PRENOLIN, Comments, April 2014

Boris Jeremić and Kohei Watanabe

UCD, LBNL

PRENOLIN meeting,
Nice, France
April 2014

(US-NRC, CNSC, DOE) ESSI Simulator System

- **ESSI-Program** is a 3D, nonlinear, time domain, parallel finite element program specifically developed for Hi-Fi modeling and simulation of Earthquake Soil/Rock Structure Interaction of NPPs on ESSI-Computer.
- **ESSI-Computer** is a distributed memory parallel computer, a cluster of clusters with multiple performance processors and multiple performance networks.
- **ESSI-Notes** are a hypertext documentation system (Theory and Formulation, Software and Hardware, Verification and Validation, and Case Studies and Practical Examples) detailing modeling and simulation of ESSI problems.

Questions and Answers

Q: Did you have difficulties with the changes proposed in iteration 2? **A:** We are still using rigid base, since we did not have time to work out the full wave field for using analytic seismic input (input is SHAKE oriented). Also used more points (space, time), interpolation

Q: What is your expectation on the variability of the results for this iteration? **A:** There was no real Verification (yet) of codes, leading to variability (large or small)

Q: Do you have a proposal for simple calculations to test the numerical method (implementation of attenuation and non-linear model). **A:** Full Verification (see next slide)

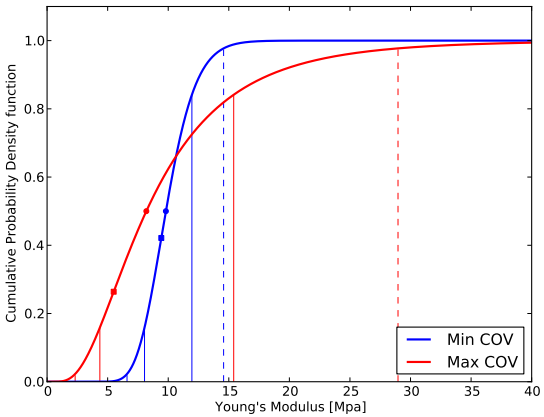
Q: Something that you want to highlight? **A:** Material modeling uncertainty and loading uncertainty! (see next to last slide)

Complete Verification

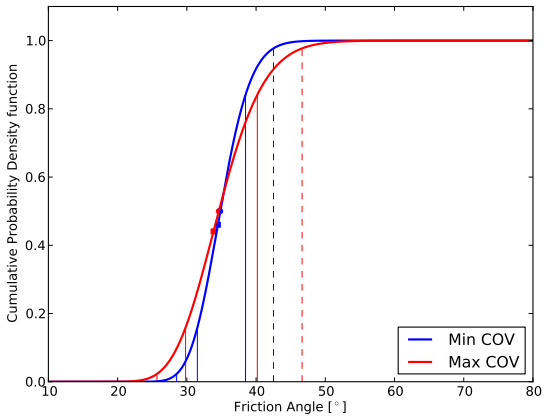
- Code verification (programming bugs, coverage, portability)
- Solver verification (pivoting, numerical errors)
- Time marching algorithm verification (Newmark, Hilber-Hughes-Taylor, &c.)
- Constitutive integration algorithm verification (linear elastic, nonlinear el., visco-el., elastic-plastic, 1D, 2D, 3D)
- Finite element(s) verification (control loads and displ.)
- Damping, energy dissipation (viscous, frictional, numerical) verification
- Wave propagation algorithm verification (control motions, wavelets)
- Parametric study for a wide range of parameters for each case (trying to "break" the model)

Uncertainty: Material Modeling and Loading

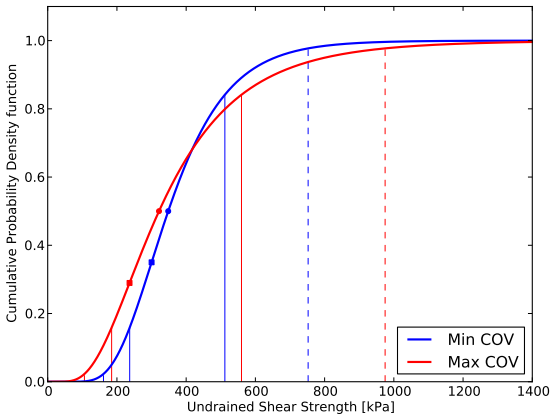
- Material modeling based on uncertain data (measuring errors, transformation errors, spatial variability)
- Seismic loading is uncertain



Elastic Modulus



Friction Angle



Shear Strength

Summary (Verification $\rightarrow$ Validation)

- Verification: detailed, address all the components separately (separate elastic, visco-elastic, (cannot expect visco-elastic to have smaller differences, &c.)
- Verification, same models (linear elastic for example) should have "no" variability
- Volume change for soil (large influence on "1D" (actually 3D) response, we use a full 3D models
- Uncertainty (material modeling, loading) is controlling