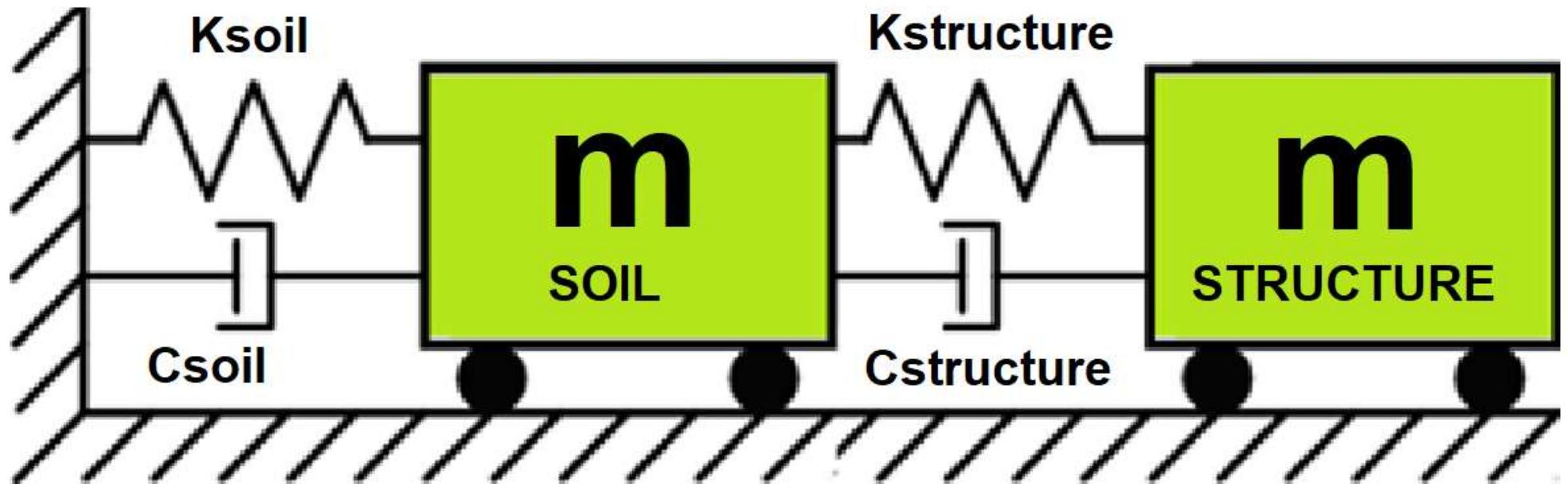
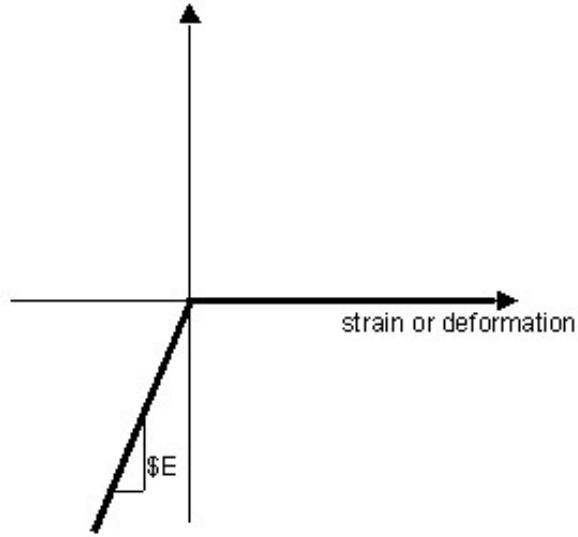


>> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<

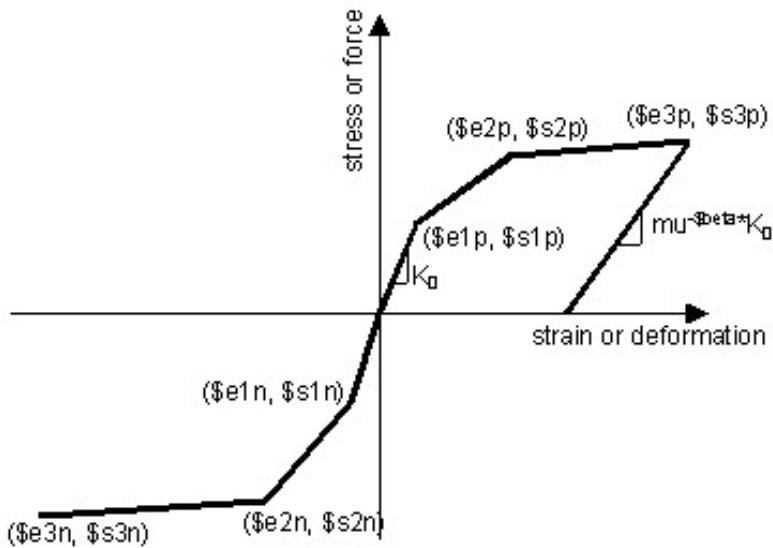
NONLINEAR DYNAMIC ANALYSIS OF A TWO-DOF SOIL-STRUCTURE SYSTEM UNDER 20 GROUND MOTIONS WITH RESPONSE SPECTRA AND DUCTILITY DAMAGE INDEX CALCULATION IN OPENSEES

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)



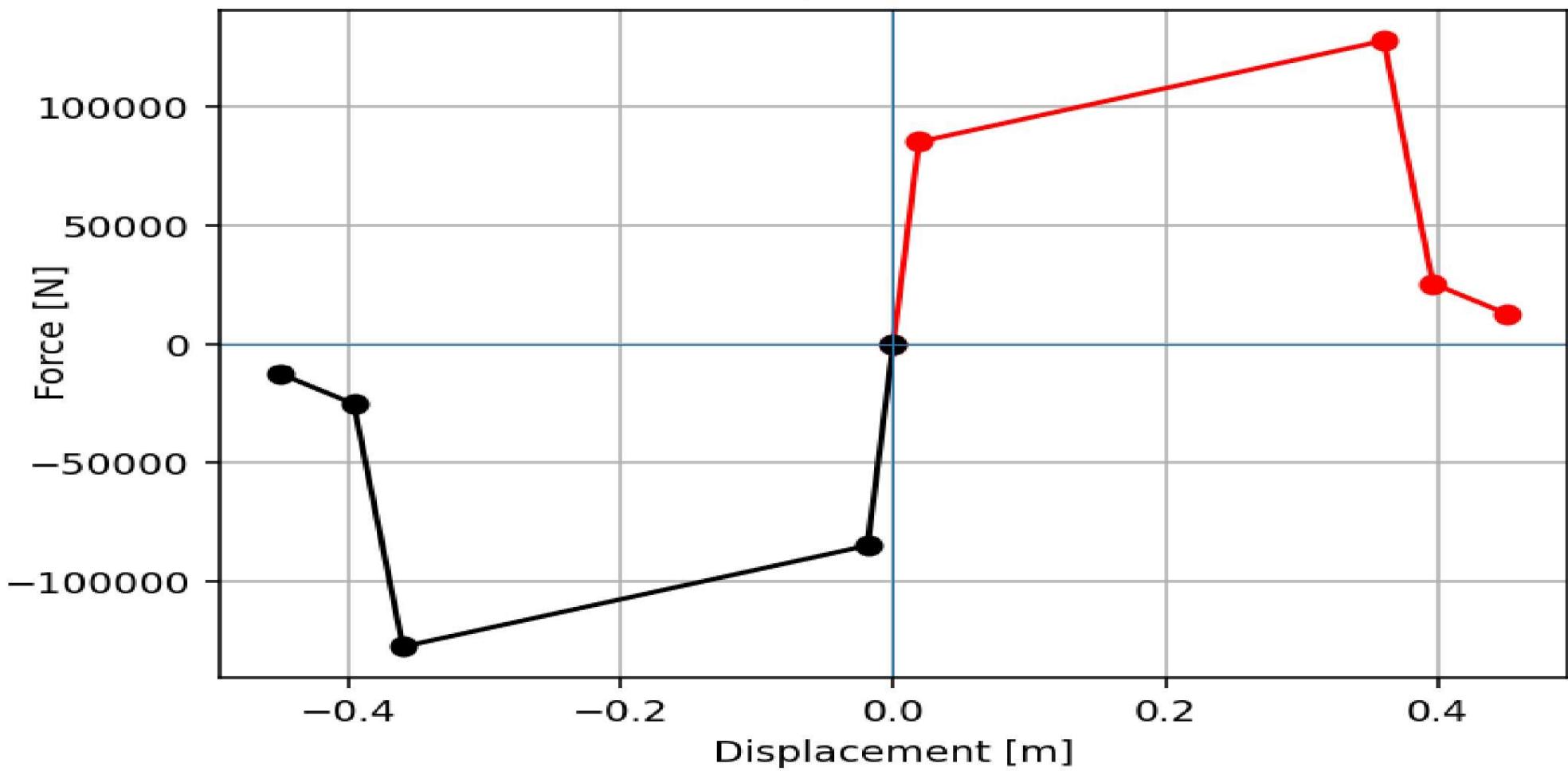


SOIL STIFFNESS



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_SDOF.py

SOIL_INELASTIC_RESPONSE_SEISMIC_SDOF.py FRAGILITY_CURVE_FUN.py

```
1 #####  
2 # >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<  
3 # NONLINEAR DYNAMIC ANALYSIS OF A TWO-DOF SOIL-STRUCTURE SYSTEM UNDER 20 GROUND MOTIONS WITH  
4 # RESPONSE SPECTRA AND DUCTILITY DAMAGE INDEX CALCULATION IN OPENSEES  
5 #  
6 # THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)  
7 # EMAIL: salar.d.ghashghaei@gmail.com  
8 #####  
9  
10 """  
11 This code implements a comprehensive nonlinear dynamic analysis framework for  
12 performance-based earthquake engineering assessment of multi-degree-of-freedom  
13 (MDOF) systems. The methodology combines traditional nonlinear time-history  
14 analysis with modern probabilistic and machine learning techniques for advanced  
15 structural performance evaluation.  
16  
17 KEY ENGINEERING OBJECTIVES:  
18 1. Comparative assessment of hysteretic models for seismic response prediction  
19 2. Probabilistic seismic demand analysis using multiple ground motions  
20 3. Development of fragility curves for performance-based earthquake engineering  
21 4. Integration of data science methods for structural reliability assessment  
22  
23 ANALYTICAL FEATURES:  
24 - Nonlinear material behavior with pinching and degradation  
25 - Response spectrum analysis across period range  
26 - Real-time structural health monitoring metrics  
27 - Statistical characterization of seismic demands  
28 - Machine learning-based damage prediction  
29  
30 Model setup:  
31 - SDOF properties: mass (m), initial stiffness (k), yield displacement (Dy), ultimate displacement (Du), viscous damping ratio (xi), Rayleigh damping coefficients (alpha1, alpha2), and damping ratio (xi).  
32 - Hysteresis models: HYSTERETICSM (pinching, stiffness degradation, strength decay).  
33 - Damping: Rayleigh (or equivalent viscous) damping specified by target damping ratio xi for the fundamental mode.  
34
```

Displacement & Base Reaction History from Last Dynamic Analysis

IPython Console Files Help Variable Explorer Debugger Plots History

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

SOIL_INELASTIC_R...UM_SEISMIC_SDOF.py FRAGILITY_CURVE_FUN.py

```
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} (\u03b7={median}, \u03b8={beta})')
17        if PLOT_KIND == True:
18            plt.plot(im_values, probabilities, lw=2, label=f'{damage_state} (\u03b7={median}, \u03b8={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()
```

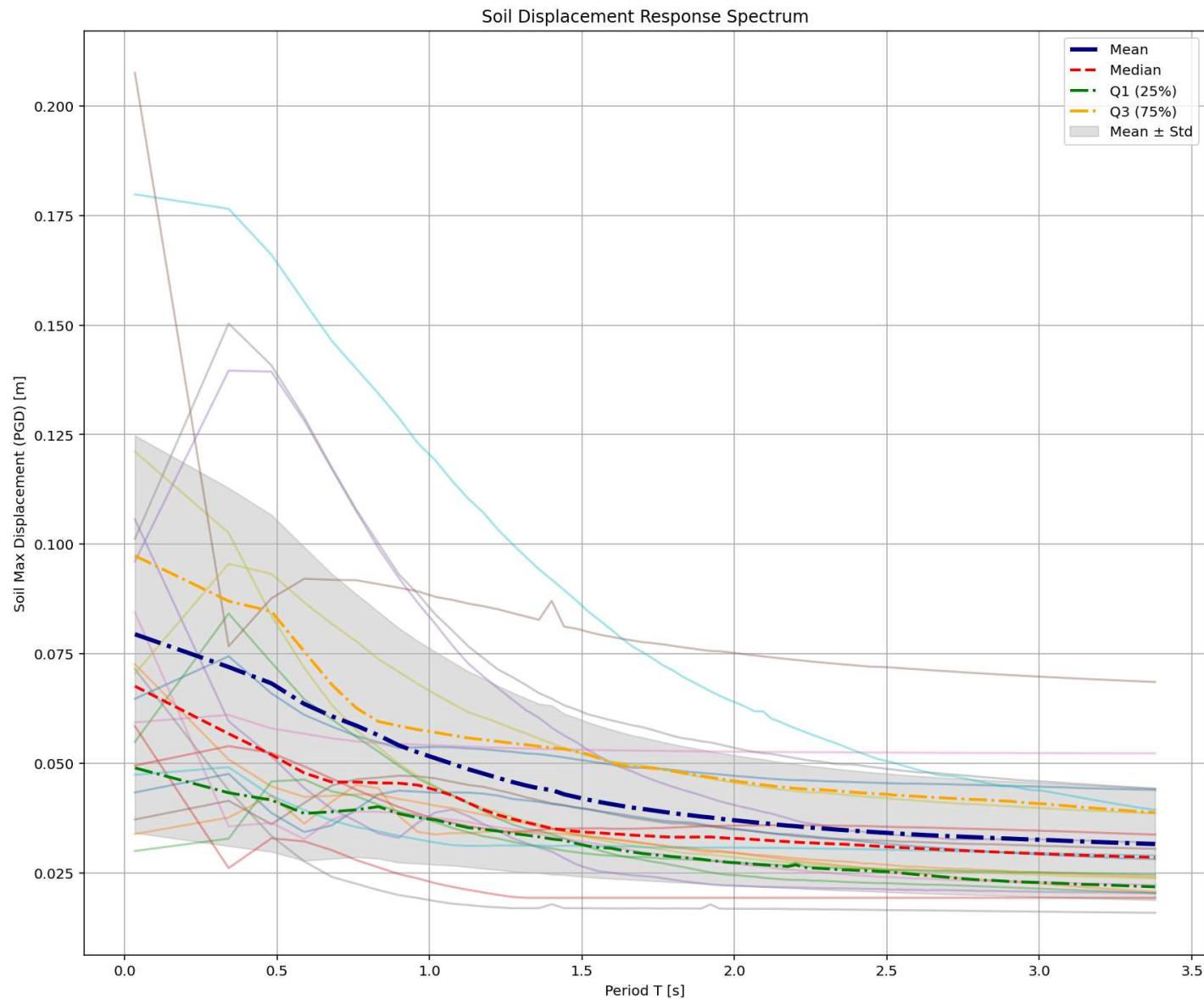
Ductility Damage Index Spectrum

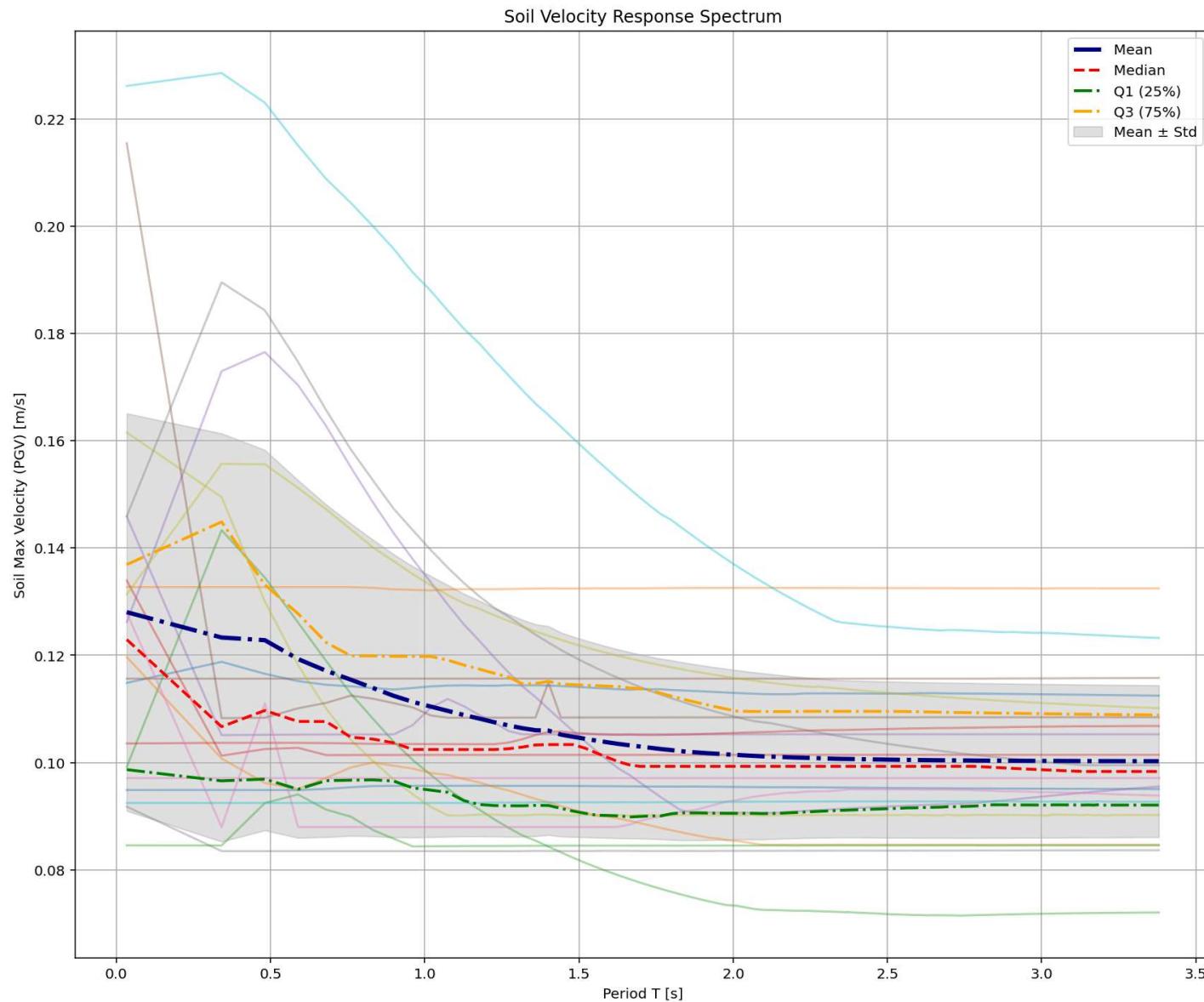
Probability of Exceedance

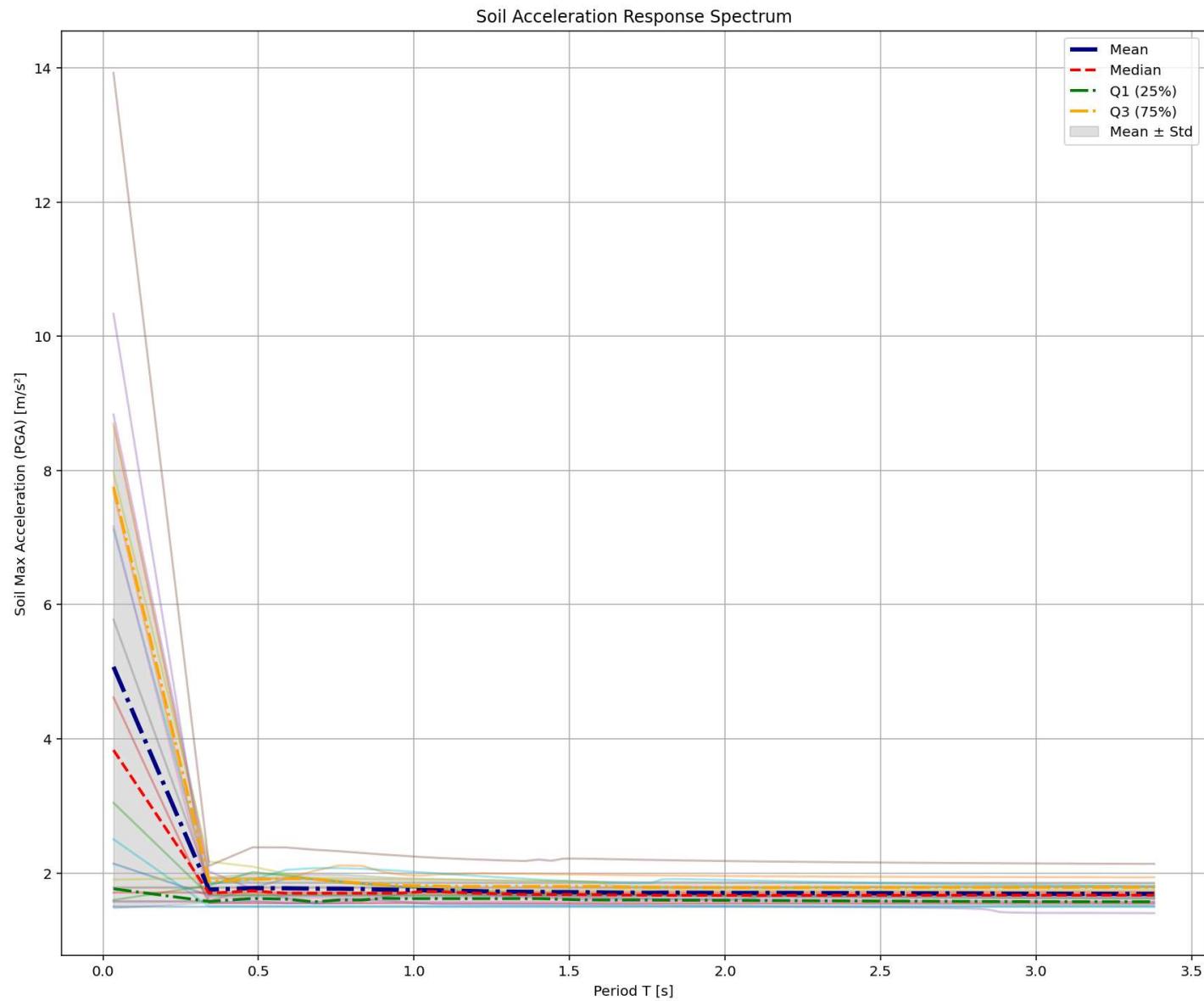
Fragility Curves

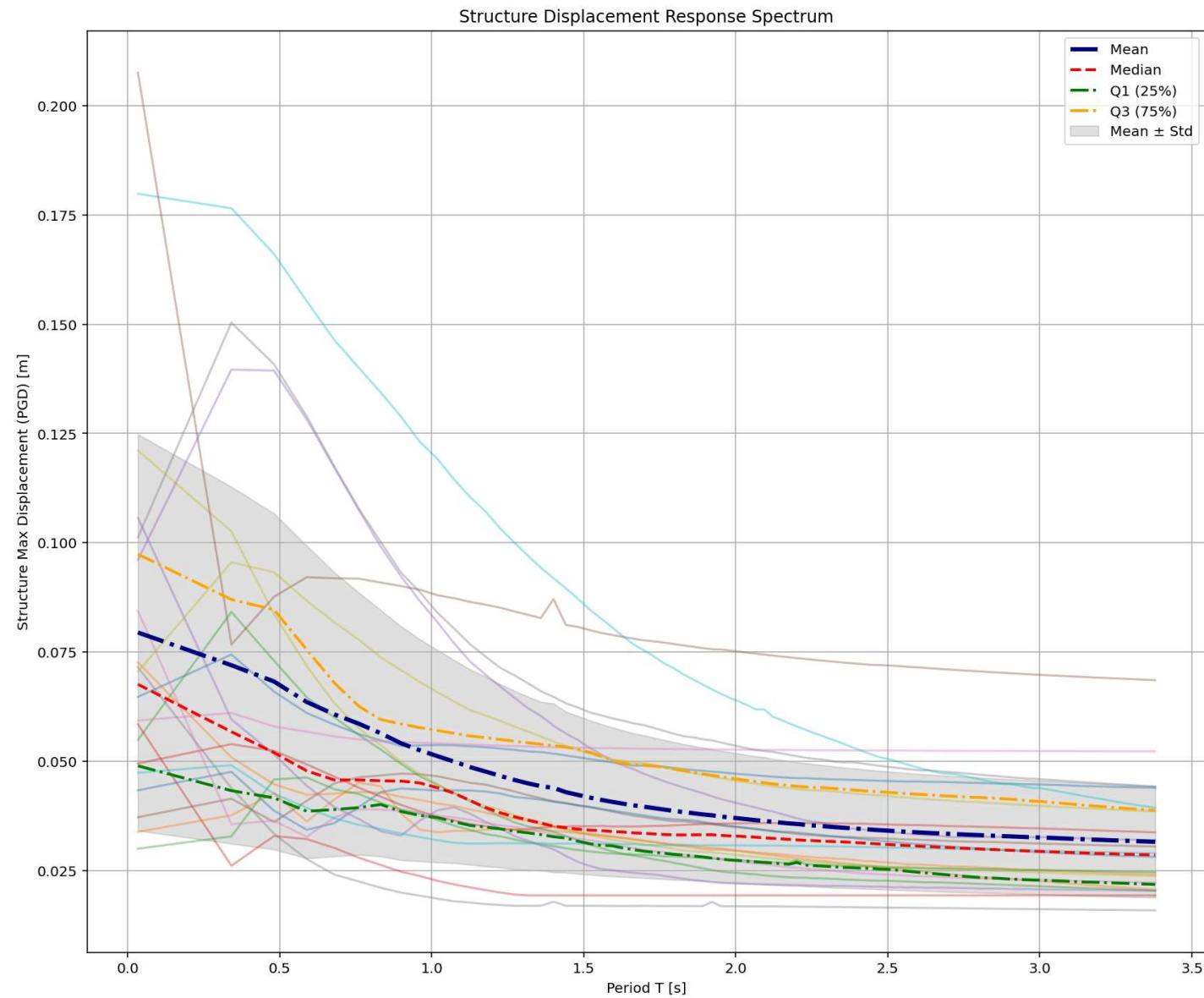
Ground Motion Intensity

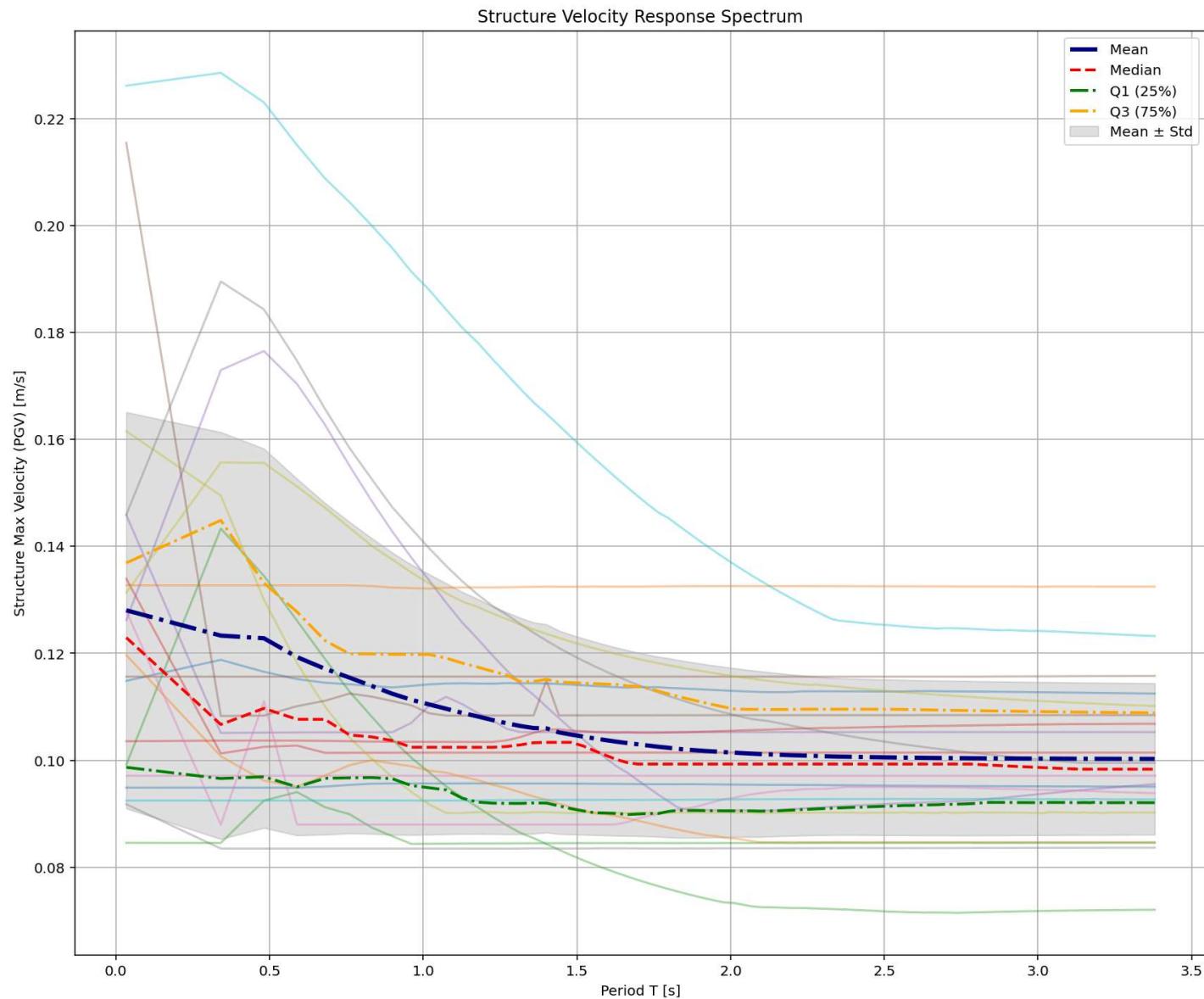
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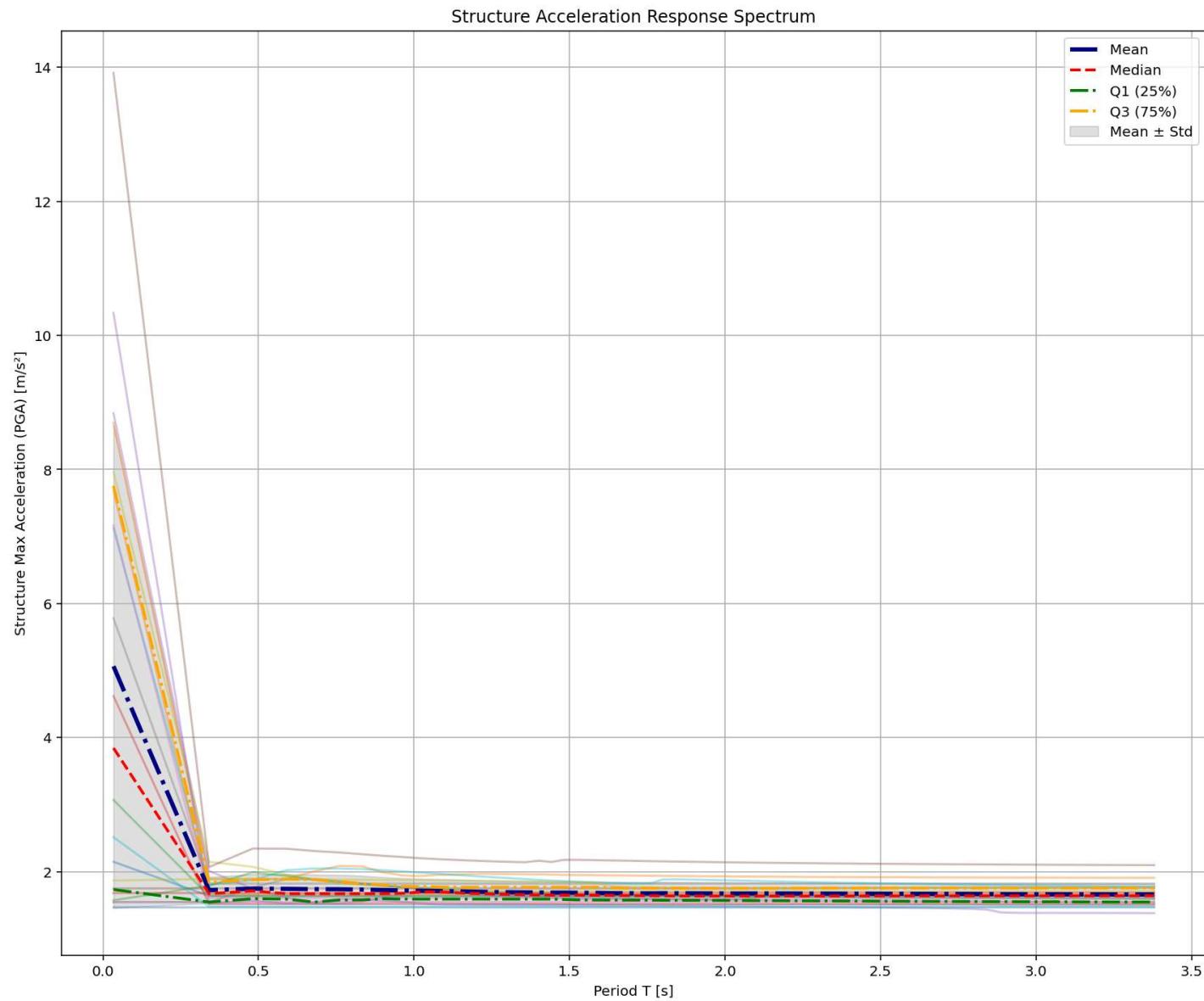


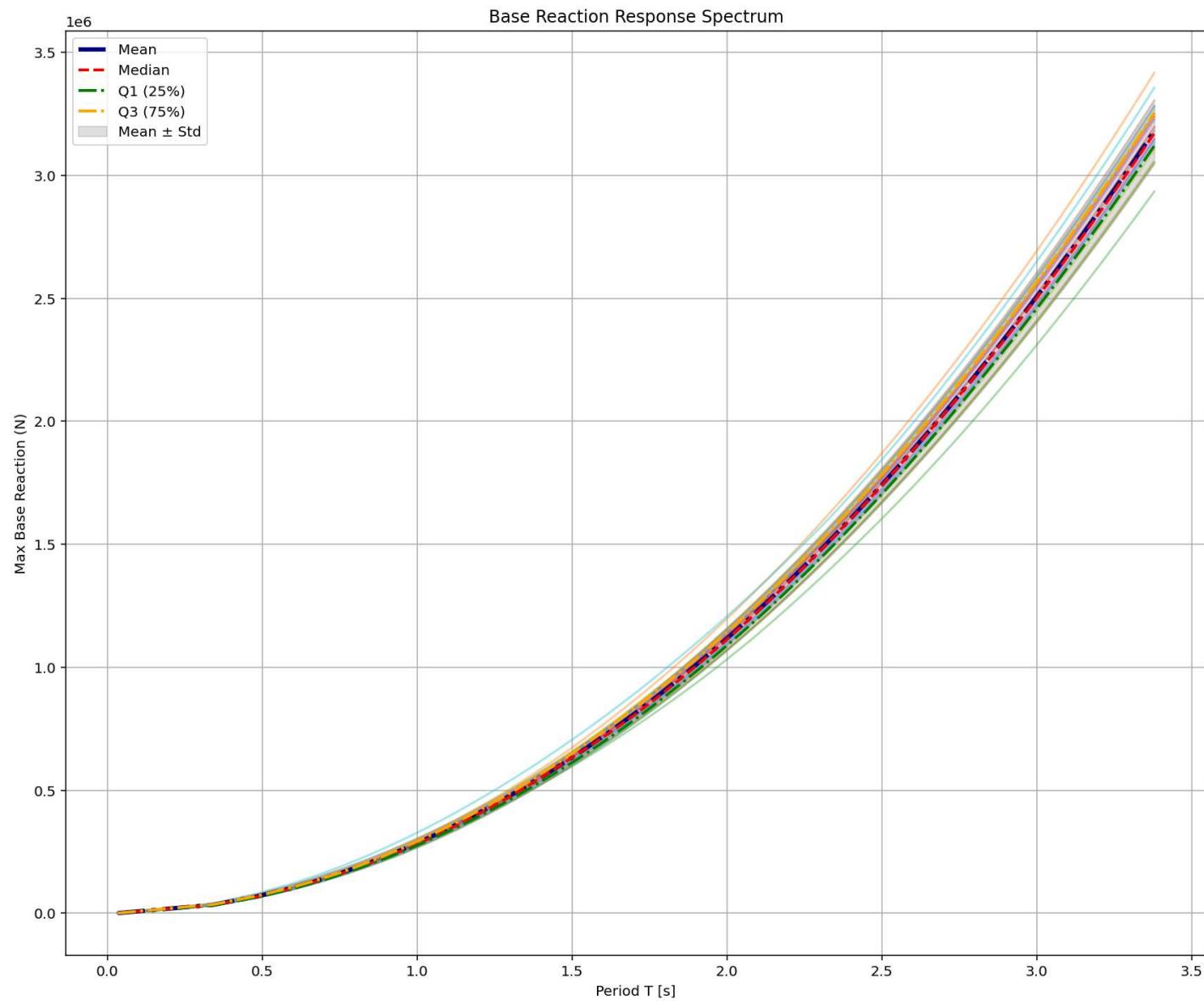


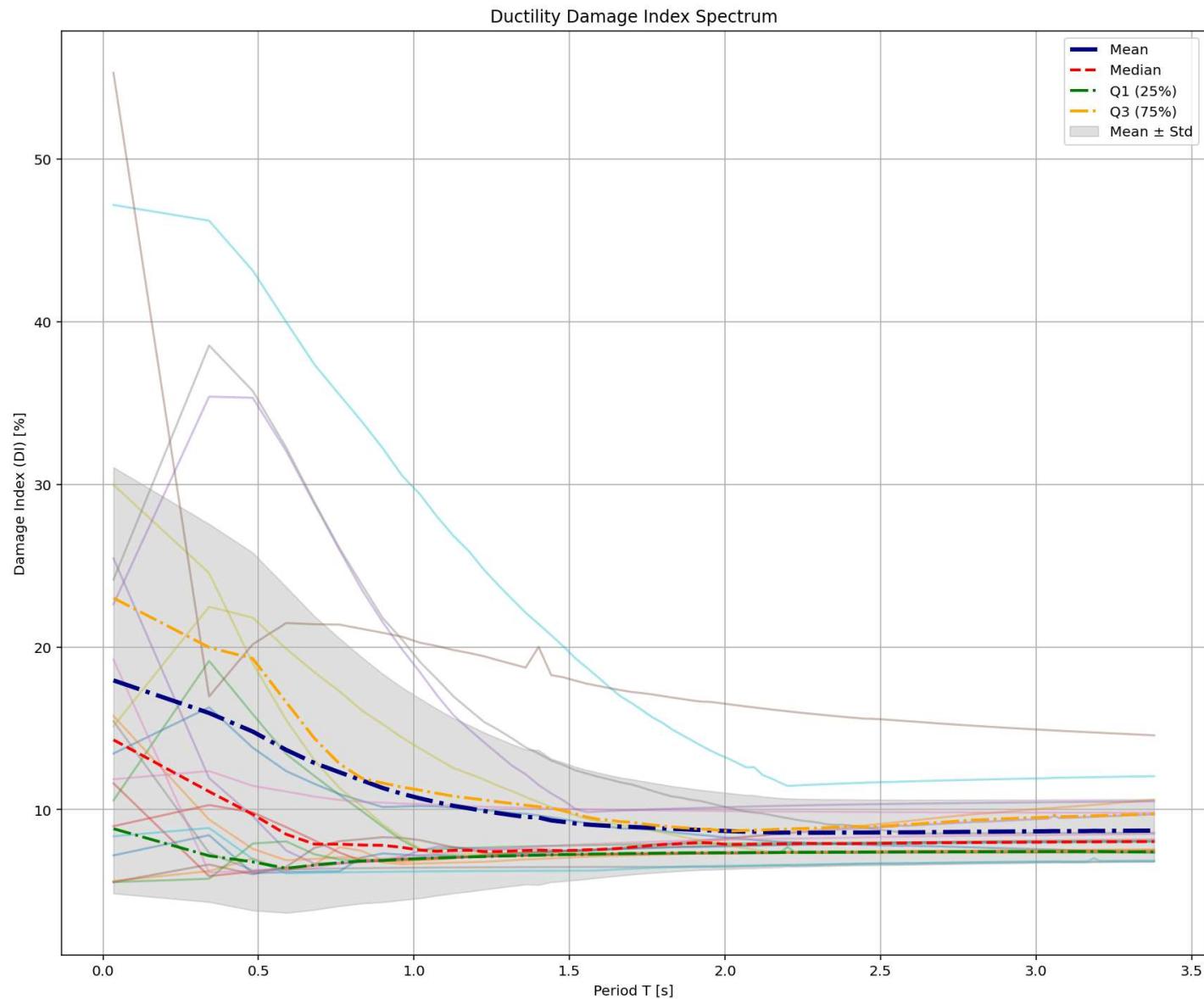


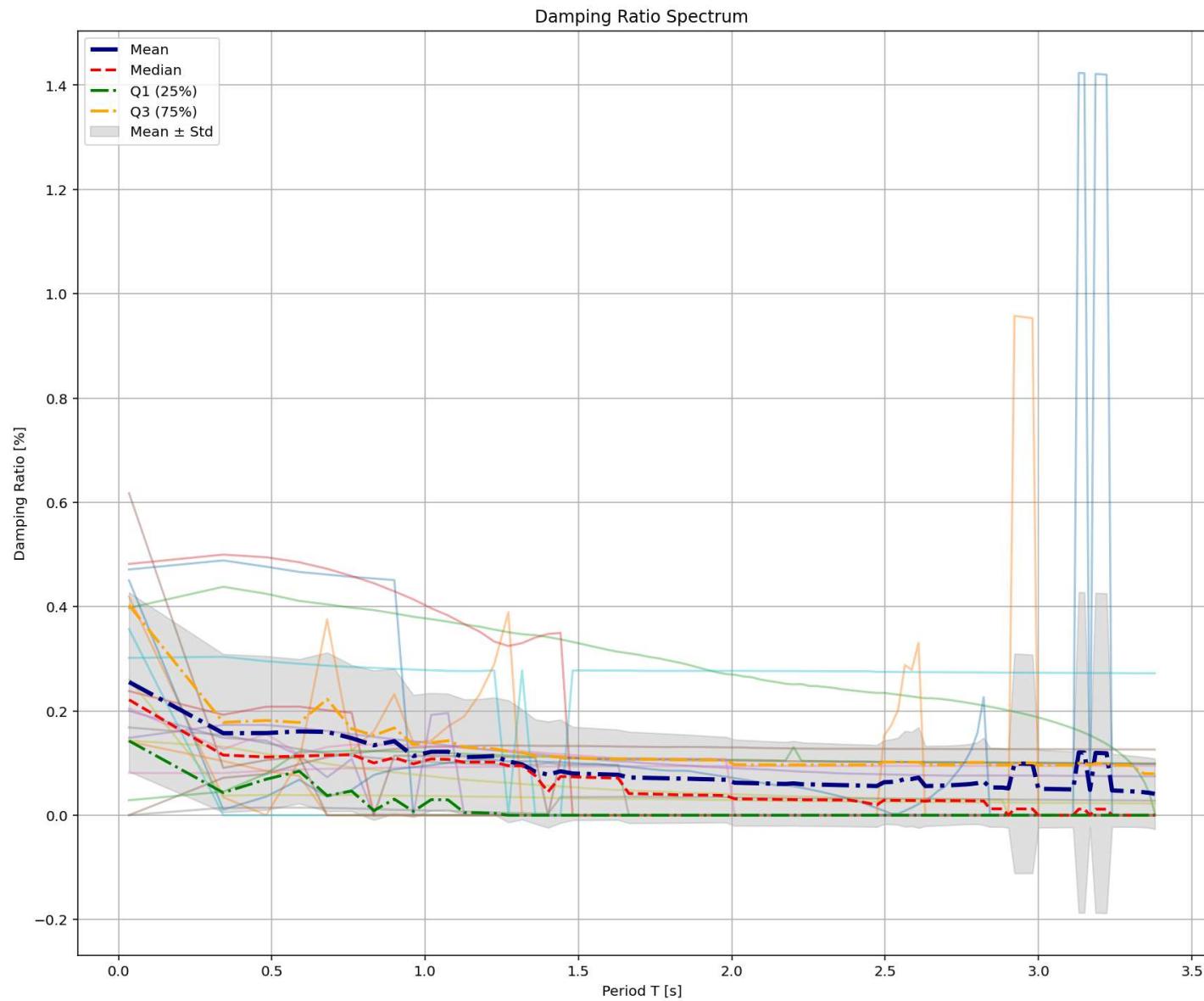


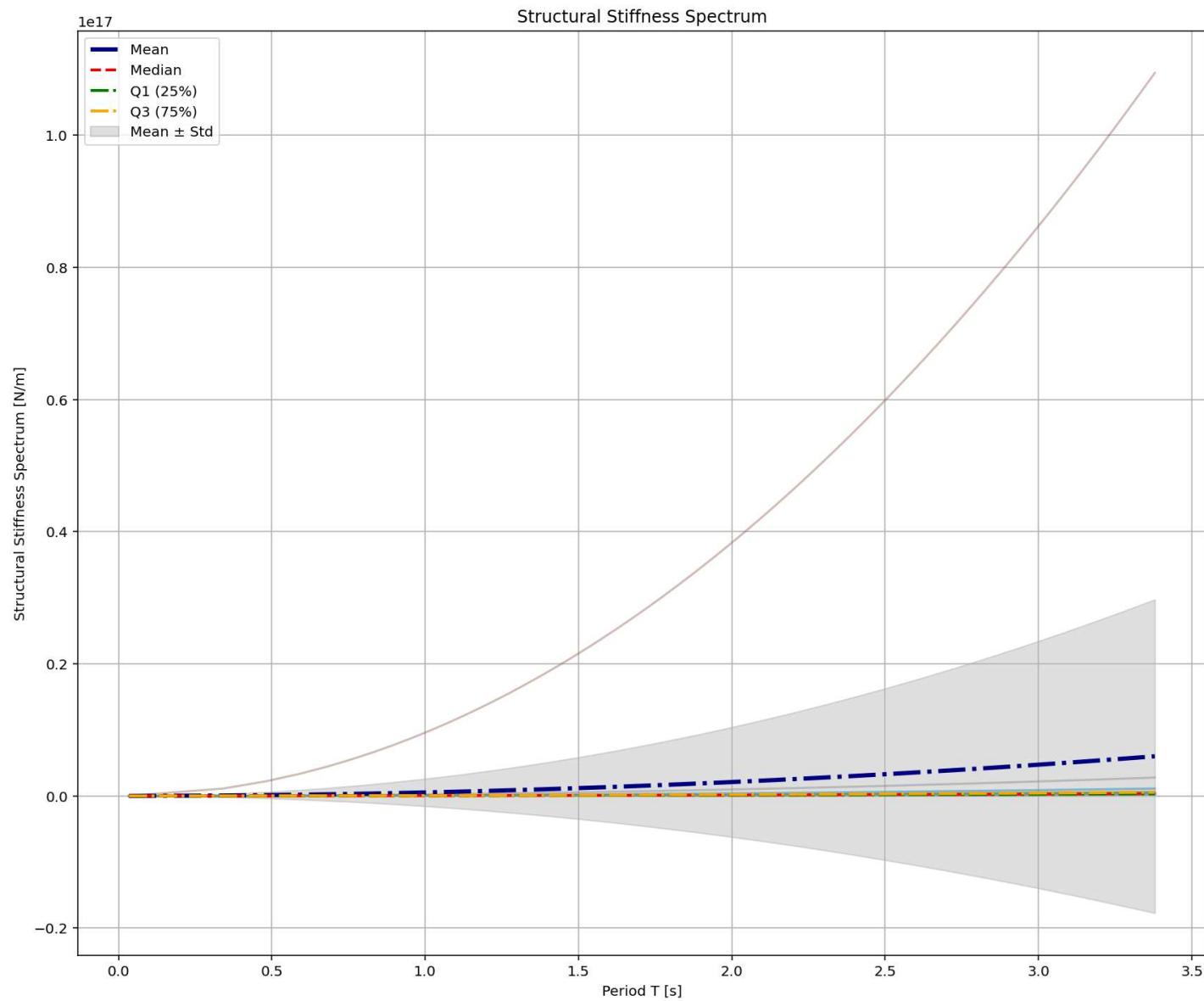












Last Analysis Structural Response + Ground Motion :: MAX. ABS. : 1.4792

