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**RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION**

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**10/16/2013**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No. 52-021**

**RAI NO.:** NO. 852-6003 REVISION 3  
**SRP SECTION:** 03.07.02 – Seismic System Analysis  
**APPLICATION SECTION:** 3.7.2  
**DATE OF RAI ISSUE:** 10/24/2011

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**QUESTION NO. RAI 03.07.02-136:**

In Appendix A of MUAP-10001(R3), "Methodology for Modeling Stiffness and Damping of the CIS," the Category 2 under the subtitle of "Structural Categories in the CIS," (Page A-2) states, "Non-primary shielding walls with  $T > 56$ " (e.g. the 67"-thick single-celled walls) are to be treated as concrete walls with no additional stiffness imparted by the steel plates. This category comprises less than 10% of the walls in the CIS."

The staff noticed that Category 2 is actually a SC wall. However, in the above quoted sentence, Category 2 wall is treated as a concrete wall in the analysis. It is not clear to the staff if the Category 2 wall is treated as an ordinary reinforced concrete wall in its design.

The applicant is requested to confirm whether the same rebar layout for concrete shear wall specified in ACI 349 is used for Category 2 wall. According to the above quoted sentences, the additional stiffness from steel plates is not considered in the analysis. As a result, the seismic force for Category 2 wall obtained from the analysis will be less than the actual force it experiences because its actual stiffness is larger than that used in the analysis.

Thus, the applicant is requested to estimate the actual seismic force this thick wall experiences and demonstrate that the potentially under-designed Category 2 wall is safe. Also, is there a possibility that the Category 2 wall is over-reinforced?

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**ANSWER:**

The relevant content of Technical Report MUAP-10001 Rev. 3 is incorporated into Technical Report MUAP-10006, Rev. 3, which supersedes Technical Report MUAP-10001 Rev. 3.

Technical Report MUAP-10001, Rev. 3, Appendix A, titled "Methodology for Modeling Stiffness and Damping of the CIS," is not included in Technical Report MUAP-10006, Rev. 3; however, the dynamic stiffness and damping information from Technical Report MUAP-11018, Rev. 1, is incorporated into Section 02.4.2.2 and Tables 02.4.1.1.3-1 and 02.4.1.1.3-2

of Technical Report MUAP-10006, Rev. 3. The stiffness and damping for seismic analysis of composite steel-concrete (SC) structures in the containment internal structure (CIS) are addressed in detail in Technical Report MUAP-11018, Rev. 1 and the design criteria for the SC walls in the CIS are addressed in Technical Report MUAP-11019, Rev. 1.

Category 2 SC walls are designed with American Concrete Institute (ACI) 394-06 as the design basis code. For SC walls, the rebar is replaced with steel faceplates that are anchored to the concrete using shear studs and connected to each other using steel tie bars. See Technical Report MUAP-11013, Rev. 2, Section 1.0 for additional discussion.

Section 1.3 of Technical Report MUAP-11018, Rev. 1 describes the overall approach for determining appropriate stiffness and damping values for dynamic analyses. For Category 2 SC walls, Sections 4.2, 5.3.1, and 6.3 of Technical Report MUAP-11018, Rev. 1 explains that the stiffness and damping values for reinforced concrete are used for the dynamic and design modeling. Those values are based on American Society of Civil Engineers (ASCE) 43-05 and US Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.61. For Category 2 SC walls, the in-plane shear stiffness due to the concrete section only is considered, which is customary for reinforced concrete sections. To evaluate the out-of-plane flexural stiffness, a procedure similar to that used for the reinforced concrete slabs was applied.

Response to RAI 894-6270 Question 03.08.03-63 (ML12096A040) provides a comparison of the resulting Category 2 stiffness values when considering a reinforced concrete approach or considering an SC-specific equations approach. Response to RAI 977-6899 Question 03.08.03-99 provides a summary of a parametric study which assesses the impact on the dynamic response when considering a range of Category 2 stiffness values. These studies demonstrate that consideration of stiffness based on reinforced concrete is reasonable for Category 2 walls.

As stated in Section 1.1 and Table 1.1-1 of Technical Report MUAP-11019, Rev. 1, the Category 2 walls have a relatively low reinforcement ratio of approximately 1.5 percent. Sections 5.1 and 5.2.2 of Technical Report MUAP-11019, Rev. 1 explain that the use of equal thickness and yield strength face plates on both sides of the SC modules results in a compression reinforcement ratio ( $\rho'$ ) that is identical to the tension reinforcement ratio ( $\rho$ ). As a result, none of the flexural tension force in the tension reinforcement is balanced by compression in the concrete, which means that the reinforcement limitation inherent in ACI 349-06 Section 10.3.5 does not apply to any portion of the tension reinforcement area. Because of the balance of tension and compression reinforcement in SC walls, the limiting concrete compression strain (0.003) cannot be reached before the tension reinforcement has yielded. This behavior comprises an essential benefit of SC construction; it is not possible for a properly detailed SC wall subjected to pure flexure to experience a nonductile (brittle) failure mode. Therefore, there are no undesirable effects due to over-reinforcement.

#### **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.

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