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MFN 08-232
Supplement 2

Docket No. 52-010

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U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: Revised Response to Portion of NRC Request for Additional Information Letter No. 198 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.7 – Seismic Design – RAI Number 3.7-63 S01

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) revised response to a portion of the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by NRC letter dated May 9, 2008 (Reference 2). The original RAI was submitted by the NRC via Reference 4 and the GEH response was submitted via Reference 3. The purpose of this revision is to clarify where the Certified Seismic Design Response Spectrum (CSDRS) is applied to the Fire Water Service Complex (FWSC).

This revised response supersedes the original response to RAI 3.8-63 Supplement 1 submitted via MFN 08-232, S01 (Reference 1). Verified DCD changes associated with this revised RAI response are identified in the enclosed DCD markups by enclosing the text within a black box.

Revision 1 to RAI Number 3.7-63, Supplement 1 is addressed in Enclosure 1.

If you have any questions or require additional information, please contact me.

Sincerely,

Lee F. Dougherty for

Richard E. Kingston
Vice President, ESBWR Licensing

References:

1. MFN 08-232, Supplement 1, Letter Richard E. Kingston to the U.S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter No. 198 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.7 – Seismic Design – RAI Number 3.7-63 S01*, August 27, 2008

2. MFN 08-471, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 198 Related to ESBWR Design Certification Application*, May 9, 2008

3. MFN 08-232 from Jim Kinsey to the U.S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter Number 124 Related to ESBWR Design Certification Application, Seismic Design, RAIs 3.7-63 and 3.7-64*, dated March 12, 2008

4. MFN 08-029, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, GEH, *Request For Additional Information Letter No. 124 Related To ESBWR Design Certification Application*, dated January 14, 2008

Enclosure:

1 Revised Response to Portion of NRC Request for Additional Information Letter No. 198 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.7 – Seismic Design – RAI Number 3.7-63 S01

cc:	AE Cubbage	USNRC (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	eDRF Section	0000-0086-5299 R1 (RAI 3.7-63 S01 R1)

ENCLOSURE 1

MFN 08-232
Supplement 2

Revised Response to Portion of NRC RAI Letter No. 198

Related to ESBWR Design Certification Application

DCD Tier 2 Section 3.7 – Seismic Design

RAI Number 3.7-63 S01 (Revision 1)

Please note, this is a revised response to RAI 3.7-63, Supplement 1 which was originally transmitted via MFN 08-232 S01. Revisions are denoted with ~~red strike through~~ text for deletions and blue underlined text for additions.

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For historical purposes, the original text of RAI 3.7-63 and the GEH response are included. The attachments (if any) are not included from the original response to avoid confusion.

NRC RAI 3.7-63

DCD Revision 4 Section 3A.4.1 states:

> *"....For the generic sites defined in Subsection 3A.3.1, the design response spectra are conservatively applied at the level of foundation in the free field. The input motion for North Anna ESP site is also defined at the foundation level.*
>
> *For the layered site cases, the input ground motion is defined as an outcrop motion at the RBFB foundation level for the RBFB and CB. The corresponding surface motion is generated for use as input to the SASSI2000 calculation for each site.*
>
> *For the FWSC, which is essentially a ground surface founded structure, the input ground motion is taken to be 1.35 times the RBFB/CB foundation input motion and is applied directly at the foundation level."*

The staff requires the following clarification and additional information related to the above statements:

(a) Based on the first two sentences above, it appears to the staff that the ground motion for the CB was applied at two different elevations: at the CB foundation level for the generic sites defined in Subsection 3A.3.1, and at the RBFB foundation level for the layered site cases. Please confirm this, or clarify what was actually done. If this is the case, please describe what differences in CB response would be expected for the layered site cases if the input ground motion had been defined as an outcrop motion at the CB foundation level.

(b) The third sentence above defines the input ground motion used for the FWSC SSI analyses as "1.35 times the RBFB/CB foundation input motion…applied directly at the foundation level." Please provide a detailed technical basis for the selection of the 1.35 factor, including pertinent quantitative information upon which this determination is based.

GEH Response

(a) GEH confirms that the ground motion for the CB was applied at the CB foundation level for the generic site cases and at the RBFB foundation level for the layered site cases.

Applying the outcrop motion at the RBFB foundation level for the layered site cases is a more conservative approach than applying the outcrop motion directly at the CB foundation level. This is demonstrated in Figure 3.7-63(1) by comparing the response spectra of the surface motion when the ground motion is applied at the RBFB foundation level and at the CB foundation level for the typical layered site Case 2 described in DCD Tier 2 Table 3A.3-3. The response spectrum of the surface motion is larger in the case when the ground motion is applied at the RBFB foundation level than in the case when the ground motion is applied at the CB foundation level. Therefore, it is expected that the CB response would be smaller for the layered site cases if the input ground motion had been defined as an outcrop motion at the CB foundation level instead at the RBFB foundation level.

(b) The technical basis for scaling the RBFB/CB foundation input motion for ground motions at other depths is to maintain a broad-band spectrum shape that is rich in all frequencies, regardless of site conditions, for the purpose of standard plant design. Broad-band design spectrum at any foundation depth is compatible with smooth site-specific ground motion response spectrum (GMRS) and associated foundation input response spectrum (FIRS) generated in accordance with RG 1.208 requirements for new units. The 1.35 scale factor was determined such that the resulting spectrum at the FWSC foundation level envelops the FIRS at the North Anna 3 site as shown in Figure 3.7-63(2) for the horizontal motion and Figure 3.7-63(3) for the vertical motion.

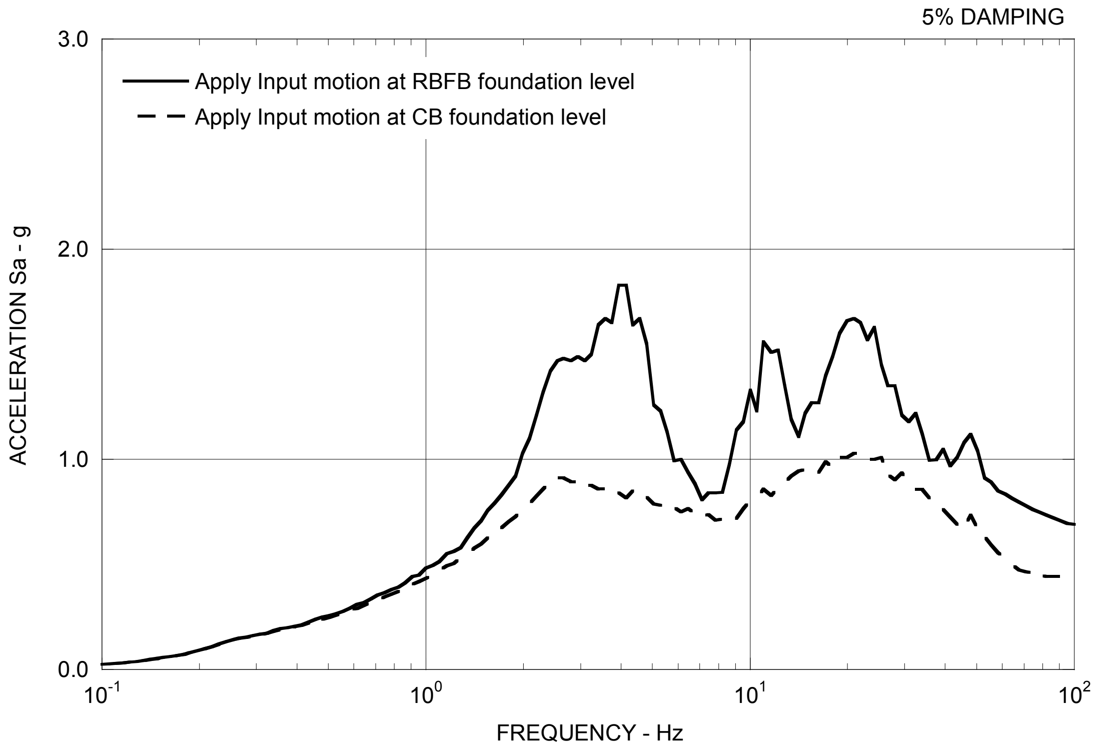


Figure 3.7-63(1) Comparison of Surface Response Spectra for Layered Case 2 when the Input Motion is applied at Different Levels

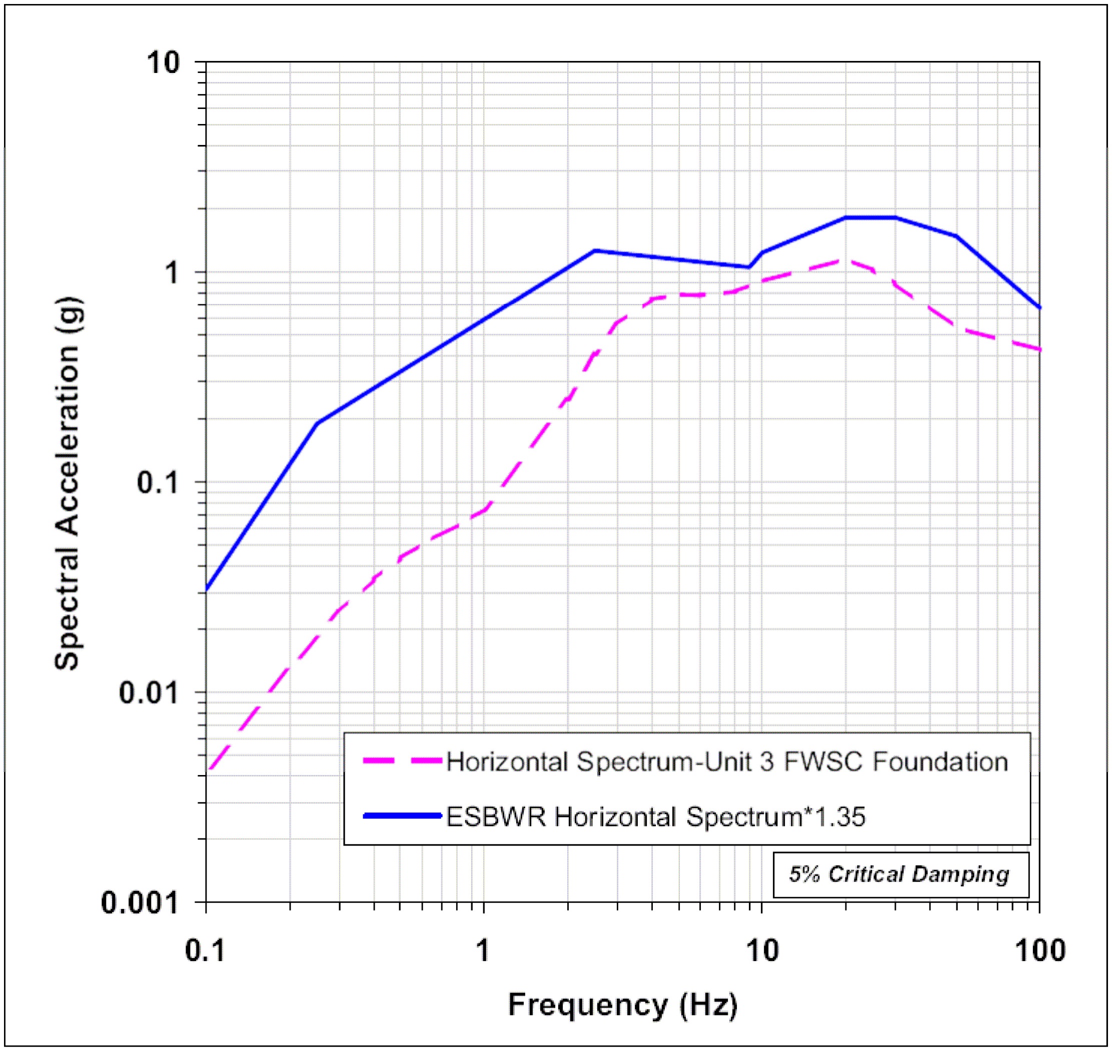


Figure 3.7-63(2) Comparison of Horizontal SSE Design Response Spectrum with NA3 Site-Specific Spectra at FWSC Foundation Level (Reproduced from North Anna 3 COLA FSAR Figure 2.0-203)

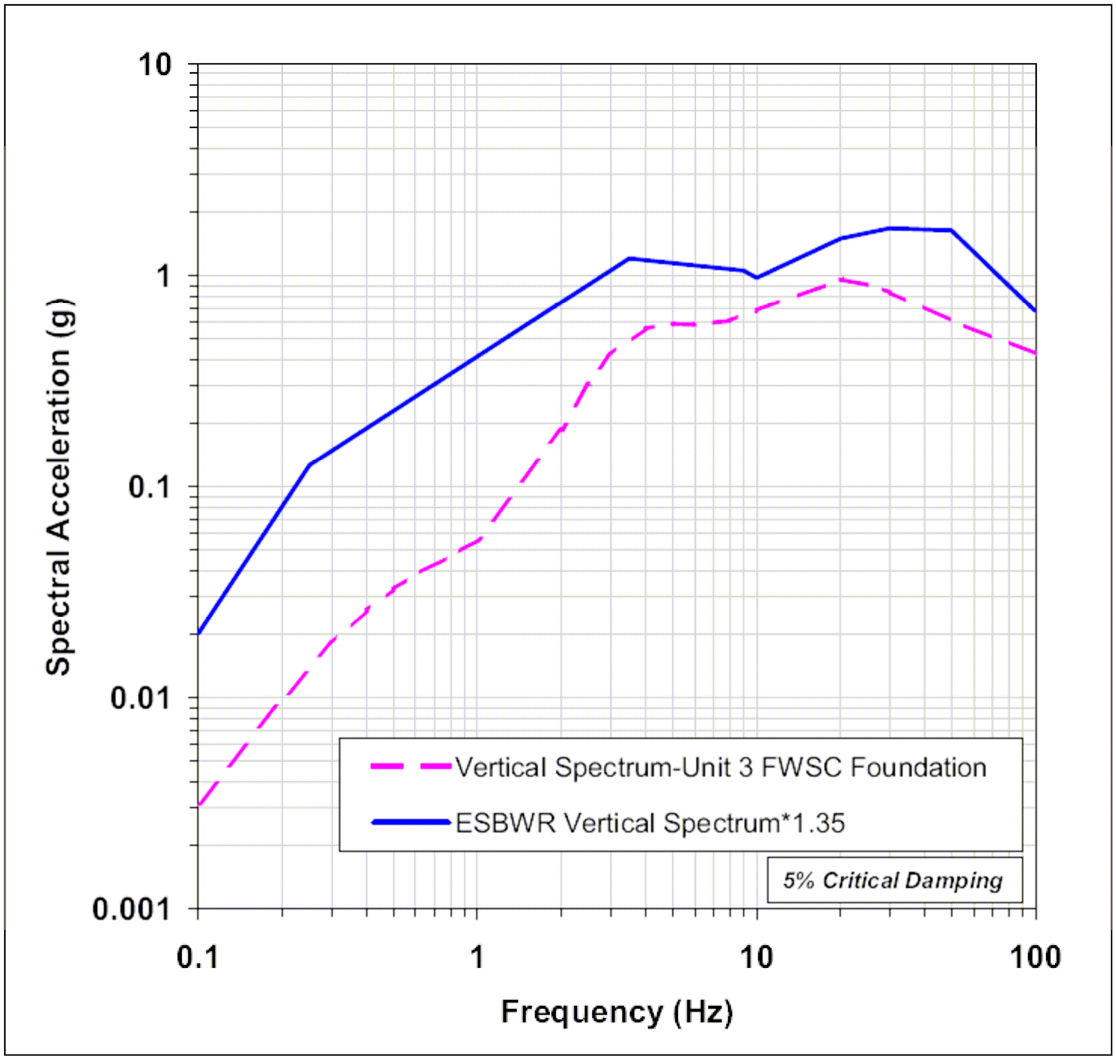


**Figure 3.7-63(3) Comparison of Vertical SSE Design Response Spectrum with NA3 Site-
Specific Spectra at FWSC Foundation Level (Reproduced from North Anna 3 COLA FSAR Figure 2.0-204)**

DCD Impact

No DCD change was made in response to this RAI.

NRC RAI 3.7-63, Supplement 1

The staff reviewed GEH's response to RAI 3.7-63, and concluded that additional information is needed before it can complete its assessment of the two technical issues covered by this RAI.

Part (1) - GEH needs to submit a comparison of the surface spectra derived by placing the input motion at the bottom of the RB/FB foundation to the surface spectra derived by placing the input motion at the bottom of the CB foundation, for each of the 4 SASSI layered soil cases. In deriving the surface spectra from the foundation motions, the method identified as the NRC method in GEH's response to RAI 3.7-16 must be used. Submit four (4) figures, similar to Figure 3.7-63(1).

In reviewing Figure 3.7-63(1), the staff noted that the surface spectra corresponding to placing the input motion at the bottom of the CB foundation (dashed line) does not appear to be correct. It resembles the spectrum of the input motion, at the foundation level. The dashed line would be expected to exhibit the same pattern of peaks and valleys as the solid line. GEH needs to confirm that the dashed line is correct, and provide an explanation for the unexpected shape.

Part (2) – The staff notes that GEH can define any surface spectrum it chooses to for design certification of the fire water service complex (FWSC). COL applicants will need to demonstrate that the site-specific surface spectrum is enveloped by the spectrum GEH has used for design certification of the FWSC. If this is not the case, then a site-specific analysis of the FWSC will be required at the COL stage. This will be in addition to the required comparisons at the RB/FB and CB foundation levels. SRP 3.7.1 specifies a check at the foundation level for each structure.

The staff believes that the surface spectra used for seismic analysis of the FWSC should envelope the 8 surface spectral plots that the staff has asked GEH to derive under Part (1) above. This would ensure consistency between the input at the RB/FB and CB foundation levels and the input at the surface for the FWSC. GEH's proposed 1.35 factor on the input motion at the bottom of the RB/FB foundation may or may not produce a suitable envelope. Based on comparing Figure 3.7-63(1) to Figure 3.7-63(2), it appears to the staff that a 1.35 factor may not be sufficient over the entire frequency range.

The staff requests GEH to re-assess its methodology for selecting the surface spectra for seismic design of the FWSC; provide the technical basis for its selection; and identify the necessary COL applicant action items to ensure the seismic adequacy of the FWSC at each site.

Revised GEH Response

Part (1) - Figures 3.7-63(4) through (7) show comparisons of the surface spectra derived by placing the input motion at the bottom of the RB/FB foundation to the surface spectra derived by placing the input motion at the bottom of the CB foundation for each of the 4 SASSI layered soil cases by using the method identified as the NRC Method in GEH's response to NRC RAI 3.7-16, Supplement 2 transmitted to the NRC via MFN 06-274, Supplement 2.

Since the fundamental frequencies of the CB in the horizontal directions are around 3 Hz, as shown in DCD Tier 2 Table 3A.7-8, the CB responses would be smaller for all layered site cases if the input ground motion had been applied at the CB foundation level instead at the RB/FB foundation level.

GEH confirms that both the solid and dashed lines in Figure 3.7-63(1) have been correctly calculated by using the method identified as the DCD Method in GEH's response to NRC RAI 3.7-16, Supplement 2 transmitted to the NRC via MFN 06-274, Supplement 2, which includes the entire soil column up to the ground surface in a single SHAKE run with outcrop motion input at the foundation level.

The reason for the dashed line resembling the foundation input spectrum is because the CB (14.9 m embedment) is shallower than the top layer (20m thick) of the layered sites (see DCD Tier 2 Table 3A.3-3). In other words, the soil properties above the foundation are the same as those below the foundation in the region of the top layer and, as a result, the surface motion resembles the foundation input motion. This can be further explained by the one-dimensional wave propagation theory below:

a. Soil displacement at layer *m* is expressed as:

$$u_m(x,t) = E_m e^{i(kx+\omega t)} + F_m e^{-i(kx-\omega t)} \qquad \text{Equation 3.7-63(1)}$$

where $k = \sqrt{\dfrac{\rho\ \omega^2}{G^*}}$, G^* is a complex soil stiffness considering damping

b. For the multi-soil layer system, the upward component, E, and the downward component, F, for each soil layer are calculated by Equation 3.7-63(2) considering the continuity of displacement and shear stress at each layer boundary.

$$E_{m+1} = \frac{1}{2} E_m (1+\alpha_m) e^{ik_m h_m} + \frac{1}{2} F_m (1-\alpha_m) e^{-ik_m h_m}$$

$$F_{m+1} = \frac{1}{2} E_m (1-\alpha_m) e^{ik_m h_m} + \frac{1}{2} F_m (1+\alpha_m) e^{-ik_m h_m} \qquad \text{Equation 3.7-63(2)}$$

where $\alpha_m = \dfrac{k_m \cdot G_m^*}{k_{m+1} \cdot G_{m+1}^*}$

c. Since the full reflection occurs at the ground surface, the E and F components are equal at the top surface layer.

$$E_1 = F_1 \qquad \text{Equation 3.7-63(3)}$$

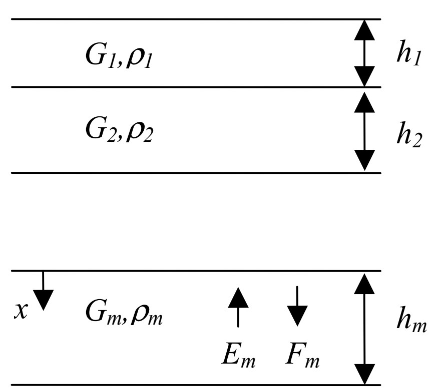
d. From Equations 3.7-63(2) and 3.7-63(3), the motion components at the second layer are derived to be:

$$E_2 = \frac{E_1}{2}\left\{(1+\alpha_1)e^{ik_1h_1} + (1-\alpha_1)e^{-ik_1h_1}\right\}$$
$$F_2 = \frac{E_1}{2}\left\{(1-\alpha_1)e^{ik_1h_1} + (1+\alpha_1)e^{-ik_1h_1}\right\} \quad \text{Equation 3.7-63(4)}$$

e. The transfer function of the ground surface displacement relative to the outcrop displacement ($2E_2$) at the top of the second layer becomes:

$$H(\omega) = \frac{E_1 + F_1}{2E_2} = \frac{E_1}{E_2}$$
$$= \frac{E_1}{\frac{E_1}{2}\left\{(1+\alpha_1)e^{ik_1h_1} + (1-\alpha_1)e^{-ik_1h_1}\right\}} \quad \text{Equation 3.7-63(5)}$$
$$= \frac{2}{(1+\alpha_1)e^{ik_1h_1} + (1-\alpha_1)e^{-ik_1h_1}}$$

f. According to the above transfer function, the response at the ground surface approaches the input motion when the soil properties of the 1st layer is the same as those of the 2nd layer, since α_1 becomes 1.0 and $H(\omega)$ approaches 1.0.



Part (2) - The surface spectra computed from the input spectra defined at the RB/FB and CB foundations, as shown in Figures 3.7-63(4) through 3.7-63(7), exhibit distinct peaks and valleys. Using these surface spectra directly as input motion could under-predict or over-predict the FWSC response depending on the SSI frequencies. The more balanced approach for the standard plant design is to maintain the broad-band characteristics in the foundation input spectra that is rich in all frequencies, regardless of site conditions. This is the technical basis for the selection of FSWC input spectra to be 1.35 times the broad-band Certified Seismic Design Response Spectra (CSDRS) for the RB/FB and CB. As stated in the original response to this RAI, the 1.35 scale factor was chosen to envelop the FWSC Foundation Input Response Spectra (FIRS) at the North Anna 3 site. To ensure the seismic adequacy of the FWSC at each site, the COL applicant is required to compare the site-specific FIRS for the FWSC with the FWSC CSDRS, which is 1.35 times the values shown in DCD Tier 2 Figures 2.0-1 and 2.0-2 as stipulated in footnote 9 to DCD Tier 2 Table 2.0-1.

DCD Tier 1 Table 5.1-1, DCD Tier 2 Table 2.0-1, DCD Tier 2 Subsection 3.7.1.1 and DCD Tier 2 Subsection 3A.4.1 will be revised in Revision 6 to clarify that the input ground motion for the Firewater Service Complex is applied directly at the foundation level, specifically at the bottom of the base slab.

DCD Tier 2 Table 1.9-3, DCD Tier 2 Table 1.9-20, DCD Tier 2 Subsection 2.0.2 and DCD Tier 2 Table 2.0-2 will be revised in Revision 6 to clarify that the COL applicant confirm that the site-specific Foundation Input Response Spectra is enveloped by the ESBWR design response spectra referenced at the foundation level.

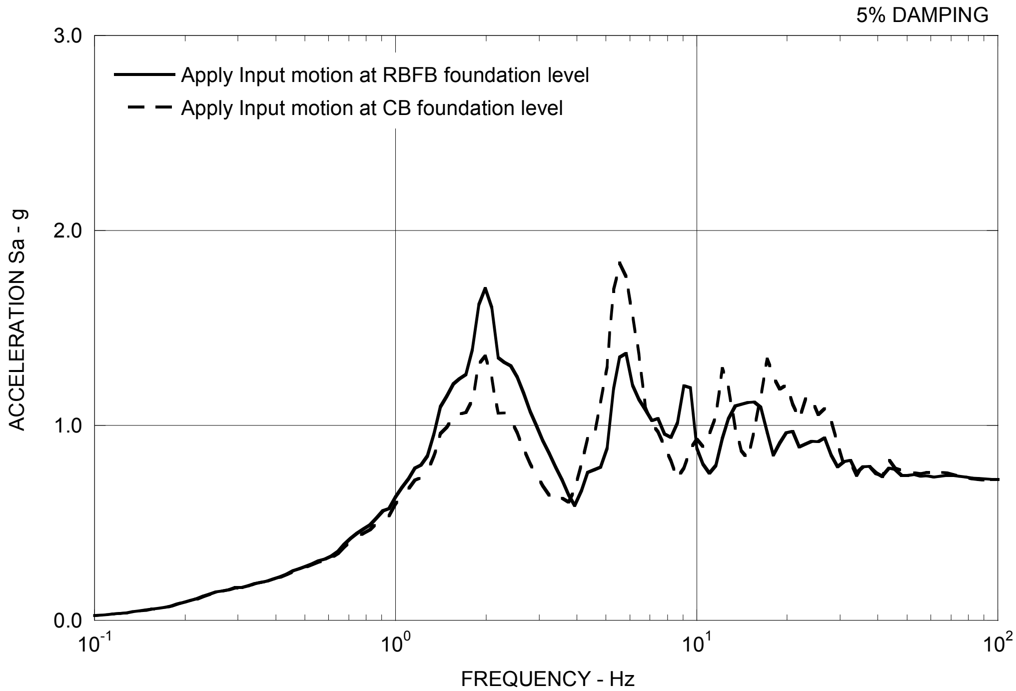


Figure 3.7-63(4) Comparison of Surface Response Spectra for Layered Case 1

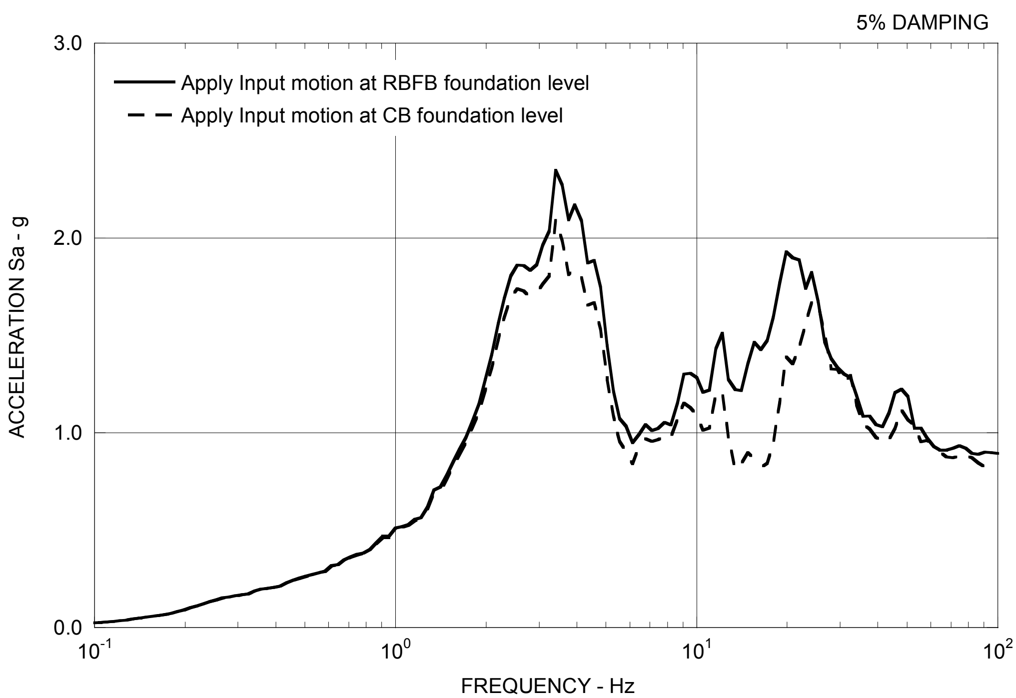


Figure 3.7-63(5) Comparison of Surface Response Spectra for Layered Case 2

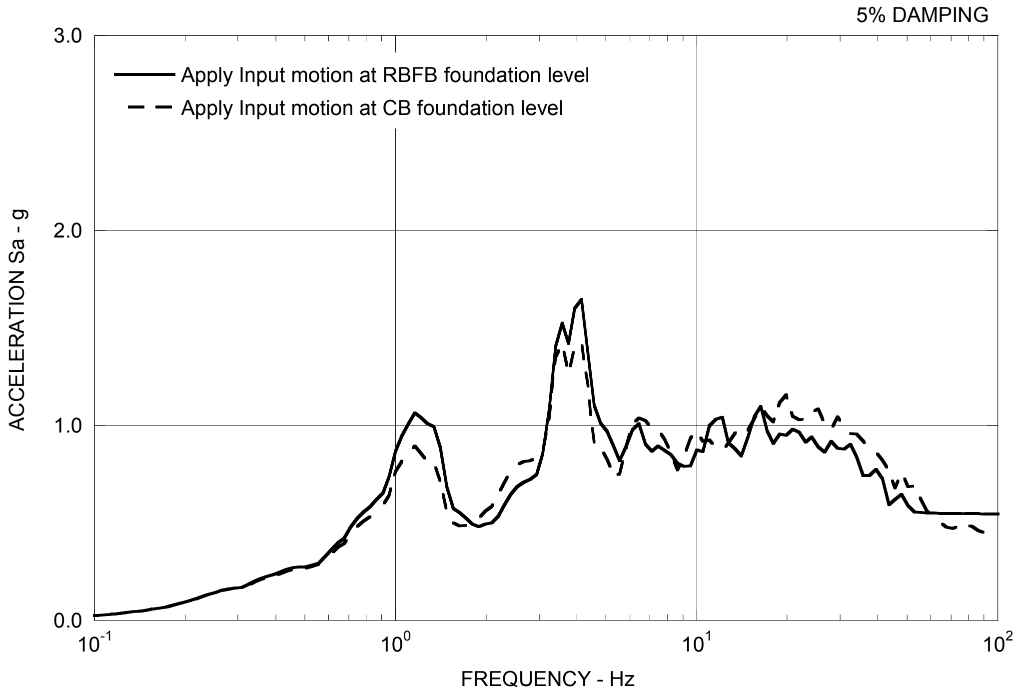


Figure 3.7-63(6) Comparison of Surface Response Spectra for Layered Case 3

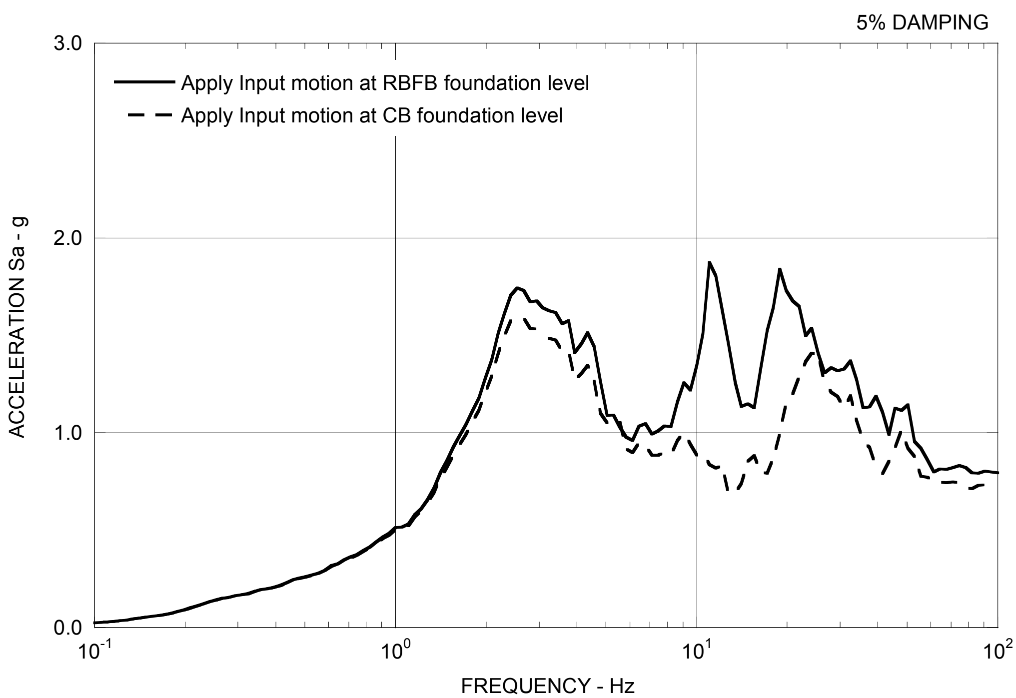


Figure 3.7-63(7) Comparison of Surface Response Spectra for Layered Case 4

DCD Impact

DCD Tier 1 Table 5.1-1, DCD Tier 2 Table 1.9-3, DCD Tier 2 Table 1.9-20, DCD Tier 2 Subsection 2.0.2, DCD Tier 2 Table 2.0-1, DCD Tier 2 Table 2.0-2, DCD Tier 2 Subsection 3.7.1.1 and DCD Tier 2 Subsection 3A.4.1 will be revised in Revision 6 as noted in the attached markups. ~~No DCD change is required in response to this RAI Supplement.~~

(4) Safe Shutdown Earthquake (SSE) design ground response spectra of 5% damping, also termed Certified Seismic Design Response Spectra (CSDRS), are defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Reactor/Fuel and Control Building structures. ~~For ground surface founded Firewater Service Complex structures, the CSDRS is 1.35 times the values shown in Figures 5.1-1 and 5.1-2~~For the Firewater Service Complex, which is essentially a surface founded structure, the CSDRS is 1.35 times the values shown in Figures 5.1-1 and 5.1-2 and is defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Firewater Service Complex structure.

(5) Settlement values are long-term (post construction) values except for differential settlement within the foundation mat. The design of the foundation mat accommodates immediate and long-term (post construction) differential settlements after the installation of the basemat.

(6) For sites not meeting the soil property requirements, a site-specific analysis is required to demonstrate the adequacy of the standard plant design.

Table 1.9-3

Summary of Differences from SRP Section 3

SRP Section	Specific SRP Acceptance Criteria	Summary Description of Difference	Section/Subsection Where Discussed
3.2.1		None	
3.2.2		None	
3.3.1		None	
3.3.2		None	
3.4.1		None	
3.4.2		None	
3.5.1		None	
3.5.2		None	
3.5.3		None	
3.6.1 and 3.6.2		None	
3.7.1	II.4-Review considerations for DC and COL applications	Supplemented by "Interim Staff Guidance on Seismic Issues Associated with High Frequency Ground Motion in Design Certification and Combined License Applications," COL/DC-ISG-1, May 2008.	Table 2.0-2
3.7.1 and 3.7.3	II- Two earthquakes, the SSE and the OBE shall be considered in the design.	The ESBWR is based on a single earthquake (SSE) design.	3.7.1 and 3.7.3
3.7.2		None	
3.7.3	II.9—For multiply supported equipment use envelope response spectra and;	Independent Support Motion Response Spectrum methods acceptable for use.	3.7.3.9
3.7.3	Combine responses from inertia effects with anchor displacements by absolute sum.	Combine responses from inertia effects with anchor displacements by SRSS.	3.7.3.9

Table 1.9-20

NRC Standard Review Plans and Branch Technical Positions Applicability to ESBWR

SRP No.	SRP Title or BTP	Appl. Rev.	Issued Date	ESBWR Appli-cable?	Comments
	Appendix C to SPLB 3-1	3	Draft 04/1996	Yes	
3.6.2	Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping	2	Draft 04/1996	Yes	
	BTP EMEB-3-1	2	Draft 04/1996	Yes	
3.6.3	Leak-Before-Break Evaluation Procedures	0	03/1987	—	Not credited.
3.7.1	Seismic Design Parameters	~~2~~3	0~~8~~3/~~1989~~2007	Yes	
	Appendix A	3~~0~~	0~~8~~3/~~1989~~2007	Yes	
	Appendix B	3	03/2007	Yes	
	Appendix C	3	03/2007	Yes	
	Appendix D	3	03/2007	Yes	
3.7.2	Seismic System Analysis	2	08/1989	Yes	
	Appendix A	0	08/1989	Yes	
3.7.3	Seismic Subsystem Analysis	2	08/1989	Yes	
3.7.4	Seismic Instrumentation	1	07/1981	Yes	
3.8.1	Concrete Containment	1	07/1981	Yes	
	Appendix	0	07/1981	Yes	
3.8.2	Steel Containment	1	07/1981	Yes	applies only to Drywell Head
3.8.3	Concrete and Steel Internal Structures of Steel or Concrete Containments	1	07/1981	Yes	
3.8.4	Other Seismic Category I Structures	1	07/1981	Yes	
	Appendix A	0	07/1981	Yes	
	Appendix B	0	07/1981	Yes	
	Appendix C	0	07/1981	Yes	

2.0-3 National Weather Service Publication Hydrometeorology Report No. 52 (HMR-52)

2.0-4 Electric Power Research Institute, “Advanced Light Water Reactor Utility Requirements Document,” Revision 6, May 1997.

2.0-5 U. S. Nuclear Regulatory Commission, "A Risk-Informed Approach to Defining the Design Basis Tornado for New Reactor Licensing," SECY 04-0200, October 26, 2004.

2.0-6 National Weather Service Publication Hydrometeorology Report No. 53 (HMR-53)

2.0-7 U. S. Nuclear Regulatory Commission, "Interim Staff Guidance on Seismic Issues Associated with High Frequency Ground Motion in Design Certification and Combined License Applications," COL/DC-ISG-1, May 2008.

2.0-8 Nuclear Energy Institute, Consistent Site-Response/ Soil-Structure Interaction Analysis and Evaluation, Draft White Paper, October 10, 2008.

ratio of the largest to the smallest shear wave velocity over the mat foundation width at the foundation level does not exceed 1.7.

(9) Safe Shutdown Earthquake (SSE) design ground response spectra of 5% damping, also termed Certified Seismic Design Response Spectra (CSDRS), are defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Reactor/Fuel and Control Building structures. ~~For ground surface founded Firewater Service Complex structures, the CSDRS is 1.35 times the values shown in Figures 2.0-1 and 2.0-2.~~ For the Firewater Service Complex, which is essentially a surface founded structure, the CSDRS is 1.35 times the values shown in Figures 2.0-1 and 2.0-2 and is defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Firewater Service Complex structure.

(10) Values reported here are actually design criteria rather than site design parameters. They are included here because they do not appear elsewhere in the DCD.

(11) If a selected site has a X/Q value that exceeds the ESBWR reference site value, the COL applicant will address how the radiological consequences associated with the controlling design basis accident continue to meet the dose reference values provided in 10 CFR ~~50.34~~52.79(a)(1)(vi) and control room operator dose limits provided in General Design Criterion 19 using site-specific X/Q values.

(12) If a selected site has X/Q values that exceed the ESBWR reference site values, the release concentrations in Table 12.2-17 would be adjusted proportionate to the change in X/Q values using the stack release information in Table 12.2-16. In addition, for a site selected that exceeds the bounding X/Q or D/Q values, the COL applicant will address how the resulting annual average doses (Table 12.2-18b) continue to meet the dose reference values provided in 10 CFR 50 Appendix I using site-specific X/Q and D/Q values.

(13) Value was selected to comply with expected requirements of southeastern coastal locations.

(14) Localized liquefaction potential under other than Seismic Category I structures is addressed per SRP 2.5.4 in Table 2.0-2.

(15) Settlement values are long-term (post-construction) values except for differential settlement within the foundation mat. The design of the foundation mat accommodates immediate and long-term (post-construction) differential settlements after the installation of the basemat.

(16) For sites not meeting the soil property requirements, a site-~~-~~specific analysis is required to demonstrate the adequacy of the standard plant design.

(17) Adjacent layers are the two layers with a total depth of 40 m (131 ft) or 60 m (197 ft) below grade. They correspond to the top and middle layers shown in Table 3A.3-3 for layered site cases 2 and 4. The first layer, termed top layer, covers the top 20 m (66 ft). The second layer, termed bottom layer, covers the next 20 m (66 ft) or 40 m (131 ft). The ratio is the equivalent uniform velocity of the bottom layer divided by the equivalent uniform velocity of the top layer. The equivalent uniform shear velocity is computed using the equation in Note (8) to this table except that 1) the depth of the soil column is the thickness of the layer under consideration and 2) either the lower bound seismic strain (i.e., strain compatible) profile or the best estimate low strain profile can be used because only

Table 2.0-2

Limits Imposed on Acceptance Criteria in Section II of SRP by ESBWR Design

Subsection	Subject	ESBWR DCD Parameters, Considerations and/or Limits	COL Information
2.5.2	Vibratory Ground Motion	Per Table 2.0-1 (and Figures 2.0-1 and 2.0-2).	COL applicant to provide site-specific information in accordance with SRP 2.5.2 and confirm that ~~it~~ the site-specific Foundation Input Response Spectra developed in accordance with Reference 2.0-7 guidance as implemented per Reference 2.0-8 is enveloped by the ESBWR design response spectra referenced at the foundation level. (COL Item 2.0-27-A)
2.5.3	Surface Faulting	ESBWR design assumes no permanent ground deformation from tectonic or non-tectonic faulting.	COL applicant to provide site-specific information in accordance with SRP 2.5.3. (COL Item 2.0-28-A)
2.5.4	Stability of Subsurface Materials and Foundations	Per Table 2.0-1.	COL applicant to provide site-specific information in accordance with SRP 2.5.4 and address: (1) localized liquefaction potential under other than Seismic Category I structures, and (2) settlement and differential settlements. (COL Item 2.0-29-A)
2.5.5	Stability of Slopes	Per Table 2.0-1.	COL applicant to provide site-specific information in accordance with SRP 2.5.5. (COL Item 2.0-30-A)

SSE) on fatigue evaluation and plant shutdown criteria are addressed in Subsections 3.7.3.2 and 3.7.4.4, respectively.

3.7.1 Seismic Design Parameters

As discussed in Standard Review Plan (SRP) 3.7.1, structures that are safety-related and that must withstand the effects of earthquakes are designed to the relevant requirements of GDC 2 and comply with Appendix S to 10 CFR 50 concerning natural phenomena. Standardized plants envelop the most severe earthquakes that affected a great number of sites where a nuclear plant may be located, with sufficient margin considering limited accuracy, quantity and period of time in which historical data have been accumulated. Seismic design parameters considered for ESBWR comprise two site conditions, generic sites and early site permit (ESP) sites. Two sites, Clinton (Reference 3.7-3) and Grand Gulf (Reference 3.7-4), have received ESPs. NRC is currently reviewing an ESP application from North Anna (Reference 3.7-2). A review of the three site conditions reveals that Clinton and Grand Gulf are bounded by the envelope of generic site and North Anna conditions. North Anna ESP site is therefore selected for further consideration in conjunction with generic sites for site enveloping seismic design of the ESBWR Standard Plant.

3.7.1.1 Design Ground Motion

The ESBWR standard plant SSE design ground motion is rich in both low and high frequencies. The low-frequency ground motion follows RG 1.60 ground spectra anchored to 0.3 g. The high-frequency ground motion matches the North Anna ESP site-specific spectra as representative of most severe rock sites in the Eastern US. These two ground motions are considered separately in the basic design. To verify the basic design the two separate inputs are further enveloped to form a single ground motion as the design basis ground motion for ESBWR. The single envelope design ground response spectra of 5% damping, also termed Certified Seismic Design Response Spectra (CSDRS), are shown in Figures 2.0-1 and 2.0-2 for horizontal and vertical direction, respectively. They are defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the Reactor Building/Fuel Building (RB/FB) and Control Building (CB) structures. Application of design ground motion at the foundation level is a conservative approach for deeply embedded foundations as compared to the compatible free-field motion deconvoluted from the free ground surface motion at the finished grade. The ESBWR RB and CB foundations are embedded at depth of 20 m (66 ft.) and 14.9 m (49 ft.), respectively. The Fuel Building (FB) shares a common foundation mat with the RB. For the Firewater Service Complex (FWSC), which is essentially a surface founded structure, the CSDRS is 1.35 times the values shown in Figures 2.0-1 and 2.0-2 and is defined as free-field outcrop spectra at the foundation level (bottom of the base slab) of the FWSC structure. The ESBWR CSDRS are higher than RG 1.60 spectra anchored to 0.1 g peak ground acceleration (PGA) at the foundation level, meeting Appendix S to 10 CFR Part 50 regulations for 0.1 g minimum PGA for the horizontal component of the SSE at the foundation level in the free-field. The development of design ground motion is delineated in the following subsections.

3.7.1.1.1 Low-Frequency Ground Motion

The ground response spectra for low-frequency ground motion are developed in accordance with RG 1.60 anchored to 0.3 g and specified at the foundation level in the free field for generic sites.

3A.4 INPUT MOTION AND DAMPING VALUES

3A.4.1 Input Motion

The time-history method is used in performing the seismic SSI analysis. Earthquake input motions in the form of synthetic acceleration time histories are generated as described in Subsection 3.7.1 for three orthogonal components designated as H_1, H_2, and V. The H_1 and H_2 are the two horizontal components mutually perpendicular to each other. In the SSI analyses, H_1 and H_2 components are used in the horizontal X-(0°) and Y-(90°) directions, respectively. The V component is used in the vertical Z-direction.

Depending on the soil characteristics at the site and subject to availability of appropriate recorded ground-motion data, the control motion is defined on the soil surface at the top of finished grade or on an outcrop or a hypothetical outcrop at a location on the top of the competent material in accordance with the NRC Standard Review Plan 3.7.1. For the generic sites defined in Subsection 3A.3.1, the design response spectra are conservatively applied at the level of foundation (bottom of the base slab) in the free field. The input motion for North Anna ESP site is also defined at the foundation level (bottom of the base slab).

For the layered site cases, the input ground motion is defined as an outcrop motion at the RB/FB foundation level for the RB/FB and CB. The corresponding surface motion is generated for use as input to the SASSI2000 calculation for each site.

For the FWSC, which is essentially a ground surface founded structure, the input ground motion is taken to be 1.35 times the RB/FB/CB foundation input motion and is applied directly at the foundation level (bottom of the base slab).

Vertically propagating plane seismic shear waves for the horizontal components and compression waves for the vertical component are assumed to generate the input motion.

3A.4.2 Damping Values

The structural components damping values used in the seismic analysis are in accordance with those specified in Regulatory Guide (RG) 1.61. These values for the SSE are summarized in Table 3.7-1.