RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

02/27/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 812-5983 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**08/23/2011**

QUESTION NO. 03.07.02-109:

In section 3.7.2.1 of the DCD (R3), the Applicant stated that the seismic response of standard plant seismic category I and II structures is obtained from site-independent analyses performed using three-dimensional SSI models with the program ACS SASSI. The applicant is requested to clarify whether the flexible volume method or subtraction method is used in performing the SSI analysis with ACS SASSI computer program and provide the technical basis and justification for the method used in the SSI analysis.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-11325 (ML11269A025).

The design-basis Soil-Structure Interaction (SSI) analyses for the standard plant Reactor Building (R/B) complex are performed using the Modified Subtraction Method. The design-basis SSI analyses for the Turbine Building (T/B) complex are being performed using the Flexible Volume Method (FVM). Compared to the Subtraction Method, the Modified Subtraction Method (MSM) adds the surface nodes of the excavated volume as interaction nodes in the analysis. The Subtraction Method is not used in performing the SSI analysis with ACS SASSI for either the R/B complex or the T/B complex.

Two studies were performed to numerically demonstrate the adequacy of using the MSM for SSI analysis of R/B complex. The studies compared the seismic responses obtained using FVM and MSM. Acceleration Transfer Function (ATF) and Acceleration Response Spectra (ARS) at various locations are compared. The studies were performed based on a model of the R/B complex structure that consisted of the Prestressed Concrete Containment Vessel (PCCV), Containment Internal Structure (CIS), east and west Power Source Buildings (PS/Bs), Auxiliary Building (A/B) supported on a common basemat. There are minor differences between this version of R/B complex and the R/B complex documented in Technical Report MUAP-10006 Rev. 3. The differences do not compromise the validity of the conclusion of the studies.

Table 1 presents the matrix for the studies. Study 1 was performed on the embedded massless basement (i.e., part of the building below finished grade) model and Study 2 was on an embedded model simulating mass and stiffness of both the basement and the superstructure. The massless basement model has comparable stiffness with the basement of the full structural model but simplifications were made to permit uniform meshing and allow adequate seismic wave transmitting capability of the excavated volume mesh. In Study 1, the same excavated volume mesh was analyzed using both MSM and FVM while excavated volume vertical meshing of Study 2 is different for MSM and FVM. Study 2 FVM vertical mesh of the excavated volume is coarser than MSM because of computational power limitation. The number of interaction nodes will significantly increase if the more detailed model used for MSM analyses is analyzed using the FVM. Different embedment conditions, i.e., contact conditions of basement perimeter walls and side soils were considered in the studies. The fully bonded embedment condition, which is considered in the design basis model as documented in Technical Report MUAP-10006 Rev. 3, assumes no separation between the walls and soils while unbonded condition assumes no contact between side walls and soils during earthquake excitation. Table 1 also presents soil profiles analyzed in the studies. Any difference of results obtained using MSM and FVM, if there are any, will occur for soft soils at relative high frequency range. Therefore soil profiles 270-200 and 560-500 were analyzed in the studies.

Responses of the soil and massless basement system obtained from Study 1 revealed kinematic SSI effect, i.e., effect of foundation stiffness on the seismic input motion. Study 2 performed SSI analyses on the complete soil structure system to obtain full response of the system to earthquake excitations. Therefore, Study 1 is used to demonstrate the adequacy of using the MSM to analyze the R/B complex and Study 2 is used to further verify the conclusions of Study 1.

The ATF and ARS comparison results were reviewed for the acceptance criteria as follows:

- For Study 1, the 5% damped ARS computed using MSM at various locations at foundation and ground surface levels should match closely the 5% damped ARS computed using FVM. At any frequency, the maximum downward deviation of MSM result from FVM result should be less than 15%.

- The same acceptance criteria as Study 1 were applied for review of Study 2 results. However, results at additional locations including critical equipment locations, building corners at the floor levels and other selected locations were reviewed as well.

Figure 1 to Figure 4 present typical ATF and ARS comparison plots at a typical location, center of basemat bottom, from Study 1 for fully bonded embedment condition. Figure 5 to Figure 6 present the typical results of Study 2 at the reactor support. Review of the ATF and ARS comparison plots indicated that the acceptance criteria are met for both Study 1 and Study 2. The 5% damping ARS computed using MSM at reviewed locations match closely to the 5% damping ARS using FVM. At a few frequencies for some locations, downward deviation of MSM is observed from Study 1 results but well below 15%.

In addition to performing the two studies to justify the applicability of the MSM on site independent SSI analyses of the R/B complex, as recommended by the DOE Report (U.S. Department of Energy, SSI Report, July 2011), visual inspection of ATF at various locations for anomalies were performed during the course of SSI analyses. Technical Report MUAP-10006, Rev. 3, Appendix 3-C presents the ATF plots at various locations throughout the R/B complex and indicates that the seismic responses for the analyzed frequencies were reasonably captured by using MSM.

In conclusion, MSM is an accurate method for the SSI analyses of the standard plant US-APWR R/B complex.

For more details and complete comparison of the ARS and ATF the studies are documented and available for audit.

Table 1 Matrix of Study Models

Study		Model Characteristic		Embedment Condition	Analyzed Soil Profile
		Structure	Excavated Volume		
Study 1	MSM	Massless Basement	7 layers	Fully Bonded and Unbonded	270-200 and 560-500
	FVM				
Study 2	MSM	Full Structure	7 layers	Unbonded	560-500
	FVM		4 layers		

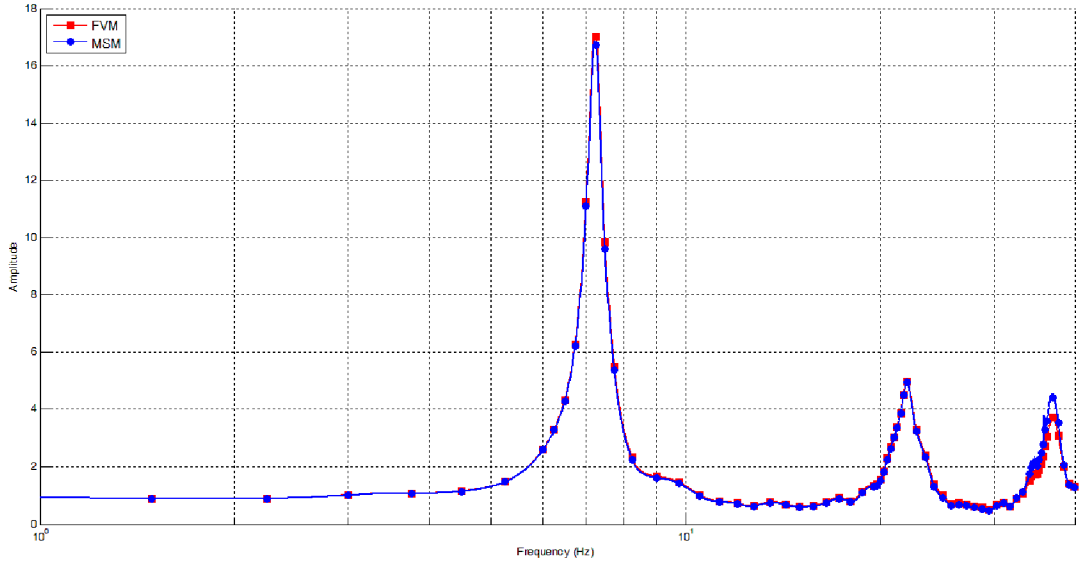

Figure 1 ATF at Center, Basemat Bottom (El. -39.667 ft), N-S Direction, 270-200 Soil

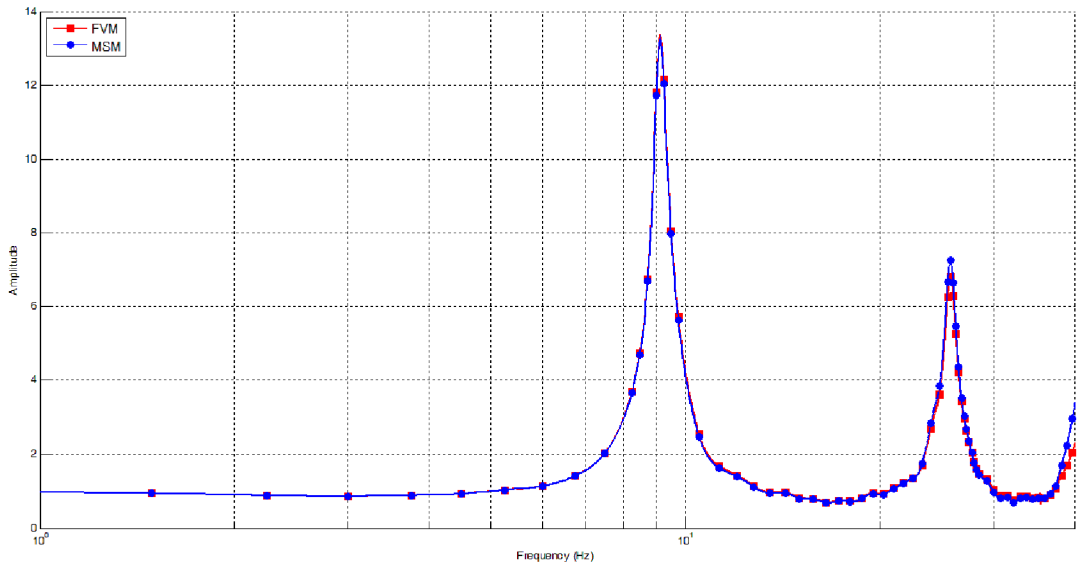

Figure 2 ATF at Center, Basemat Bottom (El. -39.667 ft), N-S Direction, 560-500 Soil

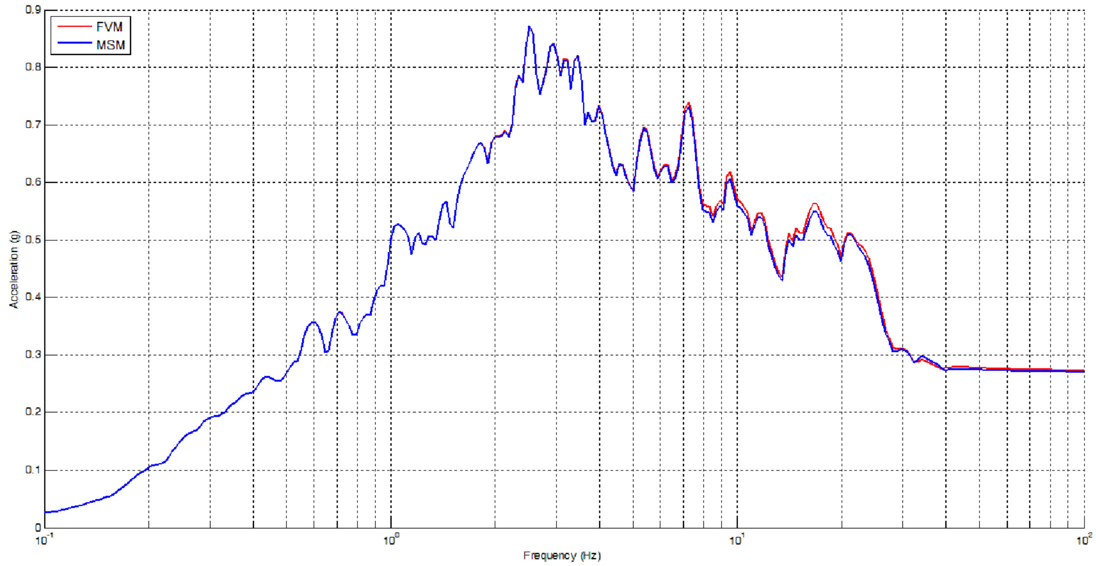

Figure 3 5% Damping ARS at Center, Basemat Bottom (El. -39.667 ft), N-S Direction, 270-200 Soil

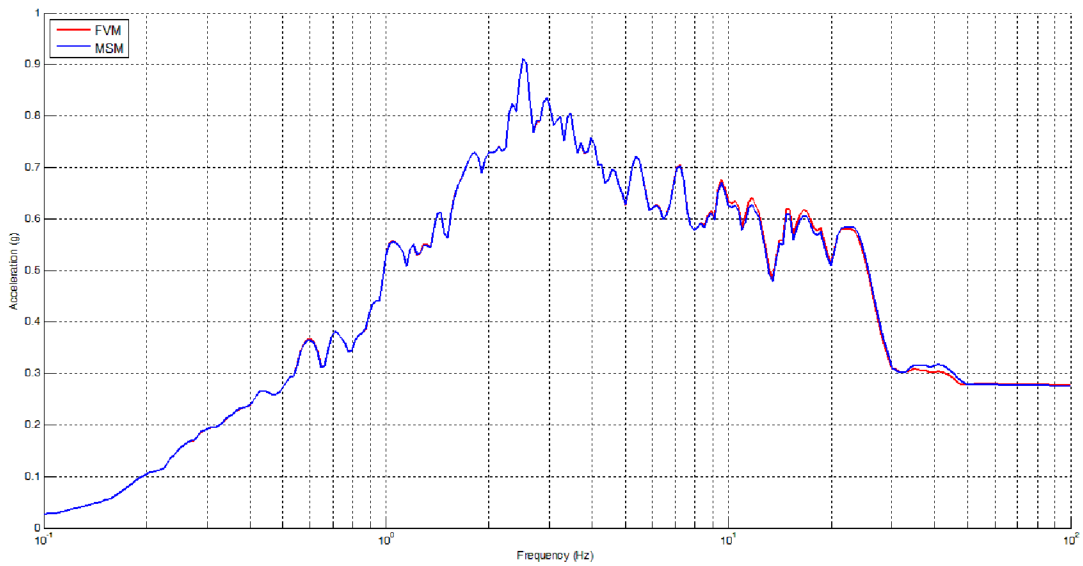

Figure 4 5% Damping ARS at Center, Basemat Bottom (El. -39.667 ft), N-S Direction, 560-500 Soil

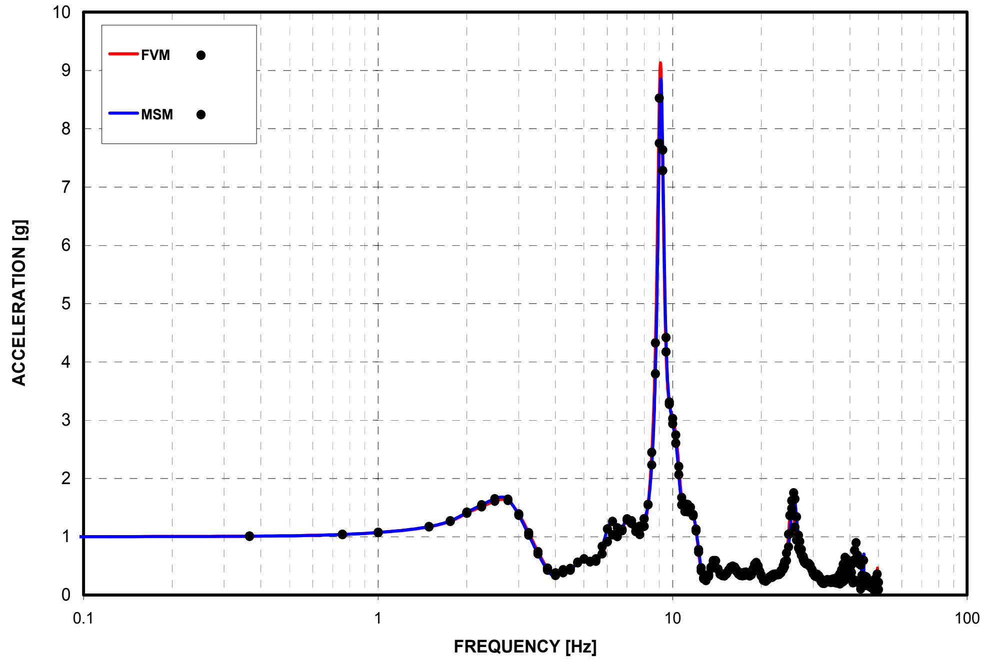

Figure 5 ATF at Reactor Support (El. 35.906 ft), N-S Direction, 560-500 Soil

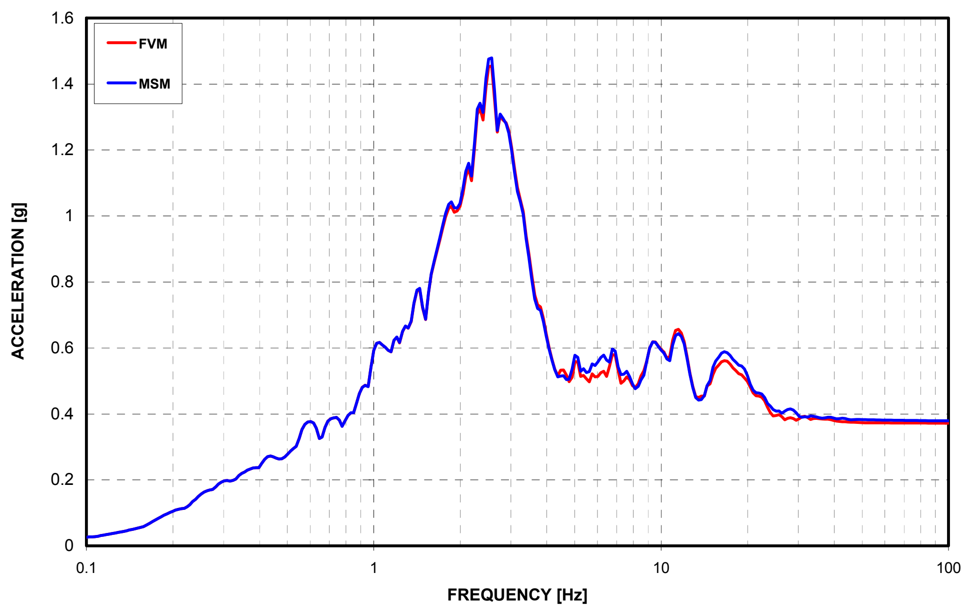

Figure 6 5% Damping ARS at Reactor Support (El. 35.906 ft), N-S Direction, 560-500 Soil

Impact on DCD

There is no impact on the DCD.

Impact on R-COLA

There is no impact on the R-COLA.

Impact on S-COLA

There is no impact on the S-COLA.

Impact on PRA

There is no impact on the PRA.

Impact on Technical/Topical Report

There is no impact on a Technical/Topical Report.

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