3D Analysis of the Influence of Varying Rock/Soil Profiles on Seismic NPP Response

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Outline

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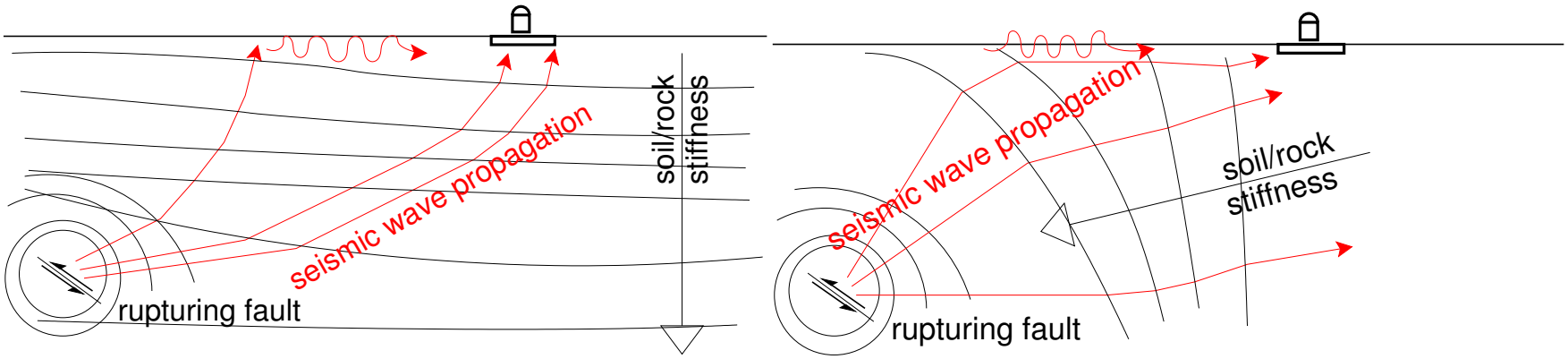
Introduction

- High fidelity numerical simulations of seismic effects on NPPs
  - Realistic seismic motions (3D, inclined motions, surface and body waves, lack of correlation, etc.)
  - Realistic solids and structures modeling
- Understanding 3D, inclined waves and their interaction with variable soil/rock profiles

Outline

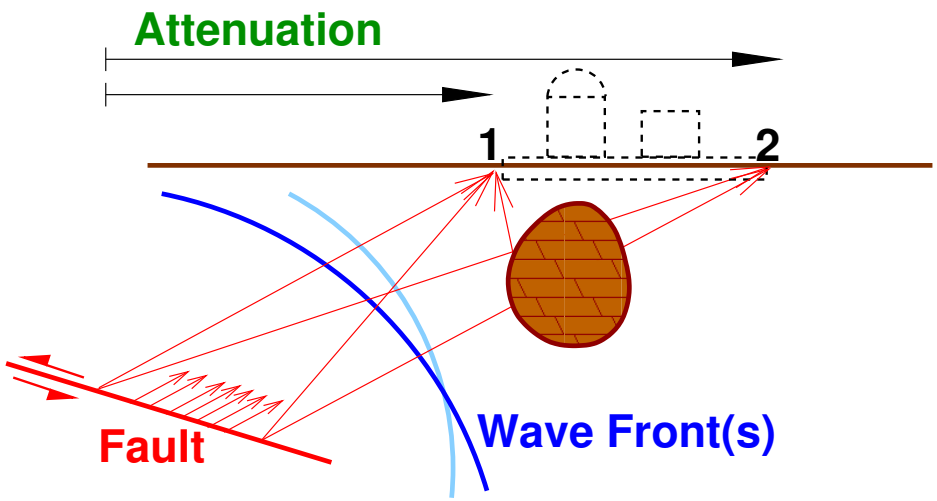
Seismic Motions

- Seismic motions: Body (SV, SH, P) and Surface (Rayleigh, Love) waves
- 3D, inclined, uncorrelated (incoherent)
- Effects of soil/rock layers on motions



Spatial Variability (Incoherence, Lack of Correlation)

- Attenuation effects,
- Wave passage effects,
- Scattering effects,
- Extended source effects

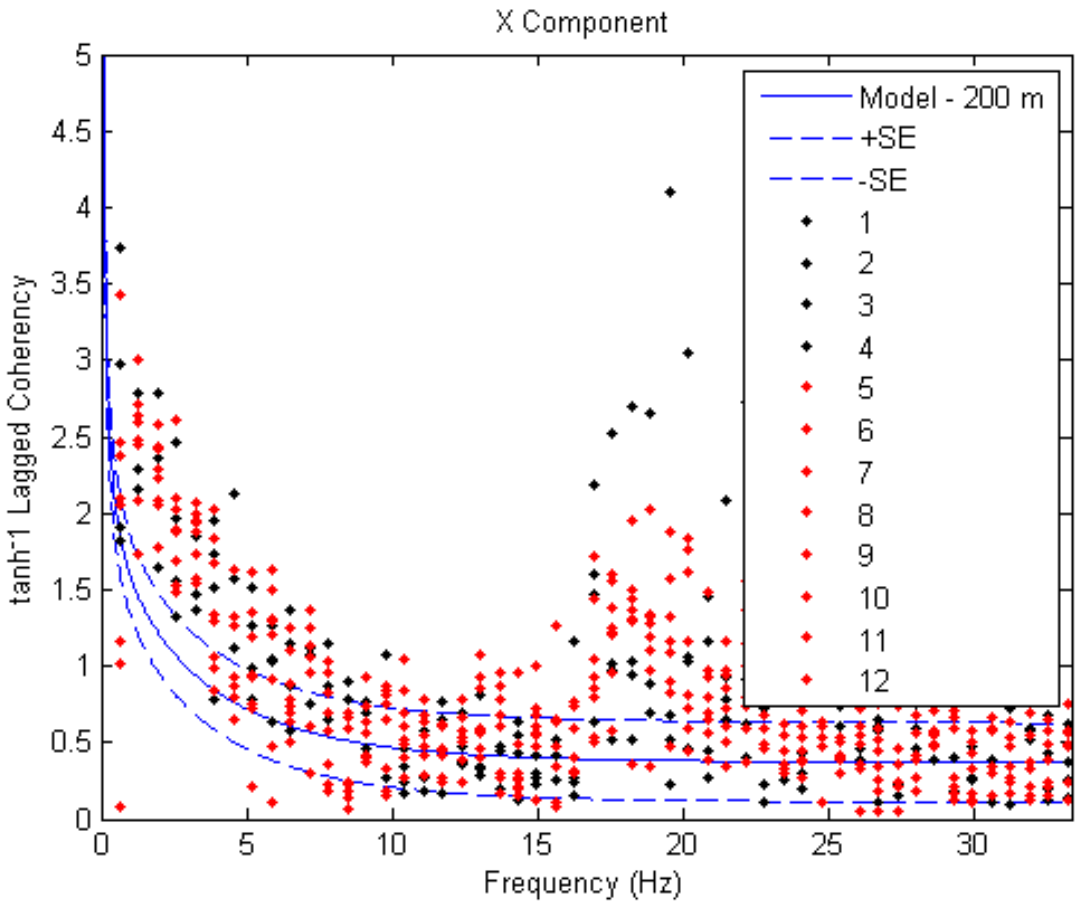


Seismic Motion Development

- Green's functions regional model up to 15Hz
- Prof. Hisada's code
- Seismic waves propagated to NPP site
- Motions input using the Domain Reduction Method
- Lack of correlation inherent in regional ground motion modeling

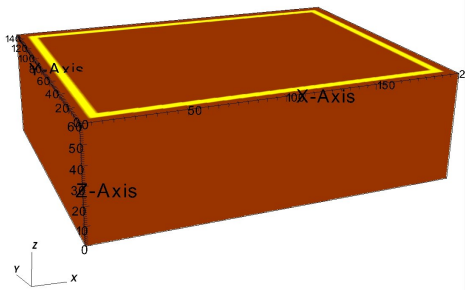
Uncorrelated/Incoherent Motions for Rock and Soil

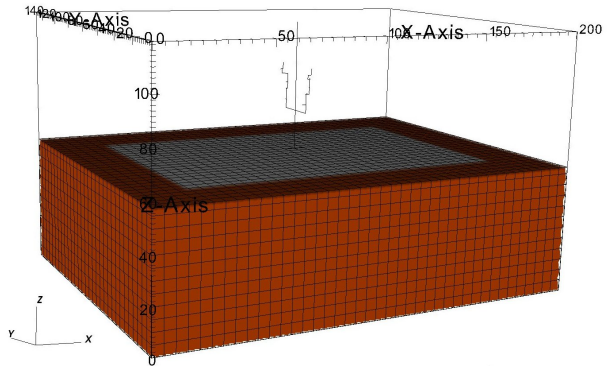
- Original lack of correlation
- T. Ancheta development
- Further lack of correlation added using Abrahamson models for rock and soil (assuming ergodicity)

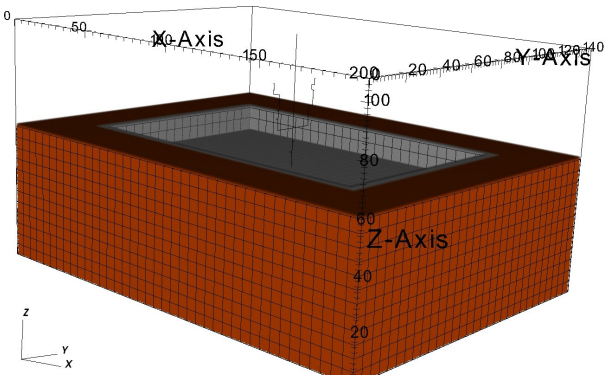


Finite Element Models for the NPP

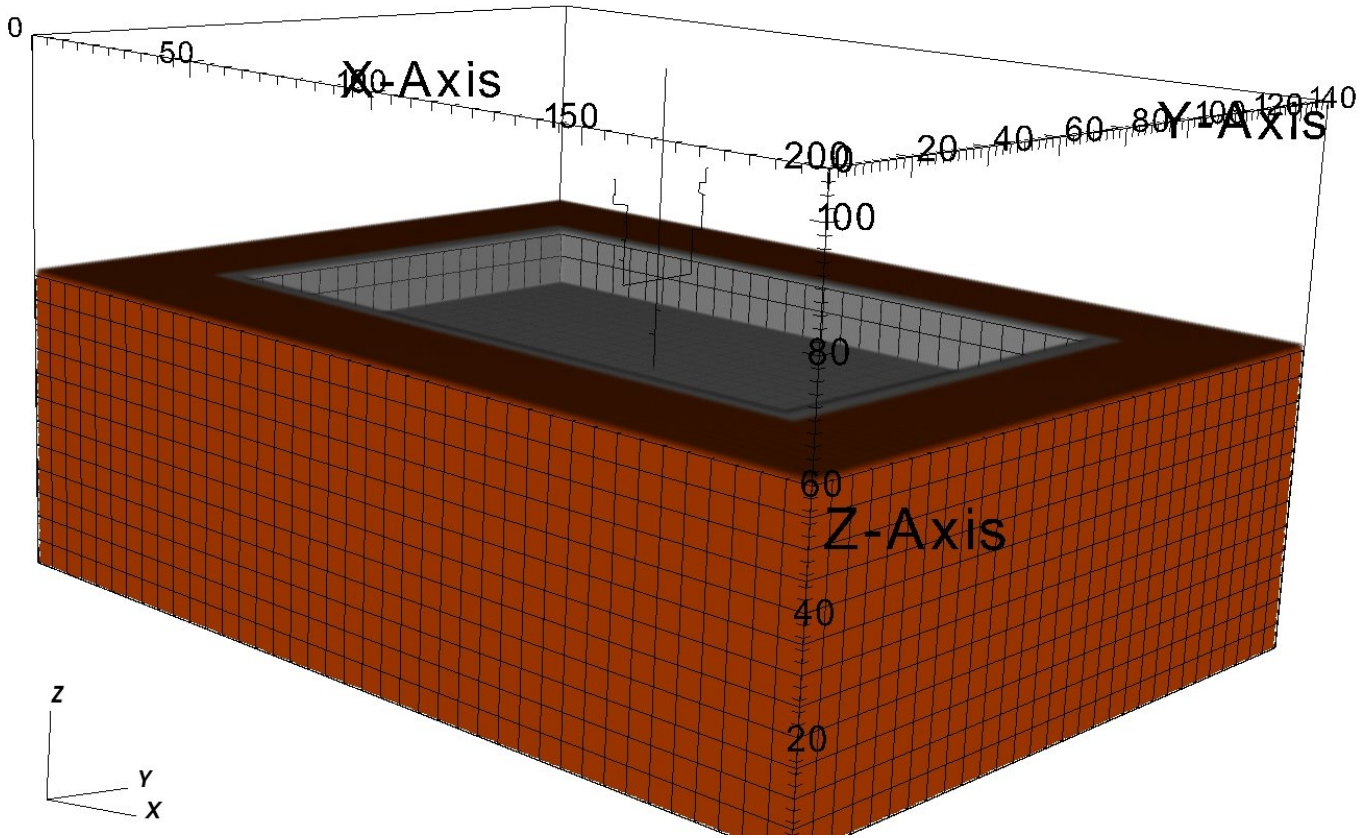
- Wave propagation with small error for given frequencies
  - $v_s = 2600$m/s, $h = 5$m, $f_{max} = 65$Hz;
  - $v_s = 1500$m/s, $h = 5$m, $f_{max} = 37$Hz;
  - $v_s = 1000$m/s, $h = 5$m, $f_{max} = 25$Hz;
  - $v_s = 300$m/s, $h = 5$m, $f_{max} = 7$Hz)
- Free field, surface and embedded foundations







3D Embedded Foundation Models

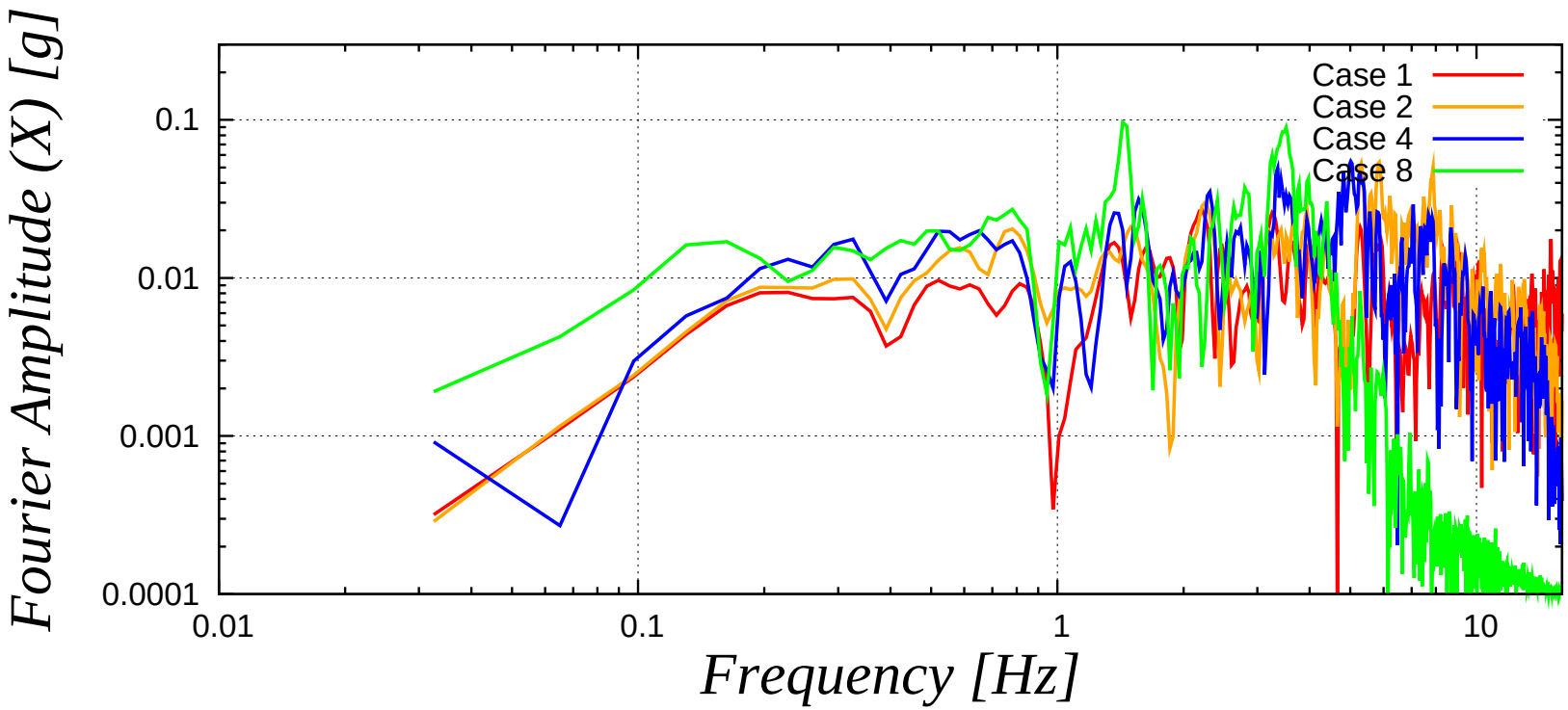


Outline

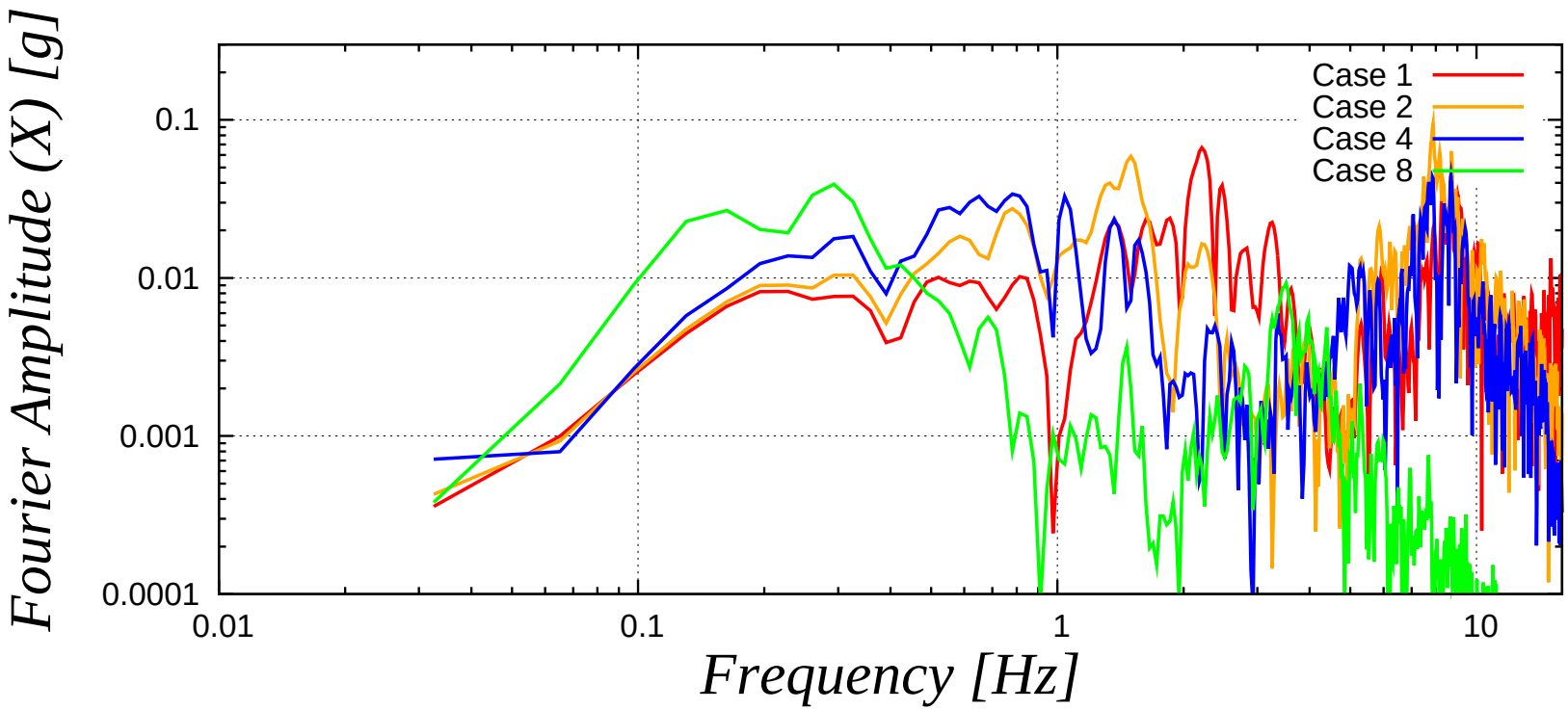
Variable Single Layer Base: Soil or Rock

- Four uniform rock/soil profiles
  - Case 1: $V_s = 2600$m/s
  - Case 2: $V_s = 1500$m/s
  - Case 4: $V_s = 1000$m/s
  - Case 8: $V_s = 300$m/s
- Gradual rise in stiffness 500m below uniform rock profiles
- Full 3D, inclined, uncorrelated motions, including body and surface waves, input using DRM

Base of the Internal Struct. on Surface Foundation



Top of the Internal Struct. on Surface Foundation



Variable Thickness Soil Layer

- Four variable thickness soil ($V_s = 300$m/s) profiles
  - Case 6: $H_{soil} = 500$m
  - Case 5: $H_{soil} = 200$m
  - Case 10: $H_{soil} = 100$m
  - Case 12: $H_{soil} = 50$m
- Stiff rock $V_s = 2600$m/s beneath these soil profiles
- Full 3D, inclined, uncorrelated motions, including body and surface waves, input using DRM

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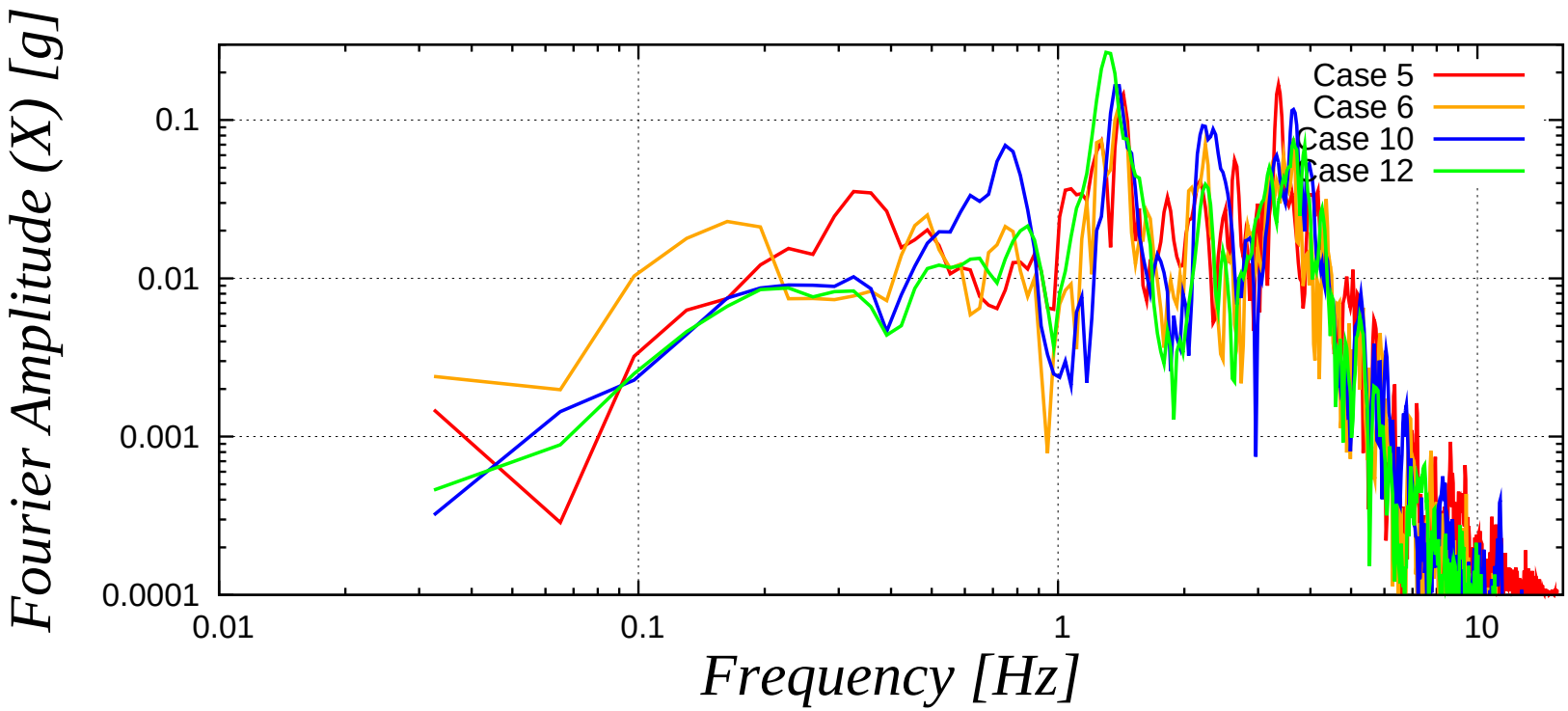

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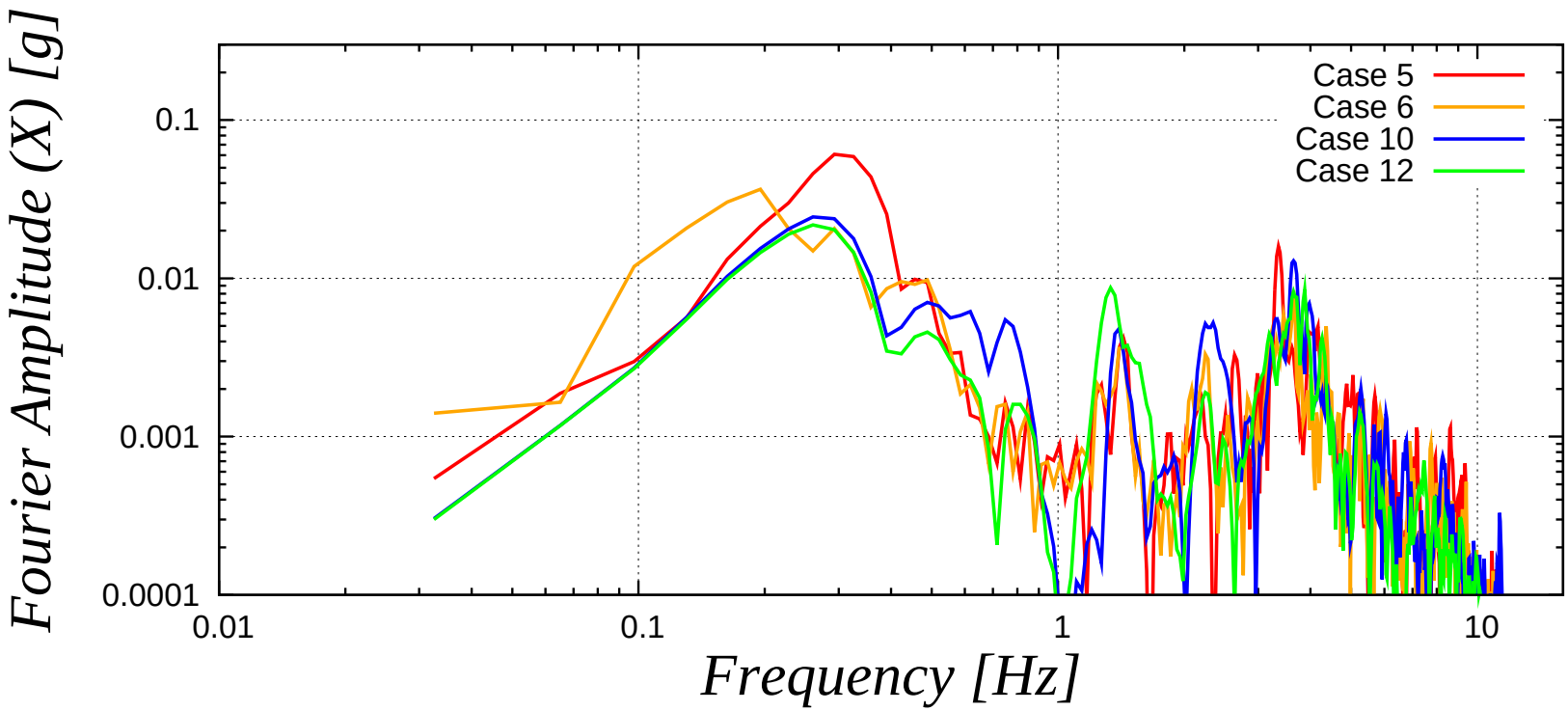

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Summary

- Realistic seismic motions (3D, inclined, uncorrelated, body and surface waves) do influence NPP ESSI response for variable soil/rock conditions
- Influences do vary in significance but are always present and need to be modeled and simulated
- Importance of high fidelity modeling to reduce modeling uncertainty
- Funding by and Collaboration with the CNSC is gratefully acknowledged