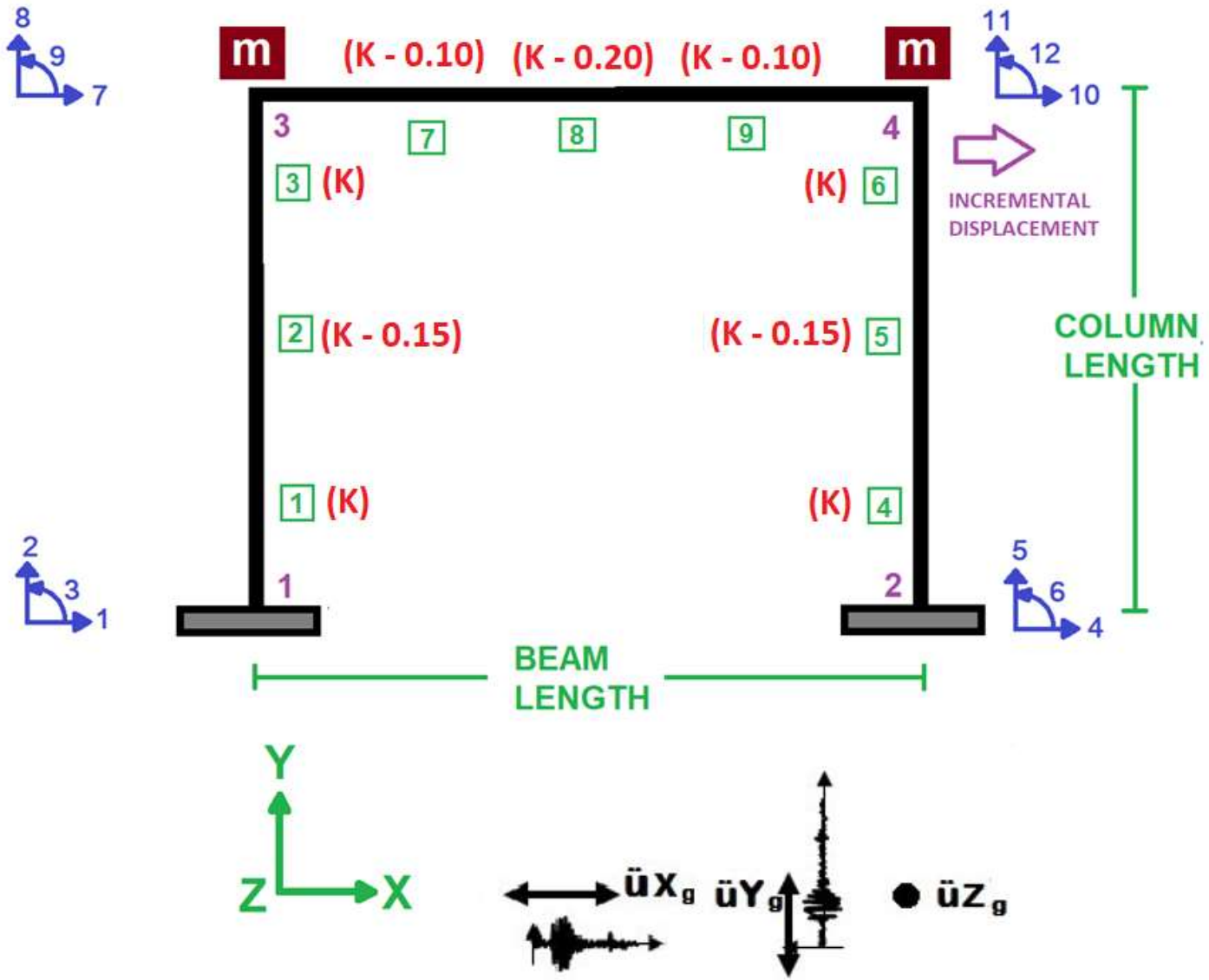
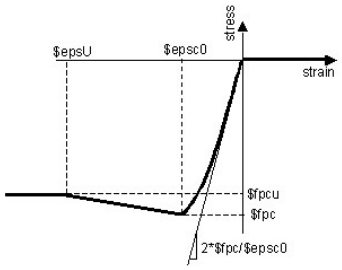
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

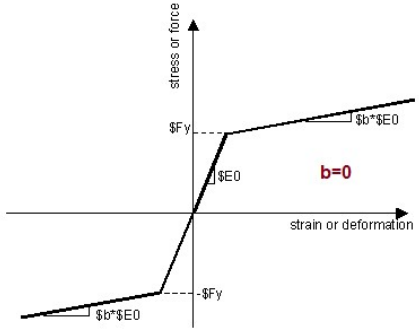
SENSITIVITY ANALYSIS OF CONCRETE FRAME BY CHANGING COLUMN REBAR DIAMETER AND CONFINEMENT ENHANCEMENT RATIO. USING OPENSEES FOR STRUCTURAL BEHAVIOR COEFFICIENT CALCULATION

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

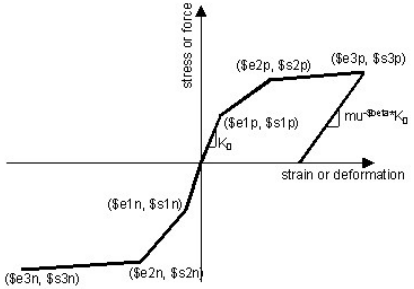

8
9
7
m
(K - 0.10)
(K - 0.20)
(K - 0.10)
m
11
12
10
3
7
8
9
4
3 (K)
(K) 6
INCREMENTAL DISPLACEMENT
2 (K - 0.15)
(K - 0.15) 5
COLUMN LENGTH
1 (K)
(K) 4
2
3
1
1
2
5
6
4
BEAM LENGTH
Y
Z
X
üXg
üYg
üZg



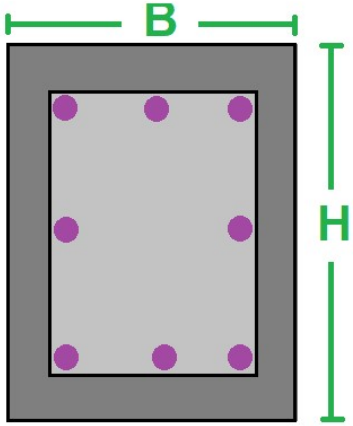
CORE AND COVER CONCRETE RELATION



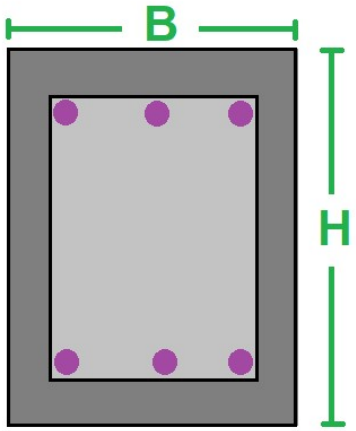
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

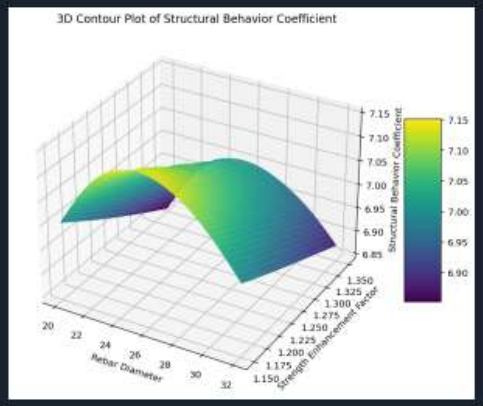
Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...SITIVITY_CONFINEMENT_ENHANCEMENT_RATIO_&_REBAR.py

SENSITIVITY_CONFIN...T_RATIO__REBAR.py

```
##########################################################################################
#                        >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#  SENSITIVITY ANALYSIS OF CONCRETE FRAME BY CHANGING COLUMN REBAR DIAMETER AND CONFINEMENT ENHANCEM
#                     USING OPENSEES FOR STRUCTURAL BEHAVIOR COEFFICIENT CALCULATION
#------------------------------------------------------------------------------------------
#                           THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                    EMAIL: salar.d.ghashghaei@gmail.com
##########################################################################################
"""
1. Objective: The code performs a sensitivity analysis on a 2D reinforced concrete frame by varying
 diameter and confinement enhancement ratios to evaluate structural behavior coefficients using Open

2. Model Setup: A nonlinear 2D frame model is created with columns, beams, and distributed plasticit
 incorporating geometric transformations (Corotational) for large displacements.

3. Material Modeling: Confined and unconfined concrete behaviors are modeled using modified Kent-Sco
 formulations, while steel reinforcement follows bilinear or hardening models.

4. Analysis Types: Both pushover (static) and dynamic analyses are supported, with Rayleigh damping

5. Key Outputs: The code extracts base shear, displacement, stiffness, ductility ratios, overstrengt
 factors, and structural behavior coefficients (R).

6. Sensitivity Parameters: Rebar diameters (20-32 mm) and confinement enhancement ratios (1.15-1.35)
 are systematically varied to assess their impact on performance.

7. Bilinear Fitting: Pushover curves are post-processed to derive elastic/plastic stiffness, ductili
 and R factors using a bilinear approximation algorithm.

8. Visualization: 3D contour plots and 2D graphs illustrate relationships between rebar, confinement
 and structural responses (e.g., stiffness, R-factors).

9. Validation: Eigenvalue analysis ensures realistic dynamic properties (periods/damping), while
 convergence checks enhance numerical robustness.
```



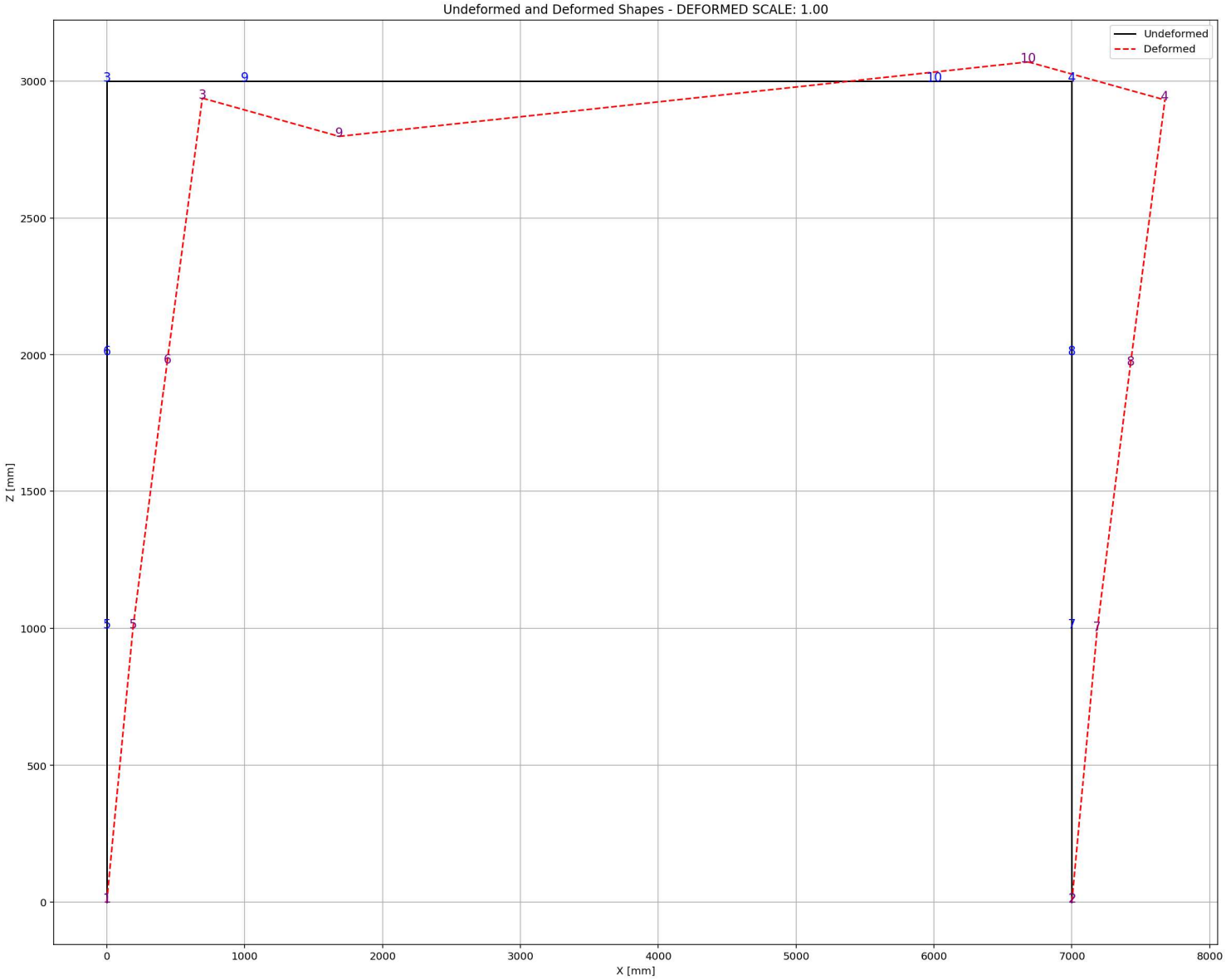
Help Variable Explorer Debugger Plots Files

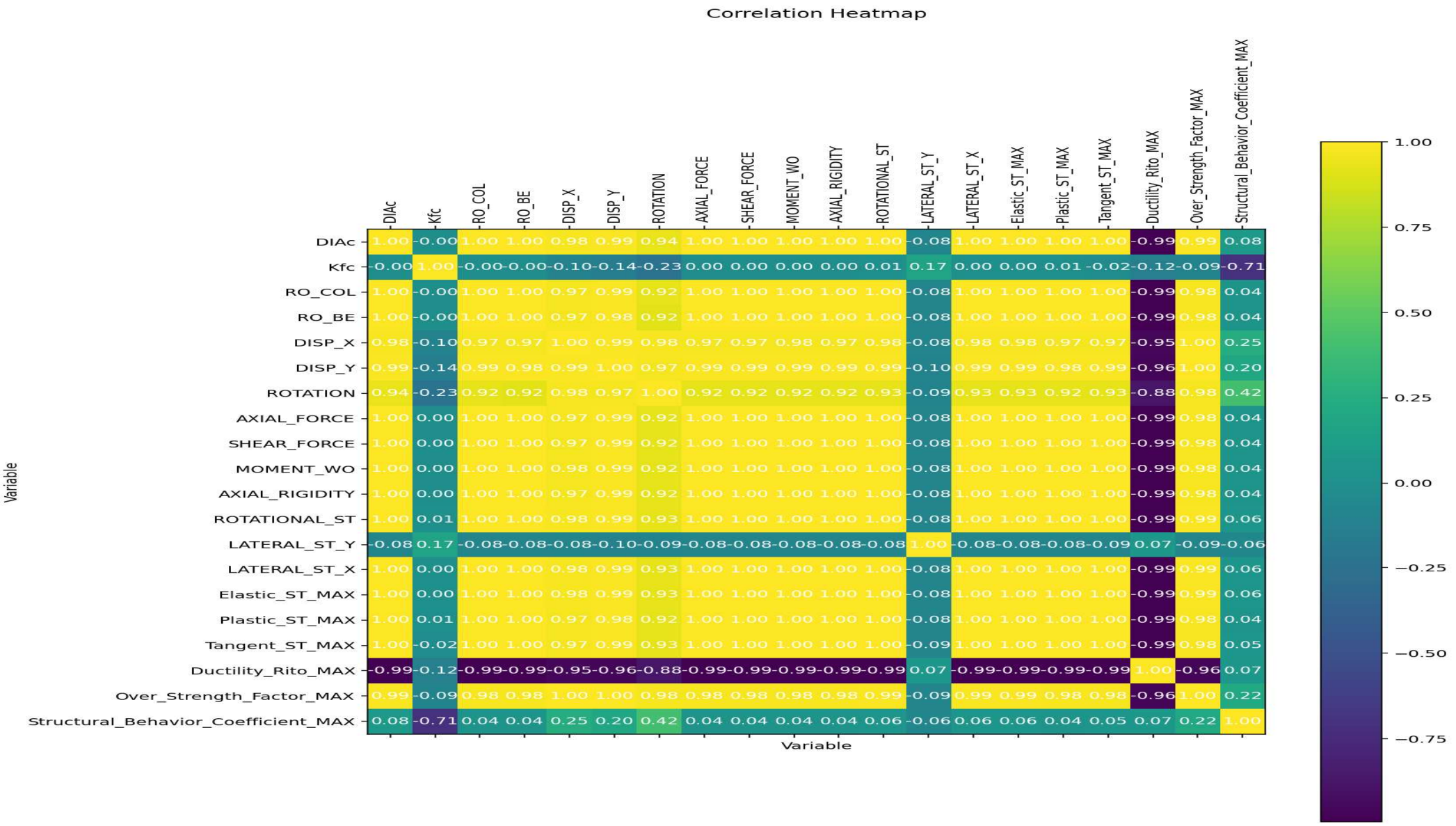
Console 1/A

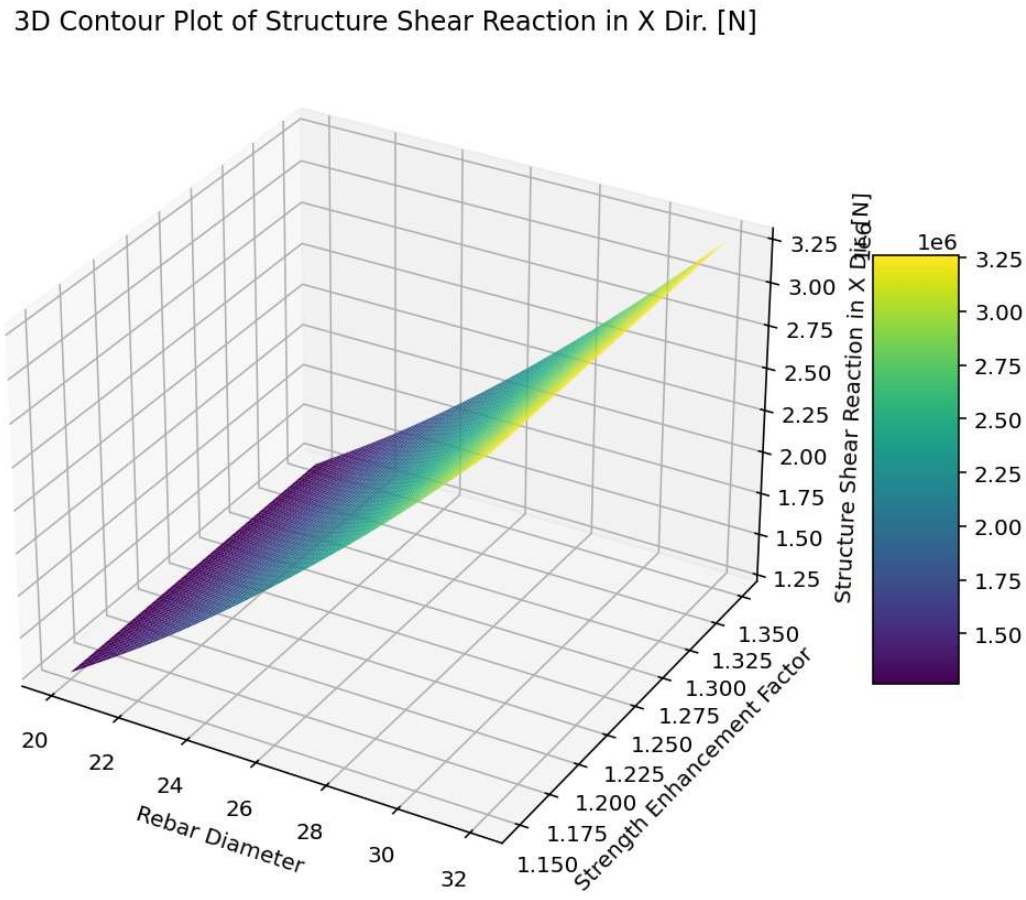
```
them also appear inline in the console, you need to uncheck
"Mute inline plotting" under the options menu of Plots.

+==========================+
=   Analysis curve fitted =
     Disp         Base Shear
----------------------------
[[0.00000000e+00 0.00000000e+00]
 [1.25736042e+02 2.61065850e+06]
 [6.93434250e+02 3.25359115e+06]]
+--------------------------+
```

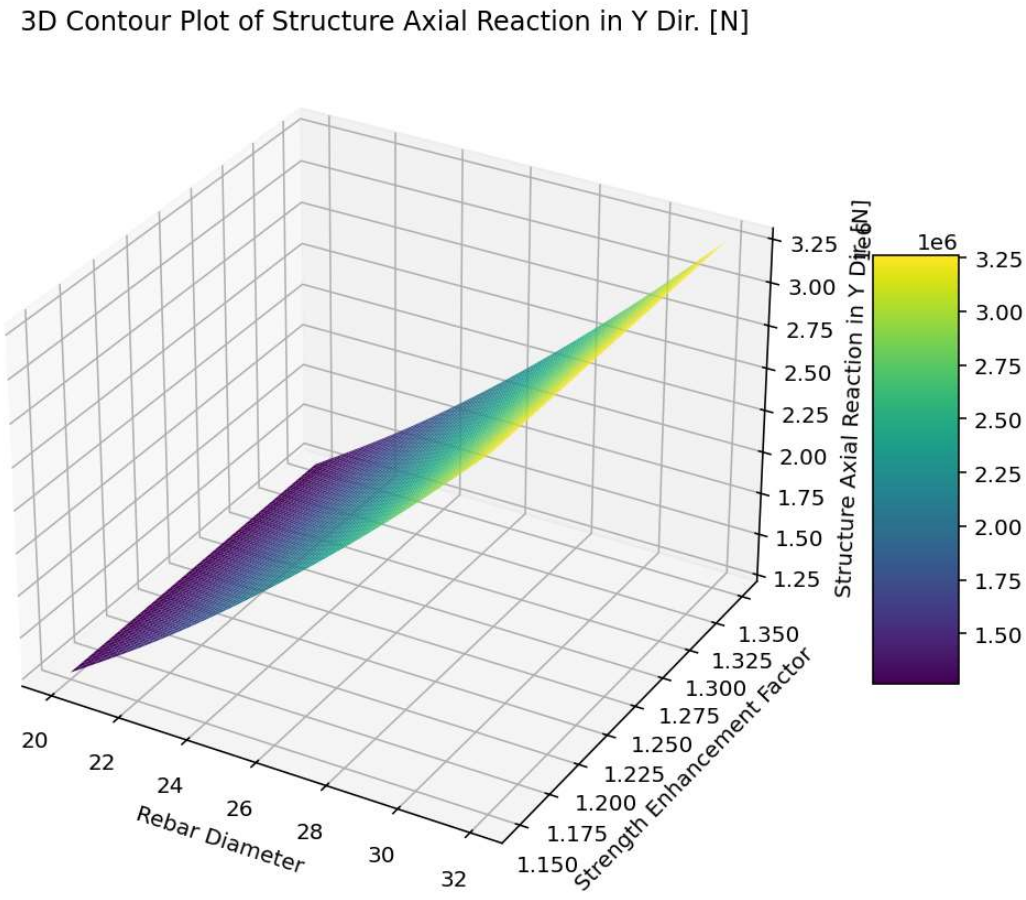
IPython Console History

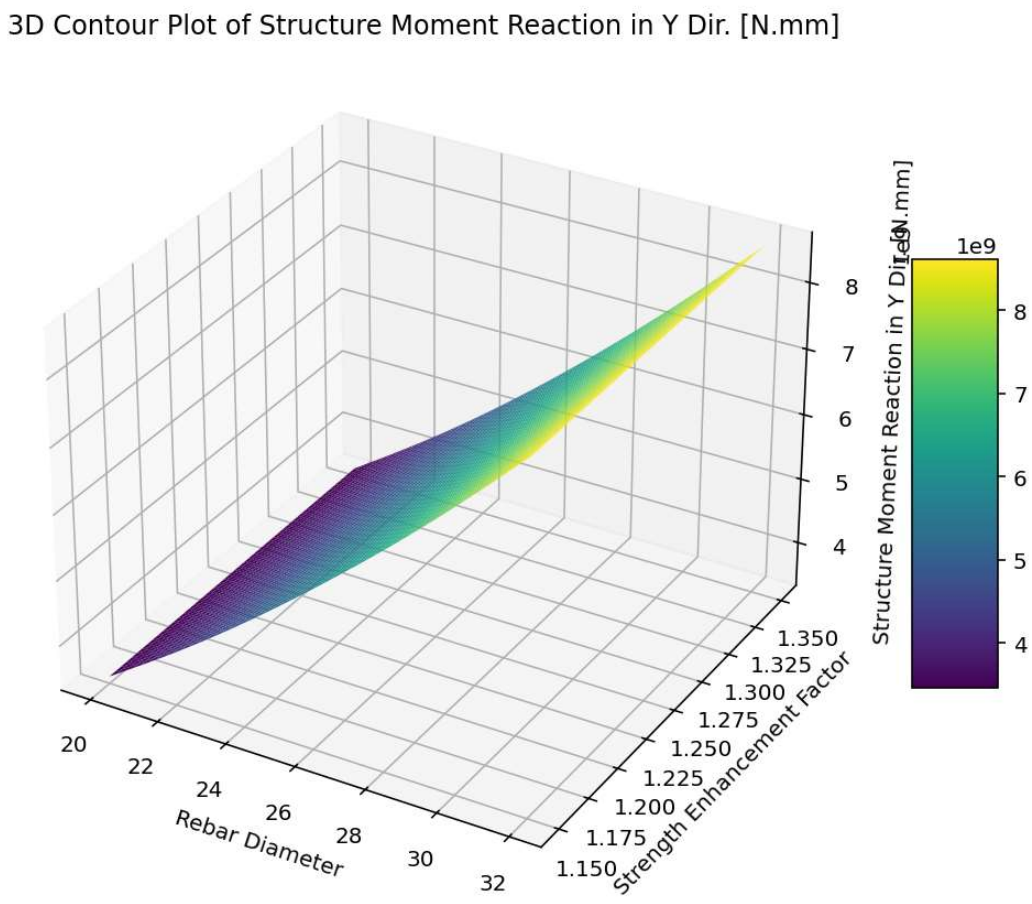
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 680, Col 2 UTF-8 CRLF RW Mem 38%

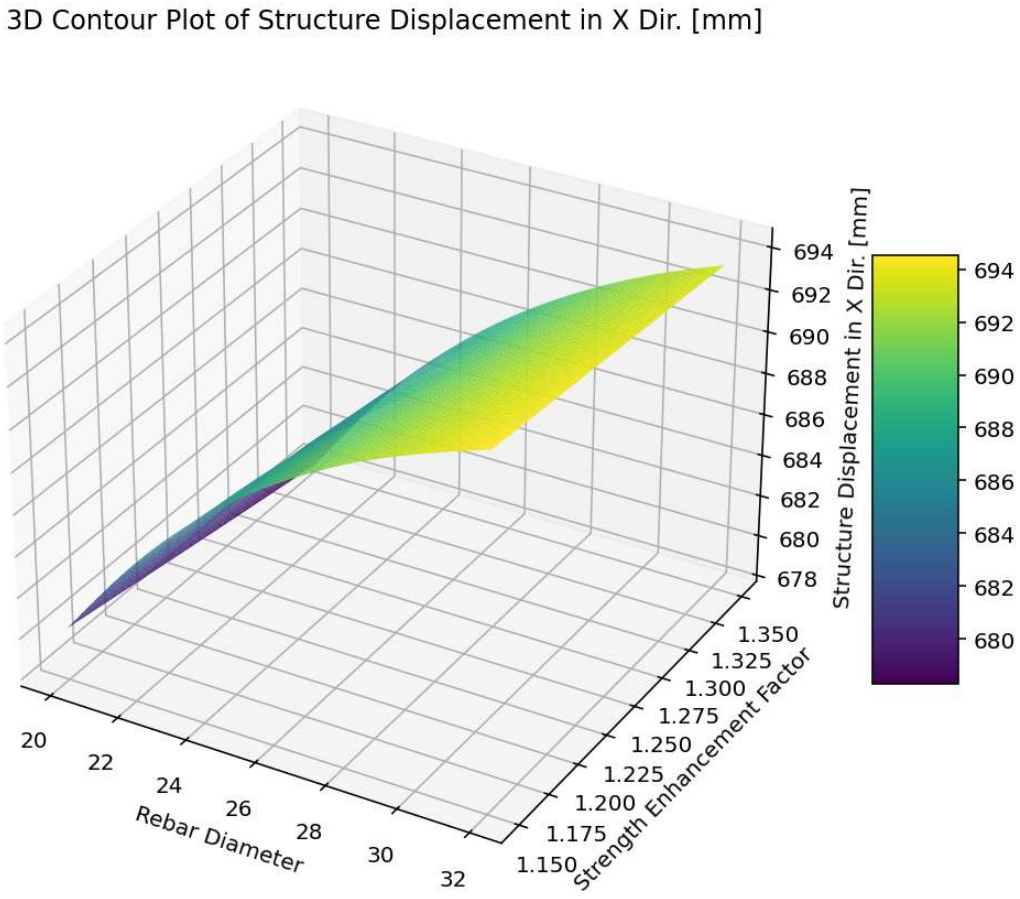

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000
8000


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
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

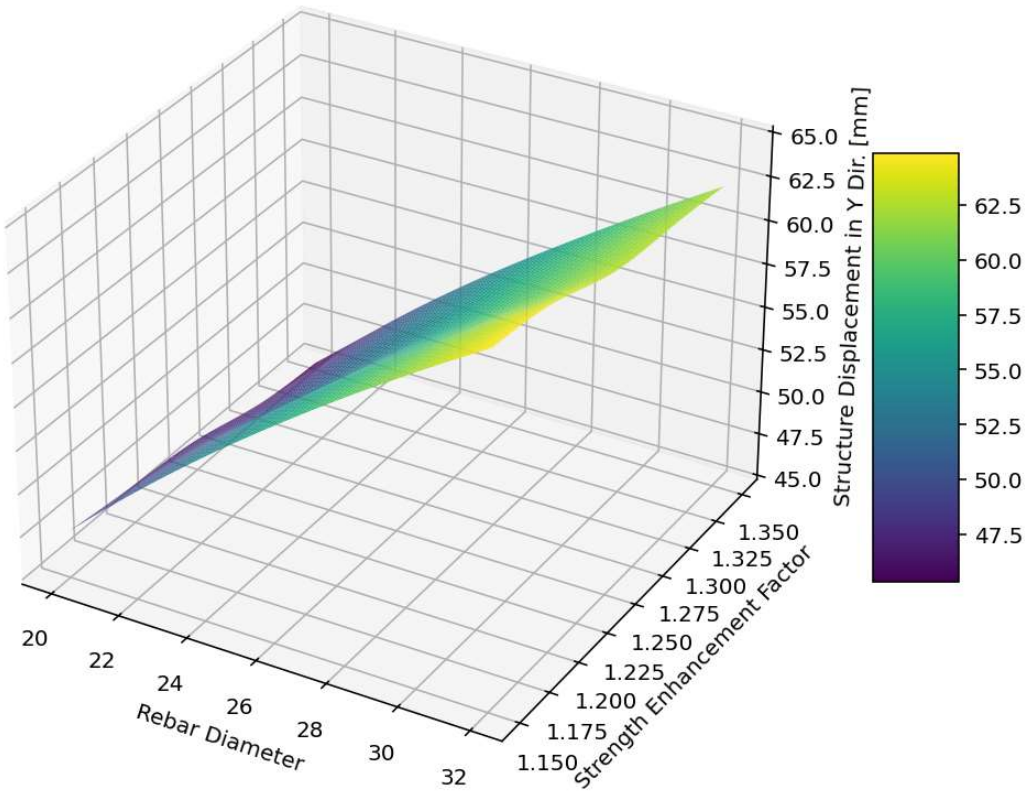

3D Contour Plot of Structure Shear Reaction in X Dir. [N]
Structure Shear Reaction in X Dir. [N]
1e6
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.350
1.325
1.300
1.275
1.250
1.225
1.200
1.175
1.150

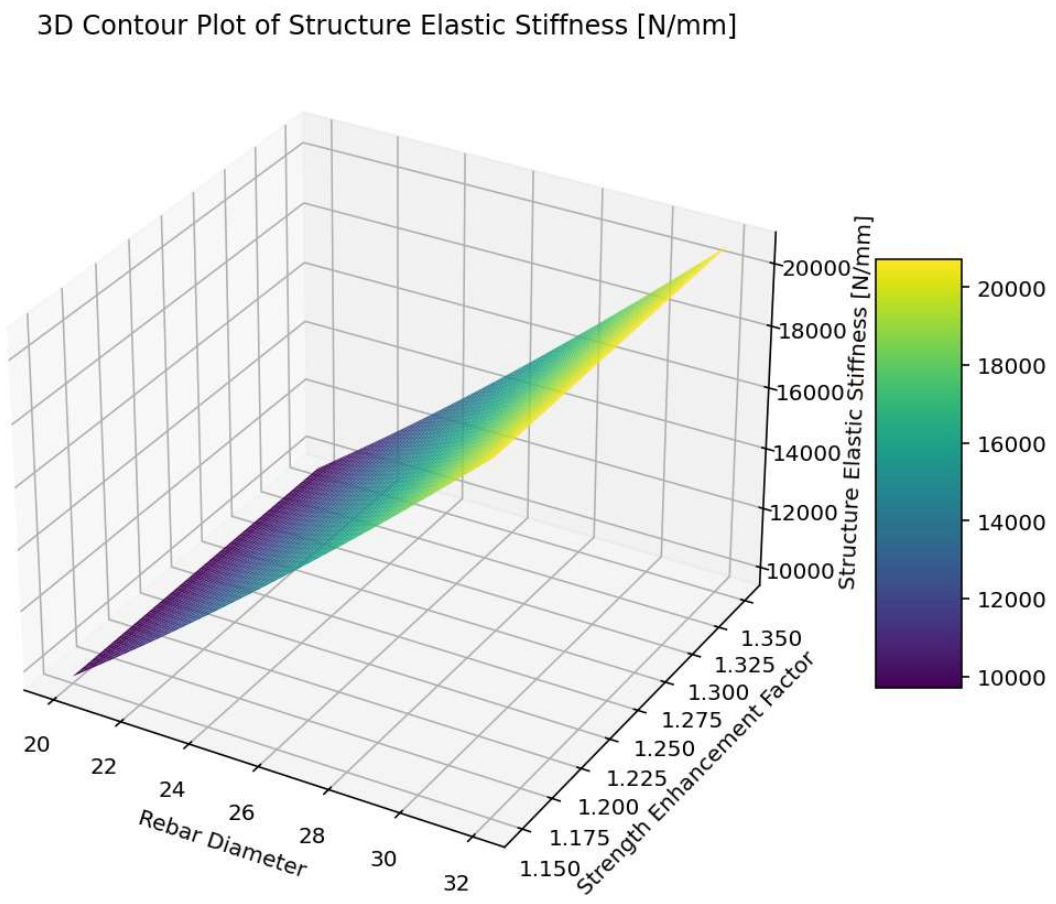

3D Contour Plot of Structure Axial Reaction in Y Dir. [N]
Structure Axial Reaction in Y Dir. [N]
1e6
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.350
1.325
1.300
1.275
1.250
1.225
1.200
1.175
1.150

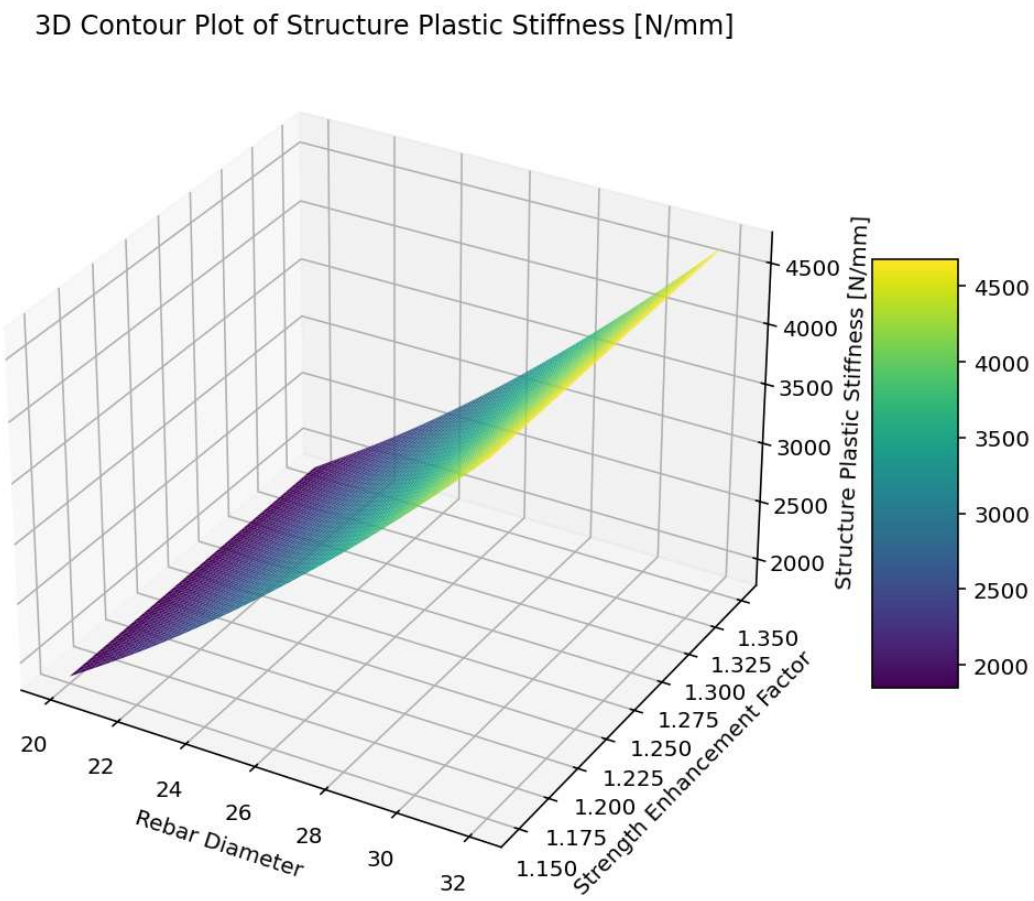

3D Contour Plot of Structure Moment Reaction in Y Dir. [N.mm]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.150
1.175
1.200
1.225
1.250
1.275
1.300
1.325
1.350
1e9
4
5
6
7
8
Structure Moment Reaction in Y Dir. [N.mm]
1e9
4
5
6
7
8

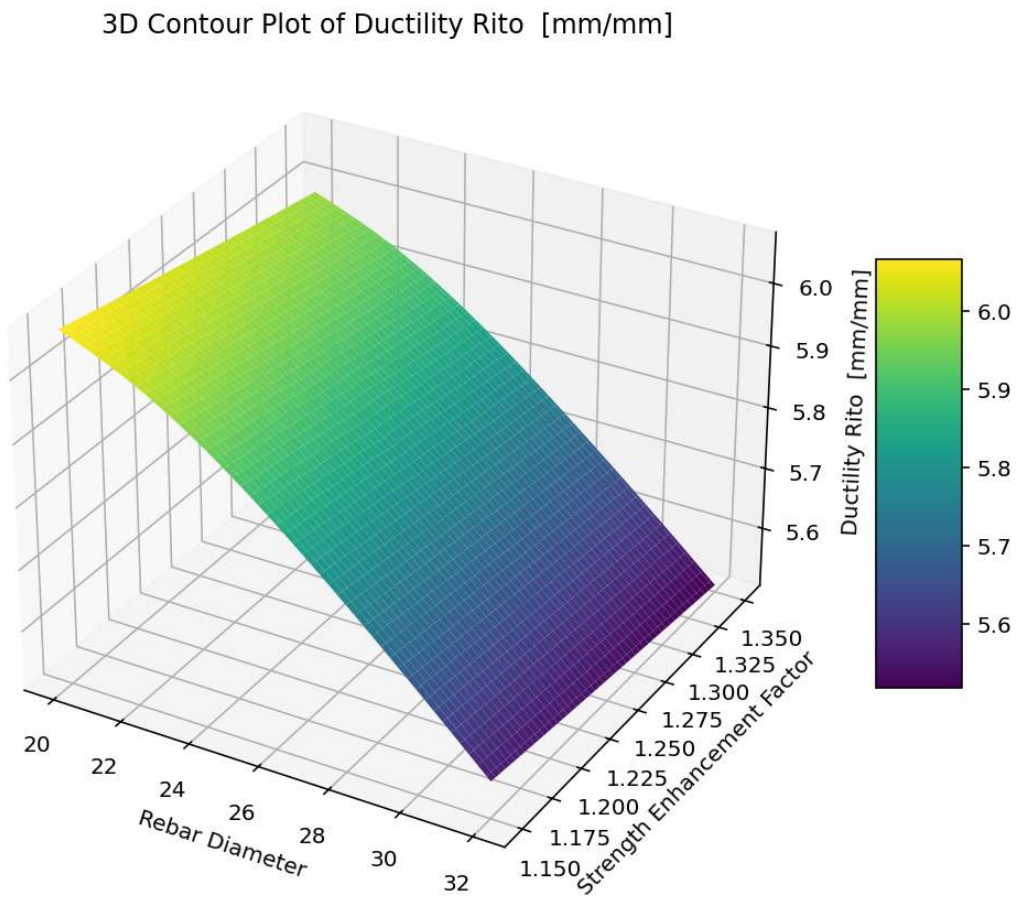

3D Contour Plot of Structure Displacement in X Dir. [mm]
Structure Displacement in X Dir. [mm]
694
692
690
688
686
684
682
680
678
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.350
1.325
1.300
1.275
1.250
1.225
1.200
1.175
1.150

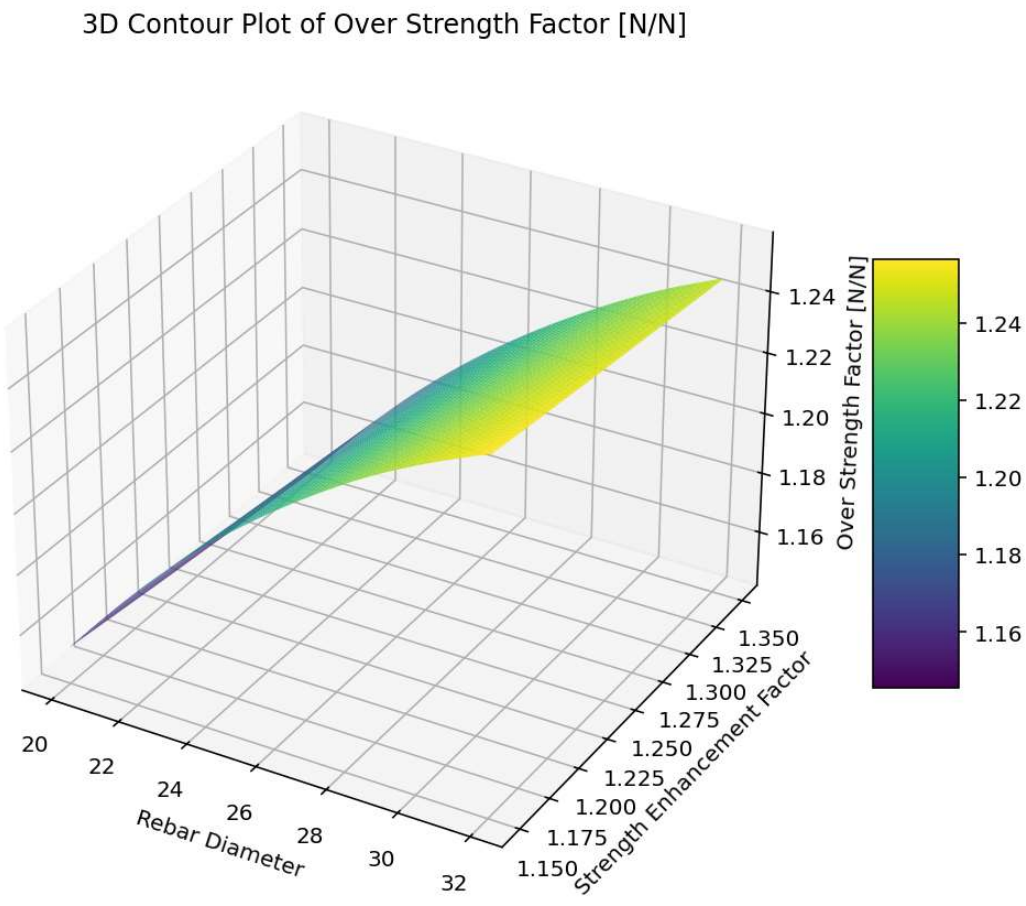
3D Contour Plot of Structure Displacement in Y Dir. [mm]

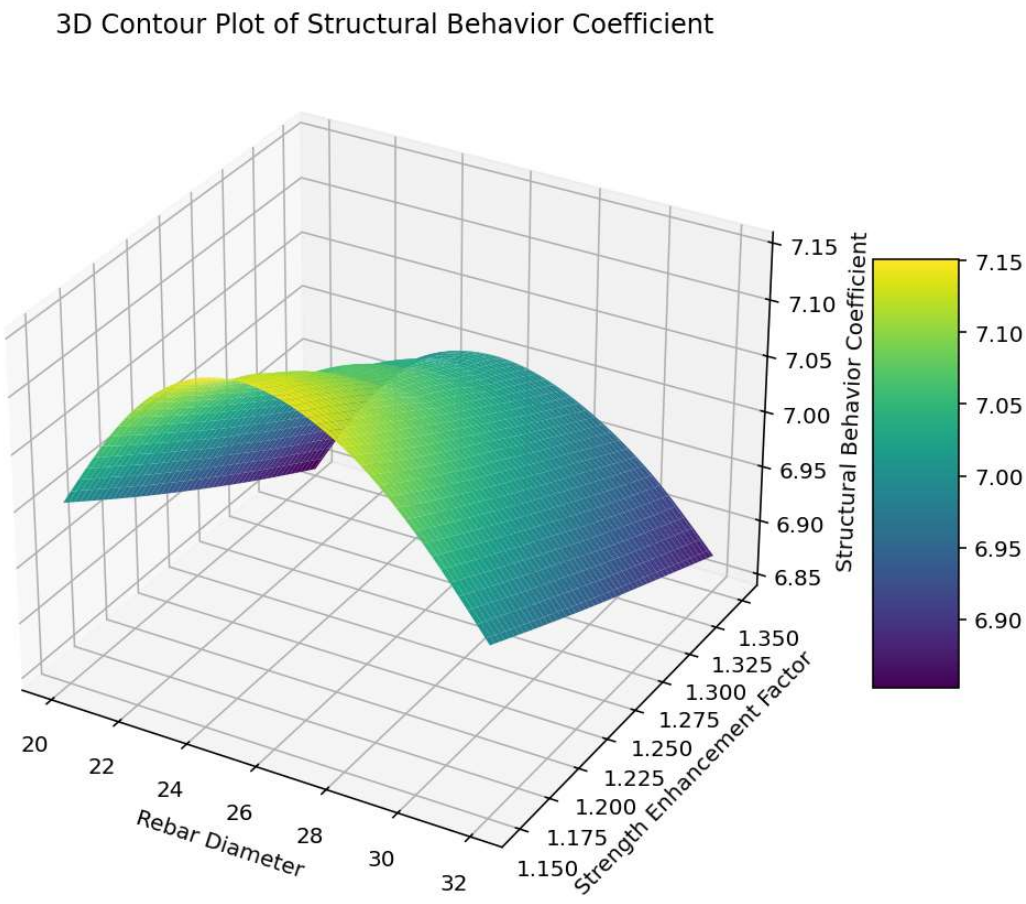


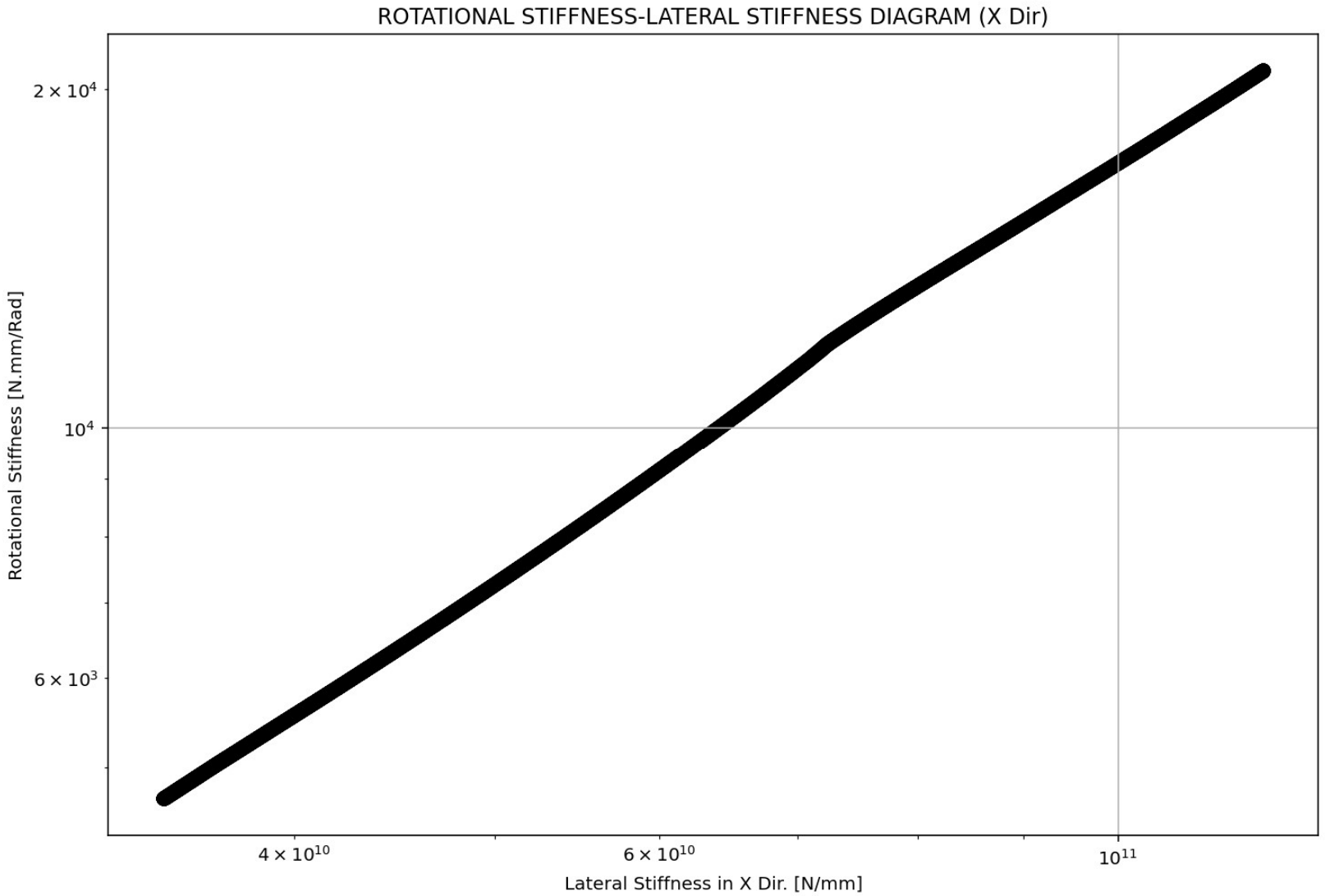

3D Contour Plot of Structure Elastic Stiffness [N/mm]
Structure Elastic Stiffness [N/mm]
20000
18000
16000
14000
12000
10000
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.350
1.325
1.300
1.275
1.250
1.225
1.200
1.175
1.150

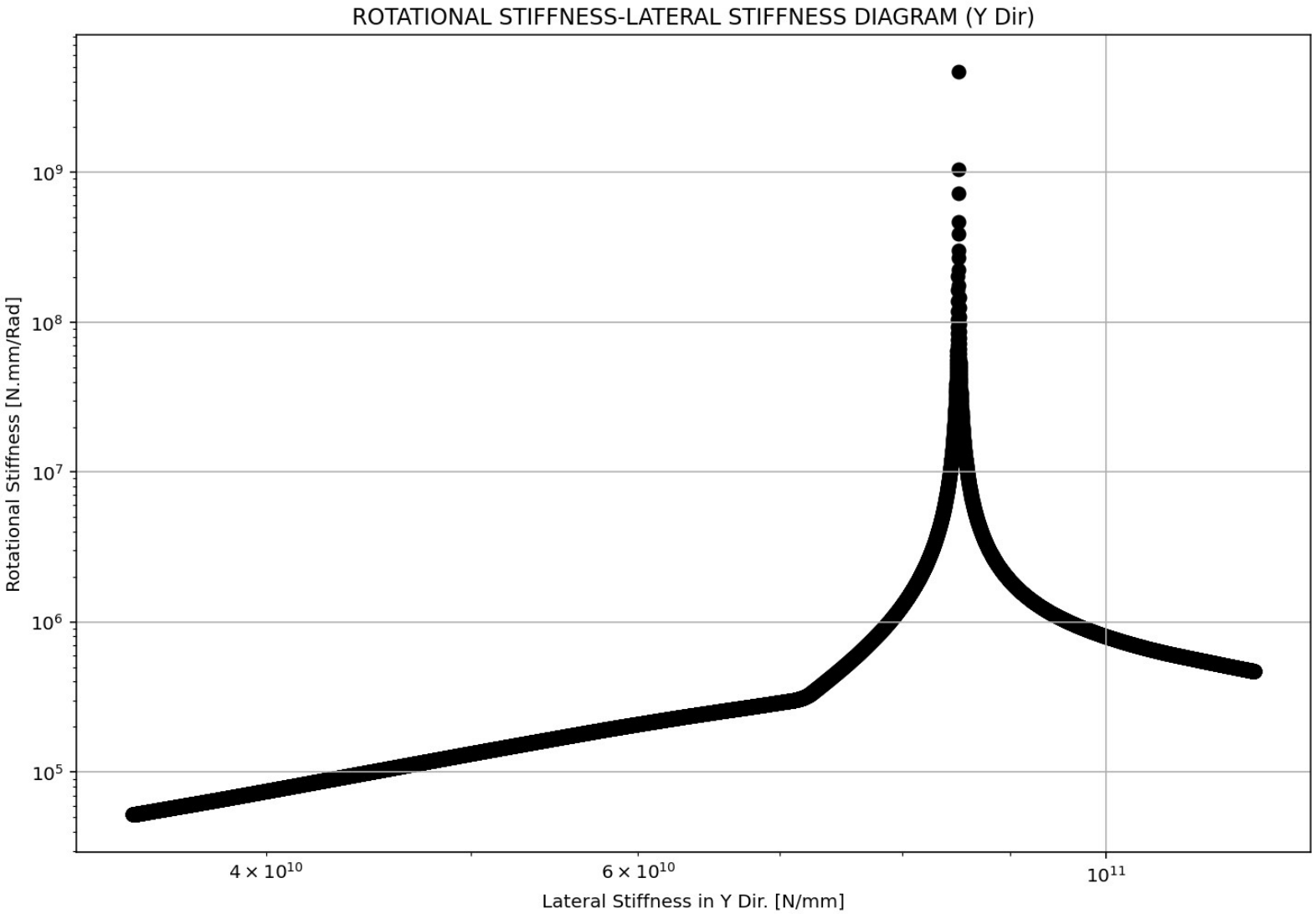

3D Contour Plot of Structure Plastic Stiffness [N/mm]
Structure Plastic Stiffness [N/mm]
4500
4000
3500
3000
2500
2000
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.350
1.325
1.300
1.275
1.250
1.225
1.200
1.175
1.150

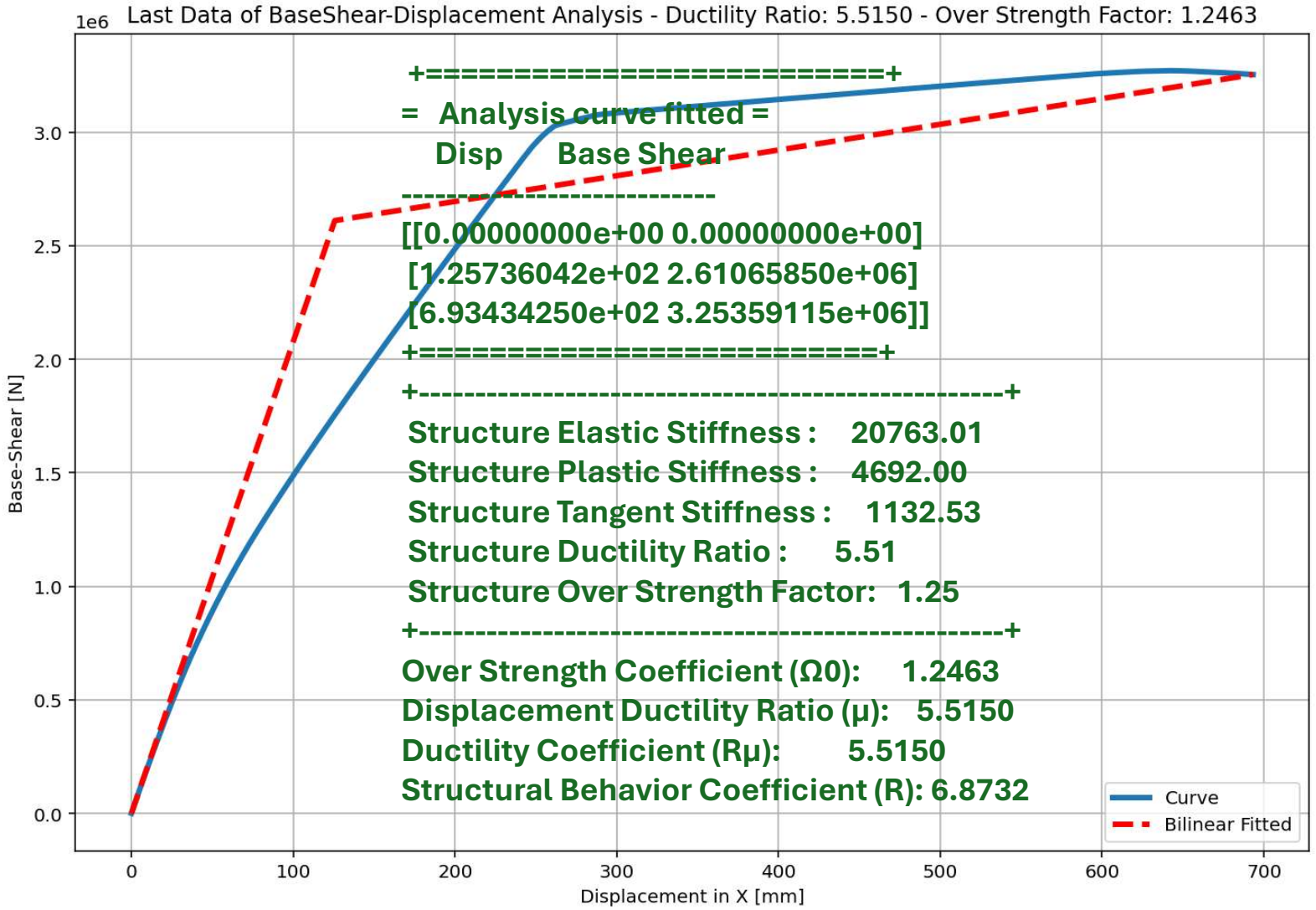

3D Contour Plot of Ductility Rito [mm/mm]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.150
1.175
1.200
1.225
1.250
1.275
1.300
1.325
1.350
Ductility Rito [mm/mm]
5.6
5.7
5.8
5.9
6.0


3D Contour Plot of Over Strength Factor [N/N]
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.150
1.175
1.200
1.225
1.250
1.275
1.300
1.325
1.350
Over Strength Factor [N/N]
1.16
1.18
1.20
1.22
1.24

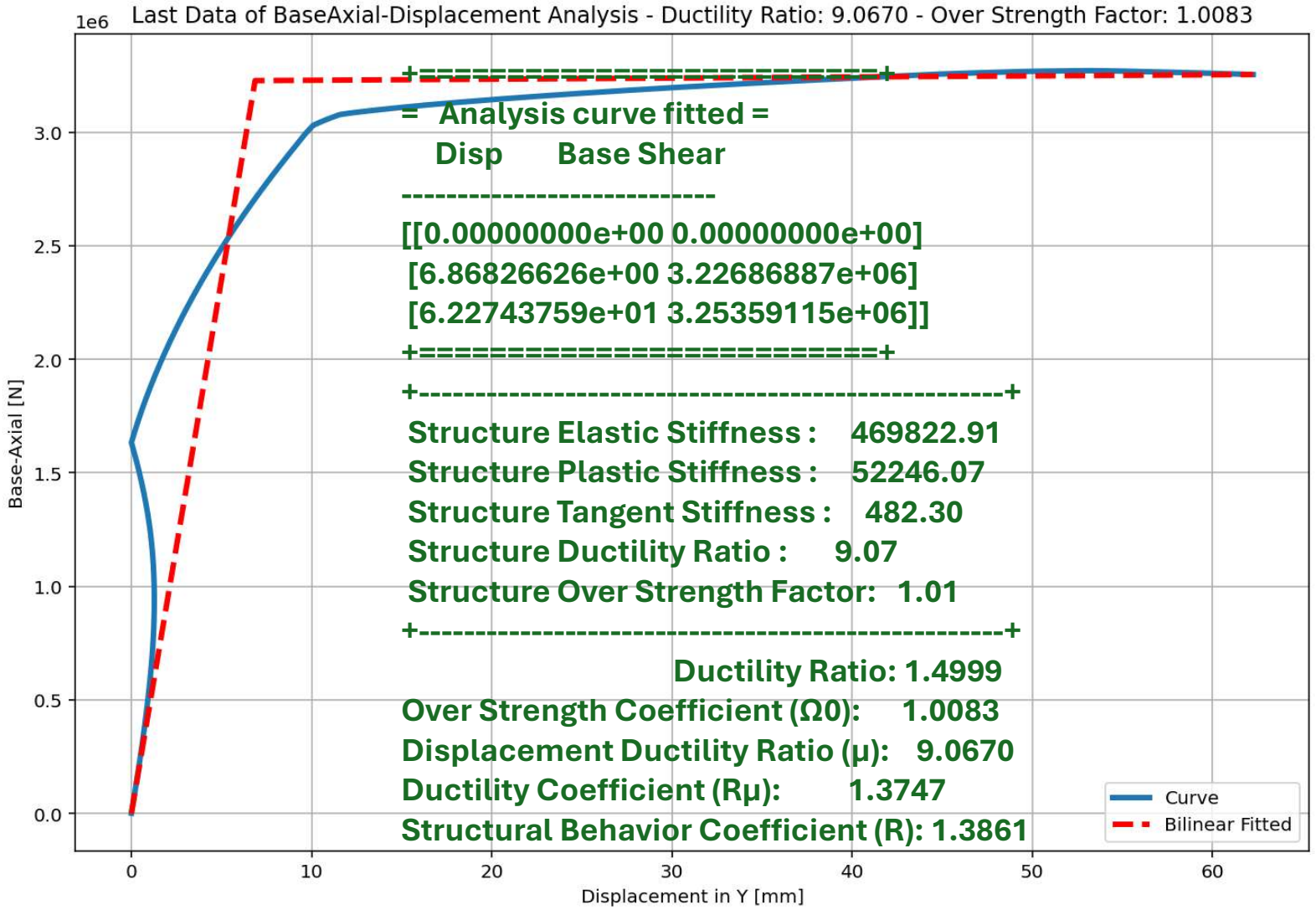

3D Contour Plot of Structural Behavior Coefficient
Structural Behavior Coefficient
7.15
7.10
7.05
7.00
6.95
6.90
6.85
Rebar Diameter
20
22
24
26
28
30
32
Strength Enhancement Factor
1.350
1.325
1.300
1.275
1.250
1.225
1.200
1.175
1.150


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM (X Dir)
Rotational Stiffness [N.mm/Rad]
2×10^4
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]
10^9
10^8
10^7
10^6
10^5
4×10^{10}
6×10^{10}
10^{11}
Lateral Stiffness in Y Dir. [N/mm]


Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 5.5150 - Over Strength Factor: 1.2463
1e6
Base-Shear [N]
Displacement in X [mm]
+============================+
= Analysis curve fitted =
Disp Base Shear

[[0.00000000e+00 0.00000000e+00]
[1.25736042e+02 2.61065850e+06]
[6.93434250e+02 3.25359115e+06]]
+============================+
+--+
Structure Elastic Stiffness : 20763.01
Structure Plastic Stiffness : 4692.00
Structure Tangent Stiffness : 1132.53
Structure Ductility Ratio : 5.51
Structure Over Strength Factor: 1.25
+--+
Over Strength Coefficient (Ω0): 1.2463
Displacement Ductility Ratio (μ): 5.5150
Ductility Coefficient (Rμ): 5.5150
Structural Behavior Coefficient (R): 6.8732
Curve
Bilinear Fitted


Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 9.0670 - Over Strength Factor: 1.0083
1e6
Base-Axial [N]
Displacement in Y [mm]
+============================+
= Analysis curve fitted =
Disp Base Shear

[[0.00000000e+00 0.00000000e+00]
[6.86826626e+00 3.22686887e+06]
[6.22743759e+01 3.25359115e+06]]
+============================+
+--+
Structure Elastic Stiffness : 469822.91
Structure Plastic Stiffness : 52246.07
Structure Tangent Stiffness : 482.30
Structure Ductility Ratio : 9.07
Structure Over Strength Factor: 1.01
+--+
Ductility Ratio: 1.4999
Over Strength Coefficient (Ω0): 1.0083
Displacement Ductility Ratio (μ): 9.0670
Ductility Coefficient (Rμ): 1.3747
Structural Behavior Coefficient (R): 1.3861
Curve
Bilinear Fitted