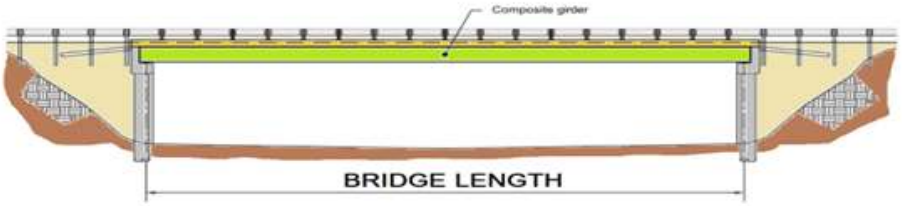
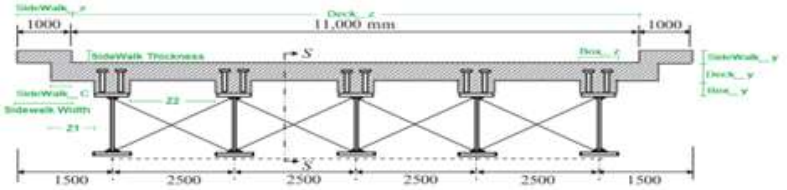
IN THE NAME OF ALLAH

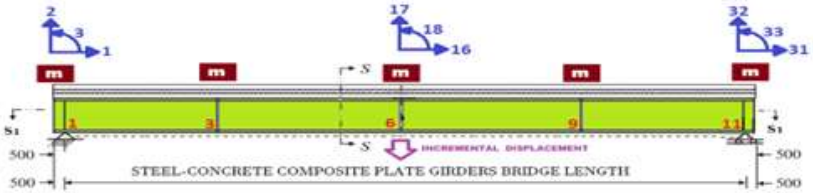
STEEL-CONCRETE COMPOSITE PLATE GIRDERS BRIDGE SUPERSTRUCTURE RUNNING MOMENT-CURVATURE, PUSHOVER AND DYNAMIC ANALYSIS FOR CALCULATE STRUCTURAL DUCTILIY DAMAGE INEX

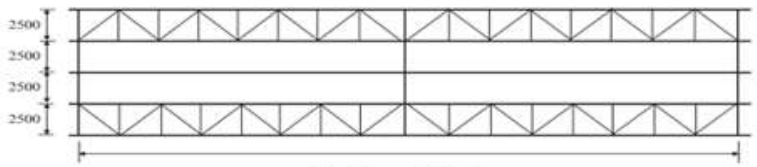
WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)



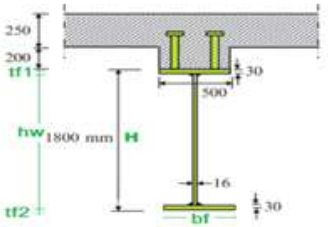


Composite bridge cross section

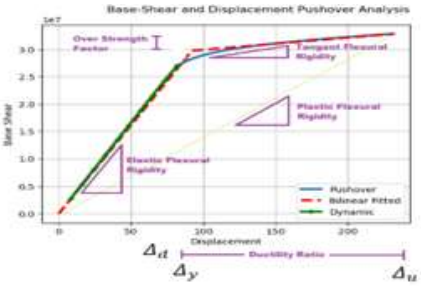




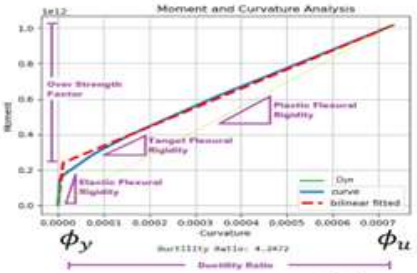
Plan of lower wind bracing
Cross Section S1-S1



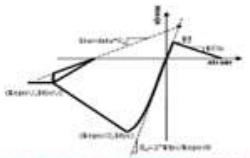
Cross section *S-S*



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



$$\text{Section Ductility Damage Index} = \frac{\Phi_d - \Phi_y}{\Phi_u - \Phi_y}$$



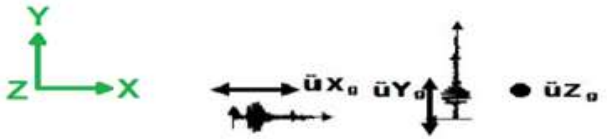
CORE AND COVER CONCRETE RELATION

STEEL REBAR AND PLATE SECTION RELATION

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

$$\text{Section Ductility Damage Index} = \frac{\Phi_d - \Phi_y}{\Phi_u - \Phi_y}$$

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



$$\text{Structure Ductility Damage Index} = \frac{\Delta_{it} - \Delta_y}{\Delta_u - \Delta_y}$$

Δ_{it} = *Lateral Displaement from Dynamic Analysis*

Δ_y = *Lateral Yield Displaement from Pushover Analysis*

Δ_u = *Lateral Ultimate Displaement from Pushover Analysis*

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

C:\Users\Dell\Desktop\OPENSEES_FILES\SINGLE_SPAN_...\SINGLE_SPAN_SIMPLY_SUPPORTED_COMPOSITE_BRIDGE.py

EL-COMPUTING.py | CONCRETE_FRAME_DUCTILITY_DAMAGE_INDEX.py | SINGLE_SPAN_SIMPLY...OMPOSITE_BRIDGE.py

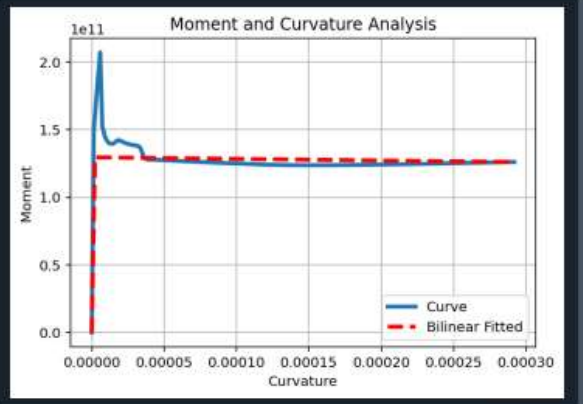
```
#          ##########################################################################################
#          #                                      IN THE NAME OF ALLAH
#          #                  STEEL-CONCRETE COMPOSITE PLATE GIRDERS BRIDGE SUPERSTRUCTURE
#          #               RUNNING MOMENT-CURVATURE, PUSHOVER AND DYNAMIC ANALYSIS FOR CALCULATE
#          #                                OPTIMUM STRUCTURAL DUCTILIY DAMAGE INEX
#          #------------------------------------------------------------------------------------------
#          #                     THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#          #                                EMAIL: salar.d.ghashghaei@gmail.com
#          ##########################################################################################

#import the os module
import os
import time as TI
import numpy as np
import openseespy.opensees as op
import opsvis as opsv
import matplotlib.pyplot as plt
import ANALYSIS_FUNCTION as S02
import PLOT_2D as S04
import SALAR_MATH as S05
#%%-------------------------------------------------
# Create a directory at specified path with name 'directory_path'
#import os
directory_path = 'C:\\OPENSEESPY_SALAR'

# Check if the directory already exists
if not os.path.exists(directory_path):
    os.mkdir(directory_path)
    print(f"Directory '{directory_path}' created successfully.")
else:
    print(f"Directory '{directory_path}' already exists. Skipping creation.")
#------------------------------------------------------------
# Create folder name
FOLDER_NAME = 'COMPOSITE BRIDGE OPTIMIZATION'
```

C:\Users\Dell

45 %



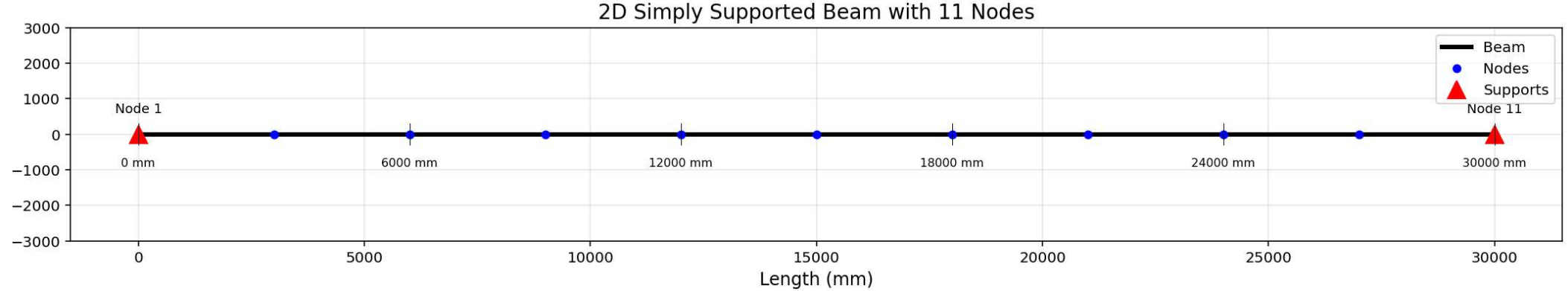
Help | Variable Explorer | Debugger | Plots | Files

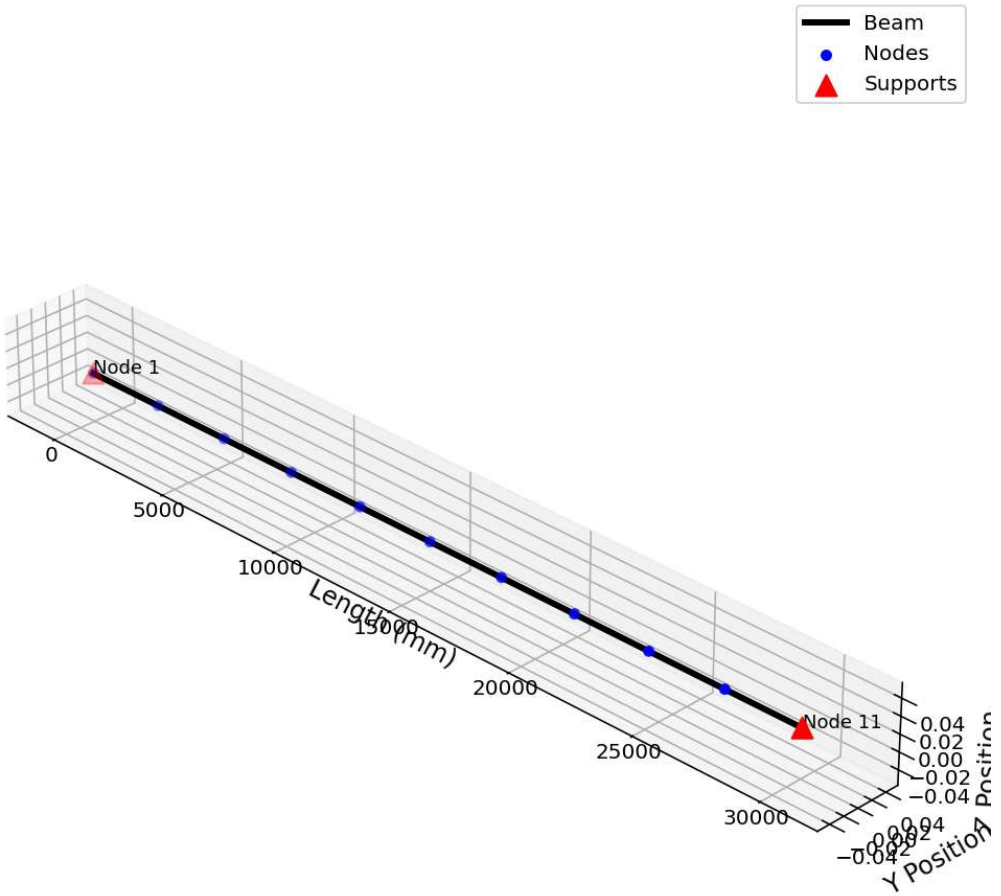
Console 1/A

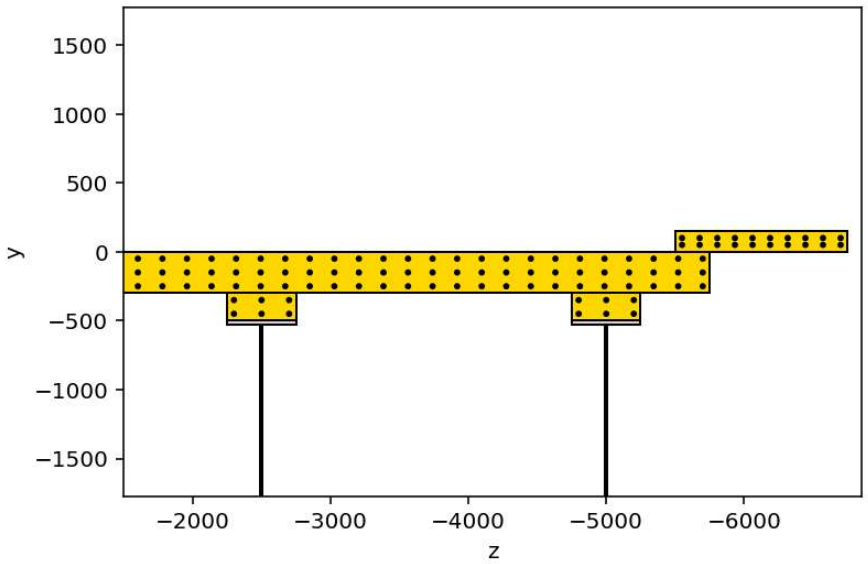
```
CTestNormDispIncr::test() - iteration: 2 current Norm: 1.04382e-14
(max: 1e-08, Norm deltaR: 0.00119821)
1218 -5.1041642071227905e-16 -7.450580596923828e-09
1219 1.841482195566861e-16 -9.685754776000977e-08
1220 -8.135819203360762e-18 -1.4901161193847656e-08
1221 -1.3730480488676494e-17 6.705522537231445e-08
1222 -7.018724453083643e-18 0.0
1223 1.6628443172577976e-16 7.450580596923828e-09
CTestNormDispIncr::test() - iteration: 2 current Norm: 2.66403e-14
(max: 1e-08, Norm deltaR: 0.0029853)
CTestNormDispIncr::test() - iteration: 2 current Norm: 2.69497e-14
```

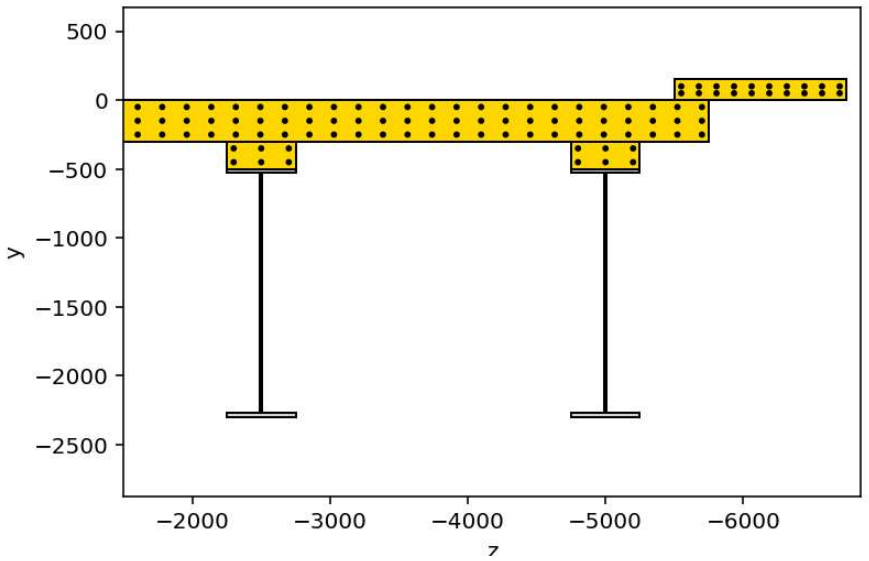
IPython Console | History

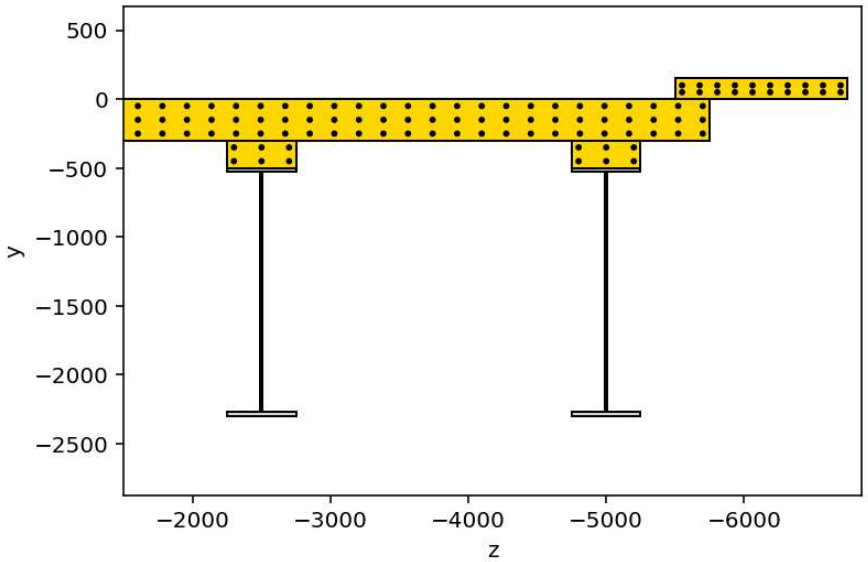
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 691 Col 35 UTF-8 CRLF RW Mem 34%

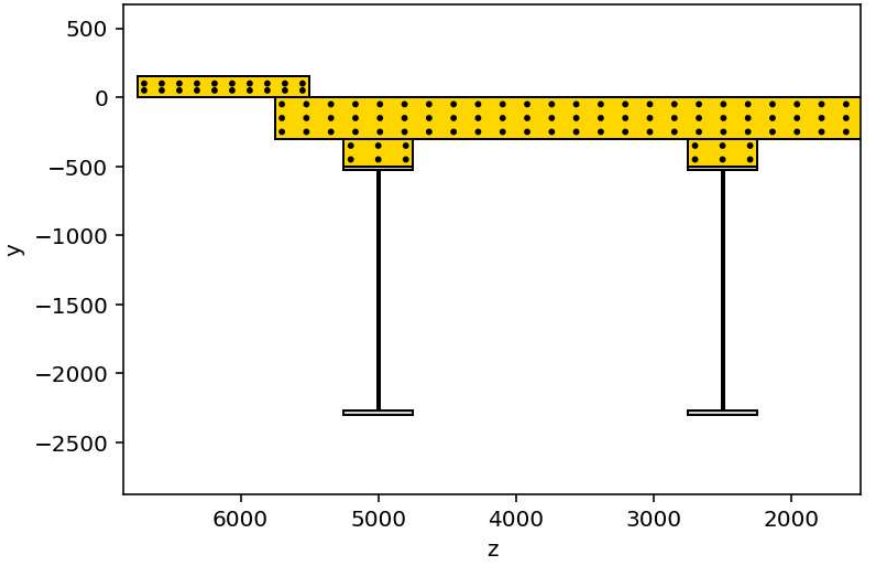

2D Simply Supported Beam with 11 Nodes
Beam
Nodes
Supports
Node 1
Node 11
0 mm
6000 mm
12000 mm
18000 mm
24000 mm
30000 mm
3000
2000
1000
0
−1000
−2000
−3000
0
5000
10000
15000
20000
25000
30000
Length (mm)

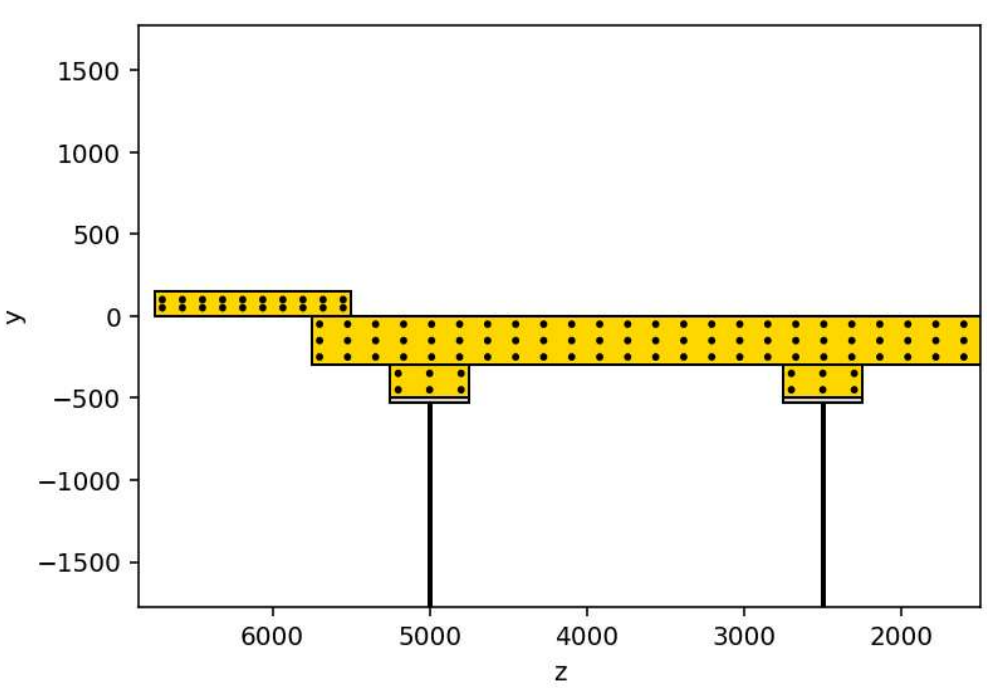

3D Simply Supported Beam with 11 Nodes
Beam
Nodes
Supports
Node 1
Node 11
0
5000
10000
15000
20000
25000
30000
Length (mm)
0.04
0.02
0.00
−0.02
−0.04
Y Position

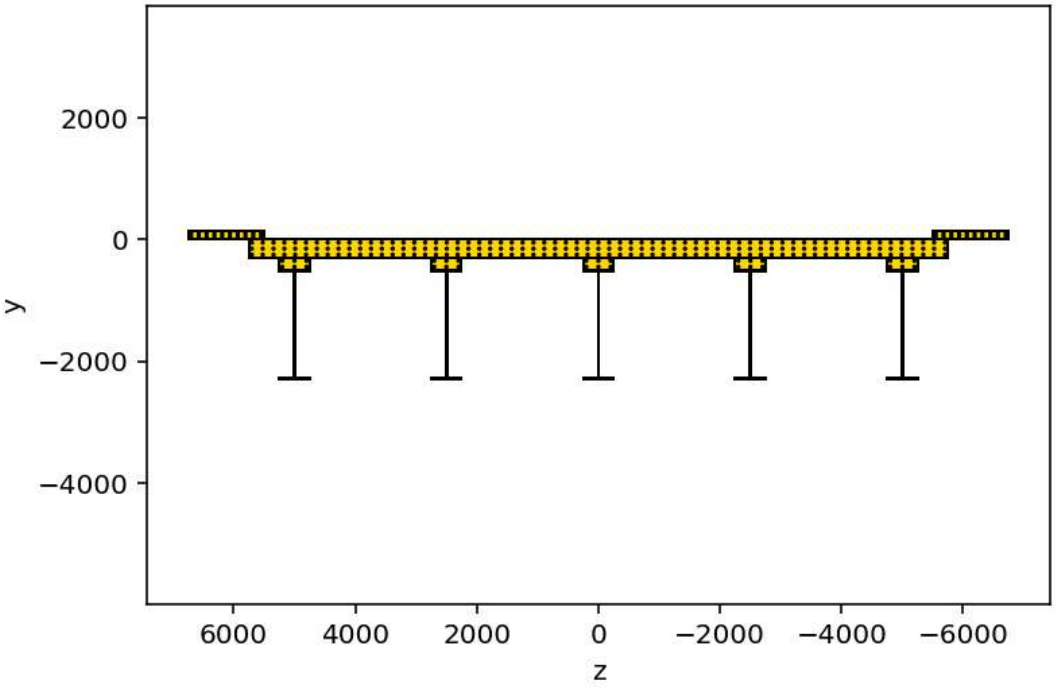

1500
1000
500
0
−500
−1000
−1500
y
−2000
−3000
−4000
−5000
−6000
z


500
0
−500
−1000
−1500
−2000
−2500
y
−2000
−3000
−4000
−5000
−6000
z

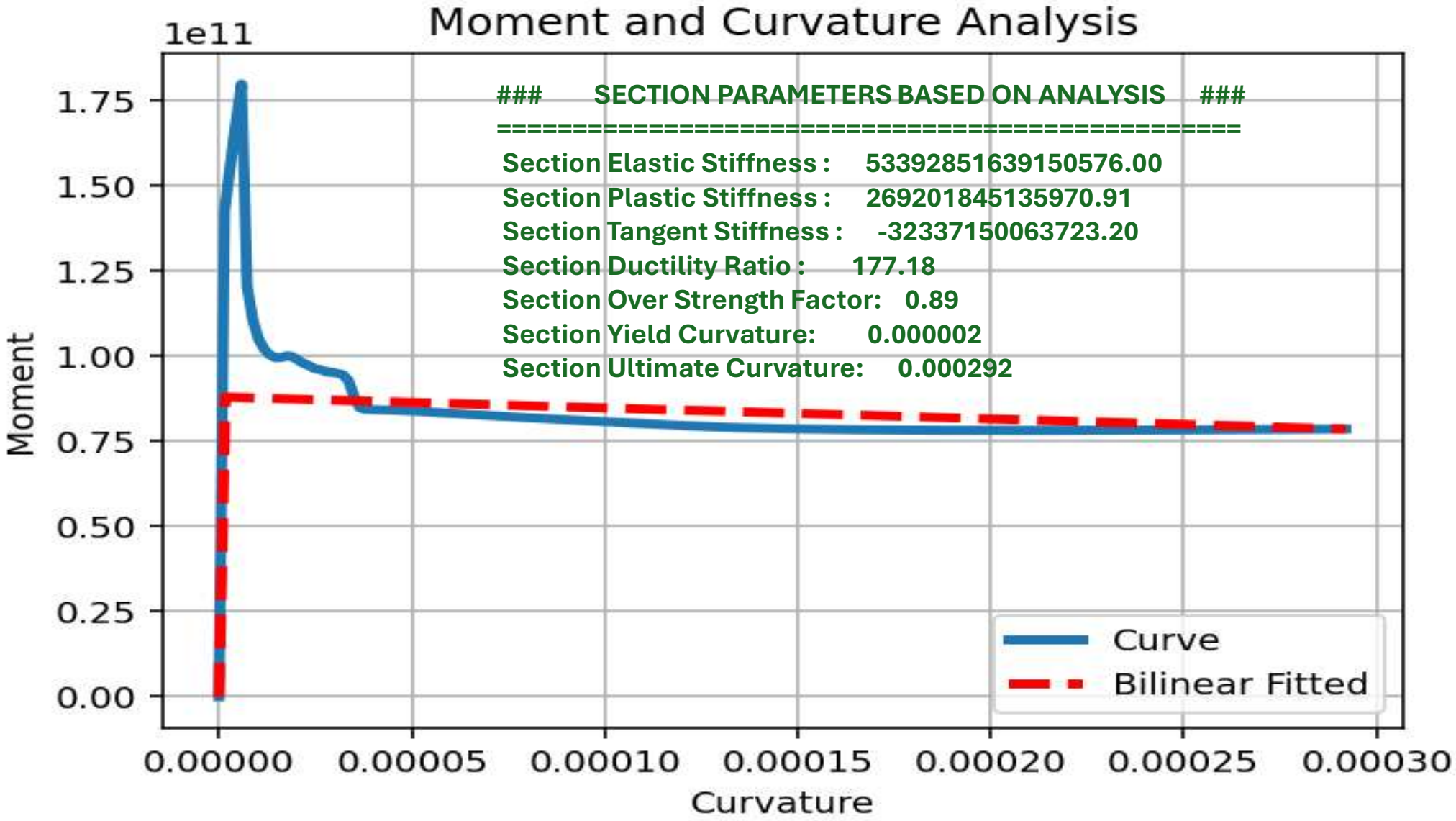

500
0
−500
−1000
−1500
−2000
−2500
y
−2000
−3000
−4000
−5000
−6000
z


500
0
−500
−1000
−1500
−2000
−2500
y
6000
5000
4000
3000
2000
z

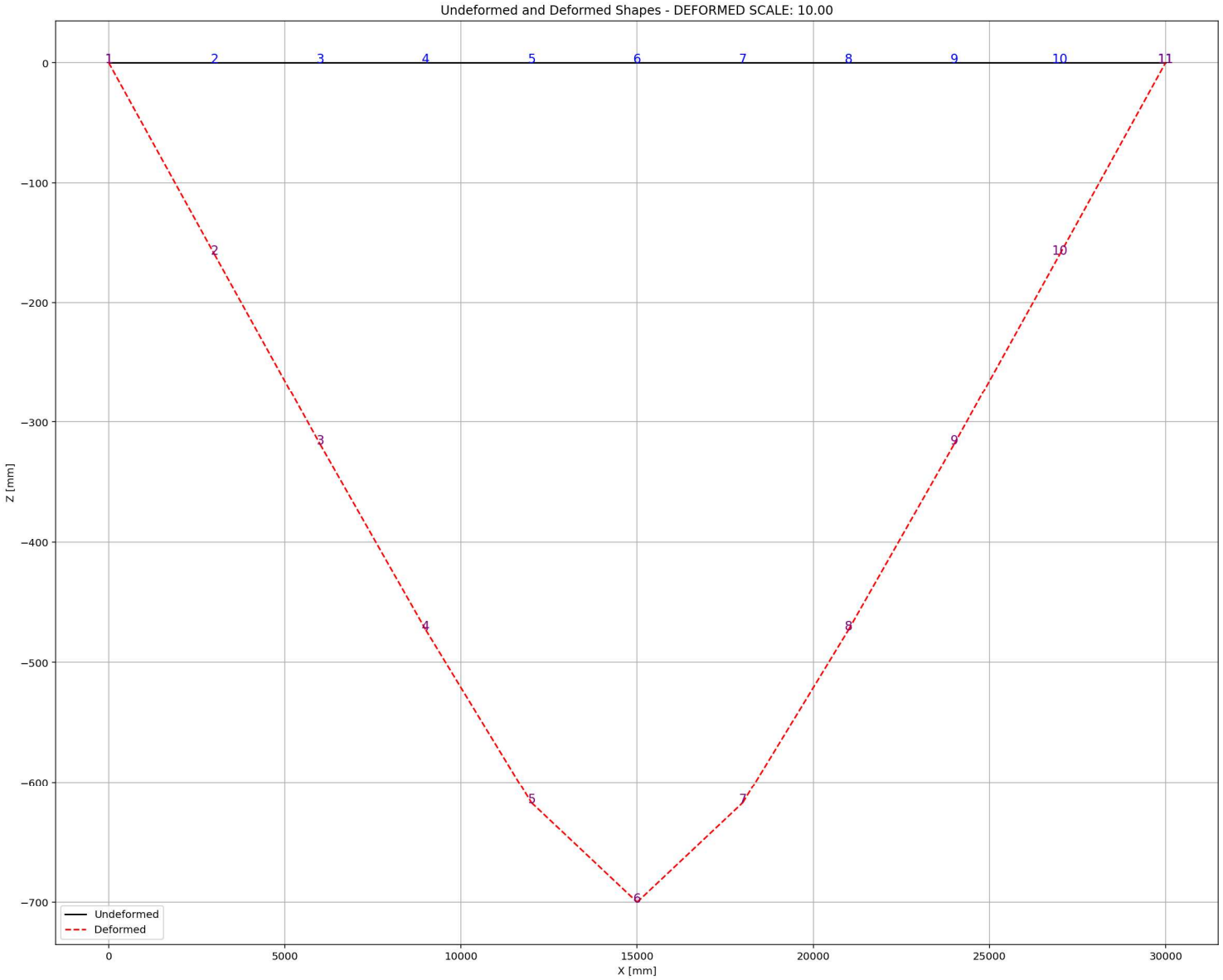

1500
1000
500
0
−500
−1000
−1500
y
6000
5000
4000
3000
2000
z

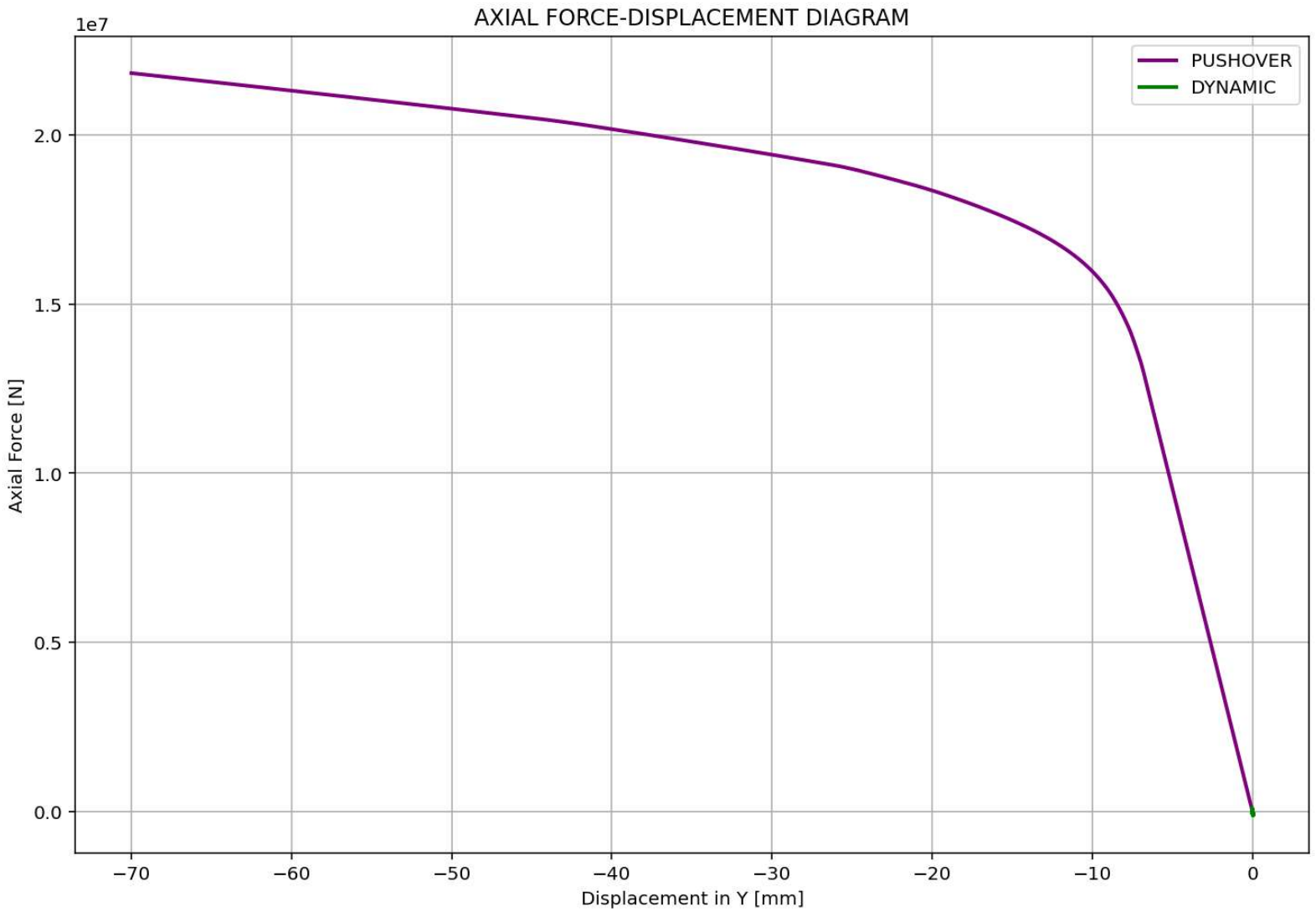

2000
0
−2000
−4000
y
6000
4000
2000
0
−2000
−4000
−6000
z

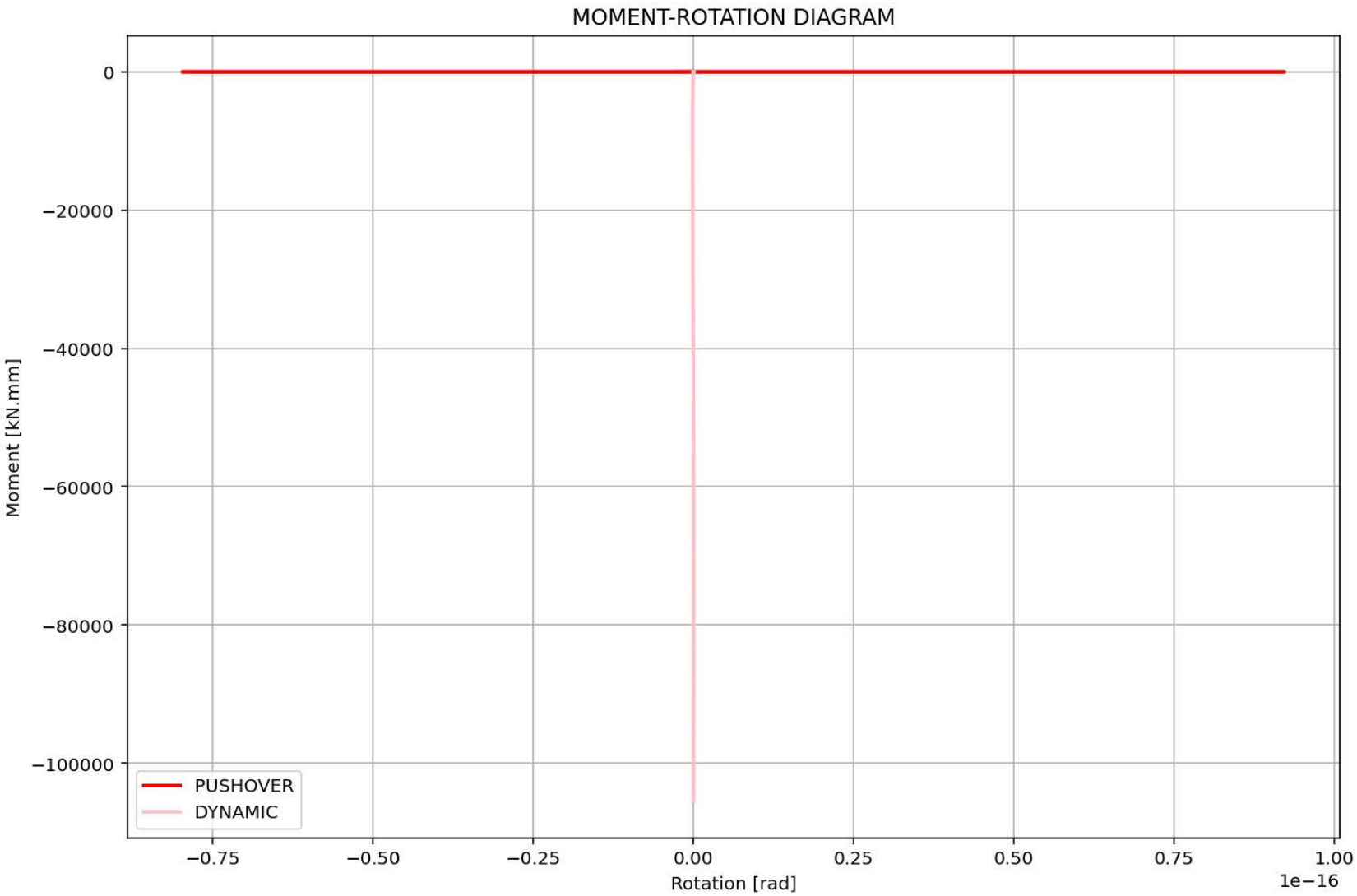
MOMENT-CURVATURE ANALYSIS

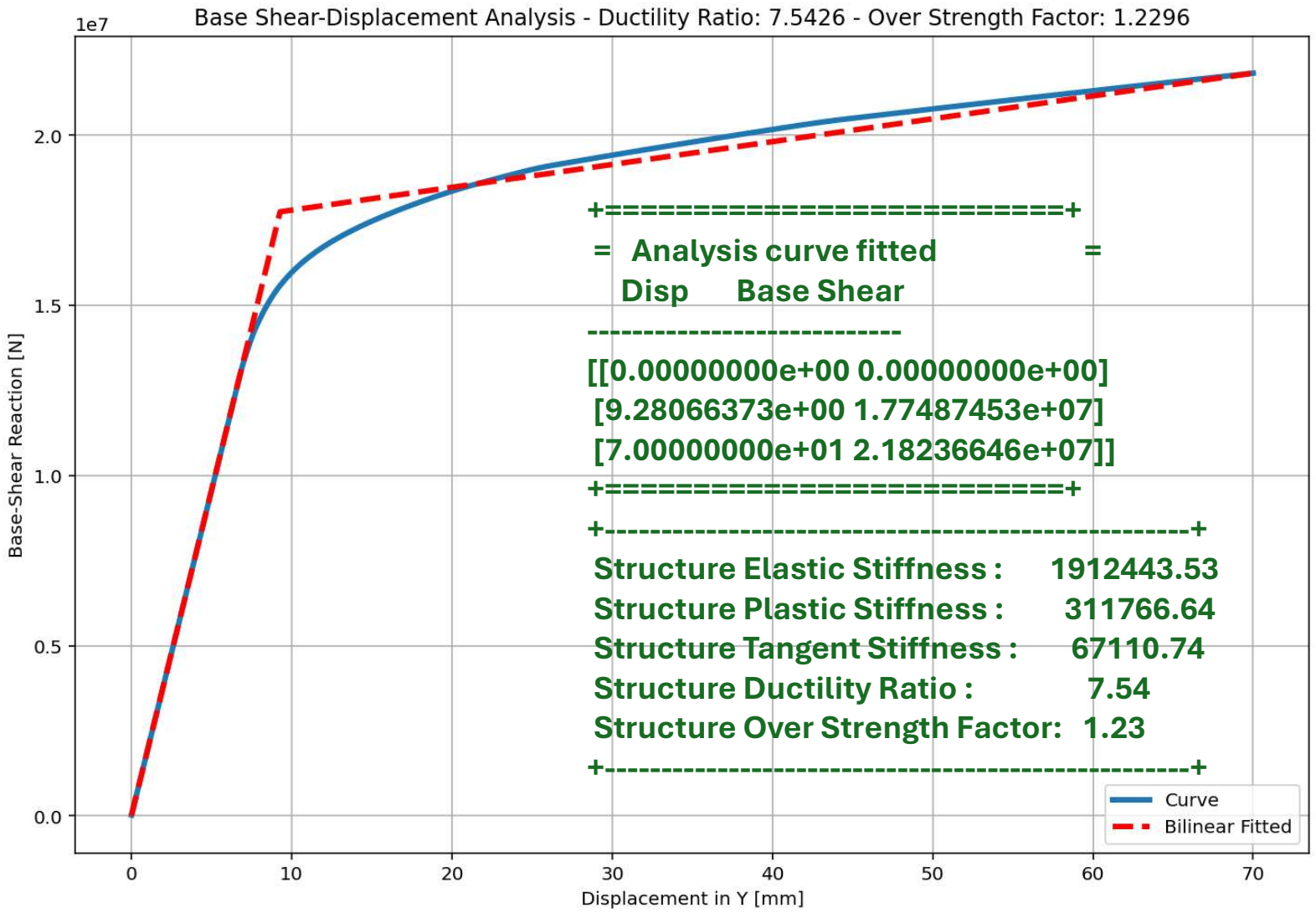

Moment and Curvature Analysis
1e11
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Moment
0.00000
0.00005
0.00010
0.00015
0.00020
0.00025
0.00030
Curvature
SECTION PARAMETERS BASED ON ANALYSIS
==========
Section Elastic Stiffness : 533928516391505 76.00
Section Plastic Stiffness : 269201845135970.91
Section Tangent Stiffness : -32337150063723.20
Section Ductility Ratio : 177.18
Section Over Strength Factor: 0.89
Section Yield Curvature: 0.000002
Section Ultimate Curvature: 0.000292
Curve
Bilinear Fitted

NONLINEAR STATIC ANALYSIS (PUSHOVER)


Undeformed and Deformed Shapes - DEFORMED SCALE: 10.00
Z [mm]
X [mm]
0
−100
−200
−300
−400
−500
−600
−700
0
5000
10000
15000
20000
25000
30000
1
2
3
4
5
6
7
8
9
10
11
Undeformed
Deformed

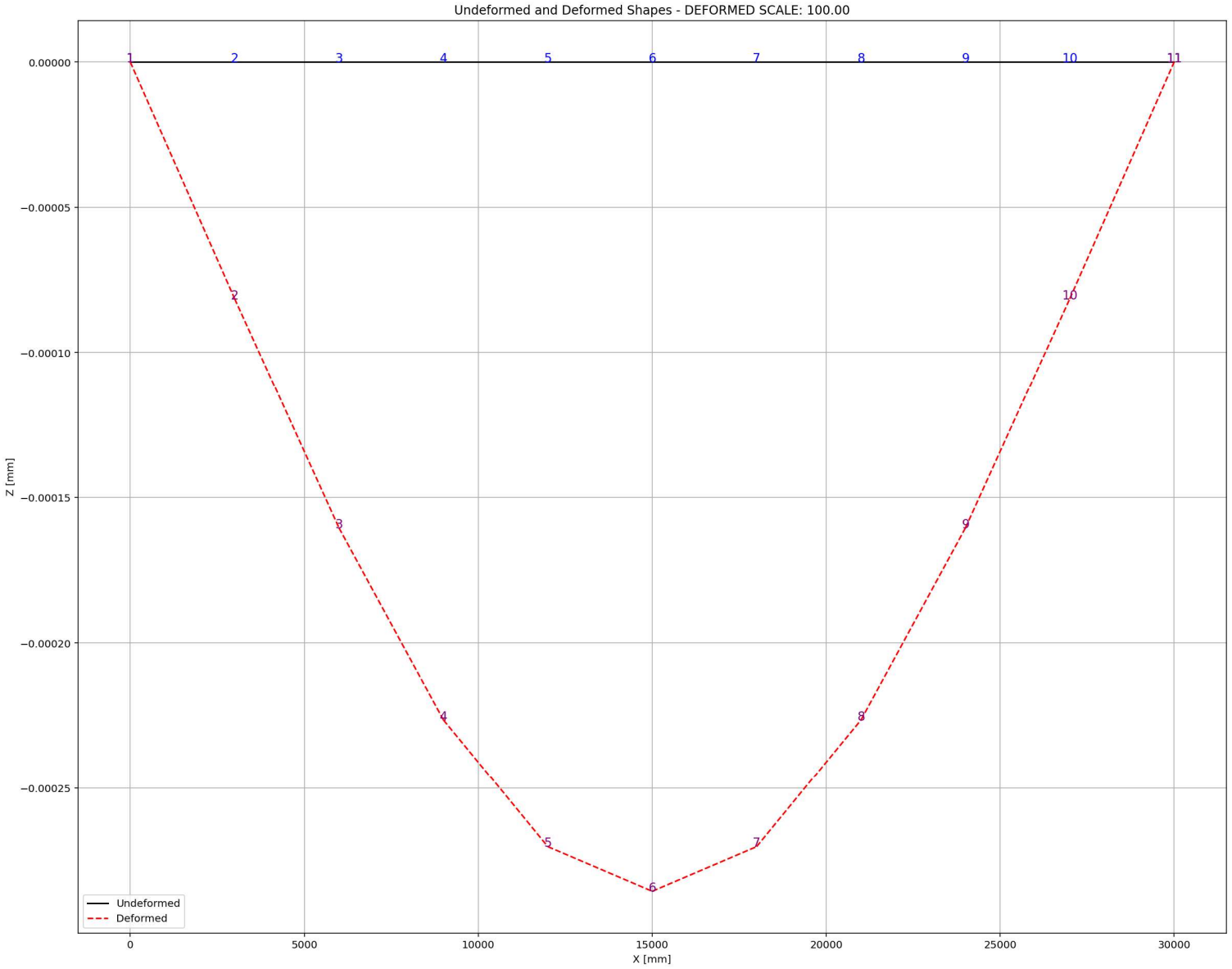

AXIAL FORCE-DISPLACEMENT DIAGRAM
1e7
PUSHOVER
DYNAMIC
2.0
1.5
1.0
0.5
0.0
Axial Force [N]
−70
−60
−50
−40
−30
−20
−10
0
Displacement in Y [mm]

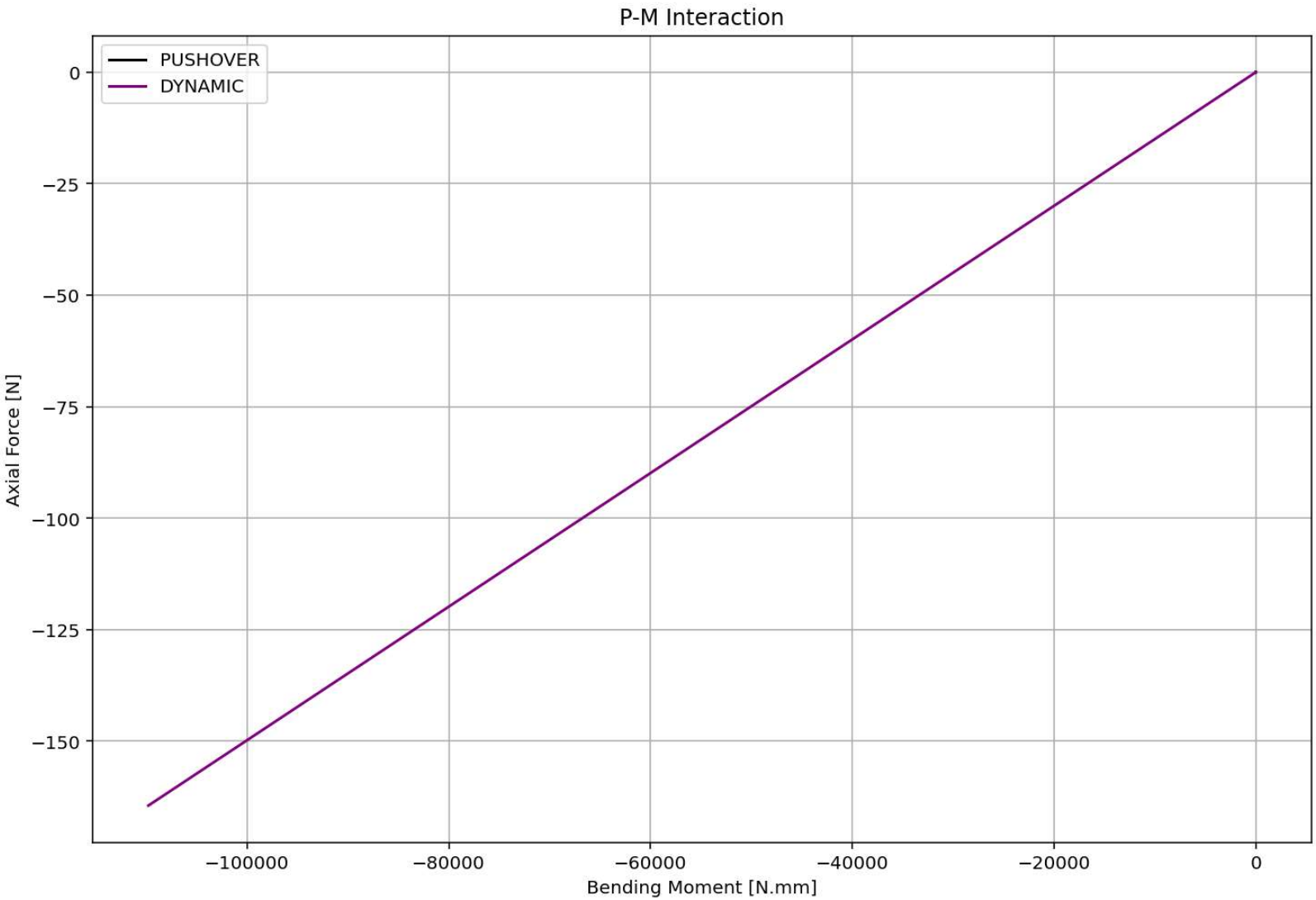

MOMENT-ROTATION DIAGRAM
Moment [kN.mm]
0
−20000
−40000
−60000
−80000
−100000
PUSHOVER
DYNAMIC
−0.75
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1e−16
Rotation [rad]

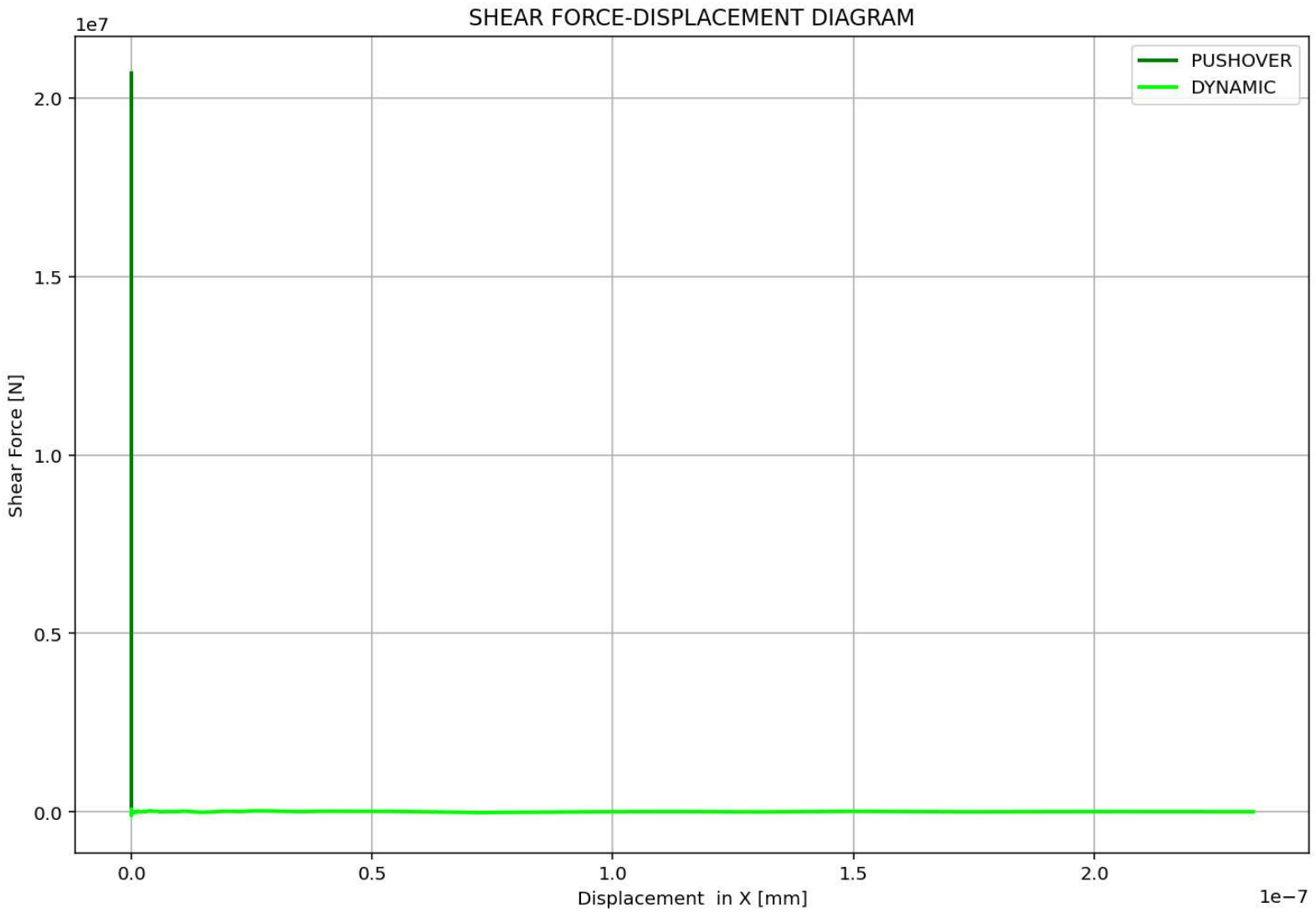

Base Shear-Displacement Analysis - Ductility Ratio: 7.5426 - Over Strength Factor: 1.2296
1e7
Base-Shear Reaction [N]
Displacement in Y [mm]
0.0
0.5
1.0
1.5
2.0
0
10
20
30
40
50
60
70
+============================+
= Analysis curve fitted =
Disp Base Shear

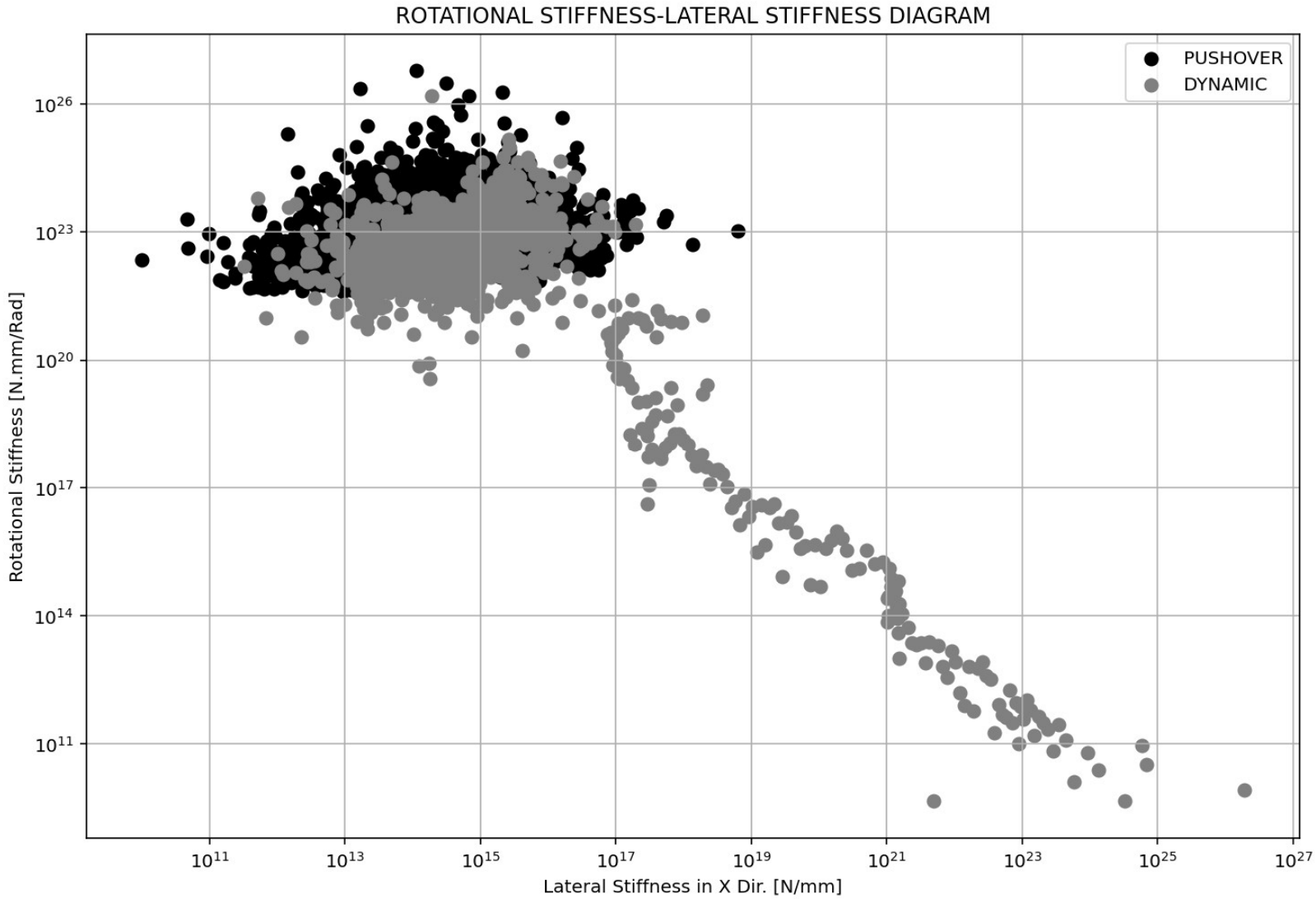
[[0.00000000e+00 0.00000000e+00]
[9.28066373e+00 1.77487453e+07]
[7.00000000e+01 2.18236646e+07]]
+============================+
+---+
Structure Elastic Stiffness : 1912443.53
Structure Plastic Stiffness : 311766.64
Structure Tangent Stiffness : 67110.74
Structure Ductility Ratio : 7.54
Structure Over Strength Factor: 1.23
+---+
Curve
Bilinear Fitted

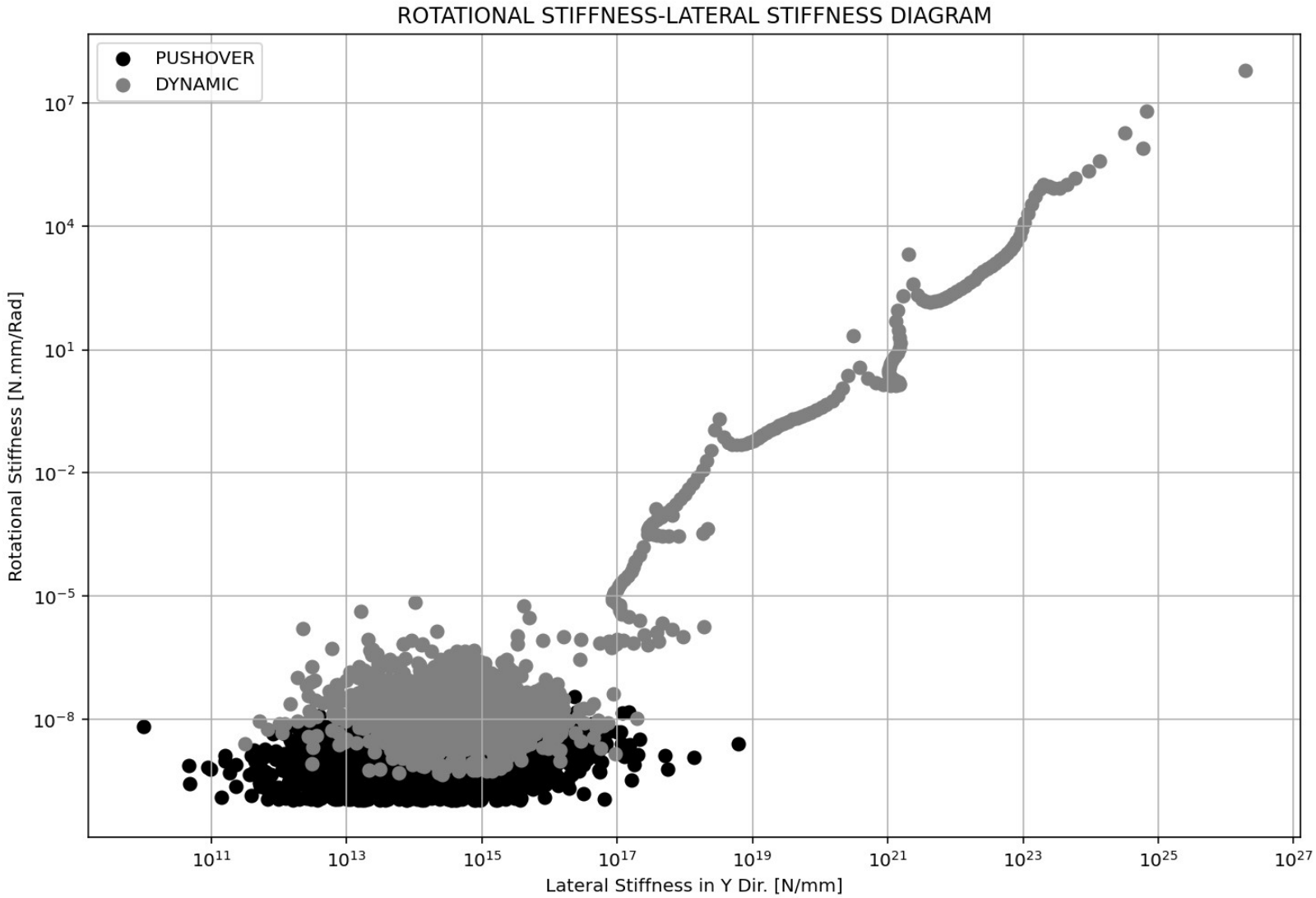
NONLINEAR DYNAMIC ANALYSIS

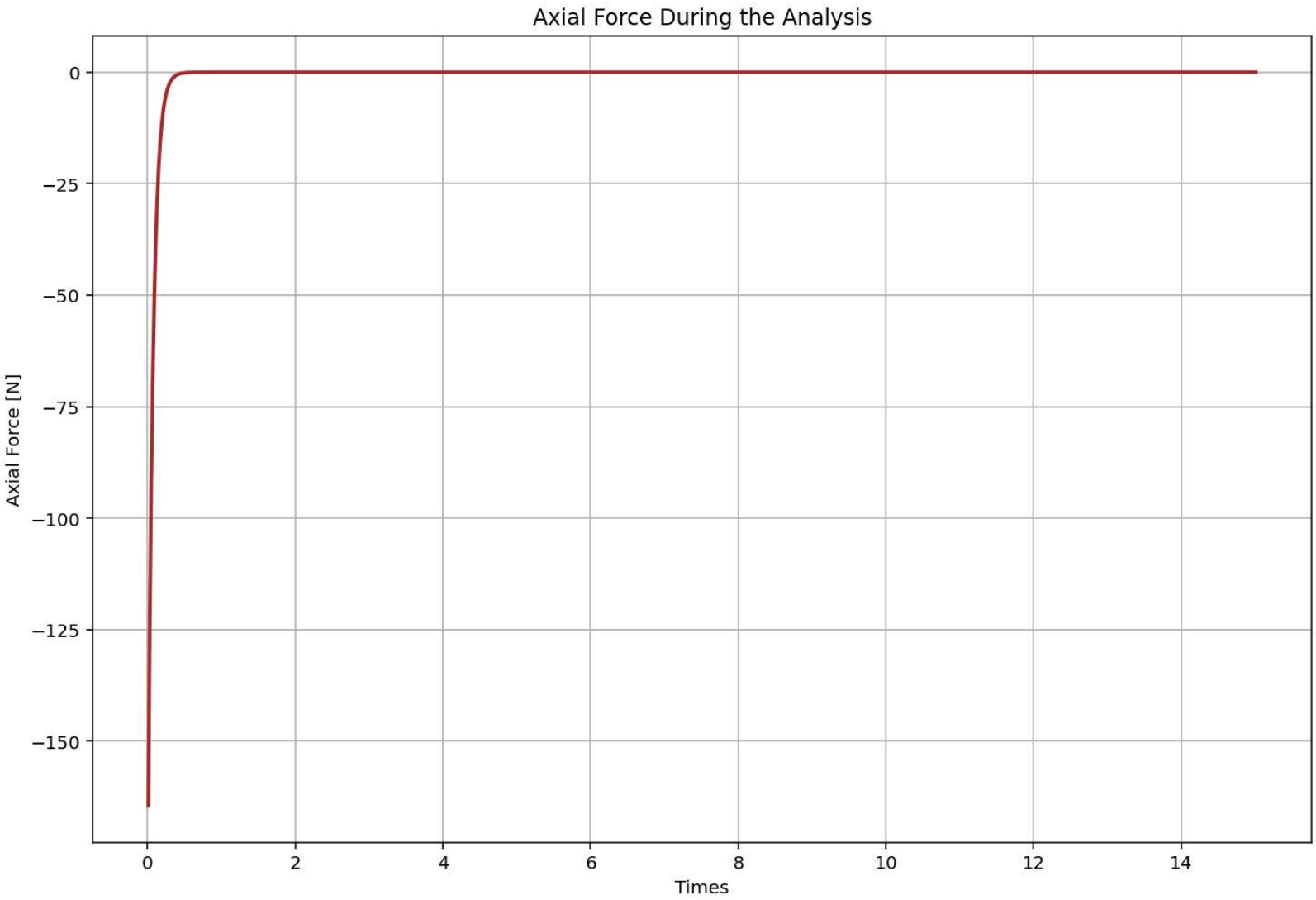

Undeformed and Deformed Shapes - DEFORMED SCALE: 100.00
Z [mm]
X [mm]
0.00000
−0.00005
−0.00010
−0.00015
−0.00020
−0.00025
0
5000
10000
15000
20000
25000
30000
1
2
3
4
5
6
7
8
9
10
11
Undeformed
Deformed

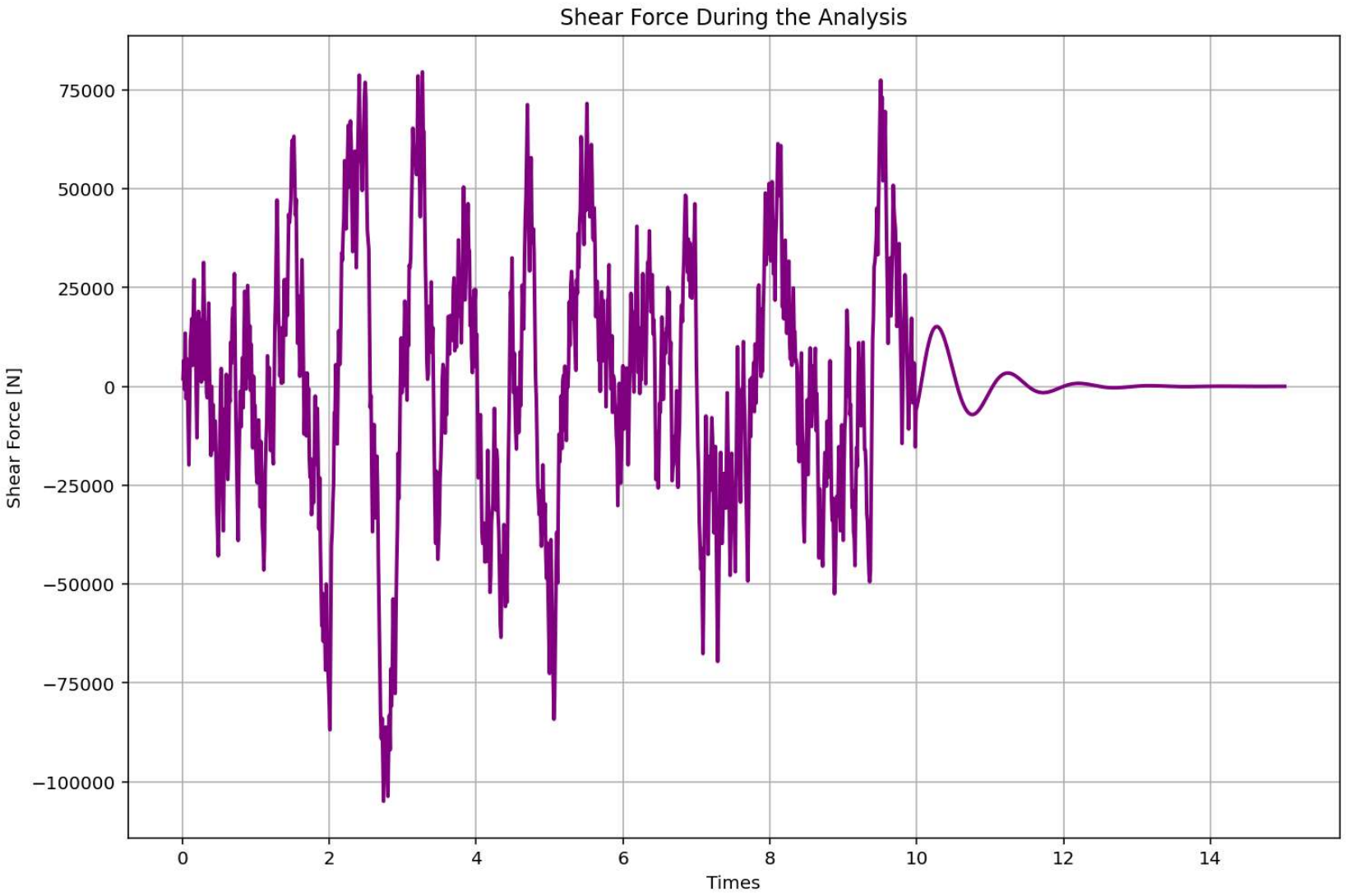

P-M Interaction
PUSHOVER
DYNAMIC
0
−25
−50
−75
−100
−125
−150
Axial Force [N]
−100000
−80000
−60000
−40000
−20000
0
Bending Moment [N.mm]

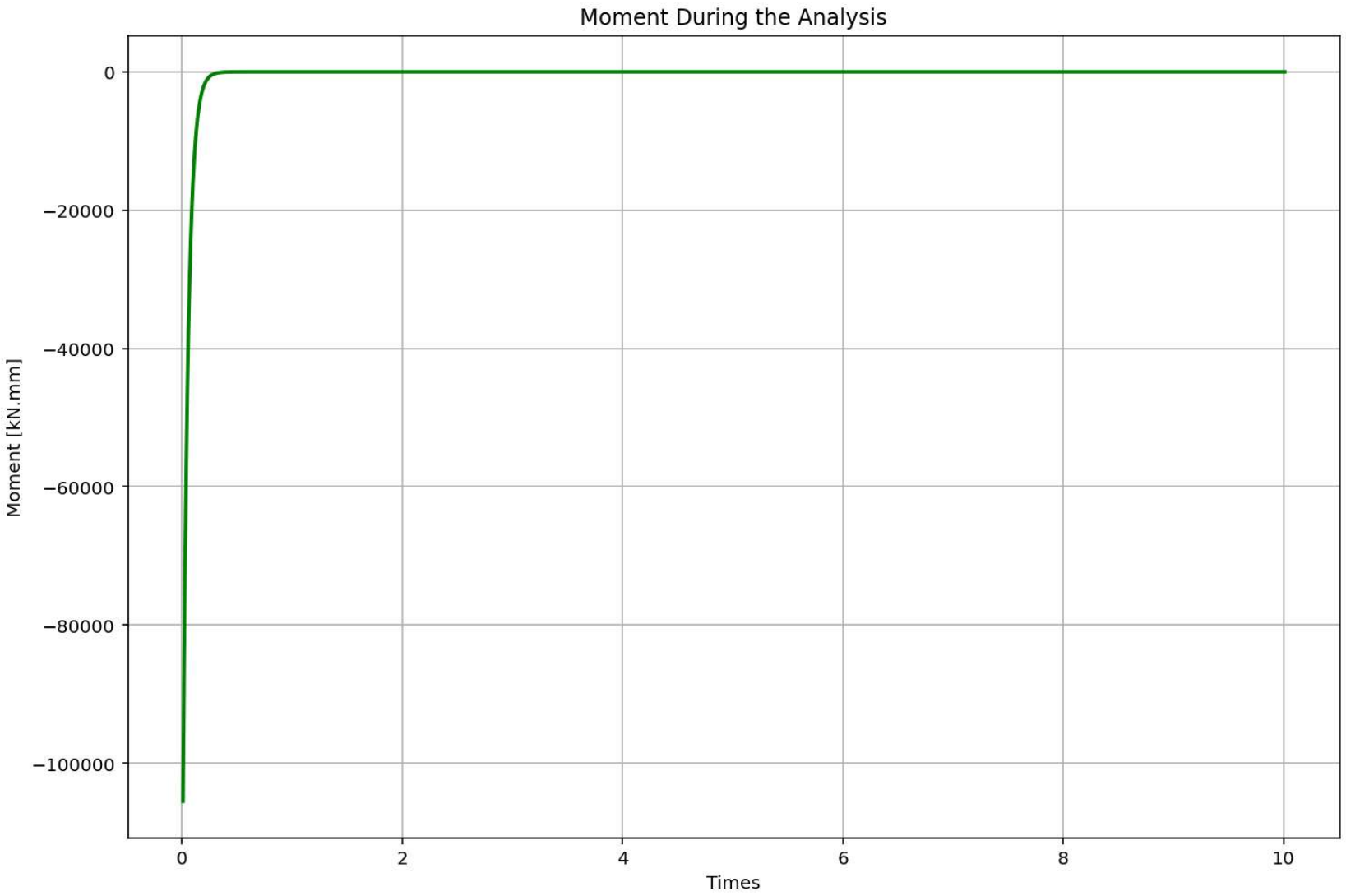

SHEAR FORCE-DISPLACEMENT DIAGRAM
1e7
2.0
1.5
1.0
0.5
0.0
Shear Force [N]
PUSHOVER
DYNAMIC
0.0
0.5
1.0
1.5
2.0
Displacement in X [mm]
1e−7

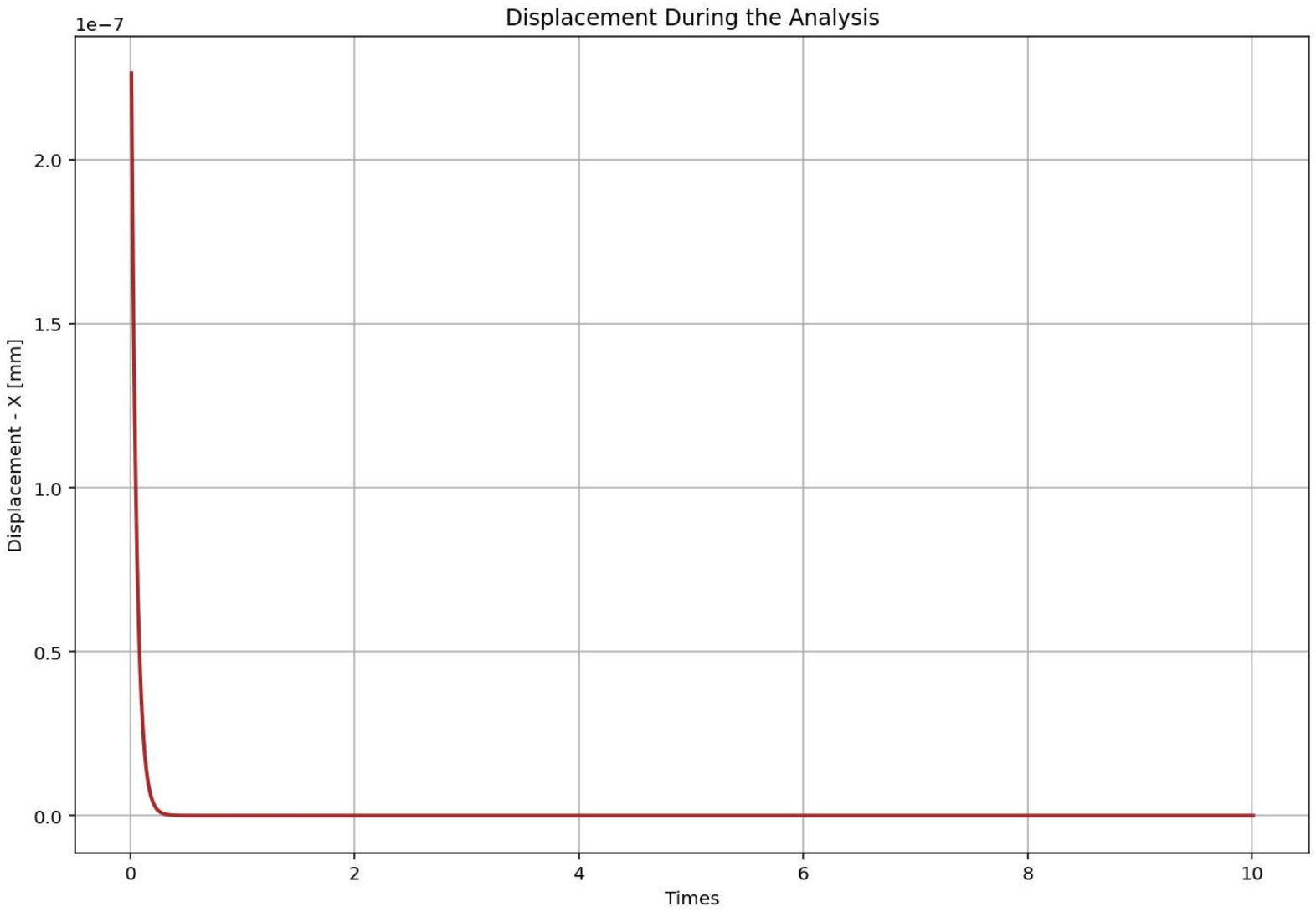

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
PUSHOVER
DYNAMIC
Rotational Stiffness [N.mm/Rad]
10^{26}
10^{23}
10^{20}
10^{17}
10^{14}
10^{11}
10^{11}
10^{13}
10^{15}
10^{17}
10^{19}
10^{21}
10^{23}
10^{25}
10^{27}
Lateral Stiffness in X Dir. [N/mm]

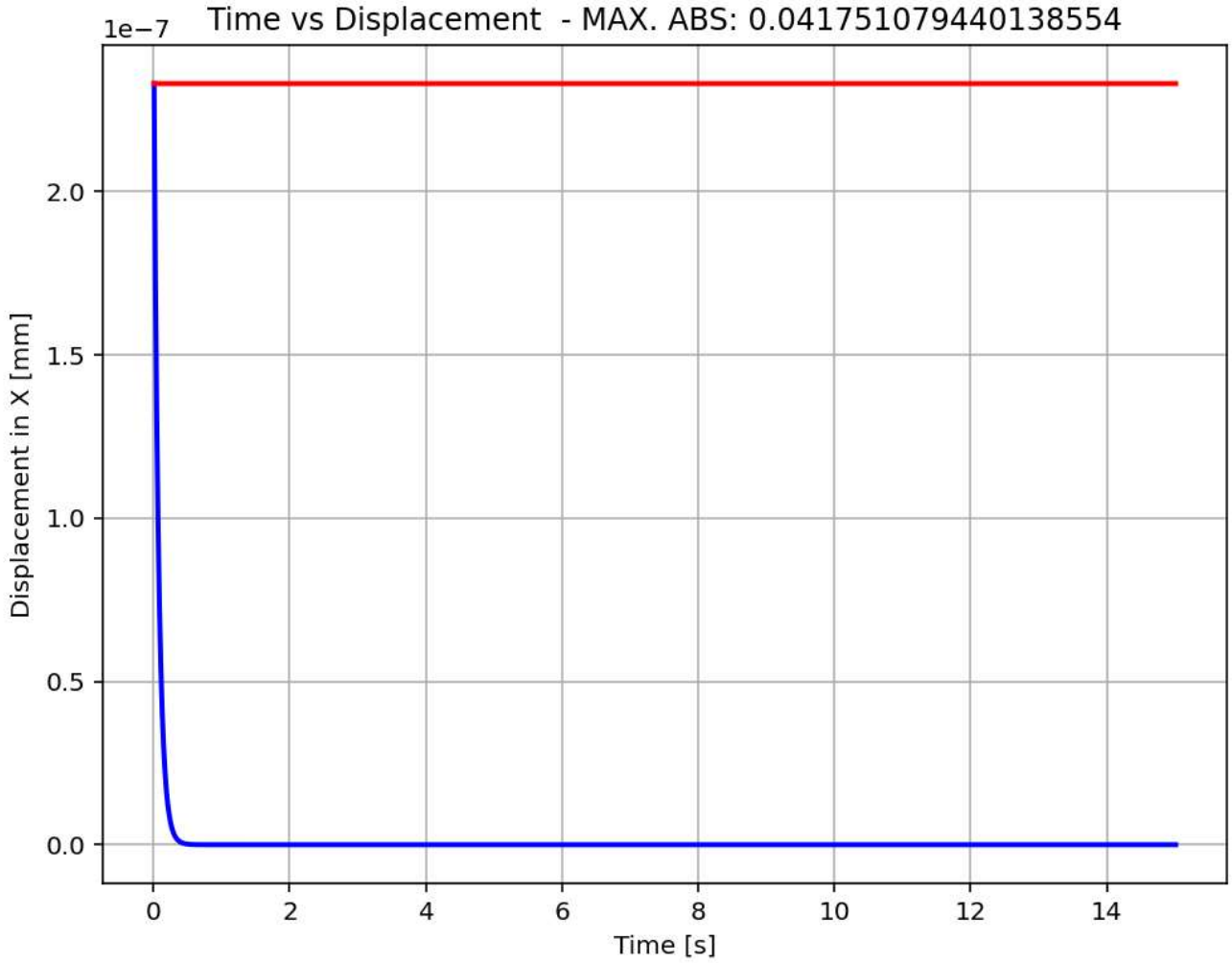

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
PUSHOVER
DYNAMIC
Rotational Stiffness [N.mm/Rad]
10^{7}
10^{4}
10^{1}
10^{-2}
10^{-5}
10^{-8}
10^{11}
10^{13}
10^{15}
10^{17}
10^{19}
10^{21}
10^{23}
10^{25}
10^{27}
Lateral Stiffness in Y Dir. [N/mm]

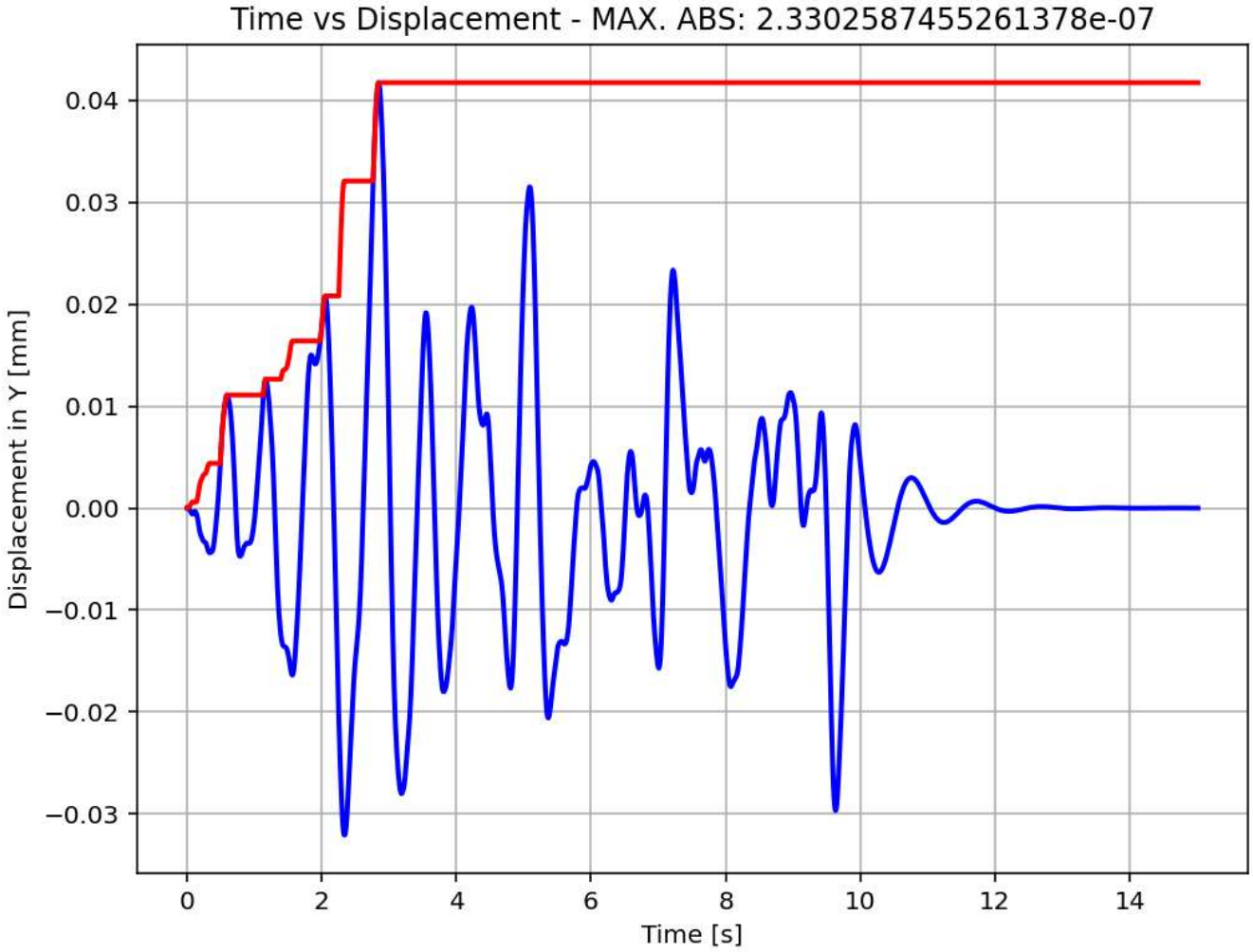

Axial Force During the Analysis
Axial Force [N]
0
−25
−50
−75
−100
−125
−150
0
2
4
6
8
10
12
14
Times

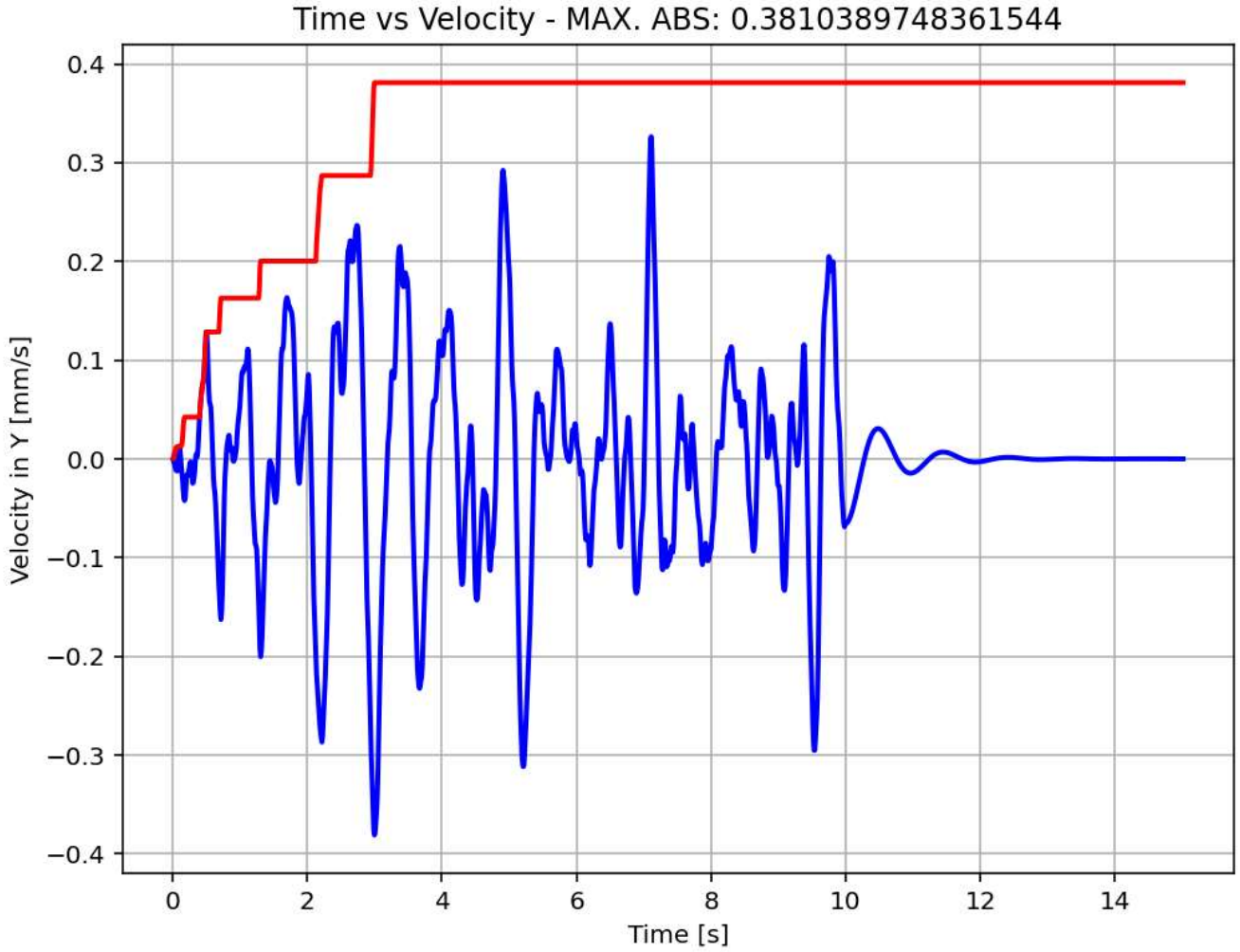

Shear Force During the Analysis
Shear Force [N]
75000
50000
25000
0
−25000
−50000
−75000
−100000
0
2
4
6
8
10
12
14
Times

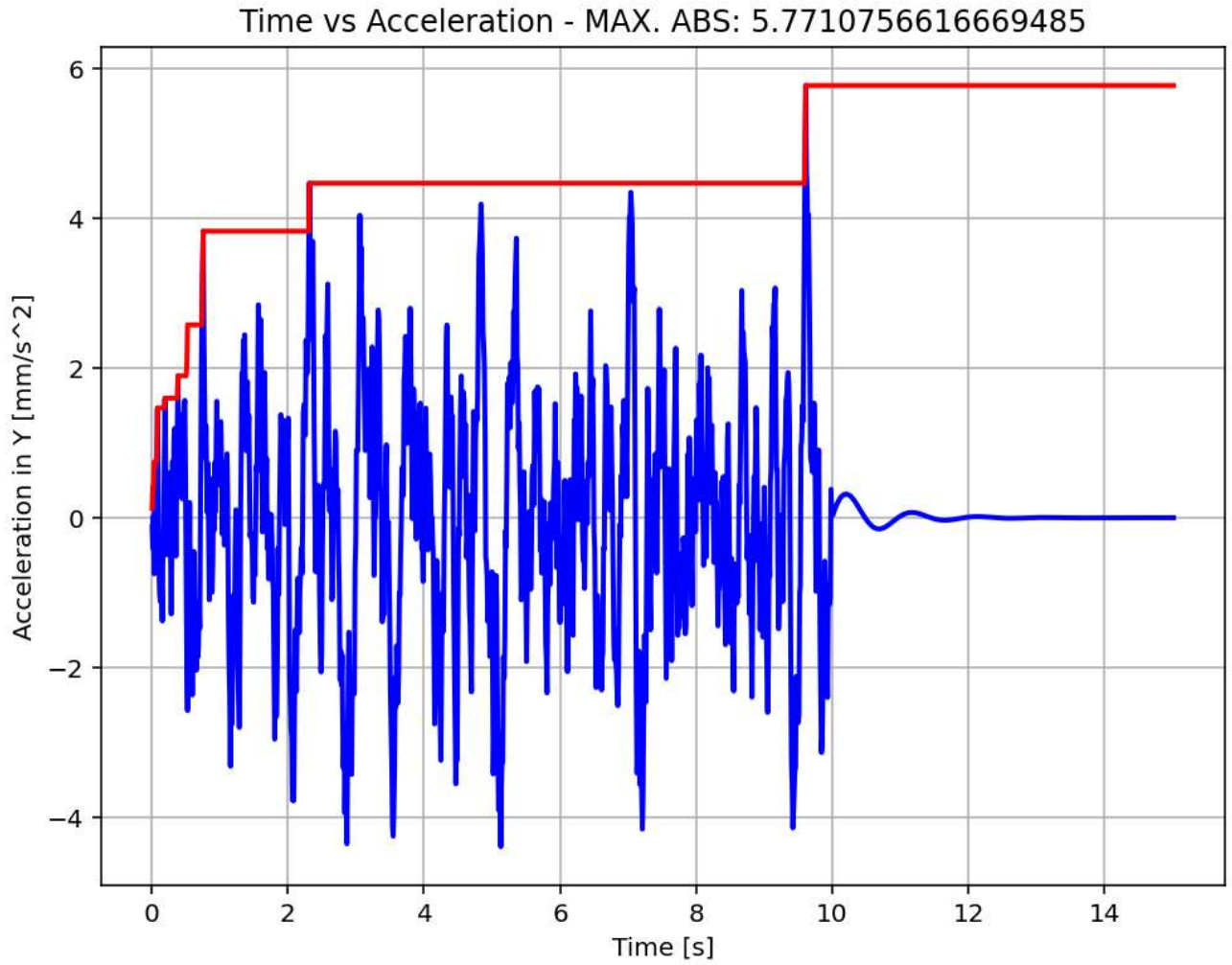

Moment During the Analysis
0
−20000
−40000
−60000
−80000
−100000
Moment [kN.mm]
0
2
4
6
8
10
Times

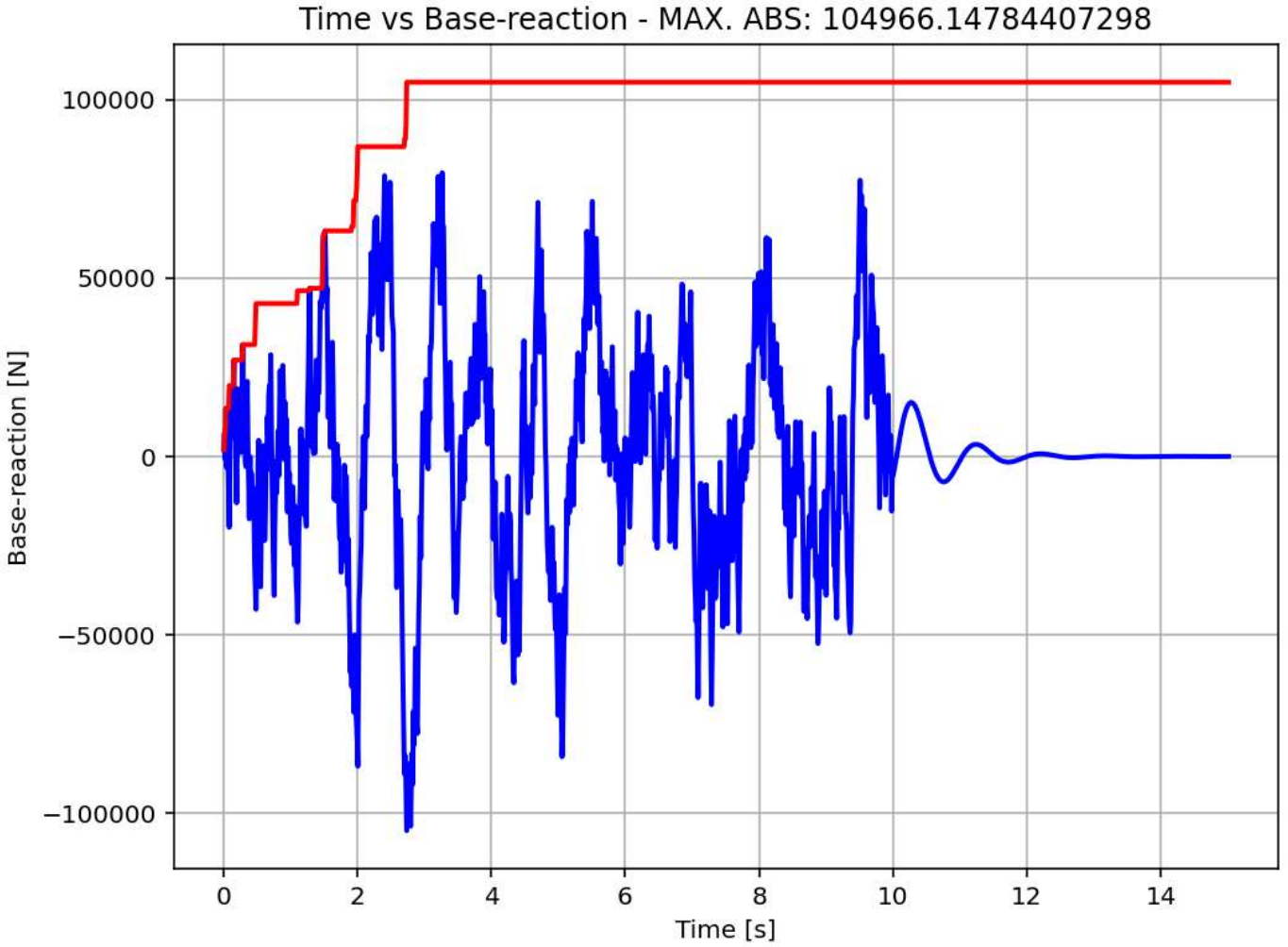

Displacement During the Analysis
1e−7
2.0
1.5
1.0
0.5
0.0
Displacement - X [mm]
0
2
4
6
8
10
Times

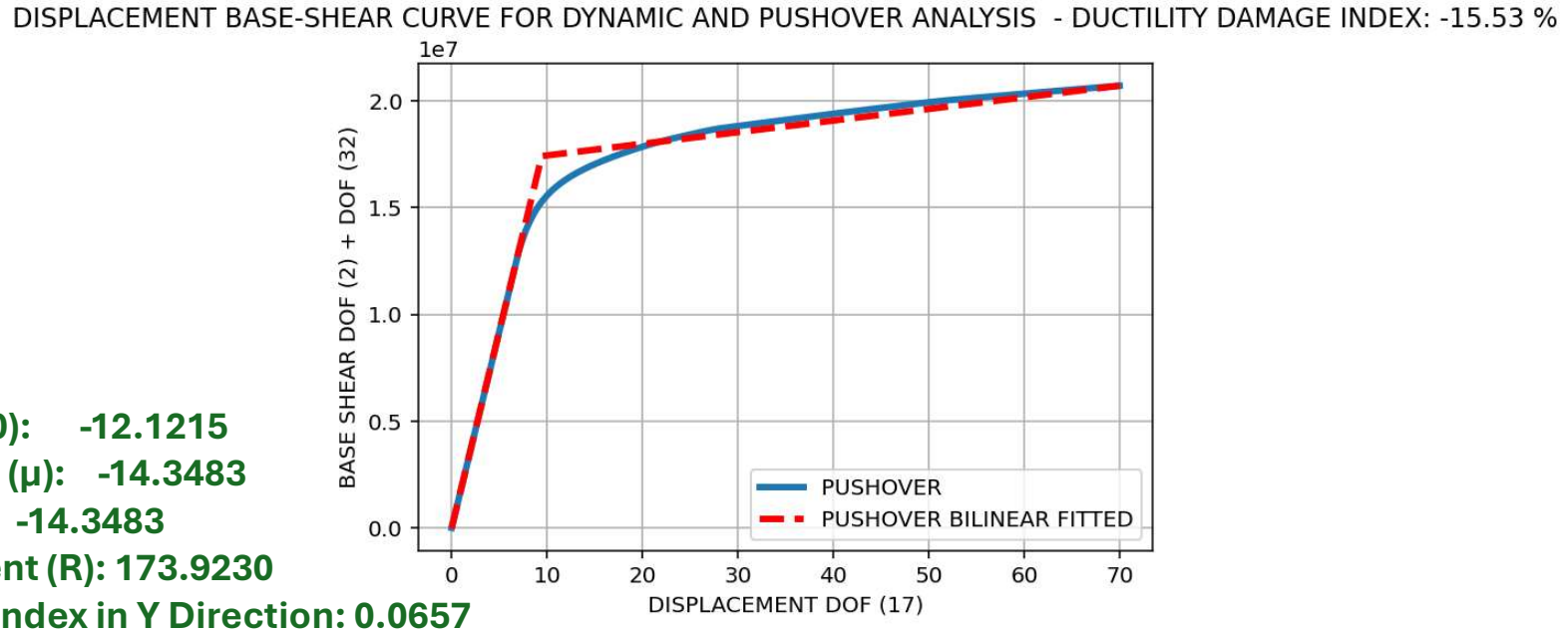

Time vs Displacement - MAX. ABS: 0.041751079440138554
1e−7
2.0
1.5
1.0
0.5
0.0
Displacement in X [mm]
0
2
4
6
8
10
12
14
Time [s]


Time vs Displacement - MAX. ABS: 2.3302587455261378e-07
Displacement in Y [mm]
0.04
0.03
0.02
0.01
0.00
−0.01
−0.02
−0.03
0
2
4
6
8
10
12
14
Time [s]


Time vs Velocity - MAX. ABS: 0.3810389748361544
Velocity in Y [mm/s]
Time [s]
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
0
2
4
6
8
10
12
14


Time vs Acceleration - MAX. ABS: 5.7710756616669485
Acceleration in Y [mm/s^2]
Time [s]
6
4
2
0
−2
−4
0
2
4
6
8
10
12
14


Time vs Base-reaction - MAX. ABS: 104966.14784407298
Base-reaction [N]
100000
50000
0
−50000
−100000
0
2
4
6
8
10
12
14
Time [s]



Over Strength Coefficient (Ω0): -12.1215
Displacement Ductility Ratio (μ): -14.3483
Ductility Coefficient (Rμ): -14.3483
Structural Behavior Coefficient (R): 173.9230
Structural Ductility Damage Index in Y Direction: 0.0657
STRUCTURAL PARAMETERS BASED ON ANALYSIS
==========
Structure Elastic Stiffness : 0.00
Structure Plastic Stiffness : 0.00
Structure Tangent Stiffness : 0.00
Structure Ductility Ratio : -14.35
Structure Over Strength Factor: -12.12
Structure Yield Displacement: 9.45
Structure Ultimate Displacement: 70.00
Structure Demand Displacement: 0.04
Structure Ductility Damage index: -15.53 %