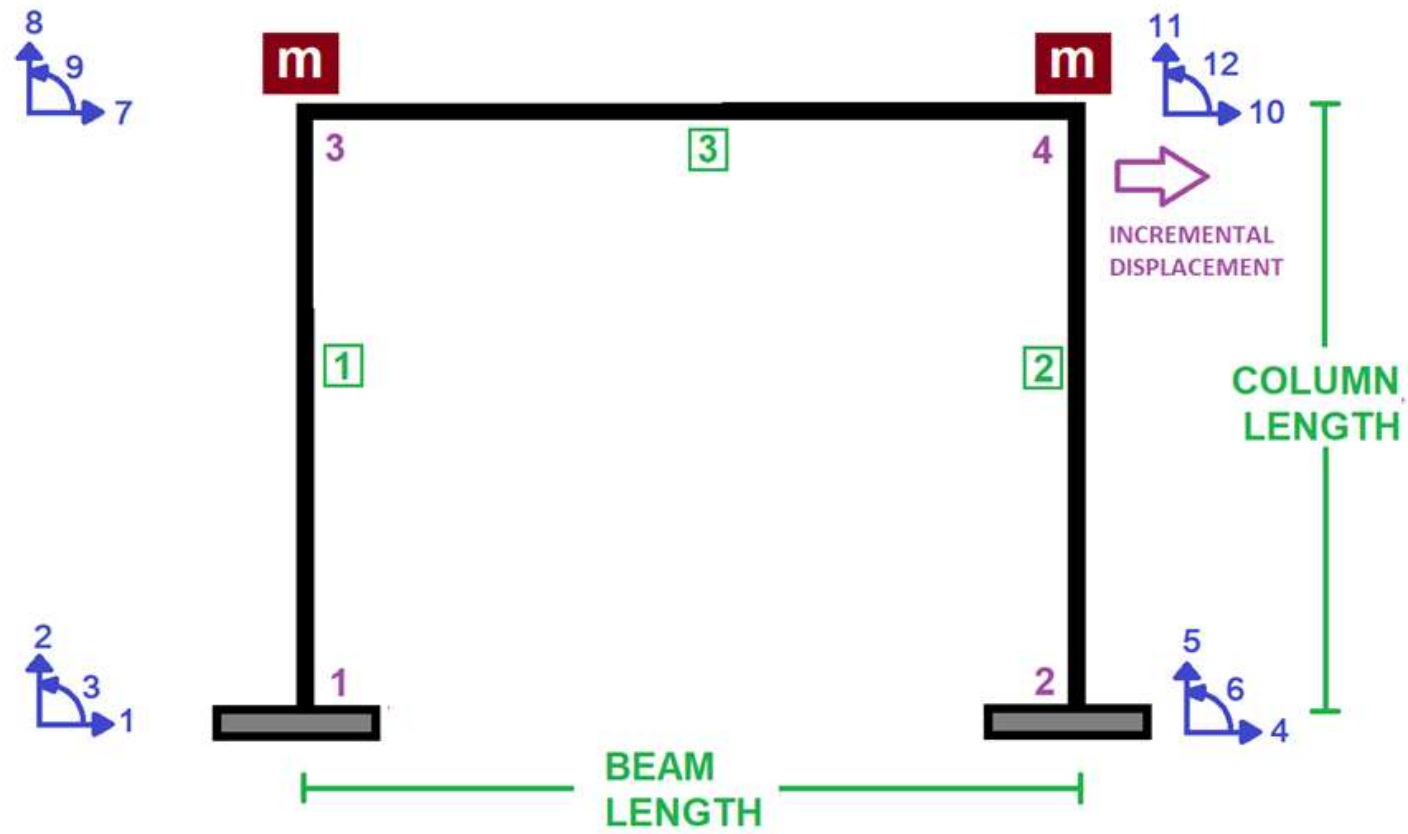
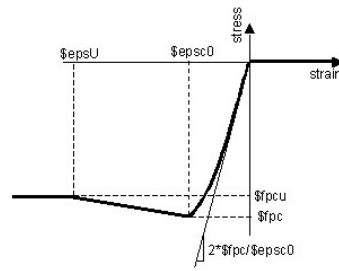


IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

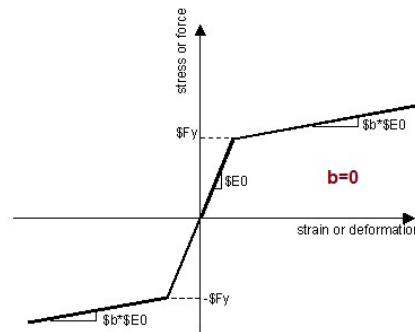
**PUSHOVER ANALYSIS OF CONCRETE FRAME.  
EVALUATING STRAIN HARDENING AND ULTIMATE  
STRAIN CRITERIA USING OPENSEES AND  
CALCULATE STRUCTURAL BEHAVIOR COEFFICIENT**

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

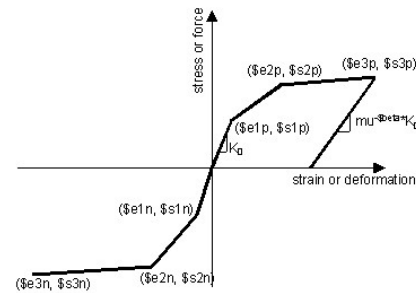




CORE AND COVER CONCRETE RELATION



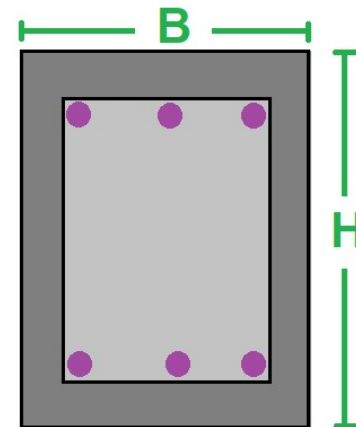
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

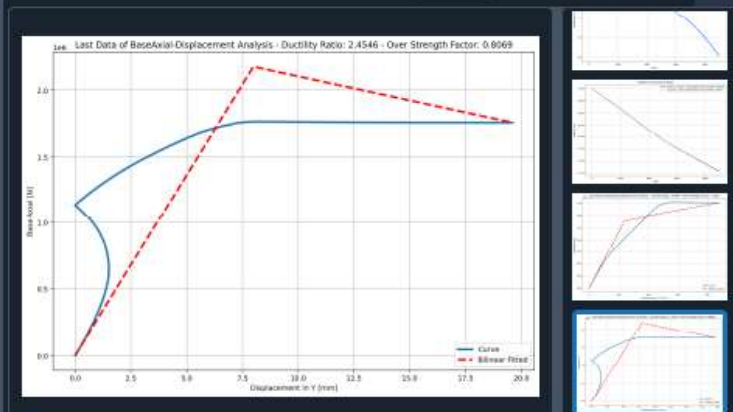
C:\Users\Dell\Desktop\OPENSEES\_FILES\CONCRETE\_FRAME\_EXAMPLES\PUSHOVER\CONCRETE\_FRAME\_PUSHOVER.py

CONCRETE\_FRAME\_PUSHOVER.py

```

1 #####
2 #                               >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
3 # PUSHOVER ANALYSIS OF CONCRETE FRAME. EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENS
4 #                               AND CALCULATE STRUCTURAL BEHAVIOR COEFFICIENT
5 #-----
6 #                               THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
7 #                               EMAIL: salar.d.ghashghaei@gmail.com
8 #####
9 """
10 1. The analysis compares nonlinear rotational behavior of concrete beam-column
11    elements under pushover lateral displacements using OpenSees.
12 2. Two material models-*Steel01* (bilinear without degradation) and *Hysteretic*
13    (tri-linear with pinching and strength/stiffness degradation)-are used.
14 3. Both models are subjected to identical loading protocols to investigate pushover
15    response under increasing drift demands.
16 4. The *Steel01* model exhibits stable hysteresis loops with no degradation, reflecting
17    idealized elastic-plastic behavior.
18 5. In contrast, the *Hysteretic* model shows strength and stiffness degradation, capturing
19    post-peak deterioration and pinching effects.
20 6. Element rotation histories reveal increasing divergence as inelastic demand accumulates
21    across cycles.
22 7. The *Hysteretic* model produces reduced energy dissipation capacity due to pinching and
23    cumulative damage.
24 8. Peak rotation capacity is reduced in the *Hysteretic* model, indicating realistic modeling
25    of damage and failure modes.
26 9. The comparison highlights the limitations of bilinear idealizations in capturing cyclic
27    degradation in seismic applications.
28 10. Advanced modeling with calibrated degradation parameters is essential for accurate
29    seismic performance prediction and collapse assessment.
30 """
31 import openseespy.opensees as ops
32 import matplotlib.pyplot as plt
33 import numpy as np
34 import time as TI

```



Help Variable Explorer Debugger Plots Files

Console 1/A

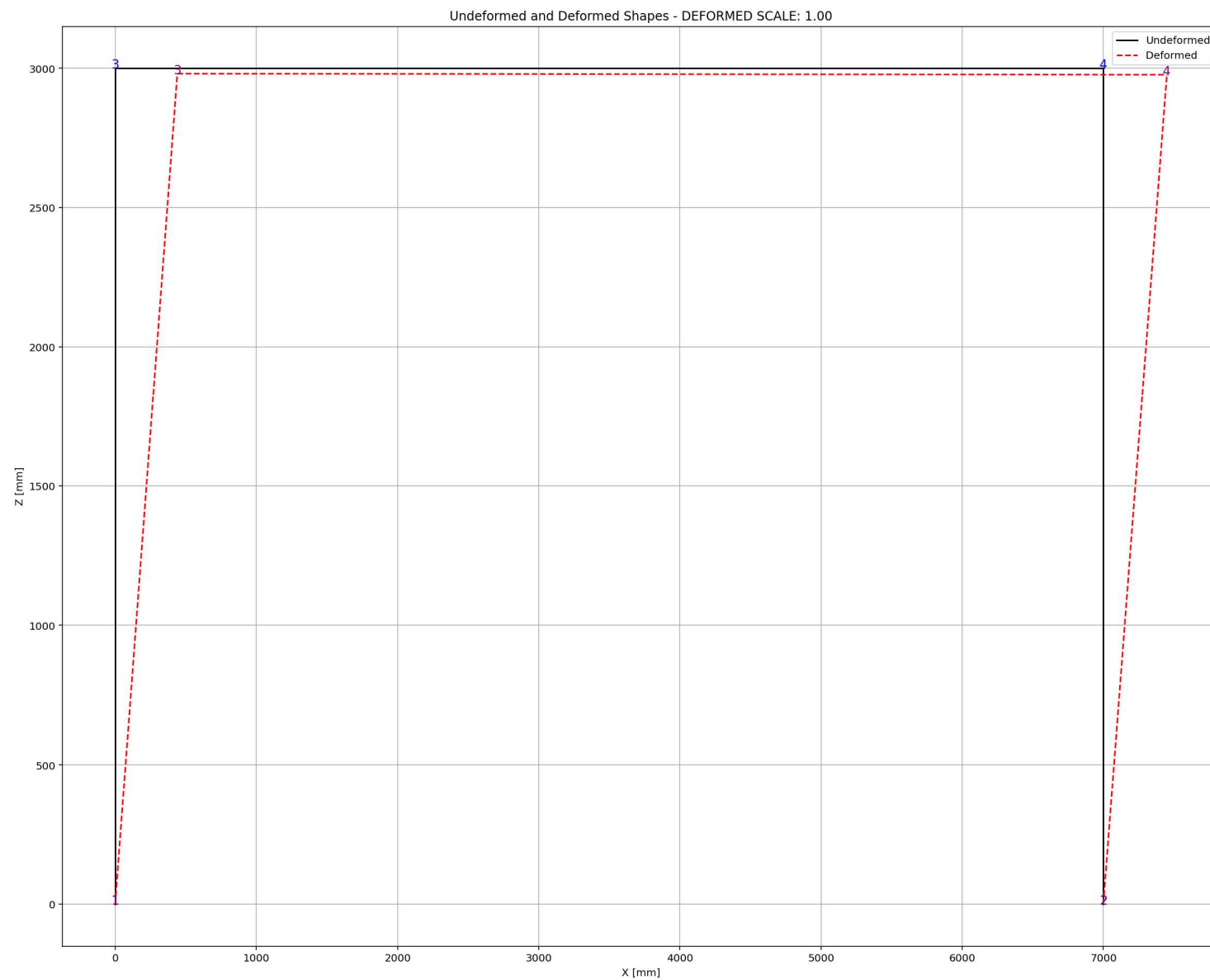
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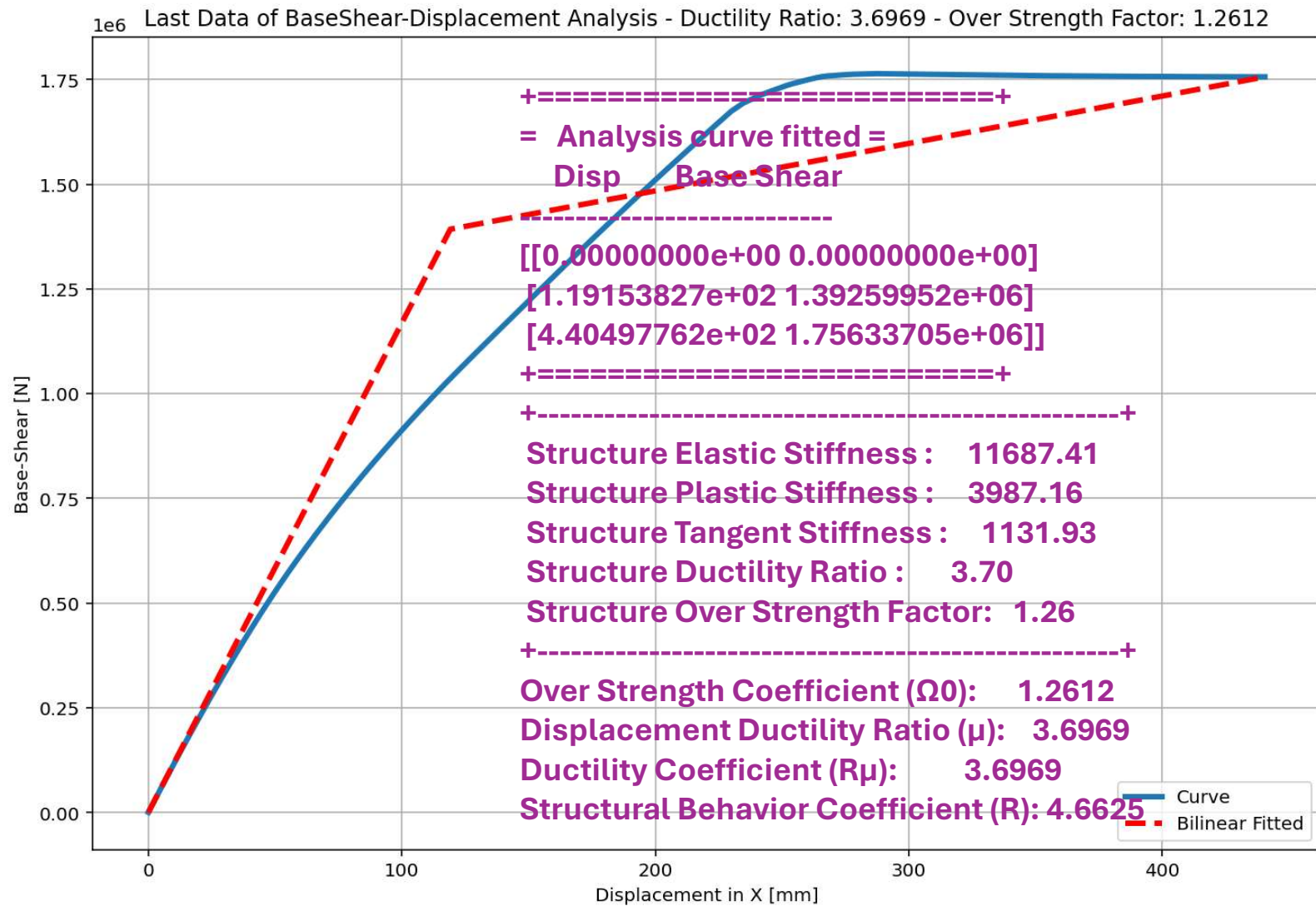
Displacement Ductility Ratio (μ): 3.6969
Ductility Coefficient (Rμ): 3.6969
Structural Behavior Coefficient (R): 4.6625
+=====+
= Analysis curve fitted =
  Disp      Base Shear
+-----+
[[0.00000000e+00 0.00000000e+00]
 [7.98659734e+00 2.17669541e+06]
 [1.96042295e+01 1.75633705e+06]]
+=====+

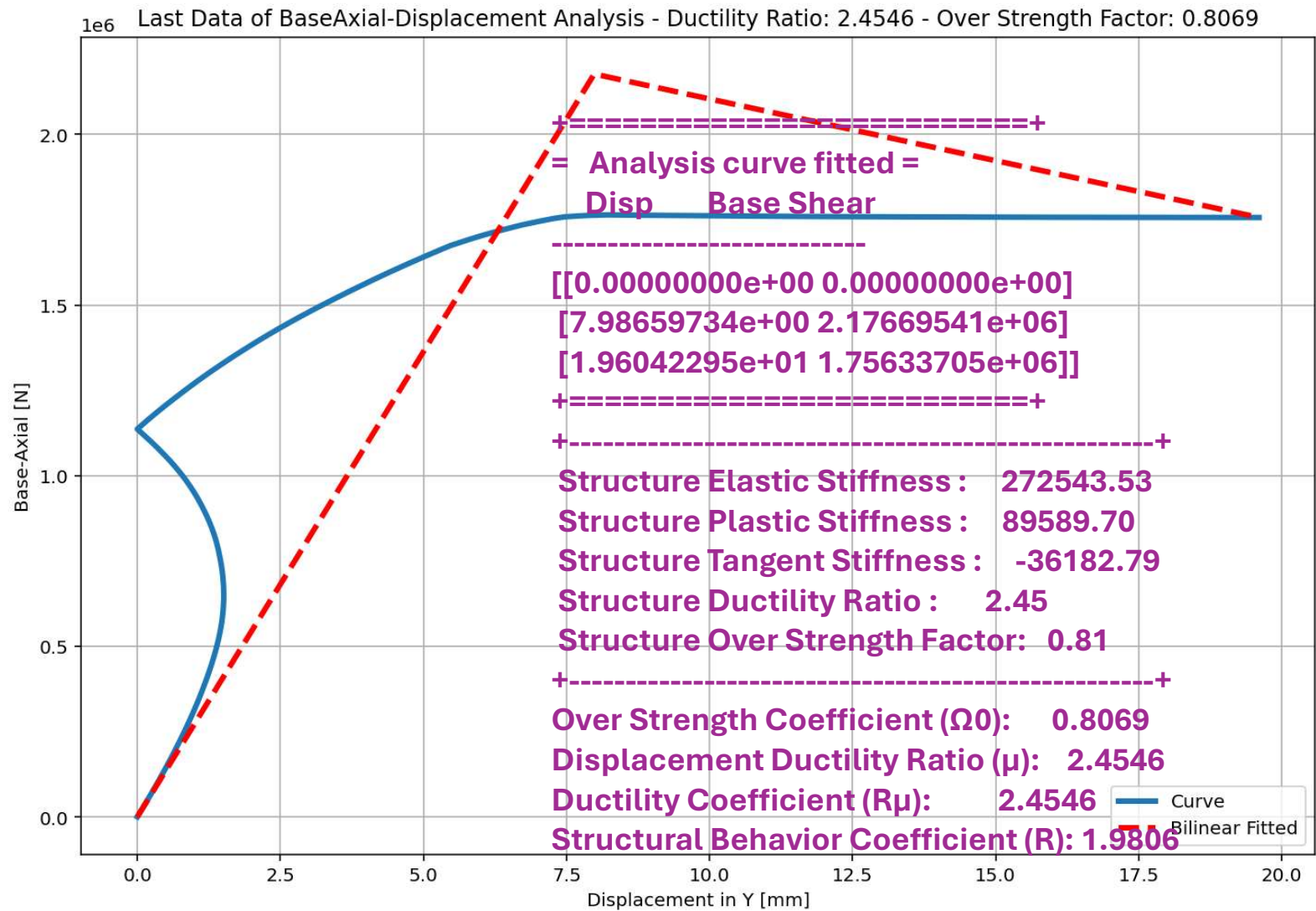
```

IPython Console History

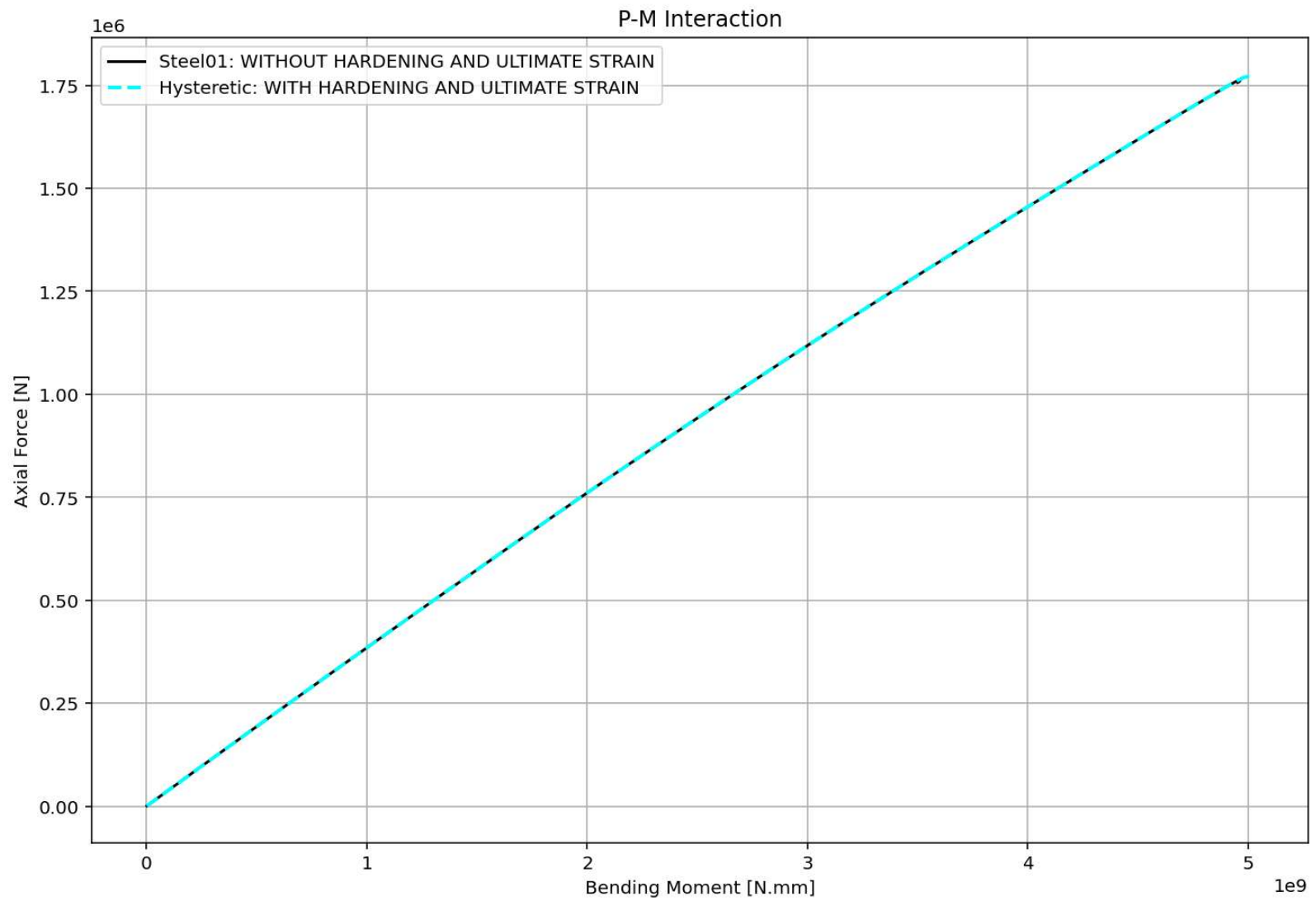
# **NONLINEAR STATIC ANALYSIS (PUSHOVER)**

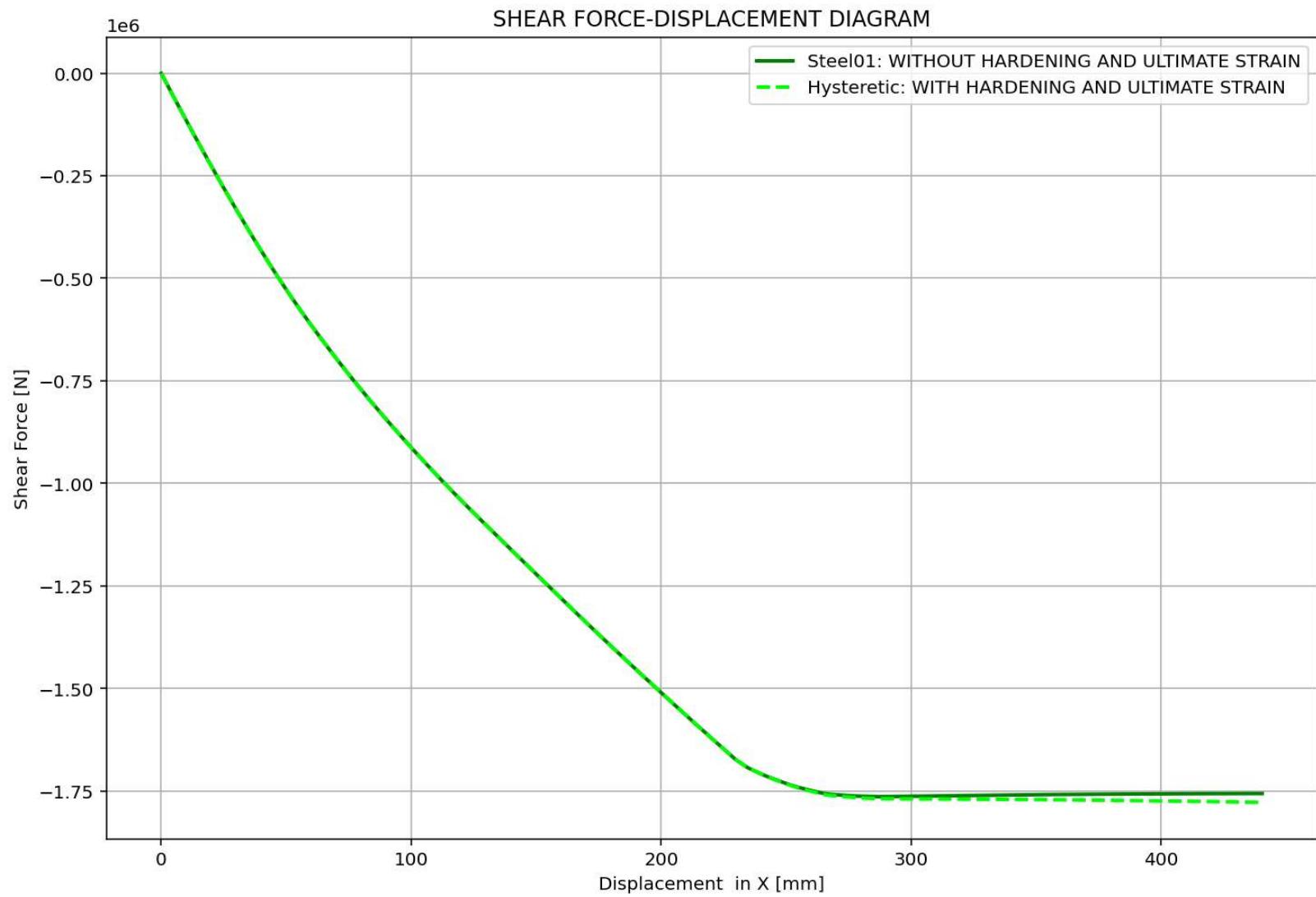


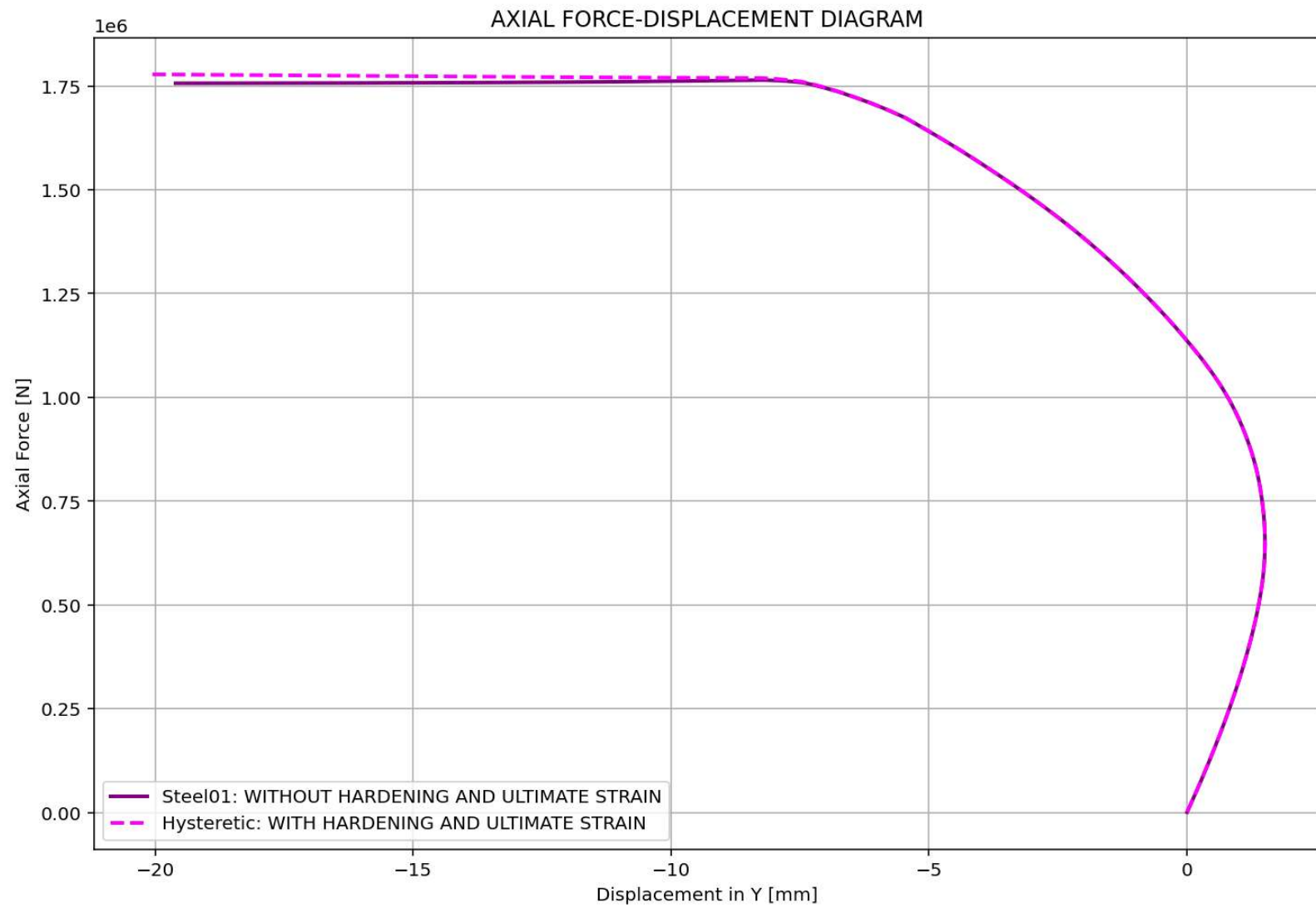


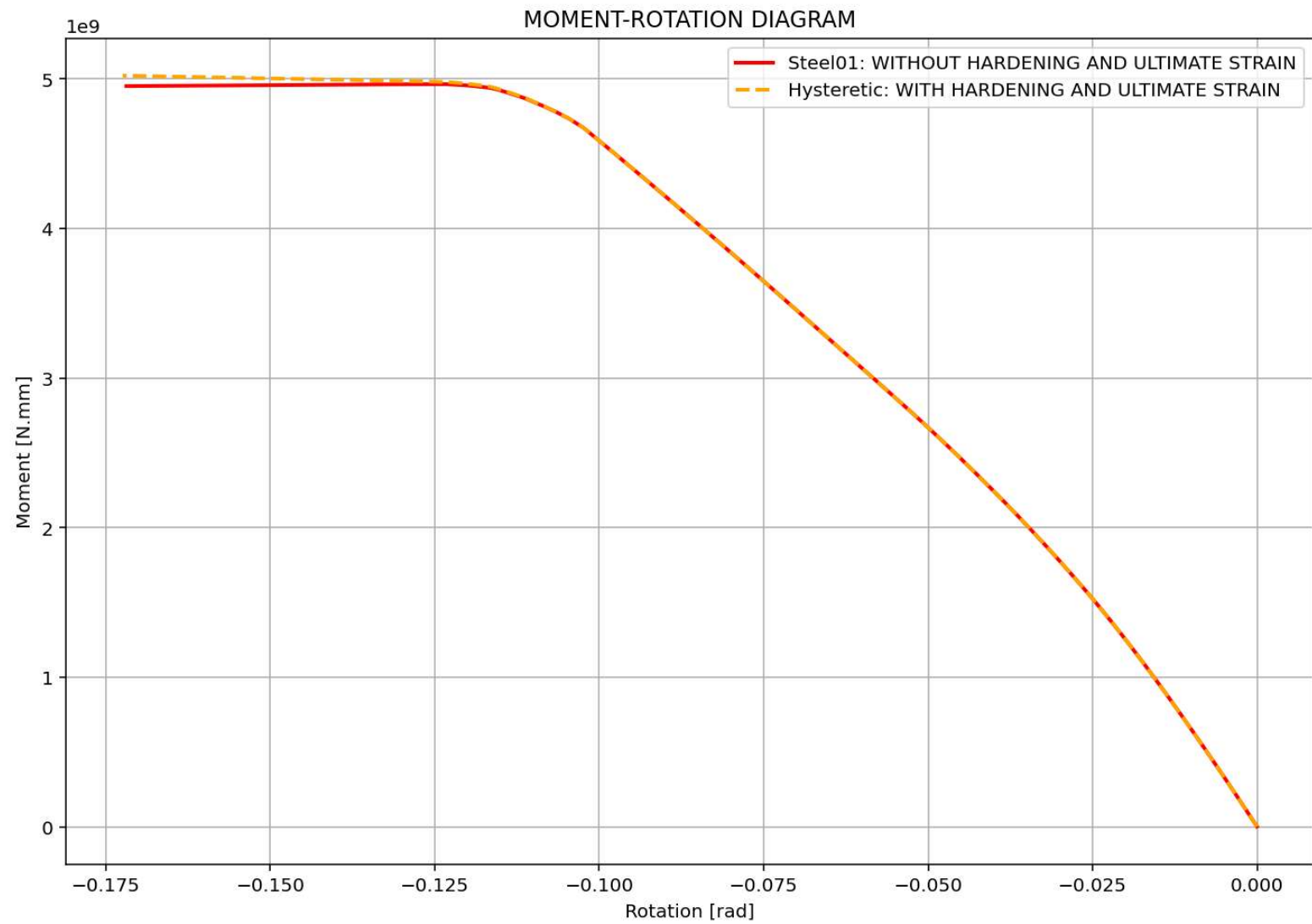


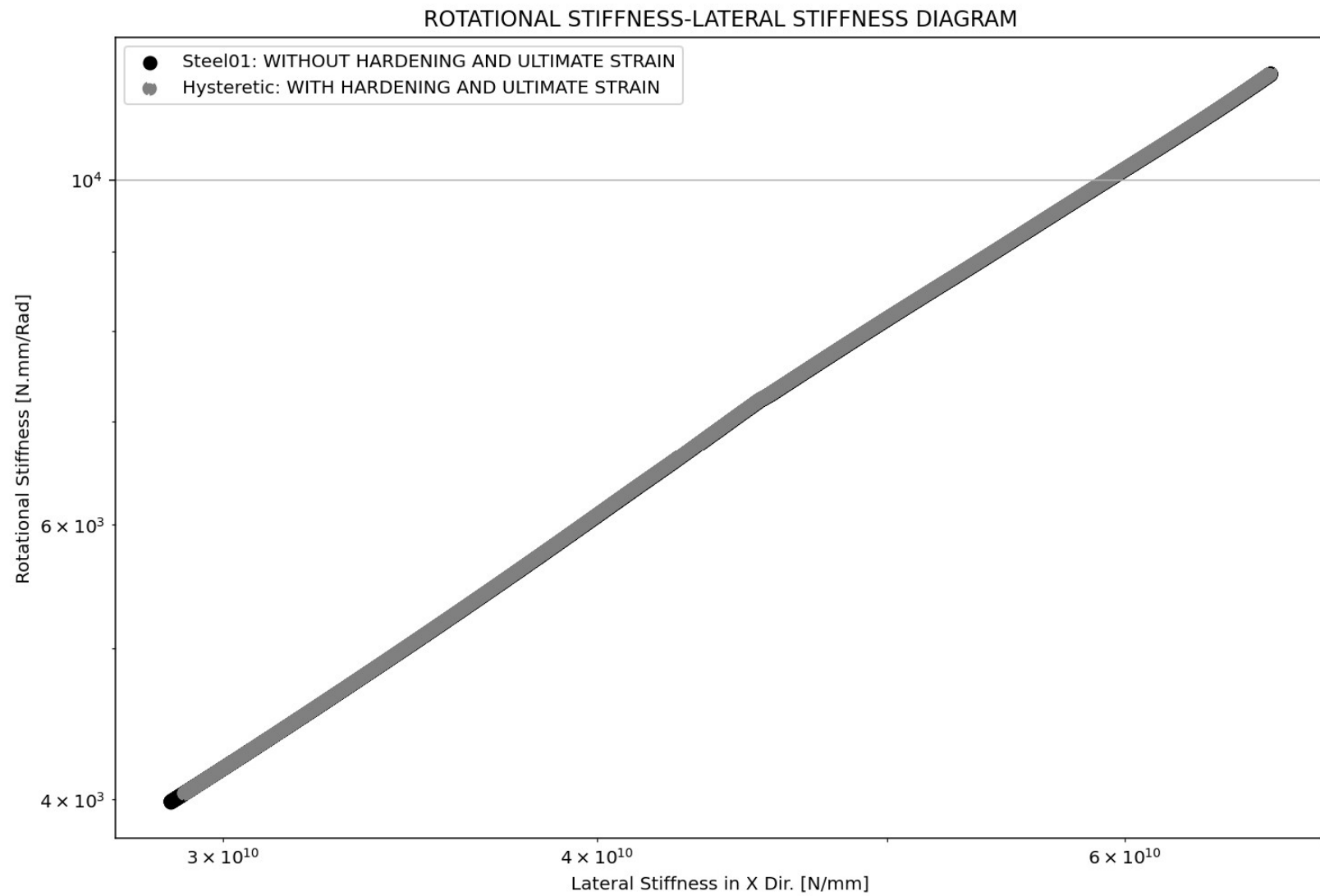












ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM

