

**Review Comments on the Annotated Outline of the
DOE Topical Report, Seismic Design Methodology
for a Geologic Repository at Yucca Mountain.**

**REVIEW COMMENTS ON THE ANNOTATED OUTLINE
OF THE
DOE TOPICAL REPORT
"SEISMIC DESIGN METHODOLOGY FOR A GEOLOGIC
REPOSITORY AT YUCCA MOUNTAIN"**

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Prepared by

**Asadul H. Chowdhury
Sui-Min (Simon) Hsiung
Renner B. Hofmann**

**Center for Nuclear Waste Regulatory Analyses
San Antonio, Texas**

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1 INTRODUCTION

The annotated outline reviewed herein is that of the second topical report in a series of three seismic topical reports that together will describe the seismic design process the U.S. Department of Energy (DOE) plans to implement for the Yucca Mountain (YM) Geologic Repository Operations Area (GROA). The first topical report is for describing the DOE's methodology to assess vibratory ground motion and fault displacement hazards. This second topical report is to describe the methodology that DOE will use to determine the appropriate seismic hazard levels for design. The third topical report is to describe the development of seismic design inputs (e.g., seismic response spectra, time histories, and fault displacement levels) for the appropriate seismic hazard levels.

Since the three topical reports together will describe DOE's seismic design process for the GROA, review of the annotated outline of one topical report at a time does not facilitate meaningful comment. However, several technical issues were identified during the scoping review of the limited information provided in the annotated outline. These issues are discussed in this review report.

2 REVIEW BACKGROUND

In the NRC Staff Site Characterization Analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada, (SCA) the NRC staff raised concern regarding the seismic design basis for the Exploratory Studies and Underground Facilities. As a result, Comment 121 was generated. This comment remains unresolved. The DOE has submitted the annotated outline for the topical report of Seismic Design Methodology for a Geologic Repository at Yucca Mountain. The topical report attempts to address the determination of appropriate seismic hazard levels (seismic design bases) and provide design methodology for repository design. Providing early guidance or input to this annotated outline will be helpful in resolving Comment 121.

This topic is related to three Key Technical Uncertainties (KTUs) which have been identified by NRC and CNWRA staffs:

- (i) Prediction of the thermal-mechanical-hydrological-chemical responses of the host rock, surrounding strata, and groundwater system to thermal loads
- (ii) Demonstration of compliance with the requirement to maintain the ability to safely retrieve high-level radioactive waste
- (iii) Prediction of the thermal, mechanical, and hydrological impact on the host rock surrounding the waste package

3 REVIEW CRITERIA

The technical review of the annotated outline for the Topical Report of Seismic Design Methodology for a Geologic Repository at Yucca Mountain is based on the Division of High-Level Waste Management Topical Report Review Plan. Specifically the review considers:

- Whether the content of the annotated outline provides sufficient information for determination whether or not the subject qualifies as a topical report

- Whether the annotated outline covers areas of concern that may lead toward resolution of open items
- Identification of new concerns

4 COMMENTS

The seven sections of the annotated outline cover the items for adequately describing the methodology needed to determine the appropriate seismic hazard levels for design. However, the DOE proposed contents of some of these sections are either inadequate or questionable as discussed in the following comments:

- It is clear from the annotated outline that DOE intends to use the safety performance goal-based seismic design method for the design of the potential high-level waste surface and subsurface facilities at YM. It is our understanding that this method has been developed primarily for surface facilities, for which a body of knowledge is available that is critical for determining the performance goals. Even with this knowledge, the use of a risk reduction-factor is essentially judgmental and may not be conservative for the repository surface facilities. Furthermore, this method, along with the risk reduction-factor, has not been applied to nuclear related facilities. The body of knowledge from which the performance goals can be derived is not currently available for subsurface facilities, especially for the conditions that will exist in the repository (such as thermal and repetitive seismic loads, etc.). As a result, the appropriateness of implementing the safety performance goal-based seismic design method to the subsurface facilities will be questionable at this point.
- As indicated in the cover letter from Mr. Ronald A. Miller to Mr. Joseph J. Holonich, "post-closure performance will not be addressed by subject topical report, but will be covered in the total system performance assessment of the site." It is not clear whether this statement implies that the safety performance goals mentioned in the annotated outline are developed to exclude post-closure performance concerns; that is, to satisfy pre-closure performance measures only. If this is true, the ultimate seismic design for underground drifts and ground support systems may not be conservative from the point of view of meeting post-closure performance objectives of 10 CFR Part 60. A clarification from DOE will be necessary to resolve this issue.
- Although Section 2.0 indicates that both vibratory ground motion and fault displacement hazards will be addressed, no detail is provided in the outline for how fault offsets will be assessed either deterministically or probabilistically. This topic should be addressed in some detail.
- The annotated outline does not mention whether the potential effects of repetitive episodes of seismic loadings will be considered in the seismic design for underground drifts and ground support systems. The concern regarding such effects is the primary basis of Comment 121 in the SCA. This comment recognizes the fact that the response and performance of a rock mass is determined by the amount of permanent joint deformation accumulated from a number of episodes of seismic activity (Brown and Hudson, 1974).

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This aspect has been confirmed at the Lucky Friday Mine field study on rock mass response to repetitive seismicity (Hsiung et al., 1992). A rock mass becomes weaker as joint deformation accumulates. That will substantially increase the potential for deleterious rock movement or fracturing of overlying or surrounding rock, leading to a noncompliance with regulatory requirement 10 CFR 60.133(e)(2). Such deleterious rock movement may change hydrological properties of and flow paths in the rock mass, and create preferential pathways, all of which may have serious implications for the repository post-closure performance. While the effects of repetitive episodes of seismic loads are most important to post-closure concerns, they are also a potential concern for the stability of drifts for the approximately 100-year operational life of the facility, especially for retrievability, given the conditions that will exist in the repository. Without considering these potential adverse effects, the design may not be conservative, and it is not clear how the method to be proposed could/would address concerns of Comment 121.

5 SUMMARY

The annotated outline of the topical report on the seismic design methodology for a geologic repository at YM contains the items for adequately describing the methodology needed to determine the appropriate seismic hazard levels for design. However, the annotated outline should be strengthened by including discussion of treatment of effects due to repetitive episodes of seismic activities, post-closure concerns listed as the second bullet in Section 4, and fault offsets. Also, the implementation of performance goal-based seismic design for a subsurface facility is questionable at this time due to lack of experience in applying it to nuclear facilities.

6 REFERENCES

- Brown, E.T., and J.A. Hudson. 1974. Fatigue Failure Characteristics of Some Models of Jointed Rock. *Earthquake Engineering and Structural Dynamics* 2: 379-386.
- Hsiung, S.M., W. Blake, A.H. Chowdhury, and T.J. Williams. 1992. Effects of Mining-Induced Seismic Events on a Deep Underground Mine. *Pure and Applied Geophysics* 139: 741-762.