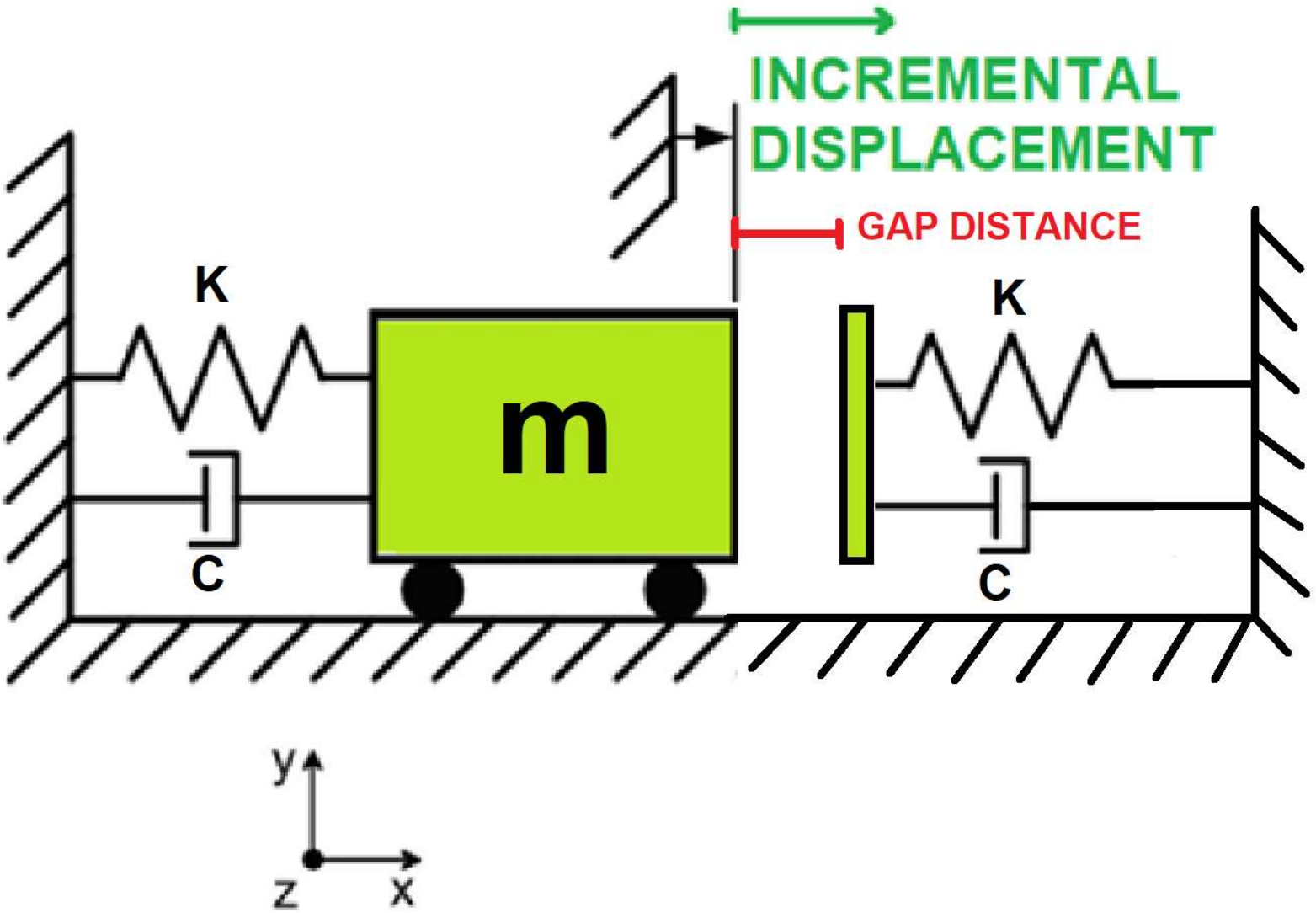
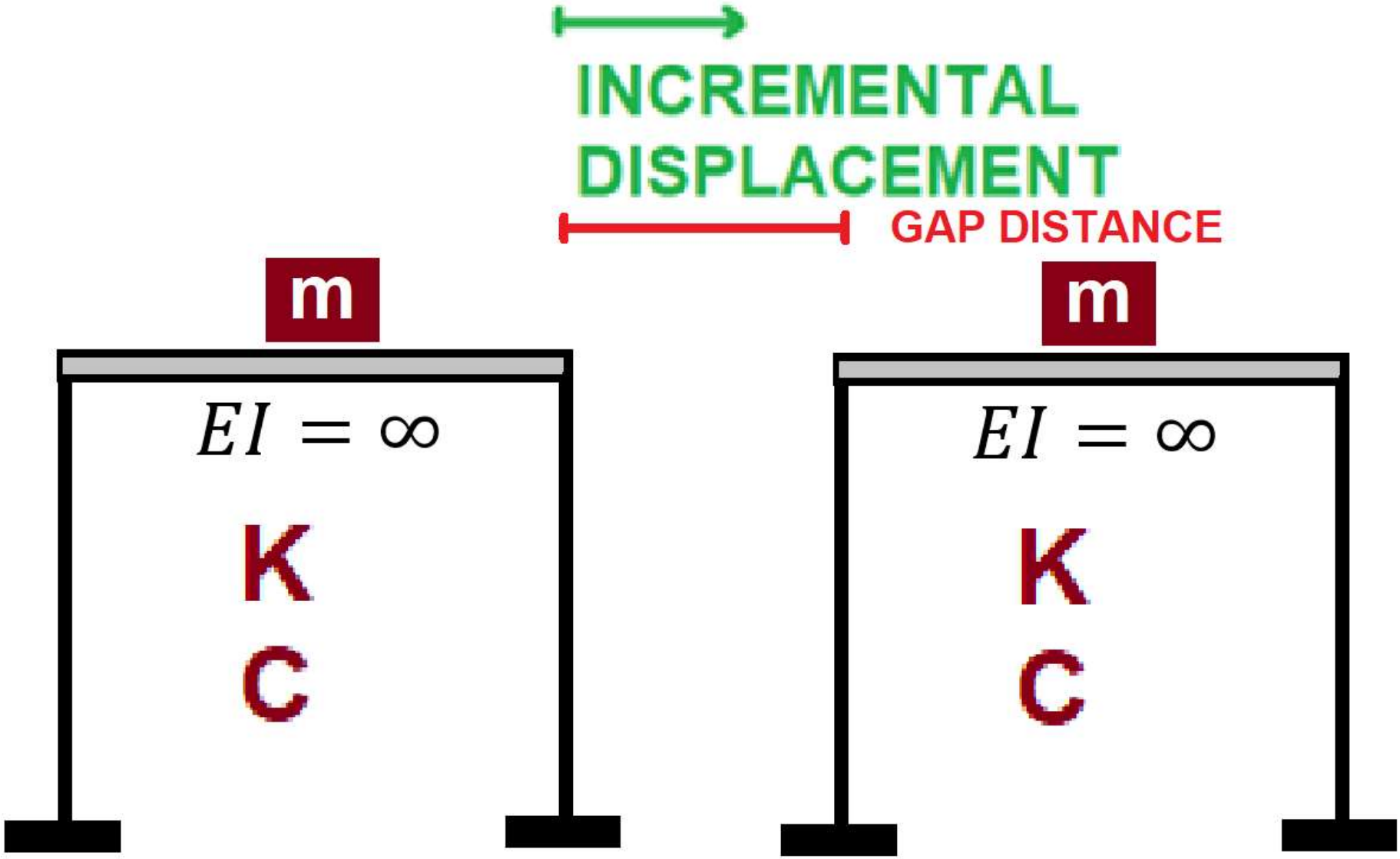
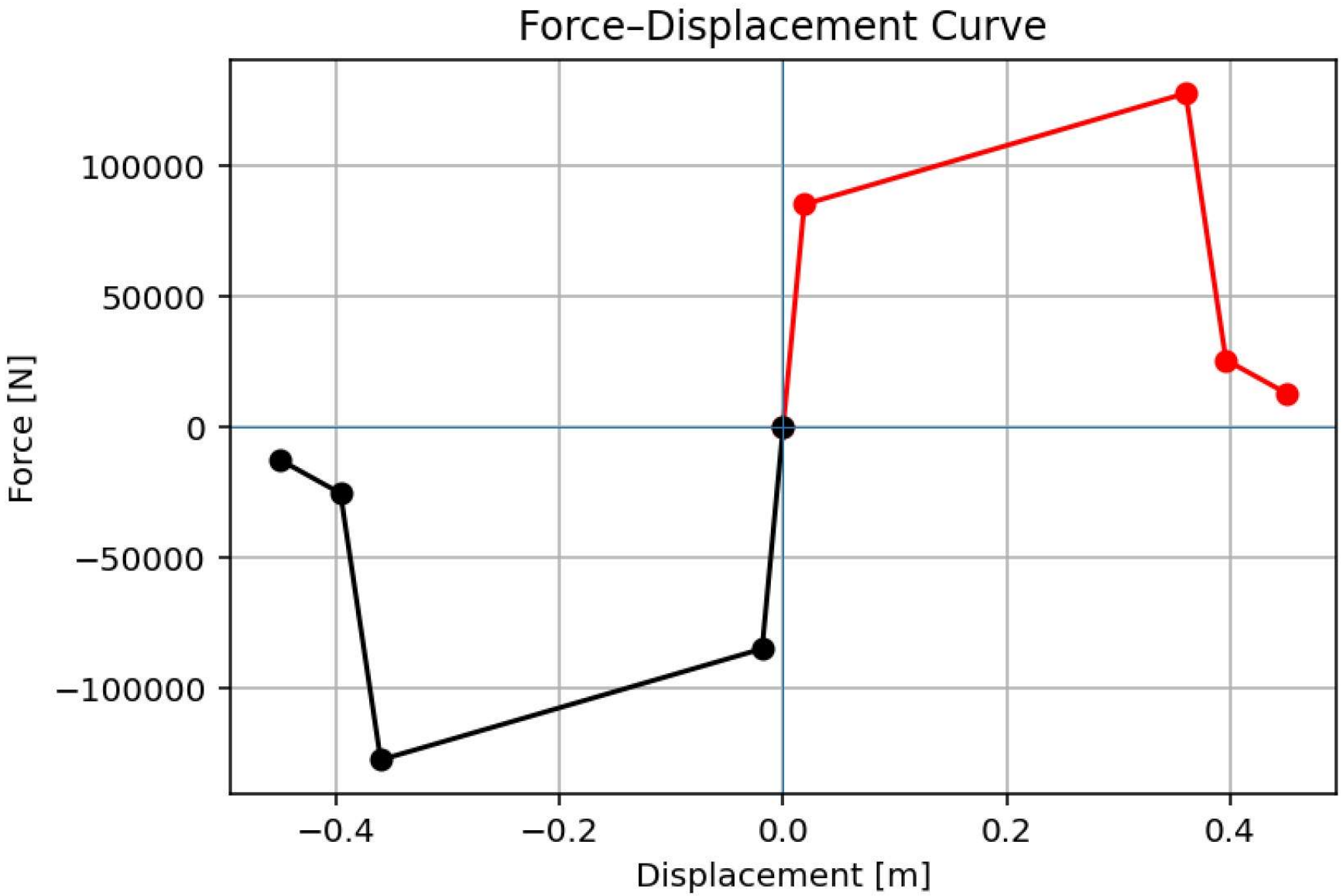
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

CONTACT-DRIVEN PUSHOVER ANALYSIS OF INELASTIC SDOF SYSTEMS: MONITORING PERIOD SHIFTS DURING SECONDARY SPRING ACTIVATION IN OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


INCREMENTAL
DISPLACEMENT
GAP DISTANCE
K
K
m
C
C
y
z
x


INCREMENTAL
DISPLACEMENT
GAP DISTANCE
m
$EI = \infty$
K
C
m
$EI = \infty$
K
C


Force–Displacement Curve
100000
50000
0
−50000
−100000
Force [N]
−0.4
−0.2
0.0
0.2
0.4
Displacement [m]

Spyder (Python 3.12)

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C:\Users\Dell\Desktop\OPENSEES_FILES\+CONTACT_PRO...ER_PERIOD\CONTACT_PROBLEM_SDOF_PUSHOVER_PERIOD.py

CONTACT_PROBLEM_SDOF_PUSHOVER_PERIOD.py

```
##########################################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
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#                                    SECONDARY SPRING ACTIVATION IN OPENSEES
#---------------------------------------------------------------------------------------------------------
#                              THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                    EMAIL: salar.d.ghashghaei@gmail.com
##########################################################################################################
"""
This script simulates the nonlinear pushover response of a single-degree-of-freedom system with a
 contact/gap mechanism. The structure has a primary spring (elastic or hysteretic) that activates
 immediately, while a secondary parallel spring engages only when displacement exceeds a specified
 gap distance. This models structural components that come into contact only after certain
 deformation thresholds, such as gap-opening in masonry infills, pounding between adjacent structures,
 or secondary bracing systems activating during strong seismic events.

The analysis tracks force-displacement response, stiffness degradation, and period elongation
 as damage accumulates. The eigenvalue analysis at each step captures how the natural period
 increases with structural softening, a critical indicator of seismic vulnerability during
 progressive damage. Contact activation causes a sudden stiffness increase when the gap closes,
 followed by further period evolution as the system yields.
"""
import openseespy.opensees as ops
import ANALYSIS_FUNCTION as S01
import EIGENVALUE_ANALYSIS_FUN as S02
import numpy as np
import matplotlib.pyplot as plt
import time as TI

#%%---------------------------------------------------------------------------------------------------
# Define  Structural Properties
FY = 85000.0                                # [N] Yield Force of Structure
FU = 1.5 * FY                               # [N] Ultimate Force of Structure
Ke = 4500000.0                              # [N/m] Spring Elastic Stiffness
```
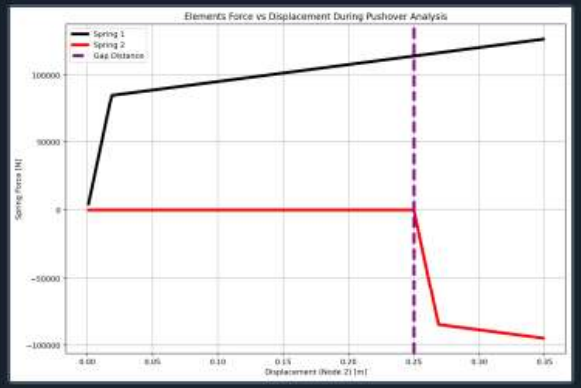
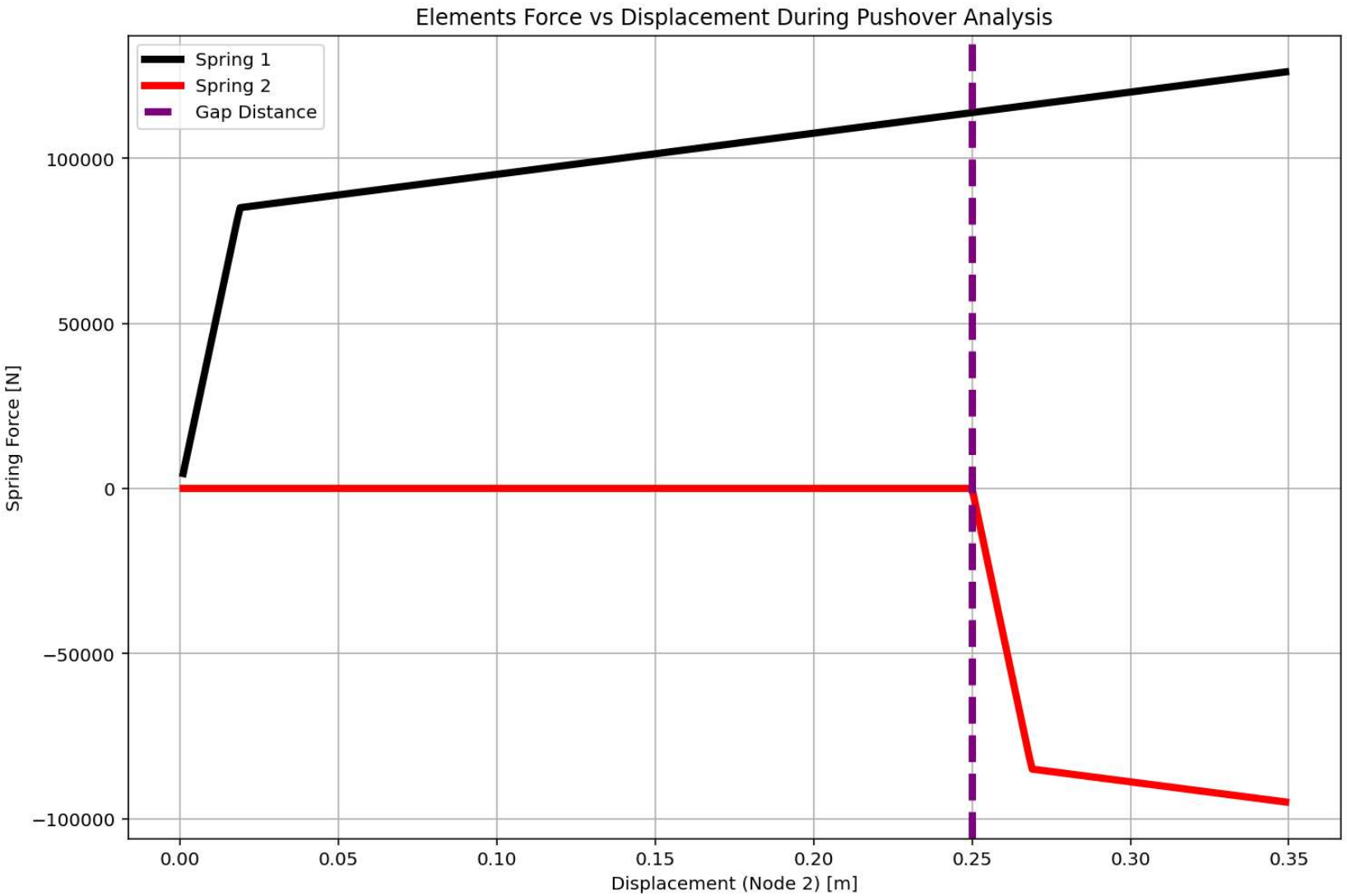
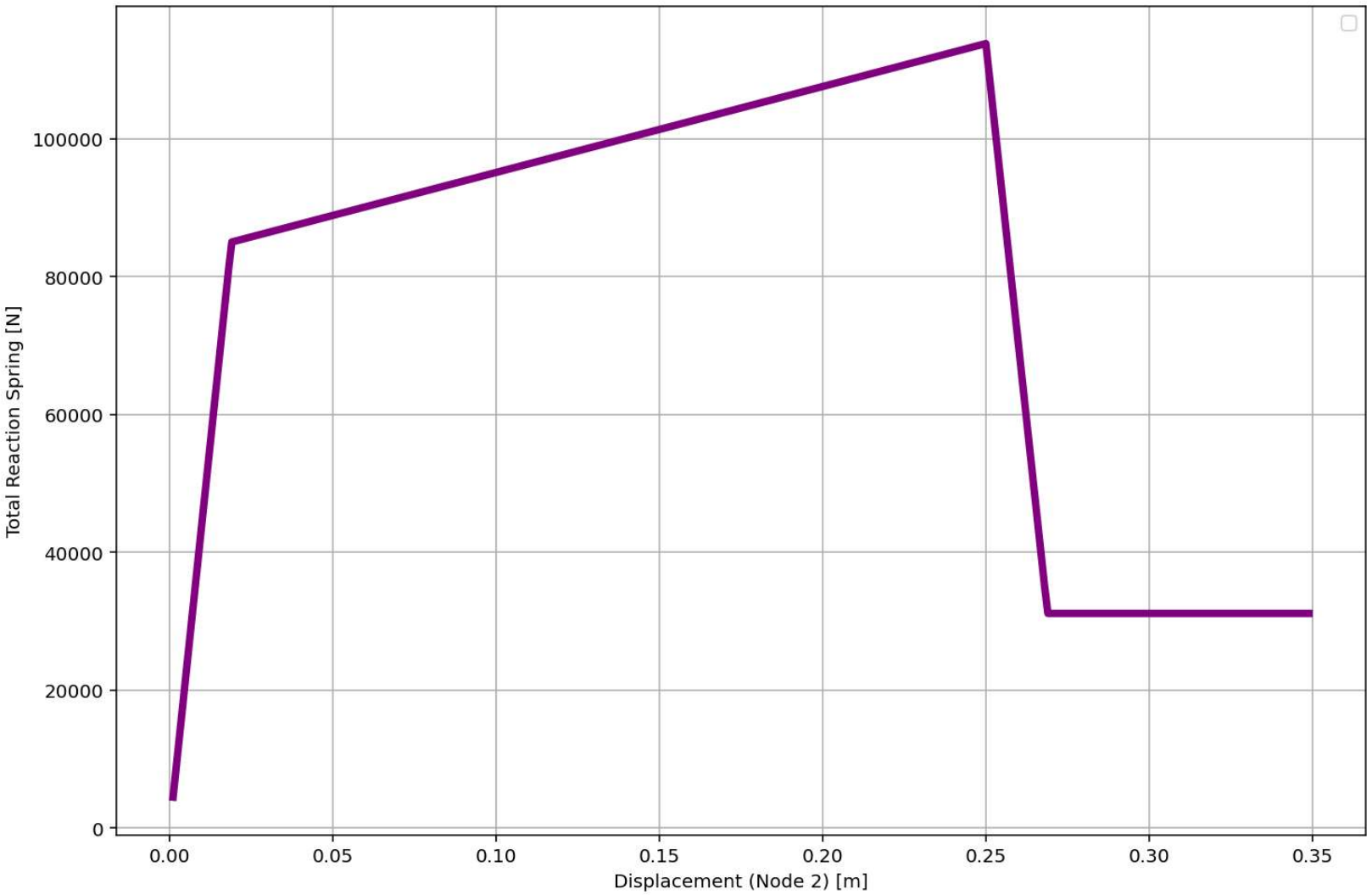
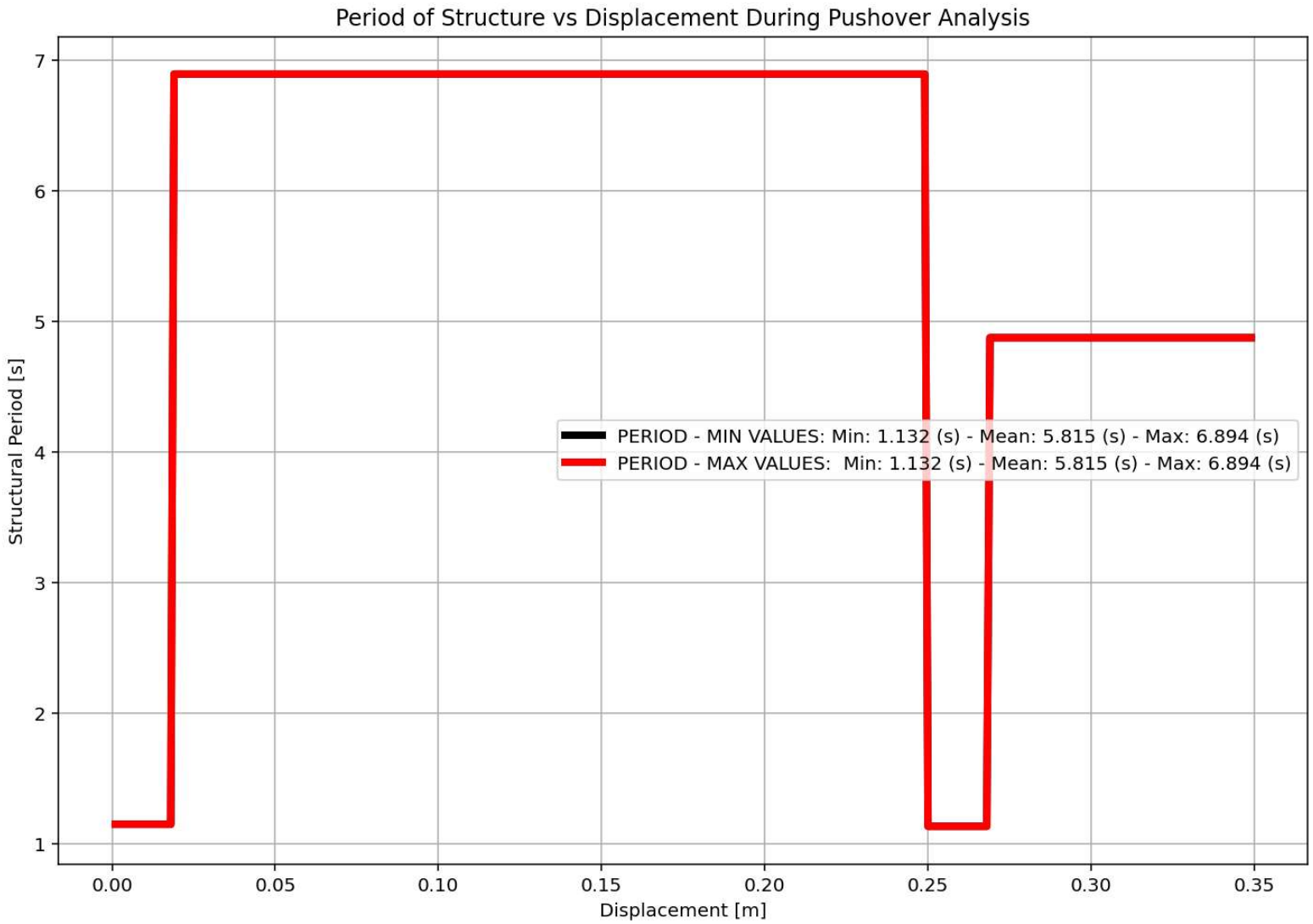



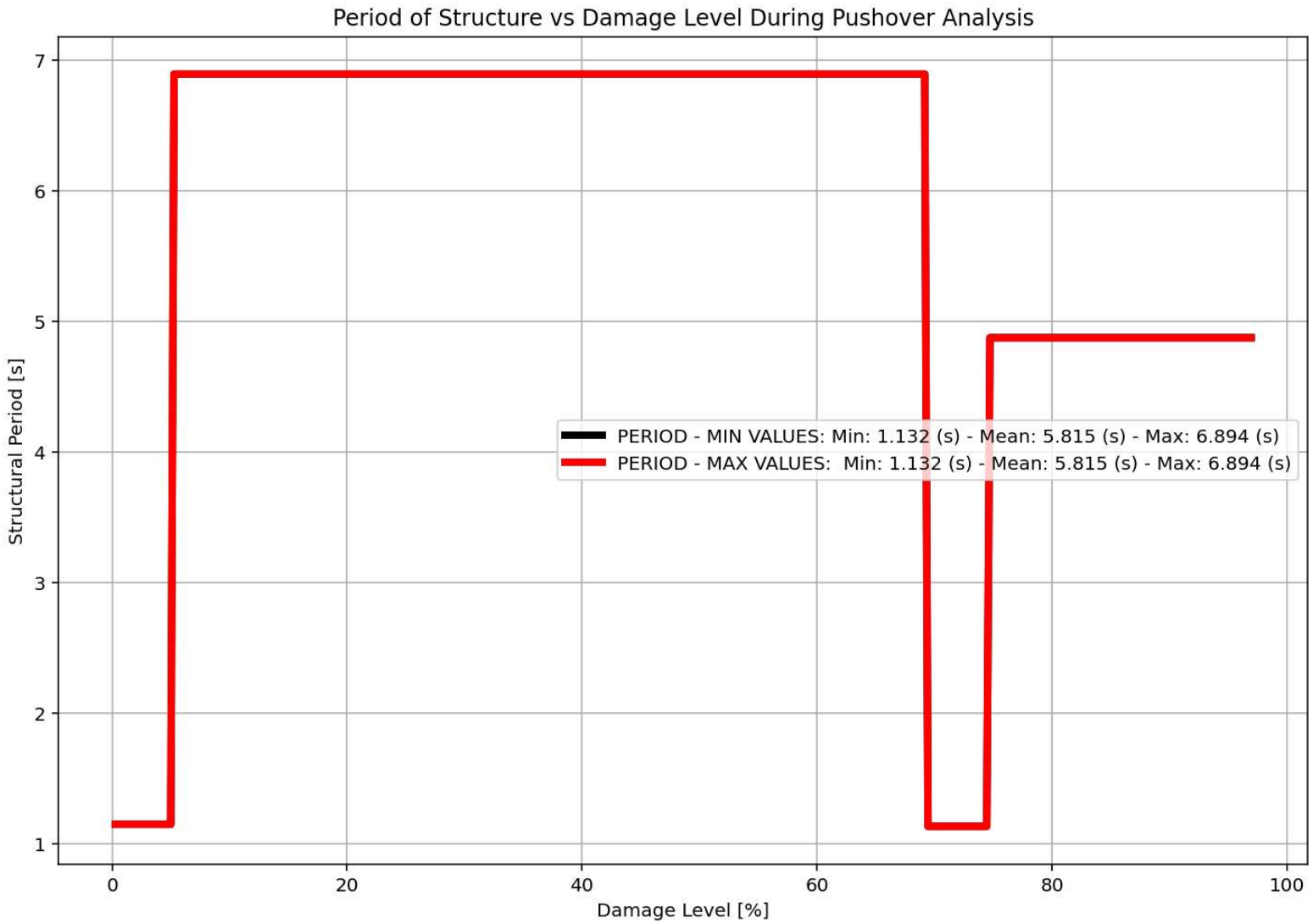
IPython Console | Files | Help | Variable Explorer | Debugger | Plots | History

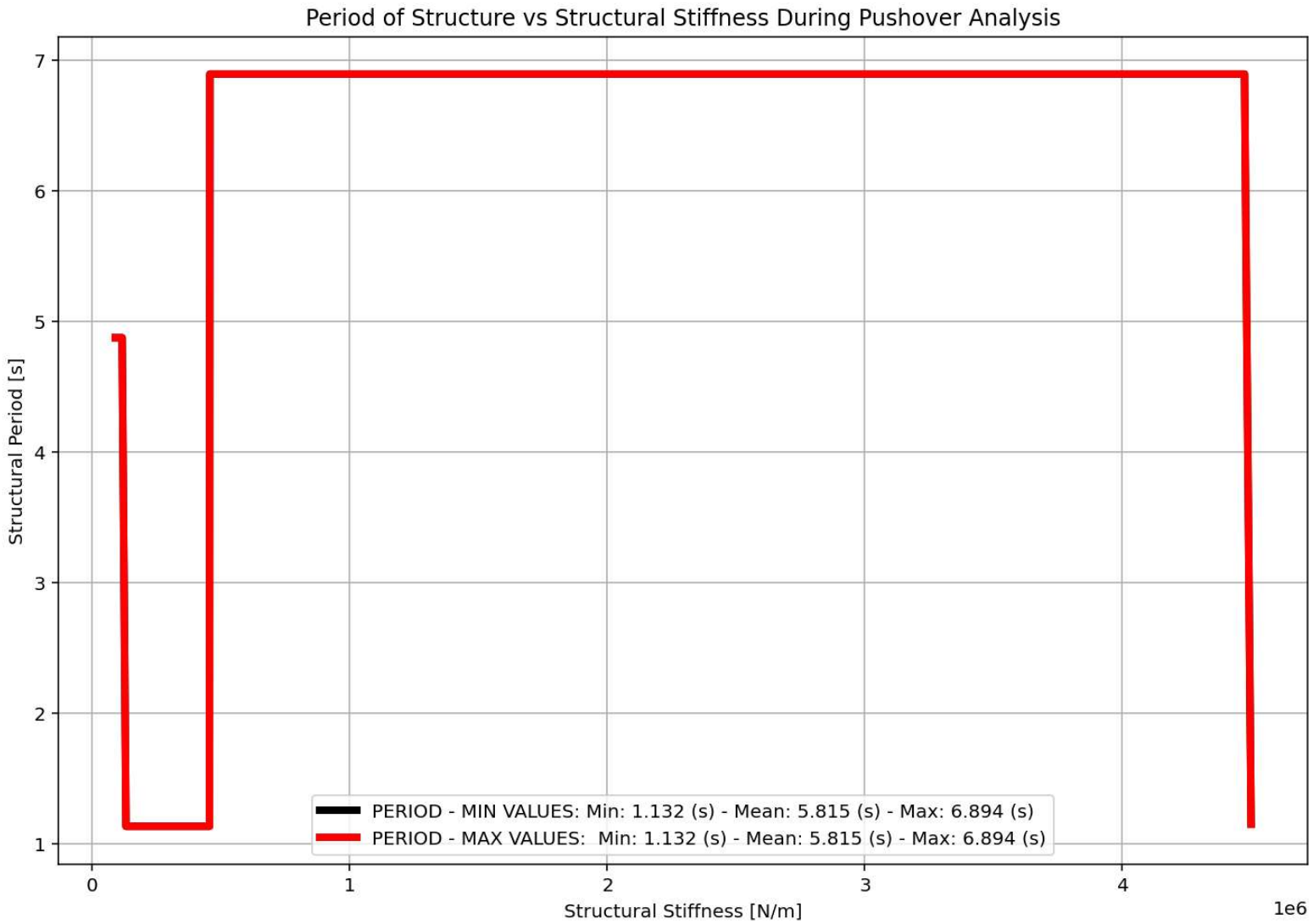
Inline | Conda: anaconda3 (Python 3.12.7) | LSP: Python | Line 1, Col 1 | UTF-8 | CRLF | RW | Mem 44%


Elements Force vs Displacement During Pushover Analysis
Spring 1
Spring 2
Gap Distance
100000
50000
0
−50000
−100000
Spring Force [N]
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Displacement (Node 2) [m]


Total Reaction Spring [N]
100000
80000
60000
40000
20000
0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Displacement (Node 2) [m]


Period of Structure vs Displacement During Pushover Analysis
Structural Period [s]
Displacement [m]
1
2
3
4
5
6
7
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
PERIOD - MIN VALUES: Min: 1.132 (s) - Mean: 5.815 (s) - Max: 6.894 (s)
PERIOD - MAX VALUES: Min: 1.132 (s) - Mean: 5.815 (s) - Max: 6.894 (s)


Period of Structure vs Damage Level During Pushover Analysis
Structural Period [s]
Damage Level [%]
PERIOD - MIN VALUES: Min: 1.132 (s) - Mean: 5.815 (s) - Max: 6.894 (s)
PERIOD - MAX VALUES: Min: 1.132 (s) - Mean: 5.815 (s) - Max: 6.894 (s)
1
2
3
4
5
6
7
0
20
40
60
80
100


Period of Structure vs Structural Stiffness During Pushover Analysis
Structural Period [s]
Structural Stiffness [N/m]
1e6
PERIOD - MIN VALUES: Min: 1.132 (s) - Mean: 5.815 (s) - Max: 6.894 (s)
PERIOD - MAX VALUES: Min: 1.132 (s) - Mean: 5.815 (s) - Max: 6.894 (s)