RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/31/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 868-6156 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**11/14/11**

QUESTION NO. RAI 03.07.02-179:

This request for additional information (RAI) is necessary for the staff to determine if the application meets the requirements of 10 CFR Part 50, Appendix A, General Design Criteria 2; 10 CFR Part 50 Appendix S; and 10 CFR Part 100; as well as the guidance in NUREG-0800, 'Standard Review Plan for the Review of Safety Analysis for Nuclear Power Plants,' Chapter 3.7.2, “Seismic System Analysis.”

Per SRP 3.7.2 Acceptance Criteria 1.A.iii, rocking and torsion should be considered in dynamic analysis. In Subsection 3.7.3.1 of the DCD (R3), the applicant states that the time-history seismic analysis of a subsystem can be performed by simultaneously applying the displacements and rotations at the interface point(s) between the subsystem and the system. It is also stated that the time history or response spectra generated at the support point of the subsystem are utilized as the input motion for performing the seismic dynamic analysis of the subsystem. However, where modal response spectra methods are discussed in Subsection 3.7.3, there is no indication that rotational information is contained in the response spectra. The applicant is requested to explain how rotational information is contained in the ISRS. The response should explain how the ISRS at the support point of a subsystem account for the building rocking effects when analyzing subsystems. The response should address how the rocking effects of the structure are characterized at the reference location of the structure (the point at which ISRS are generated) and also at the support point of the substructure. The response should include the situation in which the relative motion between the reference location and subsystem input location is significant.

ANSWER:

The global seismic models and SASSI soil-structure interaction (SSI) analyses described in DCD Subsection 3.7.2 account for rocking effects. The rotational effects are included through the detailed modeling of the building structures in the development of floor response spectra described in Subsection 3.7.2.5. From soil-structure interaction (SSI) SASSI time history analyses that include effects of rocking and torsion, in addition to the three translational responses, only translational floor design response spectra are generated in two horizontal directions and one vertical direction, as per the guidance in Regulatory Guide (RG) 1.122.

When analyzing subsystems, the transfer of rocking and torsion effects from the building structure reference location [the point on the structure at which in-structure response spectra (ISRS) are generated] to the support points of a subsystem, is described as follows:

a) When the intervening structural element (e.g., wall between floors) is rigid (i.e., frequency > 50 Hz), the transformation effect due to the rigid body motion of the intervening structure can be taken into account at intermediate attachment locations by linear interpolation of upper and lower ISRS for the attachment location of the subsystem, provided the intervening structure between those locations (wall in this example) is rigid. Similarly, the transformation effect due to the rigid body motion of an intervening structure such as a slab can be taken into account by linear interpolation from responses at the slab corners or outrigger locations provided the slab is rigid. Alternatively, when the intervening structural element (e.g., consisting of a structure supporting a subsystem such as line-mounted equipment) is rigid (i.e., frequency > 50 Hz), the transformation effect due to the rigid body motion of the intervening structure can be taken into account by adding a rigid link to the subsystem model from its support locations to the reference location of the ISRS. Enveloping ISRS are provided at sufficiently close proximity to the subsystem attachment locations for walls and floors such that contributions arising from the structural rocking and torsional effects at the reference location of the ISRS have insignificant effect on the subsystem. Thus, for cases where the intervening structure is rigid, no translational time history will be obtained by algebraic summation of the translational acceleration time histories at the reference location with time history contributions arising from the structural rocking and torsional effects. In addition, if time histories are not available for cases where the intervening structure is rigid, no translational response spectra will be obtained by absolute summation of the translational accelerations at the reference location with contributions arising from the structural rocking and torsional effects.

b) When the intervening structural element is flexible (i.e., frequency < 50 Hz) or a time history input for analysis of a rigid or flexible structure, system, and component away from the reference location of the ISRS is preferred, a new time history and/or associated ISRS at the interface can be generated from a time history analysis of a decoupled model that includes the effects of mass and flexibility of the intervening structural element, provided the applicable decoupling criteria of SRP 3.7.2 Acceptance Criteria 3B are met for the subsystem. The time history ANSYS analysis of a detailed decoupled model of the intervening structural element is performed using time history inputs from the SASSI analysis of the structure. When time histories of in-structure motions from dynamic analysis of the supporting soil-structure system are used, frequency content of the time histories are varied to be consistent with the broadening of ISRS. An acceptable method to vary the frequency content of the in-structure accelerations time histories for each soil profile is by expanding and shrinking the time history within $1/(1 \pm 0.15)$ so as to change the frequency content within ± 15%. For cases where the decoupling criteria of SRP 3.7.2 Acceptance Criteria 3B are not met, the seismic dynamic analysis of the subsystem is expanded to include the intervening structural element. Alternatively, instead of generating a new time history or new ISRS, the seismic dynamic analysis of the subsystem also can be expanded to include the intervening structural element. The response generated via modal superposition coupled with a missing mass correction ensures that the rigid mode effect is included.

In addition to the seismic response due to inertia effects discussed above regarding the situation in which the relative motion between the reference location and subsystem input location is significant, relative seismic anchor motion between the reference location and subsystem input location is addressed in DCD Subsections 3.7.3.1.7.1 and 3.7.3.1.7.2 for the Uniform Support Motion Method and Independent Support Motion Method, respectively.

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.