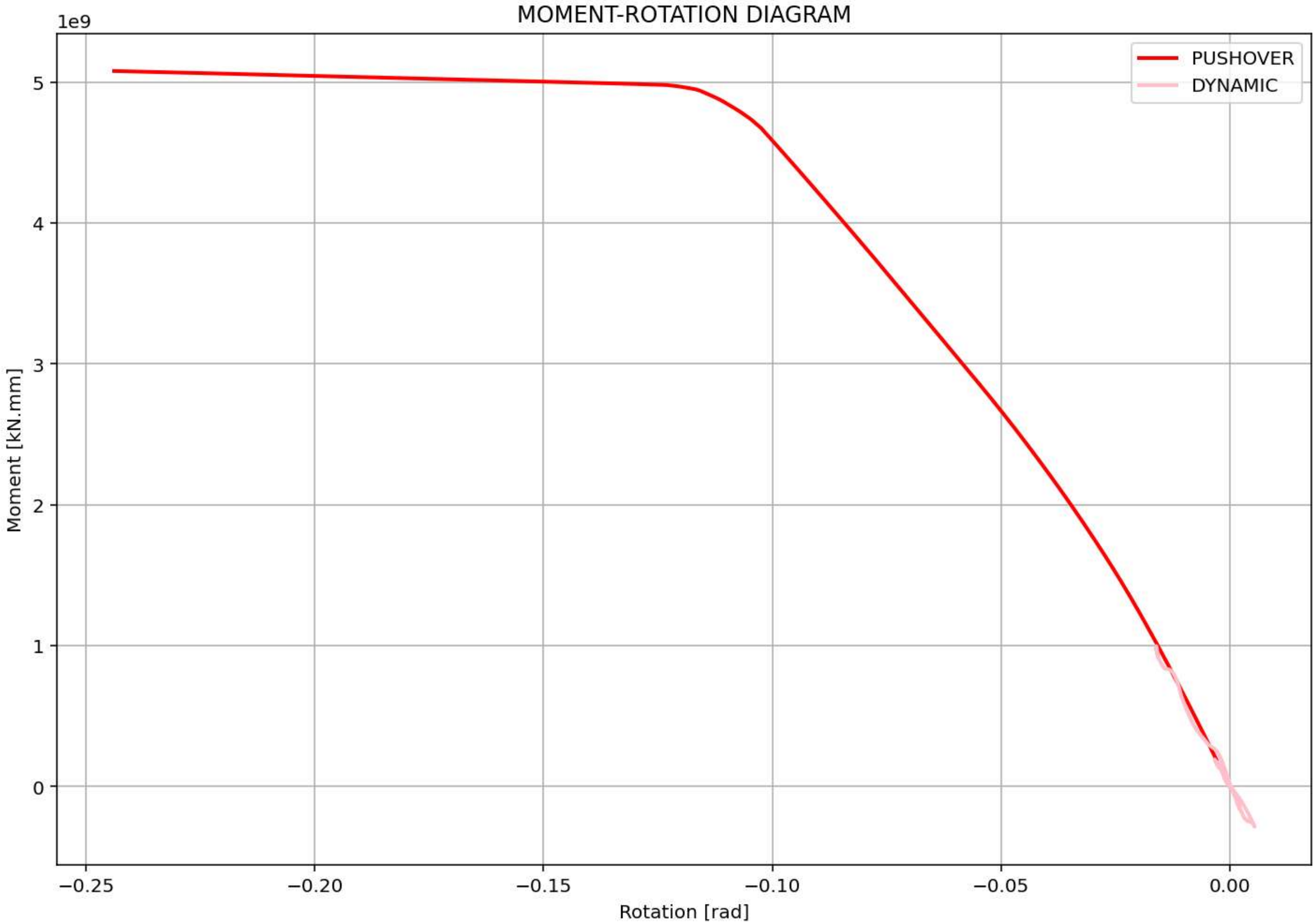
Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
3
4
3
4
1
2
0
500
1000
1500
2000
2500
3000
Z [mm]
0
1000
2000
3000
4000
5000
6000
7000
8000
X [mm]

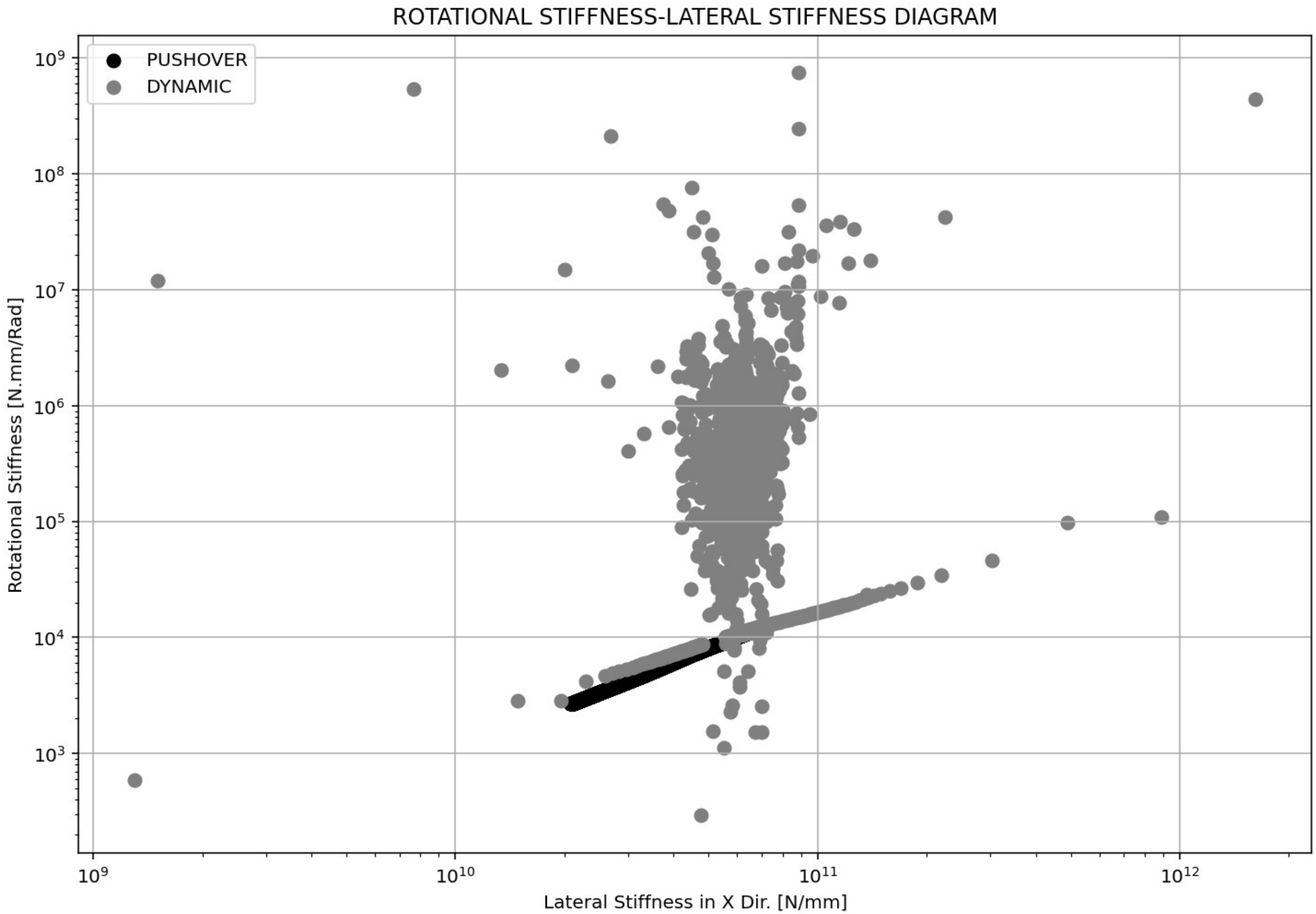


P-M Interaction
1e6
PUSHOVER
DYNAMIC
1.5
1.0
0.5
0.0
Axial Force [N]
0
1
2
3
4
5
1e9
Bending Moment [N.mm]

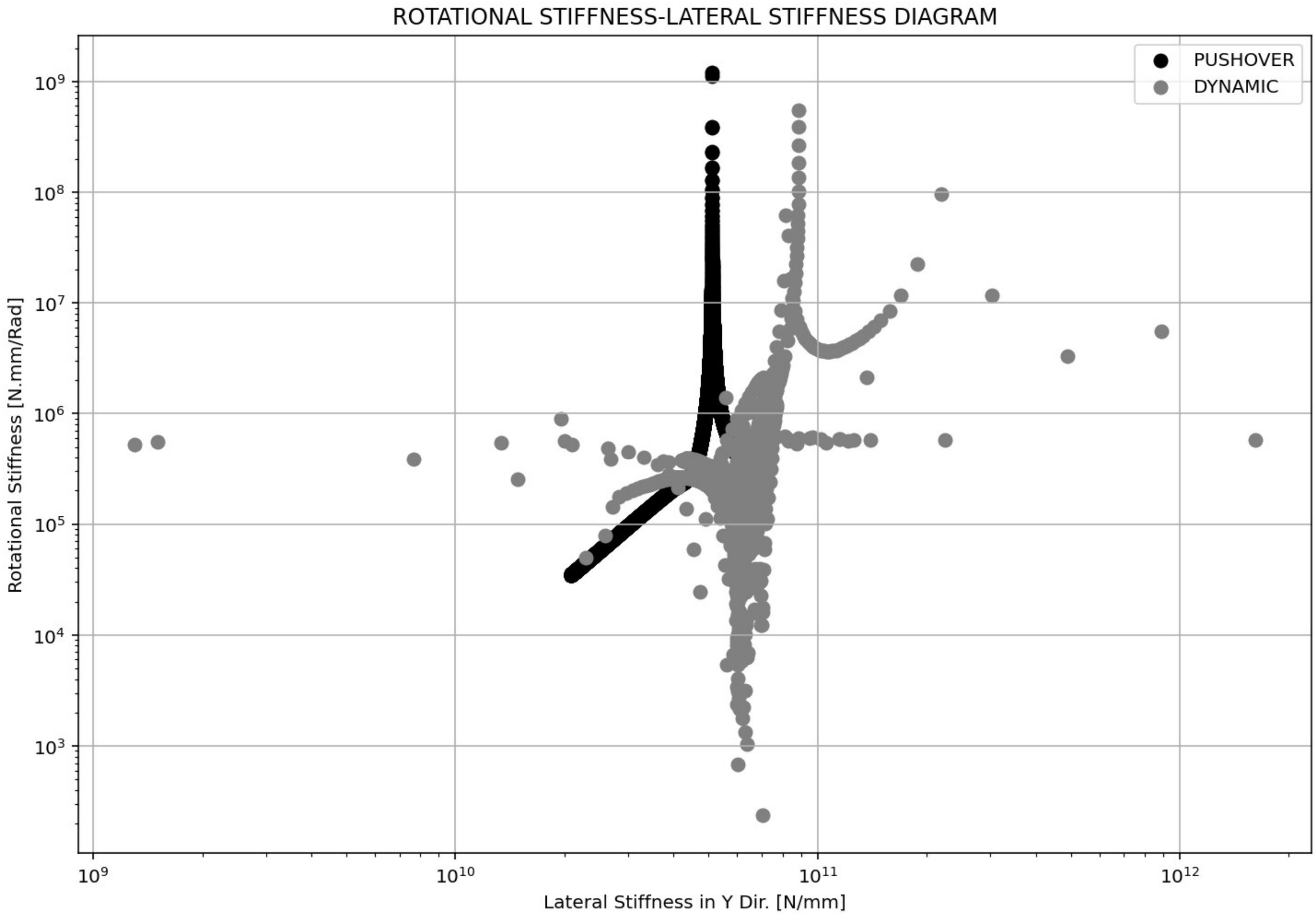

SHEAR FORCE-DISPLACEMENT DIAGRAM
1e6
PUSHOVER
DYNAMIC
Shear Force [N]
Displacement in X [mm]
6
4
2
0
−2
−4
−6
0
100
200
300
400
500
600

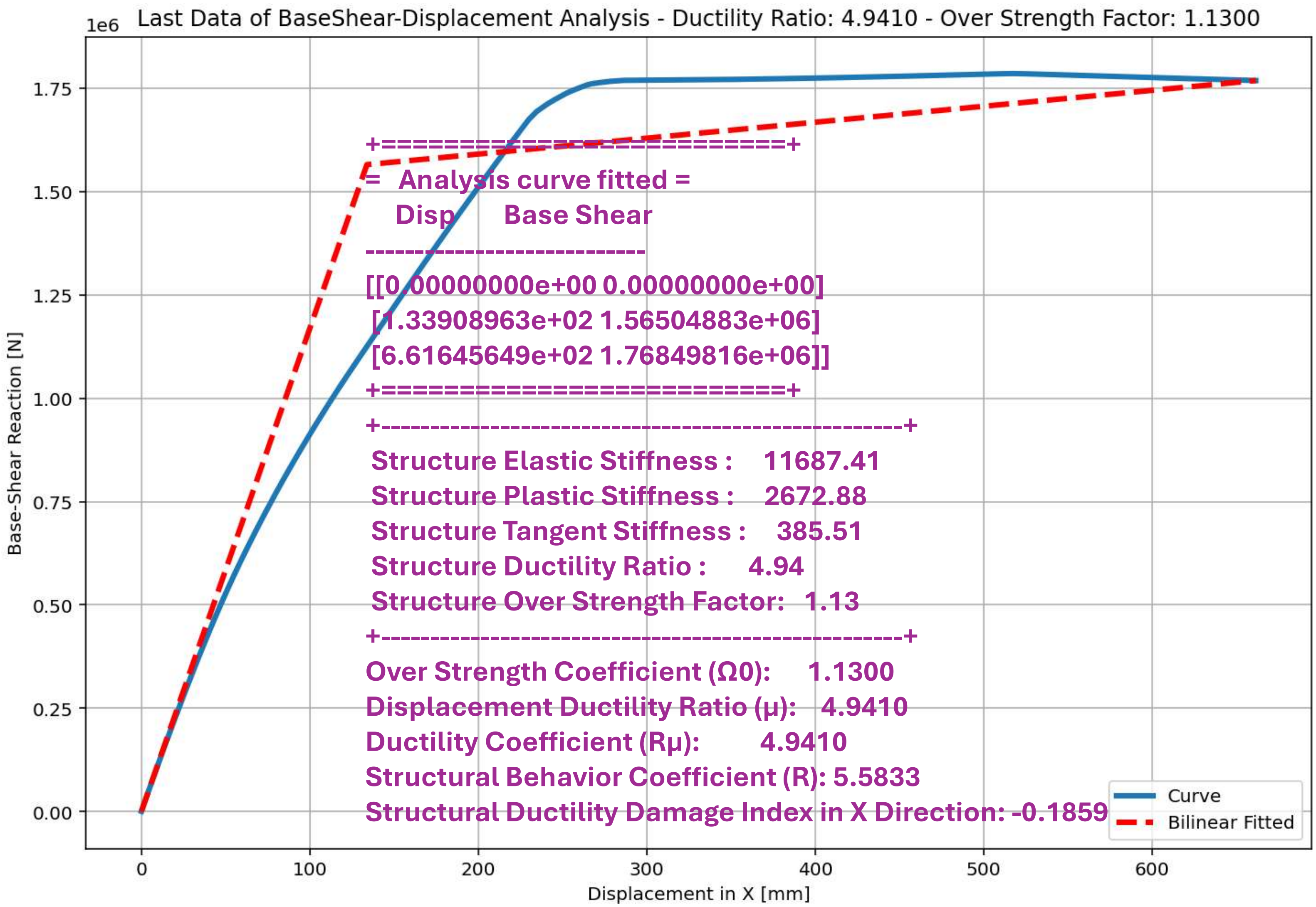

AXIAL FORCE-DISPLACEMENT DIAGRAM
1e6
PUSHOVER
DYNAMIC
Axial Force [N]
1.5
1.0
0.5
0.0
−50
−40
−30
−20
−10
0
Displacement in Y [mm]


MOMENT-ROTATION DIAGRAM
1e9
PUSHOVER
DYNAMIC
5
4
3
2
1
0
Moment [kN.mm]
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
Rotation [rad]

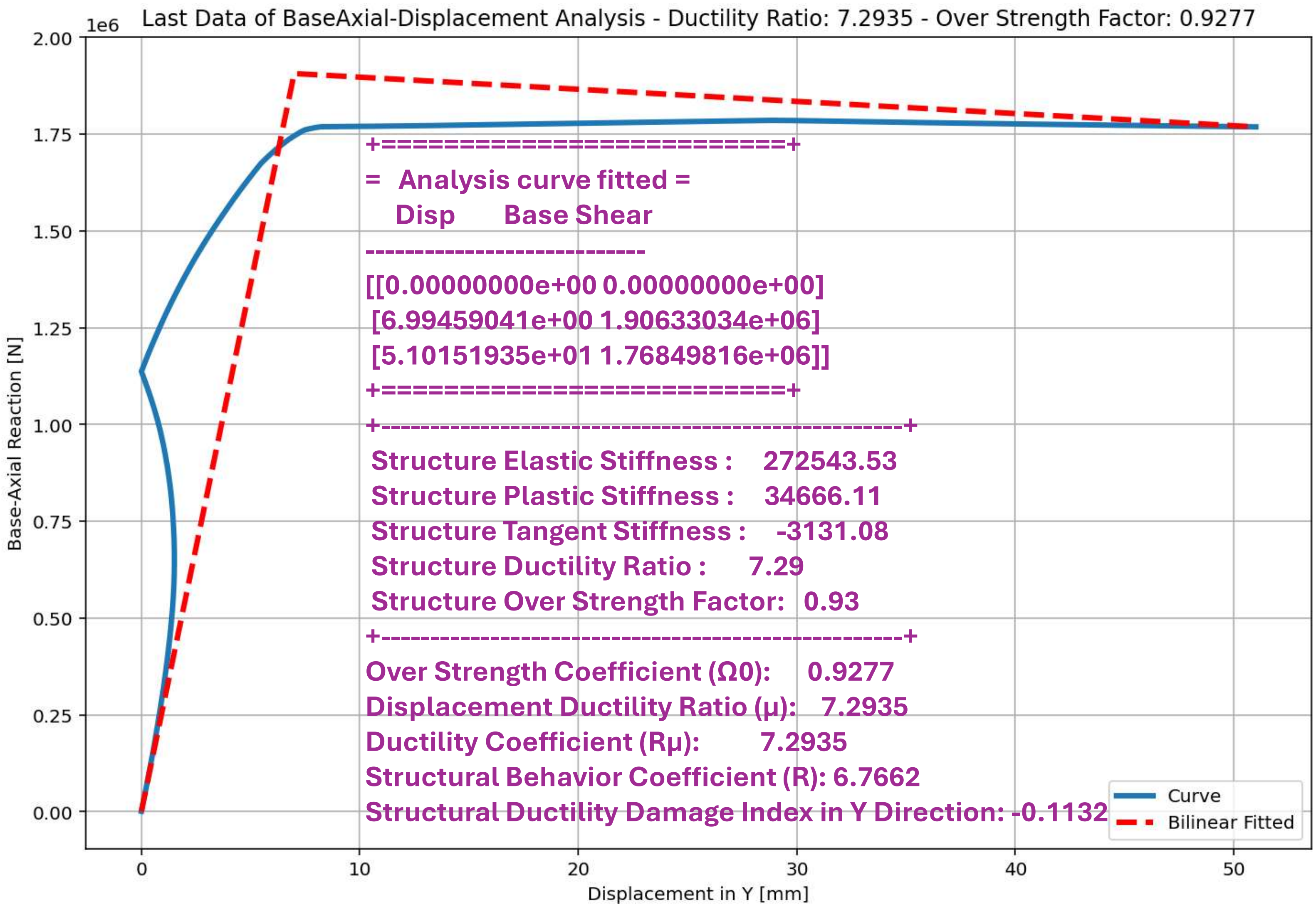


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
PUSHOVER
DYNAMIC
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in X Dir. [N/mm]
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^{10}
10^{11}
10^{12}


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
PUSHOVER
DYNAMIC
Rotational Stiffness [N.mm/Rad]
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^9
10^{10}
10^{11}
10^{12}
Lateral Stiffness in Y Dir. [N/mm]

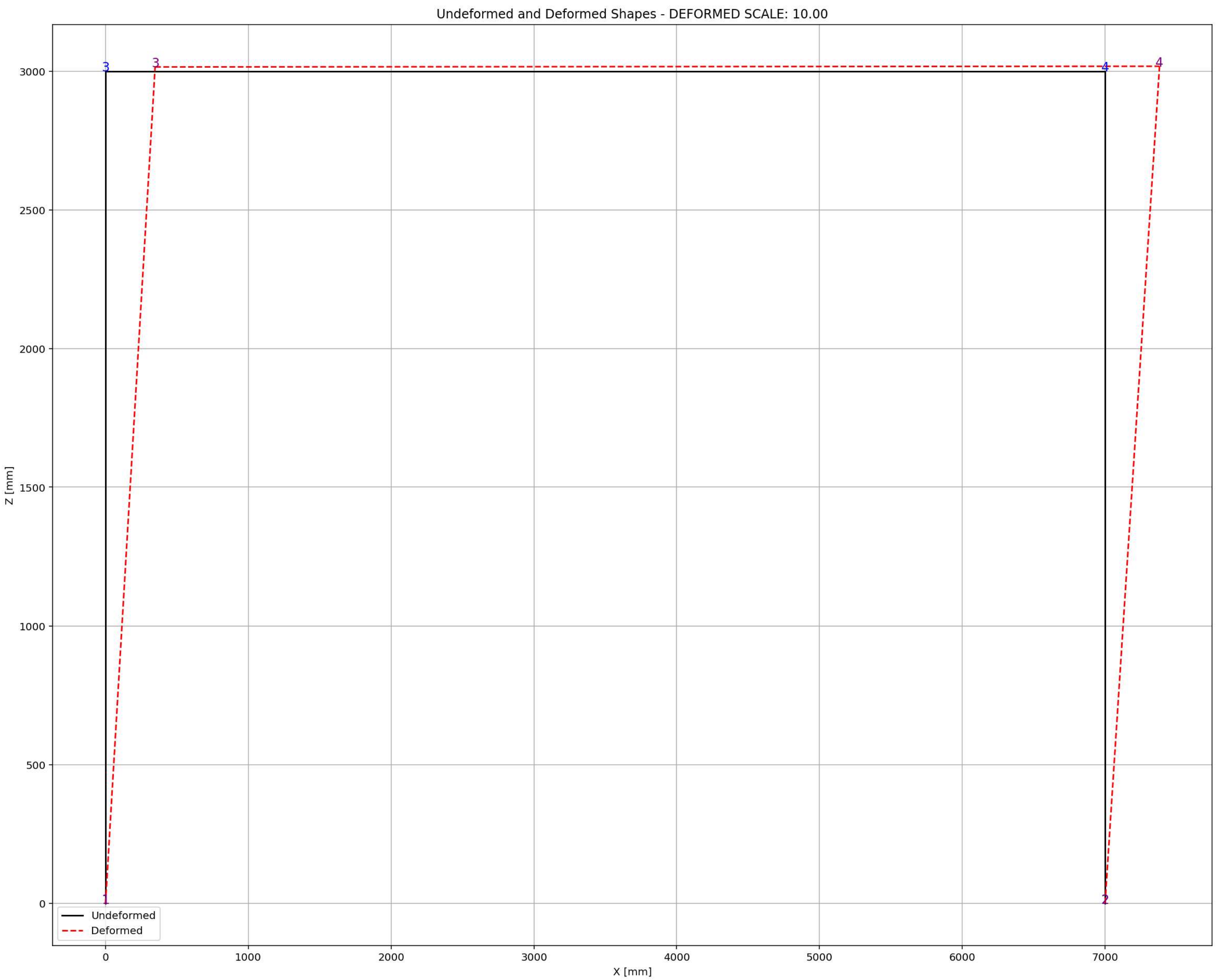

Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 4.9410 - Over Strength Factor: 1.1300
1e6
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Base-Shear Reaction [N]
0
100
200
300
400
500
600
Displacement in X [mm]
+==========================+
= Analysis curve fitted =
Disp Base Shear

[[0.00000000e+00 0.00000000e+00]
[1.33908963e+02 1.56504883e+06]
[6.61645649e+02 1.76849816e+06]]
+==========================+
+--+
Structure Elastic Stiffness : 11687.41
Structure Plastic Stiffness : 2672.88
Structure Tangent Stiffness : 385.51
Structure Ductility Ratio : 4.94
Structure Over Strength Factor: 1.13
+--+
Over Strength Coefficient (Ω0): 1.1300
Displacement Ductility Ratio (μ): 4.9410
Ductility Coefficient (Rμ): 4.9410
Structural Behavior Coefficient (R): 5.5833
Structural Ductility Damage Index in X Direction: -0.1859
Curve
Bilinear Fitted

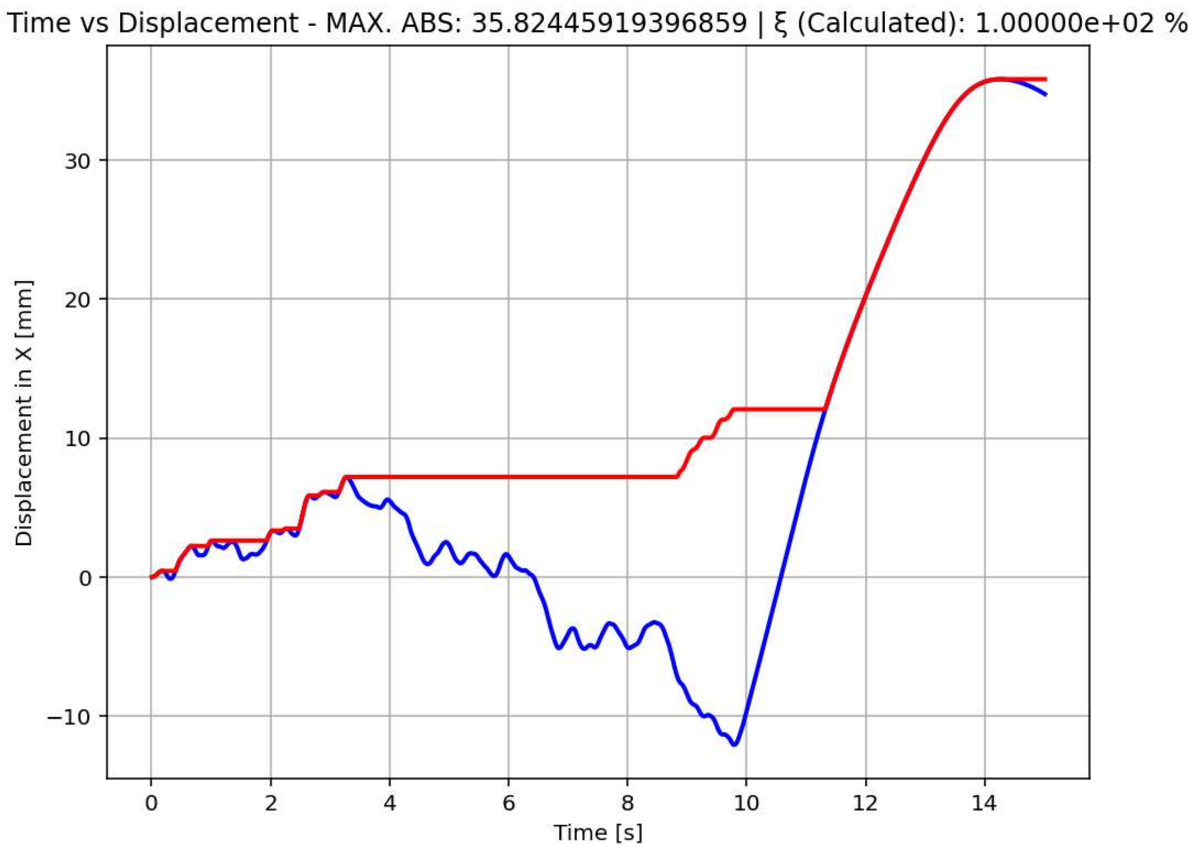

Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 7.2935 - Over Strength Factor: 0.9277
1e6
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Base-Axial Reaction [N]
0
10
20
30
40
50
Displacement in Y [mm]
+==========================+
= Analysis curve fitted =
Disp Base Shear

[[0.00000000e+00 0.00000000e+00]
[6.99459041e+00 1.90633034e+06]
[5.10151935e+01 1.76849816e+06]]
+==========================+
+---+
Structure Elastic Stiffness : 272543.53
Structure Plastic Stiffness : 34666.11
Structure Tangent Stiffness : -3131.08
Structure Ductility Ratio : 7.29
Structure Over Strength Factor: 0.93
+---+
Over Strength Coefficient (Ω0): 0.9277
Displacement Ductility Ratio (μ): 7.2935
Ductility Coefficient (Rμ): 7.2935
Structural Behavior Coefficient (R): 6.7662
Structural Ductility Damage Index in Y Direction: -0.1132
Curve
Bilinear Fitted

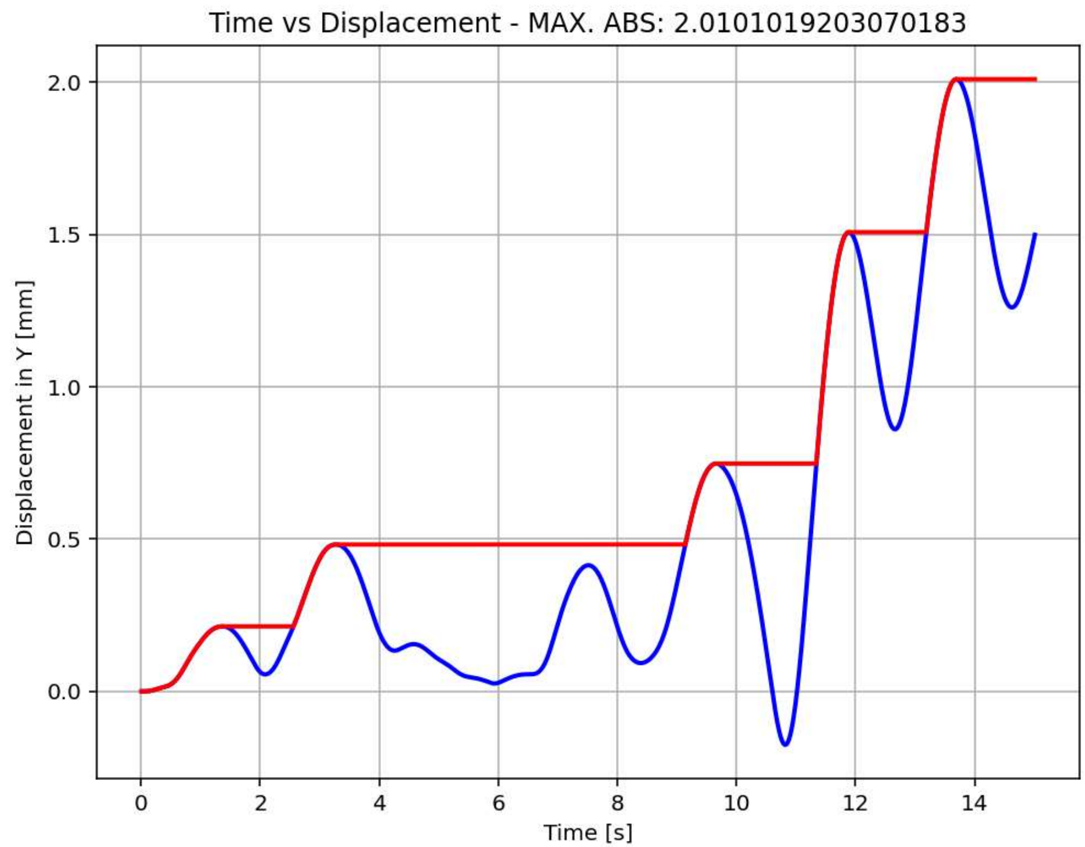
NONLINEAR DYNAMIC ANALYSIS



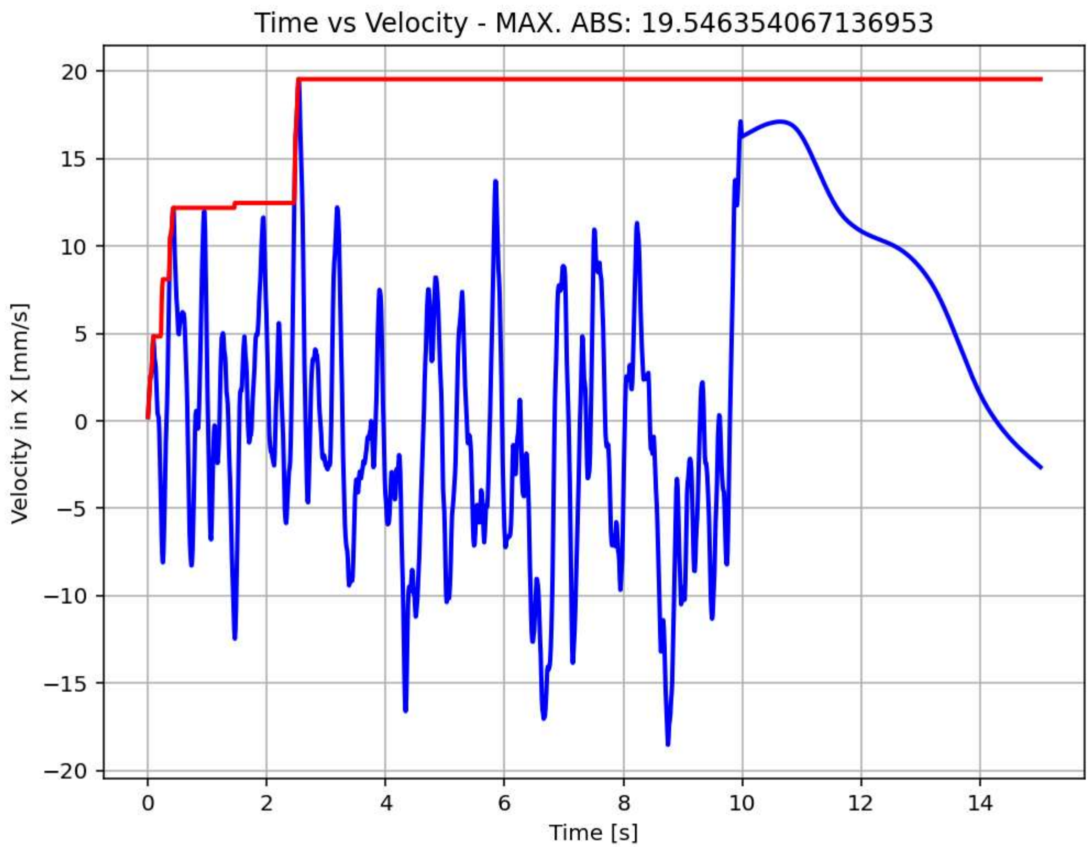
Undeformed and Deformed Shapes - DEFORMED SCALE: 10.00
Z [mm]
X [mm]
Undeformed
Deformed
1
2
3
4
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000



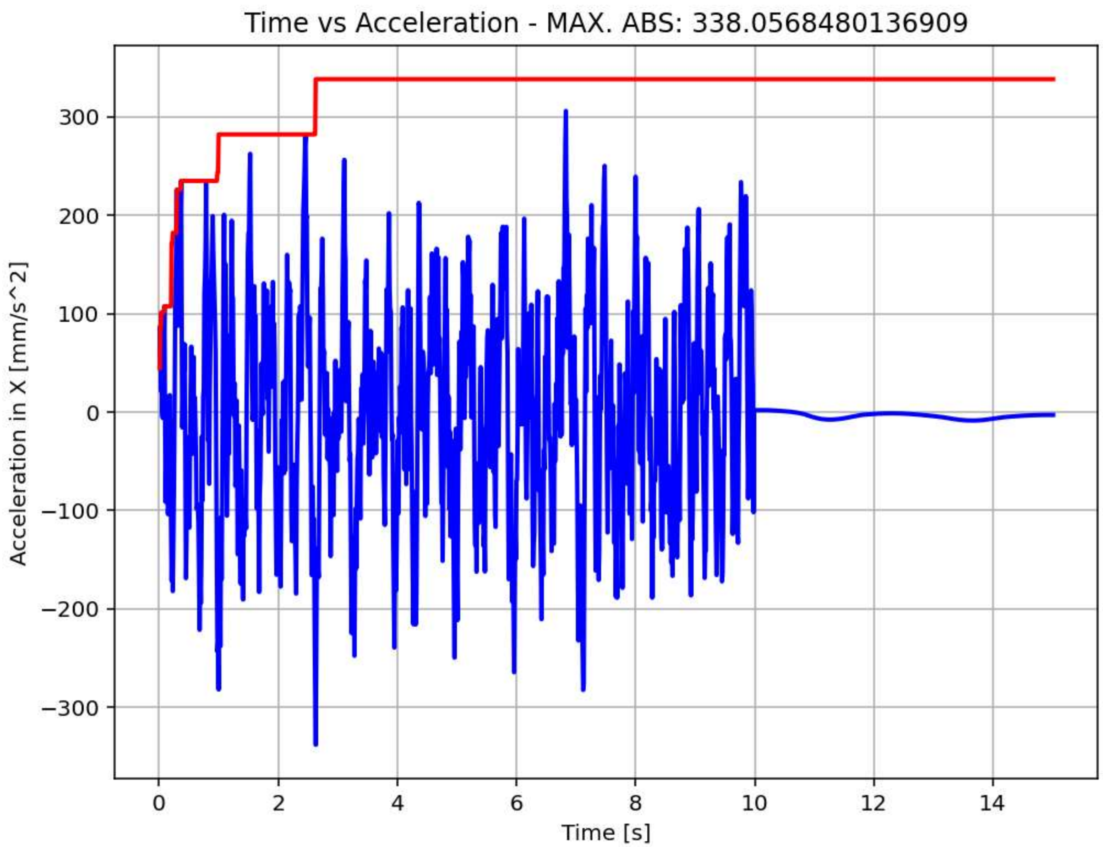
Time vs Displacement - MAX. ABS: 35.82445919396859 | ξ (Calculated): 1.00000e+02 %
Displacement in X [mm]
Time [s]
30
20
10
0
−10
0
2
4
6
8
10
12
14



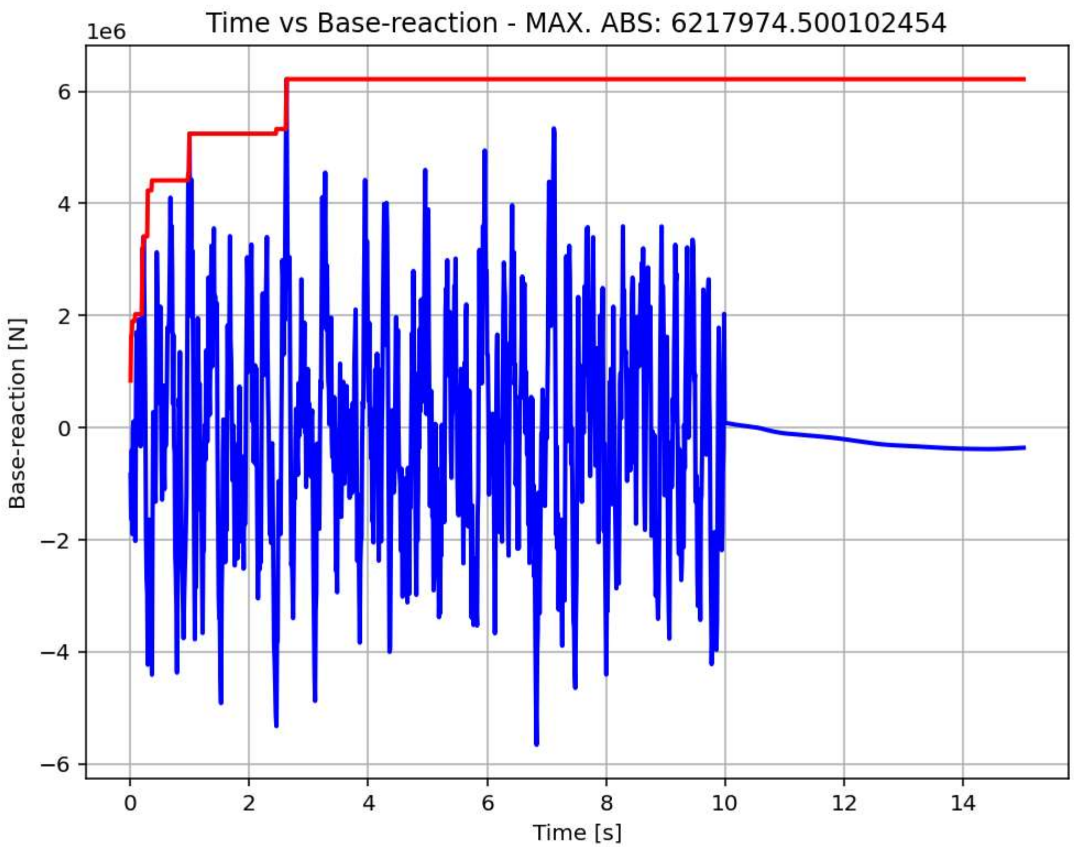
Time vs Displacement - MAX. ABS: 2.0101019203070183
2.0
1.5
1.0
0.5
0.0
Displacement in Y [mm]
0
2
4
6
8
10
12
14
Time [s]

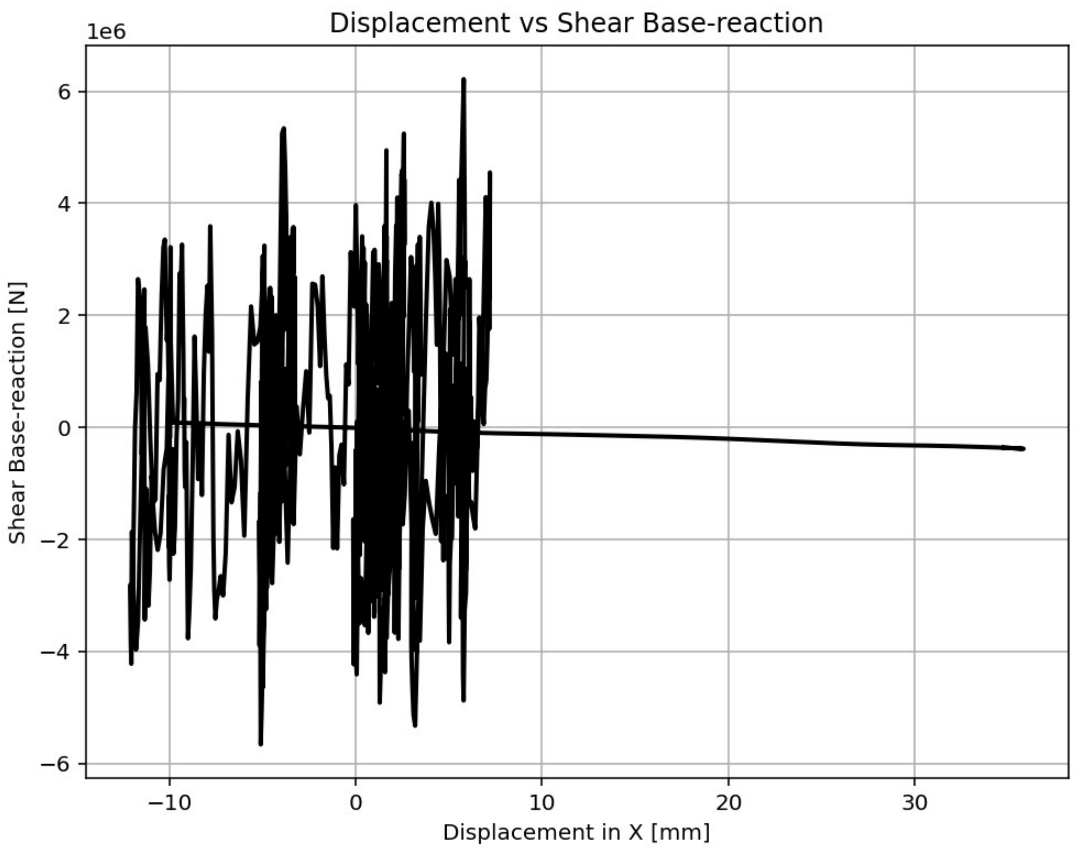


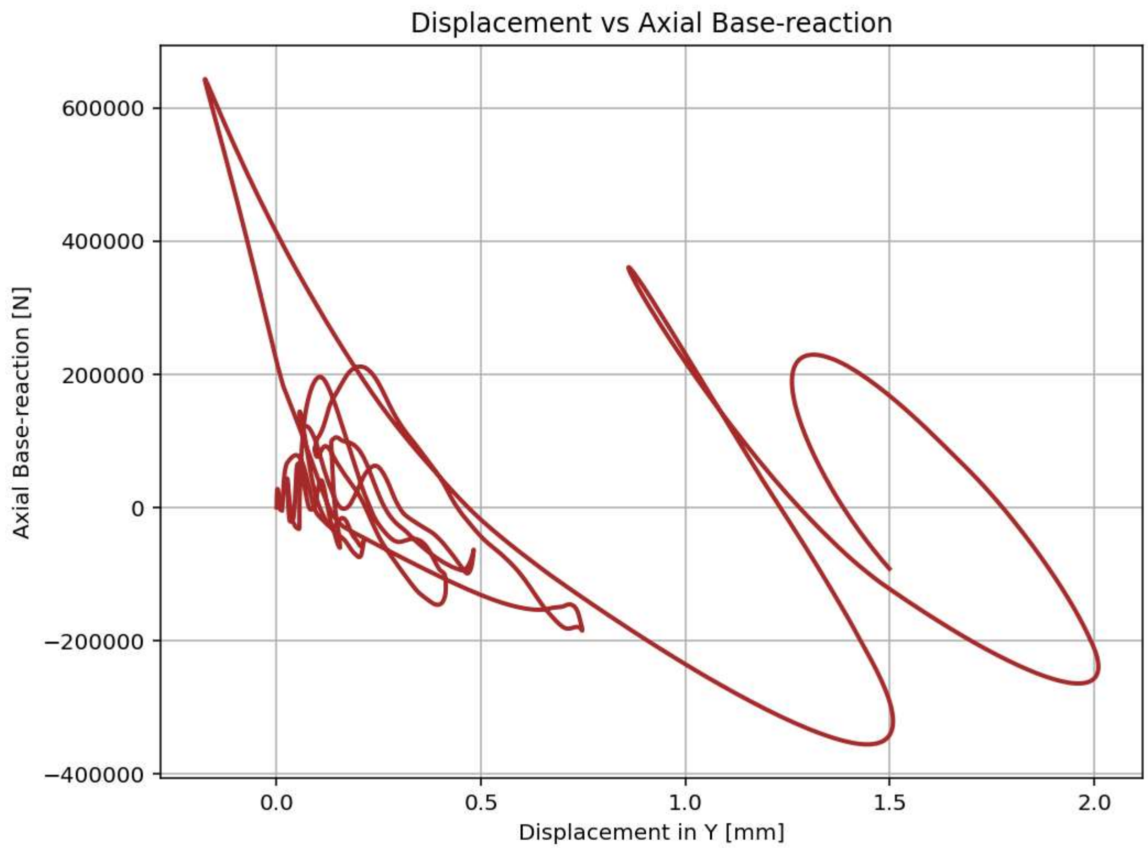
Time vs Velocity - MAX. ABS: 19.546354067136953
20
15
10
5
0
−5
−10
−15
−20
Velocity in X [mm/s]
0
2
4
6
8
10
12
14
Time [s]



Time vs Acceleration - MAX. ABS: 338.0568480136909
Acceleration in X [mm/s^2]
Time [s]
300
200
100
0
−100
−200
−300
0
2
4
6
8
10
12
14


Time vs Base-reaction - MAX. ABS: 6217974.500102454
1e6
6
4
2
0
−2
−4
−6
Base-reaction [N]
0
2
4
6
8
10
12
14
Time [s]


Displacement vs Shear Base-reaction
1e6
6
4
2
0
−2
−4
−6
Shear Base-reaction [N]
−10
0
10
20
30
Displacement in X [mm]


Displacement vs Axial Base-reaction
Axial Base-reaction [N]
600000
400000
200000
0
−200000
−400000
0.0
0.5
1.0
1.5
2.0
Displacement in Y [mm]