RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/31/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 856-6094 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
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QUESTION NO. RAI 03.07.02-172:

In Subsection 3.3 of MUAP-11011 (R0), "SSSI Analysis Methodology for the US-APWR Standard Plant Design," the third paragraph (Page 8) states, "The two different aspects of SSSI effects investigated are:

1. Effect on Ground Motion at Adjacent Structure Foundations (kinematic SSSI effect) : The influence of the SSI response of a standalone building on the ground motions at the adjacent structure foundations is assessed in the first step, and

2. Coupled Dynamic SSSI effect: A coupled SSSI model, formed as an integral dynamic system, is used to generate coupled seismic responses of adjacent structures, taking into account their mutual interaction through the supporting subgrade. The coupled dynamic SSSI effect combines the kinematic SSSI effect and the inertial SSSI effect."

In Subsection 3.3.1 of MUAP-11011 (R0), "Effect on Ground Motion at Adjacent Building Foundation Locations," the first paragraph (Page 8) states "The first step in assessing SSSI effects is to investigate how the R/B Complex, which is the heaviest building (approximately 870,000 kips) among the US-APWR plant buildings, affects the near-field site response ground motions at the foundation locations of the adjacent standard plant buildings." Further, the second paragraph (Page 8) states, "The dynamic FE model of the standalone R/B Complex includes interaction nodes at the surface of the adjacent ground (near-field) located at 10 feet or more from the foundation of the R/B Complex as shown in Figure 3.3.1-1."

Also in Subsection 3.3.1, the third paragraph (Page 9) states, "The comparisons of the field response ARS results with the ARS for the input motion provide the basis for assessing the kinematic SSSI effects." It further states "The significance of the kinematic SSSI effects for a particular generic site profile is determined based on the following guideline:

> *The effects on ground motion are considered insignificant if the amplifications of the seismic input motion due to SSI response of the standalone building are such that the 5%-damped ARS of the near-field site response motions at the near-field ground surface locations within the footprint of the adjacent structure foundation are not more than 10% higher than the corresponding 5%-damped ARS of the input ground motion for any frequency window of ± 10% centered on the frequency.*"

The applicant is requested to provide information that addresses the following relating to the above quoted paragraphs:

1. The applicant is requested to provide a formal definition of “kinematic SSSI effect” mentioned in item 1 in the first paragraph quoted above and how this information is used in SSSI analyses. Also, the applicant is requested to provide technical details that show how the dynamic SSSI analyses for the combined kinematic SSSI effect and inertia SSSI effect are performed to evaluate the design basis of standard plant SSCs.

2. In Subsection 3.1 of MUAP-11011 (R0), the first paragraph (Page 5) states that “The first priority in assessing the coupled dynamic SSSI effects is to investigate the effect of the heavier A/B and R/B Complex buildings on the seismic response of the nearby West PS/B which has much smaller dimensions and less weight.” The beginning of the second paragraph quoted above states “The first step in assessing SSSI effect is to investigate how the R/B Complex …” The staff is confused by these two statements. The applicant is requested to clarify which one of these statements represents the first step in assessing the SSSI effect on the design basis of standard plant SSCs.

3. In Subsection 3.1 of MUAP-11011 (R0), the applicant indicates that the embedment effect is neglected. Therefore, the R/B Complex is modeled as a surface supported structure. The applicant is requested to provide information that shows the elevation where the input motion to the R/B is specified. If it is not specified at the ground surface, the applicant is requested to provide technical rationale for not specifying it at the ground surface. If it is specified at the ground surface, the near-field ground motion should be the same as that of the free-field input motion because the input motion is assumed to be uniform horizontal vertically propagated waves. If the applicant determined that the near-field ground motion is different from the free-field input motion, the applicant is requested to provide technical rationale that explains why, for the surface supported structures, the near-field ground motion is not the same as that of the free-field input motion.

4. The applicant is requested to verify that, indeed, the dynamic FE model of the R/B complex is used in the analysis; since Figure 3.2-1 shows that the lumped-mass stick model is used for the R/B complex.

5. Since the R/B complex is assumed to be a surface supported structure, the surface ground motion is the same as the free-field input motion used for the SSI analyses. The Applicant is requested to provide the reason(s) for the study of the surface supported structure presented in Item 3 above.

6. If the input motion is specified at the ground surface and is assumed to be a uniform horizontal motion propagating vertically, then the motions at the ground surface are the same at any two locations. As a result of this, any two corresponding ARS at two locations are the same. The applicant is requested to provide technical basis and supporting data to justify how can two identical ARS provide the basis for assessing the kinematic SSSI effects.

7. Generally, the ‘kinematic interaction’ is associated with determination of the input motion to the rigid, massless foundation (kinematic interaction) subjected to the free field ground motion. The staff considers the calculations of the near-field ground motions and their ARS to be of no value, and should not be carried out since the model described in MUAP-11011 (R0), and the motion considered, has no kinematic interaction. The applicant is requested to provide technical information that shows why the free-field surface ground motion differs from the near-field surface ground motion. Also the applicant is requested to provide technical details that show how the near-field ground motions are used in determining the SSSI effect on the design basis of standard plant SSCs.

ANSWER:

Technical Report MUAP-11011, Rev. 0, has been superseded and its relevant information incorporated into Technical Report MUAP-10006, Rev. 3.

The reactor building (R/B) complex now consists of the reactor building (R/B), prestressedconcrete containment vessel (PCCV), containment internal structure, east and west power source buildings (PS/Bs), auxiliary building (A/B) and essential service water pipe chase (ESWPC), structurally integrated and supported on a common basemat. Because the A/B and PS/B structures are no longer separate from the R/B complex, they are not subjected to itsstructure-soil-structure interaction effects.

A structure-soil-structure interaction(SSSI) analysis of the influence of the turbine building (T/B) complex on the R/B complex was performed as described in Section 03.3.0 of Technical Report MUAP-10006. The SSSI analysis used finite element (FE) models of both the R/B complex and the T/B complex, and was performed for four of the six soil cases. The SSSI analysis produced some instances where the results were higher than the soil-structure interaction (SSI) results. As such, the design basis envelope for the US-APWR includes the SSSI results.

The following information is provided, in the same above numbered sequence, to address the questions posed above:

1. Technical Report MUAP-10006, Rev. 3 does not mention kinematic effects. The influence of the T/B on the R/B complex is computed from the structure-soil-structure interaction FE model.

The following definitions of inertial interaction and kinematic interaction are provided, as requested:

> Inertial interaction - The inertia forces (seismic acceleration exciting mass) developed in the structure due to its own vibration inducing base shear and moment, which results in the displacement of the foundation relative to the free field.
>
> Kinematic interaction - Kinematic interaction is caused by a stiff foundation (massless) in the soil, which causes the earthquake motions to deviate from those remote from the structure (effect of foundation deformation).

During earthquake events, seismic waves propagate through the ground and interact with the foundations of the buildings, and the foundations, then in turn interact with the superstructure. Soil foundation-structure interaction is a term used to describe this phenomenon. It is common to split soil foundation-structure interactioninto two mechanisms – inertial interaction and kinematic interaction. This is often referred to as soil-structureinteraction (SSI). The phenomenon of adjacent structures interacting with each other through the ground supporting their foundations is commonly referred to as structure-soil-structure interaction.

2. These two statements that confused “The first priority…” and “The first step” no longer appear in MUAP-10006 because the PCCV, R/B, A/B, and PS/Bs building structures are now combined as the same structure. Therefore, neither the A/B nor PS/B has SSSI impact on the R/B (or each other). The first step of assessing SSSIeffects of the adjacent standard plant buildings is no longer performed because this does not capture the kinematic effect.

3. Embedment is now considered in the SSSIanalyses instead of surface supported structures as documented in MUAP-10006. The base of the lowest mat foundation, which is that of the R/B

complex, is the elevation where the seismic input motion is specified in the SASSI structure-soil-structure interaction analyses. The envelope of acceleration response spectra (ARS) at the ground surface of the standard plant from results of the SASSI analyses for all subgrade profiles is compared to the certified seismic design response spectra(CSDRS) to confirm the ARS at the ground surface envelopes the CSDRS. This demonstrates that the near-field ground motion responses conservatively exceed the CSDRS consistent with its definition at the free-field.

4. Both the R/B complex and the T/B are dynamic FE models in the SSSI analysis,instead of the lumped-mass stick model previously shown in Figure 3.2-1. The R/B complex contains a lumped-mass stick model only to represent thereactor coolant loop subsystem of the R/B complex.

5. Embedment is now considered in the SSSIanalyses instead of surface supported structures as documented in MUAP-10006. Therefore, it is no longer necessary to provide the reason(s) for the study of a surface supported structure.

6. The input motion is not specified at the ground surface but at the bottom of the deepest mat foundation. Thus, ARS at any two corresponding ground surface locations now are not the same in the SASSI analysis of SSSIeffects. Therefore, it is no longer necessary to provide technical basis and supporting data to justify how two identical ARS can provide the basis for assessing the kinematic SSSI effects.

7. It is no longer necessary to provide details of calculations of the near-field ground motions and their ARS since SSSIanalysis now considers embedded structures. SSSI results are included in the design basis envelop of in-structure response spectrafor structures, systems, and componentsof the US-APWR standard plant.

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

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