Real ESSI Modeling and Simulation: Reduction of Modeling Uncertainty

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Motivation

- Improving seismic design (safety and economy) for Nuclear Facilities
- Earthquake Soil Structure Interaction (ESSI) in time and space, plays a major role in successes and failures
- Accurately follow and direct the flow of seismic energy in ESSI system to optimize for
  - Safety and
  - Economy

Seismic Energy Input and Dissipation

- Energy input: seismic waves input (flux) into SSI system
- Energy dissipation:
  - Mechanical dissipation outside of SSI domain:
    - Wave reflections
    - SSI system oscillation radiation
  - Mechanical dissipation/conversion inside SSI domain:
    - Inelasticity (plasticity, damage) of soil and rock
    - Inelasticity (plasticity, gaping) of contact zone
    - Inelasticity (plasticity, damage) of structure, foundation
    - Viscous coupling of solids and fluids (pores, soil)
  - Numerical energy dissipation and production

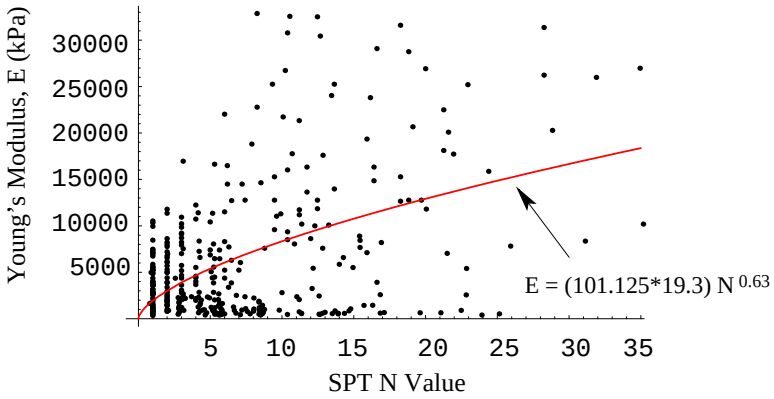
Predictive Capabilities

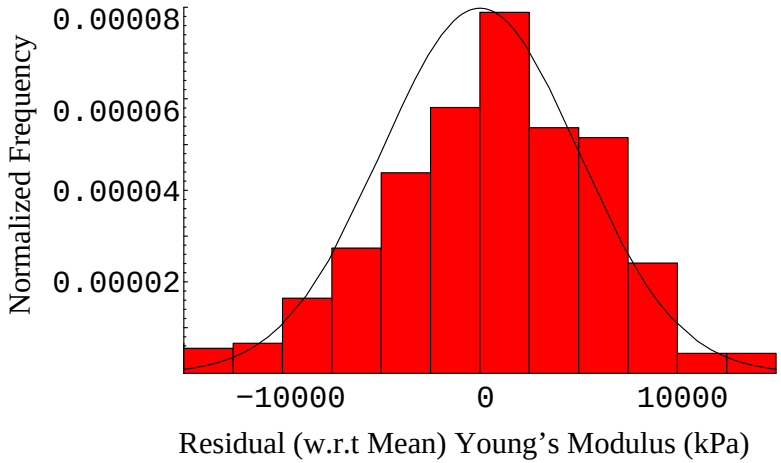
- Verification provides evidence that the model is solved correctly. Mathematics issue.
- Validation provides evidence that the correct model is solved. Physics issue.
- Prediction: use of computational model to foretell the state of a physical system under consideration under conditions for which the computational model has not been validated.
- Predictive capabilities with low Kolmogorov Complexity

Reduction of Modeling Uncertainty

- Simplified modeling: Features (important ?) are neglected (soil and structure complexity, 6D ground motions, non-linearities)
- Modeling Uncertainty: unrealistic and unnecessary modeling simplifications
- Modeling simplifications are justifiable if one or two level higher sophistication model shows that features being simplified out are not important

Uncertain Material and Loads





Transformation of SPT N-value $\rightarrow$ 1-D Young's modulus, E (cf. Phoon and Kulhawy (1999B))

Real ESSI Simulator

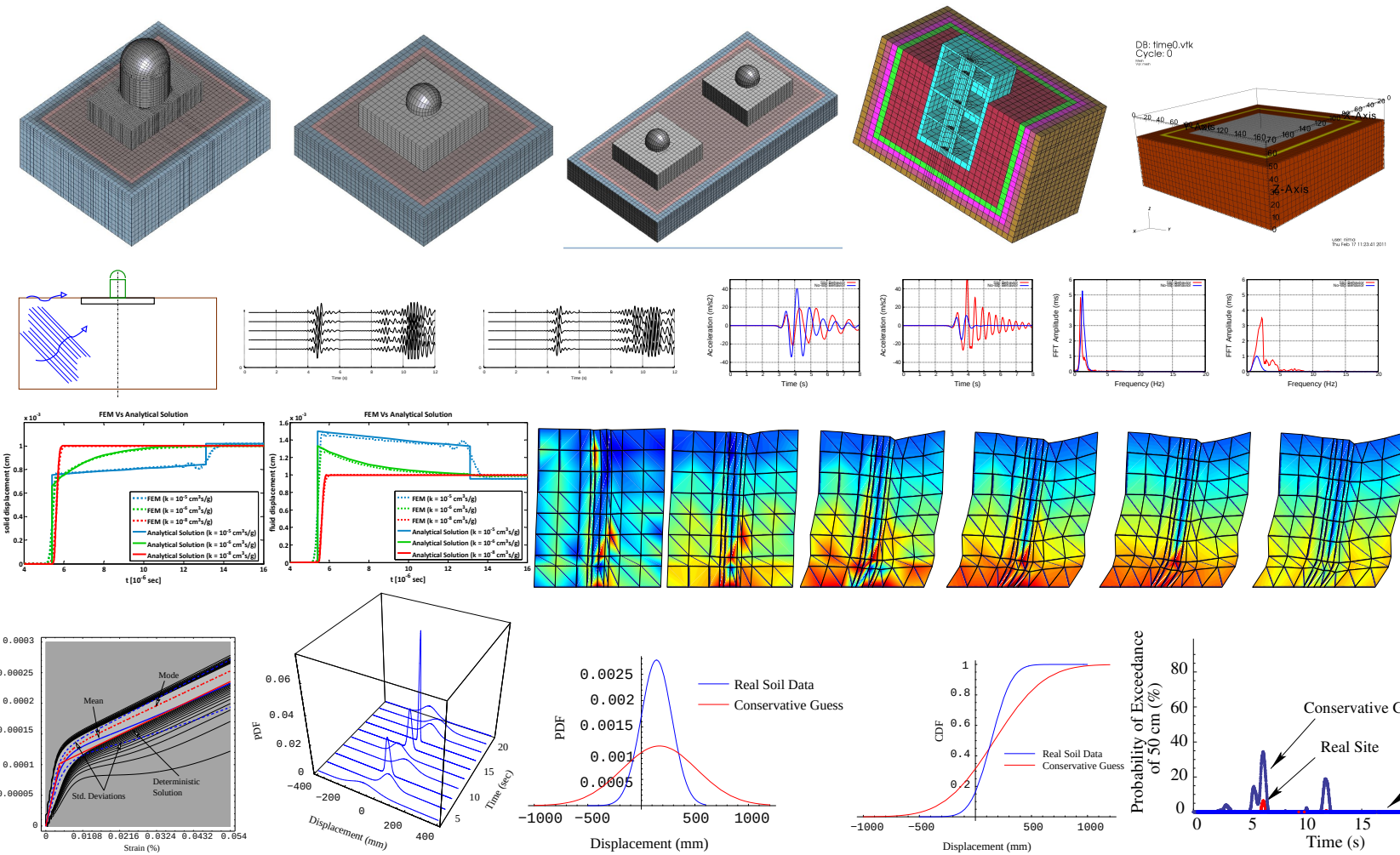
- A System for high fidelity, high performance/parallel, time domain, deterministic and probabilistic, nonlinear, 3D, finite element modeling and simulation of earthquake soil/rock structure interaction of Nuclear Facilities

- Real ESSI Simulator, also known as:
  Стварно Лако, Muy Fácil, Molto Facile, 本当に簡単 ,
  Πραγματικά Εύκολο, آسان واقعی, Très Facile, Вистински Лесно, Wirklich Einfach

Important Issues for ESSI Modeling and Simulation

- 6D, inclined, body and surface seismic waves
- Incoherent seismic motions
- Inelastic/Nonlinear material (soil, rock, concrete, steel, &c.)
- Inelastic/Nonlinear, foundation–soil, dry, saturated slip–gap
- Saturated dense and loose soil
- Buoyant forces
- Piles and pile groups
- Isolators, dissipators
- Uncertain material and loading
- Verification and Validation

Inform Designers and Regulators



Summary

- Earthquake Soil Structure Interaction, nonlinear, uncertain, in time domain, plays a decisive role in seismic performance of Nuclear Facilities
- Improve assessment of seismic performance (safety and economy) of nuclear facilities, through high fidelity, high performance, physics based modeling and simulation
- One available tool for modeling and simulation: Real ESSI Simulator, used for deterministic and probabilistic assessment of safety and economy (design, regulatory decision making, &c.)
- Education and training of users (designers, regulators, owners) proves essential

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