December 13, 2002

MEMORANDUM TO: Richard J. Barrett, Director
Division of Engineering
Office of Nuclear Reactor Regulation

FROM: Michael E. Mayfield, Director **/RA by Daniel H. Dorman Acting For/**
Division of Engineering Technology
Office of Nuclear Regulatory Research

SUBJECT: TRANSMITTAL OF NUREG/CR-6783, "STRUCTURAL SEISMIC FRAGILITY ANALYSIS OF THE SURRY CONTAINMENT"

This memorandum transmits the subject report, NUREG/CR-6783, "Structural Seismic Fragility of the Surry Containment," which is also listed as Sandia National Laboratories' (SNL) report, SAND2002-1996P, for your use. The research results described in the report are the final phase of a program entitled, "Collaboration on Seismic Proving Tests of Concrete Containment Vessels." This program has been self-initiated by RES and involved testing large scale models of both prestressed and reinforced concrete containment vessels.

NUREG/CR-6783 is SNL's final report on a trial application of analysis techniques that had been validated through a seismic proving test of a 1/8 scale model of a reinforced concrete containment conducted on the high performance shake table at the Tadotsu Engineering Center of the Nuclear Power Engineering Corporation (NUPEC). This test program was described in NUREG/CR-6707, " Seismic Analysis of a Reinforced Concrete Containment Vessel Model." (NUPEC functions in a mode very similar to a U.S. national laboratory for the Japanese Ministry of Economy, Trade, and Industry (METI).)

While the testing and analysis validation was undertaken as a collaborative effort between NRC and METI, the trial application reported in the attached NUREG/CR was an independent NRC effort. The NRC's objectives were to evaluate the maturity of the finite element analysis techniques for predicting the time dependent behavior of concrete containments subjected to design-level and failure-level seismic excitation and to identify potential improvements to the techniques, as warranted.

In general, the validation phase of the program showed that the analysis could produce results that have reasonably good agreement between the calculated time histories and the measured data with some variability as expected. In the trial application phase, described herein, SNL was tasked with taking the information obtained from the reinforced containment model tests and analysis and performing a probabilistic structural analysis of a representative nuclear power plant reinforced concrete containment structure. A model of the Surry Nuclear Power Plant containment structure was assembled that matched key features and structural parameters of the containment structure.

For this study, dynamic analyses were performed by subjecting the coarse finite element model to 30 different earthquake time-history accelerations. It was determined that 30 different actual recorded time histories from as many different earthquakes were necessary in order to capture the random behavior and variability of earthquakes. In addition, Latin Hypercube Sampling (LHS), which provides a good distribution for a limited number of analyses, was used to vary all the material and modeling parameters of the input. For this study, two separate loading cases were analyzed. Both assumed the containment was rigidly attached to rock and no soil-structure interaction or basemat uplift was permitted. The first case was at increasing earthquake levels without any internal pressure. The second case was at increasing earthquake levels while the containment vessel was loaded internally to the design pressure, or loss of coolant accident (LOCA).

The results herein show, in general, how robust the reinforced concrete containment structure is, even when it is attached to a rigid rock foundation and that the most significant variable in the response is the variability in the input earthquakes. Modeling on a rock site will produce higher stresses and strains in the containment, resulting in a conservative estimate of the structural capacity of a reinforced concrete containment. To determine the containment's functional capacity to withstand the design-basis ground motion, all failure modes and types, on a plant specific case, must be examined. Based on these results, failure will more likely be dominated by soil structure interaction and uplift, and concrete failure will most likely not be the dominant failure mode for reinforced concrete containments. In other words, other things such as penetrations and interconnections with other structures will probably fail before the reinforced concrete structure fails.

Regulatory Implications

The attached NUREG/CR documents the application of the analysis techniques validated against the tests conducted by NUPEC on a reinforced concrete containment vessel model. The validated analysis techniques and their documented application contribute to the agency's Performance Goal of improving the efficiency, effectiveness, and realism of the NRC's activities and decisions. The validated analysis techniques are available to the NRC staff and industry analysts to examine the seismic fragility and capacity of reinforced concrete containments to withstand design basis seismic challenges. The users will be able to vary the energy and frequency content of the ground motion as well as the physical parameters of the containment to obtain a probabilistic assessment of the containment. With a well documented assessment of a containment in "as-built" condition, the analysts can incorporate subroutines to further assess the effects of aging on the capacity of aged containments to withstand design basis ground motions. These validated techniques are not intended to replace current licensing analyses, but to supplement them by being available to address post-licensing issues.

If you have any questions, please call me (415-5678) or Andrew Murphy (415-6011) of my staff. Dr. Murphy has been the Program Manager for this effort for the last two years.
Attachments: As Stated

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