Software Verification and Validation Guidelines for Integrated Nonlinear Soil-Structure Interaction Analysis

Payman TEHRANI[1], Natalie DOULGERAKIS[1], Iman TALEBINEJAD[1], Benjamin KOSBAB[2], Andrew WHITTAKER[3], Michael COHEN[4]

[1] SC Solutions, Inc.; [2] Simpson Gumpertz & Heger, Inc.; [3] State University of New York at Buffalo; [4] TerraPower

This presentation introduces the preliminary products of a Department of Energy-funded initiative to develop software quality assurance (SQA) guidance for integrated nonlinear soil-structure interaction (SSI) analysis tools.

The seismic load case has a significant impact on the design and cost of nuclear power plants. Given the need to substantially reduce cost, advanced reactor designers are looking to leverage numerical tools that enable seismic analysis of an integrated vessel/support/structure/soil system. Modern nonlinear analysis tools provide a solution, capturing dynamic coupling between components (including SSI) concurrent with nonlinear behavior in one or more parts of the system. Although these methods have a rich history of technical development and implementation, SQA following nuclear industry standards remains a significant burden for those wishing to adopt such methods for advanced reactor design and licensing. The project works to establish the regulatory path to implement the developed software codes, technical guidance, and analytical methodologies in a reactor design and licensing application.

The project develops guidance for commercial grade dedication (CGD) of integrated nonlinear SSI software tools, including a test matrix of software features and test problems. The test matrix and test problems are defined with a focus on physical response and generic software features such that the products could be implemented in the dedication process for any selected software platform. The guidance is technology-neutral: supporting designers of all advanced reactors and other nuclear facilities. The significant work by researchers, software developers, and practitioners is leveraged in the creation of test problems and reference solutions. The test problems are identified and developed to exercise the nonlinear software features important for the seismic analysis of next-generation reactor designs. Important nonlinear behaviors and software features have been identified through polling and interviews with reactor designers and the broader industry involved in reactor design and licensing. The presentation details the process for translating physical nonlinear response to software features, test parameters, and solutions. The presentation also summarizes integration of this guidance into an end-user CGD program as well as example test cases and analysis results.