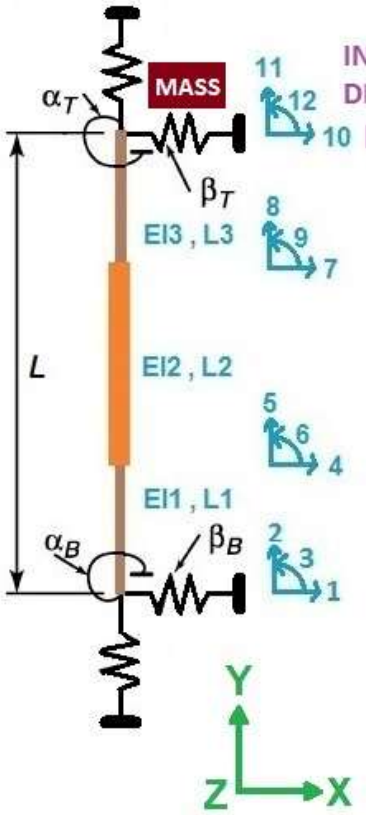
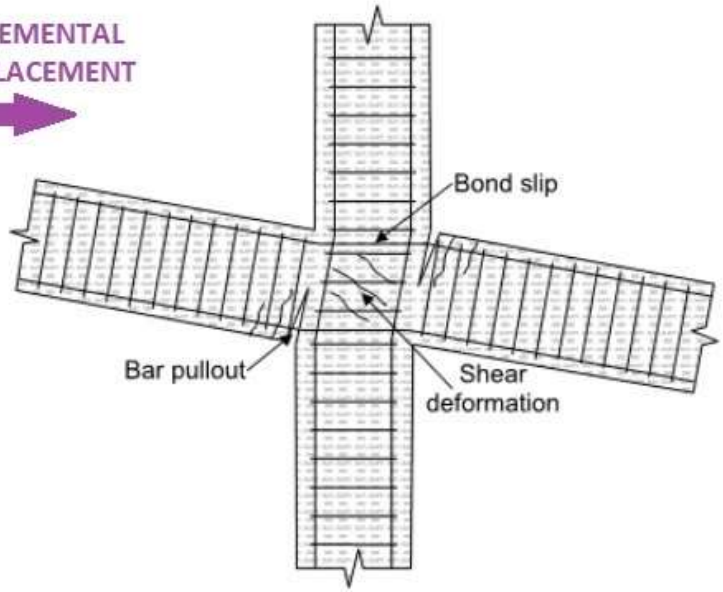
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

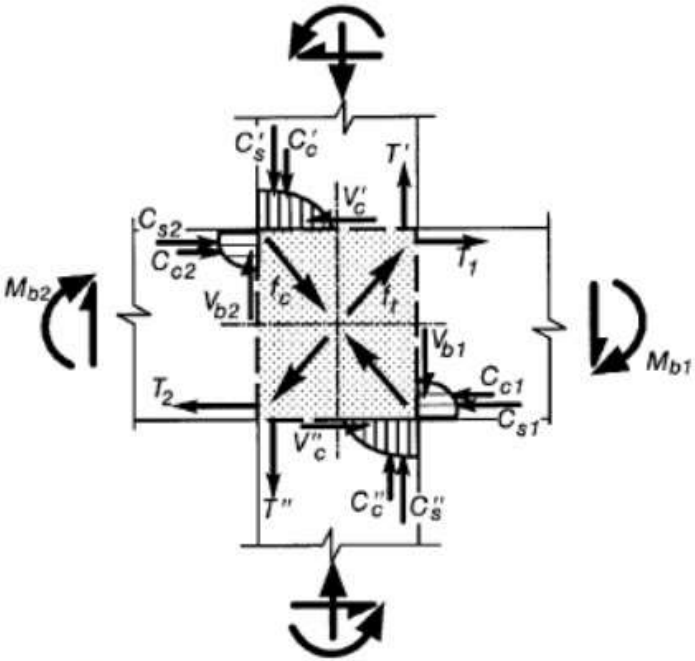
PUSHOVER AND DYNAMIC ANALYSIS OF CONCRETE COLUMNS WITH AXIAL AND ROTATIONAL SPRINGS FOR MODELING BEAM COLUMN JOINTS

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

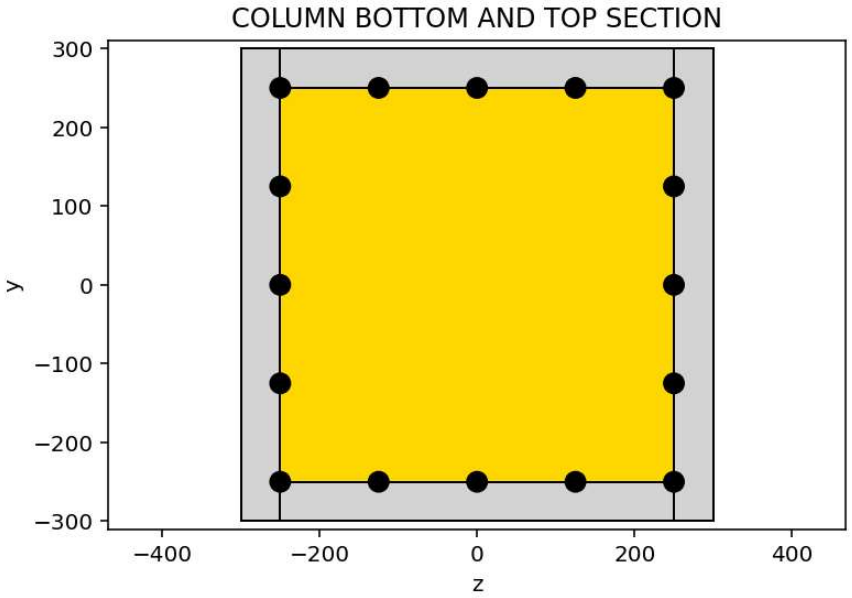


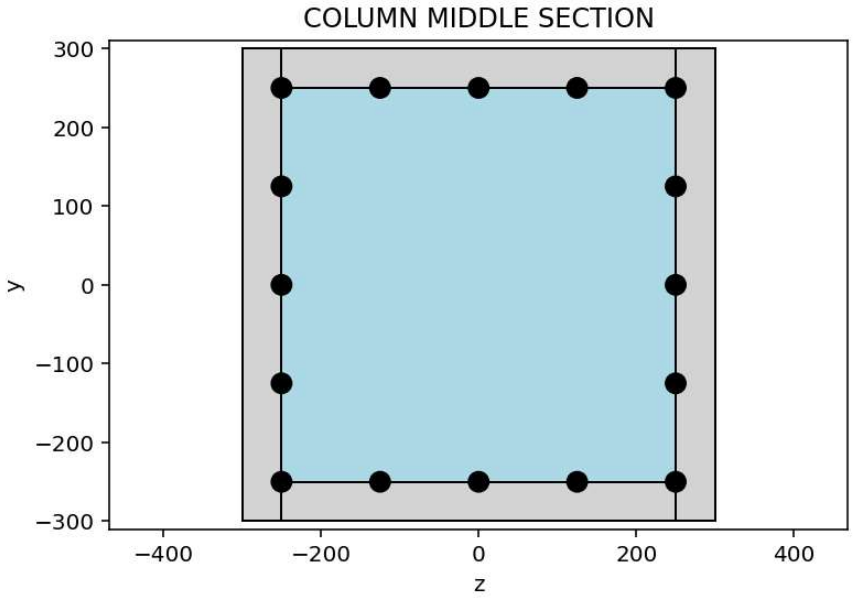
INCREMENTAL DISPLACEMENT





Concrete Joints


COLUMN BOTTOM AND TOP SECTION
300
200
100
0
−100
−200
−300
y
−400
−200
0
200
400
z


COLUMN MIDDLE SECTION
300
200
100
0
−100
−200
−300
y
−400
−200
0
200
400
z

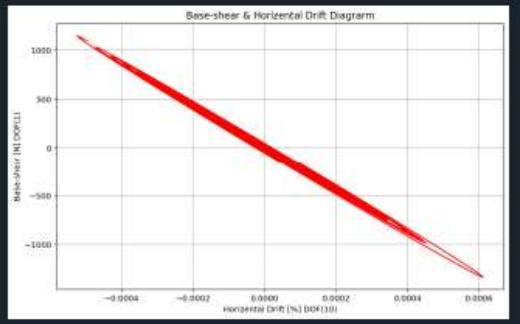
Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_COL..._JOINTS_CONTACT\CONCRETE_COLUMN_JOINTS_CONTACT.py

CONCRETE_COLUMN_JOINTS_CONTACT.py

```
#          ##########################################################################################
#          #          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<             #
#          #      PUSHOVER ANALYSIS OF CONCRETE COLUMNS WITH AXIAL AND ROTATIONAL SPRINGS          #
#          #                          FOR MODELING BEAM COLUMN JOINTS                              #
#          #        WITH AND WITHOUT EXTERNAL OBJECT CONTACT EFFECTS (CONTACT PROBLEMS)            #
#          #-----------------------------------------------------------------------------------------#
#          #              THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)                 #
#          #                       EMAIL: salar.d.ghashghaei@gmail.com                               #
#          ##########################################################################################
"""
1. Purpose:
    Performs pushover and dynamic analysis of concrete columns with axial/rotational springs to model beam-c
2. Framework:
    Uses OpenSeesPy for nonlinear structural analysis with Python scripting.
3. Features:
   - Fiber-section modeling for concrete columns (confined/unconfined) and rebars.
   - Nonlinear springs for joint behavior (axial/rotational).
4. Pushover Analysis:
   - Applies incremental displacements to study force-displacement response.
   - Tracks base shear, axial force, and moment capacities.
5. Dynamic Analysis:
   - Simulates seismic response using Newmark integration.
   - Includes Rayleigh damping and ground motion input.
6. Material Models:
   - Concrete02 for concrete (Mander model for confined).
   - Hysteretic/Steel02 for rebars and springs.
7. Section Modeling:
   - Rectangular patches/layers for core/cover concrete and rebars.
8. Contact Springs:
    Optional nonlinear springs for gap/contact effects.
9. Outputs:
    Records displacements, drifts, forces, and moments.
10. Visualization:
    Plots hysteresis curves, time histories, and fiber sections.
```



Help Variable Explorer Debugger Plots Files

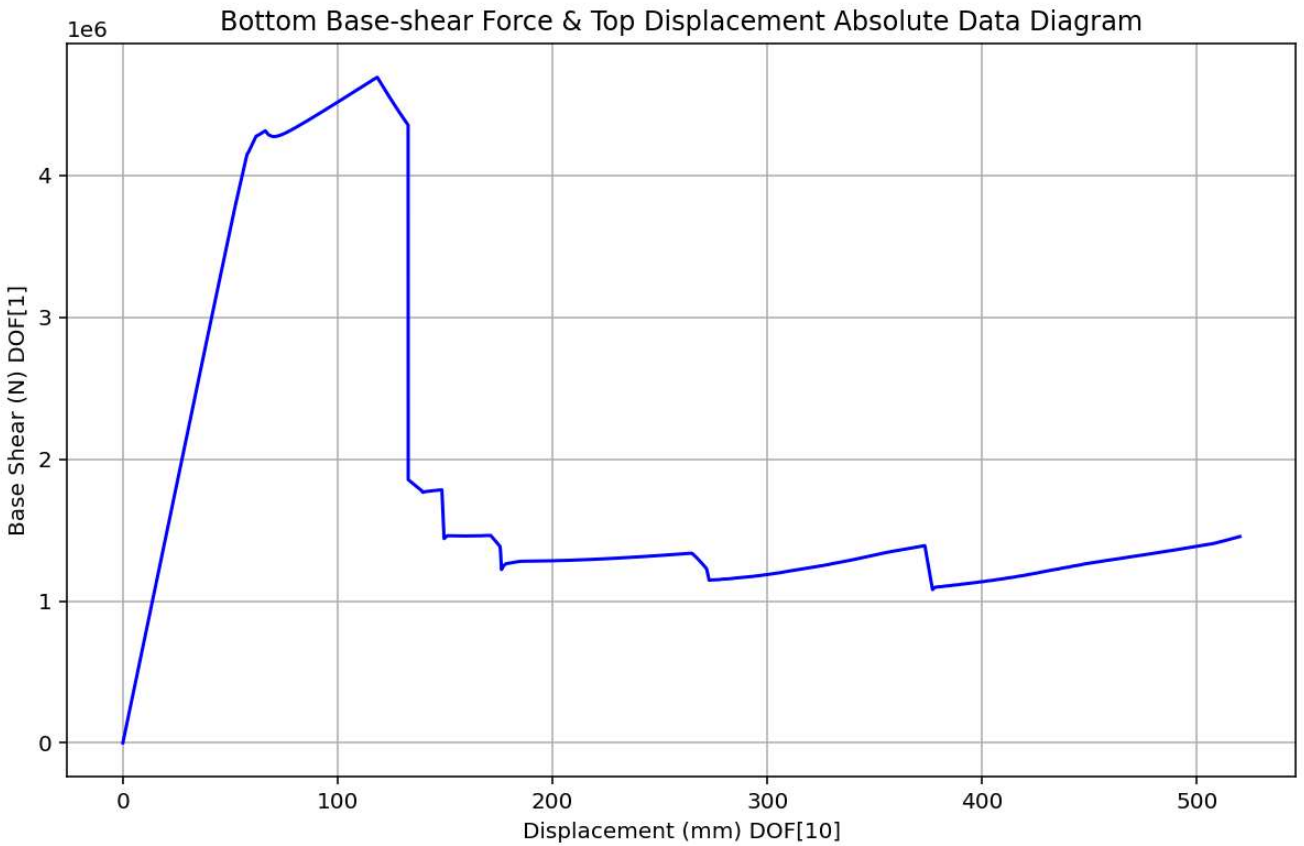
Console 1/A

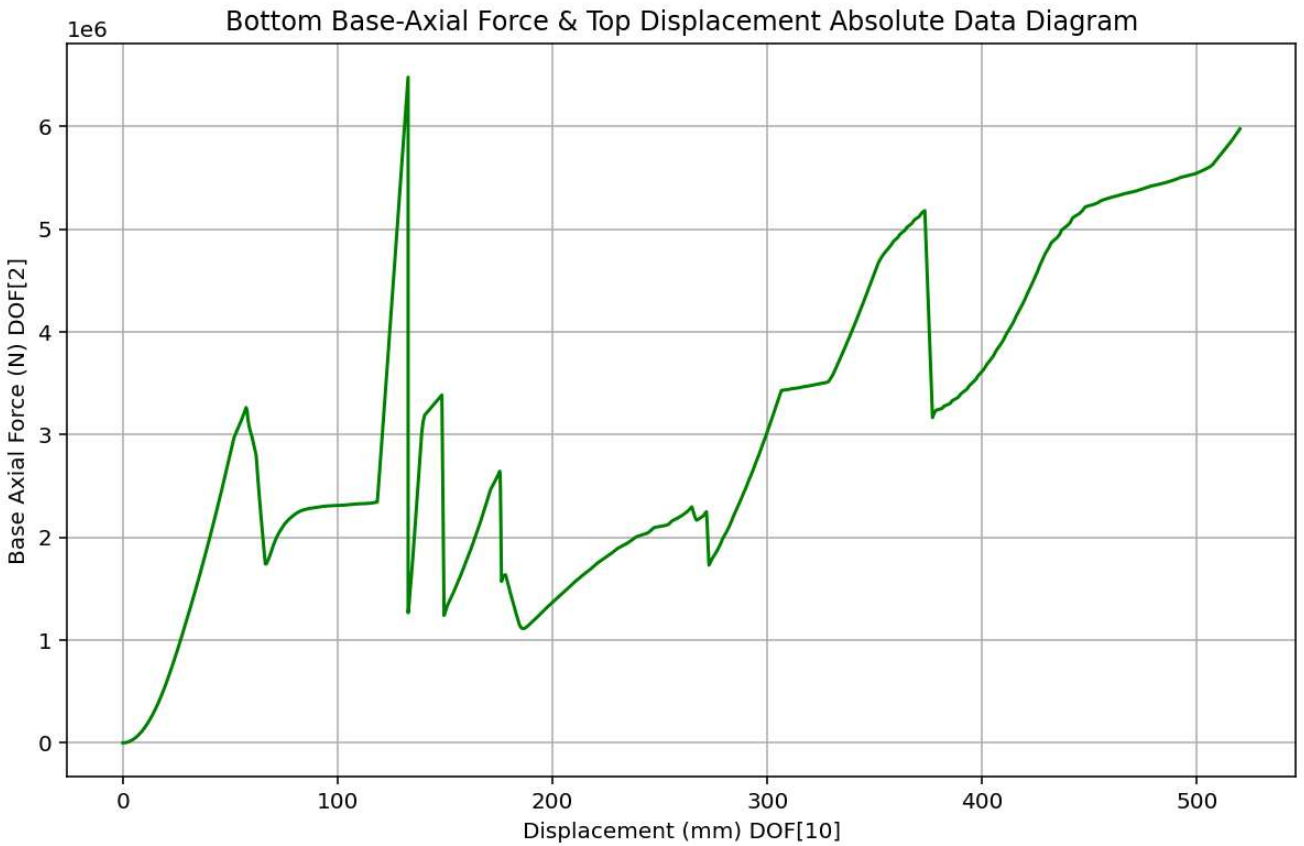
```
Consider using the default eigen solver.Period:
0.24951852676154146
Natural Frequency:  4.007718436698188

Dynamic Done.

Total time (s): 4.0625


Exact Damping Ratio: 1.06798624e-02
C:
```

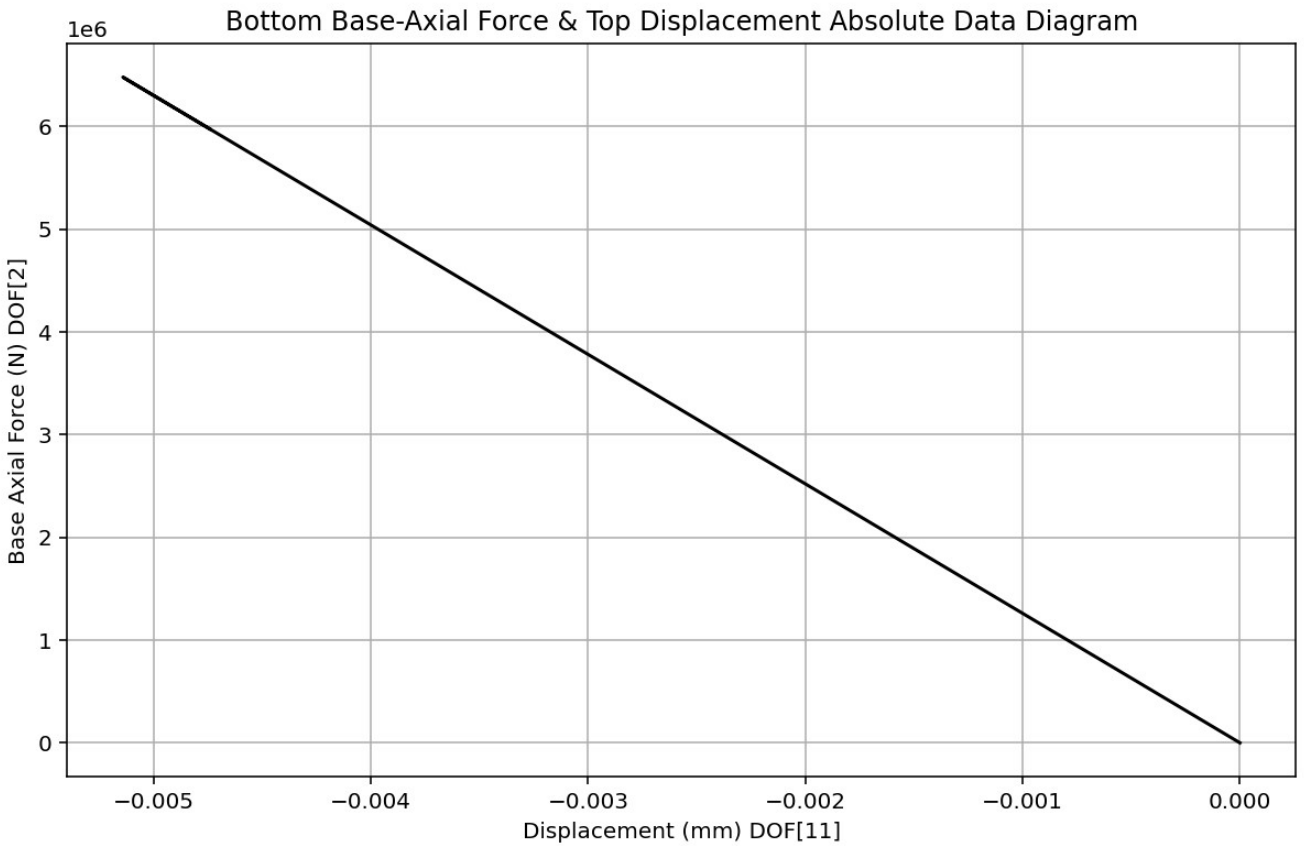
IPython Console History

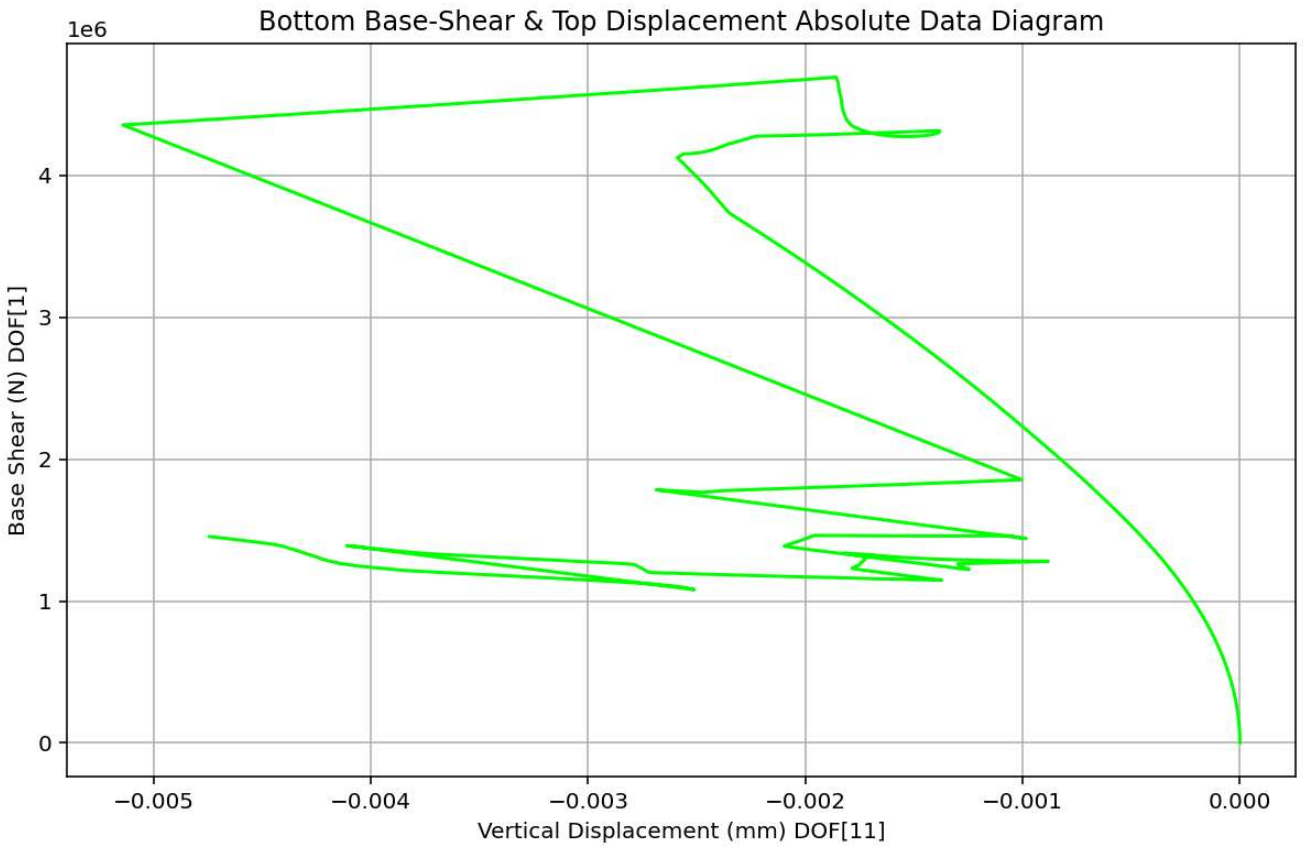
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 2, Col 97 UTF-8 CRLF RW Mem 36%

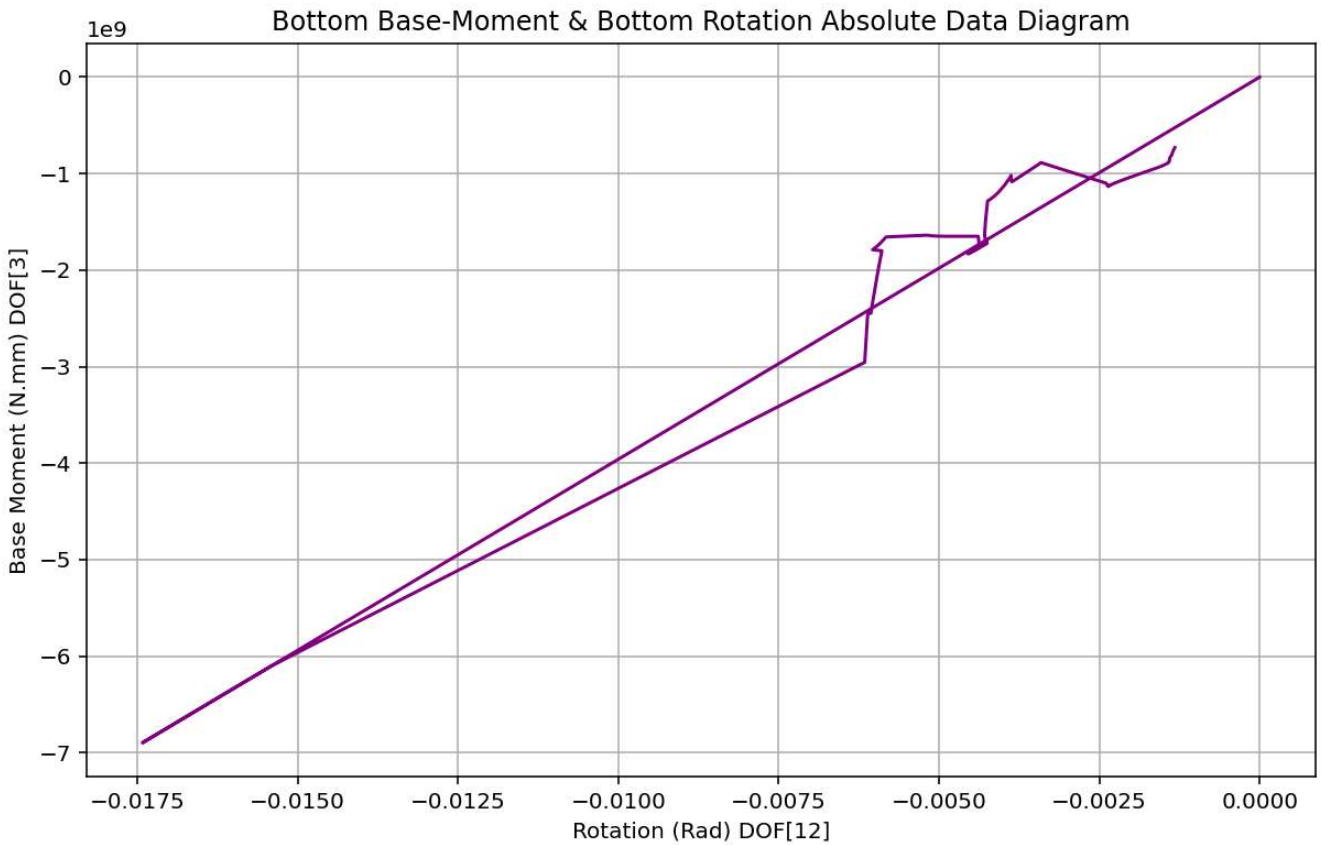
PUSHOVER ANALYSIS OF CONCRETE COLUMNS WITH AXIAL AND ROTATIONAL SPRINGS FOR MODELING BEAM COLUMN JOINTS

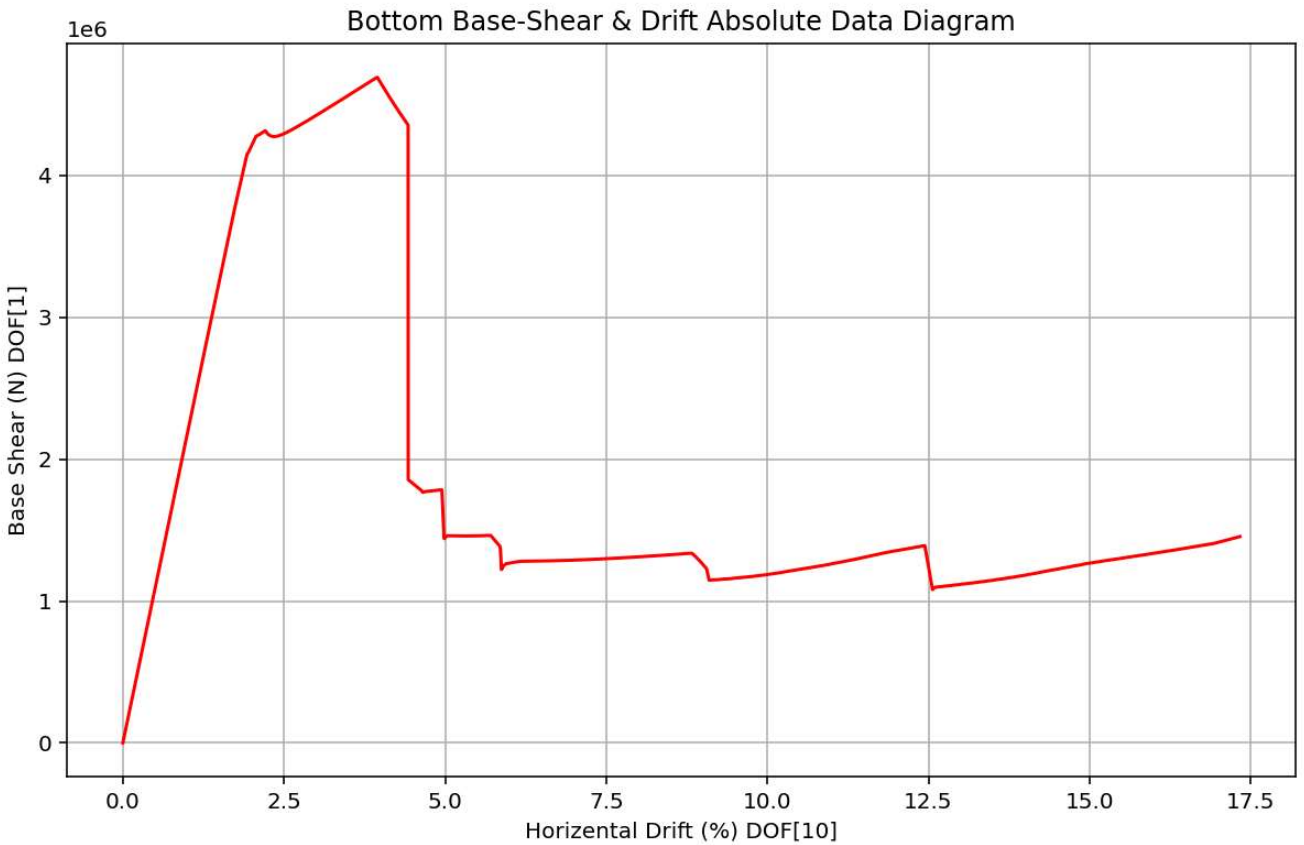

Bottom Base-shear Force & Top Displacement Absolute Data Diagram
1e6
Base Shear (N) DOF[1]
Displacement (mm) DOF[10]
0
1
2
3
4
0
100
200
300
400
500


Bottom Base-Axial Force & Top Displacement Absolute Data Diagram
1e6
Base Axial Force (N) DOF[2]
Displacement (mm) DOF[10]
0
1
2
3
4
5
6
0
100
200
300
400
500

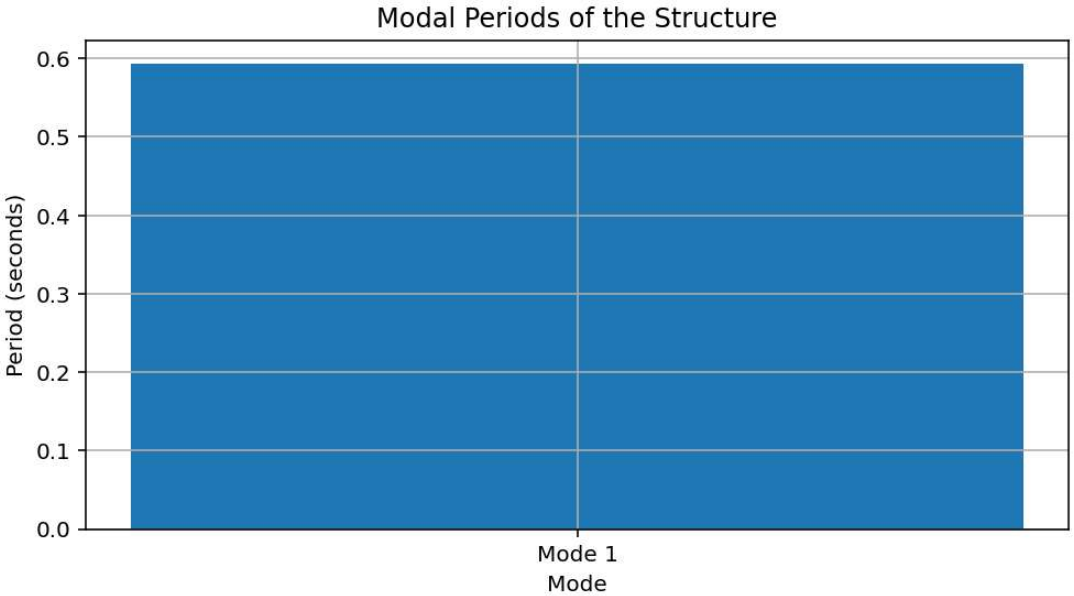

Bottom Base-Axial Force & Top Displacement Absolute Data Diagram
1e6
6
5
4
3
2
1
0
Base Axial Force (N) DOF[2]
−0.005
−0.004
−0.003
−0.002
−0.001
0.000
Displacement (mm) DOF[11]


Bottom Base-Shear & Top Displacement Absolute Data Diagram
1e6
4
3
2
1
0
Base Shear (N) DOF[1]
−0.005
−0.004
−0.003
−0.002
−0.001
0.000
Vertical Displacement (mm) DOF[11]

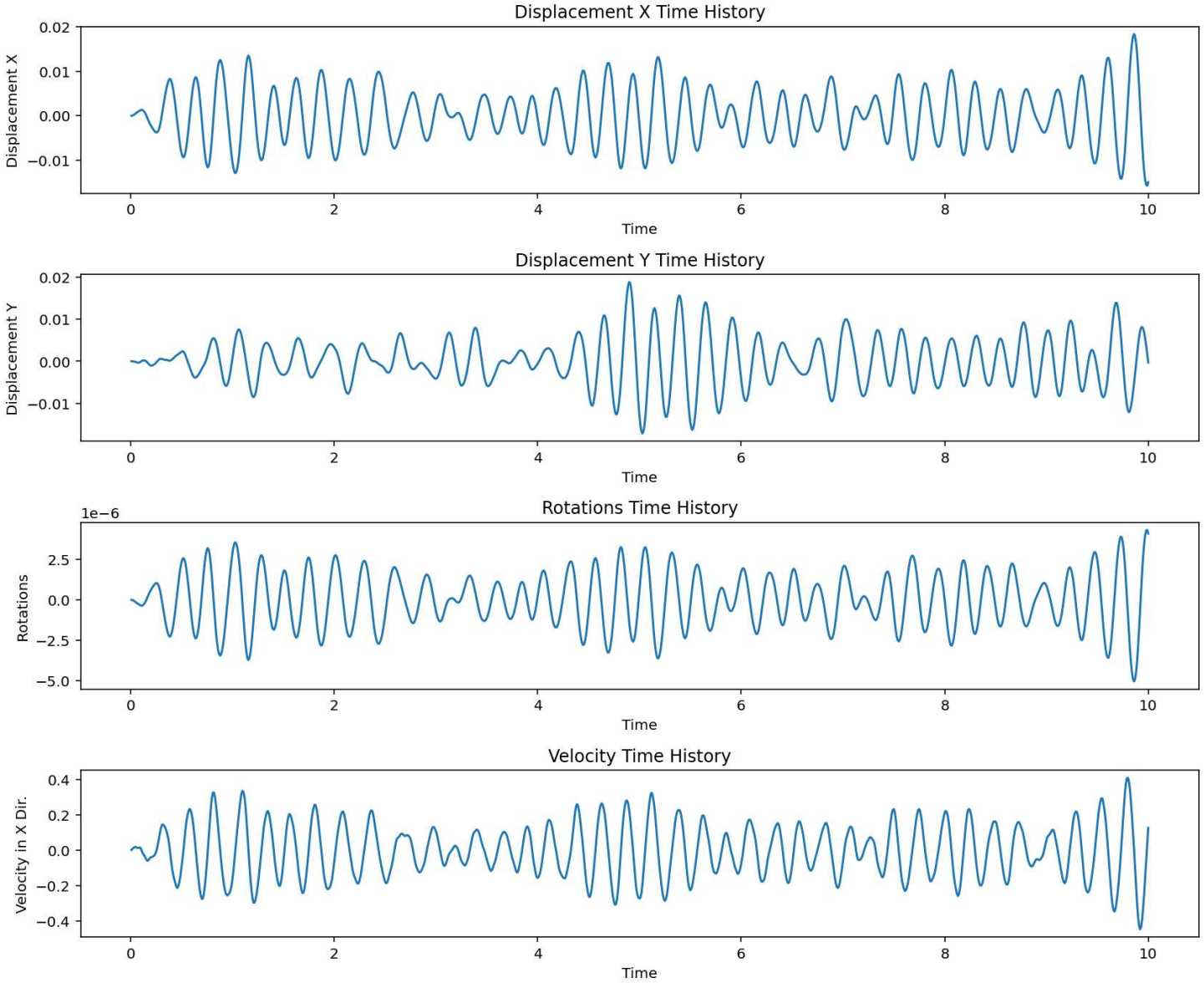

Bottom Base-Moment & Bottom Rotation Absolute Data Diagram
1e9
0
−1
−2
−3
−4
−5
−6
−7
Base Moment (N.mm) DOF[3]
−0.0175
−0.0150
−0.0125
−0.0100
−0.0075
−0.0050
−0.0025
0.0000
Rotation (Rad) DOF[12]

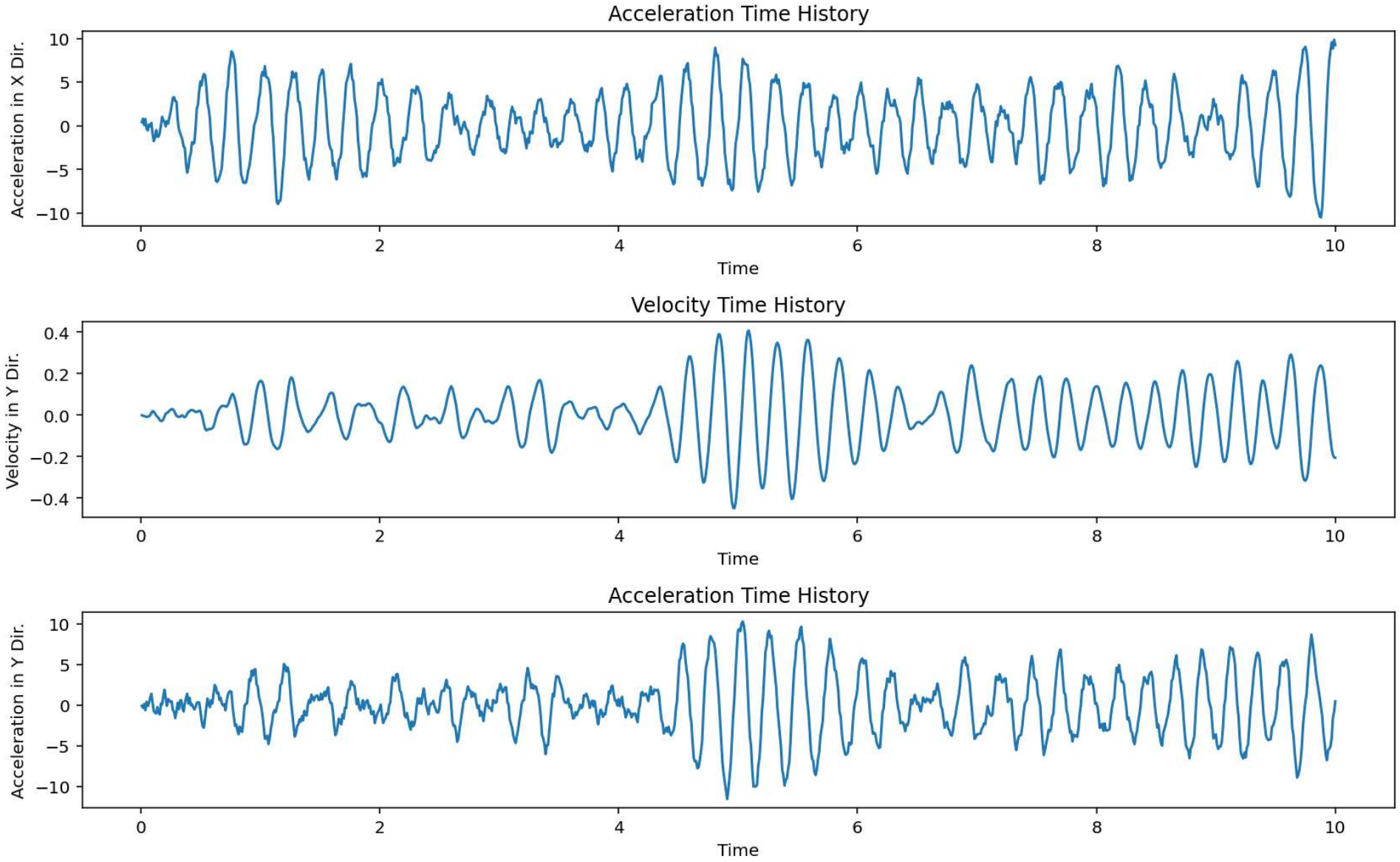

Bottom Base-Shear & Drift Absolute Data Diagram
1e6
Base Shear (N) DOF[1]
0
1
2
3
4
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Horizental Drift (%) DOF[10]

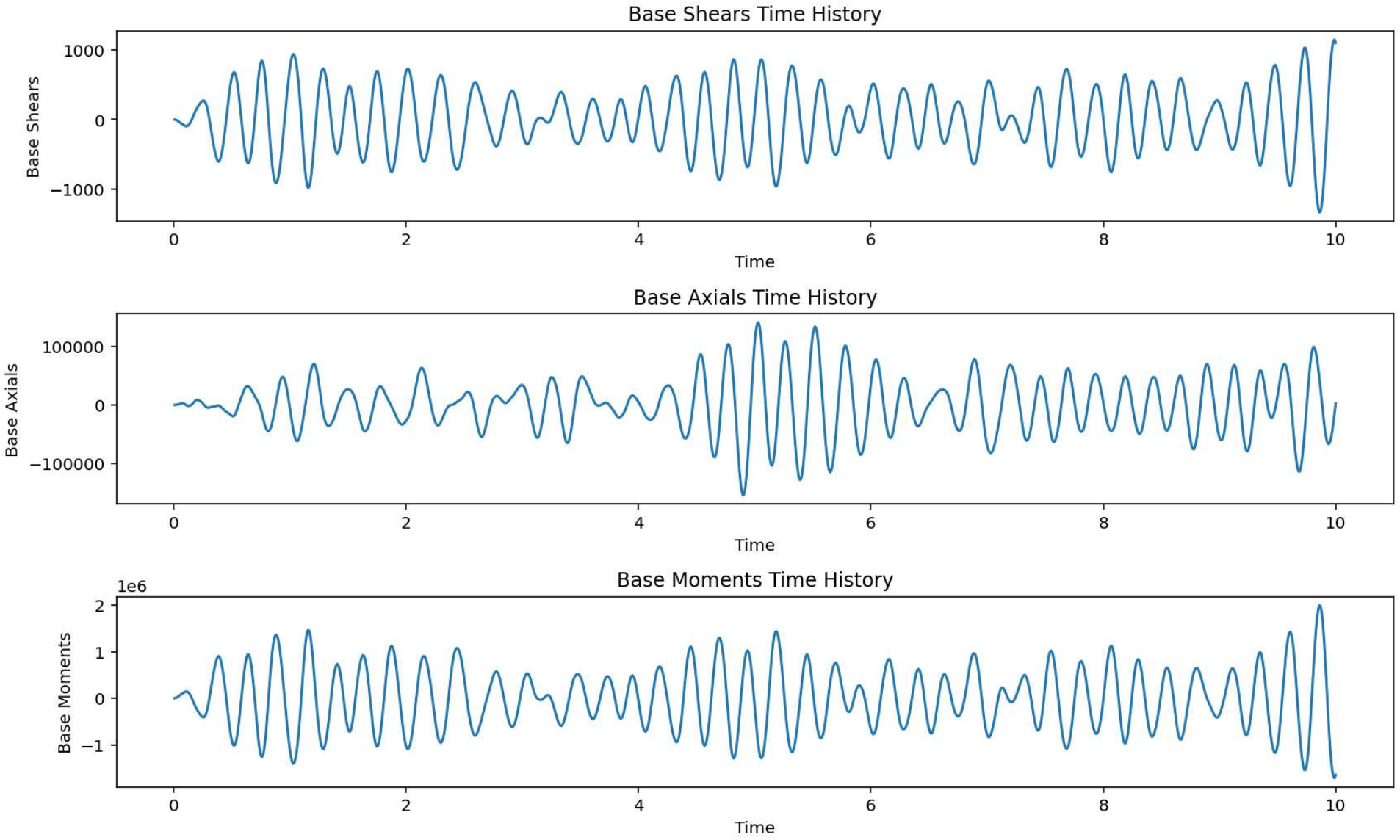
DYNAMIC ANALYSIS OF CONCRETE COLUMNS WITH AXIAL AND ROTATIONAL SPRINGS FOR MODELING BEAM COLUMN JOINTS

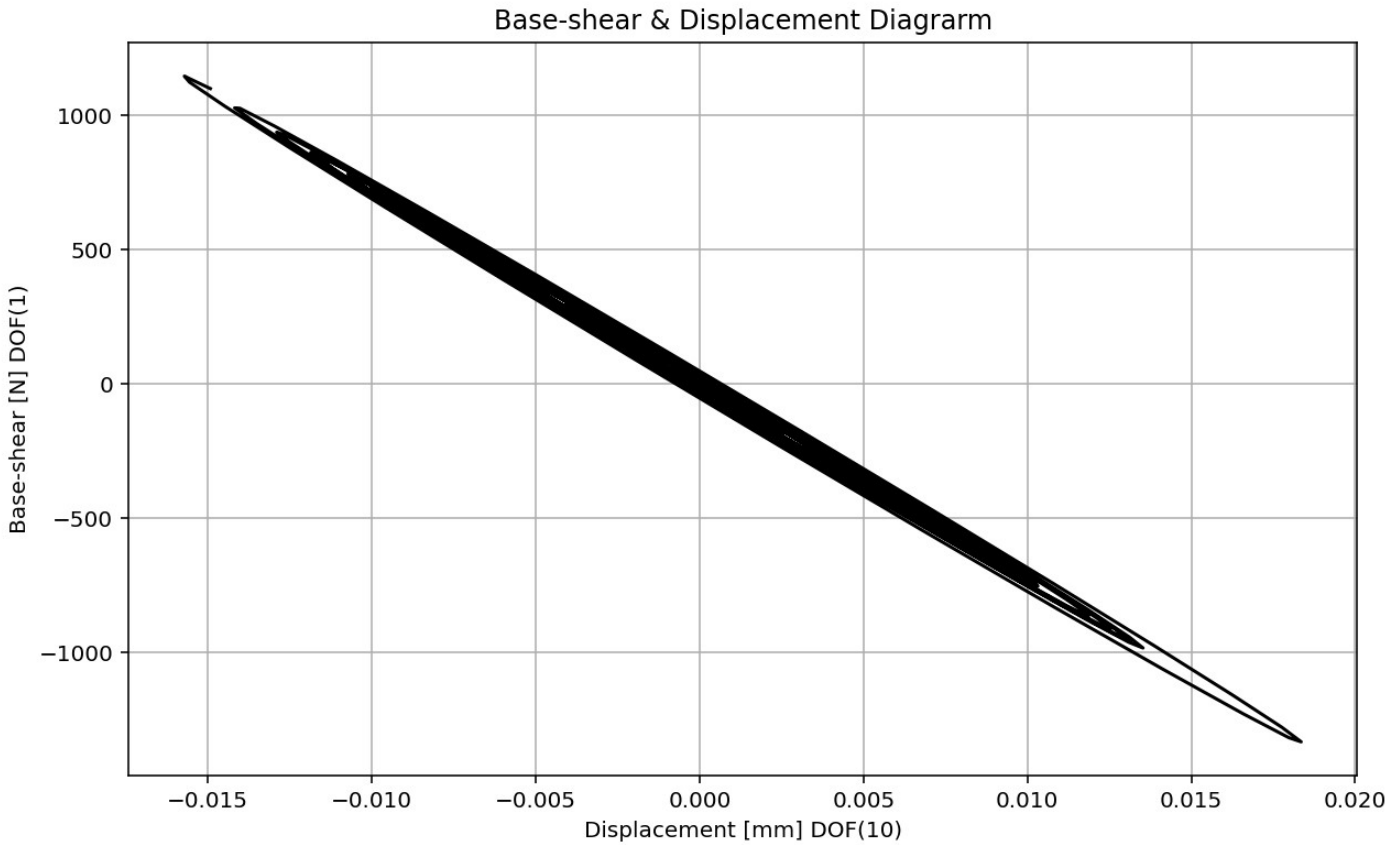


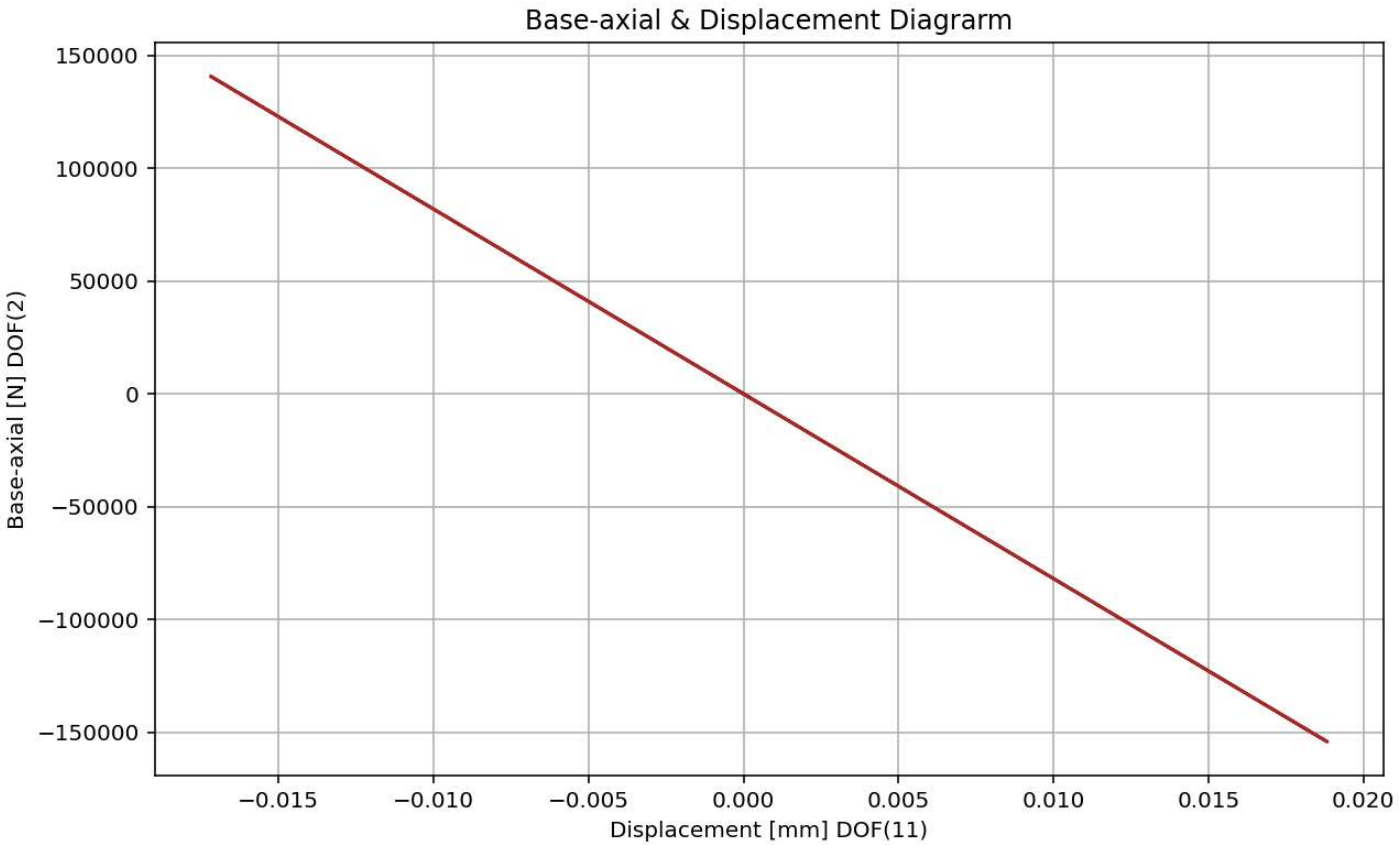
Period: 0.12475926338077073 (s)
Natural Frequency: 8.015436873396377 (Hz)

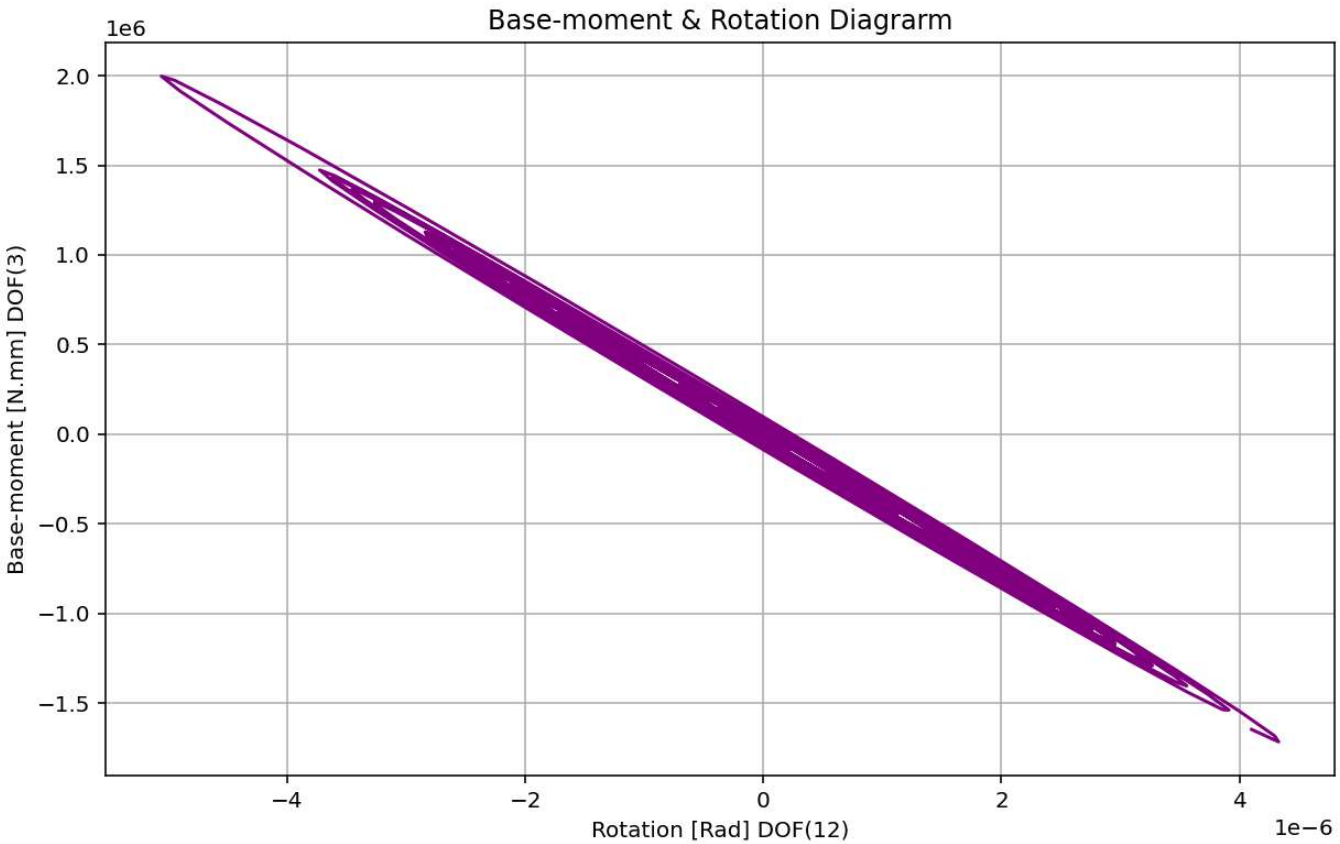

Displacement X Time History
Displacement X
0.02
0.01
0.00
−0.01
0
2
4
6
8
10
Time
Displacement Y Time History
Displacement Y
0.02
0.01
0.00
−0.01
0
2
4
6
8
10
Time
Rotations Time History
1e−6
Rotations
2.5
0.0
−2.5
−5.0
0
2
4
6
8
10
Time
Velocity Time History
Velocity in X Dir.
0.4
0.2
0.0
−0.2
−0.4
0
2
4
6
8
10
Time

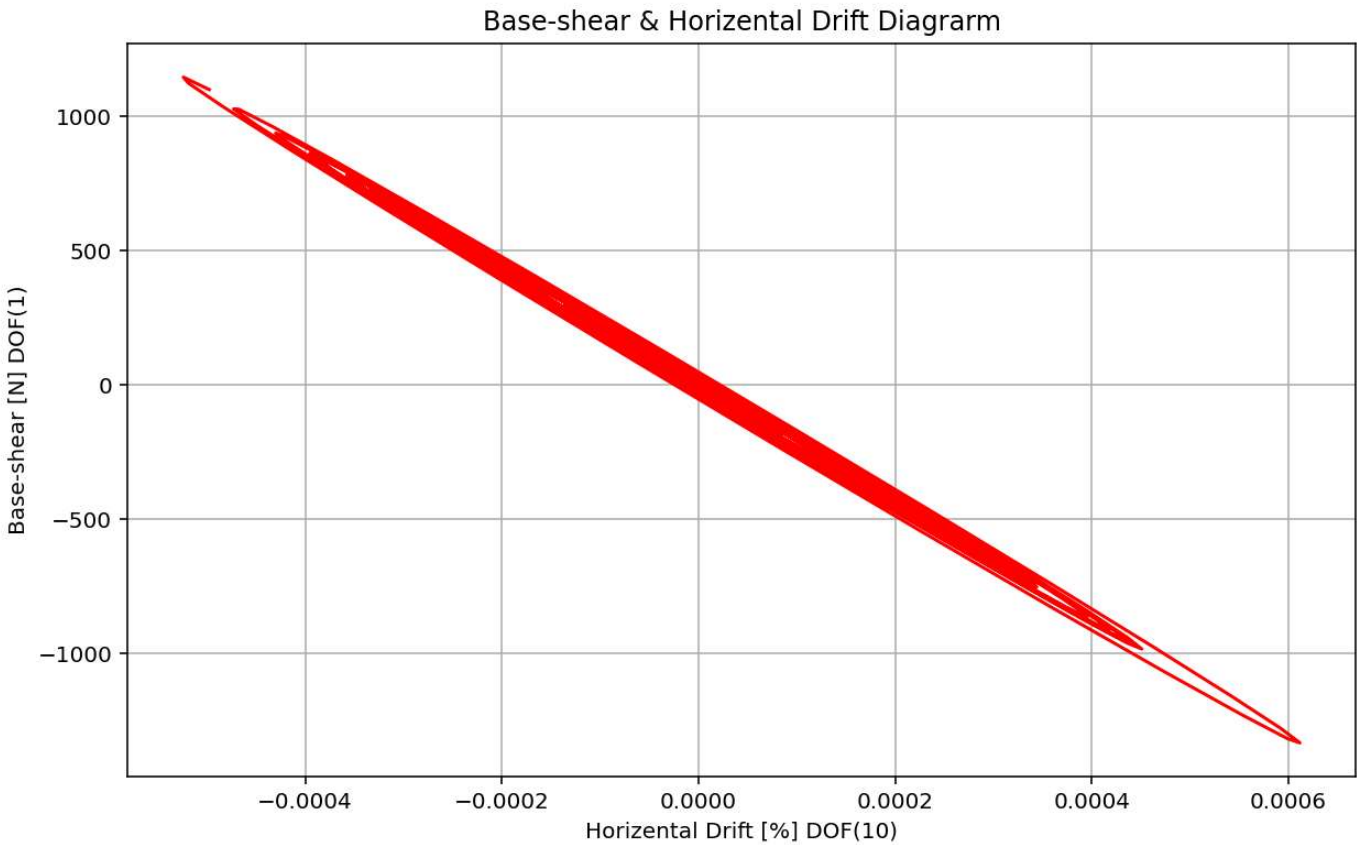

Acceleration Time History
Acceleration in X Dir.
10
5
0
−5
−10
0
2
4
6
8
10
Time
Velocity Time History
Velocity in Y Dir.
0.4
0.2
0.0
−0.2
−0.4
0
2
4
6
8
10
Time
Acceleration Time History
Acceleration in Y Dir.
10
5
0
−5
−10
0
2
4
6
8
10
Time


Base Shears Time History
Base Shears
1000
0
−1000
0
2
4
6
8
10
Time
Base Axials Time History
Base Axials
100000
0
−100000
0
2
4
6
8
10
Time
Base Moments Time History
1e6
Base Moments
2
1
0
−1
0
2
4
6
8
10
Time


Base-shear & Displacement Diagrarm
1000
500
0
−500
−1000
Base-shear [N] DOF(1)
−0.015
−0.010
−0.005
0.000
0.005
0.010
0.015
0.020
Displacement [mm] DOF(10)


Base-axial & Displacement Diagrarm
150000
100000
50000
0
−50000
−100000
−150000
Base-axial [N] DOF(2)
−0.015
−0.010
−0.005
0.000
0.005
0.010
0.015
0.020
Displacement [mm] DOF(11)


Base-moment & Rotation Diagrarm
1e6
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Base-moment [N.mm] DOF(3)
−4
−2
0
2
4
Rotation [Rad] DOF(12)
1e−6


Base-shear & Horizental Drift Diagrarm
1000
500
0
−500
−1000
Base-shear [N] DOF(1)
−0.0004
−0.0002
0.0000
0.0002
0.0004
0.0006
Horizental Drift [%] DOF(10)

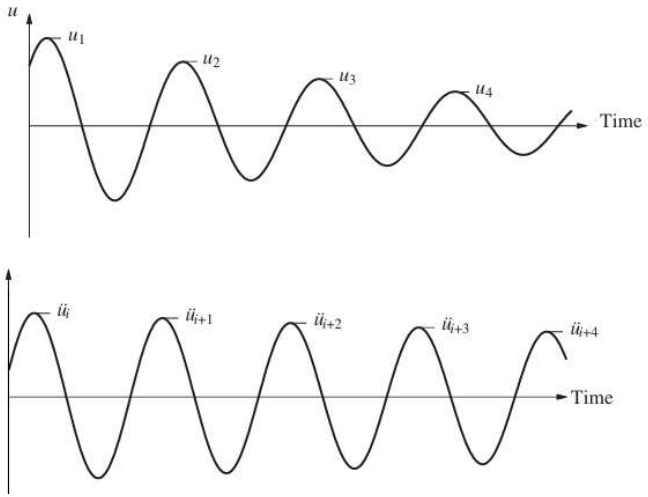
VISCOUSLY DAMPED FREE VIBRATION

$$m\ddot{u} + c\dot{u} + ku = 0$$

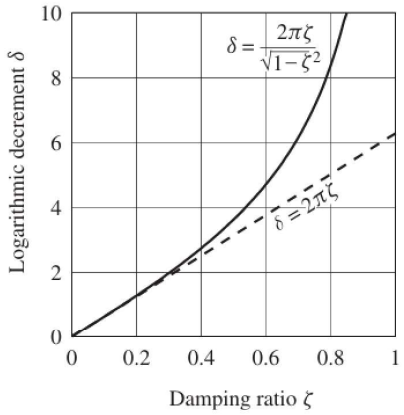
$$\ddot{u} + 2\zeta\omega_n\dot{u} + \omega_n^2 u = 0$$

$$\omega_n = \sqrt{k/m} \qquad \zeta = \frac{c}{2m\omega_n} = \frac{c}{c_{cr}} \qquad \omega_D = \omega_n\sqrt{1-\zeta^2}$$

$$u(t) = e^{-\zeta\omega_n t}\left[u(0)\cos\omega_D t + \frac{\dot{u}(0) + \zeta\omega_n u(0)}{\omega_D}\sin\omega_D t\right]$$



Exact Damping Ratio: 1.06798624e-02



Decay of Motion

$$\delta = \ln\frac{u_i}{u_{i+1}} = 2\pi\zeta$$ (APPROXIMATE RELATION)

$$\delta = \ln\frac{u_i}{u_{i+1}} = \frac{2\pi\zeta}{\sqrt{1-\zeta^2}}$$ (EXACT RELATION)

EXACT AND APPROXIMATE RELATIONS BETWEEN LOGARITHMIC DECREMENT AND DAMPING RATIO