RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

10/11/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 1045-7141 REVISION 3**
SRP SECTION:	**03.08.05 – Foundations**
APPLICATION SECTION:	**3.8.5**
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QUESTION NO. 03.08.05-56:

On April 3, 2013, the applicant submitted a markup of DCD Tier 2 Section 3.8 to provide updated information related to a seismic design change.

In Subsection 3.8.5.4.3, “Boundary Condition of Basemat,” the last sentence in the paragraph (Page 3.8-100) states, “The properties of the subgrade layers used in the FE [finite element] model of the subgrade are established based on several profiles selected from the generic layered soil profiles described in Technical Report MUAP-10006 (Reference 3.7-48) to cover the entire range of soil/rock conditions at representative nuclear power plant sites within the central and eastern US.”

The staff identified six soil profiles during the review of MUAP-10006, Revision 3, "Soil-Structure Interaction Analyses and Results for the US-APWR Standard Plant." To help the staff better understand the applicant’s approach for modeling of the basemat, the applicant is requested to address the following questions:

1. How many soil profiles were selected from these six soil profiles to perform the structural analysis?

2. How are the properties of the subgrade layers from the selected soil profiles used in the FE model?

ANSWER:

1.) Of the six soil profiles in question, the softest soil profile (270-500) and the hardest soil (rock) profile (2032-100) were selected to create enveloping conditions for equivalent static seismic analyses. The two soil profiles selected provide a lower bound and an upper bound foundation support condition for design of the basemat. For gravity load combinations, maximum forces for shear and bending occur in soft soil conditions (270-500). The maximum out – of - plane bending and maximum uplift forces occur in the hard rock soil profile (2032-100).

2.) The soil properties of the subgrade layers are used to assign the stiffness/response of the soil subgrade to the three-dimensional finite element (FE) subgrade model. Properties of the subgrade layers from the selected soil profiles were modeled in ANSYS consistent with that which is defined in Table 01.5.2.2-2 “Strain Compatible Properties For Profile 2032-100” and Table 01.5.2.2-6 “Strain Compatible Properties For Profile 270-500” of Technical report MUAP-10006, Rev. 3. Specific detail parameters assigned in the model include the shear modulus of the soil, Poisson’s ratio and the modulus of elasticity.

For computational reasons, some of the layers with relatively close geo-mechanical properties were combined together in groups of two or three with assigned equivalent uniform soil properties. Below the FE analysis model of the basemat concrete, the model uses 17 FE layer groups for the soft soil profile (270-500) and nine FE layer groups for hardest soil (rock) profile (2032-100). The equivalent uniform soil properties, such as the shear modulus, Poisson’s ratio, and the modulus of elasticity were determined for each combined group using a weighted average. Equations 1 and 2 were used to calculate the shear modulus of each soil layer and elastic modulus of each soil layer respectively.

$$G = \rho \cdot Vs^2 \qquad \text{Equation 1}$$

$$E = 2 \cdot G \cdot (1 + \upsilon) \qquad \text{Equation 2}$$

Where:

G	=	Shear modulus of the soil
ρ	=	Mass Density of the soil
Vs	=	Median shear wave velocity
E	=	Modulus of elasticity of the soil
υ	=	Poisson’s ratio of the soil

For computational efficiency, for seismic loading cases, the properties of the two separate underlying soil/rock foundation media profiles were modeled in ANSYS as a super-element using a procedure known as sub-structuring. The soil profile super-elements were modeled using three dimensional linear 8–node solid elements (SOLID45 element type) with three degrees of freedom (DOF) per node. The depth and horizontal extents of the subgrade models were chosen to capture all numerical results of interest which include primarily axial force, out-of-plane bending moment, out-of-plane shear force and deformations of the basemat.

Foundation loadings were applied to produce the maximum seismic loading effect. Dynamic lateral soil pressure at applicable locations was superimposed on the seismic loads to account for soil-structure interactions (SSI). For seismic load cases, the stiffness of the backfill soil was activated only on faces in the opposite direction of the earthquake, which allows the backfill soil stiffness to contribute only while in compression. Additionally, the effects of buoyancy were considered when the seismic acceleration was applied in the upward direction.

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.

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