

Road Map for Advanced Structural Analysis of Concrete Dams

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Outline

Introduction

Road Map
 Overview
 Example

Summary

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Motivation

- Engineer, Analyst use of numerical methods for advanced structural analysis of concrete dams
- Reduction of modeling uncertainty, ability to perform desired level of sophistication modeling and simulation
- Expert analysis system, a synergy of expert analysts and expert numerical modeling tools, for advanced structural analysis of concrete dams

Advanced Analysis of Concrete Dams

- Verification and Validation (V&V)
- Prediction of behavior of the concrete dams under conditions for which the 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.
- Goal: Predict and Inform, instead of just force fitting

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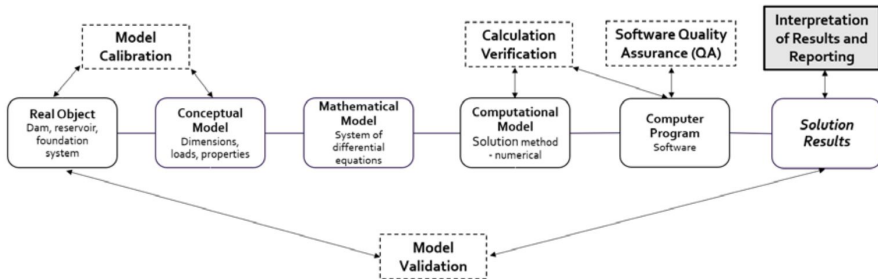
Summary

Road Map for Advanced Analysis of Concrete Dams

A Formal Process for

- Education and training of expert analysts
- Development of numerical analysis program
- Verification of numerical analysis program
- Validation of numerical analysis program
- Development of concrete dam models
- Concrete dam model verification

Road Map Components



Road Map Activities

- Numerical program
 - Quality Assurance: Verification and Validation
 - Repeatability of analysis results using the same program
 - Reproducibility of analysis results using different program
- Numerical Model
 - Identify sources of modeling errors (simplifications)
 - Identify sources of numerical errors
- Engineer, modeler, numerical analyst
 - Numerical modeling expertise
 - Numerical results interpretation expertise
- Interpretation of numerical analysis results
 - Design
 - Regulation

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Road Map, Example

Pine Flat Dam in California

- Model verification, components, full model

 - Dynamic wave propagation through rock only

 - Eigen-analysis of dam structure, with/without reservoir

 - Dynamic response of dam structure, with/without reservoir

 - Dynamic response of reservoir/fluid

 - Constitutive integrations for material response

- Model validation, components, full model

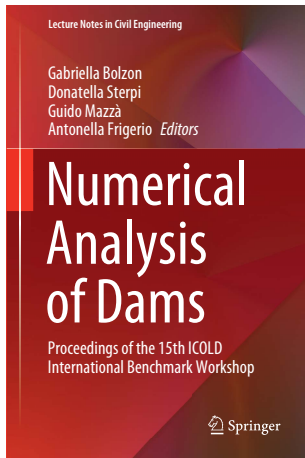
 - Seismic wave propagation through the rock

 - Constitutive modeling of rock, concrete, interfaces, joints

 - Reservoir, fluid dynamics

 - Seismic response of a concrete dam

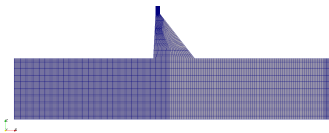
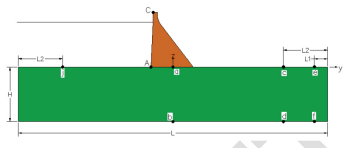
Road Map, Workshop



Yang et al. (2019)
Salamon et al. (2019)

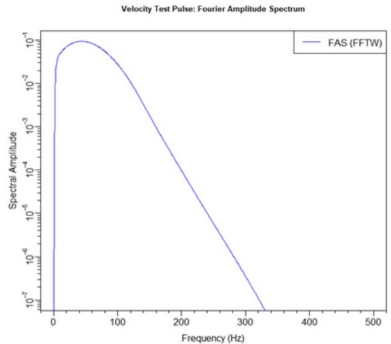
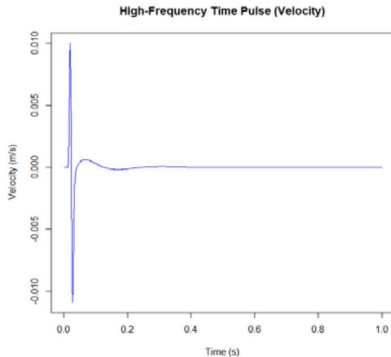
Concrete Dam – Rock – Reservoir Model

- Model components: concrete dam, rock, reservoir
- Verification and Validation of each component, model



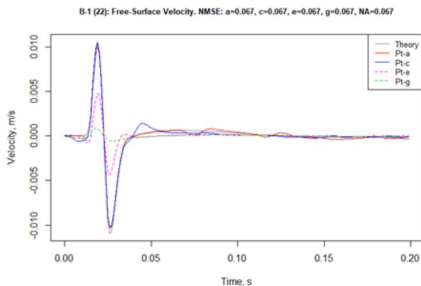
Example

Input Pulse Wave, at Depth, Only Rock

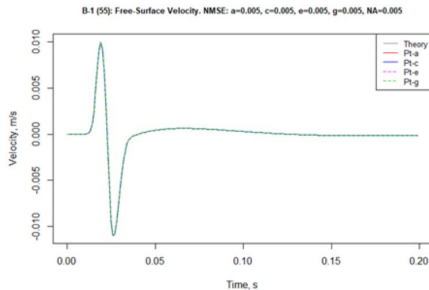


Example

Pulse Wave at Surface

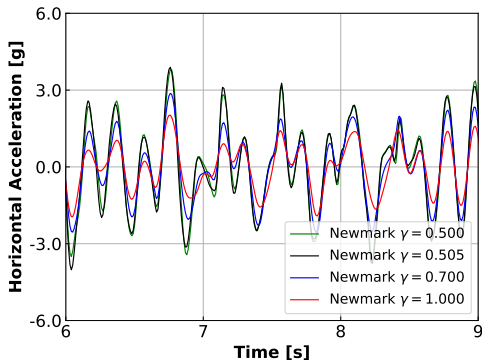


Non-reflective BC



Free field BC

Example

Numerical Damping Effects, \ddot{u}_{hor}^{top} 

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Road map: Formal process to ensure quality of results

Numerical modeling to predict and inform, rather than fit

Education and Training is the key!