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MFN 08-232
Supplement 1

Docket No. 52-010

August 27, 2008

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

Subject: 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) 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 1). The original RAI was submitted by the NRC via Reference 3 and the GEH response was submitted via Reference 2.

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,

Charles W. Bagwell
for

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

References:

1. 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

2. 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

3. 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 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	0000-0086-5299 (RAI 3.7-63 S01)

ENCLOSURE 1

MFN 08-232, Supplement 1

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

For historical purposes, the original text of RAI 3.7-63 and the GE response is 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.

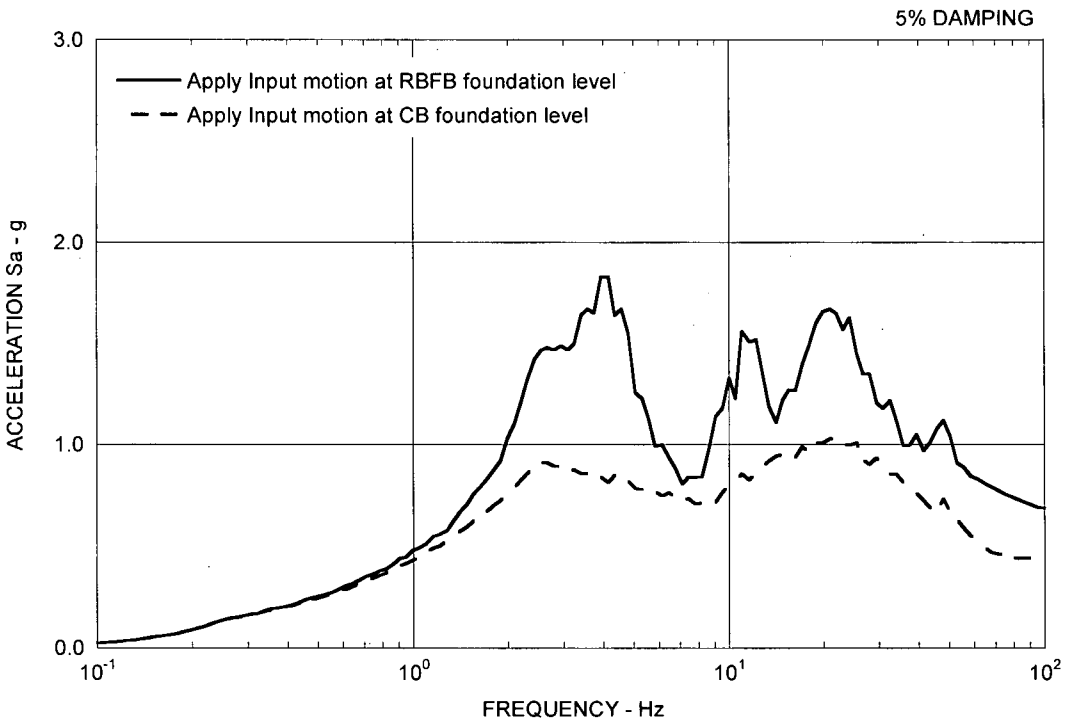


Figure 3.7-63(1) Comparison of Surface Response Spectra for Layered Case 2 when the Input Motion is applied at Different Levels

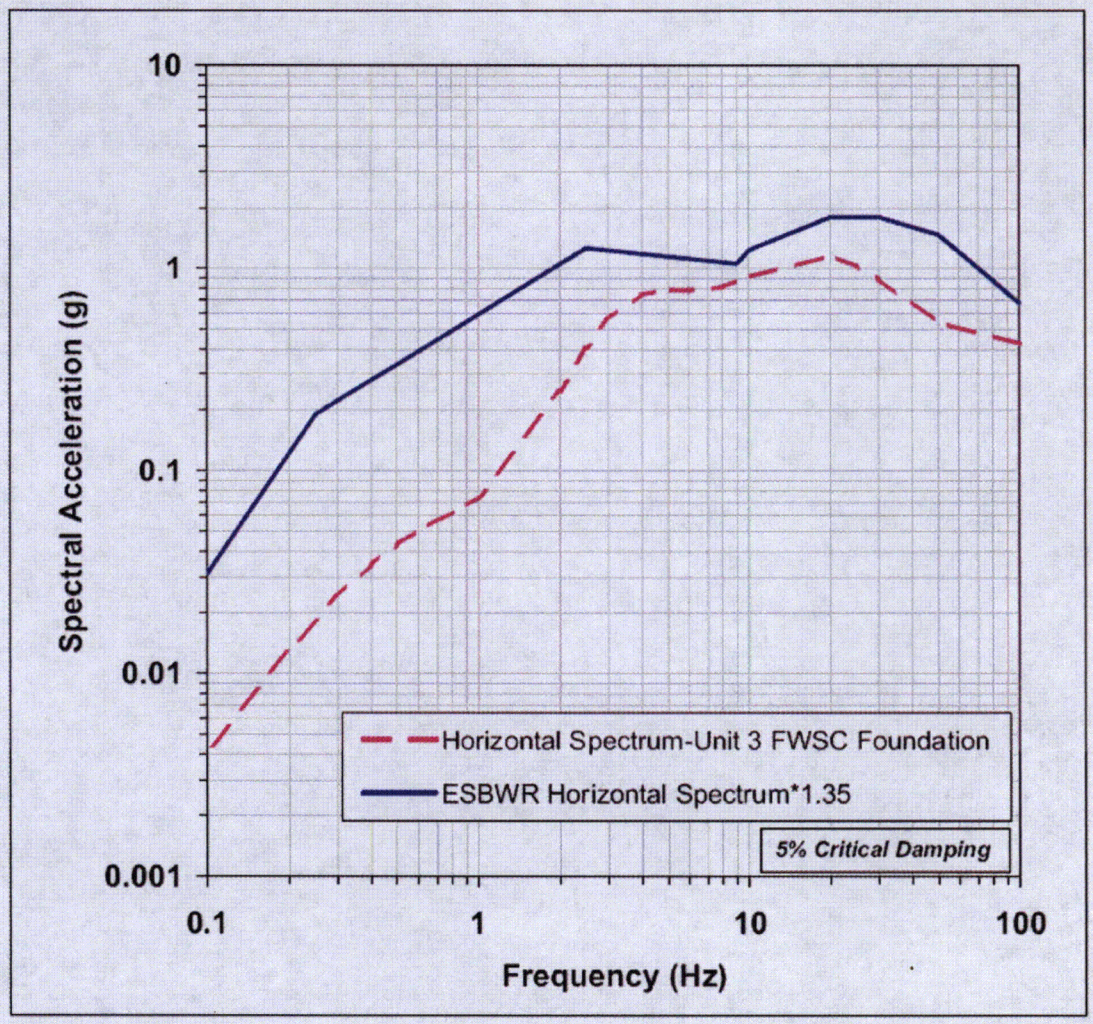


Figure 3.7-63(2) Comparison of Horizontal SSE Design Response Spectrum with NA3 Site-Specific Spectra at FWSC Foundation Level (Reproduced from North Anna 3 COLA FSAR Figure 2.0-203)

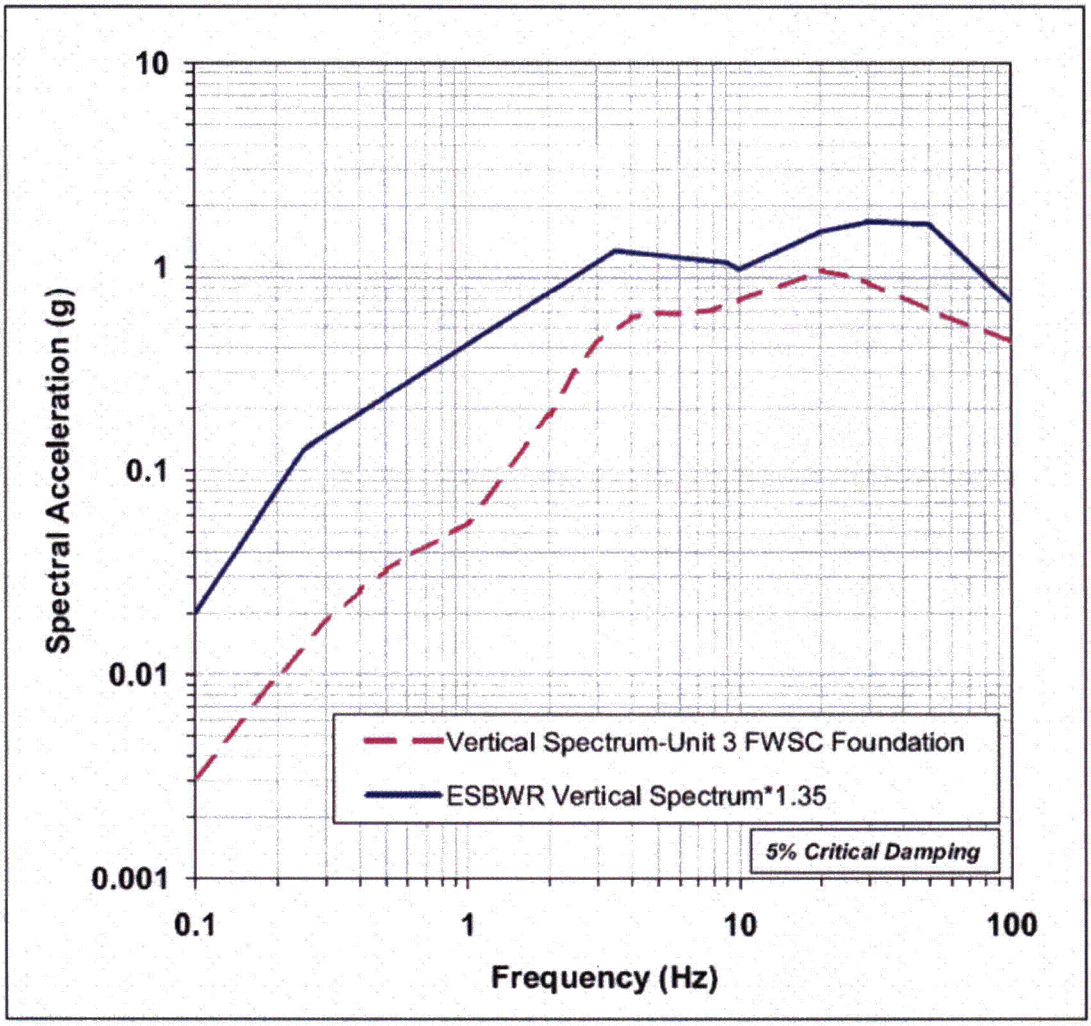


Figure 3.7-63(3) Comparison of Vertical SSE Design Response Spectrum with NA3 Site-Specific Spectra at FWSC Foundation Level (Reproduced from North Anna 3 COLA FSAR Figure 2.0-204)

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.

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 $k = \sqrt{\frac{\rho\,\omega^2}{G^*}}$, 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 $\alpha_m = \frac{k_m \cdot G_m^*}{k_{m+1} \cdot G_{m+1}^*}$

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:

$$E_2 = \frac{E_1}{2}\left\{(1+\alpha_1)e^{ik_1h_1} + (1-\alpha_1)e^{-ik_1h_1}\right\}$$

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

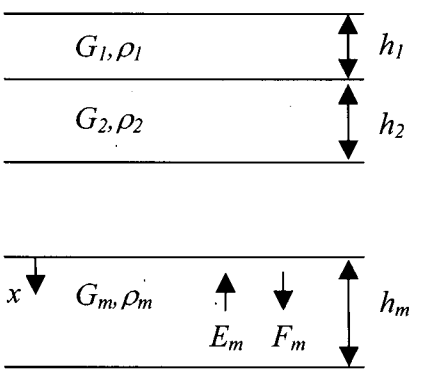
e. The transfer function of the ground surface displacement relative to the outcrop displacement ($2E_2$) at the top of the second layer becomes:

$$H(\omega) = \frac{E_1 + F_1}{2E_2'} = \frac{E_1}{E_2}$$

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

$$= \frac{2}{(1+\alpha_1)e^{ik_1h_1} + (1-\alpha_1)e^{-ik_1h_1}}$$

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.

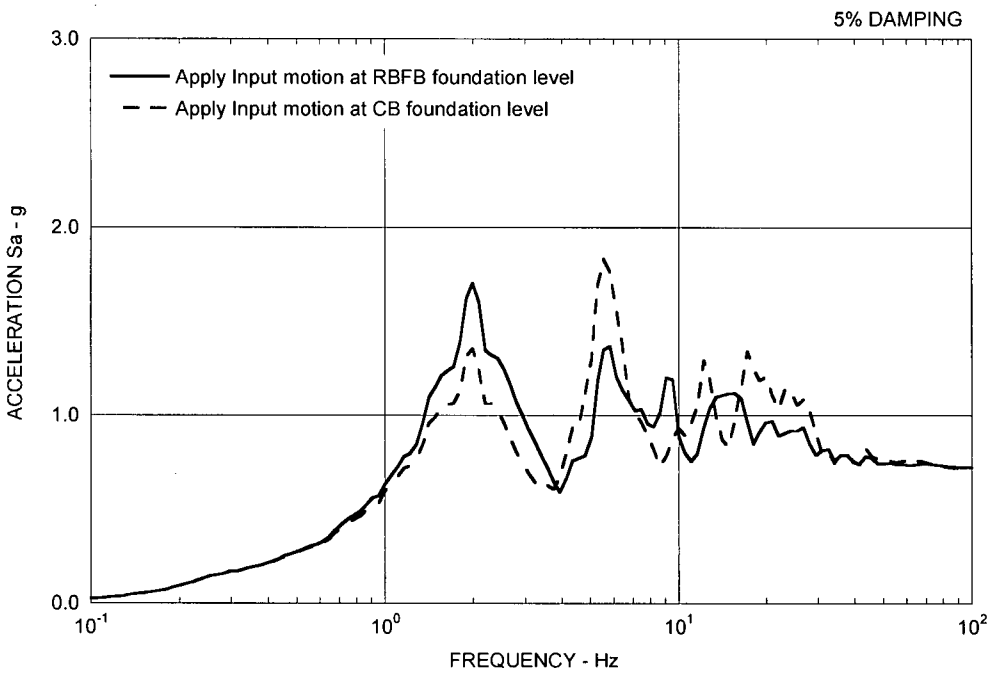


Figure 3.7-63(4) Comparison of Surface Response Spectra for Layered Case 1

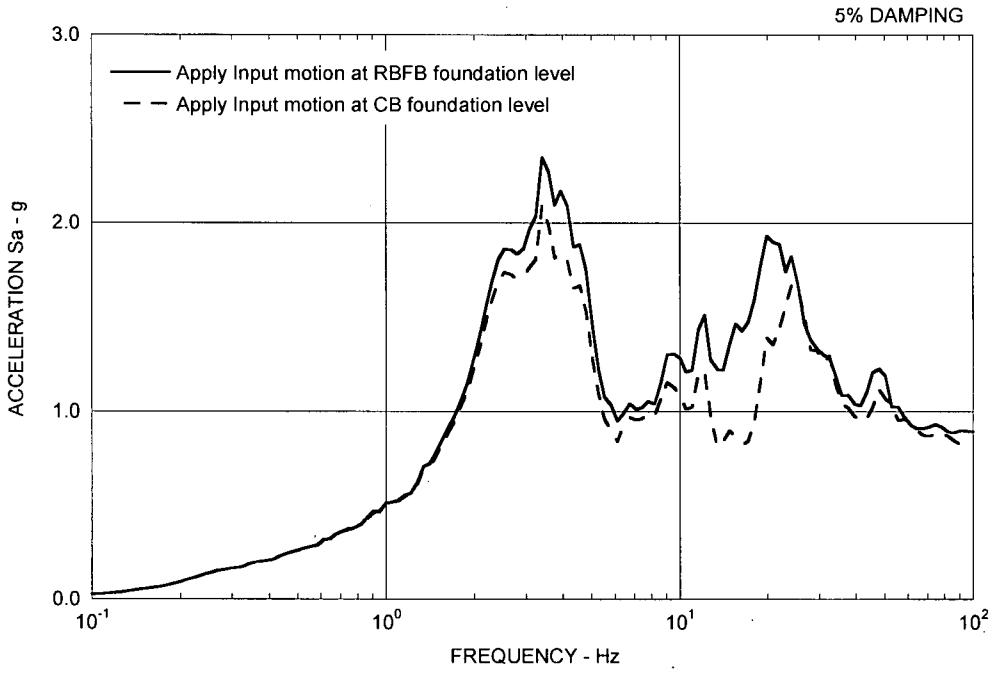


Figure 3.7-63(5) Comparison of Surface Response Spectra for Layered Case 2

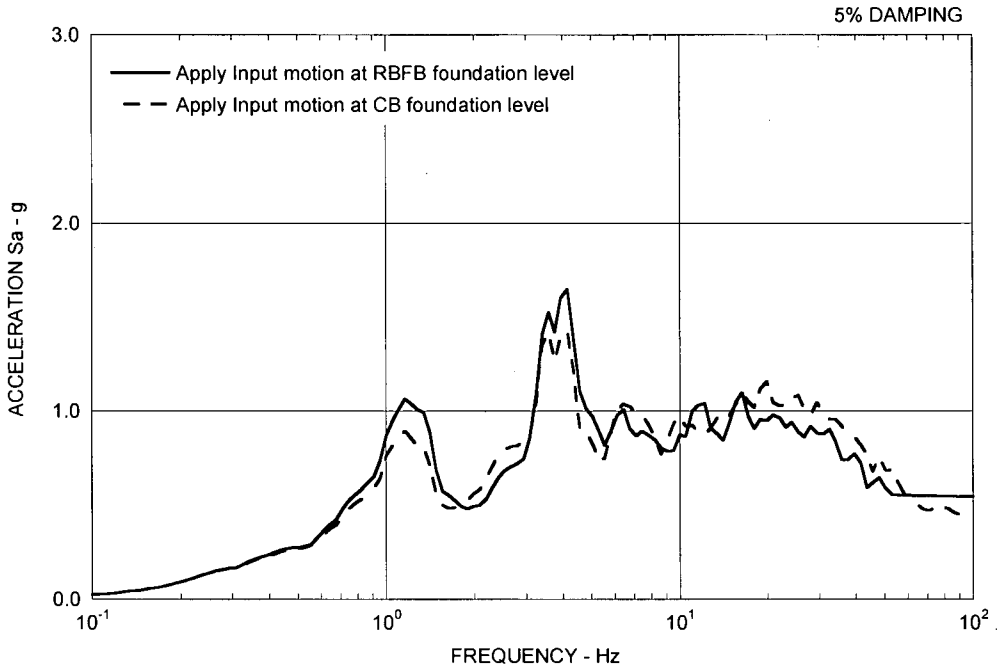


Figure 3.7-63(6) Comparison of Surface Response Spectra for Layered Case 3

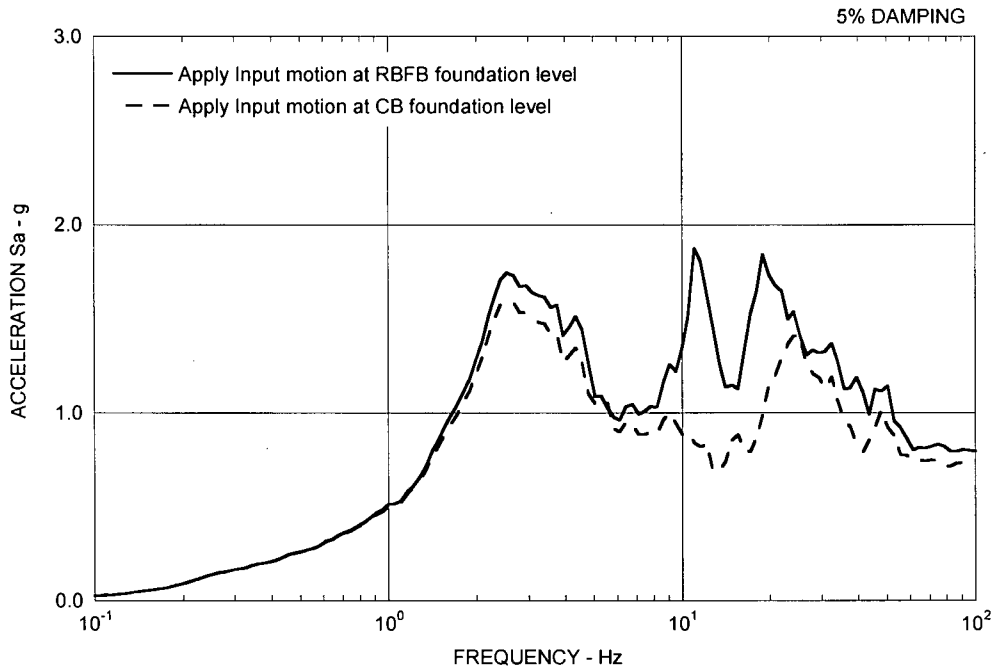


Figure 3.7-63(7) Comparison of Surface Response Spectra for Layered Case 4

DCD Impact

No DCD change is required in response to this RAI Supplement.