RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

3/24/2014

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 1060-7285 REVISION 4**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**11/15/2013**

QUESTION NO. 03.07.02-231:

The applicant submitted information in support of the adequacy of the design-basis ACS-SASSI soil-structure interaction (SSI) analysis model using the Modified Subtraction Method (MSM) in the response to RAI 812-5983, Question 03.07.02-109. The RAI response does not provide sufficient information for the staff to make a definitive determination of the acceptability of the applicant's implementation of the MSM for the US-APWR SSI analyses. To assist the staff in its review, the applicant is requested to provide the following additional information:

(1) The RAI response indicates there are “minor differences” between the model of the Reactor Building (R/B) complex used in the two comparison studies described therein, and the model documented in technical report MUAP-10006, "Soil-Structure Interaction Analysis and Results for the US-APWR Standard Plant," Revision 3. However, there is no discussion of the differences in the RAI response. Describe the model differences and explain why they are judged to be not significant for the comparison studies.

(2) Identify the S-wave passing frequencies for each of the models used in the two comparison studies described in the RAI response. Passing frequencies and corresponding layer/mesh sizes for vertical and horizontal East-West and North-South directions should be clearly identified for all the soil layers.

(3) For all six (6) soil cases described in technical report MUAP-10006, Revision 3, identify the fundamental natural frequency of the excavated soil mesh used to define the embedded SSI model of the R/B complex. Since prior staff experience indicates that any anomalies in the MSM analysis are likely to appear at or above these natural frequencies, discuss whether any identifiable anomalies exist in the computed transfer functions, at or above the natural frequency of the excavated soil mesh, in any of the comparison studies or design basis analyses performed, including the additional study requested in item (5) below.

(4) The bonding of the embedded structure to the side soil differs in the studies described in the RAI response and in the design basis analysis described in the technical report MUAP-10006, Revision 3. The comparison study denoted “study 1” in the RAI response considers both unbonded and fully bonded cases, but the comparison study denoted “study 2” considers only the unbonded case. In MUAP-10006, Revision 3, on the other hand, only fully

bonded conditions are considered. To assess the impact of the unbonded vs. bonded assumption, provide additional figures that compare the results for the unbonded vs. bonded cases that correspond to Figures 1 through 4 in the RAI response (study 1).

(5) The comparison studies described in the RAI response consider only soil cases 270-200 and 560-500. Provide the results of an additional MSM vs. Direct Method (DM) comparison study that considers soil case 900-100 and the fully-bonded model used in study 1 (kinematic interaction model). The shear wave passing frequency in this additional study should be at least as high as the passing frequency in the design basis analysis for this soil case (approx. 40 Hz).

ANSWER:

(1) The study, as described in the response to RAI 812-5983, Question 03.07.02-109, was performed on models developed based on an in-progress version of the Reactor Building Complex (R/B). The in-progress version of the R/B complex consisted of prestressed concrete containment vessel (PCCV), containment internal structure (CIS), east and west power source buildings (PS/Bs), and the auxiliary building (A/B) supported on a common basemat.

Aside from localized minor differences on thickness of a few walls, the major difference between the in-progress version of R/B complex and the final R/B complex, as documented in Technical Report MUAP-10006 Rev. 3, is that the in-progress version does not include the essential service water pipe chase (ESWPC) as shown in Figure 1. However, ESWPC only represents about an 8% increase of the foundation size in the plant's north - south direction. The foundation size in the east - west direction and the foundation embedment depth are the same for the two versions. The dynamic mass of the ESWPC is negligible when compared to the total dynamic mass of the R/B complex.

Therefore, the differences do not compromise the validity of the conclusion of the study.

(2) Tables 1 through 3 provide the S-wave passing frequencies for each of the models used in the two comparison studies described in the RAI response. Study 1 used the same excavated volume discretization with uniform horizontal meshing for Modified Subtraction Method (MSM) and Flexible Volume Method (FVM). The excavated volume for Study 2, which included finite element model of the full superstructure, used different excavated soil meshing for MSM and FVM. Study 2 models have non-uninform horizontal mesh. The horizontal passing frequencies as listed in the tables are calculated for the maximum mesh size, 9.0 ft for both NS and EW directions.

(3) Table 4 provides the fundamental natural frequencies of the excavated volumes for the six soil cases used to define the embedded Soil-Structure Interaction (SSI) model of the R/B complex. They are obtained from modal analysis using ANSYS on the excavated volumes with fixed boundary condition imposed on the top, bottom and lateral surfaces of the excavated soil volume models. The transfer functions at various locations in R/B complex for the comparison study and design basis SSI analysis performed have been reviewed for anomalies. No anomalies due to the use of MSM were found.

(4) Acceleration Transfer function (ATF) comparison plots obtained from the Study 1 for unbonded vs. fully bonded are provided as shown in Figure 2 through Figure 5. The corresponding 5% damped Acceleration Response Spectra (ARS) comparison plots are provided in Figure 6 through Figure 9 In both the ATF and the ARS plots, the unbonded

case (UE) is represented by a red line and the fully bonded case (FBE) is represented by a blue line. Please note that the comparisons are made for the response from kinematic interaction only. See response to Question 03.07.02-233 Part 2 for the embedment condition effects on the seismic response of the R/B complex including both effects of inertia and kinematic interactions.

(5) The results of an additional MSM vs.FVM (or Direct Method (DM)) comparison study that considers soil case 900-100 and the fully-bonded model used in study 1 (kinematic interaction model) will be performed as outlined by the Staff in item (5) of this RAI.

Table 1 Excavated Volume Mesh Wave Passage Frequencies of Study 1 Models

Vertical Mesh For S-Wave			
Layer	Thicness Size (ft)	Wave Passage Frequencies (Hz)	
		270-200	560-500
1	5.583	46.4	38.2
2	5.583	46.3	49.4
3	7.000	36.2	39.3
4	5.375	45.5	53.2
5	5.375	44.6	53.6
6	6.667	36.5	48.3
7	6.667	36.8	49.3
Horizontal Mesh For S-Wave in NS and EW Direction			
Layer	Mesh Size (ft)	Wave Passage Frequencies (Hz)	
		270-200	560-500
1	9.0	28.8	23.7
2	9.0	28.7	30.6
3	9.0	28.1	30.6
4	9.0	27.2	31.7
5	9.0	26.6	32.0
6	9.0	27.1	35.8
7	9.0	27.2	36.5

Table 2 Excavated Volume Mesh Wave Passage Frequencies of Study 2 Models (MSM)

Vertical Mesh For S-Wave (MSM)		
Layer	Thickness (ft)	Wave Passage Frequency (Hz)
		560-500
1	5.583	38.2
2	5.583	49.4
3	7.000	39.3
4	5.375	53.2
5	5.375	53.6
6	6.667	48.3
7	6.667	49.3
Horizontal Mesh for S- Wave in NS and EW Direction (MSM)		
Layer	Mesh Size (ft)	Wave Passage Frequency (Hz)
		560-500
1	9.0	23.7
2	9.0	30.6
3	9.0	30.6
4	9.0	31.7
5	9.0	32.0
6	9.0	35.8
7	9.0	36.5

Table 3 Excavated Volume Mesh Wave Passage Frequencies of Study 2 Model (FVM)

Vertical Mesh for S Waves (FVM)		
Layers	Thickness (ft)	Wave Passage Frequency (Hz)
		560-500
1	10.562	22.6
2	10.563	26.3
3	10.562	27.8
4	10.563	31.2
Horizontal Mesh for S- Wave in NS and EW Direction (FVM)		
Layers	Mesh Size (ft)	Wave Passage Frequency (Hz)
		560-500
1	9.0	26.5
2	9.0	30.9
3	9.0	32.7
4	9.0	36.6

Table 4 Fundamental Natural Frequencies of the Excavated Volumes

Soil Case	Fundamental Frequency (Hz)	
	NS Direction	EW Direction
270-200	16.4	16.1
270-500	15.7	15.4
560-500	18.0	17.4
900-100	28.1	28.0
900-200	28.3	28.1
2032-100	71.8	71.6

Security-Related Information – Withheld Under 10 CFR 2.390

Figure 1 Sectional View the R/B Complex

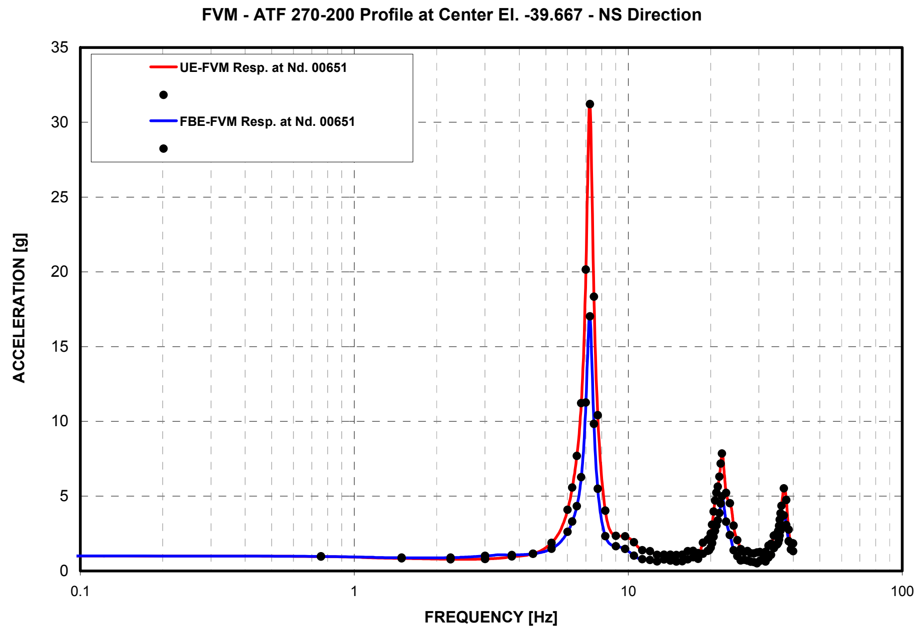

Figure 2 ATF at Center, Basemat Bottom (el. -39.667 ft), NS Direction, FVM,270-200 Soil

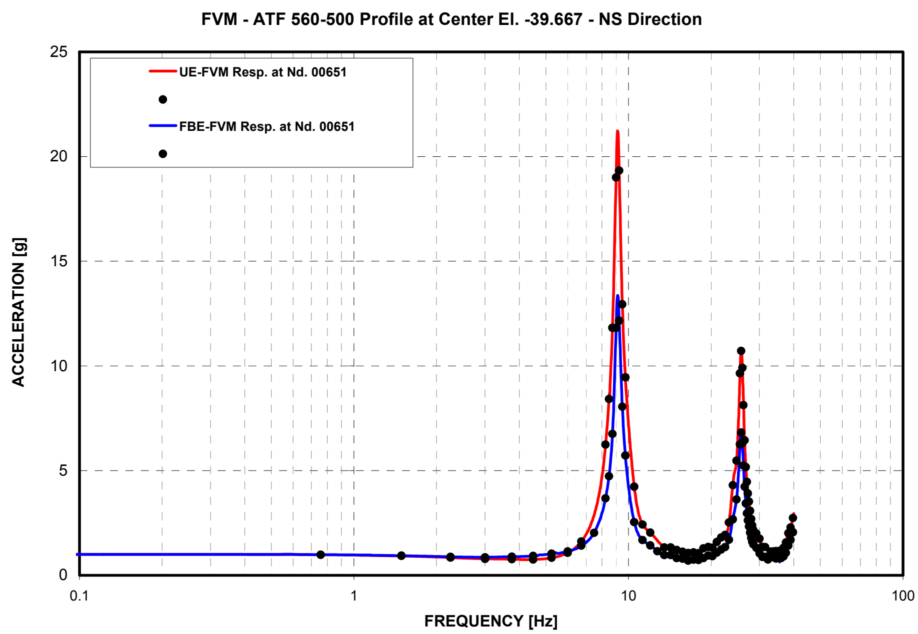

Figure 3 ATF at Center, Basemat Bottom (el. -39.667 ft), NS Direction, FVM,560-500 Soil

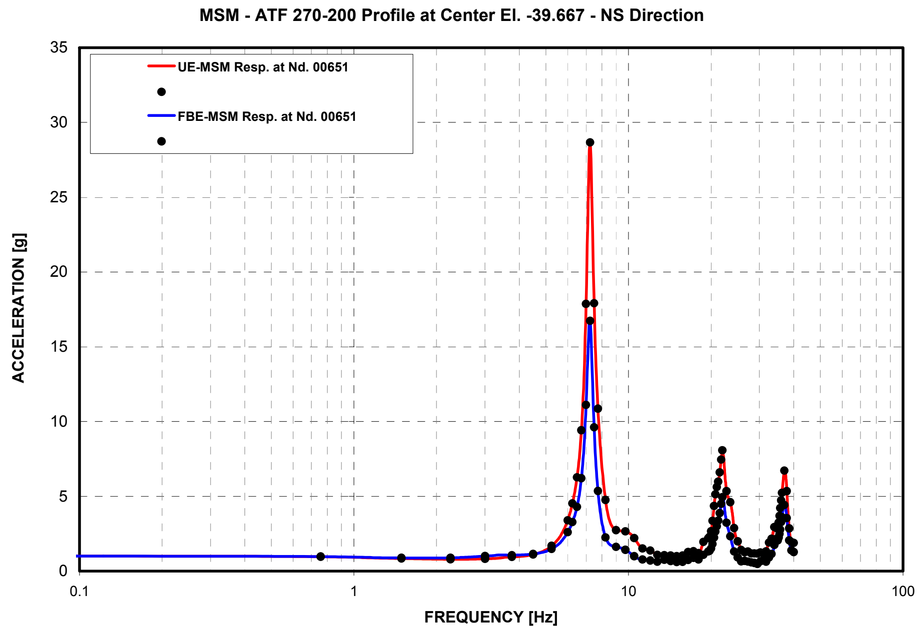

Figure 4 ATF at Center, Basemat Bottom (el. -39.667 ft), NS Direction, MSM,270-200 Soil

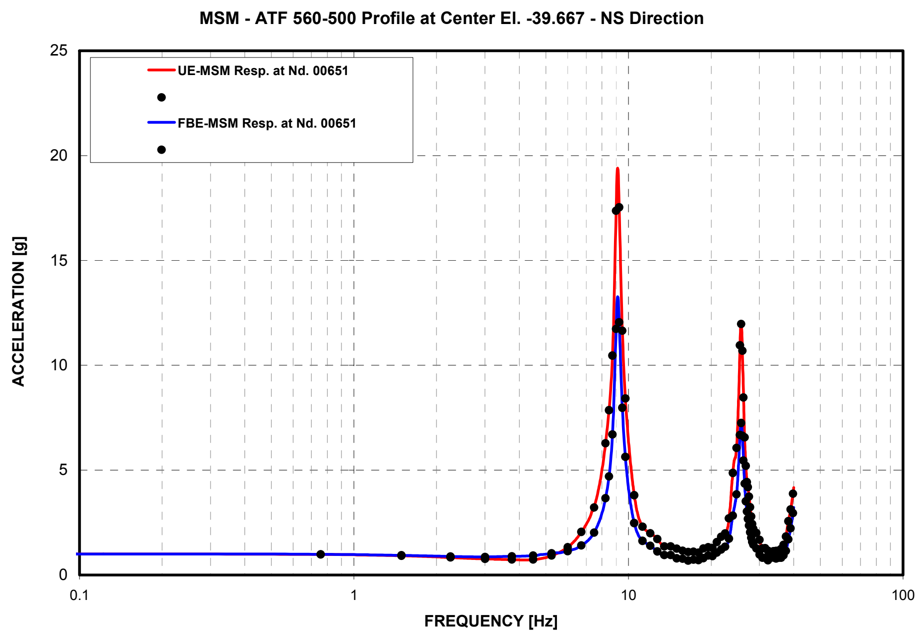

Figure 5 ATF at Center, Basemat Bottom (el. -39.667 ft), NS Direction,MSM,560-500 Soil

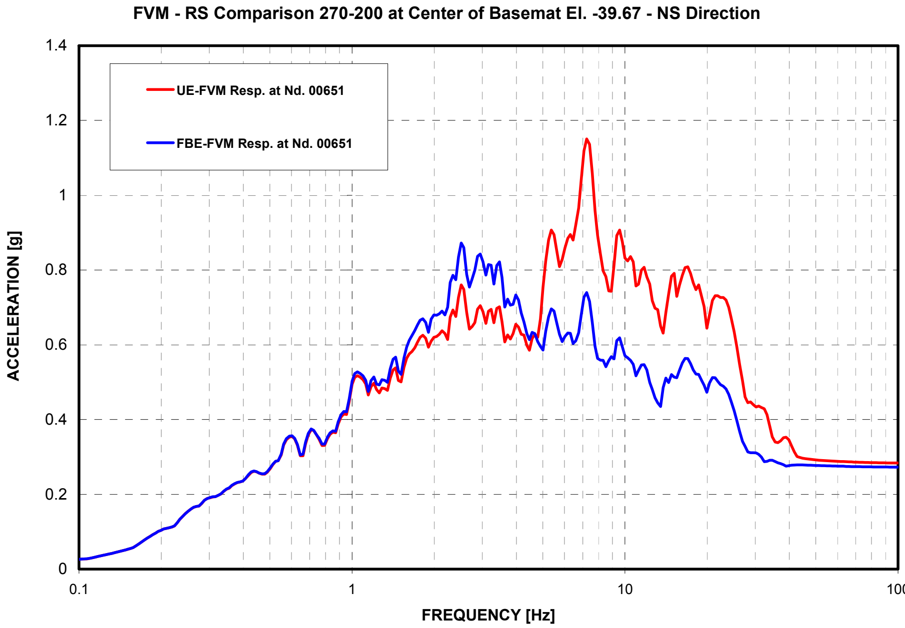

Figure 6 5% Damping ARS at Center, Basemat Bottom (el.-39.667 ft), NS Direction, FVM, 270-200 Soil

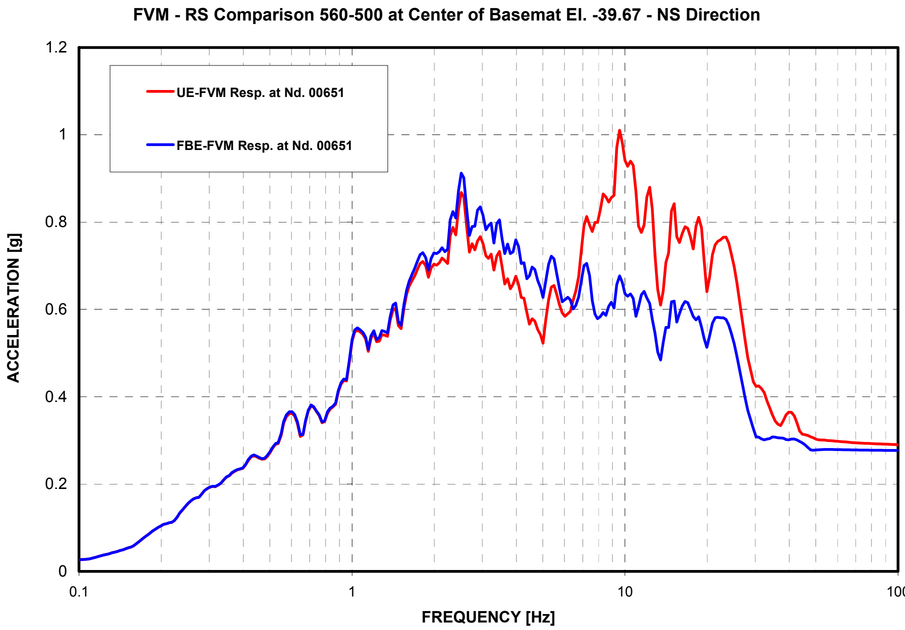

Figure 7 5% Damping ARS at Center, Basemat Bottom (el.-39.667 ft), NS Direction, FVM, 560-500 Soil

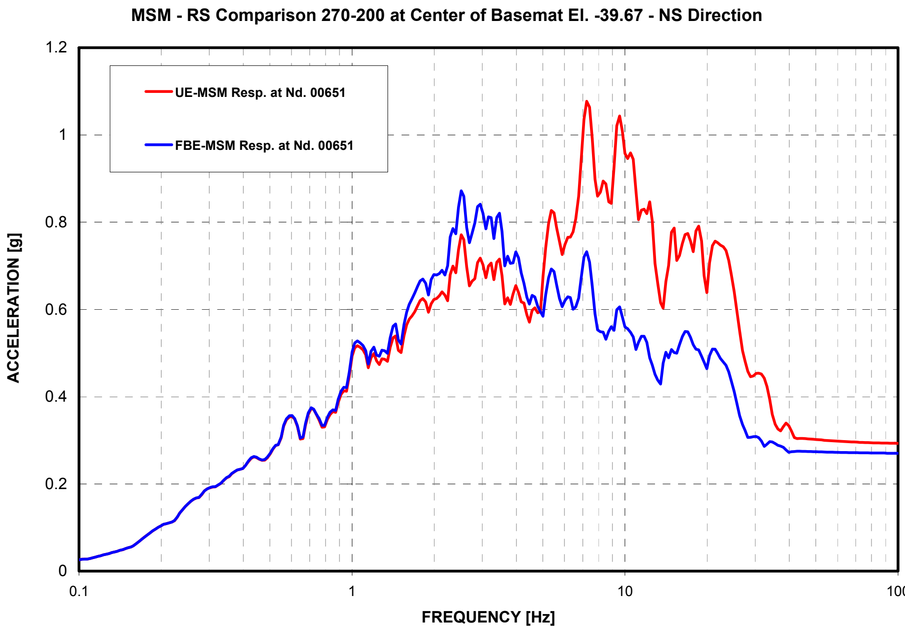

Figure 8 5% Damping ARS at Center, Basemat Bottom (el.-39.667), NS Direction, MSM, 270-200 Soil

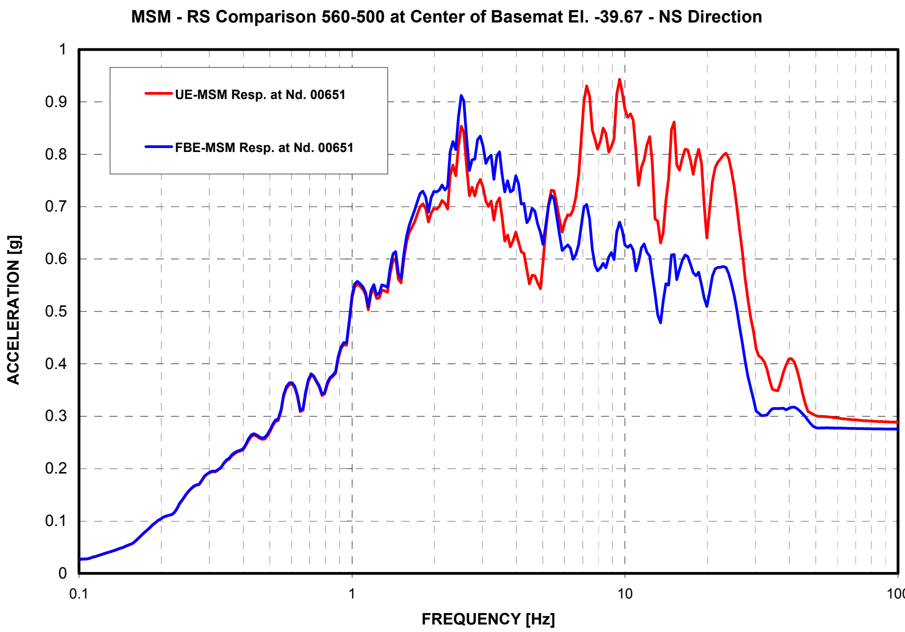

Figure 9 Damping ARS at Center, Basemat Bottom (el.-39.667), NS Direction, MSM, 560-500 Soil

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on the Technical/Topical Report.

This completes MHI’s response to the NRC’s question.