Technical Advisory Committee of the Nuclear Risk Research Center
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SUBJECT: INTERIM REPORT ON PROBABILISTIC SEISMIC HAZARD ANALYSIS ENHANCEMENTS IN JAPAN AND FAULT DISPLACEMENT EVALUATION

Dear Dr. Apostolakis:

During the sixth meeting of the Technical Advisory Committee of the Nuclear Risk Research Center (NRRC), November 7-11, 2016, we met with representatives of the NRRC staff to review the current status of the Ikata Senior Seismic Hazard Analysis Committee (SSHAC) Level 3 project, its technical findings, and key challenges for the enhancement of probabilistic seismic hazard analysis (PSHA) in Japan. We also discussed fault displacement evaluation, associated issues, and the NRRC research plan to develop methodologies for design and probabilistic risk assessment (PRA) applications. Our conclusions and recommendations are based only on the material provided in the referenced presentations and limited interactions with the staff during our meeting.

CONCLUSIONS AND RECOMMENDATIONS

1. The successful implementation of the SSHAC project for the Ikata site is a pioneering and very important initiative for seismic risk assessments, application of risk-informed approaches, and the risk-informed decision making process in Japan. Based on the progress made so far, important insights have been developed regarding technical and procedural challenges that need to be addressed for application of the SSHAC process at other sites in Japan.

2. It is important that adaptations of the SSHAC process at other sites throughout Japan preserve the fundamental technical elements of the SSHAC process.

3. Before further adaptation of the SSHAC process, the NRRC should consider a SSHAC project for one more site which has a seismo-tectonic environment with some features that are different from the Ikata site. This will provide more robust

insights for developing guidance and pertinent research to facilitate implementation of the SSHAC process in Japan.

4. As suggested by the Participatory Peer Review Panel, training of the Technical Integration team members for the Ikata project is critical for successful implementation of the SSHAC process. We also recommend that it be carried out.

BACKGROUND

In our letter of January 24, 2015 (Ref. 1), we recommended that:

> "Consistent with the recent international practice, SEPCO should implement probabilistic seismic hazard analysis (PSHA) using the Senior Seismic Hazard Analysis Committee (SSHAC) procedures (Refs. 2 and 3). In particular, the SSHAC Level 3 or higher procedure should be used for the Ikata Unit 3 site."

Since then, Shikoku Electric Power Company (SEPCO) and the NRRC have started the process of implementing the Ikata SSHAC Level 3 project.

At this meeting, we were briefed on the current status of the Ikata SSHAC Level 3 project, and the NRRC staff discussed the overall schedule for the project. The first SSHAC workshop was held in September 2016, and preliminary findings from that workshop were discussed. In addition to the findings coming from the Ikata SSHAC project, technical and procedural challenges that need to be considered for implementation of the SSHAC process throughout Japan were discussed. Some of these challenges arise from the more complex seismo-tectonic environment in Japan and its higher ground motion levels, compared to the U.S. and other countries where most experience has been gained in implementation of the SSHAC process.

We were also briefed on the research for fault displacement evaluation. Because of the potential influence of faults at some Japanese sites, consideration of displacements induced by fault movements and their impacts on plant performance is quite unique to the Japanese situation. Very little state-of-practice experience exists to address this issue, either deterministically or probabilistically. The presentation was centered around the NRRC research plan to address the issue. The plan contains the following three elements:

1. Hazard assessment: quantitative assessment of fault displacement, both deterministic and probabilistic;

2. Fragility assessment: setting design criteria and fragility evaluation of structures and equipment against fault displacement; and

3. Accident sequence evaluation related to fault displacement.

DISCUSSION

The undertaking of the Ikata SSHAC project by Shikoku Electric Power Company and the NRRC is a very significant step in development and application of PSHA technology in Japan, consistent with international practice. Both Shikoku and NRRC are to be commended for undertaking this complex, challenging, and very important project. As stated in our January 24, 2015 letter, any probabilistic seismic hazard analysis has large inherent uncertainties, as well as uncertainties related to limited data, differing interpretations, and alternate models. The explicit consideration of uncertainties and differing interpretations is critical in a PSHA to avoid controversies and enhance credibility. The fundamental goal of a SSHAC process as stated in Reference 3 is:

> "…to properly carry out and completely document the activities of evaluation and integration, defined as:
>
> *Evaluation*: The consideration of the complete set of data, models, and methods proposed by the larger technical community that are relevant to the hazard analysis.
>
> *Integration*: Representing the center, body, and range of technically defensible interpretations in light of the evaluation process (i.e., informed by the assessment of existing data, models, and methods)."

The technical issues that arise from the complex seismo-tectonic environment in Japan and the need for development of methods and models to address these issues pose significant challenges to carry out Japan-wide implementation of SSHAC projects. Some specific challenges are discussed later. While these challenges may require some adaptation of the SSHAC process, it is important that the fundamental goal of the process as stated above is maintained and its integrity preserved, particularly in light of the importance of seismic events to overall risk and its public perception. This is important for the credibility, transparency, and acceptance of the hazard results and their use in risk assessments, risk-informed decision-making, and potential acceptance of risk-informed, performance-based seismic design criteria for Japan.

To gain more robust insights and to provide more effective adaptation of the SSHAC process for Japan, at least one more SSHAC Level 3 project, similar to the Ikata project, should be implemented at a site which has seismo-tectonic features that are different in some aspects from the Ikata site. For example, a soft site that requires consideration of local subsurface features and site response evaluations may provide additional insights into technical issues, uncertainties, and development of data, methods, and models. This will allow more effective development of the guidance and may identify additional necessary research. As discussed by the NRRC staff, the experience gained from the Ikata SSHAC project has already provided significant insights about some of the technical issues that are common elements of any PSHA. The experience has also identified challenges in implementation of the SSHAC process itself. Some considerations are offered below to enhance the development of guidance and activities that may help in dealing with the challenges.

One technical issue is related to the importance of site-specific sources and associated ground motion characterization, along with the need for considering fault ruptures. Appropriate treatment of these sources will require development of site-specific models. The Ikata experience (and experience from the additional project) will provide insights into methods and data collection that are needed to characterize dominant local sources and ground motion with their associated uncertainties. These supporting activities can proceed prior to their use in the formal SSHAC process.

Another technical issue is that PSHA includes characterization of regional sources and areal sources along with the ground motion characterization. It may be worthwhile to consider the feasibility of early development of the necessary regional models, which can then be used by several sites. This may alleviate some concerns with the timeliness and needed resources for each site-specific SSHAC project.

The classification of information and knowledge from the Ikata SSHAC workshops into site-specific and generic categories is providing initial considerations needed to address the above two issues.

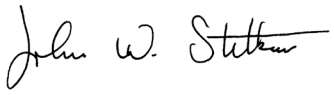
As observed by the Participatory Peer Review Panel for the Ikata project, an important issue for implementation of the SSHAC process is that training of the Technical Integration (TI) team members is crucial to success of the SSHAC process and will provide necessary insights on conduct of the TI team to fulfill its role. Such training may be considered for other potential TI teams that may be used to carry out the SSHAC process at other sites. This will enhance the broad understanding of key concepts and elements of the SSHAC process and will, to some extent, alleviate concerns related to the availability of expert resources. For example, methods to account for uncertainty and the consideration and recognition of cognitive biases are typically not part of the technical education of many experts involved in the SSHAC process. Early development and training of the TI teams may help in implementing the SSHAC process at several sites in parallel.

The NRRC interactions with other SSHAC projects, such as Diablo Canyon and other high-seismicity sites, are valuable both in terms of experience gained in those projects and feedback to guidance and approaches being developed by the NRRC. As noted in the presentation, the treatment of fault rupture models in the Diablo Canyon project and differences in current Japanese practice provide insights into potential research and model development. We agree that Japan-specific research is needed. In a similar vein, the SSHAC guidance that is currently used in the U.S. (Ref. 3) is being revised to account for the experience gained from recent hazard studies. The updated guidance may provide useful insights on some of the issues faced in Japan, particularly those related to procedural aspects of the SSHAC process.

The research project related to fault displacement is crucial for both regulatory compliance and the understanding of risk. We agree with the three basic elements of the NRRC research plan: hazard, fragility, and plant response. It is important that this research should emphasize realistic evaluations that include consideration of pertinent uncertainties and provide inputs that can be used for the risk-informed

framework. The deterministic evaluations should also have a clear understanding of how the methodology accounts for uncertainties and what margins and conservatisms are embedded to address those uncertainties. The experience gained from the SSHAC process is useful to achieve these goals.

Sincerely,



John W. Stetkar
Chairman

REFERENCES

1. "Seismic Hazard and Fragility Evaluations at Ikata Unit 3," Technical Advisory Committee Letter to Head, Nuclear Risk Research Center, January 24, 2015.

2. NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," Volumes 1 and 2, U.S. Nuclear Regulatory Commission, April 1997.

3. NUREG-2117, Revision 1, "Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies," U.S. Nuclear Regulatory Commission, April 2012.

4. "PSHA Enhancements in Japan Based on Ikata SSHAC Level 3 Project," NRRC Staff Presentation to Technical Advisory Committee, November 7, 2016, Proprietary.

5. "Fault Displacement Evaluation," NRRC Staff Presentation to Technical Advisory Committee, November 7, 2016, Proprietary.