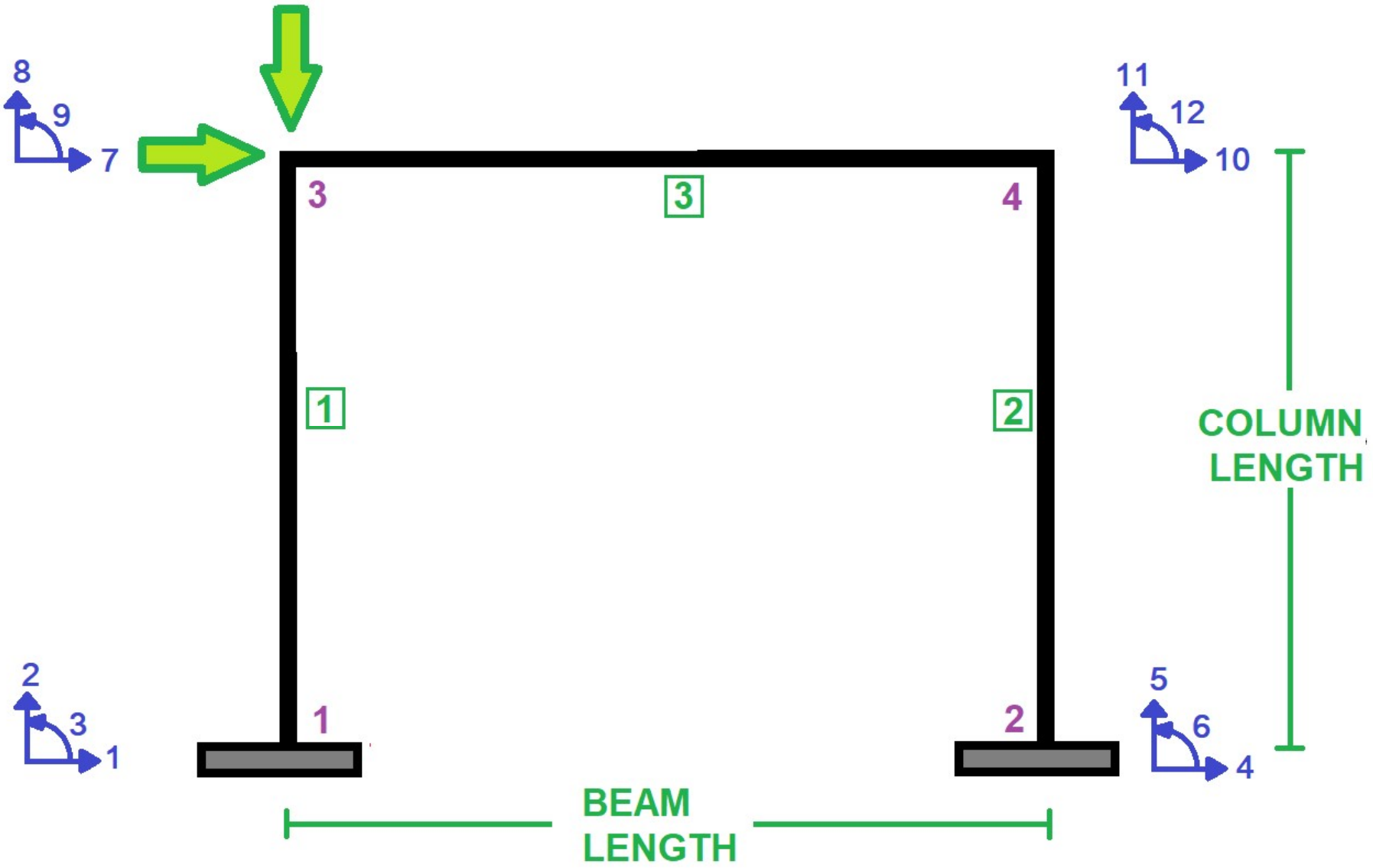
>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

SENSITIVITY ANALYSIS OF CONCRETE FRAME BY CHANGING COLUMN REBAR DIAMETER AND COLUMN SECTION DEPTH USING OPENSEES FOR STRUCTURAL BEHAVIOR COEFFICIENT CALCULATION.

BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


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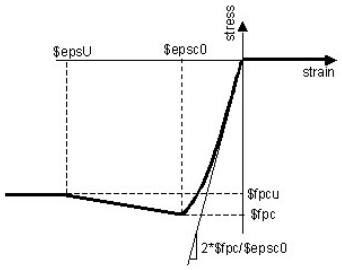
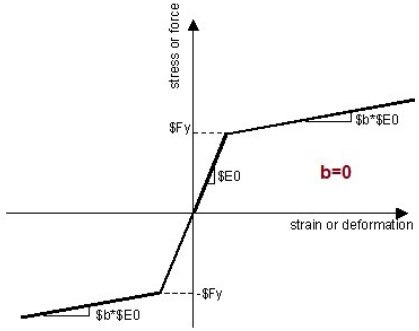
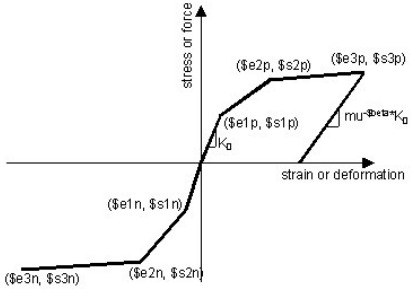
4
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH



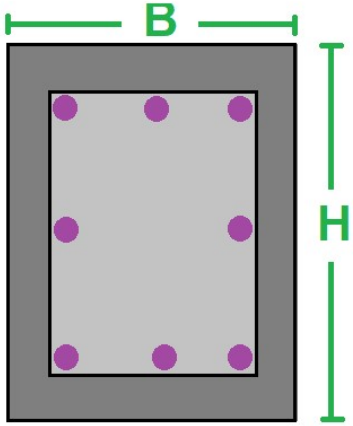
CORE AND COVER CONCRETE RELATION



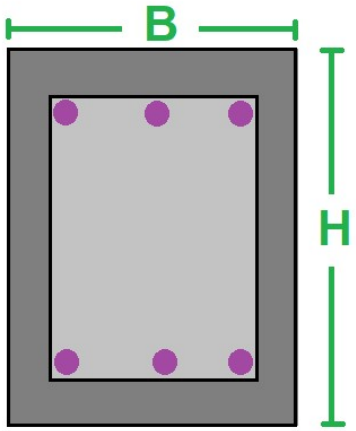
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

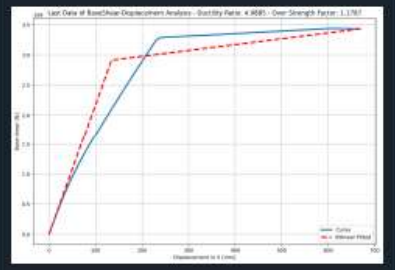
File Edit Search Source Run Debug Consoles Projects Tools View Help

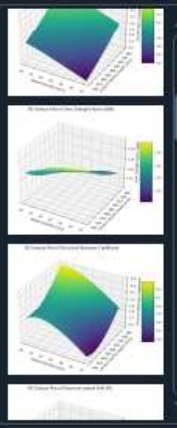
...ell\Desktop\OPENSEES_FILES\CONCRETE_FRAME_EXAMPLES\SENSITIVITY

C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...TIVITY\CONCRETE_FRAME_SENSITIVITY_REBAR_Cdepth.py

CONCRETE_FRAME_SEN...TY_REBAR_Cdepth.py

```
1  ##########################################################################################################
2  #                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<              #
3  #       SENSITIVITY ANALYSIS OF CONCRETE FRAME BY CHANGING COLUMN REBAR DIAMETER AND COLUMN SECTION DEPTH #
4  #                       USING OPENSEES FOR STRUCTURAL BEHAVIOR COEFFICIENT CALCULATION                   #
5  #-------------------------------------------------------------------------------------------------------#
6  #                              THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)               #
7  #                                        EMAIL: salar.d.ghashghaei@gmail.com                            #
8  ##########################################################################################################
9  """
10 This Python script performs a sensitivity analysis on a 2D reinforced concrete (RC) frame by varying
11  column rebar diameter and column section depth to evaluate their impact on structural behavior
12  coefficients, which are critical in earthquake engineering. The analysis is conducted using OpenSeesPy,
13  a powerful finite element framework for nonlinear structural analysis.
14
15 # Key Features:
16 1. Material Modeling:
17    - Concrete: Uses `Concrete01` (uniaxial material with linear tension/compression) or `Concrete02` (parabolic model wi
18    - Steel Reinforcement: Models rebars with hysteretic behavior (pinching, hardening, and degradation).
19
20 2. Section Modeling:
21    - Fiber-based sections for columns and beams with confined/unconfined concrete.
22    - Rebar ratio sensitivity by varying diameters (e.g., 20-32 mm).
23
24 3. Pushover Analysis:
25    - Displacement-controlled nonlinear static analysis to simulate seismic demands.
26    - Tracks base shear, displacement, stiffness degradation, and ductility.
27
28 4. Bilinear Curve Fitting:
29    - Extracts elastic stiffness, post-yield stiffness, and ultimate capacity.
30    - Computes ductility ratio (μ) and overstrength factor (Ω₀) per FEMA-356/ATC-40.
31
32 5. Structural Behavior Coefficient (R):
33    - Calculates R = Ω₀ × Rμ, where Rμ accounts for ductility (μ).
34    - Critical for seismic design codes (e.g., ASCE 7, Eurocode 8).
```



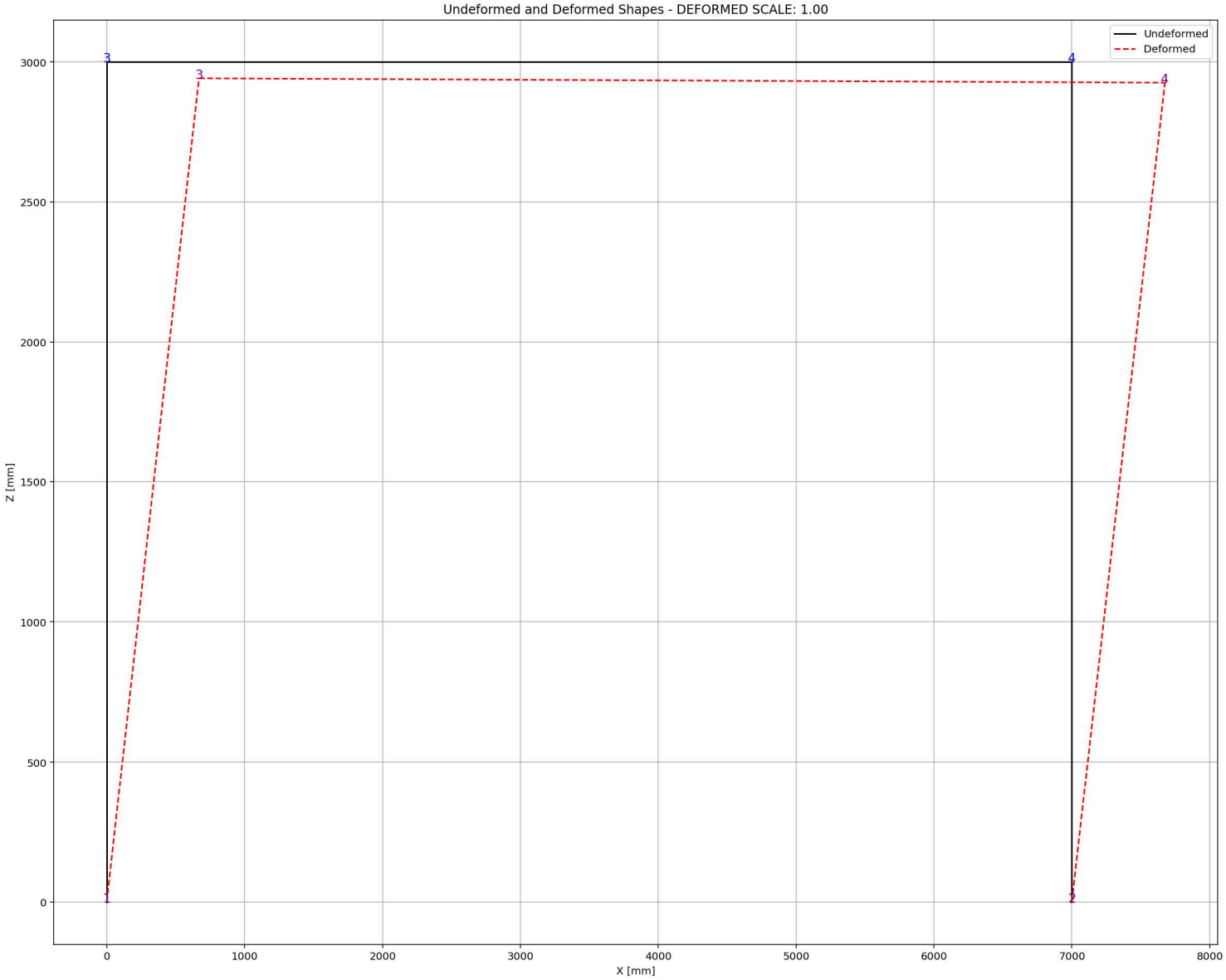


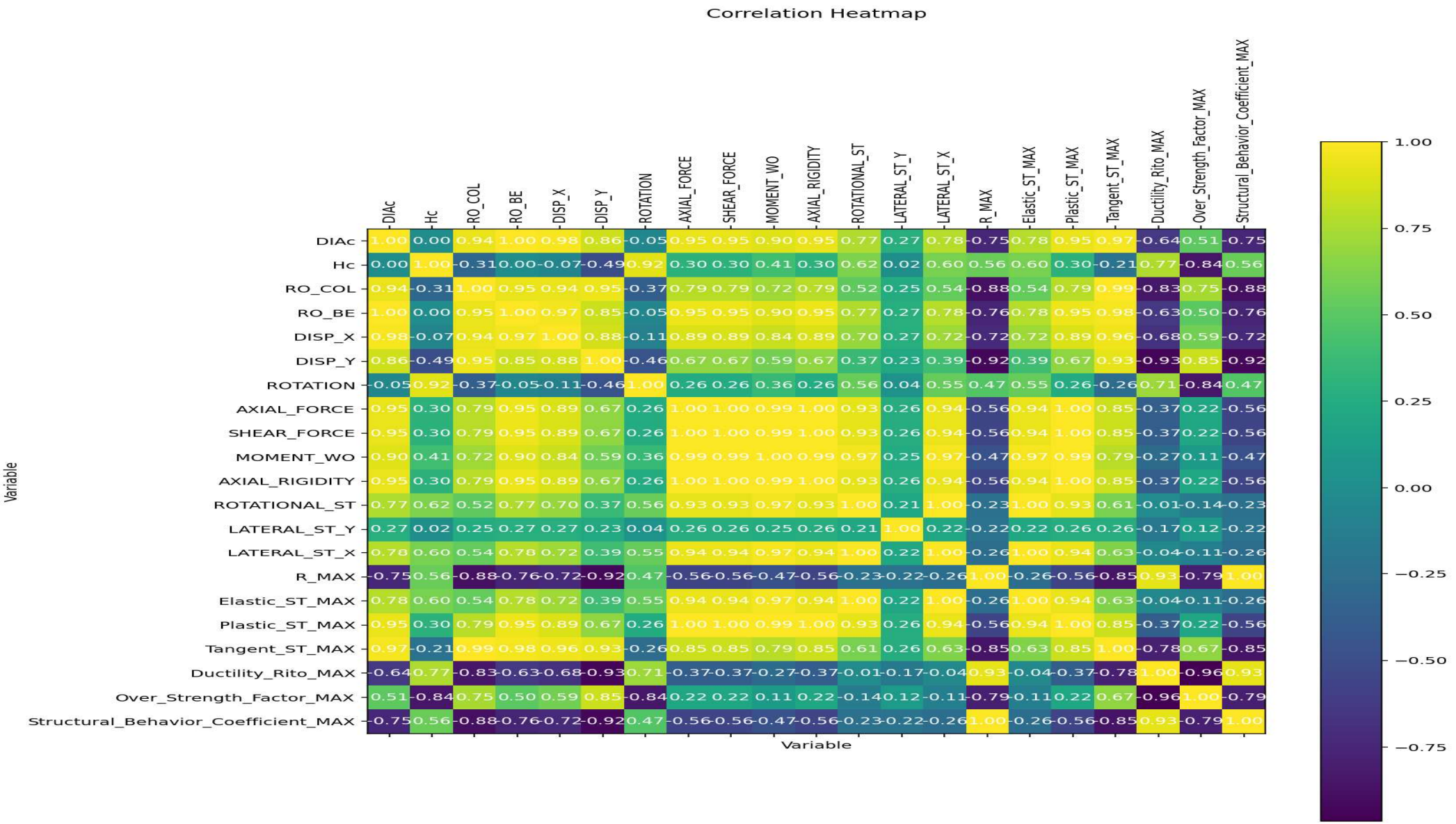
Help | Variable Explorer | Debugger | Plots | Files

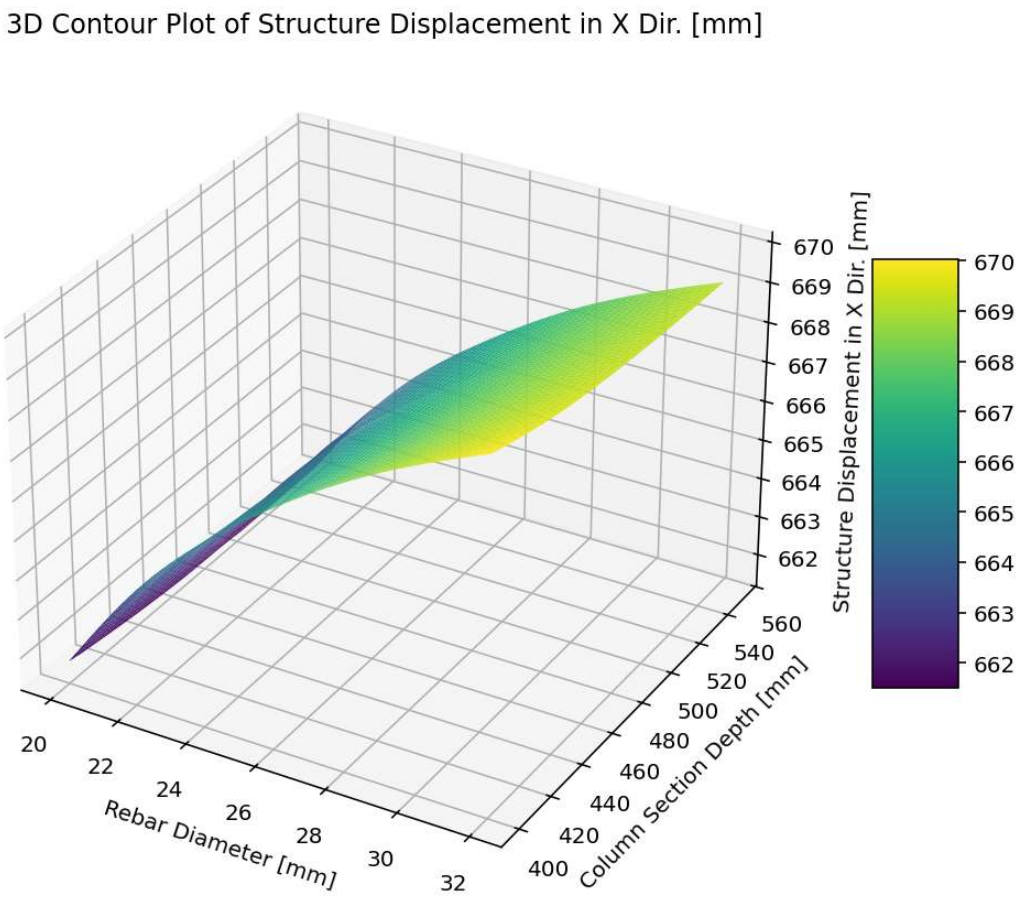
Console 1/A

```
 Structure Tangent Stiffness :     691.22
 Structure Ductility Ratio :       11.16
 Structure Over Strength Factor:   1.01
+-------------------------------------------------
--+
        Ductility Ratio: 1.4999
Over Strength Coefficient (Ω0):      1.0109
Displacement Ductility Ratio (μ):    11.1644
Ductility Coefficient (Rμ):          1.3822
Structural Behavior Coefficient (R): 1.3972
C:
```

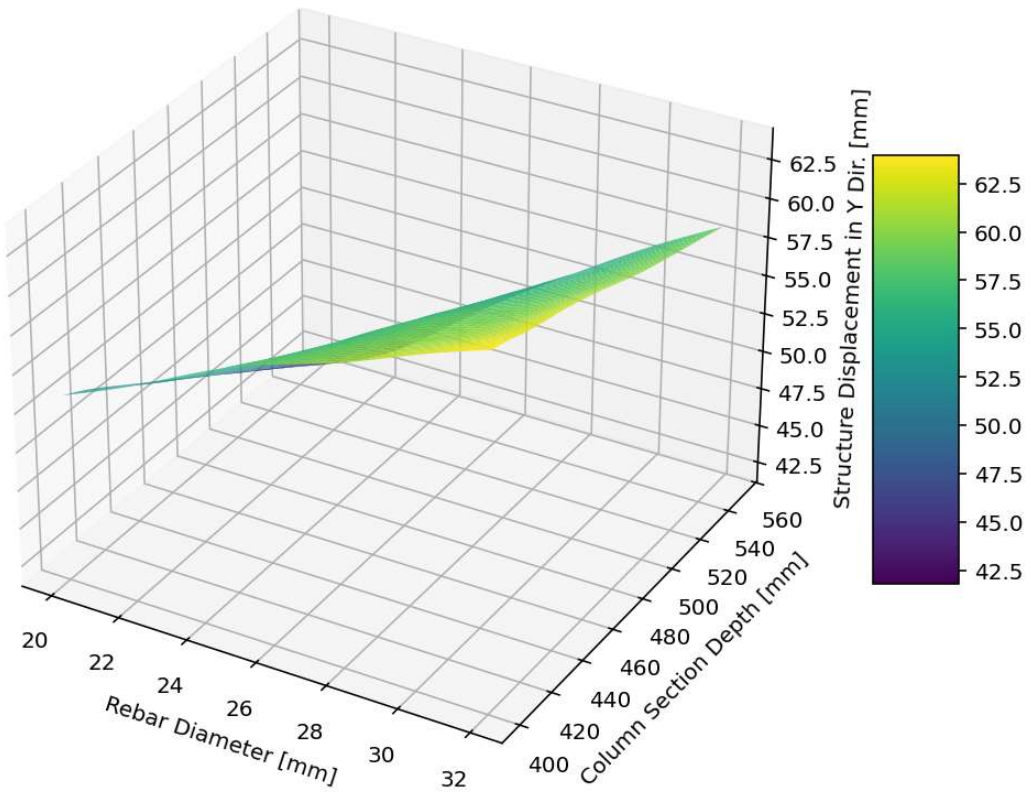
IPython Console | History

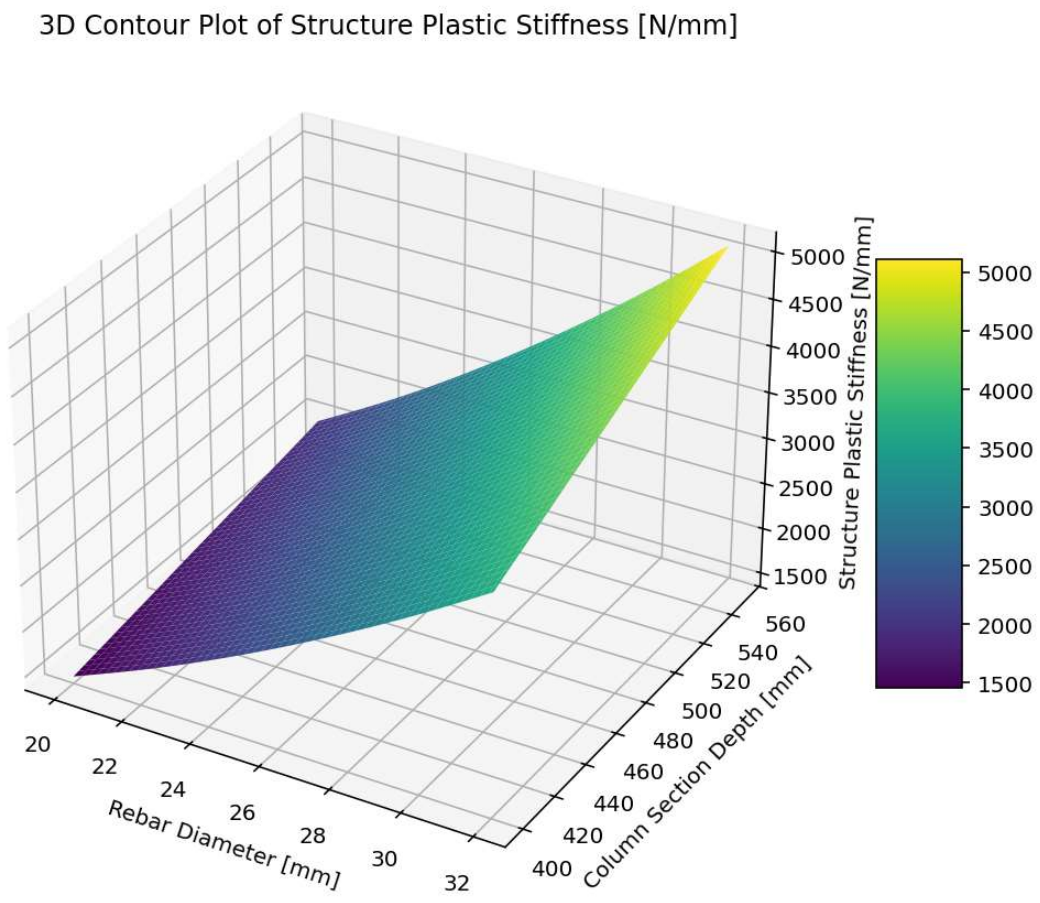

Undeformed and Deformed Shapes - DEFORMED SCALE: 1.00
Undeformed
Deformed
Z [mm]
X [mm]
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000
8000
3
4
3
4
1
2

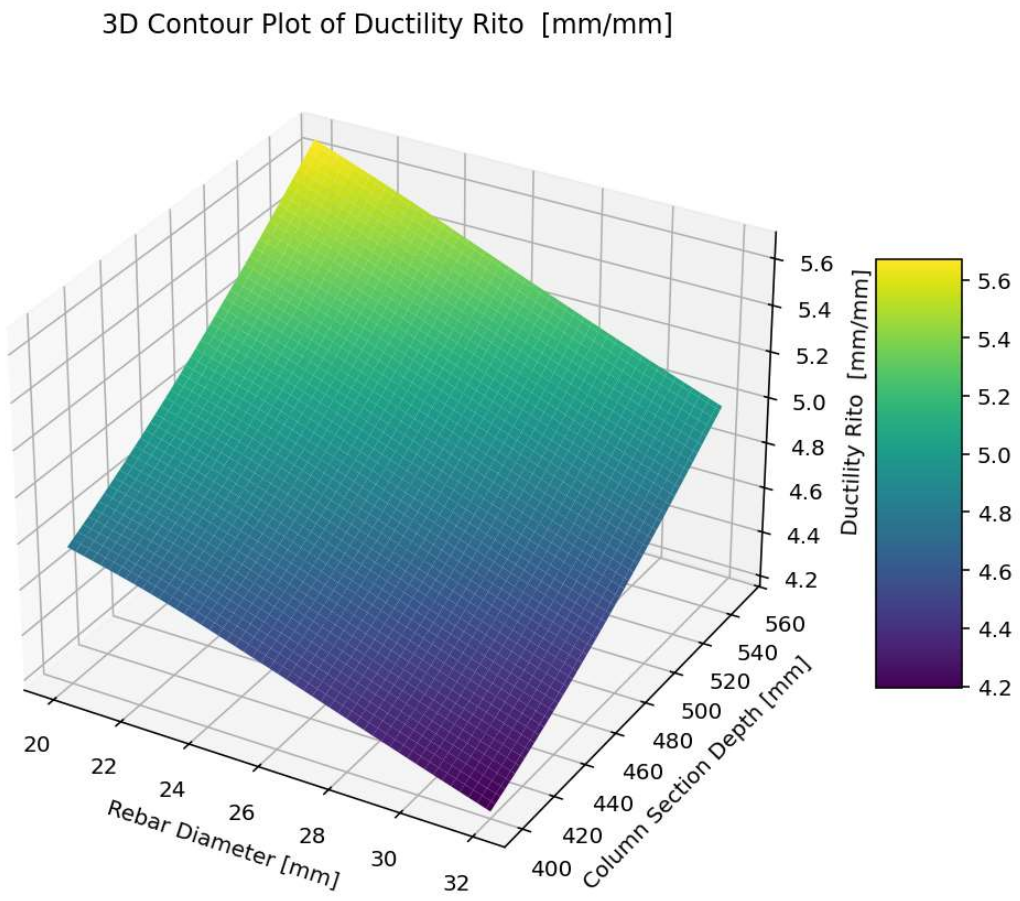

Correlation Heatmap
DIAc
Hc
RO_COL
RO_BE
DISP_X
DISP_Y
ROTATION
AXIAL_FORCE
SHEAR_FORCE
MOMENT_WO
AXIAL_RIGIDITY
ROTATIONAL_ST
LATERAL_ST_Y
LATERAL_ST_X
R_MAX
Elastic_ST_MAX
Plastic_ST_MAX
Tangent_ST_MAX
Ductility_Rito_MAX
Over_Strength_Factor_MAX
Structural_Behavior_Coefficient_MAX
Variable
Variable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

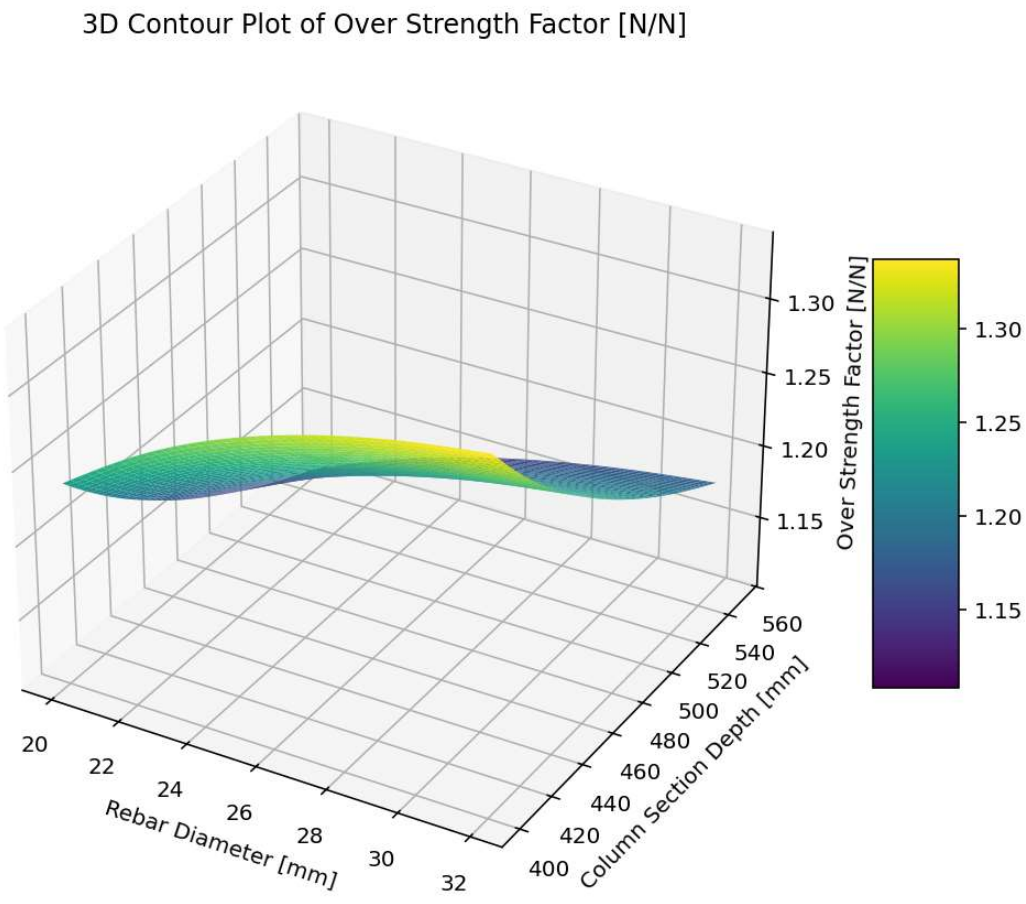

3D Contour Plot of Structure Displacement in X Dir. [mm]
Rebar Diameter [mm]
20
22
24
26
28
30
32
Column Section Depth [mm]
400
420
440
460
480
500
520
540
560
Structure Displacement in X Dir. [mm]
662
663
664
665
666
667
668
669
670

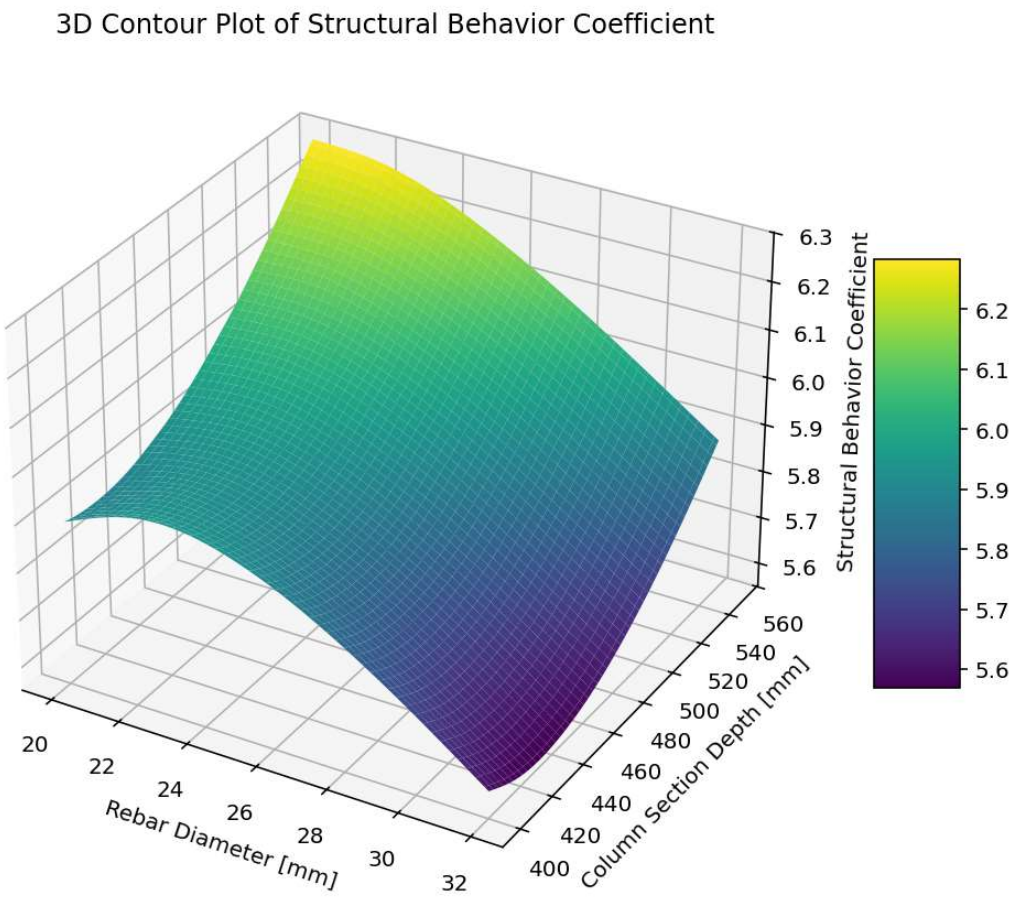
3D Contour Plot of Structure Displacement in Y Dir. [mm]

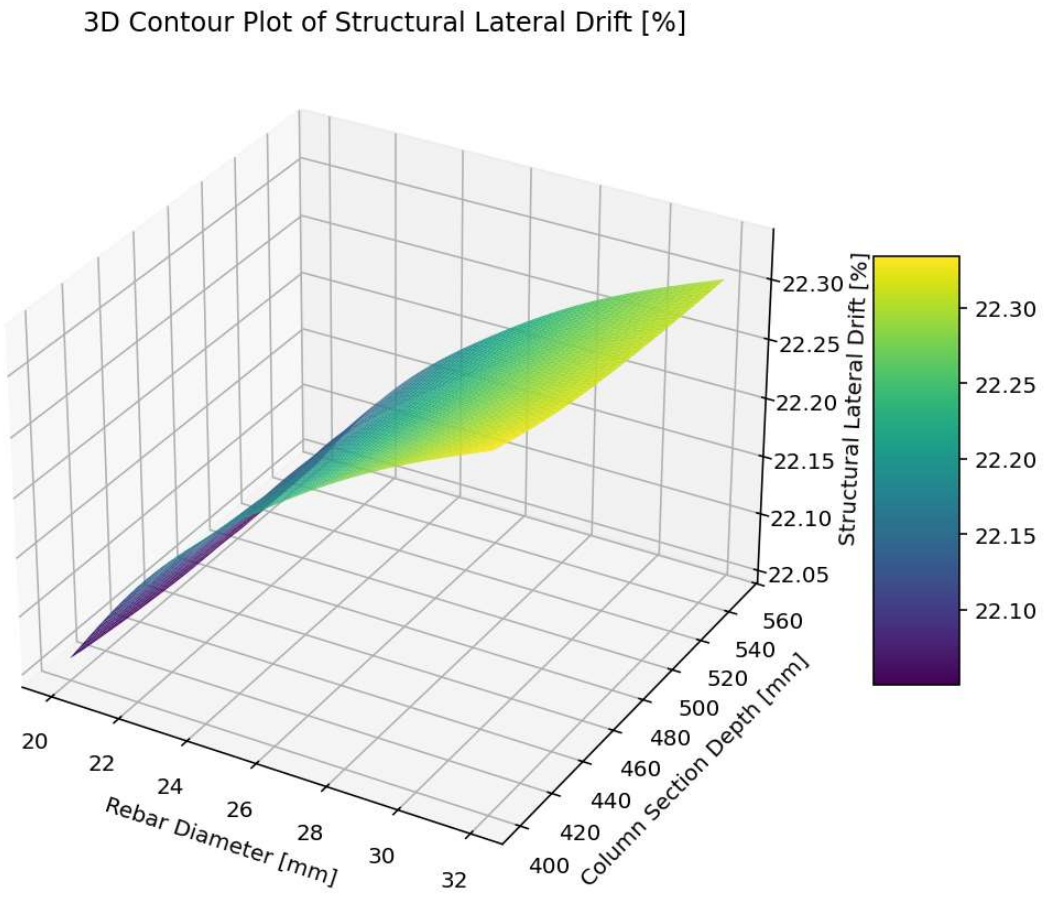


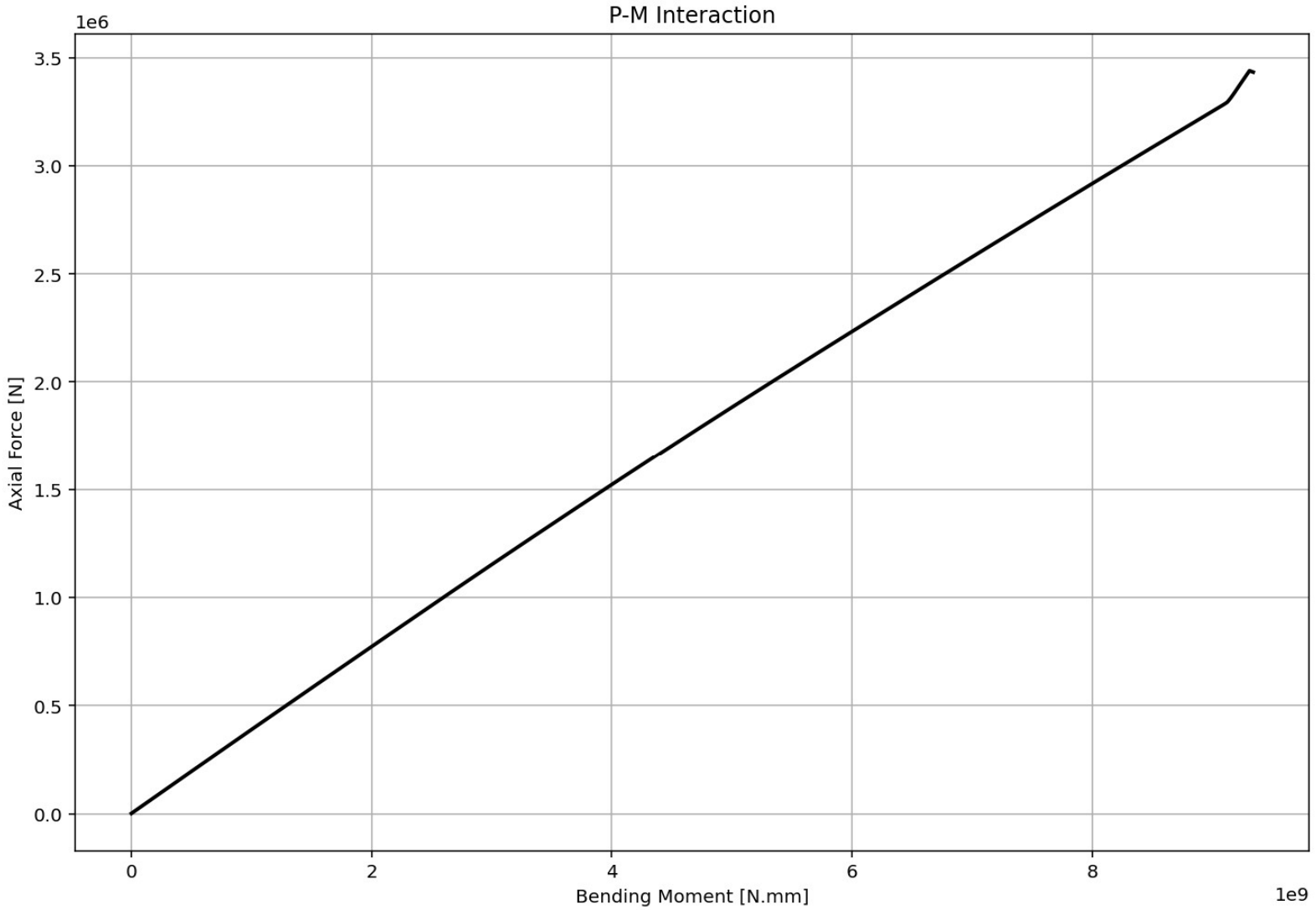

3D Contour Plot of Structure Plastic Stiffness [N/mm]
Structure Plastic Stiffness [N/mm]
5000
4500
4000
3500
3000
2500
2000
1500
Rebar Diameter [mm]
20
22
24
26
28
30
32
Column Section Depth [mm]
400
420
440
460
480
500
520
540
560

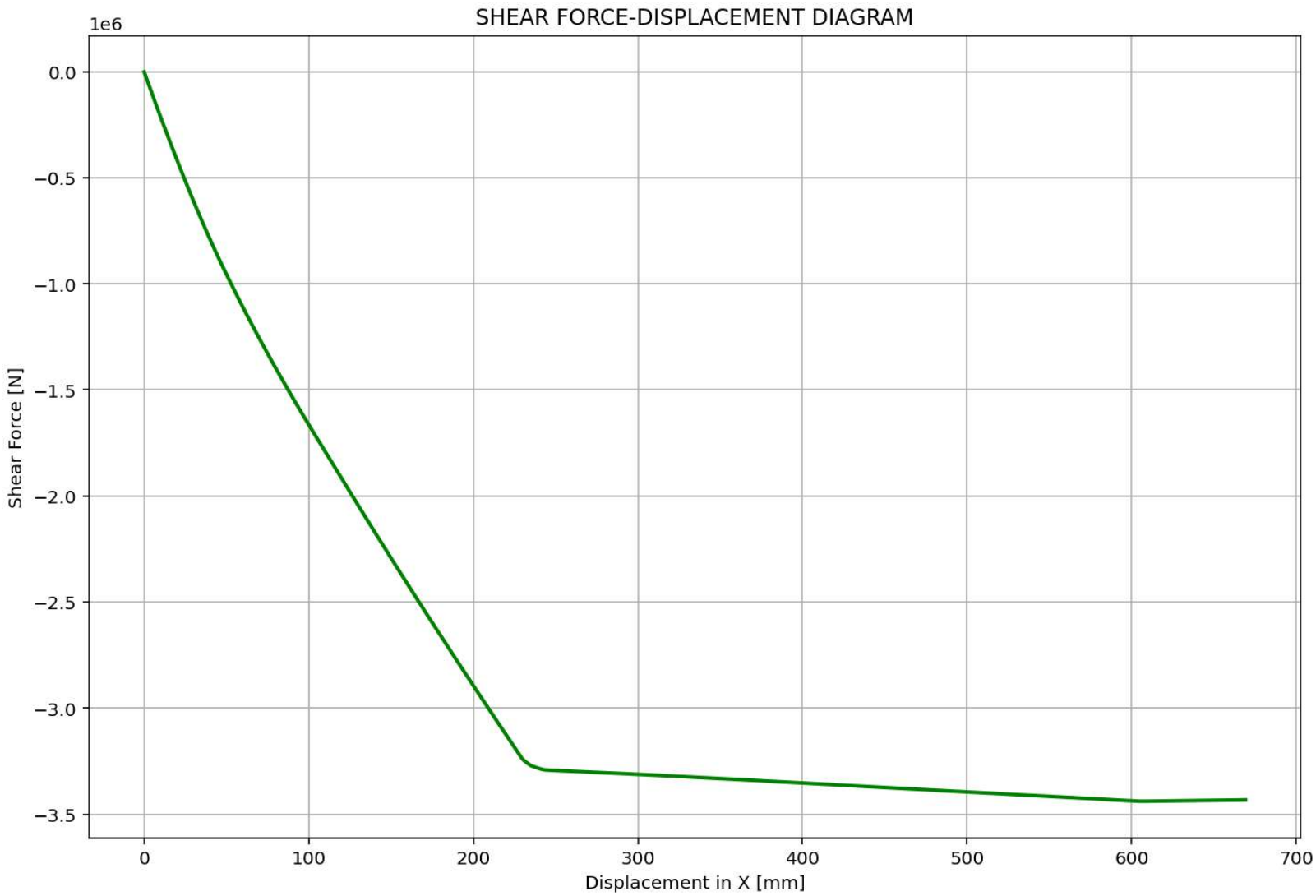

3D Contour Plot of Ductility Rito [mm/mm]
Rebar Diameter [mm]
20
22
24
26
28
30
32
Column Section Depth [mm]
400
420
440
460
480
500
520
540
560
Ductility Rito [mm/mm]
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6

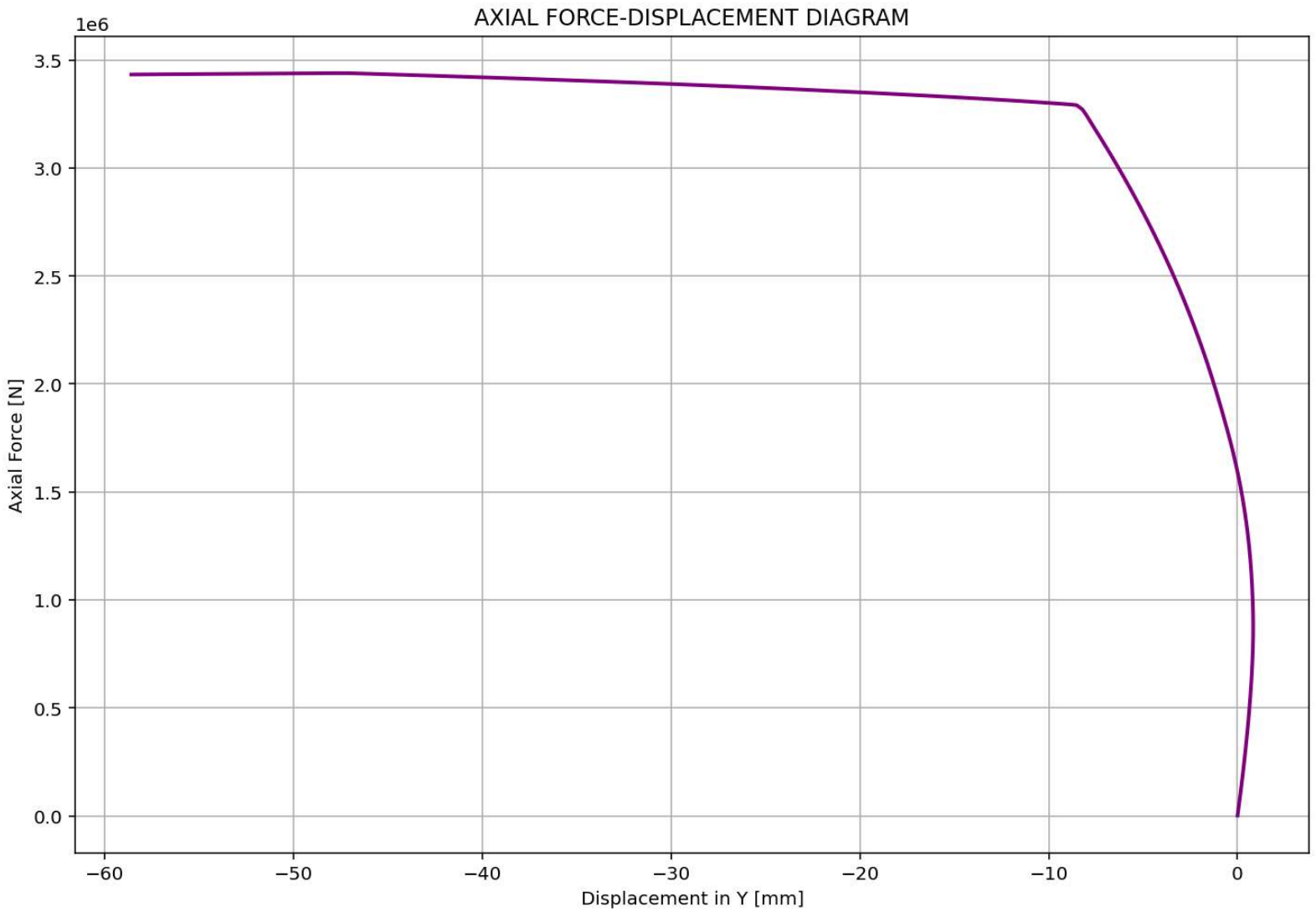

3D Contour Plot of Over Strength Factor [N/N]
Rebar Diameter [mm]
20
22
24
26
28
30
32
Column Section Depth [mm]
400
420
440
460
480
500
520
540
560
1.15
1.20
1.25
1.30
Over Strength Factor [N/N]
1.15
1.20
1.25
1.30

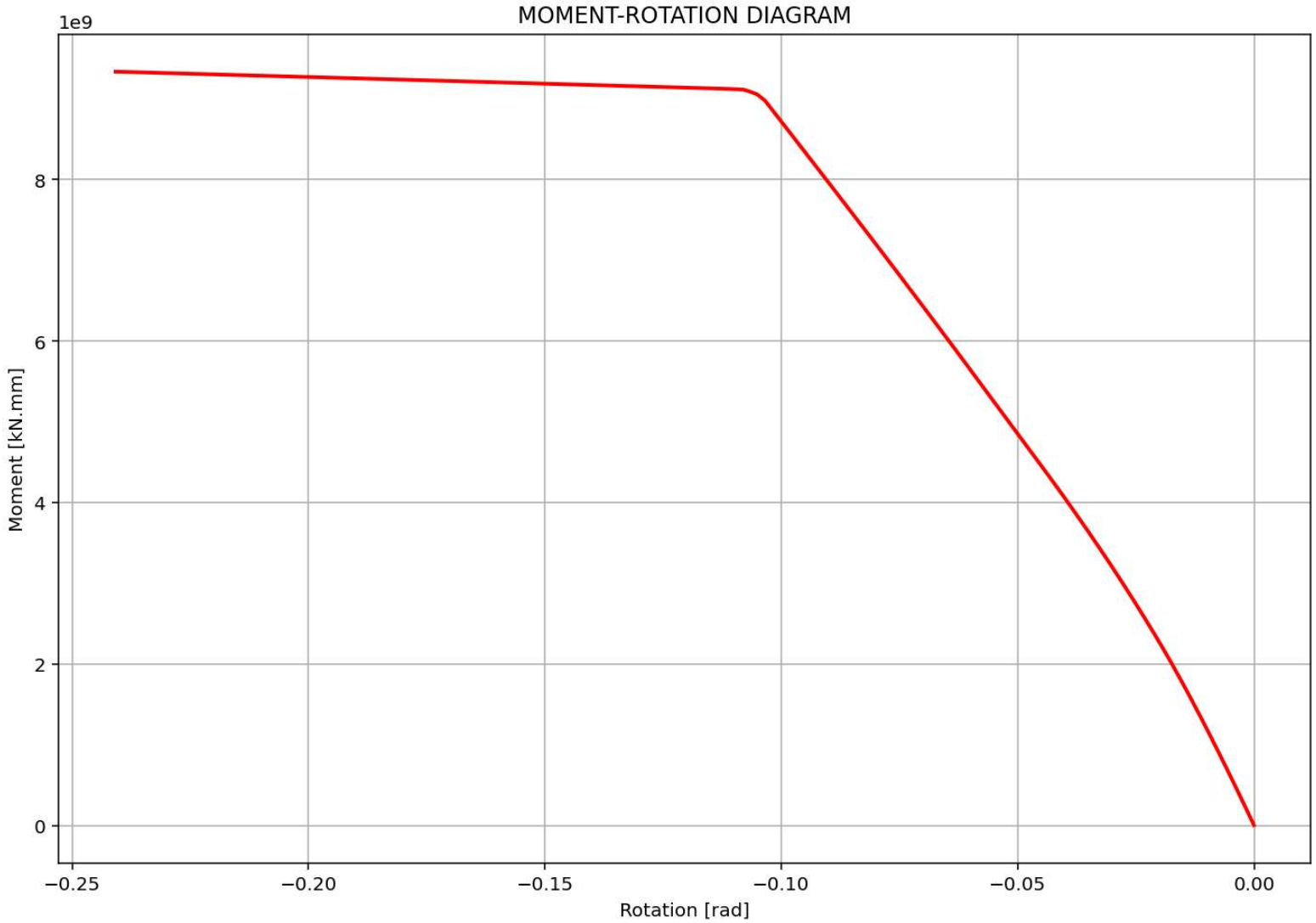

3D Contour Plot of Structural Behavior Coefficient
Rebar Diameter [mm]
Column Section Depth [mm]
Structural Behavior Coefficient
20
22
24
26
28
30
32
400
420
440
460
480
500
520
540
560
5.6
5.7
5.8
5.9
6.0
6.1
6.2
6.3

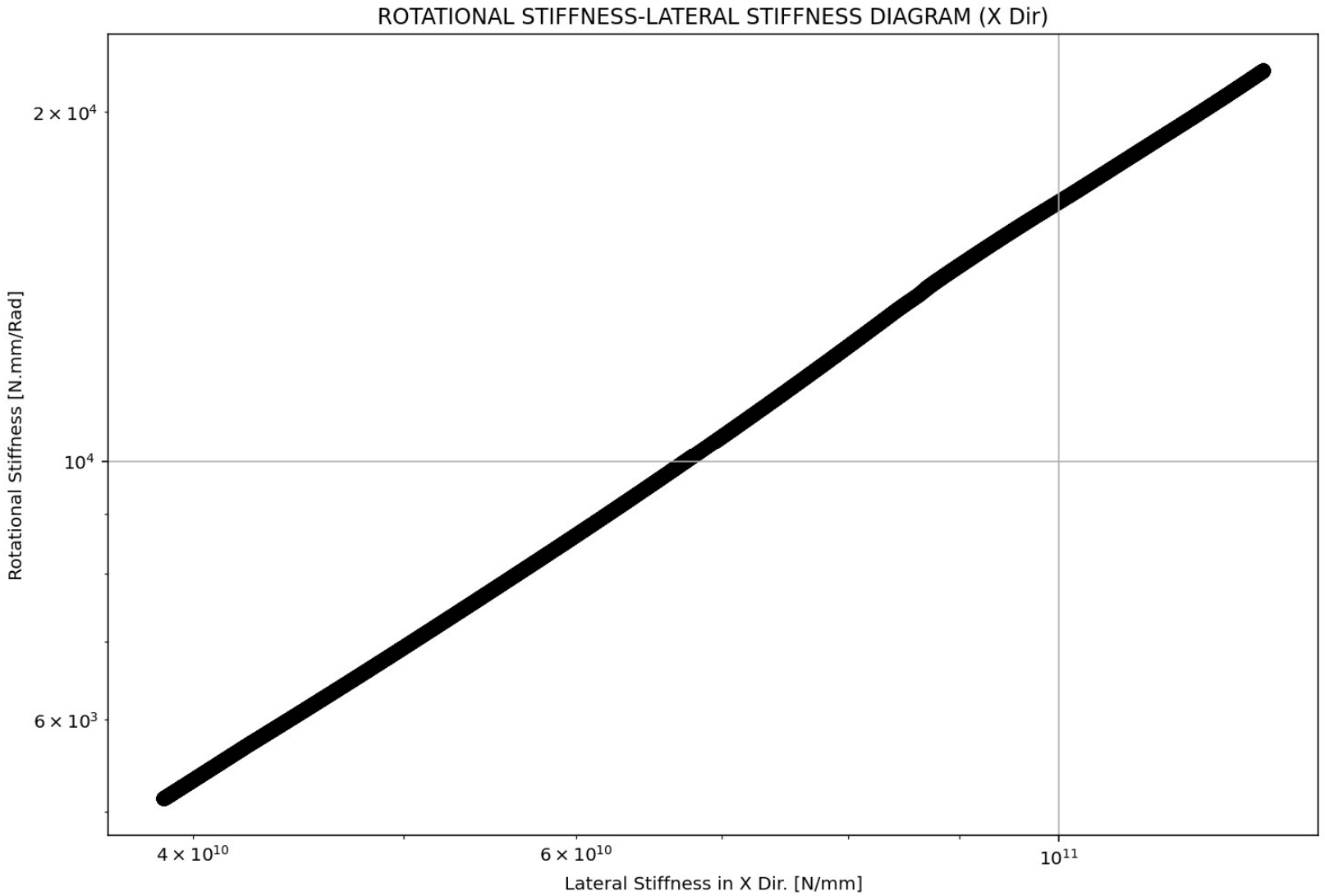

3D Contour Plot of Structural Lateral Drift [%]
Rebar Diameter [mm]
20
22
24
26
28
30
32
Column Section Depth [mm]
400
420
440
460
480
500
520
540
560
Structural Lateral Drift [%]
22.05
22.10
22.15
22.20
22.25
22.30

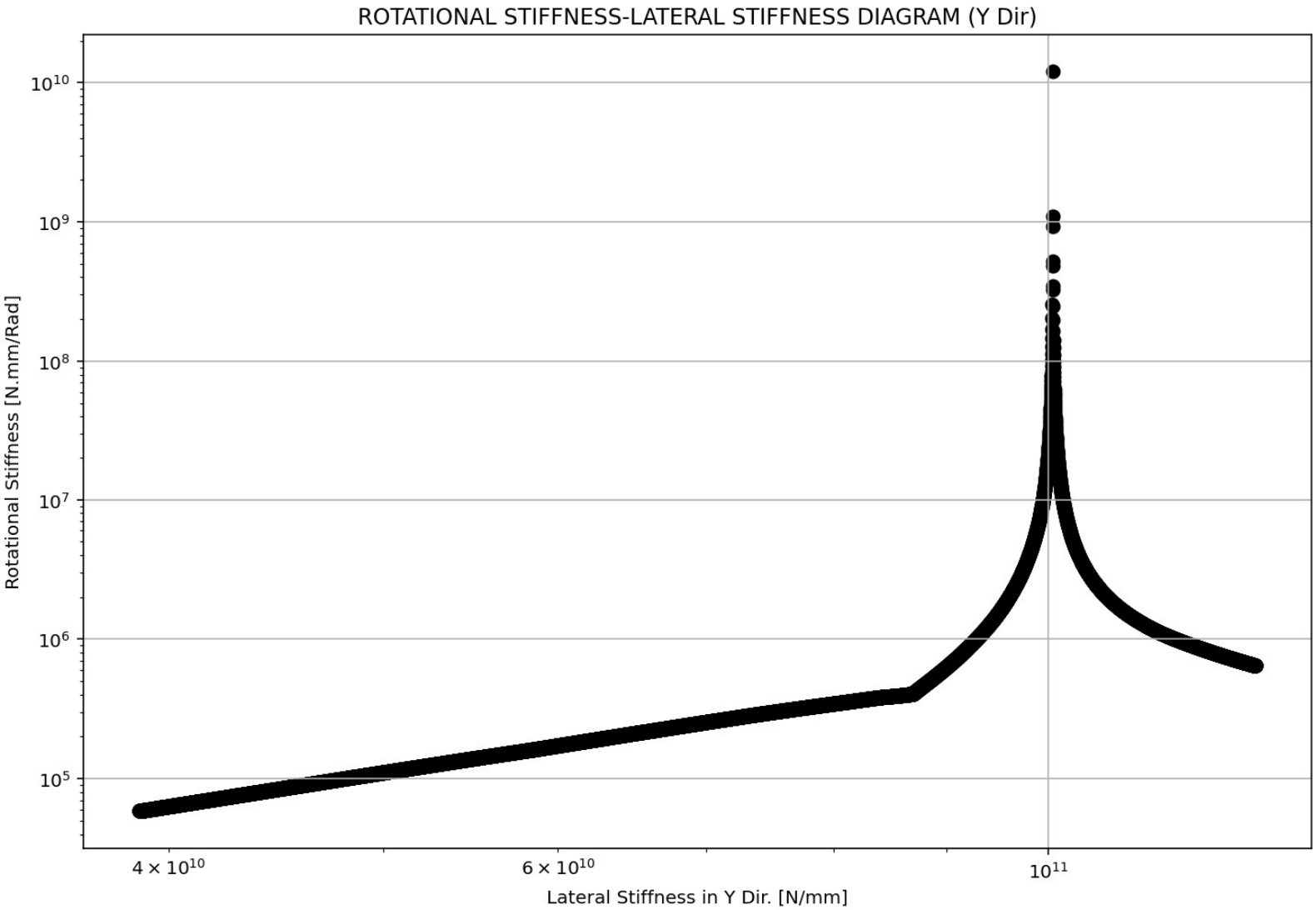

P-M Interaction
1e6
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Axial Force [N]
0
2
4
6
8
Bending Moment [N.mm]
1e9

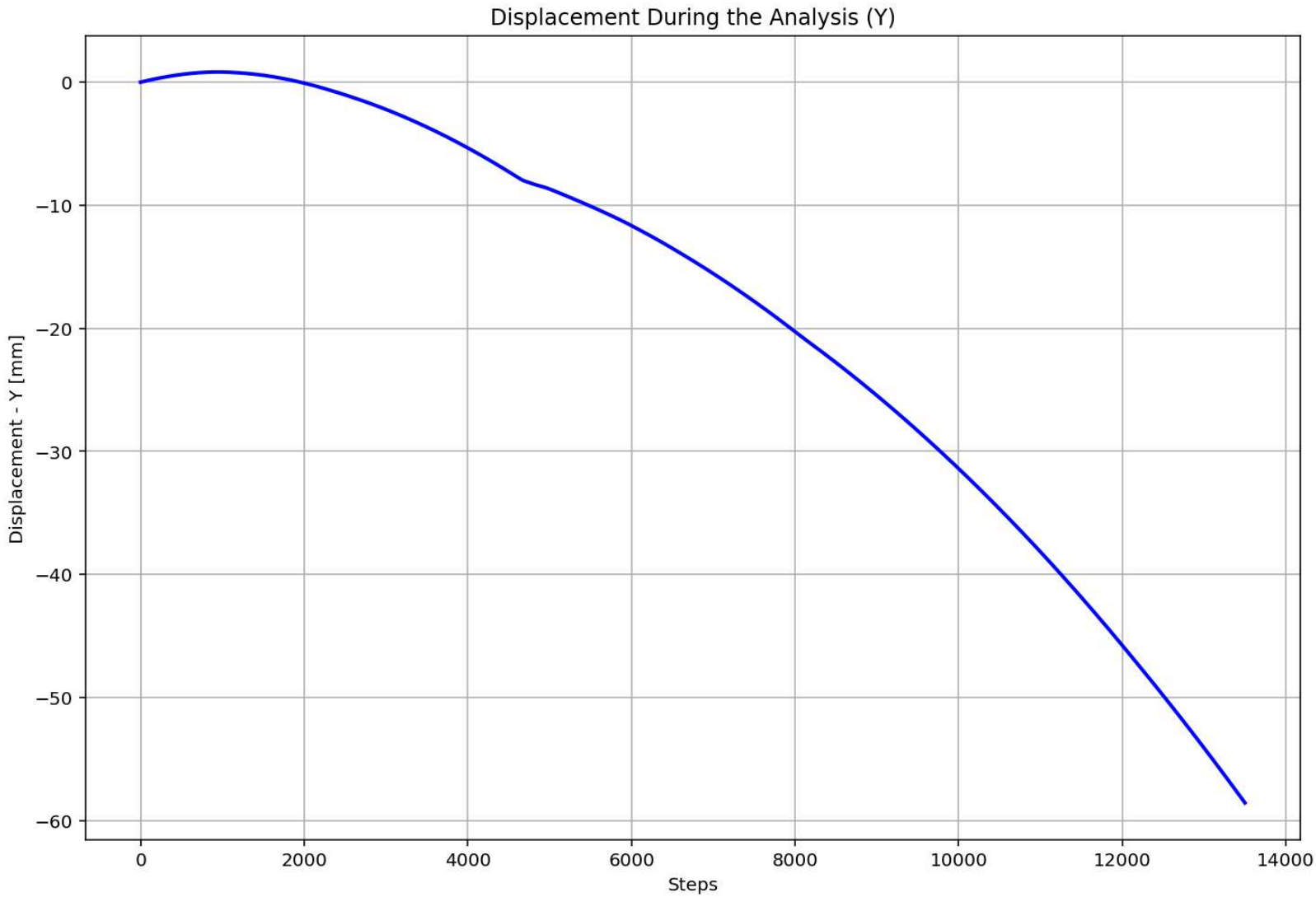

SHEAR FORCE-DISPLACEMENT DIAGRAM
1e6
0.0
−0.5
−1.0
−1.5
−2.0
−2.5
−3.0
−3.5
Shear Force [N]
0
100
200
300
400
500
600
700
Displacement in X [mm]

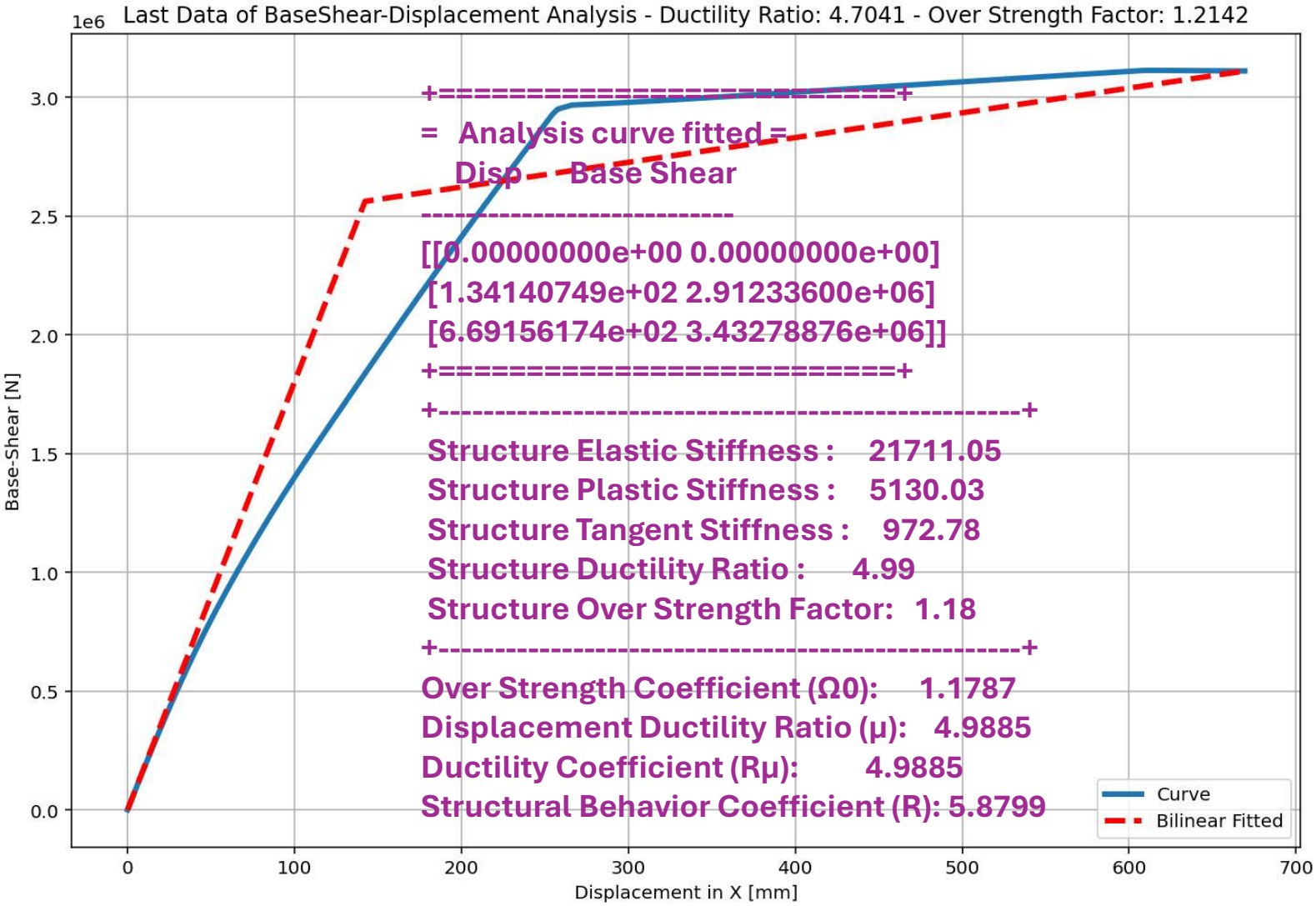

AXIAL FORCE-DISPLACEMENT DIAGRAM
1e6
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Axial Force [N]
−60
−50
−40
−30
−20
−10
0
Displacement in Y [mm]


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

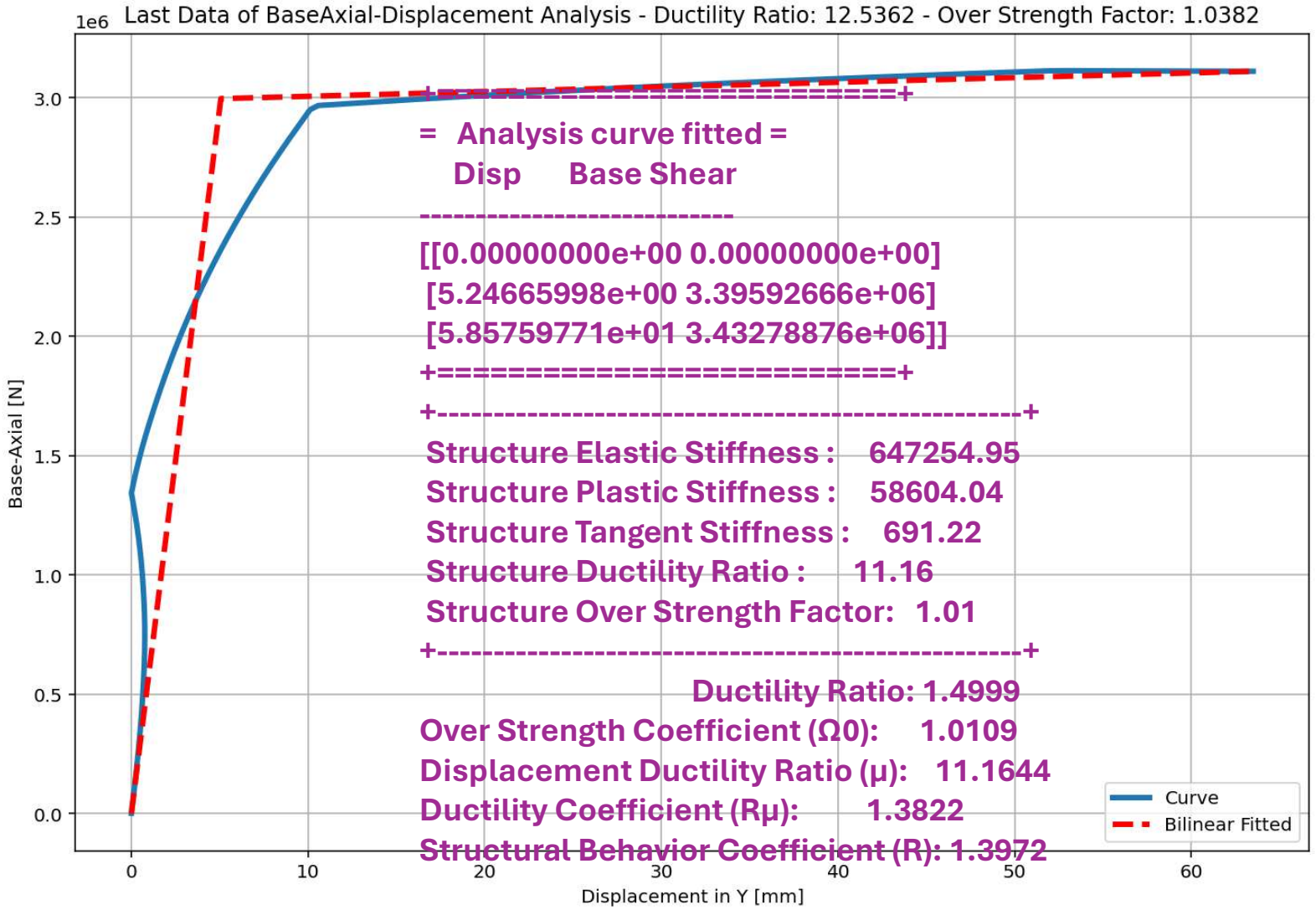

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM (X Dir)
Rotational Stiffness [N.mm/Rad]
2×10^4
10^4
6×10^3
4×10^{10}
6×10^{10}
10^{11}
Lateral Stiffness in X Dir. [N/mm]


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM (Y Dir)
Rotational Stiffness [N.mm/Rad]
10^{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]


Displacement During the Analysis (Y)
Displacement - Y [mm]
0
−10
−20
−30
−40
−50
−60
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]
[1.34140749e+02 2.91233600e+06]
[6.69156174e+02 3.43278876e+06]]
+==========================+
+----------+
Structure Elastic Stiffness : 21711.05
Structure Plastic Stiffness : 5130.03
Structure Tangent Stiffness : 972.78
Structure Ductility Ratio : 4.99
Structure Over Strength Factor: 1.18
+----------+
Over Strength Coefficient (Ω0): 1.1787
Displacement Ductility Ratio (μ): 4.9885
Ductility Coefficient (Rμ): 4.9885
Structural Behavior Coefficient (R): 5.8799
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]
[5.24665998e+00 3.39592666e+06]
[5.85759771e+01 3.43278876e+06]]
+==========================+
+----------+
Structure Elastic Stiffness : 647254.95
Structure Plastic Stiffness : 58604.04
Structure Tangent Stiffness : 691.22
Structure Ductility Ratio : 11.16
Structure Over Strength Factor: 1.01
+----------+
Ductility Ratio: 1.4999
Over Strength Coefficient (Ω0): 1.0109
Displacement Ductility Ratio (μ): 11.1644
Ductility Coefficient (Rμ): 1.3822
Structural Behavior Coefficient (R): 1.3972
Curve
Bilinear Fitted