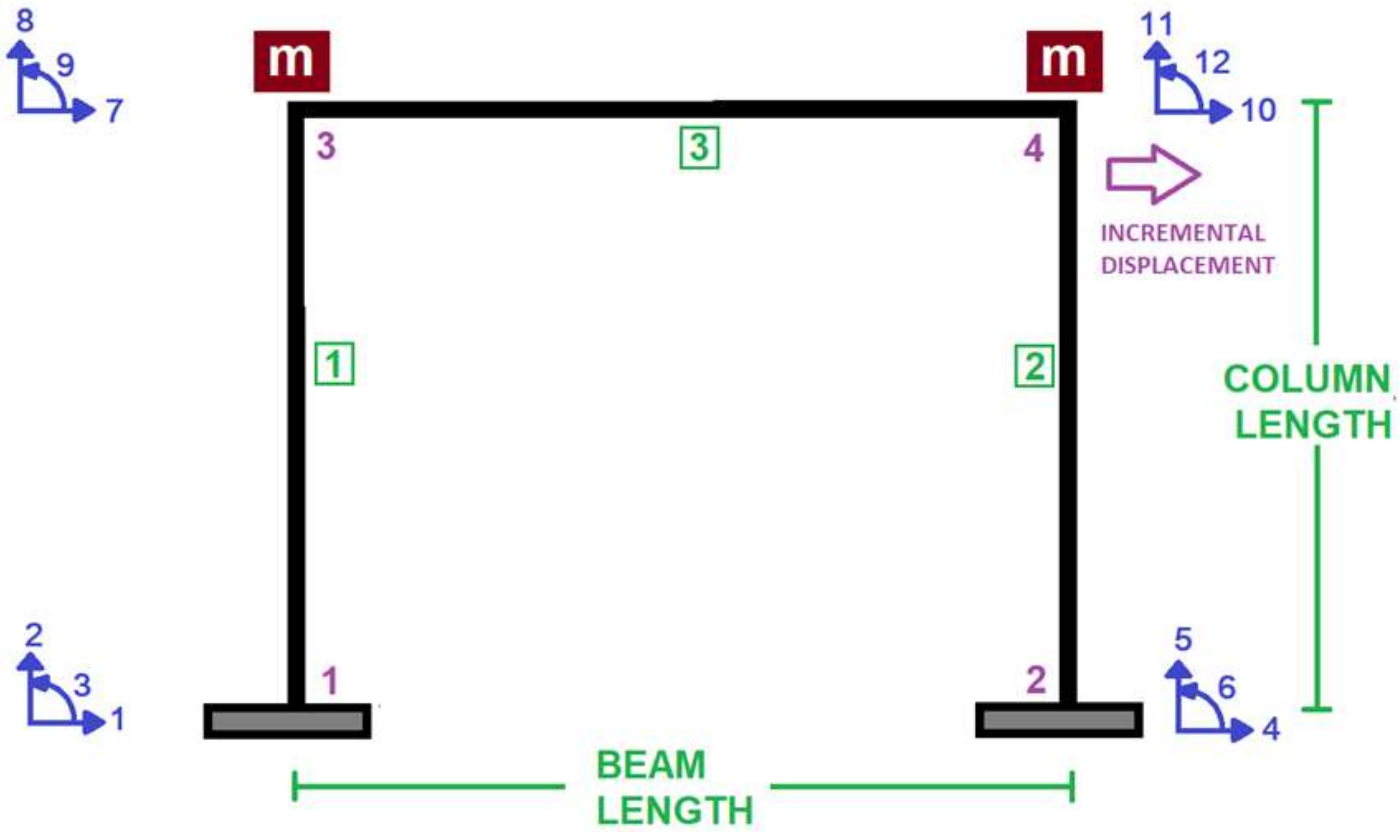
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

STRUCTURAL DUCTILITY RATIO OPTIMIZATION WITH PUSHOVER ANALYSIS OF CONCRETE FRAME SECTION. EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENSEES. FIND BEST COLUMN CONCRETE SECTION DEPTH WITH DEFINED STRUCTURAL DUCTILITY RATIO. OPTIMIZATION ALGORITHM: NEWTON-RAPHSON METHOD

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


8
9
7
m
m
11
12
10
3
3
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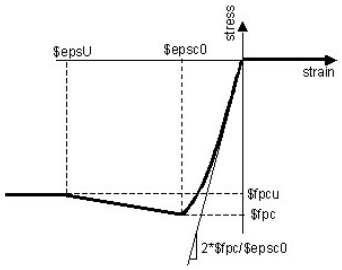
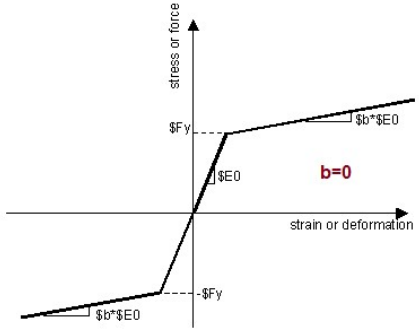
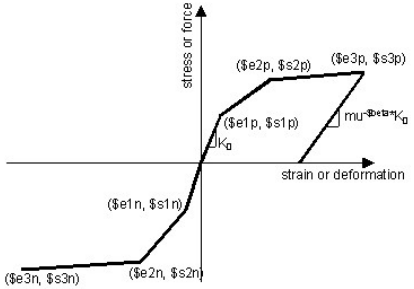
INCREMENTAL
DISPLACEMENT
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH



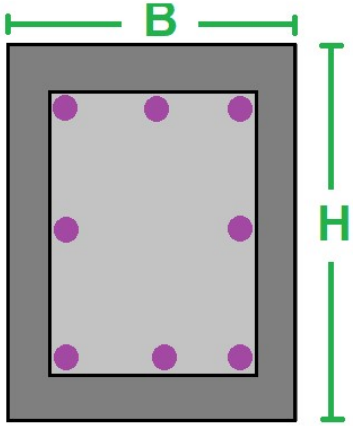
CORE AND COVER CONCRETE RELATION



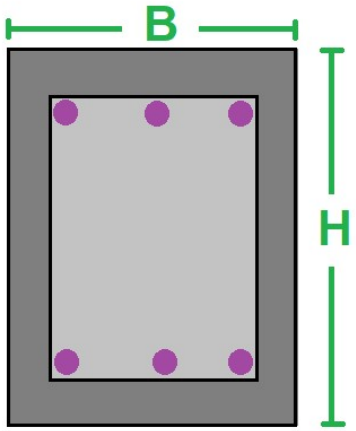
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

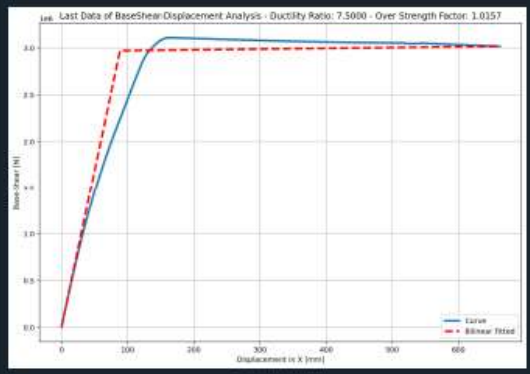
...ME_EXAMPLES\OPTIMIZATION\PUSHOVER_Cdepth_DUCT_OPTIMIZATION

C:\Users\Dell\Desktop\OPEN Save file (Ctrl+S) ETE_FRA...OPTIMIZATION\PUSHOVER_Cdepth_DUCT_OPTIMIZATION.py

PUSHOVER_Cdepth_DUCT_OPTIMIZATION.py

```
1  ##########################################################################################################
2  #                    >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<                    #
3  #         STRUCTURAL DUCTILITY RATIO OPTIMIZATION WITH PUSHOVER ANALYSIS OF CONCRETE FRAME SECTION       #
4  #               EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN CRITERIA USING OPENSEES                 #
5  #--------------------------------------------------------------------------------------------------------#
6  #             FIND BEST COLUMN CONCRETE SECTION DEPTH WITH DEFINED STRUCTURAL DUCTILITY RATIO           #
7  #                                OPTIMIZATION ALGORITHM: NEWTON-RAPHSON METHOD                           #
8  #--------------------------------------------------------------------------------------------------------#
9  #                           THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)                   #
10 #                                  EMAIL: salar.d.ghashghaei@gmail.com                                   #
11 ##########################################################################################################
12 """
13 1. The script performs pushover analysis on a concrete frame using OpenSees
14  to optimize the column rebar diameter for a target ductility ratio.
15 2. Two steel material models (*Steel01* and *Hysteretic*) and two concrete
16  models (*Concrete01* and *Concrete02*) are supported.
17 3. A frame with beam and column elements is created, and nonlinear beam-column
18  elements are used for realistic simulation.
19 4. Rebar areas are calculated based on input diameters, and sectional properties
20  are defined using confined and unconfined concrete.
21 5. The *PUSHOVER\_ANALYSIS* function incrementally applies lateral displacement
22  and records force, displacement, and stiffness data.
23 6. The response is processed to compute the bilinear approximation and extract
24  ductility and strength parameters.
25 7. A Newton-Raphson root-finding algorithm adjusts the column section depth to
26  match the target structural ductility ratio.
27 8. Finite difference approximation is used to estimate the derivative of the
28  ductility function with respect to rebar diameter.
29 9. Each iteration updates the column section depth until convergence is achieved or the
30  maximum number of iterations is reached.
31 10. Convergence is based on the residual of the diameter update (DX) relative
32  to a tolerance threshold.
33 11. The optimal column section depth is printed upon successful convergence.
34 12. This method allows automated column section depth design optimization
```

23 %



Help Variable Explorer Debugger Plots Files

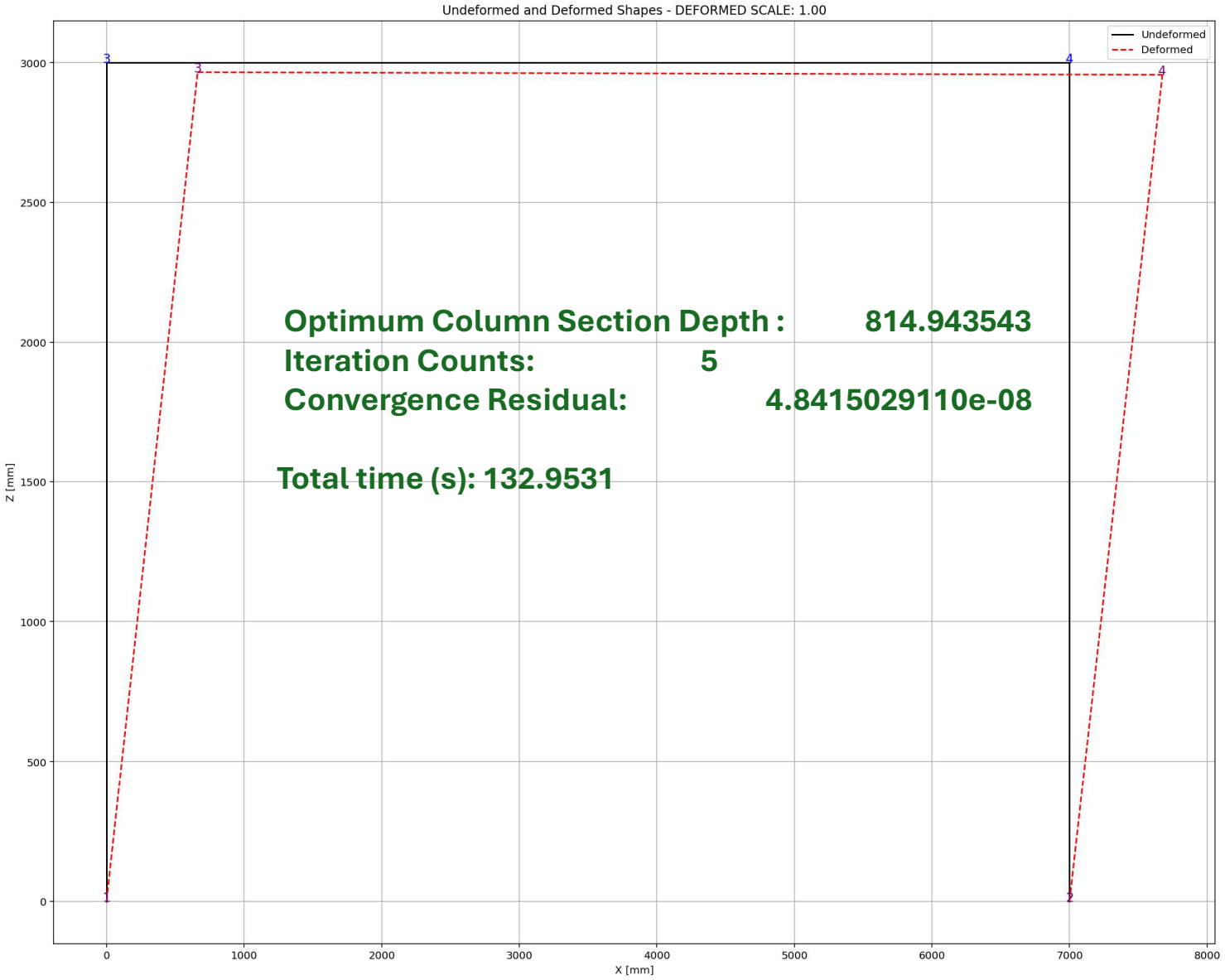
Console 1/A

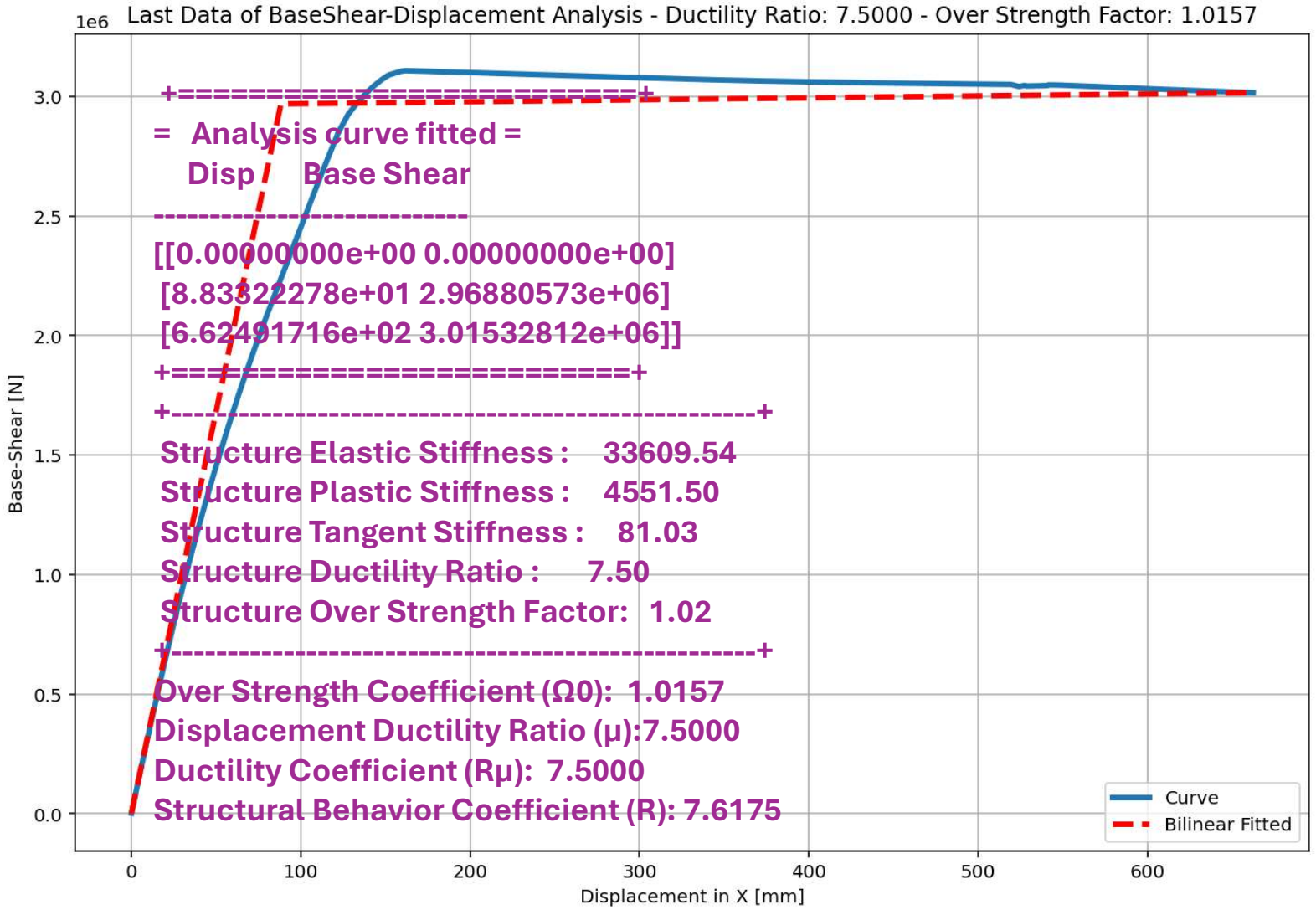
```
DX:  -4.841502911042114e-08
IT:  5  - RESIDUAL:  4.841502911042114e-08  - X:
814.9435432225227

        Optimum Column Section Depth :          814.943543
        Iteration Counts:                       5
        Convergence Residual:
4.8415029110e-08

Total time (s): 132.9531
```

IPython Console History

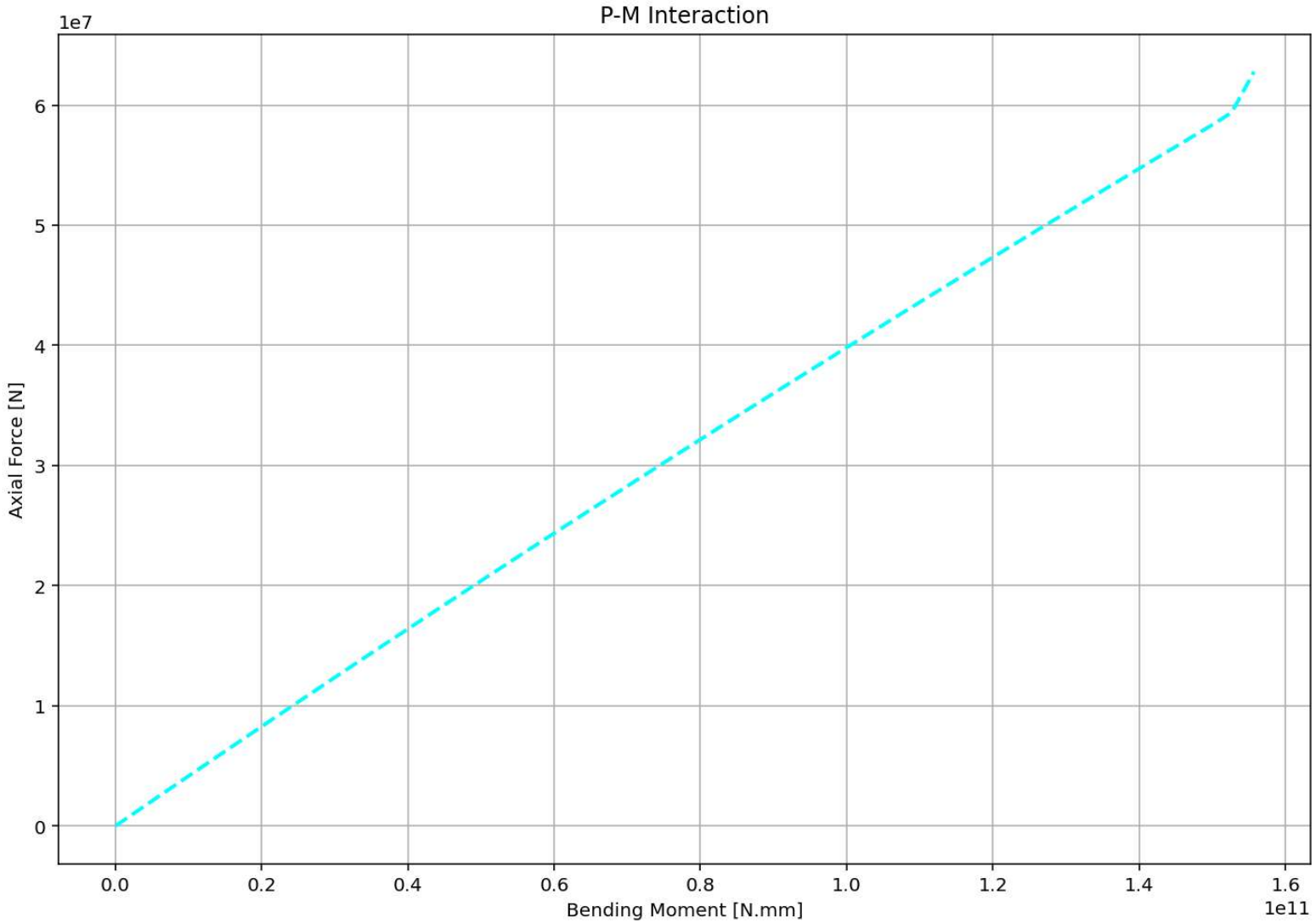
Save file | Inline | Conda: anaconda3 (Python 3.12.7) | LSP: Python | Line 7, Col 96 | UTF-8 | CRLF | RW | Mem 41%

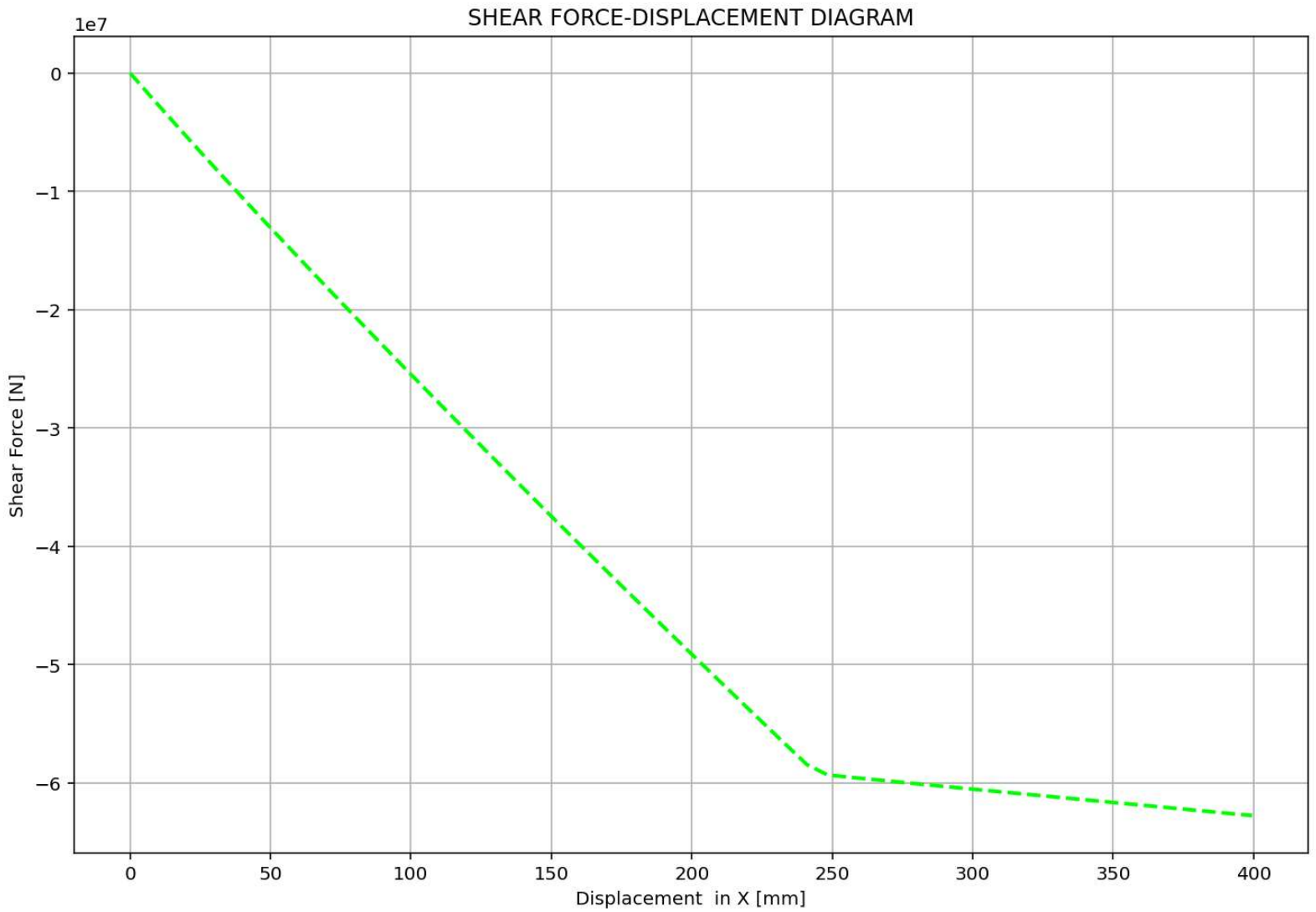
NONLINEAR STATIC ANALYSIS (PUSHOVER)

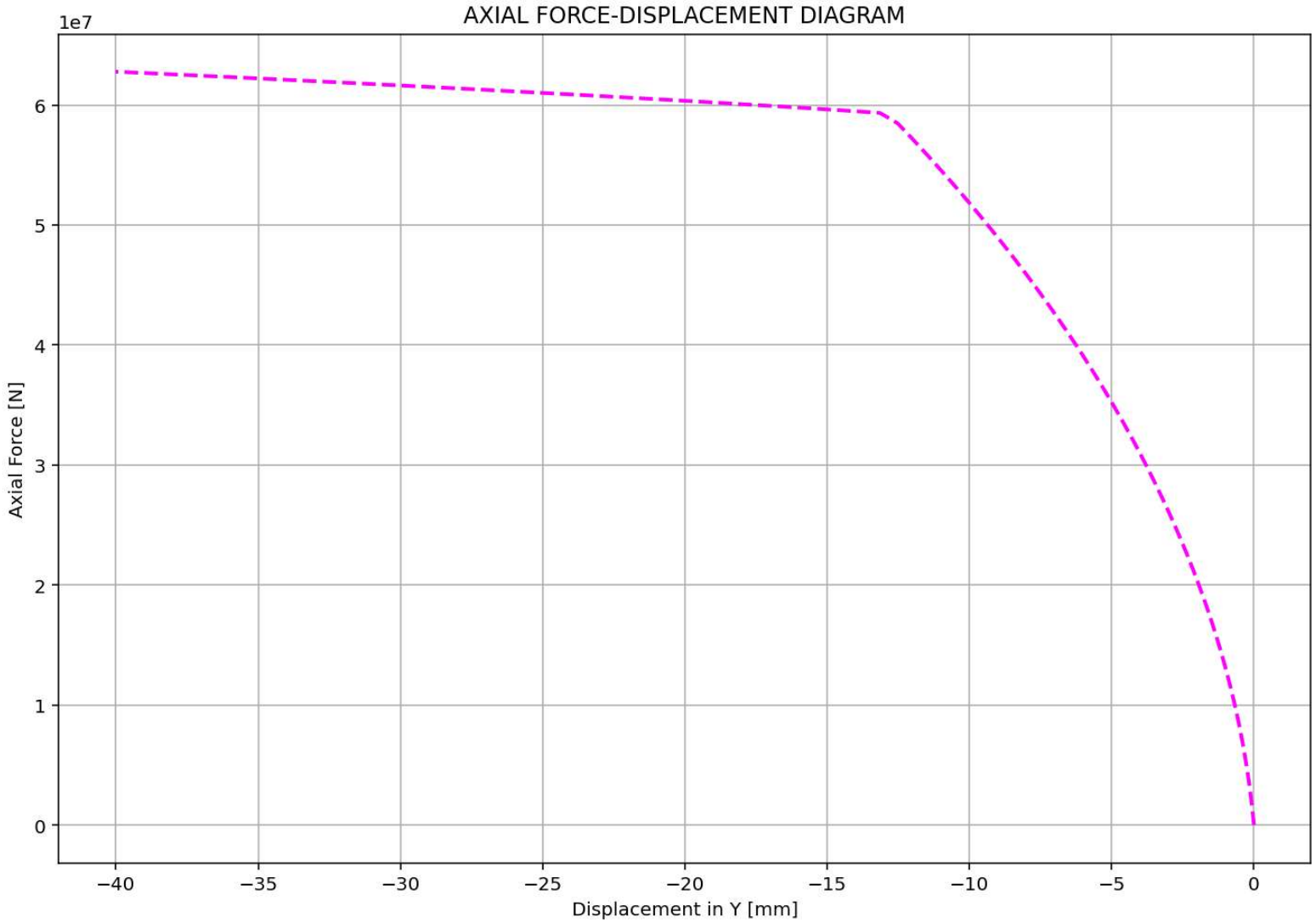

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Optimum Column Section Depth : 814.943543
Iteration Counts: 5
Convergence Residual: 4.8415029110e-08
Total time (s): 132.9531
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000
8000
1
2
3
4

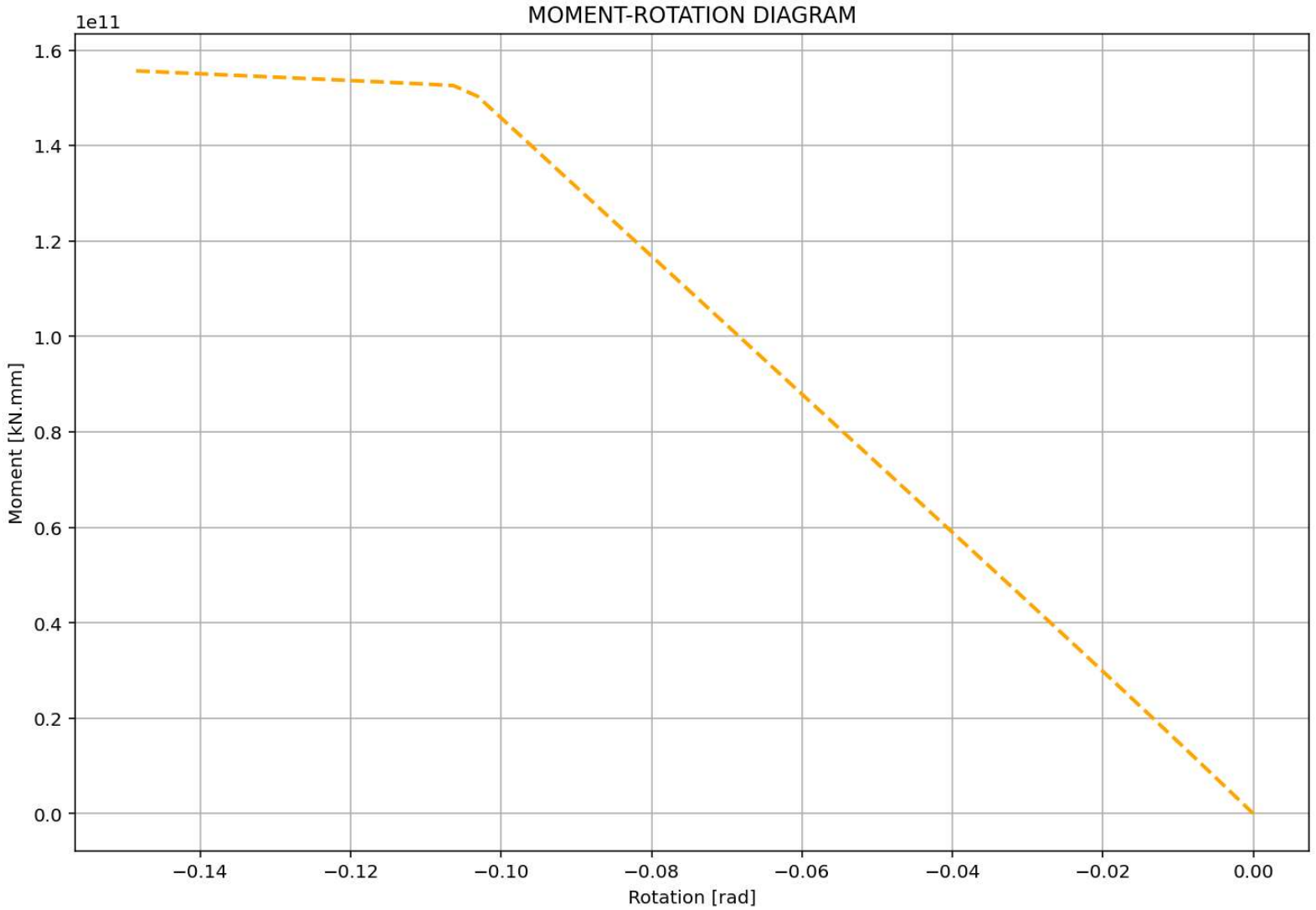

Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 7.5000 - Over Strength Factor: 1.0157
1e6
Base-Shear [N]
Displacement in X [mm]
+==========================+
= Analysis curve fitted =
Disp Base Shear

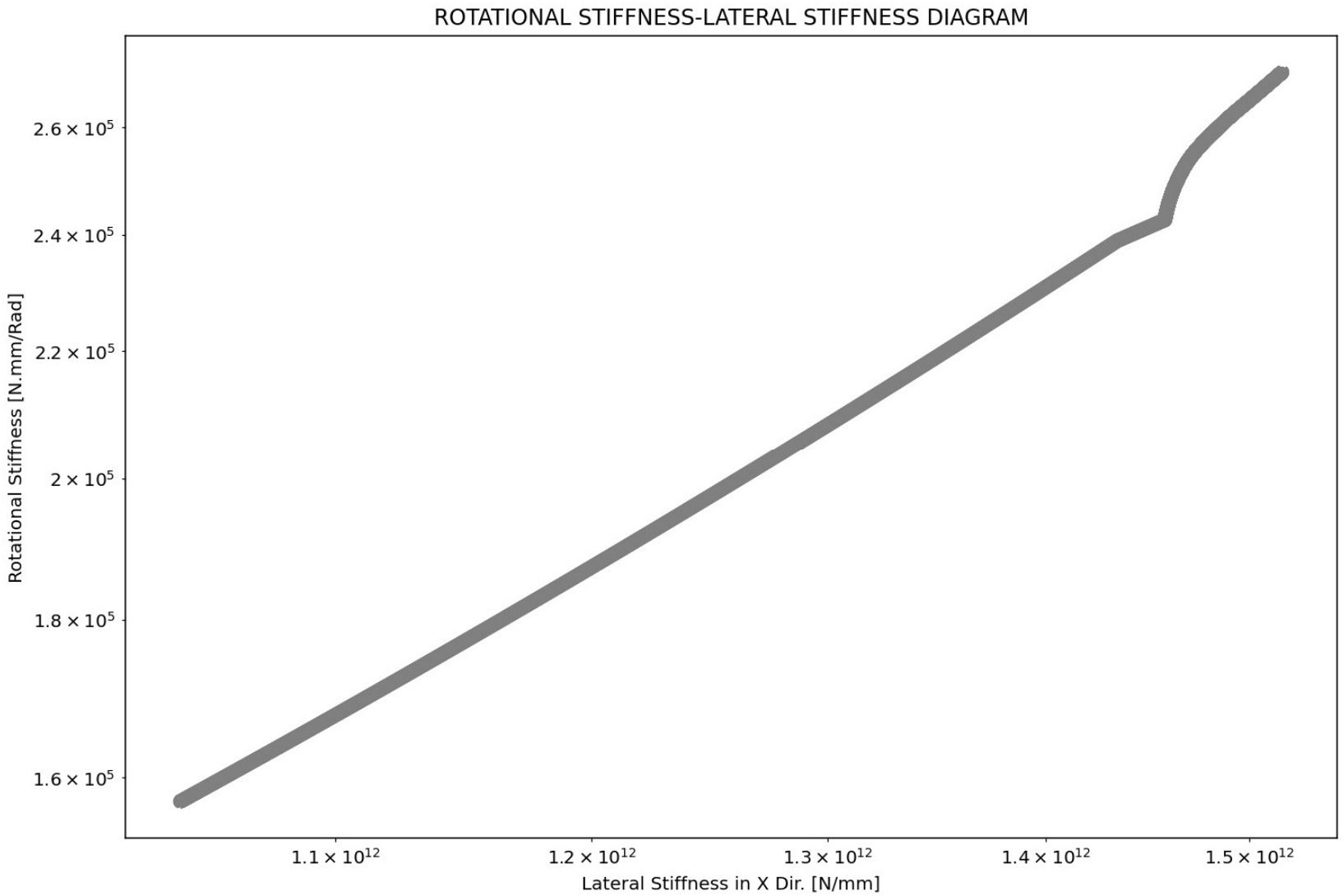
[[0.00000000e+00 0.00000000e+00]
[8.83322278e+01 2.96880573e+06]
[6.62491716e+02 3.01532812e+06]]
+==========+
+----------+
Structure Elastic Stiffness : 33609.54
Structure Plastic Stiffness : 4551.50
Structure Tangent Stiffness : 81.03
Structure Ductility Ratio : 7.50
Structure Over Strength Factor: 1.02
+----------+
Over Strength Coefficient (Ω0): 1.0157
Displacement Ductility Ratio (μ):7.5000
Ductility Coefficient (Rμ): 7.5000
Structural Behavior Coefficient (R): 7.6175
Curve
Bilinear Fitted

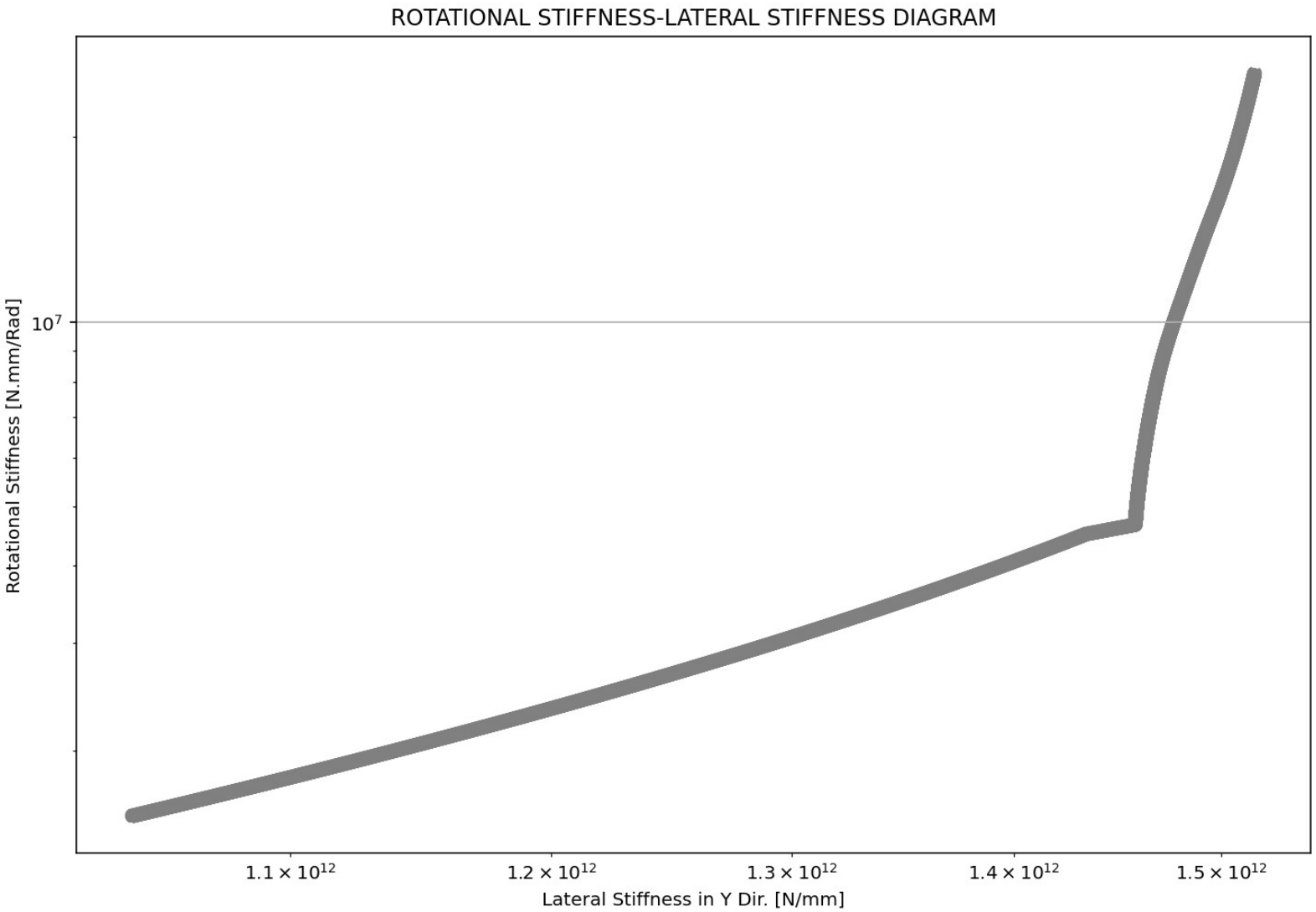

P-M Interaction
1e7
6
5
4
3
2
1
0
Axial Force [N]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1e11
Bending Moment [N.mm]


SHEAR FORCE-DISPLACEMENT DIAGRAM
1e7
0
−1
−2
−3
−4
−5
−6
Shear Force [N]
0
50
100
150
200
250
300
350
400
Displacement in X [mm]


AXIAL FORCE-DISPLACEMENT DIAGRAM
1e7
6
5
4
3
2
1
0
Axial Force [N]
−40
−35
−30
−25
−20
−15
−10
−5
0
Displacement in Y [mm]


MOMENT-ROTATION DIAGRAM
1e11
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Moment [kN.mm]
−0.14
−0.12
−0.10
−0.08
−0.06
−0.04
−0.02
0.00
Rotation [rad]


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
2.6 × 10^5
2.4 × 10^5
2.2 × 10^5
2 × 10^5
1.8 × 10^5
1.6 × 10^5
1.1 × 10^12
1.2 × 10^12
1.3 × 10^12
1.4 × 10^12
1.5 × 10^12
Lateral Stiffness in X Dir. [N/mm]


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
10^7
1.1×10^{12}
1.2×10^{12}
1.3×10^{12}
1.4×10^{12}
1.5×10^{12}
Lateral Stiffness in Y Dir. [N/mm]