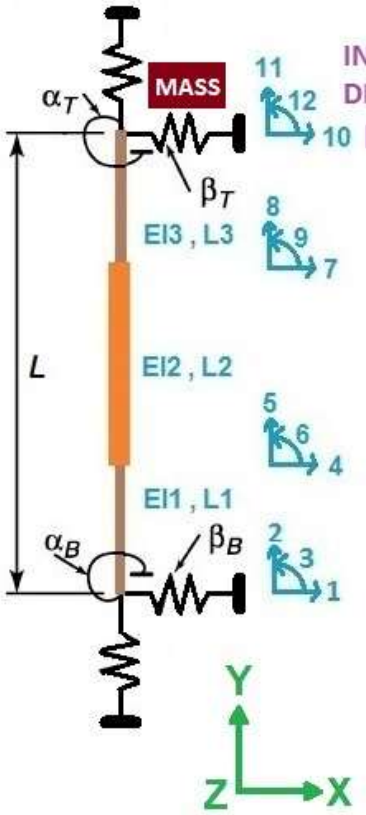
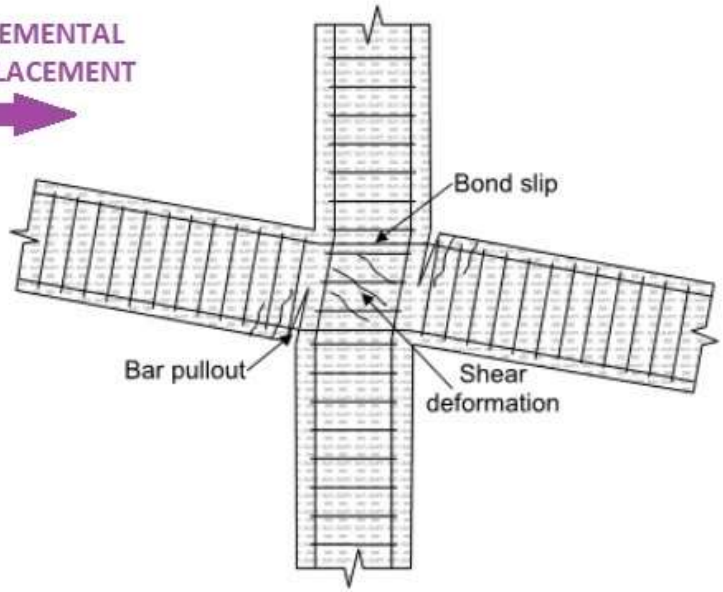
IN THE NAME OF ALLAH

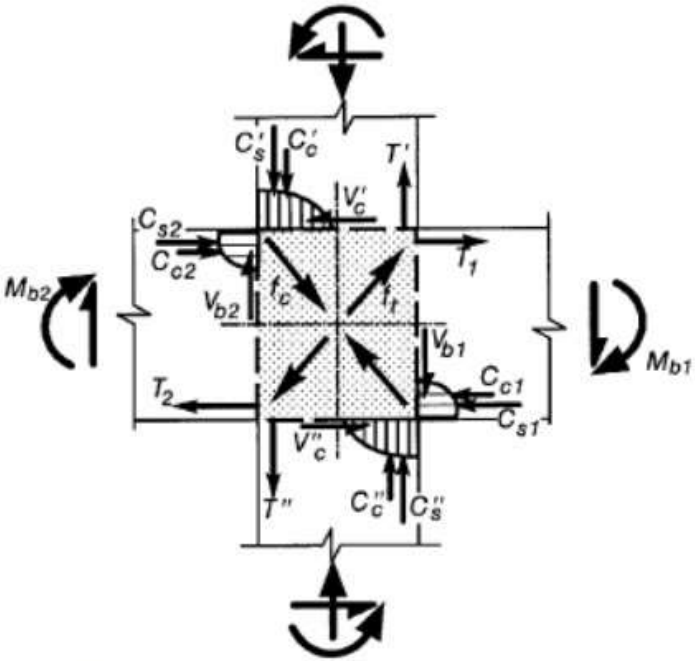
PUSHOVER ANALYSIS OF CONCRETE COLUMNS WITH AXIAL AND ROTATIONAL SPRINGS FOR MODELING BEAM COLUMN JOINTS

THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

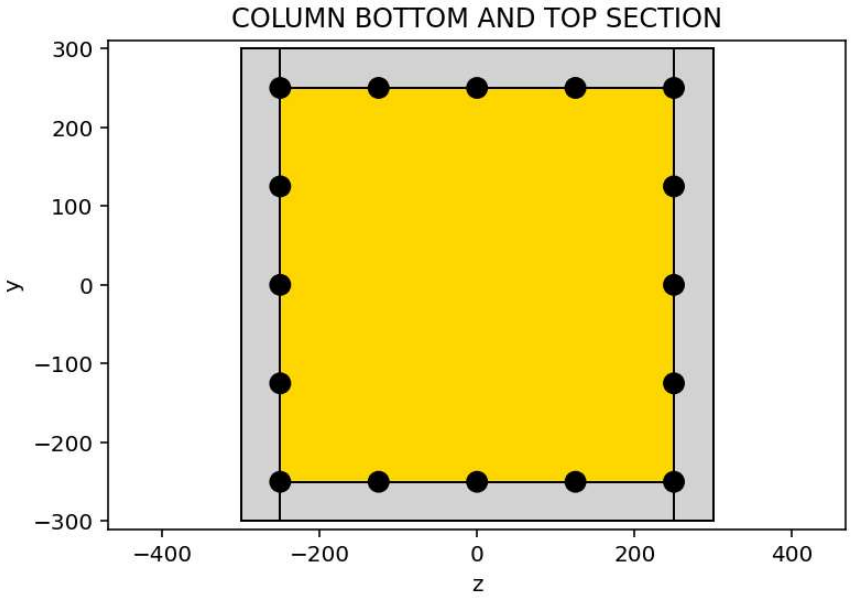


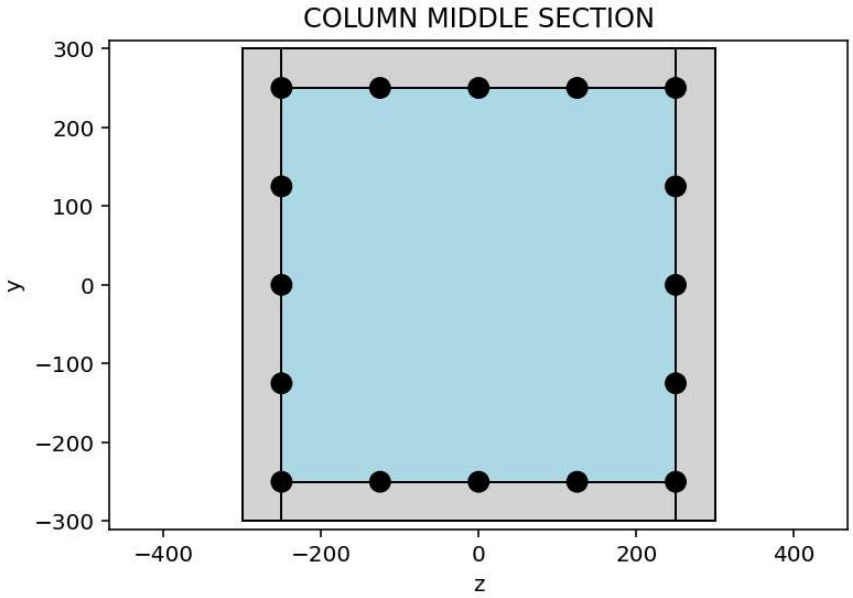
INCREMENTAL DISPLACEMENT





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

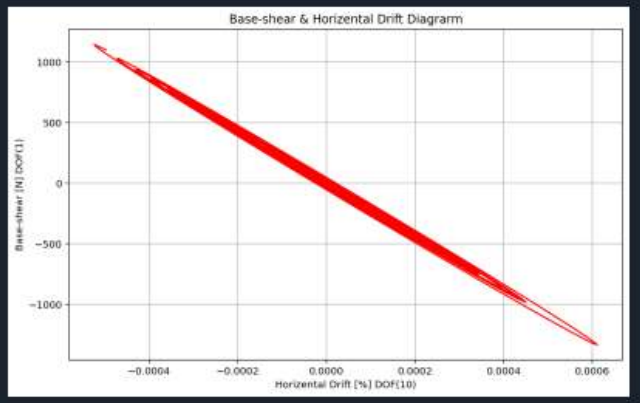
Spyder (Python 3.12)

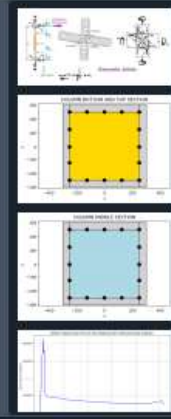
File Edit Search Source Run Debug Consoles Projects Tools View Help

C:\Users\Dell\Desktop\OPENSEES_FILES\COLUMN_JOINT...OPENSEES_COLUMN_JOINT_SPRINGS_CONCRETE_CONTACT.py

OPENSEES_COLUMN_JO...ONCRETE_CONTACT.py

```
563  REBAR_DIA = 25    # [mm] Steel Rebar Diameter
564
565  ### DEFINE LOAD PROPERTIES:
566  PX = 100.0        # [N] HORIZENTAL FORCE - DOF[10]
567  PY = 0.0          # [N] VERTICAL FORCE - DOF[11]
568  MZ = 0.0          # [N.mm] MOMENT FORCE - DOF[12]
569  MAX_DISP = 520    # [mm] MAXIMUM DISPLCEMENT - DOF[10]
570  DISP_INCR = 0.01  # [mm] EACH DISPLCEMENT INCREMENT - DOF[10]
571
572
573  ### PUSHOVER DIRECTION:
574  # [1]: X-DIRECTION - HORIZENTAL DISPLACEMENT
575  # [2]: Y-DIRECTION - VERTICAL DISPLACEMENT
576  # [3]: Z-DIRECTION - ROTATION
577  KIND = 1
578
579  ### CONTACT:
580  CONTACT = True # True: HAVE CONTACT - False: DO NOT HAVE CONTACT
581  CONTACT_DISP = 450 # [mm] CONTACT MAXIMUM DISPLCEMENT - DOF[10]
582
583  ### ANALYSIS TOLEANCE AND ITERATIONS
584  MAX_ITERATIONS = 5000   # Maximum number of iterations
585  MAX_TOLERANCE = 1.0e-10 # Specified tolerance for convergence
586
587
588  starttime = time.process_time()
589
590  ### RUN THE ANALYSIS:
591  DATA = PUSHOVER_ANALYSIS(COL, PX, PY, MZ, MAX_DISP, DISP_INCR,Bcol, Hcol,
592  displacements_x, displacements_y, drift, rotations, base_shears, base_axia
593
594  totaltime = time.process_time() - starttime
595  print(f'\nTotal time (s): {totaltime:.4f} \n\n')
596  #%%-----------------------------------------------------------------
```





Help | Variable Explorer | Debugger | Plots | Files

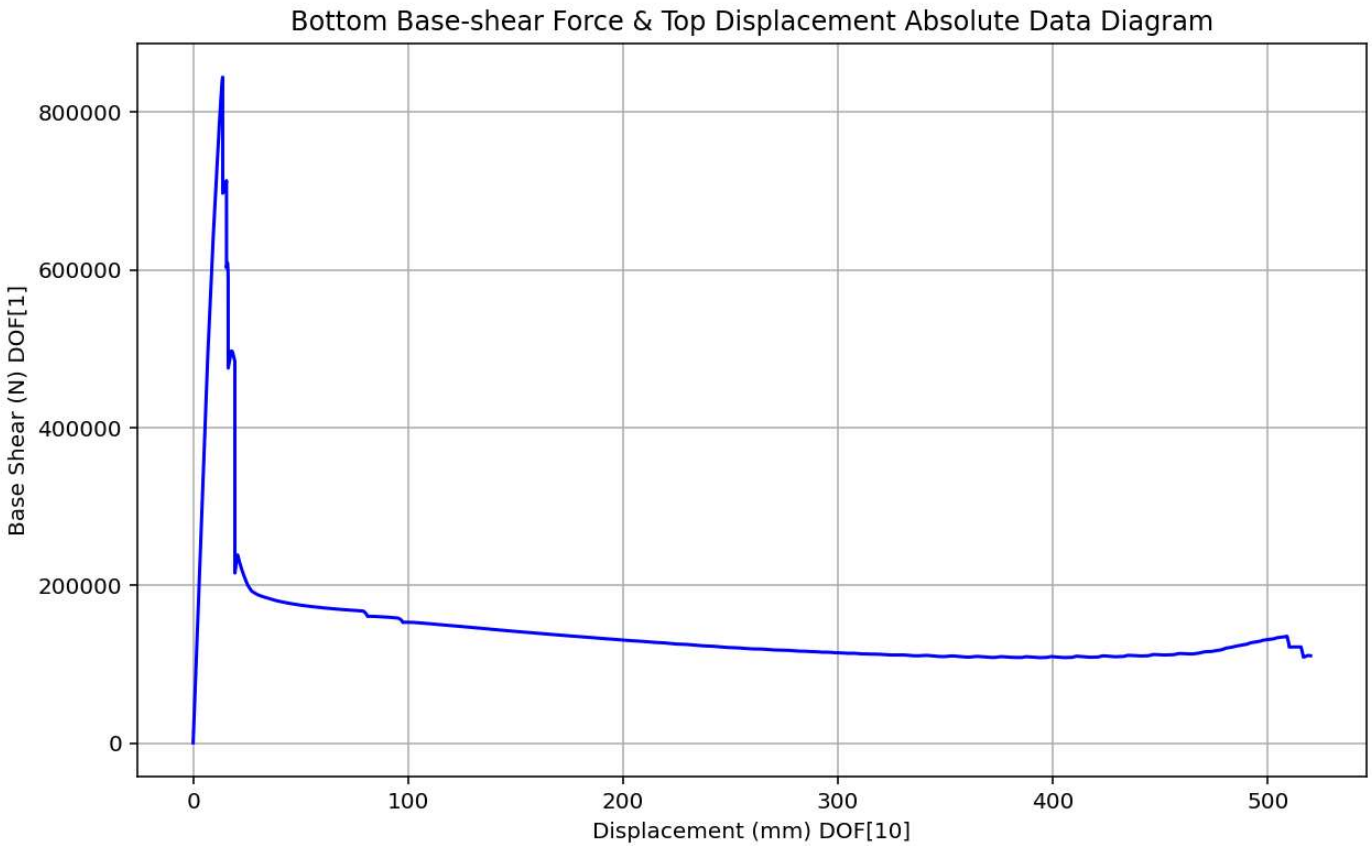
Console 1/A

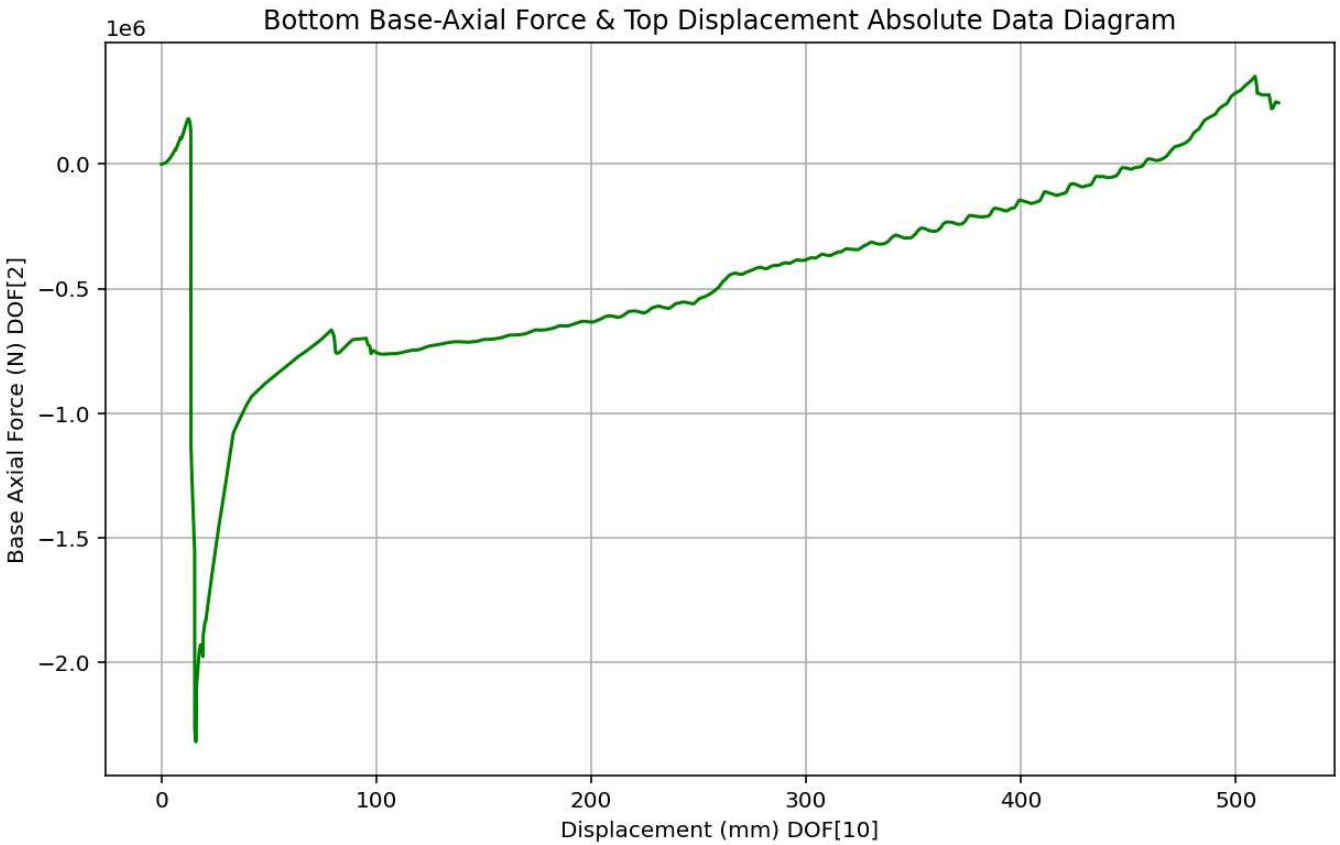
```
AcceleratedNewton::solveCurrentStep() -The ConvergenceTest object failed in test()
StaticAnalysis::analyze() - the Algorithm failed at step: 0 with domain at load factor 1.56881e+08
OpenSees > analyze failed, returned: -3 error flag
NormDispIncr KrylovNewton 0
IN STEP 45000 CONTACT DONE!
Pushover Done.

Total time (s): 415.6719


Model Built
```

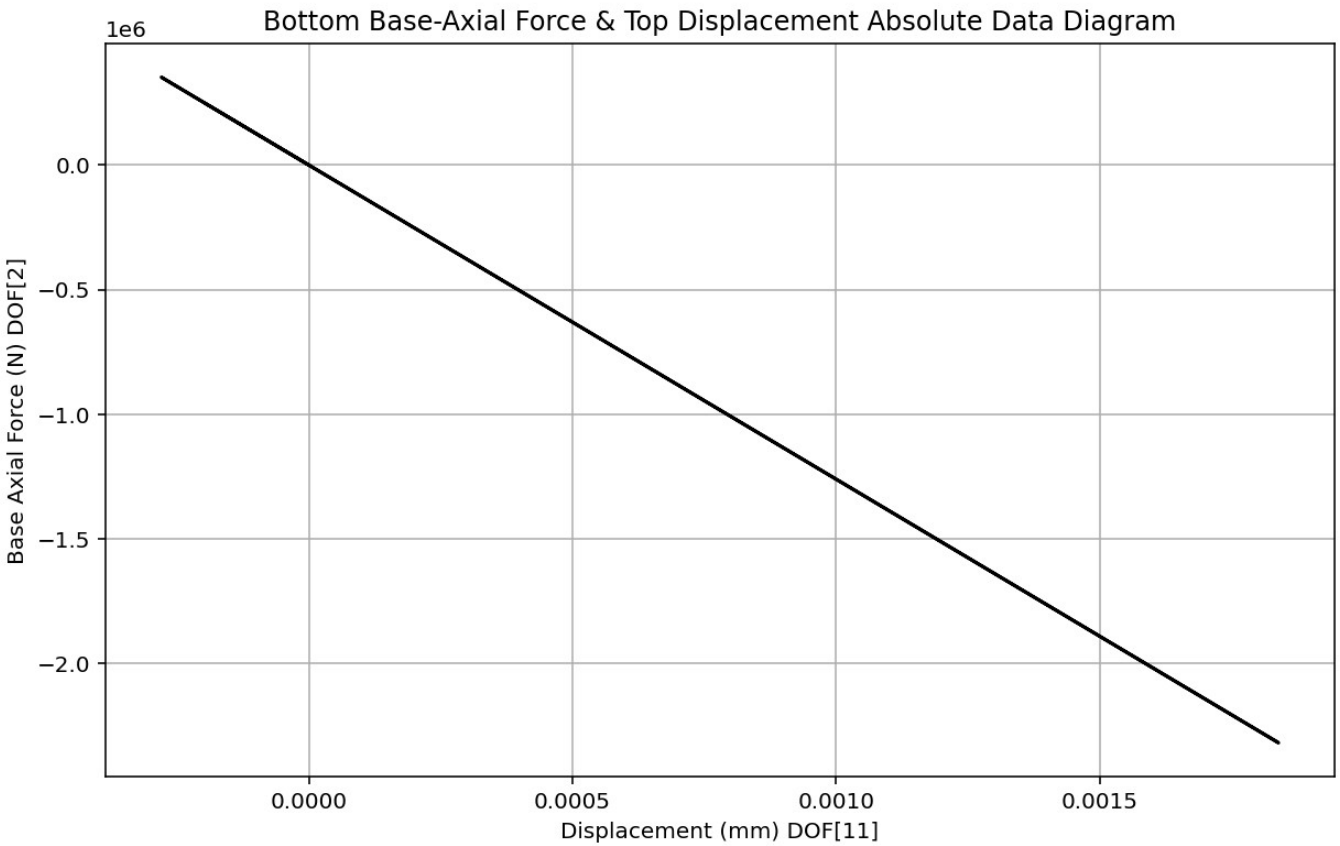
IPython Console | History

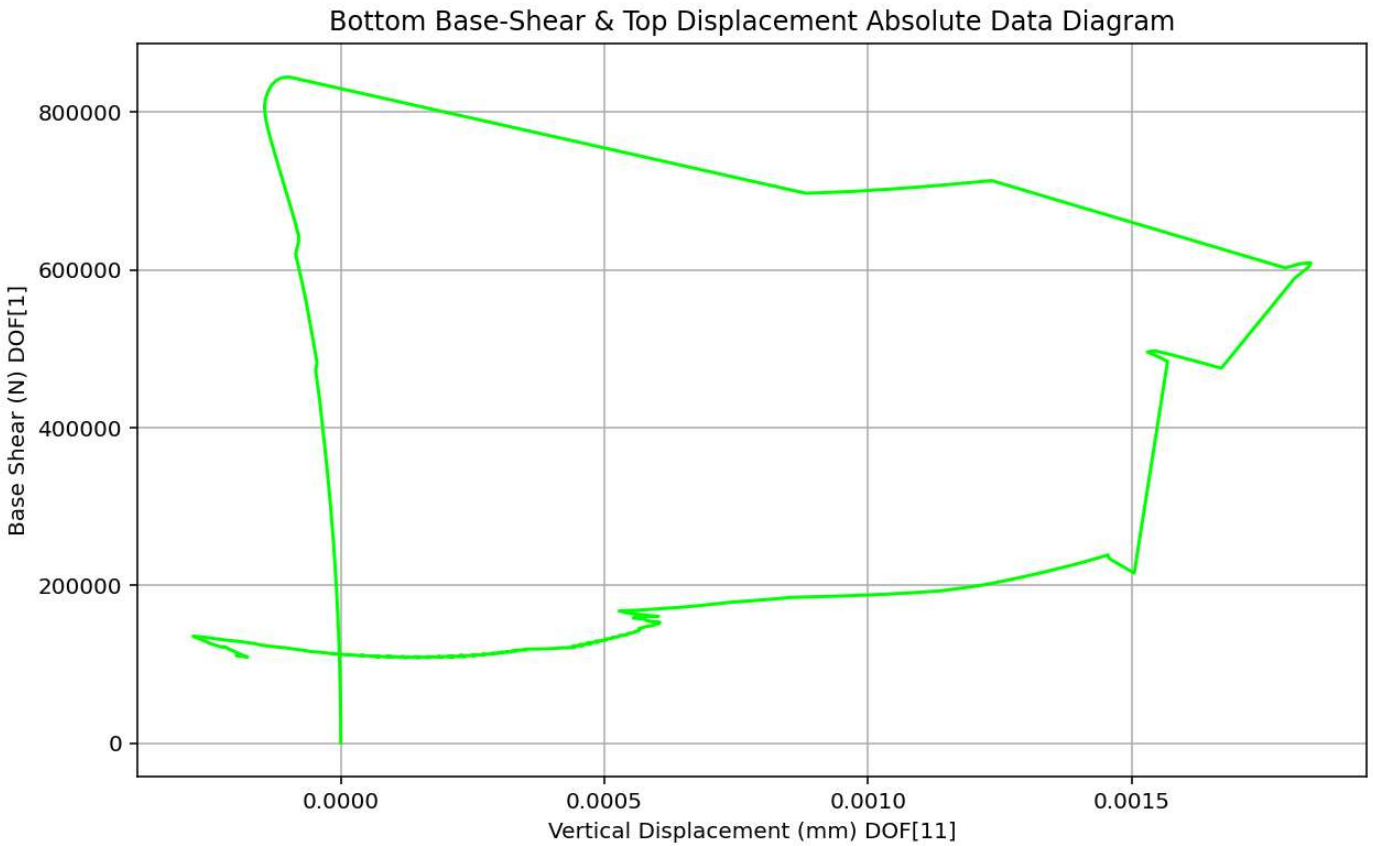
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 750, Col 31 UTF-8 CRLF RW Mem 44%

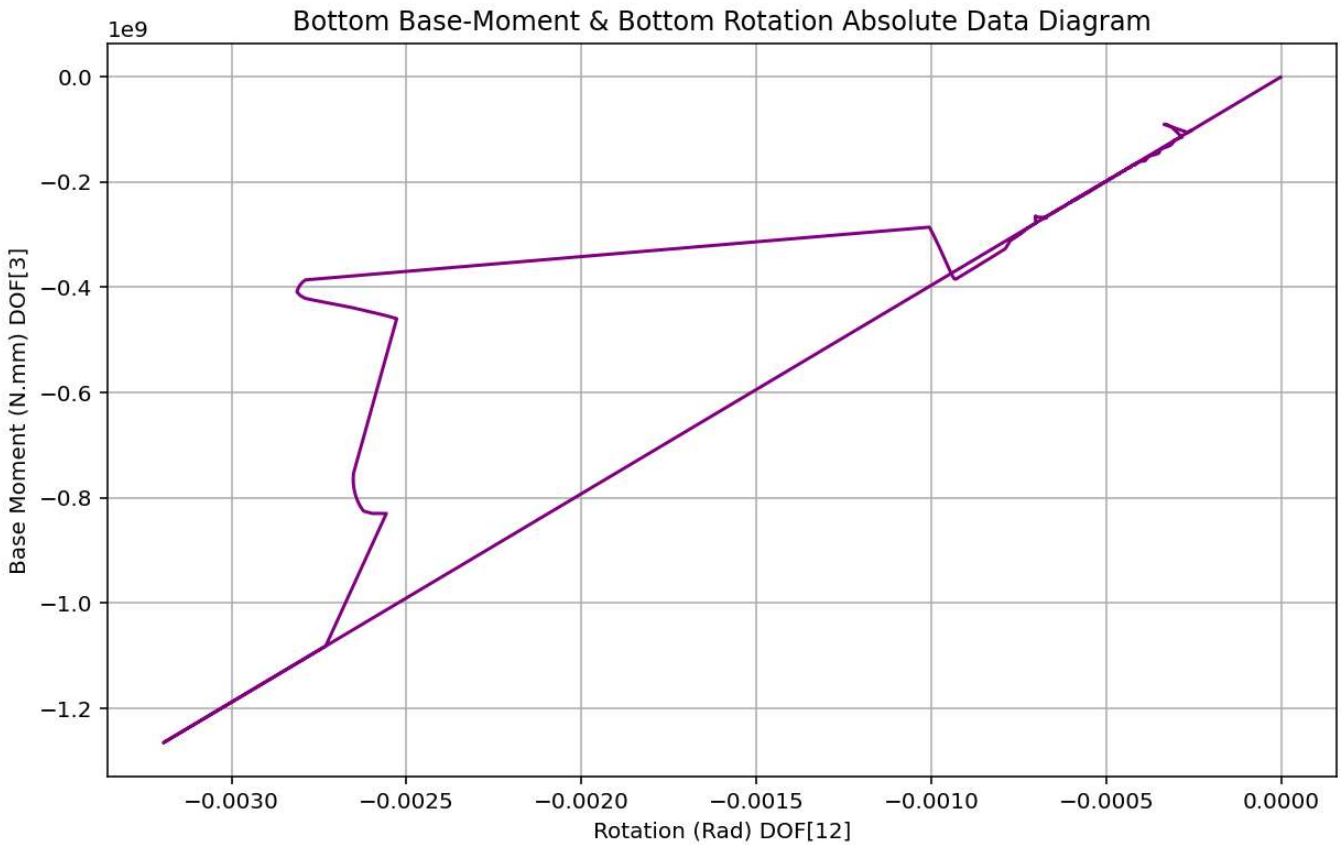
PUSHOVER ANALYSIS OF CONCRETE COLUMNS WITH AXIAL AND ROTATIONAL SPRINGS FOR MODELING BEAM COLUMN JOINTS

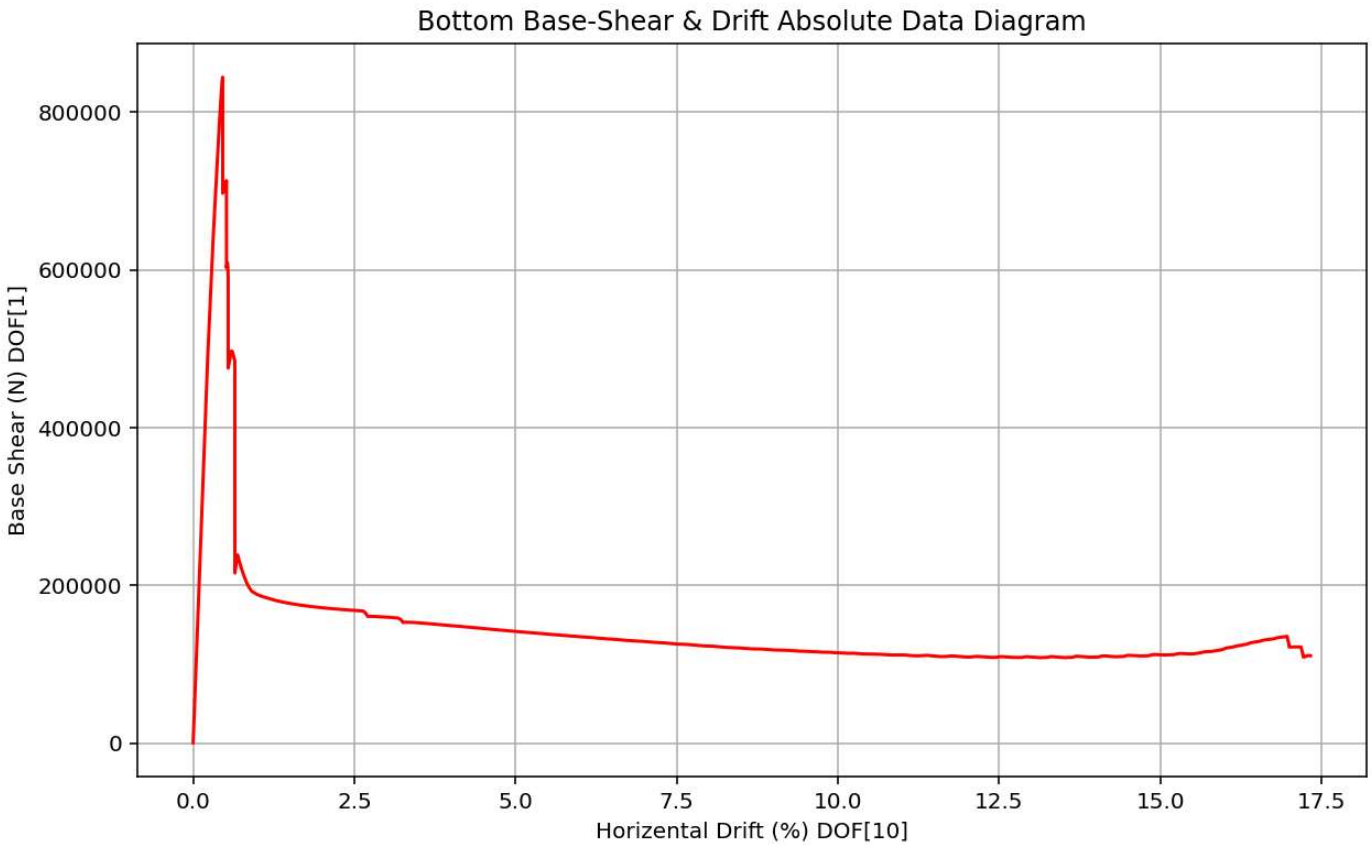

Bottom Base-shear Force & Top Displacement Absolute Data Diagram
Base Shear (N) DOF[1]
800000
600000
400000
200000
0
0
100
200
300
400
500
Displacement (mm) DOF[10]


Bottom Base-Axial Force & Top Displacement Absolute Data Diagram
1e6
0.0
−0.5
−1.0
−1.5
−2.0
Base Axial Force (N) DOF[2]
0
100
200
300
400
500
Displacement (mm) DOF[10]

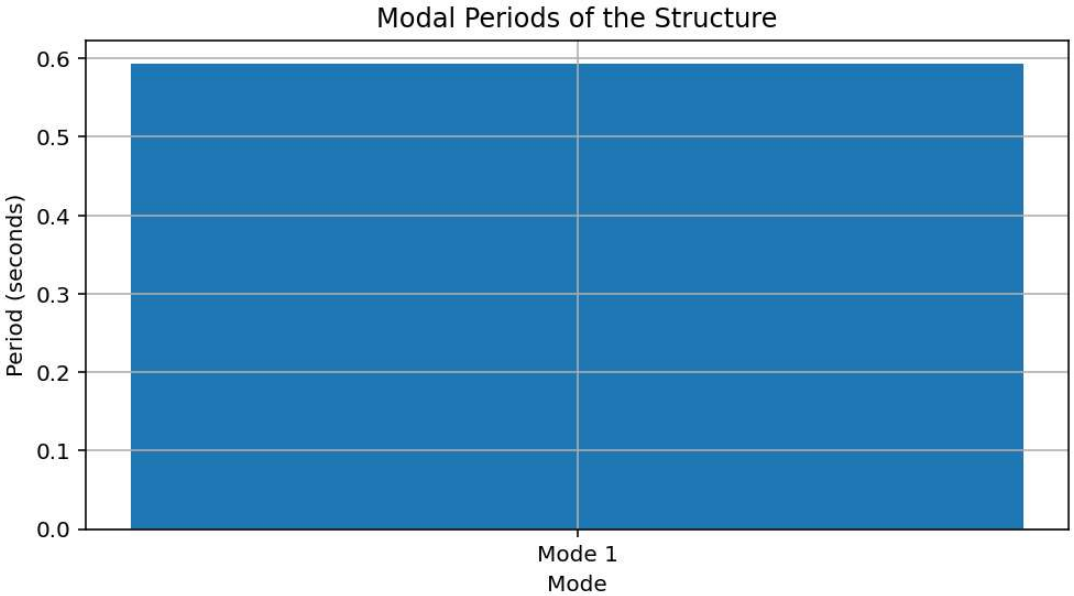

Bottom Base-Axial Force & Top Displacement Absolute Data Diagram
1e6
0.0
−0.5
−1.0
−1.5
−2.0
Base Axial Force (N) DOF[2]
0.0000
0.0005
0.0010
0.0015
Displacement (mm) DOF[11]


Bottom Base-Shear & Top Displacement Absolute Data Diagram
800000
600000
400000
200000
0
Base Shear (N) DOF[1]
0.0000
0.0005
0.0010
0.0015
Vertical Displacement (mm) DOF[11]

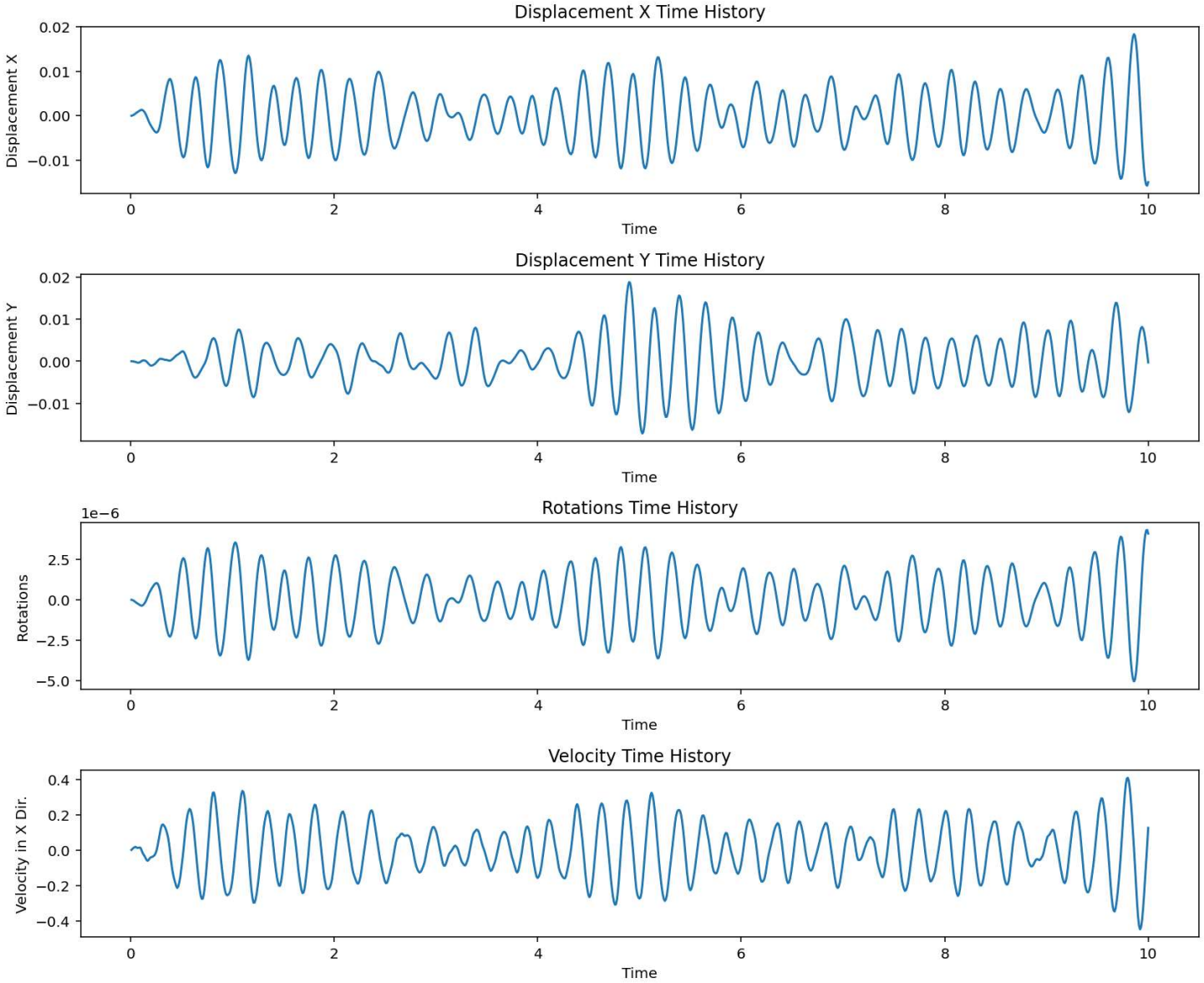

Bottom Base-Moment & Bottom Rotation Absolute Data Diagram
1e9
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
−1.2
Base Moment (N.mm) DOF[3]
−0.0030
−0.0025
−0.0020
−0.0015
−0.0010
−0.0005
0.0000
Rotation (Rad) DOF[12]

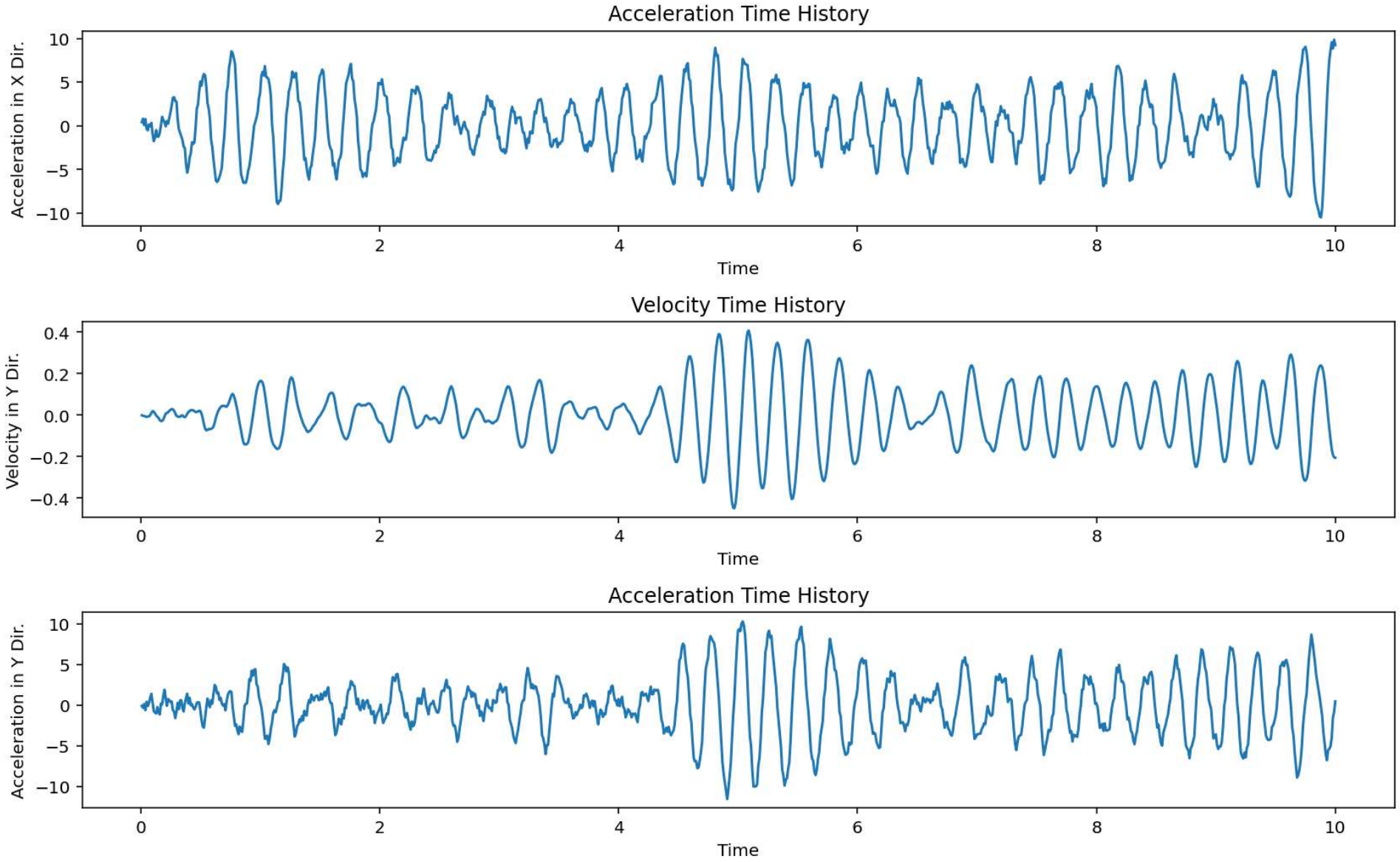

Bottom Base-Shear & Drift Absolute Data Diagram
Base Shear (N) DOF[1]
800000
600000
400000
200000
0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Horizental Drift (%) DOF[10]

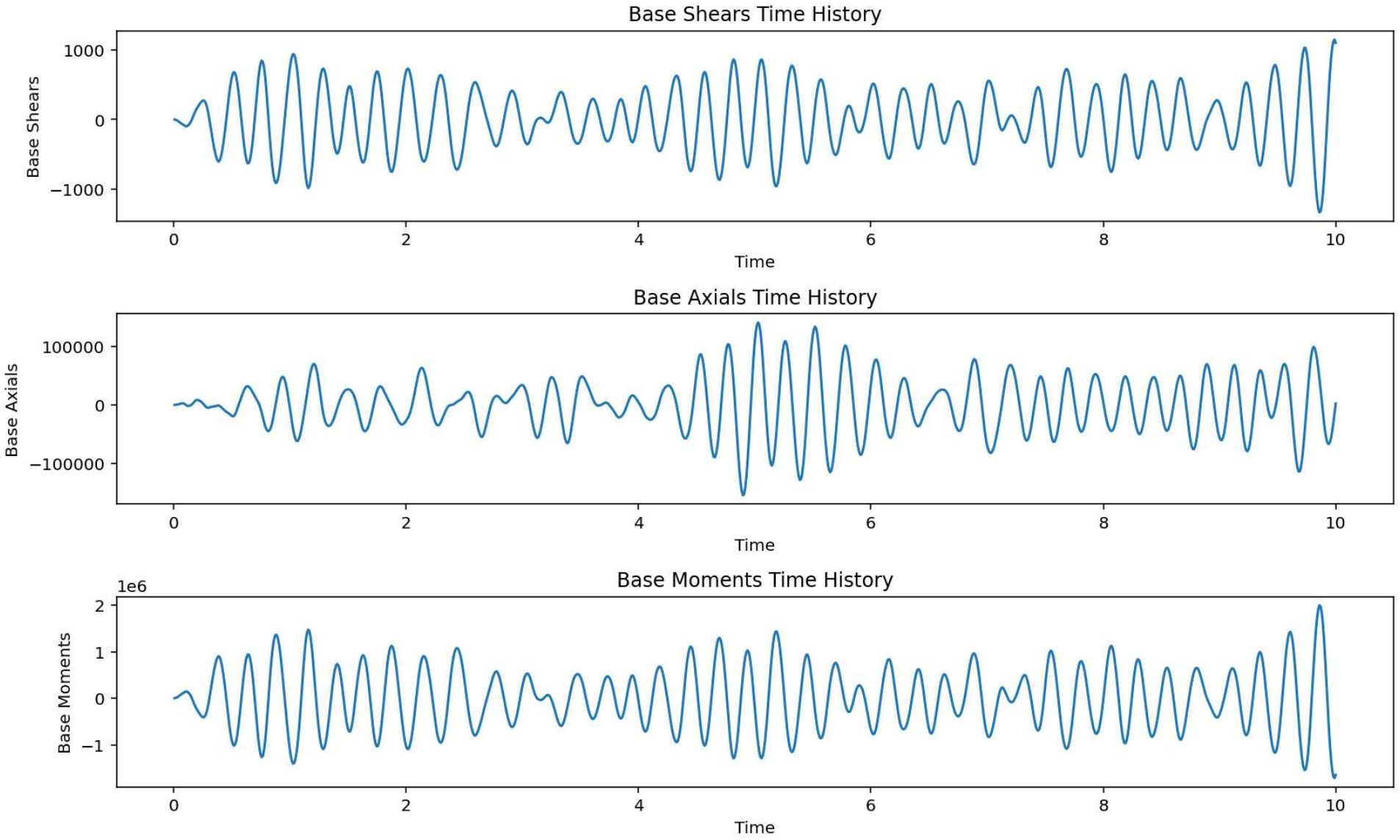
DYNAMIC ANALYSIS OF CONCRETE COLUMNS WITH AXIAL AND ROTATIONAL SPRINGS FOR MODELING BEAM COLUMN JOINTS

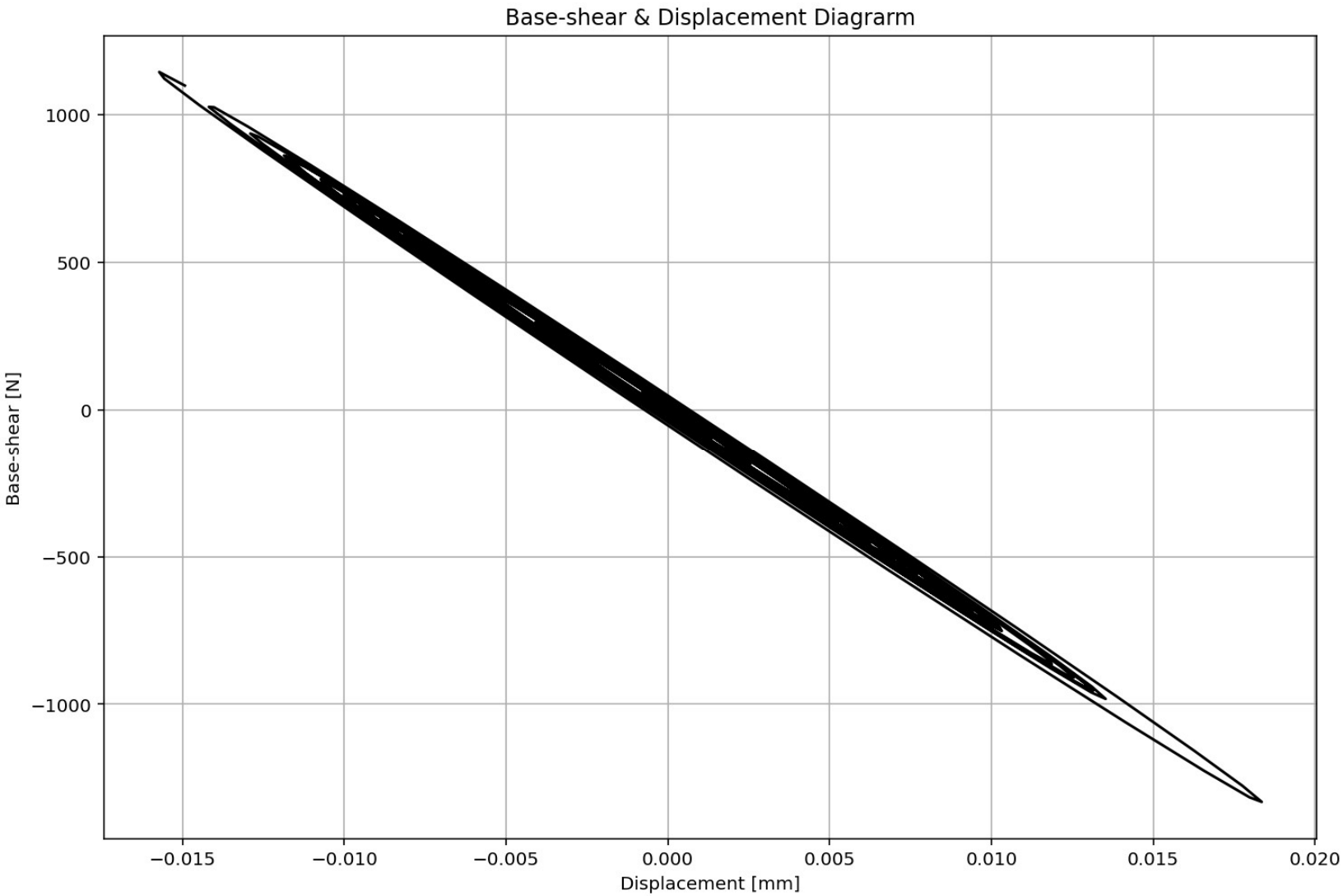


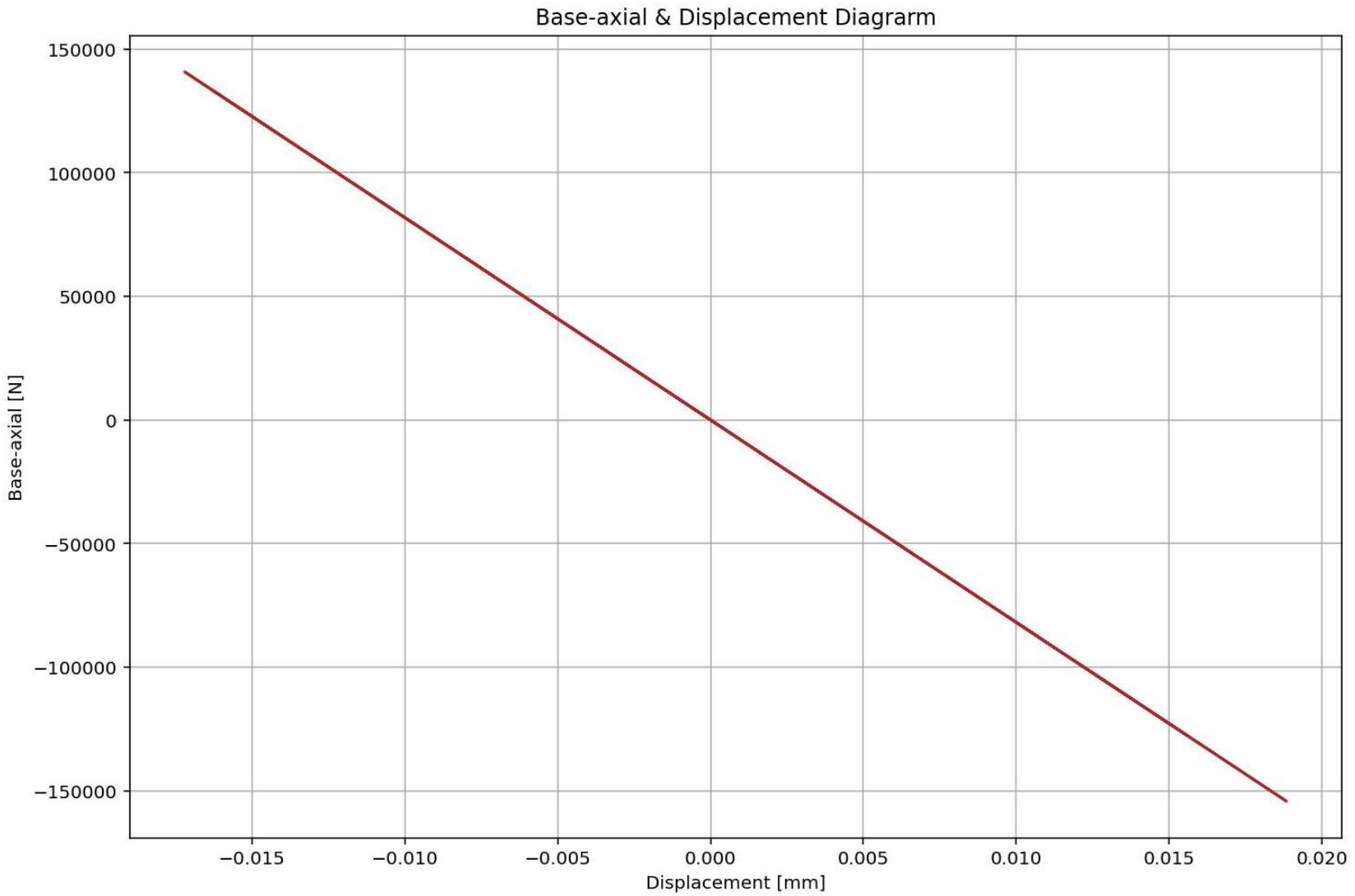
Period: 0.12475926338077073 (s)
Natural Frequency: 8.015436873396377 (Hz)

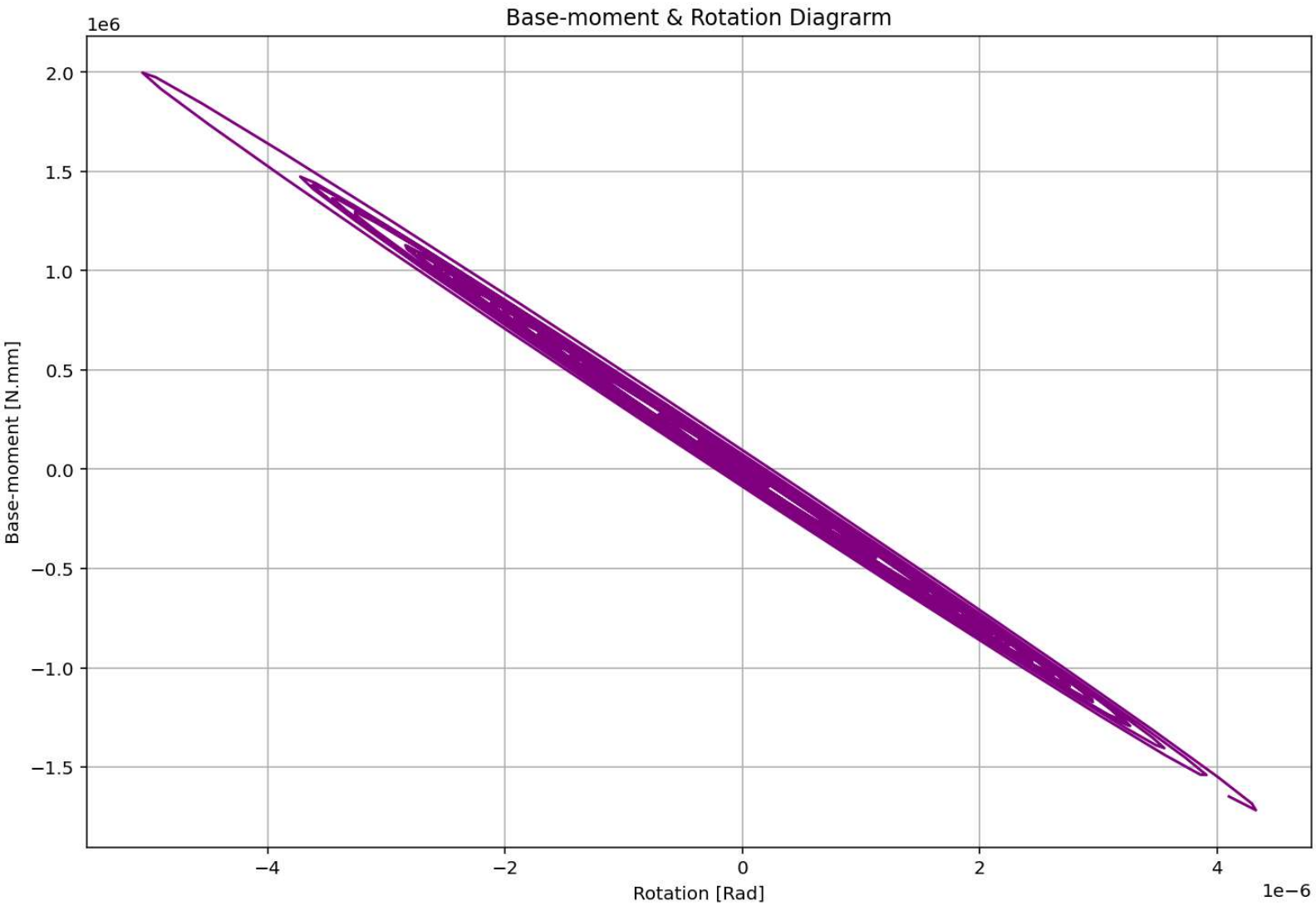

Displacement X Time History
Displacement X
0.02
0.01
0.00
−0.01
0
2
4
6
8
10
Time
Displacement Y Time History
Displacement Y
0.02
0.01
0.00
−0.01
0
2
4
6
8
10
Time
Rotations Time History
1e−6
Rotations
2.5
0.0
−2.5
−5.0
0
2
4
6
8
10
Time
Velocity Time History
Velocity in X Dir.
0.4
0.2
0.0
−0.2
−0.4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

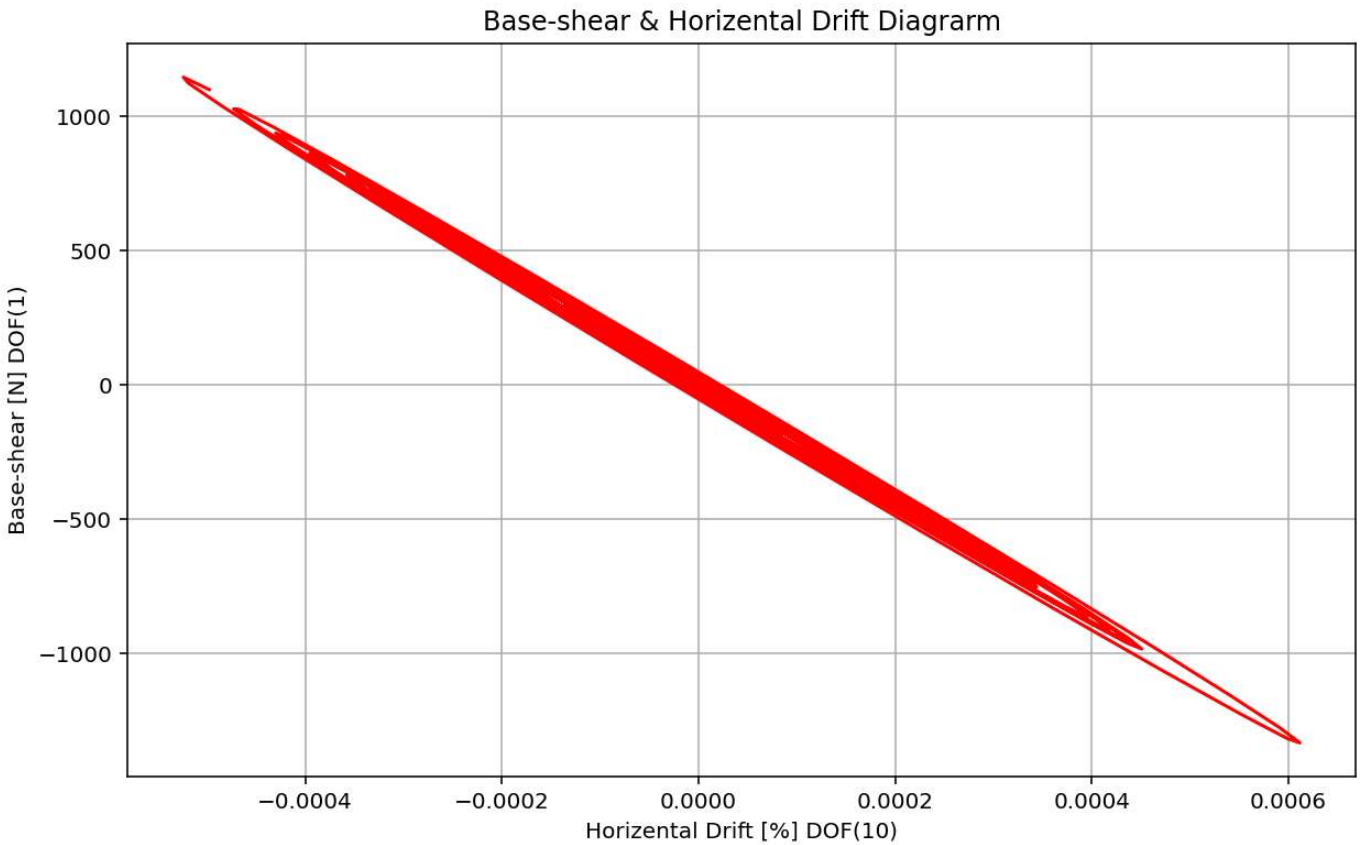

Acceleration Time History
Acceleration in X Dir.
10
5
0
−5
−10
0
2
4
6
8
10
Time
Velocity Time History
Velocity in Y Dir.
0.4
0.2
0.0
−0.2
−0.4
0
2
4
6
8
10
Time
Acceleration Time History
Acceleration in Y Dir.
10
5
0
−5
−10
0
2
4
6
8
10
Time


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
Base-shear [N]
1000
500
0
−500
−1000
−0.015
−0.010
−0.005
0.000
0.005
0.010
0.015
0.020
Displacement [mm]


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


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]
−4
−2
0
2
4
Rotation [Rad]
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)

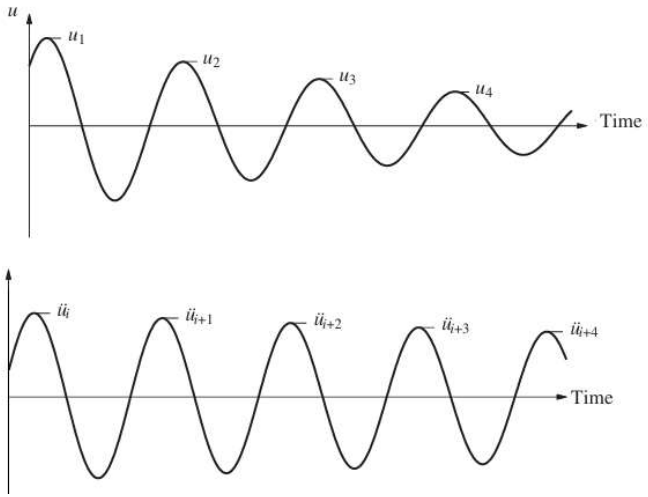
VISCOUSLY DAMPED FREE VIBRATION

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

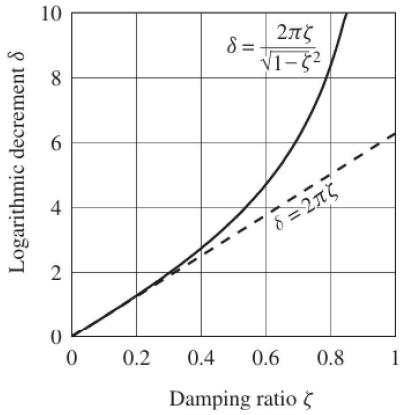
$$\ddot{u} + 2\zeta\omega_n\dot{u} + \omega_n^2 u = 0$$

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

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



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