FOREIGN TRIP REPORT

Subject

Foreign Trip Report on Attending a Workshop Entitled, "Seismic Input Motions, Incorporating Recent Geological Studies" at the National Research Institute for Earth Science and Disaster Prevention in Tsukuba, Japan

Dates of Meeting/Organizations Visited

November 15 to 17, 2004: National Research Institute for Earth Science and Disaster Prevention (NIED), Tsukuba, Japan.

November 19, 2004: E-Defense Facility, Miki City, Japan
Hokudan-Cho Earthquake Memorial Park, Hokudan-cho, Japan

Authors, Titles, and Agency Affiliations

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Sensitivity

No sensitive information was discussed during this meeting and no policy decisions affecting the U.S. Nuclear Regulatory Commission (NRC) were made.

Background/Purpose

This workshop is the third of a series of workshops, organized by the Committee on the Safety of Nuclear Installations (CSNI), of the Nuclear Energy Institute (NEI), that examine seismology and seismic engineering related to nuclear installations. The first workshop was held in 1999 at Brookhaven National Laboratories and was sponsored by the NRC. It addressed the engineering characterization of seismic input, with an emphasis on the potential benefit of collaboration between earth scientists and seismic engineers. It was followed, in 2002, by a workshop held in Istanbul, Turkey, where relations between seismological data and seismic engineering analyses were examined. This workshop is a continuation of these two workshops. It concentrated on: (1) the potential benefits of using the latest developments in the definition of seismic input through deep borehole techniques; (2) how geological information is best incorporated into seismic hazards and seismic engineering; and (3) regulatory implications. Participants at the meeting included representatives from Armenia, Austria, Brazil, Canada, Finland, France, Italy, Japan, Korea, New Zealand, Spain, Turkey, the United Kingdom, and the United States.

Abstract: Summary of Pertinent Points/Issues

The first day of the workshop (November 15) focused on regulatory and seismological considerations. The second day (November 16) was mainly comprised of a series of presentations concerning applications of deep borehole studies to asperity estimation and searching for hidden faults. The final day (November 17) of the workshop focused on engineering as well as seismic safety considerations. This workshop was followed by a field trip on November 19. The field trip involved a tour of the E-Defense facility, the world's largest 3-D full-scale shake table in Miki city, near Kobe. This was followed by a visit to the Hokudan-Cho Earthquake Memorial Park, also near Kobe. The Hokudan-Cho Earthquake Memorial Park preserves the Nojima fault rupture from the 1995 magnitude 6.9 Hanshin-Awaji Earthquake.

Attachment

Discussion

The workshop spanned 3 days. Each day was devoted to a particular aspect of seismology and seismic engineering issues related to nuclear installations. In addition, the workshop was followed by a 1 day field trip. A summary of the main activities performed on each day is provided below.

Day 1: Regulatory and Seismological Considerations

The first day of the workshop was mainly comprised of a group of presentations that focused on the relationship between regulatory requirements and guidelines and seismotectonic data. A presentations by Dr Gürpinar from the International Atomic Energy Agency (IAEA) addressed probabilistic seismic hazard analysis using physical constraints. A probabilistic seismic hazard evaluation has been an IAEA requirement since 2000. However, the limitations of this approach are evident when annual frequencies of exceedance go down to levels such as 10^{-6}. Thus, to obtain more adequate seismic data to calculate such low probabilities, IAEA recommends that paleoseismological studies (to enhance the database) be performed. In France, a region characterized by moderate seismicity, the seismic hazard assessment for nuclear facilities is guided by a specific regulation based on a deterministic approach. However, this regulation has been recently revised to incorporate recent seismotectonic knowledge. Several French presenters (e.g., Drs. Berge-Thierry, Cushing, and Baumont) discussed how recent information from geological and geophysical studies and broadband strong ground motion simulations have helped to make this deterministic approach more realistic. For example, using seismic reflection lines reinterpretations, geomorphological analysis, paleoseismicity trenching, subsurface geophysical investigations, cosmogenic nuclide dating, and geodetic and seismological surveys, they were able to better constrain the behavior of the Durance fault, one of the most active faults in France. Borehole research studies, the focus of many presentations in this workshop (in day 2), also play an important role in the estimation of ground motion and related hazard from future damaging earthquakes. Strong motion data are a combination of the effects of the local site conditions, path conditions from source to site, and the properties of the earthquake source. Borehole data are a critical component in separating the observed surface ground motions into these components. By removing the effects of the soil column, we can improve our understanding of the seismic source. This is important when calibrating methods for simulation of dynamic soil behavior at large shaking levels. Dr. Okada, NIED, indicated in his presentation, that the occurrence of the Kobe earthquake of 1995 affected the trend of earthquake, related projects in NIED. One of the projects that was developed as a result of this earthquake is the 3-D full scale earthquake testing facility (E-Defense).

Day 2: Application of Deep Borehole Measuring and Research Study

This day comprised a special session entitled, “Application of Deep Borehole Research and Measuring Study.” The keynote speech by Dr. Paul Somerville discussed differences in earthquake source and strong ground motion characteristics between shallow and buried faulting. It was suggested that strong ground motions of earthquakes which have shallow asperities (areas on the fault where slip is high) are weaker than the ground motions of earthquakes whose asperities are all deep. This was followed by presentations that discussed applications of asperity estimation and detailed fault zone property measurements (in-situ stress measurements) from deep borehole studies in Japan (e.g., the Nojima fault drilling after the 1995 Kobe earthquake). These studies are important to determine the cause and formation of asperities. Dr. Iwasa, from the Association for the Development of Earthquake Prediction,

indicated that several studies have shown that there is a slow stage of precursory slip before a dynamic rupture. If the contrast could be somehow detected, it would be useful for earthquake prediction. In addition, precise estimation of effective stress on asperities is essential for accurate strong motion prediction. Also, it was stated that a potential asperity for a future earthquake could be extracted by analyzing the background seismicity. To verify this hypothesis, the author applied the analysis to the Tokachi-Oki earthquake (M=8.0) in 2003 and found that the analysis of the seismicity rate change showed good spatial matching between the activated portion and the largely slipping area. In another presentation, Dr. Kuwahara, of the Geological Survey of Japan, indicated that hidden faults can be detected by using trapped waves. His studies showed that observations of the fault zone structures and of the principal stress directions have potential to evaluate present stress status and future irregular rupture processes of active faults.

Day 3: Engineering and Seismic Safety Considerations

The first half of the day consisted of a variety of presentations that focused on engineering considerations. Important engineering considerations included the input load (or input seismic time histories) for seismic non-linear analysis of structures and the behavior of Structures, Systems, and Component's (e.g., pressurized piping systems) of nuclear power plants under excessive seismic loads. This was followed by a series of presentations devoted to seismic safety considerations. Dr. Celebi of the United States Geological Survey discussed a case study: "Real time Seismic Monitoring needs and Relation to Damage of Structures." He reported on a recently implemented building seismic monitoring system that relate to such needs. Using Global Positioning System they were able to measure the drift of a building within less than 1 centimeter (0.4 inches) accuracy. He indicated that the unique performance benefits of this monitoring system include: 1) rapid assessment of the state of health of the building after an earthquake; 2) rapid correlation of recorded data with known specific engineering parameters; and 3) data recovery in real time. A presentation by Dr. Simos of Brookhaven National Laboratory addressed the issue of ground motion characterization for spatially variable soil and its influence on soil structure interaction. He discussed how to incorporate the uncertainties in the real spatial fluctuations in both the soil properties and layering profile when developing ground motion response. A presentation made by the Secretariat of Nuclear Safety Commission (Dr. Konno) discussed the defense-in-depth principle, which states that a safety strategy for reactor facilities in Japan should acknowledge redundancy or diversity within the operational system. This principle is difficult to apply to seismic safety in Japan at present because of the current deterministic design practice. It was noted that the current Examination Guide for Seismic Design should evolve into one that is risk-informed and performance-based. Specifically, the seismic safety design practice should use a probabilistic approach. He continued to say that seismic safety should consider the probability of ground motions in excess of design basis earthquakes, with appropriate accounting for the inherent uncertainties in the characteristics of the earthquake events. Dr. Ebisawa from the Japan Nuclear Energy Safety Organization (JNES) gave a presentation on the development of the probabilistic seismic hazard analysis (PSHA) method at JNES. In particular, its procedure for evaluating uncertainties in seismic hazard methodology is similar to that employed for the Yucca Mountain PSHA as it considers both aleatory and epistemic uncertainty. Also, the JNES elicitation process was similar to that developed and used by NRC staff. Researcher at JNES discussed their progress and the development of a new methodology for the evaluation of seismic ground motions caused by unidentified active faults. Earthquake observation data of a downhole array of 1300 meters (m) (4265 feet (ft)) depth were used to verify the new methodology.

Ms. Gonzalez also had the opportunity to visit the Research Center for Deep Geologic Environments at the National Institute of Advanced Industrial Science and Technology and meet with Dr. Sasada, the Center Director, and other Center staff. The objective of the Research Center for Deep Geologic Environments is to carry out investigations focusing on deep geologic environments of the Japanese Islands. These investigations will be used for the safety assessments for the geologic disposal of high-level radioactive waste from nuclear power plants. Ms. Gonzalez gave a short presentation that described some of the CNWRA's technical capabilities related to seismic hazard and risk assessment. Thus, future interactions between the NRC and CNWRA will be beneficial to the activities of both organizations.

Day 4: Field Trip to E-Defense and Hokudan-cho Earthquake Memorial Park
The first half of the field trip day involved a tour of the "E-Defense" facility, the world's largest 3-D full-scale shake table in Miki city, near Kobe, Japan. This facility is still under construction, but is expected to be completed by April 2005. The facility will be used to reproduce dynamic behavior of full-scale structure models subjected to large motions. During the 1995 Kobe earthquake, many reinforced concrete buildings, steel structures, bridges, and wooden houses were collapsed, and extensive liquefaction caused failure of many soil-pile foundations structure systems. Learning from those lessons, NIED, realized the importance of study on full-scale failure mechanisms of structures, and decided to construct the "E-Defense" to examine and ensure the safety of existing and future cities.

This was followed by a visit to the Hokudan-Cho Earthquake Memorial Park, also near Kobe. The Hokudan-Cho Earthquake Memorial Park preserves the Nojima fault rupture from the 1995 Hanshin-Awaji Earthquake. The park houses an approximately 400 m (1312 ft) long section of the fault. A house located adjacent to the fault, and damaged in the earthquake, is also preserved.

The workshop was extremely beneficial to NRC and the CNWRA. It provided an opportunity to interact with world-renowned seismic experts, researchers, and design engineers working in the area of nuclear installations. Such interactions enhance NRC and Center staffs' proficiency and knowledge base regarding state-of-the-art seismic and engineering activities.

Pending Actions/Planned Next Steps for NRC
We highly recommend continued NRC and CNWRA participation in future CSNI/NEI workshops, as well as similar international meetings. Such meetings ensure exposure to current scientific programs that will help the staff implement risk-informed licensing reviews and minimize litigation risk.

Points for Commission Consideration/Items of Interest
No Commission action is requested, the information is considered of some limited interest to the Commission.

Many agencies responsible for nuclear safety around the world (e.g., JNES) are adopting performance-based and risk-informed regulations. In areas related to seismic safety, performance-based and risk-informed regulations often incorporate probabilistic information about earthquakes. Although many countries characterized by low to moderate seismicity are guided by deterministically based regulations, these regulations may still require uncertainty to be addressed in the seismic hazard calculation. The emphasis of this workshop was how

detailed geologic and seismologic data (notably data obtained from deep borehole research studies), are crucial for better assessing the seismic hazard (and related uncertainty) of nuclear facilities. Thus, NRC and CNWRA staff should continue to participate in meetings with other nuclear safety agencies around the world. Scientific and technological advances, in areas related to realistic ground motion prediction, could influence the future course of seismic-related regulations and regulatory guidance.

Attachment
Meeting Agenda

References
None.