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PG&E Letter No. DCL-04-031

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

Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Supplement to Special Report 03-04: San Simeon Earthquake of December 22, 2003

Dear Commissioners and Staff:

On December 22, 2003, at 1116 PST, with Unit 1 and Unit 2 operating at 100 percent power, a 6.5 magnitude earthquake occurred 11 km northeast of San Simeon, California. Ground motion was felt and recognized as an earthquake by the control room operators. The earthquake force monitor recorded greater than 0.01g for the seismic event. Operations personnel declared an Unusual Event at 1122 PST (Reference NRC Event Notification Number 40408). On December 23, 2003, at 1212 PST, the Unusual Event was terminated upon confirmation that no damage to the plant occurred.

This is a supplement to Special Report 03-04, "San Simeon Earthquake of December 22, 2003," PG&E Letter DCL-03-184, dated January 5, 2004, submitted pursuant to Equipment Control Guideline (ECG) 51.1, "Seismic Instrumentation." This ECG requires that for seismic monitoring instruments actuated during a seismic event, "data shall be retrieved from actuated instruments and analyzed to determine the magnitude of the vibratory ground motion." This supplement is submitted to provide additional details from seismic data analysis, describing the magnitude, frequency spectrum, and resultant effect upon facility features important to safety. This submittal supersedes DCL-03-184 in its entirety.

Enclosure 1 expands on the PG&E and USGS earthquake data from the San Simeon earthquake, which analyzes the ground motion, magnitude, and frequency spectrum of this event. Enclosure 1 also provides an analysis of the San Simeon earthquake with respect to the Diablo Canyon Power Plant (DCPP) design earthquake and Hosgri earthquake. Enclosure 2 provides an analysis of the resultant effect upon facility features important to safety, and information on the lessons learned as a result of the Event Response Team review.

A025

As this event relates to the DCPP, there was no adverse effect to public health and safety, or upon facility features important to safety.

PG&E continues to evaluate the data from this earthquake. If this ongoing evaluation results in a significantly different conclusion, PG&E will submit a supplement to this report. If you have any questions, please contact me at 805-545-4600, or Mr. Lloyd Cluff at 415-973-2791.

Sincerely,

Lawrence F. Womack
Vice President Nuclear Services

swh/A0597040 AE02
Enclosures

cc: Bruce S. Mallett, Region IV
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San Simeon Earthquake of December 22, 2003

Description of the Earthquake

On December 22, 2003, at 1116 PST, a magnitude (M_W) 6.5 earthquake struck the central California coast region. The earthquake epicenter was located approximately 50 km NNW of Diablo Canyon Power Plant (DCPP), in the region 11 km northeast of San Simeon. The depth of the hypocenter was estimated to be 8 km by the United States Geological Survey (USGS). Supplementing the USGS data with additional data from Pacific Gas & Electric Company (PG&E) seismic stations lead to a focal depth of estimate of 10 km. The earthquake was widely felt from Los Angeles to San Francisco. Earthquake ground effects included rockfalls, landslides, and related ground failure effects near the epicenter; however, surface faulting was not observed. Most of the damage occurred in Paso Robles, 39 km ESE of the epicenter, where two deaths occurred due to the collapse of an unreinforced masonry building. The earthquake was also felt at DCPP in the administration building and the control room; the strong motion instruments at the plant site were triggered.

The mainshock rupture was initiated at depth and propagated unilaterally to the southeast. The mainshock triggered a vigorous aftershock sequence that extended about 30 km southeast of the mainshock epicenter. As of March 16, 2004, approximately 4200 aftershocks have occurred, including about 160 magnitude M_W 3 events, and 16 M_W 4 earthquakes (USGS Northern California Earthquake Data Center (NCEDC) website, March 17, 2004; these data are subject to change based on downgrading and upgrading earthquake magnitude by the USGS). During the first 24 hours the activity was about 50 percent higher than the average for a California sequence (USGS online report, December 24, 2003).

The San Simeon earthquake was a reverse slip event beneath the Santa Lucia Mountains. It occurred along a NW-SE trending fault plane that dips to the NE. This is a common fault mechanism along this trend (References 1 and 2).

Figure 1 shows the location of the mainshock and the first 20 hours of aftershocks (USGS NCEDC website, December 26, 2003). There is concentrated activity near the two ends of the rupture given by the mainshock epicenter and the southeast end of the aftershock zone. Most of the aftershocks near the mainshock are located between the Oceanic and Nacimiento fault zones, whereas the aftershocks near the southwest end of the rupture are not constrained by these two faults. The NE dip of the aftershock zone in-depth view (Figure 1, cross section AA') is consistent with rupture at depth along the Oceanic fault. The aftershock patterns in-depth view (along cross section BB') show more diffuse activity with and no obvious association with a fault plane. The closest distance from the aftershock zone to DCPP is about 38 km.

Strong Motion Records in the Region

The San Simeon earthquake was recorded by strong-motion accelerometers operated by the California Strong Motion Instrumentation Program (CSMIP), USGS, and PG&E.

The locations of the strong-motion stations available as of January 5 are shown in Figure 2. There is a concentration of strong motion recorders along the Parkfield segment of the San Andreas Fault, located east of the San Simeon earthquake. The approximate surface projection of the rupture plane is also shown in Figure 2.

The average horizontal peak accelerations recorded during the mainshock are shown in Figure 3. The largest recorded peak acceleration is 0.47g. The median peak acceleration from the Sadigh et al. (Reference 4) attenuation relations for rock and for soil sites are compared to the observed peak acceleration in Figure 3. This relation was selected for comparison because it is similar to the model used for characterizing the ground motion for the DCPP Long-Term Seismic Program (LTSP) evaluations (Reference 2). The black cross in Figure 3 shows the free-field peak acceleration recorded at DCPP. Note that the distances shown on this figure are measured from the inferred fault rupture plane, not from the epicenter. Ground motions have large variability, as seen by the range of PGA values from the Parkfield array, so single observations should not be over-interpreted.

Strong Motion Records at DCPP

The mainshock was felt in the control room. It triggered the Basic Seismic Monitoring System analog recorder (Kinemetrics SMA) in the control room and the digital recorders (Kinemetrics SSA) at the Unit 1 containment basemat, the top of the Unit 1 containment, the auxiliary building basemat, and the free-field pit (an underground vault south of the administrative building). The Supplemental Seismic Monitoring System was inoperable at the time of the earthquake. The replacement for the Supplemental Seismic Monitoring System has been designed, but was not yet installed at the time of the earthquake. Installation is scheduled to be complete by Fall 2004. However, three temporary accelerometers and recording stations were installed in 2003 to record any strong ground motion associated with an earthquake that might occur before the installation of the new system is complete. One temporary station is at elevation 100' in the auxiliary building and two are at elevation 85' (at-grade level, above a small basement area) in the turbine building. These three temporary accelerometers all recorded the mainshock.

The earthquake force monitor (EFM), located in the control room, indicated that a peak horizontal acceleration of 0.04g had been recorded from the accelerometer located at the Unit 1 containment basemat. The EFM displays the peak acceleration before any baseline drift is removed. After baseline correction, but prior to filtering, the peak acceleration of the horizontal component was 0.042g.

The acceleration time histories for the three components of the free-field recordings are shown in Figure 4. The strong shaking lasted about 10 seconds on the horizontal components (N-S and E-W). The vertical (U-D) and horizontal (N-S and E-W) accelerograms show long-period energy that dominates the accelerograms late in the recording (after the 10 second mark). This long-period motion is seen on the recordings at several stations and is likely due to surface waves.

Table 1 lists the peak accelerations, peak velocities and peak displacements for the recorded earthquake motions at DCPP's seven accelerometer locations, after filtering and baseline corrections are applied.

The cumulative absolute velocity (CAV) was computed for the horizontal components of the recording at the containment basemat (Reference 7). The largest value of CAV for either horizontal component is 0.07g-sec. This is significantly smaller than the threshold value of 0.16g-sec, below which earthquake ground motions are not considered to have the potential for causing damage for nuclear power plants (Reference 7).

The response spectra were computed for each recording made at DCPP for the San Simeon earthquake. The 5 percent damped response spectra from these recordings are shown in Figures 5 through 10 (Reference 5).

For the free-field ground motion (Figure 5), the horizontal spectra have a peak at 4 to 5 Hz. This is a typical spectral shape for free-field response spectra for rock sites for this magnitude and distance. The amplitudes of the free-field spectra are lower than expected for this magnitude, distance, and style-of-faulting. Current attenuation relations for rock sites in California yield median horizontal spectral accelerations that is 1.5 to 2 times larger than the recorded free-field spectra are consistent with the lower than expected peak accelerations at DCPP, shown previously in Figure 2.

Comparison with DCPP Design Basis Ground Motions

The seismic design basis for DCPP includes the following three earthquakes:

- Design Earthquake (DE): DCPP's equivalent of an Operating Basis Earthquake (OBE), having peak ground acceleration (PGA) of 0.20 g (horizontal) and 0.13 g (vertical).
- Double Design Earthquake (DDE): DCPP's original equivalent of a Safe Shutdown Earthquake (SSE). The DDE is defined as twice the DE.
- Hosgri Earthquake (HE): DCPP's highest-level design earthquake, greater than an SSE, imposed after the original construction of the plant, having a PGA of 0.75 g (horizontal) and 0.50 g (vertical).

The response spectra calculated from the free-field instrument recordings for the San Simeon earthquake mainshock are compared with the design bases free-field response spectra for the DE and the HE in Figures 12A, 12B, and 12C (Reference 6) for the Plant north-south, Plant east-west, and vertical directions, respectively. Note that since the DDE is twice the DE, a comparison with this earthquake was not required.

In all three directions, the free-field response spectra for the San Simeon earthquake recordings are enveloped by the design basis response spectra and the zero period acceleration (ZPA) values for these response spectra are less than 25 percent of the ZPA values for the DE and less than 7percent of the ZPA values for the HE.

In addition, the response spectra calculated from the containment basemat, auxiliary building basemat, and turbine building grade level instrument recordings are compared with the design basis foundation input response spectra for the DE and the HE in Figures 13A, 13B, 13C, 15A, 15B, 15C, 17A, 17B, 17C, 18A, 18B, and 18C (Reference 6). Note that foundation input response spectra are affected by soil structure interaction effects in the case of the auxiliary building and containment for the DE and by large foundation effects in the case of the auxiliary building, containment, and turbine building for the HE. As a result, the design basis foundation input response spectra are not identical to the design basis free-field response spectra.

In all three directions, the foundation level response spectra for the San Simeon earthquake recordings are enveloped by the design basis foundation input response spectra and the ZPA values for these response spectra are less than 46% of the ZPA values for the DE, and less than 13% of the ZPA values for the HE.

Evaluation of Design Basis Structural Modeling

The recordings of the structural response during the San Simeon earthquake can be used to evaluate the accuracy of the design basis structural models used for the seismic analyses of DCPP. This is done through comparisons of the responses recorded during the San Simeon earthquake and the responses predicted by the seismic analyses of the structural models.

Seismic recorders at the top of the Unit 1 containment structure, and at elevation 100' in the auxiliary building, are installed for the purpose of comparison.

- Top of Unit 1 Containment

  The design basis structural models of the containment structure are two-dimensional, axisymmetric finite element models (UFSAR Figures 3.7-5 and Figure 3.7-5A). The horizontal and vertical seismic responses of this structure are developed through separate analyses. Recordings from the San Simeon Earthquake are available for the Basic Seismic Monitoring System instrument located at the top of the containment, near the plant vent (elevation 303.5').

  Horizontal Analyses

  Design basis horizontal amplified response spectra were developed at various elevations of the containment for the DE and HE using dynamic analysis methods.

  The horizontal response spectra calculated from the top of containment instrument recordings for the San Simeon earthquake mainshock are compared with the design bases amplified response spectra for the DE and the HE in Figures 14A, and 14B (Reference 6) for the plant north-south and plant east-west directions, respectively. These comparisons indicate that the amplified response spectra for the San Simeon earthquake recordings are enveloped by the design basis DE and HE response spectra. The ZPA values for the San Simeon earthquake response spectra at this location are less than 20 percent of the ZPA values for the DE and less than 10 percent of the ZPA values for the HE.

Vertical Analyses

Design basis vertical amplified response spectra were developed at various elevations of the containment for the HE using dynamic analysis methods. The DE design basis for the containment assumes that the structure has insignificant amplification of vertical seismic motion and has been analyzed statically (UFSAR, Section 3.7.2.9). As a result, the design basis vertical DE response spectra at all elevations of the containment are equal to two-thirds of the DE horizontal ground response spectrum.

The vertical response spectrum calculated from the top of containment instrument recording for the San Simeon earthquake mainshock is compared with the design bases response spectra for the DE and HE in Figure 14C (Reference 6). This comparison indicates that the amplified response spectrum for the San Simeon earthquake recording is enveloped by the design basis HE response spectrum, but not by the design basis DE response spectrum. While the ZPA value for the San Simeon earthquake response spectrum is less than 46 percent of the ZPA value for the DE and less than 4 percent of the ZPA value for the HE, the San Simeon Earthquake response spectrum exceeds the DE response spectrum at three discrete places in the frequency range of 11 to 40 Hz.

This exceedance is due to the design basis modeling assumption of insignificant amplification of vertical seismic motion for the DE. The subsequent HE reevaluation of the containment for vertical seismic input is based on a dynamic analysis; vertical amplification was explicitly considered in the development of the vertical HE response spectrum. Since the containment, and the various safety related components supported at or near the top of the containment (e.g., plant vent, containment spray piping, etc.) have been seismically analyzed for the amplified vertical HE response spectrum, their structural integrity following an earthquake of HE magnitude has been assured, even if the vertical component of the DE is underestimated at this location.

In addition, comparisons of the frequencies associated with the major peaks in the San Simeon earthquake response spectra, to those for the major peaks in the design basis response spectra, can be used to validate the prediction of the fundamental frequencies of the containment by the design basis structural models. For the San Simeon earthquake response spectra (Figures 14A, 14B, and 14C), peaks are located at 4.17 Hz (N-S), 3.85 Hz (E-W), and 13.33 Hz (vertical). These frequencies fall within the frequency ranges (considering spectral peak widening) of 3.6 Hz to 4.2 Hz and 3.9 Hz to 4.8 Hz (horizontal), for the DE and HE models, respectively, and 11.0 Hz to 14.5 Hz (vertical), for the HE model.

- Elevation 100' in the Auxiliary Building

  The design basis structural models of the auxiliary building are two-dimensional, lumped mass stick models (UFSAR Figure 3.7-13). The horizontal and vertical seismic responses of this structure are developed through separate analyses. Recordings from the San Simeon earthquake are available for the temporary instrument located in Area GW, near the instrument rack for the Supplemental Seismic Monitoring System (elevation 100').

  Horizontal Analyses

  Design basis horizontal amplified response spectra were developed at various elevations of the auxiliary building for the DE and HE, using dynamic analysis methods.

  The horizontal response spectra calculated from the auxiliary building elevation 100' instrument recordings for the San Simeon earthquake mainshock are compared with the design bases amplified response spectra for the DE and the HE in Figures 16A, and 16B (Reference 6) for the plant north-south and plant east-west directions, respectively. These comparisons indicate that the amplified response spectra for the San Simeon earthquake recordings are enveloped by the design basis DE and HE response spectra. The ZPA values for the San Simeon earthquake response spectra at this location are less than 16 percent of the ZPA values for the DE and less than 6 percent of the ZPA values for the HE.

  Vertical Analyses

  Design basis vertical amplified response spectra were developed at various elevations of the auxiliary building for the HE using dynamic analysis methods. The DE design basis for the auxiliary building assumes that the structure has insignificant amplification of vertical seismic motion and has been analyzed statically (UFSAR, Section 3.7.2.9). As a result, the design basis vertical DE response spectra at all elevations of the auxiliary building are equal to two-thirds of the DE horizontal ground response spectrum.

  The vertical response spectrum calculated from the auxiliary building elevation 100' instrument recording for the San Simeon earthquake mainshock is compared with the design bases amplified response spectra for the DE and HE in Figure 16C (Reference 6). This comparison indicates that the amplified response spectrum for the San Simeon earthquake recording is enveloped by the design basis DE and HE response spectra. The ZPA value for the San Simeon earthquake response spectrum at this location is less than 42 percent of the ZPA value for the DE and less than 10 percent of the ZPA value for the HE.

Conclusions

The free-field ground motion recorded at DCPP during the San Simeon earthquake had a peak horizontal acceleration of approximately 0.05g. The ground motion was less than 24 percent of the DE ground motion and less than 7 percent of the HE ground motion, with a CAV value that is below the threshold for a potentially damaging ground motion (for any nuclear power plant, not just high seismic designs such as DCPP).

The design basis input motions associated with the DE and HE envelop the input motions for the building foundations.

The amplified response spectra at the top of the Unit 1 containment confirm the natural frequencies calculated in the design basis structural response calculations.

The amplified response spectra for the recordings associated with the higher elevations in the buildings are enveloped by the design basis amplified response spectra at these locations, except for the vertical response at the top of the containment for the DE. This exception is based on the design basis assumption that the containment is rigid in the vertical direction for the DE, but is not of concern, since the vertical flexibility and resulting amplification are considered in the analysis for the HE and the amplified HE response spectrum are used in the seismic analysis of the containment and attached safety related components.

References

1. Seismicity of South-Central Coastal California: October 1987 through January 1997, *Bull Seism. Soc. Am.* 91, no. 6, pp. 1629-1658, McLaren, M. K. and Savage, W. U., 2001.

2. Safety Evaluation Report Related to the Operation of Diablo Canyon Nuclear Power Plant Units 1 and 2, (Long Term Seismic Program), U.S. Nuclear Regulatory Commission, Docket Nos. 50-275, 50-23, NUREG-0675, 1991.

3. Units 1 and 2 Diablo Canyon Power Plant - Final Safety Analysis Report Update, Revision 15, September 2003.

4. Attenuation Relationships for Shallow Crustal Earthquakes Based on California Strong Motion Data, Sadigh, K., C-Y Chang, J. A. Egan, F. Makdisi, and R. R. Youngs, Seism. Res. Let., Vol 68, 180-189, 1997.

5. Response Spectra for Ground Motions Recorded at DCPP During the Dec. 22, 2003 San Simeon Earthquake, Geosciences Department Calculation No. GEO.DCPP.04.01, rev. 0.

6. San Simeon Earthquake of December 22, 2003 – Post Earthquake Evaluation of Records, DCPP Civil Engineering Department Calculation No. 72.8.2, rev. 0.

7. A Criterion for Determining Exceedance of the Operating Basis Earthquake, Electric Power Research Institute Report No. NP-5930, July 1988.

Definitions

Amplified Response Spectra – the response spectra at elevations in a structure that are above the foundation level. These spectra are amplified relative to the input response spectra at the foundation level.

Baseline Drift – residual displacement at the end of an earthquake displacement time history. Baseline drift is determined through the double integration of an earthquake acceleration time history in the time domain.

Baseline Correction – removal of the baseline drift from an earthquake displacement time history record through the application of high order polynomial.

Cumulative Absolute Velocity (CAV) – area under an absolute accelerogram, determined by the following integral:

$$CAV = \int |a(t)|\, d(t)$$

Where:

$|a(t)|$	=	absolute acceleration
$|d(t)|$	=	time increment

The integration is performed in one-second intervals, and summed for all intervals where the maximum absolute acceleration equals or exceeds 0.025 g.

This parameter is used to relate measured ground motion record to the potential for structural damage.

Filtering – processing of an earthquake acceleration time history recording to eliminate noise for the low frequency portion of the motion, due to a low signal-to-noise ratio in the recording.

Frequency – reciprocal of period. Measured in cycles per second or Hertz (Hz).

Peak Ground Acceleration (PGA) – maximum absolute value of the acceleration at any time point in an earthquake ground motion acceleration time history.

Response Spectra – mathematical relationship defining the maximum absolute value of the acceleration response (spectral acceleration) of a single degree of freedom oscillator when subjected to an input acceleration time history. The frequency of the oscillator is varied over a range to determine the spectral accelerations for systems having differing frequencies. Response spectra are typically represented by a curve comparing the frequency (abscissa) and spectral acceleration (ordinate).

Zero Period Acceleration (ZPA) – calculated spectral acceleration value at a period equal to 0.0 sec. This corresponds to the maximum absolute value of the acceleration at any point in the acceleration time history.

Table 1 - San Simeon Earthquake Peak Acceleration Values Basic Seismic Monitoring System and Temporary Accelerometers

(after filtering and baseline correction)

Instrument location and Name	Component	Peak Acceleration (g)	Peak Velocity (cm/s)	Peak Displacement (cm)
Free-Field (South of Admin Bldg) DC12032	N-S (Channel 1)	0.034	8.3	7.4
	U-D (Channel 2)	0.022	7.6	6.3
	E-W (Channel 3)	0.046	8.2	4.9
Containment Basemat – Unit 1 (elev 89) CP001	N-S (Channel 1)	0.033	8.2	7.6
	U-D (Channel 2)	0.036	8.1	6.3
	E-W (Channel 3)	0.041	7.9	5.0
Aux. Bldg. Basemat, Area K (elev 64) CP002	N-S (Channel 1)	0.038	8.0	7.9
	U-D (Channel 2)	0.023	7.9	7.1
	E-W (Channel 3)	0.039	9.1	7.3
Top of Containment – Unit 1 (elev 303.5) CP003	N-S (Channel 1)	0.236	10.9	9.0
	U-D (Channel 2)	0.060	8.0	7.6
	E-W (Channel 3)	0.144	10.9	5.6
Aux. Bldg., Area GW (elev 100) DC356	U-D (Channel 1)	0.026	7.9	6.8
	E-W (Channel 2)	0.055	9.4	7.0
	N-S (Channel 3)	0.043	8.7	7.8
Turbine Bldg. Grade Level – North end, (elev 85) TB1356	U-D (Channel 1)	0.025	8.0	6.9
	E-W (Channel 2)	0.048	9.0	8.3
	N-S (Channel 3)	0.039	8.6	8.3
Turbine Bldg. Grade Level – South end, (elev 85) TB2356	U-D (Channel 1)	0.026	8.0	7.15
	E-W (Channel 2)	0.061	9.3	7.4
	N-S (Channel 3)	0.037	9.2	8.0

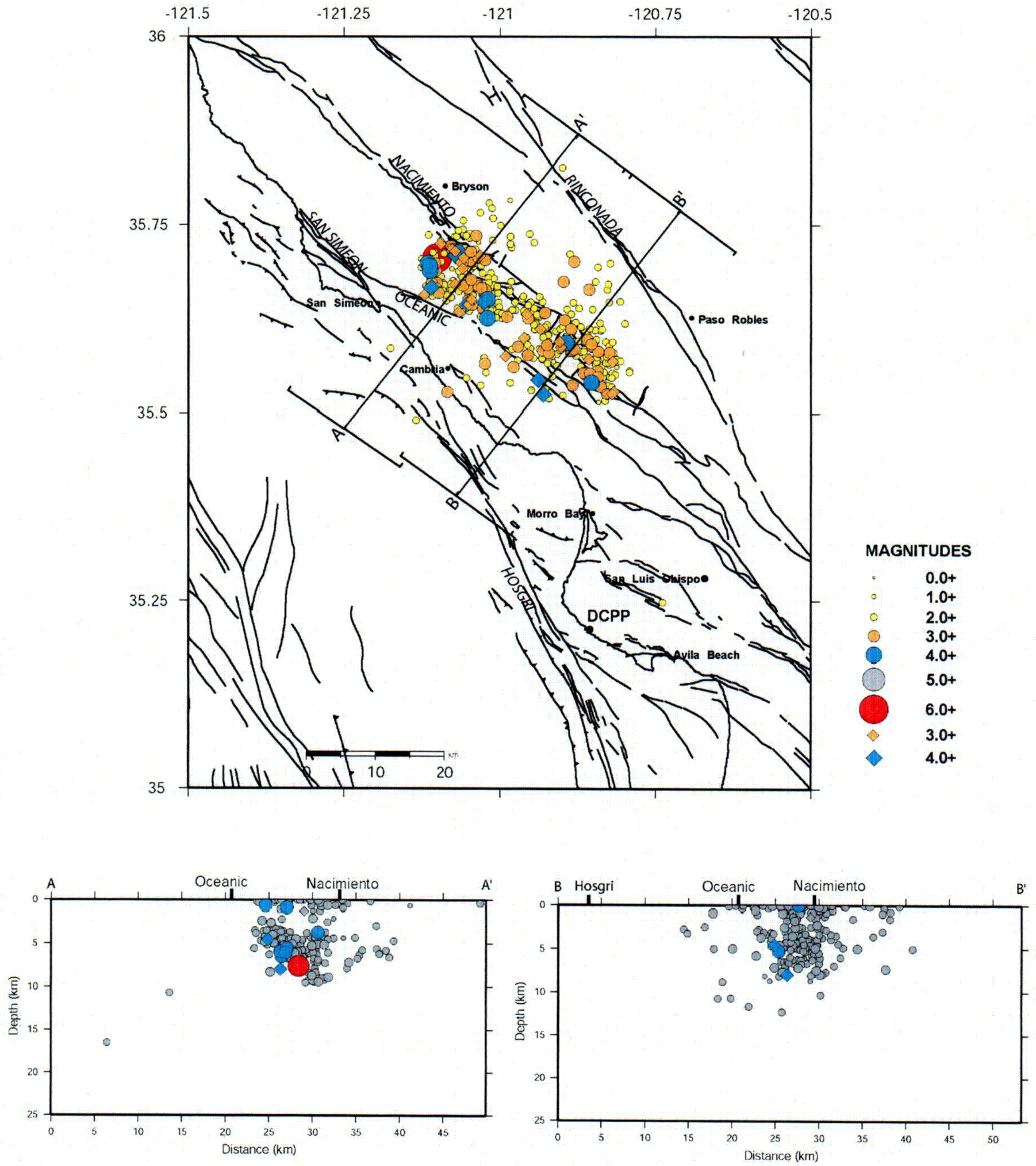

Figure 1 Epicenters of San Simeon Earthquake (large red circle) of December 22, 2003, 1115 PST, and aftershocks through 23 December 2003, 0651 PST

Notes:

1. Nearby faults are labeled.
2. Symbols: diamonds are preliminary locations from the USGS website; circles are events that have been reviewed by USGS seismologists NCEDC.
3. Seismicity cross sections AA' and BB' are also shown.

C01

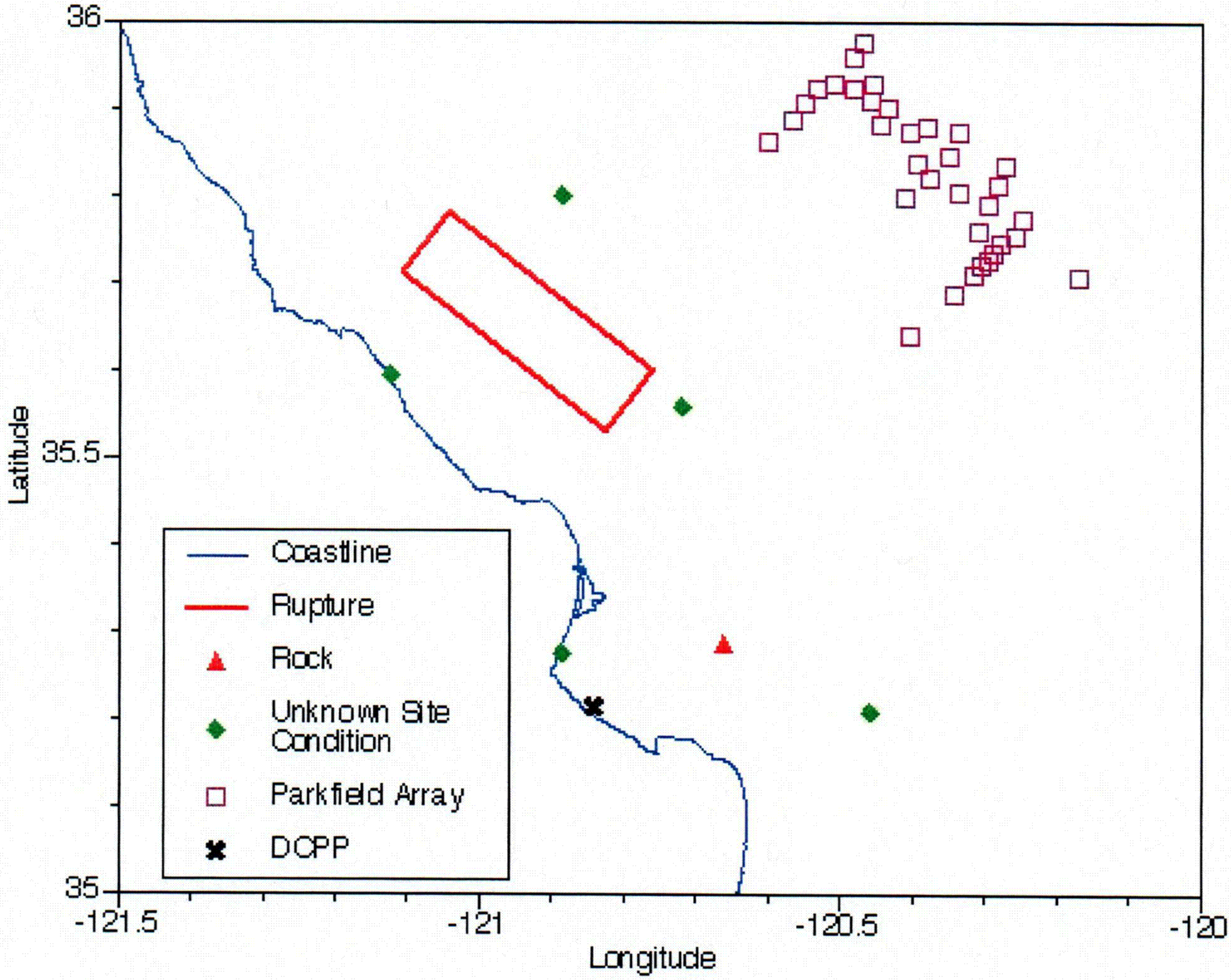

Figure 2 Map Showing Locations of the Strong Motion Accelerometers that Recorded the San Simeon Earthquake Mainshock

C02

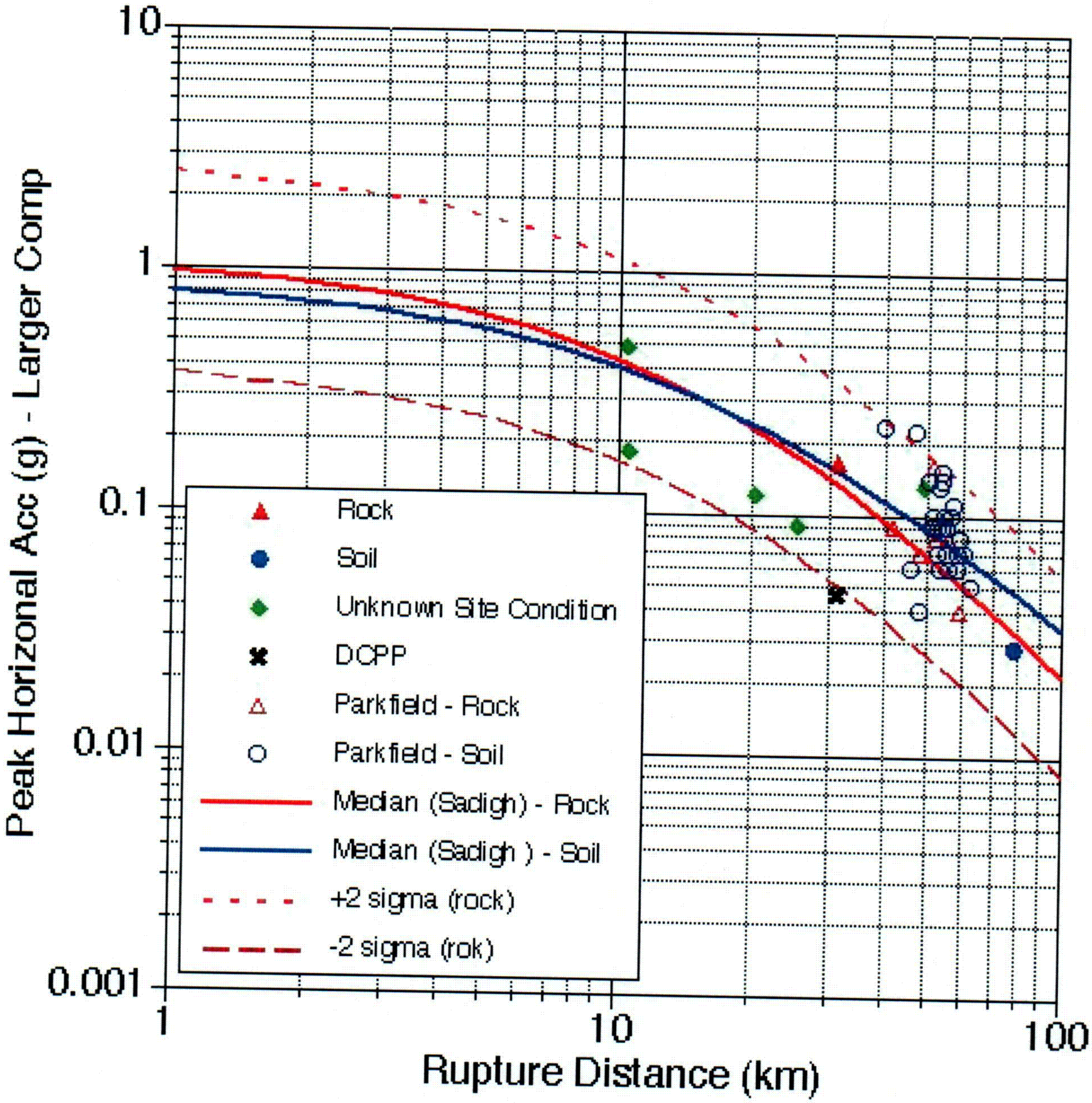

Figure 3 Attenuation of Peak Horizontal Acceleration from the San Simeon Earthquake Mainshock

C03

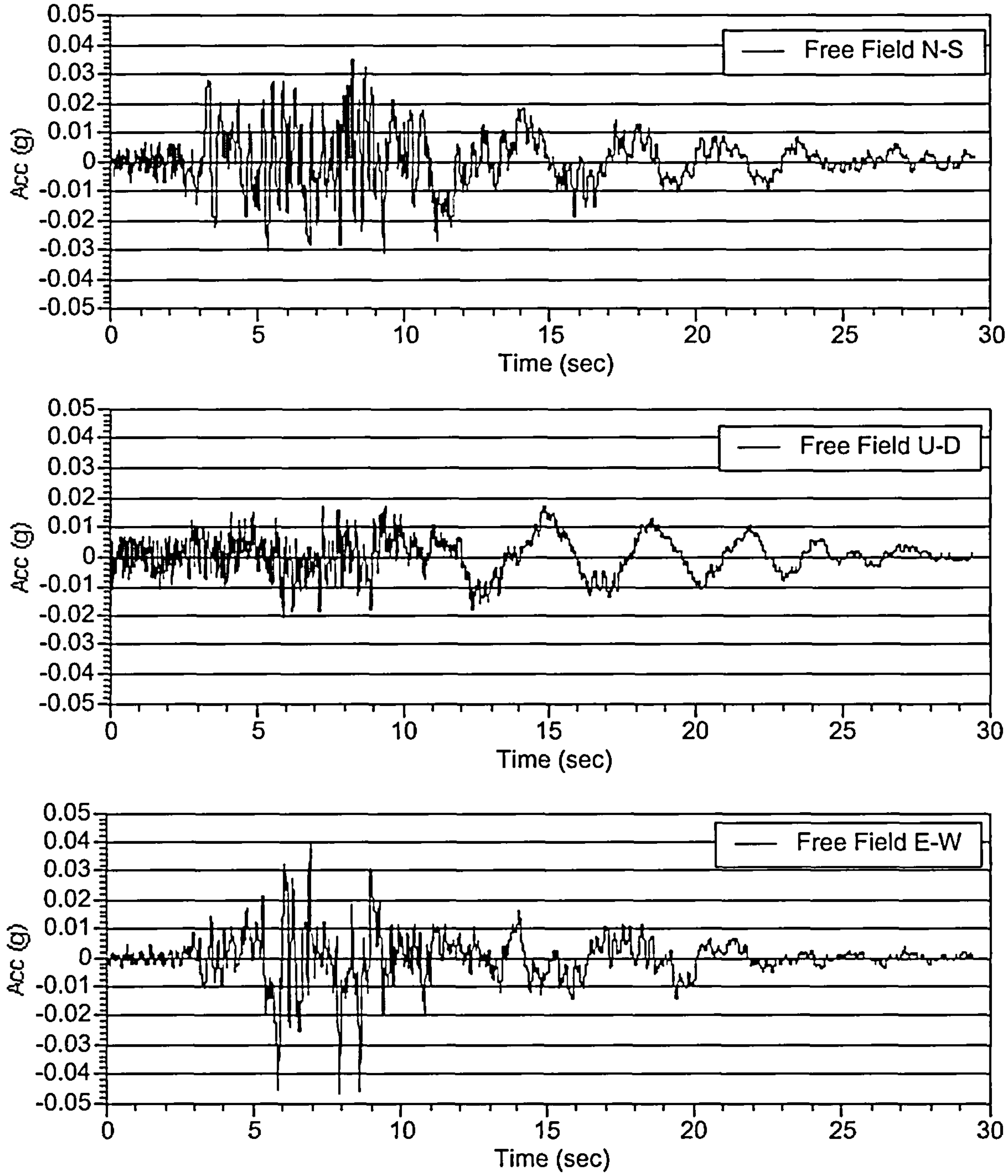

Figure 4 Free-Field Acceleration Time Histories Recorded at DCPP for the San Simeon Earthquake Main Shock

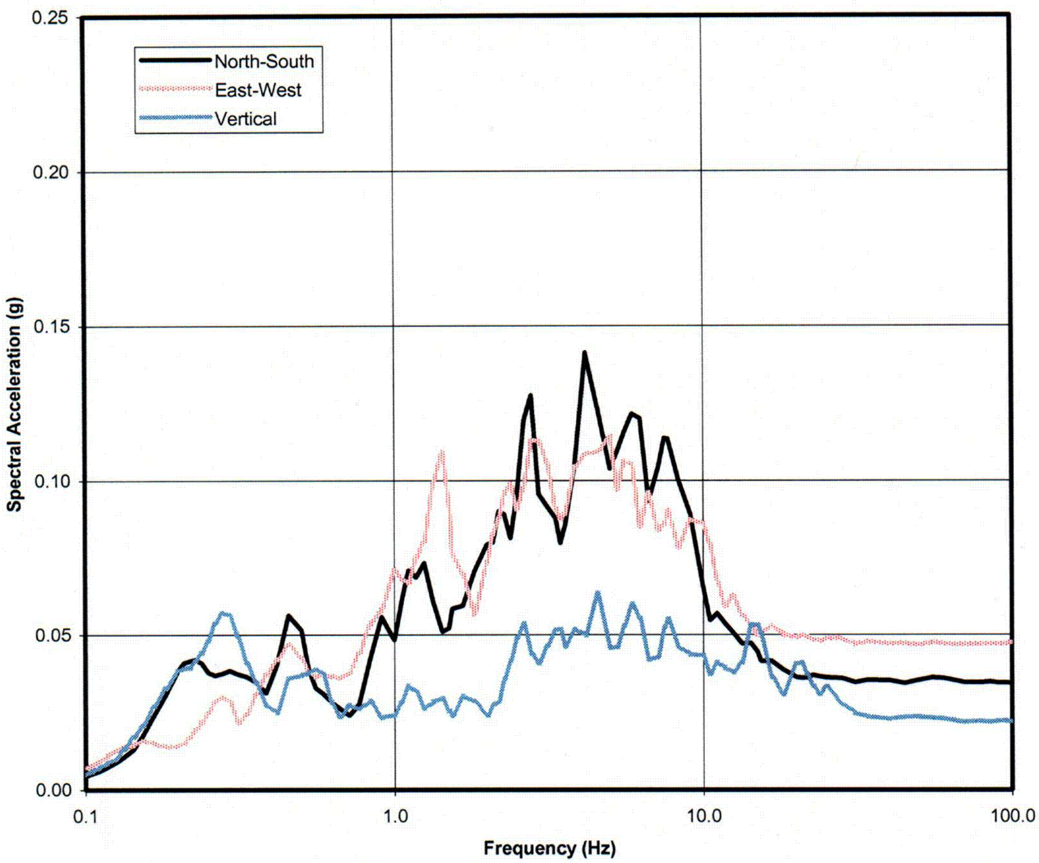

Figure 5 San Simeon Earthquake Response Spectra
(5% Damping)

Free Field Ground Motion at DCPP

C04

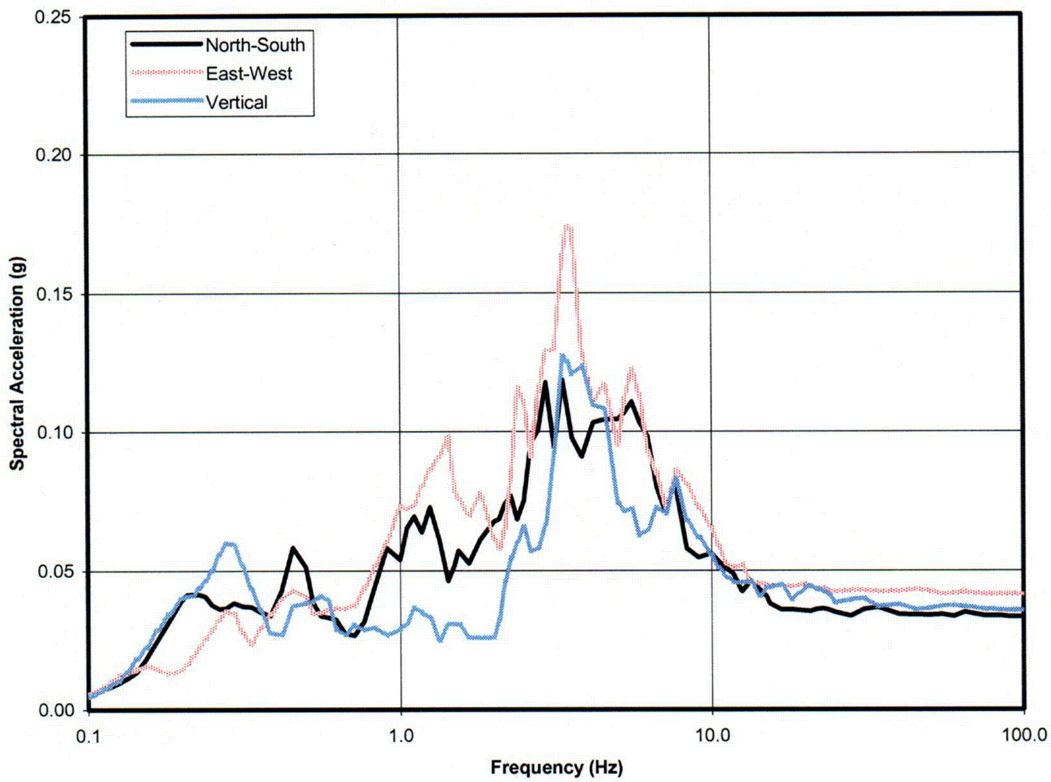

Figure 6 San Simeon Earthquake Response Spectra
(5% Damping)

Unit 1Contaiment Basemat

C05

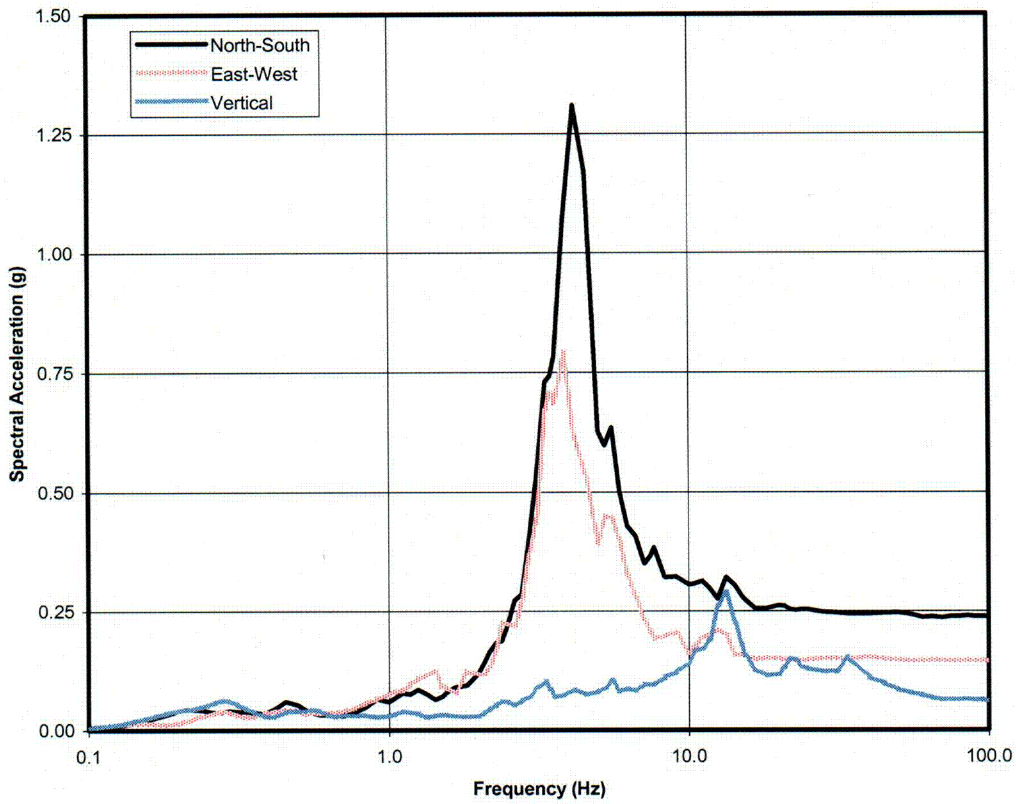

Figure 7 San Simeon Earthquake Response Spectra
(5% Damping)

Top of Unit 1Contaiment

C06

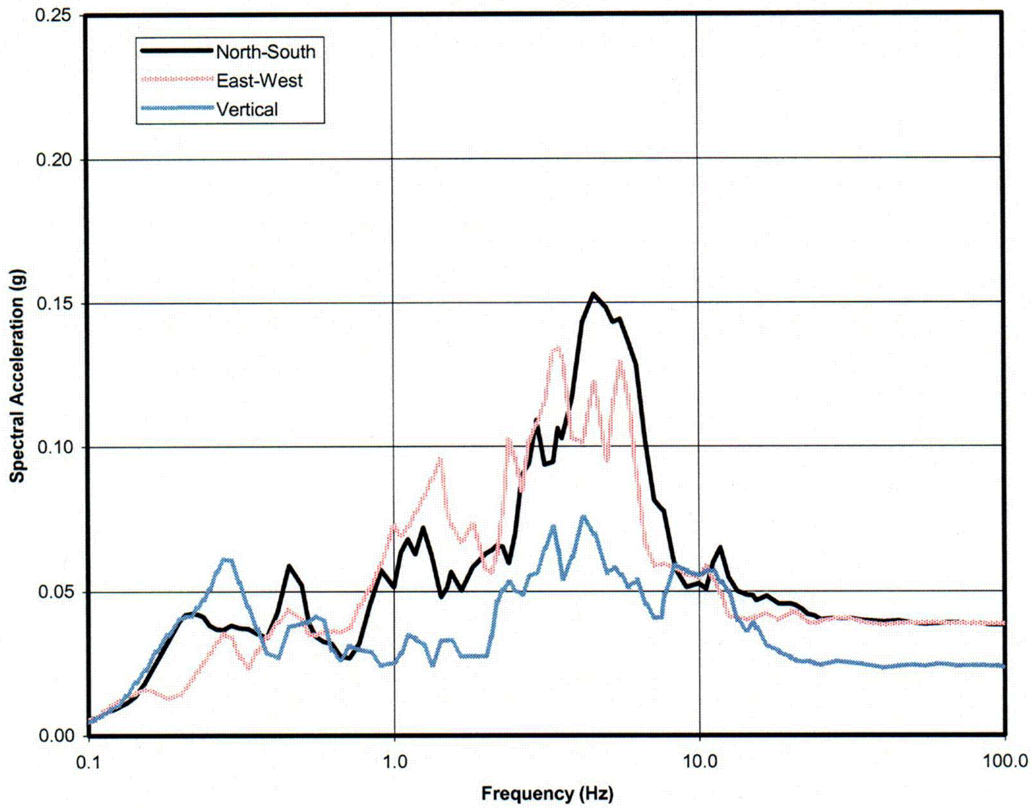

Figure 8 San Simeon Earthquake Response Spectra
(5% Damping)

Auxiliary Building Basemat

C07

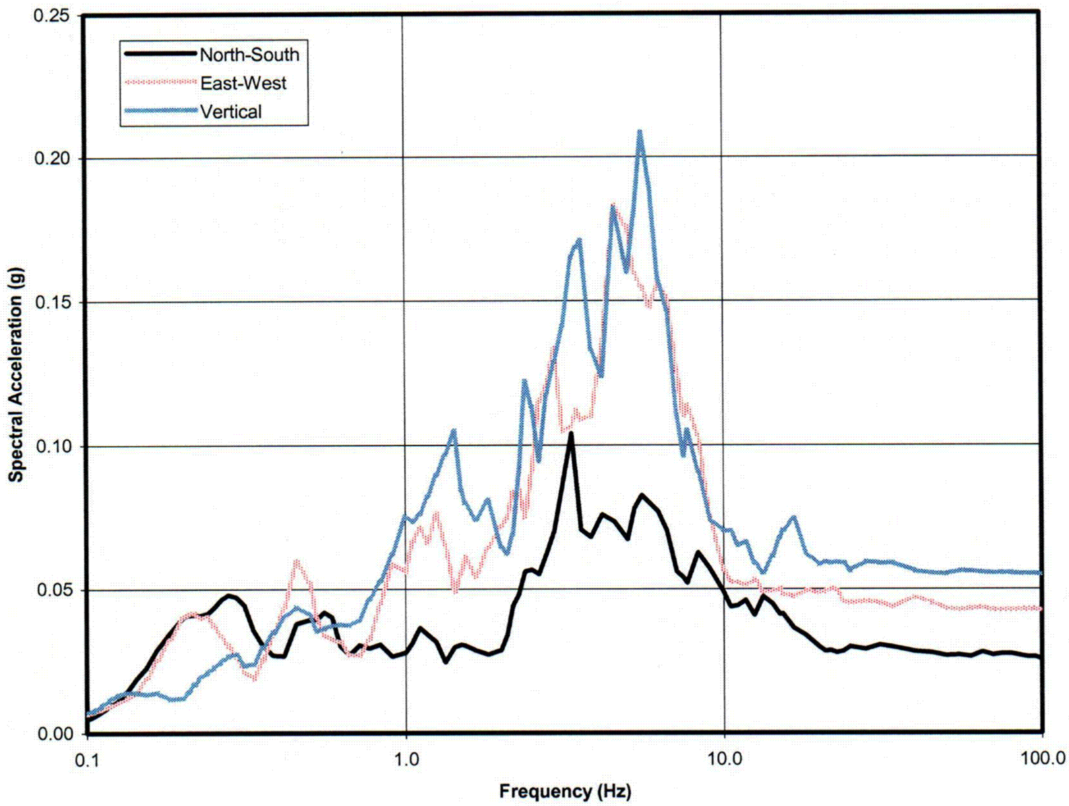

Figure 9 San Simeon Earthquake Response Spectra
(5% Damping)

Auxiliary Building, Elev. 100'

C08

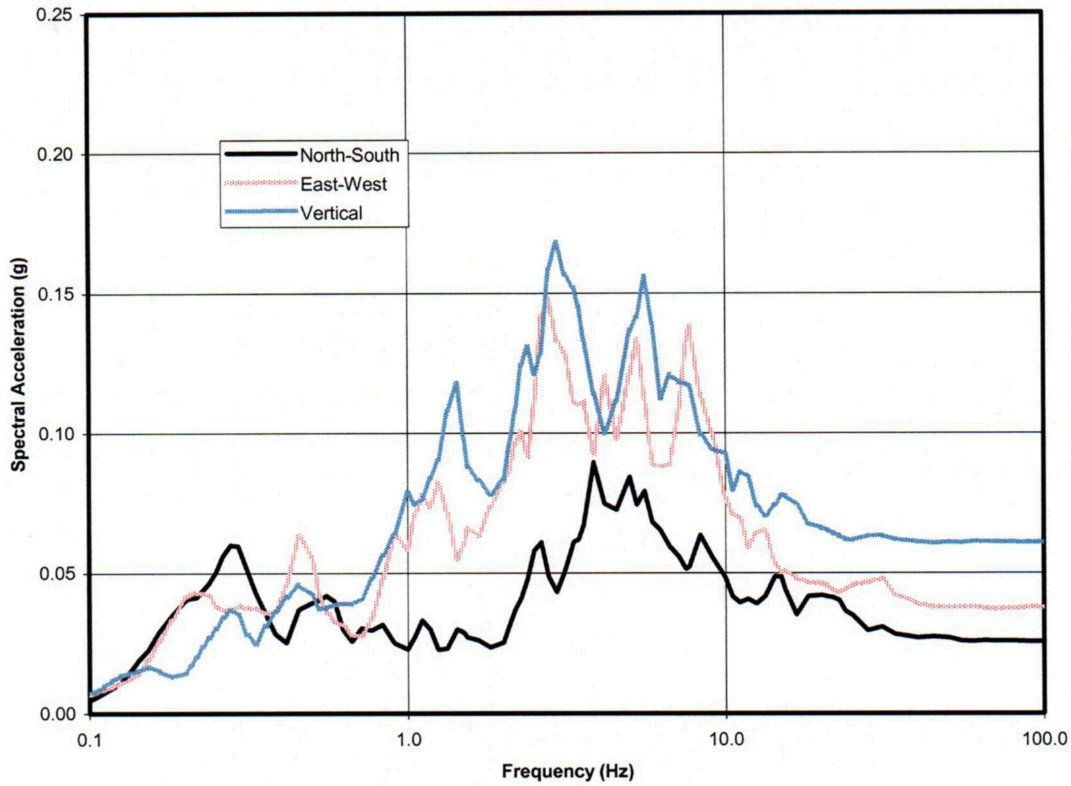

Figure 10 San Simeon Earthquake Response Spectra
(5% Damping)

Turbine Building Grade Level, Elev. 85', South End

C09

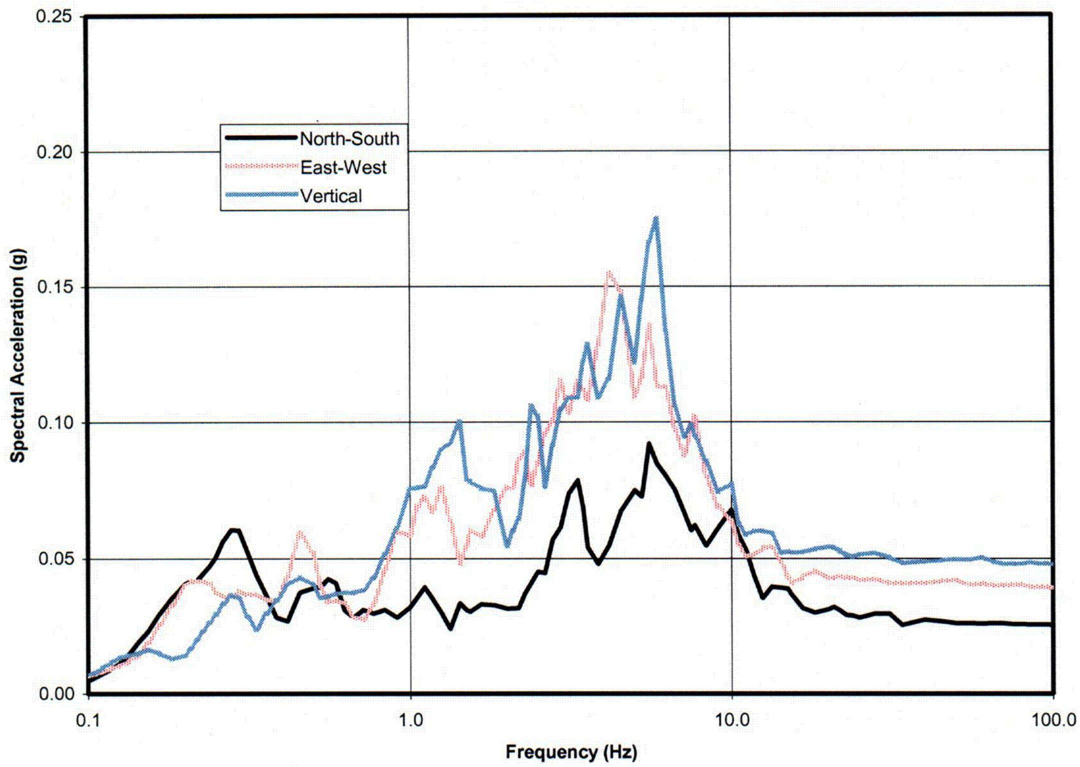

Figure 11 San Simeon Earthquake Response Spectra
(5% Damping)

Turbine Building Grade Level, Elev. 85', North End

C10

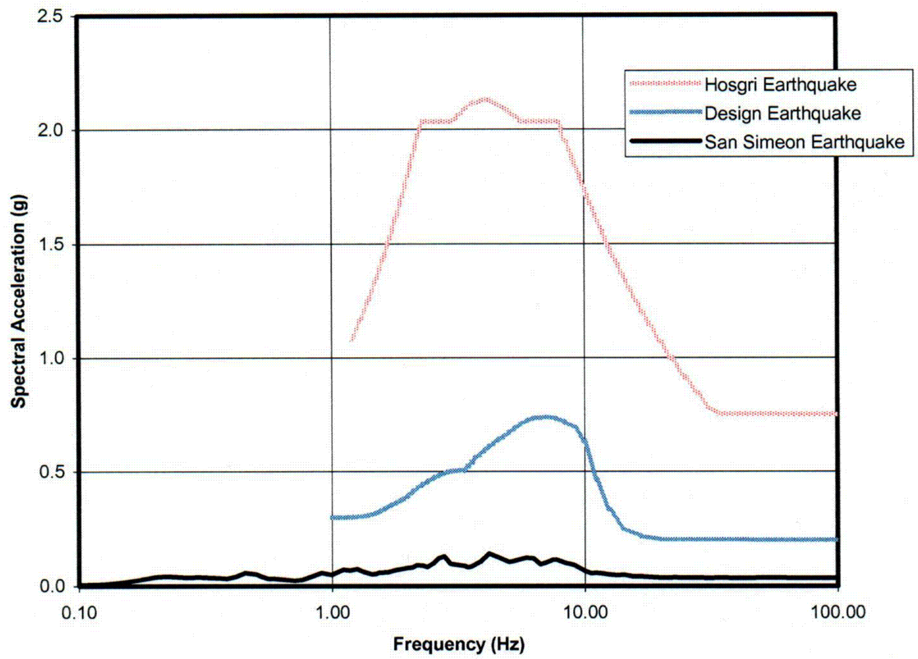

Figure 12A Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Free Field Ground Motion - Plant North-South Direction

C11

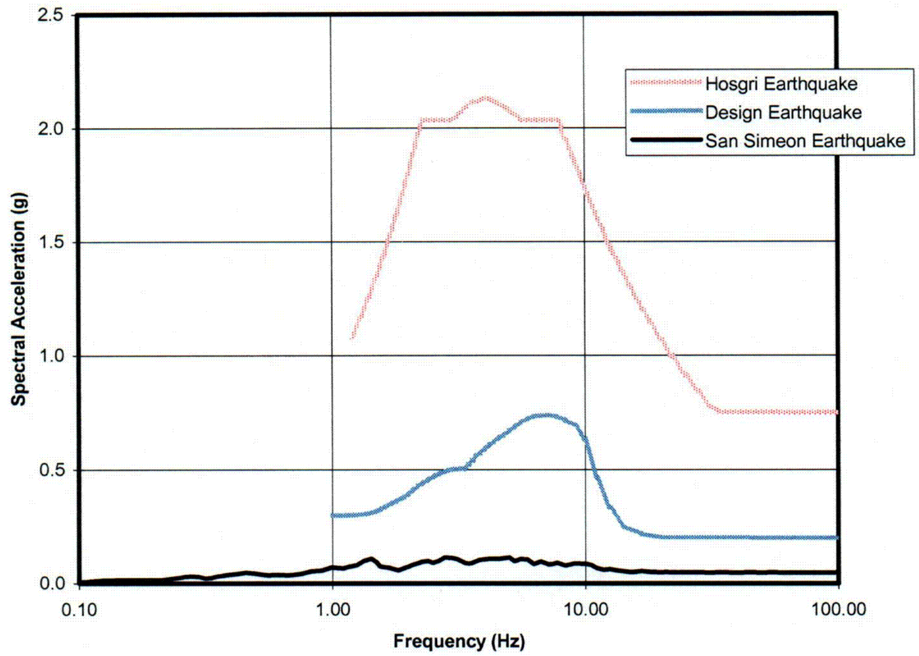

Figure 12B Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Free Field Ground Motion - Plant East-West Direction

C12

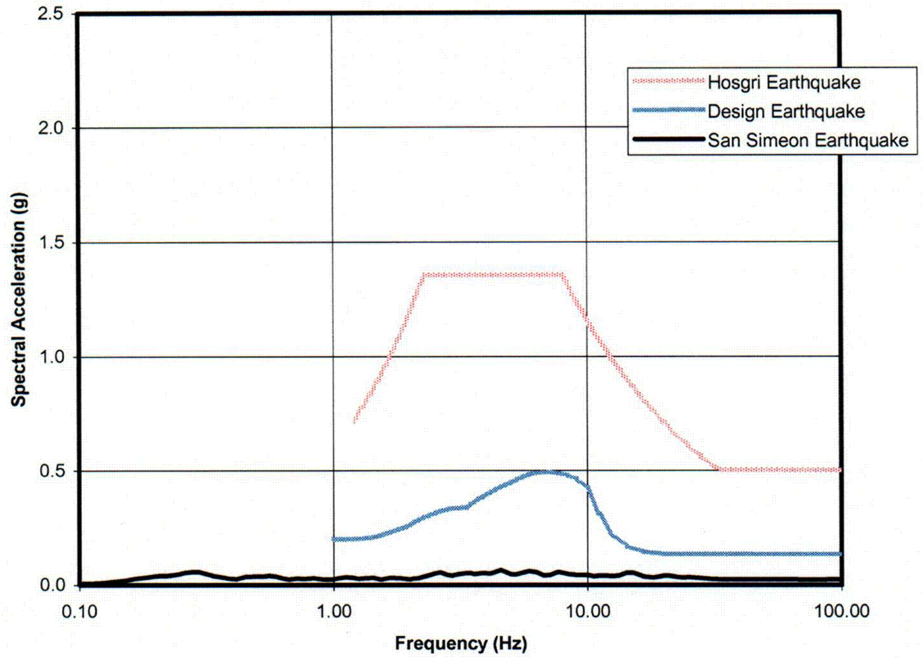

Figure 12C Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Free Field Ground Motion - Vertical Direction

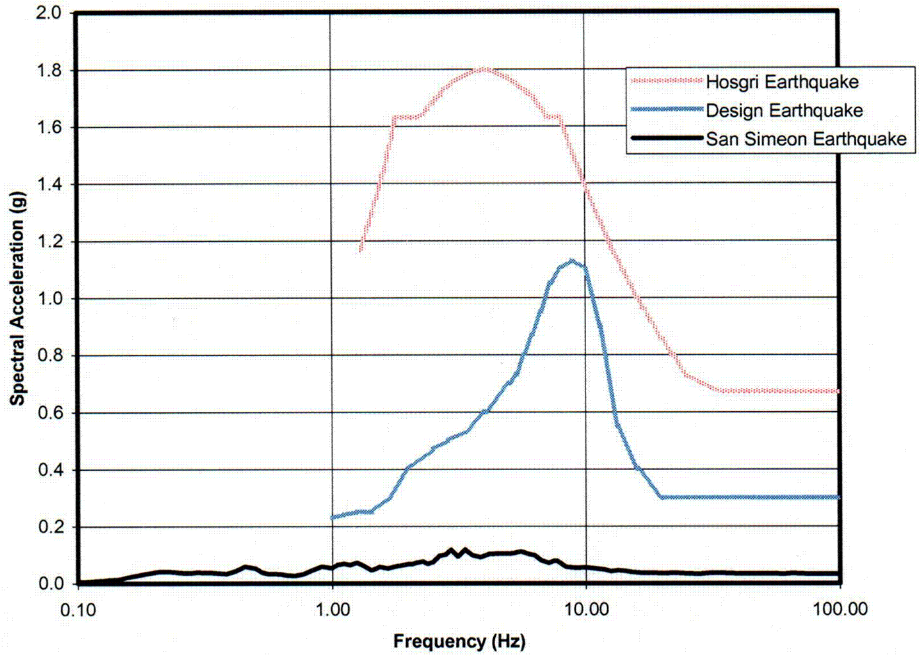

Figure 13A Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Unit 1 Contaiment Basemat - Plant North-South Direction

C14

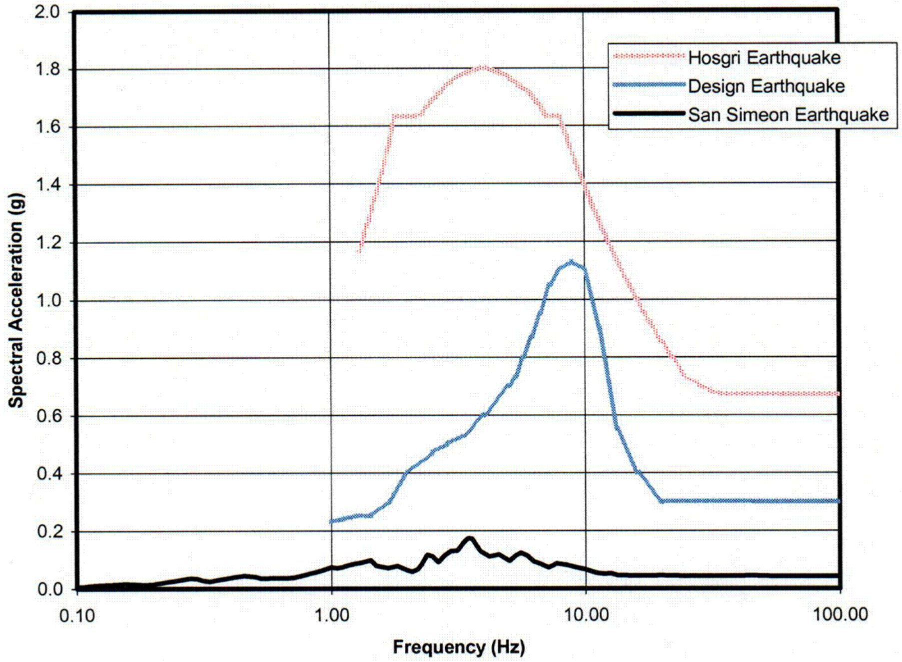

Figure 13B Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Unit 1Contaiment Basemat - Plant East-West Direction

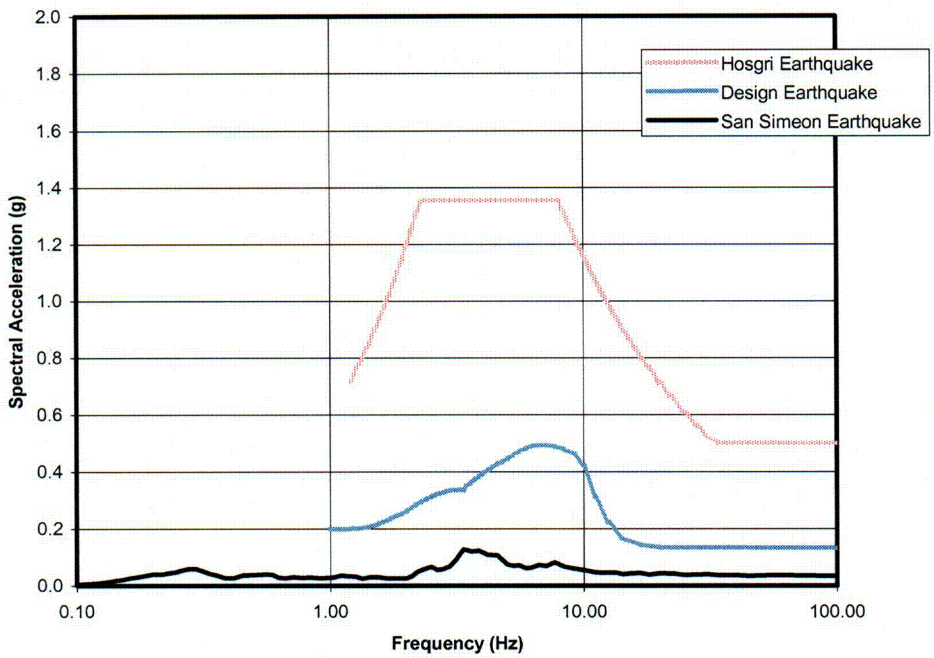

Figure 13C Compariosn of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Unit 1 Containment Basemat - Vertical Direction

C16

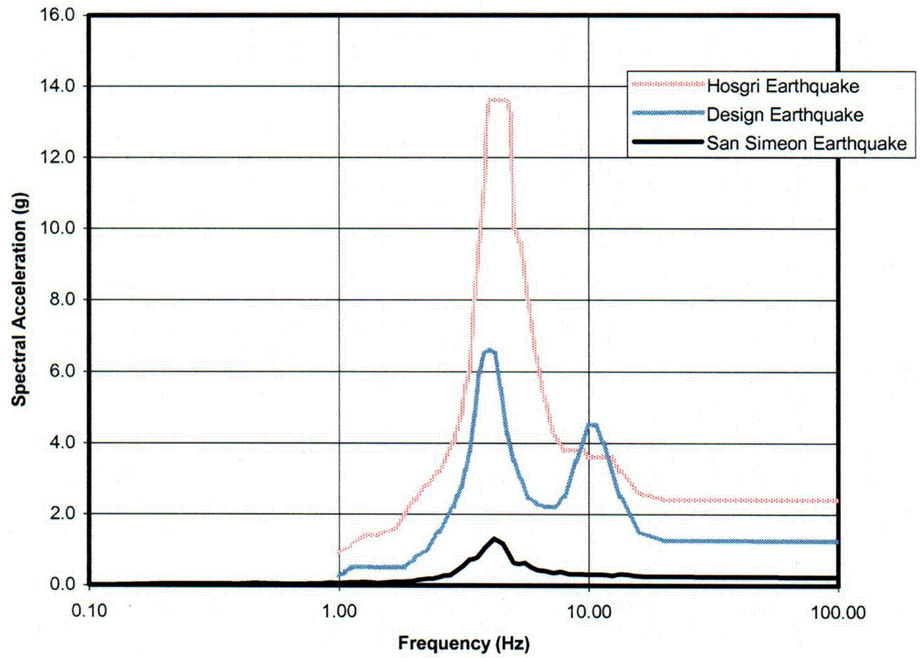

Figure 14A Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Top of Unit 1 Contaiment - Plant North-South Direction

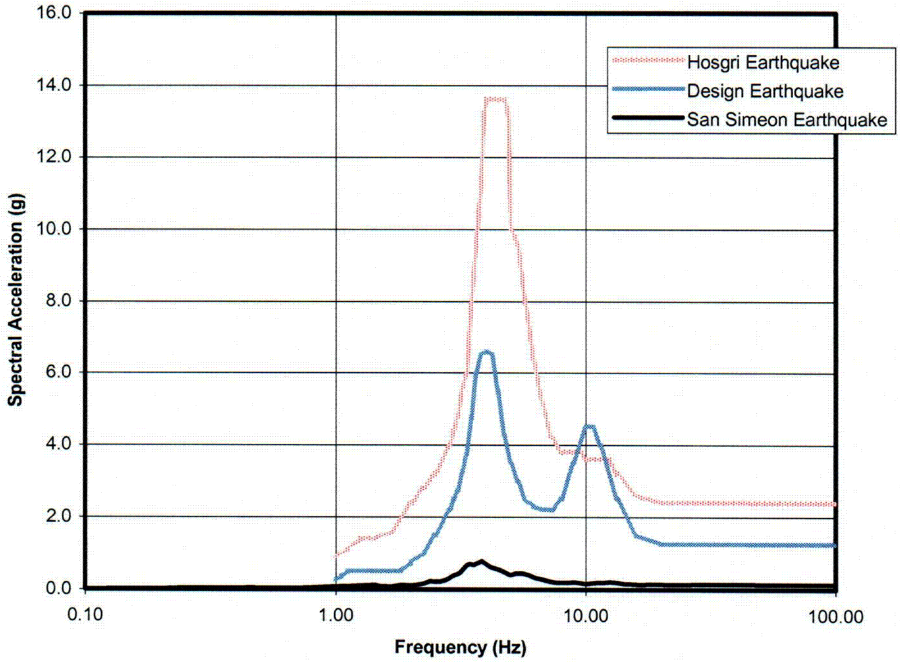

Figure 14B Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Top of Unit 1 Contaiment - Plant East-West Direction

C18

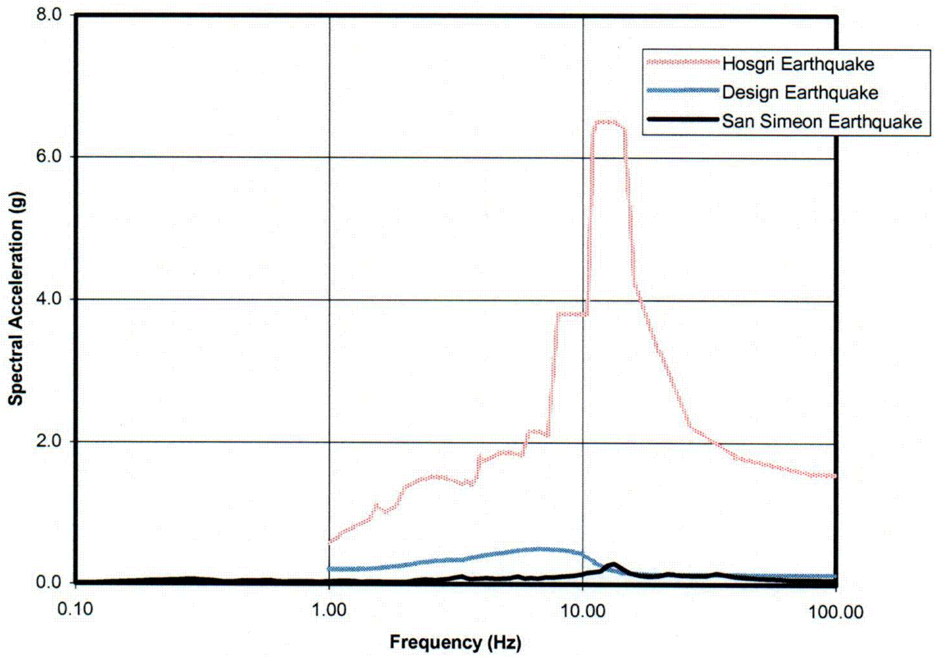

Figure 14C Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Top of Unit 1 Contaiment - Vertical Direction

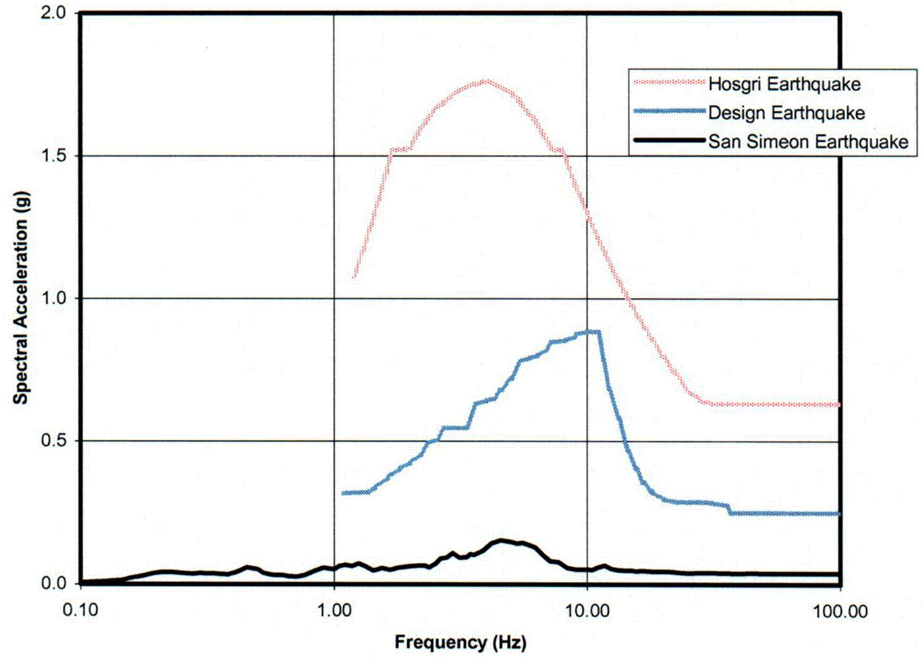

Figure 15A Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Auxiliary Building Basemat - Plant North-South Direction

C20

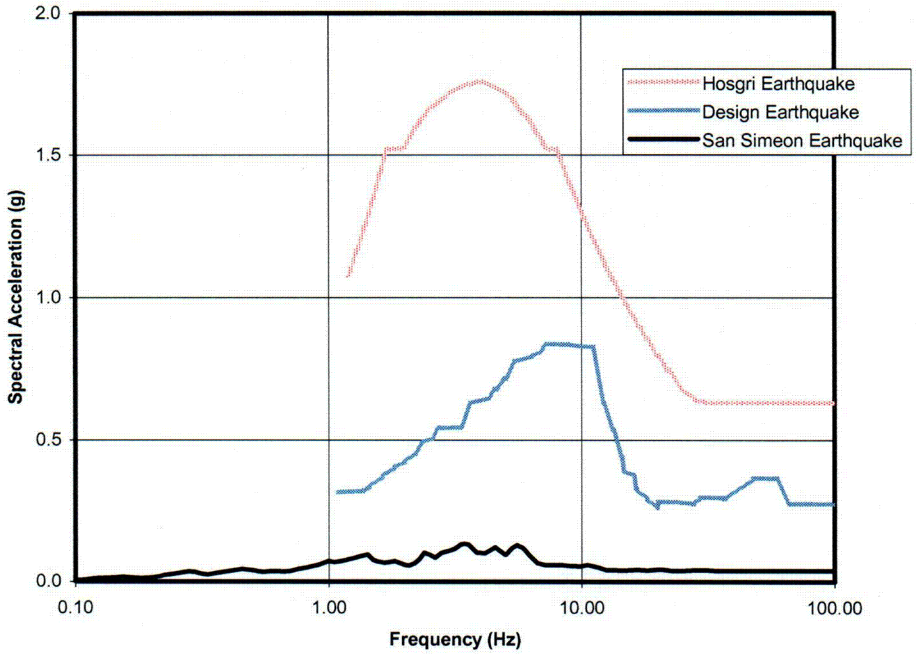

Figure 15B Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Auxiliary Building Basemat - Plant East-West Direction

C21

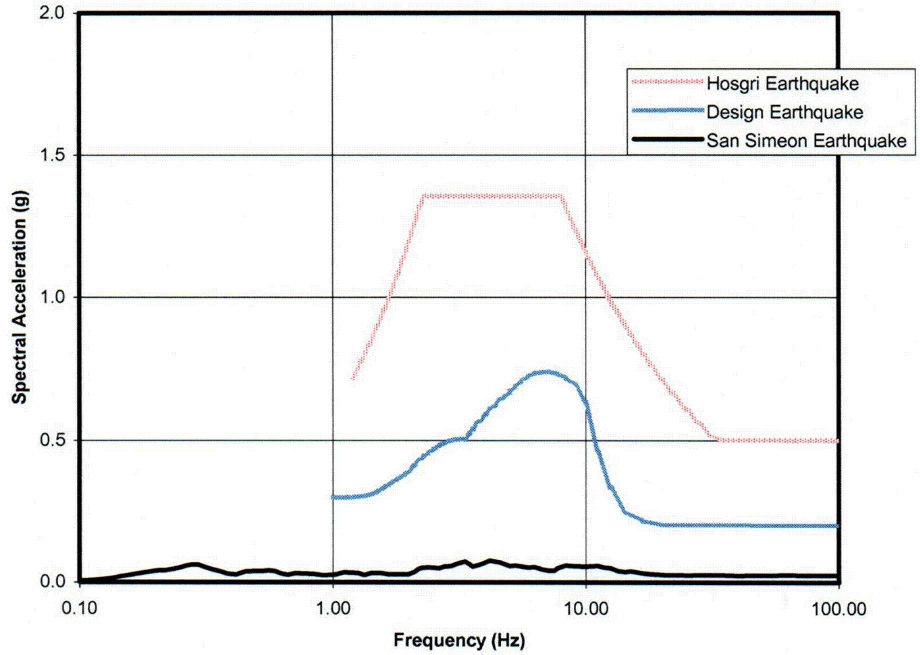

Figure 15C Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Auxiliary Building Basemat - Vertical Direction

C22

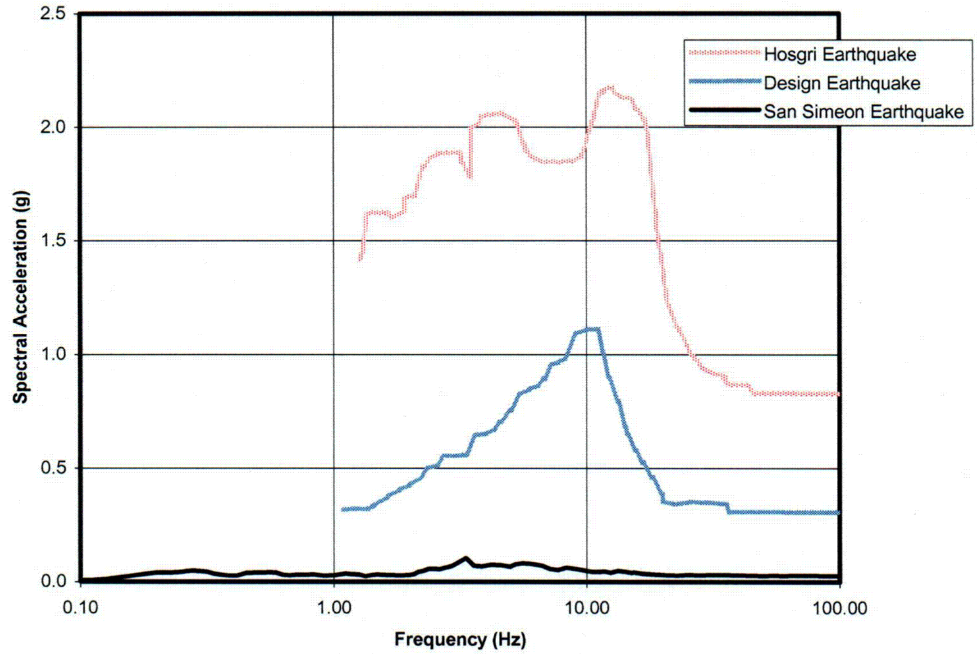

Figure 16A Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Auxiliary Building, Elev. 100' - Plant North-South Direction

C23

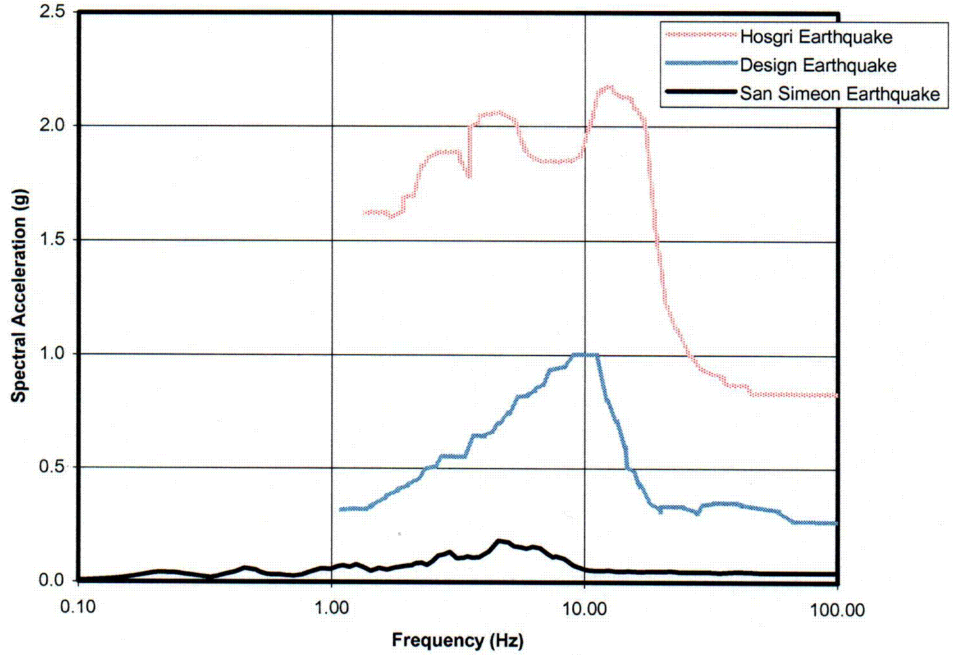

Figure 16B Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Auxiliary Building, Elev. 100' - Plant East-West Direction

C24

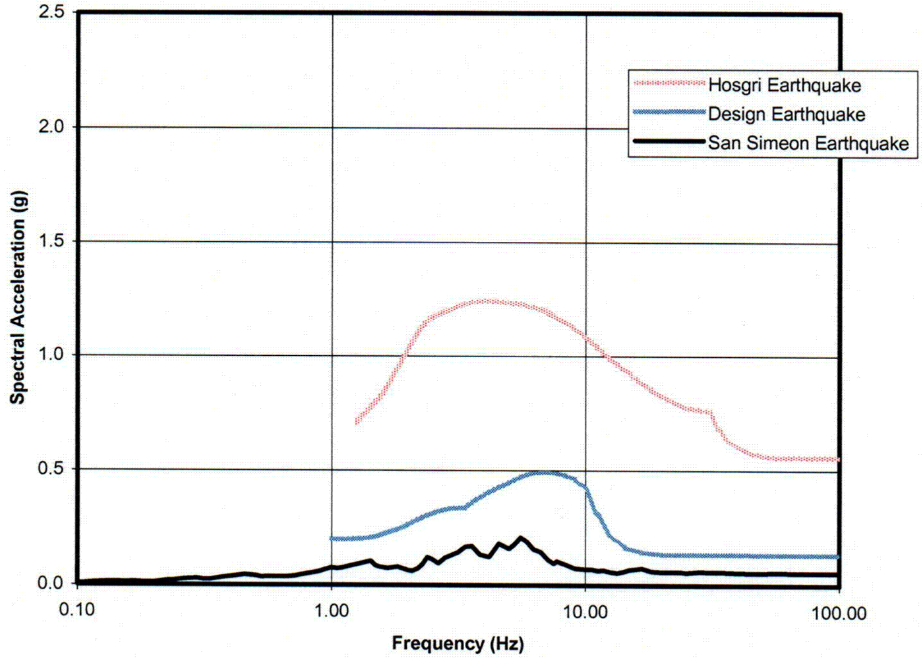

Figure 16C Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Auxiliary Building, Elev. 100' - Vertical Direction

C25

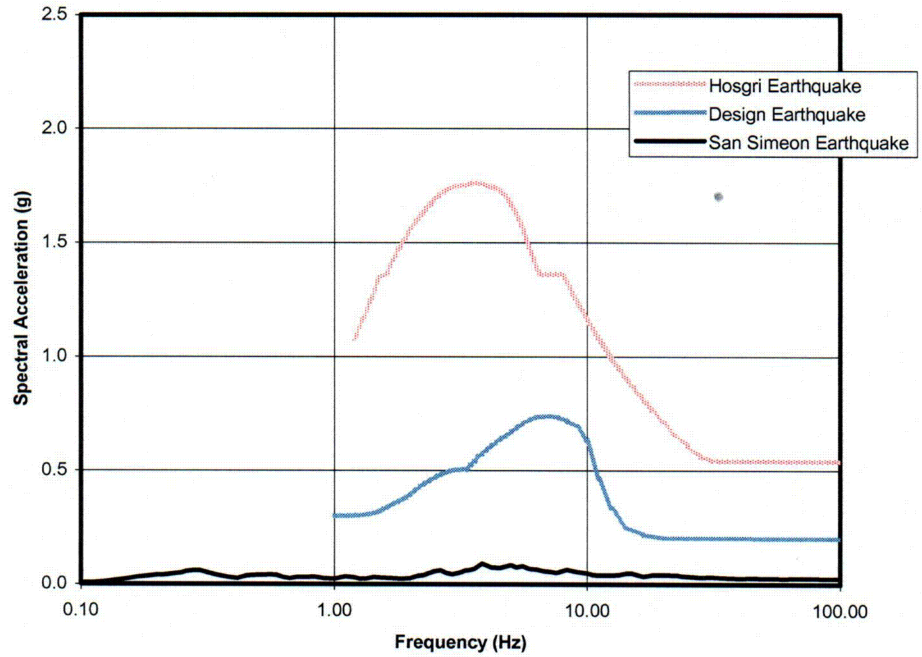

Figure 17A Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Turbine Building Grade Level, Elev. 85', South End - Plant North-South Direction

C26

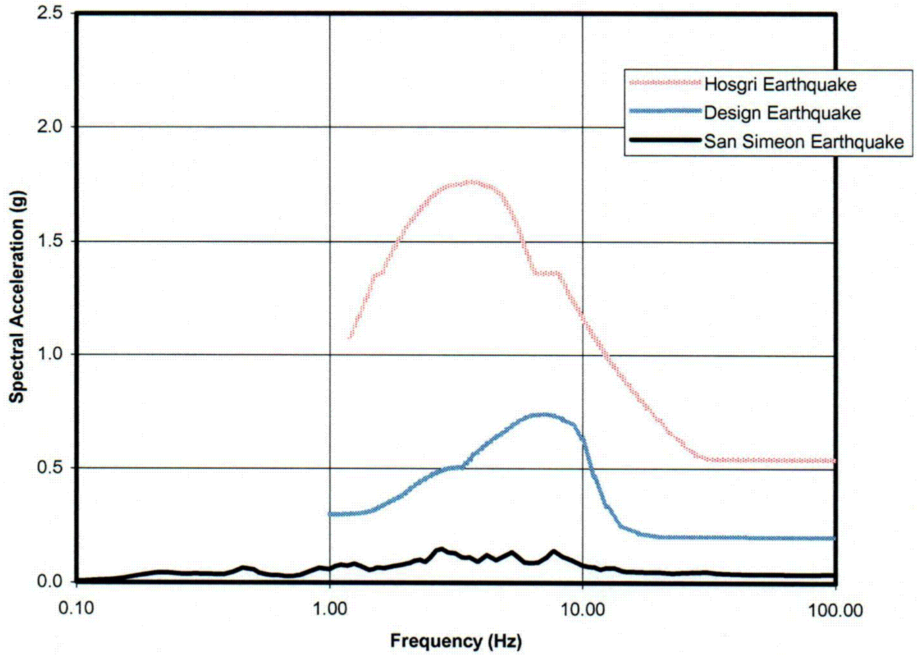

Figure 17B Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Turbine Building Grade Level, Elev. 85', South End - Plant East-West Direction

C27

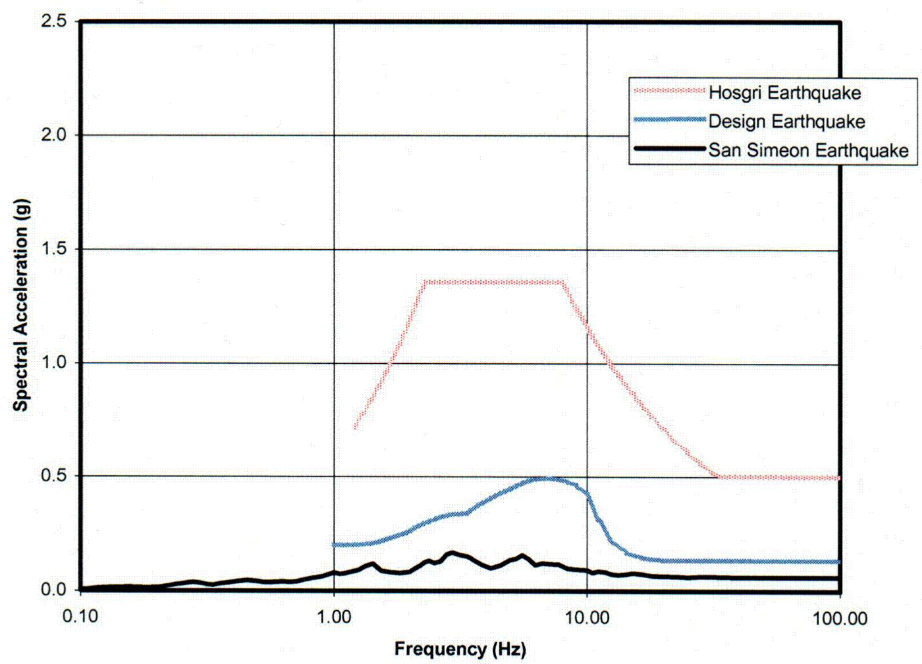

Figure 17C Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Turbine Building Grade Level, Elev. 85', South End - Vertical Direction

C28

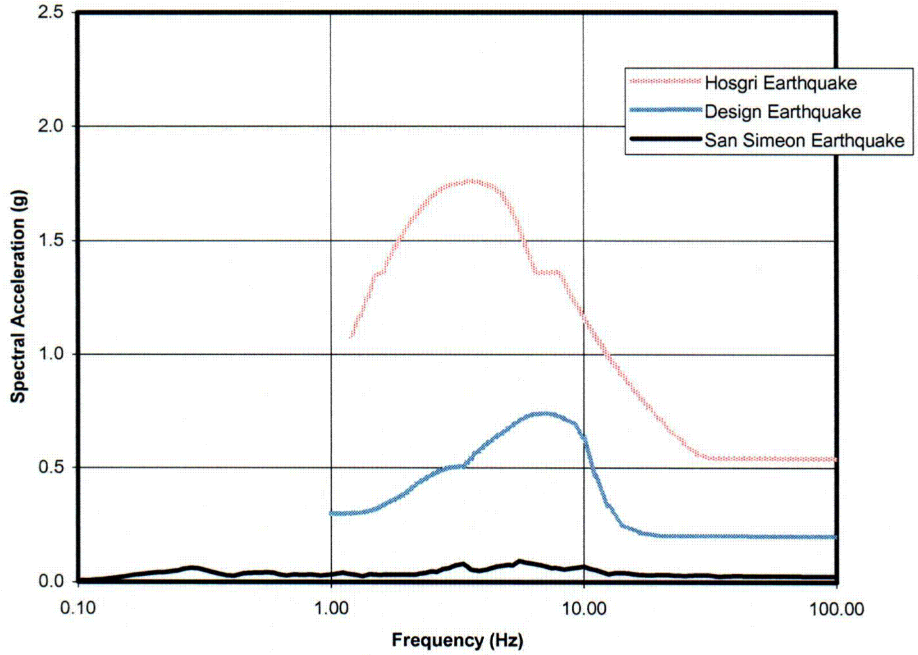

Figure 18A Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Turbine Building Grade Level, Elev. 85', North End - Plant North-South Direction

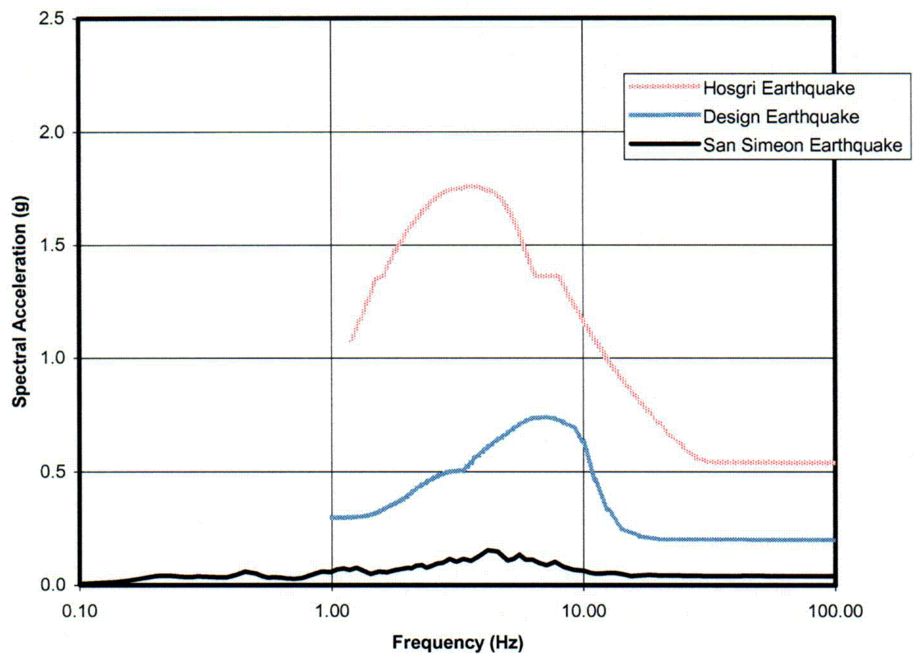

Figure 18B Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Turbine Building Grade Level, Elev. 85', North End - Plant East-West Direction

C30

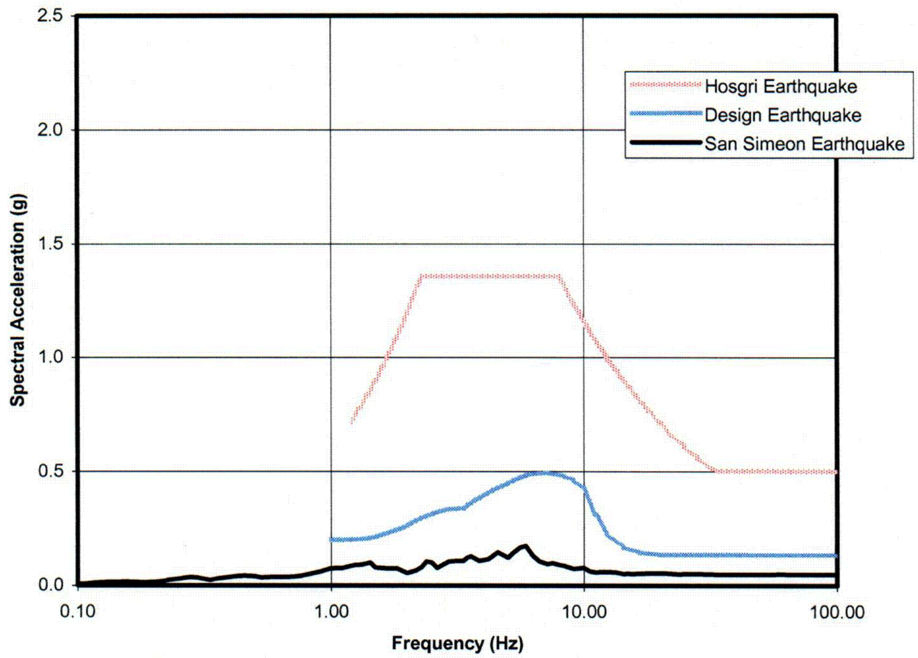

Figure 18C Comparison of the San Simeon Earthquake Response Spectrum with the DCPP Design Basis Response Spectra (5% Damping)

Turbine Building Grade Level, Elev. 85', North End - Vertical Direction

C31

Analysis of The Resultant Effect Upon Facility Features Important To Safety For The San Simeon Earthquake of December 22, 2003

Plant Systems Response

The San Simeon Earthquake registered 0.04g at the plant site, as read by the earthquake force monitor (EFM) in the control room. During this event, numerous alarms were received on both units. Many of the alarms were associated with movement of fluid levels in various systems. Examples of the level alarms include; spent fuel pools, electro-hydraulic (EH) control system oil and feedwater pump lube oil reservoirs. Some alarms actuated due to vibration of non-safety related switch contacts. When the seismic activity stopped, the alarms that were received cleared and returned to normal. Operations responded by dispatching people into the power plant to visually verify systems that had received level alarms. As a result of the contact chatter of non-safety related sensors, the Unit 2 EH oil reservoir low-low level sensor actuated and stopped the EH pumps. Operators were alerted by a backup alarm, which warned of low system pressure, and took action to restore the operation of the Unit 2 EH pumps that had tripped off due to a low-low system level lockout.

Investigations in response to alarms revealed no leakage from any associated systems and no damage caused by the earthquake. It was noted that the seismically induced wave action in the Unit 1 spent fuel pool was of sufficient magnitude to cause a small amount of water to splash up onto the surrounding deck of the pool. Plant personnel were dispatched to clean this area.

Using Casualty Procedure (CP) M-4, "Earthquake," operators directed inspections and checked systems for leakage. All systems continued to operate normally. No visible damage was discovered. Operations personnel performed tank inventory checks specified by CP M-4; no systems were found to be leaking as a result of the earthquake. DCPP Fire Brigade personnel conducted plant inspections, including systems inside both containment structures, to verify the continued integrity of fire protection features. No observable damage was discovered within the power plant. No fire protection impairments were found. Operations personnel also performed an inventory check of the diesel fuel oil storage tanks. No abnormalities were observed.

Seismic Monitoring Instrumentation Response

The main shock triggered the Basic Seismic Monitoring System analog recorder (Kinemetrics SMA) in the control room and the digital recorders (Kinemetrics SSA) at the Unit 1 containment base, top of containment, the auxiliary building, and the free-field pit locations (near the fitness trailer). In addition, three temporary accelerometers located in the auxiliary and turbine buildings triggered and recorded data as a result of the event. The EFM located in the control room measured 0.04g on the horizontal component. All functional seismic monitoring instrumentation operated as designed.

Event Response Team Lessons Learned

Following the San Simeon earthquake, DCPP formed an Event Response Team (ERT). The goals of the ERT were as follows:

- Capture, understand, and implement lessons learned from the event
- Capture and understand the seismology of the event as it relates to DCPP design features

The ERT developed focus areas of specific interest. The ERT explored each focus area to determine lessons learned utilizing operations, maintenance, engineering, and plant safety personnel. The following actions were taken:

- Personnel Safety: All plant personnel received a tailboard on earthquake safety and actions to take during and after an earthquake. General employee training has been enhanced, emphasizing personnel safety, safe locations, and casualty assistance.

- Revision to Procedure M-4, "Earthquake:" Based on lessons learned from implementation of this procedure and human factors, the ERT revised this procedure, to expand the involvement of engineering, operations, and security personnel. The new revision was also expanded to verify the integrity of temporary attachments and construction aids, such as scaffolding. In addition, the ERT developed guidance on completing the procedure following an earthquake.

- Emergency Plan Implementation: The event prompted implementation of DCPP's Emergency Plan at the Notice of Unusual Event level. The ERT reviewed the effectiveness of communications tools used by PG&E and its interaction with the San Luis Obispo Office of Emergency Services during the event. No specific recommendations were made.

- Training: The ERT reviewed and will implement recommended improvements for plant personnel training, operator training, and the simulator scenario/modeling. Applicable plant personnel will be trained on procedure changes in accordance with standard DCPP procedure change policy.

- Plant Systems Response: The ERT utilized operations and engineering personnel to evaluate the plant system response and make recommendations for enhancements. Engineering evaluated alarms caused by mercury switches and tank sloshing, recommending replacement of several alarm switches. As an example, the turbine trip alarm is actuated by a mercury switch and will be replaced to ensure a false alarm does not result in a turbine trip. Operations and engineering evaluated the EH control system lockout problem and will incorporate recommendations to improve the EH system operation. Engineering reaffirmed that the assumptions for the safety-related relay chatter analysis were not impacted by this event. Additionally, engineering reviewed and made recommendations for the performance of discretionary surveillances following an earthquake.

- Plant Civil Response: In addition to the seismic data analysis performed by Geosciences, DCPP's civil engineering personnel reviewed the performance and response of structures in the protected area and other onsite buildings, and reviewed the soils response throughout the owner-controlled area. Civil engineering reviewed the existing seismic interaction program. Enhancements will be incorporated into a civil engineering earthquake inspection procedure.

- Offsite Power Sources: The ERT concurred with recommendations for action to validate the integrity of offsite power sources. These recommendations include post-earthquake activities such as transmission line fly-overs, switchyard thermography, and electrical systems inspections.

The ERT action items and recommendations are incorporated into DCPP's corrective action program. Capturing lessons learned and evaluating enhancements is an ongoing process of the ERT. Although many of the recommendations for improvements have been implemented, the ERT continues to explore other opportunities to improve the plant response and personnel safety for future seismic events.

Early Warning System

During the San Simeon earthquake, power outages resulted in the loss of 56 of 131 early warning system sirens, only 9 of which were located in protective action zones 1 through 5. Alternative means of notifying the general public of an emergency were available. All evacuation routes remained available. Power was restored to all but 4 of the sirens within approximately 14 hours; the last 4 sirens had their power restored within approximately 36 hours.

DCPP has also revised procedures to more conservatively report inoperable sirens to the NRC.