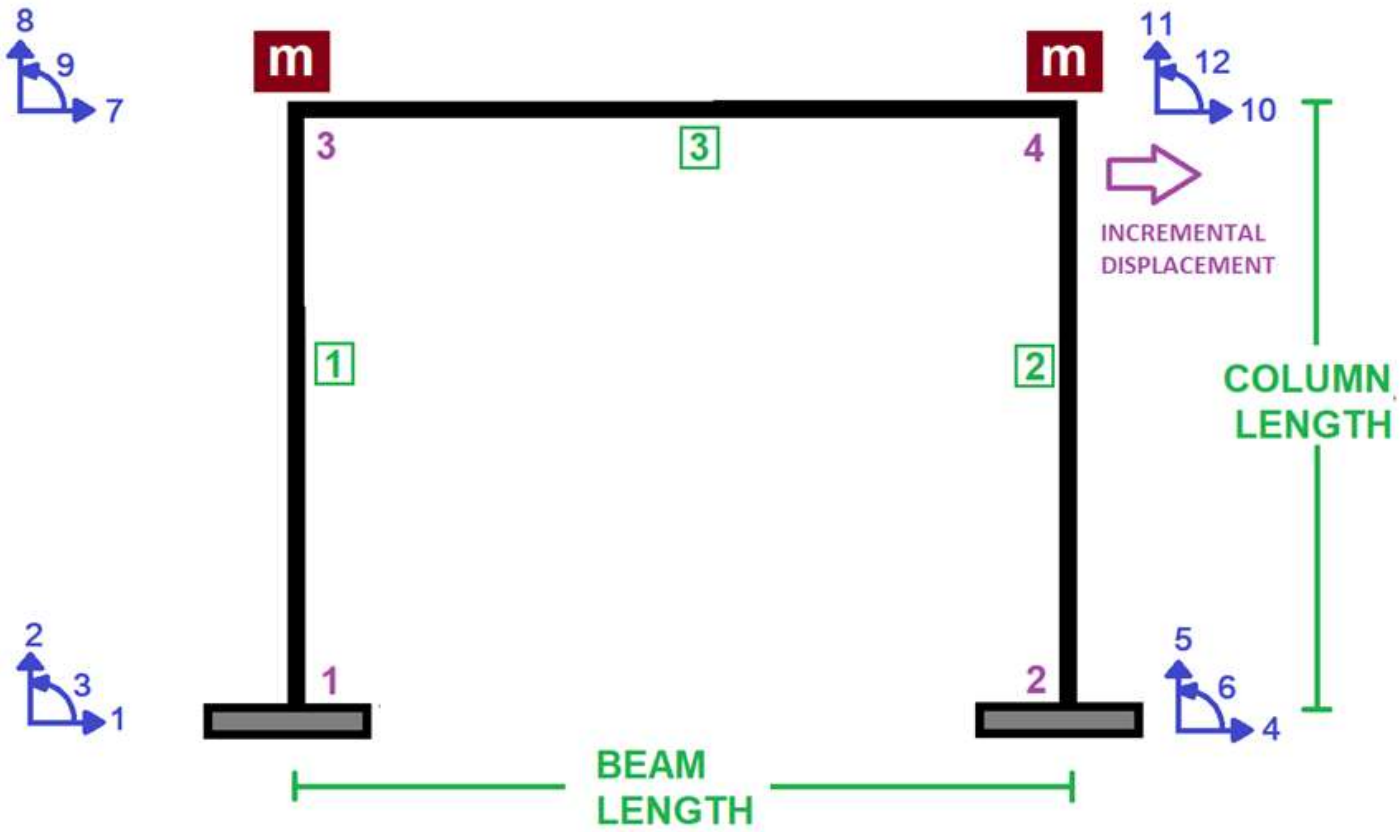
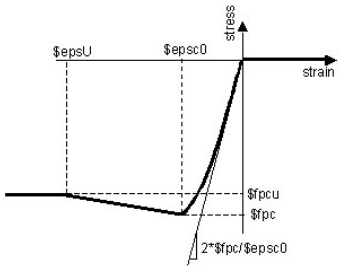
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

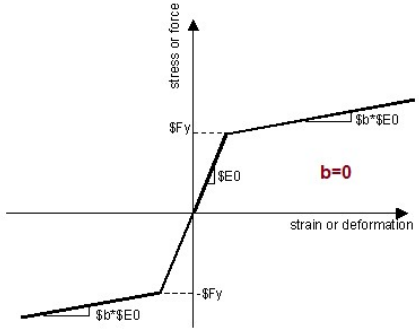
OPTIMIZATION OF STRUCTURAL BEHAVIOR COEFFICIENT USING PUSHOVER ANALYSIS OF CONCRETE FRAME SECTIONS: EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN EFFECTS IN OPENSEES. DETERMINING OPTIMAL COLUMN SECTION REBAR DIAMETER FOR A TARGET STRUCTURAL BEHAVIOR COEFFICIENT VIA THE NEWTON-RAPHSON METHOD.

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

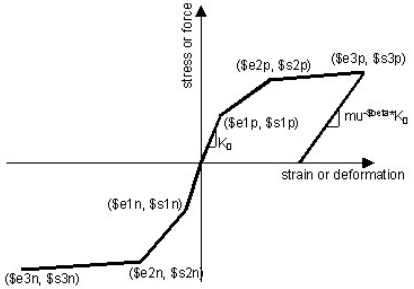

8
9
7
m
m
11
12
10
3
3
4
INCREMENTAL
DISPLACEMENT
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH



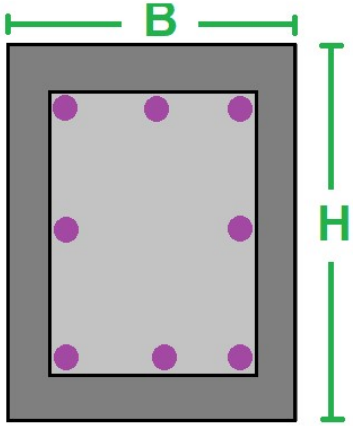
CORE AND COVER CONCRETE RELATION



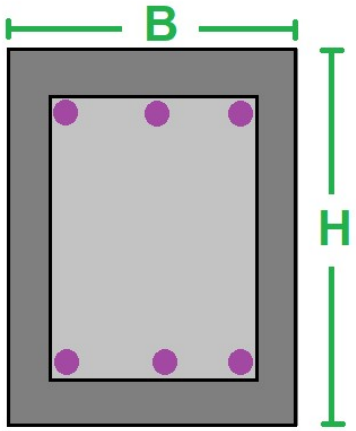
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

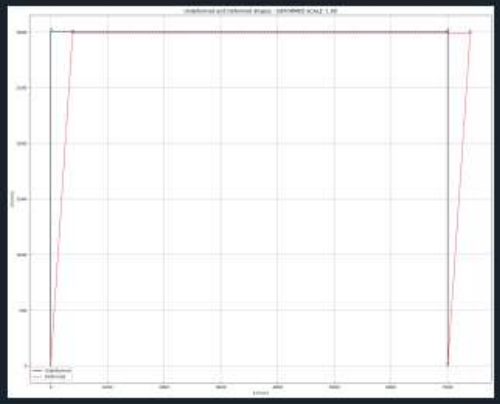
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...AME_PUSHOVER_STRUCTURAL_BEHAVIOR_COEFFICIENT_R.py

CONCRETE_FRAME_PUS...R_COEFFICIENT_R.py

```
##########################################################################################
#                  >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
# OPTIMIZATION OF STRUCTURAL BEHAVIOR COEFFICIENT USING PUSHOVER ANALYSIS OF CONCRETE FRAME SECT
# EVALUATING STRAIN HARDENING AND ULTIMATE STRAIN EFFECTS IN OPENSEES. DETERMINING OPTIMAL COLUM
# REBAR DIAMETER FOR A TARGET STRUCTURAL BEHAVIOR COEFFICIENT VIA THE NEWTON-RAPHSON METHOD.
#------------------------------------------------------------------------------------------
#                            OPTIMIZATION ALGORITHM: NEWTON-RAPHSON METHOD
#------------------------------------------------------------------------------------------
#                          THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                    EMAIL: salar.d.ghashghaei@gmail.com
##########################################################################################
"""
1. The script performs pushover analysis on a concrete frame using OpenSees
 to optimize the column rebar diameter for a target ductility ratio.
2. Two steel material models (*Steel01* and *Hysteretic*) and two concrete
 models (*Concrete01* and *Concrete02*) are supported.
3. A frame with beam and column elements is created, and nonlinear beam-column
 elements are used for realistic simulation.
4. Rebar areas are calculated based on input diameters, and sectional properties
 are defined using confined and unconfined concrete.
5. The *PUSHOVER\_ANALYSIS* function incrementally applies lateral displacement
 and records force, displacement, and stiffness data.
6. The response is processed to compute the bilinear approximation and extract
 ductility and strength parameters.
7. A Newton-Raphson root-finding algorithm adjusts the column rebar diameter to
 match the target structural ductility ratio.
8. Finite difference approximation is used to estimate the derivative of the
 ductility function with respect to rebar diameter.
9. Each iteration updates the rebar size until convergence is achieved or the
 maximum number of iterations is reached.
10. Convergence is based on the residual of the diameter update (DX) relative
 to a tolerance threshold.
11. The optimal column and beam rebar diameters are printed upon successful convergence.
12. This method allows automated rebar design optimization based on seismic
```

...TE_FRAME_EXAMPLES\OPTIMIZATION\PUSHOVER_REBAR_OPTIMIZATION

13 %



Help Variable Explorer Debugger Plots Files

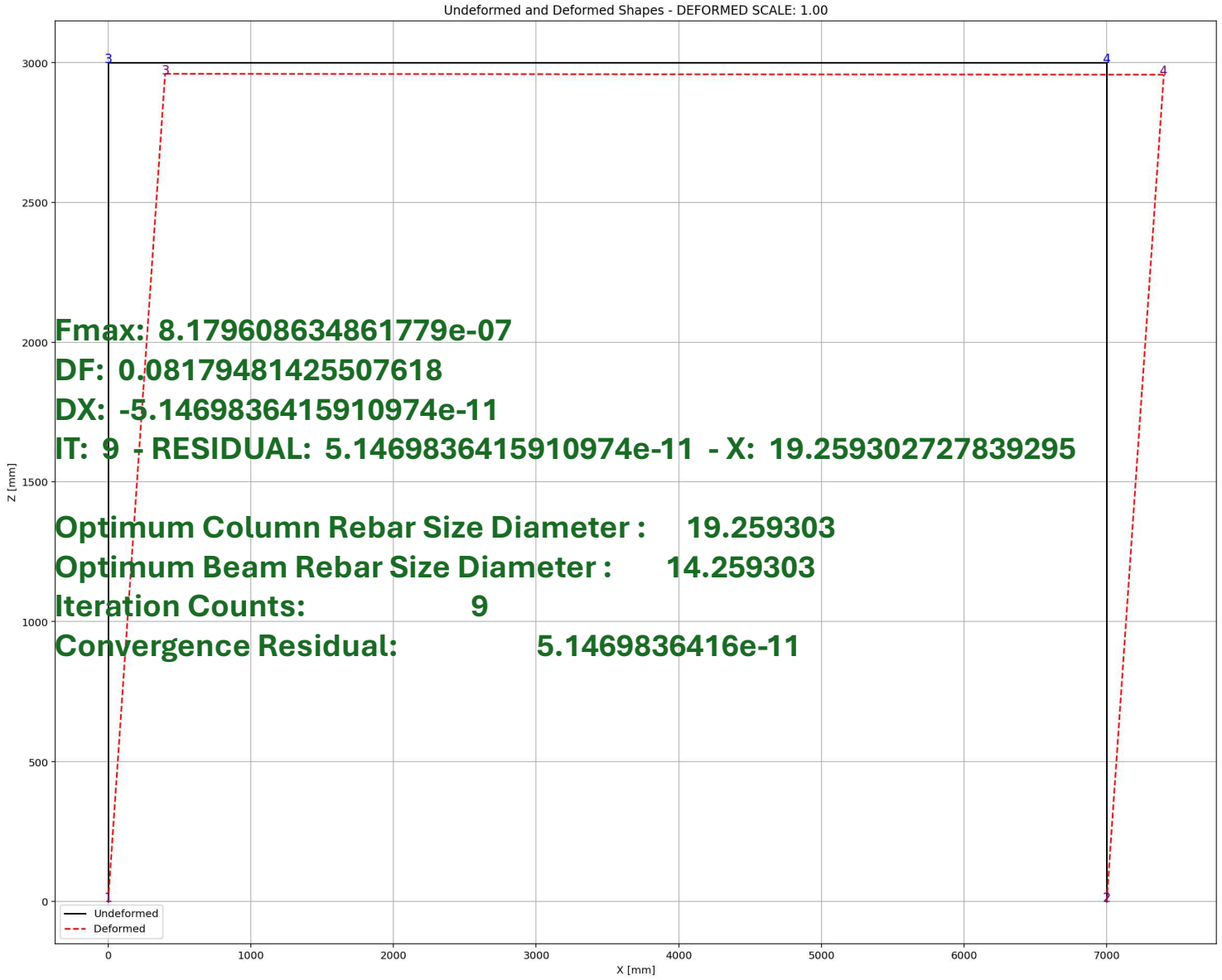
Console 1/A

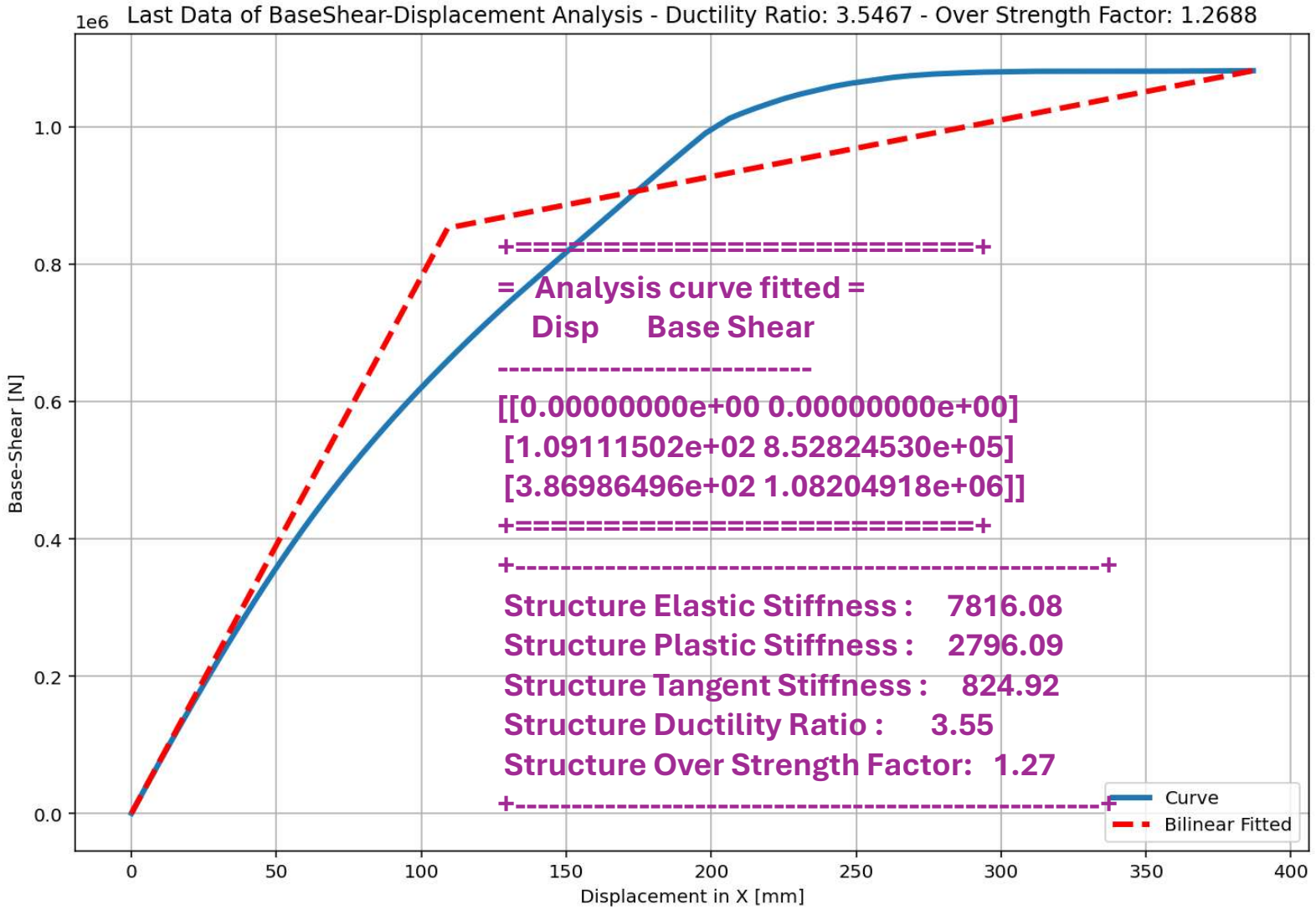
```
+-----------------------------------------------------+
Fmax:  8.179608634861779e-07
DF:  0.08179481425507618
DX:  -5.1469836415910974e-11
IT:  9  - RESIDUAL:  5.1469836415910974e-11  - X:  19.259302727839295

         Optimum Column Rebar Size Diameter :      19.259303
         Optimum Beam Rebar Size Diameter :        14.259303
         Iteration Counts:                         9
         Convergence Residual:                     5.1469836416e-11

Total time (s): 149.9469
```

IPython Console History

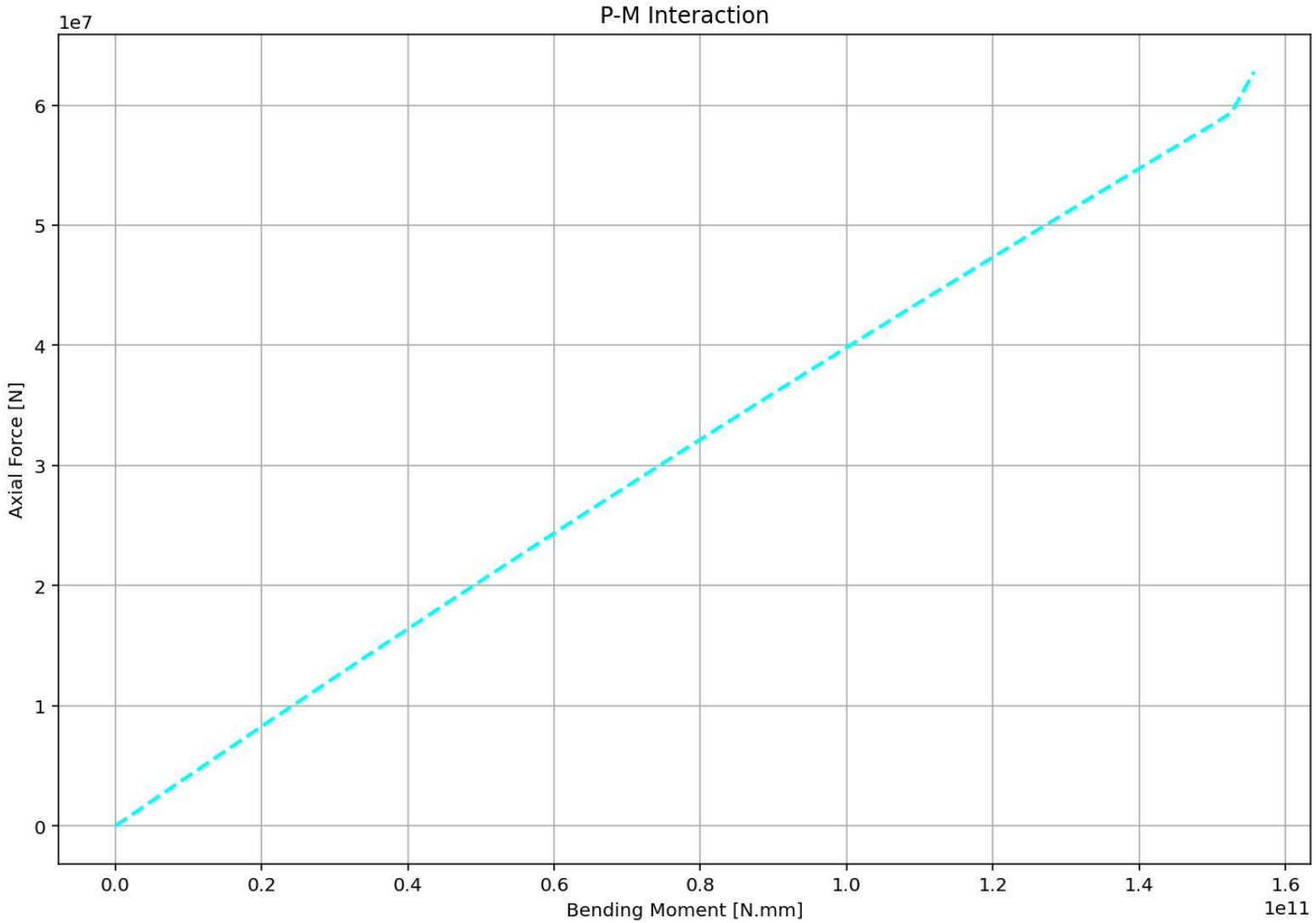
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 285, Col 13 UTF-8 CRLF RW Mem 42%

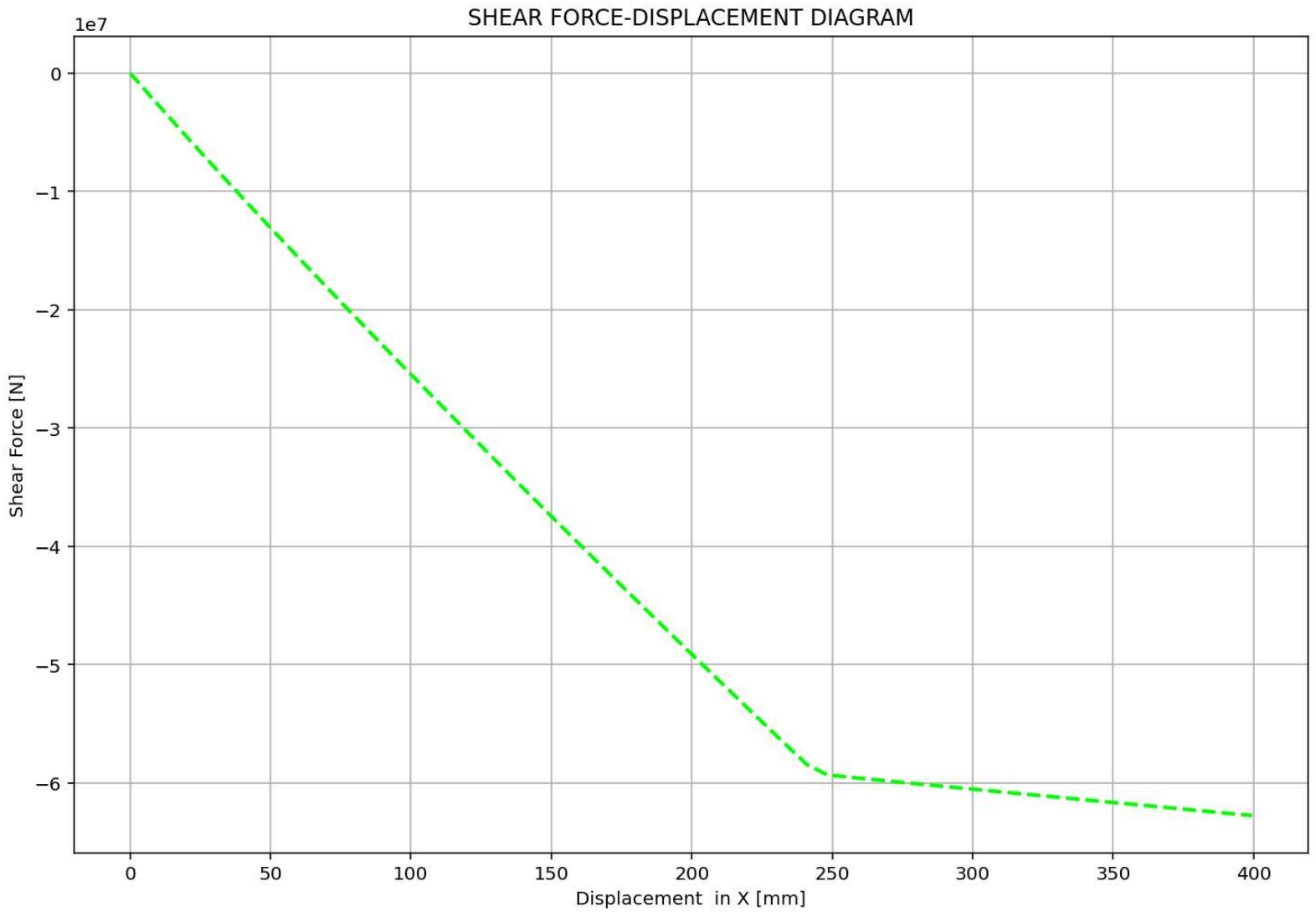
NONLINEAR STATIC ANALYSIS (PUSHOVER)

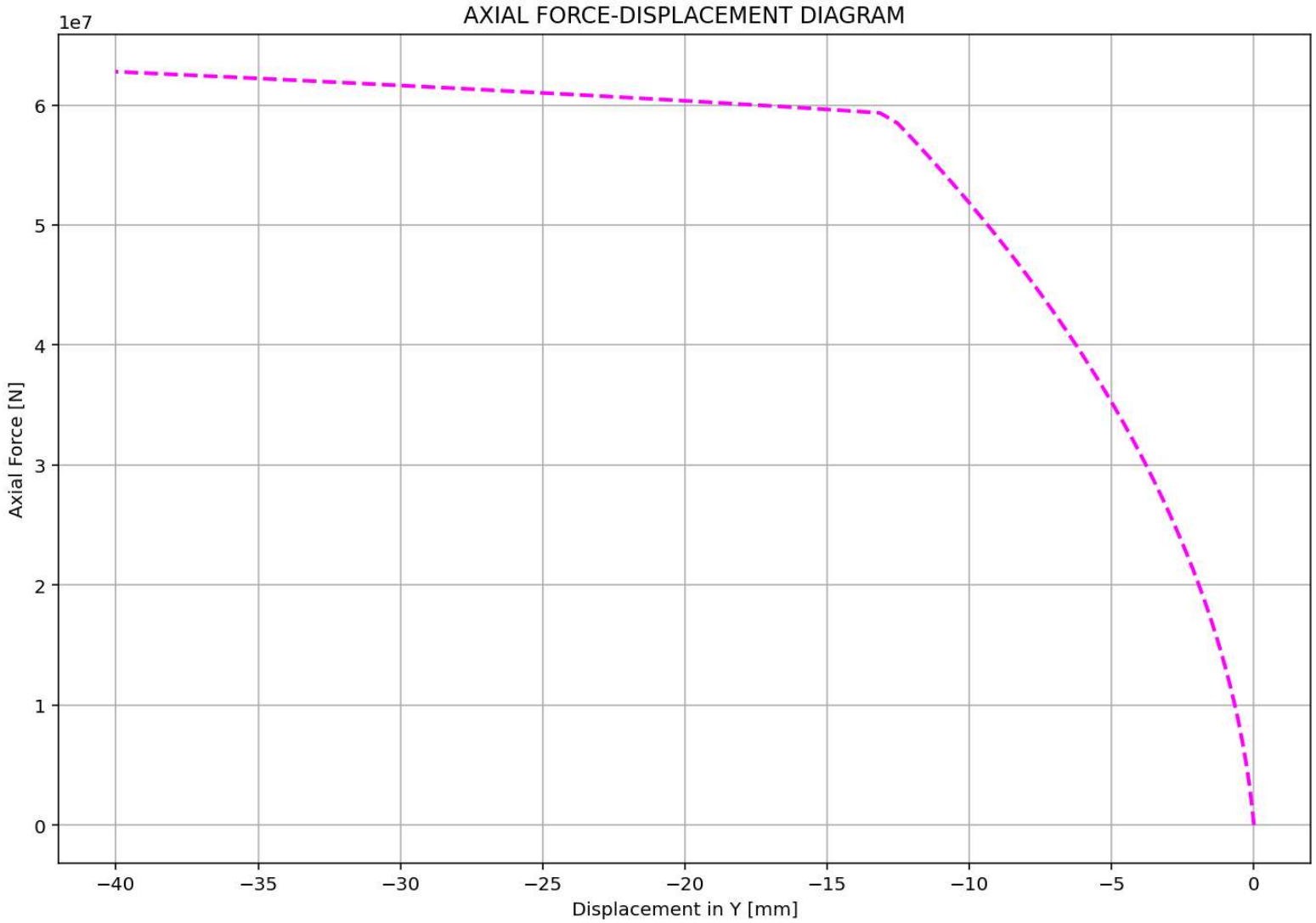

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Z [mm]
X [mm]
Undeformed
Deformed
Fmax: 8.179608634861779e-07
DF: 0.08179481425507618
DX: -5.1469836415910974e-11
IT: 9 - RESIDUAL: 5.1469836415910974e-11 - X: 19.259302727839295
Optimum Column Rebar Size Diameter : 19.259303
Optimum Beam Rebar Size Diameter : 14.259303
Iteration Counts: 9
Convergence Residual: 5.1469836416e-11

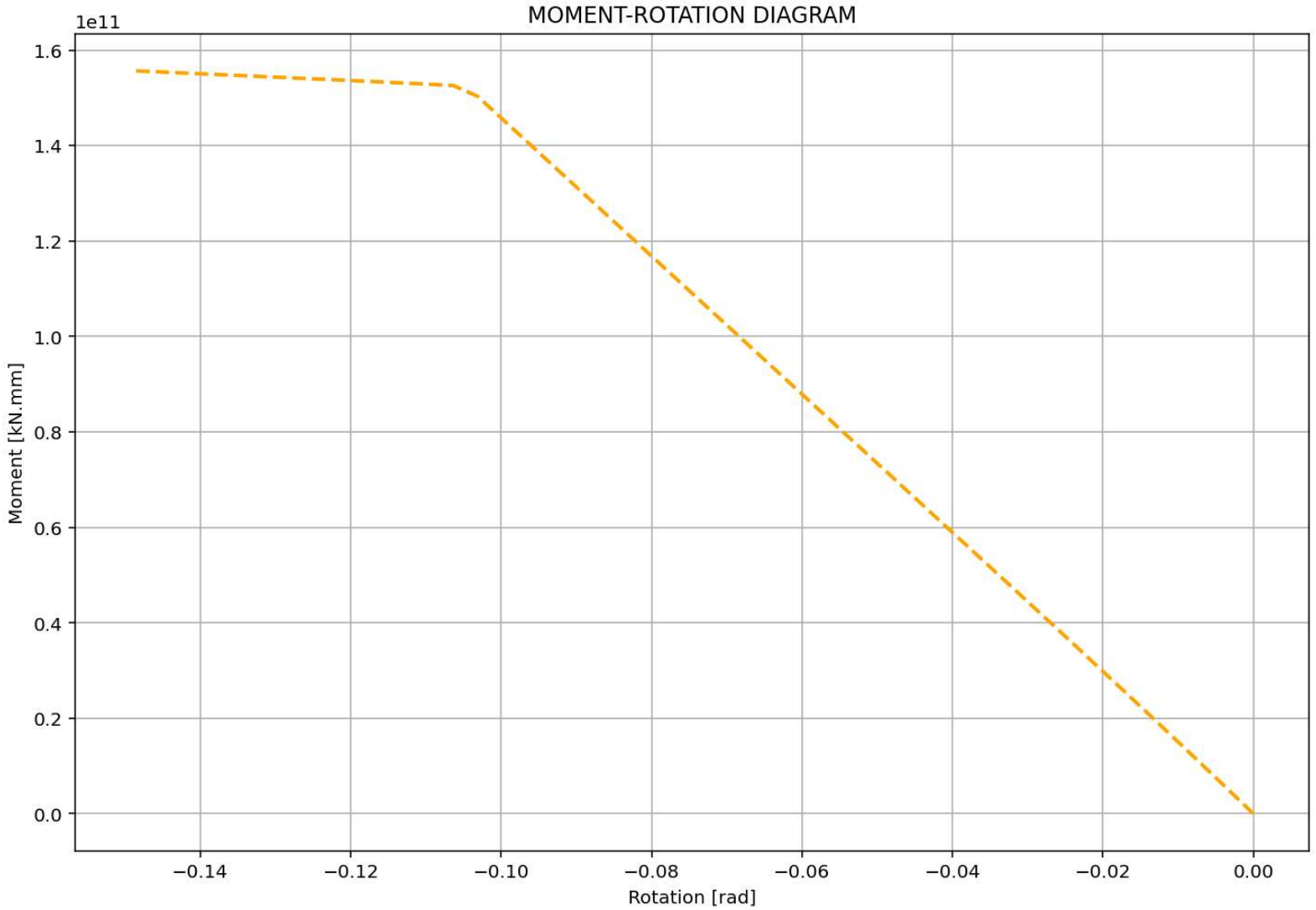

Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 3.5467 - Over Strength Factor: 1.2688
1e6
Base-Shear [N]
Displacement in X [mm]
0.0
0.2
0.4
0.6
0.8
1.0
0
50
100
150
200
250
300
350
400
+==========================+
= Analysis curve fitted =
Disp Base Shear

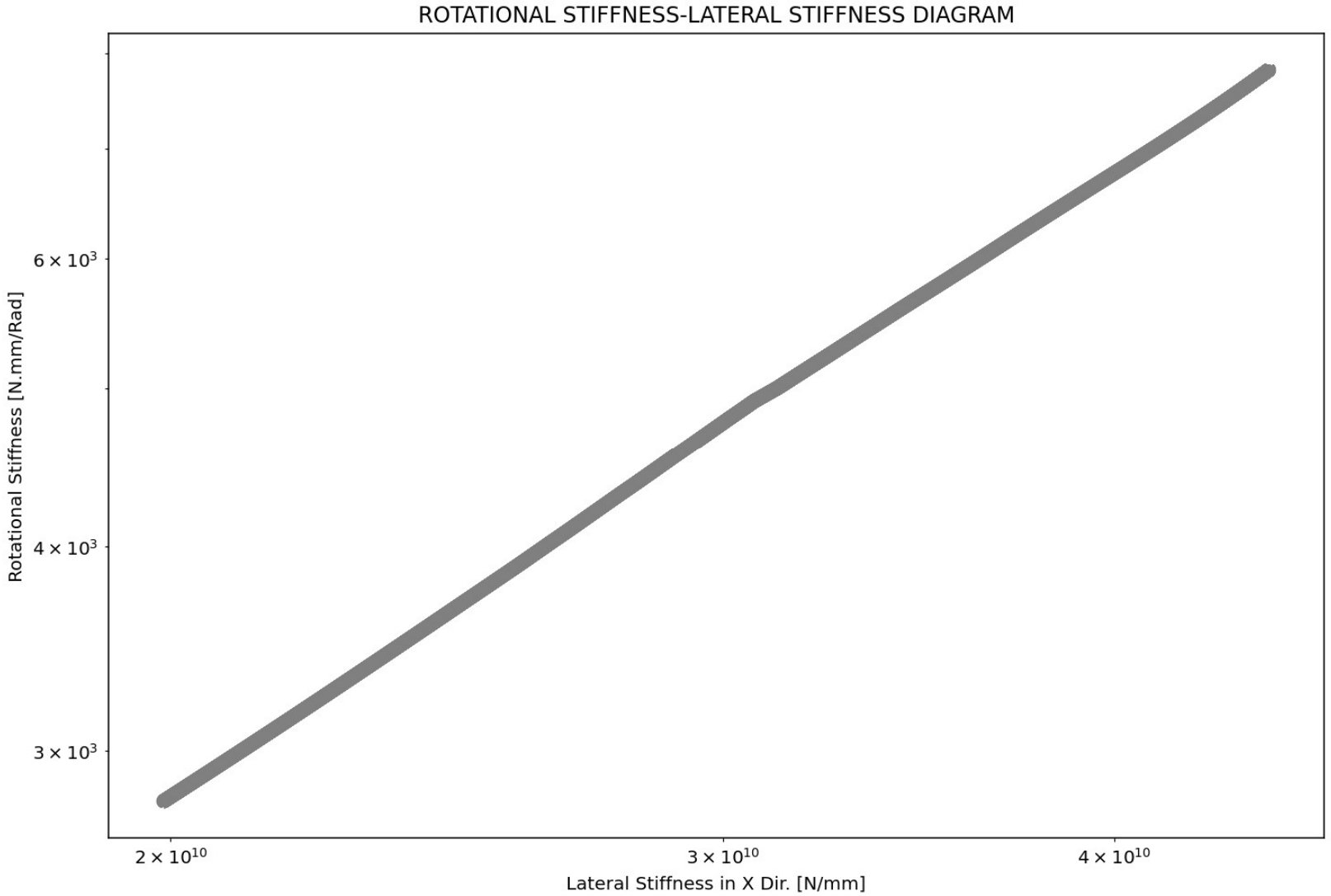
[[0.00000000e+00 0.00000000e+00]
[1.09111502e+02 8.52824530e+05]
[3.86986496e+02 1.08204918e+06]]
+==========================+
+---+
Structure Elastic Stiffness : 7816.08
Structure Plastic Stiffness : 2796.09
Structure Tangent Stiffness : 824.92
Structure Ductility Ratio : 3.55
Structure Over Strength Factor: 1.27
+---+
Curve
Bilinear Fitted

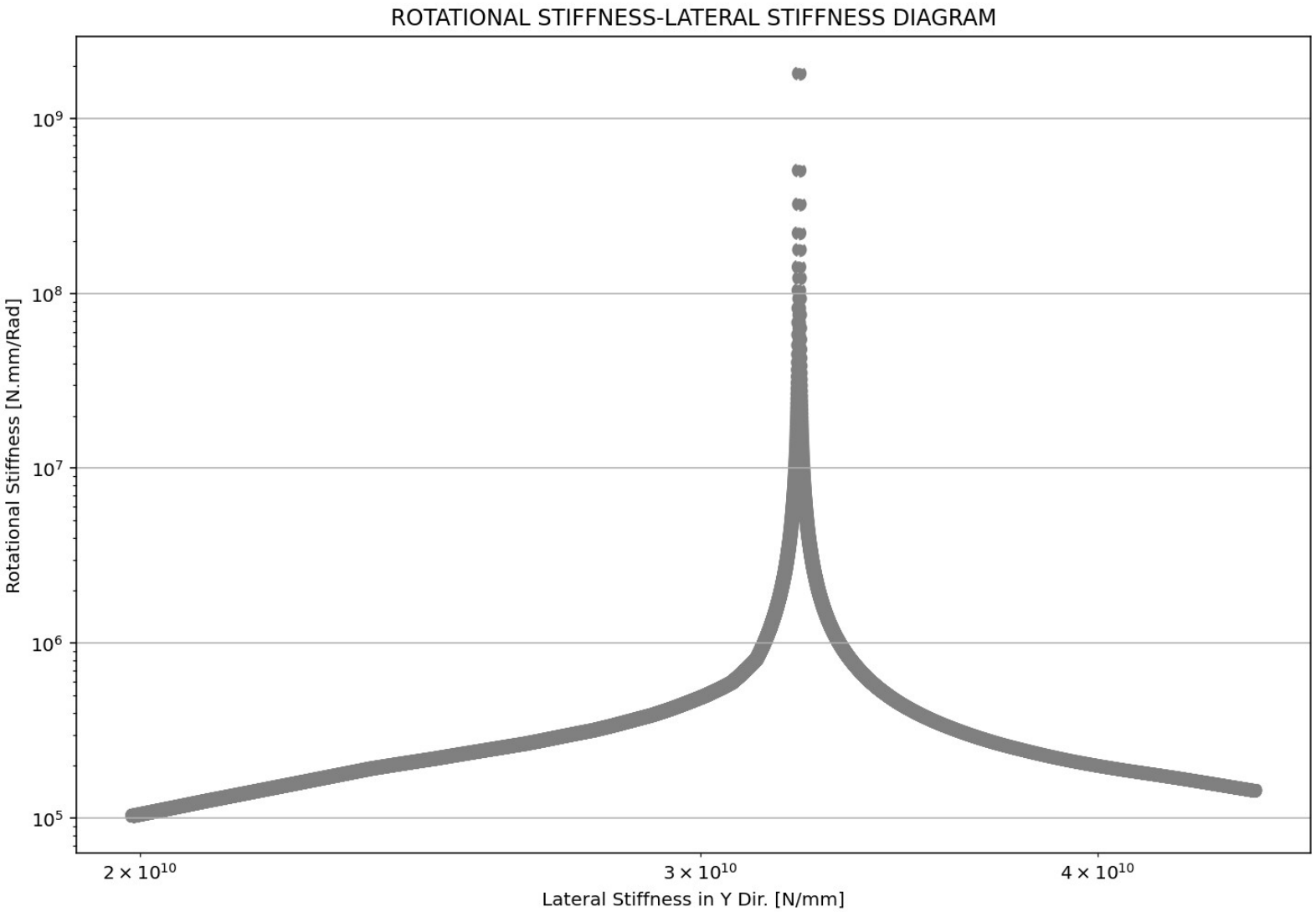

P-M Interaction
1e7
6
5
4
3
2
1
0
Axial Force [N]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1e11
Bending Moment [N.mm]


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]
6 × 10^3
4 × 10^3
3 × 10^3
2 × 10^10
3 × 10^10
4 × 10^10
Lateral Stiffness in X Dir. [N/mm]


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
10^9
10^8
10^7
10^6
10^5
2×10^{10}
3×10^{10}
4×10^{10}
Lateral Stiffness in Y Dir. [N/mm]