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UniStar
NUCLEAR ENERGY

10 CFR 50.4
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July 15, 2009

UN#09-320

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: UniStar Nuclear Energy, NRC Docket No. 52-016
Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3,
RAI No. 58, Seismic Design Parameters,
RAI No. 63, Seismic Subsystem Analysis, and
RAI No. 65, Seismic System Analysis

References:

1) John Rycyna (NRC) to Robert Poche (UniStar Nuclear Energy), "RAI No. 58 SEB2 1966.doc (PUBLIC)" email dated February 17, 2009

2) John Rycyna (NRC) to Robert Poche (UniStar Nuclear Energy), "RAI No. 63 SEB2 1973.doc (PUBLIC)" email dated February 18, 2009

3) John Rycyna (NRC) to Robert Poche (UniStar Nuclear Energy), "RAI No. 65 SEB2 1971.doc (PUBLIC)" email dated February 18, 2009

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4) UniStar Nuclear Energy Letter UN#09-291, from Greg Gibson to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 58, Seismic Design Parameters, RAI No. 63, Seismic Subsystem Analysis, RAI No. 65, Seismic System Analysis, and RAI 112, Seismic Design Parameters, dated June 12, 2009

The purpose of this letter is to respond to the requests for additional information (RAIs) identified in the NRC e-mail correspondence to UniStar Nuclear Energy, dated February 17, 2009 (Reference 1), and February 18, 2009 (References 2 and 3). These RAIs address Seismic Design and Analysis, as discussed in Section 3.7 of the Final Safety Analysis Report (FSAR), as submitted in Part 2 of the CCNPP Unit 3 Combined License Application (COLA), Revision 5.

Reference 4 provided a schedule for the expected response dates and stated that a response schedule for RAI 65, Questions 03.07.02-17 and 03.07.02-19 would be provided shortly after AREVA responded to a related U.S. Evolutionary Power Reactor Design Certification Application RAI. Based on the recent AREVA response, a response to CCNPP Unit 3 RAI 65 Questions 03.07.02-17 and 03.07.02-19 will be provided by October 16, 2009.

Enclosure 1 provides the schedule for responses to the RAIs specified in References 1, 2, and 3, updated with the revised schedule for Questions 03.07.02-17 and 03.07.02-19. Enclosure 2 provides our responses to RAI No. 58, Questions 03.07.01-2 and 03.07.01-4; RAI No. 63, Question 03.07.03-1; and RAI No. 65, Question 03.07.02-15. These responses do not impact COLA content and do not include any new regulatory commitments.

If there are any questions regarding this transmittal, please contact me at (410) 470-4205, or Mr. Michael J. Yox at (410) 495-2436.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on July 15, 2009

Greg Gibson

Enclosures:

1) Response Summary for Requests for Additional Information, RAI No. 58, Seismic Design Parameters; RAI No. 63, Seismic Subsystem Analysis; and RAI No. 65, Seismic System Analysis; Calvert Cliffs Nuclear Power Plant Unit 3

2) Response to NRC Request for Additional Information, RAI No. 58, Seismic Design Parameters, Questions 03.07.01-2 and 03.07.01-4; and RAI No. 63, Seismic Subsystem Analysis, Question 03.07.03-01; and RAI No. 65, Seismic System Analysis, Question 03.07.02-15; Calvert Cliffs Nuclear Power Plant, Unit 3

cc: John Rycyna, NRC Project Manager, U.S. EPR COL Application
Laura Quinn, NRC Environmental Project Manager, U.S. EPR COL Application
Getachew Tesfaye, NRC Project Manager, U.S. EPR DC Application (w/o enclosure)
Loren Plisco, Deputy Regional Administrator, NRC Region II (w/o enclosure)
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U.S. NRC Region I Office

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Enclosure 1

Response Summary for Requests for Additional Information, RAI No. 58, Seismic Design Parameters; RAI No. 63, Seismic Subsystem Analysis; and RAI No. 65, Seismic System Analysis; Calvert Cliffs Nuclear Power Plant Unit 3

Response Summary for Requests for Additional Information

RAI Set 58 Question	Description of RAI Item	Response Date
03.07.01-1	Justify assumptions of rigid basemat in SSI analysis of Nuclear Island including lower bound soil properties (where shear wave velocity is less than 1000 fps)	September 15, 2009
	Identify impact on the SSI analysis results and on the design of the foundation mat and supported superstructure.	September 15, 2009
03.07.01-2	This Letter – See Enclosure 2.	Response submitted
03.07.01-3	For EPGB and ESWB, provide methodology to calculate FIRS at grade elevation computed from the GMRS which were determined at an applicable elevation 41 ft below grade.	August 29, 2009
	Describe computer codes, soil column model, and the basis for the shear wave velocity of the structural backfill that supports both the EPGB and ESWB and the impact of this backfill on the development of the FIRS.	December 29, 2009
	Provide in the FSAR the spectra at the foundation level of each structure meeting Appendix S requirements.	December 29, 2009
	Provide in the FSAR a comparison of the FIRS at the foundation level of each structure meeting the requirements of Appendix S to the CSDRS provided in the U.S. EPR FSAR.	December 29, 2009
	Provide the basis for not performing confirmatory analysis for the EPGB and ESWB similar to that for NI.	July 29, 2009
03.07.01-4	This Letter – See Enclosure 2.	Response submitted
03.07.01-5	For Ultimate Heat Sink Electrical Building, provide and include in the RAI response FSAR the horizontal and vertical spectra depicting design spectra and applicable envelope.	August 29, 2009
	Provide in the FSAR a reconciliation of the design response spectrum with the horizontal foundation input response spectra (FIRS) for this structure which meets the minimum requirements of 10 CFR Part 50, Appendix S.	December 29, 2009

Response Summary for Requests for Additional Information

RAI Set 58 Question	Description of RAI Item	Response Date
	Include a description of how the FIRS are developed including the soil model, soil properties, backfill properties, computer programs and analysis assumptions.	December 29, 2009
03.07.01-6	Provide in the FSAR how the design response spectrum and assumed soil properties used in the analysis of the UHS MWIS will be reconciled with the FIRS that meets the requirements of Appendix S and the final soil properties determined from the site final geotechnical studies.	September 14, 2009
	Include in the FSAR a comparison of the FIRS with the design response spectra used in the analysis.	December 29, 2009
	Include a description of how the FIRS are developed including the soil model, soil properties, computer programs, and analysis assumptions.	December 29, 2009
03.07.01-7	Provide in the FSAR a discussion of the site-specific spectra that were considered for buried utilities.	December 29, 2009
	Provide justification for the use of the EUR soft soil spectrum including possible displacement and velocity differences that may exist with the use of this spectrum as opposed to using a site specific spectrum.	December 29, 2009
	Provide a comparison of the EUR soft soil spectrum with appropriate site specific spectra that are applicable to buried utilities.	December 29, 2009
03.07.01-8	See UniStar Nuclear Energy letter UN#09-228, dated May 1, 2009	Response submitted
03.07.01-9	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.01-10	State explicitly or by reference design ground motion time histories for RAI partial Nuclear Island, EPGB and ESWB structures.	September 15, 2009
	What are the site specific design ground motions and their bases that apply to these structures? Provide this information in Section 3.7.1.1.2 of the FSAR.	December 29, 2009

Response Summary for Requests for Additional Information

RAI Set 63 Question	Description of RAI Item	Response Date
03.07.03-1	This Letter – See Enclosure 2.	Response submitted

RAI Set 65 Question	Description of RAI Item	Response Date
03.07.02-1	See UniStar Nuclear Energy letter UN#09-228, dated May 1, 2009	Response submitted
03.07.02-2	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.02-3	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.02-4	Provide results of SSI analysis for Ultimate Heat Sink Electrical Building that meet the acceptance criteria 4.A.vii of SRP 3.7.1 and acceptance criteria 4 of SRP 3.7.2 using subgrade model of final soil and backfill properties or justify alternative.	December 29, 2009
	Include SSSI effects from UHS MWIS.	December 29, 2009
	Reconcile with the results of assumed seismic response and ISRS.	December 29, 2009
03.07.02-5	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.02-6	Describe how the SSI analysis performed for Ultimate Heat Sink Makeup Water Intake Structure (UHS MWIS) meets the acceptance criteria and 4.A.vii of SRP 3.7.1 or justify alternative.	December 29, 2009
	Provide a figure depicting the soil-structure model used for the seismic analysis.	December 29, 2009

Response Summary for Requests for Additional Information

RAI Set 65 Question	Description of RAI Item	Response Date
	Provide the basis for the assumed soil properties and profile used to calculate the frequency independent impedance functions.	August 15, 2009
	Provide the method and formulas used to calculate the values of the soil springs under the foundation as well as the lateral soil springs that represent the embedment effects.	August 15, 2009
	State whether the soil properties used in the analysis are strain dependent or simply the low strain values. If these are low strain values, justify their use and quantify the impact of not using strain dependent properties on the results of the analysis. If the soil properties are strain dependent, describe how the final soil properties are determined in the analysis.	August 15, 2009
	For large values of Poisson's ratio, the dynamic stiffness and damping are frequency dependent. Provide justification for assuming that the impedance functions of the supporting foundation are frequency independent.	August 15, 2009
	Confirm that the control motion is applied at the base of the soil structure analysis model.	August 15, 2009
	Provide a reconciliation of the final soil properties and the foundation input response spectra (FIRS) that are based on these properties with the seismic analysis results described in the FSAR.	December 29, 2009
03.07.02-7	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.02-8	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.02-9	See UniStar Nuclear Energy letter UN#09-126, dated March 19, 2009	Response submitted
03.07.02-10	See UniStar Nuclear Energy letter UN#09-228, dated May 1, 2009	Response submitted
03.07.02-11	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted

Response Summary for Requests for Additional Information

RAI Set 65 Question	Description of RAI Item	Response Date
03.07.02-12	Provide results of a structure-to-structure interaction analysis between UHS MWIS and EB.	December 29, 2009
03.07.02-13	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.02-14	See UniStar Nuclear Energy letter UN#09-228, dated May 1, 2009	Response submitted
03.07.02-15	This Letter – See Enclosure 2.	Response submitted
03.07.02-16	See UniStar Nuclear Energy letter UN#09-126, dated March 19, 2009	Response submitted

Response Summary for Requests for Additional Information

RAI Set 65 Question	Description of RAI Item	Response Date
03.07.02-17	The interaction of non-seismic Category I structures with Seismic Category I systems is described in FSAR Section 3.7.2.8. In this section on page 3.0-41, it states that fire protection SSCs are categorized as either Seismic Category II-SSE, meaning the SSC must remain functional during and after a Safe Shutdown Earthquake (SSE), or Seismic Category II, meaning the SSC must remain intact after an SSE without deleterious interaction with a Seismic Category I or Seismic Category II-SSE SSC. In the U.S. EPR FSAR on page 3.7-95, it states that Seismic Category II is designed to the same criteria as Seismic Category I structures. In SRP 3.7.2, SRP Acceptance Criteria 8, which addresses the interaction of non-Category I structures with Category I SSCs, it states that when non-Category I structures are designed to prevent failure under SSE conditions; the margin of safety shall be equivalent to that of the Seismic Category I structure. • Describe how this margin of safety is achieved for the Seismic Category II-SSE and Seismic Category II portions of the fire protection system. Include in your response the seismic inputs, loading combinations, codes and acceptance criteria. What are the differences in the method of design for these two seismic categories? • Describe the basis and provide figures in the FSAR of the design response spectra used to analyze above ground seismic Category II and seismic Category II-SSE fire protection SSCs including the fire protection tanks. • What are the methods of analysis and acceptance criteria for both the buried and above ground portions of the fire protection system that are Seismic Category II-SSE that will ensure that these portions of the system will remain functional following an SSE event? • What are the modeling and analysis methods used for the fire protection tanks and to what extent do the fire protection tanks meet the acceptance criteria of SRP 3.7.3, SRP Acceptance Criteria 14.A. thru J? When the tank analysis does not meet the acceptance criteria, provide the technical justification for not doing so.	October 16, 2009
03.07.02-18	Clarify the seismic classification of fire protection tank and building.	July 29, 2009
	Reconcile the U.S. EPR seismic analysis for NAB with the site-specific soil properties and foundation input response spectra (FIRS)	September 15, 2009

Response Summary for Requests for Additional Information

RAI Set 65 Question	Description of RAI Item	Response Date
	Demonstrate in the FSAR that the displacement of this structure relative to the nuclear island common basemat structure is enveloped by the results of the U.S. EPR analysis.	September 15, 2009
03.07.02-19	In FSAR Section 3.7.2.8 on page 3.0-42 it states that the conventional seismic switchgear building, conventional seismic grids systems control building, the conventional seismic circulating water intake structure and the Seismic Category II retaining wall surrounding the CCNPP Unit 3 intake channel could potentially interact with Seismic Category I SSCs. For each of the above structures, describe in the FSAR how the seismic interaction acceptance criteria of SRP 3.7.2, SRP Acceptance Criteria 8 are met, or justify an alternative. If they are intended to meet criterion B, provide the technical basis for the determination that the collapse of the non-Category I structure is acceptable. For criterion C, confirm that the structure will be analyzed and designed to have a margin of safety equivalent to that of a Category I structure and state how this will be accomplished.	October 16, 2009
03.07.02-20	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.02-21	See UniStar Nuclear Energy letter UN#09-228, dated May 1, 2009	Response submitted
03.07.02-22	See UniStar Nuclear Energy letter UN#09-126, dated March 19, 2009	Response submitted
03.07.02-23	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted
03.07.02-24	Per COLA item 3.7-1, address that the seismic response of the nuclear island common base mat structures, seismic Category II structures, the Nuclear Auxiliary Building and the Radioactive Waste Processing Building is within the parameters of Section 3.7 of U.S. EPR FSAR.	September 15, 2009
	Provide a summary for each structure, either directly or by reference, which describes how the COL item is met.	September 15, 2009
03.07.02-25	See UniStar Nuclear Energy letter UN#09-228, dated May 1, 2009	Response submitted
03.07.02-26	See UniStar Nuclear Energy letter UN#09-291, dated June 12, 2009.	Response submitted

Enclosure 2

**Response to NRC Request for Additional Information,
RAI No. 58, Seismic Design Parameters, Question 03.07.01-2 and 03.07.01-4;
RAI No. 63, Seismic Subsystem Analysis, Question 03.07.03-01; and
RAI No. 65, Seismic System Analysis; Question 03.07.02-15;
Calvert Cliffs Nuclear Power Plant Unit 3**

RAI No. 58

Question 03.07.01-2

Provide a figure in the FSAR depicting the soil-structure-interaction (SSI) model for the nuclear island (NI) common basemat structure including the model of the supporting subgrade. In addition, provide the following information:

State whether or not embedment effects were considered in this analysis and, if not, what is the justification for not including them and what impact could this have on the analysis results?

Describe the properties of the structural backfill and how the fill was modeled in the SSI analysis.

As the groundwater table is close to the bottom of the basemat, how are groundwater effects treated in the SSI confirmatory analysis?

Describe the computer codes used to analyze the site-specific SSI of the NI common basemat structure including a description of the code, extent of application in the analysis, and basis for computer code validation. Provide similar information for the codes used in the development of foundation input response spectra for each of the seismic Category I structures, as well as for the codes used in the seismic analysis of other SSCs covered in FSAR Sections 3.7.1, 3.7.2, and 3.7.3.

Response

Provide a Figure in the FSAR depicting the soil-structure-interaction (SSI) model for the nuclear island (NI) common basemat structure including the model of the supporting subgrade:

The SSI model used for the U.S. EPR FSAR is used for confirmatory analyses as identified in the Calvert Cliffs Nuclear Power Plant Unit 3 (CCNPP Unit 3) FSAR Section 3.7.1.1.1. The confirmatory analyses indicate that the site-specific CCNPP Unit 3 SSI is bounded by the generic U.S. EPR SSI. U.S. EPR FSAR Tier 2 Figure 3.7.2-63 depicts the SSI model for the nuclear island (NI) common basemat structure including a model of the supporting subgrade. This figure is applicable to CCNPP Unit 3.

State whether or not embedment effects were considered in this analysis and, if not, what is the justification for not including them and what impact could this have on the analysis results:

Parametric analyses were performed to identify the impact of embedment effects on analysis results. The SSI model used for the U.S. EPR design was modified to include embedment effects. SSI analyses of the embedded U.S. EPR model were performed for the generic U.S. EPR soil profile and control motion combinations. Results of analysis of the embedded model versus the surface-founded model for Soil case 1u (with a uniform shear-wave velocity of 700 fps) were compared. This soil case is representative of the CCNPP Unit 3 soil profile, and embedment modeling produces comparable results to in-structure response spectra generated from the surface-founded model. Since the CCNPP Unit 3 foundation input response spectra (FIRS) is significantly smaller than the European Utility Requirements (EUR) Soft Soil ground motion as shown in COLA FSAR Figures 3.7-1 and 3.7-2, CCNPP Unit 3 is bounded by the certified design.

Describe the properties of the structural backfill and how the fill was modeled in the SSI analysis:

The NI common basemat structure confirmatory SSI analysis is based on undisturbed in-situ material. Discrete thin strata or localized areas of the foundation bearing soils may be encountered during construction that do not meet the COLA required soil properties. In the event substandard materials are encountered they will be replaced with engineered structural fill that has characteristics comparable to the site soil properties of the undisturbed material considered in the analyses, or a site-specific validation will be performed.

The confirmatory SSI analysis is based upon undisturbed site soils, and load bearing structural backfill was not considered for the NI. The construction sequence currently does not include a gross or generic undercut of the NI; therefore, structural fill below the foundation elevation was not considered in the analyses. Evaluation of current geotechnical data indicates that if soft soil conditions are encountered in the NI area, the depth of the undercut should be small. Properties of the replacement materials are to be comparable to undisturbed site soils considered in the analyses.

As the groundwater table is close to the bottom of the basemat, how are groundwater effects treated in the SSI confirmatory analysis:

For submerged soil layers, the water P-wave velocity (4800 fps) is used where the soil P-wave velocity is less than that of water.

Describe the computer codes used to analyze the site-specific SSI of the NI common basemat structure including a description of the code, extent of application in the analysis, and basis for computer code validation:

The Nuclear Island Common Basemat Structures site-specific SSI was analyzed using AREVA SASSI code version 4.1B and RESPEC version 1.1A. SASSI consists of a number of interrelated computer program modules used to solve a wide range of dynamic soil-structure interaction problems in two dimensions or three dimensions. RESPEC computes the response spectra of acceleration time histories digitized at equal intervals. Both codes have been verified and validated in accordance with the AREVA 10 CFR 50 Appendix B QA program.

Provide similar information (description of code, extent of application in the analysis and basis for computer code validation) for the codes used in the development of foundation input response spectra for each of the seismic Category I structures:

Two computer codes, SOILSIM and RVTSITE described in Table 1 (Summary of Computer Codes Used To Generate FIRS for CCNPP Unit 3 Seismic Category I Structures), were used in the development of the FIRS for the Seismic Category I structures, namely, Nuclear Island Common Basemat (NICBM) Structures, the Essential Service Water Building (ESWB) and the Emergency Power Generating Building (EPGB). No FIRS, based on site response analysis, was developed for the Ultimate Heat Sink Makeup Water Intake Structure (UHS MWIS) and Ultimate Heat Sink Electrical Building (UHS EB). As discussed in FSAR Section 3.7.1.1, the ground motion response spectrum (GMRS) developed for NICBM structures was used as representative FIRS for UHS MWIS.

Upon completion of geotechnical investigations for in-situ soils and structural fill in the intake area, FIRS for the UHS MWIS and UHS EB will be developed. Furthermore, new FIRS for EPGB and ESWB structures will be developed upon completion of geotechnical investigations for the structure fill in the NI area. The information about computer codes to be used in the future work related to FIRS development will be provided after completion of these geotechnical investigations.

Table 1 provides descriptions of the various codes, extent of application in the analyses, and validation basis for the computer codes.

Provide similar information (description of code, extent of application in the analysis and basis for computer code validation) for the codes used in the seismic analysis of other SSCs covered in FSAR Sections 3.7.1, 3.7.2, and 3.7.3.

The computer code GT STRUDL described in Table 2 (Summary of Computer Codes Used to Perform Seismic Analysis of the Seismic Category I Structures Covered in FSAR Sections 3.7.1, 3.7.2, and 3.7.3) was used to create the finite-element model of the UHS MWIS and to perform subsequent soil-structure interaction analysis using time-history method.

The computer codes described in Table 3 (Summary of Computer Codes Which will be Used for Seismic Category I Structures Covered in FSAR Sections 3.7.1, 3.7.2 and 3.7.3) will be utilized to perform the future seismic reconciliation of NICBM, EPGB, ESWB, UHS MWIS, and UHS EB.

Table 1: Summary of Computer Codes Used to Generate FIRS for CCNPP Unit 3 Seismic Category I Structures

Computer Code	Description of Code	Extent of Application in Analysis	Basis for Computer Code Validation
SOILSIM	SOILSIM calculates sets of random, correlated parameters of the soil profile, including shear-wave velocity, stiffness vs. strain, and damping vs. strain. The program uses as input site-specific estimates of shear-wave velocity vs. depth and its associated uncertainty, soil unit-weight vs. depth, parameters for the randomization of layer thickness, damping curves and their associated uncertainty, and modulus-reduction curves and their associated uncertainty.	Development of randomized soil profiles for the soil column at the NICBM structures and at the EPGB and ESWB.	The computer code is proprietary to Risk Engineering Inc. The basis for validation of the software is comparison of output from program to independent calculations. Validation manuals and files for SOILSIM are archived at Risk Engineering Inc. offices in Boulder, Colorado and are controlled under Risk Engineering's QA Program. The program is in compliance with the requirements of ASME NQA-1-1994.
RVTSITE	RVTSITE calculates site response, based on soil profiles developed by SOILSIM, given an input rock motion, characterized as an elastic response spectrum representing rock motion at the base of the profile or at a rock outcrop. The site conditions are characterized by low-strain shear wave velocity profile, the unit weight vs. depth, and the damping and modulus reduction curves for the various soil units. An equivalent-linear formulation of site response is used to represent non-linear soil behavior, and the solution is obtained using random-vibration theory. The site response is calculated for multiple profiles in order to characterize uncertainty in the site conditions. The median site response and site response variance are calculated over a wide range of spectral periods.	Site response analysis and development of FIRS for NICBM Structures and ESWB/EPGB structures. The FIRS for EPGB and ESWB structures were based on assumed backfill properties.	The computer code is proprietary to Risk Engineering Inc. The basis for validation of the software is comparisons to published site response calculations using the independent program SHAKE91, supplemented by additional comparisons of program output to hand calculations. Validation manuals and files for RVTSITE are archived at Risk Engineering Inc. offices in Boulder, Colorado and are controlled under Risk Engineering's QA Program. The program is in compliance with the requirements of ASME NQA-1-1994.

Table 2: Summary of Computer Codes Used to Perform Seismic Analysis of the Seismic Category I Structures Coverd in FSAR Sections 3.7.1, 3.7.2, and 3.7.3.

Computer Code	Description of Code	Extent of Application in Analysis	Basis for Computer Code Validation
GT STRUDL	GT STRUDL is a general purpose structural engineering computer program to perform finite- element modeling and subsequent static and dynamic analyses.	GT STRUDL was used to create the finite-element model and to perform soil-structure interaction analysis of UHS MWIS by time-history method.	GT STRUDL is a commercial structural engineering program developed by Georgia Tech. Quality Assurance (QA) and Quality Control (QC) requirements for safety related structures are documented in the vendor's validation and verification manuals. GT STRUDL is a computer program accepted per Bechtel's Engineering Department and QA Procedures. The program is in compliance with the requirements of ASME NQA-1-1994.

Table 3: Summary of Computer Codes Which will be Used for Seismic Category I Structures Covered in FSAR Sections 3.7.1, 3.7.2 and 3.7.3

Computer Code	Description of Code	Extent of Application in Analysis	Basis for Computer Code Validation
SETARGET	SETARGET generates acceleration response spectra interpolated at specified evenly log-spaced frequency intervals for a given frequency spectrum. The interpolated spectrum created in SETARGET is compatible for further applications using the program RSPM.	This program will be used to generate broad band CCNPP Unit 3 design SSE response spectra. The design SSE spectra Is generated as the envelope of interpolated RG 1.60 spectrum scaled to PGA of 0.1 g and interpolated EUR soft soil spectrum scaled to PGA of 0.15 g. Each spectrum is interpolated at evenly log-spaced frequency intervals. The target spectrum is then developed by enveloping the two spectra. The generated design SSE spectrum, appropriately modified for SSSI effects from NI will be used for the seismic analysis of the EPGB and ESWB structures. The design SSE spectrum will also be used in the seismic analysis of UHS MWIS and UHS EB.	This program is developed and maintained in accordance with Bechtel's engineering department and QA procedures. Validation Manuals are maintained in Computer Services Library in Bechtel' Frederick offices. Validation of the computer code was performed by comparing individual response spectra to the corresponding generated response spectra based on evenly log-spaced frequency intervals in a Microsoft Excel environment. The program is in compliance with the requirements of ASME NQA-1-1994.

Table 3: Summary of Computer Codes Which will be Used for Seismic Category I Structures Covered in FSAR Sections 3.7.1, 3.7.2 and 3.7.3

Computer Code	Description of Code	Extent of Application in Analysis	Basis for Computer Code Validation
RSPM	RSPM develops response spectrum compatible time histories.	The program will be used to generate time histories compatible with target response spectra generated by the program SETARGET.	This program is developed and maintained in accordance with Bechtel's engineering department and QA procedures. Validation Manuals are maintained in Computer Services Library in Bechtel' Frederick offices. Validation of the computer code was performed for each individual component of the computer code against various applicable independent programs. The program is in compliance with the requirements of ASME NQA-1-1994.
GT STRUDL	See Table 2 for description of this code.	This program will be used to create finite-element models of UHS EB and to modify existing finite-element models of UHS MWIS.	See Table 2 for description of this code.
SASSI 2000	SASSI 2000, a system for analysis of soil-structure interaction, consists of a number of interrelated computer program modules which can be used to solve a wide range of dynamic soil-structure interaction problems in two or three dimensional space.	This program will be used for the soil structure interaction analyses of UHS MWIS and UHS EB, based on structural finite element models created by GT STRUDL. SASSI 2000 program will also be used to perform site-specific seismic reconciliation of EPGB and ESWB.	This program is developed and maintained in accordance with Bechtel's engineering department and QA procedures. Validation Manuals are maintained in Computer Services Library in Bechtel' Frederick offices. The program is in compliance with the requirements of ASME NQA-1-1994.

COLA Impact

None

RAI No. 58

Question 03.07.01-4

In FSAR Section 3.7.1.1.1, on page 3.0-32, it discusses the design response spectrum used to analyze the Ultimate Heat Sink (UHS) Makeup Water Intake Structure. The spectral comparison between the European Utility Requirements (EUR) soft soil spectrum scaled to 0.15 g, the RG 1.60 spectrum scaled to 0.1 g, and the ground motion response spectra (GMRS) shown in Fig. 3.7-38 indicates that the RG 1.60 spectrum and GMRS exceed the EUR spectrum at frequencies below 0.7 and 0.4, respectively. What is the corresponding comparison of displacements and velocities for these spectrum motions, and if the EUR displacements are exceeded, how will this be addressed in the design of piping and other appurtenances connected to these buildings including the design of buried utilities?

Response

Revision 5 of the FSAR, Figure 3.7-38, provides comparison of EUR soft soil spectrum scaled to 0.15 g with RG 1.60 spectrum scaled to 0.1g and site-specific horizontal GMRS (with PGA of 0.067 g). As described in FSAR Section 3.7.1.1.1, the scaled down EUR soft spectrum was selected as design response spectrum for the UHS Makeup Water Intake Structure (MWIS). Due to the unavailability of FIRS and other sub-surface investigation information, the GMRS at the bottom of Nuclear Island, NI, (approximate Elevation 44 ft) was considered conservative representation of FIRS at the bottom of UHS MWIS. The comparison with RG 1.60 spectrum was provided as additional information. A discussion is also presented in Section 3.7.2.4 to assess and address impact of exceedance of the design response spectrum by the representative FIRS (same as GMRS at NI) in the low frequency region.

However, as discussed during the NRC onsite technical audit (March 17 through 19, 2009) and NRC public meeting (April 17, 2009), the EUR soft soil spectrum scaled to 0.15g will be enriched in the low frequency region to envelop RG 1.60 spectrum scaled to 0.1g and the representative FIRS (GMRS underneath NI). The horizontal and vertical GMRS for NI were updated to a PGA of 0.0755 g as reported in Table 2.5-22 and Figure 2.5-87 of enclosure to Unistar Nuclear Energy letter UN#08-027[1].

Figure 1 in this response depicts the updated design response spectrum for UHS MWIS. The modified design response spectrum envelops the RG 1.60 spectrum scaled to 0.1g and representative FIRS (new GMRS with PGA of 0.0755 g for NI submitted in Unistar Nuclear Energy letter UN#08-027[1]). Therefore, the displacement and velocity spectra for these motions (i.e., RG 1.60 and GMRS for NI) will also be enveloped by those for the updated design response spectrum.

Once the sub-surface investigation at the location of the UHS MWIS is complete, it will be demonstrated that the actual FIRS for the UHS MWIS are enveloped by the design response

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[1] UniStar Nuclear Energy Letter UN#08-027, from George Vanderheyden (UniStar Nuclear Energy) to Document Control Desk, U.S. NRC, Submittal of Supplemental Information for the Calvert Cliffs Nuclear Plant, Unit 3, Combined License Application Updated Information for Ground Motion Response Spectrum, dated July 31, 2008

spectrum. As a result, no special assumptions or design procedures are required for the design of piping and other appurtenances connected to UHS MWIS.

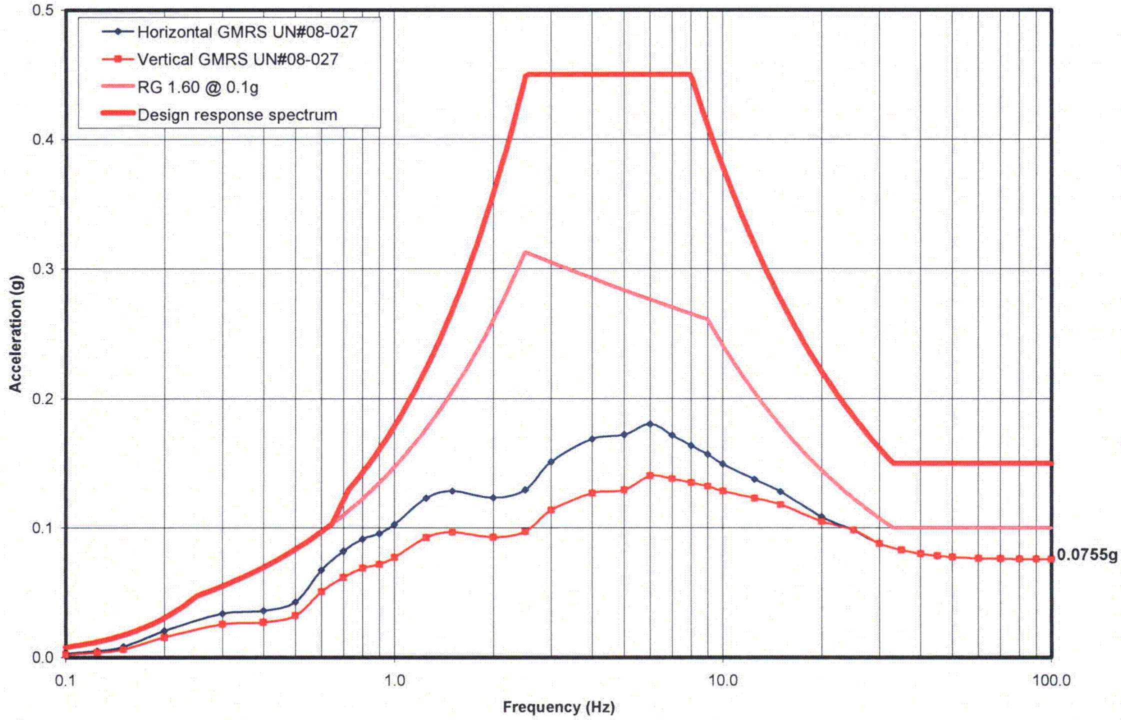

Figure 1: Comparison of Calvert Cliffs Site SSE 5% damping spectrum, RG 1.60 spectrum scaled to 0.1g and GMRS for NI structures

COLA Impact

FSAR sections will be updated once the sub-surface investigation at the location of the UHS MWIS is available and the seismic reconciliation using SASSI is completed as indicated in the response summary for RAIs in Enclosure 1 for RAI Set 65 Question 03.07.01-6.

RAI No. 63

Question 03.07.03-1

FSAR Section 3.7.3.12 starting on page 3.0-45 describes the analysis for buried Seismic Category I piping, conduits and tunnels. For the analysis of these buried utilities, provide the following information:

- Describe any computer codes used for the analysis and their application to the analysis and design of buried utilities.
- Provide the soil properties used in the analysis and explain how differences in soil properties were accommodated in the analysis.
- Provide the design codes and acceptance criteria for each category of buried utilities.
- Describe the missile protection provided for safety-related buried utilities.
- Describe how ground water effects were considered in the analysis.
- For utility runs that are both above and below ground, describe how above ground inertial effects were combined with below ground seismic wave effects.
- Describe how the wave velocities were determined for calculating the maximum axial strain.
- Provide the basis for determining the maximum friction force per unit length of pipe.
- Describe how the building anchor point displacements were determined and how these were combined with seismic wave effects and soil loads.

Response

Seismic Category (SC) I buried commodities are in the form of either buried piping or ductbanks (i.e., no tunnels). No calculations have yet been performed for analysis and design of any of these SCI buried commodities. The following responses describe the analysis methods to be used during the detailed design phase.

Computer codes used for the analysis and their application to the analysis and design of buried utilities:

Long/unconstrained segments of buried utilities are subjected to axial and bending stresses due to strains imposed by passing seismic waves. Calculation of these stresses as well as stresses due to surcharge and pressure do not require any computer codes as simple hand computations can be made using readily available closed form equations (for example, ASCE 4-98 and 1983 ASCE Report - Seismic Response of Buried Pipes and Structural Components). The axial force induced in the buried commodities due to seismic waves or thermal load is however limited by the friction coefficient between the commodity surface and the surrounding soil material (which can be the backfill material or bedding). The axial force and the associated stresses are thus limited by the magnitude of the friction force and are calculated without use of a computer code.

As noted in ASCE 4-98 Commentary and the 1983 ASCE Report, shear strains/stresses caused by passing seismic waves are generally ignored unless the buried commodity is supported on very rigid layer (e.g., permafrost). Since Calvert Cliffs is a soil site and conventional bedding materials will be used to support the buried commodities (especially buried pipes), shear strains/stresses are ignored for long segments.

Analysis of segments with bends (direction changes) and/or involving anchors at building entry locations generally requires the use of computer codes to obtain the additional bending stresses caused by axial force acting on the intersecting leg (in case of bends or tees) or anchor movement. As explained in the 1983 ASCE Report and in Appendix VII of ASME B31.1, these are conservatively treated as static analysis problems, whereby the axial force due to seismic waves or thermal load is conservatively applied as a static force on piping segments to assess the flexural and shear stresses caused in the intersecting legs. In the case of anchors, the maximum anchor movement in each direction is applied separately as a support movement for obtaining the resulting stresses in the buried segments. For simple piping layouts, the necessary analyses could be performed using available closed form formulas for beams-on-elastic-foundations; however, the use of computer codes makes it possible to analyze more complex configurations and perform design iterations, if necessary. The computer codes evaluate the beam-on-elastic-foundation behavior, which requires that appropriately refined element sizes be used to model the buried segments. The elastic support is modeled using the dynamic modulus of subgrade reaction considering the target soil strains due to the peak ground response parameters. Appendix VII of ASME B31.1 provides guidance on how computer models can be developed for various situations. For buried piping, such analyses can be performed using GTSTRUDL, SUPERPIPE, ANSYS, or ME101. For non-piping buried commodities such as ductbanks, either ANSYS or GTSTRUDL will be used to perform the necessary beam-on-elastic-foundation static analysis for calculation of the bending moments and shear forces in the ductbank.

Soil properties used in the analysis and explanation how differences in soil properties were accommodated in the analysis:

Implementation of the equations provided in ASCE Report (1983) and the beam-on-elastic-foundation analysis methods for analysis of constrained segments per Appendix VII of ASME B31.1, requires several soil parameters. For the soil media surrounding the various buried commodities, the following soil properties are needed:

a) Shear wave velocity
b) Compression wave velocity
c) Surface (Rayleigh) wave velocity
d) Peak Particle Velocity (peak ground velocity, PGV)
e) Peak Particle Acceleration (peak ground acceleration, PGA)
f) Peak Particle Displacement (peak ground displacement, PGD)
g) Dynamic Modulus of Elasticity of soil for strain level corresponding to peak ground motion and the corresponding Dynamic Modulus of Subgrade Reaction for buried commodity

h) Friction coefficient between buried commodity's surface and surrounding soil
i) Modulus degradation and soil damping variation with soil strain level for backfill and bedding material (if the characteristics and/or depth of backfill surrounding the buried commodity is considered significant enough to influence the soil amplification behavior)

Values for the above soil properties will be determined during the geotechnical site investigation. The soil investigations are conducted at frequent intervals along the buried commodity runs to ascertain if native soil properties (Items a, b, c, g, and i above) vary, which could warrant soil amplification studies to be performed for various locations along the buried commodity segment(s). If the backfill material extends well below the buried commodity (more than several feet) and if its modulus degradation and damping characteristics are significantly different than the native soil properties in the surrounding area, then the backfill properties will be used to obtain the spectrum at the buried commodity elevation. Most likely any such exercise will be shown to be unnecessary because the site-specific SSE chosen for Calvert Cliffs will well exceed the spectrum obtained from site response analyses.

The PGD, PGV, and PGA values are based on the site-specific SSE chosen for the Calvert Cliffs Unit 3 site (for buried commodities in the vicinity of the NI, the enveloped spectrum due to SSSI effects are considered). As explained in the 1983 ASCE Report, it is difficult to attribute specific values to the various types of seismic waves that produce the particle motion. As such, the same maximum PGD, PGV, and PGA values are conservatively assigned for all types of seismic waves.

The PGD value is determined directly from the constant displacement portion of the acceleration spectra. For determination of PGV, the greater of values based on: (i) Equation 5-10 in NCHRP Report No. 611 "Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments" (Transportation Research Board, 2008), and (ii) the empirical rule of 4 ft/sec PGV per 1.0g PGA, is used to provide a conservative value. The dynamic modulus of the soil is based on the target strain level corresponding to the shaking associated with the site-specific SSE. The associated dynamic modulus of subgrade reaction is determined using the equations presented in ASME B31.1 Appendix VII as well as the 1983 ASCE Report; however, geotechnical experts will also be consulted to obtain an estimate directly based on the soil dynamic moduli for the soil layers below the piping. A variation of -50% to +100% is considered relative to the best estimate value.

For buried piping, the friction coefficient is based on the recommendations provided in the 1983 ASCE report. For concrete ductbanks, the friction coefficients are the same as the friction coefficient considered for evaluating sliding stability of foundations.

The supporting soil media is also evaluated for the potential for sudden ground failure due to soil liquefaction, soil settlement, or permanent ground deformation. It is expected that such potential does not exist (either appropriate soil improvement is to be performed or the layout of the buried commodities altered to avoid any problematic locations).

Design codes and acceptance criteria for each category of buried utilities:

The design codes and the acceptance criteria are as follows:

Buried Piping: Seismic Category I buried piping systems such as UHS Makeup Water System are analyzed in accordance with ASME B&PV, Section III, Div. 1 and B31.1 design codes. The load combinations and stress acceptance criteria specified in Section 3.10, Table 3-4 of ANP-10264NP-A[2] are used to verify the adequacy of buried piping.

Ductbanks: Design of ductbanks are in accordance with IEEE 628 and ACI 349.

Missile protection provided for safety-related buried utilities:

Missile protection is per RG 1.76, Rev. 1. The soil cover on top of the buried commodities is a minimum of 3 ft and will be shown to be adequate to resist the vertical tornado missiles identified in RG 1.76. The relevant equations provided in ASCE Manual of Practice No. 58 (1980) are used to demonstrate the adequacy of the soil cover, or if necessary, barrier design requirements in SRP Section 3.5.3 followed to design appropriate tornado missile barrier. Missiles other than tornado missiles are not applicable to the buried commodities.

Consideration of ground water effects in the analysis:

The presence of ground water will increase the compression wave velocity. Given that the same PGA and PGV values are conservatively assigned to all types of seismic waves, an increase in compression wave velocity will in turn reduce the corresponding axial and bending strains induced into the buried commodities as they are inversely proportional to wave velocity and the square of wave velocity, respectively. As such, it is conservative to ignore the effect of ground water on stresses caused in long and unrestrained segments of buried commodities.

For short/restrained segments, the presence of ground water may increase the associated soil impedance in the vertical direction. It is conservative to ignore such increase because a smaller soil spring value estimate will lead to prediction of larger bending moments in the buried commodity.

How above ground inertial effects were combined with below ground seismic wave effects for utility runs that are both above and below ground:

The above-ground (and within building) utility runs are isolated from the underground runs by using a rigid anchor at the building entry point. This eliminates the need for combining the inertial effects of above-ground segment's response with below-ground seismic wave effects. Stresses caused in the below-ground segment due to anchor movement are calculated by performing static analysis of the segment as a beam-on-elastic-foundation. The stresses due to wave effects, anchor movement, and axial friction forces are combined in an square root of the sum of the squares (SRSS) manner.

Determination of wave velocities for calculating the maximum axial strain:

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[2] ANP-10264NP-A, Revision 0, U.S EPR Piping Analysis and Pipe Support Design Topical Report" AREVA NP Inc. November 2008."

Please see response to the second sub-question for additional discussion. Geotechnical investigations along buried commodity runs provide estimates of P-wave and S-wave velocities for the in situ soil media. The velocity values for the bedding/backfill material, if significantly different than the underlying in situ material, are determined in the same manner as for the structural backfill material used under the SCI EPGB and ESWB foundations.

Basis for determining the maximum friction force per unit length of pipe:

The friction coefficient values recommended in the 1983 ASCE Report are used for determining the maximum friction force per unit length of pipe. Pipe suppliers will be consulted to establish conservative bounds on the friction coefficient. For buried ductbanks, the friction coefficient is the same as that used for concrete foundation/soil interface, which is recommended by geotechnical practice.

Determination of building anchor point displacements and how these were combined with seismic wave effects and soil loads:

Building anchor point displacements consist of two components: settlements and seismic movement. To the extent practical, the tie-in activities for buried commodities are deferred until a significant portion of the settlement has already occurred. Geotechnical engineers perform the settlement analyses to provide the expected additional settlement after the tie-ins of buried commodities. The stresses caused due to this residual settlement are treated as a static load case that is combined with other static load cases.

Typically the anchor point seismic displacement is obtained from soil-structure interaction analysis of the building computing relative displacement with respect to free field in three directions and imposing the relative displacements to the pipe. For Calvert Cliffs, the anchor point seismic displacements are obtained from the seismic reconciliation analyses for standard plant facilities and from the design calculations for the site-specific structures.

The SRSS method is used to combine the stresses due to building seismic movement and seismic wave effects. The effect of soil load (i.e., overburden/surcharge) and building (non-seismic) settlement due to the sustained loads is considered as static load cases. The stresses due to static load cases are added to the seismically induced stresses to calculate the total stress. For ductbanks, the load combinations are in accordance with ACI 349. For piping, the load combinations are per ANP-10264NP-A[2].

COLA Impact

None

RAI No. 65

Question 03.07.02-15

In FSAR Section 3.7.2.6 on page 3.0-40, it states that for the Ultimate Heat Sink (UHS) Makeup Water Intake Structure (MWIS), three statistically independent time histories are applied for each of the six soil cases to determine accelerations at select locations. Describe how the accelerations obtained from this dynamic analysis are applied to the static model to obtain forces and moments for structural design and provide examples of how the three components of earthquake motion are combined and compare the results to those of the 100-40-40 rule presented in RG 1.92, Revision 2. The use of an equivalent static approach to determine forces and moments in the structure may not be conservative as dynamically computed forces and moments will retain the appropriate sign from the analysis and the static approach will not. How will this be addressed in the development of loads used in the design of the structure?

Response

Describe how the accelerations obtained from the dynamic analysis are applied to the static model:

Figure 1 shows the geometry of the Ultimate Heat Sink (UHS) Makeup Water Intake Structure (MWIS), including the X, Y and Z coordinate axes from the GT STRUDL model.

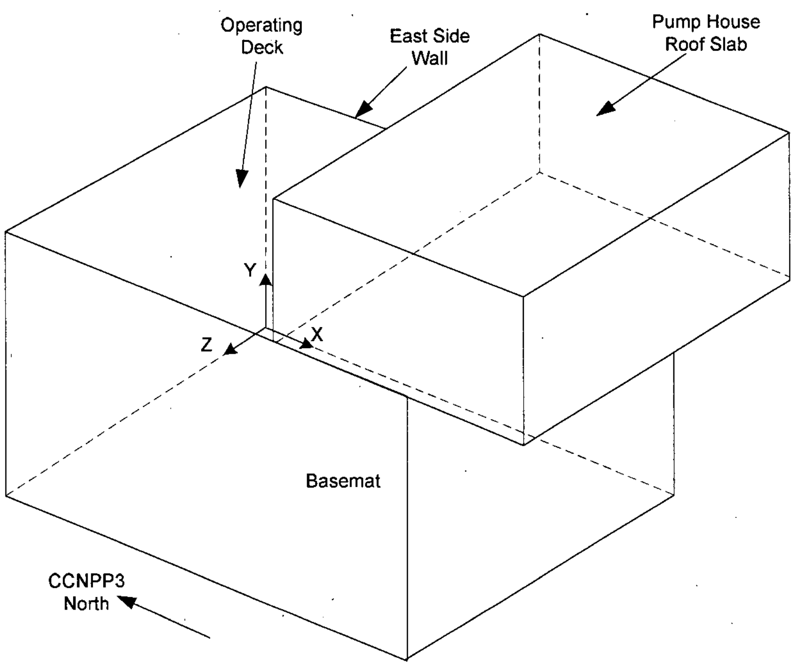


Figure 1: UHS MWIS Geometry (internal walls and openings not shown for clarity)

As described in FSAR Section 3.7.2.6, the time history analysis of UHS MWIS is performed for statistically independent time histories in the three directions for six soil cases. For a structural panel (wall/slab) under consideration, the three components of maximum acceleration response (i.e., absolute peak values from acceleration response time history) are determined at each joint of GT STRUDL finite element model for each soil case and in each direction of earthquake, resulting in a total of 54 acceleration values (i.e., 6 soil cases × 3 time histories × 3 directional components) at each joint. As an example, for soil analysis case 1 (soil case with 50% shear modulus and without embedment), Figures 2, 3 and 4 respectively show the joint acceleration values along X, Y and Z directions for operating deck slab at Elevation 11.5 ft, when SSE ground motion is applied along Z direction. In these figures, typically referred to as bubble plots, the diameter of the bubble represents the magnitude of the acceleration.

From the joint acceleration values (bubble plots), for each soil case and in each direction of SSE motion, a weighted average acceleration value is determined for each structural panel for three acceleration components. The joint inertia, as illustrated in Equation 1, is used as the weighting factor. If the joint acceleration profiles vary significantly over any structural panel, the weighted average accelerations may be calculated for smaller regions of the structural panel. However, the variation in the joint acceleration profiles for various panels of the UHS MWIS is insignificant and a single value of the weighted average acceleration value is determined for each panel.

$$a_{mw,lji} = \frac{\sum m_k a_{k,lji}}{\sum m_k} \tag{1}$$

where, for each structural panel,

- $a_{mw,lji}$ is the mass weighted average acceleration for soil case l for acceleration component j for SSE motion along i,
- m_k is the lumped mass (inertia) for joint k within the panel, and
- $a_{k,lji}$ is the acceleration value at joint k for soil case l for acceleration component j for SSE motion along i.

This procedure results in a total of 54 acceleration values (i.e. 6 soil cases × 3 time histories × 3 components) for each structural panel. These weighted averaged values are enveloped for the six soil cases, resulting in 9 acceleration values for each panel. Table 1 shows the enveloped weighted averaged acceleration values for typical structural panels for UHS MWIS identified in Figure 1. FSAR Table 3.7-6 presents the same information for the basemat, operating deck and pump house roof slab.

Table 1: Uniform Mass Weighted Acceleration values used for Equivalent Static Analysis of UHS MWIS

Panel	SSE Motion Along X (E_X)			SSE Motion Along Y (E_Y)			SSE Motion Along Z (E_Z)		
	Axx (g)	Ayx (g)	Azx (g)	Axy (g)	Ayy (g)	Azy (g)	Axz (g)	Ayz (g)	Azz (g)
Basemat	0.27	0.09	0.00	0.07	0.30	0.00	0.02	0.07	0.24
Operating Deck	0.30	0.11	0.00	0.05	0.31	0.00	0.02	0.08	0.35
Pump Roof Slab	0.39	0.15	0.00	0.09	0.33	0.00	0.02	0.08	0.38
East Side Wall	0.28	0.09	0.00	0.05	0.30	0.00	0.05	0.14	0.30

For the subsequent equivalent static analysis, equivalent joint seismic forces for the static model are computed as the products of the acceleration values (A_{ji}) from Table 1 and the joint masses (m_k).

Figure 2: Acceleration along X due to SSE along Z for Operating Deck Slab (Soil Case 1)

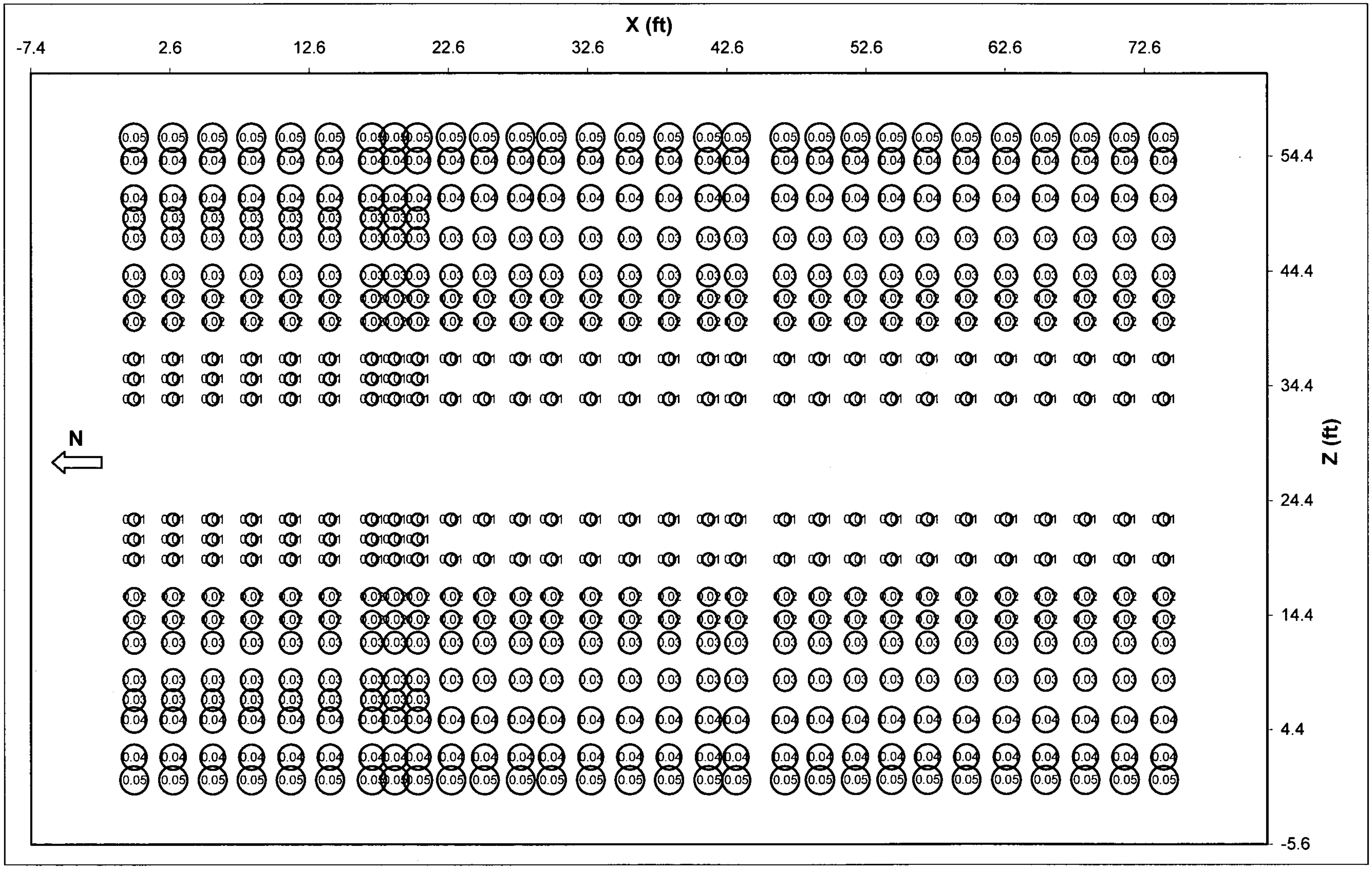


Figure 3: Acceleration along Y due to SSE along Z for Operating Deck Slab (Soil Case 1)

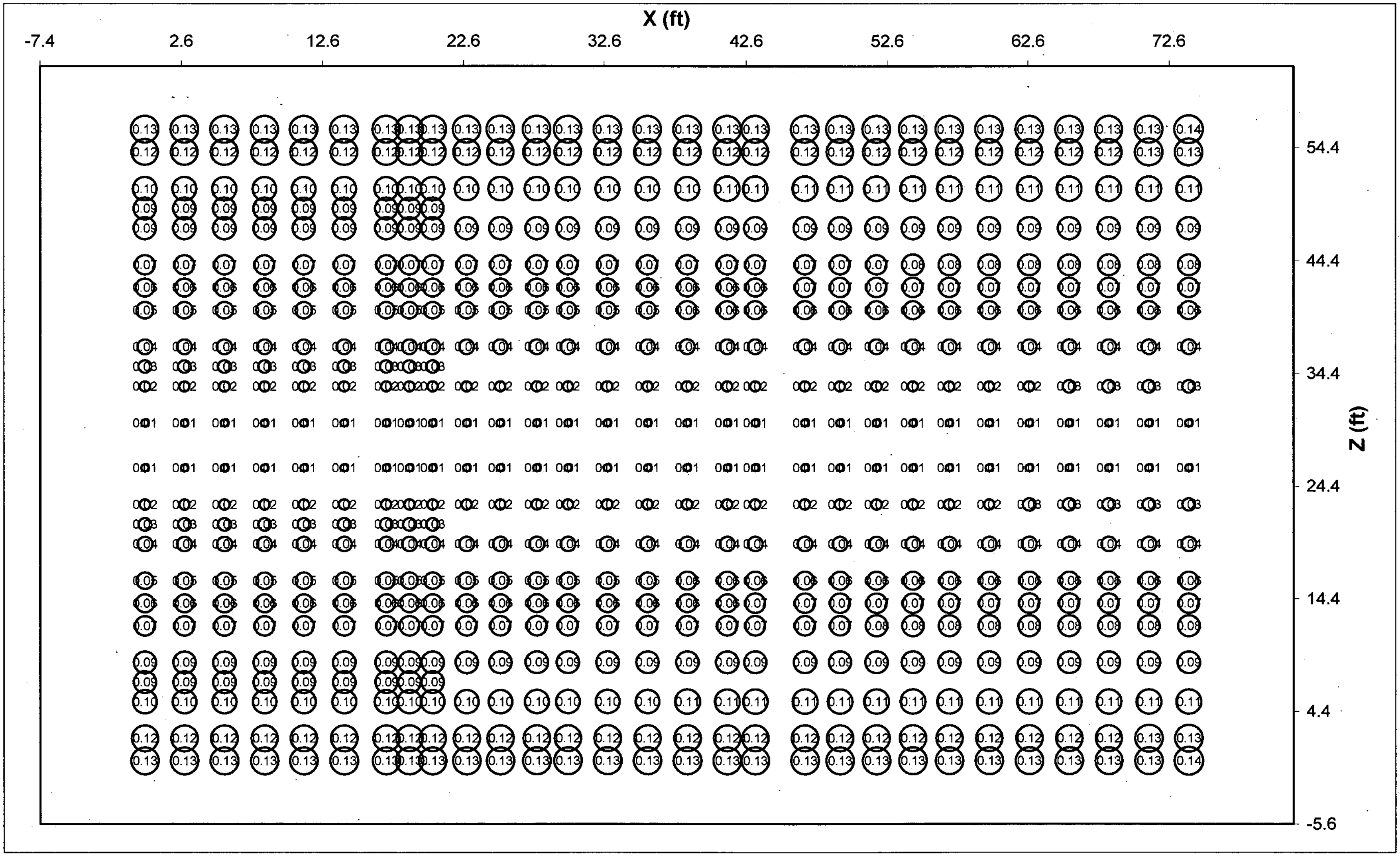
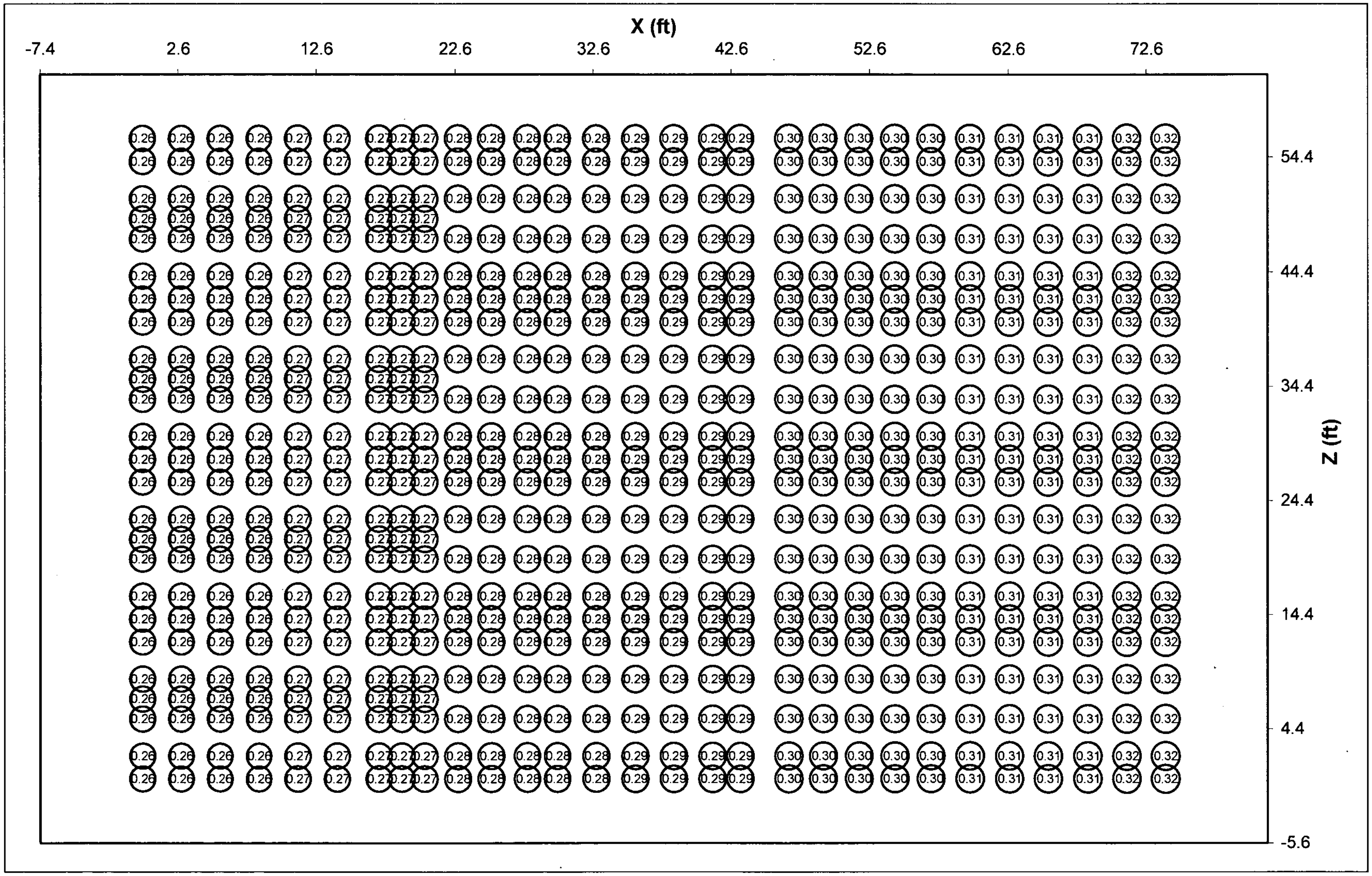


Figure 4: Acceleration along Z due to SSE along Z for Operating Deck Slab (Soil Case 1)

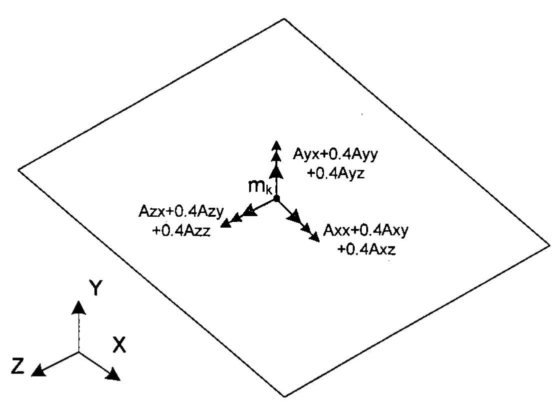


Provide examples of how the three components of earthquake motion are combined, and compare the results to those of the 100-40-40 rule presented in RG 1.92, Revision 2:

The co-directional response combination is performed using the 100-40-40 rule described in ASCE 4-98, such that when 100% SSE is applied in one direction, 40% SSE is applied in the other two directions. As shown in Equation (2), the co-directional response combination results in twenty four (24) load combinations, including variations in signs (plus or minus) of the applicable seismic force components.

$$
\begin{aligned}
E &= \pm 1.0|E_x| \pm 0.4|E_y| \pm 0.4|E_z| \\
E &= \pm 0.4|E_x| \pm 1.0|E_y| \pm 0.4|E_z| \\
E &= \pm 0.4|E_x| \pm 0.4|E_y| \pm 1.0|E_z|
\end{aligned}
\tag{2}
$$

where E is the combined earthquake response, and E_x, E_y, and E_z represent the responses due to SSE motion in X, Y, and Z directions, respectively. Note that each of E_x, E_y, and E_z include components in the three directions as shown in Table 1 and Figure 5. Figure 5 illustrates the application of one such combination for joint 'k' within the operating deck, where 100% SSE is applied along positive X, and 40% SSE is applied along positive Y and positive Z directions.



$1.0E_X + 0.4E_Y + 0.4E_Z$

Figure 5: Typical 100-40-40 Co-directional Seismic Combination for Operating Deck

The above methodology is the same as that presented in Regulatory Position C.2 of RG 1.92, Revision 2. Therefore, the comparison of responses mentioned in the question is not presented here.

Describe why the equivalent static approach to determine forces and moments is appropriate, since the dynamically computed forces and moments will retain the appropriate sign from the analysis and the static approach will not:

For each of the six soil analysis cases, the cumulative mass participation in any direction for the first six global soil-driven modes is at least 98.83% (refer COLA FSAR Tables 3.7-7 through 3.7-12). The higher modes, with their associated curvature reversals produce accelerations with opposite signs in various regions of the structure. Since the mass participation associated with such higher modes is small (approximately 1%), the structural accelerations (for a given soil case and direction of SSE motion) for structural panels are governed predominantly by the global soil-driven modes. The co-directional response combinations based on 100-40-40 combination rule consider the variation in signs (plus or minus) to account for the effect of reversal of earthquake forces on the overall structural response.

The maximum acceleration of embedded portion of UHS MWIS is less than 0.35g, but conservatively the hydrodynamic forces and dynamic soil pressures used in the equivalent static analysis are calculated using a design acceleration of 0.5 g.

Therefore, the equivalent static analysis for UHS MWIS, in lieu of a dynamic analysis, is appropriate for both global and local responses.

COLA Impact

None