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

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SMiRT 21, New Delhi, India, November 2011
Outline

Introduction

The Issues and Modelling Approaches
  The Problem
  The Modelling

Simulations Results
  Variable Single Layer Base: Soil or Rock
  Variable Thickness Soil Layer

Summary
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Summary
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- 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
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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
  - $v_s = 2600\text{m/s}$, $h = 5\text{m}$, $f_{\text{max}} = 65\text{Hz}$
  - $v_s = 1500\text{m/s}$, $h = 5\text{m}$, $f_{\text{max}} = 37\text{Hz}$
  - $v_s = 1000\text{m/s}$, $h = 5\text{m}$, $f_{\text{max}} = 25\text{Hz}$
  - $v_s = 300\text{m/s}$, $h = 5\text{m}$, $f_{\text{max}} = 7\text{Hz}$
- Free field, surface and embedded foundations

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Varying Rock/Soil Profiles
3D Embedded Foundation Models
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Variable Single Layer Base: Soil or Rock

- Four uniform rock/soil profiles
  - Case 1: $V_s = 2600\text{m/s}$
  - Case 2: $V_s = 1500\text{m/s}$
  - Case 4: $V_s = 1000\text{m/s}$
  - Case 8: $V_s = 300\text{m/s}$

- 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

![Graph showing Fourier Amplitude (X) vs Frequency (Hz) with different cases](image)

- **Case 1**
- **Case 2**
- **Case 4**
- **Case 8**
Top of the Internal Struct. on Surface Foundation

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Varying Rock/Soil Profiles
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
Base of the Internal Struct. on Surface Foundation

![Graph showing Fourier Amplitude (X) vs. Frequency (Hz) for different cases.](image-url)
Top of the Internal Struct. on Surface Foundation

![Graph showing Fourier Amplitude (X) versus Frequency [Hz] for different cases.]

- Case 5
- Case 6
- Case 10
- Case 12

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Varying Rock/Soil Profiles
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- 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