RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

12/18/2013

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**

QUESTION NO. RAI 03.07.02-113:

With respect to Section 4.3 of MUAP 10001 (R3), "ACS SASSI Dynamic Finite Element Model of R/B Complex," and Section 4.4 of MUAP 10001 (R3), "ACS SASSI Dynamic Finite Element Model of PS/B, " the applicant is requested to provide the following additional information:

(i) Section 4.3.1 of MUAP 10001(R3), the applicant discussed the SASSI problem of connecting different element types having differing end conditions together at a common node. It has been found that the improper definition of constraint conditions at the free degrees-of-freedom can lead to potential improper restraint to the entire model when considering SSI responses. The Applicant is requested to provide descriptions of the connectivity used in SASSI between beam and shell elements and between beam and brick elements, and examples of computed responses using the defined connectivity.

(ii) In Figures 4.3.1.1-6 and 4.3.1.1-7, massless rigid beams and massless surface beams are used to connect structural beams to shell elements. It appears that the rigid beams would be adequate for this purpose. Explain why surface beams are needed and how the stiffness of these surface beams is determined.

(iii) In section 4.3.1.2, the maximum mesh size for concrete was determined to be 20 ft, in order to transfer a shear wave up to 70 Hz, based on a calculation of shear wave propagation. This is not necessarily adequate to accurately capture local out-of-plane vibration modes of walls and floors up to 70 Hz. How have the local out-of-plane modes been incorporated in the dynamic model? Is the detailed model refined enough to adequately represent these modes up to 70 Hz? Have the dynamic and detailed models been compared to confirm the sufficiency of the dynamic model?

(iv) On page 4-28, it is stated that "the effective width of concrete (before transformation to steel section) is based on AISC 360-05, Section I3. The requirements in AISC 360-05 are applicable when the flange of the composite section is in compression. When the flange is in tension, smaller values of 'be' could be used.

Since the flange (concrete slab of the composite floor) may be in both tension and compression during earthquake excitation, a smaller 'be' would appear to be appropriate. AISC 360-05, Section A1 refers to the provisions of ANSI/AISC N690 or ANSI/AISC N690L for nuclear safety-related structures.

The applicant is requested to confirm whether it has considered provisions of ANSI/AISC N690 or ANSI/AISC N690L in the calculation of 'b_e'.

ANSWER:

As discussed with the Nuclear Regulatory Commission (NRC) staff during the Design Certification Document (DCD) Tier 2, Section 3.7.1, 3.7.2, and 3.7.3 Audit conducted in September 23-27, 2013, this answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-13017 (ML13057A418).

Technical Report MUAP-10001 has been incorporated into Technical Report MUAP-10006, Rev. 3. The seismic methodology has been updated to perform soil-structure interaction (SSI) analyses of the US-APWR reactor building (R/B) complex, which now consists of the R/B, prestressed concrete containment vessel (PCCV), containment internal structure (CIS), east power source building (PS/B), west PS/B, auxiliary building (A/B), and essential service water pipe chase (ESWPC) all on a common basemat, using a dynamic finite element (FE) model.

(i) Section 02.4.1.1.1 of Technical Report MUAP-10006, Rev. 3 corresponds to and supersedes Section 4.3.1.1 of Technical Report MUAP-10001. The connectivity between the various elements is described in Section 02.4.1.1.1 of Technical Report MUAP-10006, Rev. 3.

To validate the technique used to connect the shell element (wall) and the solid element (basemat), a study was performed on a flexible wall panel that is located in the basement of the west PS/B to investigate the effect of the rotational stiffness on its out-of-plane dynamic properties. The flexible wall panel dimension is approximately 30 ft (high) x 55 ft (long) x1.5 ft (thick). In the study, the panel is assumed to be simply supported by the ground slab at top and other basement walls at the two ends. Compared to the fixed condition at intersection of the wall and the basemat, which doesn't allow rotation of the wall at the top of the basemat, with the arrangement described above, the difference on the fundamental frequencies of the out-of-plane vibration is negligible.

Analysis for walls is described in the response to RAI 1060-7285 Question 03.07.02-239.

(ii) The previous Technical Report MUAP-10001, Rev. 3 Figures 4.3.1.1-6 and 4.3.1.1-7 correspond to Figures 02.4.1.1.1-7 and 02.4.1.1.1-8 in Technical Report MUAP-10006, Rev. 3. As described in the last paragraph of Section 02.4.1.1.1 massless rigid beams and massless surface beams are used to connect structural beams to shell elements. Massless surface beams are necessary to simulate a rigid base and transfer the bending moments of the attached reactor coolant loop (RCL) structural members into walls or slabs by coupled forces transferred to nodes of the shell elements from the attaching surface beams. The surface beams are assigned with axial stiffness (EA/L) and bending stiffness (EI) of ten times the corresponding wall element stiffness. The surface beams are then considered as rigid compared to the wall with this assumption. Their stiffness effect is local and does not affect the global responses of seismic accelerations and in-structure response spectra (ISRS).

(iii) Section 02.4.1.1.2 of Technical Report MUAP-10006, Rev. 3, which superseded the referenced Section 4.3.1.2 of Technical Report MUAP-10001, Rev. 3, determined that the mesh size needed to be equal to or less than 21 ft in order to be able to transfer shear waves with frequencies up to 70 Hz for modeling of concrete fill, but does not address walls and slabs. The average mesh size of 9 feet for the solid elements representing the concrete fill in the dynamic model satisfies this requirement. To accurately capture local out-of-plane vibration modes of floors, which have lower frequencies than walls, Section 02.4.1.1.8 of Technical Report MUAP-10006, Rev. 3 addresses modeling of slabs, which need more refined mesh than walls to capture responses of the local out-of-plane modes up to 70 Hz for the uncracked model. In accordance with the requirements of SRP 3.7.2, the validation is based on comparison of responses obtained from a series of static and dynamic analyses performed on the dynamic FE models and detailed FE models with a more refined mesh that includes important structural details such as eccentricities and openings comparable with the mesh size in walls and slabs. Sections 02.5.1.3 and 02.5.1.5 of Technical Report MUAP-10006, Rev. 3 present the results of the validation analyses performed to confirm the sufficiency of the dynamic model. Thus, the detailed model is refined enough to adequately represent the dynamic properties of the US-APWR standard plant seismic category I structures.

(iv) The provisions of ANSI/AISC N690 have been considered in the calculation of 'b_e' in addition to the provisions of ANSI/AISC 360-05. The sentences of Section I3 state, "Above requirements are applicable when the flange of the composite section is in compression. When the flange is in tension, smaller values of 'b_e' could be used," are not included in Technical Report MUAP-10006, Rev. 3. Two bounding stiffness levels are modeled in the SSI analysis. For the full stiffness case (uncracked), the composite beam stiffness is represented by the 75% linear equivalent stiffness of the transformed section under positive moment, which corresponds to the slab under compressive load and without cracking. The 75% is required per the Code to consider the difference in stiffness along the beam length. For the reduced stiffness case, no composite effect for the beams is considered. The stiffness of the steel beam alone is considered to model the out-of-plane stiffness of the beam supported slab/roof system, in addition to the reduced stiffness of slab/roof represented by 50% reduction of concrete Young's modulus.

As discussed with the Nuclear Regulatory Commission (NRC) staff during the Design Certification Document (DCD) Tier 2, Section 3.7.1, 3.7.2, and 3.7.3 Audit conducted in September 23-27, 2013, in regard to the Fuel Handling Area (FH/A), the crane supporting columns are continuously anchored to the walls. Similar to the steel beam supported slab/roof in FH/A, the stiffening effect of the steel columns on the out-of-plane stiffness of the wall are considered. Figure 1 presents the two types of wall/column configuration in FH/A. The stiffness consideration for Type I column/wall system for the FH/A south wall is the same as the one described above for the beam supported slab system, i.e. composite effect is considered for full stiffness case while steel column stiffness alone in addition to reduced slab stiffness is considered for reduced stiffness cases. As shown in Figure 1, for the Type II column/wall system, stiffener with sectional dimension of 4' x 4' is installed outside of the FH/A north wall at location of each column. The steel-concrete composite effects of the beam/wall/stiffener system on the out-of-plane stiffness of the wall are evaluated and considered for both cases of full stiffness and reduced stiffness. The methodology used for evaluation of the composite effects is described in Section 2.4.1.1.6 of MUAP 10006 Rev. 3. In the evaluation, the width of the outside stiffener is directly used as effective flange width "b_e" for the Type II column/wall system. Uncracked concrete Young's modulus is used for full stiffness case and 50% of reduction of the Young's modulus is used for reduced stiffness case for the stiffener and the portion of the wall that function as a "flange" in composite section evaluation. Note 2 of MUAP-10006 Table 02.4.1.1.3-1 will be changed to reflect the differences in reduced stiffness for the columns in FHA.

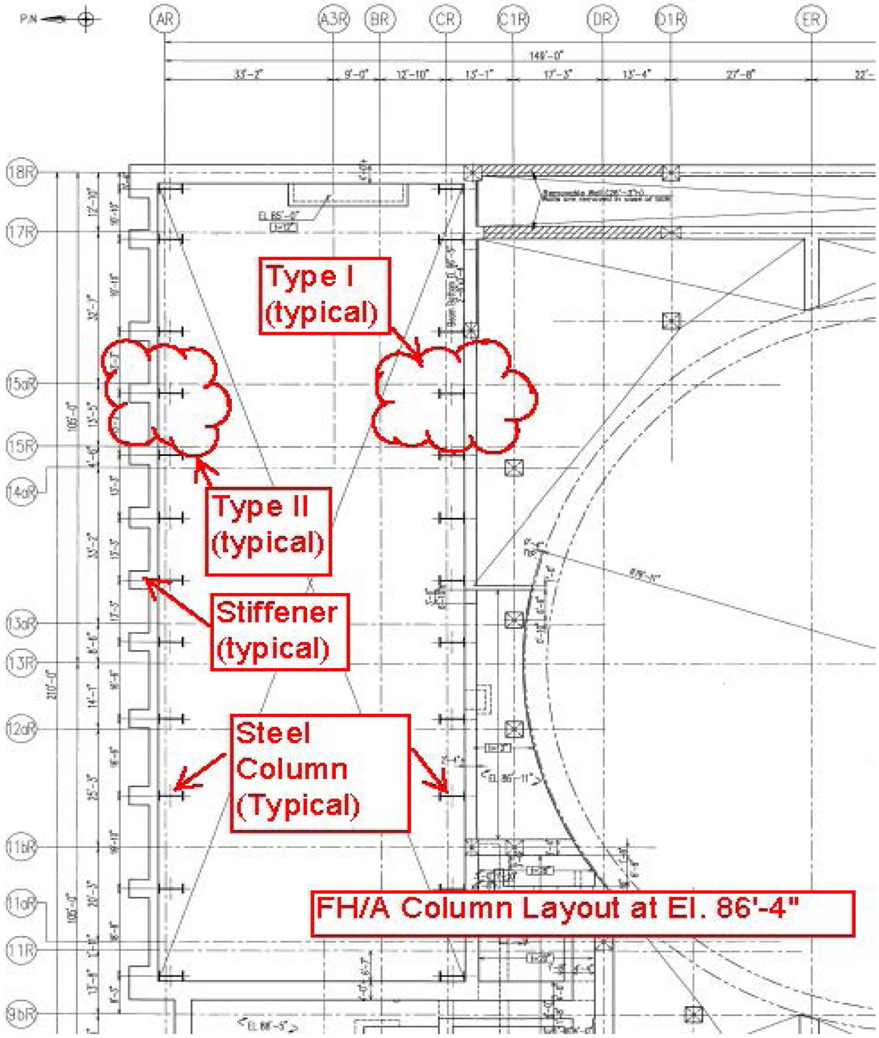

Figure 1 FH/A Steel Column

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, Revision 3, is revised per the above as shown in Attachment 1.

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

Table 02.4.1.1.3-1 Assigned Stiffness and Damping Properties

DCD_03.07.02-113