Stress Test Seismic Motions for Nuclear Installations

Hexiang Wang, Yuang Feng, Han Yang, Fangbo Wang,

Boris Jeremić

University of California, Davis, CA
Lawrence Berkeley National Laboratory, Berkeley, CA

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Outline

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Motivation

Improve modeling and simulation for infrastructure objects

Control and reduce modeling uncertainty

Goal: Predict and Inform rather than fit

System for modeling and simulation of Earthquakes, Soils, Structures and their Interaction:

Real-ESSI Simulator, **`http://real-essi.info/`**

Prediction under Uncertainty

- Modeling Uncertainty, Simplifying assumptions

  Low, medium, high sophistication modeling and simulation

  Choice of sophistication level for confidence in results

- Parametric Uncertainty, $M\ddot{u}_i + C\dot{u}_i + K^{ep}u_i = F(t)$,

  Uncertain mass M, viscous damping C and stiffness K^{ep}

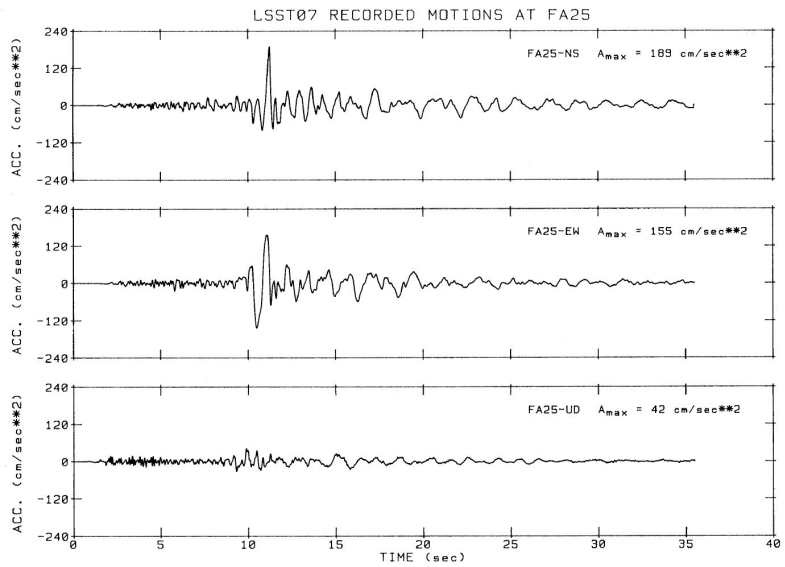
  Propagation of uncertainty in loads, $F(t)$

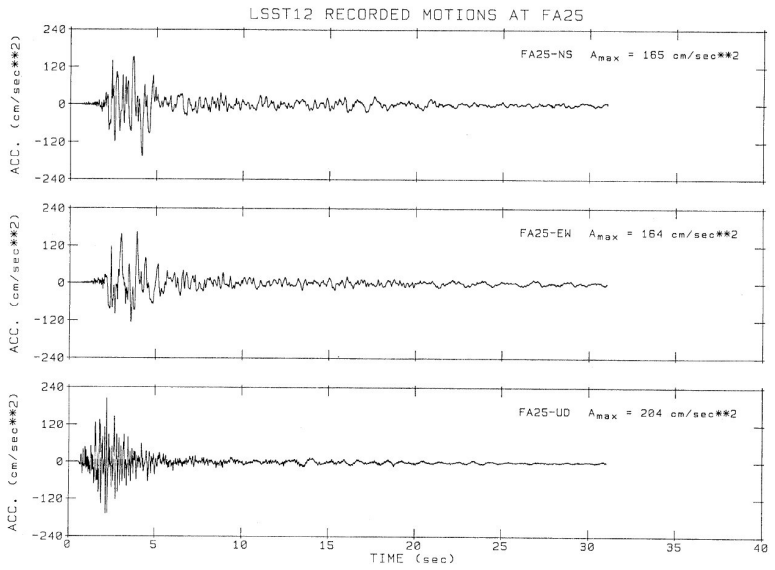
  Results are PDFs and CDFs for σ_{ij}, ϵ_{ij}, u_i, $\dot{u}_i$, $\ddot{u}_i$

Outline

3C, 6C Seismic Motions

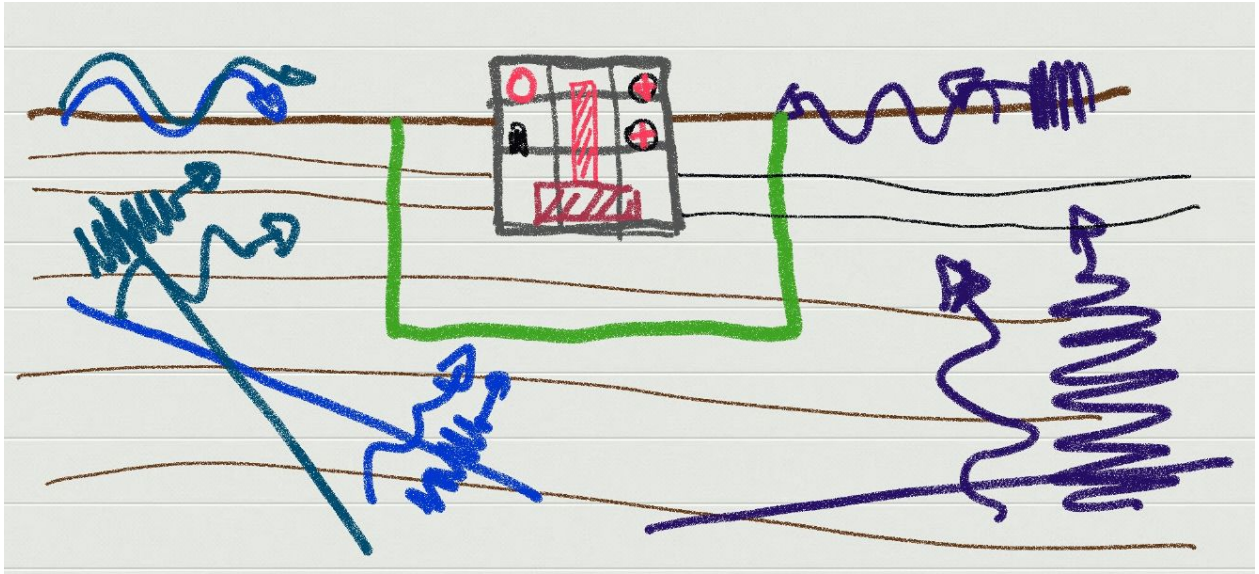
- All (most) measured motions are full 3C, 6C
- One example of an almost 2C motion (LSST07, LSST12)



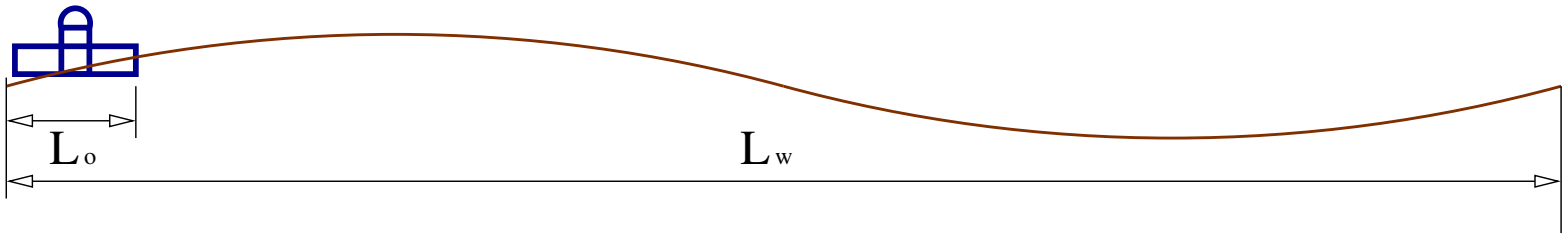


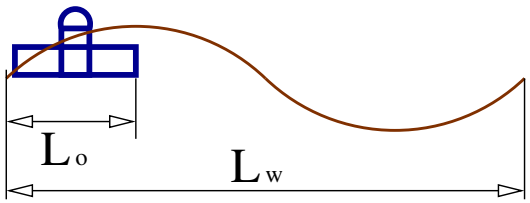
Stress Test Motions

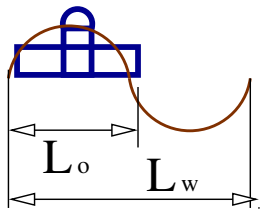
- Variation in inclination, frequency, energy, duration...
- Deterministic and Probabilistic
- Stress test the soil-structure system



Seismic Motion Wave Lengths

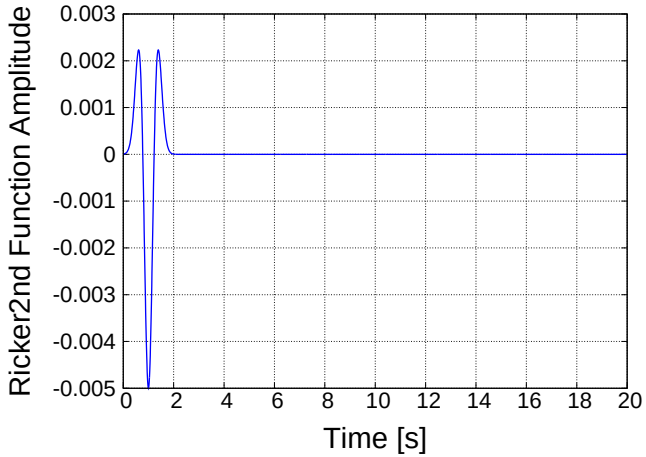


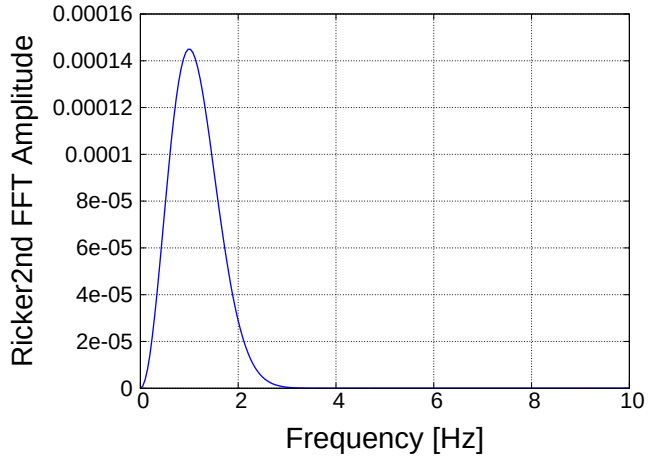




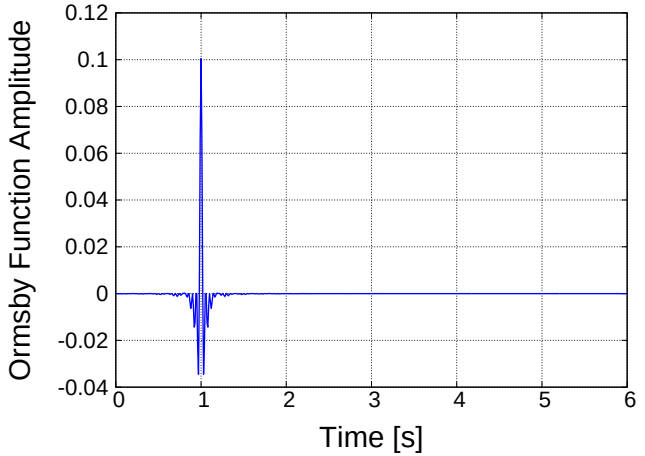
Stress Test Source Signals

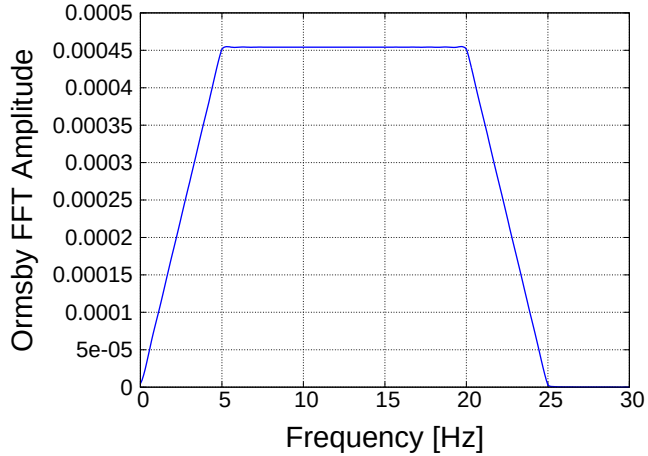
- Ricker





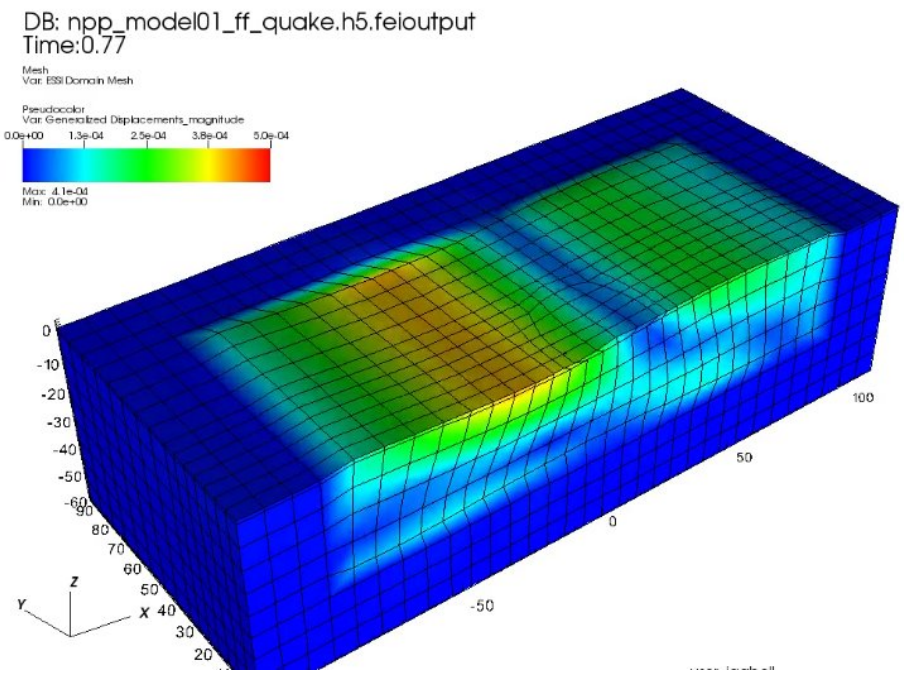
- Ormsby

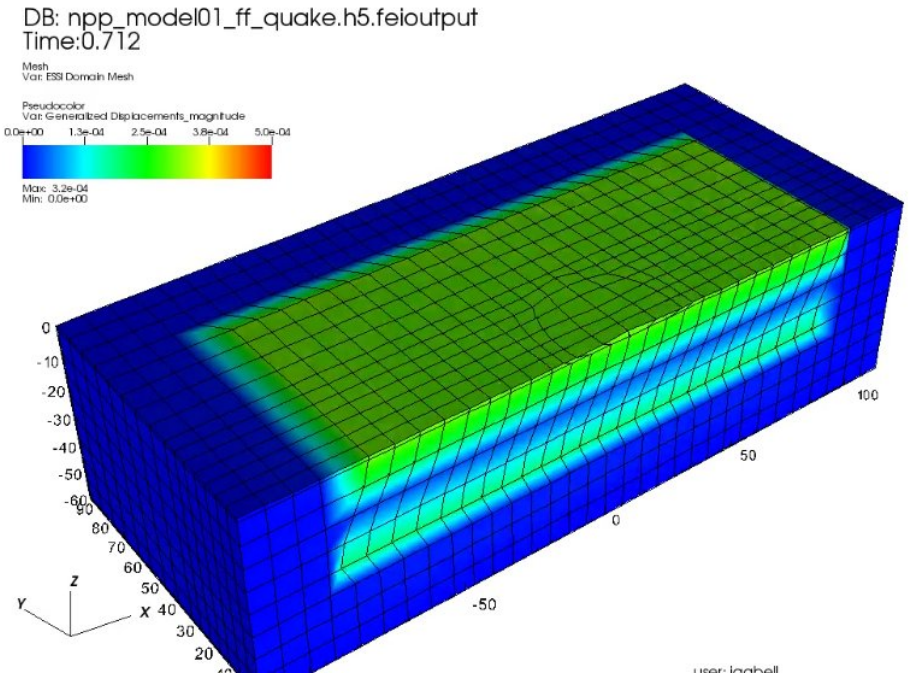




1C vs 6C Free Field Motions

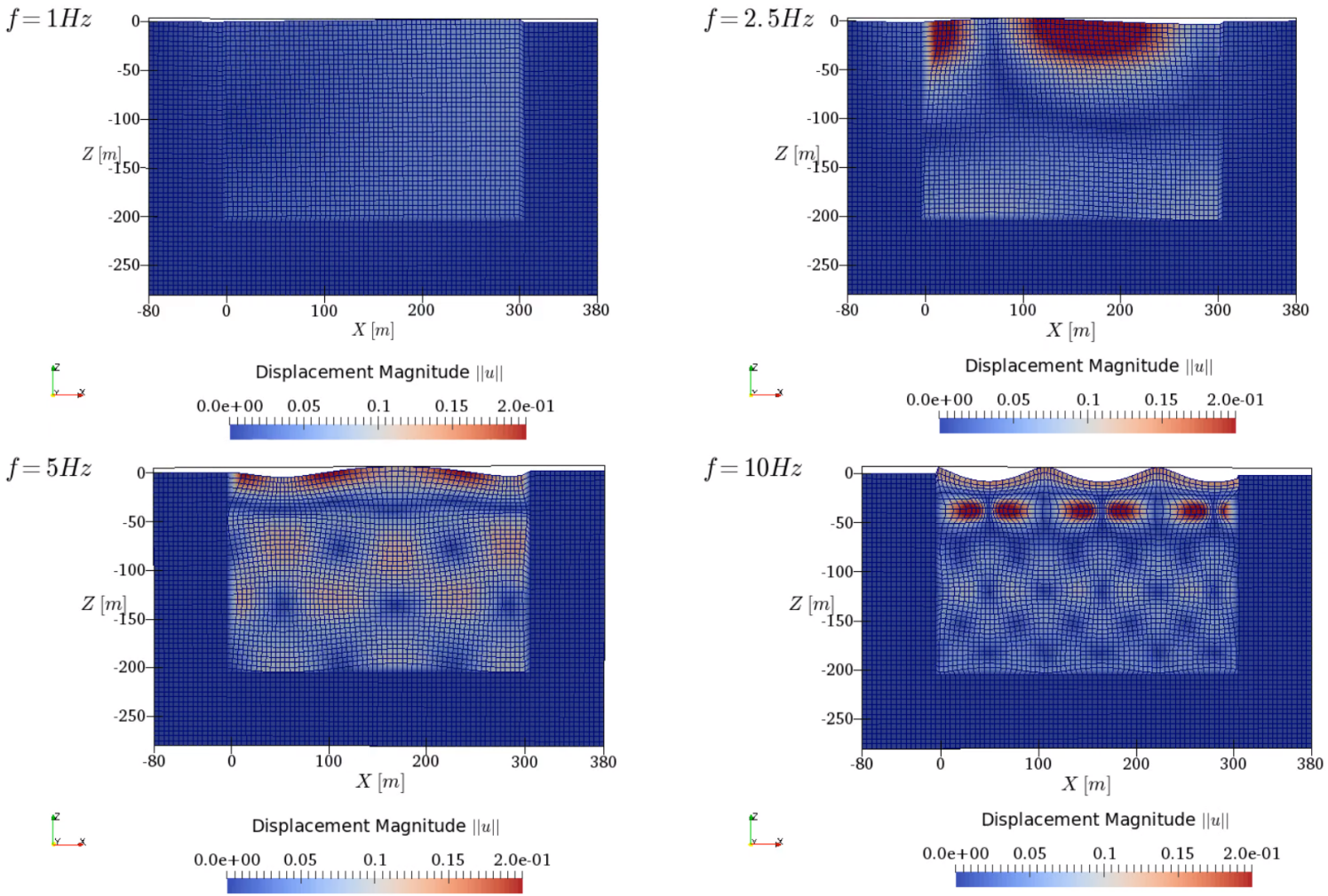
- One component of motions, 1C from 6C
- Excellent fit





(MP4) (MP4)

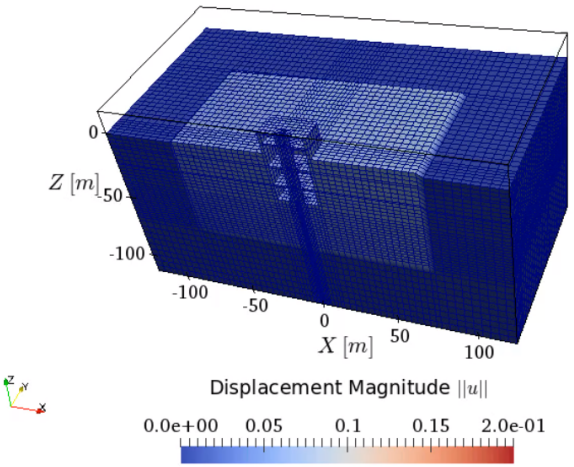
Free Field, Variation in Input Frequency, $\theta = 60^o$



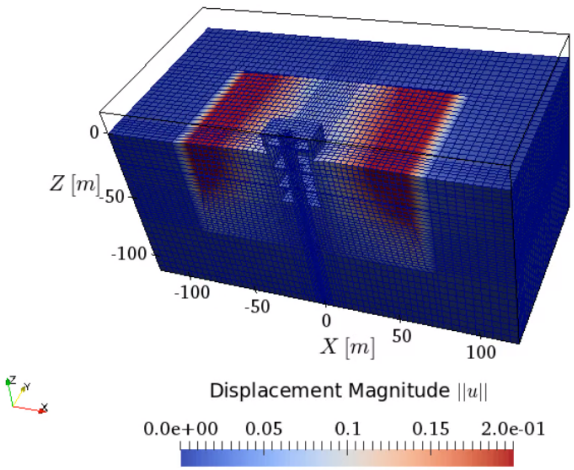
(MP4)

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

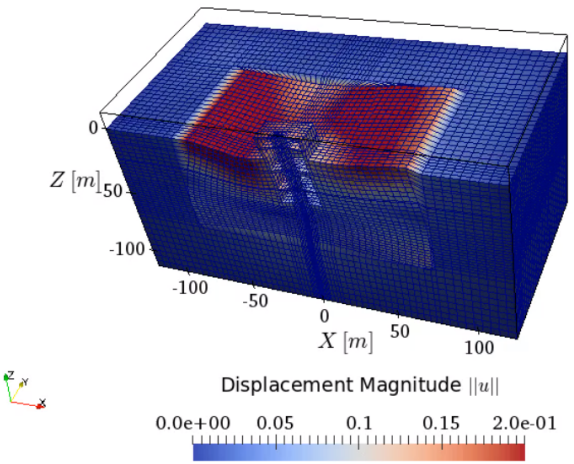
$f = 1Hz$



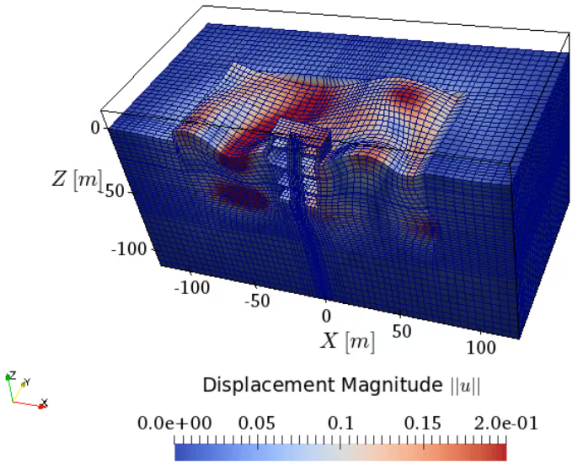
$f = 2.5Hz$



$f = 5Hz$



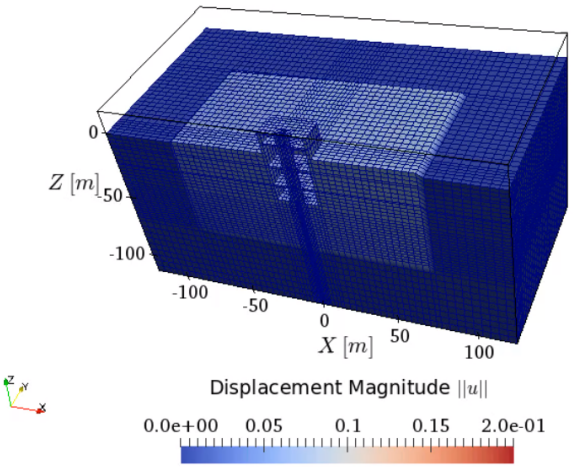
$f = 10Hz$



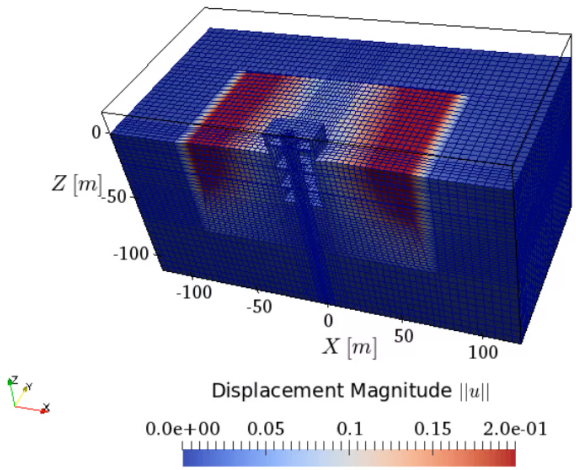
(MP4)

SMR ESSI, Variation in Input Frequency, REAL TIME

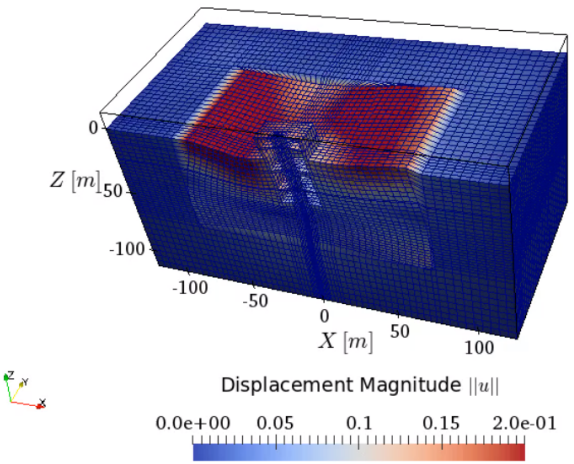
$f = 1Hz$



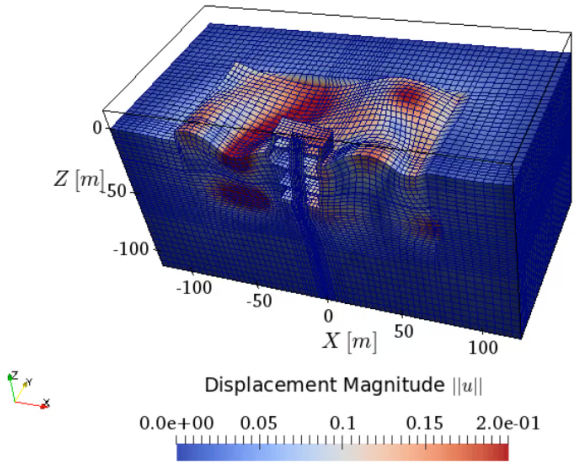
$f = 2.5Hz$



$f = 5Hz$

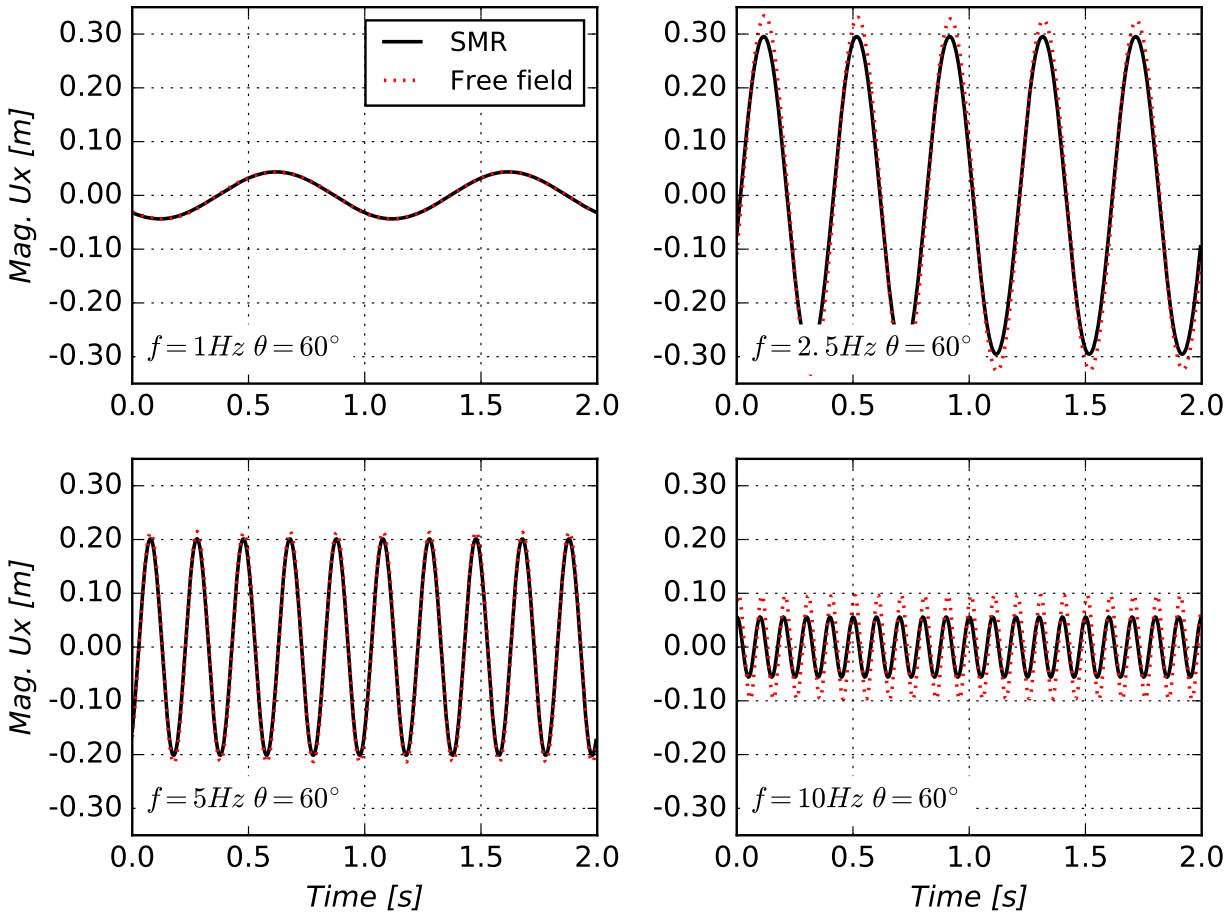


$f = 10Hz$

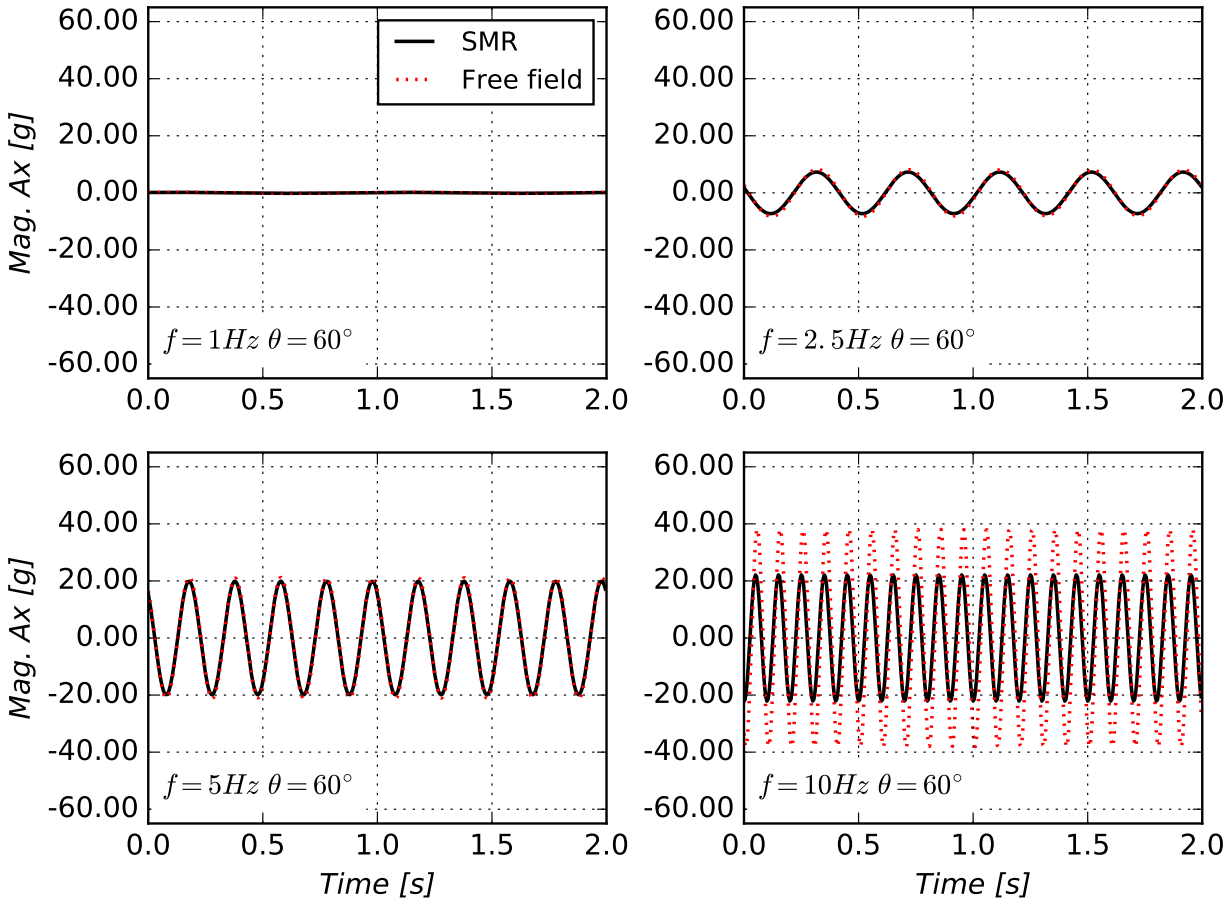


(MP4)

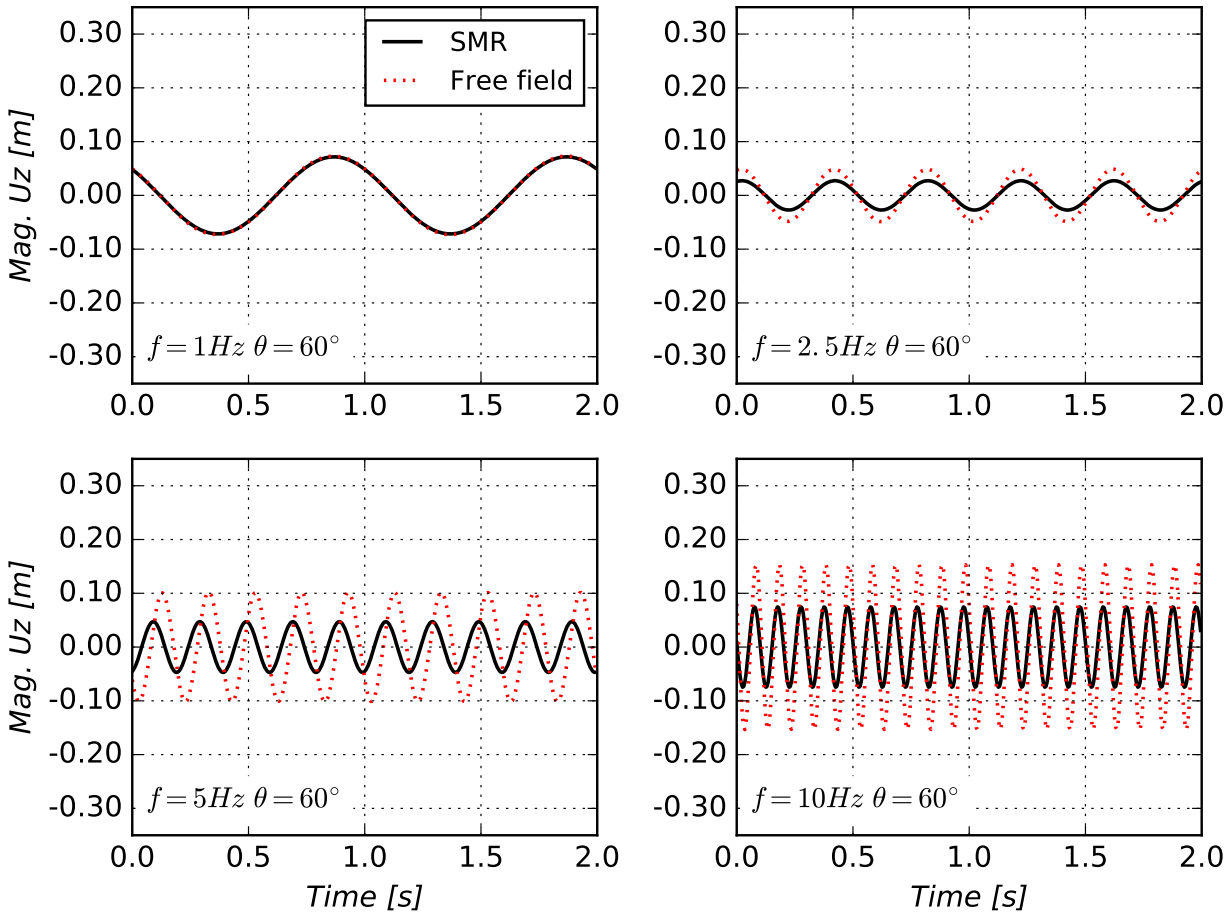
Free Field vs ESSI Motions, Horizontal Displacements



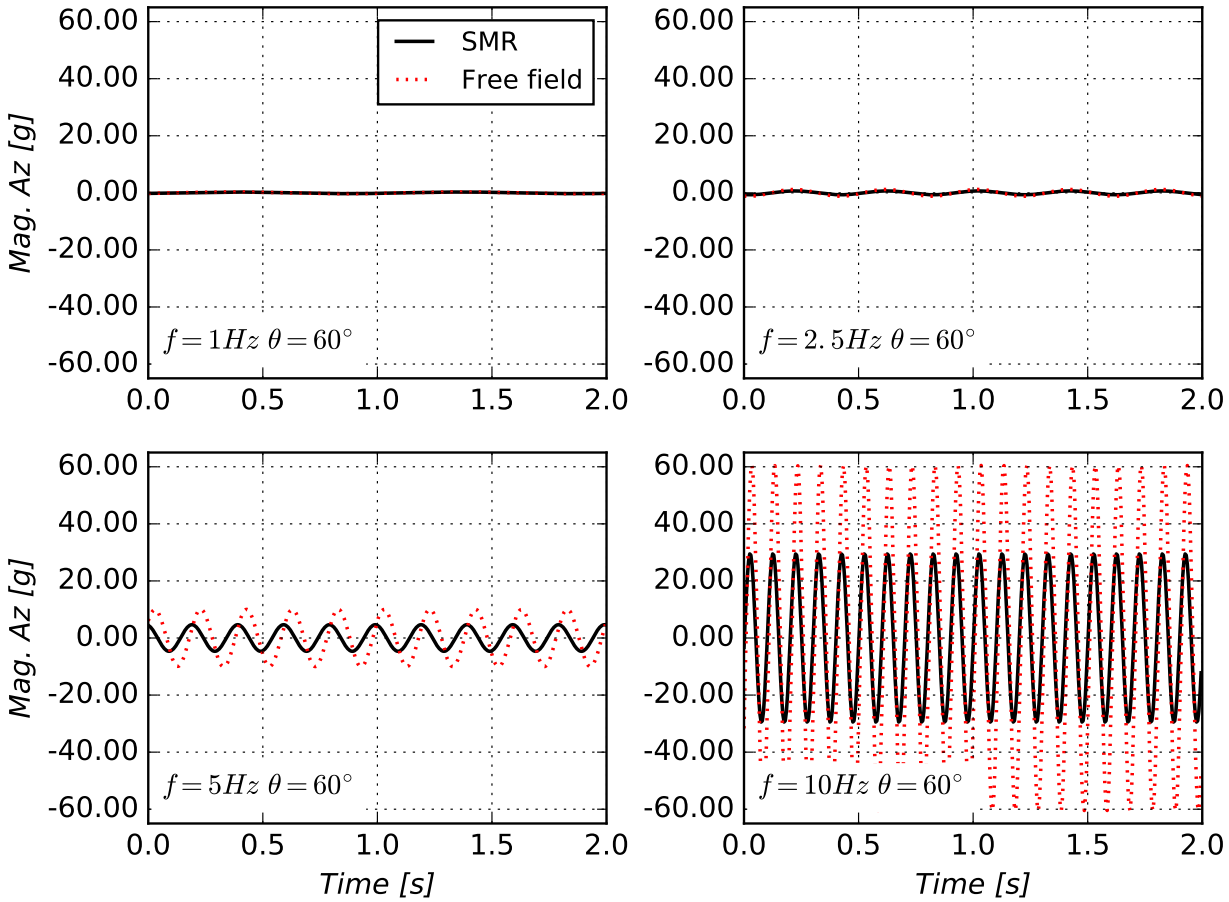
Free Field vs ESSI Motions, Horizontal Accelerations



Free Field vs ESSI Motions, Vertical Displacements

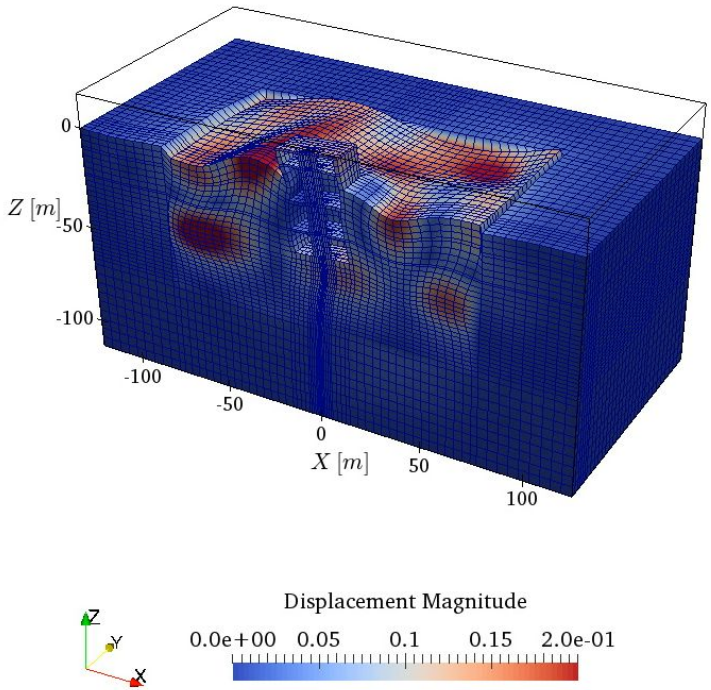


Free Field vs ESSI Motions, Vertical Accelerations

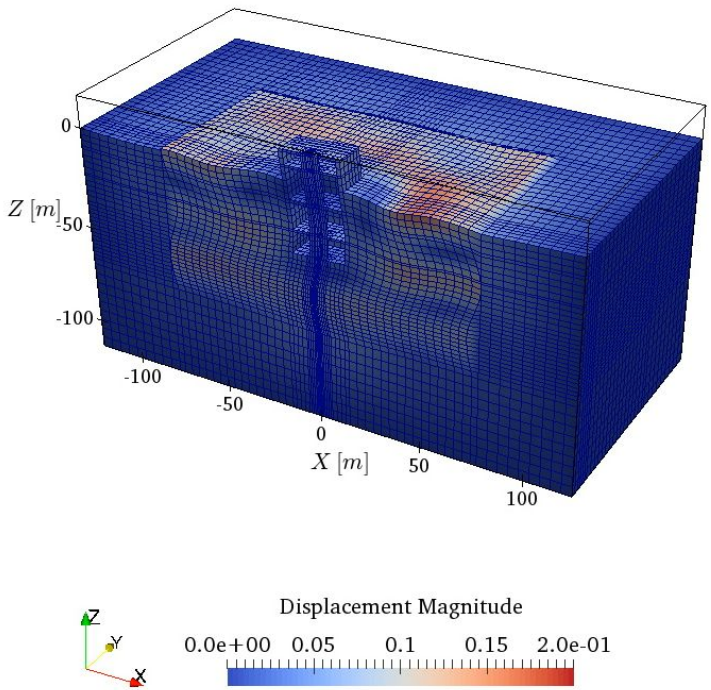


SMR ESSI, 3C vs 3×1C

$3C$



$3 \times 1C$



(OGV)

Outline

Summary

- Numerical modeling to predict and inform, rather than fit
- Stress test motions for improving design
- Stress test motions for assessing performance
- **http://real-essi.info/**