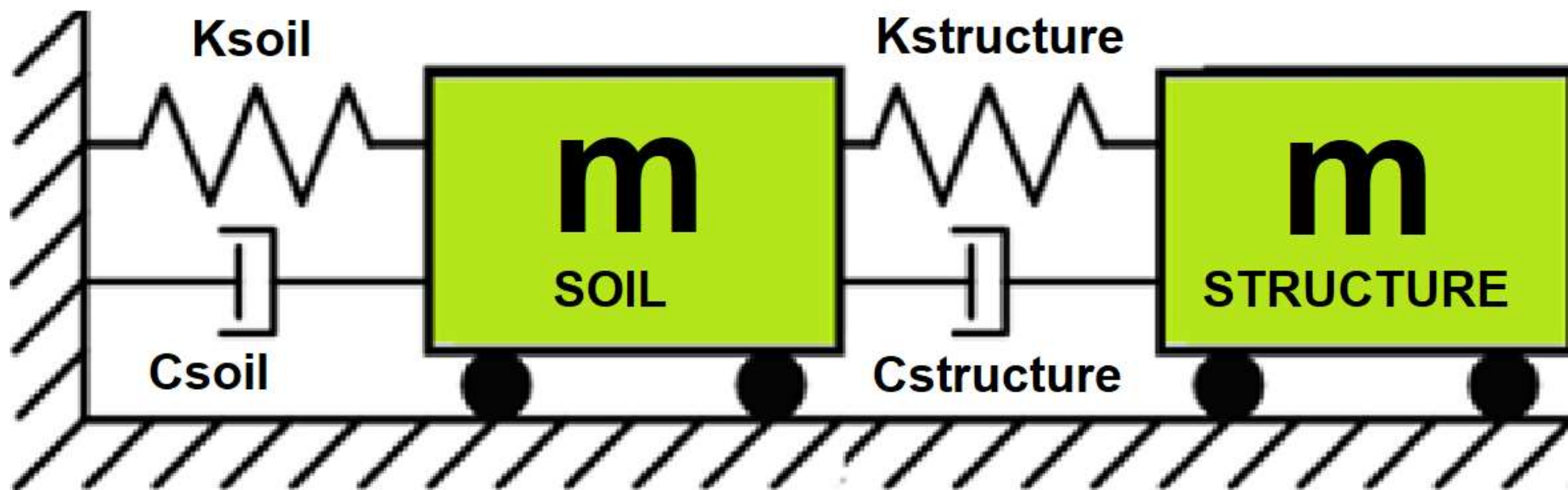
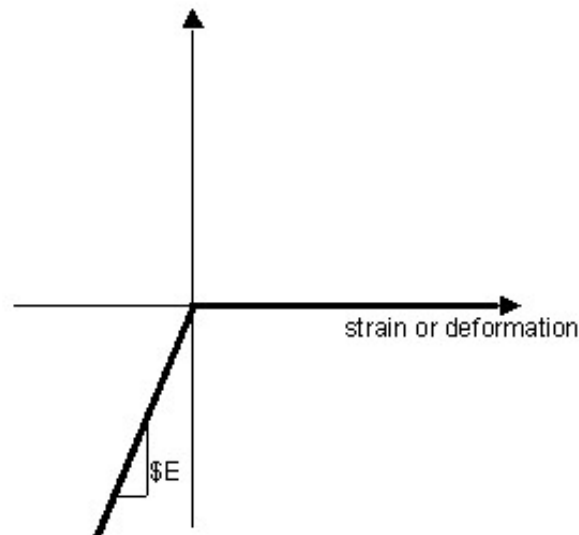


>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

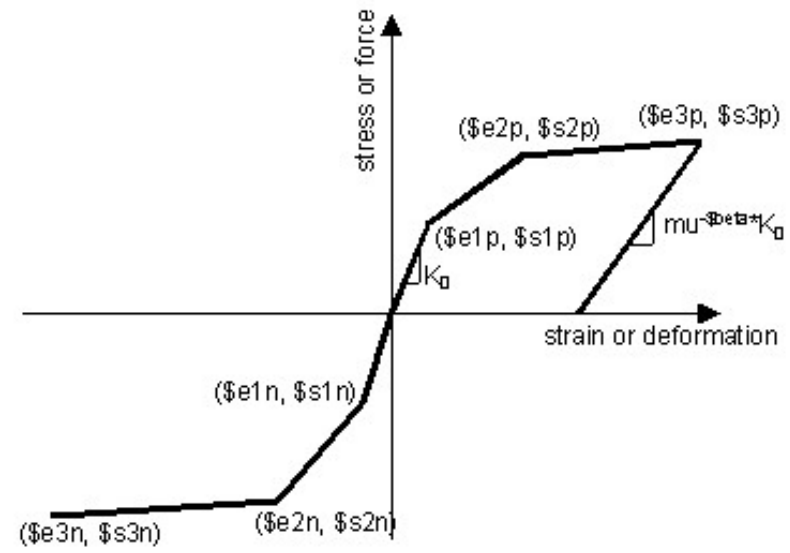
NONLINEAR DYNAMIC ANALYSIS OF A TWO-DOF SOIL-STRUCTURE SYSTEM UNDER 20 GROUND MOTIONS WITH RESPONSE SPECTRA AND DUCTILITY DAMAGE INDEX CALCULATION IN OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)



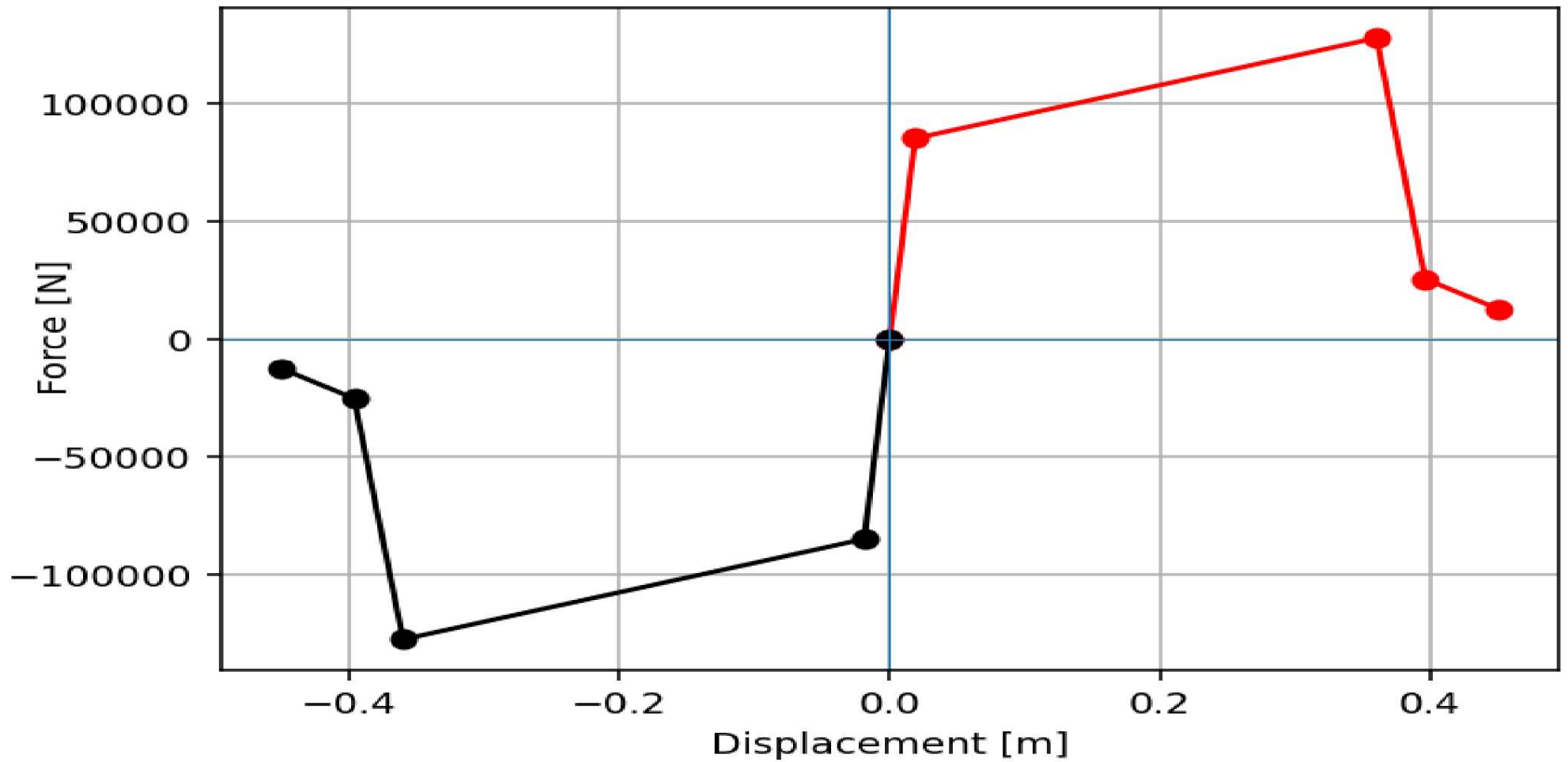


SOIL STIFFNESS



STRUCTURE STIFFNESS

Force-Displacement Curve



$$\text{Structural Ductility Damage Index} = \frac{\Delta_d - \Delta_y}{\Delta_u - \Delta_y}$$

Δ_d = Lateral Displacement from Dynamic Analysis

Δ_y = Lateral Yield Displacement from Pushover Analysis

Δ_u = Lateral Ultimate Displacement from Pushover Analysis

Spyder (Python 3.12)

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C:\Users\ DELL\Desktop\OPENSEES_FILES\MDOF_RESPONSE_SPECTRUM_SEISMIC

...

SOIL_INELASTIC_R...UM_SEISMIC_SDOF.py

FRAGILITY_CURVE_FUN.py

```
#####
#                               >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<                               #
#   NONLINEAR DYNAMIC ANALYSIS OF A TWO-DOF SOIL-STRUCTURE SYSTEM UNDER 20 GROUND MOTIONS WITH                               #
#   RESPONSE SPECTRA AND DUCTILITY DAMAGE INDEX CALCULATION IN OPENSEES                               #
#-----#
#                               THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)                               #
#                               EMAIL: salar.d.ghashghaei@gmail.com                               #
#-----#
"""
This code implements a comprehensive nonlinear dynamic analysis framework for
performance-based earthquake engineering assessment of multi-degree-of-freedom
(MDOF) systems. The methodology combines traditional nonlinear time-history
analysis with modern probabilistic and machine learning techniques for advanced
structural performance evaluation.

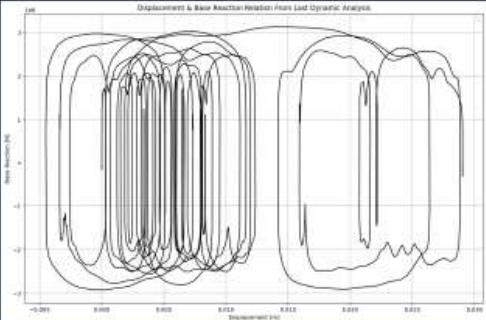
KEY ENGINEERING OBJECTIVES:
1. Comparative assessment of hysteretic models for seismic response prediction
2. Probabilistic seismic demand analysis using multiple ground motions
3. Development of fragility curves for performance-based earthquake engineering
4. Integration of data science methods for structural reliability assessment

ANALYTICAL FEATURES:
- Nonlinear material behavior with pinching and degradation
- Response spectrum analysis across period range
- Real-time structural health monitoring metrics
- Statistical characterization of seismic demands
- Machine learning-based damage prediction
-----
Model setup:
- SDOF properties: mass (m), initial stiffness (k), yield displacement (Dy), ultimate displacement (Du), visc
- Hysteresis models: HYSTERETICSM (pinching, stiffness degradation, strength decay).
- Damping: Rayleigh (or equivalent viscous) damping specified by target damping ratio xi for the fundamental

```

18 %

Displacement & Base Reaction History from Load Dynamic Analysis



IPython Console

Files

Help

Variable Explorer

Debugger

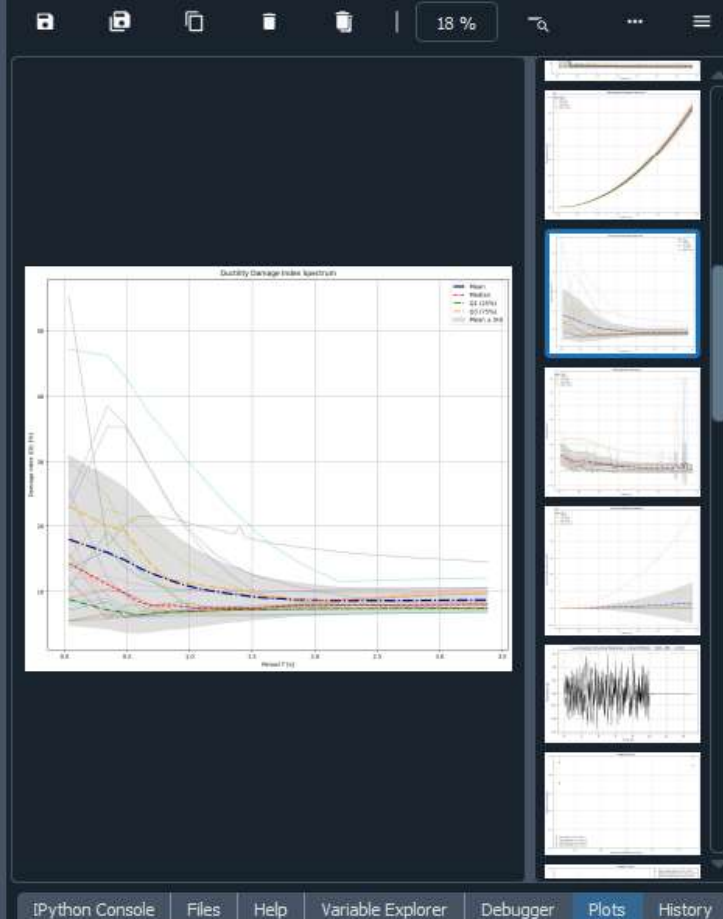
Plots

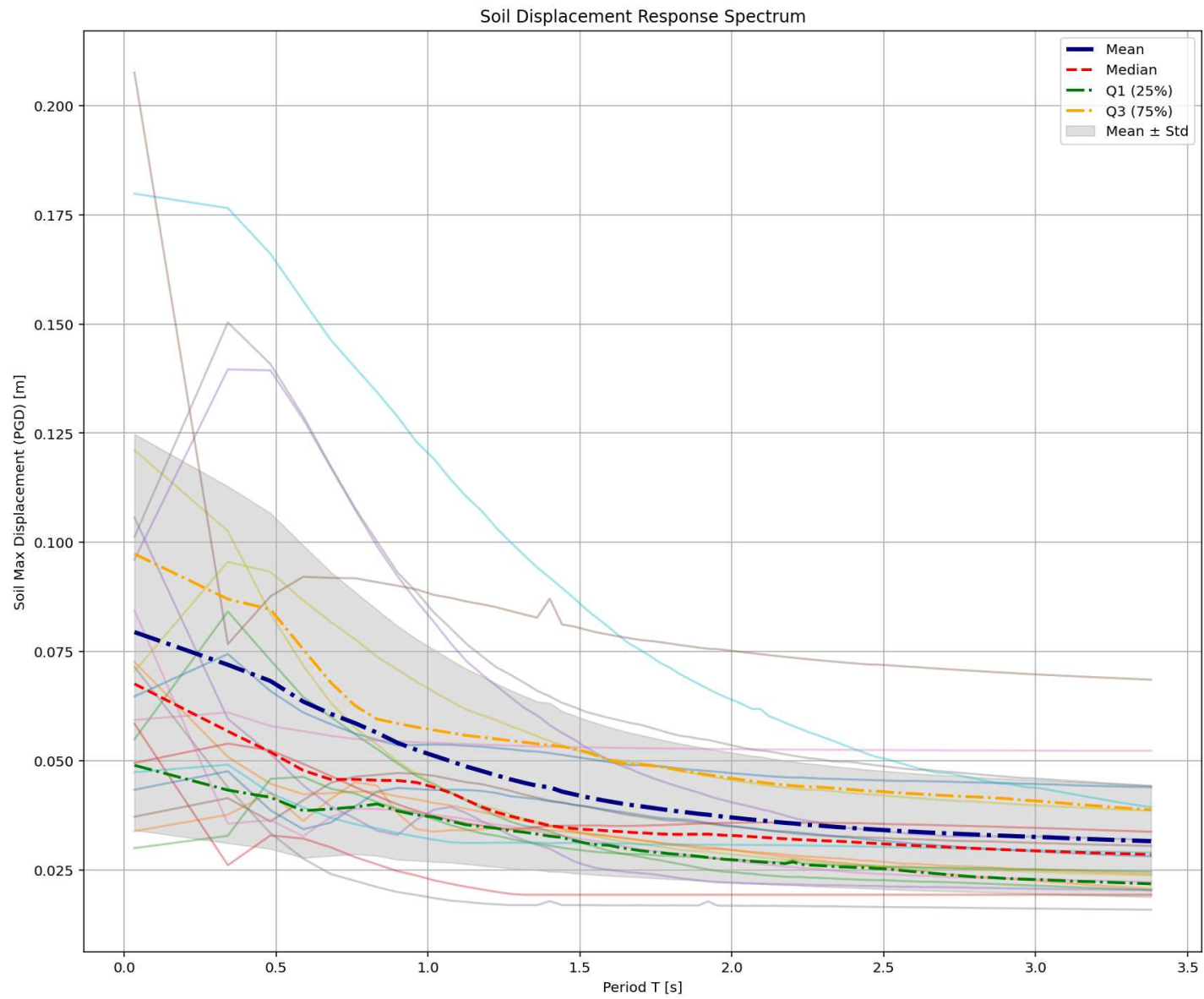
History

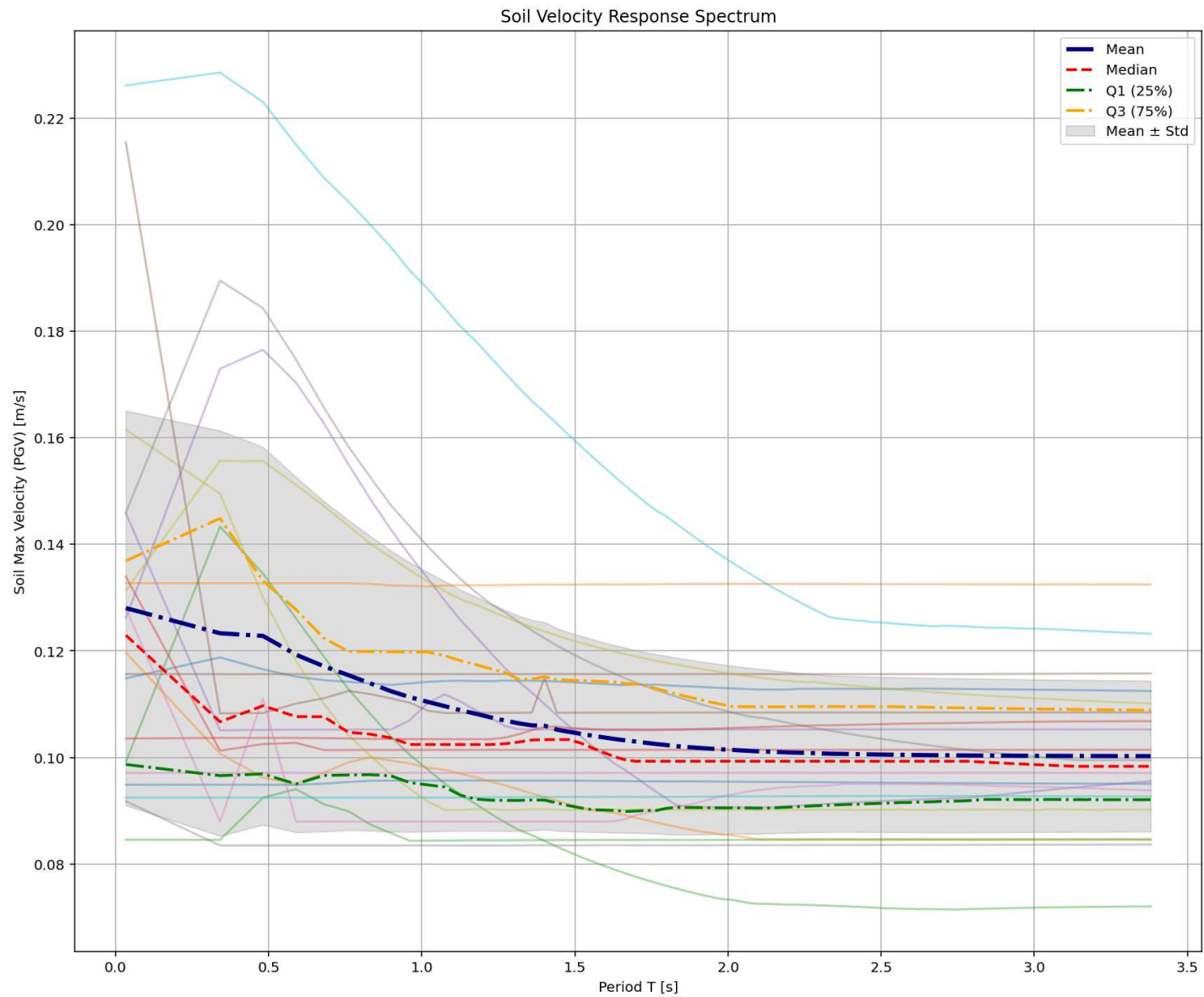
C:\Users\Del\Desktop\OPENSEES_FILES\SDOF_RESPONSE_SPECTRUM_SEISMIC\FRAGILITY_CURVE_FUN.py

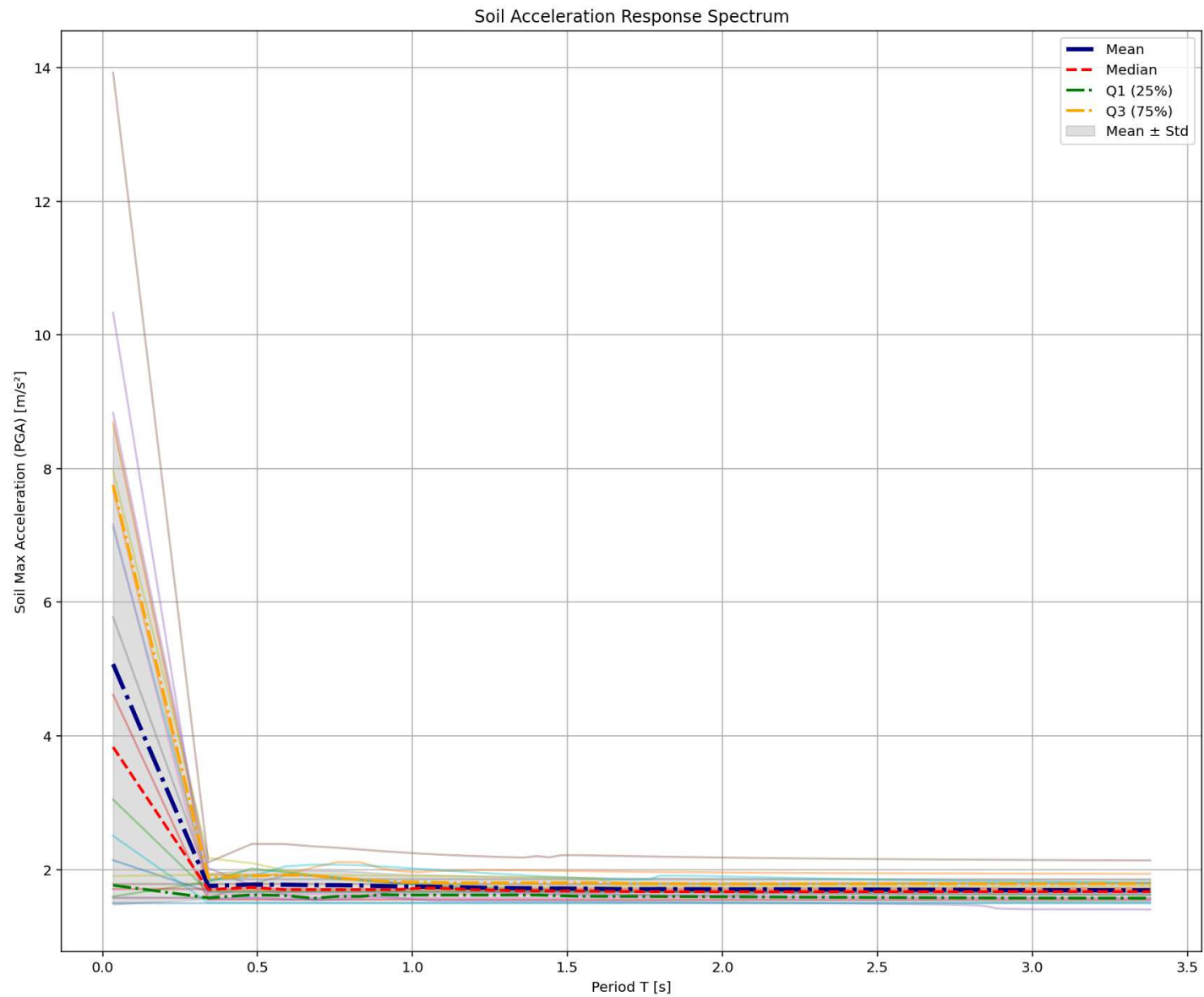
SOIL_INELASTIC_R...UM_SEISMIC_SDOF.py X FRAGILITY_CURVE_FUN.py X

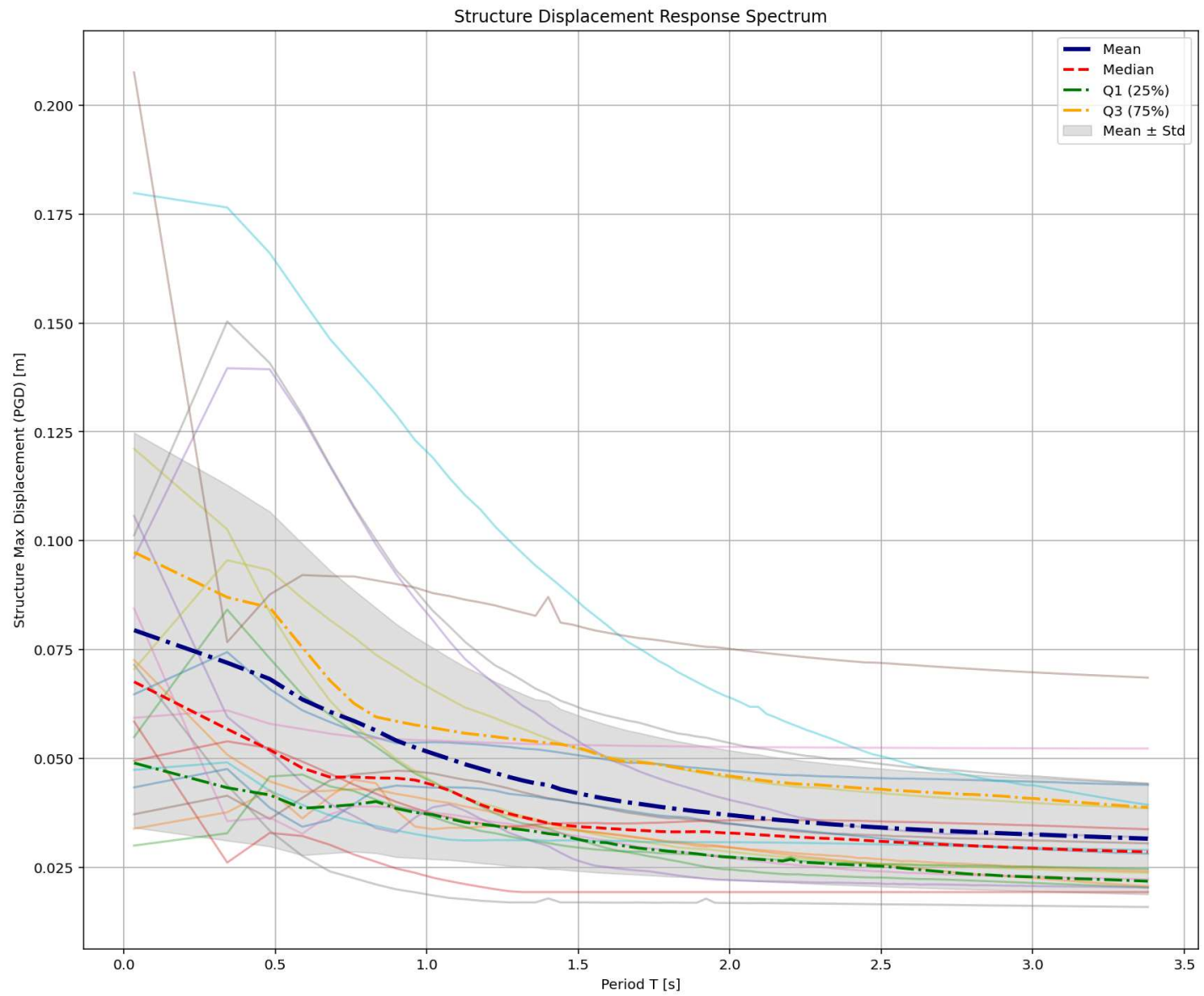
```
1 def FRAGILITY_CURVE(im_values, damage_states, X_LABEL, SEMILOGY=True, PLOT_KIND=True):
2     # THIS FUNCTION WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
3     from scipy.stats import norm
4     import numpy as np
5     import matplotlib.pyplot as plt
6
7     # Fragility curves
8     plt.figure(1, figsize=(12, 8))
9     # Calculate and plot fragility curves for each damage state
10    for damage_state, (median, beta) in damage_states.items():
11        # Calculate log-normal probabilities
12        ln_im = np.log(im_values)
13        ln_median = np.log(median)
14        probabilities = norm.cdf((ln_im - ln_median) / beta)
15        if PLOT_KIND == False:
16            plt.scatter(im_values, probabilities, marker='o', label=f'{damage_state} ( $\eta$ = $\{median\}$ ,  $\theta$ = $\{beta\}$ )')
17        if PLOT_KIND == True:
18            plt.plot(im_values, probabilities, lw=2, label=f'{damage_state} ( $\eta$ = $\{median\}$ ,  $\theta$ = $\{beta\}$ )')
19    plt.xlabel(X_LABEL)
20    plt.ylabel('Probability of Exceedance')
21    plt.title('Fragility Curves')
22    plt.legend()
23    if PLOT_KIND == True:
24        plt.semilogy()
25        plt.ylim(0, 1.0)
26        plt.grid(True)
27        plt.tight_layout()
28    plt.show()
```

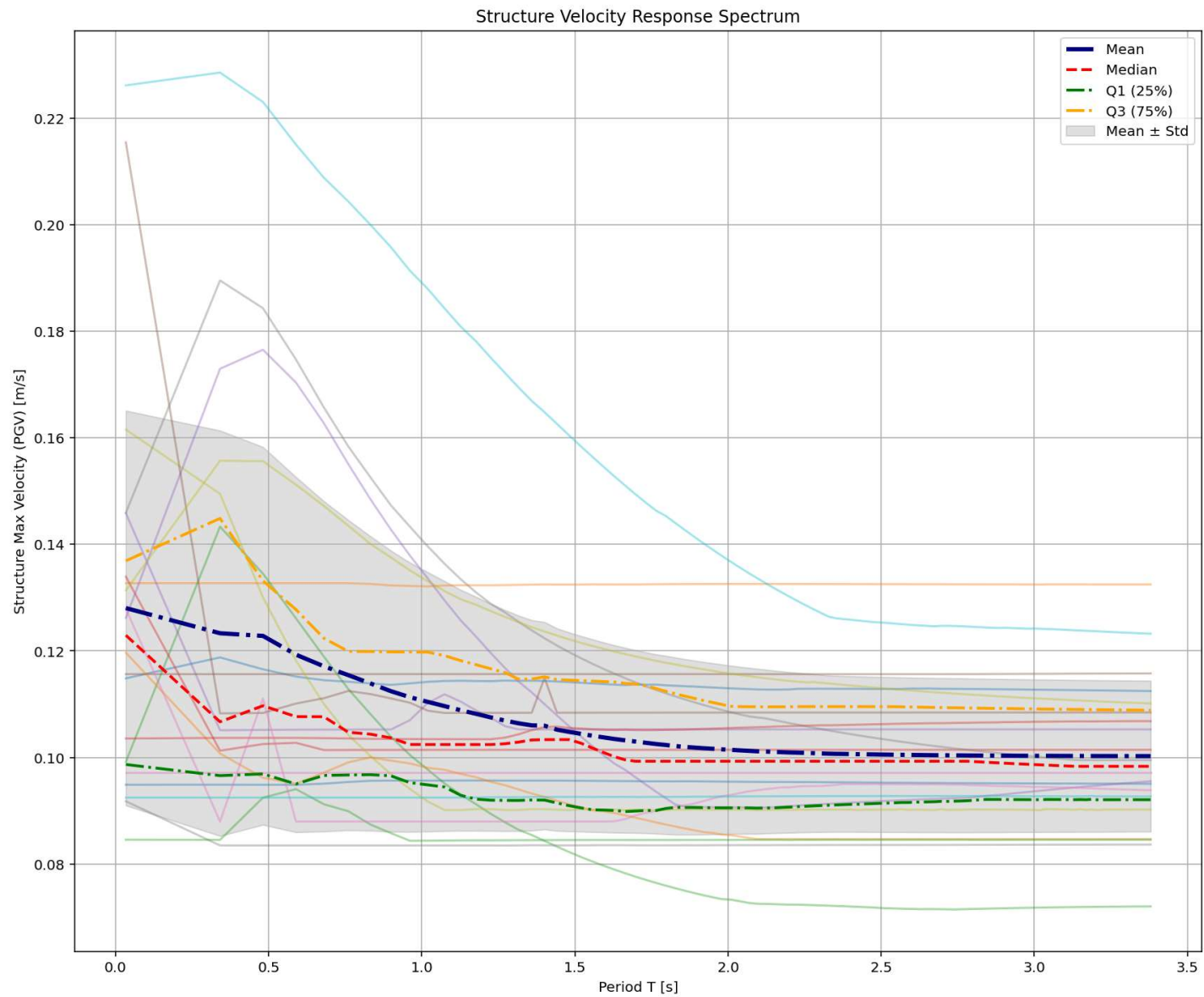


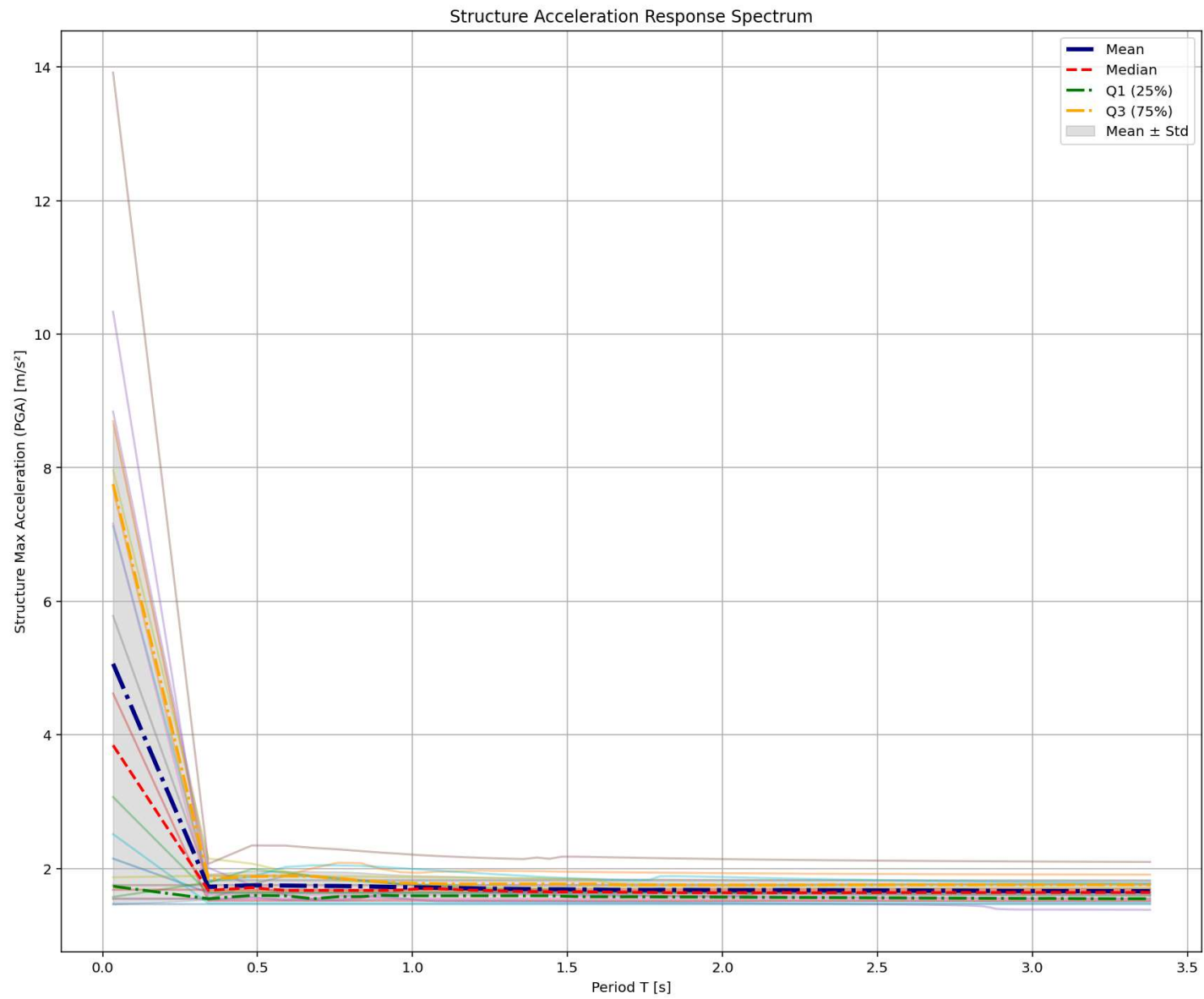


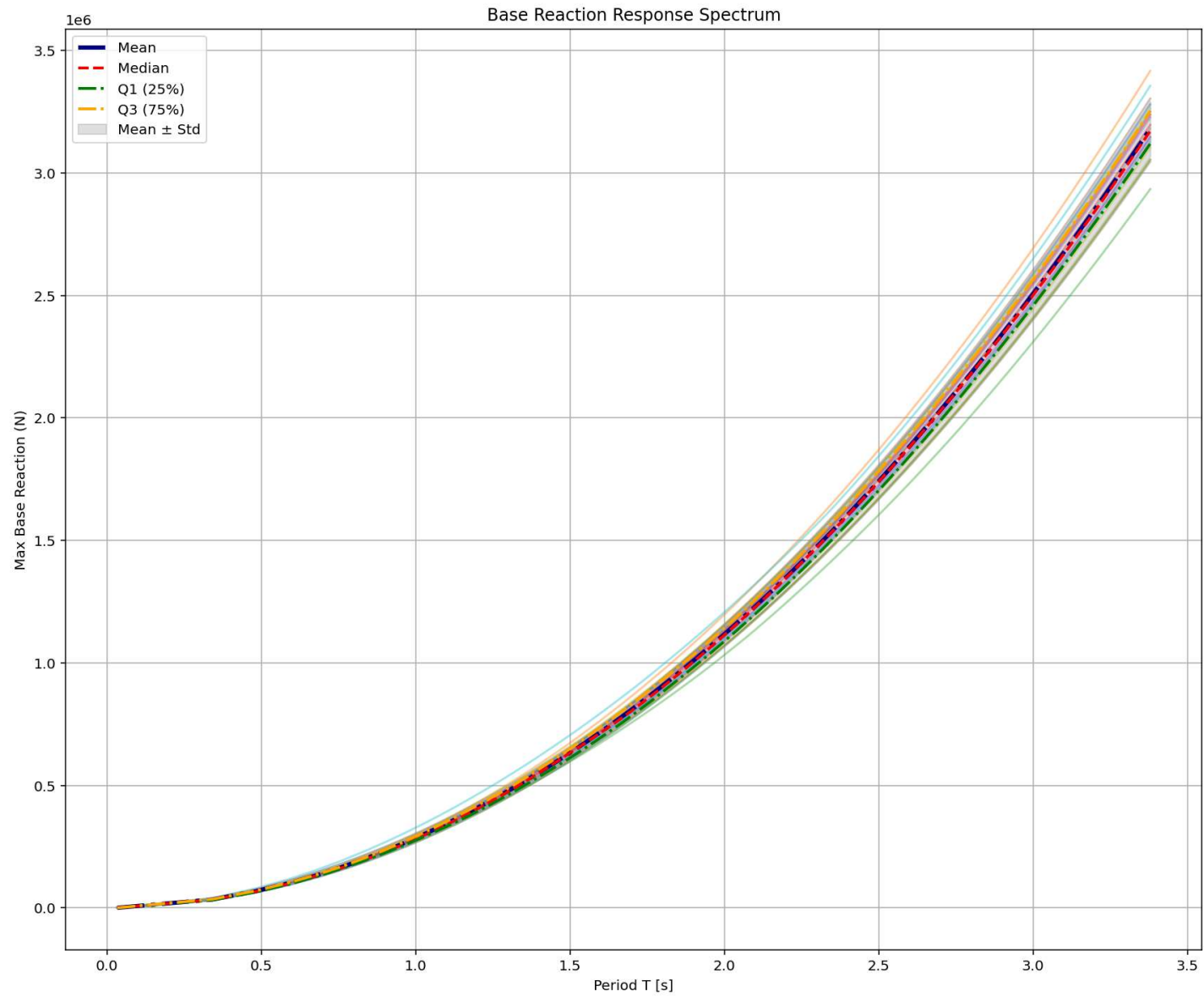


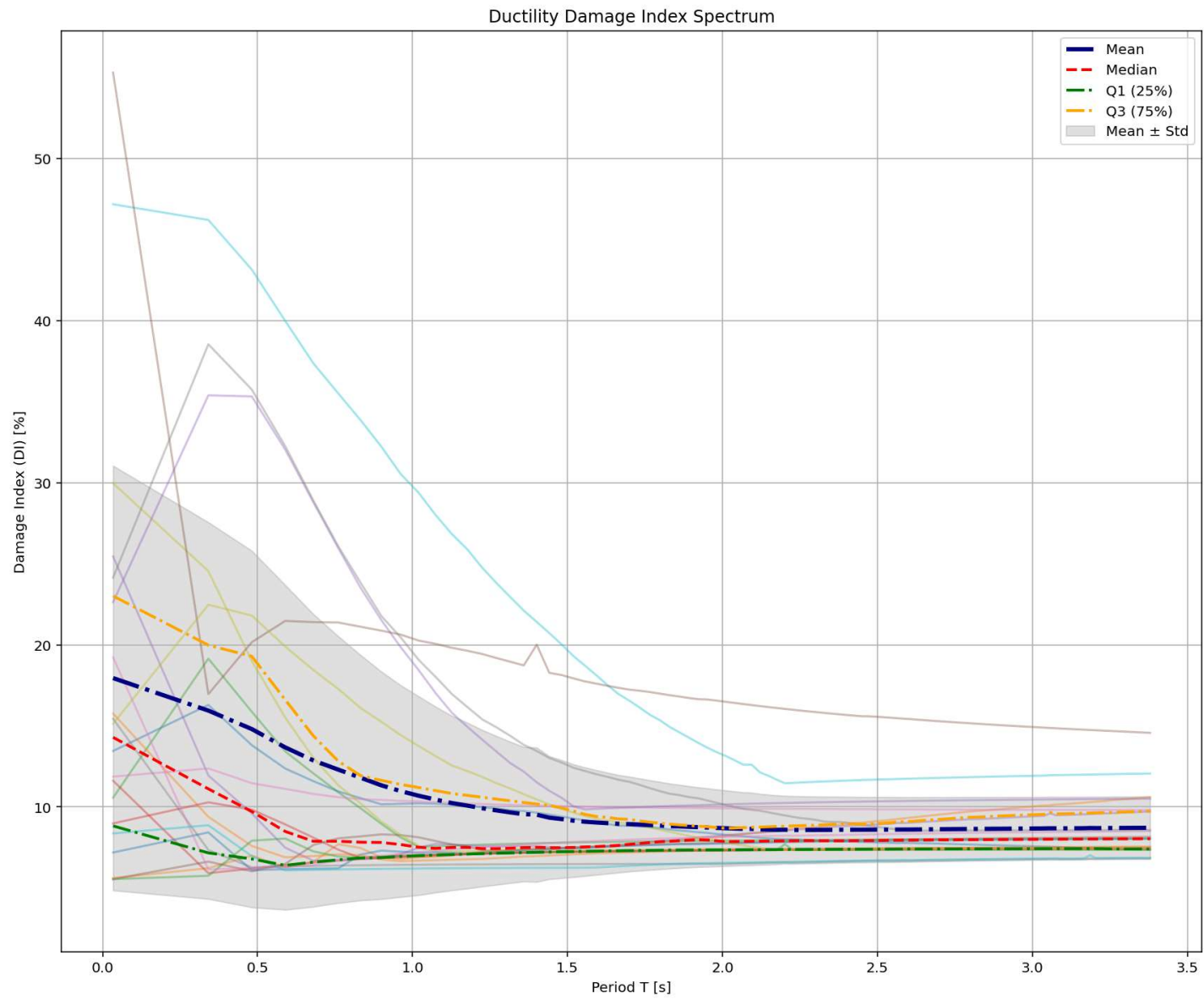


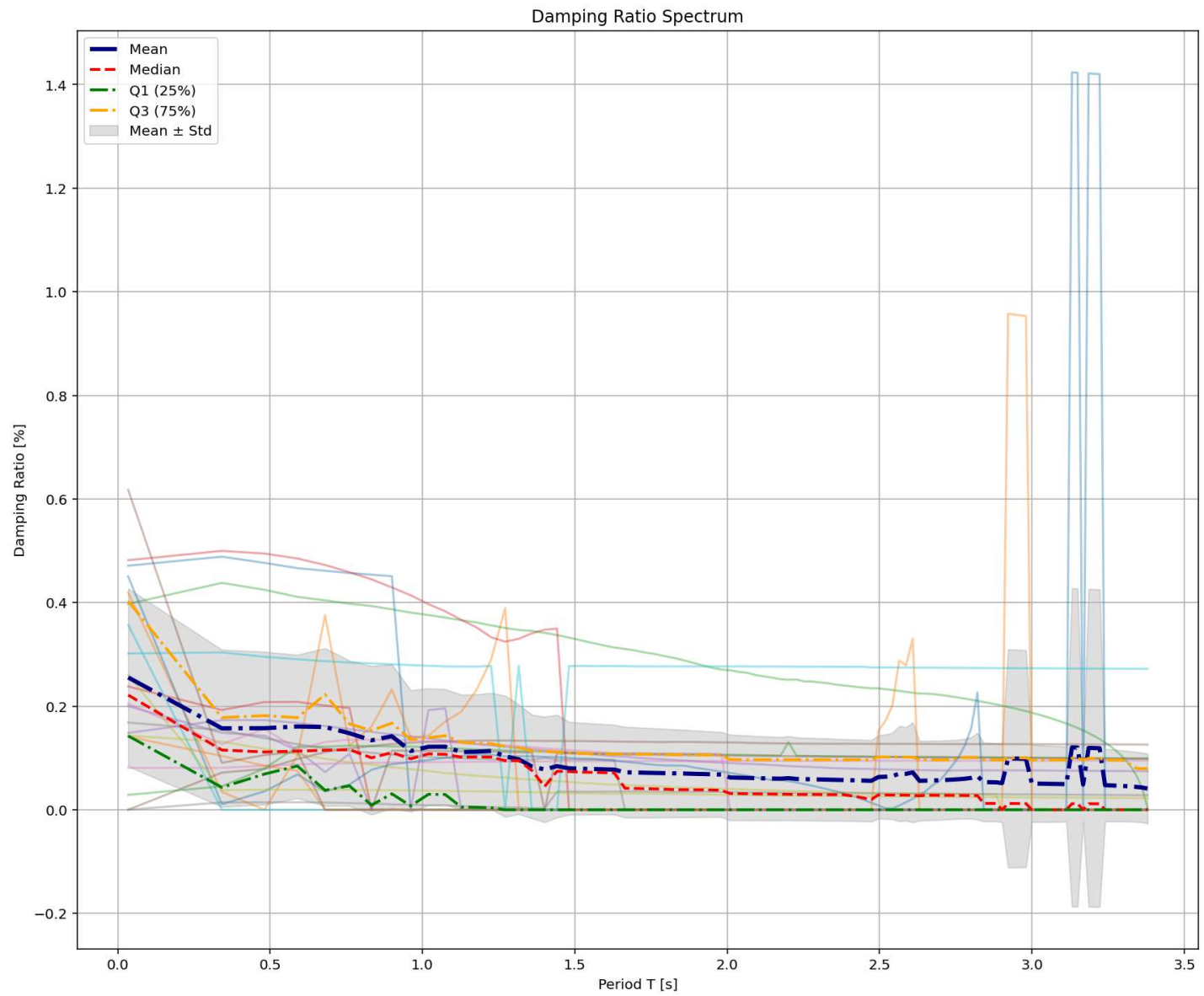


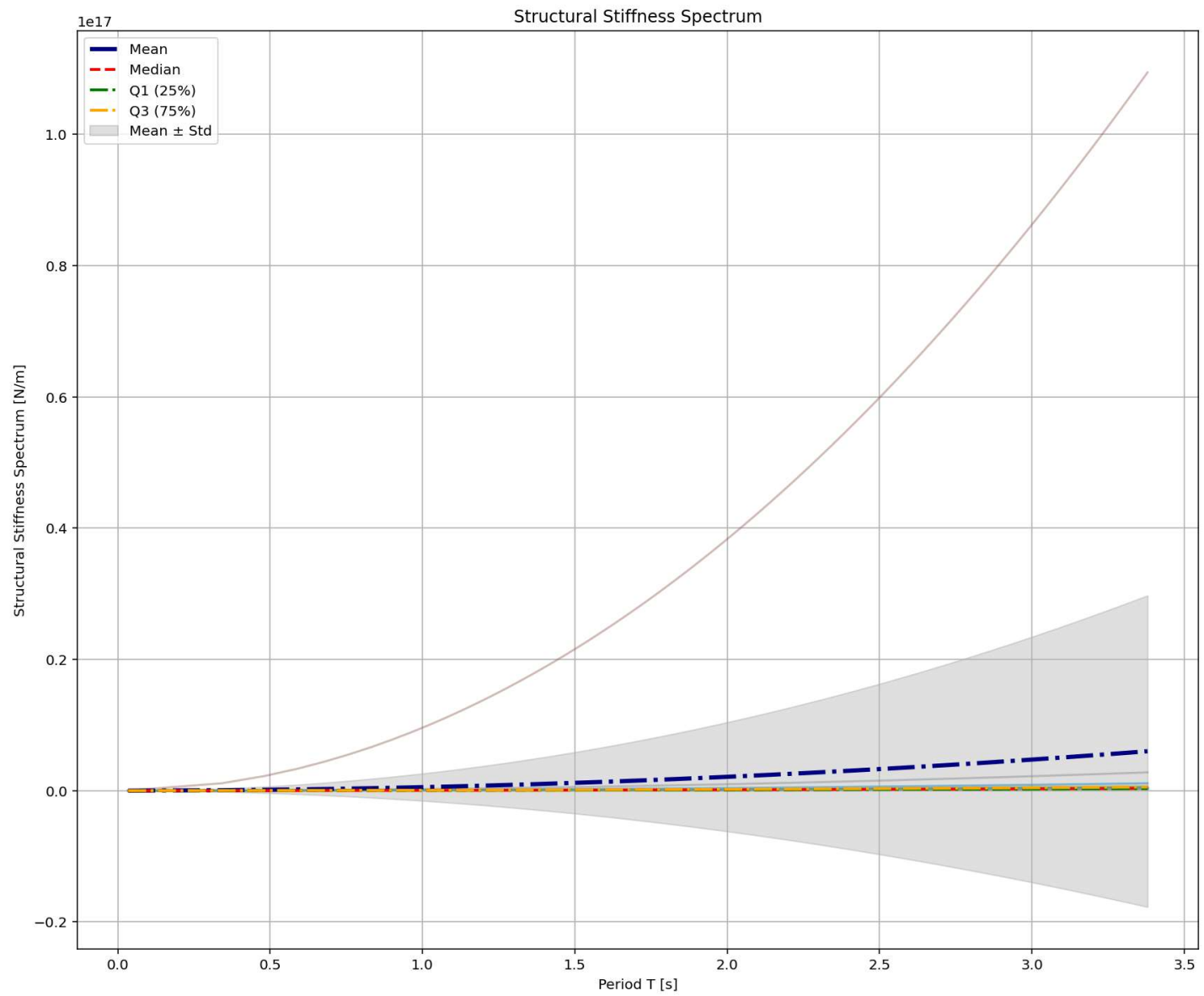




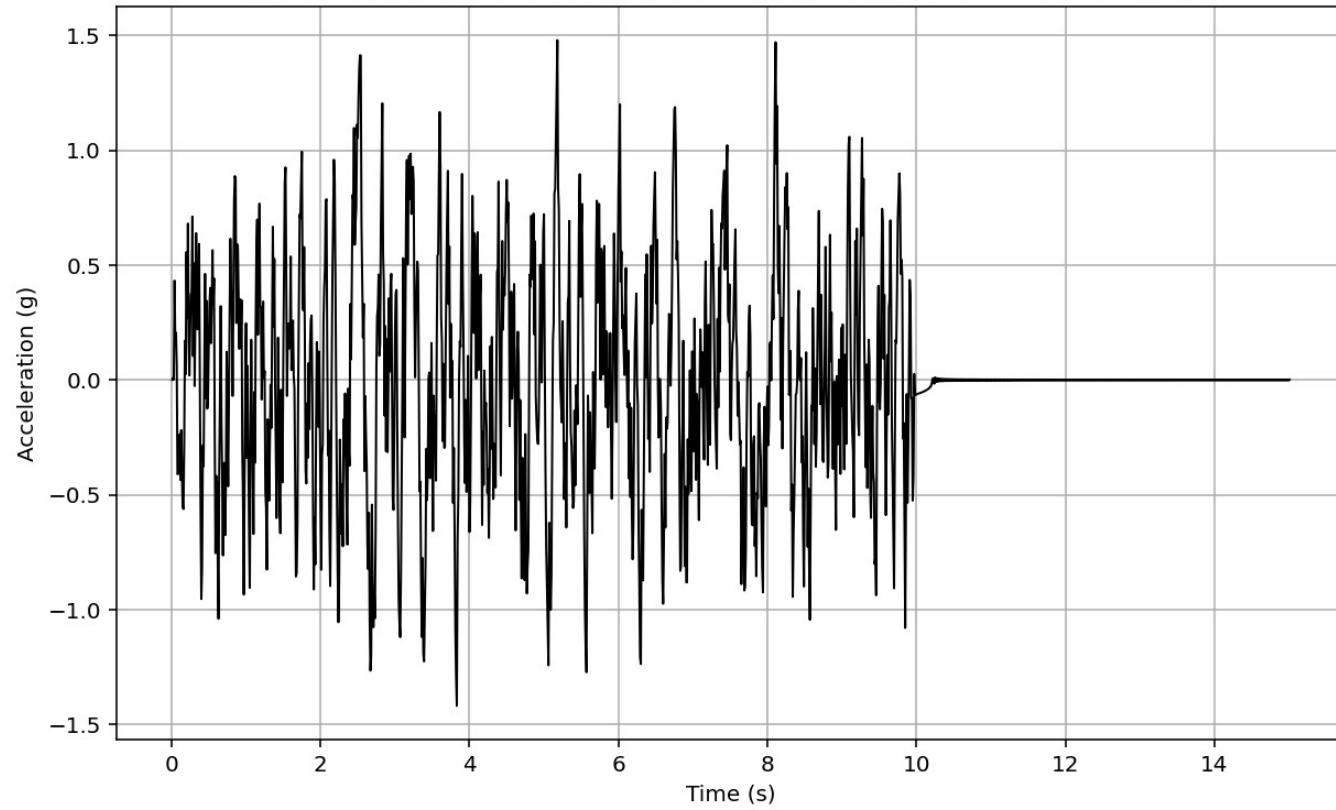


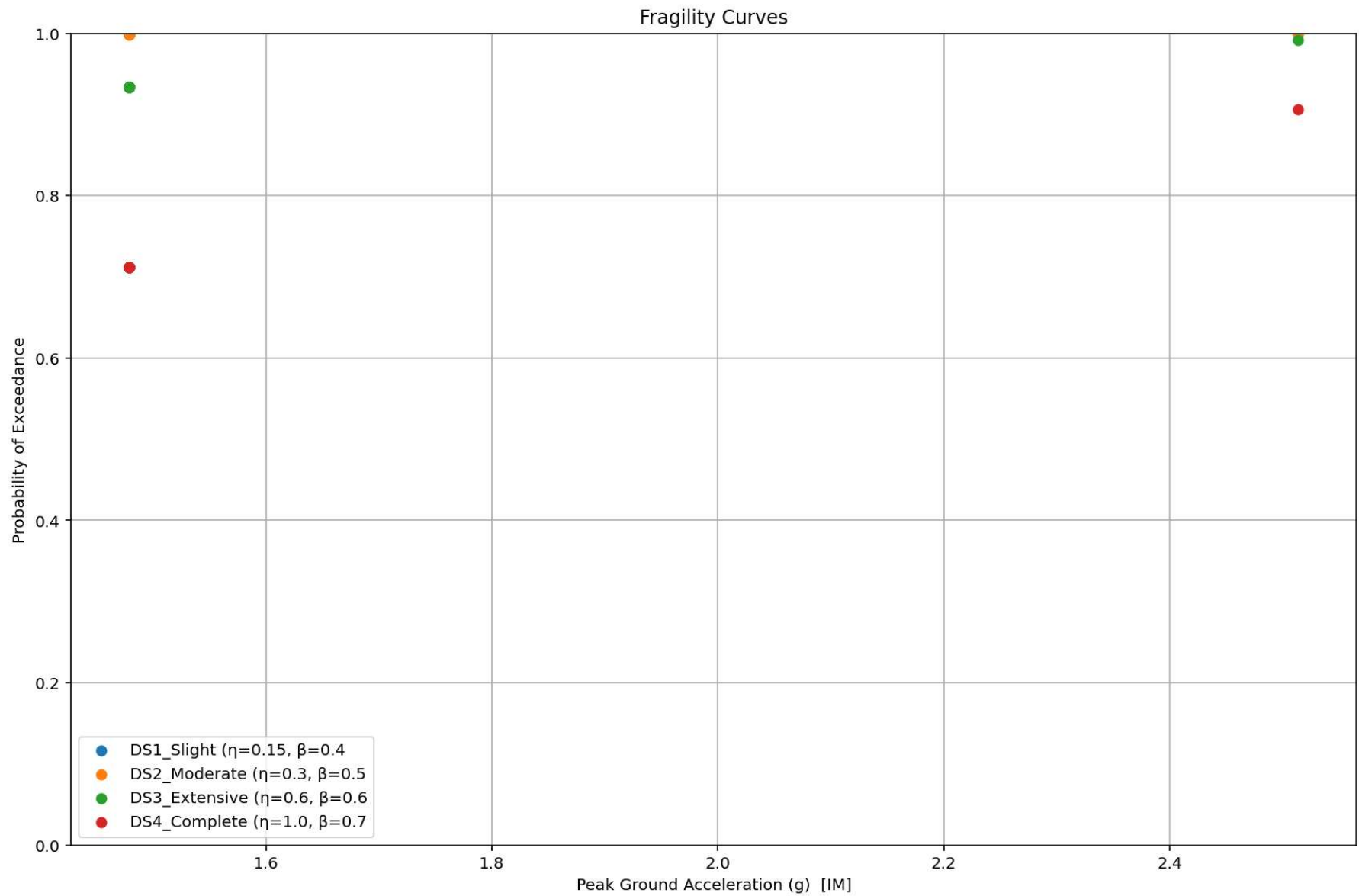




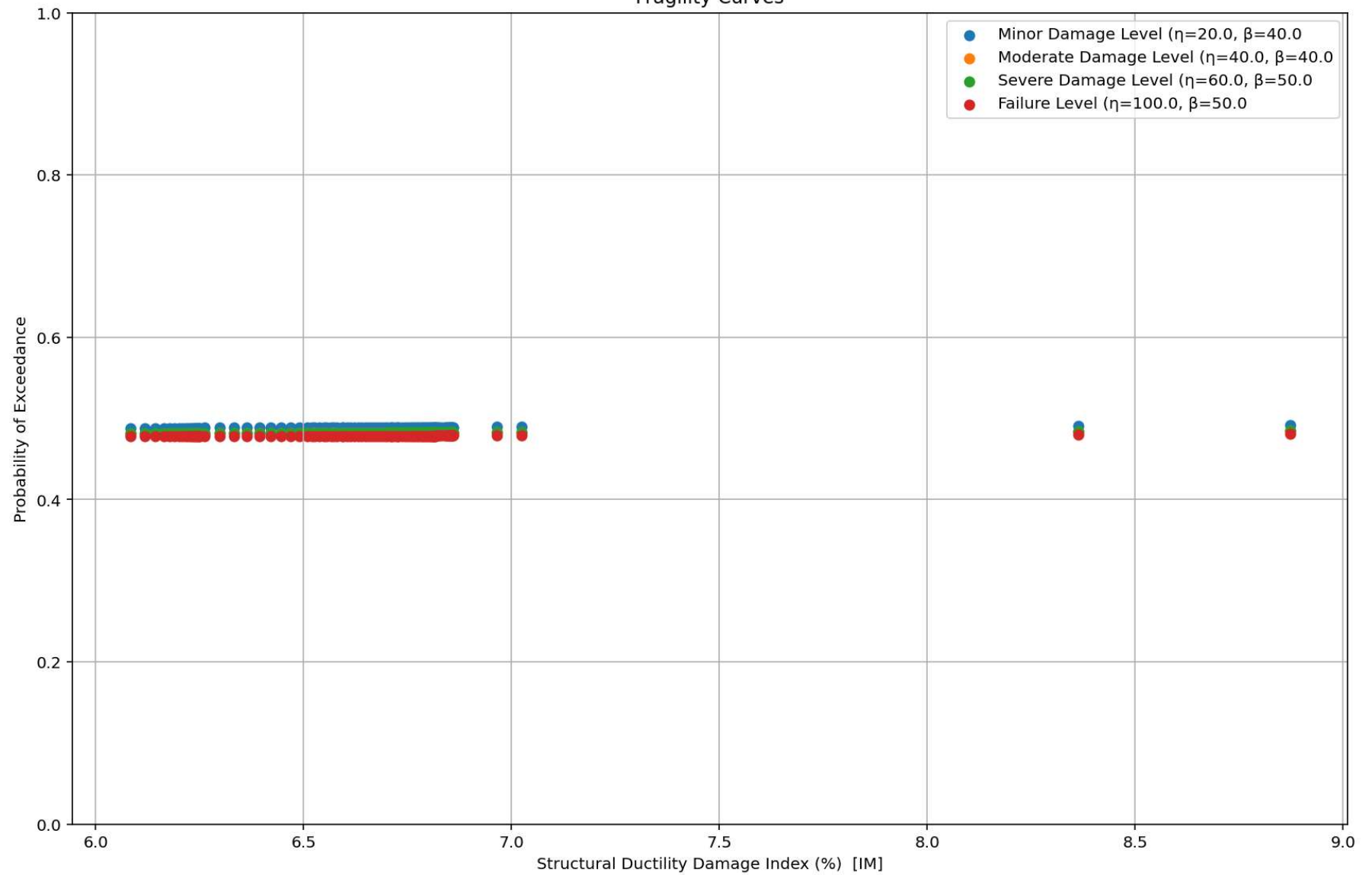


Last Analysis Structural Response + Ground Motion ::: MAX. ABS. : 1.4792

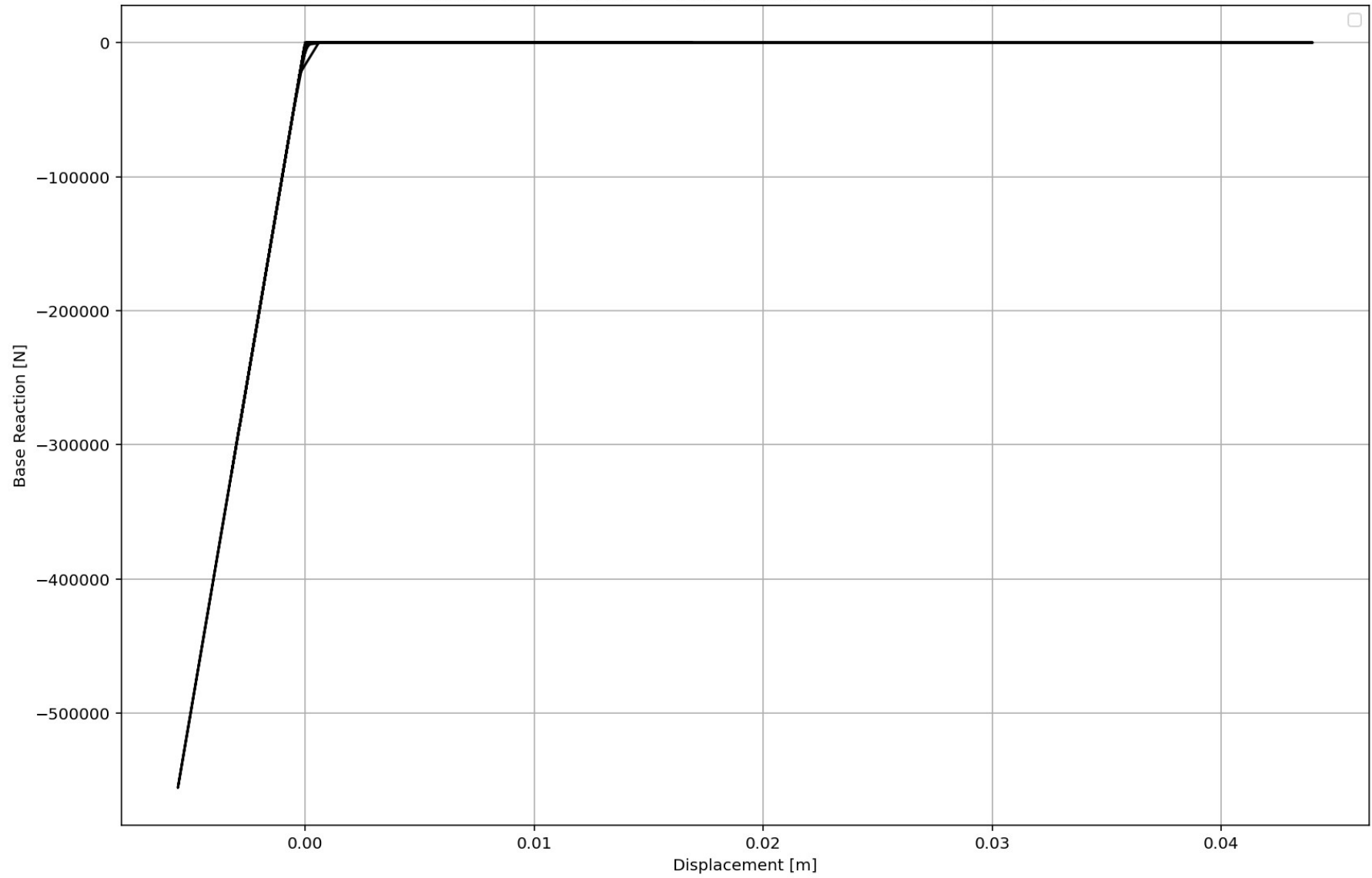




Fragility Curves



Displacement & Base Reaction Relation From Last Dynamic Analysis



Time vs Displacement - MAX. ABS: 0.029037971425009405

