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TOKYO, JAPAN

August 12, 2011

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: Mr. Jeffery A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-11262

Subject: MHI's Responses to US-APWR DCD RAI No. 776-5851 Revision 3 (SRP 03.07.02)

Reference: 1) "Request for Additional Information No. 776-5851 Revision 3, SRP Section: 03.07.02 – Seismic Systems Analysis," dated 06/15/2011.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Responses to Request for Additional Information No. 776-5851, Revision 3."

Enclosed are the responses to seven (7) RAIs contained within Reference 1. They are RAIs 3.7.2-68, 69, 71, 73, 77, 81, and 83. Of the RAIs in Reference 1, ten (10) will not be answered within this package. Those RAI responses have a 45-day response time, as agreed to between the NRC and MHI, and will be issued at a later date by separate transmittals.

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of this submittal. His contact information is provided below.

Sincerely,

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

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NRO

Enclosure:

1. Responses to Request for Additional Information No. 776-5851, Revision 3

CC: J. A. Ciocco
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Enclosure 1

UAP-HF-11262
Docket No. 52-021

Responses to Request for Additional Information No. 776-5851,
Revision 3

August, 2011

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

8/12/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 776-5851 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic Systems Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/15/11**

QUESTION NO. RAI 03.07.02-68:

In Section 1.0 of the MUAP-11001 (R0), the last sentence in the 4th paragraph states, "The certified seismic design response spectra (CSDRS) and the CSDRS compatible time histories that were developed in Section 5.2 of MHI TR MUAP-10001 (Reference 7.1) define the ground motion for the standard design of the A/B."

The staff is unable to determine where the CSDRS is applied to the A/B structure in conducting the seismic responses described in this Report. The Applicant is requested to specify where the CSDRS is located for the standard design of the A/B.

ANSWER:

The CSDRS is applied at the bottom nominal elevation of the A/B. The S-waves propagating upward represent the two horizontal components of the design earthquake motion H1 and H2 that are applied in N-S and E-W direction, respectively. The vertical component of the design earthquake (V) is represented by vertically propagating P-waves. The three components of the earthquake are applied to the model separately. This will be clarified in MUAP-11001, Revision 2.

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 the Technical/Topical Report.

8/12/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	NO. 776-5851 REVISION 3
SRP SECTION:	03.07.02 – Seismic Systems Analysis
APPLICATION SECTION:	3.7.2
DATE OF RAI ISSUE:	06/15/11

QUESTION NO. RAI 03.07.02-69:

In Subsection 2.2 of the MUAP-11001 (R0), "Material Properties," (page 6) the last sentence states "The critical damping ratio of 7% is for bolted steel structures at SSE stress level per Regulatory Guide 1.61(Reference 7.13)."

The staff noticed that 7% is allowed only if "Bolted Steel with Bearing Connections," are used. Otherwise, damping is limited to 4% (e.g., welded or bolted with friction joints). The Applicant is requested to provide a confirmatory statement in the Report that "Bolted Steel with Bearing Connections" are used.

ANSWER:

Subsection 2.2 will be revised in Revision 2 of MUAP-11001 to identify that 7% damping is for Bolted Steel with Bearing Connections.

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 the Technical/Topical Report.

8/12/2011

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DATE OF RAI ISSUE:	**06/15/11**

QUESTION NO. RAI 03.07.02-71:

In Subsection 2.3.2.1of MUAP-11001 (R0), "Reduction of Stiffness for Concrete Cracking," the paragraph (page 7) states, "The elastic modulus and wall/slab thicknesses of the shell elements are modified so that the out-of-plane flexural stiffness is reduced by 50% while the in-plane shear and axial stiffness remains unchanged."

The Applicant is requested to provide technical basis and justification for not reducing the shear stiffness.

ANSWER:

In MUAP-11001, Revision 1, Section 2.3.2.1 has been revised to indicate that all stiffness values (including shear stiffness) for the cracked condition have been reduced by 50% of the uncracked stiffness values.

In accordance with ASCE 4-98, Section 3.1.3, and ASCE/SEI 43-05, Section 3.4.1, traditional reinforced concrete members and elements are to be modeled as either cracked or uncracked sections, depending on their stress level due to the most critical load combinations that include seismic design loads. For the uncracked sections/elements, the stiffness is directly obtained from the concrete linear elastic properties and the section or element geometric dimensions. For cracked concrete, a reduction of the uncracked concrete stiffness is taken into account. Table 3-1 of ASCE/SEI 43-05 indicates cracked flexural and shear stiffness values that are 50% of the uncracked values are appropriate and are therefore used in the analysis of the A/B to address the effects of concrete cracking on the seismic response.

The consideration of reduced stiffness is based on the premise that the main purpose of the site-independent SSI analyses is to provide input for the evaluation of the A/B reinforced concrete structure, stability of the building and the gap between the buildings. The design of the reinforced concrete shear wall structures is based on the ultimate capacity of the reinforced concrete sections that addresses code stress limits corresponding to reduced cracked concrete stiffness properties and higher SSE material damping levels as discussed in Regulatory Position C.1.2 of RG 1.61. Likewise, the stability evaluations are also based on consideration of ultimate conditions. The lower stiffness of the reinforced concrete members amplifies the deformations of the A/B structure and thus provides higher values for the seismic displacement of the building relative to ground motion.

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 the Technical/Topical Report.

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QUESTION NO. RAI 03.07.02-73:

Subsection 3.2 of MUAP-11001 (R0), states that "Table 3.2-1 summarizes the results of the modal analyses of the three different FE models for the dominant natural frequencies in horizontal N-S and E-W directions."

Table 3.2-1 did not show the results of the modal analyses for the vertical direction excitation. Applicant is requested to provide in Table 3.2-1 the corresponding data for the vertical direction so that the staff can assess the accuracy of the model in the vertical direction.

ANSWER:

In MUAP-11001, Revision 1, Table 3.2-1 has been updated and revised to provide the latest data including the vertical direction of excitation.

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 the Technical/Topical Report.

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

8/12/2011

US-APWR Design Certification

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Docket No. 52-021

RAI NO.:	**NO. 776-5851 REVISION 3**
SRP SECTION:	**03.07.02 – Seismic Systems Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**06/15/11**

QUESTION NO. RAI 03.07.02-77:

In Subsection 4.3 of MUAP-10001 (R0), "Results of Dynamic FE Model SSI Analyses," the fifth paragraph (page 55) states, "Figure 4.3-1 shows that the maximum displacement relative to the free-field ground surface is 0.92 inches in the East-West direction."

The staff is not able to determine whether or not 0.92 inches includes the contribution from the SSE motions in the North –South (NS) and East –West (EW) directions including the displacement in NS direction caused by the SSE motion in the EW direction, and the displacement in EW direction caused by the SSE motion in the NS direction. The Applicant is requested to provide detailed information that shows how the various components of the horizontal seismic displacements are combined.

ANSWER:

The SSI analysis provides the maximum displacements for selected nodes relative to a reference node or free field motion. The following is the procedure used for the calculation of maximum displacements.

1. Develop nodal displacements from the results of SSI analyses of each generic soil profile.
2. Use the SRSS method to combine the seismic displacements that are due to three components of the earthquake (NS, EW, and Vertical) that are applied separately to the model. Each displacement in a particular direction is therefore the SRSS combination of the individual displacements in that direction due to each of the three components of the earthquake.
3. Envelope the SRSS seismic displacements from the SSI analyses of the eight generic soil profiles at the 4 edge nodes and the center node of the A/B model.

This method is consistent with Regulatory Position C2.2 of RG 1.92.

Section 4.3 will be updated to reflect the latest analysis results in MUAP-11001, Revision 2.

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 the Technical/Topical Report.

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QUESTION NO. RAI 03.07.02-81:

In Section 5.5 of MUAP-11001 (R0), "Structural Integrity Evaluation Results," the second paragraph (page 70) states, "The required reinforcement due to out-of-plane bending moments and in-plane forces are calculated by program "WALL" and is shown in Table 5.5-2. Similarly, the required reinforcement due to out-of-plane bending moments and out-of plane shear force in slabs are calculated by program "SLAB". These required reinforcements are calculated in element level and are defined as "Demands."

The Applicant is requested to clarify how the effect of concrete cracking are considered in the calculation of the design forces and moments.

ANSWER:

The analyses documented in Revision 1 to MUAP-11001 were performed using 50% reduced stiffness both in the out of plane and in-plane directions to account for cracking of the reinforced concrete walls and slabs of the A/B. The resulting moments and shears determined by the ANSYS program are consistent with these stiffness values.

The walls and slabs of the A/B are then evaluated with the ANSYS post-processing FORTRAN routines "wall.exe" and "slab.exe" respectively. In both post-processors, axial load (in-plane horizontal direct forces in the case of slabs) – out-of-plane moment capacity curves are developed to evaluate the interaction between out-of-plane flexure and in-plane direct forces. The development of these curves is based on stress and strain compatibility across the cross-sections of the shell elements using the assumptions of Section 10.2 of ACI 349-01. The programs also apply the general principles and requirements for the design of cross-section due to flexure and axial loads of Section 10.3 of ACI 349-01.

In both processors, the interaction between in-plane direct forces and transverse shear is evaluated through the inclusion of in-plane forces (N_u in Chapter 11 of ACI 349-01) in the determination of the transverse shear capacity, V_c, of the element or cross-section. If the in-plane forces are compressive, N_u is positive and formula 11-4 of Section 11.3.1.2 is used to calculate V_c. If the in-plane forces are tensile, N_u is negative and formula 11-8 of Section 11.3.2.3 is used to calculate V_c. If shear reinforcing is required at a particular cross-section, it is designed to the requirements of Section 11.5.6 of ACI 349-01.

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 the Technical/Topical Report.

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QUESTION NO. RAI 03.07.02-83:

On Page A1 of Appendix A of the MUAP-11001 (R0) under Key Features, the second bullet states, "Program Checks Minimum Reinforcement in Accordance with Section 7.12 of ACI 349-01."

Requirements for minimum reinforcement are also specified in Section 14.3 of ACI 349-01. The Applicant is requested to confirm that the program also checks for minimum reinforcement requirements in Section 14.3 of ACI 349-01, and that the A/B design meets the ACI code requirements.

ANSWER:

The walls of the A/B are evaluated with the ANSYS post-processing FORTRAN routine "wall.exe". The post-processor checks for the minimum reinforcement requirements of Sections 7.12, 14.3 and 21.6 such that the A/B walls meet the minimum reinforcement requirements of ACI 349-01. The discussion in Appendix A will be revised in MUAP-11001, Revision 2, to provide the above clarifications.

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 the Technical/Topical Report.