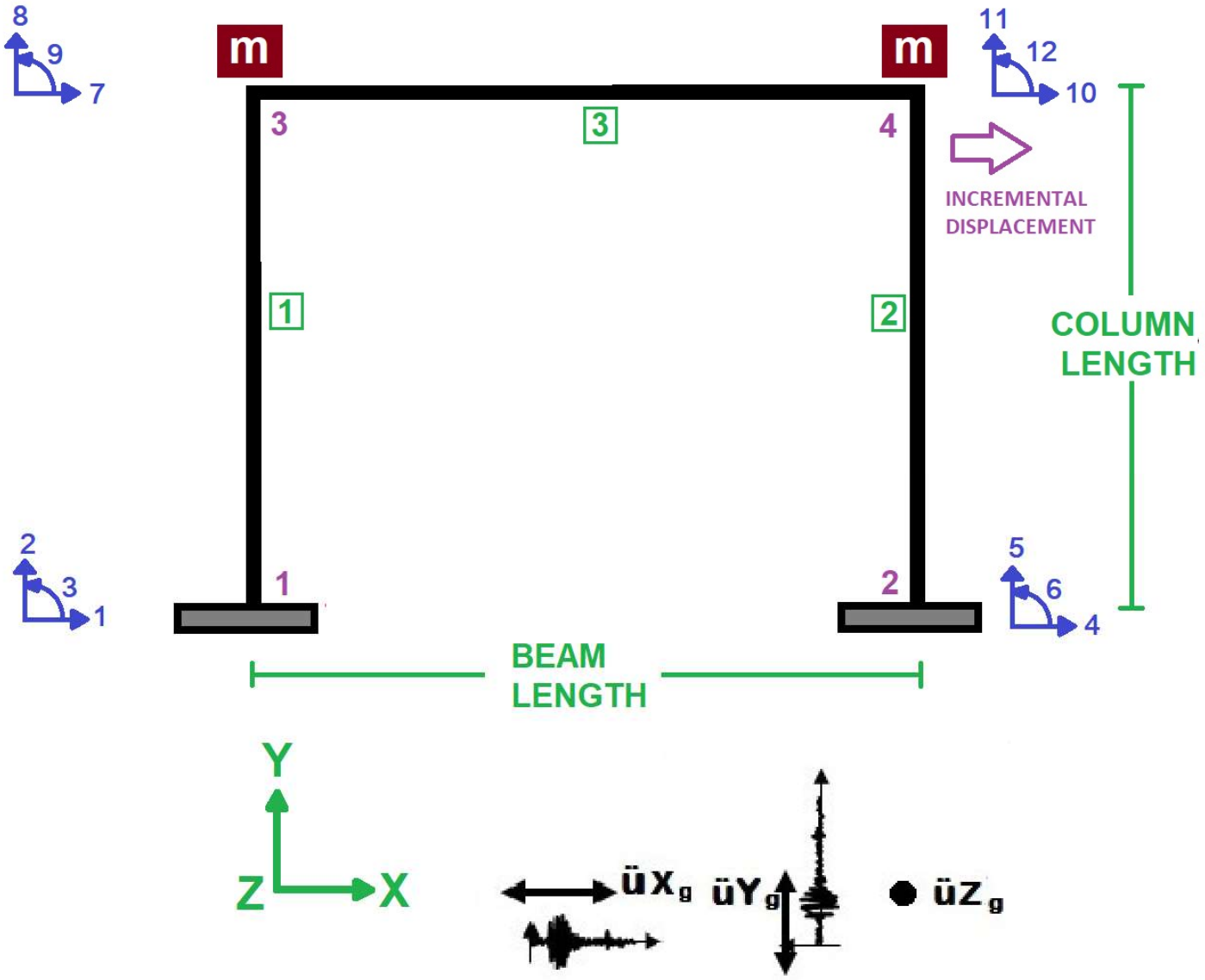
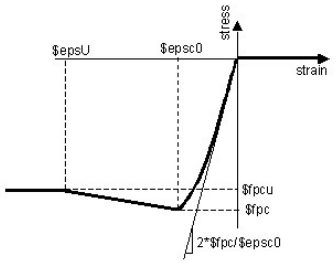
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

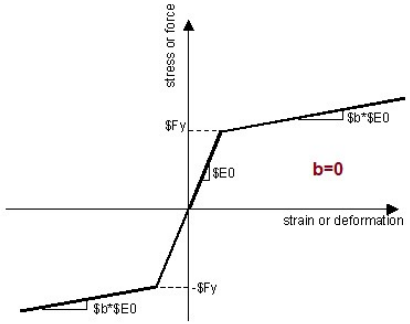
OPTIMIZATION OF COLUMN SECTION DEPTH BASED ON TARGET STRUCTURAL PERIOD FOR CONCRETE FRAME USING OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)

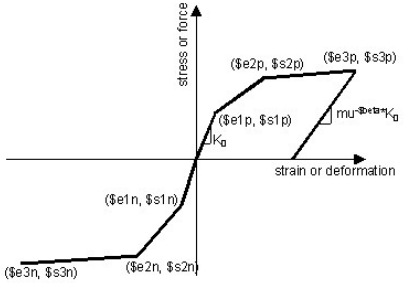

8
9
7
m
m
11
12
10
3
3
4
INCREMENTAL
DISPLACEMENT
1
2
COLUMN
LENGTH
2
3
1
1
2
5
6
4
BEAM
LENGTH
Y
Z
X
üX g
üY g
üZ g



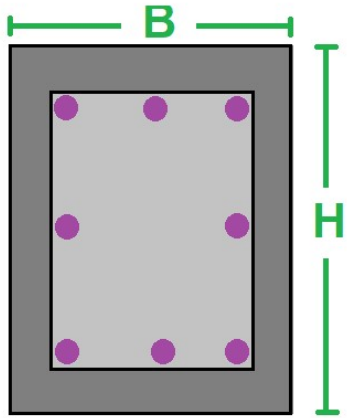
CORE AND COVER CONCRETE REALTION



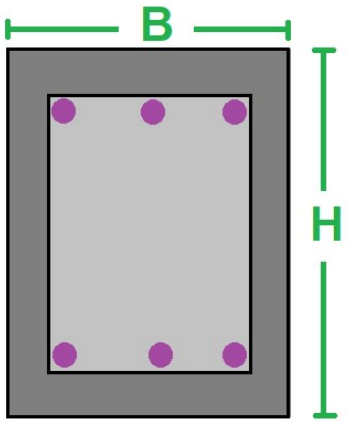
WITHOUT HARDENING AND ULTIMATE STRAIN



WITH HARDENING AND ULTIMATE STRAIN



COLUMN SECTION



BEAM SECTION

Spyder (Python 3.12)

File Edit Search Source Run Debug Consoles Projects Tools View Help

C:\Users\Dell\Desktop\OPENSEES_FILES\CONCRETE_FRA...PTIMIZATION\DYNAMIC_Cdepth_PERIOD_OPTIMIZATION.py

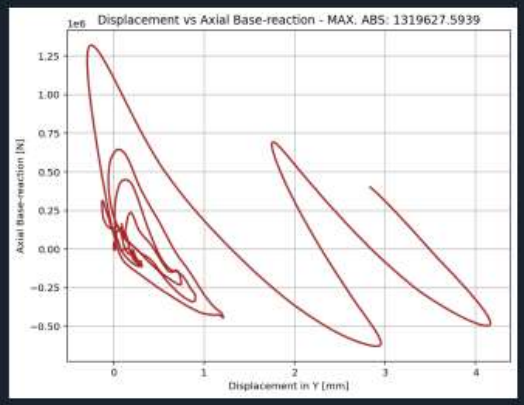
DYNAMIC_Cdepth_PERIOD_OPTIMIZATION.py

```
#############################################################################################################
#                          >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<
#      OPTIMIZATION OF COLUMN SECTION DEPTH BASED ON TARGET STRUCTURAL PERIOD FOR CONCRETE FRAME USING
#-------------------------------------------------------------------------------------------------------
#                                  OPTIMIZATION ALGORITHM: NEWTON-RAPHSON METHOD
#-------------------------------------------------------------------------------------------------------
#                               THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
#                                        EMAIL: salar.d.ghashghaei@gmail.com
#############################################################################################################
"""
1. This Python script performs nonlinear dynamic and pushover analysis of a 2D reinforced concrete fra
2. The code implements a Newton-Raphson optimization algorithm to determine optimal column depth basec
3. Advanced material models include confined/unconfined concrete (Concrete01) and hysteretic steel rei
4. The frame consists of two nonlinear beam-column elements (columns) and one beam element with distri
5. Dynamic analysis features Rayleigh damping calibrated using the first two modal frequencies.
6. The script can perform both displacement-controlled pushover and time-history analyses under seismi
7. Key outputs include force-displacement responses, stiffness degradation, and period-dependent behav
8. The analysis tracks base reactions, displacements, rotations, and section stiffnesses throughout lc
9. Advanced features include corotational geometric transformations for large displacements.
10. The code implements logarithmic decrement analysis to estimate damping ratios from free vibration
11. Comprehensive plotting functions visualize hysteresis loops, P-M interactions, and time-history re
12. The optimization process automatically adjusts column depth to match a target fundamental period.
13. Results are exported to Excel for post-processing, including peak responses and cumulative maxima.
14. The model includes concentrated nodal masses and accounts for element mass contributions.
15. Both stiffness-proportional and mass-proportional damping components are considered.
16. The script handles convergence issues with automatic analysis restart capabilities.
17. Statistical analysis of results includes histograms and box plots of key response parameters.
18. The implementation demonstrates best practices for nonlinear frame analysis in OpenSees.
19. The code is well-commented with references to OpenSees documentation and theory manuals.
20. This provides a robust template for performance-based seismic design optimization of concrete fram

The script represents a sophisticated integration of structural dynamics theory, numerical optimizatic
 and nonlinear finite element analysis for seismic design applications.
"""
```

...E_EXAMPLES\OPTIMIZATION\DYNAMIC_Cdepth_PERIOD_OPTIMIZATION

32 %



Help Variable Explorer Debugger Plots Files

Console 1/A

```
Lobatto
    End 1 Forces (P V M): 270408 184668 3.76963e+08
    End 2 Forces (P V M): -270408 -184668 1.7704e+08

Element: 3 Type: ForceBeamColumn2d  Connected Nodes: 3 4
    Number of Sections: 5   Mass density: 6.36044
Lobatto
    End 1 Forces (P V M): 1056.37 -50385 -1.75653e+08
    End 2 Forces (P V M): -1056.37 50385 -1.77041e+08

In [2]:
```

IPython Console History

NONLINEAR DYNAMIC ANALYSIS RESULTS

PERIOD_01 : 1.32113890 - PERIOD_02 : 9.34380605
F: 1.843806048673832
Structure First Period: 1.3211389075865452
Structure Second Period: 9.343806261665975
Fmin: 1.843806261665975
Structure First Period: 1.3211389003907277
Structure Second Period: 9.34380583568142
Fmax: 1.8438058356814206
DF: -0.02129922771487713
DX: -86.56680295436094
IT: 1 - RESIDUAL: 86.56680295436094 - X: 586.5668029543609

Structure First Period: 1.2938764559626208
Structure Second Period: 7.81336791685246
PERIOD_01 : 1.29387646 - PERIOD_02 : 7.81336792
F: 0.3133679168524601
Structure First Period: 1.2938764587320013
Structure Second Period: 7.813368063685243
Fmin: 0.3133680636852434
Structure First Period: 1.2938764531932436
Structure Second Period: 7.8133677700197985
Fmax: 0.31336777001979854
DF: -0.014683272242521637
DX: -21.34183114476149
IT: 2 - RESIDUAL: 21.34183114476149 - X: 607.9086340991224

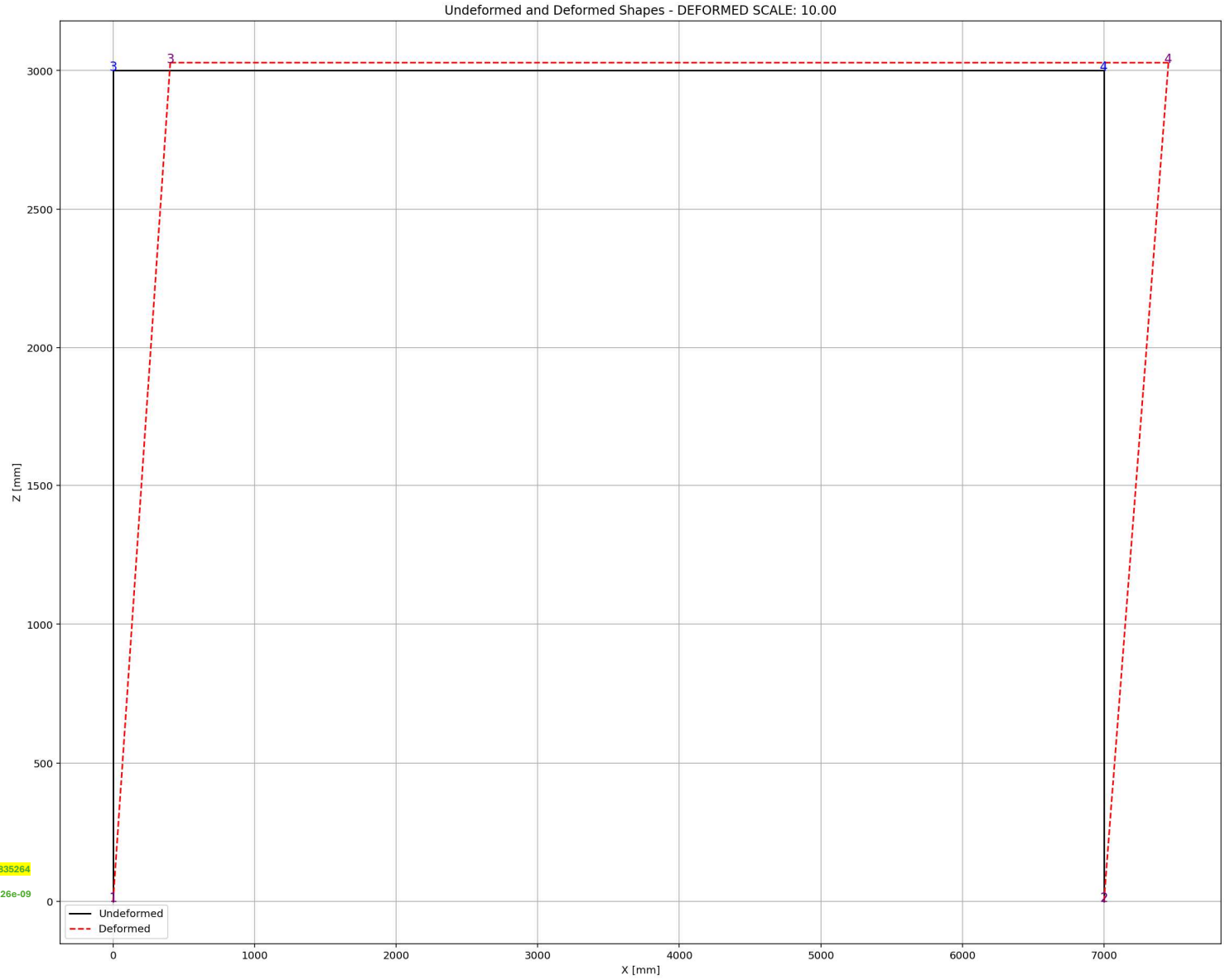
Structure First Period: 1.2881289006602148
Structure Second Period: 7.51251922775103
PERIOD_01 : 1.28812890 - PERIOD_02 : 7.51251923
F: 0.01251922775102976
Structure First Period: 1.2881289032798524
Structure Second Period: 7.512519363090006
Fmin: 0.01251936309000623
Structure First Period: 1.2881288980405776
Structure Second Period: 7.51251909241217
Fmax: 0.012519092412169641
DF: -0.013533891829453635
DX: -0.9250279157532739
IT: 3 - RESIDUAL: 0.9250279157532739 - X: 608.8336620148757

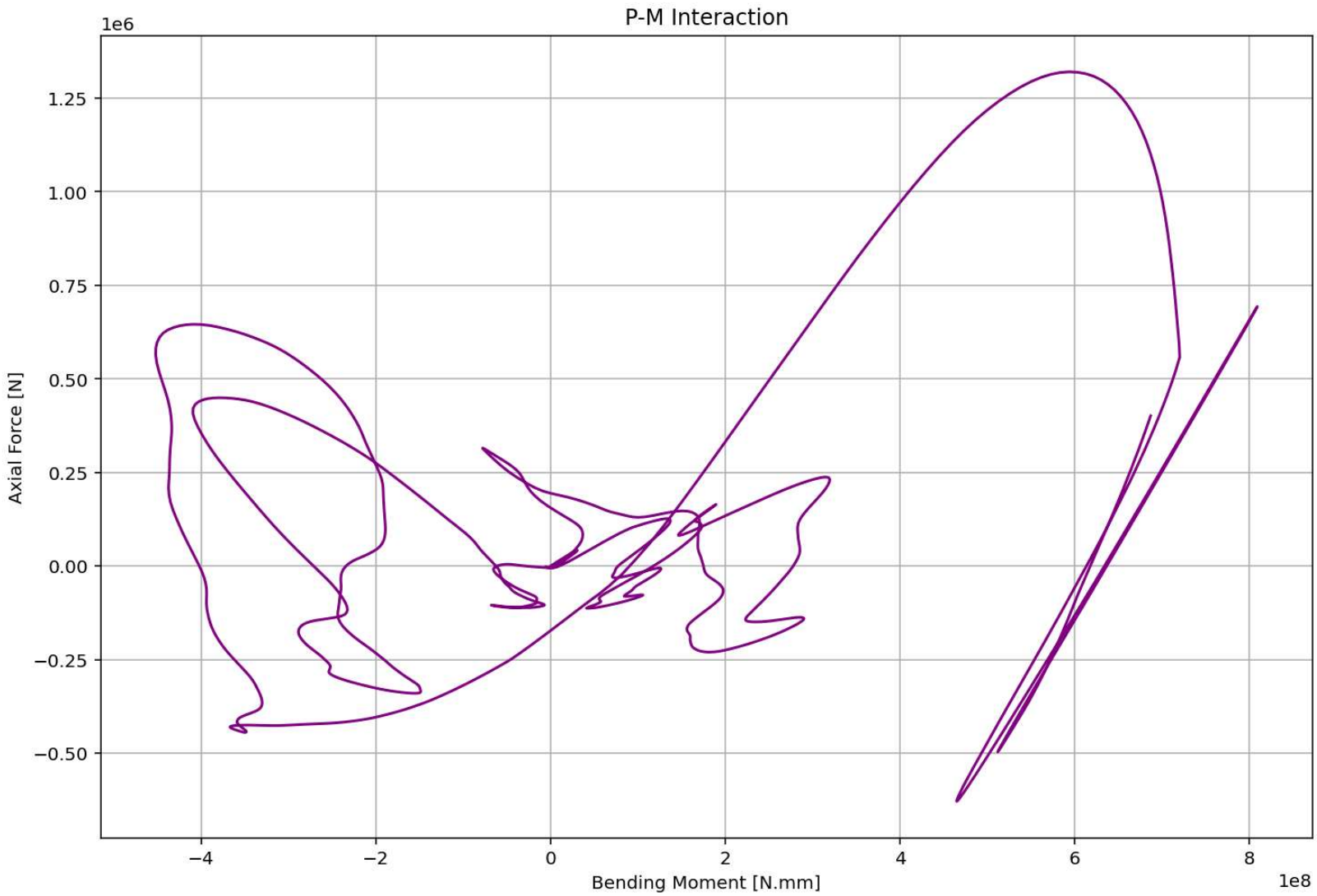
Structure First Period: 1.287886860074277
Structure Second Period: 7.500021607458597
PERIOD_01 : 1.28788686 - PERIOD_02 : 7.50002161
F: 2.16074585965841 95e-05
Structure First Period: 1.287886862687799
Structure Second Period: 7.5000217423308575
Fmin: 2.1742330857499326e-05
Structure First Period: 1.287886857460755
Structure Second Period: 7.500021472586389
Fmax: 2.1472586388959 77e-05
DF: -0.013487223426977833
DX: -0.001602068706993009
IT: 4 - RESIDUAL: 0.001602068706993009 - X: 608.8352640835827

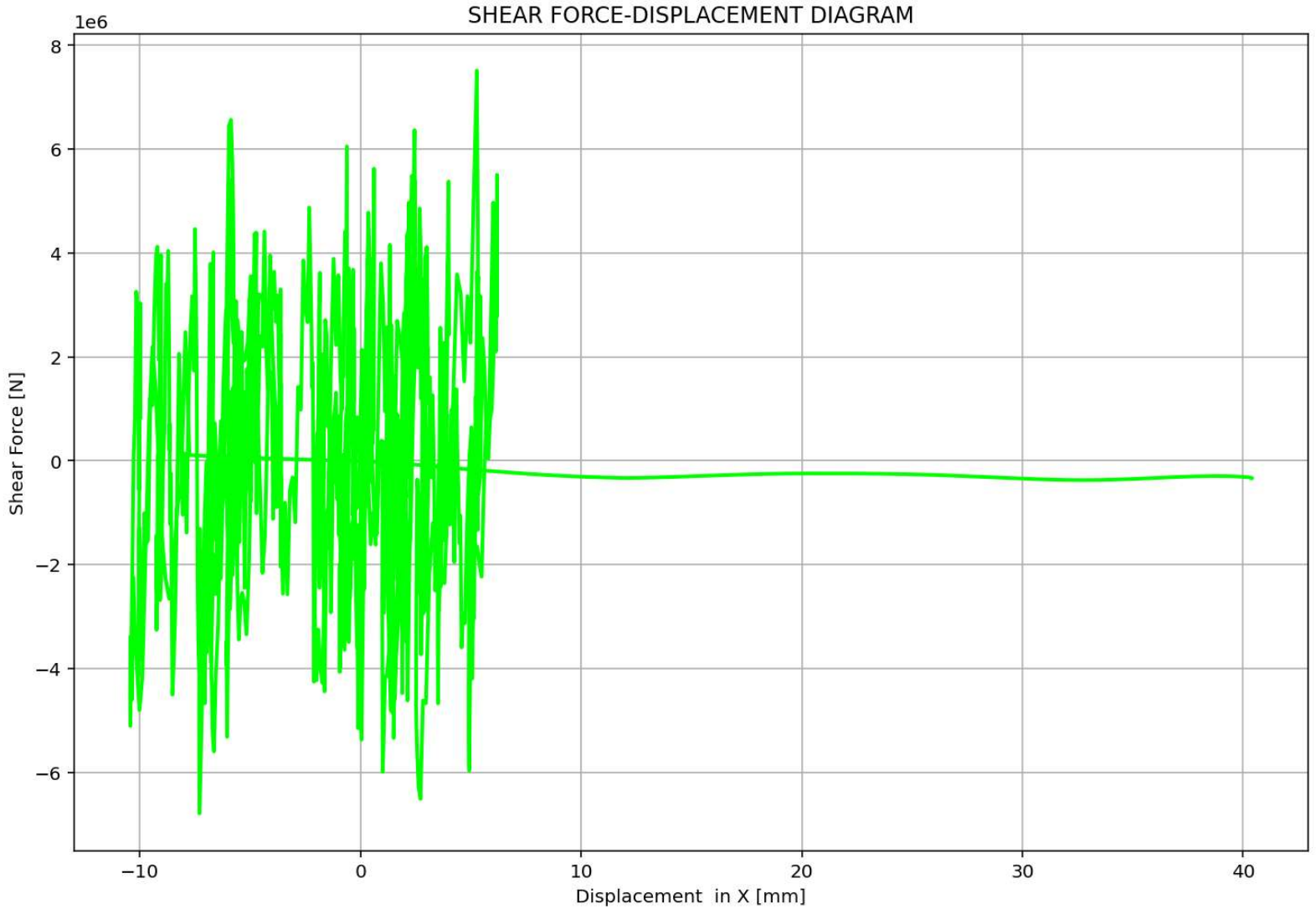
Structure First Period: 1.2878864413712046
Structure Second Period: 7.500000000080559
PERIOD_01 : 1.28788644 - PERIOD_02 : 7.50000000
F: 8.055867084522106e-11
Structure First Period: 1.2878864439847162
Structure Second Period: 7.500000134951995
Fmin: 1.3495199535640268e-07
Structure First Period: 1.2878864387576943
Structure Second Period: 7.499999865209172
Fmax: -1.3479082827672073e-07
DF: -0.013487141181656169
DX: -5.972998262581305e-09
IT: 5 - RESIDUAL: 5.972998262581305e-09 - X: 608.8352640895557

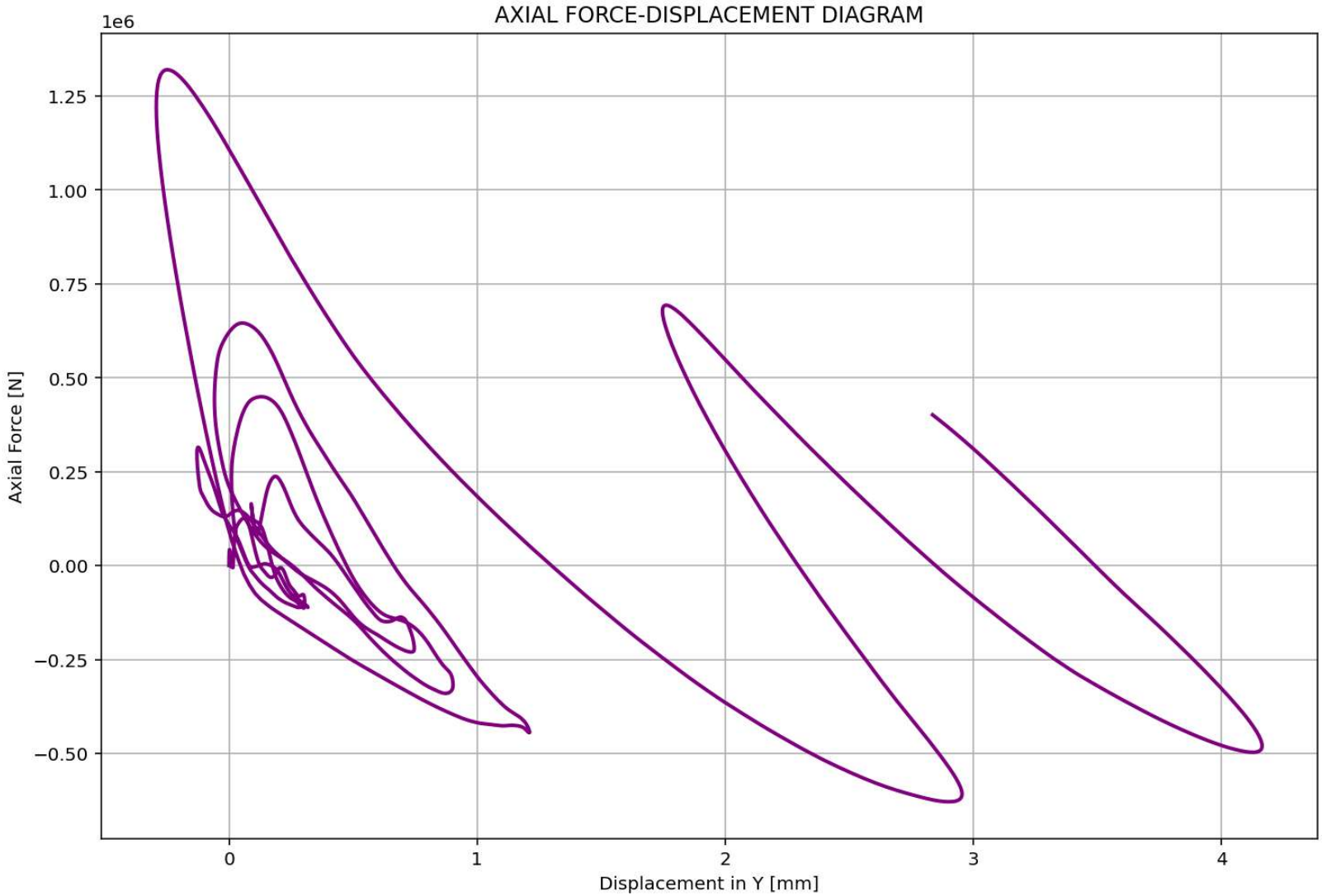
Optimum Column Section Depth : 608.835264
Iteration Counts: 5
Convergence Residual: 5.9729982626e-09

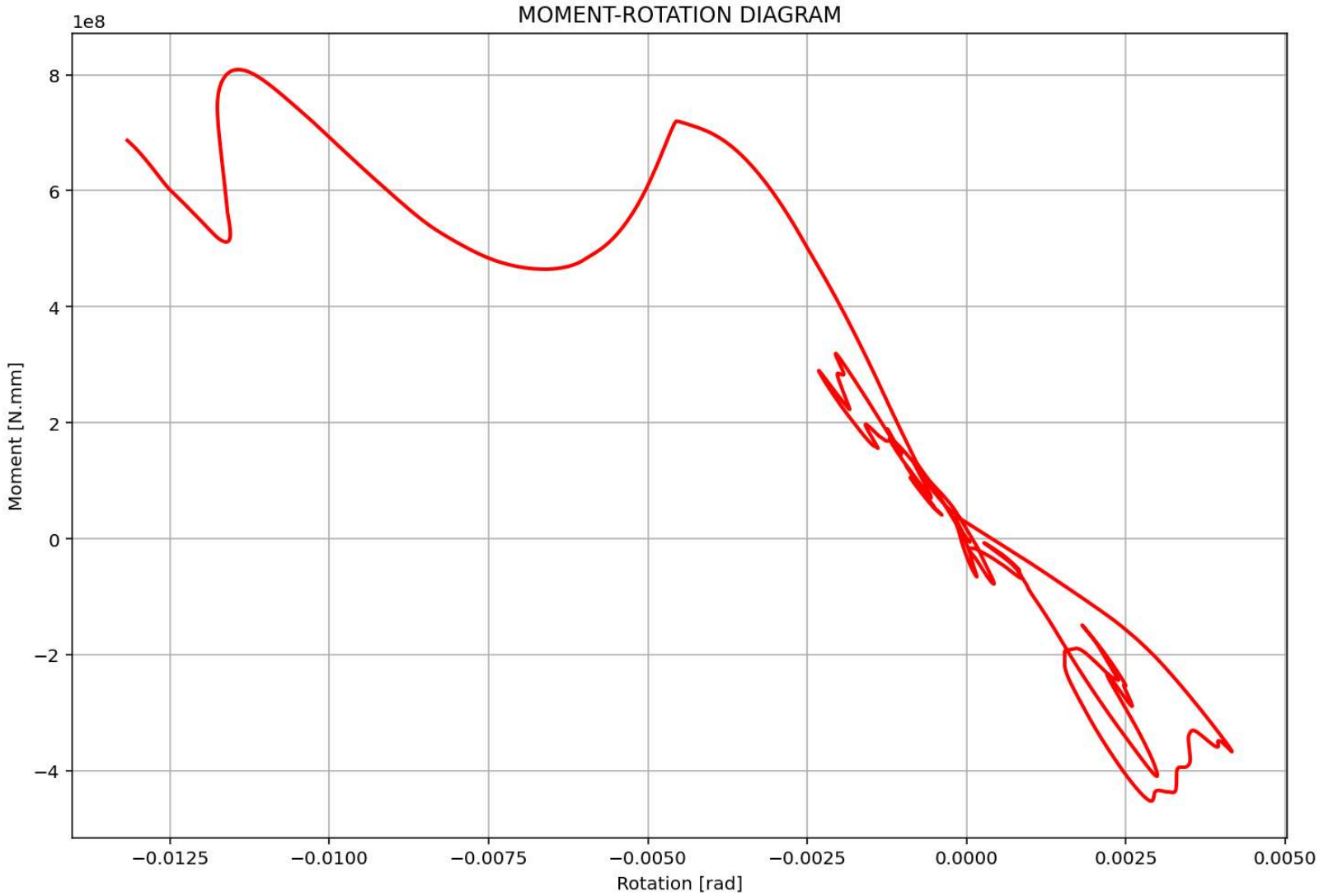
Total time (s): 12.8281

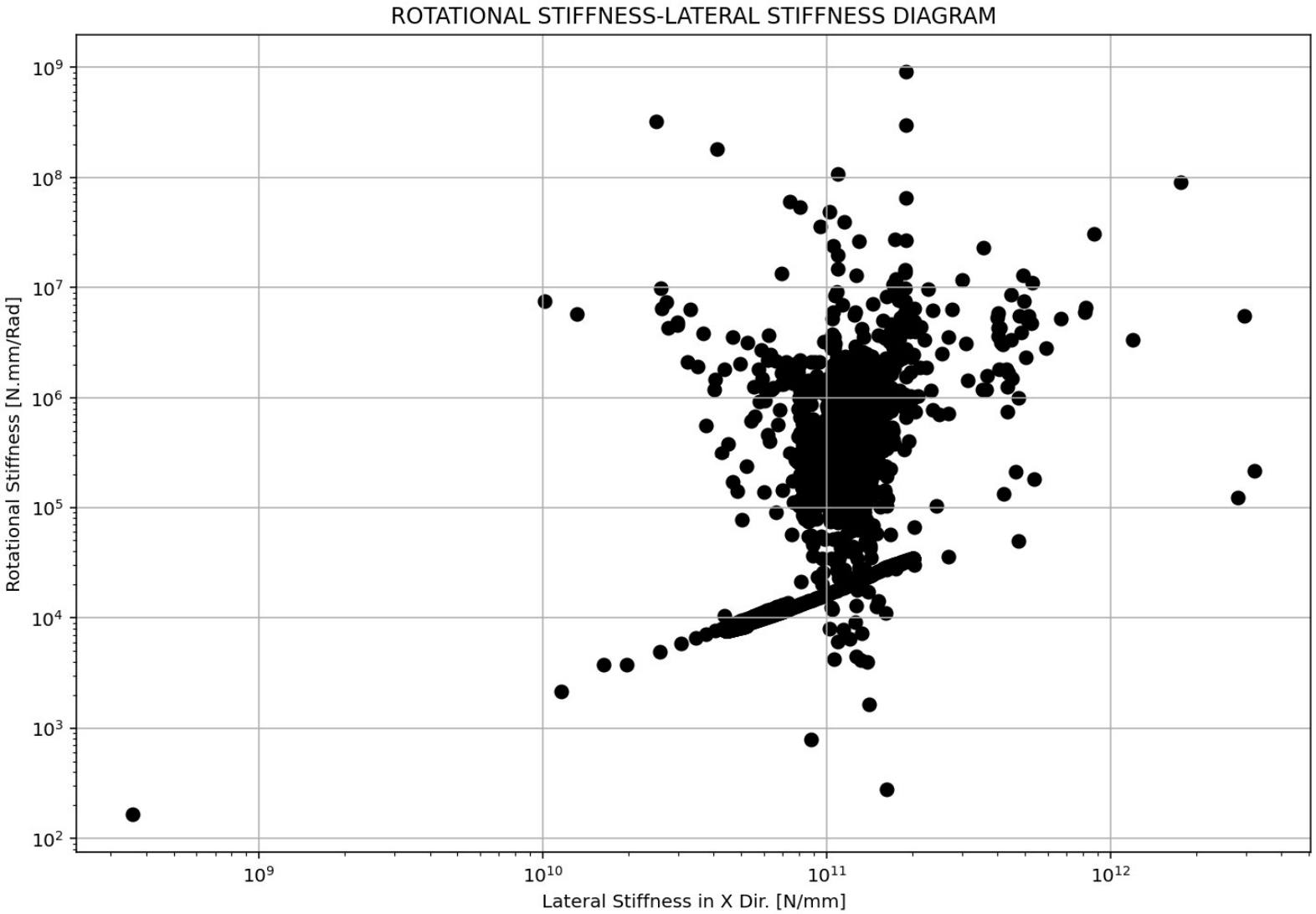


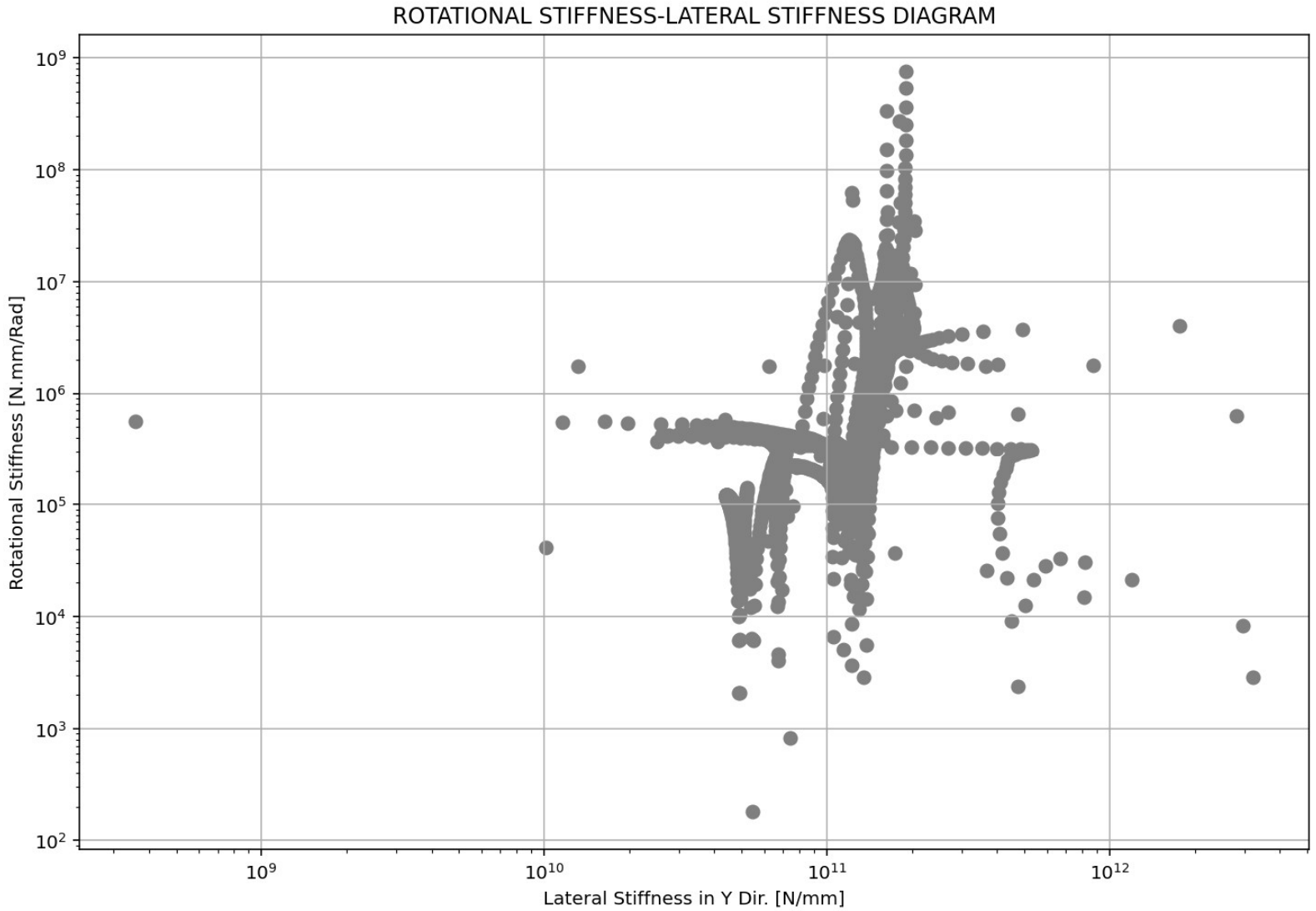

P-M Interaction
1e6
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
Axial Force [N]
−4
−2
0
2
4
6
8
1e8
Bending Moment [N.mm]

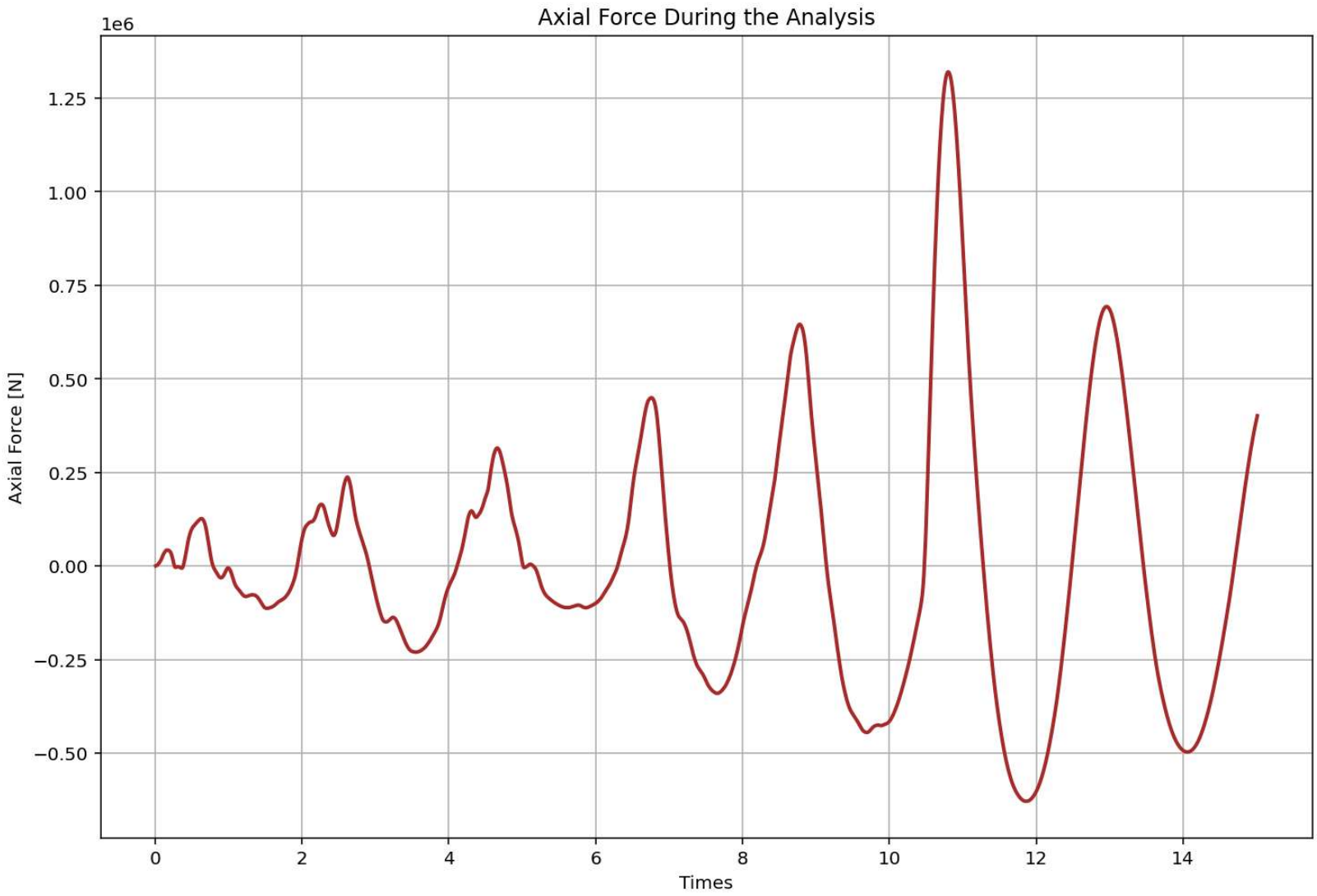

SHEAR FORCE-DISPLACEMENT DIAGRAM
1e6
8
6
4
2
0
−2
−4
−6
Shear Force [N]
−10
0
10
20
30
40
Displacement in X [mm]

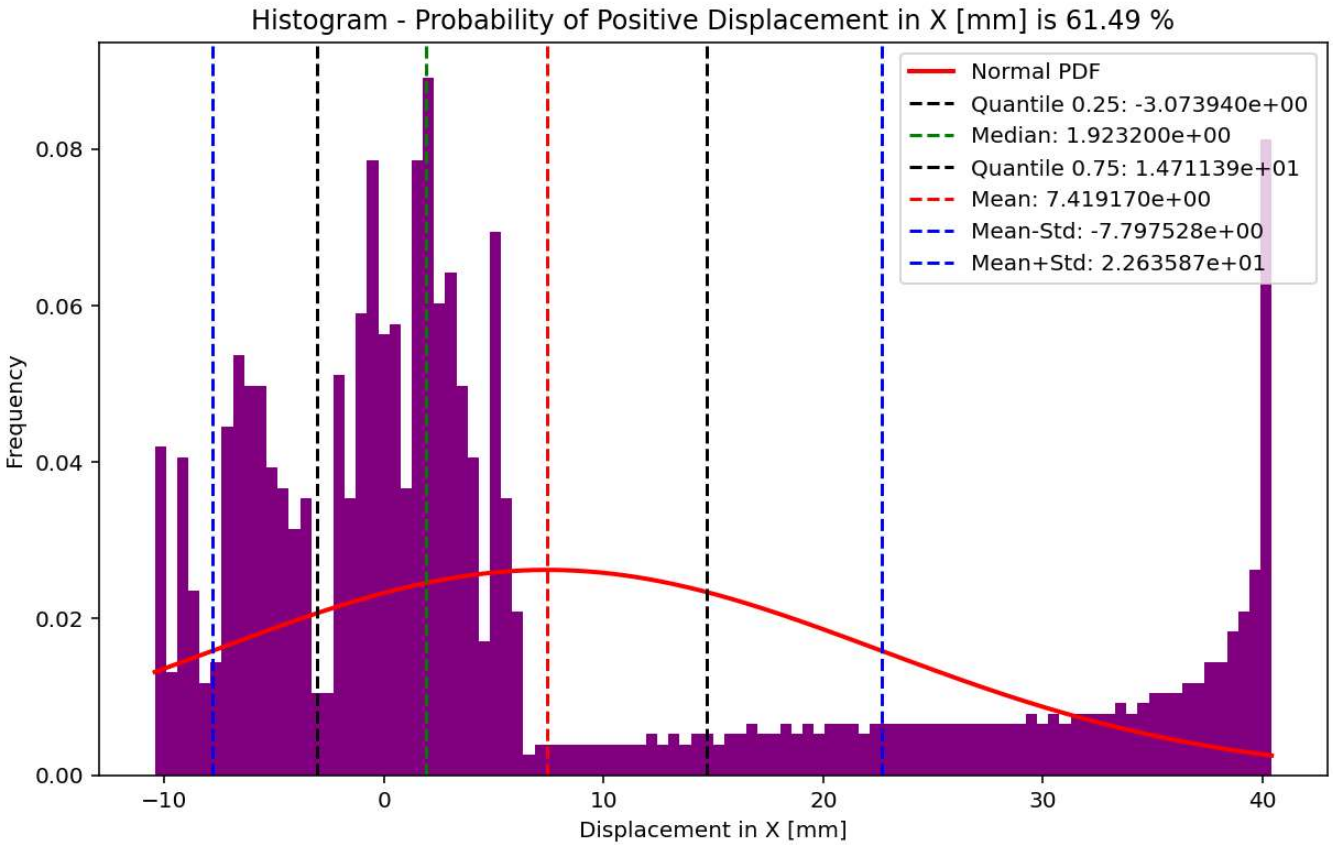

AXIAL FORCE-DISPLACEMENT DIAGRAM
1e6
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
Axial Force [N]
0
1
2
3
4
Displacement in Y [mm]

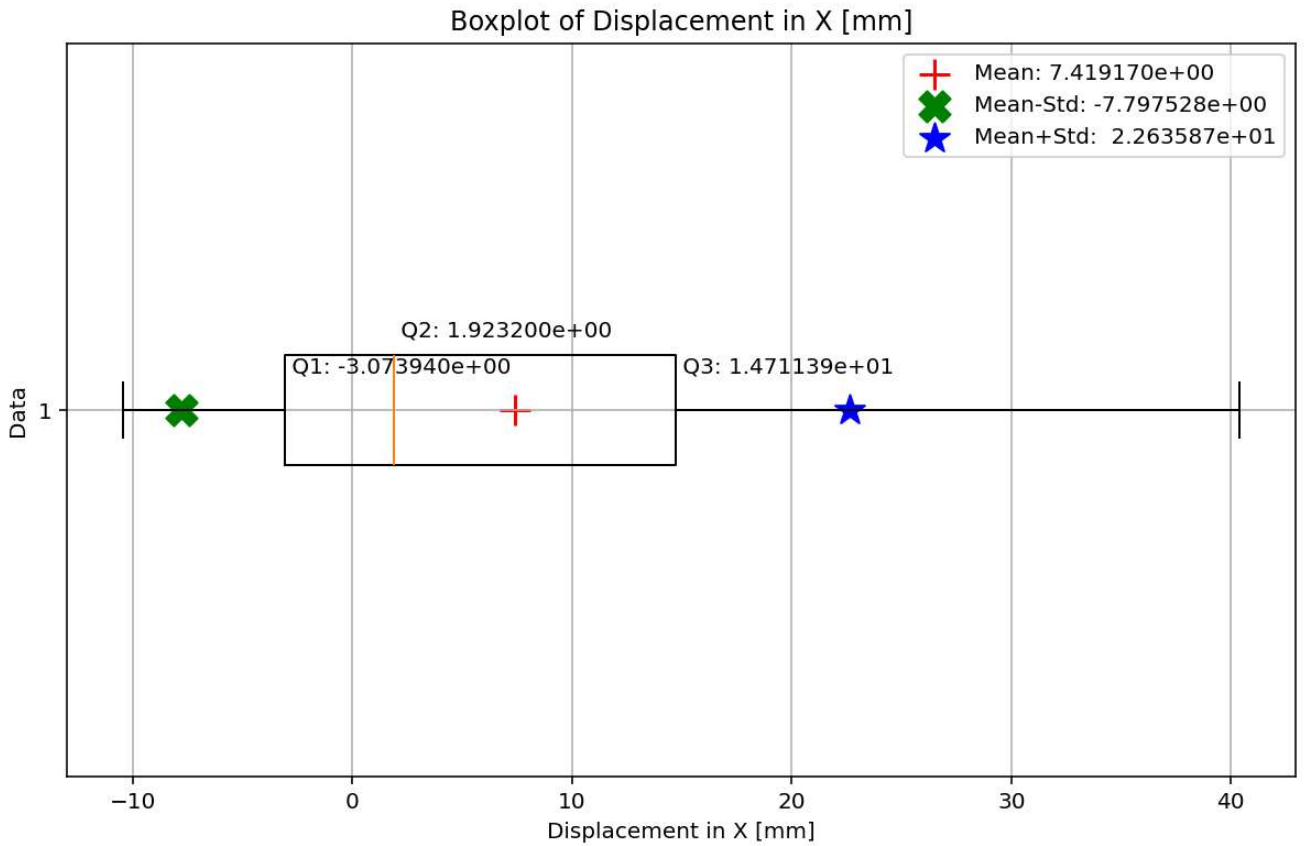

MOMENT-ROTATION DIAGRAM
1e8
8
6
4
2
0
−2
−4
Moment [N.mm]
−0.0125
−0.0100
−0.0075
−0.0050
−0.0025
0.0000
0.0025
0.0050
Rotation [rad]

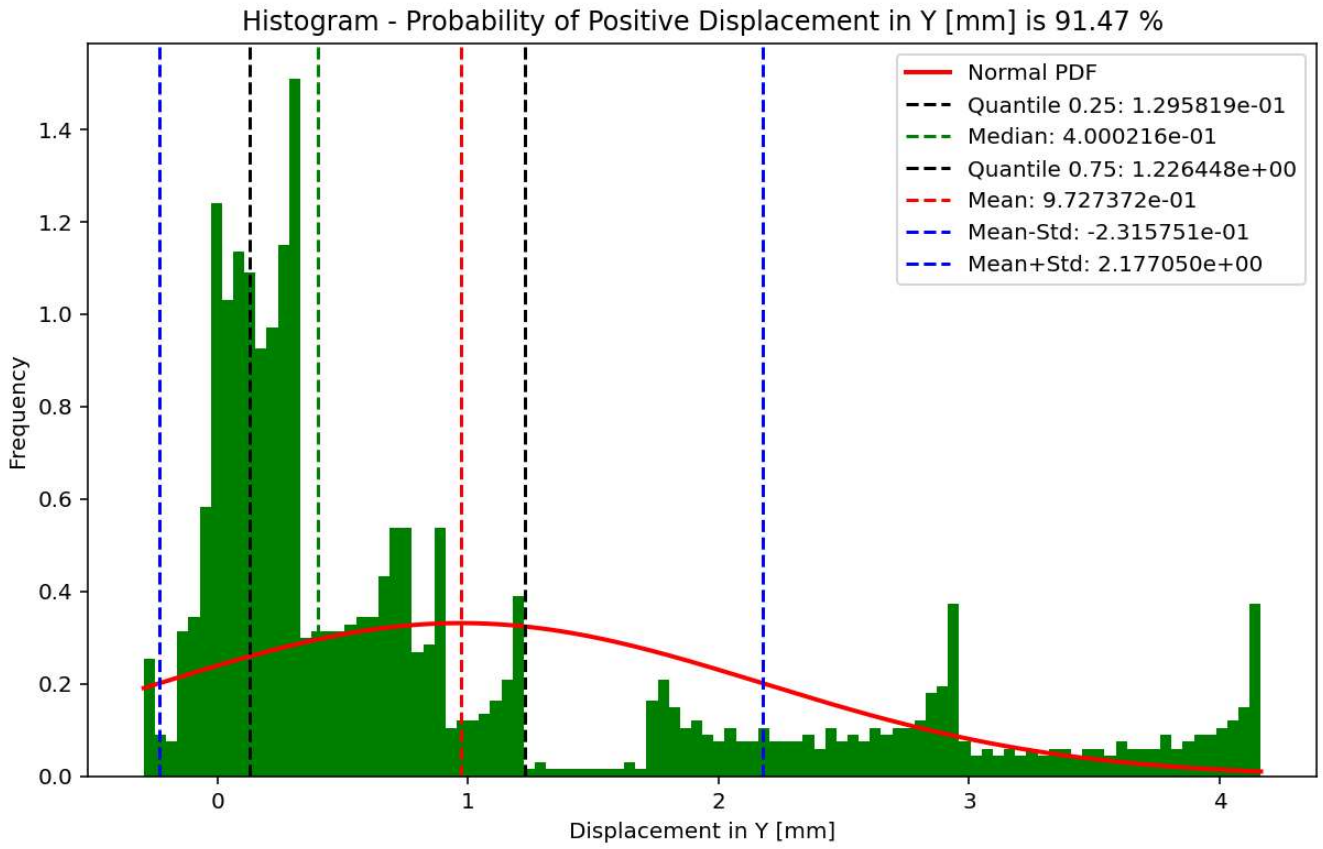

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in X Dir. [N/mm]
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{9}
10^{10}
10^{11}
10^{12}

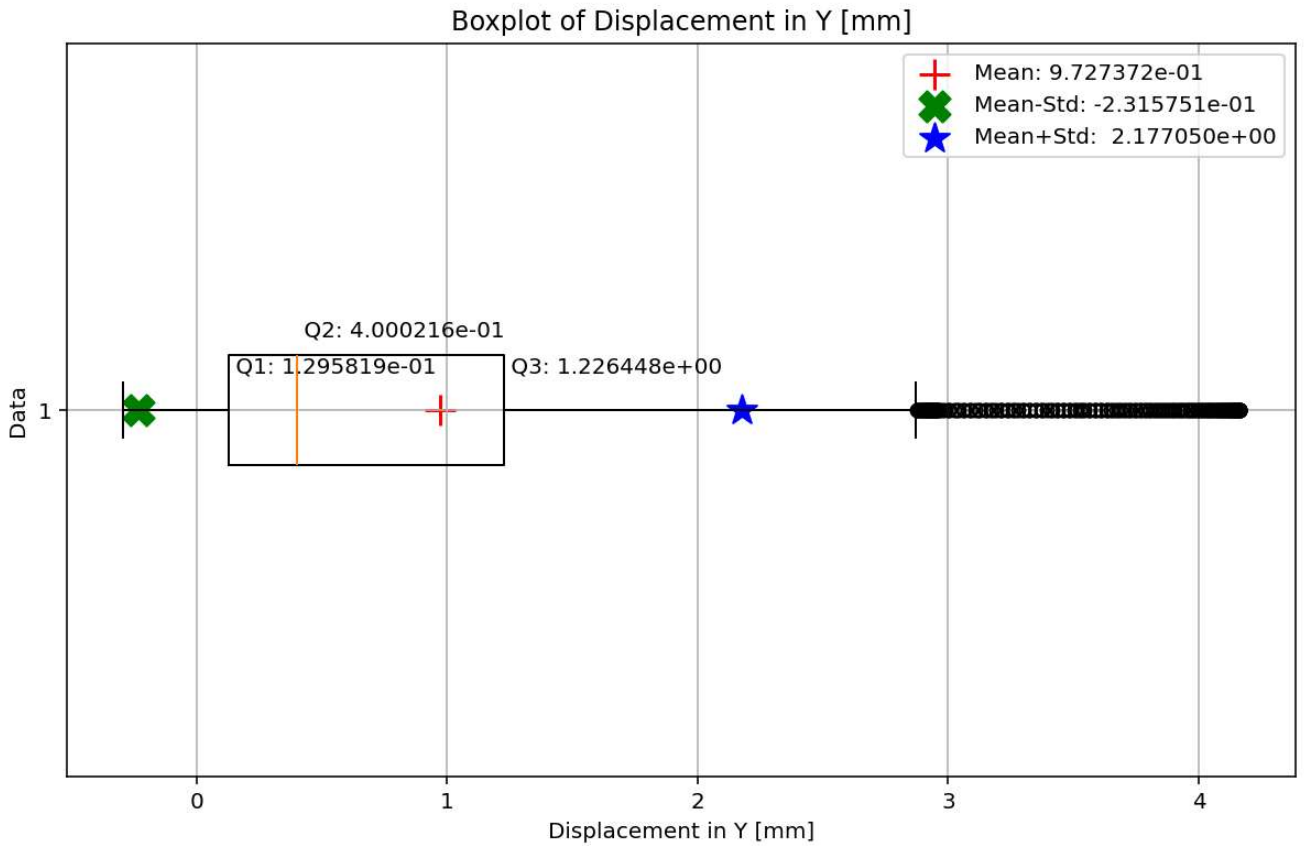

ROTATIONAL STIFFNESS-LATERAL STIFFNESS DIAGRAM
Rotational Stiffness [N.mm/Rad]
Lateral Stiffness in Y Dir. [N/mm]
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{9}
10^{10}
10^{11}
10^{12}

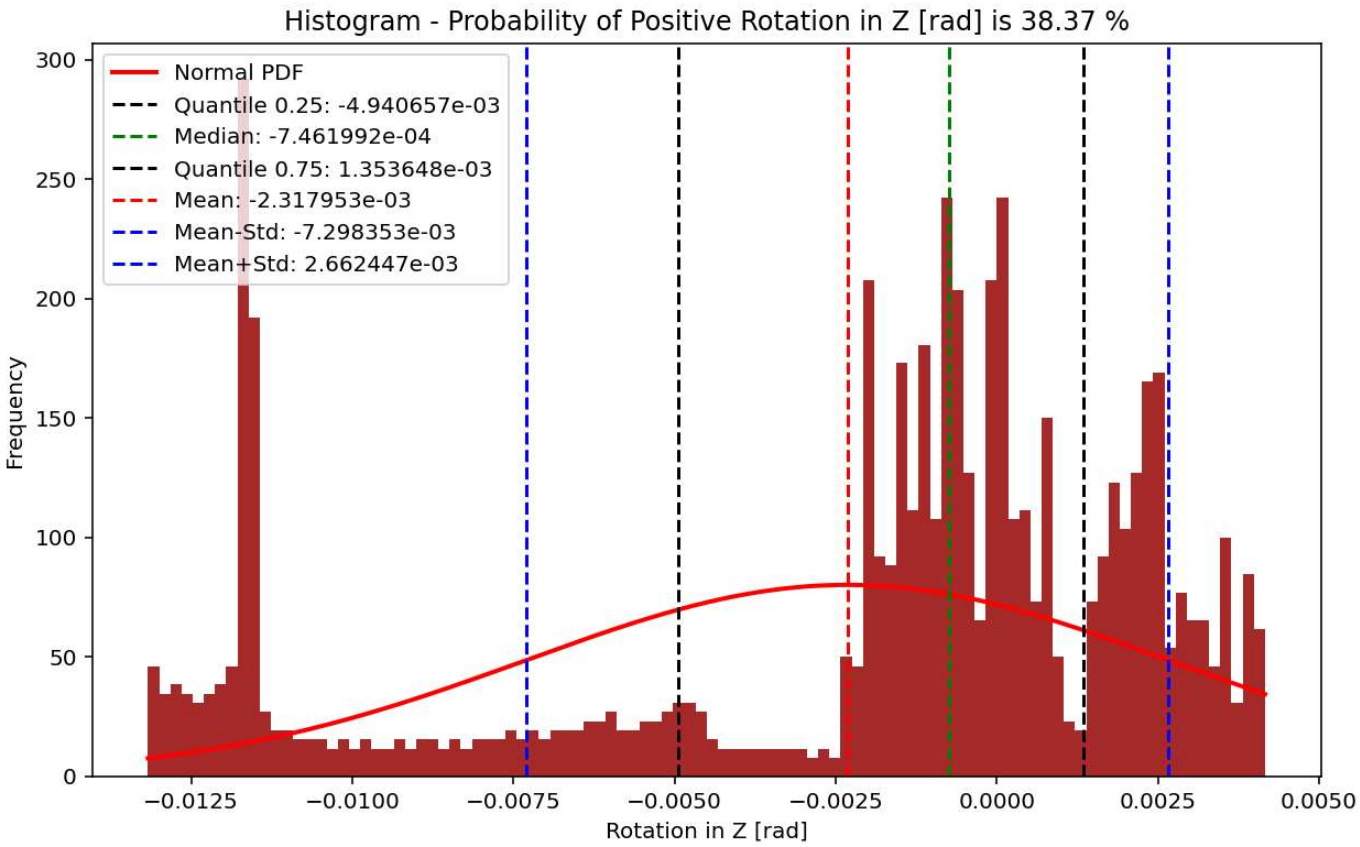

Axial Force During the Analysis
1e6
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
Axial Force [N]
0
2
4
6
8
10
12
14
Times

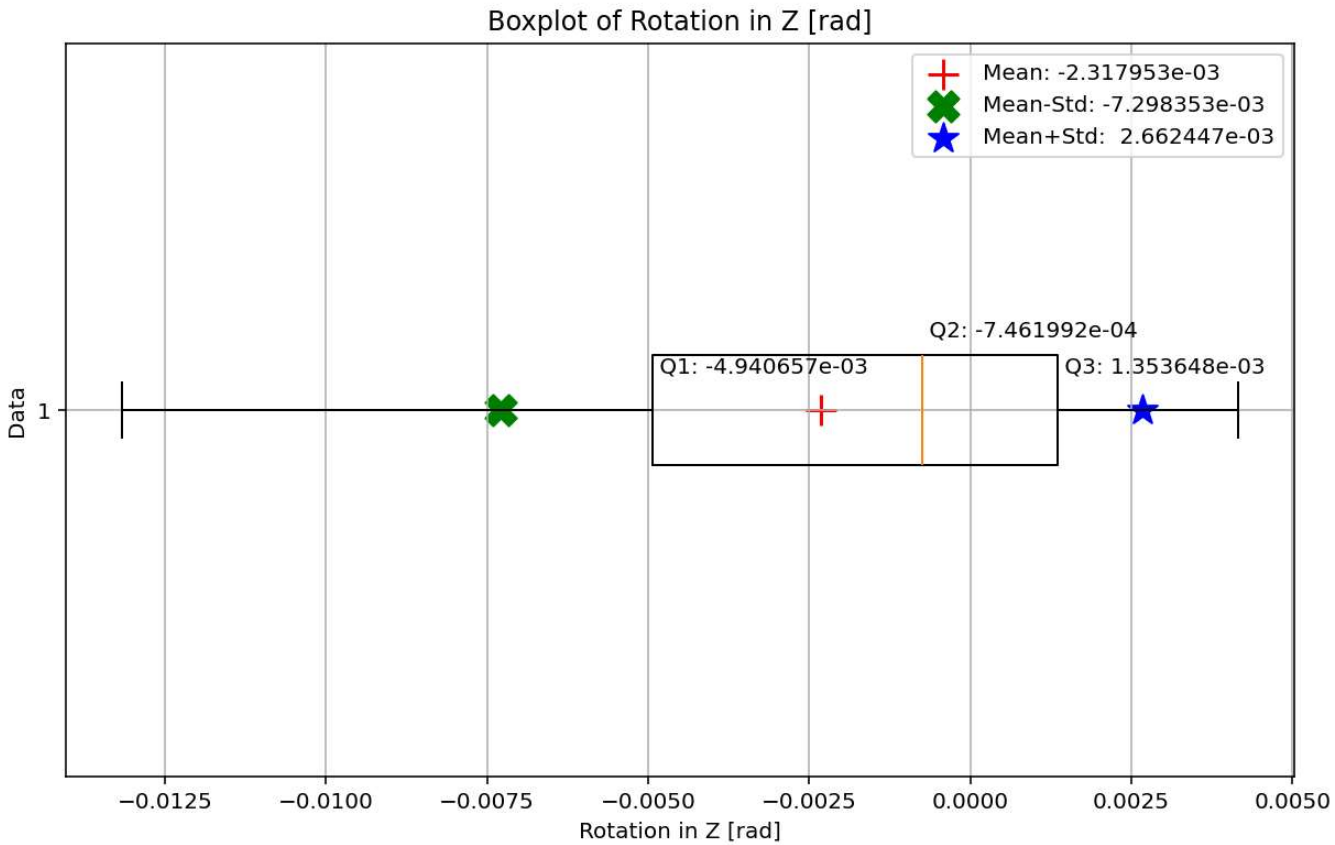

Histogram - Probability of Positive Displacement in X [mm] is 61.49 %
Normal PDF
Quantile 0.25: -3.073940e+00
Median: 1.923200e+00
Quantile 0.75: 1.471139e+01
Mean: 7.419170e+00
Mean-Std: -7.797528e+00
Mean+Std: 2.263587e+01
Frequency
0.00
0.02
0.04
0.06
0.08
−10
0
10
20
30
40
Displacement in X [mm]

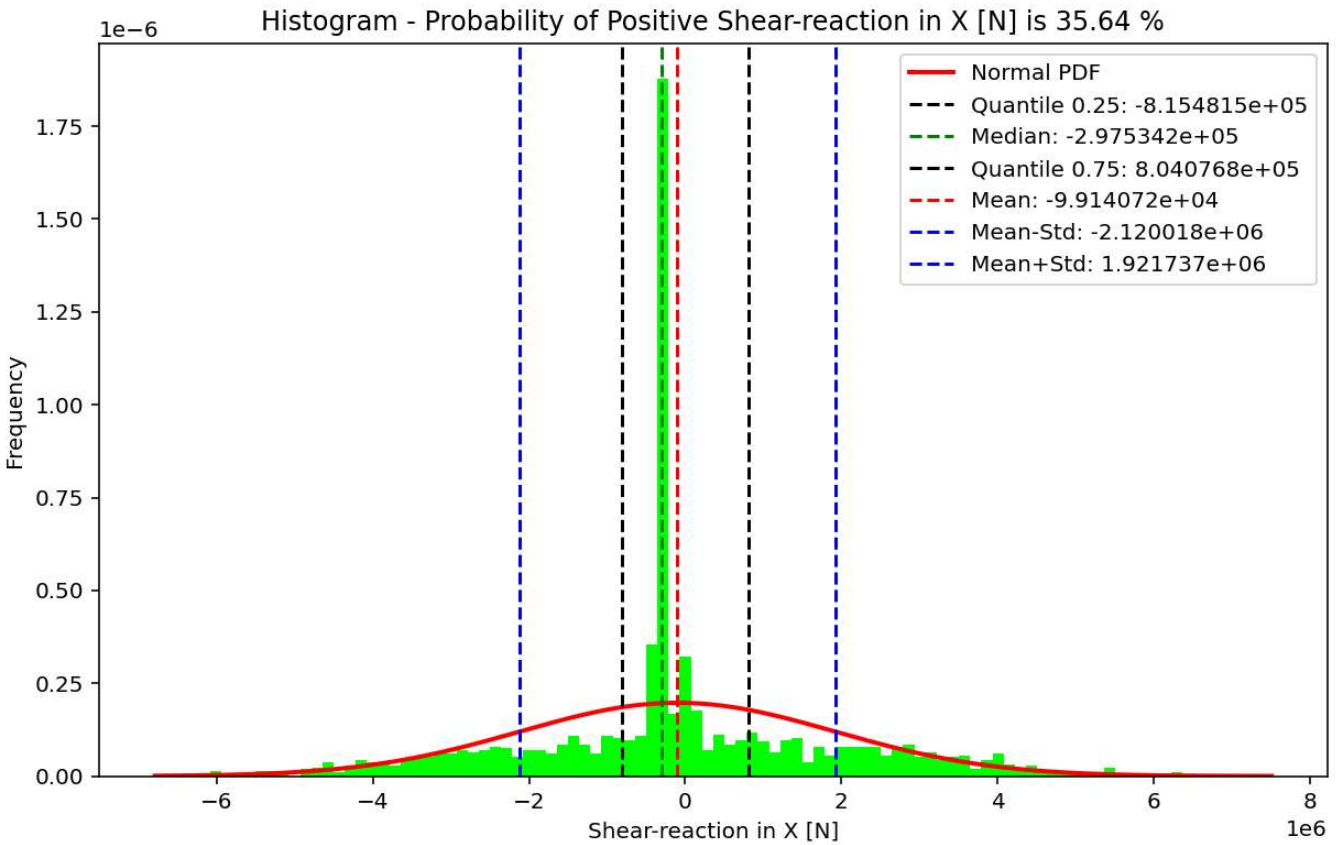

Boxplot of Displacement in X [mm]
Mean: 7.419170e+00
Mean-Std: -7.797528e+00
Mean+Std: 2.263587e+01
Q2: 1.923200e+00
Q1: -3.073940e+00
Q3: 1.471139e+01
Data
1
−10
0
10
20
30
40
Displacement in X [mm]

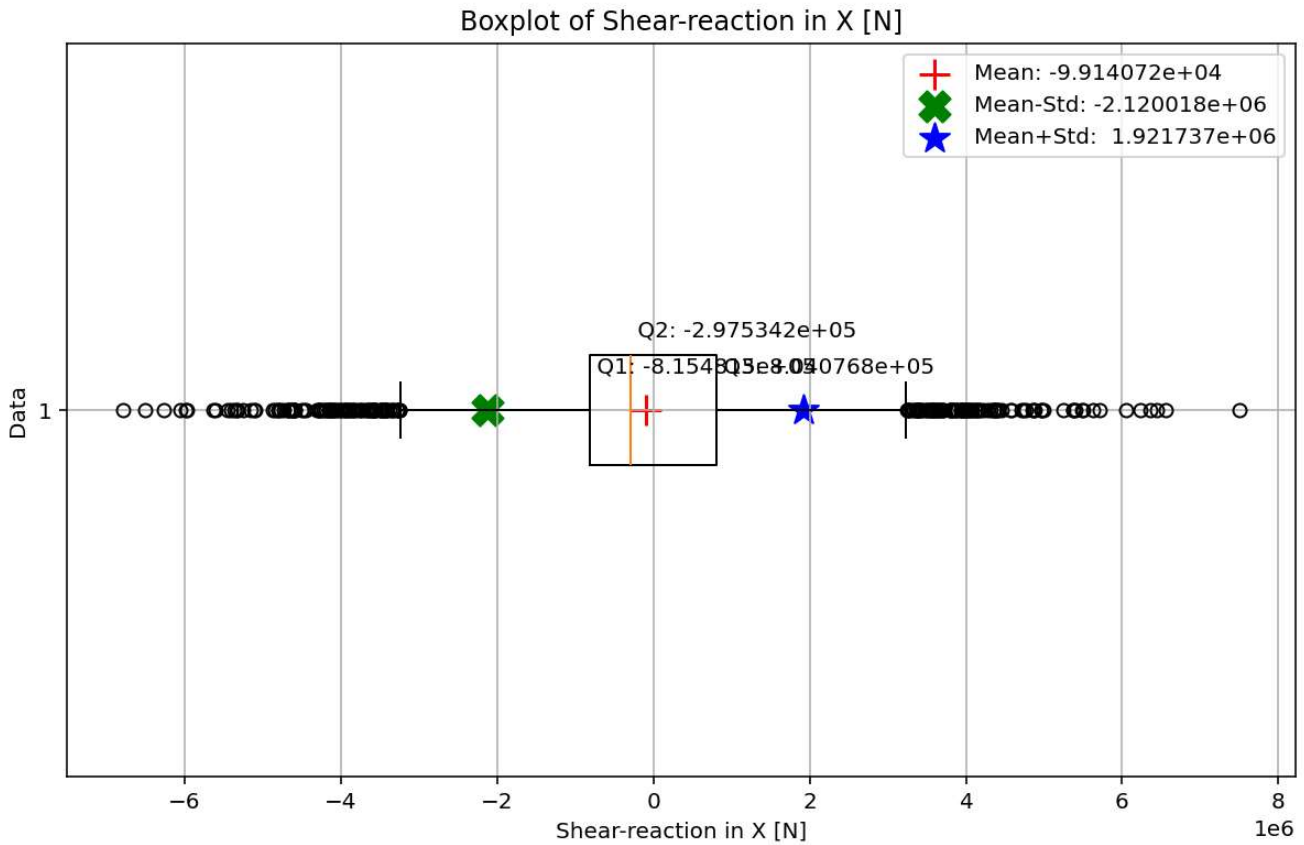

Histogram - Probability of Positive Displacement in Y [mm] is 91.47 %
Normal PDF
Quantile 0.25: 1.295819e-01
Median: 4.000216e-01
Quantile 0.75: 1.226448e+00
Mean: 9.727372e-01
Mean-Std: -2.315751e-01
Mean+Std: 2.177050e+00
Frequency
Displacement in Y [mm]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0
1
2
3
4

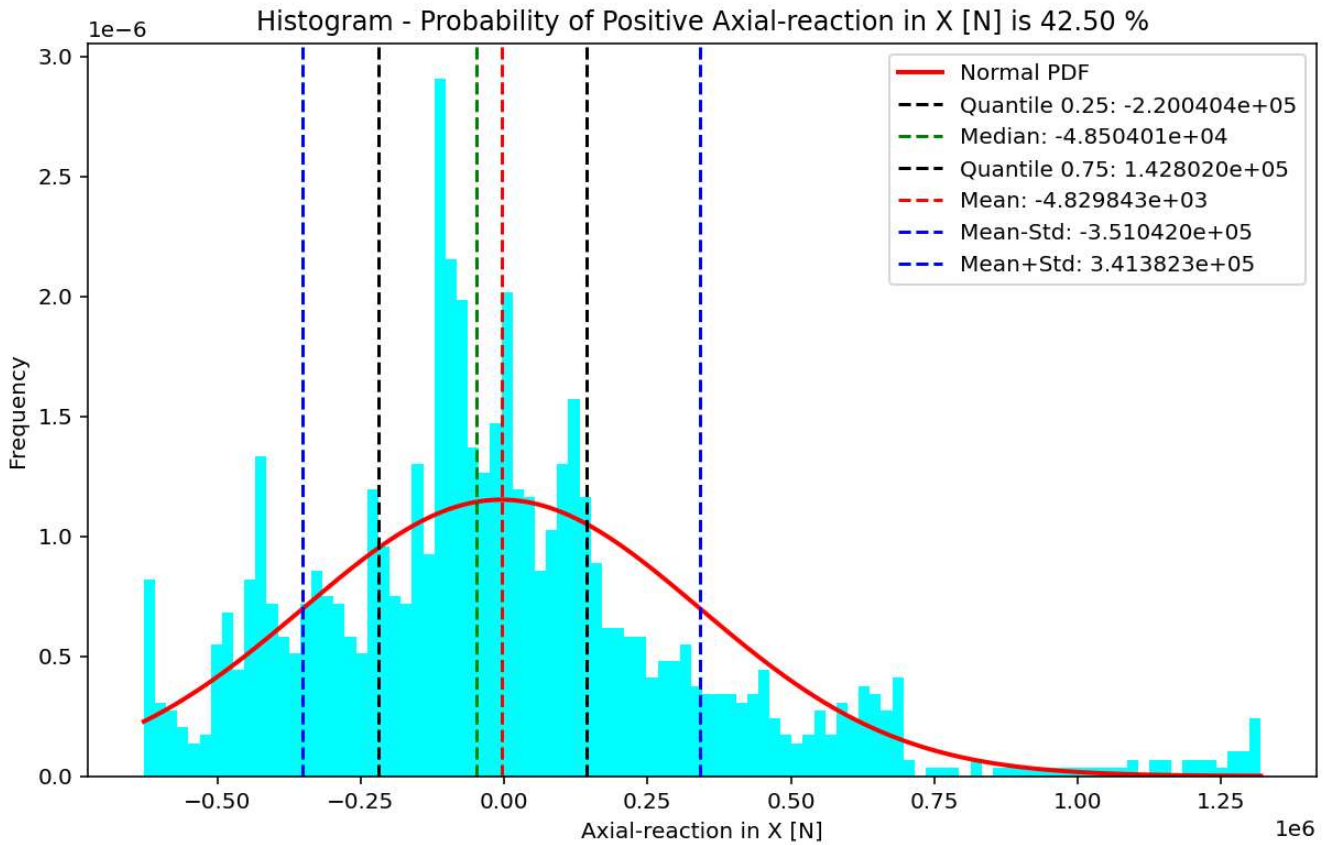

Boxplot of Displacement in Y [mm]
Mean: 9.727372e-01
Mean-Std: -2.315751e-01
Mean+Std: 2.177050e+00
Q2: 4.000216e-01
Q1: 1.295819e-01
Q3: 1.226448e+00
Data
1
0
1
2
3
4
Displacement in Y [mm]

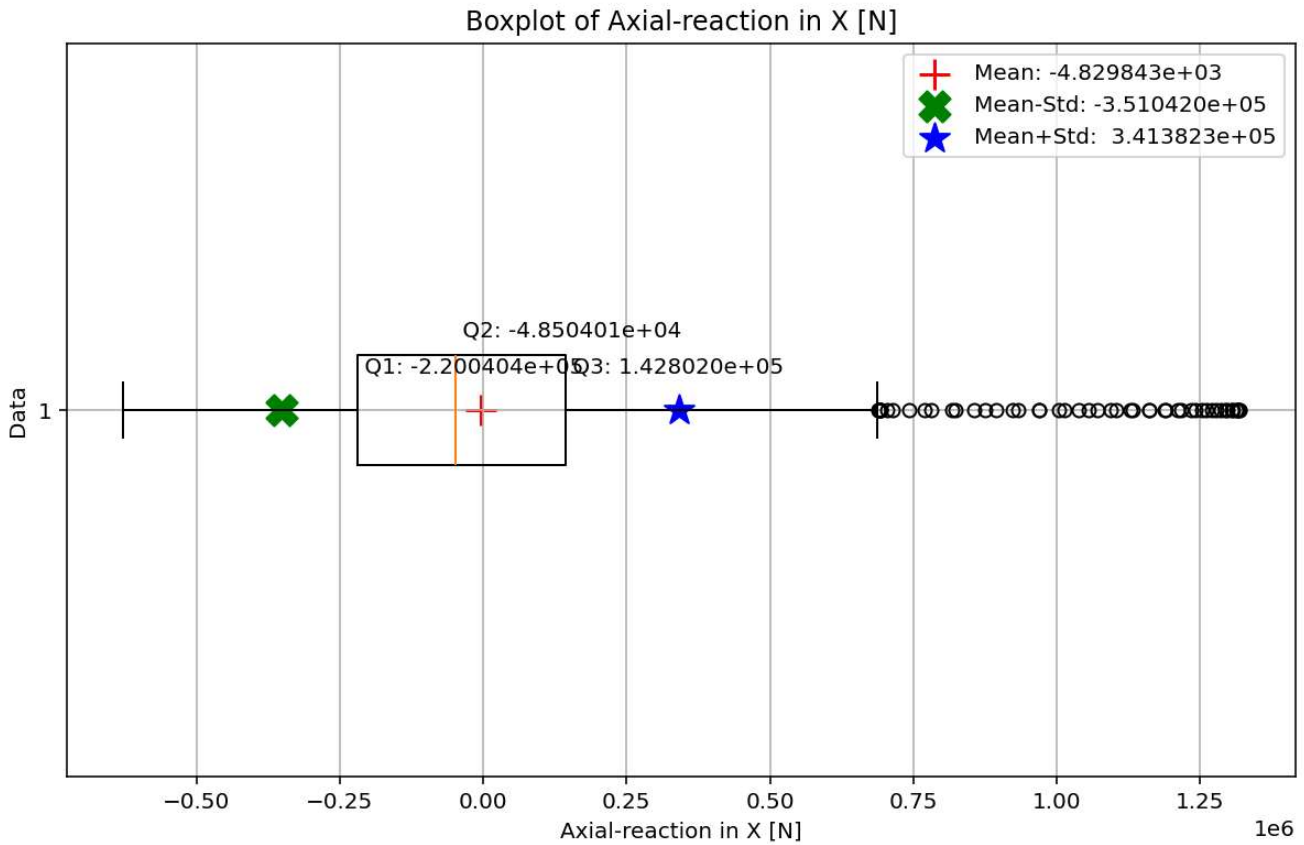

Histogram - Probability of Positive Rotation in Z [rad] is 38.37 %
Normal PDF
Quantile 0.25: -4.940657e-03
Median: -7.461992e-04
Quantile 0.75: 1.353648e-03
Mean: -2.317953e-03
Mean-Std: -7.298353e-03
Mean+Std: 2.662447e-03
Frequency
Rotation in Z [rad]
300
250
200
150
100
50
0
−0.0125
−0.0100
−0.0075
−0.0050
−0.0025
0.0000
0.0025
0.0050

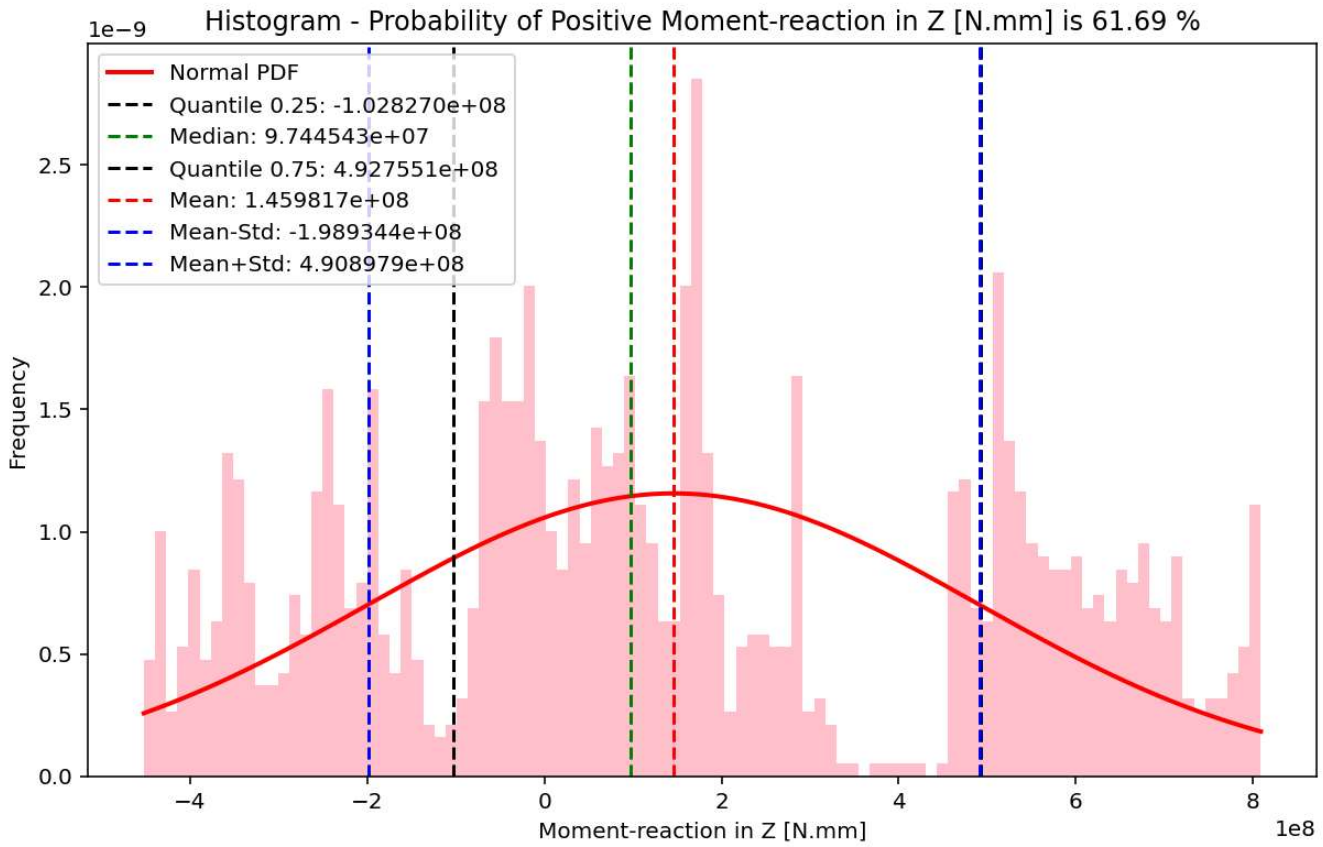

Boxplot of Rotation in Z [rad]
Mean: -2.317953e-03
Mean-Std: -7.298353e-03
Mean+Std: 2.662447e-03
Q2: -7.461992e-04
Q1: -4.940657e-03
Q3: 1.353648e-03
Data
1
−0.0125
−0.0100
−0.0075
−0.0050
−0.0025
0.0000
0.0025
0.0050
Rotation in Z [rad]

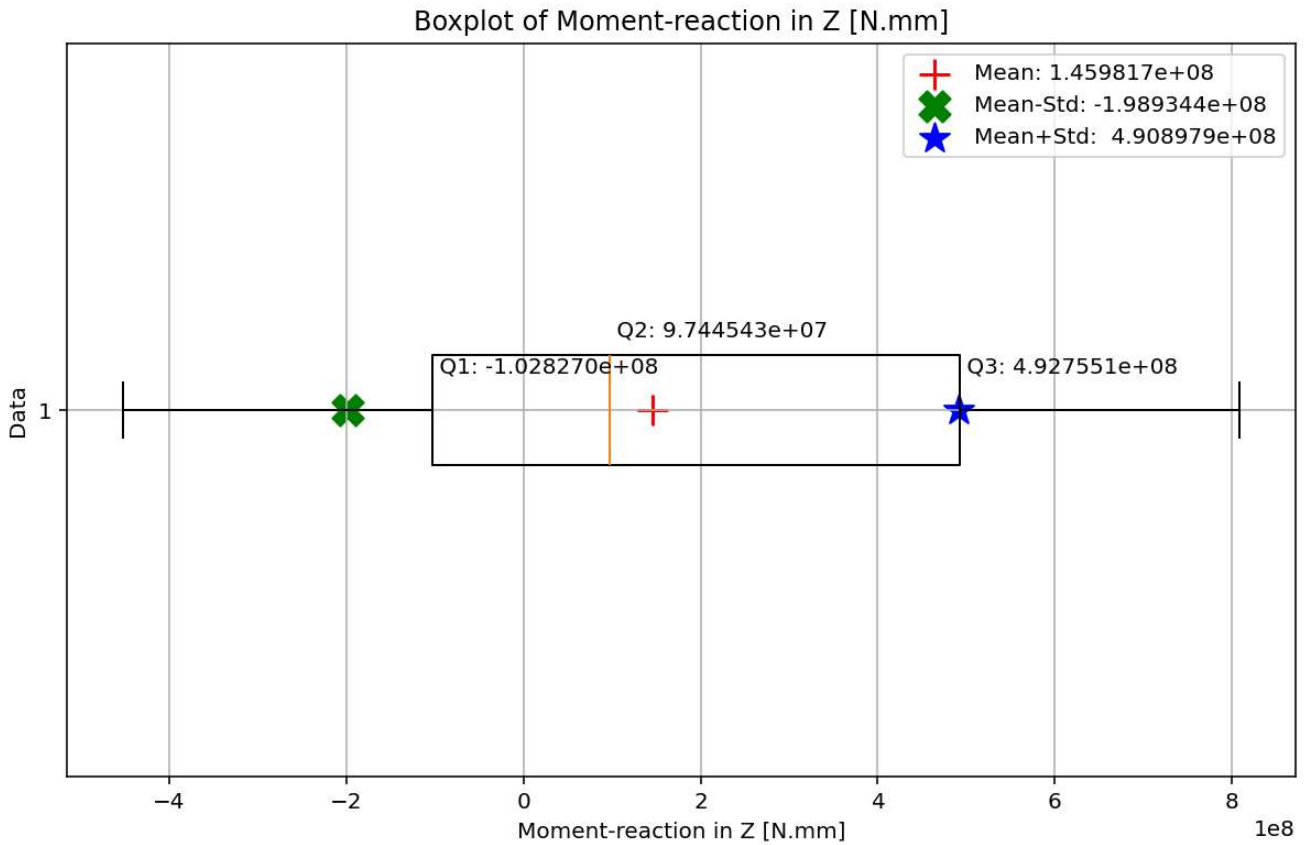

Histogram - Probability of Positive Shear-reaction in X [N] is 35.64 %
1e−6
Frequency
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
−6
−4
−2
0
2
4
6
8
1e6
Shear-reaction in X [N]
Normal PDF
Quantile 0.25: -8.154815e+05
Median: -2.975342e+05
Quantile 0.75: 8.040768e+05
Mean: -9.914072e+04
Mean-Std: -2.120018e+06
Mean+Std: 1.921737e+06

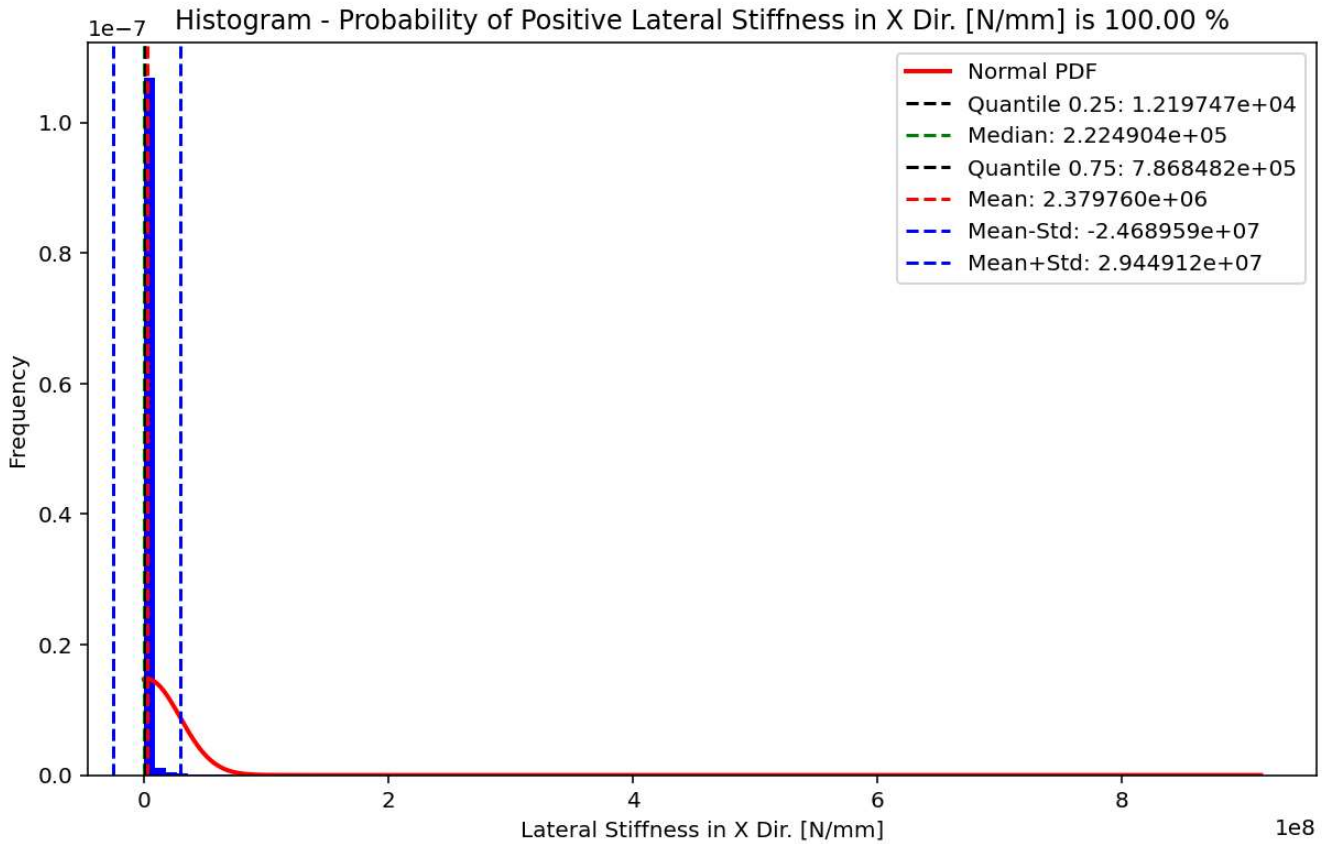

Boxplot of Shear-reaction in X [N]
Mean: -9.914072e+04
Mean-Std: -2.120018e+06
Mean+Std: 1.921737e+06
Q2: -2.975342e+05
Q1: -8.154305e+05
Q3: 8.040768e+05
Data
1
−6
−4
−2
0
2
4
6
8
1e6
Shear-reaction in X [N]

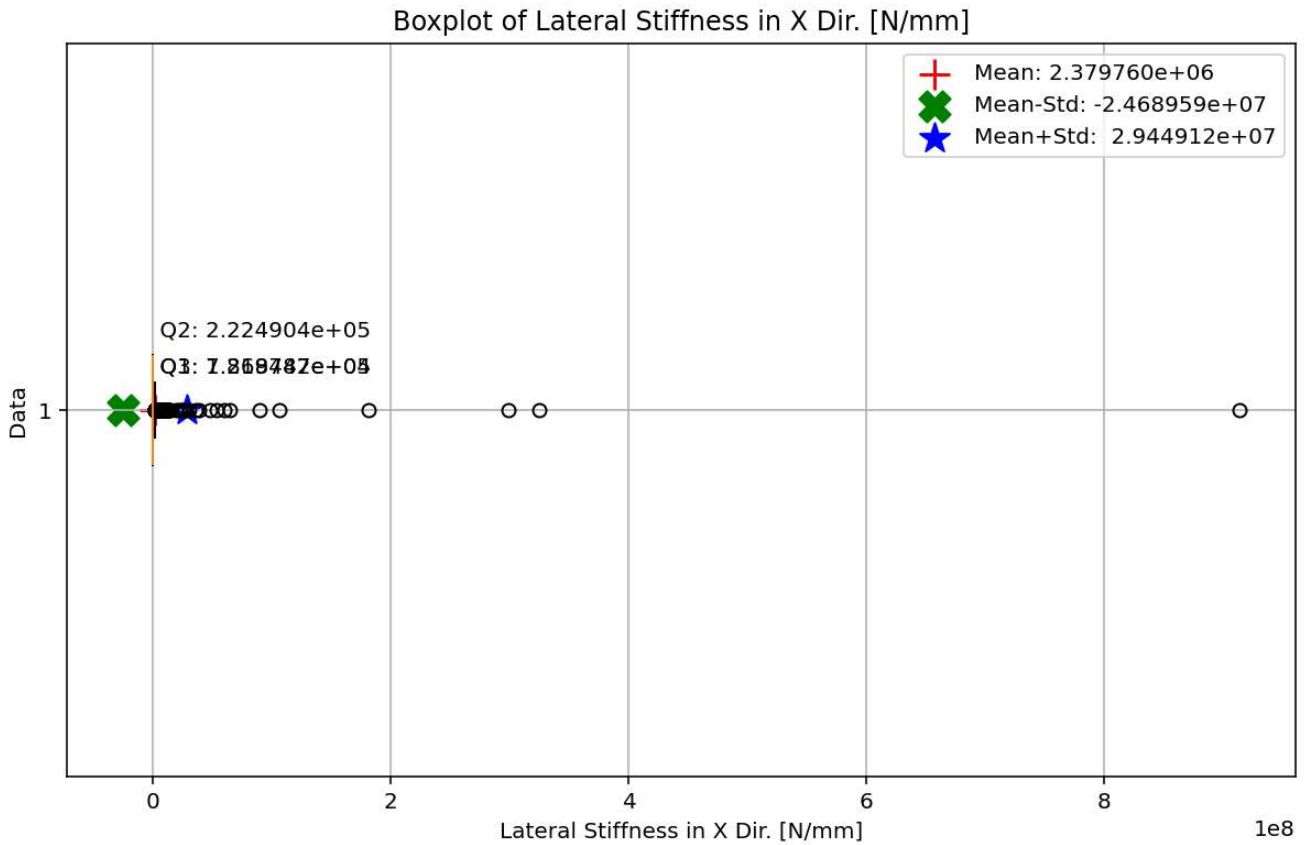

Histogram - Probability of Positive Axial-reaction in X [N] is 42.50 %
1e−6
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Frequency
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1e6
Axial-reaction in X [N]
Normal PDF
Quantile 0.25: -2.200404e+05
Median: -4.850401e+04
Quantile 0.75: 1.428020e+05
Mean: -4.829843e+03
Mean-Std: -3.510420e+05
Mean+Std: 3.413823e+05

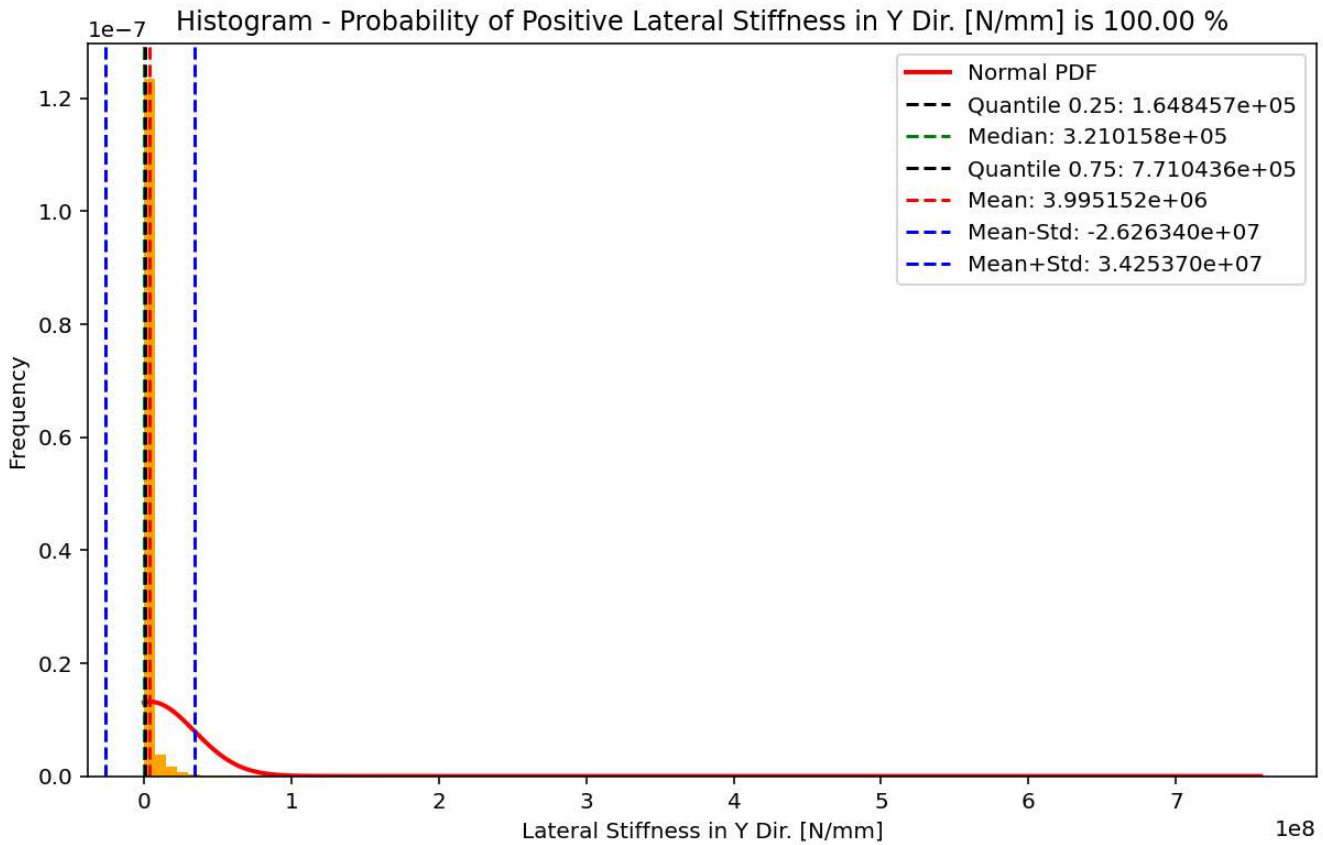

Boxplot of Axial-reaction in X [N]
Mean: -4.829843e+03
Mean-Std: -3.510420e+05
Mean+Std: 3.413823e+05
Q2: -4.850401e+04
Q1: -2.200404e+05
Q3: 1.428020e+05
Data
1
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1e6
Axial-reaction in X [N]

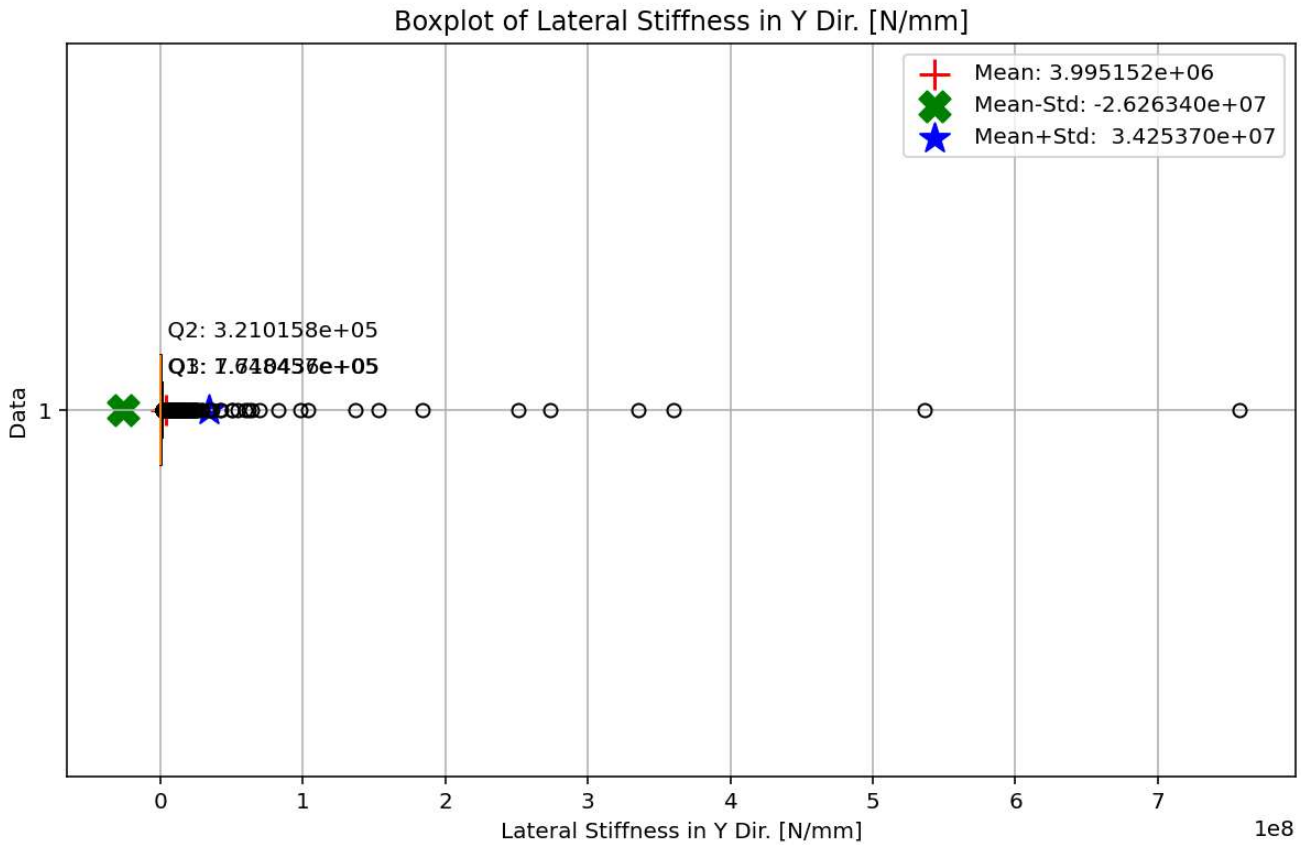

Histogram - Probability of Positive Moment-reaction in Z [N.mm] is 61.69 %
1e−9
Normal PDF
Quantile 0.25: -1.028270e+08
Median: 9.744543e+07
Quantile 0.75: 4.927551e+08
Mean: 1.459817e+08
Mean-Std: -1.989344e+08
Mean+Std: 4.908979e+08
Frequency
0.0
0.5
1.0
1.5
2.0
2.5
−4
−2
0
2
4
6
8
Moment-reaction in Z [N.mm]
1e8

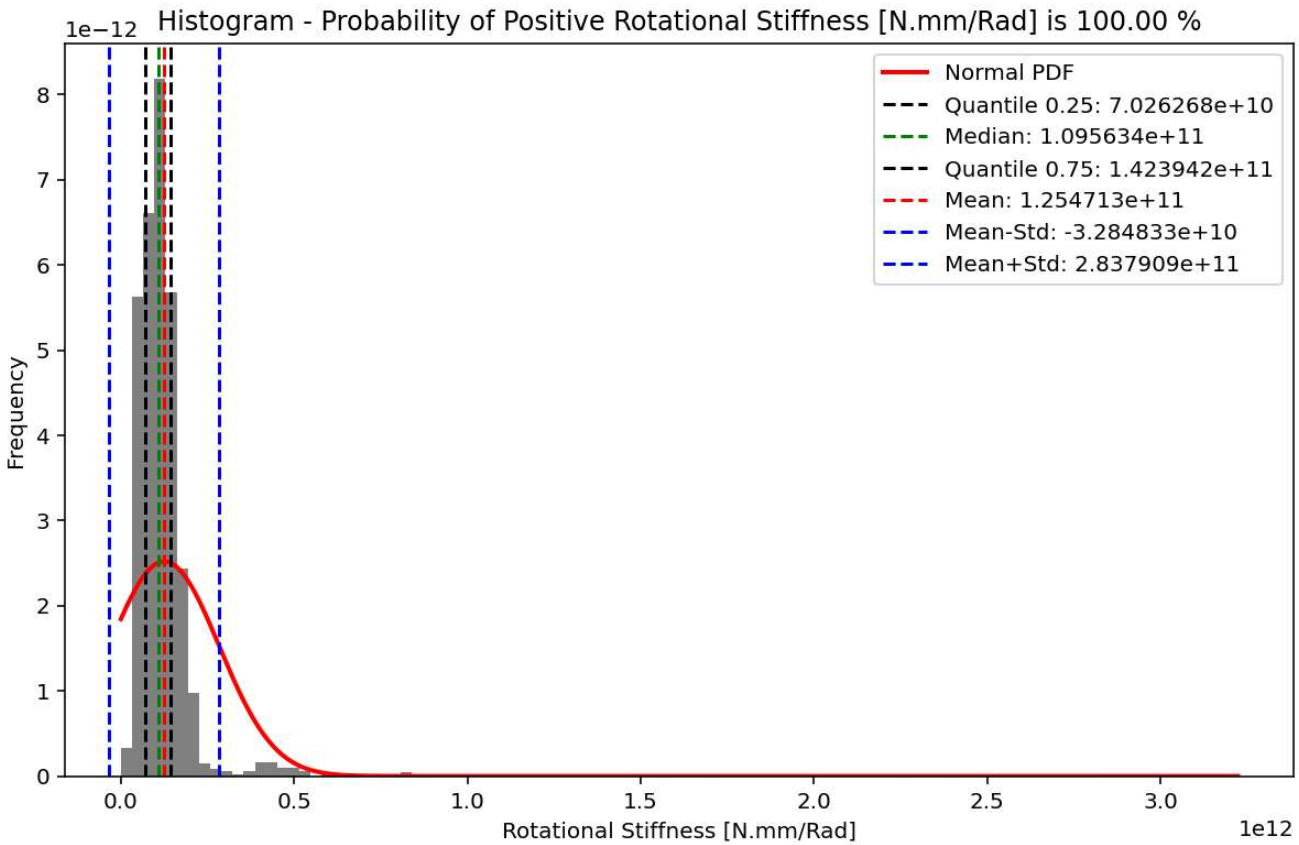

Boxplot of Moment-reaction in Z [N.mm]
Mean: 1.459817e+08
Mean-Std: -1.989344e+08
Mean+Std: 4.908979e+08
Q2: 9.744543e+07
Q1: -1.028270e+08
Q3: 4.927551e+08
Data
1
−4
−2
0
2
4
6
8
Moment-reaction in Z [N.mm]
1e8

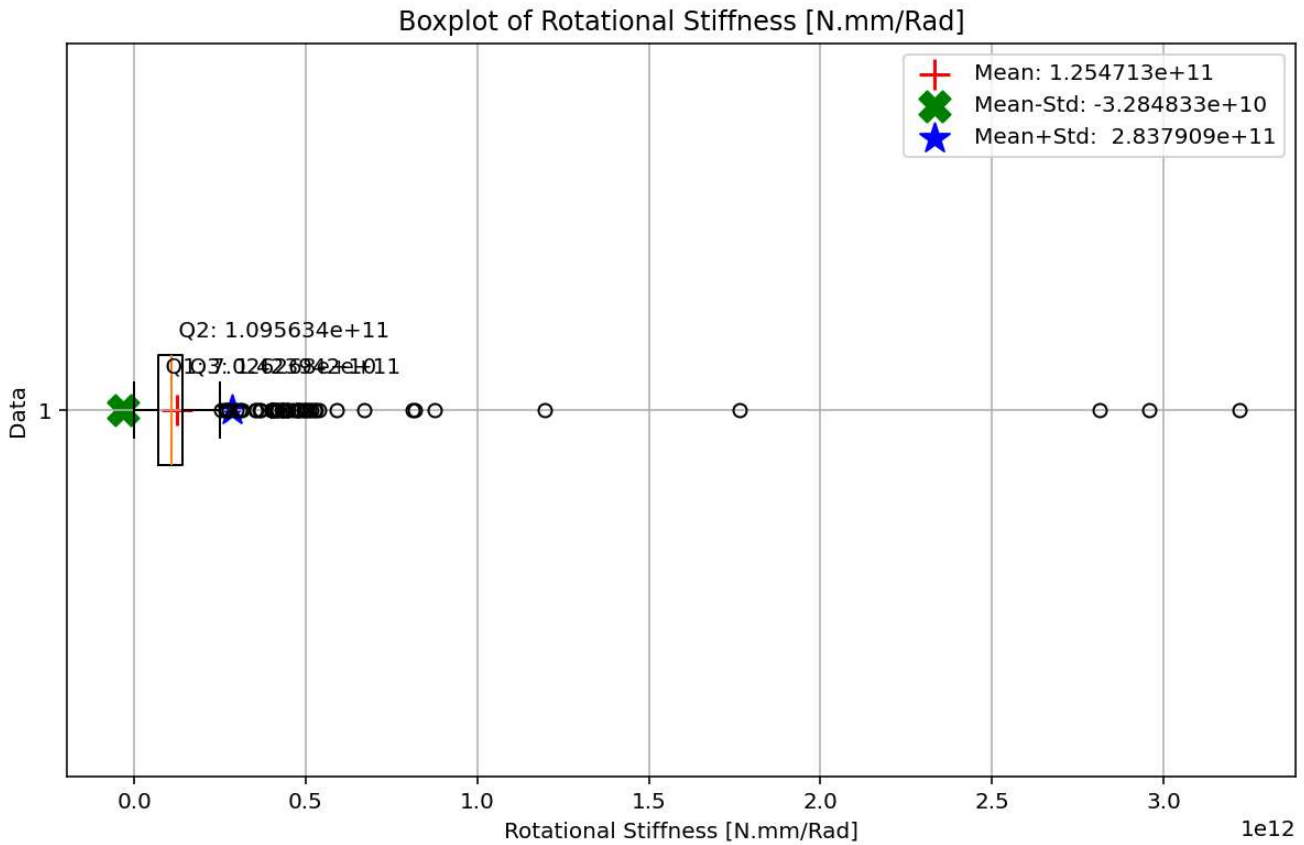

Histogram - Probability of Positive Lateral Stiffness in X Dir. [N/mm] is 100.00 %
1e−7
Frequency
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
1e8
Lateral Stiffness in X Dir. [N/mm]
Normal PDF
Quantile 0.25: 1.219747e+04
Median: 2.224904e+05
Quantile 0.75: 7.868482e+05
Mean: 2.379760e+06
Mean-Std: -2.468959e+07
Mean+Std: 2.944912e+07

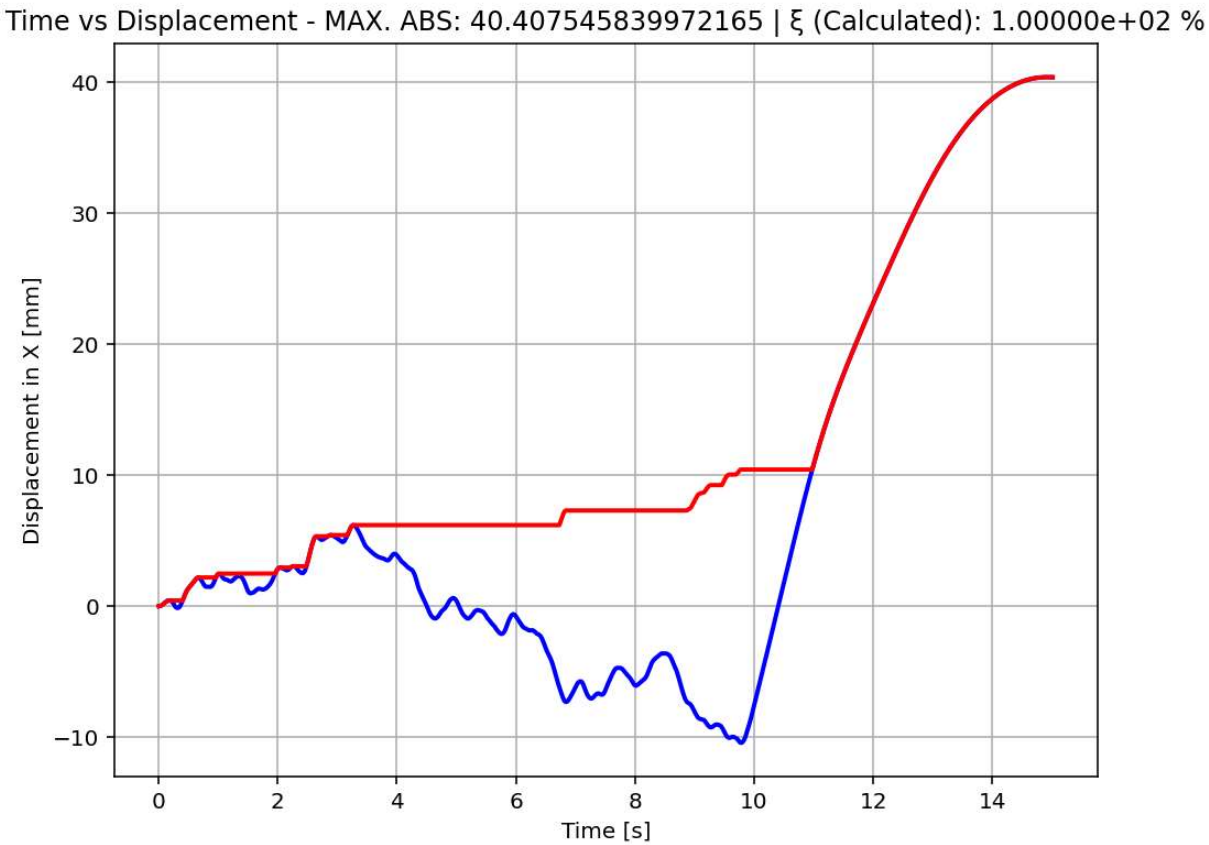

Boxplot of Lateral Stiffness in X Dir. [N/mm]
Mean: 2.379760e+06
Mean-Std: -2.468959e+07
Mean+Std: 2.944912e+07
Q2: 2.224904e+05
Data
1
0
2
4
6
8
Lateral Stiffness in X Dir. [N/mm]
1e8

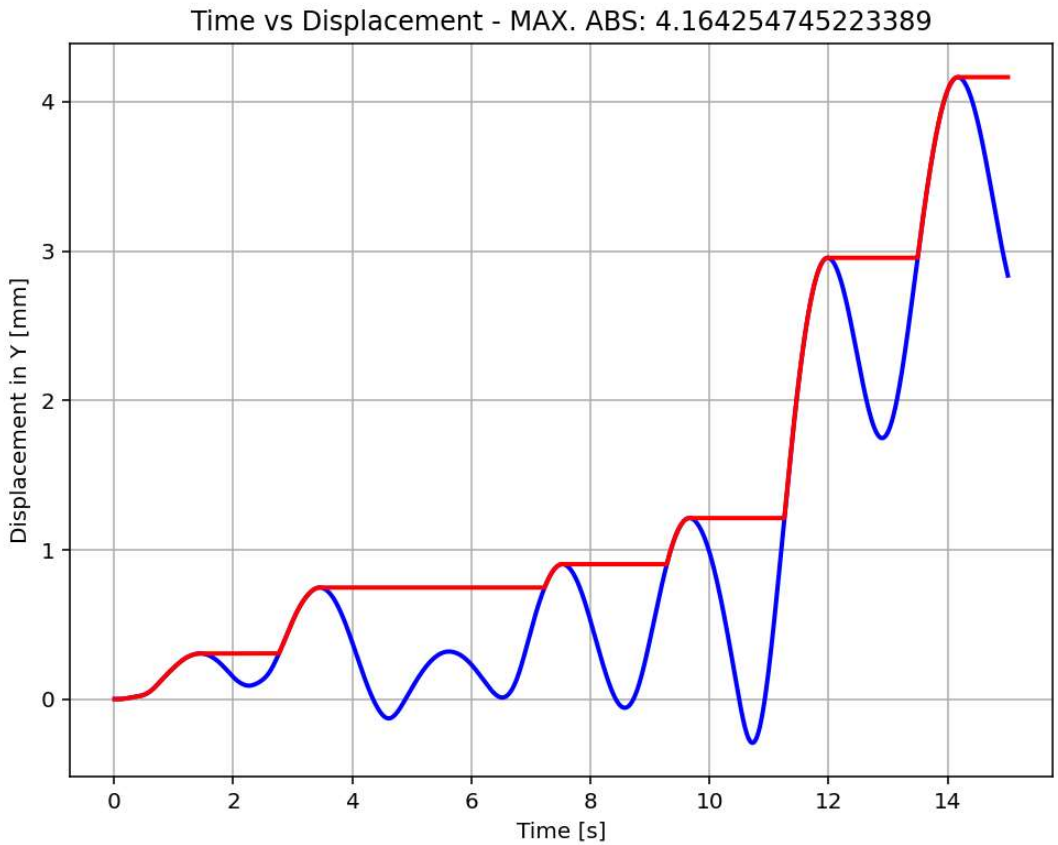

Histogram - Probability of Positive Lateral Stiffness in Y Dir. [N/mm] is 100.00 %
1e−7
Frequency
Lateral Stiffness in Y Dir. [N/mm]
1e8
Normal PDF
Quantile 0.25: 1.648457e+05
Median: 3.210158e+05
Quantile 0.75: 7.710436e+05
Mean: 3.995152e+06
Mean-Std: -2.626340e+07
Mean+Std: 3.425370e+07

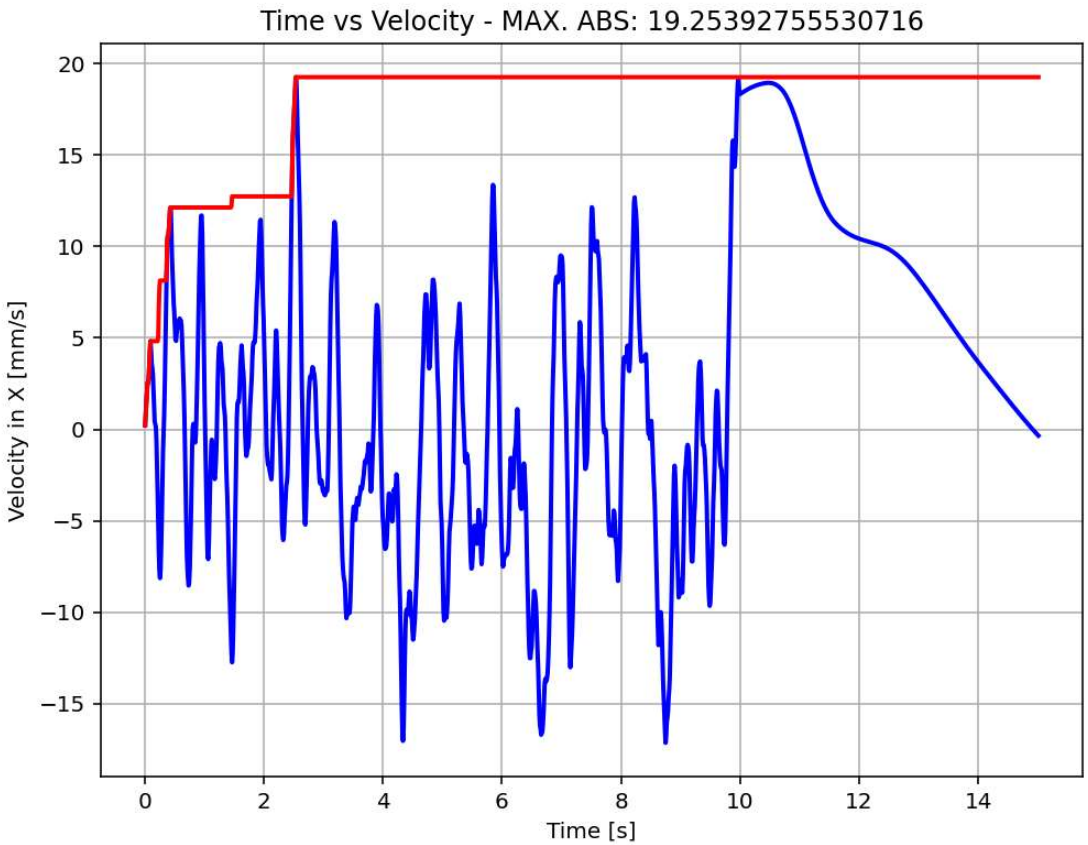

Boxplot of Lateral Stiffness in Y Dir. [N/mm]
Mean: 3.995152e+06
Mean-Std: -2.626340e+07
Mean+Std: 3.425370e+07
Q2: 3.210158e+05
Data
1
0
1
2
3
4
5
6
7
Lateral Stiffness in Y Dir. [N/mm]
1e8

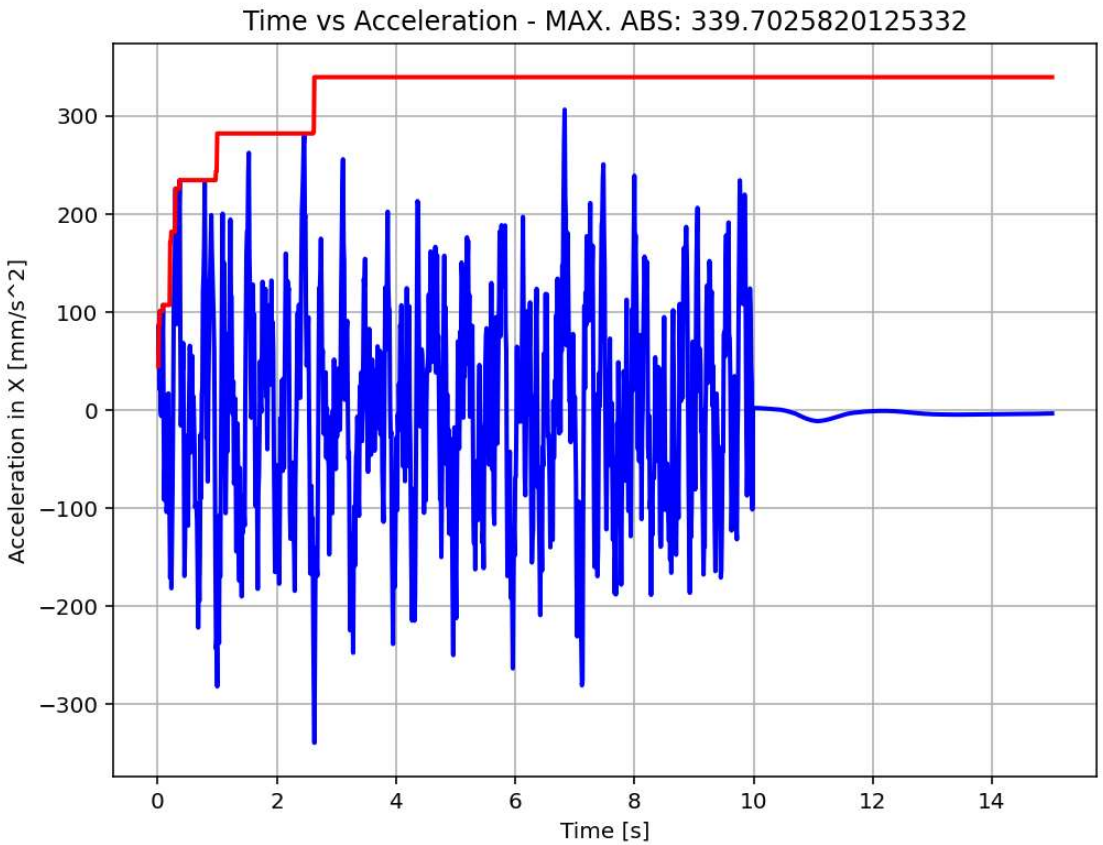

Histogram - Probability of Positive Rotational Stiffness [N.mm/Rad] is 100.00 %
1e−12
Frequency
Rotational Stiffness [N.mm/Rad]
1e12
Normal PDF
Quantile 0.25: 7.026268e+10
Median: 1.095634e+11
Quantile 0.75: 1.423942e+11
Mean: 1.254713e+11
Mean-Std: -3.284833e+10
Mean+Std: 2.837909e+11

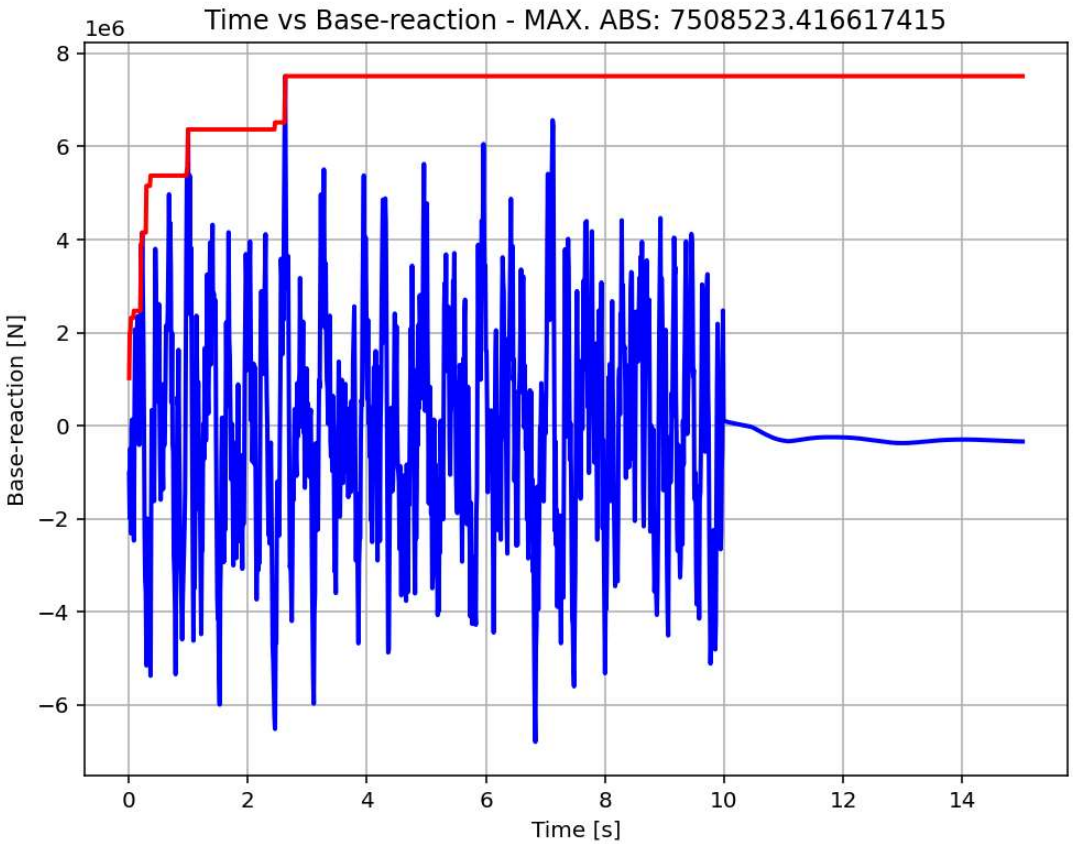

Boxplot of Rotational Stiffness [N.mm/Rad]
Mean: 1.254713e+11
Mean-Std: -3.284833e+10
Mean+Std: 2.837909e+11
Q2: 1.095634e+11
Data
1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Rotational Stiffness [N.mm/Rad]
1e12

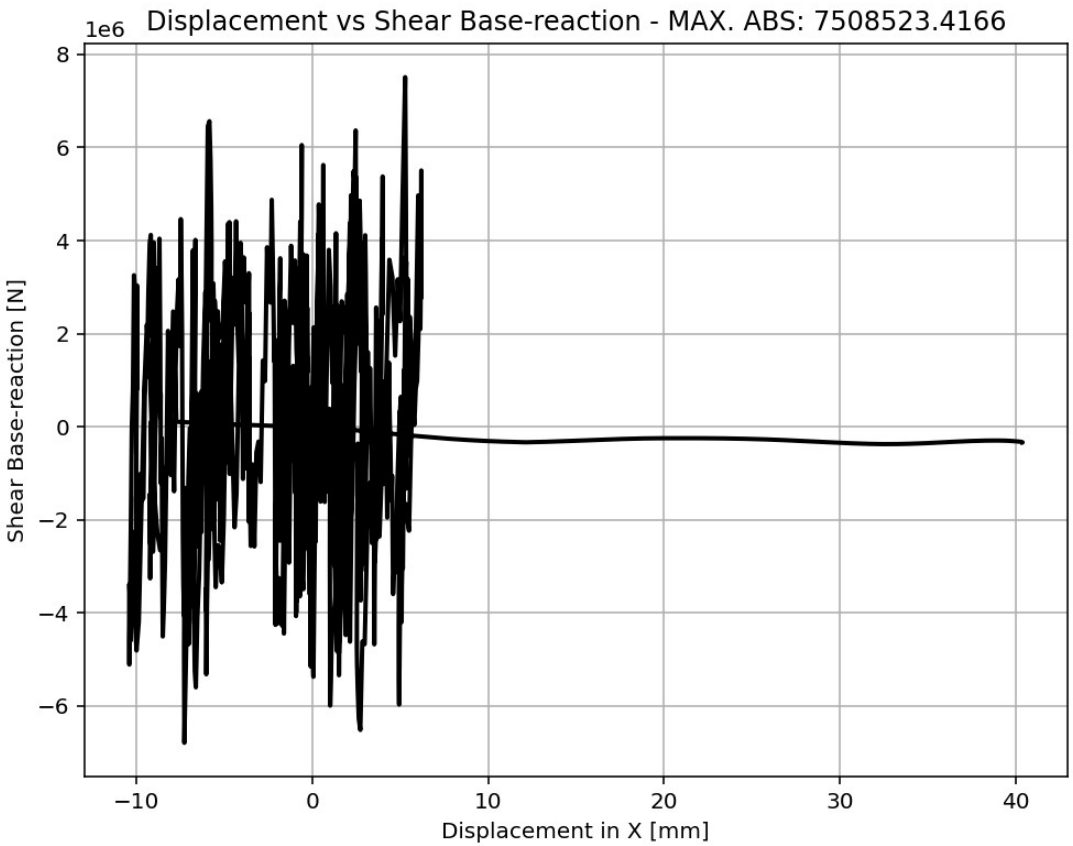

Time vs Displacement - MAX. ABS: 40.407545839972165 | ξ (Calculated): 1.00000e+02 %
Displacement in X [mm]
Time [s]
40
30
20
10
0
−10
0
2
4
6
8
10
12
14

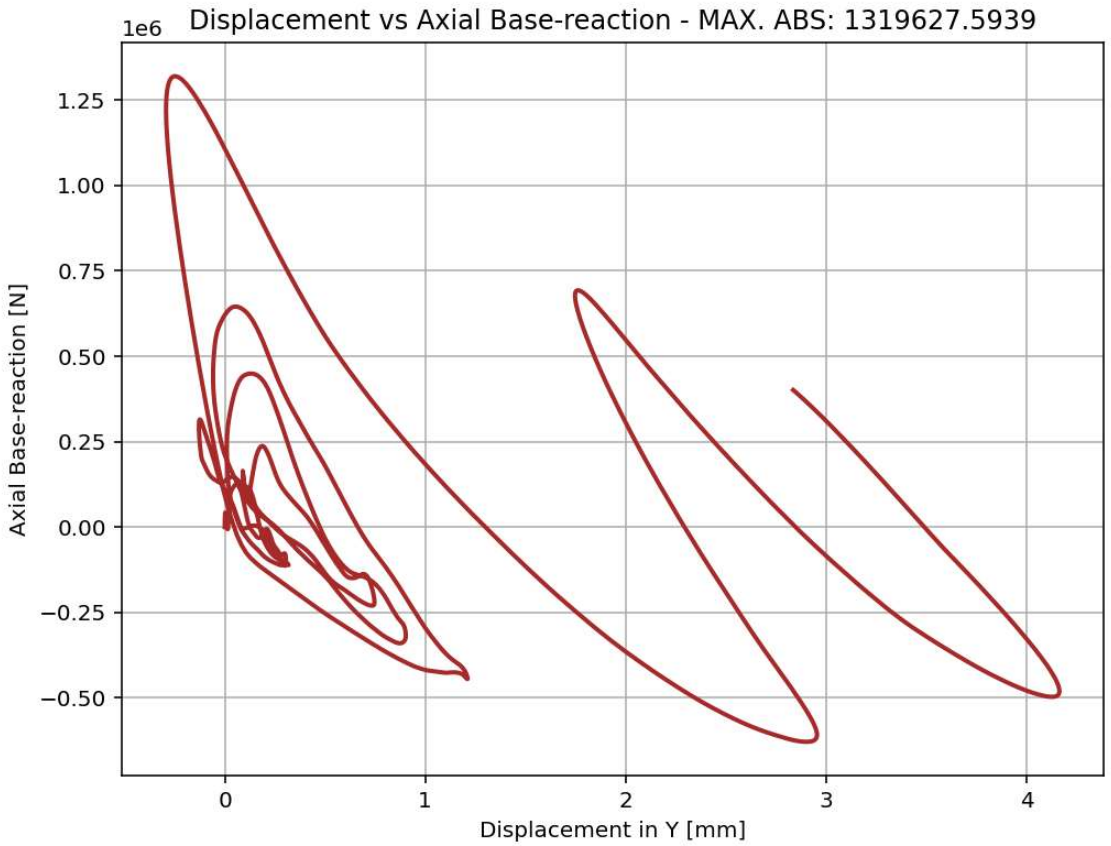

Time vs Displacement - MAX. ABS: 4.164254745223389
Displacement in Y [mm]
Time [s]
0
1
2
3
4
0
2
4
6
8
10
12
14


Time vs Velocity - MAX. ABS: 19.25392755530716
Velocity in X [mm/s]
Time [s]
20
15
10
5
0
−5
−10
−15
0
2
4
6
8
10
12
14


Time vs Acceleration - MAX. ABS: 339.7025820125332
Acceleration in X [mm/s^2]
Time [s]
300
200
100
0
−100
−200
−300
0
2
4
6
8
10
12
14


Time vs Base-reaction - MAX. ABS: 7508523.416617415
1e6
8
6
4
2
0
−2
−4
−6
Base-reaction [N]
0
2
4
6
8
10
12
14
Time [s]


Displacement vs Shear Base-reaction - MAX. ABS: 7508523.4166
1e6
8
6
4
2
0
−2
−4
−6
Shear Base-reaction [N]
−10
0
10
20
30
40
Displacement in X [mm]


Displacement vs Axial Base-reaction - MAX. ABS: 1319627.5939
1e6
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
Axial Base-reaction [N]
0
1
2
3
4
Displacement in Y [mm]