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MFN 06-274 Supplement 2

Docket No. 52-010

November 21, 2007

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

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 109 – Related to ESBWR Design Certification Application – RAI Number 3.7-16 Supplement 2**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by the Reference 1 NRC letter. GEH response to RAI Number 3.7-16 Supplement 2 is addressed in Enclosure 1.

If you have any questions or require additional information, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Vice President, ESBWR Licensing

D068
NRO

Reference:

1. MFN 07-555, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 109 Related to the ESBWR Design Certification Application*, October 12, 2007.

Enclosure:

1. MFN 06-274 Supplement 2 – Response to Portion of NRC Request for Additional Information Letter No. 100 – Related to ESBWR Design Certification Application – RAI Number 3.7-16 S02

cc:	AE Cubbage	USNRC (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	eDRF	0000-0075-4267

ENCLOSURE 1

MFN 06-274, SUPPLEMENT 2

Partial Response to NRC RAI Letter No. 109
Related to ESBWR Design Certification Application[1]

RAI Number 3.7-16 S02

[1] Original Response and Supplement 1 previously submitted under MFNs 06-274 and 06-274S1 are included to provide historical continuity during review.

NRC RAI 3.7-16

In DCD Section 3.7.2.1.1, the applicant presents the formulation of the equations of motion in terms of undamped eigenvalues and mode shapes, with solutions obtained by integration in the time domain. The applicant is requested to address the limitations of this formulation, particularly for the case of frequency-dependent SSI stiffness and damping coefficients.

GEH Response

As stated in DCD Section 3A.5, the base spring is evaluated from vibration admittance theory, based on three dimensional wave propagation theory for uniform half space soil. Though the spring values consist of frequency dependent real and imaginary parts, they are simplified and replaced with frequency-independent soil spring Kc, and damping coefficient Cc, respectively, for the time history analysis solved in the time domain.

The sites considered in the seismic analysis of the ESBWR standard plant cover a wide range of uniform soil/rock sites. For uniform sites the use of frequency-independent soil properties in the formulation is an acceptable approach in accordance with guidance of ASCE 4-98, Section 3.3.4.2.2.

The effects of frequency-dependent SSI stiffness and damping coefficients are evaluated for additional layered sites. See response to RAI 3.7-30 for details.

DCD Impact

No DCD change was made in response to this RAI.

NRC RAI 3.7-16, Supplement 1

NRC Assessment Following the November 2, 2006 Audit

a. *NRC staff consultants (BNL) to compare the results of their confirmatory analysis at the top of the CB and the top of basemat against the GE design spectra.*

b. *Provide for the RB, a smooth plot of the transfer functions at the top of the building, top of the basemat and at the top of the four corners of the embedded walls.*

GEH Response

a. GE design spectra at the top of the CB and at the top of basemat were provided to NRC/BNL at the November 2, 2006 audit by GE.

b. For the RB, the SASSI transfer functions were provided as follows:

Figures 3.7-16(1) through 3.7-16(3) show the original transfer functions at the top of the RBFB building, top of basemat, and at the four corners at the top of the embedded walls, in X, Y and Z directions respectively. The soil condition is the layered site case 1 shown in the response to RAI 3.7-30 provided under MFN 06-274.

By adding more frequency points near the spikes, all the spikes were eliminated except for the peak at 7.8 Hz in Y direction as shown in Figures 3.7-16(4) through 3.7-16(6).

Adding frequencies near the peak at 7.8 Hz in Y direction actually increases the peak amplitude as shown in Figure 3.7-16(5). A careful examination of the model did not reveal any problems associated with connectivities. The cause of the spike anomaly in the transfer function is related to differences in the calculation of the deconvolution and amplification of motion by SASSI, in which deconvolution process of the free field is performed by a methodology that is slightly different than the finite element methodology used to develop the structural response. This difference shows up in this case as a discontinuity in the transfer functions and has little impact on the response spectra.

Figures 3.7-16(7) through 3.7-16(9) show FRS at the top of the RBFB and the top of basemat, for X, Y and Z direction respectively. They are calculated from the both original and refined transfer functions and compared with the design basis FRS. The differences in FRS between the original and refined transfer functions are not significant, and the both FRS are bounded by the design basis FRS.

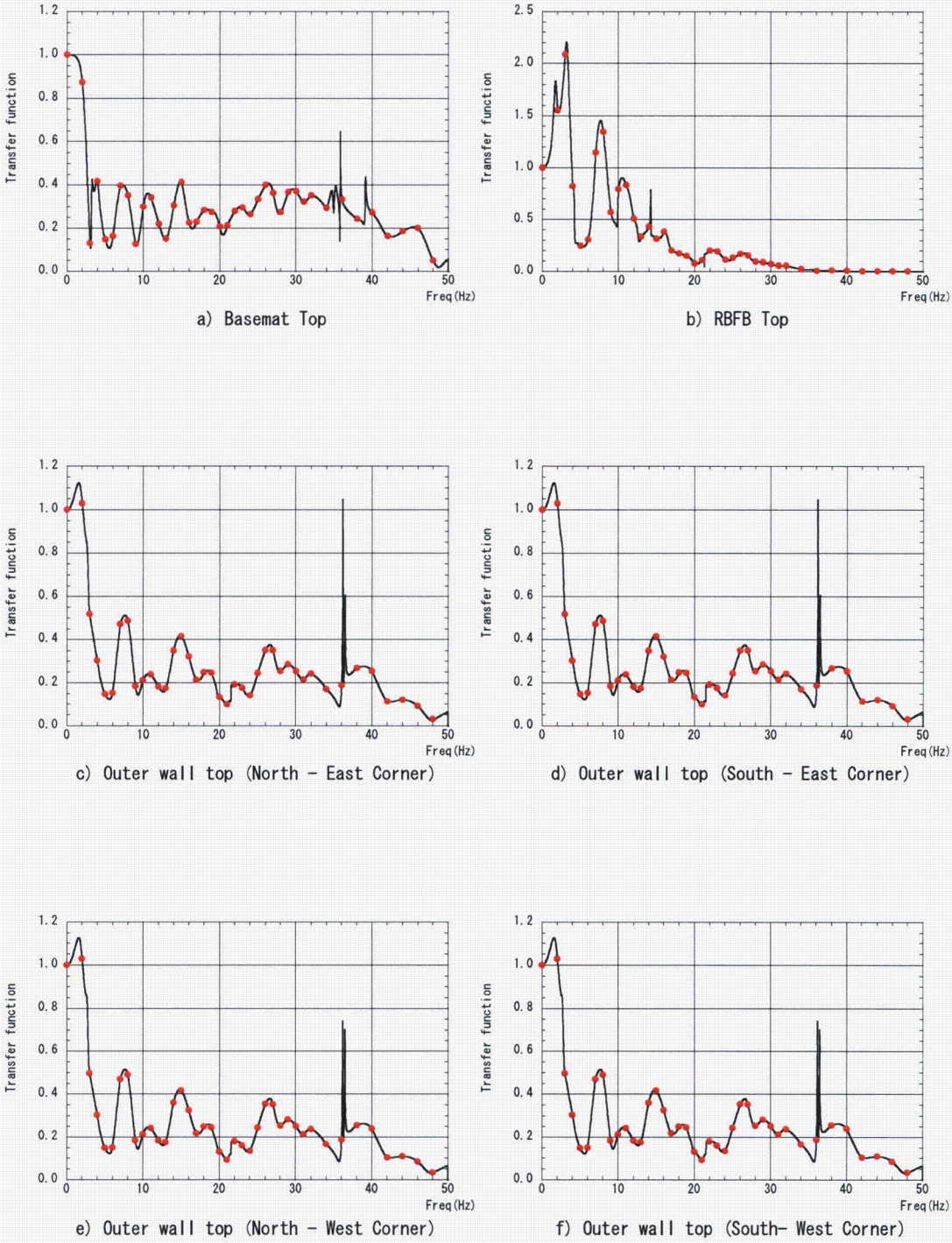


Figure 3.7-16(1) Original Transfer Function for RBFB in X Direction

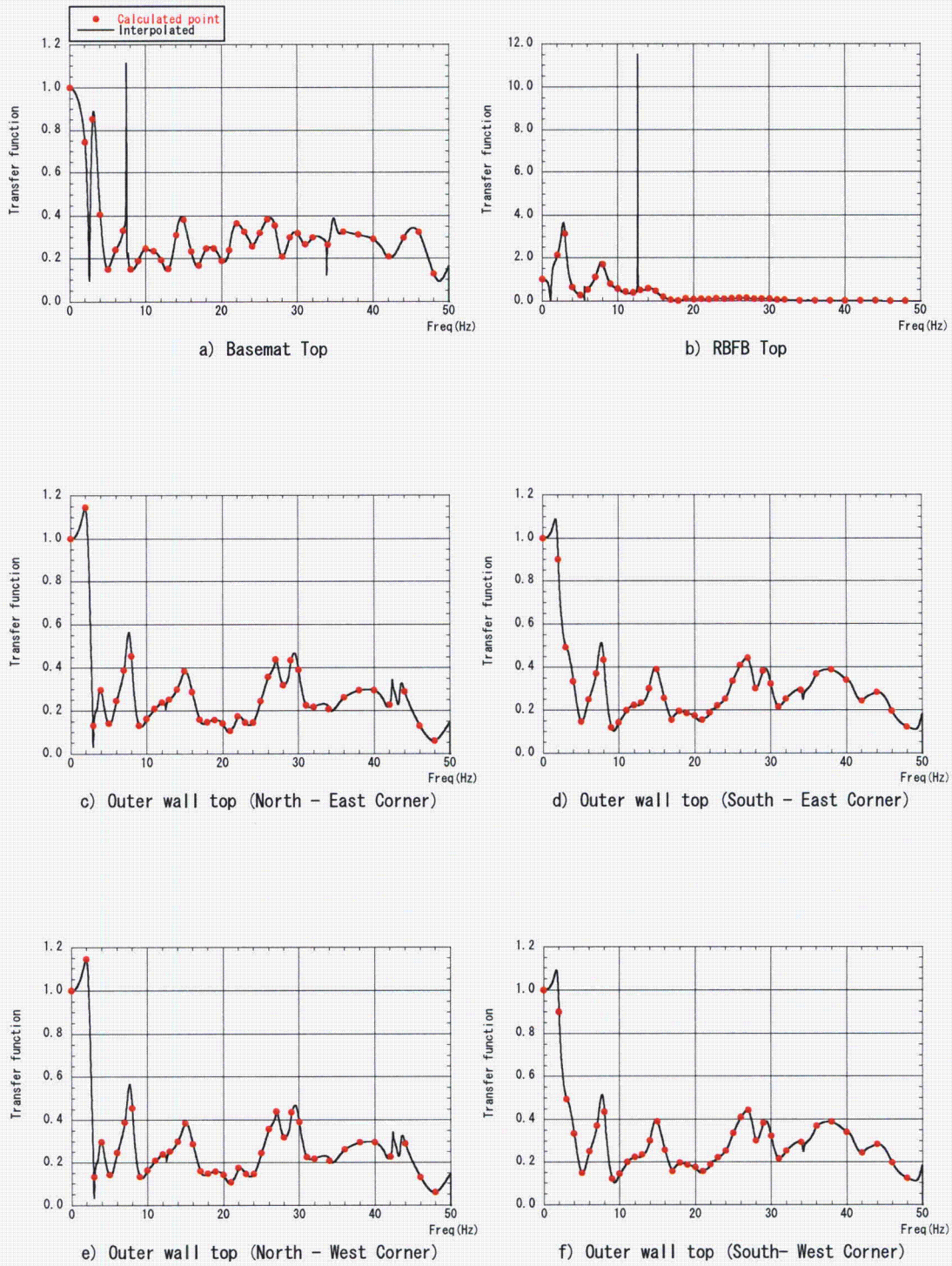


Figure 3.7-16(2) Original Transfer Function for RBFB in Y Direction

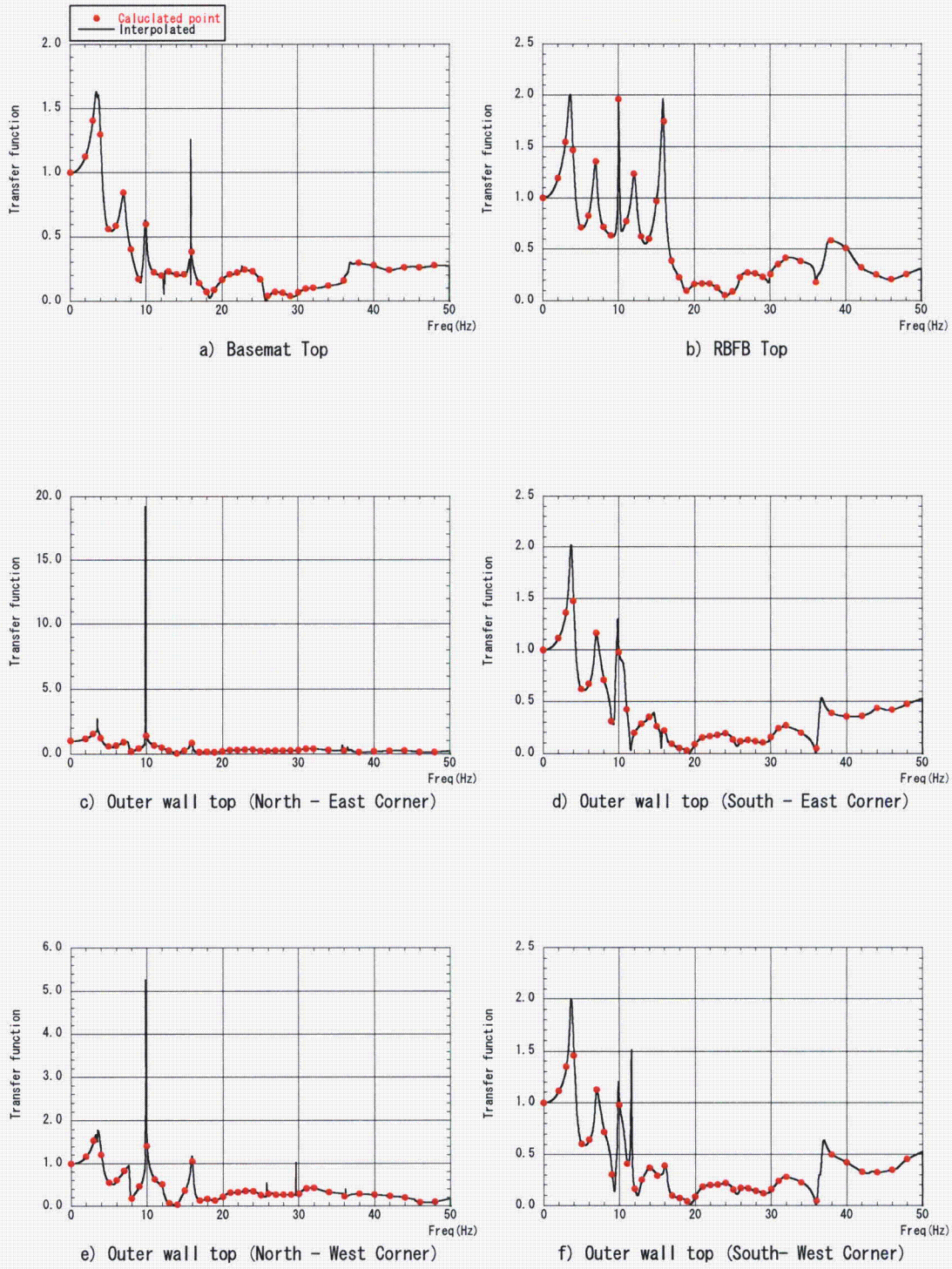
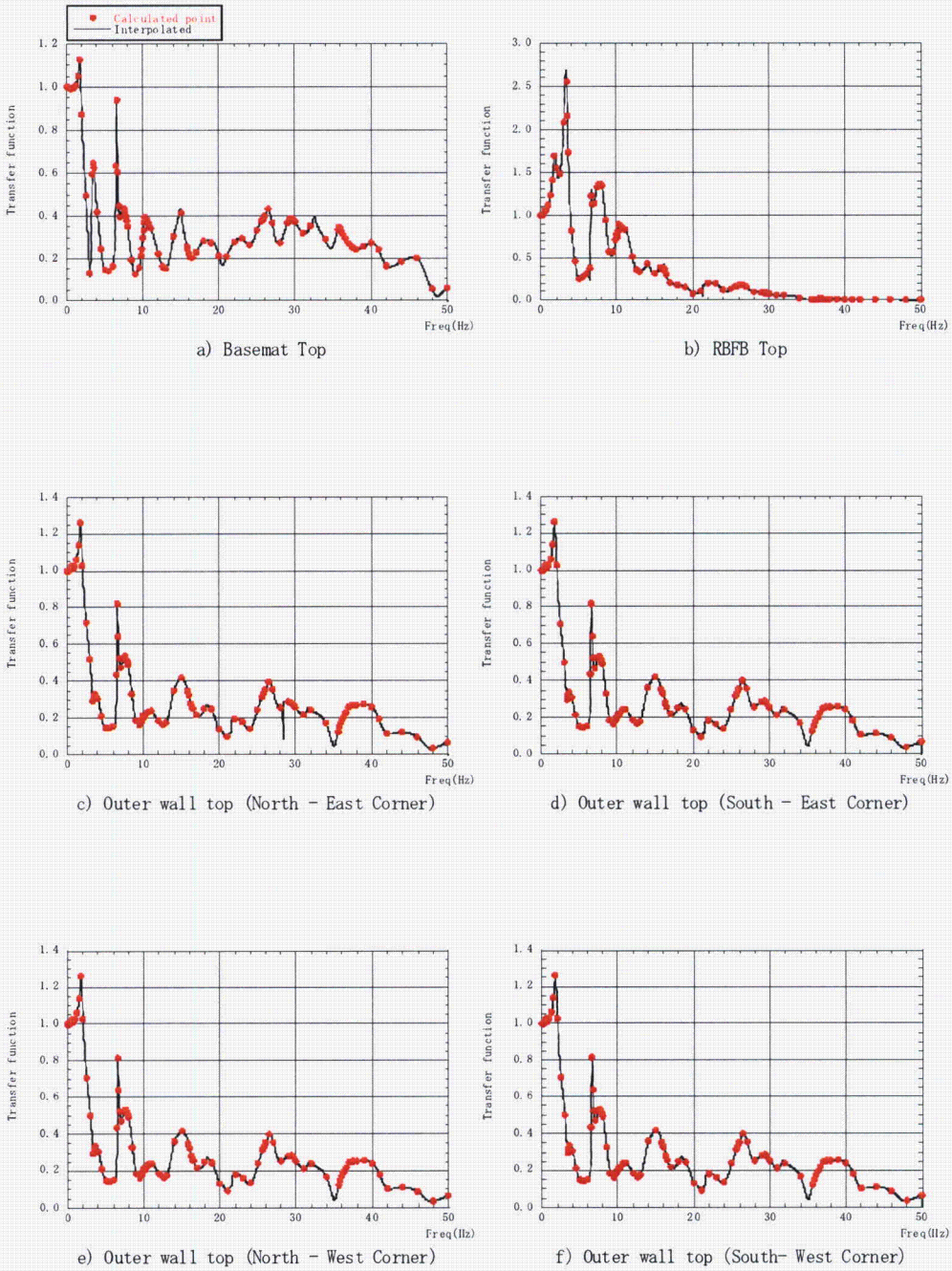


Figure 3.7-16(3) Original Transfer Function for RBFB in Z Direction



a) Basemat Top

b) RBFB Top

c) Outer wall top (North - East Corner)

d) Outer wall top (South - East Corner)

e) Outer wall top (North - West Corner)

f) Outer wall top (South- West Corner)

Figure 3.7-16(4) Refined Transfer Function for RBFB in X Direction

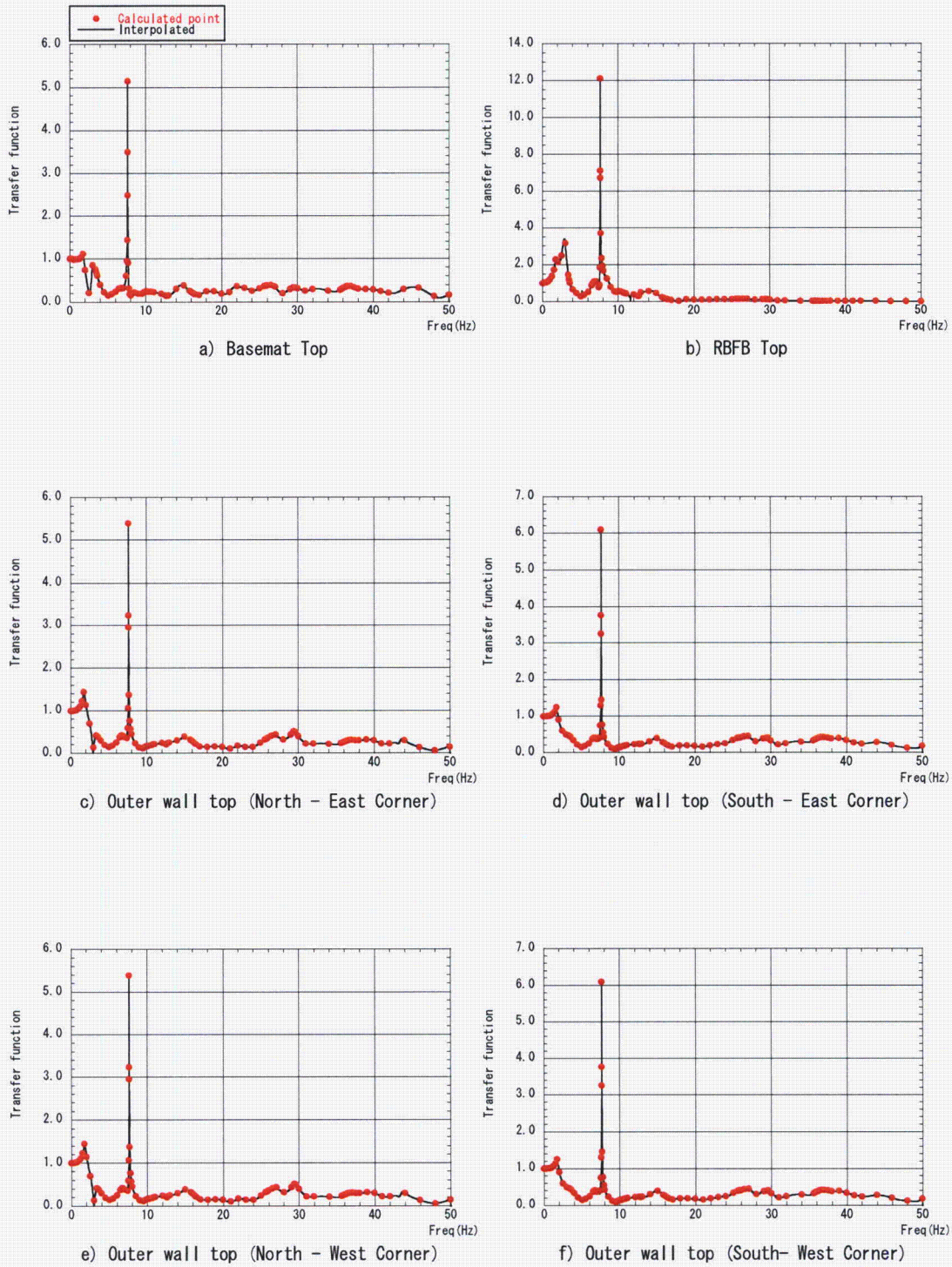
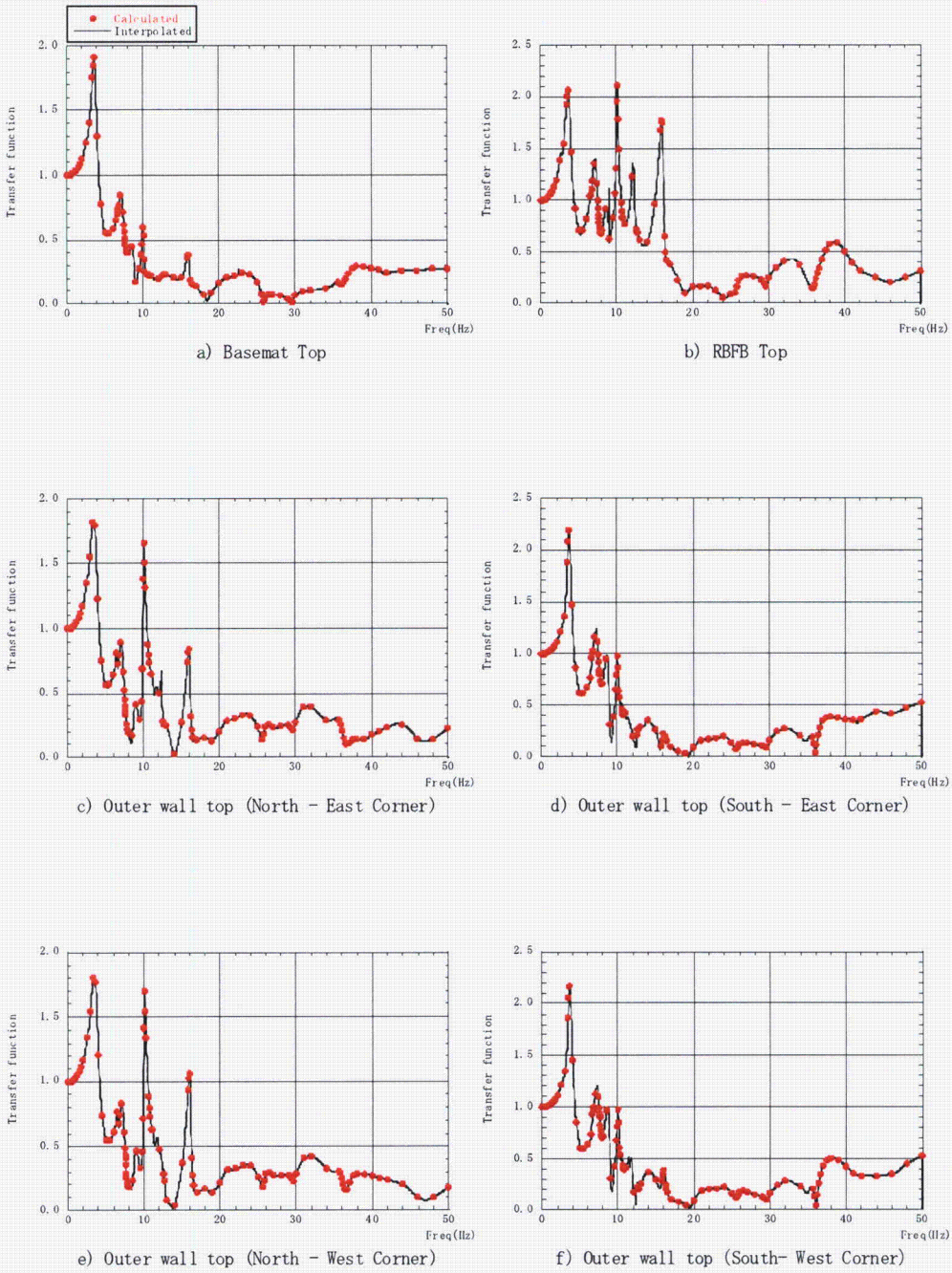


Figure 3.7-16(5) Refined Transfer Function for RBFB in Y Direction



a) Basemat Top

b) RBFB Top

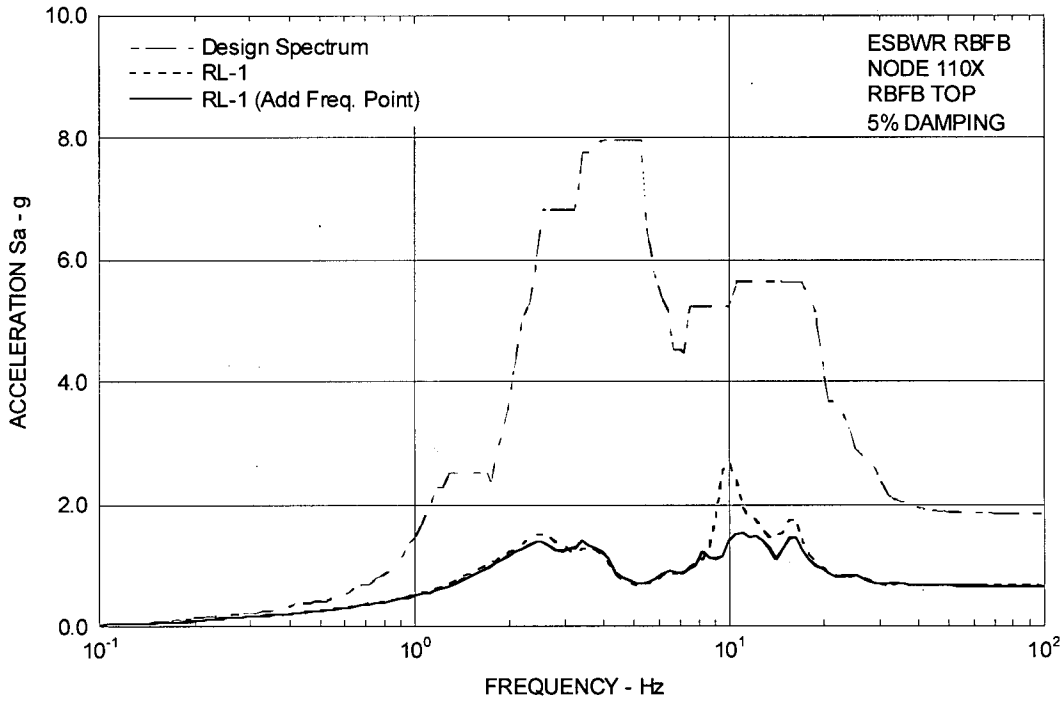
c) Outer wall top (North - East Corner)

d) Outer wall top (South - East Corner)

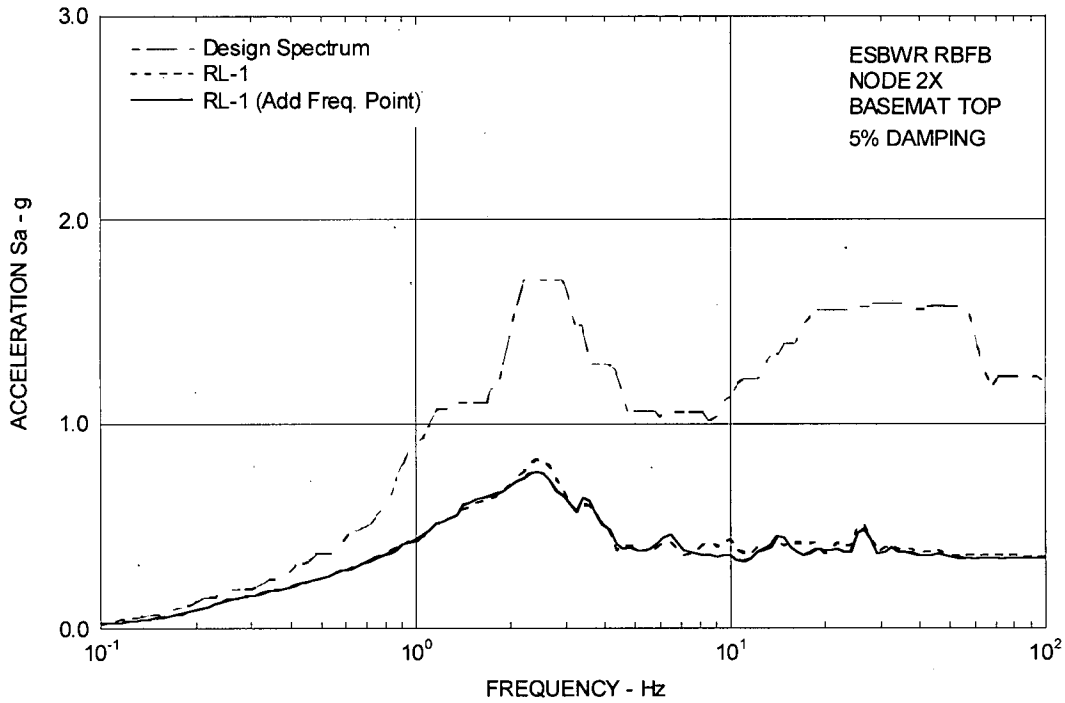
e) Outer wall top (North - West Corner)

f) Outer wall top (South- West Corner)

Figure 3.7-16(6) Refined Transfer Function for RBFB in Z Direction

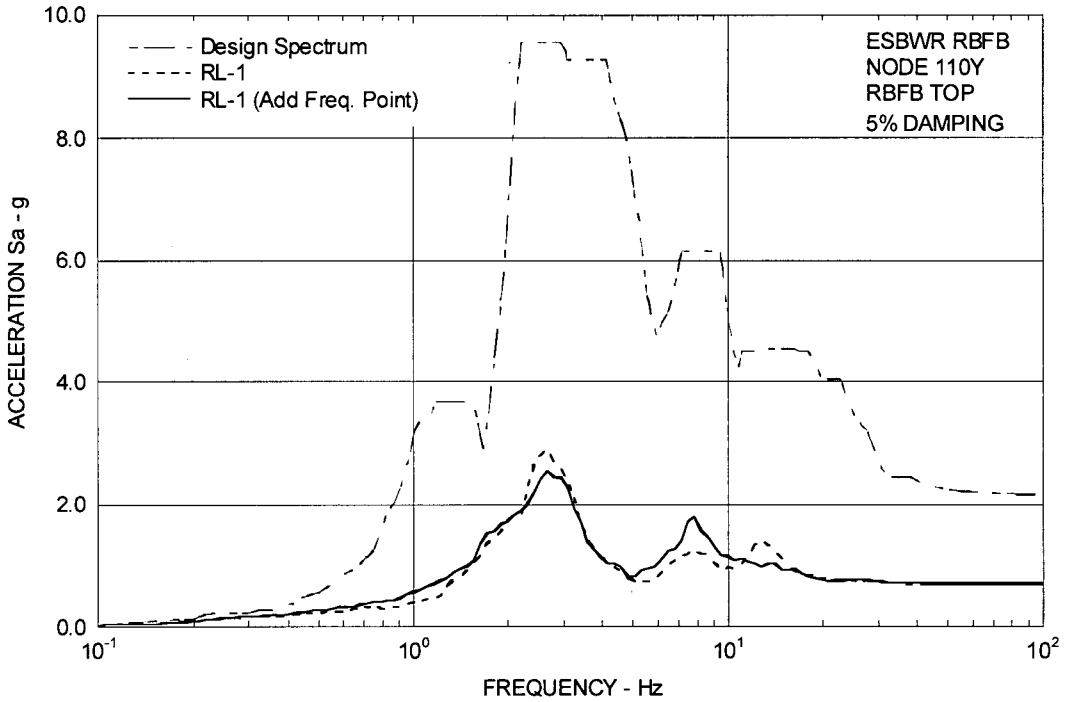


(a) Top of RBFB

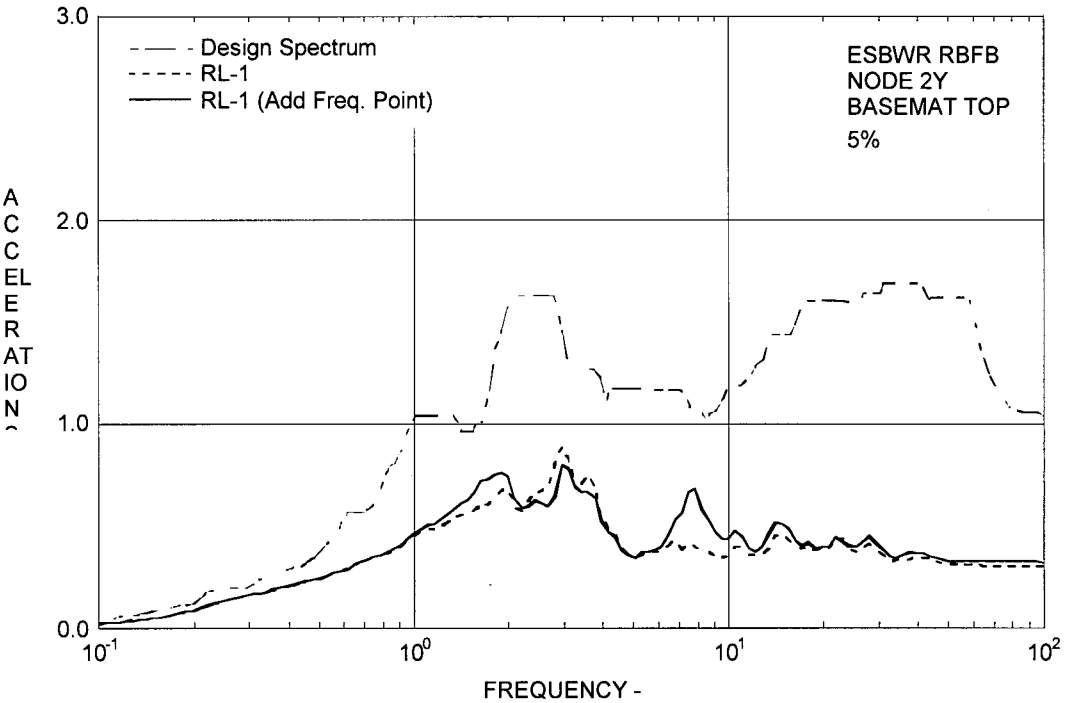


(b) Top of Basemat

Figure 3.7-16(7) FRS in X Direction

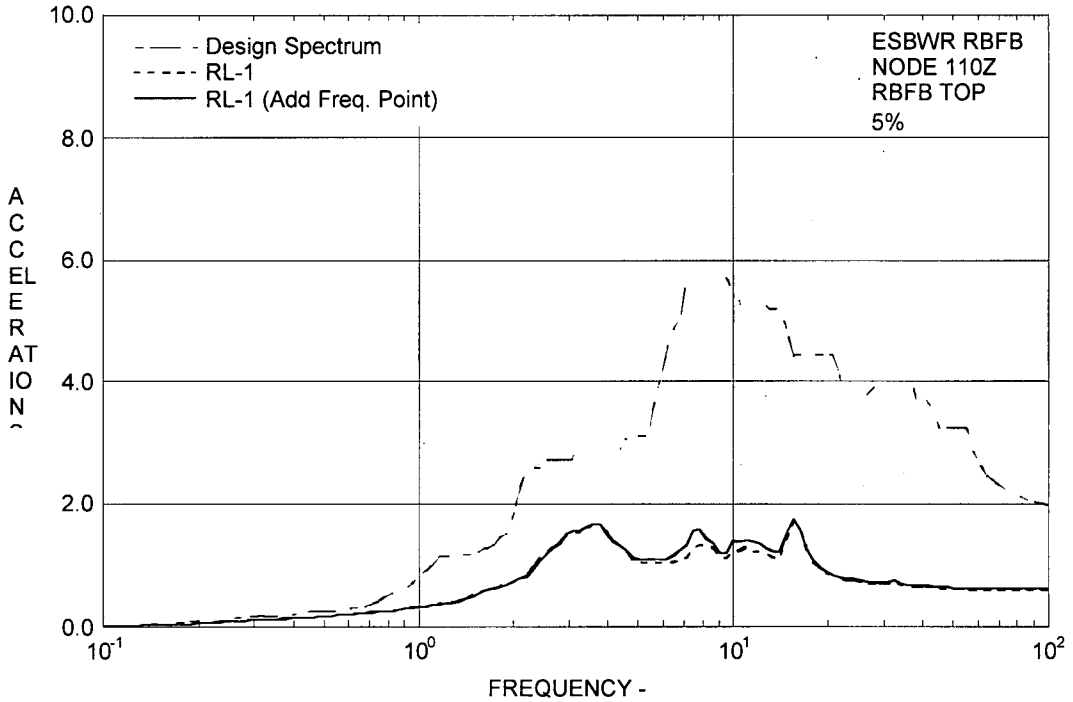


(a) Top of RBFB

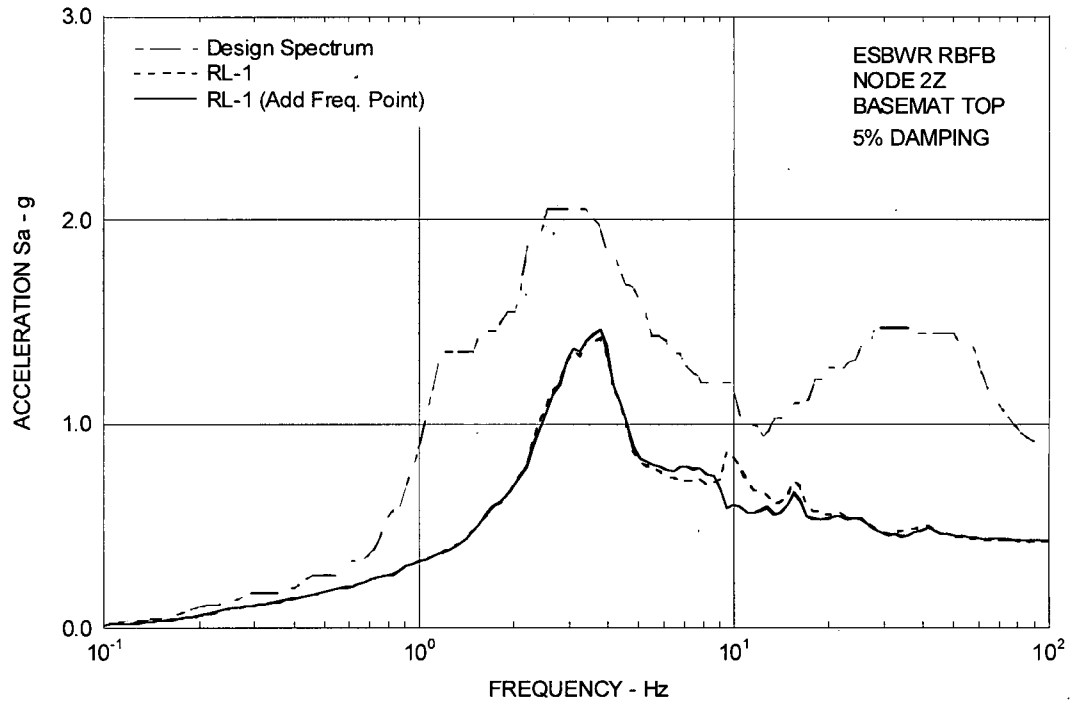


(b) Top of Basemat

Figure 3.7-16(8) FRS in Y Direction



(a) Top of RBFB



(b) Top of Basemat

Figure 3.7-16(9) FRS in Z Direction

DCD Impact

No DCD change was made in response to this RAI Supplement.

NRC RAI 3.7-16, Supplement 2

A number of issues need to be addressed in order to resolve the differences between GEH's results and the staff's confirmatory analysis results of seismic analysis for the Control Building (CB).

(1A) The staff noted that, in comparing the GE design spectrum at the basemat to the GEH design spectrum at the top of stick, there appears to be a significant inconsistency in the amplification from the basemat to the top of stick. The design spectra (FRS) at the basemat shows a depression around 10 Hz, but the FRS at the top of stick shows a very significant peak around 10 Hz. The FRS is amplified in the vicinity of 10 Hz by a factor of about 6, while the remainder of the FRS is amplified by a factor of about 2. This includes what appears to be a fundamental mode response at about 3 Hz. Please explain.

(1B) Submit the individual FRS results at both the basemat and at top of stick, for all cases analyzed (DAC-3N and SASSI), and confirm that the design spectra provided to the staff at the October 30 - November 2, 2006 audit are correct.

(1C) The staff cannot correlate the design spectrum at top of stick, provided to the staff at the October 30-November 2, 2006, audit, with the comparable design spectrum in DCD Rev. 3 Appendix 3A. Explain this apparent discrepancy.

(1D) The design spectrum for the CB basemat, provided to the staff at the October 30-November 2, 2006, audit, is not included in DCD Rev. 3, Appendix 3A. The staff requests GEH to explain why the amplification factor in the 10 Hz range is 6. The staff also requests that the design spectrum for the CB basemat be included in the next revision of DCD Appendix 3A.

(2) The following statement was added to DCD Rev. 3, Appendix 3A.4.1, Input Motion: "For the layered site cases, the input ground motion is defined as an outcrop motion at the RBFB foundation level for all the buildings. The corresponding surface motion is generated for use as input to the SASSI calculation for each site."

The staff requests GEH to address whether its approach to developing the surface motion is consistent with the latest update to SRP 3.7.1 (March 2007). If there are any differences, provide the technical basis for the acceptability of each difference. The staff also requests that GEH submit an example of the implementation of its approach, to include (1) a description of the methodology employed to develop the surface motion; (2) the soil column data used to transfer the input ground motion to the surface; and (3) the resulting surface motion time history.

GEH Response

(1A) The fundamental frequency of the fixed base model is about 10 Hz as shown in Figure 3.7-16(13). Due to the lack of beneficial SSI effects, the fixed base amplification factor is relatively large. For other soil cases with SSI effect included, the fundamental frequencies are lower and their amplification factors are smaller, as shown in Figures 3.7-16(10) through 3.7-16(12) and 3.7-16(14) through 3.7-16(17).

(1B) Figures 3.7-16(10) through 3.7-16(17) show the individual FRS results at both the basemat top (EL -7.40) and the top of stick (EL 9.06) at the second floor (not at the penthouse roof), for all cases analyzed (DAC-3N and SASSI) for the DCD Revision 3 CB model. It is confirmed that the design spectra provided to the staff at the October 30 - November 2, 2006 audit are correct.

(1C) The design spectra in Figures 3A.9-1g, 3A.9-2g, and 3A.9-3g of DCD Tier 2, Revision 3, Appendix 3A have been corrected. The corrected design spectra are shown in Figures 3.7-16(18) through 3.7-16(20). Note that the CB seismic analysis has been updated to reflect the changes associated with reclassification to Seismic C-I for the entire building. Appendices 3A and 3G have been updated in DCD Tier 2, Revision 4.

(1D) Please see the response to (1A) above. The design spectra for the CB basemat have been included in DCD Tier 2, Revision 4.

(2) This issue is addressed by performing SHAKE analyses for two problems considered in the staff's confirmatory analysis and received from the NRC on August 13, 2007. The problem descriptions are included in Attachment 1 for reference. Two approaches are used in the SHAKE analysis for Problem 6. One approach, termed NRC Method herein, involves two separate SHAKE runs. In the first run (Step 6a) the soil layer above the foundation level is not included and the foundation input motion is applied as outcrop motion to the soil column below the foundation. The resulting bedrock motion is then applied in the second SHAKE run (Step 6b) for the entire soil column up to the ground surface. The other approach, termed DCD Method herein, includes the entire soil column up to ground surface in a single SHAKE run with outcrop motion input at the foundation level. For Problem 4 only one-step SHAKE analysis is performed because the bedrock is at the foundation level for which the NRC and DCD Methods are the same.

The SHAKE–calculated ground surface response spectra of the two methods are compared in Figure 3.7-16(21) for problem 4 and Figure 3.7-16(22) for problem 6. The enveloping surface spectra of DCD SASSI layered site cases CL-1 to CL-4 are also included in these figures for reference. For problem 6 the surface motion using the DCD Method is different from that using the NRC Method. To address the effect on SSI response, SASSI analyses are performed using the surface input motion calculated by the NRC Method and the resulting response spectra at the upper level (EL. 9.06m) and at the top of basemat (EL. –7.4m) are compared with the DCD design spectra in Figures 3.7-16(23) and 3.7-16(24), respectively. The floor response spectra for problems 4 and 6, as shown, are enveloped by the design spectra.

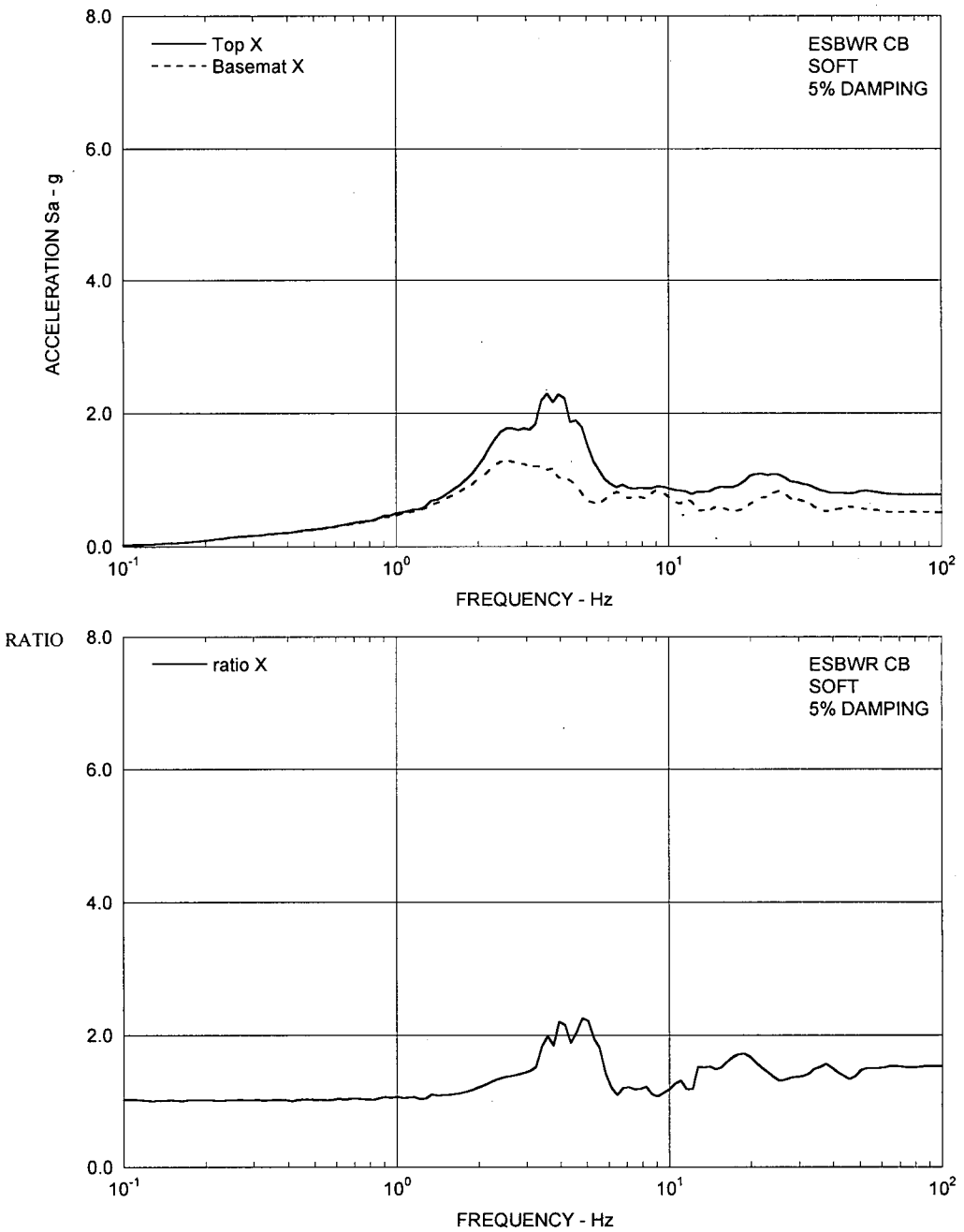


Figure 3.7-16(10) Uniform Soft Site [CU-3]

- SSI Fundamental Frequency: 3.4 Hz (from DAC3N)

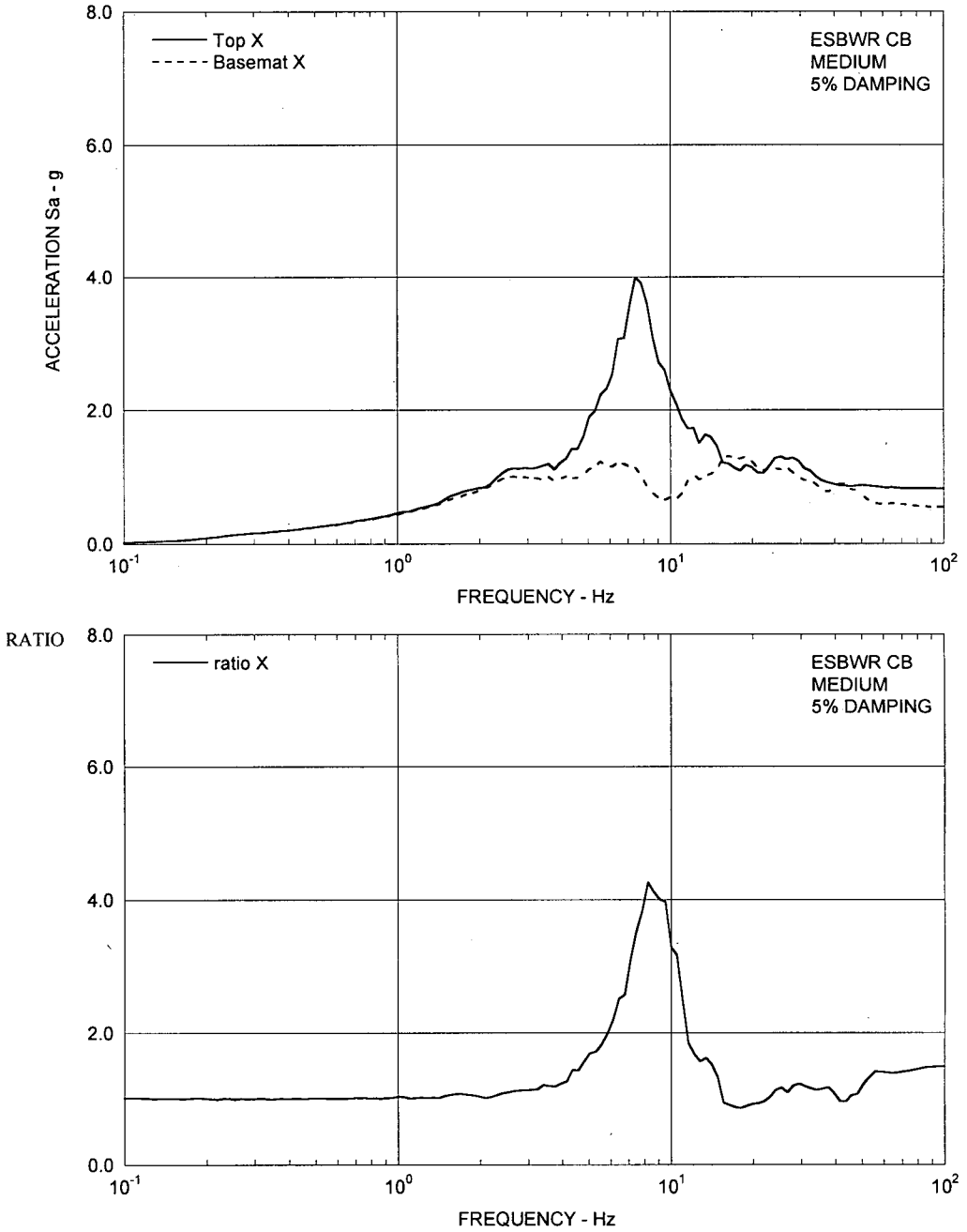
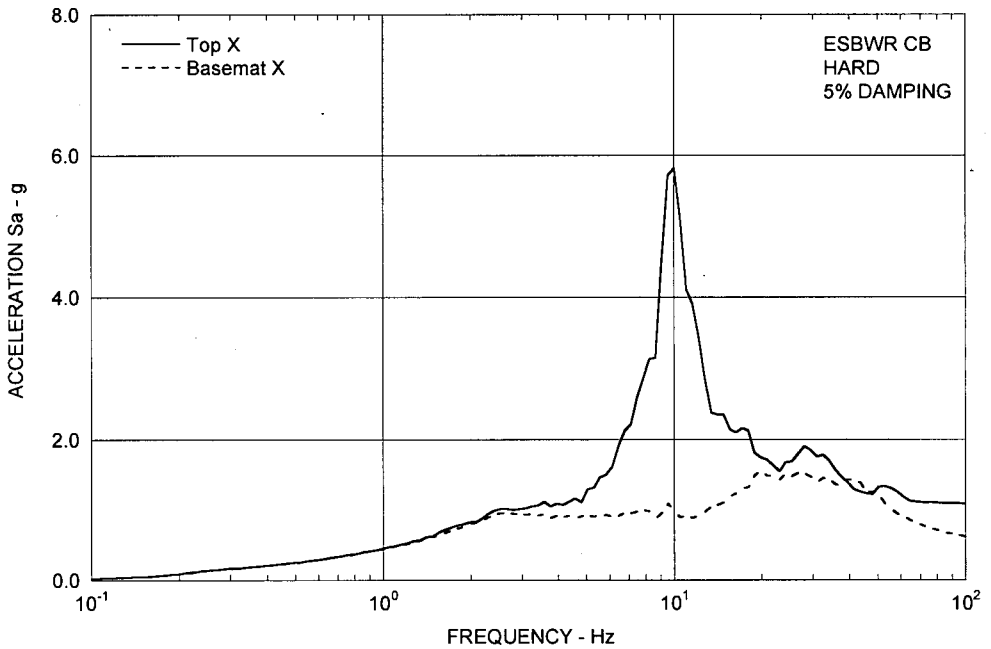


Figure 3.7-16(11) Uniform Medium Site [CU-3]

- SSI Fundamental Frequency: 7.4 Hz (from DAC3N)



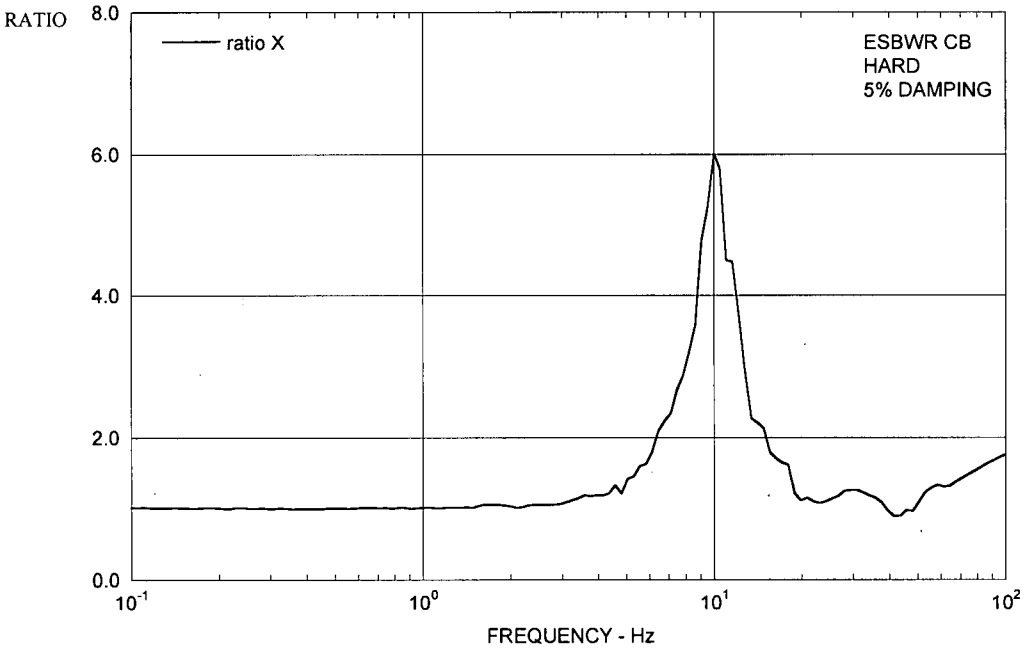


Figure 3.7-16(12) Uniform Hard Site [CU-3]

- SSI Fundamental Frequency: 9.9 Hz (from DAC3N)

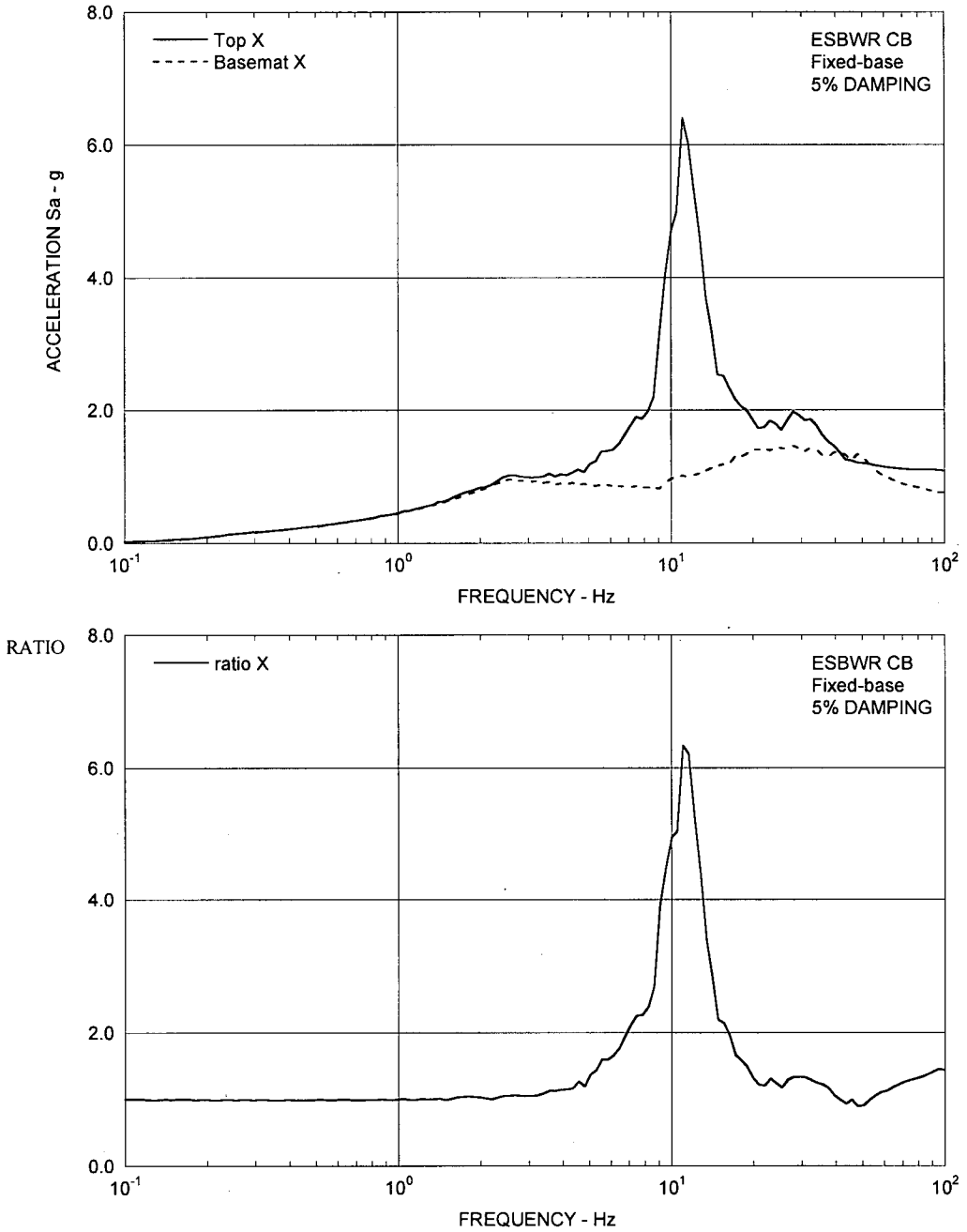
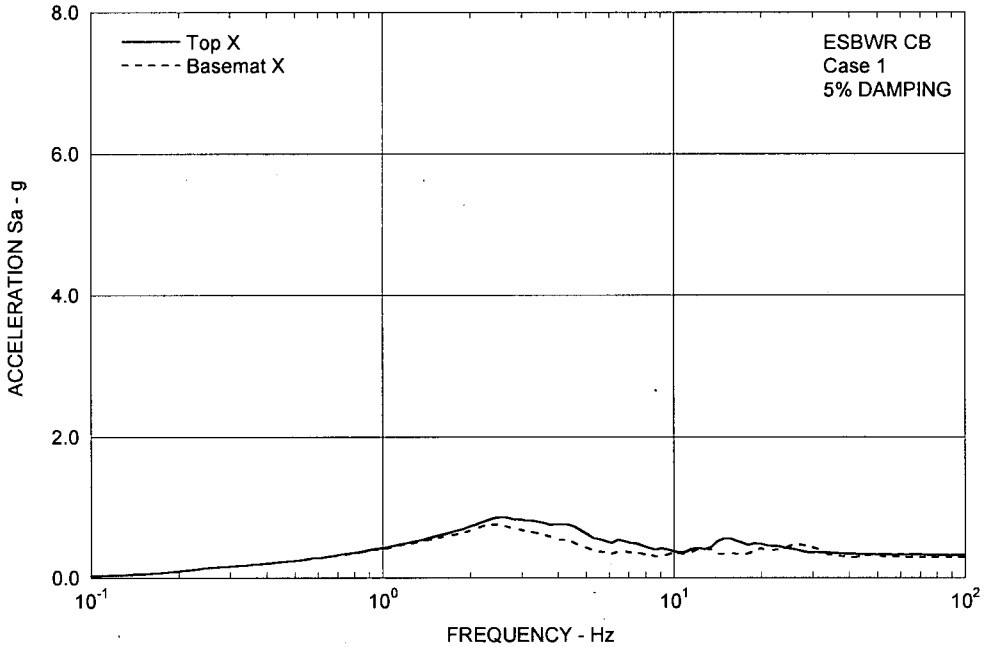


Figure 3.7-16(13) Fixed-base Case [CU-3]

- SSI Fundamental Frequency: 10.9 Hz (from DAC3N)



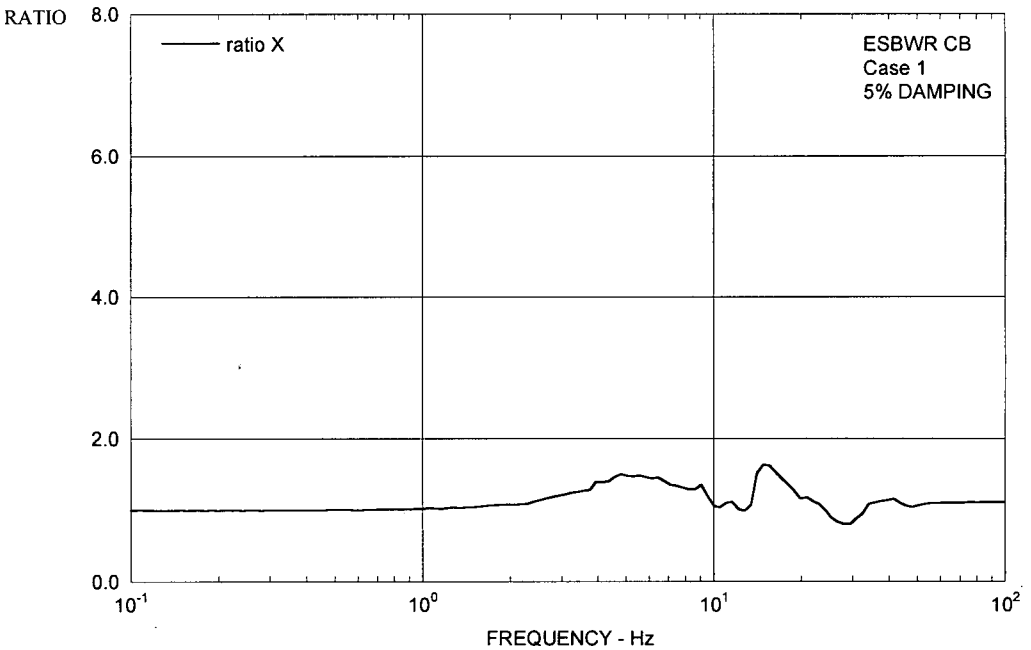


Figure 3.7-16(14) Layered Case 1 [CL-1]

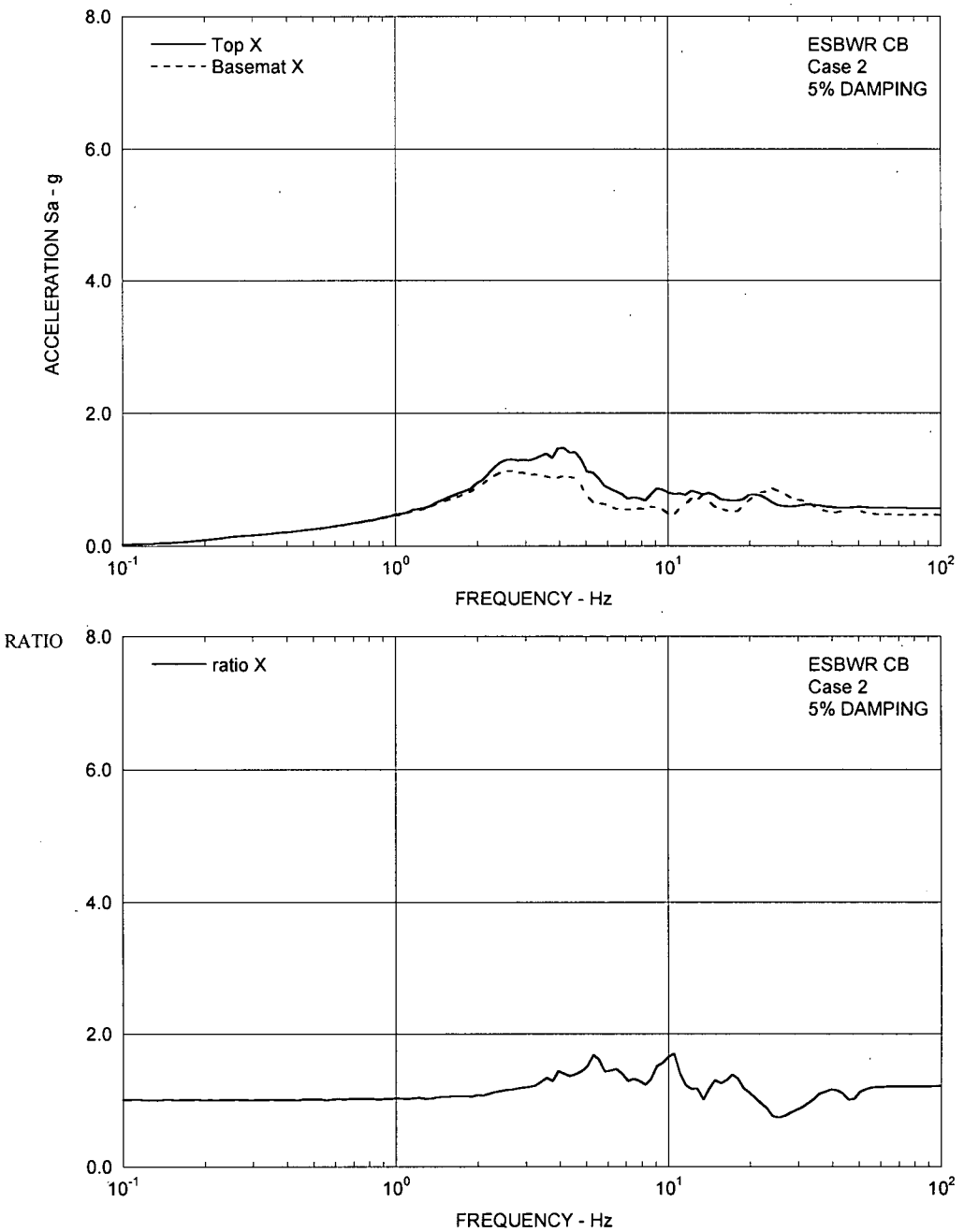


Figure 3.7-16(15) Layered Case 2 [CL-2]

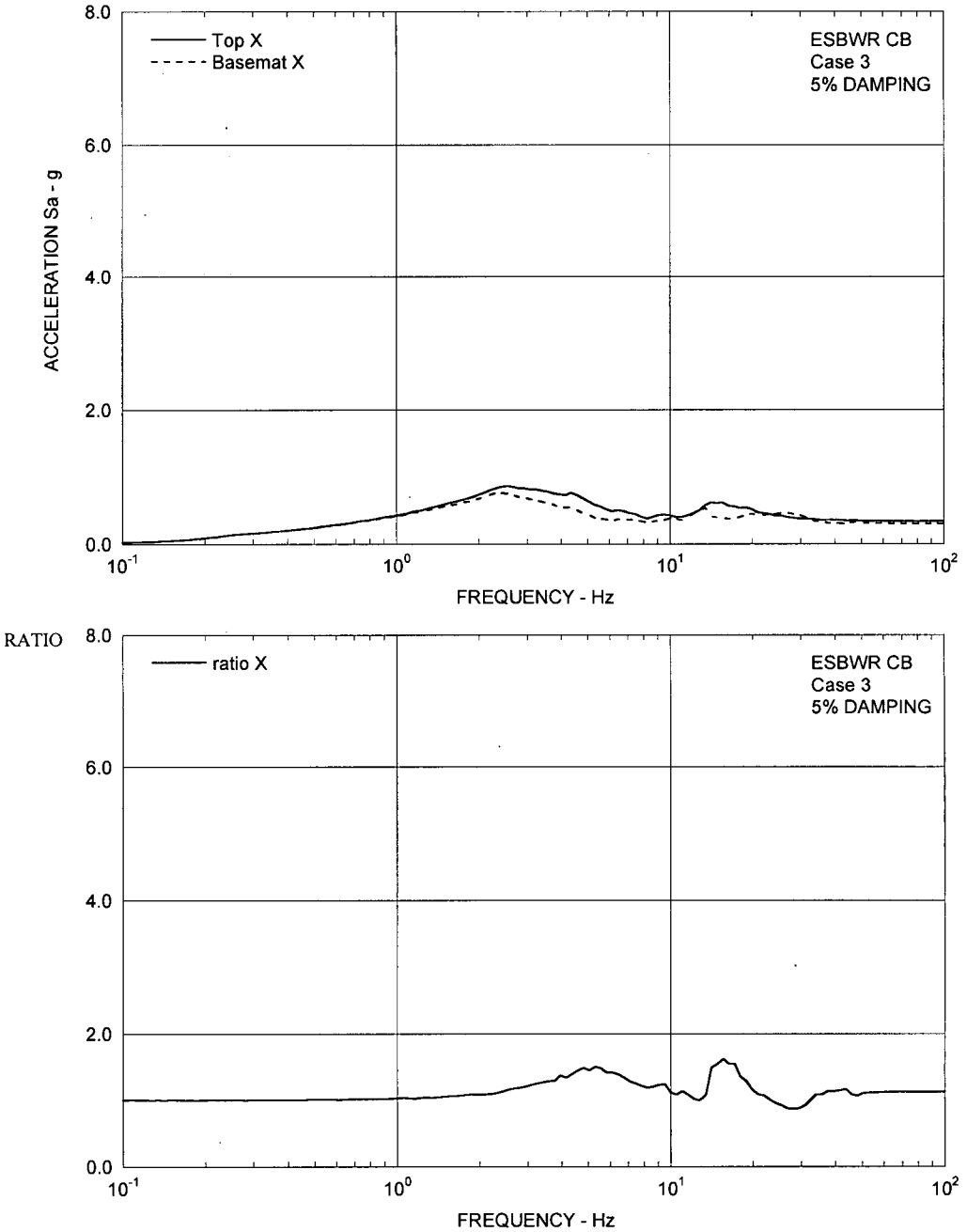


Figure 3.7-16(16) Layered Case 3 [CL-3]

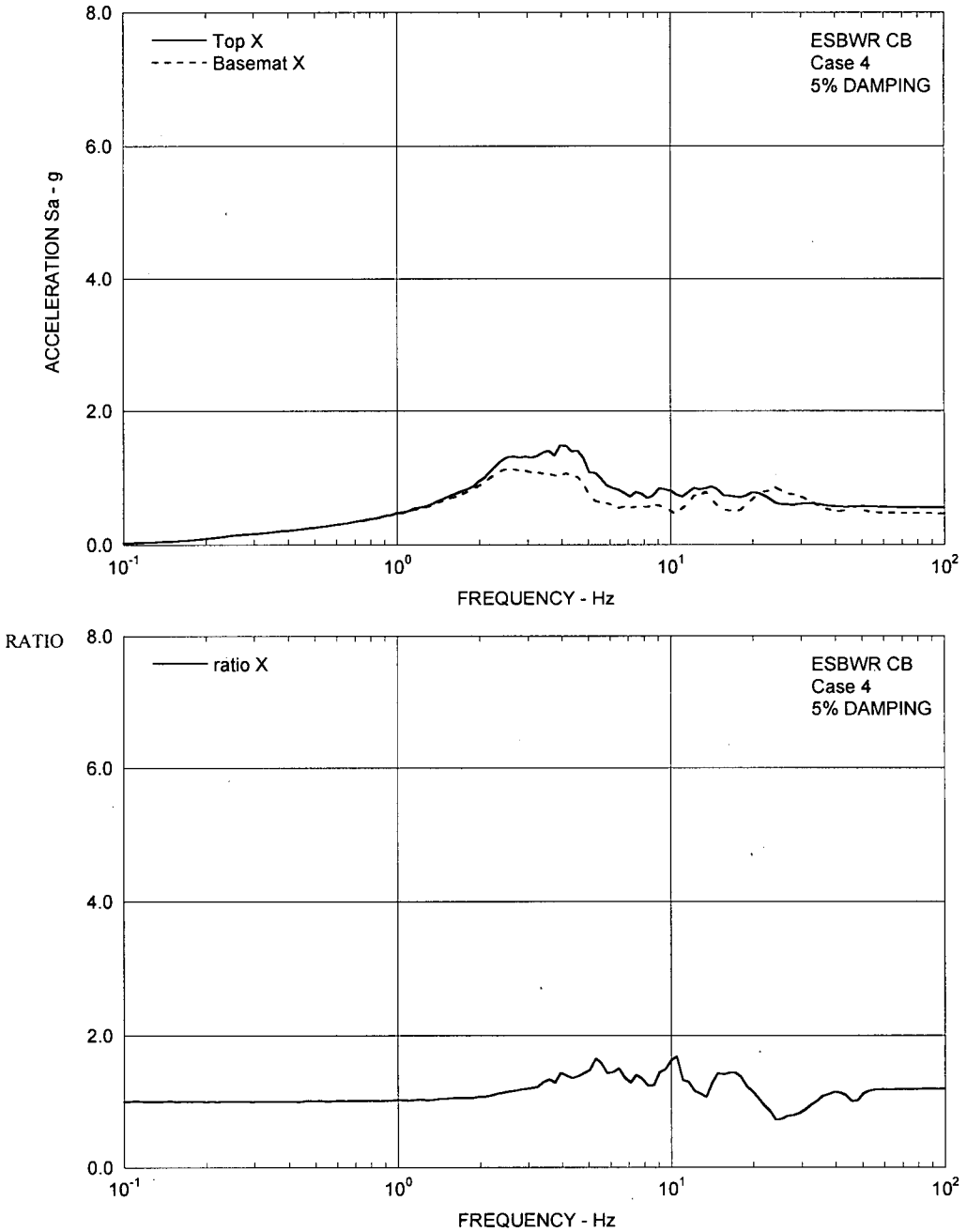


Figure 3.7-16(17) Layered Case 4 [CL-4]

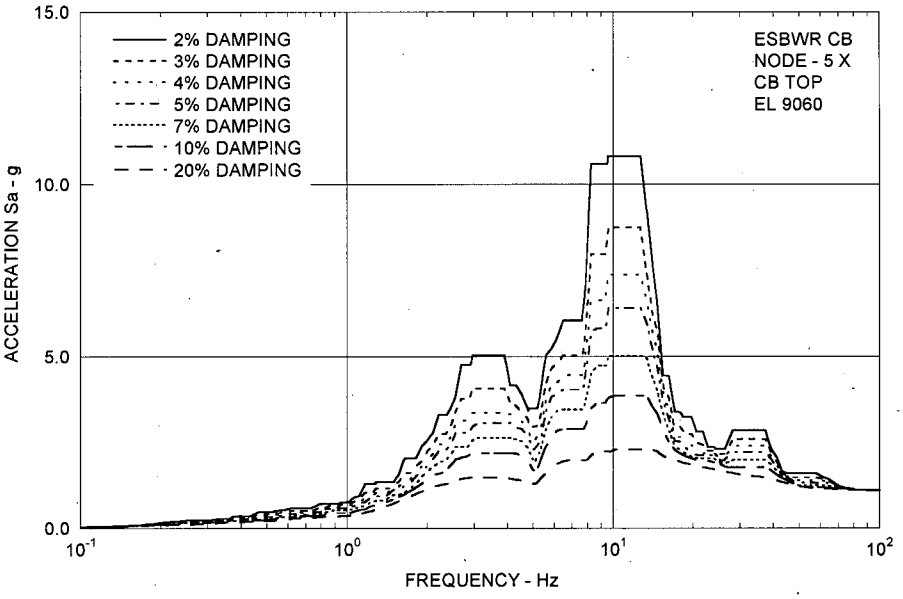


Figure 3.7-16(18) Enveloping Floor Response Spectra – CB Top X

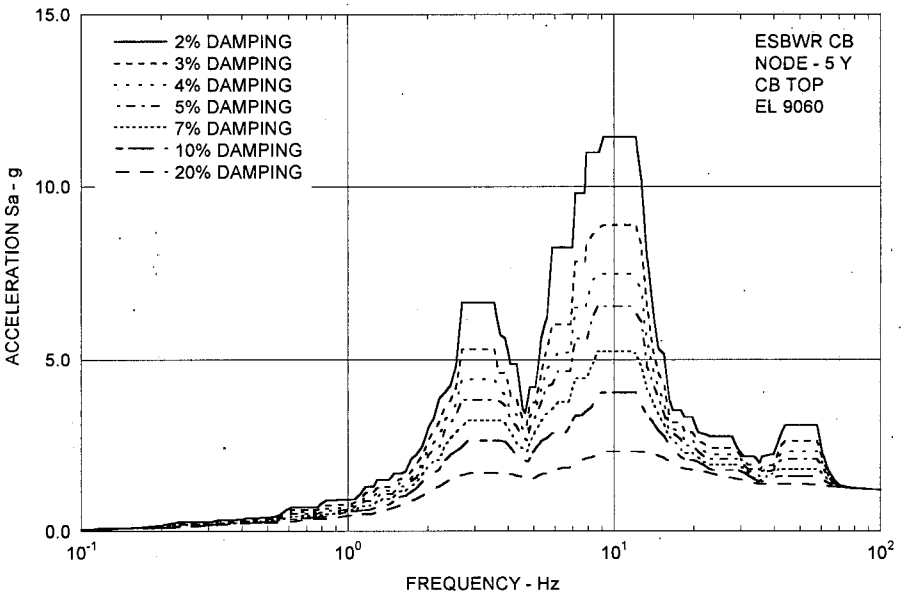


Figure 3.7-16(19) Enveloping Floor Response Spectra – CB Top Y

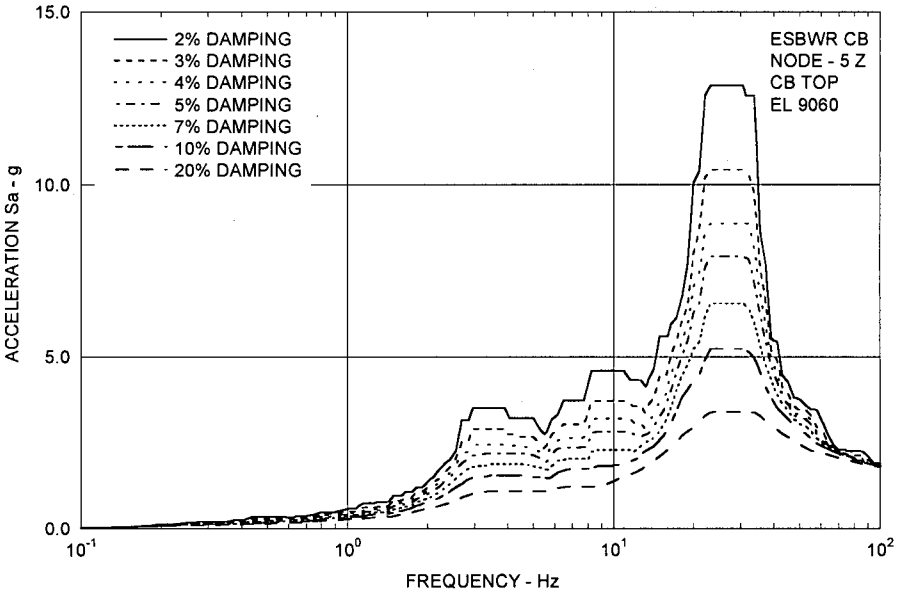


Figure 3.7-16(20) Enveloping Floor Response Spectra – CB Top Z

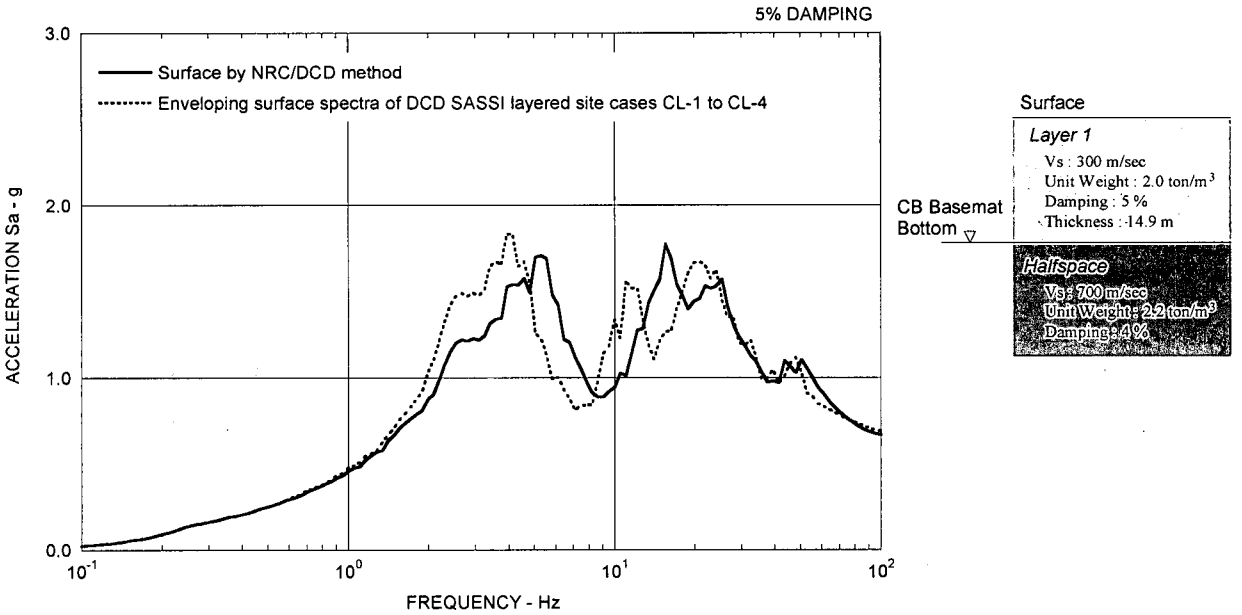


Figure 3.7-16(21) Ground Surface Response Spectra for Problem 4

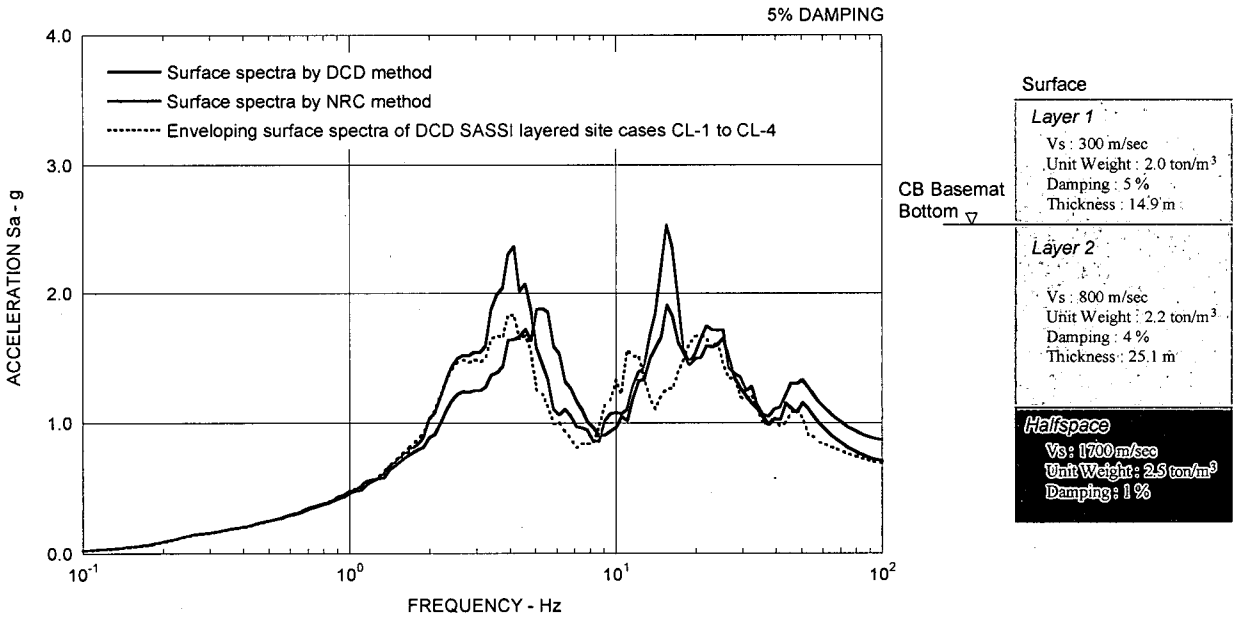


Figure 3.7-16(22) Ground Surface Response Spectra for Problem 6

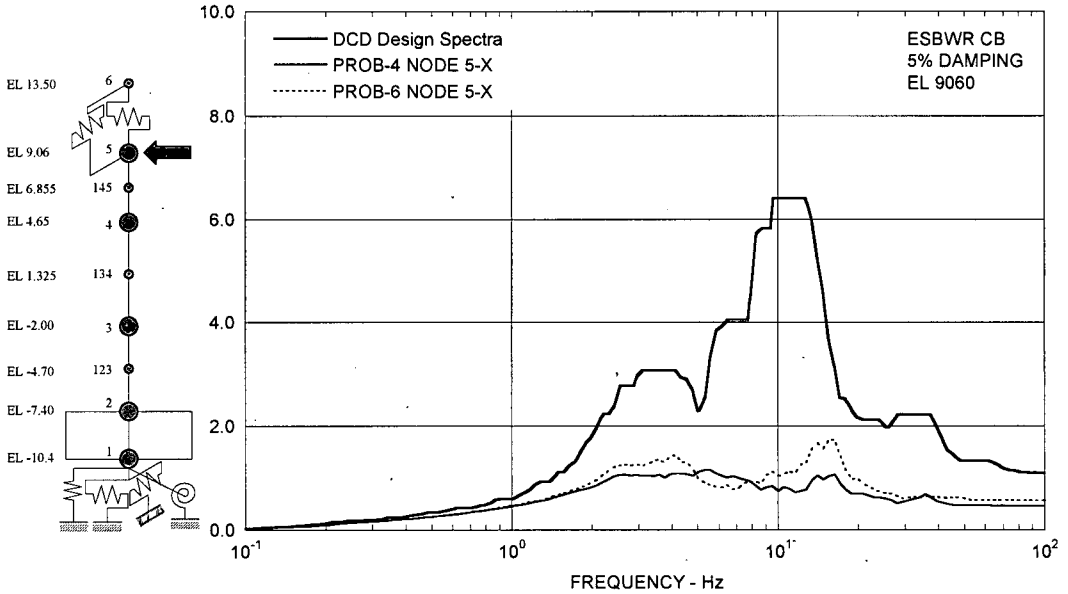


Figure 3.7-16(23) Floor Response Spectra of CB – EL 9.06 m –

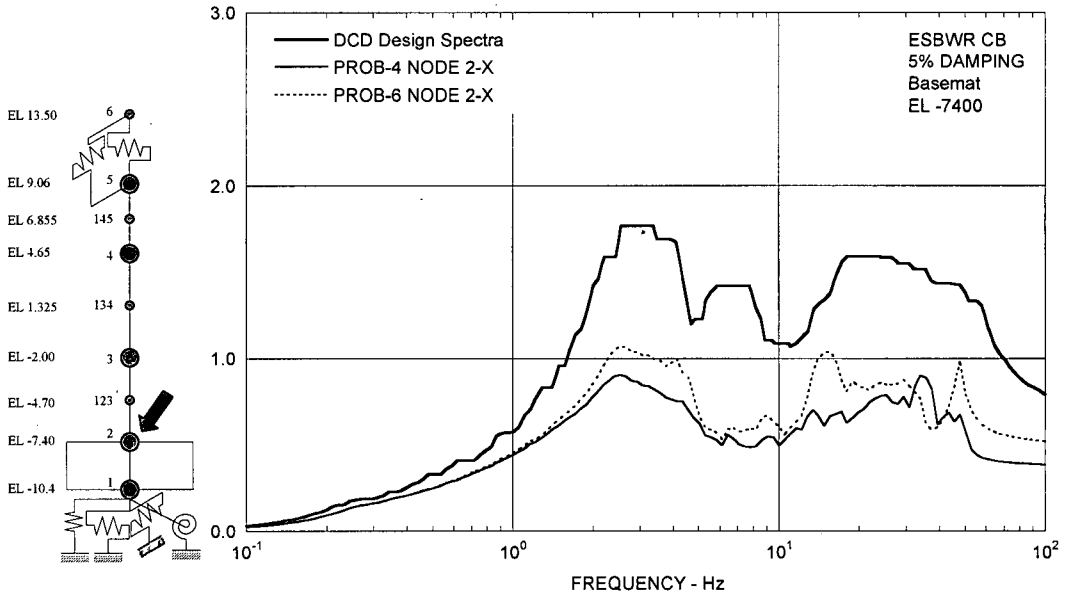


Figure 3.7-16(24) Floor Response Spectra of CB – EL -7.4 m –

DCD Impact

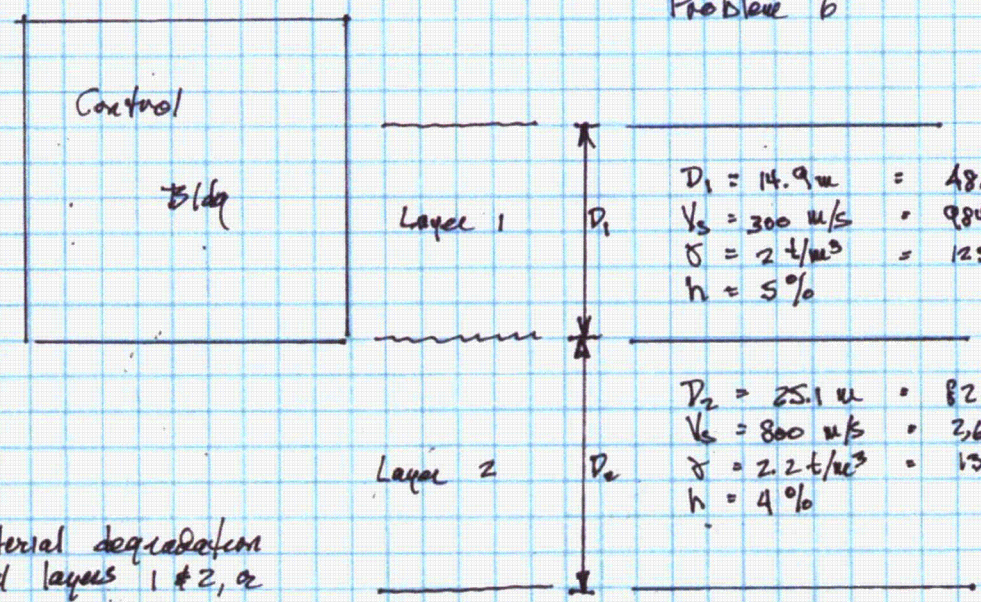
No DCD change is required in response to this RAI Supplement.

ATTACHMENT 1

MFN 06-274, SUPPLEMENT 2

-DCD Tier 2 Section 3.7 – RAI Number 3.7-16 S02

Problem 6



Layer 1:
$D_1 = 14.9\,m = 48.9$ ft
$V_s = 300$ m/s $= 984.3$ fps
$\gamma = 2$ t/m³ $= 125$ pcf
$h = 5\%$

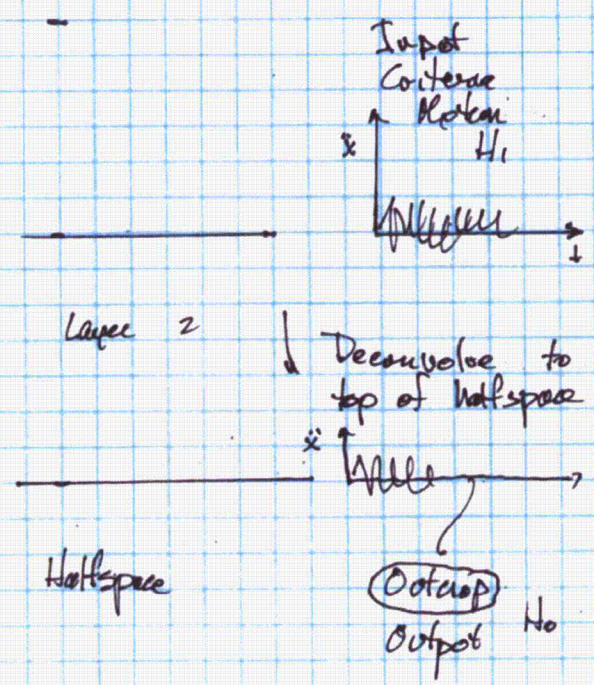
Layer 2:
$D_2 = 25.1\,m = 82.9$ ft
$V_s = 800$ m/s $= 2{,}624.7$ fps
$\gamma = 2.2$ t/m³ $= 137.5$ pcf
$h = 4\%$

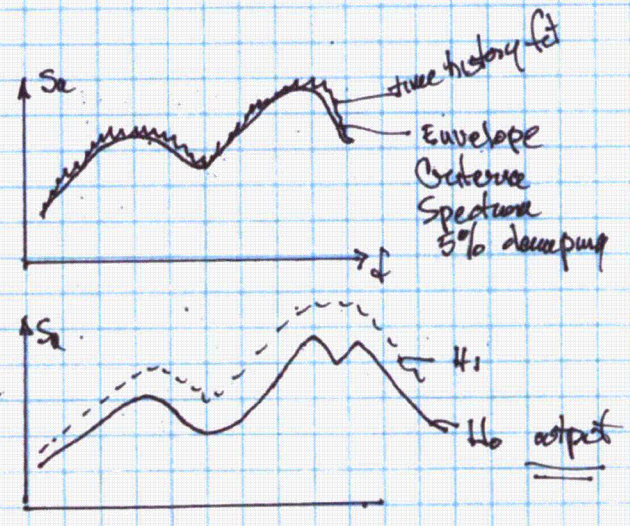
Halfspace:
$V_s = 1{,}700$ m/s $= 5{,}577.4$ fps
$\gamma = 2.5$ t/m³ $= 156.25$ pcf
$h = 1\%$

No material degradation for soil layers 1 & 2, or

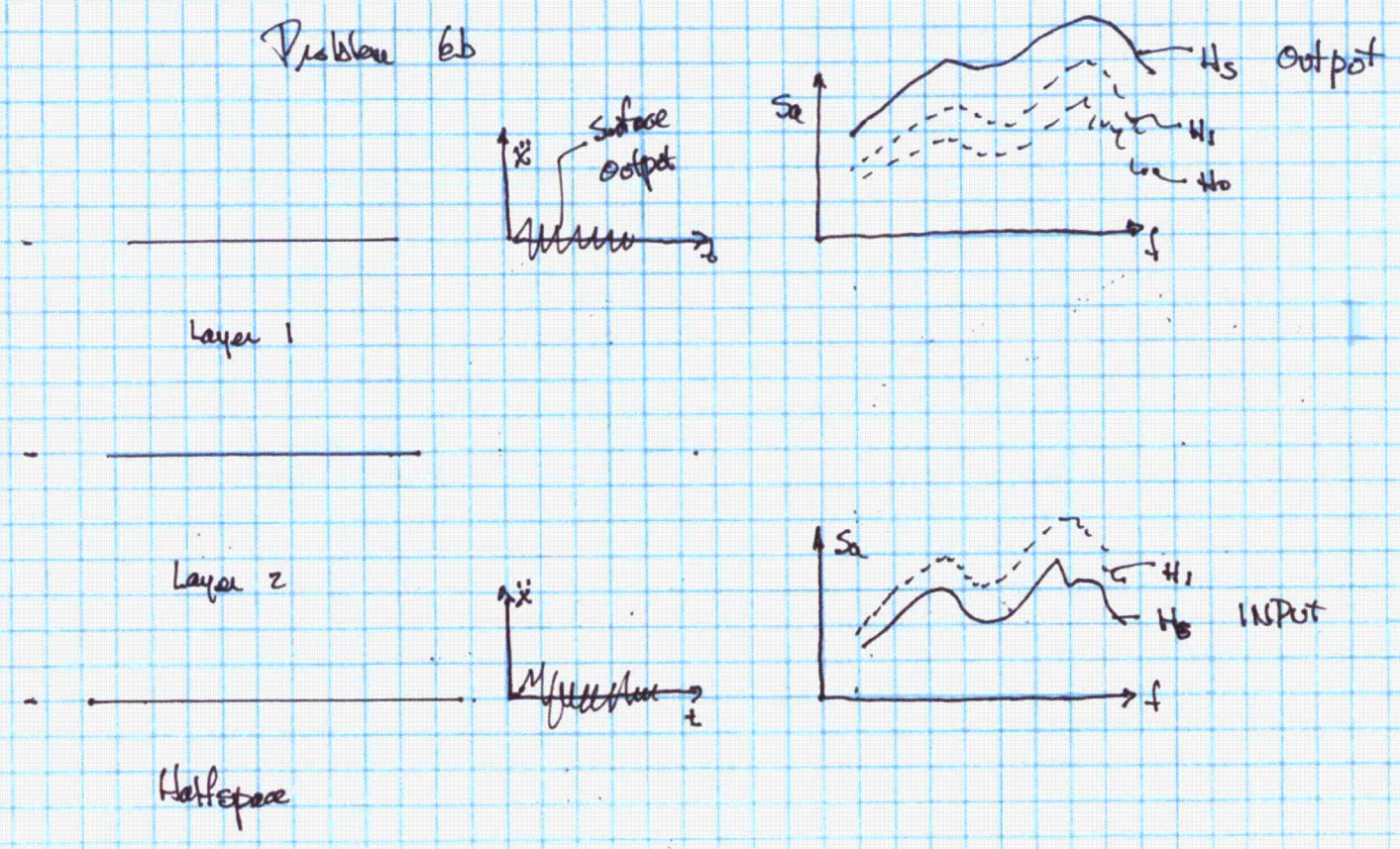
$G/G_{max} = 1$

Problem 6a

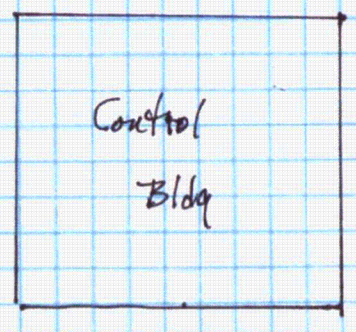

Input
Criterion
Motion
H_1
$\ddot{x}$
Layer 2
Deconvolve to
top of halfspace
$\ddot{x}$
Halfspace
Outcrop
Output
H_0


Sa
time history fct
Envelope
Criterion
Spectrum
5% damping
f
Sa
H_1
H_0 output

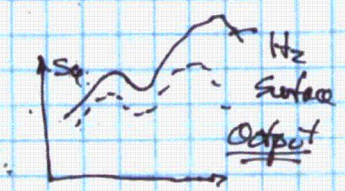
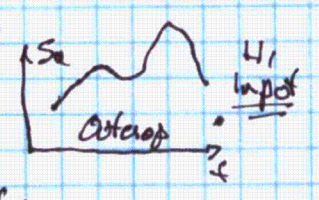
Problem 6b


Surface output
$\ddot{x}$
t
Sa
f
H_S Output
H_1
H_0
Layer 1
Layer 2
Halfspace
$\ddot{x}$
t
Sa
f
H_1
H_B INPUT

Problem 4



Layer 1

$D_1 = 14.9\ m$ $= 48.9\ ft$
$V_s = 300\ m/s$ $= 984.3\ fps$
$\gamma = 2.0\ t/m^3$ $= 125\ pcf$
$h = 5\ \%$

$V_s = 700\ m/s$ $= 2,296.6\ fps$
$\gamma = 2.2\ t/m^3$ $= 137.5\ pcf$
$h = 4\ \%$