

Stress Test Motions for Soil-Structure Systems

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Outline

Introduction

Stress Test Motions

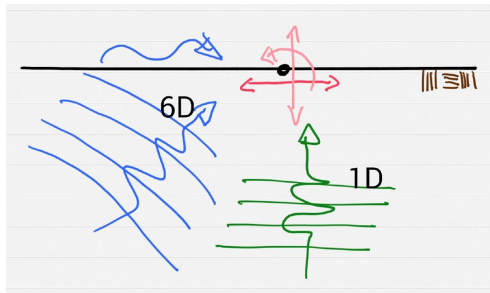
Summary

Motivation

- Earthquake Soil Structure Interaction (ESSI) systems
- Improve analysis of nonlinear ESSI systems
- Account for all 6 seismic motion components (6C, 3T+3R)
- Stress test, shake-out nuclear energy ESSI system
- Stress test motions variations
 - Signals (real motions, wavelets...)
 - Energy
 - Strike angles
 - Duration

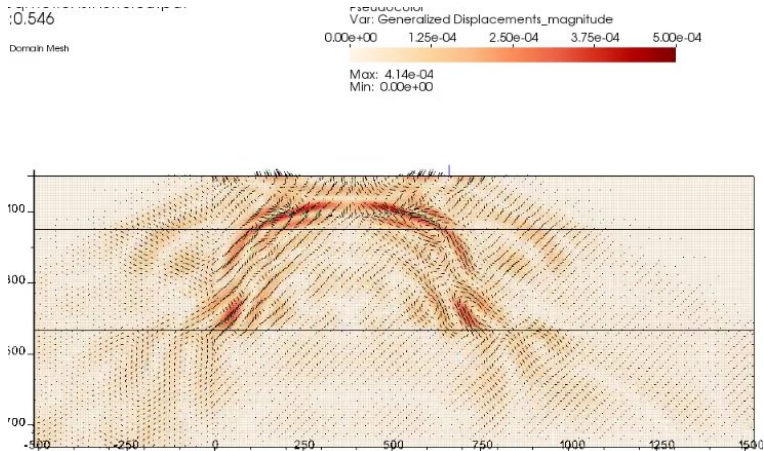
ESSI: 6C vs 1C Seismic Motions

- Assume: full 3C/6C motions, recorded only 1C
- From 1C motions, de-convolute/convolute 1C
- Apply 6C and 1C to ESSI system



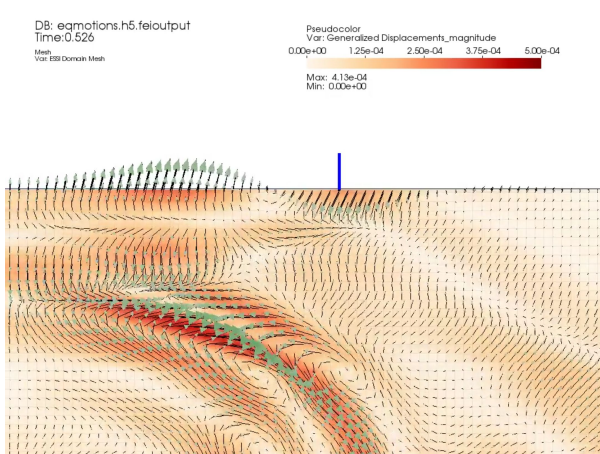
Realistic Ground Motions

- Free field, regional scale models



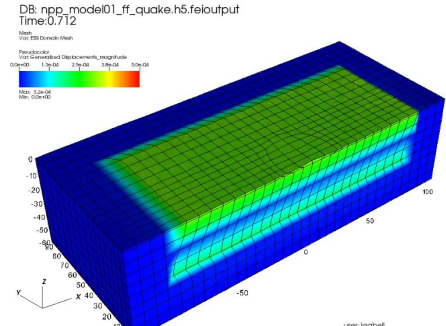
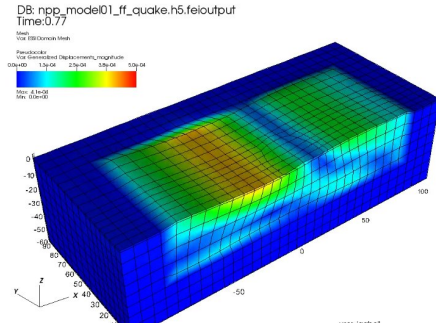
Development of Realistic Motions

- Sources will send both P and S waves



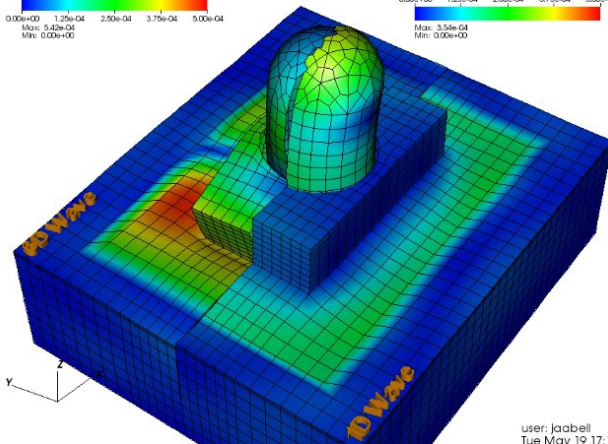
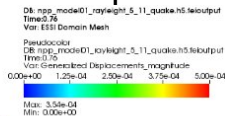
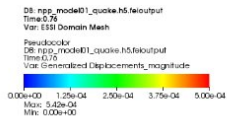
1C vs 6C Free Field Motions

- One component of motions, 1C from 6C
- Excellent fit, incomplete mechanics



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6C vs 1C NPP ESSI Response Comparison



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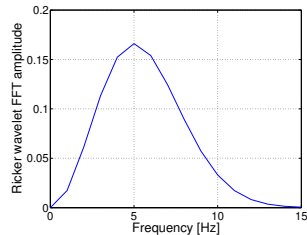
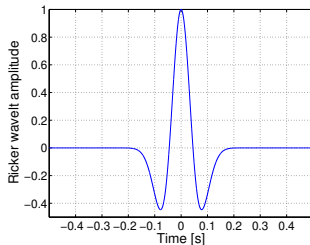
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Stress Test Motions

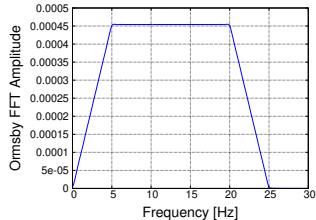
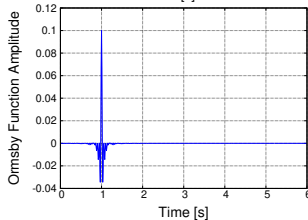
- Excite SSI system with a suite of motions
- Recorded waves, and/or wavelets
- Variation in wave direction and inclination
- Variation in wave frequency, energy and duration
- Plane wave stress test motions:
 - 1D-1C and/or 3D-1C
 - 3D-3×1C
 - 3D-6C (Thomson/Haskel's solution)
- "Break" the system, shake-out strong and weak links

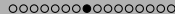
Example Stress Test Signals

- Ricker

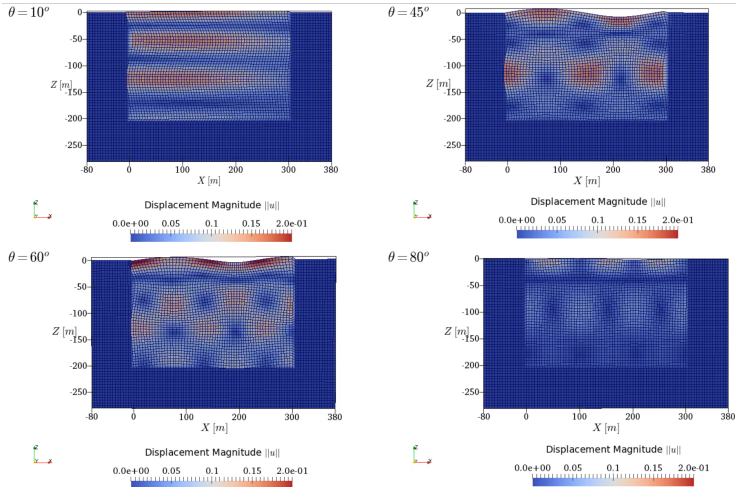


- Ormsby

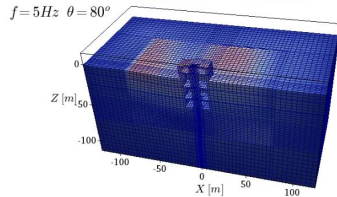
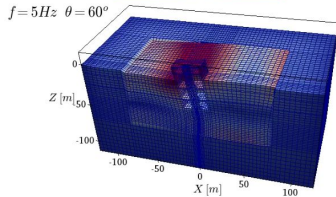
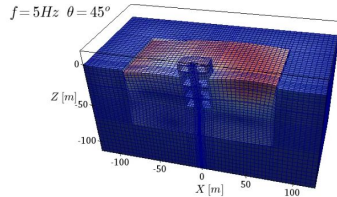
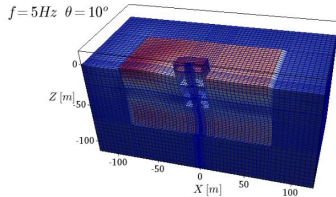




Free Field, Variation in Input Wave Angle, $f = 5\text{Hz}$

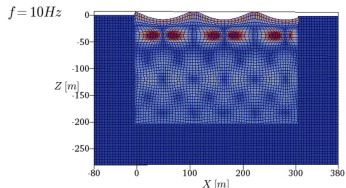
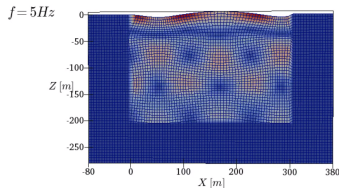
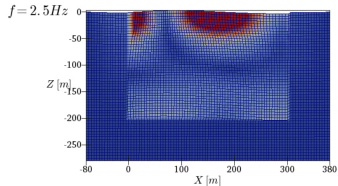
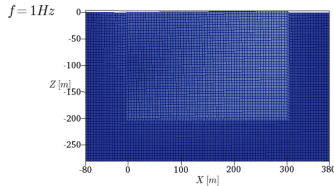


SMR ESSI, Variation in Input Wave Angle, $f = 5\text{Hz}$



(MP4)

Free Field, Variation in Input Frequency, $\theta = 60^\circ$

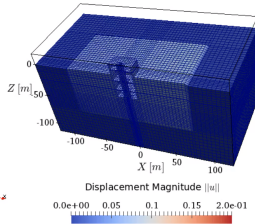


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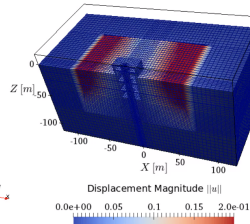


SMR ESSI, Variation in Input Frequency, $\theta = 60^\circ$

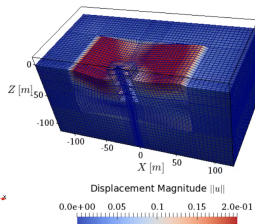
$f = 1\text{Hz}$



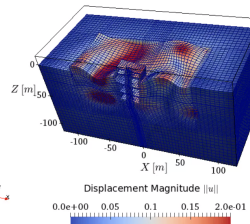
$f = 2.5\text{Hz}$



$f = 5\text{Hz}$



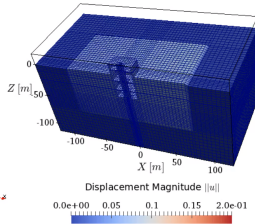
$f = 10\text{Hz}$



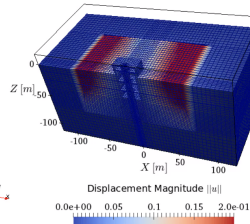
(MP4)

SMR ESSI, Variation in Input Frequency, REAL TIME

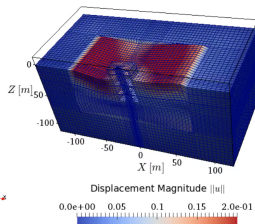
$f = 1\text{Hz}$



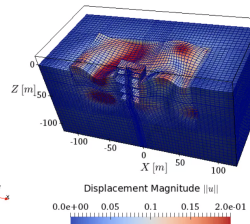
$f = 2.5\text{Hz}$



$f = 5\text{Hz}$

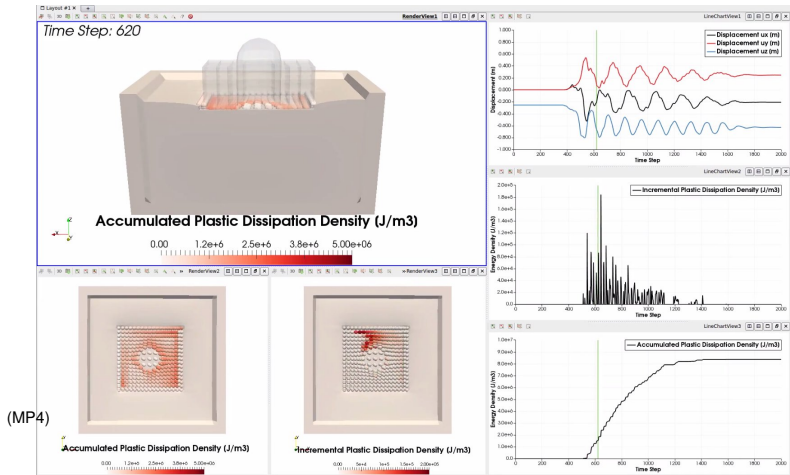


$f = 10\text{Hz}$

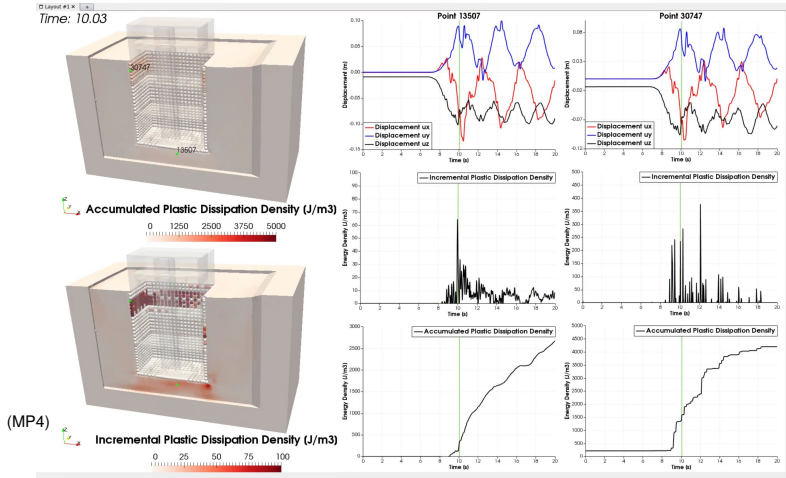


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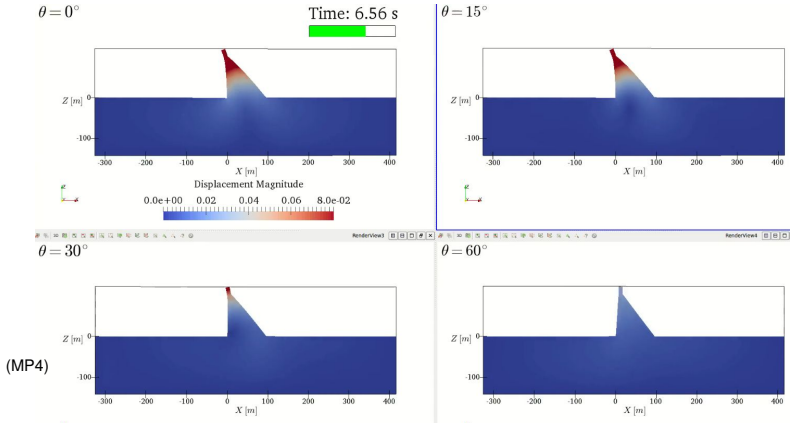
NPP ESSI, Energy Dissipation, Weak Link



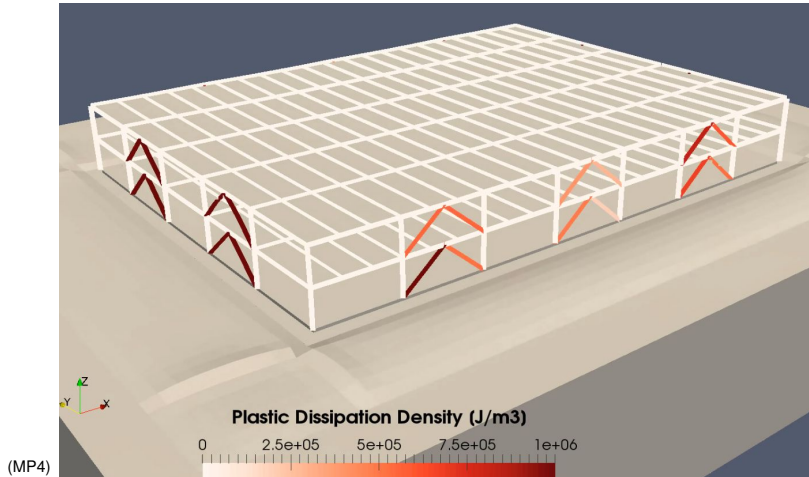
SMR ESSI, Energy Dissipation, Weak Link



Energy Infrastructure, Inclined Seismic Waves



BRB Energy Dissipation, Weak Link



Summary

Stress test, shake-out nuclear energy ESSI system

Stress test motions variations: signal, energy, inclination and direction angle, duration

Advance safety and economy of energy ESSI systems

Students: Feng, Yang, Behbehani, Sinha, Wang, Pisanó, Abell, Tafazzoli, Jie, Preisig, Tasiopoulou, Watanabe...

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