

Software Verification and Validation Guidelines for Nonlinear Soil-Structure Interaction Analysis to Enable Cost-Effective Advanced Reactor Design

PI: Ben Kosbab – SC Solutions, Inc.

Collaborators: Michael Cohen, TerraPower, LLC
Andrew Whittaker, Consultant

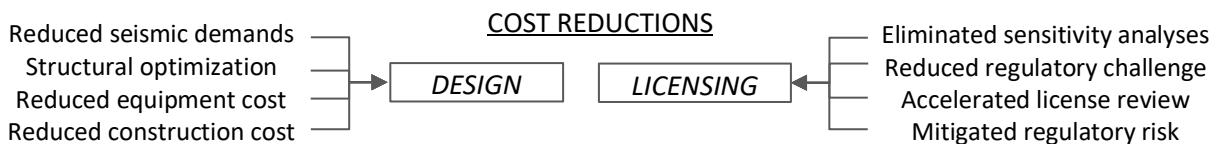
Pathway: Regulatory Assistance Grant

Abstract

The project objective is to develop software quality assurance (SQA) verification and validation (V&V) guidance for nonlinear time domain (NLTD) soil-structure interaction (SSI) analysis tools to facilitate cost reductions in nuclear plant licensing and construction. Advanced reactor (AR) design innovations such as fluid-submerged components, seismic protective systems (e.g. isolators and dampers), and deep embedment reduce the cost of nuclear energy. Performing the required licensing analysis of these design innovations using traditional equivalent linear frequency domain SSI software necessitates significant analysis compromises and excessive conservatism that increase the cost and schedule of licensing and construction. To realize structural optimization, the nuclear industry is investing in the codes, technical guidance, and analytical methodologies needed to adopt coupled NLTD SSI analysis for nuclear plant design. However, SQA requirements of the regulatory environment, together with regulatory precedence for traditional software tools, challenge cost-effective design and licensing using coupled NLTD SSI analysis. The proposed project will establish the regulatory path to implement the codes, guidance, and methodologies in a reactor design and licensing application.

The main product will be a V&V guidance document for coupled NLTD SSI software. The guidance document will be accompanied by a publicly accessible, web-based tool of software features mapped to developed test problems, allowing expansion for future AR needs and dissemination of lessons learned. The major project tasks include stakeholder interaction, software feature identification, test problem development, and industry education. AR designer surveys, interviews, and guidance from an AR designer advisory board will tailor the work to industry needs. Through a software developer advisory board, the project will leverage previous software testing programs to build from the database of existing test features and test problems. Additionally, regulator meetings will be conducted to incorporate regulator and stakeholder experience in the V&V guidance and to achieve regulator support.

The project impact is cost-effective licensing of AR design innovations, enabled by regulator-supported seismic analysis tools for realistic analysis of nonlinear systems. The benefits to AR designers are reduced design and regulatory costs:



The project team is comprised of nonlinear analysis experts across the nuclear sector: SC Solutions (analysis consultant), TerraPower (AR designer), and Dr. Andrew Whittaker (researcher and nuclear standards chair). SC Solutions is a nuclear leader in NLTD SSI analysis, with expertise in software V&V development and implementation. Additionally, the Nuclear Energy regulatory assistance grant provides a unique opportunity to leverage cooperative agreements with DOE and the NRC to facilitate proactive, up-front regulator engagement, which is key to reducing AR regulatory cost and schedule.

