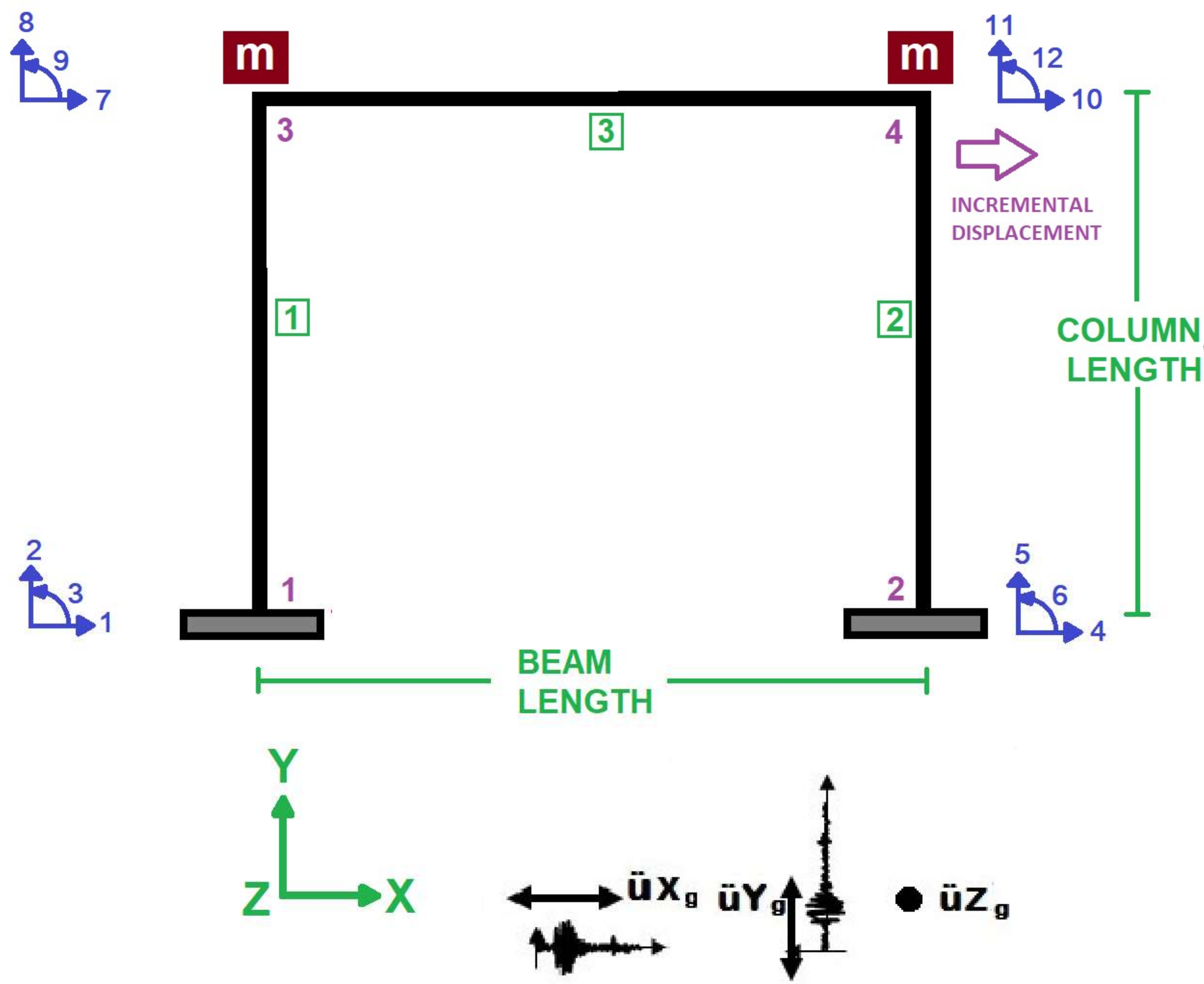
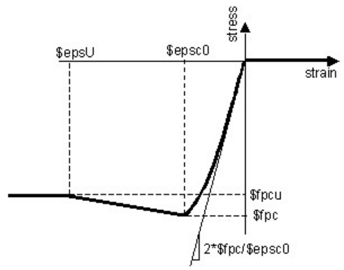
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

SEISMIC ANALYSIS OF CONCRETE FRAME. EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENSEES

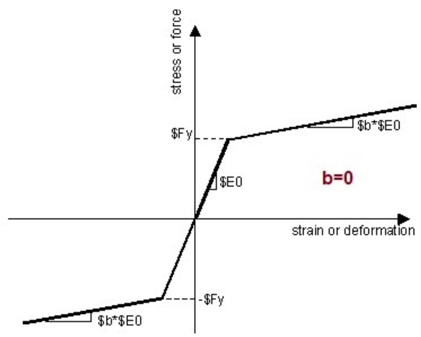
WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)



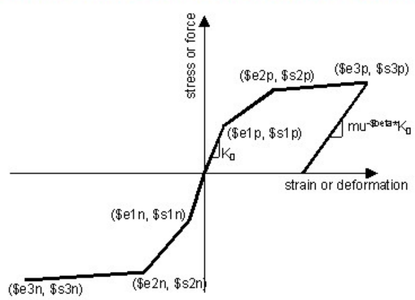
8
9
7
m
m
11
12
10
3
3
4
INCREMENTAL
DISPLACEMENT
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH
Y
Z
X
üX_g
üY_g
üZ_g



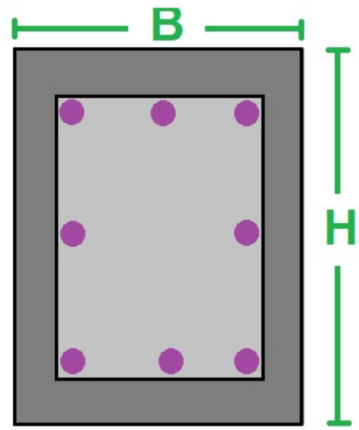
CORE AND COVER CONCRETE RELATION



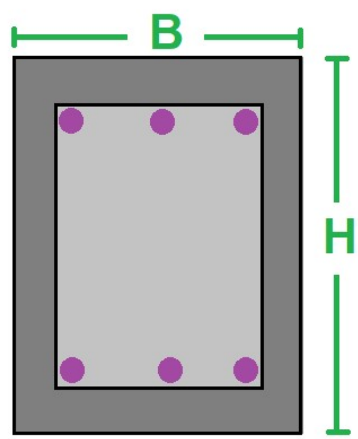
WITHOUT HARDENING AND ULTIMATE STRAIN



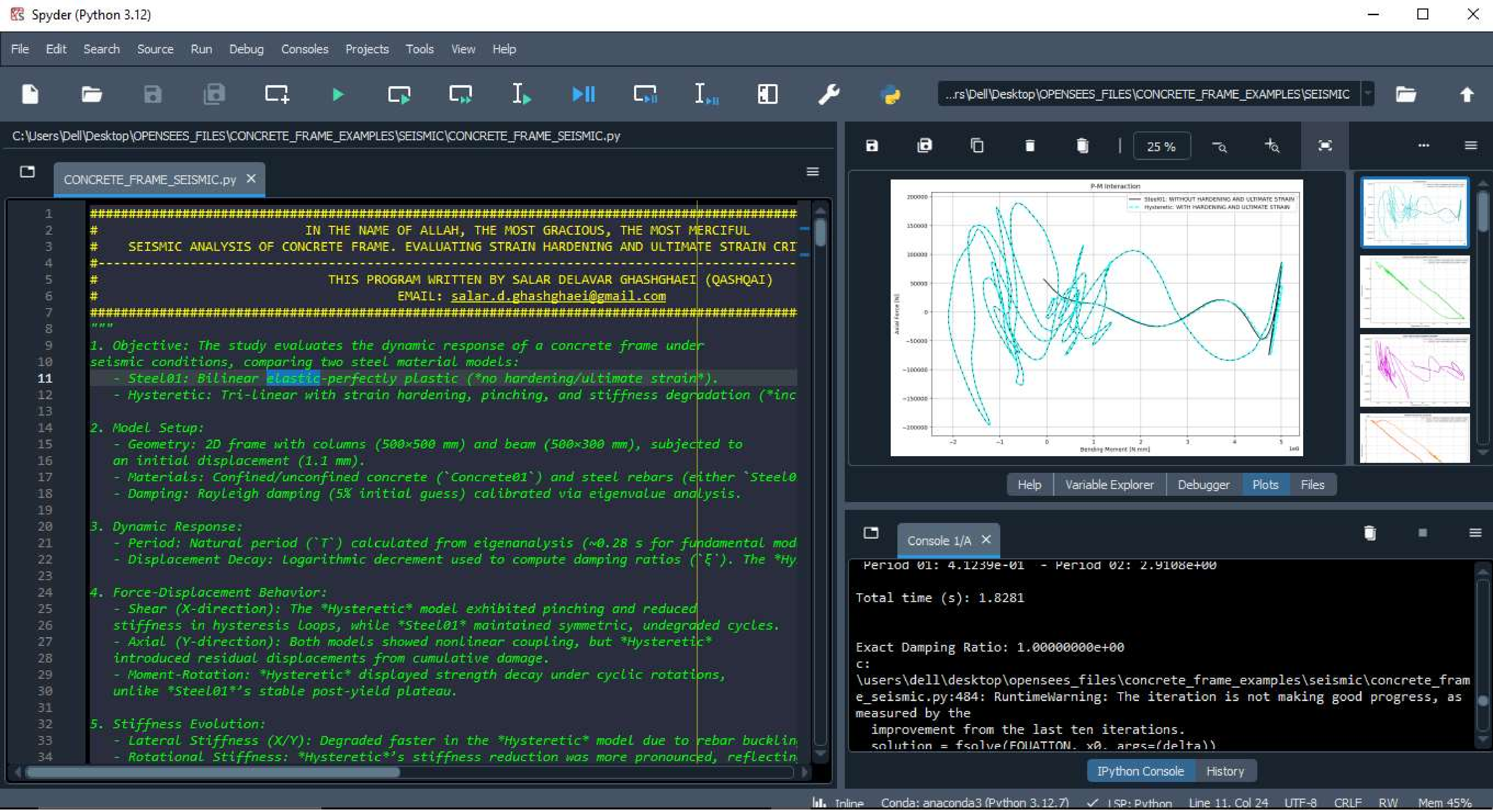
WITH HARDENING AND ULTIMATE STRAIN



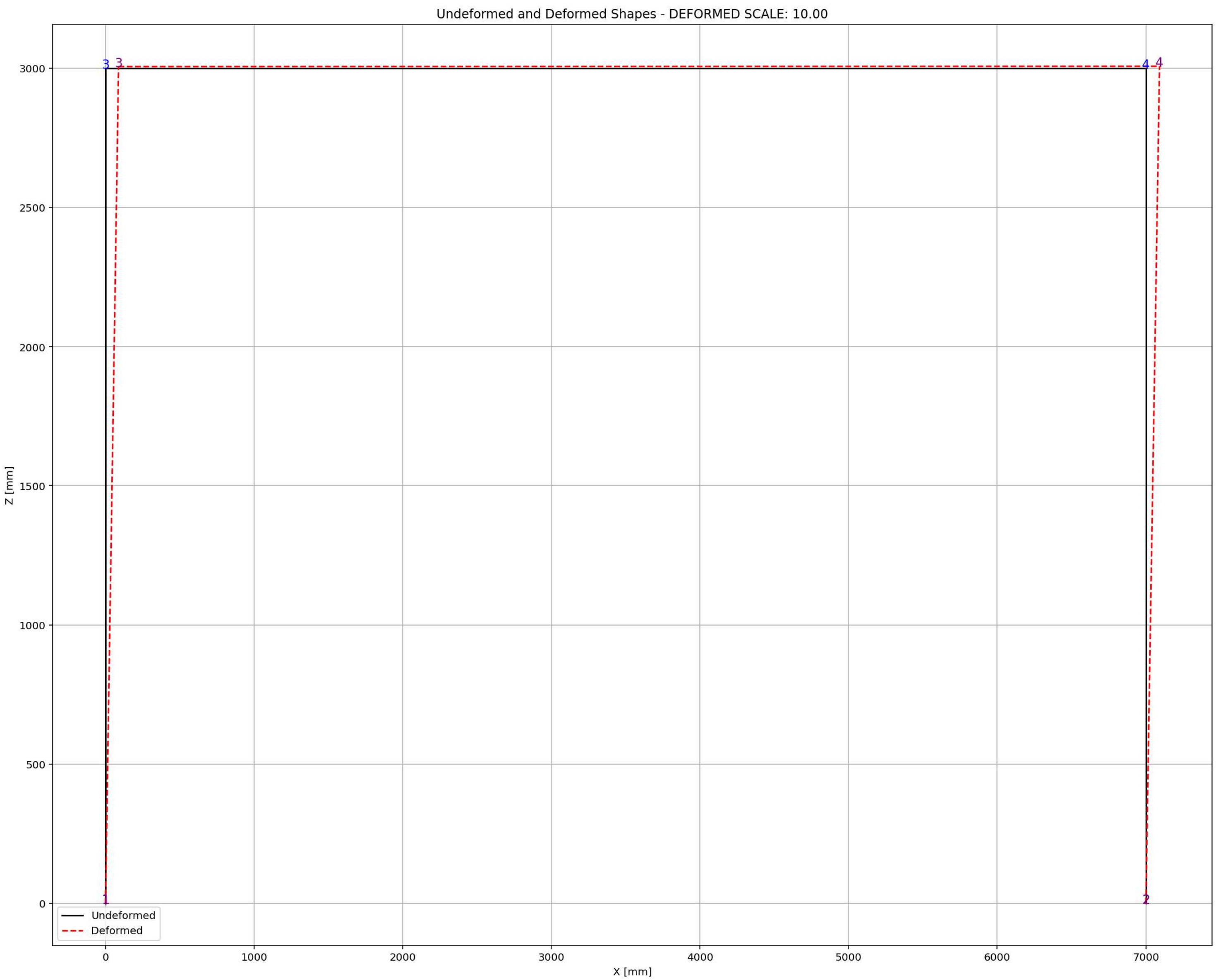
COLUMN SECTION



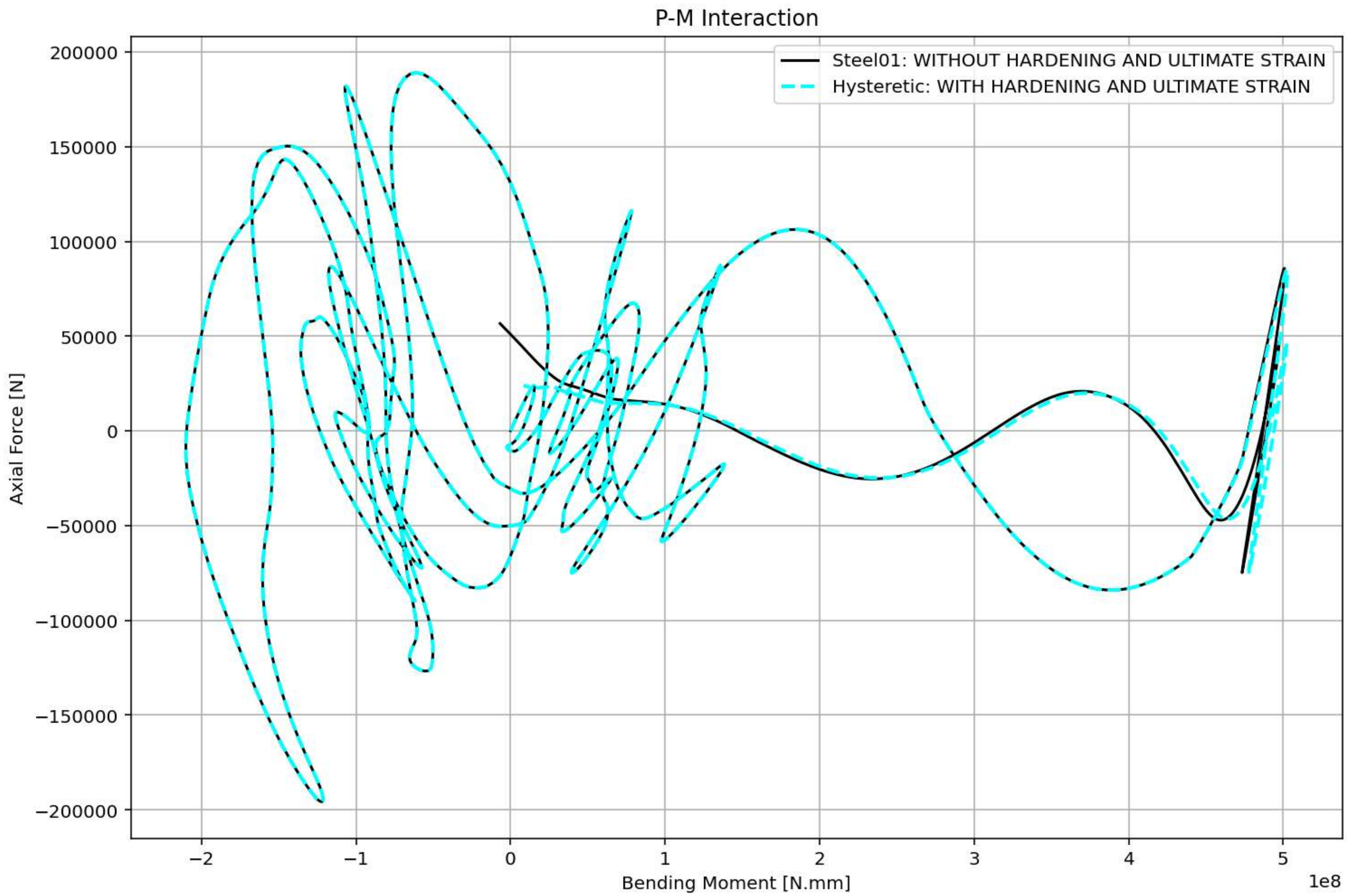
BEAM SECTION

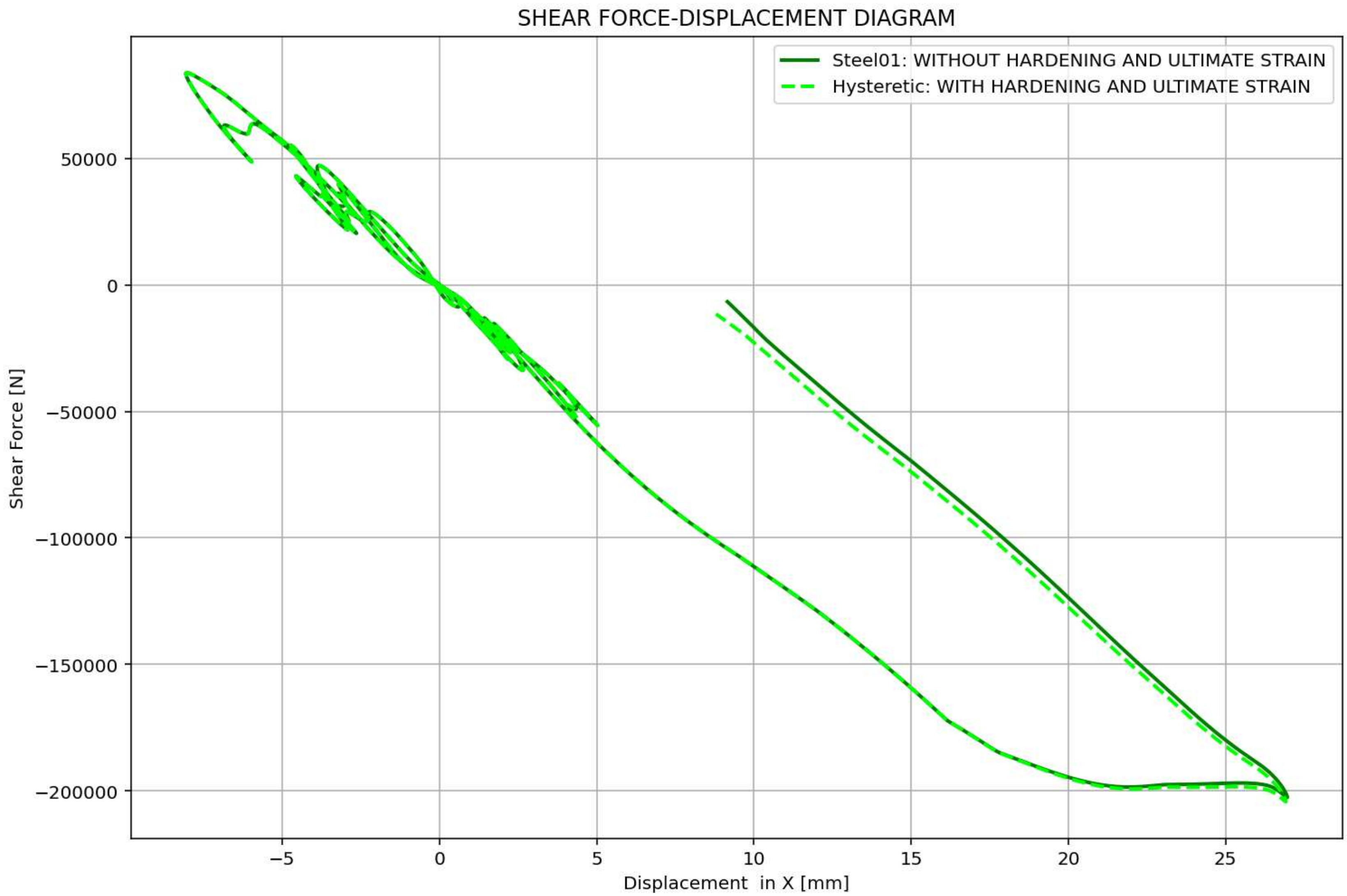

Spyder (Python 3.12)
File Edit Search Source Run Debug Consoles Projects Tools View Help
...rs\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRAME_EXAMPLES\SEISMIC
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRAME_EXAMPLES\SEISMIC\CONCRETE_FRAME_SEISMIC.py
CONCRETE_FRAME_SEISMIC.py
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL
SEISMIC ANALYSIS OF CONCRETE FRAME. EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRI
THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
EMAIL: salar.d.ghashghaei@gmail.com
1. Objective: The study evaluates the dynamic response of a concrete frame under seismic conditions, comparing two steel material models:
- Steel01: Bilinear elastic-perfectly plastic (*no hardening/ultimate strain*).
- Hysteretic: Tri-linear with strain hardening, pinching, and stiffness degradation (*inc
2. Model Setup:
- Geometry: 2D frame with columns (500×500 mm) and beam (500×300 mm), subjected to an initial displacement (1.1 mm).
- Materials: Confined/unconfined concrete (`Concrete01`) and steel rebars (either `Steel0
- Damping: Rayleigh damping (5% initial guess) calibrated via eigenvalue analysis.
3. Dynamic Response:
- Period: Natural period (`T`) calculated from eigenanalysis (~0.28 s for fundamental mod
- Displacement Decay: Logarithmic decrement used to compute damping ratios (`ξ`). The *Hy
4. Force-Displacement Behavior:
- Shear (X-direction): The *Hysteretic* model exhibited pinching and reduced stiffness in hysteresis loops, while *Steel01* maintained symmetric, undegraded cycles.
- Axial (Y-direction): Both models showed nonlinear coupling, but *Hysteretic* introduced residual displacements from cumulative damage.
- Moment-Rotation: *Hysteretic* displayed strength decay under cyclic rotations, unlike *Steel01*'s stable post-yield plateau.
5. Stiffness Evolution:
- Lateral Stiffness (X/Y): Degraded faster in the *Hysteretic* model due to rebar bucklin
- Rotational Stiffness: *Hysteretic*'s stiffness reduction was more pronounced, reflectin
25 %
P-M Interaction
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Bending Moment [N.mm]
Help Variable Explorer Debugger Plots Files
Console 1/A
Period 01: 4.1239e-01 - Period 02: 2.9108e+00
Total time (s): 1.8281
Exact Damping Ratio: 1.00000000e+00
c:
\users\dell\desktop\opensees_files\concrete_frame_examples\seismic\concrete_frame_seismic.py:484: RuntimeWarning: The iteration is not making good progress, as measured by the
improvement from the last ten iterations.
solution = fsolve(EQUATION, x0, args=(delta))
IPython Console History
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 11, Col 24 UTF-8 CRLF RW Mem 45%

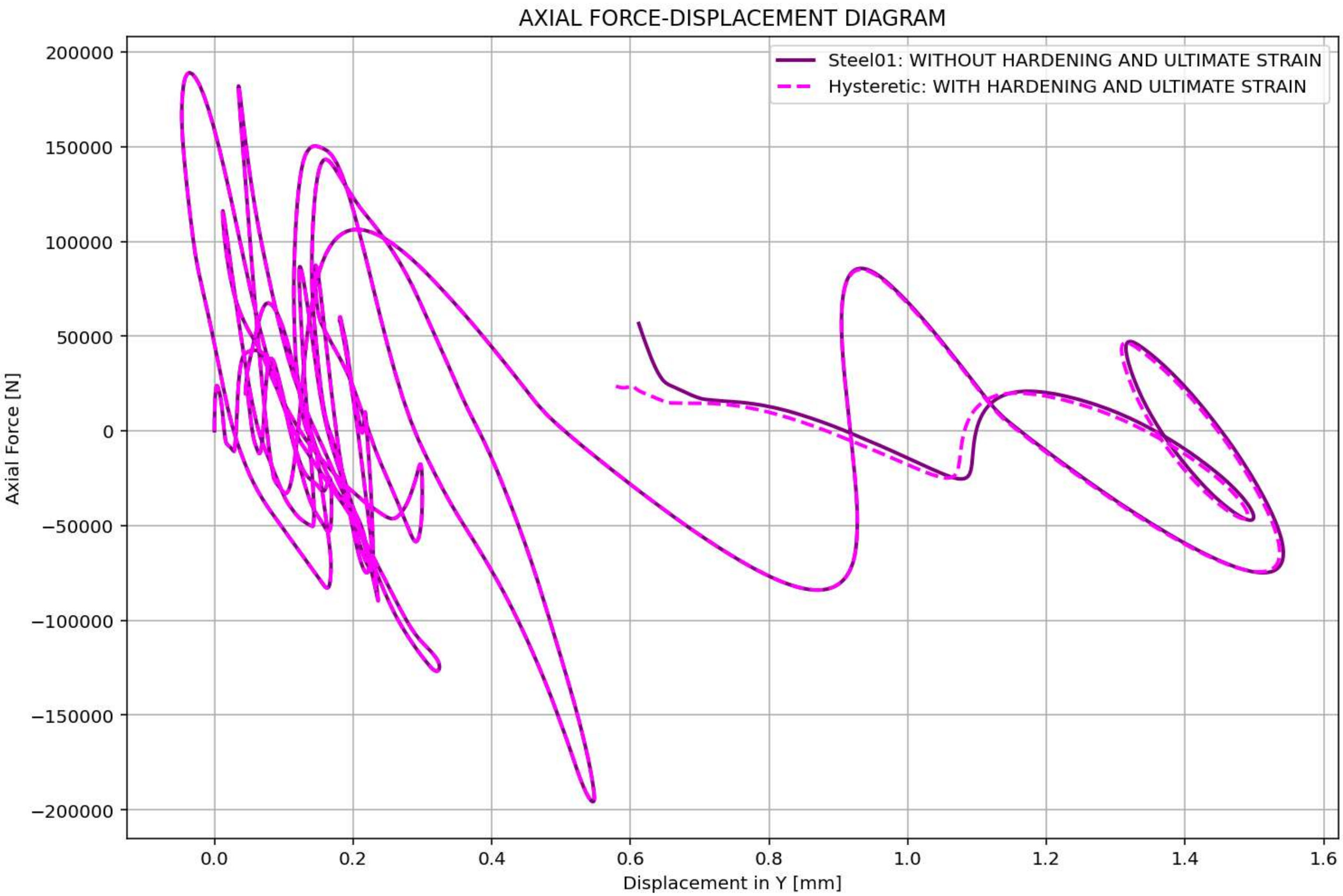
NONLINEAR DYNAMIC ANALYSIS



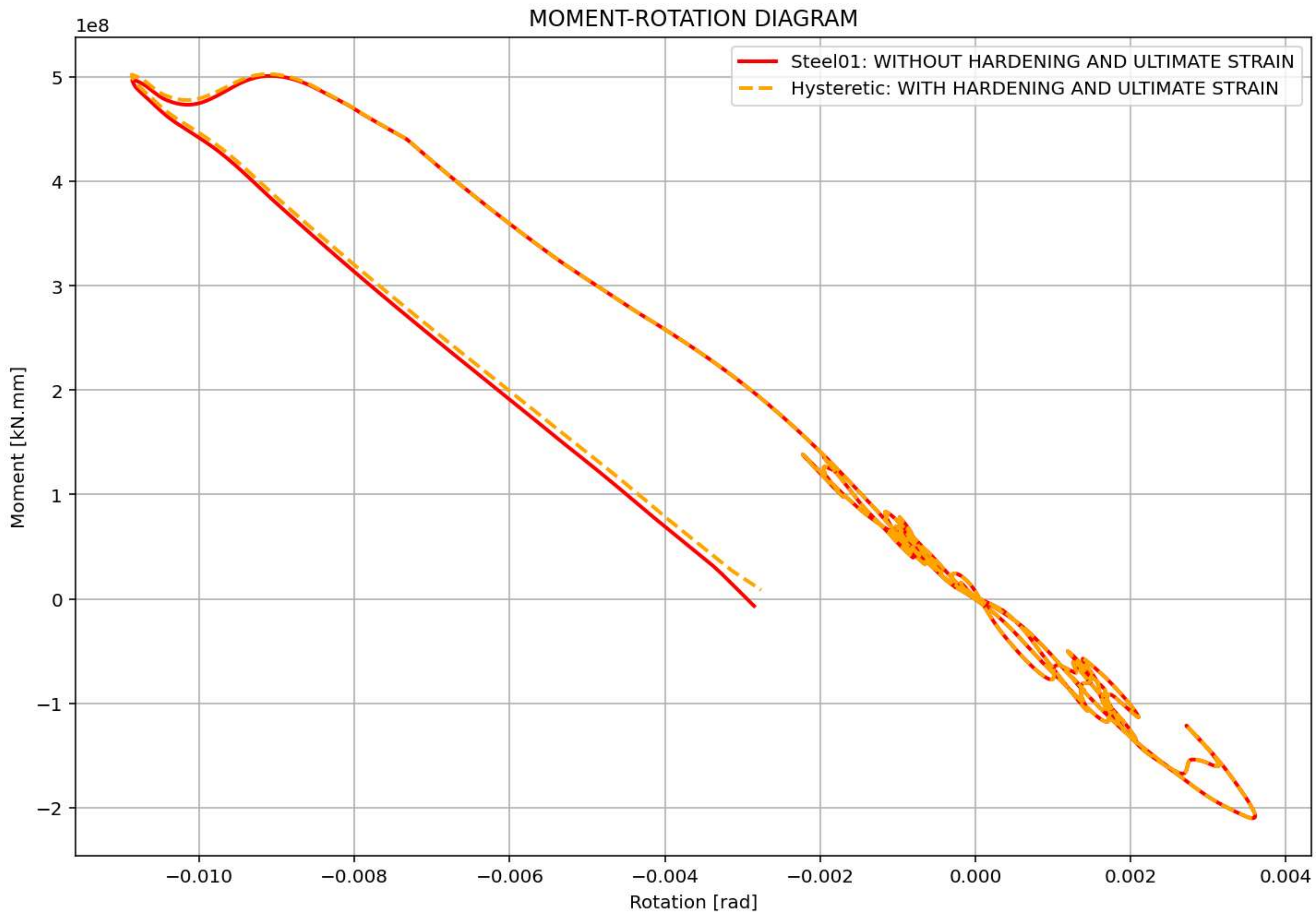
Undeformed and Deformed Shapes - DEFORMED SCALE: 10.00
3000
2500
2000
1500
1000
500
0
Z [mm]
0
1000
2000
3000
4000
5000
6000
7000
X [mm]
1
2
3
4
Undeformed
Deformed


P-M Interaction
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Axial Force [N]
200000
150000
100000
50000
0
−50000
−100000
−150000
−200000
Bending Moment [N.mm]
−2
−1
0
1
2
3
4
5
1e8

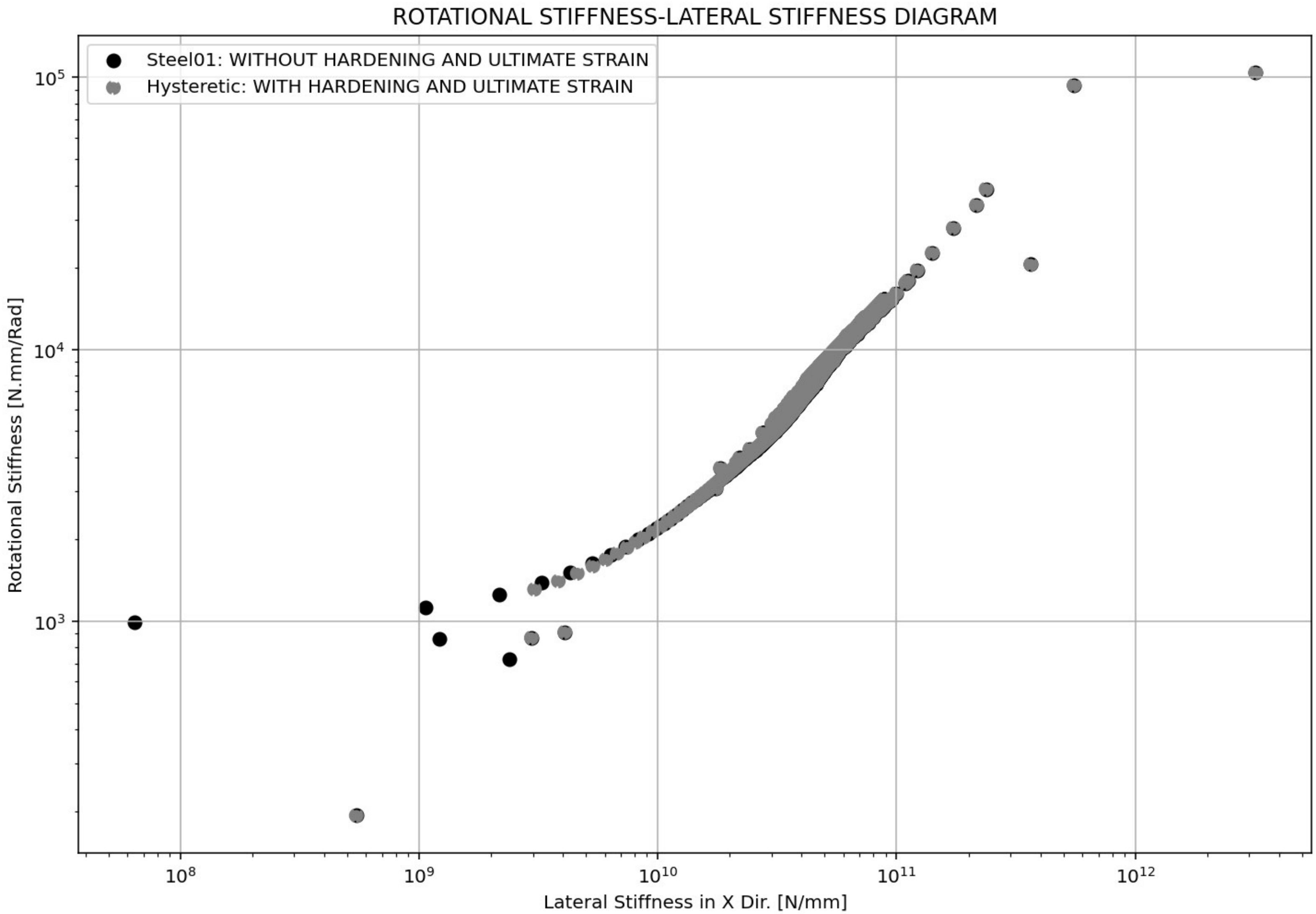

SHEAR FORCE-DISPLACEMENT DIAGRAM
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Shear Force [N]
50000
0
−50000
−100000
−150000
−200000
Displacement in X [mm]
−5
0
5
10
15
20
25

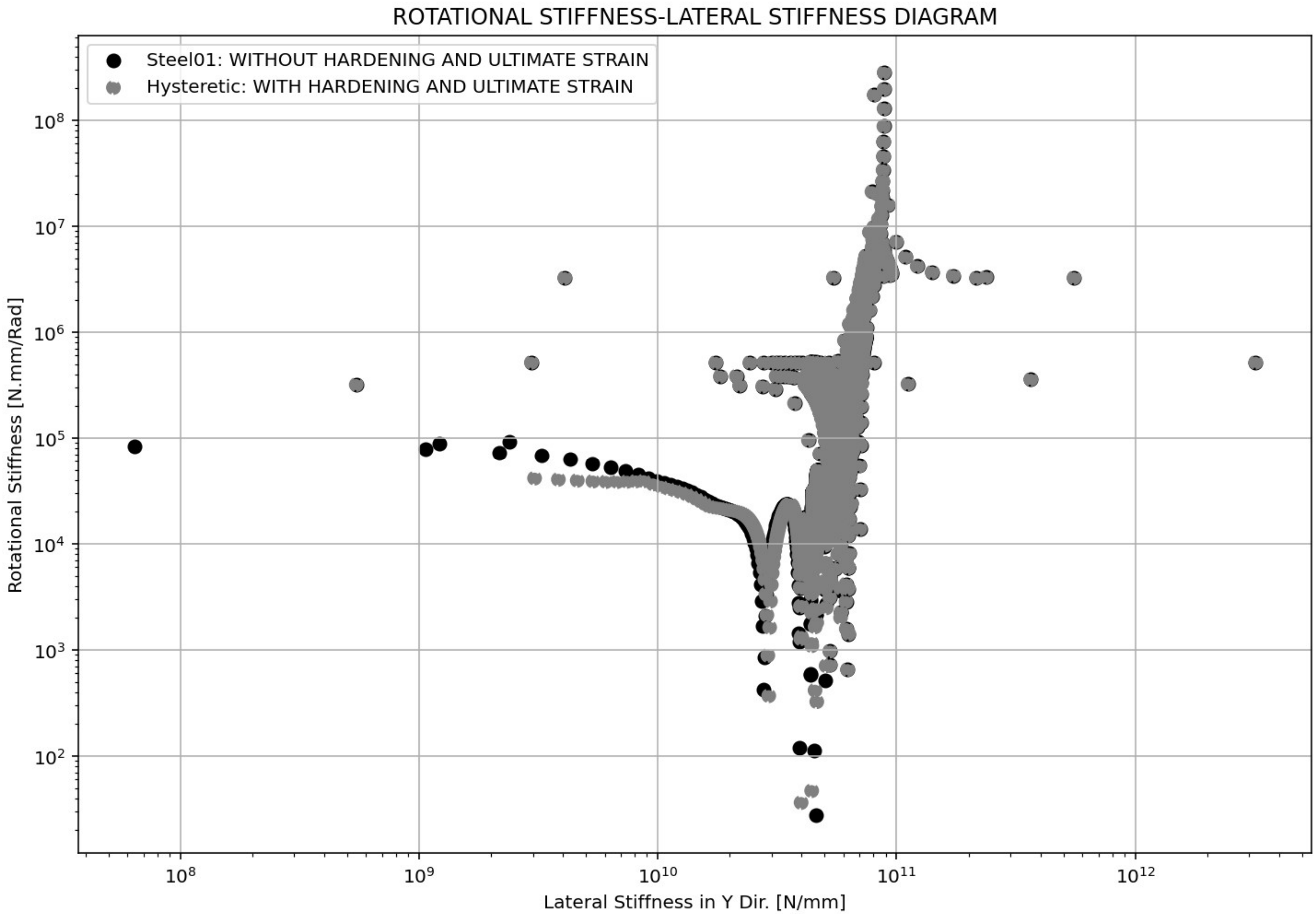


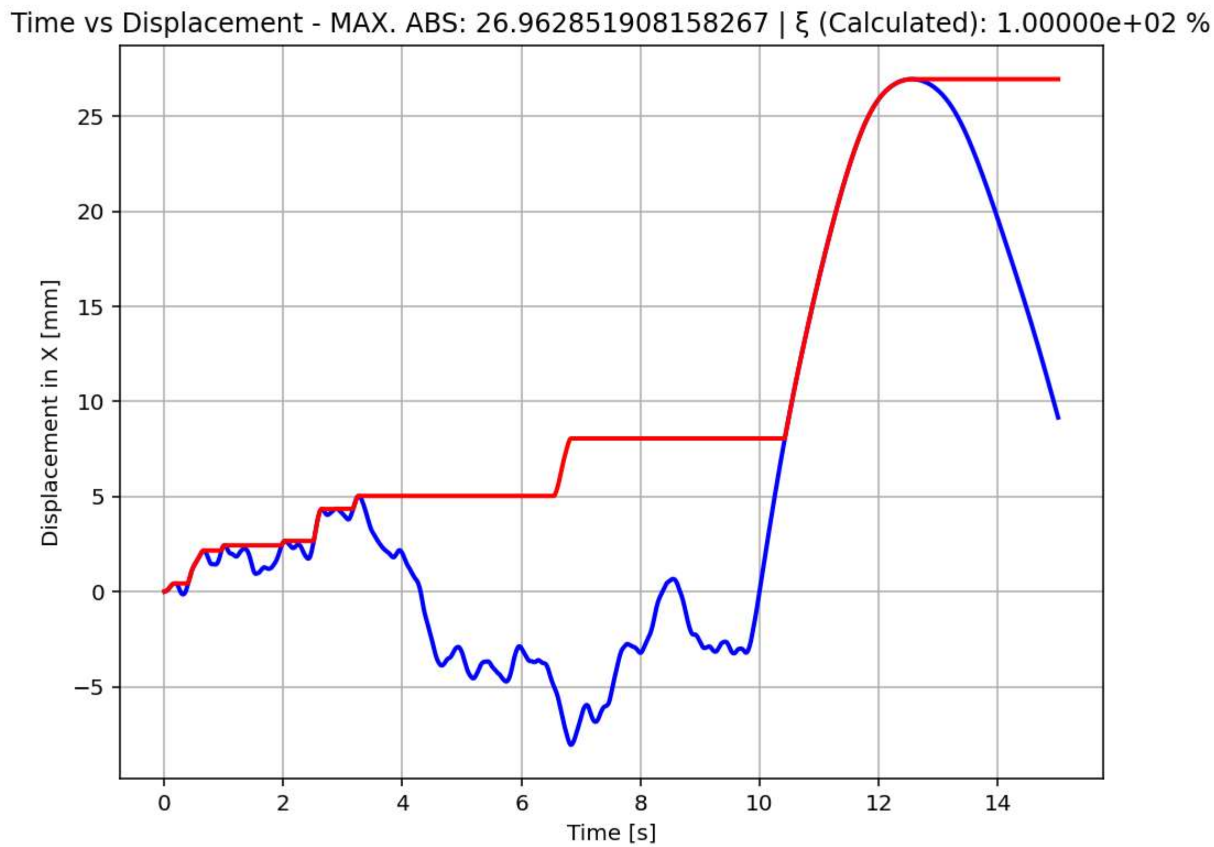
AXIAL FORCE-DISPLACEMENT DIAGRAM
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Axial Force [N]
Displacement in Y [mm]
200000
150000
100000
50000
0
−50000
−100000
−150000
−200000
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6



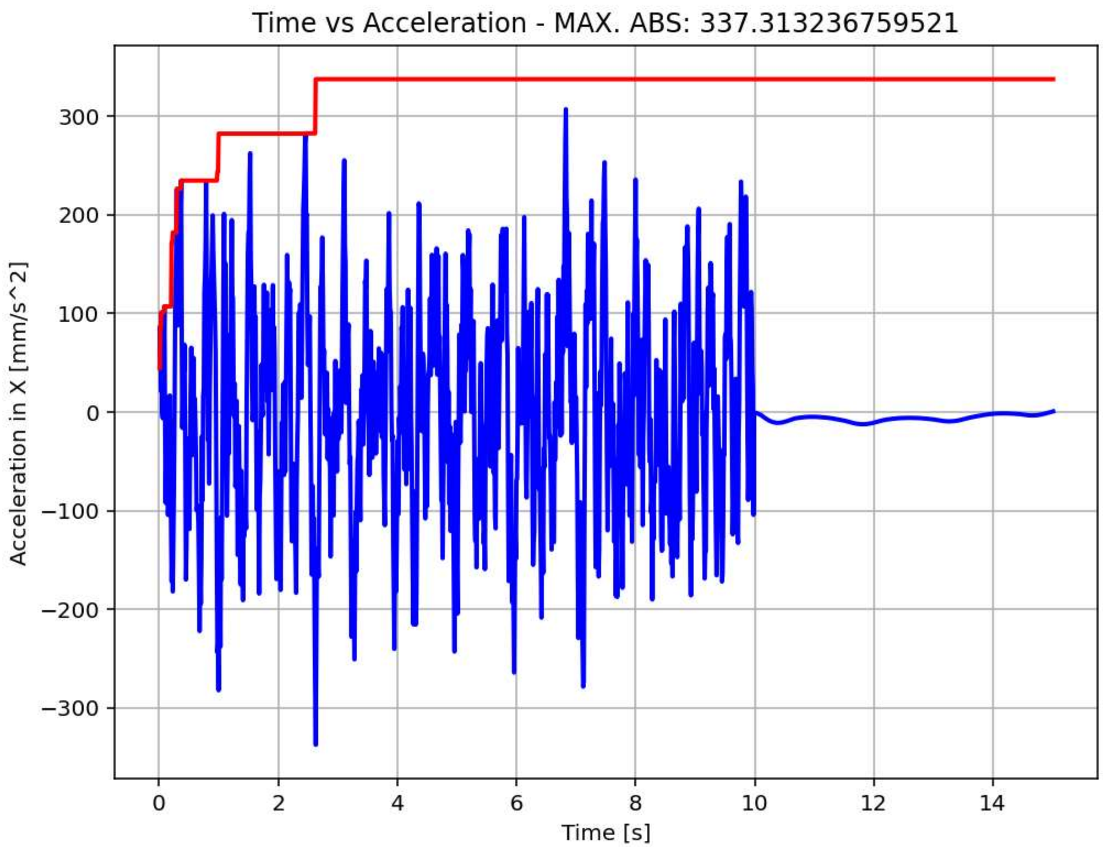
MOMENT-ROTATION DIAGRAM
1e8
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Moment [kN.mm]
Rotation [rad]
5
4
3
2
1
0
−1
−2
−0.010
−0.008
−0.006
−0.004
−0.002
0.000
0.002
0.004

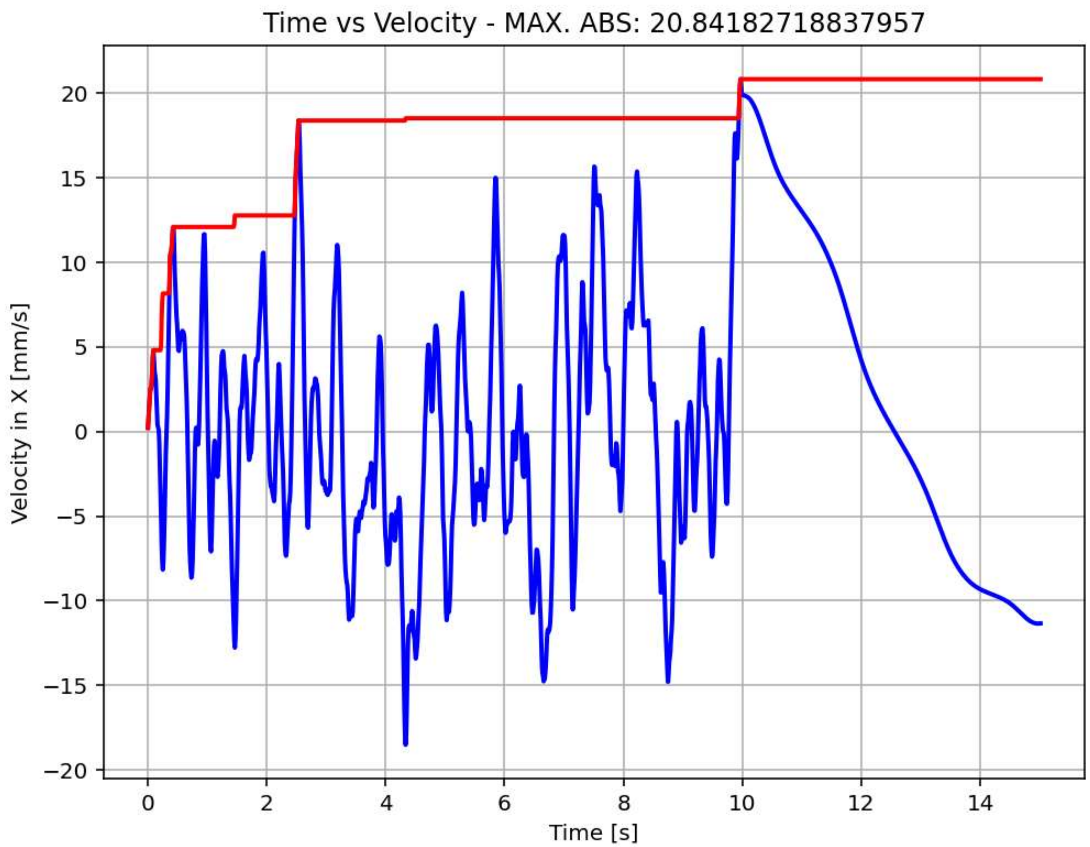

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in X Dir. [N/mm]
10^3
10^4
10^5
10^8
10^9
10^{10}
10^{11}
10^{12}

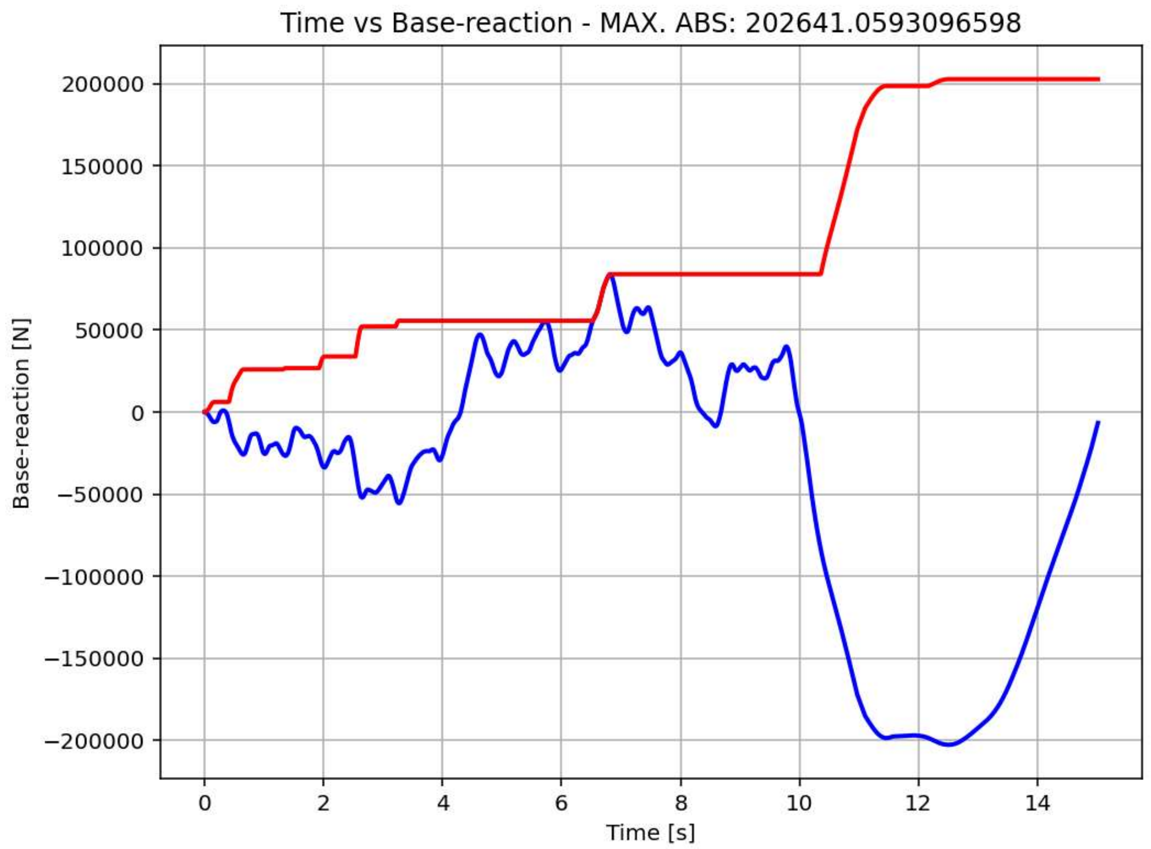

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in Y Dir. [N/mm]
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^8
10^9
10^{10}
10^{11}
10^{12}



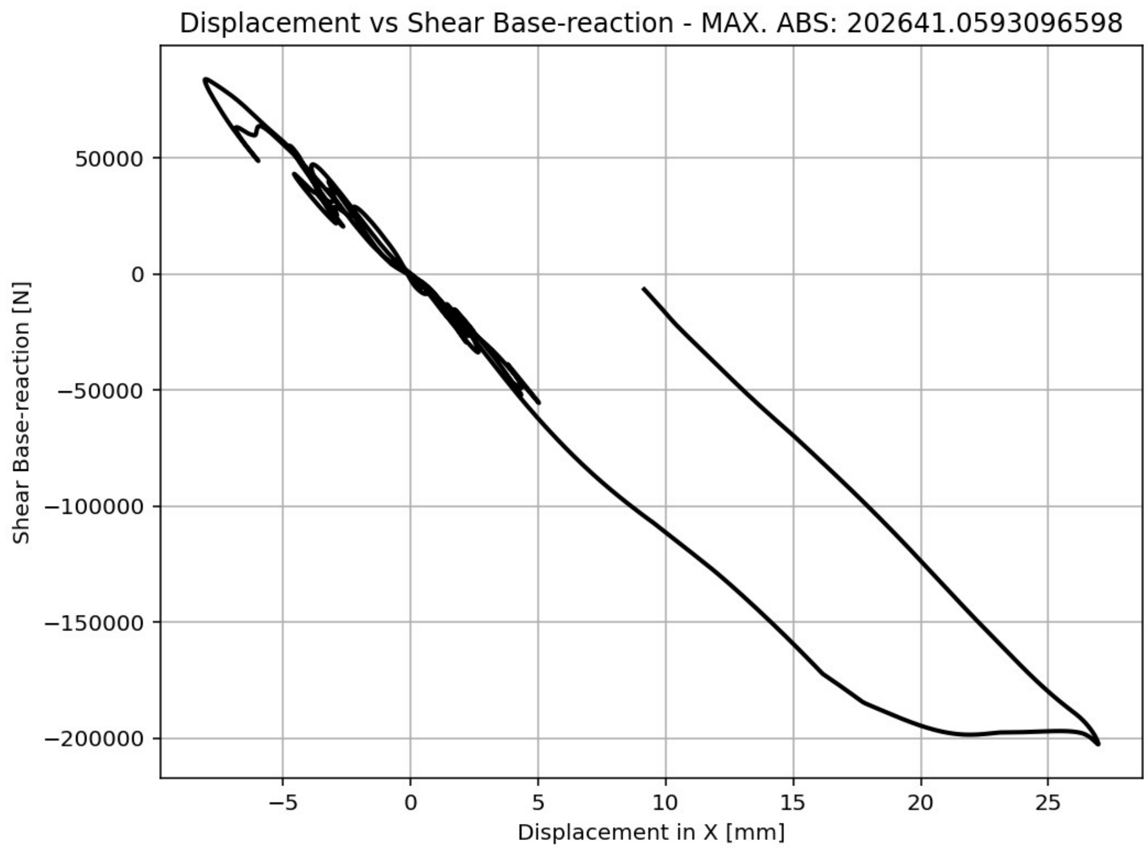
Time vs Displacement - MAX. ABS: 26.962851908158267 | ξ (Calculated): 1.00000e+02 %
Displacement in X [mm]
Time [s]
25
20
15
10
5
0
−5
0
2
4
6
8
10
12
14

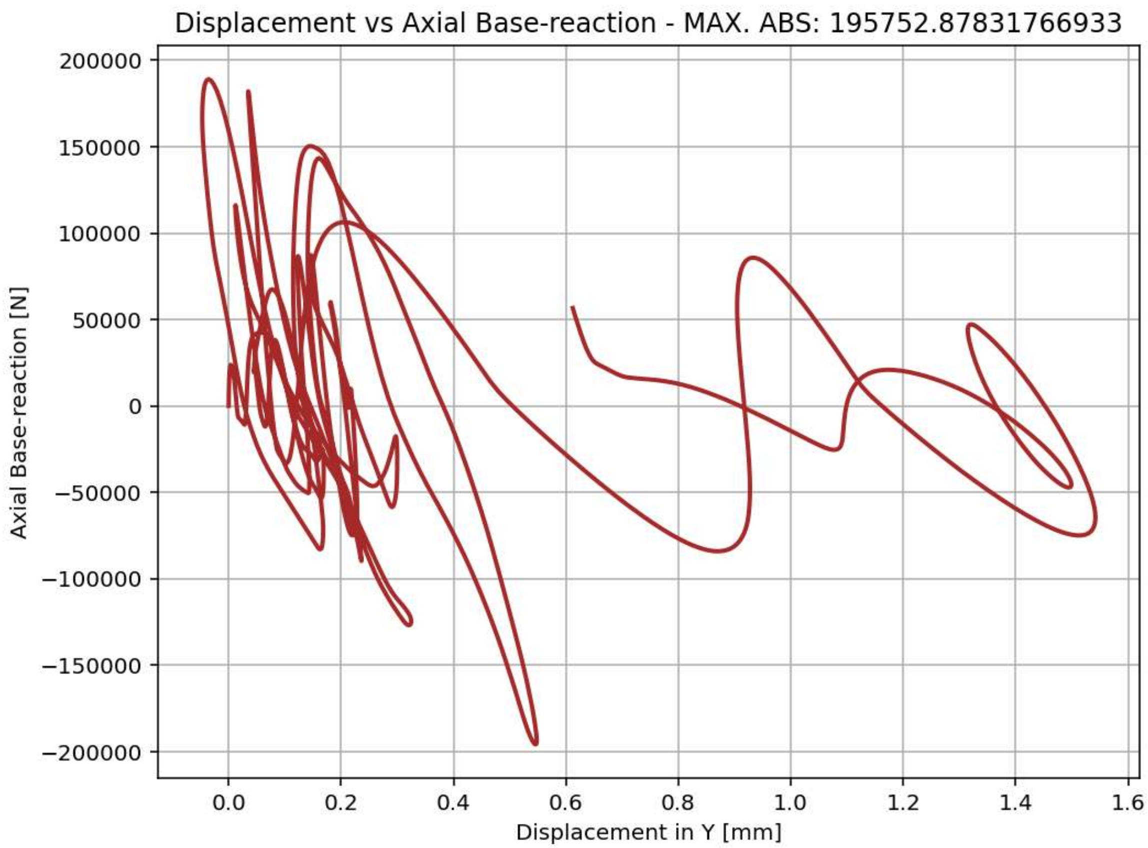

Time vs Acceleration - MAX. ABS: 337.313236759521
Acceleration in X [mm/s^2]
Time [s]
300
200
100
0
−100
−200
−300
0
2
4
6
8
10
12
14


Time vs Velocity - MAX. ABS: 20.84182718837957
Velocity in X [mm/s]
Time [s]
20
15
10
5
0
−5
−10
−15
−20
0
2
4
6
8
10
12
14



Time vs Base-reaction - MAX. ABS: 202641.0593096598
200000
150000
100000
50000
0
−50000
−100000
−150000
−200000
Base-reaction [N]
0
2
4
6
8
10
12
14
Time [s]


Displacement vs Shear Base-reaction - MAX. ABS: 202641.0593096598
Shear Base-reaction [N]
50000
0
−50000
−100000
−150000
−200000
−5
0
5
10
15
20
25
Displacement in X [mm]


Displacement vs Axial Base-reaction - MAX. ABS: 195752.87831766933
200000
150000
100000
50000
0
−50000
−100000
−150000
−200000
Axial Base-reaction [N]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Displacement in Y [mm]