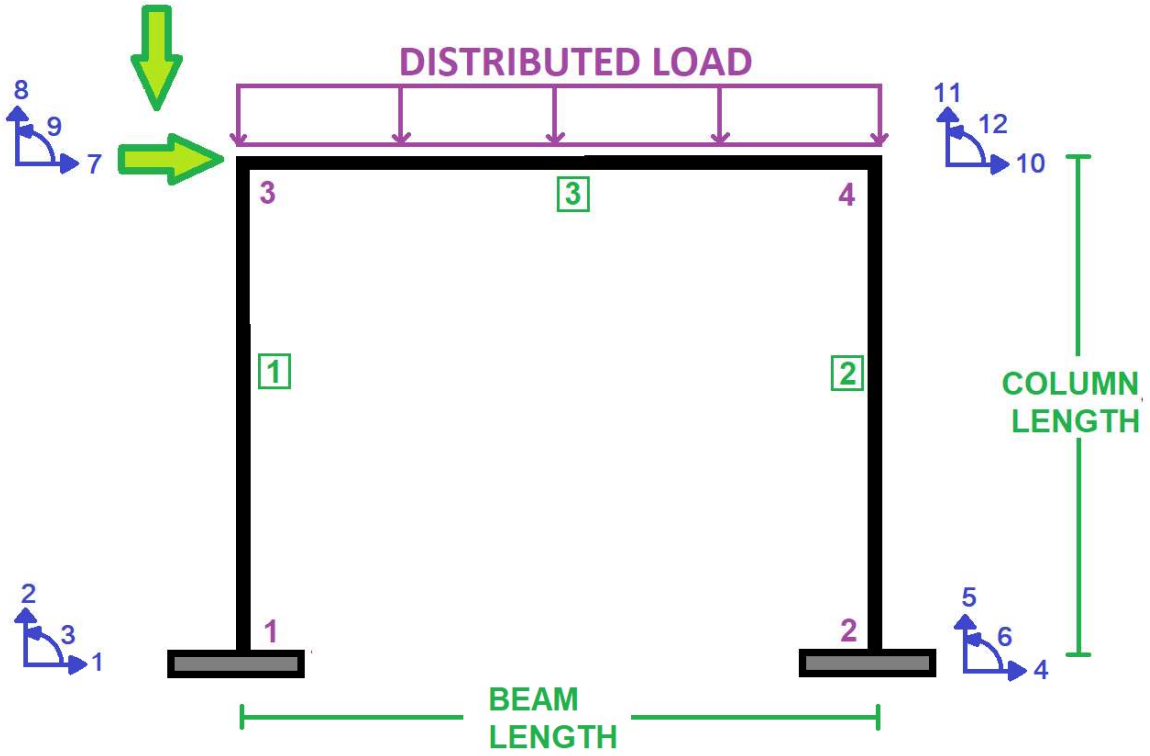
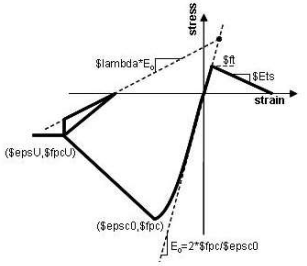
IN THE NAME OF ALLAH

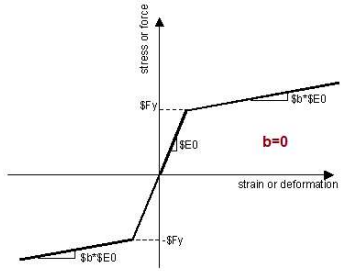
SENSITIVITY ANALYSIS OF CONCRETE FRAME BY CHANGING COLUMN REBAR DIAMETER AND COLUMN SECTION DEPTH. ANALYZING CREEP AND SHRINKAGE OF A CONCRETE FRAME. EVALUATING STRAIN HARDENING USING OPENSEES AND CALCULATE STRUCTURAL BEHAVIOR COEFFICIENT

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

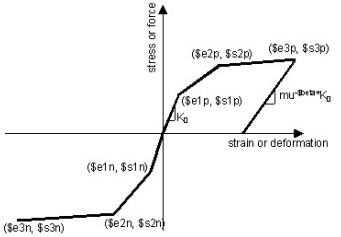




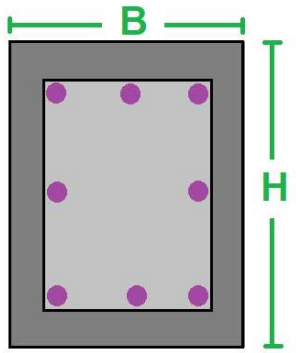
CORE AND COVER CONCRETE REALTION



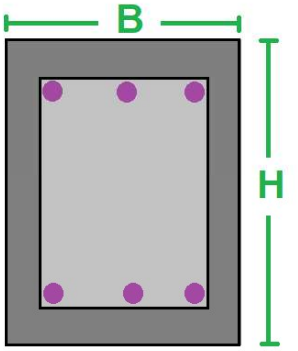
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

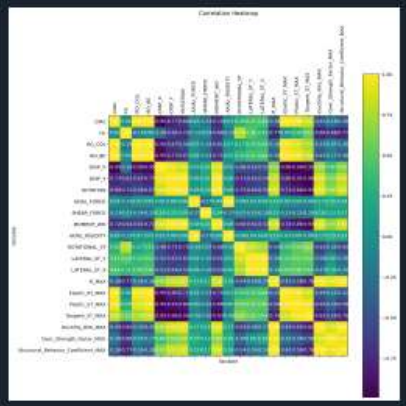
...NKAGE\CREEP_AND_SHRINKAGE_SENSITIVITY_ANALYSIS_REBAR_Cdepth

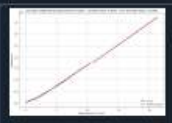
C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...E_CREEP_AND_SHRINKAGE_SENSITIVITY_REBAR_Cdepth.py

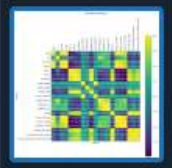
CONCRETE_FRAME_CRE...TY_REBAR_Cdepth.py

```
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
4  #             ANALYZING CREEP AND SHRINKAGE OF A CONCRETE FRAME. EVALUATING STRAIN HARDENIN
5  #           AND ULTIMATE STRAIN CRITERIA USING OPENSEES AND CALCULATE STRUCTURAL BEHAVIOR CO
6  #------------------------------------------------------------------------------------------
7  #                              THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
8  #                                        EMAIL: salar.d.ghashghaei@gmail.com
9  ##########################################################################################
10 """
11 [1] The analysis compares nonlinear rotational behavior of concrete beam-column
12  elements under creep and shrinkage using OpenSees.
13 [2] Two material models—*Steel01* (bilinear without degradation) and *Hysteretic*
14  (tri-linear with pinching and strength/stiffness degradation)—are used.
15 [3] Both models are subjected to identical loading protocols to investigate pushover
16  response under increasing drift demands.
17 [4] In contrast, the *Hysteretic* model shows strength and stiffness degradation, capturing
18  post-peak deterioration and pinching effects.
19 [5] Element rotation histories reveal increasing divergence as inelastic demand accumulates
20  across cycles.
21 [6] The *Hysteretic* model produces reduced energy dissipation capacity due to pinching and
22 cumulative damage.
23 [7] Peak rotation capacity is reduced in the *Hysteretic* model, indicating realistic modeli
24  of damage and failure modes.
25 [8] The comparison highlights the limitations of bilinear idealizations in capturing cyclic
26  degradation in seismic applications.
27 [9] Advanced modeling with calibrated degradation parameters is essential for accurate
28  seismic performance prediction and collapse assessment.
29
30 BOOK: Creep and Shrinkage, Their Effect on the Behavior of Concrete Structures
31 'https://link.springer.com/book/10.1007/978-1-4612-5424-9'
32 WIKOPEDIA:
33 'https://en.wikipedia.org/wiki/Creep_and_shrinkage_of_concrete'
34 PAPER: Experimental investigation on the fundamental behavior of concrete creep
```

15 %







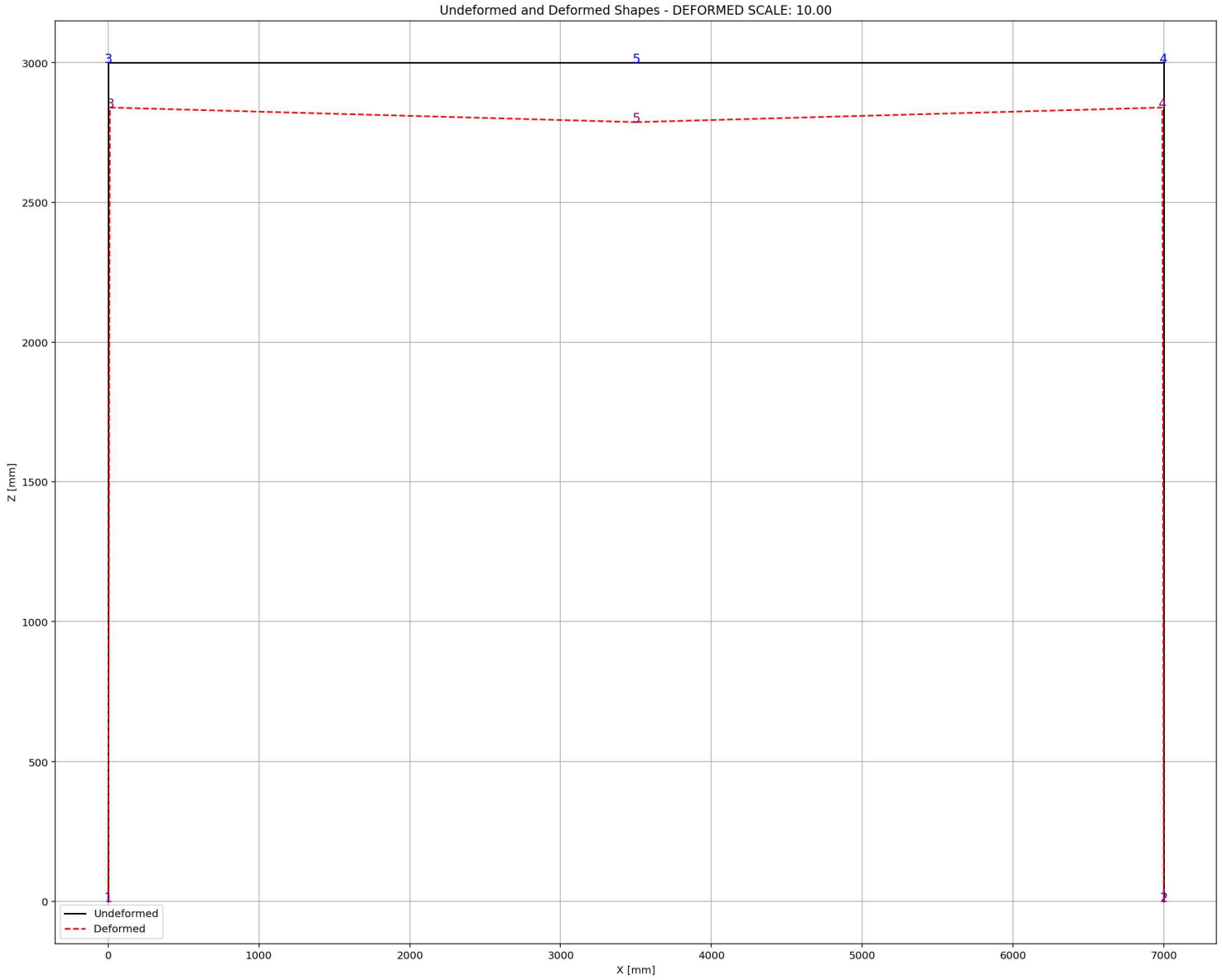
Help Variable Explorer Debugger Plots Files

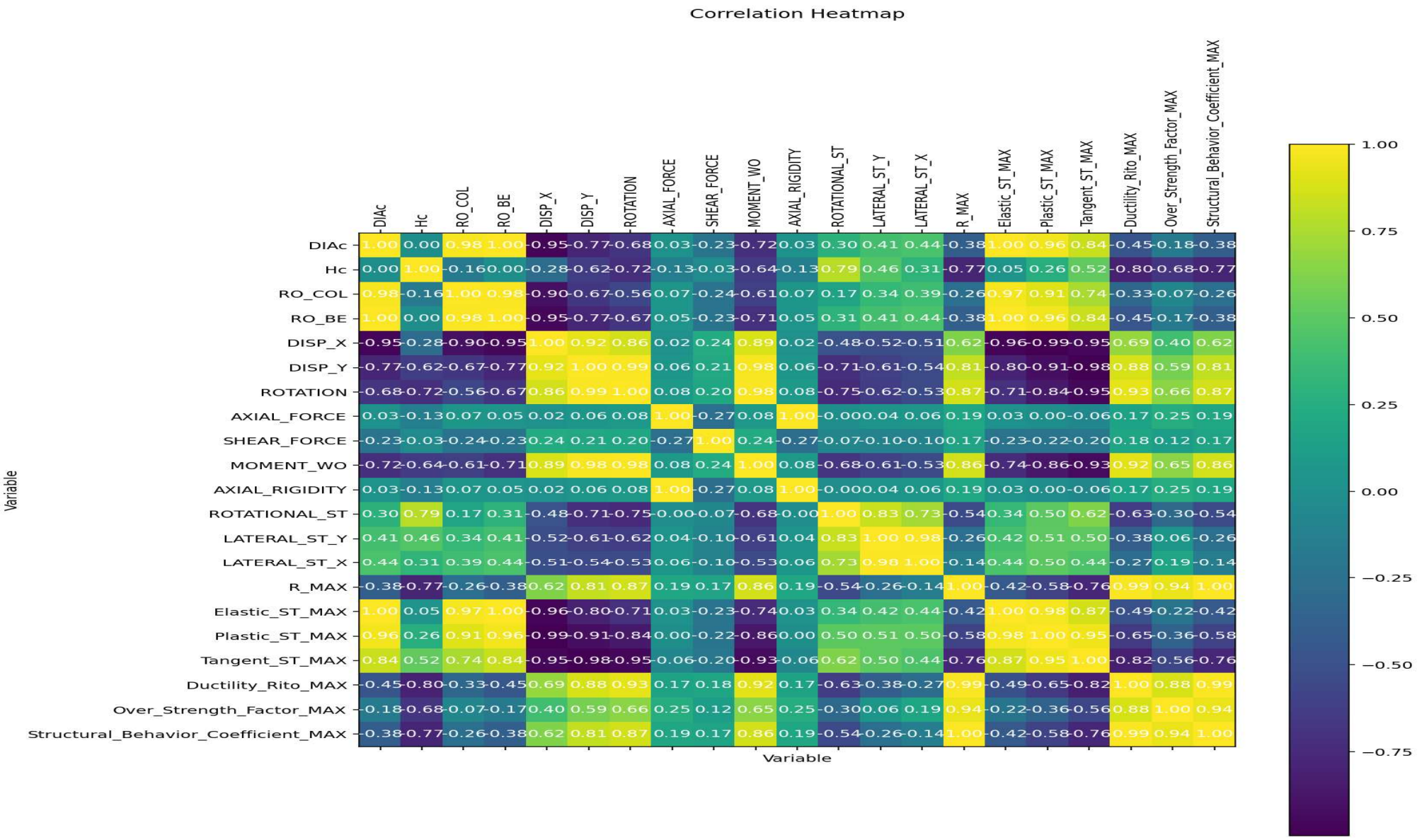
Console 1/A

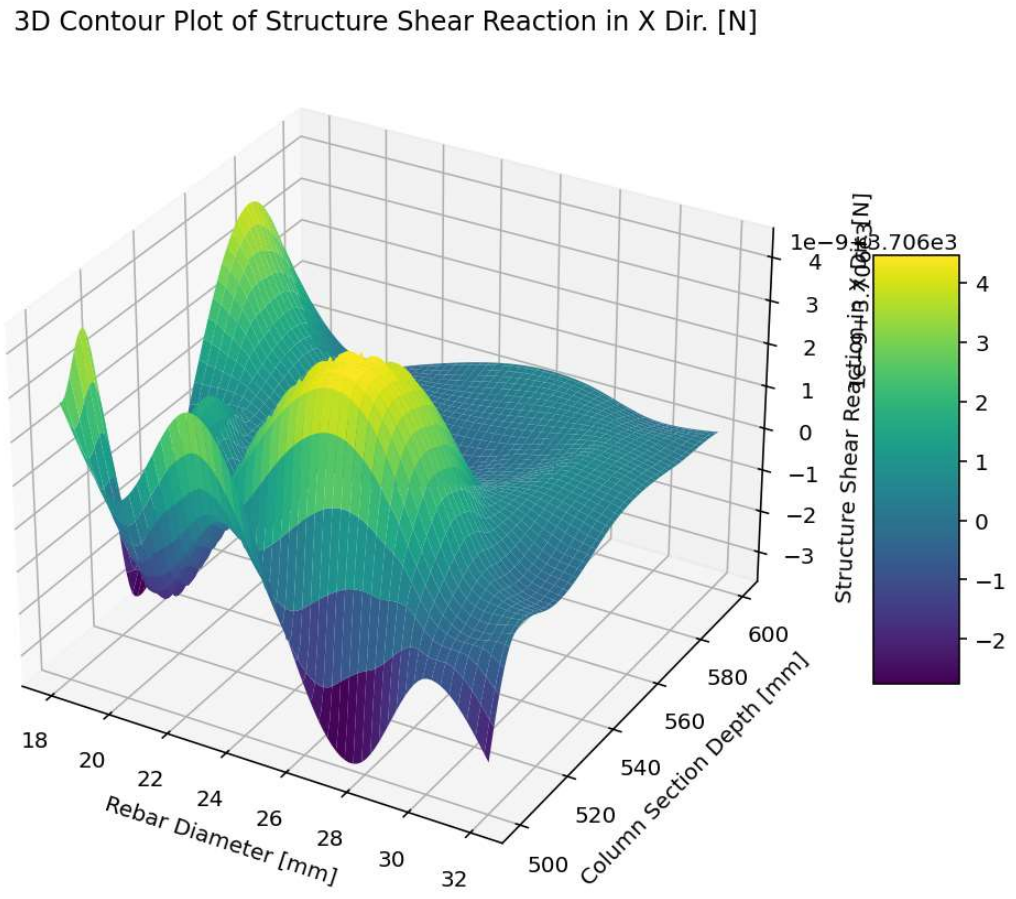
```
Node: 2
   Coordinates  : 7000 0
   Disps: 0 0 0
    unbalanced Load: 0 0 0
    reaction: -219741 1.85303e+07 1.88423e+08
   ID : -1 -1 -1


Node: 3
   Coordinates  : 0 3000
```

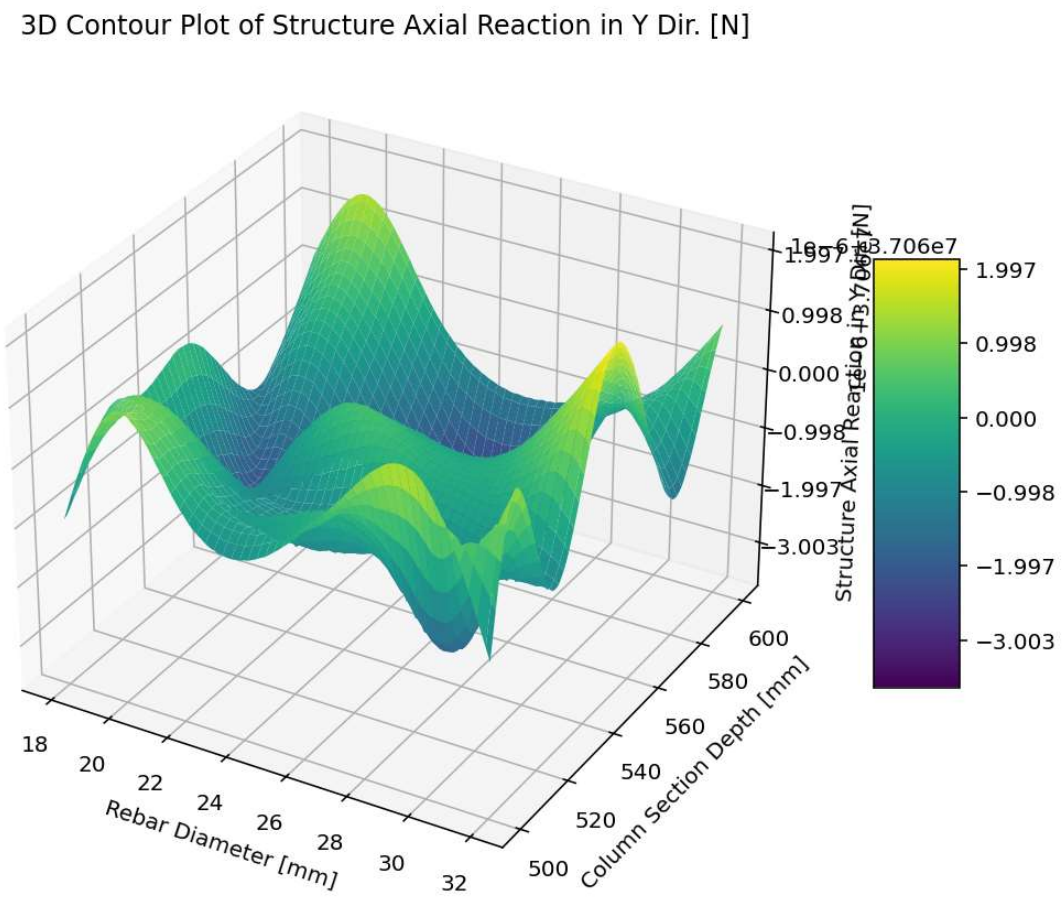
IPython Console History

Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 3, Col 1 UTF-8 CRLF RW Mem 44%

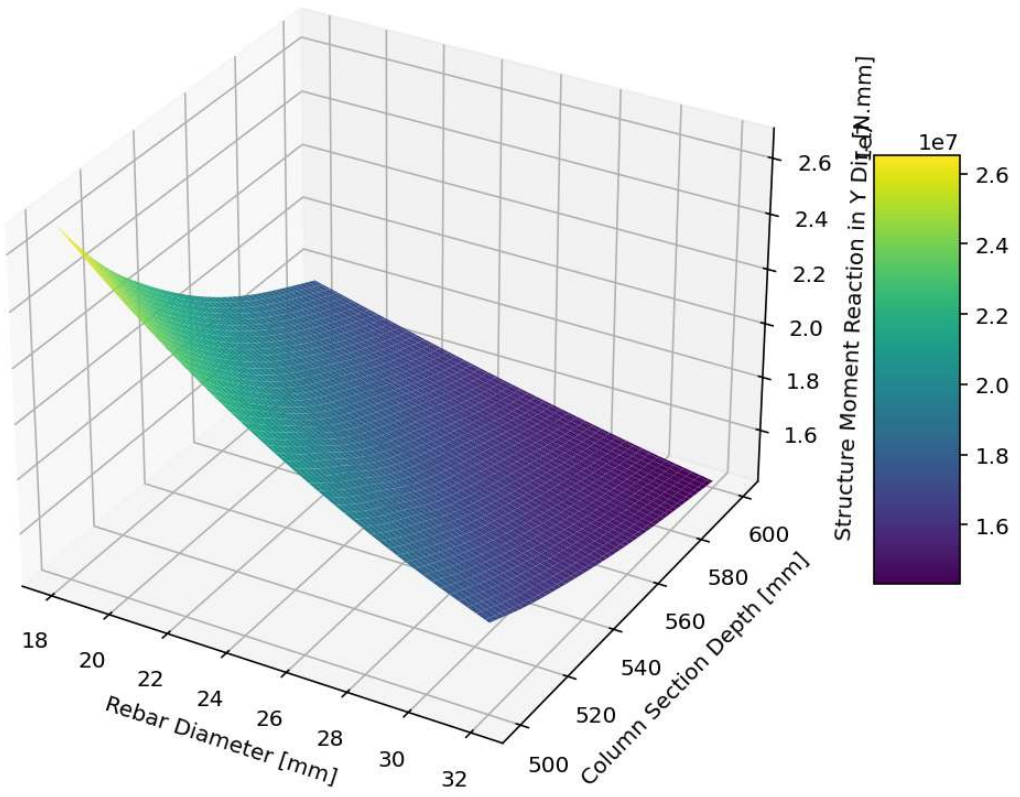

Undeformed and Deformed Shapes - DEFORMED SCALE: 10.00
Z [mm]
X [mm]
Undeformed
Deformed
3
5
4
3
5
4
1
2
0
500
1000
1500
2000
2500
3000
0
1000
2000
3000
4000
5000
6000
7000

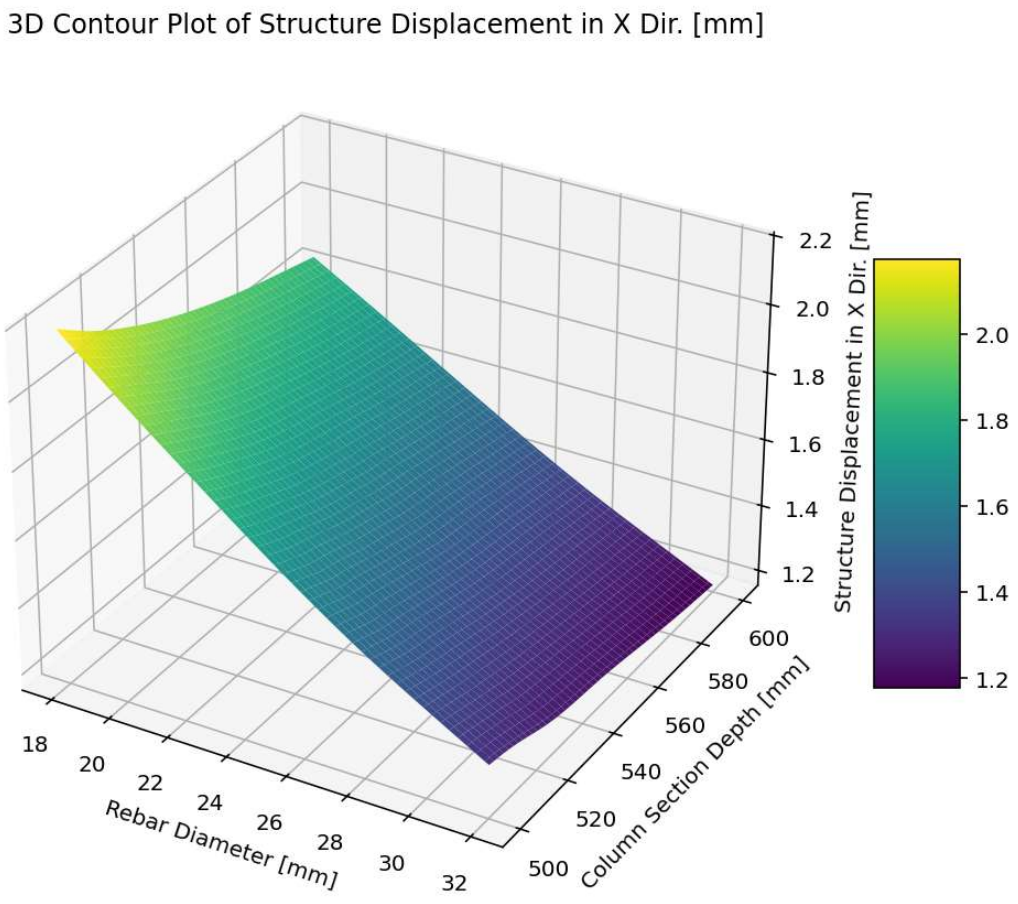

Correlation Heatmap
DIAc
Hc
RO_COL
RO_BE
DISP_X
DISP_Y
ROTATION
AXIAL_FORCE
SHEAR_FORCE
MOMENT_WO
AXIAL_RIGIDITY
ROTATIONAL_ST
LATERAL_ST_Y
LATERAL_ST_X
R_MAX
Elastic_ST_MAX
Plastic_ST_MAX
Tangent_ST_MAX
Ductility_Rito_MAX
Over_Strength_Factor_MAX
Structural_Behavior_Coefficient_MAX
Variable
Variable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

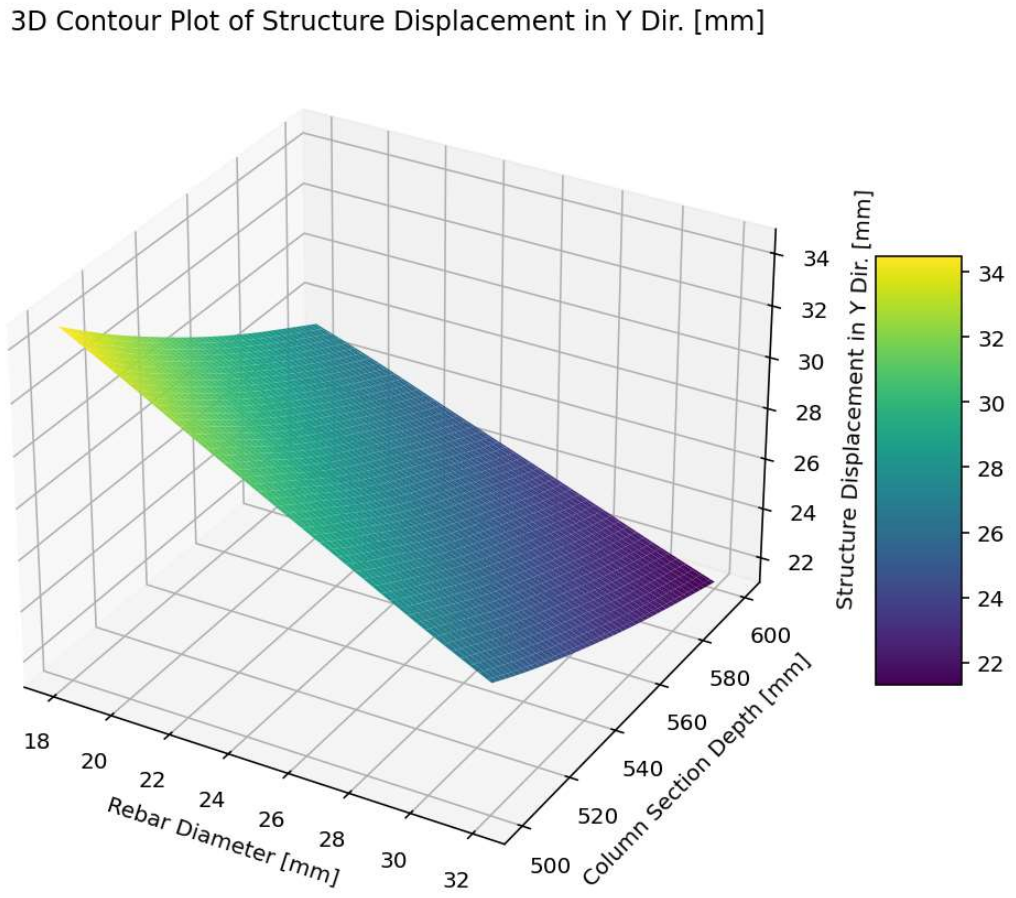

3D Contour Plot of Structure Shear Reaction in X Dir. [N]
1e−9+3.706e3
4
3
2
1
0
−1
−2
−3
Structure Shear Reaction in X Dir. [N]
18
20
22
24
26
28
30
32
Rebar Diameter [mm]
500
520
540
560
580
600
Column Section Depth [mm]

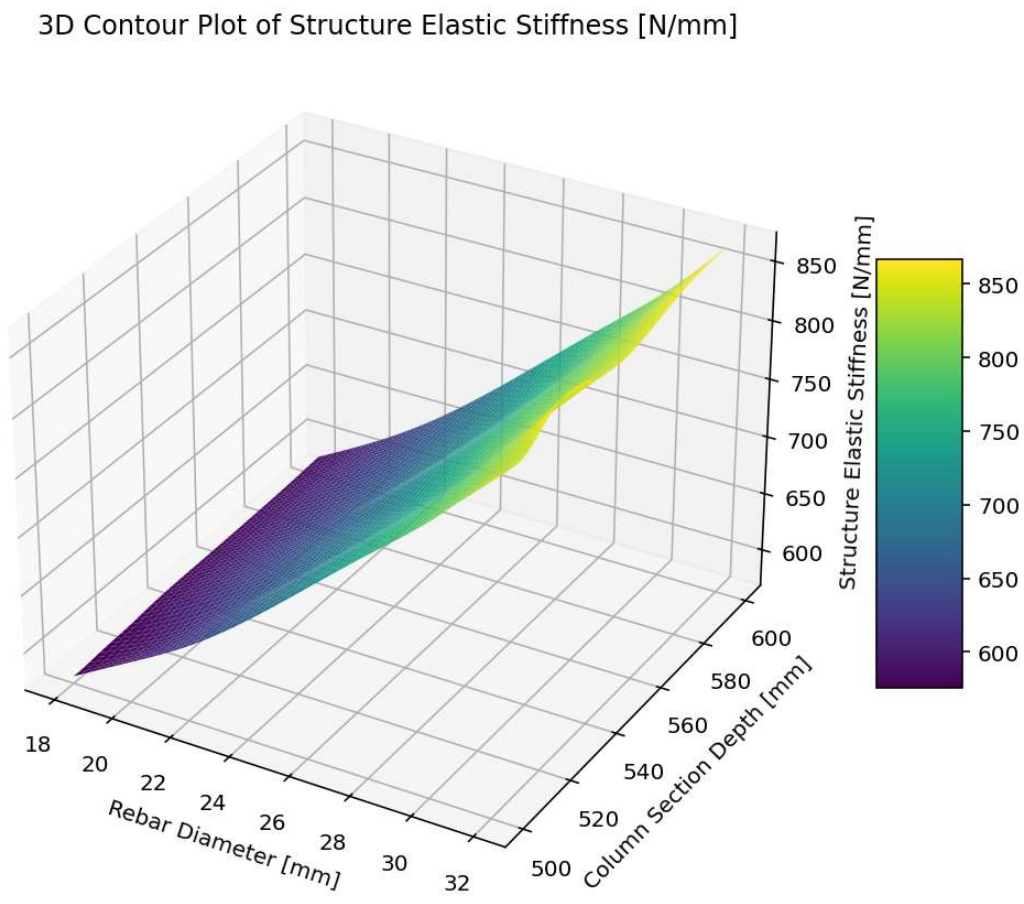

3D Contour Plot of Structure Axial Reaction in Y Dir. [N]
1e−6 +3.706e7
1.997
0.998
0.000
−0.998
−1.997
−3.003
Structure Axial Reaction in Y Dir. [N]
18
20
22
24
26
28
30
32
Rebar Diameter [mm]
500
520
540
560
580
600
Column Section Depth [mm]

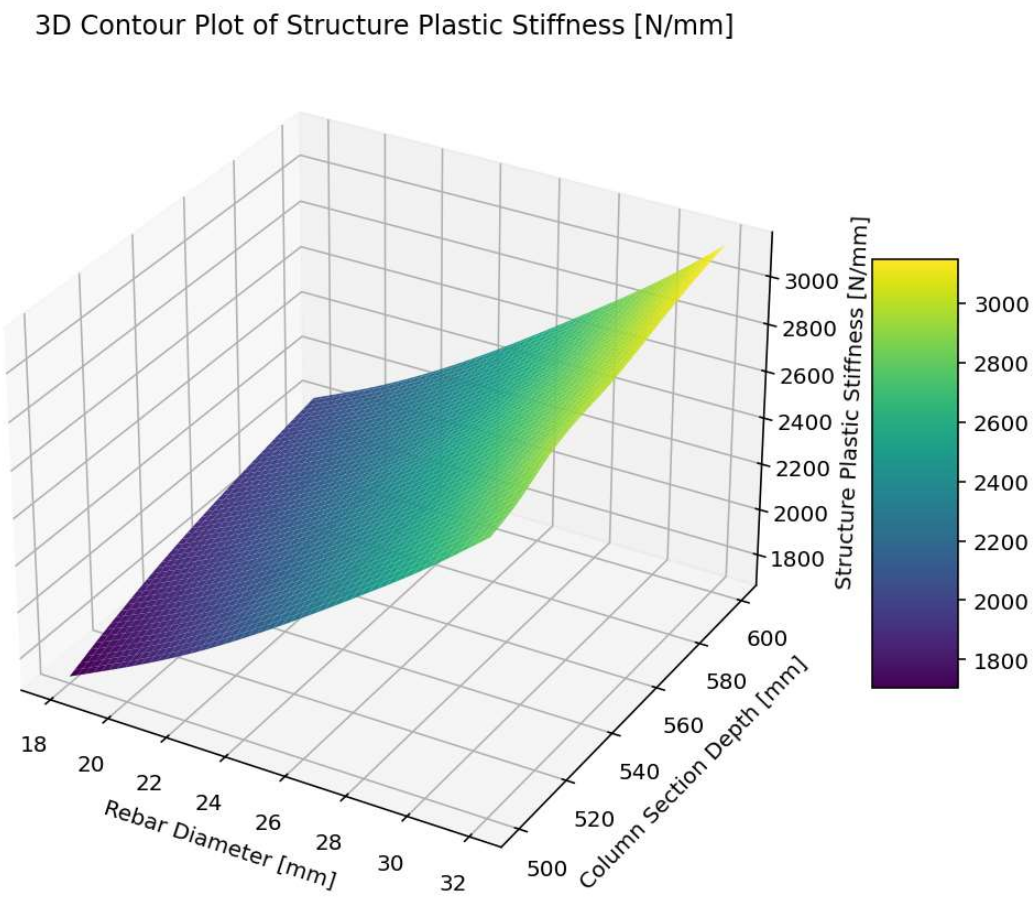
3D Contour Plot of Structure Moment Reaction in Y Dir. [N.mm]

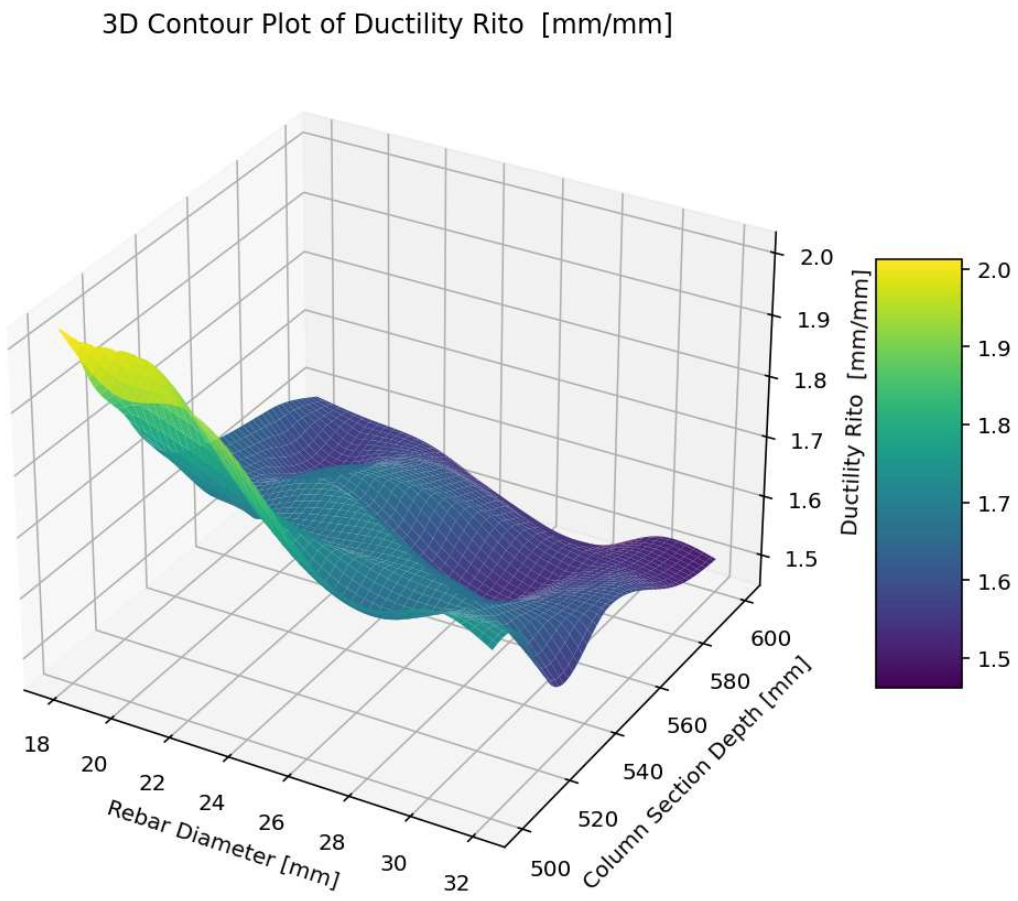


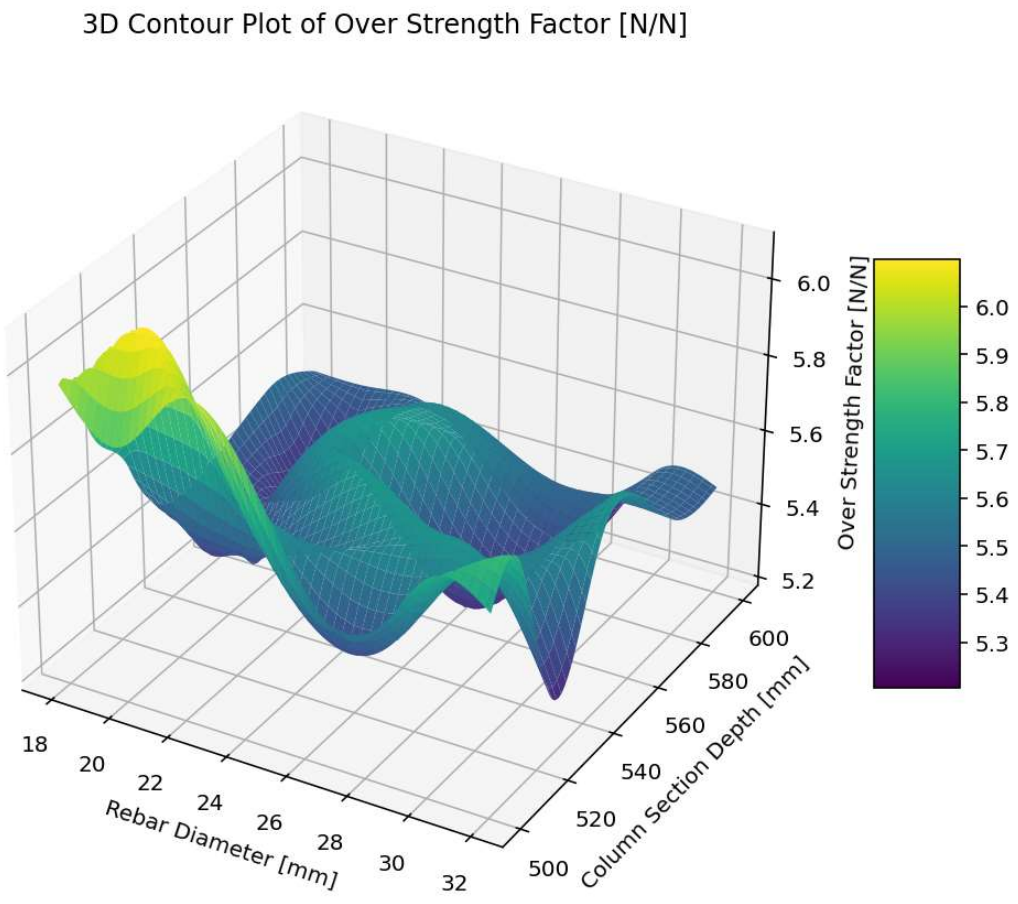

3D Contour Plot of Structure Displacement in X Dir. [mm]
Rebar Diameter [mm]
18
20
22
24
26
28
30
32
Column Section Depth [mm]
500
520
540
560
580
600
Structure Displacement in X Dir. [mm]
1.2
1.4
1.6
1.8
2.0
2.2

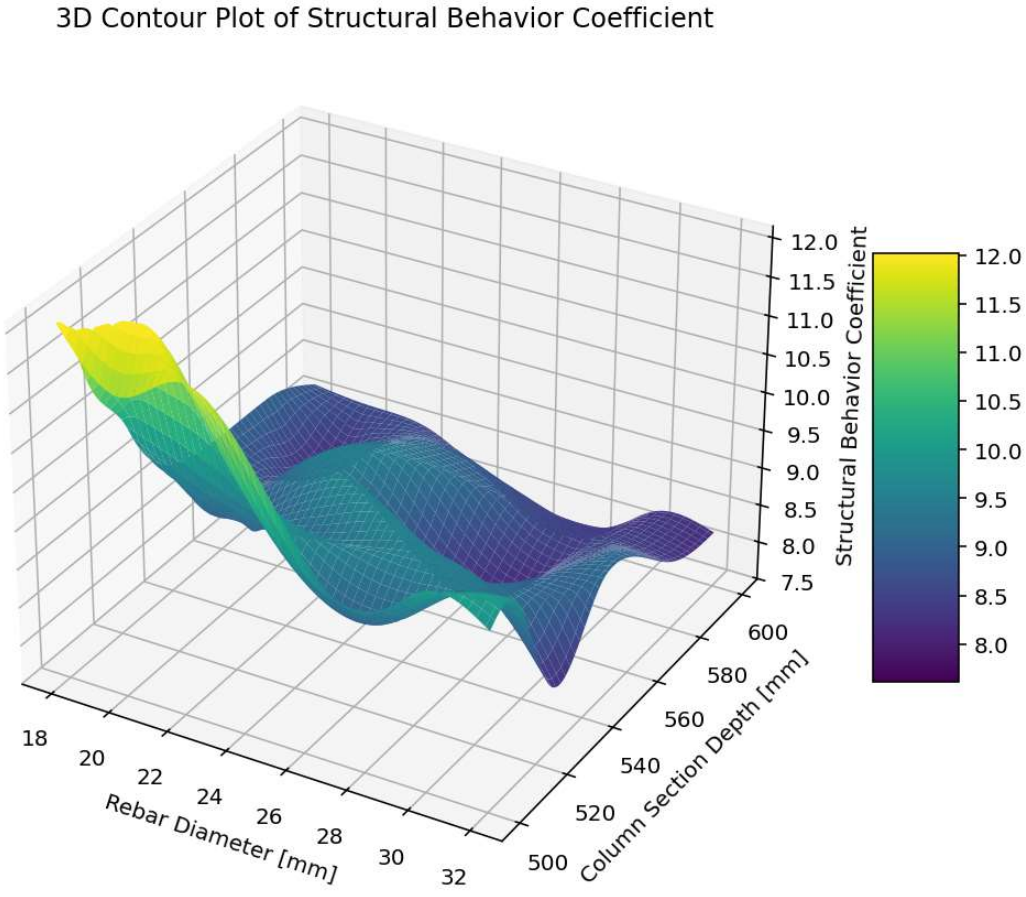

3D Contour Plot of Structure Displacement in Y Dir. [mm]
Rebar Diameter [mm]
18
20
22
24
26
28
30
32
Column Section Depth [mm]
500
520
540
560
580
600
Structure Displacement in Y Dir. [mm]
22
24
26
28
30
32
34

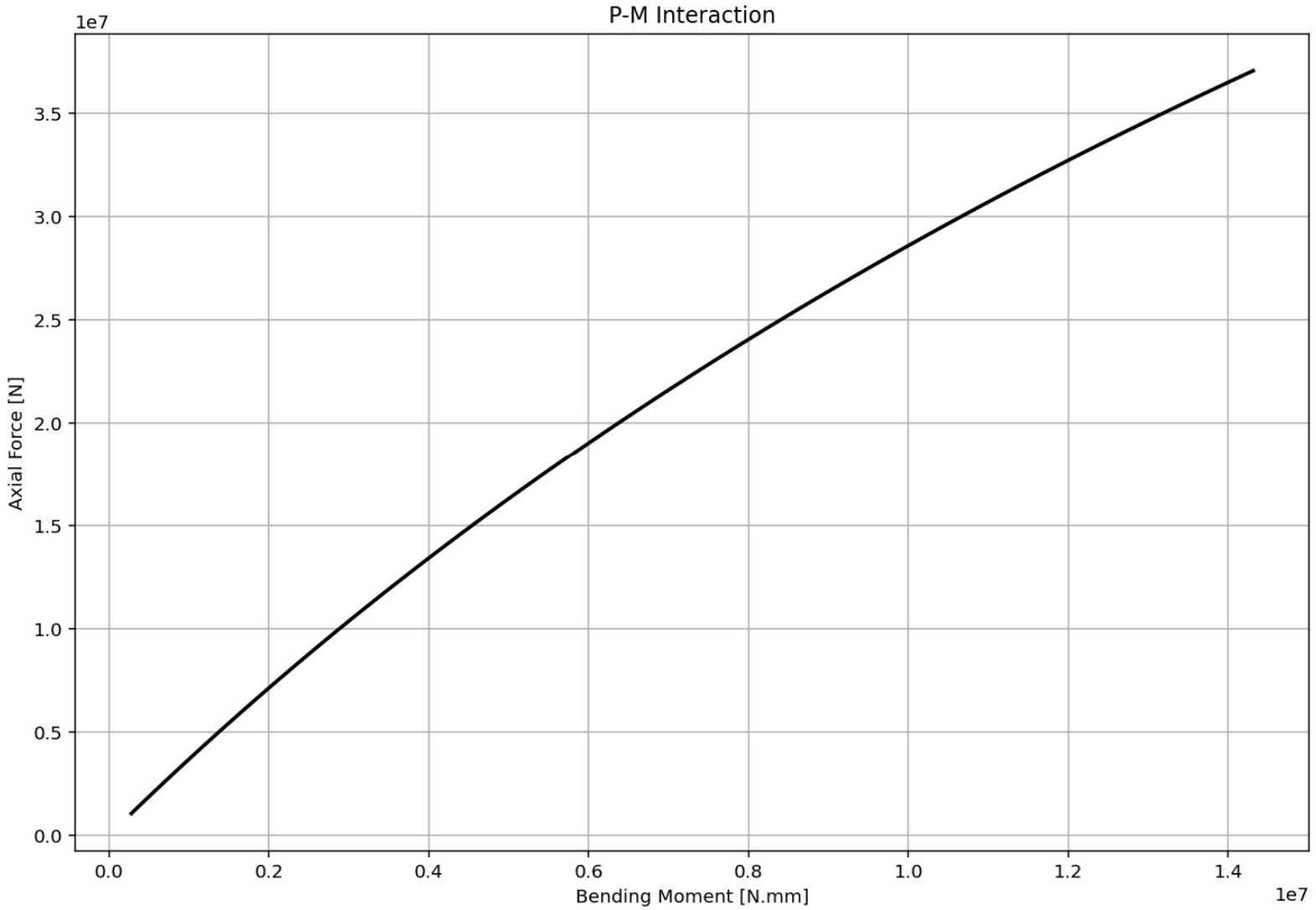

3D Contour Plot of Structure Elastic Stiffness [N/mm]
Structure Elastic Stiffness [N/mm]
850
800
750
700
650
600
Rebar Diameter [mm]
18
20
22
24
26
28
30
32
Column Section Depth [mm]
500
520
540
560
580
600

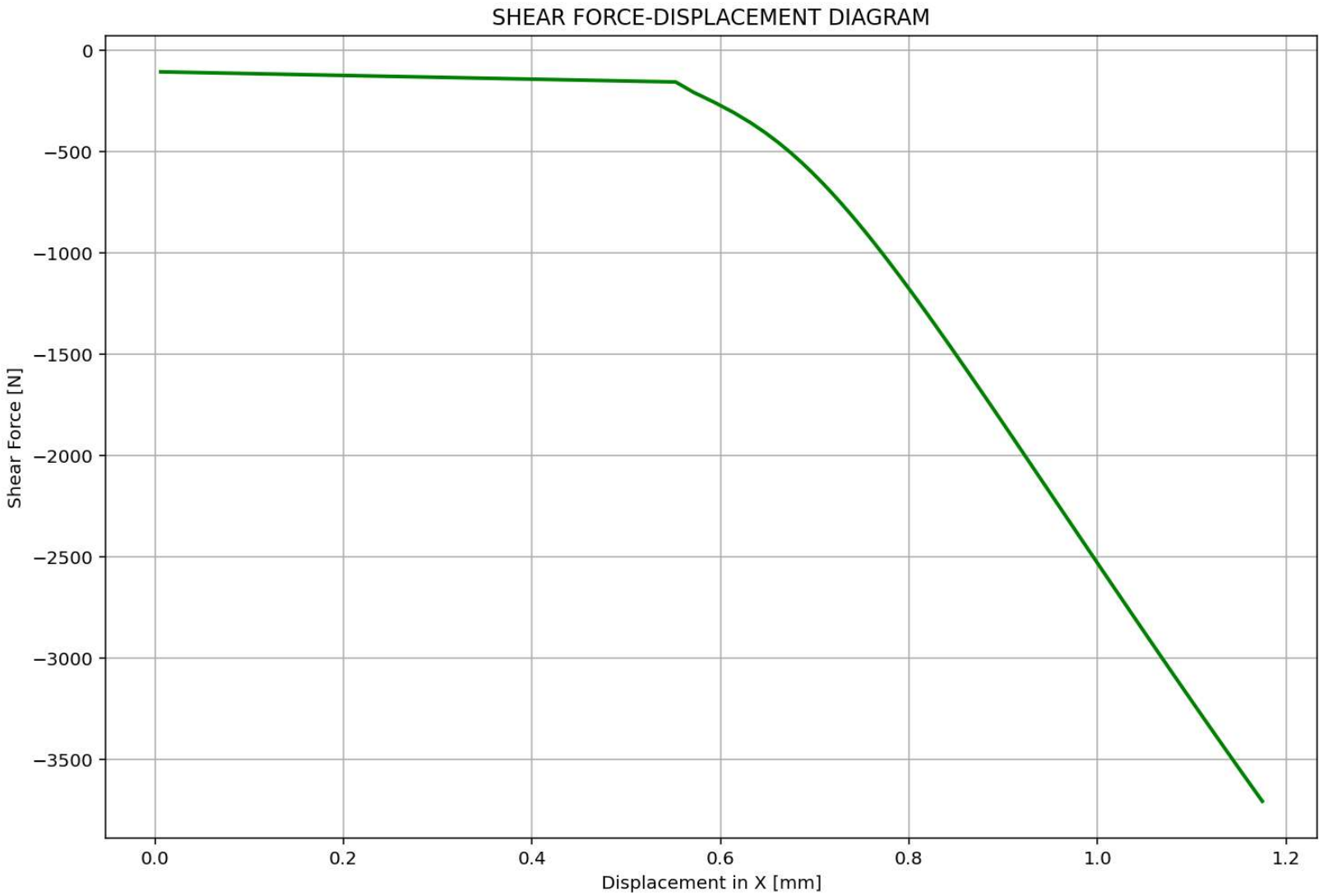

3D Contour Plot of Structure Plastic Stiffness [N/mm]
Structure Plastic Stiffness [N/mm]
3000
2800
2600
2400
2200
2000
1800
Rebar Diameter [mm]
18
20
22
24
26
28
30
32
Column Section Depth [mm]
500
520
540
560
580
600

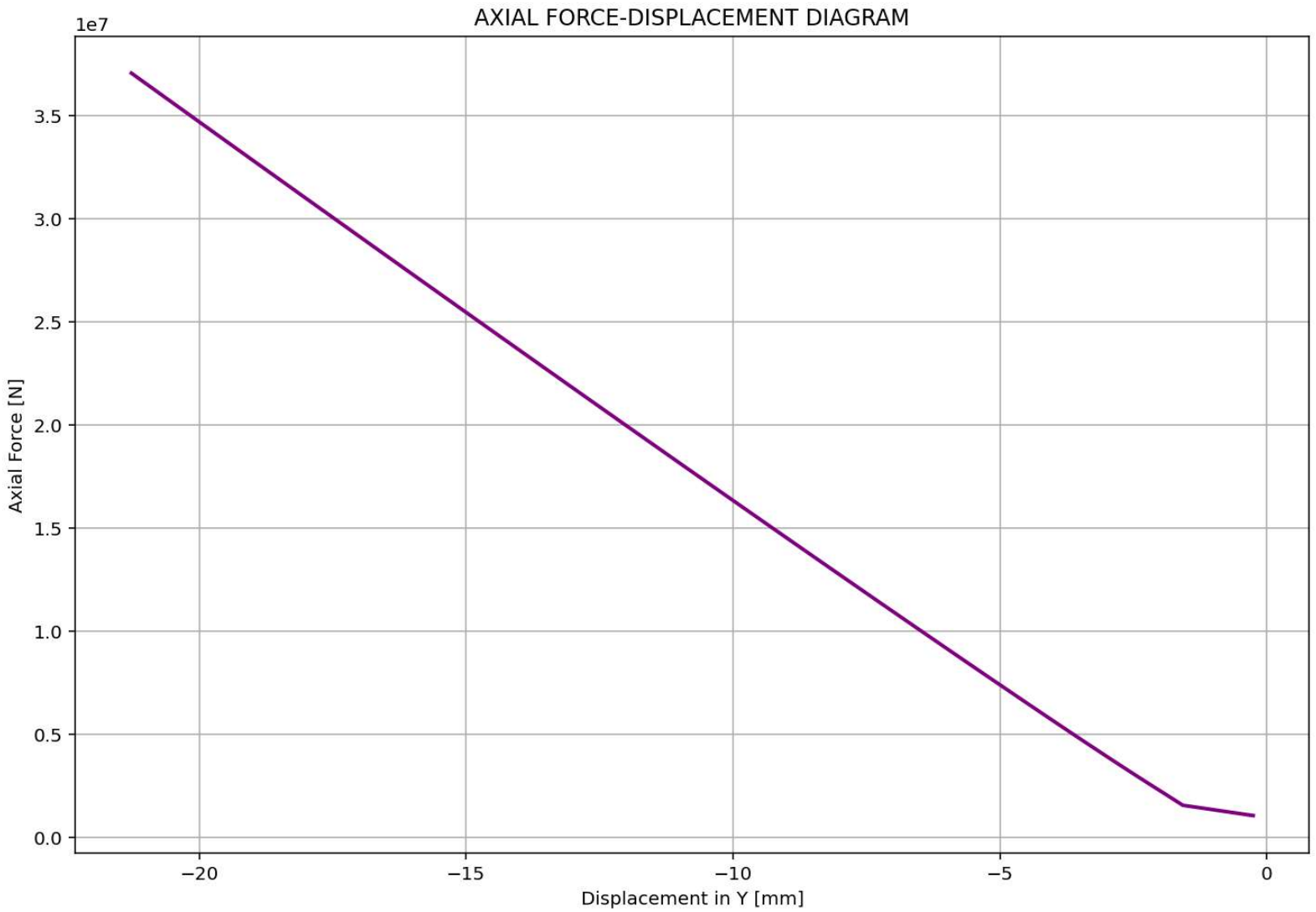

3D Contour Plot of Ductility Rito [mm/mm]
Rebar Diameter [mm]
18
20
22
24
26
28
30
32
Column Section Depth [mm]
500
520
540
560
580
600
Ductility Rito [mm/mm]
1.5
1.6
1.7
1.8
1.9
2.0

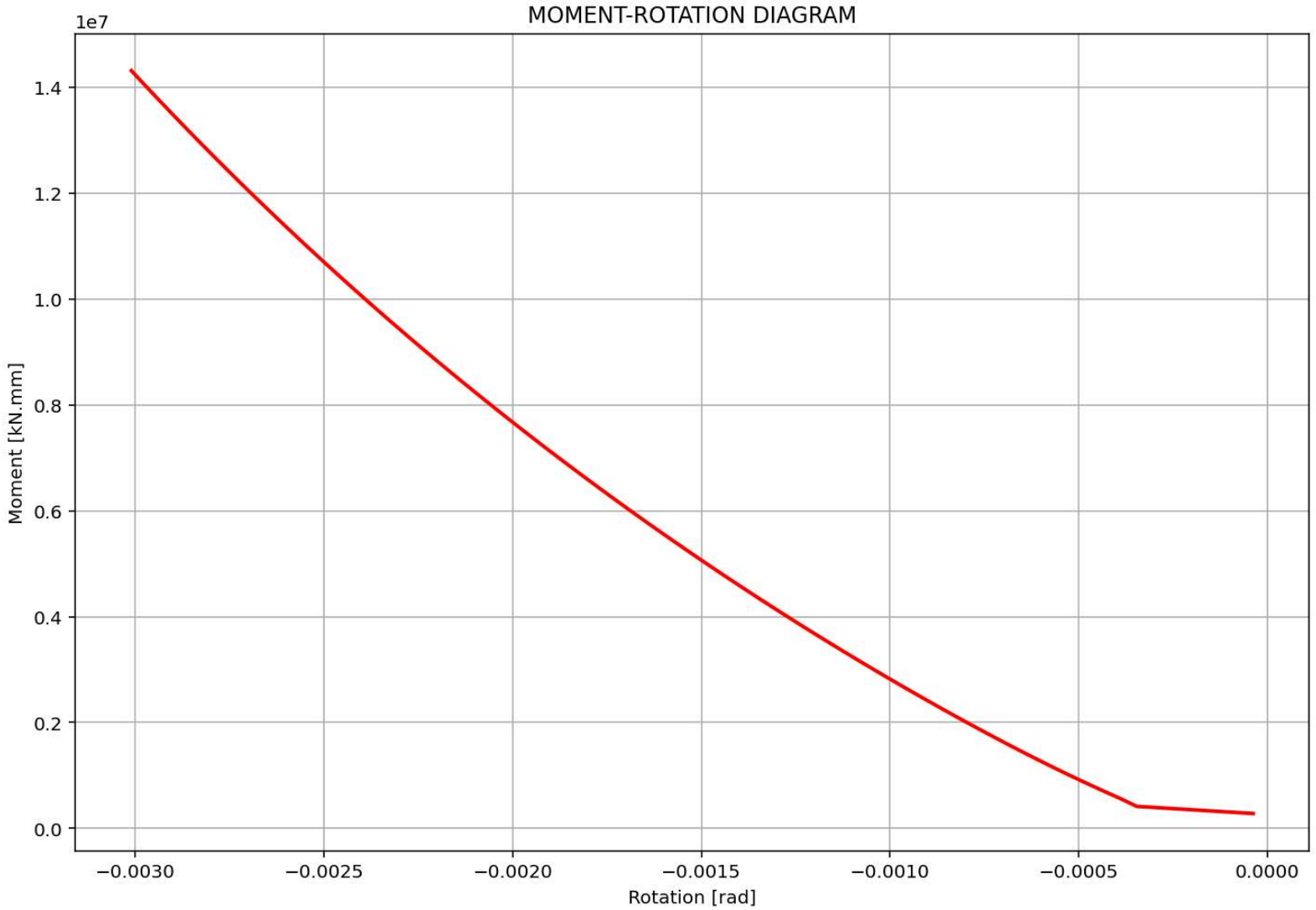

3D Contour Plot of Over Strength Factor [N/N]
Rebar Diameter [mm]
18
20
22
24
26
28
30
32
Column Section Depth [mm]
500
520
540
560
580
600
5.2
5.4
5.6
5.8
6.0
Over Strength Factor [N/N]
5.3
5.4
5.5
5.6
5.7
5.8
5.9
6.0

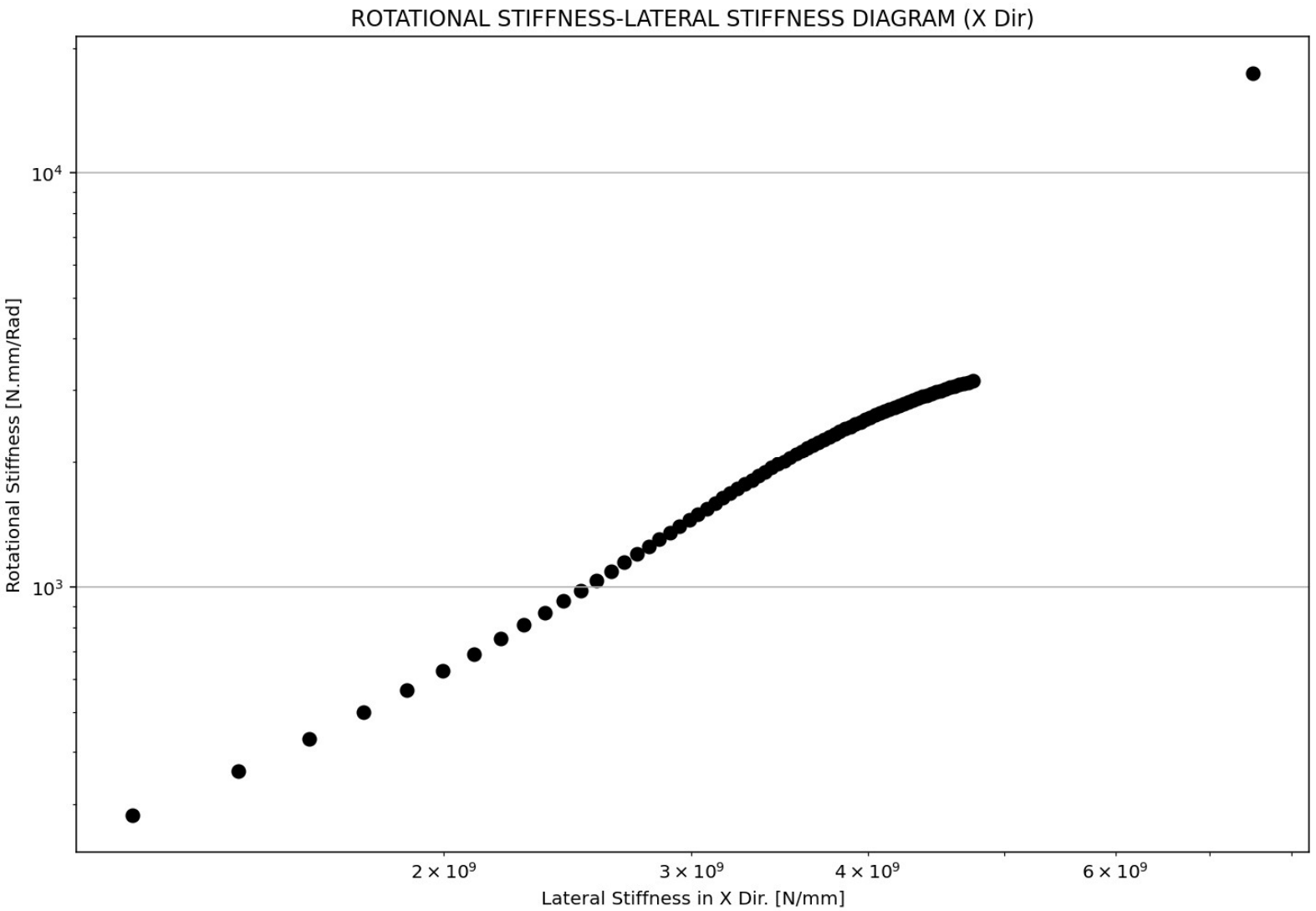

3D Contour Plot of Structural Behavior Coefficient
Structural Behavior Coefficient
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
Rebar Diameter [mm]
18
20
22
24
26
28
30
32
Column Section Depth [mm]
500
520
540
560
580
600

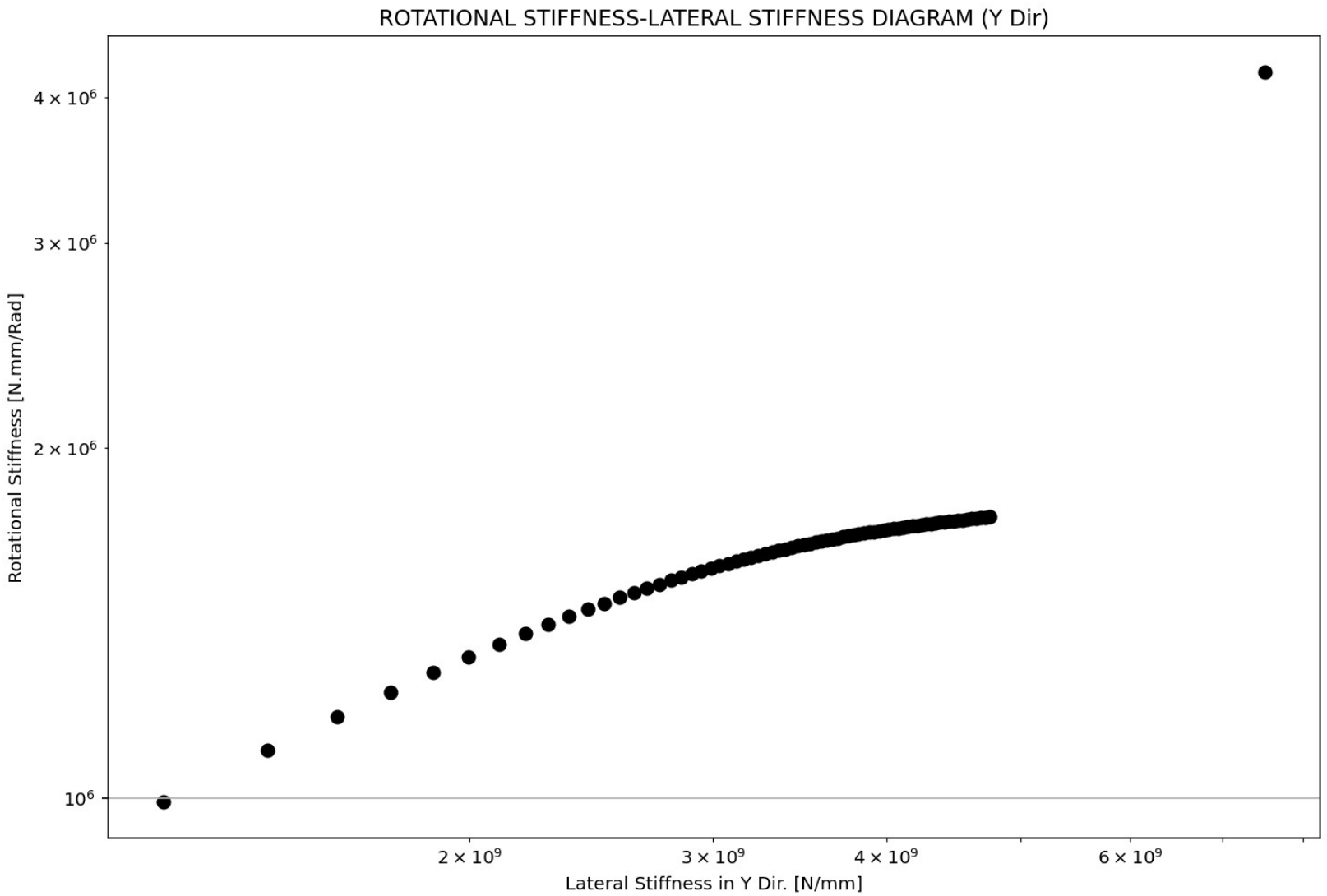

P-M Interaction
1e7
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Axial Force [N]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1e7
Bending Moment [N.mm]

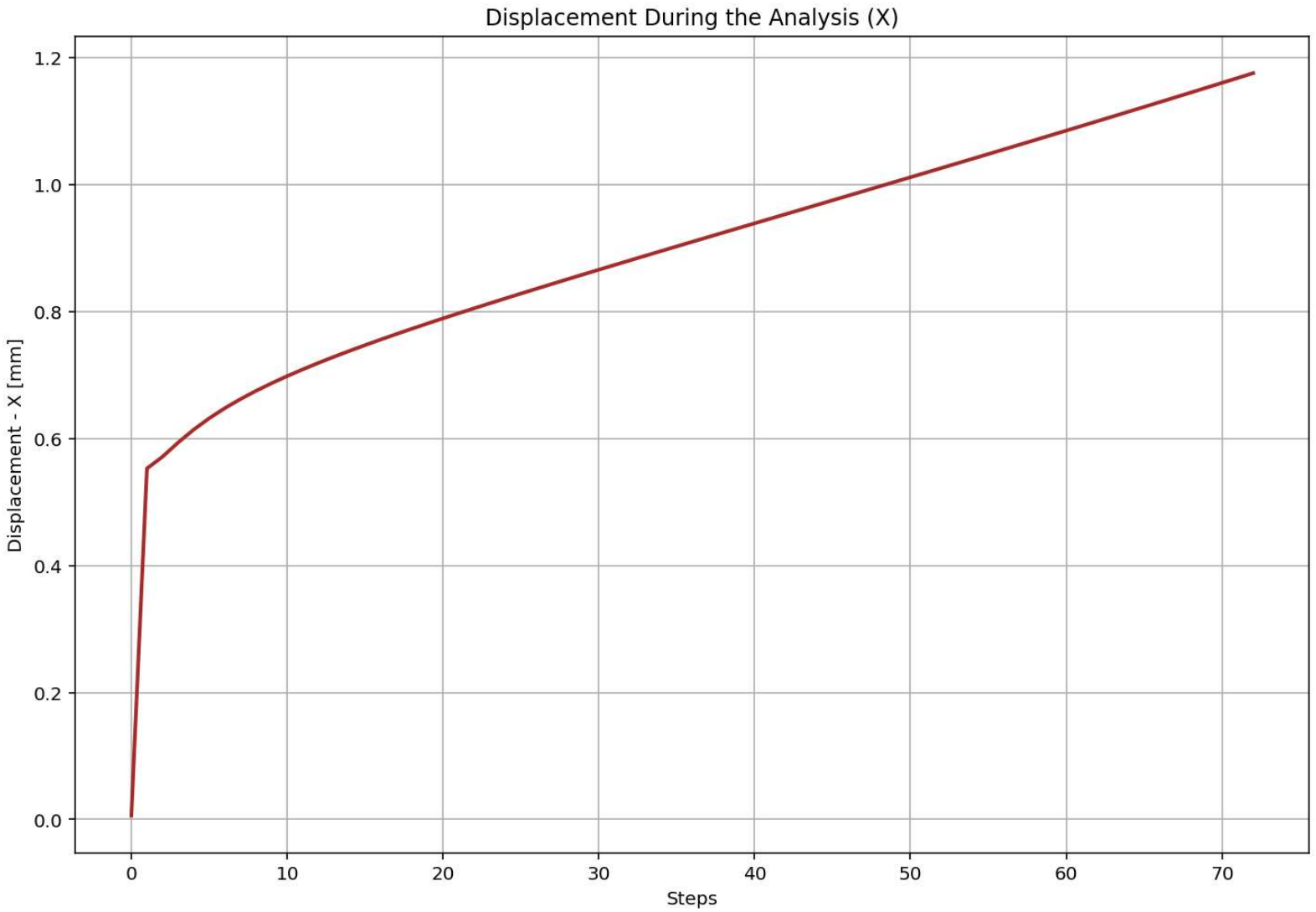

SHEAR FORCE-DISPLACEMENT DIAGRAM
Shear Force [N]
0
−500
−1000
−1500
−2000
−2500
−3000
−3500
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Displacement in X [mm]

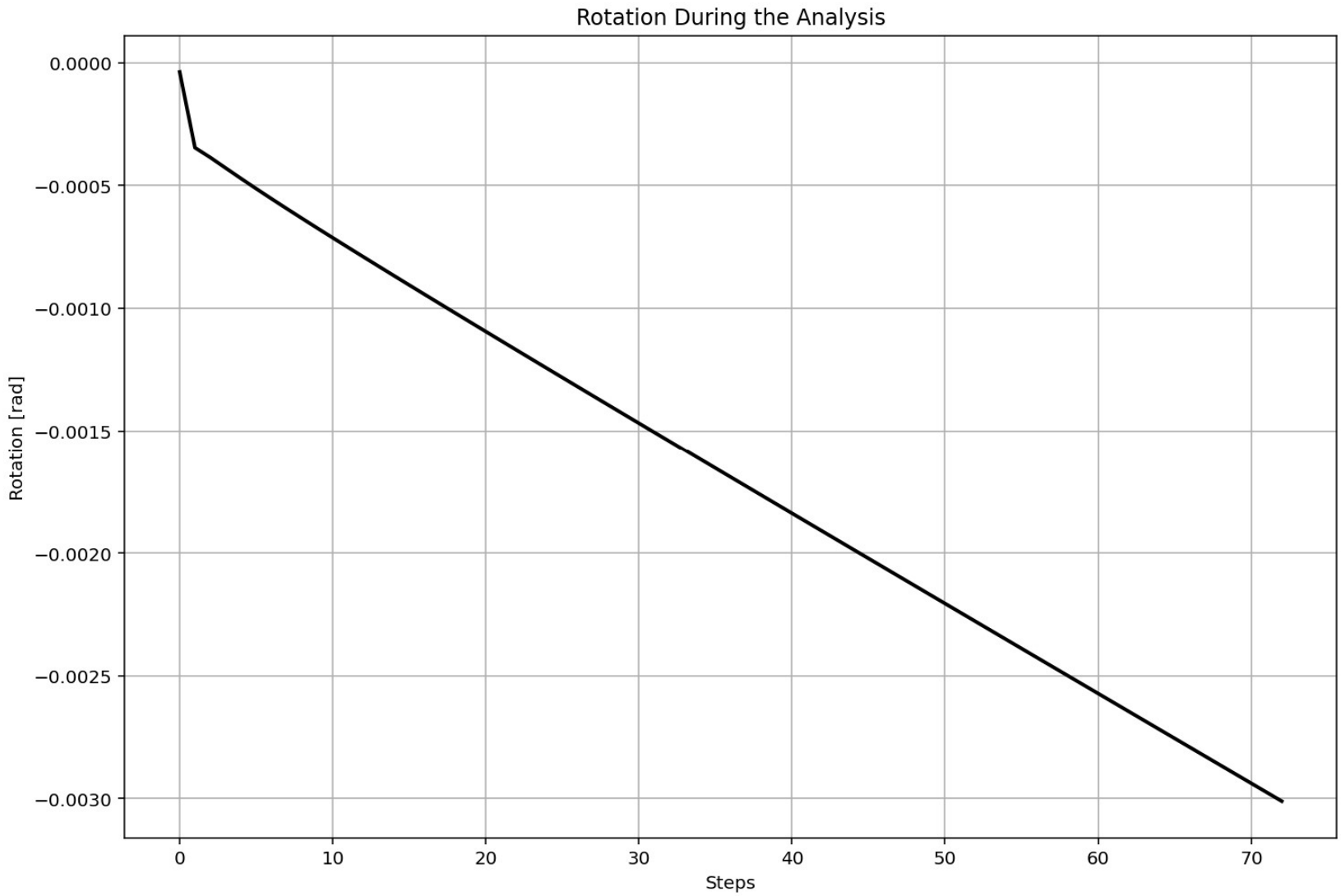

AXIAL FORCE-DISPLACEMENT DIAGRAM
1e7
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Axial Force [N]
−20
−15
−10
−5
0
Displacement in Y [mm]

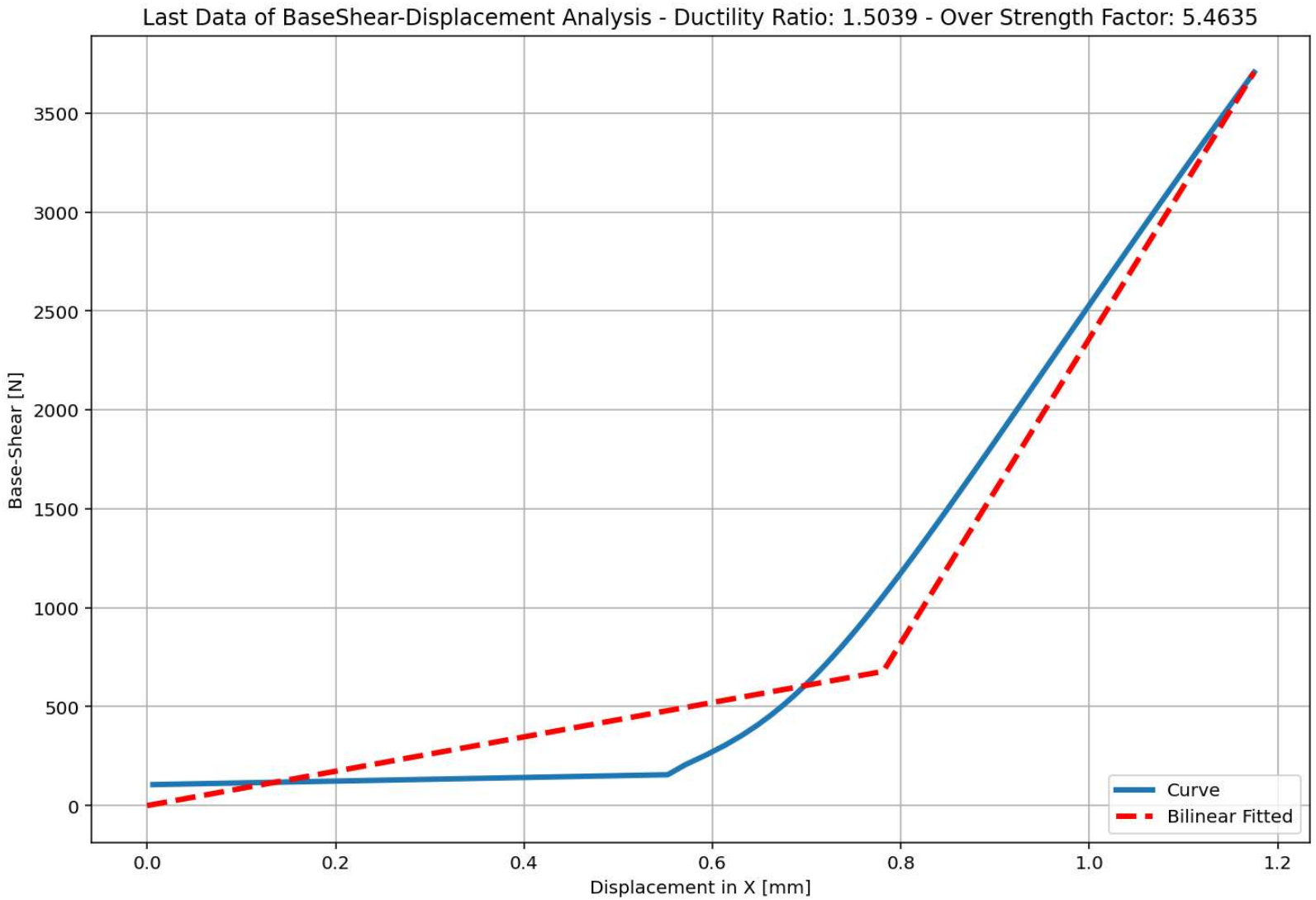

MOMENT-ROTATION DIAGRAM
1e7
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Moment [kN.mm]
−0.0030
−0.0025
−0.0020
−0.0015
−0.0010
−0.0005
0.0000
Rotation [rad]

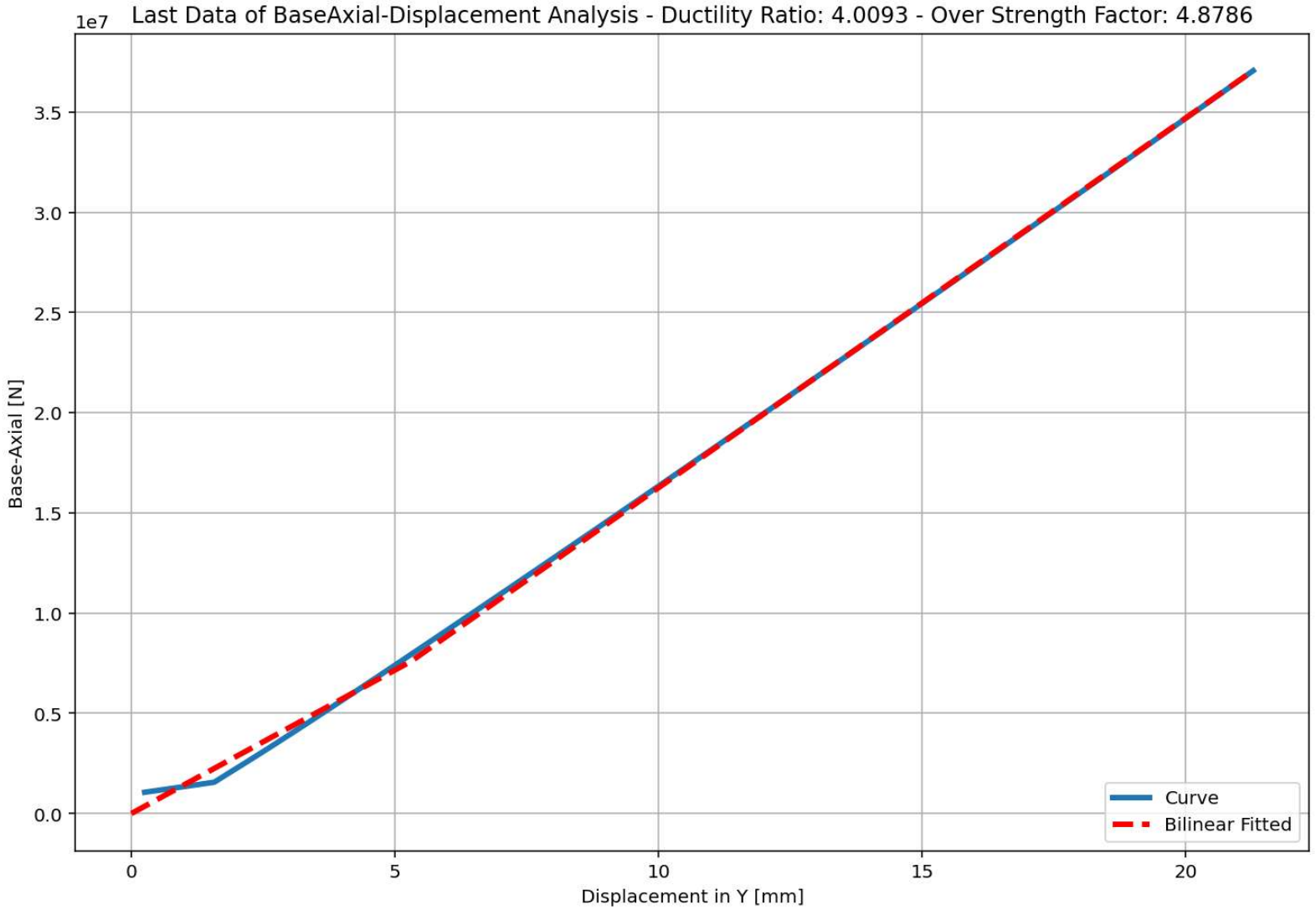

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM (X Dir)
Rotational Stiffness [N.mm/Rad]
10^4
10^3
2×10^9
3×10^9
4×10^9
6×10^9
Lateral Stiffness in X Dir. [N/mm]


ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM (Y Dir)
Rotational Stiffness [N.mm/Rad]
4×10^6
3×10^6
2×10^6
10^6
2×10^9
3×10^9
4×10^9
6×10^9
Lateral Stiffness in Y Dir. [N/mm]


Displacement During the Analysis (X)
Displacement - X [mm]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
60
70
Steps


Rotation During the Analysis
0.0000
−0.0005
−0.0010
−0.0015
−0.0020
−0.0025
−0.0030
Rotation [rad]
0
10
20
30
40
50
60
70
Steps


Last Data of BaseShear-Displacement Analysis - Ductility Ratio: 1.5039 - Over Strength Factor: 5.4635
Base-Shear [N]
3500
3000
2500
2000
1500
1000
500
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Displacement in X [mm]
Curve
Bilinear Fitted


Last Data of BaseAxial-Displacement Analysis - Ductility Ratio: 4.0093 - Over Strength Factor: 4.8786
1e7
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Base-Axial [N]
0
5
10
15
20
Displacement in Y [mm]
Curve
Bilinear Fitted