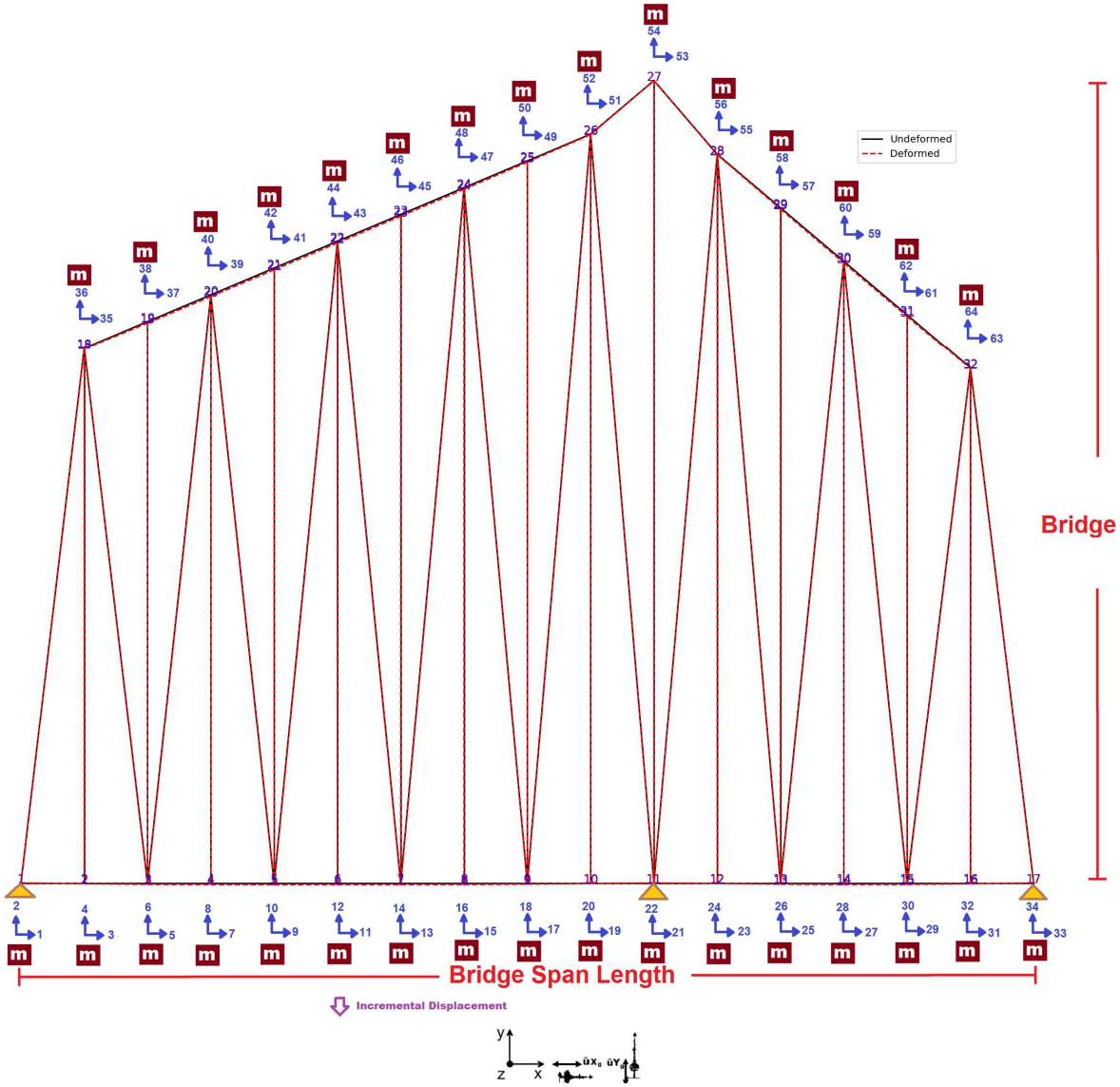
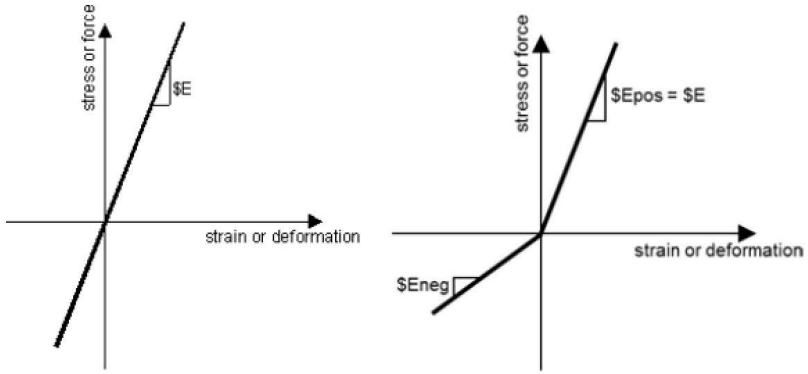
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

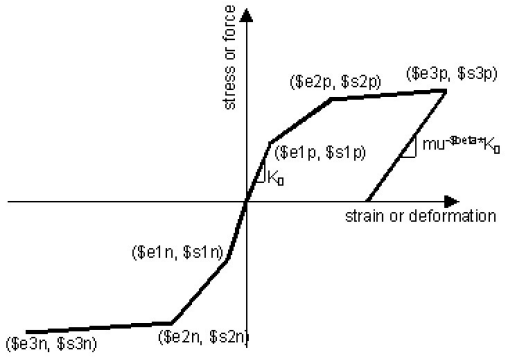
COMPREHENSIVE NONLINEAR SEISMIC ASSESSMENT OF STEEL TRUSS BRIDGES: AN OPENSEES FRAMEWORK FOR STATIC PUSHOVER, CYCLIC DEGRADATION, STATIC TIME-HISTORY AND DYNAMIC TIME-HISTORY ANALYSIS

THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)





TRUSS ELEMENT ELASTIC MATERIAL



TRUSS ELEMENT INELASTIC MATERIAL

$$Axial\ Ductility\ Damage\ Index = \frac{\varepsilon_d - \varepsilon_y}{\varepsilon_u - \varepsilon_y}$$

$$Structure\ Ductility\ Damage\ Index = \frac{\Delta_d - \Delta_y}{\Delta_u - \Delta_y}$$

Spyder (Python 3.12)

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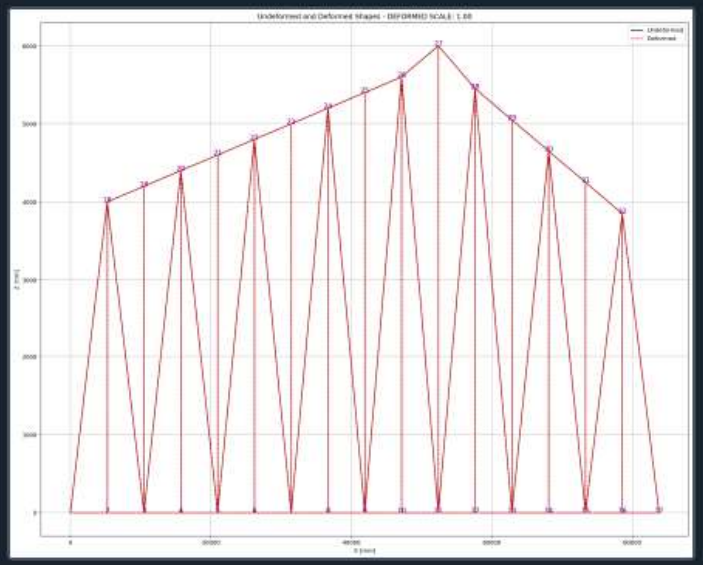
...Dell\Desktop\OPENSEES_FILES\+BRIDGE_RAILROAD_TRUSS_TWO_SPANS

C:\Users\Dell\Desktop\OPENSEES_FILES\+BRIDGE_RAIL..._Flint River Bridge_Tuscaloosa Railroad Bridge.py

BRIDGE_RAILROAD_TR...Railroad Bridge.py

```
##########################################################################################
#                  >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#      COMPREHENSIVE NONLINEAR SEISMIC ASSESSMENT OF STEEL TRUSS BRIDGES: AN OPENSEES FRAM
#       STATIC PUSHOVER, CYCLIC DEGRADATION, STATIC TIME-HISTORY AND DYNAMIC TIME-HISTORY
#----------------------------------------------------------------------------------------
#                          THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                   EMAIL: salar.d.ghashghaei@gmail.com
##########################################################################################
"""
Key Specifications of the Tuscaloosa Railroad Bridge
-Type of Usage: Railroad (Owned by the Kansas City Southern Railway)
-Feature Crossed: Black Warrior River
-Location: Tuscaloosa, Tuscaloosa County, Alabama, United States
-Structure Type: Metal Continuous Rivet-Connected Polygonal Warren
 Through Truss (Main Spans); Metal Deck Girder and Timber Trestle (Approach Spans)
-Construction Date: 1924
-Builder/Contractor: American Bridge Company of New York, New York
-Total Structure Length: Approximately 3,600 feet (1,097.3 meters)
-Main Span Length: 275 feet (83.8 meters)
-Number of Main Spans: 2
-Notable Feature: It replaced an earlier bridge dating from 1896-99.
 Its design is significant for using solid plates with holes on its
 members instead of the decorative V-lacing or lattice commonly used
 on older bridges. Assuming the 1924 date is accurate, this is one
 of the earliest known examples of this modernized design style.
------------------------------------------------------------------------
The bridge is an unusual asymmetrical continuous through truss structure.
 The main spans are the steel trusses, while the approaches consist of metal
 deck girder spans and a very long series of timber trestle spans.
 It was documented by the Historic American Engineering Record (HAER).
------------------------------------------------------------------------
Nonlinear Seismic Performance Assessment of Warren Steel Truss Bridges:
An OpenSeesPy Framework for Material and Geometric Nonlinearity Under Static, Cyclic, and
------------------------------------------------------------------------
```

19 %



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STATIC ANALYSIS

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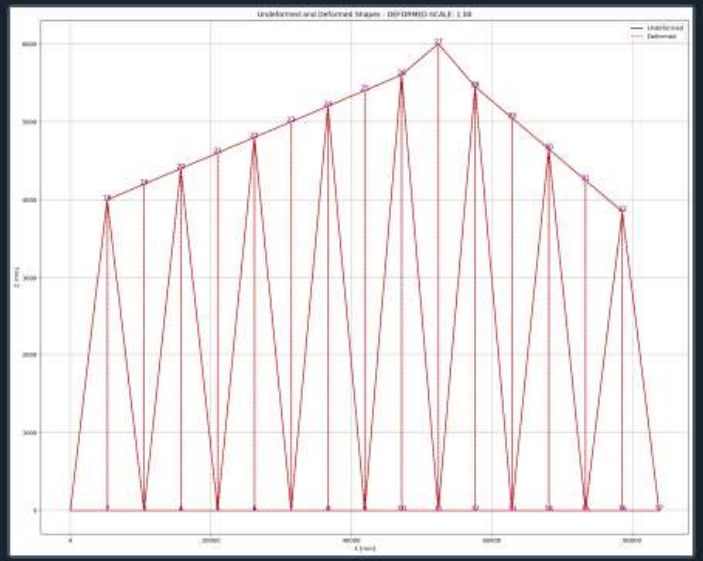
BRIDGE_RAILROAD_TR...Railroad Bridge.py

```
#%%-----------------------------------------------------
L = 83800.0          # [mm] Bridge Length
H = 6000.0           # [mm] Bridge Height
A_chord = 2*2009.0   # [mm^2] Section Area for chord elements - 2 x IPE160
A_diag  = 2*2040.0   # [mm^2] Section Area for diagonal elements - 2 x UNP140
TOTAL_MASS = 0.0     # [kg] Total Mass of Structure
#%%-----------------------------------------------------
# PERIOD ANALYSIS
#ELE_TYPE = 'Truss'      # MATERIAL NONLINEARITY
ELE_TYPE = 'corotTruss'  # MATERIAL AND GEOMETRIC NONLINEARITIES
MAT_TYPE = 'INELASTIC'   # 'ELASTIC' OR 'INELASTIC'
ANAL_TYPE = 'PERIOD'

DATA = WARREN_TRUSS_BRIDGE(L, H, A_chord, A_diag, MAT_TYPE, ELE_TYPE, ANAL_TYPE, TOTAL_MAS
(PERIOD_MIN_X, PERIOD_MAX_X) = DATA
print('Structure First Period:  ', PERIOD_MIN_X)
print('Structure Second Period: ', PERIOD_MAX_X)

S01.PLOT_2D_FRAME_TRUSS(deformed_scale=1.0)
#%%-----------------------------------------------------
# STATIC ANALYSIS
#ELE_TYPE = 'Truss'      # MATERIAL NONLINEARITY
ELE_TYPE = 'corotTruss'  # MATERIAL AND GEOMETRIC NONLINEARITIES
MAT_TYPE = 'INELASTIC'   # 'ELASTIC' OR 'INELASTIC'
ANAL_TYPE = 'STATIC'

DATA = WARREN_TRUSS_BRIDGE(L, H, A_chord, A_diag, MAT_TYPE, ELE_TYPE, ANA _TYPE, TOTAL_MAS
(reaction, disp_mid,
 ele_force, ele_stress, ele_strain,
 node_displacementsX, node_displacementsY,
 dispX, dispY) = DATA

S01.PLOT_2D_FRAME_TRUSS(deformed_scale=1.0)
```

19 %



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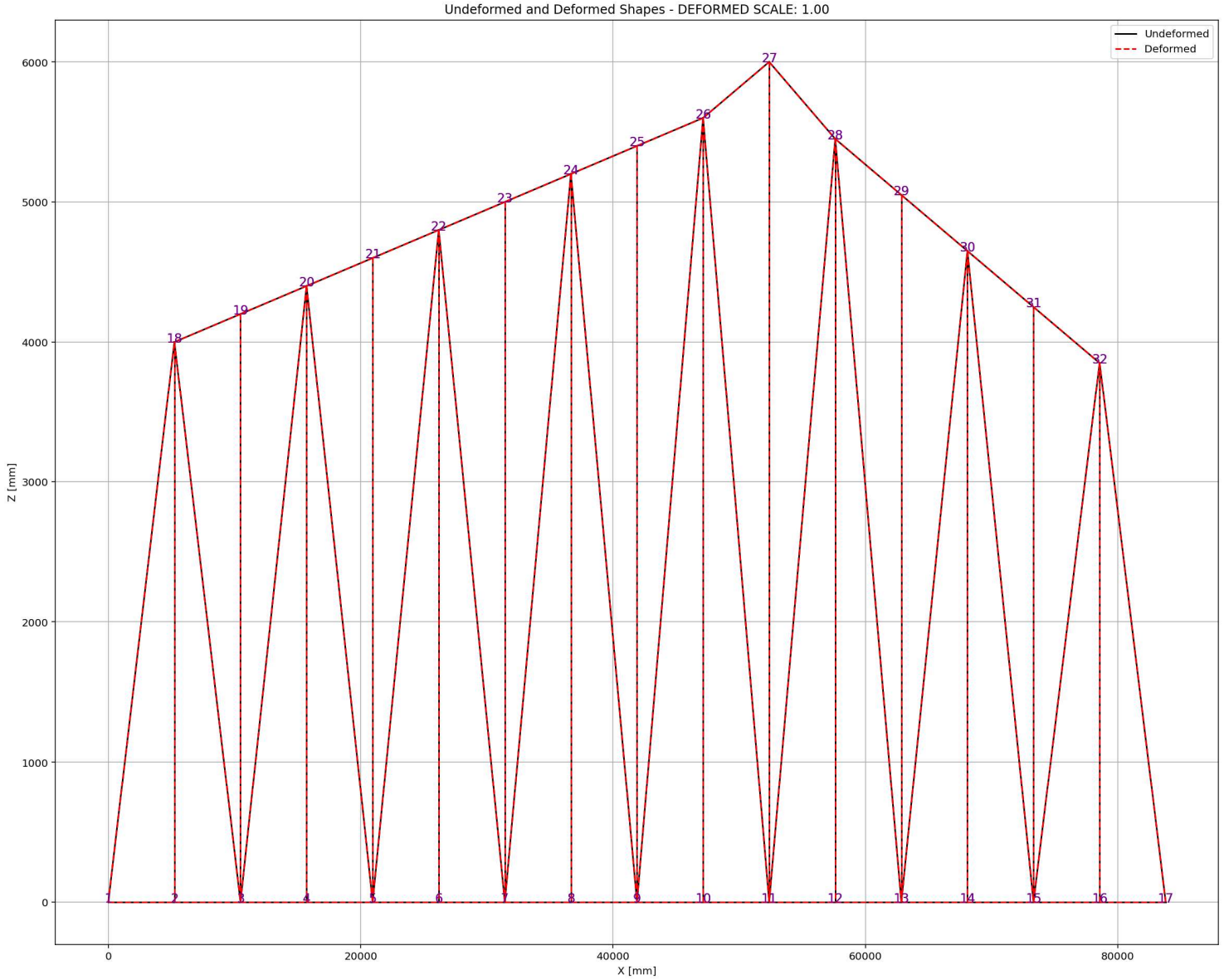
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 71, Col 216 UTF-8 CRLF RW Mem 58%


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
1000
2000
3000
4000
5000
6000
0
20000
40000
60000
80000
1
2
3
4
5
6
7
8
9
10
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PUSHOVER ANALYSIS

Spyder (Python 3.12)

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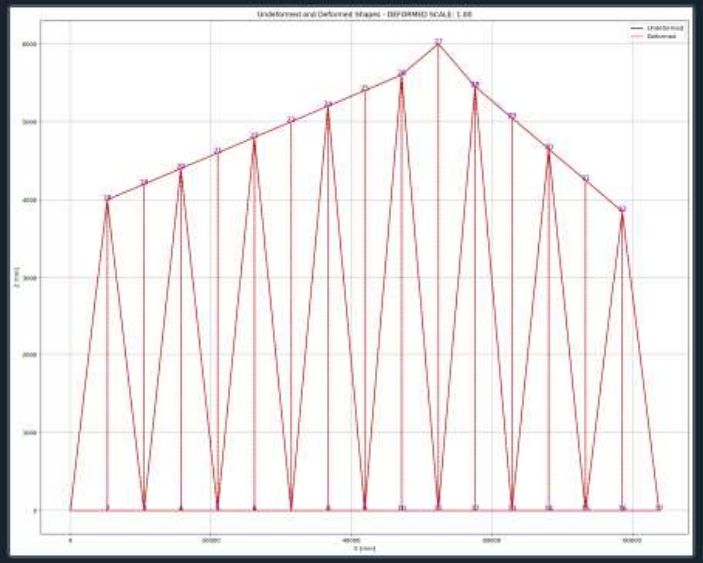
BRIDGE_RAILROAD_TR...Railroad Bridge.py

```
1287  # PUSHOVER ANALYSIS (STATIC TIME-HISTORY ANALYSIS)
1288  #ELE_TYPE = 'Truss'      # MATERIAL NONLINEARITY
1289  ELE_TYPE = 'corotTruss'  # MATERIAL AND GEOMETRIC NONLINEARITIES
1290  MAT_TYPE = 'INELASTIC'   # 'ELASTIC' OR 'INELASTIC'
1291  ANAL_TYPE = 'PUSHOVER'
1292
1293  DATA = WARREN_TRUSS_BRIDGE(L, H, A_chord, A_diag, MAT_TYPE, ELE_TYPE, ANAL_TYPE, TOTAL_MAS
1294  (reaction_PUSH, disp_mid_PUSH,
1295   ele_force_PUSH, ele_stress_PUSH, ele_strain_PUSH,
1296   node_displacementsX_PUSH, node_displacementsY_PUSH,
1297    dispX_PUSH, dispY_PUSH,
1298   PERIOD_MIN_PUSH, PERIOD_MAX_PUSH) = DATA
1299
1300
1301  XDATA = disp_mid_PUSH
1302  YDATA = reaction_PUSH
1303  XLABEL = 'Displacement in Middle Span [mm]'
1304  YLABEL = 'Base Reaction [N]'
1305  TITLE = 'Base Reaction and Displacement of Structure During Pushover Analysis'
1306  COLOR = 'black'
1307  SEMILOGY = False
1308  PLOT(XDATA, YDATA, TITLE, XLABEL, YLABEL, COLOR, SEMILOGY)
1309
1310  # BILINEAR CURVE DATA
1311  DATA = S07.BILNEAR_CURVE(np.abs(disp_mid_PUSH), np.abs(reaction_PUSH), SLOPE_NODE=10)
1312  (X_PUSH, Y_PUSH, Elastic_ST, Plastic_ST, Tangent_ST, Ductility_Rito, Over_Strength_Factor)
1313
1314  # PLOT STRUCTURAL PERIOD DURING THE ANALYSIS
1315  plt.figure(0, figsize=(12, 8))
1316  plt.plot(disp_mid_PUSH, PERIOD_MIN_PUSH, linewidth=3)
1317  plt.plot(disp_mid_PUSH, PERIOD_MAX_PUSH, linewidth=3)
1318  plt.title('Period of Structure During Pushover Analysis')
1319  plt.ylabel('Structural Period [s]')
1320  plt.xlabel('Displacement [mm]')
```

19 %



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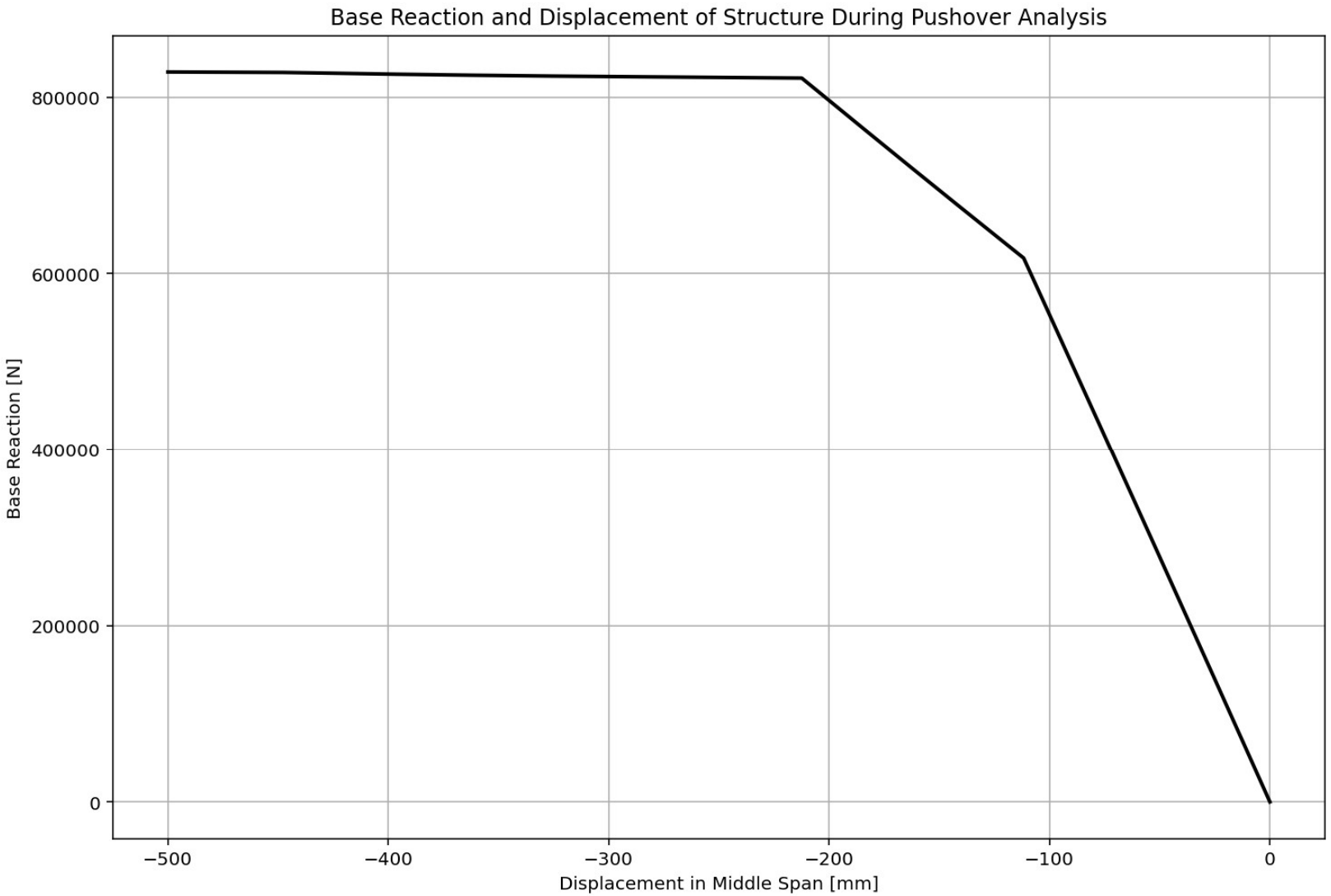
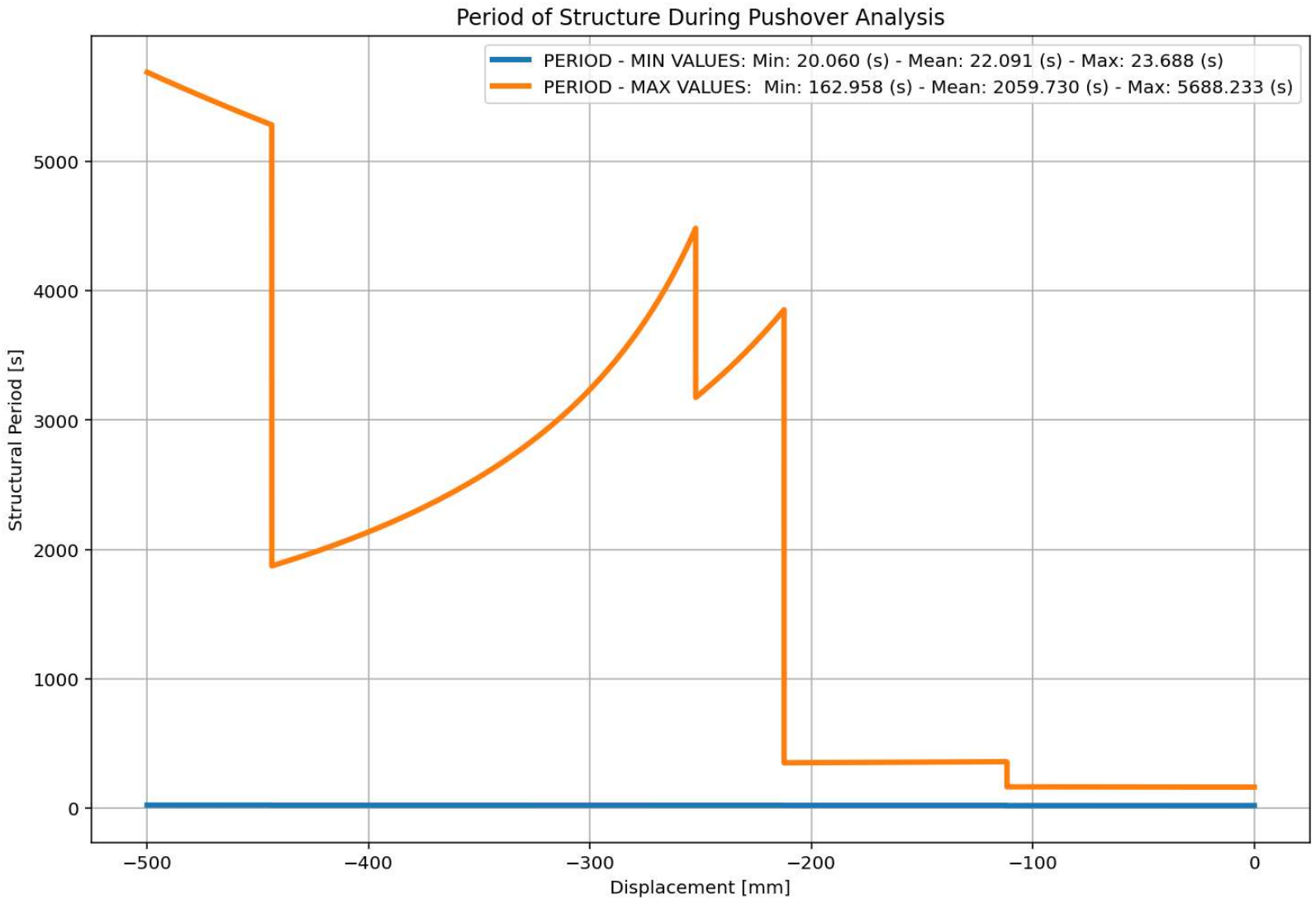
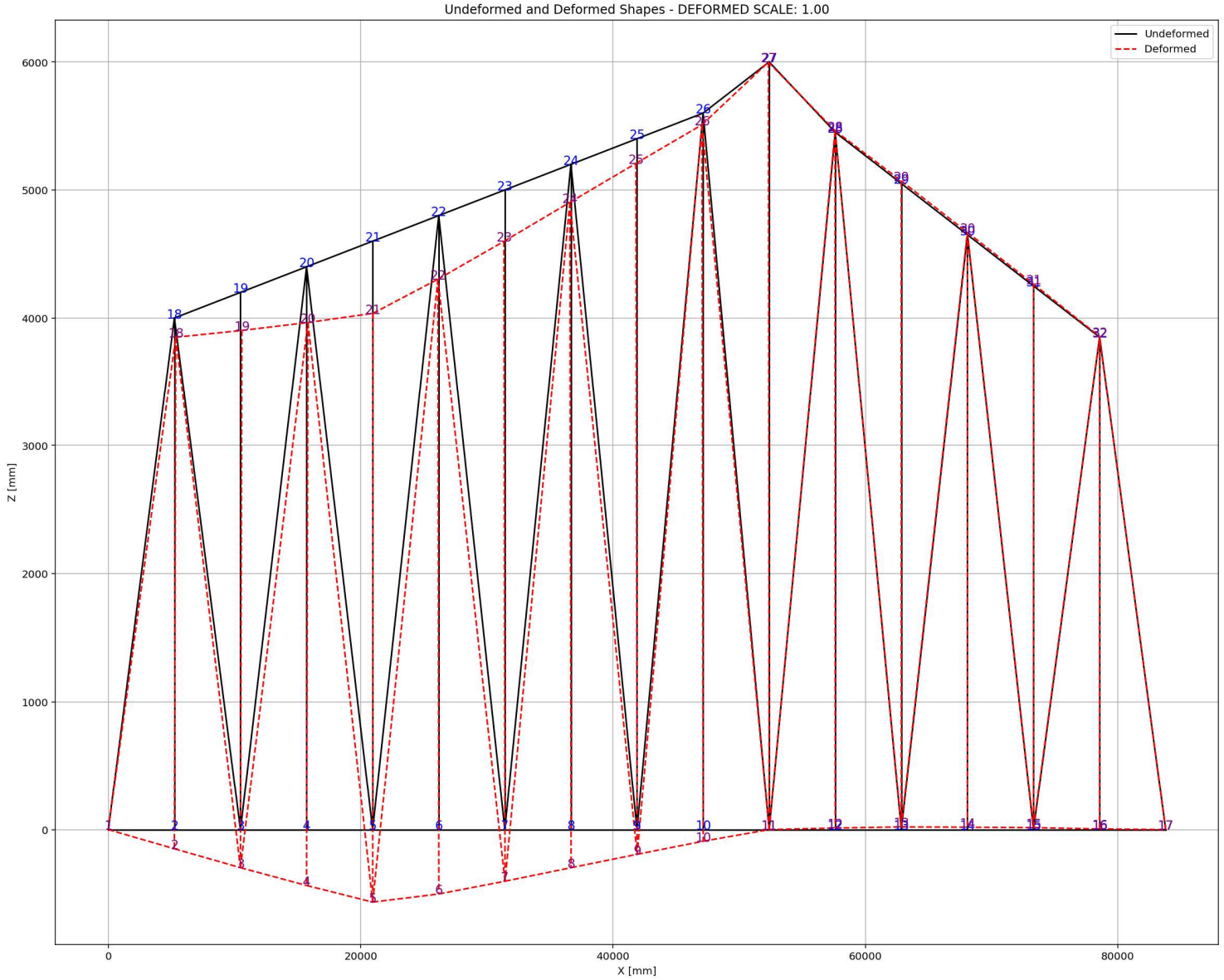

Base Reaction and Displacement of Structure During Pushover Analysis
Base Reaction [N]
800000
600000
400000
200000
0
−500
−400
−300
−200
−100
0
Displacement in Middle Span [mm]


Period of Structure During Pushover Analysis
PERIOD - MIN VALUES: Min: 20.060 (s) - Mean: 22.091 (s) - Max: 23.688 (s)
PERIOD - MAX VALUES: Min: 162.958 (s) - Mean: 2059.730 (s) - Max: 5688.233 (s)
Structural Period [s]
5000
4000
3000
2000
1000
0
−500
−400
−300
−200
−100
0
Displacement [mm]


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
1000
2000
3000
4000
5000
6000
0
20000
40000
60000
80000

CYCLIC DISPLACEMENT ANALYSIS

Spyder (Python 3.12)

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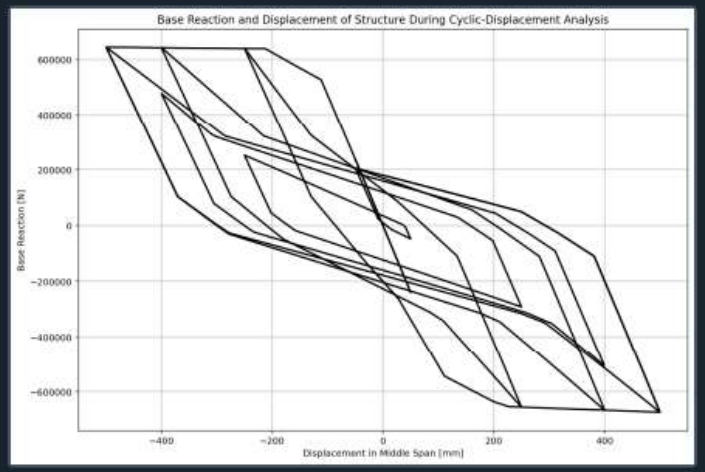
BRIDGE_RAILROAD_TR...Railroad Bridge.py

```
1330  # CYCLIC DISPLACEMENT ANALYSIS (STATIC TIME-HISTORY ANALYSIS)
1331  #ELE_TYPE = 'Truss'      # MATERIAL NONLINEARITY
1332  ELE_TYPE = 'corotTruss'  # MATERIAL AND GEOMETRIC NONLINEARITIES
1333  MAT_TYPE = 'INELASTIC'   # 'ELASTIC' OR 'INELASTIC'
1334  ANAL_TYPE = 'CYCLIC_DISPLACEMENT'
1335
1336  DATA = WARREN_TRUSS_BRIDGE(L, H, A_chord, A_diag, MAT_TYPE, ELE_TYPE, ANAL_TYPE, TOTAL_MAS
1337  (reaction_CP, disp_mid_CP,
1338   ele_force_CP, ele_stress_CP, ele_strain_CP,
1339   node_displacementsX_CP, node_displacementsY_CP,
1340    dispX_CP, dispY_CP,
1341   PERIOD_MIN_CP, PERIOD_MAX_CP) = DATA
1342
1343
1344  XDATA = disp_mid_CP
1345  YDATA = reaction_CP
1346  XLABEL = 'Displacement in Middle Span [mm]'
1347  YLABEL = 'Base Reaction [N]'
1348  TITLE = 'Base Reaction and Displacement of Structure During Cyclic-Displacement Analysis'
1349  COLOR = 'black'
1350  SEMILOGY = False
1351  PLOT(XDATA, YDATA, TITLE, XLABEL, YLABEL, COLOR, SEMILOGY)
1352
1353  # PLOT STRUCTURAL PERIOD DURING THE ANALYSIS
1354  plt.figure(0, figsize=(12, 8))
1355  plt.plot(disp_mid_CP, PERIOD_MIN_CP, linewidth=3)
1356  plt.plot(disp_mid_CP, PERIOD_MAX_CP, linewidth=3)
1357  plt.title('Period of Structure During Cyclic Displacement Analysis')
1358  plt.ylabel('Structural Period [s]')
1359  plt.xlabel('Displacement [mm]')
1360  #plt.semilogy()
1361  plt.grid()
1362  plt.legend([f'PERIOD - MIN VALUES: Min: {np.min(PERIOD_MIN_CP):.3f} (s) - Mean: {np.mean(P
1363              f'PERIOD - MAX VALUES:  Min: {np.min(PERIOD_MAX_CP):.3f} (s) - Mean: {np.mean(
```



30 %

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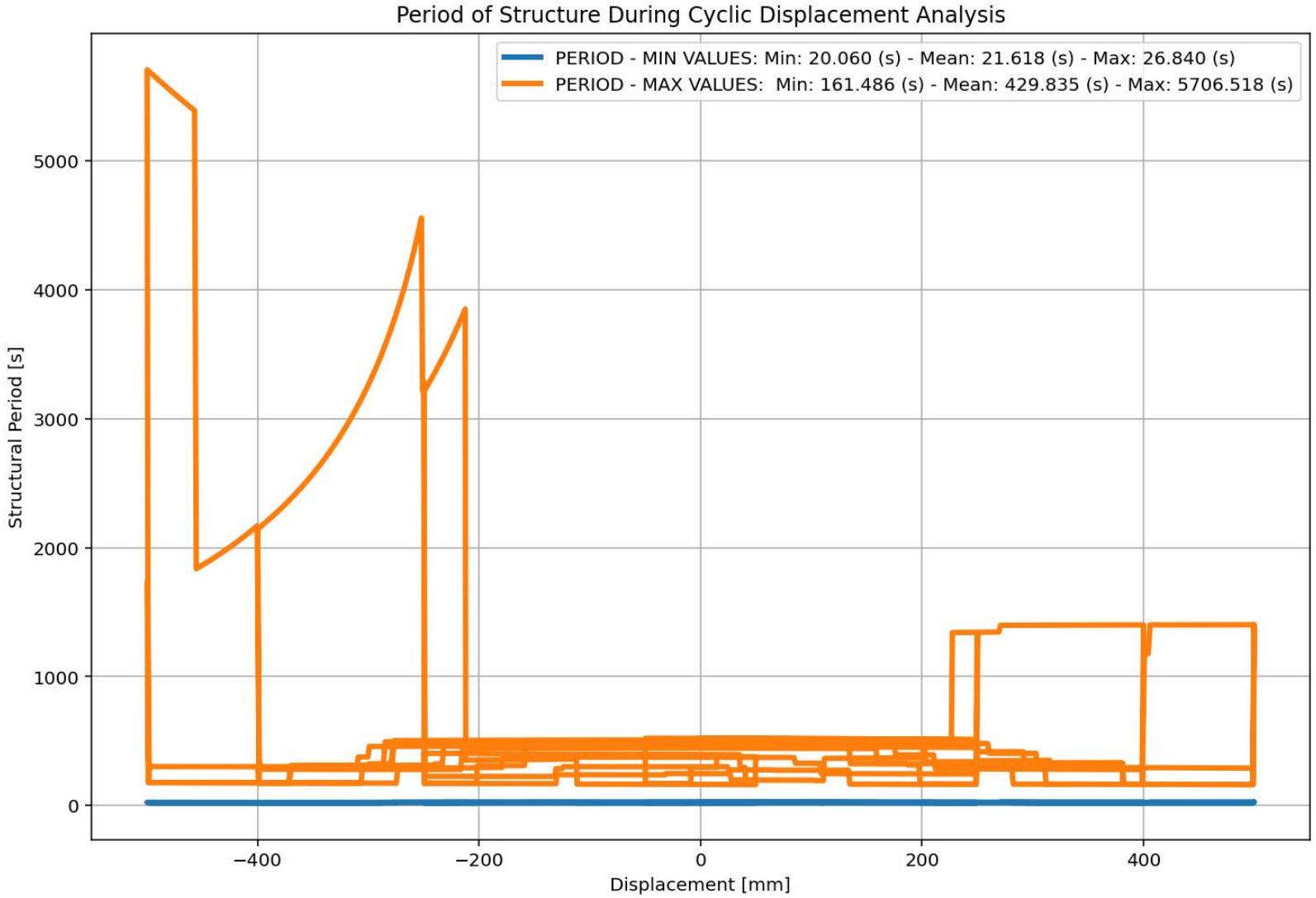
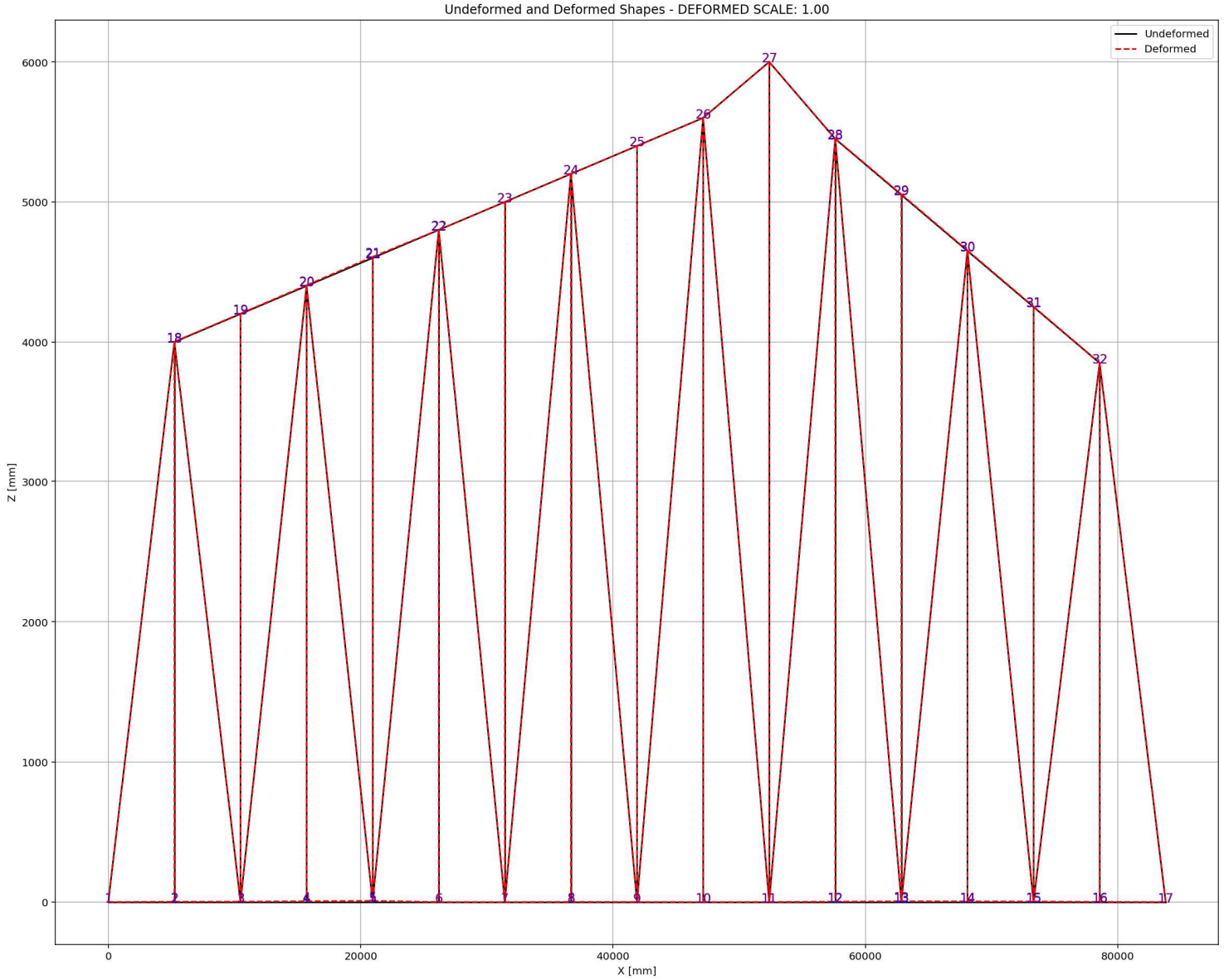
Base Reaction and Displacement of Structure During Cyclic-Displacement Analysis
Base Reaction [N]
600000
400000
200000
0
−200000
−400000
−600000
−400
−200
0
200
400
Displacement in Middle Span [mm]


Period of Structure During Cyclic Displacement Analysis
PERIOD - MIN VALUES: Min: 20.060 (s) - Mean: 21.618 (s) - Max: 26.840 (s)
PERIOD - MAX VALUES: Min: 161.486 (s) - Mean: 429.835 (s) - Max: 5706.518 (s)
Structural Period [s]
5000
4000
3000
2000
1000
0
−400
−200
0
200
400
Displacement [mm]


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
1000
2000
3000
4000
5000
6000
0
20000
40000
60000
80000
1
2
3
4
5
6
8
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STATIC TIME-HISTORY WITH EXTERNALTIME-DEPENDENTLOADING ANALYSIS

Spyder (Python 3.12)

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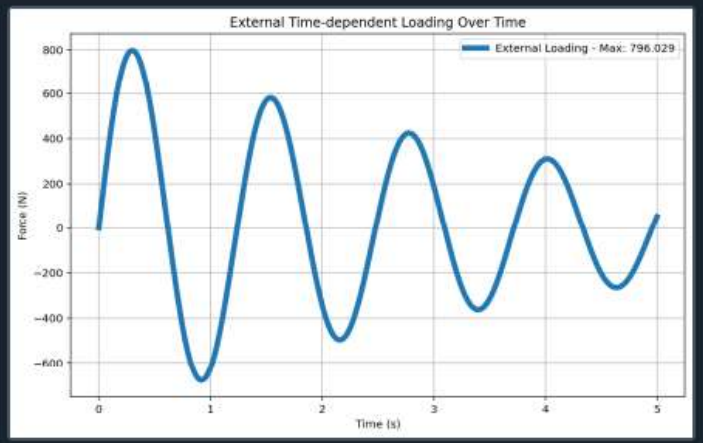
BRIDGE_RAILROAD_TR...Railroad Bridge.py

```
1369  # EXTERNAL TIME-DEPENDENT LOADING ANALYSIS (STATIC TIME-HISTORY ANALYSIS)
1370  #ELE_TYPE = 'Truss'      # MATERIAL NONLINEARITY
1371  ELE_TYPE = 'corotTruss'  # MATERIAL AND GEOMETRIC NONLINEARITIES
1372  MAT_TYPE = 'INELASTIC'   # 'ELASTIC' OR 'INELASTIC'
1373  ANAL_TYPE = 'STATIC_EXTERNAL_TIME-DEPENDENT_LOADING'
1374
1375  DATA = WARREN_TRUSS_BRIDGE(L, H, A_chord, A_diag, MAT_TYPE, ELE_TYPE, ANAL_TYPE, TOTAL_MAS
1376
1377  (reaction_ETDLS, disp_mid_ETDLS,
1378   ele_force_ETDLS, ele_stress_ETDLS, ele_strain_ETDLS,
1379   node_displacementsX_ETDLS, node_displacementsY_ETDLS,
1380    dispX_ETDLS, dispY_ETDLS,
1381   PERIOD_MIN_ETDLS, PERIOD_MAX_ETDLS) = DATA
1382
1383
1384  XDATA = disp_mid_ETDLS
1385  YDATA = reaction_ETDLS
1386  XLABEL = 'Displacement in Middle Span [mm]'
1387  YLABEL = 'Base Reaction [N]'
1388  TITLE = 'Base Reaction and Displacement of Structure During Static External Time-deper dent
1389  COLOR = 'black'
1390  SEMILOGY = False
1391  PLOT(XDATA, YDATA, TITLE, XLABEL, YLABEL, COLOR, SEMILOGY)
1392
1393  # PLOT STRUCTURAL PERIOD DURING THE ANALYSIS
1394  plt.figure(0, figsize=(12, 8))
1395  plt.plot(disp_mid_ETDLS, PERIOD_MIN_ETDLS, linewidth=3)
1396  plt.plot(disp_mid_ETDLS, PERIOD_MAX_ETDLS, linewidth=3)
1397  plt.title('Period of Structure During Static External Time-dependent Loading Analysis'
1398  plt.ylabel('Structural Period [s]')
1399  plt.xlabel('Displacement [mm]')
1400  #plt.semilogy()
1401  plt.grid()
1402  plt.legend([f'PERIOD - MIN VALUES: Min: {np.min(PERIOD_MIN_ETDLS):.3f} (s) - Mean: {np.mea
```



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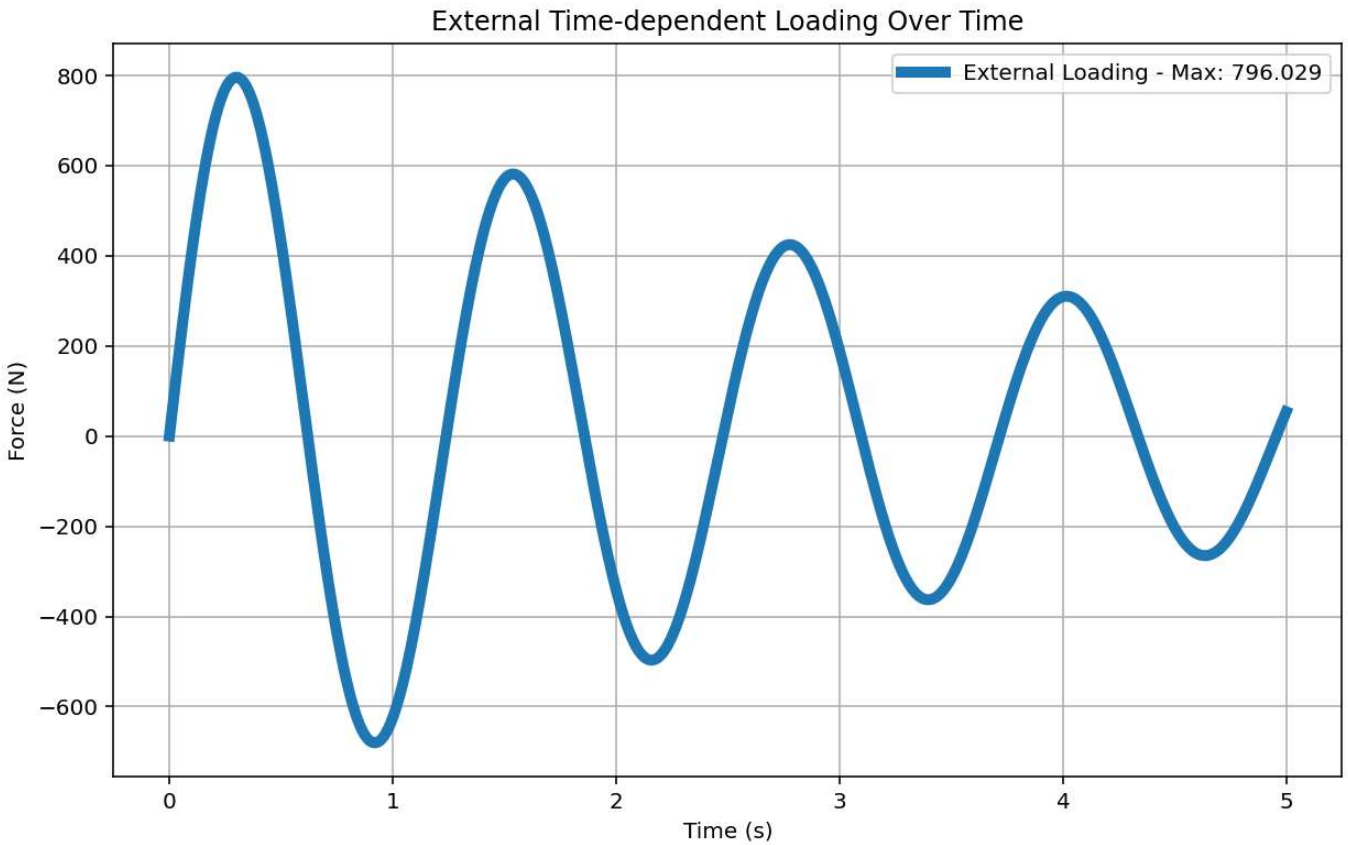
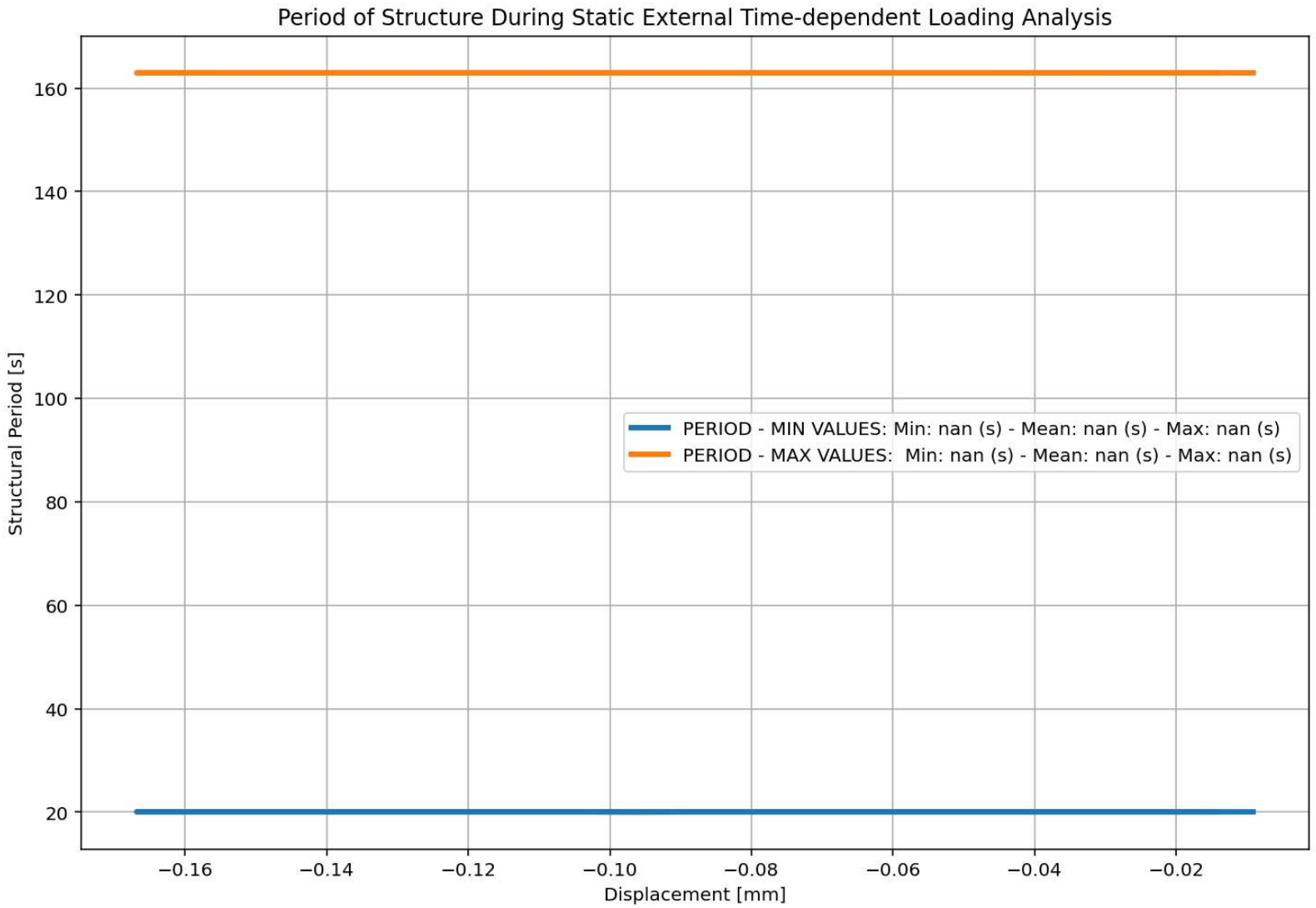
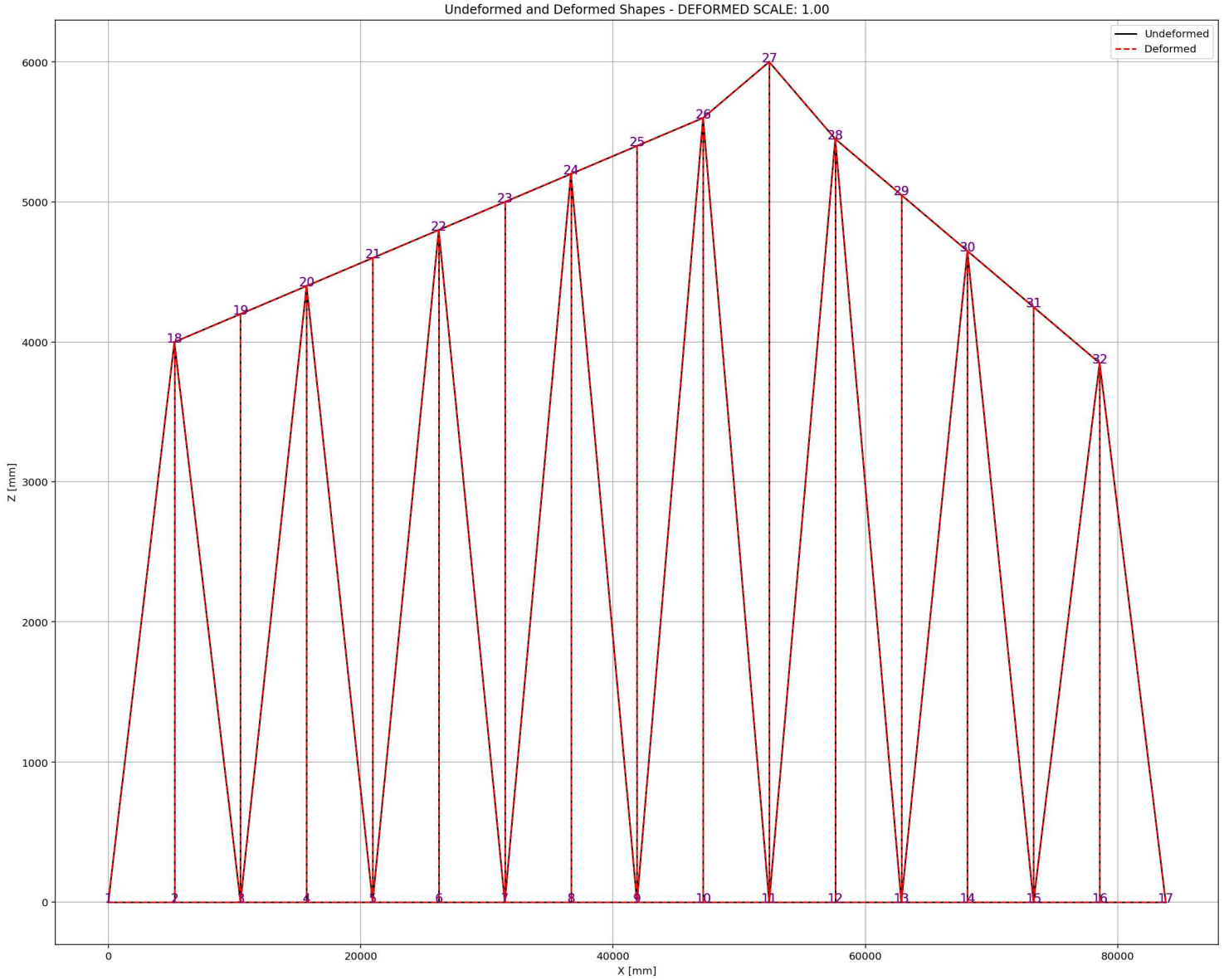

External Time-dependent Loading Over Time
External Loading - Max: 796.029
Force (N)
800
600
400
200
0
−200
−400
−600
0
1
2
3
4
5
Time (s)


Base Reaction and Displacement of Structure During Static External Time-dependent Loading Analysis
Base Reaction [N]
800
700
600
500
400
300
200
100
0
−0.175
−0.150
−0.125
−0.100
−0.075
−0.050
−0.025
0.000
Displacement in Middle Span [mm]


Period of Structure During Static External Time-dependent Loading Analysis
Structural Period [s]
160
140
120
100
80
60
40
20
−0.16
−0.14
−0.12
−0.10
−0.08
−0.06
−0.04
−0.02
Displacement [mm]
PERIOD - MIN VALUES: Min: nan (s) - Mean: nan (s) - Max: nan (s)
PERIOD - MAX VALUES: Min: nan (s) - Mean: nan (s) - Max: nan (s)


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
1000
2000
3000
4000
5000
6000
0
20000
40000
60000
80000
1
2
3
4
5
6
7
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DYNAMIC TIME-HISTORY WITH EXTERNALTIME-DEPENDENTLOADING ANALYSIS

Spyder (Python 3.12)

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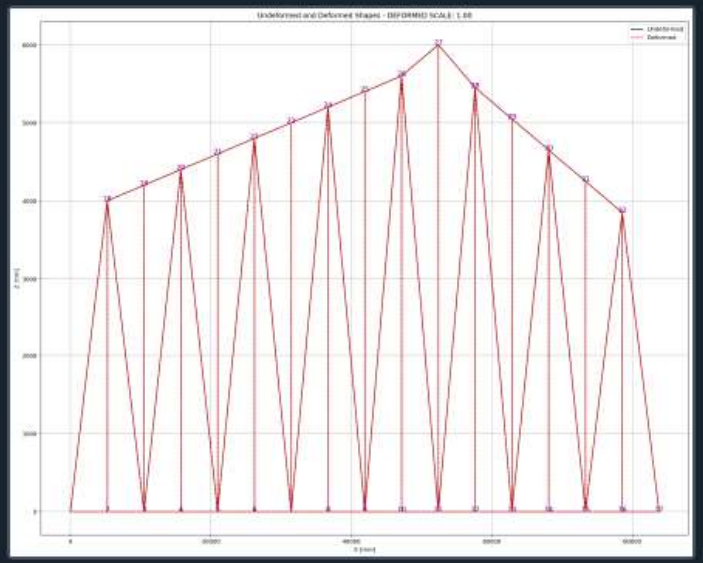
BRIDGE_RAILROAD_TR...Railroad Bridge.py

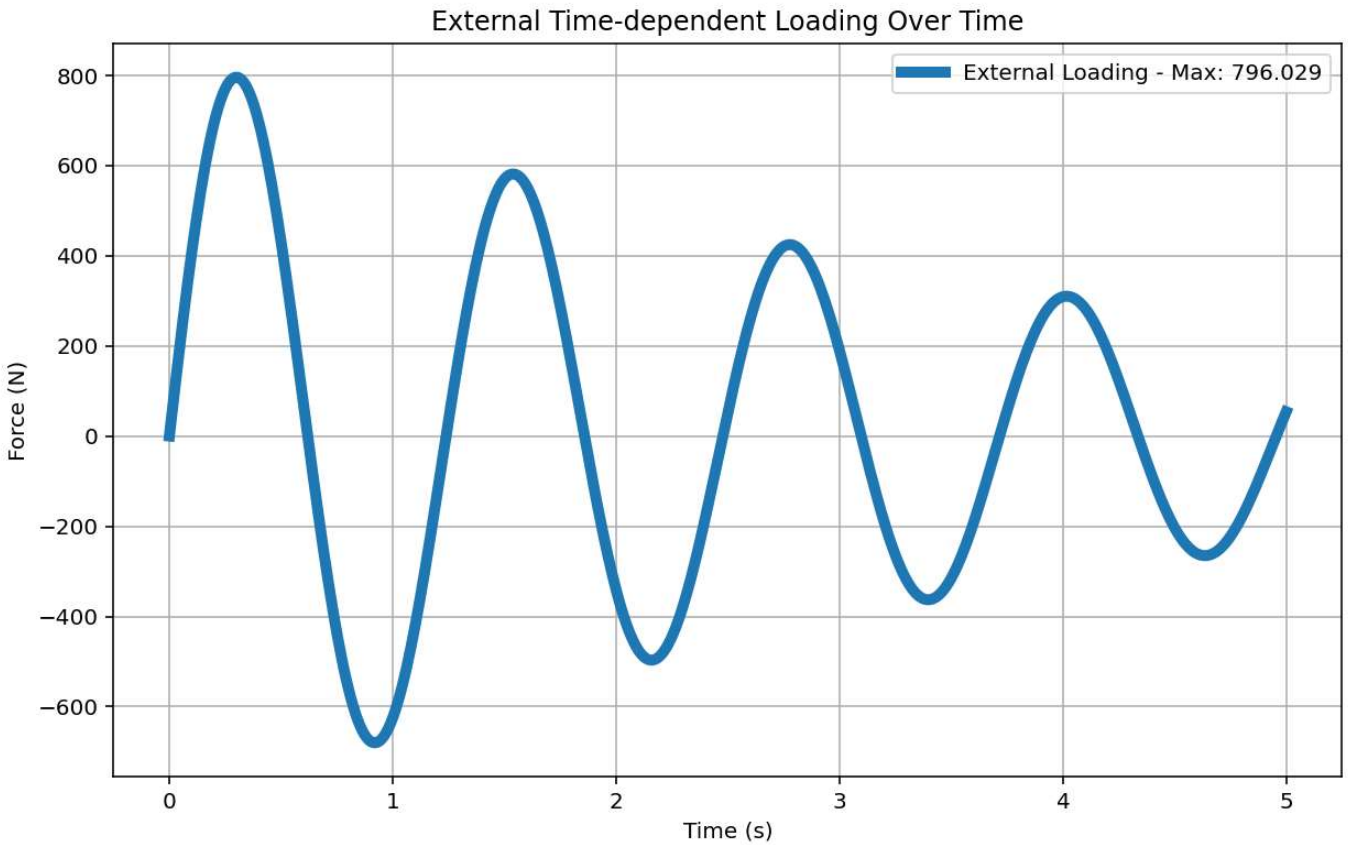
```
1409    # EXTERNAL TIME-DEPENDENT LOADING ANALYSIS (DYNAMIC TIME-HISTORY ANALYSIS)
1410    #ELE_TYPE = 'Truss'      # MATERIAL NONLINEARITY
1411    ELE_TYPE = 'corotTruss'  # MATERIAL AND GEOMETRIC NONLINEARITIES
1412    MAT_TYPE = 'INELASTIC'   # 'ELASTIC' OR 'INELASTIC'
1413    ANAL_TYPE = 'DYNAMIC_EXTERNAL_TIME-DEPENDENT_LOADING'
1414
1415    DATA = WARREN_TRUSS_BRIDGE(L, H, A_chord, A_diag, MAT_TYPE, ELE_TYPE, ANAL_TYPE, TOTA _MAS
1416
1417    time_ETDLD, reaction_ETDLD, disp_mid_ETDLD,
1418    ele_force_ETDLD, ele_stress_ETDLD, ele_strain_ETDLD,
1419    node_displacementsX_ETDLD, node_displacementsY_ETDLD,
1420    dispX_ETDLD, dispY_ETDLD,
1421    veloX_ETDLD, veloY_ETDLD,
1422    accX_ETDLD, accY_ETDLD,
1423    stiffness_ETDLD, PERIOD_ETDLD, damping_ratio_ETDLD,
1424    PERIOD_MIN_ETDLD, PERIOD_MAX_ETDLD) = DATA
1425
1426
1427    XDATA = disp_mid_ETDLD
1428    YDATA = reaction_ETDLD
1429    XLABEL = 'Displacement in Middle Span [mm]'
1430    YLABEL = 'Base Reaction [N]'
1431    TITLE = 'Base Reaction and Displacement of Structure During Dynamic External Time-dep nden
1432    COLOR = 'black'
1433    SEMILOGY = False
1434    PLOT(XDATA, YDATA, TITLE, XLABEL, YLABEL, COLOR, SEMILOGY)
1435
1436    PLOT_TIME_HISTORY(time_ETDLD, reaction_ETDLD, disp_mid_ETDLD,
1437                      dispX_ETDLD, dispY_ETDLD,
1438                      veloX_ETDLD, veloY_ETDLD,
1439                      accX_ETDLD, accY_ETDLD)
1440
1441    # PLOT ELEMENTS AXIAL FORCE
1442    YLABEL = 'Element Axial Force [N]'
```

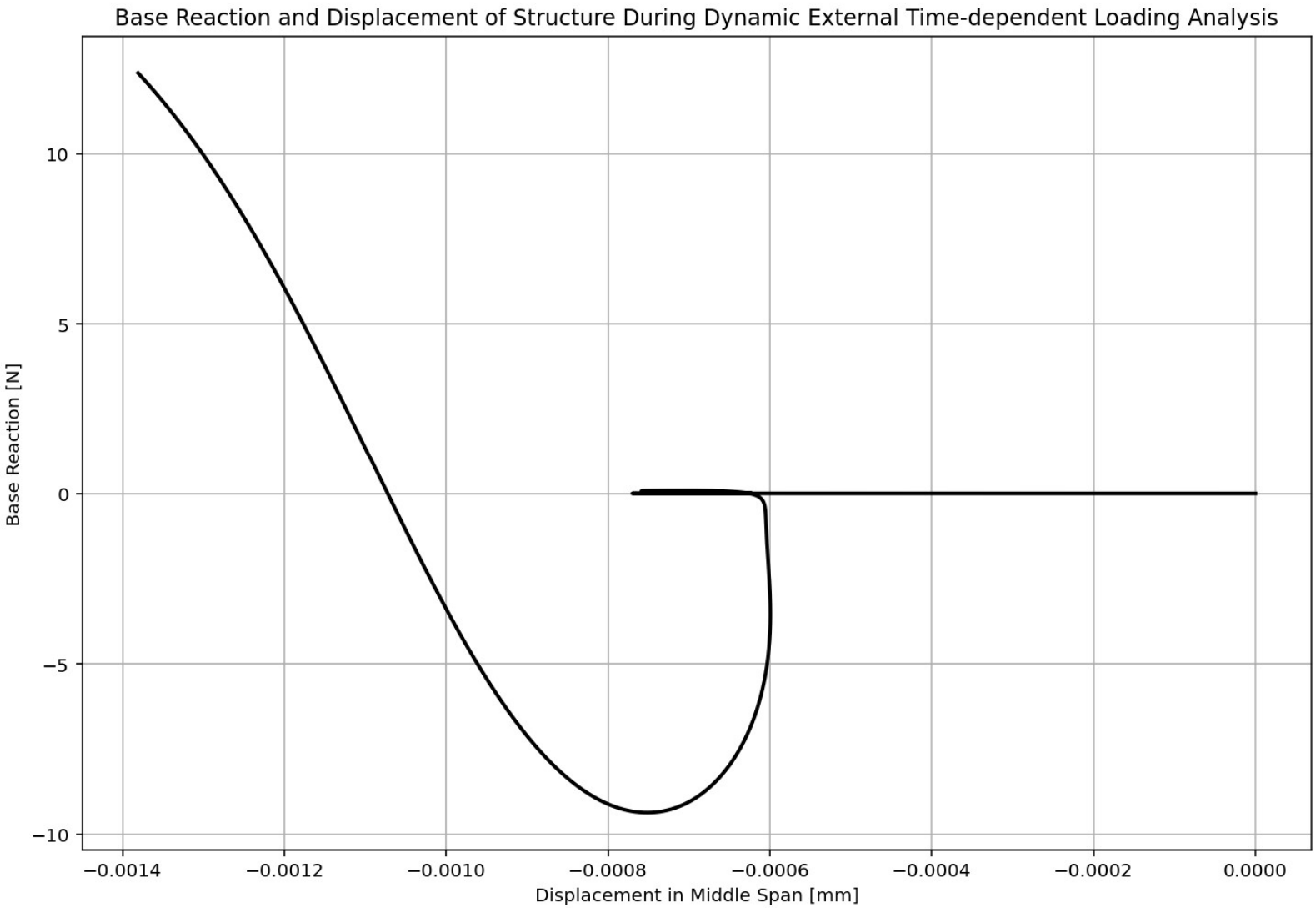
19 %

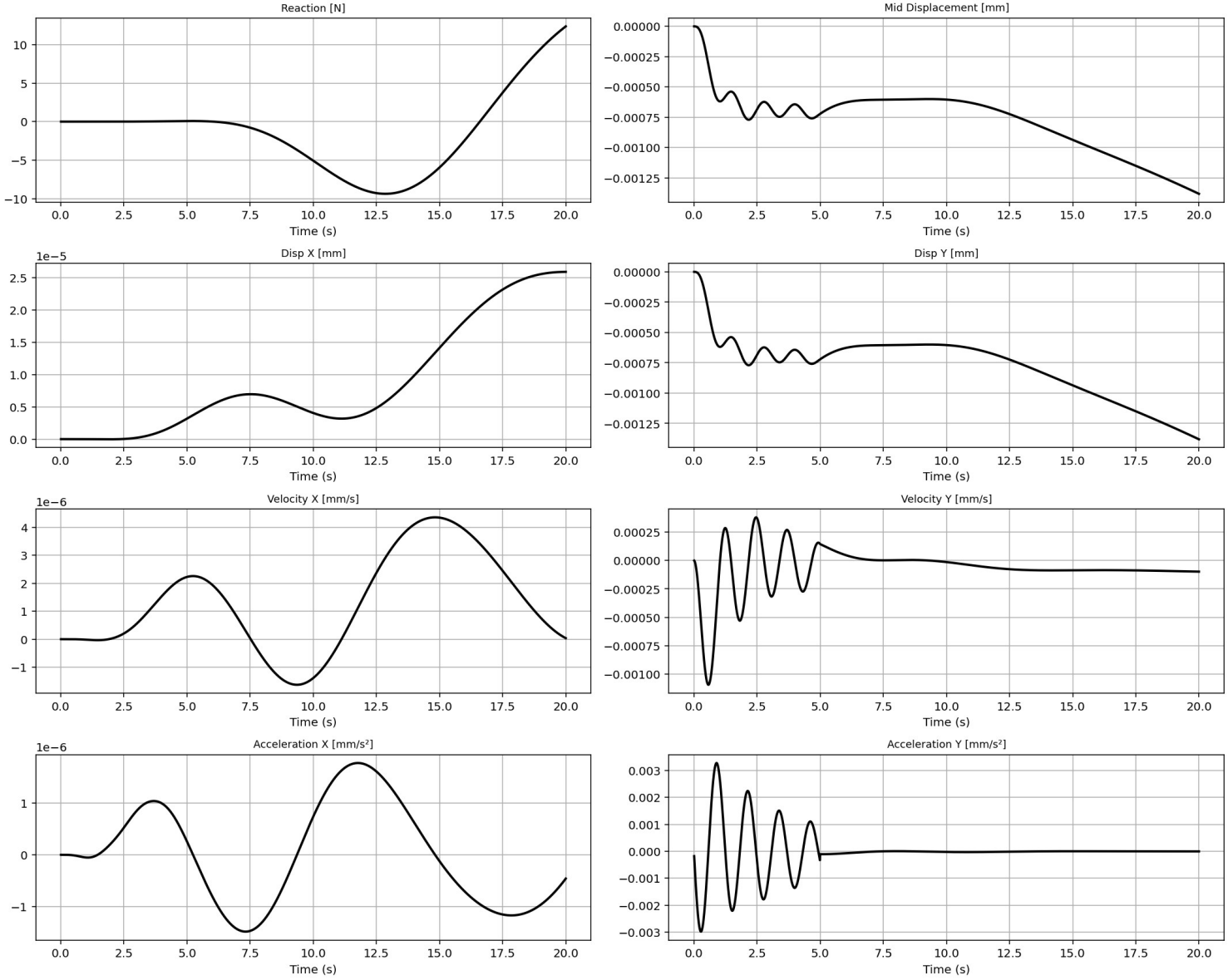


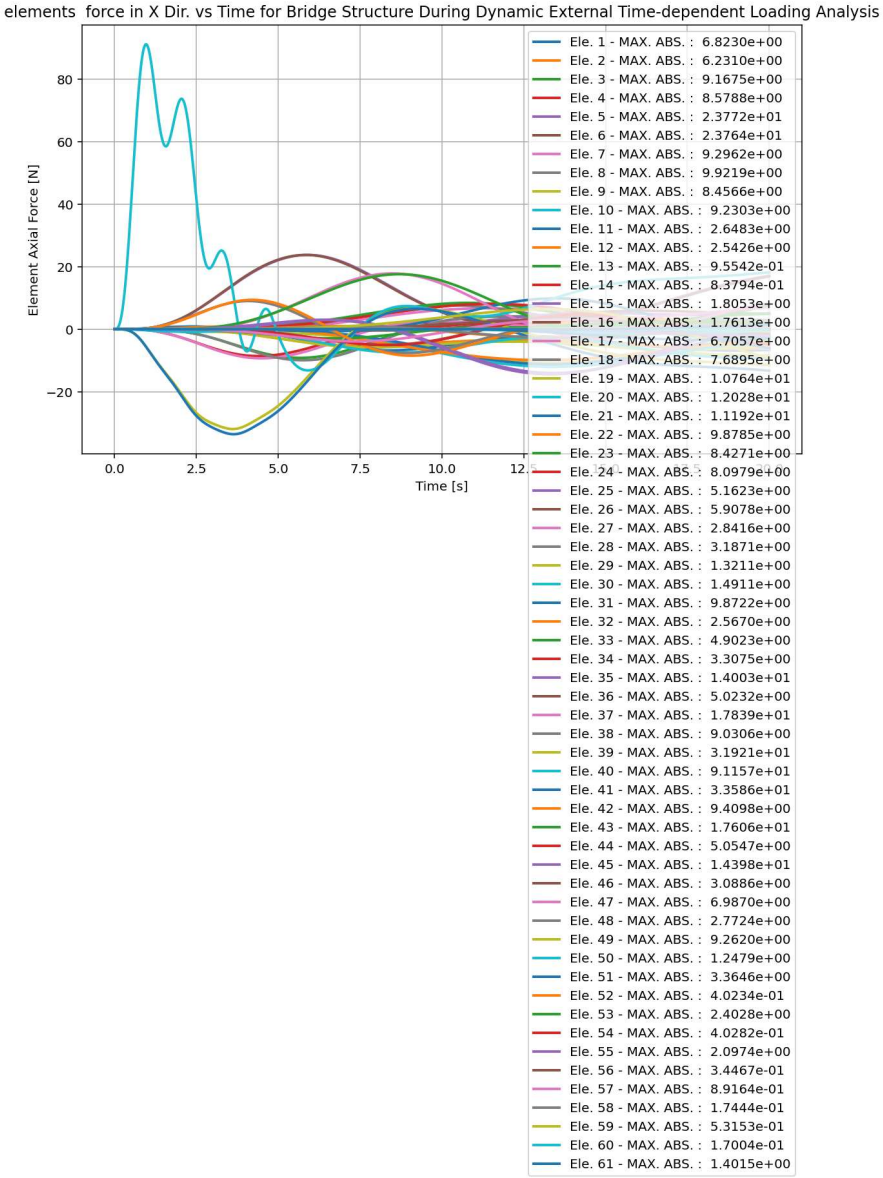
IPython Console | Files | Help | Variable Explorer | Debugger | Plots | History

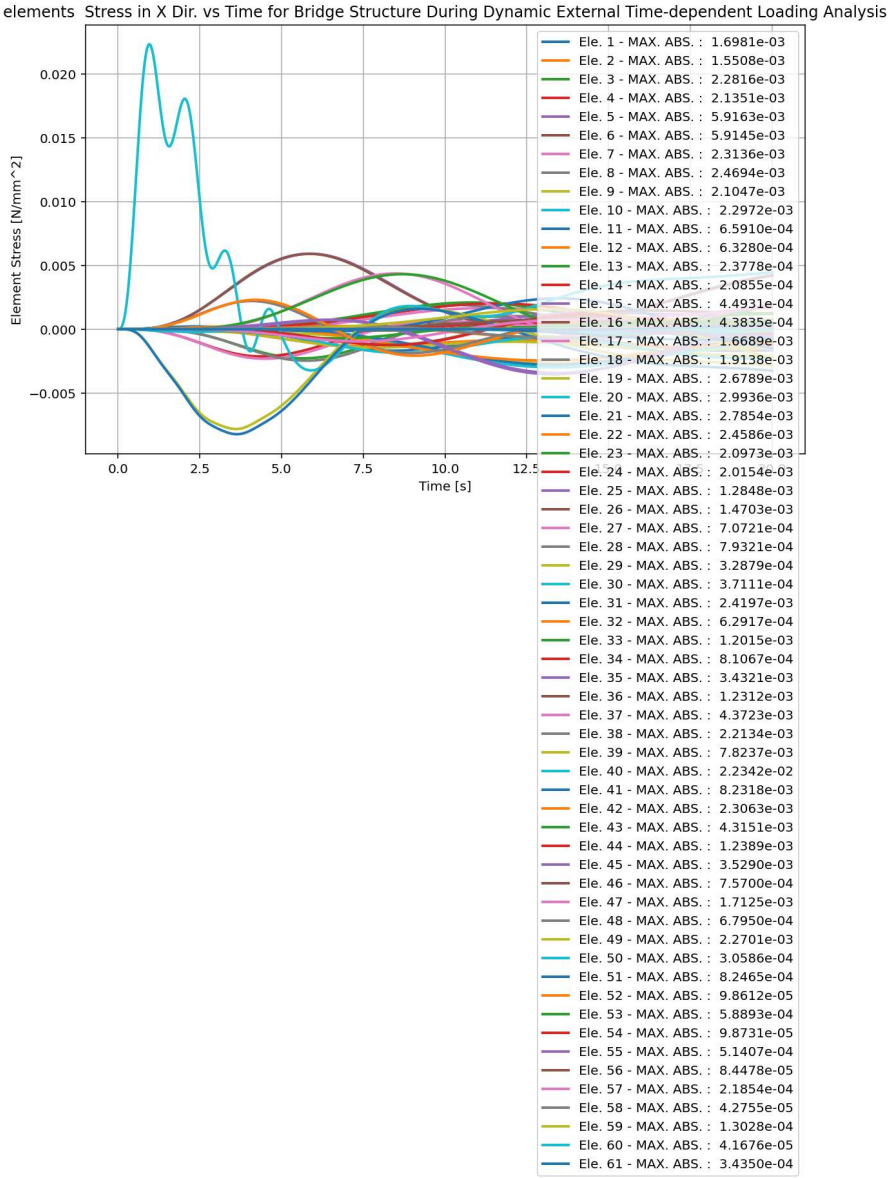
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 71, Col 216 UTF-8 CRLF RW Mem 59%

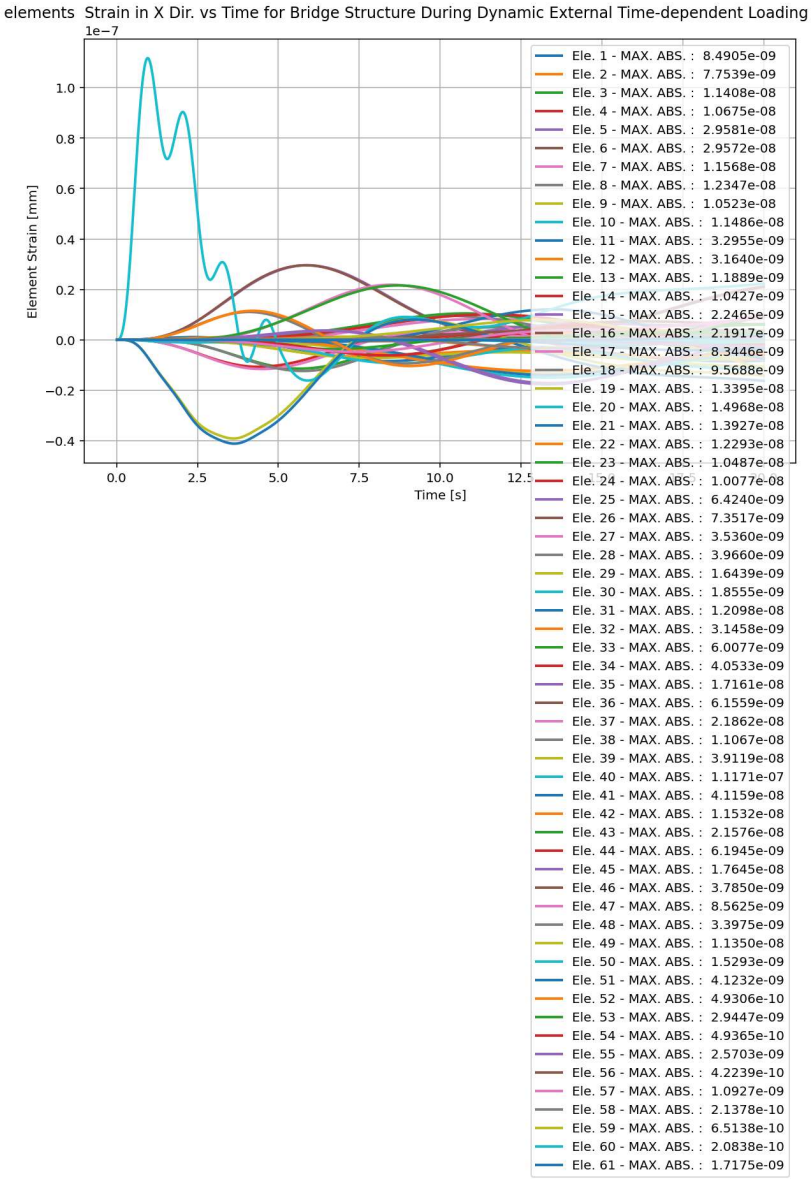

External Time-dependent Loading Over Time
External Loading - Max: 796.029
Force (N)
800
600
400
200
0
−200
−400
−600
0
1
2
3
4
5
Time (s)


Base Reaction and Displacement of Structure During Dynamic External Time-dependent Loading Analysis
Base Reaction [N]
10
5
0
−5
−10
−0.0014
−0.0012
−0.0010
−0.0008
−0.0006
−0.0004
−0.0002
0.0000
Displacement in Middle Span [mm]

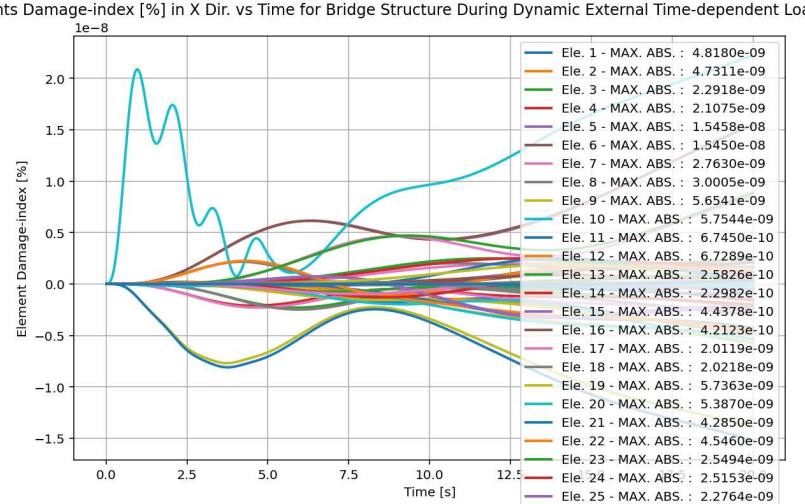

Reaction [N]
Time (s)
Mid Displacement [mm]
Time (s)
Disp X [mm]
1e−5
Time (s)
Disp Y [mm]
Time (s)
Velocity X [mm/s]
1e−6
Time (s)
Velocity Y [mm/s]
Time (s)
Acceleration X [mm/s²]
1e−6
Time (s)
Acceleration Y [mm/s²]
Time (s)


elements force in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
Element Axial Force [N]
Time [s]
Ele. 1 - MAX. ABS. : 6.8230e+00
Ele. 2 - MAX. ABS. : 6.2310e+00
Ele. 3 - MAX. ABS. : 9.1675e+00
Ele. 4 - MAX. ABS. : 8.5788e+00
Ele. 5 - MAX. ABS. : 2.3772e+01
Ele. 6 - MAX. ABS. : 2.3764e+01
Ele. 7 - MAX. ABS. : 9.2962e+00
Ele. 8 - MAX. ABS. : 9.9219e+00
Ele. 9 - MAX. ABS. : 8.4566e+00
Ele. 10 - MAX. ABS. : 9.2303e+00
Ele. 11 - MAX. ABS. : 2.6483e+00
Ele. 12 - MAX. ABS. : 2.5426e+00
Ele. 13 - MAX. ABS. : 9.5542e-01
Ele. 14 - MAX. ABS. : 8.3794e-01
Ele. 15 - MAX. ABS. : 1.8053e+00
Ele. 16 - MAX. ABS. : 1.7613e+00
Ele. 17 - MAX. ABS. : 6.7057e+00
Ele. 18 - MAX. ABS. : 7.6895e+00
Ele. 19 - MAX. ABS. : 1.0764e+01
Ele. 20 - MAX. ABS. : 1.2028e+01
Ele. 21 - MAX. ABS. : 1.1192e+01
Ele. 22 - MAX. ABS. : 9.8785e+00
Ele. 23 - MAX. ABS. : 8.4271e+00
Ele. 24 - MAX. ABS. : 8.0979e+00
Ele. 25 - MAX. ABS. : 5.1623e+00
Ele. 26 - MAX. ABS. : 5.9078e+00
Ele. 27 - MAX. ABS. : 2.8416e+00
Ele. 28 - MAX. ABS. : 3.1871e+00
Ele. 29 - MAX. ABS. : 1.3211e+00
Ele. 30 - MAX. ABS. : 1.4911e+00
Ele. 31 - MAX. ABS. : 9.8722e+00
Ele. 32 - MAX. ABS. : 2.5670e+00
Ele. 33 - MAX. ABS. : 4.9023e+00
Ele. 34 - MAX. ABS. : 3.3075e+00
Ele. 35 - MAX. ABS. : 1.4003e+01
Ele. 36 - MAX. ABS. : 5.0232e+00
Ele. 37 - MAX. ABS. : 1.7839e+01
Ele. 38 - MAX. ABS. : 9.0306e+00
Ele. 39 - MAX. ABS. : 3.1921e+01
Ele. 40 - MAX. ABS. : 9.1157e+01
Ele. 41 - MAX. ABS. : 3.3586e+01
Ele. 42 - MAX. ABS. : 9.4098e+00
Ele. 43 - MAX. ABS. : 1.7606e+01
Ele. 44 - MAX. ABS. : 5.0547e+00
Ele. 45 - MAX. ABS. : 1.4398e+01
Ele. 46 - MAX. ABS. : 3.0886e+00
Ele. 47 - MAX. ABS. : 6.9870e+00
Ele. 48 - MAX. ABS. : 2.7724e+00
Ele. 49 - MAX. ABS. : 9.2620e+00
Ele. 50 - MAX. ABS. : 1.2479e+00
Ele. 51 - MAX. ABS. : 3.3646e+00
Ele. 52 - MAX. ABS. : 4.0234e-01
Ele. 53 - MAX. ABS. : 2.4028e+00
Ele. 54 - MAX. ABS. : 4.0282e-01
Ele. 55 - MAX. ABS. : 2.0974e+00
Ele. 56 - MAX. ABS. : 3.4467e-01
Ele. 57 - MAX. ABS. : 8.9164e-01
Ele. 58 - MAX. ABS. : 1.7444e-01
Ele. 59 - MAX. ABS. : 5.3153e-01
Ele. 60 - MAX. ABS. : 1.7004e-01
Ele. 61 - MAX. ABS. : 1.4015e+00

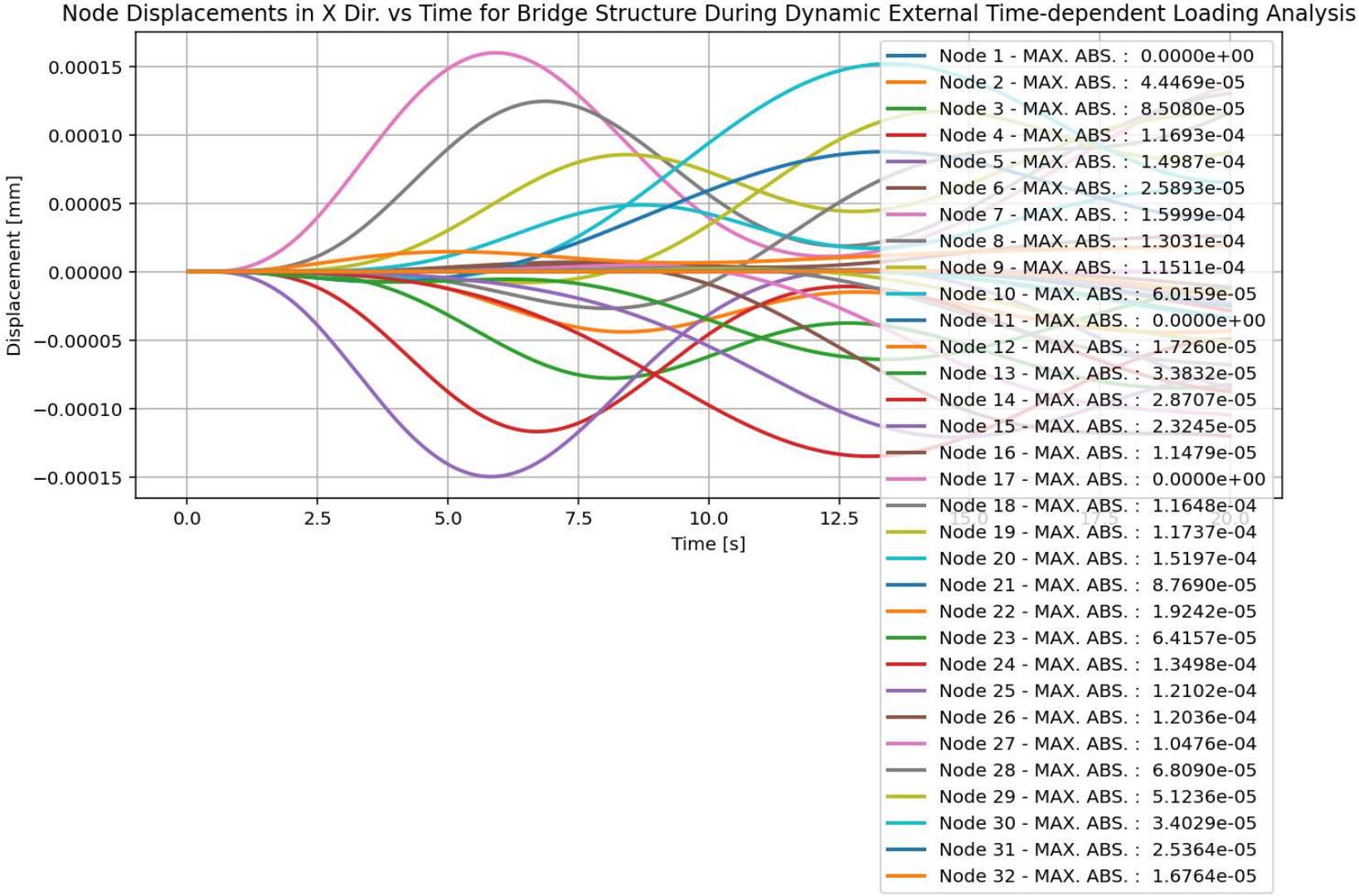

elements Stress in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
Element Stress [N/mm^2]
Time [s]
0.020
0.015
0.010
0.005
0.000
−0.005
0.0
2.5
5.0
7.5
10.0
12.5
Ele. 1 - MAX. ABS. : 1.6981e-03
Ele. 2 - MAX. ABS. : 1.5508e-03
Ele. 3 - MAX. ABS. : 2.2816e-03
Ele. 4 - MAX. ABS. : 2.1351e-03
Ele. 5 - MAX. ABS. : 5.9163e-03
Ele. 6 - MAX. ABS. : 5.9145e-03
Ele. 7 - MAX. ABS. : 2.3136e-03
Ele. 8 - MAX. ABS. : 2.4694e-03
Ele. 9 - MAX. ABS. : 2.1047e-03
Ele. 10 - MAX. ABS. : 2.2972e-03
Ele. 11 - MAX. ABS. : 6.5910e-04
Ele. 12 - MAX. ABS. : 6.3280e-04
Ele. 13 - MAX. ABS. : 2.3778e-04
Ele. 14 - MAX. ABS. : 2.0855e-04
Ele. 15 - MAX. ABS. : 4.4931e-04
Ele. 16 - MAX. ABS. : 4.3835e-04
Ele. 17 - MAX. ABS. : 1.6689e-03
Ele. 18 - MAX. ABS. : 1.9138e-03
Ele. 19 - MAX. ABS. : 2.6789e-03
Ele. 20 - MAX. ABS. : 2.9936e-03
Ele. 21 - MAX. ABS. : 2.7854e-03
Ele. 22 - MAX. ABS. : 2.4586e-03
Ele. 23 - MAX. ABS. : 2.0973e-03
Ele. 24 - MAX. ABS. : 2.0154e-03
Ele. 25 - MAX. ABS. : 1.2848e-03
Ele. 26 - MAX. ABS. : 1.4703e-03
Ele. 27 - MAX. ABS. : 7.0721e-04
Ele. 28 - MAX. ABS. : 7.9321e-04
Ele. 29 - MAX. ABS. : 3.2879e-04
Ele. 30 - MAX. ABS. : 3.7111e-04
Ele. 31 - MAX. ABS. : 2.4197e-03
Ele. 32 - MAX. ABS. : 6.2917e-04
Ele. 33 - MAX. ABS. : 1.2015e-03
Ele. 34 - MAX. ABS. : 8.1067e-04
Ele. 35 - MAX. ABS. : 3.4321e-03
Ele. 36 - MAX. ABS. : 1.2312e-03
Ele. 37 - MAX. ABS. : 4.3723e-03
Ele. 38 - MAX. ABS. : 2.2134e-03
Ele. 39 - MAX. ABS. : 7.8237e-03
Ele. 40 - MAX. ABS. : 2.2342e-02
Ele. 41 - MAX. ABS. : 8.2318e-03
Ele. 42 - MAX. ABS. : 2.3063e-03
Ele. 43 - MAX. ABS. : 4.3151e-03
Ele. 44 - MAX. ABS. : 1.2389e-03
Ele. 45 - MAX. ABS. : 3.5290e-03
Ele. 46 - MAX. ABS. : 7.5700e-04
Ele. 47 - MAX. ABS. : 1.7125e-03
Ele. 48 - MAX. ABS. : 6.7950e-04
Ele. 49 - MAX. ABS. : 2.2701e-03
Ele. 50 - MAX. ABS. : 3.0586e-04
Ele. 51 - MAX. ABS. : 8.2465e-04
Ele. 52 - MAX. ABS. : 9.8612e-05
Ele. 53 - MAX. ABS. : 5.8893e-04
Ele. 54 - MAX. ABS. : 9.8731e-05
Ele. 55 - MAX. ABS. : 5.1407e-04
Ele. 56 - MAX. ABS. : 8.4478e-05
Ele. 57 - MAX. ABS. : 2.1854e-04
Ele. 58 - MAX. ABS. : 4.2755e-05
Ele. 59 - MAX. ABS. : 1.3028e-04
Ele. 60 - MAX. ABS. : 4.1676e-05
Ele. 61 - MAX. ABS. : 3.4350e-04

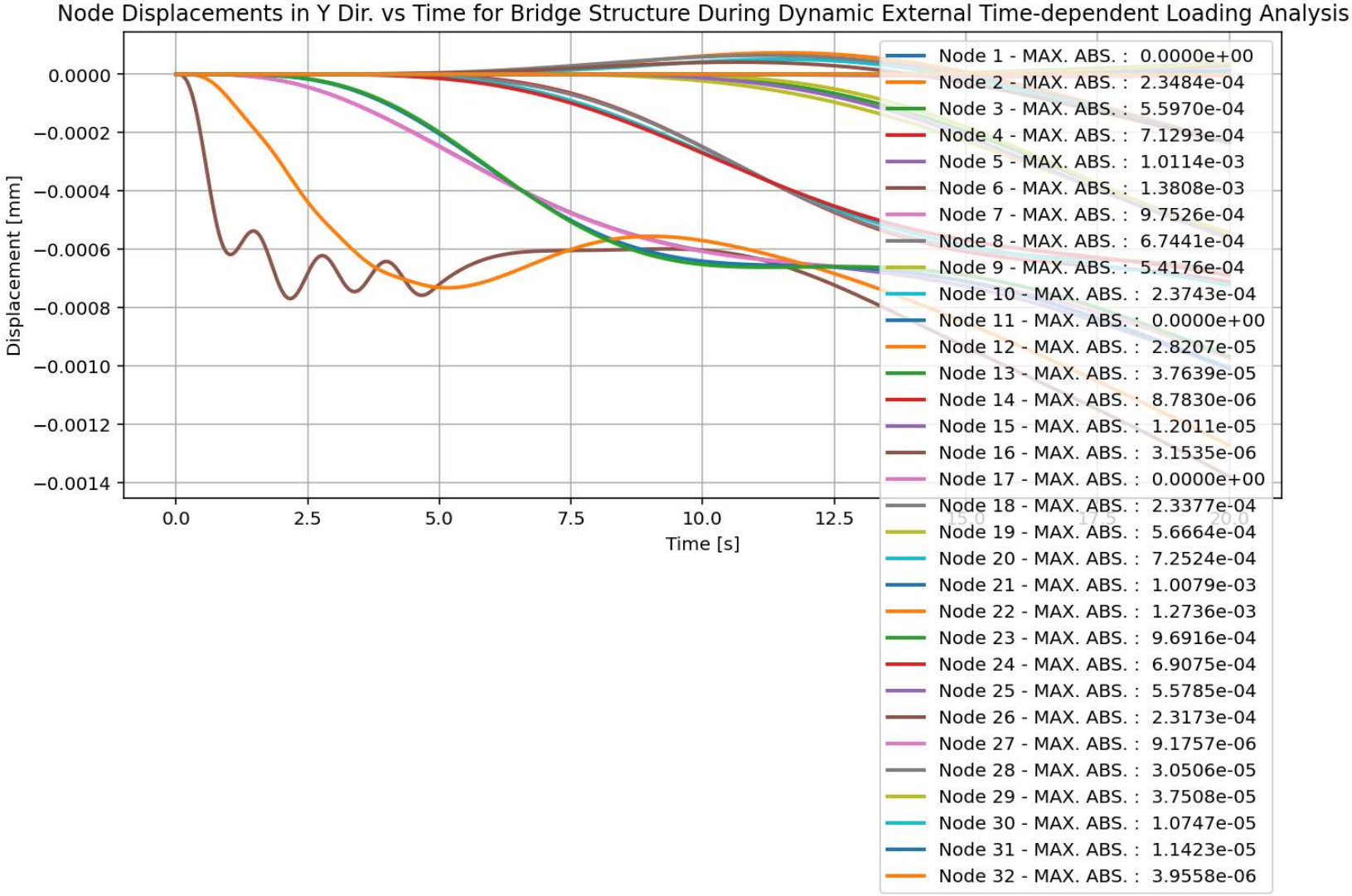

elements Strain in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
1e−7
Element Strain [mm]
Time [s]
Ele. 1 - MAX. ABS. : 8.4905e-09
Ele. 2 - MAX. ABS. : 7.7539e-09
Ele. 3 - MAX. ABS. : 1.1408e-08
Ele. 4 - MAX. ABS. : 1.0675e-08
Ele. 5 - MAX. ABS. : 2.9581e-08
Ele. 6 - MAX. ABS. : 2.9572e-08
Ele. 7 - MAX. ABS. : 1.1568e-08
Ele. 8 - MAX. ABS. : 1.2347e-08
Ele. 9 - MAX. ABS. : 1.0523e-08
Ele. 10 - MAX. ABS. : 1.1486e-08
Ele. 11 - MAX. ABS. : 3.2955e-09
Ele. 12 - MAX. ABS. : 3.1640e-09
Ele. 13 - MAX. ABS. : 1.1889e-09
Ele. 14 - MAX. ABS. : 1.0427e-09
Ele. 15 - MAX. ABS. : 2.2465e-09
Ele. 16 - MAX. ABS. : 2.1917e-09
Ele. 17 - MAX. ABS. : 8.3446e-09
Ele. 18 - MAX. ABS. : 9.5688e-09
Ele. 19 - MAX. ABS. : 1.3395e-08
Ele. 20 - MAX. ABS. : 1.4968e-08
Ele. 21 - MAX. ABS. : 1.3927e-08
Ele. 22 - MAX. ABS. : 1.2293e-08
Ele. 23 - MAX. ABS. : 1.0487e-08
Ele. 24 - MAX. ABS. : 1.0077e-08
Ele. 25 - MAX. ABS. : 6.4240e-09
Ele. 26 - MAX. ABS. : 7.3517e-09
Ele. 27 - MAX. ABS. : 3.5360e-09
Ele. 28 - MAX. ABS. : 3.9660e-09
Ele. 29 - MAX. ABS. : 1.6439e-09
Ele. 30 - MAX. ABS. : 1.8555e-09
Ele. 31 - MAX. ABS. : 1.2098e-08
Ele. 32 - MAX. ABS. : 3.1458e-09
Ele. 33 - MAX. ABS. : 6.0077e-09
Ele. 34 - MAX. ABS. : 4.0533e-09
Ele. 35 - MAX. ABS. : 1.7161e-08
Ele. 36 - MAX. ABS. : 6.1559e-09
Ele. 37 - MAX. ABS. : 2.1862e-08
Ele. 38 - MAX. ABS. : 1.1067e-08
Ele. 39 - MAX. ABS. : 3.9119e-08
Ele. 40 - MAX. ABS. : 1.1171e-07
Ele. 41 - MAX. ABS. : 4.1159e-08
Ele. 42 - MAX. ABS. : 1.1532e-08
Ele. 43 - MAX. ABS. : 2.1576e-08
Ele. 44 - MAX. ABS. : 6.1945e-09
Ele. 45 - MAX. ABS. : 1.7645e-08
Ele. 46 - MAX. ABS. : 3.7850e-09
Ele. 47 - MAX. ABS. : 8.5625e-09
Ele. 48 - MAX. ABS. : 3.3975e-09
Ele. 49 - MAX. ABS. : 1.1350e-08
Ele. 50 - MAX. ABS. : 1.5293e-09
Ele. 51 - MAX. ABS. : 4.1232e-09
Ele. 52 - MAX. ABS. : 4.9306e-10
Ele. 53 - MAX. ABS. : 2.9447e-09
Ele. 54 - MAX. ABS. : 4.9365e-10
Ele. 55 - MAX. ABS. : 2.5703e-09
Ele. 56 - MAX. ABS. : 4.2239e-10
Ele. 57 - MAX. ABS. : 1.0927e-09
Ele. 58 - MAX. ABS. : 2.1378e-10
Ele. 59 - MAX. ABS. : 6.5138e-10
Ele. 60 - MAX. ABS. : 2.0838e-10
Ele. 61 - MAX. ABS. : 1.7175e-09

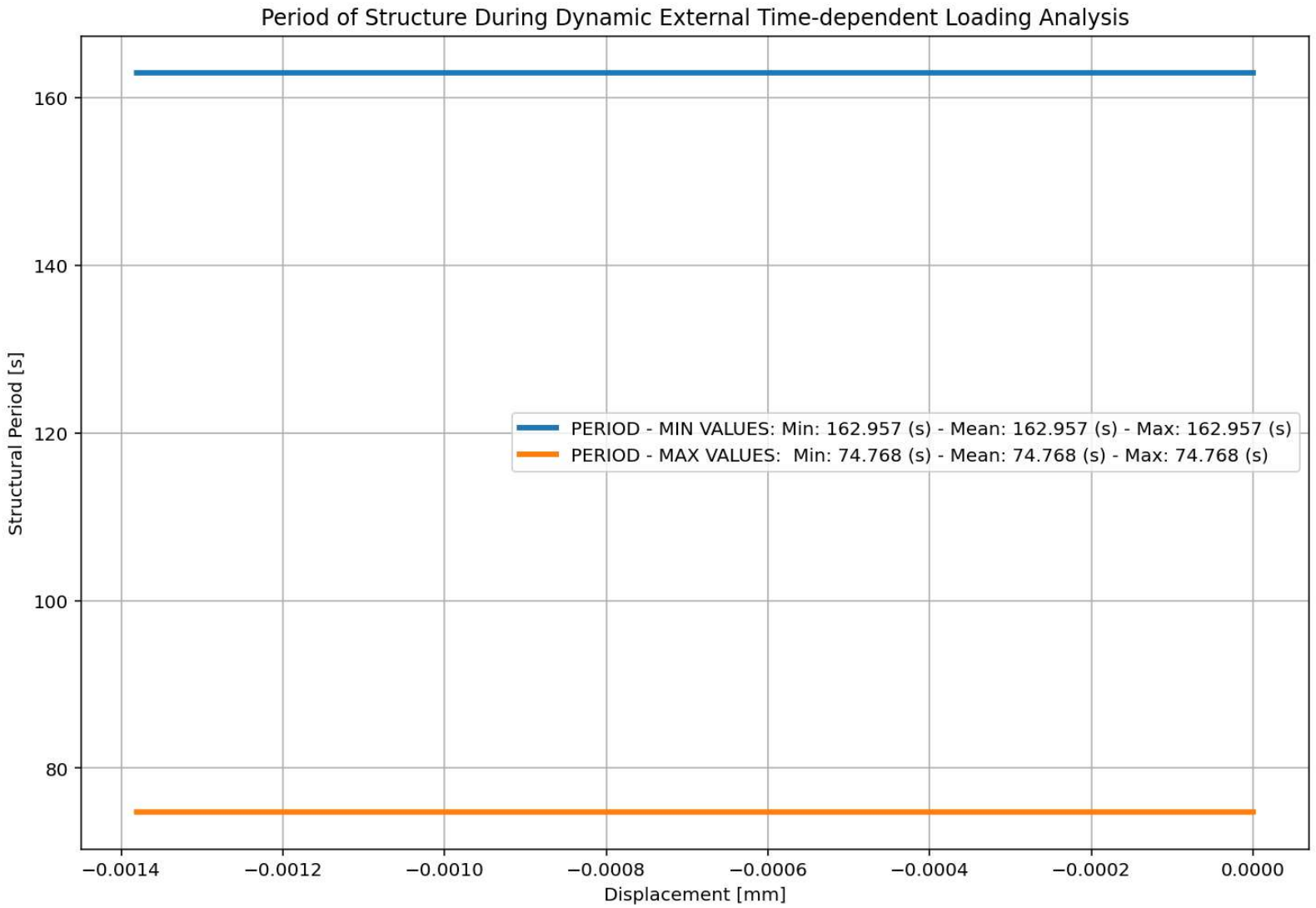
elements Damage-index [%] in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis

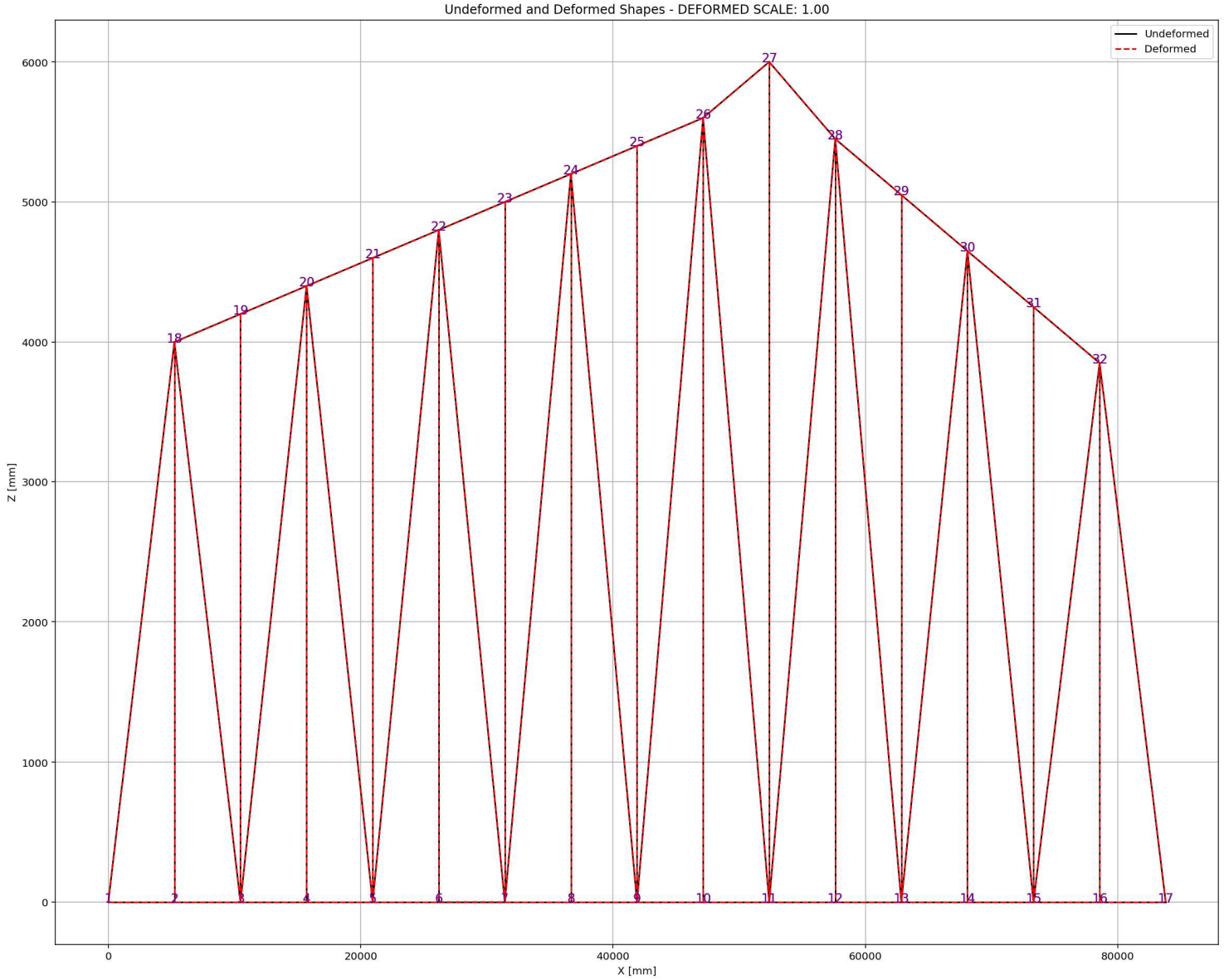


Ele. 1 - MAX. ABS. : 4.8180e-09
Ele. 2 - MAX. ABS. : 4.7311e-09
Ele. 3 - MAX. ABS. : 2.2918e-09
Ele. 4 - MAX. ABS. : 2.1075e-09
Ele. 5 - MAX. ABS. : 1.5458e-08
Ele. 6 - MAX. ABS. : 1.5450e-08
Ele. 7 - MAX. ABS. : 2.7630e-09
Ele. 8 - MAX. ABS. : 3.0005e-09
Ele. 9 - MAX. ABS. : 5.6541e-09
Ele. 10 - MAX. ABS. : 5.7544e-09
Ele. 11 - MAX. ABS. : 6.7450e-10
Ele. 12 - MAX. ABS. : 6.7289e-10
Ele. 13 - MAX. ABS. : 2.5826e-10
Ele. 14 - MAX. ABS. : 2.2982e-10
Ele. 15 - MAX. ABS. : 4.4378e-10
Ele. 16 - MAX. ABS. : 4.2123e-10
Ele. 17 - MAX. ABS. : 2.0119e-09
Ele. 18 - MAX. ABS. : 2.0218e-09
Ele. 19 - MAX. ABS. : 5.7363e-09
Ele. 20 - MAX. ABS. : 5.3870e-09
Ele. 21 - MAX. ABS. : 4.2850e-09
Ele. 22 - MAX. ABS. : 4.5460e-09
Ele. 23 - MAX. ABS. : 2.5494e-09
Ele. 24 - MAX. ABS. : 2.5153e-09
Ele. 25 - MAX. ABS. : 2.2764e-09
Ele. 26 - MAX. ABS. : 2.0993e-09
Ele. 27 - MAX. ABS. : 9.1244e-10
Ele. 28 - MAX. ABS. : 9.4177e-10
Ele. 29 - MAX. ABS. : 3.8003e-10
Ele. 30 - MAX. ABS. : 3.9039e-10
Ele. 31 - MAX. ABS. : 2.5213e-09
Ele. 32 - MAX. ABS. : 4.9781e-10
Ele. 33 - MAX. ABS. : 7.2961e-10
Ele. 34 - MAX. ABS. : 8.7571e-10
Ele. 35 - MAX. ABS. : 3.2373e-09
Ele. 36 - MAX. ABS. : 1.5038e-09
Ele. 37 - MAX. ABS. : 8.5460e-09
Ele. 38 - MAX. ABS. : 2.1587e-09
Ele. 39 - MAX. ABS. : 1.3851e-08
Ele. 40 - MAX. ABS. : 2.2254e-08
Ele. 41 - MAX. ABS. : 1.5224e-08
Ele. 42 - MAX. ABS. : 2.2540e-09
Ele. 43 - MAX. ABS. : 8.8628e-09
Ele. 44 - MAX. ABS. : 1.5674e-09
Ele. 45 - MAX. ABS. : 3.2897e-09
Ele. 46 - MAX. ABS. : 8.5474e-10
Ele. 47 - MAX. ABS. : 1.0021e-09
Ele. 48 - MAX. ABS. : 5.7570e-10
Ele. 49 - MAX. ABS. : 1.9054e-09
Ele. 50 - MAX. ABS. : 3.4330e-10
Ele. 51 - MAX. ABS. : 9.3201e-10
Ele. 52 - MAX. ABS. : 1.1406e-10
Ele. 53 - MAX. ABS. : 7.1603e-10
Ele. 54 - MAX. ABS. : 9.9216e-11
Ele. 55 - MAX. ABS. : 5.5635e-10
Ele. 56 - MAX. ABS. : 8.7237e-11
Ele. 57 - MAX. ABS. : 2.4559e-10
Ele. 58 - MAX. ABS. : 4.3338e-11
Ele. 59 - MAX. ABS. : 1.2119e-10
Ele. 60 - MAX. ABS. : 4.1429e-11
Ele. 61 - MAX. ABS. : 3.3919e-10


Node Displacements in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
Displacement [mm]
0.00015
0.00010
0.00005
0.00000
−0.00005
−0.00010
−0.00015
0.0
2.5
5.0
7.5
10.0
12.5
Time [s]
Node 1 - MAX. ABS. : 0.0000e+00
Node 2 - MAX. ABS. : 4.4469e-05
Node 3 - MAX. ABS. : 8.5080e-05
Node 4 - MAX. ABS. : 1.1693e-04
Node 5 - MAX. ABS. : 1.4987e-04
Node 6 - MAX. ABS. : 2.5893e-05
Node 7 - MAX. ABS. : 1.5999e-04
Node 8 - MAX. ABS. : 1.3031e-04
Node 9 - MAX. ABS. : 1.1511e-04
Node 10 - MAX. ABS. : 6.0159e-05
Node 11 - MAX. ABS. : 0.0000e+00
Node 12 - MAX. ABS. : 1.7260e-05
Node 13 - MAX. ABS. : 3.3832e-05
Node 14 - MAX. ABS. : 2.8707e-05
Node 15 - MAX. ABS. : 2.3245e-05
Node 16 - MAX. ABS. : 1.1479e-05
Node 17 - MAX. ABS. : 0.0000e+00
Node 18 - MAX. ABS. : 1.1648e-04
Node 19 - MAX. ABS. : 1.1737e-04
Node 20 - MAX. ABS. : 1.5197e-04
Node 21 - MAX. ABS. : 8.7690e-05
Node 22 - MAX. ABS. : 1.9242e-05
Node 23 - MAX. ABS. : 6.4157e-05
Node 24 - MAX. ABS. : 1.3498e-04
Node 25 - MAX. ABS. : 1.2102e-04
Node 26 - MAX. ABS. : 1.2036e-04
Node 27 - MAX. ABS. : 1.0476e-04
Node 28 - MAX. ABS. : 6.8090e-05
Node 29 - MAX. ABS. : 5.1236e-05
Node 30 - MAX. ABS. : 3.4029e-05
Node 31 - MAX. ABS. : 2.5364e-05
Node 32 - MAX. ABS. : 1.6764e-05


Node Displacements in Y Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
Displacement [mm]
0.0000
−0.0002
−0.0004
−0.0006
−0.0008
−0.0010
−0.0012
−0.0014
0.0
2.5
5.0
7.5
10.0
12.5
Time [s]
Node 1 - MAX. ABS. : 0.0000e+00
Node 2 - MAX. ABS. : 2.3484e-04
Node 3 - MAX. ABS. : 5.5970e-04
Node 4 - MAX. ABS. : 7.1293e-04
Node 5 - MAX. ABS. : 1.0114e-03
Node 6 - MAX. ABS. : 1.3808e-03
Node 7 - MAX. ABS. : 9.7526e-04
Node 8 - MAX. ABS. : 6.7441e-04
Node 9 - MAX. ABS. : 5.4176e-04
Node 10 - MAX. ABS. : 2.3743e-04
Node 11 - MAX. ABS. : 0.0000e+00
Node 12 - MAX. ABS. : 2.8207e-05
Node 13 - MAX. ABS. : 3.7639e-05
Node 14 - MAX. ABS. : 8.7830e-06
Node 15 - MAX. ABS. : 1.2011e-05
Node 16 - MAX. ABS. : 3.1535e-06
Node 17 - MAX. ABS. : 0.0000e+00
Node 18 - MAX. ABS. : 2.3377e-04
Node 19 - MAX. ABS. : 5.6664e-04
Node 20 - MAX. ABS. : 7.2524e-04
Node 21 - MAX. ABS. : 1.0079e-03
Node 22 - MAX. ABS. : 1.2736e-03
Node 23 - MAX. ABS. : 9.6916e-04
Node 24 - MAX. ABS. : 6.9075e-04
Node 25 - MAX. ABS. : 5.5785e-04
Node 26 - MAX. ABS. : 2.3173e-04
Node 27 - MAX. ABS. : 9.1757e-06
Node 28 - MAX. ABS. : 3.0506e-05
Node 29 - MAX. ABS. : 3.7508e-05
Node 30 - MAX. ABS. : 1.0747e-05
Node 31 - MAX. ABS. : 1.1423e-05
Node 32 - MAX. ABS. : 3.9558e-06


Period of Structure During Dynamic External Time-dependent Loading Analysis
Structural Period [s]
160
140
120
100
80
−0.0014
−0.0012
−0.0010
−0.0008
−0.0006
−0.0004
−0.0002
0.0000
Displacement [mm]
PERIOD - MIN VALUES: Min: 162.957 (s) - Mean: 162.957 (s) - Max: 162.957 (s)
PERIOD - MAX VALUES: Min: 74.768 (s) - Mean: 74.768 (s) - Max: 74.768 (s)


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
1000
2000
3000
4000
5000
6000
0
20000
40000
60000
80000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
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30
31
32

FREE-VIBRATION ANALYSIS

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

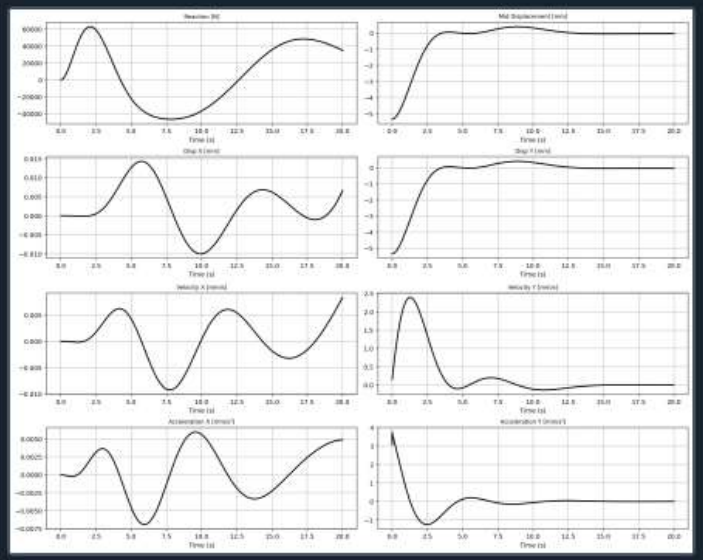
...Dell\Desktop\OPENSEES_FILES\+BRIDGE_RAILROAD_TRUSS_TWO_SPANS

C:\Users\Dell\Desktop\OPENSEES_FILES\+BRIDGE_RAIL..._Flint River Bridge_Tuscaloosa Railroad Bridge.py

BRIDGE_RAILROAD_TR...Railroad Bridge.py

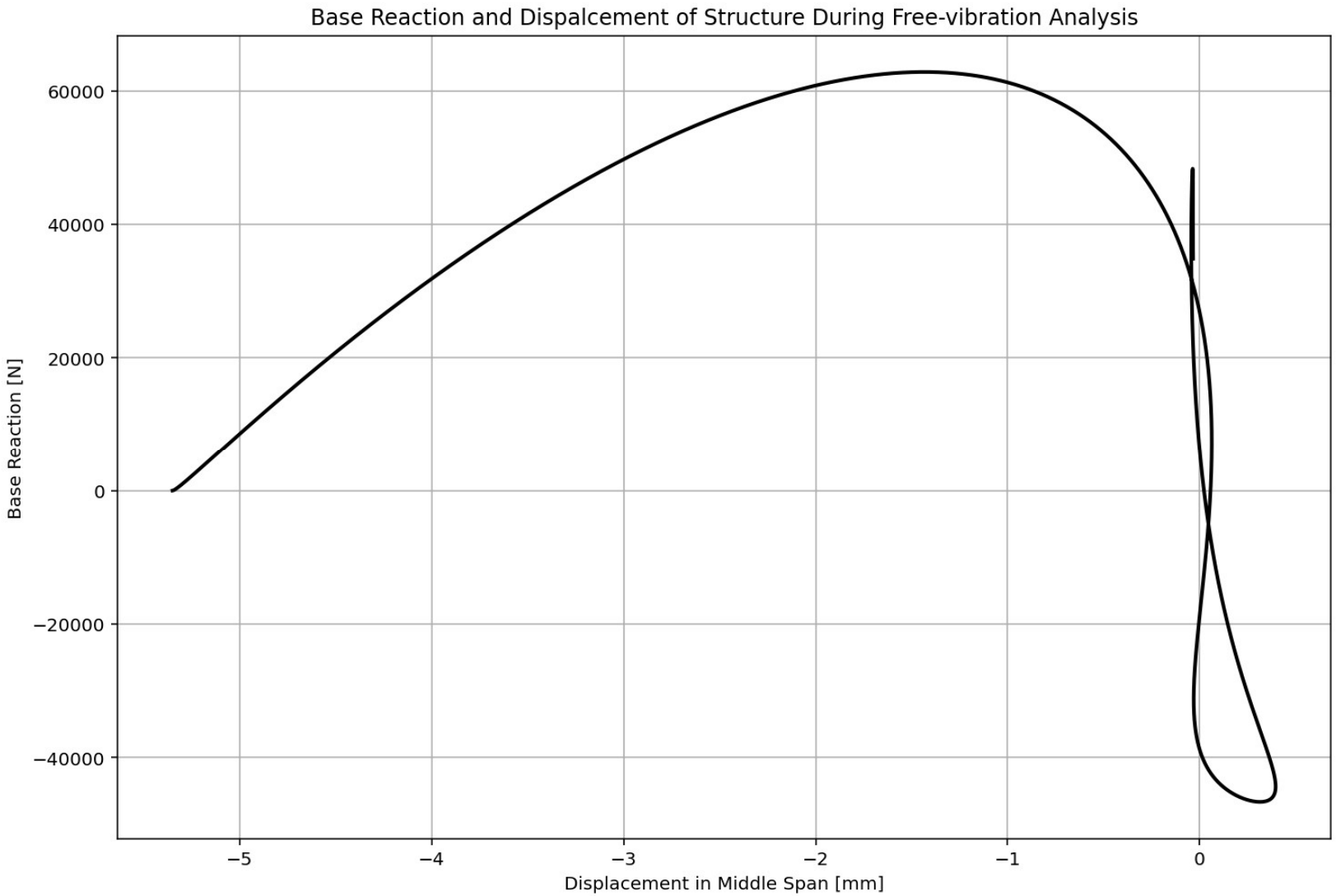
```
1475    # FREE-VIBRATION ANALYSIS (DYNAMIC TIME-HISTORY ANALYSIS)
1476    #ELE_TYPE = 'Truss'      # MATERIAL NONLINEARITY
1477    ELE_TYPE = 'corotTruss'  # MATERIAL AND GEOMETRIC NONLINEARITY
1478    MAT_TYPE = 'INELASTIC'   # 'ELASTIC' OR 'INELASTIC'
1479    ANAL_TYPE = 'FREE-VIBRATION'
1480    DATA = WARREN_TRUSS_BRIDGE(L, H, A_chord, A_diag, MAT_TYPE, ELE_TYPE, ANAL_TYPE, TOTAL_MAS
1481
1482    (time_FV, reaction_FV, disp_mid_FV,
1483    ele_force_FV, ele_stress_FV, ele_strain_FV,
1484    node_displacementsX_FV, node_displacementsY_FV,
1485    dispX_FV, dispY_FV,
1486    veloX_FV, veloY_FV,
1487    accX_FV, accY_FV,
1488    stiffness_FV, PERIOD_FV, damping_ratio_FV,
1489    PERIOD_MIN_FV, PERIOD_MAX_FV) = DATA
1490
1491    XDATA = disp_mid_FV
1492    YDATA = reaction_FV
1493    XLABEL = 'Displacement in Middle Span [mm]'
1494    YLABEL = 'Base Reaction [N]'
1495    TITLE = 'Base Reaction and Dispalcement of Structure During Free-vibration Analysis'
1496    COLOR = 'black'
1497    SEMILOGY = False
1498    PLOT(XDATA, YDATA, TITLE, XLABEL, YLABEL, COLOR, SEMILOGY)
1499
1500    PLOT_TIME_HISTORY(time_FV, reaction_FV, disp_mid_FV,
1501                      dispX_FV, dispY_FV,
1502                      veloX_FV, veloY_FV,
1503                      accX_FV, accY_FV)
1504
1505    # PLOT ELEMENTS AXIAL FORCE
1506    YLABEL = 'Element Axial Force [N]'
1507    TITLE = "elements  force in X Dir. vs Time for Bridge Structure During Free-vibration Anal
1508    PLOT_FORCES(time_FV, ele_force_FV, YLABEL, TITLE) # BRIDGE STRUCTURE - ELEMENTS AXIAL FORC
```

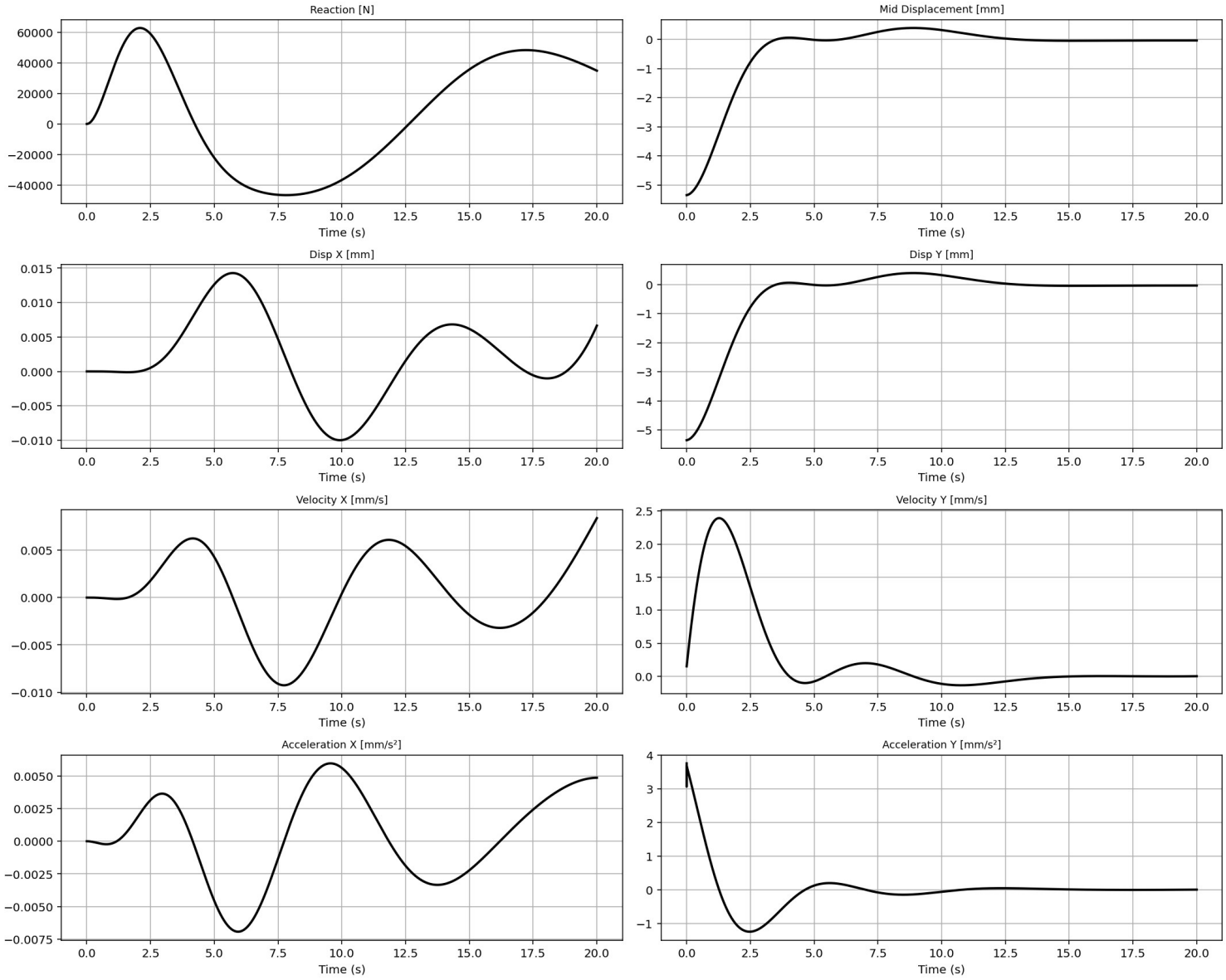
21 %

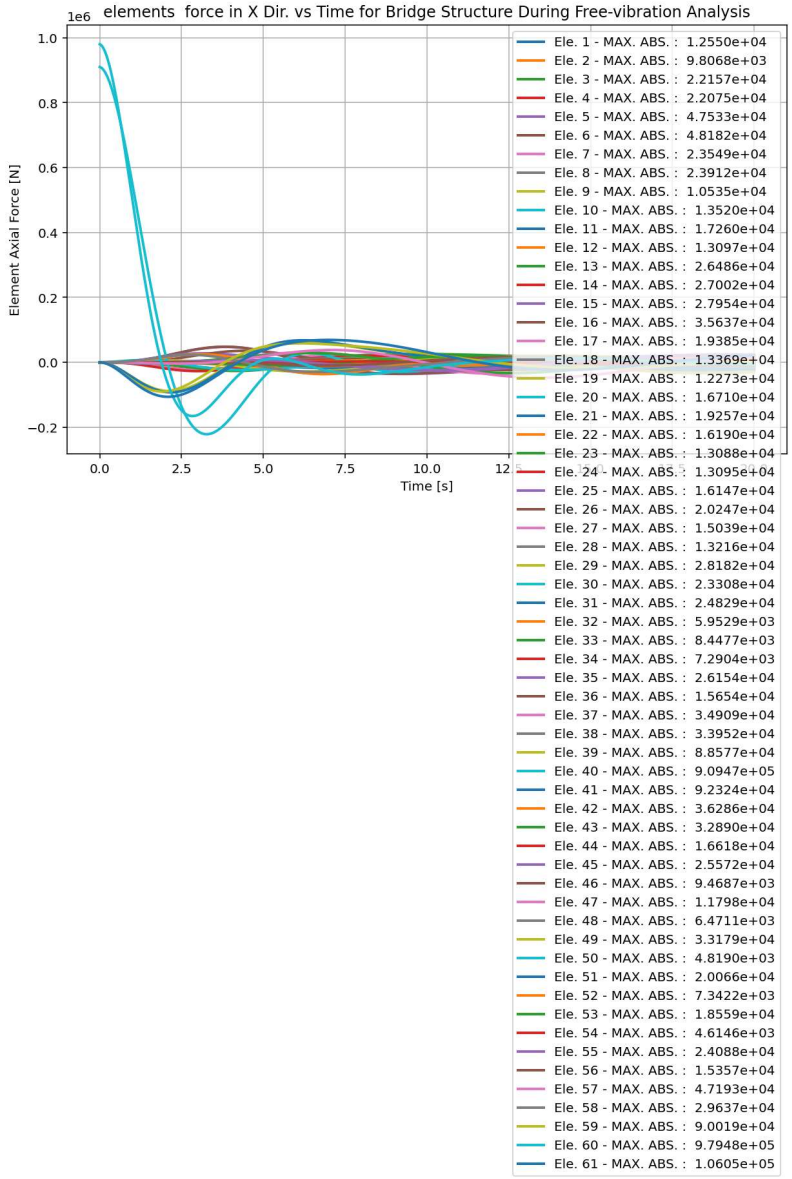


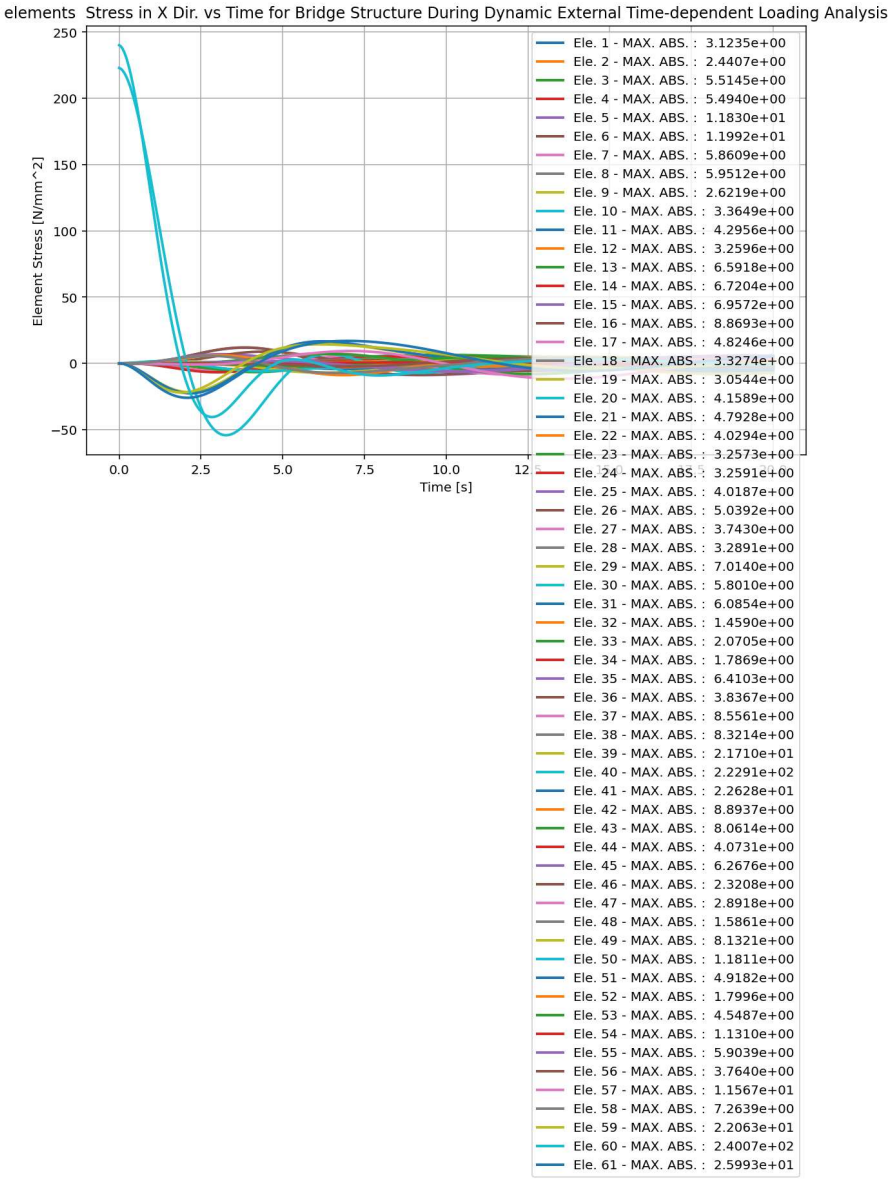
IPython Console | Files | Help | Variable Explorer | Debugger | Plots | History

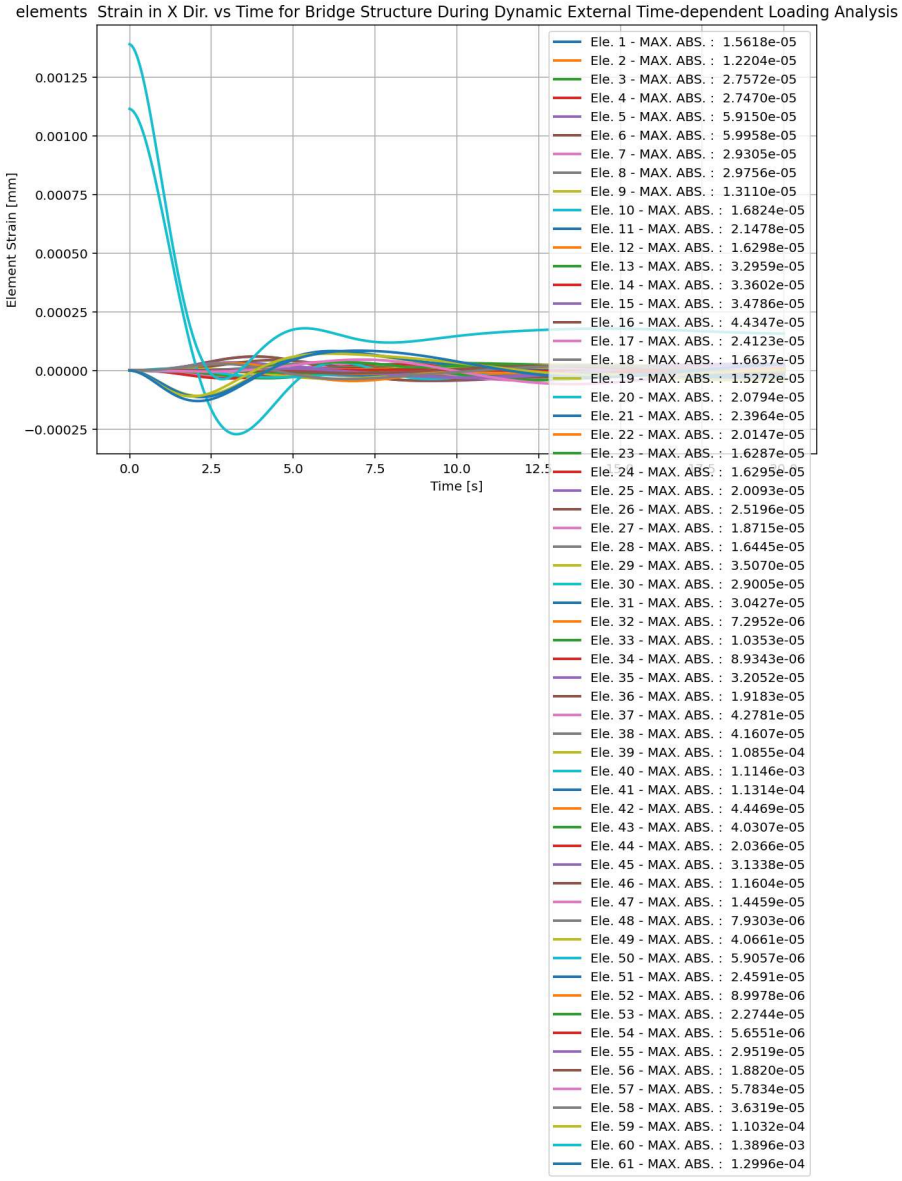
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 71, Col 216 UTF-8 CRLF RW Mem 60%

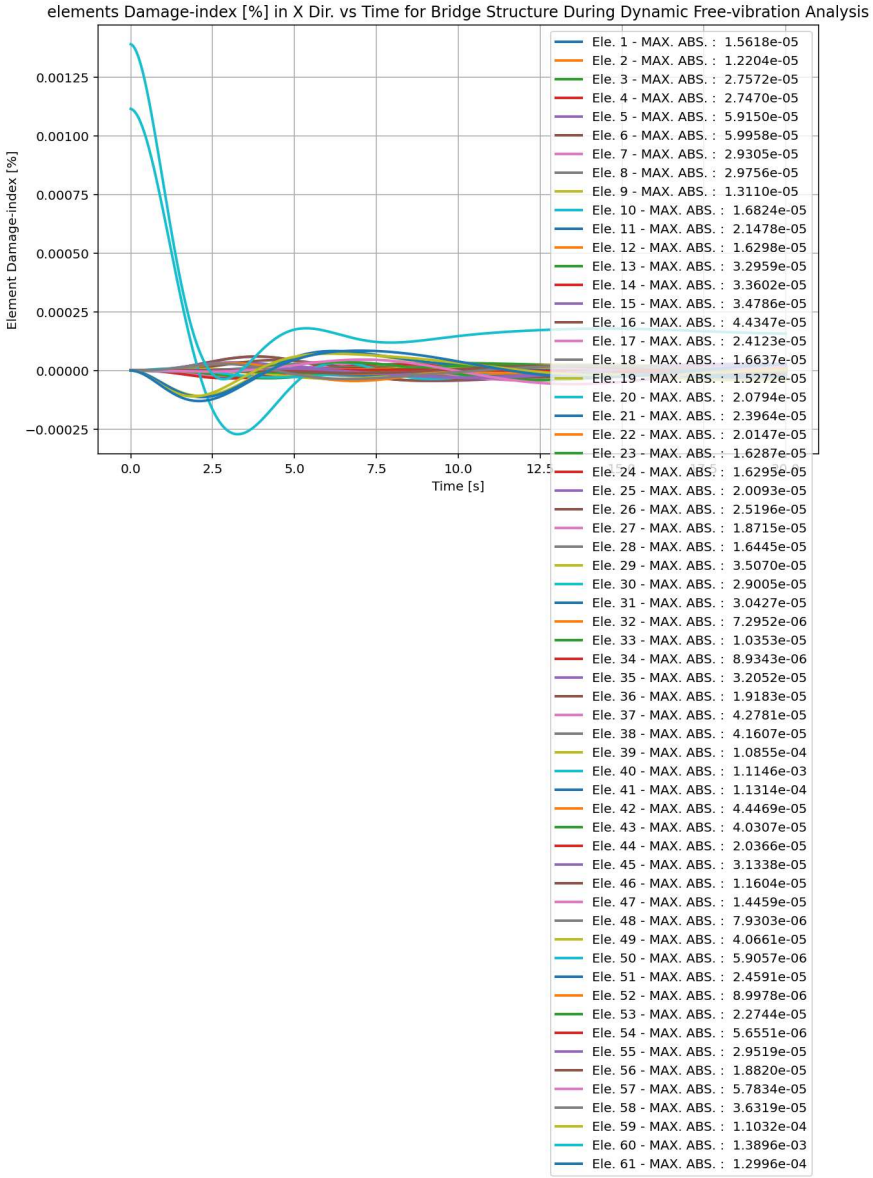

Base Reaction and Dispalcement of Structure During Free-vibration Analysis
60000
40000
20000
0
−20000
−40000
Base Reaction [N]
−5
−4
−3
−2
−1
0
Displacement in Middle Span [mm]

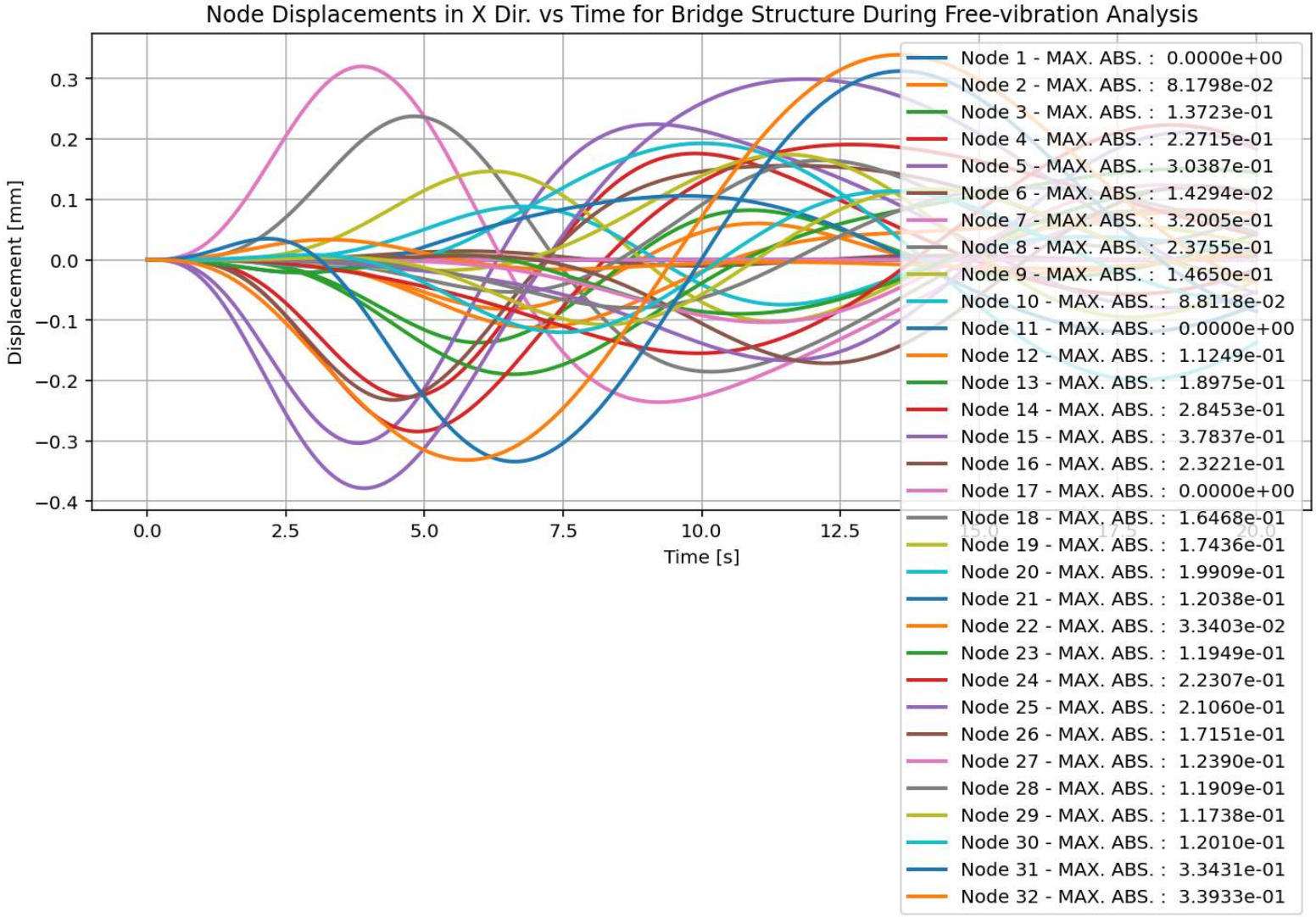

Reaction [N]
Time (s)
Mid Displacement [mm]
Time (s)
Disp X [mm]
Time (s)
Disp Y [mm]
Time (s)
Velocity X [mm/s]
Time (s)
Velocity Y [mm/s]
Time (s)
Acceleration X [mm/s²]
Time (s)
Acceleration Y [mm/s²]
Time (s)

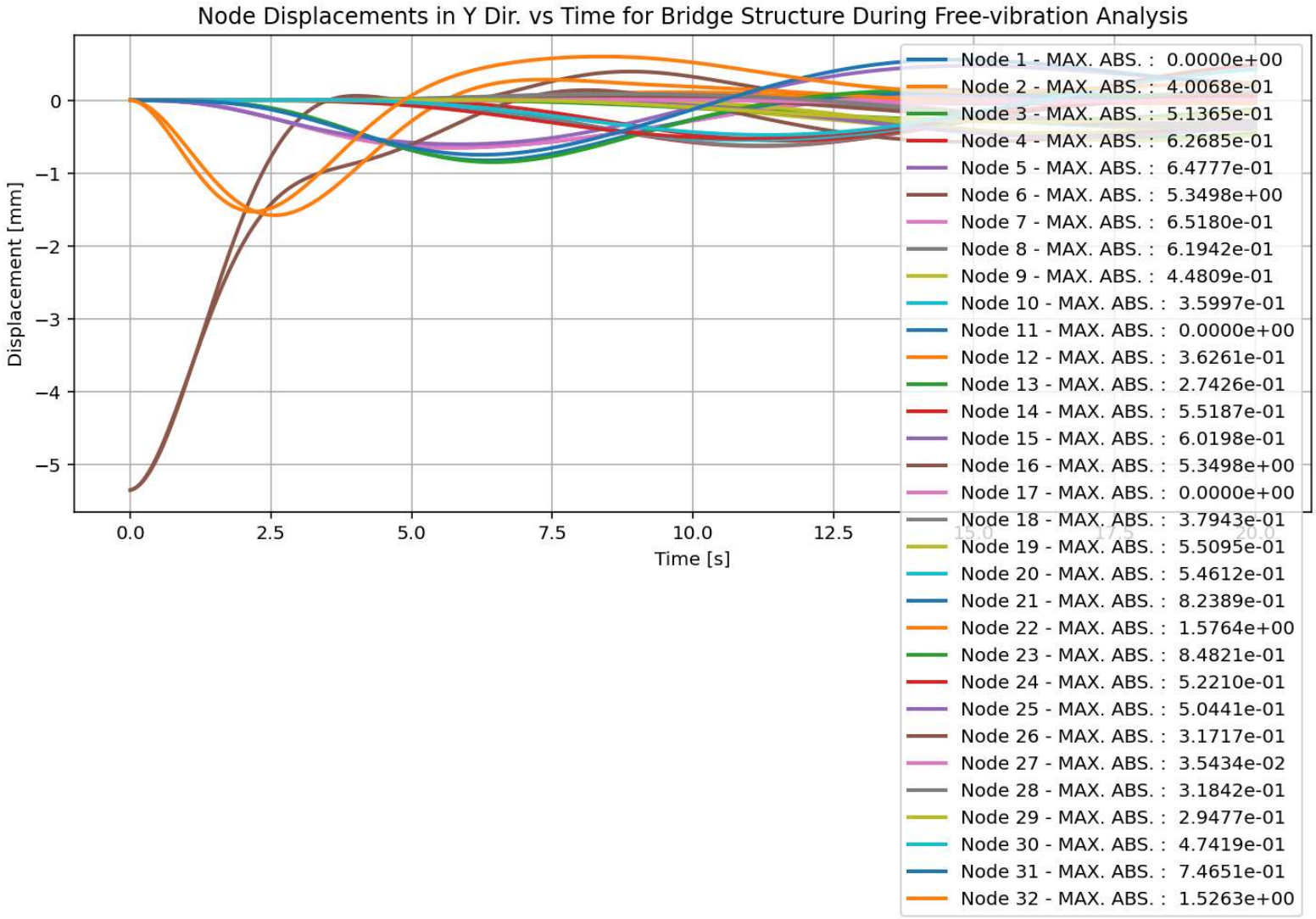

elements force in X Dir. vs Time for Bridge Structure During Free-vibration Analysis
1e6
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
Element Axial Force [N]
0.0
2.5
5.0
7.5
10.0
12.5
Time [s]
Ele. 1 - MAX. ABS. : 1.2550e+04
Ele. 2 - MAX. ABS. : 9.8068e+03
Ele. 3 - MAX. ABS. : 2.2157e+04
Ele. 4 - MAX. ABS. : 2.2075e+04
Ele. 5 - MAX. ABS. : 4.7533e+04
Ele. 6 - MAX. ABS. : 4.8182e+04
Ele. 7 - MAX. ABS. : 2.3549e+04
Ele. 8 - MAX. ABS. : 2.3912e+04
Ele. 9 - MAX. ABS. : 1.0535e+04
Ele. 10 - MAX. ABS. : 1.3520e+04
Ele. 11 - MAX. ABS. : 1.7260e+04
Ele. 12 - MAX. ABS. : 1.3097e+04
Ele. 13 - MAX. ABS. : 2.6486e+04
Ele. 14 - MAX. ABS. : 2.7002e+04
Ele. 15 - MAX. ABS. : 2.7954e+04
Ele. 16 - MAX. ABS. : 3.5637e+04
Ele. 17 - MAX. ABS. : 1.9385e+04
Ele. 18 - MAX. ABS. : 1.3369e+04
Ele. 19 - MAX. ABS. : 1.2273e+04
Ele. 20 - MAX. ABS. : 1.6710e+04
Ele. 21 - MAX. ABS. : 1.9257e+04
Ele. 22 - MAX. ABS. : 1.6190e+04
Ele. 23 - MAX. ABS. : 1.3088e+04
Ele. 24 - MAX. ABS. : 1.3095e+04
Ele. 25 - MAX. ABS. : 1.6147e+04
Ele. 26 - MAX. ABS. : 2.0247e+04
Ele. 27 - MAX. ABS. : 1.5039e+04
Ele. 28 - MAX. ABS. : 1.3216e+04
Ele. 29 - MAX. ABS. : 2.8182e+04
Ele. 30 - MAX. ABS. : 2.3308e+04
Ele. 31 - MAX. ABS. : 2.4829e+04
Ele. 32 - MAX. ABS. : 5.9529e+03
Ele. 33 - MAX. ABS. : 8.4477e+03
Ele. 34 - MAX. ABS. : 7.2904e+03
Ele. 35 - MAX. ABS. : 2.6154e+04
Ele. 36 - MAX. ABS. : 1.5654e+04
Ele. 37 - MAX. ABS. : 3.4909e+04
Ele. 38 - MAX. ABS. : 3.3952e+04
Ele. 39 - MAX. ABS. : 8.8577e+04
Ele. 40 - MAX. ABS. : 9.0947e+05
Ele. 41 - MAX. ABS. : 9.2324e+04
Ele. 42 - MAX. ABS. : 3.6286e+04
Ele. 43 - MAX. ABS. : 3.2890e+04
Ele. 44 - MAX. ABS. : 1.6618e+04
Ele. 45 - MAX. ABS. : 2.5572e+04
Ele. 46 - MAX. ABS. : 9.4687e+03
Ele. 47 - MAX. ABS. : 1.1798e+04
Ele. 48 - MAX. ABS. : 6.4711e+03
Ele. 49 - MAX. ABS. : 3.3179e+04
Ele. 50 - MAX. ABS. : 4.8190e+03
Ele. 51 - MAX. ABS. : 2.0066e+04
Ele. 52 - MAX. ABS. : 7.3422e+03
Ele. 53 - MAX. ABS. : 1.8559e+04
Ele. 54 - MAX. ABS. : 4.6146e+03
Ele. 55 - MAX. ABS. : 2.4088e+04
Ele. 56 - MAX. ABS. : 1.5357e+04
Ele. 57 - MAX. ABS. : 4.7193e+04
Ele. 58 - MAX. ABS. : 2.9637e+04
Ele. 59 - MAX. ABS. : 9.0019e+04
Ele. 60 - MAX. ABS. : 9.7948e+05
Ele. 61 - MAX. ABS. : 1.0605e+05

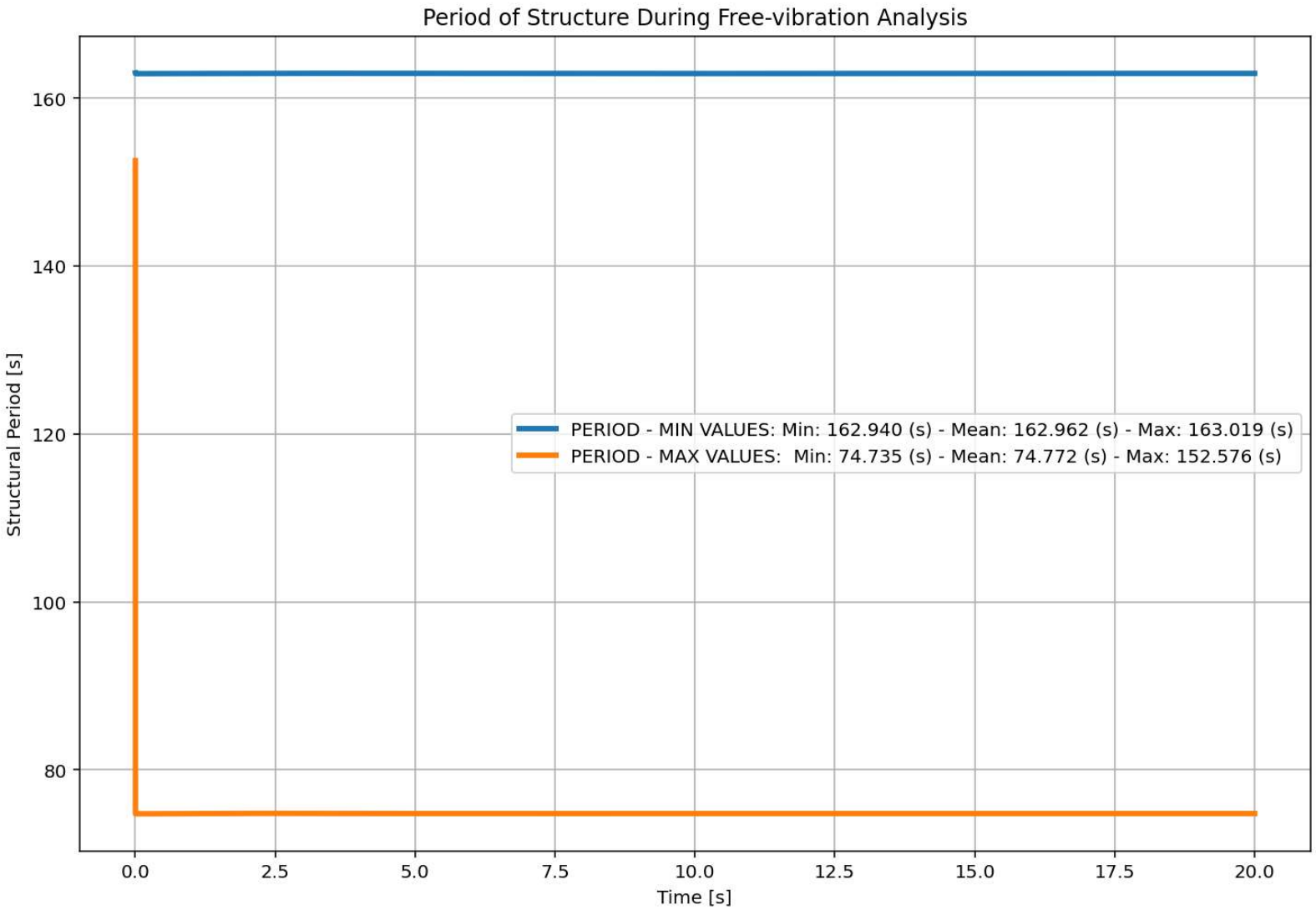

elements Stress in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
Element Stress [N/mm^2]
Time [s]
250
200
150
100
50
0
−50
0.0
2.5
5.0
7.5
10.0
Ele. 1 - MAX. ABS. : 3.1235e+00
Ele. 2 - MAX. ABS. : 2.4407e+00
Ele. 3 - MAX. ABS. : 5.5145e+00
Ele. 4 - MAX. ABS. : 5.4940e+00
Ele. 5 - MAX. ABS. : 1.1830e+01
Ele. 6 - MAX. ABS. : 1.1992e+01
Ele. 7 - MAX. ABS. : 5.8609e+00
Ele. 8 - MAX. ABS. : 5.9512e+00
Ele. 9 - MAX. ABS. : 2.6219e+00
Ele. 10 - MAX. ABS. : 3.3649e+00
Ele. 11 - MAX. ABS. : 4.2956e+00
Ele. 12 - MAX. ABS. : 3.2596e+00
Ele. 13 - MAX. ABS. : 6.5918e+00
Ele. 14 - MAX. ABS. : 6.7204e+00
Ele. 15 - MAX. ABS. : 6.9572e+00
Ele. 16 - MAX. ABS. : 8.8693e+00
Ele. 17 - MAX. ABS. : 4.8246e+00
Ele. 18 - MAX. ABS. : 3.3274e+00
Ele. 19 - MAX. ABS. : 3.0544e+00
Ele. 20 - MAX. ABS. : 4.1589e+00
Ele. 21 - MAX. ABS. : 4.7928e+00
Ele. 22 - MAX. ABS. : 4.0294e+00
Ele. 23 - MAX. ABS. : 3.2573e+00
Ele. 24 - MAX. ABS. : 3.2591e+00
Ele. 25 - MAX. ABS. : 4.0187e+00
Ele. 26 - MAX. ABS. : 5.0392e+00
Ele. 27 - MAX. ABS. : 3.7430e+00
Ele. 28 - MAX. ABS. : 3.2891e+00
Ele. 29 - MAX. ABS. : 7.0140e+00
Ele. 30 - MAX. ABS. : 5.8010e+00
Ele. 31 - MAX. ABS. : 6.0854e+00
Ele. 32 - MAX. ABS. : 1.4590e+00
Ele. 33 - MAX. ABS. : 2.0705e+00
Ele. 34 - MAX. ABS. : 1.7869e+00
Ele. 35 - MAX. ABS. : 6.4103e+00
Ele. 36 - MAX. ABS. : 3.8367e+00
Ele. 37 - MAX. ABS. : 8.5561e+00
Ele. 38 - MAX. ABS. : 8.3214e+00
Ele. 39 - MAX. ABS. : 2.1710e+01
Ele. 40 - MAX. ABS. : 2.2291e+02
Ele. 41 - MAX. ABS. : 2.2628e+01
Ele. 42 - MAX. ABS. : 8.8937e+00
Ele. 43 - MAX. ABS. : 8.0614e+00
Ele. 44 - MAX. ABS. : 4.0731e+00
Ele. 45 - MAX. ABS. : 6.2676e+00
Ele. 46 - MAX. ABS. : 2.3208e+00
Ele. 47 - MAX. ABS. : 2.8918e+00
Ele. 48 - MAX. ABS. : 1.5861e+00
Ele. 49 - MAX. ABS. : 8.1321e+00
Ele. 50 - MAX. ABS. : 1.1811e+00
Ele. 51 - MAX. ABS. : 4.9182e+00
Ele. 52 - MAX. ABS. : 1.7996e+00
Ele. 53 - MAX. ABS. : 4.5487e+00
Ele. 54 - MAX. ABS. : 1.1310e+00
Ele. 55 - MAX. ABS. : 5.9039e+00
Ele. 56 - MAX. ABS. : 3.7640e+00
Ele. 57 - MAX. ABS. : 1.1567e+01
Ele. 58 - MAX. ABS. : 7.2639e+00
Ele. 59 - MAX. ABS. : 2.2063e+01
Ele. 60 - MAX. ABS. : 2.4007e+02
Ele. 61 - MAX. ABS. : 2.5993e+01

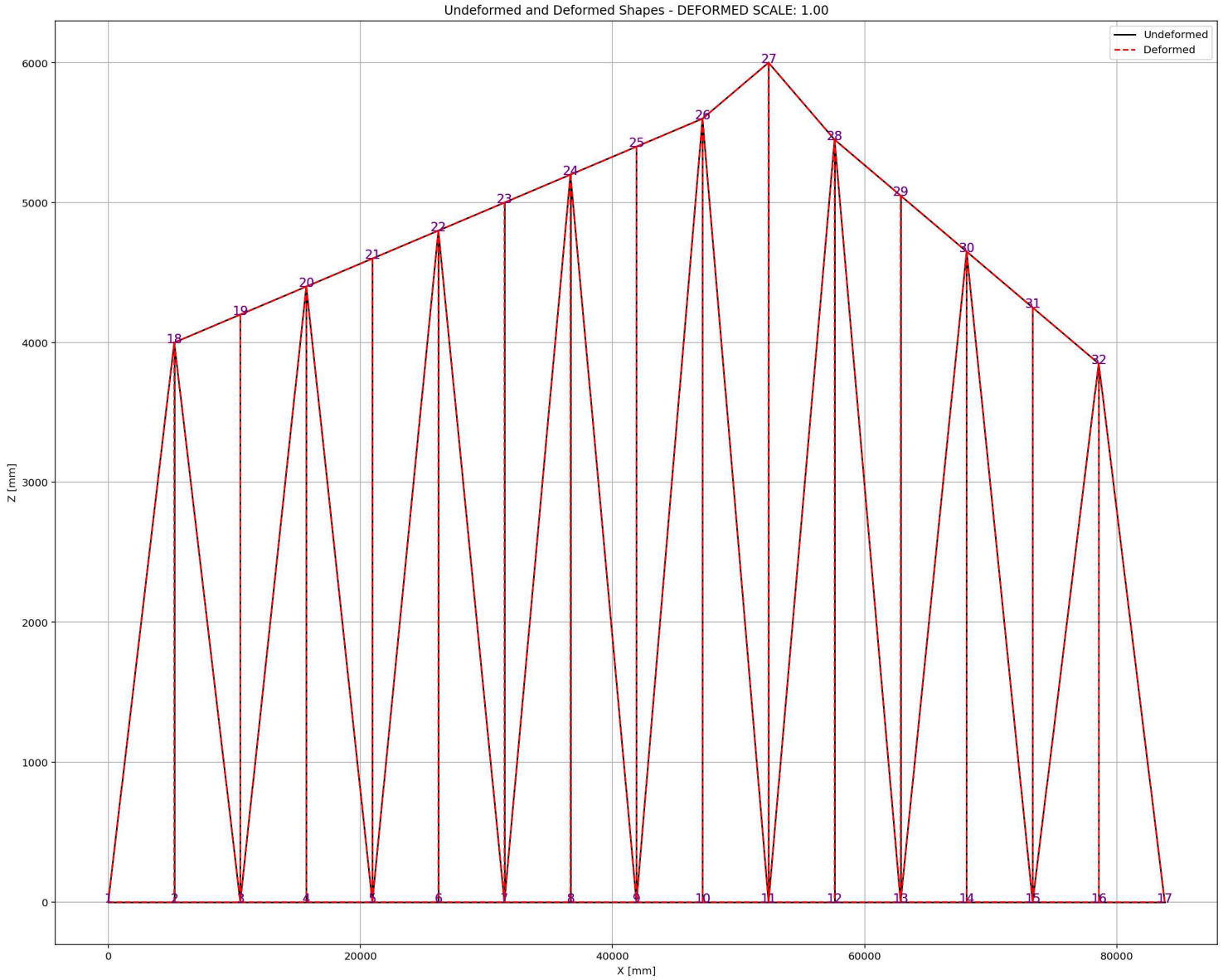

elements Strain in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
Element Strain [mm]
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
−0.00025
0.0
2.5
5.0
7.5
10.0
12.5
Time [s]
Ele. 1 - MAX. ABS. : 1.5618e-05
Ele. 2 - MAX. ABS. : 1.2204e-05
Ele. 3 - MAX. ABS. : 2.7572e-05
Ele. 4 - MAX. ABS. : 2.7470e-05
Ele. 5 - MAX. ABS. : 5.9150e-05
Ele. 6 - MAX. ABS. : 5.9958e-05
Ele. 7 - MAX. ABS. : 2.9305e-05
Ele. 8 - MAX. ABS. : 2.9756e-05
Ele. 9 - MAX. ABS. : 1.3110e-05
Ele. 10 - MAX. ABS. : 1.6824e-05
Ele. 11 - MAX. ABS. : 2.1478e-05
Ele. 12 - MAX. ABS. : 1.6298e-05
Ele. 13 - MAX. ABS. : 3.2959e-05
Ele. 14 - MAX. ABS. : 3.3602e-05
Ele. 15 - MAX. ABS. : 3.4786e-05
Ele. 16 - MAX. ABS. : 4.4347e-05
Ele. 17 - MAX. ABS. : 2.4123e-05
Ele. 18 - MAX. ABS. : 1.6637e-05
Ele. 19 - MAX. ABS. : 1.5272e-05
Ele. 20 - MAX. ABS. : 2.0794e-05
Ele. 21 - MAX. ABS. : 2.3964e-05
Ele. 22 - MAX. ABS. : 2.0147e-05
Ele. 23 - MAX. ABS. : 1.6287e-05
Ele. 24 - MAX. ABS. : 1.6295e-05
Ele. 25 - MAX. ABS. : 2.0093e-05
Ele. 26 - MAX. ABS. : 2.5196e-05
Ele. 27 - MAX. ABS. : 1.8715e-05
Ele. 28 - MAX. ABS. : 1.6445e-05
Ele. 29 - MAX. ABS. : 3.5070e-05
Ele. 30 - MAX. ABS. : 2.9005e-05
Ele. 31 - MAX. ABS. : 3.0427e-05
Ele. 32 - MAX. ABS. : 7.2952e-06
Ele. 33 - MAX. ABS. : 1.0353e-05
Ele. 34 - MAX. ABS. : 8.9343e-06
Ele. 35 - MAX. ABS. : 3.2052e-05
Ele. 36 - MAX. ABS. : 1.9183e-05
Ele. 37 - MAX. ABS. : 4.2781e-05
Ele. 38 - MAX. ABS. : 4.1607e-05
Ele. 39 - MAX. ABS. : 1.0855e-04
Ele. 40 - MAX. ABS. : 1.1146e-03
Ele. 41 - MAX. ABS. : 1.1314e-04
Ele. 42 - MAX. ABS. : 4.4469e-05
Ele. 43 - MAX. ABS. : 4.0307e-05
Ele. 44 - MAX. ABS. : 2.0366e-05
Ele. 45 - MAX. ABS. : 3.1338e-05
Ele. 46 - MAX. ABS. : 1.1604e-05
Ele. 47 - MAX. ABS. : 1.4459e-05
Ele. 48 - MAX. ABS. : 7.9303e-06
Ele. 49 - MAX. ABS. : 4.0661e-05
Ele. 50 - MAX. ABS. : 5.9057e-06
Ele. 51 - MAX. ABS. : 2.4591e-05
Ele. 52 - MAX. ABS. : 8.9978e-06
Ele. 53 - MAX. ABS. : 2.2744e-05
Ele. 54 - MAX. ABS. : 5.6551e-06
Ele. 55 - MAX. ABS. : 2.9519e-05
Ele. 56 - MAX. ABS. : 1.8820e-05
Ele. 57 - MAX. ABS. : 5.7834e-05
Ele. 58 - MAX. ABS. : 3.6319e-05
Ele. 59 - MAX. ABS. : 1.1032e-04
Ele. 60 - MAX. ABS. : 1.3896e-03
Ele. 61 - MAX. ABS. : 1.2996e-04


elements Damage-index [%] in X Dir. vs Time for Bridge Structure During Dynamic Free-vibration Analysis
Element Damage-index [%]
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
−0.00025
0.0
2.5
5.0
7.5
10.0
12.5
Time [s]
Ele. 1 - MAX. ABS. : 1.5618e-05
Ele. 2 - MAX. ABS. : 1.2204e-05
Ele. 3 - MAX. ABS. : 2.7572e-05
Ele. 4 - MAX. ABS. : 2.7470e-05
Ele. 5 - MAX. ABS. : 5.9150e-05
Ele. 6 - MAX. ABS. : 5.9958e-05
Ele. 7 - MAX. ABS. : 2.9305e-05
Ele. 8 - MAX. ABS. : 2.9756e-05
Ele. 9 - MAX. ABS. : 1.3110e-05
Ele. 10 - MAX. ABS. : 1.6824e-05
Ele. 11 - MAX. ABS. : 2.1478e-05
Ele. 12 - MAX. ABS. : 1.6298e-05
Ele. 13 - MAX. ABS. : 3.2959e-05
Ele. 14 - MAX. ABS. : 3.3602e-05
Ele. 15 - MAX. ABS. : 3.4786e-05
Ele. 16 - MAX. ABS. : 4.4347e-05
Ele. 17 - MAX. ABS. : 2.4123e-05
Ele. 18 - MAX. ABS. : 1.6637e-05
Ele. 19 - MAX. ABS. : 1.5272e-05
Ele. 20 - MAX. ABS. : 2.0794e-05
Ele. 21 - MAX. ABS. : 2.3964e-05
Ele. 22 - MAX. ABS. : 2.0147e-05
Ele. 23 - MAX. ABS. : 1.6287e-05
Ele. 24 - MAX. ABS. : 1.6295e-05
Ele. 25 - MAX. ABS. : 2.0093e-05
Ele. 26 - MAX. ABS. : 2.5196e-05
Ele. 27 - MAX. ABS. : 1.8715e-05
Ele. 28 - MAX. ABS. : 1.6445e-05
Ele. 29 - MAX. ABS. : 3.5070e-05
Ele. 30 - MAX. ABS. : 2.9005e-05
Ele. 31 - MAX. ABS. : 3.0427e-05
Ele. 32 - MAX. ABS. : 7.2952e-06
Ele. 33 - MAX. ABS. : 1.0353e-05
Ele. 34 - MAX. ABS. : 8.9343e-06
Ele. 35 - MAX. ABS. : 3.2052e-05
Ele. 36 - MAX. ABS. : 1.9183e-05
Ele. 37 - MAX. ABS. : 4.2781e-05
Ele. 38 - MAX. ABS. : 4.1607e-05
Ele. 39 - MAX. ABS. : 1.0855e-04
Ele. 40 - MAX. ABS. : 1.1146e-03
Ele. 41 - MAX. ABS. : 1.1314e-04
Ele. 42 - MAX. ABS. : 4.4469e-05
Ele. 43 - MAX. ABS. : 4.0307e-05
Ele. 44 - MAX. ABS. : 2.0366e-05
Ele. 45 - MAX. ABS. : 3.1338e-05
Ele. 46 - MAX. ABS. : 1.1604e-05
Ele. 47 - MAX. ABS. : 1.4459e-05
Ele. 48 - MAX. ABS. : 7.9303e-06
Ele. 49 - MAX. ABS. : 4.0661e-05
Ele. 50 - MAX. ABS. : 5.9057e-06
Ele. 51 - MAX. ABS. : 2.4591e-05
Ele. 52 - MAX. ABS. : 8.9978e-06
Ele. 53 - MAX. ABS. : 2.2744e-05
Ele. 54 - MAX. ABS. : 5.6551e-06
Ele. 55 - MAX. ABS. : 2.9519e-05
Ele. 56 - MAX. ABS. : 1.8820e-05
Ele. 57 - MAX. ABS. : 5.7834e-05
Ele. 58 - MAX. ABS. : 3.6319e-05
Ele. 59 - MAX. ABS. : 1.1032e-04
Ele. 60 - MAX. ABS. : 1.3896e-03
Ele. 61 - MAX. ABS. : 1.2996e-04


Node Displacements in X Dir. vs Time for Bridge Structure During Free-vibration Analysis
Displacement [mm]
Time [s]
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
0.0
2.5
5.0
7.5
10.0
12.5
Node 1 - MAX. ABS. : 0.0000e+00
Node 2 - MAX. ABS. : 8.1798e-02
Node 3 - MAX. ABS. : 1.3723e-01
Node 4 - MAX. ABS. : 2.2715e-01
Node 5 - MAX. ABS. : 3.0387e-01
Node 6 - MAX. ABS. : 1.4294e-02
Node 7 - MAX. ABS. : 3.2005e-01
Node 8 - MAX. ABS. : 2.3755e-01
Node 9 - MAX. ABS. : 1.4650e-01
Node 10 - MAX. ABS. : 8.8118e-02
Node 11 - MAX. ABS. : 0.0000e+00
Node 12 - MAX. ABS. : 1.1249e-01
Node 13 - MAX. ABS. : 1.8975e-01
Node 14 - MAX. ABS. : 2.8453e-01
Node 15 - MAX. ABS. : 3.7837e-01
Node 16 - MAX. ABS. : 2.3221e-01
Node 17 - MAX. ABS. : 0.0000e+00
Node 18 - MAX. ABS. : 1.6468e-01
Node 19 - MAX. ABS. : 1.7436e-01
Node 20 - MAX. ABS. : 1.9909e-01
Node 21 - MAX. ABS. : 1.2038e-01
Node 22 - MAX. ABS. : 3.3403e-02
Node 23 - MAX. ABS. : 1.1949e-01
Node 24 - MAX. ABS. : 2.2307e-01
Node 25 - MAX. ABS. : 2.1060e-01
Node 26 - MAX. ABS. : 1.7151e-01
Node 27 - MAX. ABS. : 1.2390e-01
Node 28 - MAX. ABS. : 1.1909e-01
Node 29 - MAX. ABS. : 1.1738e-01
Node 30 - MAX. ABS. : 1.2010e-01
Node 31 - MAX. ABS. : 3.3431e-01
Node 32 - MAX. ABS. : 3.3933e-01


Node Displacements in Y Dir. vs Time for Bridge Structure During Free-vibration Analysis
Displacement [mm]
0
−1
−2
−3
−4
−5
0.0
2.5
5.0
7.5
10.0
12.5
Time [s]
Node 1 - MAX. ABS. : 0.0000e+00
Node 2 - MAX. ABS. : 4.0068e-01
Node 3 - MAX. ABS. : 5.1365e-01
Node 4 - MAX. ABS. : 6.2685e-01
Node 5 - MAX. ABS. : 6.4777e-01
Node 6 - MAX. ABS. : 5.3498e+00
Node 7 - MAX. ABS. : 6.5180e-01
Node 8 - MAX. ABS. : 6.1942e-01
Node 9 - MAX. ABS. : 4.4809e-01
Node 10 - MAX. ABS. : 3.5997e-01
Node 11 - MAX. ABS. : 0.0000e+00
Node 12 - MAX. ABS. : 3.6261e-01
Node 13 - MAX. ABS. : 2.7426e-01
Node 14 - MAX. ABS. : 5.5187e-01
Node 15 - MAX. ABS. : 6.0198e-01
Node 16 - MAX. ABS. : 5.3498e+00
Node 17 - MAX. ABS. : 0.0000e+00
Node 18 - MAX. ABS. : 3.7943e-01
Node 19 - MAX. ABS. : 5.5095e-01
Node 20 - MAX. ABS. : 5.4612e-01
Node 21 - MAX. ABS. : 8.2389e-01
Node 22 - MAX. ABS. : 1.5764e+00
Node 23 - MAX. ABS. : 8.4821e-01
Node 24 - MAX. ABS. : 5.2210e-01
Node 25 - MAX. ABS. : 5.0441e-01
Node 26 - MAX. ABS. : 3.1717e-01
Node 27 - MAX. ABS. : 3.5434e-02
Node 28 - MAX. ABS. : 3.1842e-01
Node 29 - MAX. ABS. : 2.9477e-01
Node 30 - MAX. ABS. : 4.7419e-01
Node 31 - MAX. ABS. : 7.4651e-01
Node 32 - MAX. ABS. : 1.5263e+00


Period of Structure During Free-vibration Analysis
Structural Period [s]
160
140
120
100
80
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Time [s]
PERIOD - MIN VALUES: Min: 162.940 (s) - Mean: 162.962 (s) - Max: 163.019 (s)
PERIOD - MAX VALUES: Min: 74.735 (s) - Mean: 74.772 (s) - Max: 152.576 (s)


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
1000
2000
3000
4000
5000
6000
0
20000
40000
60000
80000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

SEISMIC ANALYSIS

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

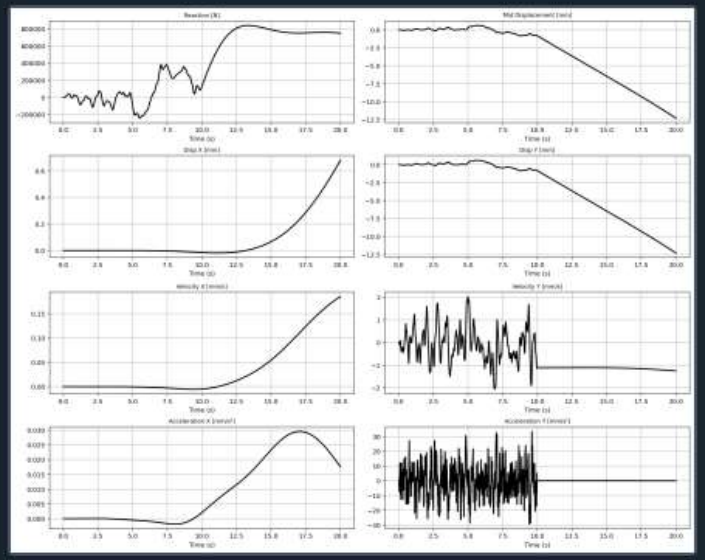
...Dell\Desktop\OPENSEES_FILES\+BRIDGE_RAILROAD_TRUSS_TWO_SPANS

C:\Users\Dell\Desktop\OPENSEES_FILES\+BRIDGE_RAIL..._Flint River Bridge_Tuscaloosa Railroad Bridge.py

BRIDGE_RAILROAD_TR...Railroad Bridge.py

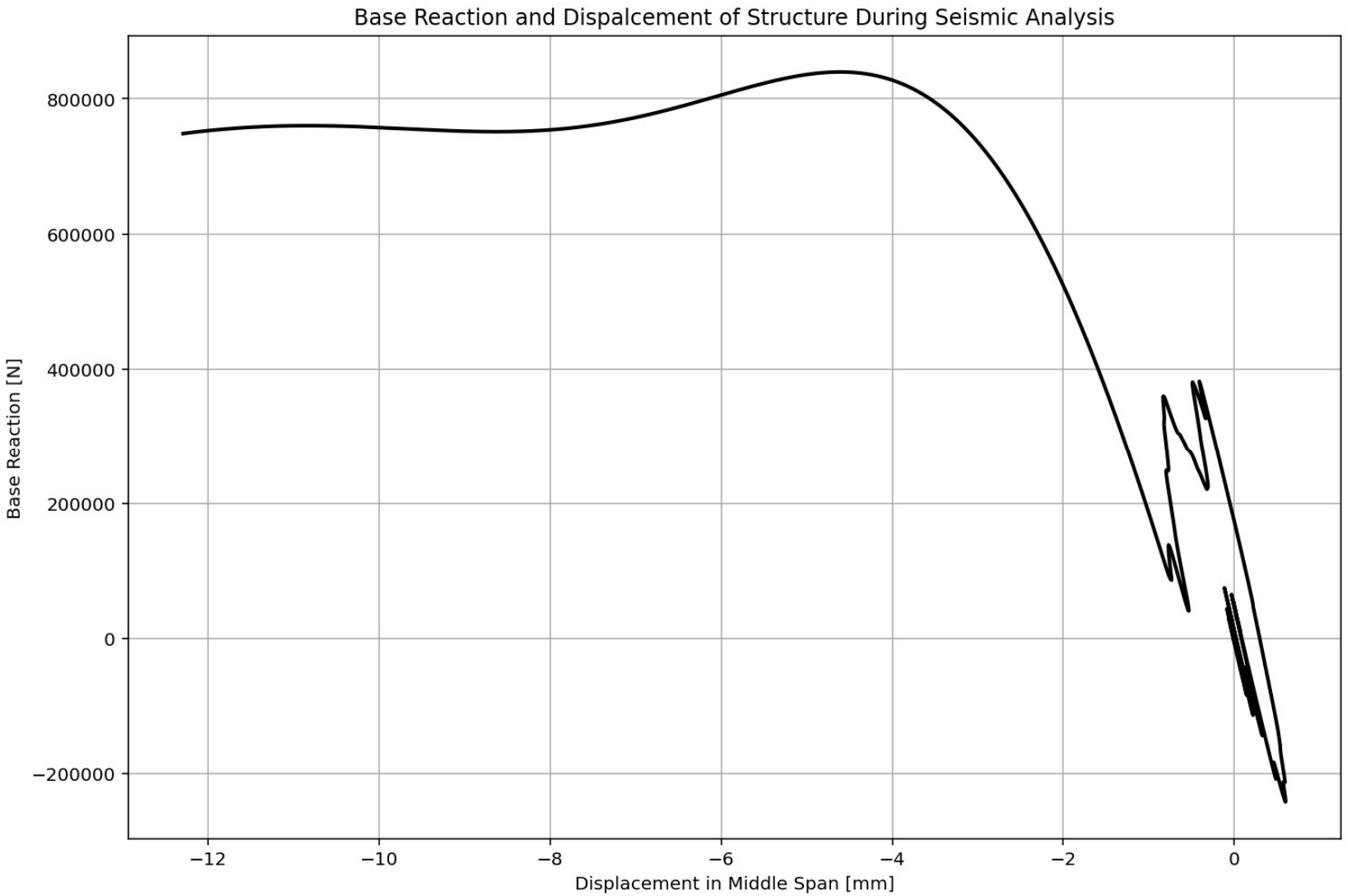
```
1538  # SEISMIC ANALYSIS (DYNAMIC TIME-HISTORY ANALYSIS)
1539  #ELE_TYPE = 'Truss'      # MATERIAL NONLINEARITY
1540  ELE_TYPE = 'corotTruss'  # MATERIAL AND GEOMETRIC NONLINEARITY
1541  MAT_TYPE = 'INELASTIC'   # 'ELASTIC' OR 'INELASTIC'
1542  ANAL_TYPE = 'SEISMIC'
1543
1544  DATA = WARREN_TRUSS_BRIDGE(L, H, A_chord, A_diag, MAT_TYPE, ELE_TYPE, ANAL_TYPE, TOTAL_MAS
1545
1546  (time_SEI, reaction_SEI, disp_mid_SEI,
1547   ele_axialforce_SEI, ele_stress_SEI, ele_strain_SEI,
1548   node_displacementsX_SEI, node_displacementsY_SEI,
1549   dispX_SEI, dispY_SEI,
1550   veloX_SEI, veloY_SEI,
1551   accX_SEI, accY_SEI,
1552   stiffness_SEI, PERIOD_SEI, damping_ratio_SEI,
1553   PERIOD_MIN_SEI, PERIOD_MAX_SEI) = DATA
1554
1555
1556  XDATA = disp_mid_SEI
1557  YDATA = reaction_SEI
1558  XLABEL = 'Displacement in Middle Span [mm]'
1559  YLABEL = 'Base Reaction [N]'
1560  TITLE = 'Base Reaction and Dispalcement of Structure During Seismic Analysis'
1561  COLOR = 'black'
1562  SEMILOGY = False
1563  PLOT(XDATA, YDATA, TITLE, XLABEL, YLABEL, COLOR, SEMILOGY)
1564
1565  PLOT_TIME_HISTORY(time_SEI, reaction_SEI, disp_mid_SEI,
1566                    dispX_SEI, dispY_SEI,
1567                    veloX_SEI, veloY_SEI,
1568                    accX_SEI, accY_SEI)
1569
1570  # PLOT ELEMENTS AXIAL FORCE
1571  YLABEL = 'Element Axial Force [N]'
```

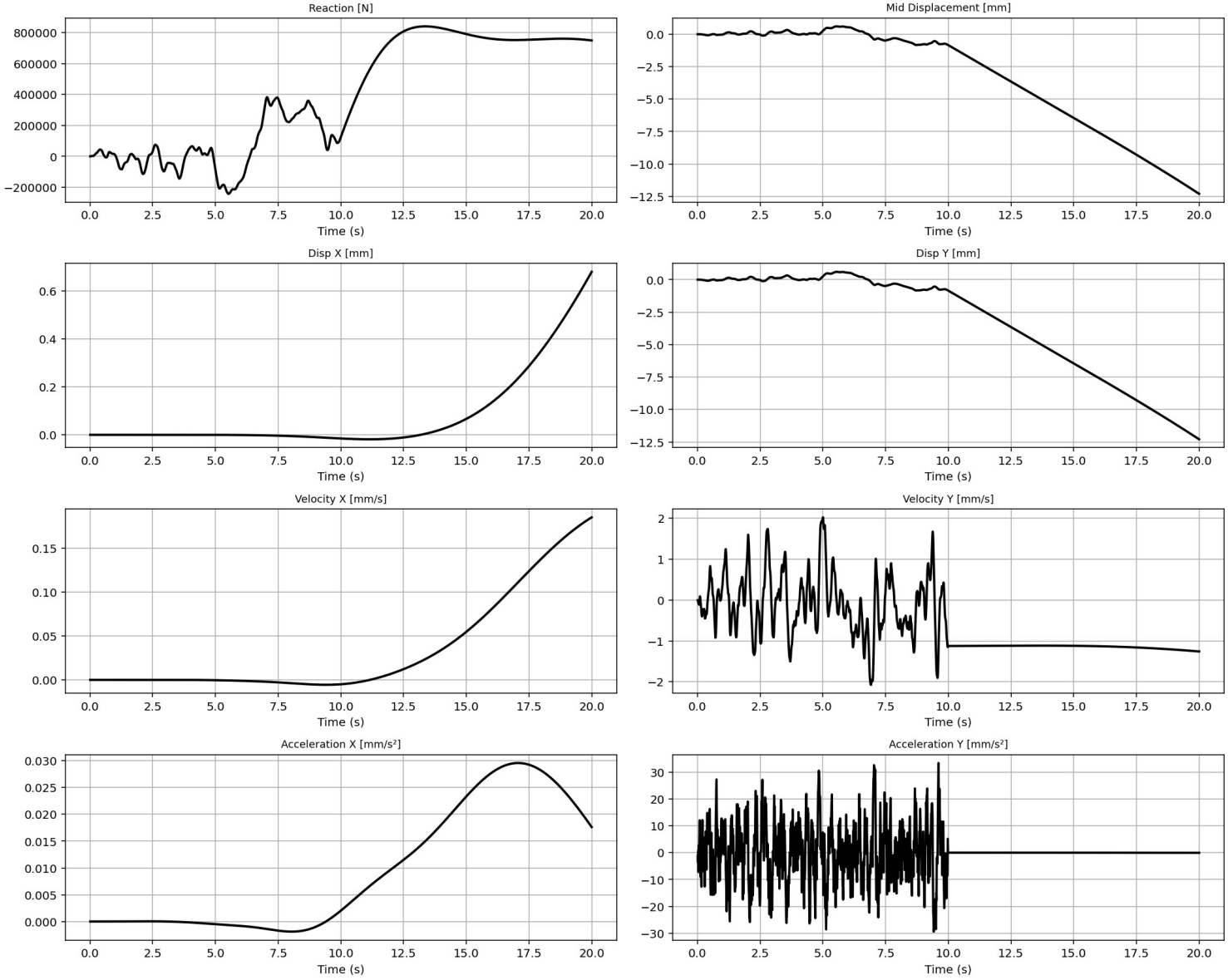
21 %

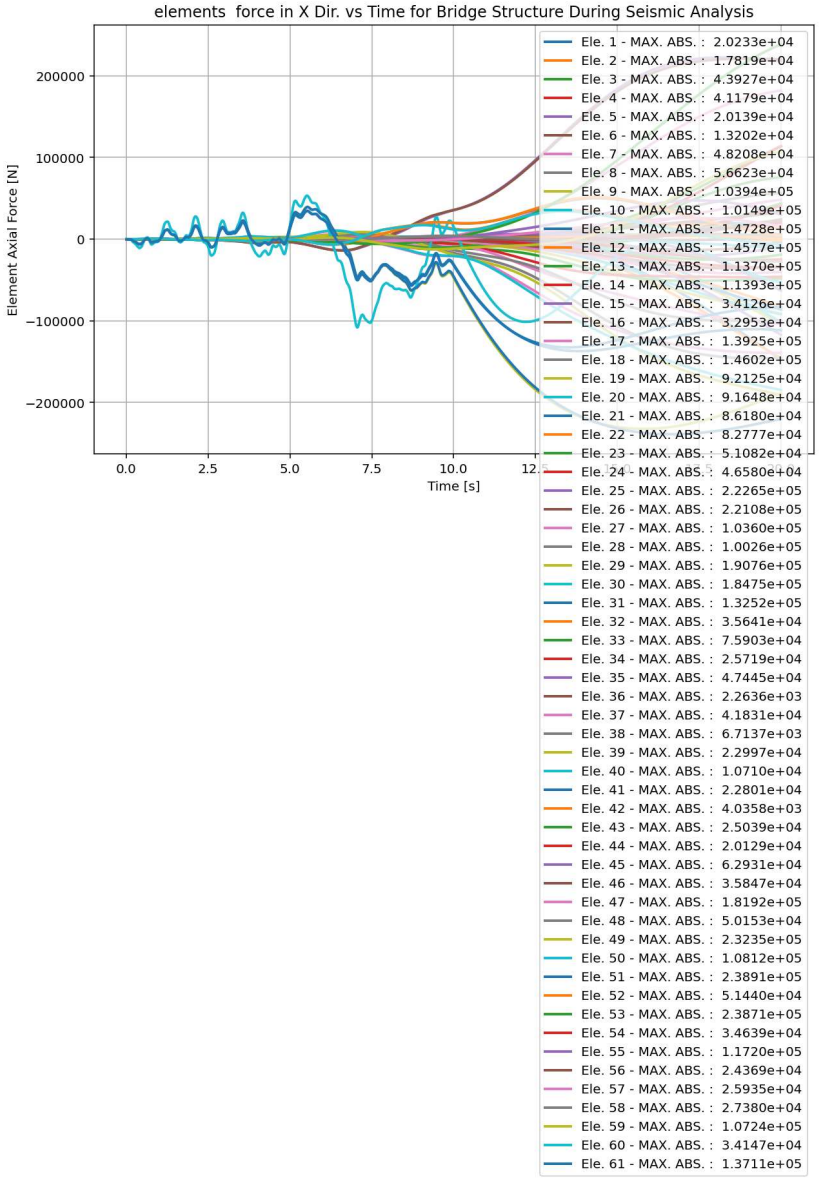


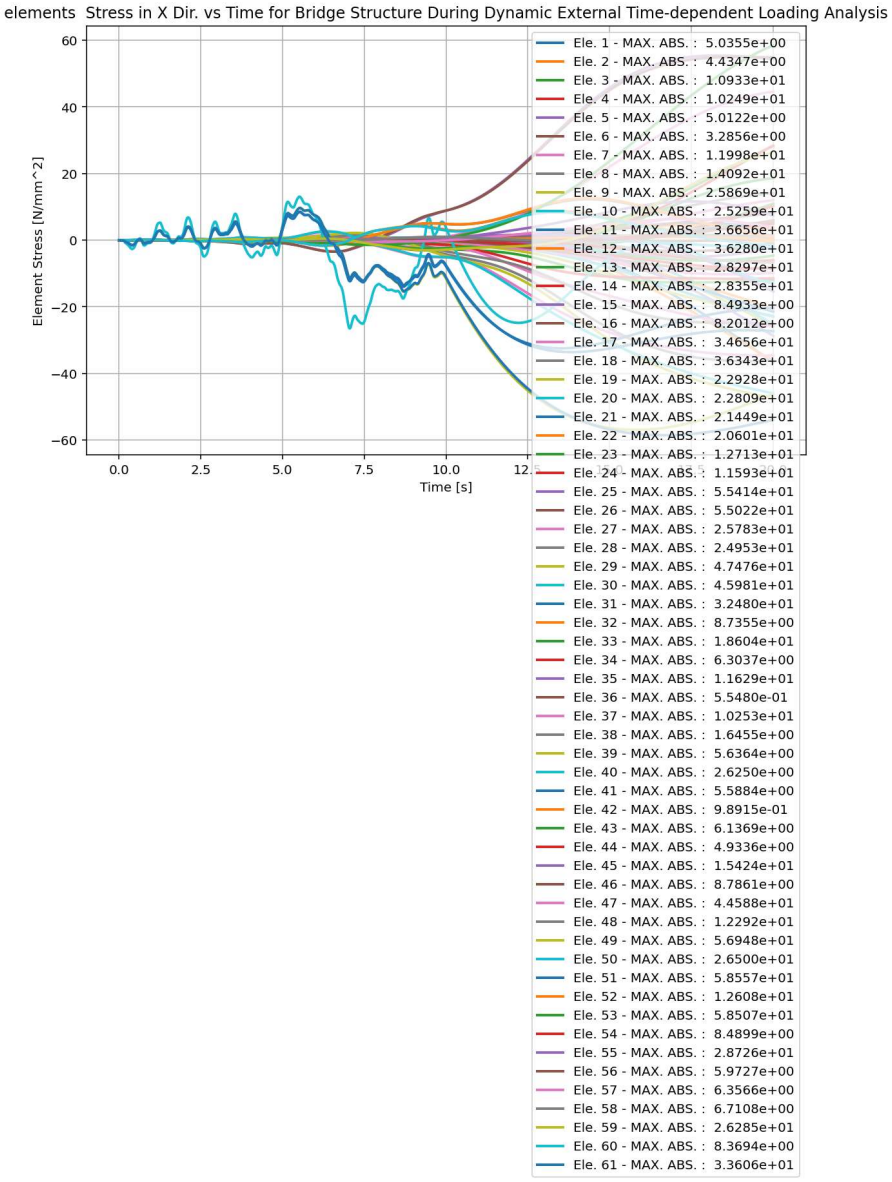
IPython Console | Files | Help | Variable Explorer | Debugger | Plots | History

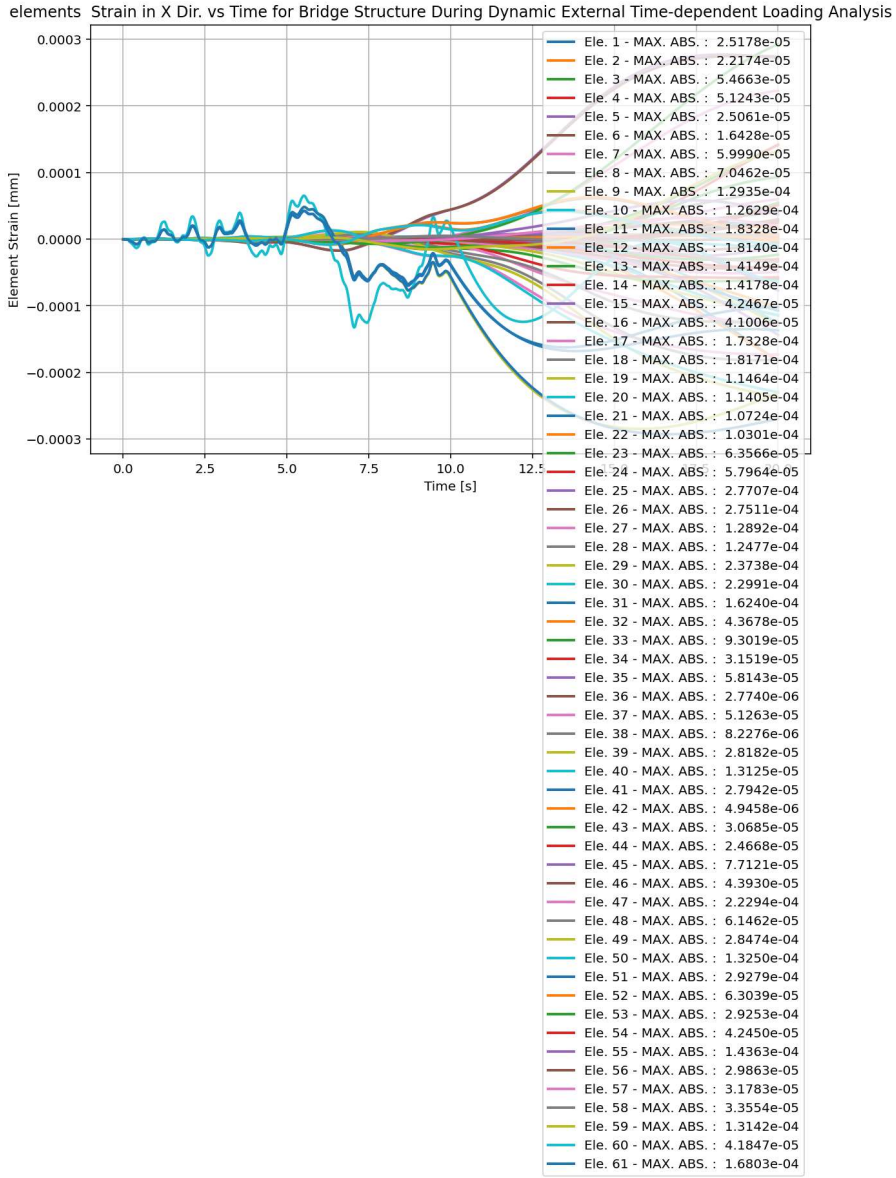
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 71, Col 216 UTF-8 CRLF RW Mem 59%

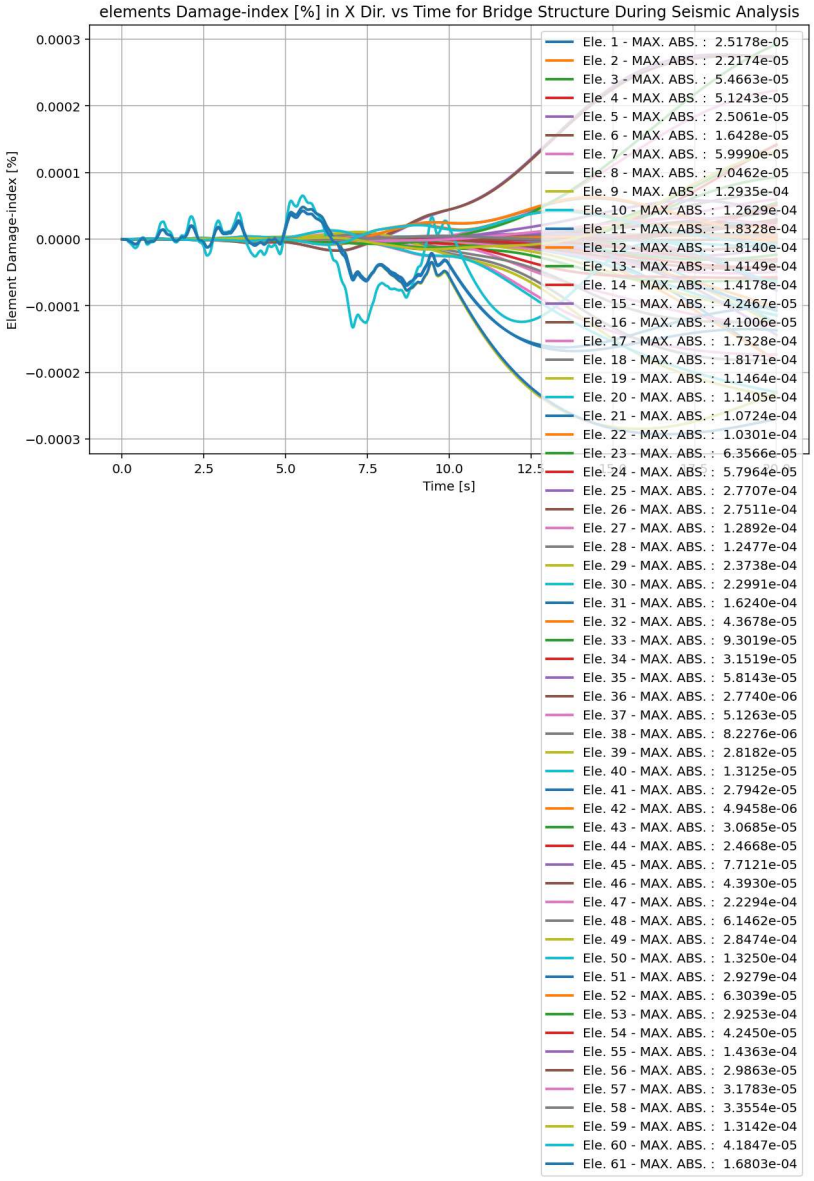

Base Reaction and Dispalcement of Structure During Seismic Analysis
Base Reaction [N]
800000
600000
400000
200000
0
−200000
−12
−10
−8
−6
−4
−2
0
Displacement in Middle Span [mm]

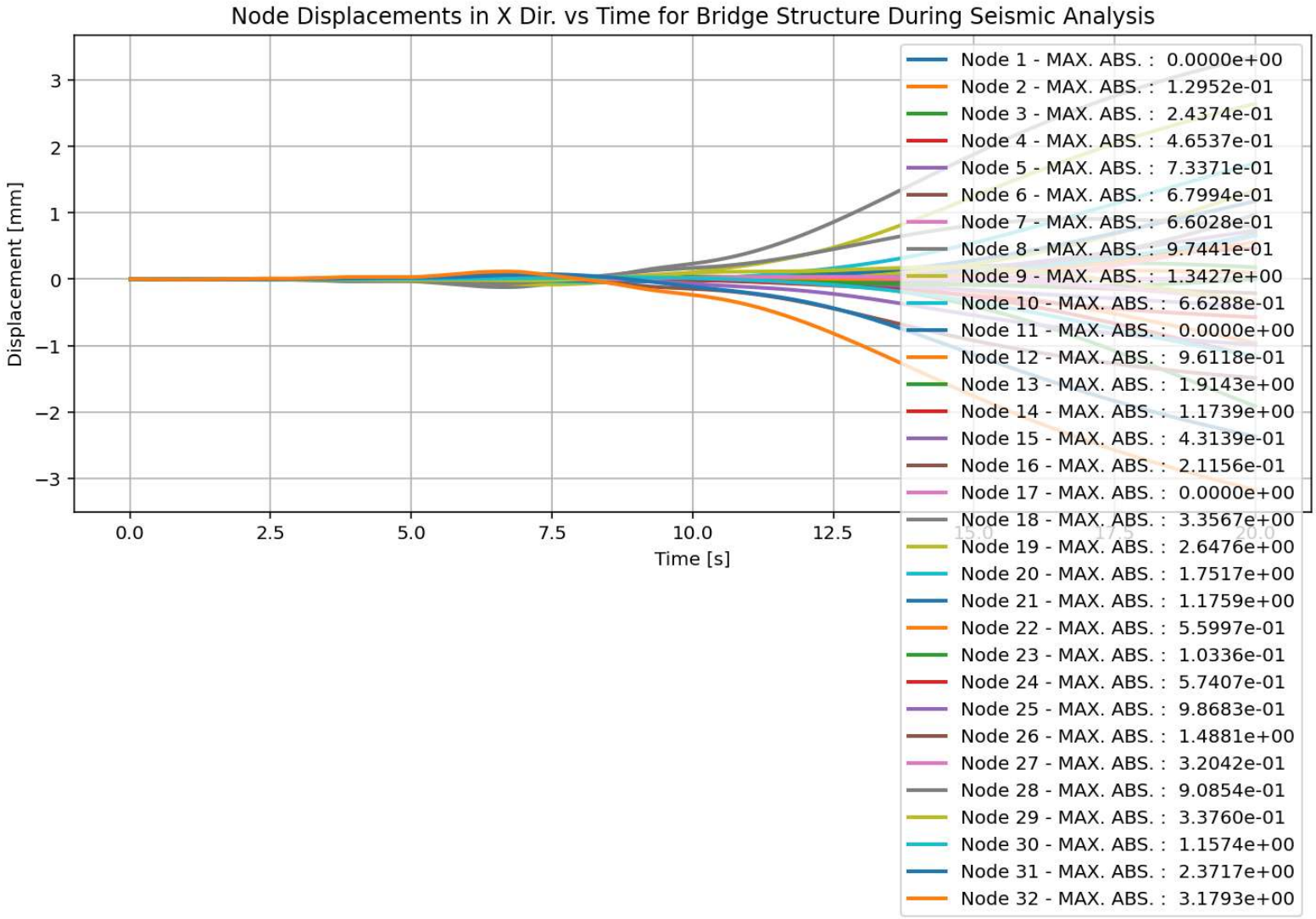

Reaction [N]
Time (s)
Mid Displacement [mm]
Time (s)
Disp X [mm]
Time (s)
Disp Y [mm]
Time (s)
Velocity X [mm/s]
Time (s)
Velocity Y [mm/s]
Time (s)
Acceleration X [mm/s²]
Time (s)
Acceleration Y [mm/s²]
Time (s)

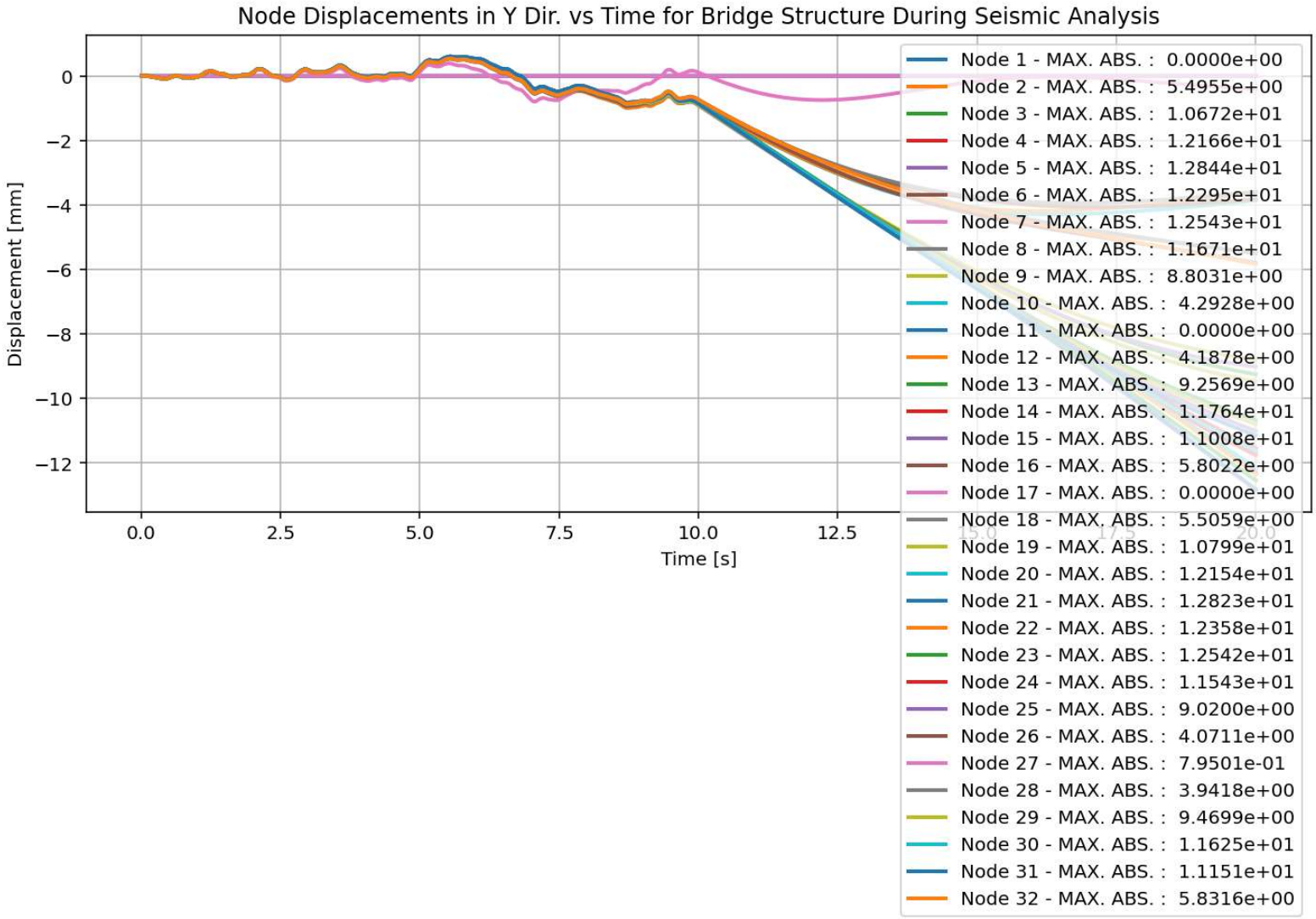

elements force in X Dir. vs Time for Bridge Structure During Seismic Analysis
Element Axial Force [N]
Time [s]
200000
100000
0
−100000
−200000
0.0
2.5
5.0
7.5
10.0
Ele. 1 - MAX. ABS. : 2.0233e+04
Ele. 2 - MAX. ABS. : 1.7819e+04
Ele. 3 - MAX. ABS. : 4.3927e+04
Ele. 4 - MAX. ABS. : 4.1179e+04
Ele. 5 - MAX. ABS. : 2.0139e+04
Ele. 6 - MAX. ABS. : 1.3202e+04
Ele. 7 - MAX. ABS. : 4.8208e+04
Ele. 8 - MAX. ABS. : 5.6623e+04
Ele. 9 - MAX. ABS. : 1.0394e+05
Ele. 10 - MAX. ABS. : 1.0149e+05
Ele. 11 - MAX. ABS. : 1.4728e+05
Ele. 12 - MAX. ABS. : 1.4577e+05
Ele. 13 - MAX. ABS. : 1.1370e+05
Ele. 14 - MAX. ABS. : 1.1393e+05
Ele. 15 - MAX. ABS. : 3.4126e+04
Ele. 16 - MAX. ABS. : 3.2953e+04
Ele. 17 - MAX. ABS. : 1.3925e+05
Ele. 18 - MAX. ABS. : 1.4602e+05
Ele. 19 - MAX. ABS. : 9.2125e+04
Ele. 20 - MAX. ABS. : 9.1648e+04
Ele. 21 - MAX. ABS. : 8.6180e+04
Ele. 22 - MAX. ABS. : 8.2777e+04
Ele. 23 - MAX. ABS. : 5.1082e+04
Ele. 24 - MAX. ABS. : 4.6580e+04
Ele. 25 - MAX. ABS. : 2.2265e+05
Ele. 26 - MAX. ABS. : 2.2108e+05
Ele. 27 - MAX. ABS. : 1.0360e+05
Ele. 28 - MAX. ABS. : 1.0026e+05
Ele. 29 - MAX. ABS. : 1.9076e+05
Ele. 30 - MAX. ABS. : 1.8475e+05
Ele. 31 - MAX. ABS. : 1.3252e+05
Ele. 32 - MAX. ABS. : 3.5641e+04
Ele. 33 - MAX. ABS. : 7.5903e+04
Ele. 34 - MAX. ABS. : 2.5719e+04
Ele. 35 - MAX. ABS. : 4.7445e+04
Ele. 36 - MAX. ABS. : 2.2636e+03
Ele. 37 - MAX. ABS. : 4.1831e+04
Ele. 38 - MAX. ABS. : 6.7137e+03
Ele. 39 - MAX. ABS. : 2.2997e+04
Ele. 40 - MAX. ABS. : 1.0710e+04
Ele. 41 - MAX. ABS. : 2.2801e+04
Ele. 42 - MAX. ABS. : 4.0358e+03
Ele. 43 - MAX. ABS. : 2.5039e+04
Ele. 44 - MAX. ABS. : 2.0129e+04
Ele. 45 - MAX. ABS. : 6.2931e+04
Ele. 46 - MAX. ABS. : 3.5847e+04
Ele. 47 - MAX. ABS. : 1.8192e+05
Ele. 48 - MAX. ABS. : 5.0153e+04
Ele. 49 - MAX. ABS. : 2.3235e+05
Ele. 50 - MAX. ABS. : 1.0812e+05
Ele. 51 - MAX. ABS. : 2.3891e+05
Ele. 52 - MAX. ABS. : 5.1440e+04
Ele. 53 - MAX. ABS. : 2.3871e+05
Ele. 54 - MAX. ABS. : 3.4639e+04
Ele. 55 - MAX. ABS. : 1.1720e+05
Ele. 56 - MAX. ABS. : 2.4369e+04
Ele. 57 - MAX. ABS. : 2.5935e+04
Ele. 58 - MAX. ABS. : 2.7380e+04
Ele. 59 - MAX. ABS. : 1.0724e+05
Ele. 60 - MAX. ABS. : 3.4147e+04
Ele. 61 - MAX. ABS. : 1.3711e+05

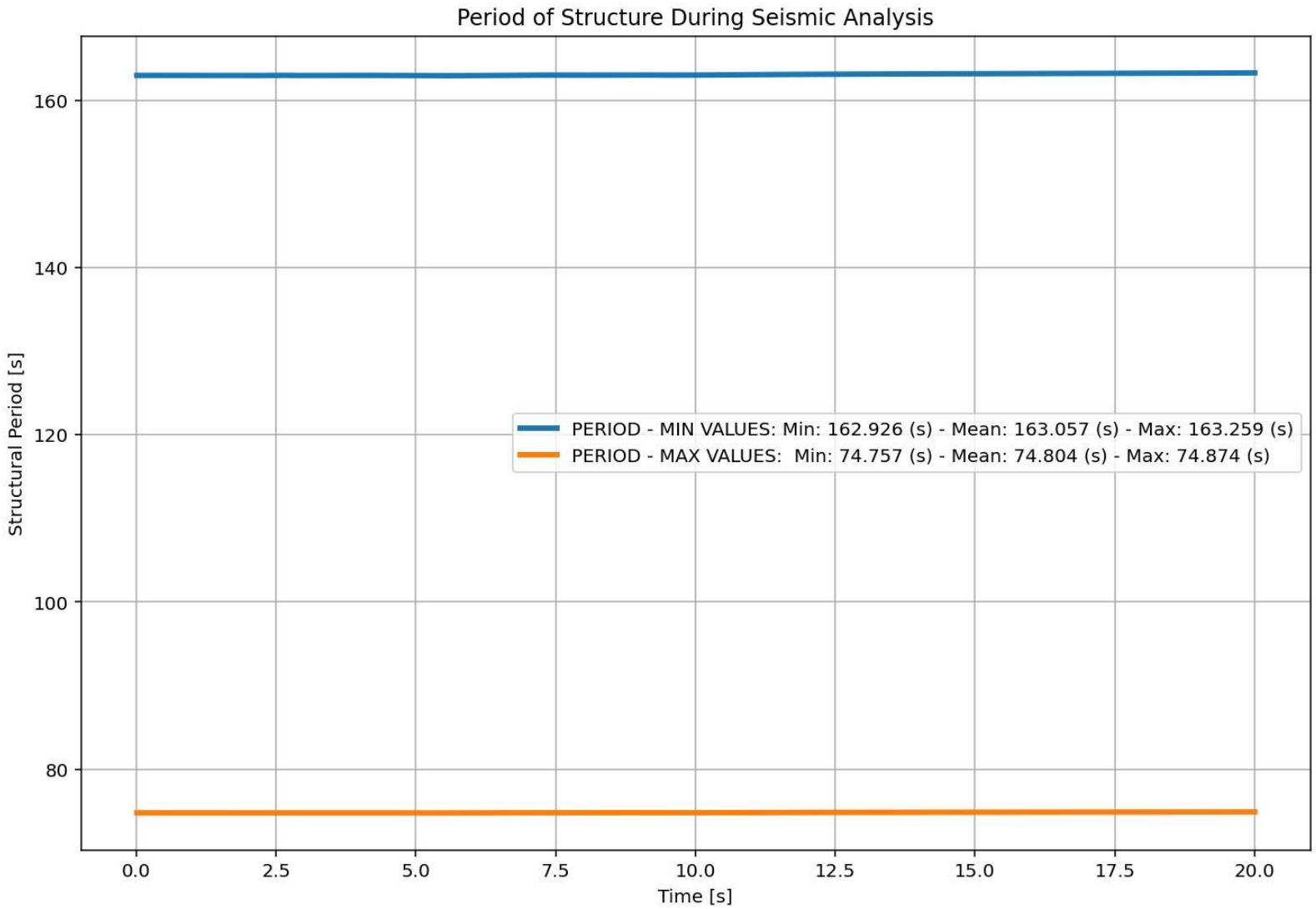

elements Stress in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
Element Stress [N/mm^2]
Time [s]
60
40
20
0
−20
−40
−60
0.0
2.5
5.0
7.5
10.0
Ele. 1 - MAX. ABS. : 5.0355e+00
Ele. 2 - MAX. ABS. : 4.4347e+00
Ele. 3 - MAX. ABS. : 1.0933e+01
Ele. 4 - MAX. ABS. : 1.0249e+01
Ele. 5 - MAX. ABS. : 5.0122e+00
Ele. 6 - MAX. ABS. : 3.2856e+00
Ele. 7 - MAX. ABS. : 1.1998e+01
Ele. 8 - MAX. ABS. : 1.4092e+01
Ele. 9 - MAX. ABS. : 2.5869e+01
Ele. 10 - MAX. ABS. : 2.5259e+01
Ele. 11 - MAX. ABS. : 3.6656e+01
Ele. 12 - MAX. ABS. : 3.6280e+01
Ele. 13 - MAX. ABS. : 2.8297e+01
Ele. 14 - MAX. ABS. : 2.8355e+01
Ele. 15 - MAX. ABS. : 8.4933e+00
Ele. 16 - MAX. ABS. : 8.2012e+00
Ele. 17 - MAX. ABS. : 3.4656e+01
Ele. 18 - MAX. ABS. : 3.6343e+01
Ele. 19 - MAX. ABS. : 2.2928e+01
Ele. 20 - MAX. ABS. : 2.2809e+01
Ele. 21 - MAX. ABS. : 2.1449e+01
Ele. 22 - MAX. ABS. : 2.0601e+01
Ele. 23 - MAX. ABS. : 1.2713e+01
Ele. 24 - MAX. ABS. : 1.1593e+01
Ele. 25 - MAX. ABS. : 5.5414e+01
Ele. 26 - MAX. ABS. : 5.5022e+01
Ele. 27 - MAX. ABS. : 2.5783e+01
Ele. 28 - MAX. ABS. : 2.4953e+01
Ele. 29 - MAX. ABS. : 4.7476e+01
Ele. 30 - MAX. ABS. : 4.5981e+01
Ele. 31 - MAX. ABS. : 3.2480e+01
Ele. 32 - MAX. ABS. : 8.7355e+00
Ele. 33 - MAX. ABS. : 1.8604e+01
Ele. 34 - MAX. ABS. : 6.3037e+00
Ele. 35 - MAX. ABS. : 1.1629e+01
Ele. 36 - MAX. ABS. : 5.5480e-01
Ele. 37 - MAX. ABS. : 1.0253e+01
Ele. 38 - MAX. ABS. : 1.6455e+00
Ele. 39 - MAX. ABS. : 5.6364e+00
Ele. 40 - MAX. ABS. : 2.6250e+00
Ele. 41 - MAX. ABS. : 5.5884e+00
Ele. 42 - MAX. ABS. : 9.8915e-01
Ele. 43 - MAX. ABS. : 6.1369e+00
Ele. 44 - MAX. ABS. : 4.9336e+00
Ele. 45 - MAX. ABS. : 1.5424e+01
Ele. 46 - MAX. ABS. : 8.7861e+00
Ele. 47 - MAX. ABS. : 4.4588e+01
Ele. 48 - MAX. ABS. : 1.2292e+01
Ele. 49 - MAX. ABS. : 5.6948e+01
Ele. 50 - MAX. ABS. : 2.6500e+01
Ele. 51 - MAX. ABS. : 5.8557e+01
Ele. 52 - MAX. ABS. : 1.2608e+01
Ele. 53 - MAX. ABS. : 5.8507e+01
Ele. 54 - MAX. ABS. : 8.4899e+00
Ele. 55 - MAX. ABS. : 2.8726e+01
Ele. 56 - MAX. ABS. : 5.9727e+00
Ele. 57 - MAX. ABS. : 6.3566e+00
Ele. 58 - MAX. ABS. : 6.7108e+00
Ele. 59 - MAX. ABS. : 2.6285e+01
Ele. 60 - MAX. ABS. : 8.3694e+00
Ele. 61 - MAX. ABS. : 3.3606e+01

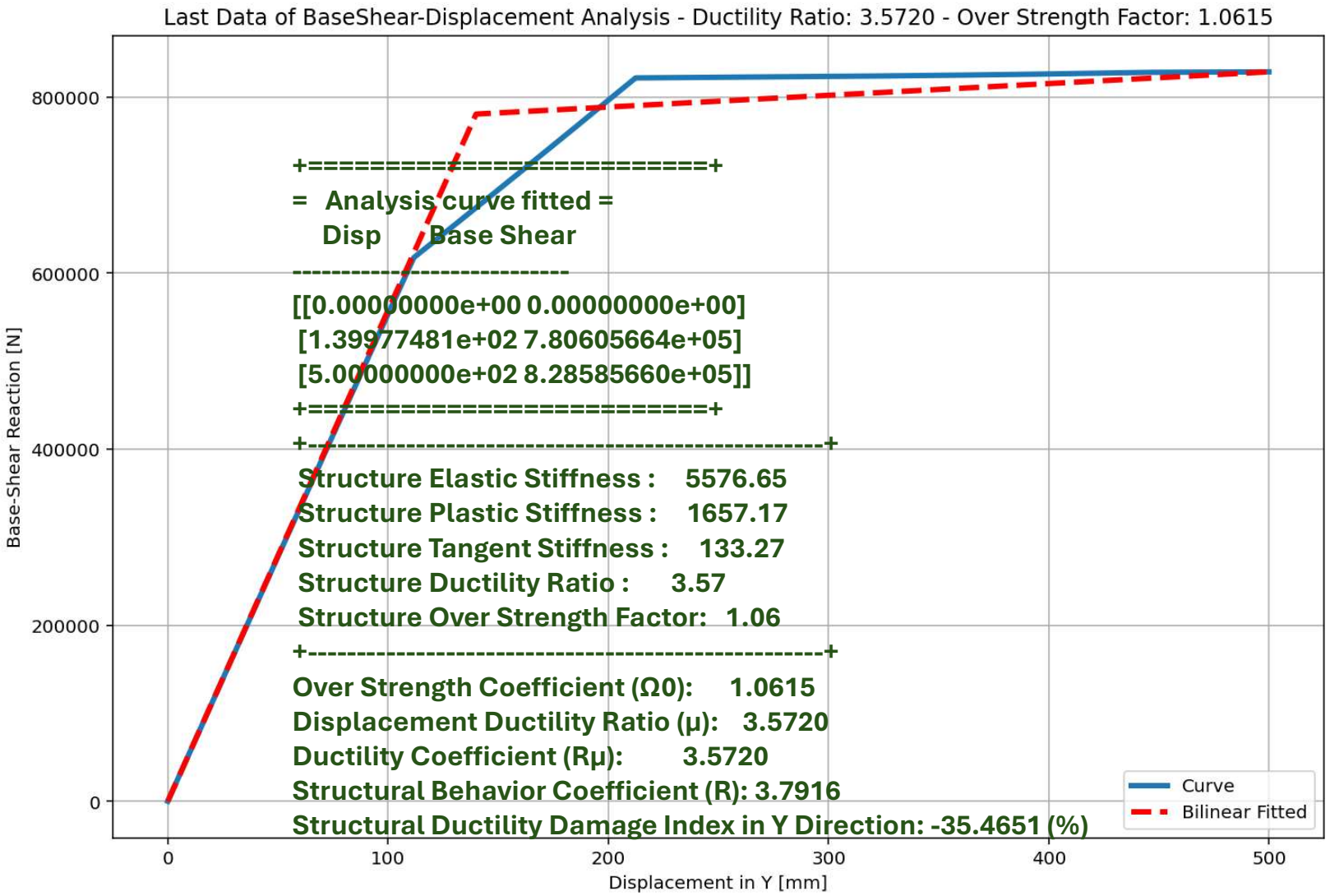

elements Strain in X Dir. vs Time for Bridge Structure During Dynamic External Time-dependent Loading Analysis
Element Strain [mm]
Time [s]
0.0003
0.0002
0.0001
0.0000
−0.0001
−0.0002
−0.0003
0.0
2.5
5.0
7.5
10.0
12.5
Ele. 1 - MAX. ABS. : 2.5178e-05
Ele. 2 - MAX. ABS. : 2.2174e-05
Ele. 3 - MAX. ABS. : 5.4663e-05
Ele. 4 - MAX. ABS. : 5.1243e-05
Ele. 5 - MAX. ABS. : 2.5061e-05
Ele. 6 - MAX. ABS. : 1.6428e-05
Ele. 7 - MAX. ABS. : 5.9990e-05
Ele. 8 - MAX. ABS. : 7.0462e-05
Ele. 9 - MAX. ABS. : 1.2935e-04
Ele. 10 - MAX. ABS. : 1.2629e-04
Ele. 11 - MAX. ABS. : 1.8328e-04
Ele. 12 - MAX. ABS. : 1.8140e-04
Ele. 13 - MAX. ABS. : 1.4149e-04
Ele. 14 - MAX. ABS. : 1.4178e-04
Ele. 15 - MAX. ABS. : 4.2467e-05
Ele. 16 - MAX. ABS. : 4.1006e-05
Ele. 17 - MAX. ABS. : 1.7328e-04
Ele. 18 - MAX. ABS. : 1.8171e-04
Ele. 19 - MAX. ABS. : 1.1464e-04
Ele. 20 - MAX. ABS. : 1.1405e-04
Ele. 21 - MAX. ABS. : 1.0724e-04
Ele. 22 - MAX. ABS. : 1.0301e-04
Ele. 23 - MAX. ABS. : 6.3566e-05
Ele. 24 - MAX. ABS. : 5.7964e-05
Ele. 25 - MAX. ABS. : 2.7707e-04
Ele. 26 - MAX. ABS. : 2.7511e-04
Ele. 27 - MAX. ABS. : 1.2892e-04
Ele. 28 - MAX. ABS. : 1.2477e-04
Ele. 29 - MAX. ABS. : 2.3738e-04
Ele. 30 - MAX. ABS. : 2.2991e-04
Ele. 31 - MAX. ABS. : 1.6240e-04
Ele. 32 - MAX. ABS. : 4.3678e-05
Ele. 33 - MAX. ABS. : 9.3019e-05
Ele. 34 - MAX. ABS. : 3.1519e-05
Ele. 35 - MAX. ABS. : 5.8143e-05
Ele. 36 - MAX. ABS. : 2.7740e-06
Ele. 37 - MAX. ABS. : 5.1263e-05
Ele. 38 - MAX. ABS. : 8.2276e-06
Ele. 39 - MAX. ABS. : 2.8182e-05
Ele. 40 - MAX. ABS. : 1.3125e-05
Ele. 41 - MAX. ABS. : 2.7942e-05
Ele. 42 - MAX. ABS. : 4.9458e-06
Ele. 43 - MAX. ABS. : 3.0685e-05
Ele. 44 - MAX. ABS. : 2.4668e-05
Ele. 45 - MAX. ABS. : 7.7121e-05
Ele. 46 - MAX. ABS. : 4.3930e-05
Ele. 47 - MAX. ABS. : 2.2294e-04
Ele. 48 - MAX. ABS. : 6.1462e-05
Ele. 49 - MAX. ABS. : 2.8474e-04
Ele. 50 - MAX. ABS. : 1.3250e-04
Ele. 51 - MAX. ABS. : 2.9279e-04
Ele. 52 - MAX. ABS. : 6.3039e-05
Ele. 53 - MAX. ABS. : 2.9253e-04
Ele. 54 - MAX. ABS. : 4.2450e-05
Ele. 55 - MAX. ABS. : 1.4363e-04
Ele. 56 - MAX. ABS. : 2.9863e-05
Ele. 57 - MAX. ABS. : 3.1783e-05
Ele. 58 - MAX. ABS. : 3.3554e-05
Ele. 59 - MAX. ABS. : 1.3142e-04
Ele. 60 - MAX. ABS. : 4.1847e-05
Ele. 61 - MAX. ABS. : 1.6803e-04


elements Damage-index [%] in X Dir. vs Time for Bridge Structure During Seismic Analysis
Element Damage-index [%]
Time [s]
0.0003
0.0002
0.0001
0.0000
−0.0001
−0.0002
−0.0003
0.0
2.5
5.0
7.5
10.0
12.5
Ele. 1 - MAX. ABS. : 2.5178e-05
Ele. 2 - MAX. ABS. : 2.2174e-05
Ele. 3 - MAX. ABS. : 5.4663e-05
Ele. 4 - MAX. ABS. : 5.1243e-05
Ele. 5 - MAX. ABS. : 2.5061e-05
Ele. 6 - MAX. ABS. : 1.6428e-05
Ele. 7 - MAX. ABS. : 5.9990e-05
Ele. 8 - MAX. ABS. : 7.0462e-05
Ele. 9 - MAX. ABS. : 1.2935e-04
Ele. 10 - MAX. ABS. : 1.2629e-04
Ele. 11 - MAX. ABS. : 1.8328e-04
Ele. 12 - MAX. ABS. : 1.8140e-04
Ele. 13 - MAX. ABS. : 1.4149e-04
Ele. 14 - MAX. ABS. : 1.4178e-04
Ele. 15 - MAX. ABS. : 4.2467e-05
Ele. 16 - MAX. ABS. : 4.1006e-05
Ele. 17 - MAX. ABS. : 1.7328e-04
Ele. 18 - MAX. ABS. : 1.8171e-04
Ele. 19 - MAX. ABS. : 1.1464e-04
Ele. 20 - MAX. ABS. : 1.1405e-04
Ele. 21 - MAX. ABS. : 1.0724e-04
Ele. 22 - MAX. ABS. : 1.0301e-04
Ele. 23 - MAX. ABS. : 6.3566e-05
Ele. 24 - MAX. ABS. : 5.7964e-05
Ele. 25 - MAX. ABS. : 2.7707e-04
Ele. 26 - MAX. ABS. : 2.7511e-04
Ele. 27 - MAX. ABS. : 1.2892e-04
Ele. 28 - MAX. ABS. : 1.2477e-04
Ele. 29 - MAX. ABS. : 2.3738e-04
Ele. 30 - MAX. ABS. : 2.2991e-04
Ele. 31 - MAX. ABS. : 1.6240e-04
Ele. 32 - MAX. ABS. : 4.3678e-05
Ele. 33 - MAX. ABS. : 9.3019e-05
Ele. 34 - MAX. ABS. : 3.1519e-05
Ele. 35 - MAX. ABS. : 5.8143e-05
Ele. 36 - MAX. ABS. : 2.7740e-06
Ele. 37 - MAX. ABS. : 5.1263e-05
Ele. 38 - MAX. ABS. : 8.2276e-06
Ele. 39 - MAX. ABS. : 2.8182e-05
Ele. 40 - MAX. ABS. : 1.3125e-05
Ele. 41 - MAX. ABS. : 2.7942e-05
Ele. 42 - MAX. ABS. : 4.9458e-06
Ele. 43 - MAX. ABS. : 3.0685e-05
Ele. 44 - MAX. ABS. : 2.4668e-05
Ele. 45 - MAX. ABS. : 7.7121e-05
Ele. 46 - MAX. ABS. : 4.3930e-05
Ele. 47 - MAX. ABS. : 2.2294e-04
Ele. 48 - MAX. ABS. : 6.1462e-05
Ele. 49 - MAX. ABS. : 2.8474e-04
Ele. 50 - MAX. ABS. : 1.3250e-04
Ele. 51 - MAX. ABS. : 2.9279e-04
Ele. 52 - MAX. ABS. : 6.3039e-05
Ele. 53 - MAX. ABS. : 2.9253e-04
Ele. 54 - MAX. ABS. : 4.2450e-05
Ele. 55 - MAX. ABS. : 1.4363e-04
Ele. 56 - MAX. ABS. : 2.9863e-05
Ele. 57 - MAX. ABS. : 3.1783e-05
Ele. 58 - MAX. ABS. : 3.3554e-05
Ele. 59 - MAX. ABS. : 1.3142e-04
Ele. 60 - MAX. ABS. : 4.1847e-05
Ele. 61 - MAX. ABS. : 1.6803e-04

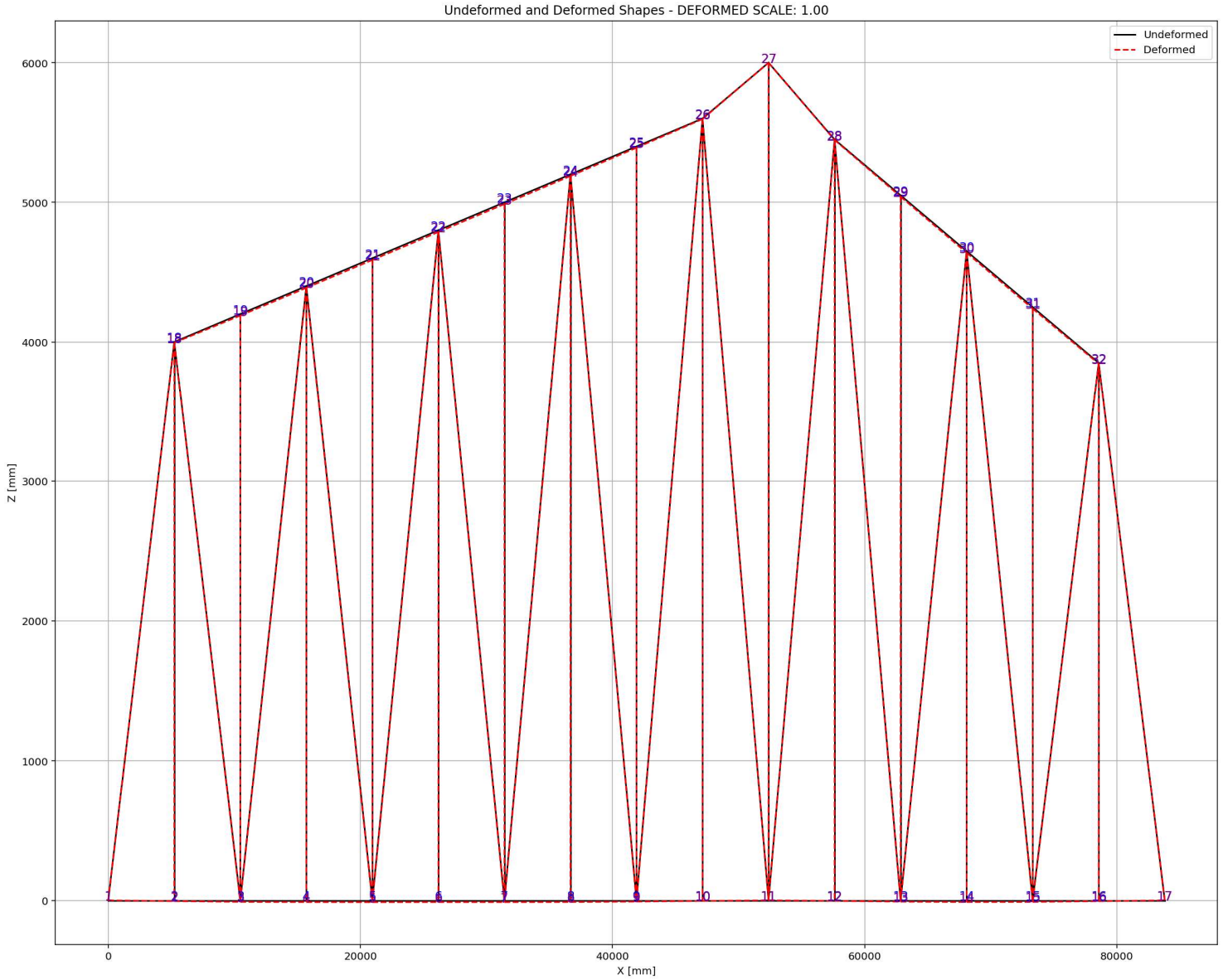

Node Displacements in X Dir. vs Time for Bridge Structure During Seismic Analysis
Displacement [mm]
Time [s]
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
3
2
1
0
−1
−2
−3
Node 1 - MAX. ABS. : 0.0000e+00
Node 2 - MAX. ABS. : 1.2952e-01
Node 3 - MAX. ABS. : 2.4374e-01
Node 4 - MAX. ABS. : 4.6537e-01
Node 5 - MAX. ABS. : 7.3371e-01
Node 6 - MAX. ABS. : 6.7994e-01
Node 7 - MAX. ABS. : 6.6028e-01
Node 8 - MAX. ABS. : 9.7441e-01
Node 9 - MAX. ABS. : 1.3427e+00
Node 10 - MAX. ABS. : 6.6288e-01
Node 11 - MAX. ABS. : 0.0000e+00
Node 12 - MAX. ABS. : 9.6118e-01
Node 13 - MAX. ABS. : 1.9143e+00
Node 14 - MAX. ABS. : 1.1739e+00
Node 15 - MAX. ABS. : 4.3139e-01
Node 16 - MAX. ABS. : 2.1156e-01
Node 17 - MAX. ABS. : 0.0000e+00
Node 18 - MAX. ABS. : 3.3567e+00
Node 19 - MAX. ABS. : 2.6476e+00
Node 20 - MAX. ABS. : 1.7517e+00
Node 21 - MAX. ABS. : 1.1759e+00
Node 22 - MAX. ABS. : 5.5997e-01
Node 23 - MAX. ABS. : 1.0336e-01
Node 24 - MAX. ABS. : 5.7407e-01
Node 25 - MAX. ABS. : 9.8683e-01
Node 26 - MAX. ABS. : 1.4881e+00
Node 27 - MAX. ABS. : 3.2042e-01
Node 28 - MAX. ABS. : 9.0854e-01
Node 29 - MAX. ABS. : 3.3760e-01
Node 30 - MAX. ABS. : 1.1574e+00
Node 31 - MAX. ABS. : 2.3717e+00
Node 32 - MAX. ABS. : 3.1793e+00


Node Displacements in Y Dir. vs Time for Bridge Structure During Seismic Analysis
Displacement [mm]
0
−2
−4
−6
−8
−10
−12
0.0
2.5
5.0
7.5
10.0
12.5
Time [s]
Node 1 - MAX. ABS. : 0.0000e+00
Node 2 - MAX. ABS. : 5.4955e+00
Node 3 - MAX. ABS. : 1.0672e+01
Node 4 - MAX. ABS. : 1.2166e+01
Node 5 - MAX. ABS. : 1.2844e+01
Node 6 - MAX. ABS. : 1.2295e+01
Node 7 - MAX. ABS. : 1.2543e+01
Node 8 - MAX. ABS. : 1.1671e+01
Node 9 - MAX. ABS. : 8.8031e+00
Node 10 - MAX. ABS. : 4.2928e+00
Node 11 - MAX. ABS. : 0.0000e+00
Node 12 - MAX. ABS. : 4.1878e+00
Node 13 - MAX. ABS. : 9.2569e+00
Node 14 - MAX. ABS. : 1.1764e+01
Node 15 - MAX. ABS. : 1.1008e+01
Node 16 - MAX. ABS. : 5.8022e+00
Node 17 - MAX. ABS. : 0.0000e+00
Node 18 - MAX. ABS. : 5.5059e+00
Node 19 - MAX. ABS. : 1.0799e+01
Node 20 - MAX. ABS. : 1.2154e+01
Node 21 - MAX. ABS. : 1.2823e+01
Node 22 - MAX. ABS. : 1.2358e+01
Node 23 - MAX. ABS. : 1.2542e+01
Node 24 - MAX. ABS. : 1.1543e+01
Node 25 - MAX. ABS. : 9.0200e+00
Node 26 - MAX. ABS. : 4.0711e+00
Node 27 - MAX. ABS. : 7.9501e-01
Node 28 - MAX. ABS. : 3.9418e+00
Node 29 - MAX. ABS. : 9.4699e+00
Node 30 - MAX. ABS. : 1.1625e+01
Node 31 - MAX. ABS. : 1.1151e+01
Node 32 - MAX. ABS. : 5.8316e+00


Period of Structure During Seismic Analysis
Structural Period [s]
160
140
120
100
80
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Time [s]
PERIOD - MIN VALUES: Min: 162.926 (s) - Mean: 163.057 (s) - Max: 163.259 (s)
PERIOD - MAX VALUES: Min: 74.757 (s) - Mean: 74.804 (s) - Max: 74.874 (s)


Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 3.5720 - Over Strength Factor: 1.0615
Base-Shear Reaction [N]
Displacement in Y [mm]
0
200000
400000
600000
800000
0
100
200
300
400
500
+============================+
= Analysis curve fitted =
Disp Base Shear

[[0.00000000e+00 0.00000000e+00]
[1.39977481e+02 7.80605664e+05]
[5.00000000e+02 8.28585660e+05]]
+============================+
+---+
Structure Elastic Stiffness : 5576.65
Structure Plastic Stiffness : 1657.17
Structure Tangent Stiffness : 133.27
Structure Ductility Ratio : 3.57
Structure Over Strength Factor: 1.06
+---+
Over Strength Coefficient (Ω0): 1.0615
Displacement Ductility Ratio (μ): 3.5720
Ductility Coefficient (Rμ): 3.5720
Structural Behavior Coefficient (R): 3.7916
Structural Ductility Damage Index in Y Direction: -35.4651 (%)
Curve
Bilinear Fitted


Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
1000
2000
3000
4000
5000
6000
0
20000
40000
60000
80000
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32