Modeling and Simulation
Earthquake Soil/Rock Structure Interaction

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Outline

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Motivation

Improve modeling and simulation for infrastructure objects

Use select fidelity (high $\leftrightarrow$ low) numerical models to analyze static and dynamic behavior of soil/rock structure fluid systems

Reduction of modeling uncertainty, ability to perform desired level of sophistication modeling and simulation

Development of an expert system for modeling and simulation of Earthquake, Soil/Rock, Structure and their Interaction, Real-ESSI: http://real-essi.info/

Predictive Capabilities

Prediction under Uncertainty: use of computational model to predict the state of SSI system under conditions for which the computational model has not been validated.

Verification provides evidence that the model is solved correctly. Mathematics issue.

Validation provides evidence that the correct model is solved. Physics issue.

Modeling and parametric uncertainties are always present

Goal: Predict and Inform rather than (force) Fit

Modeling and Parametric Uncertainty

Simplified modeling: Features (important ?) are neglected (3C, 6C ground motions, inelasticity)

Modeling Uncertainty: unrealistic and unnecessary modeling simplifications

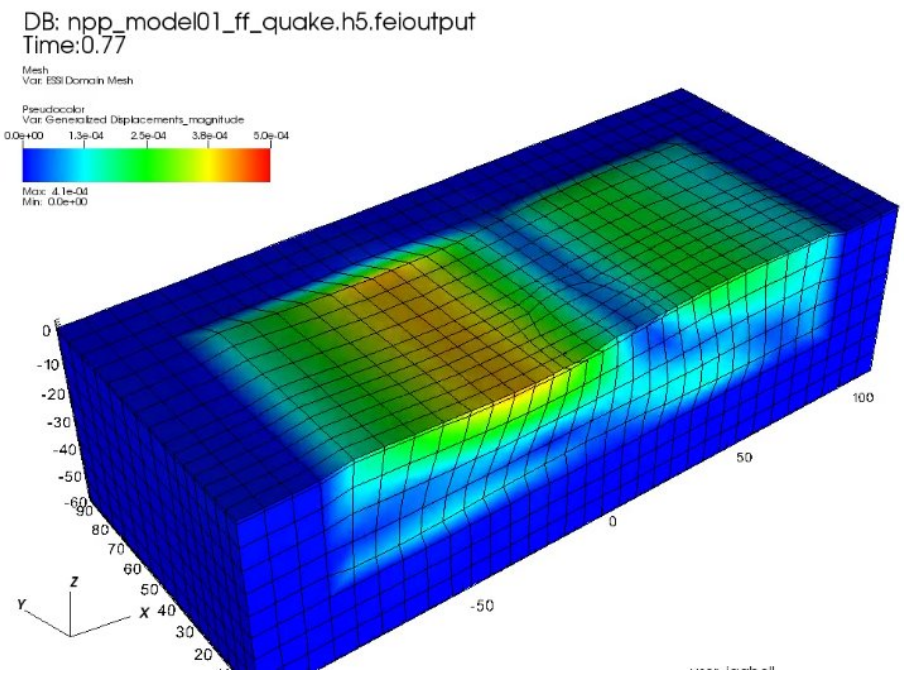
Modeling simplifications are justifiable if one or two level higher sophistication model shows that features being simplified out are not important

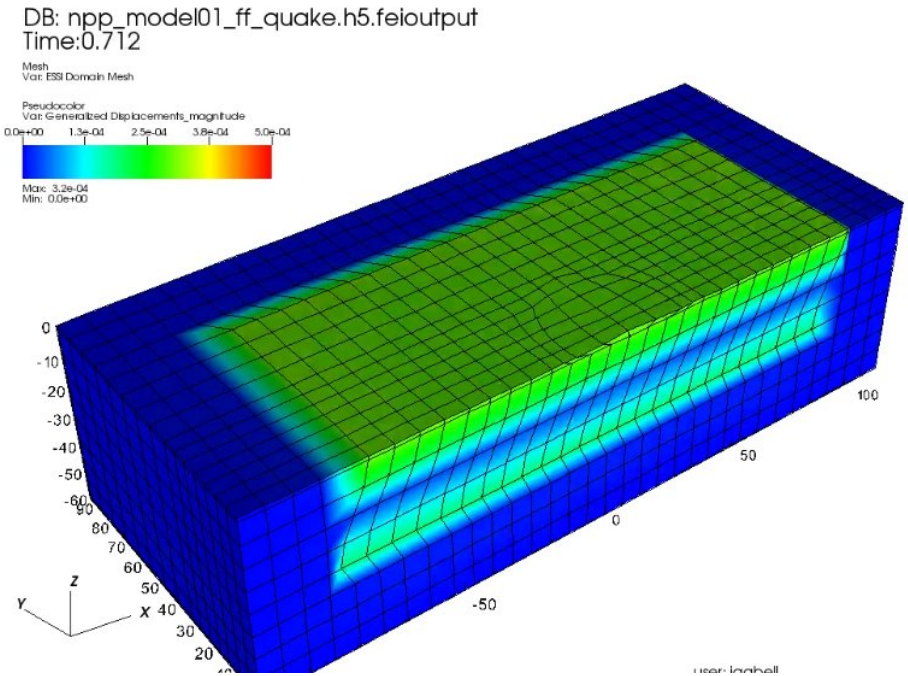
Material behavior and system loads are uncertain!
"Le doute n’est pas une condition agréable, mais la certitude est absurde" Voltaire

Modeling Uncertainty: 1C vs 6C Free Field Motions

One component of motions, 1C from 6C

Excellent fit





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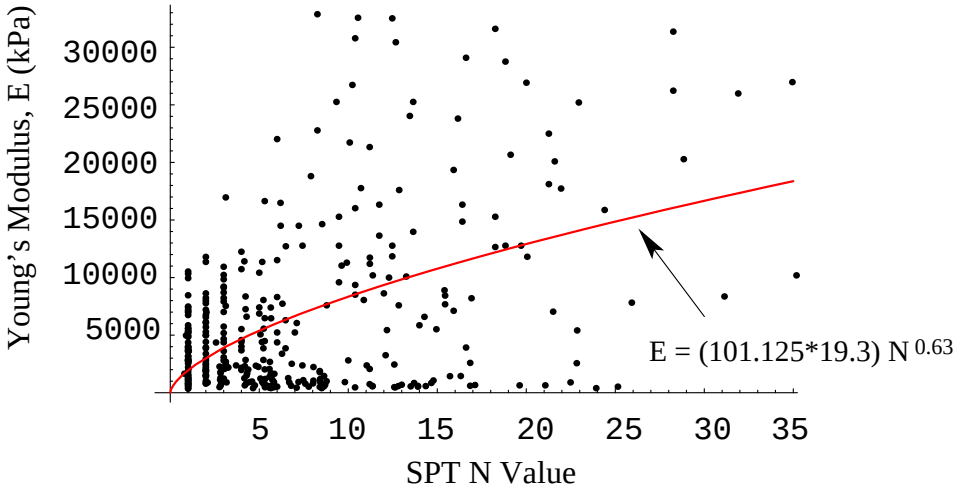
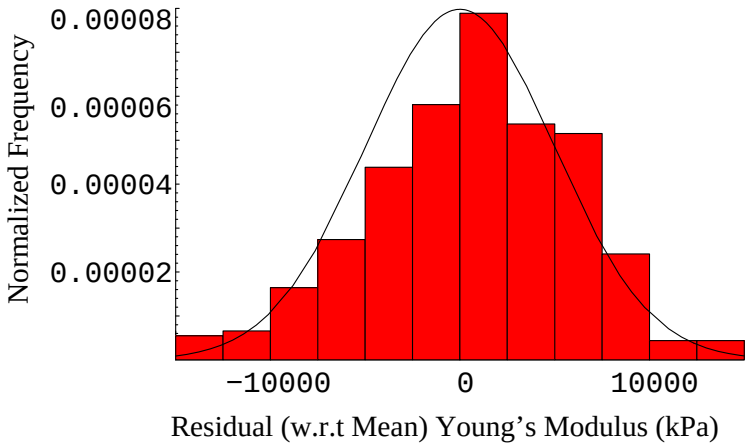
Parametric Uncertainty: Soil Stiffness



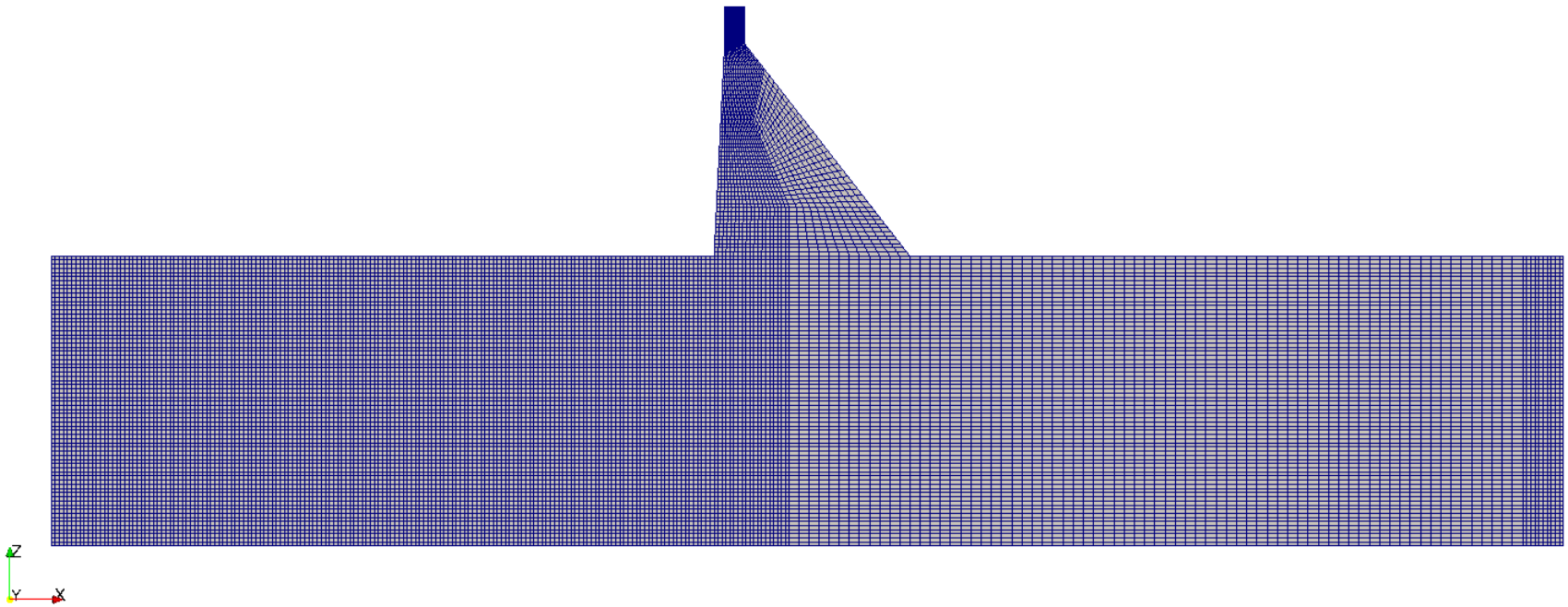


cf. Phoon and Kulhawy (1999B)

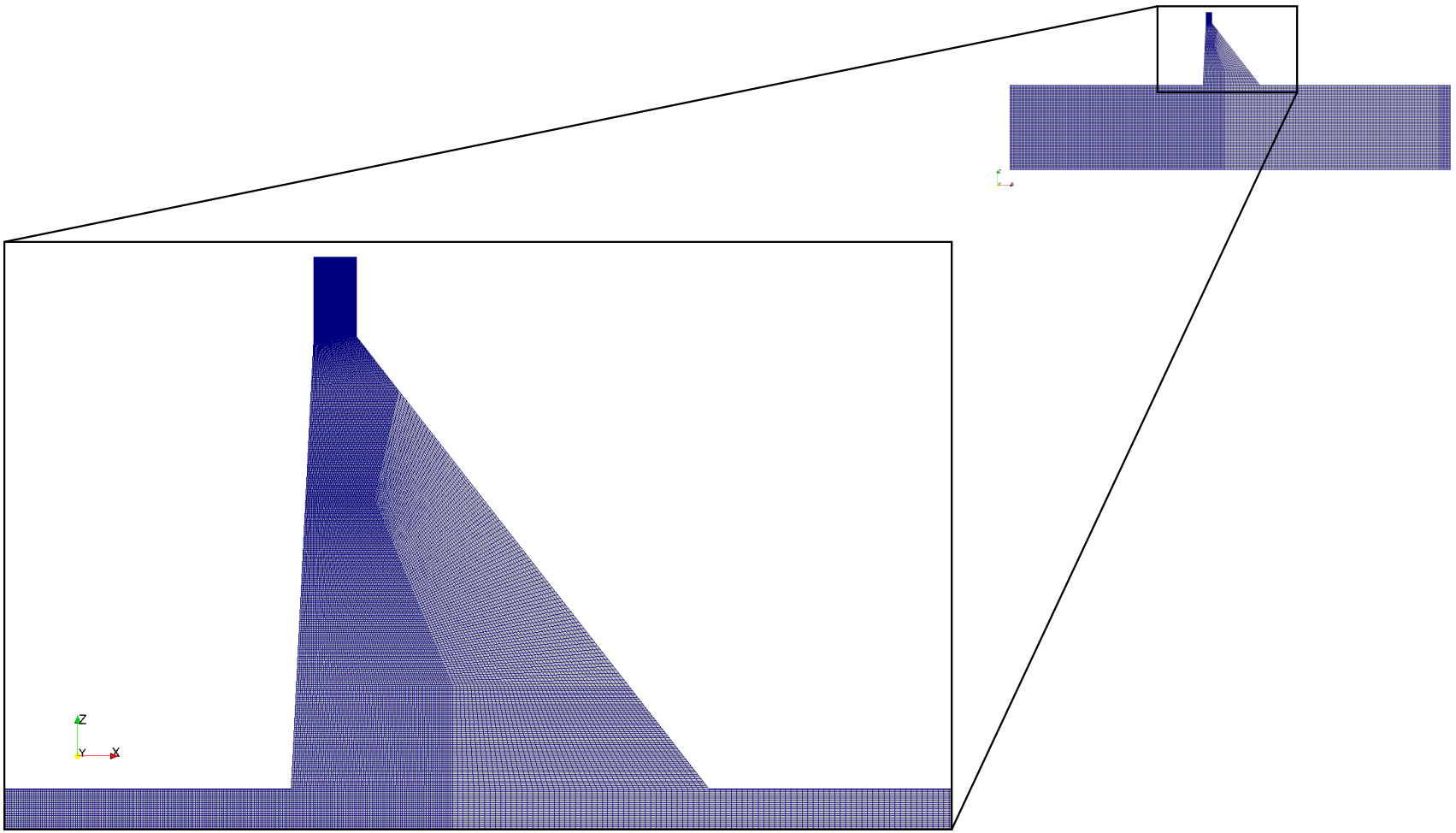
Outline

Pine Flat Dam, Model

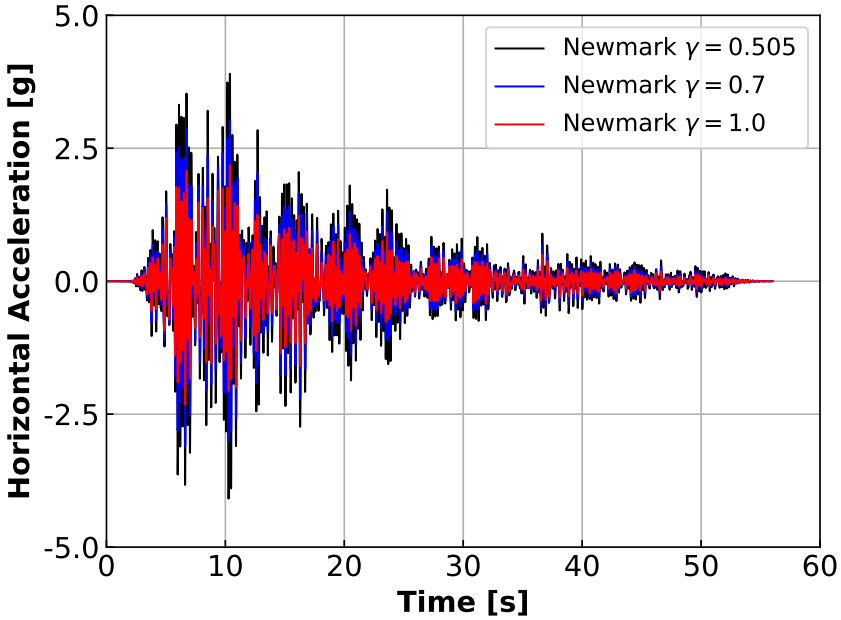
3D solids, with BCs for 2D analysis
Linear elastic and inelastic material and interfaces
Energy dissipation: material, viscous, numerical, radiation
Seismic input, 1C, 3C, 6C, 3$\times$1C, using DRM

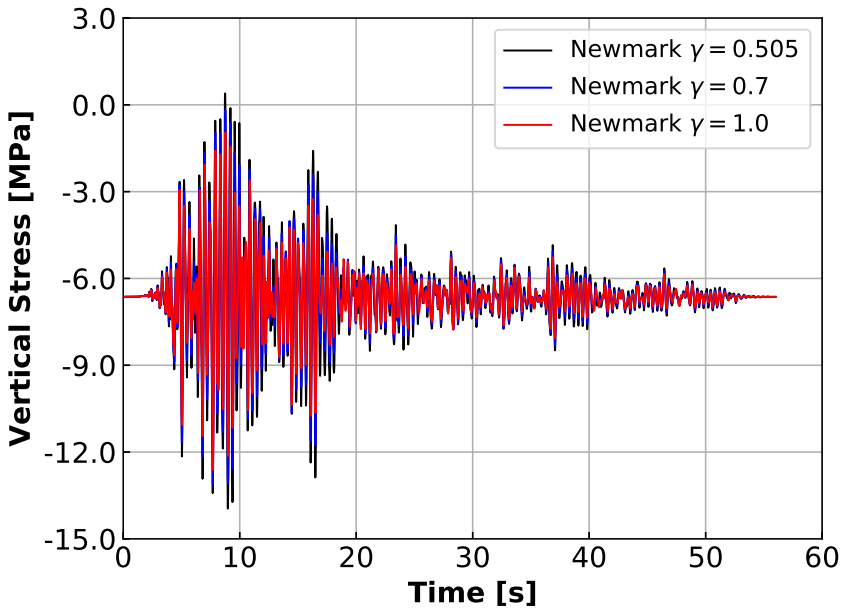


Mesh Refinement Effects

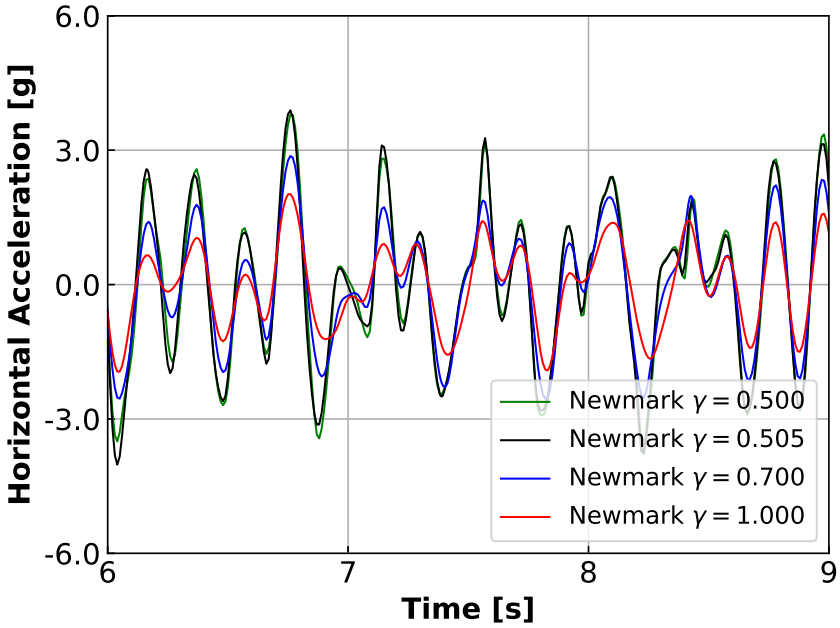


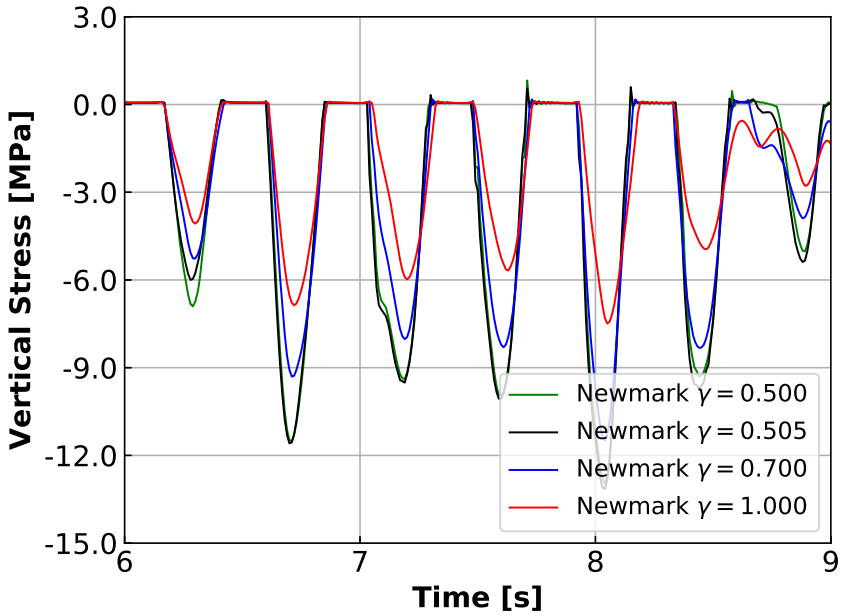
Numerical Damping Effects, Dry, Elastic $\ddot{u}_{hor}^{top}$, σ_v^{heel}



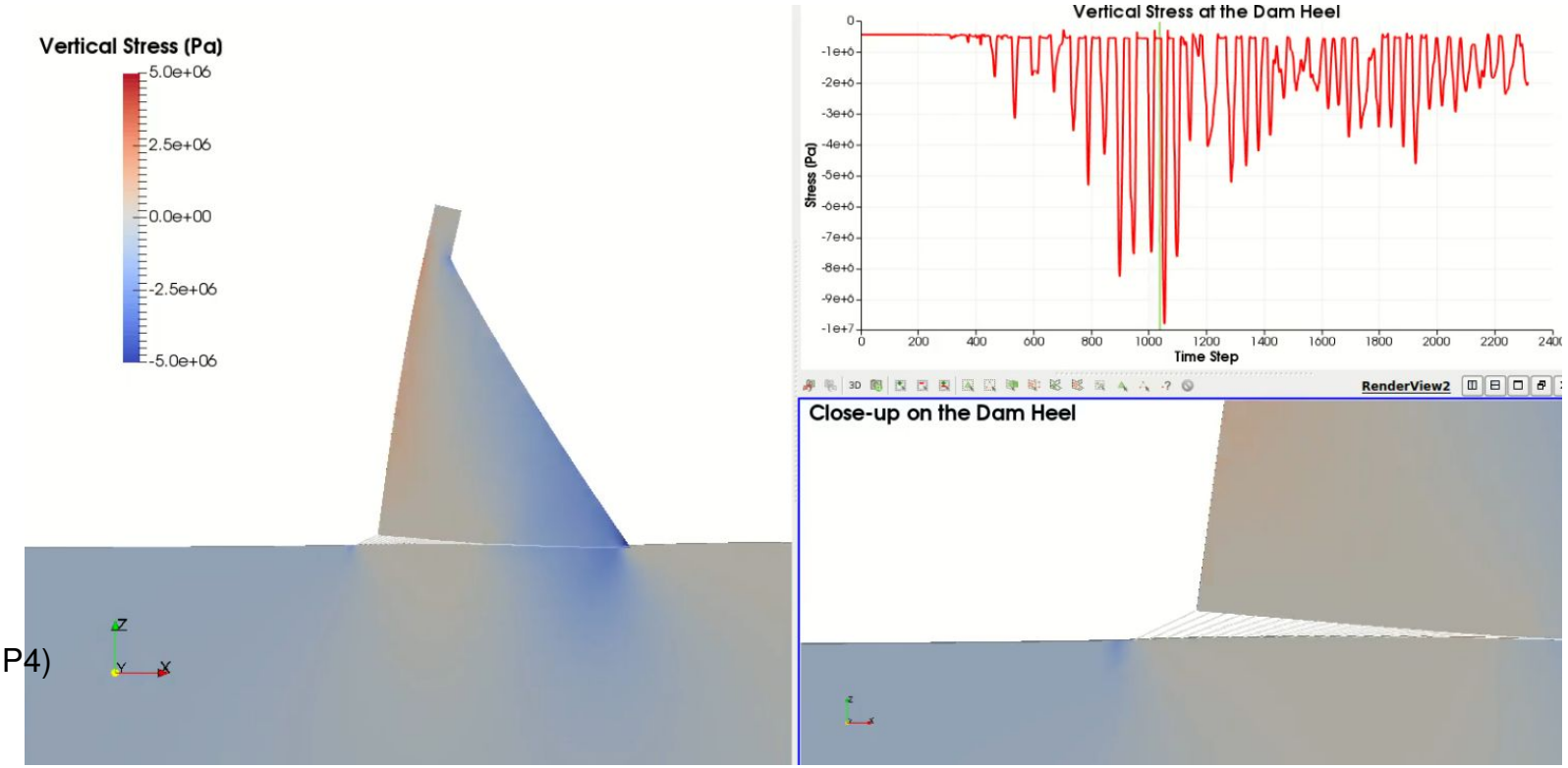


Numerical Damping Effects, Wet, Inelastic $\ddot{u}_{hor}^{top}$, σ_v^{heel}





Pine Flat Dam, Inelastic Interface, Hydrostatic



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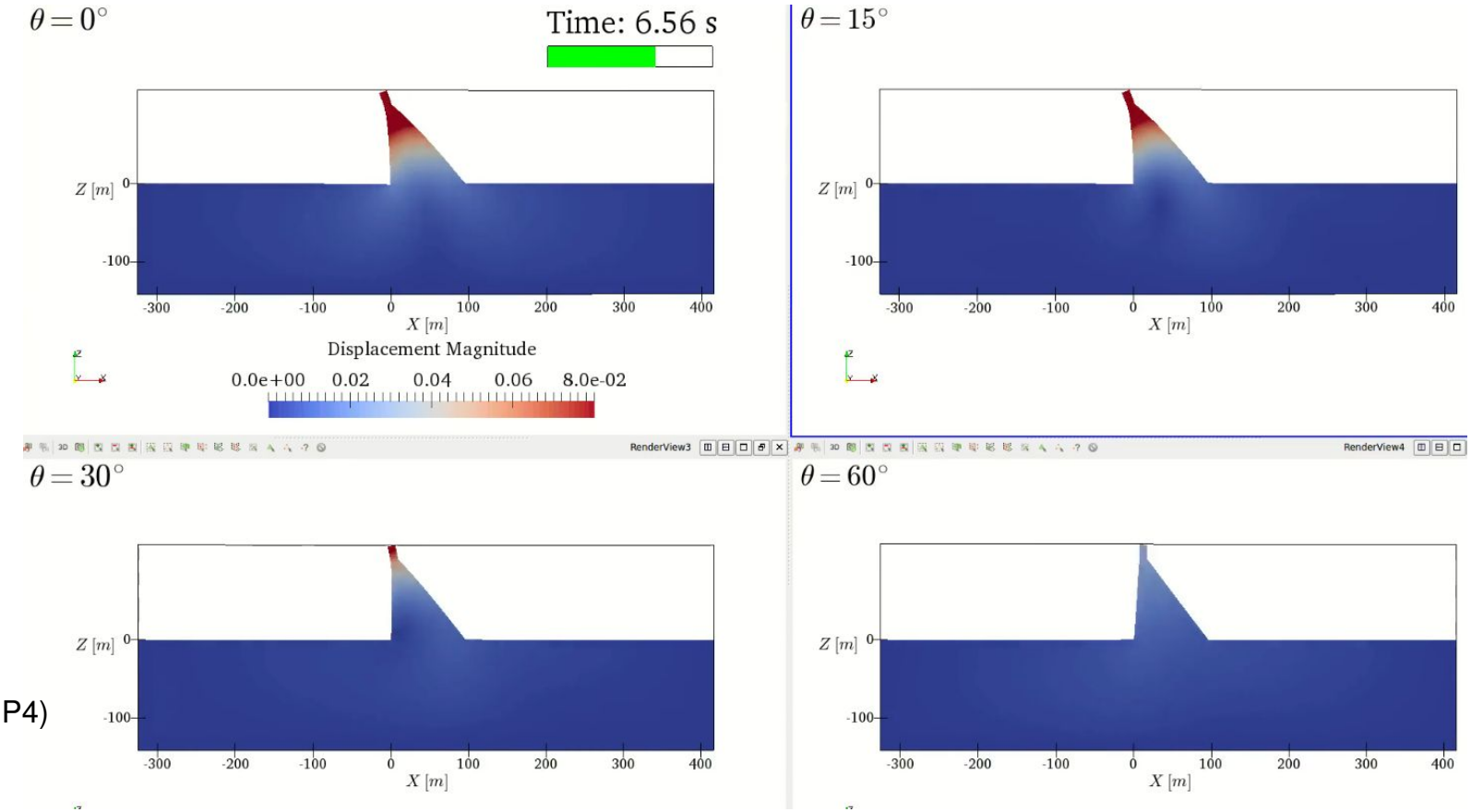
Seismic Response, Inclined Plane Waves



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Summary

Numerical modeling to predict and inform, rather than fit

Brave effort of ICOLD, assess numerical analysis of dams!

Education and Training is the key

`http://real-essi.info/`