RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/29/2013

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

RAI NO.:	**NO. 657-5135 REVISION 2**
SRP SECTION:	**03.08.05 – Foundations**
APPLICATION SECTION:	**3.8.5**
DATE OF RAI ISSUE:	**11/15/2010**

QUESTION NO. 03.08.05-39:

In the response to Part 1 of Question 03.08.05-30, MHI states that the total dynamic lateral pressure is the sum of the Wood's pressure and the Westergaard's hydrodynamic pressure. The staff does not accept this answer unless additional data are provided to support this response by MHI. The Wood's solution is based on the classical elastic wave theory which is not applicable for the fluid-saturated porous media. MHI is requested to provide numerical data to support the statement that the lateral pressure based on the elastic wave theory in the porous media is enveloped by the Wood's pressure.

In the response to Part 2, MHI states that the lateral earth pressure induced by the vertical earthquake is given by K_0 $(a_v/g)\gamma_e Z_w$ in which K_0 is at-rest coefficient of soil. The staff is not aware of this equation. MHI is requested to provide the technical basis for this equation.

In the response to Part 3, MHI provides a detailed answer that includes the explanation of the active and passive pressure. The staff finds the response somewhat hard to follow. Perhaps the question asked by the staff was not clearly stated. Reiterating its concern as expressed in the initial RAI question: the staff noticed that Wood's solution does not consider the earth pressure due to the rotation of the wall at its base and requested that the Applicant provide information addressing this earth pressure. Notice that the rotation of the wall at its base is a result of the SSI analysis. So, the earth pressure should be calculated within the frame of theory of elasticity, because the SSI analysis performed is within the frame of linear elasticity. MHI is requested to address this concern.

ANSWER:

This answer revises and replaces the previous MHI answer that was transmitted by letter UAP-HF-10351 (ML110040127).

As described in the response to RAI 212-1950, Question 3.7.2-13, the basemat and below grade exterior walls of the US-APWR seismic category I buildings are designed using an conservative envelope of the dynamic plus static pressure profile and total passive pressure profile. The magnitudes of the two pressure profiles are developed following the

requirements of Standard Review Plan (SRP) 3.8.4 Acceptance Criterion II.4.H (Reference 1) that states:

> "Consideration of dynamic lateral soil pressures on embedded walls is acceptable if the lateral earth pressure loads are evaluated for two cases. These are: (1) lateral earth pressure equal to the sum of the static earth pressure plus the dynamic earth pressure calculated in accordance with American Society of Civil Engineers (ASCE) 4-98, Section 3.5.3.2; and (2) lateral earth pressure equal to the passive earth pressure. If these methods are shown to be overly conservative for the cases considered, then the staff reviews alternative methods on a case-by-case basis."

The envelope of the two pressure profiles is applied to the detailed model as equivalent static loads for purposes of design, in combination with other applicable loads.

Part 1.

Wood's formula for dynamic lateral earth pressure on fixed base rigid walls is used to benchmark other studies based on elastic wave propagation (Reference 2) and in general envelops the results obtained with more advanced formulas (Reference 3). It is determined that the use of saturated unit weight for the soil provides the most conservative case for including the effects of groundwater in the calculations of the dynamic earth pressures because it considers that the response of the two phases of the system, the ground water and the soil, to be completely in-phase and does not consider the dissipation of energy due to the viscous flow of the ground water as indicated in the response to RAI 212-1950, Question 3.7.2-13.

Part 2.

The earth pressure induced by the vertical earthquake is removed from the methodology to compute the lateral earth pressure. Refer to the response to RAI 212-1950, Question 3.7.2-13 for the current methodology.

Part 3.

The displacement and/or rotation of the exterior wall at base towards the backfill soil will induce passive pressure on the below-grade wall. In the case that the displacement and/or rotation of the wall is sufficiently large, plastic yield will happen in the backfill soil mass. In this situation, the full passive pressure is reached. The envelope of the dynamic plus static pressure profile and total passive pressure profile, as described in the response to RAI 212-1950, Question 3.7.2-13, is the maximum lateral pressure that the backfill soil can take. Any additional wall displacement and/or rotation cannot induce pressures that exceed this pressure envelope, as the backfill soil has already failed at this point. Therefore, the effect of any rotation of the exterior wall at base has been considered in the pressure envelope, which is applied to the detailed model to design the exterior walls of the basement.

References:

1. Other Seismic Category I Structures, NUREG-0800, SRP 3.8.4, Rev. 3, U.S. Nuclear Regulatory Commission, Washington, DC, May, 2010.

2. Velestos, A.S. and Youan, A.H. (1994). Dynamic Soil Pressures on Rigid Vertical Walls. Earthq. Eng. Struct. Dynamics, 23(3):275-301.

3. Ostadan, F. (2008). Seismic Soil Pressure on Building Walls - An Updated Approach. Bechtel Technology J., 1(1):1-10.

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/Topical Report

There is no impact on the Technical/Topical Report.

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