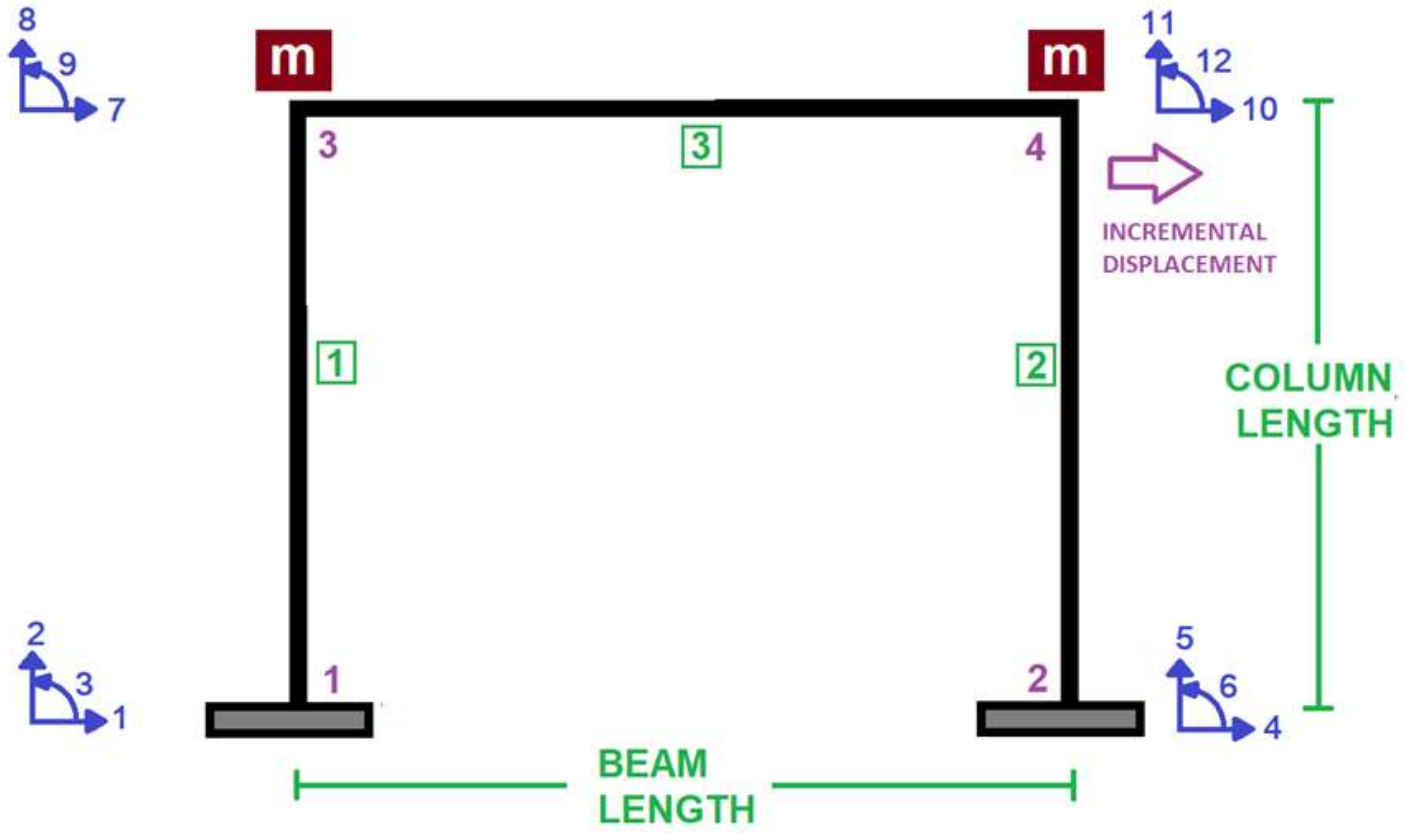
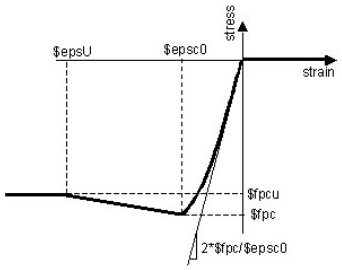
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

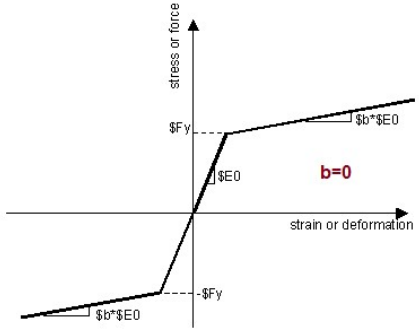
REVERSED CYCLIC PUSHOVER ANALYSIS OF CONCRETE FRAME. EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

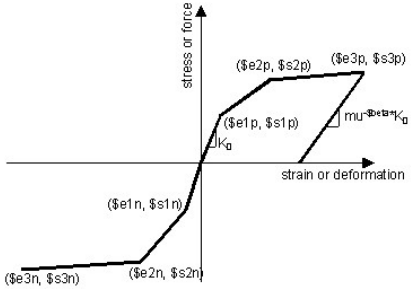

8
9
7
m
m
11
12
10
3
3
4
INCREMENTAL
DISPLACEMENT
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH



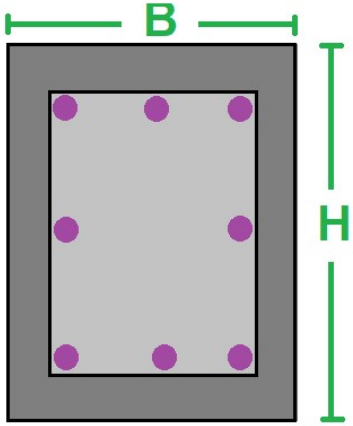
CORE AND COVER CONCRETE RELATION



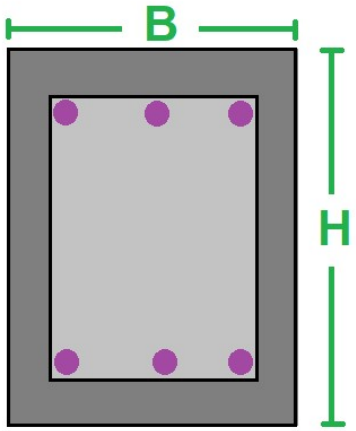
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

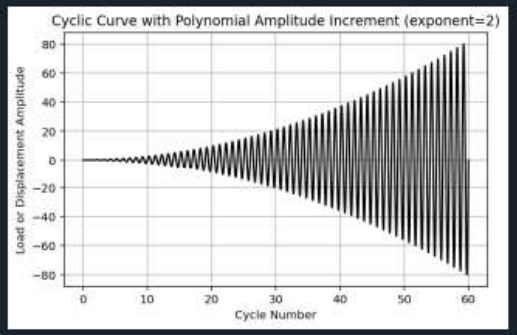
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...EXAMPLES\CYCLIC_PUSHOVER\CONCRETE_FRAME_CYCLIC.py

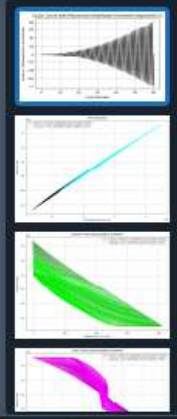
CONCRETE_FRAME_CYCLIC.py

```
##########################################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
# REVERSED CYCLIC PUSHOVER ANALYSIS OF CONCRETE FRAME. EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITEI
#---------------------------------------------------------------------------------------------------------
#                                    THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                                EMAIL: salar.d.ghashghaei@gmail.com
##########################################################################################################
"""
1. The code performs a 'reversed cyclic pushover analysis' of a reinforced concrete frame using OpenSees to
2. Two steel material models are compared: 'Steel01' (bilinear elastic-perfectly plastic) and 'Hysteretic' (
3. The 'Hysteretic model' captures strength/stiffness degradation and pinching effects, critical for seismic
4. Confined/unconfined concrete behaviors are modeled using 'Concrete01', distinguishing core and cover respe
5. A 'corotational geometric transformation' is used to account for large displacements and P-Delta effects.
6. The analysis employs 'displacement control' with an exponential amplitude growth protocol to simulate incr
7. Key outputs include 'moment-rotation', 'shear-drift', and 'P-M interaction' curves to assess nonlinear beh
8. The 'Hysteretic model' shows reduced energy dissipation and accelerated degradation compared to the ideal
9. Results highlight the importance of 'calibrated degradation parameters' for accurate seismic performance
10. The framework supports 'performance-based earthquake engineering' by quantifying cyclic damage and failu
"""
import openseespy.opensees as ops
import matplotlib.pyplot as plt
import numpy as np
import time as TI
import ANALYSIS_FUNCTION as S02
import CONCRETE_SECTION_FUN as S03
import PLOT_2D as S04


def CYCLIC_LOADING(num_cycles, samples_per_cycle, MAX_VALUE, EXPO=False, exponent=2):
    import numpy as np
    import matplotlib.pyplot as plt

    t_cycle = np.linspace(0, 2 * np.pi, samples_per_cycle)
```





Help Variable Explorer Debugger Plots Files

Console 1/A

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29964 -1.1580841481468767 20.033487163387743 477298.0227227006
29965 -1.1280582484211479 18.83277619082112 483295.0107773236
29966 -1.0978535005533487 17.66421430878711 489135.7947551324
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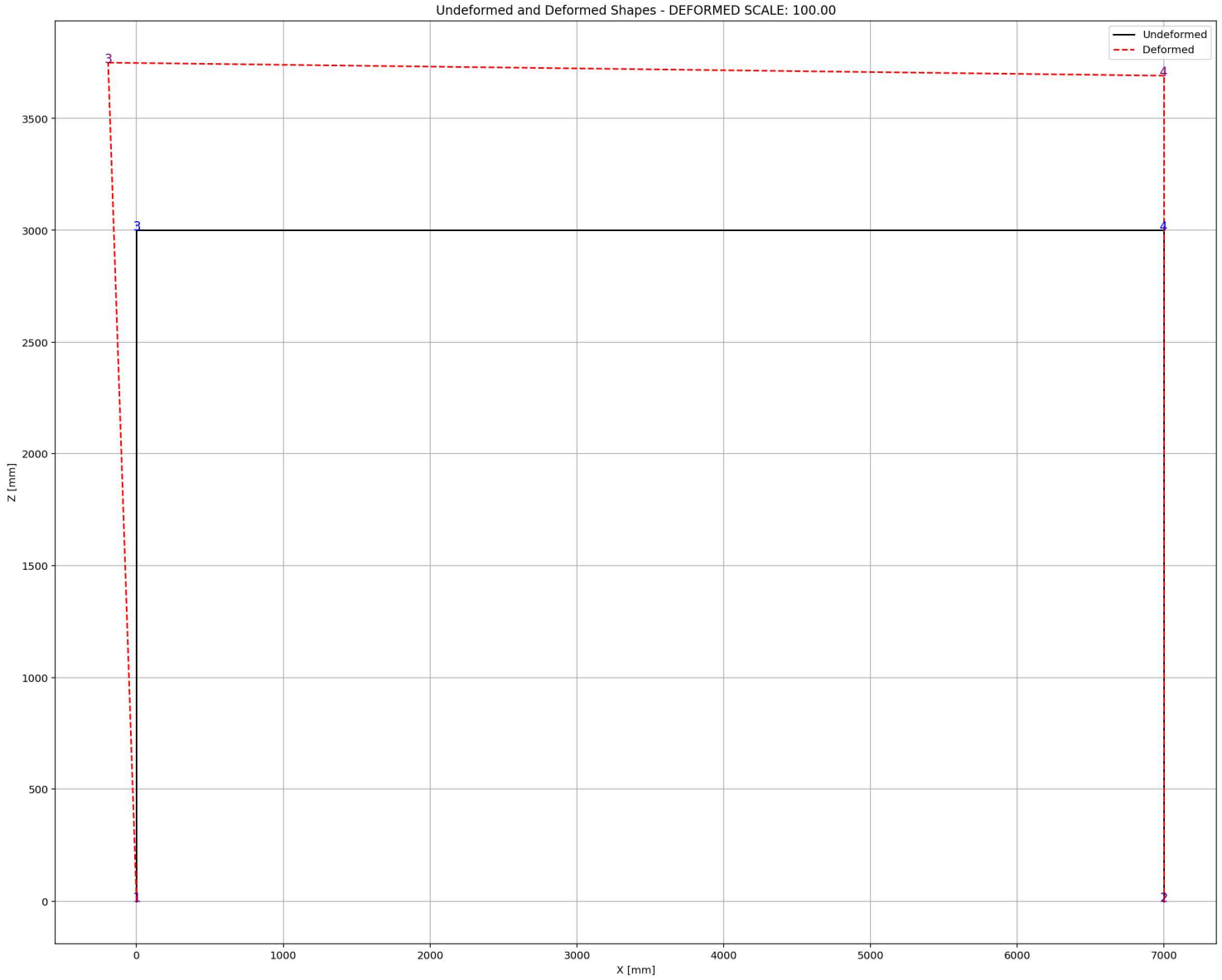
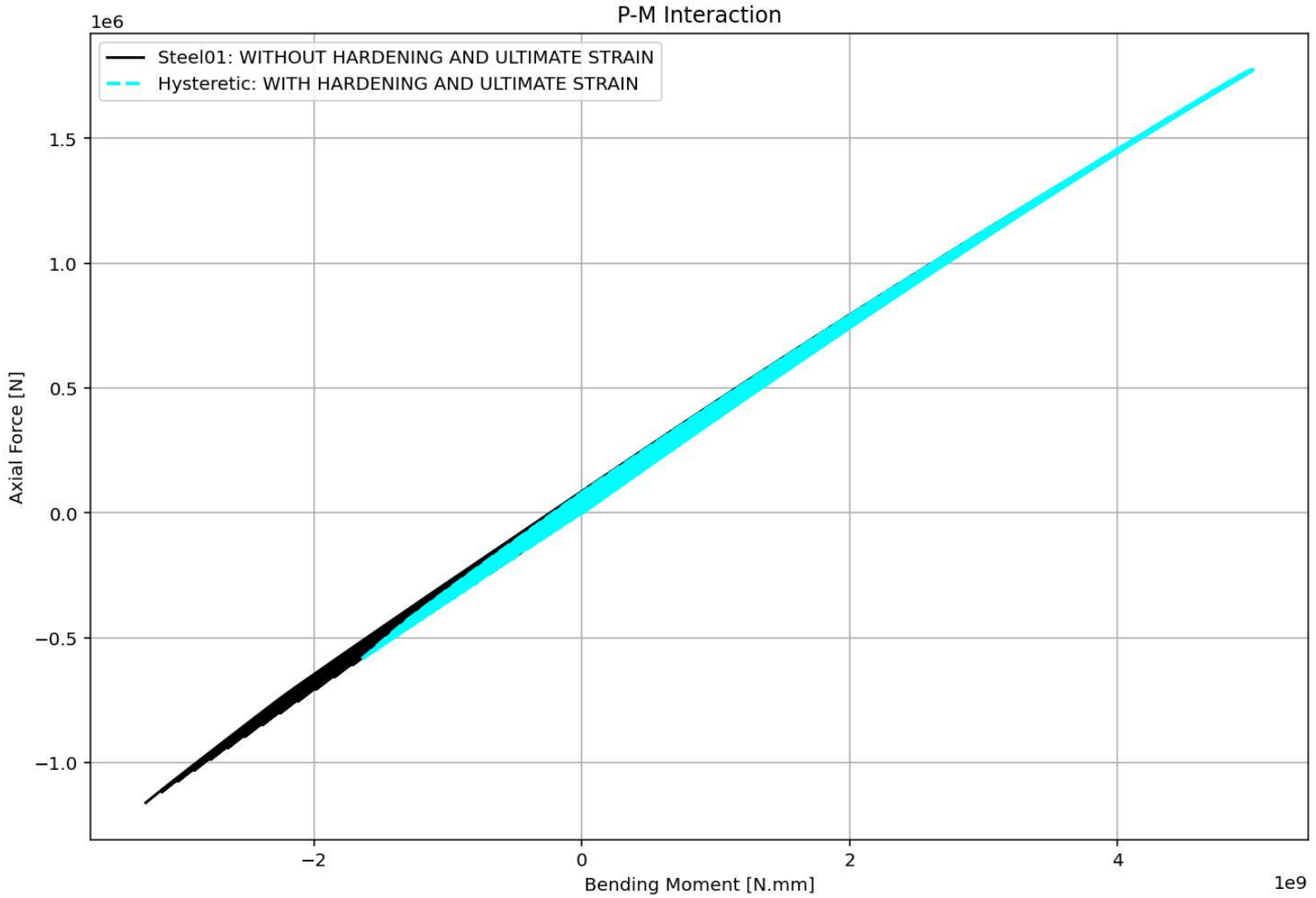
29968 -1.0369266432505775 15.424239519723749 500343.2617660108
29969 -1.0062141934721396 14.352782702529288 505708.970181093
29970 -0.9753422133332208 13.314072332494 510913.9463775632
29971 -0.9443155974359243 12.308414188316283 515948.78079084284
29972 -0.9131392648991188 11.335960009139031 520815.70709337224
29973 -0.8818181585785219 10.396844401975905 525518.6602235851
```

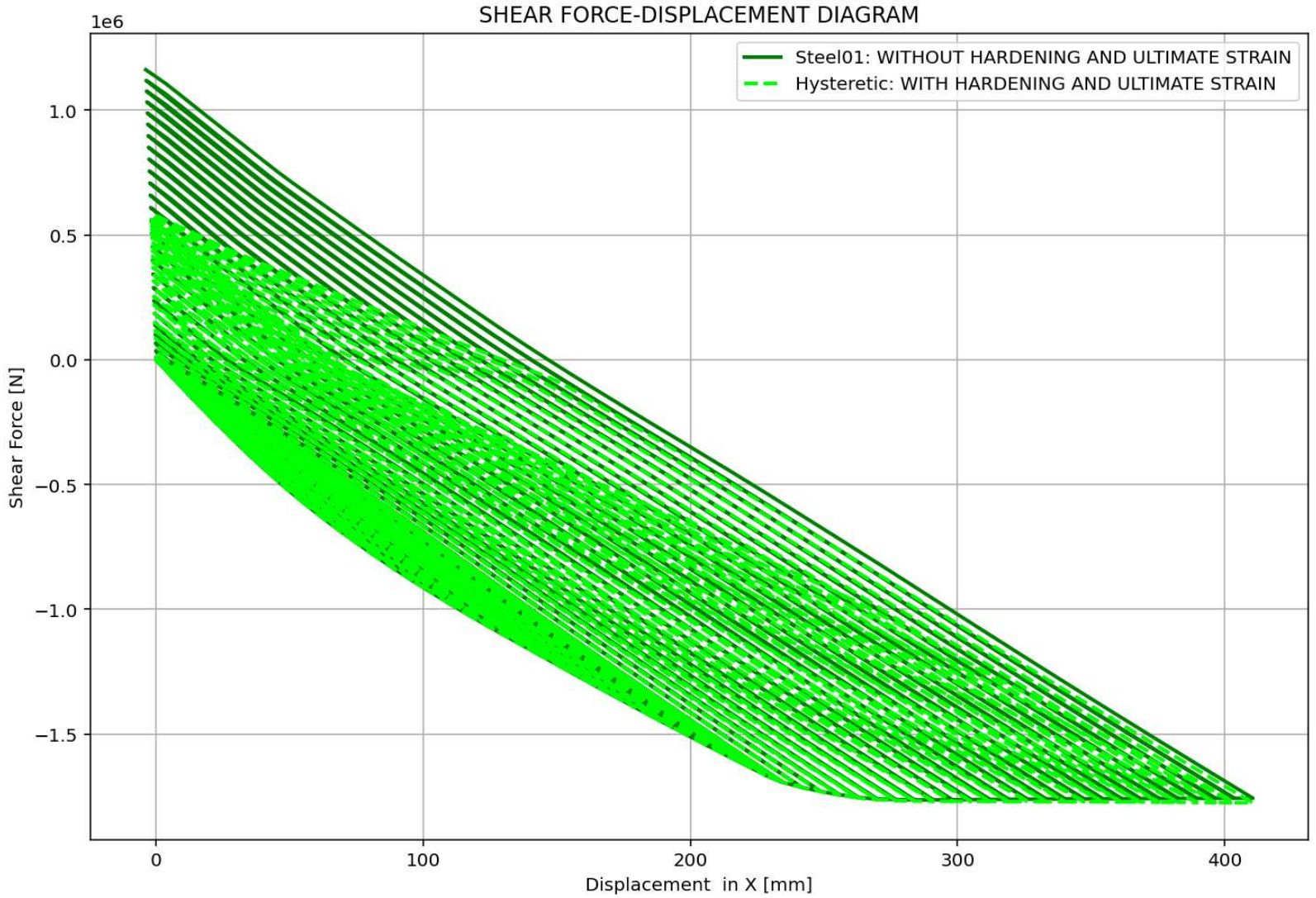
IPython Console History

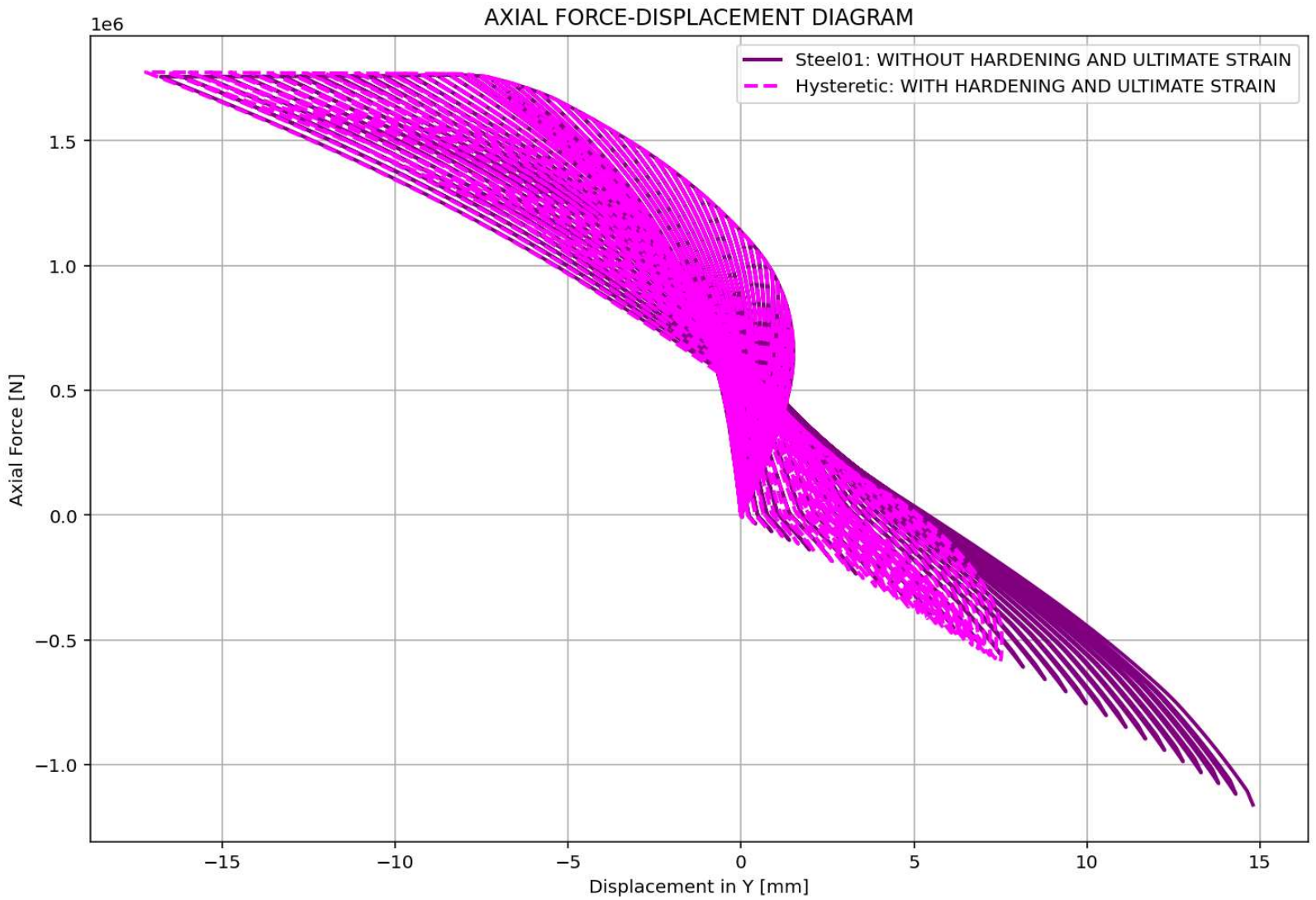
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 17, Col 75 UTF-8 CRLF RW Mem 42%

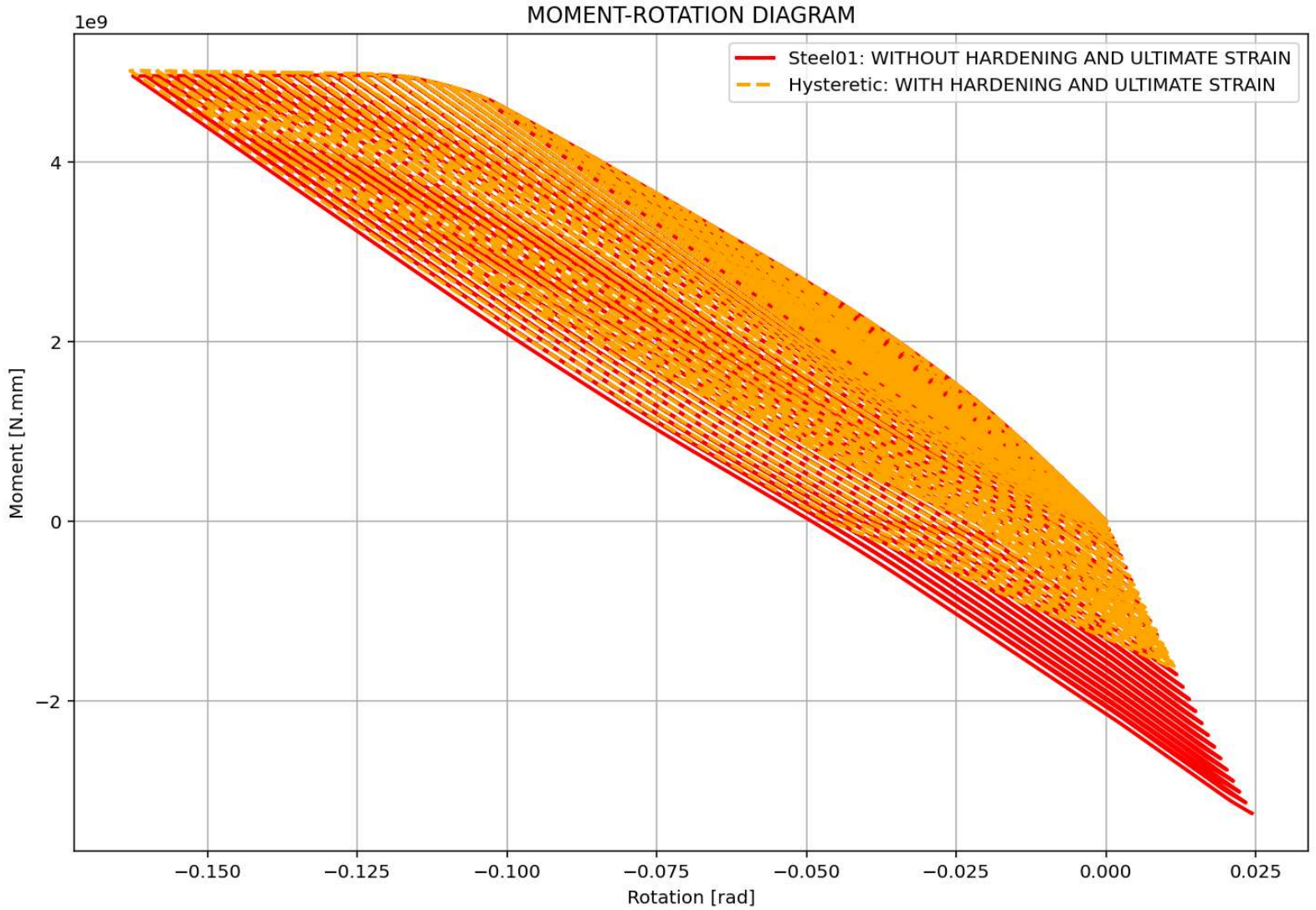
REVERSED CYCLIC PUSHOVER ANALYSIS

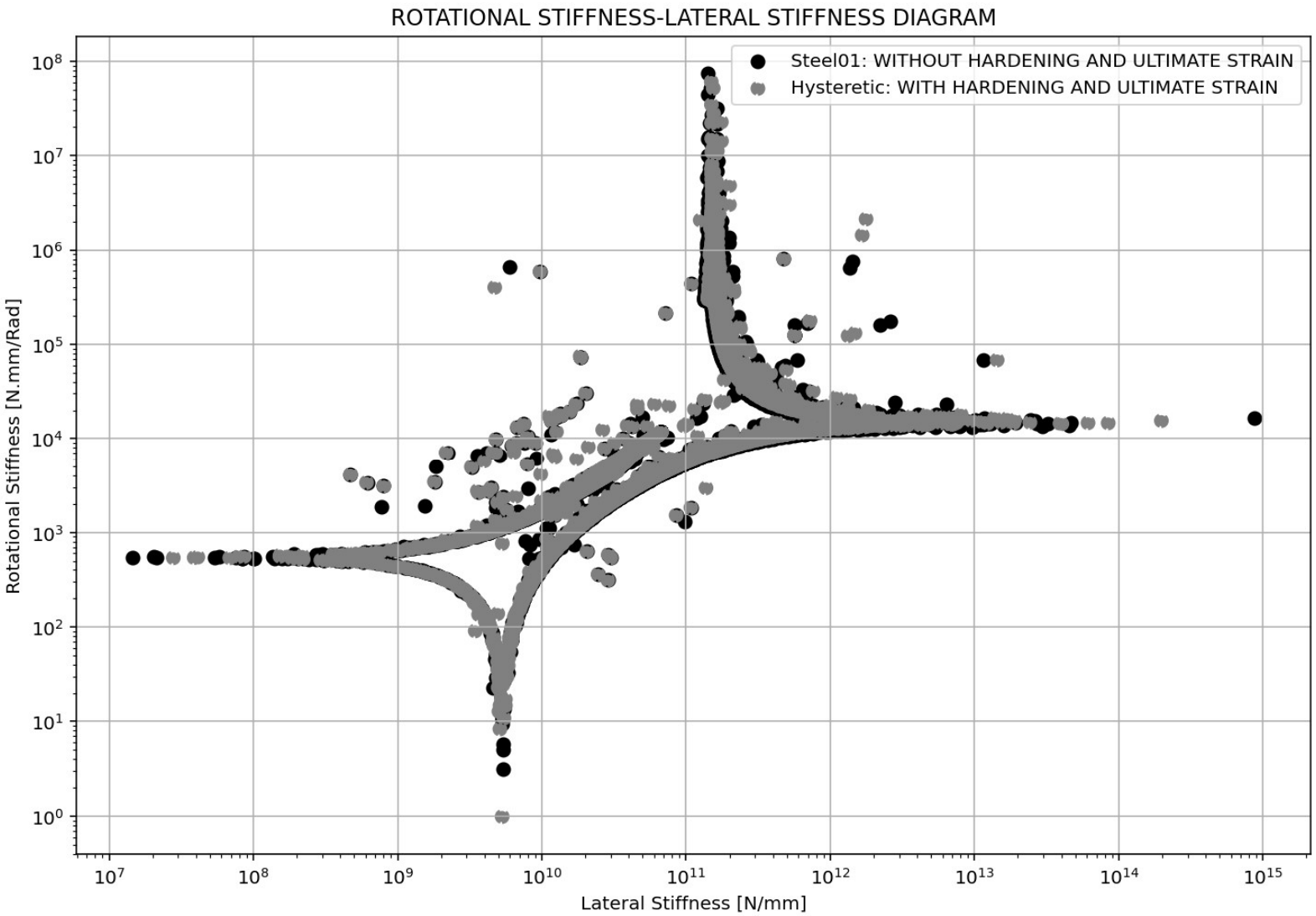

Undeformed and Deformed Shapes - DEFORMED SCALE: 100.00
Undeformed
Deformed
3
4
3
4
1
2
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
3500
0
1000
2000
3000
4000
5000
6000
7000


P-M Interaction
1e6
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
1.5
1.0
0.5
0.0
−0.5
−1.0
Axial Force [N]
−2
0
2
4
Bending Moment [N.mm]
1e9


SHEAR FORCE-DISPLACEMENT DIAGRAM
1e6
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
1.0
0.5
0.0
−0.5
−1.0
−1.5
Shear Force [N]
0
100
200
300
400
Displacement in X [mm]


AXIAL FORCE-DISPLACEMENT DIAGRAM
1e6
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Axial Force [N]
1.5
1.0
0.5
0.0
−0.5
−1.0
−15
−10
−5
0
5
10
15
Displacement in Y [mm]


MOMENT-ROTATION DIAGRAM
1e9
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Moment [N.mm]
4
2
0
−2
−0.150
−0.125
−0.100
−0.075
−0.050
−0.025
0.000
0.025
Rotation [rad]


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness [N/mm]
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^7
10^8
10^9
10^{10}
10^{11}
10^{12}
10^{13}
10^{14}
10^{15}