MINUTES FROM SEISMIC LESSONS-LEARNED PANEL
SEPTEMBER 23-24, 2008

Background

The Chief of Nuclear Safety (CNS) hosted the third meeting of the seismic lessons-learned panel at the DOE Forrestal Building in September 2008. These workshops are intended for experts involved in seismic hazard assessments and resulting facility designs across the DOE complex to share experience from their work. The workshops occur approximately twice per year.

Participants

John Ake, U.S. Nuclear Regulatory Commission *
Tim Arcano, DOE-CNS
Said Bolourchi, SGH
Carl Costantino, CJC & Associates
Brent Gutierrez, DOE-Savannah River
Robert Jackson, Schnabel Engineering, LLC
Jeff Kimball, Defense Nuclear Facilities Safety Board (DNFSB)
Chip Lagdon, DOE-CNS
Fred Loceff, FLTS
Steve McDuffie, DOE-CNS
Larry Salamone, SRNS
Caroline Serafinas, DOE-CNS
J. Carl Stepp, EHS
Ali Tabatabai, Link Technologies *

* attended the workshop on September 24 only

Summary

Mr. Lagdon, host of the workshop, opened the workshop with introductory remarks thanking participants for their attendance and stating the importance of this work. Many projects across the DOE complex currently have seismic characterization and design issues. With the addition of Steve McDuffie to the CNS staff effective September 29, CNS can devote greater effort toward implementing recommendations from these workshops. Tim Arcano has been working to help the Office of Environmental Management (EM) establish Technical Authority, with Headquarters technical representation on all major projects.

Development of Criteria for Ground Motion Generation at DOE Sites – Carl Costantino

Dr. Costantino discussed ground motion issues for soil structure interaction (SSI) analyses. His method begins with a uniform hazard spectrum as the target and then develops a synthetic time history with 5percent damping to closely match the target. Fitting rules from NUREG/CR-6728, *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard and Risk-Consistent Motions Spectra Guidelines*, are used with a seed ground motion, but the lack of

guidance for selecting seed earthquakes is an issue. An analysis of in-structure spectra using 5percent damping indicates little sensitivity to seed selection, as long as they are properly scaled to a 5percent damped target spectrum. For targets with higher damping, much variability was observed, since different record sets were used to develop the relationships. The spectral ratios for various damping percentages are highly variable; the peaks in one spectrum do not align with peaks in another. Dr. Costantino is planning for the Los Alamos National Laboratory to publish the results of this work in the near future. He also mentioned that Bob Youngs is working on a software tool that will allow one to enter a response spectrum and then generate a time history to fit the spectrum.

After this presentation, Mr. Lagdon shared his thoughts on seismic standards and external regulation of DOE. He first expressed his desire to continue standards-based seismic characterization and design rather than relying on expert-based systems, acknowledging that seismic design for our current major construction projects has not been good or efficient. One outcome from this workshop should be a framework for revising DOE natural phenomena standards. DOE should consider using American Nuclear Society (ANS) and other industry standards when appropriate, but may need to provide contractors with more detailed guidance since industry standards do not explicitly address the different hazard categories of our facilities.

A draft Government Accountability Office report seems to favor external DOE regulation, despite several past studies that cast doubt on its efficacy. The draft *Report on Nuclear Safety* requires Congress to consider legislation for DNFSB or the U.S. Nuclear Regulatory Commission (NRC) to assume responsibility for independent regulatory oversight of the Department's nuclear facilities. Mr. Lagdon believes that some continue to favor external regulation because DOE lacks internal processes that would give credibility to its nuclear safety program and because DOE's regulatory process is not always transparent.

Dr. Salamone suggested that for transparency with respect to seismic issues, DOE could have a broad group of experts beyond DOE staff develop standards. The Central and Eastern U.S. (CEUS) Seismic Source Characterization project could serve as a model for gaining consensus from the experts. Mr. Lagdon also mentioned the importance of the Technical Authority, ensuring that DOE has the right technical expertise applied to its projects. For a time the discussion turned to the topic of diminishing technical expertise in the areas of seismic hazard assessment and design and U.S. nuclear technology.

Mr. Lagdon closed out this discussion by stating that the CNS must work to gain cooperation from the DOE Office of Science and the National Nuclear Security Administration in setting seismic characterization and design standards.

Update on Seismic Qualification of Equipment Standards – Systems and Components Analysis and Qualification – George Antaki

This presentation was delivered by Mr. Lagdon since Mr. Antaki was unable to attend. Mr. Antaki provided three recommendations:

1) provide contractors with a roadmap to navigate the multitude of DOE-specific requirements;

2) provide contractor guidance for seismic design, perhaps in a revision to DOE-STD-1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, beginning with a seismic equipment list; and
3) establish guidance similar to NRC Regulatory Guides that are reviewed and approved generically with DNFSB staff.

Jeff Kimball stated that he disagreed with the suggestion to adopt applicable NRC guidance; he believes existing DOE guidance is sufficient.

DNFSB Observations and Feedback – Jeff Kimball

Dr. Kimball provided his observations related to natural phenomena hazards (NPH) assessments and structural design requirements. He recommended that the seismic lessons-learned panel include participation by all DOE programs associated with nuclear facilities and that it transition to a panel that can address all NPH and structural design issues, not just seismic hazards. Dr. Kimball noted that more than a decade has passed since DOE has held a conference on NPH. Re-establishing such a conference and providing training may be beneficial. Dr. Kimball believes the panel needs to develop a written plan similar to an implementation plan that describes future actions,. He also sees value in providing contractors with more specific criteria for performing the 10-year NPH assessment reviews required by DOE O 420.1B, *Facility Safety*. Dr. Kimball would also like to see DOE issue criteria for screening modeled soil profiles to help guard against inclusion of inappropriate soil profiles in site response models. In regard to tornado winds, Dr. Kimball believes DOE should adopt the Enhanced Fujita scale as the NRC has. Finally, he suggests that DOE guidance on seismic monitoring be reviewed. Increasing strong motion instrumentation at some DOE facilities may be beneficial. Dr. Costantino interjected that DOE projects too often shorten the time available for site characterization, resulting in inadequate NPH characterization and design, project delays, and rework. Dr. Kimball closed with two key messages: 1) DOE's effort on NPH characterization and design must be broader, and 2) the effort moving forward must be spelled out explicitly in a plan. DOE's response to the past DNFSB recommendation on fire protection was cited as a success story.

Discussion of the Peer Review Activity for the Waste Treatment and Immobilization Facility at Hanford – Fred Loceff

Mr. Loceff provided a report on the recent peer review of Hanford's Waste Treatment and Immobilization Plant (WTP) ground motion spectra. The review comprised three phases: geotechnical and seismic characterization, structural analysis and design since 2003, and equipment since 2005. Mr. Loceff provided the background of the WTP seismic design problem, describing the genesis of the original ground motion (OGM), revised ground motion (RGM), and WTP-specific ground motion (WSGM). After the OGM was used as the basis for design, questions arose about the impact from basalt interbed velocities. This led the project to use the very conservative RGM, while the WSGM was developed from data gathered from the deep borehole project. The WSGM is recognized to contain conservatism above regulatory requirements; it is based on a standard mean curve at the ground surface. All WTP structures are designed to the RGM, but select equipment (approximately 5 percent) is being designed to the

less conservative WSGM to reduce project costs and delays. The week before the panel meeting, the DNFSB was briefed on this approach and concurred with it. The peer review team examined in detail the OGM and RGM SSI analyses and the changes to the SSI input for the WSGM. The peer review team had several comments that were adequately addressed. At the time of the workshop, the only remaining issue was to fill in some spectral dips on the in-structure response spectra, which Bechtel National staff had agreed to complete.

Updated Discussion of Savannah River's Salt Waste Processing Facility (SWPF) Project Issues, Including Finite Element, GTStrudl, Thermal, Tornado, Settlement Zones, and WTP Ground Motion Spectra – Fred Loceff and Brent Gutierrez

Mr. Loceff started the discussion on myriad design topics at the SWPF. He noted that SWPF designers elected to largely follow the finite element meshing (FEM) criteria developed for WTP, but other DOE projects have developed meshing criteria without formal justification. Mr. Loceff recommended that DOE develop guidance on FEM criteria that should be similar to the WTP criteria. The guidance should allow for use with a variety of structural software packages. A peer review of the SWPF structural analysis discovered the incorrect use of combining results in a nonlinear analysis and an incorrect use of analysis sequence that resulted in using the wrong model stiffness. Mr. Loceff discussed a lesson learned from the SWPF analysis in which a static nonlinear analysis indicated premature equilibrium convergence under certain conditions. Some analyses and design calculations had to be revised as a result of these discoveries, but in general, no design changes resulted. The SWPF Project has elected not to include thermal effects from diurnal variations, in accordance with guidance in Section 1.3 of the American Concrete Institute (ACI) document 349.1R-07, *Reinforced Concrete Design for Thermal Effects on Nuclear Power Plant Structures*. Mr. Loceff recommended that DOE adopt these criteria, as well as guidelines for addressing thermal loads in designing structures, especially for fire demands. With regard to SWPF and other DOE projects, Mr. Loceff noted that DOE-STD-1020 does not address the combined application of tornado missiles with associated wind loads and pressure differentials. He suggested that DOE provide guidance to perform such analyses in future projects.

Dr. Gutierrez continued the discussion on the SWPF Project with an overview of the Savannah River soft zones. These zones tend to occur about 150 feet below the ground surface, more commonly in the southeast portion of the site. The zones occur in an unpredictable pattern, and a given borehole has a 25 to 35 percent chance of encountering a soft zone. Several structures have been monitored, and only a couple inches of settlement have been detected, suggesting soft zones have not collapsed. At the SWPF site, the soft zones are well-characterized due to abundant borings. Recovering material from soft zones is very difficult; hence, defining their properties, which is necessary for settlement calculations, is likewise a challenge. With the uncertainties at the SWPF site, a decision was made to mitigate potential settlement through engineering. The base mat was increased from five to eight feet thick at a cost of about $15 million. A current objective is to develop a sitewide approach to evaluating soft zones. Researchers at Georgia Tech have proposed a four-year program to examine the geologic formation containing the soft zones, model its behavior, and determine the effects on foundation engineering. The SWPF borings changed the conceptual model of soft zones, as zones as thick as 16 feet were discovered. Nonetheless, the most extreme surface settlement due to collapse would be about 20 inches, with 8 inches a more likely figure. In the past, grout was injected in

an attempt to solidify soft zones. Grout injected near K Reactor was apparently ineffective, as later borings encountered thin lenses of grout, but the nearby soil remained unconsolidated. Liquefaction of surrounding soils may be necessary to cause a collapse of soft zone cavities; collapse has not been found to happen statically. The occurrence of several large earthquakes in the Charleston area does not appear to have impacted the soft zones. Dr. Kimball commented that he suspects the Georgia Tech analysis may find that the soft zones pose little threat to site structural stability. Dr. Stepp commented that such thin horizons are not likely to be impacted by seismic waves, given seismic wavelengths. A seismic wave will not normally impact a structure unless the structure length scale is greater than one-eighth of the seismic wavelength.

The Integrated Waste Treatment Unit (IWTU) Construction Supervision – Said Bolourchi

Dr. Bolourchi provided an overview of the IWTU with numerous photos documenting construction progress. At present, extensive rebar has been placed, and concrete is being placed in the structure. A key lesson learned from this process is that having a design engineer in the field to address questions as they arise is quite beneficial.

Paducah Seismic Evaluation Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Cell Disposal Design and Construction Project – Brent Gutierrez

Dr. Gutierrez provided the first presentation of the second day of the workshop. He explained that the DOE Paducah Field Office requested that an independent Headquarters team review the existing seismic characterization work and recommend additional data to be collected before a landfill is constructed should DOE opt to pursue the onsite waste disposal option. Dr. Gutierrez presented the basic geologic and seismologic setting and summarized some surface faulting studies conducted in the area. Dr. Kimball suggested that if faulting at the Barnes Creek Site, which is about 12 miles northeast of the Paducah Site, is determined to be of the Holocene period, it should raise concern and should be dominant in the probabilistic seismic hazard assessment (PSHA). He also suggested that since NRC certified the Paducah Gaseous Diffusion Plant in the 1990s, the NRC Safety Evaluation Report should contain a thorough seismic hazard assessment for the site. Dr. Gutierrez mentioned that a draft document from the DOE Project Office to the Commonwealth of Kentucky states that a landfill would meet Performance Category (PC)-3 design criteria, so DOE may be committed to designing a landfill to PC-3 standards. Up to now, the primary focus has been on peak ground acceleration at the site, and no performance standard has been established for the landfill structure or surrounding soils. Kentucky regulations are silent on design standards for such a landfill, other than a setback distance of 200 feet from any fault with Holocene displacement. Dr. Kimball stated that the setback requirement probably stems from Environmental Protection Agency (EPA) regulations for CERCLA waste disposal. Dr. Kimball also recommended that DOE add a fifth person to the independent review team with extensive experience in site characterization.

Update on the Current Status of Lessons Learned from the Earthquakes on July 16, 2007, at Niigataken Chuetsu-oki, and on May 12, 2008, in Sichuan, China – Carl Stepp

Dr. Stepp provided this update on the earthquakes at Niigata-ken Chuetsu-oki, Japan on July 16, 2007, and in Sichuan, China on May 12, 2008. The 2007 event affected the Kashiwazaki-

Kariwa nuclear site, which with its seven reactors, is the single largest commercial nuclear site in the world. The seismic hazard of this site was recognized, and the plants were built to a robust design. Recorded motion during the event was more than twice the design basis ground motion, yet no safety systems were damaged. Some nonsafety systems were significantly damaged. Although the plants were well designed with respect to ground motion, initial site characterization did not adequately define nearby fault zones and their displacement potential. The site lies in the limb of an active syncline. Bob Jackson mentioned that displacements of as much as a meter accompanied this event. Although none of the units have returned to operation since the event, the Japanese government is very reluctant to abandon this site for power generation because of the very costly investment in site transmission capability.

The Sichuan earthquake was measured at magnitude 8.0 and had 270 km of surface rupture. Bob Jackson has been in contact with the National Science Foundation team that investigated the event, and he provided additional information. Nearly 70,000 people lost their lives, and 18,000 are still listed as missing. Much soil failure and a great number of landslides accompanied this event, which was caused by an oblique thrust fault at the eastern margin of the Tibetan Plateau. This is considered to be a low-probability, high-consequence event. Ground motion lasted for 90 seconds in Sichuan, and 500 seconds 1500 km away in Beijing. Liquefaction was not a major problem during this event, but many critical facilities, including 17 electrical substations, were damaged. Much of the construction in the area used precast concrete. Schools and hospitals seemed to suffer a disproportionate level of damage. The Chinese government has dedicated $150 billion over the next five years for recovery. The Chinese are updating their design standards, and the new code will consider the degree of importance of facilities.

Update on CEUS Seismic Source Characterization Project – Larry Salamone

Dr. Salamone provided the final presentation of the workshop on the status of the CEUS Seismic Source Characterization Project that is jointly funded by the Electric Power Research Institute and DOE. This project follows the Senior Seismic Hazard Assessment Committee (SSHAC) process described in NUREG/CR-6372, *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*, as a Level 3 study. John Ake mentioned that NRC is currently working to update the SSHAC guidance to incorporate lessons learned from PSHAs performed over the past decade. These lessons will be considered during the CEUS Project. Several representative sites across the CEUS will be chosen to test the model's sensitivity to seismic source zone definitions. The commercial nuclear industry wants these sites to be generic rather than current or planned nuclear plant sites. Workshop participants agreed that DOE should follow this same approach, rather than request that a DOE site be used as a demonstration site. Dr. Costantino suggested the project consider variable concepts when computing the hazard at soil sites; he said he would record some ideas on this and pass them on. Dr. Stepp serves as co-chair of the Participatory Peer Review Panel (PPRP) for the CEUS Project. He commented that the SSHAC guidance does not clearly define the role of the PPRP for a Level 3 study and that the PPRP is still working to define its role. The consensus is that the PPRP needs a higher level of involvement at intermediate steps of the process than they might in a Level 4 study. Performing a Level 3 rather than a Level 4 study will save the project one to two years; performing a Level 4 study for the CEUS would prove challenging due to the need to assemble multiple teams of experts. This led to a comment that the seismic lessons-learned

panel should be concerned with training new people in the field of seismic hazard assessment. Dr. Stepp opined that uncertainties in paleoliquefaction and the CEUS strain budget are fertile areas for future research. Dr. Salamone closed the discussion by stating that the CEUS Project will significantly benefit DOE by assisting sites in performing NPH assessments prior to designing and building facilities. Multiple DOE projects have suffered delays because of a need to revisit NPH characterization after design and construction have begun.

In the closing discussion, Dr. Kimball mentioned that he has just learned that the Pantex Plant is beginning a PSHA update, but he thinks those performing the update may not be seeking adequate outside guidance. Mr. Lagdon posed the question of how we make others within DOE understand that adequate NPH characterization is necessary for DOE sites, even if no new facilities are planned. Dr. Kimball suggested that the panel members provide input on DOE's highest priorities for helping sites improve their NPH characterization and design. Mr. Lagdon asked the panel members to provide this feedback directly to him by October 10, 2008.

The next workshop is tentatively scheduled for early 2009 at a location to be determined. Scheduling the workshop in coordination with a workshop for the CEUS Project will be considered.

Follow-up Actions:

Action	Due Date	Lead
CNS will schedule the next panel workshop to discuss seismic and other NPH issues affecting DOE facilities	12/5/2008	S. McDuffie
CNS and Dr. Costantino will meet with DNFSB staff to discuss time history work for SSI analyses	12/19/2008	S. McDuffie
CNS will draft an implementation plan for updating and enhancing DOE guidance for NPH characterization and design	12/31/2008	S. McDuffie