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

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

K1+K2+K3+K4

m1+m2+m3+m4

C1+C2+C3+C4

INCREMENTAL
DISPLACEMENT

y

z   x
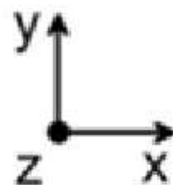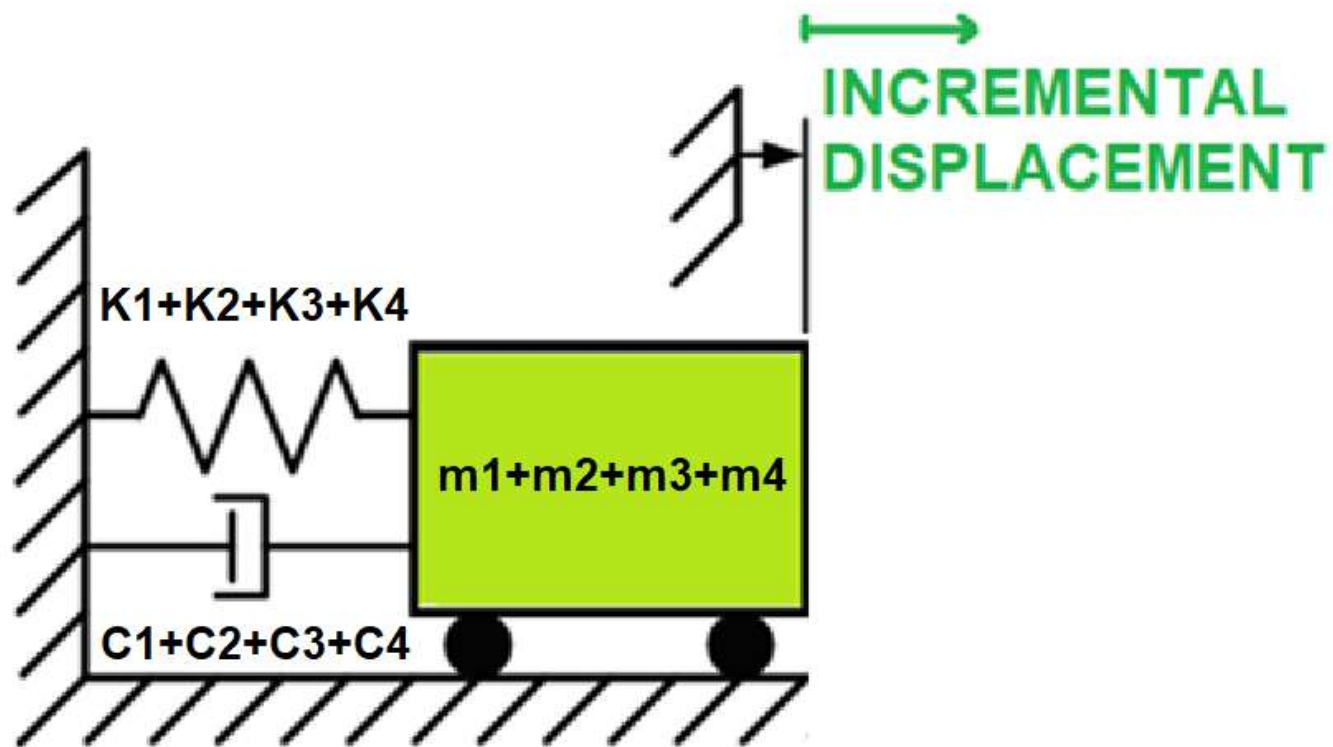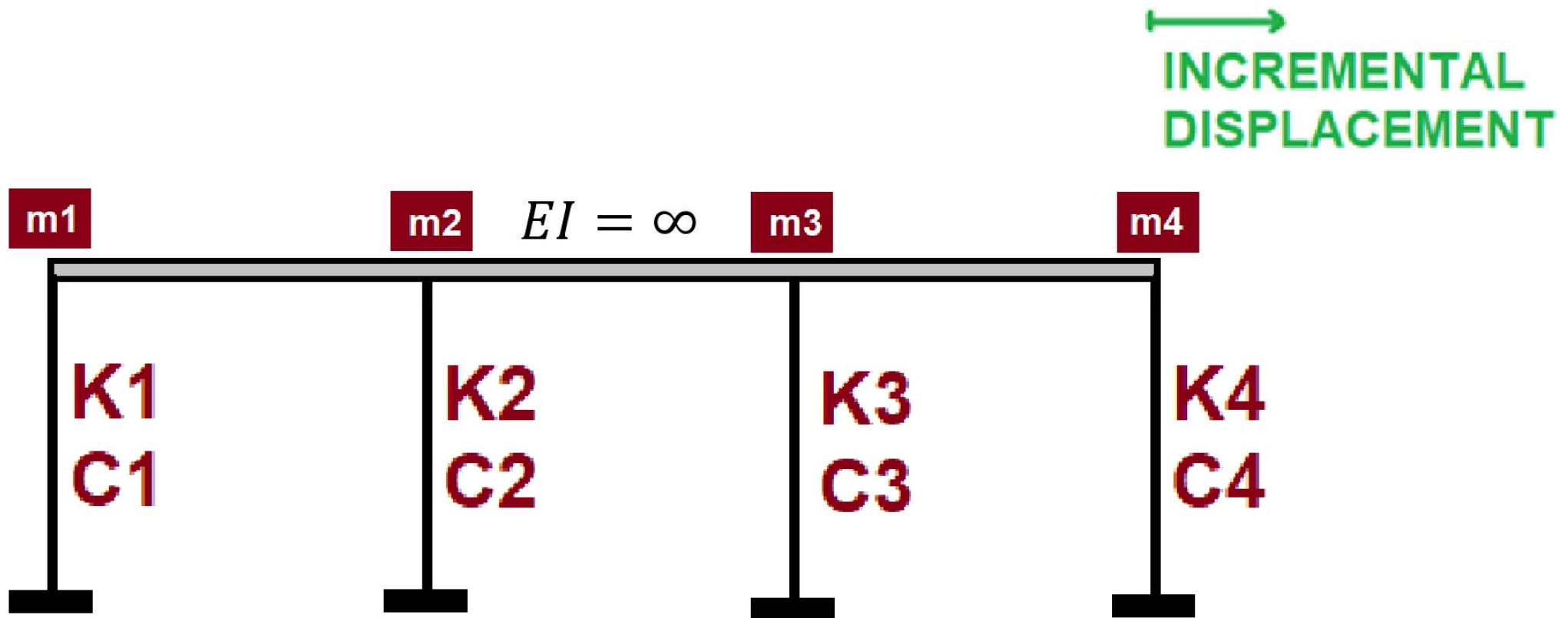
Spyder (Python 3.12)

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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

```python
##############################################################################################
#                            >> 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
```
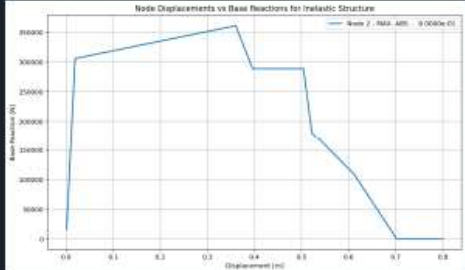
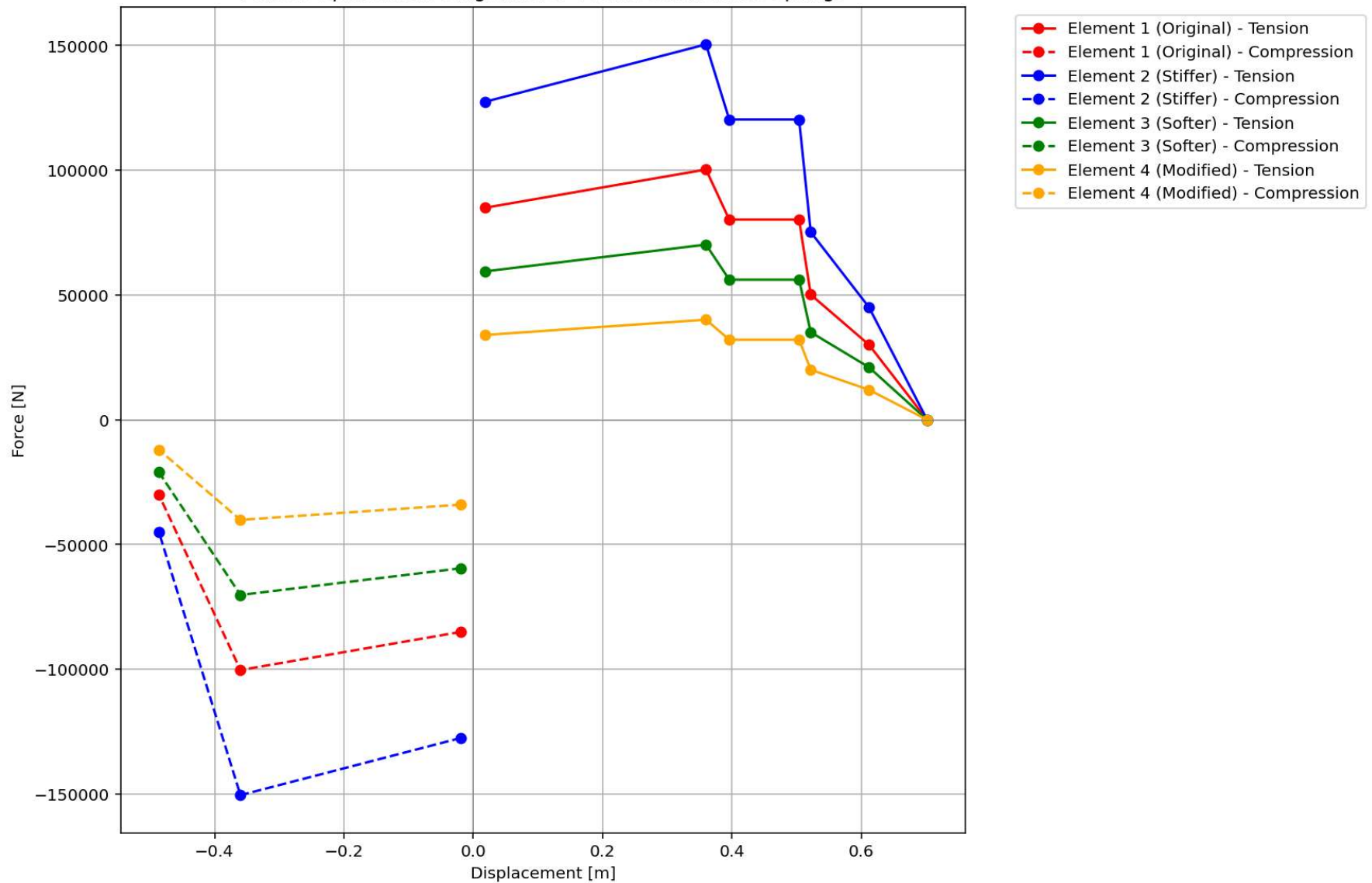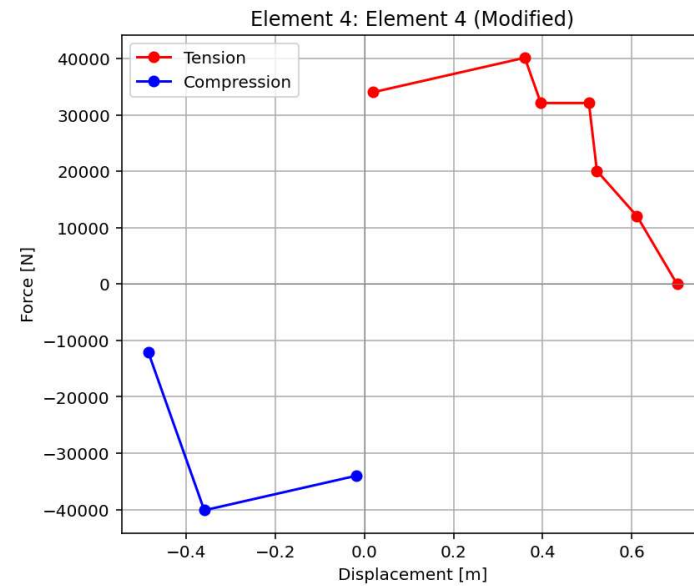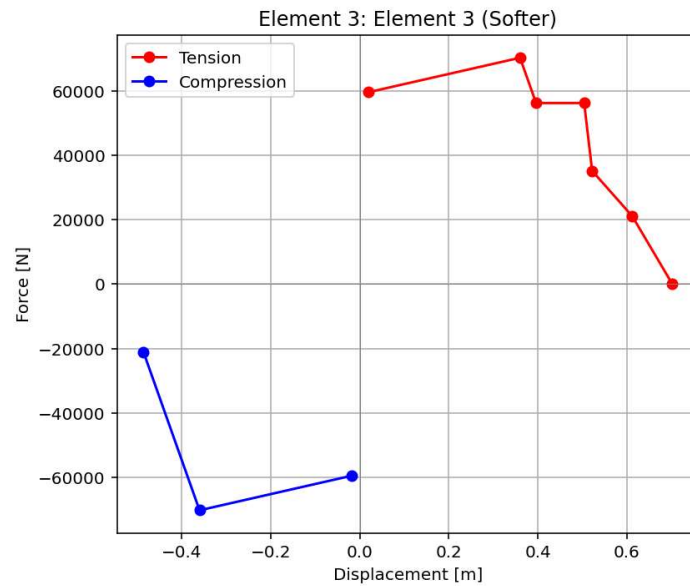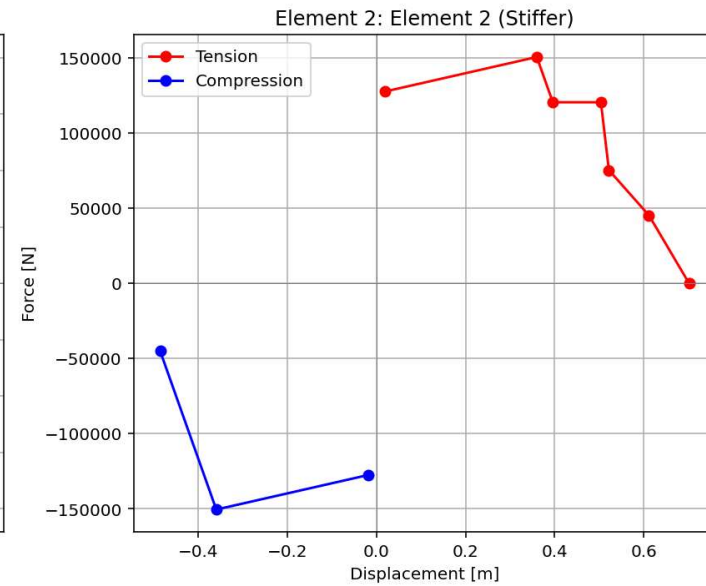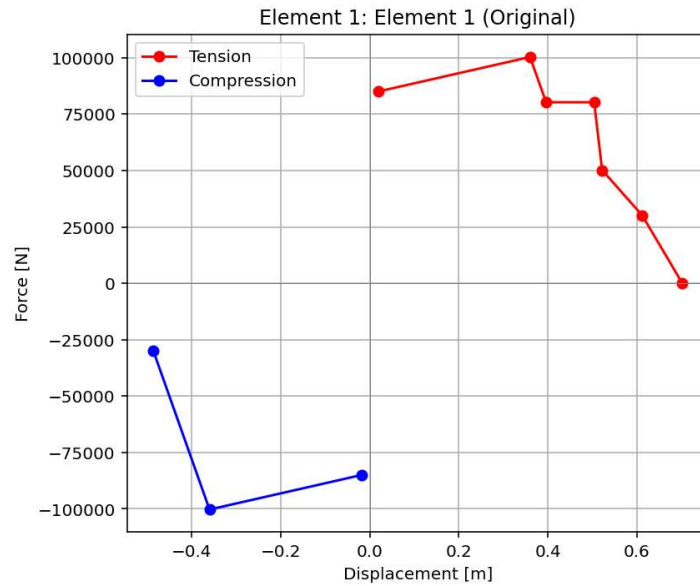Python Console   Files   Help   Variable Explorer   Debugger   Plots

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

Element 1: Element 1 (Original)

Element 2: Element 2 (Stiffer)

Element 3: Element 3 (Softer)

Element 4: Element 4 (Modified)

Period of Structure vs Damage level During Pushover Analysis

ELASTIC PERIOD - MIN VALUES: Min: 1.439 (s) - Mean: 1.439 (s) - Max: 1.439 (s)
ELASTIC PERIOD - MAX VALUES: Min: 1.439 (s) - Mean: 1.439 (s) - Max: 1.439 (s)
INELASTIC PERIOD - MIN VALUES: Min: 1.439 (s) - Mean: 13.747 (s) - Max: 14.416 (s)
INELASTIC PERIOD - MAX VALUES: Min: 1.439 (s) - Mean: 13.747 (s) - Max: 14.416 (s)

Period of Structure vs Structural Stiffness During Pushover Analysis

ELASTIC PERIOD - MIN VALUES: Min: 1.439 (s) - Mean: 1.439 (s) - Max: 1.439 (s)
ELASTIC PERIOD - MAX VALUES: Min: 1.439 (s) - Mean: 1.439 (s) - Max: 1.439 (s)
INELASTIC PERIOD - MIN VALUES: Min: 1.439 (s) - Mean: 13.747 (s) - Max: 14.416 (s)
INELASTIC PERIOD - MAX VALUES: Min: 1.439 (s) - Mean: 13.747 (s) - Max: 14.416 (s)

Node Displacements vs Base Reactions for Elastic Structure

Displacement vs Base-reaction

Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 18.4798 - Over Strength Factor: 1.1744

+========================+
= Analysis curve fitted =
    Disp   Base Shear
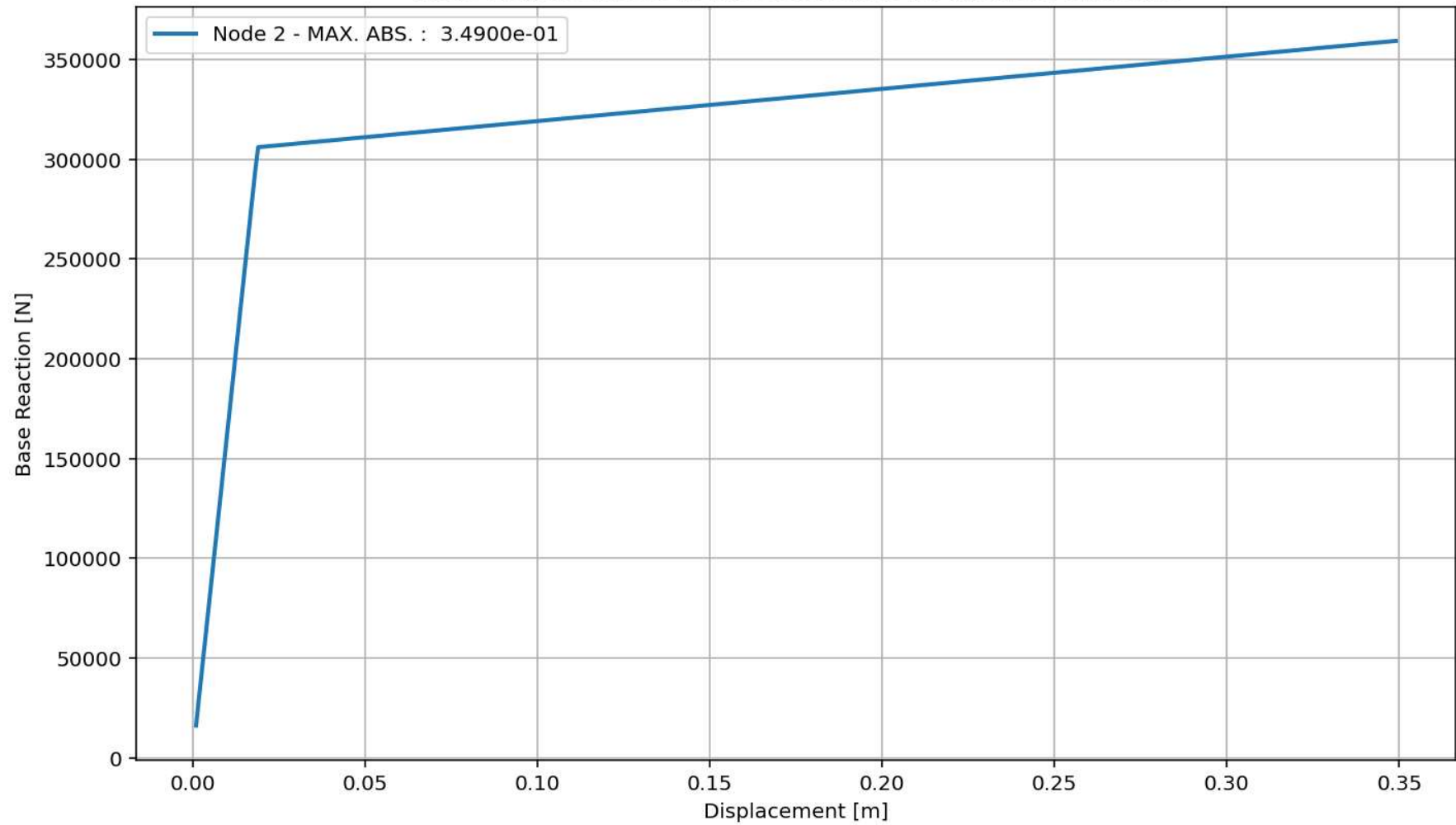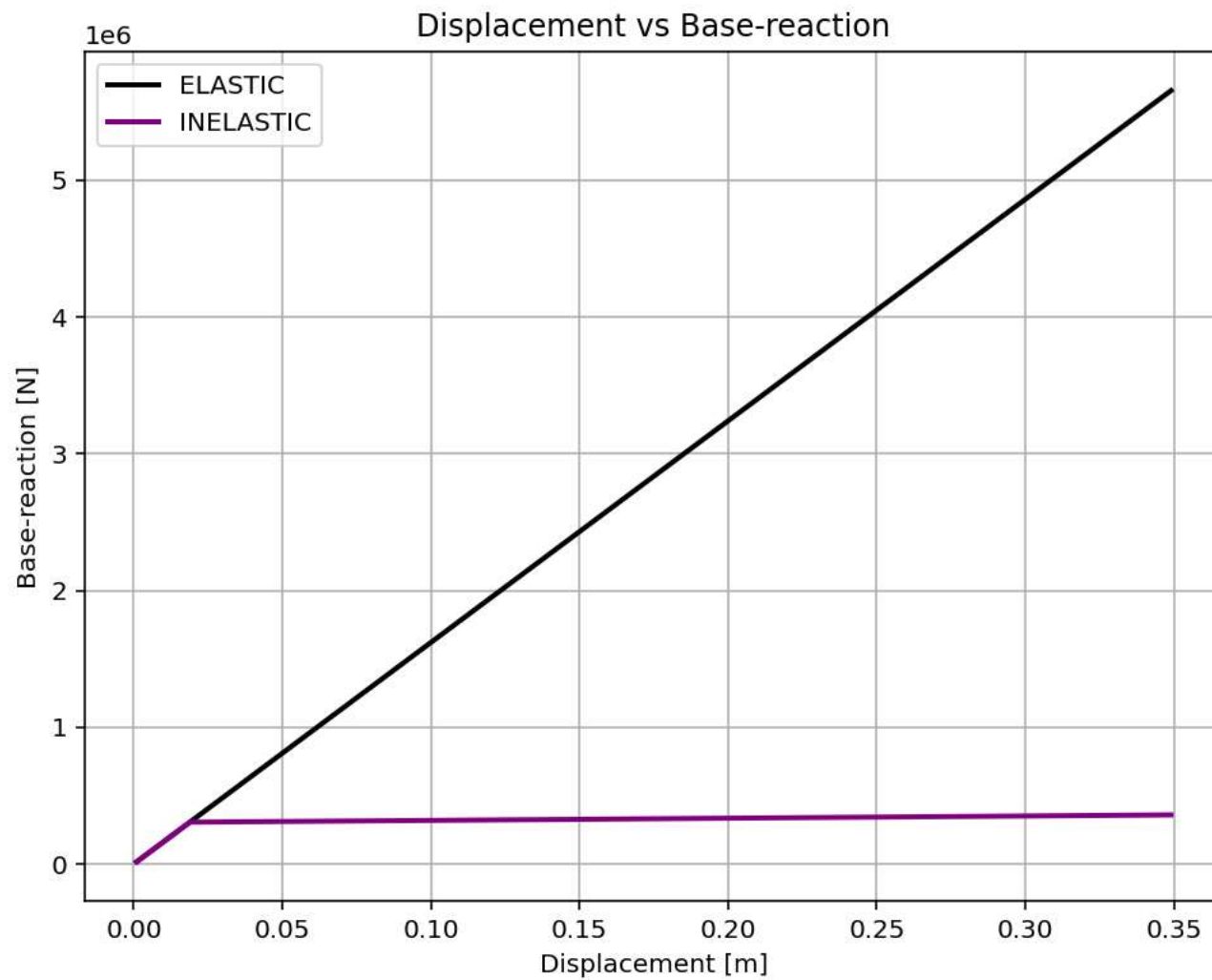-----------------------------
[[0.00000000e+00 0.00000000e+00]
 [1.88855299e-02 3.05945585e+05]
 [3.49000000e-01 3.59303805e+05]]
+========================+
+--+
 Structure Elastic Stiffness :   16200000.00
 Structure Plastic Stiffness :   1029523.80
 Structure Tangent Stiffness :   161635.51
 Structure 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

Base-Shear Reaction [N]

Displacement in X [m]

Curve
Bilinear Fitted