## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

**03/29/2013**

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No. 52-021**

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| **RAI NO.:** | **NO. 94-1491 REVISION 1** |
| **SRP SECTION:** | **02.05.04 – Stability of Subsurface Materials and Foundations** |
| **APPLICATION SECTION:** | **2.5.4** |
| **DATE OF RAI ISSUE:** | **11/06/2008** |

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**QUESTION NO. 02.05.04-01:**

Related to tables 2.1 -1 (Tier 1) and 2.0-1 (Tier 2) "Key Site Parameters":

a) Clarify your use of "average" static and dynamic bearing capacity rather than a minimum value. Please explain how the dynamic bearing pressure was determined.

b) Clarify why there is not a parameter value for settlement in Tier 1 and a description in Tier 2, Section 2.5.4.

Clarify the restrictions with regard to soil liquefaction, which states only "none."

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**ANSWER:**

This answer revises and replaces the previous MHI response that was transmitted by letter UAP-HF-08272 (ML083430037).

a) Design Control Document (DCD) Tables 2.1-1 (Tier 1) and 2.0-1 (Tier 2) "Key Site Parameters" have been revised to identify minimum allowable static and dynamic bearing capacities rather than average values.

The specified minimum allowable dynamic bearing capacity is determined as follows:

1. Calculate maximum dynamic toe pressure for each soil profile and at each time step of the design basis time history, using a simplified method assuming rigid basemat and subgrade. These pressures are used only to identify the critical time step for computing dynamic bearing pressure demand for each soil profile. The critical time steps and corresponding loads are determined for two scenarios: (1) with buoyancy (ground water level at one foot below the plant grade), and (2) without buoyancy (ground water level at the bottom of the basemat). Both cracked and uncracked concrete section properties are considered.

The method to determine the maximum toe pressures, using rigid basemat assumption, are described below.

i. Calculate the vertical forces and overturning moments due to inertia forces using nodal acceleration time histories obtained through soil-structure interaction (SSI) analysis.

ii. Compute additional overturning moments due to earth lateral pressures, including dynamic and surcharge pressures

iii. Add the overturning moments due to the eccentricity of self-weight (Dead Load plus 25 percent Live Load) of the reactor building (R/B) complex.

iv. Calculate the vertical forces (including inertia, self-weight, and buoyancy) and overturning moments from the 3 Steps i through iii above, with respect to the centroid at the bottom of the basemat.

v. Calculate pseudo-static bearing pressures due to the forces and moments from Step iv. During the analysis, when certain portions of the mat indicate that negative (tensile) stresses have developed, the soil/foundation contact area is reduced by removing the tensile area, and the pressures are then adjusted to maintain force and moment equilibrium. This process is iteratively continued until all tensile stresses are removed without violating equilibrium.

vi. Report pseudo-static bearing pressures at corners of the R/B complex after the iteration process of Step v is converged. Identify the time steps producing maximum toe pressures for the six soil profiles.

2. For each case analyzed (namely: soil profile, ground water level, and concrete section properties) determine the vertical load (i.e., inertia plus self-weight and buoyancy forces) and two overturning moments considering all inertia forces and static plus dynamic lateral earth pressures, at the critical time step identified at Step 1.

3. For eccentrically loaded footings, a reduced effective area B’ x L’, within the confines of the physical footing, is used to calculate the bearing pressure demand as shown in Figure 1 below (Reference 1). Note that the irregular basemat area of the R/B complex is transformed into a rectangular area by conservatively removing the base area of the East power source building (PS/B).

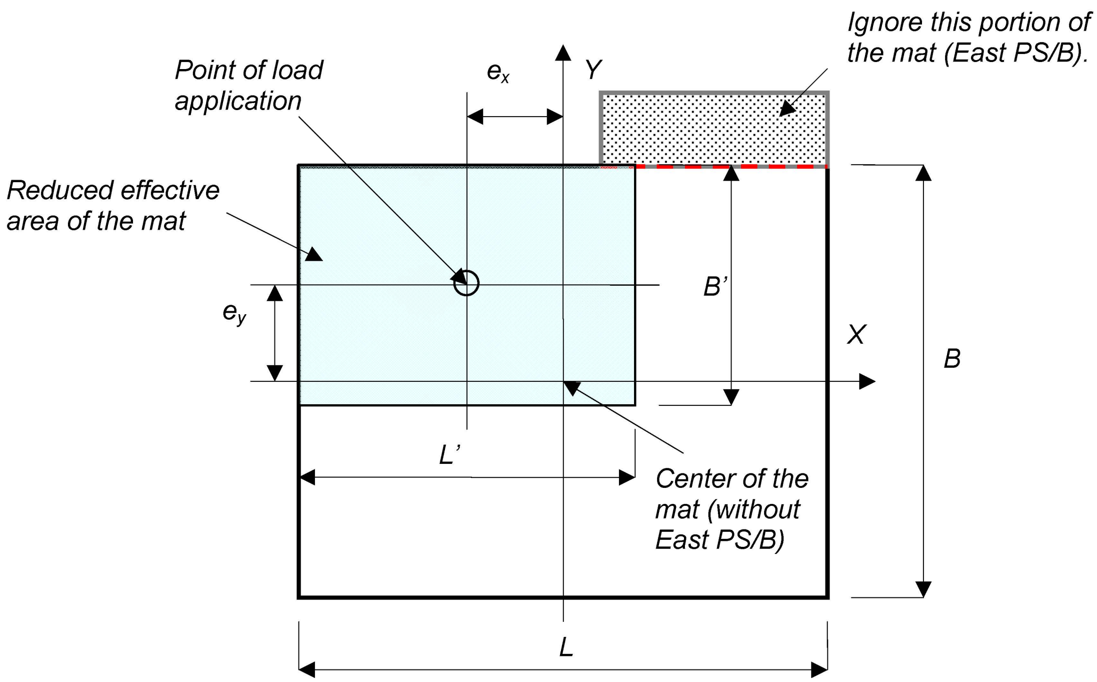


Figure 1, Reduced Effective Area for Eccentrically Loaded Basemat

In Figure 1:

$B' = B - 2e_y$, $L' = L - 2e_x$;

$e_x = \dfrac{M_y}{F_z}$, eccentricity in X direction;

$e_y = \dfrac{M_x}{F_z}$, eccentricity in Y direction;

$M_x$ and $M_y$ are the overturning moments in the X and Y directions, respectively.

The maximum value of dynamic bearing pressure demand for the two ground water level scenarios are computed and presented in Tables 1 and 2, respectively. The envelope of results from cracked and uncracked concrete section properties is considered. These pressures range between 17 ksf and 21 ksf for ground water level at 1 ft below plant grade, and between 20 ksf and 22 ksf for ground water level at the basemat elevation. A conservative value for minimum allowable dynamic bearing capacity of 35 ksf was selected. These values are included in Table 2.0-1 of Tier 2 of the DCD and in Table 2.1-1 of Tier 1 of the DCD.

Table 1, Maximum Dynamic Bearing Pressure Demand for the Scenario of Ground Water Level at One ft below Plant Grade

| Max Dynamic Bearing Pressure Demand (ksf) - GWL = -1ft | | | |
|---|---|---|---|
| Soil | Uncracked | Cracked | Envelope |
| 270-200 | 18.0 | 18.8 | 18.8 |
| 270-500 | 16.9 | 17.2 | 17.2 |
| 560-500 | 18.2 | 18.7 | 18.7 |
| 900-100 | 19.6 | 20.9 | 20.9 |
| 900-200 | 20.2 | 21.1 | 21.1 |
| 2032-100 | 19.9 | 20.3 | 20.3 |

Table 2, Maximum Dynamic Bearing Pressure Demand for the Scenario of Ground Water Level at the Bottom of the Basemat

| Max Dynamic Bearing Pressure Demand (ksf) - GWL = -42.25ft | | | |
|---|---|---|---|
| Soil | Uncracked | Cracked | Envelope |
| 270-200 | 20.2 | 20.8 | 20.8 |
| 270-500 | 19.2 | 19.5 | 19.5 |
| 560-500 | 20.3 | 20.6 | 20.6 |
| 900-100 | 21.4 | 21.4 | 21.4 |
| 900-200 | 21.4 | 21.7 | 21.7 |
| 2032-100 | 21.9 | 21.0 | 21.9 |

Maximum static bearing pressure demand can be calculated using the same methodology described above. The self-weight of the R/B Complex is $1.269\text{x}10^6$ Kips. Due to the eccentricities of the self-weight and lateral earth pressure from surcharge, there are some small overturning moments existing in R/B Complex:

$$M_x = 1.425 \times 10^7 \, kip \cdot ft$$

$$M_y = -1.875 \times 10^7 \, kip \cdot ft$$

For the scenario of ground water level at one ft below the plant grade, the buoyancy force is:

$$F_{buoy} = 3.216 \times 10^5 \, kips$$

Table 3 presents the maximum static bearing pressures for the two ground water level scenarios. The maximum static bearing pressure demand is 13.1 ksf by enveloping both scenarios. Therefore, the minimum allowable static bearing capacity in the DCD is conservatively specified as 15 ksf in Table 2.0-1 of the DCD.

Table 3, Maximum Static Bearing Pressure Demands

| Ground Water Level | Fz (k) | Mx (k-ft) | My (k-ft) | ex (ft) | ey (ft) | Max Static Bearing Pressure Demand (ksf) |
|---|---|---|---|---|---|---|
| GWL=-39.67ft | 1.269E+06 | 1.425E+07 | -1.875E+07 | -14.78 | 11.23 | 13.1 |
| GWL=-1ft | 9.474E+05 | 1.425E+07 | -1.875E+07 | -19.79 | 15.04 | 10.4 |

b) DCD Tables 2.1 -1 (Tier 1) and 2.0-1 (Tier 2) "Key Site Parameters" have been revised to identify parameter values for settlement. Additionally, Subsection 2.5.4 has been revised to clarify parameter value for settlement.

c) The US-APWR standard plant design is based on the premise that there is no potential for liquefaction. The Combined License (COL) Applicant is required by Subsection 2.5.4.8 of the DCD to analyze for the potential of liquefaction occurring at the site. Compliance with site parameters as stated in Table 2.0-1 requires that there is no potential for soil liquefaction for seismic category I structures.

**Reference:**

1. AASHTO LRFD Bridge Design Specifications, 2009 Interim Revisions, Washington, DC.

**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.

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