RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

03/29/2013

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:	**02/25/2009**

QUESTION NO. 03.07.02-01 (03.07.02-13):

It is stated in Section 3.7.2.8 of the DCD that dynamic increases in seismic lateral earth pressure on below-grade exterior walls were accounted for in the design of the USAPWR Seismic Category I structures by applying conservative maximum static and dynamic lateral pressure profiles in accordance with ASCE 4-98. The staff has not reviewed and endorsed ASCE 4-98 for this application. Currently this ASCE standard is under revision. Describe the pressure distribution profiles and the application of these pressure profiles to below-grade exterior walls in the seismic models, and what models are affected. Explain the basis for determining the lateral pressure distribution profiles to be conservative.

ANSWER:

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

The pressure distribution profiles to below-grade exterior walls are developed following the requirements of Standard Review Plan (SRP) 3.8.4, Acceptance Criterion II.4.H (Reference 1) and presented in DCD Subsection 3.8.4. SRP 3.8.4, Acceptance Criterion II.4.H 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 Mechanical 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."

Therefore, the two cases are investigated to compute the pressure distribution profiles. 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. Regarding the effects of Groundwater Level, two scenarios are considered: (1) Groundwater Level at plant grade, and (2) Groundwater Level at the bottom of the basemat level. To be conservative, Case (1) calculation of dynamic plus static earth pressures assumes Groundwater Level

Scenario #1, while passive pressure (Case (2)) is computed assuming Groundwater Level Scenario #2.

<u>Case (1), conservatively assuming Groundwater Level Scenario #1</u>

The total lateral earth pressure required by Acceptance Criterion II.4.H, Case (1) consists of following three categories.

i. Dynamic Lateral Earth Pressure

The horizontal earthquake excitation induced lateral pressure, denoted as p_{sh}, is calculated by interpolating and applying Wood's solution included in ASCE 4-98 Figure 3.5-1 (Reference 2) for the following soil and seismic parameters:

Poisson's ratio ν = 0.4 (conservative value for granular soil)

Soil unit weight: saturated (Groundwater Level Scenario #1) γ_{sat} = 130 pcf,

Wall height H = 42.25 ft

Horizontal seismic coefficient in g's α_h = 0.5

The saturated unit weight of 130 pcf of the backfill soil is used assuming that the pore water moves together (in-phase) with the soil during earthquake shaking, and the inertial force is proportional to the total weight of the embedment soil. This assumption is conservative since it does not consider the dissipation of energy due to the viscous flow of the ground water in the soil skeleton. The soil-structure interaction (SSI) and structure-soil-structure interaction (SSSI) analyses of the fully embedded reactor building (R/B) complex result in a maximum average horizontal acceleration of 0.499g (as shown in Table 1) along the embedment depth for 12 selected vertical sections through the backfill in the vicinity of the basement walls, denoted as Group 1 through Group 12 in Figure 1. Therefore, a value of 0.5 is used for the horizontal seismic coefficient.

Table 1. Maximum Horizontal Average Accelerations*

Weighted Average Maximum Acceleration - Horizontal						
SSI Analysis (12 Cases)						
Group Number	1	2	3	4	5	6
Acceleration (g)	**0.405**	**0.410**	**0.413**	**0.499**	**0.442**	**0.446**
Group Number	7	8	9	10	11	12
Acceleration (g)	**0.419**	**0.428**	**0.417**	**0.403**	**0.420**	**0.480**
SSSI Analysis (8 Cases)						
Group Number	10	11	12			
Acceleration (g)	**0.446**	**0.418**	**0.419**			
Maximum Value for Horizontal Average Acceleration				**0.499**		

* The 12 SSI cases contain SASSI analyses for six soil profiles with cracked and uncracked stiffness levels. The eight SSSI cases contain SASSI analyses for four

soil profiles (excluding 270-500 and 2032-100 profiles) with cracked and uncracked stiffness levels.

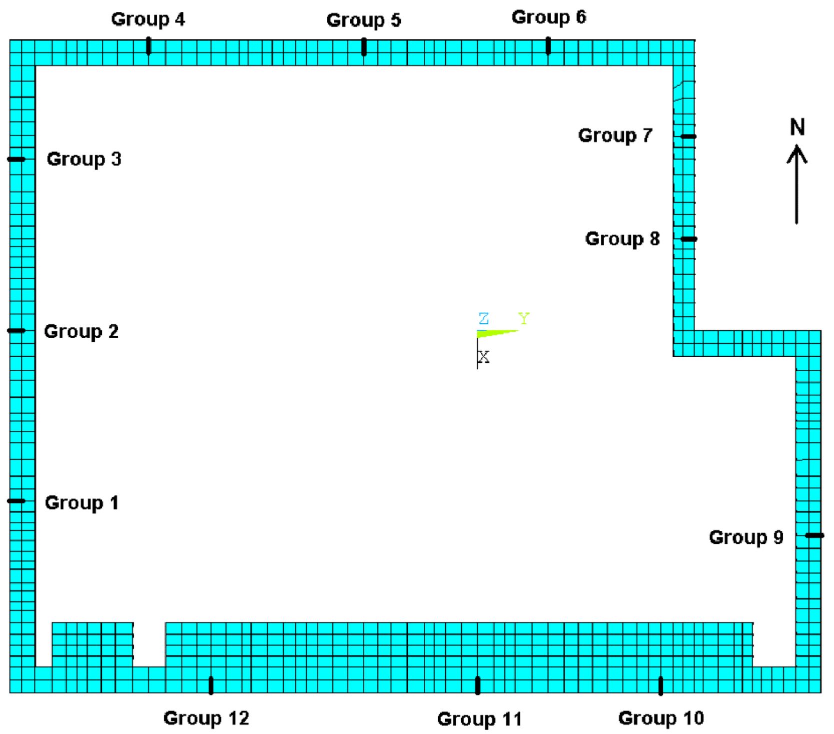

Figure 1. Grouping for Seismic Coefficient Analysis

ii. Static Lateral Earth Pressure

The static lateral earth pressures on the exterior walls consist of static at-rest earth pressure, and pressure due to surcharge. The total static lateral earth pressure at depth of z from the ground surface is calculated as:

$$p_{static} = K_0 \cdot \gamma_{eff} \cdot z + K_0 \cdot p_{surcharge}$$

where $p_{surcharge}$ = 450 psf is a surcharge load on the ground surface (Reference 3).

iii. Hydrostatic Pressure

The hydrostatic pressure on the wall at depth of z from the ground surface is calculated as:

$$p_{hydro} = \gamma_{water} \cdot z$$

where γ_{water} = 62.4 pcf is the unit weight of water.

Therefore, the total static and dynamic lateral earth pressure for Case (1) on the exterior walls is calculated as follows:

$$p_s = p_{sh} + p_{static} + p_{hydro}$$

Case (2), conservatively assuming Groundwater Level Scenario #2

The passive earth pressure, assuming Rankine's theory, has the expression:

$$p_p = K_p \cdot \gamma_{unsat} \cdot z + K_p \cdot p_{surcharge}$$

where γ_{unsat} is taken as in-situ unit weight (125 pcf) for Groundwater Level Scenario #2, and K_p =3.69 is the passive earth pressure coefficient calculated assuming an internal friction angle of 35°.

Figure 2, below presents both "Dynamic + Static Pressure" and "Total Passive Pressure" profiles. It is concluded that the total passive earth pressure is greater than the dynamic plus static lateral earth pressure below elevation -3.0 ft, while the dynamic plus static lateral earth pressure is the controlling pressure profile above elevation -3.0 ft. Therefore, a conservative envelope of the two pressure profiles is applied to the detailed model to design the exterior walls below-grade in combination with other applicable loads.

Furthermore, lateral earth pressure on the below grade walls of the R/B complex may be affected by relative sliding between the R/B complex, the turbine building (T/B), the access building (AC/B) and the tank house. Refer to response to RAI 855-6090, Question 03.08.05-43 and RAI 960-6709, Question 03.07.02-212, part (c), for considering the relative sliding effect to determine lateral earth pressure at those locations.

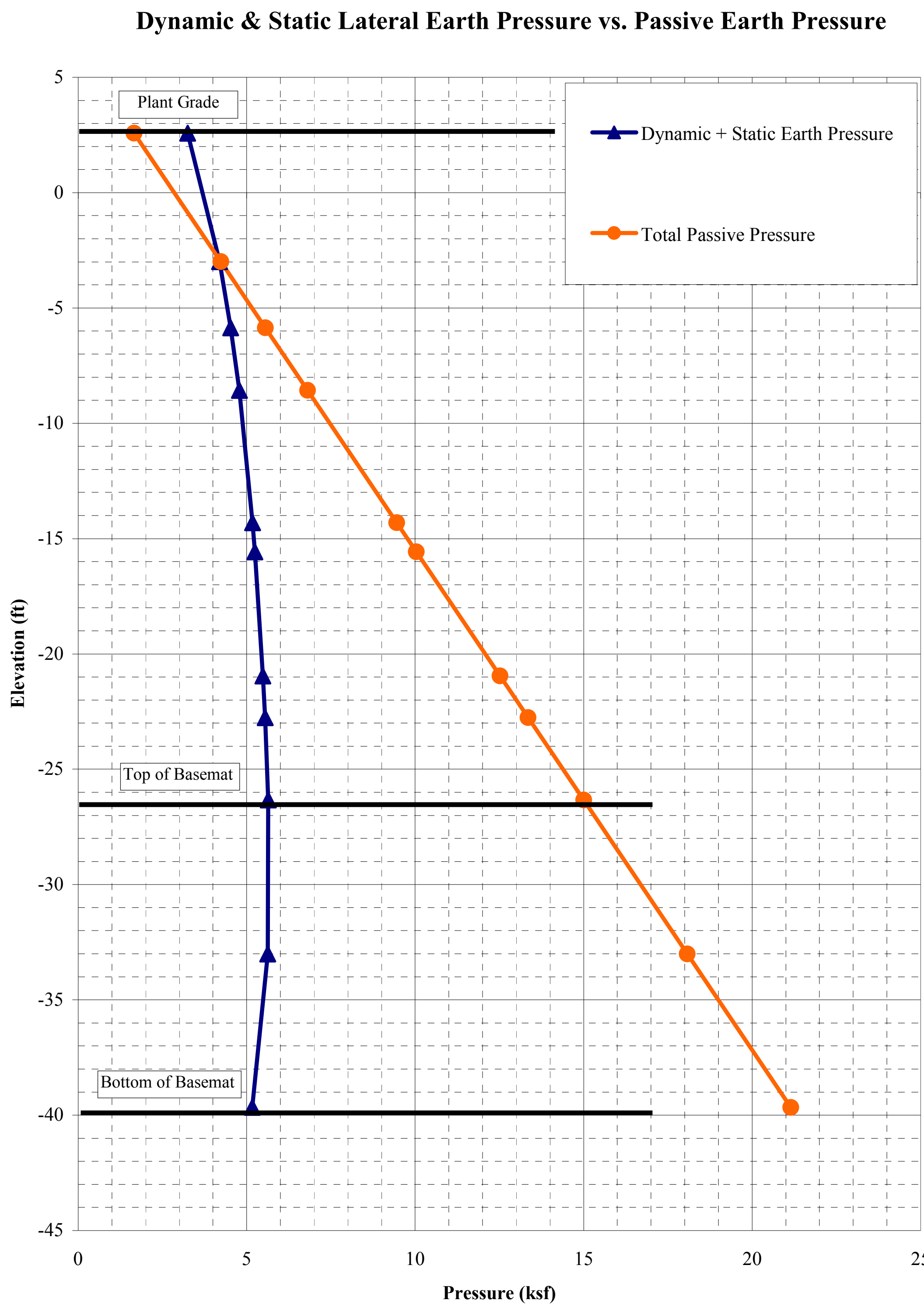

Figure 2. Dynamic and Static Lateral Earth Pressure vs. Passive Earth Pressure Profiles

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. Seismic Analysis of Safety Related Nuclear Structures, American Society of Civil Engineers, ASCE 4-98, Reston, Virginia, 2000.

3. US-APWR Standard Design Civil Structural Design Criteria, Mitsubishi Heavy Industries, N0-CF00003, Revision 4, August, 2012.

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.