RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

1/31/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 212-1950 REVISION 1**
SRP SECTION:	**03.07.02 – Seismic System Analysis**
APPLICATION SECTION:	**3.7.2**
DATE OF RAI ISSUE:	**02/25/09**

QUESTION NO. RAI 03.07.02-01 (03.07.02-01):

The seismic analysis methods described in section 3.7.2.1 of the DCD state that the methods conform to the requirements of SRP Subsections 3.7.1 and 3.7.2 and generally to industry standard ASCE 4-98. The staff has not reviewed and endorsed ASCE 4-98 for this application. Currently this ASCE standard is under revision. The applicant need to provide justification independent of ASCE 4-98 in all instances where this standard is relied upon as the basis for seismic analysis. The lumped mass stick models described in Section 3.7.2.1 of the DCD use frequency-independent impedance functions for the half-space modeling of the soil media. The SRP acceptance criteria 3.7.2.II.4 state that for the half-space modeling of the soil media, the lumped parameter (soil spring) method and the compliance function method are acceptable provided that frequency variation and layering effects are incorporated. Provide justification including studies and test data for using frequency-independent impedance functions for the half-space modeling of the soil media.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-09188 (ML091320443).

The methodology used for site-independent seismic response analyses has been revised to consider the frequency dependence of soil-structure interaction response instead of using frequency-independent impedance functions for the half-space modeling of the soil media. As described in DCD Subsection 3.7.2.1, ACS SASSI was used for seismic response soil-structure interaction (SSI) analyses of the three-dimensional dynamic finite element (FE) models of the reactor building (R/B) complex, embedded in backfill and founded on generic layered subgrade profiles. ACS SASSI employs the complex response method and FE technique to solve for the seismic response of the soil-structure interaction system in the frequency domain. This approach captures the frequency dependence of the SSI system and addresses the effect of the layering of the subgrade. DCD Subsection 3.7.2.4.4 provides a discussion relating to site-independent SSI analyses. DCD Subsection 3.7.1.3 describes the generic subgrade profiles used as input for the seismic response analyses.

Technical Report MUAP-10006, Rev. 3, defines the seismic standards that the seismic response SSI analyses are based on, including SRP 3.7.1. The SRP is supplemented with ASCE 4-98 as necessary to establish industry practices where appropriate. ASCE 4-98 is used to provide guidance on the effects of

cracking on reinforced concrete shear wall structures as discussed in Technical Report MUAP-10006, Rev. 3, Section 02.4.2.1. Reduced stiffness values from ASCE/SEI 43-05 were used in the analyses to include the effects of cracking on reinforced concrete shear wall structures.

Table 1 below has been provided to describe the basis for each instance where ASCE 4-98 is referenced in the DCD.

TABLE 1

Question RAI 3.7.2-01

ASCE 4-98 References In DCD Sections 3.7 and 3.8

DCD Tier 2 Section Where ASCE 4-98 is Referenced, and Description of Use of ASCE 4-98	Remarks
Subsection 3.7.2.8: Dynamic lateral pressure distribution profiles are developed in part using analysis methods provided in Section 3.5.3 of ASCE 4-98 (Reference 3.7-9).	Dynamic lateral earth pressures are calculated in a manner consistent with ASCE 4-98 guidance as described in DCD Subsection 3.8.4.4.3. The reference to ASCE 4-98 is kept because computation of dynamic lateral earth pressures in accordance with ASCE 4 is permitted, as described in SRP 3.8.4 Section II.4.H.
Subsection 3.7.3.1.2: In accordance with ASCE 4-98, Subsection 3.2.5.2, for cantilever beams with uniform mass distribution, the equivalent-static-load base shear is determined using the peak acceleration, and the base moment is determined using the peak acceleration times a factor of 1.1.	The factors cited at the left are based on the following references: • Stevenson, J. D. and W. S. Lapay, "Amplification Factors to be used in Simplified Seismic Dynamic Analysis of Piping System," Proceedings, American Society of Mechanical Engineers, 1974. • Czarnecki, R. M., et al, "Justification for a Static Coefficient of 1.0," in Seismic Verification of Nuclear Plant Equipment Anchorage, EPRI NP-5228-SL, Revision 1, Volume 1, 1991. • Niehoff, Dennis and Gurbuz, Orhan, "Multi-Mode Factor for Cantilevered Structures with Variable Mass and Stiffness," Bechtel Technical Paper, Bechtel Corporation, San Francisco, California, 2007.
Subsection 3.7.3.5: Static load factors are chosen to be sufficiently conservative to capture multi-modal response effects.	Refer to DCD Subsections 3.7.3.1.2 and 3.7.3.1.3 and entry above for justification.

DCD Tier 2 Section Where ASCE 4-98 is Referenced, and **Description of Use of ASCE 4-98**	**Remarks**
<u>Subsection 3.7.3.9:</u> Hydrodynamic loads on these liquid-retaining vessels are determined using methods that conform to the provisions of Subsection II.14 of SRP 3.7.3 and guidance of ASCE 4-98, Subsection 3.5.4.	SRP 3.7.3 Subsection II.14 states that ASCE 4-98 contains “acceptable calculation techniques for implementation of” seismic analysis of above-ground tanks.
<u>Subsection 3.8.3.4.2:</u> The hydrodynamic analyses take into account the flexibility of walls in considering fluid-structure interaction. Sloshing height, however, may be calculated using a conservative simplified assumption of a rigid tank shell in accordance with guidance provided in ASCE 4-98, Subsection 3.5.4.3.	SRP 3.7.3 Subsection II.14 states that ASCE 4-98 contains acceptable calculation techniques for implementation of seismic analysis of above-ground tanks.
<u>Subsection 3.8.4.4.3:</u> Dynamic lateral earth pressure is calculated, in part, in accordance with ASCE 4-98.	Use of ASCE 4 to calculate dynamic lateral earth pressure is permitted by SRP 3.8.4 II.4.H. Commentary Section C3.5.3.2 of ASCE 4-98 provides standard industry references as the basis of the approach that is presented in the standard. These references are: • J. H. Wood, “Earthquake-Induced Soil Pressures to Structures”, EERI 73-05, California Institute of Technology, Pasadena, Ca., 1973. • H. B. Seed and R. V. Whitman, “Design of Earth Retaining Structures for Dynamic Loads”, ASCE Specialty Conference on Lateral Stresses and Earth Retaining Structures, June 1970. Since the methodology presented is the standard industry practice to calculate earth pressures, ASCE 4-98 is considered justifiable.

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 Report

There is no impact on a Technical/Topical Report.

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