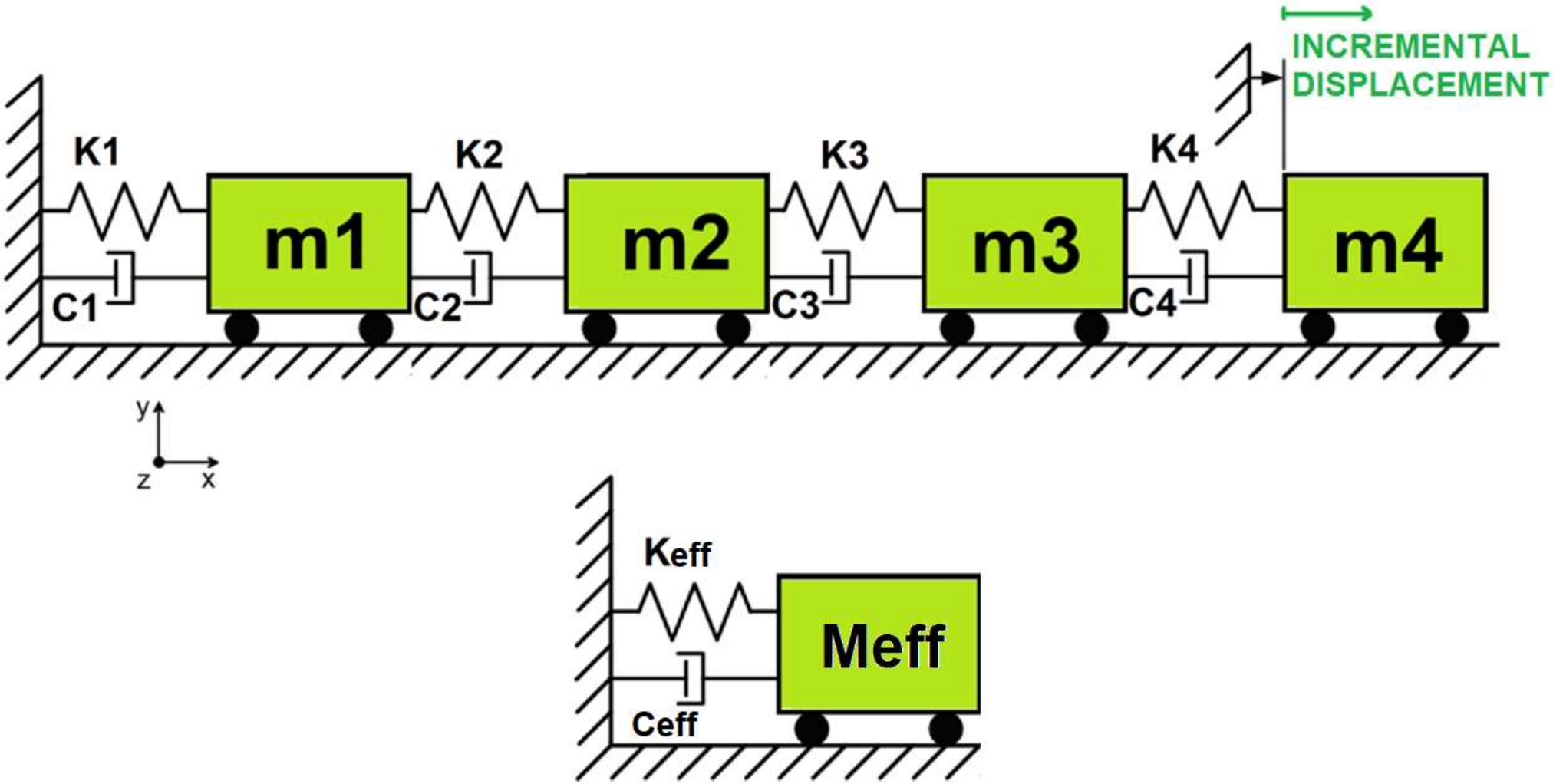
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

COMPARATIVE PUSHOVER ANALYSIS OF A MDOF 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
Keff
Meff
Ceff

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

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

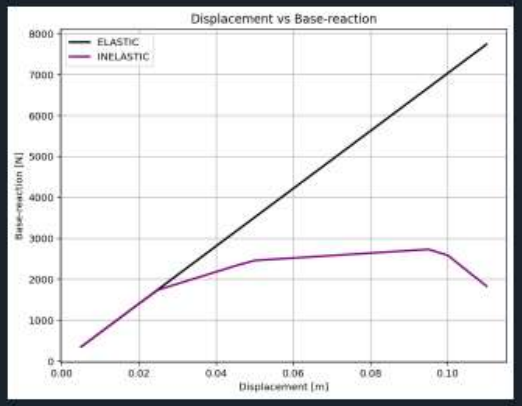
C:\Users\Dell\Desktop\OPENSEES_FILES\MDOF_SPRING\PUSHOVER_MDOF\PUSHOVER_MDOF.py

PUSHOVER_MDOF.py

```
#############################################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#            COMPARATIVE PUSHOVER ANALYSIS OF A MDOF STRUCTURE: ELASTIC VS INELASTIC RESPONSE USING OPI
#                DISPLACEMENT-BASED DESIGN APPROACH: CONVERTING MULTI-DEGREE-OF-FREEDOM SYSTEMS TO EQU
#                                        SINGLE-DEGREE-OF-FREEDOM MODELS
#-------------------------------------------------------------------------------------------------------
#     NONLINEAR STATIC PUSHOVER ASSESSMENT: DISPLACEMENT-BASED EQUIVALENT SDOF FORMULATION FOR ELASTIC
#                                  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 Multi Degree of Freedom (MDOF)
 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.
"""
```

32 %



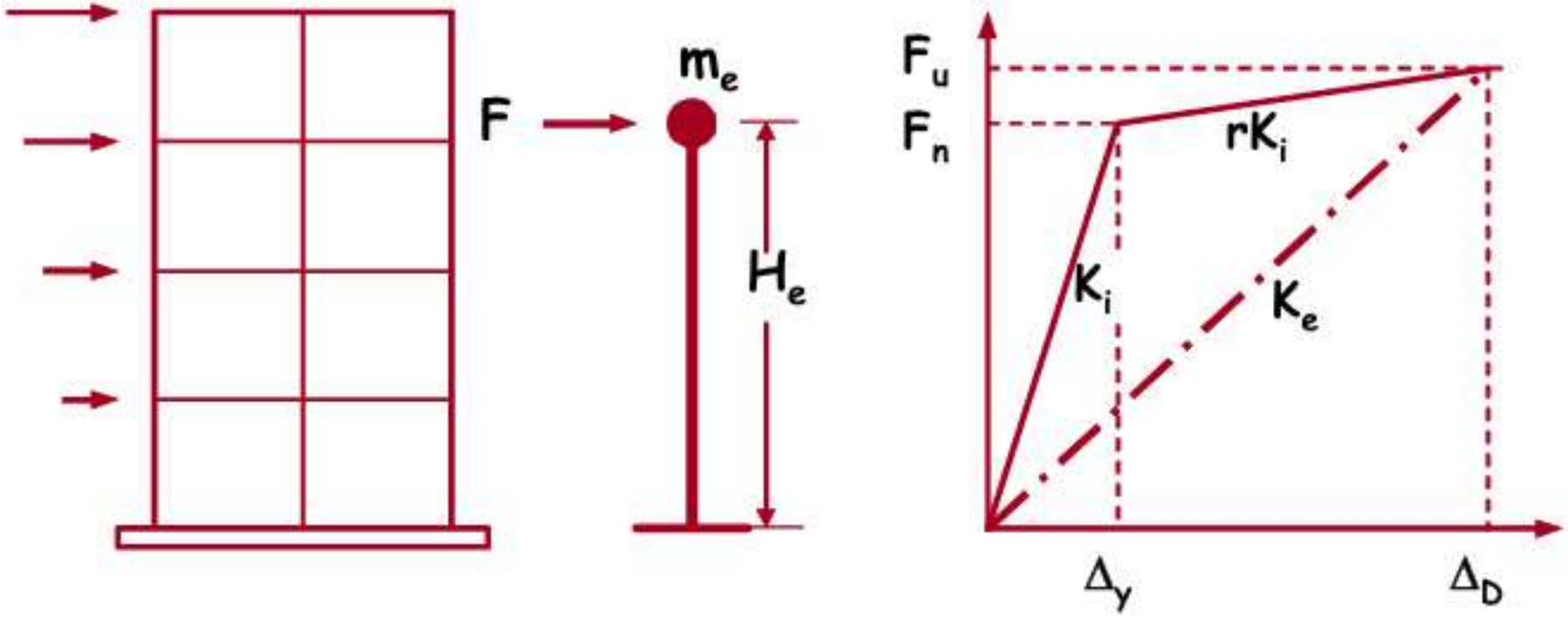
Help Variable Explorer Debugger Plots Files

Console 1/A

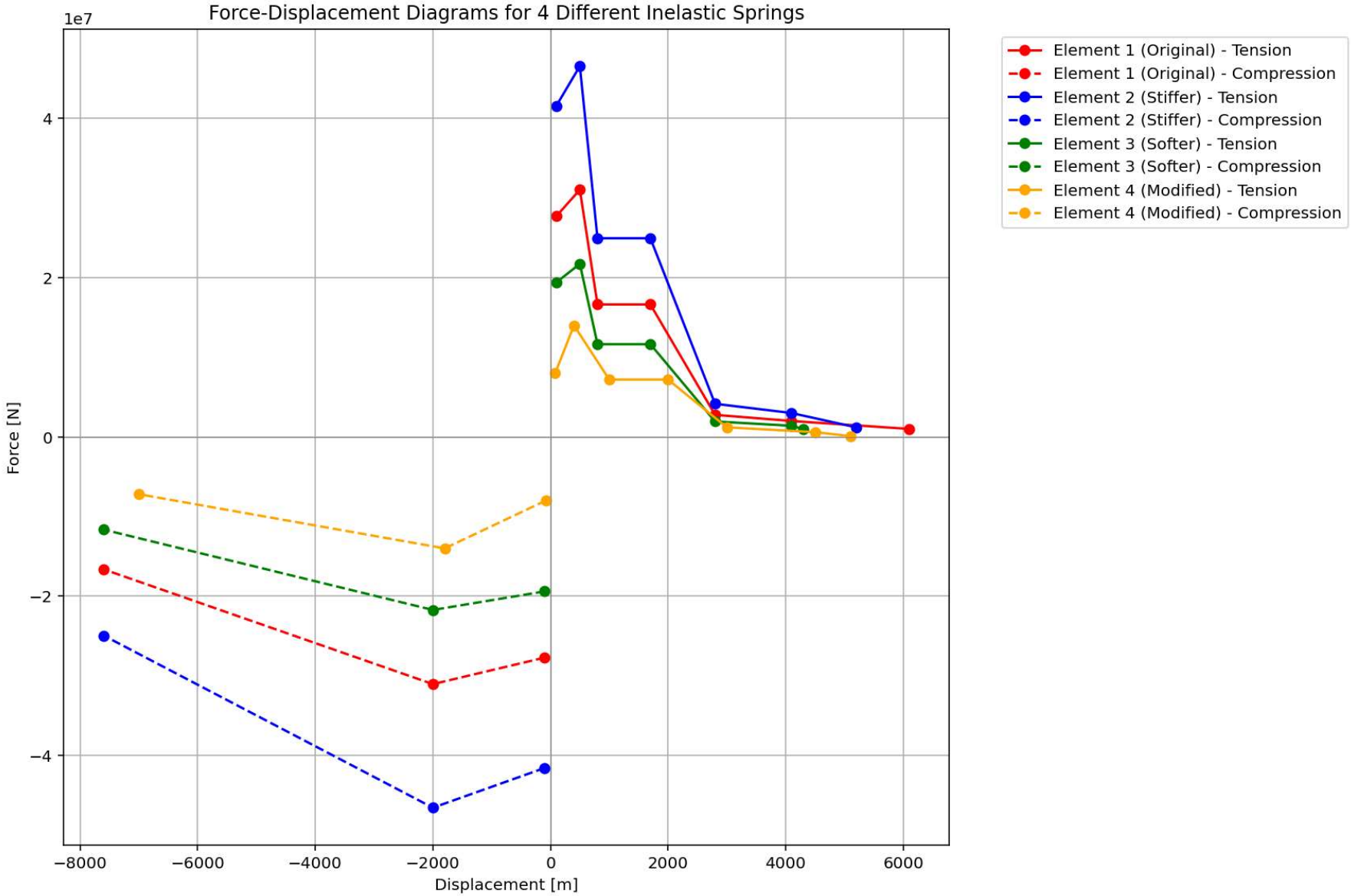
lambda	omega	period	frequency
8.449e-03	0.0919	68.3563	0.0146
1.426e-01	0.3776	16.6395	0.0601
1.767e+00	1.3294	4.7264	0.2116
4.502e+01	6.7094	0.9365	1.0678

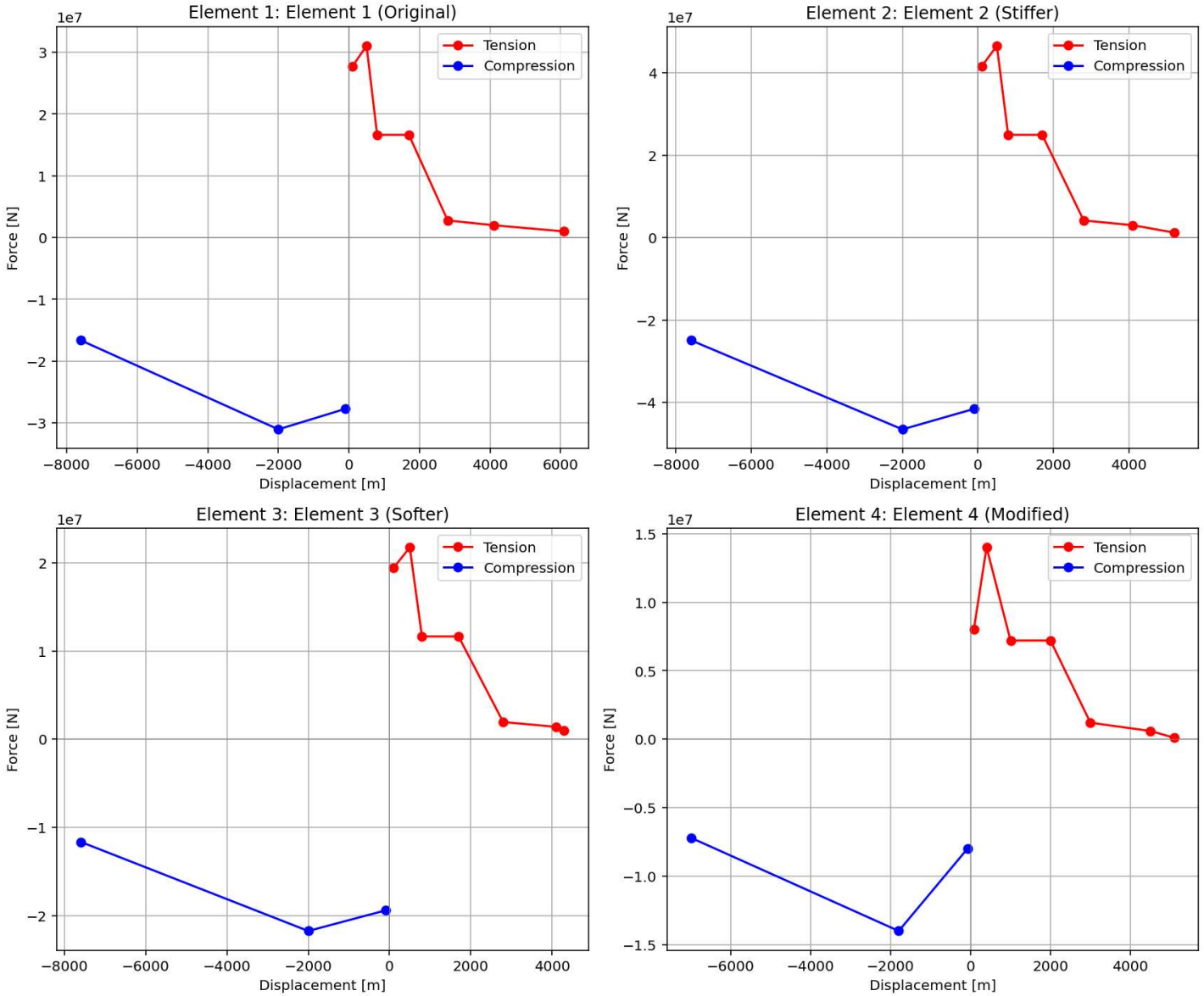
IPython Console History

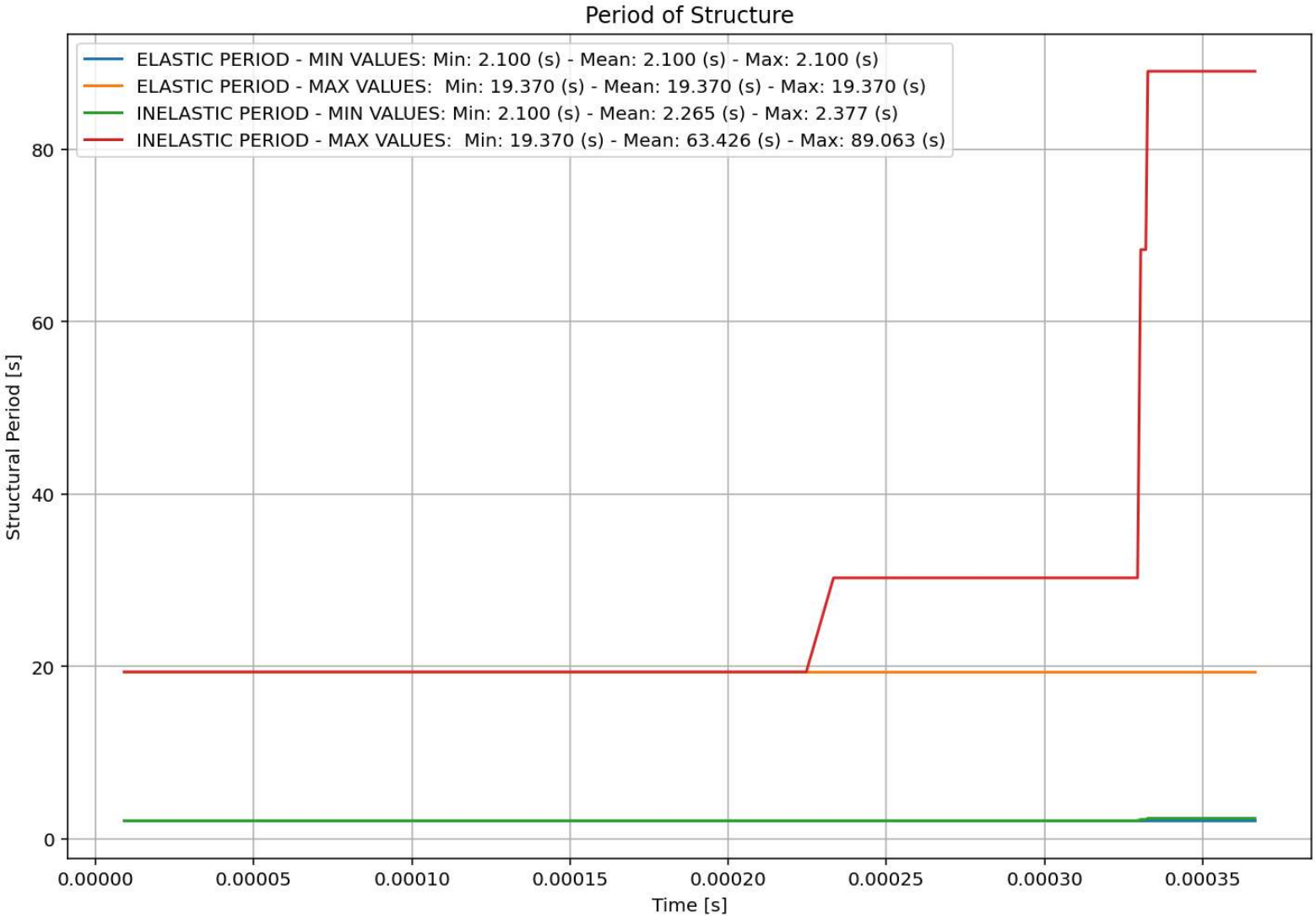
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 6, Col 119 UTF-8 CRLF RW Mem 42%

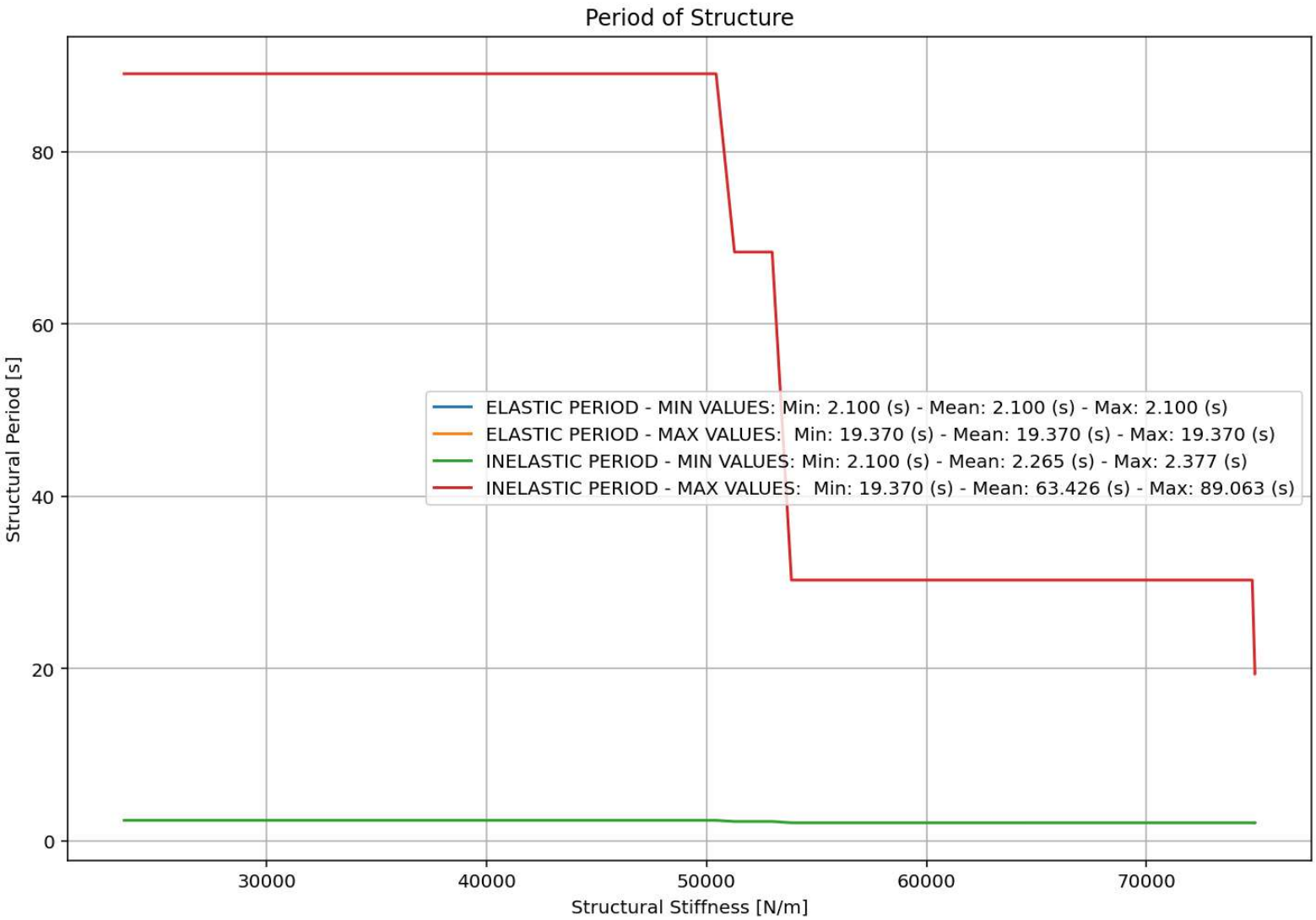


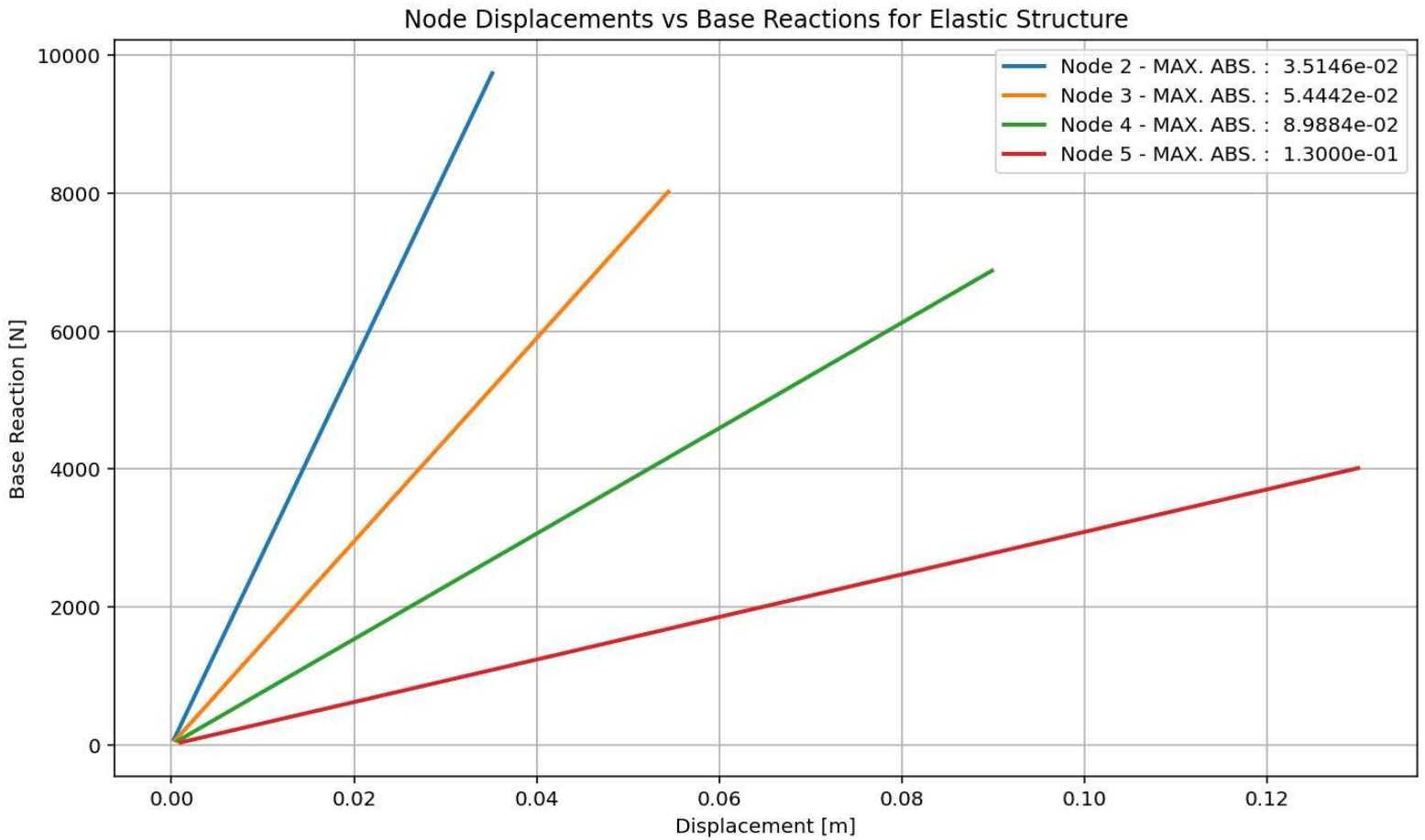
Structure Elastic Stiffness : 74942.52
Structure Plastic Stiffness : 23510.68
Structure Tangent Stiffness : 5012.99
Structure Ductility Ratio : 3.78
Structure Over Strength Factor: 1.19

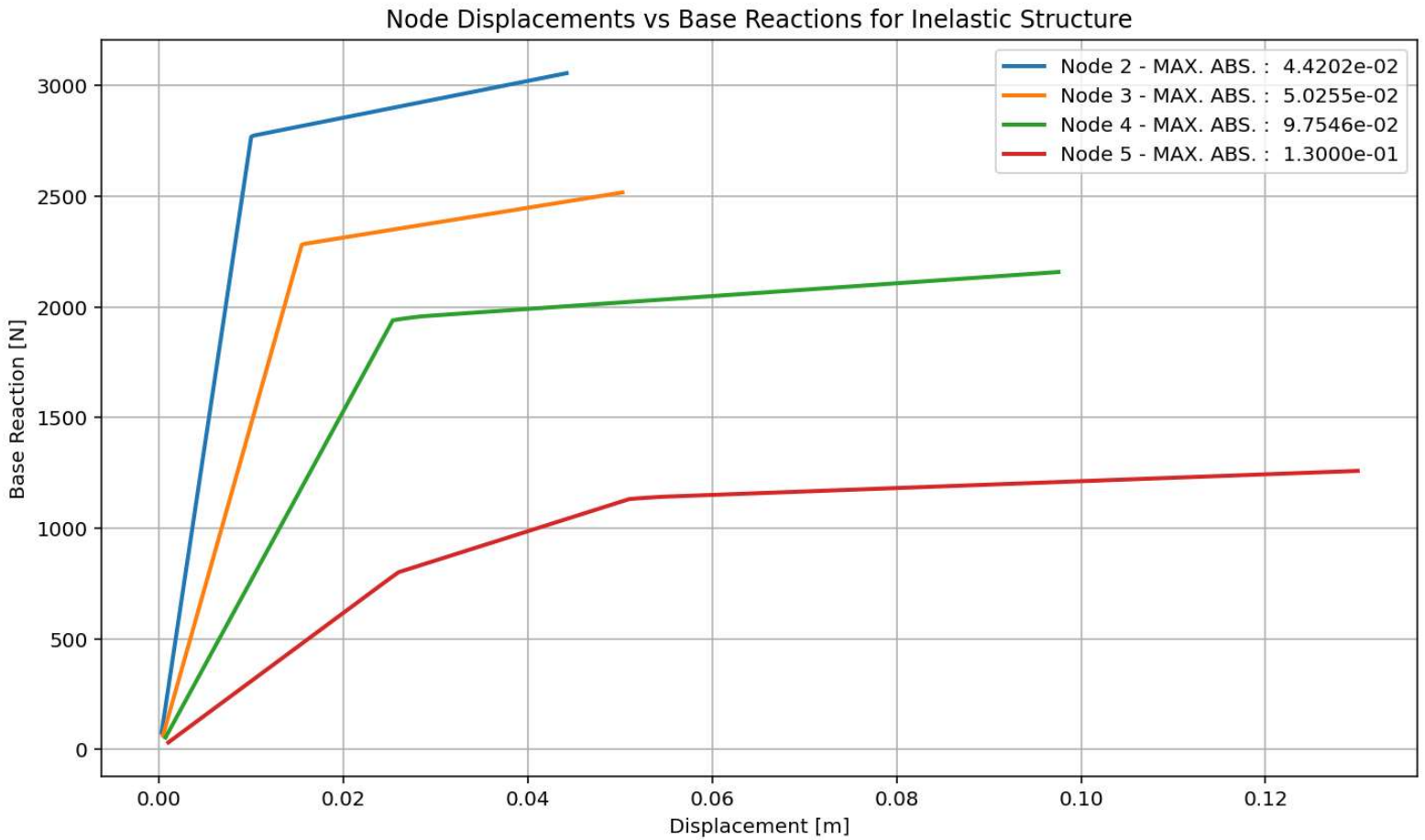

Force-Displacement Diagrams for 4 Different Inelastic Springs
1e7
4
2
0
−2
−4
Force [N]
−8000
−6000
−4000
−2000
0
2000
4000
6000
Displacement [m]
Element 1 (Original) - Tension
Element 1 (Original) - Compression
Element 2 (Stiffer) - Tension
Element 2 (Stiffer) - Compression
Element 3 (Softer) - Tension
Element 3 (Softer) - Compression
Element 4 (Modified) - Tension
Element 4 (Modified) - Compression

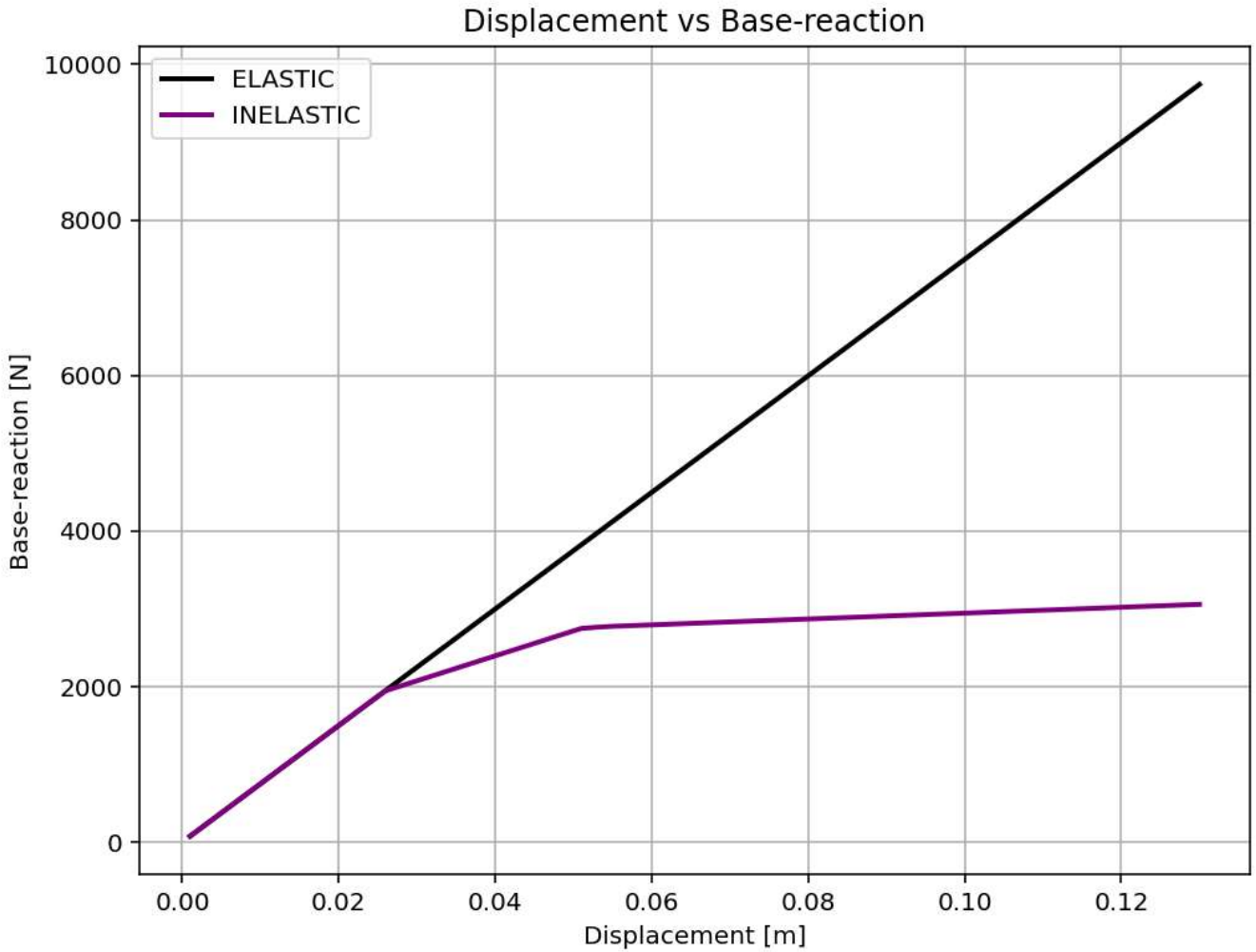

Element 1: Element 1 (Original)
Element 2: Element 2 (Stiffer)
Element 3: Element 3 (Softer)
Element 4: Element 4 (Modified)
Tension
Compression
Force [N]
Displacement [m]
1e7

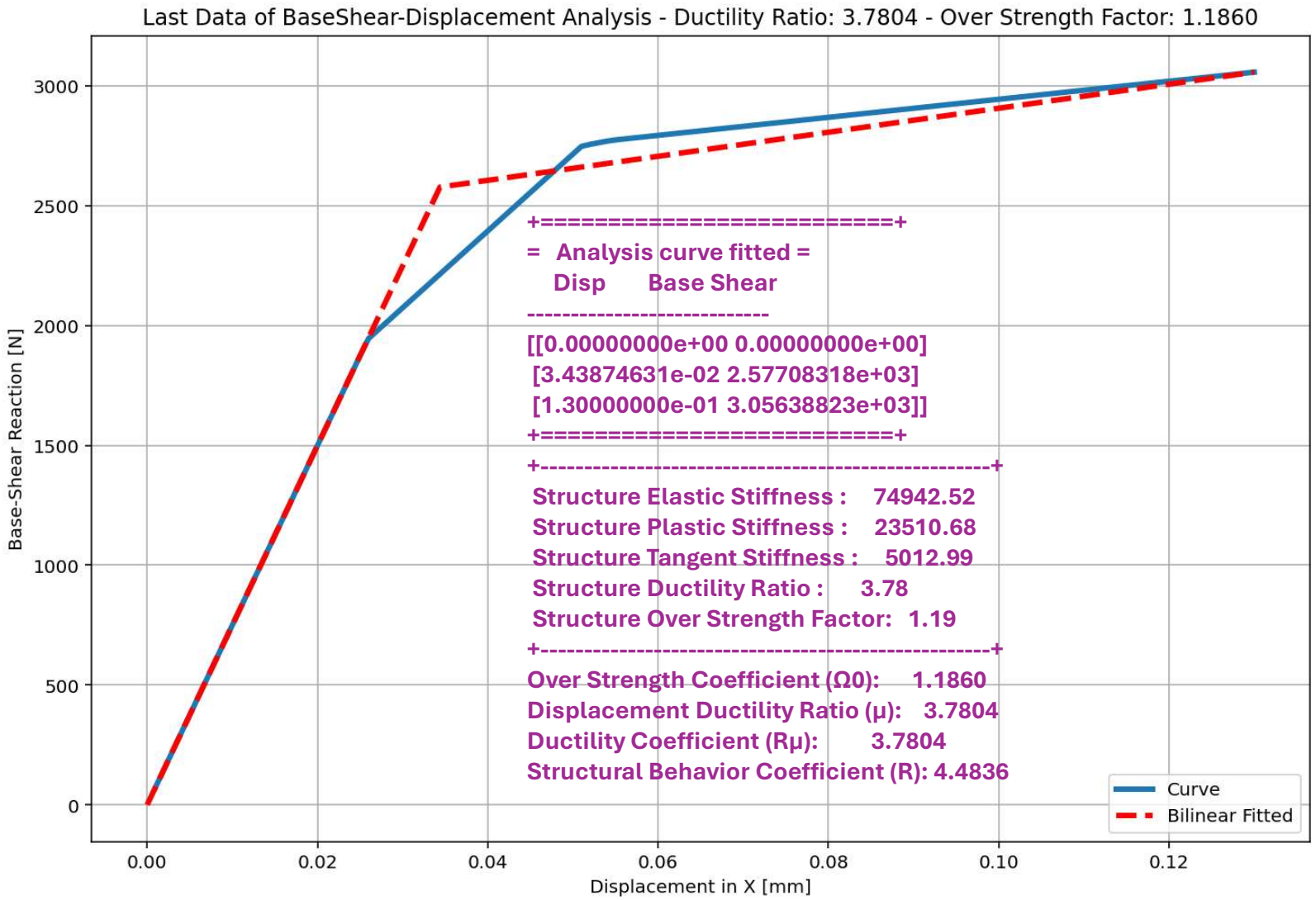

Period of Structure
ELASTIC PERIOD - MIN VALUES: Min: 2.100 (s) - Mean: 2.100 (s) - Max: 2.100 (s)
ELASTIC PERIOD - MAX VALUES: Min: 19.370 (s) - Mean: 19.370 (s) - Max: 19.370 (s)
INELASTIC PERIOD - MIN VALUES: Min: 2.100 (s) - Mean: 2.265 (s) - Max: 2.377 (s)
INELASTIC PERIOD - MAX VALUES: Min: 19.370 (s) - Mean: 63.426 (s) - Max: 89.063 (s)
Structural Period [s]
0
20
40
60
80
0.00000
0.00005
0.00010
0.00015
0.00020
0.00025
0.00030
0.00035
Time [s]


Period of Structure
Structural Period [s]
Structural Stiffness [N/m]
0
20
40
60
80
30000
40000
50000
60000
70000
ELASTIC PERIOD - MIN VALUES: Min: 2.100 (s) - Mean: 2.100 (s) - Max: 2.100 (s)
ELASTIC PERIOD - MAX VALUES: Min: 19.370 (s) - Mean: 19.370 (s) - Max: 19.370 (s)
INELASTIC PERIOD - MIN VALUES: Min: 2.100 (s) - Mean: 2.265 (s) - Max: 2.377 (s)
INELASTIC PERIOD - MAX VALUES: Min: 19.370 (s) - Mean: 63.426 (s) - Max: 89.063 (s)


Node Displacements vs Base Reactions for Elastic Structure
Node 2 - MAX. ABS. : 3.5146e-02
Node 3 - MAX. ABS. : 5.4442e-02
Node 4 - MAX. ABS. : 8.9884e-02
Node 5 - MAX. ABS. : 1.3000e-01
Base Reaction [N]
10000
8000
6000
4000
2000
0
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Displacement [m]


Node Displacements vs Base Reactions for Inelastic Structure
Node 2 - MAX. ABS. : 4.4202e-02
Node 3 - MAX. ABS. : 5.0255e-02
Node 4 - MAX. ABS. : 9.7546e-02
Node 5 - MAX. ABS. : 1.3000e-01
Base Reaction [N]
Displacement [m]
0
500
1000
1500
2000
2500
3000
0.00
0.02
0.04
0.06
0.08
0.10
0.12


Displacement vs Base-reaction
ELASTIC
INELASTIC
Base-reaction [N]
10000
8000
6000
4000
2000
0
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Displacement [m]


Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 3.7804 - Over Strength Factor: 1.1860
Base-Shear Reaction [N]
Displacement in X [mm]
0
500
1000
1500
2000
2500
3000
0.00
0.02
0.04
0.06
0.08
0.10
0.12
+==========================+
= Analysis curve fitted =
Disp Base Shear

[[0.00000000e+00 0.00000000e+00]
[3.43874631e-02 2.57708318e+03]
[1.30000000e-01 3.05638823e+03]]
+==========================+
+--+
Structure Elastic Stiffness : 74942.52
Structure Plastic Stiffness : 23510.68
Structure Tangent Stiffness : 5012.99
Structure Ductility Ratio : 3.78
Structure Over Strength Factor: 1.19
+--+
Over Strength Coefficient (Ω0): 1.1860
Displacement Ductility Ratio (μ): 3.7804
Ductility Coefficient (Rμ): 3.7804
Structural Behavior Coefficient (R): 4.4836
Curve
Bilinear Fitted