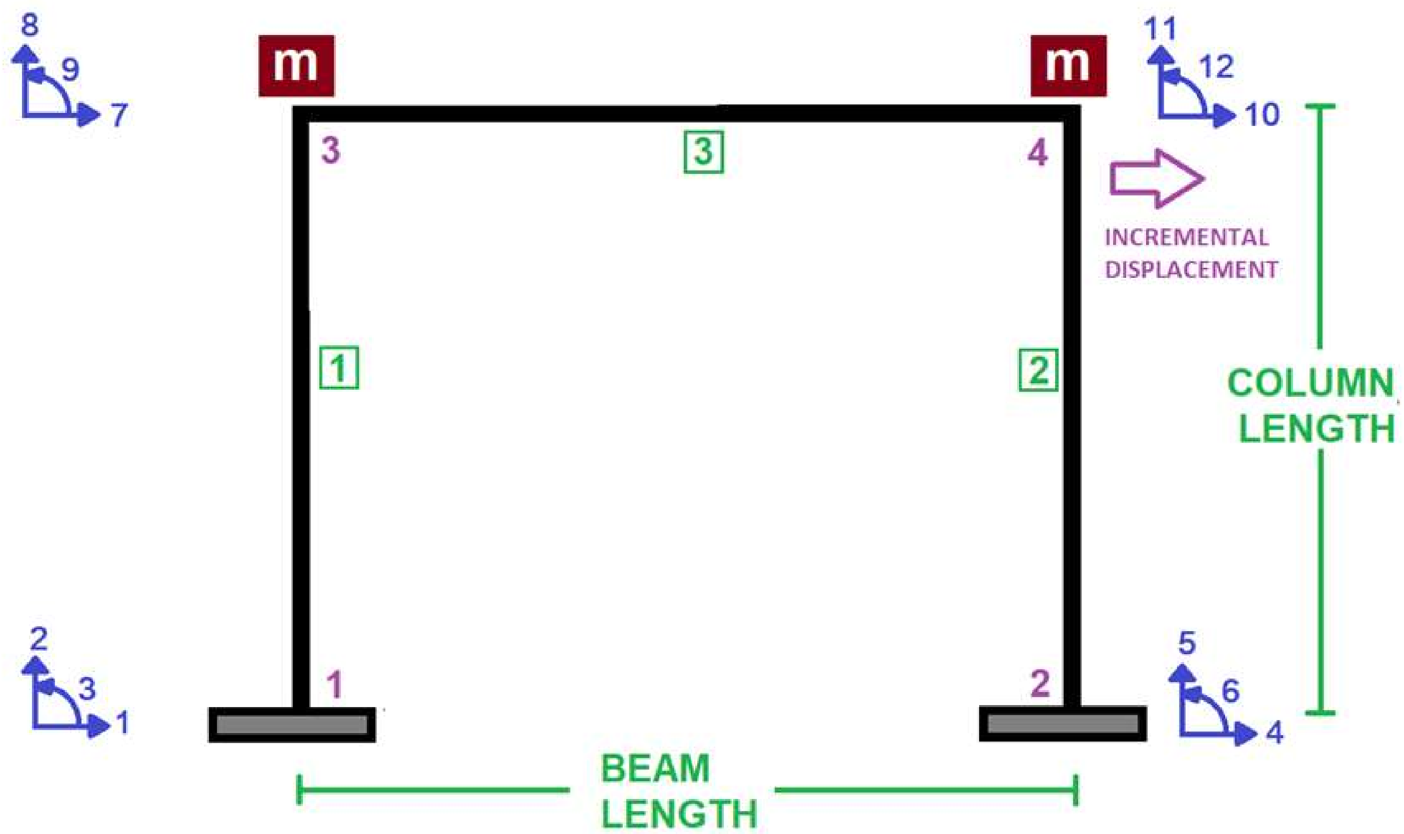
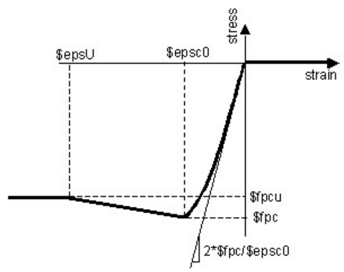
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

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

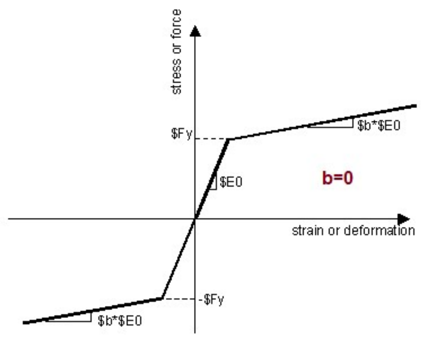
WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)



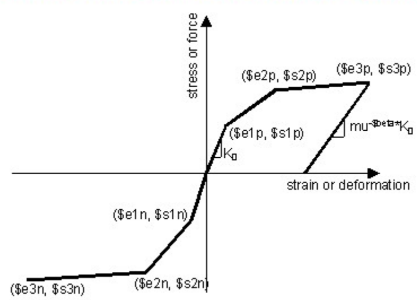
m
m
8
9
7
11
12
10
3
3
4
INCREMENTAL
DISPLACEMENT
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH



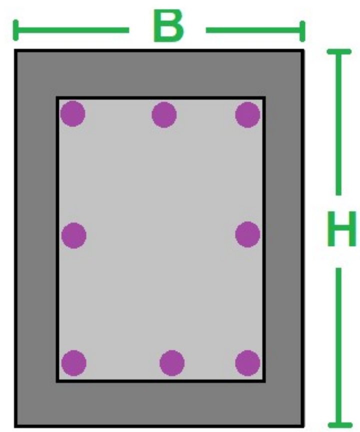
CORE AND COVER CONCRETE RELATION



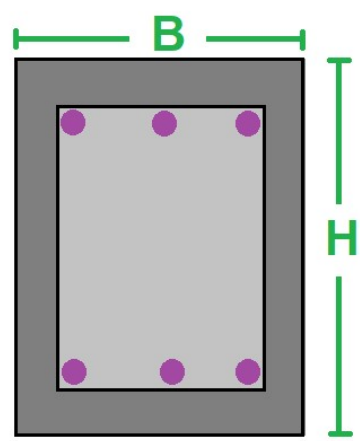
WITHOUT HARDENING AND ULTIMATE STRAIN



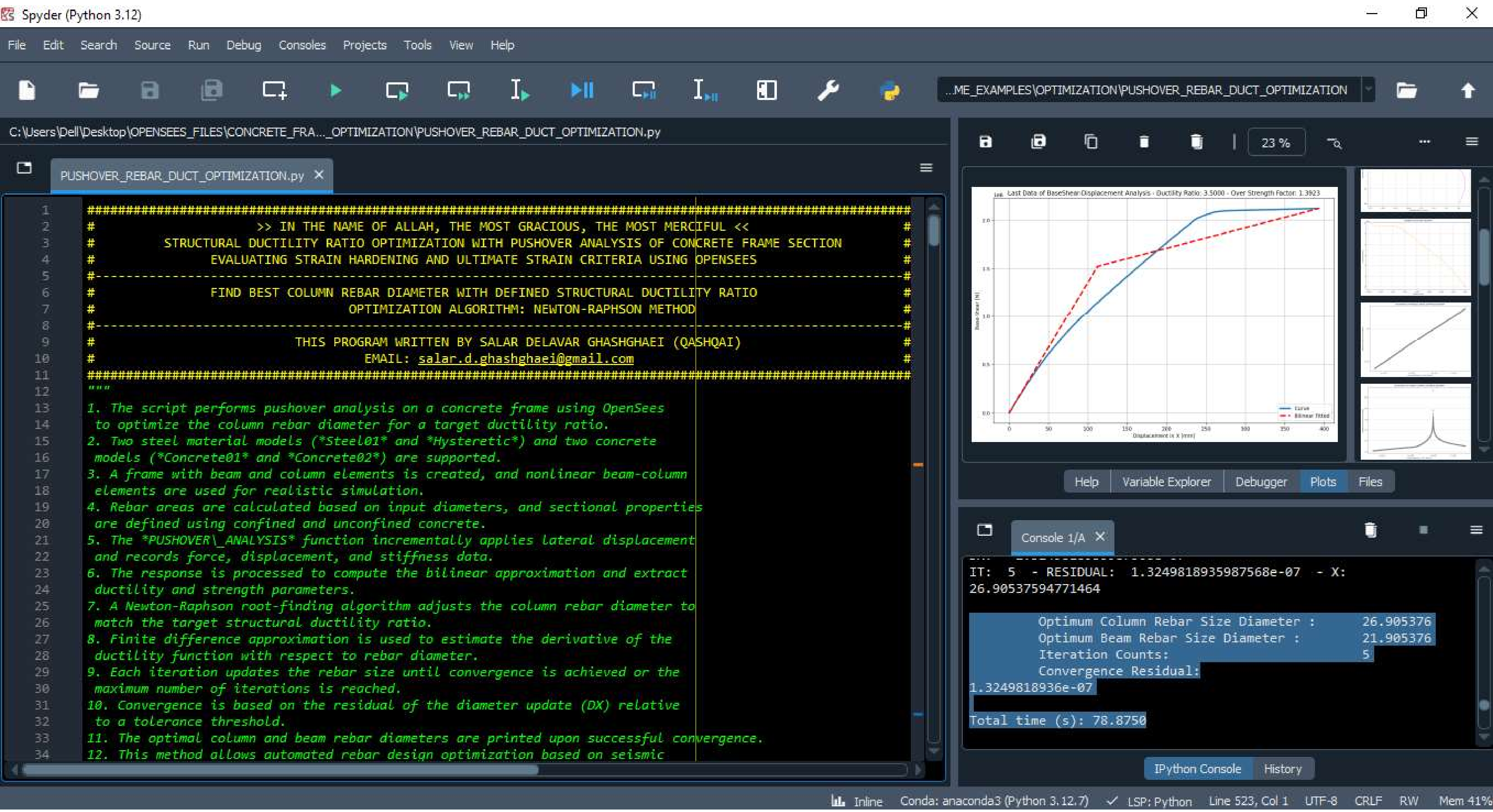
WITH HARDENING AND ULTIMATE STRAIN



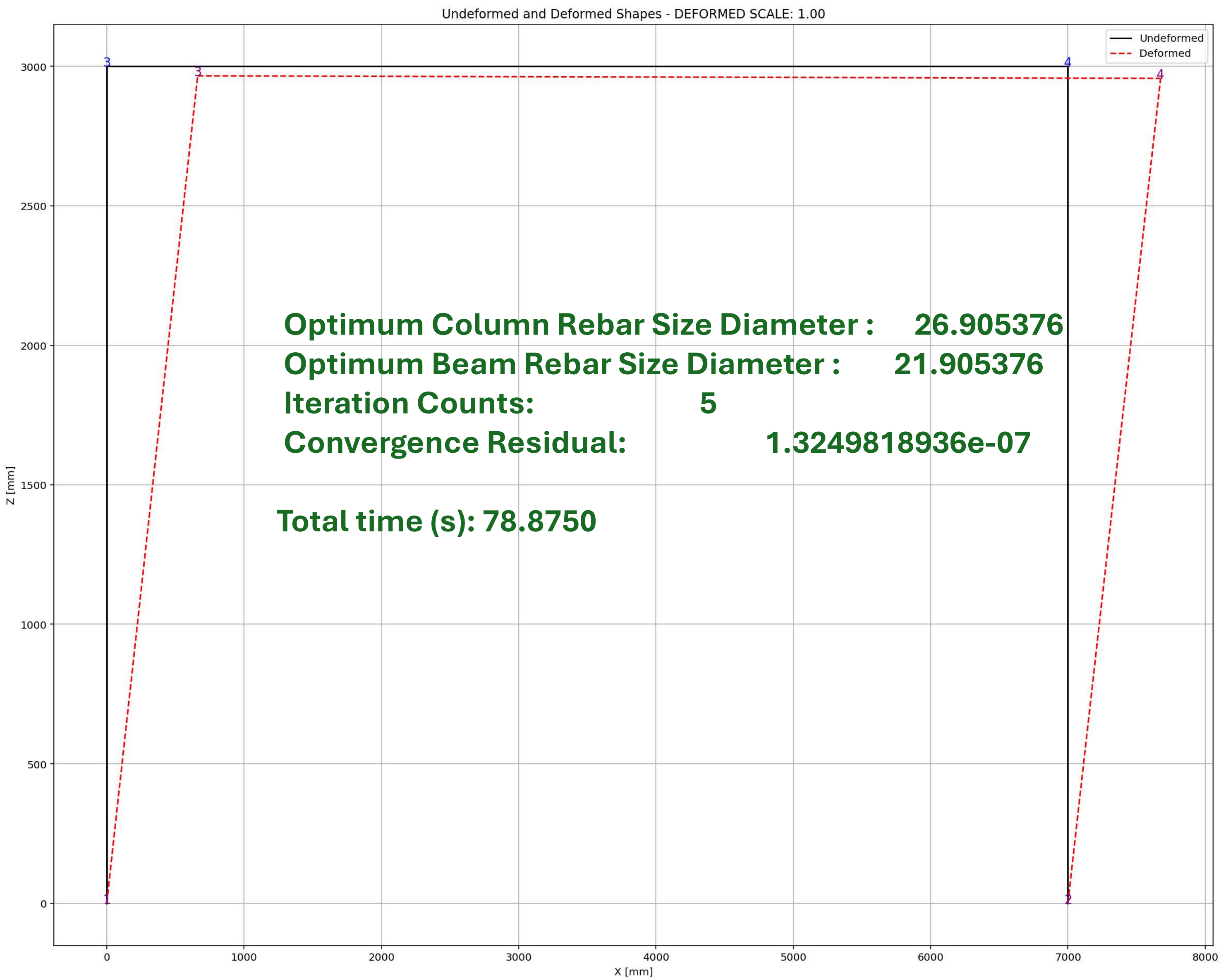
COLUMN SECTION

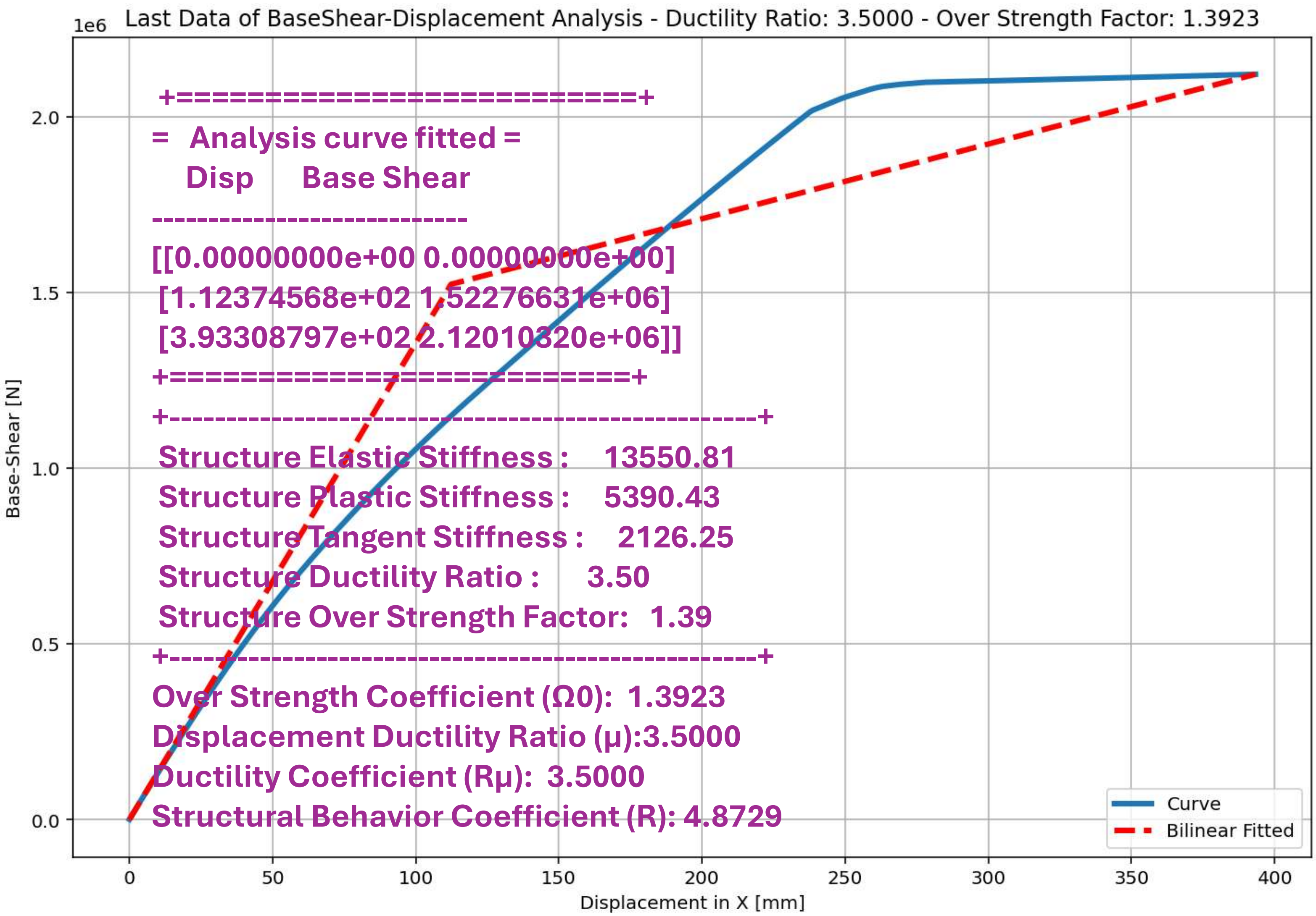


BEAM SECTION

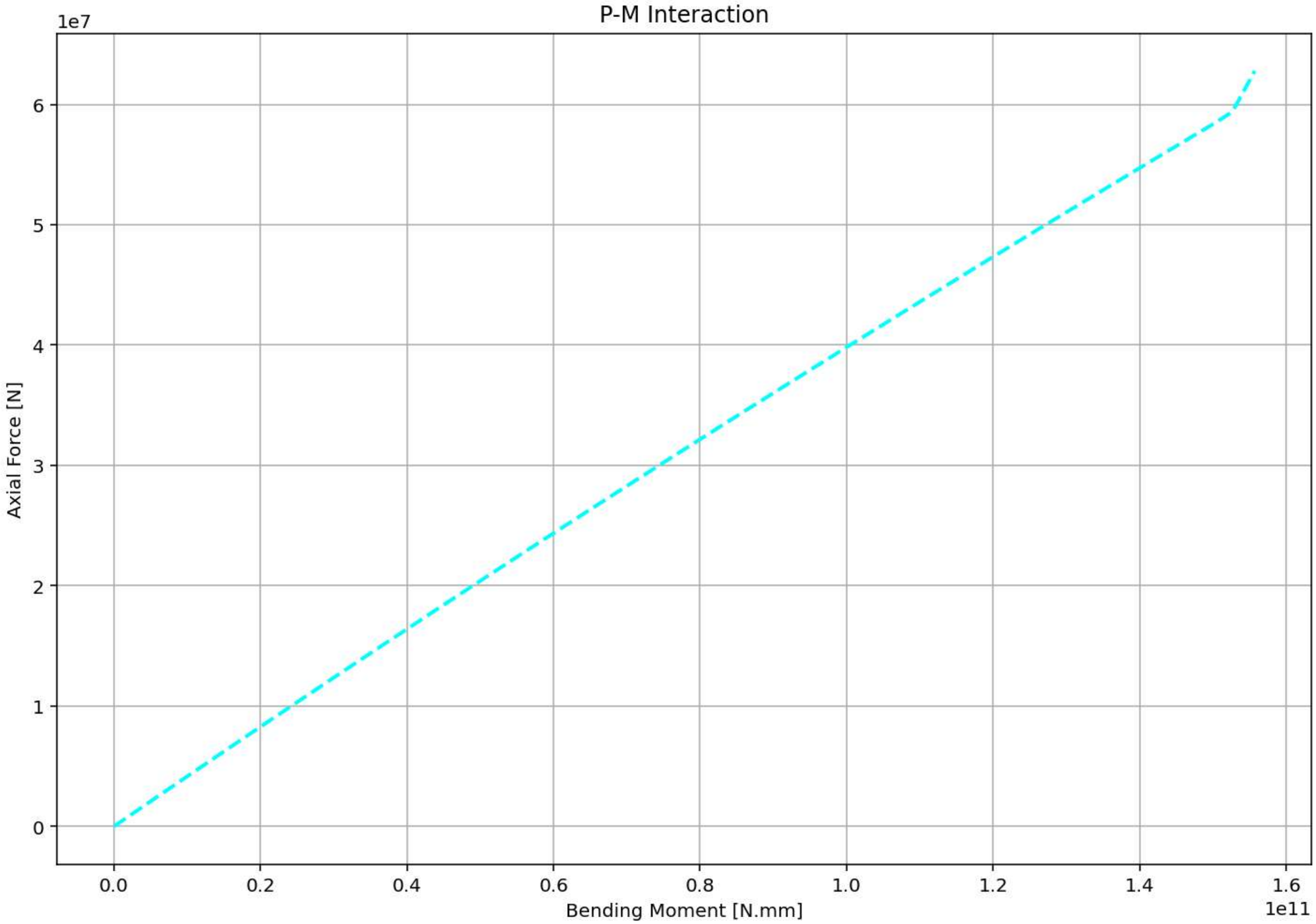

Spyder (Python 3.12)
File Edit Search Source Run Debug Consoles Projects Tools View Help
...ME_EXAMPLES\OPTIMIZATION\PUSHOVER_REBAR_DUCT_OPTIMIZATION
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA..._OPTIMIZATION\PUSHOVER_REBAR_DUCT_OPTIMIZATION.py
PUSHOVER_REBAR_DUCT_OPTIMIZATION.py
>> IN THE NAME 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 REBAR DIAMETER WITH DEFINED STRUCTURAL DUCTILITY RATIO
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
23 %
Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 3.5000 - Over Strength Factor: 1.3923
Help Variable Explorer Debugger Plots Files
Console 1/A
IT: 5 - RESIDUAL: 1.3249818935987568e-07 - X: 26.90537594771464
Optimum Column Rebar Size Diameter : 26.905376
Optimum Beam Rebar Size Diameter : 21.905376
Iteration Counts: 5
Convergence Residual: 1.3249818936e-07
Total time (s): 78.8750
IPython Console History
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 523, Col 1 UTF-8 CRLF RW Mem 41%

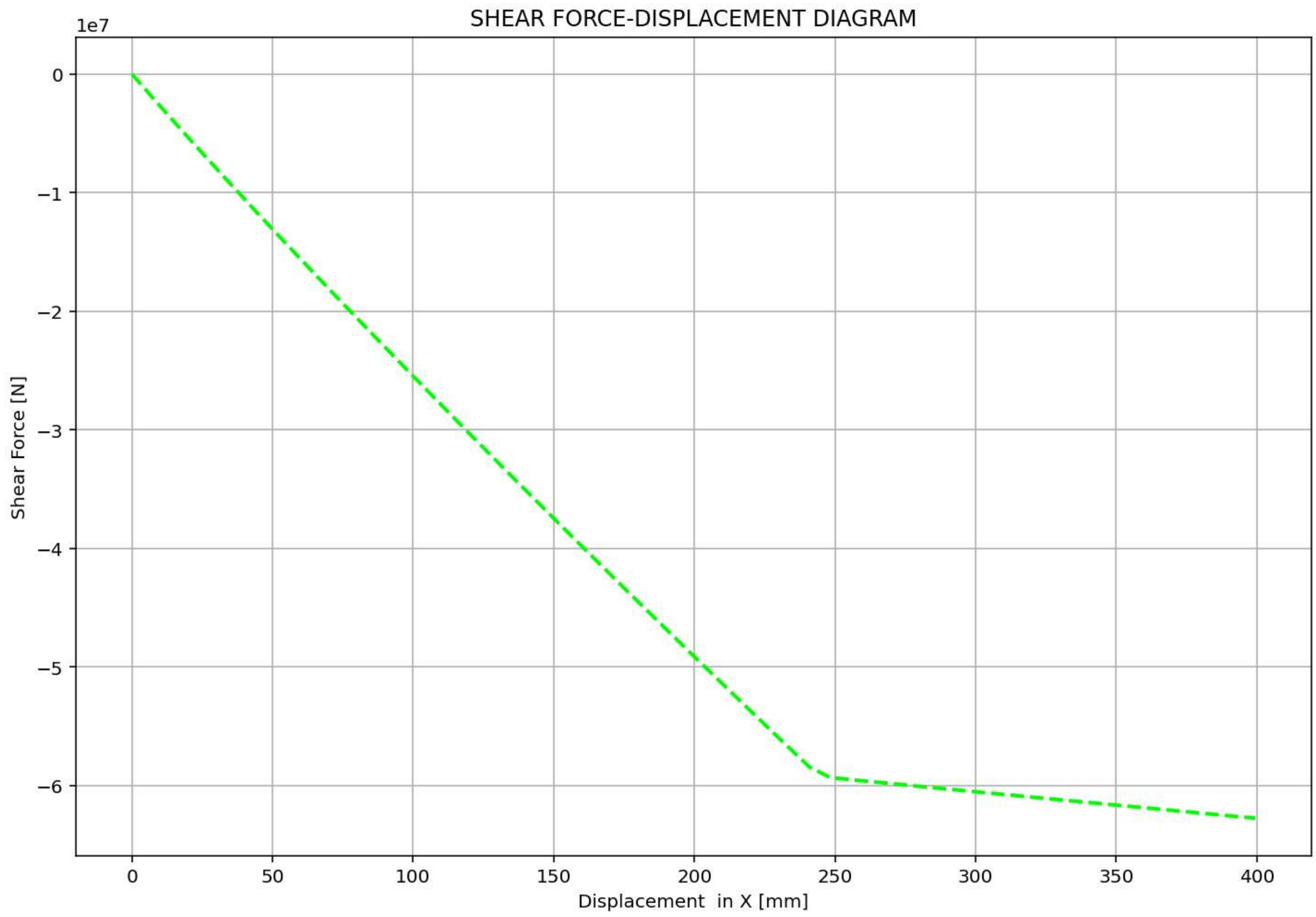
NONLINEAR STATIC ANALYSIS (PUSHOVER)

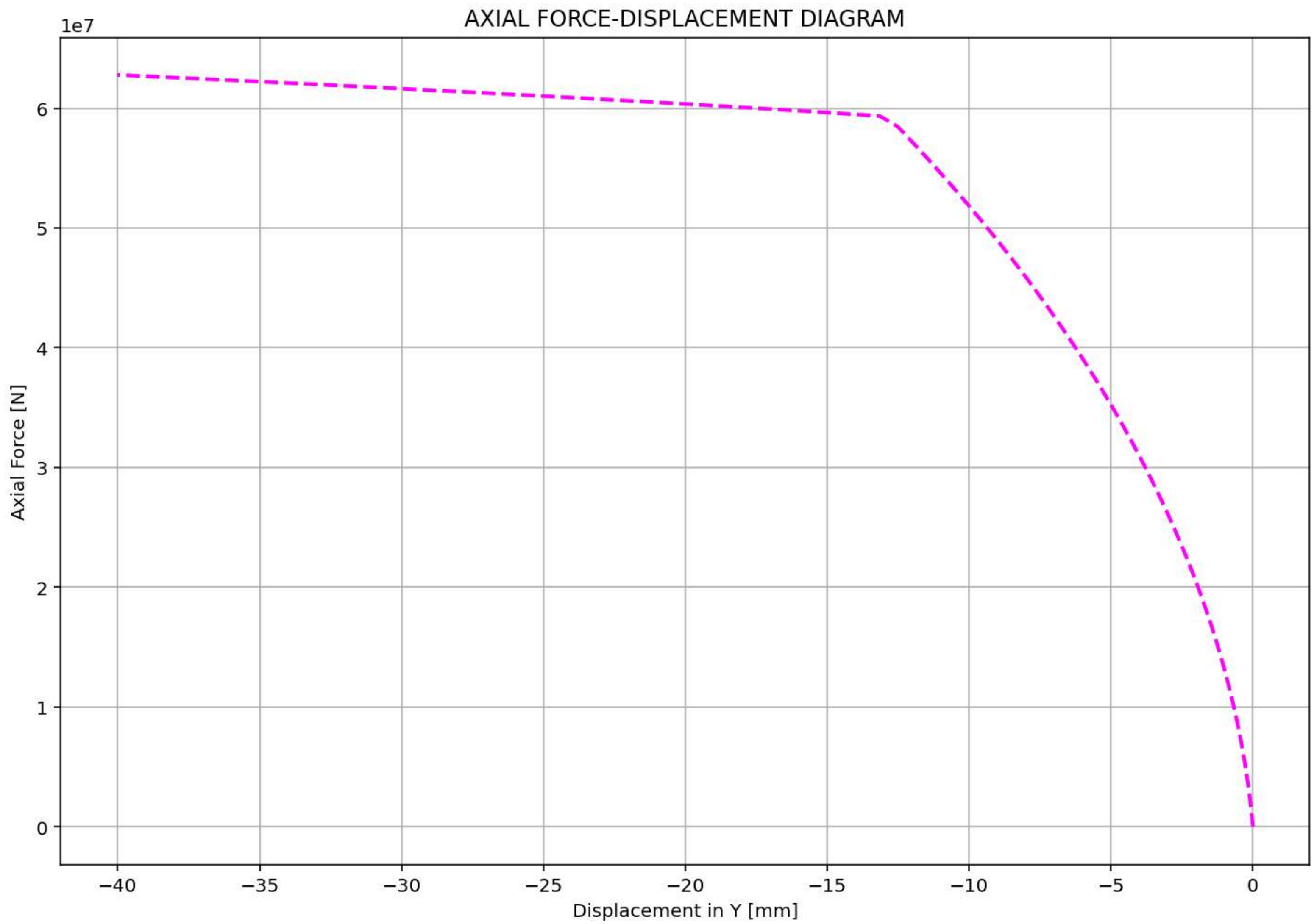

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
4000
5000
6000
7000
8000
1
2
3
4
Optimum Column Rebar Size Diameter : 26.905376
Optimum Beam Rebar Size Diameter : 21.905376
Iteration Counts: 5
Convergence Residual: 1.3249818936e-07
Total time (s): 78.8750

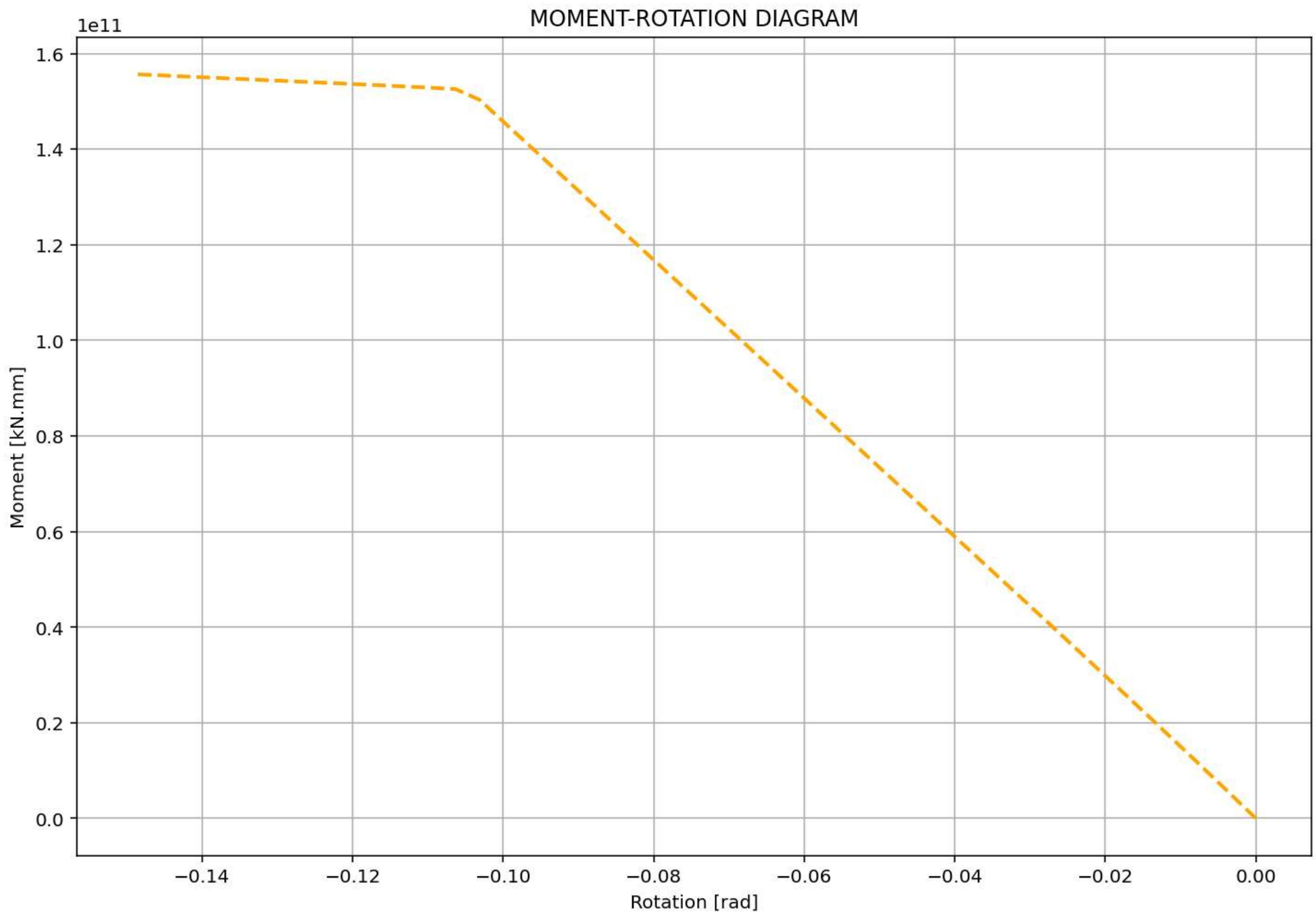

Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 3.5000 - Over Strength Factor: 1.3923
1e6
Base-Shear [N]
0.0
0.5
1.0
1.5
2.0
Displacement in X [mm]
0
50
100
150
200
250
300
350
400
Curve
Bilinear Fitted
+===========================+
= Analysis curve fitted =
Disp Base Shear

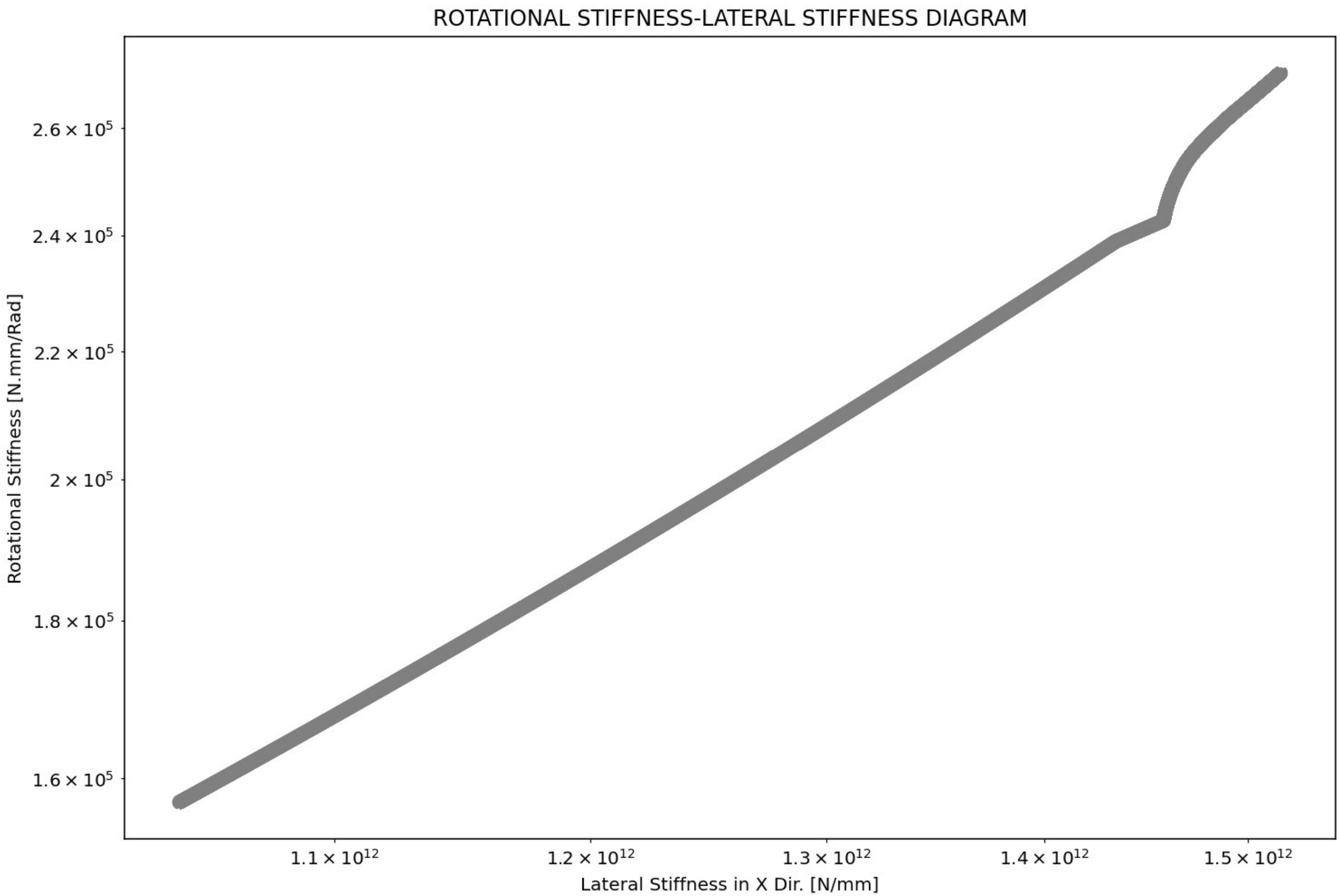
[[0.00000000e+00 0.00000000e+00]
[1.12374568e+02 1.52276631e+06]
[3.93308797e+02 2.12010320e+06]]
+===========================+
+--+
Structure Elastic Stiffness : 13550.81
Structure Plastic Stiffness : 5390.43
Structure Tangent Stiffness : 2126.25
Structure Ductility Ratio : 3.50
Structure Over Strength Factor: 1.39
+--+
Over Strength Coefficient (Ω0): 1.3923
Displacement Ductility Ratio (μ):3.5000
Ductility Coefficient (Rμ): 3.5000
Structural Behavior Coefficient (R): 4.8729

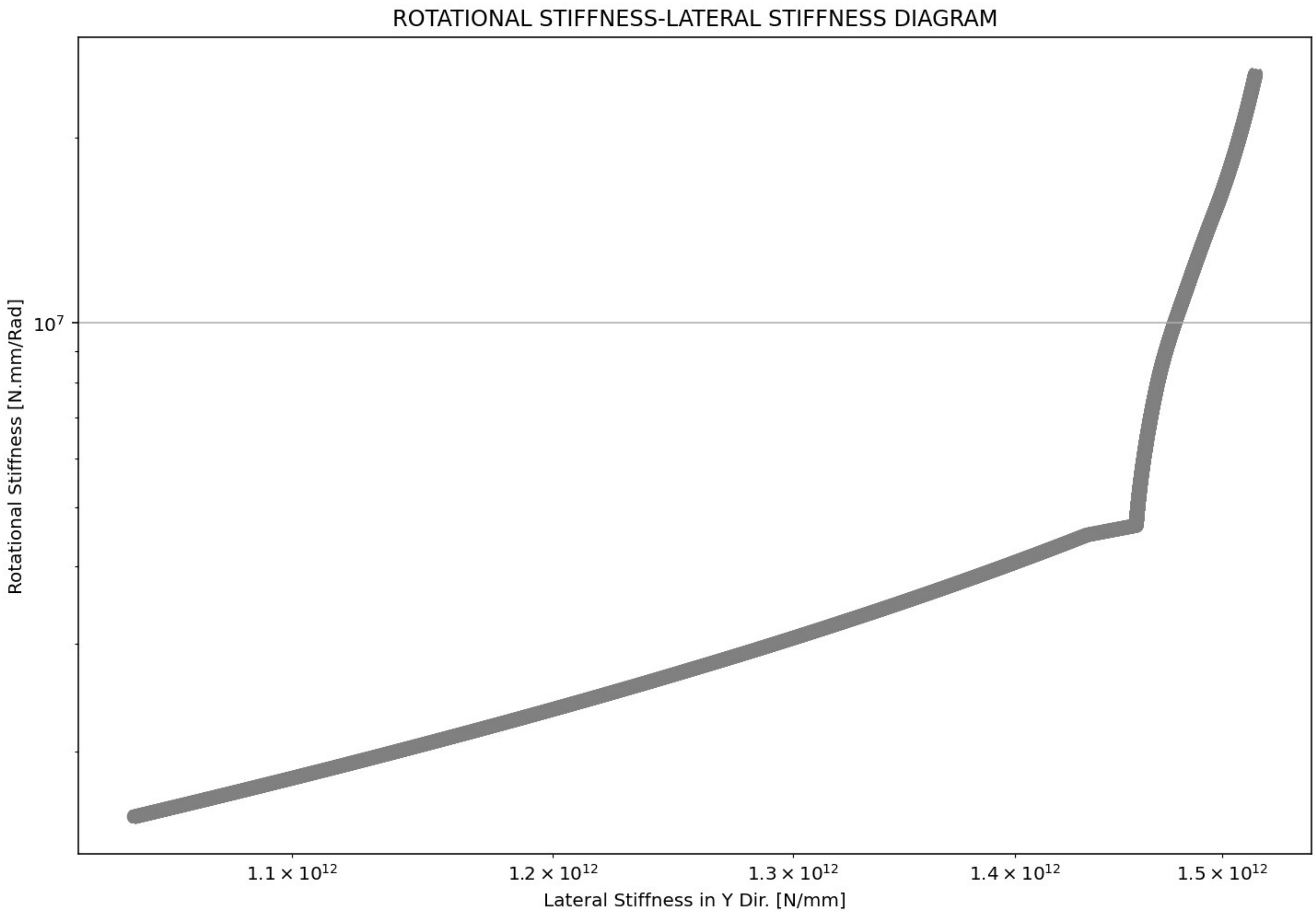

P-M Interaction
1e7
6
5
4
3
2
1
0
Axial Force [N]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1e11
Bending Moment [N.mm]


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]