DEFENSE NUCLEAR FACILITIES SAFETY BOARD

625 Indiana Avenue, NW, Suite 700, Washington, D.C. 20004-2901
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July 29, 2004

Mr. Paul M. Golan
Acting Assistant Secretary for
Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0113

Dear Mr. Golan:

In its letter of January 21, 2003, the Defense Nuclear Facilities Safety Board (Board) discussed design uncertainties for the Waste Treatment Plant (WTP), at the Hanford Site, including an assessment of the ground motion design criteria. The Board concluded that the Hanford ground motion criteria did not appear to be appropriately conservative. The Board understood that to compensate for this issue, the WTP contractor was implementing acceptably conservative design features, and observed that this conservatism should be maintained for all future design work at Hanford unless site-specific attenuation relationships were developed. The Board summarized a number of technical issues to be addressed should the Hanford ground motion criteria be reassessed. Subsequently, the Office of River Protection (ORP) has undertaken the collection of additional subsurface data, specifically shear wave velocity data. It is important that these new data be properly analyzed to address the uncertainties in the estimates of ground motion.

The enclosed report reviews a number of specific technical issues that need to be addressed as the newly acquired shear wave velocity data are analyzed. The Board believes resolution of these technical issues is critical to managing the structural design margins as a function of design uncertainties for WTP structures, systems, and components. Therefore, pursuant to 42 U.S.C. § 2286b(d), the Board requests a program plan within 30 days of receipt of this letter specifying how ground motion issues will be addressed. Moreover, the Board requests upon completion of this work a report on the findings of the field studies and subsequent analysis of field data, and resulting conclusions regarding the adequacy of the current Hanford ground motion criteria and the impact of the design of WTP structures and components.

Sincerely,

John T. Conway
Chairman

c: Mr. Roy J. Schepens
Mr. Keith A. Klein
Mr. Mark B. Whitaker, Jr.

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

July 16, 2004

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: J. Kimball

SUBJECT: Design Basis Earthquake Ground Motion Criteria for the Hanford Site and Waste Treatment Plant

This report documents the results of reviews performed by the staff of the Defense Nuclear Facilities Safety Board (Board) regarding the Probabilistic Seismic Hazard Analysis for the Hanford Site and the resulting design basis earthquake ground motion criteria used for the Waste Treatment Plant (WTP). Staff members J. Blackman and J. Kimball and outside expert P. Rizzo participated in these reviews.

Background. In its letter of January 21, 2003, the Board discussed design uncertainties for the WTP, including an assessment of the ground motion design criteria. The Board concluded that the Hanford ground motion criteria did not appear to be appropriately conservative. The Board understood that to compensate for this issue, the WTP contractor was implementing acceptably conservative design features, and observed that this conservatism should be maintained for all future design work at Hanford unless site-specific attenuation relationships were developed. The Board summarized a number of technical issues to be addressed should the Hanford ground motion criteria be reassessed. Subsequently, the Office of River Protection has undertaken the collection of additional subsurface data, specifically shear wave velocity (Vs) data.

Discussion. The design basis earthquake ground motion criteria for Hanford are derived from the estimates of ground motion contained in *Probabilistic Seismic Hazard Analysis, DOE Hanford Site, Washington* (WHC-SD-W236A-TI-002, Rev. 1A, October 1996). The ground motion attenuation relationships used in that study are empirical soil ground motion models for California. Appendix A of the report includes a site response analysis in an attempt to demonstrate that the relative site response for Hanford is similar to or more conservative than the site response using the California empirical soil ground motion models. Since that report was published, additional work on site response sensitivity was completed.

The Board's staff developed Figure 1 from these site response analyses to illustrate the Vs profile for California and the Vs profile used for the Hanford site. It is important to note that the Hanford bedrock Vs profile shown in Figure 1 is based on velocity data taken ~20 km from the WTP site.

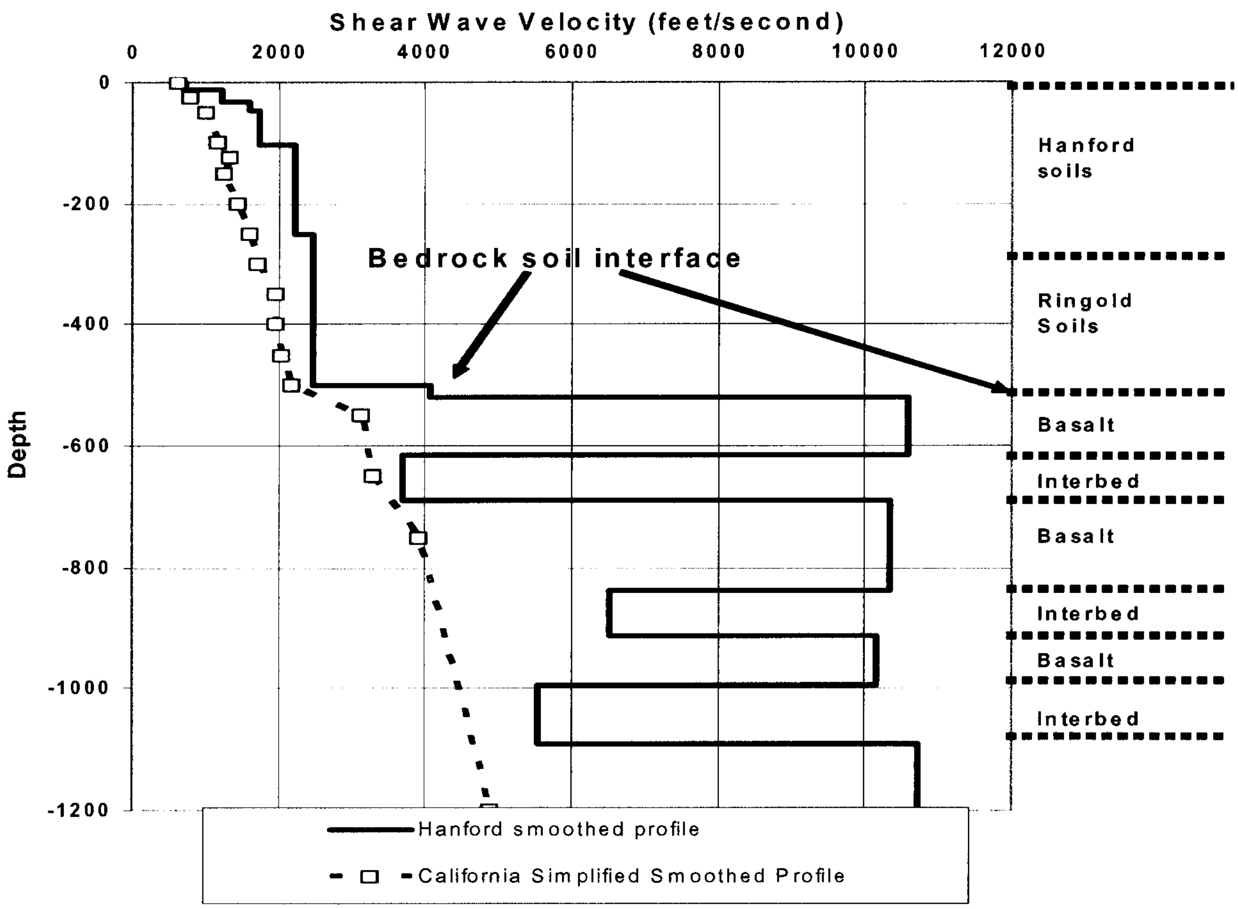
In general, the potential for ground motion amplification is enhanced when large impedance contrasts exist, such as when a high Vs bedrock material underlies a low Vs soil material. The magnitude of amplification depends on the thickness and damping characteristics of the overlying soils. As such, the large impedance contrast at the bedrock soil interface seen in Figure 1 should result in more ground motion amplification through the soil for Hanford relative to California. This point was demonstrated in the 1996 Probabilistic Seismic Hazard Analysis through limited sensitivity studies that showed the site response at Hanford being as much as 50 percent greater than that of California if the bedrock is assumed to be one continuous unit (i.e., all basalt).

However, the Hanford bedrock is not continuous, as seen by the bedrock interbeds shown in Figure 1. The 1996 analysis predicted a significant energy reduction resulting from the arrangement of these bedrock interbeds. This energy reduction counteracted the large soil amplification, resulting in comparable ground motion for Hanford relative to California. Thus the behavior of the bedrock interbeds plays a critical role in determining the site ground motion.

Early assessments conducted by the Board's staff estimated that the site response at Hanford could be about 15 percent greater than that at California sites in the frequency range of 4 to10 hertz. This was communicated to DOE in the Board's letter of January 21, 2003. However, differences in the characterization of the soils and bedrock at the WTP site could have a significant impact on the difference between the WTP site response and that at California sites. While it may be expected that ground motion changes of up to 15 percent can be addressed by implementing acceptably conservative compensatory design features (e.g., demand/capacity ratio $\leq$0.85), the same might not be the case if the ground motion were to increase by as much as 50 percent. Thus understanding Vs for the WTP site soil, basalt, and interbeds is essential.

Site Investigations—Discussions with Office of River Protection personnel revealed that additional site investigations are under way to gather Vs data. The gathering of these additional data is likely to improve greatly the understanding of Vs for both the soils and bedrock at the Hanford Site. Vs data are being gathered in the upper ~600 feet at the Integrated Disposal Facility site, in the same soil units that underlie the WTP site. The Integrated Disposal Facility site is about 6,000 feet west of the WTP site. The use of up to five existing boreholes near the WTP site is being explored, with some expectation that good Vs data can be obtained to depths of ~300 feet. The use of a technique called spectral analysis of surface waves in and near the Integrated Disposal Facility site and the WTP site is also being investigated, in the anticipation that the results could add Vs data to a depth of several hundred feet. Finally, the drilling of a ~2,000 feet deep borehole is being discussed, which if pursued could add Vs data below the bedrock soil interface. As discussed above, the bedrock comprises both basalt and sedimentary interbeds, and large Vs differences between these two materials are expected.

Figure 1: Comparison of smoothed shear wave velocity profile for Hanford to a simplified shear wave velocity model for California. Both profiles have 500 feet of soil over bedrock. For Hanford the bedrock is alternating layers of basalt and sedimentary interbeds. The comparison shows the difference in shear wave velocity profiles to a depth of 1,200 feet. The assumed California profile represents a gradual Vs increase with depth compared to the Hanford profile showing large Vs reversals below the soil-bedrock interface.



Site Response Modeling Technical Issues—It is presumed that collected Vs data, supplemented by laboratory testing, will be used to address uncertainties in seismic response. It is important that analysis of these data properly address all applicable technical issues, including the following:

- Comparison of the geology and the intervening paleo-channel between the Integrated Disposal Facility site and the WTP site; the overall thickness of soil (depth to bedrock); the thickness of individual soil layers (Hanford and Ringold formations); Vs for all layers (soil, basalt bedrock, sedimentary interbeds); and potential lateral variation in Vs.

- The accuracy of downhole Vs measurements given the potential effects of intermediate "hard" layers that may mask or cause surface-generated waves to bypass underlying, "softer" layers.

- How Vs in the basalt and sedimentary interbeds is derived from borehole logs and laboratory data; how laboratory data were corrected to account for deep confining pressures; and the uncertainty in how laboratory data are extrapolated to derive Vs representative of the expected depth. This issue is particularly pertinent if it is decided that no deep borehole is necessary.

- The justification for selection of damping and modulus degradation curves and the final dynamic strain levels. This information is necessary to understand the degree of nonlinear response that is being modeled.

- The relative significance of the upper crustal rock site response, particularly with respect to model assumptions for both the basalt and the interbeds. Site response modeling should attempt to provide clarification regarding which geologic layer assumptions control which frequency ranges. For example, for frequencies between 4 and 10 hertz, the analyst should determine the overall proportion of site response associated with attenuation within the interbeds versus amplification that may result from the bedrock soil impedance contrast. This issue encompasses the justification of the site response model relative to the conditions being modeled, such as the alternating Vs within the upper crust. The sensitivity of rock site responses to model assumptions (gradient versus alternating velocities) should be explored. This issue is particularly pertinent if the Vs for the basalt layers is decreased.

- The relative significance of the soil site response with respect to model assumptions for the Ringold and Hanford formations.

- Vs comparisons between expected upper crustal velocities at WTP are very different than those generally associated with California rock Vs profiles. Given the basalt interbed Vs profile, the analyst should address how rock ground motion attenuation models for WTP or Hanford can be developed.