September 18, 2020 Project No. 99902043

U.S. Nuclear Regulatory Commission
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SUBJECT: NuScale Power, LLC Submittal of Presentation Materials Entitled "ACRS Subcommittee Presentation: NuScale Topical Report – Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis," PM-0920-71643, Revision 0

The purpose of this submittal is to provide presentation materials to the NRC for use during the upcoming Advisory Committee on Reactor Safegurads (ACRS) NuScale Subcommittee Meeting on September 22, 2020. The materials support NuScale's presentation of the "Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis" topical report.

The enclosure to this letter is the nonproprietary presentation entitled "ACRS Subcommittee Presentation: NuScale Topical Report – Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis," PM-0920-71643, Revision 0.

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions, please contact Kyra Perkins at 704-713-5220 or at kperkins@nuscalepower.com.

Sincerely,

Zackary W. Rad
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Enclosure: "ACRS Subcommittee Presentation: NuScale Topical Report – Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis," PM-0920-71643, Revision 0

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"ACRS Subcommittee Presentation: NuScale Topical Report – Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis," PM-0920-71643, Revision 0

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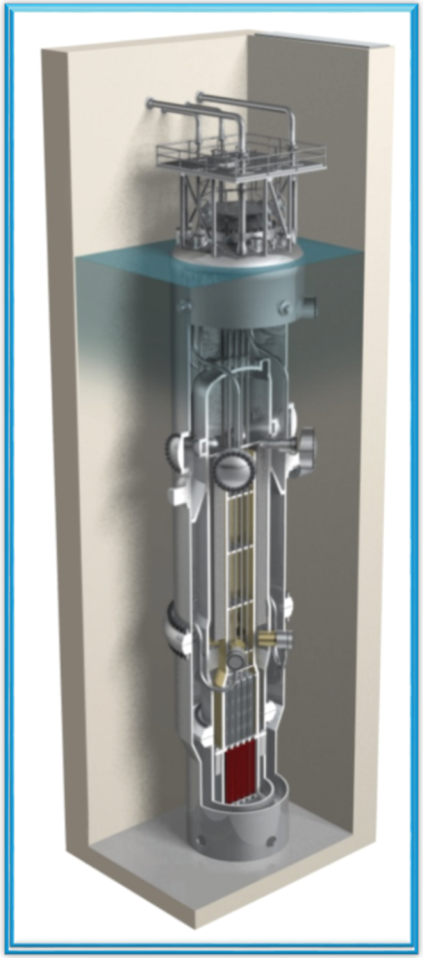
ACRS Subcommittee Presentation



NuScale Topical Report

Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis

September 22, 2020

PM-0920-71643
Revision: 0

Template #: 0000-21727-F01 R6

Presenters

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Agenda

- Purpose
- Features of Methodology
- Applications
- Background
- Soil Library Methodology
- Topical Report Demonstration Problems
- Topical Report Review
- Summary

Purpose

- The Frequency Domain Soil-Structure-Fluid Interaction Analysis topical report (Soil Library TR) describes a more efficient process, for use by an applicant or licensee, to perform seismic analyses of complex, interacting structures, soils, fluid systems, and major mechanical components.

Features of the Soil Library Methodology

- Eliminates assumptions at the interfaces between the civil structural and substructure analyses (single model vs. seven different models)
- Single larger model can be used for seismic and nonseismic loading
- Major improvement in runtimes to generate analysis results
- Simpler method
- Facilitates parametric studies for alternate module configurations (any number of module in any location)
- Uses latest finite element technologies and improvements
- Provides additional element formulations that are not in older codes such as SASSI

Applications

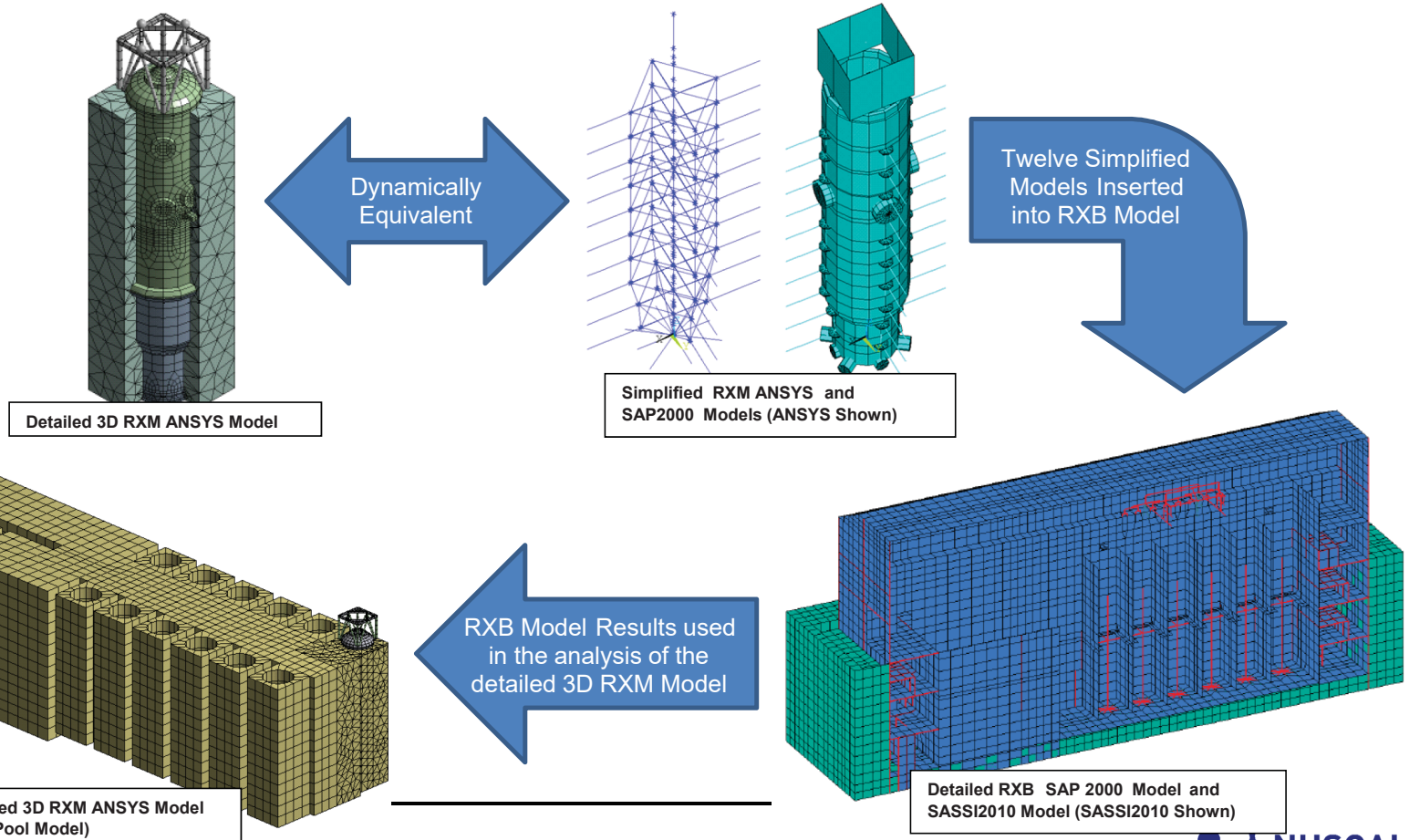
- Analysis of Detailed Design Certification Applications and Standard Design Approval Applications
- Site Specific Combined License (COL) Analyses
  - Site specific soil library generation for Combined Licenses
  - Evaluation of adequacy of NuScale design as specified in existing COL Items using proposed methodology

Background

- Current seismic analysis methodology
  - provides an accurate and conservative evaluation of seismic loads/demand
  - Conforms to NRC regulatory guidelines
  - Uses multi-step dynamic analysis for SSI analysis of building and subsequent detailed analysis of substructures

Background

- Time history method is used for evaluating non-linear behavior (e.g. module liftoff at skirt support)
- Several “cut-boundaries”



Soil Library Methodology

- Eliminates two-step analysis process
  - Analysis using single structural model of building, backfill, pool water, and individual power modules
  - Simplifies data exchange and interfacing analyses
- Analysis time shorter by order of magnitude
- Takes full advantage of structural analysis capabilities of ANSYS
  - Overcomes limitations of SASSI structural model size and mesh refinement

Soil Library Methodology

- Proposed methodology in Topical Report
  - Use of a SASSI calculated impedance library
  - No change to seismic inputs and soil properties.
  - Revision to the basic assumptions and methodology for SSI analysis
    - Uses SASSI direct method versus modified subtraction method
  - The replacement of the SASSI building model with an integrated ANSYS model, and using the ANSYS solver
  - Dynamic analysis for SSI is functionally the same as SASSI

Soil Library Methodology

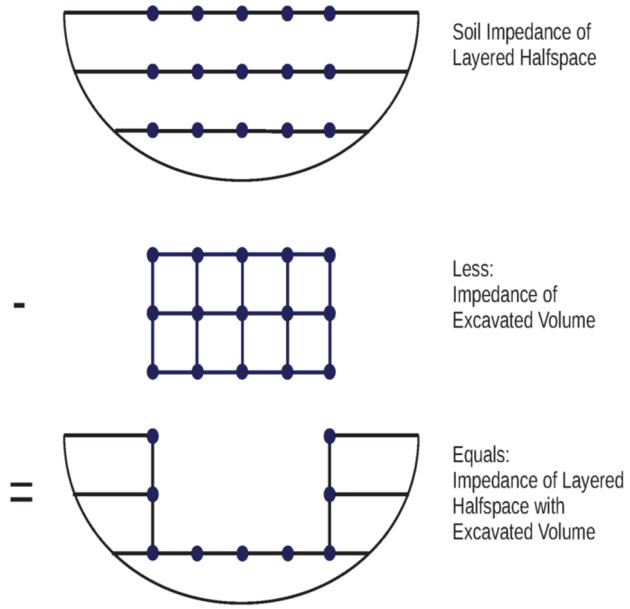
- Dynamic Analysis performed in the frequency domain
  - Soil impedance from SASSI + ANSYS structural model + ANSYS equation solver and post-processing
- Validated using example problems
  - Demonstrates equivalent results from traditional SASSI versus the library method
- Methodology assumes linear elastic or equivalent linear-elastic analysis
  - This applies to both soil and structural properties, constraints, and boundary conditions
- Uses one-step dynamic analysis for SSFI of buildings, RXMs, and pool water
  - Saving of overall analysis calendar time
  - Seismic analysis methods of secondary SSCs and fuel unchanged

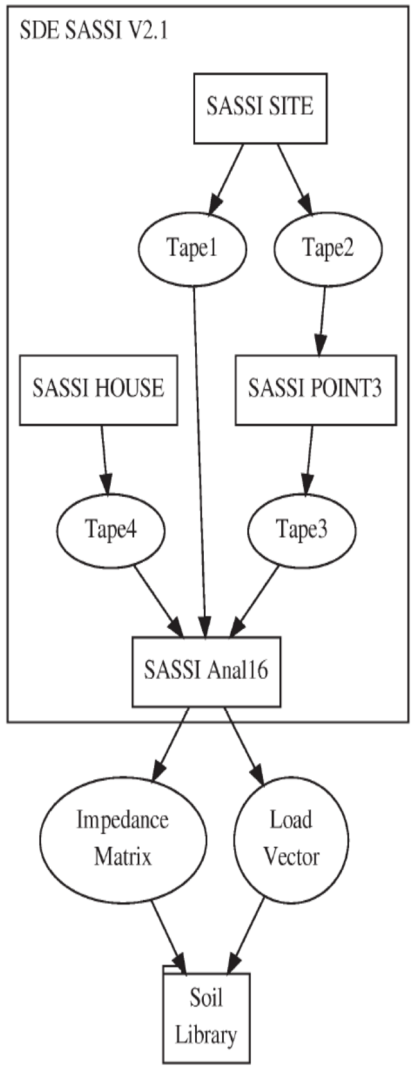
Soil Library Methodology

SASSI Direct method

Matrix reduction

Soil impedance/load vectors calculated by SASSI Anal16 and exported in Matrix Market format

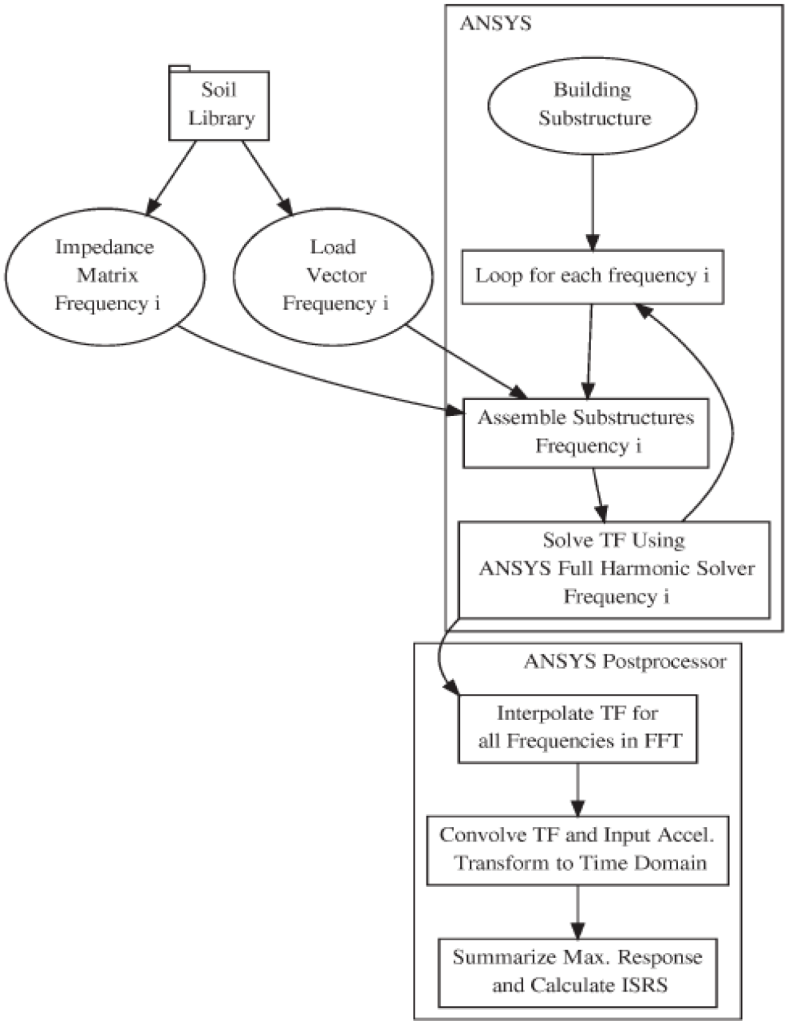




Soil Library Methodology

Combine soil and structural matrices and solve using ANSYS full harmonic solver

Interpolation of transfer function during post-processing by ANSYS uses same method as SASSI



ANSYS frequency domain solution

Topical Report Demonstration Problems

- Compared ANSYS and SASSI results
  - 1. PWR on surface of halfspace
  - 2. Embedded Building w/o fluid
  - 3. Embedded Building with fluid
  - 4. Representative Reactor Building with Soil-Structure-Fluid Interaction
- Conclusions
  - Excellent results comparisons
    - Transfer functions
    - Acceleration time histories and response spectra
    - Structural member design forces
    - Acoustic pressure time histories
  - ANSYS + Soil Library solution is functionally equivalent to a SASSI solution

Topical Report Review

- NRC Request for Additional Information (RAI) 9676 requested the inclusion of additional demonstration problems representative of more complex SMR structures
  - RAI 9676 response provided June 17, 2019
  - Topical Report Revision 1 submitted November 19, 2019 incorporated RAI 9676 responses (ML19168A249)
- Subsequent NRC audit requested supplemental discussion of software Verification and Validation process
  - Topical Report Revision 2 submitted September 2, 2020 augmented the V&V discussion

Summary

- Current methodology provides an accurate and conservative evaluation of seismic loads/demand
- Proposed methodology utilizes a one step analysis that is functionally equivalent and computationally more efficient
- NRC review and approval documented by safety evaluation

Acronyms

ANSYS – Analysis Simulation software

COL – Combined License

DCA – Design Certification Application

PWR – Pressurized Water Reactor

RXM – Reactor Module

SASSI – Analysis Software for Soil-Structure Interaction finite element analysis

SDA – Standard Design Application

SMR – Small Modular Reactor

SSFI – Soil Structure Fluid Interaction

SSI – Soil Structure Interaction

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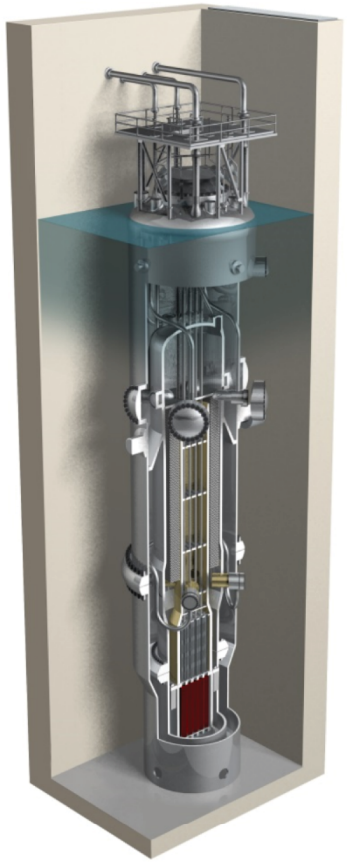

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