MINUTES FROM SEISMIC LESSONS-LEARNED PANEL
MAY 11, 2010

Background

The Chief of Nuclear Safety (CNS) hosted the sixth meeting of the seismic lessons-learned panel at the DOE Forrestal Building on May 11, 2010. This panel was commissioned by CNS in August 2007, and it meets approximately twice per year. 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.

Participants

John Ake, U.S. Nuclear Regulatory Commission (NRC)
Said Bolourchi, Simpson Gumpertz & Heger
Adam Cloar, DOE-Oak Ridge
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, Frederick Loceff Technical Services
Jennifer McCloskey, DOE Office of Environmental Management (EM)
Steve McDuffie, DOE-CNS
Gerry Meyers, DOE Office of Health, Safety, and Security (HSS)
Jim O'Brien, DOE-HSS
Cliff Roblee, California Department of Transportation **
Larry Salomone, Savannah River Nuclear Solutions, LLC (SRNS)
J. Carl Stepp, Earthquake Hazard Solutions
Ali Tabatabai, Link Technologies
Loren Turner, California Department of Transportation **

** Indicates participation by teleconference

Summary

Mr. Lagdon opened the workshop with a reminder of the importance of maintaining discipline on DOE construction projects. Hanford's Waste Treatment Plant (WTP) in particular has attracted great interest from the Secretary in recent months. The Secretary is relying on construction project reviews (CPRs) that follow the Office of Science model to ensure that projects are maintained on schedule and budget. These CPRs are expert-based, and they ensure that the right persons are involved to provide project peer review. The CPRs are helping drive resolution of technical issues. DOE is working to promote better technical authority in the organization, and a technical advisory panel is planned specifically for WTP. On an unrelated topic, Mr. Lagdon noted that he obtained some funding from EM to help support the Next Generation Attenuation – East project.

Development of Central and Eastern U.S. (CEUS) Seismic Source Characterization (SSC) Model – Larry Salomone

Dr. Salomone provided a progress report on this ongoing project, which is slated for completion in December 2010. He reminded the participants of the project goals and objectives. This project will replace the two seismic source characterizations produced by the Electric Power Research Institute (EPRI) and Lawrence Livermore National Laboratory 20 years ago. It will provide a probabilistic seismic hazard curve for a rock site, as well as on a deep or shallow generic soil profile, at any location in the CEUS. The calculations will rely on the EPRI 2004 attenuation relationships. The project follows the Senior Seismic Hazard Analysis Committee (SSHAC) guidance for a level 3 study, and the results will be suitable for use with DOE nuclear facilities and commercial reactors. The technical integrators are presently finalizing the model input parameters and beginning the documentation. The draft report is slated for completion by July 31, 2010, to be followed by a comment period for sponsors and peer reviewers. The model results will be compared with those from the most recent U.S. Geological Survey maps before the final report is published. The participatory peer review panel has been highly engaged throughout the project, providing both technical and process oversight. The scope has increased since the project began in mid-2008, and Dr. Salomone is currently pursuing incremental funding from the sponsors. A subcontract has been awarded, and development underway, for a public website to host the final model and report. Mr. Kimball noted that model implementation may be hampered if the NRC staff places conditions on its use. The NRC must solicit public comment along with its detailed technical review, and the DNFSB may have reservations if DOE implements the model before NRC has fully accepted it.

Savannah River Site Probabilistic Seismic Hazard Assessment (PSHA) Update Project – Larry Salomone

Dr. Salomone discussed how the new CEUS SSC model will be used at the Savannah River Site (SRS) to provide an update to the site-wide PSHA. SRS aims to have new seismic hazard curves for the site, relying on the CEUS output, within one year of CEUS project completion. Savannah River Nuclear Solutions, LLC (SRNS), the SRS management and operating contractor, is currently soliciting a subcontractor to provide hazard curves at multiple frequencies (between 1 Hz and 100 Hz) and return periods. Dr. Costantino recommended that calculations for 0.5 Hz also be performed, since that is close to the soil column frequency at SRS. With preliminary results soon available from the CEUS project, the subcontractor will have a general idea of the form of the new hazard curves by the end of 2010. This will give site contractors some indication of how the new curves might differ from those currently in use. Dr. Salomone noted that the American Society of Mechanical Engineers (ASME) Standard, *Quality Assurance Requirements for Nuclear Facility Applications* (NQA-1-2000), will be applied to the work, which is the standard currently in use at SRS. The subcontract is very specific about qualifications of personnel who may perform this work, incorporating a lesson

learned during some past subcontracting work on DOE projects. The DOE contracting officer is currently reviewing the statement of work for this subcontract.

Foundation Input Response Spectra (FIRS) – Carl Costantino

Dr. Costantino first provided a historical overview of site response and soil-structure interaction (SSI) modeling. Site response generally propagates one-dimensional waves from depth through a soil column to determine PSHA ground motions at the surface, and SSI calculations use a best estimate of soil column properties and make assumptions about three-dimensional variability. Problems arise because the probabilistic site response, using 60-120 realizations of soil profiles, is often inconsistent with three (lower-bound, best estimate, and upper-bound) deterministic soil column properties used in SSI calculations. A building foundation should normally have a dip in its input spectrum, but the probabilistic FIRS smoothes the spectrum and effectively eliminates the benefits that should be realized by embedding structures below the surface. This process yields design inputs that are overly conservative in many cases, particularly at the Chemistry and Metallurgy Research Replacement Facility at the Los Alamos National Laboratory. Dr. Costantino believes that a solution may lie in performing SSI calculations with a larger number of soil profiles (perhaps 60) and using the mean of that output rather than designing to envelop the results of the three deterministic profiles. He proposes to perform some sample calculations to demonstrate that such a method will still lead to a design greater than 80 percent confidence of non-exceedance on a hazard curve. Publishing such calculations will allow others to reference the method and prevent expensive over-design of certain structures and components on future projects. The participants agreed that such an effort would be quite valuable.

DOE Adoption of ANSI/ANS Standards – Brent Gutierrez

Dr. Gutierrez provided a follow-up to his presentation in March 2009 on DOE's adoption of American National Standards Institute/American Nuclear Society (ANSI/ANS)-2.27, *Criteria for Investigations of Nuclear Facility Sites for Seismic Hazard Assessments*, and ANSI/ANS-2.29, *Probabilistic Seismic Hazard Analysis*, on seismic hazard investigation criteria and PSHA. The companion standards ANSI/ANS-2.26, *Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design*, and American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) 43-05, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities*, for categorization of components and design of structures are already referenced by DOE-STD-1189-2008, *Integration of Safety into the Design Process*, as acceptable for use. The panel expressed consensus in 2009 that these new standards should be formally adopted by DOE, with some minor amplifications as recommended by Dr. Gutierrez. The amplifications include 1) ensuring that all sources contributing greater than 1 percent to a site's seismic hazard are considered; 2) the term "maximum considered earthquake" be stated as an annual probability of exceedance; 3) response analysis characterization in 2.27 should refer to section 5.4 of 2.29; and 4) the lower-bound magnitude in 2.29 should recommend use of EPRI TR 1012965, *Use of Cumulative Absolute Velocity (CAV) in Determining Effects of Small Magnitude Earthquakes on Seismic Hazard Analysis.* A

logical vehicle for adopting the new standards would be an update to DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and Non-Nuclear Facilities*, on the mitigation of natural phenomena hazards at DOE facilities, but DOE-HSS is awaiting issue of the new ANS 2.3 standard on extreme winds before beginning their planned update to DOE G 420.1-2. Dr. Gutierrez suggested that in the interim, DOE-EM could issue formal guidance to its field offices adopting 2.27 and 2.29 with the amplifications. Dr. Ake suggested that for seismic design category (SDC) 3 facilities, a lower-bound magnitude cutoff may be preferable to relying on CAV; otherwise zero hazard might be predicted at some lower seismicity sites. Moreover, recent developments in incoherence may impact some CAV calculations. Dr. Gutierrez agreed that CAV and incoherence should be revisited, and he plans to discuss this with Dr. Stepp in the coming months. Once this is resolved in the fall of 2010, Drs. McDuffie and Gutierrez will review the status of ANS 2.3 and DOE G 420.1-2 and decide whether EM should proceed with interim guidance or await revision of G 420.1-2 as the permanent vehicle for accepting 2.27 and 2.29 with amplifications.

Geotechnical Virtual Data Center (GVDC) Project – Cliff Roblee and Loren Turner

On the recommendation of Dr. Stepp, Mr. Roblee and Mr. Turner were asked to discuss the GVDC. The presentation was made by teleconference while their presentation slides were projected at the meeting. The purpose of this project is to share geologic data, especially borehole data, among organizations. The individual data owners maintain storage and control of their data, determining what data to share and the terms of use. The GVDC tracks the data available from each participant, and the Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS) is a standard format used for transferring data. To share data, providers must have the capability to create DIGGS files and metaDIGGS files, which reflect the available data sets. The GVDC harvests and stores metaDIGGS files. The GVDC has a web interface that can show available data on a map, and it has searching tools for users to filter and select data for transfer. Once a user identifies data he or she would like to access, the GVDC retrieves the DIGGS files from the data owner and transmits them to the user. The GVDC is quality-neutral; each data owner is responsible for the quality of the data made available. The GVDC is intended for public use, but its architecture allows for a non-public, standalone data sharing system. Dr. Salomone suggested that DOE query its sites on their available data that could be shared in such a system.

Composite Construction Modeling at WTP – Fred Loceff

Mr. Loceff discussed the composite construction at Hanford's WTP and the ongoing effort to further model its performance in seismic events. Composite construction is desirable at some DOE facilities because of the vertical seismic loads and heavy commodity loads, and it also eliminates the need for shoring concrete slabs and reduces floor-to-ceiling height. In July 2009, a DNFSB study suggested that some column moments are higher with composite construction, and Bechtel National, Inc. (BNI) did not provide concise, timely answers to diffuse this concern. BNI eventually provided a response to demonstrate that the design moments in the Low-Activity Waste (LAW)

facility exceed the moments predicted by the DNFSB model, but the DNFSB staff then raised questions about the High-Level Waste (HLW) and Pretreatment Facilities. Discussions expanded to include other evaluation and behavior issues with composite construction, but no agreement was reached. As a result, the DNFSB sent a letter to DOE on December 2, 2009, outlining its concerns and requesting a response. On March 26, 2010, the two sides agreed on a path toward resolution. Refined and remodeled sections, comprising approximately 25 percent of each building, were analyzed. The new models have refined meshing, an offset between the slab and beam, and include shear stud stiffness. The draft results were provided to the DNFSB staff; the initial feedback is that they do not address the staff concerns. The DOE/BNI response is that the draft calculations for the LAW Facility will be expanded and revised, but the agreed-to modeling technique will be maintained. DOE and BNI do not believe composite modeling is necessary for the HLW and Pretreatment Facilities because the thick slabs are supported by substantial shear walls. DOE's fundamental position is that due to conservative assumptions and design methodology, the forces and moments used in design are greater than those developed with the composite model. Mr. Loceff is a member of DOE's independent peer review team, and the team does not believe this refined modeling effort is necessary. If such overly complex modeling becomes an expectation for all composite construction, the economies derived from this construction may disappear for future DOE projects. Mr. Loceff believes that a key lesson from this experience is that much of the contention could have been avoided if the initial reviewer questions had been answered concisely and promptly.

Structure-Soil-Structure Interaction (SSSI) Effects – Said Bolourchi

Dr. Bolourchi presented an analysis of the impact of a heavy structure on the seismic input for an adjacent structure. The analysis examines the impact of a representative reactor building on adjacent structures, allowing soil layering and embedment to vary. The primary conclusion is that a heavy structure can significantly impact the response of an adjacent structure more than one footprint dimension away. In contrast to a relatively smooth input spectrum of acceleration versus frequency, the output spectra at some nodes along the X direction away from a deeply embedded structure show dips in the 2-5 Hz range. Results are similar for nodes along the Y direction. The modeling shows amplification from structure-to-structure interactions in the shallow surface, for some frequencies out to 2.5 times the structural width. One method to predict the SSSI effect is to use a multiplier with the input spectrum, but another method in development may be able to predict the effect from attenuation relationships and wave formulations at each frequency. These predictions may reduce excessive conservatism in the scaling method. The predictive methods require additional work to demonstrate a match for varying soil layers, structures, and embedment. This study also found that the soil-structure interaction effect of an adjacent structure can amplify the response above the level calculated if the structure were not present at that point. Dr. Bolourchi stated that he has not yet examined the effects from two equal-weight, adjacent buildings. Dr. Costantino pointed out that considering incoherence would likely affect the results of this study.

Salt Waste Processing Facility (SWPF): A Look Back – Fred Loceff

Mr. Loceff provided a review of the SWPF project to date. Construction of this performance category (PC)-3 facility at Savannah River is well underway, but the project has been troubled at times. The facility was originally slated to be PC-2, and the initial SSI analysis was fairly simplistic as a result. The initial SSI did not reflect current practice or site-specific features by including soil profile layering and soft zones. Design reviewers lost confidence in the designers, so the SWPF contractor (Parsons) hired additional expertise for the SSI effort. This led to formation of an SWPF structural design team, including subcontractors, reviewers, and DOE staff, to manage the design. The soil layering and soft zone issues engendered considerable discussion with the DNFSB staff, and the design team made a conservative decision to increase the central processing area base mat thickness to 8 feet. Design team reviews also led to other improvements that simplified the load path and transferred loads though in-plane forces. A two-step seismic and structural analysis was performed, in which Parsons completed a static model with the Georgia Tech Structural Design Language (GTSTRUDL) software, followed by CJC & Associates modeling the SSI. The three-dimensional GTSTRUDL model used a meshing and element size consistent with the guidance developed for Hanford's WTP, ensuring adequate refinement to obtain reliable structural demands. DNFSB staff interface continued as design progressed, and the interactions were generally positive and nonconfrontational. The DNFSB staff was particularly pleased with the quality of the Summary Structural Report. Mr. Loceff's primary message is that active participation by DOE reviewers and the structural consultants helped lead to a design consistent with DOE and national consensus standards, as well as good engineering practice. At the end of the presentation, Dr. Gutierrez noted that SWPF design performance has declined since the structural design team was disbanded. Some design modifications have been necessary during construction, in part due to slow material deliveries, and new design calculations have been found to have some basic errors.

Discussion of Current Issues at DOE Sites – Steve McDuffie

Dr. McDuffie led a discussion of ongoing seismic issues at DOE sites, first providing an update of the new PSHA planned for the Hanford Site. The Office of River Protection (ORP) and Richland Operations Office agreed in August 2009 to co-sponsor a new PSHA at SSHAC level 3, with ORP managing the project. ORP is contracting with Pacific Northwest National Laboratory (PNNL) to perform the assessment. ORP provided funds to PNNL in December 2009 to update an existing project plan and draft a quality assurance plan (QAP) for the project. The project plan provided in January 2010 calls for performing both seismic source characterization and ground motion prediction elements, with a total duration of 145 weeks. ORP staff have since raised concerns about the QAP and enforcement of the Price-Anderson Amendments Act on the project, leading to delays. ORP is in the process of providing additional funds to PNNL to revise the QAP, and the project is expected to commence in summer 2010. Dr. Gutierrez suggested from his Savannah River experience that PNNL will need to obtain DOE approval if they plan to establish any sole-source subcontracts as part of the project. Dr. Salomone noted

that the CEUS project can provide some valuable lessons for the Hanford PSHA. For example, on CEUS, the project manager and technical integrator team leader both understood their respective roles and stuck to them. The technical integrator team must be free to focus exclusively on the technical issues without distraction by project management issues.

Battelle Energy Alliance (BEA) is currently performing a review of the PSHA at the Idaho Site; this is known as the Seismic Assessment Evaluation Project. This lengthy study, self-funded by BEA, will determine whether the Idaho PSHA should be updated. Most personnel involved with the project already agree that an update is necessary, yet this evaluation is scheduled to continue through fiscal year 2010 and possibly beyond. Dr. Costantino participated in a recent peer review of this project, which raised several concerns. For example, in any future site response calculations, BEA plans to derive shear wave velocity (Vs) profiles using Poisson's ratios chosen through professional judgment rather than collecting borehole data. BEA also plans to apply the DOE 1020-series standards to a PSHA update, whereas the panelists believe they would be better served by the new ANS standards. The consensus of the panel is that DOE management attention to the Idaho seismic hazard assessment is necessary to avoid repeating past shortcomings in seismic hazard calculations, as affected Hanford's WTP.

The panelists also discussed quality assurance (QA) requirements as they apply to projects conducted per SSHAC guidelines. Dr. Ake noted that a rigid application of QA requirements could lead to the exclusion of important data during a PSHA. Dr. Stepp mentioned an ongoing need to educate those involved on the QA aspects inherent to the SSHAC process. Dr. Salomone mentioned that certain aspects of the NQA-1 standard are applied to the pending update to the Savannah River PSHA. The consensus of the panel is that formal QA requirements should be applied to software used in PSHA calculations, to project documentation, and to efforts to collect new data in support of a PSHA. Aside from these elements, the SSHAC process, if implemented properly, provides adequate QA for a PSHA.

Finally, the panelists discussed structural design issues at DOE facilities that were recently raised by the DNFSB staff. Mr. Lagdon prefaced this discussion with his concern about the rules of engagement with DNFSB staff. He believes the DNFSB staff has in some cases asked DOE to perform structural analysis and design work that is beyond a level required by DOE or industry standards, and the technical bases for these requests have been poorly supported. On March 15, 2010, DOE received a letter from the DNFSB raising five geotechnical and structural engineering issues at the Y-12 Uranium Processing Facility (UPF) currently in design. Mr. Loceff is familiar with these issues and provided the status and his perspective. The first issue relates to high-frequency ground motion and the possibility of removing additional weathered shale below the future structure; Mr. Loceff believes this is nearing resolution and additional shale removal will not be required. The second issue is to determine whether ground motion incoherence should be directly incorporated into seismic design. The UPF project does plan perform an SSI analysis, both with and without incoherence effects; Mr. Loceff believes the outcome may lead the designers to incorporate incoherence. The third issue

concerns structural analysis and design. Part of this relates to composite beam evaluation, similar to the ongoing concern at WTP. Mr. Loceff believes this will eventually be resolved in the same manner as the WTP issue. Another analysis issue is the finite element mesh refinement. The DNFSB staff does not believe the WTP modeling guidelines are sufficient for UPF. Mr. Loceff disagrees; in his opinion, revising the model to satisfy the staff would have little effect on the facility response spectra. The fourth issue is the spacing between adjacent structures. Mr. Loceff believes this is not a concern because structures adjacent to the primary have a lower response frequency, so the planned two-inch spacing is adequate. Finally, DNFSB staff raised an issue with the effects of an accidental internal blast. Mr. Loceff believes this issue has been resolved to the staff's satisfaction. The March 15 letter also stated a concern with the lack of independent peer review currently in place for the civil and structural design of UPF.

Two WTP structural design issues presently concern the DNFSB staff, as communicated in December 2009. The first is the structural steel composite design and analysis that Mr. Loceff discussed during his presentation dedicated to the topic. The second is the performance categorization of the piping inside Pretreatment Facility hot cells. This was discussed in the Board's periodic report to Congress dated December 7, 2009. The Board believes it is essential that piping in hot cells retain integrity during a design basis seismic event, necessitating classification as PC-3. DOE disagrees with this strategy, preferring to rely on the PC-3 structure and ventilation system to protect facility workers during such an event. The panel consensus view aligns with DOE's position that the piping inside the hot cells need not be categorized as PC-3.

Follow-up Actions:

Action	Due Date	Lead
Pursue funding opportunities from CNS, EM, and the National Nuclear Security Administration (NNSA) to support performing and publishing sample FIRS calculations.	6/30/2010	S. McDuffie
Review use of cumulative absolute velocity and incoherence in seismic hazard calculations.	8/31/2010	B. Gutierrez, C. Stepp
Provide draft guidance to accompany adoption of ANSI/ANS-2.27 and -2.29 to include in the next revision to DOE G 420.1-2, or possibly issue as EM guidance.	9/30/2010	B. Gutierrez