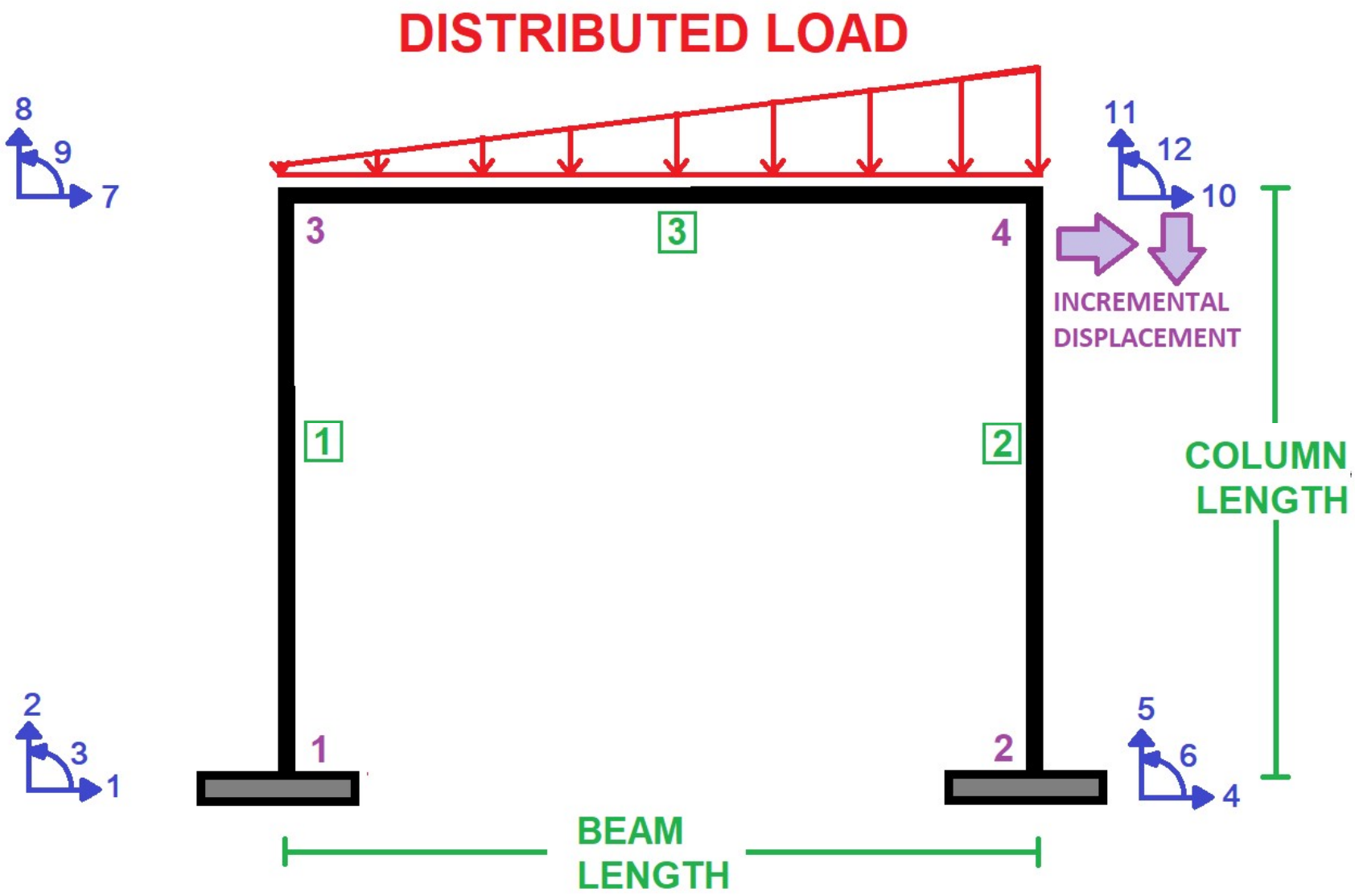
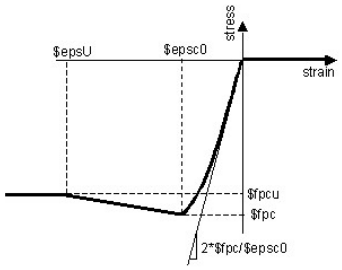
IN THE NAME OF ALLAH

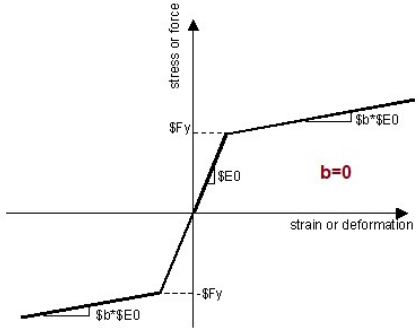
PROGRESSIVE COLLAPSE ANALYSIS OF CONCRETE FRAME.
EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENSEES.
DISPLACEMENT CONTROL

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

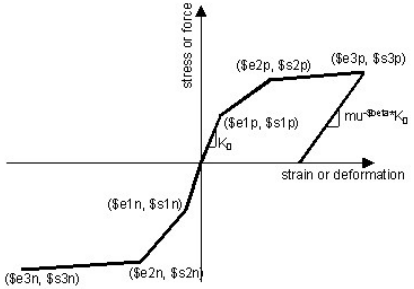

DISTRIBUTED LOAD
8
9
7
11
12
10
3
3
4
INCREMENTAL
DISPLACEMENT
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH



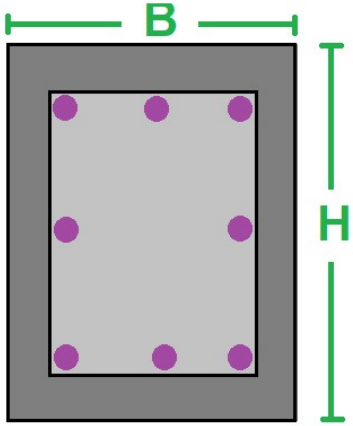
CORE AND COVER CONCRETE RELATION



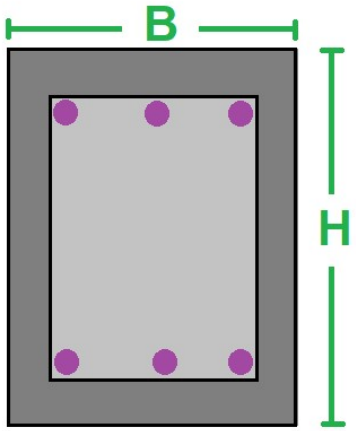
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

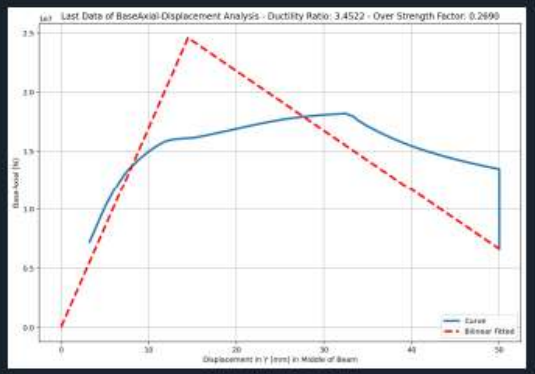
...PENSEES_FILES\CONCRETE_FRAME_EXAMPLES\PROGRESSIVE_COLLAPSE

C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...OLLAPSE\CONCRETE_FRAME_PROGRESSIVE_COLLAPSE_DC.py

AME_POST_BUCKLING.py | CONCRETE_FRAME_INC...ISTRIBUTED_LOAD.py | CONCRETE_FRAME_PRO...IVE_COLLAPSE_DC.py

```
##########################################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#                                  PROGRESSIVE COLLAPSE ANALYSIS OF CONCRETE FRAME.
#                        EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENSEES
#--------------------------------------------------------------------------------------------------------
#                                                DISPLACEMET CONTROL
#--------------------------------------------------------------------------------------------------------
#                                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] In contrast, the *Hysteretic* model shows strength and stiffness degradation, capturing
 post-peak deterioration and pinching effects.
[5] Element rotation histories reveal increasing divergence as inelastic demand accumulates
 across cycles.
[6] The *Hysteretic* model produces reduced energy dissipation capacity due to pinching and
cumulative damage.
[7] Peak rotation capacity is reduced in the *Hysteretic* model, indicating realistic modeling
 of damage and failure modes.
[8] The comparison highlights the limitations of bilinear idealizations in capturing cyclic
 degradation in seismic applications.
[9] Advanced modeling with calibrated degradation parameters is essential for accurate
 seismic performance prediction and collapse assessment.
-------------------------------------------------------------------------------
 Progressive collapse of reinforced concrete frames occurs when a local failure—due to accidental
  actions such as impact, explosion or fire—triggers a chain reaction of element removals, leading
  to partial or total structural loss. Advanced assessment hinges on capturing nonlinear material
  behavior, geometric effects, and load-redistribution mechanisms that dictate whether alternative
```

23 %

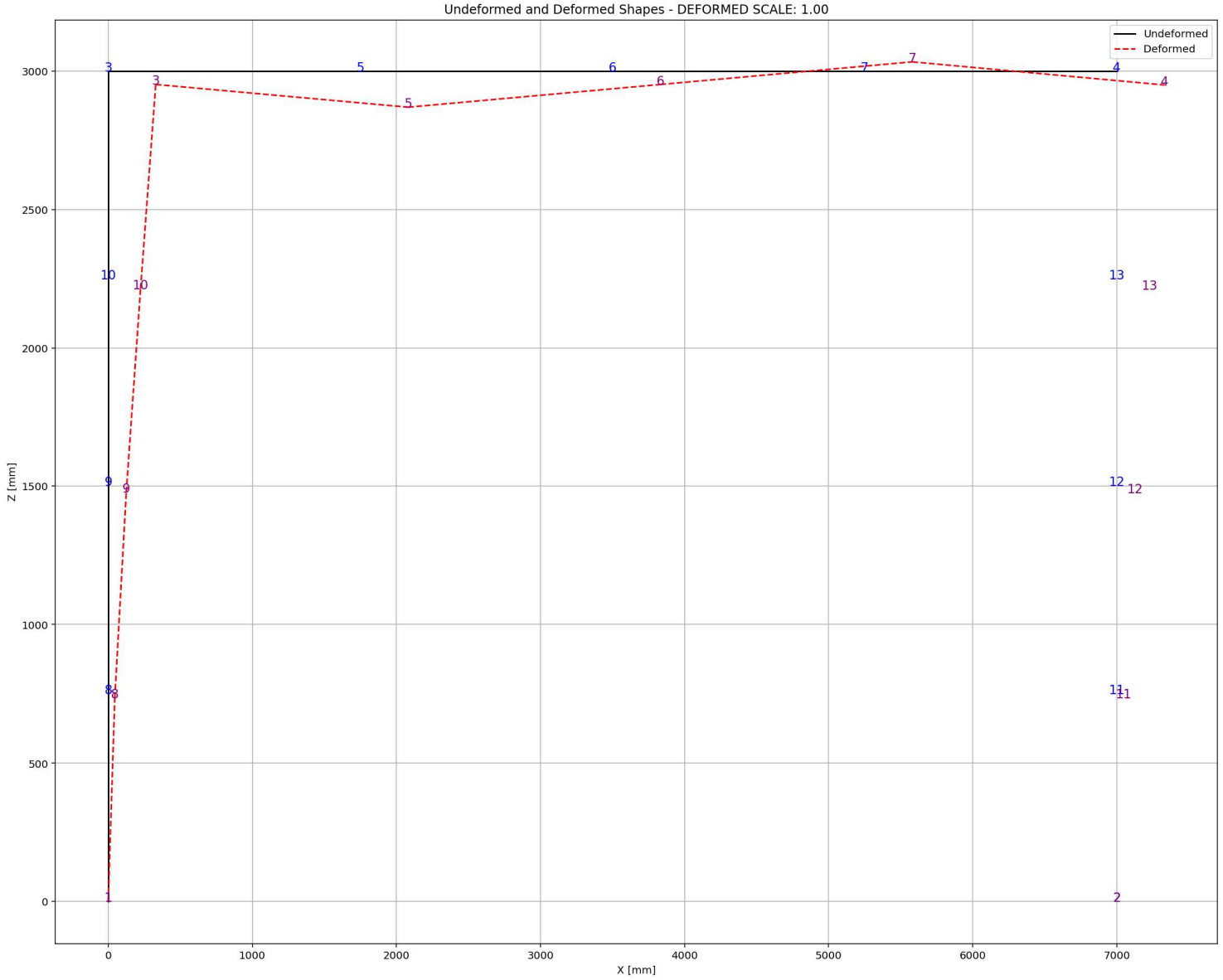


Help | Variable Explorer | Debugger | Plots | Files

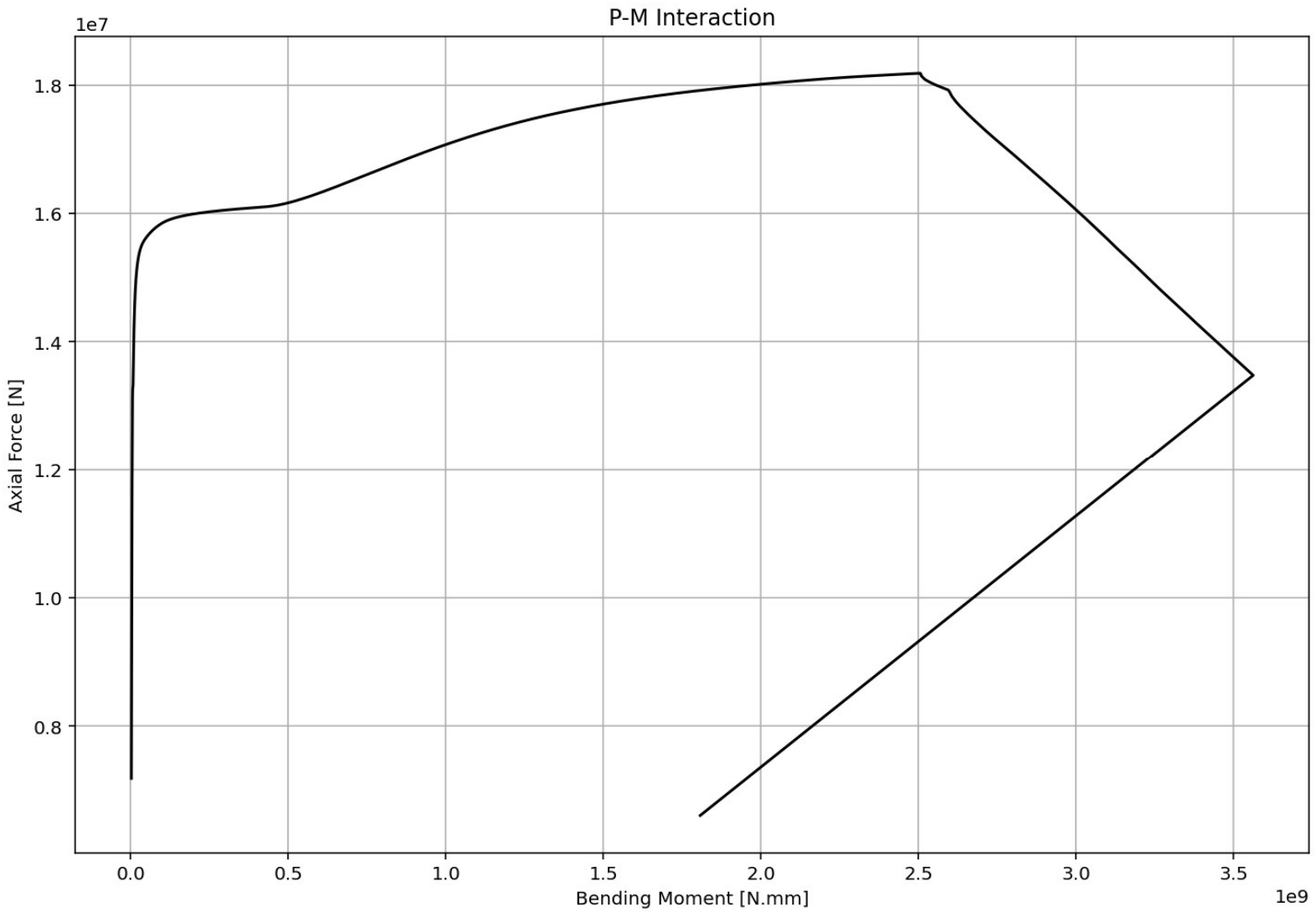
Console 1/A

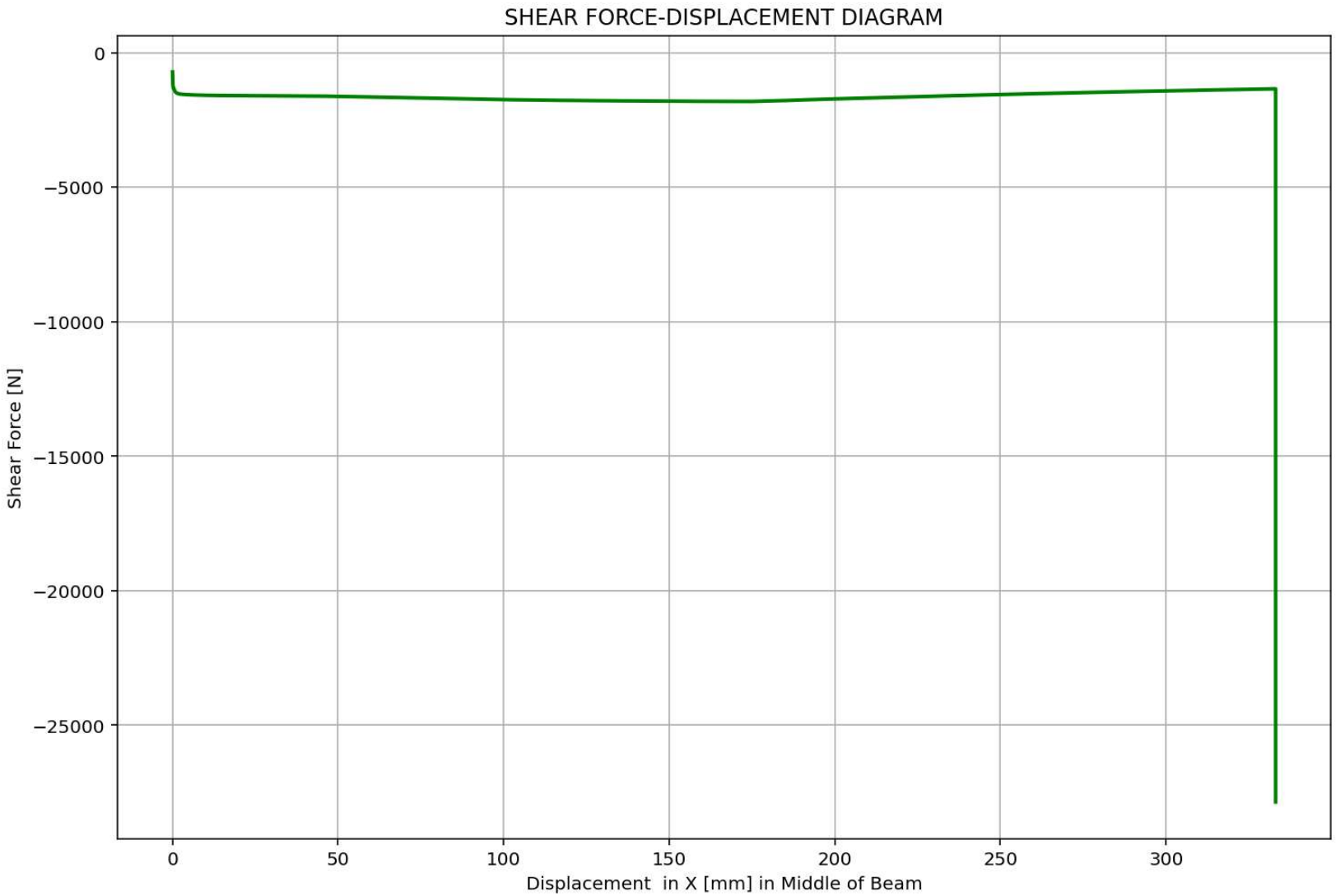
```
NormDispIncr KrylovNewton -2
NormDispIncr SecantNewton -2
NormDispIncr RaphsonNewton -2
NormDispIncr PeriodicNewton -2
NormDispIncr BFGS -2
NormDispIncr Broyden -2
NormDispIncr NewtonLineSearch -2
RelativeEnergyIncr KrylovNewton -2
RelativeEnergyIncr SecantNewton -2
RelativeEnergyIncr RaphsonNewton -2
RelativeEnergyIncr PeriodicNewton -2
```

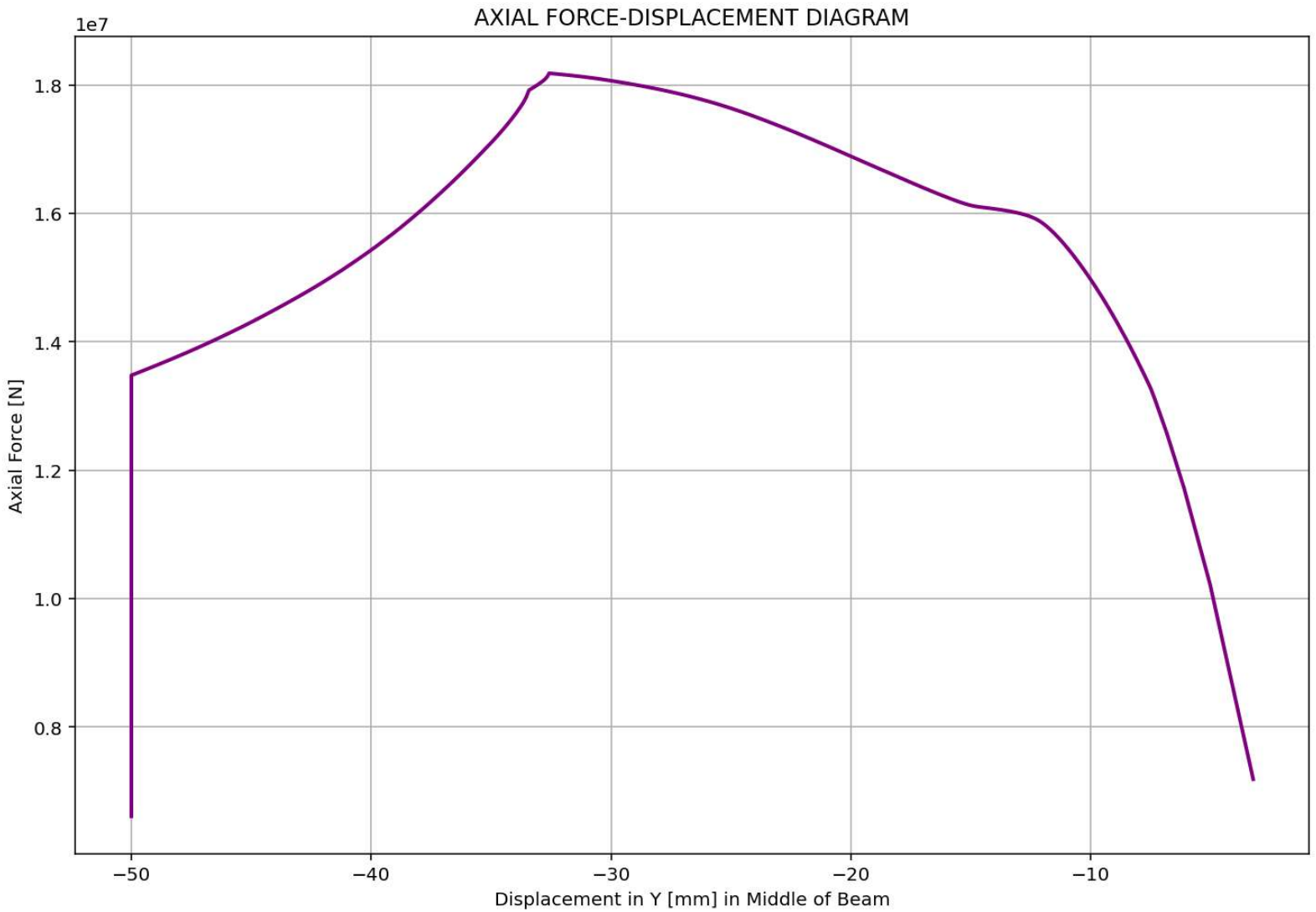
IPython Console | History

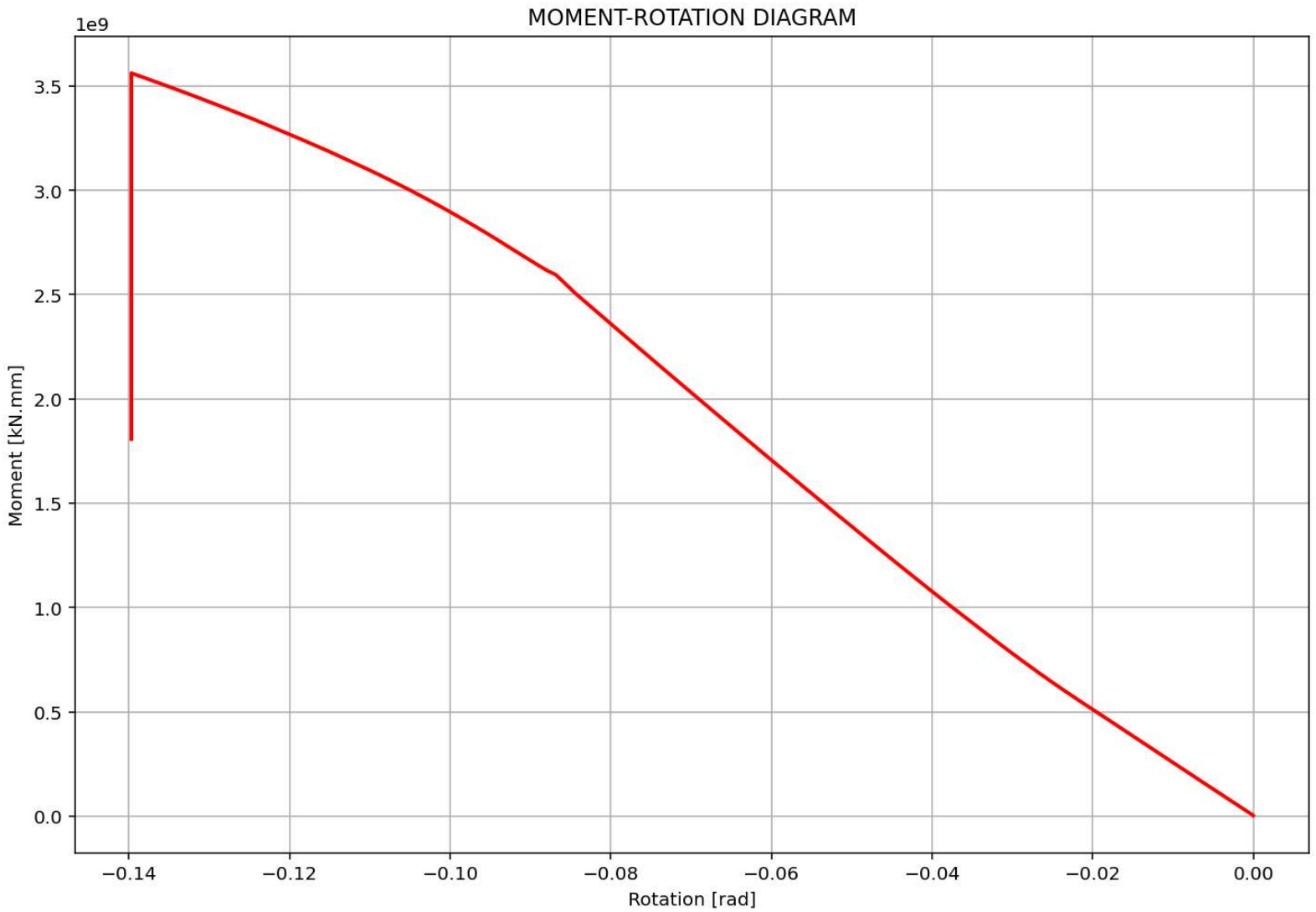

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000

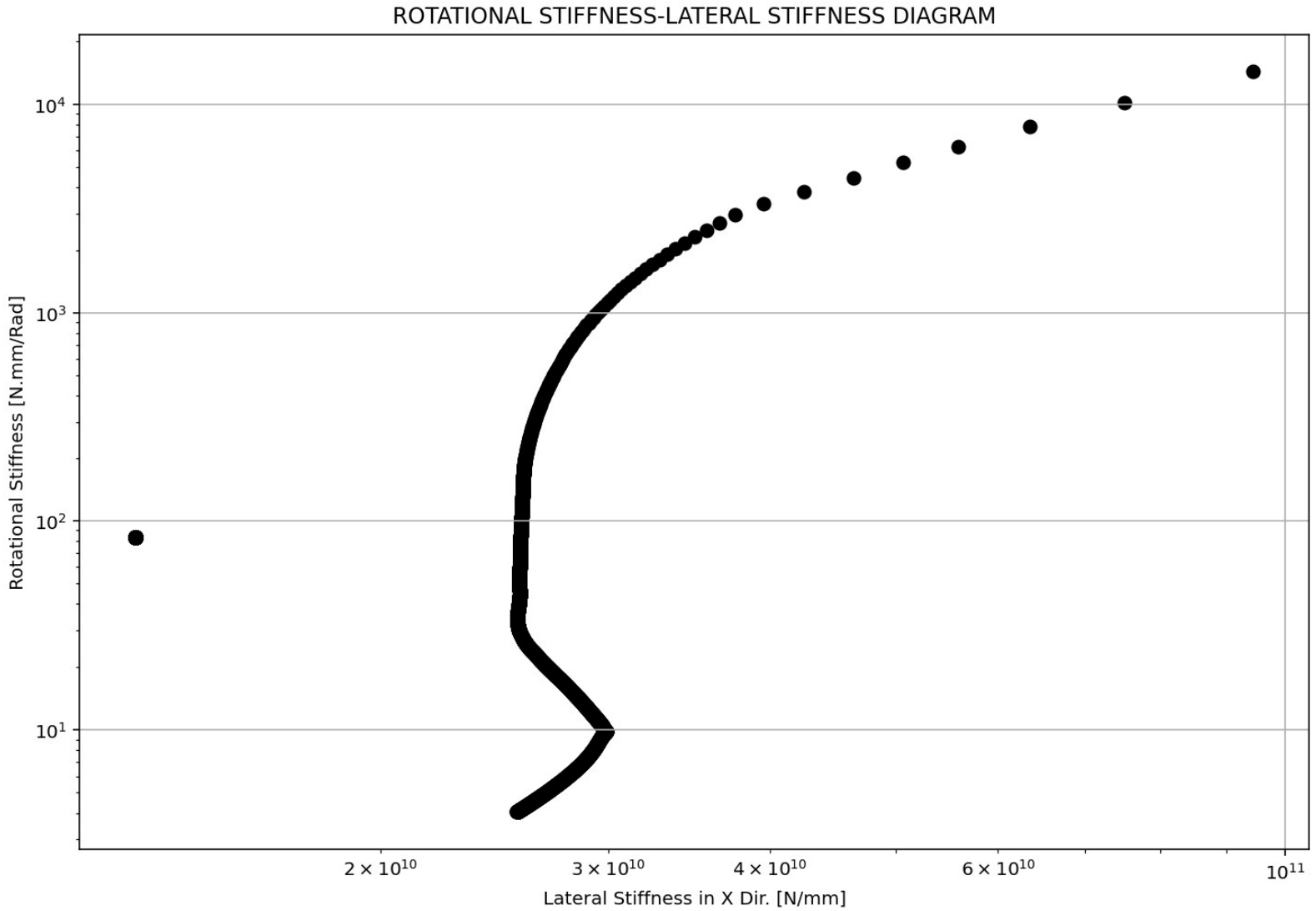
DISPLACEMENT CONTROL

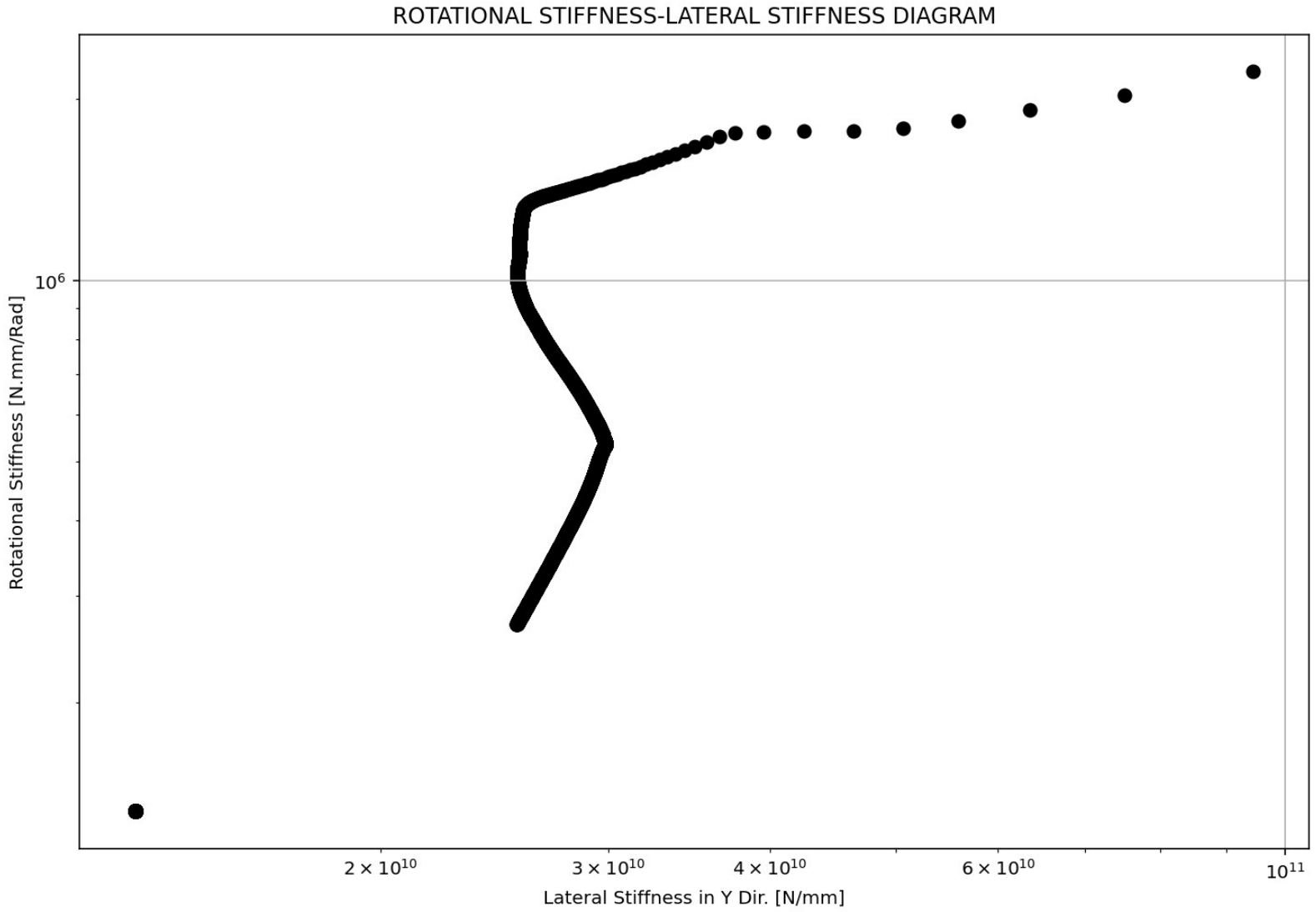

P-M Interaction
1e7
1.8
1.6
1.4
1.2
1.0
0.8
Axial Force [N]
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Bending Moment [N.mm]
1e9

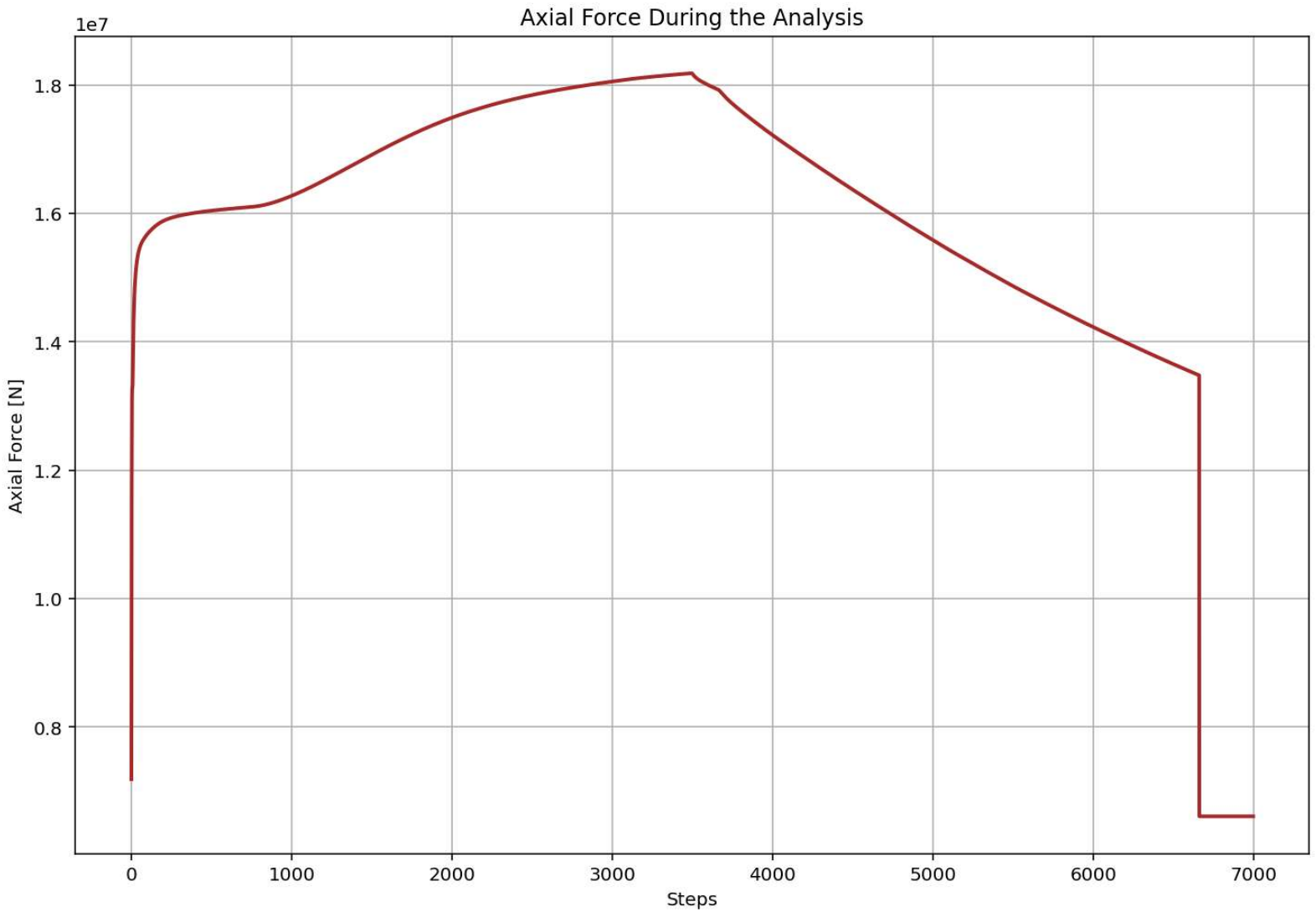

SHEAR FORCE-DISPLACEMENT DIAGRAM
0
−5000
−10000
−15000
−20000
−25000
Shear Force [N]
0
50
100
150
200
250
300
Displacement in X [mm] in Middle of Beam

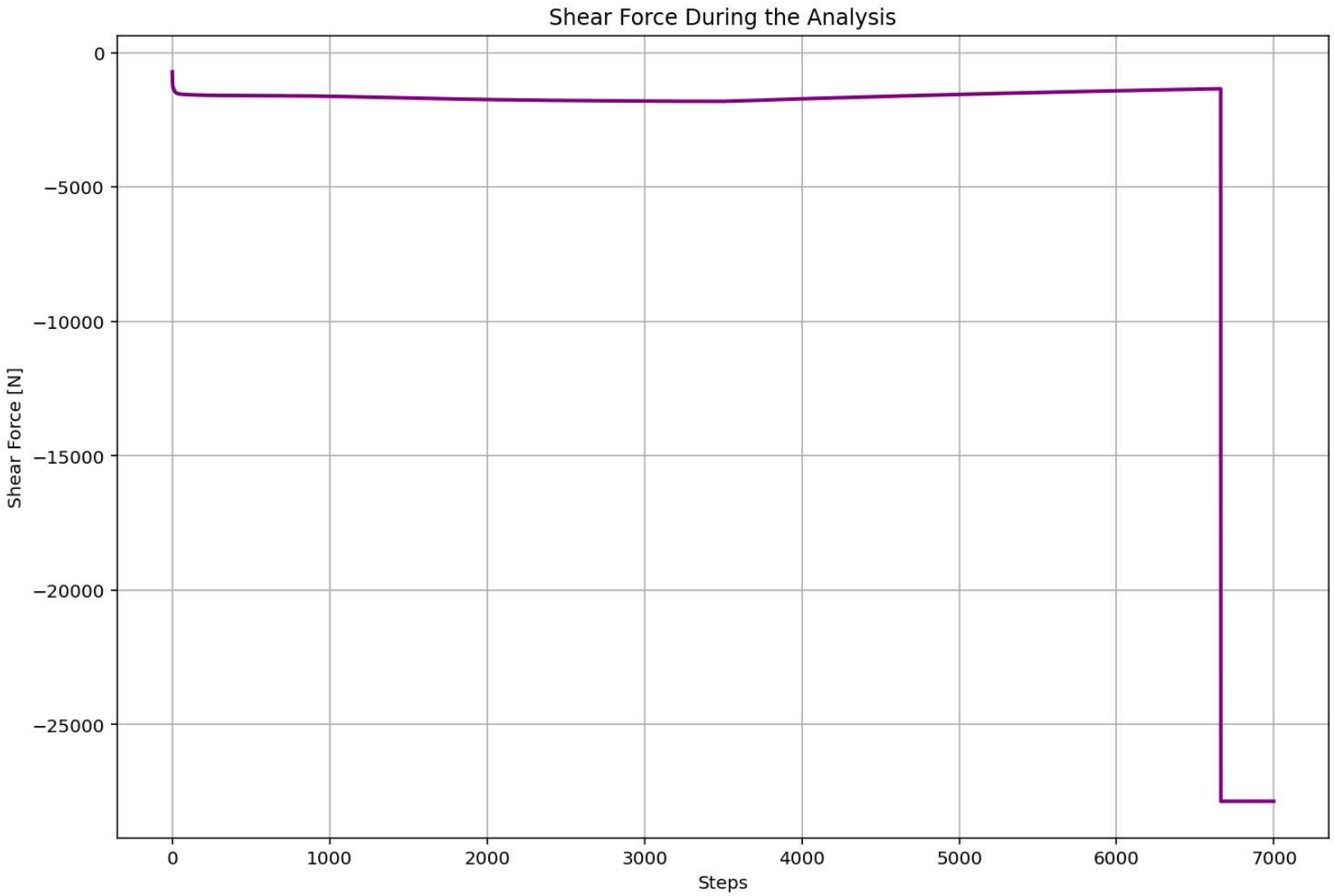

AXIAL FORCE-DISPLACEMENT DIAGRAM
1e7
1.8
1.6
1.4
1.2
1.0
0.8
Axial Force [N]
−50
−40
−30
−20
−10
Displacement in Y [mm] in Middle of Beam

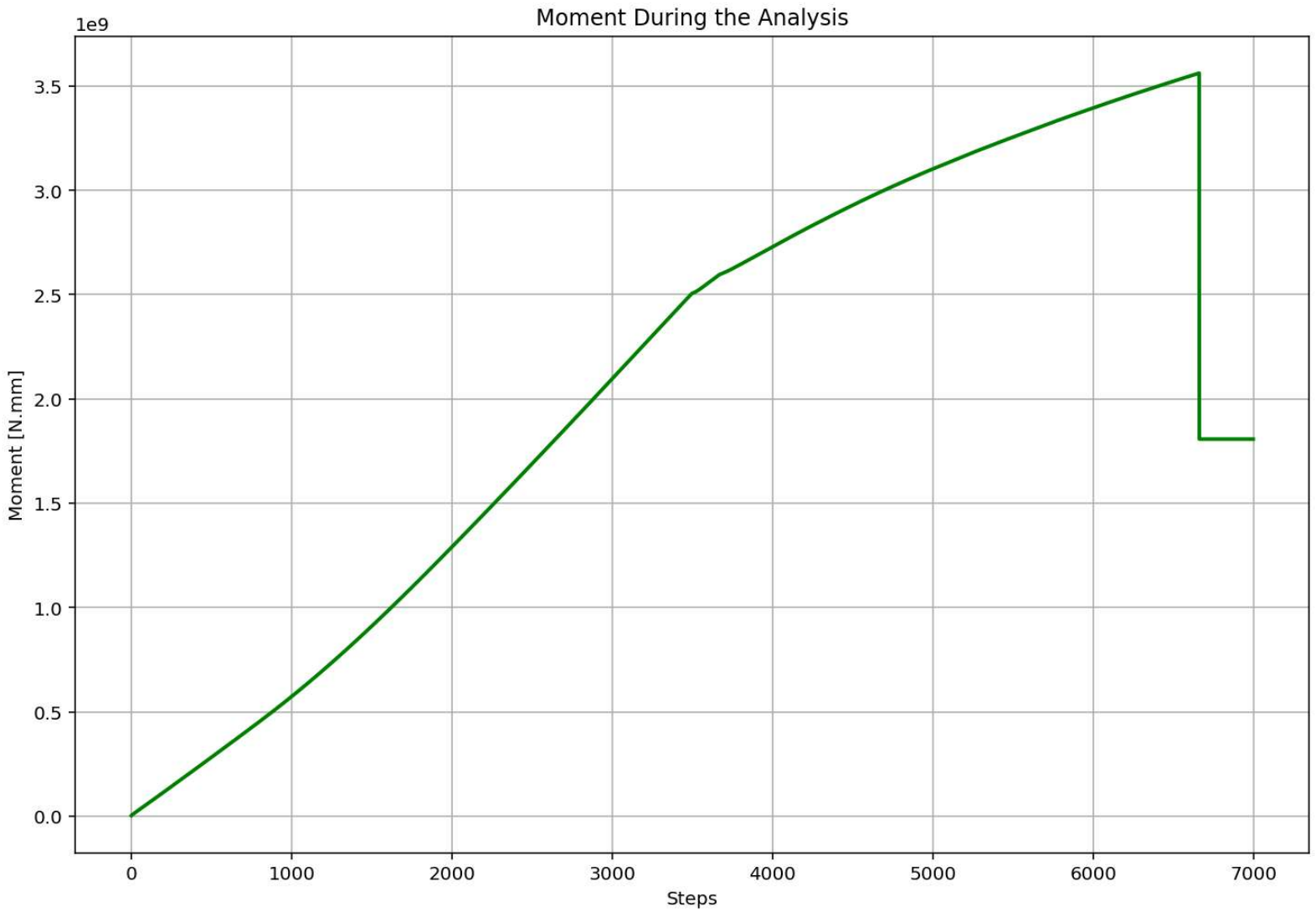

MOMENT-ROTATION DIAGRAM
1e9
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Moment [kN.mm]
−0.14
−0.12
−0.10
−0.08
−0.06
−0.04
−0.02
0.00
Rotation [rad]

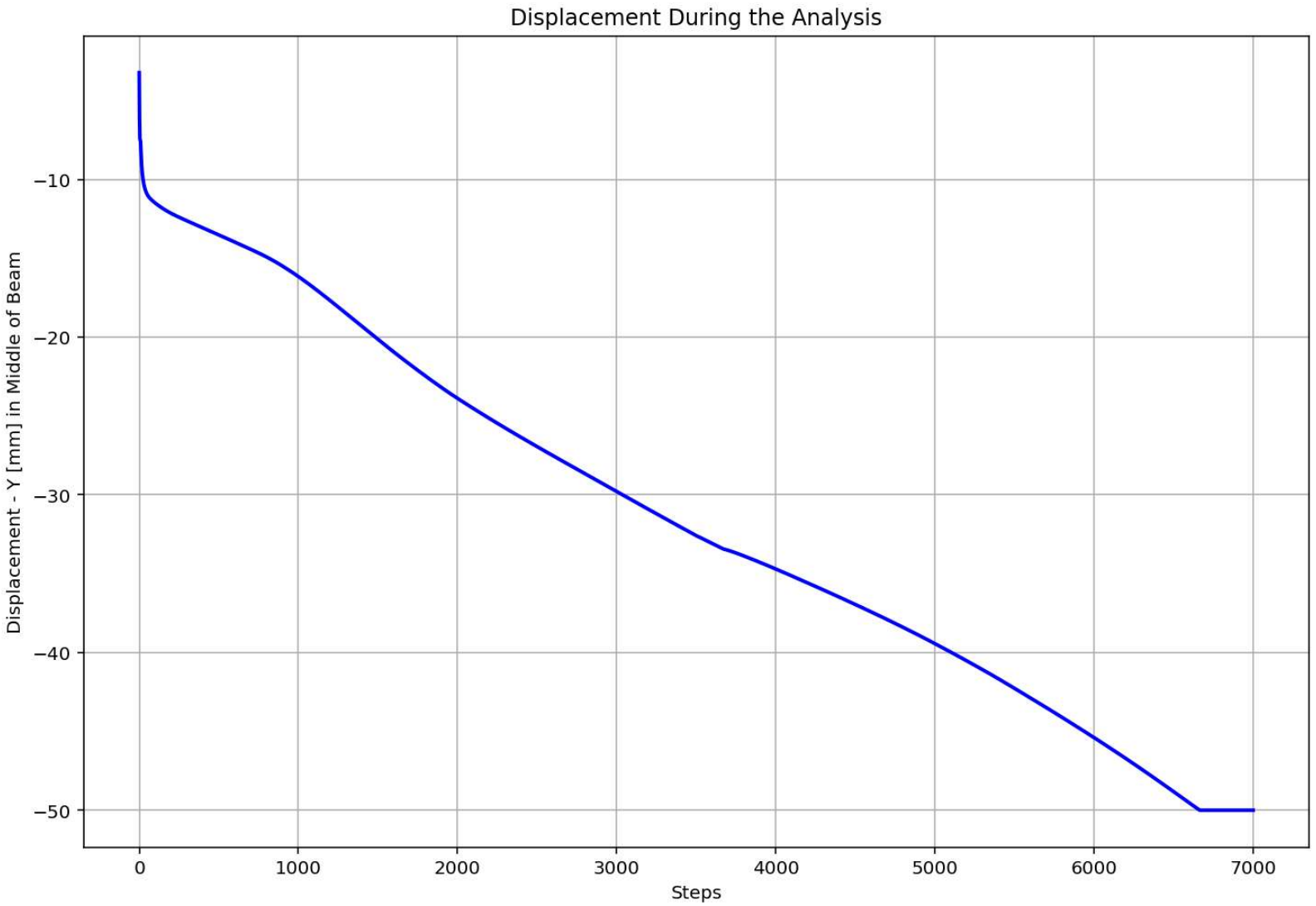

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
10^4
10^3
10^2
10^1
2×10^{10}
3×10^{10}
4×10^{10}
6×10^{10}
10^{11}
Lateral Stiffness in X Dir. [N/mm]

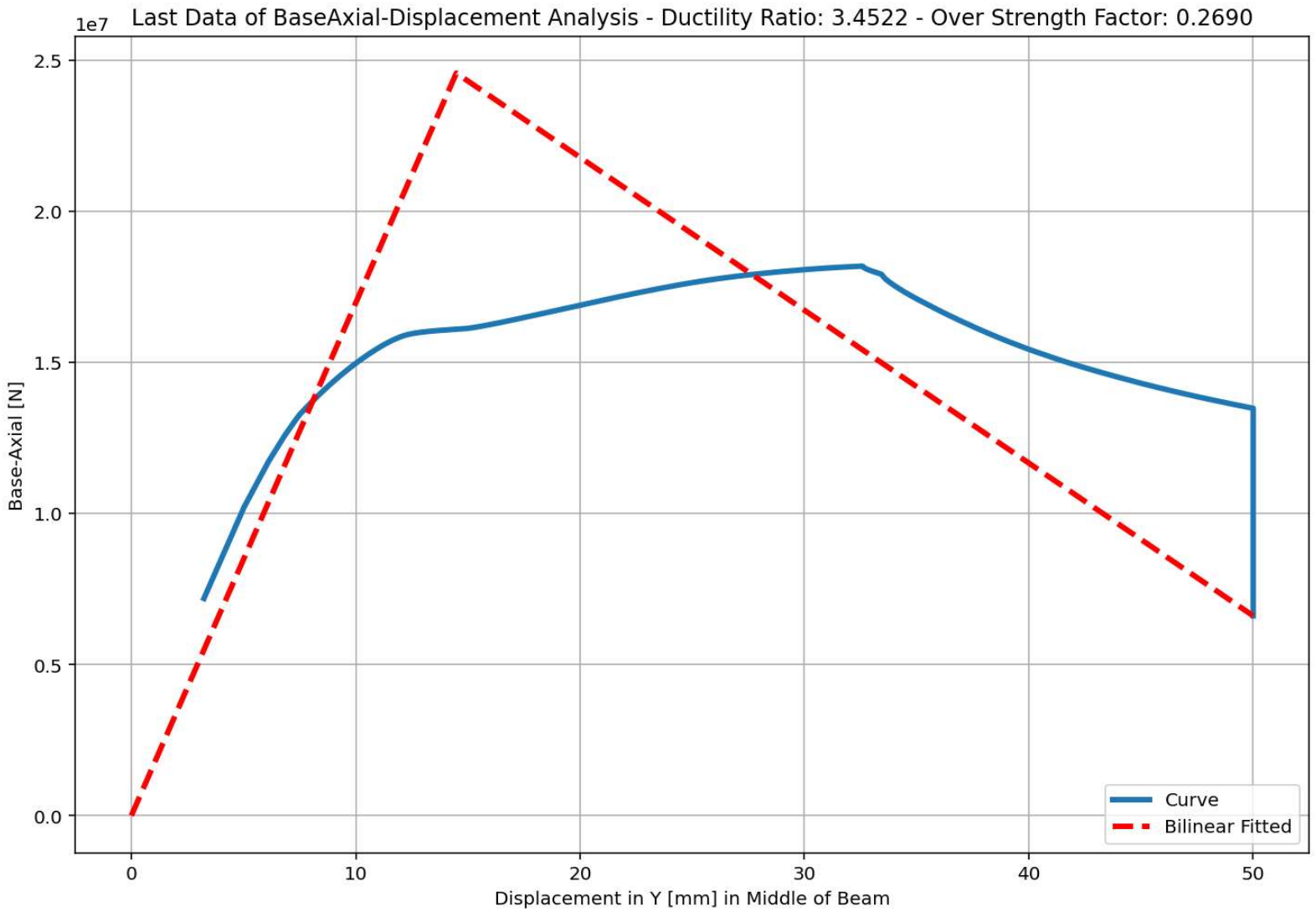

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
10^6
2×10^{10}
3×10^{10}
4×10^{10}
6×10^{10}
10^{11}
Lateral Stiffness in Y Dir. [N/mm]


Axial Force During the Analysis
1e7
1.8
1.6
1.4
1.2
1.0
0.8
Axial Force [N]
0
1000
2000
3000
4000
5000
6000
7000
Steps


Shear Force During the Analysis
Shear Force [N]
0
−5000
−10000
−15000
−20000
−25000
0
1000
2000
3000
4000
5000
6000
7000
Steps


Moment During the Analysis
1e9
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Moment [N.mm]
0
1000
2000
3000
4000
5000
6000
7000
Steps


Displacement During the Analysis
Displacement - Y [mm] in Middle of Beam
−10
−20
−30
−40
−50
0
1000
2000
3000
4000
5000
6000
7000
Steps


Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 3.4522 - Over Strength Factor: 0.2690
1e7
2.5
2.0
1.5
1.0
0.5
0.0
Base-Axial [N]
0
10
20
30
40
50
Displacement in Y [mm] in Middle of Beam
Curve
Bilinear Fitted