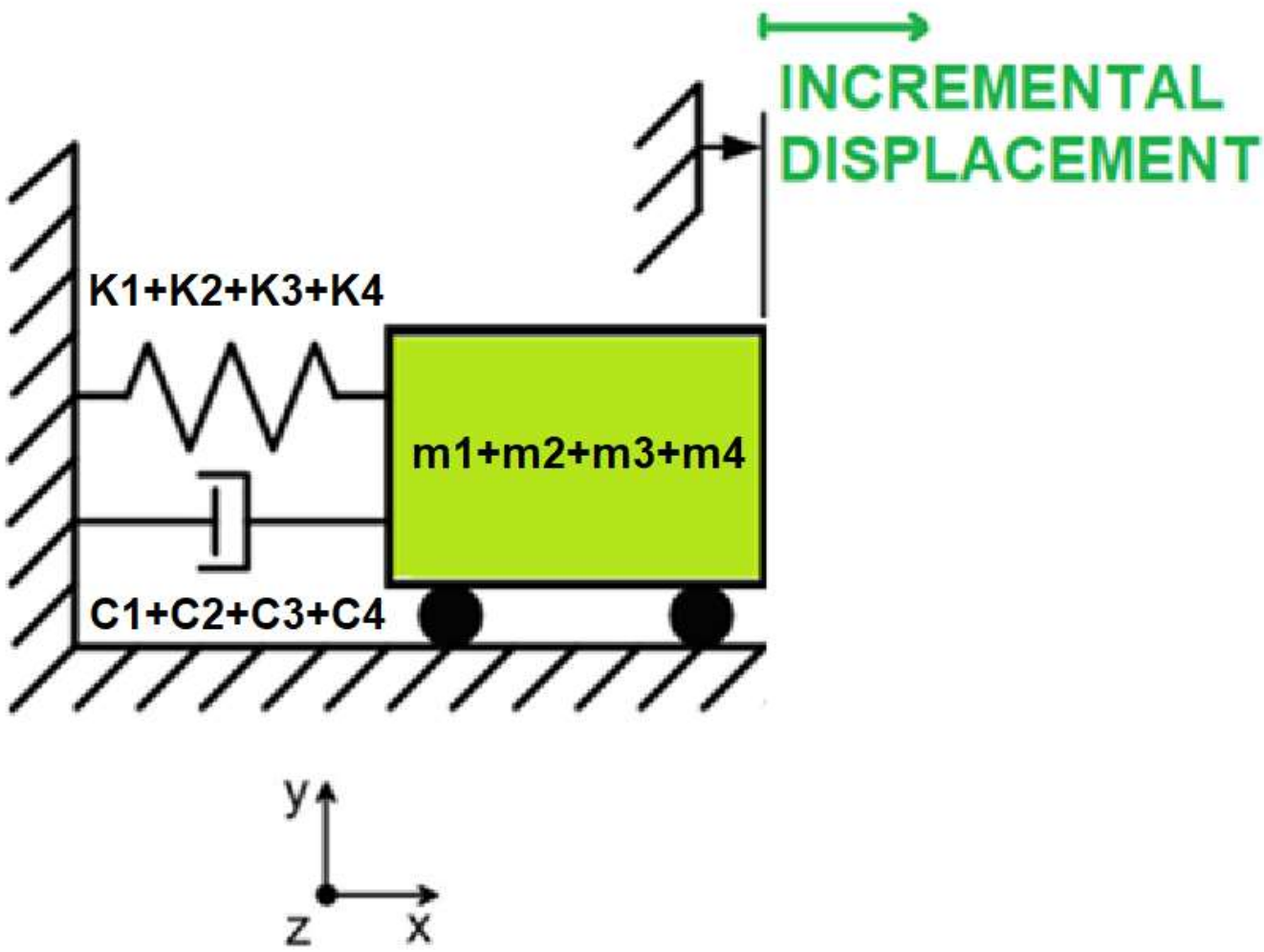
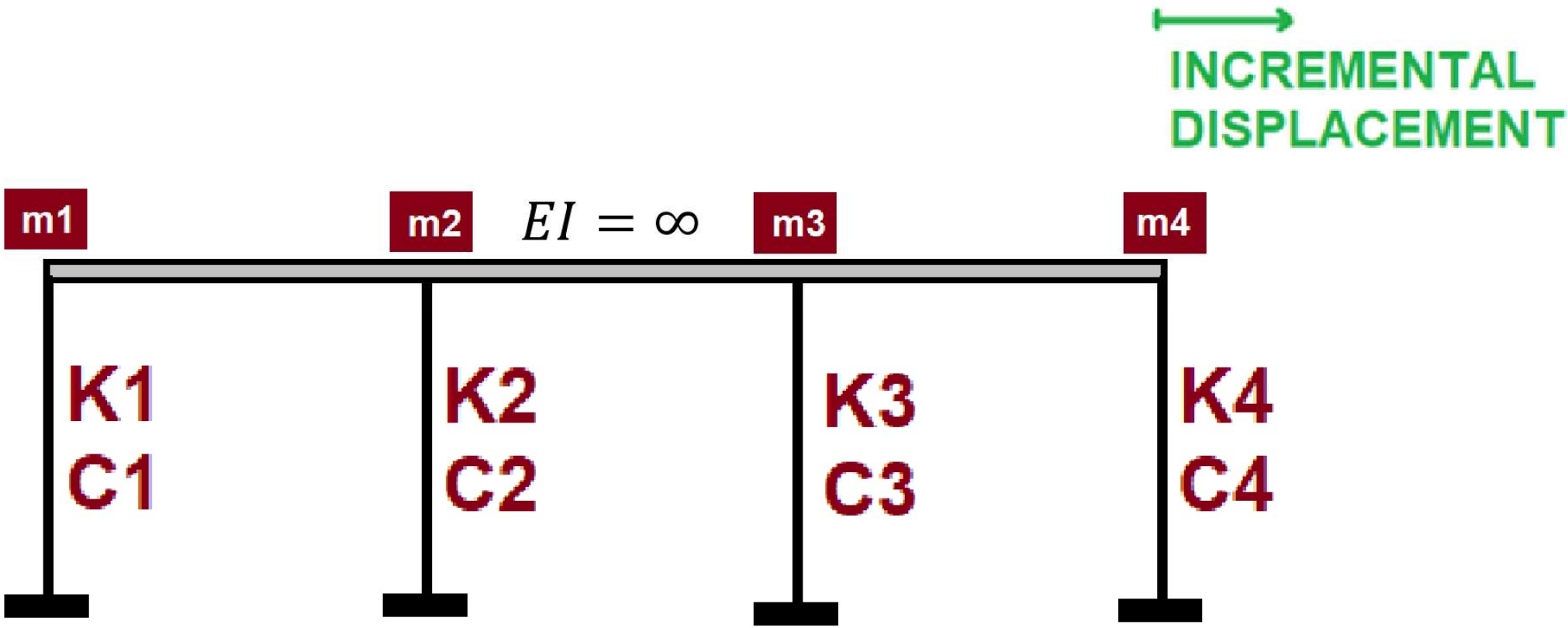
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

# COMPARATIVE PUSHOVER ANALYSIS OF A SDOF STRUCTURE: ELASTIC VS INELASTIC RESPONSE USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


INCREMENTAL
DISPLACEMENT
K1+K2+K3+K4
m1+m2+m3+m4
C1+C2+C3+C4
y
z
x


INCREMENTAL
DISPLACEMENT
m1
m2
$EI = \infty$
m3
m4
K1
C1
K2
C2
K3
C3
K4
C4

Spyder (Python 3.12)

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C:\Users\Dell\Desktop\OPENSEES_FILES\MDOF_SPRING\PUSHOVER_SDOF

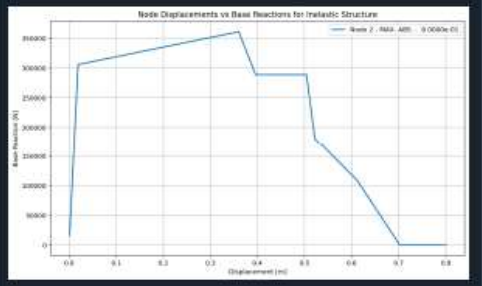
C:\Users\Dell\Desktop\OPENSEES_FILES\MDOF_SPRING\PUSHOVER_SDOF\PUSHOVER_SDOF.py

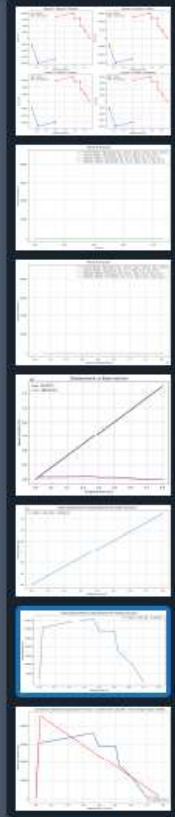
PUSHOVER_SDOF.py

```
##########################################################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#           COMPARATIVE PUSHOVER ANALYSIS OF A MDOF STRUCTURE: ELASTIC VS INELASTIC RESPONSE USING OPENSEES
#-------------------------------------------------------------------------------------------------------------------------
#     NONLINEAR STATIC PUSHOVER ASSESSMENT: DISPLACEMENT-BASED EQUIVALENT SDOF FORMULATION FOR ELASTIC AND INELA
#                                  MDOF STRUCTURAL RESPONSE SIMULATION VIA OPENSEES PLATFORM
#-------------------------------------------------------------------------------------------------------------------------
#                               THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                        EMAIL: salar.d.ghashghaei@gmail.com
##########################################################################################################################
"""
Performs pushover analysis of a Single Degree of Freedom (SDOF)
 structure using OpenSeesPy, comparing elastic and inelastic spring behavior.
-------------------------------------------------------------------------
Key features include:
1. Implements both elastic (linear) and hysteretic (nonlinear) material models for structural springs.
2. Supports initial incremental displacement.
3. Uses Newmark's method for time integration with Newton-Raphson iteration.
4. Calculates damping ratios using logarithmic decrement from response peaks.
5. Generates force-displacement backbone curves for inelastic material.
6. Tracks and plots time-history responses (displacement, reactions).
7. Compares elastic vs inelastic system performance.
8. Includes convergence checks and analysis stability monitoring.
9. Outputs model data in JSON format for post-processing.
10. Provides theoretical validation through natural frequency calculations.

Particularly useful for earthquake engineering applications,
allowing evaluation of structural response under free vibration
 with different material nonlinearities and damping characteristics.
 The hysteretic material model captures energy dissipation
 inelastic deformation, while the elastic case serves as a reference for linear behavior.
"""
import openseespy.opensees as ops
import numpy as np
```

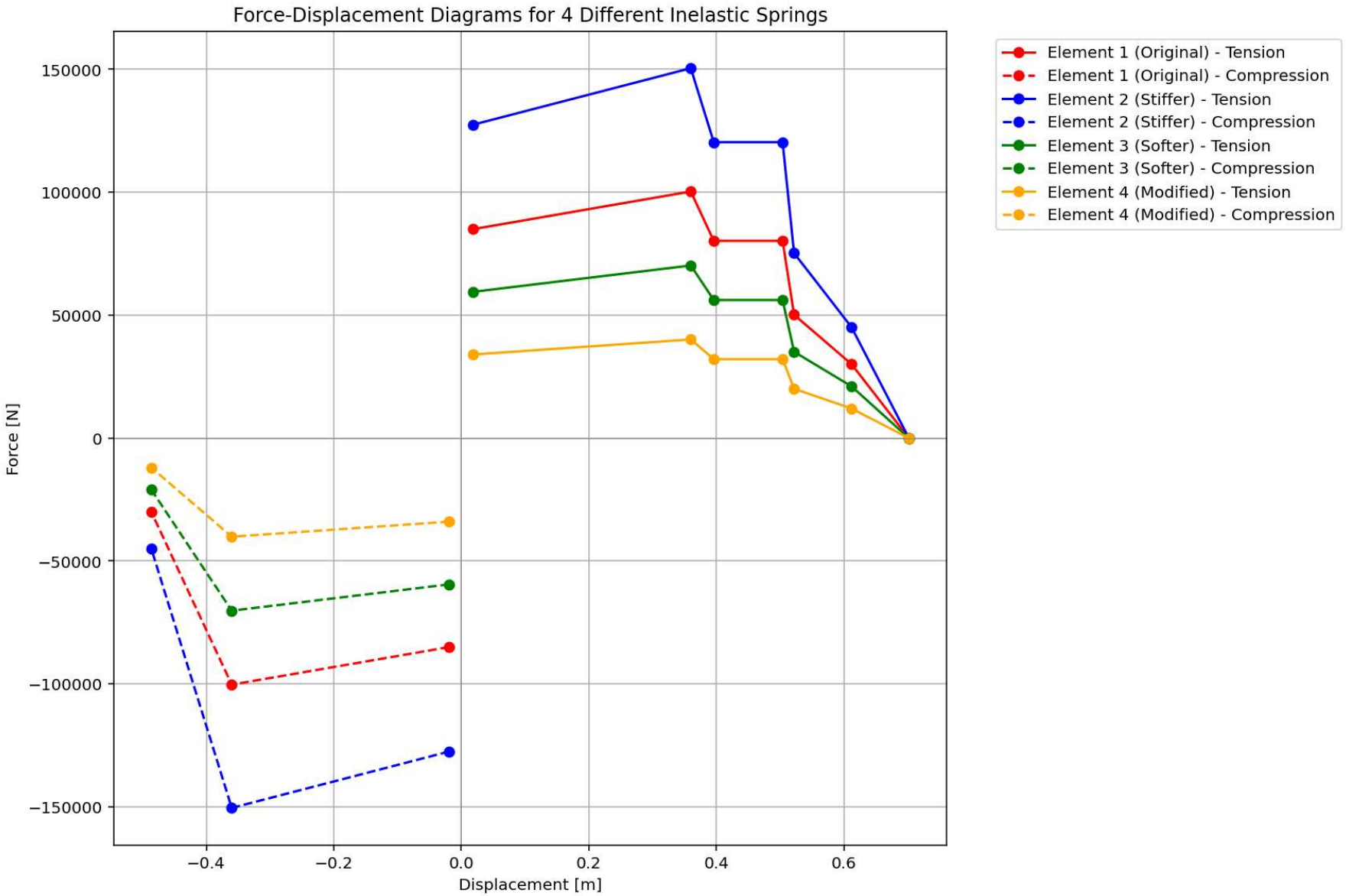
21 %

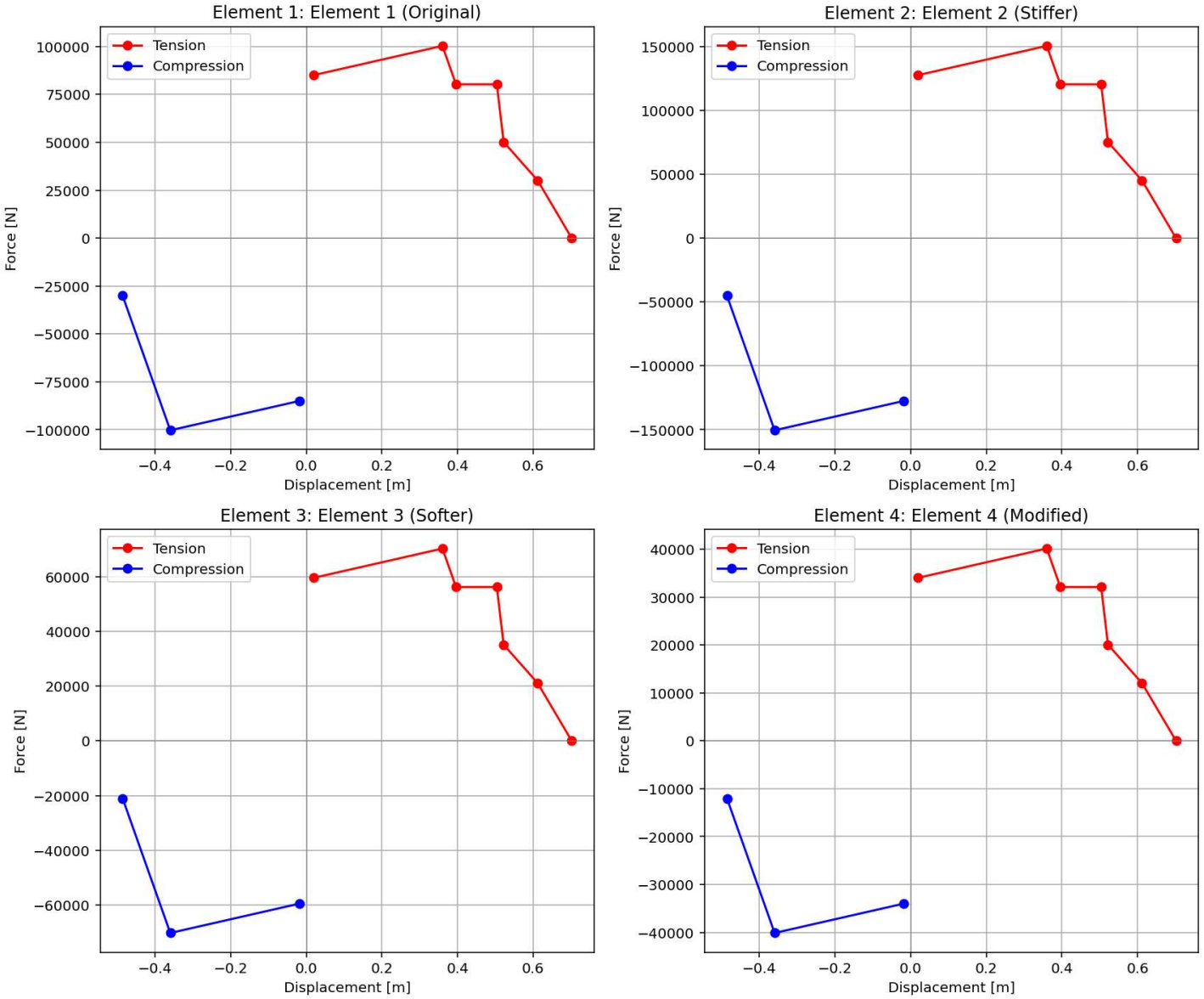


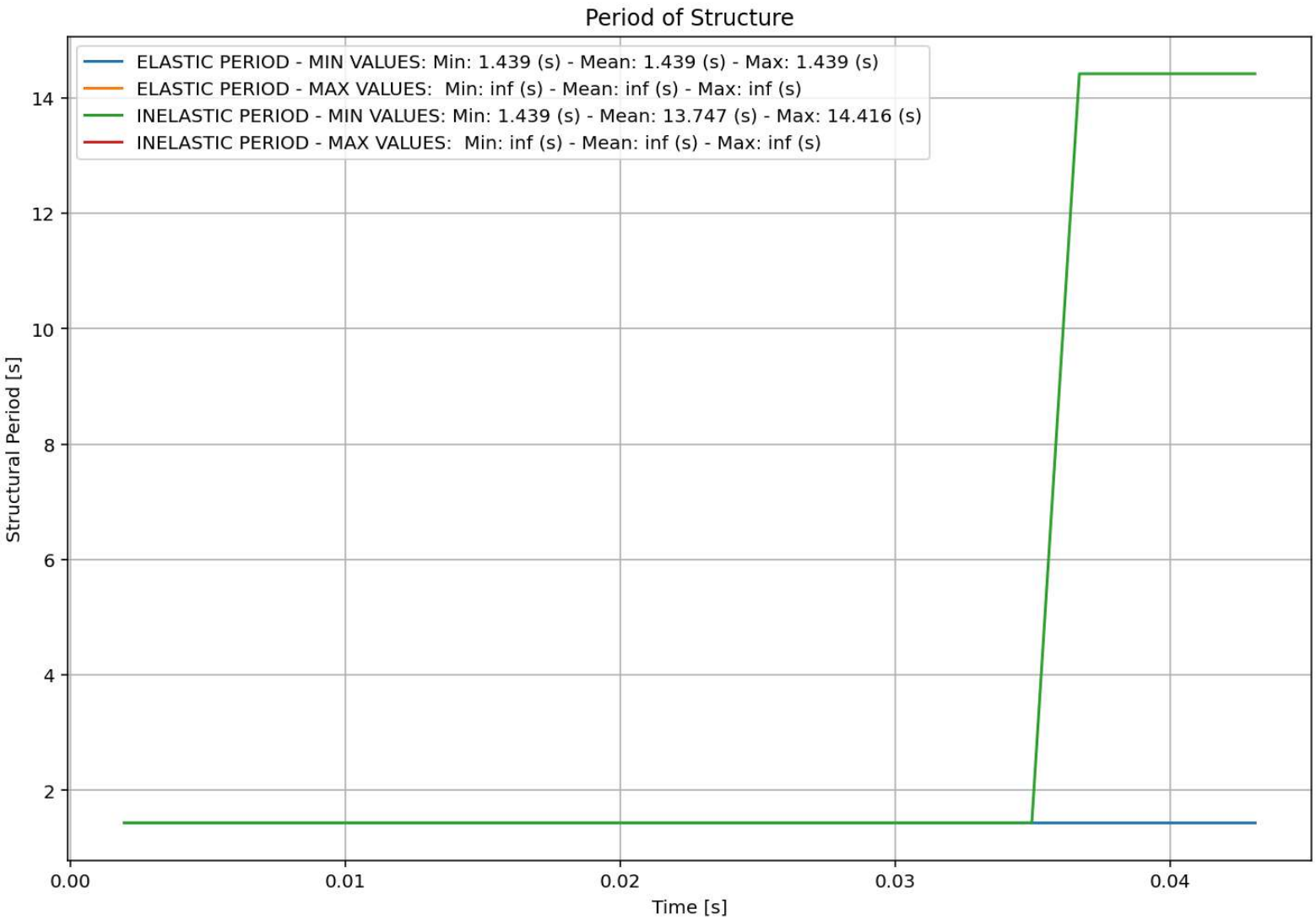



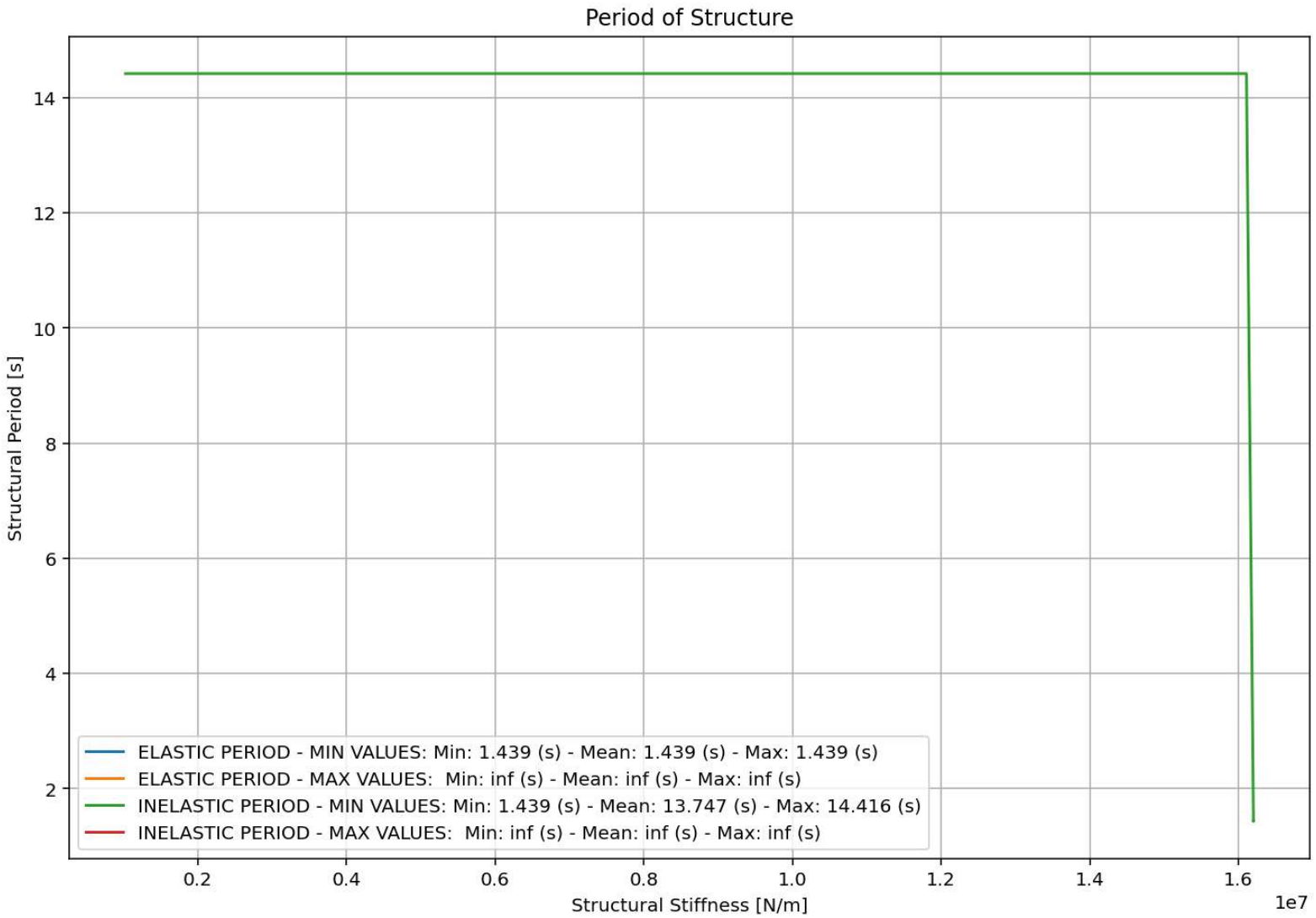
(Python Console | Files | Help | Variable Explorer | Debugger | Plots

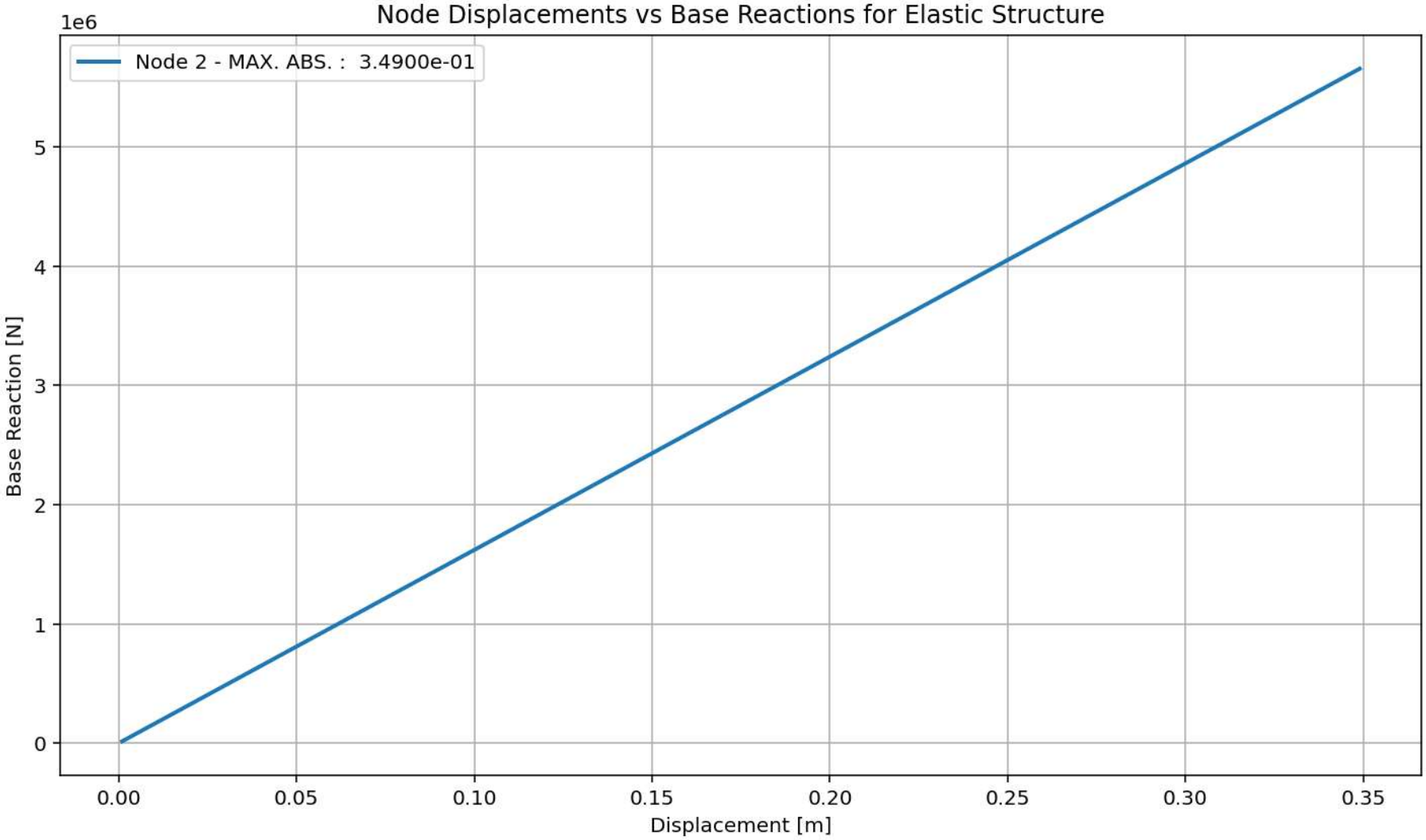
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 306, Col 57 UTF-8 CRLF RW Mem 49%

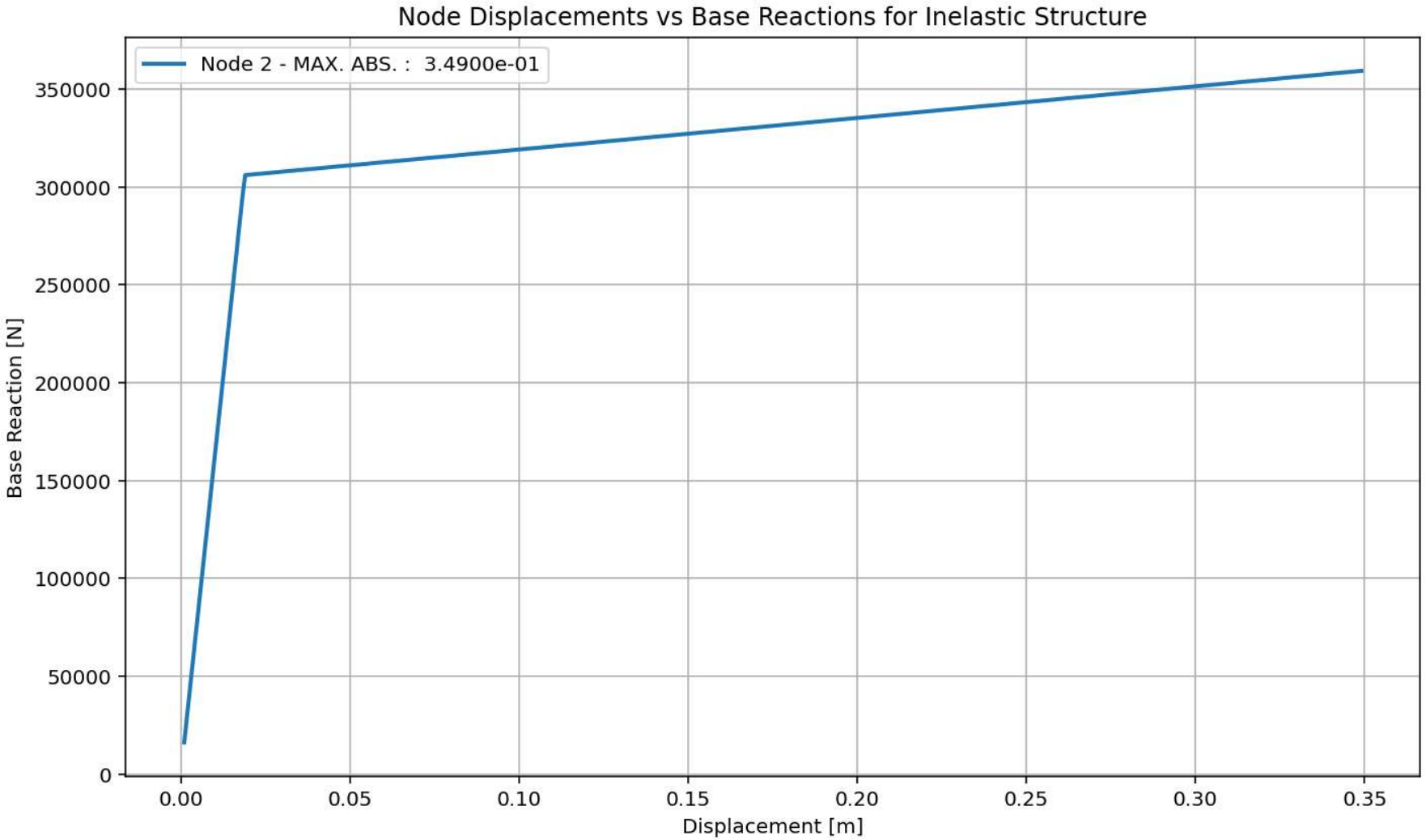

Force-Displacement Diagrams for 4 Different Inelastic Springs
Force [N]
Displacement [m]
150000
100000
50000
0
−50000
−100000
−150000
−0.4
−0.2
0.0
0.2
0.4
0.6
Element 1 (Original) - Tension
Element 1 (Original) - Compression
Element 2 (Stiffer) - Tension
Element 2 (Stiffer) - Compression
Element 3 (Softer) - Tension
Element 3 (Softer) - Compression
Element 4 (Modified) - Tension
Element 4 (Modified) - Compression

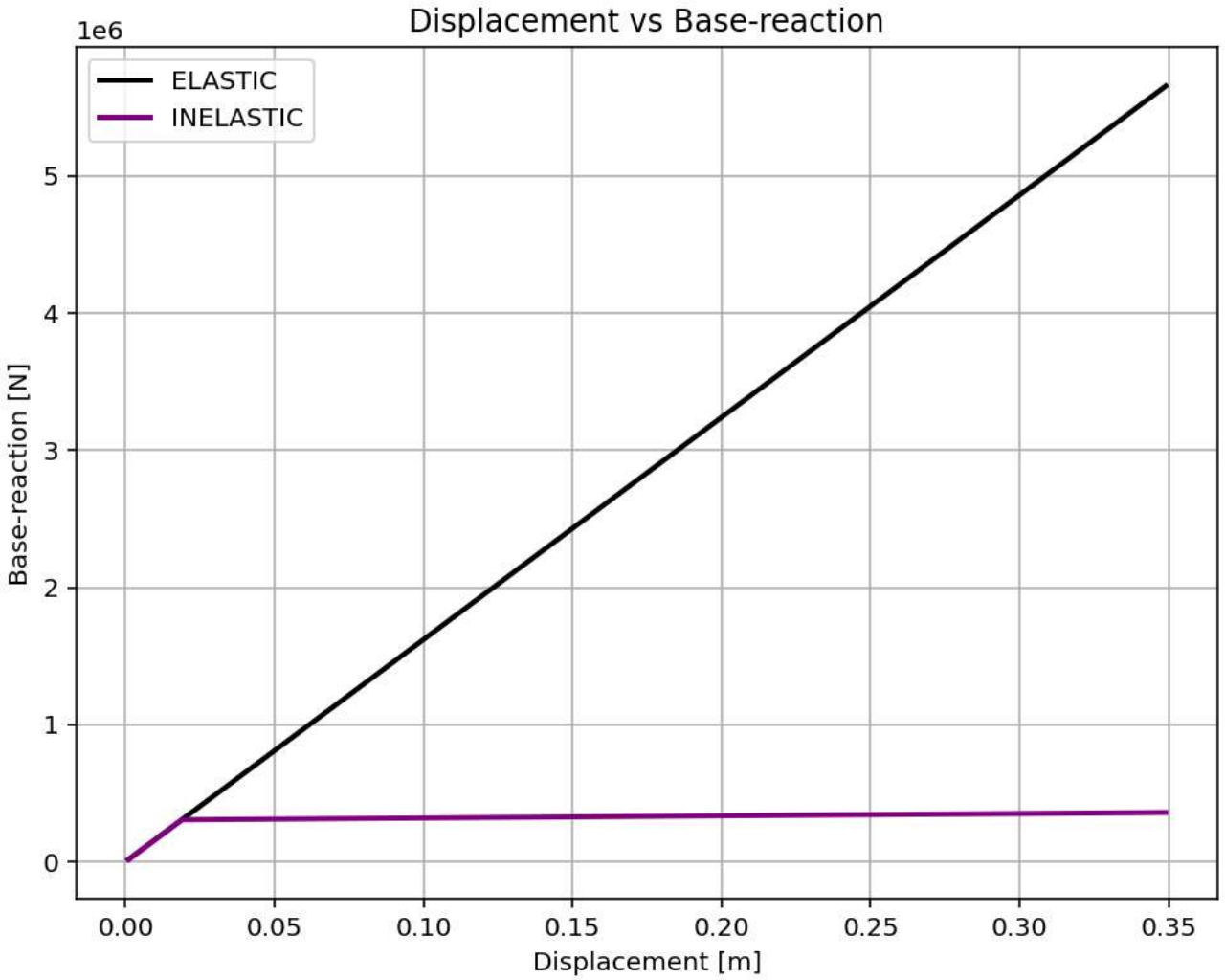

Element 1: Element 1 (Original)
Element 2: Element 2 (Stiffer)
Element 3: Element 3 (Softer)
Element 4: Element 4 (Modified)
Tension
Compression
Force [N]
Displacement [m]

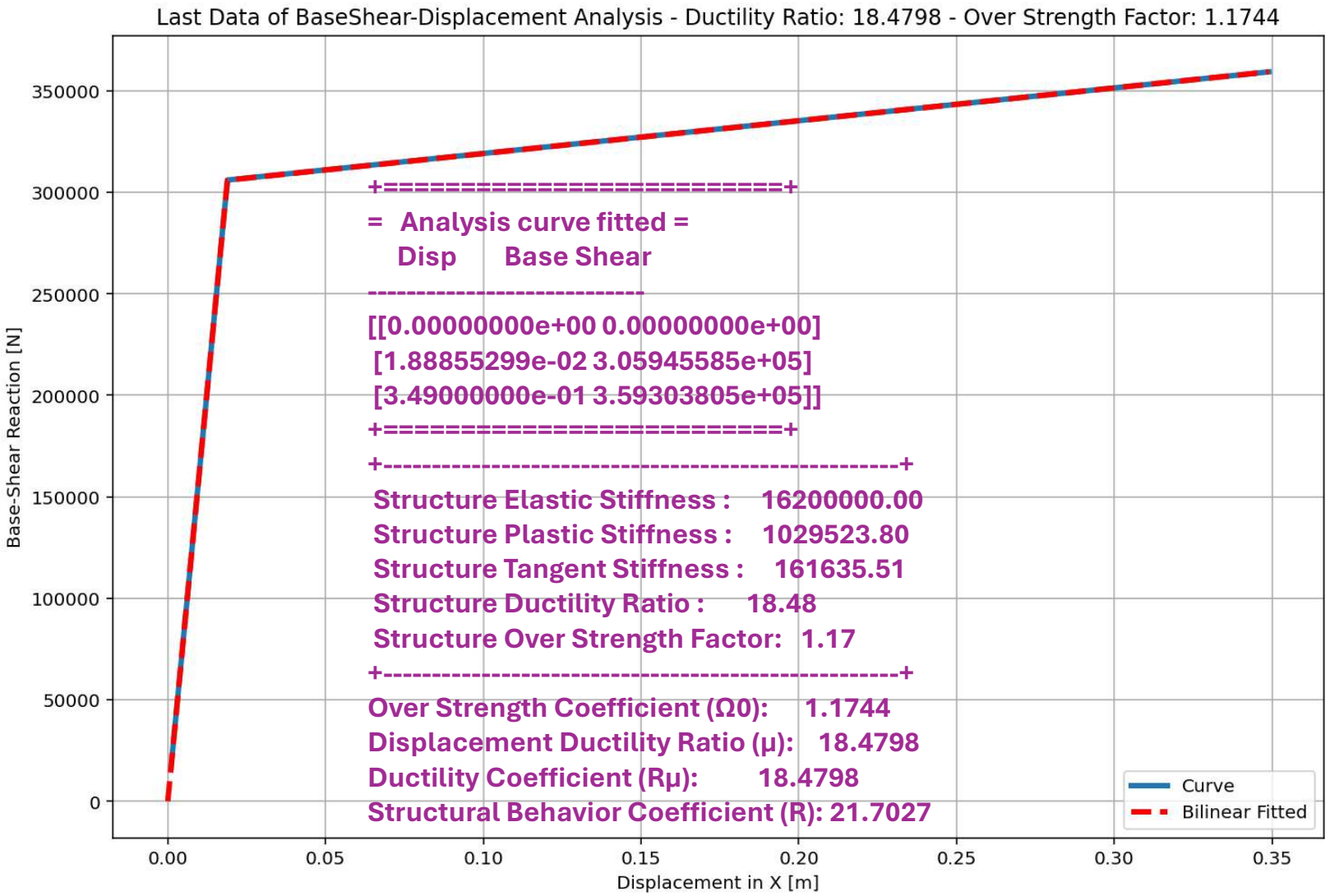

Period of Structure
ELASTIC PERIOD - MIN VALUES: Min: 1.439 (s) - Mean: 1.439 (s) - Max: 1.439 (s)
ELASTIC PERIOD - MAX VALUES: Min: inf (s) - Mean: inf (s) - Max: inf (s)
INELASTIC PERIOD - MIN VALUES: Min: 1.439 (s) - Mean: 13.747 (s) - Max: 14.416 (s)
INELASTIC PERIOD - MAX VALUES: Min: inf (s) - Mean: inf (s) - Max: inf (s)
Structural Period [s]
14
12
10
8
6
4
2
0.00
0.01
0.02
0.03
0.04
Time [s]


Period of Structure
Structural Period [s]
14
12
10
8
6
4
2
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1e7
Structural Stiffness [N/m]
ELASTIC PERIOD - MIN VALUES: Min: 1.439 (s) - Mean: 1.439 (s) - Max: 1.439 (s)
ELASTIC PERIOD - MAX VALUES: Min: inf (s) - Mean: inf (s) - Max: inf (s)
INELASTIC PERIOD - MIN VALUES: Min: 1.439 (s) - Mean: 13.747 (s) - Max: 14.416 (s)
INELASTIC PERIOD - MAX VALUES: Min: inf (s) - Mean: inf (s) - Max: inf (s)


Node Displacements vs Base Reactions for Elastic Structure
1e6
Node 2 - MAX. ABS. : 3.4900e-01
Base Reaction [N]
0
1
2
3
4
5
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Displacement [m]


Node Displacements vs Base Reactions for Inelastic Structure
Node 2 - MAX. ABS. : 3.4900e-01
Base Reaction [N]
Displacement [m]
0
50000
100000
150000
200000
250000
300000
350000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35


Displacement vs Base-reaction
1e6
ELASTIC
INELASTIC
Base-reaction [N]
0
1
2
3
4
5
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Displacement [m]


Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 18.4798 - Over Strength Factor: 1.1744
Base-Shear Reaction [N]
Displacement in X [m]
0
50000
100000
150000
200000
250000
300000
350000
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
+============================+
= Analysis curve fitted =
Disp Base Shear
----------------------------
[[0.00000000e+00 0.00000000e+00]
[1.88855299e-02 3.05945585e+05]
[3.49000000e-01 3.59303805e+05]]
+============================+
+------------------------------------------------+
Structure Elastic Stiffness : 16200000.00
Structure Plastic Stiffness : 1029523.80
Structure Tangent Stiffness : 161635.51
Structure Ductility Ratio : 18.48
Structure Over Strength Factor: 1.17
+------------------------------------------------+
Over Strength Coefficient (Ω0): 1.1744
Displacement Ductility Ratio (μ): 18.4798
Ductility Coefficient (Rμ): 18.4798
Structural Behavior Coefficient (R): 21.7027
Curve
Bilinear Fitted