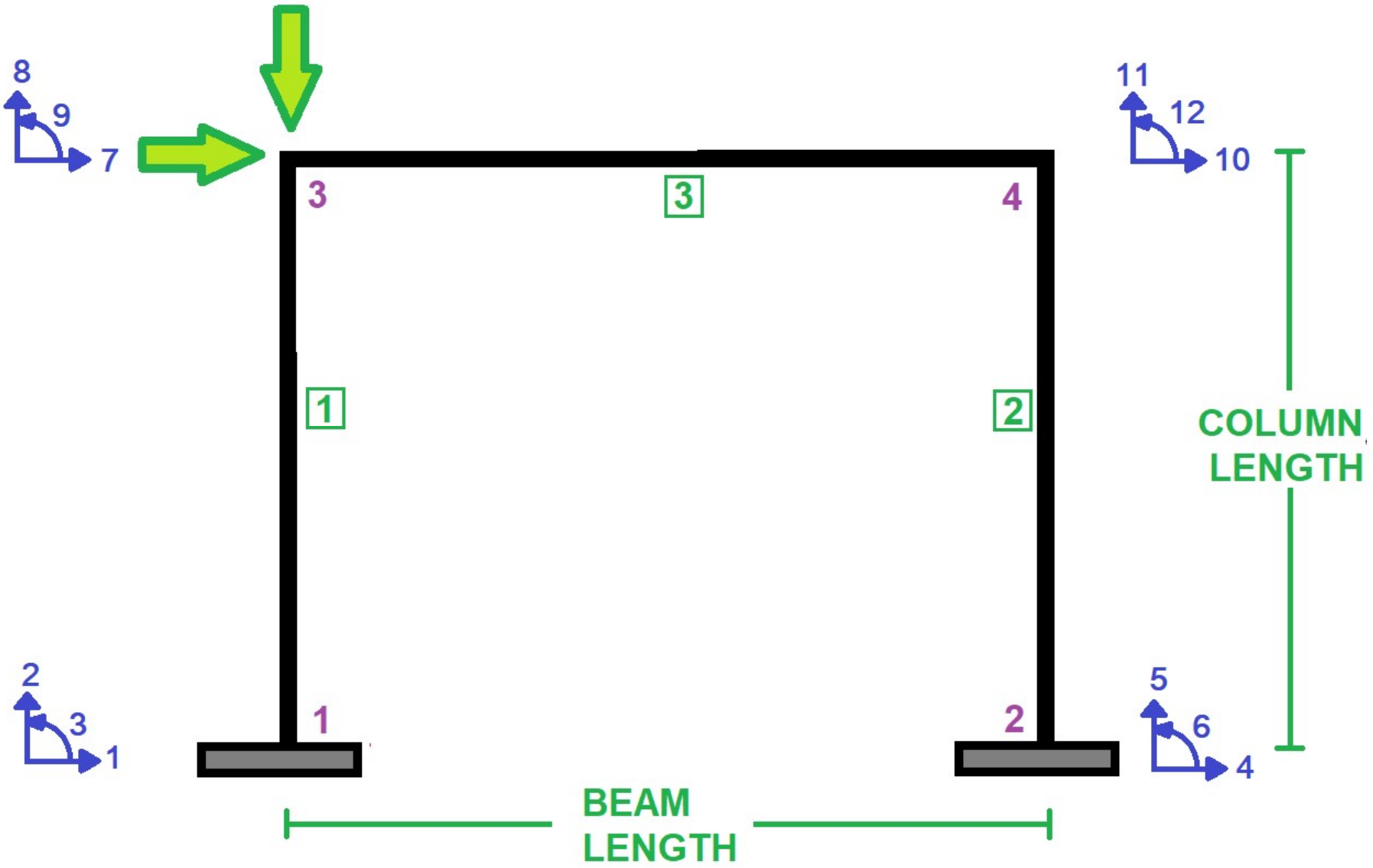
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

SENSITIVITY ANALYSIS OF CONCRETE FRAME BY CHANGING COLUMN REBAR DIAMETER AND STRENGTH ENHANCEMENT FACTOR USING OPENSEES FOR STRUCTURAL BEHAVIOR COEFFICIENT CALCULATION.

BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


8
9
7
11
12
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3
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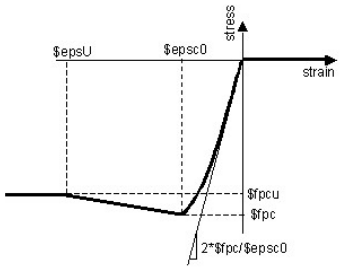
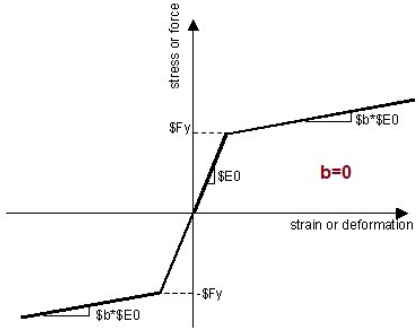
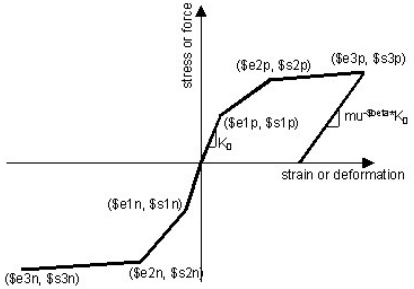
4
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH



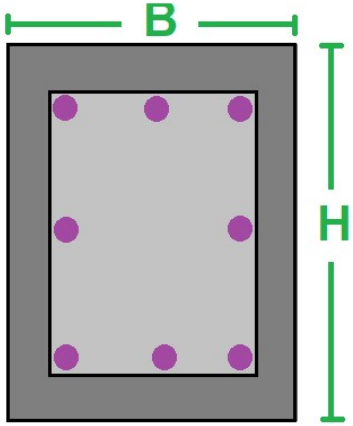
CORE AND COVER CONCRETE RELATION



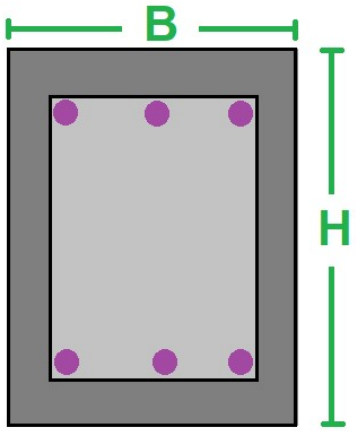
WITHOUT HARDENING AND ULTIMATE STRAIN



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...SENSITIVITY\CONCRETE_FRAME_SENSITIVITY_REBAR_K.py

CONCRETE_FRAME_SENSITIVITY_REBAR_K.py*

```
#############################################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<                 #
#  SENSITIVITY ANALYSIS OF CONCRETE FRAME BY CHANGING COLUMN REBAR DIAMETER AND STRENGTH ENHANCEMENT FACTOR  #
#                       USING OPENSEES FOR STRUCTURAL BEHAVIOR COEFFICIENT CALCULATION                      #
#-----------------------------------------------------------------------------------------------------------#
#                              THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)                   #
#                                        EMAIL: salar.d.ghashghaei@gmail.com                                #
#############################################################################################################
"""
1. The analysis compares nonlinear rotational behavior of concrete beam-column
 elements under pushover lateral displacements using OpenSees.
2. Two material models—*Steel01* (bilinear without degradation) and *Hysteretic*
 (tri-linear with pinching and strength/stiffness degradation)—are used.
3. Both models are subjected to identical loading protocols to investigate pushover
 response under increasing drift demands.
4. The *Steel01* model exhibits stable hysteresis loops with no degradation, reflecting
 idealized elastic-plastic behavior.
5. In contrast, the *Hysteretic* model shows strength and stiffness degradation, capturing
 post-peak deterioration and pinching effects.
6. Element rotation histories reveal increasing divergence as inelastic demand accumulates
 across cycles.
7. The *Hysteretic* model produces reduced energy dissipation capacity due to pinching and
cumulative damage.
8. Peak rotation capacity is reduced in the *Hysteretic* model, indicating realistic modeling
 of damage and failure modes.
9. The comparison highlights the limitations of bilinear idealizations in capturing cyclic
 degradation in seismic applications.
10. Advanced modeling with calibrated degradation parameters is essential for accurate
 seismic performance prediction and collapse assessment.
"""
import openseespy.opensees as ops
import matplotlib.pyplot as plt
import numpy as np
import time as TI
```

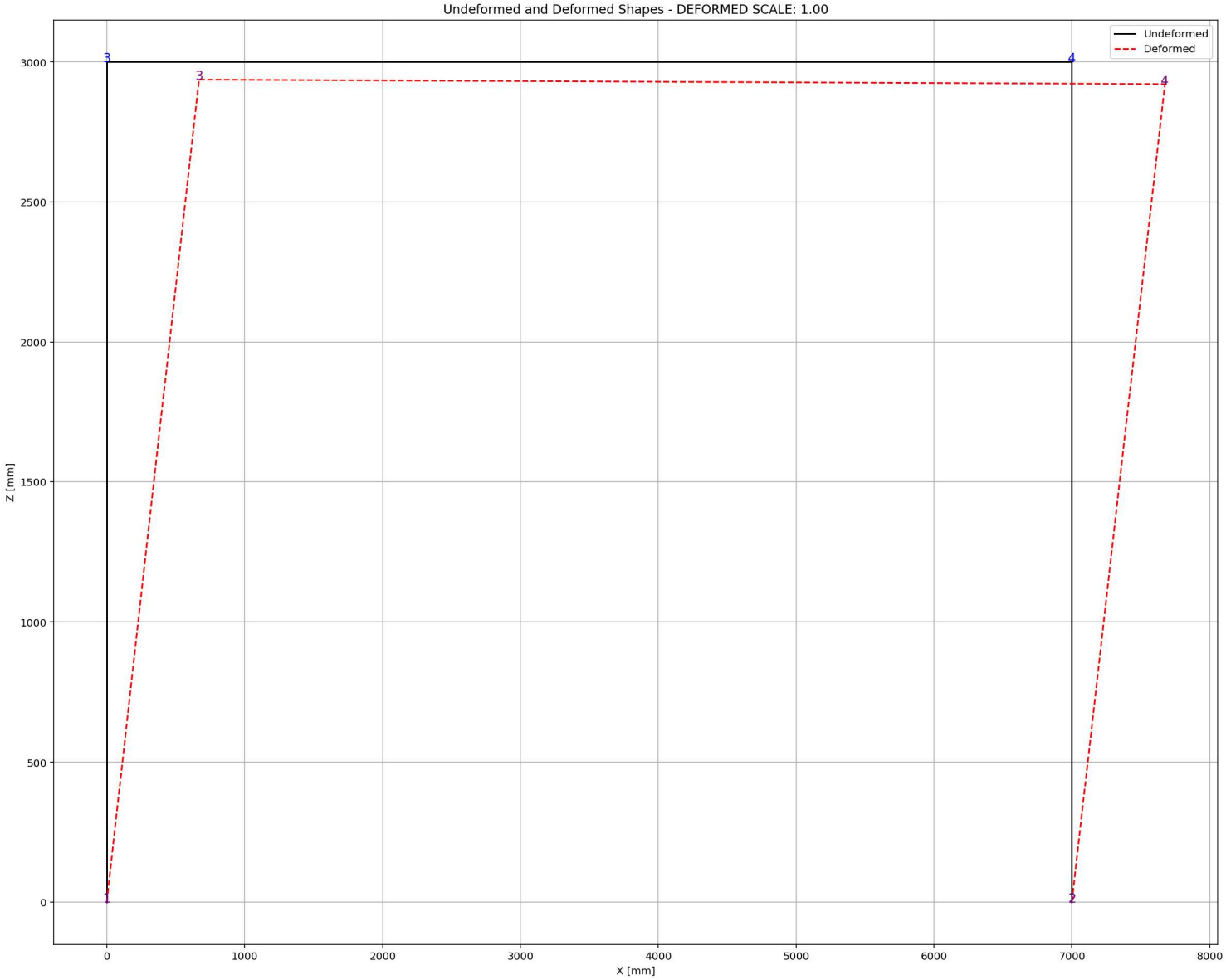
Help | Variable Explorer | Debugger | Plots | Files

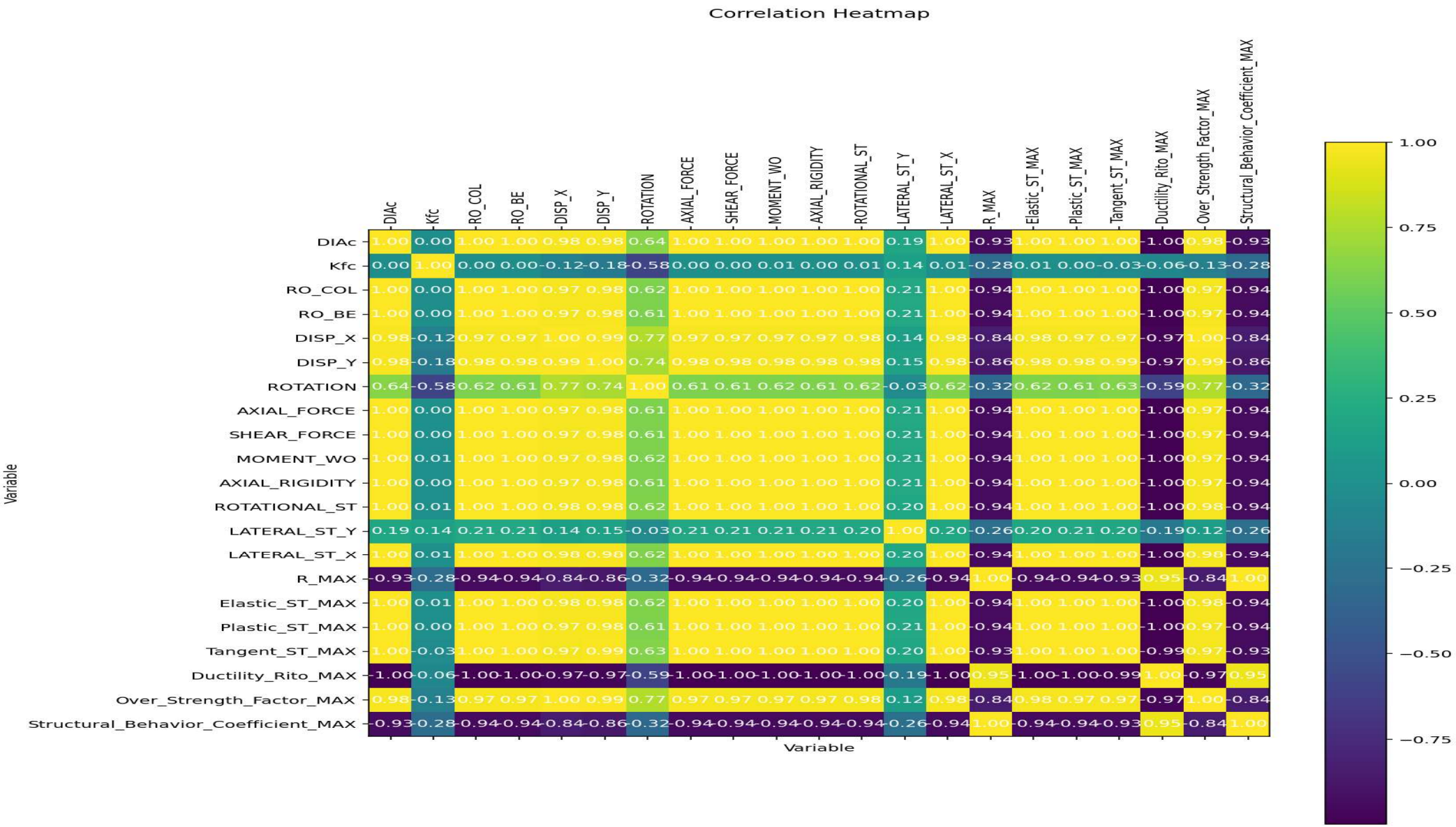
Console 1/A

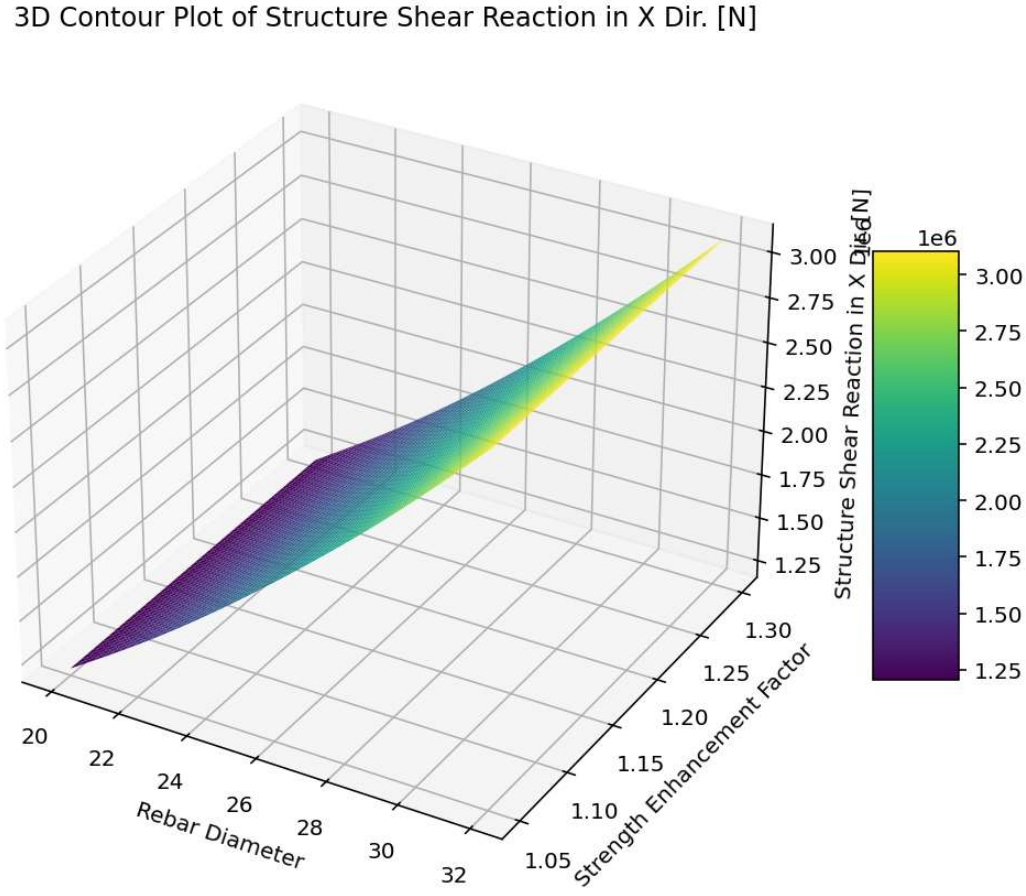
```
     Disp       Base Shear
----------------------------
[[0.00000000e+00 0.00000000e+00]
 [1.42276504e+02 2.56199251e+06]
 [6.69281364e+02 3.11075543e+06]]
+==========================+
+-------------------------------------------------
--+
 Structure Elastic Stiffness :     18007.14
 Structure Plastic Stiffness :     4647.90
 Structure Tangent Stiffness :     1041.29
```

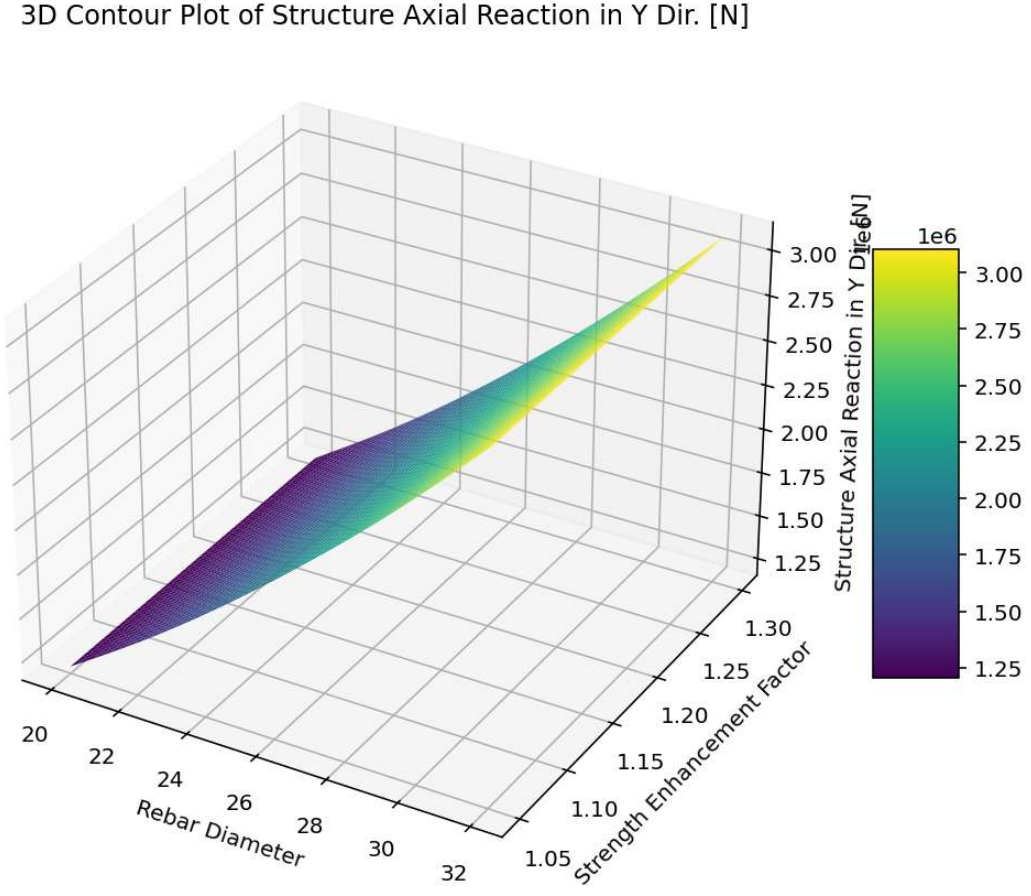
IPython Console | History

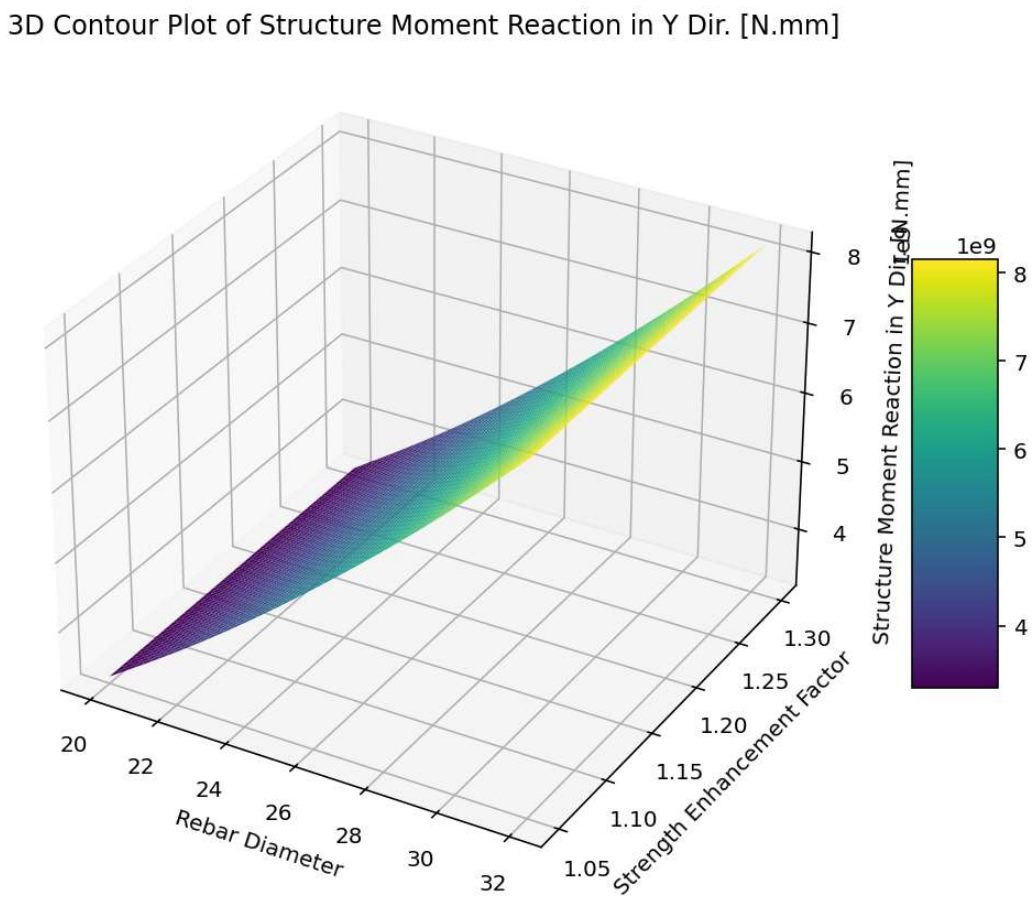
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 531, Col 31 UTF-8 CRLF RW Mem 41%

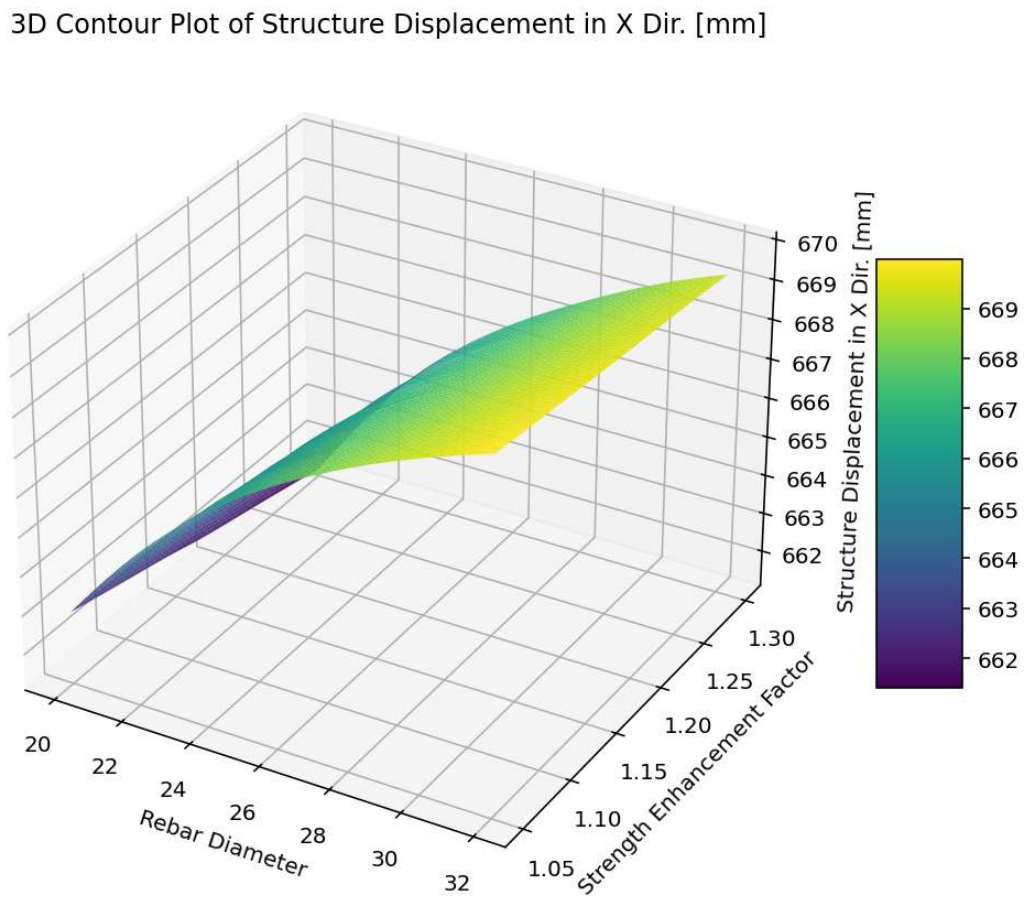

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000
8000
3
4
3
4
1
2

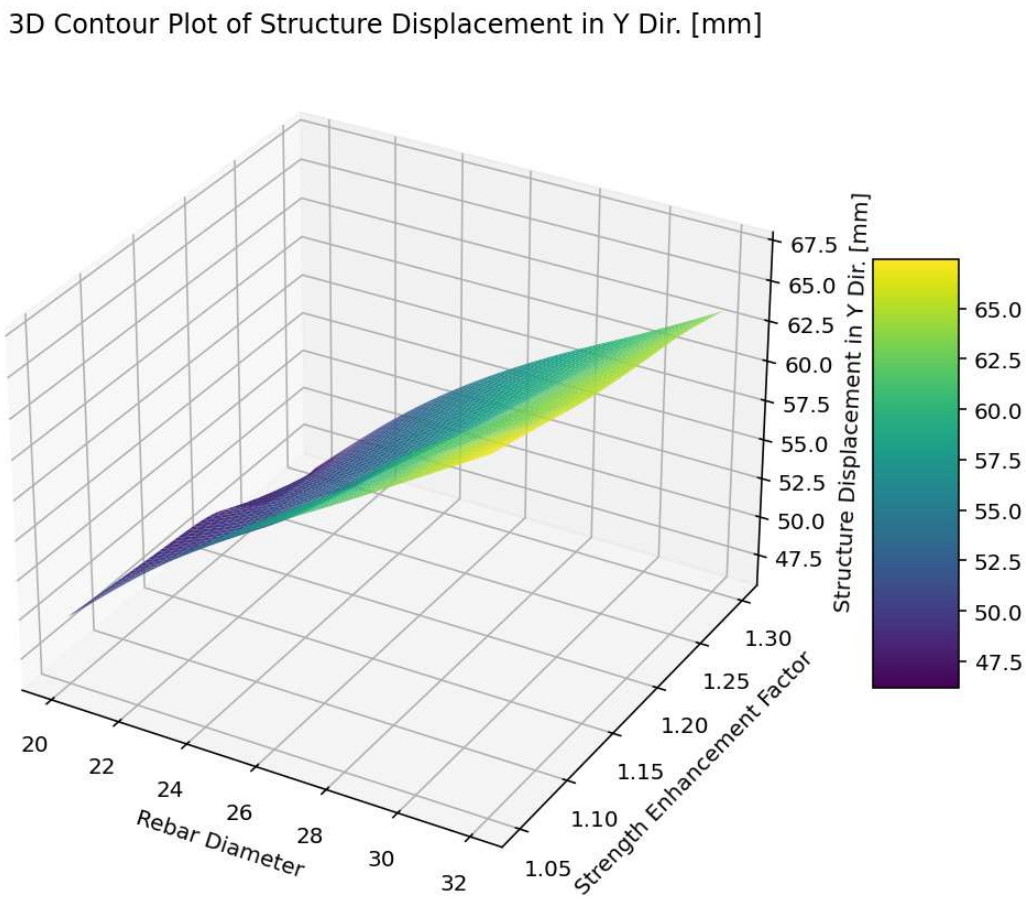

Correlation Heatmap
DIAc
Kfc
RO_COL
RO_BE
DISP_X
DISP_Y
ROTATION
AXIAL_FORCE
SHEAR_FORCE
MOMENT_WO
AXIAL_RIGIDITY
ROTATIONAL_ST
LATERAL_ST_Y
LATERAL_ST_X
R_MAX
Elastic_ST_MAX
Plastic_ST_MAX
Tangent_ST_MAX
Ductility_Rito_MAX
Over_Strength_Factor_MAX
Structural_Behavior_Coefficient_MAX
Variable
Variable
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75

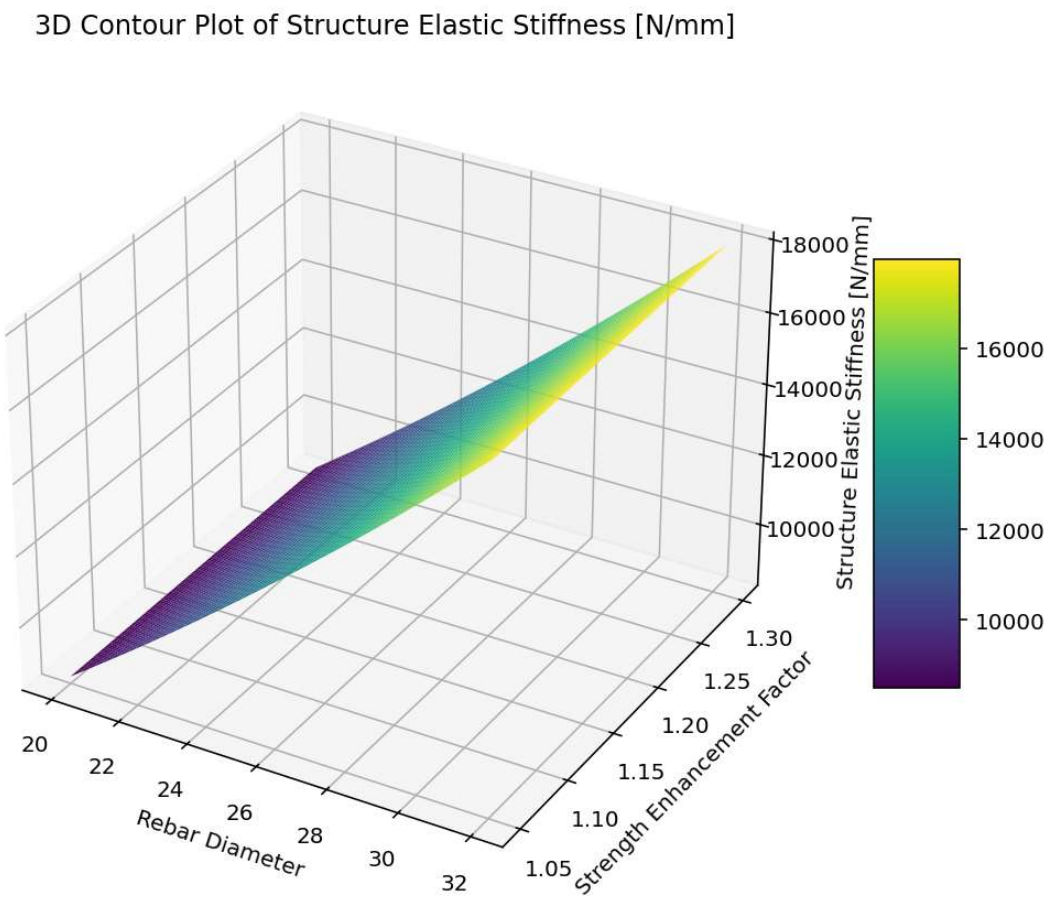

3D Contour Plot of Structure Shear Reaction in X Dir. [N]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
Structure Shear Reaction in X Dir. [N]
1e6
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25

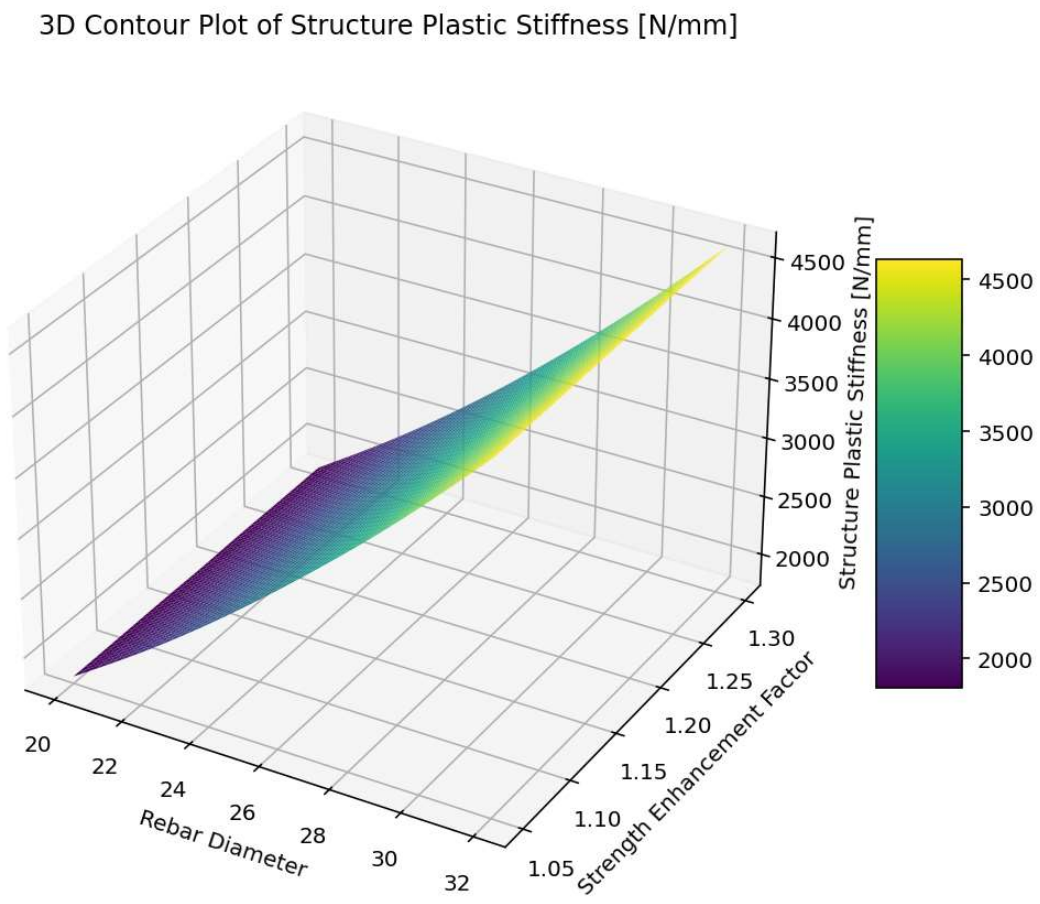

3D Contour Plot of Structure Axial Reaction in Y Dir. [N]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
Structure Axial Reaction in Y Dir. [N]
1e6
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1e6
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25

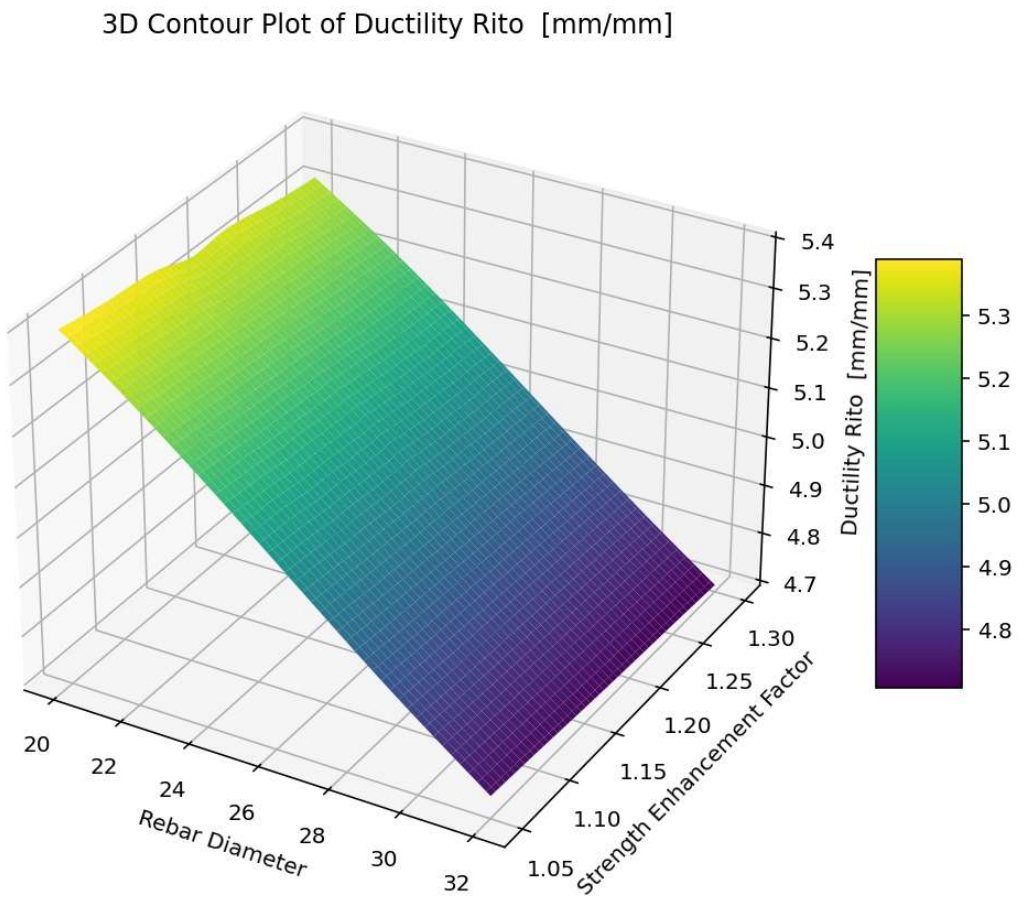

3D Contour Plot of Structure Moment Reaction in Y Dir. [N.mm]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
Structure Moment Reaction in Y Dir. [N.mm]
1e9
4
5
6
7
8

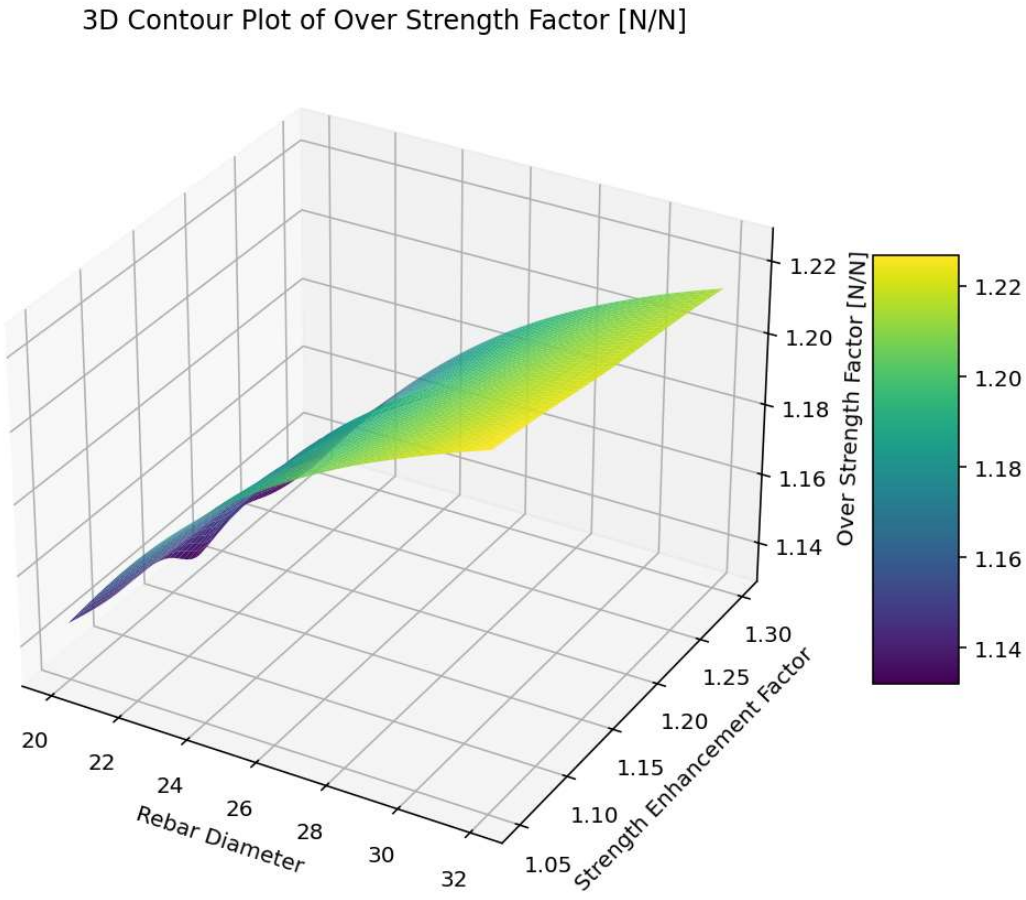

3D Contour Plot of Structure Displacement in X Dir. [mm]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
670
669
668
667
666
665
664
663
662
Structure Displacement in X Dir. [mm]
669
668
667
666
665
664
663
662

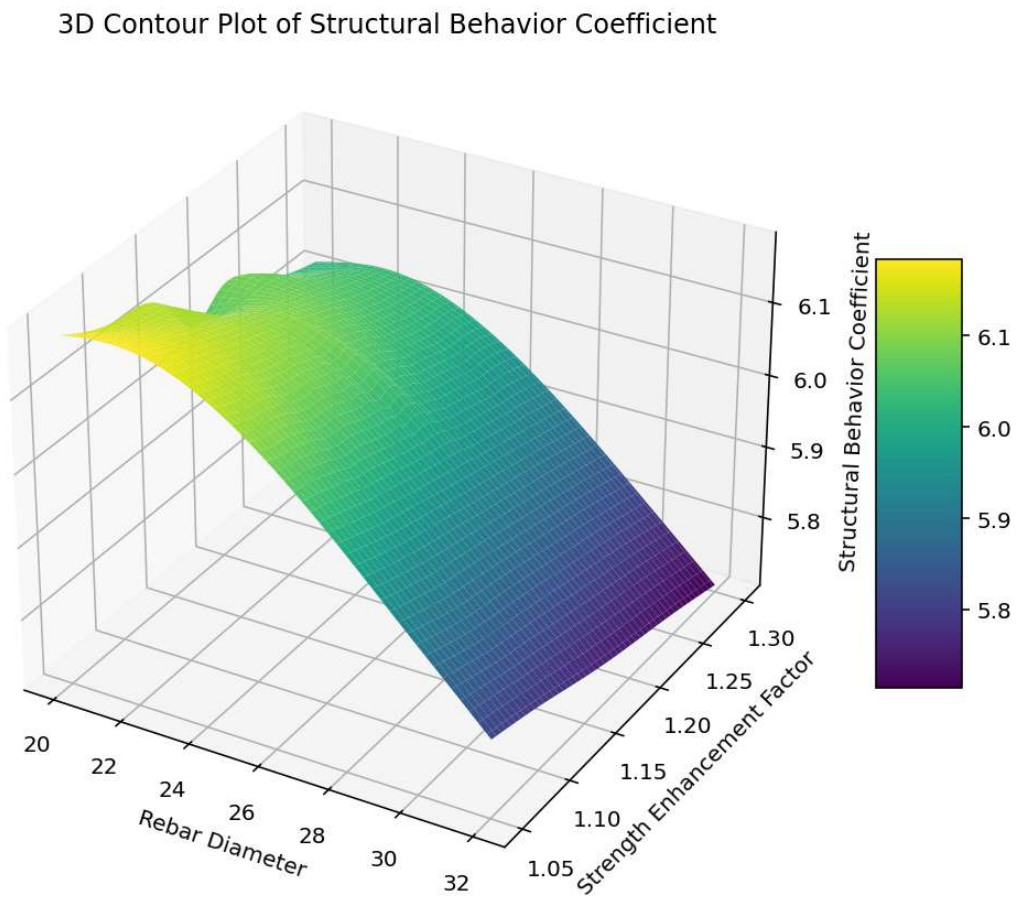

3D Contour Plot of Structure Displacement in Y Dir. [mm]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
Structure Displacement in Y Dir. [mm]
47.5
50.0
52.5
55.0
57.5
60.0
62.5
65.0
67.5

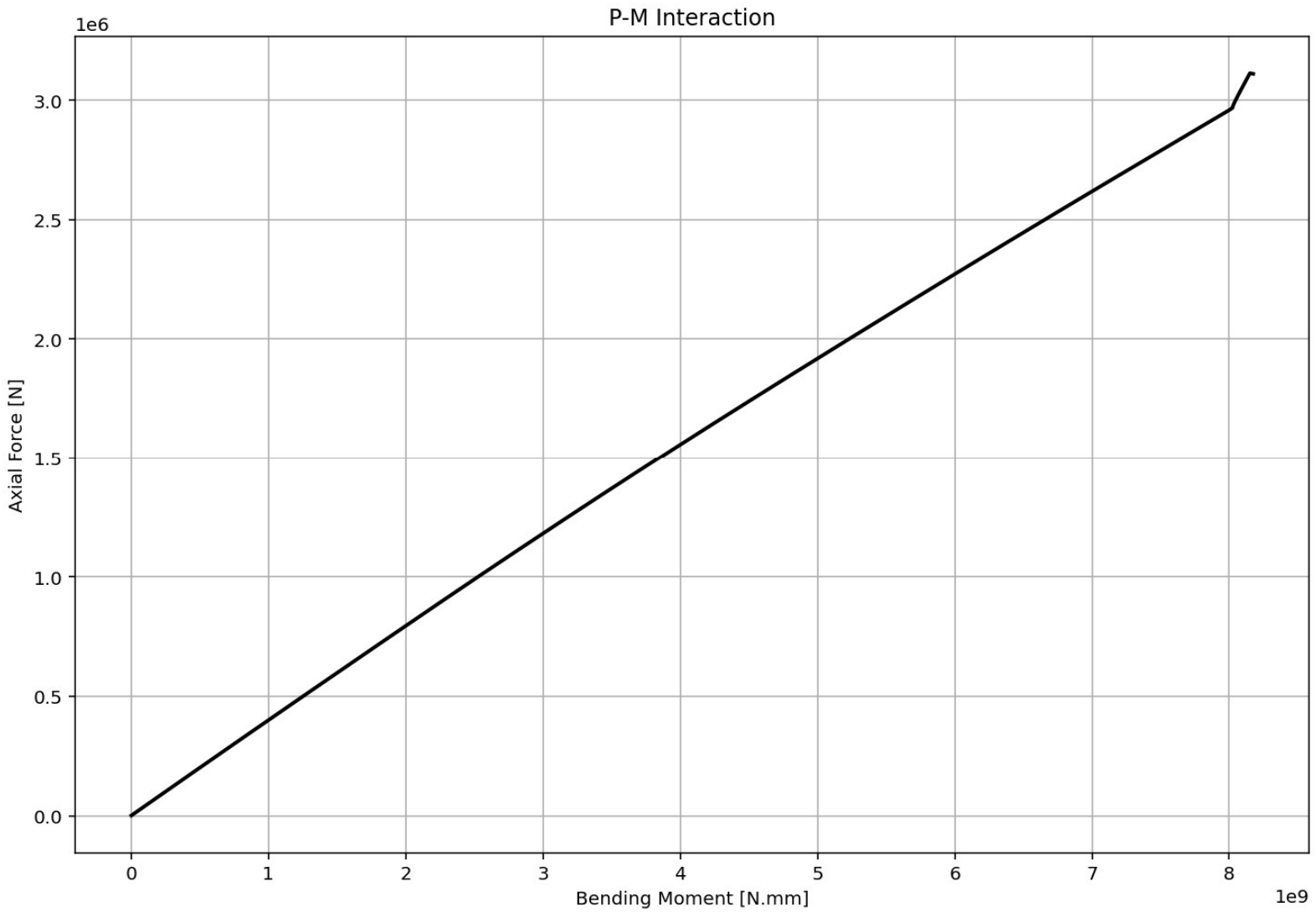

3D Contour Plot of Structure Elastic Stiffness [N/mm]
Structure Elastic Stiffness [N/mm]
18000
16000
14000
12000
10000
16000
14000
12000
10000
20
22
24
26
28
30
32
Rebar Diameter
1.30
1.25
1.20
1.15
1.10
1.05
Strength Enhancement Factor

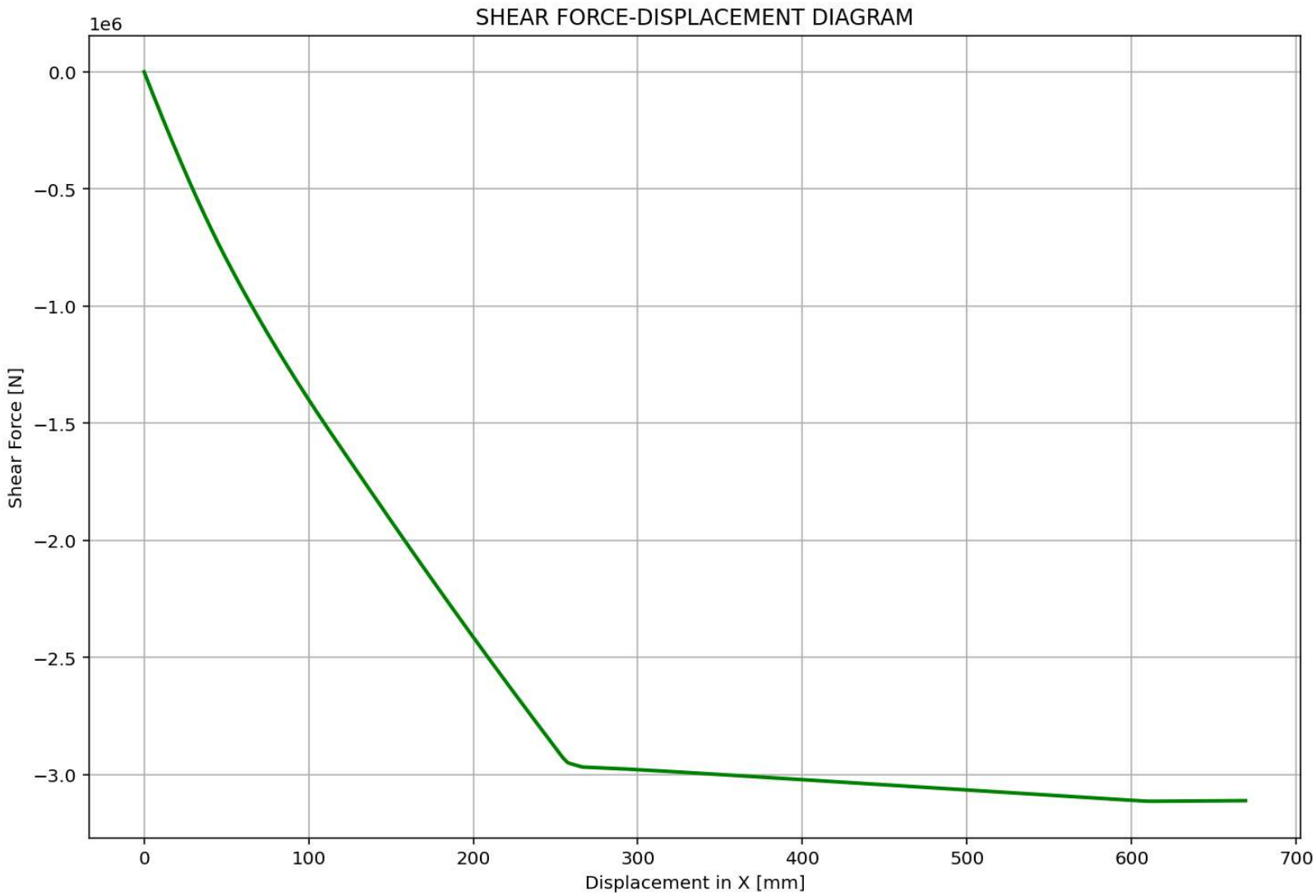

3D Contour Plot of Structure Plastic Stiffness [N/mm]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
Structure Plastic Stiffness [N/mm]
2000
2500
3000
3500
4000
4500

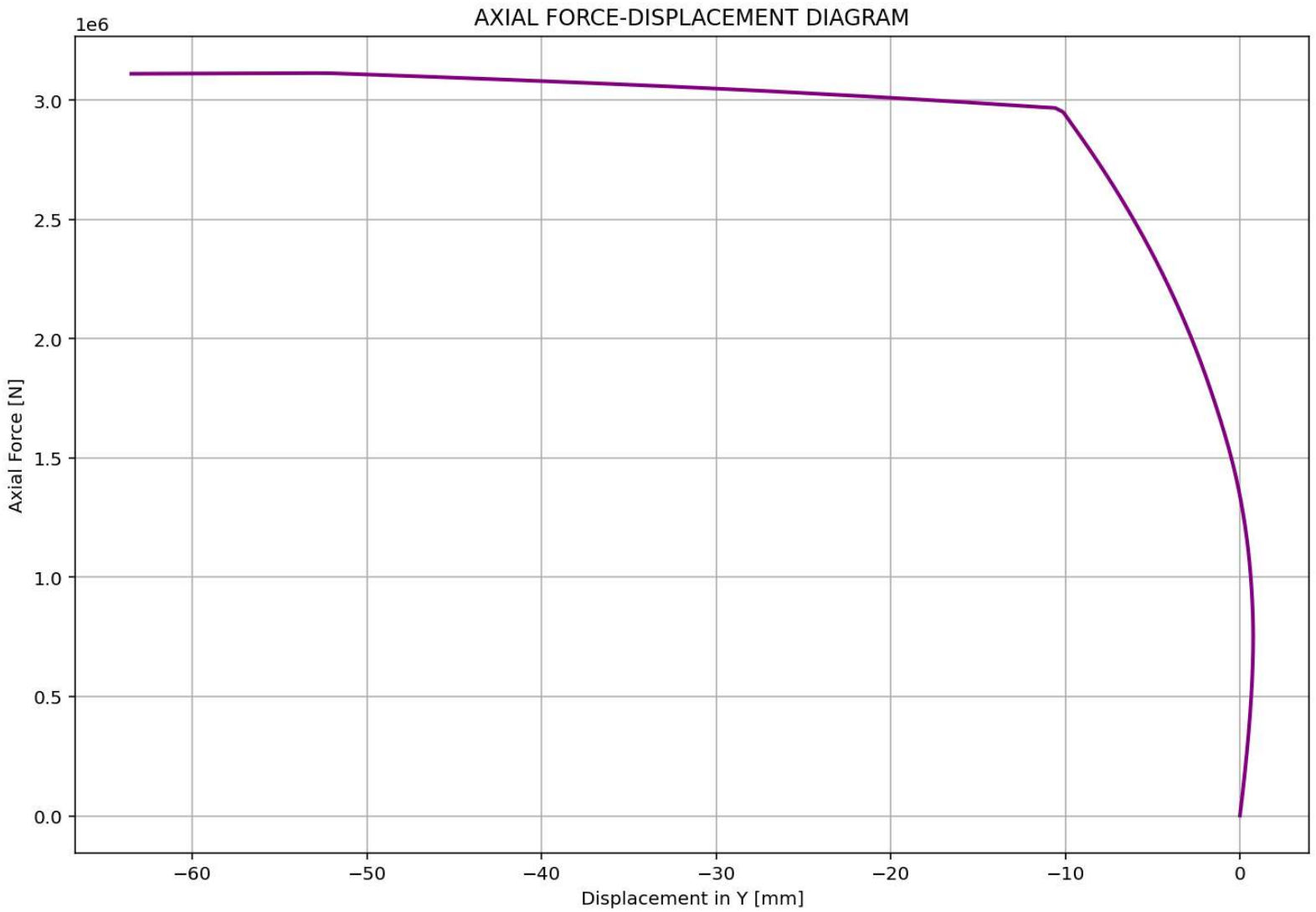

3D Contour Plot of Ductility Rito [mm/mm]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
Ductility Rito [mm/mm]
4.7
4.8
4.9
5.0
5.1
5.2
5.3
5.4

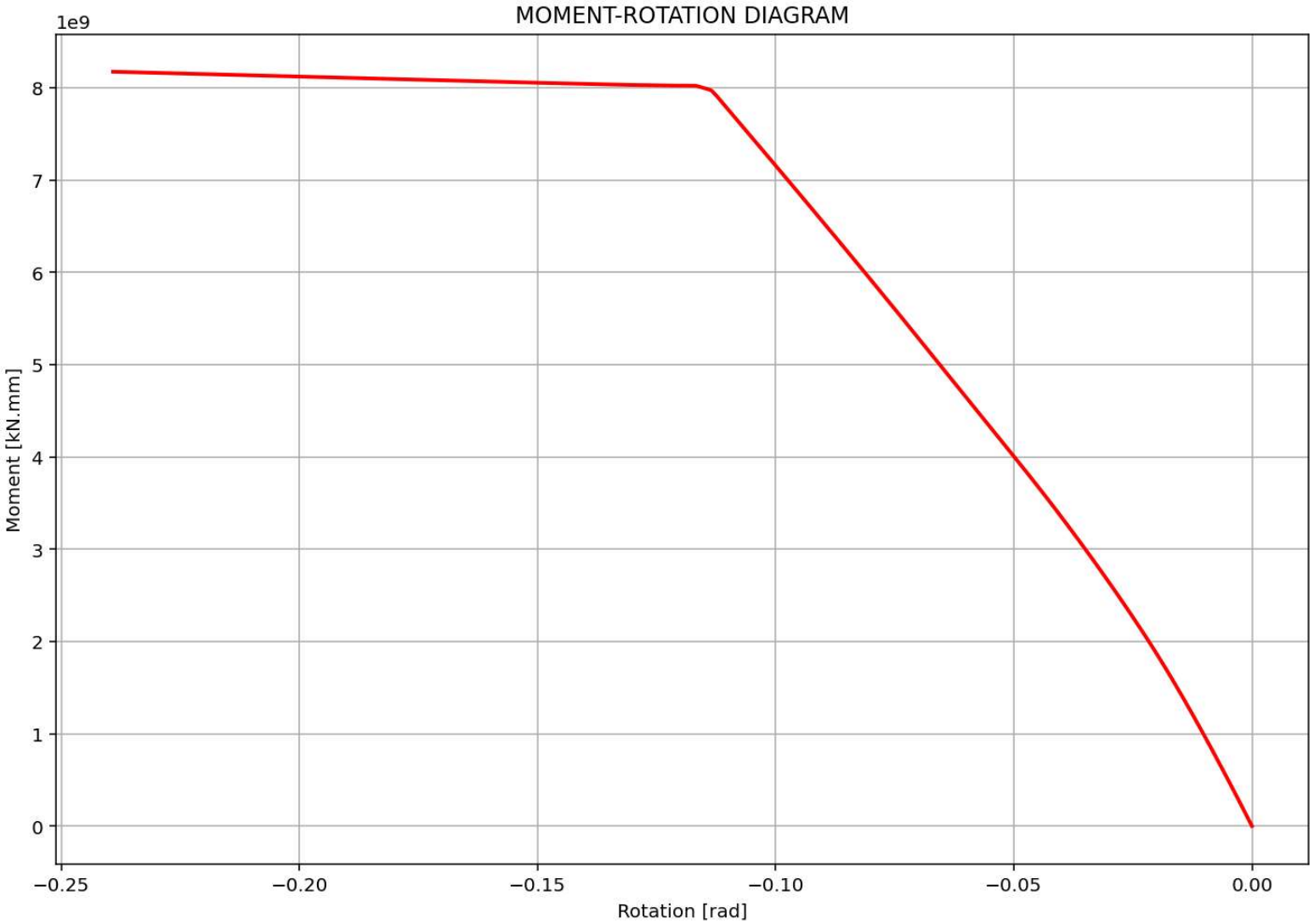

3D Contour Plot of Over Strength Factor [N/N]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
Over Strength Factor [N/N]
1.14
1.16
1.18
1.20
1.22

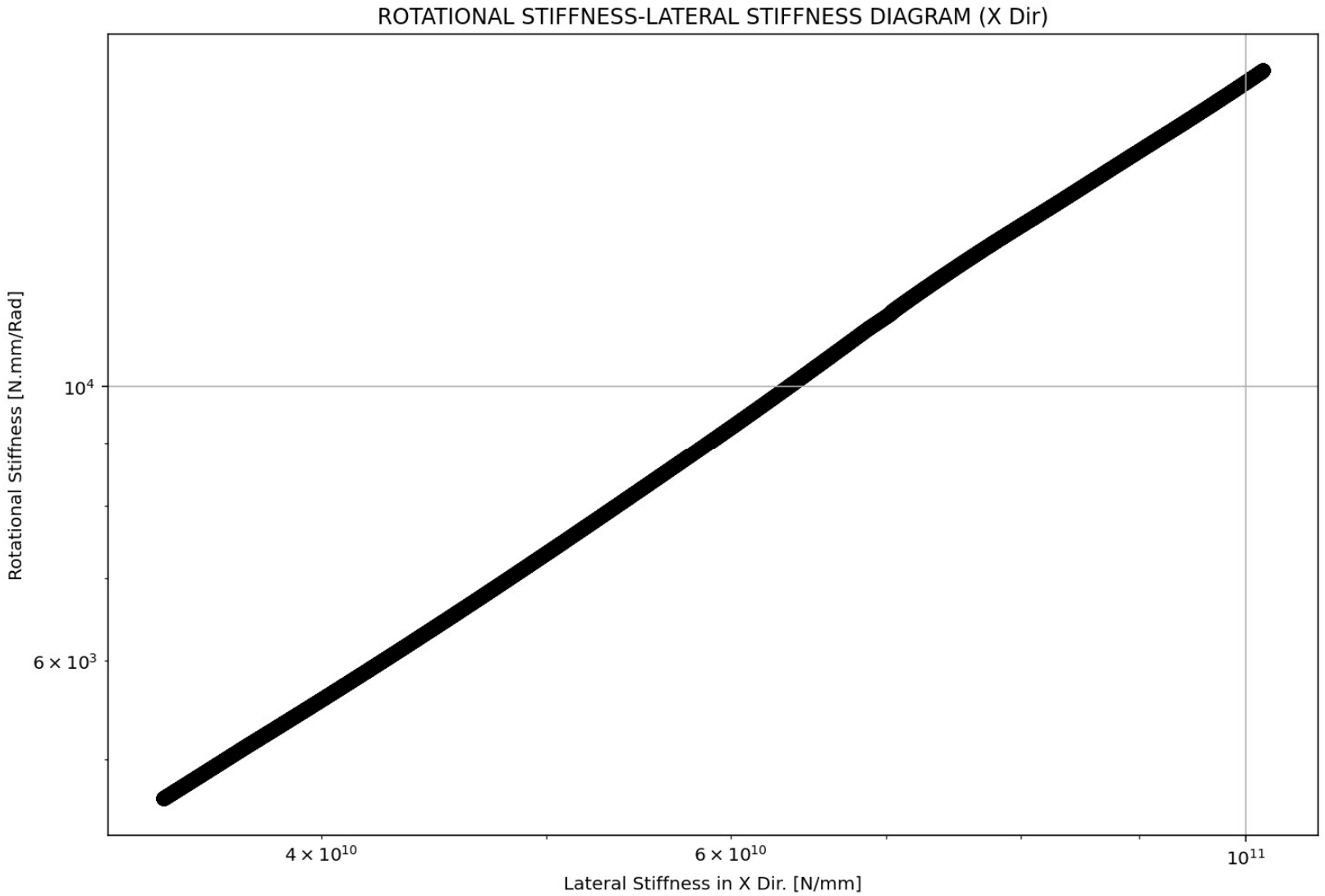

3D Contour Plot of Structural Behavior Coefficient
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.05
1.10
1.15
1.20
1.25
1.30
Structural Behavior Coefficient
5.8
5.9
6.0
6.1

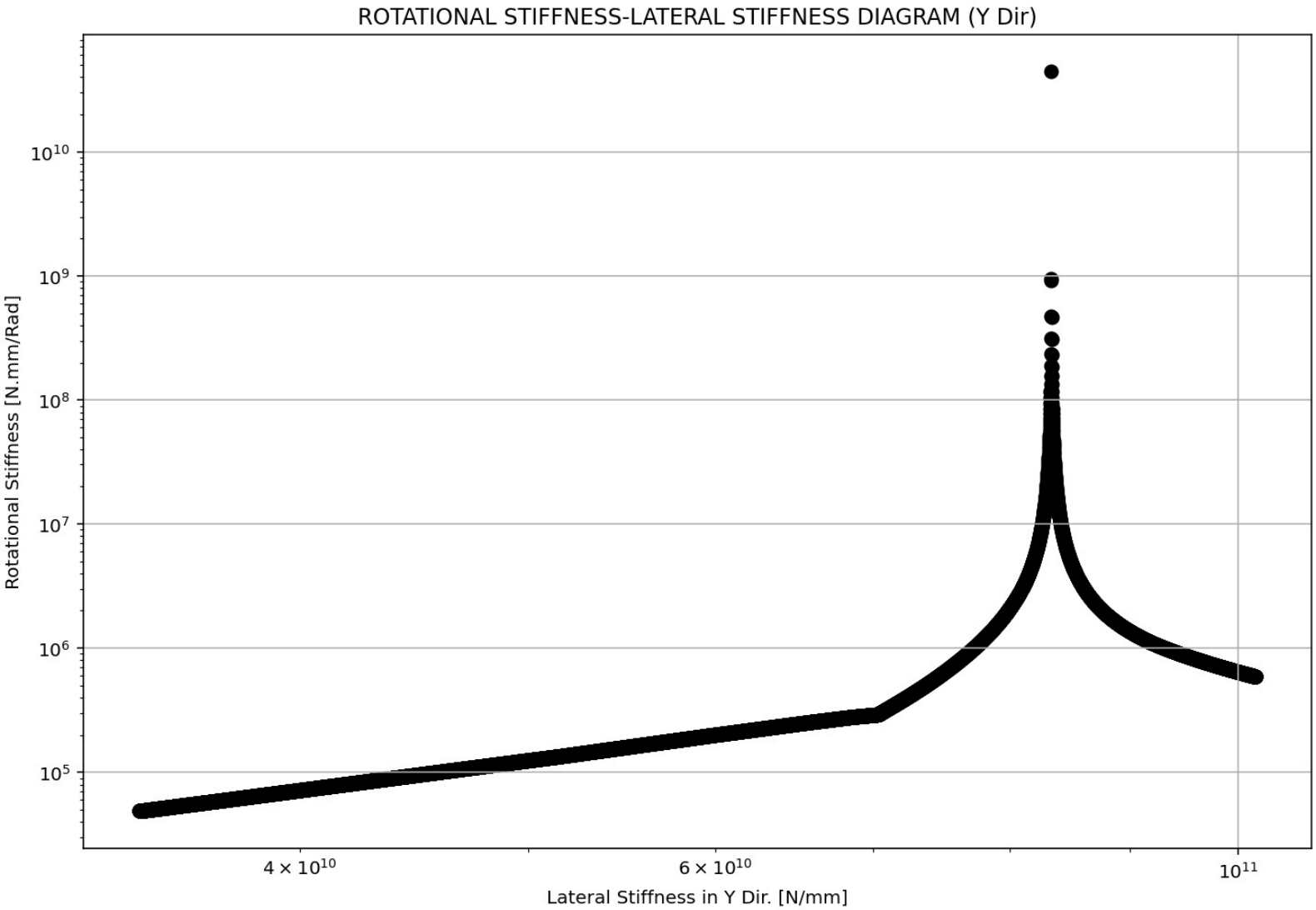

P-M Interaction
1e6
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Axial Force [N]
0
1
2
3
4
5
6
7
8
Bending Moment [N.mm]
1e9

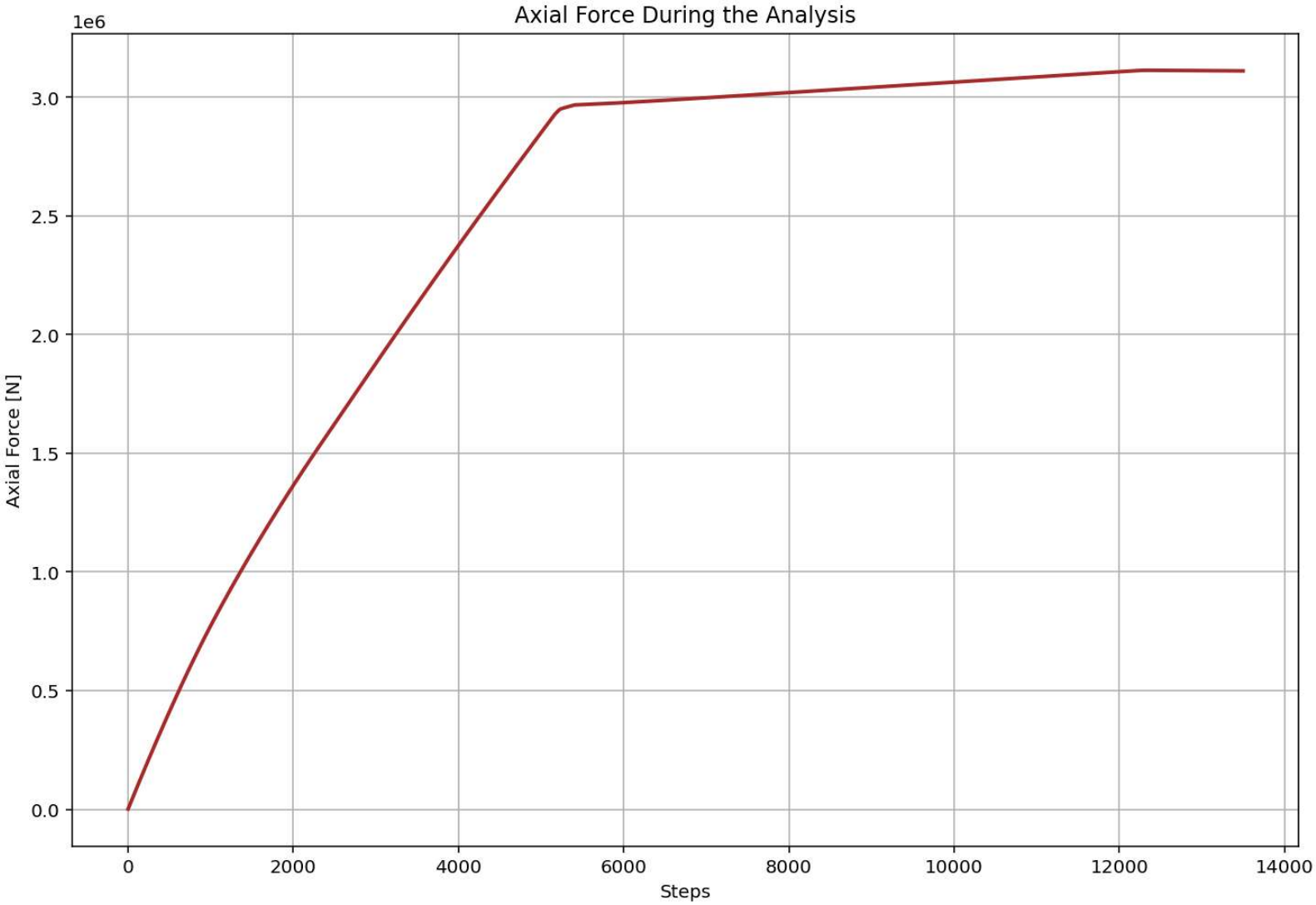

SHEAR FORCE-DISPLACEMENT DIAGRAM
1e6
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
Shear Force [N]
0
100
200
300
400
500
600
700
Displacement in X [mm]

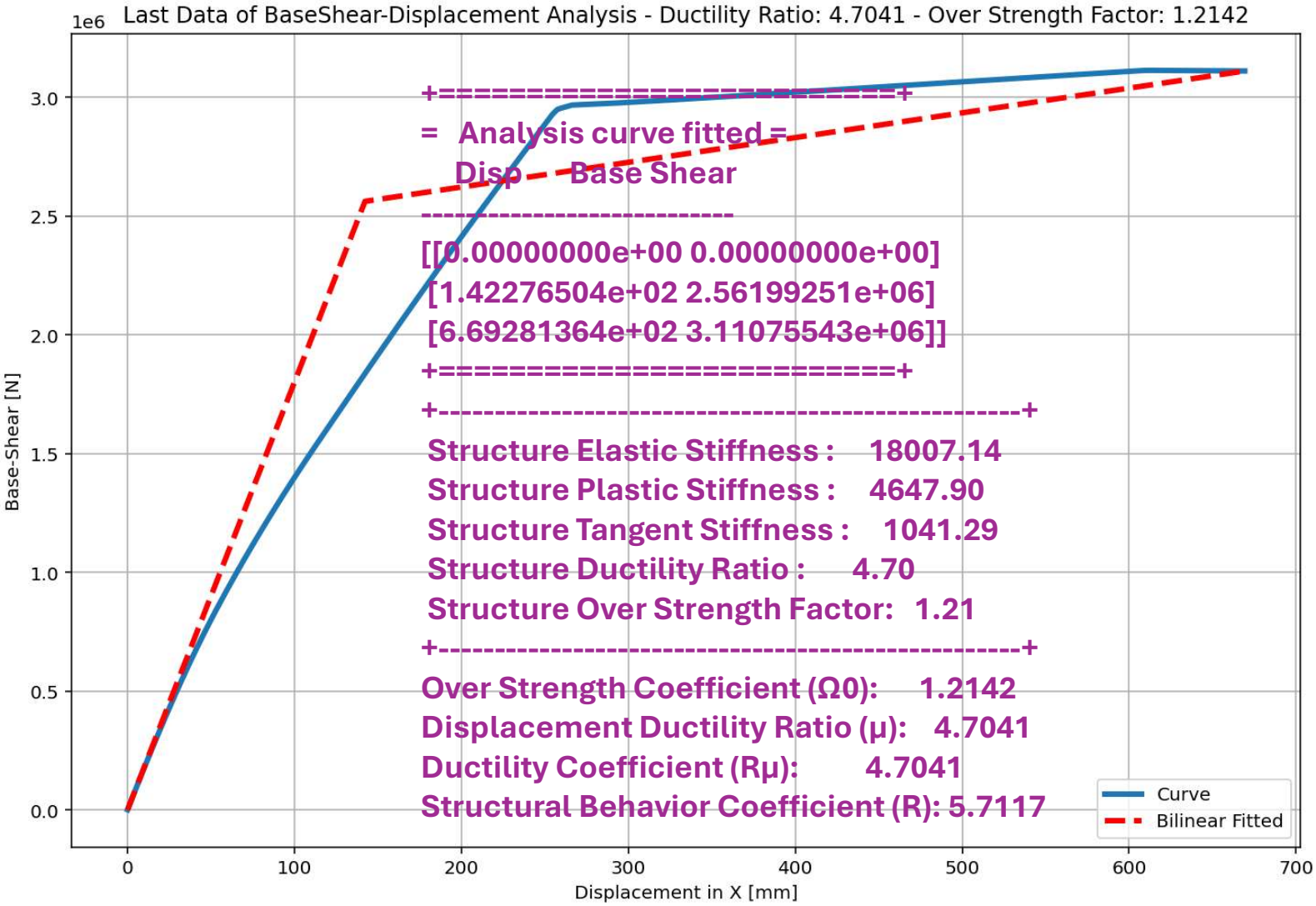

AXIAL FORCE-DISPLACEMENT DIAGRAM
1e6
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Axial Force [N]
−60
−50
−40
−30
−20
−10
0
Displacement in Y [mm]

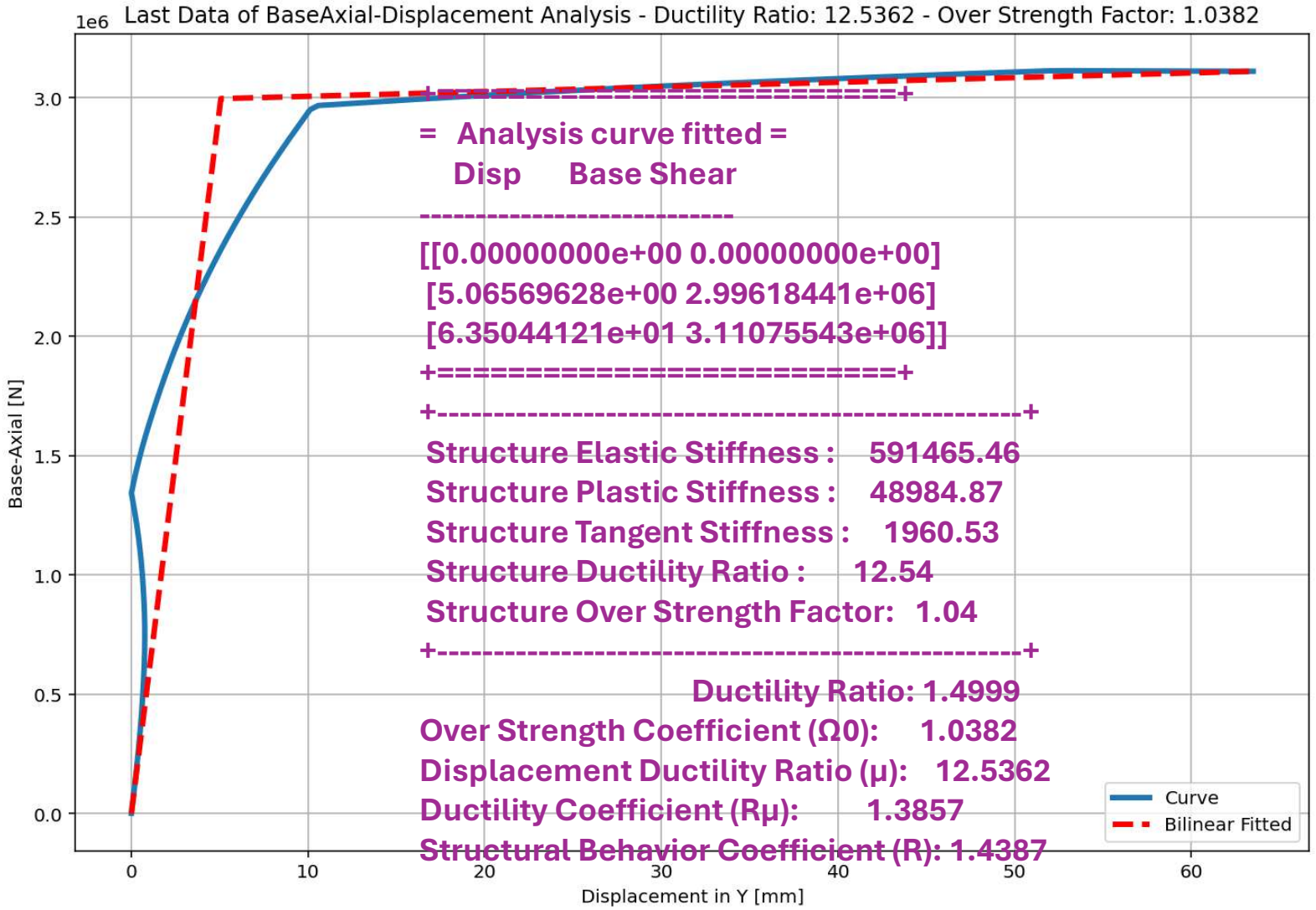

MOMENT-ROTATION DIAGRAM
1e9
8
7
6
5
4
3
2
1
0
Moment [kN.mm]
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
Rotation [rad]


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM (X Dir)
Rotational Stiffness [N.mm/Rad]
10^4
6×10^3
4×10^{10}
6×10^{10}
10^{11}
Lateral Stiffness in X Dir. [N/mm]


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM (Y Dir)
Rotational Stiffness [N.mm/Rad]
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
4×10^{10}
6×10^{10}
10^{11}
Lateral Stiffness in Y Dir. [N/mm]


Axial Force During the Analysis
1e6
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Axial Force [N]
0
2000
4000
6000
8000
10000
12000
14000
Steps


Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 4.7041 - Over Strength Factor: 1.2142
1e6
Base-Shear [N]
Displacement in X [mm]
+==========+
= Analysis curve fitted =
Disp Base Shear
[[0.00000000e+00 0.00000000e+00]
[1.42276504e+02 2.56199251e+06]
[6.69281364e+02 3.11075543e+06]]
Structure Elastic Stiffness : 18007.14
Structure Plastic Stiffness : 4647.90
Structure Tangent Stiffness : 1041.29
Structure Ductility Ratio : 4.70
Structure Over Strength Factor: 1.21
Over Strength Coefficient (Ω0): 1.2142
Displacement Ductility Ratio (μ): 4.7041
Ductility Coefficient (Rμ): 4.7041
Structural Behavior Coefficient (R): 5.7117
Curve
Bilinear Fitted


Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 12.5362 - Over Strength Factor: 1.0382
1e6
Base-Axial [N]
Displacement in Y [mm]
+==========================+
= Analysis curve fitted =
Disp Base Shear

[[0.00000000e+00 0.00000000e+00]
[5.06569628e+00 2.99618441e+06]
[6.35044121e+01 3.11075543e+06]]
+==========================+
+----------+
Structure Elastic Stiffness : 591465.46
Structure Plastic Stiffness : 48984.87
Structure Tangent Stiffness : 1960.53
Structure Ductility Ratio : 12.54
Structure Over Strength Factor: 1.04
+----------+
Ductility Ratio: 1.4999
Over Strength Coefficient (Ω0): 1.0382
Displacement Ductility Ratio (μ): 12.5362
Ductility Coefficient (Rμ): 1.3857
Structural Behavior Coefficient (R): 1.4387
Curve
Bilinear Fitted