Westinghouse

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, D.C. 20555

Direct tel: 412-374-6206
Direct fax: 724-940-8505
e-mail: sisk1rb@westinghouse.com

Your ref: Docket No. 52-006
Our ref: DCP_NRC_002648

October 7, 2009

Subject: AP1000 Response to Request for Additional Information (SRP 3)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 3. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-SRP3.7.1-SEB1-10 R3

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

John DeBlasio
for/

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Request for Additional Information on SRP Section 3

D063
NRO

cc:	D. Jaffe	-	U.S. NRC	1E
	E. McKenna	-	U.S. NRC	1E
	B. Gleaves	-	U.S. NRC	1E
	T. Spink	-	TVA	1E
	P. Hastings	-	Duke Power	1E
	R. Kitchen	-	Progress Energy	1E
	A. Monroe	-	SCANA	1E
	P. Jacobs	-	Florida Power & Light	1E
	C. Pierce	-	Southern Company	1E
	E. Schmiech	-	Westinghouse	1E
	G. Zinke	-	NuStart/Entergy	1E
	R. Grumbir	-	NuStart	1E
	D. Lindgren	-	Westinghouse	1E

ENCLOSURE 1

Response to Request for Additional Information on SRP Section 3

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP3.7.1-SEB1-10
Revision: 3

Question:

The staff requests that Westinghouse augment Figures 5.2-1 through 5.2-6 in TR-115, by adding the HRHF broadened spectra from the NI20 fixed base analysis, without any reduction for incoherency or other considerations. This will provide the staff with results needed to conduct an evaluation of the effect of incoherency.

Additional Request by NRC Audit during April 13th to 17th (Revision 2):

Perform additional calculations using EPRI model and rectangular foundation and AP1000 on hard rock foundation.

Additional Request (Revision 3)

A. Westinghouse will provide explanation why the incoherent response has a significant reduction when compared to coherent response in low frequencies (below 10Hz)
B. Review interpolation function for NI20 SASSI model.
C. Reanalysis of seismic response will correct/clarify values and results will be re□issued as a new revision to RAI□SRP3.7.1□SEB1□10.

Westinghouse Response (Revision 0 and 1):

It is noted that Westinghouse uses the NEI recommended coherency function that reduces high frequency ground motions by accounting for special seismic wave incoherency. The rock-based coherency function that is being used was developed by Dr. Norman A. Abrahamson. This function is consistent with the requirements of the "Common Understanding" developed by the NRC staff and industry representatives during the December 20-21, 2006 public meeting. Since Westinghouse is using the coherency function that is consistent with the "Common Understanding" between the NRC and industry, it is not considered necessary to provide this information. There is nothing unique in the Westinghouse application of the coherency function.

In response to the question raised by the NRC during May 19-23, 2008, Westinghouse has provided the response spectra for the HRHF broadened NI20 model with coherent and incoherent considerations in Figure RAI-SRP3.7.1-SEB1-10-1 to RAI-SRP3.7.1-SEB1-10-21 (5% damping).

Westinghouse Response (Revision 2):

In Figures RAI-SRP3.7.1-SEB1-10-1 to RAI-SRP3.7.1-SEB1-10-21 some of the reductions ratios (defined as Incoherent response / coherent response) are shown to be less than 0.5 in some cases. Analyses have been performed using the EPRI model to provide the staff with additional results needed to conduct an evaluation of the effect of incoherency. The results show that the size and shape of the basemat has a significant effect on the reductions obtained from incoherence.

The following three cases using the EPRI Stick model have been analyzed:

1. EPRI AP1000 stick model with EPRI soil profile (Shear wave velocity, Vs, from 3300 fps to 8500 fps at depth of 130 ft) and EPRI input time history.
2. EPRI AP1000 stick model with EPRI soil profile and HRHF input time history.
3. EPRI AP1000 stick model (basemat size 158' by 254') with HRHF soil profile (Average Vs=8000 fps below grade) and HRHF input time history.

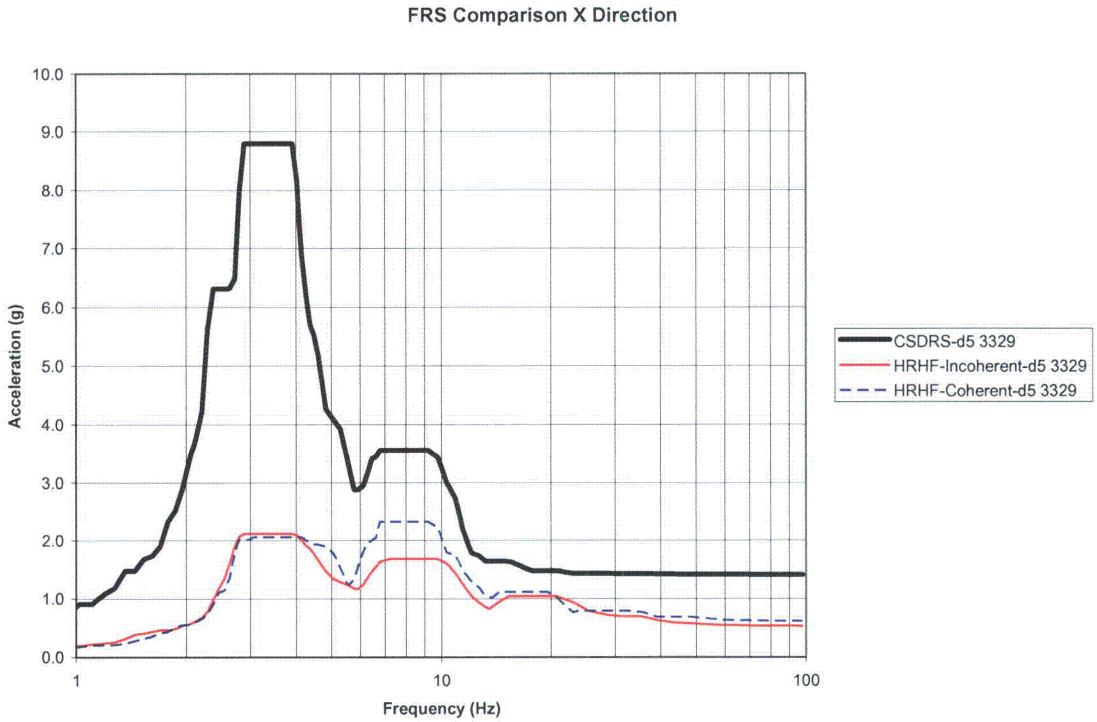
Four Locations are selected for comparison:

A. Nuclear Island foundation at elevation 60.5' (Node 1).
B. Top of Containment Internal Structure Mass Center at elevation 169' (Node 129).
C. Top of Steel Containment Vessel at elevation 281.9' (Node 45).
D. Top of Shield Building at elevation 333.3' (node 18).

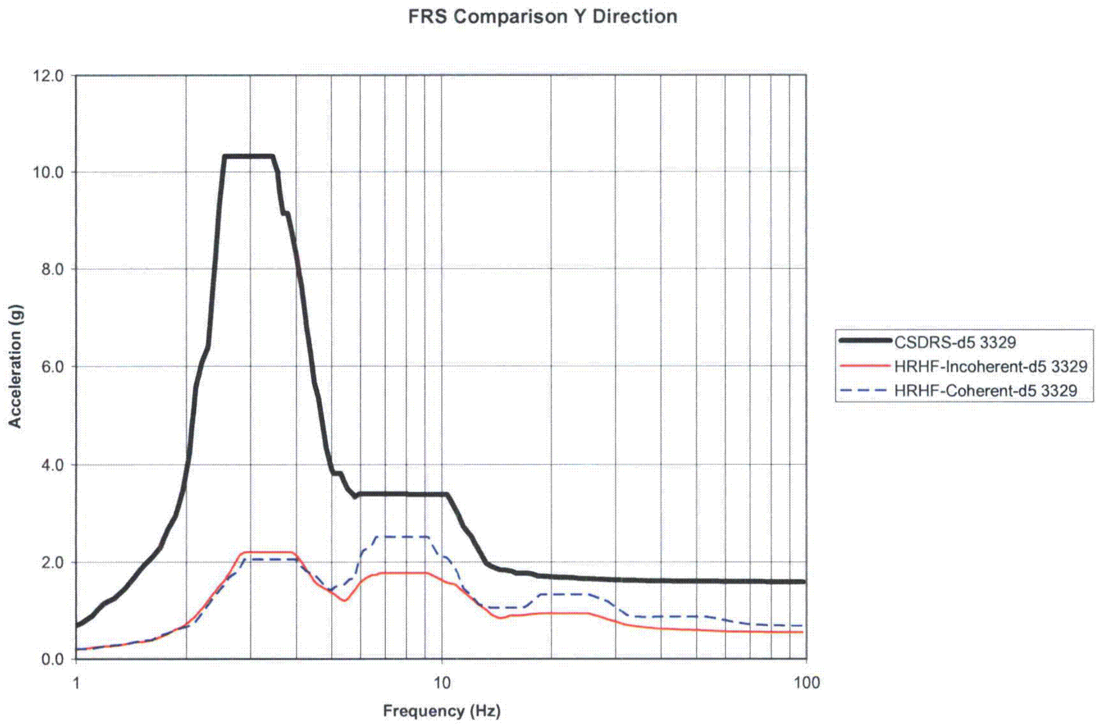
The 5% damping floor response spectra of four nodes and the reduction factors (Coh/Incoh) are shown in Figures RAI-SRP3.7.1-SEB1-10-22 to RAI-SRP3.7.1-SEB1-10-33. The Nuclear Island foundation results at elevation 60.5' (Node 1) show that the larger foundation will have larger reduction in response due to incoherency effects. The results for Top of Containment Internal Structure Mass Center at elevation 169' (Node 129), show reductions of the magnitude seen in the NI20 results. The top of the steel containment vessel and the top of the shield building also show similar results.

Finally, Figures RAI-SRP3.7.1-SEB1-10-34 to RAI-SRP3.7.1-SEB1-10-36 show a comparison of basemat response at the center (node 1 and 1153) and edges (node 230 and 1047) of the basemat of the EPRI and NI20 models. As can be seen the reductions are similar.

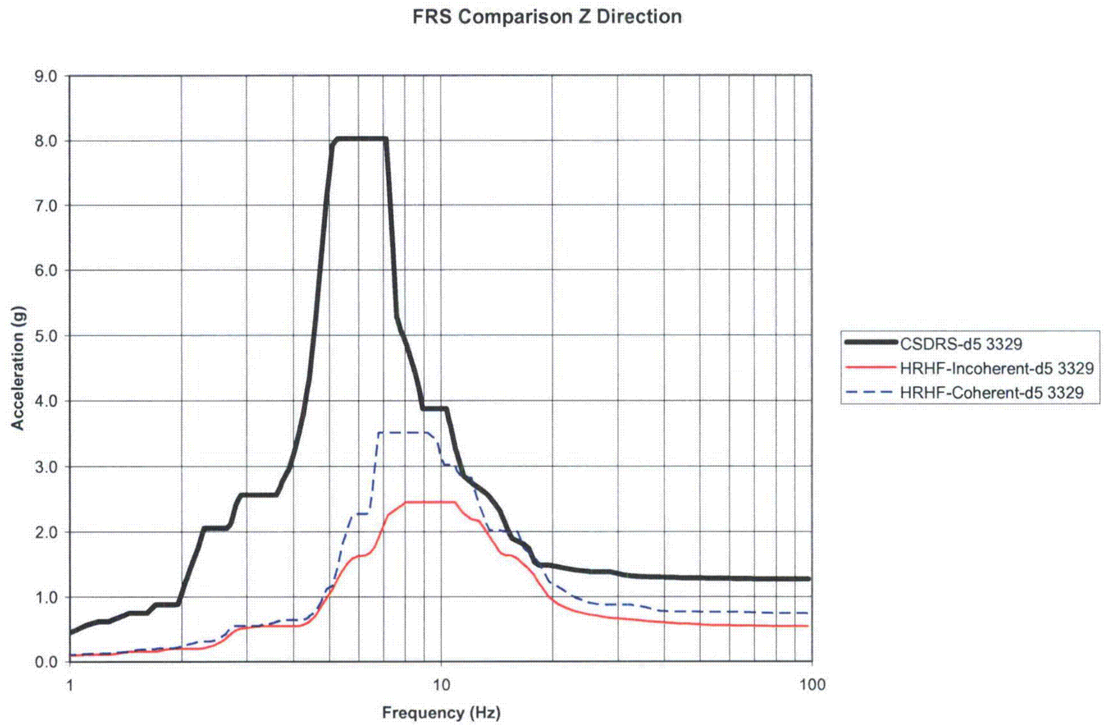
Thus, in conclusion the NI20 achieves similar reductions as the EPRI model for the same size foundation. The good comparisons show that the validated EPRI incoherent SSI methodology (Abrahamson, 2007 Hard-Rock Coherency Functions, Reference 1) was implemented correctly to the NI20 model ACS SASSI analyses.



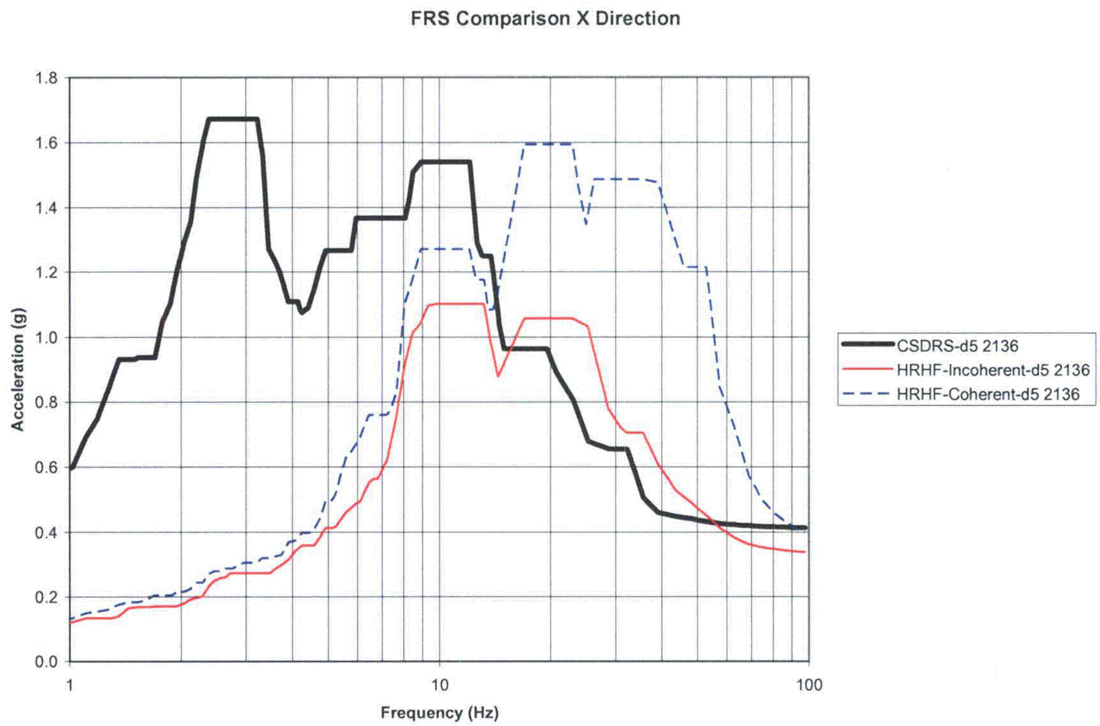
RAI-SRP3.7.1-SEB1-10-1: ASB at Elevation 327.4' X-Direction



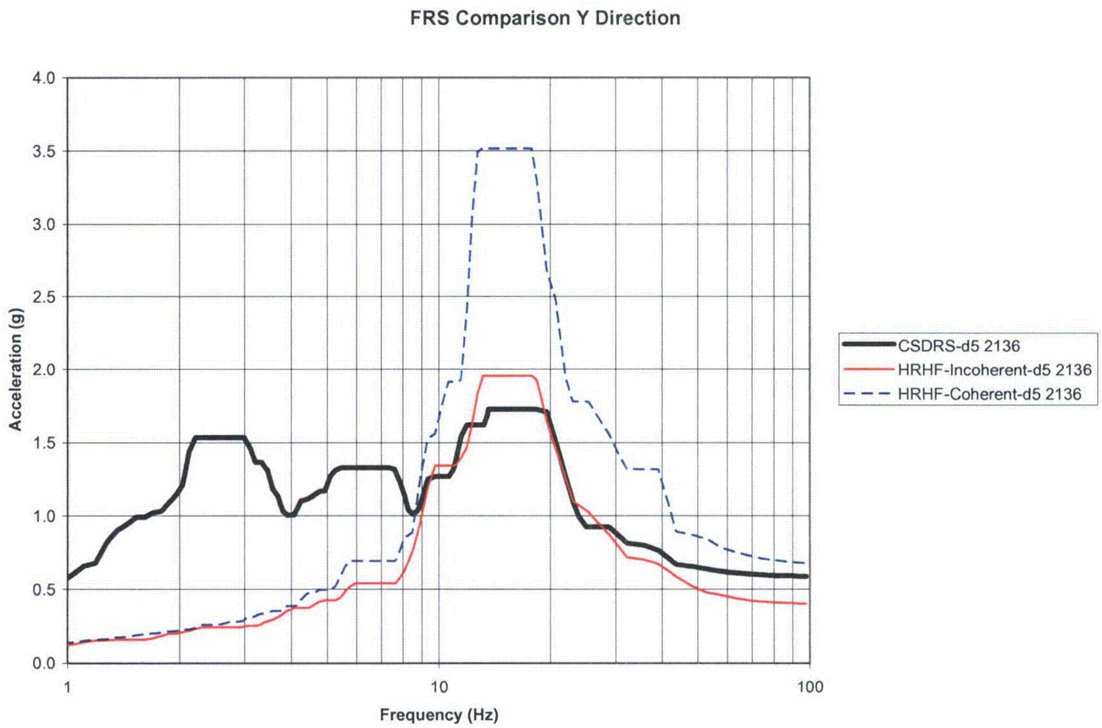
RAI-SRP3.7.1-SEB1-10-2: ASB at Elevation 327.4' Y-Direction



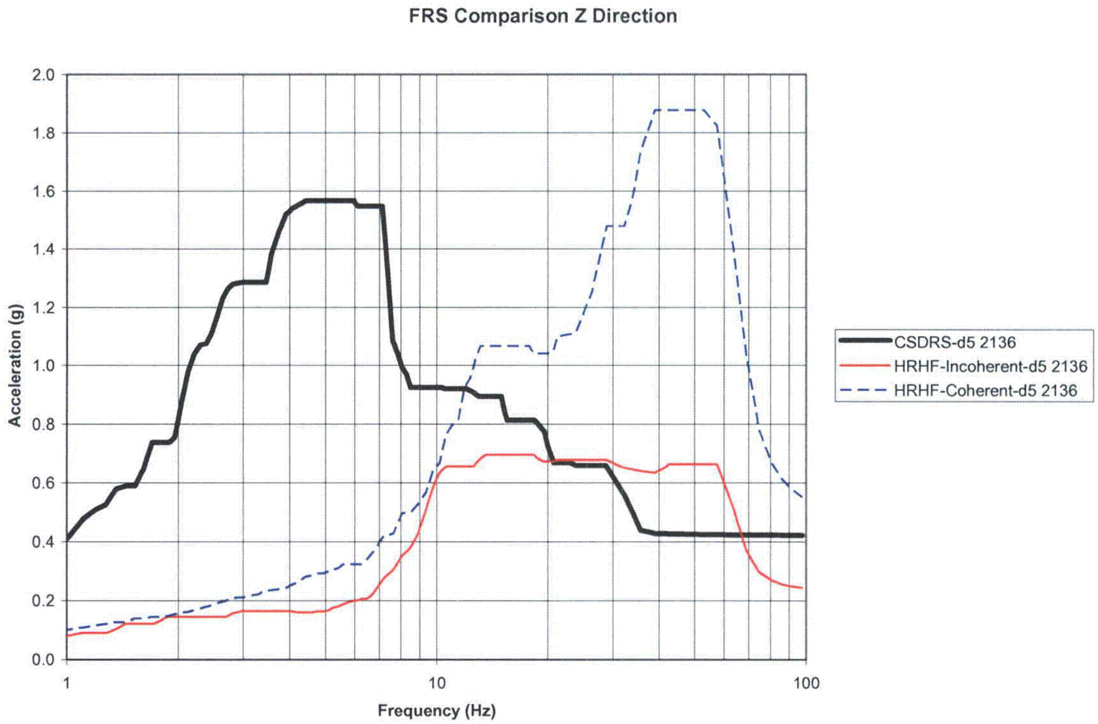
RAI-SRP3.7.1-SEB1-10-3: ASB at Elevation 327.4' Z-Directions



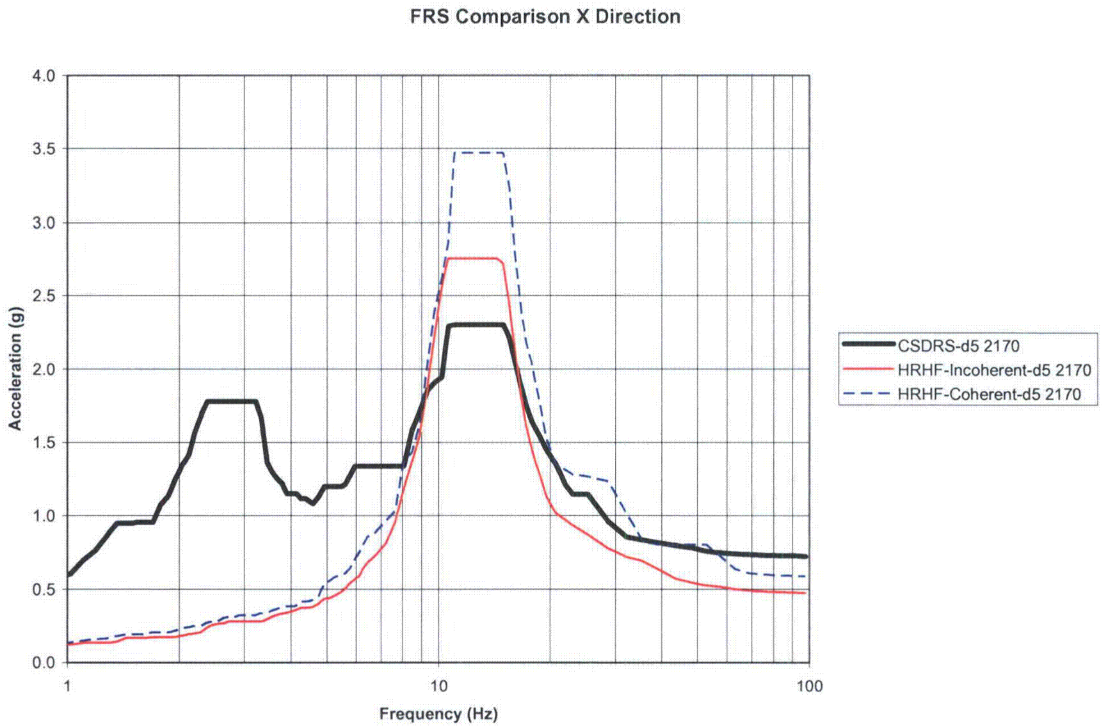
RAI-SRP3.7.1-SEB1-10-4: East Side Containment Operating Floor (Elevation 134.25') X-Direction



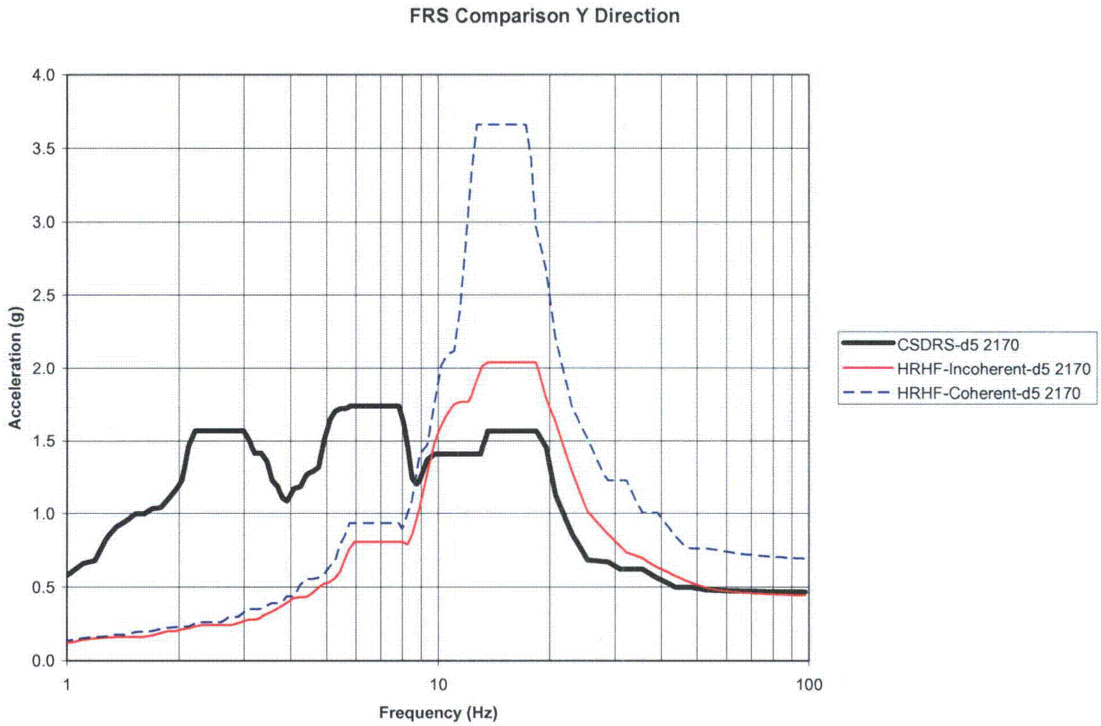
RAI-SRP3.7.1-SEB1-10-5: East Side Containment Operating Floor (Elevation 134.25') Y-Direction



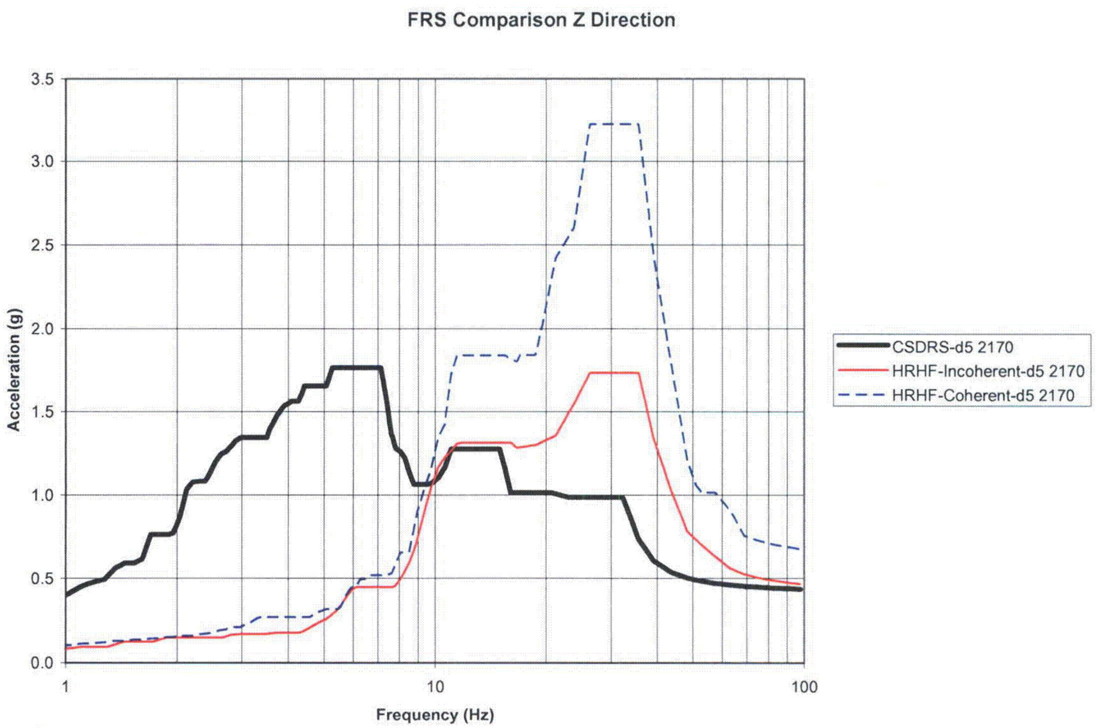
RAI-SRP3.7.1-SEB1-10-6: East Side Containment Operating Floor (Elevation 134.25') Z-Direction



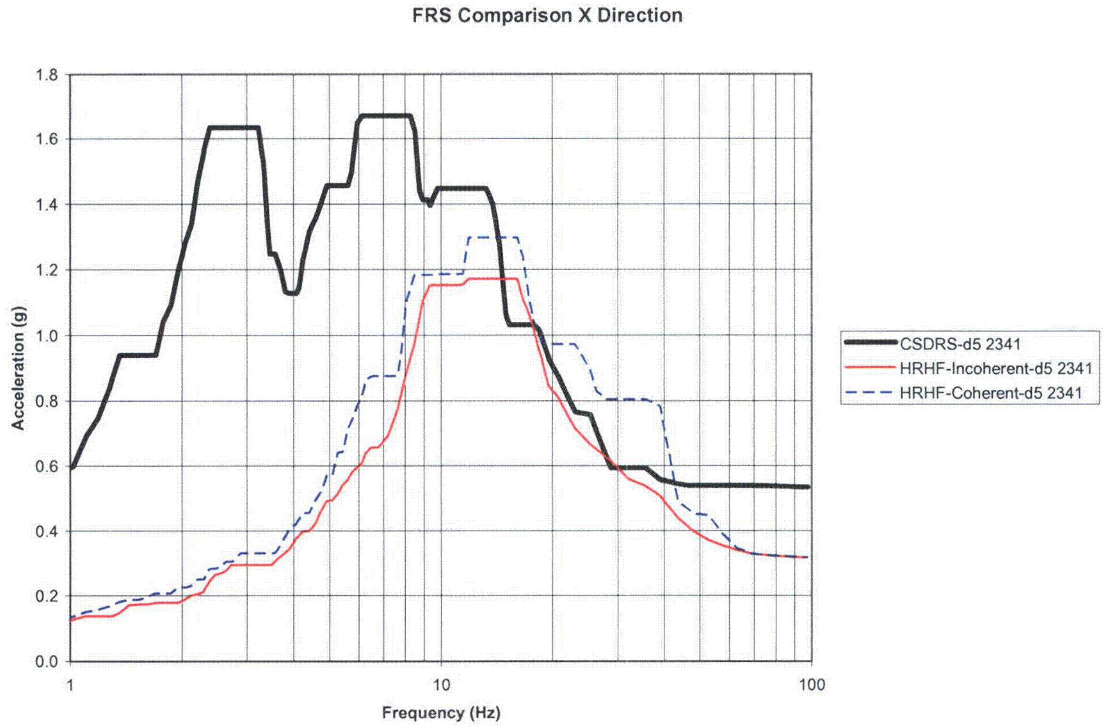
RAI-SRP3.7.1-SEB1-10-7: West Side Containment Operating Floor (Elevation 134.25') X-Direction



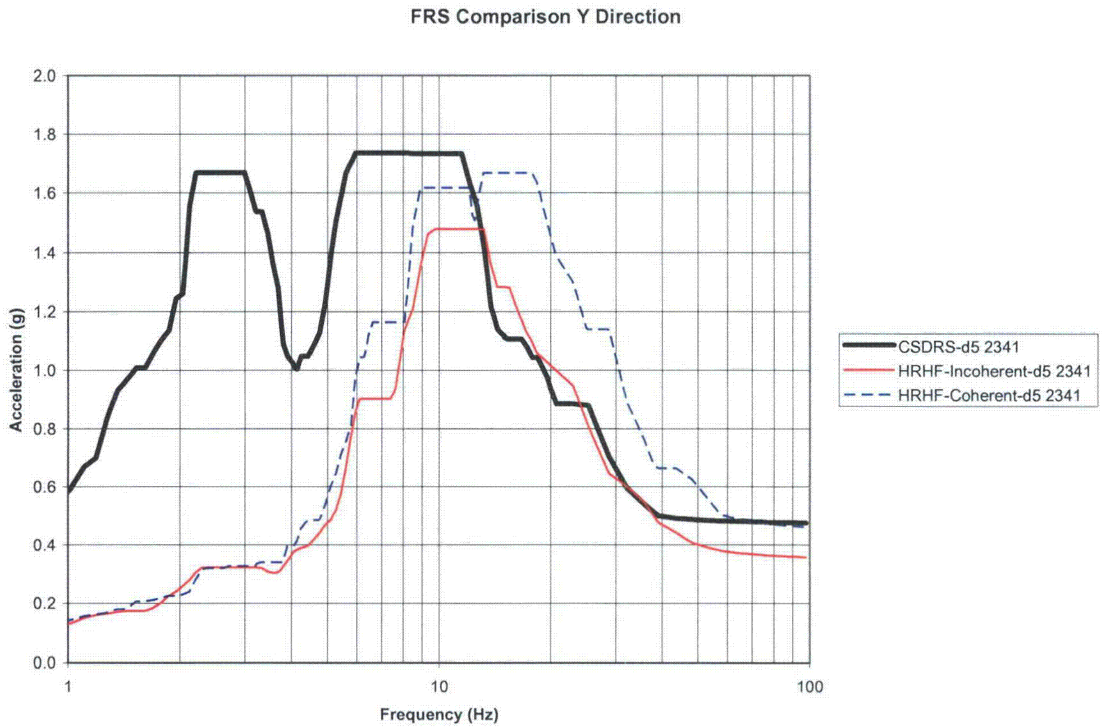
RAI-SRP3.7.1-SEB1-10-8: West Side Containment Operating Floor (Elevation 134.25') Y-Direction



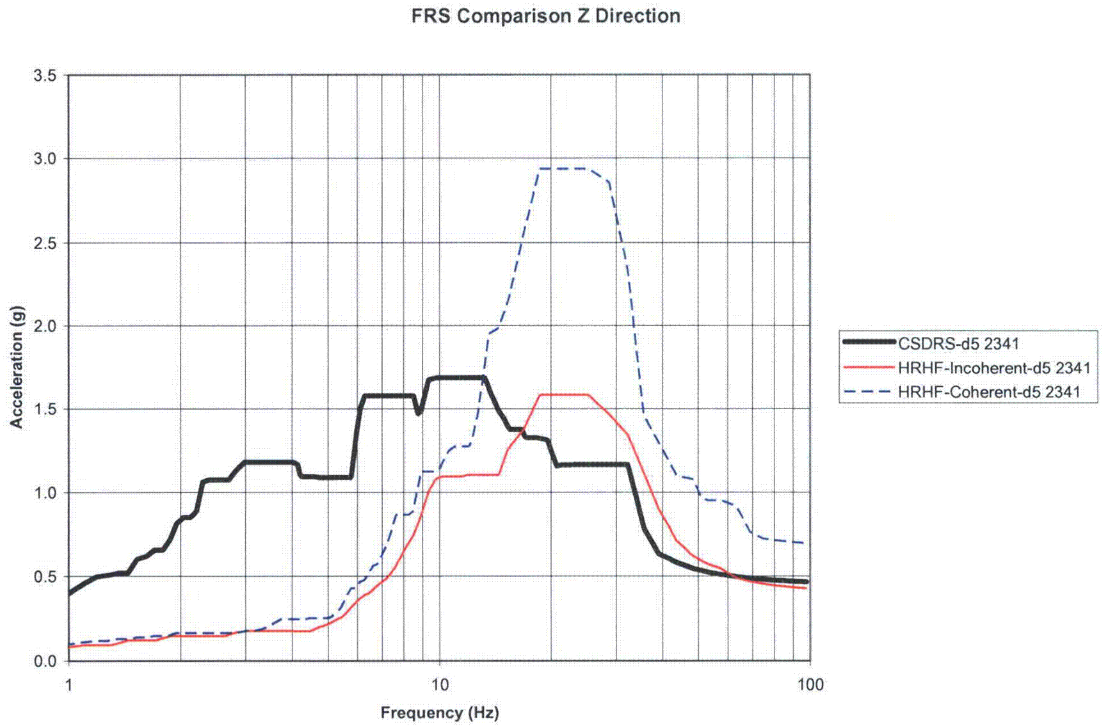
RAI-SRP3.7.1-SEB1-10-9: West Side Containment Operating Floor (Elevation 134.25') Z-Direction



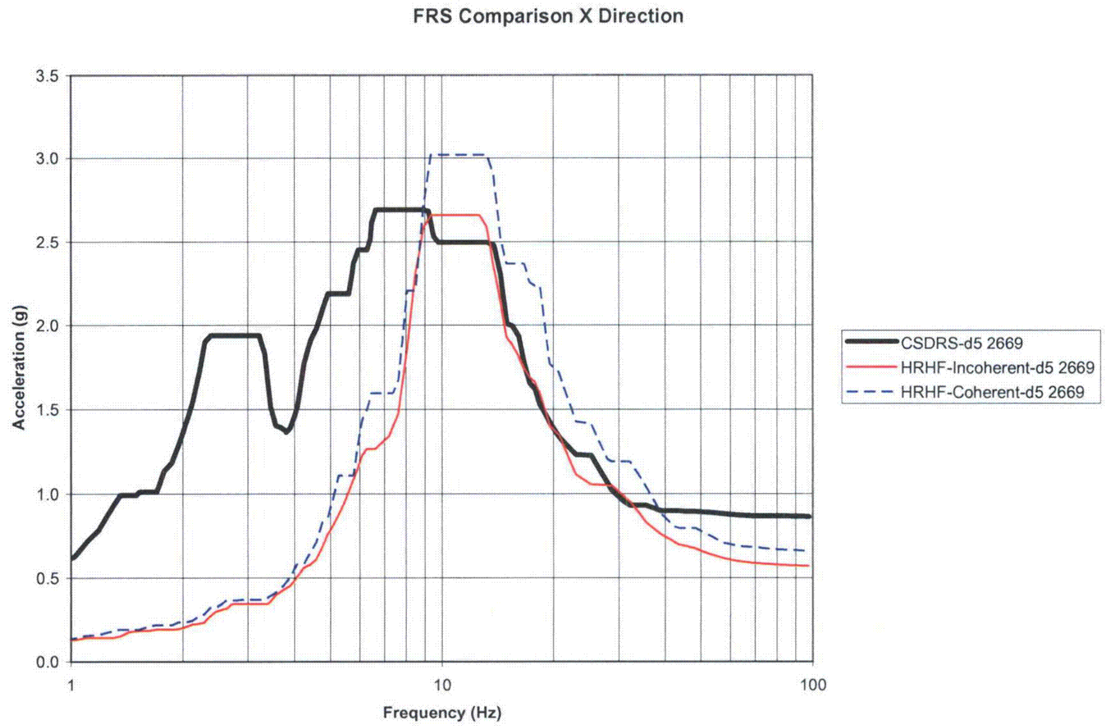
RAI-SRP3.7.1-SEB1-10-10: ASB at Northeast Corner (Elevation 134.5') X-Direction



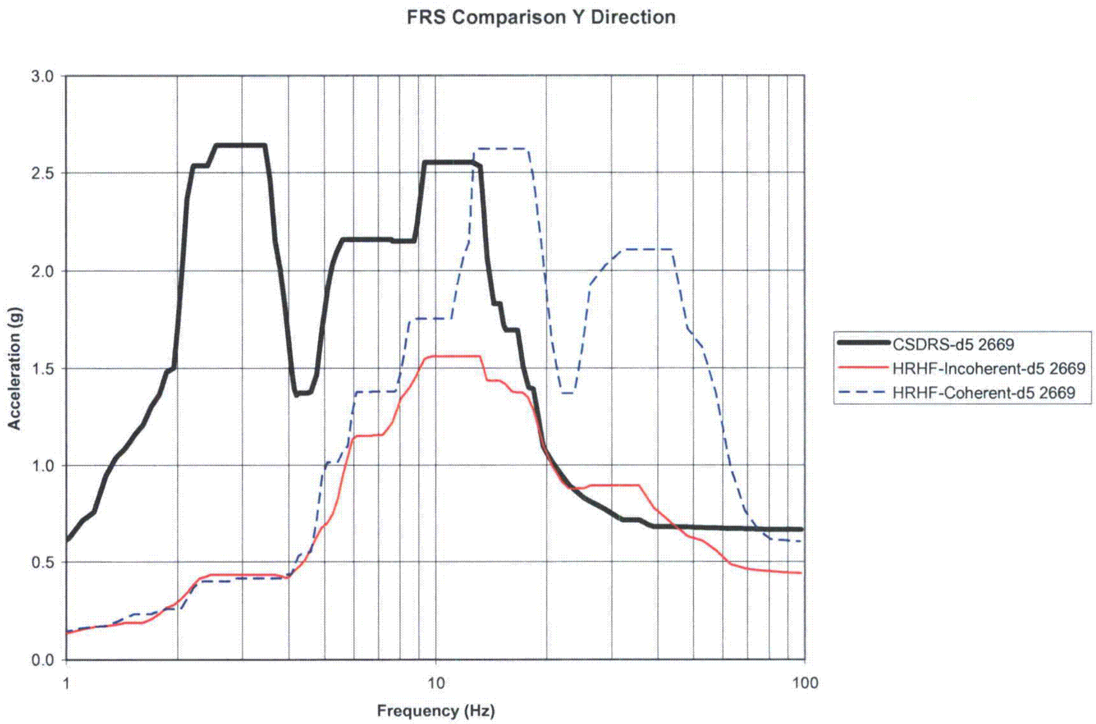
RAI-SRP3.7.1-SEB1-10-11: ASB at Northeast Corner (Elevation 134.5') Y-Direction



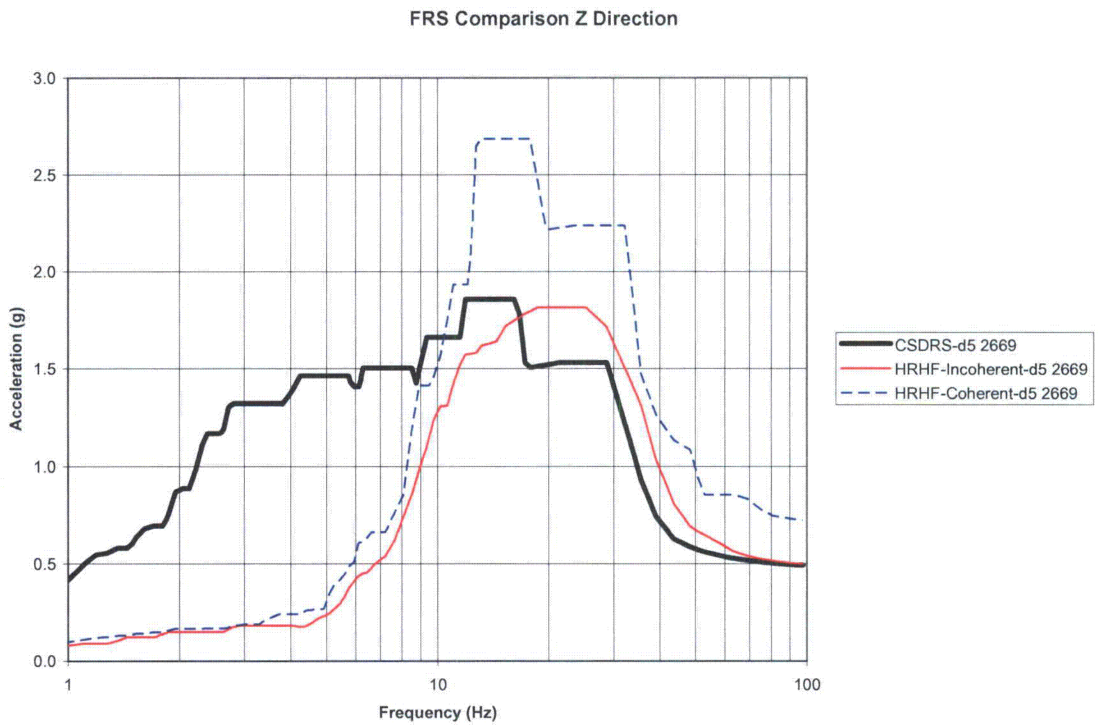
RAI-SRP3.7.1-SEB1-10-12: ASB at Northeast Corner (Elevation 134.5') Z-Direction



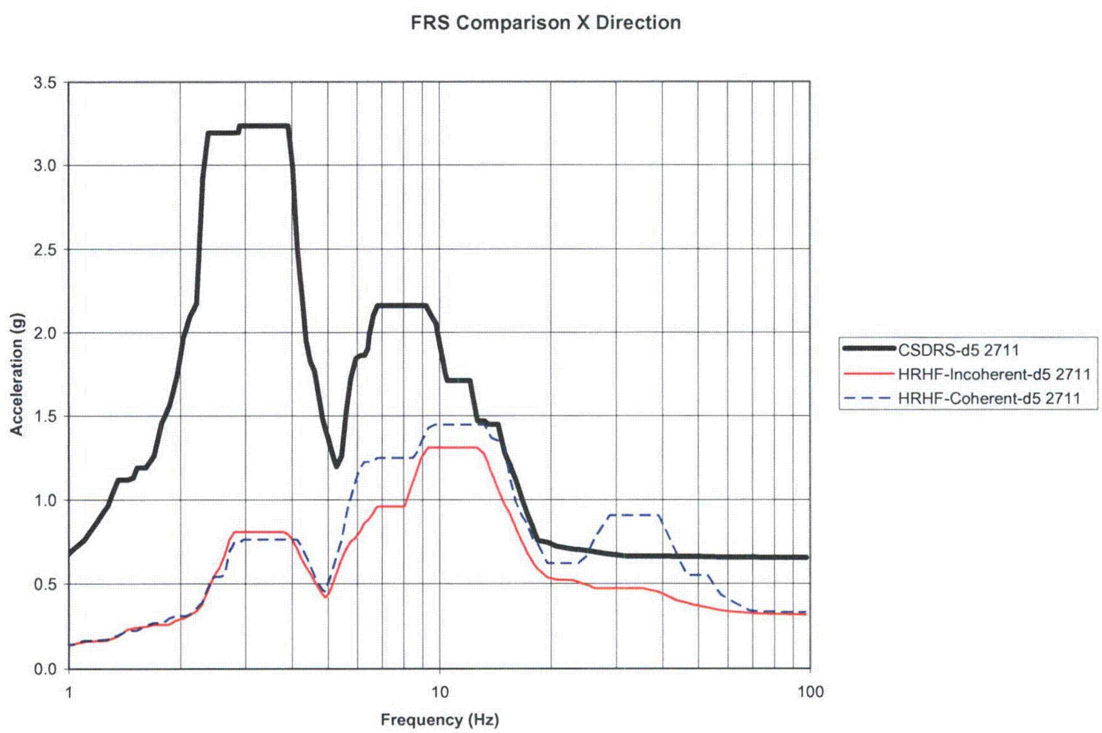
RAI-SRP3.7.1-SEB1-10-13: ASB at Fuel Building Roof (Elevation 179.56') X-Direction



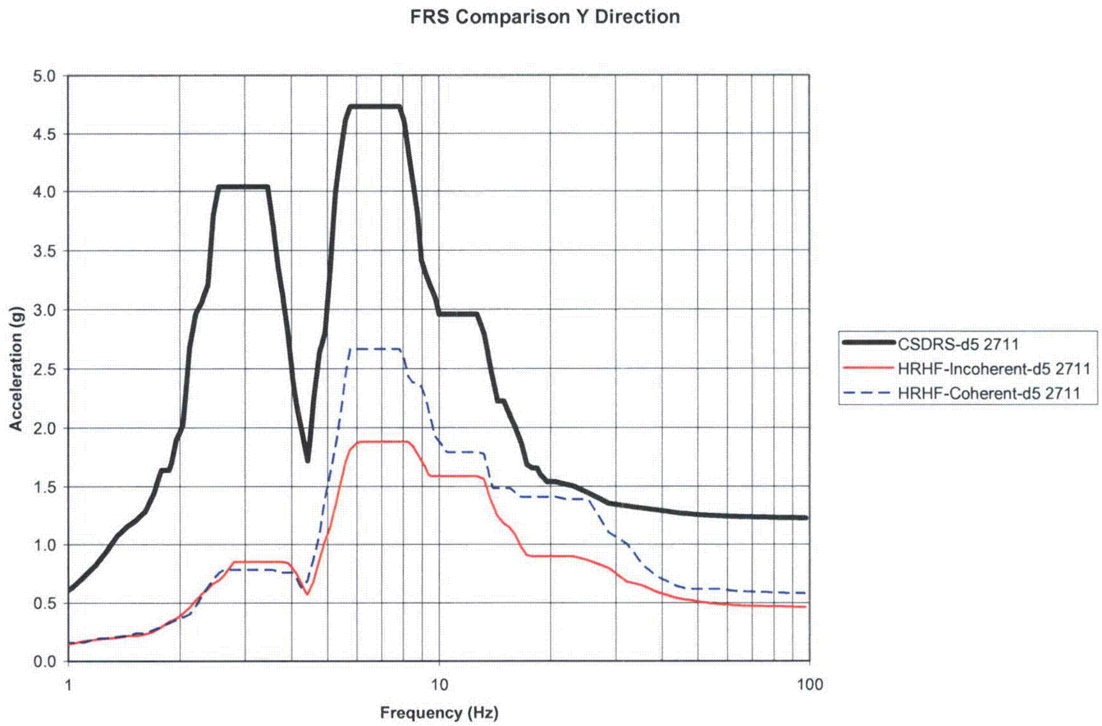
RAI-SRP3.7.1-SEB1-10-14: ASB at Fuel Building Roof (Elevation 179.56') Y-Direction



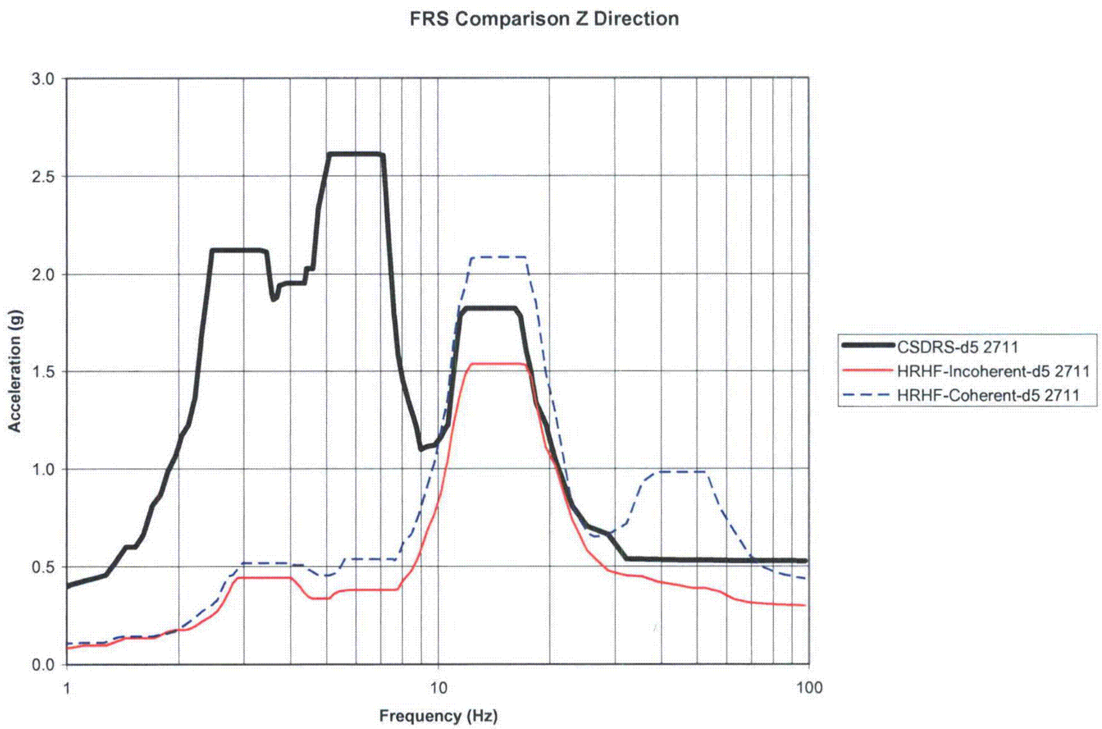
RAI-SRP3.7.1-SEB1-10-15: ASB at Fuel Building Roof (Elevation 179.56') Z-Direction



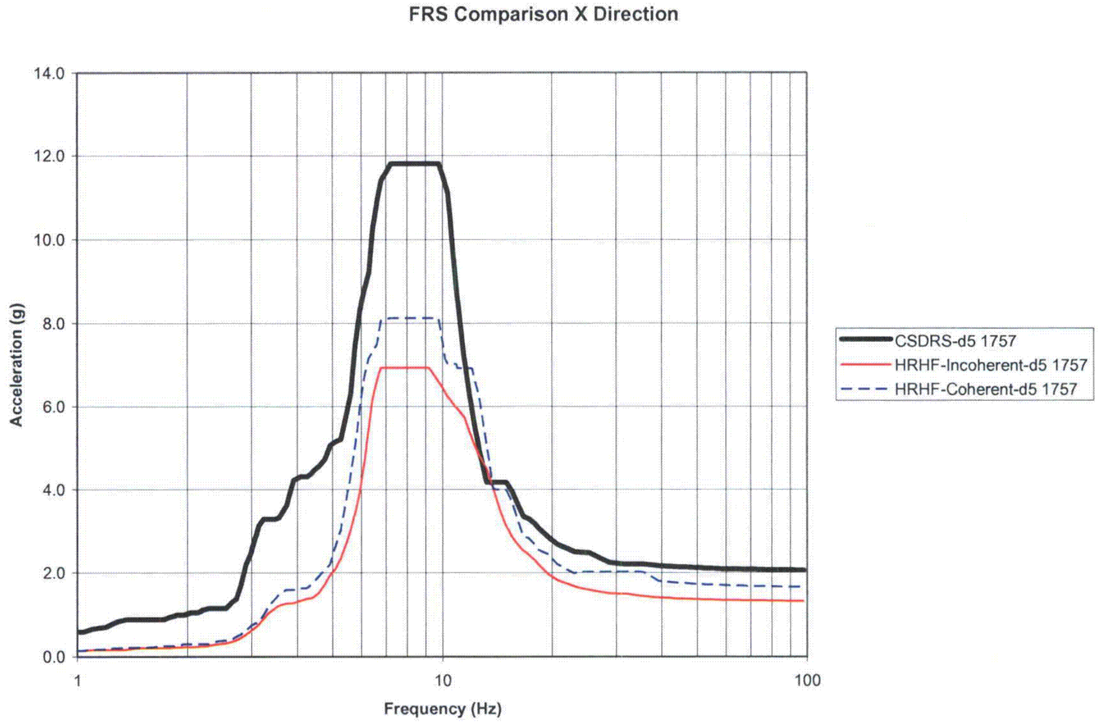
RAI-SRP3.7.1-SEB1-10-16: FRS Nodes – Elevation 180' X-Direction



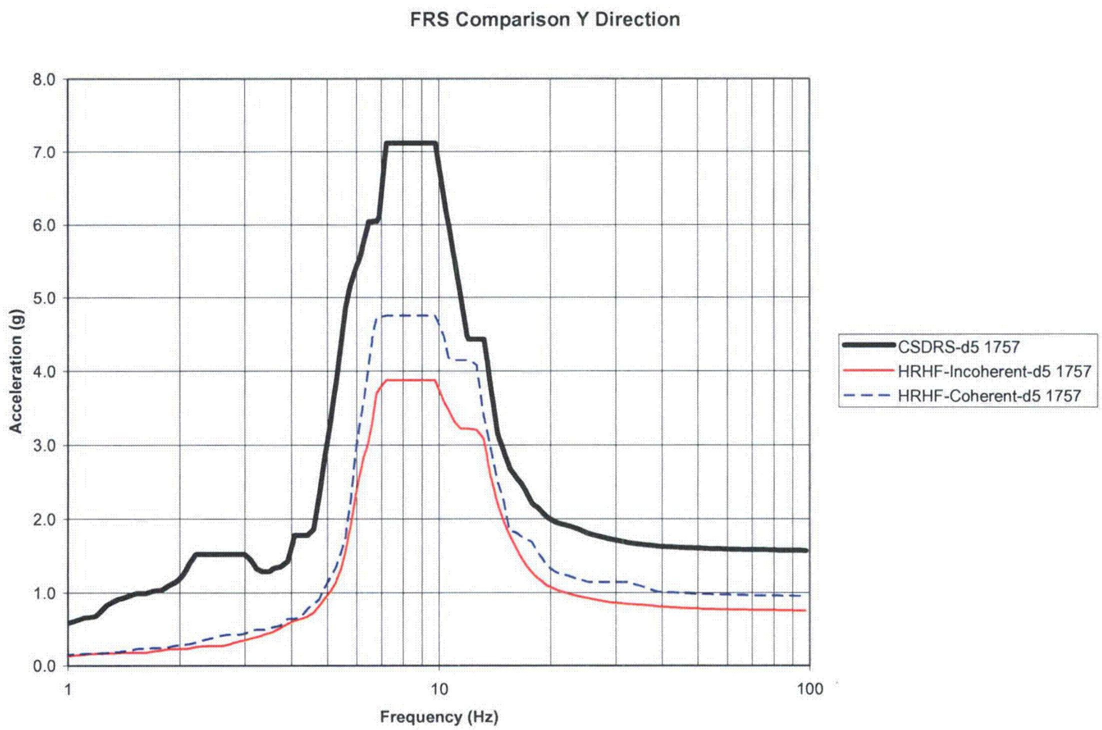
RAI-SRP3.7.1-SEB1-10-17: FRS Nodes – Elevation 180' Y-Direction



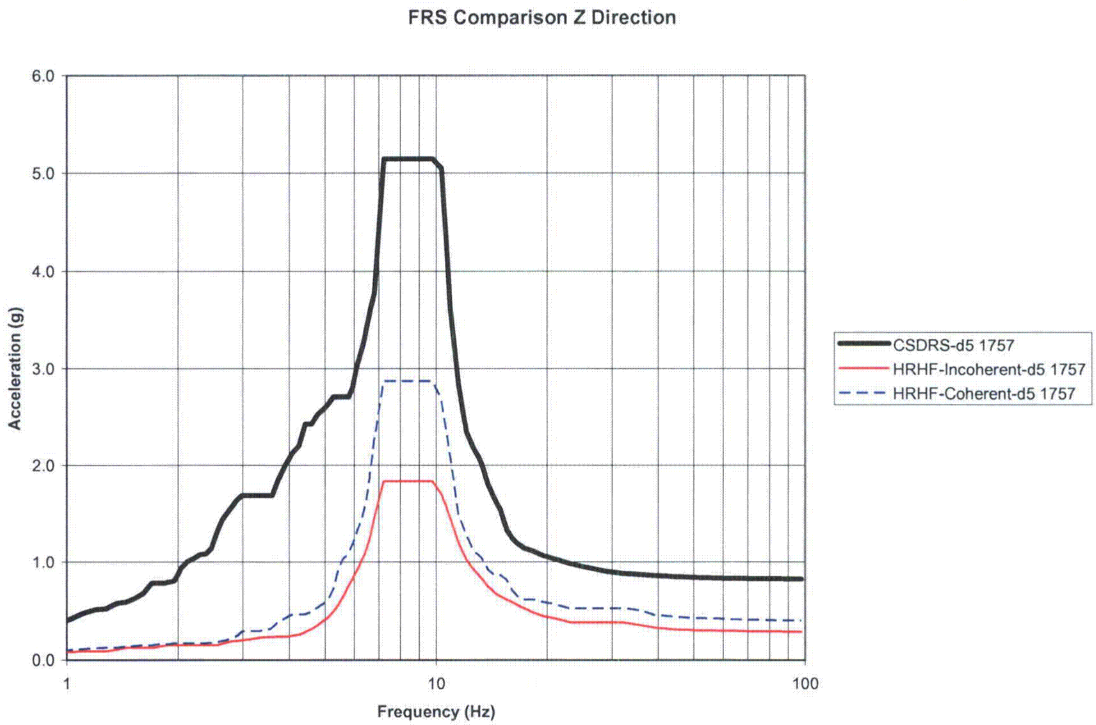
RAI-SRP3.7.1-SEB1-10-18: FRS Nodes – Elevation 180' Z-Direction



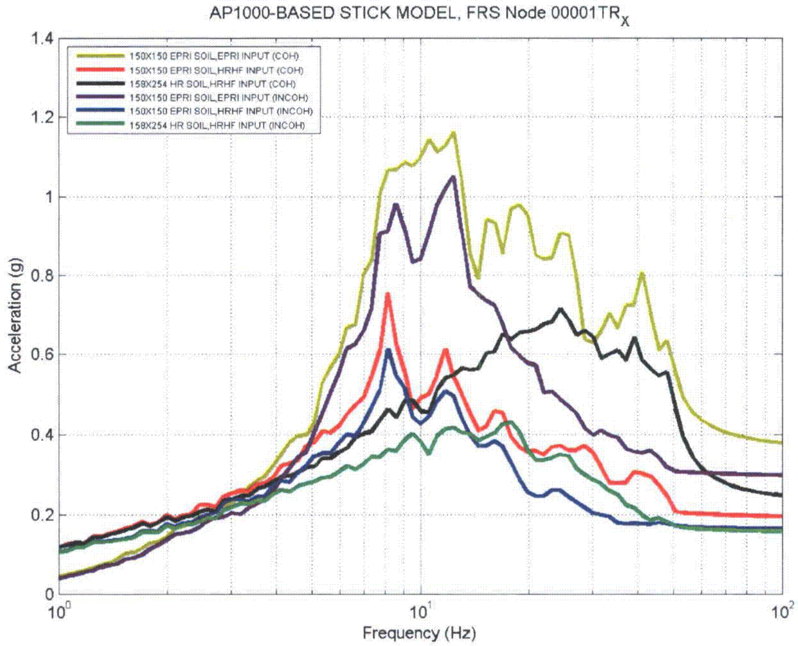
RAI-SRP3.7.1-SEB1-10-19: Reactor Coolant Pump – Elevation 99' X-Direction

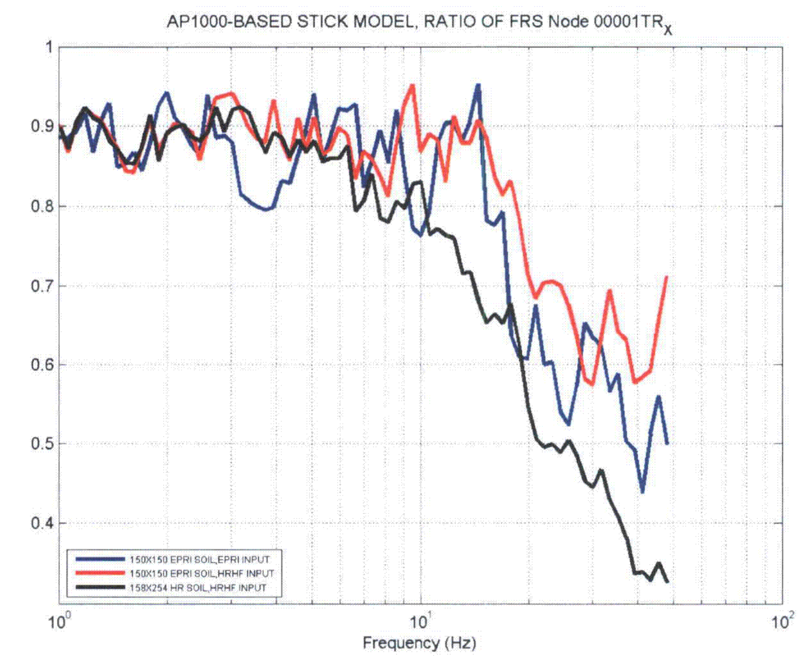


RAI-SRP3.7.1-SEB1-10-20: Reactor Coolant Pump – Elevation 99' Y-Direction

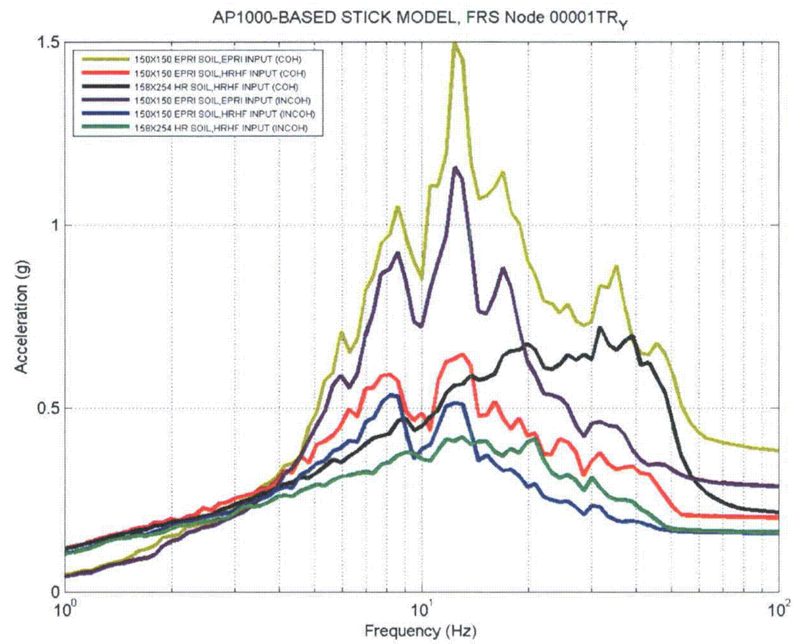


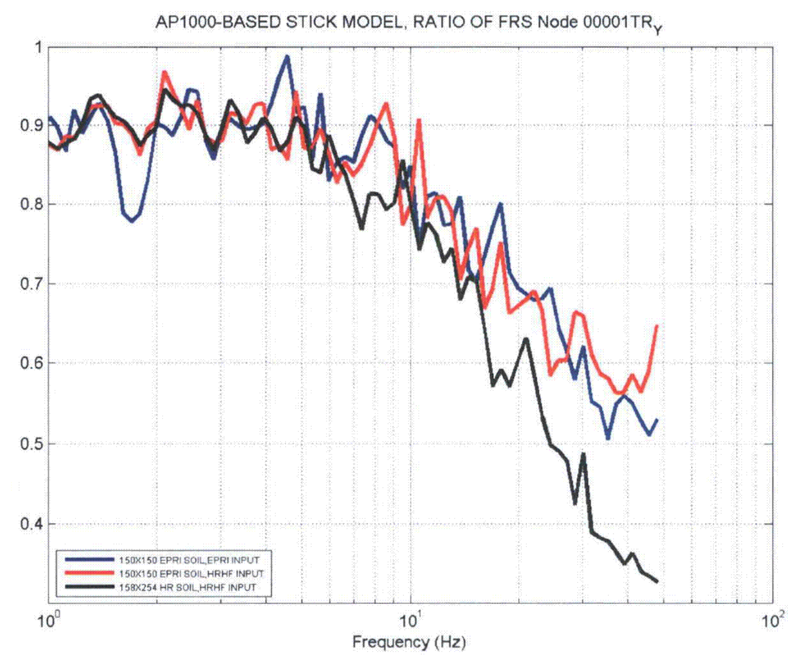
RAI-SRP3.7.1-SEB1-10-21: Reactor Coolant Pump – Elevation 99' Z-Direction



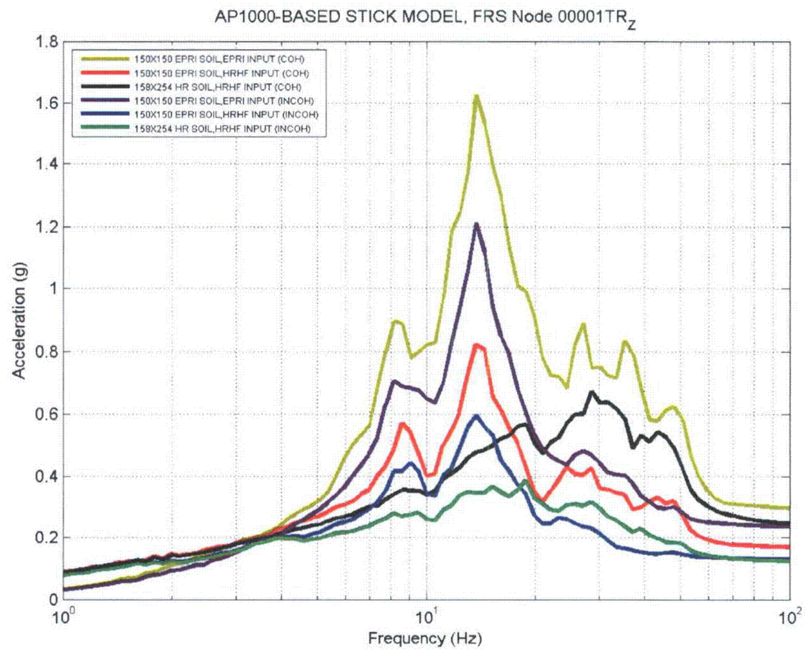


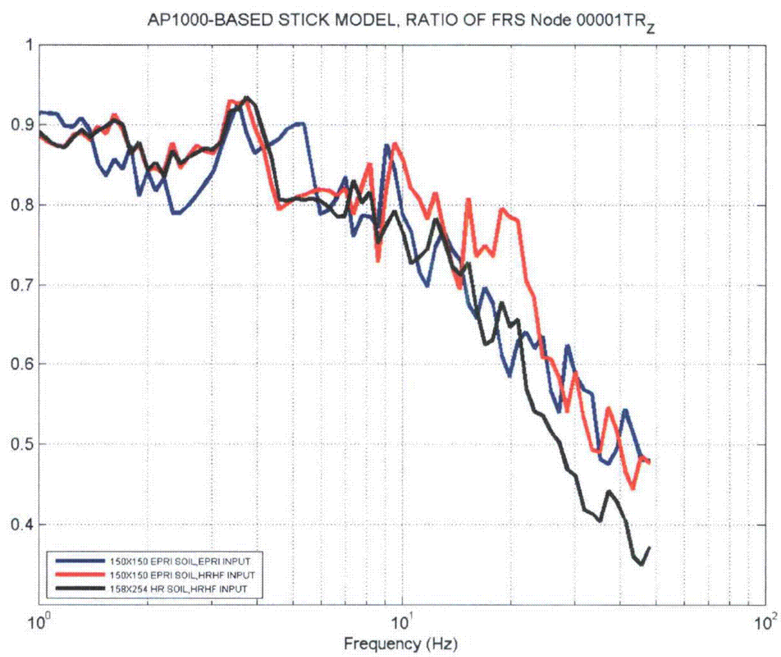
RAI-SRP3.7.1-SEB1-10-22: Foundation of Auxiliary Shield Building – Elevation 60.5' X-Direction



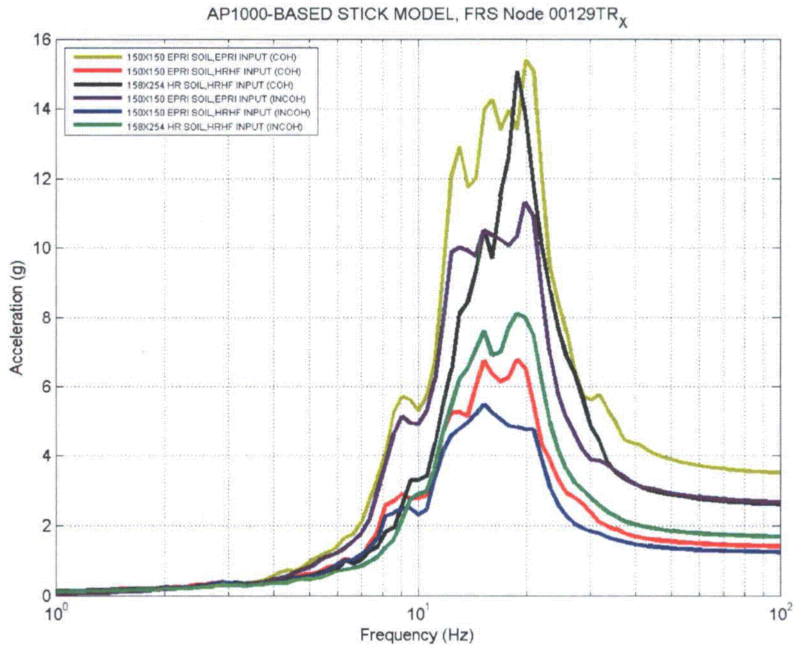


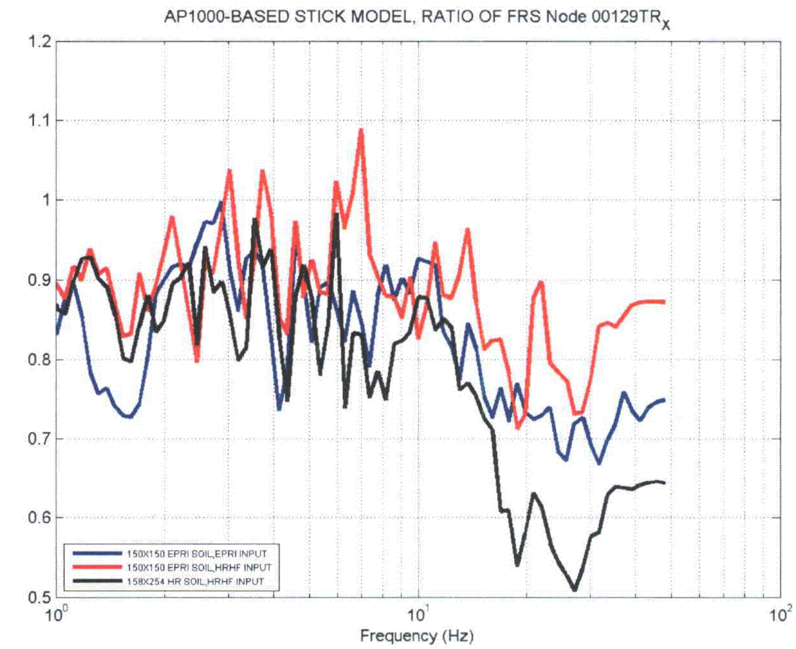
RAI-SRP3.7.1-SEB1-10-23: Foundation of Auxiliary Shield Building – Elevation 60.5' Y-Direction



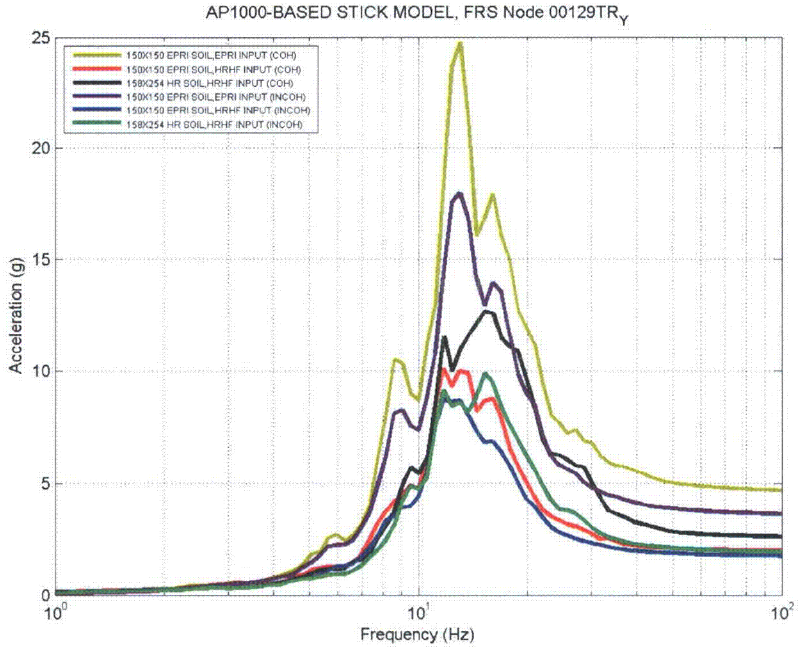


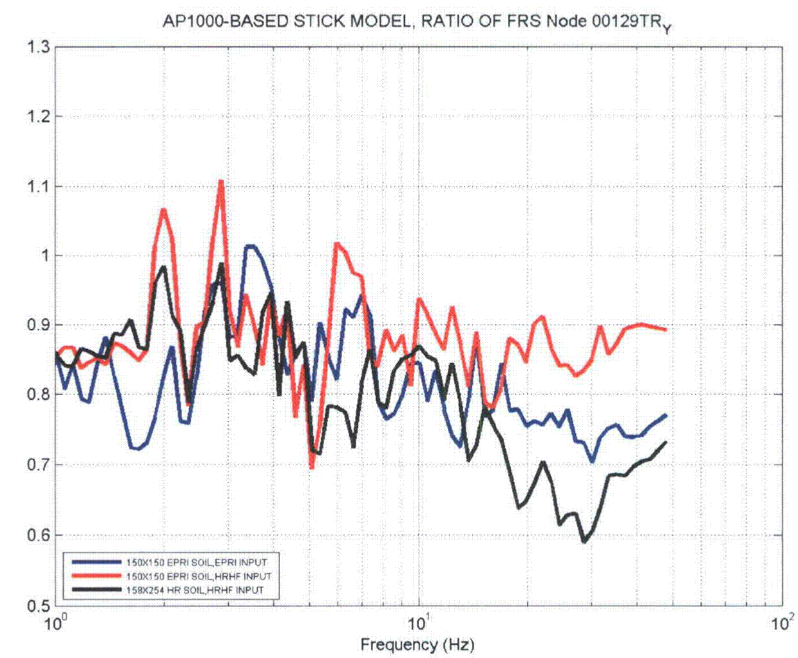
RAI-SRP3.7.1-SEB1-10-24: Foundation of Auxiliary Shield Building – Elevation 60.5' Z-Direction



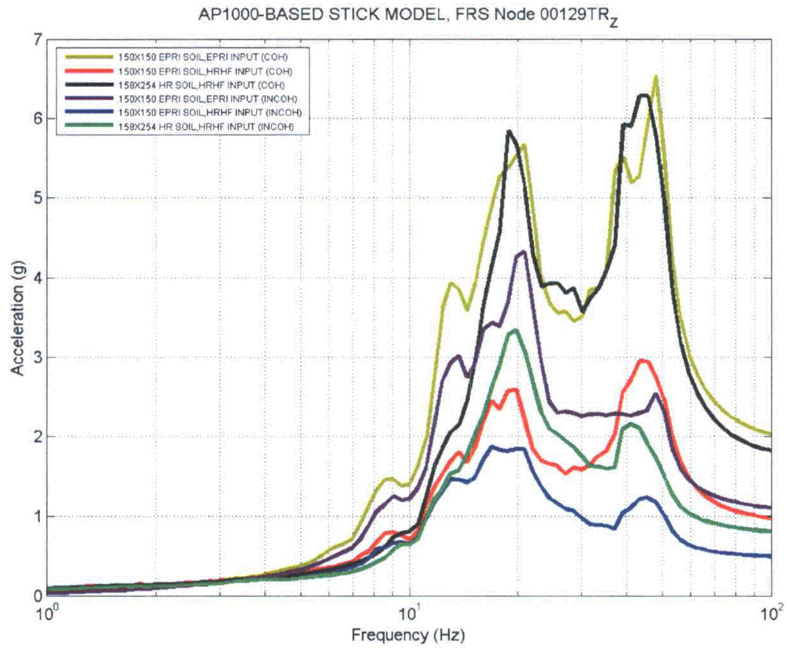


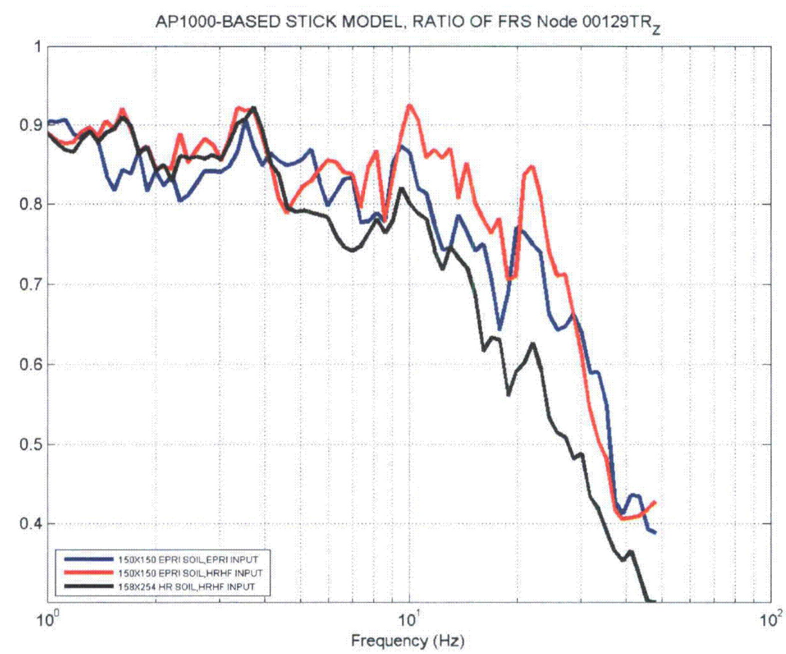
RAI-SRP3.7.1-SEB1-10-25: Top of CIS Mass Center– Elevation 169' X-Direction



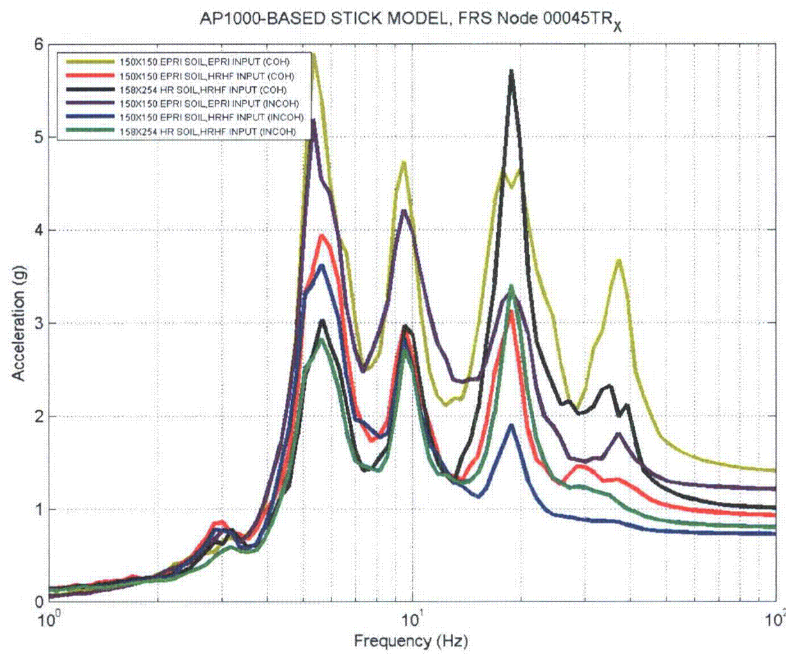


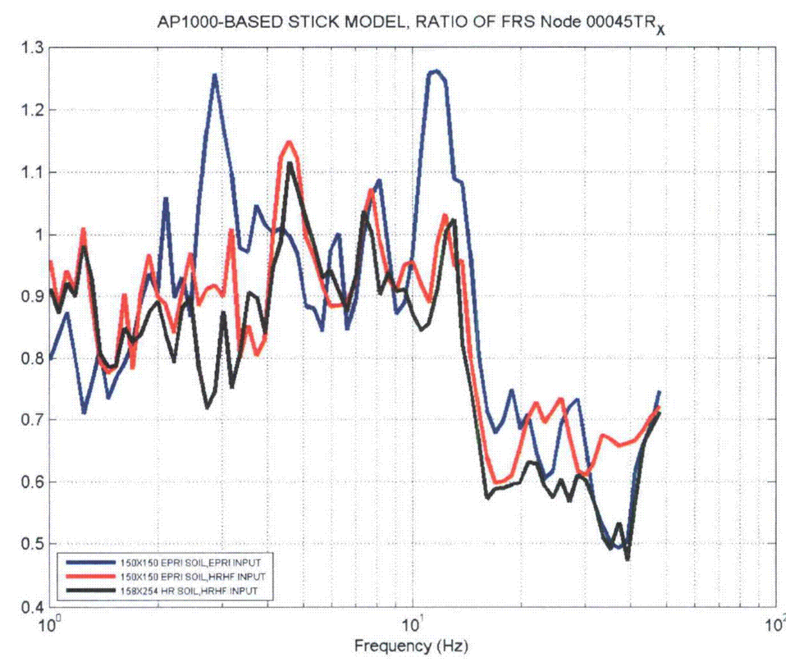
RAI-SRP3.7.1-SEB1-10-26: Top of CIS Mass Center– Elevation 169' Y-Direction



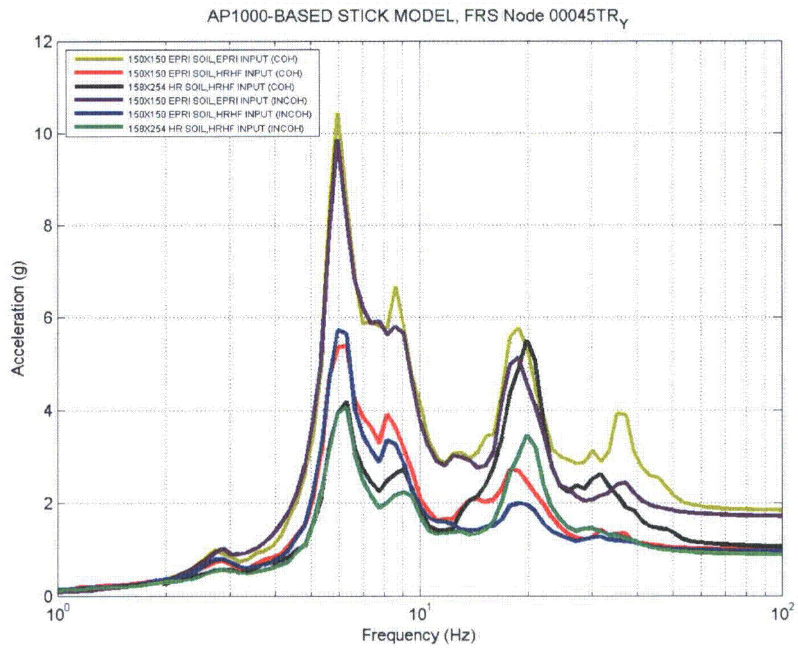


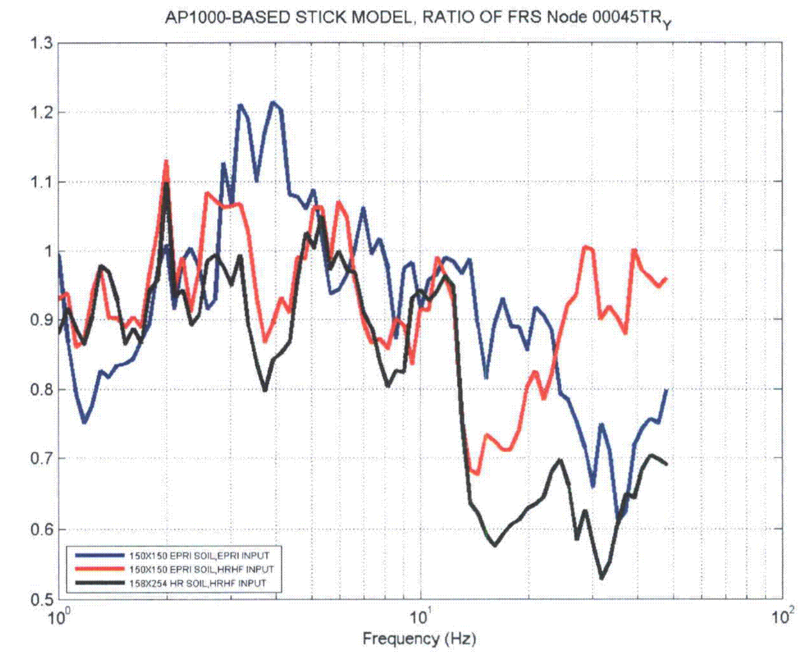
RAI-SRP3.7.1-SEB1-10-27: Top of CIS Mass Center– Elevation 169' Z-Direction



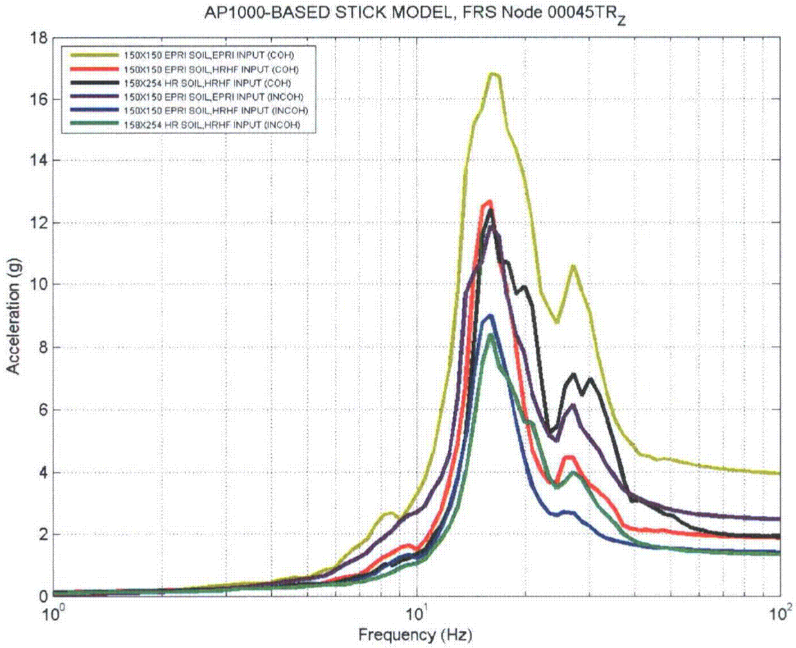


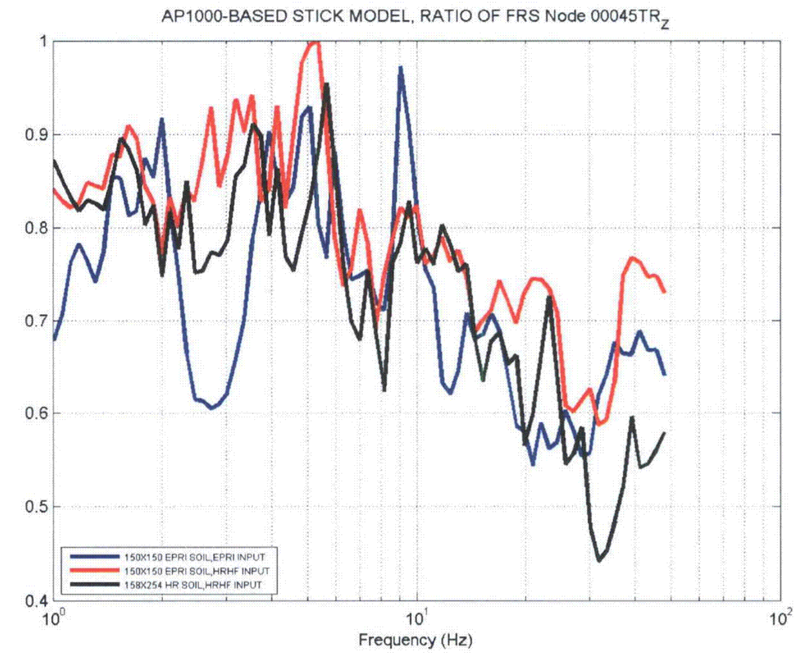
RAI-SRP3.7.1-SEB1-10-28: Top of Steel Containment Vessel – Elevation 281.9' X-Direction



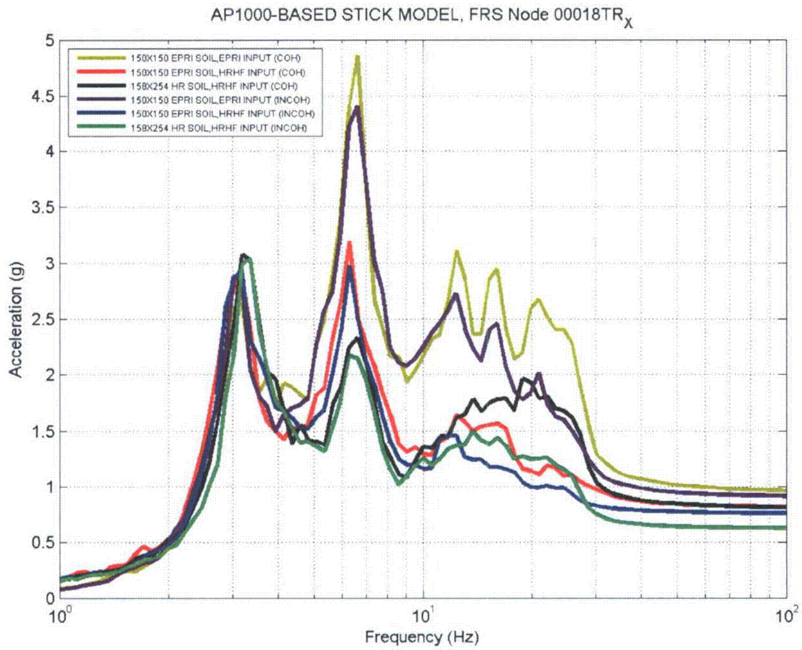


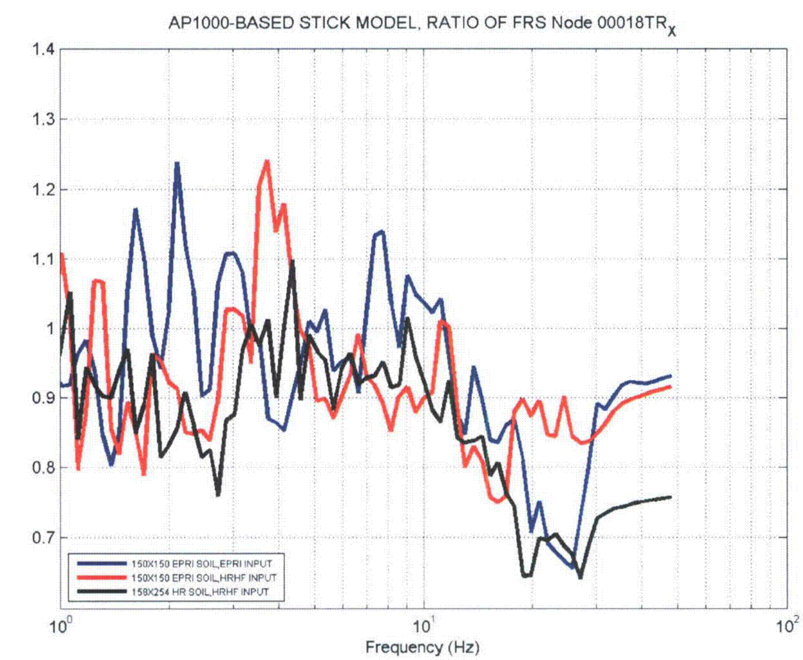
RAI-SRP3.7.1-SEB1-10-29: Top of Steel Containment Vessel – Elevation 281.9' Y-Direction



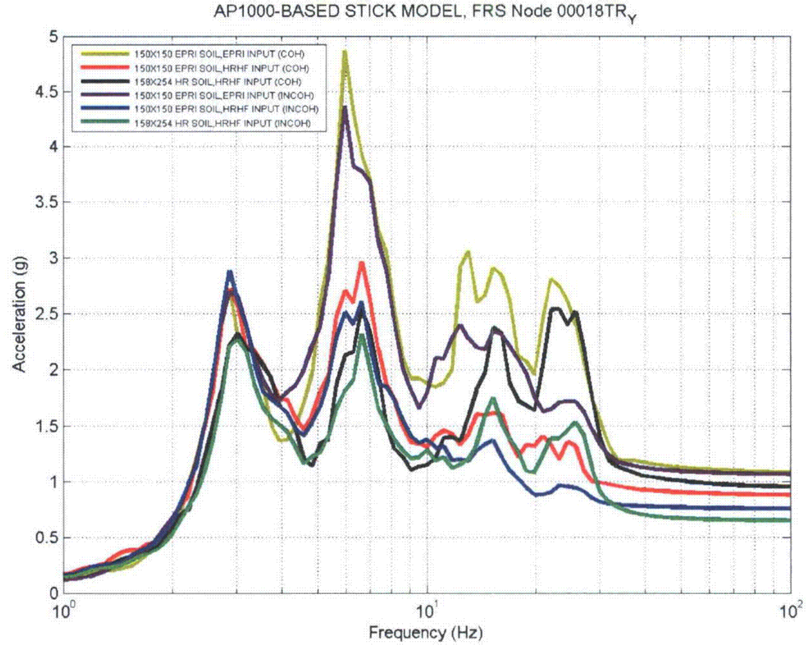


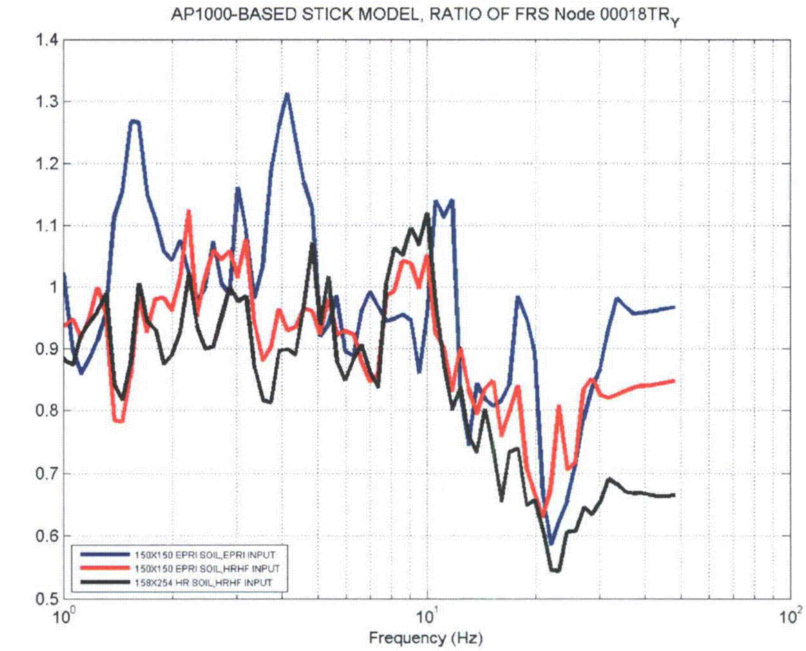
RAI-SRP3.7.1-SEB1-10-30: Top of Steel Containment Vessel – Elevation 281.9' Z-Direction



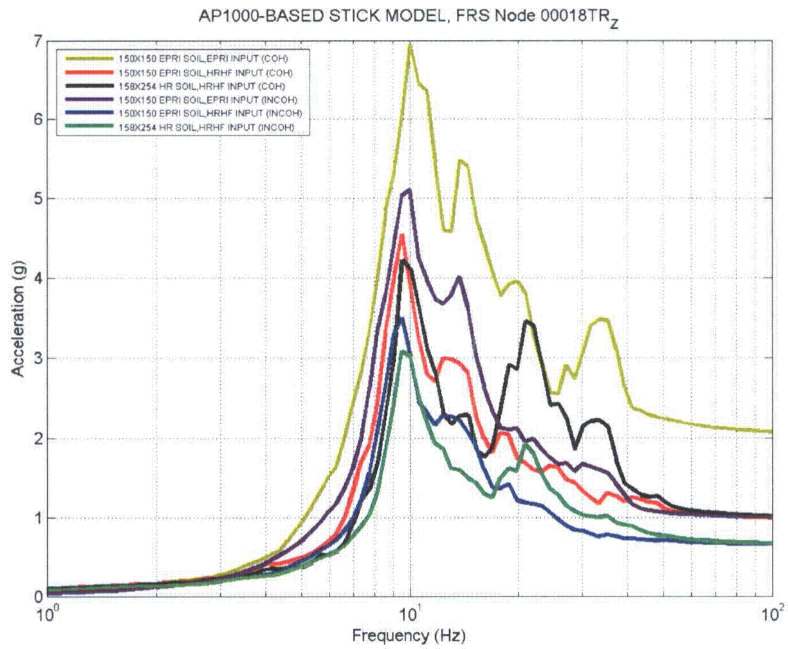


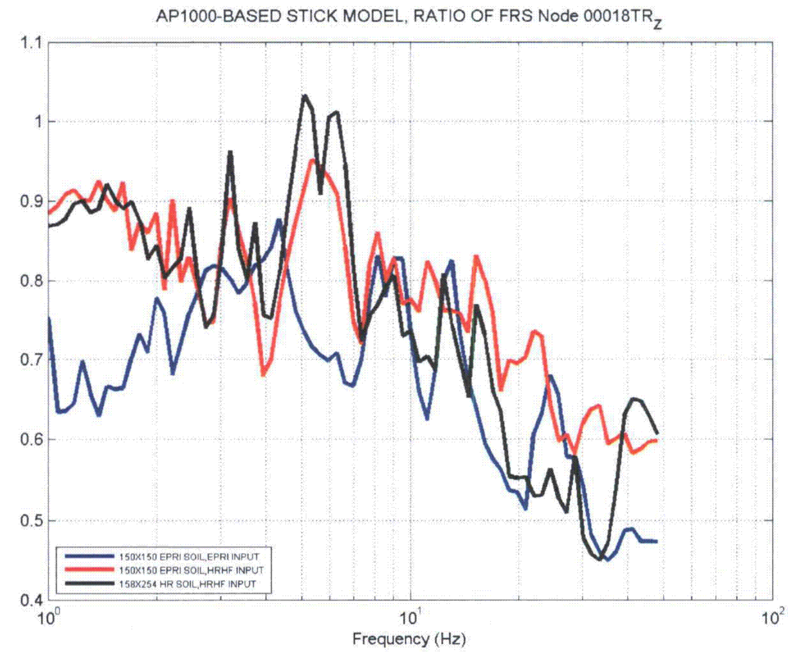
RAI-SRP3.7.1-SEB1-10-31: Top of Shield Building – Elevation 333.3' X-Direction



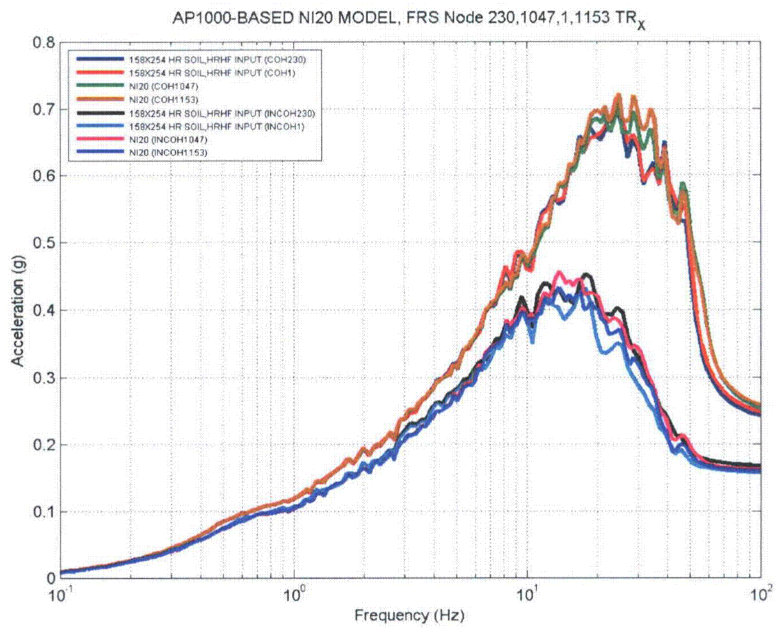


RAI-SRP3.7.1-SEB1-10-32: Top of Shield Building – Elevation 333.3' Y-Direction

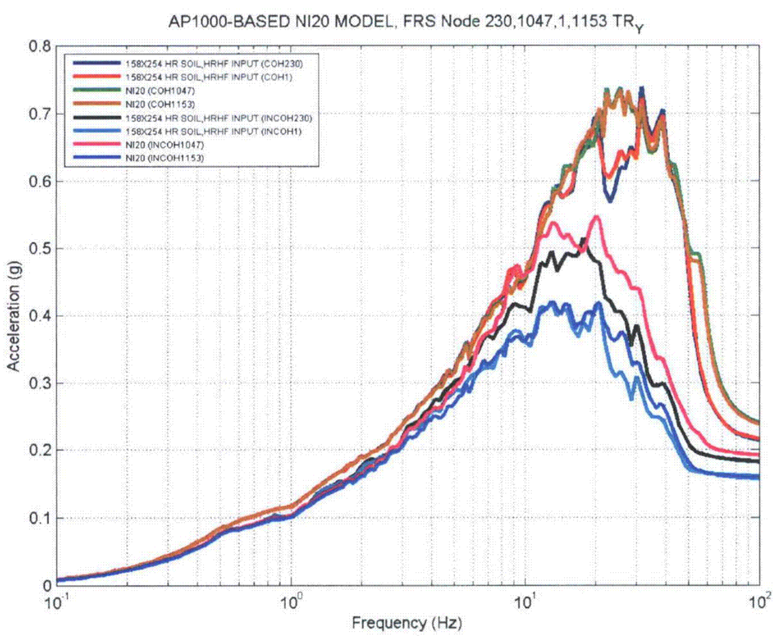




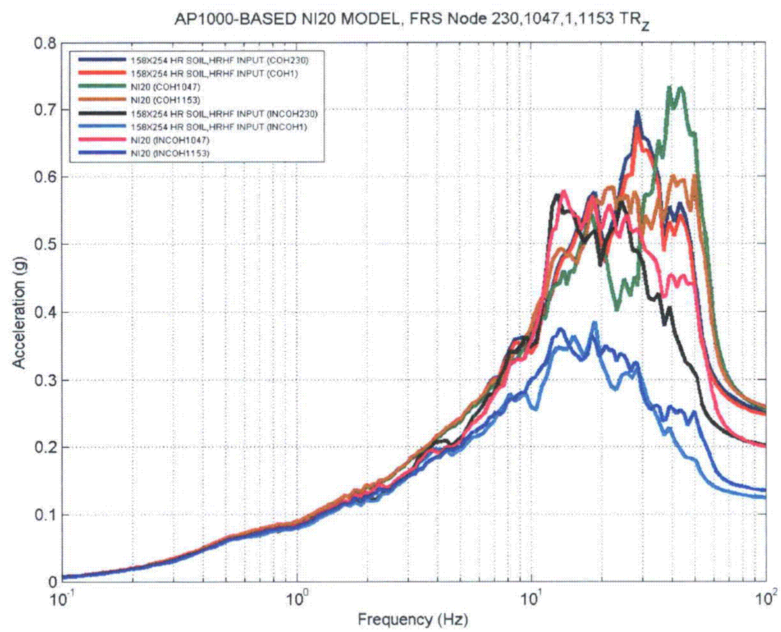
RAI-SRP3.7.1-SEB1-10-33: Top of Shield Building – Elevation 333.3' Z-Direction



RAI-SRP3.7.1-SEB1-10-34: NI20 Basemat – Elevation 60.5' X-Direction



RAI-SRP3.7.1-SEB1-10-35: NI20 Basemat – Elevation 60.5' Y-Direction



RAI-SRP3.7.1-SEB1-10-36: NI20 Basemat – Elevation 60.5' Z-Direction

Reference:

1. Draft EPRI Report, "Hard-Rock Coherency Functions Based on the Pinyon Flat Array Data," July 5, 2007, (ADAMS Accession NO. ML071980104).

Westinghouse Response (Revision 3):

a. The following is an explanation as to why the incoherent response has a significant reduction when compared to the coherent response at low frequencies (below 10 Hz). The incoherent response below 10 Hz as shown in Figures RAI-SRP3.7.1-SEB1-10-1 to 3, 10-16 to 17, and 10-19 to 21 show significant reduction compared to the coherent response. Node 3329 shows a 26%, 36% and 33% reduction in X, Y and Z direction, respectively. Node 2711 shows a 31% and 30% reduction in X and Y direction, respectively. Node 1757 shows a 12%, 19% and 28% reduction in X, Y and Z direction, respectively. The incoherent runs are based on the 2007 Abrahamson coherency function shown in Figure RAI-SRP3.7.1-SEB1-10-37. The average reduction between 6 to 9 Hz is up to 20% for horizontal and up to 30% for vertical direction.

   This reduction of incoherent Floor Response Spectra (FRS) in the 6 to 9 Hz range is a cumulative effect of two reductions due to the incoherency effects and the sharp peak clipping from statistical averaging. The sharp peaks are smoothed by averaging the 25 incoherent FRS curves. The reduction due to incoherency is expected based on the 2007 Abrahamson coherency function for hard-rock. It is noted that the 2007 Abrahamson coherency function shows a smaller reduction when compared to the 2005 coherency function which the EPRI report is based on. The HRHF incoherent analysis shows a consistent reduction as shown in the approved EPRI technical report (Reference 1).

   The EPRI report TR-1015111 "Program on Technical Innovation: Validation of CLASSI and SASSI Code to treat Seismic Wave Incoherence in Soil-Structure Interaction (SSI) Analysis of Nuclear Power Plant (NPP) Structure" (Reference 2) shows the similar reduction. Figure RAI-SRP3.7.1-SEB1-10-38 from the EPRI report shows the incoherent response reduction of node 118 in the horizontal direction. Node 118 in the X Direction shows coherent 5.2g versus incoherent 4.4g between 6-7 Hz, a 15% reduction. Node 118 in the Y Direction shows coherent 5.7g versus incoherent 4.1g between 6-7 Hz, a 28% reduction. Figure RAI-SRP3.7.1-SEB1-10-39 and 40 from the EPRI report show the incoherent response reduction of node 1 and Node 129 in the vertical direction. Node 1 in the Z Direction shows coherent at 0.9g versus incoherent at 0.63g between 8-9 Hz, a 30% reduction and Node 129 in the Z Direction shows coherent at 2.0g versus incoherent at 1.1g between 8-9 Hz, a 45% reduction.

b. The interpolation function for the NI20 SASSI model was reviewed. In ACS SASSI for the numerical simulations of incoherent motions, an arbitrary set of random phase angles are used in conjunction with the spectral factorization of the coherency matrix at each frequency, from the first frequency to the highest frequency selected. Due to the simulation of the set of random phases at each frequency, each simulation has a different transfer function phase angle that is the same at all interaction nodes. At the first frequency, there is no difference between coherent and incoherent motions since the transfer function amplitudes are constant and equal to 1.00 at all nodes. The ground motion is a static translation with the same amplitude in space in the given input direction (e.g., no phase angle variations occur). The arbitrary values of the random phase angles at first frequency does not affect the Fourier transform calculations or any physics of the seismic incoherent SSI analysis, as long as these phase angle values are the same at all interaction nodes, so that there is no relative phase angle variations between different nodal motions.

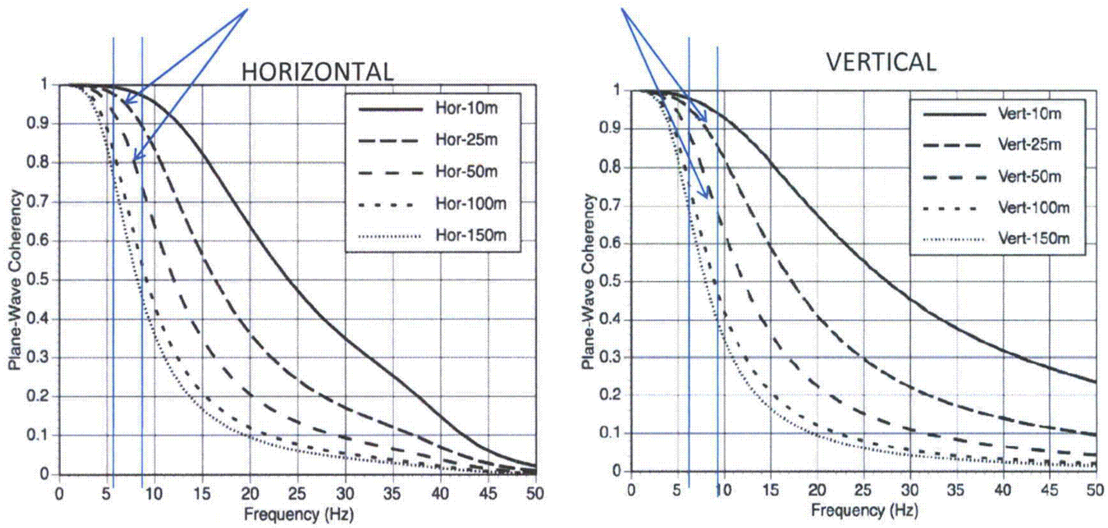
   The HRHF tape 8 submitted has been verified and the transfer function amplitude of 1.0 is for all nodes.

The reanalysis of the seismic response to correct or clarify the values is not required. The reanalysis is not required based on the EPRI technical report and the Abrahamson coherency function. The EPRI report TR-1015111 "Program on Technical Innovation: Validation of CLASSI and SASSI Code to treat Seismic Wave Incoherence in Soil-Structure Interaction (SSI) Analysis of Nuclear Power Plant (NPP) Structure" is referenced in the Office of New Reactors "Transmittal of Final Interim Staff Guidance – Notice of Availability of the Final Interim Staff Guidance DC/COL-ISG-01 on Seismic Issues Associated with High Frequency Ground Motion" document. The guidance indicates that the use of the SASSI incoherency approach is considered acceptable for treatment of random phasing effects. This EPRI report shows the similar incoherent response reduction. In addition, the reduction due to incoherency is expected based on the 2007 Abrahamson coherency function for hard-rock. It is noted that the 2007 Abrahamson coherency function shows a smaller reduction when compared to the 2005 coherency function which the EPRI report is based on.

Reference:

2. "Program on Technical Innovation: Validation of CLASSI and SASSI Code to treat Seismic Wave Incoherence in Soil-Structure Interaction (SSI) Analysis of Nuclear Power Plant Structure", EPRI report TR-1015111, Final Report, November 2007.

2007 ABRAHAMSON COHERENCY



RAI-SRP3.7.1-SEB1-10-37: The 2007 Abrahamson coherency function

CLASSI and SASSI In-Structure Response Spectra Comparisons

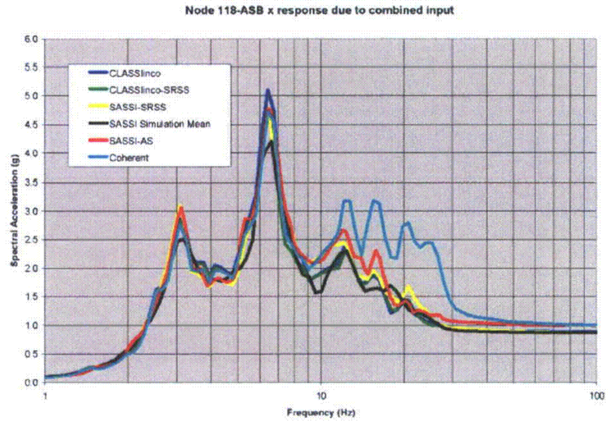


Figure 5-11
ASB Outrigger Response Spectra – X Direction – CLASSIinco, CLASSIinco-SRSS, SASSI-SRSS, SASSI Simulation Mean, SASSI-AS (Node 118)

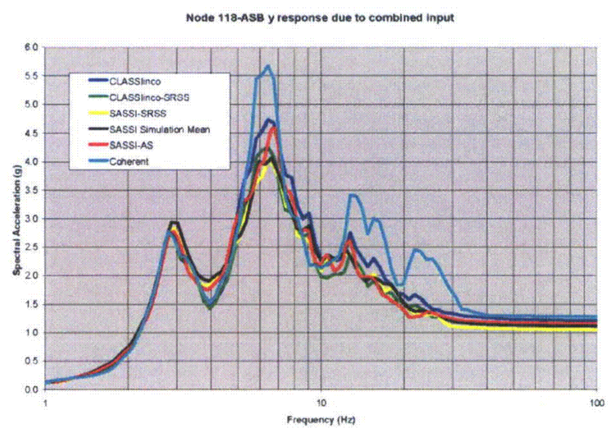


Figure 5-12
ASB Outrigger Response Spectra – Y Direction Due – CLASSIinco, CLASSIinco-SRSS, SASSI-SRSS, SASSI Simulation Mean, SASSI-AS (Node 118)

5-10

RAI-SRP3.7.1-SEB1-10-38: EPRI TR- 1015111 Node 118

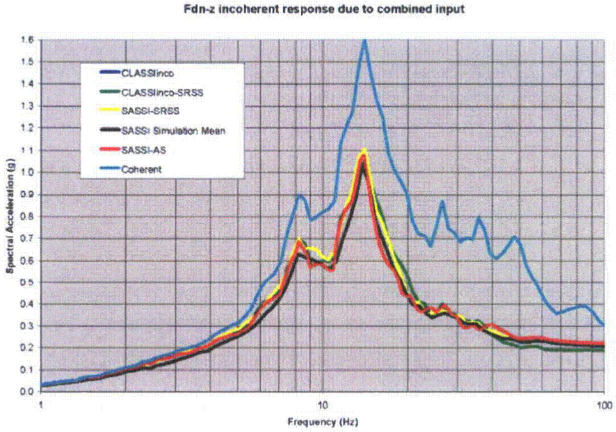


Figure 5-4
Center of Foundation Response Spectra – Z Direction – CLASSIinco, CLASSIinco-SRSS, SASSI-SRSS, SASSI Simulation Mean, SASSI-AS (Node 1)

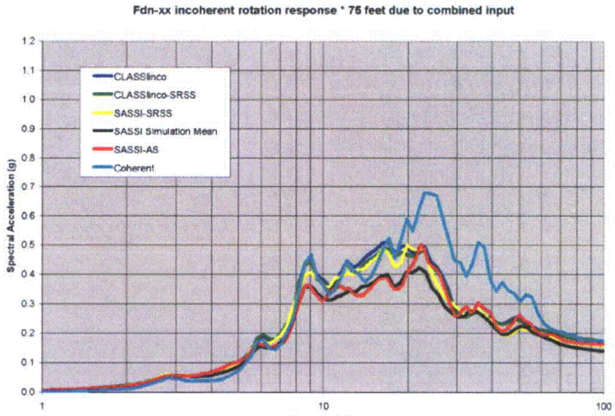


Figure 5-5
Edge of Foundation Response Spectra –XX Rotation – CLASSIinco, CLASSIinco-SRSS, SASSI-SRSS, SASSI Simulation Mean, SASSI-AS (Node 1)

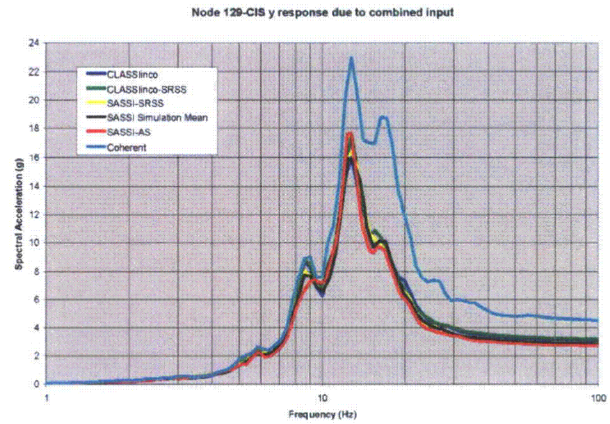


Figure 5-18
Top of CIS Horizontal Mass Center Response Spectra – Y Direction – CLASSIinco, CLASSIinco-SRSS, SASSI-SRSS, SASSI Simulation Mean, SASSI-AS (Node 129)

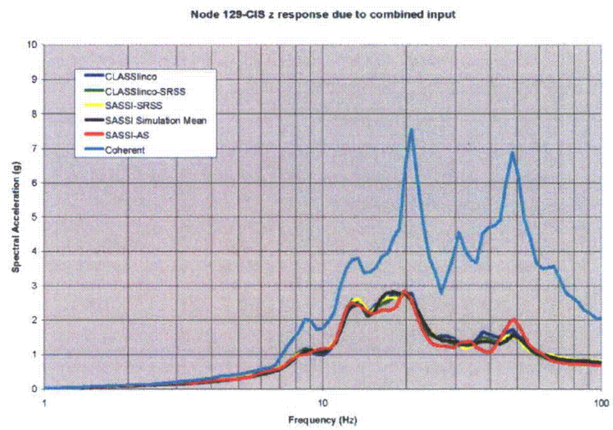


Figure 5-19
Top of CIS Horizontal Mass Center Response Spectra – Z Direction – CLASSIinco, CLASSIinco-SRSS, SASSI-SRSS, SASSI Simulation Mean, SASSI-AS (Node 129)

Design Control Document (DCD) Revision: None

PRA Revision: None

Technical Report (TR) Revision: The Figure RAI-SRP3.7.1-SEB1-10-1 to RAI-SRP3.7.1-SEB1-10-21 will replace Figure 5.2-1 through 5.2-6 in TR-115. See also RAI-SRP3.7.1-SEB1-11 for changes to Section 5.2.

5.2 Comparison of CSDRS and HRHF Response Spectra

To show the significance of the HRHF response spectra, the CSDRS and HRHF seismic responses are compared. Figures 5.2-1 through 5.2-6 (5% damping) compare the response spectra with coherent and incoherent considerations at a number of locations in the nuclear island. There are some exceedances, mostly above the 15 Hz region. These curves are typical of the plant comparative responses found throughout the plant.