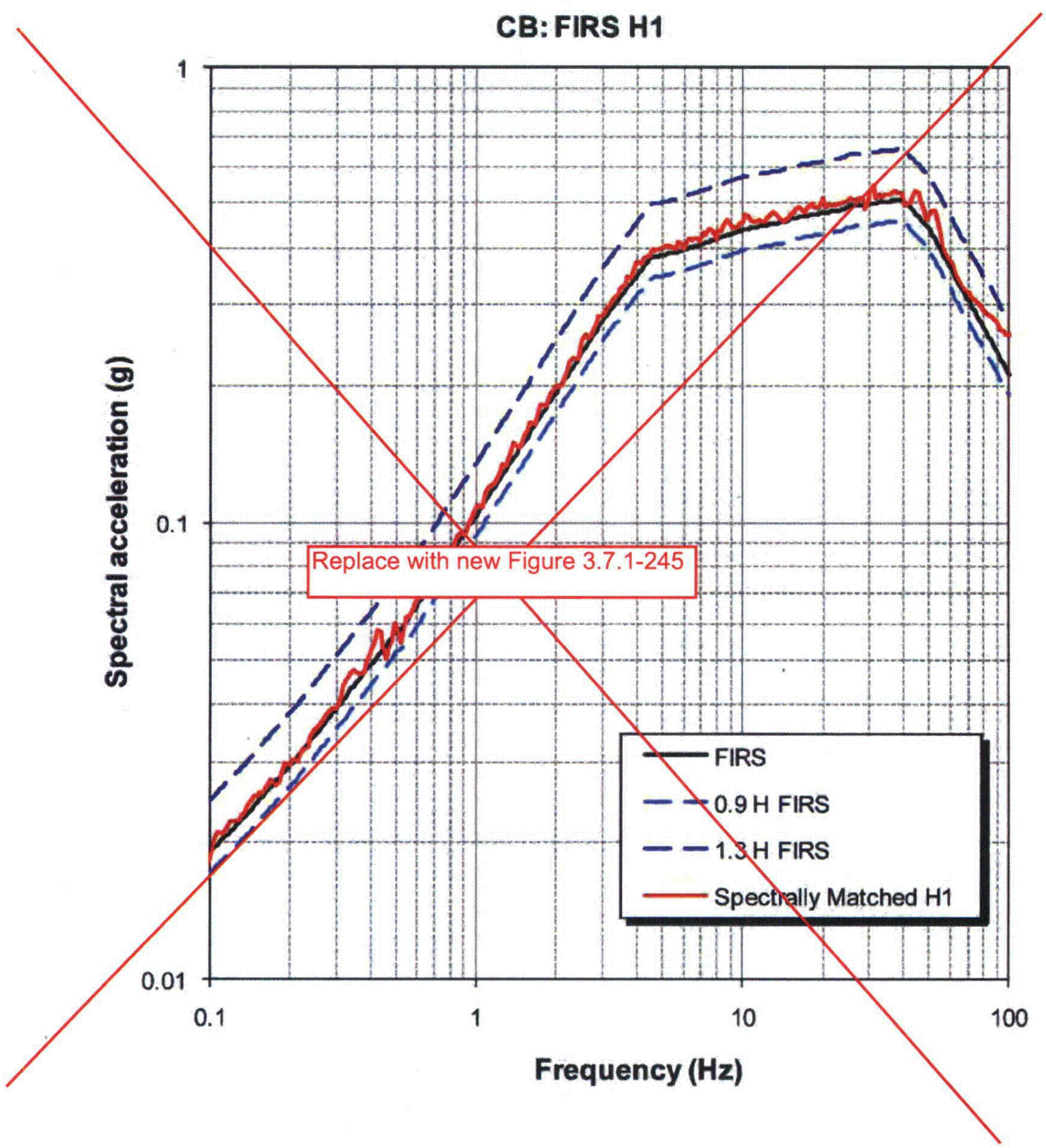
Figure 3.7.1-237 Response Spectrum for Spectrally Matched Horizontal (H1) Component for the Fermi 3 CB SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-245

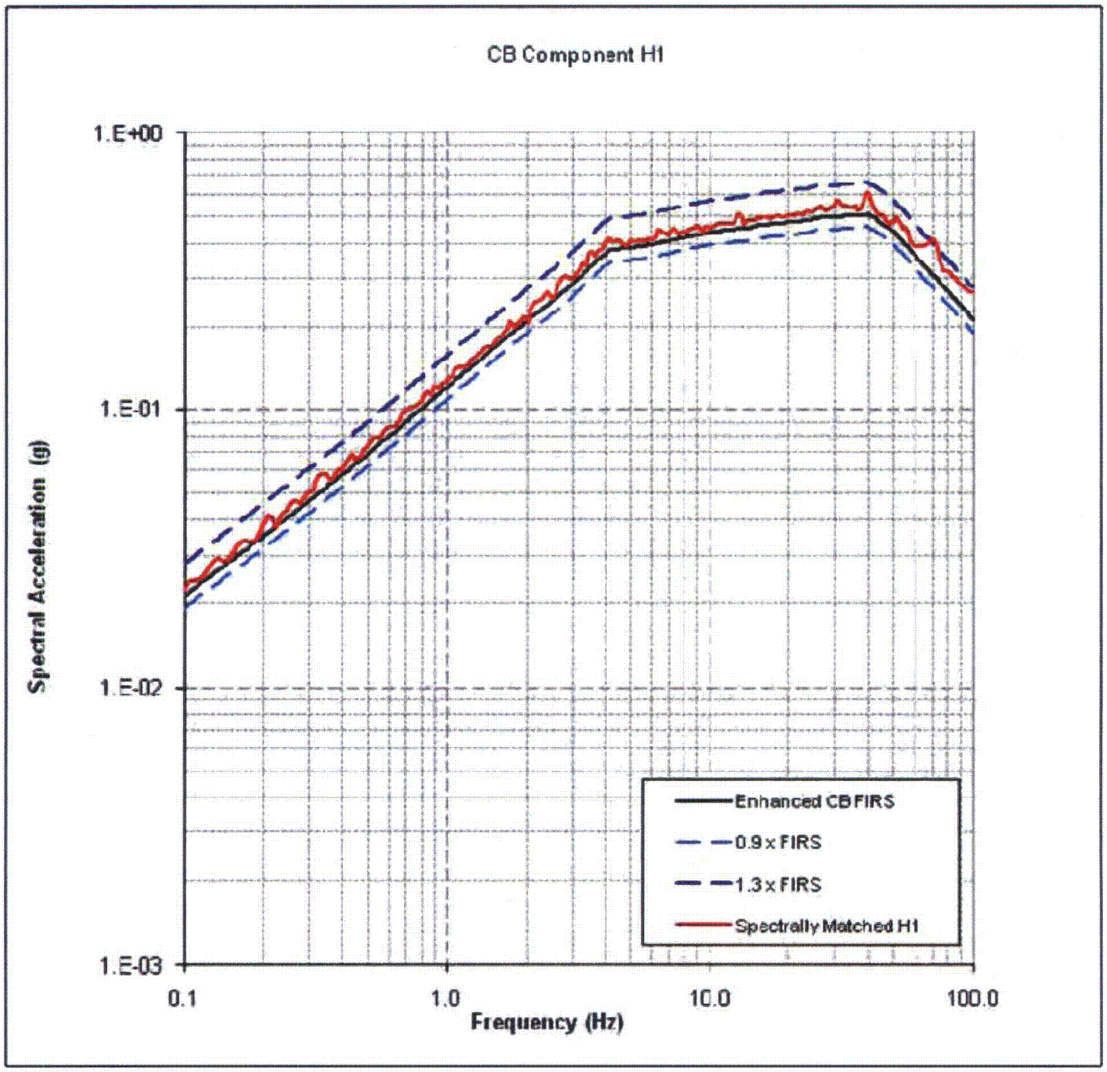
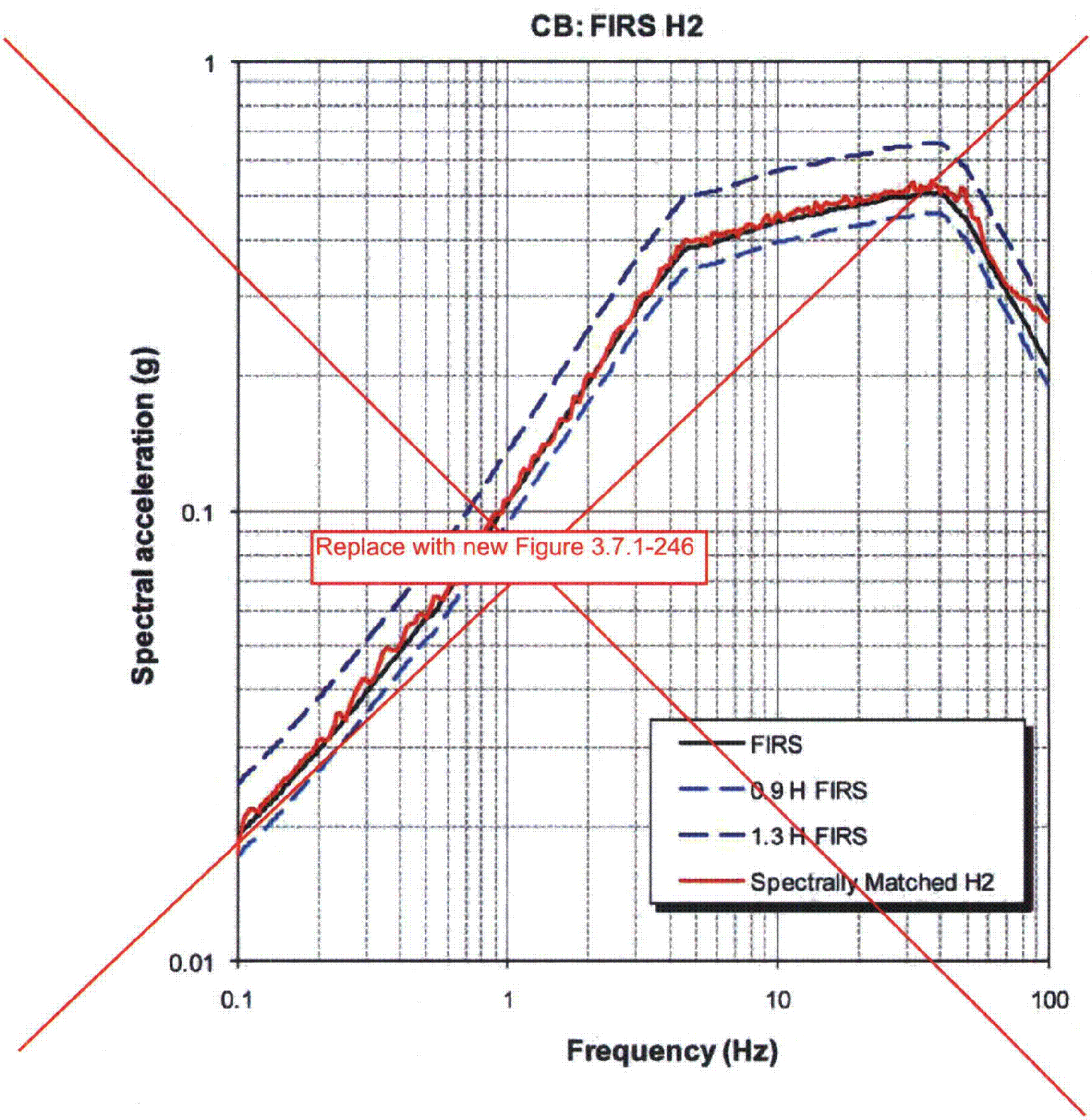


Figure 3.7.1-245: Response Spectrum for Spectrally Matched Horizontal (H1) Component for the Fermi 3 CB SSI FIRS.

Figure 3.7.1-238 Response Spectrum for Spectrally Matched Horizontal (H2) Component for the Fermi 3 CB SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-246

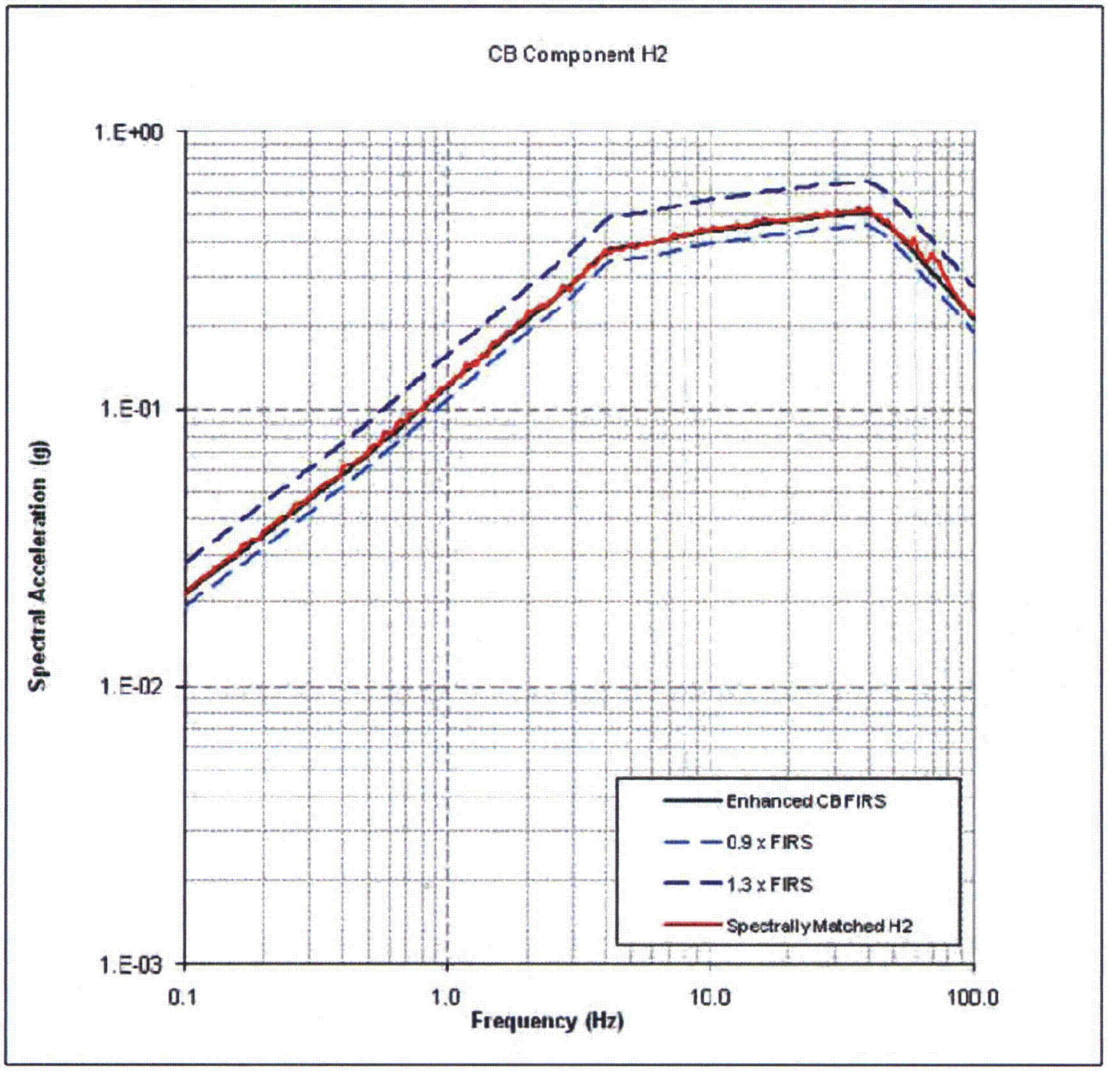
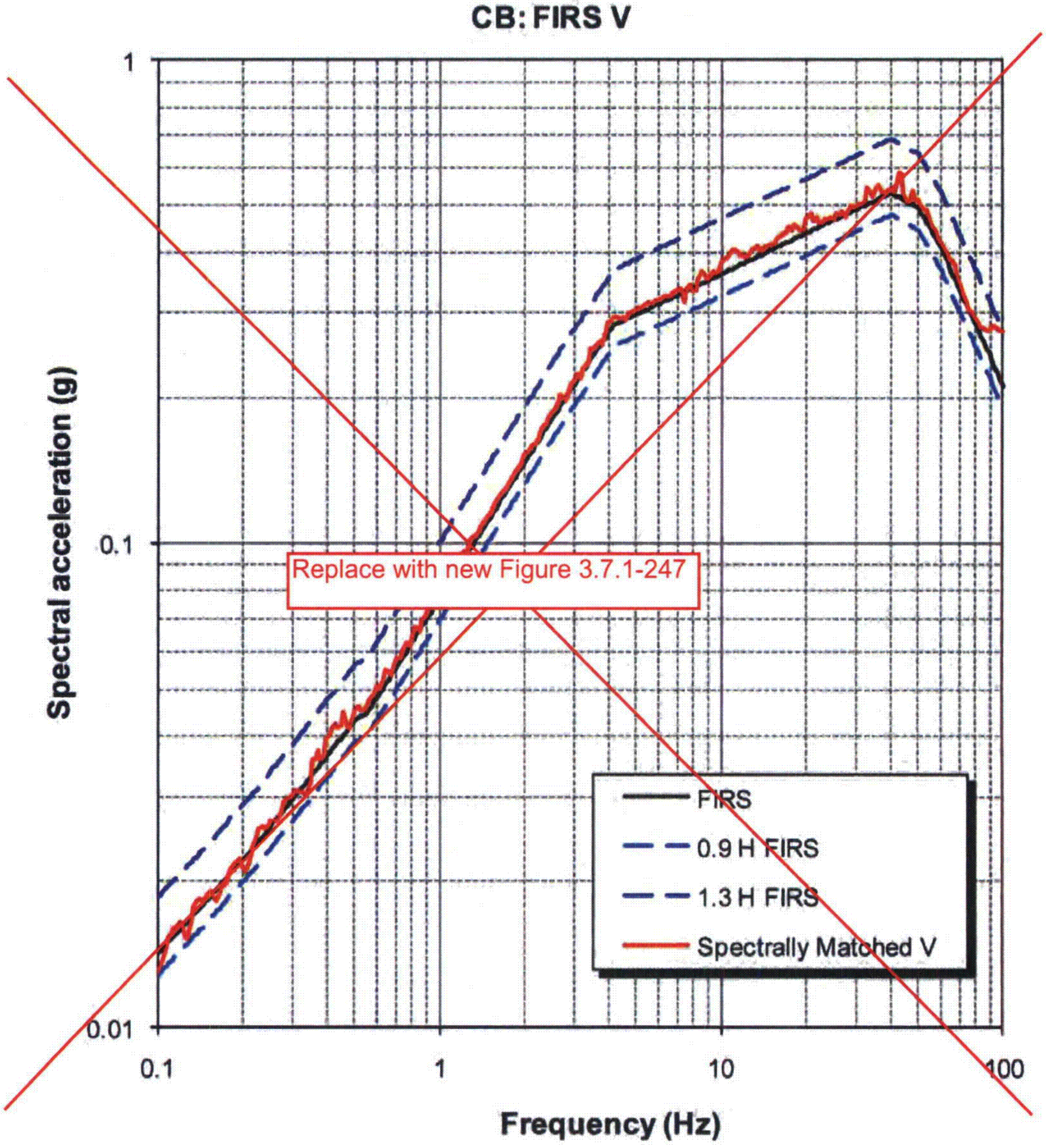


Figure 3.7.1-246: Response Spectrum for Spectrally Matched Horizontal (H2) Component for the Fermi 3 CB SSI FIRS.

Figure 3.7.1-239 Response Spectrum for Spectrally Matched Vertical (V) Component for the Fermi 3 CB SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-247

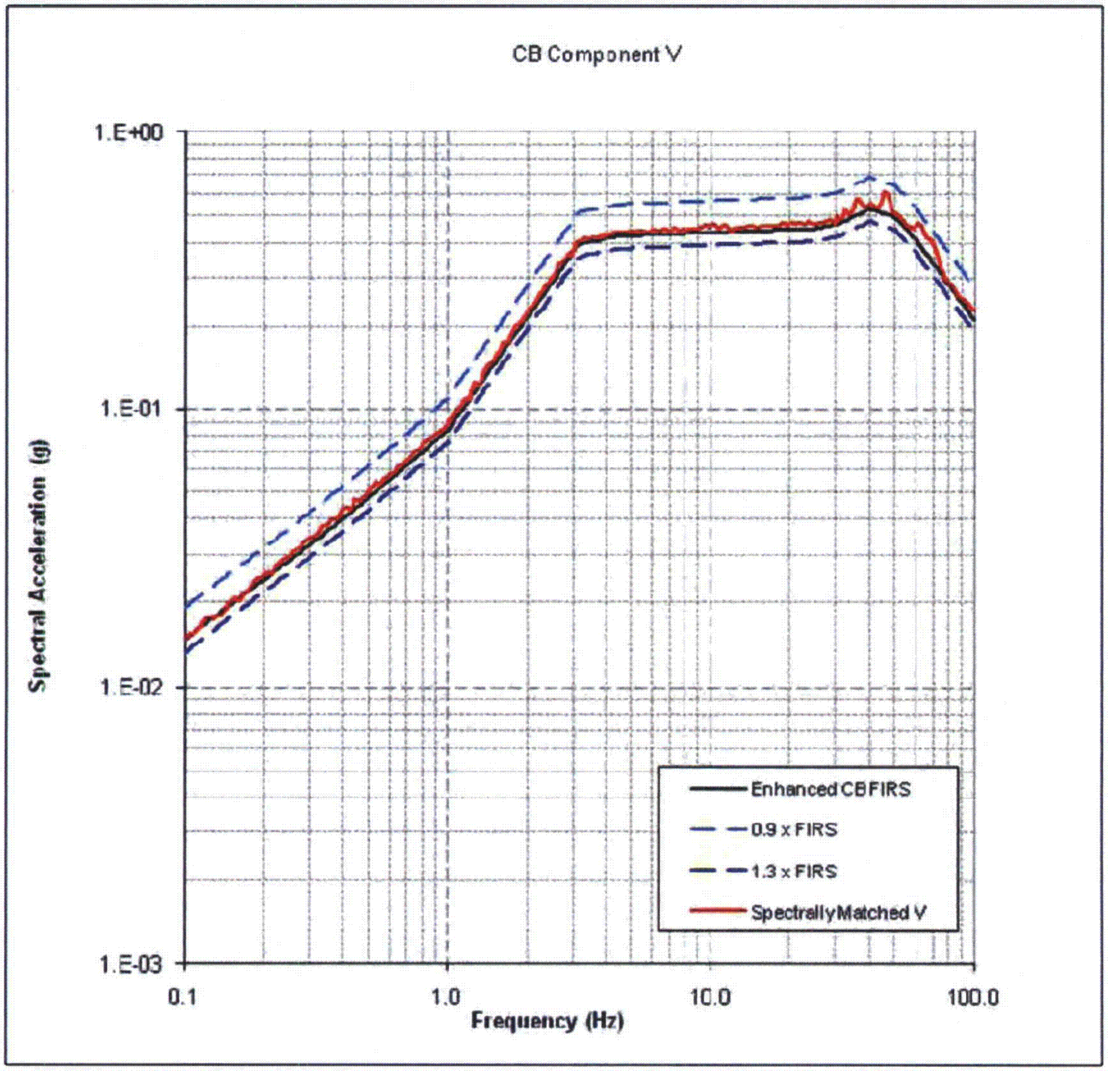
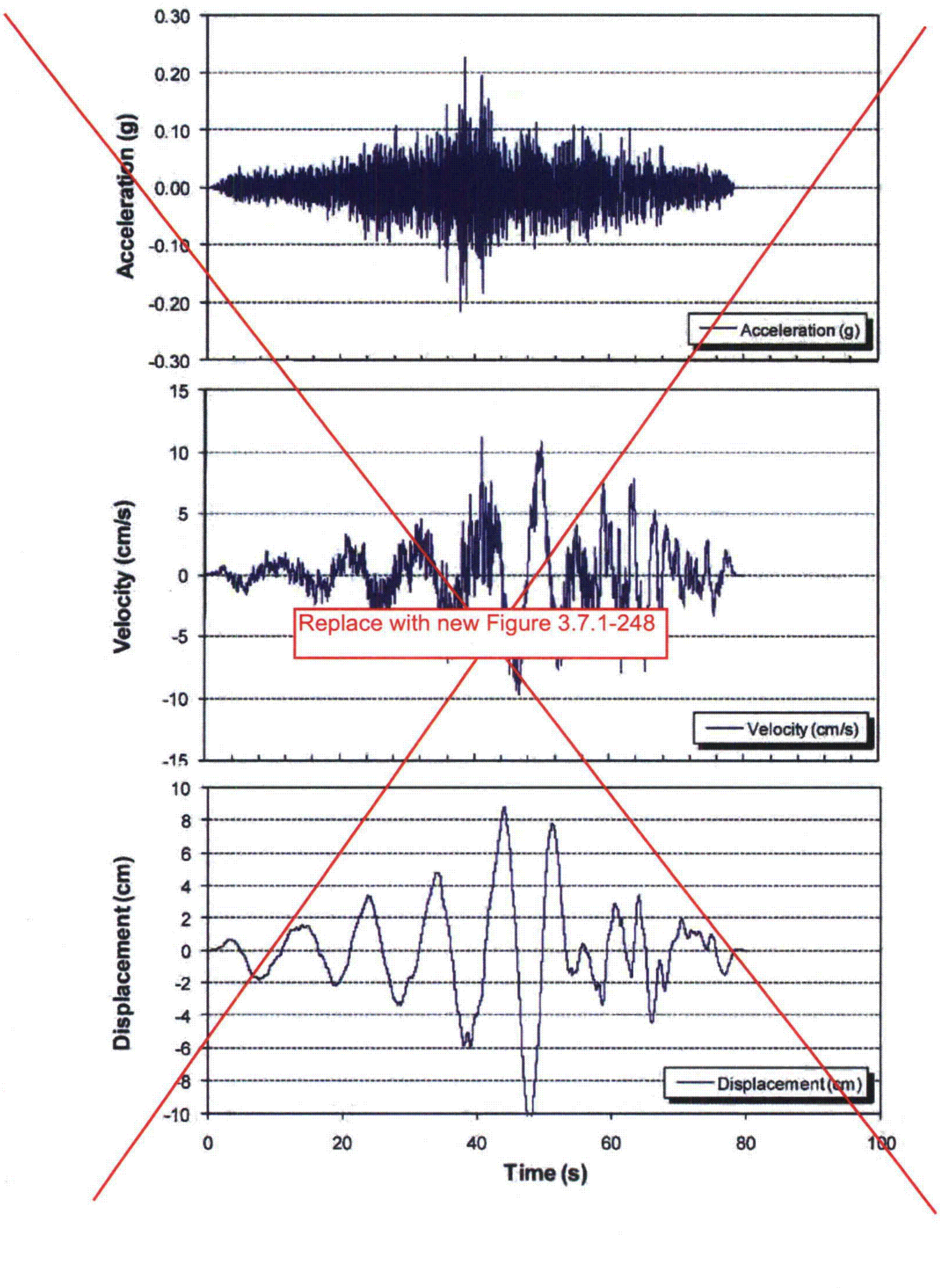


Figure 3.7.1-247: Response Spectrum for Spectrally Matched Vertical (V) Component for the Fermi 3 CB SSI FIRS.

Figure 3.7.1-240 Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H1) Component Compatible with the RB/FB Horizontal SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-248

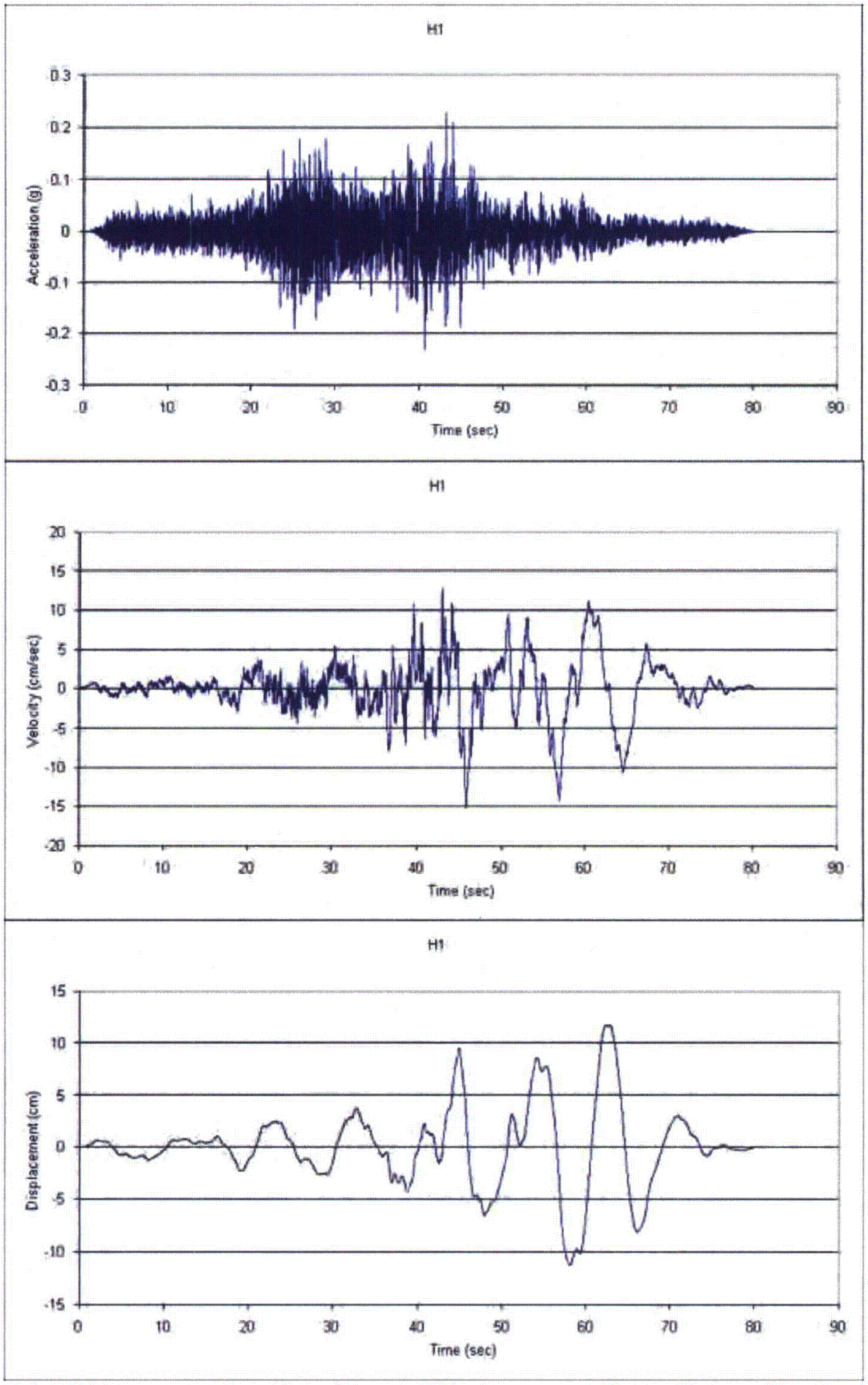
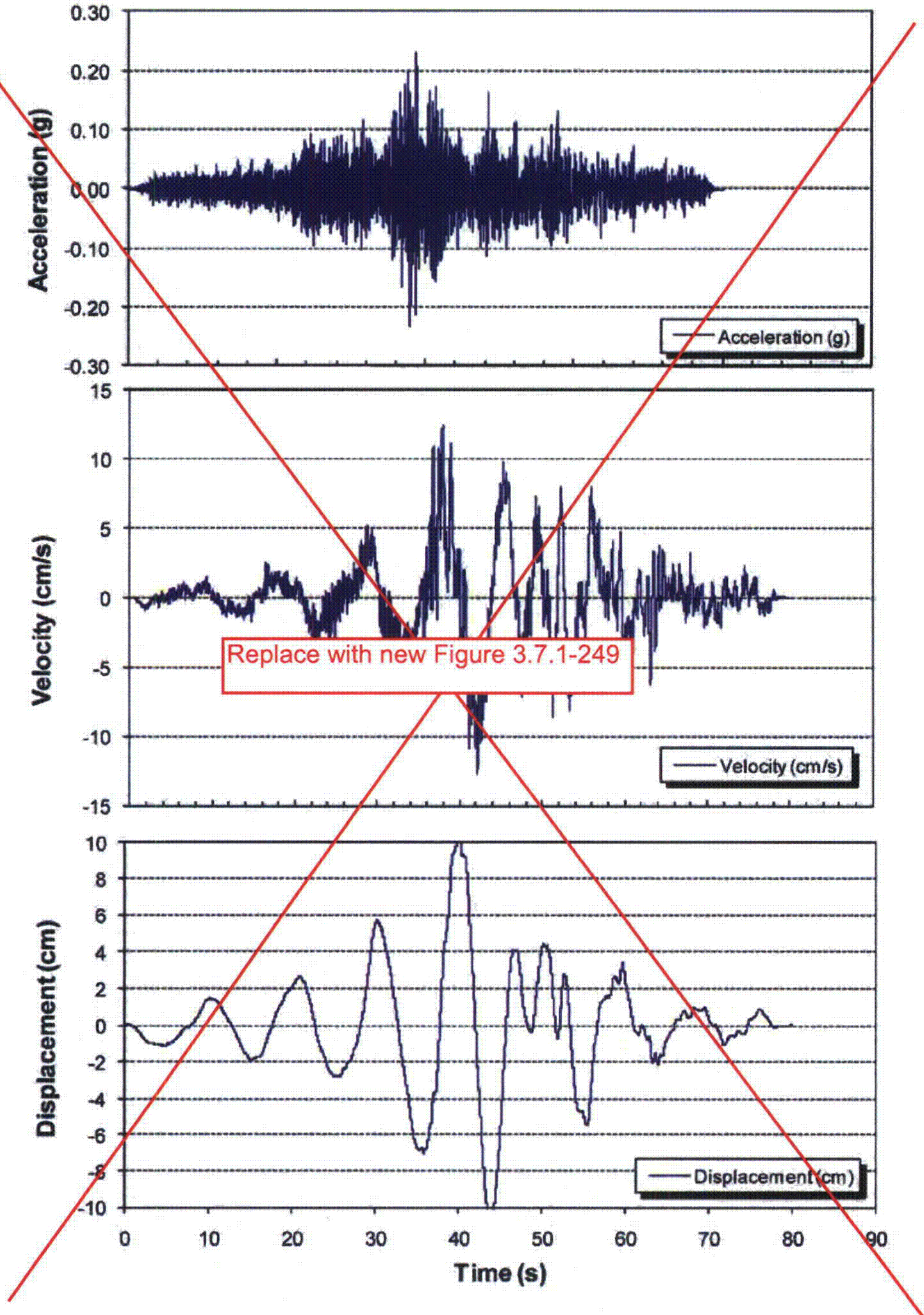


Figure 3.7.1-248: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H1) Component Compatible with the RB/FB Horizontal SSI FIRS.

Figure 3.7.1-241 Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H2) Component Compatible with the RB/FB Horizontal SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-249

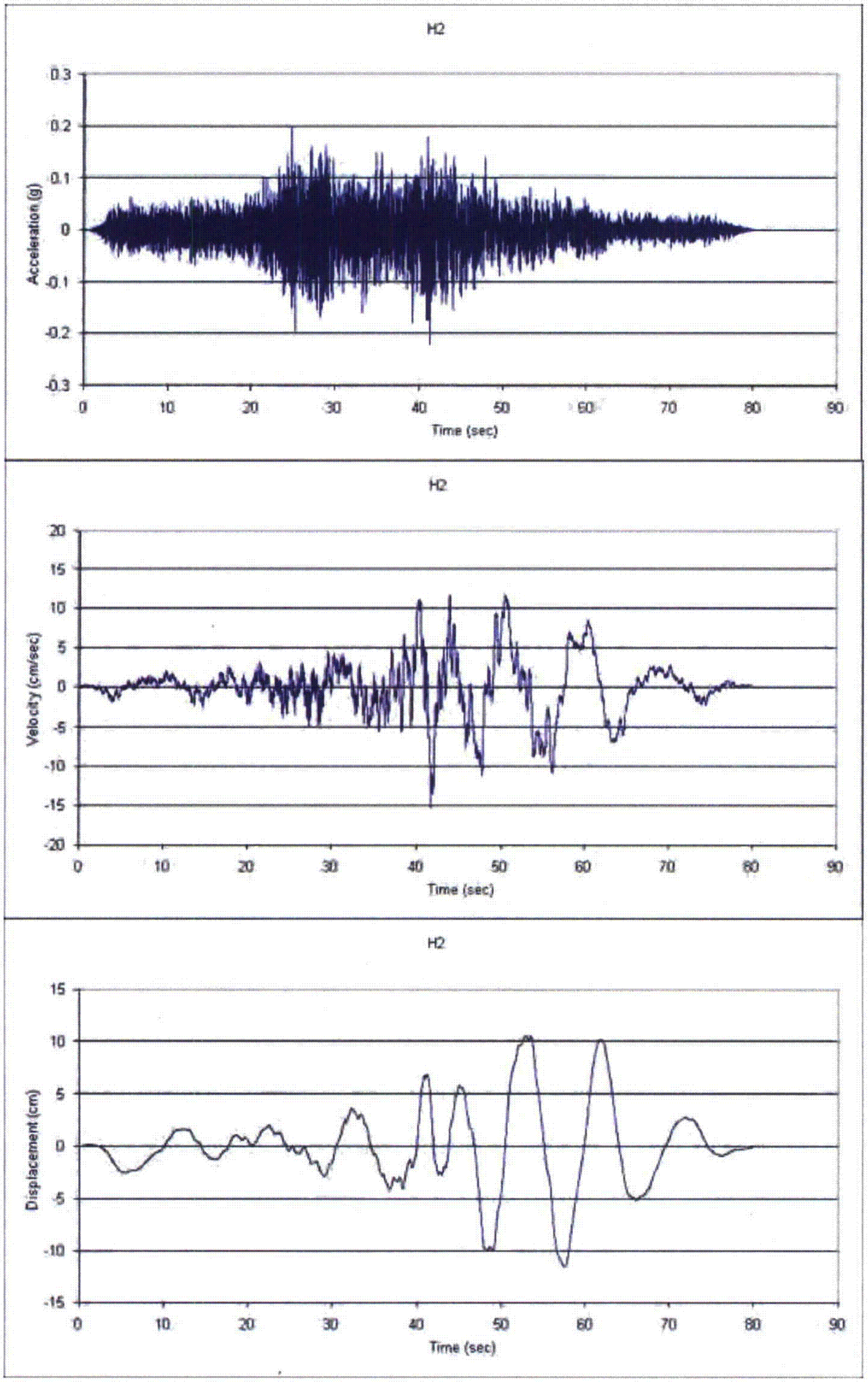
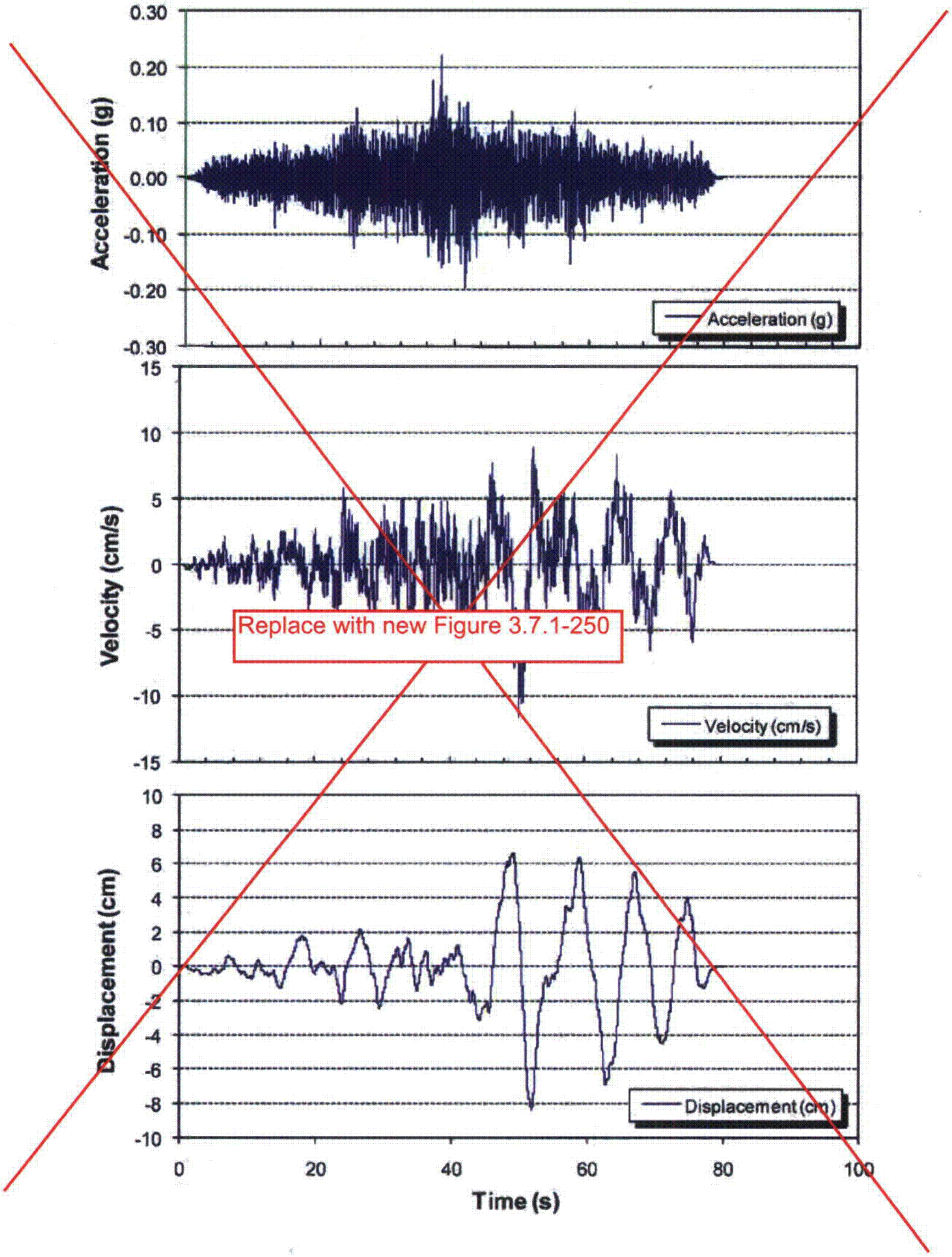


Figure 3.7.1-249: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H2) Component Compatible with the RB/FB Horizontal SSI FIRS.

Figure 3.7.1-242 Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Vertical (V) Component Compatible with the RB/FB Vertical SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-250

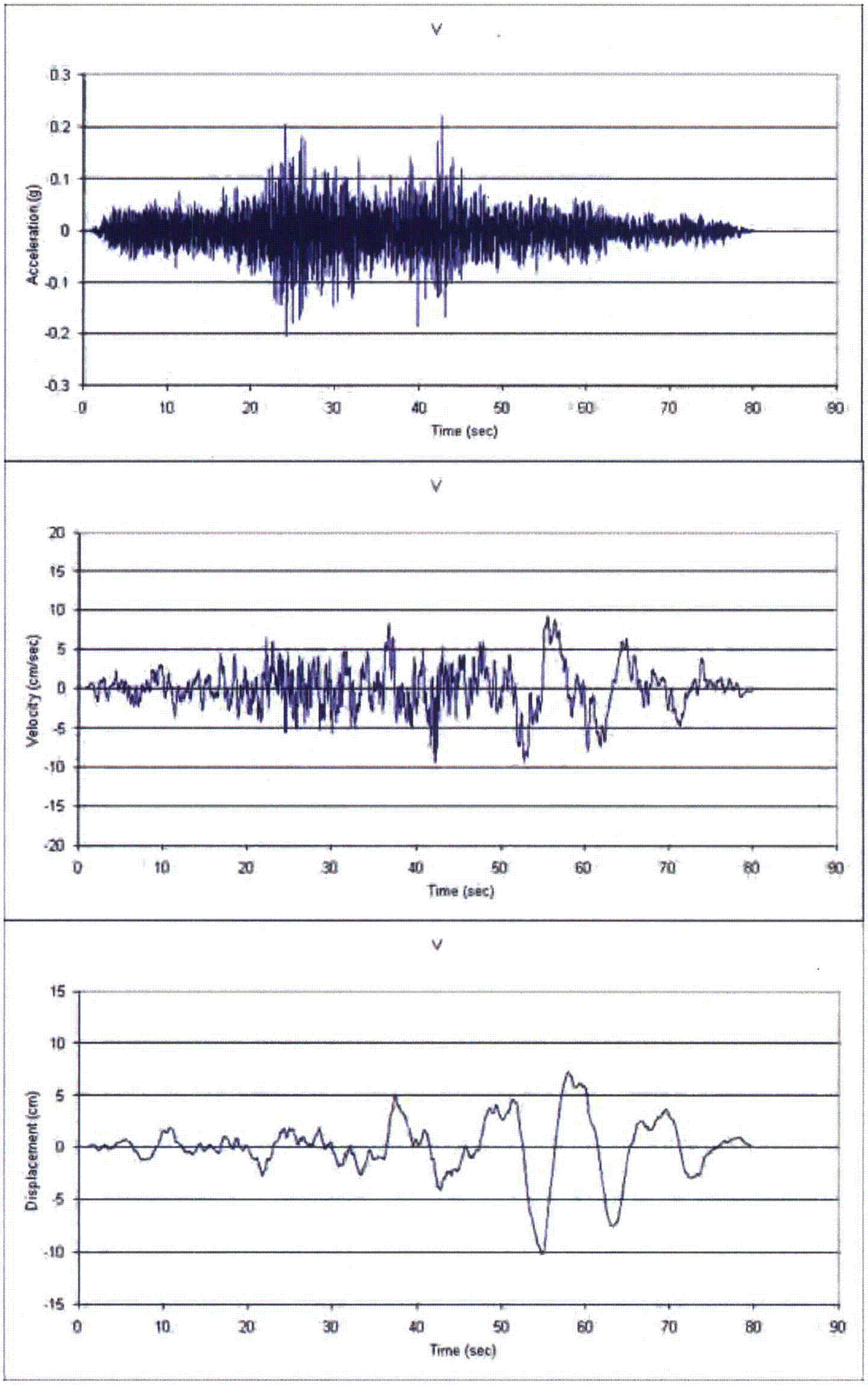
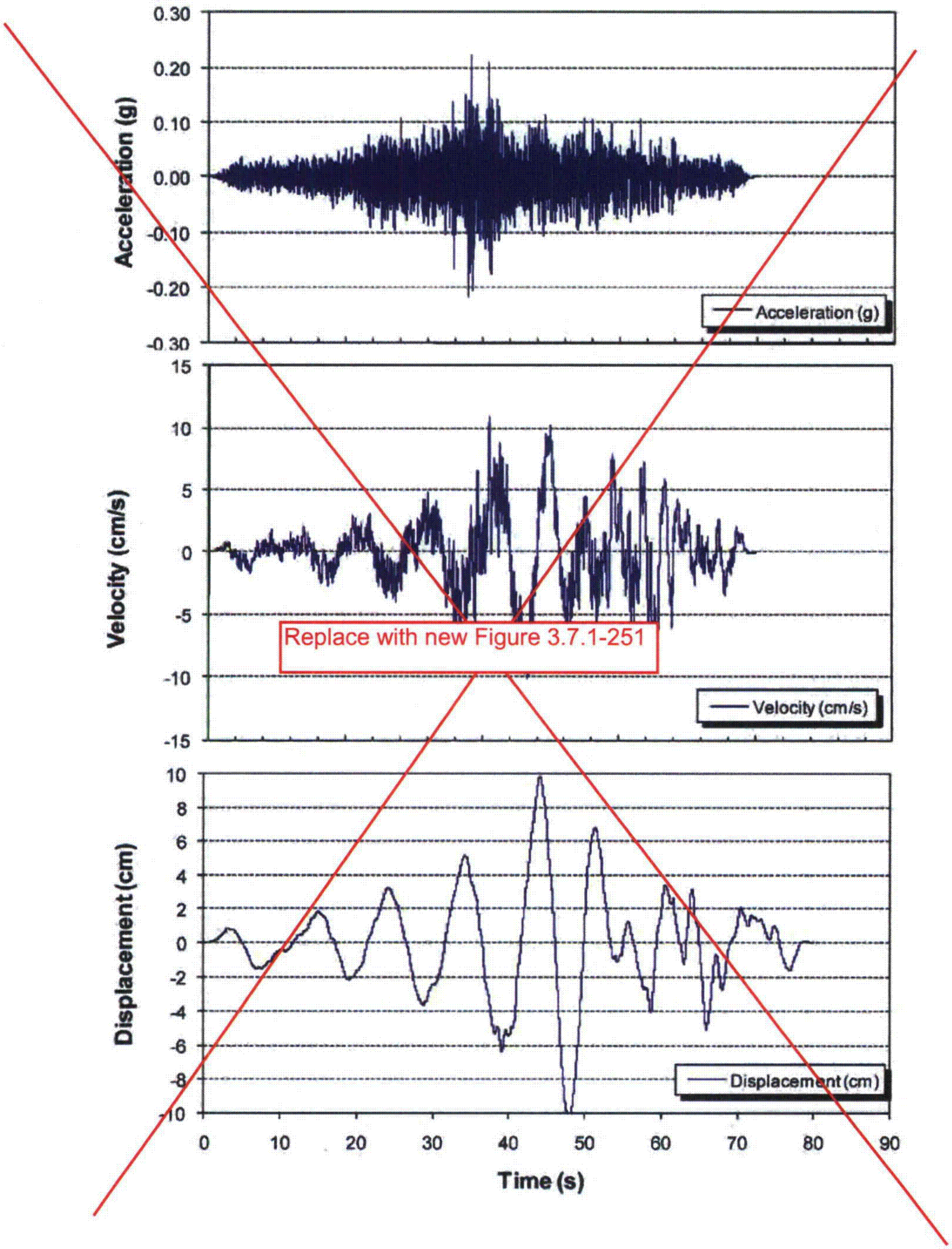


Figure 3.7.1-250: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Vertical (V) Component Compatible with the RB/FB Vertical SSI FIRS.

Figure 3.7.1-243 Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H1) Component Compatible with the CB Horizontal SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-251

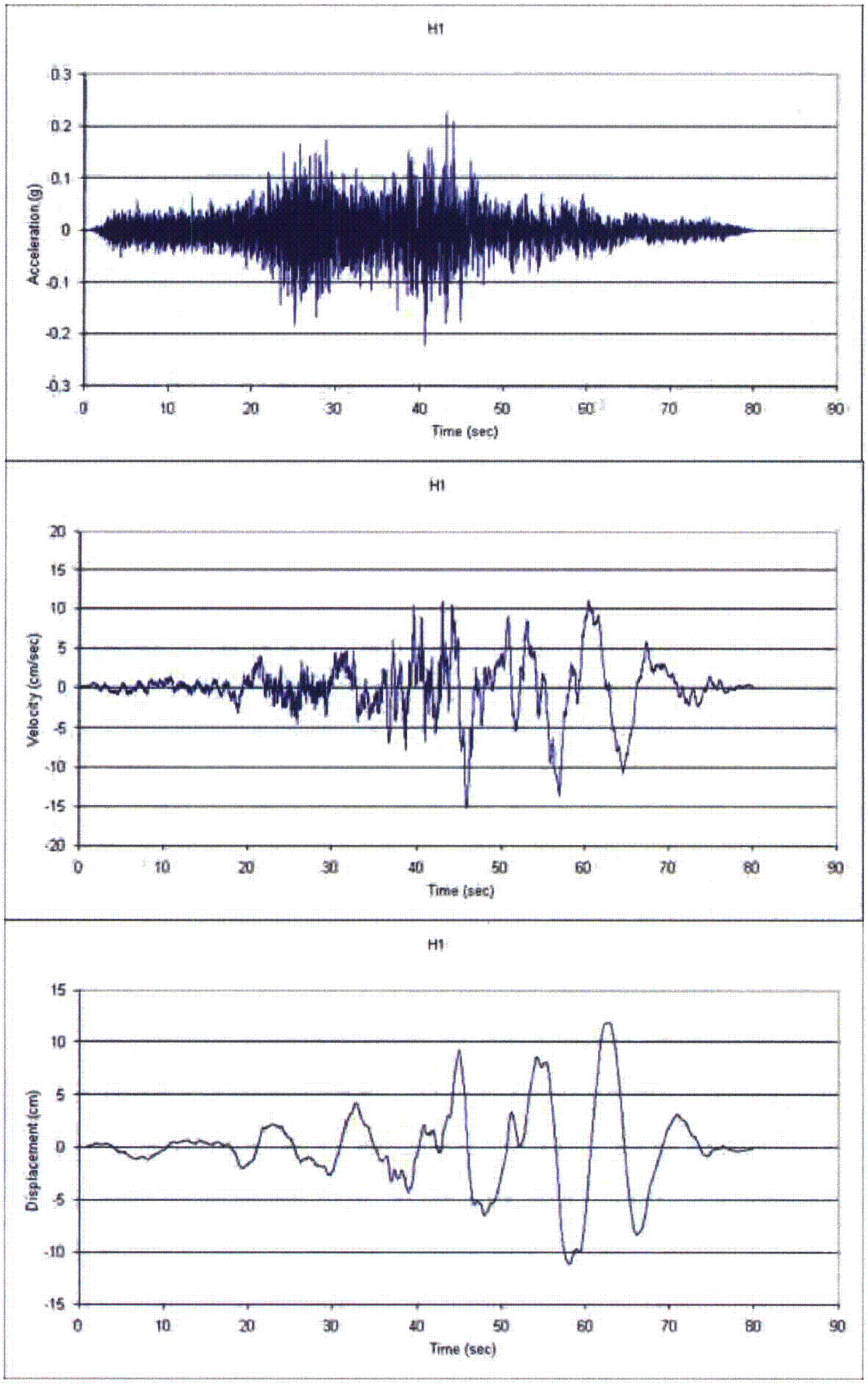
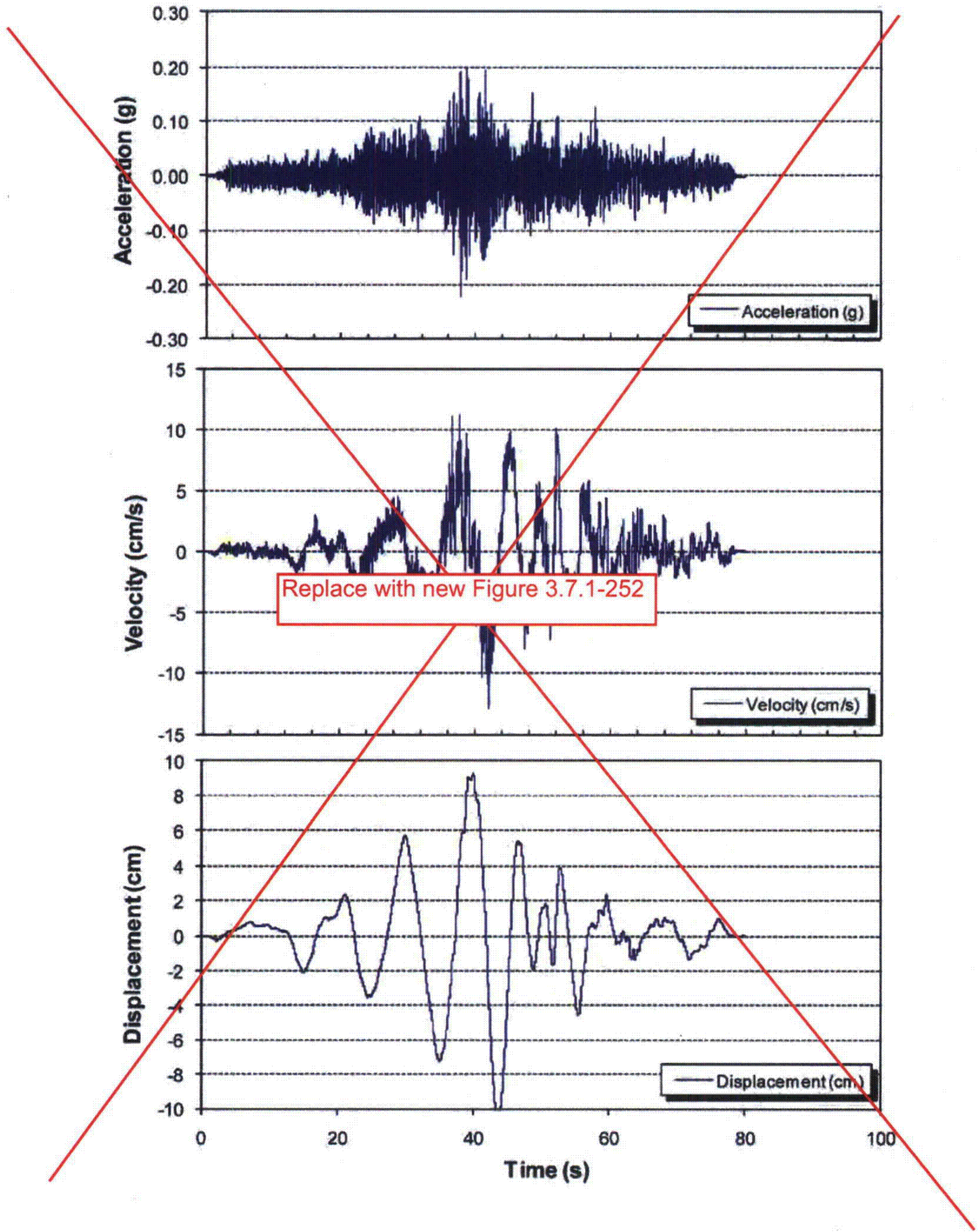


Figure 3.7.1-251: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H1) Component Compatible with the CB Horizontal SSI FIRS.

Figure 3.7.1-244 Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H2) Component Compatible with the CB Horizontal SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-252

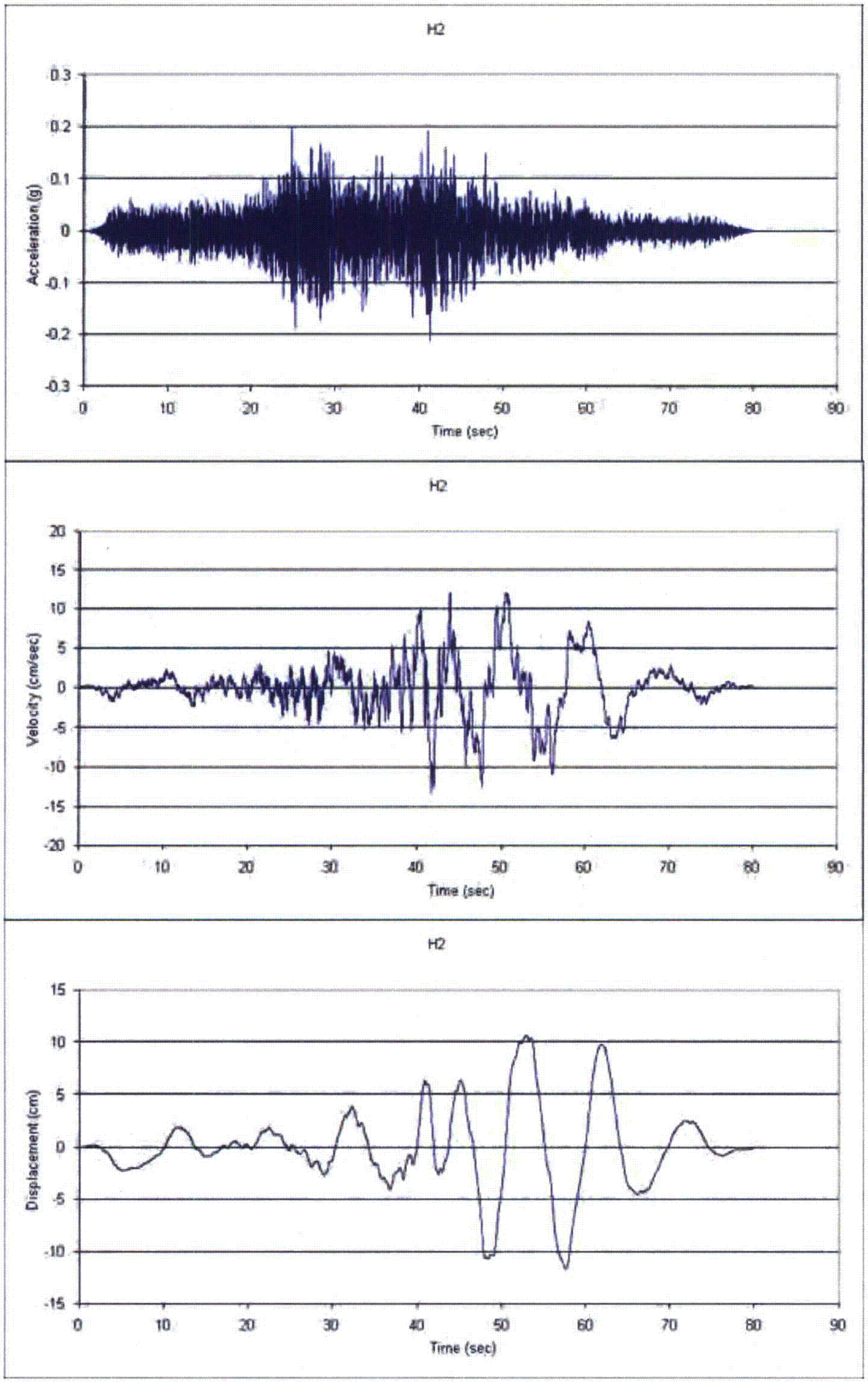
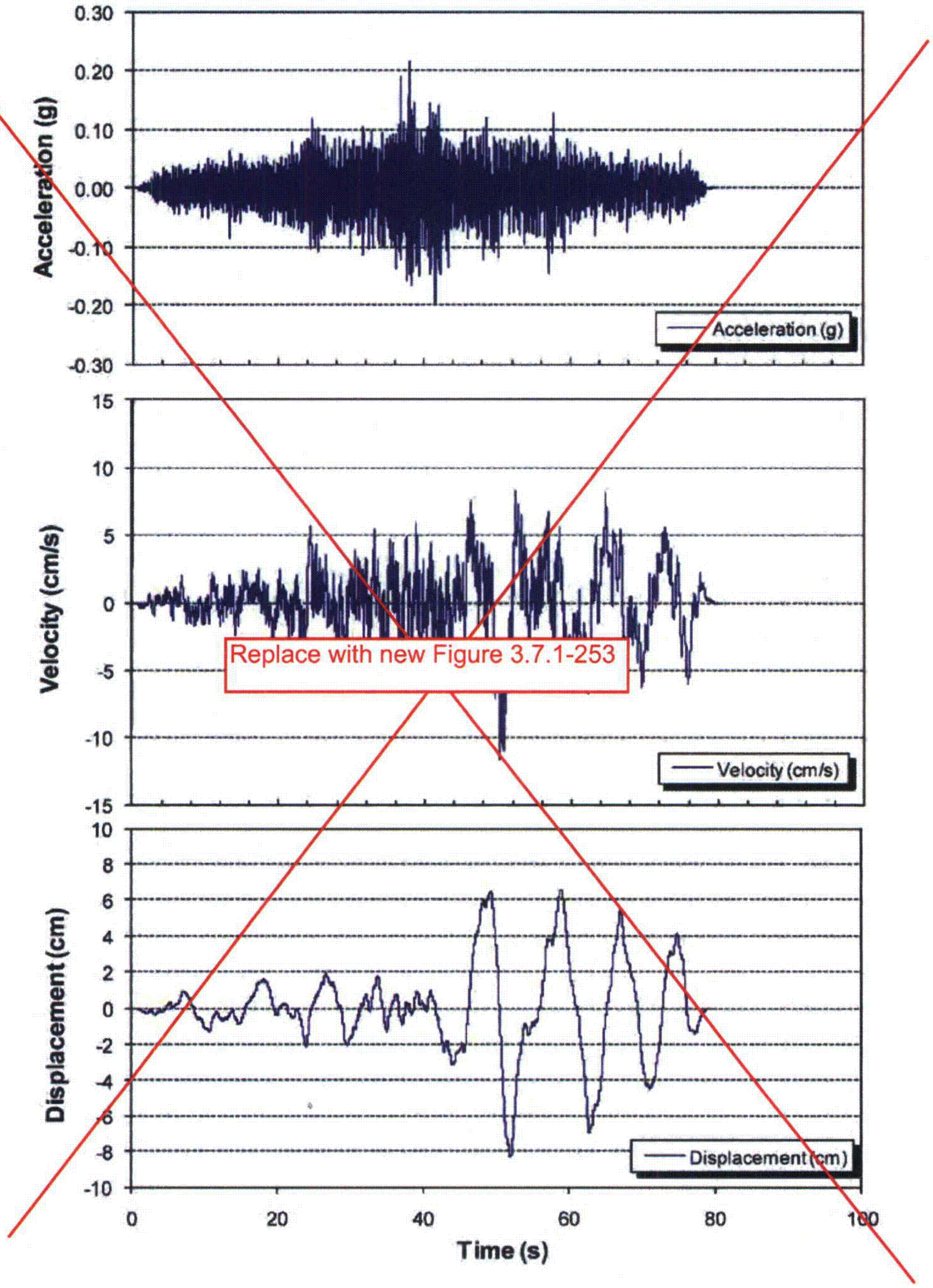


Figure 3.7.1-252: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H2) Component Compatible with the CB Horizontal SSI FIRS.

Figure 3.7.1-245 Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Vertical (V) Component Compatible with the CB Vertical SSI FIRS [EF3 SUP 3.7-2]



New Figure 3.7.1-253

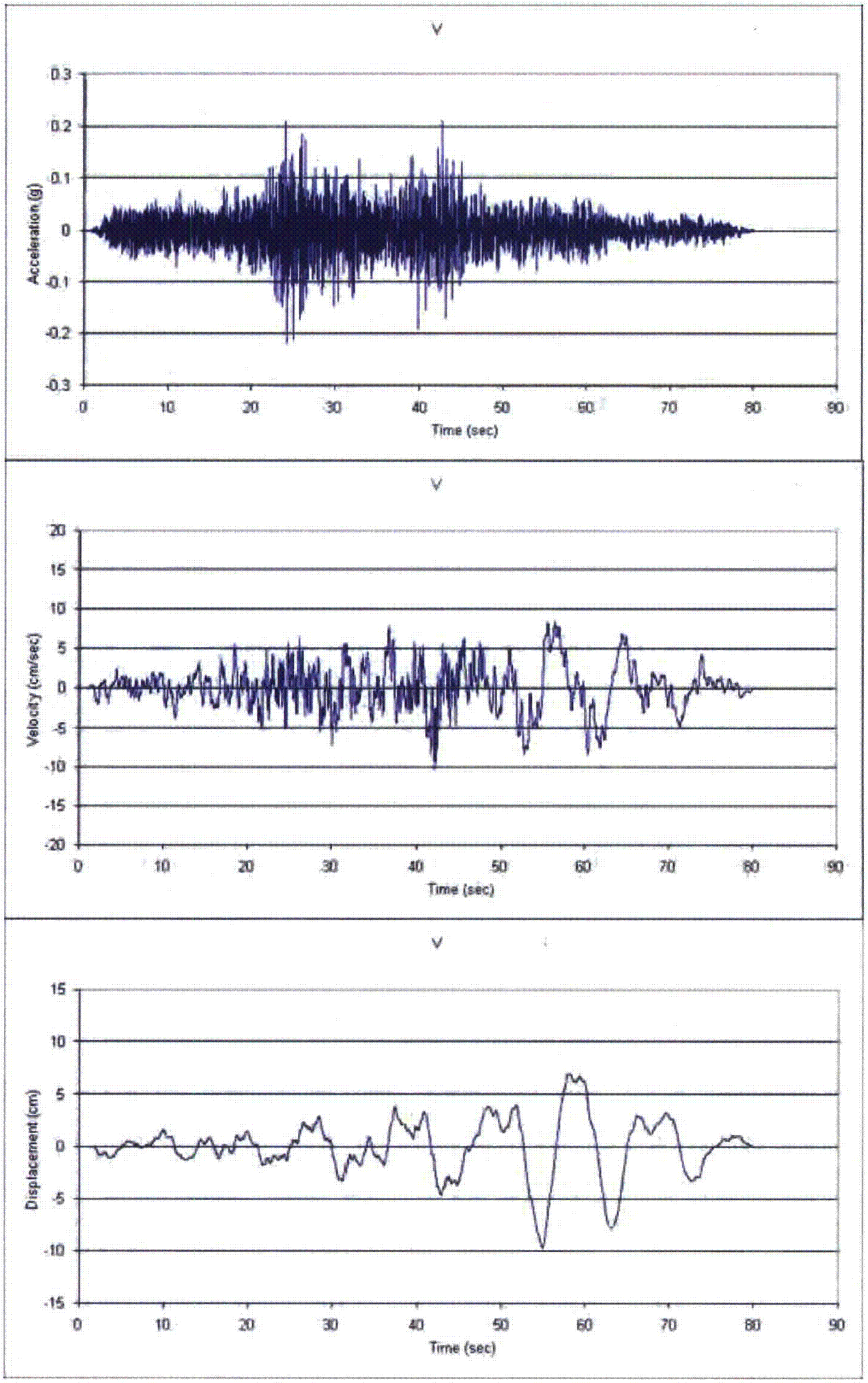
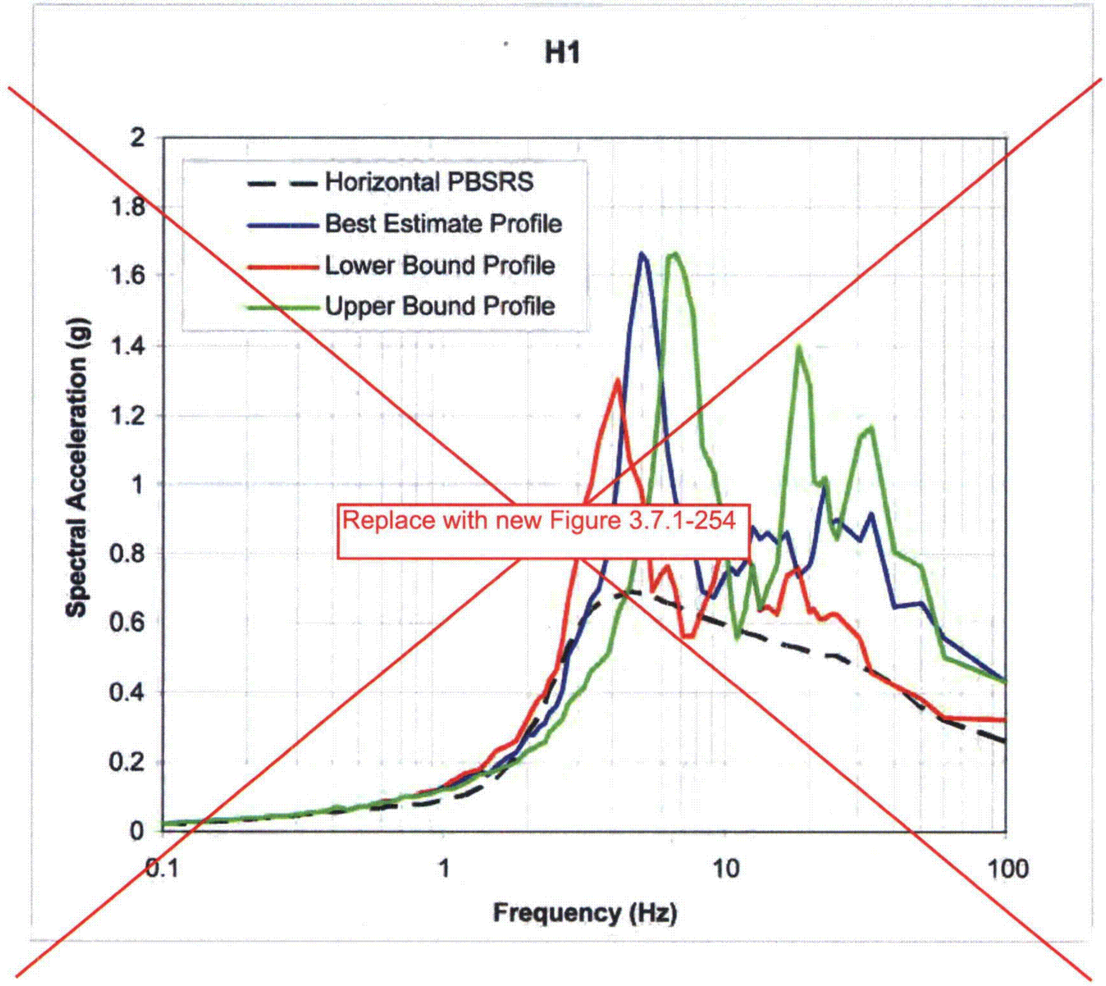


Figure 3.7.1-253: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Vertical (V) Component Compatible with the CB Vertical SSI FIRS.

Figure 3.7.1-246 Comparison of Response Spectra of Computed Horizontal (H1) Component Surface Motions for SSI Profiles Using the RB/FB SCOR FIRS Input Motion to the Horizontal PBSRS [EF3 SUP 3.7-2]



New Figure 3.7.1-254

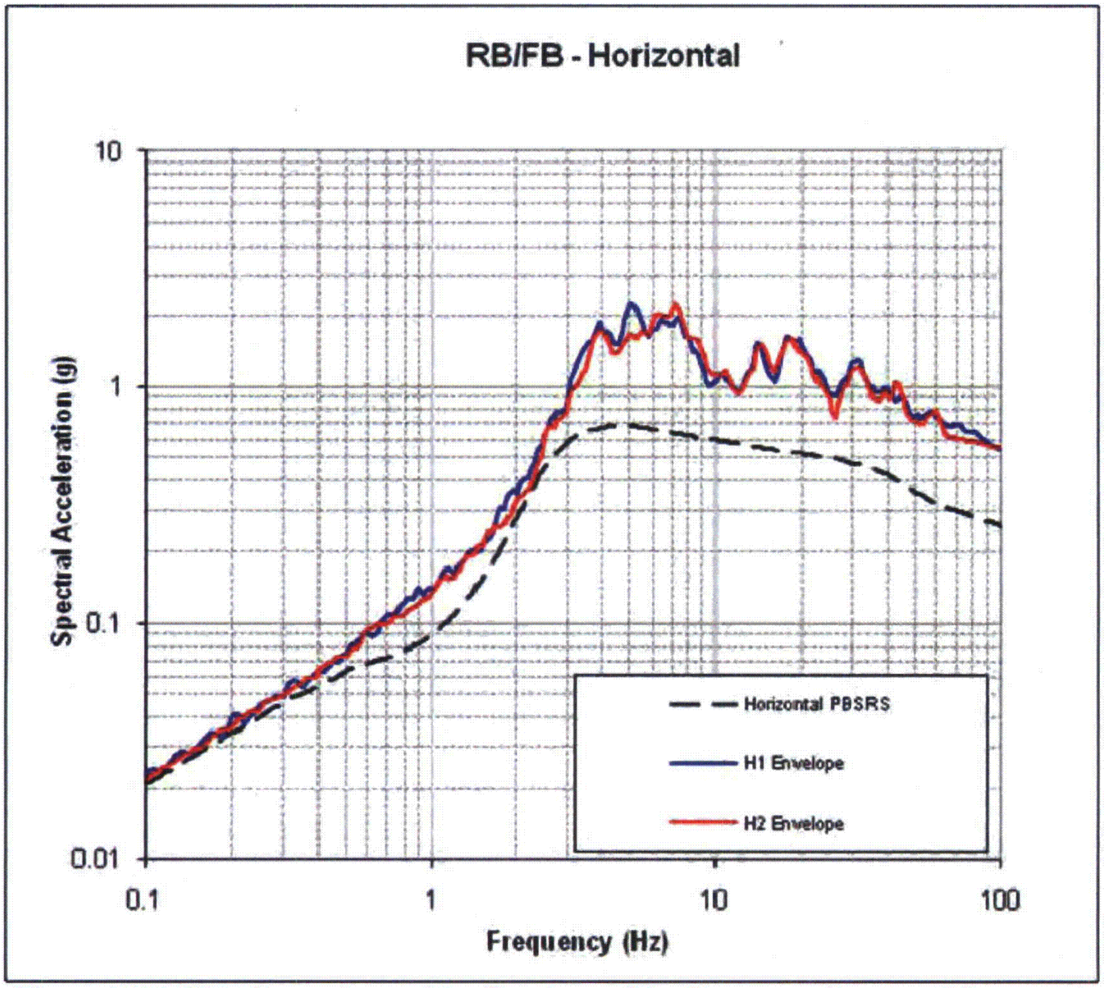


Figure 3.7.1-254: Comparison of the Envelope of the Response Spectra of Computed Horizontal (H1 and H2) Component Surface Motions Using the RB/FB SSI FIRS Input Motion with the Horizontal PBSRS.

Figure 3.7.1-247 Comparison of Response Spectra of Computed Horizontal (H2) Component Surface Motions for SSI Profiles Using the RB/FB SCOR FIRS Input Motion to the Horizontal PBSRS [EF3 SUP 3.7-2]

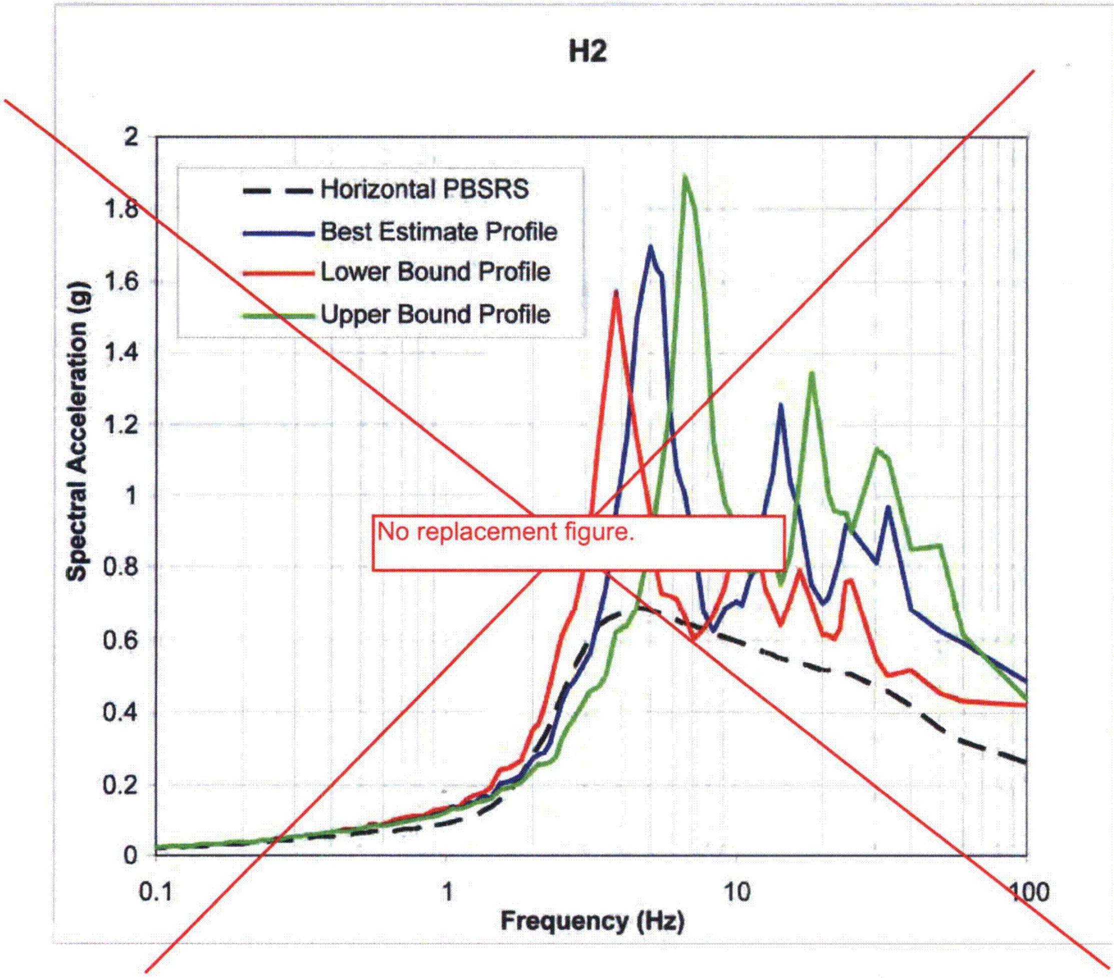
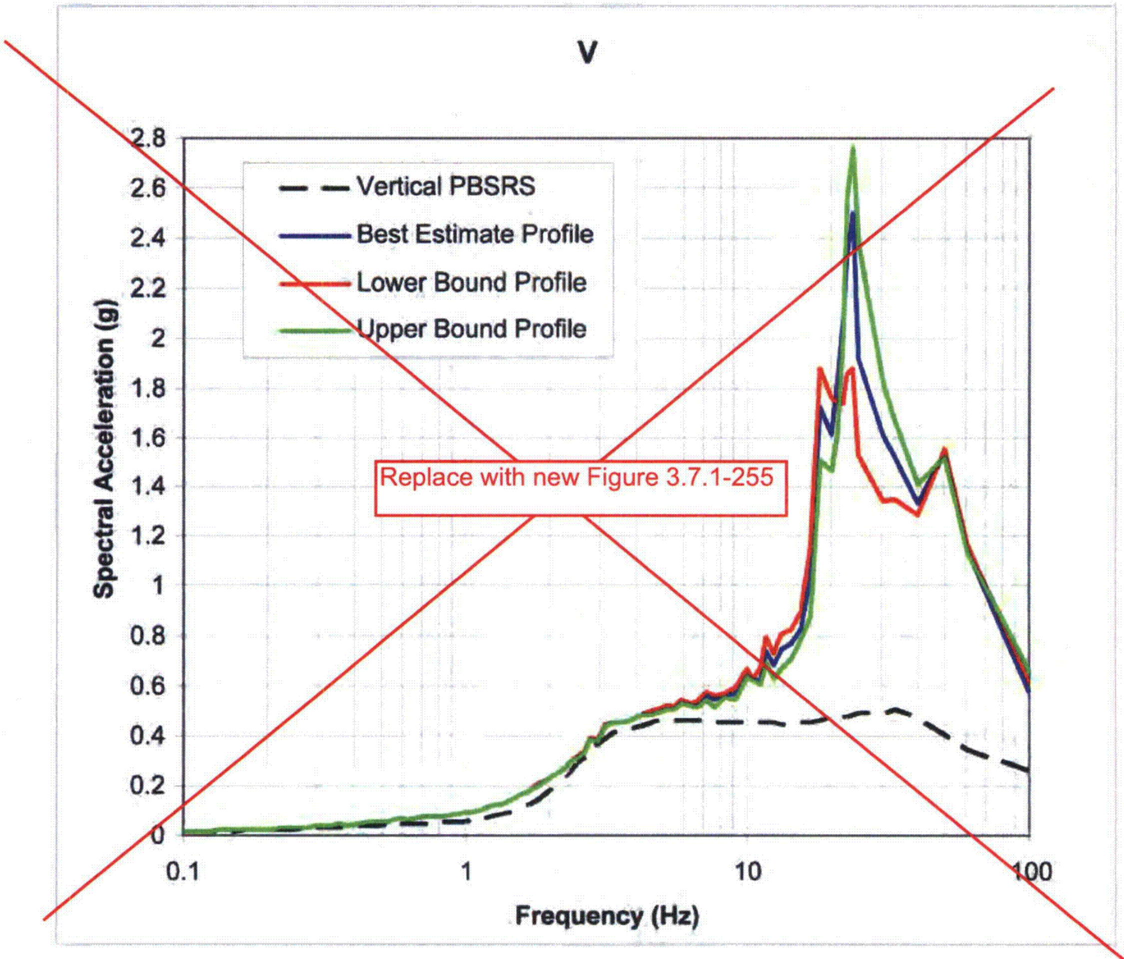


Figure 3.7.1-248 Comparison of Response Spectra of Computed Vertical (V) Component Surface Motions for SSI Profiles Using the RB/FB SCOR FIRS Input Motion to the Vertical PBSRS [EF3 SUP 3.7-2]



New Figure 3.7.1-255

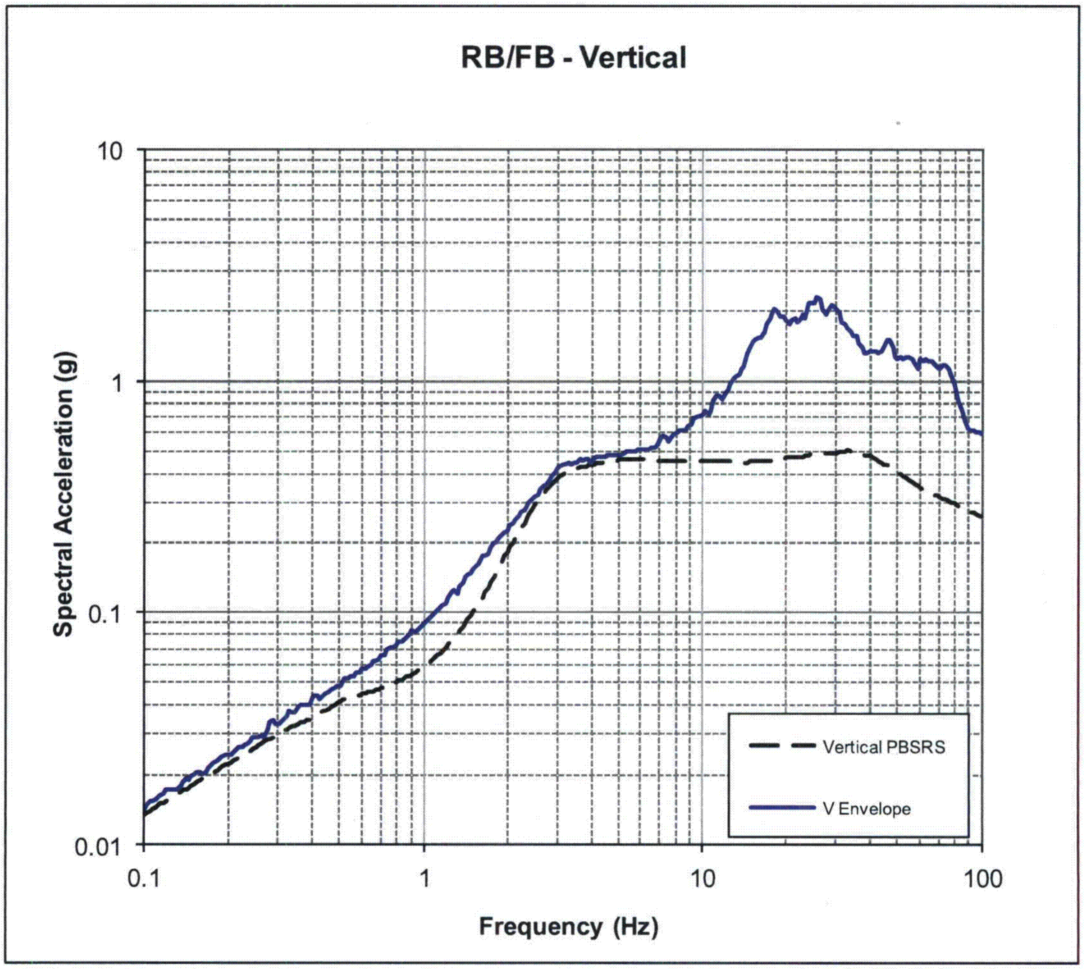
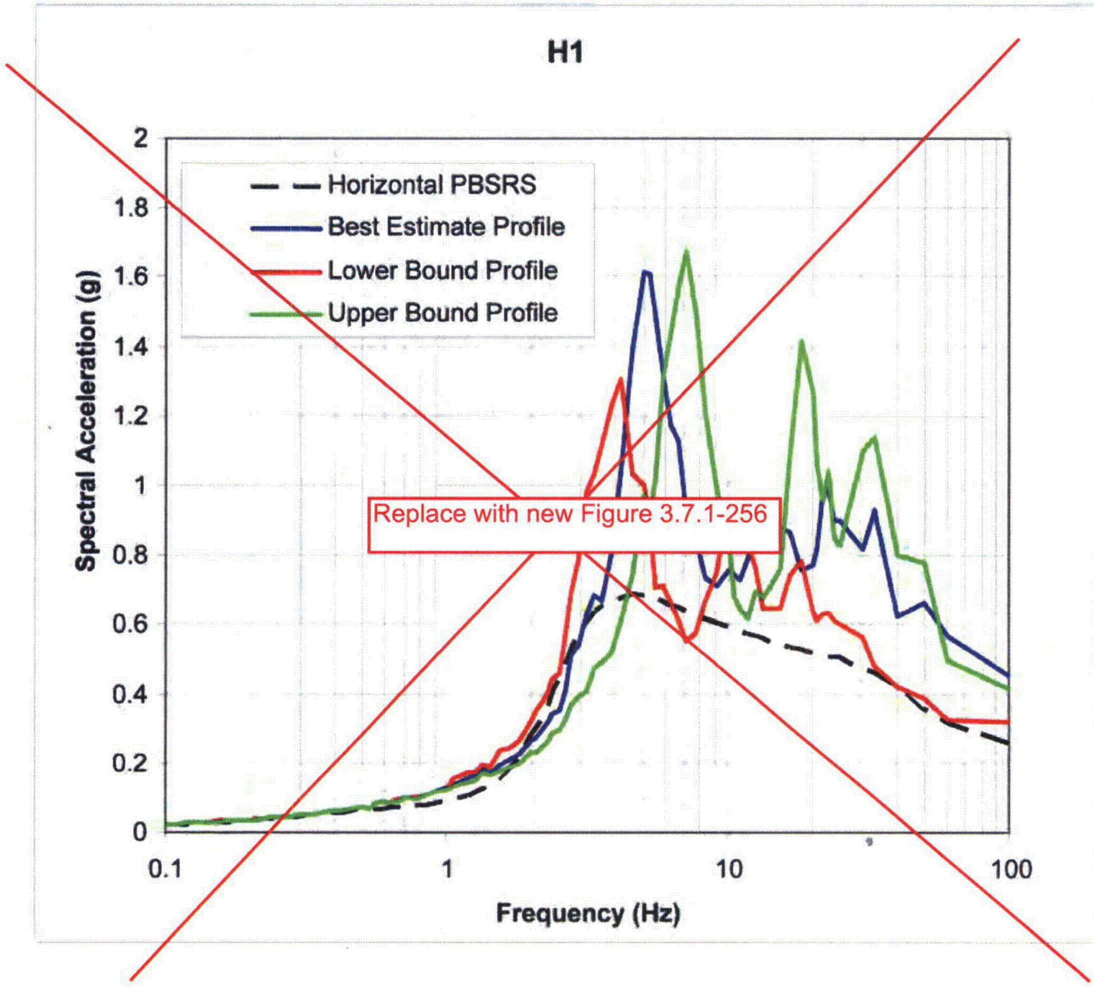


Figure 3.7.1-255: Comparison of the Envelope of the Response Spectra of Computed Vertical (V) Component Surface Motions Using the RB/FB SSI FIRS Input Motion with the Vertical PBSRS.

Figure 3.7.1-249 Comparison of Response Spectra of Computed Horizontal (H1) Component Surface Motions for SSI Profiles Using the CB SCOR FIRS Input Motion to the Horizontal PBSRS [EF3 SUP 3.7-2]



New Figure 3.7.1-256

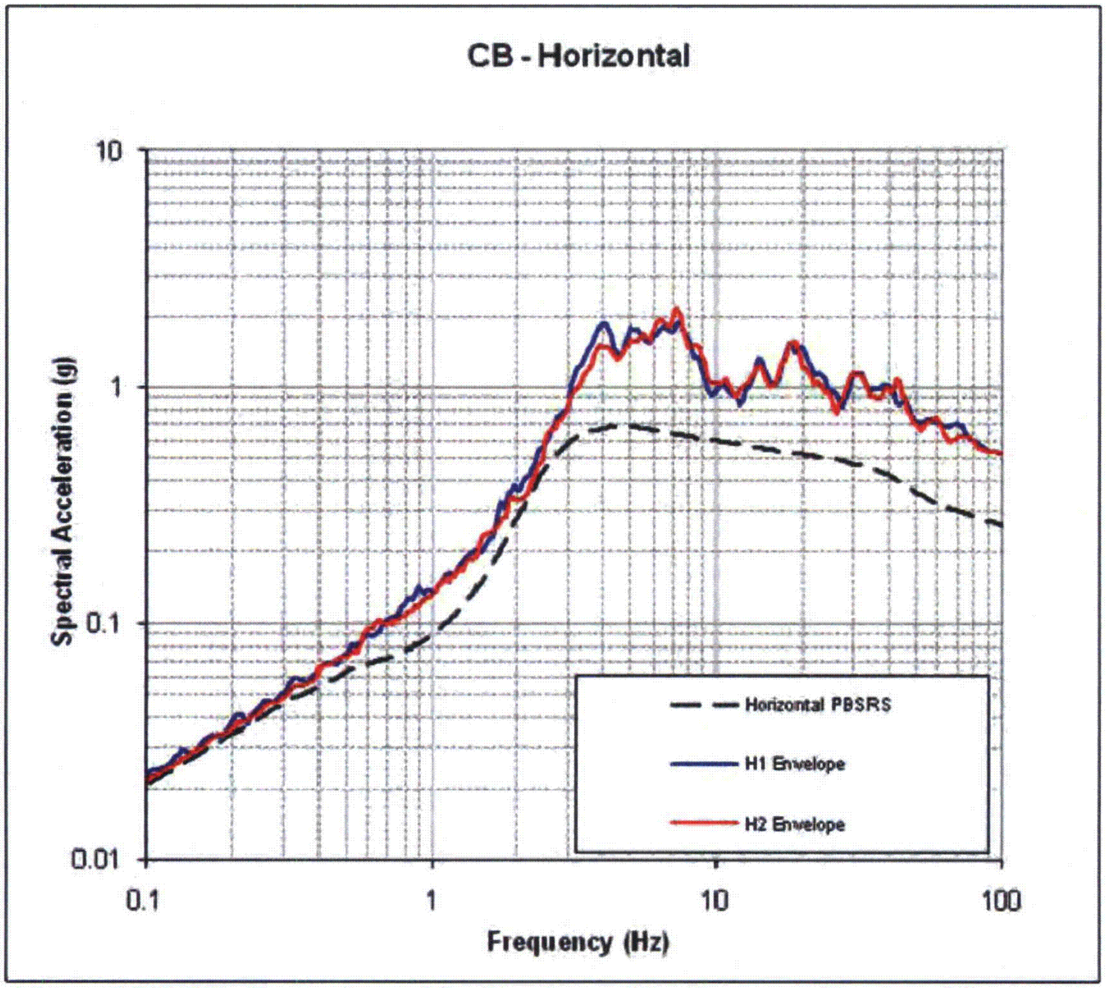


Figure 3.7.1-256: Comparison of the Envelope of the Response Spectra of Computed Horizontal (H1 and H2) Component Surface Motions Using CB SSI FIRS Input Motion with the Horizontal PBSRS.

Fighre 3.7.1-250 Comparison of Response Spectra of Computed Horizontal (H2) Component Surface Motions for SSI Profiles Using the CB SCOR FIRS Input Motion to the Horizontal PBSRS [EF3 SUP 3.7-2]

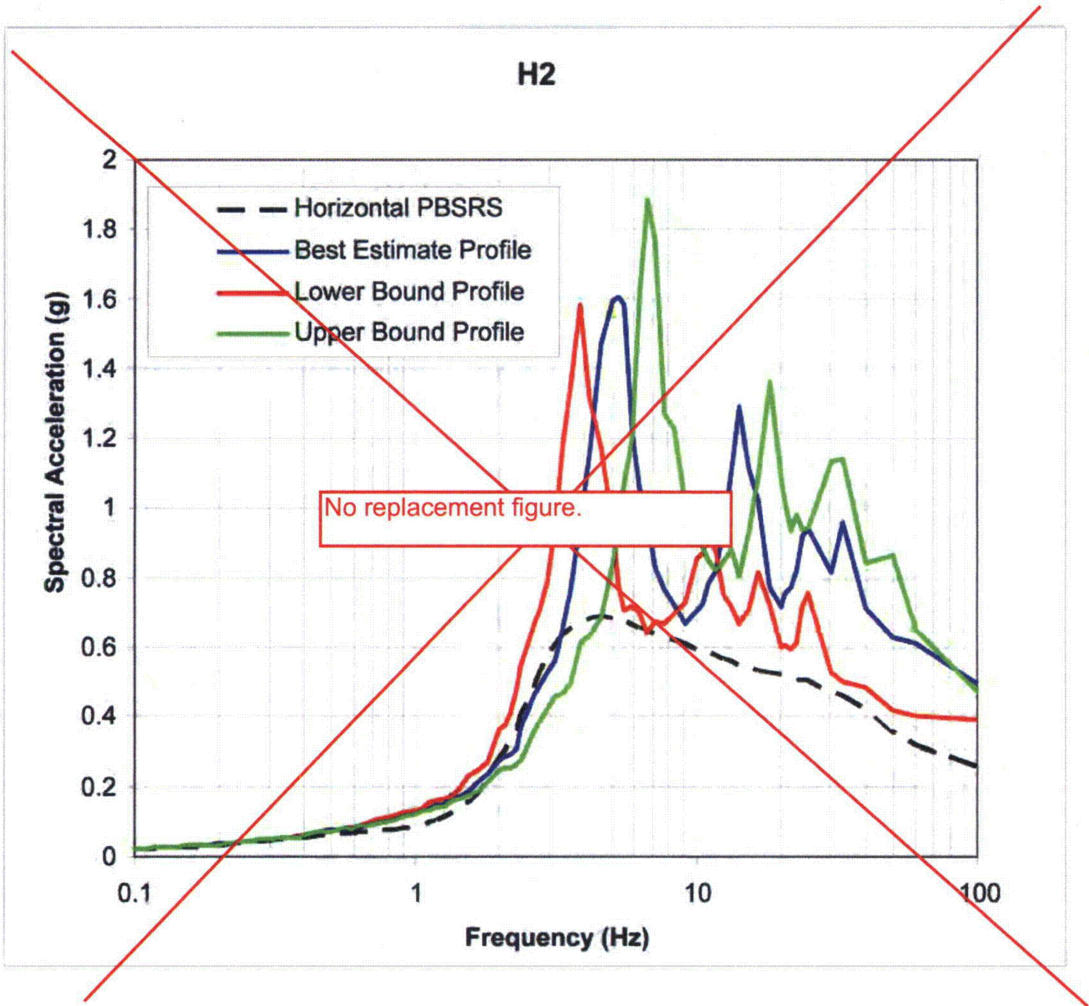
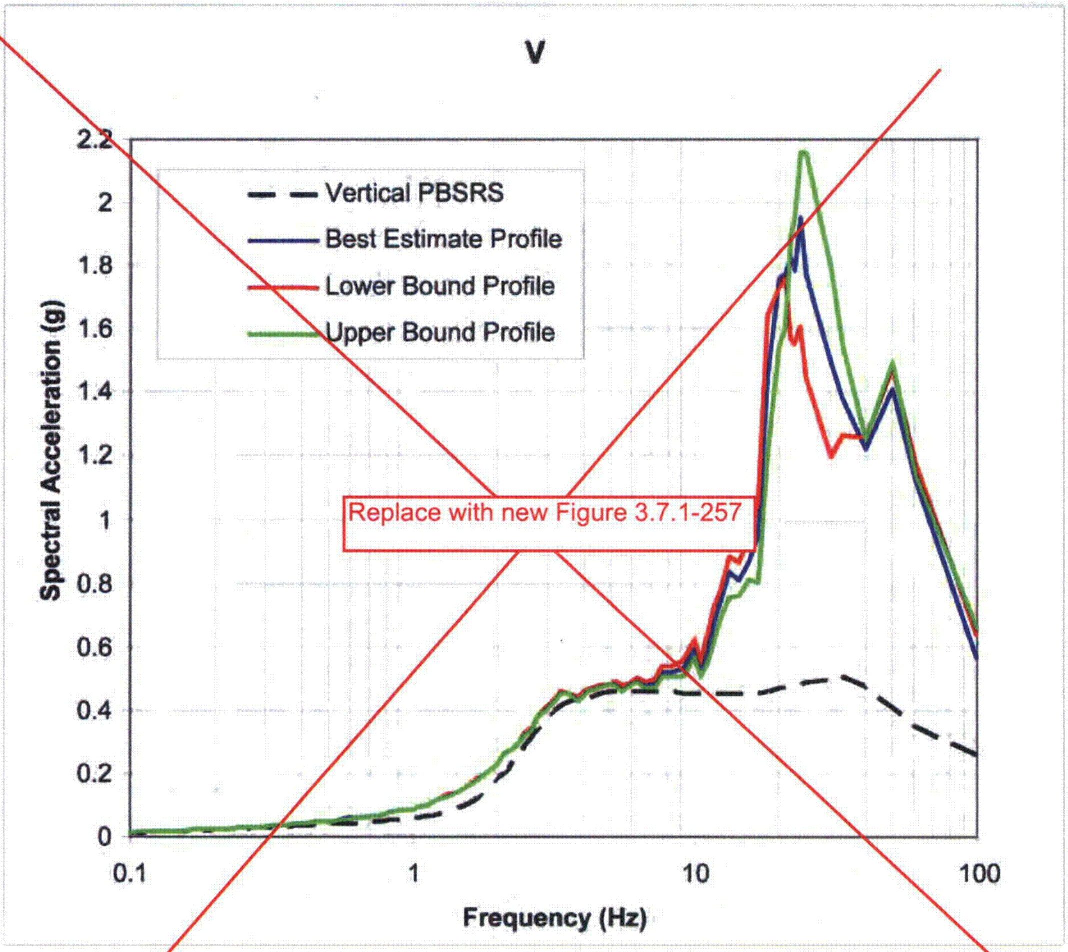


Figure 3.7.1-251 Comparison of Response Spectra of Computed Vertical (V) Component Surface Motions for SSI Profiles Using the CB SCOR FIRS Input Motion to the Vertical PBSRS
[EF3 SUP 3.7-2]



New Figure 3.7.1-257

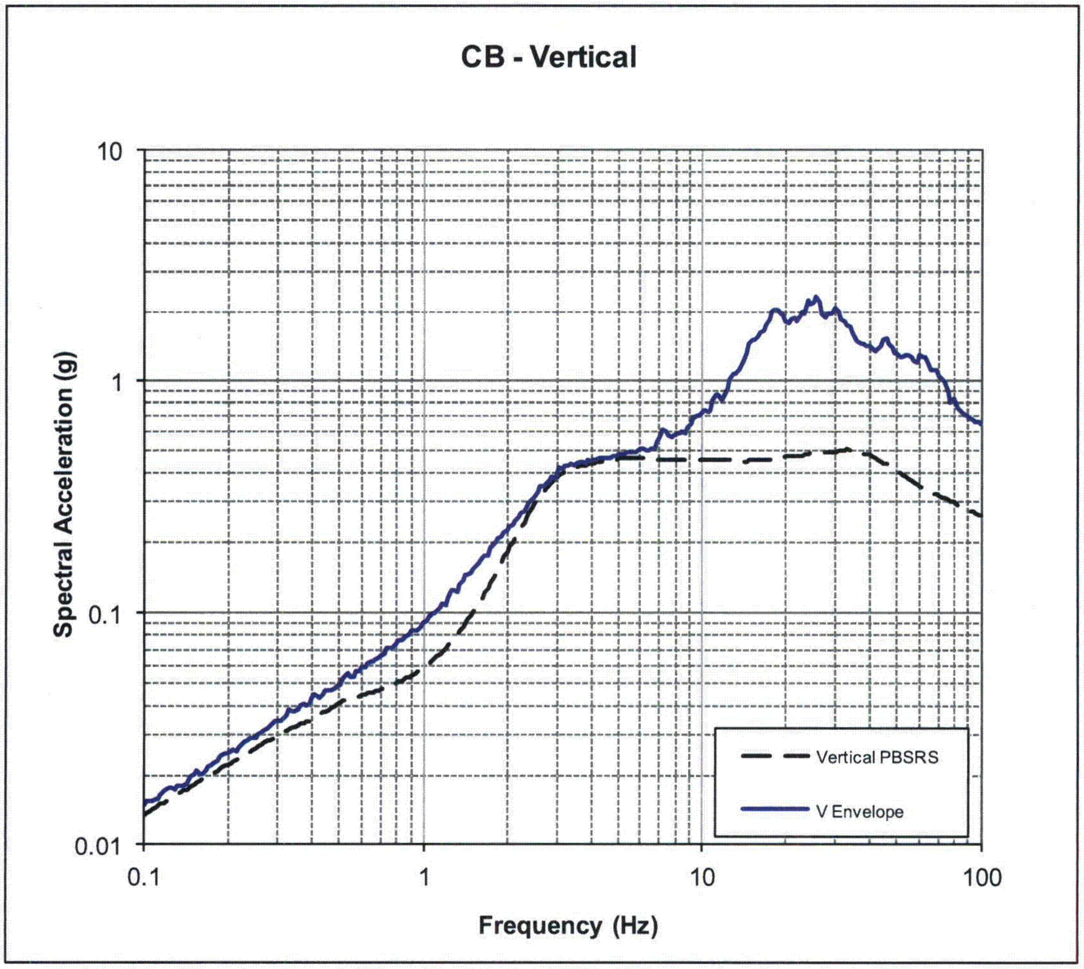
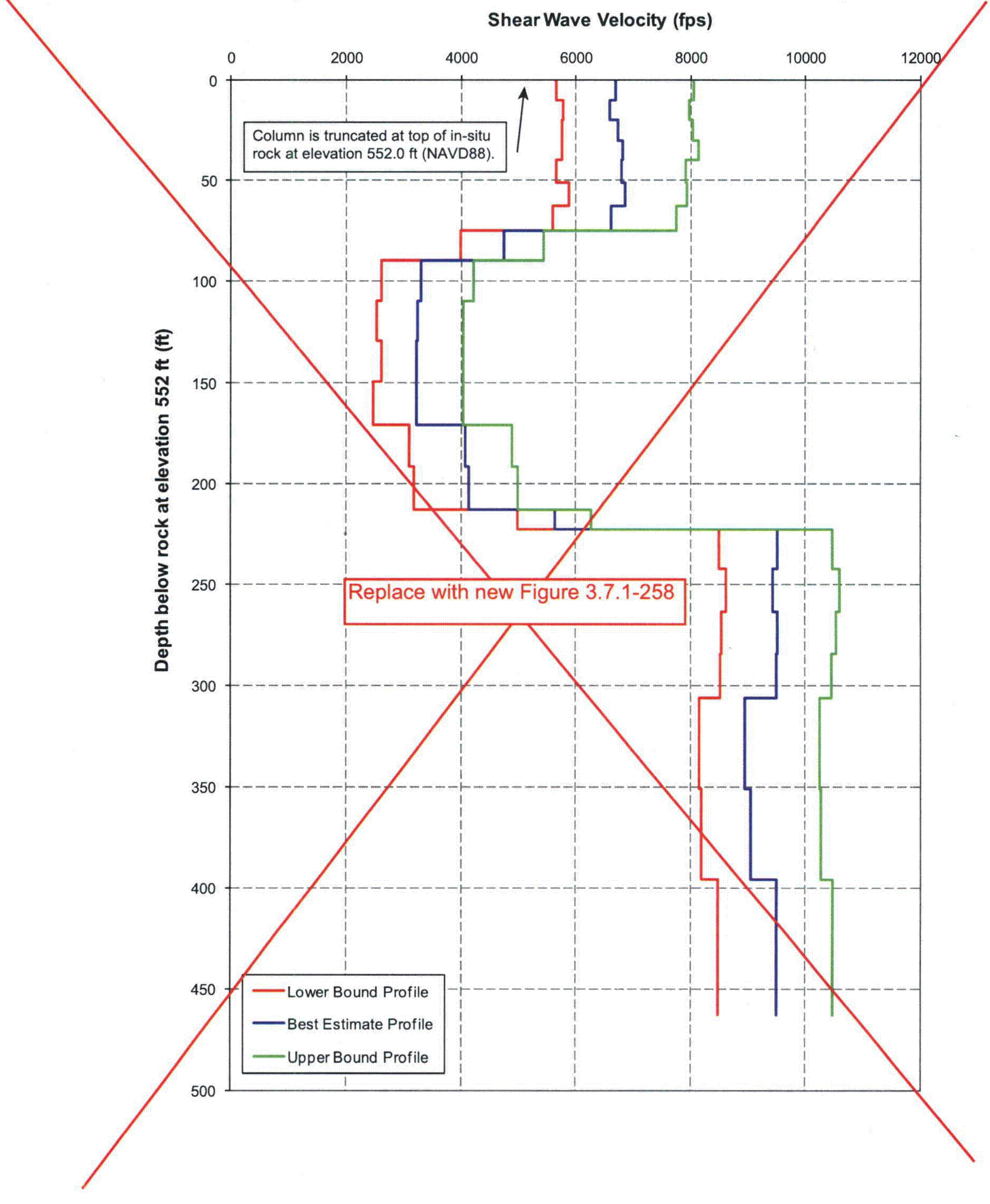


Figure 3.7.1-257: Comparison of the Envelope of the Response Spectra of Computed Vertical (V) Component Surface Motions Using the CB SSI FIRS Input Motion with the Vertical PBSRS.

Figure 3.7.1-252 Lower Bound, Best Estimate, and Upper Bound Shear Wave Velocity Profiles for the Fermi 3 Site-Specific SSI Analyses [EF3 SUP 3.7-2]



New Figure 3.7.1-258

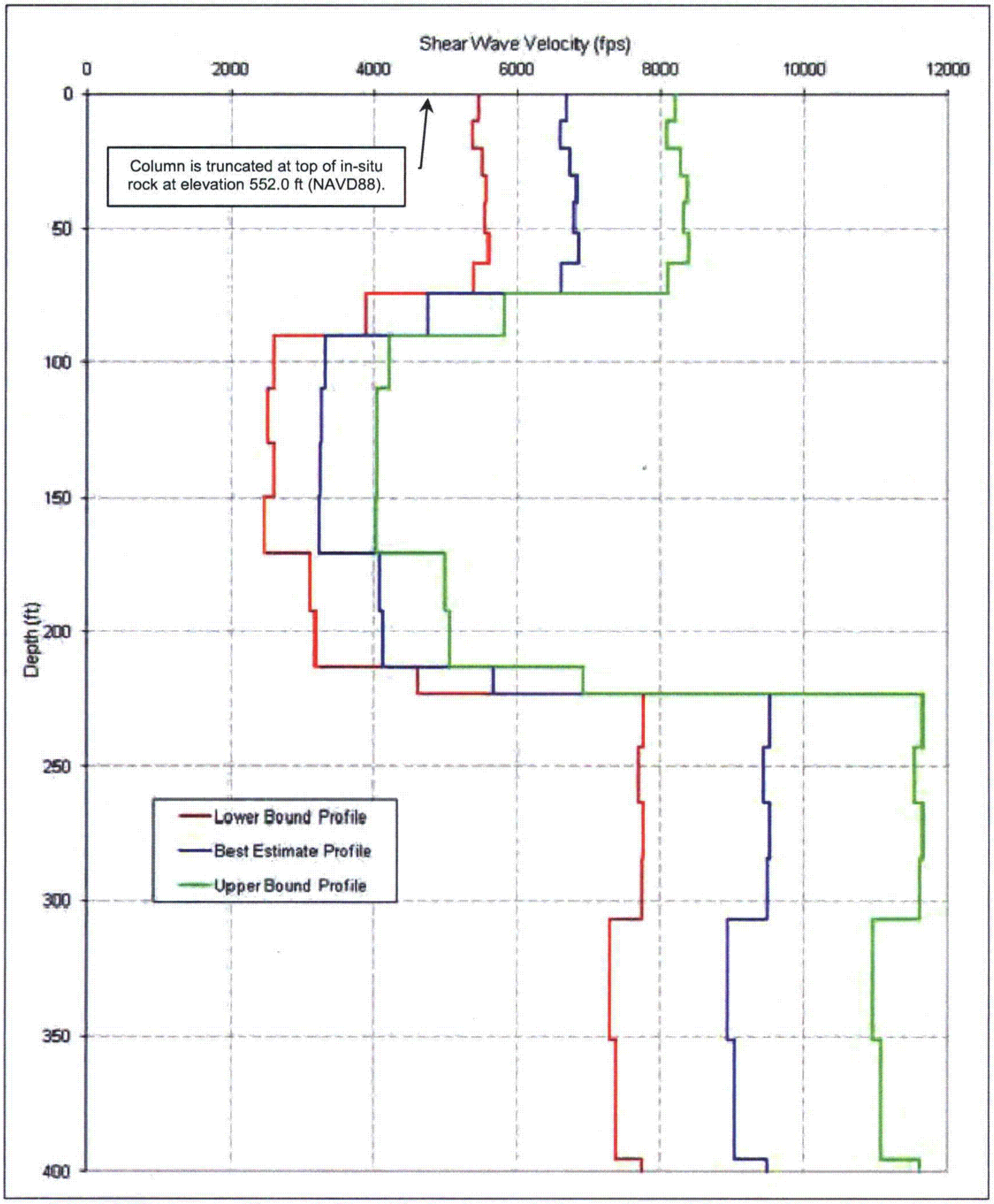
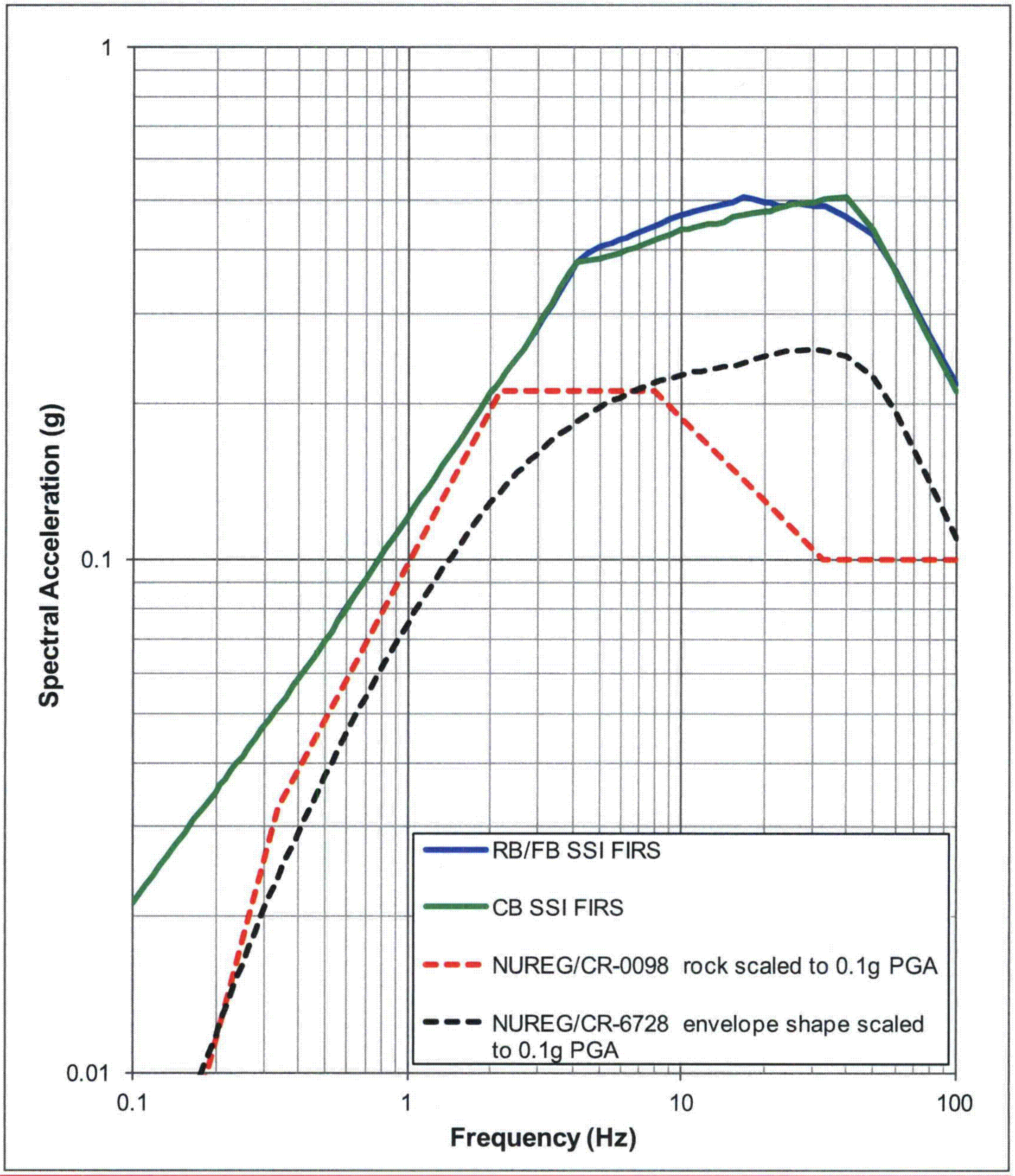


Figure 3.7.1-258: Lower Bound, Best Estimate and Upper Bound Shear Wave Velocity Profiles for the Fermi 3 Site-Specific SSI Analyses.

Insert new Figure 3.7.1-259

Figure 3.7.1-259 **Comparison of Fermi 3 RB/FB and CB SSI FIRS with the NUREG/CR-0098 (Reference 3.7.1-210) median rock spectral shape and enveloping NUREG/CR-6728 (Reference 2.5.2-255) CEUS spectral shape, both scaled to a minimum PGA of 0.1g. All spectra are for 5 % damping.**



Attachment 9
NRC3-12-0003
(17 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6244)

RAI Question No. 03.07.01-7

NRC RAI 03.07.01-7

EF3 FSAR Section 3.7.1.1.5, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, indicates that the KAU078 recording of the Chi-Chi, Taiwan earthquake was used as the seed for generating artificial time histories, which are subsequently modified for input to the site-specific SSI analysis. It also indicates that this record set was selected because it is representative of a distant recording of a large magnitude earthquake, consistent with the large contribution of the New Madrid source to the seismic hazard at the Fermi 3 site. It further states that "the PGV/PGA values would be lower than those for large, distant earthquakes as the PGA is enriched to represent smaller magnitude, closer earthquakes." However, based on the information provided in EF3 FSAR Tables 3.7.1-211 and 3.7.1-214, it appears that PGV/PGA values for the artificial time histories are higher than the selected seed time histories, for the two horizontal components.

SRP Acceptance Criteria 3.7.1.II.1B also specifies that PGV/PGA should be consistent with the characteristic values for the controlling earthquake. As such, the applicant is requested to provide further justification of the acceptability of the PGV/PGA values for the artificial time histories being higher than the selected controlling earthquake. The applicant is also requested to provide comparison of the response spectra of the artificial time histories and the estimated target spectra (SSI FIRS) at 2 percent and 10 percent damping values for RB/FB and CB.

Response

As described in the response to RAI 03.07.01-6, the analysis for development of inputs for the site-specific Soil-Structure Interaction (SSI) analyses has been revised. In order to meet the Standard Review Plan 3.7.1 guidance for statistically independent ground motion, new seed time histories were selected for the development of the SSI input acceleration time histories. The proposed markup for FSAR Subsection 3.7.1 is included with the response to RAI 03.07.01-6. As shown in the markup, the TAP078 recordings of the 1999 Chi-Chi, Taiwan, M 7.6 earthquake is now used as the seed time histories. The markups for FSAR Tables 3.7.1-213 and 3.7.1-216 are used to compare the PGV/PGA ratios for the selected seed time histories (FSAR Table 3.7.1-213) and the spectrally matched (artificial) time histories (FSAR Table 3.7.1-216).

The values of PGA and PGV for the seed time histories listed in FSAR Table 3.7.1-213 are tabulated below along with the resulting values of PGV/PGA.

PGA, PGV, and PGV/PGA for Seed Time Histories

Seed Time History	PGA (g)	PGV (cm/sec)	PGV/PGA (cm/s/g)
TAP 078-N	0.088	13.0	147.7
TAP 078-W	0.094	10.7	113.8
TAP 078-V	0.063	8.6	136.5

PGV/PGA ratios of the matched time histories are listed in FSAR Table 3.7.1-216 (see revisions to FSAR Subsection 3.7.1 included in the response to RAI 03.07.01-6) The ratios are lower than those for the seed time histories. As stated in FSAR Subsection 3.7.1.1.5, the PGV/PGA values for the matched time histories are lower than those for large, distant earthquakes (i.e., the seed time histories) since the PGA of the matched time histories are enriched to represent a smaller magnitude, closer earthquake.

Table 3-6 of NUREG/CR-6728 (McGuire et al., 2001) lists median (mean log) values of PGV/PGA for records in the central and eastern United States (CEUS) database contained in the report. The average values for horizontal records in the rock, distance 100 to 200 km, magnitude 7+ bin is 72.50 cm/s/g with a natural log standard error of 0.47. The values of PGV/PGA for the horizontal components of the matched time histories (FSAR Table 3.7.1-216) are in the range of 61 to 69 cm/s/g. These values are consistent with NUREG/CR-6728 as they differ from the median value given in NUREG/CR-6728 by less than one standard deviation.

The requested comparisons require development of Reactor Building/Fuel Building (RB/FB) and Control Building (CB) SSI foundation input response spectra (FIRS) for 2 percent and 10 percent damping. These FIRS were developed using scale factors for response spectral amplitudes relative to 5 percent damped spectra. Damping scale factors are influenced by the frequency content of the associated ground motions. The SSI FIRS represent motions on CEUS rock sites. Table 1 of SRP 3.7.1 Appendix C lists damping scale factors derived from analysis of the CEUS time history database contained in NUREG/CR-6728 (McGuire et al., 2001). Figure 1 shows the response spectral ratios for 2 percent over 5 percent damping and 10 percent over 5 percent damping taken from Table 1 of SRP 3.7.1 Appendix C.

The values listed in Table 1 of SRP 3.7.1 Appendix C represent averages of the spectral ratios obtained for recordings in all magnitude and distance bins. As shown on Figure 1, the spectral ratios trend towards unity as the spectral frequency decreases below 1 Hz. This reflects the range in magnitudes – including numerous recordings from magnitudes less than 6 – represented in the database. The effect of damping on spectral ordinates at low frequencies is magnitude dependent (e.g., Bommer and Mendis, 2005; Cameron and Green, 2007). Cameron and Green (2007) have performed a similar analysis to that described in SRP 3.7.1 Appendix C with the modification that separate scale factors are computed for the different magnitude bins. The Fermi 3 site hazard at low spectral frequencies is due to large magnitude earthquakes (see FSAR Table 2.5.2-219) and the seed time histories used to develop the SSI input time histories are recordings of the **M** 7.6 1999 Chi-Chi, Taiwan, earthquake. Also shown on Figure 1 are the spectral ratios developed by Cameron and Green (2007) from **M** 7+ recordings in the NUREG/CR-6728 CEUS rock site time history database. The Cameron and Green (2007) **M** 7+ ratios are similar to those from Table 1 of SRP 3.7.1 Appendix C for frequencies above 1 Hz. At frequencies below 1 Hz, the Cameron and Green (2007) **M** 7+ ratios do not trend towards unity. They show a stronger damping effect than those from Table 1 of SRP 3.7.1 Appendix C. This effect results from the greater energy content at low frequencies in recordings from larger magnitude earthquakes. This effect is reduced in the spectral ratios of Table 1 of SRP 3.7.1 Appendix C by including a range of magnitudes. Both sets of spectral ratios were used to develop estimated SSI FIRS for 2 percent and 10 percent damping in the following comparisons; however, the Cameron and Green (2007) spectral ratios are considered more appropriate because of the earthquake magnitude associated with the SSI FIRS time histories. These estimated FIRS are developed only for the frequency range contained in the two sets of spectral ratios (0.1 to 20 Hz for the Cameron and Green spectral ratios and 0.5 to 80 Hz for the SRP spectral ratios). Based on the fact that that there is little to no difference between the spectral ratios for CEUS horizontal and vertical motions presented in Appendix C of SRP 3.7.1, the Cameron and Green (2007) spectral ratios for horizontal motions were used to estimate vertical FIRS.

Figures 2 through 13 show the RB/FB and CB SSI FIRS scaled to 2 percent damping and 10 percent damping. Shown on each of the plots is the corresponding 2 percent or 10 percent damped spectrum for an individual SSI time history. The time history spectra are in good agreement with the scaled FIRS.

References:

1. Bommer, J.J., and R. Mendis, 2005, Scaling of spectral displacement ordinates with damping ratios, Earthquake Engineering and Structural Dynamics, v. 34, p. 145–165

2. Cameron, W.I., and R.A. Green, 2007, Damping correction factors for horizontal ground-motion response spectra, Bulletin of the Seismological Society of America, v. 97, p. 934–960.

3. McGuire, R. W., 2001, Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines, NUREG/CR-6728. U.S. Nuclear Regulatory Commission, Washington D.C.

Proposed COLA Revision

None.

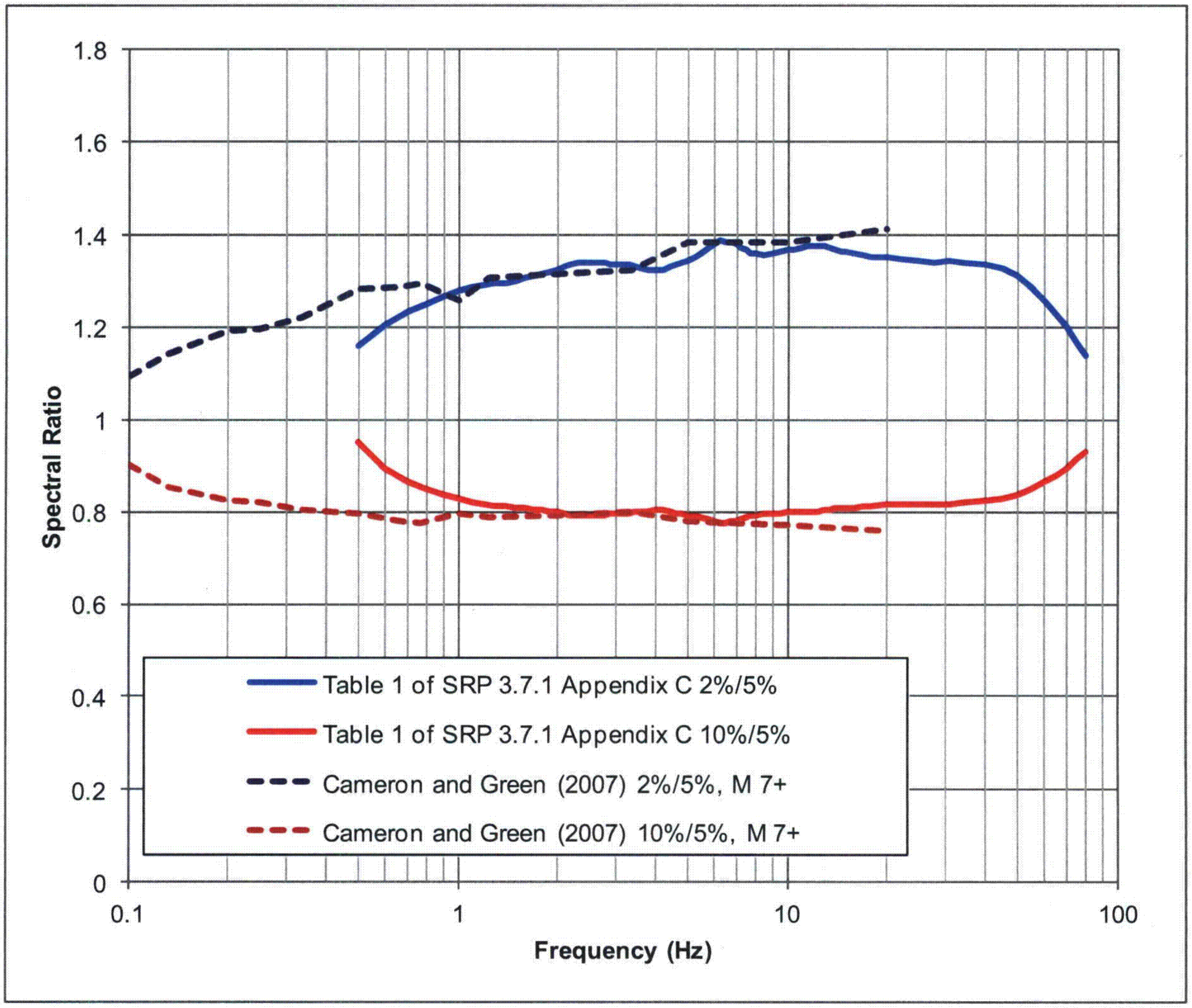


Figure 1: Spectral ratios for 2% damping over 5% damping and 10% damping over 5% damping developed from the NUREG/CR-6728 CEUS rock site time history database.

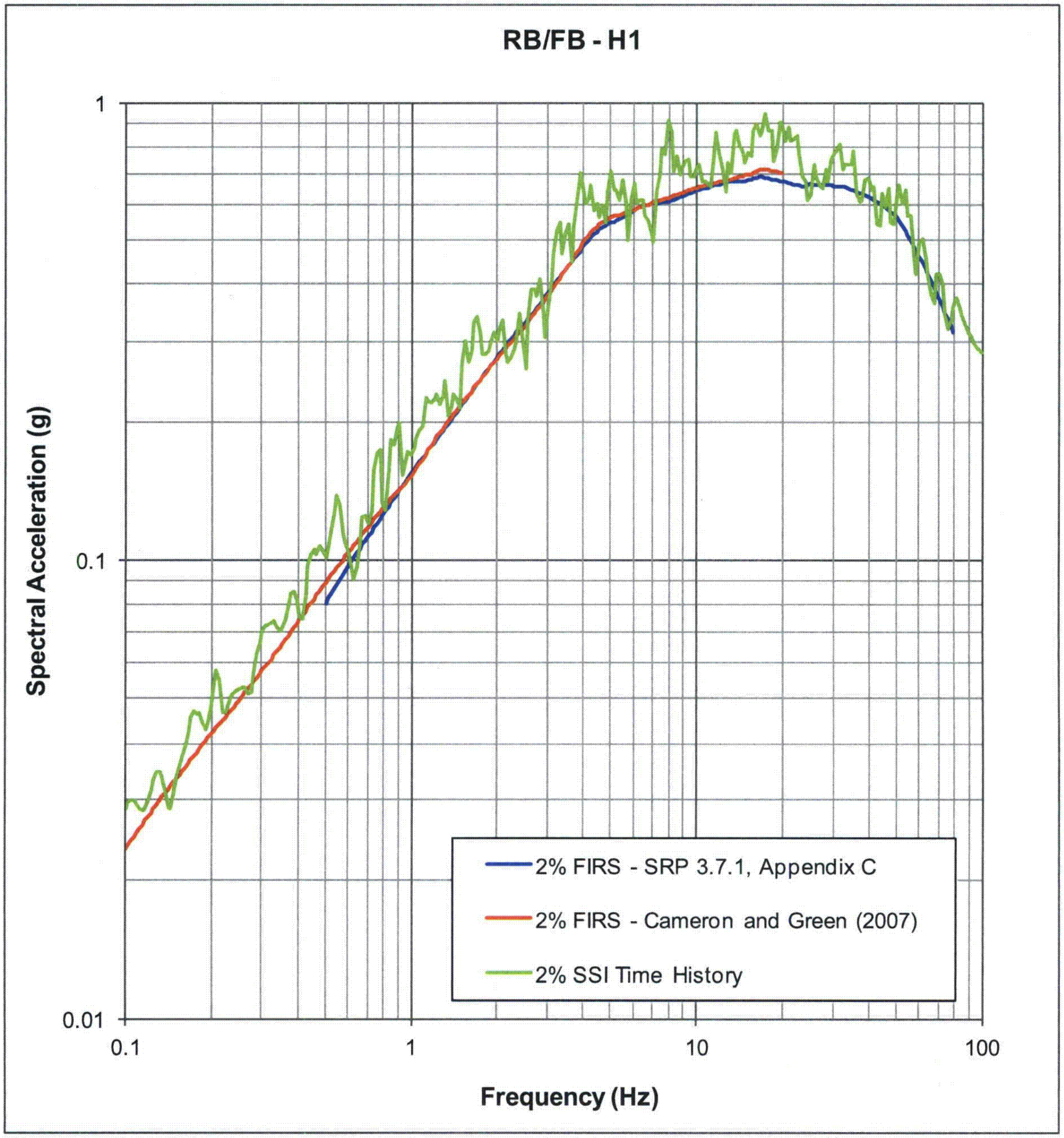


Figure 2: RB/FB horizontal estimated 2% damped FIRS compared to the 2% damped spectrum for the RB/FB H1 SSI time history.

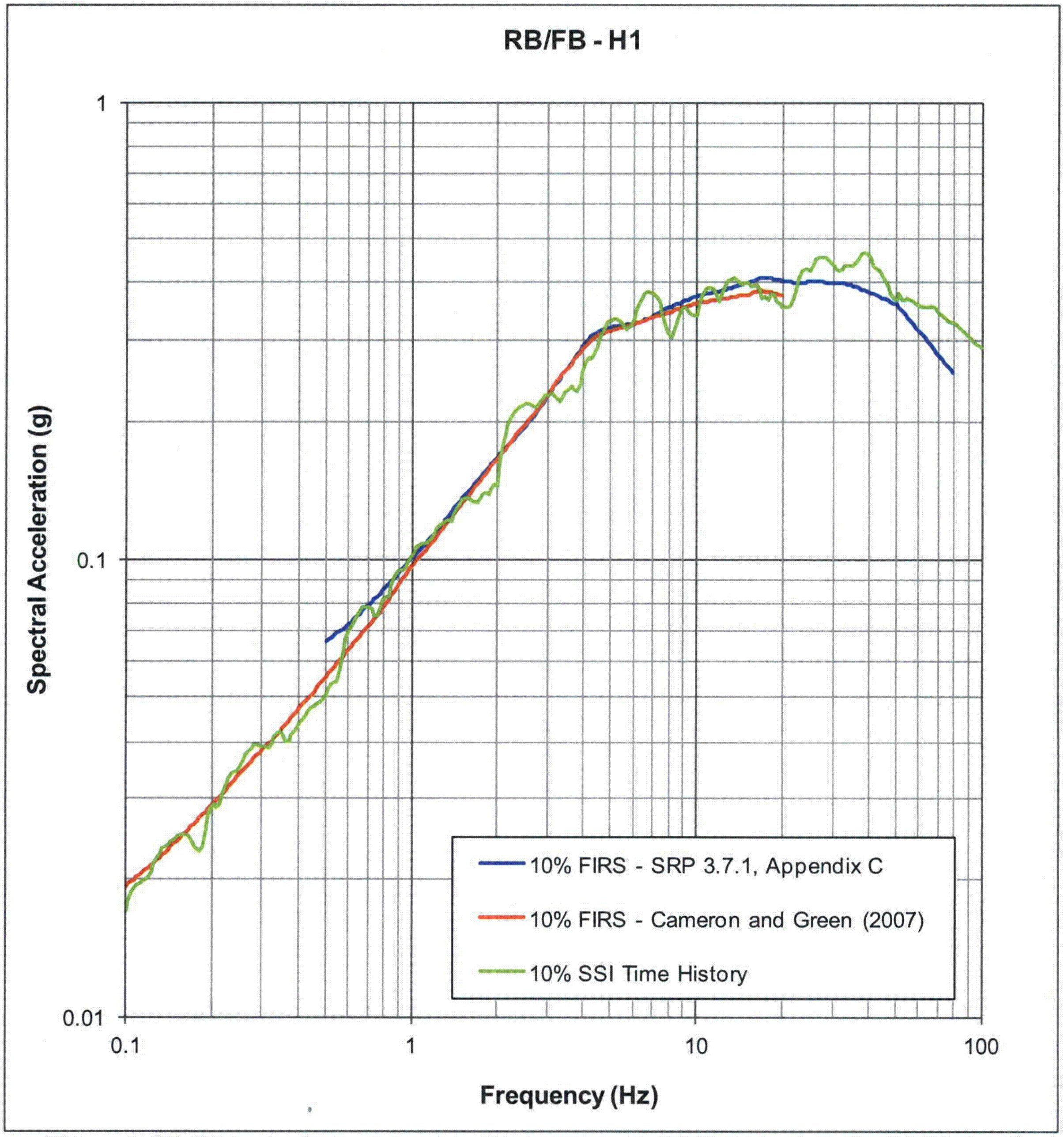


Figure 3: RB/FB horizontal estimated 10% damped FIRS compared to the 10% damped spectrum for the RB/FB H1 SSI time history.

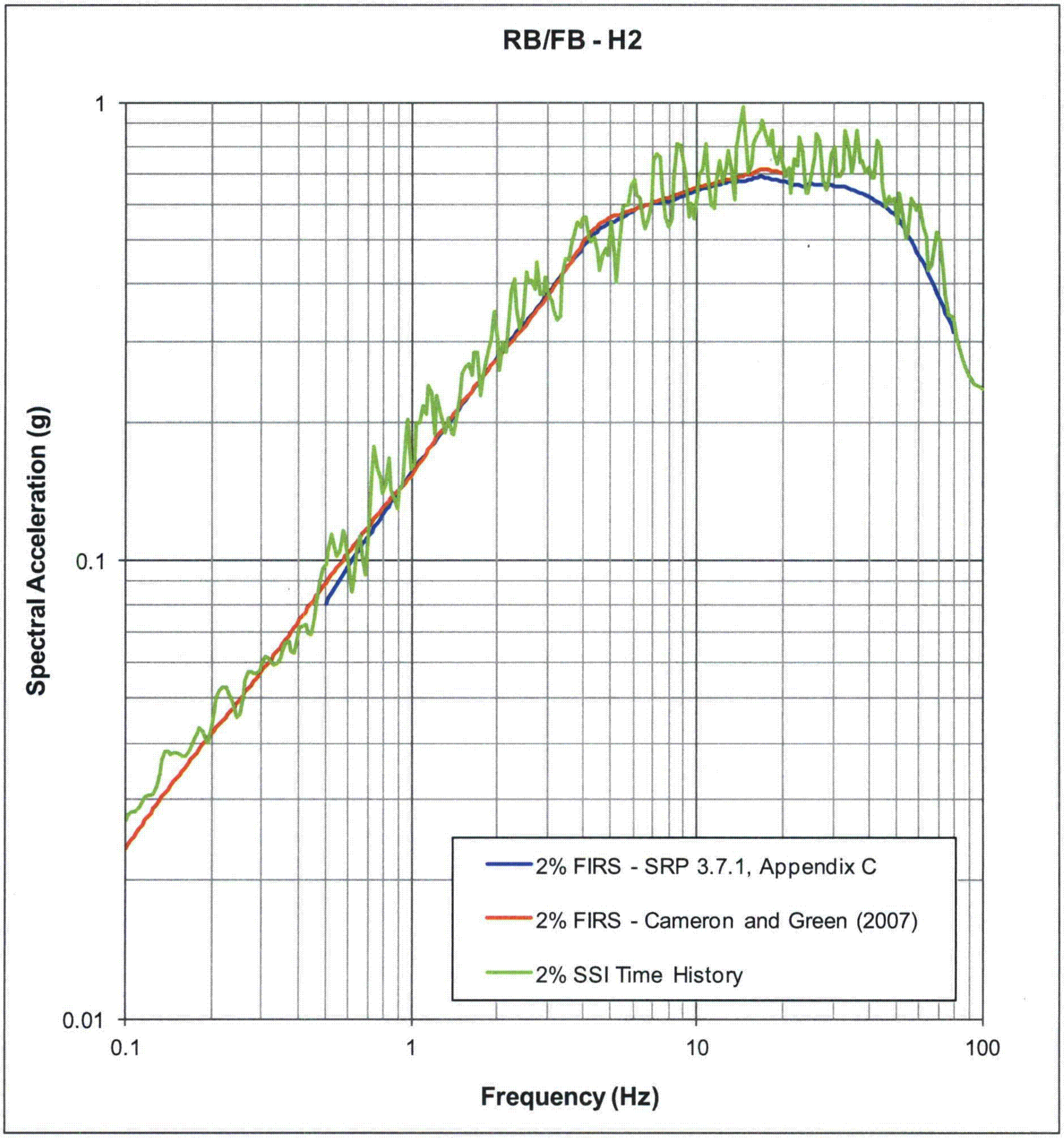


Figure 4: RB/FB horizontal estimated 2% damped FIRS compared to the 2% damped spectrum for the RB/FB H2 SSI time history.

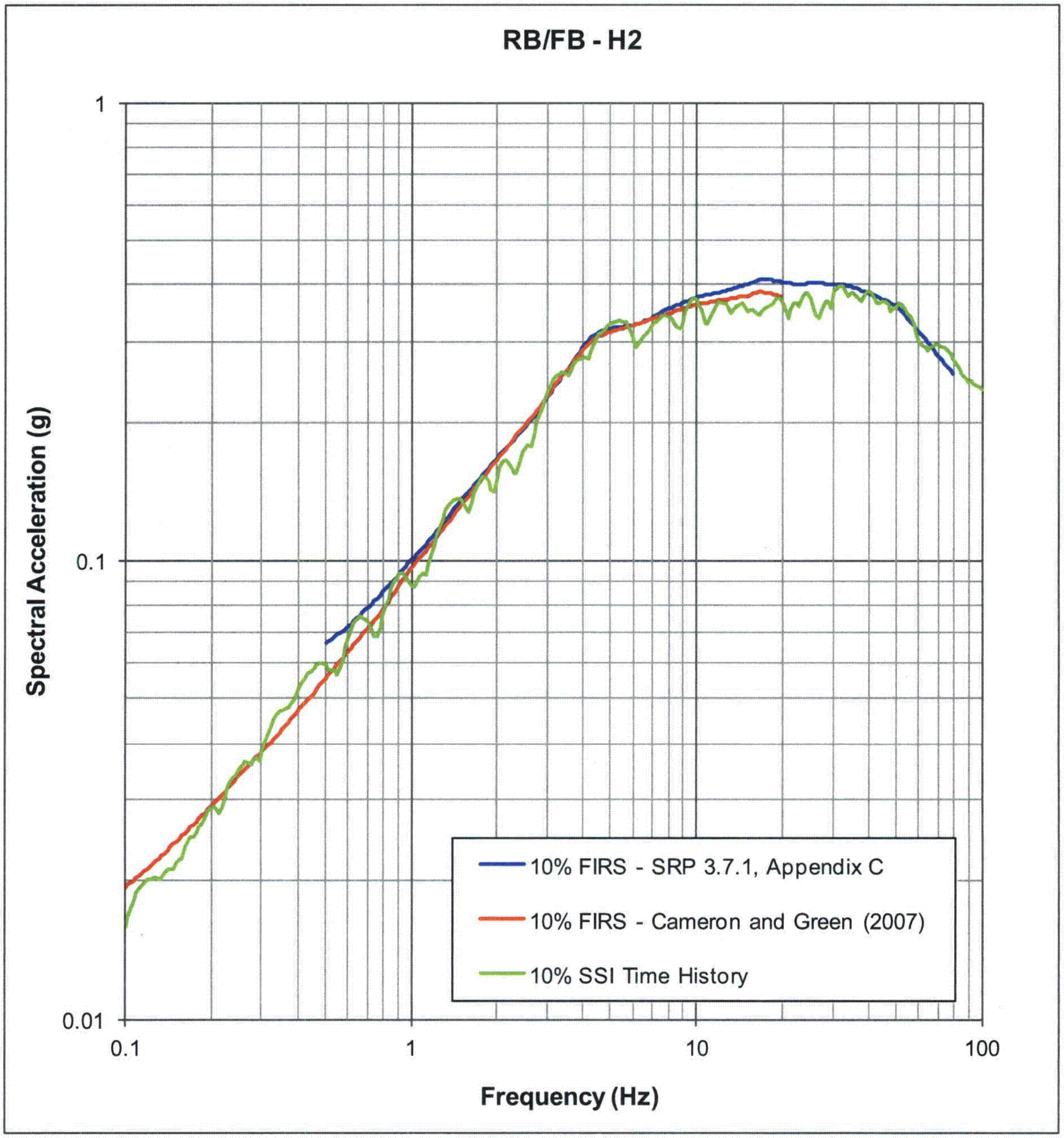


Figure 5: RB/FB horizontal estimated 10% damped FIRS compared to the 10% damped spectrum for the RB/FB H2 SSI time history.

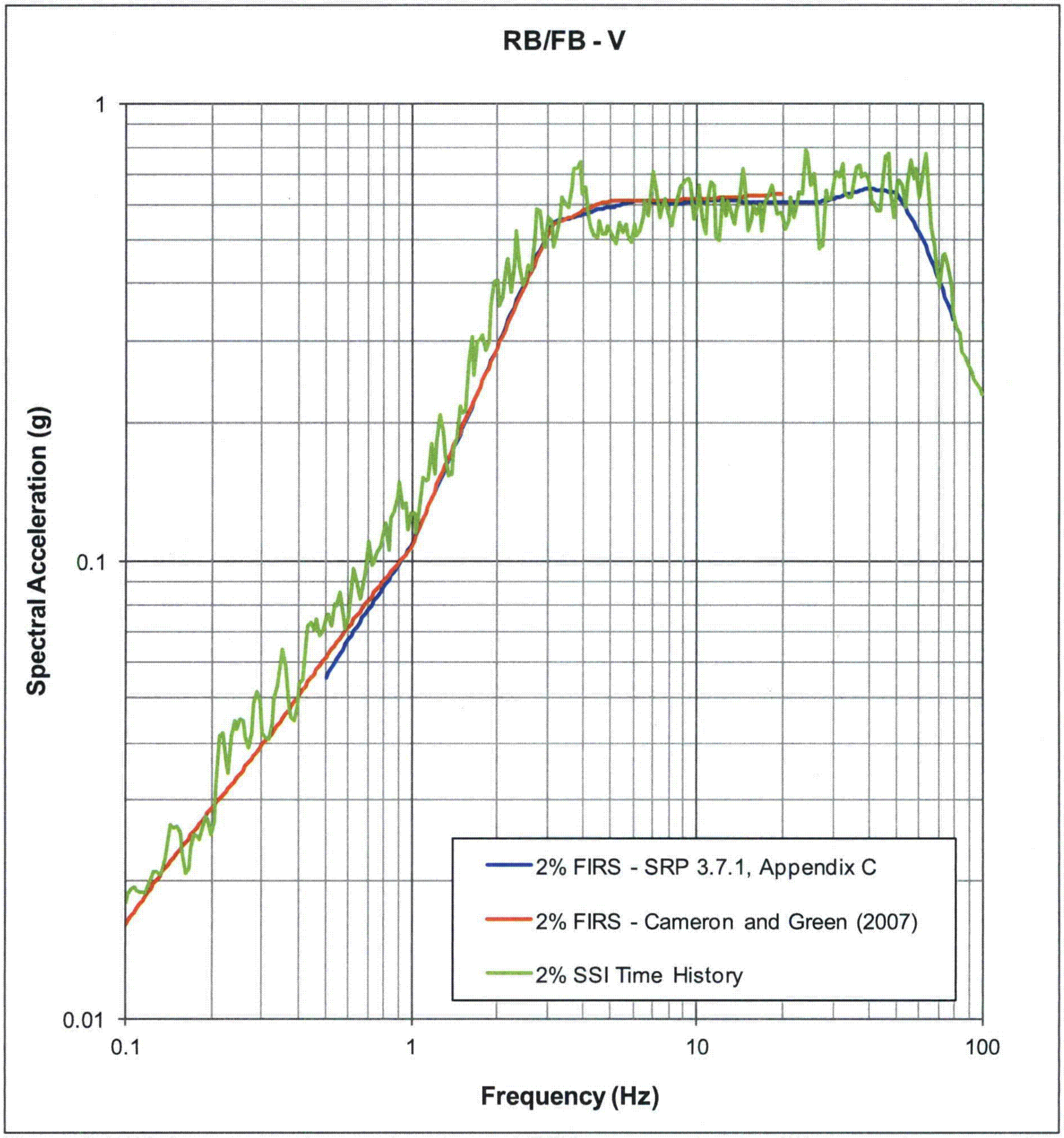


Figure 6: RB/FB vertical estimated 2% damped FIRS compared to the 2% damped spectrum for the RB/FB V SSI time history.

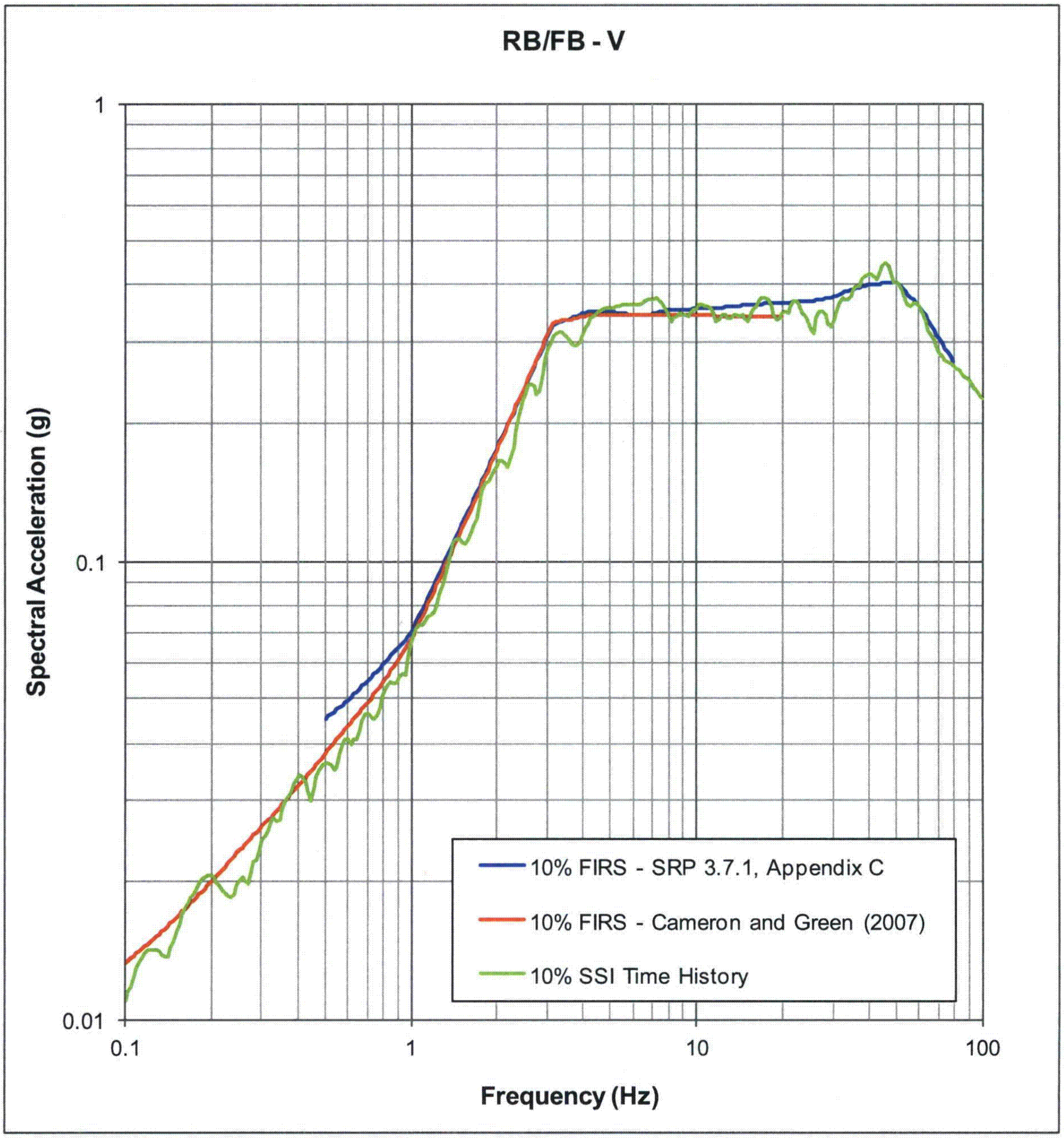


Figure 7: RB/FB vertical estimated 10% damped FIRS compared to the 10% damped spectrum for the RB/FB V SSI time history.

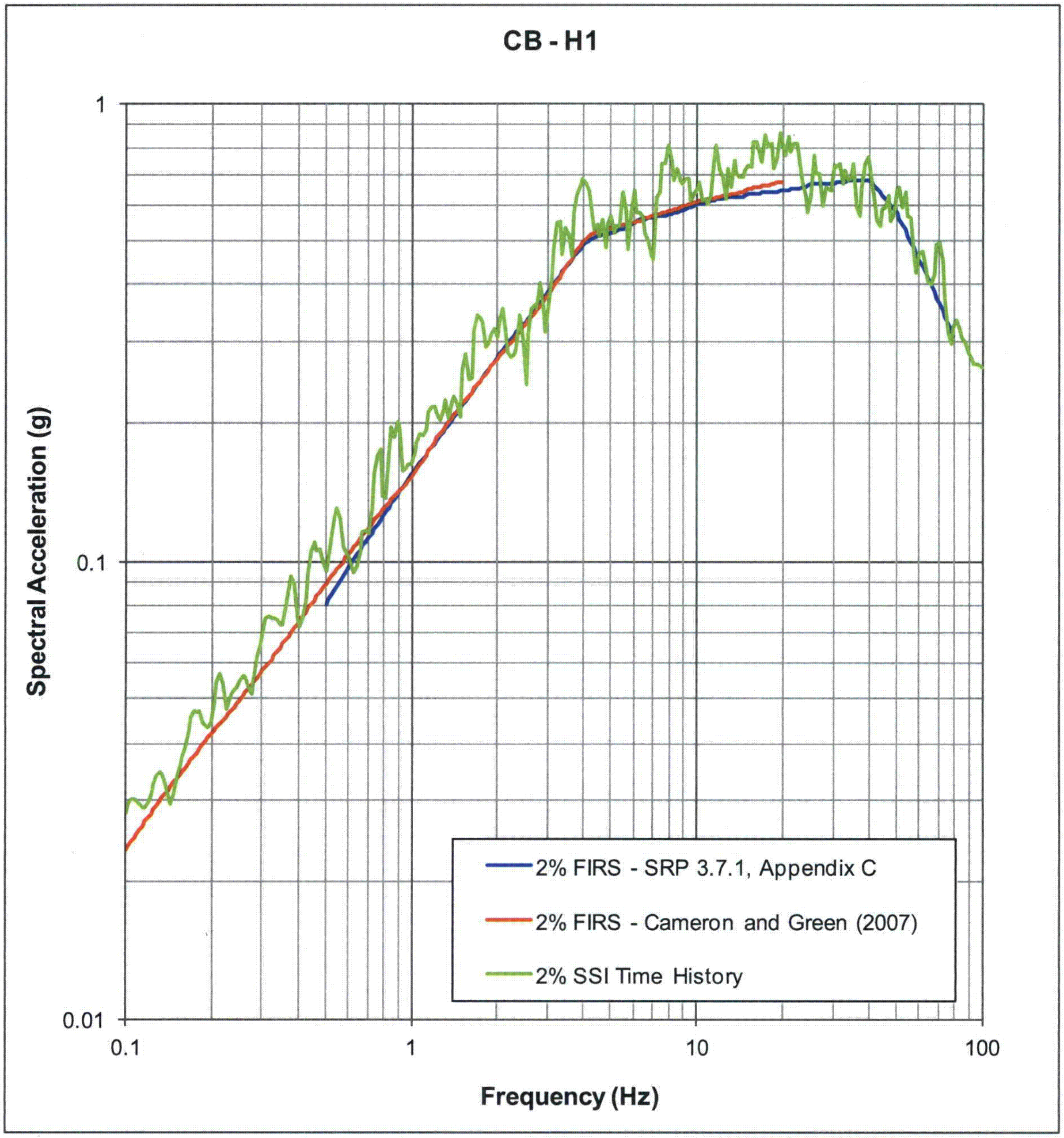


Figure 8: CB horizontal estimated 2% damped FIRS compared to the 2% damped spectrum for the CB H1 SSI time history.

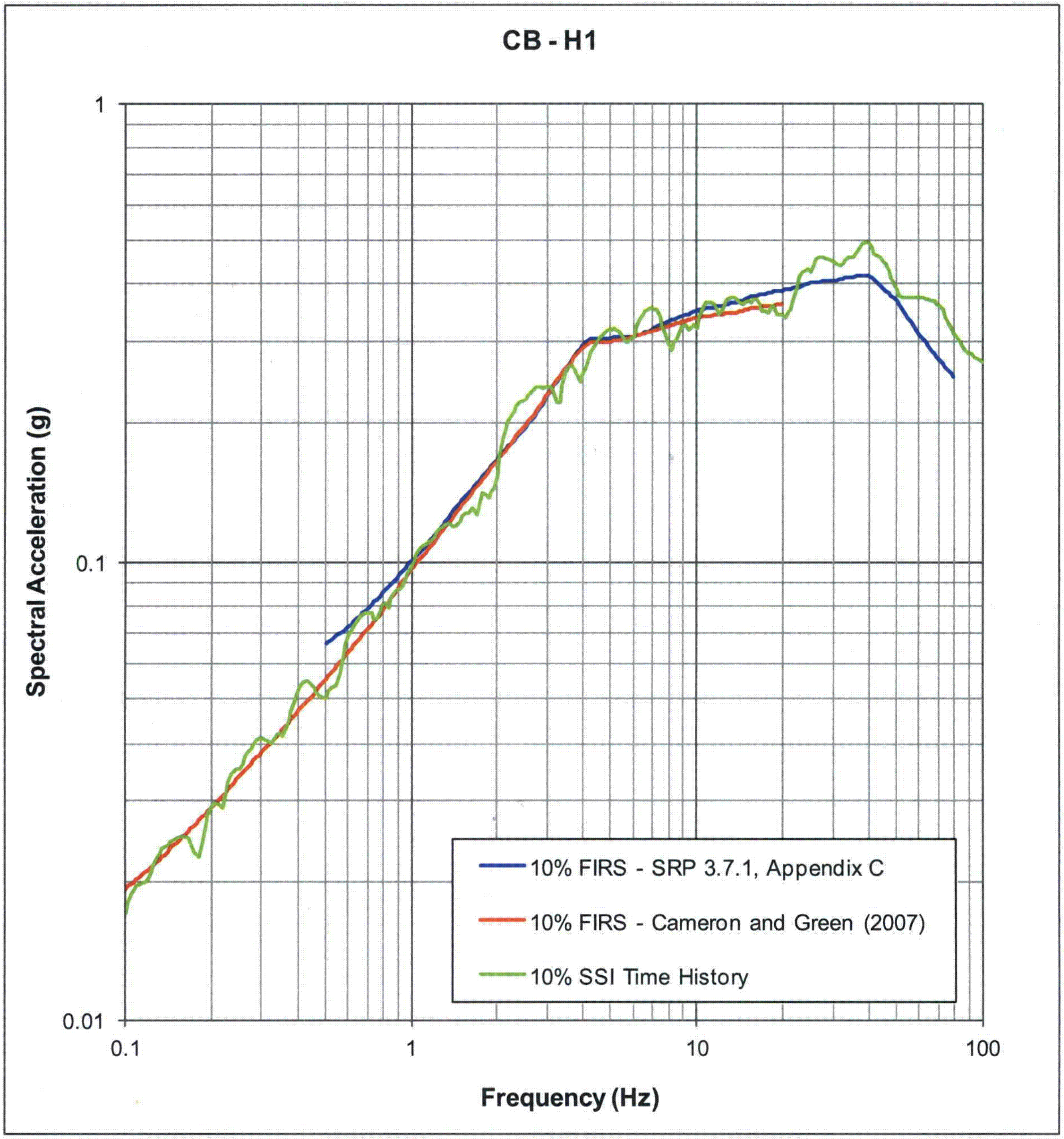


Figure 9: CB horizontal estimated 10% damped FIRS compared to the 10% damped spectrum for the CB H1 SSI time history.

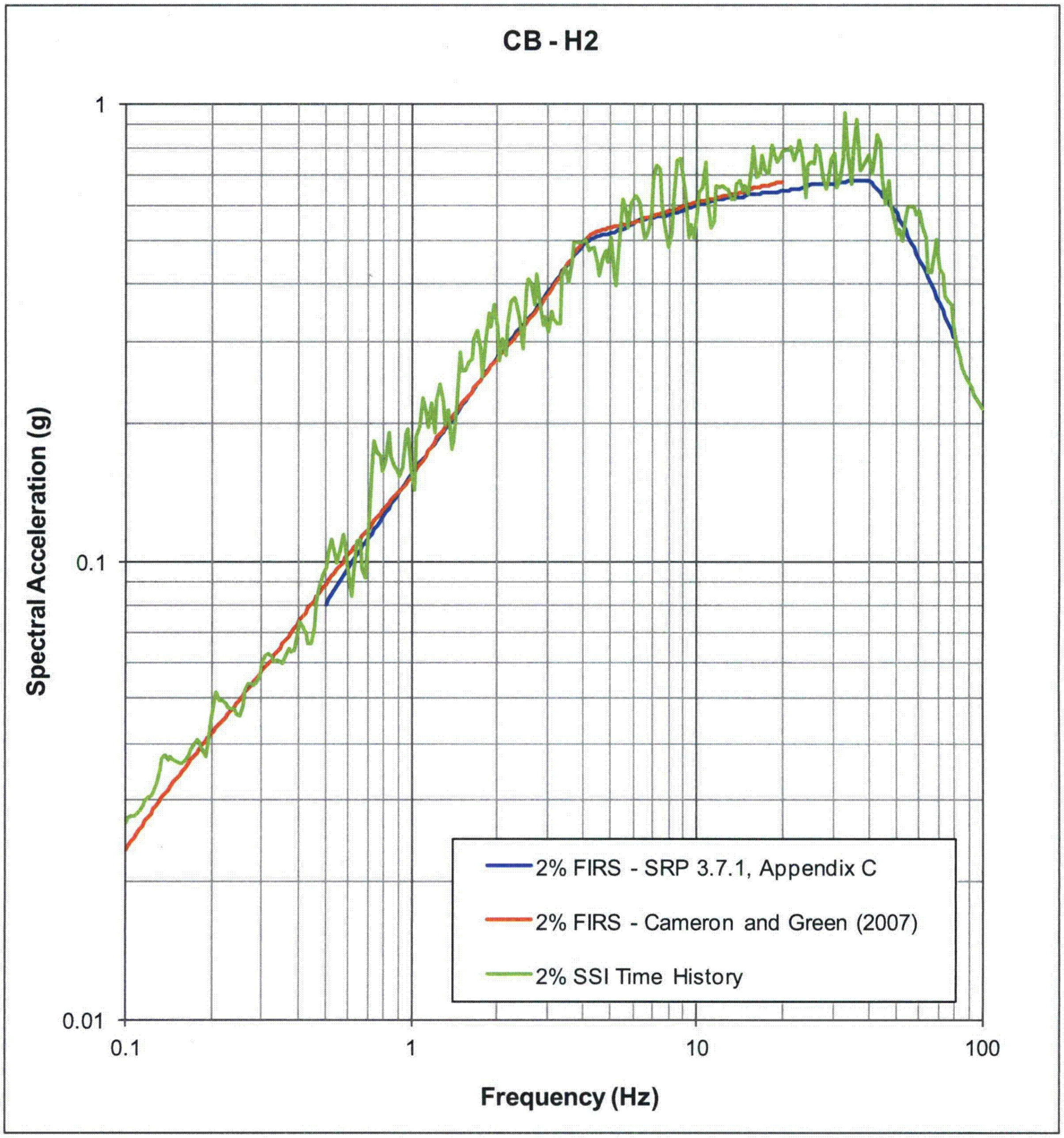


Figure 10: CB horizontal estimated 2% damped FIRS compared to the 2% damped spectrum for the CB H2 SSI time history.

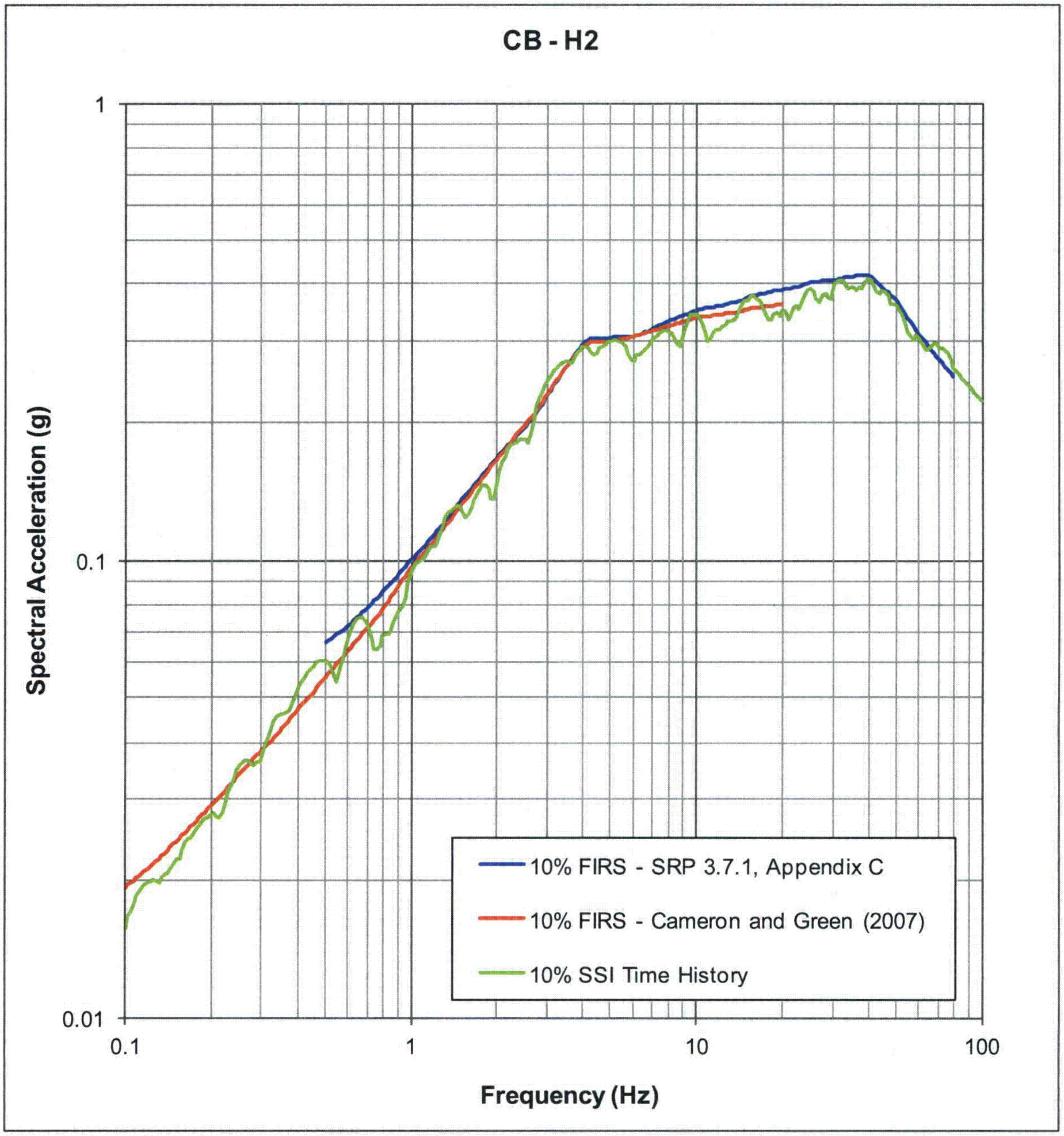


Figure 11: CB horizontal estimated 10% damped FIRS compared to the 10% damped spectrum for the CB H2 SSI time history.

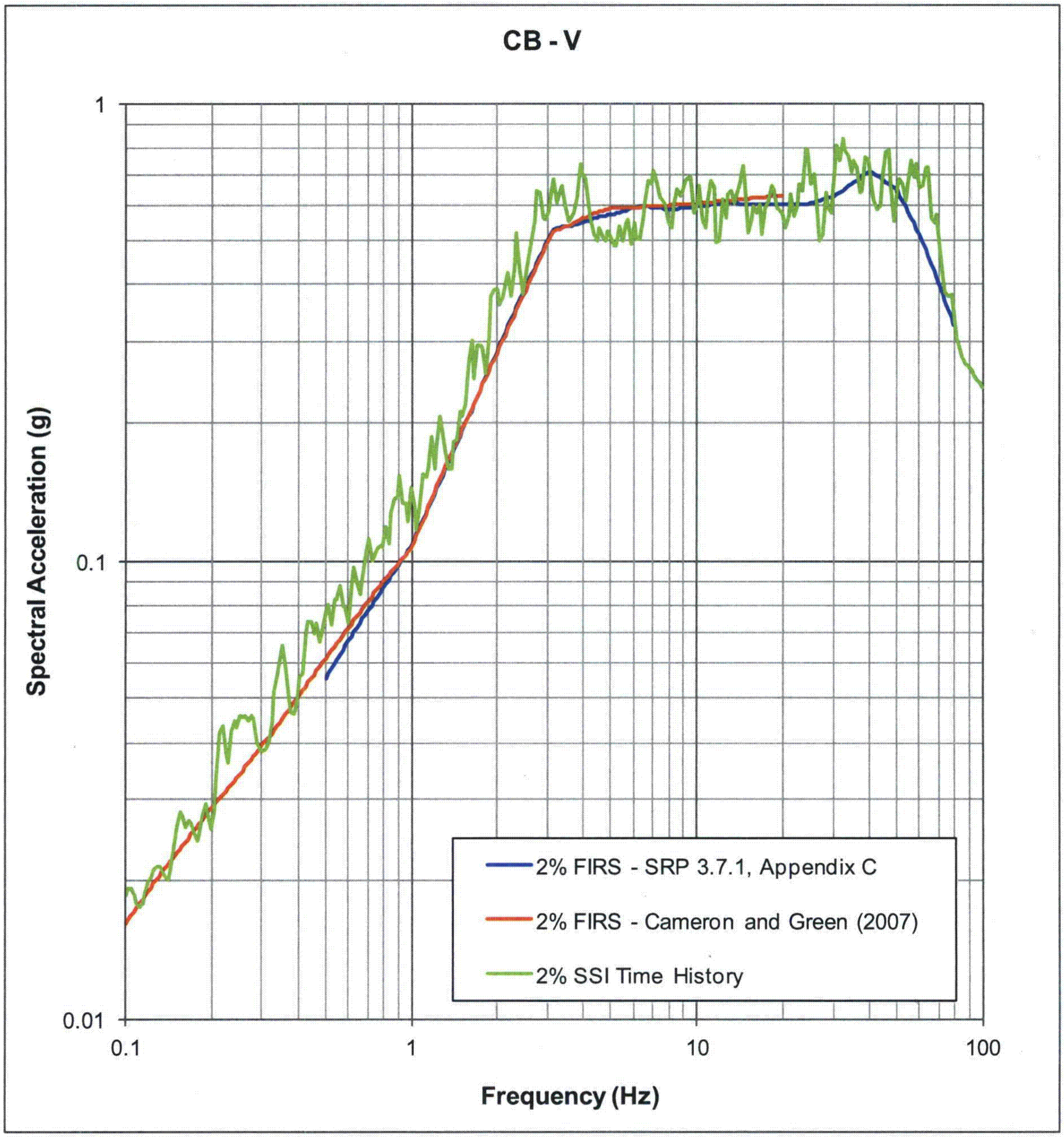


Figure 12: CB vertical estimated 2% damped FIRS compared to the 2% damped spectrum for the CB V SSI time history.

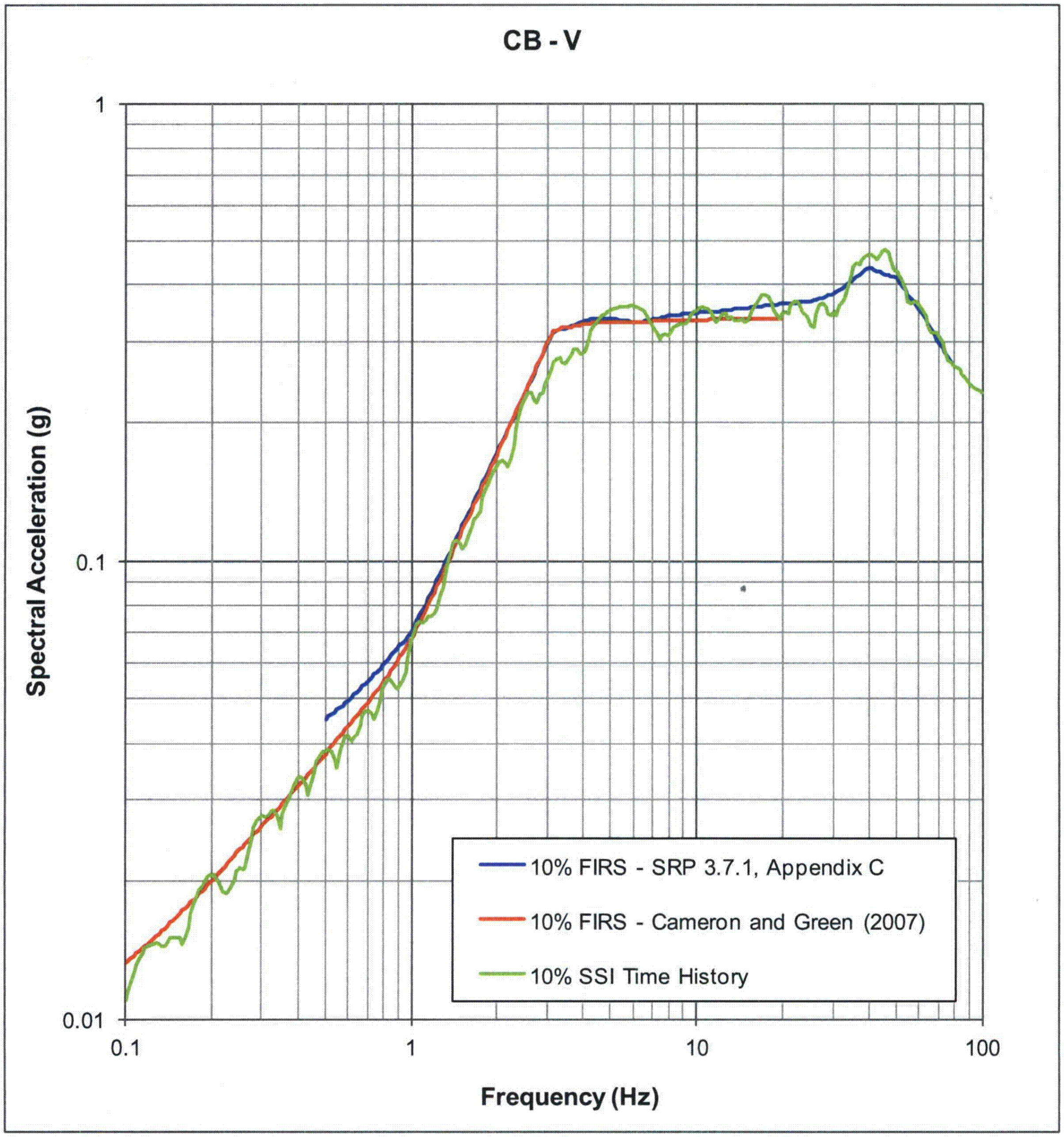


Figure 13: CB vertical estimated 10% damped FIRS compared to the 10% damped spectrum for the CB V SSI time history.

Attachment 10
NRC3-12-0003
(7 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6244)

RAI Question No. 03.07.01-8

NRC RAI 03.07.01-8

EF3 FSAR Section 3.7.1.1.4.6 and Table 3.7.1-210, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, indicate that the PGA for the RB/FB and CB horizontal FIRS are higher than 0.1g. It is implied that this is sufficient to meet the requirements in 10 CFR Part 50, Appendix S, for minimum horizontal ground motion at the foundation level in the freefield.

However, the guidance in SRP 3.7.1 and ISG-017 also indicates that, to satisfy the regulatory requirements, the minimum horizontal PGA of 0.1g should correspond to a smooth broad-band spectral shape such as the one described in RG 1.60. Therefore, the applicant is requested to provide in the FSAR comparison plots of the RB/FB and CB horizontal FIRS with the RG 1.60 horizontal spectrum anchored at 0.1 g, which demonstrate that the RB/FB and CB horizontal FIRS envelope the RG 1.60 spectrum at all frequencies of interest. The staff needs this information to confirm that the site-specific seismic input used in the site-specific SSI analysis meets 10 CFR Part 50, Appendix S.

Response

The Reactor Building/Fuel Building (RB/FB) and Control Building (CB) foundation input response spectra (FIRS) represent smooth broad-band response spectra. As discussed in Section 3.1 of NUREG/CR-6926 (Braverman et al., 2007), the approach specified in current regulatory guidance produces a broad-banded safe shutdown earthquake (SSE) spectrum. This approach involves the following steps:

- Perform probabilistic seismic hazard analyses (PSHA) to develop uniform hazard response spectra (UHRS) for the site.
- Deaggregate the hazard to identify controlling earthquakes for high frequency (HF, 5 to 10 Hz) and low frequency (LF, 1 to 2.5 Hz) ground motions.
- Develop appropriate response spectral shapes for the HF and LF controlling earthquakes.
- Scale the HF and LF spectral shapes to the UHRS values for HF and LF.
- Envelope the scaled HF and LF spectral shapes (and the UHRS) to produce the smooth broad-banded SSE spectrum.

As described in FSAR Subsection 2.5.2, these steps were followed in the development of the ground motion response spectra (GMRS) for the Fermi 3 site. FSAR Table 2.5.2-219 lists the HF and LF controlling earthquakes for the Fermi 3 site. These results, summarized in Table 1, indicate that the GMRS and the associated FIRS represent the contributions of ground motions from a wide range of earthquake magnitudes.

Table 1: Fermi 3 Site Controlling Earthquakes

Hazard Level	Distance (km)	Magnitude (m_b)	Magnitude (M)**
10^{-4} HF	44	5.9	5.6
10^{-4} LF	224	6.8	6.9
10^{-4} LF *	500	7.1	7.4
10^{-5} HF	13.7	5.8	5.5
10^{-5} LF	107	6.7	6.7
10^{-5} LF *	504	7.2	7.6

* computed using earthquakes with distances > 100 km
** computed using an average of the m_b to moment magnitude (**M**) conversions presented in FSAR Subsection 2.5.2.4.2.3.

The resulting FIRS are smooth broad-band spectra without any valleys at localized frequencies. As the FIRS peak ground acceleration (PGA) values are greater than 0.1g, these FIRS are considered to meet the requirements of 10 CFR Part 50, Appendix S, for minimum horizontal ground motion at the foundation level.

SRP 3.7.1 states that:

> *The response spectrum associated with this minimum PGA should be a smooth broad-band response spectra (e.g., RG 1.60, or other appropriate shaped spectra if justified) considered as an outcrop response spectra at the free-field foundation level.*

The Regulatory Guide (RG) 1.60 spectral shape was derived from statistical analyses of strong motion records obtained primarily at deep soil sites in the western United States (NUREG/CR-6926, Section 3.1). As the Fermi 3 RB/FB and CB are to be founded on relatively hard rock (Bass Islands Group with a shear wave velocity of 6,650 fps [2027 m/s]) in the central and eastern United States (CEUS), the RG 1.60 spectral shape is not considered appropriate. At a minimum, a rock site spectral shape should be considered. For example, NUREG-1407 (Chen et al., 1991) utilized the median response spectral shape for rock sites developed in NUREG/CR-0098 (Newmark and Hall, 1978) to characterize ground motions for CEUS nuclear power plants founded on rock. Figure 1 shows that the median NUREG/CR-0098 response spectral shape for rock sites scaled to 0.1g PGA is enveloped by the Fermi 3 SSI FIRS.

Section 3.1 of NUREG/CR-6926 suggests that the CEUS spectral shapes provided in NUREG/CR-6728 (McGuire et al., 2001) are more appropriate for hard rock sites. Figure 2 shows CEUS rock site spectral shapes developed using the relationships presented in NUREG/CR-6728. These shapes are developed using the average of the 10^{-4} and 10^{-5} controlling earthquake magnitudes and log average of the controlling earthquake distances. NUREG/CR-6728 presents spectral shapes based on two alternative models for the shape of the earthquake source spectra: a single corner model and a double corner model. Figure 2 shows both of these spectral shapes. A single enveloping spectral shape is constructed, as shown by the heavy dashed line on Figure 2. Figure 1 shows that the RB/FB and CB SSI FIRS are greater than the enveloping NUREG/CR-6728 spectral shape from Figure 2 scaled to a PGA of 0.1g.

Figure 3 compares the RG 1.60 spectral shape scaled to the minimum PGA of 0.1g to the SSI FIRS. The scaled RG 1.60 spectral shape exceeds the Fermi 3 SSI FIRS between frequencies of 0.23 and 3 Hz. However, as discussed above, the RG 1.60 spectral shape is not considered appropriate to characterize CEUS ground motions on rock sites.

In summary, the Fermi 3 SSI FIRS represent broad-band response spectra. As the PGA for the FIRS exceeds 0.1 g, these FIRS are considered to directly meet the requirements of 10 CFR Part 50, Appendix S, and the guidance in SRP 3.7.1 for the minimum level of ground motions. Section 5.4(c) of Interim Staff Guidance DC/COL-ISG-017 specifies that a description of how the minimum foundation-level seismic ground motion input criterion is met be provided in the FSAR. FSAR Subsection 3.7.1.1.4.6 will be amended to provide a discussion of how this requirement is met. The FSAR markups associated with this response are included in the response to RAI 03.07.01-6.

References:

1. Braverman, J.I., J. Xu, B.R. Ellingwood, C.J. Costantino, R.J. Morante, and C.H. Hofmayer, 2007, Evaluation of the Seismic Design Criteria in ASCE/SEI Standard 43-05 for Application to Nuclear Power Plants, Brookhaven National Laboratory, NUREG/CR-6926.

2. Chen, J.T., N.C. Chokshi, R.M. Kenneally, G.B. Kelly, W.D. Beckner, C. McCracken, A.J. Murphy, L. Reiter, and D. Jeng, 1991, Procedural and submittal guidance for the individual plant examination of external events (IPEEE) for severe accident vulnerabilities, NUREG-1407, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research

3. McGuire, R.K., W.J. Silva, and C.J. Costantino, 2001, *Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines*, NUREG/CR-6728, U.S. Nuclear Regulatory Commission, Washington D.C.

4. Newmark, N.M. J.A. Blume, and K.K. Kapur, 1973, Seismic design spectra for nuclear power plants, American Society of Civil Engineers Journal of the Power Division, v. 99, no. P02, p. 287-303.

5. Newmark, N.M. and W.J. Hall, 1978, Development of criteria for seismic review of selected nuclear power plants, NUREG/CR-0098, U.S. Nuclear Regulatory Commission: Washington D.C.

Proposed COLA Revision

FSAR Subsection 3.7.1.1.4.6, FSAR Subsection 3.7.1.4, and new FSAR Figure 3.7.1-259 are revised as shown on the markup included in the response to RAI 03.07.01-6.

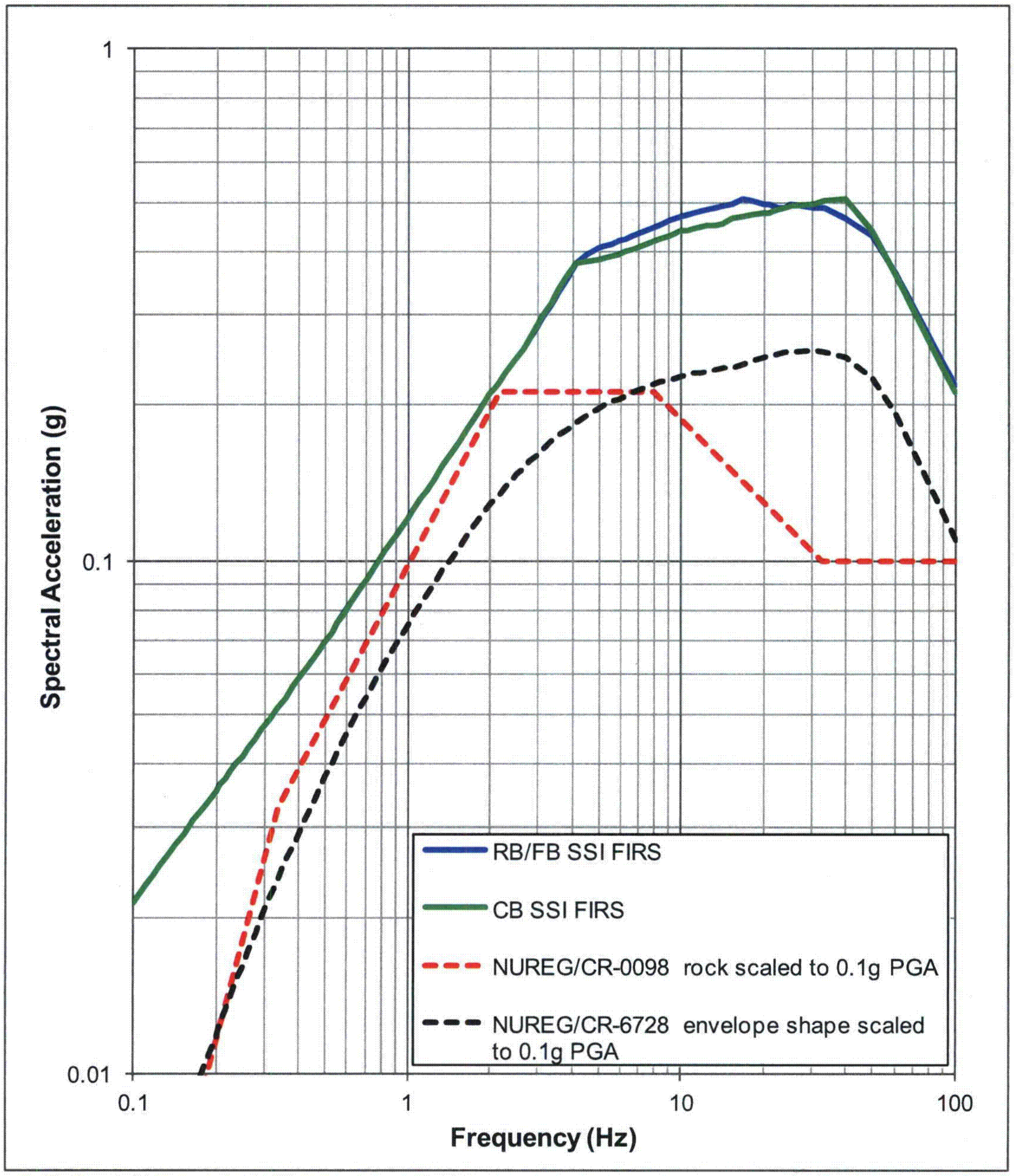


Figure 1: Comparison of Fermi 3 RB/FB and CB SSI FIRS with the NUREG/CR-0098 median rock spectral shape and enveloping NUREG/CR-6728 CEUS spectral shape, both scaled to a minimum PGA of 0.1g. All spectra are for 5% damping.

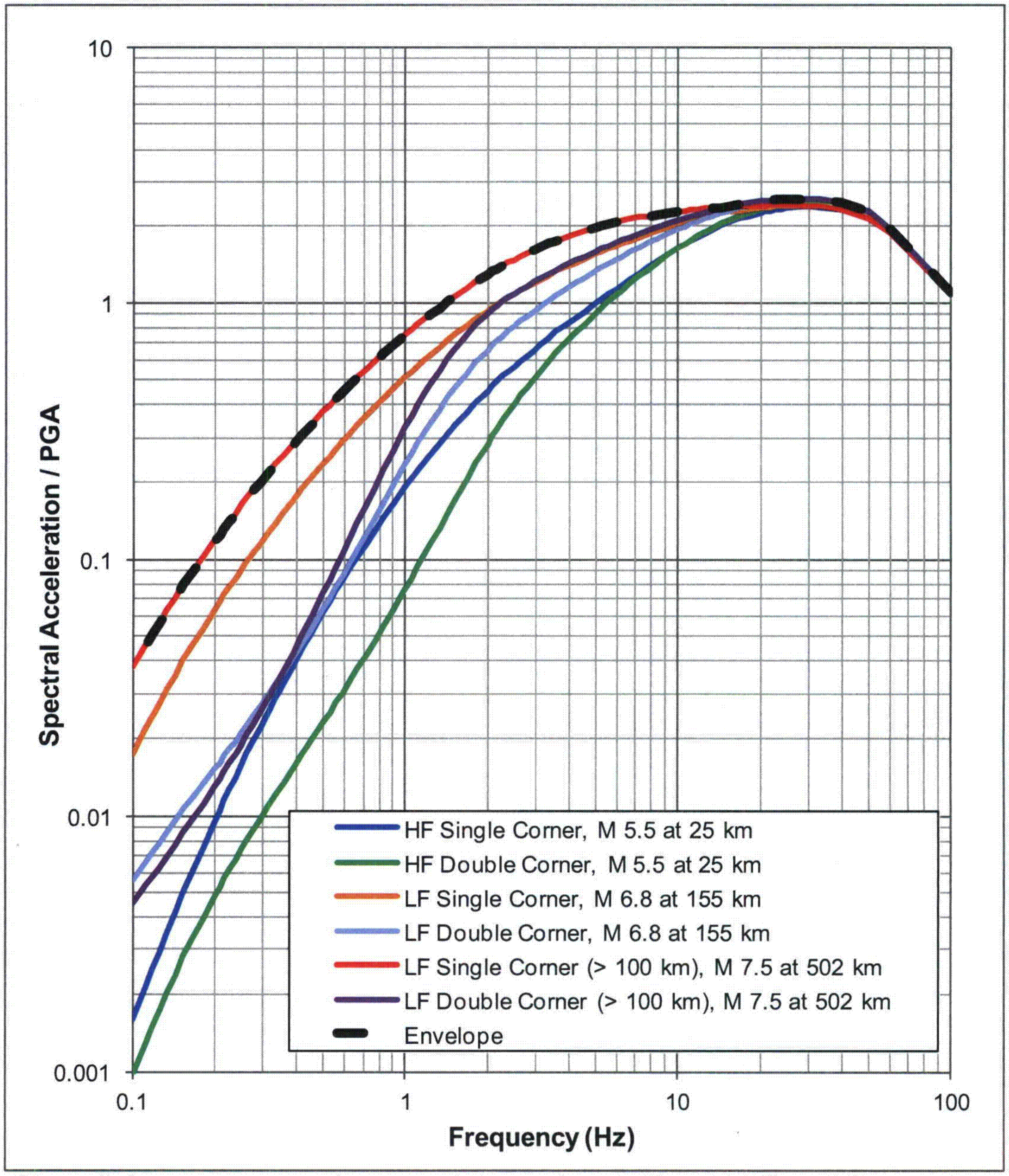


Figure 2: Response spectral shapes (5% damping) for Fermi 3 HF and LF controlling earthquakes based on NUREG/CR-6728 CEUS rock spectral shapes.

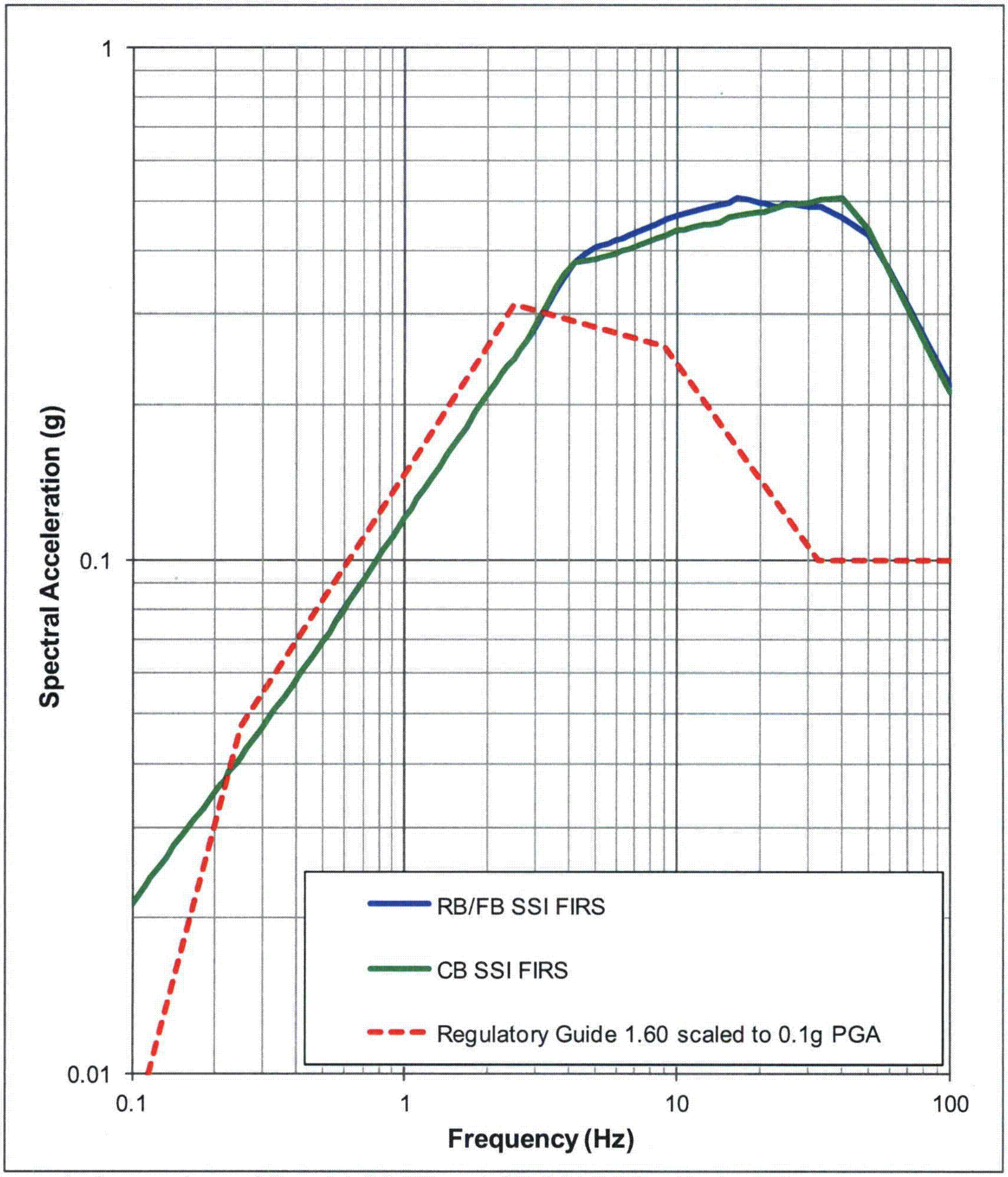


Figure 3: Comparison of Fermi 3 RB/FB and CB SSI FIRS with the RG 1.60 spectral shape scaled to minimum PGA of 0.1g. All spectra are for 5 % damping.

Attachment 11
NRC3-12-0003
(19 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6243)

RAI Question No. 03.07.02-5

NRC RAI 03.07.02-5

ESBWR DCD Tier 2 Section 3.7.2.8 identifies the following:

- *Turbine Building (TB), Service Building (SB), and Ancillary Diesel Building (ADB), as Seismic Category II structures, are to be analyzed using the same methods as Seismic Category I structures (including structure-soil-structure interaction with adjacent Seismic Category I structures) for full SSE loads.*

- *The Radwaste Building (RW), as an RW-IIa structure per RG 1.143, is also to be analyzed using the same methods as Seismic Category I structures (including structure-soil-structure interaction with adjacent Seismic Category I structures) for full SSE loads.*

- *Seismic input motions for the Seismic Category II structures are based on the design spectra defined in DCD Table 3.7-2 with the applicable scale factors applied at the corresponding foundation level at the bottom of the base slab. The scale factors are based on the assumed DCD soil properties.*

- *Seismic gaps between the non-Seismic Category I structures listed above and the Seismic Category I structures are no less than the calculated maximum relative displacements between the structures during an SSE event.*

ESBWR DCD Tier 1 Section 2.16 includes the following ITAAC to ensure that the above analysis and design commitments are met:

- *Table 2.16.8-1, Item 1 (TB): The TB analysis and design is the same as a Seismic Category I structure, including the load combinations and the acceptance criteria, for loads associated with:*

    - *Natural phenomenon – wind, floods, tornadoes (excluding tornado missiles), earthquakes, rain and snow. In addition, the TB is designed for hurricane wind to protect RTNSS systems.*

    - *Normal plant operation — live loads and dead loads.*

- *Tables 2.16.9-1, 2.16.10-1, and 2.16.11-1 have similar design commitments for the RW, SB, and ADB.*

In EF3 FSAR Section 3.7.2.8, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, the applicant states that Fermi 3 site-specific analysis will be performed for the Seismic Category II structures if referenced DCD backfill requirements are not met. Since the backfill requirements are not being met for the Fermi 3 site, the applicant is requested to describe in the FSAR how the above ESBWR DCD commitments and ITAAC are implemented for the site-specific conditions of the Fermi 3 site, including a description of the site-specific analysis to be performed. The applicant is also requested to describe how the seismic input for the Seismic Category II structures (for the site specific analysis) will consider the site-specific scale factors, including the effect of structure-soil-structure interaction, to ensure that the seismic input specified in the DCD for these structures will still be bounding.

In addition, explain why EF3 FSAR Figures 2.5.4-201 through 2.5.4-204, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, only show the TB and RW, and not the SB and ADB, and why Table 2.5.4-224 lists the TB as "nonseismic" and not as Seismic Category II.

Response

The FSAR will be revised and an associated ITAAC will be added to describe how the ESBWR DCD commitments and DCD ITAACs for the Seismic Category II structures (Turbine Building [TB], Service Building [SB] and Ancillary Diesel Building [ADB]) and the Seismic Category NS Radwaste Building (RW) structure are implemented for the site-specific conditions of the Fermi 3 site, including a description of the site-specific analyses to be performed if the DCD backfill requirements for these structures are not met for the Fermi 3 site.

Earthquake ground motion inputs for the site-specific analyses of the Seismic Category II structures will be developed following the approach used to develop the inputs for the Seismic Category I structures as described in FSAR Subsection 3.7.1. For those structures modeled as surface structures, appropriate foundation input response spectra (FIRS) will be developed from 1-D site response analyses of the full soil column (in-situ rock plus engineered granular backfill) truncated at the foundation elevation (i.e., the approaches described in Sections 3.2.1 and 3.2.2 of NEI, 2009). The soil and rock properties developed for analysis of the Category I structures will be used. The input ground motions for these analyses will be the input acceleration time histories developed to represent the hard rock ground motions at elevation 156 ft NAVD88. For those structures modeled as embedded structures, appropriate FIRS will be developed from 1-D site response analyses of the full soil column, extracting soil column outcrop response (SCOR) motions at the appropriate elevations to develop SCOR FIRS. Again, the soil and rock properties developed for analysis of the Category I structures will be used and the input ground motions for these analyses will be the input acceleration time histories developed to represent the hard rock ground motions at elevation 156 ft NAVD88. The resulting ground motions will thus reflect the site-specific conditions. In addition, SSI analyses using these site-specific ground motions will be performed as necessary to ensure that the seismic input specified in the DCD for these structures is bounding.

Standard Review Plan Section 2.5.4, SRP Acceptance Criteria 2.5.4.3 – Foundation Interfaces, indicates the following should be included within the discussion in the FSAR:

> *...the discussion of the relationship of foundations and underlying materials is acceptable if it includes*
>
> *(1) a plot plan or plans showing the locations of all site explorations, such as borings, trenches, seismic lines, piezometers, geologic profiles, and excavations with the locations of the safety-related facilities superimposed thereon;*
> *(2) profiles illustrating the detailed relationship of the foundations of all seismic Category I and other safety-related facilities to the subsurface materials;*
> *(3) logs of core borings and test pits; and*
> *(4) logs and maps of exploratory trenches in the application for an early site permit or COL.*

The information provided in FSAR Figures 2.5.4-201 through 2.5.4-204 satisfies SRP 2.5.4 Acceptance Criteria – Foundation Interfaces, Item (2) by providing profiles illustrating the detailed relationship of all Seismic Category I (Reactor Building/Fuel Building [RB/FB], Control Building [CB], and Fire Water Service Complex [FWSC]) and other safety-related facilities (none) to the subsurface materials. The SB and ADB are Seismic Category II and are not required to be shown on these figures to meet SRP 2.5.4 Acceptance Criteria – Foundation Interface, Item (2). The RW and TB are included on FSAR Figures 2.5.4-201 through 2.5.4-204 because they are located down inside the excavation for the Seismic Category I structures. The locations of the SB and ADB, relative to the other structures, are shown on FSAR Figure 2.1-204 and Figure 2.5.1-236.

The text of FSAR Section 2.5.4.3 is being updated to clarify which structures are shown.

FSAR Table 2.5.4-224 will be revised to identify the TB as Seismic Category II consistent with the DCD.

References:

1. Nuclear Energy Institute (NEI), 2009, Consistent site response/soil-structure interaction analysis and evaluation, Letter to Mr. Nilesh Chokshi from Russel Bell, dated June 12, 2009.

Proposed COLA Revision

FSAR Subsection 2.5.4.3, FSAR Subsection 3.7.2.8, FSAR Table 2.5.4-224, and Part 10, Section 2.4 are revised as shown on the attached markups.

Markup of Detroit Edison COLA
(following 14 pages)

The following markup represents how Detroit Edison intends to reflect this RAI response in the next submittal of the Fermi 3 COLA. However, the same COLA content may be impacted by responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be different than presented here.

confirm the estimated shear strain level in Salina Unit F is less than 0.03 percent.

2. Core recovery and RQD in Salina Group Unit F was poor. Testable samples from Salina Group Unit F were collected and preserved. These samples likely represent the more intact portions of the bedrock and hence testing under static or dynamic loading conditions would possibly give high values not representative of the overall Unit F.

Using an estimated average V_s of 305 m/s (1,000 fps) for till, the strain levels induced in till during the design earthquake was estimated to be 0.03 percent, with a resultant modulus reduction that would not exceed 20 percent. Therefore, only Resonant Column and Torsional Shear (RCTS) Testing is needed to obtain the dynamic response of the till. The RCTS testing will provide the dynamic response of soils up to shear strain of approximately 0.5 percent. No cyclic triaxial and cyclic direct simple shear tests are required. Figure 2.5.2-271 and Figure 2.5.2-272 show that within the elevation range of the glacial till (elevations of approximately 168 to 172 m [552 to 563 ft]) the computed shear strains in the randomized site profiles were all less than or equal to 0.1 percent. The RCTS testing provides the modulus reduction characteristic of glacial till up to shear strain of approximately 0.3 percent as shown on Figure 2.5.4-226. Therefore, these results confirm that cyclic triaxial and cyclic direct simple shear tests were not necessary since RCTS testing provides the modulus reduction characteristic for glacial till up to approximately 0.3 percent.

A number of dynamic tests on samples of glacial till to obtain the modulus reduction and damping curves as a function of strain were performed. Four RCTS tests were performed on glacial till as presented in Subsection 2.5.4.7.3.

2.5.4.3 Foundation Interface

Figure 2.5.1-236 shows the locations of the site explorations including borings, monitoring wells, piezometers and the test pit at Fermi 3 for the geotechnical investigation. ~~Locations of ESBWR facilities including all Seismic Category I structures are also shown on~~ Figure 2.5.4-201. The ~~Seismic Category I structures for the ESBWR technology are:~~

shows the plan view of the excavation (discussed in Subsection 2.5.4.5) for the following ESBWR technology structures:

- Reactor Building/Fuel Building (RB/FB)
- Control Building (CB)

, Seismic Category I

Turbine Building (TB), Seismic Category II
Radwaste Building (RW), Nonseismic

- Firewater Service Complex (FWSC) , Seismic Category I

excavation plan view on Figure 2.5.4-201. The geologic cross-sections show the

Figure 2.5.4-202 through Figure 2.5.4-204 show geologic cross-sections through the ~~Seismic Category I structures showing the detailed~~ relationship of the foundations of all Seismic Category I structures to the subsurface materials.

Table 2.5.4-224 provides the foundation elevations of the major structures in the Power Block area. The key dimensions of the foundations for the RB/FB, CB, and the FWSC are provided in the DCD Table 3.8-13. The finished ground level grade (finish grade) of elevation 179.6 m (589.3 ft) NAVD 88 was obtained from Subsection 2.4.1.

The RB/FB embedment depth is 20 m (65.6 ft) below finish grade. The base elevation of the RB/FB foundation is at 159.6 m (523.7 ft) NAVD 88. As shown on Figure 2.5.4-202 and Figure 2.5.4-203, the base of the RB/FB foundation lies on Bass Islands Group. The CB embedment depth is 14.9 m (48.9 ft) below finish grade resulting in a foundation base elevation of 164.7 m (540.4 ft) NAVD 88. As shown on Figure 2.5.4-202, the base of the CB foundation is also founded on Bass Islands Group. The embedment depth of the foundation base of the FWSC is 2.35 m (7.7 ft), at elevation 177.3 m (581.6 ft) NAVD 88. The FWSC foundation base is within fill material as shown on Figure 2.5.4-202; however, the existing subsurface materials including fill, lacustrine and glacial till are to be removed and backfill consisting of fill concrete will reestablish the foundation grade of the FWSC. Concrete is used to backfill the gap between the RB/FB and CB and excavated bedrock up to the top of the Bass Islands Group bedrock at Elevation 168.2 m (552.0 ft) NAVD 88. The gap between the RB/FB and the CB up to the top of the Bass Islands Group bedrock at Elevation 168.2 m (552.0 ft) NAVD 88 is also backfilled with fill concrete.

The static and dynamic engineering properties of the fill concrete fill under the FWCS are discussed in Subsection 2.5.4.5.4.2.

Figure 2.5.4-203 shows that the foundation base of the Radwaste Building (RW) is founded on Bass Islands Group, while the foundation base level of the Turbine Building (TB) is within glacial till as shown on Figure 2.5.4-203 and Figure 2.5.4-204. The glacial till will be removed underneath the TB and replaced with fill concrete to reduce the interaction between the TB and RB since they are located in close proximity.

Table 2.5.4-224 Foundation Elevations of Major Structures in the Power Block Area

[EF3 COL 2.0-29-A]

Building	Structure Category[1]	Final Surface Grade Elevation in NAVD 88[2] (feet)	Bottom of Foundation Elevation in NAVD 88 (feet)	Depth of Foundation[3] (feet)
Reactor Building/Fuel Building (RB/FB)	I	589.3	523.7	65.6[3]
Control Building (CB)	I	589.3	540.4	48.9[3]
Firewater Service Complex (FWSC)	I	589.3	581.6	7.7[3]
Radwaste Building (RW)	NS	589.3	537.3	52
Turbine Building (TB)	~~NS~~ II	589.3	563.4	25.9
Service Building (SB)	II	589.3	573.9	15.4

Note:

1. Information from DCD Table 3.2-1.
2. Information from Subsection 2.4.1.
3. Information from DCD Table 3.8-13.

I - Seismic Category I
II - Seismic Category II
NS - Nonseismic

site-specific factors of safety for sliding and overturning for the RB/FB and CB are 3.09 for sliding and 1,029 for overturning (presented in Subsection 3.8.5).

- The Fermi 3 RB/FB and CB are stable against floatation with a minimum factor of safety of 1.85 (presented in Subsection 3.8.5).
- The dynamic bearing demands from the Fermi 3 site-specific SSI analyses are considerably below the allowable dynamic bearing capacities for the Bass Islands Group bedrock at the Fermi 3 site (presented in Subsection 3.8.5).

3.7.2.8 Interaction of Non-Category I Structures with Seismic Category I Structures

Add the following at the end of this section.

EF3 SUP 3.7-5

The locations of structures are provided in Figure 2.1-204. Non-Category I structures within the scope of the DCD are addressed in the DCD. Non-Category I structures outside the scope of the DCD are located at least a distance of its height above grade from Seismic Category I structures. Thus, the collapse of any site specific non-Category I structure, system, or component will not cause the non-Category I structure, system, or component to strike a Seismic Category I structure, system, or component.

For the Seismic Category II structures and Radwaste Building, Fermi 3 site-specific analyses will be performed if the Referenced DCD backfill requirements are not met.

Insert 1

3.7.2.14 Determination of Seismic Category I Structure Overturning Moments

Add the following at the end of the Subsection 3.7.2.14.

The Fermi 3 site-specific stability evaluation against overturning is presented in Subsection 3.8.5.

Insert 1

The locations of structures are provided in Figure 2.1-204. Non-Category I structures within the scope of the DCD are addressed in the DCD. Each site-specific non-Category I structure outside the scope of the DCD is located at least a distance of the structure's height above grade from Seismic Category I structures. Thus, the collapse of any site specific non-Category I structure, system, or component will not cause the non-Category I structure, system, or component to strike a Seismic Category I structure, system, or component.

The design and analysis of the Seismic Category II structures (TB, SB, and ADB) and the Seismic Category NS Radwaste Building (RW) structure will be completed as part of the detailed design phase for the ESBWR standard plant. The design and analysis for these structures will be in accordance with the ESBWR DCD, considering the soil property requirements in DCD Tier 1 Table 5.1-1, to ensure that the acceptance criteria in DCD Tier 1 ITAAC Tables 2.16.8-1, 2.16.9-1, 2.16.10-1, and 2.16.11-1 are met. DCD Section 3.7.2.8 describes the seismic design and analysis for the TB, SB, ADB and RW structures to preclude any adverse interaction with Seismic Category I structures.

If the soil property requirements in DCD Tier 1 Table 5.1-1 are not met, Fermi 3 site-specific seismic SSI analyses using the Fermi 3 soil properties will be performed to demonstrate the adequacy of the standard plant design for the TB, SB, ADB, and the RW structures, as follows:

- These Fermi 3 site-specific seismic SSI analyses for the TB, RW, SB, and ADB structures will be consistent with the site-specific seismic SSI analyses for the Seismic Category I RB/FB and CB structures presented in FSAR Subsection 3.7.2.4 and will be performed using the Fermi 3 soil properties and the methodologies described in DCD Subsections 3.7.2.8.1, 3.7.2.8.2, 3.7.2.8.3, and 3.7.2.8.4, respectively, and DCD Appendix 3A.
- In addition to these site-specific seismic SSI analyses, site-specific seismic structure-soil-structure interaction (SSSI) analyses to evaluate any adverse effects between the TB, RW, SB, and ADB structures and adjacent Seismic Category I structures will be performed using the methodologies described in DCD Subsections 3.7.2.8.1, 3.7.2.8.2, 3.7.2.8.3, and 3.7.2.8.4, respectively, and DCD Appendix 3A.

Results of these site-specific seismic SSI and seismic SSSI analyses, if needed, will be discussed as part of the ITAAC completion package for the TB, RW, SB, and ADB structures to demonstrate that acceptance criteria in ITAAC Tables 2.4.15-1, 2.4.16-1, 2.4.17-1 and 2.4.18-1, respectively, are met.

2.4.14 METEOROLOGICAL MONITORING SYSTEM

No entry for this system.

Insert 2 after this page

Insert 2

2.4.15 ITAAC for the Turbine Building

Design Description

The Turbine Building is a Seismic Category II building. The design and analysis of the Turbine Building will preclude any adverse interaction with Seismic Category I structures, considering the soil properties. If necessary, soil-structure interaction (SSI) analyses using Fermi 3 soil properties will be performed following the same methodology used in the ESBWR Standard Plant Turbine Building seismic SSI analyses.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.4.15-1 provides a definition of the inspections, tests, and/or analyses, together with associated acceptance criteria for the Turbine Building.

Table 2.4.15-1 ITAAC For The Turbine Building		
Design Commitment	**Inspections, Tests, and Analyses**	**Acceptance Criteria**
1. Determine if the Fermi 3 soil properties meet the site parameters in DCD Tier 1 Table 5.1-1. If not, then Fermi 3 site-specific seismic soil-structure interaction (SSI) analyses using the Fermi 3 soil properties will be performed for the Turbine Building (TB). The Fermi 3 TB site-specific seismic SSI analyses shall follow the same methodology used in the ESBWR TB seismic analyses specified in DCD Tier 1 ITAAC Table 2.16.8-1.	Fermi 3 soil properties will be determined. Site-specific SSI and SSSI analyses of the TB will be conducted, if necessary.	The Fermi 3 soil properties either (1) meet the site parameters in DCD Tier 1 Table 5.1-1, or (2) site-specific SSI analyses will be conducted. The results of Fermi 3 site-specific seismic SSI analyses of the TB are compared with the ESBWR TB seismic responses presented in DCD Tier 1 ITAAC Table 2.16.8-1 seismic analyses to confirm the Fermi 3 SSI is adequate for the ESBWR TB seismic design.

2.4.16 ITAAC for the Radwaste Building

Design Description

The Radwaste Building is a Seismic Category NS building. The design and analysis of the Radwaste Building will preclude any adverse interaction with Seismic Category I structures, considering the soil properties. If necessary, soil-structure interaction (SSI) analyses using Fermi 3 soil properties will be performed following the same methodology used in the ESBWR Standard Plant Radwaste Building seismic SSI analyses.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.4.16-1 provides a definition of the inspections, tests, and/or analyses, together with associated acceptance criteria for the Radwaste Building.

Table 2.4.16-1 ITAAC For The Radwaste Building		
Design Commitment	**Inspections, Tests, and Analyses**	**Acceptance Criteria**
1. Determine if the Fermi 3 soil properties meet the site parameters in DCD Tier 1 Table 5.1-1. If not, then Fermi 3 site-specific seismic soil-structure interaction (SSI) analyses using the Fermi 3 soil properties will be performed for the Radwaste Building (RW). The Fermi 3 RW site-specific seismic SSI analyses shall follow the same methodology used in the ESBWR RW seismic analyses specified in DCD Tier 1 ITAAC Table 2.16.9-1.	Fermi 3 soil properties will be determined. Site-specific SSI and SSSI analyses of the TB will be conducted, if necessary.	The Fermi 3 soil properties either (1) meet the site parameters in DCD Tier 1 Table 5.1-1, or (2) site-specific SSI analyses will be conducted. The results of Fermi 3 site-specific seismic SSI analyses of the RW are compared with the ESBWR RW seismic responses presented in DCD Tier 1 ITAAC Table 2.16.9-1 seismic analyses to confirm the Fermi 3 SSI is adequate for the ESBWR RW seismic design.

2.4.17 ITAAC for the Service Building

Design Description

The Service Building is a Seismic Category II building. The design and analysis of the Service Building will preclude any adverse interaction with Seismic Category I structures, considering the soil properties. If necessary, soil-structure interaction (SSI) analyses using Fermi 3 soil properties will be performed following the same methodology used in the ESBWR Standard Plant Service Building seismic SSI analyses.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.4.17-1 provides a definition of the inspections, tests, and/or analyses, together with associated acceptance criteria for the Service Building.

Table 2.4.17-1 ITAAC For The Service Building		
Design Commitment	**Inspections, Tests, and Analyses**	**Acceptance Criteria**
1. Determine if the Fermi 3 soil properties meet the site parameters in DCD Tier 1 Table 5.1-1. If not, then Fermi 3 site-specific seismic soil-structure interaction (SSI) analyses using the Fermi 3 soil properties will be performed for the Service Building (SB). The Fermi 3 SB site-specific seismic SSI analyses shall follow the same methodology used in the ESBWR SB seismic analyses specified in DCD Tier 1 ITAAC Table 2.16.10-1.	Fermi 3 soil properties will be determined. Site-specific SSI and SSSI analyses of the TB will be conducted, if necessary.	The Fermi 3 soil properties either (1) meet the site parameters in DCD Tier 1 Table 5.1-1, or (2) site-specific SSI analyses will be conducted. The results of Fermi 3 site-specific seismic SSI analyses of the SB are compared with the ESBWR SB seismic responses presented in DCD Tier 1 ITAAC Table 2.16.10-1 seismic analyses to confirm the Fermi 3 SSI is adequate for the ESBWR SB seismic design.

2.4.18 ITAAC for the Ancillary Diesel Building

Design Description

The Ancillary Diesel Building is a Seismic Category II building. The design and analysis of the Ancillary Diesel Building will preclude any adverse interaction with Seismic Category I structures, considering the soil properties. If necessary, soil-structure interaction (SSI) analyses using Fermi 3 soil properties will be performed following the same methodology used in the ESBWR Standard Plant Ancillary Diesel Building seismic SSI analyses.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.4.18-1 provides a definition of the inspections, tests, and/or analyses, together with associated acceptance criteria for the Ancillary Diesel Building.

Table 2.4.18-1 ITAAC For The Ancillary Diesel Building		
Design Commitment	**Inspections, Tests, and Analyses**	**Acceptance Criteria**
1. Determine if the Fermi 3 soil properties meet the site parameters in DCD Tier 1 Table 5.1-1. If not, then Fermi 3 site-specific seismic soil-structure interaction (SSI) analyses using the Fermi 3 soil properties will be performed for the Ancillary Diesel Building (ADB). The Fermi 3 ADB site-specific seismic SSI analyses shall follow the same methodology used in the ESBWR ADB seismic analyses specified in DCD Tier 1 ITAAC Table 2.16.11-1.	Fermi 3 soil properties will be determined. Site-specific SSI and SSSI analyses of the TB will be conducted, if necessary.	The Fermi 3 soil properties either (1) meet the site parameters in DCD Tier 1 Table 5.1-1, or (2) site-specific SSI analyses will be conducted. The results of Fermi 3 site-specific seismic SSI analyses of the ADB are compared with the ESBWR ADB seismic responses presented in DCD Tier 1 ITAAC Table 2.16.11-1 seismic analyses to confirm the Fermi 3 SSI is adequate for the ESBWR ADB seismic design.

Attachment 12
NRC3-12-0003
(3 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6243)

RAI Question No. 03.07.02-6

NRC RAI 03.07.02-6

EF3 FSAR Sections 3.7.1, 3.7.2, and 3.8.5, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, indicate that engineered granular backfill above the Bass Islands Group rock is not included in the site-specific SSI analyses performed for the RB/FB and CB. The rationale given for exclusion of the backfill is that it is not credited for resistance of sliding and overturning forces, and thus serves no safety-related function. It is also implied that, because the site-specific SSI analyses "do not take credit for the benefits provided by the backfill surrounding the RB/FB and CB" (EF3 FSAR Section 3.7.2.4.1), the computed SSI responses (seismic loads, vertical accelerations, and in-structure response spectra) are appropriate for comparison to the reference ESBWR DCD design values.

However, EF3 FSAR Figures 2.5.4-201 through 2.5.4-204 show that the RB/FB and CB are deeply embedded structures with two-thirds or more of their depth in the granular fill (above rock and concrete). As such, the applicant is requested to provide further justification for ignoring embedment effects on SSI response. The justification should include the potential impact of this modeling approach on in-structure response spectra (over the entire frequency range of interest), lateral wall pressures, and other seismic loads.

Response

As noted above, Fermi 3 site-specific soil-structure interaction (SSI) analyses, excluding side backfill above the bedrock, described in FSAR Subsection 3.7.2.4 were performed using the Fermi 3 site Foundation Input Response Spectra (FIRS). Analyses show that the Fermi 3 Floor Response Spectra (FRS) at all elevations of the Reactor Building/Fuel Building (RB/FB) and Control Building (CB) are enveloped by ESBWR DCD FRS with considerable margin. In the analyses, soil above the bedrock was not considered for simplicity and to provide a conservative result. Further justification requested in this RAI will be addressed by quantitative analyses that will include backfill soil above the bedrock.

Fermi 3 site-specific SSI analyses using the subtraction method will be performed. These analyses will utilize the original seismic inputs. The strain-compatible soil profiles for the best estimate, lower bound, and upper bound engineered granular backfill above the bedrock surrounding the RB/FB and CB, as described in FSAR Tables 3.7.1-205, 3.7.1-206, and 3.7.1-207, respectively, will be included in the analyses.

The additional comparative study using the subtraction method of the SASSI2000 computer program and the direct method of the SASSI2000 computer program was performed for the RB/FB and CB using the Fermi 3 site conditions. The result of the comparative study shows almost identical results between the subtraction method and direct method. Detroit Edison is currently performing analyses of the RB/FB and CB using the direct method utilizing enhanced time histories. Preliminary results indicate that existing time history and enhanced time history results are almost identical. Therefore the use of the subtraction method and original inputs is acceptable.

According to FSAR Table 3.7.1-206, the strain-compatible soil profiles for the lower bound engineered granular backfill shear wave velocity range from 408 ft/s to 608 ft/s (124 m/s to 185 m/s). For this backfill soil, if finite elements are modeled up to 50 Hz, the number of elements will exceed the SASSI2000 limitation because the mesh size needs to be smaller to satisfy the requirements of the SASSI2000 computer code (i.e., $l = V_s/(5f) = 124/(5x50) = 0.5$ m). However, because the dominant frequency of the backfill above the bedrock is about 2.7 Hz (i.e., $f = V_s/(4h) = 124/(4x11.3) = 2.7$ Hz), the lower bound engineered granular backfill will not impact the building response in the higher frequency range. The mesh size used in the current Fermi 3 site-specific SASSI model can consider frequency up to 25 Hz and will be more than adequate to evaluate the potential impact of the engineered granular backfill effect on the embedded RB/FB and CB structures.

A revised response including the SASSI additional analyses results with the backfill above the bedrock will be provided by April 30, 2012.

Proposed COLA Revision

None.

Attachment 13
NRC3-12-0003
(52 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6243)

RAI Question No. 03.07.02-7

NRC RAI 03.07.02-7

The Defense Nuclear Facilities Safety Board has recently identified a technical issue with the SASSI2000 code, concerning the use of the subtraction method for SSI analysis of embedded structures. To address this issue, during the Public Meeting held July 21, 2011, GEH made a presentation showing comparisons of SSI response between the direct and subtraction methods of SASSI2000 (see ADAMS Accession Number ML112020435). The presentation indicated that SSI analyses for the CB were performed using both methods. Comparisons in terms of transfer functions and floor response spectra at the CB roof and basemat appear to indicate very close agreement between the two methods. However, the presentation did not provide figures that show the excavated volume. The applicant is requested to provide the geometry and properties of the excavated volume modeled in both SASSI analyses.

Considering that the RB/FB has a significantly larger footprint and is more deeply embedded than the CB (i.e., significantly larger excavated volume), it may not be possible to extrapolate the comparison results for the CB to the RB/FB. Therefore, the applicant is requested to provide an additional comparative study for the RB/FB along the lines of the study performed for the CB.

Details of the comparative studies discussed above should be included in the relevant sections of the EF3 FSAR.

Response

The geometry and properties of the excavated volume modeled in both SASSI analyses will be provided by February 29, 2012.

The additional comparative study using the subtraction method of the SASSI2000 computer program and the direct method, which is also known as the flexible volume method, of the SASSI2000 computer program was performed for the ESBWR Reactor Building/Fuel Building (RB/FB) using the Fermi 3 site conditions.

Comparisons in terms of transfer functions and floor response spectra (FRS) at selected RB/FB locations indicate almost identical results between the subtraction method and direct method. The results of this study are described below and shown in the referenced figures.

- The overall site-specific SASSI2000 RB/FB soil-structure interaction (SSI) analysis model is depicted in Figures 1-1 through 1-3. The SSI analysis model horizontal X-direction and Y-direction represent the plant North-South direction and East-West direction, respectively, of the Fermi 3 site. The Z-direction represents the vertical direction.

- For the RB/FB locations and node numbers, consistent with the RB/FB seismic model shown in DCD Tier 2 Figure 3A.7-4, listed in Table 1, the transfer functions obtained by the SASSI2000 direct method are plotted for comparison with those obtained by the SASSI2000 subtraction method on Figures 1.1-1a through 1.1-3f. The transfer functions generated by the SASSI2000 direct and subtraction methods agree well, with minor deviations at higher frequencies and some local spikes. The effects of the local spikes are not seen in the FRS as described in the following paragraph.

- The FRS at the RB/FB locations listed in Table 1 below, obtained by the SASSI2000 direct method, are plotted in Figures 1.2-1a through 1.2-9f. To allow comparison of results, the FRS at the same selected RB/FB locations obtained by the SASSI2000 subtraction method described in Detroit Edison's response to NRC RAI 02.05.04-38 (NRC3-11-0020, dated June 17, 2011 [ML11171A568]) and the ESBWR standard plant enveloping seismic SSI FRS described in DCD Tier 2 Appendix 3A are also plotted in Figures 1.2-1a through 1.2-9f. There is excellent agreement between the FRS for the SASSI2000 subtraction and direct methods for the RB/FB. No effect due to the spikes in the transfer functions described above is seen in the FRS. The RB/FB seismic SSI FRS for the Fermi 3 site-specific conditions are fully enveloped by the ESBWR standard plant seismic SSI DCD FRS, with a large margin between the seismic SSI DCD FRS and the Fermi 3 site-specific SSI FRS.

As described in the transmittal letter, Detroit Edison is currently performing SSI analyses using the direct method and revised seismic inputs. The revised SSI analyses will be available for NRC audit the week of April 23rd 2012, including the necessary FSAR markups.

Proposed COLA Revision

None.

Table 1 RB/FB Direct and Subtraction Methods Comparison Locations

Location	Node Number
RB/FB Refueling Floor	109
Reinforced Concrete Containment Vessel (RCCV) Top Slab	208
Vent Wall (V/W) Top	701
Reactor Shield Wall (RSW) Top	707
Reactor Pressure Vessel (RPV) Top	801
RB/FB Basemat	2

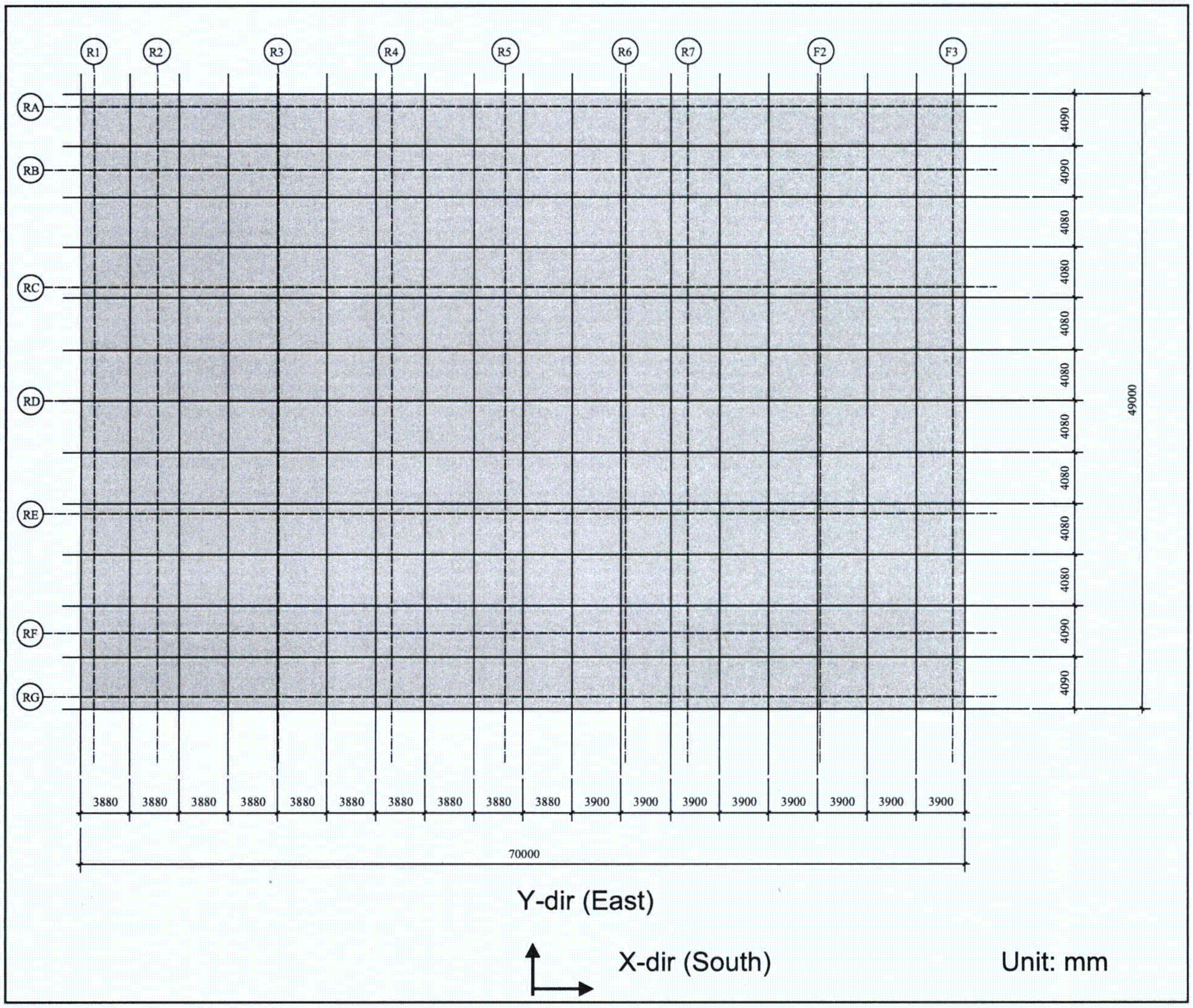
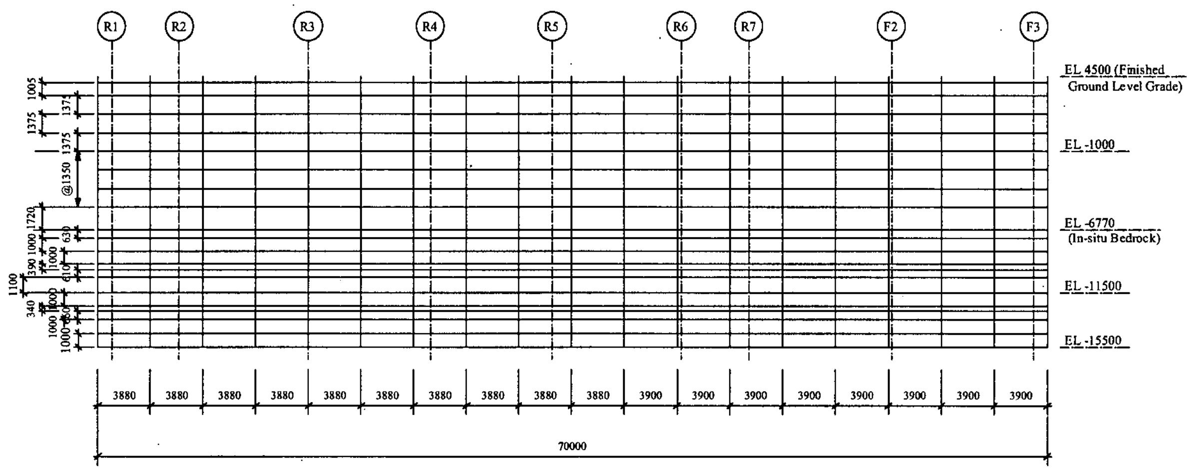
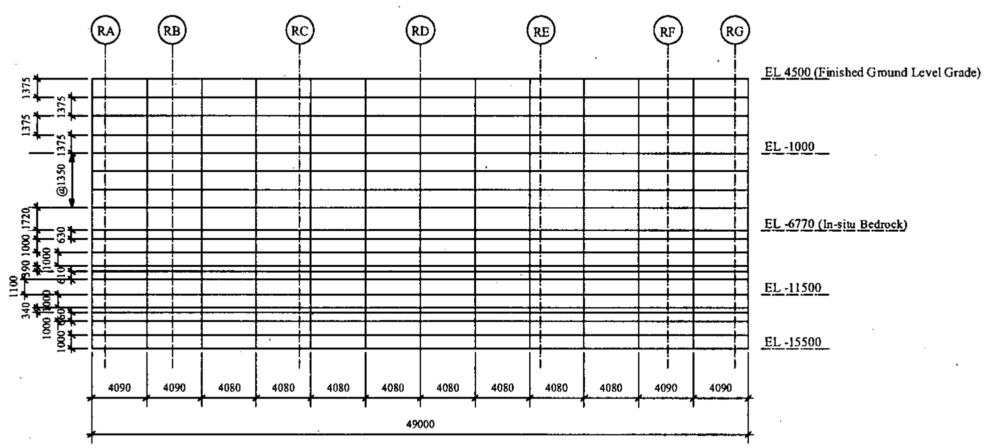


Figure 1-1 SASSI2000 Plate Elements for RB/FB Basemat



(a) Walls on Column Rows RA and RG



(b) Walls on Column Rows R1 and F3

Unit: mm

Figure 1-2 SASSI2000 Plate Elements for RB/FB Exterior Walls

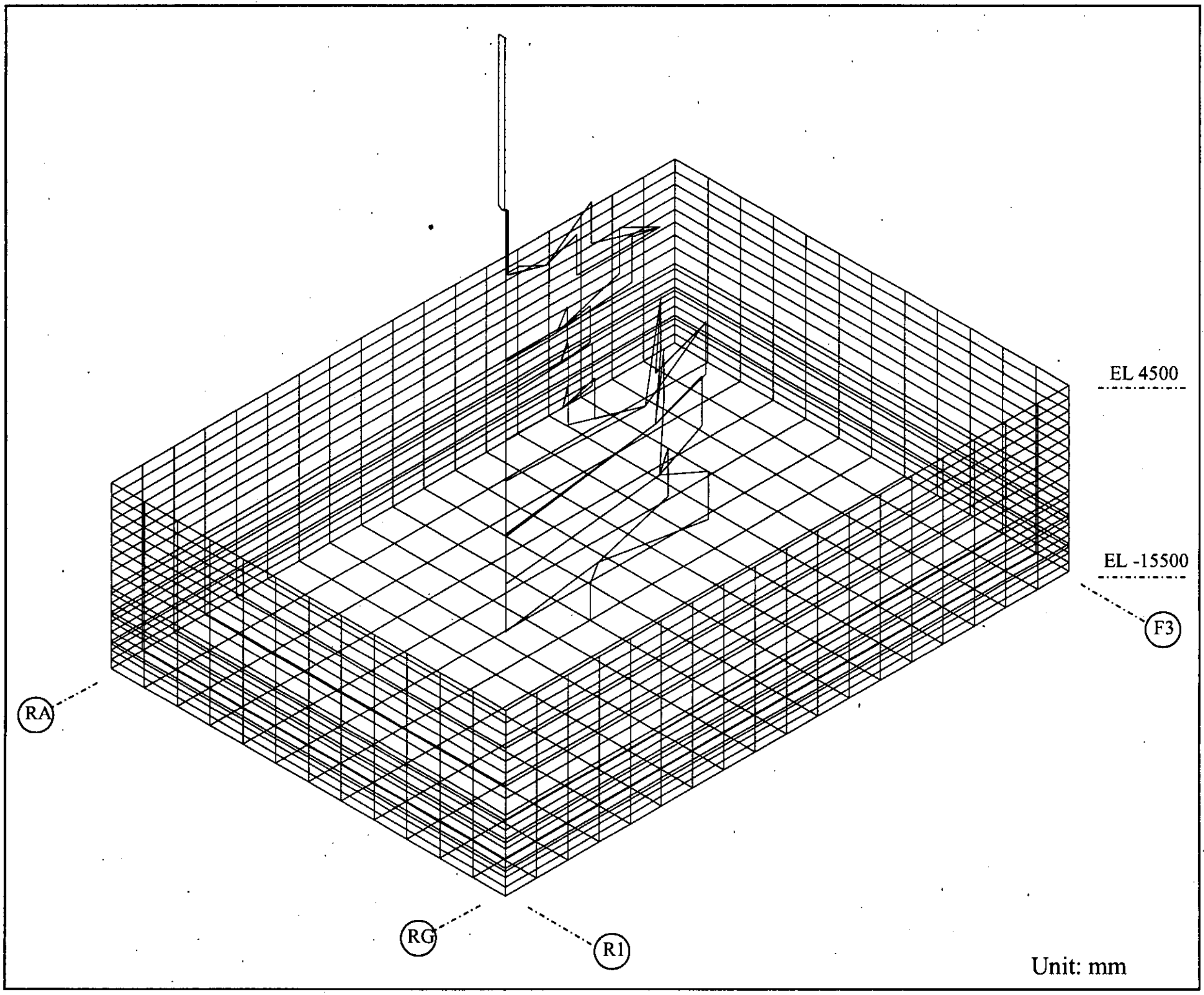
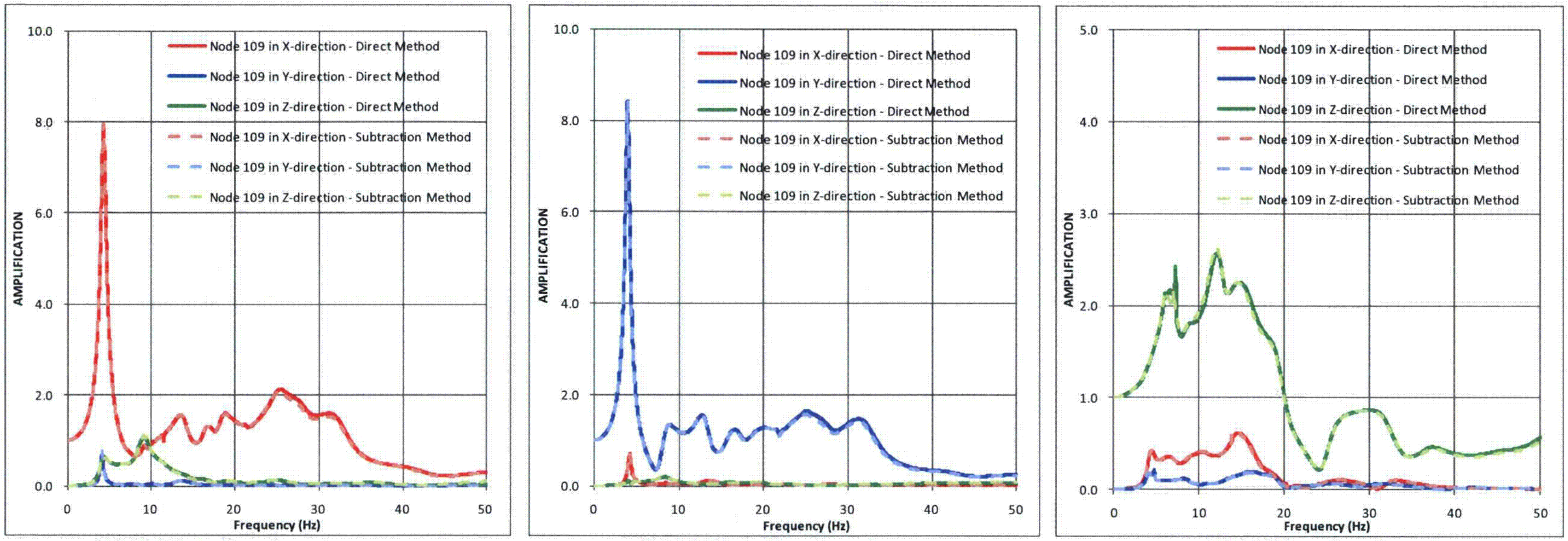
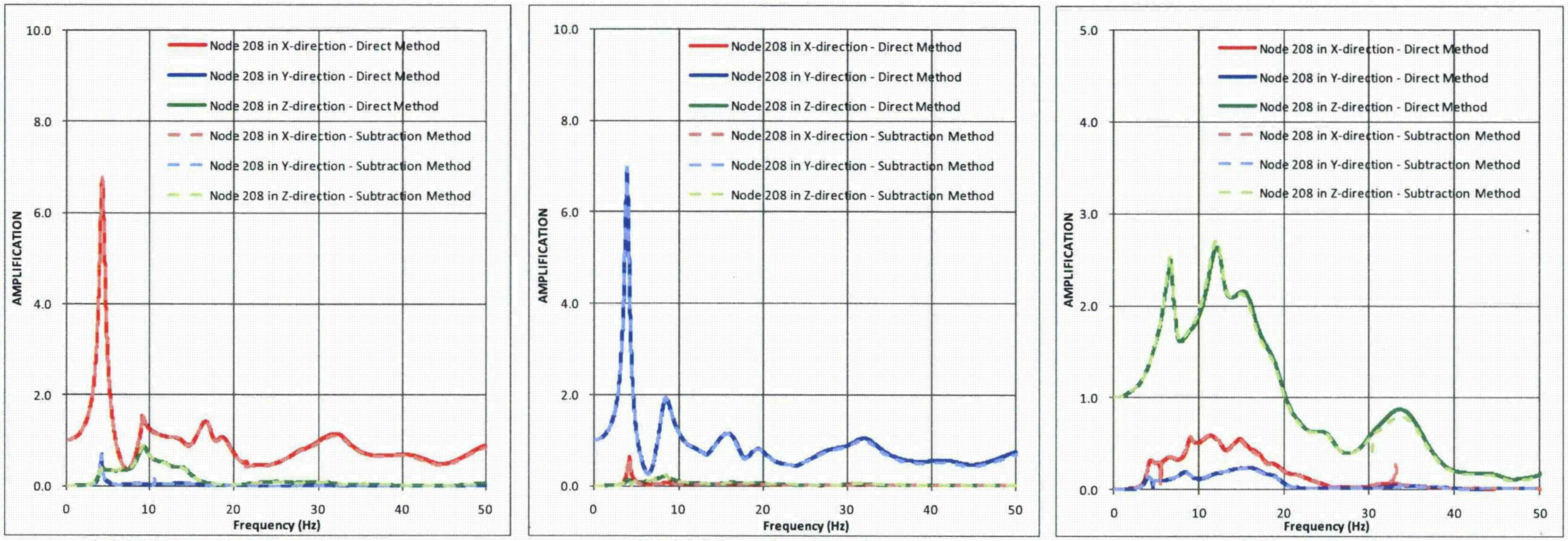


Figure 1-3 Overview of RB/FB SASSI2000 SSI Model



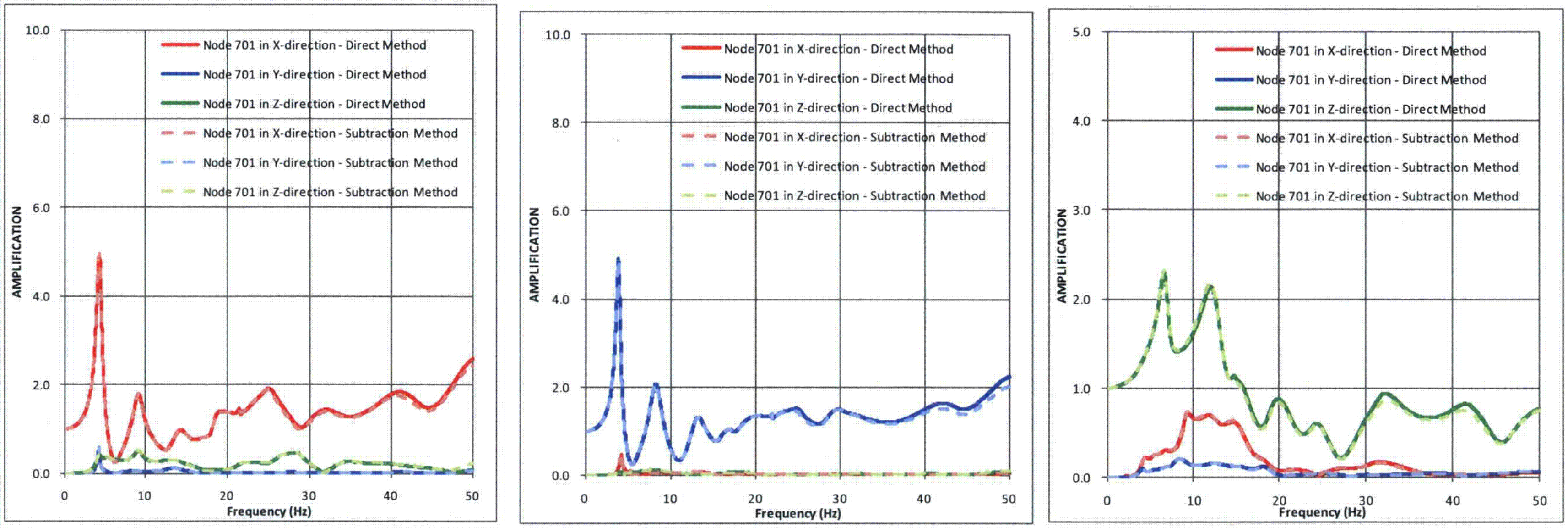
(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-1a Transfer functions – RB/FB Refueling Floor at Best Estimate Subsurface Profile



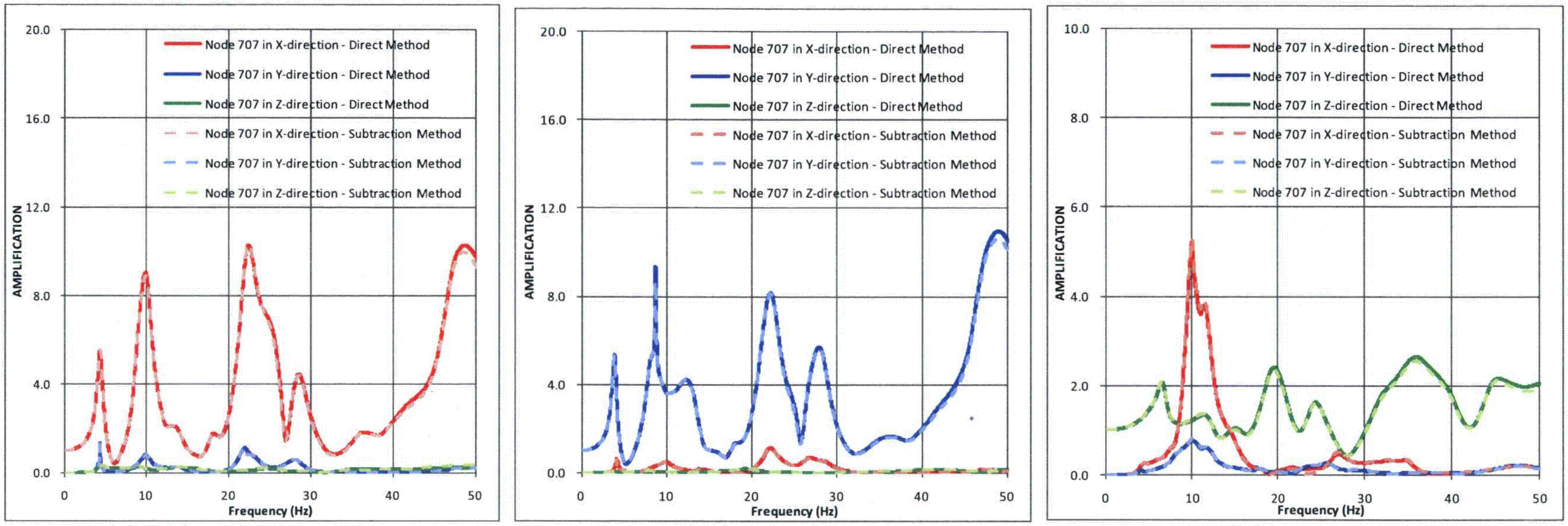
(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-1b Transfer functions – RCCV Top Slab at Best Estimate Subsurface Profile



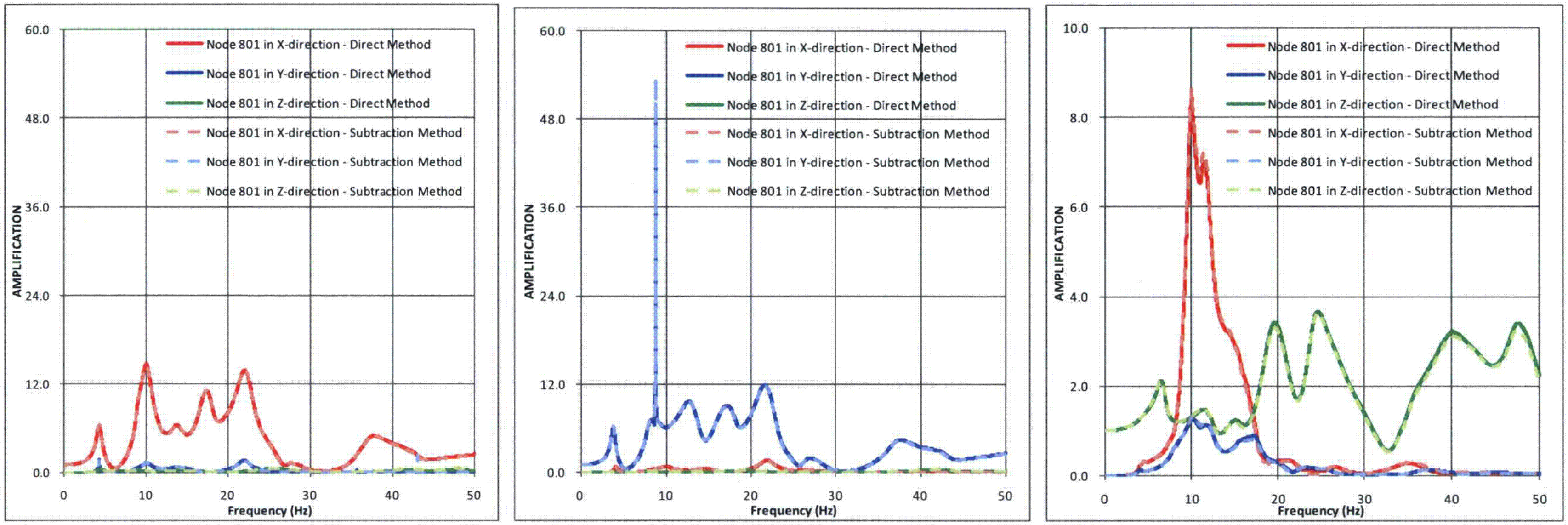
(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-1c Transfer functions – Vent Wall Top at Best Estimate Subsurface Profile



(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-1d Transfer functions – RSW Top at Best Estimate Subsurface Profile



(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-1e Transfer functions – RPV Top at Best Estimate Subsurface Profile

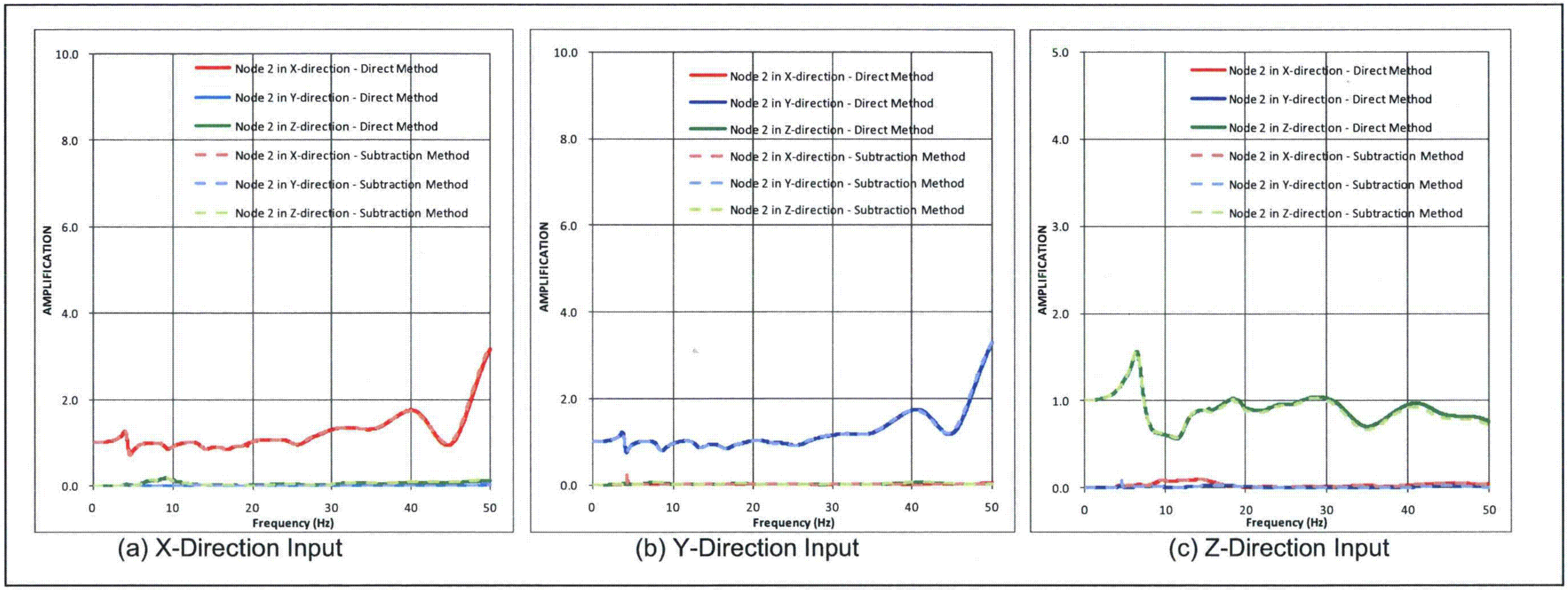
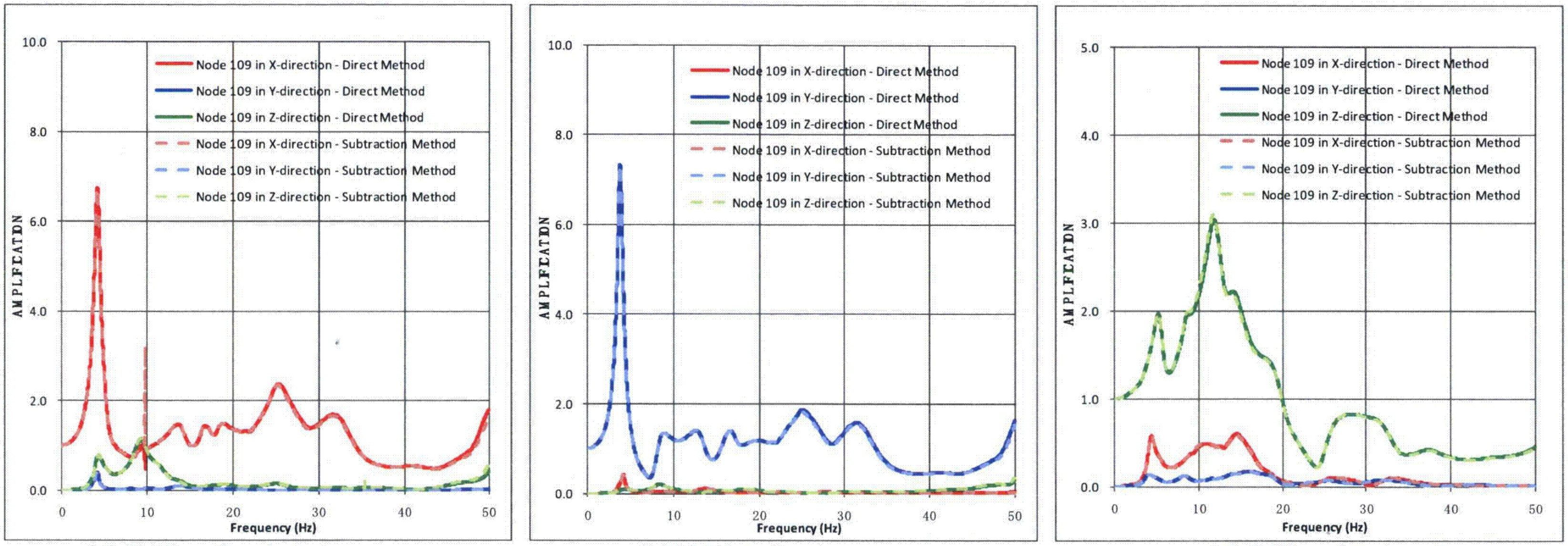
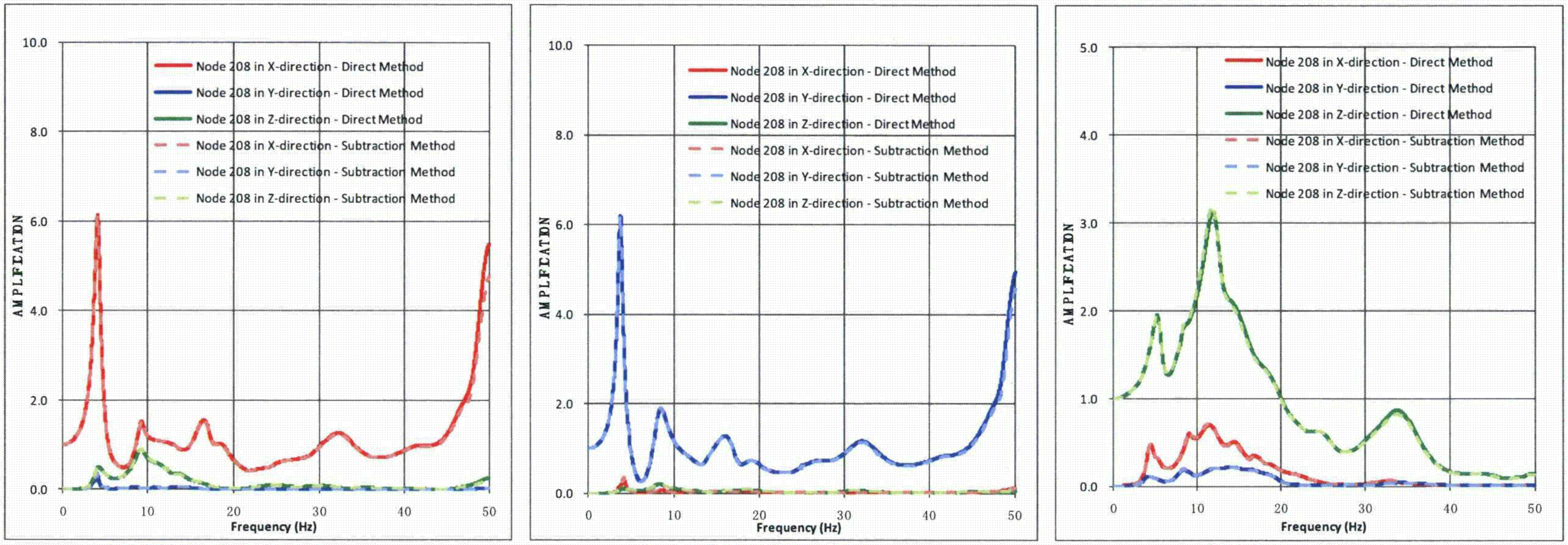


Figure 1.1-1f Transfer functions – RB/FB Basemat at Best Estimate Subsurface Profile



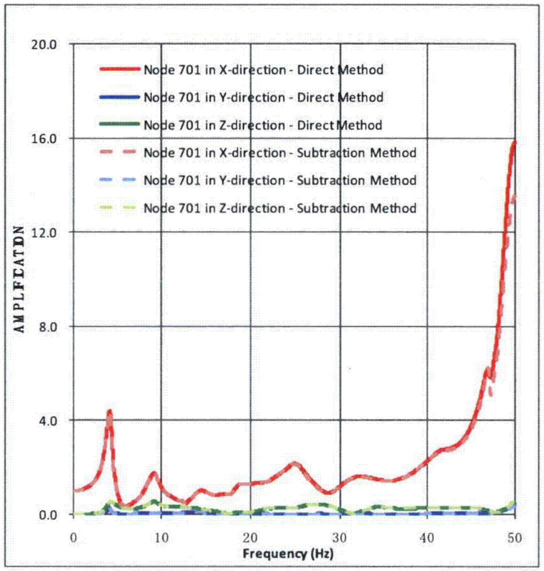
(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-2a Transfer functions – RB/FB Refueling Floor at Lower Bound Subsurface Profile

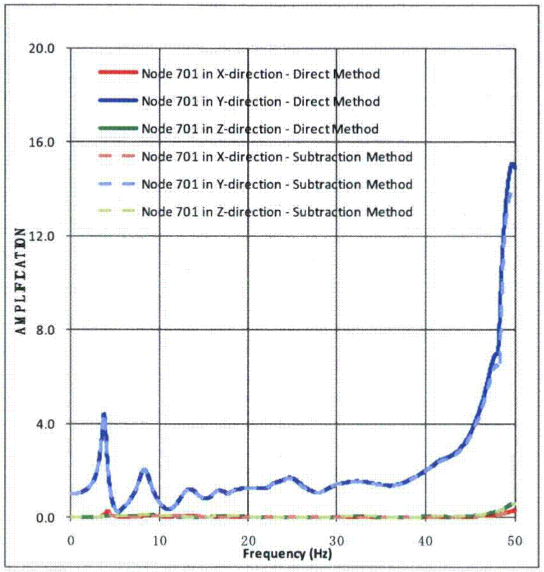


(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

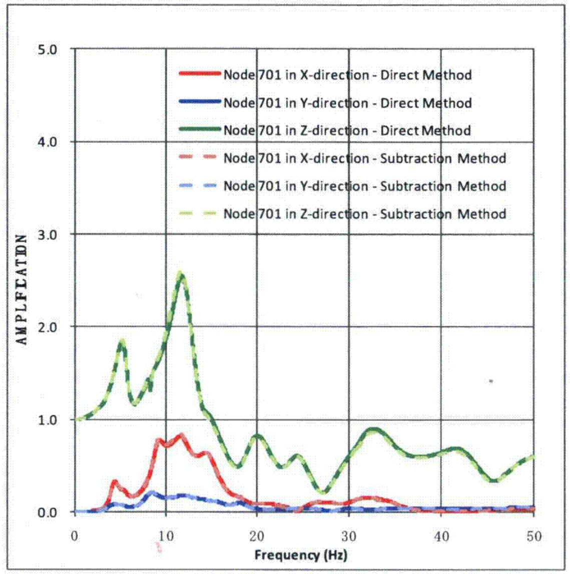
Figure 1.1-2b Transfer functions – RCCV Top Slab at Lower Bound Subsurface Profile



(a) X-Direction Input

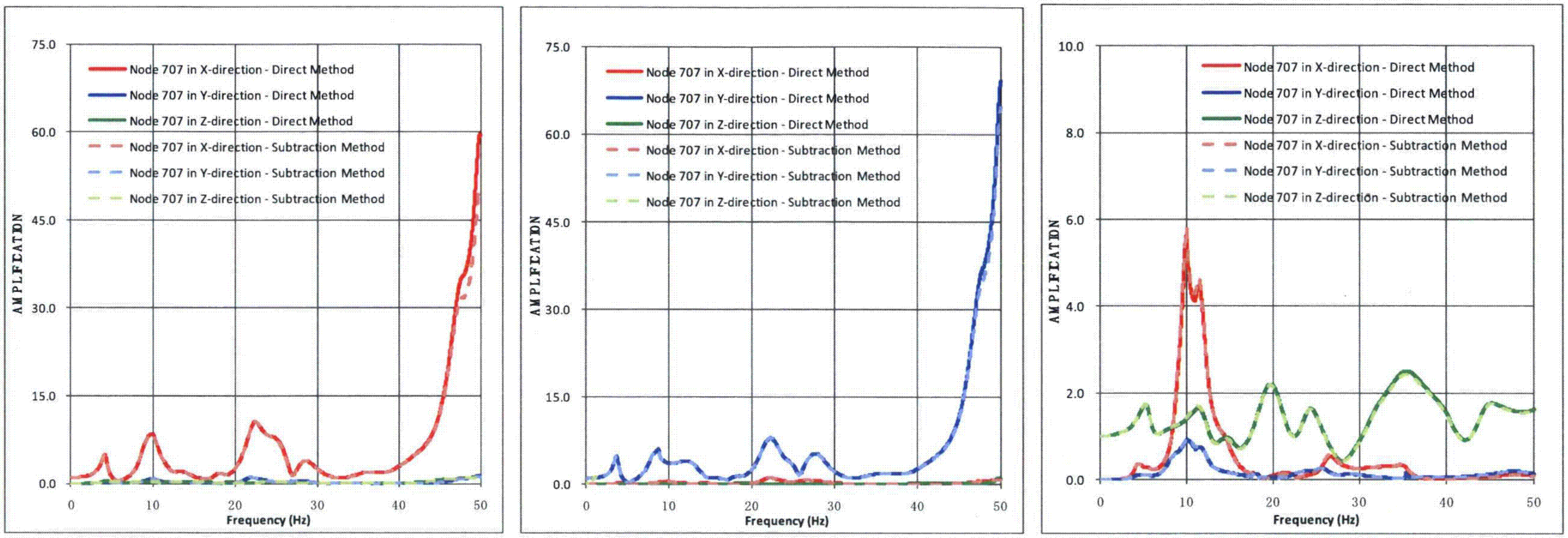


(b) Y-Direction Input



(c) Z-Direction Input

Figure 1.1-2c Transfer functions – Vent Wall Top at Lower Bound Subsurface Profile



(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-2d Transfer functions – RSW Top at Lower Bound Subsurface Profile

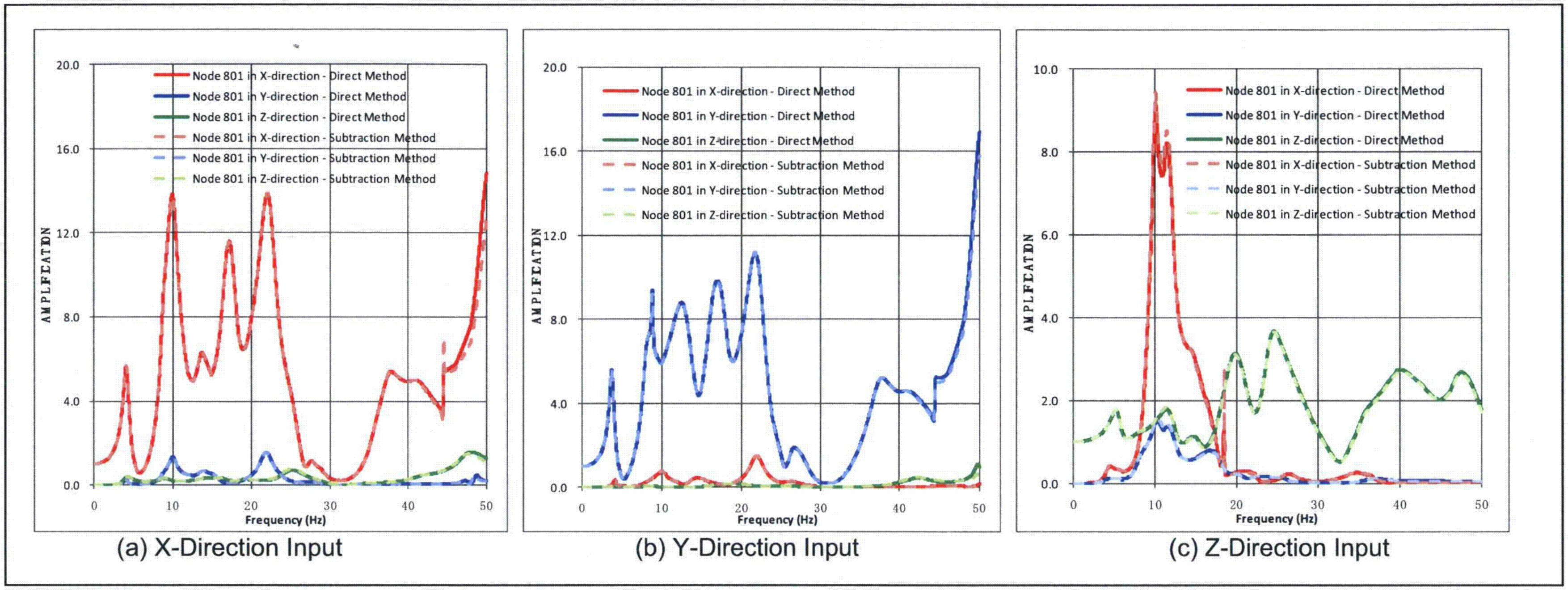


Figure 1.1-2e Transfer functions – RPV Top at Lower Bound Subsurface Profile

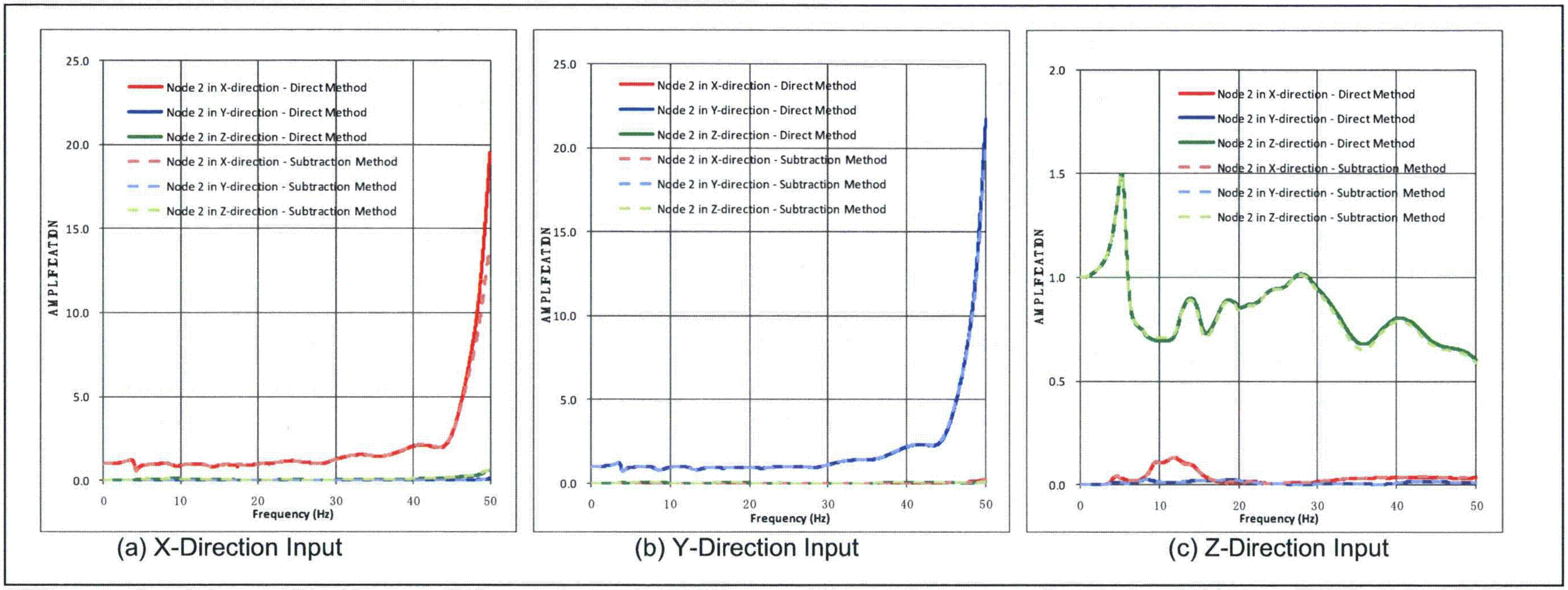
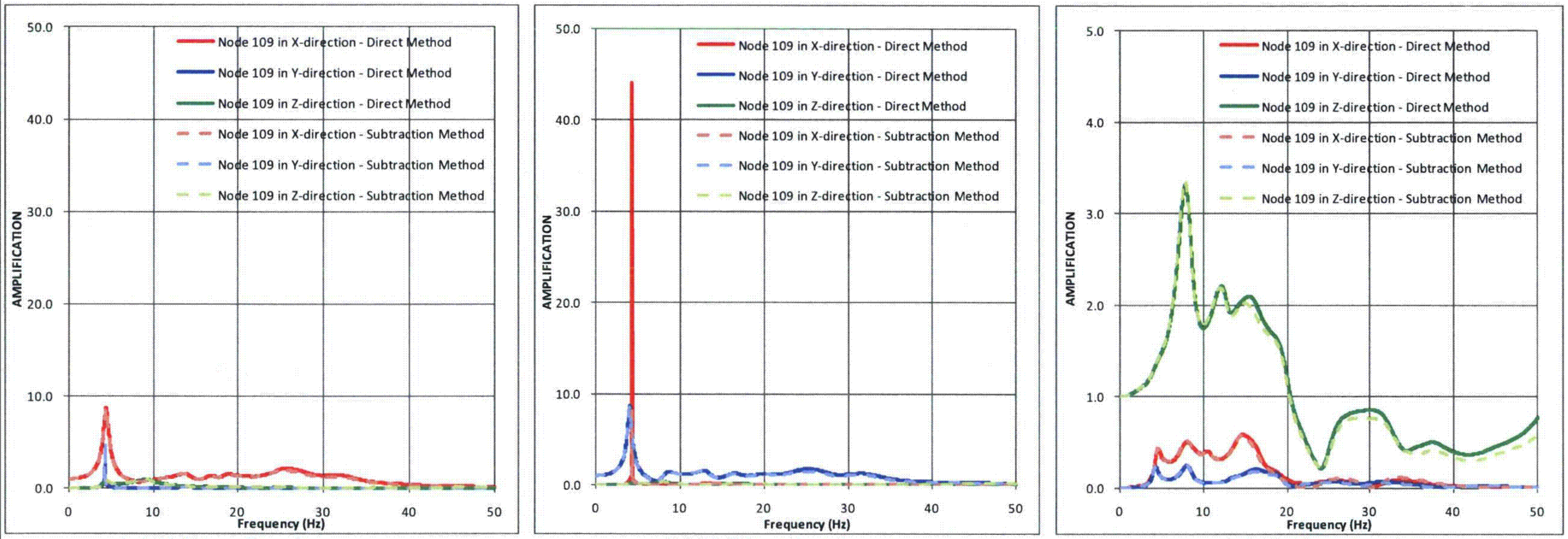


Figure 1.1-2f Transfer functions – RB/FB Basemat at Lower Bound Subsurface Profile



(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-3a Transfer functions – RB/FB Refueling Floor at Upper Bound Subsurface Profile

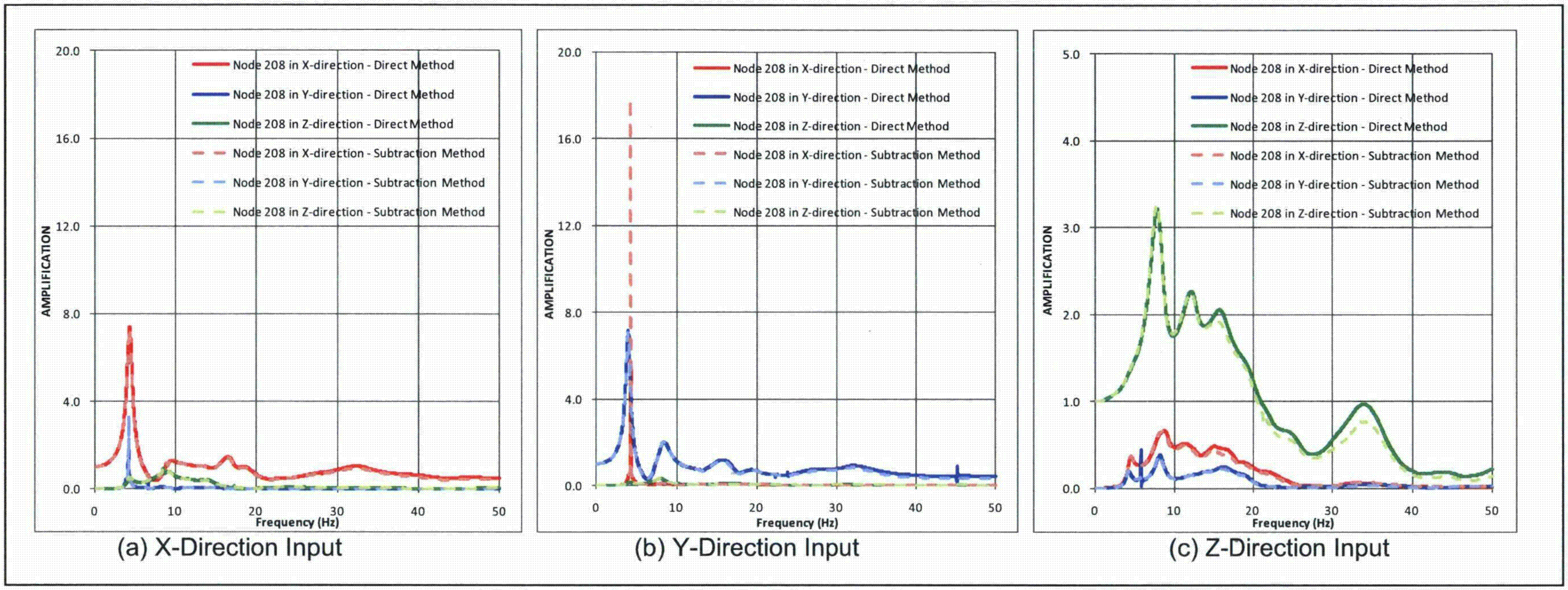
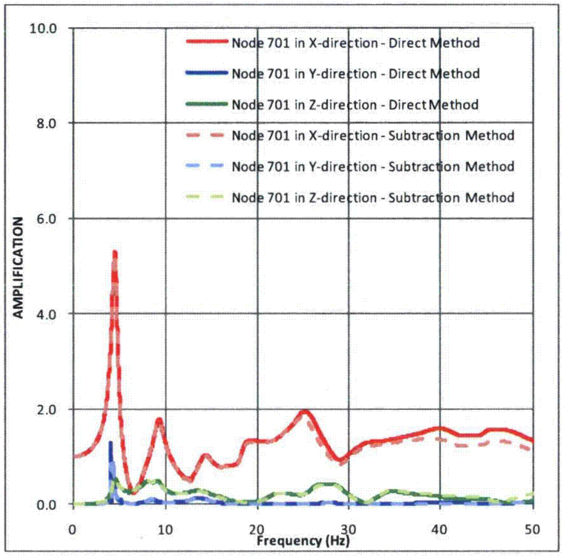
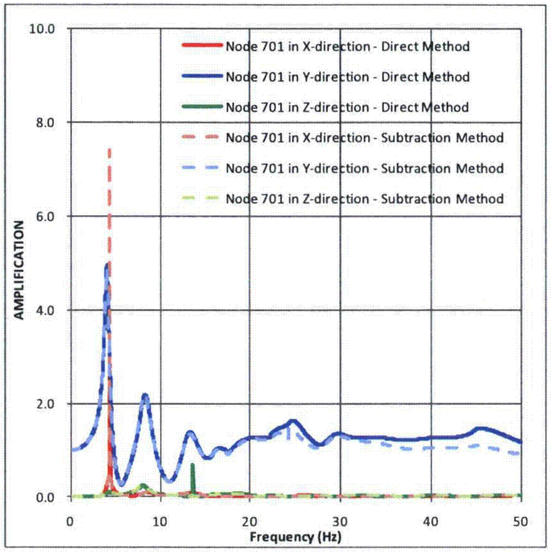


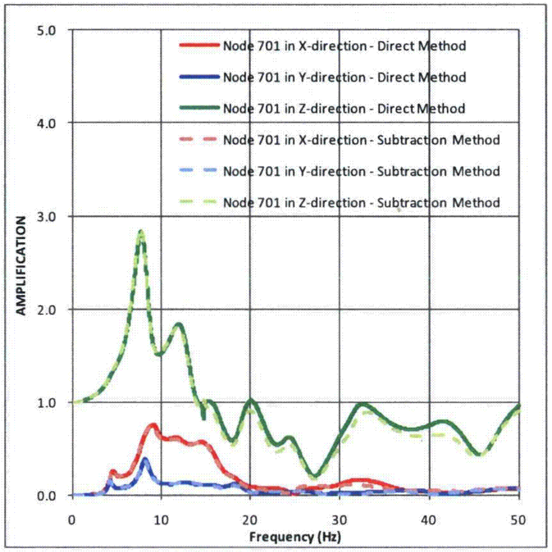
Figure 1.1-3b Transfer functions – RCCV Top Slab at Upper Bound Subsurface Profile



(a) X-Direction Input

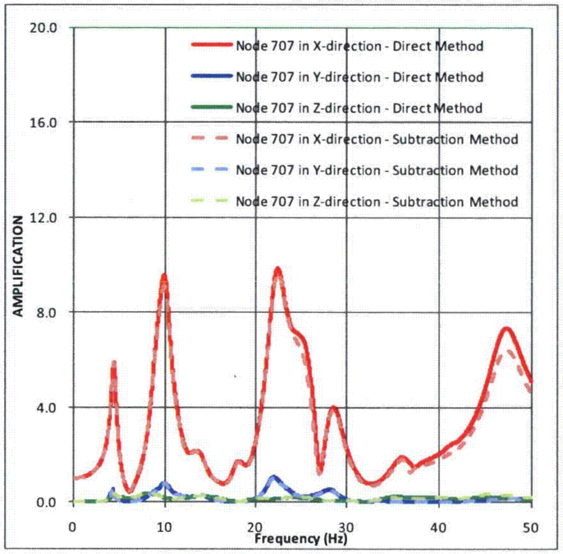


(b) Y-Direction Input

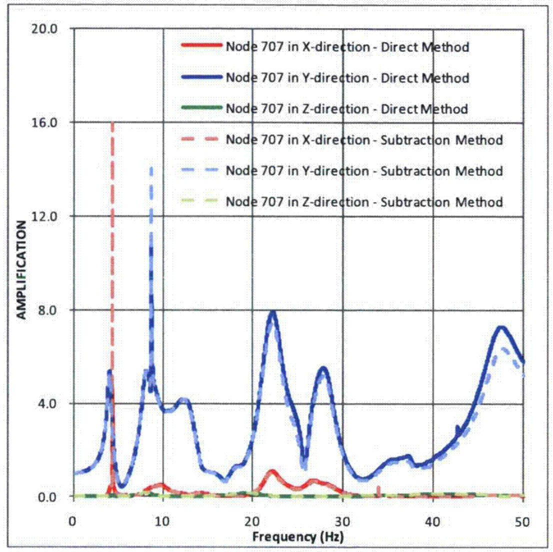


(c) Z-Direction Input

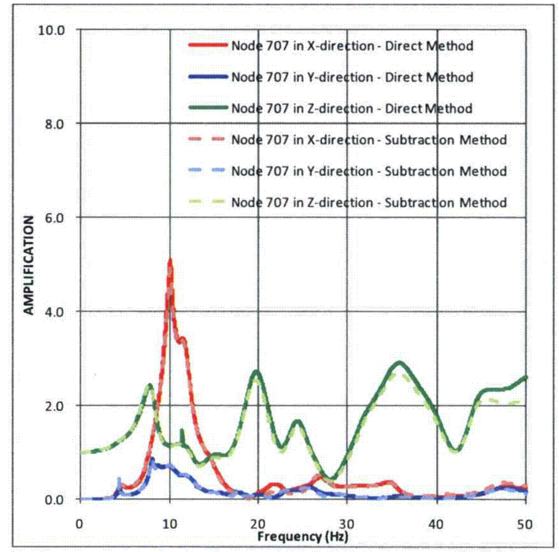
Figure 1.1-3c Transfer functions – Vent Wall Top at Upper Bound Subsurface Profile



(a) X-Direction Input

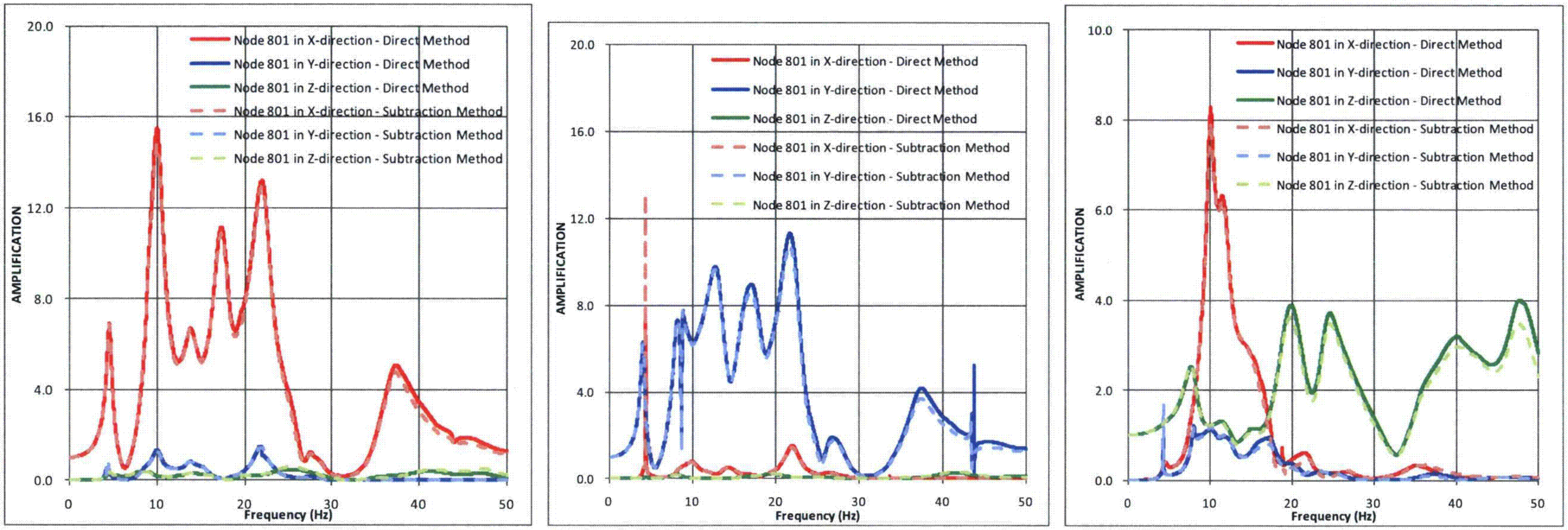


(b) Y-Direction Input



(c) Z-Direction Input

Figure 1.1-3d Transfer functions – RSW Top at Upper Bound Subsurface Profile



(a) X-Direction Input (b) Y-Direction Input (c) Z-Direction Input

Figure 1.1-3e Transfer functions – RPV Top at Upper Bound Subsurface Profile

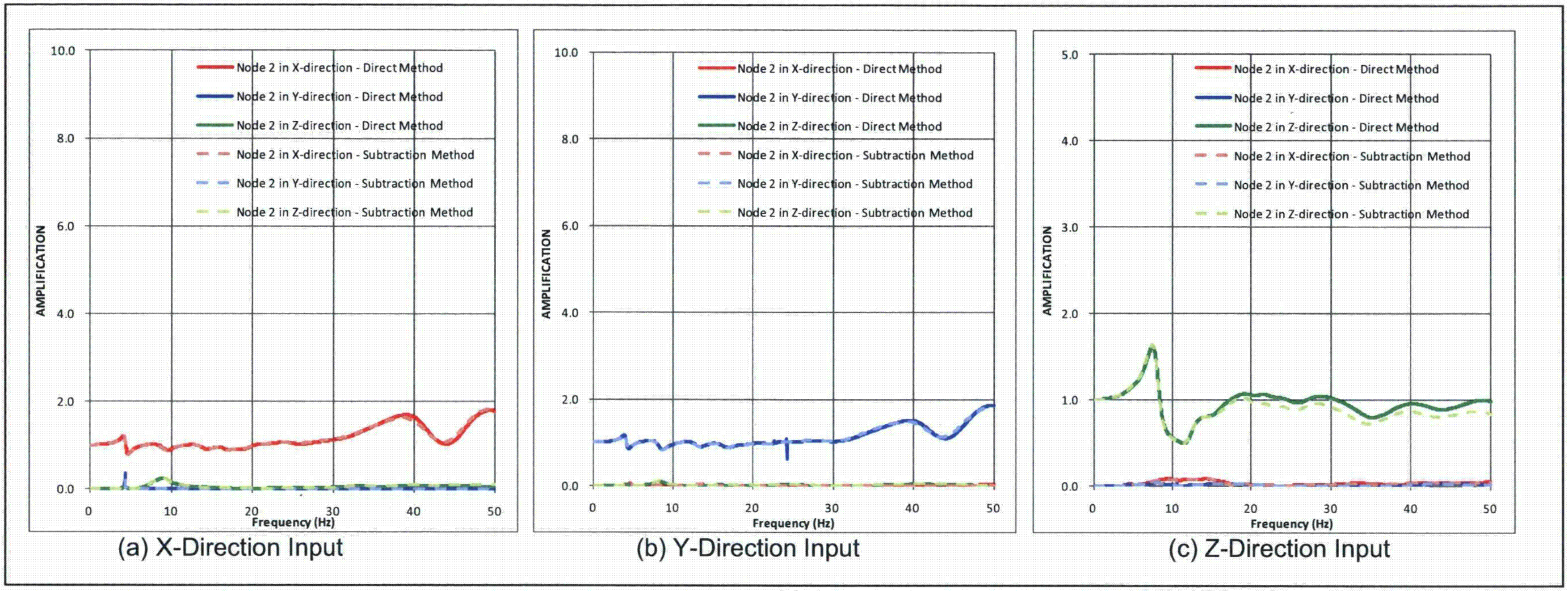


Figure 1.1-3f Transfer functions – RB/FB Basemat at Upper Bound Subsurface Profile

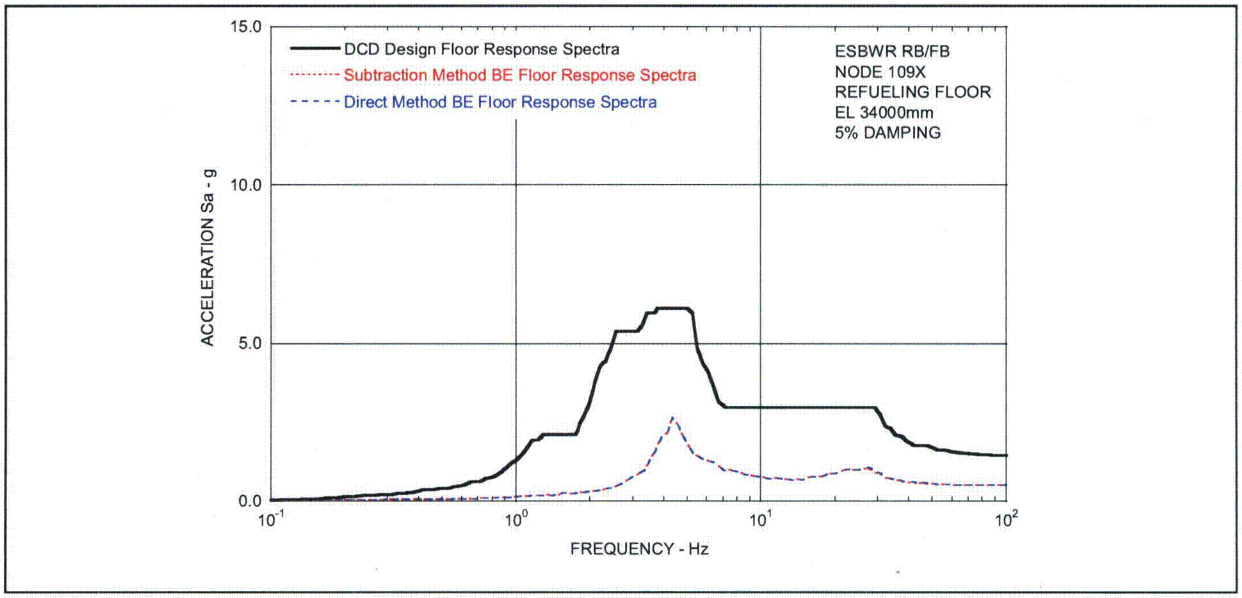


Figure 1.2-1a Floor Response Spectra Best Estimate – RB/FB Refueling Floor in X-Direction

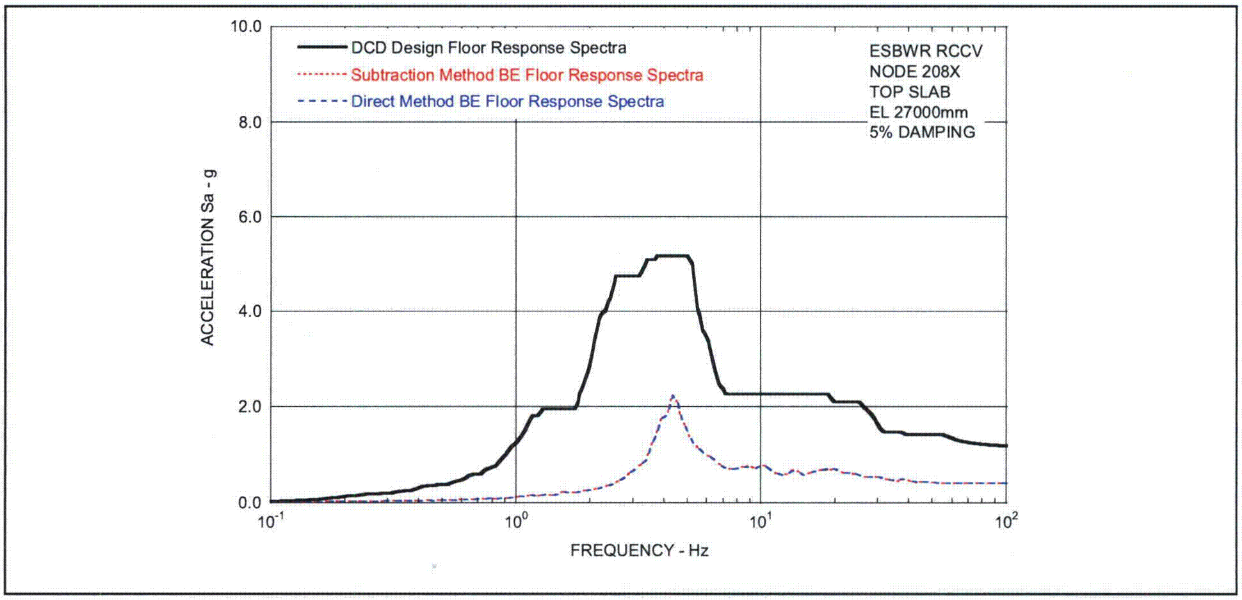


Figure 1.2-1b Floor Response Spectra Best Estimate – RCCV Top Slab in X-Direction

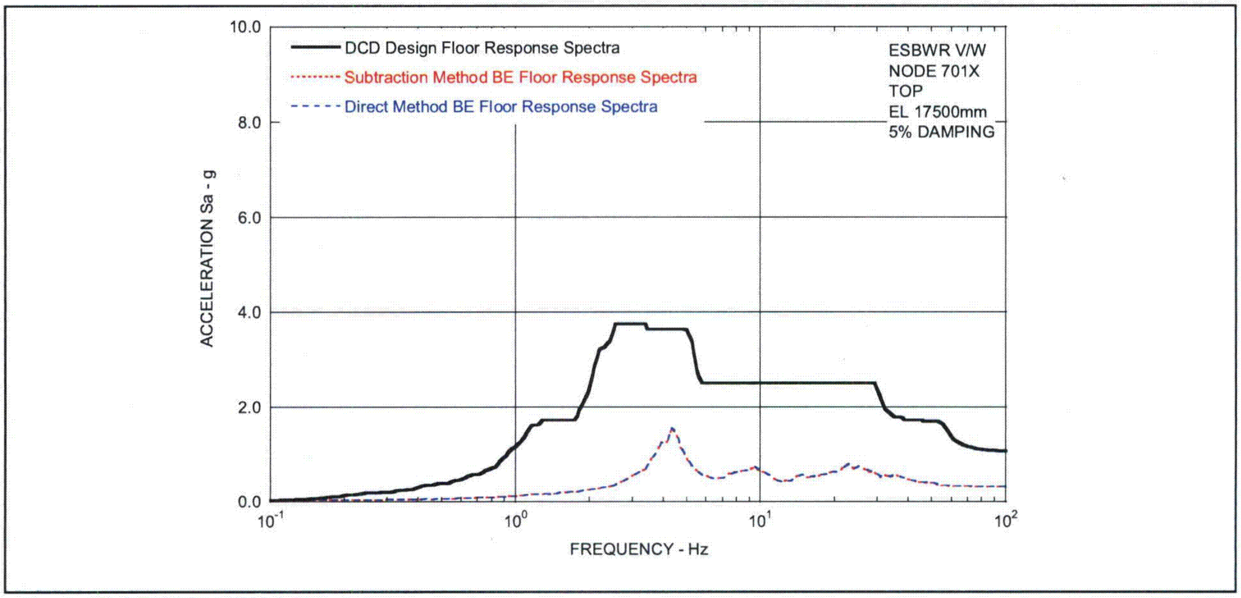


Figure 1.2-1c Floor Response Spectra Best Estimate – Vent Wall Top in X-Direction

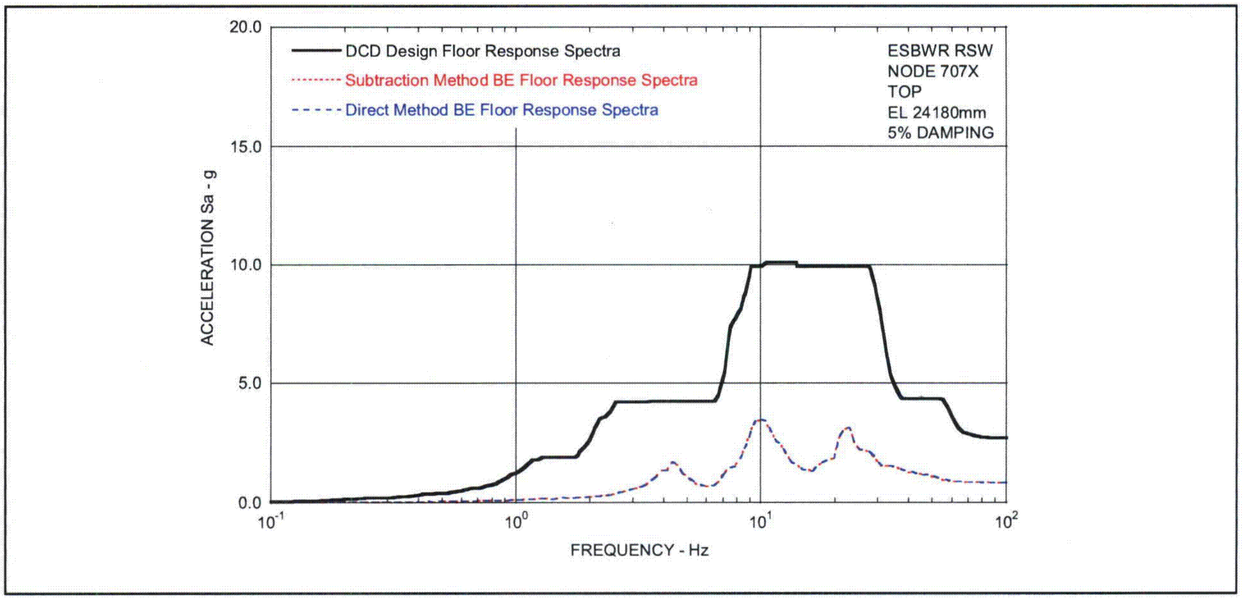


Figure 1.2-1d Floor Response Spectra Best Estimate – RSW Top in X-Direction

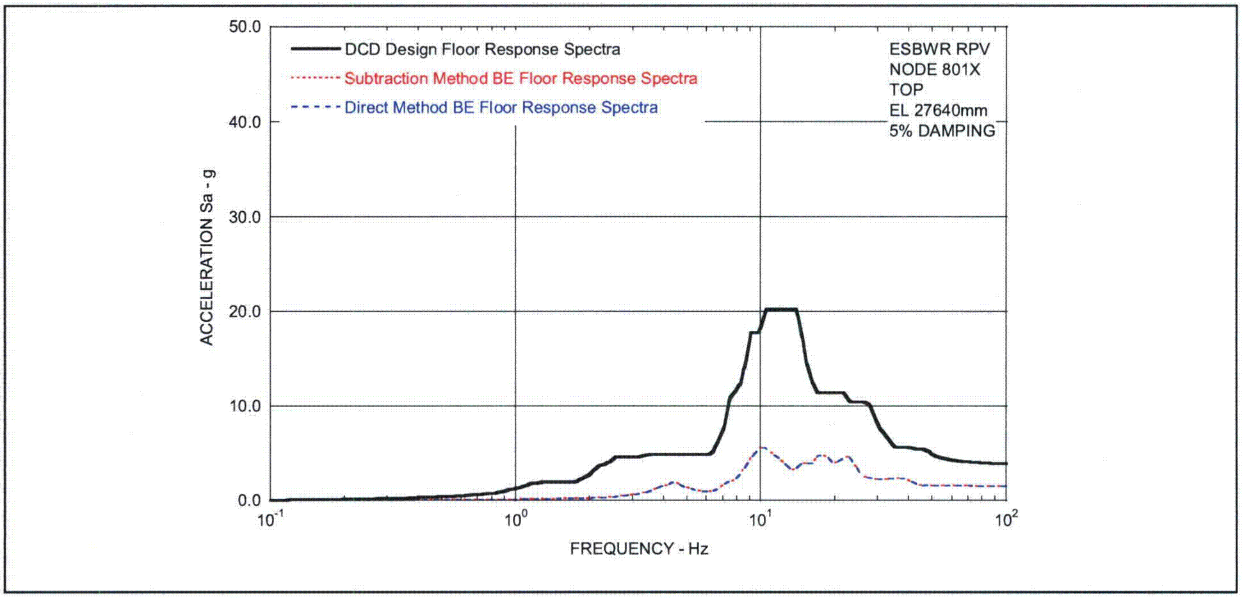


Figure 1.2-1e Floor Response Spectra Best Estimate – RPV Top in X-Direction

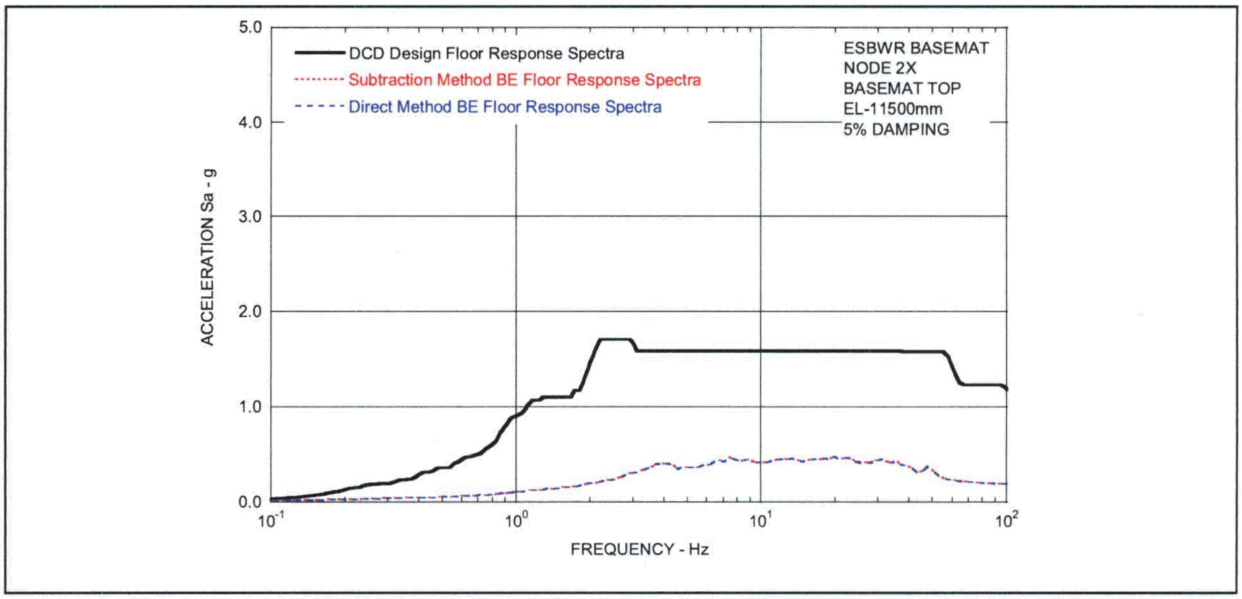


Figure 1.2-1f Floor Response Spectra Best Estimate – RB/FB Basemat in X-Direction

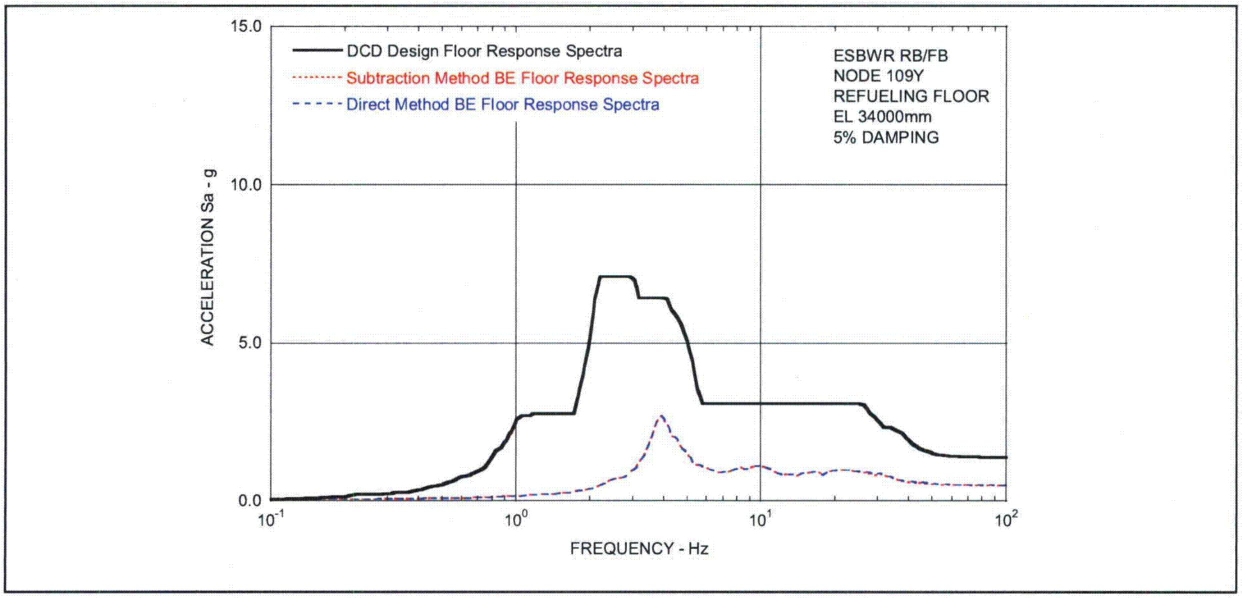


Figure 1.2-2a Floor Response Spectra Best Estimate – RB/FB Refueling Floor in Y-Direction

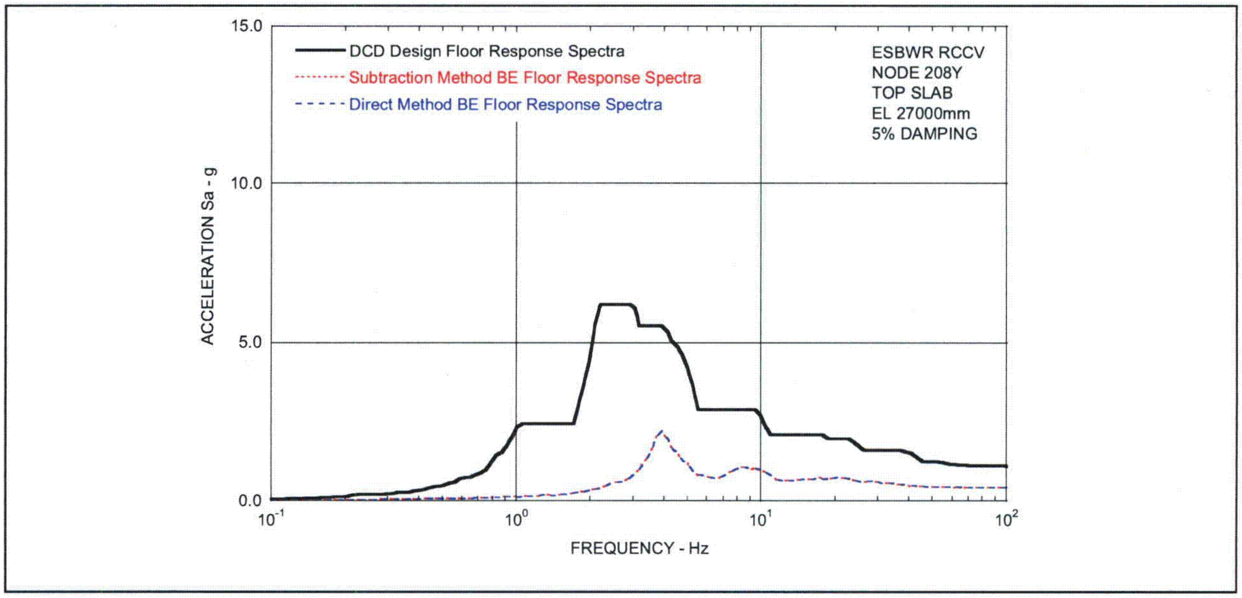


Figure 1.2-2b Floor Response Spectra Best Estimate – RCCV Top Slab in Y-Direction

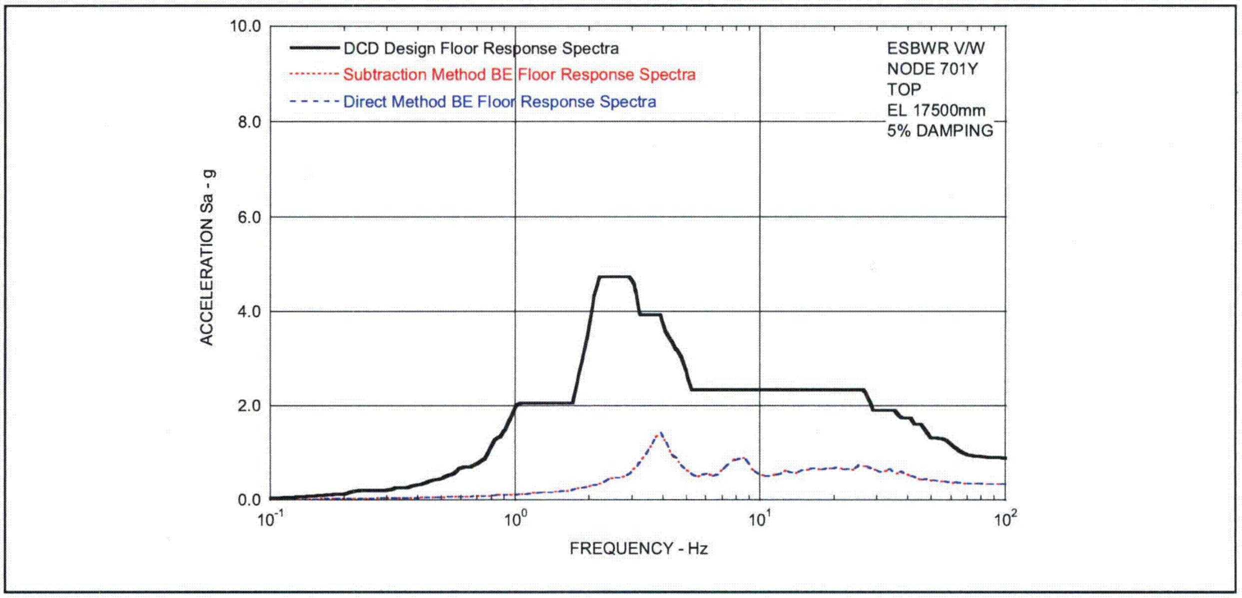


Figure 1.2-2c Floor Response Spectra Best Estimate – Vent Wall Top in Y-Direction

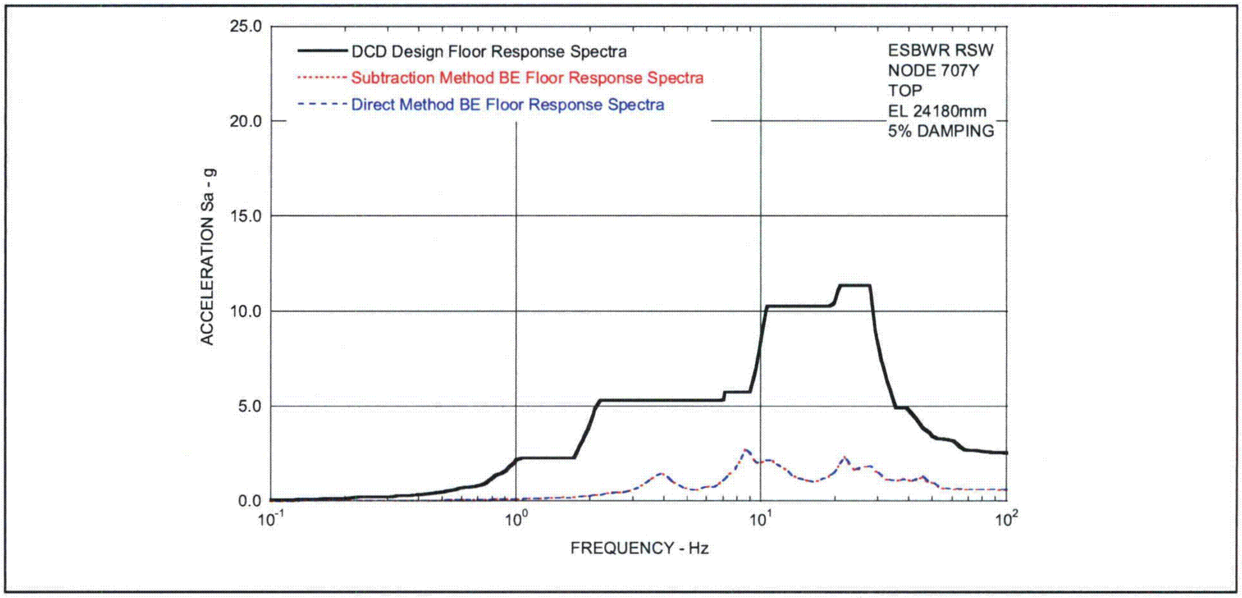


Figure 1.2-2d Floor Response Spectra Best Estimate – RSW Top in Y-Direction

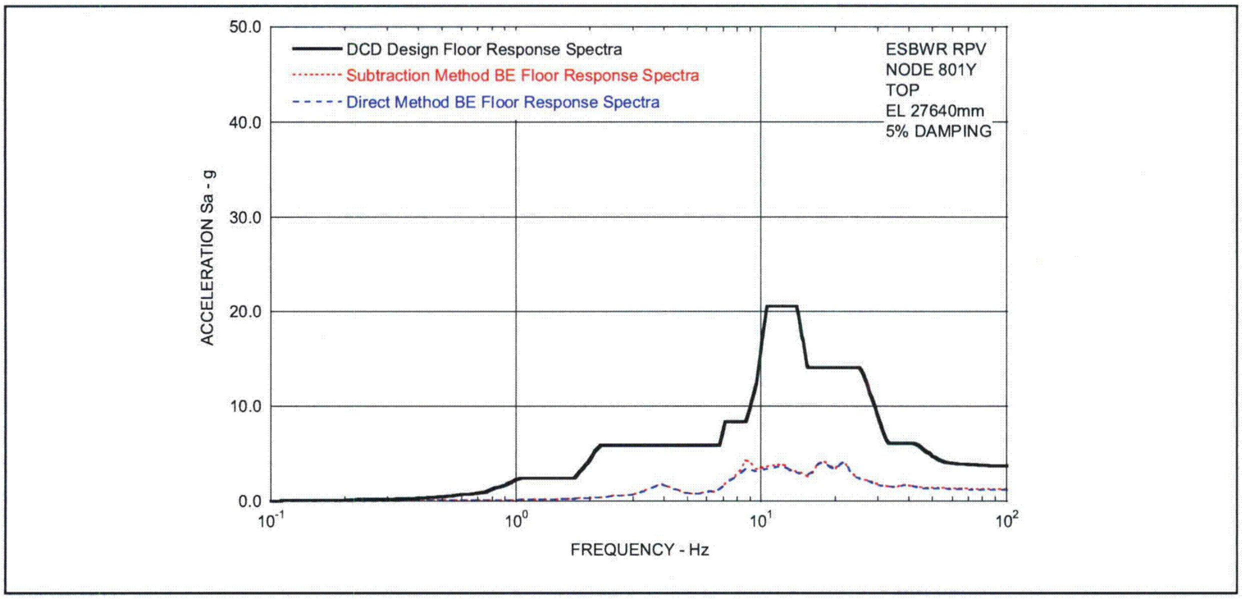


Figure 1.2-2e Floor Response Spectra Best Estimate – RPV Top in Y-Direction

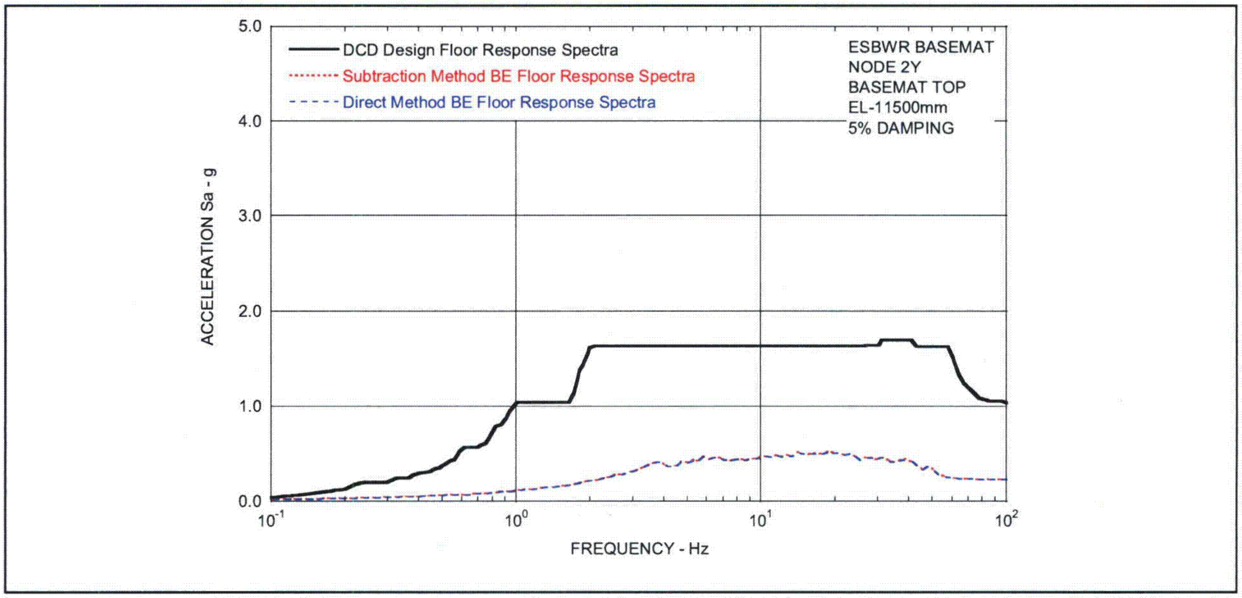


Figure 1.2-2f Floor Response Spectra Best Estimate – RB/FB Basemat in Y-Direction

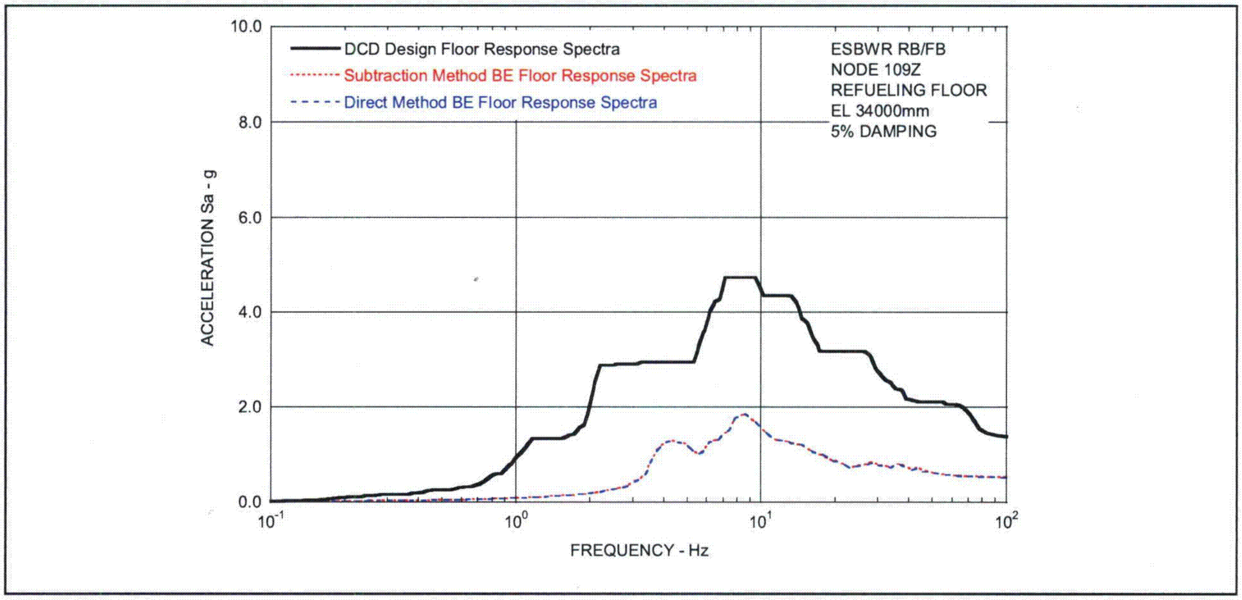


Figure 1.2-3a Floor Response Spectra Best Estimate – RB/FB Refueling Floor in Z-Direction

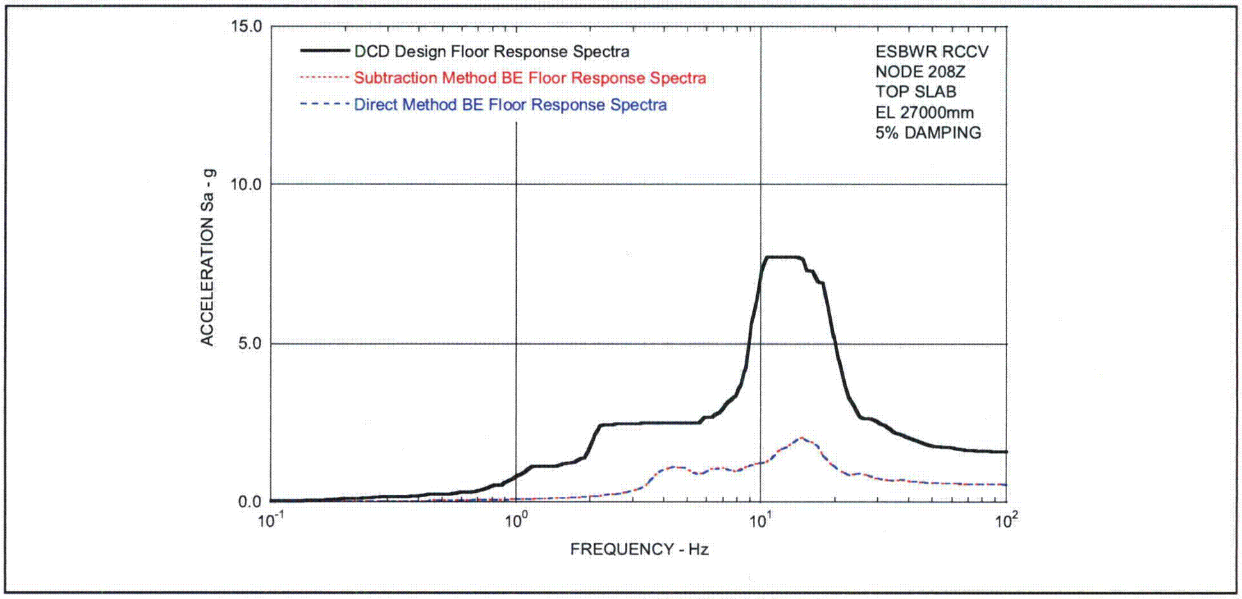


Figure 1.2-3b Floor Response Spectra Best Estimate – RCCV Top Slab in Z-Direction

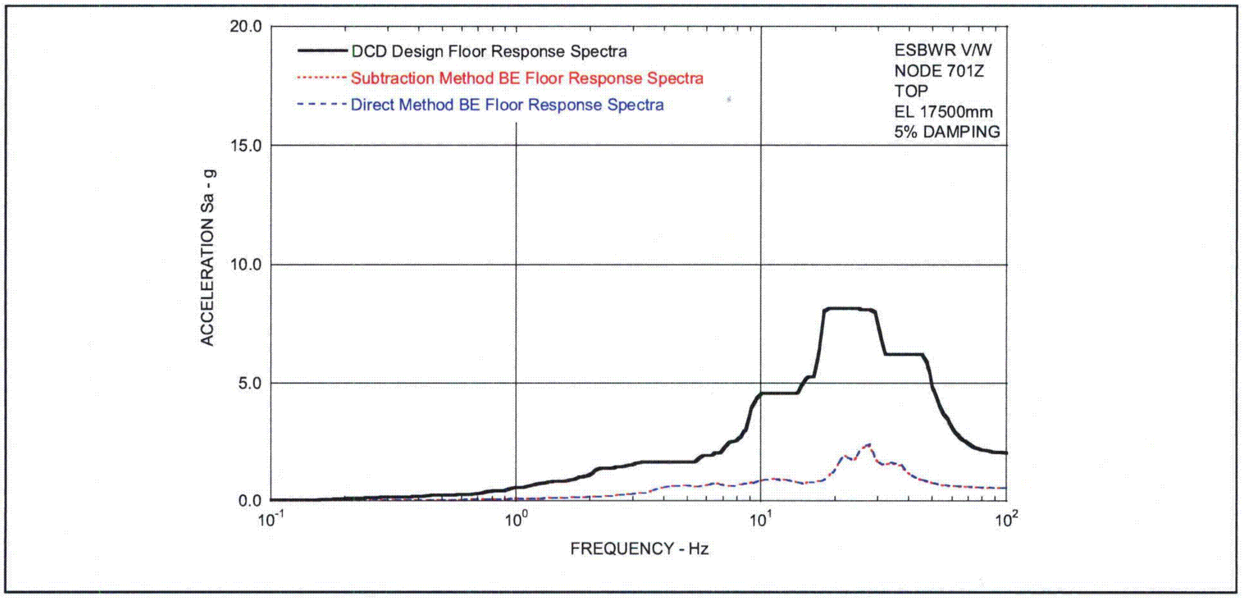


Figure 1.2-3c Floor Response Spectra Best Estimate – Vent Wall Top in Z-Direction

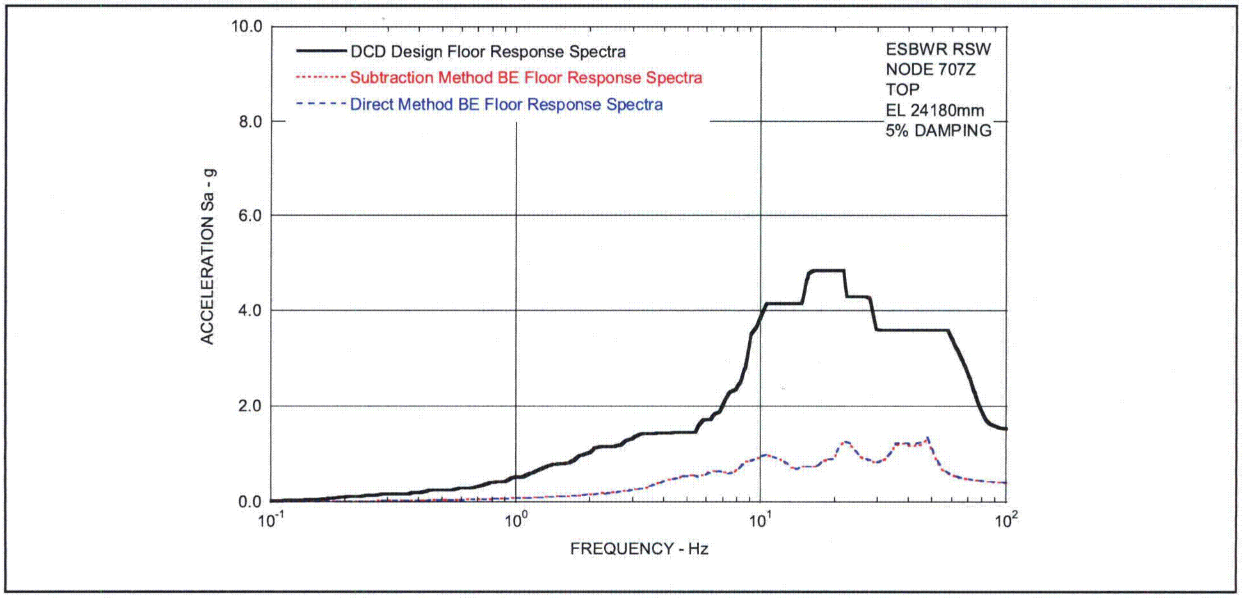


Figure 1.2-3d Floor Response Spectra Best Estimate – RSW Top in Z-Direction

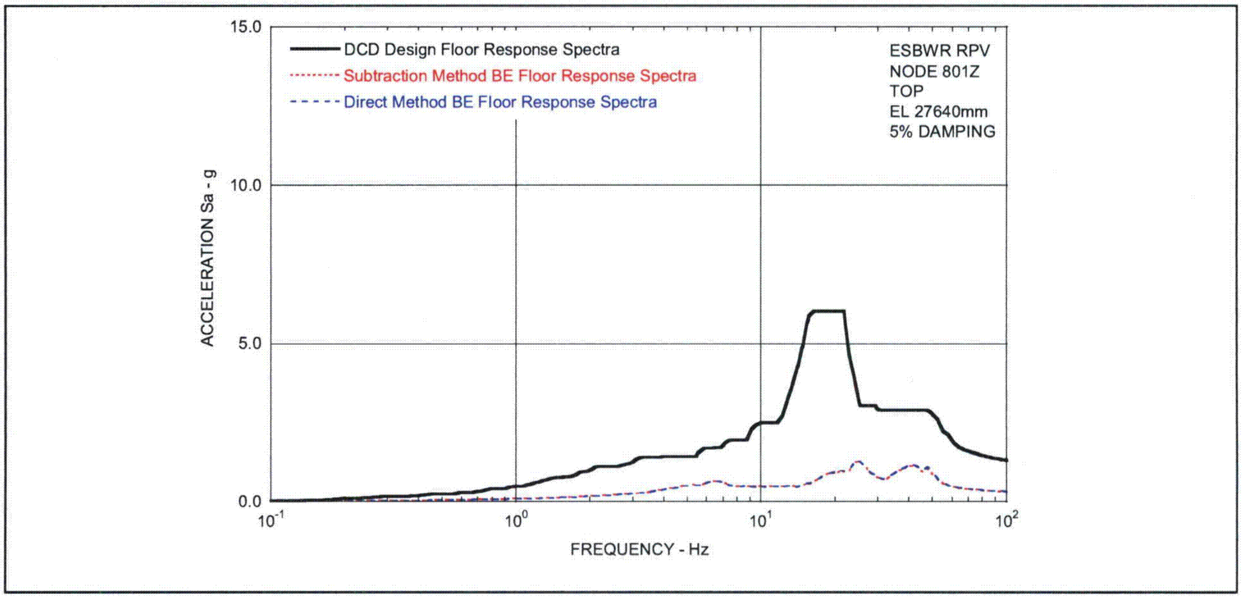


Figure 1.2-3e Floor Response Spectra Best Estimate – RPV Top in Z-Direction

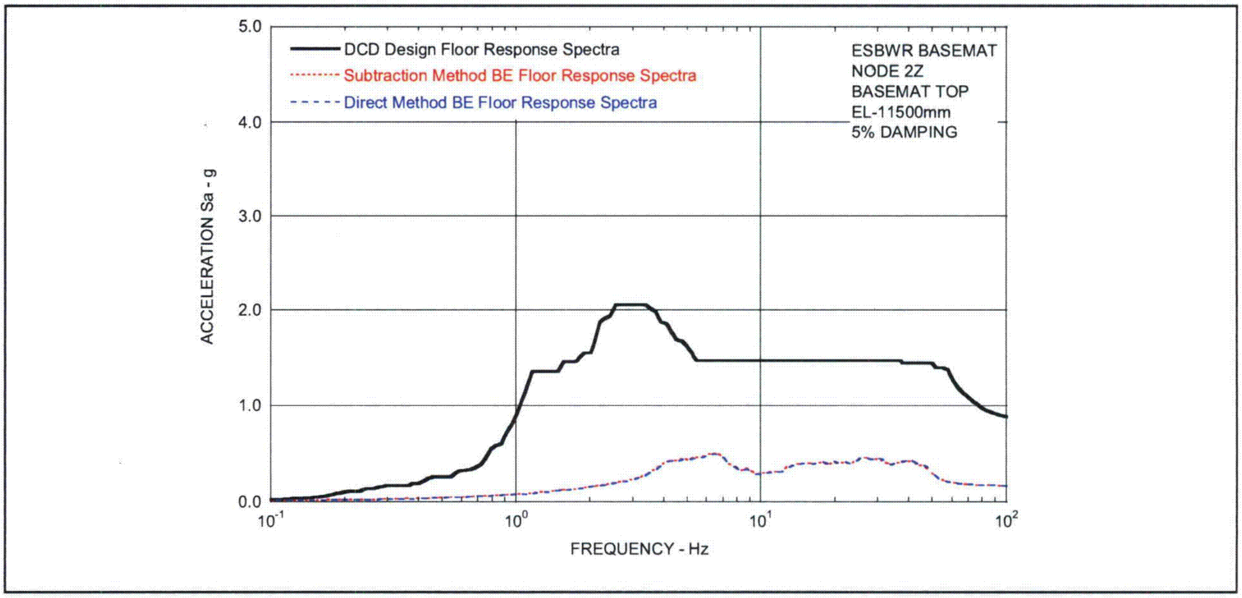


Figure 1.2-3f Floor Response Spectra Best Estimate – RB/FB Basemat in Z-Direction

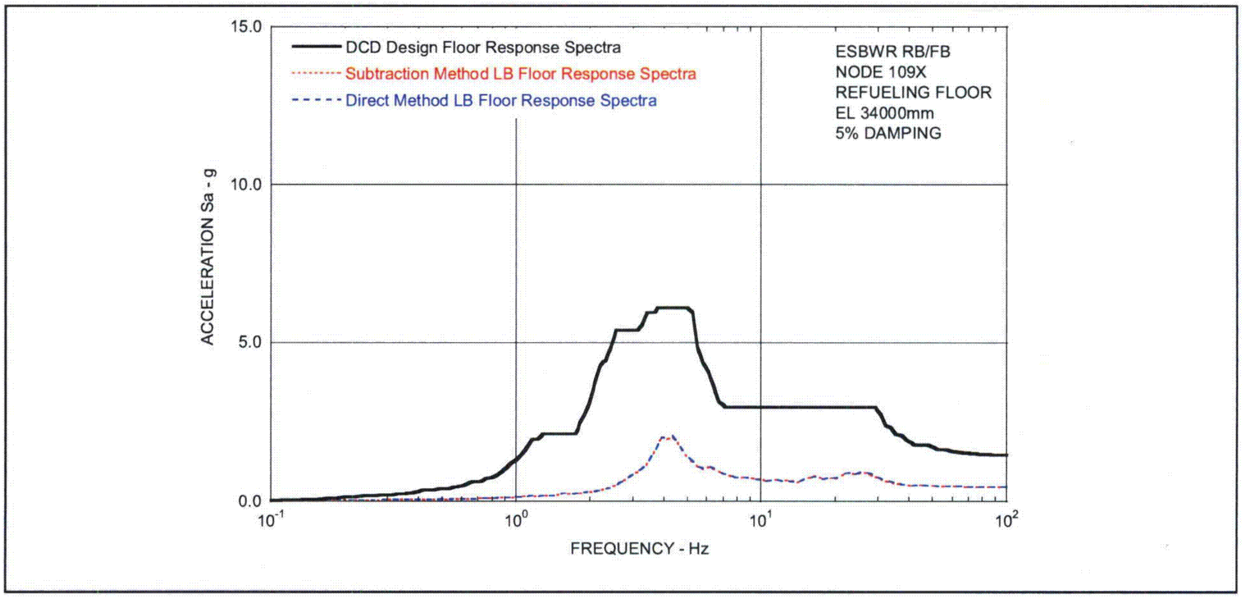


Figure 1.2-4a Floor Response Spectra Lower Bound – RB/FB Refueling Floor in X-Direction

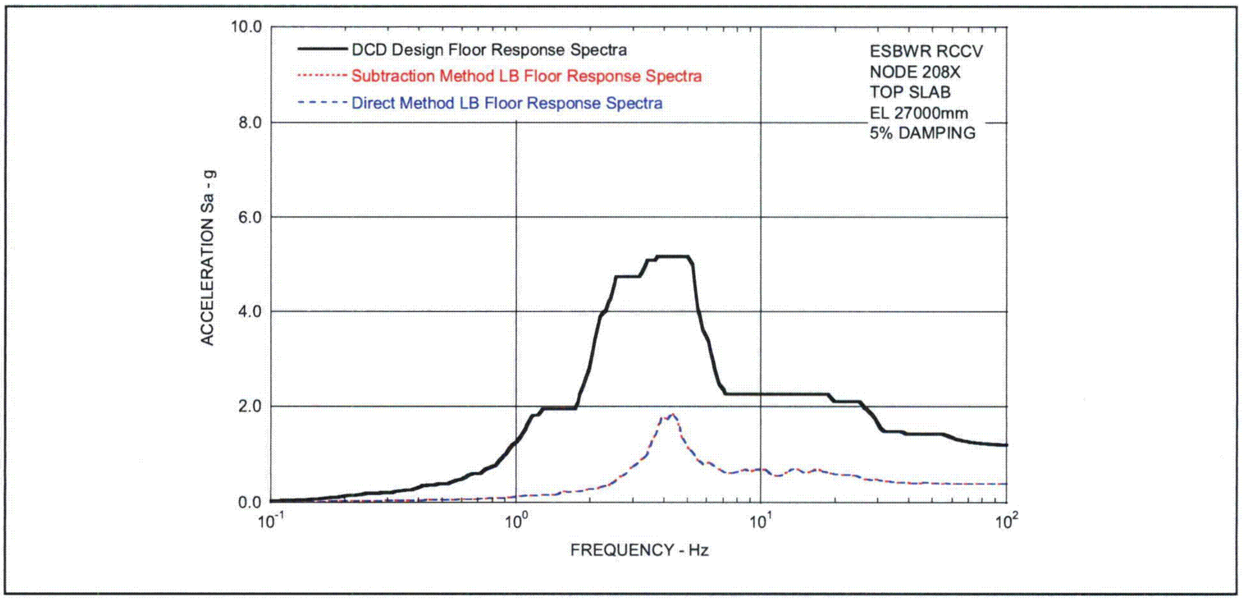


Figure 1.2-4b Floor Response Spectra Lower Bound – RCCV Top Slab in X-Direction

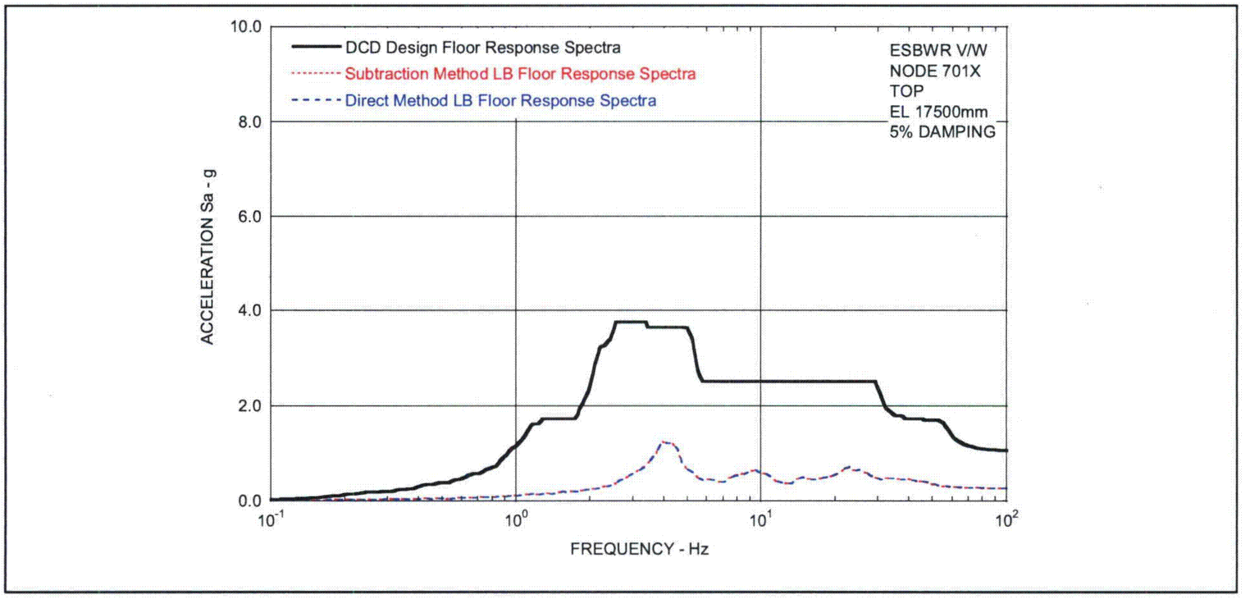


Figure 1.2-4c Floor Response Spectra Lower Bound – Vent Wall Top in X-Direction

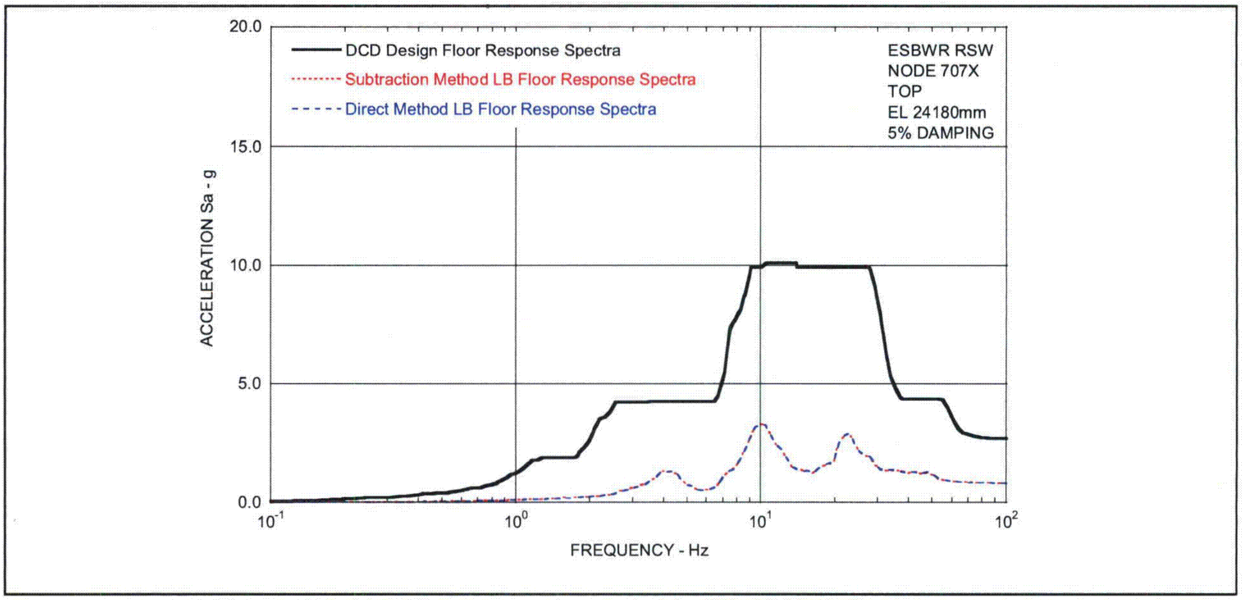


Figure 1.2-4d Floor Response Spectra Lower Bound – RSW Top in X-Direction

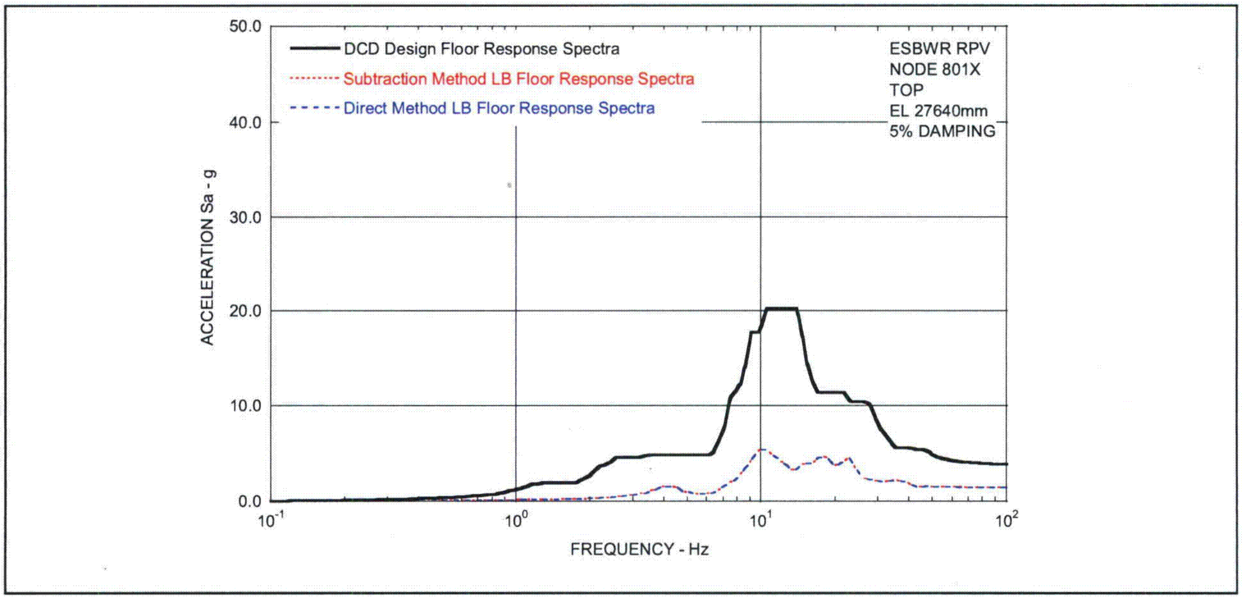


Figure 1.2-4e Floor Response Spectra Lower Bound – RPV Top in X-Direction

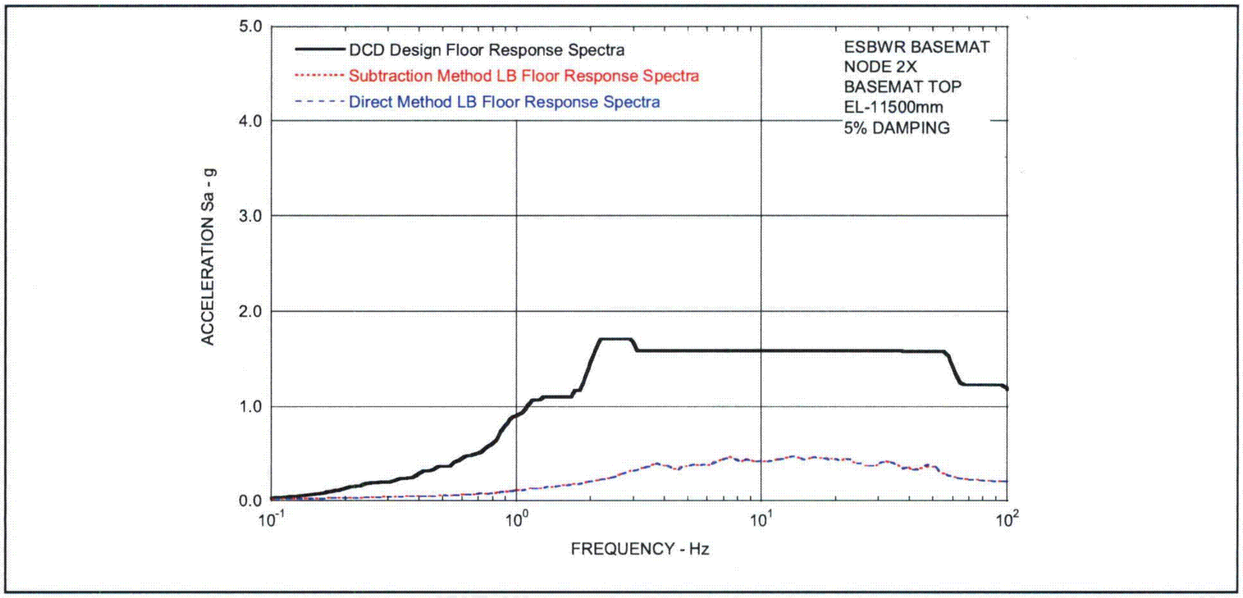


Figure 1.2-4f Floor Response Spectra Lower Bound – RB/FB Basemat in X-Direction

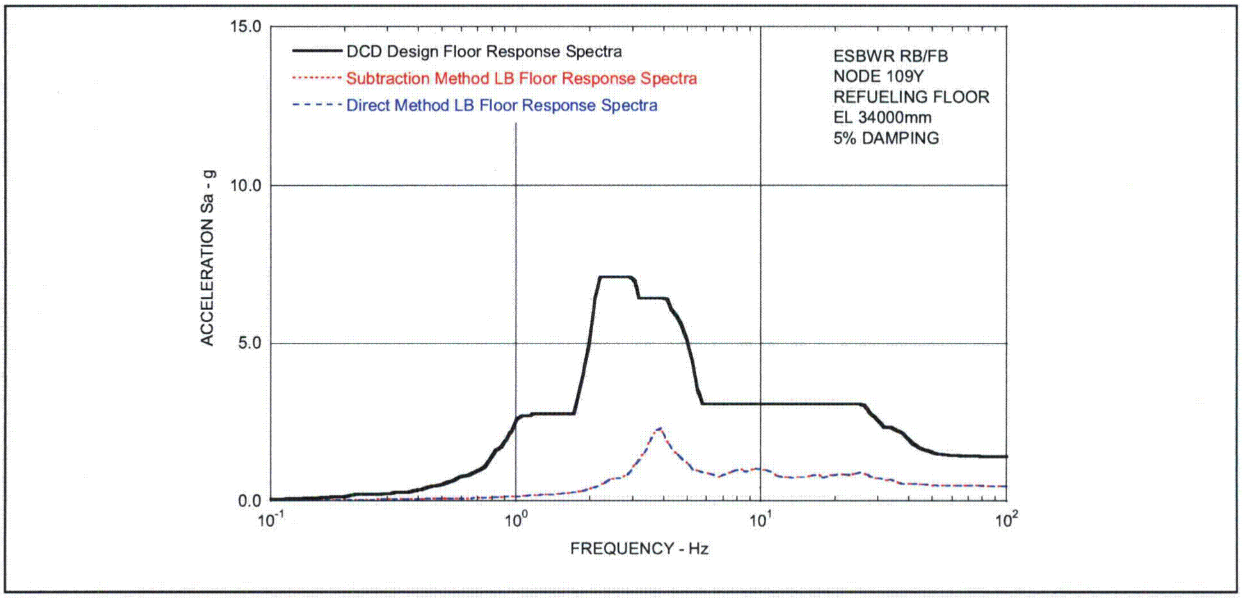


Figure 1.2-5a Floor Response Spectra Lower Bound – RB/FB Refueling Floor in Y-Direction

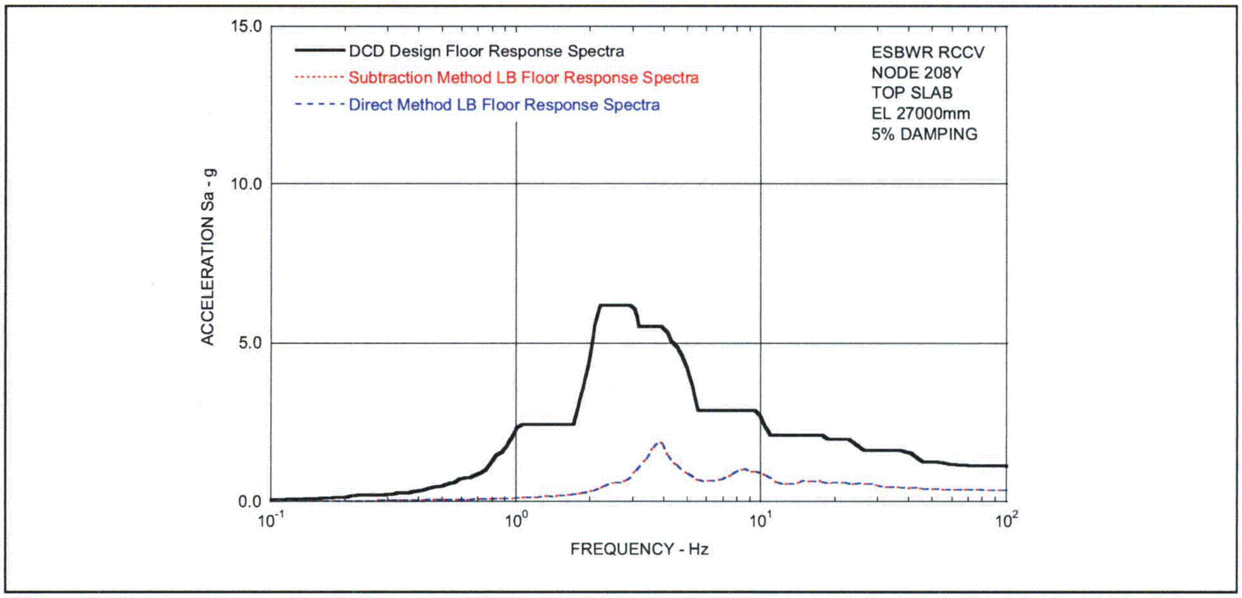


Figure 1.2-5b Floor Response Spectra Lower Bound – RCCV Top Slab in Y-Direction

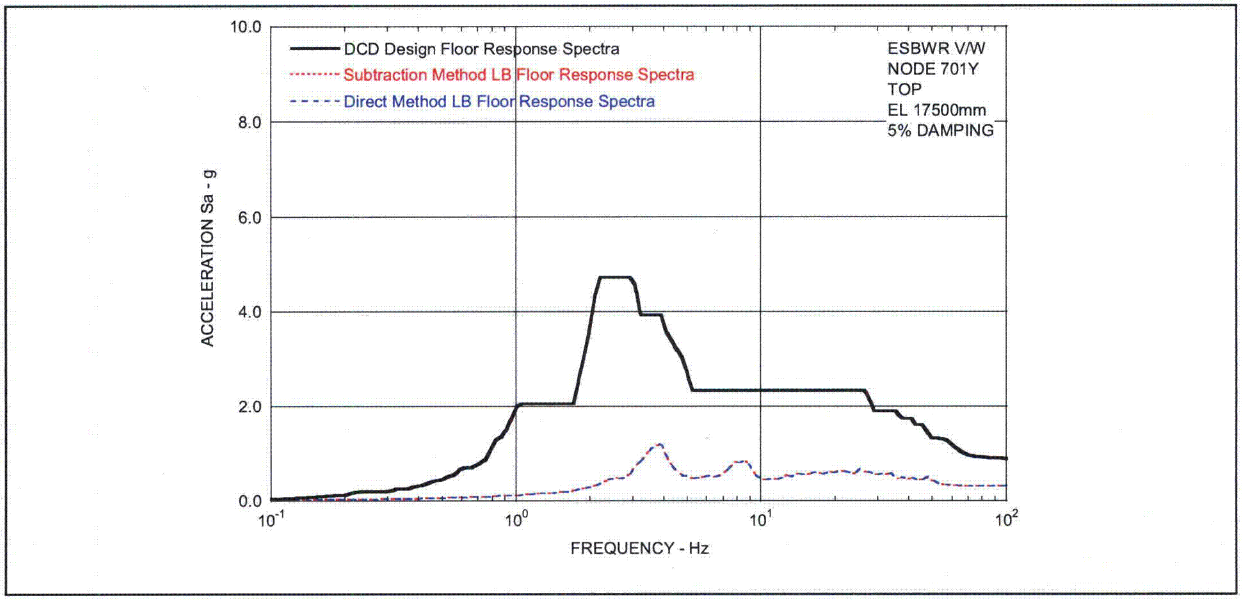


Figure 1.2-5c Floor Response Spectra Lower Bound – Vent Wall Top in Y-Direction

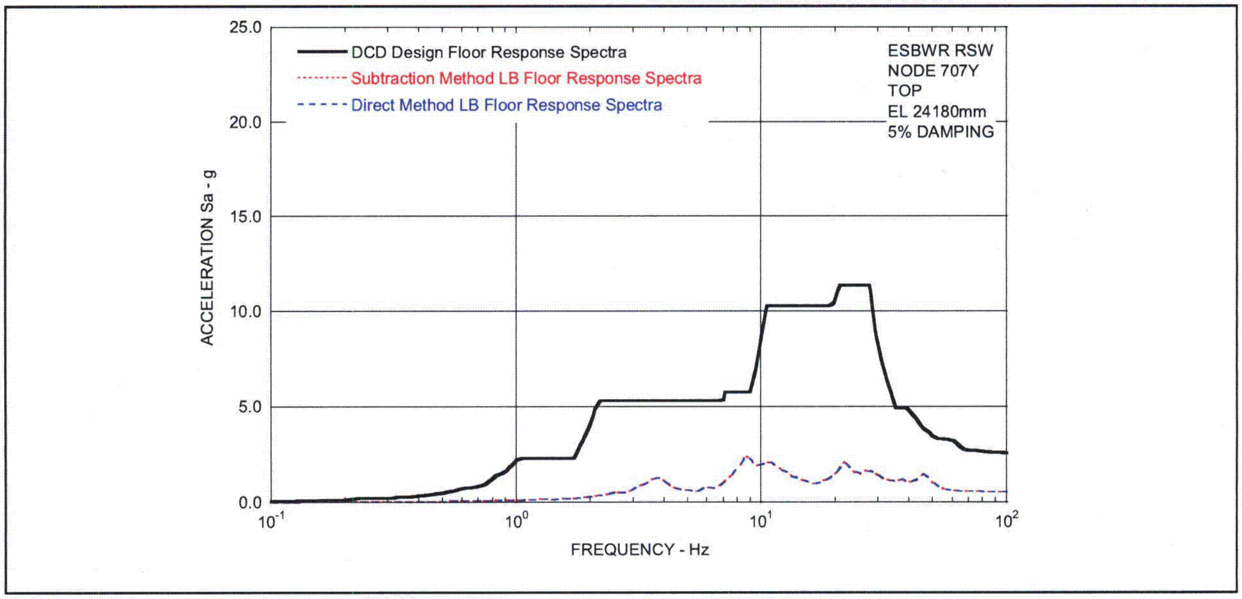


Figure 1.2-5d Floor Response Spectra Lower Bound – RSW Top in Y-Direction

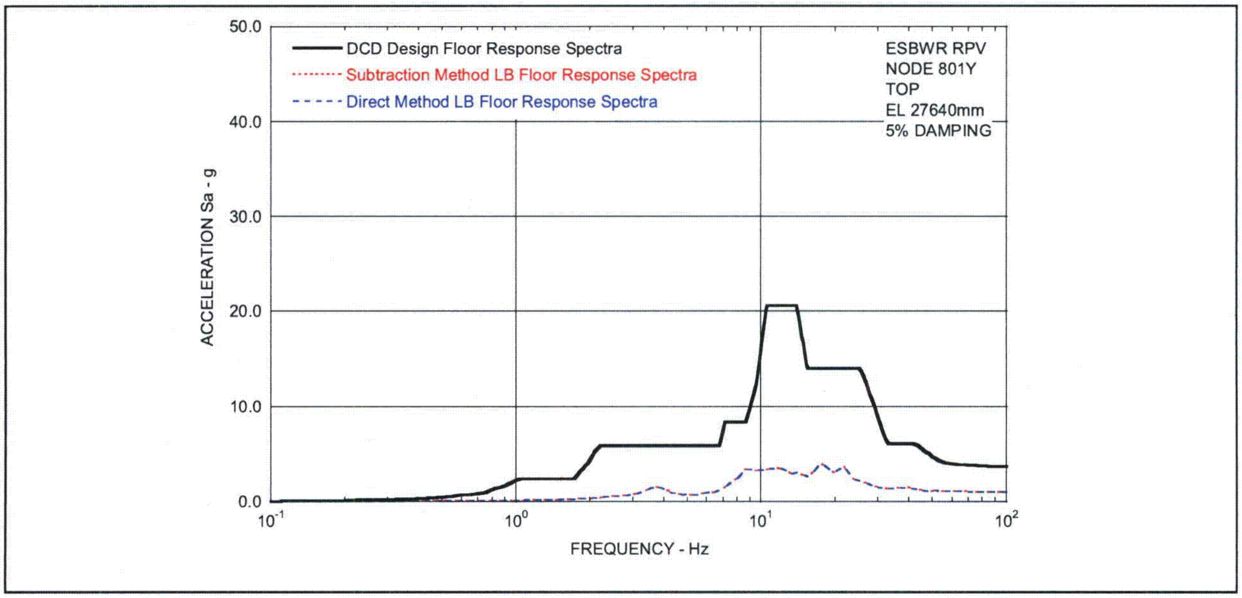


Figure 1.2-5e Floor Response Spectra Lower Bound – RPV Top in Y-Direction

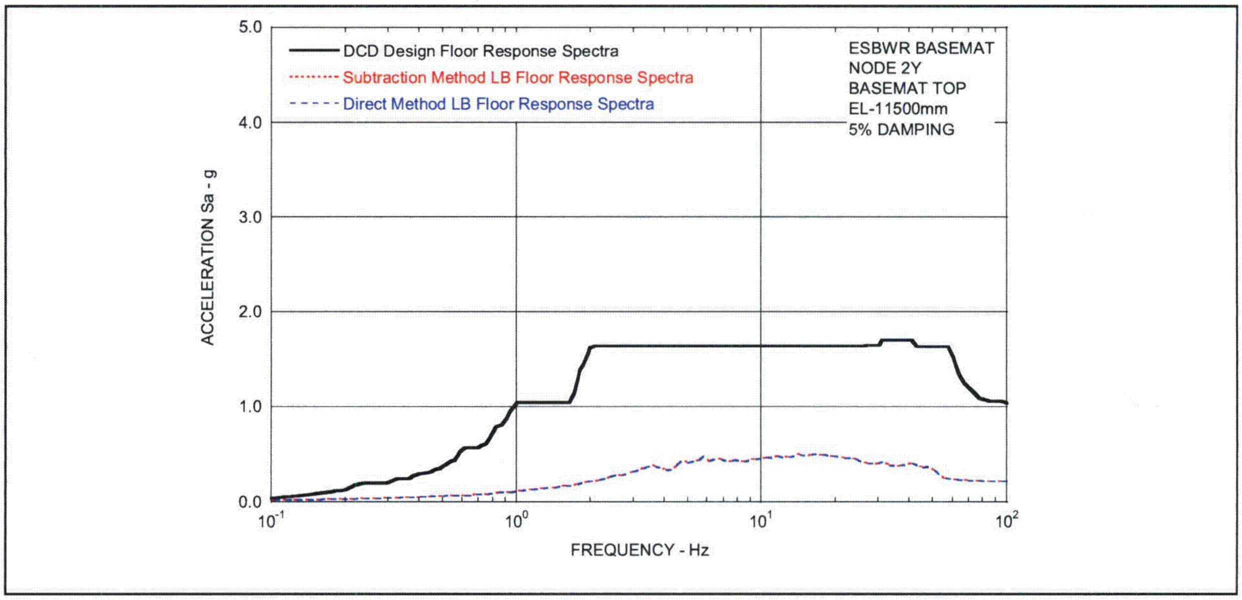


Figure 1.2-5f Floor Response Spectra Lower Bound – RB/FB Basemat in Y-Direction

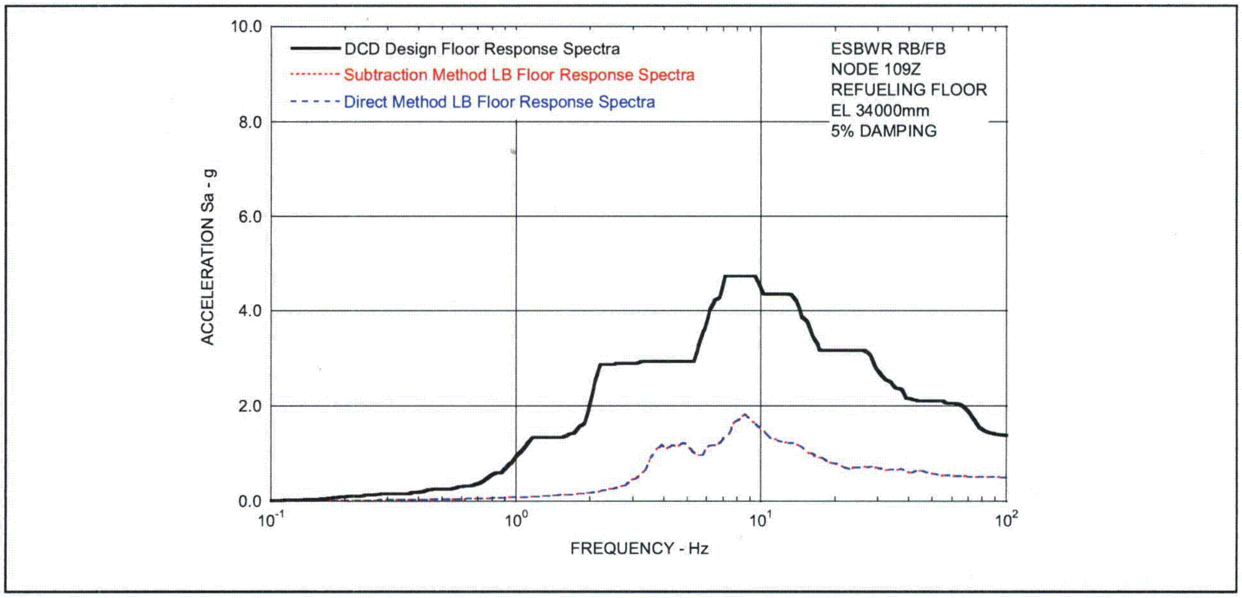


Figure 1.2-6a Floor Response Spectra Lower Bound – RB/FB Refueling Floor in Z-Direction

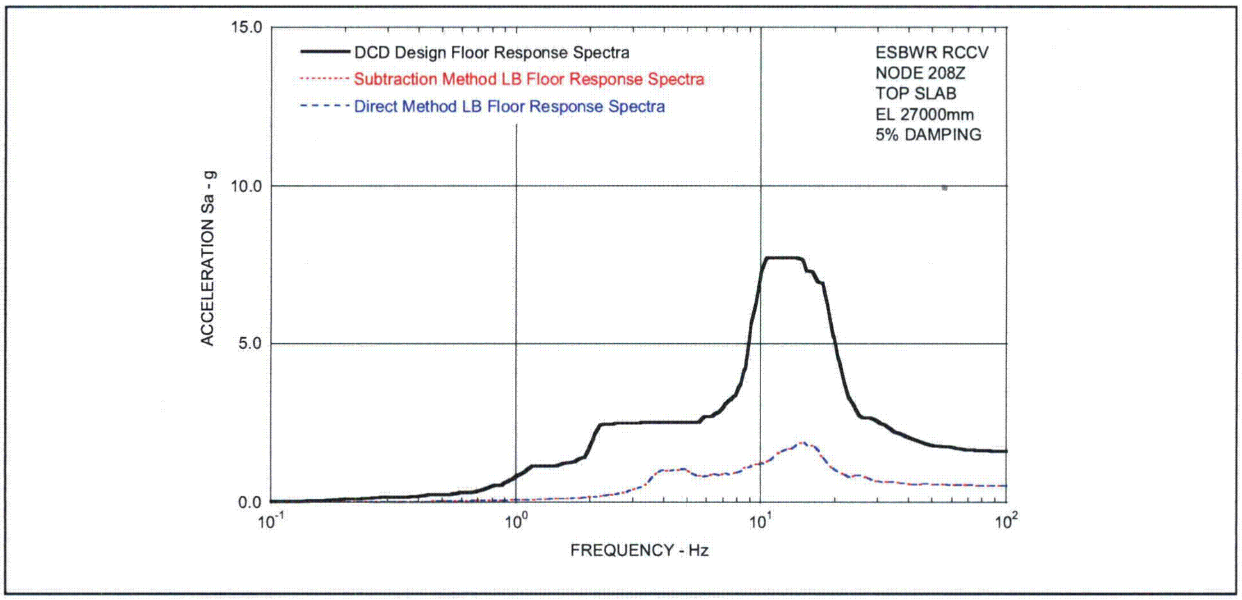


Figure 1.2-6b Floor Response Spectra Lower Bound – RCCV Top Slab in Z-Direction

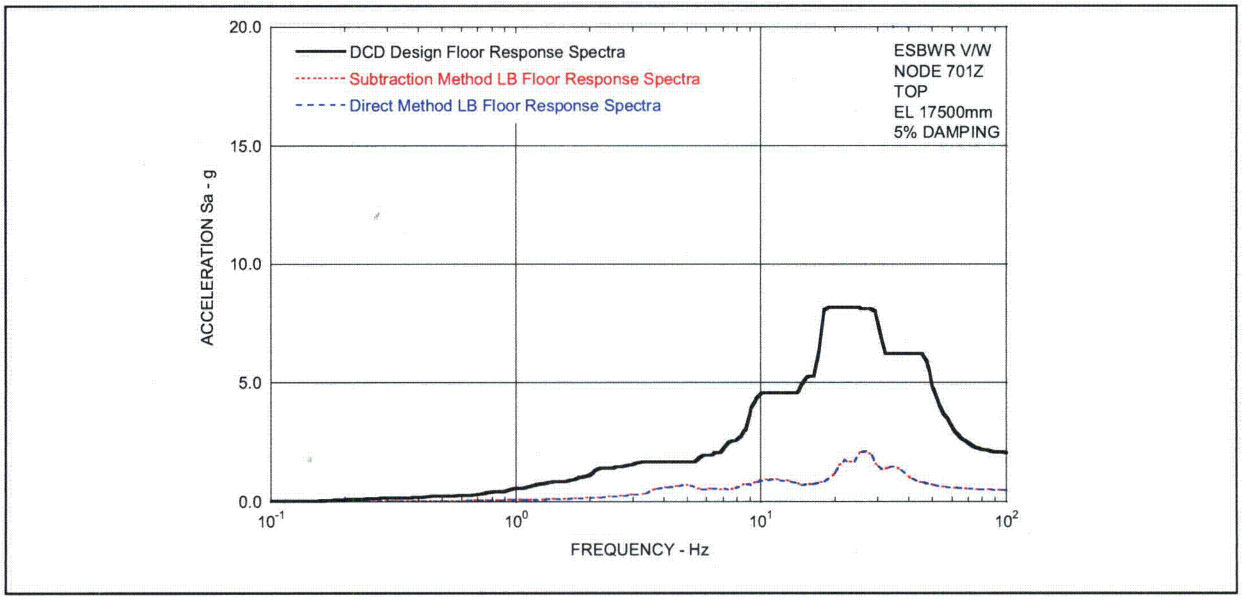


Figure 1.2-6c Floor Response Spectra Lower Bound – Vent Wall Top in Z-Direction

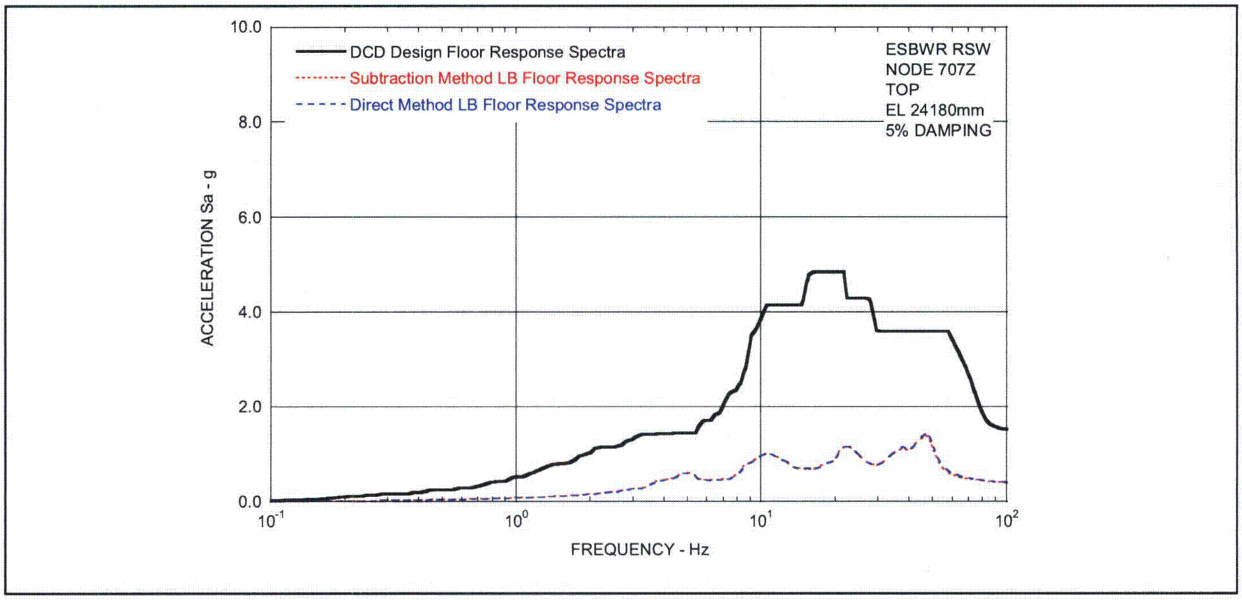


Figure 1.2-6d Floor Response Spectra Lower Bound – RSW Top in Z-Direction

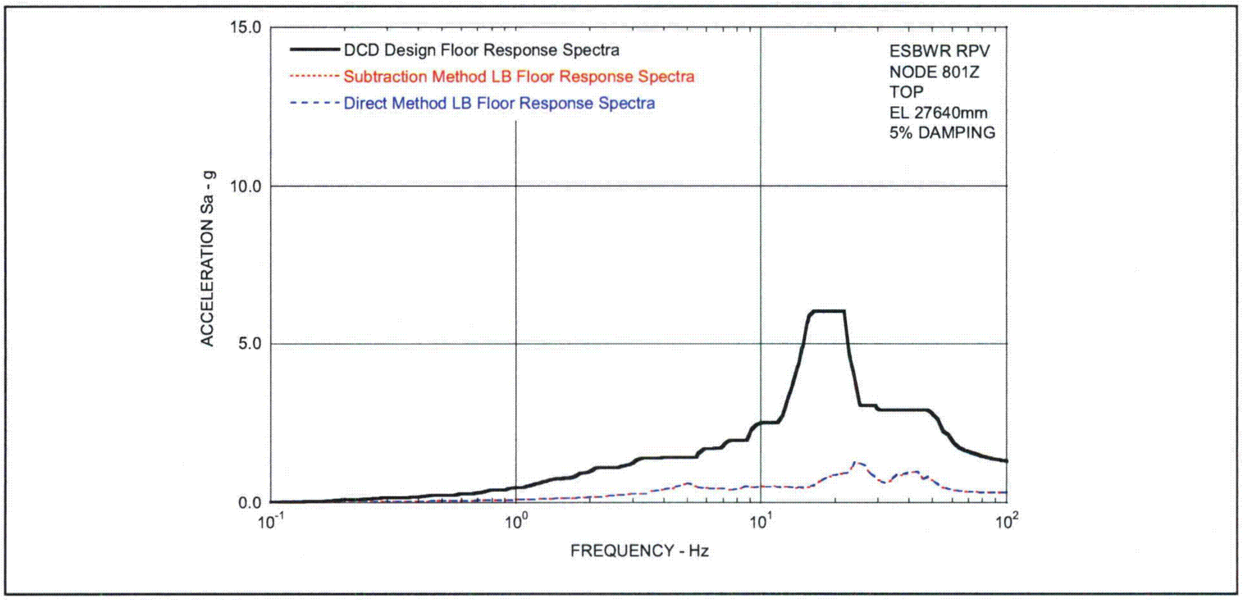


Figure 1.2-6e Floor Response Spectra Lower Bound – RPV Top in Z-Direction

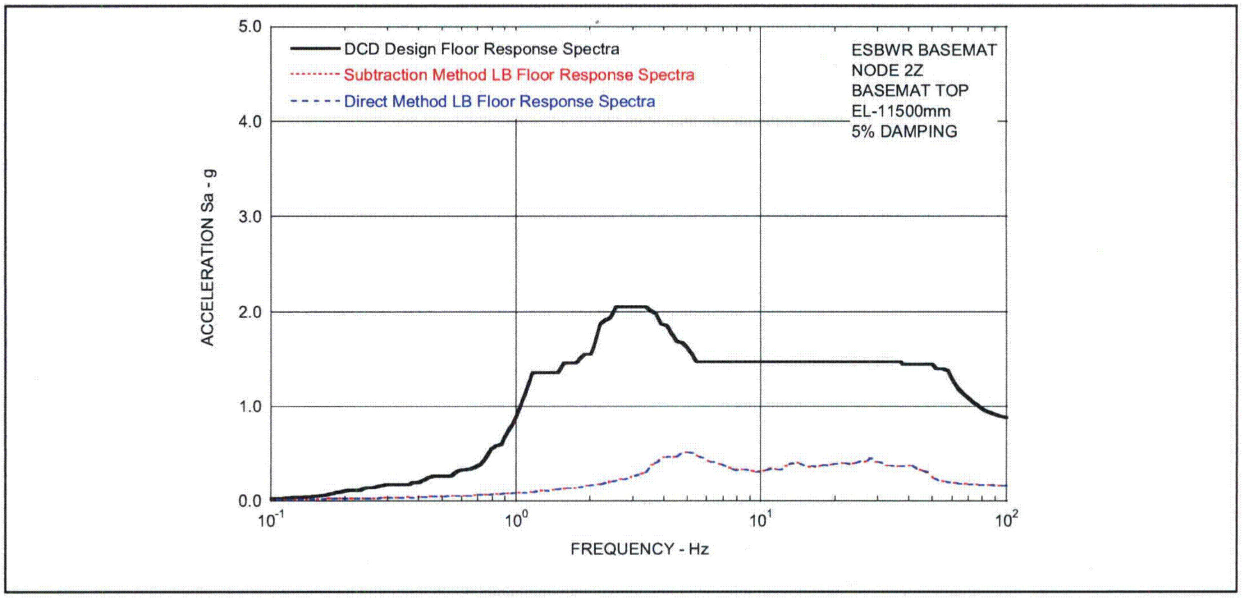


Figure 1.2-6f Floor Response Spectra Lower Bound – RB/FB Basemat in Z-Direction

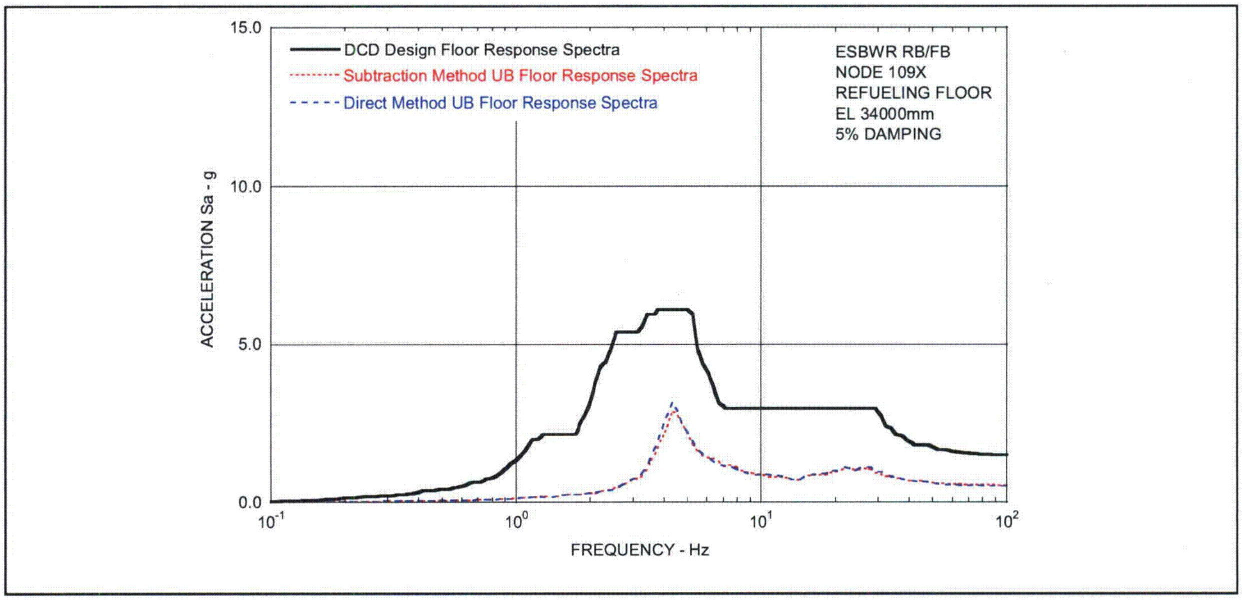


Figure 1.2-7a Floor Response Spectra Upper Bound – RB/FB Refueling Floor in X-Direction

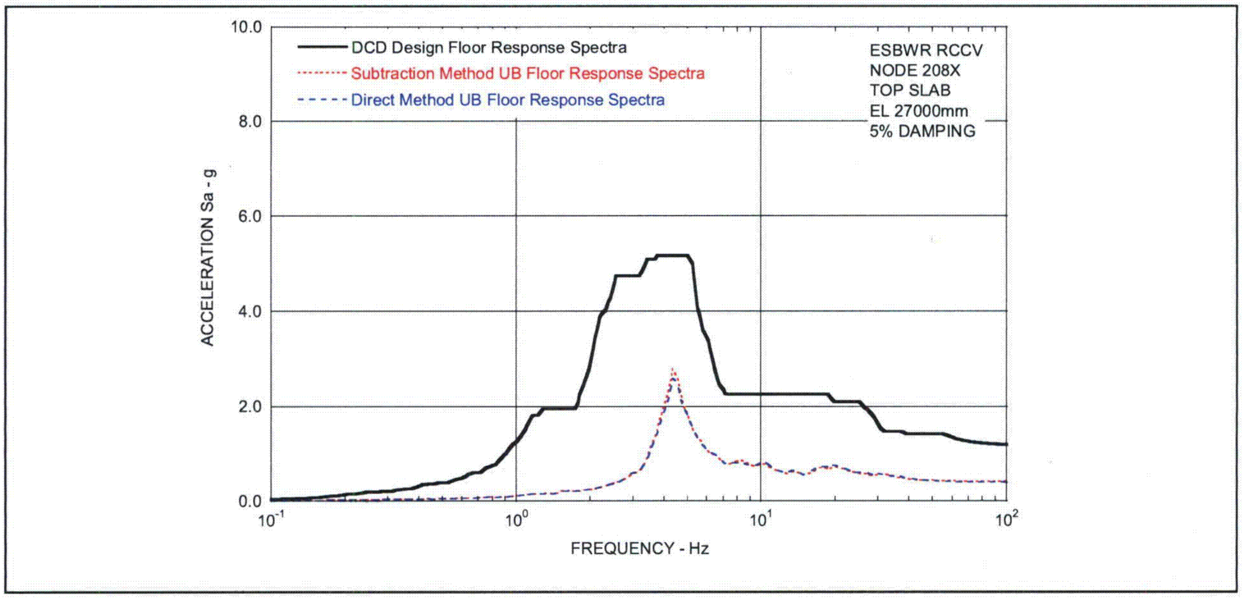


Figure 1.2-7b Floor Response Spectra Upper Bound – RCCV Top Slab in X-Direction

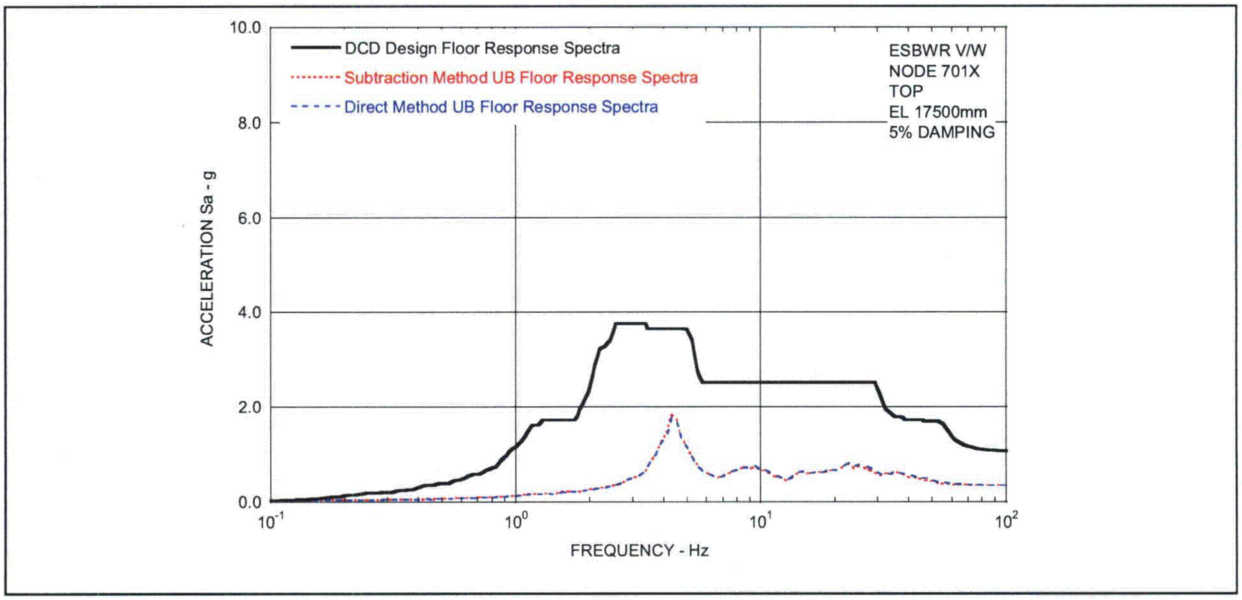


Figure 1.2-7c Floor Response Spectra Upper Bound – Vent Wall Top in X-Direction

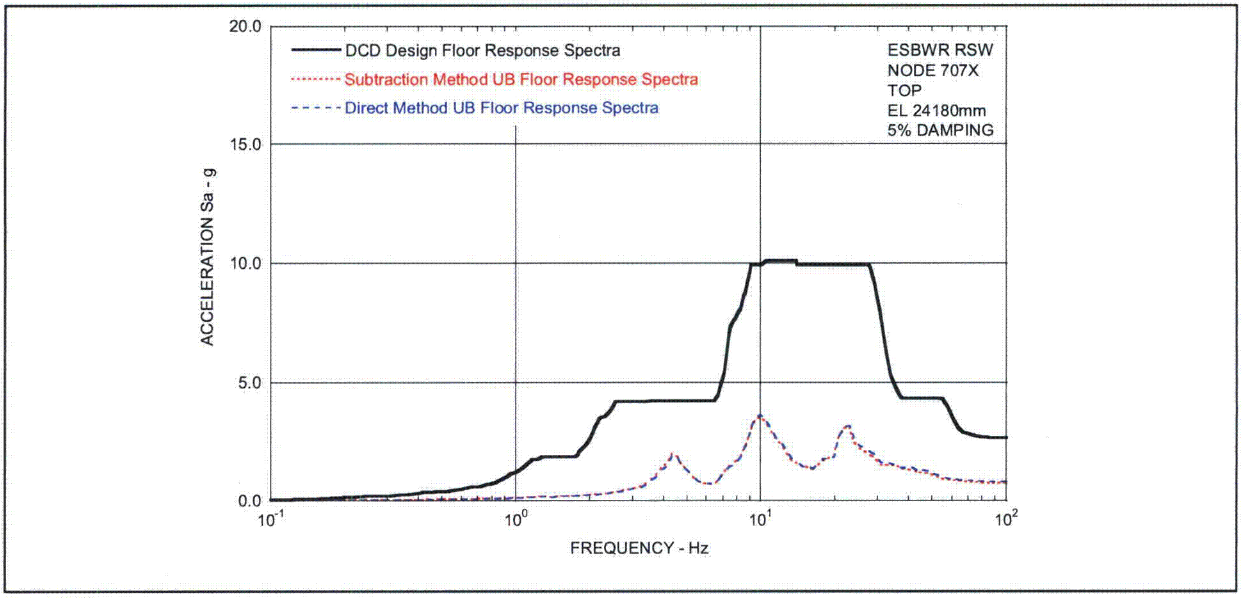


Figure 1.2-7d Floor Response Spectra Upper Bound – RSW Top in X-Direction

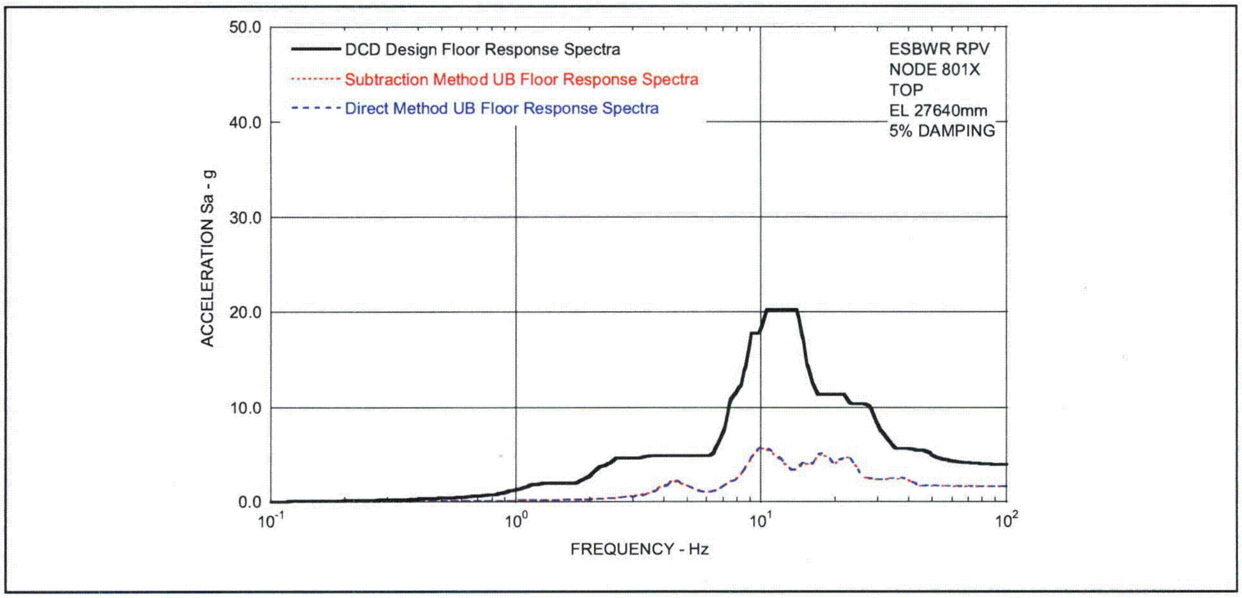


Figure 1.2-7e Floor Response Spectra Upper Bound – RPV Top in X-Direction

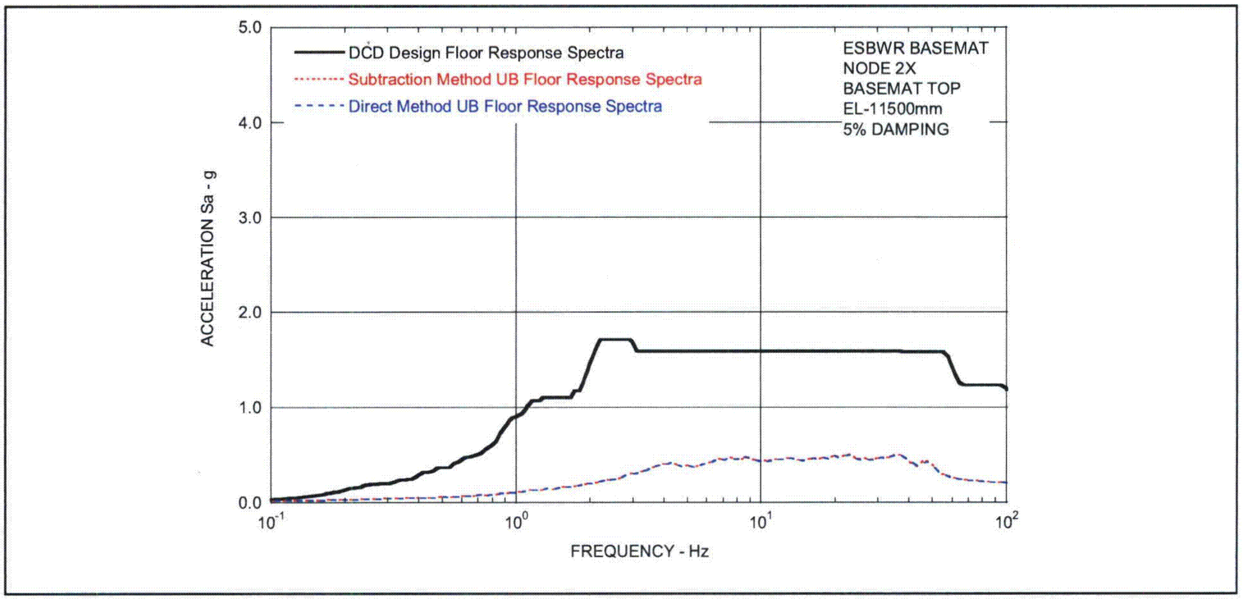


Figure 1.2-7f Floor Response Spectra Upper Bound – RB/FB Basemat in X-Direction

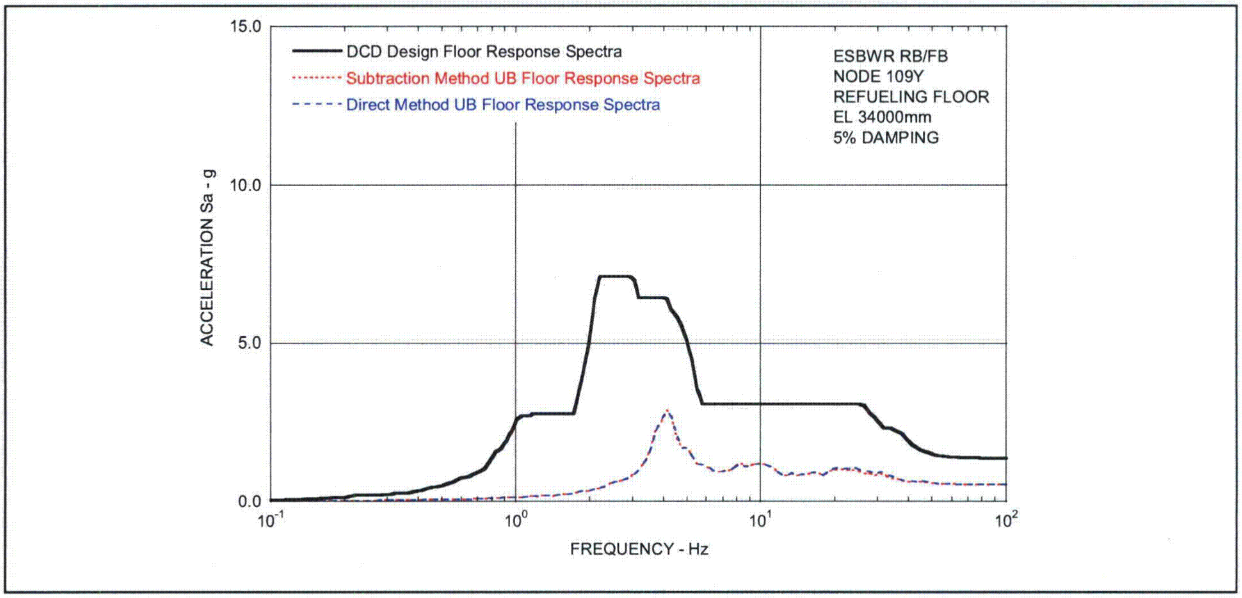


Figure 1.2-8a Floor Response Spectra Upper Bound – RB/FB Refueling Floor in Y-Direction

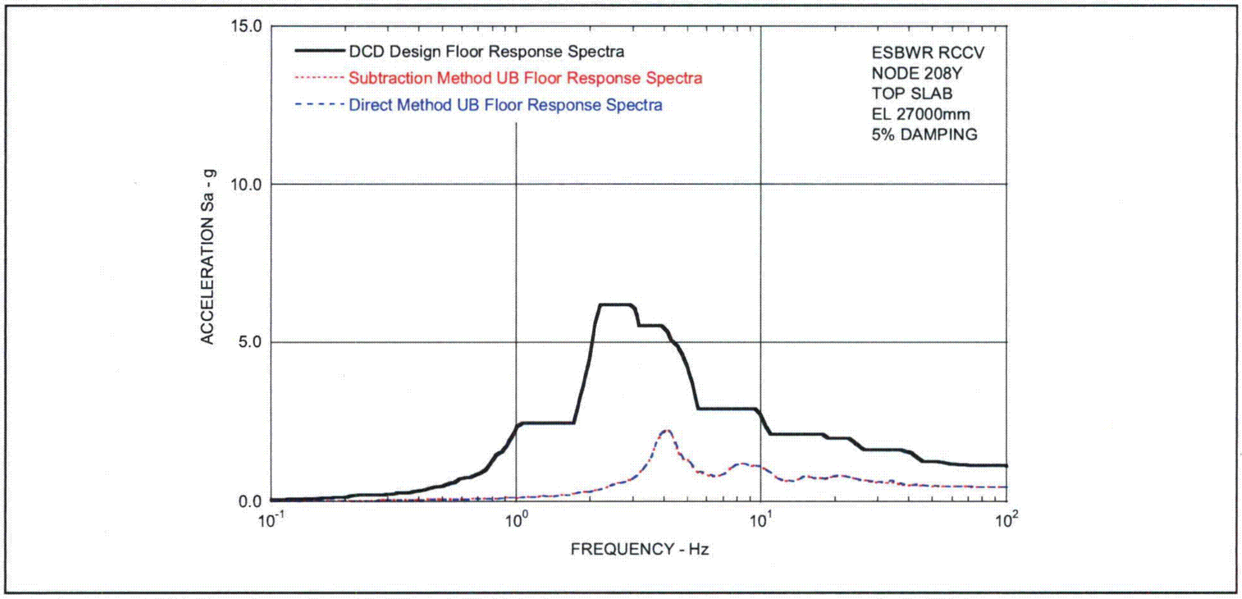


Figure 1.2-8b Floor Response Spectra Upper Bound – RCCV Top Slab in Y-Direction

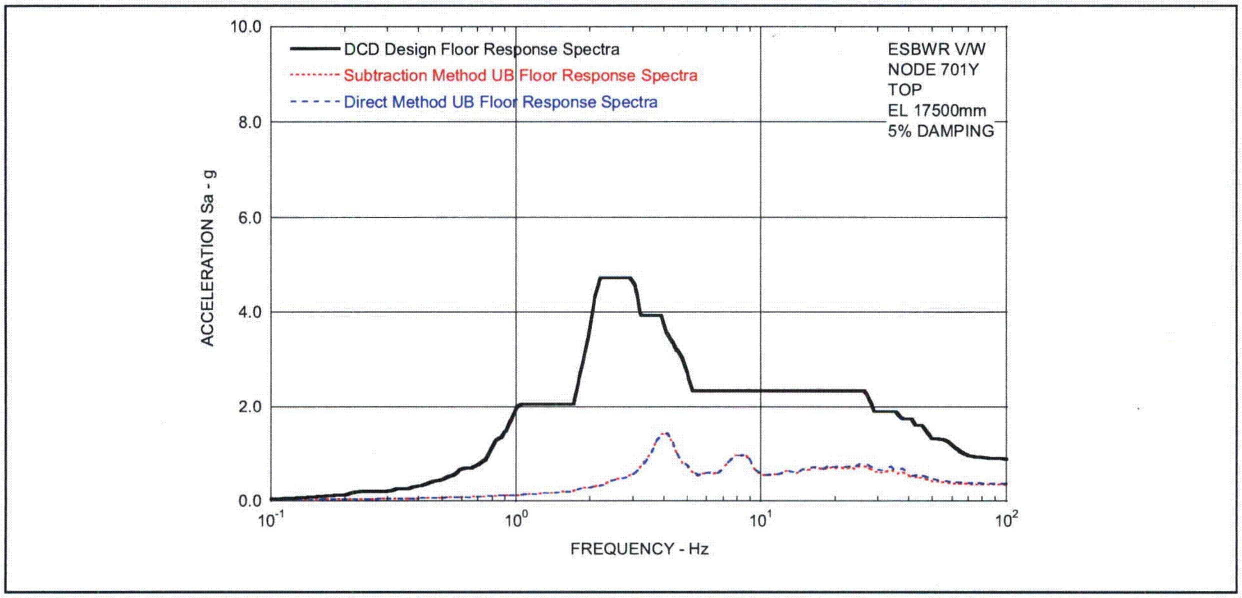


Figure 1.2-8c Floor Response Spectra Upper Bound – Vent Wall Top in Y-Direction

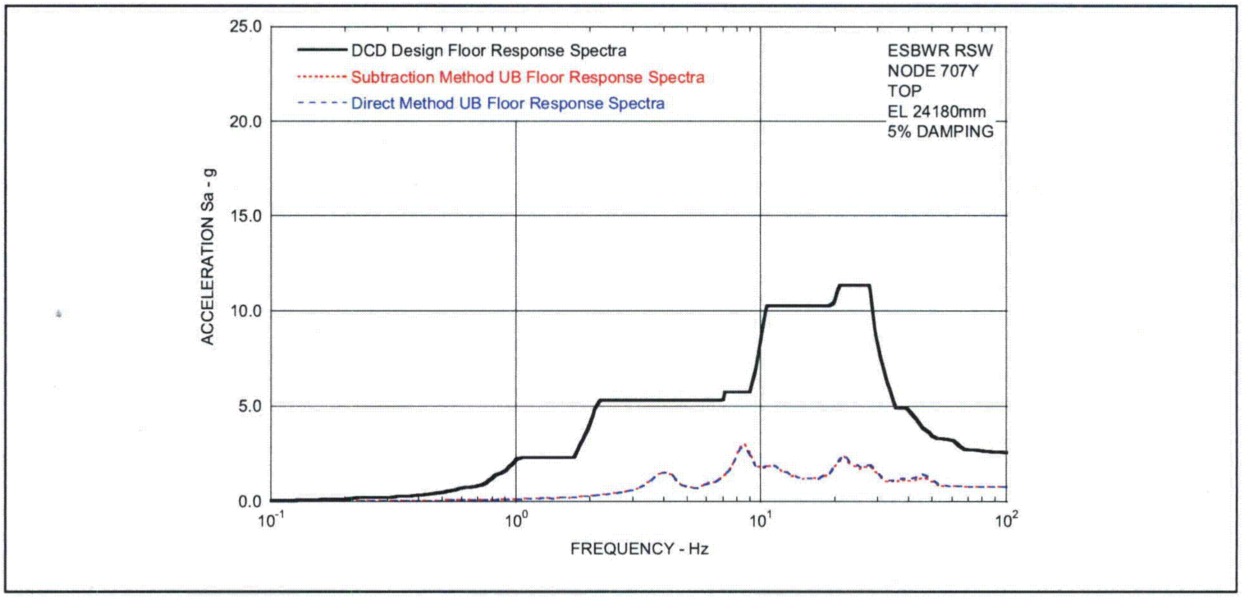


Figure 1.2-8d Floor Response Spectra Upper Bound – RSW Top in Y-Direction

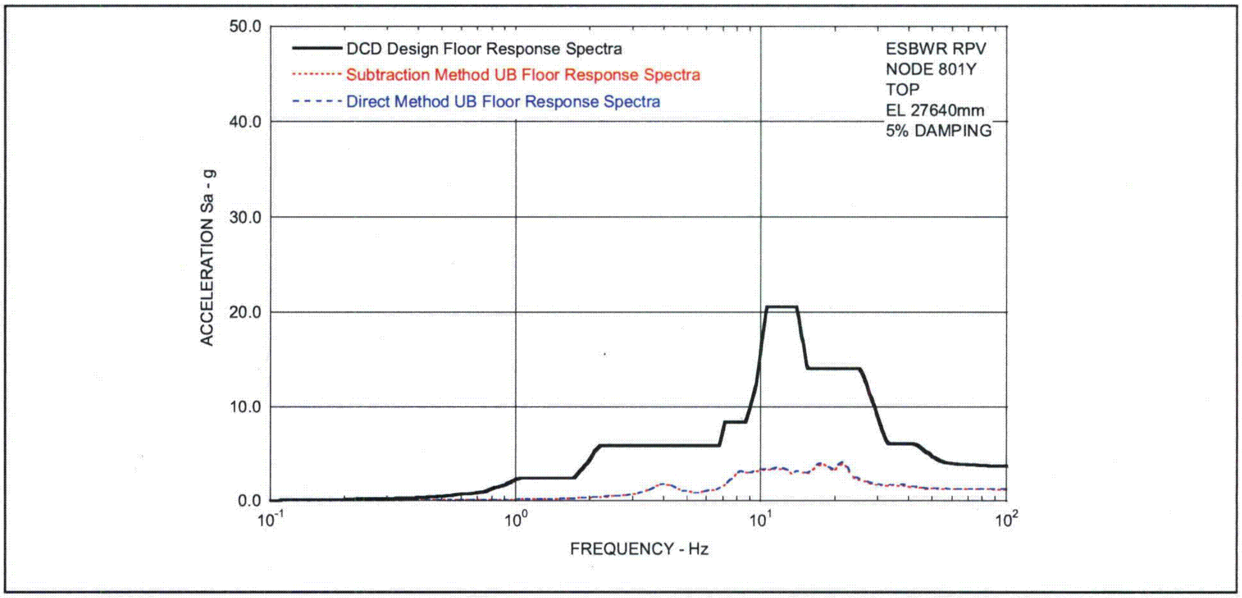


Figure 1.2-8e Floor Response Spectra Upper Bound – RPV Top in Y-Direction

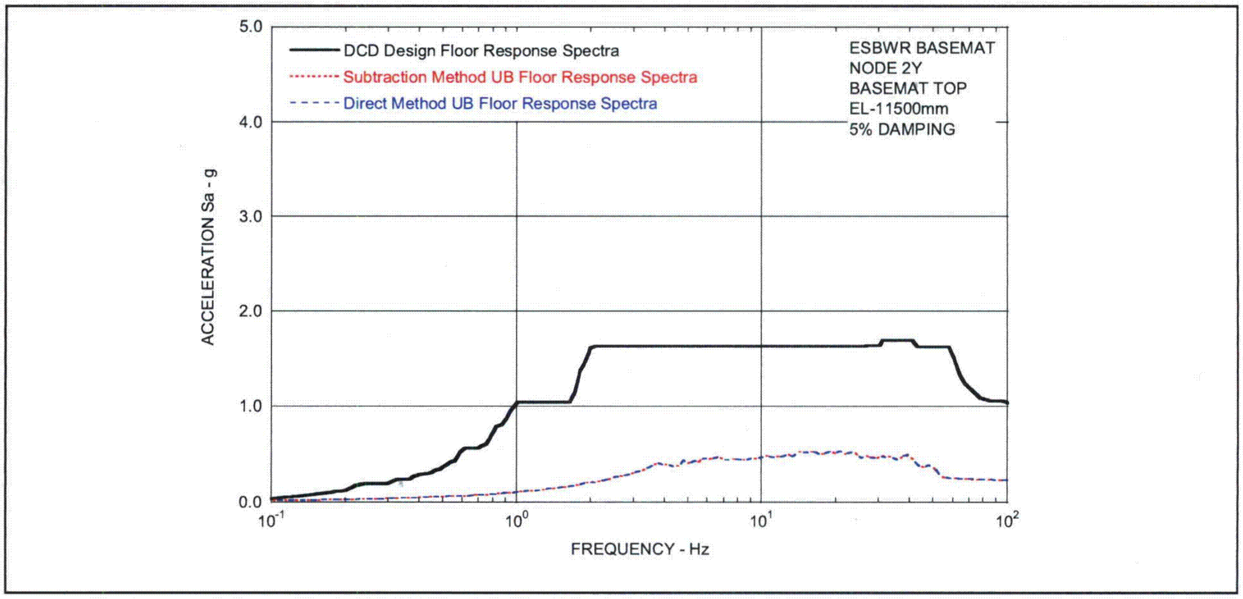


Figure 1.2-8f Floor Response Spectra Upper Bound – RB/FB Basemat in Y-Direction

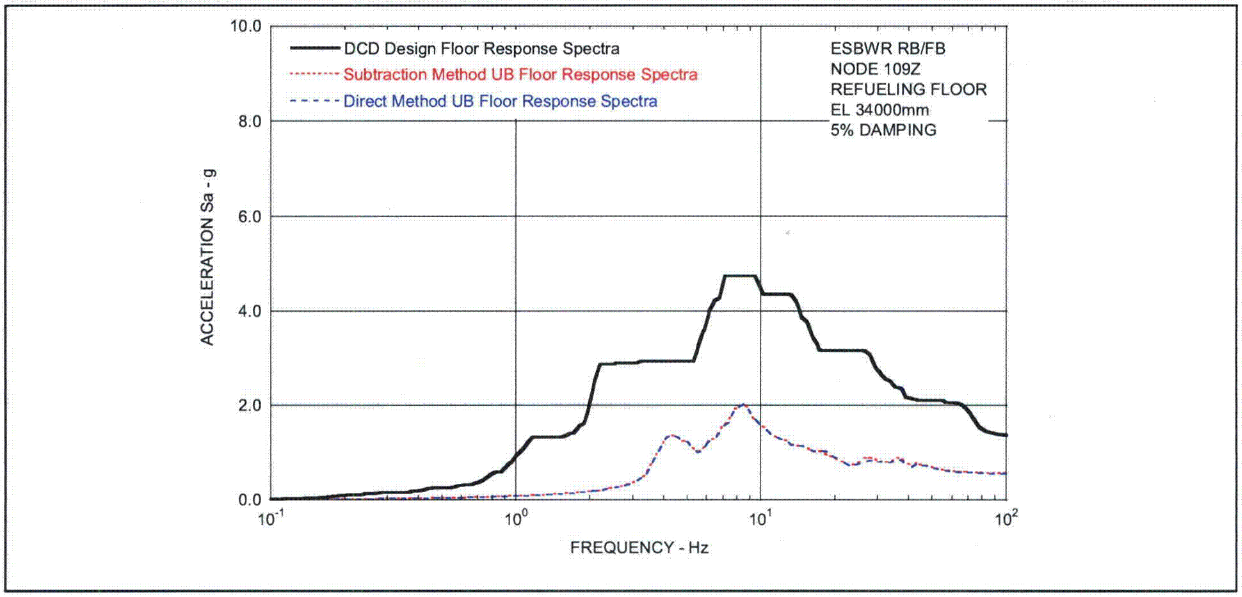


Figure 1.2-9a Floor Response Spectra Upper Bound – RB/FB Refueling Floor in Z-Direction

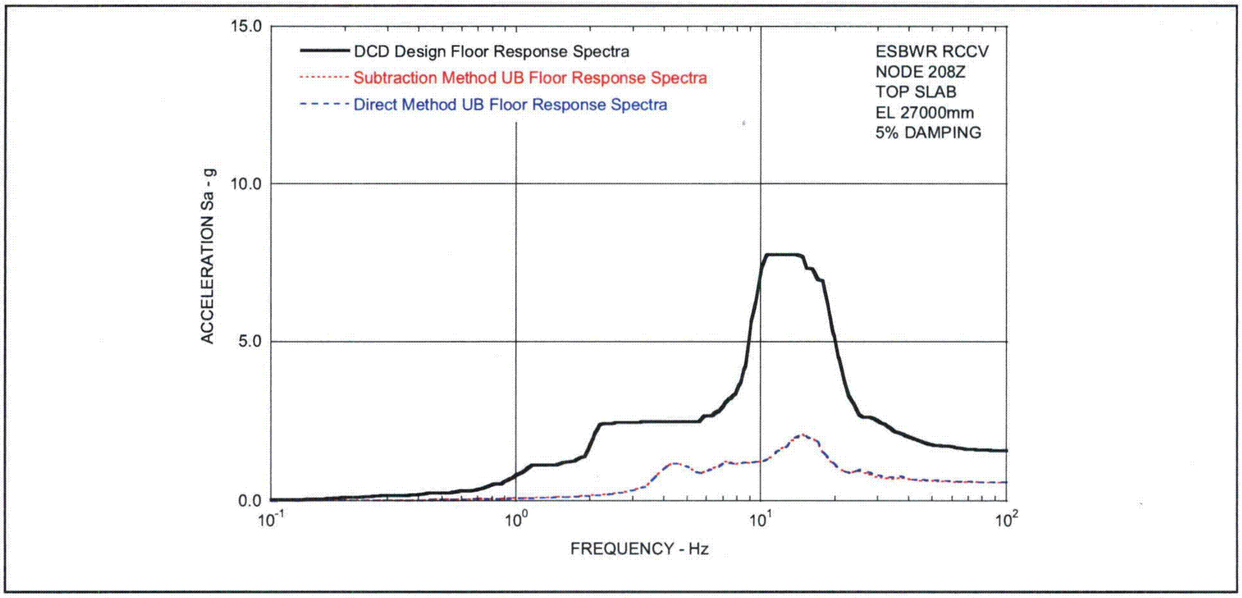


Figure 1.2-9b Floor Response Spectra Upper Bound – RCCV Top Slab in Z-Direction

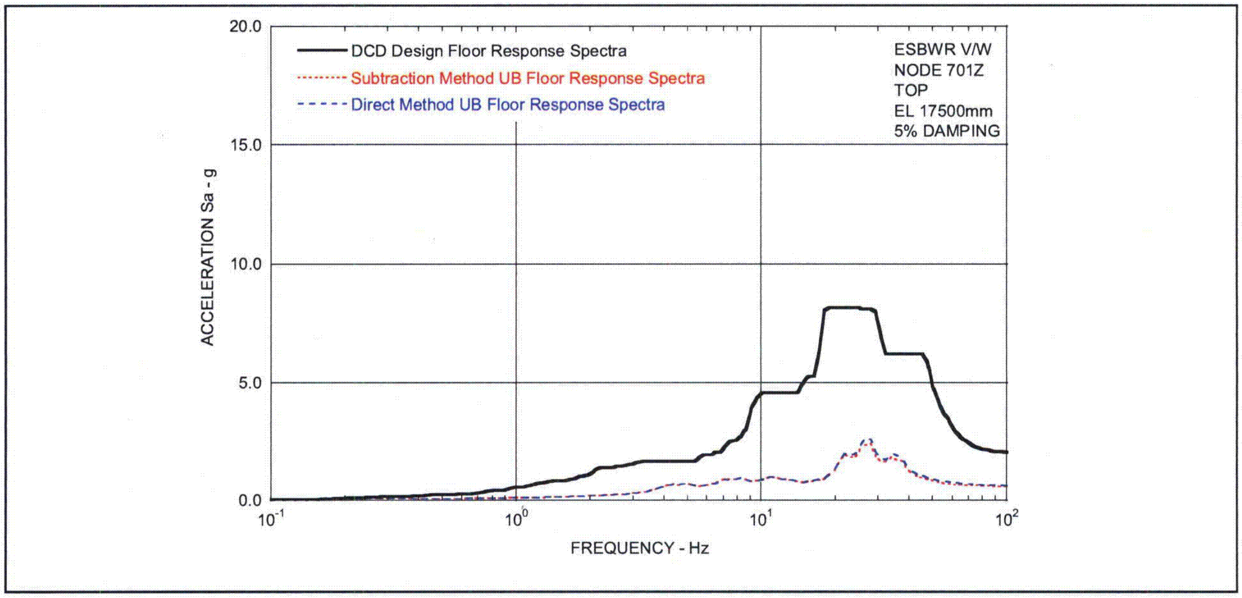


Figure 1.2-9c Floor Response Spectra Upper Bound – Vent Wall Top in Z-Direction

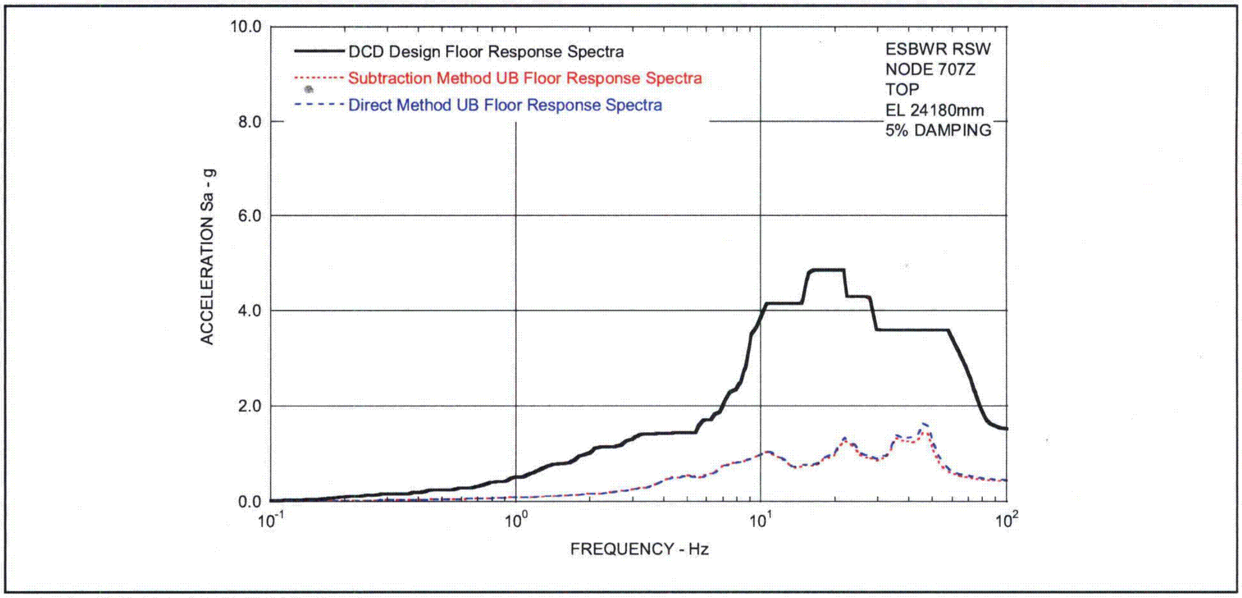


Figure 1.2-9d Floor Response Spectra Upper Bound – RSW Top in Z-Direction

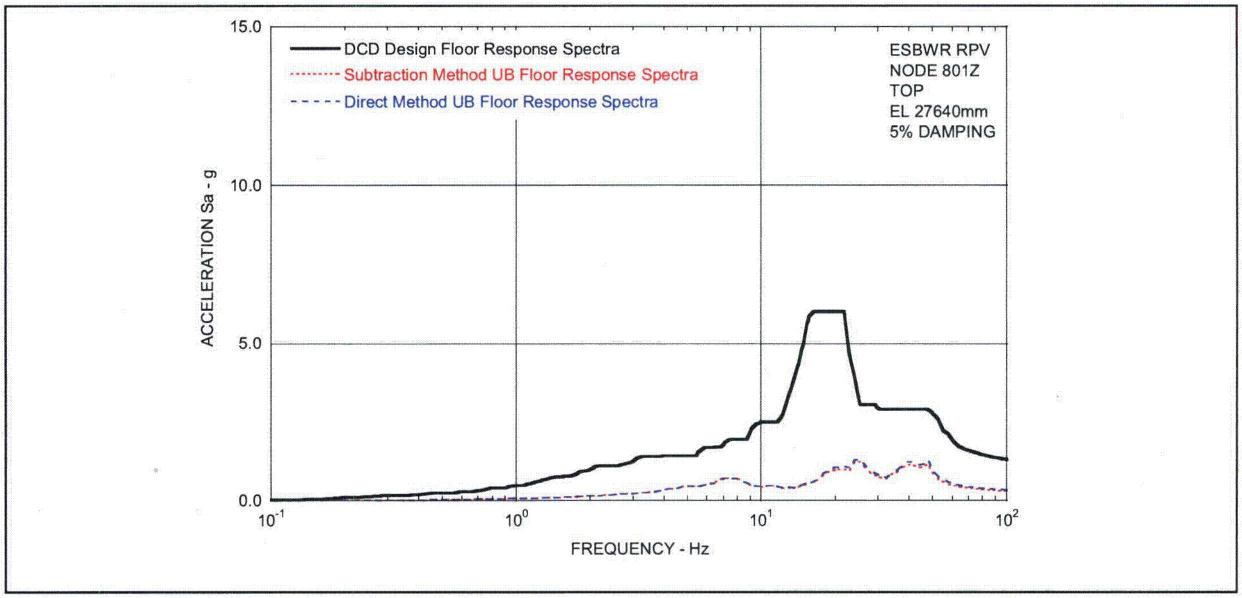


Figure 1.2-9e Floor Response Spectra Upper Bound – RPV Top in Z-Direction

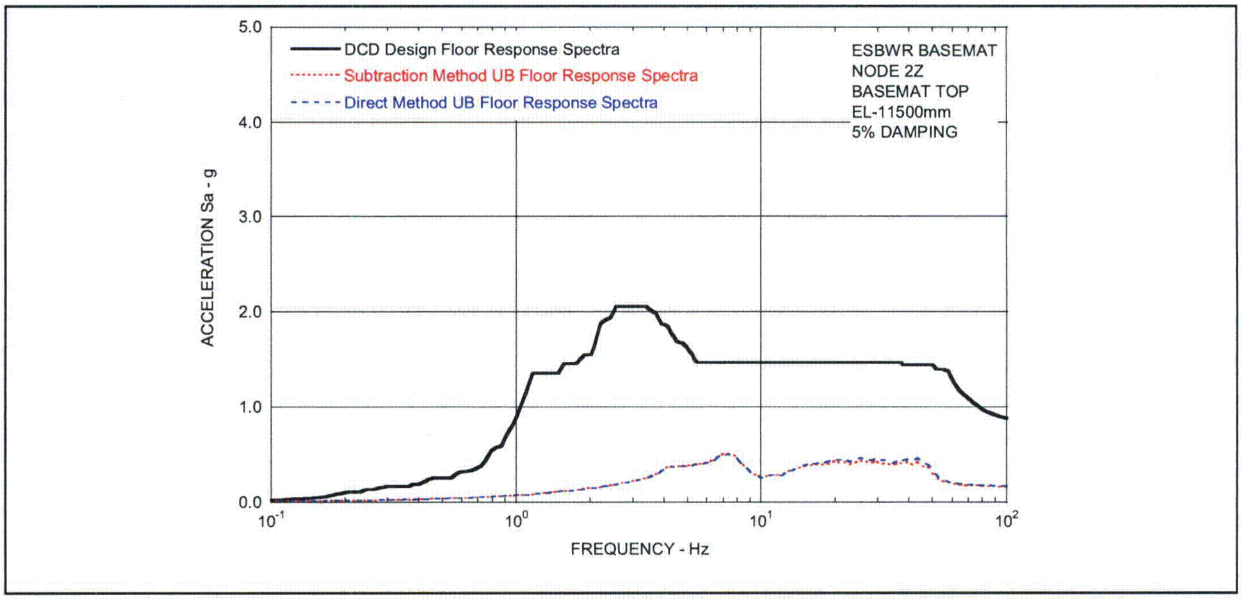


Figure 1.2-9f Floor Response Spectra Upper Bound – RB/FB Basemat in Z-Direction

Attachment 14
NRC3-12-0003
(2 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6243)

RAI Question No. 03.07.02-8

NRC RAI 03.07.02-8

ESBWR DCD Appendix 3A.8.11 describes the SSI analyses performed to evaluate the structure-soil-structure-interaction (SSSI) effects of the RB/FB on the CB, and the effects of the CB on the FWSC. These analysis cases are termed CL-6 and FL-5 in the ESBWR DCD. Based on these limited analysis cases, it was concluded that SSSI effects were bounded by other analysis cases and would not affect the ESBWR DCD design envelope.

EF3 FSAR Figure 2.5.4-202, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, shows a cross section through the RB/FB, CB and FWSC with the extent of concrete fill and granular fill. Since these site conditions deviate significantly from cases CL-6 and FL-5, analyzed in the ESBWR DCD, the applicant is requested to explain how SSSI effects are evaluated between these structures. What is the basis for neglecting the granular fill in the site-specific analyses in the context of SSSI, given that these structures are deeply embedded and in close proximity to each other? What is the basis for including concrete fill between the RB/FB and CB gap? Does the addition of the stiff concrete fill between the CB and the RB/FB introduce potential interaction between the two structures?

Response

For the ESBWR Standard Plant, structure-soil-structure interaction (SSSI) analyses were performed between the Reactor Building/Fuel Building (RB/FB) and Control Building (CB) and between the CB and Fire Water Service Complex (FWSC). Results of these SSSI analyses indicated that the Floor Response Spectra (FRS) due to SSSI is insignificant and the ESBWR Standard Plant FRS enveloped the SSSI FRS by significant margin.

The Fermi 3 Foundation Input Response Spectra (FIRS) is enveloped by the ESBWR Standard Plant Certified Seismic Design Response Spectra (CSDRS) by considerable margin. Therefore, for the Fermi 3 site, the effect of SSSI between the RB/FB Complex and CB and between the CB and FWSC will be insignificant and no additional analyses are warranted.

However additional SSSI analyses will be performed between the RB/FB and CB and between the CB and FWSC with the backfill soil over the bedrock using the SASSI2000 computer code to provide the quantitative results and to compare to the ESBWR Standard Plant envelope. As discussed in Attachment 12 of this letter in response to RAI 03.07.02-6, the use of the subtraction method and original inputs is acceptable.

A revised response including the additional SASSI analyses results will be provided by April 30, 2012.

Proposed COLA Revision

None.

Attachment 15
NRC3-12-0003
(2 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6245)

RAI Question No. 03.08.05-1

NRC RAI 03.08.05-1

EF3 FSAR Table 1.9-204, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, references the 2006 edition of ACI 349. However, ESBWR DCD Tables 3.8-6 and 3.8-9 reference the 2001 edition of ACI 349. The applicant is requested to provide justification for using 2006 code edition of ACI 349.

Response

ESBWR DCD Section 1.9.2 states that Table 1.9-22 provides the Industrial Codes and Standards that are applicable to the ESBWR standard plant design. ESBWR DCD Table 1.9-22 identifies that ACI 349-01/349R-01 is applicable to the ESBWR standard plant design. Fermi 3 FSAR Subsection 1.9.2 states that FSAR Table 1.9-204 identifies the Industrial Codes and Standards that are applicable to those portions of the Fermi 3 design that are beyond the scope of the ESBWR DCD. Fermi 3 FSAR Table 1.9-204 identifies that ACI 349-06 is applicable to portions of the Fermi 3 site-specific design that are beyond the scope of the ESBWR DCD. Therefore, it is acceptable for the FSAR to specify different editions of Industrial Codes and Standards for Fermi 3 site-specific design that are beyond the scope of the ESBWR DCD.

For Fermi 3, the portions of ACI 349-06 that apply are Table 4.3.1 (Requirements for Concrete Exposed to Sulfate-Containing Solutions) and Section 11.7 (Shear-Friction). Review of ACI 349-01 and 349-06 shows that for the applicable portions of both ACI 349 code editions, the code requirements remain the same.

Proposed COLA Revision

None.

Attachment 16
NRC3-12-0003
(2 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6245)

RAI Question No. 03.08.05-2

NRC RAI 03.08.05-2

EF3 FSAR Section 3.8.5.5.1, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, discusses the site-specific seismic stability evaluations performed for the RB/FB, CB, and FWSC at the Fermi 3 site. It is indicated that the stability evaluations for overturning, sliding, and flotation are performed using the methodology described in ESBWR DCD Section 3.8.5.5. In particular, the calculated factors of safety against sliding are 5.48 and 3.09 for the RB/FB and CB, respectively. However, it is not clear how the resisting forces needed to calculate these factors of safety were computed.

To determine whether the stability evaluations are consistent with the methodology described in the ESBWR DCD, provide the following information for the RB/FB and CB:

(a) Provide the numerical values for each of the terms in the equation used to evaluate the factors of safety against sliding (see ESBWR DCD Section 3.8.5.5). Also provide a detailed explanation of how each value was obtained, including the assumed coefficient of friction at the various foundation-rock interfaces.

(b) Explain if shear keys are provided as described in ESBWR DCD. The staff notes that EF3 FSAR Figures 2.5.4-201 through 2.5.4-204 do not show shear keys.

Response

(a) Provide the numerical values for each of the terms in the equation used to evaluate the factors of safety against sliding (see ESBWR DCD Section 3.8.5.5). Also provide a detailed explanation of how each value was obtained, including the assumed coefficient of friction at the various foundation-rock interfaces.

The response to part (a) will be provided by February 29, 2012.

(b) Explain if shear keys are provided as described in ESBWR DCD. The staff notes that EF3 FSAR Figures 2.5.4-201 through 2.5.4-204 do not show shear keys.

As described in the ESBWR Design Control Document (DCD), Appendix 3G, shear keys are provided for the Reactor Building/Fuel Building (RB/FB, Section 3G.1) and the Fire Water Service Complex (FWSC, Section 3G.4). Per FSAR Chapter 3, Appendix G of the DCD is incorporated by reference with no departures or supplements. Therefore, by reference, the Fermi 3 design includes the shear keys as described in the DCD. The purpose of FSAR Figures 2.5.4-201 through 2.5.4-204 is to show the excavation configurations. Depicting the shear keys on the RB/FB and FWSC is beyond the level of detail needed for these figures.

Proposed COLA Revision

None.

Attachment 17
NRC3-12-0003
(2 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6245)

RAI Question No. 03.08.05-3

NRC RAI 03.08.05-3

In the stability evaluations described in EF3 FSAR Section 3.8.5.5.1, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, it is assumed that the RB/FB and CB are partially embedded in rock, ignoring the backfill. Therefore, it is assumed that seismic base shears and overturning moments are transferred from each structure to the rock by a combination of friction and bearing pressure at the various foundation-rock interfaces.

EF3 FSAR Figure 2.5.4-202, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, indicates that stiff concrete fill is placed in the bottom portion of the gap between the RB/FB and CB, up to elevation 552 ft approximately. The applicant is requested to explain how the seismic load (in the E-W direction) imposed by the CB bearing against the concrete fill is transferred to the underlying rock. Is base friction sufficient to resist the entire load or will a certain fraction of this load be transferred to the adjacent RB/FB? Has this been considered in the design?

The above questions are also appropriate to the potential transfer of seismic loads from the RB/FB to the CB through the concrete fill.

Response

The response to this RAI will be provided by February 29, 2012. The requested information will be extracted from the calculation supporting FSAR Subsection 3.8.5.5.1.

Proposed COLA Revision

None.

Attachment 18
NRC3-12-0003
(14 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6245)

RAI Question No. 03.08.05-4

NRC RAI 03.08.05-4

EF3 FSAR Section 2.5.4.10.3 discusses static and dynamic lateral earth pressures for the RB/FB and CB below-grade walls at the Fermi site. At rest-conditions are assumed, consistent with the assumptions in ESBWR DCD Section 3.8.5 and Appendix 3G. These pressures are shown in EF3 FSAR Figures 2.5.4-230 and 4-231. However, no discussion is given regarding the lateral pressures on the portions of below-grade walls that are embedded in rock. Also, no discussion is given regarding additional lateral pressures due to: (i) static and dynamic surcharge loads from adjacent Seismic Category I and II structures; and (ii) effects of structure-to-structure interaction through the surrounding backfill, concrete fill, or rock.

The staff notes that the methodology used to estimate seismic lateral earth pressures is based on EF3 FSAR Reference 2.5.4-247 (Ostadan and White, 1998), which deviates from the methodology used in the ESBWR DCD Section 3.8.5, Appendix 3A, and Appendix 3G (envelope of the method described in ASCE 4-98 Section 3.5.3.2 and pressures obtained from the SSI analysis) and also from the guidance in SRP 3.8.4.II.4H.

To determine whether the lateral pressures for the RB/FB and CB below-grade walls at the Fermi site are bounded by those considered in the ESBWR DCD, provide the following information:

(a) Comparison of seismic lateral earth pressures shown in EF3 FSAR Figures 2.5.4-230 and 4-231 with those obtained using the method described in ASCE 4-98 Section 3.5.3.2 and also with those given in ESBWR DCD Tables 3A.8.8-1 and 3A.8.8-2, and ESBWR DCD Sections 3G.1.5.2.1 and 3G.2.5.2 (Figures 3G.1-19, 3G.1-27, 3G.2-12, and 3G.2-15), which were used for the design of the walls.

(b) For the portions of below-grade walls that are embedded in rock, provide estimates of the seismic lateral pressures imposed by the surrounding rock, which are compatible with the results of the site-specific SSI analyses performed and with the assumptions of the sliding stability calculations discussed in EF3 FSAR Sections 3.7.2 and 3.8.5, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38.

(c) Provide estimates of additional static and dynamic lateral pressures imposed from adjacent Seismic Category I and II structures. This should also include possible effects of structure-to- structure interaction through the surrounding backfill, concrete fill, or rock.

(d) Modify EF3 FSAR Figures 2.5.4-230 and 4-231 to incorporate the pressures discussed in items (b) and (c) above and compare with the lateral pressures given in ESBWR DCD Tables 3A.8.8-1 and 3A.8.8-2, and ESBWR DCD Sections 3G.1.5.2.1 and 3G..2.5.2, which were used for the design of the walls. If site-specific SSI analyses that consider the backfill become available, include the lateral pressures from the SSI analyses in the comparison.

Response

(a) *Comparison of seismic lateral earth pressures shown in EF3 FSAR Figures 2.5.4-230 and 4-231 with those obtained using the method described in ASCE 4-98 Section 3.5.3.2 and also with those given in ESBWR DCD Tables 3A.8.8-1 and 3A.8.8-2, and ESBWR DCD Sections 3G.1.5.2.1 and 3G.2.5.2 (Figures 3G.1-19, 3G.1-27, 3G.2-12, and 3G.2-15), which were used for the design of the walls.*

For comparison with the seismic lateral earth pressures in Fermi 3 FSAR, Revision 3 (calculated using the approach in FSAR Reference 2.5.4-247), the seismic lateral earth pressures were recalculated using the approach in ASCE 4-98 (Reference 1), Section 3.5.3.2. Soil properties used to calculate the static and seismic lateral earth pressures are provided in FSAR Subsection 2.5.4.10.3. The Reference 1 method for calculation of seismic lateral earth pressures used the largest peak ground accelerations (at 100 Hz) from comparison of the soil column outcrop response (SCOR [response to RAI 03.07.01-6]) and the truncated soil column response (TSCR) spectra (FSAR Subsection 2.5.2) at the foundation level, i.e., foundation input response spectra (FIRS). This resulted in using TSCR peak ground accelerations of 0.2185g and 0.2125g for the Reactor Building/Fuel Building (RB/FB) and Control Building (CB), respectively. Use of the peak ground acceleration is consistent with the method described in Reference 2, GEH's response to NRC RAI Number 3.8-96 S05 Revision 1. The seismic lateral earth pressures above the RB/FB and CB basemats along the embedded walls calculated using FSAR Reference 2.5.4-247 are greater than the pressures calculated using Reference 1.

Figures 1 and 3 present the seismic lateral earth pressures calculated using Reference 1 for the RB/FB and CB, respectively. For comparison, FSAR, Revision 3, Figures 2.5.4-230 (Figure 2) and 2.5.4-231 (Figure 4) are included in this RAI response. Figures 1 through 4 also present the static lateral earth pressures from the FSAR, Revision 3. The seismic lateral earth pressures calculated using Reference 1 are less than the seismic lateral earth pressures calculated using FSAR Reference 2.5.4-247 above the top of the basemat for both the RB/FB (Elevation -11.5 meters on Table 3A.8.8-1) and CB (Elevation -7.4 meters on Table 3A.8.8-2).

For both the RB/FB and the CB, the ESBWR DCD, Revision 9 static and seismic lateral earth pressures are greater than the static and seismic lateral earth pressures calculated for Fermi 3 using the approach in FSAR Reference 2.5.4-247 and Reference 1. Figures 7, 8, 11, and 12, and Tables 3A.8.8-1 and 3A.8.8-2 from the ESBWR DCD, Revision 9 are provided for comparison to the lateral earth pressures calculated for Fermi 3 using the approach in FSAR Reference 2.5.4-247 and Reference 1. Figures 5, 6, 9, and 10 are the same as Figures 1 through 4, respectively, except the values are converted to metric units and the depths are converted to elevation for direct comparison with the ESBWR DCD, Revision 9 figures. ESBWR DCD, Revision 9 Tables 3A.8.8-1 and 3A.8.8-2, columns titled "Envelope" were used to develop ESBWR DCD, Revision 9 Figures 3G.1-27 and 3G.2-15 (RAI Figures 8 and 12), respectively; therefore, comparison with the figures automatically provides comparison with the tables.

(b) *For the portions of below-grade walls that are embedded in rock, provide estimates of the seismic lateral pressures imposed by the surrounding rock, which are compatible with the results of the site-specific SSI analyses performed and with the assumptions of the sliding stability calculations discussed in EF3 FSAR Sections 3.7.2 and 3.8.5, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38.*

The response to part (b) will be provided by February 29, 2012.

(c) *Provide estimates of additional static and dynamic lateral pressures imposed from adjacent Seismic Category I and II structures. This should also include possible effects of structure-to- structure interaction through the surrounding backfill, concrete fill, or rock.*

For the ESBWR Standard Plant, structure-soil-structure interaction (SSSI) analyses were performed between the RB/FB and CB and between the CB and Fire Water Service Complex (FWSC). Results of these SSSI analyses indicated that the Floor Response Spectra (FRS) due to SSSI is insignificant and the ESBWR Standard Plant FRS enveloped the SSSI FRS by significant margin.

The Fermi 3 Foundation Input Response Spectra (FIRS) is enveloped by the ESBWR Standard Plant Certified Seismic Design Response Spectra (CSDRS) by considerable margin. Therefore, for the Fermi 3 site, the effect of SSSI between the RB/FB and CB and between the CB and FWSC will be insignificant and no additional analyses are warranted.

However, as requested by the NRC in this RAI, additional SSSI analyses will be performed between the RB/FB and CB and between the CB and FWSC with the backfill soil over the bedrock using the SASSI2000 computer code to provide the quantitative results and to compare to the ESBWR Standard Plant envelope. As discussed in Attachment 12 of this letter, in response to RAI 03.07.02-6, the use of the subtraction method and original inputs is acceptable.

As described in the transmittal letter, Detroit Edison is currently performing SSI analyses using the direct method and revised seismic inputs. The revised SSI analyses will be available for NRC audit the week of April 23rd 2012, including the necessary FSAR markups.

A revised response including the additional SASSI analyses results will be provided by April 30, 2012.

(d) *Modify EF3 FSAR Figures 2.5.4-230 and 4-231 to incorporate the pressures discussed in items (b) and (c) above and compare with the lateral pressures given in ESBWR DCD Tables 3A.8.8-1 and 3A.8.8-2, and ESBWR DCD Sections 3G.1.5.2.1 and 3G..2.5.2, which were used for the design of the walls. If site-specific SSI analyses that consider the backfill become available, include the lateral pressures from the SSI analyses in the comparison.*

The information from parts (b) and (c) and the revised SASSI analyses results will be incorporated into the FSAR following completion of parts (b) and (c). The response to part (d) will be provided by April 30, 2012.

<u>References:</u>

1. ASCE 4-98, Seismic Analysis of Safety-Related Nuclear Structures and Commentary, 1998.

2. GEH Letter MFN 09-772, Revised Response to portion of NRC RAI Letter No. 386 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.8 –

Seismic Category I Structures; RAI Number 3.8-96 S05 Revision 1, January 20, 2010.

Proposed COLA Revision

None.

(Finished Ground Level Grade at Depth = 0)

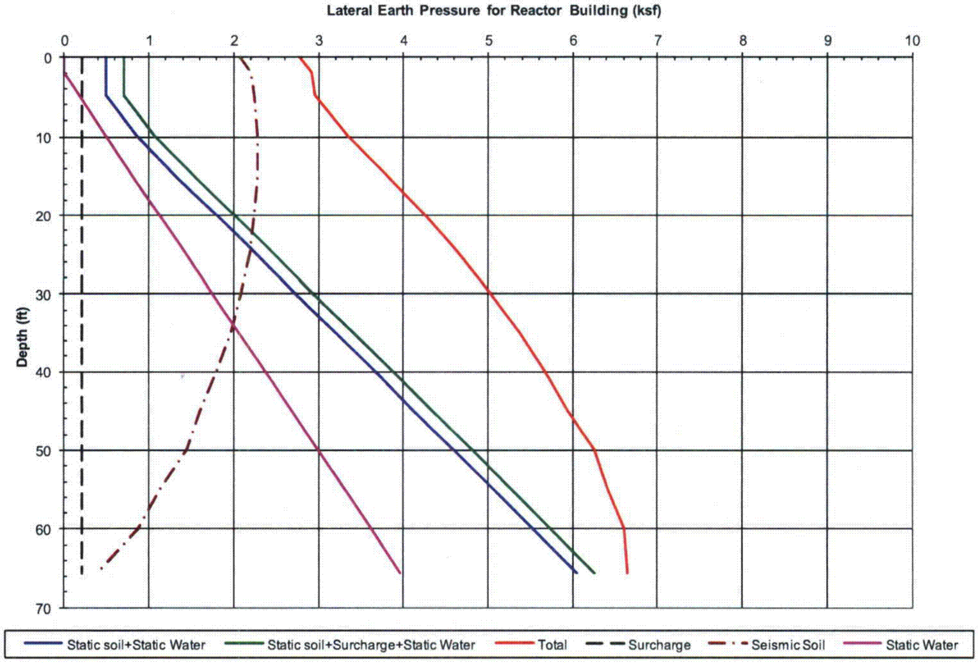
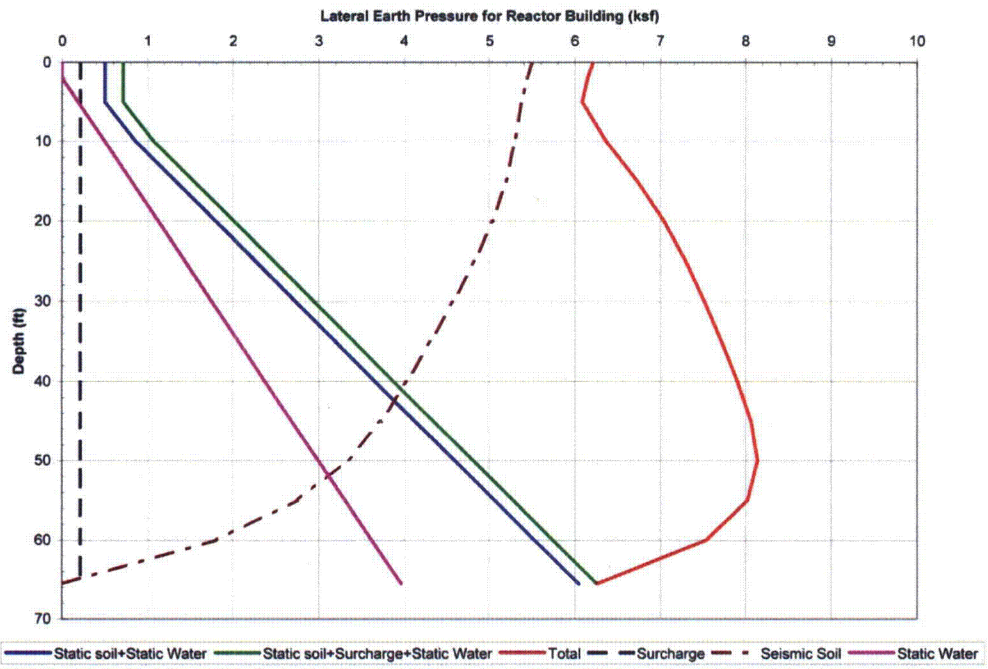


Figure 1 – RB/FB Lateral Earth Pressures with Seismic Lateral Earth Pressure Calculated using the Method in Reference 1



Notes:
1. Lateral load of 500 psf due to compaction is included in the static soil pressure.
2. Total = Static Soil + Static Water + Surcharge + Seismic Soil.

Figure 2 – RB/FB Lateral Earth Pressures with Seismic Lateral Earth Pressure Calculated using the Method in FSAR Reference 2.5.4-247 (FSAR Revision 3, Figure 2.5.4-230)

(Finished Ground Level Grade at Depth = 0)

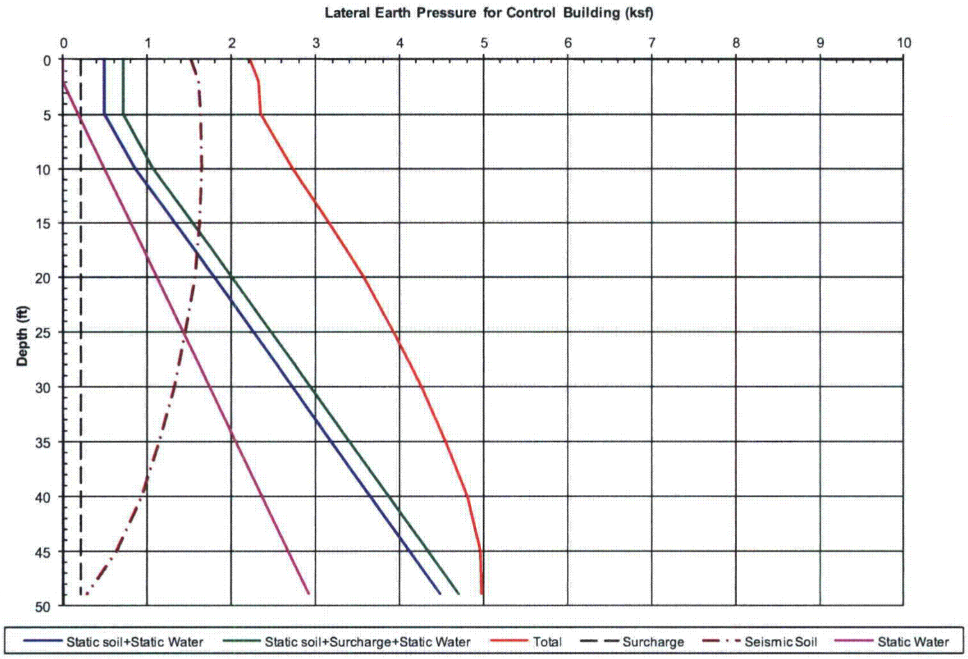


Figure 3 – CB Lateral Earth Pressures with Seismic Lateral Earth Pressure Calculated using the Method in Reference 1

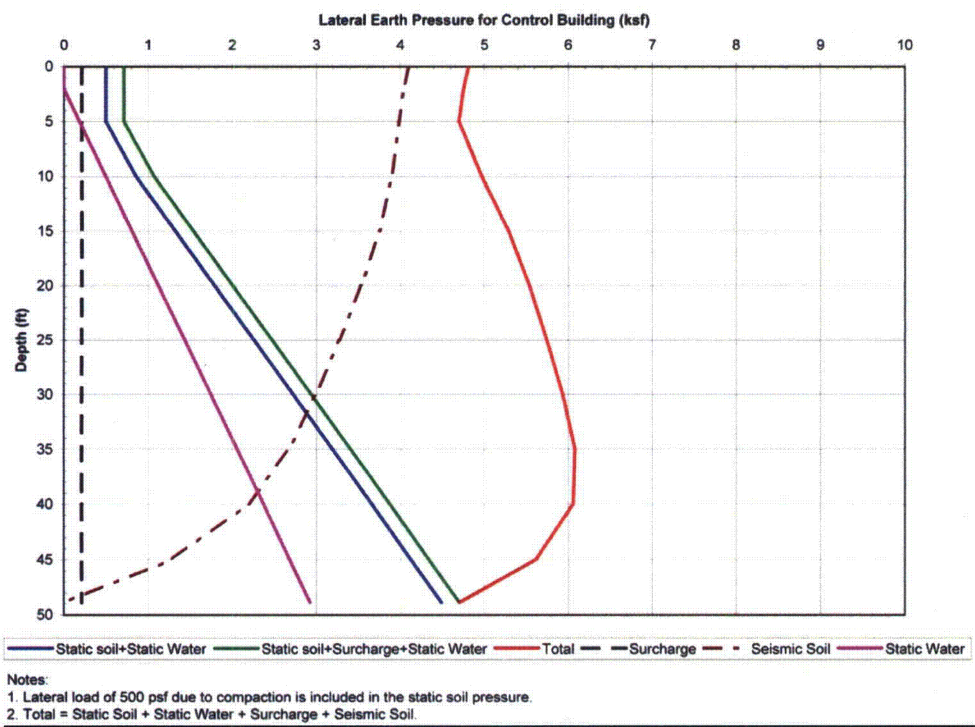


Figure 4 – CB Lateral Earth Pressures with Seismic Lateral Earth Pressure Calculated using the Method in FSAR Reference 2.5.4-247 (FSAR Revision 3, Figure 2.5.4-231)

(Finished Ground Level Grade at Elevation = 4.5 m)

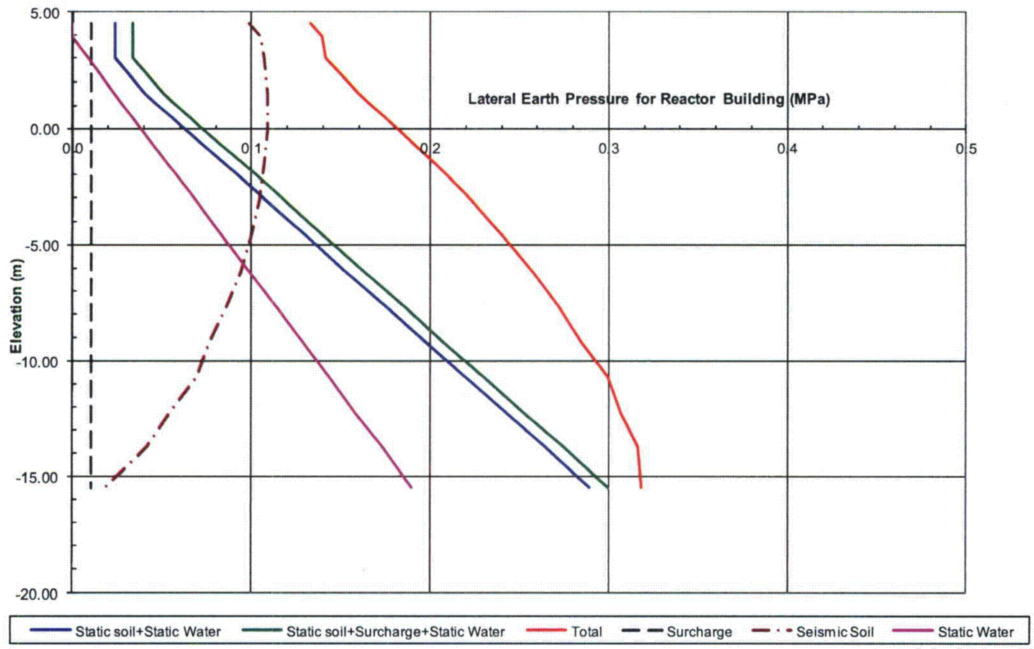


Figure 5 – Metric Units RB/FB Lateral Earth Pressures with Seismic Lateral Earth Pressure in Accordance with Reference 1

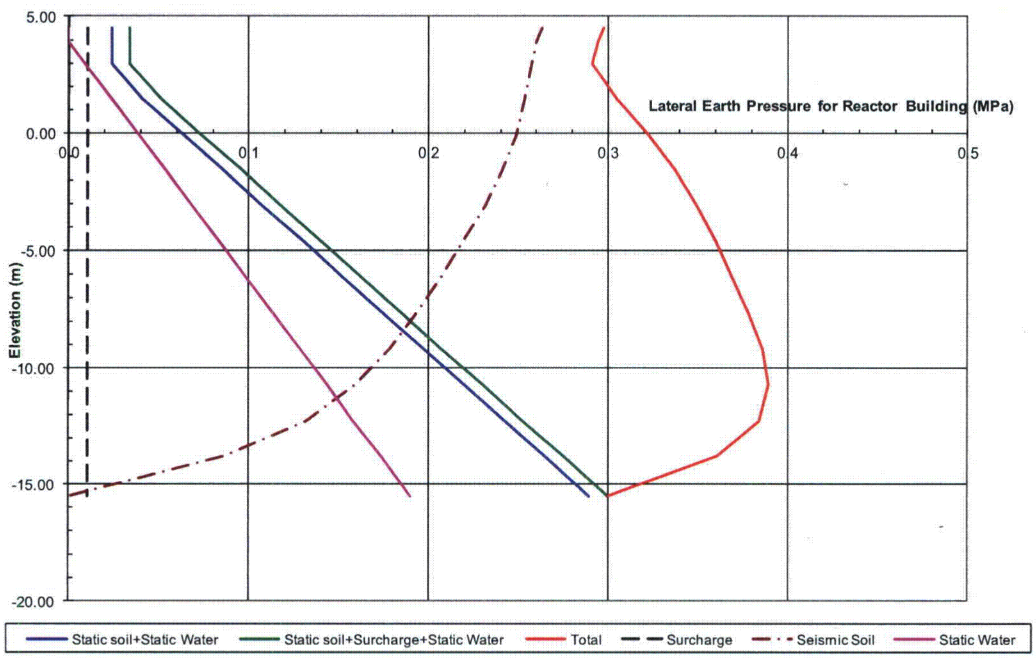


Figure 6 – Metric Units RB/FB Lateral Earth Pressures with Seismic Lateral Earth Pressure in Accordance with FSAR Reference 2.5.4-247

(Finished Ground Level Grade at Elevation = 4.5 m)

26A6642AN Rev. 09

ESBWR | Design Control Document/Tier 2

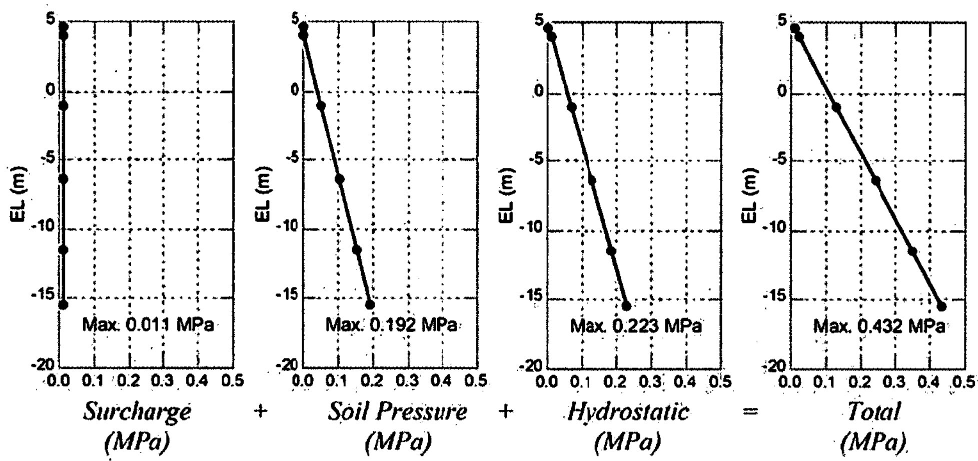


Figure 3G.1-19. Soil Pressure at Rest

Figure 7 – ESBWR DCD, Revision 9, Figure 3G.1-19 RB/FB Static Lateral Earth Pressures

26A6642AN Rev. 09

ESBWR | Design Control Document/Tier 2

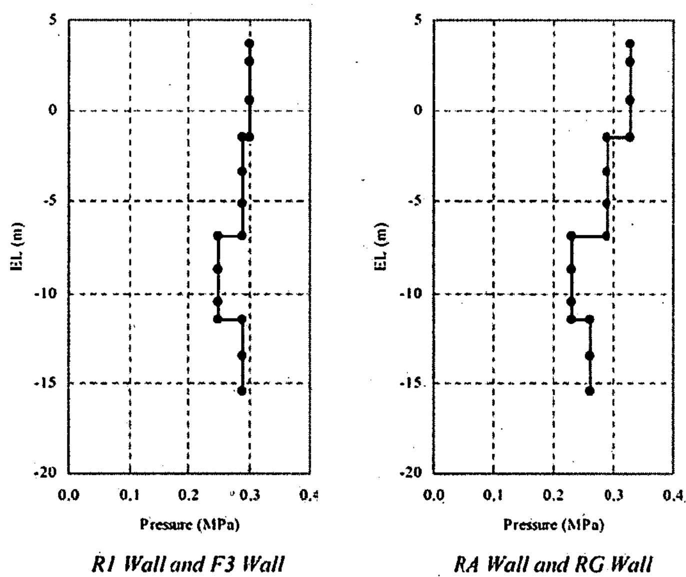


Figure 3G.1-27. Seismic Lateral Soil Pressure

ESBWR DCD Figure 3G.1-27 for the RB/FB seismic lateral earth pressures was developed using the maximum seismic pressures from ESBWR DCD Table 3A.8.8-1 for the respective walls.

Figure 8 – ESBWR DCD, Revision 9, Figure 3G.1-27 RB/FB Seismic Lateral Earth Pressures

(Finished Ground Level Grade at Elevation = 4.5 m)

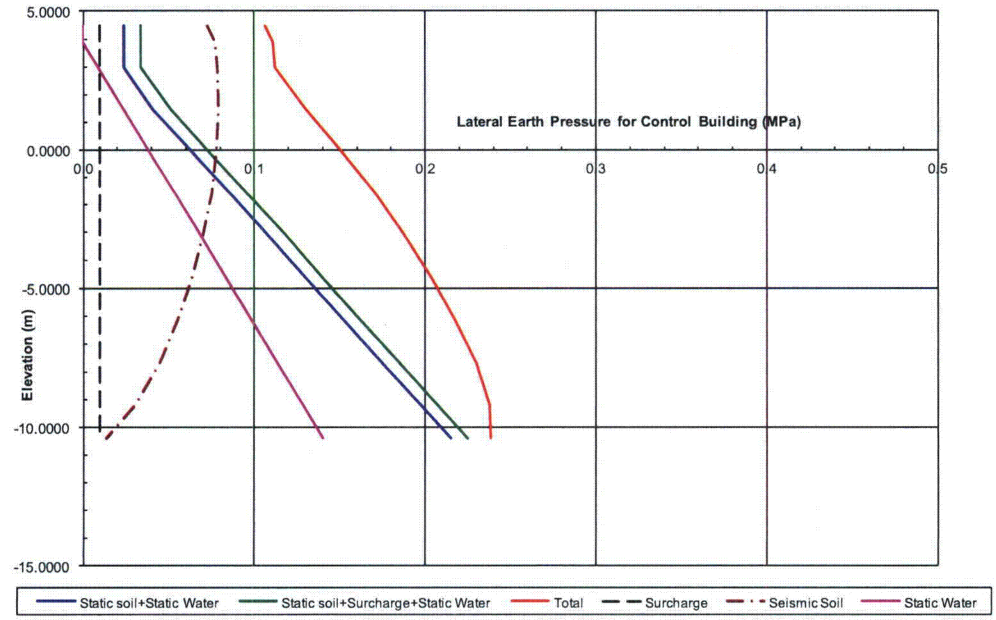


Figure 9 – Metric Units CB Lateral Earth Pressures with Seismic Lateral Earth Pressure in Accordance with Reference 1

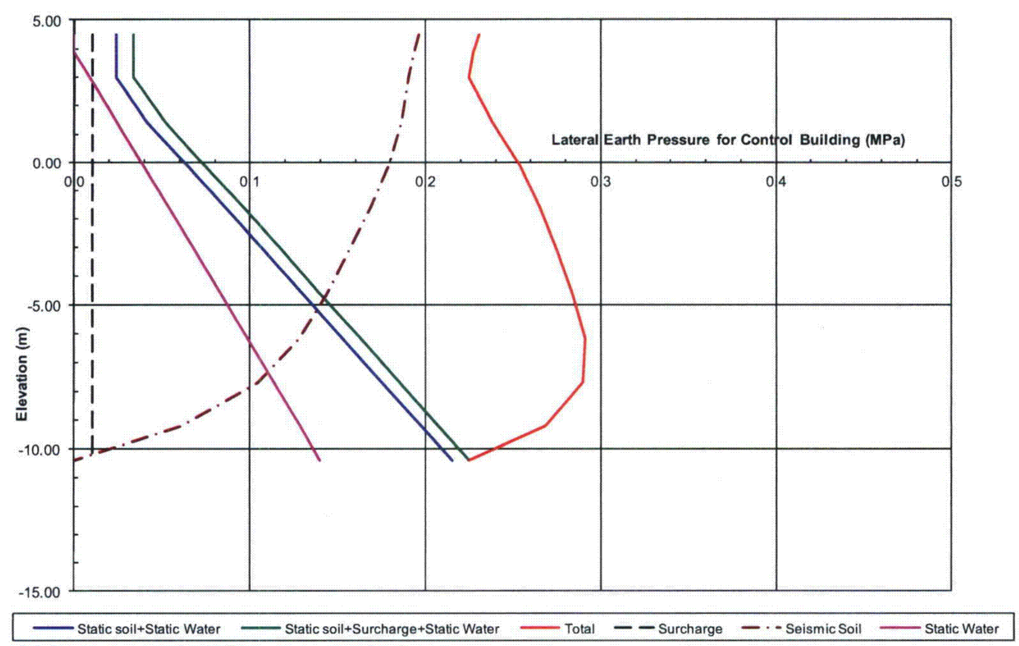
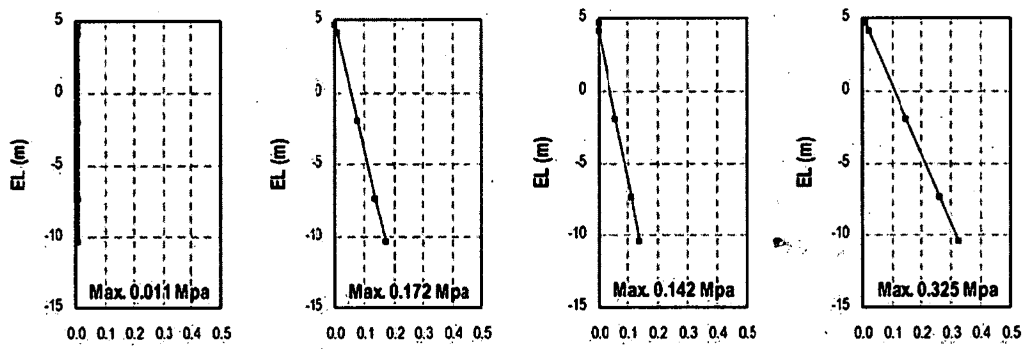


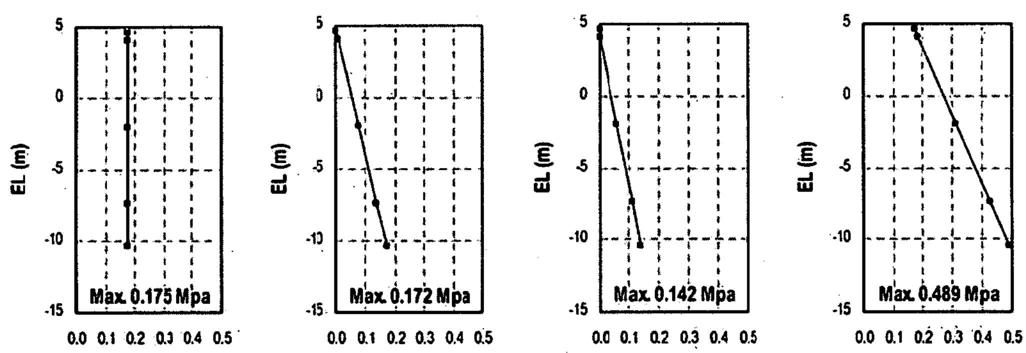
Figure 10 – Metric Units CB Lateral Earth Pressures with Seismic Lateral Earth Pressure in Accordance with FSAR Reference 2.5.4-247

(Finished Ground Level Grade at Elevation = 4.5 m)



Surcharge (MPa) + *Soil Pressure (MPa)* + *Hydrostatic (MPa)* = *Total (MPa)*

Pressure on Walls CA, CD & C1



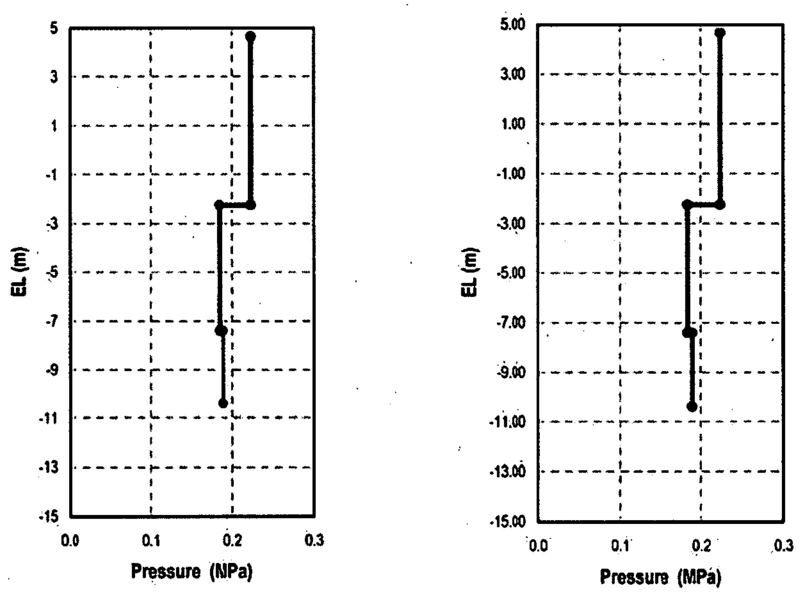
Surcharge (MPa) + *Soil Pressure (MPa)* + *Hydrostatic (MPa)* = *Total (MPa)*

Pressure on Wall C5

Figure 3G.2-12. Soil Pressure at Rest

Figure 11 – ESBWR DCD, Revision 9, Figure 3G.2-12 CB Static Lateral Earth Pressures

(Finished Ground Level Grade at Elevation = 4.5 m)



C1 Wall and C5 Wall *CA Wall and CD Wall*

Figure 3G.2-15. Seismic Lateral Soil Pressure

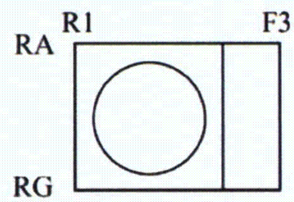
ESBWR DCD Figure 3G.2-15 for the CB seismic lateral earth pressures was developed using the maximum seismic pressures from ESBWR DCD Table 3A.8.8-2 for the respective walls.

Figure 12 – ESBWR DCD, Revision 9, Figure 3G.2-15 CB Seismic Lateral Earth Pressures

Table 3A.8.8-1

Lateral Soil Pressure – RB/FB

Floor Level (m)	R1 and F3 Wall Soil Pressure (MPa)					RA and RG Wall Soil Pressure (MPa)					ASCE 4-98 (MPa)	Envelope (MPa)	
	RL-1	RL-2	RL-3	RL-4	RL-5	RL-1	RL-2	RL-3	RL-4	RL-5		R1 and F3 Wall	RA and RG Wall
4.65													
Slab													
3.65 / -1.00	0.20	0.19	0.24	0.19	0.21	0.27	0.17	0.33	0.19	0.22	0.30	0.30	0.33
Slab													
-2.00 / -6.40	0.15	0.21	0.20	0.21	0.26	0.17	0.19	0.21	0.19	0.20	0.29	0.29	0.29
Slab													
-7.40 / -11.50	0.19	0.21	0.20	0.21	0.25	0.18	0.19	0.18	0.20	0.20	0.23	0.25	0.23
Basemat	0.29	0.24	0.28	0.25	0.23	0.25	0.24	0.25	0.26	0.20	0.16	0.29	0.26



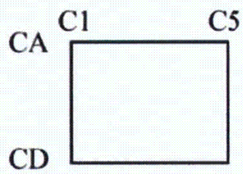
RL RB layered case

SI to U.S. Customary units conversion (SI units are the controlling units and U.S. Customary units are for reference only): 25.4 mm = 1 in, 1 Pa = 1.45038x10-4 psi

Table 3A.8.8-2

Lateral Soil Pressure - CB

Floor Level (m)	C1 and C5 Wall Soil Pressure (MPa)						CA and CD Wall Soil Pressure (MPa)						ASCE 4-98 (MPa)	Envelope (MPa)	
	CL-1	CL-2	CL-3	CL-4	CL-5	CL-6	CL-1	CL-2	CL-3	CL-4	CL-5	CL-6		C1 and C5 Wall	CA and CD Wall
4.65															
Slab															
3.95 to -2.00	0.08	0.15	0.08	0.15	0.12	0.14	0.10	0.13	0.09	0.13	0.11	0.12	0.22	0.22	0.22
Slab															
-2.50 to -7.40	0.10	0.14	0.09	0.14	0.14	0.13	0.10	0.13	0.10	0.13	0.14	0.13	0.18	0.18	0.18
Basemat	0.14	0.19	0.13	0.19	0.17	0.18	0.14	0.19	0.13	0.19	0.16	0.17	0.12	0.19	0.19



CL = CB layered case
SI to U.S. Customary units conversion (SI units are the controlling units and U.S. Customary units are for reference only): 25.4 mm = 1 in, 1 Pa = 1.45038x10-4 psi

ESBWR DCD, Revision 9, Table 3A.8.8-2

Attachment 19
NRC3-12-0003
(2 pages)

Response to RAI Letter No. 70
(eRAI Tracking No. 6245)

RAI Question No. 03.08.05-5

NRC RAI 03.08.05-5

EF3 FSAR Section 3.8.5.5.1, as modified by the markups included with the response to RAI Letter 55 Question 02.05.04-38, indicates that shear failure through the fill concrete below the FSWC is evaluated using shear-friction resistance per the ACI 318 and 349 codes. However, the shear-friction resistance described in these codes assumes yielding of reinforcement through the shear plane, which acts as a clamping force. Therefore, explain whether the fill concrete below the FSWC is reinforced or not. If it is not, explain how the shear resistance is developed. If it is reinforced, describe how the reinforcement is selected.

Response

The fill concrete below the Fire Water Service Complex (FWSC) is reinforced with shear-friction reinforcement as stated in FSAR Section 3.8.5.5.1, Revision 4 (markup submitted in response to NRC RAI Letter No. 55, RAI 02.05.04-38 [ML11171A568]):

> "Failure through the fill concrete at or below the base of the shear keys considering the maximum amount of shear resistance from shear-friction reinforcement allowed in ACI 318, Section 11.6 and the corresponding portions of ACI 349, Section 11.7."

Thus, as described in the FSAR, the shear-friction reinforcement for the fill concrete below the FWSC to support the FWSC shear load will be selected during detailed design by applying concrete codes ACI 318, Section 11.6, and ACI 349, Section 11.7, for Shear-Friction and ACI 318, Section 9.3.5, Design Strength, for structural plain concrete. The codes will be used to apply any strength reductions associated with plain concrete and to select the amount of shear-friction reinforcement required throughout full depth of the fill concrete below the FWSC.

Proposed COLA Revision

None.