RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

3/24/2014

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 1060-7285 REVISION 0**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**11/15/2013**

QUESTION NO. 03.07.02-236:

Section 02.4.1.1.4, “Modeling of Mass,” of MUAP-10006, "Soil-Structure Interaction Analysis and Results for the US-APWR Standard Plant," Revision 3, and Figure 02.4.1.1.4-1 “Example of Hydrodynamic Masses”, show that the impulsive mass is separated into two parts: impulsive mass and constrained mass. Section 02.4.1.1.4 states:

> "The impulsive mass is rigidly fastened to the walls as it moves with the walls responding to the seismic excitation. Depending on the ratio of the water depth to the pit width, the lower portion of the impulsive part can be considered as fully constrained which responds as a rigid body. The impulsive pressure is evenly and uniformly divided into a pressure force on the wall accelerating into the fluid, and a suction force on the opposite wall accelerating away from the fluid.”

From the paragraph above, it is unclear how the constrained and impulsive components of the impulsive mass are calculated and how each is incorporated into the dynamic finite element (FE) model. What is the significance of the “impulsive pressure” in this context? The staff requests the applicant to clarify in Section 02.4.1.1.4 of MUAP-10006, Revision 3, how the water mass is incorporated in the dynamic FE model.

ANSWER:

Technical Report MUAP-10006, Rev. 3 Section 02.4.1.1.4 is revised to clarify how the water mass is incorporated in the dynamic finite element model.

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

Technical Report MUAP-10006, Rev. 3 is revised as shown in Attachment 1.

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

02.4.1.1.4

(pools). The dynamic characteristics of the racks are not modeled or coupled with the structure. Liquid masses contained in the SFP, Emergency Feed Water Pits (EFWP), and Refueling Water Storage Pit (RWSP) are modeled as directional masses using mass elements attached to walls and slabs. In accordance with Reference 02-6, the hydrodynamic responses of the water in the SFP and the EFWPs are evaluated, and the hydrodynamic masses can beare separated into three parts from bottom to top: constrained, impulsive, and convective. The constrained part only exists in the SFP where the ratio of the water depth to the pit width is greater than 1.5 the lower impulsive and the upper convective parts. Figure 02.4.1.1.4-1 shows a representative idealization of fluid mass distribution indynamic model for the SFP when it is subject to seismic motion in the NS direction. The constrained and impulsive masses, simulated in the Dynamic FE model using mass elements with horizontal translational masses, are is rigidly fastened to the walls as theyit moves with the walls responding to the seismic excitation. Depending on the ratio of the water depth to the pit width, the lower portion of the impulsive part can be considered as fully constrained which responds as a rigid body. The resulting effect is that the impulsive forcepressure is evenly and uniformly divided into a pressure force on the wall accelerating into the fluid, and a suction force on the opposite wall accelerating away from the fluid. The evaluation presented in Figure 02.4.1.1.4-1 shows theThe convective mass is also included in the Dynamic FE model and is fastened to the walls by springs that produce the period of vibration corresponding to the period of fluid sloshing which is usually several seconds. The stiffnesses's of these connecting springs are calculated based on the sloshing period and are usually small enough such that the effective forces transferred to the walls are negligible. Thus, these convective masses are not included in the Dynamic FE model. The vertical liquid masses representing the total weight of the liquid are modeled using mass elements with vertical translational masses fastened to the nodes of the bottom slabs of the pits in the Dynamic FE model.

02.4.1.1.5 Adjustment of Stiffness and Mass Properties

The mesh of the Dynamic FE model does not always permit an accurate modeling of the openings in the walls. The elastic modulus and thickness of shell elements are adjusted to accurately model the reduction of shear stiffness of the wall due to openings.

The density of shell elements is also adjusted to accurately represent the mass of the wall accounting for openings and the adjusted wall thickness.

Finite element analyses are performed using ANSYS to obtain the stiffness reduction factors needed to adjust the material properties and account for the reduced stiffness due to the shear wall openings. The correction factors are obtained by comparing the results from the static analyses of two detailed solid FE models shown in Figure 02.4.1.1.5-1A and B. Model A represents the actual geometry of the wall with openings, and model B represents the wall without openings. Unit displacements are applied at the top of each model in both the in-plane and the out-of-plane directions, to generate the reactions at the bottom, which are then used to calculate the in-plane and out-of-plane wall stiffness. The ratio between the reactions obtained from model A and model B is used to determine out-of-plane stiffness reduction factors (m) and the in-plane stiffness reduction factor (n) that are then used to determine the adjusted elastic modulus (E_o), thickness (t_o), and density (γ_o) of the wall as described in Section 02.4.1.1.7.

02.4.1.1.6 Stiffness of Composite Steel-Concrete Beams and Columns

In the FH/A, the crane supporting steel columns and girts are continuously anchored to the exterior concrete walls with headed steel studs. The steel roof beams are also continuously