REQUEST FOR ADDITIONAL INFORMATION 219-1908 REVISION 0

2/26/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 03.04.02 - Analysis Procedures
Application Section: 03.04.02 - Analysis Procedures

QUESTIONS for Structural Engineering Branch 1 (AP1000/EPR Projects) (SEB1)

03.04.02-1

RAI 3.4.2-01

1. RAI Text

In light of the NIST and FEMA report, Hurricane Katrina event had significantly exceeded the base flood elevations by as much as 15 feet along parts of the Louisiana and Mississippi Gulf Coast. Furthermore, if the Figure C.1-Probable Maximum Surge Estimates, Gulf Coast, in Appendix C, "Simplified Methods of Estimating Probable Maximum Surges," of Regulatory Guide 1.59, is to be used, the updated info provided by the NIST findings needs to be considered for PMF evaluations. The applicant is requested to verify that whether such update information regarding the PMF will be considered and implemented into the US-AWPR DCD.

2. Concern:

To meet the requirements of GDC 2, 10 CFR 52.17, and 10 CFR Part 100, estimates of the probable maximum hurricane (PMH) and the probable maximum storm surge, i.e., the storm surge induced by the PMH, are needed. The PMH, as defined by NOAA NWS Report 23, should be estimated for coastal locations that may be exposed to these events. If a PMH is not considered as a design basis for the proposed site, documentation of the reasons should be provided. The storm surge induced by the PMH should be estimated as recommended by Regulatory Guide 1.59, supplemented by current best practices.

GDC 2 also requires that design bases for SSCs reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and the surrounding region, with sufficient margin for the limited accuracy and quantity of the historical data and the period of time in which the data have been accumulated.

FEMA 548 report, *Summary Report on Building Performance: Hurricane Katrina 2005*, states that "Katrina significantly exceeded the base flood elevations by as much as 15 feet along parts of the Louisiana and Mississippi Gulf Coast. Flooding extended well beyond the inland limits of the Special Flood Hazard Area, and the highest storm surge in U.S. history was recorded on the Mississippi coast." Furthermore, in 2005 NIST coordinated a multi-organizational reconnaissance on the performance and damage to physical structure due to Hurricanes Katrina and Rita. The FEMA, U.S. Army Corps of

Engineers, and other agencies participated in this reconnaissance effort. The principal findings of this initiative were documented in NIST Technical Note 1476, Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Report. Some of the key findings related to the floods are quoted below.

"In coastal areas and in New Orleans, storm surge was the dominant cause of damage. Storm surge heights, in general, exceed the levels defined by existing flood hazard maps as well as historical records. While design provisions exist to address storm surge and flooding, existing flood hazard maps–which provide the basis for design of structures–are outdated and not consistent with the risks posed by storm surge in these coastal areas. Better definition of the storm surge hazard is required to appropriately apply existing design provisions and elevation levels to mitigate the effects of storm surge on buildings and residences."

"The NIST-led team observed failures of the levees and floodwalls in New Orleans by three different mechanisms: rotational failure of the floodwall-sheet pile system triggered by soil erosion due to overtopping; massive erosion and scour of the earthen levee at the levee/floodwall junction (with water overtopping); and sliding instability of the floodwall-levee system due to foundation failure (without water overtopping). The foundation failures due to sliding instability at the above breaches could have been possibly caused either by underseepage erosion or by shear failure within the clay in the foundation beneath the levee and the floodwall."

As a part of its reconnaissance, NIST is making 23 recommendations for specific improvements in the way that buildings, physical infrastructure, and residential structures are designed, constructed, maintained, and operated in hurricane prone regions. It is important to note that these recommendations may apply to other hurricane-prone regions of the country. The recommendations 6-14 are associated with Standards, Codes, and Practices. These recommendations address the need for development or modification of codes, standards, and practices with a view toward improving the performance of building, physical structures, and associated equipment in future hurricanes based upon the observed damage due to Hurricanes Katrina and Rita. It is expected that this initiative will lead to better provision for flood design.

In addition to floods produced by severe hydrometeorological conditions, the most severe seismically induced floods reasonably expected should be considered for each site. For example, the seismically induced landslide along a lake, reservoir, river, or seashore, reasonably severe wave action should be considered coincident with the probable maximum water level conditions. Furthermore, along streams and estuaries, seismically induced floods may be produced by dam failures. Along lakeshores, coastlines, and estuaries, seismically induced or tsunami-type flooding should be considered.

3. Applicant References:

DCD Tier 2, Revision 1, Section 3.4 and Section 2.4.

4. Context

Structural integrity of Seismic Category I structures, which assures that SSCs important to safety are protected, and not compromised according to GDC-2 in the Appendix A to Part 50 of 10 CFR.

5. Priority/Impact

Medium – information is essential to completing a technical review and resolving a safety issue of PMF. The review can continue, but cannot be completed without the requested additional information.

6. Dependencies

Internal – There are interfaces with SRP Chapter 3.0, Section 3.4.2, and SRP Chapter 2, Section 2.4.2, 2.4.3, 2.4.5, 2.4.6, and 2.4.12.
External – There are no external dependencies.

03.04.02-2

RAI 3.4.2-02

1. RAI Text

No specific codes or standards were identified in the DCD for flood load design that can provide guidance for hydrostatic and hydrodynamics loads evaluations, such as that in the Chapter 5 of ASCE-07-05, Shore Protection Manual, or Coastal Engineering Manual (U.S. Army Corps of Engineers EM 1110-2-1100, 30 April 2002).

The staff requests the applicant to provide information on this subject.

2. Concern:

In SRP 3.4.2."Analysis Procedures," the Accept Criteria Section specifies the criteria necessary to meet the relevant requirements of GDC 2.,where, in the case of a flood level below the proposed plant grade only its hydrostatic effects need be considered; however, if the peak maximum flood level is above the proposed plant grade the dynamic loads of wave action should be considered. However, no specific code or standards were identified in flood design of the DCD that can be used for hydrostatic and hydrodynamics loads evaluations, such as in the Chapter 5 of ASCE-07-05, ASCE.SEI-24-05 (Flood Resistant Design and Construction), Shore Protection Manual, or Coastal Engineering Manual (U.S. Army Corps of Engineers EM 1110-2-1100, 30 April 2002).

3. Applicant References:

DCD Tier 2, Revision 1, Section 3.4.2 and Section 2.4.

4. Context

Structural integrity of Seismic Category I structures, which assures that SSCs important to safety are protected, and not compromised according to GDC-2 in the Appendix A to Part 50 of 10 CFR.

5. Priority/Impact

Medium – information is essential to completing a technical review and resolving a safety issue of flood load design. The review can continue, but cannot be completed without the requested additional information.

6. Dependencies

Internal – There are interfaces with SRP Chapter 3.0, Section 3.4.2
External – There are no external dependencies.

03.04.02-3

RAI 3.4.2-03

1. RAI Text

In the case of *Fp* evaluation in Section 3.8.5.5.2 of *Sliding Acceptance Criteria ,* only the passive earth pressure was considered, and only the active pressure was used for *Fh* evaluation. As for *Fd* evaluation for sliding caused by earthquake, only the active soil pressure was considered in the DCD. The staff requests the applicant to provide the justification for these approaches.

2. Concern:

DCD Section 3.4.2, “Analyses Procedures,” refers to DCD Sections 2.4 and 3.8 for guidance on the loads and load combination (static and dynamics loads) due to ground water or flood level.

Structural acceptance criteria, discussed in detail in DCD Subsections 3.8.1.5 and 3.8.4.5, state that the design soil conditions are as provided in DCD Section 2.5, and the site-specific COL is to assure the design criteria listed in DCD Chapter 2, Table 2.0-1 is met or exceeded. It is known that the soil response characterization (such as the effective stress level) has strong relation with the ground water or flood water level. The load combinations applicable to the design of the seismic category I nuclear island basemat include acceptance criteria for overturning, sliding, and flotation were described in DCD Table 3.8.5-1. On the subject related to the liquid loads, normally, the vertical and lateral pressures of liquids are treated as dead loads except for external pressures due to ground water which are treated as live loads. Hydrodynamic loads due to seismic sloshing are calculated per ASCE Standard 4-98, and included in earthquake load *Es*, as described in DCD Section 3.8.

Typical loads and load combinations are detailed in DCD Subsection 3.8.4.3, such as the *Liquid Load* and *Earth Pressure* **(H)**, where the passive and active earth pressures are used in the “*Sliding Acceptance Criteria” evaluation*, which is described below.

Sliding Acceptance Criteria
The factor of safety against sliding caused by wind or tornado is identified by the ratio:
F_{Ssw} = [*Fs* + *Fp*] / *Fh* , not less than F_{Ssl} as determined from Table 3.8.5-1,
where
F_{Ssw} = Structure factor of safety against sliding caused by wind or tornado
Fs = Shear (or sliding) resistance along bottom of structure basemat
Fp = Resistance due to maximum passive soil pressure, neglecting any contribution of surcharge
Fh = Lateral force due to active soil pressure, including surcharge, and tornado or wind load, as applicable

The factor of safety against sliding caused by earthquake is identified by the ratio:
F_{Sse} = [*Fs* + *Fp*] / [*Fd* + *Fh*], not less than F_{Ssl} as determined from Table 3.8.5-1
where
F_{Sse} = Structure factor of safety against sliding caused by earthquake
Fs = Shear (or sliding) resistance along the bottom of the basemat
Fp = Resistance due to maximum passive soil pressure, neglecting any contribution of surcharge
Fd = Dynamic lateral force, including dynamic active earth pressures caused by seismic loads
Fh = Lateral force due to all loads except seismic loads

In the case of *Fp* evaluation, only the passive earth pressure was considered in the DCD. It is not clear whether the active earth pressure was also considered in the opposite side of building. Moreover, from the conservative standpoint, the active earth pressure also needs to be considered in the *Fp* evaluation. The same argument is also applied for the *Fh* evaluation, where both the passive and active earth pressures need to be considered, and from the conservative view point only the passive earth pressure needs be considered.

As for *Fd* evaluation for sliding caused by earthquake, only the active soil pressure was considered in the DCD. In reality due to cyclic nature of the seismic loading, the passive earth pressure also needs to be considered.

3. Applicant References:

DCD Tier 2, Revision 1, Section 3.4.2, and Section 3.8.5.

4. Context

Structural integrity of Seismic Category I structures, which assures that SSCs important to safety are protected, and not compromised according to GDC-2 in the Appendix A to Part 50 of 10 CFR.

5. Priority/Impact

Medium – information is essential to completing a technical review and resolving a safety issue. The review can continue, but cannot be completed without the requested additional information.

6. Dependencies

Internal – There are interfaces with SRP Chapter 3.0, Section 3.4.2, and Section 3.8.5.
External – There are no external dependencies.

03.04.02-4

RAI 3.4.2-04

1. RAI Text

The loads and load combinations are described in the Subsection 3.8.4.3 of the DCD. The earthquake load is considered with both terms of *Es* and *Ess.* This may cause some confusion. Furthermore, in the DCD *Es* was formally defined as Young's modulus, not earthquake load. Thus, the staff requests the applicant to provide a consistent definition for earthquake load**.**

2. Concern:

Typical loads and load combinations are detailed in Subsection 3.8.4.3. Load combinations to be utilized for the design of the containment internal structure include hydrostatic, pressure, and thermal loads as summarized below. Hydrostatic loads reflect the water inventory and its location during various plant conditions. Seismic category I concrete structures are designed for impulsive and impactive loads in accordance with the ACI 349 Code (Reference 3.8-8 of the DCD), and special provisions of Appendix C of the same code, with exceptions given in RG 1.142.

In Liquid Loads (F) categor*y*, hydrodynamic loads due to seismic sloshing are calculated per ASCE Standard 4-98, and included as part of the earthquake load, which is defined as *Es* in the DCD. However, in *Earth Pressure (H)* category, the dynamic soil pressure induced during an SSE event, is considered as an earthquake load, in this case the earthquake load is defined as *Ess*. which appears not to be self-consistent and Es may be confused with the term defined for Young's modulus.

3. Applicant References:

DCD Tier 2, Revision 1, Section 3.4, and Section 3.8.

4. Context

Structural integrity of Seismic Category I structures, which assures that SSCs important to safety are protected, and not compromised according to GDC-2 in the Appendix A to Part 50 of 10 CFR.

5. Priority/Impact

Medium – information is essential to completing a technical review and resolving a safety issue. The review can continue, but cannot be completed without the requested additional information.

6. Dependencies

Internal – There are interfaces with SRP Chapter 3.0, Section 3.4.2, and Section 3.8.5.
External – There are no external dependencies.