HITACHI

GE Hitachi Nuclear Energy

Richard E. Kingston
Vice President, ESBWR Licensing

P.O. Box 780
3901 Castle Hayne Road, M/C A-65
Wilmington, NC 28402 USA

T 910.819.6192
F 910.362.6192
rick.kingston@ge.com

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Subject: **Response to Portion of NRC RAI Letter No. 323 Related to ESBWR Design Certification Application – DCD Tier 2 Section 3.7 – Seismic Design; RAI Numbers 3.7-69 thru 3.7-72**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to a portion of the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) letter number 323 sent by NRC letter dated April 6, 2009 (Reference 1). RAI Numbers 3.7-69 thru 3.7-72 are addressed in Enclosure 1.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

Reference:

1. MFN 09-245 Letter from U.S. Nuclear Regulatory Commission to J. G. Head, GEH, *Request For Additional Information Letter No. 323 Related to ESBWR Design Certification* dated April 6, 2009

Enclosure:

1. Response to Portion of NRC RAI Letter No. 323 Related to ESBWR Design Certification Application - DCD Tier 2 Section 3.7 – Seismic Design; RAI Numbers 3.7-69 thru 3.7-72

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	eDRF Section	0000-0101-1579 (RAI 3.7-69 thru -72)

ENCLOSURE 1

MFN 09-391

Response to Portion of NRC RAI Letter No. 323
Related to ESBWR Design Certification Application

DCD Tier 2 Section 3.7 – Seismic Design

RAI Numbers 3.7-69, 3.7-70, 3.7-71 & 3.7-72

NRC RAI 3.7-69

Confirm that all new SASSI analyses conducted in support of the RAI 3.8-94 response, including the three (3) uniform site cases with embedment, used the "NRC Method" (as defined by GEH) to derive the surface spectra. If this is not the case, provide technical justification for the method employed.

GEH Response

There is no difference between the "NRC Method" and the "DCD Method" in the surface spectra calculated by SHAKE for all new SASSI analyses of the three uniform site cases with embedment since the soil layer is uniform and treated as halfspace below the basemat.

It is similar to the NRC's Problem 4 in GEH's response to NRC RAI 3.7-16 S02 (MFN 06-274 S02, dated 11/21/07). The surface spectra for this problem are calculated by one-step SHAKE analysis for the entire soil column because the halfspace is at the foundation level for which the "NRC Method" and "DCD Method" are the same.

DCD Impact

No DCD change is required in response to this RAI.

NRC RAI 3.7-70

Describe in detail how it was determined that a shear wave velocity ratio of 2.5 or less between the top and middle layers is acceptable, while a shear wave velocity ratio greater than 2.5 between the top and middle layers is not acceptable. Include numerical results from any parametric studies conducted.

GEH Response

The new ESBWR Standard Plant site interface parameter for the maximum ratio of soil shear wave velocities in adjacent layers, as proposed in GEH's response to NRC RAIs 3.8-94 S03 (MFN 06-407 S13, dated 2/20/09) and 3.8-96 S03 (MFN 06-407 S14, dated 2/20/09), will not be included in Revision 6 of DCD Tier 2 Table 2.0-1.

DCD Impact

No DCD change is required in response to this RAI.

NRC RAI 3.7-71

With the exclusion of Layered Cases 2 and 4, the staff is concerned that GEH has not included a sufficient diversity of layered site cases to draw generic conclusions about the response of the ESBWR Category I structures for a realistic range of possible site conditions. Layered Cases 1 and 3 only examine the sensitivity of the structural response for two (2) different thicknesses (20m and 40m) of a 300 m/s shear wave velocity layer above bedrock (1700 m/s shear wave velocity). This is hardly representative of the realistic range of possible site conditions. Provide the technical basis, including numerical results as applicable, for concluding that the only restriction for layered sites is the 2.5 ratio discussed in RAI 3.7-70.

GEH Response

Layered site soil Cases L-2 and L-4 are no longer excluded from the foundation stability evaluation, and all layered site soil cases are considered in the ESBWR Standard Plant design.

DCD Impact

No DCD change is required in response to this RAI.

NRC RAI 3.7-72

GEH states in the DCD, through Rev. 5, and in prior RAI responses, that ignoring embedment effects is conservative. Conceptually, the staff concurred with this. Therefore, the finding that in-structure response spectra generated at the top of the CB using the new SASSI analysis results for uniform sites with embedment significantly exceed the DAC-3N analysis results for uniform sites without embedment requires further evaluation. The staff reviewed the new response spectra comparisons included in the response to RAI 3.8-94, and noted that the significant exceedances are in the 2 horizontal directions, at about 15 Hz, for the hard uniform site.

(1) *To better characterize these results and understand this behavior, the staff requests GEH to provide separate one-to-one comparisons between DAC-3N results and SASSI results for (1) each of the 3 uniform site cases (soft, medium, hard), (2) for each direction (X,Y,Z), and (3) for the CB Top and the CB Basemat, a total of 18 comparisons.*

(2) *The staff also requests GEH to evaluate whether each "with embedment" exceedance can be explained on physical grounds, or if it is potentially an indication of a modeling or numerical error.*

GEH Response

(1) Separate one-to-one comparisons of floor response spectra between DAC3N results and SASSI results for (1) each of the 3 uniform site cases (soft, medium, hard), (2) for each direction (X,Y,Z), and (3) for the CB Top and the CB Basemat are shown in Figures 3.7-72(1) through 3.7-72(18).

The DAC3N floor response spectra at the CB Basemat envelop the SASSI floor response spectra due to the embedment effect. At the CB Top for the hard site case, the spectral peak frequencies of the SASSI floor response spectra in the horizontal directions (X,Y) shift from a peak frequency of approximately 8.5 Hz for the DAC3N results to a peak frequency of approximately 17 Hz for the SASSI results. At the CB Top for the hard site case, the spectral peak frequency of the SASSI floor response spectra in the vertical direction (Z) shifts from a peak frequency of approximately 21 Hz for the DAC3N results to a peak frequency of approximately 28 Hz for the SASSI results. This frequency shift is attributed to the constraining effect of the surrounding soil.

The embedment effect on the CB response is pronounced because a large portion (62%) of the building is embedded. As a result, the entire SSI system is much more rigid when embedment is taken into account.

(2) The "with embedment" exceedance is attributed to local amplification of the superstructure above grade. Figure 3.7-72(19) shows the comparison of the floor response spectra in the X-direction of all five floors of the CB obtained by SASSI for the hard site case. Figure 3.7-72(20) shows the corresponding DAC3N results.

Figures 3.7-72(21) and 3.7-72(22) show similar comparisons in the Y-direction. The SASSI results exhibit larger variations in response amplification between floors than the DAC3N results at locations above grade (EL 4.50).

To further confirm that the SASSI responses above grade are caused by local amplification, the two above grade floors are modeled as a two-mass system with a fixed base at grade level. The primary natural frequency of this system is calculated to be 21 Hz for the X-direction and 18 Hz for the Y-direction. Since the embedded portion is not perfectly rigid, the fixed based frequencies of the two-mass superstructure system can be considered in good agreement with the 17 Hz peak frequency of the SASSI response spectra at floors above grade for the hard site case.

Thus, it is confirmed that this “with embedment” exceedance is caused by local modes of the superstructure above grade due to the constraint effect of the surrounding hard soil below grade and is not caused by modeling nor numerical error.

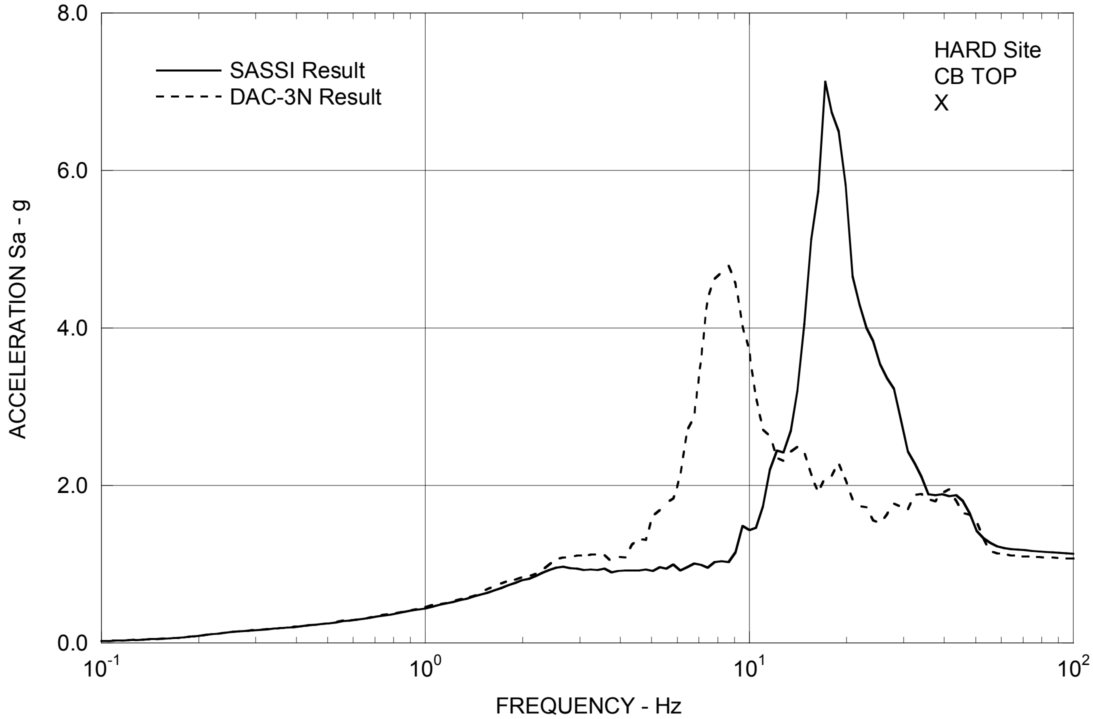

Figure 3.7-72(1) Comparison of FRS by SASSI and DAC3N
- Hard Site, CB Top, X-Direction –

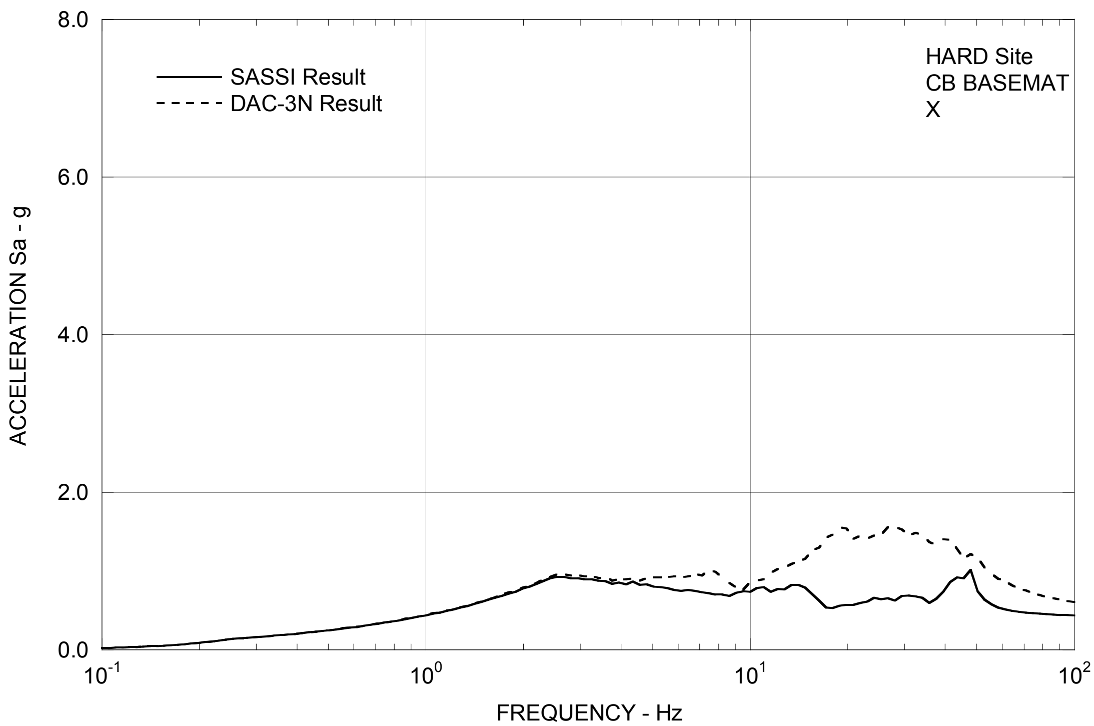

Figure 3.7-72(2) Comparison of FRS by SASSI and DAC3N
- Hard Site, CB Basemat, X-Direction -

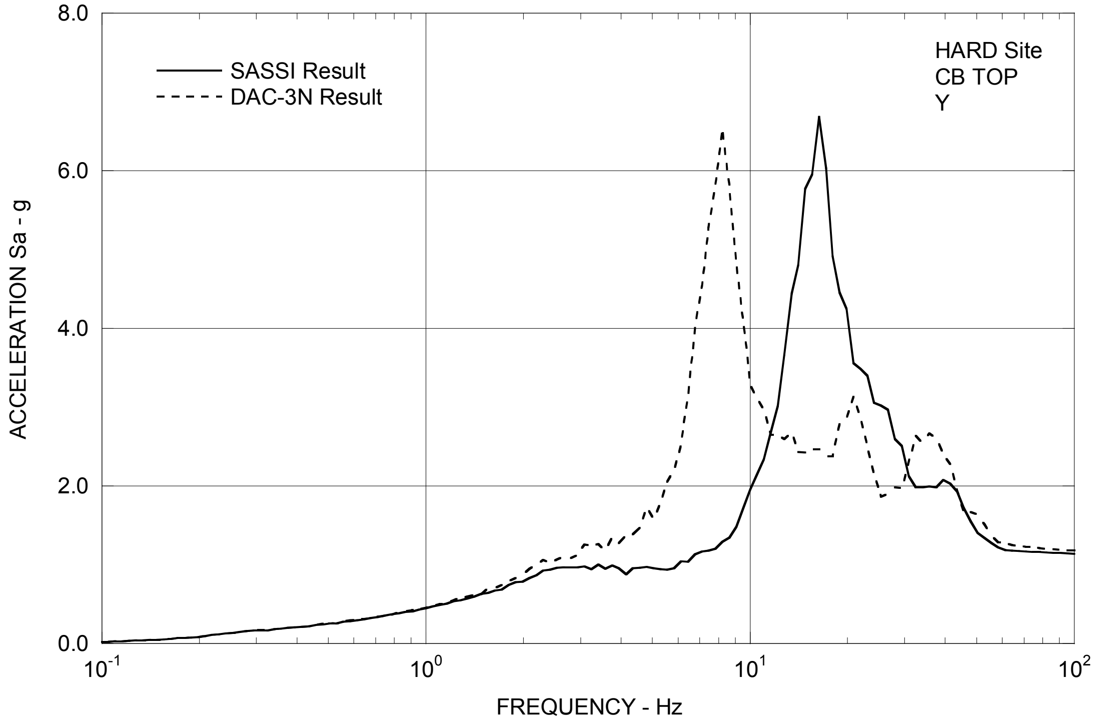

Figure 3.7-72(3) Comparison of FRS by SASSI and DAC3N
- Hard Site, CB Top, Y-Direction –

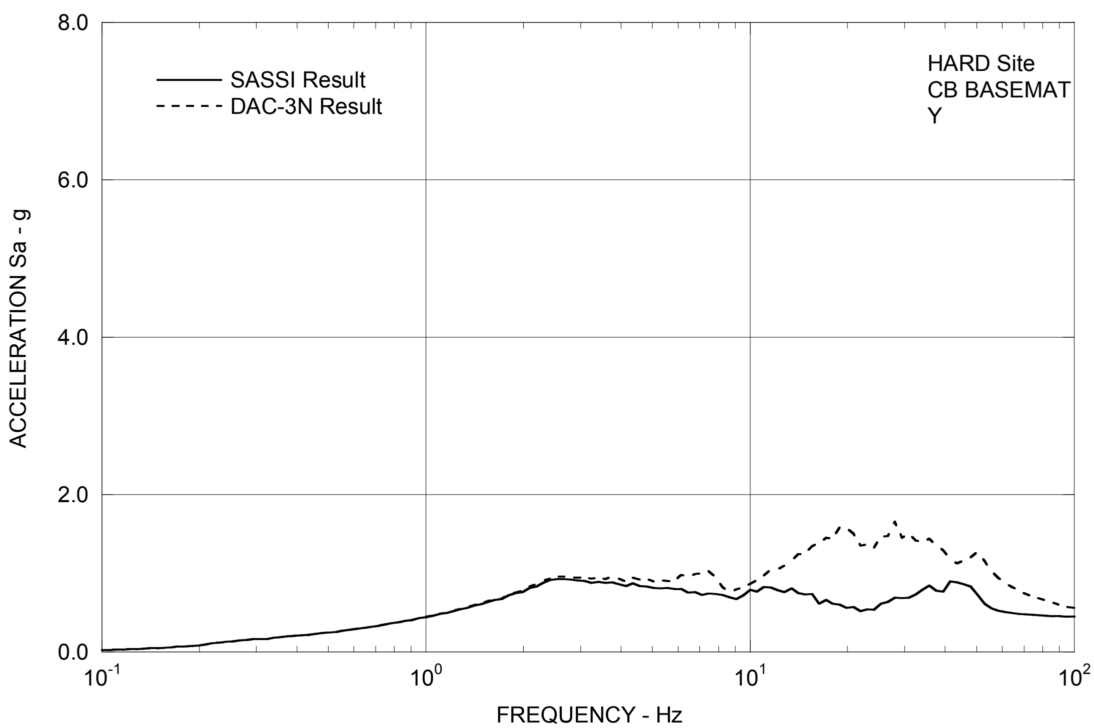

Figure 3.7-72(4) Comparison of FRS by SASSI and DAC3N
- Hard Site, CB Basemat, Y-Direction -

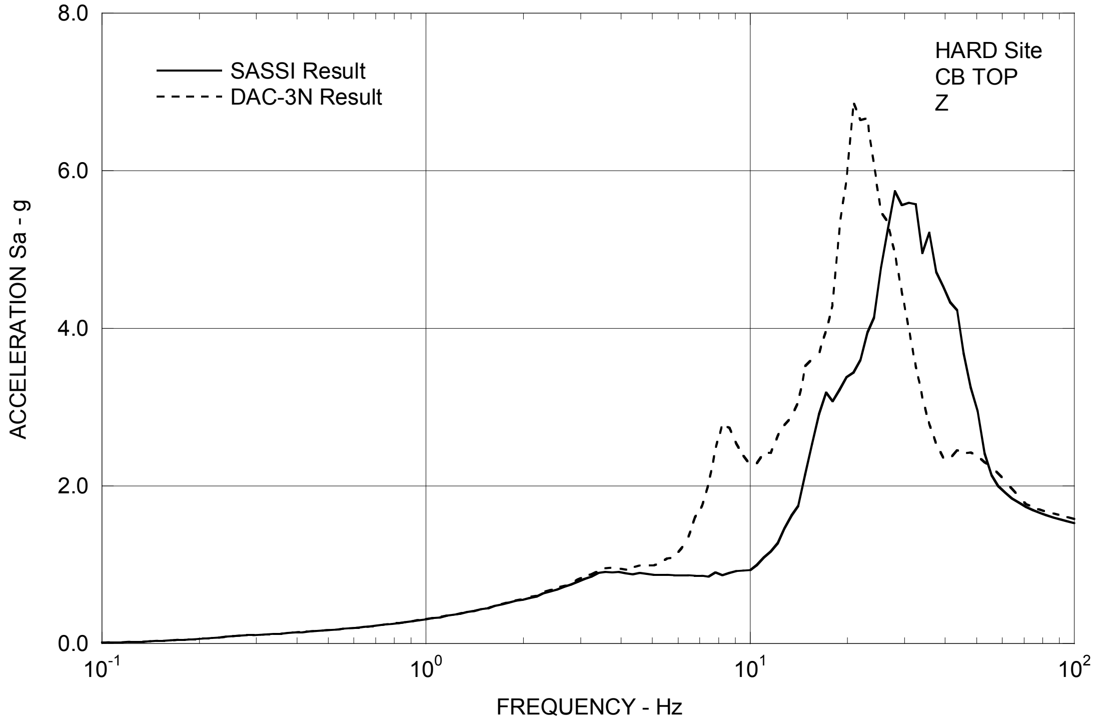

Figure 3.7-72(5) Comparison of FRS by SASSI and DAC3N - Hard Site, CB Top, Z-Direction –

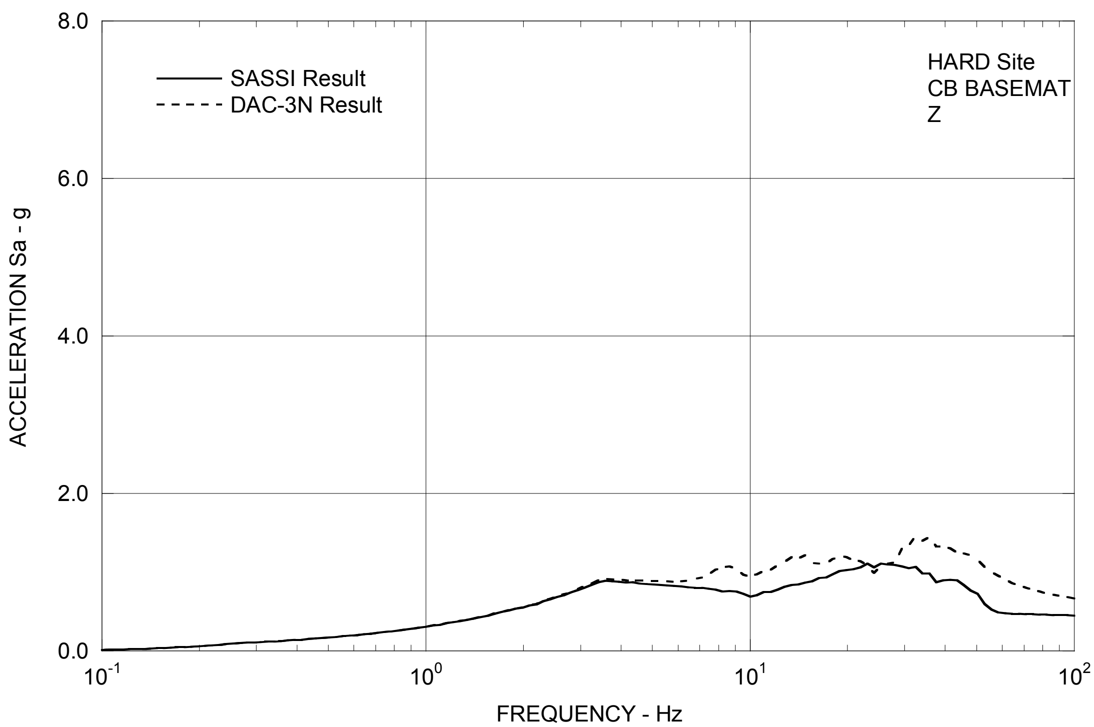

Figure 3.7-72(6) Comparison of FRS by SASSI and DAC3N - Hard Site, CB Basemat, Z-Direction -

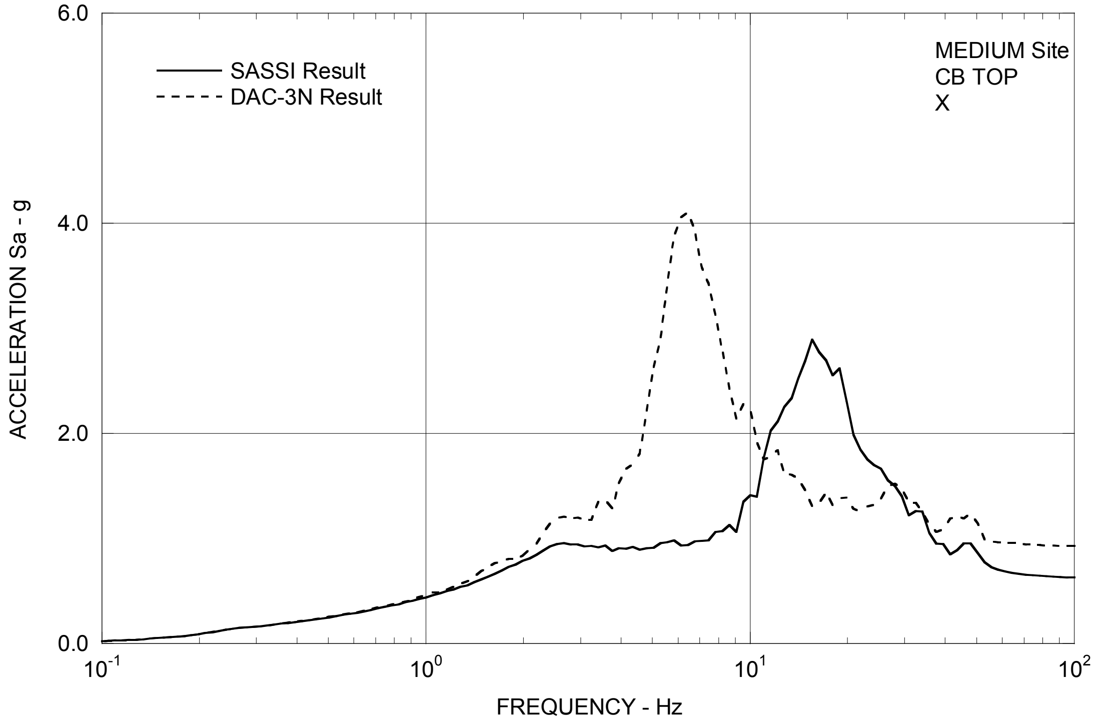

Figure 3.7-72(7) Comparison of FRS by SASSI and DAC3N - Medium Site, CB Top, X-Direction –

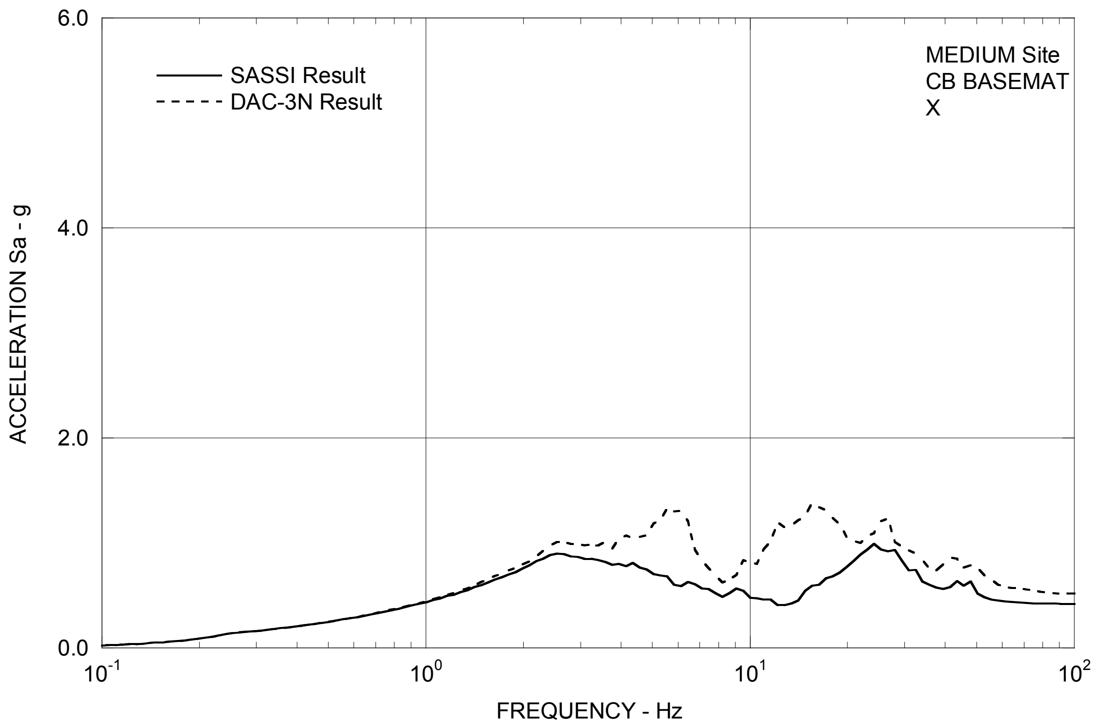

Figure 3.7-72(8) Comparison of FRS by SASSI and DAC3N - Medium Site, CB Basemat, X-Direction -

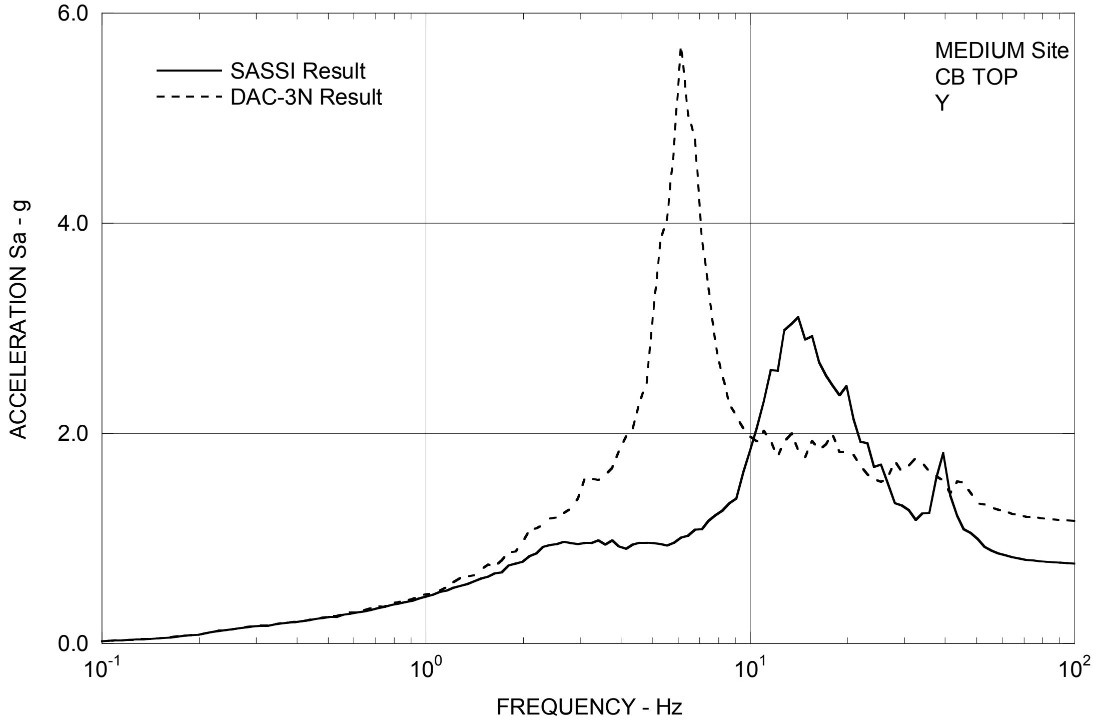

Figure 3.7-72(9) Comparison of FRS by SASSI and DAC3N
- Medium Site, CB Top, Y-Direction –

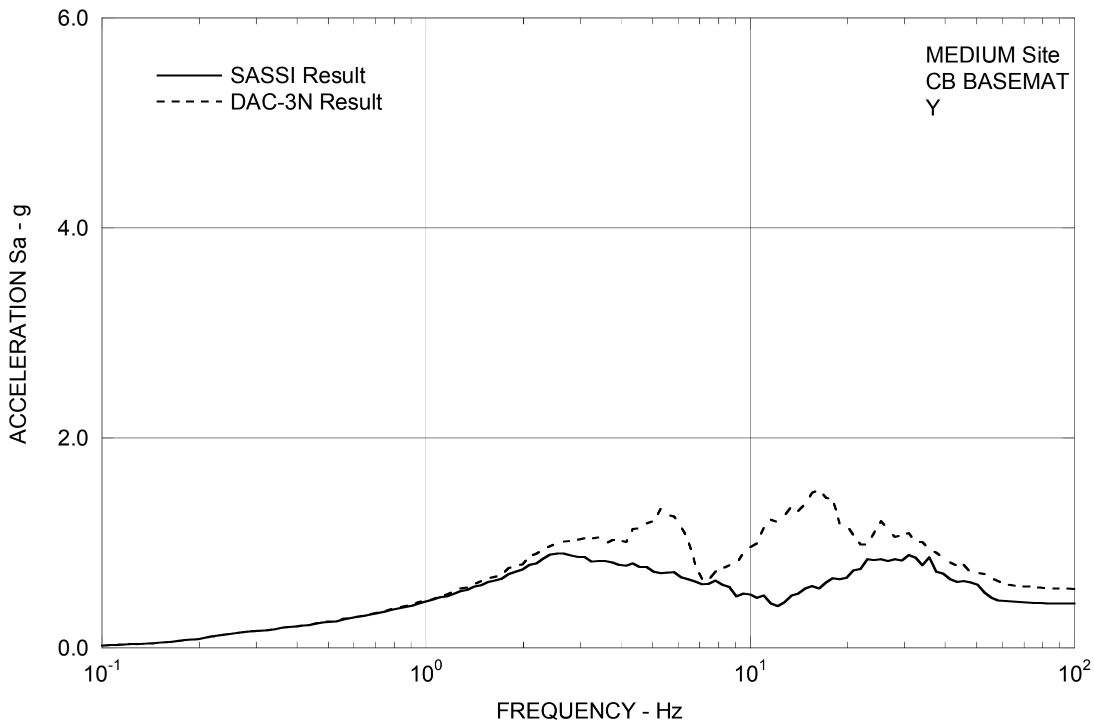

Figure 3.7-72(10) Comparison of FRS by SASSI and DAC3N
- Medium Site, CB Basemat, Y-Direction -

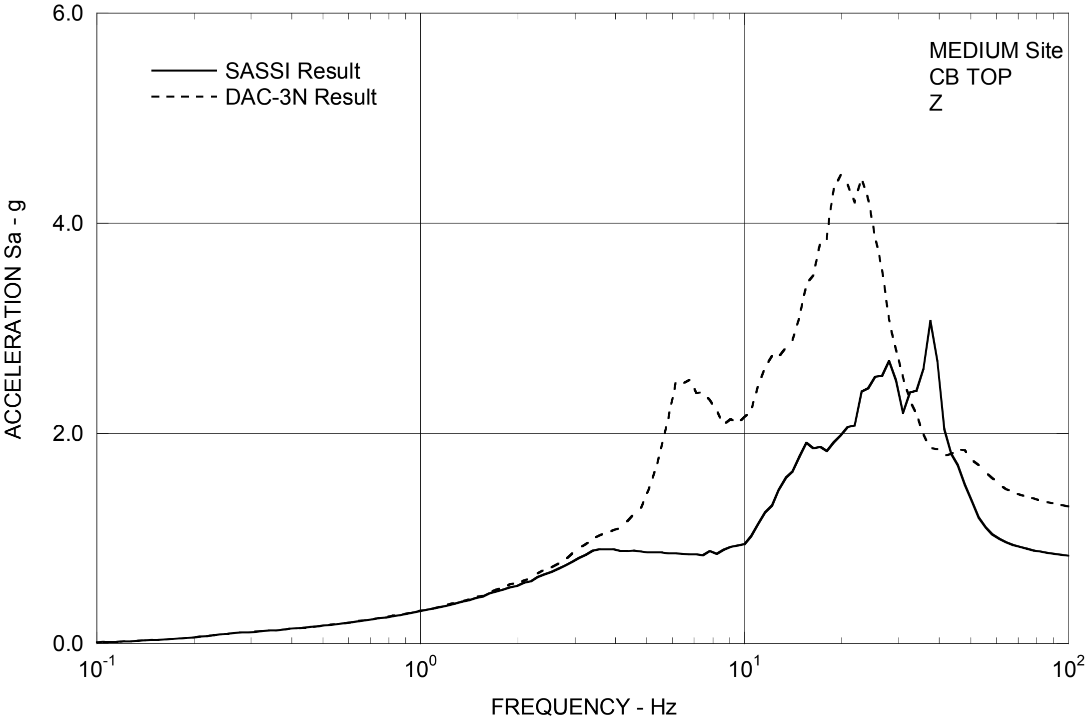

Figure 3.7-72(11) Comparison of FRS by SASSI and DAC3N - Medium Site, CB Top, Z-Direction –

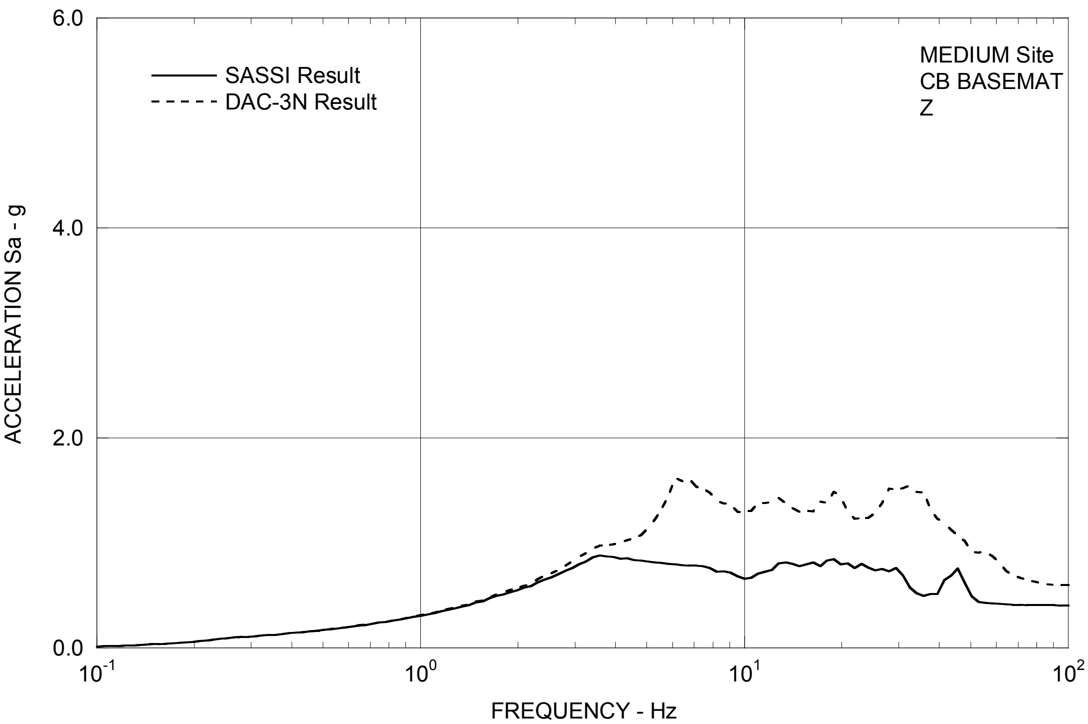

Figure 3.7-72(12) Comparison of FRS by SASSI and DAC3N - Medium Site, CB Basemat, Z-Direction –

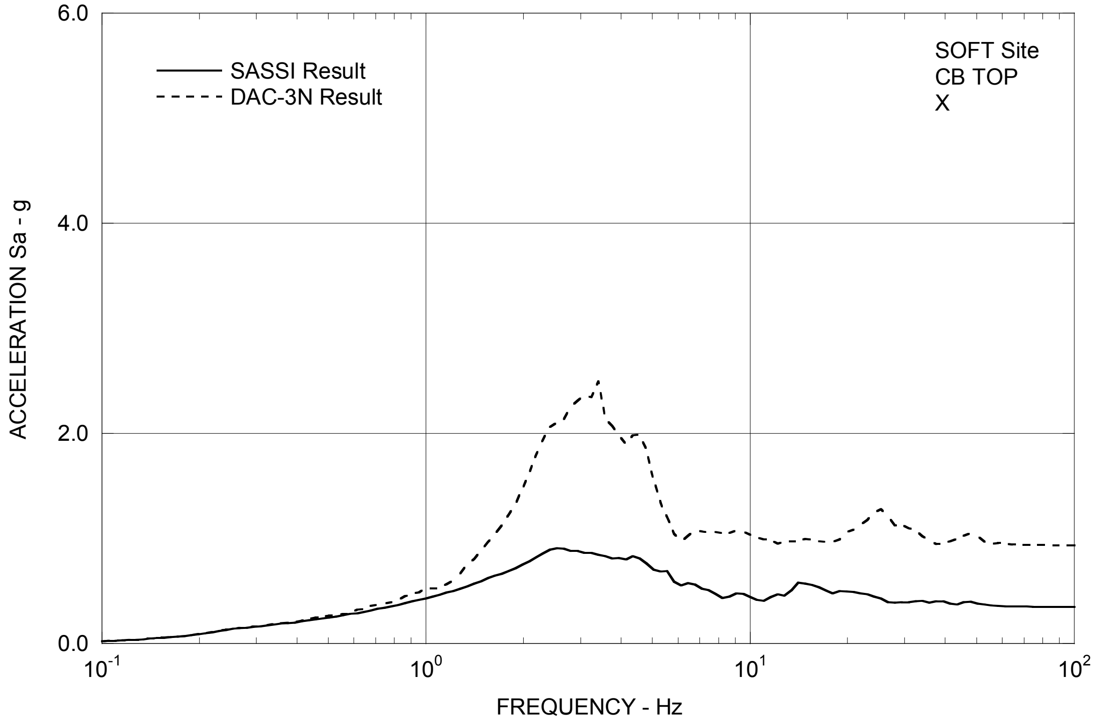

Figure 3.7-72(13) Comparison of FRS by SASSI and DAC3N - Soft Site, CB Top, X-Direction –

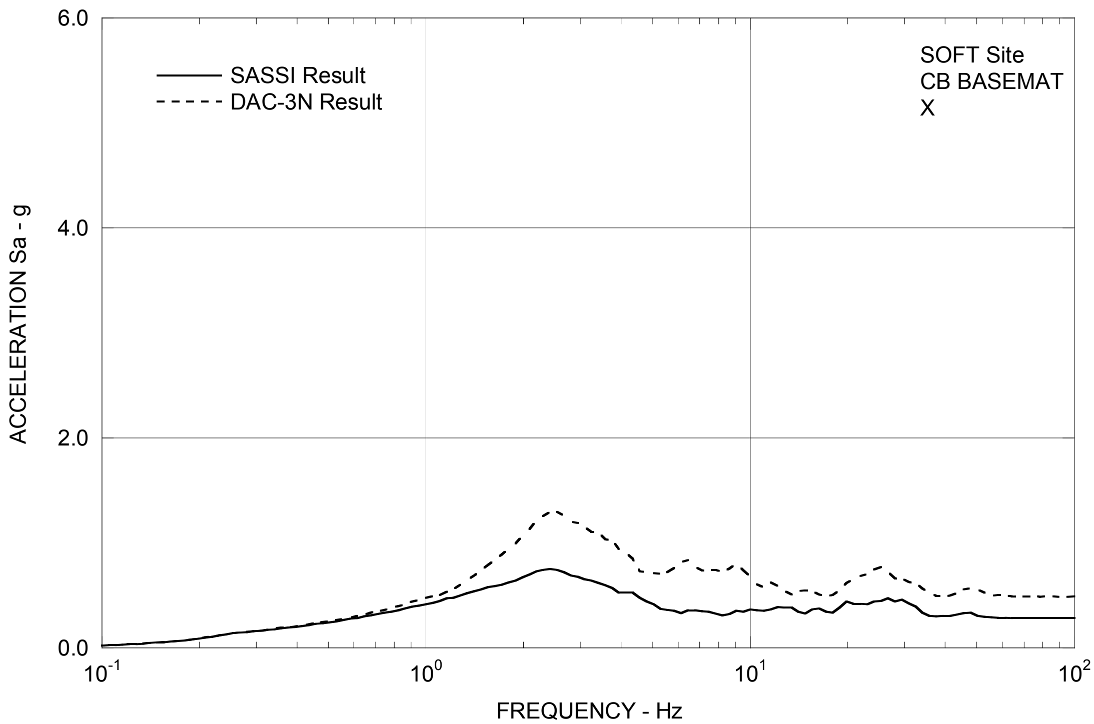

Figure 3.7-72(14) Comparison of FRS by SASSI and DAC3N - Soft Site, CB Basemat, X-Direction –

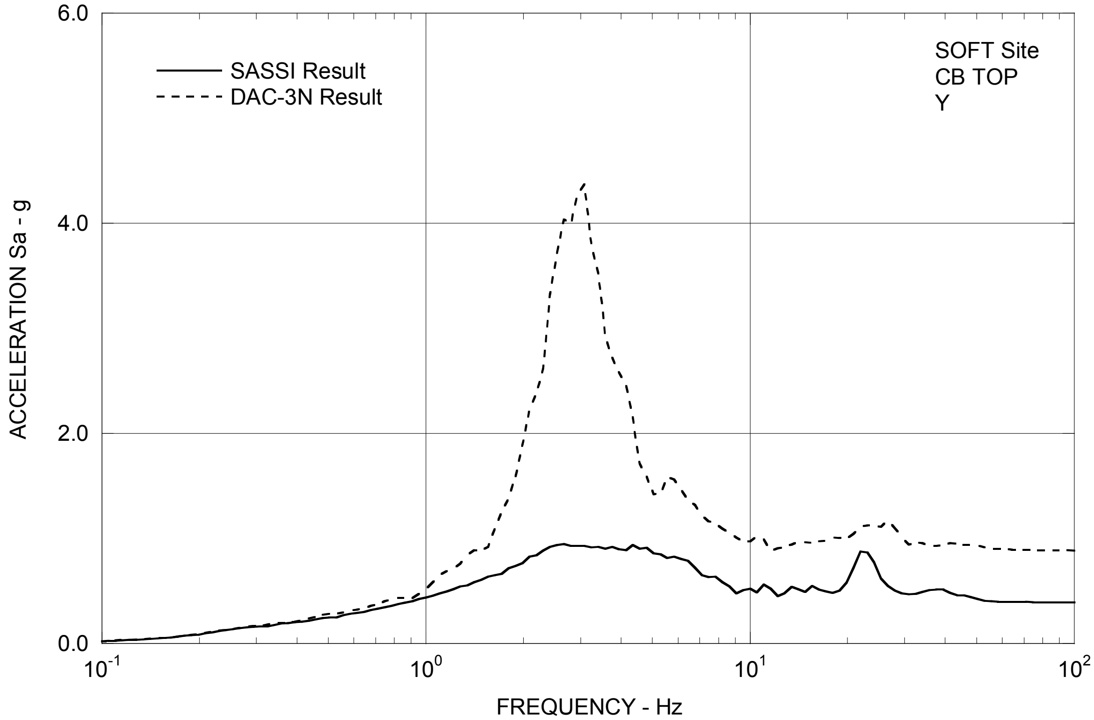

Figure 3.7-72(15) Comparison of FRS by SASSI and DAC3N
- Soft Site, CB Top, Y-Direction –

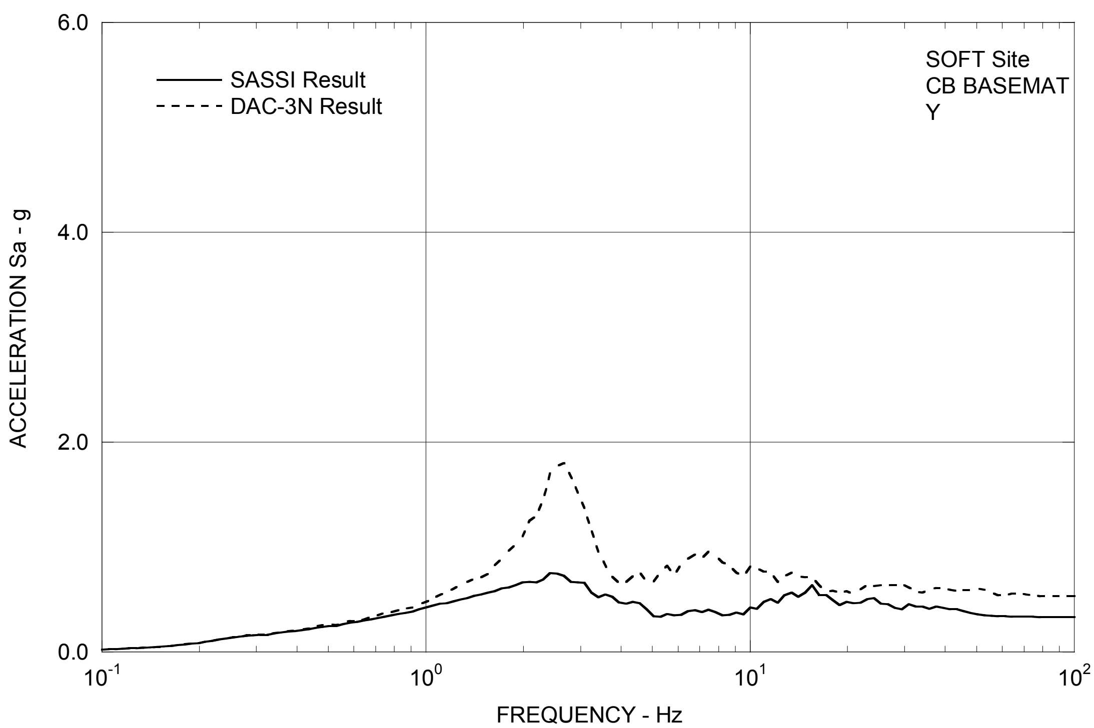

Figure 3.7-72(16) Comparison of FRS by SASSI and DAC3N
- Soft Site, CB Basemat, Y-Direction -

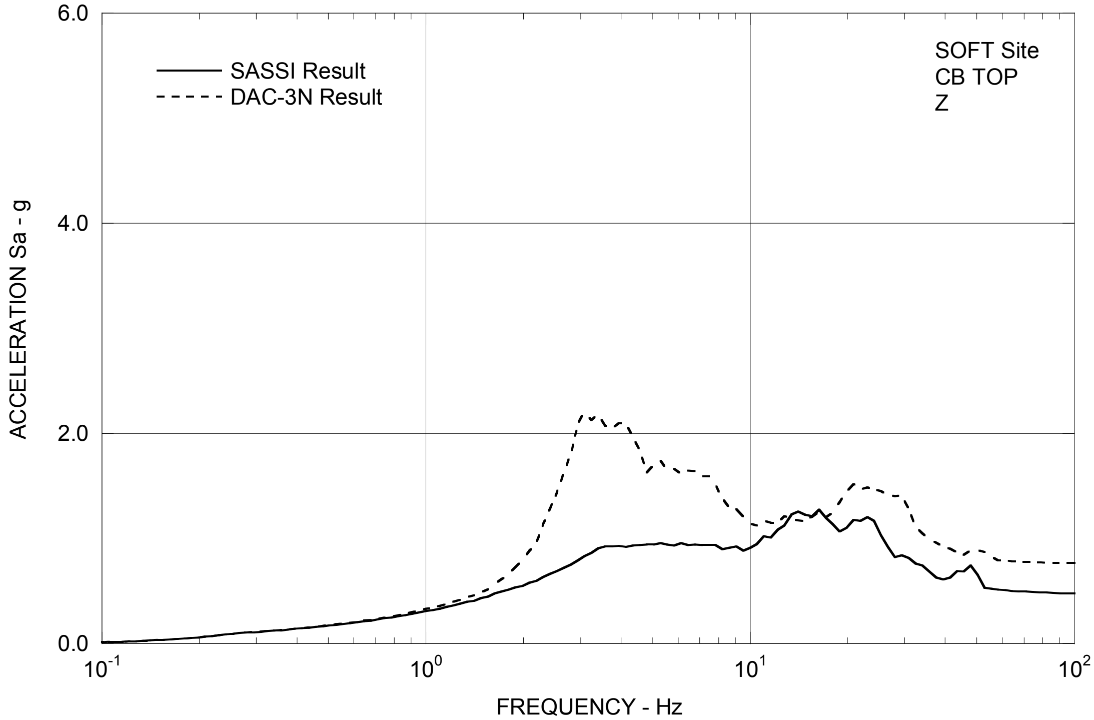

Figure 3.7-72(17) Comparison of FRS by SASSI and DAC3N
- Soft Site, CB Top, Z-Direction –

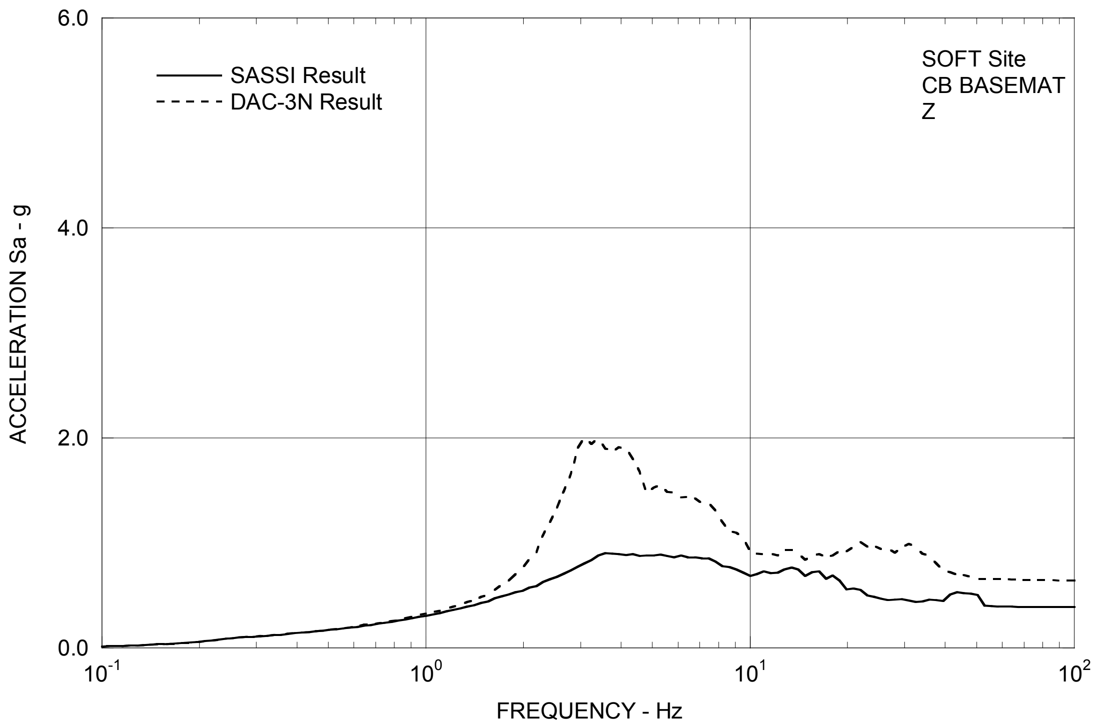

Figure 3.7-72(18) Comparison of FRS by SASSI and DAC3N
- Soft Site, CB Basemat, Z-Direction -

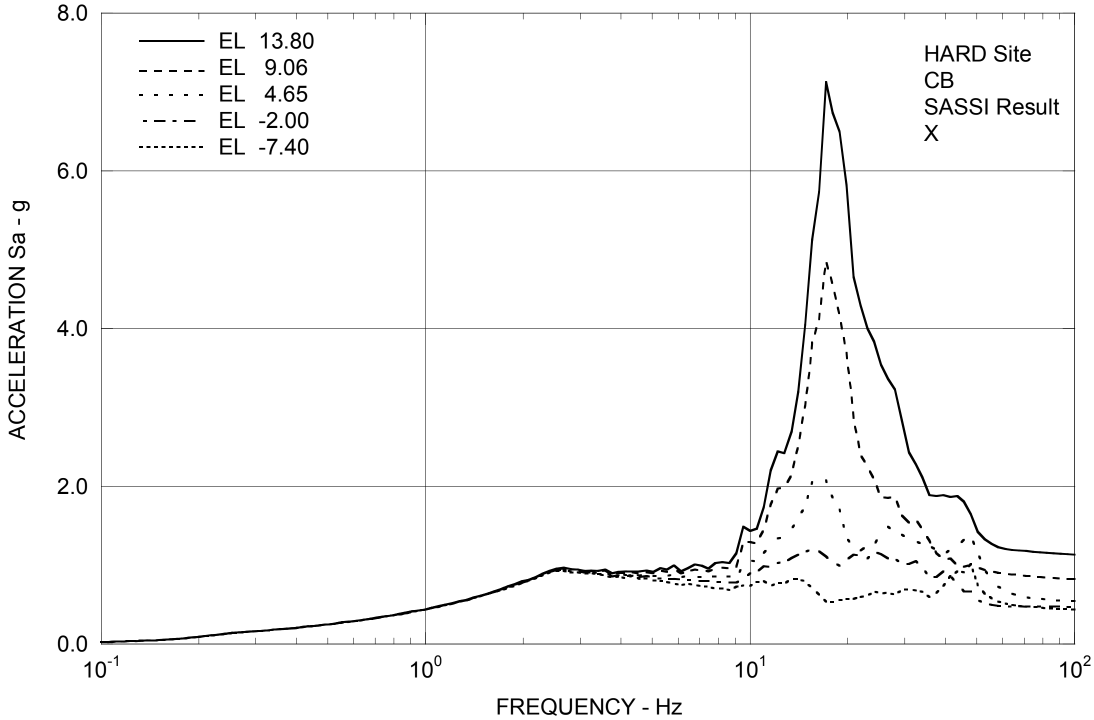

Figure 3.7-72(19) Comparison of FRS by SASSI
- Hard Site, CB, X-Direction –

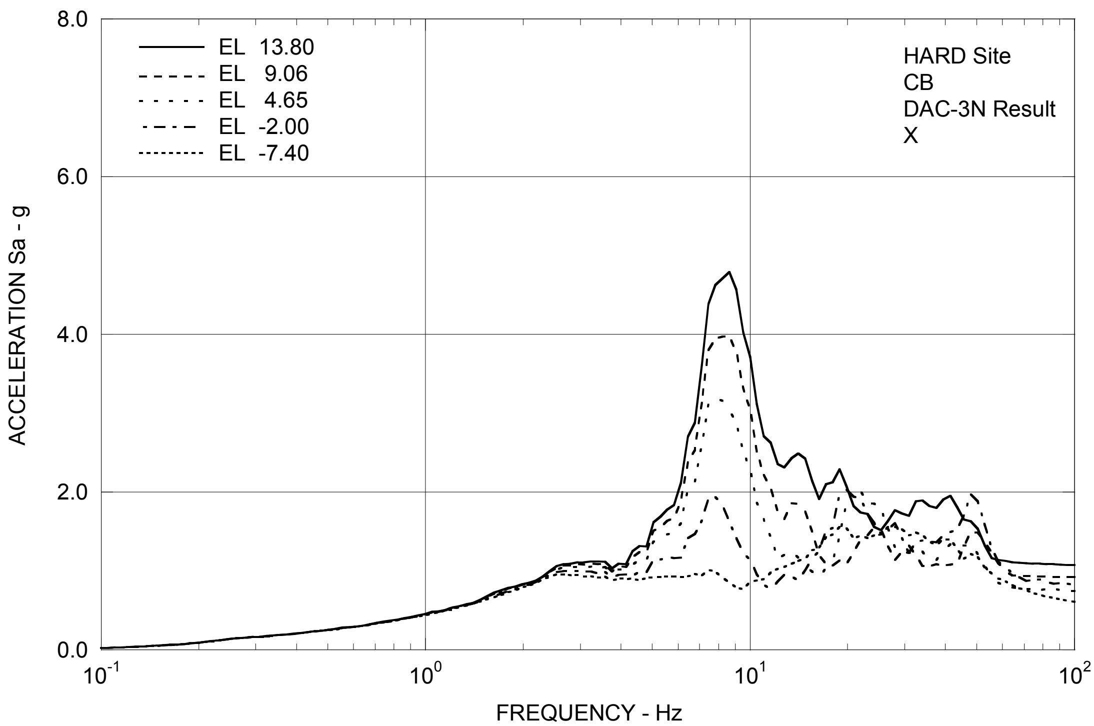

Figure 3.7-72(20) Comparison of FRS by DAC3N
- Hard Site, CB, X-Direction –

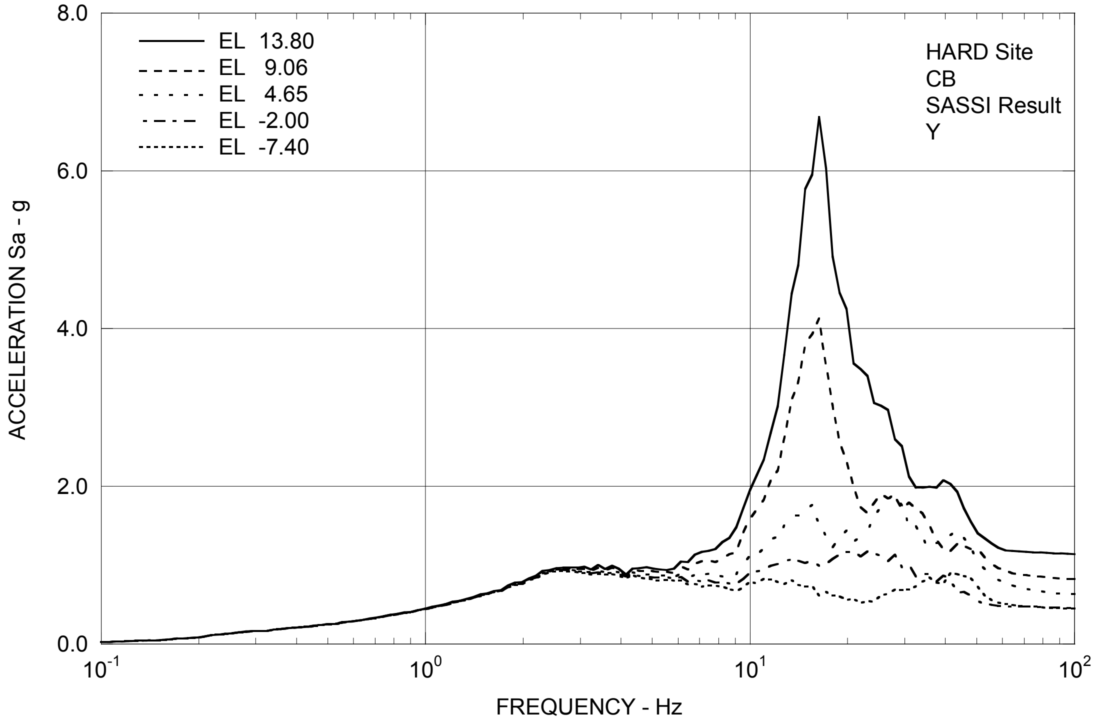

Figure 3.7-72(21) Comparison of FRS by SASSI - Hard Site, CB, Y-Direction –

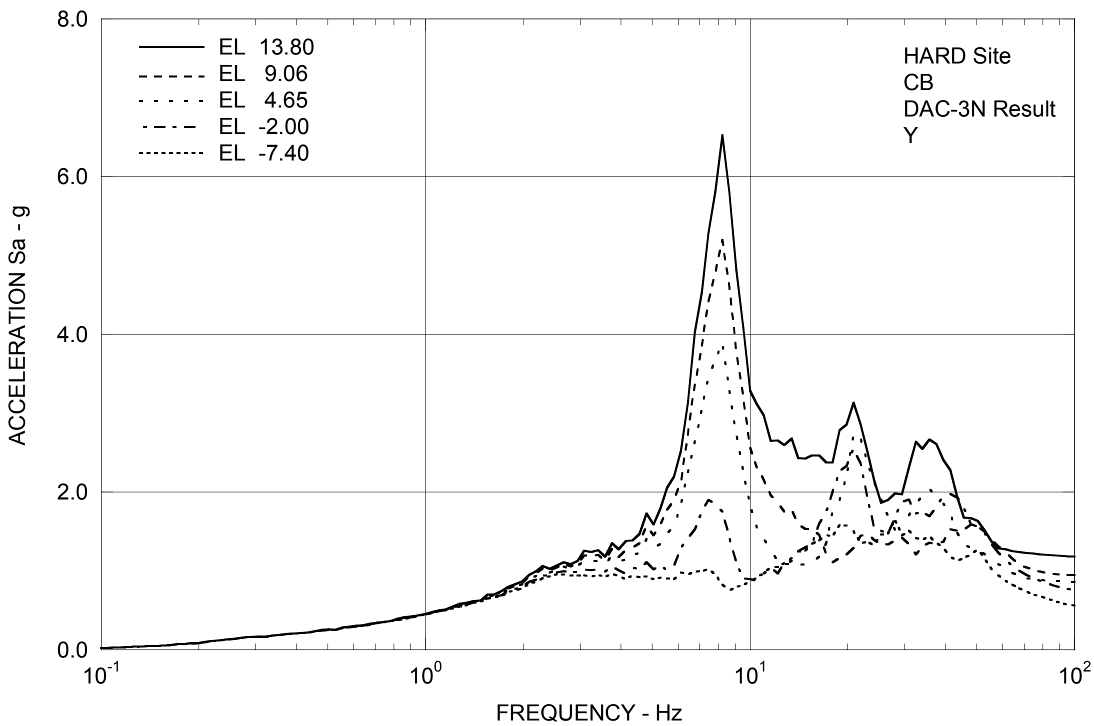

Figure 3.7-72(22) Comparison of FRS by DAC3N - Hard Site, CB, Y-Direction –

DCD Impact

No DCD change is required in response to this RAI.