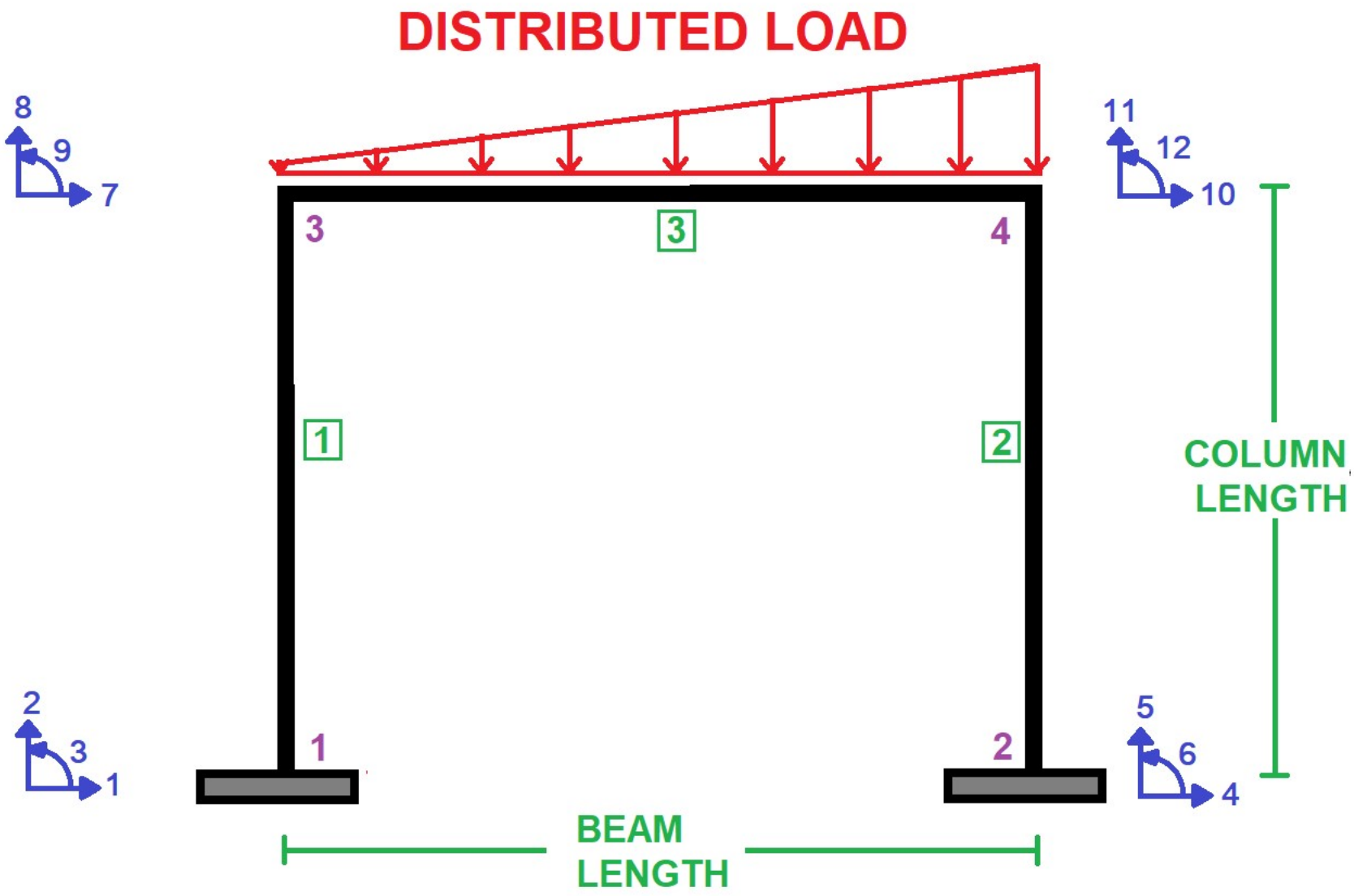
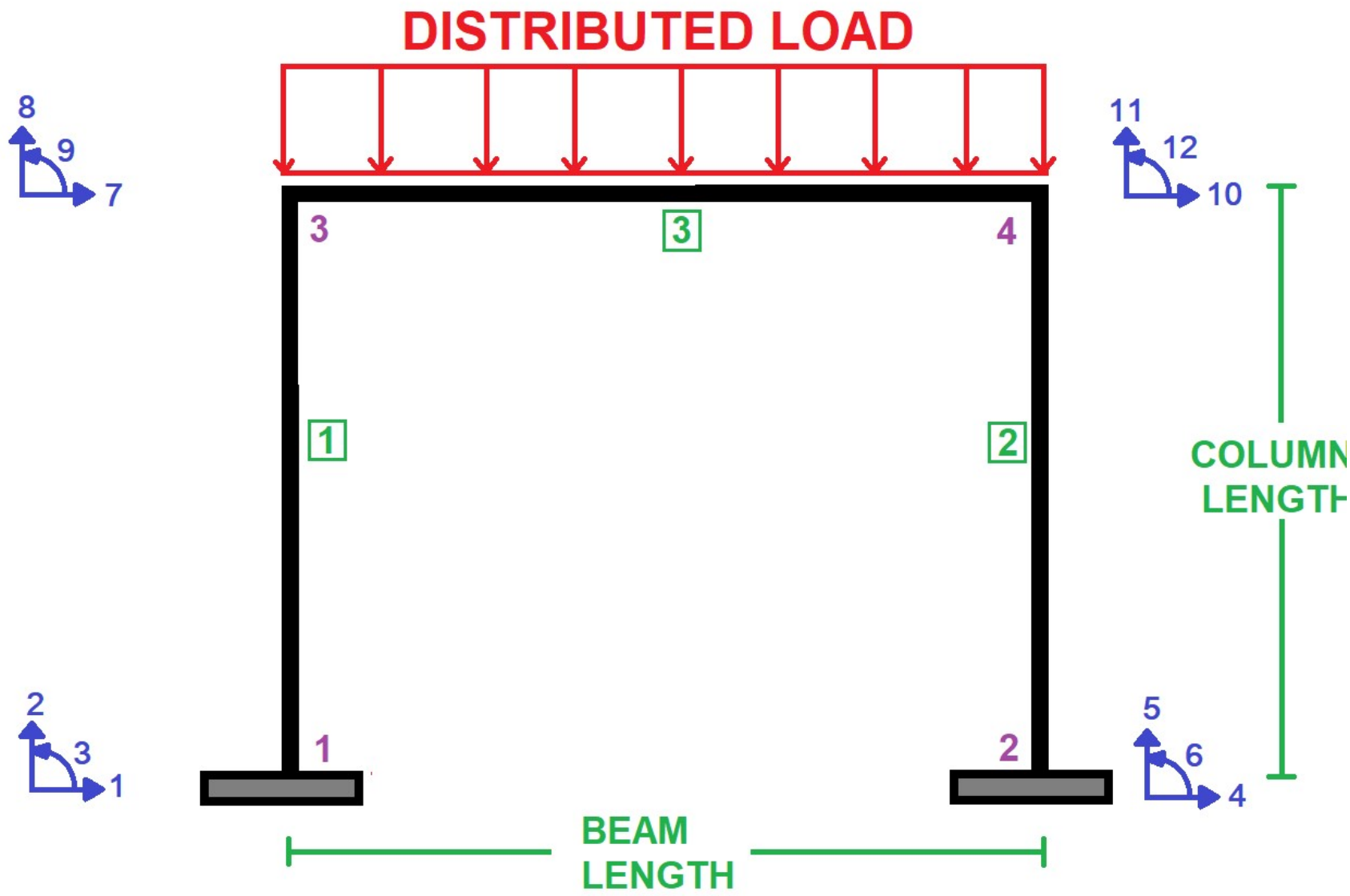
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

PUSHOVER ANALYSIS WITH INCREMENTAL RECTANGULAR OR TRIANGULAR DISTRIBUTED LOAD OF CONCRETE FRAME. EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


DISTRIBUTED LOAD
8
9
7
11
12
10
3
3
4
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH


DISTRIBUTED LOAD
8
9
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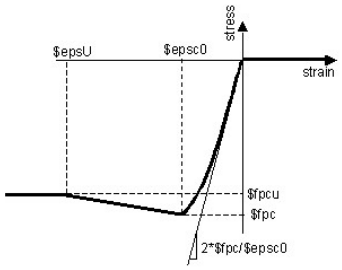
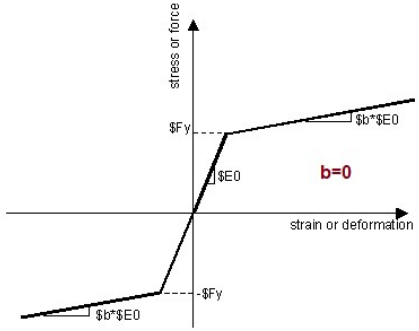
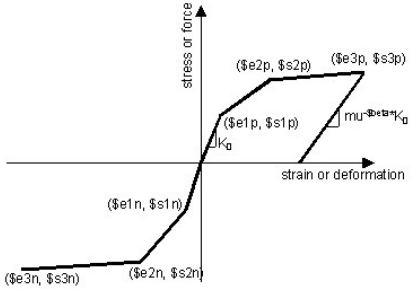
12
10
3
3
4
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH



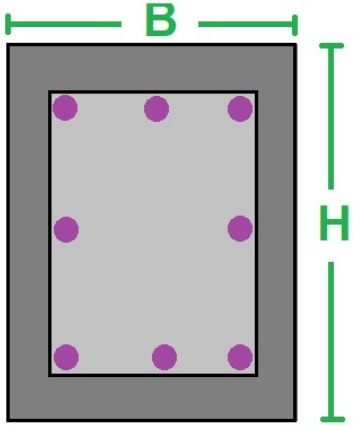
CORE AND COVER CONCRETE RELATION



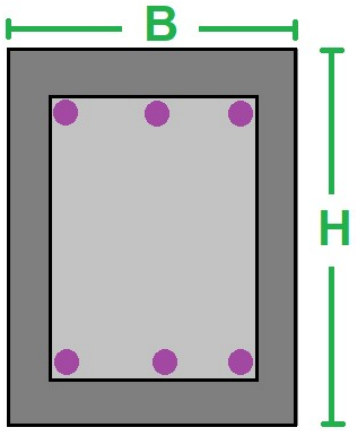
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

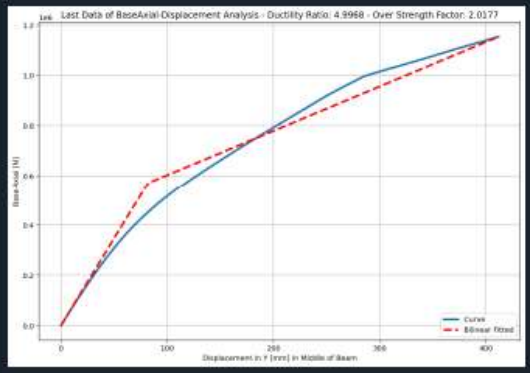
...FILES\CONCRETE_FRAME_EXAMPLES\INCREMENTAL_DISTRIBUTED_LOAD

C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...AD\CONCRETE_FRAME_INCREMENTAL_DISTRIBUTED_LOAD.py

ONCRETE_FRAME_PUSHOVER.py | CONCRETE_FRAME_POST_BUCKLING.py | CONCRETE_FRAME_INC...ISTRIBUTED_LOAD.py*

```
#############################################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#       PUSHOVER ANALYSIS WITH INCREMENTAL RECTANGULAR OR TRIANGULAR DISTRIBUTED LOAD OF CONCRETE FRAME.
#                  EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENSEES
#-------------------------------------------------------------------------------------------------------------
#                              THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                        EMAIL: salar.d.ghashghaei@gmail.com
#############################################################################################################
"""
1. The analysis compares nonlinear rotational behavior of concrete beam-column
 elements under pushover lateral displacements using OpenSees.
2. Two material models—*Steel01* (bilinear without degradation) and *Hysteretic*
 (tri-linear with pinching and strength/stiffness degradation)—are used.
3. Both models are subjected to identical loading protocols to investigate pushover
 response under increasing drift demands.
4. The *Steel01* model exhibits stable hysteresis loops with no degradation, reflecting
 idealized elastic-plastic behavior.
5. In contrast, the *Hysteretic* model shows strength and stiffness degradation, capturing
 post-peak deterioration and pinching effects.
6. Element rotation histories reveal increasing divergence as inelastic demand accumulates
 across cycles.
7. The *Hysteretic* model produces reduced energy dissipation capacity due to pinching and
cumulative damage.
8. Peak rotation capacity is reduced in the *Hysteretic* model, indicating realistic modeling
 of damage and failure modes.
9. The comparison highlights the limitations of bilinear idealizations in capturing cyclic
 degradation in seismic applications.
10. Advanced modeling with calibrated degradation parameters is essential for accurate
 seismic performance prediction and collapse assessment.
"""
import openseespy.opensees as ops
import matplotlib.pyplot as plt
import numpy as np
import time as TI
```

23 %



Help | Variable Explorer | Debugger | Plots | Files

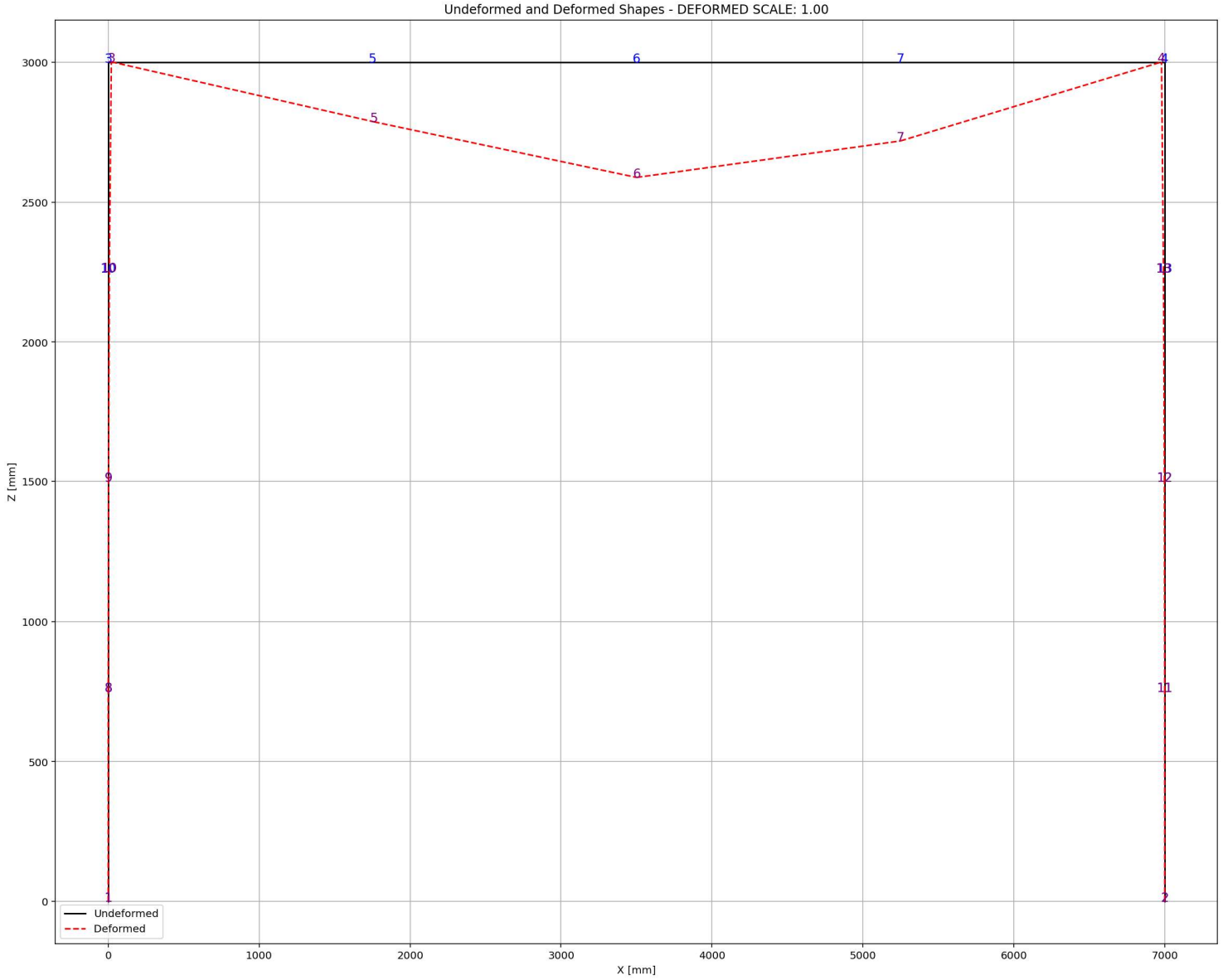
Console 1/A

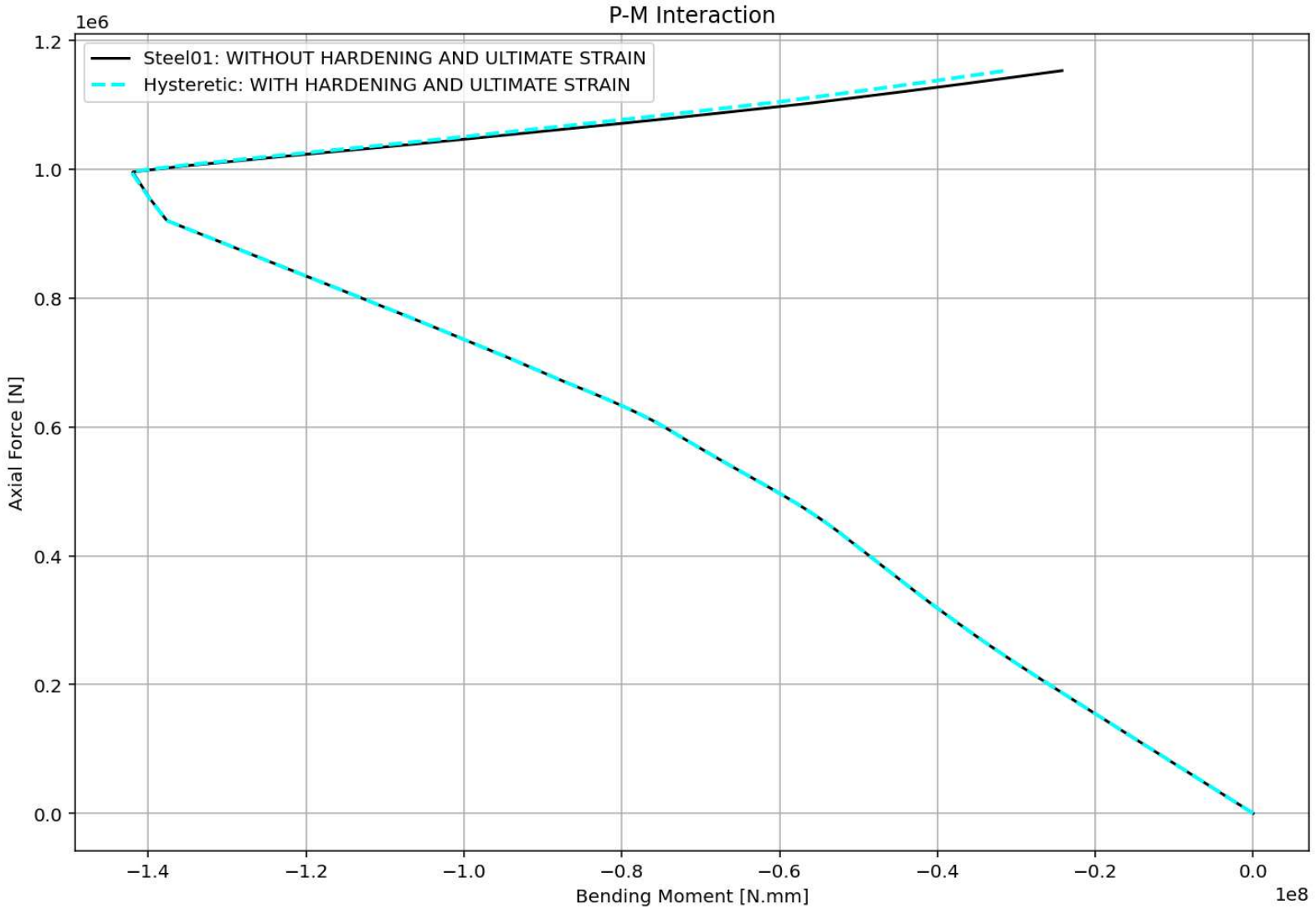
```
Beam2dUniformLoad - tag 43871
  Transverse: 0.3719
  Axial:      0
  Element acted on: 12
Beam2dUniformLoad - tag 43872
  Transverse: 0.093
  Axial:      0
  Element acted on: 9
Beam2dUniformLoad - tag 43873
  Transverse: 0.186
  Axial:      0
```

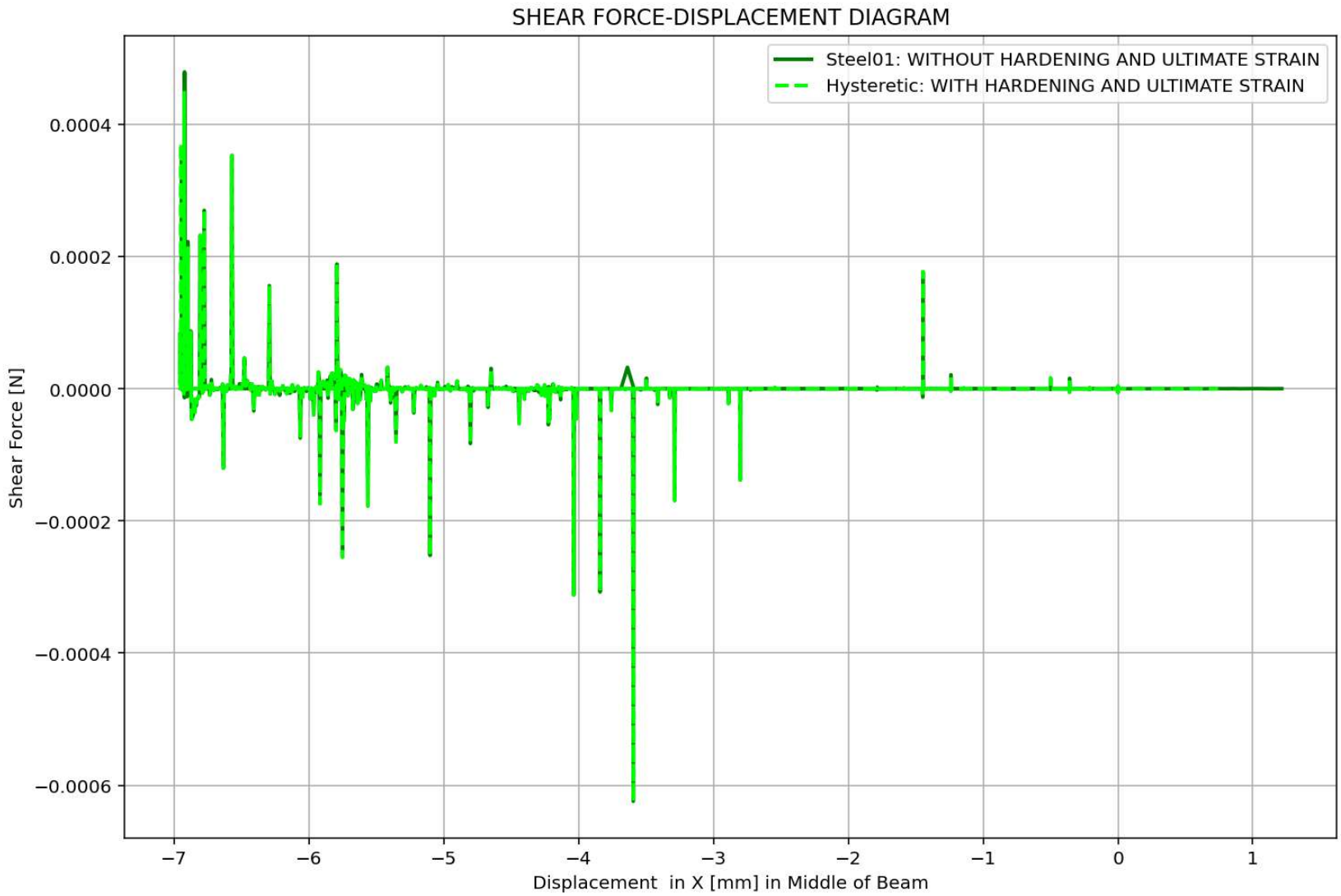
IPython Console | History

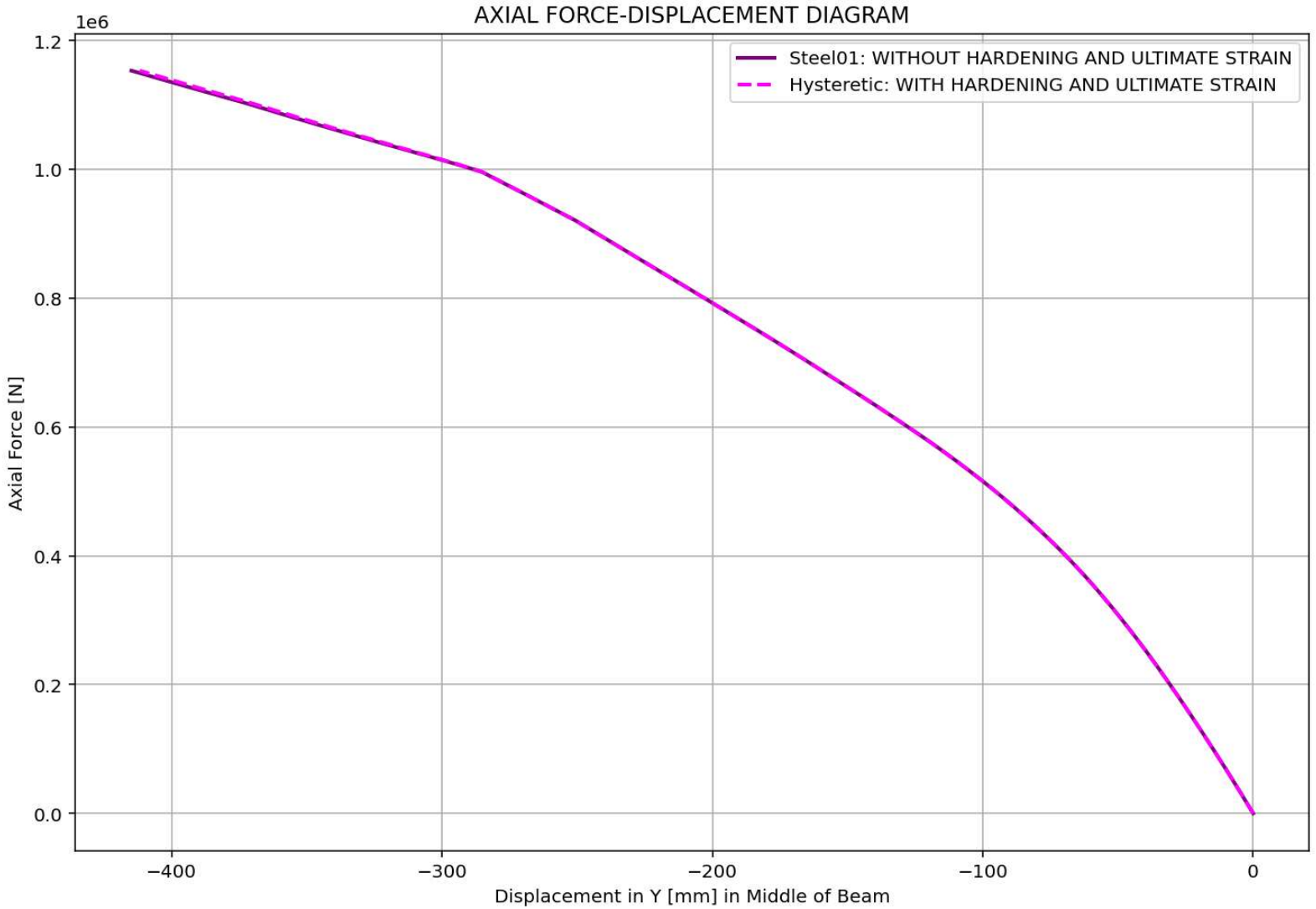
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 4, Col 20 UTF-8 CRLF RW Mem 39%

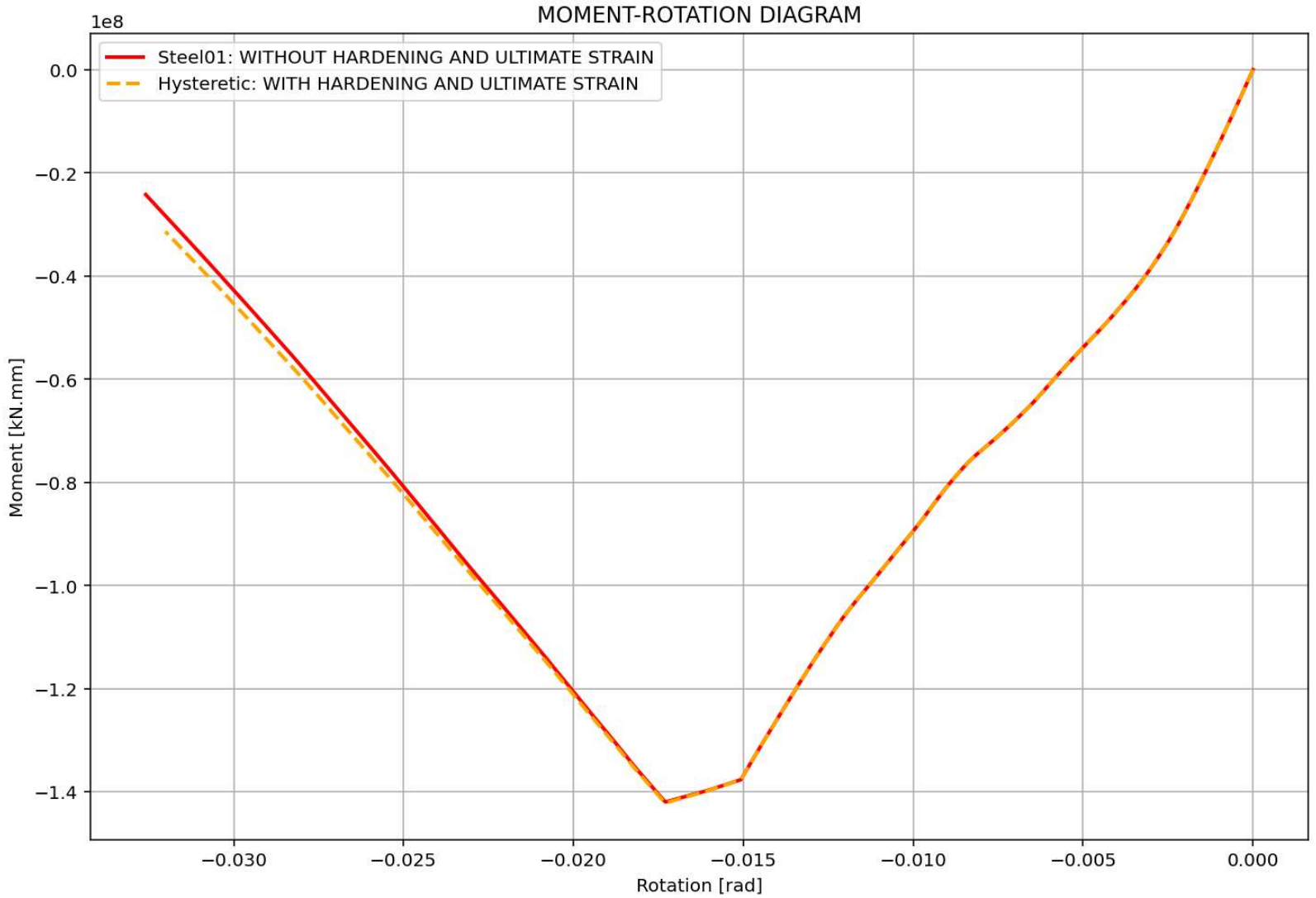
NONLINEAR STATIC ANALYSIS (PUSHOVER)

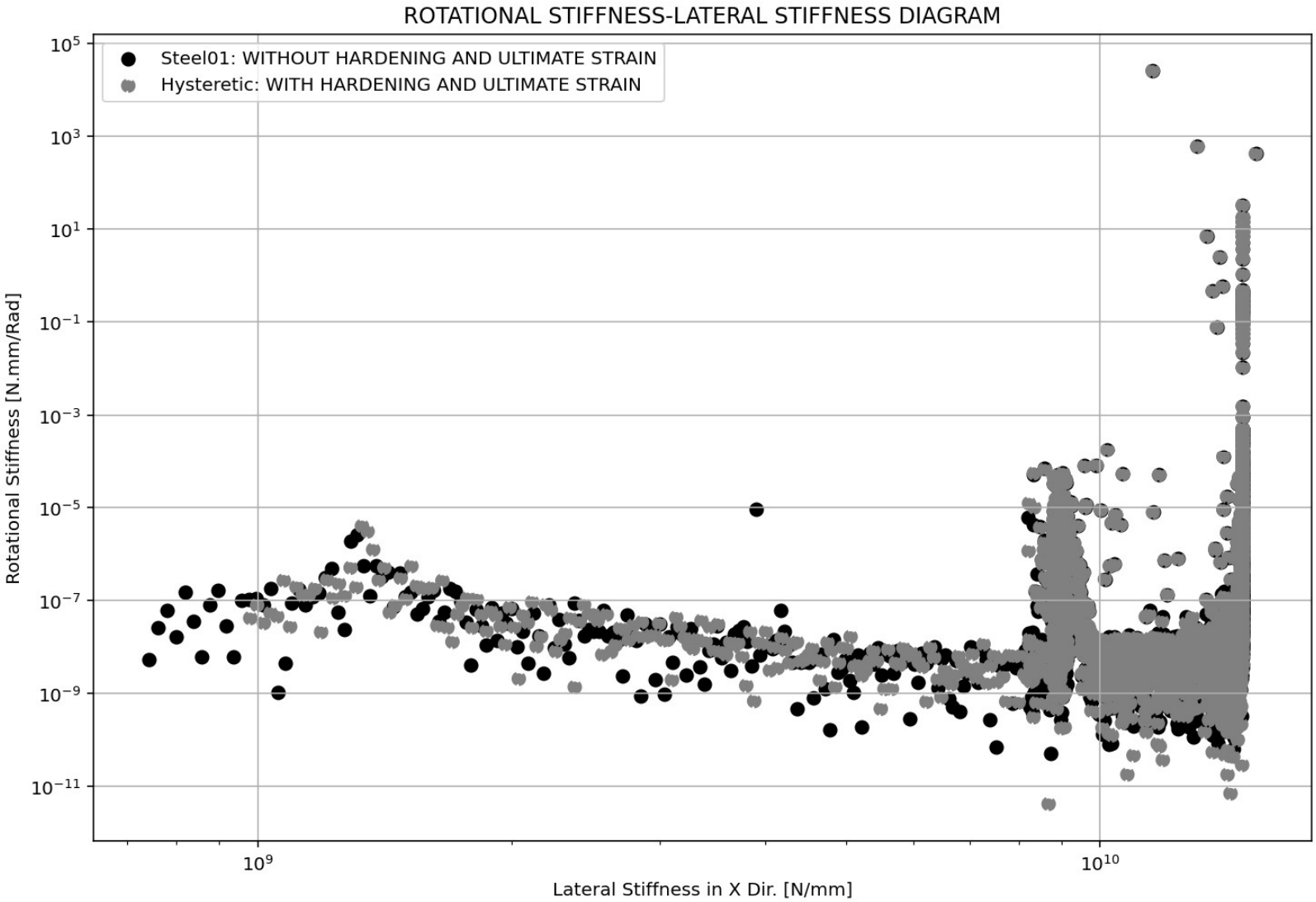

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Z [mm]
X [mm]
Undeformed
Deformed
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000
1
2
3
4
5
6
7
8
9
10
11
12
13

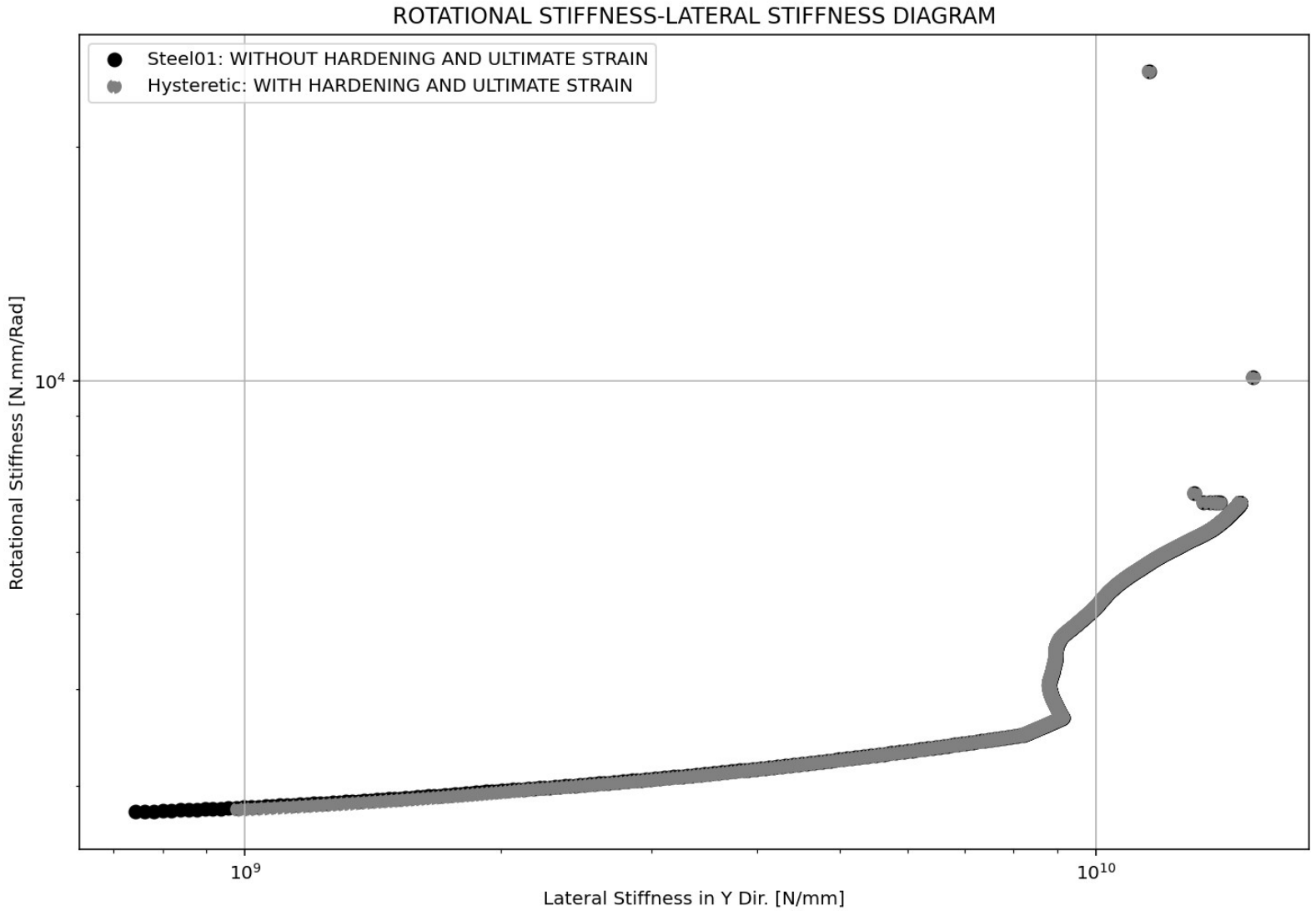

P-M Interaction
1e6
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Axial Force [N]
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
−1.4
−1.2
−1.0
−0.8
−0.6
−0.4
−0.2
0.0
Bending Moment [N.mm]
1e8

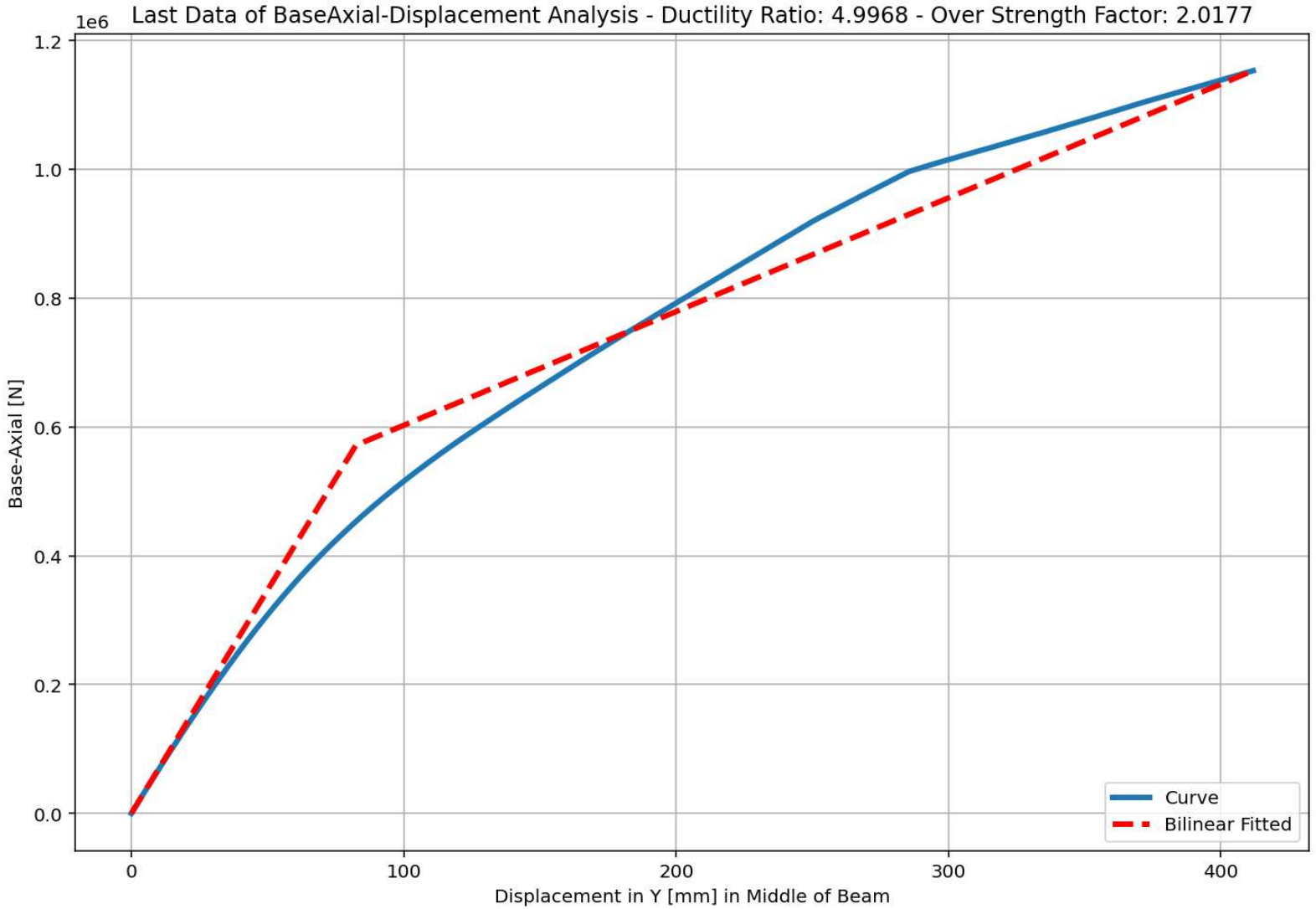

SHEAR FORCE-DISPLACEMENT DIAGRAM
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
Shear Force [N]
0.0004
0.0002
0.0000
−0.0002
−0.0004
−0.0006
−7
−6
−5
−4
−3
−2
−1
0
1
Displacement in X [mm] in Middle of Beam


AXIAL FORCE-DISPLACEMENT DIAGRAM
1e6
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Axial Force [N]
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
−400
−300
−200
−100
0
Displacement in Y [mm] in Middle of Beam


MOMENT-ROTATION DIAGRAM
1e8
Steel01: WITHOUT HARDENING AND ULTIMATE STRAIN
Hysteretic: WITH HARDENING AND ULTIMATE STRAIN
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
−1.4
Moment [kN.mm]
−0.030
−0.025
−0.020
−0.015
−0.010
−0.005
0.000
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 in X Dir. [N/mm]
10^{5}
10^{3}
10^{1}
10^{-1}
10^{-3}
10^{-5}
10^{-7}
10^{-9}
10^{-11}
10^{9}
10^{10}


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


Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 4.9968 - Over Strength Factor: 2.0177
1e6
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Base-Axial [N]
0
100
200
300
400
Displacement in Y [mm] in Middle of Beam
Curve
Bilinear Fitted