Insert 3.7.1.1-1

Figure 2.0-201 and Figure 2.0-202 provide the CSDRS, which envelopes the site-specific design ground motions (FIRS) developed in Subsection 2.5.2 for the RB/FB and CB and is used for design of the ESBWR RB/FB and CB. Figure 2.0-203 and Figure 2.0-204 provide the FWSC CSDRS, which envelopes the site-specific design ground motions (FIRS) for the FWSC and is used for design of the FWSC.

For the Fermi 3 RB/FB and CB, site-specific soil-structure interaction (SSI) analyses were performed to address the following conditions:

- Partial embedment in the Bass Islands Group bedrock of the RB/FB and CB Seismic Category I structures, as shown on Figure 2.5.4-202 and Figure 2.5.4-203, to confirm that the Referenced DCD design is applicable for this case.
- To demonstrate that the Referenced DCD requirements for the backfill surrounding Seismic Category I structures above the top of bedrock can be neglected for RB/FB and CB with the RB/FB and CB partially embedded in the bedrock at the Fermi 3 site.

Figure 2.0-201, Figure 2.0-202, Figure 2.0-203, and Figure 2.0-204 show that the FIRS developed in Subsection 2.5.2 are enveloped by the CSDRS in both horizontal and vertical directions for the RB/FB, CB, and FWSC. Therefore, the Fermi 3 site-specific SSI analyses were not performed to address any exceedance of the CSDRS, rather the Fermi 3 site-specific SSI analyses were performed to address the two Fermi 3 site-specific conditions outlined above.

The site-specific SSI analyses developed hazard-consistent seismic input for site response and SSI analyses consistent with Interim Staff Guidance DC/COL-ISG-017 and a NEI developed white paper (Reference 3.7.1-206). The design ground motion for the SSI analyses (herein called SSI FIRS) is based on an enveloped combination of the FIRS developed in Subsection 2.5.2 for a subsurface profile truncated at the foundation level (Truncated Soil Column Response [TSCR]) and outcrop response FIRS developed for the full soil column to finished ground level grade (Subsection 3.7.1.1.4). Due to the site-specific SSI analyses completed for Fermi 3, the site-specific SSE applicable for plant shut down purposes is the lower of the two SSI FIRS for the RB/FB or CB.

The operating basis earthquake (OBE) is one-third of the SSE. These SSE and OBE definitions are used in conjunction with the criteria specified in DCD Section 3.7.4.4 to determine whether a plant shutdown is required following a seismic event.

Insert 3.7.1.1.4-1

3.7.1.1.4 Fermi 3 Site-Specific SSI Ground Motion

In the SASSI2000 model for the Fermi 3 site-specific SSI analyses, the RB/FB and CB are modeled as partially embedded structures that penetrate into the Bass Islands Group bedrock. The elevation of the top of the Bass Islands Group bedrock is 168.2 m (552.0 ft) NAVD 88. The engineered granular backfill surrounding the RB/FB and CB above the Bass Islands Group bedrock is not included in the model.

The RB/FB and CB FIRS presented in Subsection 2.5.2 were developed as Truncated Soil Column Response (TSCR) outcropping motions with all material above the foundation levels removed (herein called TSCR FIRS). In order to consider the potential influence of material above the foundation levels in the SSI analyses, a second set of FIRS were developed for the Fermi 3 site as a Soil Column Outcrop Response at the RB/FB and CB foundation levels (herein called SCOR FIRS). The SCOR FIRS at the RB/FB and CB foundation levels were developed based on the full soil column to the finished ground level grade at Elevation 179.6 m (589.3 ft) NAVD 88 using the procedure described in Section 5.2.1 of the Interim Staff Guidance DC/COL-ISG-017 and Section 3.2.3 of the NEI developed white paper (Reference 3.7.1-206). This approach was developed to ensure hazard-consistent seismic input for the site-specific SSI analyses. The Fermi 3 site-specific SSI FIRS was then developed by enveloping the site-specific hazard-consistent FIRS computed as a TSCR FIRS, presented in Subsection 2.5.2, and the SCOR FIRS, presented in the Subsection 3.7.1.1.4.1, to capture the maximum site response effects of both soil columns. The enveloping Fermi 3 site-specific SSI FIRS are used as seismic inputs for Fermi 3 site-specific SSI analyses for the RB/FB and CB.

Development of the SSI FIRS and ground motion time histories in three directions (two horizontal and one vertical) compatible with the SSI FIRS are discussed in the following subsections.

3.7.1.1.4.1 Full Soil Column Ground Motions

The process described in Section 3.2.3 of the NEI developed white paper (Reference 3.7.1-206) for development of a SCOR FIRS requires the development of the Performance-Based Surface Response Spectra (PBSRS) at the finished ground level grade. The SCOR FIRS at the RB/FB and CB foundation levels are then computed as outcropping motions from within this full soil column site response analysis. The method used to develop the site-specific PBSRS at the finished ground level grade for the Fermi 3 site is exactly the same as that used in Subsection 2.5.2.5 to develop the TSCR FIRS with the exception that the soil column is extended to the finished ground level grade instead of being truncated at the foundation level. The method in Subsection 2.5.2 employs Approach 2B outlined in NUREG/CR-6728 (Reference 2.5.2-270) to develop hazard-consistent surface spectra at the ground surface and foundation levels from the generic hard rock Uniform Hazard Response Spectrum (UHRS) presented in Subsection 2.5.2.4. As described in Subsection 2.5.2.5, the following steps are involved in this approach:

1. Characterize the dynamic properties of the subsurface materials.

2. Randomize these properties to represent their uncertainty and variability across the site.

3. Based on the deaggregation of the rock hazard, define the distribution of magnitudes contributing to the controlling earthquakes for high-frequency (HF) and low-frequency (LF) ground motions and define the response spectra appropriate for each of the deaggregation earthquakes (DE).

4. Obtain appropriate rock site time histories to weakly match the response spectra for the DEs to be used as input at the base of the subsurface profiles.

5. Compute mean site amplification functions for the HF and LF controlling earthquakes based on the weighted average of the amplification functions for the DEs.

6. Scale the response spectra for the controlling earthquakes (defined in the same manner as the reference earthquake [RE]) by the mean amplification function to obtain surface motions.

7. Envelop these scaled spectra to obtain surface motions at the finished ground level grade that are hazard-consistent with the generic CEUS hard rock hazard levels.

The Fermi 3 site-specific PBSRS at the finished ground level grade and the SCOR FIRS were developed by repeating the analysis steps presented above using the full soil column. Analysis steps 1 and 2 are described below in Subsection 3.7.1.1.4.1.1. Analysis steps 3 and 4 are based on the rock hazard for the Fermi 3 site and are the same as those performed for the TSCR analyses presented in Subsection 2.5.2.4 and Subsection 2.5.2.5. The input rock motions for the site response analyses presented in Subsection 2.5.2.5 are used in the full soil column analysis without modification. Step 5 is described in Subsection 3.7.1.1.4.1.2. Steps 6 and 7 are described in Subsection 3.7.1.1.4.2.

3.7.1.1.4.1.1 Dynamic Properties for the Full Soil Column Profile

The PBSRS surface at the finished ground level grade for the Fermi 3 site is Elevation 179.6 m (589.3 ft) NAVD 88. This elevation will be achieved by excavating and removing the existing overburden to the top of the Bass Islands Group bedrock unit at Elevation 168.2 m (552.0 ft) NAVD 88, and backfilling with engineered granular backfill to the finished ground level grade. This process results in an average engineered granular backfill thickness of approximately 11.2 m (37 ft). Below the engineered granular backfill is bedrock and the fill concrete between the foundation walls and the bedrock. Subsection 2.5.2.5.1 discusses the development of the dynamic engineering properties for the in-situ bedrock material. The dynamic engineering properties for the in-situ bedrock material used in the site response analysis for computing the PBSRS at the finished ground level grade and SCOR FIRS are provided in Table 3.7.1-201, Table 3.7.1-202 and Table 3.7.1-203 below layer number 9.

Above the bedrock, the shear-wave velocity (V_S) for the engineered granular backfill is estimated based on empirical relationships for angular-grained material from Richart et al (Reference 3.7.1-201):

$$V_S = [159 - (53.5)e](\overline{\sigma_0})^{0.25}$$

Where:

V_S is the shear wave velocity in ft/sec
e is the void ratio
$\overline{\sigma_0}$ is the average effective confining pressure in lb/ft^2 defined as

$$\overline{\sigma_0} = \frac{1}{3}(\sigma_V' + 2\sigma_H')$$

σ_V' is the effective vertical stress in lb/ft^2
σ_H' is the effective horizontal stress in lb/ft^2 with $\sigma_H' = k_0\sigma_V'$
k_0 is the at-rest earth pressure coefficient

Figure 3.7.1-201 shows the estimated three shear wave velocity profiles (the lower-range [LR], intermediate-range [IR] and upper-range [UR] site response analysis profiles) for the engineered granular backfill used as input to the site response analysis for computing the PBSRS at the finished ground level grade and SCOR FIRS. A range of values for the engineered granular backfill is used to assess the potential variability of the fill shear-wave velocities in the full soil column site response analyses. The three shear wave velocity profiles for the engineered granular backfill are provided in layers 1 through 9 in Table 3.7.1-201, Table 3.7.1-202 and Table 3.7.1-203 for the LR, IR and UR profiles, respectively. As stated in Subsection 2.5.2.5.1, a single velocity profile is appropriate for the in-situ material at the Fermi 3 site; therefore, the velocity profile does not change below the engineered granular backfill. The groundwater table is assumed to be at the maximum historical groundwater elevation of 175.6 m (576.11 ft) NAVD 88 (Subsection 2.4.12) for estimating the shear wave velocities of the engineered granular backfill.

3.7.1.1.4.1.1.1 Density

Unit weights for the LR, IR and UR site response analysis profiles are provided in Table 3.7.1-201, Table 3.7.1-202 and Table 3.7.1-203, respectively, for engineered granular backfill and bedrock. A range of values for the engineered granular backfill is used to assess the potential variability of density in the full soil column site response analyses.

3.7.1.1.4.1.1.2 Shear Modulus Reduction and Damping

The upper 11.3 m (37 ft) of the Fermi 3 full soil column site response analysis profile consists of engineered granular backfill. The modulus reduction and damping relationships for the engineered granular backfill used in the site response analyses are chosen from EPRI generic sand curves (Reference 2.5.4-229). Figure 3.7.1-202 presents the modulus reduction and damping relationships for the 0 to 6.1 m (20 ft) and 6.1 m to 15.2 m (20 to 50 ft) depth ranges. The damping ratio curves were limited to a maximum of 15 percent damping for site response analyses as recommended in Appendix E of Regulatory Guide 1.208. The type of modulus reduction and damping relationship for engineered granular backfill in the LR, IR and UR site response analysis profiles are provided in Table 3.7.1-201, Table 3.7.1-202, and Table 3.7.1-203.

Below 11.3 m (37 ft), the remaining portion of the full soil column site response analysis profile consists of dolomite and claystone bedrock as discussed in Subsection 2.5.2.5.1.2. The bedrock is expected to remain essentially linear at low to moderate levels of shaking. Damping within the in situ dolomite and claystone bedrock is characterized by a high-frequency attenuation parameter (κ) that ranges from 0.001 and 0.003 seconds (Subsection 2.5.2.5.1). The values of κ established in Subsection 2.5.2.5.1 are used to develop the full soil column site response analysis for the Fermi 3 site.

3.7.1.1.4.1.1.3 Randomization of Dynamic Properties

Site response analyses for the full soil column profile were conducted using randomized dynamic soil properties following the methods described in Subsection 2.5.2.5.1.3. The randomized dynamic soil properties included shear wave velocity, modulus reduction, and damping. Additionally, the locations of velocity layer boundaries were randomized to vary uniformly within the range of layer thickness observed in the site borings.

Sixty randomized V_S profiles were generated for each of the LR, IR and UR site response analysis profiles (a total of 180 randomized V_S profiles for all three site response analysis profiles). The statistics of the randomized profiles are summarized by comparing to the input target values for median velocity and standard deviation (sigma) of $\ln(V_s)$ for the LR, IR and UR profiles. As an example of this process, Figure 3.7.1-203 to Figure 3.7.1-205 show the 60 randomized velocity profiles and the statistics of the randomized shear wave velocity profiles for the IR site response analysis profile.

The modulus reduction and damping relationships were also randomized as shown on Figure 3.7.1-206 and Figure 3.7.1-207. The standard deviation in the modulus reduction and damping were set so that the randomized relationships fell within recommended bounds provided by Silva (Reference 2.5.2-287).

The damping in the sedimentary bedrock beneath the engineered granular backfill was computed using the randomized sedimentary bedrock layer velocities and thicknesses, and the selected values of κ described in Subsection 2.5.2.5.1.

3.7.1.1.4.1.2 Site Amplification Functions

A process similar to the description for developing the GMRS and FIRS site amplification functions in Subsection 2.5.2.5.3 was repeated to produce mean site amplification functions for the PBSRS at the finished ground level grade and the SCOR FIRS at the RB/FB and CB foundation levels.

Figure 3.7.1-208 shows the site response logic tree used to compute the controlling earthquake or RE mean amplification function and the weights assigned to the bedrock damping values and the subsurface profiles. This logic tree is similar to Figure 2.5.2-266; however, instead of including uncertainty in the shear modulus and damping curves for the glacial till that will be excavated during construction, the logic tree includes the three LR, IR and UR site response analysis profiles to assess uncertainty in the dynamic properties of the engineered granular backfill. For each DE, mean amplification functions were computed using three bedrock damping values (κ) and the LR, IR and UR profiles. The results from the three DEs are then combined to produce a weighted mean amplification function for the RE. The weights assigned to the DEs are given in Table 2.5.2-222.

The mean amplification functions were then smoothed to remove small dips and peaks considered an artifact of the finite number of analyses. Linear interpolation in logarithmic space (log-log interpolation) smoothed the HF and LF amplification function above 1 Hz and below 10 Hz, respectively.

Figure 3.7.1-209 shows the mean PBSRS site amplification functions at the finished ground level grade for the 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6} exceedence levels of input ground motion. Both the original and smoothed PBSRS site amplification functions are presented. Because of the non-linear behavior of the engineered granular backfill, the site amplification is sensitive to the level of input motion for most frequencies.

The SCOR site amplification functions at the RB/FB and CB foundation levels were obtained from the results of the site response analyses for the full soil column profile. Again, the mean amplification functions were smoothed to remove small features considered artifacts of the analyses. Figure 3.7.1-210 and Figure 3.7.1-211 show both the mean and smoothed SCOR site amplification functions for 10^{-4} and 10^{-5} exceedence levels of input ground motions at the RB/FB and CB foundation levels, respectively. These amplification functions show little sensitivity to the two different levels of motions because both foundations are founded in the same bedrock unit that has a relatively high and uniform shear-wave velocity.

3.7.1.1.4.2 Surface Hazard Spectra for PBSRS and SCOR FIRS

The surface UHRS at the finished ground level grade and at the RB/FB and CB foundation levels were constructed following the procedures described in Subsection 2.5.2.6 for the GMRS at the top of competent material. The appropriate site amplification functions were used to scale the generic hard rock UHRS and the LF and HF RE to obtain the surface UHRS at the finished ground level grade and for the RB/FB and CB SCOR foundation levels. For the generic hard rock UHRS, the HF amplification function is used for frequencies above 5 Hz and the LF amplification function is used for frequencies below 2.5 Hz. Frequencies between 2.5 and 5 Hz use a weighted combination of the HF and LF amplifications.

Figure 3.7.1-212 shows the surface spectra, for the scaled LF and HF RE and the scaled hard rock UHRS, and the envelop spectrum for the 10^{-4} exceedance level ground motions at the finished ground level grade. The amplification functions and the corresponding surface spectrum show a slight dip in the frequency range of 6 to 25 Hz. The dip was conservatively removed in constructing the enveloped surface UHRS for the 10^{-4} exceedance level ground motions. As a result, the final spectra will be conservative in the frequency range of approximately 6 to 25 Hz.

Figure 3.7.1-213 shows the SCOR spectra, for the scaled LF and HF RE and the scaled hard rock UHRS, and the envelop spectrum for the 10^{-4} exceedance level ground motions at the RB/FB foundation level developed using the full soil column. The SCOR UHRS at the RB/FB foundation level was developed using the same process described for the finished ground level grade surface UHRS, including smoothing through the dip in the spectrum between approximately 6 and 25 Hz.

Similar operations were performed to develop the SCOR UHRS for the 10^{-4} exceedance level ground motions at the CB foundation level, and the 10^{-5} exceedance level motions at both the finished ground level grade surface, and the RB/FB and CB foundation levels.

3.7.1.1.4.3 Incorporation of Cumulative Absolute Velocity (CAV)

The EPRI CAV model was implemented in a second set of PSHA calculations for the full soil column at the Fermi 3 site following the procedures described in Subsection 2.5.2.6.2. Again, two sets of calculations were performed. The first set incorporated the CAV filter and site amplification, and the second set was performed using only site amplification. The purpose of performing these two sets of calculations is to provide ratios of CAV/no-CAV spectral values at the seven spectral frequencies used in the PSHA calculations. These spectral ratios are then used to adjust the smooth surface UHRS discussed in Subsection 3.7.1.1.4.2 to produce the final hazard-consistent surface UHRS.

Figure 3.7.1-214 through Figure 3.7.1-220 compare the surface mean hazard curves computed with and without CAV at the finished ground level grade for the seven spectral frequencies of 0.5, 1, 2.5, 5, 10, 25, and 100 Hz, respectively. Also shown on these figures is the corresponding generic CEUS hard rock hazard curve from Subsection 2.5.2.4.4.

The surface mean hazard results shown on Figure 3.7.1-214 through Figure 3.7.1-220 are interpolated to obtain the spectral accelerations corresponding to mean annual frequencies of exceedance of 10^{-4} and 10^{-5}. The ratio of the spectral accelerations computed with CAV to those computed without CAV for the seven spectral frequencies are then used to scale the smooth surface spectra described in Subsection 3.7.1.1.4.2 to produce hazard-consistent surface UHRS that are based on the use of the CAV filter. The CAV/no-CAV spectral ratios at intermediate periods are obtained by log-log interpolation. Figure 3.7.1-221 shows the resulting mean 10^{-4} and 10^{-5} surface UHRS, with and without CAV, at the finished ground level grade.

3.7.1.1.4.4 PBSRS at the Finished Ground Level Grade

3.7.1.1.4.4.1 Horizontal PBSRS

Development of the horizontal PBSRS at the finished ground level follows the same processes for development of the GMRS provided in Regulatory Guide 1.208 and Subsection 2.5.2.6.3. Figure 3.7.1-222 shows the horizontal PBSRS at the finished ground level grade calculated using a design factor (DF) (10^{-4} UHRS x DF) and the minimum value (10^{-5} UHRS x 0.45) when the DF exceeds 4.2. The final PBSRS is the envelope of the two horizontal PBSRS curves. Figure 3.7.1-222 also shows the 10^{-4} and 10^{-5} surface UHRS at the finished ground level grade. Table 3.7.1-204 presents the resulting horizontal PBSRS values.

3.7.1.1.4.4.2 Vertical PBSRS

The vertical GMRS developed in Subsection 2.5.2.6.3 used vertical to horizontal (V/H) spectral ratios recommended by NUREG/CR-6728 (Reference 2.5.2-270) for CEUS bedrock sites. The vertical PBSRS at the finished ground level grade was also constructed using V/H spectral ratios; however, the full soil column profile consists of a thin layer of soil over bedrock. This profile is somewhat different than the generic rock conditions for which the V/H ratios shown on Figure 2.5.2-287 were developed. At present, there are no published V/H ratios for ground motions in the CEUS for the conditions represented by the full soil column profile, a profile with a thin soil layer over bedrock. Therefore, the V/H ratios for the vertical PBSRS were developed by examining differences between bedrock and shallow soil site V/H ratios for western US (WUS) data and using the differences to adjust the CEUS hard rock V/H values.

The WUS V/H ratios recommended in NUREG/CR-6728 (Reference 2.5.2-270) were based on ground motion relationships for a generic bedrock site classification. More recently, Campbell and Bozorgnia (Reference 3.7.1-203) developed empirical ground motion prediction equations for bedrock sites that contained explicit categorization for firm bedrock (V_{S30} 830 m/s ± 339 [2723 ft/s ± 1112 ft/s]) and soft rock (V_{S30} 421 m/s ± 109 [1381 ft/s ± 358 ft/s]) sites, where V_{S30} is the average shear wave velocity in the upper 30 m (100 ft). The soft bedrock V/H ratios are used to indicate the potential behavior of a shallow stiff soil site. The results obtained using Campbell and Bozorgnia (2003) suggest that the peak in the V/H ratios for soft bedrock shifts slightly towards lower frequencies compared to the peak for firm bedrock sites. The V/H ratios are also lower on soft bedrock for frequencies less than about 3 Hz.

The Pacific Earthquake Engineering Research (PEER) Center's Next Generation Attenuation (NGA) Project (Reference 3.7.1-207) developed an extensive data base of strong motion records from active tectonic environments. The records from this data base were analyzed to evaluate the appropriate WUS V/H values for soft and firm bedrock sites. A set of 21 records was selected from the PEER NGA database that met the following criteria:

- $0.2\ g \le PGA \le 0.5\ g$, where PGA is peak ground acceleration
- Depth to V_S of 1 km/sec (3,280 ft/s) < 100 m (328 ft) to obtain records on bedrock and shallow soil sites
- Lowpass filter used in record processing ≥ 20 Hz to obtain V/H values at moderately high frequencies.
- Vertical component available from the PEER NGA database.

These data were used to compute average V/H ratios based on V_{S30} for bedrock sites [V_{S30} > 650 m/s (2133 ft/s)] and shallow soil sites [V_{S30} < 650 m/s (2133 ft/s)]. The PEER NGA data set is limited, but suggests a trend similar to Campbell and Bozorgnia (2003) results, with a slight shift in the peak of the V/H ratios towards lower frequencies at shallow soil sites.

Figure 3.7.1-223 shows V/H spectral ratios as a function of frequency used for generating the vertical PBSRS at the finished ground level grade, and the V/H spectral ratios recommended by NUREG/CR-6728 (Reference 2.5.2-270) for CEUS bedrock sites with a PGA between 0.2 g and 0.5 g. The V/H spectral ratios used for generating the vertical PBSRS are based on the V/H spectral ratios recommended by NUREG/CR-6728 (Reference 2.5.2-270) for CEUS bedrock sites with a shift in the frequencies above 10 Hz to represent the shift in the peak V/H spectral ratios towards lower frequencies in the Campbell and Bozorgnia (Reference 3.7.1-203) and PEER NGA comparisons. Additionally, at frequencies below 5 Hz the V/H spectral ratio is reduced slightly to reflect the differences observed in the Campbell and Bozorgnia (Reference 3.7.1-203) comparison of firm and soft bedrock sites. The resulting vertical PBSRS is listed in Table 3.7.1-204 along with the values of V/H. Figure 3.7.1-224 shows the horizontal and vertical PBSRS (5 percent damping) at the finished ground level grade.

3.7.1.1.4.4.3 Deterministic Profiles for the Full Soil Column

Three deterministic profiles, the best estimate (BE), lower bound (LB) and upper bound (UB), were developed from the PBSRS site response analysis following the requirements of SRP 3.7.2 and guidance from the Interim Staff Guidance DC/COL-ISG-017. These profiles were based on the statistics of the iterated soil properties for the randomized full soil column profile described in Subsection 3.7.1.1.4.1.1.3.

The full soil column BE profile was set equal to values interpolated between the median iterated soil properties for the 10^{-4} and 10^{-5} exceedance level ground motions. The resulting subsurface layers and the corresponding strain compatible dynamic engineering properties for the full soil column BE profile are listed in Table 3.7.1-205.

The full soil column LB profile was set equal to the 16th percentile of the distribution of randomized soil properties, and the full soil column UB profile was set equal to the 84th percentile of the distribution of randomized soil properties. The range in the full soil column UB and LB shear wave velocities was increased where necessary to maintain the minimum variation from the shear modulus for the BE profile (G_{best}), more than 1.5 x G_{best} or G_{best} / 1.5, to define the range as required in SRP 3.7.2. Table 3.7.1-206 and Table 3.7.1-207 list the resulting subsurface layers and the corresponding strain compatible dynamic engineering properties for the full soil column LB and UB profiles, respectively.

Figure 3.7.1-225 shows the full soil column LB, BE and UB subsurface shear wave velocity profiles for the Fermi 3 site near the RB/FB and CB. The corresponding damping ratios were obtained from the statistics of the iterated profiles assuming negative correlation between shear wave velocity (V_S) and damping: that is the 16th percentile damping was used for the full soil column UB profile and the 84th percentile damping was used for the full soil column LB profile. The compression wave velocities were based on the measured shear wave velocities for the in situ materials, the recommend Poisson's ratios in Table 2.5.4-202, and the relationship from Kramer (Reference 2.5.4-232) presented as follows:

$$\frac{V_P}{V_S} = \sqrt{\frac{2-2v}{1-2v}}$$

Where:

V_P is the compression wave velocity
V_S is the shear wave velocity
ν is Poisson's ratio

Although the bedrock is below the groundwater table at the site, compression wave velocities exceeded the 1,524 m/s (5,000 ft/sec) (velocity in water); therefore, a minimum value of 1,524 m/s (5,000 ft/sec) for the bedrock compression wave velocity below the water table was not imposed.

3.7.1.1.4.5 SCOR FIRS

The process described in Subsection 3.7.1.1.4.4 was used to develop the SCOR FIRS at the RB/FB and CB foundation levels. The SCOR FIRS are shown on Figure 3.7.1-226 and Figure 3.7.1-227 for the RB/FB and CB, respectively. The spectral accelerations for the RB/FB and CB SCOR FIRS are provided in Table 3.7.1-208 and Table 3.7.1-209, respectively. Also shown on Figure 3.7.1-226 and Figure 3.7.1-227 are the ESBWR CSDRS (Reference 2.5.2-291). The SCOR FIRS for the RB/FB and CB are enveloped by the ESBWR CSDRS

Since the RB/FB and CB foundation levels are within the bedrock units, the vertical SCOR FIRS were generated using the V/H spectral ratios for hard rock recommended by NUREG/CR-6728 (Reference 2.5.2-270) for CEUS bedrock sites. The recommended CEUS hard rock V/H spectral ratios for 0.2 g ≤ PGA ≤ 0.5 g are shown on Figure 3.7.1-223 (red curve). Although the PGA for the horizontal SCOR FIRS is slightly less than 0.2 g, the V/H spectral ratios for a PGA between 0.2 g and 0.5 g were used. Because the vertical PBSRS was based on modified V/H spectral ratios for a PGA between 0.2 g and 0.5 g, use of the rock V/H spectral ratios for this PGA range to develop the vertical SCOR FIRS maintains consistent vertical to horiznontal spectral ratios between the PBSRS and SCOR FIRS.

3.7.1.1.4.6 SSI FIRS

The horizontal SSI FIRS was developed by enveloping the horizontal TSCR FIRS from Subsection 2.5.2 and the horizontal SCOR FIRS developed in Subsection 3.7.1.1.4.5 to capture the maximum site response effects from full and truncated subsurface profiles. The final SSI FIRS was smoothed by log-log interpolation to remove a dip between about 0.5 and 2 Hz. Figure 3.7.1-228 and Figure 3.7.1-229 show the TSCR FIRS, the SCOR FIRS, the enveloped FIRS, and the final smoothed horizontal SSI FIRS at the RB/FB and CB foundation levels (herein called horizontal SSI FIRS), respectively. The RB/FB and CB horizontal SSI FIRS values are provided in Table 3.7.1-210.

A similar procedure was used to construct the vertical SSI FIRS as was used for the horizontal SSI FIRS. Figure 3.7.1-230 and Figure 3.7.1-231 show the TSCR FIRS, the SCOR FIRS, the enveloped FIRS, and the final smoothed vertical SSI FIRS at the RB/FB and CB foundation levels (herein called vertical SSI FIRS), respectively. The RB/FB and CB vertical SSI FIRS values are also provided in Table 3.7.1-210.

The final smoothed horizontal and vertical SSI FIRS for the RB/FB and CB used for development of the ground motion time histories are shown on Figure 3.7.1-232 and Figure 3.7.1-233, respectively. Table 3.7.1-210 provides the PGA – listed as the 100 Hz value – for the RB/FB and CB horizontal SSI FIRS. As shown on the footnote in Table 3.7.1-210, the PGA for RB/FB and CB horizontal SSI FIRS are higher than the 0.1 g requirement of SRP 3.7.1 Section II (Acceptance Criteria), Revision 3.

Insert 3.7.1.1.5-1

Two sets of three orthogonal time histories (two horizontal and one vertical component) were generated to match the horizontal and vertical SSI FIRS (Subsection 3.7.1.1.4.6) for the RB/FB and CB, respectively, in accordance with the criteria of NUREG/CR-6728 (Reference 2.5.2-270). The selected seed time history is the 1999 Chi-Chi Taiwan Earthquake, KAU078 station, chosen from the CEUS record library provided in UREG/CR-6728 (Reference 2.5.2-270). This time history represents a distant recording of a large magnitude (moment magnitude 7.6) earthquake, consistent with the large contribution of the New Madrid source to the hazard at the Fermi 3 site. Details of this record are provided in Table 3.7.1-211.

A single set of time histories (two horizontal and one vertical component) was developed for both the RB/FB and CB foundation levels to satisfy the enveloping requirements of Option 1, Approach 2 of SRP 3.7.1 Section II (Acceptance Criteria), Revision 3. Per paragraph 2(d) of Approach 2, in lieu of the power spectrum density requirement, the requirement that the computed 5 percent damped response spectrum of the time history does not exceed the target response spectrum at any frequency by more than 30 percent was met. Table 3.7.1-212 and Table 3.7.1-213 presents the correlation coefficients between each combination of time history components (two horizontal and one vertical). The correlation coefficients all fall below the recommended criteria of 0.3 given in NUREG/CR-6728 (Reference 2.5.2-270). This criterion was used in place of the SRP criterion of 0.16 based on the following statements in NUREG/CR-6728 (Reference 2.5.2-270):

> "Directional correlation coefficients between pairs of records are typically required to be relatively low to ensure that a structure or structural element cannot be oriented in an analysis in such a manner so as to minimize some important directional response quantity of interest. However, if the limiting value is made too low, a significant number of empirical recordings in any earthquake bin may unnecessarily be eliminated from further consideration as a seed for generating design ground motions. Since the response quantity is a function of the structural characteristics and not of the empirical bin data sets, it is recommended that the upper limit for the zero-lag cross-correlation coefficient between any two design ground motions be 0.3. For correlation coefficients less than this limit, no significant reduction in response will be attained by orientation of the structure"
>
> "The current NRC staff position limits the correlation between component pairs of artificial acceleration records of a three component enveloping set to a value of 0.16 or less. This is based on some early limited computational results generated by Chen (1975). More complete evaluations were generated by Hadjian (1978, 1981) who included the effect of recorder orientation to estimate maximum values of correlations for a somewhat larger data set. The results of this computation indicated maximum values of acceleration correlation coefficients of 0.32. The data summary of Tables 5-4 and 5-5 do not include the effect of recorder orientation. As mentioned in Section 5.3, a value of 0.3 is recommended for the acceptance criteria."

Spectral matching was performed using the time-domain spectral matching procedure proposed by Lilhanand and Tseng (Reference 3.7.1-204) and later modified by Abrahamson (Reference 3.7.1-205). Figure 3.7.1-234 through Figure 3.7.1-239 show the comparison of the response spectrum in the two horizontal and one vertical direction for the following:

- The SSI FIRS.
- 1.3 times (30 percent greater) the SSI FIRS.
- 0.9 times (10 percent less) the SSI FIRS at the RB/FB and CB levels.
- Response spectrum for the spectrally matched time history.

The response spectra for the spectrally-matched time histories were calculated for comparison with the SSI FIRS at 301 spectral frequency points (or 100 frequencies per spectral decade). As shown in Figure 3.7.1-234 through Figure 3.7.1-239 the 5 percent damped response spectra of the spectrally-matched time histories are within the range of 0.9 to 1.3 times the SSI FIRS at any frequency. Therefore, the criteria of Option 1, Approach 2 of SRP 3.7.1 Section II (Acceptance Criteria), Revision 3 are satisfied.

The time step and duration of the matched time histories are 0.005 seconds and 80 seconds, respectively. The duration of the time histories for Arias Intensity to rise from 5 percent to 75 percent is greater than the minimum 6 second duration identified in SRP 3.7.1, Section II (Acceptance Criteria), Revision 3, and consistent with the characteristic earthquake duration of NUREG/CR-6728 (Reference 2.5.2-270). Details of the matched time histories including the PGA, peak ground velocity (PGV), and peak ground displacement (PGD) are presented in Table 3.7.1-214. Figure 3.7.1-240 to Figure 3.7.1-245 present the matched time histories (outcropping motions) compatible with the RB/FB and CB SSI FIRS at the foundation levels. The duration, and the values of PGV/PGA and PGA*PGD/PGV^2 are generally consistent with the characteristic values reported in NUREG/CR-6728 (Reference 2.5.2-270). The hard rock UHRS for the FERMI 3 site represents a combination of hazard from large, distant earthquakes and smaller, closer earthquakes. Thus, it is expected 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. Spectral matching of the time histories to response spectra extended to a period of 10 seconds also enriches the PGD values, leading to an increase in the values of PGA*PGD/PGV^2.

In accordance with Interim Staff Guidance DC/COL-ISG-017 and the NEI developed white paper (Reference 3.7.1-206), the spectrally-matched time histories compatible with the RB/FB and CB SSI FIRS were then input as outcropping motions at the foundation level into the three deterministic LB, BE, and UB SSI profiles shown on Figure 3.7.1-252 (see Subsection 3.7.1.3) to compute the resulting in-column motions at the RB/FB and CB foundation levels using the program SHAKE (Reference 2.5.2-282). A total of 18 SHAKE analyses were performed using combinations of the three SSI profiles (LB, BE, UB), the three time history components (two horizontal [H1, H2] and one vertical [V] components) and the two foundation levels (RB/FB and CB). The SHAKE analyses were performed using SSI profiles shown on Figure 3.7.1-252 (see Subsection 3.7.1.3) without iteration of soil properties to generate in-column motions at the foundation levels for input into the SASSI2000 computer program for the Fermi 3 site-specific SSI analysis.

Interim Staff Guidance DC/COL-ISG-017 and the NEI developed white paper (Reference 3.7.1-206) state that time histories matched to the outcrop FIRS should be convolved from the foundation level up to the finished ground level grade using the full soil column LB, BE, and UB subsurface profiles, and that the resulting envelope of the three surface spectra from the time histories should envelop the PBSRS at the finished ground level grade. This comparison was made by matching the seed time history using the methods discussed in this section to the SCOR FIRS presented in this Subsection 3.7.1.1.4.5. The matched time histories compatible with the SCOR FIRS were then input into the three deterministic soil column profiles (LB, BE, and UB) for the full soil column, shown on Figure 3.7.1-225, and convolved to the PBSRS level at finished ground level grade with SHAKE analyses. Figure 3.7.1-246 to Figure 3.7.1-251 show the comparison of the PBSRS at the finished ground level grade with the surface response spectra obtained from SHAKE analyses using the LB, BE, and UB full soil column profiles and the matched time histories compatible with the RB/FB and CB SCOR FIRS. The envelope of the three response spectra at the ground surface exceeds the PBSRS at the finished ground level grade for each component of motion, satisfying the requirement specified in Interim Staff Guidance DC/COL-ISG-017 and the NEI developed white paper (Reference 3.7.1-206).

The SSI FIRS is the envelop of the TSCR FIRS and the SCOR FIRS, resulting in spectral accelerations larger than or equal to the SCOR FIRS. Therefore, based on the comparison with the SCOR FIRS, the same comparison using the SSI FIRS would envelop the PBSRS at the finished ground level grade with a greater margin.

Insert 3.7.1.2-1

3.7.1.2 Percentage of Critical Damping Values

Add the following at the end of Subsection 3.7.1.2.

Table 3.7.1-215 through Table 3.7.1-217 provide the damping ratio for subsurface material properties used in Fermi 3 site-specific SSI analyses for the RB/FB and CB.

Insert 3.7.1.3-1

Subsection 2.5.4 provides engineering properties of subsurface materials at the Fermi 3 site. The design groundwater elevation assumed for development of the LB, BE and UB subsurface profiles is provided in Subsection 3.7.1.1.4.1.1. Table 3.7.1-215 through Table 3.7.1-217 provide the strain compatible dynamic engineering properties of subsurface material for the LB, BE and UB subsurface profiles, respectively, used for the Fermi 3 site-specific SSI analyses for the RB/FB and CB. The three profiles are identical to the full soil column profiles developed in Subsection 3.7.1.1.4.4.3 with the approximately 11.2 m (37 ft) engineered granular fill material removed above the top of the Bass Islands Group bedrock. Figure 3.7.1-252 shows the LB, BE and UB subsurface shear wave velocity profiles for the Fermi 3 site-specific SSI analysis.

A 0.3 foot difference is observed between the elevation of the closest layer boundary to the RB/FB and CB foundation levels (Elevation 523.4 ft and 540.1 ft NAVD 88) and the actual elevation of the RB/FB and CB foundations (Elevation 523.7 ft and 540.4 ft NAVD 88). This difference is due to randomization of the dynamic properties in Subsection 3.7.1.1.4.1.1.3 which included randomization of the layer elevations. This difference is negligible and, therefore, the bottom of the RB/FB and CB foundation levels are set at Elevation 540.1 and 523.4 ft NAVD 88, respectively, for the Fermi 3 site-specific SSI analyses.

Insert 3.7.1.4-1

3.7.1.4 References

3.7.1-201 Richart, F.E., Woods, R.D., and J.R. Hall, "Vibration of Soils and Foundations," Prentice-Hall, 1970.

3.7.1-202 Bowles, J.E., "Foundation Analysis and Design," McGraw-Hill, 1996.

3.7.1-203 Campbell, K.W., and Y. Bozorgnia, "Updated Near-Source Ground-Motion (Attenuation) Relations for the Horizontal and Vertical Components of Peak Ground Acceleration and Acceleration Response Spectra," *Bulletin of the Seismological Society of America*, Vol. 93, No. 1, 2003.

3.7.1-204 Lilhanand, K., and W.S. Tseng, "Development and application of realistic earthquake time histories compatible with multiple-damping response spectra," *Proceedings of the 9th World Conference on Earthquake Engineering*, Tokyo-Kyoto, Japan, v. II, 1988.

3.7.1-205 Abrahamson, N., "Non-stationary spectral matching," *Seismological Research Letters*, Vol. 63, No. 1, 1992.

3.7.1-206 Nuclear Energy Institute (NEI) White Paper, "Consistent site response/soil-structure interaction analysis and evaluation," NEI, June 12, 2009.

3.7.1-207 Power, M., B. Chiou, N. Abrahamson, Y. Bozorgnia, T. Shantz, and C. Robless, "An Overview of the NGA Project," *Earthquake Spectra*, Vol. 24, pp. 3-21, 2008.

Table 3.7.1-201 Full Soil Column Site Response Analysis Profile: Lower Range

Layer Number	Thickness (ft.)	Shear Wave Velocity (fps)	Unit Weight (kips/ft.^{3})	Material Curves	Soil/Rock Type
Finished Ground Level Grade, Top of Profile Elevation 589.3 ft.					
1	2.9	418	0.119	EPRI 0 – 20 feet	Backfill
2	2.9	550	0.119	EPRI 0 – 20 feet	Backfill
3	4.2	638	0.119	EPRI 0 – 20 feet	Backfill
4	3.2	702	0.119	EPRI 0 – 20 feet	Backfill
5	2.5	733	0.119	EPRI 0 – 20 feet	Backfill
6	4.3	754	0.119	EPRI 0 – 20 feet	Backfill
7	5.0	780	0.119	EPRI 20 – 50 feet	Backfill
8	5.0	805	0.119	EPRI 20 – 50 feet	Backfill
9	7.0	834	0.119	EPRI 20 – 50 feet	Backfill
10	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
11	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
12	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
13	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
14	11.0	6650	0.150	Linear, κ layer 1	Bass Islands
15	12.0	6650	0.150	Linear, κ layer 1	Bass Islands
16	12.0	6650	0.150	Linear, κ layer 1	Bass Islands
17	15.0	4600	0.150	Linear, κ layer 2	Bass Islands
18	20.0	3350	0.150	Linear, κ layer 3	Salina F
19	20.0	3350	0.150	Linear, κ layer 3	Salina F
20	20.0	3350	0.150	Linear, κ layer 3	Salina F
21	21.0	3350	0.150	Linear, κ layer 3	Salina F
22	21.0	4050	0.150	Linear, κ layer 3	Salina F
23	21.0	4050	0.150	Linear, κ layer 3	Salina F
24	10.0	5600	0.150	Linear, κ layer 4	Salina E
25	20.0	9450	0.150	Linear, κ layer 4	Salina E
26	21.0	9450	0.150	Linear, κ layer 4	Salina E
27	21.0	9450	0.150	Linear, κ layer 4	Salina E
28	21.0	9450	0.150	Linear, κ layer 4	Salina E
29	45.0	9000	0.160	Linear, κ layer 4	Salina C
30	45.0	9000	0.160	Linear, κ layer 4	Salina C
Halfspace		9300	0.169	0.1% Damping	Salina B

Table 3.7.1-202 Full Soil Column Site Response Analysis Profile: Intermediate Range

Layer Number	Thickness (ft.)	Shear Wave Velocity (fps)	Unit Weight (kips/ft.^{3})	Material Curves	Soil/Rock Type
Finished Ground Level Grade, Top of Profile Elevation 589.3 ft.					
1	2.9	549	0.133	EPRI 0 – 20 feet	Backfill
2	2.9	613	0.133	EPRI 0 – 20 feet	Backfill
3	4.2	690	0.133	EPRI 0 – 20 feet	Backfill
4	3.2	760	0.133	EPRI 0 – 20 feet	Backfill
5	2.5	794	0.133	EPRI 0 – 20 feet	Backfill
6	4.3	819	0.133	EPRI 0 – 20 feet	Backfill
7	5.0	850	0.133	EPRI 20 – 50 feet	Backfill
8	5.0	879	0.133	EPRI 20 – 50 feet	Backfill
9	7.0	913	0.133	EPRI 20 – 50 feet	Backfill
10	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
11	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
12	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
13	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
14	11.0	6650	0.150	Linear, κ layer 1	Bass Islands
15	12.0	6650	0.150	Linear, κ layer 1	Bass Islands
16	12.0	6650	0.150	Linear, κ layer 1	Bass Islands
17	15.0	4600	0.150	Linear, κ layer 2	Bass Islands
18	20.0	3350	0.150	Linear, κ layer 3	Salina F
19	20.0	3350	0.150	Linear, κ layer 3	Salina F
20	20.0	3350	0.150	Linear, κ layer 3	Salina F
21	21.0	3350	0.150	Linear, κ layer 3	Salina F
22	21.0	4050	0.150	Linear, κ layer 3	Salina F
23	21.0	4050	0.150	Linear, κ layer 3	Salina F
24	10.0	5600	0.150	Linear, κ layer 4	Salina E
25	20.0	9450	0.150	Linear, κ layer 4	Salina E
26	21.0	9450	0.150	Linear, κ layer 4	Salina E
27	21.0	9450	0.150	Linear, κ layer 4	Salina E
28	21.0	9450	0.150	Linear, κ layer 4	Salina E
29	45.0	9000	0.160	Linear, κ layer 4	Salina C
30	45.0	9000	0.160	Linear, κ layer 4	Salina C
Halfspace		9300	0.169	0.1% Damping	Salina B

Table 3.7.1-203 Full Soil Column Site Response Analysis Profile: Upper Range

Layer Number	Thickness (ft.)	Shear Wave Velocity (fps)	Unit Weight (kips/ft.^{3})	Material Curves	Soil/Rock Type
Finished Ground Level Grade, Top of Profile Elevation 589.3 ft.					
1	2.9	670	0.146	EPRI 0 – 20 feet	Backfill
2	2.9	722	0.146	EPRI 0 – 20 feet	Backfill
3	4.2	773	0.146	EPRI 0 – 20 feet	Backfill
4	3.2	818	0.146	EPRI 0 – 20 feet	Backfill
5	2.5	842	0.146	EPRI 0 – 20 feet	Backfill
6	4.3	867	0.146	EPRI 0 – 20 feet	Backfill
7	5.0	901	0.146	EPRI 20 – 50 feet	Backfill
8	5.0	934	0.146	EPRI 20 – 50 feet	Backfill
9	7.0	972	0.146	EPRI 20 – 50 feet	Backfill
10	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
11	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
12	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
13	10.0	6650	0.150	Linear, κ layer 1	Bass Islands
14	11.0	6650	0.150	Linear, κ layer 1	Bass Islands
15	12.0	6650	0.150	Linear, κ layer 1	Bass Islands
16	12.0	6650	0.150	Linear, κ layer 1	Bass Islands
17	15.0	4600	0.150	Linear, κ layer 2	Bass Islands
18	20.0	3350	0.150	Linear, κ layer 3	Salina F
19	20.0	3350	0.150	Linear, κ layer 3	Salina F
20	20.0	3350	0.150	Linear, κ layer 3	Salina F
21	21.0	3350	0.150	Linear, κ layer 3	Salina F
22	21.0	4050	0.150	Linear, κ layer 3	Salina F
23	21.0	4050	0.150	Linear, κ layer 3	Salina F
24	10.0	5600	0.150	Linear, κ layer 4	Salina E
25	20.0	9450	0.150	Linear, κ layer 4	Salina E
26	21.0	9450	0.150	Linear, κ layer 4	Salina E
27	21.0	9450	0.150	Linear, κ layer 4	Salina E
28	21.0	9450	0.150	Linear, κ layer 4	Salina E
29	45.0	9000	0.160	Linear, κ layer 4	Salina C
30	45.0	9000	0.160	Linear, κ layer 4	Salina C
Halfspace		9300	0.169	0.1% Damping	Salina B

Table 3.7.1-204 Horizontal and Vertical PBSRS at the Finished Ground Level Grade with Associated V/H Ratios

T (sec)	F (Hz)	Horizontal PBSRS (g)	V/H	Vertical PBSRS (g)
0.0100	100.0000	0.2604	1.000	0.2604
0.0166	60.2410	0.3197	1.088	0.3479
0.0200	50.0000	0.3605	1.133	0.4084
0.0250	40.0000	0.4229	1.129	0.4775
0.0300	33.3333	0.4618	1.097	0.5066
0.0330	30.3030	0.4714	1.049	0.4945
0.0400	25.0000	0.5085	0.967	0.4920
0.0420	23.8095	0.5066	0.954	0.4834
0.0440	22.7273	0.5059	0.940	0.4756
0.0460	21.7391	0.5124	0.926	0.4744
0.0480	20.8333	0.5161	0.912	0.4709
0.0500	20.0000	0.5212	0.900	0.4689
0.0550	18.1818	0.5286	0.873	0.4612
0.0600	16.6667	0.5354	0.852	0.4560
0.0650	15.3846	0.5447	0.832	0.4531
0.0700	14.2857	0.5534	0.814	0.4504
0.0750	13.3333	0.5617	0.802	0.4506
0.0800	12.5000	0.5695	0.793	0.4516
0.0850	11.7647	0.5770	0.784	0.4525
0.0900	11.1111	0.5841	0.776	0.4534
0.0950	10.5263	0.5909	0.769	0.4542
0.1000	10.0000	0.5975	0.762	0.4550
0.1100	9.0909	0.6093	0.748	0.4560
0.1200	8.3333	0.6203	0.737	0.4570
0.1300	7.6923	0.6305	0.726	0.4579
0.1400	7.1429	0.6402	0.717	0.4587
0.1500	6.6667	0.6493	0.708	0.4595
0.1600	6.2500	0.6580	0.699	0.4602
0.1700	5.8824	0.6662	0.692	0.4609
0.1800	5.5556	0.6741	0.685	0.4615
0.1900	5.2632	0.6797	0.678	0.4608
0.2000	5.0000	0.6852	0.672	0.4602
0.2200	4.5455	0.6897	0.660	0.4554
0.2400	4.1667	0.6820	0.650	0.4433
0.2600	3.8462	0.6677	0.650	0.4340
0.2800	3.5714	0.6559	0.650	0.4264
0.3000	3.3333	0.6393	0.650	0.4155

Table 3.7.1-204 Horizontal and Vertical PBSRS at the Finished Ground Level Grade with Associated V/H Ratios (Continued)

T (sec)	F (Hz)	Horizontal PBSRS (g)	V/H	Vertical PBSRS (g)
0.3200	3.1250	0.6109	0.650	0.3971
0.3400	2.9412	0.5728	0.650	0.3723
0.3600	2.7778	0.5333	0.650	0.3467
0.3800	2.6316	0.4897	0.650	0.3183
0.4000	2.5000	0.4491	0.650	0.2919
0.4200	2.3810	0.4093	0.650	0.2660
0.4400	2.2727	0.3710	0.650	0.2411
0.4600	2.1739	0.3358	0.650	0.2182
0.4800	2.0833	0.3094	0.650	0.2011
0.5000	2.0000	0.2850	0.650	0.1852
0.5500	1.8182	0.2291	0.650	0.1489
0.6000	1.6667	0.1890	0.650	0.1228
0.6500	1.5385	0.1613	0.650	0.1048
0.7000	1.4286	0.1410	0.650	0.0916
0.7500	1.3333	0.1257	0.650	0.0817
0.8000	1.2500	0.1143	0.650	0.0743
0.8500	1.1765	0.1058	0.650	0.0688
0.9000	1.1111	0.0998	0.650	0.0648
0.9500	1.0526	0.0946	0.650	0.0615
1.0000	1.0000	0.0889	0.650	0.0578
1.1000	0.9091	0.0833	0.650	0.0542
1.2000	0.8333	0.0794	0.650	0.0516
1.3000	0.7692	0.0754	0.650	0.0490
1.4000	0.7143	0.0730	0.650	0.0474
1.5000	0.6667	0.0711	0.650	0.0462
1.6000	0.6250	0.0694	0.650	0.0451
1.7000	0.5882	0.0679	0.650	0.0441
1.8000	0.5556	0.0671	0.650	0.0436
1.9000	0.5263	0.0653	0.650	0.0425
2.0000	0.5000	0.0640	0.650	0.0416
2.2000	0.4545	0.0592	0.650	0.0385
2.4000	0.4167	0.0557	0.650	0.0362
2.6000	0.3846	0.0529	0.650	0.0344
2.8000	0.3571	0.0510	0.650	0.0331
3.0000	0.3333	0.0494	0.650	0.0321
3.2000	0.3125	0.0474	0.650	0.0308
3.4000	0.2941	0.0454	0.650	0.0295

Table 3.7.1-204 Horizontal and Vertical PBSRS at the Finished Ground Level Grade with Associated V/H Ratios (Continued)

T (sec)	F (Hz)	Horizontal PBSRS (g)	V/H	Vertical PBSRS (g)
3.6000	0.2778	0.0436	0.650	0.0283
3.8000	0.2632	0.0420	0.650	0.0273
4.0000	0.2500	0.0404	0.650	0.0263
4.2000	0.2381	0.0391	0.650	0.0254
4.4000	0.2273	0.0378	0.650	0.0246
4.6000	0.2174	0.0366	0.650	0.0238
4.8000	0.2083	0.0355	0.650	0.0231
5.0000	0.2000	0.0345	0.650	0.0224
5.5000	0.1818	0.0322	0.650	0.0209
6.0000	0.1667	0.0303	0.650	0.0197
6.5000	0.1538	0.0286	0.650	0.0186
7.0000	0.1429	0.0271	0.650	0.0176
7.5000	0.1333	0.0258	0.650	0.0168
8.0000	0.1250	0.0246	0.650	0.0160
8.5000	0.1176	0.0236	0.650	0.0153
9.0000	0.1111	0.0226	0.650	0.0147
10.0000	0.1000	0.0210	0.650	0.0136

Table 3.7.1-205 Full Soil Column Deterministic Profile: Best Estimate

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.9	2.9	132.5	557	2.73	1028	586
2	2.9	5.8	132.5	588	4.19	1148	583
3	4.2	10	132.5	622	5.09	1291	579
4	3.2	13.2	132.5	663	5.49	1422	576
5	2.5	15.7	132.5	680	5.87	5000	573
6	4.3	20	132.5	702	6.08	5000	569
7	5	25	132.5	750	4.39	5000	564
8	5	30	132.5	772	4.54	5000	559
9	7	37	132.5	795	4.56	5000	552
10	9.9	46.9	150.0	6689	0.95	13202	542
11	2	48.9	150.0	6592	0.95	13202	540
12	8	56.9	150.0	6592	0.95	13202	532
13	8	64.9	150.0	6745	0.95	13202	524
14	2	66.9	150.0	6745	0.95	13202	522
15	10.2	77.1	150.0	6825	0.95	13202	512
16	11.1	88.2	150.0	6790	0.95	13202	501
17	11.9	100.1	150.0	6853	0.95	13202	489
18	11.7	111.8	150.0	6609	0.95	13202	477
19	15	126.8	150.0	4752	1.37	9835	462
20	20	146.8	150.0	3309	1.91	7889	442
21	19.9	166.7	150.0	3252	1.91	7889	422
22	19.9	186.6	150.0	3235	1.91	7889	402
23	21.2	207.8	150.0	3218	1.91	7889	381
24	21.1	228.9	150.0	4072	1.91	9537	360
25	21.1	250	150.0	4132	1.91	9537	339
26	9.8	259.8	150.0	5650	0.73	10477	329
27	19.7	279.5	150.0	9523	0.73	17679	310
28	21	300.5	150.0	9439	0.73	17679	289
29	20.5	321	150.0	9525	0.73	17679	268
30	22.1	343.1	150.0	9491	0.73	17679	246
31	45	388.1	160.0	8943	0.73	16282	201
32	44.6	432.7	160.0	9049	0.73	16282	156
33	Half Space	432.7	169.0	9494	0.10	17100	

Table 3.7.1-206 Full Soil Column Deterministic Profile: Lower Bound

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.9	2.9	119	408	4.07	781	586
2	2.9	5.8	119	426	6.55	1028	583
3	4.2	10	119	432	7.84	1193	579
4	3.2	13.2	119	485	8.23	1314	576
5	2.5	15.7	119	501	8.5	5000	573
6	4.3	20	119	513	8.65	5000	569
7	5	25	119	574	6.45	5000	564
8	5	30	119	610	6.59	5000	559
9	7	37	119	608	6.9	5000	552
10	9.9	46.9	150	5666	1.51	10779	542
11	2	48.9	150	5780	1.51	10779	540
12	8	56.9	150	5780	1.51	10779	532
13	8	64.9	150	5761	1.51	10779	524
14	2	66.9	150	5761	1.51	10779	522
15	10.2	77.1	150	5766	1.51	10779	512
16	11.1	88.2	150	5659	1.51	10779	501
17	11.9	100.1	150	5877	1.51	10779	489
18	11.7	111.8	150	5609	1.51	10779	477
19	15	126.8	150	4003	2.18	8030	462
20	20	146.8	150	2616	2.88	6441	442
21	19.9	166.7	150	2529	2.88	6441	422
22	19.9	186.6	150	2611	2.88	6441	402
23	21.2	207.8	150	2478	2.88	6441	381
24	21.1	228.9	150	3111	2.88	7787	360
25	21.1	250	150	3189	2.88	7787	339
26	9.8	259.8	150	4998	1.12	8554	329
27	19.7	279.5	150	8501	1.12	14435	310
28	21	300.5	150	8628	1.12	14435	289
29	20.5	321	150	8542	1.12	14435	268
30	22.1	343.1	150	8516	1.12	14435	246
31	45	388.1	160	8156	1.12	13294	201
32	44.6	432.7	160	8202	1.12	13294	156
33	Half Space	432.7	169	8490	0.1	13962	

Table 3.7.1-207 Full Soil Column Deterministic Profile: Upper Bound

Layer	Thickness (ft)	Total Depth (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation of Layer Base (ft)
1	2.9	2.9	146	734	1.79	1253	586
2	2.9	5.8	146	751	2.84	1350	583
3	4.2	10	146	816	3.39	1446	579
4	3.2	13.2	146	891	3.48	1530	576
5	2.5	15.7	146	939	3.61	5000	573
6	4.3	20	146	930	3.85	5000	569
7	5	25	146	1021	2.81	5000	564
8	5	30	146	1032	2.86	5000	559
9	7	37	146	1041	2.97	5000	552
10	9.9	46.9	150	8063	0.48	16169	542
11	2	48.9	150	7967	0.48	16169	540
12	8	56.9	150	7967	0.48	16169	532
13	8	64.9	150	8042	0.48	16169	524
14	2	66.9	150	8042	0.48	16169	522
15	10.2	77.1	150	8130	0.48	16169	512
16	11.1	88.2	150	7924	0.48	16169	501
17	11.9	100.1	150	7928	0.48	16169	489
18	11.7	111.8	150	7754	0.48	16169	477
19	15	126.8	150	5439	0.68	12046	462
20	20	146.8	150	4221	0.95	9662	442
21	19.9	166.7	150	4042	0.95	9662	422
22	19.9	186.6	150	4041	0.95	9662	402
23	21.2	207.8	150	4033	0.95	9662	381
24	21.1	228.9	150	4898	0.95	11681	360
25	21.1	250	150	4989	0.95	11681	339
26	9.8	259.8	150	6264	0.36	12831	329
27	19.7	279.5	150	10472	0.36	21653	310
28	21	300.5	150	10596	0.36	21653	289
29	20.5	321	150	10526	0.36	21653	268
30	22.1	343.1	150	10456	0.36	21653	246
31	45	388.1	160	10247	0.36	19941	201
32	44.6	432.7	160	10276	0.36	19941	156
33	Half Space	432.7	169	10476	0.1	20943	

Table 3.7.1-208 Horizontal and Vertical RB/FB SCOR FIRS with Associated V/H Ratios

T (sec)	F (Hz)	Horizontal RB/FB FIRS (g)	V/H	Vertical RB/FB FIRS (g)
0.0100	100.0000	0.1882	1.0000	0.1882
0.0166	60.2410	0.3517	1.1374	0.4000
0.0200	50.0000	0.4174	1.1244	0.4694
0.0250	40.0000	0.4663	1.0426	0.4862
0.0300	33.3333	0.4867	0.9675	0.4709
0.0330	30.3030	0.4894	0.9400	0.4600
0.0400	25.0000	0.4948	0.8800	0.4354
0.0420	23.8095	0.4881	0.8681	0.4237
0.0440	22.7273	0.4817	0.8569	0.4128
0.0460	21.7391	0.4757	0.8461	0.4025
0.0480	20.8333	0.4701	0.8355	0.3928
0.0500	20.0000	0.4647	0.8255	0.3836
0.0550	18.1818	0.4468	0.8069	0.3605
0.0600	16.6667	0.4311	0.7984	0.3441
0.0650	15.3846	0.4126	0.7906	0.3262
0.0700	14.2857	0.4047	0.7834	0.3170
0.0750	13.3333	0.3974	0.7769	0.3087
0.0800	12.5000	0.3906	0.7708	0.3011
0.0850	11.7647	0.3849	0.7651	0.2945
0.0900	11.1111	0.3801	0.7597	0.2887
0.0950	10.5263	0.3756	0.7547	0.2834
0.1000	10.0000	0.3713	0.7500	0.2785
0.1100	9.0909	0.3633	0.7500	0.2725
0.1200	8.3333	0.3561	0.7500	0.2671
0.1300	7.6923	0.3496	0.7500	0.2622
0.1400	7.1429	0.3437	0.7500	0.2578
0.1500	6.6667	0.3383	0.7500	0.2537
0.1600	6.2500	0.3333	0.7500	0.2500
0.1700	5.8824	0.3287	0.7500	0.2465
0.1800	5.5556	0.3244	0.7500	0.2433
0.1900	5.2632	0.3204	0.7500	0.2403
0.2000	5.0000	0.3166	0.7500	0.2375
0.2200	4.5455	0.3106	0.7500	0.2329
0.2400	4.1667	0.3064	0.7500	0.2298
0.2600	3.8462	0.3022	0.7500	0.2266
0.2800	3.5714	0.2970	0.7500	0.2228
0.3000	3.3333	0.2947	0.7500	0.2210

Table 3.7.1-208 Horizontal and Vertical RB/FB SCOR FIRS with Associated V/H Ratios (Continued)

T (sec)	F (Hz)	Horizontal RB/FB FIRS (g)	V/H	Vertical RB/FB FIRS (g)
0.3200	3.1250	0.2896	0.7500	0.2172
0.3400	2.9412	0.2789	0.7500	0.2092
0.3600	2.7778	0.2647	0.7500	0.1985
0.3800	2.6316	0.2517	0.7500	0.1888
0.4000	2.5000	0.2361	0.7500	0.1771
0.4200	2.3810	0.2210	0.7500	0.1657
0.4400	2.2727	0.2069	0.7500	0.1552
0.4600	2.1739	0.1927	0.7500	0.1445
0.4800	2.0833	0.1817	0.7500	0.1363
0.5000	2.0000	0.1706	0.7500	0.1279
0.5500	1.8182	0.1467	0.7500	0.1101
0.6000	1.6667	0.1290	0.7500	0.0968
0.6500	1.5385	0.1148	0.7500	0.0861
0.7000	1.4286	0.1035	0.7500	0.0777
0.7500	1.3333	0.0953	0.7500	0.0715
0.8000	1.2500	0.0898	0.7500	0.0673
0.8500	1.1765	0.0850	0.7500	0.0638
0.9000	1.1111	0.0813	0.7500	0.0610
0.9500	1.0526	0.0777	0.7500	0.0583
1.0000	1.0000	0.0744	0.7500	0.0558
1.1000	0.9091	0.0713	0.7500	0.0535
1.2000	0.8333	0.0687	0.7500	0.0515
1.3000	0.7692	0.0665	0.7500	0.0499
1.4000	0.7143	0.0648	0.7500	0.0486
1.5000	0.6667	0.0634	0.7500	0.0476
1.6000	0.6250	0.0621	0.7500	0.0466
1.7000	0.5882	0.0607	0.7500	0.0455
1.8000	0.5556	0.0598	0.7500	0.0448
1.9000	0.5263	0.0587	0.7500	0.0440
2.0000	0.5000	0.0578	0.7500	0.0433
2.2000	0.4545	0.0536	0.7500	0.0402
2.4000	0.4167	0.0502	0.7500	0.0377
2.6000	0.3846	0.0473	0.7500	0.0355
2.8000	0.3571	0.0448	0.7500	0.0336
3.0000	0.3333	0.0426	0.7500	0.0320
3.2000	0.3125	0.0406	0.7500	0.0305
3.4000	0.2941	0.0389	0.7500	0.0292

Table 3.7.1-208 Horizontal and Vertical RB/FB SCOR FIRS with Associated V/H Ratios (Continued)

T (sec)	F (Hz)	Horizontal RB/FB FIRS (g)	V/H	Vertical RB/FB FIRS (g)
3.6000	0.2778	0.0373	0.7500	0.0280
3.8000	0.2632	0.0358	0.7500	0.0269
4.0000	0.2500	0.0345	0.7500	0.0259
4.2000	0.2381	0.0333	0.7500	0.0250
4.4000	0.2273	0.0322	0.7500	0.0241
4.6000	0.2174	0.0312	0.7500	0.0234
4.8000	0.2083	0.0302	0.7500	0.0227
5.0000	0.2000	0.0294	0.7500	0.0220
5.5000	0.1818	0.0274	0.7500	0.0206
6.0000	0.1667	0.0258	0.7500	0.0193
6.5000	0.1538	0.0243	0.7500	0.0182
7.0000	0.1429	0.0231	0.7500	0.0173
7.5000	0.1333	0.0220	0.7500	0.0165
8.0000	0.1250	0.0210	0.7500	0.0157
8.5000	0.1176	0.0201	0.7500	0.0151
9.0000	0.1111	0.0193	0.7500	0.0145
10.0000	0.1000	0.0179	0.7500	0.0134

Table 3.7.1-209 Horizontal and Vertical CB SCOR FIRS with Associated V/H Ratios

T (sec)	F (Hz)	Horizontal CB FIRS (g)	V/H	Vertical CB FIRS (g)
0.0100	100.0000	0.1878	1.0000	0.1878
0.0166	60.2410	0.3511	1.1374	0.3994
0.0200	50.0000	0.4167	1.1244	0.4686
0.0250	40.0000	0.4655	1.0426	0.4854
0.0300	33.3333	0.4859	0.9675	0.4702
0.0330	30.3030	0.4886	0.9400	0.4593
0.0400	25.0000	0.4940	0.8800	0.4347
0.0420	23.8095	0.4869	0.8681	0.4227
0.0440	22.7273	0.4803	0.8569	0.4116
0.0460	21.7391	0.4741	0.8461	0.4012
0.0480	20.8333	0.4682	0.8355	0.3912
0.0500	20.0000	0.4626	0.8255	0.3819
0.0550	18.1818	0.4499	0.8069	0.3630
0.0600	16.6667	0.4385	0.7984	0.3501
0.0650	15.3846	0.4283	0.7906	0.3386
0.0700	14.2857	0.4191	0.7834	0.3283
0.0750	13.3333	0.4107	0.7769	0.3190
0.0800	12.5000	0.4030	0.7708	0.3106
0.0850	11.7647	0.3959	0.7651	0.3029
0.0900	11.1111	0.3893	0.7597	0.2957
0.0950	10.5263	0.3833	0.7547	0.2893
0.1000	10.0000	0.3785	0.7500	0.2839
0.1100	9.0909	0.3695	0.7500	0.2771
0.1200	8.3333	0.3614	0.7500	0.2710
0.1300	7.6923	0.3541	0.7500	0.2656
0.1400	7.1429	0.3475	0.7500	0.2606
0.1500	6.6667	0.3415	0.7500	0.2561
0.1600	6.2500	0.3359	0.7500	0.2520
0.1700	5.8824	0.3308	0.7500	0.2481
0.1800	5.5556	0.3260	0.7500	0.2445
0.1900	5.2632	0.3216	0.7500	0.2412
0.2000	5.0000	0.3174	0.7500	0.2381
0.2200	4.5455	0.3107	0.7500	0.2330
0.2400	4.1667	0.3066	0.7500	0.2300
0.2600	3.8462	0.3024	0.7500	0.2268
0.2800	3.5714	0.2972	0.7500	0.2229
0.3000	3.3333	0.2949	0.7500	0.2212

Table 3.7.1-209 Horizontal and Vertical CB SCOR FIRS with Associated V/H Ratios (Continued)

T (sec)	F (Hz)	Horizontal CB FIRS (g)	V/H	Vertical CB FIRS (g)
0.3200	3.1250	0.2900	0.7500	0.2175
0.3400	2.9412	0.2793	0.7500	0.2094
0.3600	2.7778	0.2650	0.7500	0.1987
0.3800	2.6316	0.2520	0.7500	0.1890
0.4000	2.5000	0.2363	0.7500	0.1772
0.4200	2.3810	0.2212	0.7500	0.1659
0.4400	2.2727	0.2070	0.7500	0.1553
0.4600	2.1739	0.1928	0.7500	0.1446
0.4800	2.0833	0.1818	0.7500	0.1364
0.5000	2.0000	0.1707	0.7500	0.1280
0.5500	1.8182	0.1468	0.7500	0.1101
0.6000	1.6667	0.1291	0.7500	0.0968
0.6500	1.5385	0.1148	0.7500	0.0861
0.7000	1.4286	0.1036	0.7500	0.0777
0.7500	1.3333	0.0953	0.7500	0.0715
0.8000	1.2500	0.0898	0.7500	0.0673
0.8500	1.1765	0.0850	0.7500	0.0638
0.9000	1.1111	0.0813	0.7500	0.0610
0.9500	1.0526	0.0777	0.7500	0.0583
1.0000	1.0000	0.0744	0.7500	0.0558
1.1000	0.9091	0.0713	0.7500	0.0535
1.2000	0.8333	0.0687	0.7500	0.0515
1.3000	0.7692	0.0665	0.7500	0.0499
1.4000	0.7143	0.0648	0.7500	0.0486
1.5000	0.6667	0.0634	0.7500	0.0476
1.6000	0.6250	0.0621	0.7500	0.0465
1.7000	0.5882	0.0607	0.7500	0.0455
1.8000	0.5556	0.0598	0.7500	0.0448
1.9000	0.5263	0.0587	0.7500	0.0440
2.0000	0.5000	0.0578	0.7500	0.0433
2.2000	0.4545	0.0536	0.7500	0.0402
2.4000	0.4167	0.0502	0.7500	0.0377
2.6000	0.3846	0.0473	0.7500	0.0355
2.8000	0.3571	0.0448	0.7500	0.0336
3.0000	0.3333	0.0426	0.7500	0.0320
3.2000	0.3125	0.0406	0.7500	0.0305
3.4000	0.2941	0.0389	0.7500	0.0292

Table 3.7.1-209 Horizontal and Vertical CB SCOR FIRS with Associated V/H Ratios (Continued)

T (sec)	F (Hz)	Horizontal CB FIRS (g)	V/H	Vertical CB FIRS (g)
3.6000	0.2778	0.0373	0.7500	0.0280
3.8000	0.2632	0.0358	0.7500	0.0269
4.0000	0.2500	0.0345	0.7500	0.0259
4.2000	0.2381	0.0333	0.7500	0.0250
4.4000	0.2273	0.0322	0.7500	0.0241
4.6000	0.2174	0.0312	0.7500	0.0234
4.8000	0.2083	0.0302	0.7500	0.0227
5.0000	0.2000	0.0294	0.7500	0.0220
5.5000	0.1818	0.0274	0.7500	0.0206
6.0000	0.1667	0.0258	0.7500	0.0193
6.5000	0.1538	0.0243	0.7500	0.0182
7.0000	0.1429	0.0231	0.7500	0.0173
7.5000	0.1333	0.0220	0.7500	0.0165
8.0000	0.1250	0.0210	0.7500	0.0157
8.5000	0.1176	0.0201	0.7500	0.0151
9.0000	0.1111	0.0193	0.7500	0.0145
10.0000	0.1000	0.0179	0.7500	0.0134

Table 3.7.1-210 Horizontal and Vertical SSI FIRS for RB/FB and CB

Period (sec)	Frequency (Hz)	Horizontal FIRS for RB/FB (g)	Vertical FIRS for RB/FB (g)	Horizontal FIRS for CB (g)	Vertical FIRS for CB (g)
10	0.10	0.019	0.014	0.019	0.014
9	0.11	0.020	0.015	0.020	0.015
8.5	0.12	0.021	0.016	0.021	0.016
8	0.13	0.022	0.016	0.022	0.016
7.5	0.13	0.023	0.017	0.023	0.017
7	0.14	0.024	0.018	0.024	0.018
6.5	0.15	0.025	0.019	0.025	0.019
6	0.17	0.026	0.020	0.026	0.020
5.5	0.18	0.028	0.021	0.028	0.021
5	0.20	0.029	0.022	0.030	0.022
4.8	0.21	0.030	0.023	0.030	0.023
4.6	0.22	0.031	0.023	0.031	0.023
4.4	0.23	0.032	0.024	0.032	0.024
4.2	0.24	0.033	0.025	0.033	0.025
4	0.25	0.035	0.026	0.035	0.026
3.8	0.26	0.036	0.027	0.036	0.027
3.6	0.28	0.037	0.028	0.037	0.028
3.4	0.29	0.039	0.029	0.039	0.029
3.2	0.31	0.041	0.030	0.041	0.030
3	0.33	0.043	0.032	0.043	0.032
2.8	0.36	0.045	0.034	0.045	0.034
2.6	0.38	0.047	0.035	0.047	0.035
2.4	0.42	0.050	0.038	0.050	0.038
2.2	0.45	0.054	0.040	0.054	0.040
2	0.50	0.058	0.043	0.058	0.043
1.9	0.53	0.059	0.044	0.059	0.044
1.8	0.56	0.062	0.045	0.062	0.045
1.7	0.59	0.065	0.047	0.065	0.047
1.6	0.63	0.068	0.050	0.068	0.050
1.5	0.67	0.073	0.053	0.073	0.053
1.4	0.71	0.077	0.057	0.077	0.057
1.3	0.77	0.082	0.061	0.082	0.061
1.2	0.83	0.089	0.065	0.089	0.065
1.1	0.91	0.096	0.071	0.096	0.071
1	1.00	0.104	0.077	0.104	0.077
0.95	1.05	0.109	0.081	0.109	0.081
0.9	1.11	0.115	0.085	0.115	0.085

Table 3.7.1-210 Horizontal and Vertical SSI FIRS for RB/FB and CB (Continued)

Period (sec)	Frequency (Hz)	Horizontal FIRS for RB/FB (g)	Vertical FIRS for RB/FB (g)	Horizontal FIRS for CB (g)	Vertical FIRS for CB (g)
0.85	1.18	0.121	0.090	0.121	0.090
0.8	1.25	0.127	0.095	0.127	0.095
0.75	1.33	0.135	0.101	0.135	0.101
0.7	1.43	0.144	0.107	0.144	0.107
0.65	1.54	0.153	0.115	0.154	0.115
0.6	1.67	0.165	0.124	0.165	0.124
0.55	1.82	0.178	0.134	0.178	0.134
0.5	2.00	0.194	0.146	0.194	0.147
0.48	2.08	0.201	0.152	0.202	0.152
0.46	2.17	0.209	0.158	0.209	0.158
0.44	2.27	0.218	0.165	0.218	0.165
0.42	2.38	0.227	0.172	0.227	0.172
0.4	2.50	0.237	0.180	0.237	0.180
0.38	2.63	0.248	0.189	0.249	0.189
0.36	2.78	0.261	0.198	0.261	0.199
0.34	2.94	0.274	0.209	0.275	0.209
0.32	3.13	0.290	0.220	0.290	0.221
0.3	3.33	0.305	0.233	0.304	0.234
0.28	3.57	0.323	0.248	0.320	0.248
0.26	3.85	0.344	0.264	0.338	0.265
0.24	4.17	0.367	0.283	0.359	0.284
0.22	4.55	0.395	0.289	0.383	0.291
0.2	5.00	0.406	0.296	0.386	0.298
0.19	5.26	0.409	0.300	0.389	0.303
0.18	5.56	0.414	0.303	0.391	0.307
0.17	5.88	0.419	0.308	0.395	0.312
0.16	6.25	0.425	0.312	0.400	0.317
0.15	6.67	0.431	0.317	0.405	0.323
0.14	7.14	0.437	0.322	0.410	0.329
0.13	7.69	0.444	0.328	0.417	0.336
0.12	8.33	0.452	0.334	0.423	0.344
0.11	9.09	0.461	0.341	0.431	0.352
0.1	10.00	0.470	0.349	0.439	0.362
0.095	10.53	0.473	0.353	0.441	0.367
0.09	11.11	0.477	0.358	0.444	0.372
0.085	11.76	0.480	0.363	0.447	0.378
0.08	12.50	0.484	0.368	0.450	0.385

Table 3.7.1-210 Horizontal and Vertical SSI FIRS for RB/FB and CB (Continued)

Period (sec)	Frequency (Hz)	Horizontal FIRS for RB/FB (g)	Vertical FIRS for RB/FB (g)	Horizontal FIRS for CB (g)	Vertical FIRS for CB (g)
0.075	13.33	0.488	0.374	0.453	0.392
0.07	14.29	0.492	0.380	0.456	0.399
0.065	15.38	0.497	0.387	0.465	0.407
0.06	16.67	0.509	0.394	0.468	0.417
0.055	18.18	0.503	0.403	0.472	0.427
0.05	20.00	0.497	0.412	0.477	0.438
0.048	20.83	0.495	0.416	0.479	0.443
0.046	21.74	0.492	0.420	0.481	0.448
0.044	22.73	0.490	0.425	0.483	0.454
0.042	23.81	0.488	0.430	0.487	0.460
0.04	25.00	0.495	0.435	0.494	0.466
0.033	30.30	0.489	0.455	0.498	0.492
0.03	33.33	0.487	0.465	0.503	0.505
0.025	40.00	0.466	0.486	0.509	0.531
0.02	50.00	0.432	0.485	0.441	0.496
0.0166	60.24	0.366	0.416	0.360	0.410
0.01	100.00	0.218(1)	0.218	0.212(2)	0.212

Notes:

(1) Value indicates the peak ground acceleration for RB/FB horizontal SSI FIRS (greater than 0.1 g).

(2) Value indicates the peak ground acceleration for CB horizontal SSI FIRS (greater than 0.1 g).

Table 3.7.1-211 Seed Time History Recording Details

Earthquake Event	Station	Component	Record Parameters: PGA (g)	PGV (cm/s)	PGD (cm)	Duration (sec)
1999 Chi-Chi, Taiwan **M** 7.6	KAU078 R = 103 km	KAU078-North	0.066	2.2	1.54	30.3
		KAU078-West	0.114	3.7	1.05	25.4
		KAU078-Vertical	0.046	4.0	3.45	32.1

Notes:

Duration is defined as the time interval between the time history points at which 5% and 75% of the normalized Arias intensity (total energy measure) has been recorded.

Table 3.7.1-212 Cross Correlation Coefficients for the Matched Time Histories Corresponding to the SSI FIRS at the RB/FB Level

Correlated Components	Cross Correlation Coefficient
Horizontal (H1) – Horizontal (H2)	-0.28
Horizontal (H1) – Vertical (V)	-0.06
Horizontal (H2) – Vertical (V)	0.16

Table 3.7.1-213 Cross Correlation Coefficients for the Matched Time Histories Corresponding to the SSI FIRS at the CB Level

Correlated Components	Cross Correlation Coefficient
Horizontal (H1) – Horizontal (H2)	-0.29
Horizontal (H1) – Vertical (V)	-0.05
Horizontal (H2) – Vertical (V)	0.16

Table 3.7.1-214 Matched Time History (Outcrop) Parameters

Response Spectrum	Component	Record Parameters: PGA (g)	PGV (cm/s)	PGD (cm)	Duration (sec)	PGV/PGA (cm/s/g)	$\frac{PGA*PGD}{(PGV)^2}$
RB/FB SSI FIRS	Horizontal 1	0.226	11.2	10.54	30.74	49.56	18.63
	Horizontal 2	0.232	12.7	10.56	26.08	54.74	14.90
	Vertical	0.220	11.7	8.43	35.03	53.18	13.29
CB SSI FIRS	Horizontal 1	0.224	10.9	10.47	30.75	48.66	19.36
	Horizontal 2	0.219	12.9	10.42	26.50	58.90	13.45
	Vertical	0.216	11.6	8.37	34.21	53.70	13.18

Notes:

Duration is defined as the time interval between the time history points at which 5% and 75% of the normalized Arias intensity (total energy measure) has been recorded.

Table 3.7.1-215 Best Estimate Properties for Fermi 3 SSI Analyses Based on the Soil Column Truncated at the Top of In Situ Bedrock

Layer	Thickness (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation at Top of Layer (ft)
SSI Profile, Top of Profile Elevation 552.0 ft.						
1	9.9	150.0	6689	0.95	13202	552.0
2	2	150.0	6592	0.95	13202	542.1
3	8	150.0	6592	0.95	13202	540.1
4	8	150.0	6745	0.95	13202	532.1
5	2	150.0	6745	0.95	13202	524.1
6	10.2	150.0	6825	0.95	13202	522.1
7	11.1	150.0	6790	0.95	13202	511.9
8	11.9	150.0	6853	0.95	13202	500.8
9	11.7	150.0	6609	0.95	13202	488.9
10	15	150.0	4752	1.37	9835	477.2
11	20	150.0	3309	1.91	7889	462.2
12	19.9	150.0	3252	1.91	7889	442.2
13	19.9	150.0	3235	1.91	7889	422.3
14	21.2	150.0	3218	1.91	7889	402.4
15	21.1	150.0	4072	1.91	9537	381.2
16	21.1	150.0	4132	1.91	9537	360.1
17	9.8	150.0	5650	0.73	10477	339.0
18	19.7	150.0	9523	0.73	17679	329.2
19	21	150.0	9439	0.73	17679	309.5
20	20.5	150.0	9525	0.73	17679	288.5
21	22.1	150.0	9491	0.73	17679	268.0
22	45	160.0	8943	0.73	16282	245.9
23	44.6	160.0	9049	0.73	16282	200.9
24	Half Space	169.0	9494	0.10	17100	

Notes:

1. The top of in situ (Bass Islands Group) bedrock is at EL. 552.0 ft NAVD 88 (top of layer No.1).
2. The bottom of CB basemat is at EL. 540.1 ft NAVD 88 (top of layer No. 3).
3. The bottom of RB/FB basemat is at EL. 523.4 ft NAVD 88 (within layer No. 5).
4. For SSI analyses presented in Subsection 3.7.2, the following elevation references are used in the SASSI2000 model:
   - EL. -6770 mm is the top of in-situ (Bass Islands Group) bedrock which is equivalent to EL. 552.0 ft NAVD 88.
   - EL. -10400 mm is at the bottom of CB basemat which is equivalent to EL. 540.1 ft NAVD 88.
   - EL. -15500 mm is at the bottom of RB/FB basemat which is equivalent to EL. 523.4 ft NAVD 88.
5. An interface layer is generated within layer No. 5 at EL. 523.4 ft NAVD 88 for SASSI2000 SSI analyses to define the interaction nodes at the bottom of the RB/FB.

Table 3.7.1-216 Lower Bound Properties for Fermi 3 SSI Analyses Based on the Soil Column Truncated at the Top of In Situ Bedrock

Layer	Thickness (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation at Top of Layer (ft)
SSI Profile, Top of Profile Elevation 552.0 ft.						
1	9.9	150	5666	1.51	10779	552.0
2	2	150	5780	1.51	10779	542.1
3	8	150	5780	1.51	10779	540.1
4	8	150	5761	1.51	10779	532.1
5	2	150	5761	1.51	10779	524.1
6	10.2	150	5766	1.51	10779	522.1
7	11.1	150	5659	1.51	10779	511.9
8	11.9	150	5877	1.51	10779	500.8
9	11.7	150	5609	1.51	10779	488.9
10	15	150	4003	2.18	8030	477.2
11	20	150	2616	2.88	6441	462.2
12	19.9	150	2529	2.88	6441	442.2
13	19.9	150	2611	2.88	6441	422.3
14	21.2	150	2478	2.88	6441	402.4
15	21.1	150	3111	2.88	7787	381.2
16	21.1	150	3189	2.88	7787	360.1
17	9.8	150	4998	1.12	8554	339.0
18	19.7	150	8501	1.12	14435	329.2
19	21	150	8628	1.12	14435	309.5
20	20.5	150	8542	1.12	14435	288.5
21	22.1	150	8516	1.12	14435	268.0
22	45	160	8156	1.12	13294	245.9
23	44.6	160	8202	1.12	13294	200.9
24	Half Space	169	8490	0.1	13962	

Notes:

1. The top of in situ (Bass Islands Group) bedrock is at EL. 552.0 ft NAVD 88 (top of layer No.1).
2. The bottom of CB basemat is at EL. 540.1 ft NAVD 88 (top of layer No. 3).
3. The bottom of RB/FB basemat is at EL. 523.4 ft NAVD 88 (within layer No. 5).
4. For SSI analyses presented in Subsection 3.7.2, the following elevation references are used in the SASSI2000 model:
    - EL. -6770 mm is the top of in-situ (Bass Islands Group) bedrock which is equivalent to EL. 552.0 ft NAVD 88.
    - EL. -10400 mm is at the bottom of CB basemat which is equivalent to EL. 540.1 ft NAVD 88.
    - EL. -15500 mm is at the bottom of RB/FB basemat which is equivalent to EL. 523.4 ft NAVD 88.
5. An interface layer is generated within layer No. 5 at EL. 523.4 ft NAVD 88 for SASSI2000 SSI analyses to define the interaction nodes at the bottom of the RB/FB.

Table 3.7.1-217 Upper Bound Properties for Fermi 3 SSI Analyses Based on the Soil Column Truncated at the Top of In Situ Bedrock

Layer	Thickness (ft)	Unit Weight (pcf)	Shear Wave Velocity (ft/sec)	Damping Ratio (%)	Compression Wave Velocity (ft/sec)	Elevation at Top of Layer (ft)
SSI Profile, Top of Profile Elevation 552.0 ft.						
1	9.9	150	8063	0.48	16169	552.0
2	2	150	7967	0.48	16169	542.1
3	8	150	7967	0.48	16169	540.1
4	8	150	8042	0.48	16169	532.1
5	2	150	8042	0.48	16169	524.1
6	10.2	150	8130	0.48	16169	522.1
7	11.1	150	7924	0.48	16169	511.9
8	11.9	150	7928	0.48	16169	500.8
9	11.7	150	7754	0.48	16169	488.9
10	15	150	5439	0.68	12046	477.2
11	20	150	4221	0.95	9662	462.2
12	19.9	150	4042	0.95	9662	442.2
13	19.9	150	4041	0.95	9662	422.3
14	21.2	150	4033	0.95	9662	402.4
15	21.1	150	4898	0.95	11681	381.2
16	21.1	150	4989	0.95	11681	360.1
17	9.8	150	6264	0.36	12831	339.0
18	19.7	150	10472	0.36	21653	329.2
19	21	150	10596	0.36	21653	309.5
20	20.5	150	10526	0.36	21653	288.5
21	22.1	150	10456	0.36	21653	268.0
22	45	160	10247	0.36	19941	245.9
23	44.6	160	10276	0.36	19941	200.9
24	Half Space	169	10476	0.1	20943	

Notes:

1. The top of in situ (Bass Islands Group) bedrock is at EL. 552.0 ft NAVD 88 (top of layer No.1).
2. The bottom of CB basemat is at EL. 540.1 ft NAVD 88 (top of layer No. 3).
3. The bottom of RB/FB basemat is at EL. 523.4 ft NAVD 88 (within layer No. 5).
4. For SSI analyses presented in Subsection 3.7.2, the following elevation references are used in the SASSI2000 model:
    - EL. -6770 mm is the top of in-situ (Bass Islands Group) bedrock which is equivalent to EL. 552.0 ft NAVD 88.
    - EL. -10400 mm is at the bottom of CB basemat which is equivalent to EL. 540.1 ft NAVD 88.
    - EL. -15500 mm is at the bottom of RB/FB basemat which is equivalent to EL. 523.4 ft NAVD 88.
5. An interface layer is generated within layer No. 5 at EL. 523.4 ft NAVD 88 for SASSI2000 SSI analyses to define the interaction nodes at the bottom of the RB/FB.

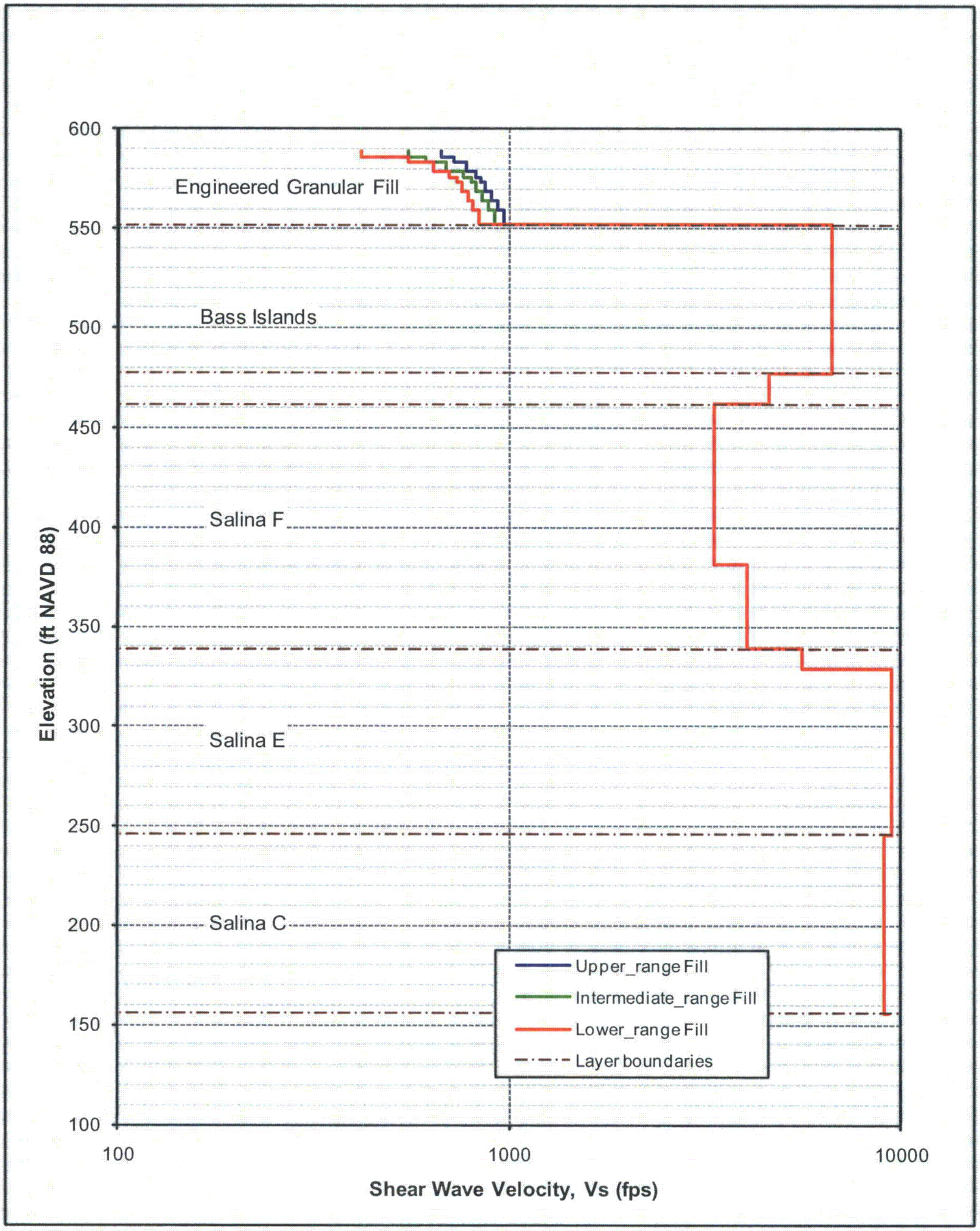

Figure 3.7.1-201: Shear Wave Velocity Profiles for Site Response Analysis Representing the Intermediate and Bounding Estimates.

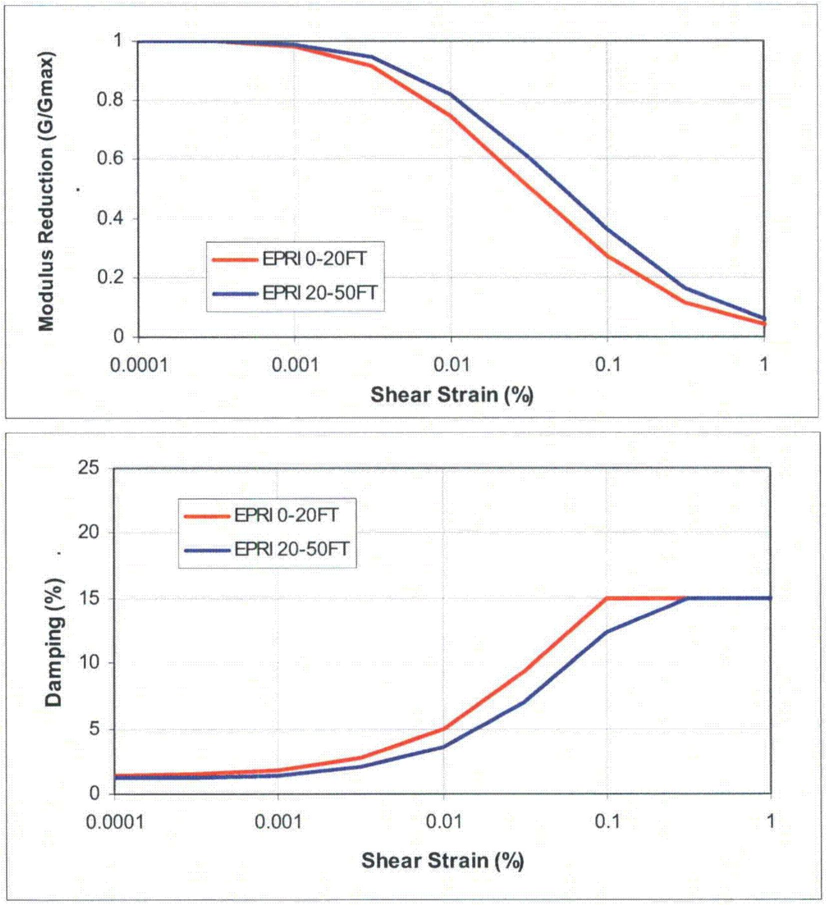

Figure 3.7.1-202: Modulus Reduction and Damping Relationships Used for the Engineered Granular Backfill Material.

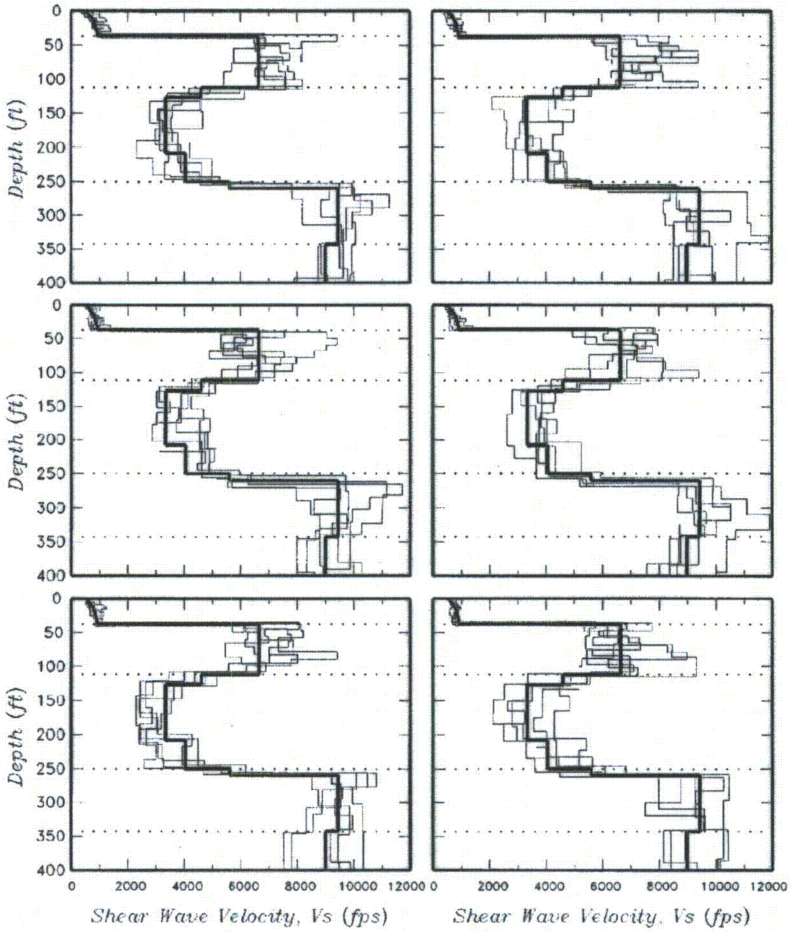

Figure 3.7.1-203: Randomized Shear Wave Velocity Profiles 1-30 for the Intermediate Range Site Response Analysis Profile.

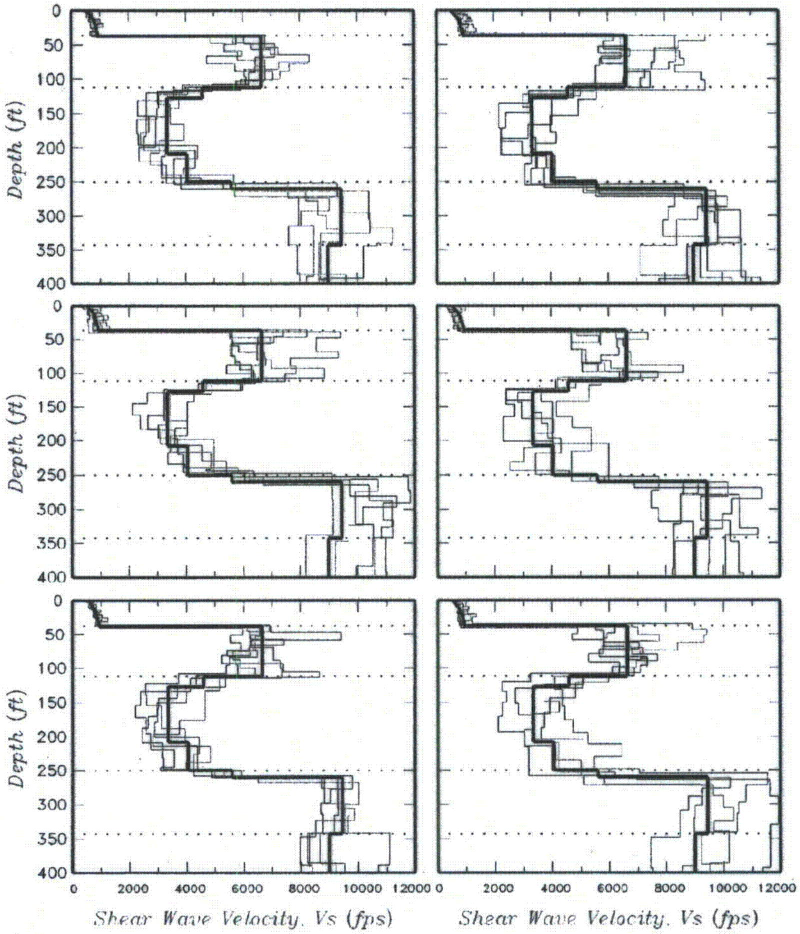

Figure 3.7.1-204: Randomized Shear Wave Velocity Profiles 31-60 for the Intermediate Range Site Response Analysis Profile.

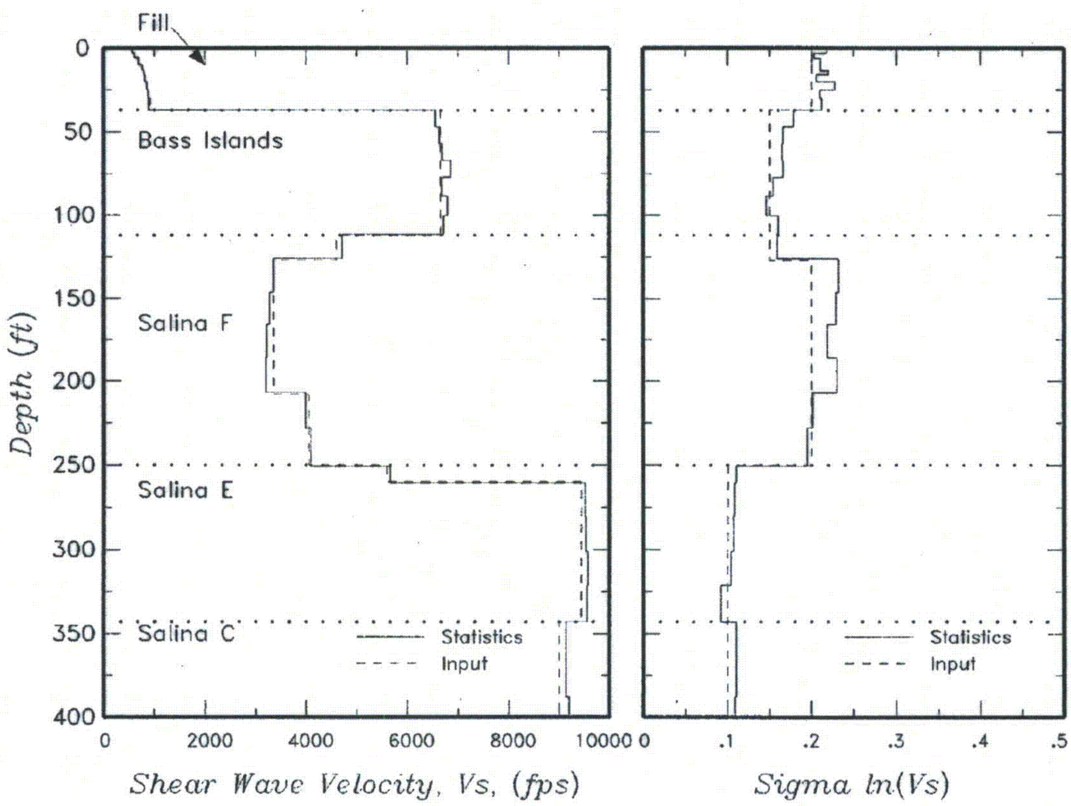

Figure 3.7.1-205: Statistics of Randomized Shear Wave Velocity Profiles for the Intermediate Range Site Response Analysis Profile.

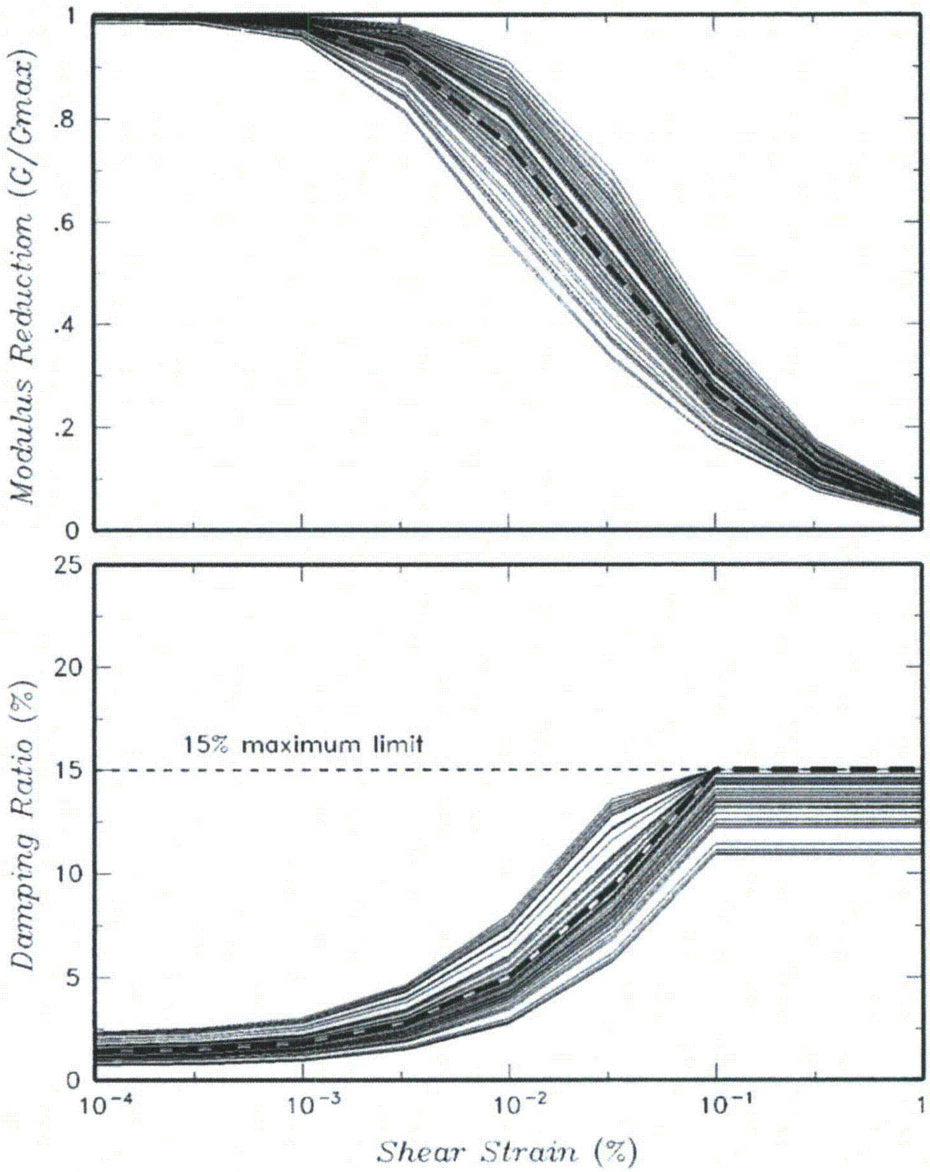

Figure 3.7.1-206: Randomized Shear Modulus Reduction and Damping Relationships Used for 0 to 20 Feet Depth Engineered Granular Backfill Material.

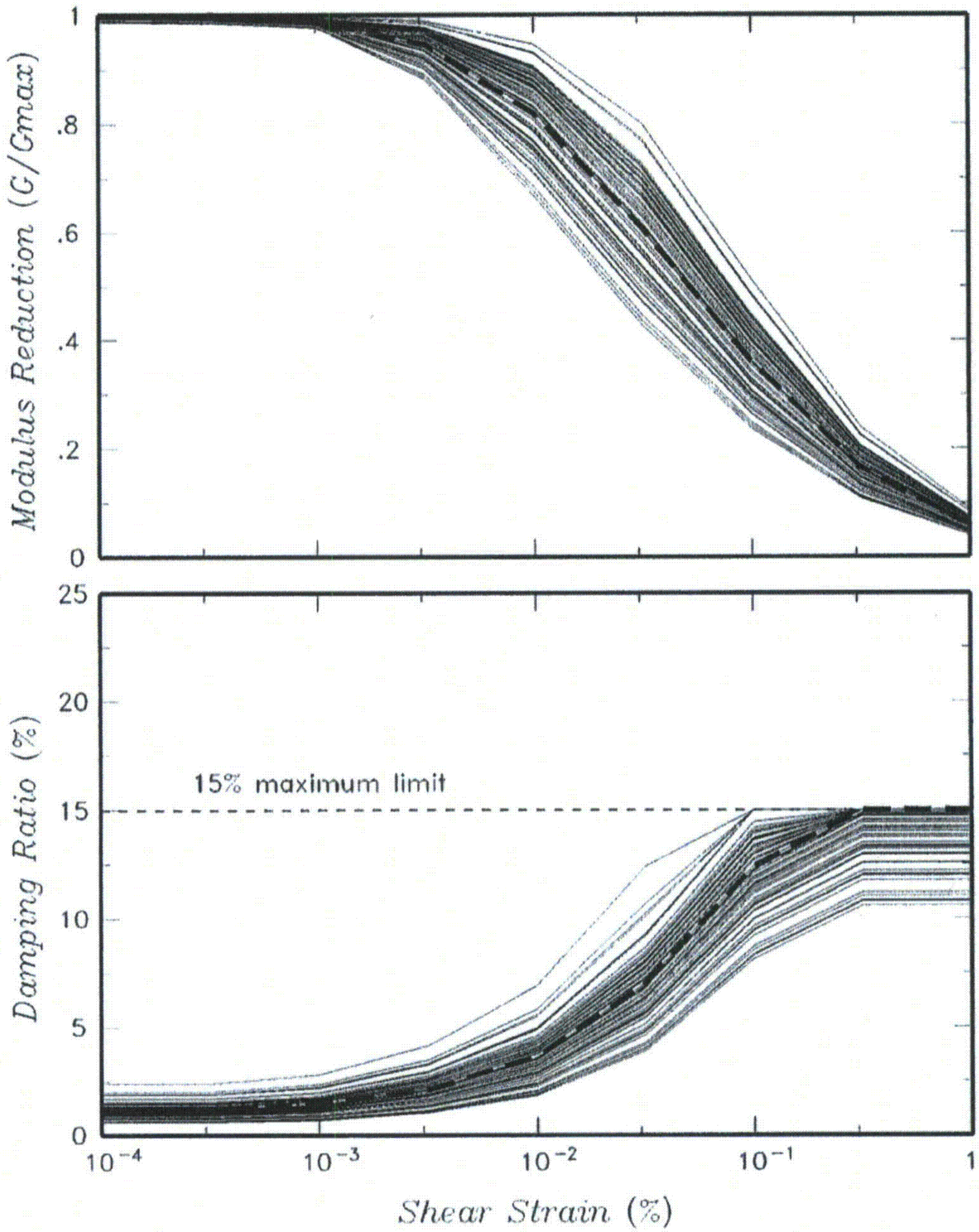

Figure 3.7.1-207: Randomized Shear Modulus Reduction and Damping Relationships Used for 20 to 50 Feet Depth Engineered Granular Backfill Material.

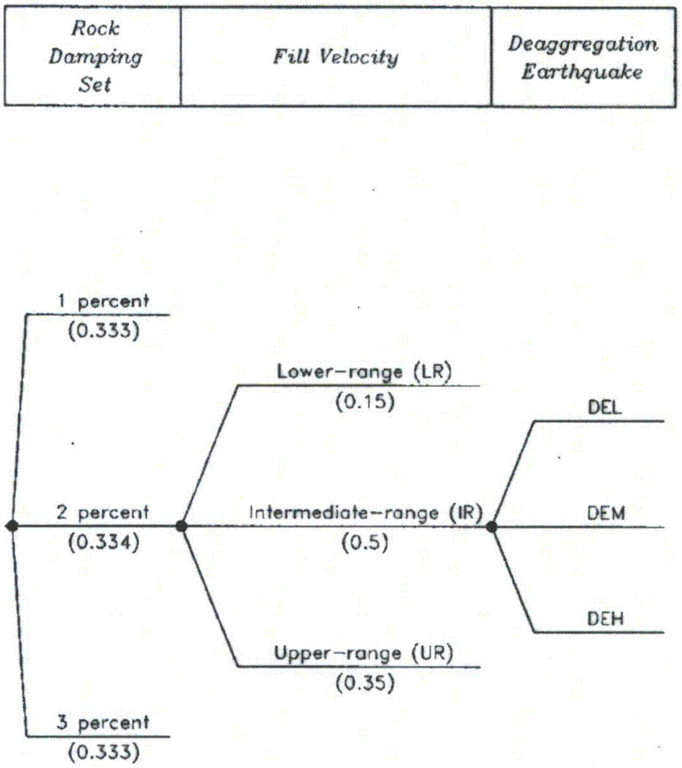

Figure 3.7.1-208: Site Response Logic Tree for Full Soil Column Profile.

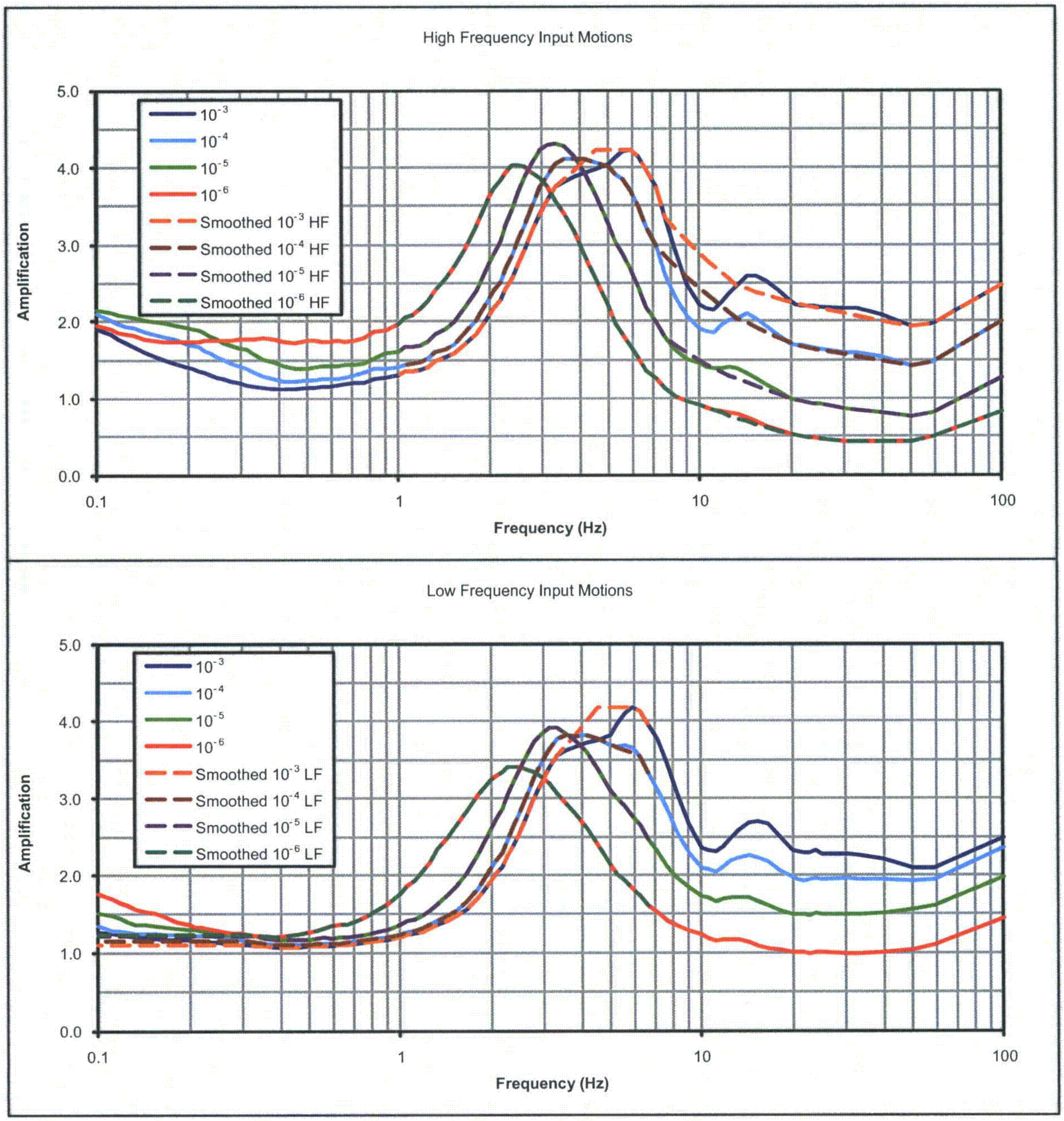

Figure 3.7.1-209: PBSRS Amplification Functions for the Fermi 3 Site.

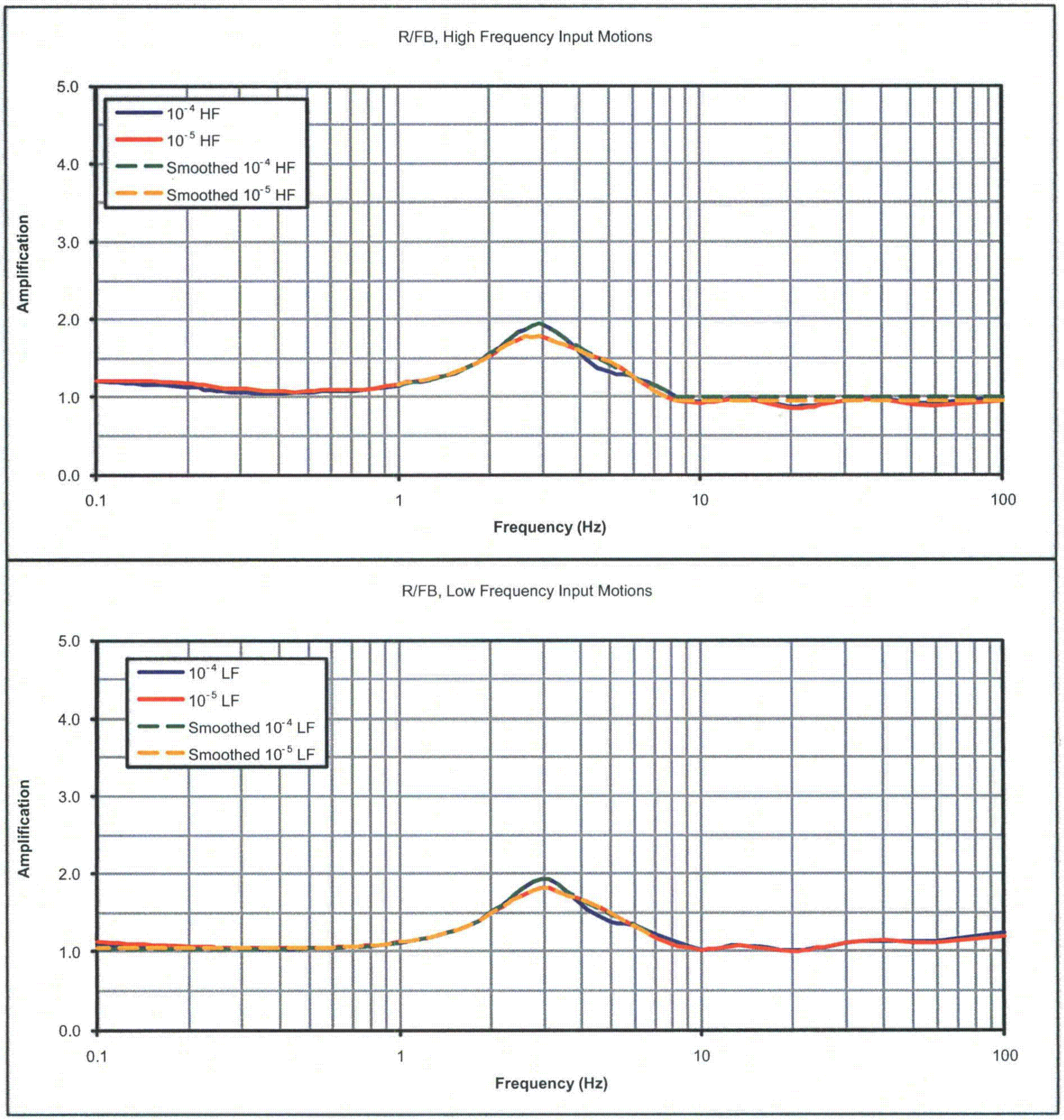

Figure 3.7.1-210: RB/FB SCOR Amplification Functions for the Fermi 3 Site.

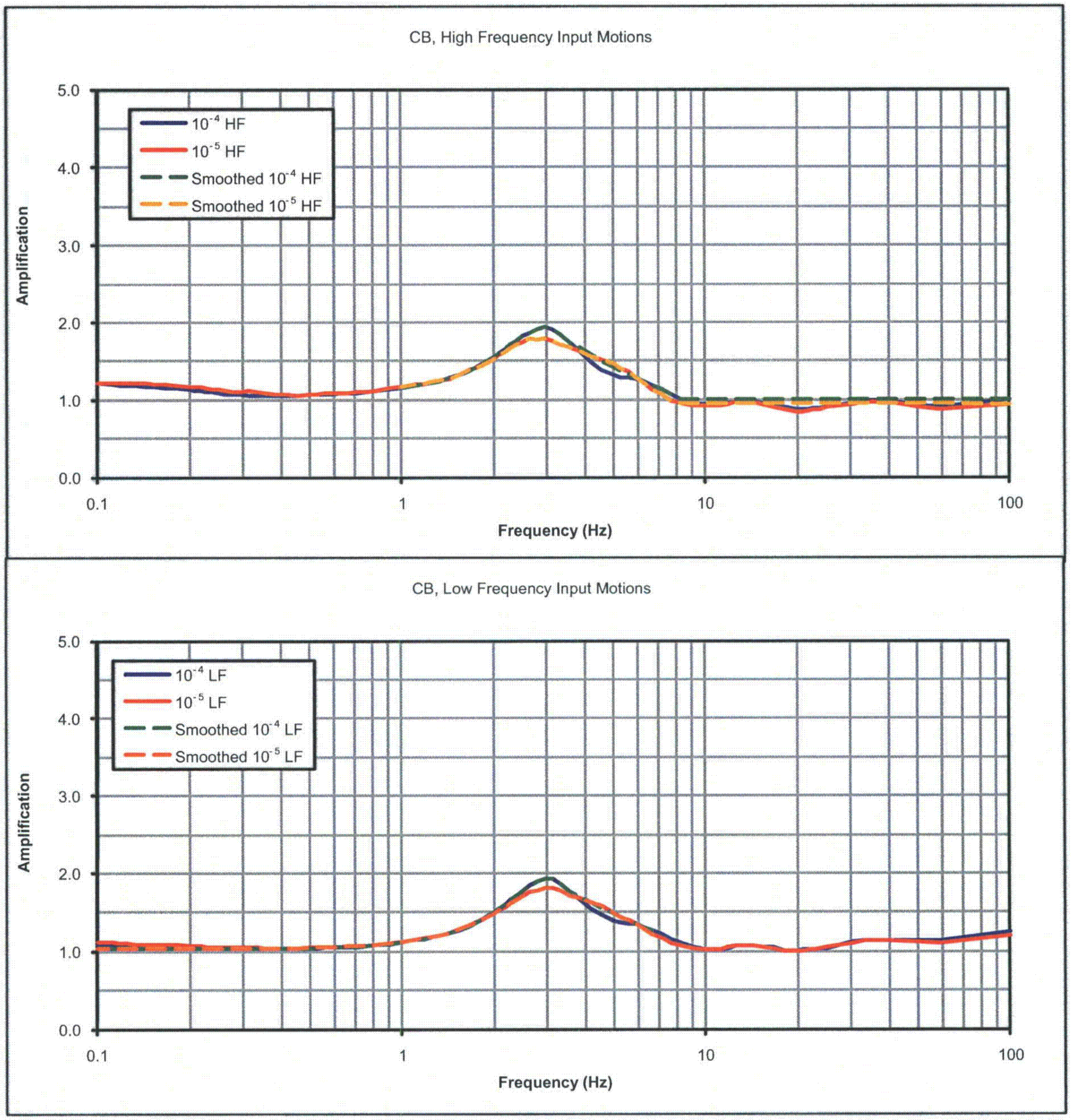

Figure 3.7.1-211: CB SCOR Amplification Functions for the Fermi 3 Site.

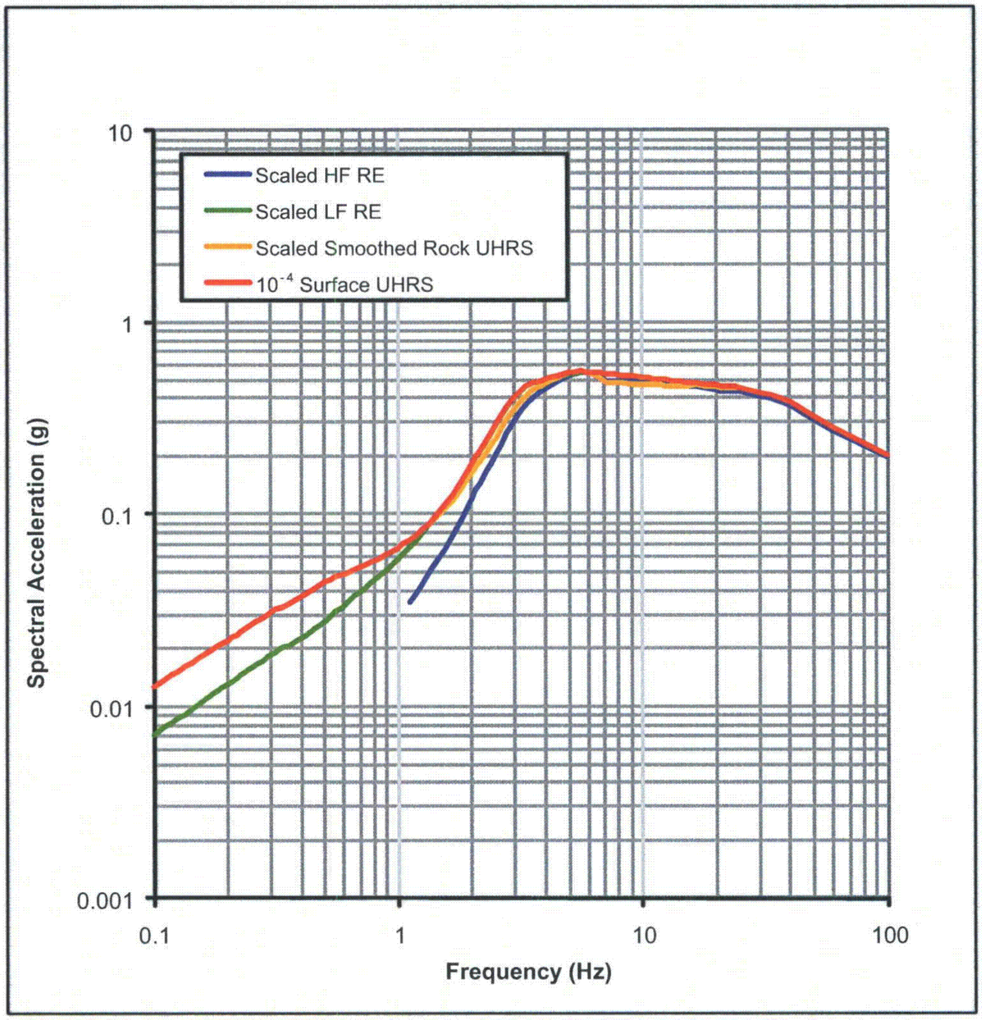

Figure 3.7.1-212: Development of 10^{-4} Surface UHRS at the Finished Ground Level Grade for the Full Soil Column Profile.

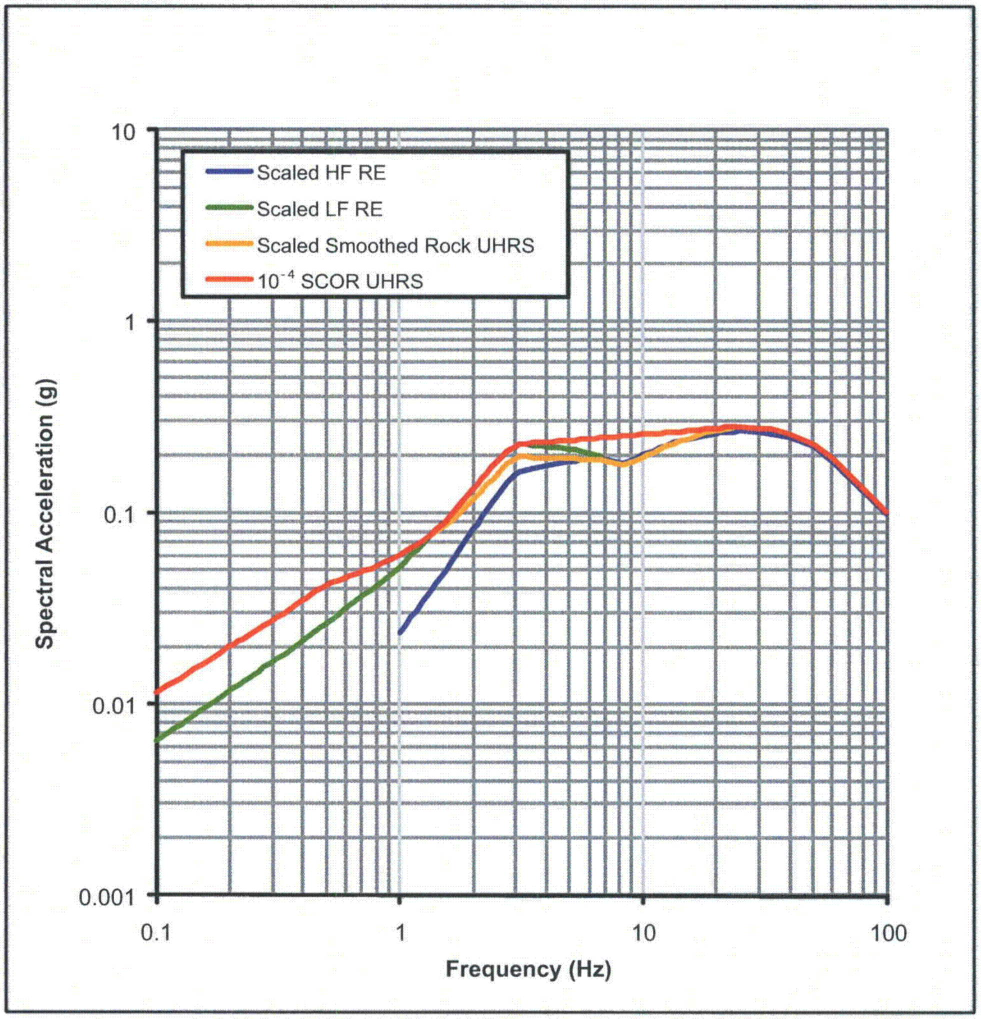

Figure 3.7.1-213: Development of 10^{-4} SCOR UHRS at the RB/FB Foundation Level for the Full Soil Column Profile.

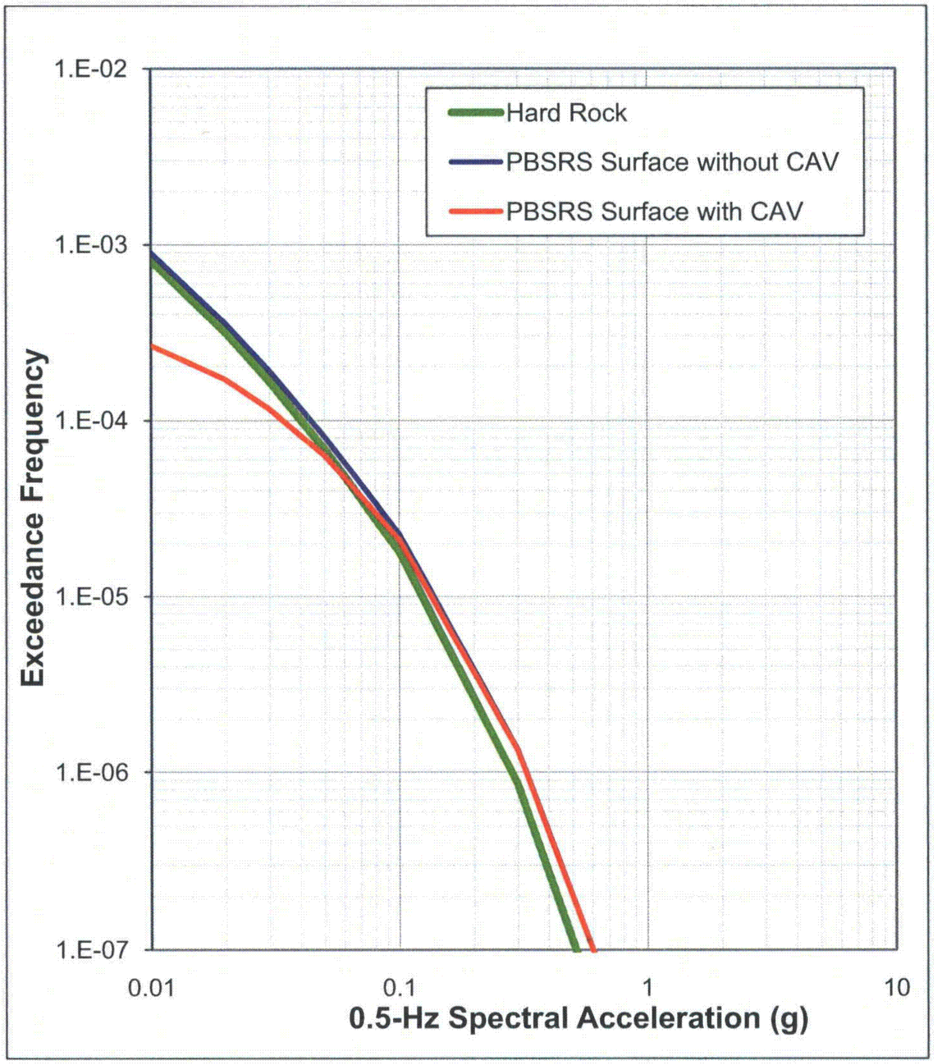

Figure 3.7.1-214: Surface Hazard Curves at Finished Ground Level Grade for the Full Soil Column Profile Computed With and Without CAV for 0.5 Hz Spectral Acceleration.

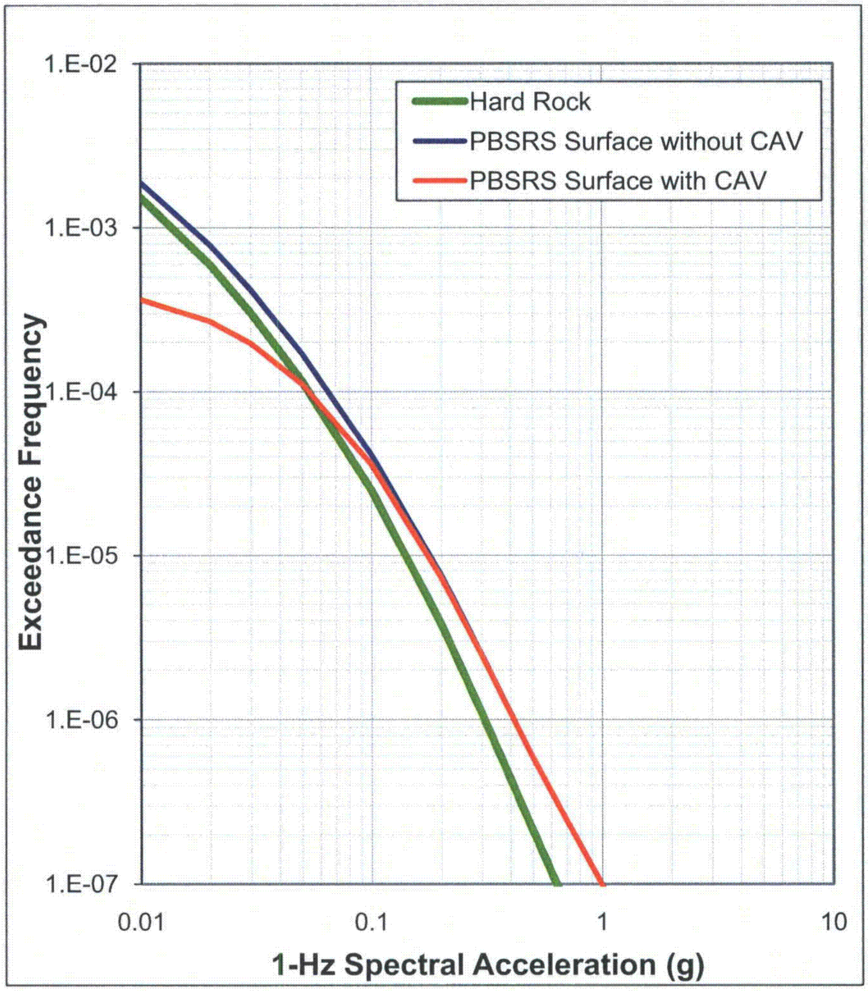

Figure 3.7.1-215: Surface Hazard Curves at Finished Ground Level Grade for the Full Soil Column Profile Computed With and Without CAV for 1 Hz Spectral Acceleration.

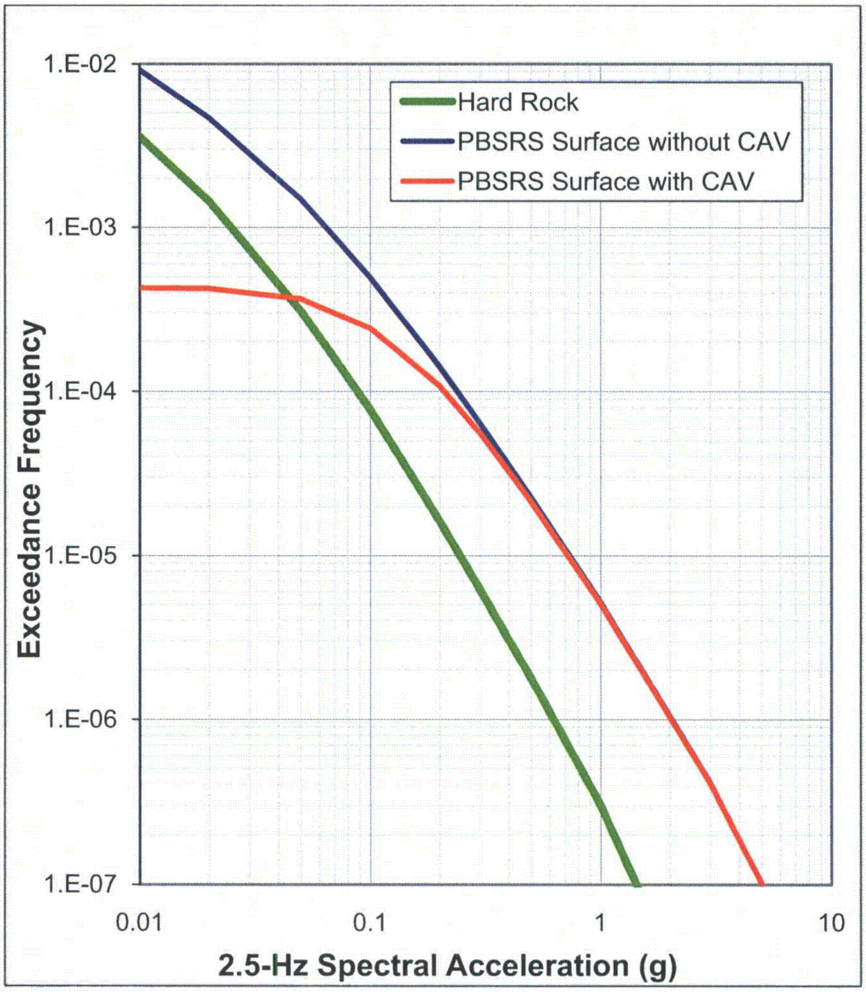

Figure 3.7.1-216: Surface Hazard Curves at Finished Ground Level Grade for the Full Soil Column Profile Computed With and Without CAV for 2.5 Hz Spectral Acceleration.

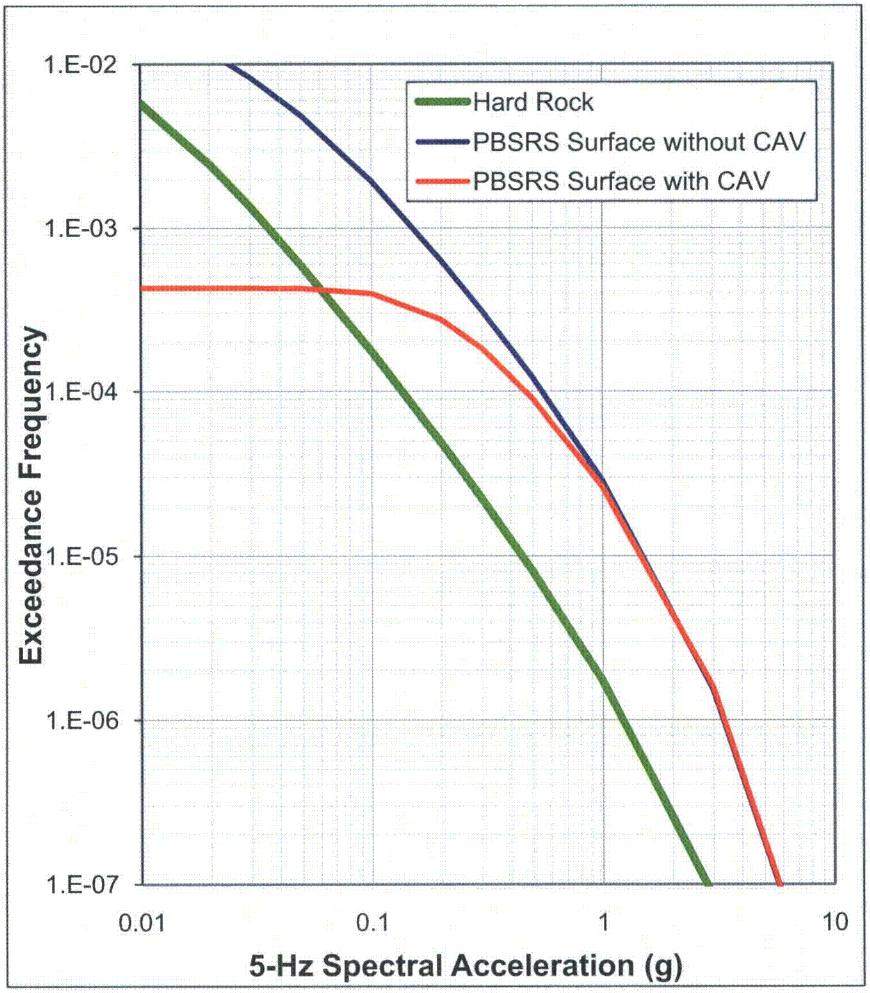

Figure 3.7.1-217: Surface Hazard Curves at Finished Ground Level Grade for the Full Soil Column Profile Computed With and Without CAV for 5 Hz Spectral Acceleration.

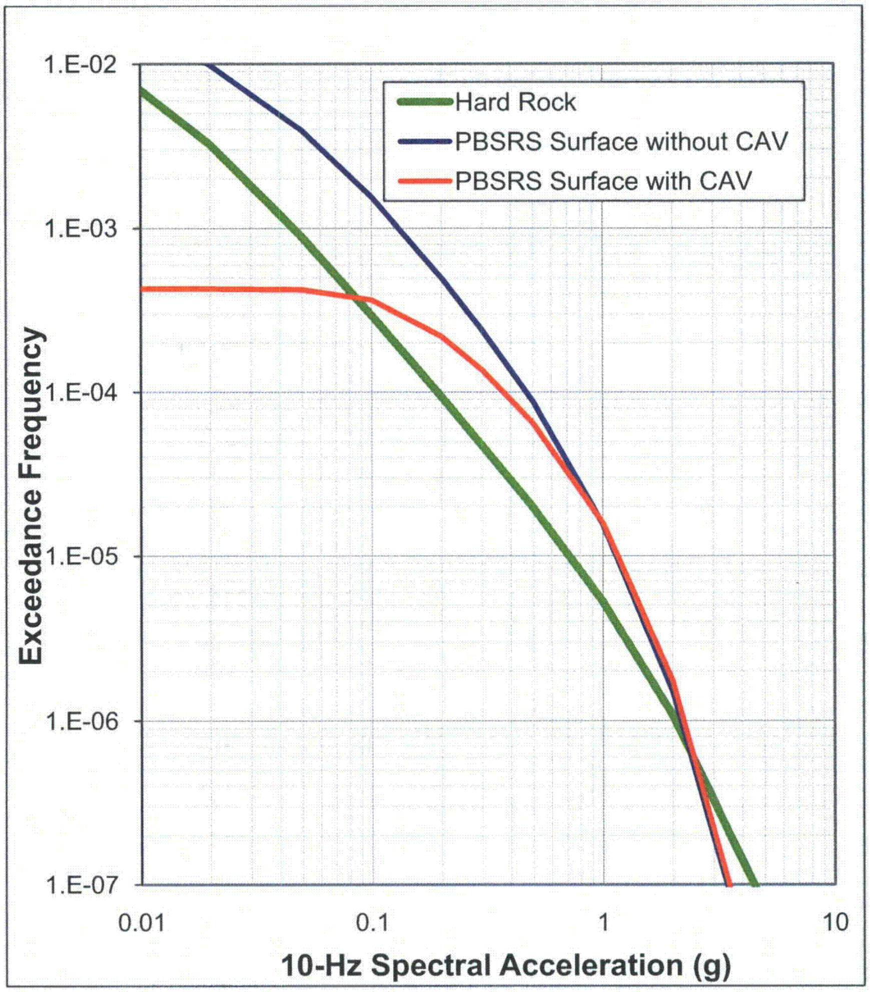

Figure 3.7.1-218: Surface Hazard Curves at Finished Ground Level Grade for the Full Soil Column Profile Computed With and Without CAV for 10 Hz Spectral Acceleration.

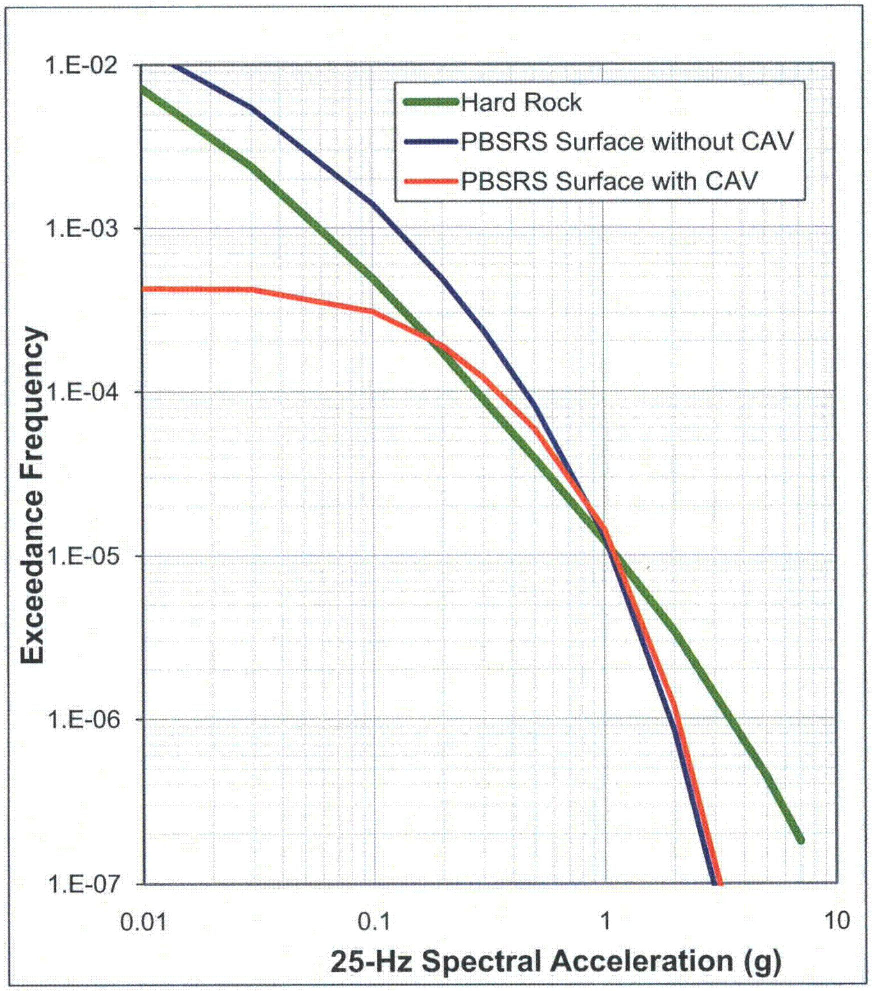

Figure 3.7.1-219: Surface Hazard Curves at Finished Ground Level Grade for the Full Soil Column Profile Computed With and Without CAV for 25 Hz Spectral Acceleration.

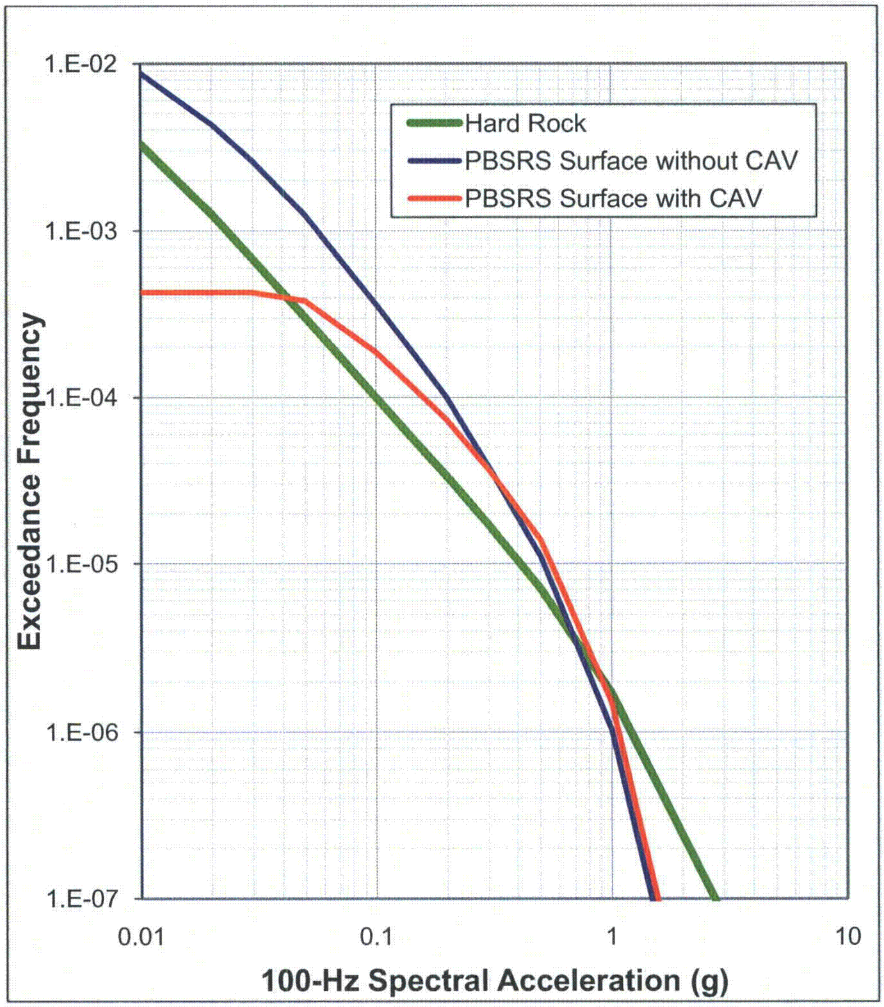

Figure 3.7.1-220: Surface Hazard Curves at Finished Ground Level Grade for the Full Soil Column Profile Computed With and Without CAV for 100 Hz Spectral Acceleration.

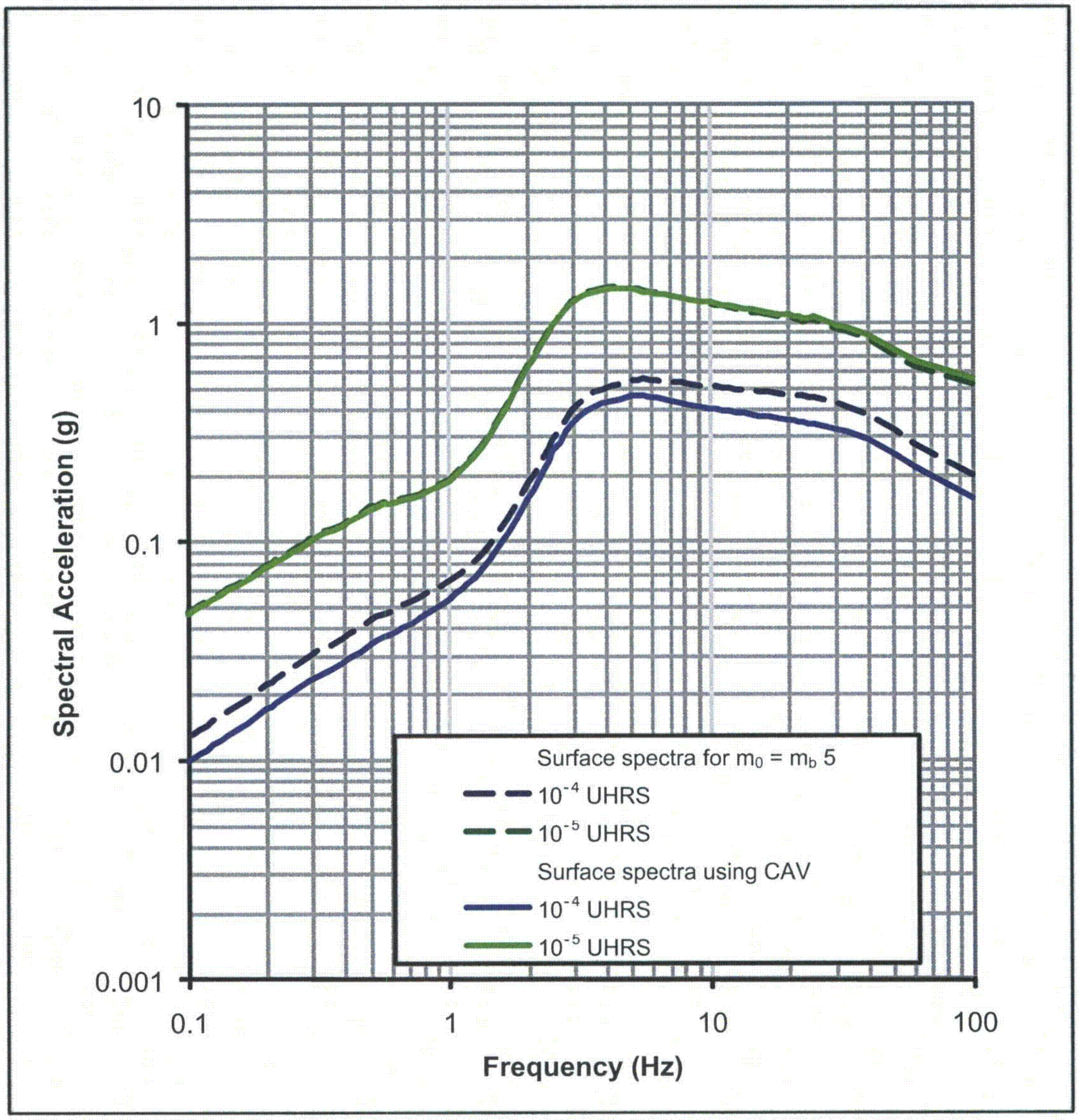

Figure 3.7.1-221: Surface UHRS at the Finished Ground Level Grade Computed With and Without CAV.

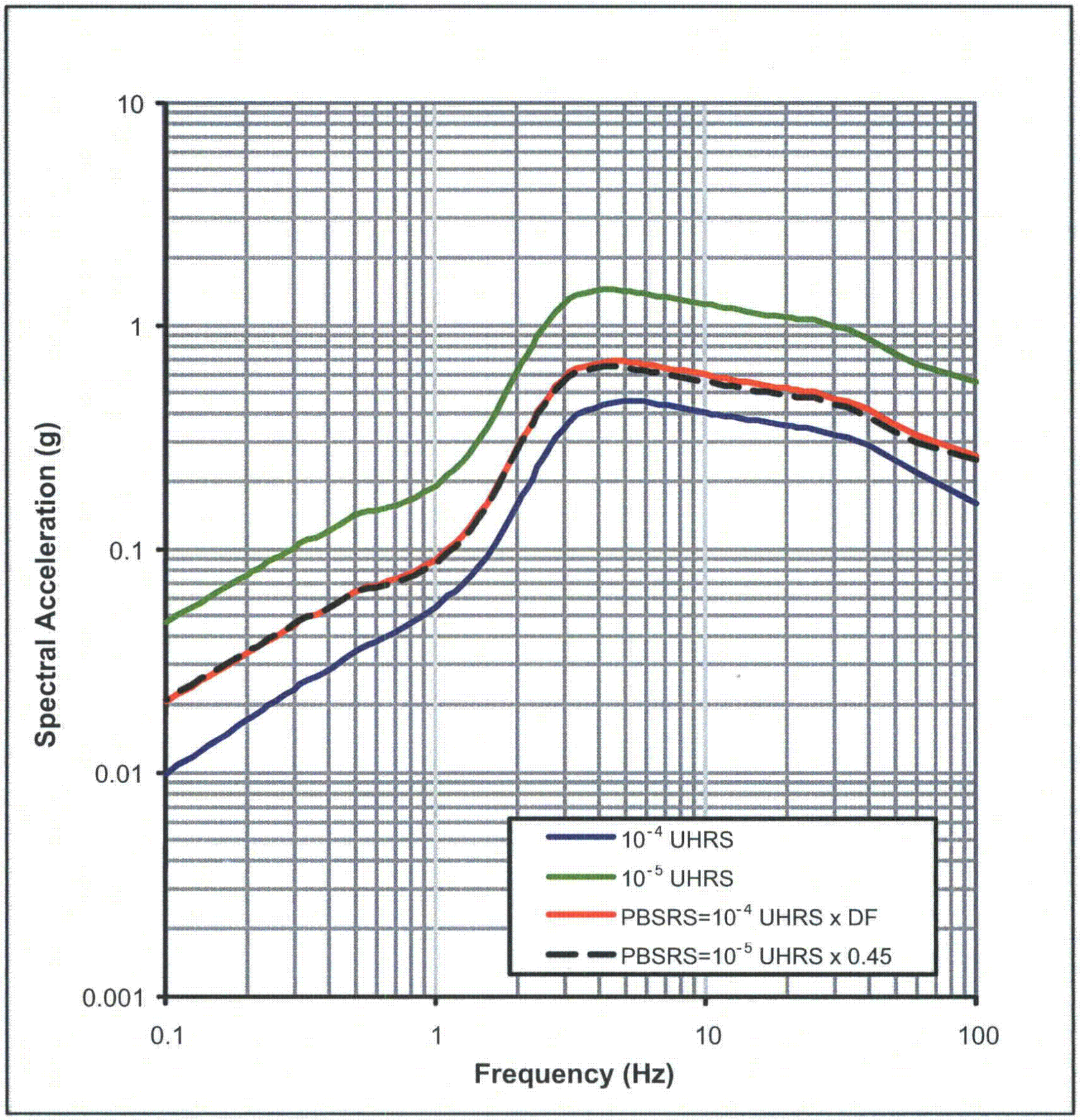

Figure 3.7.1-222: Horizontal PBSRS for the Fermi 3 Site.

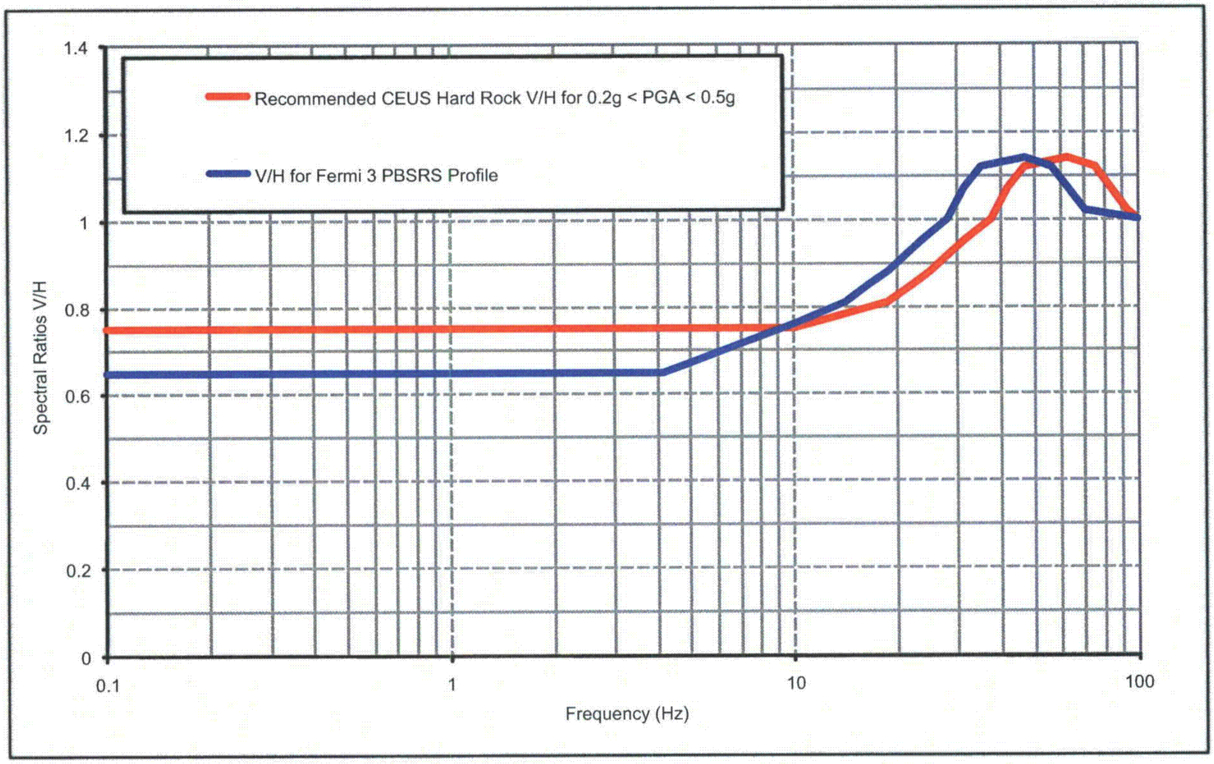

Figure 3.7.1-223: Vertical to Horizontal Spectral Ratios Developed for Fermi 3 Full Soil Column Profile.

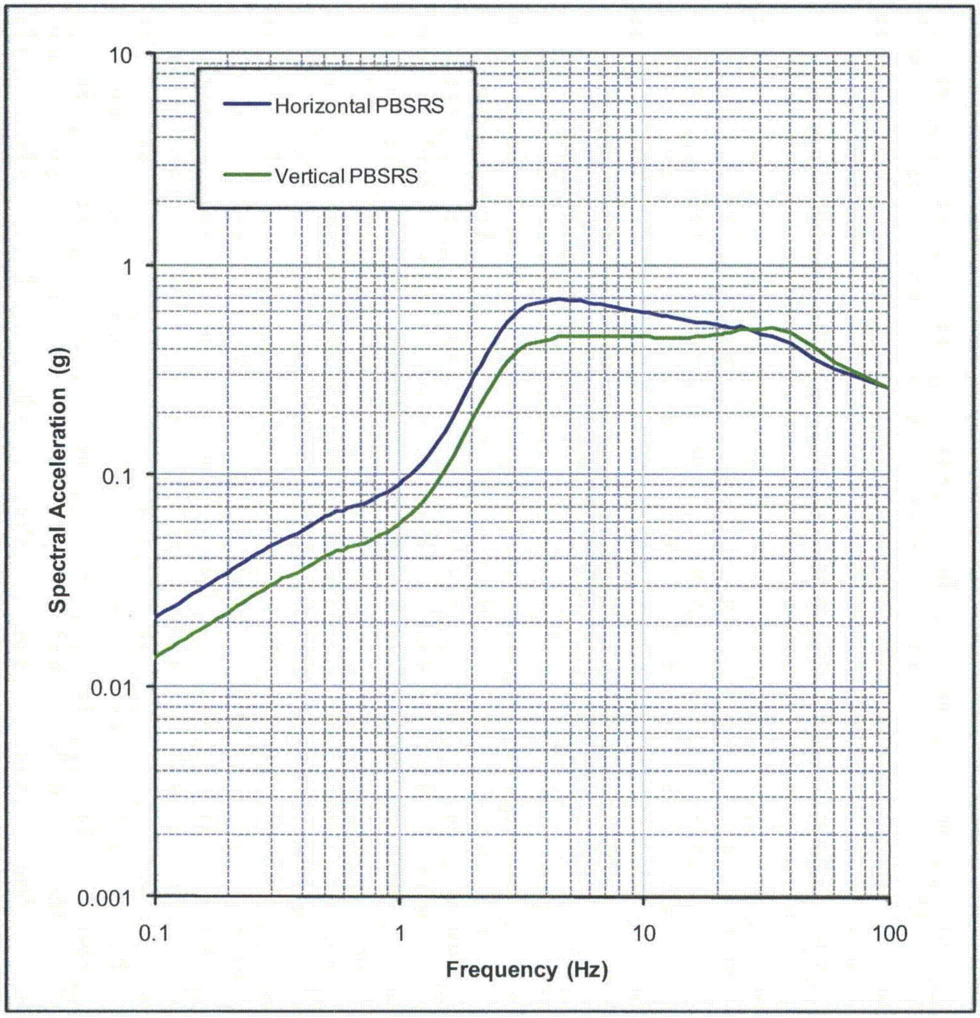

Figure 3.7.1-224: Fermi 3 PBSRS at Finished Ground Level Grade (5% Damping).

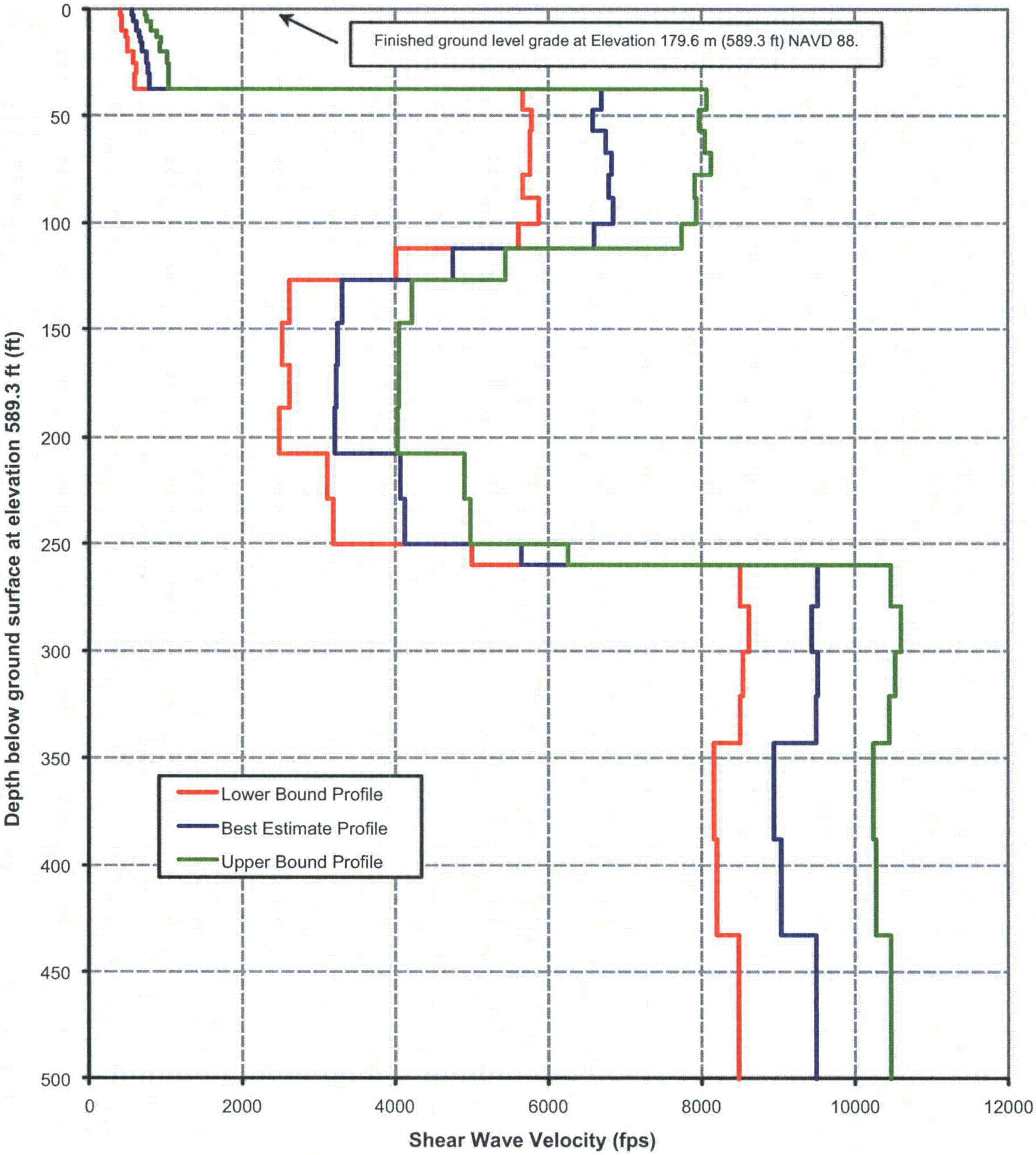

Figure 3.7.1-225: Lower Bound, Best Estimate and Upper Bound Shear Wave Velocity Profiles for the Full Soil Column.

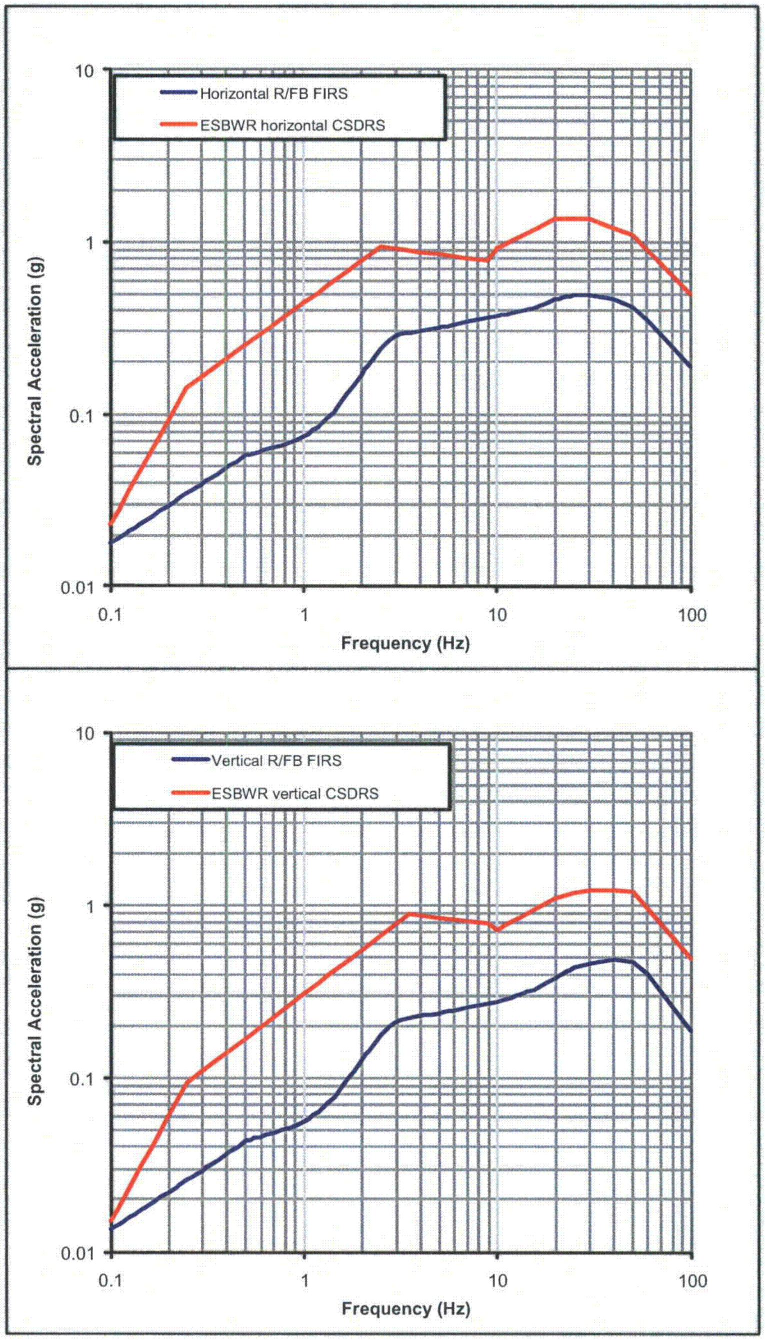

Figure 3.7.1-226: Fermi 3 RB/FB SCOR FIRS (5% Damping).

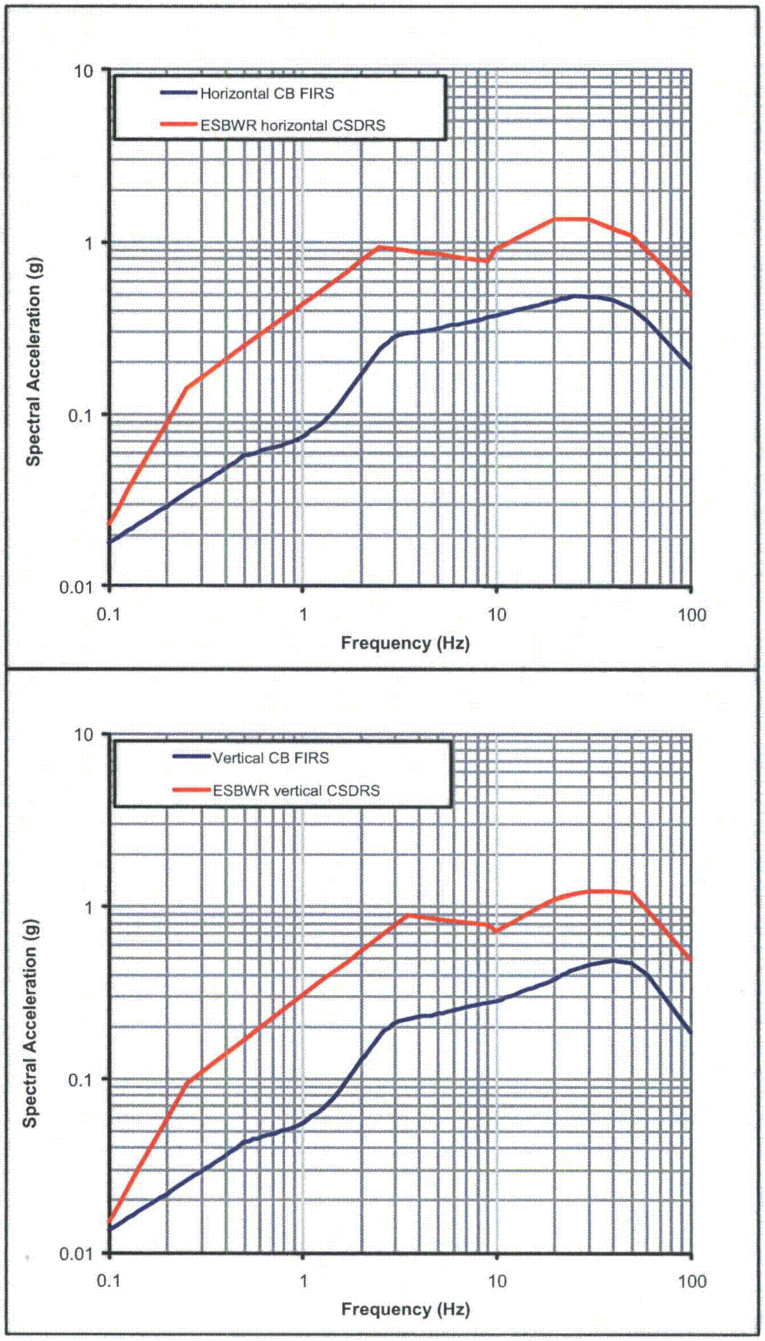

Figure 3.7.1-227: Fermi 3 CB SCOR FIRS (5% Damping).

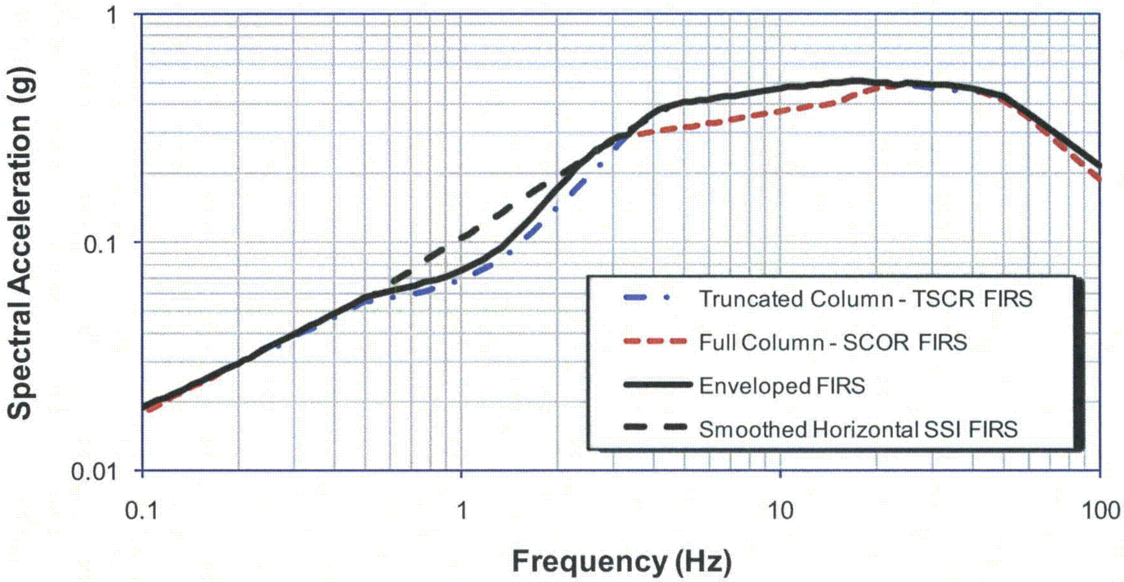

Figure 3.7.1-228: Development of Horizontal Fermi 3 SSI FIRS for the RB/FB.

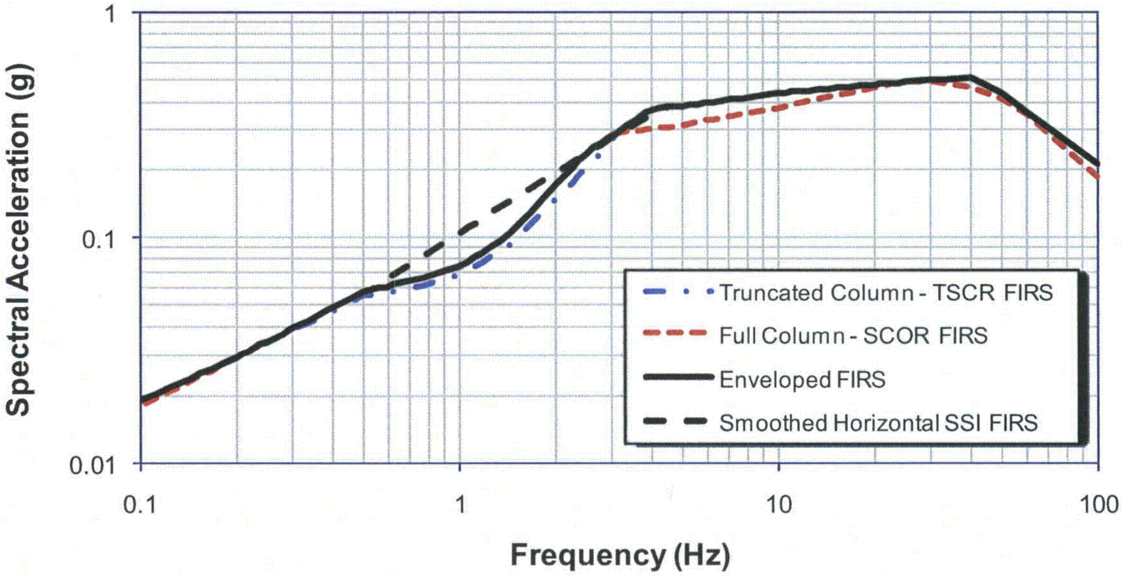

Figure 3.7.1-229: Development of Horizontal Fermi 3 SSI FIRS for the CB.

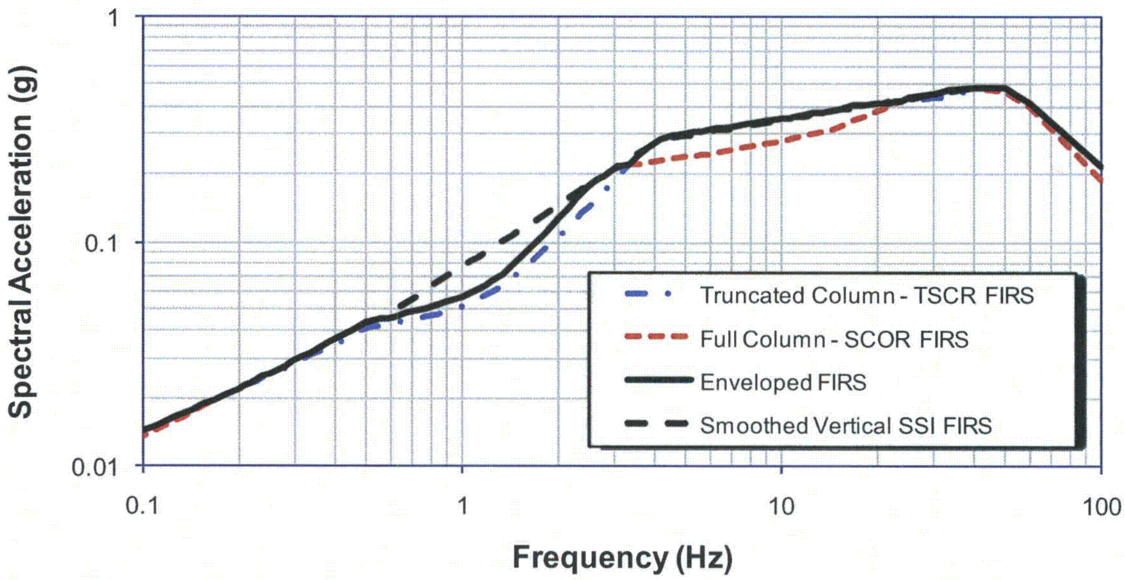

Figure 3.7.1-230: Development of Vertical Fermi 3 SSI FIRS for the RB/FB.

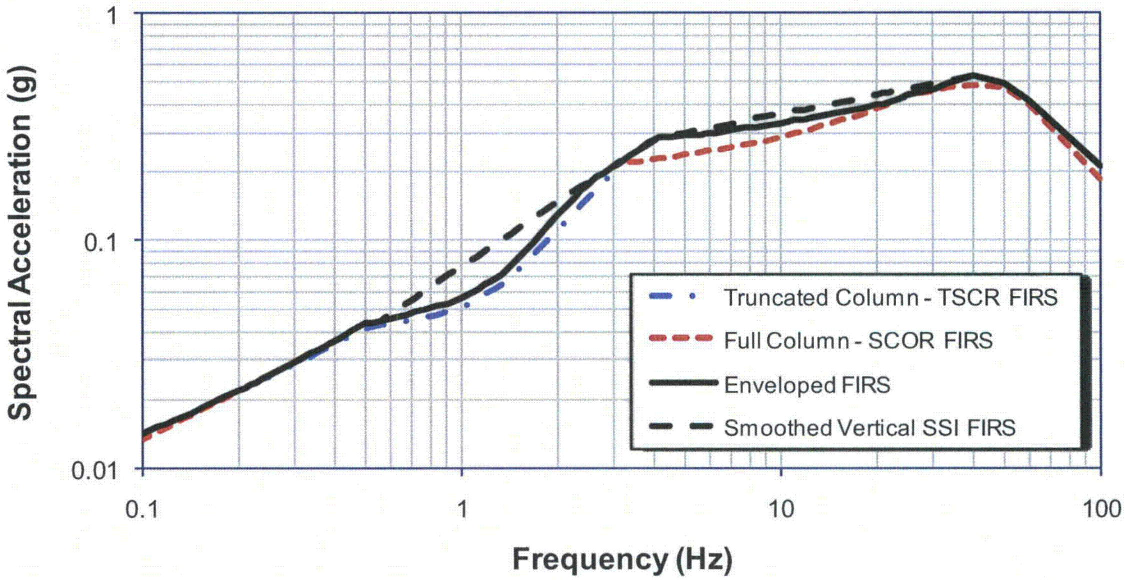

Figure 3.7.1-231: Development of Vertical Fermi 3 SSI FIRS for the CB.

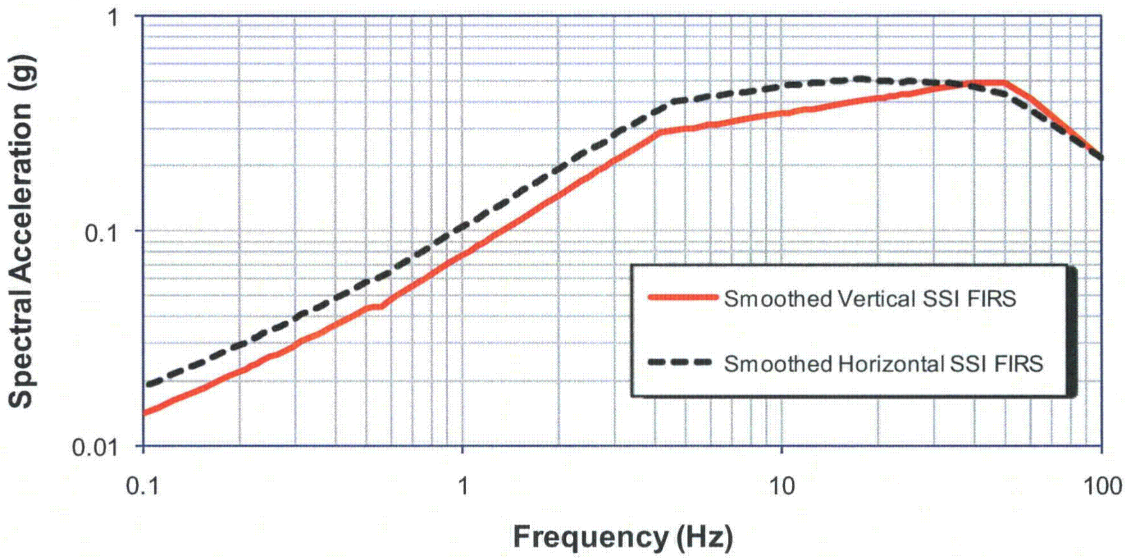

Figure 3.7.1-232: Horizontal and Vertical Fermi 3 SSI FIRS for the RB/FB.

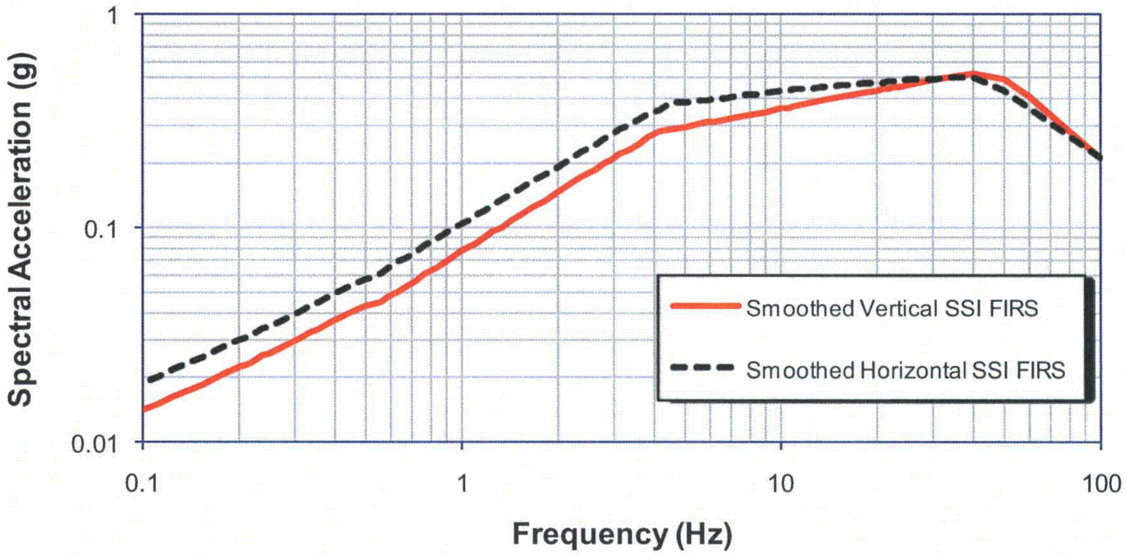

Figure 3.7.1-233: Horizontal and Vertical Fermi 3 SSI FIRS for the CB.

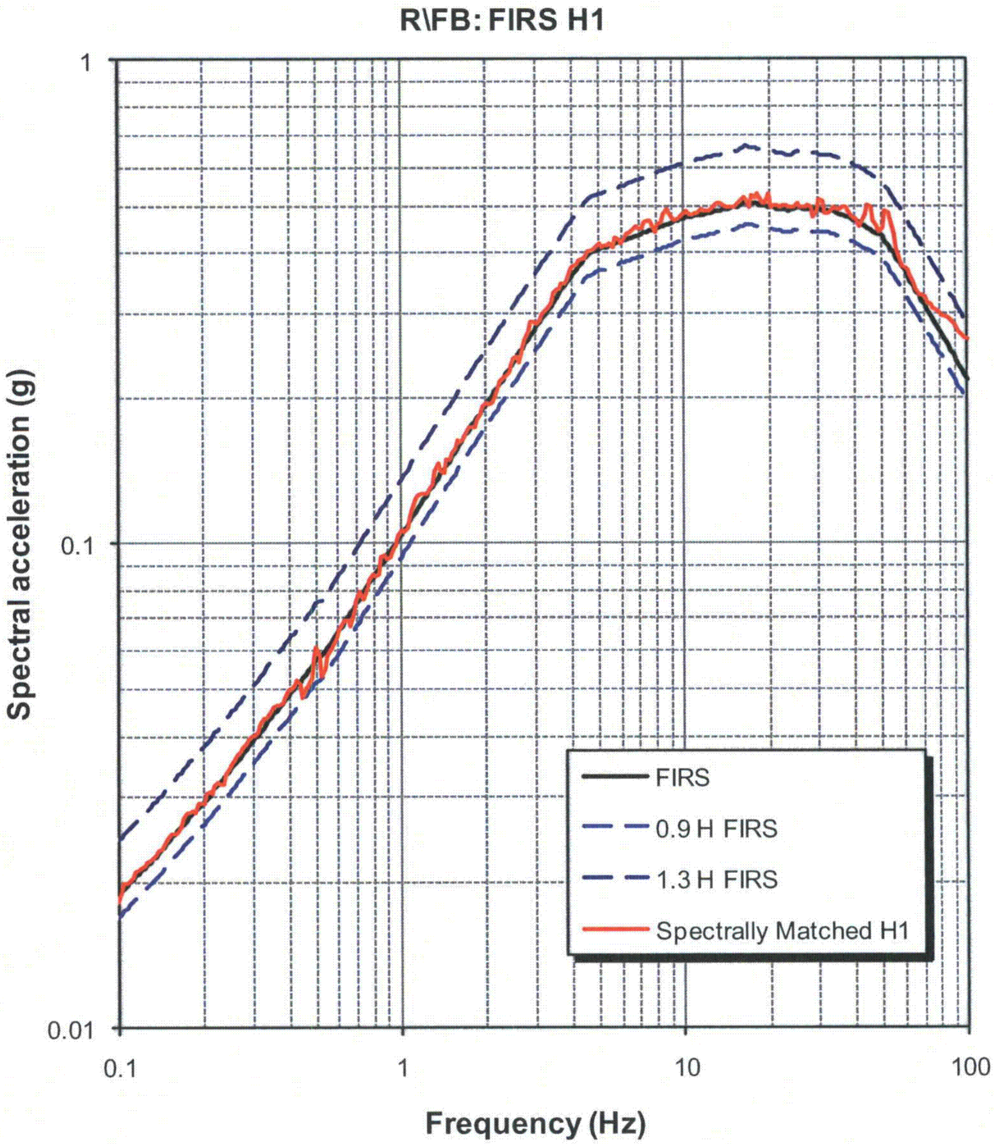

Figure 3.7.1-234: Response Spectrum for Spectrally Matched Horizontal (H1) Component for the Fermi 3 RB/FB SSI FIRS.

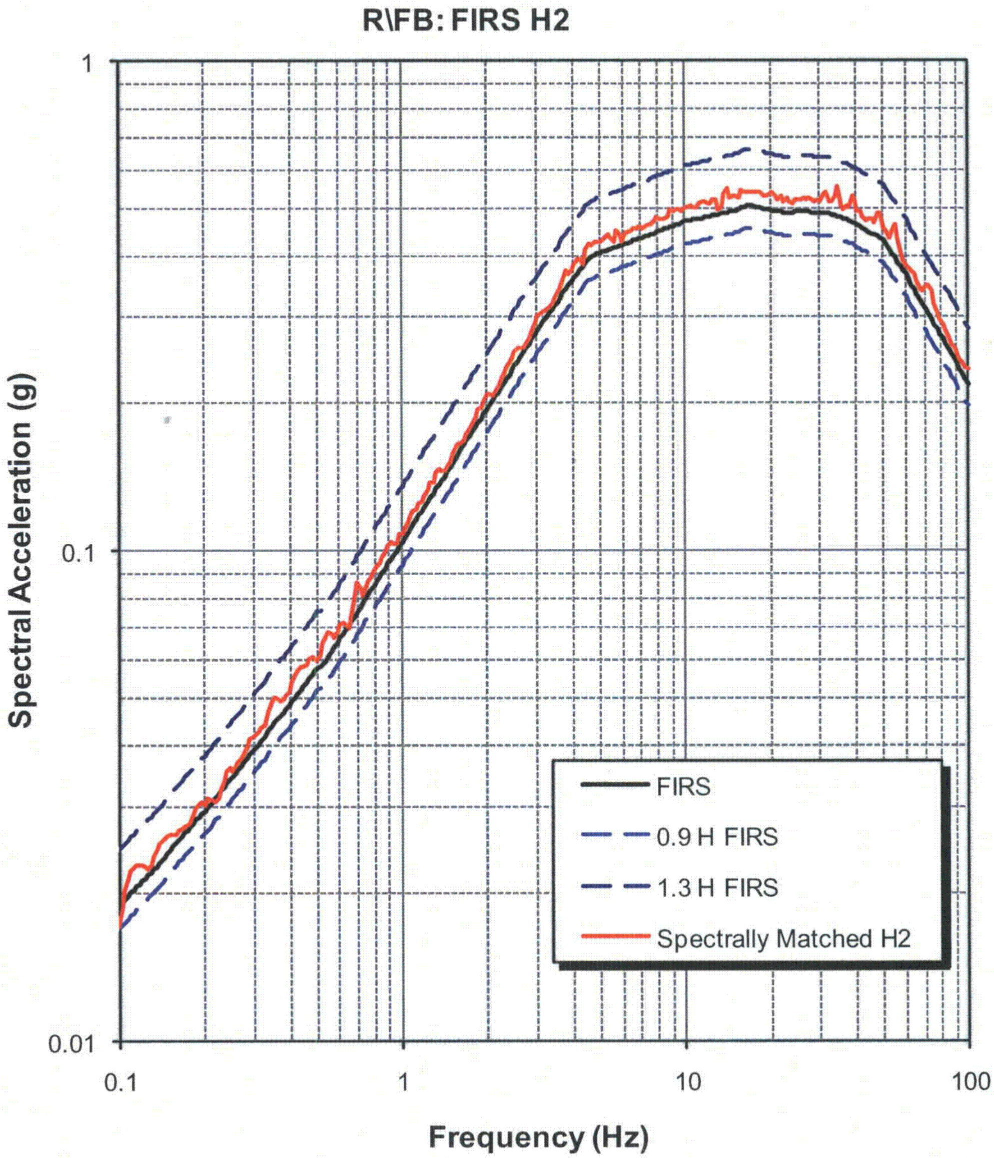

Figure 3.7.1-235: Response Spectrum for Spectrally Matched Horizontal (H2) Component for the Fermi 3 RB/FB SSI FIRS.

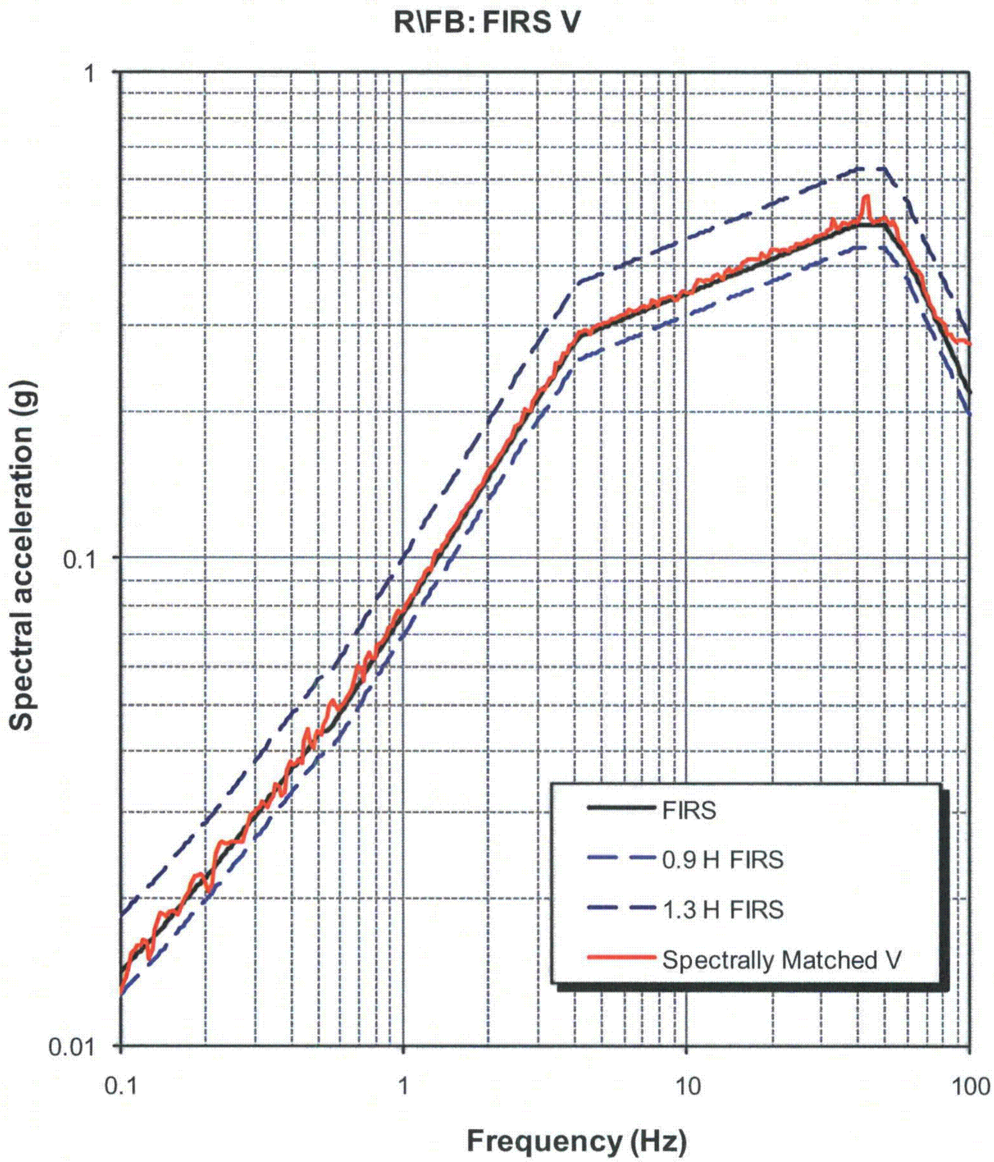

Figure 3.7.1-236: Response Spectrum for Spectrally Matched Vertical (V) Component for the Fermi 3 RB/FB SSI FIRS.

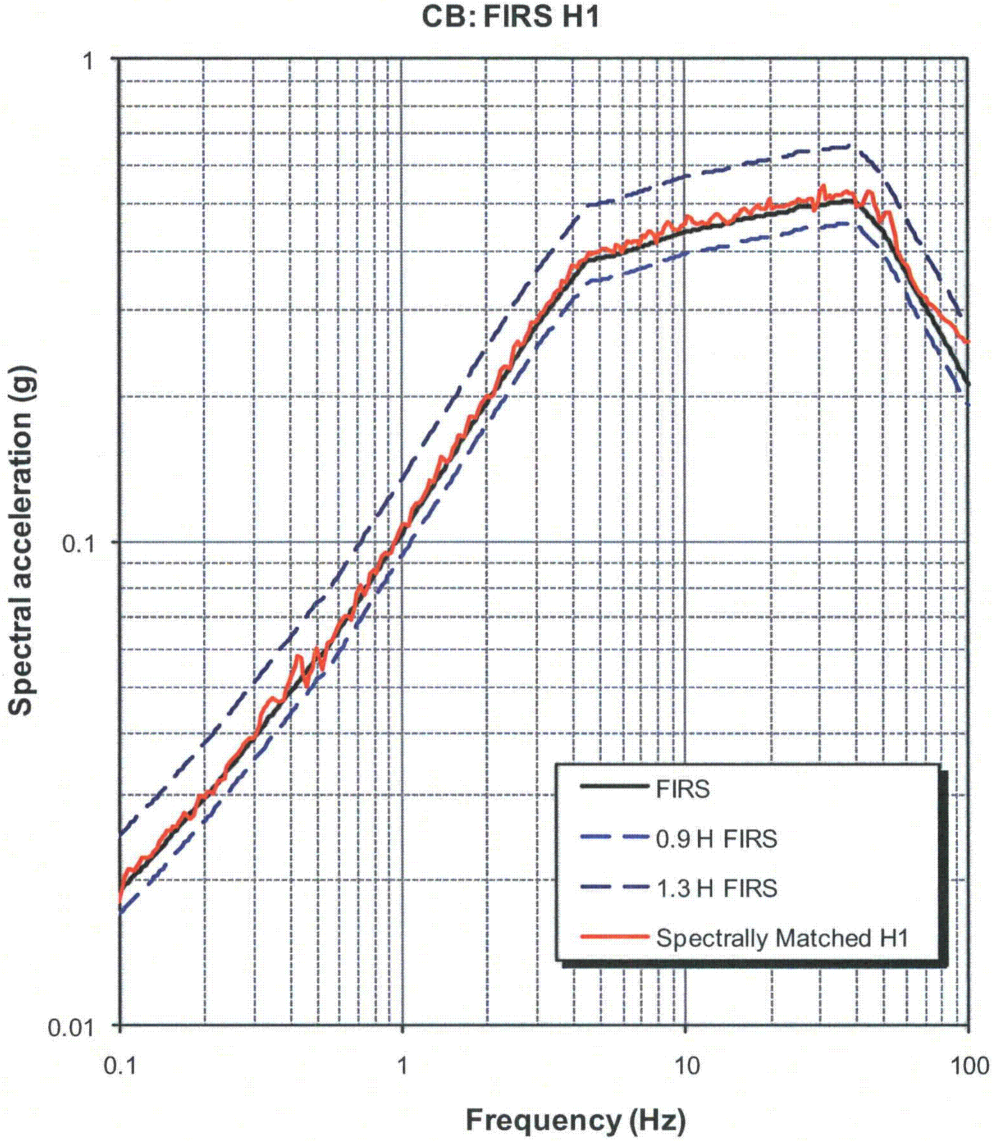

Figure 3.7.1-237: Response Spectrum for Spectrally Matched Horizontal (H1) Component for the Fermi 3 CB SSI FIRS.

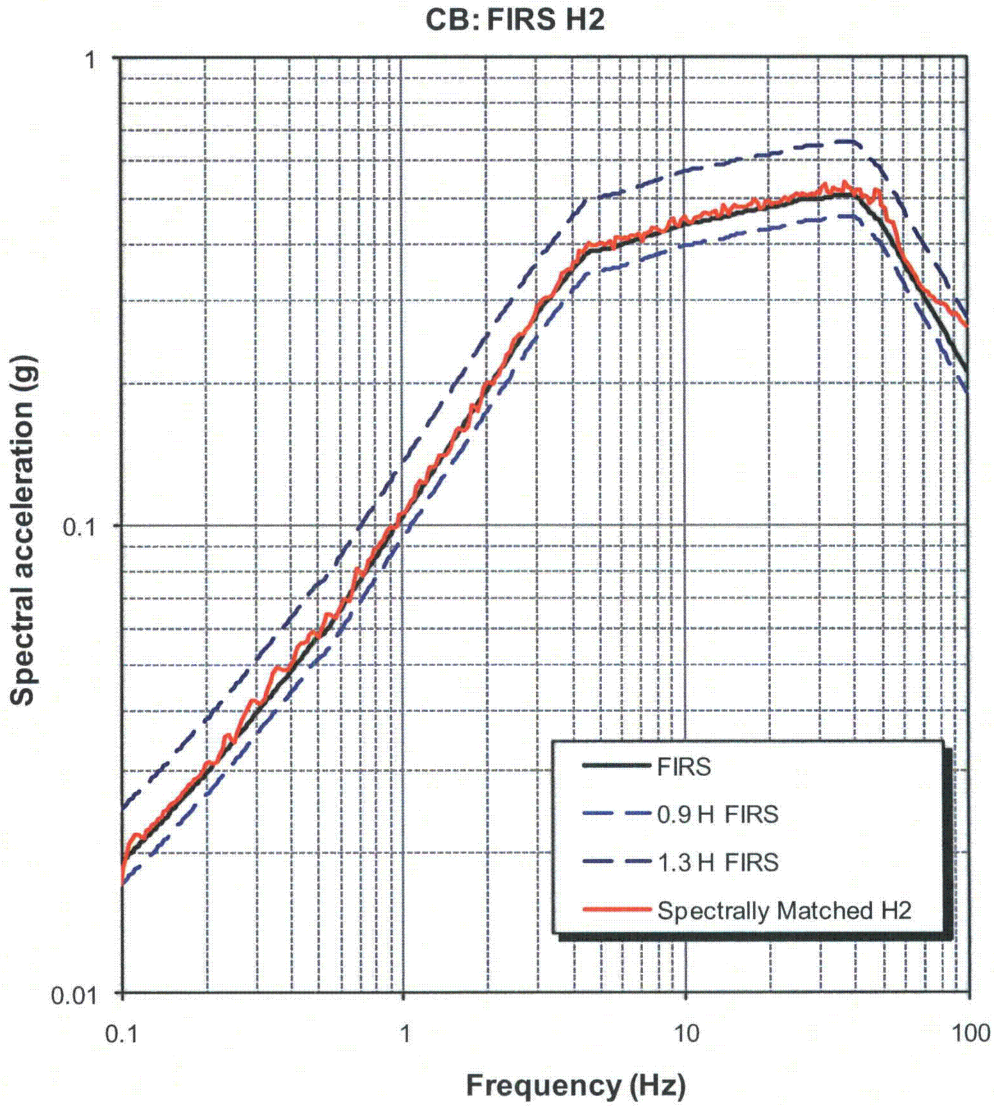

Figure 3.7.1-238: Response Spectrum for Spectrally Matched Horizontal (H2) Component for the Fermi 3 CB SSI FIRS.

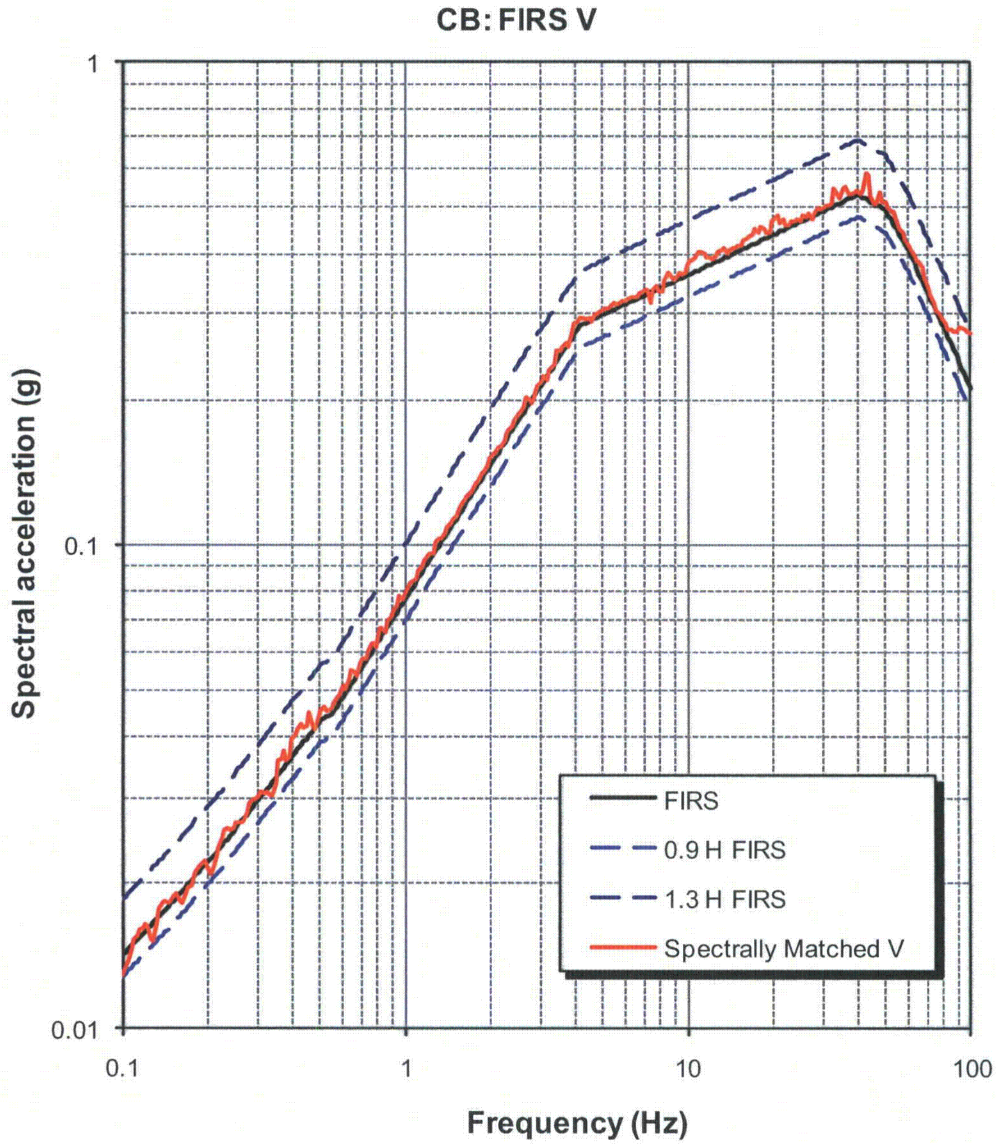

Figure 3.7.1-239: Response Spectrum for Spectrally Matched Vertical (V) Component for the Fermi 3 CB SSI FIRS.

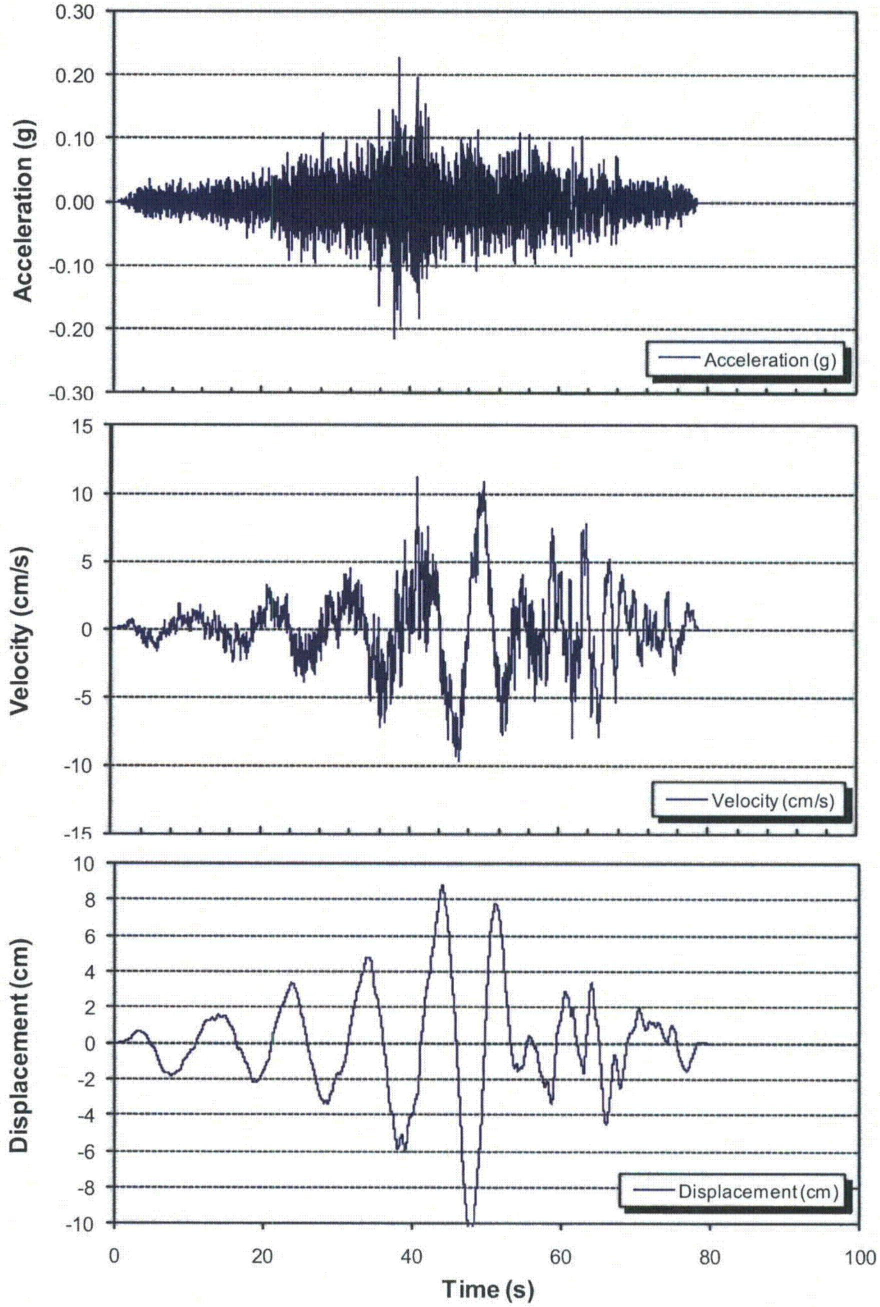

Figure 3.7.1-240: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H1) Component Compatible with the RB/FB Horizontal SSI FIRS.

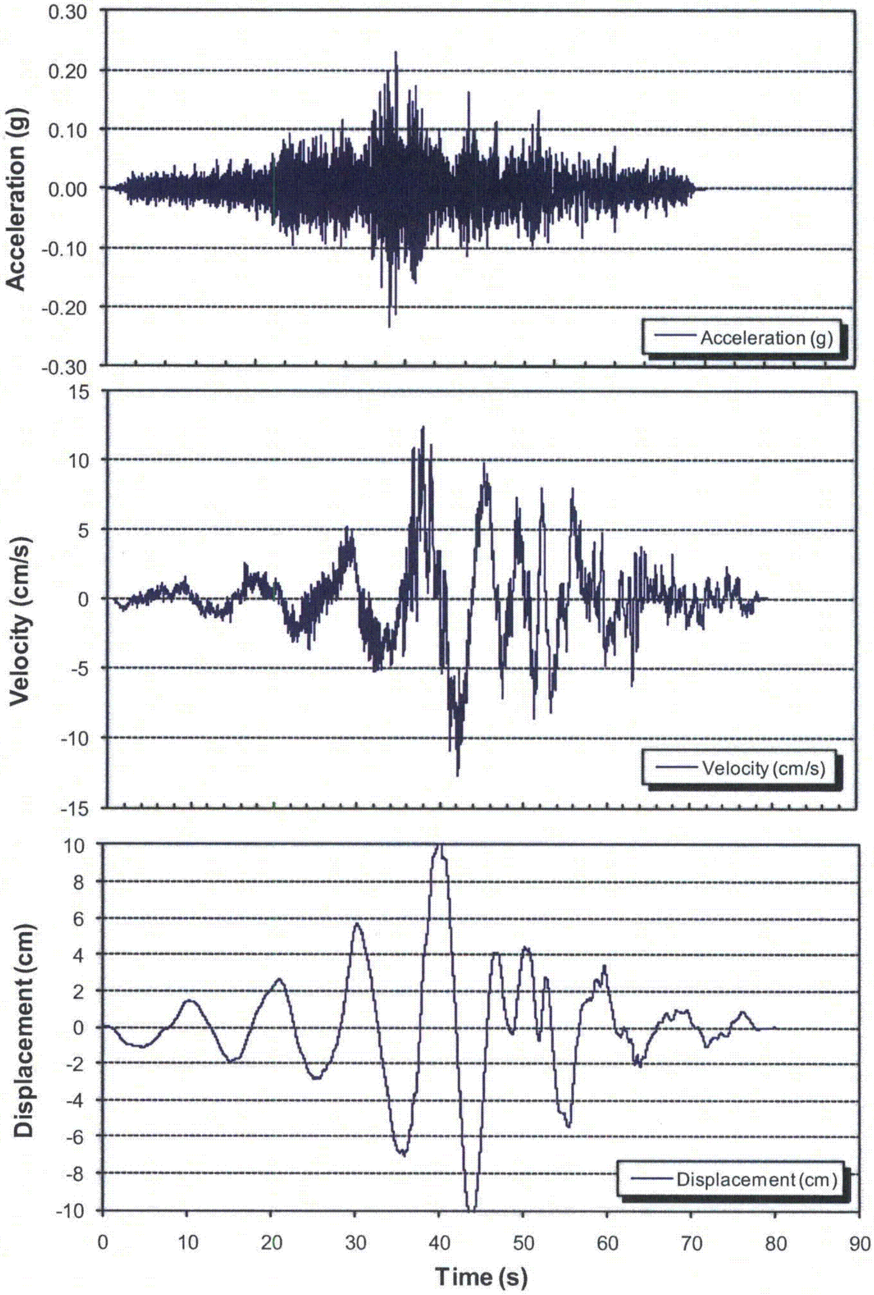

Figure 3.7.1-241: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H2) Component Compatible with the RB/FB Horizontal SSI FIRS.

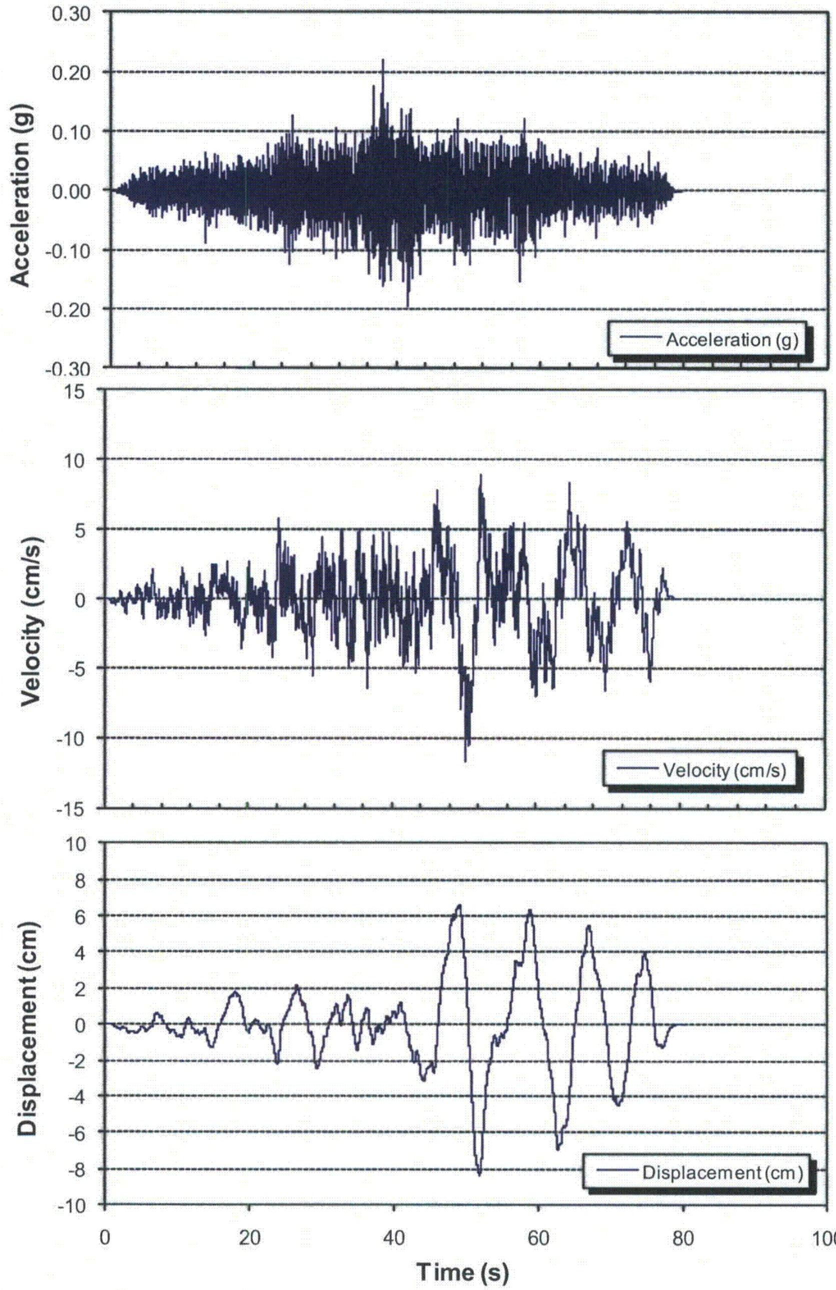

Figure 3.7.1-242: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Vertical (V) Component Compatible with the RB/FB Vertical SSI FIRS.

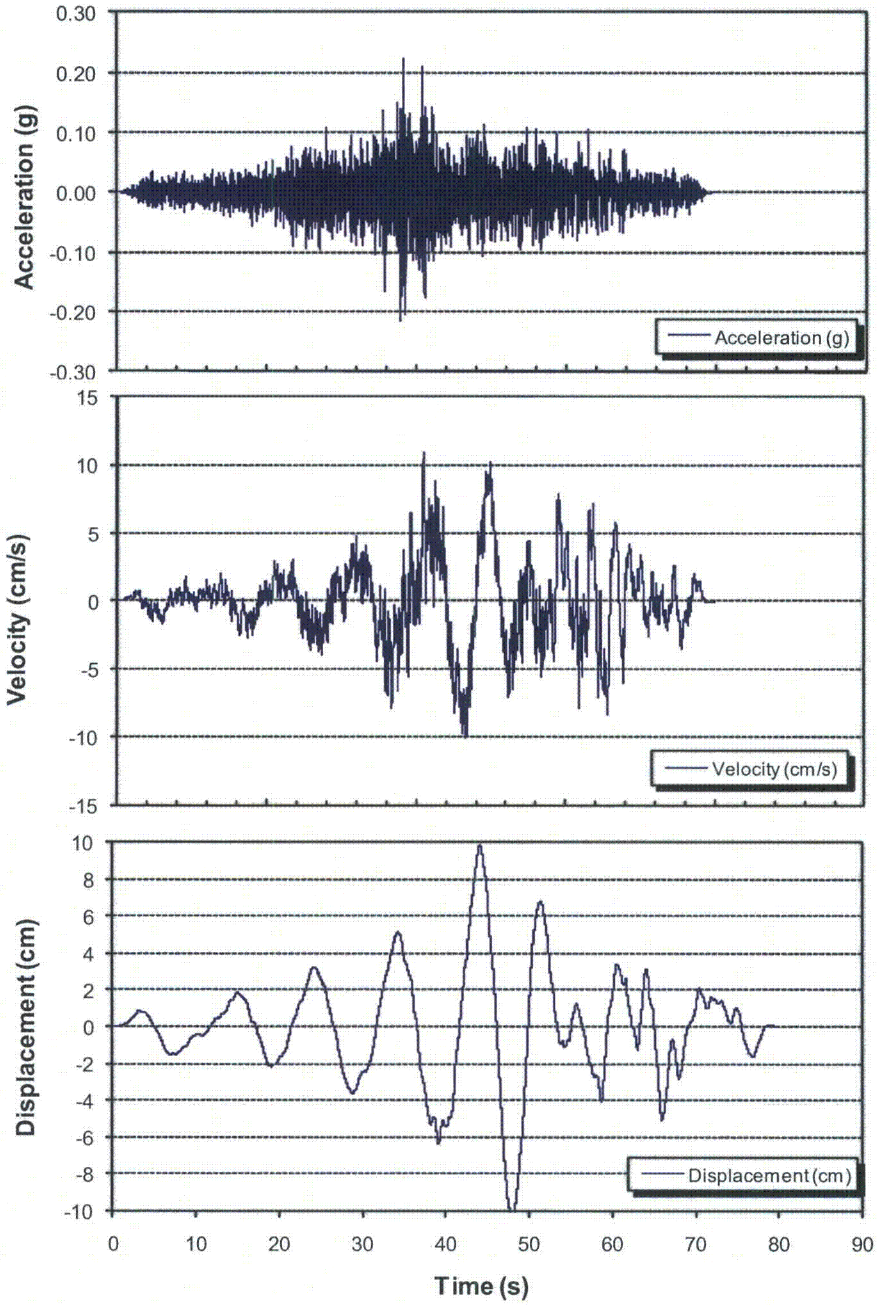

Figure 3.7.1-243: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H1) Component Compatible with the CB Horizontal SSI FIRS.

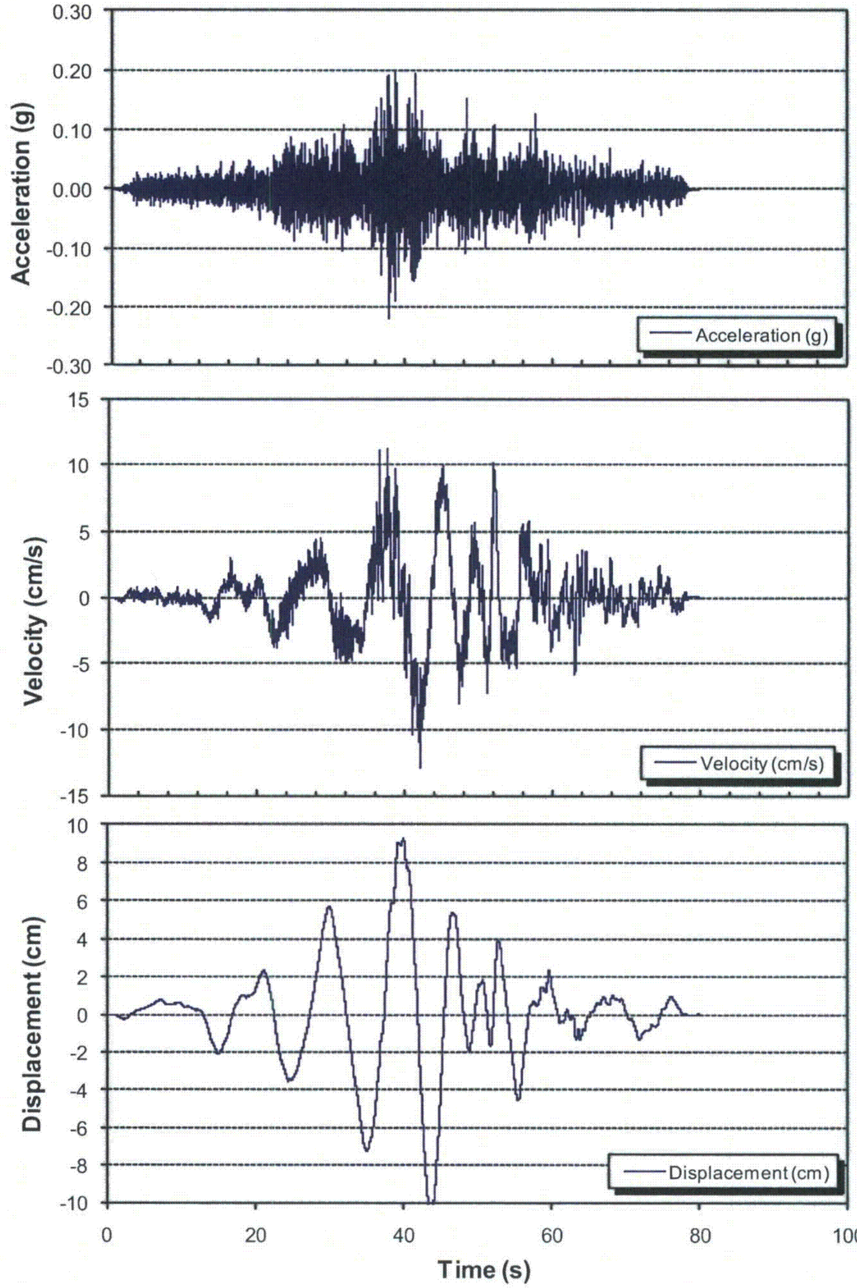

Figure 3.7.1-244: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Horizontal (H2) Component Compatible with the CB Horizontal SSI FIRS.

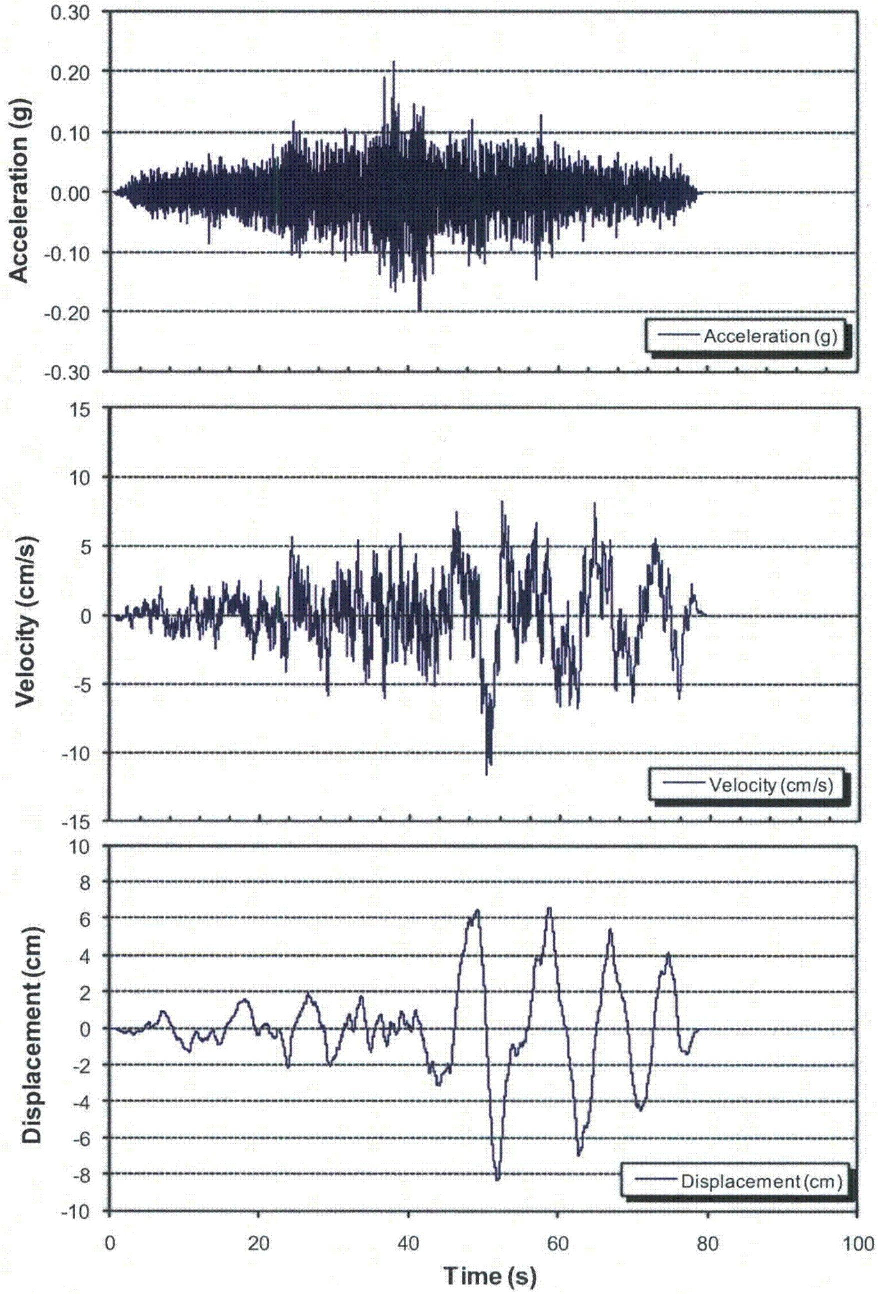

Figure 3.7.1-245: Acceleration, Velocity, and Displacement Time Histories for the SSI FIRS Vertical (V) Component Compatible with the CB Vertical SSI FIRS.

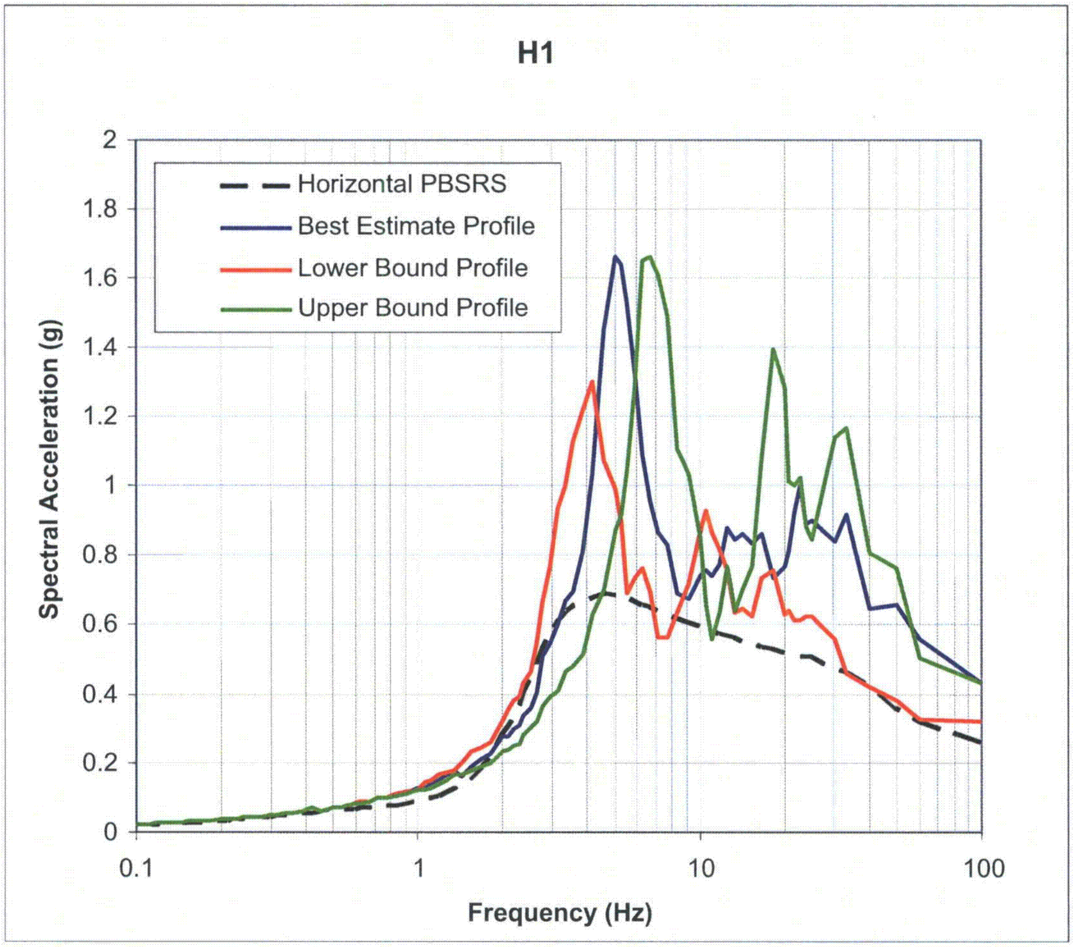

Figure 3.7.1-246: Comparison of Response Spectra of Computed Horizontal (H1) Component Surface Motions for SSI Profiles Using the RB/FB SCOR FIRS Input Motion to the Horizontal PBSRS.

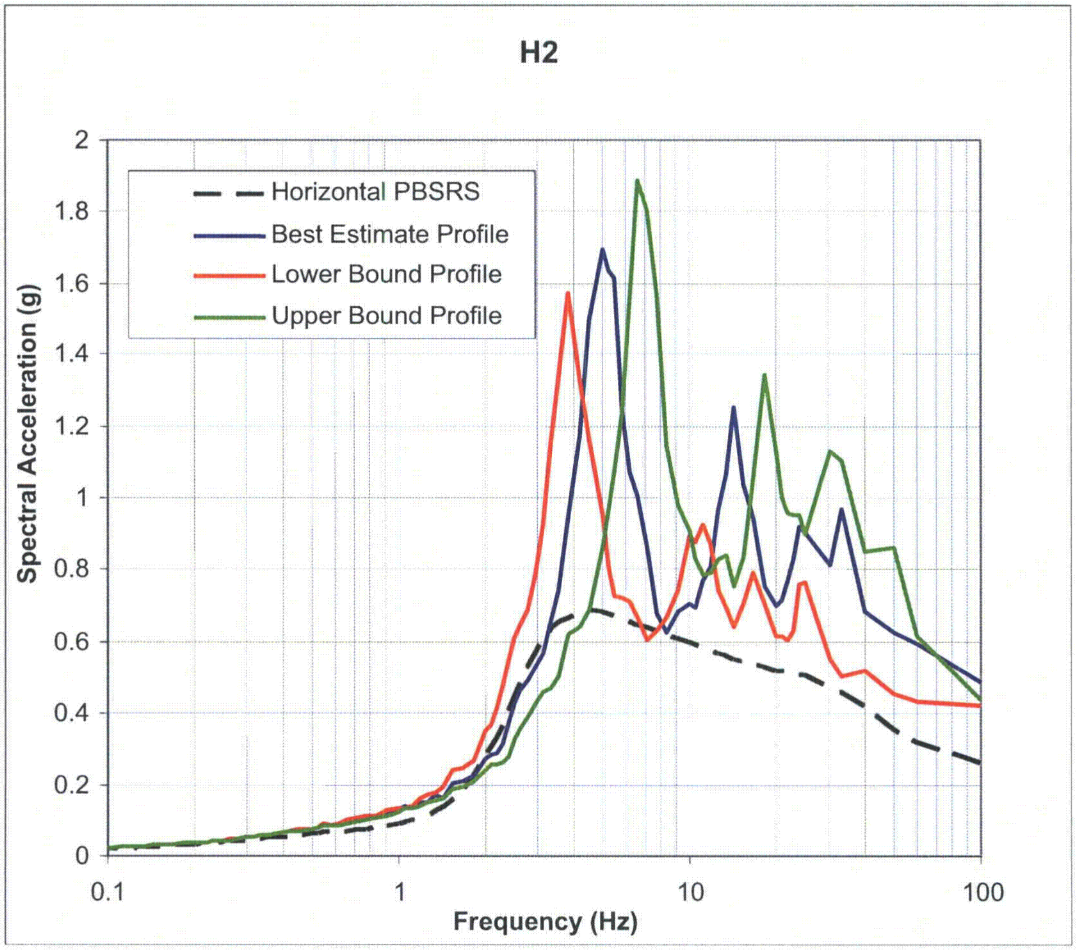

Figure 3.7.1-247: Comparison of Response Spectra of Computed Horizontal (H2) Component Surface Motions for SSI Profiles Using the RB/FB SCOR FIRS Input Motion to the Horizontal PBSRS.

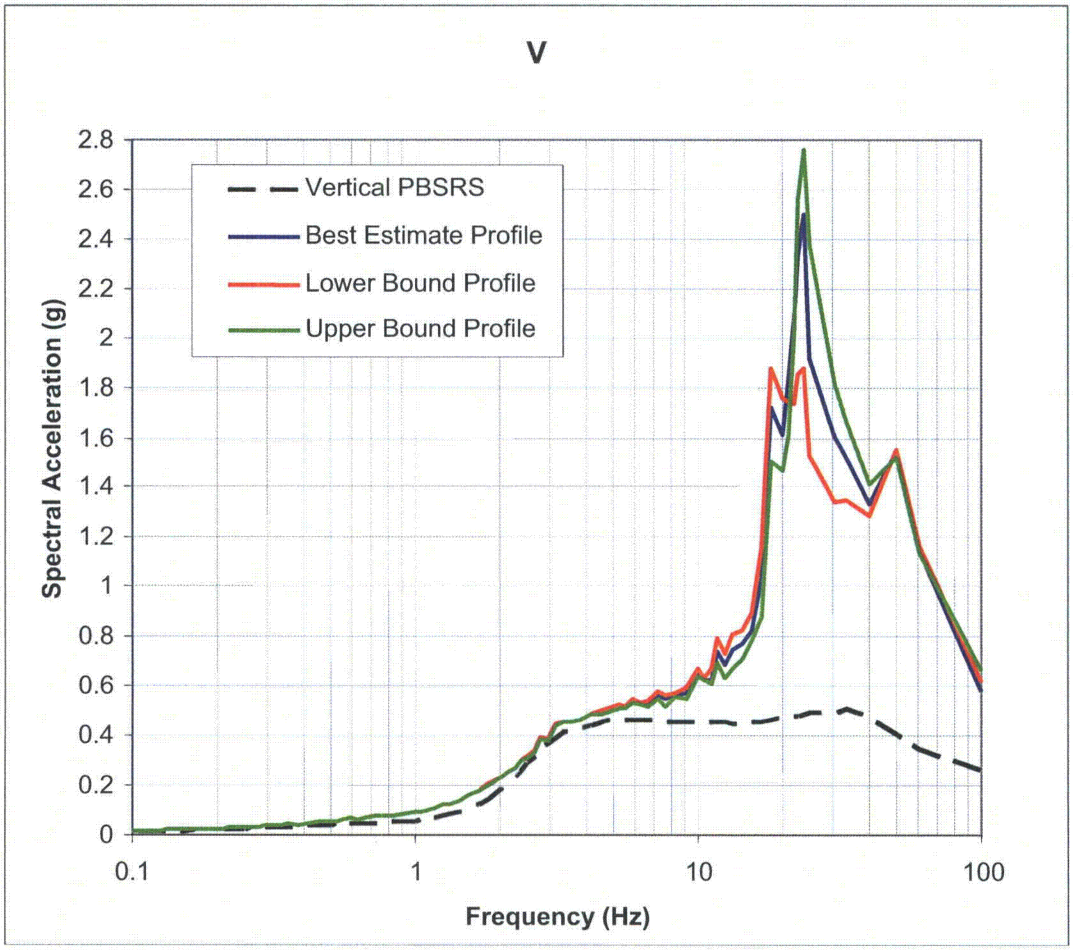

Figure 3.7.1-248: Comparison of Response Spectra of Computed Vertical (V) Component Surface Motions for SSI Profiles Using RB/FB SCOR FIRS Input Motion to the Vertical PBSRS.

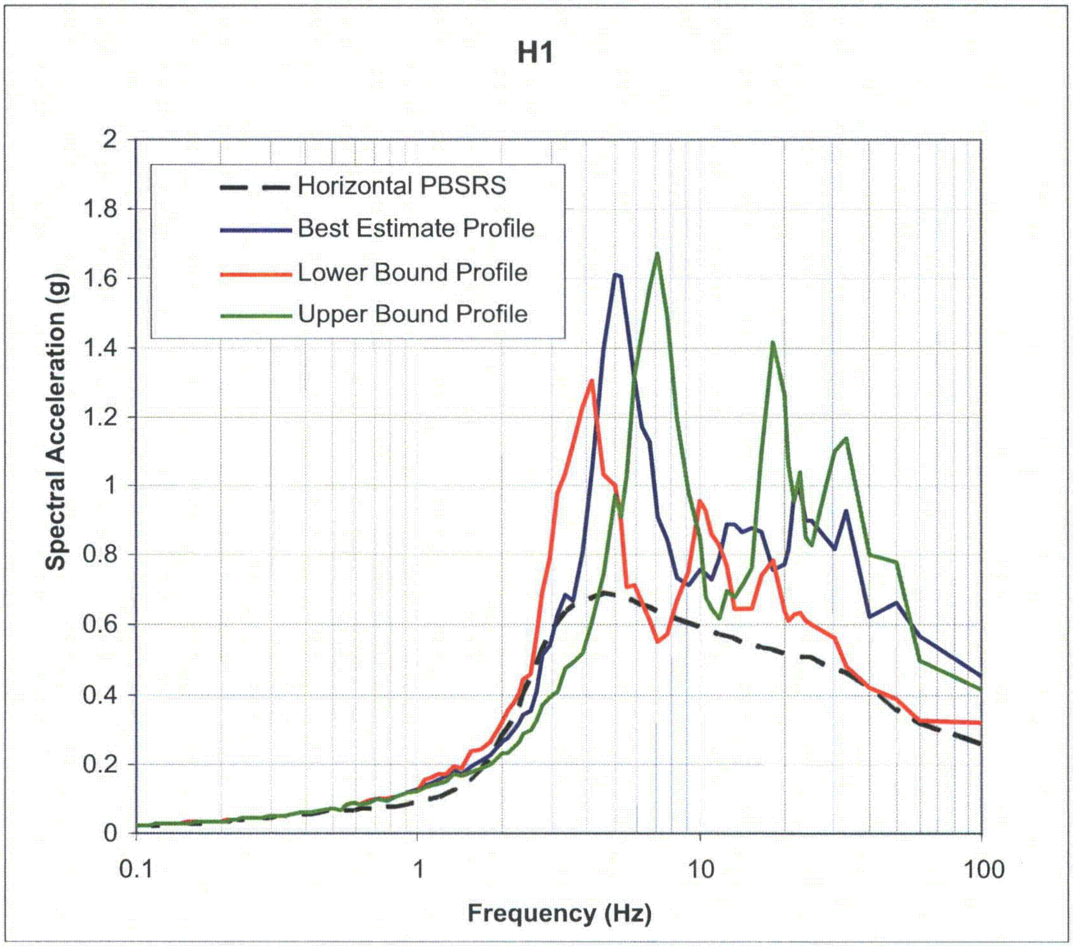

Figure 3.7.1-249: Comparison of Response Spectra of Computed Horizontal (H1) Component Surface Motions for SSI Profiles Using CB SCOR FIRS Input Motion to Horizontal PBSRS.

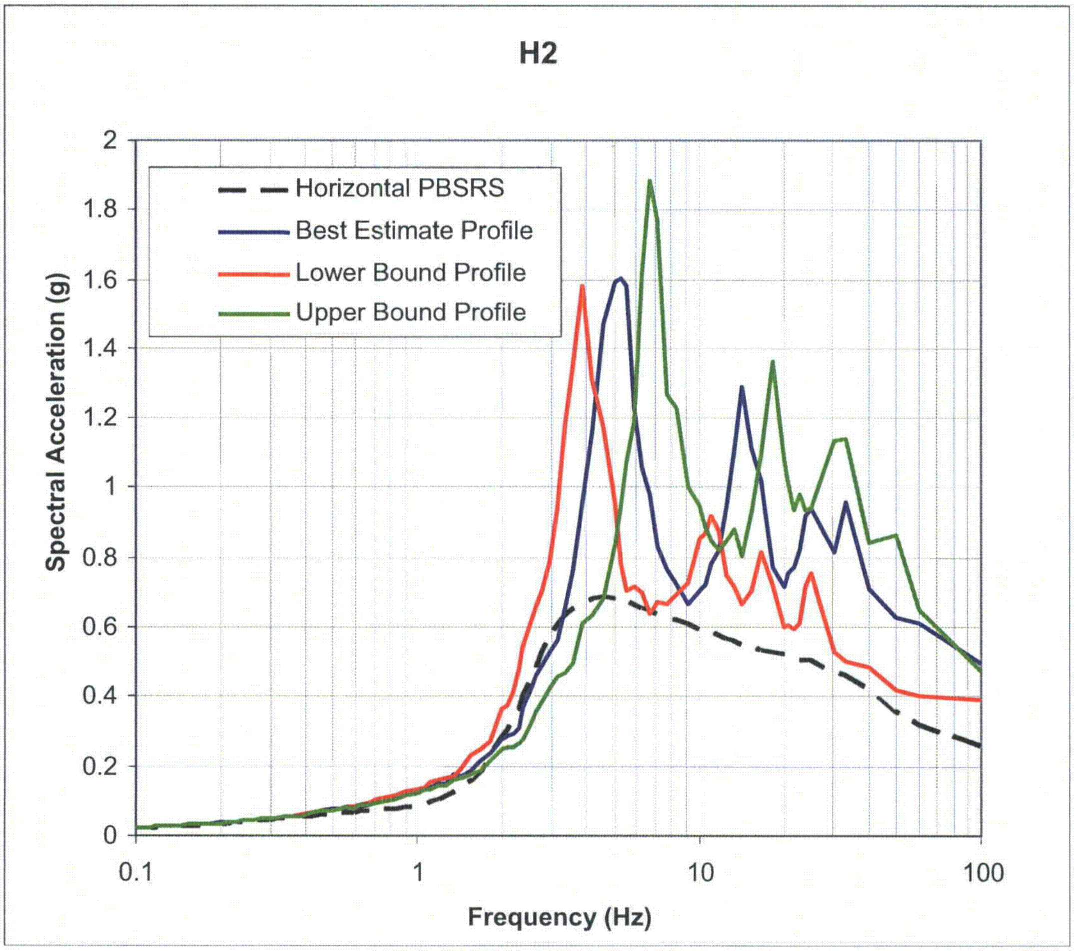

Figure 3.7.1-250: Comparison of Response Spectra of Computed Horizontal (H2) Component Surface Motions for SSI Profiles Using CB SCOR FIRS Input Motion to the Horizontal PBSRS.

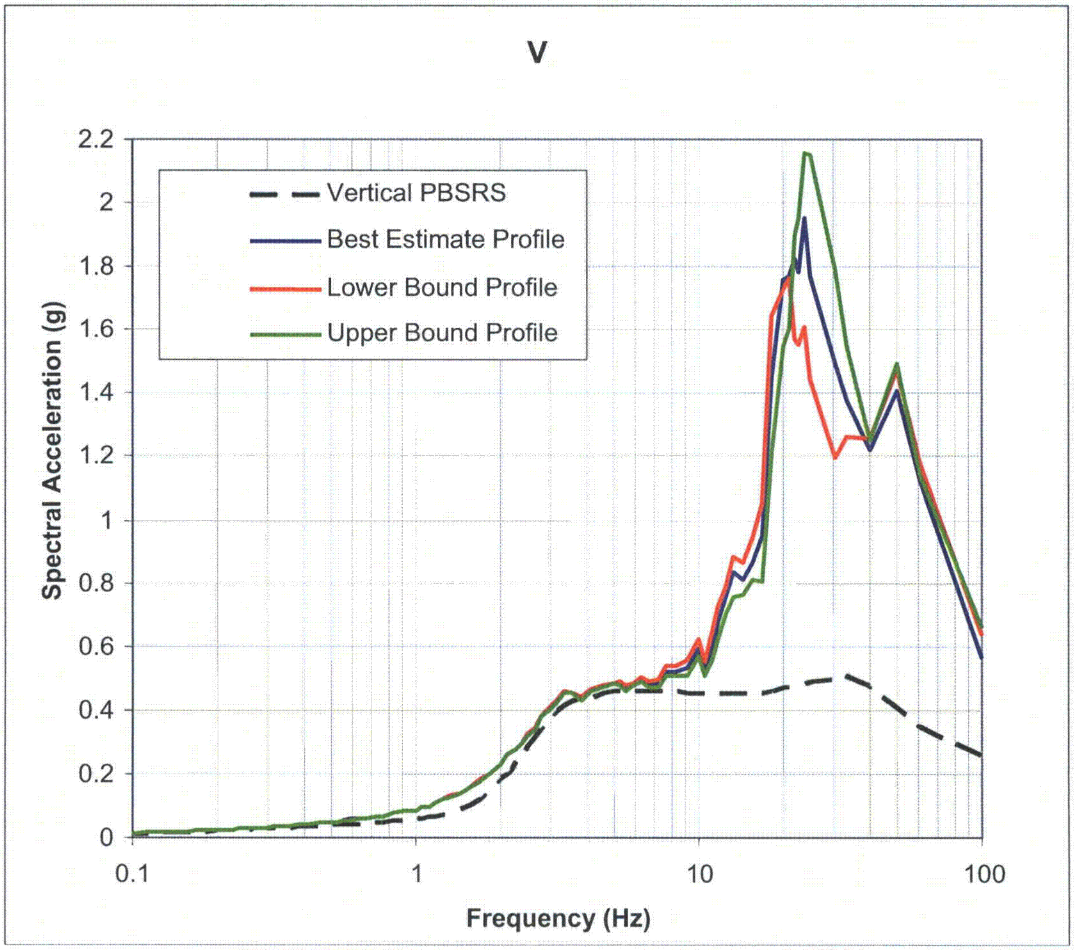

Figure 3.7.1-251: Comparison of Response Spectra of Computed Vertical (V) Component Surface Motions for SSI Profiles Using CB SCOR FIRS Input Motion to the Vertical PBSRS.

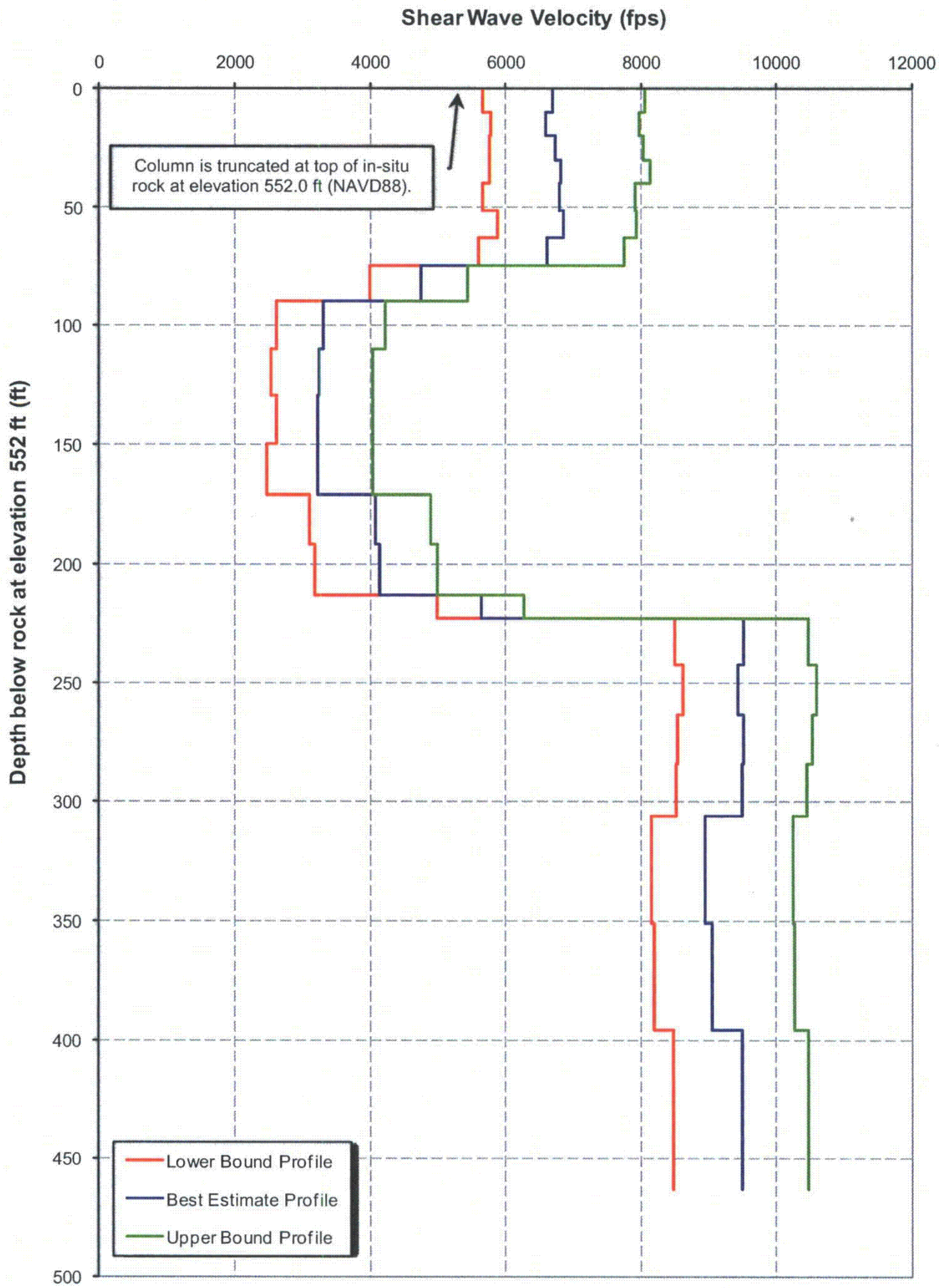

Figure 3.7.1-252: Lower Bound, Best Estimate and Upper Bound Shear Wave Velocity Profiles for the Fermi 3 Site-Specific SSI Analyses.